THE COMPUTER MUSEUM REPORT

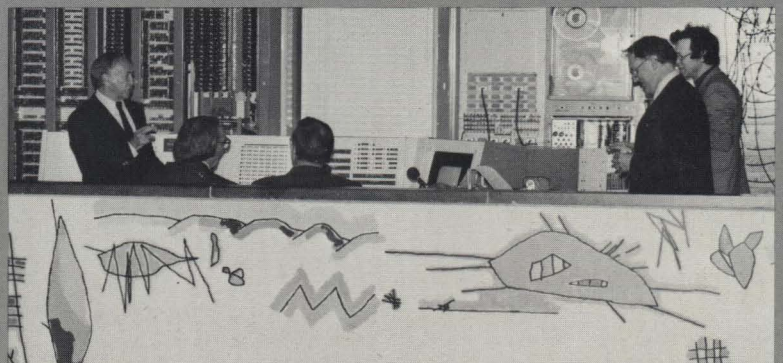Number 8   SPRING 1984

The first three stages in the life of the TX-0 computer: Designed at Lincoln Laboratory in 1955. Moved to MIT in July, 1958. Running again at The Computer Museum, November 13, 1983.

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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.

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 is temporarily closed in preparation for its move to Boston. It will reopen at Museum Wharf in downtown Boston in fall 1984. For more information, call (617) 426-2800.

STAFF

Director
Gwen Bell

Administration
Geri Rodgers, Coordinator

Communications
Stephanie Haack, Coordinator
Brenda Erie

Exhibits and Archives
Meredith Stelling, Coordinator
Oliver B. R. Strimpel, Visiting Curator
Beth Parkhurst, Research Fellow
Paul Ceruzzi, Research Associate
Wendy Blakeman; John McKenzie;
Gregory Welch; Bill Wisheart.

Programs and Membership
Christine Rudomin, Coordinator

Store
Carole Strecker, Coordinator

The Computer Museum
300 Congress Street
Boston, Massachusetts 02210
(617) 426-2800

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The Director's Letter

I'm often asked, "Will there be a lot of interactive exhibits in The Computer Museum?"

I don't have a short answer. The long answer compares two exhibits: the TX-0, the first transistorized computer, one of the first computers used for interactive graphics, and a planned exhibition called "The Computer and the Image."

Seeing the TX-0 exhibit—with its banks of switches, bulky Flexowriter, rows of toggle switches, wall of supplies, with its heavy steel chairs with peeling vinyl covers, tile floor and venetian blinds—sends the viewer back to the late fifties. And on days that John McKenzie, with his dapper bow tie, set of tools and complete machine log, is busily maintaining the machine, the visitor has the extra advantage of a demonstration or discussion of the machine's state. One of its demonstration programs of a mouse learning its way to cheese (or a martini) has been a favorite for 25 years—even though its graphics don't measure up to those on a handheld child's toy. For many, this seems to be involving enough, although not really "interactive."

To take the next step, to make the TX-0 operable by the visitor, is to put the clock back: the machine fills a room, yet is less powerful than many programmable calculators, takes a half-hour to start and demands programming in its assembly language MACRO. This is an investment in time that most museumgoers don't make. But what about the rare person who feels that they must program the TX-0? For them, the machine is to be simulated on the Museum's VAX. Dan Klein from the Mellon Institute has put a number of the instruction sets for the classic machines, including the TX-0, on the VAX. The serious visitor can then have easy access to classic machines at a terminal in the new library of the Museum.

Another way to experience the TX-0 in action is truly vicarious: watching a 1961 made-for-television film about the machine, how it was used, with demonstrations of many of the programs. Such classic films will be used with many of the exhibits on super computers and vacuum tube machines that took in the order of 100,000 watts to turn on. Even if we got one of these machines together, the Museum could never afford to run it. Nor does it make any sense when the same computing power is available on a machine that requires a hundredth of the electrical power. To experience the size and power decline of the machines through the generations brings home the point better than any textbook statement.

Historic machines will only be one dimension of The Computer Museum when it moves to Boston. Several exhibition areas will emphasize contemporary computing with interactive exhibits that demystify the "black box." The first of these is "The Computer and the Image Gallery" now being planned by Oliver Strimpel, on leave from The Science Museum, London. The aim of the exhibition is to convey the full breadth of computer imaging, from computer-aided design to the simulation of galaxy evolution, from Landsat image-processing to computer-drawn animation.

In explaining the concepts of computer graphics, interactive displays will be used. What better way to understand how resolution affects a picture than to alter the resolution yourself? Or stretch the contrast, or distort the image with a simple mathematical function?

Computer graphics can also portray objects that do not exist in real life. Interaction allows the visitor to walk around them or zoom in on areas of interest. Simulations using computer graphics often rely on the choice of parameters by the user, who gets more involved by entering his own choice.

The focus of The Computer Museum is not to create "interactive" exhibits, but to preserve and explain the scientific and technological history of computing in the most appropriate and exciting way that it can be done.

Gwen Bell

Oliver B. R. Strimpel

The TX-0: Its Past and Present

Up and Running. For the third time in its history the TX-0 was fully operational, this time at The Computer Museum. It was built at Lincoln Laboratory in 1955 as an experimental computer to test transistors, and had its first birth in 1956. Then in 1958 it was dismantled and reborn at Massachusetts Institute of Technology (MIT) where it operated until the mid-sixties.

The TX-0 fills a room, yet has less memory than many personal computers. And unlike today's personal computers, the TX-0 demands a skilled user to maintain full-scale operation.

The machine is a good example of what computing was really like 20 years ago.

Jack Dennis and John McKenzie were responsible for the TX-0 at MIT before its shutdown. This time around McKenzie was the operations manager and the first to witness it come back to life. He worked for months preparing the classic, 1955 computer for its debut at The Computer Museum.

His efforts paid off when TX-0 alumni, Museum members and other computer buffs united on Sunday, November 13th, to display their enthusi-

asm for keeping the artifact in working order. For one day, those who had been vital to the development and day-to-day operations of the TX-0 reminisced about the days when it was at the apex of computer technology.

A series of events were held touching on all phases of the TX-0's past. The day's events were videotaped for the

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PAPER TAPE PUNCH

PUNCHY
STORAGE PUNCH OUT ROUTINE
READ-IN MODE OR INPUT ROUTINE FORMAT

CORRECTED BINARY RECORD OF THE PROGRAM

PRINCE
STORAGE PRINT OUT ROUTINE
OCTAL INSTRUCTIONS OR CONSTANTS

HARK
CONVERSION ROUTINE
USED FOR EXAMINATION AND MODIFICATION OF STORAGE

BE BRIEF
REDUCES WORDING OF QUESTIONS

"YES SIR"
"BE BRIEF"
"FINISHED"
"PUNCHY"
"FINISHED"
"PRINCE"
STOP CODE BUTTON
"HARK"

QUESTIONS

ANSWERS TO QUESTIONS AND TAPE TITLE

QUESTIONS AND THEN STORAGE PRINT-OUT

ANSWERS TO QUESTIONS

EXAMINATIONS ALSO ERROR INFORMATION

CURRENT ADDRESS REQUESTS AND MODIFICATIONS

Museum's archives. Included in the program was a lecture by TX-0 alumni and MIT Professor Jack Dennis on the history of the machine; a luncheon for the alumni; and a hands-on demonstration of the star attraction—the TX-0.

One alumni favorite was the mouse and maze program. Everyone focused on the mouse as he scurried across the cathode ray tube (CRT) screen to catch a piece of cheese. Old stories about the TX-0 abounded during the reunion with some alumni suggesting they should have brought cards for old times' sake, because bridge was often played during breaks in the TX-0 room.

CONTROL TRANSFER TO PROGRAM BEING DEBUGGED

ME CONTROL TRANSFER ROUTINE

"ME"

"GO TO" OR "SUM ERROR"

R READ-IN ROUTINE

"R"

"FINISHED"

SURPRISE POST MORTEM REVIEW OF PROGRAM

"SURPRISE"

"FINISHED"

PATH ROUTINE SEQUENCE RECORD

"PATH"

PHOTO ELECTRIC PAPER TAPE READER

"FINISHED" FIND MEMORY SEARCH ROUTINE

"FIND"

EXPEDITE MAIN DISPATCHER FOR REQUESTED ROUTINES

ORIGINAL BINARY TAPE OF THE PROGRAM

ROUTINE SEQUENCE RECORD

RECORD OF ALL REGISTERS WHOSE CONTENTS HAVE CHANGED FROM ORIGINAL FORM

"GO TO" IF TAPE WAS READ-IN CORRECTLY

"SUM ERROR" IF NOT

LIST OF POSSIBLE NAMES

ALSO

ERROR INFORMATION

NAME OF REQUESTED ROUTINE

QUESTIONS AND THEN INFORMATION CONCERNING MEMORY
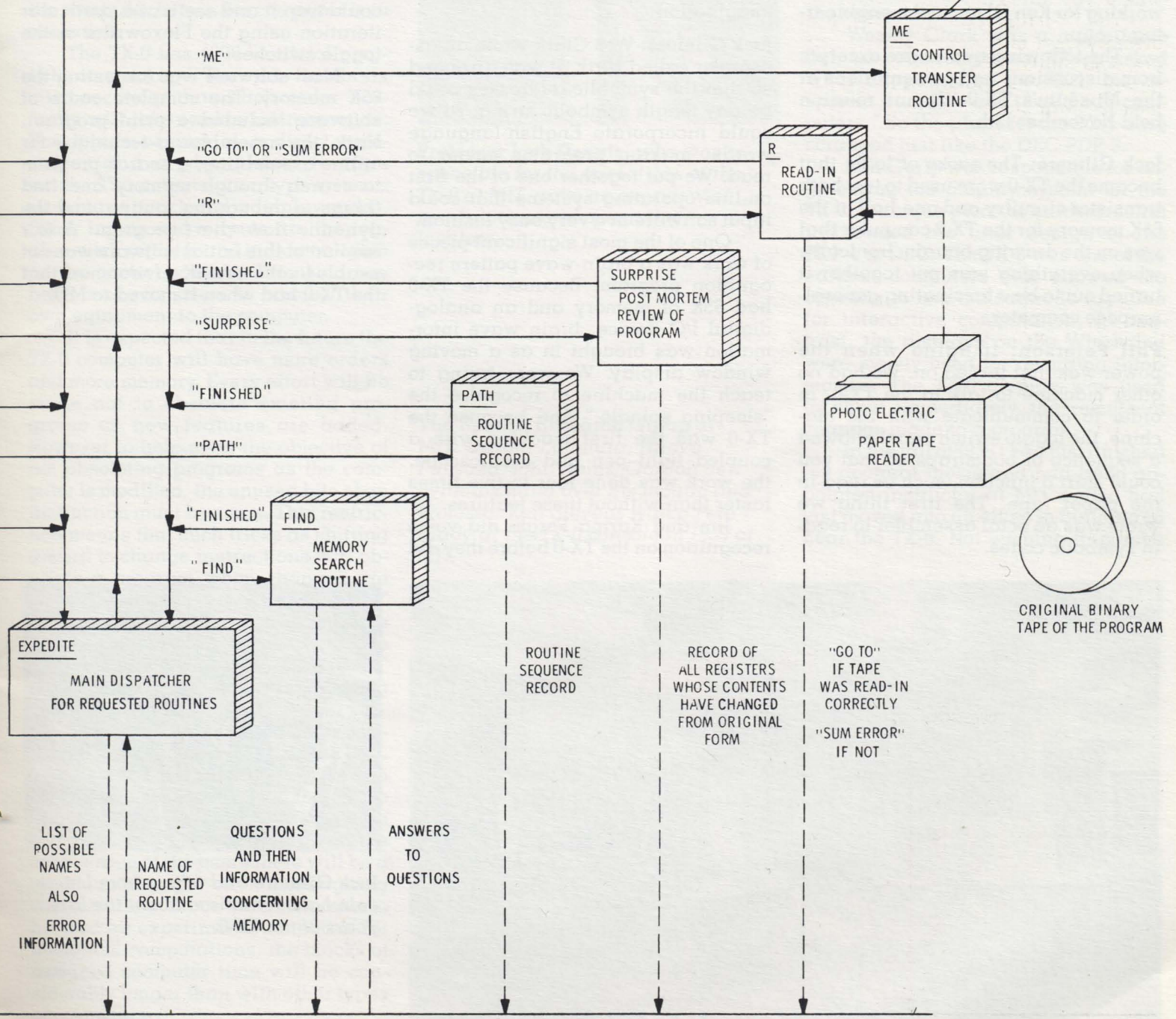
ANSWERS TO QUESTIONS

FIG. 2

TX-0 DIRECT INPUT UTILITY SYSTEM

The TX-0 at Lincoln Labs

The TX-0 and its original software were created at Lincoln Laboratory. Its original team included Wesley Clark as the logic designer and Ken Olsen as the engineer in charge of building the machine. Phil Peterson, Jack Gilmore, John Frankovich and Jim Forgie worked on logic design under Wes Clark. Bob Hudson and Chuck Norman were involved in the construction working for Ken Olsen in the engineering group.

The following quotes are excerpts from discussions and presentations at the Museum's TX-0 alumni reunion held November 13th.

Jack Gilmore: The racks of logic that became the TX-0 were used to test both transistor circuitry and one-half of the 65K memory for the TX-2 computer that was on the drawing boards. Ironically, when everything was put together it turned out to be a fascinating general-purpose computer.

Phil Peterson: Imagine when the power was first turned on. We had no other machine to talk to the TX-0. In order to communicate with the machine, the toggle switch panel allowed a sequence of bootstraps so that you could start a function, such as read-in the paper tape. The first thing we wrote was an octal assembler to read-in symbolic codes.

Architecturally, the machine introduced the idea of micro-coding. You could hit the carry pulse having never done anything else. A random number generator that would make nice little patterns on the face of the CRT could be done with no instruction. Once the programmers got the idea of micro-programming they were only limited in their experiments by their imagination.
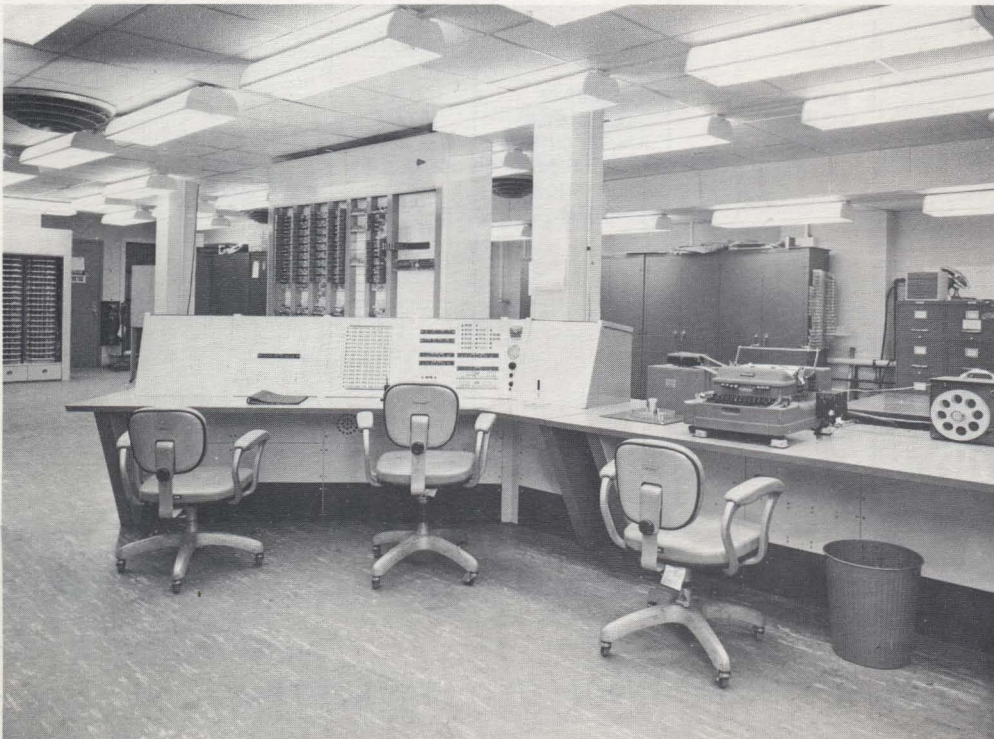
Jack Gilmore: Wes Clark wrote an assembler called Hark. It was arranged so that the symbolic addresses could be any length symbolic string, so we could incorporate English-language words, making programs easier to read. We put together one of the first on-line operating systems that could input software in a very easy fashion.

One of the most significant pieces of work was a brain-wave pattern recognition program. Because the TX-0 had 65K of memory and an analog-digital I/O device, brain wave information was brought in as a moving window display. We were trying to teach the machine to recognize the "sleeping spindle." And because the TX-0 was the first machine with a coupled light pen and oscilloscope, the work was done four to five times faster than without these features.

Jim and Karma Forgie did voice recognition on the TX-0 before they did it on the TX-2. Because the program took 10-20 minutes to execute, Jim had the problem of finding out where it was. We rigged up a technique so he could draw a flow chart, put it on celluloid over the CRT, and in his software, slow down or speed up the program from the toggle switches. He could literally watch the voice program running through its steps. He could trap it and see it at a particular iteration using the Flexowriter or the toggle switches.

Most software was for testing the 65K memory. The complete cadre of software included a print program, Hark, the assembler, a technique for online assembling, a search program to search through memory and find things, a debugging routine, and the dynamic flow chart program. A fair amount of this initial software was not usable for the new 4K environment that the TX-0 had when it moved to MIT.

Jack Gilmore and others from Lincoln Labs reminisce about the first years of the TX-0.

In July 1958, the TX-0 was taken out of Lincoln Laboratories and installed in room 26-248 at MIT. John McKenzie recorded that it took 100 days of work to get the machine up and running.

The following is from a memorandum, dated July 23, 1958, to TX-0 users from Earle W. Pughe, Jr.:

This memo is written as an aide to those who wish to write programs for the computer before the computer is in operation.

The TX-0 has 4096 words of magnetic core storage. The cycle time is six microseconds, thus each order normally will take twelve microseconds. The inputs consist of a direct typewriter and a photo-electric tape reader. The outputs are a typewriter, a paper tape punch and a display scope. Other inputs and outputs are the toggle switch register and indicator lights on the control console. Provision has been made for users to connect their own equipment to the computer.
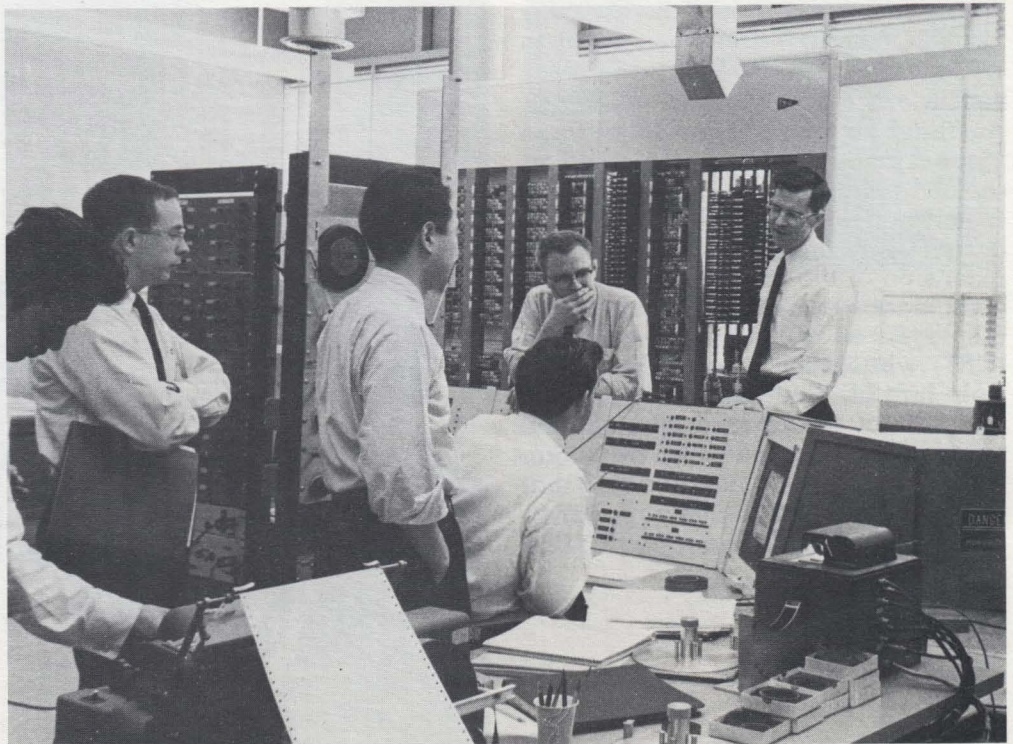
It is expected that in the future the TX-0 computer will have more orders and more memory. Every effort will be made not to obsolete existing programs as new features are added. However to help meet the objective of not obsoleting programs as the computer is modified, the unused bits of an instruction must be zeros. This restriction means that such tricks as shifting a word to change instructions will obsolete a program when changes are made to the computer. Bits "0" and "1" are now used for the instruction, bits "6" thru "17" are now used for the address and bits "2", "3", "4" and "5" must be zero for all orders except "operate."

The Ad Hoc Committee on Experimental Computation (Chairman: Prof. J. F. Reintjes) is the faculty group in charge of the computer and they have final decision as to who may use the computer. It is expected that with the cooperation of the users there will be a minimum of paper work in assigning computer time. Since the computer is to be used for experiments instead of for numerical computations, the blocks of assigned computer time will be considerably longer than with other types of computers.

Professor Jack Dennis, *who was responsible for the operations of the TX-0 at MIT, gave an overview of its evolution and use at the Institute.*

The Speech Research Group at MIT. *Osamu Fujimura, Hiroya Fujisaka, John Heinz, Gordon Bell (with his hand over his mouth) and Professor Ken Stevens watch Pete Brady at the TX-0 console in 1959 at MIT.*

Professor Jack Dennis: Because the TX-0 was created as a memory test computer, it had some peculiar characteristics. The size of the address for the TX-2 memory was 16 bits, while the TX-0 had an 18-bit word. How do you build a machine with a 16-bit address and an 18-bit word size? Since an ordinary single-address instruction format was used, only two bits were left for the operation code.

Wesley Clark was a major force behind both computers. When asked what happened to the TX-1, his response was, "We don't build odd computers." So the plans for the TX-1 were scrapped just like the DEC PDP-3.

Ben Gurly was responsible for engineering the display system for the TX-0, a unique piece of hardware that influenced his later design of the PDP-1 at DEC. The TX-0 was one of the earliest computers that allowed the operator to use the cathode ray tube for interactive computation. In contrast, the displays on the Whirlwind were mostly used for recording information. The TX-0 display was used to show immediately the results of changes made to a program.

In the fall of 1958 I had just finished my doctoral thesis and had been appointed instructor at MIT. I also had just moved into an office in Building 26 near the TX-0. Not wishing to pursue

Debugging

further my doctoral investigations in operations research, I was open to new and interesting adventures. With a new computer down the hall, the hackery in my blood soon got me involved in its programs.

This computer, unlike MIT's number cruncher, the 7090, had the feature of being intimate with its users. You could actually go up to the console and ask the machine to execute instructions and programs specifically for you. The display program, which generated interesting patterns, triggered immediate reactions to fix it up and try it again. If one was careful in choosing the number in the "live" register of the machine, you could cause some wonderful patterns. You could do this with a program consisting of a single instruction—repeated endlessly. Such informal interaction with a computer was completely new to the world.

How do you build a sensible machine code with just two bits?

1) You must be able to store information into memory locations.

2) You must be able to get information out of the memory, so one can operate on it in the central processing unit. The TX-0 does not have an instruction code "load." In the TX-0, one got information into the accumulator by clearing the accumulator and then executing an "add" instruction.

3) The third instruction of the TX-0 was transfer negative: transfer control to the location specified by the address.

4) The operate instruction was next. Anything not done by the other three kinds of instructions was done by operate instructions. The remaining 16 bits instead of referring to a memory location were simply a micro-coded extension of the operation code. One combination would cause a point to be displayed on the cathrode ray tube (CRT) whose coordinates were the right half of the accumulator and the left half of the accumulator. In the same instruction you could transform the contents of the accumulator so that it would cause (on the next repetition of instruction) a different point to be plotted on the CRT.

In the fifties a substance called FLIT was used regularly around the house to get rid of flies. Thomas Stockham and I called the debugging program we wrote for the TX-0, FLIT, which meant Flexowriter Interrogation Tape. It was a successer to UT3 written at Lincoln Laboratory and provided a medium for symbolic debugging. You could take the symbol table generated by the assembly program and load it into the debugger. The debugger could then talk to you about your program in terms of your symbolic addresses and symbolic instruction codes.

FLIT allowed one to insert breakpoints in a program and then run it. The debugger would take over control whenever a breakpoint was reached, whereupon the user could interrogate the state of a program and decide to go on or not.

The project to write FLIT was suggested by Professor Thomas Stockham who, perchance, shared my office in Building 26. We wanted FLIT to be a very interactive program, but we could not work with the cathrode ray display, perhaps because the character tables would take up too much memory. But more likely because many users would want to debug programs that used the display. Tom suggested that as soon as the typist had typed something that was in error—something that would not make sense for any continuation—the program should tell the user about it. Tom invented an idea he called "handslapping." Immediately upon typing an error, the program would type back a red question mark. This meant a lot of repairs to the Flexowriter because one would try to continue while it was typing back at you. Full-duplex communication and displays have now eliminated that problem.

About this time I heard of something called a "macro assembly" program and that Doug McIlroy had programmed one at Bell Labs. From this inspiration I wrote the program MACRO for the TX-0. This program was to lead to macro assemblers for the PDP-1 and other computers. MACRO turned out to be a large program. To debug it, it was necessary to use a simpler debugging tool than FLIT because FLIT took up too much memory, so I wrote a program called MicroFLIT. FLIT and MicroFLIT were forerunners of debuggers written for other computers, including DDT (Digital Debugging Tape) written by Alan Kotok for the PDP-1.

Alan Kotok. *TX-0 alumni Alan Kotok (center) recalls his TX-0 days at MIT as Jack Dennis (left) and John McKenzie (right) look on.*

Managing the TX-0

After the TX-0 had been at MIT for about a year and half, I took over responsibility for the machine and immediately set about extending the machine's instruction code. Since we were not likely to afford the 65,000 registers the TX-2 had, we enlarged the op code to four bits and added an index register. The operate command was redesigned to provide more capability, including logical "and" and "or", and more input/output orders. With these changes the TX-0 lost its original power to generate fancy patterns through repeated executions of a single instruction.

Installing the new instruction set was a big undertaking. The machine was constantly in use by research staff and students. We made the changes by pulling one panel at a time during scheduled maintenance periods, and almost always had the machine back in operation on time. The correctness of the alterations had already been checked through simulation using a register transfer language to describe the new instruction set.

John McKenzie has managed every move the TX-0 has made, and managed operation and maintenance of the machine while it was at MIT. He can tell you what it was like to replace the switches on the TX-0 console. I recall that when the machine first arrived at MIT, several switches had special designations: one was labelled "Suppress Wes;" and another was labelled "Dump Phil." These functions, doubtlessly referring to Wes Clark and Phil Peterson, are no longer present in the machine.
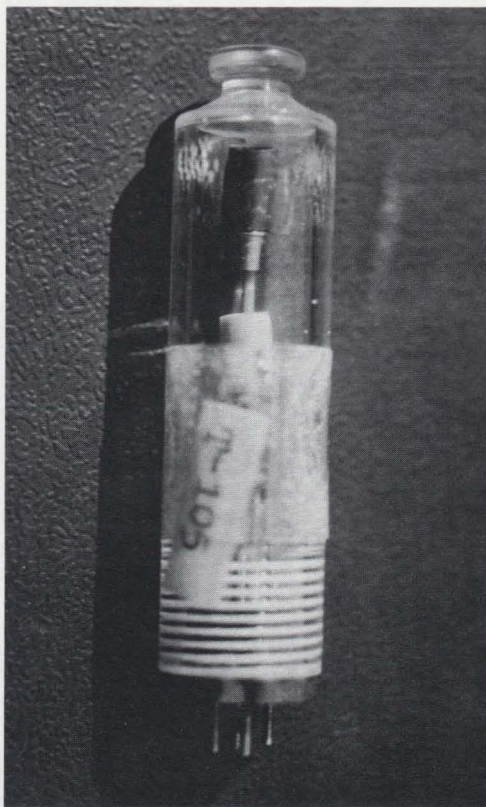
In my time one principle user of the machine was Gordon Bell who was working with Professor Ken Stevens and Arthur House on speech recognition. Pattern recognition was of great interest also.

Some of the people who worked on the TX-0 became heads of the Information Processing Technology Office (IPTO) of the Advanced Research Projects Agency of the government, where MIT has obtained lots of money to carry out research. One of the directors of IPTO was Ivan Sutherland, who created the program "Sketchpad" on the TX-2. This benchmark graphics program allowed a user to create sketches on the display by using a light pen. Using the TX-0 light pen, Ivan and Claude Shannon wrote a program that would search a maze. It would act like it was inside a cave and would decide how to move by following the walls.

Larry Roberts, who also became director of IPTO, used the TX-0 for creating a kind of artificial intelligence program. His program recognized hand-drawn letters by learning from its experience.

In 1961, when John McCarthy was advocating timesharing as a way to use computers effectively and DEC donated a PDP-1 computer to the Electrical Engineering Department, my attention shifted to building a time-sharing system around the new machine.

TX-0 transistor. *The first TX-0 transistors were in tubes to make it easier to test and replace them. The TX-0 had only 12 transistor failures, and almost every transistor that lasted more than 500 hours is still operational today.*

Maintaining the TX-0

John McKenzie: When the TX-0 was built, transistors that operated at a five megahertz speed were not available. Lincoln Lab put Philco surface-barrier transistors, costing $40 each, into bottles that contained 10 transistors. These were designed to be tested in a "transistor-checker." Ken Olsen, Ben Gurley and other designers didn't know whether transistors were here to stay. The engineers thought they might have to replace transistors like they replaced vacuum tubes, or at least annually check them. With little deterioration after 10,000 hours, it was clear that these transistors were good. It wasn't worthwhile testing them anymore. No one cared and the industry was moving ahead to new products. At MIT, only a dozen unaccountable failures may have been due to transistors. Most transistor failures occured within 500 hours after installation. Otherwise they made it, and are still working today.

Every time another feature was added to the machine, another power supply was added as a self-contained unit. The machine is cycled on in sequence and cycled off in sequence. You get the memory pulses before you turn on the read-write memory current.

John McKenzie, *who spent months revitalizing the TX-0 for its Computer Museum debut, enjoys watching the machine perform on TX-0 alumni day.*

Electronic Systems Lab Group

Doug Ross: John Ward had only observed the art of programming on the Whirlwind. When the TX-0 came, John decided he should program.

John Ward: I signed up and there I was in the room alone with the computer. I was terrified.

Doug Ross: Earlier at Egeland Air Force we built an elementary mouse solving a maze problem on the 1103. So John and I did a mouse and maze program. I did the logic and John the display.

John Ward: . . . very slowly. There was no assembler. You had to figure out all the addresses yourself. The style of the program was reminiscent of Shannon's mouse that used relays.
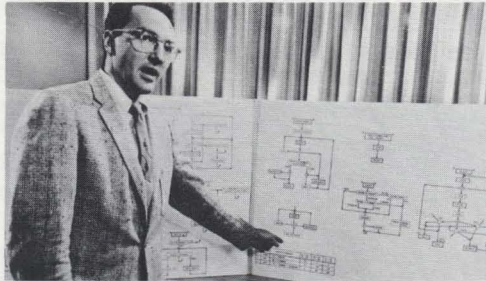
Doug Ross: It had more flexibility because we were able to use the light pen to place the mouse and either hide the three chunks of cheese or the three martinis.

For MIT's centennial in 1961, CBS did some specials on the Institute. The CBS director said, "Gee, Westerns are so cut and dried couldn't you write a program for one?" And I was talked into it. The memory was used to keep, track of everything down to the actors' hands. The logic choreographed the movement of each object, hands, guns, glasses, doors, etc. A line of English script was written for each direction, even if it went wrong. That's how we got the loop sequence which was an actual error run. If you watch closely, the sheriff puts his gun in the robber's holster, and other strange things.
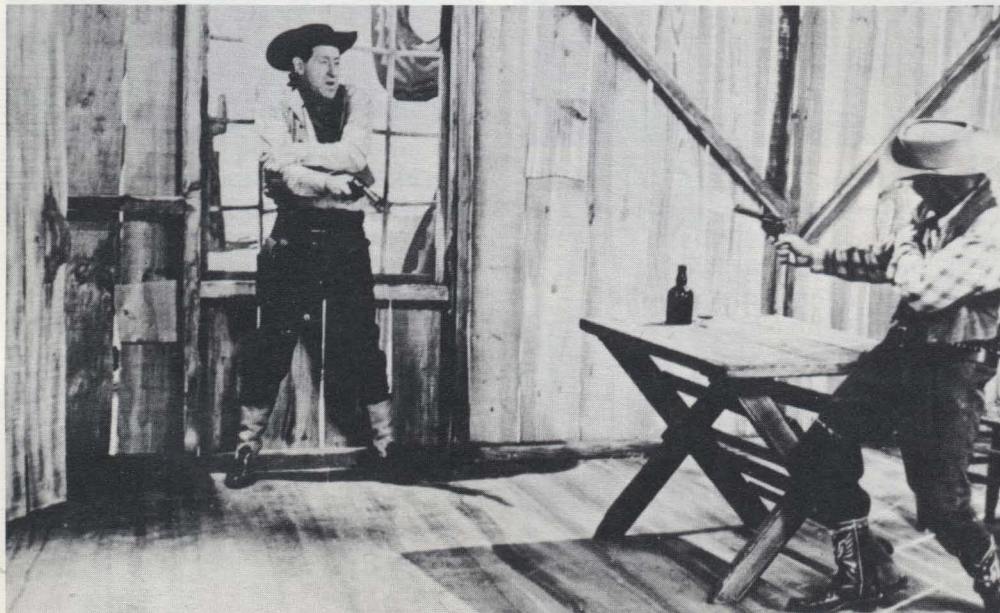

Doug Ross. Seated at the TX-0's "L" shaped console, Ross explains how he and John Ward designed the Mouse and Maze program: "I did the logic and John did the display."

Doug Ross *explains the flowchart for the logical choices in "Saga," the 1961 TX-0-written Western.*

Dit Morse: I've been asked if the error sequence was rigged. Well, it turns out that the CBS people were in the TX-0 room when the machine got into that loop. They saw what the programmer was doing and they grabbed that sucker so fast—they knew it was theater.

The program's 13,000 line code was macro generated. One of the first and only programs that I wrote with a real deadline. CBS would not postpone the shooting under any circumstances. It took six calendar weeks to deliver six skits.

Cognitive Information Processing Group (CIPG)

Don Troxel: As a graduate student I used the TX-0 because I had a lot of numbers to reduce statistically, and it was the best desk calculator around. People in our group started to use it because of the display capability. At CIPG under the late Sam Mason we measured reading speed.

John Allen: The first speech synthesis by rules scheme introduced in England by Holmes, Mattingly, and Scherm was first implemented on the TX-0. It made heavy use of this wonderful bank of switches to control the various parameters of that synthesis.

Don Troxel: When Francis Li called me over to hear it, I expected it to have a Chinese accent, but it had an English one since that was where the rules were made.

John Allen: We did experiments with pitch using the switches for control. The TX-0 and PDP-1 were used to start to build a reading machine for the blind. The character recognition part ran on the PDP-1 and the speech synthesis on the TX-0. The tenuous connection was often lashed together firmly enough so that we could read characters on the PDP-1 and have speech output on the TX-0.

When John McKenzie let you turn the machine on, you were then part of the in group. One Saturday, a professor, who will go nameless, called me on the phone and said, "I just turned the TX-0 on and it won't go."

I said, "Just put your hands on the console and don't do anything until I arrive." Fortunately he hadn't done anything disastrous. He just hadn't started up the clock sequence.

Gordon Bell: Actually with improper clocks when you started you could ruin the core memory.

John Allen: The price of the TX-0 was $3 million—from the development costs on the books at MIT.
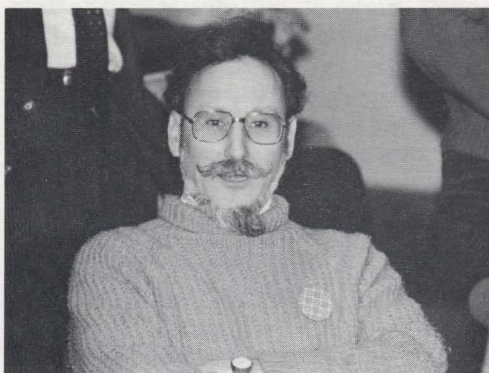
Gordon Bell: That was a bargain because it led directly to the TX-2 and Digital Equipment's first products.

Actor Jack Gilford *played the role of the robber in a "shoot out with the sheriff." The climax of "Saga" written in 1961 by the TX-0 with the help of programmers Dit Morse and Doug Ross.*

Speech Research Laboratory of the Research Laboratory for Electronics

Gordon Bell: I was a member of the research staff of Professor Kenneth N. Stevens' speech research laboratory. The laboratory continues to train researchers and do research in analysis and synthesis of speech. Some colleagues who worked on the TX-0 included Arthur House, now at the Institute for Defense Analysis; Osamu Fujimura of Bell Labs; Hiroya Fujisaki, University of Tokyo; John Heinz, John Hopkins; Morris Halle, MIT, and Pete Brady.

Speech was taken into the computer using a tape loop with sampling pulses on one tape channel. The audio (speech) signal was passed through a bank of 24 filters and read in via TX-0's Epsco analog-to-digital converter. The goal was to recognize the speech by analyzing the frequencies of the resulting acoustic input. The analysis was carried out by a technique we invented called analysis-by-synthesis; the computer posted a model of the speech and compared it with that to be analyzed by adjusting the model's parameters.

Reminiscing. *Shag Graetz's first hands-on programming experience was at the TX-0 console, although he was a seasoned programmer before coming to MIT.*

Gathering vignettes. *Steve Levey (left) who is writing a book on hackers, gathers tidbits from recollections of Electronic Systems Lab Group alumni Doug Ross (center) and Harrison (Dit) Morse.*

The Hackers

Alan Kotok: In the fall of 1958, I was one of the earliest of the undergraduate crew to come in. Jack gave a couple of introductory talks to the Tech model railroad crowd, and brought us over to demonstrate the TX-0. When we saw it, we said, "Oh, neat—there's all this time available." We negotiated with Earle Pughe and John McKenzie for time. They said if the faculty advisor was amenable, then we could use the machine without any supervision.

Jack Dennis: As an undergraduate I wrote a large linear program on the Whirlwind to solve the transportation problem. After midnight, I could get my hands directly on the Whirlwind, and get scope postmortems all on my own. This led me to believe that informal direct programming by students was the way to work with machines. Then we formalized it on the TX-0.

Dave Gross: I was a freshman at MIT in 1957 and got a tour of the new TX-0 computer room. In 1958 we, the model railroaders, discovered the TX-0. I was told that under no circumstances could I turn it on, since I was not an authorized user. The most elaborate program I wrote for the machine was a three by three matrix of dots that made a search. One night Alan Kotok and I had the idea that it would be awfully nice if you didn't have to run your program tape through the reader twice. So we wrote a program that put it on mag tape the first time with enough space for binary to be added.

Alan Kotok: Before that no one had used the tape except to write from the beginning and fill it full. Here we wrote—and then left space along the way.

Dave Gross: We tuned it to leave just the right amount of space.

Alan Kotok: We put two load points on all tapes, with the utility at the beginning and then a point that allowed use at the end. We did anything to avoid having to punch another binary program on this Flexowriter that punches ten characters per second.

Dave Gross: Alan, do you remember the expensive tape recorder program? You had your FM receiver here in the computer room and we said we'd hook up the audio to the A to D converter and write a program to record on that tape.

Alan Kotok: That was digital recording more than 20 years ahead of its time.

Dave Gross: It would write the whole tape as one long record. Play back through the accummulator created a whistle, so we used the scope's D/A converter fed back into the speaker that was under the console.

Jack Dennis: Could you recognize Beethoven?

Alan Kotok and Dave Gross: It wasn't bad, considering . . .

Alan Kotok: After the PDP-1 arrived and before any of the fancy high speed links had been installed between the machines, the hackers of the day and I were contemplating how we could make use of both computers. We hooked up a serial line between the two with a buffered program to the typewriter. You could type a line at one machine and it would come out on the other.

After we got it working, I said, "What can we do with this?"

Someone said, "Play chess."

Since some of us had been working on chess on the 7090, we got together a panel of chess players in the TX-0 room with a chess board. Some of us sat in the PDP-1 room with a chess board and waited for an unsuspecting chess player to walk down the hall and into the room. Some fairly gullible graduate student was enticed to play this great new PDP-1 chess program. Our victim typed his plays in. The group in the other room replied. It worked well for a while, but then there was confusion about one of the moves with an argument over the terminal. Alas, our victim smelled a rat and started for the door to the connecting TX-0 room.

Gordon Bell: In the spring of 1960, I went out to DEC and bought some modules so that we could add a mag tape unit on the machine.
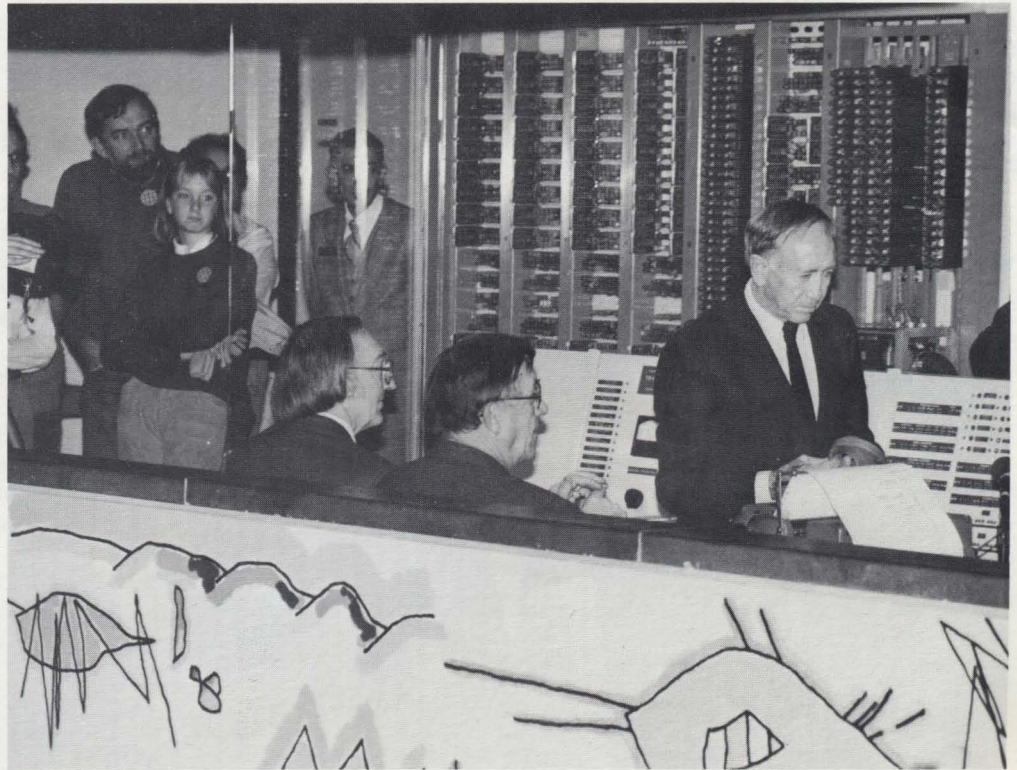
Alan Kotok: And that took us into big time computing.

Jack Dennis: I remember that my dream at the time was getting support for interactive programming on the TX-0, even though the one itty-bitty tape unit was the only bit of auxiliary storage we had. I was dreaming up schemes to keep peoples' files and images on this tape unit, so that one user could take the machine over from another, but that project was scuttled when the PDP-1 arrived in 1961. Then we started to use it to build a timesharing system.

Shag Graetz: By 1961 this machine was a legend among programmers. I had been eased out of the nest at Harvard where I used the 704, with about three times this amount of equipment, that no ordinary programmer could ever use. I came to write a diagnostic program for the 906/2 tape drive—every bit the kludge that it appears to be.

My first question was, "Who is the operator and how do I submit my programs?" Jack Dennis said, "This is it. What you see is what you get." The entire room of machinery was under the control of whoever was signed up to use it at the time. During the next academic year, I went to work for Doug Ross; the PDP-1 arrived and I moved over to work on it, where in our spare time we developed SPACEWAR!

Deja vu. *John McKenzie who was the technician on the TX-0 at MIT, once again readies the machine, but this time at The Computer Museum.*

The Move to the Museum

John McKenzie: The TX-0's life came to an end when each of the labs got their very own computers. When I saw a note in the paper that Bob Everett was presenting the Whirlwind to the Smithsonian, then I thought that's the place for the TX-0. However, they weren't interested. A little bit later, I saw a short paragraph in a DECUS newsletter that DEC was starting a museum. And we said that was the way to go. Stan Schultz came down and we started to plan the move. We were about to move the machine on April 19th (a holiday), when the contract officer at MIT said, "Hey you can't give away this $3 million to a private individual." Everything came to a halt for two years. First it had to be offered to all military groups, then to all groups with government contracts, then various universities, then secondary schools, and finally to general services who could advertise it. On the first go-around DEC was outbid $2500 by an outfit in St. Louis that wanted the I/O. Then it was re-advertised. This time DEC was outbid $50 by a surplus dealer in Ohio. Roy Gould got busy on the phone and noted that it would cost a lot more than the price of $350 to move the machine. DEC gave them an extra $100 and took title to the machine.

Stan Schultz: John Connally and I spent many hours labelling all the wires.

John McKenzie: The dismantling took about a week, and then unfortunately it went into a warehouse for about two years.

Stan Schultz: Initially we set up the processor and console, and it was on exhibit from the summer of 1979 until 1981.

John Mckenzie: We never burned any bridges so that we could make it run again. Fifteen different power supplies were lost in the warehouse. Then we had to buy some new ones. But the CPU is pure.

Twice in bringing up the machine I was stymied. Once with the core memory, and I called on Dick Best to do some circuit analysis and he got me out of that hole. Later on, in setting up the paper tape reader, Alan Kotok did some analysis and we made it work. It needs to be in a computer room environment with a cooler, steady temperature.

Stan Schultz: While on exhibit, some people must have taken souvenir bottles from the console. When we let it be known that the machine was being brought up again, bottles would mysteriously appear on the console.

The TX-0 at The Computer Museum in Marlboro. *With the Museum closed and moving to Boston, the TX-0 will once again be packed, moved and reconstructed in a new location. This is the fourth move for a machine that started out as transistor-test circuitry and may end up as the longest-living operating computer.*

Here we go! *Flipping switches while watching the indicator lights on the control console of the TX-0, John McKenzie prepares the machine for operation.*

Computing at Burndy Corporation

by Gregory W. Welch

The clacking of paper on plastic as a pile of cards is jostled into alignment. The shuffling and slapping of paper cards traveling at high-speed through mechanical sorting devices; the whirring of electric motors; and the clicking of relays. These were the sounds of an office in days-gone-by, right? Wrong!

Until last November these were the everyday sounds of the Accounts Receivable Department at Burndy Corporation in Norwalk, Connecticut. The source of these noises was the collection of old IBM card accounting machines upon which Burndy still kept its accounts receivable. However, after over 30 years of faithful service, these anachronisms were finally being retired, to be replaced by a soundlessly efficient Univac 1100/82.

Unlike most machines their age, these antiques were not destined for "that great metal crusher in the sky." Instead, and quite rightly, they were to be enshrined as representative of a breed of machines which for years was the standard of office automation. They were headed for The Computer Museum.

In the 1940's Burndy Corporation, then located in New York City, started leasing IBM card accounting machines to manage various functions of its operations, such as keeping track of inventory, performing sales analysis, engineering applications, production control, and accounting operations. By 1950, when Burndy moved to Norwalk, it employed approximately 25 people working two shifts to operate its close-to 30 machines.

The card machines were run in much the same way a modern, batch-processing computer center is today. A given department would submit written documents to keypunch operators, who would punch the data contained therein onto 12-by-80 character computer cards. These cards would then be sorted, collated, calculated, reproduced, interpreted, or printed according to the wishes of the department requiring the information. However, each of these operations was performed by a separate machine. Hence, it was up to the operator to perform the functions of a central processing unit, such as synchronising the operations and transferring the data from one machine to the next. The "program" was the department's instructions to the operator as to what they wanted done with the data.
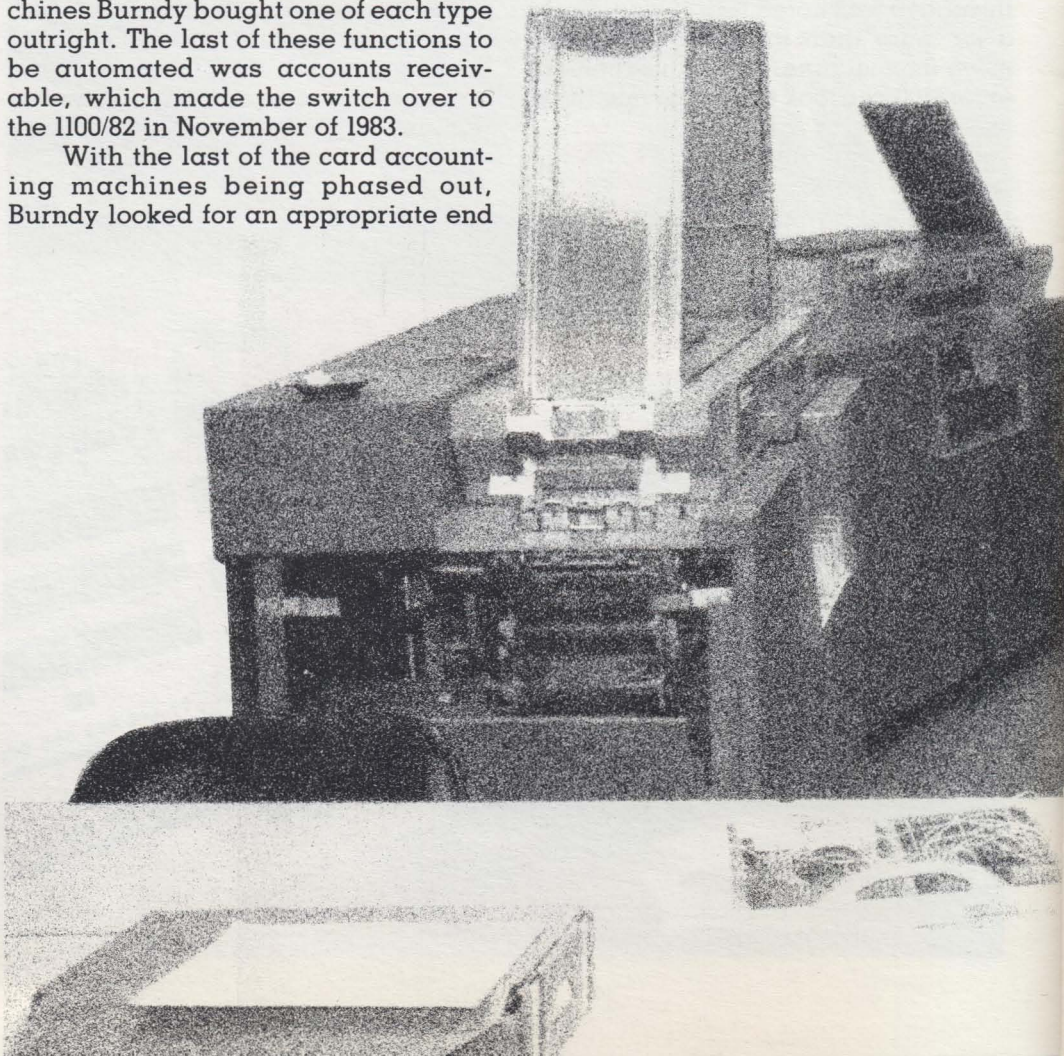
In the early 1960's Burndy began to modernize its office equipment when it up-graded to an IBM 1401 system. Over time it continued to transfer more of its operations to computers. As it did so, its appetite for computer power increased. Burndy soon moved on to an IBM 360/40, then to an RCA Spectra 70, a Univac 1100/11, a Univac 1100/81, and finally a Univac 1100/82. Concurrently, since the number of operations to which the accounting machines were applied was steadily decreasing, Burndy retained fewer and fewer in service. The equipment was bought from IBM by MAI, a leasing company, that continued to lease it to Burndy and service it.

According to Marjorie L. Canto, Manager of Burndy's EDP, User Support Service Department, by "late in the 1970's approximately 90 percent of the Burndy functions had been automated." Finally, with only a couple of functions being filled by the card machines Burndy bought one of each type outright. The last of these functions to be automated was accounts receivable, which made the switch over to the 1100/82 in November of 1983.

With the last of the card accounting machines being phased out, Burndy looked for an appropriate end for these machines which had been a part of its operations for so long. Knowing that Burn Dibner, the founder of Burndy, was very interested in history, Ms. Canto contacted him to see if he would want the machines. He suggested that she contact The Computer Museum to investigate the possibility of donating them. When Ms. Canto approached us, at first we were unsure what these machines were, let alone what their historical significance was. However, after a trip down to Norwalk to inspect them—and seeing them in running order—and several phone calls to IBM, we decided to accept one working example of each of the four types of machines Burndy still had. These were: a #557 Interpreter, serial# 16592; a #083 Sorter, serial# 16329; a #088 Collator, serial# 17000; and a #519 Reproducer, serial# 40093.

The Interpreter is used to print, in alphanumeric characters, some or all of the information encoded in the holes of a card on specified areas on the face

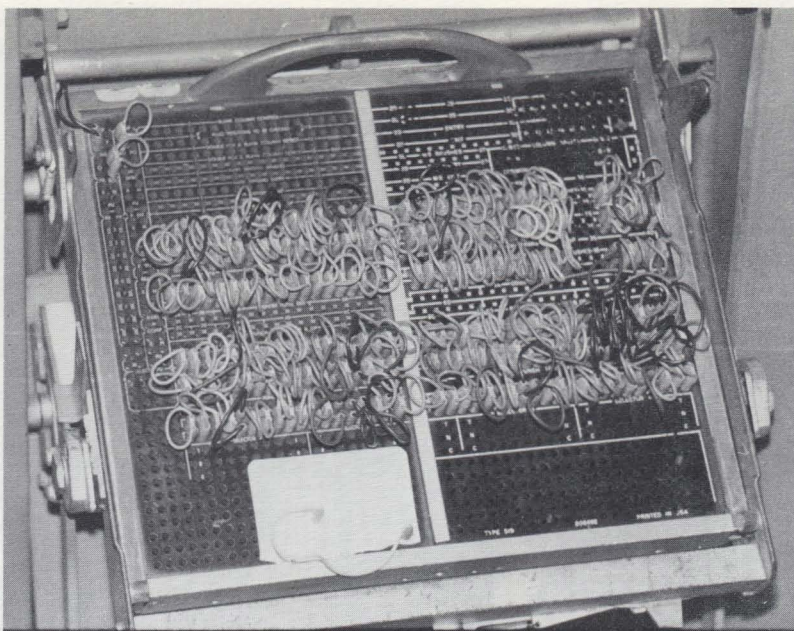of the card, according to a program wired on a plug board.

The Sorter separates a stack of cards into piles having the same value in a particular column. The setting of a contact brush, which reads one column at a time, determines which field the stack will be sorted on. It can also be set to only select cards with a particular value (or values) in a column.

The Collator merges two similarly sorted stacks of cards together under the instruction of a wired plug board.

The Reproducer simply reproduces a stack of cards in part or in whole, again controlled by a the wiring of a plug board.
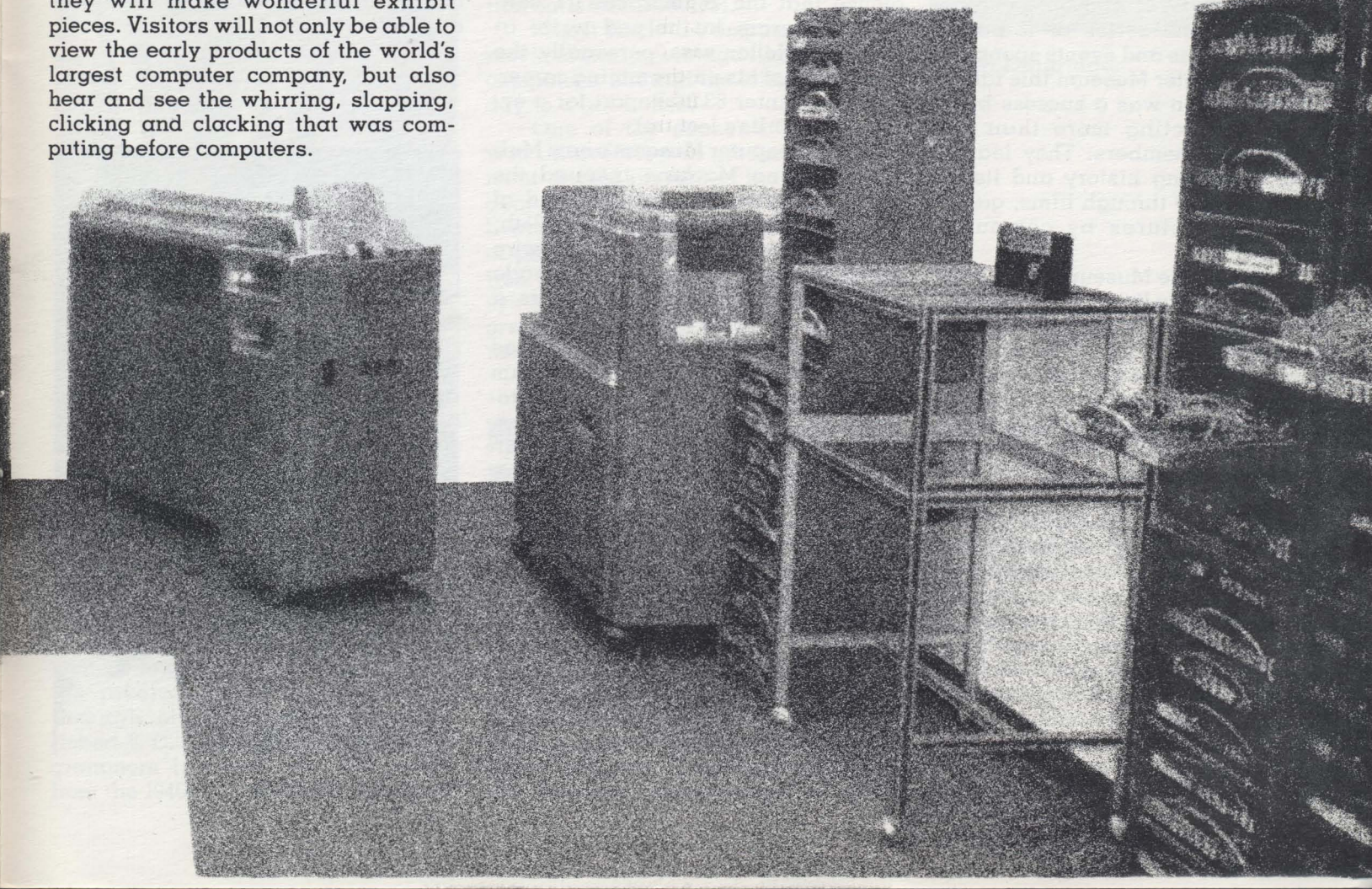
It was machines such as these with which IBM dominated the pre-computer business machine market, giving them an advantage when the business computer market blossommed. Therefore, they are of significant historical importance because they represent the formation of the marketbase which was the foundation of IBM's computer buisness.

As operational artifacts of historical value, and their operativeness, they will make wonderful exhibit pieces. Visitors will not only be able to view the early products of the world's largest computer company, but also hear and see the whirring, slapping, clicking and clacking that was computing before computers.

Plugboard Program Central Unit.

Card Accounting Machines. *The complete card computing installation at Burndy Corporation, pictured here, filled an entire room. The varied components are now part of the Museum's collection.*

Inside Stories on Computer History Told at Fall Programs

Stories of untimely mechanical failures, eccentric bosses and annoying bugs; conventional narratives; and demonstrations of classic machines highlighted the series of 15 educational programs and events sponsored by The Computer Museum this fall.

The season was a success by all counts, attracting more than 1500 visitors and members. They learned about computing history and its impact on society through films, gallery talks and lectures by computing pioneers.

A tour of the Museum's new quarters in downtown Boston on September 11th got the season off to a lively start. Members viewed the open space in Museum Wharf and heard about the Museum's gallery plans—from the two-story exhibit for the gigantic SAGE computer to the plans for expanding the generations galleries.

A week later, the Museum's new, circa 1974 Kurzweil Reading Machine for the blind was introduced by **Gail Yarnell** and **Randy Stern** of Kurzweil Computer Products. Stern told how the software designers demonstrated the machine's peculiar accent, and Yarnell showed off the machine's reading capabilities by letting it read the "Star Spangled Banner" aloud.

On September 22nd, **Alan Perlis** shared some of his renowned computing epigrams at a Museum lecture entitled "The Evolution of Software." Perlis, head of Yale University's Computer Science Department, told the audience that the 26-character IT software program he helped write at Carnegie Mellon was "personally, the high point" of his programming career. (See the Winter 83/84 Report for a synopsis of Perlis's lecture).

The Computer Museum's new Multiwire Wiring Machine inspired the next lecture by **Joseph Hammond** of PCK Technology on September 25th. He chronicled the history of multiwire technology and explained how it made smaller, more compact computers a reality.

Computer memorabilia reigned the following week, when the Museum sponsored its first yard sale on October 2nd. Machine nameplates, consoles and core memories sold the fastest. Counting them and the more obscure objects d' computer, the cash-and-carry sale grossed more than $1000.

Just four days later, the focus changed dramatically as **Dr. Jerrold Petrofsky** stepped up to The Computer Museum podium to tell the story behind an invention that makes it possible for paraplegics to walk again.

His pioneering work made it possible for 22-year-old Nan Davis, who has been paralyzed from her waist down for four years, to walk with the

Incredible . . . no not the audience, but the presentation on computer graphics by Robert Langridge that required 3-dimensional glasses for the event.

Dr. Jerrold Petrofsky.

assistance of an electrical stimulation-feedback system designed by Petrofsky.

Then on October 9th, **R. Michael Hord**, author of *The ILLIAC IV, The First Supercomputer*, talked about that machine's achievements and shortcomings. Decommissioned and moved to the Museum in 1983, it had been one of the fastest and biggest machines of its time, capable of 300 million operations per second.

Computer research was the topic of discussion the following week when **Perry Crawford** of IBM's Systems Research Insitute gave a talk entitled "Computing Decisions: What Good Ideas Have We Left Behind?" He said that "in terms of their development, computers are where cars were in 1910."

On October 20th, Analogic president **Bernard Gordon**, presented his perceptions of computer engineers from Eckert and Mauchly, inventors of one of the first digital electronic computers, to today's engineers.
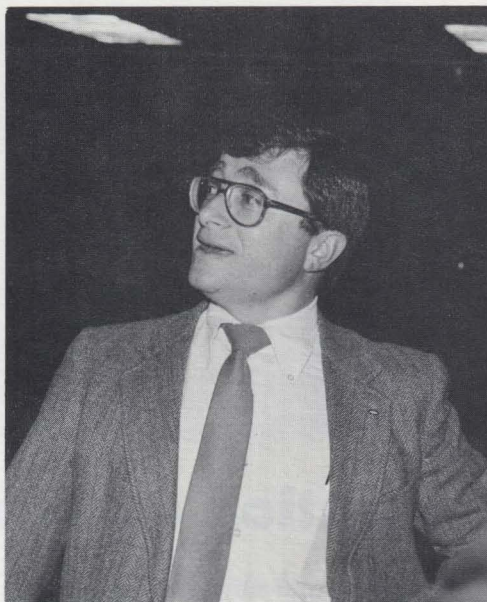

Bernard Gordon (center).

Gordon said there has been a dramatic decline in engineering productivity since the days of Eckert and Mauchly. He attributed the change to overspecialization of engineering tasks, and recommended returning to a Renaissance approach—training and hiring well-rounded engineers who can tackle a variety of assignments. (A transcript of Bernard Gordon's lecture will be featured in the next issue of the Report).

Then on October 23rd, Museum visitors learned the inside history of the revolutionary Harvard Mark I through Mark IV computers from **Robert V. D. Campbell**, one of the programmers involved with the project from the 1940s.

Sunday afternoon, October 30th, **Andries van Dam** presented two hours of classic films and video clips that illustrated the history and rapid expansion of computer graphics. Van Dam, chairman of Brown University's

Andries van Dam.

Computer Science Department, told the audience that computer graphics was such a new field in 1964 that it was difficult to find even 30 people to support a new computer graphics association called SIGGRAPH.

"See It Then," a Computer Museum movie featuring vintage films on early computers, showed the following Sunday to a full-house.

One of the season's highlights was an overview of product development at IBM presented by vice president **Bob O. Evans**, November 10th. Evans reviewed the alternating cycles of product diversity and standardization at IBM from meat slicers to card systems and whole families of computers. (A transcript of his talk will run in the next issue of the Report.)

Robert Noyce to Speak at Museum May 11th

Robert Noyce, inventor of the integrated circuit and vice chairman of Intel, will speak to Museum members and guests on May 11th at Museum Wharf, Boston.

It will be the first such event in the new quarters and will take place by partially completed exhibits. The Museum is not slated to open to the general public until this fall when the first four galleries will be complete.

The story of the TX-0, the star of the Museum's November 13th program, can be found elsewhere in this issue.
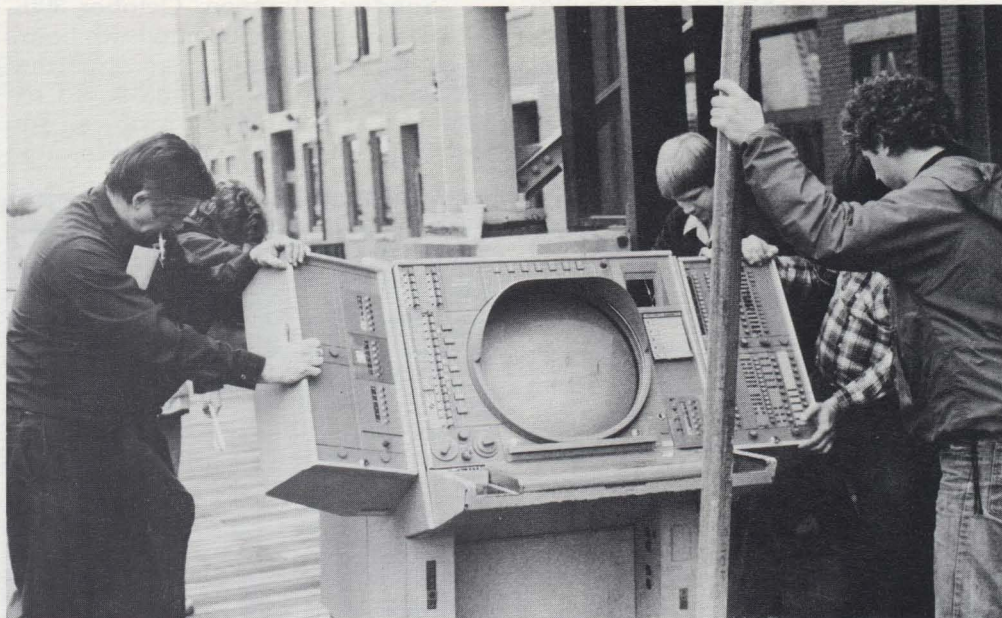
To complete the fall series, **Robert Langridge** gave an illustrated lecture on the use of 3-dimensional computer graphics for molecular research. Langridge, director of the Computer Graphics Laboratory at the University of California, San Francisco, described how interactive computer graphics are used to analyze genetic structures.

Robert Langridge.

Noyce's presentation continues the Museum's tradition of sponsoring lectures by computer pioneers. The lectures are videotaped for historic purposes and kept in the Museum's archives. Excerpts from the lectures are also featured in The Computer Museum Report.

The Sage Arrives. *Cooperation of the Museum Wharf staff, the exhibits department and the movers were needed to heft a console of the SAGE Air Defense System into the elevator at the Museum's new quarters in Boston. The SAGE was the first machine to use command and control CRT display consoles on which operators identified targets by pointing at them with light pens. A total of 40,000 pounds of SAGE components were delivered in October. They will be used to recreate the SAGE installation at The Computer Museum.*

The Members' Association and the Move to Boston

While it might have felt that way, packing up The Computer Museum and moving it to Boston wasn't anything like taking down a circus and magically re-appearing the next day.

In a series of packing parties that took place between January and March, the Members' Association lent over two hundred man-hours to the project—making the move to Boston a physical reality. "Party" is a loosely defined term here, because packing the Four Generations exhibit, the calculator cases, the Fairchild chip exhibit, the memory cases, and the super computers is a huge job.

The process began with the exhibits department acting as "advance men"—coming in ahead of time to pallete boxes, wrap toggles, put skins on certain machines, and take the "skirts" off others. Then, the job of packing could begin. Each piece had to be taken down from its resting place, assigned an inventory number, wrapped, boxed, and boxed again. It took Connie Bachman, Barbara Beeton, Joe Cascio, Helene Faguerquist, Reed Fleming, Kate Fulton, Shag Graetz, Ed Galvin, Ian MacLennan, Mary McKenney, Nick Reinhardt, Bill Ricker, Kitty Selfridge, Diane Sherman, and Alex Vanderberg, plus the entire exhibits department, a day to do the calculators and the Four Generations exhibit.

The job of getting the exhibits out the door and down to Boston was done by Almac Moving Company, that generously donated the entire cost of the move.

Packing and now unpacking provides a rare opportunity for some real "hands-on" interaction with the exhibits. "You find you really study a piece when you spend a half-hour wrapping it," according to one member.

Museum Brings Computer History to Audiences Nationwide

A new film edited by the Museum is bringing computing history to life for computer rookies and aficionados from California to New York.

Called "See It Then: Classic Films of Early Computing," the 38-minute feature illustrates some of the benchmarks in computer history.

In the past six months, the Museum's director Gwen Bell has shown it to more than a dozen groups, including the Stanford IEEE student chapter in California, the Big Apple User's Group in New York, and the Assoication for Computing Machinery (ACM) in Philadelphia.

Museum members are sent invitations to such presentations made in their area. Dozens of Silicon Valley members came to the talk given there, and members came from Washington and New Jersey to see the Museum's presentation and visit its booth at the New York ACM conference in October.

New England area supporters will have a chance to view "See It Then" at the upcoming ELECTRO '84 trade show in Boston's Hynes Auditorium, May 15-

If you would like to roll up your sleeves and help with the unpacking and the refit, please contact Chris Rudomin at (617) 426-2800. We need all the help we can get!

17, where it will be shown in the Museum's booth.

"See It Then" combines four classic clips of early computers. If features the ENIAC, one the first electronic digital computers, being programmed with plug boards. In the second segment, EDSAC designer Maurice Wilkes narrates a 1951 movie on the EDSAC that he calls a "commercial for micro-programming."

Next, the viewer sees Edward R. Murrow interviewing the Whirlwind computer and Jay Forrester, one of its designers, at MIT. The final clip features a computer-written Western acted out by Hollywood actors in a 1961 CBS special titled "The Thinking Machine." Narrators Wayne David and Jerome Weisner explore the question, "Can machines think?"

If your group is interested in a presentation by the director that includes "See It Then," contact Stephanie Haack, Communications Coordinator at The Computer Museum, 300 Congress Street, Boston, MA 02210.

What is a Founder?

Any individual or corporation who gives more than $250 or $2500 respectfully during the Museum's first two years.

On March 14, 1982, The Computer Museum was given provisional status until June 24, 1984 by the IRS as a public, non-profit charitable foundation. During this time, the Museum has to prove that it is indeed a widely supported public institution.

This is a unique opportunity to help establish the only international museum devoted exclusively to computers and the history of information processing.

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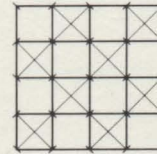☐ *Founder*   *$250*
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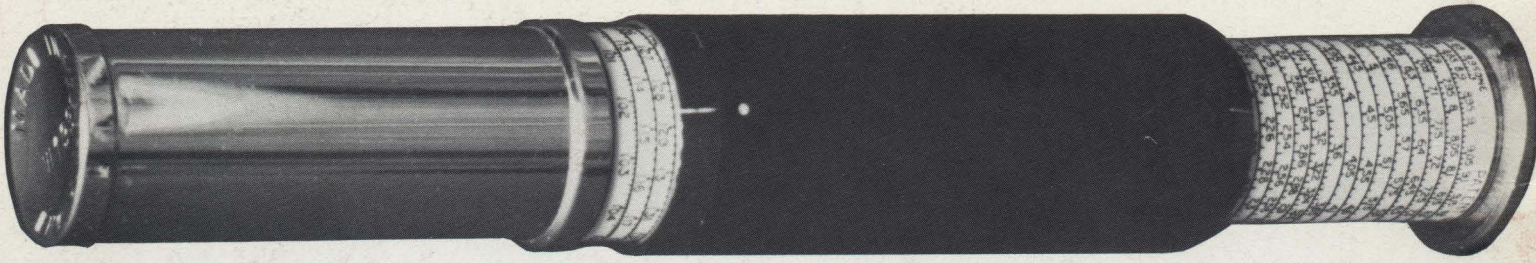
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Membership Coordinator

The Computer Museum
300 Congress Street
Boston, MA 02210

Otis King's Pocket Calculator is a rare pocket-sized cylindrical slide rule manufactured by Carbic, Ltd. in London in the early 1920's. The spiral logarithmic scale, printed on both the smaller rotating and larger fixed tubes (called "cylinder" and "holder") is a double scale with five places of accuracy. The cylinders can be moved relative to each other either axially or rotationally. Two arrows at either end of the sliding black cover form the tubular cursor (that mark the logarithmic numbers and their roots).

Otis King's Pocket Calculator, gift of Harvard University Professor I. Bernard Cohen, was moved to Boston with the Calculator Collection in February and will be on permanent display in the Pre-Computing exhibit.

The Computer Museum

300 Congress Street
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02210