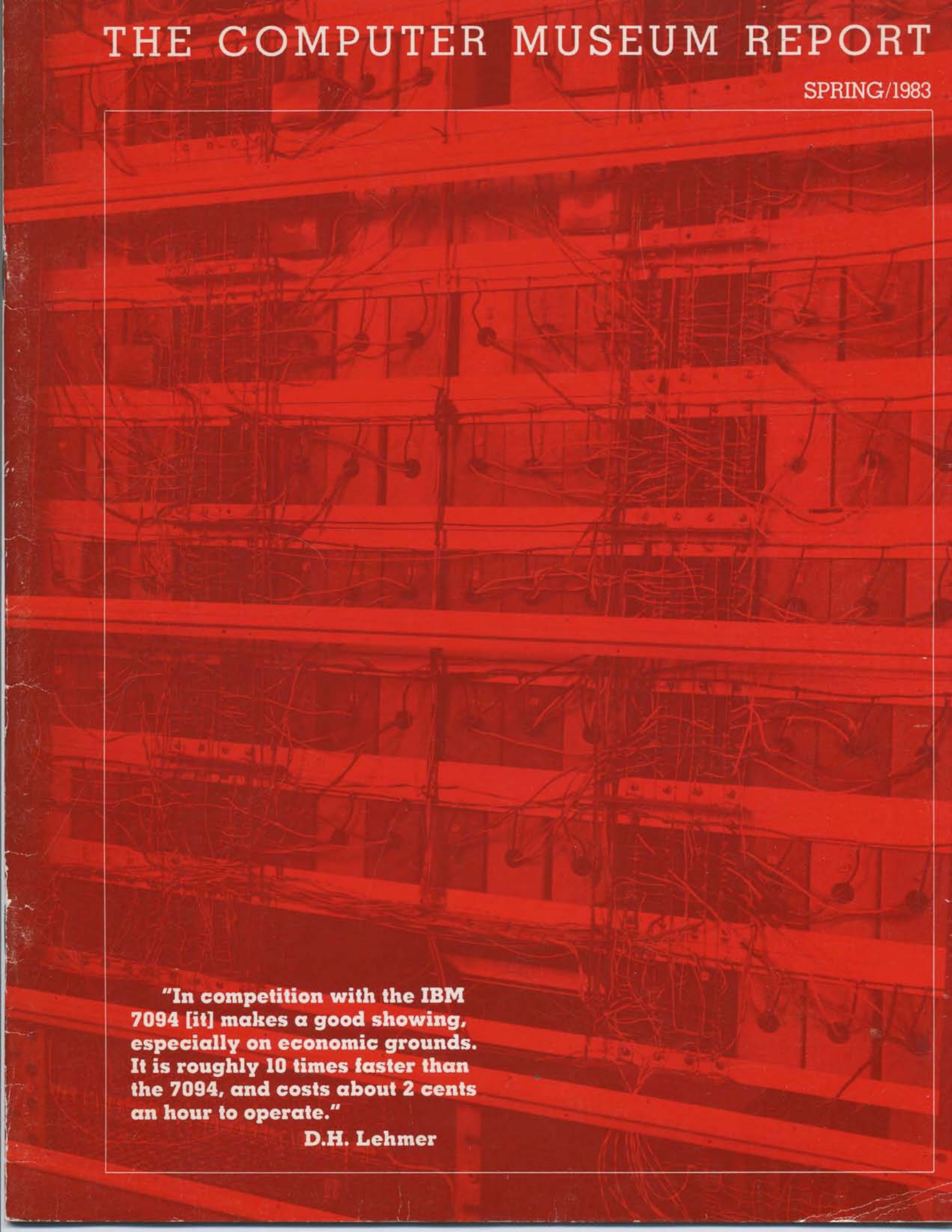
THE COMPUTER MUSEUM REPORT

SPRING/1983



"In competition with the IBM 7094 [it] makes a good showing, especially on economic grounds. It is roughly 10 times faster than the 7094, and costs about 2 cents an hour to operate."

D.H. Lehmer

PHOTO CREDITS:

Robert Bonifield, Cover, pp. 2, 3, 4;
David Bromfield pp. 3, 12, 14, 15;
Data General Corporation p. 5;
IBM archives pp 8, 9, 10, 11, 12;
MITRE Corporation p. 13.

THE COMPUTER MUSEUM

The Computer Museum is a non-profit, public, charitable foundation dedicated to preserving and exhibiting an industry-wide, broad-based collection of the history of information processing. Computer history is interpreted through exhibits, publications, videotapes, lectures, educational programs, and other programs. The Museum archives both artifacts and documentation and makes the materials available for scholarly use.

The Computer Museum is open to the public Sunday through Friday from 1:00 to 6:00 pm. There is no charge for admission. The Museum's lecture hall and reception facilities are available for rent on a prearranged basis. For information call 617-467-4443.

Museum membership is available to individuals and non-profit organizations for $25 annually and to businesses for $125 annually. Members receive the quarterly Report, invitations to all lectures and special programs, new posters, and a ten percent discount in the Museum store.

A Founders program is in effect during the initial two-year period of the Museum, until June 10, 1984. During this period individuals and non-profit organizations may become Founders for $250 and businesses and charitable Foundations may become Founders for $2500. Founders receive all benefits of membership and recognition for their important role in establishing the Museum.

THE COMPUTER MUSEUM REPORT (ISSN 0736-5438)

The Computer Museum Report is published quarterly by The Computer Museum, One Iron Way, Marlboro, MA 01752. Annual subscription is part of the membership of the Museum ($25 per year for individuals and nonprofit organizations and $125 for corporations).

The purpose is to report on the programs and exhibitions of the Museum. The contents of The Computer Museum Report may not be reproduced without written consent.

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The design and production of the Report is done by Benson and Clemons.

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THE DIRECTOR'S LETTER

The Computer Museum Report now has an ISSN (an International Standard Serial Number), another benchmark in our development. The purpose of the publication is to report on the Museum's activities with the material in each issue derived directly from our own projects, thus providing a record and a means of communication to our worldwide membership. This issue only covers a part of our fall program of three lectures, seven Sunday afternoon talks, the production of "Pray, Mr. Babbage . . .", the members' field trip to Canada, a variety of additions to the collection, and a number of new products available in the Museum store.

Both the Museum and the Report have seasonal rhythms. Writing this letter during our January-February hibernation, I'm recalling all the wonderful activities of the fall season and anticipating Gene Amdahl's talk that starts our spring season on March 10th. Derrick Lehmer opened the fall lecture series October 7th, 1982 and dedicated the exhibit of his sieve machines to the Museum. No sooner was the exhibit mounted than *The Scientific American* sent a photographer to shoot these unique machines for their November issue. As a result the Museum was given the excellent photos that appear on the cover and in the first article of this Report.

On October 8, 1982, the Museum's first excursion took off for North Bay, Canada to see the AN/FSQ-7. By the time you are reading Gordon Bell's trip report (page 13), the decommission of the Q-7 will have commenced and we will be puzzling over how to fit a representative exhibit of it in the Museum.

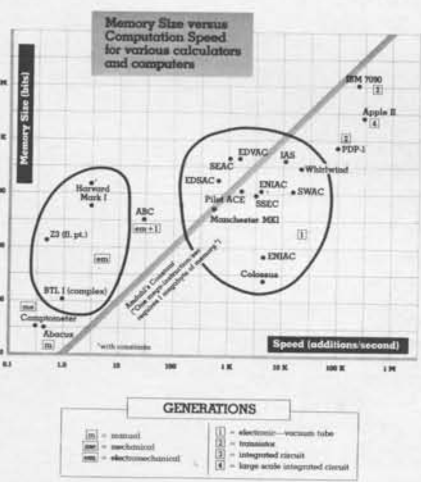
The Fall also inaugurated Bits and Bites, a series of informal Sunday afternoon talks, ranging from technical presentations to reminiscences about the everyday use and development of computers. These complement the formal lecture series focusing on significant events in the evolution of information processing. The session "Inside the Soul of a New Machine" with Tom West and Tracy Kidder (reported on page 5) provided an almost anthropological view of the species "computer engineer." Tracy was on the spot to record how Tom behaved at breakfast, as well as at work. In the Spring, the reminiscences of the group that designed the first computer space game will tell the Computer Museum audience why they ever tackled such a project and also provide insights into the everyday environment of a university computer center in 1962.

Often the lectures and talks lead to changing or further developing an exhibit. Herbert Grosch's lecture on IBM's SSEC at Columbia's Watson Laboratory (extracted on pages 8 to12), the two articles on the SSEC in the October 1982 *Annals of the History of Computing*, and a flurry of letters to the Museum convinced us to add the SSEC to The Pioneer Computer Timeline. With a start up date in January 1948, the SSEC did comparable work to the ENIAC and preceded the EDSAC and Manchester machines.

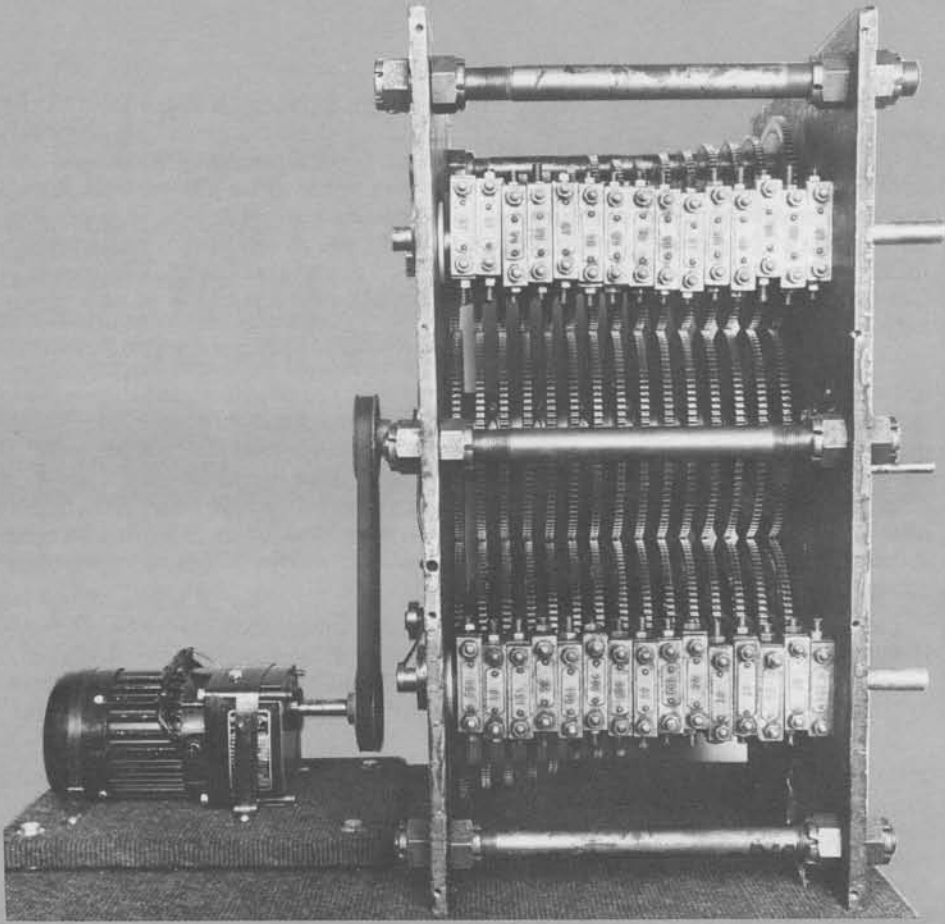
Feedback from members and visitors also helps the Museum preserve the accuracy of its exhibits. Our exhibit coordinator Jamie Parker keeps an ongoing list of text corrections to make. The original text on the Pioneer Computer Timeline was put up crediting "George" Aiken for the Harvard Mark I, the corrected version with an error from the typesetter read "Harvard" Aiken and finally we got Howard's name correct. Several letters pointed out the inaccurate placement of Amdahl's constant on the cover chart of the Fall Report. The corrected version is reprinted on this page and is also available in color in the slide sets listed on the back page. For longer than I am pleased to report the specifications on the Whirlwind read that it used 150,000 kw of power. A number of visitors took great pleasure in drawing this error to our attention, and in some fanciful moments, I've thought of the deliberate introduction of errors providing ongoing "treasure hunts" for mistakes. But this added confusion is hardly needed. Our goal is the presentation of the clearest picture possible of the history of information processing to provide a perspective of the present and future as if viewed through a rear view mirror.

Gwen Bell
Director

Corrected version, cover Winter 1983 Report.



THE PIONEER COMPUTER TIMELINE



This Photoelectric Number Sieve, built by Dr. Lehmer in 1932, performs 300,000 tests per minute using 30 gears arranged tangentially. Each gear has a number of holes equal to a multiple of a prime. For any problem, all holes that do not represent solutions are plugged with toothpicks. A solution is found when light, originally supplied by an automobile headlight lamp, passes through all 30 wheels. A photo-electric cell detects this brief flash of light, and a vacuum-tube amplifier multiplies the resulting signal 700,000,000 times to stop the motor.

Number sieves perform tests on numbers to eliminate those numbers that cannot be solutions to a problem, and thus find those that are solutions. Dr. Lehmer's machines search numbers sequentially, from any starting point that may be chosen, looking for a number that has an acceptable remainder modulo, each of a number of primes.

Consider the following problem: Find a value of x for which $91894770302976x^2 + 287722528867021824x + 256527596541064768$ is a perfect square.

These large coefficients are not arbitrary numbers. In fact they arise quite naturally in an investigation into the possible factors of the Mersenne number $2^{79} - 1$. The numbers $2^n - 1$ where n is a prime have been the subject of investigation since the time of Euclid. Twelve of these numbers have been proved prime and twelve composite ones have been completely factored. Since 1924 it has been known that if a value of x exists for which the formula above is a square then $0 < x < 39110012$.

D.H. Lehmer explored the problem with his photoelectric number sieve. The problem was considered in each of the finite arithmetics corresponding to a prime or a power of a prime where $p < 127$, and the appropriate holes in the corresponding gears were stopped up. This presents the problem to the machine, which, canvassing numbers at the rate of 300,000 a minute, can cover the above range for x in about two hours without attention. As a matter of fact, during the first test the power was automatically shut off in 12 seconds and the machine coasted to a stop.

Reversing the machine slowly and substituting the human eye for the photo-electric cell, the light was seen to shine through at $x = 56523$ according to the reading on the revolution counter. Substituting this value of x in the formula we obtain at once the number 309853160646773276521024, which is the square of 556644555032. Hence our problem is solved. Incidentally this leads to the factorization:

$2^{79} - 1 = 2687 \cdot 20202973 \cdot 1113491139767.$

D.H. Lehmer's Number Sieves

Richard Rubinstein

Richard Rubinstein, a human factors engineer at Digital Equipment Corporation and an active volunteer at The Computer Museum, compiled this article, based on his experience planning and supervising the Lehmer Number Sieves exhibit.

Dick Rubinstein (left) and Derrick Henry Lehmer (right) pause in front of Lehmer's Photoelectric Number Sieve after Lehmer's dedication of the exhibit, October 7, 1982.

Derrick Henry Lehmer is the son of a leading American number theorist, Derrick Norman Lehmer (1867–1938). D.H. Lehmer designed and built the number sieves shown in the accompanying photographs of the Museum's Number Sieve exhibit to further his own research in number theory. He presented the number sieves to the Computer Museum, and on October 7, 1982, he dedicated the exhibit with a lecture on the sieves. Videotapes of his lecture are in the Museum archives.

As a user of ENIAC, Dr. Lehmer was in charge of operations, maintenance, and much of the trouble shooting. Dr. Lehmer continues to use computers, such as the Cray 1 and ILLIAC IV, to support his work with number theory. He is professor of mathematics Emeritus at the University of California, Berkeley.

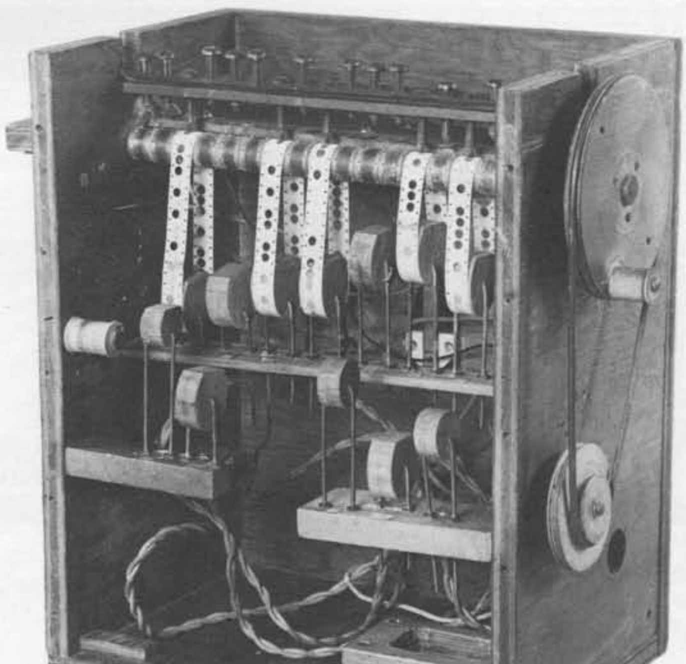
The number sieve idea dates back to the Greek Eratosthenes who lived in Alexandria about 230 B.C. His sieve provided a way to find prime numbers by removing composite numbers from a list of the positive integers.

The first mechanical realization of a sieve process was over 200 years ago, by Karl Hindenberg, a German, and Anton Felkel, an Austrian. They invented what is now called the stencil method. Using this technique, Felkel produced a compilation of the factors of the integers up to 408,000, published by the Austrian government in 1776. Few copies were sold, and those remaining were scrapped and used for making cartridges for the war against Turkey.

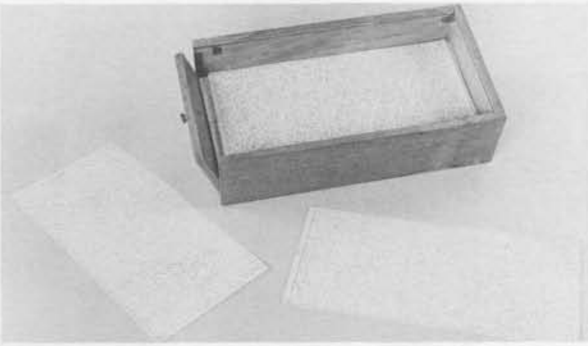
These sieves were specialized, useful only for finding primes and for finding the factors of composite integers. A more general approach, the strip method, used by A.M. Legendre in 1794, allowed searching for numbers with far broader properties, but was still a slow and error-prone manual technique. The strip method was the best available technique when D.H. Lehmer developed his first machine.

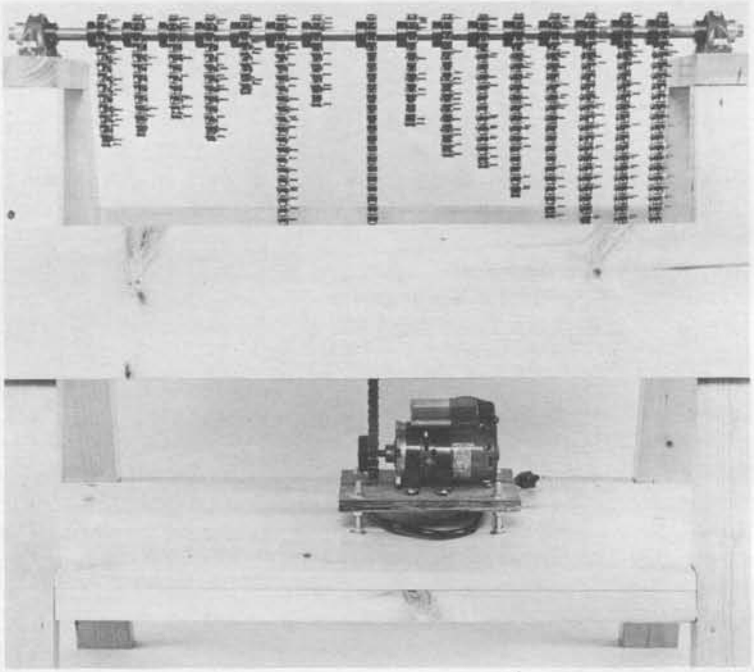
Dr. Lehmer built the first electromechanical number sieve in 1926. It used 19 bicycle chains, and performed a process similar to the strip method. The rotating chains simulate the effect of the shifting strips of paper, and have the major advantage that no upper limit of the search need be established at the outset. The machine can be left running indefinitely in search of numbers with the desired properties. In 1932, Lehmer built a far faster machine using 30 tangential gears, capable of performing 300,000 tests per minute. Later, he also built a sieve that used 16mm film, and another with vacuum tubes and delay lines. These machines did efficiently and inexpensively what no commercial calculating equipment then available could do at all.

This small sieve, employing 16mm film as the computing elements, was built as a complement to the large photoelectric machine. It was used for relatively short problems, and performed about 3000 tests per minute. Easier to set up than the photoelectric model, it could be supplied with as many as 18 film loops.



These stencils were used by D.N. Lehmer (D.H. Lehmer's father) to produce a table of factors up to 10 million. A great deal of kitchen-table work was performed by the whole Lehmer family in order to create these cardboard pieces. Number theory seems to be a family activity with the Lehmers. Dr. Lehmer is now working with his grandson on a new machine using integrated circuit technology.



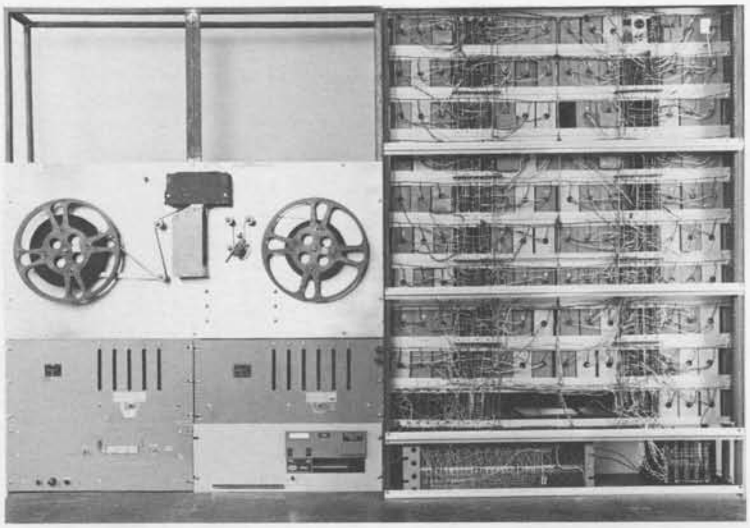


The Bicycle Chain Sieve, built in 1926 but later destroyed, is being replicated at the Computer Museum by Roberto Canepa, Andrew Kristoffy and Richard Rubinstein. This photograph shows the Museum's working model before the installation of micro-switches and a counter. The original 19-chain machine could perform 3000 tests per minute. It was used to factor the number:

9999000099990001

which is a factor of $10^{20} + 1$. The machine ran for about two hours, finding the solution:

1676321 • 5964848081



Constructed in 1966 as an unsponsored educational project of the Departments of Mathematics and Electrical Engineering at the University of California, Berkeley, the Delay Line Number Sieve performed 1 million tests per second. Navy surplus delay lines store the acceptable remainders for each modulus and circulate them synchronously. The machine has an idle mode in which all of the delay lines are connected in series and the data recirculated, so that the machine may be "stopped" and loaded.

"In competition with the IBM 7094 [it] makes a good showing, especially on economic grounds. It is roughly 10 times faster than the 7094, and costs about 2 cents an hour to operate."

D.H. Lehmer

Inside "The Soul of a New Machine"

Tracy Kidder and Tom West

Tracy Kidder (left) and Tom West (right) discuss The Soul of the New Machine during the Museum's Bits and Bites series.

Tom West: I think it's probably important to point out that Tracy and I have never done this before . . . and will probably never do it again! I am still doing computers and Tracy is still writing books. Neither of us has yet become P.R. junkies, but that may change after looking at such a large group of people who seem to think we have something to say.

Tracy Kidder: We would like to find out what you are interested in and try to answer your questions.

Q: How did you two first get together? Did you start writing at the time the project was started?

Kidder: About six years before I started, I had been a journalist writing for the *Atlantic Monthly*. I went in to my editor one day because I had nothing to do and asked him what I should do next. He said "Look into computers." I asked where I should start and he told me to go see West, whom he knew. So I did and then one thing led to another.

West: It was a little more complex than that. Tracy decided that he was going to write "The Book" about all computers. He went to the library and found that there had already been many stories written about the whole world of computers. Then it was going to be the whole world of mini-computers, which I suspect even today is too big a story to tell. It kept narrowing and narrowing, until, rather accidentally it became focused on a single machine.

Q: What was it like for you, as someone who is used to working with machines in a crisis situation, to be shadowed by a person with a notebook?

West: There are some real advantages to having a writer on a project. Tracy was about the best early warning system you could imagine. I would suggest that every program manager hire some guy from the street, teach him how to write on steno pads and have him walk around listening to people. The young engineers walk around thinking that this must be an incredibly important program because somebody is writing about it. One disadvantage is that you could wind up with the most well-recorded failure in history.

Just Tracy looking at the thing actually changes the way it works. There is all this uncertainty involved. It's not the way it would work under normal circumstances, it has been perturbed. It is a little disarming to wake up in the morning, go down to breakfast and find Tracy Kidder interviewing your wife and two daughters with a steno pad.

Kidder: Most good journalists, and I certainly aspire to be one, think of themselves as good anthropologists who come in to observe the customs of the natives and don't want to change those customs in the process. Just the fact that you are there changes things. But, if you are never there at breakfast then you would never know what happens at breakfast.

Q: What sort of reaction did you get from Data General and from people in the book, after the book came out?

West: For me, it was like three years of psychoanalysis embedded in about twenty-four hours. I hadn't read the book before Tracy went to the printers with it and I don't think many of the other people had either. It was a shock then, to all of a sudden see a whole piece of your life in print, a piece that maybe you would have chosen to rewrite very carefully.

I don't think Data General was certain, even after reading the book, what the public reaction was going to be. It was a fairly accurate representation of what they do every day for a living. And I don't think that the story is unique. Otherwise, why do so many people read the book? Why do so many people buy the book and send it home to Mom to explain what they do? And why do they give it to their girl friends to explain that this is the reason they are not home until eleven o'clock at night? The general answer is that the everyday life of designing computers had been pretty opaque.

But from my point of view the reviewers tell you what you are supposed to think about the character.

Kidder: That's right, you have been called Captain Ahab, The Prince of Darkness, Machiavelli, Tom Swift . . .

West: Gatsby and Horatio Alger. It's been kind of eerie.

Q: The paperback book says it is soon to be made into a major motion picture. What is exciting to the lay person about high technology?

Kidder: I think this is kind of fun, frankly. Columbia wanted to turn this into a movie, one way or another. As to why they find it interesting, I don't know. I found the story interesting and I rate as a lay person. At one time during my research, Data General had some understandable fears about trade secrets. West pointed out in a rather sardonic way that I would never learn enough to be able to convey a trade secret.

West: When people ask why D.G. allowed a Pulitzer Prize winning book to be written about their machine, that is not what they agreed to. A guy was going to write a little piece about a couple of guys sitting down in a lab sort of dreaming up their own thing. Even at printing time there was really no way of knowing that there was quite so much interest in Tracy's book.

Q: What are some of the advantages of a closed management style versus a more open one?

West: In support of this sort of closed management style, I knew more about what was going on in every single one of those organizations than any manager at that level in most companies does. It's not a question of not having the information, it's a question of not having the style.

If somebody walks into your office after five minutes of staring at a sheet of paper and asks: "Should we make this register sixteen bits wide or thirty-two bits wide?" you know the answer to this question if you have been through it over and over and over again. So you can tell him the answer, and he goes back and puts it in. Then he sits around for another five minutes before coming back with the next question. In some sense that is sort of what happens.

If you can send him back to his office and he thinks a little while longer, ten minutes, fifteen minutes, or a half an hour, and then he gets a little scared because he's got to have the right answer by the time he goes back in again, you extend his span of attention before he is finally ready to go and scream for help.

It seems to me that that is one of the most valuable lessons that you can teach a kid who is coming into this business right out of school. A span of attention of five minutes or even a half an hour is not really going to do it. There are some problems that only yield after three hours of just staring at them. I'm sure all of those who have been doing design work have seen exactly that same thing happen. It is the ability not to give up even after two hours of trying to stare something down. Part of that is what is embedded in that whole style of trying to make the easy answers difficult to get.

Q: It is very clear at the end of the book that you couldn't keep a good team together, but it is also sort of sad that so many of them end up leaving Data General.

West: At the end of this program, an awful lot of people, not only left the program, but also left Data General. This is not a totally anomalous phenomenon to D.G. People don't leave projects in the middle, they leave them at the end, with an incredible postpartum depression at the end of something that they poured so much adrenalin into. They go home and with more time on their hands. They begin to ask themselves why the heck they ever did it in the first place and would they ever be willing to do it again. If the answer is yes, then what are the odds of their doing it successfully again? Is it a coin toss, fifty-fifty each time, or do the odds keep piling up against you?

I read in Time Magazine that statistically I'm burned out and washed up at forty-three. I think there is going to be not only a shortage of engineers in the next ten years but a shortage of engineering managers with enough street sense to be able to manage all the college graduates who are graduating with all kinds of notions about things that can be done but quite possibly shouldn't be done. Just like all these people who are putting 68000s on a board and calling it a computer. There is going to be a great need for people to be able to see the way technology is going and be able to manage these people coming out of school.

In this machine we had a straightforward design. We were highly leveraged on PALs because it provided quite a bit of logic compression. Almost everyone drew out these PALs, except the guy who was designing the system cache. He was doing it all on four by five file cards. Every week or so I'd ask him how he was coming on his design. He'd show me this big deck of file cards with Boolean equations written on them and a whole room full of Karnaugh maps and things to try to reduce these down to something that made sense. There was no way of telling where the guy was. Design review time was coming and all the managers were getting anxious. The big deck of cards was still there, and he was still worrying about the various mapping things that he'd learned in college. We really came perilously close to firing that guy. But finally when the design review day came, it was a deck of cards with a well-defined set of Boolean expressions for each one of those PALs. We used one hundred and sixty of them in the machine and about forty of them on the system cache. He built the thing, and it worked the first time. At that stage of the game I said to myself; thank God I didn't fire him.

Q: Would you attribute the intimidation some of your subordinates felt toward you to their inexperience?

West: In the first place, I would sure hate to defend what I did four years ago. At some level in the organization you expect to have people who are going to fight back, regardless of what the issue is, if they feel strongly about it. If they don't feel strongly about it, then they had better go away and do it your way.

Q: The book mentions the fun part, the engineers doing the design, but I don't remember hearing about the paper work and bureaucracy, meetings etc. Did you find some way around that?

Kidder: You know the old joke about the bum who is looking for his quarter under the street light, even though he dropped it half a mile away because the light is better. This book doesn't take on, in any detail, the software part of the project which is at least half. There were some things that I saw more of than others. I was also able to drag a certain amount of that information out of Tom. Then one day I said to Tom: "I don't know much about what you've been up to lately," and Tom said, "Oh you noticed."

I always thought that the salient characteristic of this team, which I thought was charming, was that no one ever seemed to take pert charts at all seriously. A nucleus had built computers before and they knew what was required. They knew, I think, that what was required could simply not be embodied in a pert chart.

Q: If you could do this over again, would you fight harder for a mode bit?

West: No, quite the contrary. In hindsight I thought that was a really spectacular decision. Tracy said half the work may have been software where I would guess eighty percent of the work was software. Without the mode bit we could drop sixteen bit programs on that machine and run them. For a long period of time that was exactly what we were doing. We also had three or four hundred thousand lines of diagnostic code, all of which would have had to be rewritten. So for the time being, having that absolute compatability was the only thing that could get it there on time.

The point is that the machine doesn't have a golden moment of when you all of a sudden stop implementing the mode bit and then move on to a different identity. Mode bits tend to increase in a geometric fashion, and I've seen a lot of machine families that are now going into their two-to-the-sixth mode bit. Intel is going to solve all their incompatability problems at the chip level with mode bits and it is going to go to huge numbers, I think.

Q: I wonder if you could say something about Ed DeCastro's involvement. The novel makes it seem like he was very rarely checking on the project.

West: That is one of the most difficult questions to answer because once again I think most of the people who were working on the project itself would assume that I had no visibility, barricading myself in my office. Mr. DeCastro is more than likely to let something go with benign neglect, assuming that local management would find a way to solve its problems. He was certainly not involved on a daily or weekly or even monthly basis.

Q: What about Carl Carmen, who was the vice-president of engineering at that time?

West: He was involved during the program, in making sure that the environmental issues were taken care of, that the PC shop worked at the right speed and that things didn't get lost in the mill. He also barricaded the team against the rest of the organization.

Q: Since you weren't able to tell us much about software, those of us who are in software felt a little cheated. Could you tell us what the organization of the software development's side was?

West: When Tracy talked about looking under the street light for the quarter it is because hardware tends to be a lot easier to see, it has a lot more of a visual effect than writing code does.

The reason for having the sixteen bit identity in the machine initially was because we didn't believe that we were going to have any software at all. There was a guy who decided that he could take our existing sixteen bit operating system and by taking it module by module convert it and run it initially in just a couple of the rings with only a couple of the features, and then incrementally get there over a period of a year and a half. He put together a team of twenty volunteers all signing up for a kamikaze mission because nobody really believed that it could be done. Then he decided that we were going to have the software to announce at the same time that we had the hardware to announce. All we had planned to announce was thirty-two bit hardware, which would get some pressure off our back and point to futures. He managed to do it. The reason that he managed to do it was that he didn't decide okay, I've got a clean sheet of paper and I'm going to develop an O.S. all the way from the ground up, based on the first principles of computer science. The relationship was quite close. In the final analysis, the only thing we really had to de-bug in the thirty-two bit part of the machine was the operating system which had already been run through thirty-two bit simulators. At that stage of the game we were using system software to de-bug the hardware.

Q: What happened to the competing design?

West: The competing design is still alive. It's always difficult to know the answer to "What if?". It would be naive to suppose that D.G. was only working on extensions to the Eagle family of machines. It would also be naive to assume that we are just pragmatically going to follow technology and wander along incrementing the existing product line. The question is when, not whether.

Q: The book mentions a saying in Mr. West's office that anything worth doing is not necessarily worth doing well or something along those lines.

Kidder: One of the things that I began to learn about engineers is that they are aesthetes as much as they pretend to be something else. I've seen this most vividly in the intersection of engineers and non-computer scientists. The engineer talks about technical symmetry and the scientist says I just want something that works. I think that that was what that piece of cryptic puzzling advice was. How did it go? Not everything worth doing is worth doing well.

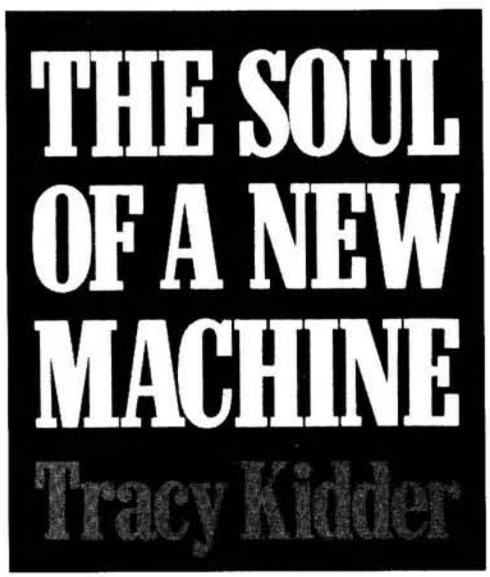
West: I am very comfortable with that notion. I suspect that there are more people who fail in our industry because they try to do it perfectly, as opposed to doing it on time and on cost.

Q: What are you doing now, respectively, and secondly, are you (Tracy) sick and tired of computers?

West: We are still basically doing the same thing—designing machines—at Data General. The book portrays people leaving, which was true at the time Tracy had to go to press, but since that time a large number of people did stay. All those people have formed a nucleus to build multiple different machines, going in different directions, they build bigger ones, smaller ones, faster and cheaper ones.

Kidder: I'm digging out from under. I'm writing some articles about atmospheric research. To be honest, I'm a little tired of my book. I put it on my shelf and won't read it again for years. I think I know what's wrong with it. In some sense, writing a book is like building a computer. There are rewards but one of the main ones is that Sisyphean one that if you do one you get to do another. So, I have an opportunity now to write a better one.

Extracted from a talk by Tracy Kidder, author of The Soul of a New Machine *and Tom West, the chief designer of the machine, Data General's Eagle, in the Museum's "Bits and Bites" series, given October 17th, 1982.*



Tracy Kidder autographed copies of The Soul of the New Machine for the Museum. Remaining copies of the autographed copy are available for $18.00 (including shipping) from the Museum store.

Recollections of the Watson Scientific Laboratory, 1945–1950

Herbert Grosch

The heroes of this story are Thomas Watson Sr. and Wallace Eckert. Tom Watson Sr., when I first met him, was in his seventies. In the 20's, 30's and 40's, he supported what he thought of as scientific research, but what we call applied research. At that time, this kind of support was uncommon for even the most advanced American industries.

Wallace Eckert's prime life interest was the theory of the motion of the moon. Astronomy provided one of the earliest groups of people who had substantial problems which had to be solved with computation regardless of the form, whether it be pencil and paper, logarithm tables, or with the most advanced modern solid-state computing devices. In the thirties, a major problem was that crossing the Pacific required the measurement of both longitude and latitude. The chronometers were inaccurate and a very accurate clock was needed. Many many years ago the motion of the moon among the stars was suggested as a clock. As a consequence, a great effort was put on the determination of the proper position of the moon. One of Babbage's interests was in building astronomical tables helpful for navigation. Even today, people who are doing algebra on computers, often use the enormously complex and lengthy formulas of the litteral lunar theory as an example.

In 1945, IBM remodeled this fraternity house and donated it to Columbia University for the Watson Laboratory. The first concept of the SSEC was formulated in this building and the group that eventually built the NORC (Naval Ordnance Research Calculator) worked on the upper floors and in the basement.

Eckert discovered a series of articles by L.J. Comrie, a New Zealander who by that time had penetrated the scientific establishment in England sufficiently to become the Director of the Nautical Almanac office at the Royal Greenwich Observatory. These articles explained how Comrie had rented Hollerith machines from the British Tabulating Machine Company and had done the calculation of the positions of the moon for every hour or every six hours or something for hundreds and hundreds of years on a mass production all-parallel basis.

Inspired by this, Eckert, with the help of the American Astronomical Society of which he was a junior member and Columbia University where Thomas Watson Sr. was a Trustee, approached the IBM Corporation, a less than one-hundred million dollar business. They donated some special equipment which he installed and called it The Thomas J. Watson Astronomical Computing Bureau which flourished in the late years of the thirties.

Then the War threatened. The U.S. Naval Observatory had to manufacture a new publication called the Air Almanac for the use of navigators crossing the Atlantic by air, especially for bomber navigation, when the skies were clear and bubble sextant observations and so on were possible. They had run out of old-fashioned people who could do this with paper and pencil and logarithm tables. Wallace Eckert's war work was the real McCoy—carrying out very complicated calculations, the sort that

This famous photograph of Thomas Watson Sr. hung over the fireplace in the Watson Laboratory at Columbia University for which he furnished the money and a large part of the inspiration.

Wallace Eckert

strained the professional astronomer. Done, however, in parallel so you didn't have the problem of a complex sequence, but doing a single simple operation to hundreds or thousands of pieces of data at one time and then moving on. With methods he developed for automatic proof-reading, he was able to produce the Air Almanac. Since that time literally millions and millions of characters have been printed by the calculations of such equipment, printed by his automatic printing machine, and proof-read by automatic devices without one single error ever having been detected.

In 1941, I became an optical designer which involved lots and lots of calculations on Monroes and Fridens. Then, in the early spring of 1945, an announcement in *Science* stated that Thomas Watson Sr. had called Wallace Eckert back from Washington and had asked him to establish a new scientific computing laboratory at Columbia University. Before he left Washington, I wrote Wallace asking if I could come around in the evenings and try out some of my ideas on optical design on his nice new shiny IBM machines. One of the incentives for beginning the laboratory was that the computational facilities at Los Alamos had run out of capacity. Wallace accepted the charge of setting up a shop of IBM machines at Columbia with the first task to supplement the Los Alamos calculations on the Alamogordo burst. While I only hoped for an invitation to maybe around one night a week, instead a little man from the Manhattan Project showed up at my optical company and took me away. I said, "You know you can't do that, there is no such thing as a civilian draft." He essentially said, "Tell that to General Grove." The next thing I knew I was an IBM employee. In the rush they forgot to pass me through IBM headquarters. As a result, although I received an identification card and all that, nobody had paused to tell me that you could not have hair on your face and work for IBM. So I was not only a very early scientific punch card operator and supervisor but I also was the first bearded sport-coated IBM employee.

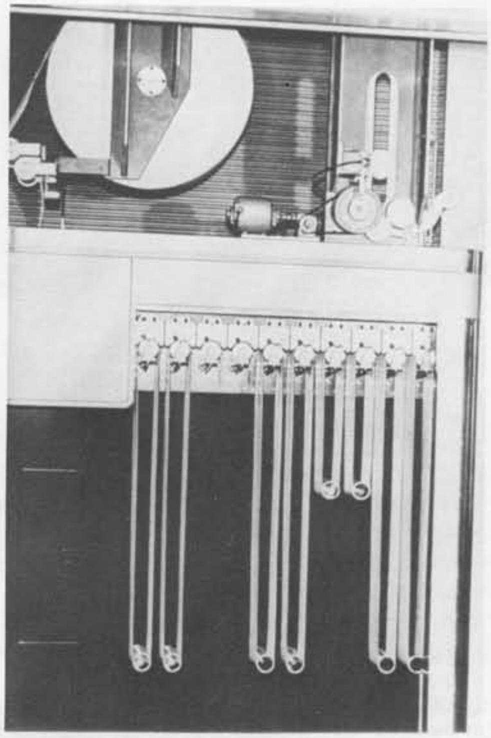
1946. Boom. ENIAC. For the first time IBM felt threatened by a development that they had not really foreseen or understood. One of the responses to the ENIAC announcement was the mass production (mass being about twenty units) of the 603 calculating punch operating at around six thousand cards an hour while its electro-mechanical competitors did six hundred. IBM had produced it out of their own patents, their own Eccles-Jordan flip-flops and so forth, originating primarily with a gentleman by the name of Halsey Dickinson. But, this card calculator was not enough for either Eckert or Thomas Watson Sr. who was incensed that someone would produce something that he didn't know about and hadn't sponsored.

A group of people were brought together to write the specifications for a gigantic new machine, the SSEC. With almost no electronic gear available on the market, the arithmetic units were designed around the standard 25L6 radio vacuum tubes. The design of the SSEC went ahead day and night, seven days a week at the IBM engineering laboratory in Endicott. Along with the electronics, a complete panoply of peripheral equipment was designed: high speed card readers, auxiliary tape punches, card punches, fancy console, storage devices, and a major table look up unit in contrast to the setting switches on ENIAC's function table panel.

The whole thing was to be installed in beautiful quarters in the IBM world headquarters at the corner of Madison Avenue and 57th Street, since torn down. Since no sizable ground floor space was available, they bought out a store called the French Bootery around the corner on 57th Street. They tore out the shoe store shelving and put power supplies with a gigantic air-conditioning unit in the basement. The equivalent of false floors was created by a raised floor with the enormous amount of electronic cabling under it. The machine was put together at Endicott, ran, taken apart, and moved to New York City.

On Mr. Watson's final inspection about two or three days before the opening ceremony, he was disturbed by the fact that there were large columns marching down the center of the room. He said, "Everything is lovely, you gentlemen have done a beautiful job but I think we should remove those columns." Unfortunately, they held the building up. Nevertheless, the four-color brochure which had been printed for opening day was recalled and a two color sepia print center-fold inserted showing the machine room minus its columns.

After the dedication, Thomas Watson Sr. said, "It's wonderful how these people out at Endicott and these people in New York have slaved over this ma-



The SSEC tape drive consisted of a four hundred pound reel of card stock which had to be lifted with a chain hoist. It is sliced, unlike the average roll of card stock, to the length of the punch card rather than to the width. In other words, it is eighty columns wide. It passes through a punch unit in the square box at the upper left and is punched with two round sprocket holes and up to seventy-eight conventional IBM rectangular holes. One line of this punching constitutes a line of instructions or data. It could then go to as many as desired of the succeeding ten stations or loops used as subroutines. Sixteen feet high racks of wire contact relays (equivalent of what we would call core or central memory) were behind the scenes. The electronic memory in the arithmetic unit was only a few words, since the tapes were used as input and long-term memory devices.

The SSEC used conventional IBM 405 tabulators rehoused with the tape slugs turned upside down, and the wires crossed so as to make it work out of the back instead of the front for the sake of appearance. The 12,000 inch and a quarter diameter 25L6 boggles out of which the arithmetic circuits were made can be seen in the back of the photo.

This Lake wire contact relay was made in 4's, 6's and 10's. The whole unit was about two inches high. Because of the nature of the armature, a little thin plated wire, they were nearly as fast as the telephone relays.

chine for the last year. Their wives have let them work all hours. They have been diligent and successful. We will celebrate by having a weekend at the Waldorf." On two days notice telegrams went out to all of the senior people that had shared this activity, inviting them and their wives to come to an old-fashioned family get-together at the Waldorf. That is a somewhat large family. Rumor had it that the Waldorf was chosen not only because Mr. Watson liked it very much, but because all bar bills were charged as restaurant. At the luncheon, the old man got up and told us how he loved us, how wonderfully we had behaved, and how we were all part of the IBM family. It was a fantastic exhibition of the kind of excitement that Watson, then in his mid-seventies, could generate.

The Lab's decoration was in my hands and I worked with Mary Noble Smith, the curator of fine arts, who helped me furnish the place with the IBM ceramics and paintings. The ceramics came from a program "the old boy" had sponsored at Syracuse University before the war. He liked it so much that he bought it all and put it in a warehouse where we retrieved some pieces. The old man objected to my choice of French Impressionist paintings in the lobby and remarked that there should be pictures of telescopes and so forth. The next day Mary Noble said, "What are we going to do about those photographs that Mr. Watson wanted?" I said that we weren't going to do anything about it. When they closed the building to move to 115th Street, those paintings were still on the wall. Wallace Eckert was asked for his opinion on paintings of great American scientists commissioned by IBM. Wallace who was a Yale man liked Willard Gibbs, so we hung Willard in the library. Mary Noble came down to me wringing her hands saying, "I don't understand it, we wanted you to have 5 or 6 at least."

I asked to see the list and said, "We will take Ben Franklin."

"But Dr. Grosch," she objected.

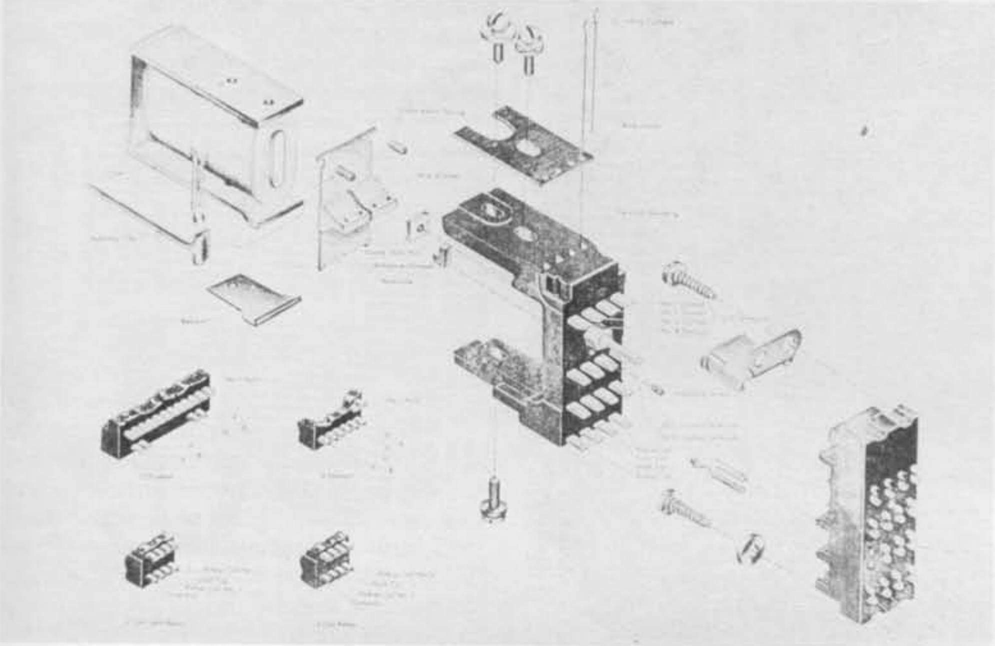
I said, "Ben was sort of an amateur natural philosopher, lightning and all that business. But the rest of these guys like the Wright brothers and Edison are inventors, we don't want them here in the Watson Lab."

She said, "I don't understand the difference. What do you mean by a scientist?"

About six weeks later the art van drove up and they delivered a portrait of Newton which I hung in the library with great pride. When I saw her again I asked her where she had found the portrait. She said; "I had it painted for you."

The Lab's electronics group was very special. Rex Seeber was recruited from Aiken's Harvard Mark I with the experience of running a big machine which practically no one else in the world had at that time. He was invaluable as the man who lived downtown with the SSEC in its plate glass and stainless steel palace and turned out very useful work. Eckert was well aware of the fact that IBM did not have modern pulse technology at its disposal. What was needed was to go to the more modern mega-hertz kind of technology which was available in large quantity

The Pioneer Computers	Start up	Completion	Program	Word length
IBM SSEC 57th Street at Madison, New York City	10/46	1/48	78 hole punched tape (IBM card stock), punched cards, plugboards.	20 decimal digits (19 + sign) double precision table lookup 14×14 arithmetic



at Bell Labs and M.I.T. With the help of I.I. Robie who was Eckert's close friend from his days as an astronomy professor, Eckert hired two young and one mature electronics engineers. They arrived simultaneously and put my nose out of joint because they knew an awful lot of things I hadn't even dreamed of yet. Byhavens built the NORC and was interested from the beginning in doing that kind of activity. John Lenz was more concerned with a tool for individuals and less with building a gigantic machine for number crunching. He built a smaller machine or the pieces of a smaller machine which led toward the IBM 610. Robert Walker, who was the more mature man, first continued to play with analog circuitry and then ended up interested in a simultaneous equation solver.

I mention this because one of his visitors was Clifford Berry, the coworker of Atanasoff. Berry was interested in infra-red spectroscopy and had published an article in *The Journal of Applied Physics* on a knob-twiddling analog simultaneous equation solver. Walker wrote to him, had him brought in and they talked with Francis Murphy of the Columbia Math Department and others about how to build a machine of this sort at the Watson Laboratory. By the time it was a useful tool, the technology had moved on towards digital computers. With a 604 you could solve ten equations and ten unknowns to six or eight figures in a reasonable amount of time. In contrast, Walker's analog device took quite a long time to twiddle all the knobs and was less accurate.

The practical computer shop was used by people in chemistry and geophysics at Columbia, by Wallace Eckert, L.H. Thomas, and myself for our research, and for work for General Electric on unclassified nuclear energy and steam turbine design. We helped install the 604's, and watched the CPC develop. We saw people like George Finn, Bill Woodbury and Rex Rice from the aerospace industry demand that IBM build a more sophisticated machine for mass production. Ed Teller especially came to us for calculations in partial differential equations of partial integral differential equations which were tougher than what we had done on the punch card machines. With those we used special relay calculators built for us by Hans Peter Loon who later became head of The Information Society of America. He was a great guy at whomping up special machines using those Lake wire contact relays and his own design methods for survey calculations, cryptography or whatever was needed.

As word spread that a machine was becoming available at the consulting service at Columbia, people began to drift in and say, "Hey, what should I do to start doing this?" In 1948 when I ran the conference at Endicott we were hard put to come up with fifty or sixty people who really wanted to do advanced technical calculation on punch card machines. When the CPC's began to come out and word of the Defense Calculator began to spread there began to be hundreds of installations that became interested in doing it with thousands of people. A.C.M. had started in 1947, the IEEE and its predecessor societies began to talk about applications and not just about the details of construction. There was a time around 1950 when computing went from a small coterie of enthusiasts to being commercially practical. No mass production had occurred: the UNIVAC 1's had not yet been produced; the 701's were still two or three years from major delivery; but the scent was in the air. It was obvious that there were going to be large numbers of sophisticated number crunchers which were going to need trained people, professional operators and software artists. And they were going to be used not only in science and engineering where they were already popular but in business as well.

Yet Wallace always wanted to do astronomy. One of the things we built at the Watson Laboratory was an automatic measuring engine to measure gigantic photographs of the stars. A punch card went in, the machine made a rough setting, a photo-cell made a more accu-

Memory size (words)	Add time	Memory type	I/O	Technology	Floor space est. sq. ft.
8 words electronic, 150 words relay, 20000 words tape (including 5000 lines of table lookup)	0.3 ms	relays, wide tape	wide tape, punched cards, line printers	12500 vacuum tubes 21400 relays 40000 pluggable connections	3050 (special room)

rate setting and the punch recorded it on the initial card. It sped up the process of astronomical measurement by a factor of five or six. If he had wanted to abandon astronomy and become a computer man, I'm sure he would have been a much better known figure. His contributions were enormous but they were disguised by the fact that he really did them in order to do better astronomy. That helped us all, helped astronomy, but it was a direction that did not please IBM so much.

The Watson Lab was very valuable as a consulting service and as a point of contact between IBM and academia. As a part of astronomical research it was unequalled. As a signal that Thomas Watson Sr. who furnished the money and much of the incentive for this was committing his rather small company to a scientific and engineering enterprise that was unfamiliar to it, it was very significant. One of the things that we did was to teach courses in machine operation and numerical analysis. I think that the main thing that it did was to bring a whole bunch of youngsters into the trade. Because of its location at a University, because we offered courses, because we tried to get young people from customer installations to come and take special work on numerical analysis and punch card machine operation, we passed several hundred bright new people through that shop before it moved to physical research. In the long run, the fact that we had Backus, McClelland, and people like that did more good out in the world than just telling GE that yes, they ought to get a defense calculator.

Extracted from a Museum Lecture given by Dr. Grosch on October 22, 1982. It provides a complementary, personal view of the Watson Laboratory at the time of the SSEC to the two articles appearing in the October 1982 Annals of the History of Computing: *"The SSEC in Historical Perspective" by Charles J. Bashe and "A Large-Scale, General-Purpose Electronic Digital Calculator—The SSEC" by John C. McPherson, Frank E. Hamilton, and Robert R. Seeber, Jr.*

As a result of this lecture and the two articles, the Museum's Pioneer Computer Timeline is being revised to include the SSEC: the first machine to combine electronic computation with a stored program and capable of operating on its own instructions as data.

NORC was the pinnacle of achievement of the old Watson Laboratory. Although it wasn't delivered until 1953 or so, the work had gone on from 1948. It was also, in a sense, the culmination of the decimal machine.

Four of the staff from the Watson Lab travelled to the Computer Museum to hear Dr. Grosch's lecture and visit with Dr. Grosch (second from right). Dr. L.H. Thomas (left) and his wife Naomi drove from South Carolina, William McClelland (second from left) and Donald Pendrey (right) arrived from Connecticut, and John and Alice Lentz (not pictured) travelled from Chappaqua, New York.

Museum News

Field Trip to North Bay

Gordon Bell

The high point of the first Computer Museum members' field trip was the visit to the SAGE AN/FSQ-7 computer prior to its decommissioning after operating "around-the-clock" since 1962. The "Q-7", once known as Whirlwind II, grew out of the Whirlwind project at MIT and became the prototype for the nation's air defense systems. In turn, this technology formed the basis of modern air traffic control!

Seventeen museum members made the trip to North Bay, Canada and the National Museum of Science and Technology in Ottawa. The group included Bob Crago from IBM, one of the key designers; Kent Redmond and Tom Smith, historians writing the SAGE story; Henry Tropp, who is writing an article for the Annals of the History of Computing; and Richard Solomon who photographed and videotaped the Q-7 as part of an MIT Project on the History of Computing. We left Friday noon, 8 October, from Bedford, Mass. for North Bay, arrived and visited the "hole" where we were completely briefed by members of the staff and original installation team, had dinner with the Canadian Air Force leaders, including the Commanding NORAD General (U.S.), flew on to Ottawa where we spent the night prior to visiting the National Museum of Science and Technology and returned Saturday afternoon.

The Q-7

Bob Everett's paper on the SAGE computer was published in '57, and the machine was operational in Canada in '62. The machine created many patents as by-products, including perhaps the first associative store (using a drum). The machine is duplexed with a warm standby (I mean warm since the duplexed machine uses about 1 Megawatt of power to heat 55,000 tubes, 175,000 diodes and 13,000 transistors in 7,000 plug-ins!). The 6 microsecond, 32-bit word machine has $4 \times 64K \times 32$-bit core memories and about the same memory in twelve 10.7" diameter, 2900 rpm drums, 6 of which are for secondary memory. There is no use of interrupts and I/O is done in an elegant fashion by loading/unloading parallel tracks of the drums with the external world completely in parallel with computing. That is, the I/O state becomes part of the computer's memory state. A single I/O channel is then used to move a drum track to and from the primary core memory.

The main I/O is a scan and height radar that tracks targets and finds their altitude. The operator's radar consoles plot the terrain and targets according to operator switch requests. The computer sends information to be plotted on 20" round Hughes Charactron (vector and alpha gun) tubes or displayed on small alphanumeric storage tubes for supplementary information. Communication lines connect neighboring air defense sectors and the overall command. The operating system of 1 Mword is stored on 728 tape drives and the drums.

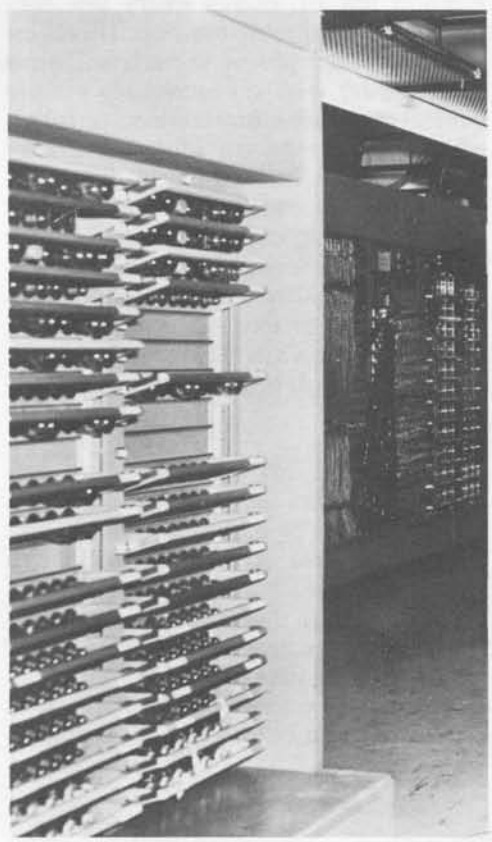
The computer logic is stored in many open bays 15' to 30' long, each of which has a bay of voltage marginal check switches on the left side, followed by up to a maximum of 15 panels. The vertical panels are about 7' high by 2' wide and hold about 20 plug-in logic units. The separate right and left half of the arithmetic units are about 30' each or about 2' per bit. Two sets of the AMD 2901 Four-bit Microprocessor Slice would be an overkill for this 32 bit function today. The machine does vector (of length 2) arithmetic to handle the co-ordinate operations. The room with one cpu, drum and memory is about $50' \times 150'$, and the room with two cpu consoles, tapes and card I/O printer is about $25' \times 50'$. The several dozen radar consoles are in a very large room.

Underground Site

The enormity of the machine was dwarfed by the underground building which encloses it. The building hollowed out of stone by hardrock miners is 600' beneath the surface, and connected

The AN/FSQ-7 control room has been an integral part of the SAGE air defense system from 1962 until powering down in the spring of 1983.

These are only a few of the 55,000 vacuum tubes in replacable plug-in modules that support the SAGE AN/FSQ-7 at North Bay, Canada.



by a 6000' tunnel which can be sealed off in seconds if there are very large, atmospheric disturbances. The building is about 150,000 square feet and has 10 standby 100 Kw generators and an air conditioner that can operate closed loop into an underground pond.

Cost and Reliability

The machine and software cost about $25M in 1962 and the site about $25M. The facility costs several million to operate per year, including about $1M to IBM. Three people are needed to maintain the software. Initially, one hundred people were used to install the machine and set up its maintenance. When you count the radar, planes, etc. and operational costs, the computer cost is almost an incidental.

The reliability is fantastic! With ONE COMPUTER, AVAILABILITY IS 99.83% and with DUPLEX OPERATION, AVAILABILITY IS 99.97%! Having wondered why such an obsolete computer would be still used, it was clear: the reliability and the overwhelming fixed costs for radar, airplanes, etc. Marginal checking and incredibly conservative design were the key. Each week they regularly replace 300 tubes and an additional 5 tubes that are showing signs of deterioration.

Even though the program is about 1 Mword, written in assembly language and Jovial, the key here is the aging and the fact that the program is NOT interrupt driven. The program simply cycles through the job queue every few seconds in a round robin fashion. This is an excellent example of superb software engineering with an incredibly simple overall structure since it is non-parallel, all the bugs that an interrupt driven system would have had are avoided. Users identify overload by the lengthened cycle time. The high reliability demonstrates learning curves as applied to reliability. This obvious notion just occurred to me: since all the software I see is always changing, it doesn't reach ultra-high reliability.

Bottom Line

I doubt if any of the existing personal computers that operate today will either operate or be found in 25 years, simply because technology will have changed so much in performance and reliability as to make them uneconomical at the personal level. How many of us still repair and use our 10 year old HP35's? Furthermore, all the floppies will have worn out and we'll be glad to be rid of them.

Gordon Bell,

October 7th, Charles Bachman, Chairman of the Museum's executive committee, Kitty Selfridge, Chairman of the Museum's membership association, talking with Mike Woodger of the National Physical Laboratory after the lecture by Derrick Lehmer.

October 7th, Derrick Lehmer and Richard Clippinger reminisce about their days using the ENIAC.

The Founders Program

During the initial two-year period of the Museum, until June 10, 1984, the Founders Program is in effect. The purpose is to build a strong foundation for The Computer Museum. This provides participants with a unique opportunity to help The Computer Museum become established as an industry-wide Museum that will have enough support to continue its efforts to preserve the history of information processing.

New Individual Founders

We are pleased to announce that our list of individual founders has now grown to one hundred and seventy-six individuals who have contributed $250 or more to The Computer Museum.

John Atanasoff
Harut Barsamian
G.C. Belden
James and Roberta Bell
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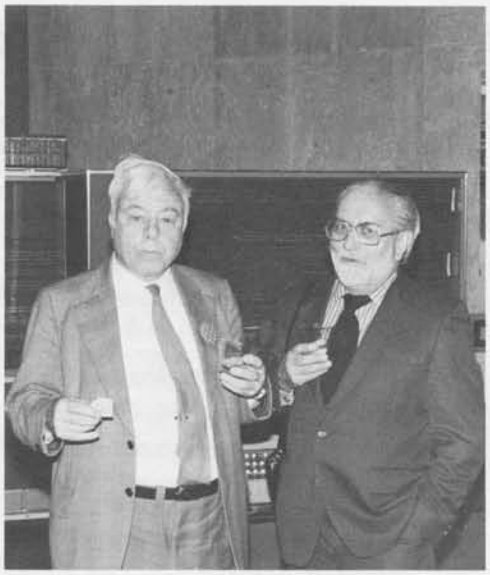

October 22nd, Dr. L.H. Thomas and Herbert Grosch after Grosch's lecture on the SSEC.

November 18th, Dr. and Mrs. Weizenbaum with Dr. and Mrs. Harry Huskey. During Huskey's lecture on the architecture of "Turing" computers, from the Pilot ACE to the Bendix G-15, he pointed out that before becoming famous Joe Weizenbaum worked with him on the G-15.

John F. Smith
Steve Spellman
David K. Stevenson
George Stibitz
David Tarabar
George E. Valley, Jr.
W. Joe Watson
Harvey W. Wiggins, Jr.
Richard H. Yen

Corporate Founders

Contributing $2500 or more.

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Pray, Mr. Babbage . . .

Friday night, December 10, 1982, The Computer Museum in association with the New Ehrlich Theatre presented the premier performance of *Pray, Mr. Babbage . . .*, a character study in dramatic form written by Maurice Wilkes. This one act play is set on November 19th, 1856, when Babbage was 75 years old. The main characters are Babbage; Charles Few, his solicitor; Sir Edward Ryan, his brother-in-law; Babbage's son Henry and his wife Min.

In Wilkes' introduction to the play, he states, "As long as anyone can remember, Babbage has been working on a vast mechanical digital computer—which he calls his Analytical Engine—but has never succeeded in producing anything that would work. In consequence, the world has written him off as a crank, a verdict that history will one day triumphantly reverse. Nor is he free from the Victorian failing of indulging in personal vendettas, conducted in print, with those who have crossed his path. However, you would be very wrong if you were to think of him as an embittered and isolated man. . . ." At this time, the author is working on the kind of rewrite that is only possible after seeing a work produced.

The play was performed by actors associated with the New Ehrlich Theatre, a non-profit organization, located in the Boston Center for the Arts. Chris Rudomin, the Museum's program coordinator, worked with them to transform the cafeteria we use as a lecture hall, into a theatre. The Mayor's Office of Cultural Affairs in Marlboro, donated a stage and Lee Swanson of Warehouse Antiques provided wonderful Victorian furniture to properly fit out Babbage's study.

The evening started at 8 PM with tree trimming, street musicians in the galleries, and seasonal potions. The play was put on at 9 PM, and the merriment continued until 11 when a crew of hardy folks struck the set—and the magic of theatre disappeared before our very eyes. All in all, more than 50 volunteers worked to make the evening a success.

The Computer Museum Slide Collection

The Computer Museum staff are currently involved in the production of a slide collection that will be available for public use and acquisition. The slide collection is intended to highlight important developments in the history of information processing as presented to the public through the Museum's broad-based collection of artifacts, photographs and documents. The series of slides consider a vast array of topics from the theory of computers to the significant technological advances of each generation and their practical use in pioneer and commercial computers. Each slide will be accompanied by a brief description of the slide and its relationship to the history of information processing.

The Computer Museum staff would appreciate your suggestions for improving the slide collection in both its scope and presentation.

Please indicate below which sets you wish to purchase and return this page with a check or money order to:

The Computer Museum
1 Iron Way
Marlboro, MA 01752

☐ Page	$25.00 (32 slide set)
☐ Set 1	$3.50
☐ Set 2	$3.50
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Set 1: Information Processing History Graphs and Charts

1.1 Theory of Computer Generations.
1.2 Tree of Computer Evolution from 1950 to the 1980's.
1.3 The Pioneer Computers: Memory Size versus Computation Speed.
1.4 Speed of Calculations versus Generation for Manual through ULSI Technology.

Set 2: Early Calculating Devices

2.1 Napier's Bones: 17th Century Mechanical Aid to Multiplication.
2.2 Pascaline: Mechanical Adding Machine Invented by Blaise Pascal (1645).
2.3 Thomas Arithmometer: First Four-Function Practical Mechanical Calculator (1820).
2.4 Thacher's Cylindrical Slide Rule: Achieved the Equivalence of a Sixty Foot Slide Rule (1881).

Set 3: Hollerith's Tabulator and Sorter for the 1890 U.S. Census

3.1 The Computer Museum's Exhibit of Herman Hollerith's Tabulating and Sorting Machine.
3.2 Pantograph: Manual Device used to Punch Blank Census Cards.
3.3 Punched Card Reader.
3.4 Punched Card Sorter.

Set 4: MIT's Whirlwind Computer (1945–1953)

4.1 16K Core Memory Stack, Fixed Head Drum and Roomsized Console.
4.2 Fixed Head Drum for Secondary Memory.
4.3 A few of Whirlwind's 5000 Vacuum Tubes.
4.4 Arithmetic Elements of the 32-foot Long, 16-Bit Word.

Set 5: Early Computers

5.1 SAGE: AN/FSQ-7 Vacuum Tube Computer for Air Defense (1957).
5.2 TX-0: MIT's Full-scale, Transistorized Computer (1956).
5.3 PDP-1: Second Generation Computer, First Video Game "Space War" (1960).
5.4 PDP-8: First Mini-Computer (1965).

Set 6: Super Computers

6.1 IBM 7030: "Stretch" Console (1961).
6.2 CDC 6600: Console and Processing Cabinet, designed by Seymour Cray (1964).
6.3 Texas Instrument's ASC (Advanced Scientific Computer): Chassis Harness Interconnect of a Processing Unit (1971).
6.4 Burrough's ILLIAC IV: Burroughs Disk, Processing Cabinet and Processing Element with Fairchild Semiconductor Memory (1975).

Set 7: Logic Technology

7.1 Vacuum Tubes and British Valves from the Mark I circa 1950.
7.2 Transistor Circuitry Modules from a PDP-8 circa 1965.
7.3 Integrated Circuit Board from a PDP-11 circa 1972.
7.4 Micro-processor: Computer on a Silicon Chip circa 1976.

Set 8: Memory Technology

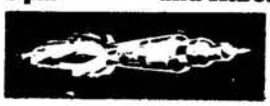
8.1 William's Tube: Cathode Ray Tube for Primary Memory circa 1948.
8.2 Core Memory Plane circa 1958.
8.3 Fixed Head Drum from English Electric's DEUCE circa 1957.
8.4 Hard Magnetic Disk from the "Stretch" circa 1961.

The Computer Museum Bits and Bites

Bits of history and bites for sustenance
Eight Sunday Afternoons

At 2 pm, a guided tour will cover the highpoints of the Museum.

AT 3 PM, TALKS ON...

March 20 3 pm	**Oliver Selfridge**	**Ruminations on the Beginnings of AI and What Ought to Lie Ahead**	As a young assistant to Norbert Weiner, and as one of only ten participants in the first conference on Artificial Intelligence at Dartmouth, Oliver Selfridge has been involved in the development of AI from the beginning. It is from this perspective that Selfridge asks the questions, what were the early developers dreaming of in the 50's and are we dreaming the same things today?
March 27 3 pm	**Steve Russell, Shag Graetz, and Alan Kotok**	**Spacewar! The First Video Game** 	Russell, Graetz, and Kotok were graduate students at MIT when the new PDP-1, the first small-scale, interactive computer arrived. What started out as a demonstration of its resources turned into the development of a computer-based video game—Spacewar! Russell, Graetz, and Kotok, tell how their shared passion for sci-fi movies, games and computers drove them to invent the first video-game that is the grandfather of contemporary games. And of course, the game will be demonstrated and you will have an opportunity for a match with the past masters!
April 3	**Museum closed for Easter**		
April 10 3 pm 	**Ramon Alonso and Albert Hopkins**	**Designing AGC: The Apollo Guidance Computer** 	When NASA wanted MIT's Draper Lab to design, construct, and deploy a computer for the Apollo mission, mini-computers were a thing of the future. What was developed was the AGC, a user-friendly computer measuring one cubic foot, that flawlessly guided the Apollo mission to the moon. Alonso and Hopkins, two of its key architects discuss how size, weight, and layout of the space capsule affected the AGC's design.
April 17 3 pm	**Ted Bonn** 	**Early Technical Innovations at UNIVAC**	As a member of the UNIVAC I team Ted Bonn will describe its pioneering role in the development of thin film for magnetic recordings and early computer peripherals.
April 24 3 pm	**Donald Davies**	**Early History of Cipher Machines**	Dr. Donald Davies, of England's National Physical Laboratory, will talk about cipher machines, in particular the little-known Siemens T52 (used in France and Norway after World War II). He will relate it to both earlier code machines and lessons relevant to contemporary data security.
May 1 3 pm	**Charles Adams and Jack Gilmore**	**Whirlwind for the Small-scale User**	Charles Adams and Jack Gilmore, who were responsible for developing software for MIT's Whirlwind, the first real-time computer, tell how it was not only used for large-scale problem solving for the Office of Naval Research, but also put to practical everyday use. They will reveal how it became the first, largest, and most expensive word processor ever.
May 8 3 pm	**Grace Morton**	**The Computer as Poet**	Grace Morton is a Cambridge-based computer programmer experimenting with a new application of computer technology—generating poetry. Mother's Day provides the inspiration for her work in self-generating poetry and poetry based upon user interaction.
May 15 3 pm	**Ron Resch** 	**The EGG: Evolution of a Cultural Monument**	A former user of the super computers at Livermore and currently Director of the Computer Graphics Center at Boston University, Ron Resch put together his unique background in computers, the sciences, and the fine arts to design, develop, and construct the world's largest decorated Easter egg (thirty-one feet tall). This project included a number of mathematical and engineering firsts, including the development of the first geometry for an egg, and resulted in a splendid sculpture for a Ukrainian community of the plains of Alberta. Ron will show a film explaining the process, showing the construction and will talk about what's next.

The Computer Museum One Iron Way Marlboro, Massachusetts 01752

THE END BIT

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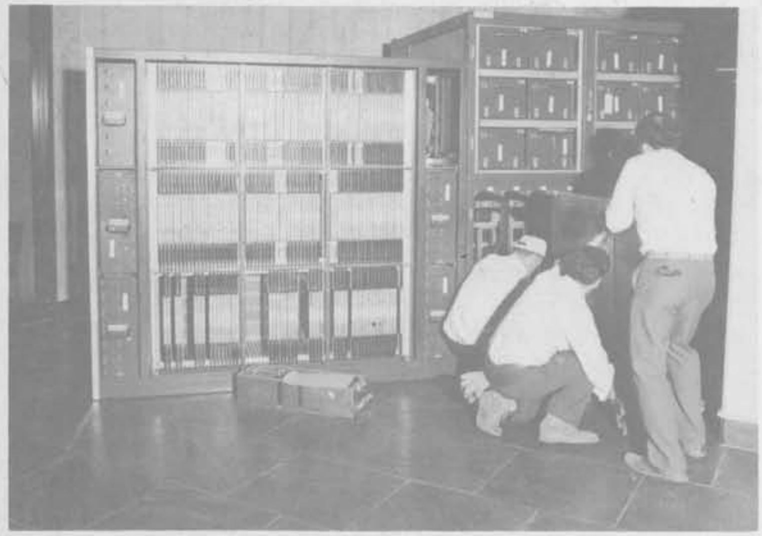
A newsbrief of the collection



What are these people doing to that machine? Under the guidance of Jay Patton of Burroughs Corporation, museum volunteers are piecing together the Illiac IV, the most recent addition to the Super Computers gallery. Mr. Patton coordinated the machine's installation at NASA Ames in 1971, deinstalled it last fall, and reinstalled it at the Computer Museum. The Illiac IV is on long term loan to the Museum from NASA. For a feature article on the Illiac IV, look for the Summer issue of the *Report*.

The
Computer
Museum

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