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History of SEAC Presented by Russell A. Kirsch

Russell Kirsch:
The National Bureau of Standards built the first computer with an internally stored program in the United States. The Standards Electronic Automatic Computer, which we call SEAC, did its first productive computation in April of 1950 here at the National Bureau of Standards, which is now called NIST, the National Institute of Standards and Technology. We are here today to show you how everything was started inside the federal government, although of course there are some commercial interests, which would have you believe otherwise.

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Members of the Team

 We have here today three of the engineers among the group of eleven who received a medal from the Department of Commerce for the design of SEAC, which in turn is part of a larger group of about 33 engineers and technicians and mathematicians who were involved in the design of this first computer. We have first Ruth Hauter Cahn, who was one of the first early design engineers. And, Robert Elbourn, Bob, perhaps came earlier than any of the other of us. And, Sidney Greenwald,. My name is Russell Kirsch and I came to the Bureau of Standards shortly after SEAC began its first productive computation and I was involved in the design of additions and modifications for the SEAC over a period of its whole lifetime and have remained at the Bureau of Standards for a continuous period, which is now in its 52nd year.

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What makes it the first computer

I mentioned in my introduction that SEAC was the first computer but I think it's worthwhile for us to explain what we mean by the "first

computer." Certainly, the first computer was Babbage's computer in the 1800's but in no sense was it the computer that we think of today. would one of you like to discuss the question of what was the first computer and in what sense was SEAC the first computer? Do you want to try that Bob?

Elbourn:
Well, ENIAC is usually been pushed in the newspapers as the first computer but it was not a stored program computer it normally was a wired program that had to be re-wired for any other problem for the next problem Actually, it was designed to compute range tables for Aberdeen Proving Ground. That's what it was set up for the single program and it was usually not changed from that. John von Neumann suggested that the table of drag coefficients could be used for storing instructions for the machine and make it into a stored program computer. but not one in which you could change the instructions stored there through the machine so it really wasn't the kind of machine we're talking about but what John von Neumann suggested did lead to the type of machine we're talking about.

Of course, all of this was after April of 1950 when the SEAC did its first productive computation with the exception of the ENIAC which was 4 years earlier. But it was not, as you point out, a stored program computer.

Elbourn

April of '51, that's right.

Cahn: It was much slower, also, wasn't it?

Kirsch: The ENIAC?

Cahn: Um hmm

Kirsch: slower, yes, but in all these cases so much faster than electro-mechanical machines that the age of electronic machines was really introduced by the ENIAC but the big jump was to the stored program concept which SEAC led with.

Elbourn: Yea, I would say that is correct.

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Why was it built

Kirsch: I think it may be worthwhile to mention something about why the SEAC was built. , , the government was interested in purchasing a commercial computer, and let a contract to the UNIVAC company for the construction of what became the first commercial computer. And, there was the question of who would be the contract monitor, and a bunch of you smart guys were likely candidates to be the paper pushers who would monitor the, commercial contract. The, UNIVAC computer was, in a certain sense, more ambitious than SEAC because Eckert and Mauchly were, had their mind, had their eyes on commercial business applications which would involve numerical as well as alpha-numerical computations. And, that made the delivery time of the UNIVAC quite a bit more delayed than had originally been anticipated. SO, the Bureau of Standards was asked, volunteered really, to go ahead and sort of put together what was then called, "an interim computer," and in those days I guess we knew that "interim" meant "permanently on into the future." So the SEAC was sort of thrown together, as it were, and in fact went into operation, was it about a year or so before the UNIVAC was delivered and became the first machine.

Greenwald: Well, , as far as I know, in 1947 we were just working on various components, coders, decoders, , I remember working on, , looking and seeing how many, how much we could put on a tape per inch and all that kind of thing, you

know this wire recorder. And, there were just many miscellaneous little projects that didn't seem to have any coherence. And, then all of a sudden in 1948, I wasn't sure exactly what happened but we got the go ahead to build something and that set the spark. I mean all of a sudden the place really came to life and, for the next twenty months in building that machine I have never felt anything such, so, so much exhilaration. It was just a tremendous part—I would say the best part of my career, anywhere at any time, it was just fantastic. You were discovering new things all the time. You didn't know what was finally gonna come out of this because digital computers were a very unknown quantity. They called them giant brains and there was all kind of hoopla in the newspapers. But, you really didn't know what was going to come out of this. It was just a fantastic time and I don't expect I'll have an experience like that again.

Kirsch:	That was all caused by $150,000 that George Dantzig managed to liberate from the Air Force.

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Kirsch:	There were a number of applications of the SEAC computer that we introduced. Of course it's well know that we started the field of image processing in 1957 with a scanner based on a rotating drum lathe type device that Ruth's husband, Leonard Cahn built and we demonstrated the first image processing on the SEAC computer. A more unusual example was a problem that was posed by the Patent Office, which is part of the Department of Commerce. They wanted to be able to search for chemical compounds in the patent files and until that day the only way of searching was based on the nomenclature, on the names of the chemical compounds. It became clear to us that one could actually feed in the graph theoretic description of an organic molecule to the SEAC and one could

search for fragments based on the topology of the molecule rather than the name of the molecule, you see. And, so we wrote this code for structure searching on steroid molecules and fragments thereof and it was an extremely ponderous code, but it ran, you see. And, we did convince the patent office that this was the way to go, which subsequently they did do. But because the code was so ponderous it was something that we hoped you would never have to use. Well in those days the idea of something you that you hope you would never have to use was the H-bomb. So of course we called the code the "H-bomb" code. Well, some how or other the code sheets got misplaced and when it became known that the H-bomb code sheets had been misplaced, the FBI came in. And, of course it took a lot of explaining to explain that this had nothing to do with the H-bomb, it was just a name that we chose to use for the code sheets. But the Patent Office did benefit by this introduction of the use of computers for searching in chemical literature, which of course now is a routine thing that not only the Patent Office but all the chemical companies use every day.

Greenwald: Well, for example, they studied the flow of traffic. I mean, you know, today we have   we talk about gridlock and so on and it seems to me, I remember they ran programs on SEAC that would try to talk about what the timing should be with lights on this avenue and that avenue and so on to make the maximum progress. There are very many interesting programs

Cahn: I am very much aware of that one because Leonard worked on that. And, I remember very well when they were giving the presentation at some hotel or something or other. What they did was have a movie camera and they would shoot every so often and they had this, when they ran that thing that showed the traffic moving and so forth. It was just dots on it and so forth. They made this movie tape and sent it to be developed and so forth. The post office lost it somewhere- somewhere in the mail. So, they ran the whole thing again and Leonard brought it home and developed it in our dark room in case they didn't find it.

Kirsch: Another example of a very interesting simulation is the one that Bob and I worked on. It was an attempt to simulate the behavior of naval vessels on a radar display. And, Bob got the differential equations for the motion of a ship given a specific rudder and velocity command. And, I remember a demonstration that we did for some navy admirals in which I was running this program using actual numerical data that we got from David Taylor Model Basin about the dynamics of ship motions. And, I was in the process of explaining to an admiral that here is a certain type of ship and if you give it a certain velocity and rudder you can see that it will collide with another ship, which is of course much more desirable than doing it on the ocean. And, this admiral said no, no no that won't collide. I said, oh no, you're mistaken because you can see that with this rudder and velocity command the two ships will collide. He said, run it. And, I ran it and they did not collide. I said, oh, how do you know that. He said, I used to be the commander of one of those ships, which is of course is a great form of compliment. And, we had many experiences like that in which we were convinced that the kind of simulation programs that we ran were in fact good simulations because they held to the mirror to nature, as it were.

Elbourn: That brings up the fighter simulator. The combined digital and analogue computing operation that we had. We had built a model of the cockpit of a jet aircraft and put all the instruments in there. Our analogue computer systems operated the instruments but the SEAC did the trajectory and the altitude of the airplane in space although it was just sitting there in the lab. In there the jet pilots came over from Andrew's and tested our simulator, got out and said yes that's a pretty realistic simulation. So the guys came up and invited me down to get in it. I got in and the first thing that bothered me was the artificial horizon because it looked like a little airplane that you would control with a

joystick. As a model builder, I was familiar with radio-controlled airplanes. It turns out that the artificial horizon, to try to correct that requires exactly the opposite motion and I was just beginning to get squared away with that when my hand reached in and pulled the throttle back and pushed this thing up to simulating 1500 knots. I'd get things straightened out and then my mind would flip over and use the other model and everything would start spinning crazily. When I finally gave up and crawled out, they said well Mr. Elbourn you're 900 feet under ground and inverted. The boys got a big kick out of that.

Elbourn: we mentioned Joe Wegstein. On TV nowadays you see a lot about computer matching of fingerprints and Joe was really a pioneer in that field. He developed computer matching under FBI sponsorship for a number of years.

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Kirsch   Another one of the successful experiments with the SEAC computer was to start the field of image processing, digital imaging as we know it today. In 1957 we built the first scanner which could scan a photograph and read it into the limited memory that we had on the SEAC computer. This is the first picture that was ever scanned in a computer. It's a picture of my son when he was born in 1957 and when we read it into the SEAC computer it was possible to print out the scanned image . And this is the first picture that was ever fed into a computer. It consisted of only 176 by 176 pixels, each pixel being only one binary digit, that is black and white and from this grew the whole field that we now know of which includes everything from CT scanners to earth satellite moniotoring to bar code readers to all the amazing things that are done with digital

imaging. And so we see that there have been changes that took place. Some of the changes are very big., the changes in the technology. Some of the changes are less big. Here's my son today and you can see that people have changed less than computers have in these 40 or 50 years.

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Users of SEAC

Kirsch: We are all engineers having had responsibility for the design, the construction, the maintenance and operation of the SEAC computer. But, there was an entirely separate group of people, mathematicians, whose primary goal was to use the computer for productive computation. Bob would you like to describe the role of the mathematicians in starting the SEAC computer?

Elbourn: Well they worked at , designing computers in a broad, general way. They had a machine development laboratory, which produced descriptions of the list of instructions that the machine if constructed should perform. And, with that list they wrote programs. The programmers got tired after several years of writing programs that they could never test- they had no machine to run them on to see if they would run. They complained they wanted to build a machine. That I think was primarily what motivated Sam Alexander to go after that $150,000 for the Air Force to get our machine started. Before that time we had been directed by the committees that , oversaw the mathematical development by the government to work on computer components on our funding as components for the next generation of computers. That's why we were after that time had not built, undertaken to build a machine.

Kirsch: The, the community of mathematicians working on SEAC was a truly illustrious bunch of people. Their field of numerical analysis was sort of in the doldrums until a truly spectacular group of mathematicians arrived in the Washington, D.C. area after the war and were all assigned by various agencies to work at the Bureau of Standards using the SEAC computer. And, this created a sudden great leap forward in the whole area of numerical methods for doing mathematical computation. And so that analysis using formal mathematical methods began to be replaced by analysis using numerical approximations. As we know today the field of numerical analysis got a very strong head start through the use of the computer, the SEAC computer, by the illustrious group of mathematicians, many of whom were at the National Bureau of Standards as employees, others of whom were delegated to the National Bureau of Standards by other agencies.

Elbourn: We had many alumni at the mathematical- WPA Mathematical Tables Project under Arnold Long during the depression. They did their calculations with desk calculators, and learned a lot about numerical analysis.

Kirsch: And actually the government's, one of the government's most popular technical publications, the all time sort of "best seller," was the Handbook of Mathematical Functions, produced by, edited by Irene Stegun and Milton Abramowitz, based entirely on the contributions from mathematicians who were using the SEAC for numerical computation. And, to this day, that becomes an important publication, which I understand, I've heard recently is now being updated. Instead of being just in printed form, will in fact be available on the Web so that people can continue

the process that was so illustriously begun by mathematicians on the SEAC but now one can do this at home, on one's own personal computer, using the best that's being thought and said by contemporary mathematicians.

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Influence of SEAC

Kirsch: The SEAC had an immense influence on computing government in academia and industry. At first the SEAC, of course, was the only computer available to the government. But we did have a missionary in the form of Sam Alexander, the head of the computer laboratory. And, Sam would go around to other government agencies explaining what computers were, giving them the opportunity to actually do computation on the SEAC and in the process learning not only about computers but learning about the business they were in ordinarily. And, of course there are tales perhaps appocraphil about people who, when they were exposed by people like Sam, to the notion of computing, went back and did a study of how to use computers and proceeded to improve their own operating procedures before they actually used the computer and of course achieved an even greater benefit after implementing some of the operative procedures on the computer. We had a very distinguished group of alumni from academia and from industry who were working on the SEAC computer who went out to become heads of large corporations, heads of computer science departments and carried the experience that they started gathering on SEAC onto later computers and into other institutions. So, in a certain sense, SEAC not only did valuable computations but it did very valuable education. Are there comments that you want to make

about some of the influence of the SEAC on , computing everywhere else?

Greenwald: Well, we know for example, that our whole logical design group as it turned out one day up and went to IBM and

Kirsch: This was Al Leiner and his group.

Greenwald: Yes, yes. So, that happened to a lot of people- going to various corporations and taking what they had learned from SEAC to other fields.

Elbourn: Well we worked closely with the Atomic Energy Commission. Sam Alexander had clearance and he was a consultant to the committees that recommended computing facilities for all the atomic energy laboratories. I went with him on those trips a time or two but they used a a very large amount of time on the SEAC when there were no other computers available that early day. And of course we couldn't go near the machine when they were using it.

Greenwald: But one of the - I think we outta point out was that one of the difficulties with SEAC was that it was serving two purposes. On the one hand, it was an experimental machine, on the other hand , it was doing useful work. And, it would work 24 hours a day and the engineering staff had something like eight hours of prime time. We would come on sort of during the afternoon and so on. But, that was very difficult because on the one hand if you're building something and experimenting with something, you're making changes and so on and then someone comes on at five or six in the evening and they want to use the machine. And, who knows what you've done to upset

things. So, it was a very difficult task to keep those things going but somehow we managed

Kirsch: In the area of education, the National Bureau of Standards actually paid for my honeymoon. When we were married in 1955, I was given the assignment to go around to Air Force bases all over the country teaching them about computers. So, we had this wonderful honeymoon, thanks to the federal government, in which we to these God forsaken places on Air Force bases and I would teach the general staff about computers which was quite a startling experience because here you would have majors, officers, generals and stuff deferring to this young kid who was telling them about this whole new world of the future. And, of course, the world of the future came to pass and is now, of course, very routinely part of the operations of everybody, including the Air Force.

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Components Tubes Wires How Did It all Work?

Kirsch: Sidney mentioned working on components on the SEAC and we are fortunate to have today from the storehouse at the Bureau some of the components of the original SEAC computer and we'd like to discuss those with you today. I'll tell you what we have here and then we can discuss the individual devices. This cabinet contains two tubes that were part of the mercury memory, which in its vast capacity consisted of 10 K bites of storages. That's ten kilobytes, some hundreds of thousands times less of what we have nowadays in a small laptop computer. This is the amplifier that was used to re-circulate the acoustic pulses in the memory. On your left you see some of the typical

wiring of the kind that was used in the SEAC, with vacuum tubes showing and all the hand wired soldered joints. And finally we have here a magnetic wire cartridge which was the main device used for putting information into the computer and taking it out of the computer. Would any of you like to discuss any of these devices in particular?

Greenwald: Well, I'd like to make one comment about… I said that I had worked on radar equipment before this and in working with other engineers on the equipment, you built it and you would design the circuit and you put it in this, rusty equipment, and if something failed you would adjust the value of a resistor, a capacitor and so on. That wouldn't do for computers and I found that out very early and it was really an eye-opener. We, we when we, computers are have to have extreme reliability. Remember that when you have a television set, you have in those days, you might have, say twelve, fifteen tubes or twenty tubes or whatever it was and they were always burning out and you had to go to the drug store and replace them and so on. Well, can you imagine a computer then, SEAC had something like 1300 tubes, but you'd be forever replacing burning out tubes and resistors would go bad and everything else. But how do you get a machine with that many components, and I think that had, I don't know how many resistors, I think it had maybe 15,000 diodes on that order. It was just a fantastic amount of equipment and it all had to work. There was no redundancy in this machine, remember. There was no checking. And, it still had to work hour after hour to be useful. Well, what we did when we designed this circuit, the main circuit for the machine, we employed

what was called to me, a very novel thing, "worst case," and you assume that every resistor can have its worst value or its best value, same thing with the diodes, same the tubes and so on, and you designed such that no matter what happens within those limits of parameters, that thing is just gonna chug away and work and work and work. And, you ended up with an extremely reliable main stage that was used throughout the machine. That to me, I said, was a real eye-opener and is, I think, what I think made the machine work, and work as well as it did.

Kirsch: Well did the fact that there was one main stage consisting of a vacuum tube and a post- transformer feeding the diode logic network, made it possible to do a kind of marginal checking that we did in which we could lower the return voltage from all of the vacuum tubes uniformly through the whole computer, thereby decreasing the tolerances that you had designed into the components and we could cause the machine to marginally fail during testing time. That was a very important notion of having, create a worst case which of course you had designed for.

Greenwald: Worse than worse. [laughter]

Cahn: Well I think that one of the main things was the type of way we designed the thing there. The tubes were used only for amplification. All the switching and so on was done with the diodes.

Kirsch: Ruth refers to the germanium diodes. And, at the risk of [laughter] doing something very dangerous, I'm going to unplug one. This is an old vacuum tube base in which there are one, two, three, three

diodes wired in. And, this is the way in which all the logic was done on the SEAC computer with germanium diodes, which were a notoriously unreliable component.

Cahn: They were pretty much unknown.

Kirsch: Unknown, yes. Remember, this is before there were transistors so this is one of the early solid state devices and it was not possible to do marginal checking so what we would do is what I just did: unplug them, test them, put them back in thereby possibly creating more problems than had actually existed ahead of time. We also compiled vast records on the tests which were utterly useless. Another one of the components that you see here is this magnetic wire device. Ruth…

Cahn: It's not in the original computer.

Kirsch: Right. Would you like to describe the out scriber that you and I built for using the wire cartridges?

Cahn: Yes. The original, first, the original input and output of the computer is a tape or typewriter…

Elbourn: Perforated paper tape

Cahn: …which is very slow getting into the computer and very slow getting out. So, one of the first things they wanted to do was speed that up and they went to this wire cartridge here which you could somebody built what we call an inscriber which put information from the tape onto the wire there and this one into the computer---seconds instead of hours that perhaps a long tape would have taken and so forth. But that means that outside of the computer you had to put the information on the wire and

take it from the wire back on to tape and that one that did the second thing was what we call the out scriber, which was a little more difficult than putting it onto the wire.

Kirsch: One of the difficulties with the out scriber was that the magnetic wire on which information was recorded quite densely and could be read very rapidly by the computer, had to be read very slowly for purposes of driving paper tape punch and since the wire was moving very slowly, the magnitude of the signals that we read were very, very weak. One of the problems we encountered was some noise that was very hard to detect and it would occur in bursts at various times and I remember trying to determine where it came from. And, so I did some radio detection triangulation and we discovered that there seemed to be bursts that were coming from the National Security Agency at which point we decided there's no point in trying to find out what was causing it but we did manage to circumvent the difficulties. We had other kinds of problems on the out scriber that I remember.

Cahn: Yes, that was our baby.

Kirsch: Right. One of the problems, perhaps one the earliest problems in human factors design was that there was a reset button on the out scriber and this is one of those buttons that you push that doesn't give a click. So, it was what I called a "non-satisfaction" type button. And, we would find people pushing the thing, almost pushing over the cabinet of the out scriber because they didn't hear anything click, you see. Very elementary thing that we learned later on—is necessary.

Cahn: I think they had the same problem when they controlled the computer…mathematicians push those buttons to death.

Greenwald: Well, you talk about problems, I was involved in in, in designing the circuitry for the wiring, for the wire input, we used to call it the wire dumper, and also the tape units and one of the problems we had was on the floor above us there was what they called the tube lab and they fabricated original tubes of various kinds and in the fabrication they have to out gas these tubes. You know first they get a very good vacuum and then they have to out gas it. Well, in order to do that they had a RF transmitter there of I don't know some unknown huge power, and it would pulse repeatedly while we were trying to work the machinery.

Kirsh: Not only was the pulse repeated but it was aimed at us. [laughter]

Greenwald: And trying to get that interference out we had to do an awful, awful lot of grounding and shielding and so on to try to avoid that. But they made life difficult, but we, we overcame it.

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How Did It All Work Part 2

Kirsch: On the SEAC computer we had a device which was a modification of an old office dictating machine which was used to let the programmers store their programs and their data in such a way that they could remove it from the computer . This wire cartridge is one of the devices that was used to store information external to the computer. It consisted of two reels of steel wire with a thin magnetic plating on the wire and the information stored in binary form in such a way that the programmers could record their programs on the wire, bring it to the computer and then record the results on the wire from the computer and remove it where a separate device called the outscriber could convert the information from the wire to a punched

paper tape and then from the punched paper tape to a printed form which people could read. Here you see the operator plugging one of those cartridges into the device on the computer which would read the information from the wire cartridge. And that was the ponderous method that we used to put information into the computer and to remove it from the computer. I have a prize find here i"d like to show you . Ruth was mentioning the input/output problem and after the wire cartridge was transcribed to paper tape, it became necessary to run the paper tape on a Teletype machine to actually make a printed hard copy. And, those of us who were involved in working with computers and using limited resources, at times had to use all kinds of ingenuity to be able to make do with our limited resources. Here's one such example: [laughter] One night, we ran out of paper for the printer and some clever person managed to print out the results notwithstanding our limited resources, which demonstrates what you can do with ingenuity and limited resources. It also demonstrates that they don't make toilet paper the way they used to. [laughter]

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Memory of SEAC

Kirsch We would like to talk a bit about the memory of the SEAC computer. My own laptop here contains 500 megabytes of information which to most people nowadays is not at all startling. What might seem more startling is to understand that on the SEAC we had 10 kilobytes of memory, that's 25,000 times less memory on the SEAC than we have in my little laptop computer here. Can we discuss the question of how the memory on the SEAC worked, two different kinds of memory?

Elbourn: Presper Eckert Jr. of the Moore School project had worked during the war on the problem of illuminating the ground return from radars and the trick they adopted to do it was to store one return from one thing in an acoustic pipe of mercury and then subtract that from the return of the next thing in the radar and then a different stationary part cancelled out. Only moving targets produced an output that was detected.

Kirsch: This is one of the pipes in which the mercury was stored on the SEAC memory.

Elbourn: So, in that machine they adopted this, , mercury acoustic line and we copied their plan for the SEAC memory and that same type of memory was adopted in England for the ACE and the EDSAC. Except in their version, their lines went down, they used a 45 degree reflector at the bottom of another that came back up. The amplifier circuits were on top. But this was a fairly widely used form of computer memory at that time.

Kirsch: The acoustic memory for SEAC consisted of glass tubes of which these are two examples here with mercury and quartz crystal at opposite ends of the glass tubes. Then, the signal that would be fed into the quartz crystal at one end would propagate down in exactly 384 microseconds to the other end where the signal would be read by another quartz crystal transducer fed into this amplifier and re-circulated back so that one could put information into the memory or take it out by using the correct timing and pulling out the signal at just the point when it came out of the mercury delay line. The total size of the memory consisted of eight foot high racks of amplifiers and mercury tubes like this, two big cabinets, which would have taken at least the space

from me to Ruth, eight feet high in two large cabinets, and that was a total of 512 words of 48 bits each of memory. There was also an electrostatic memory.

Greenwald: Well before we go to that I want to point out that there were, I think 64 of these to make the memory, right?

Greenwald: And it's kind of interesting, you know, we, we, we play with our machines today and we don't care what the temperature is in the house and so on. This memory was so the temperature had to be keep, kept so precise, they had a thick aluminum plate, the whole size of the cabinet inside and that had to be kept plus or minus a quarter of degree Fahrenheit, I believe, in order for this thing to work. Otherwise, the delays would change. So, if for any reason the power went off in the building, let's say, and that temperature was disturbed, you might have to wait 24 hours for the thing to stabilize again. That's how precise things had to be.

Kirsch: Actually the mercury acoustic memory was one of the more notoriously unreliable parts of the computer and so we had very sophisticated diagnostic programs which could put information into the memory and read it back out and compare what had gone in with what had gone out to see whether the memory was failing. And, quite typically any failure that was detected would be a failure in the memory, in the acoustic memory much more so than in any of the other components.

Greenwald: Yea. There was another trick that we pulled, I don't know I guess whether other people copied this from us. But, on

the main bus where all the information went out, we had a little radio and you could hear, you could hear the information across change somewhat. But, you could hear the machine actually working and you could tell whether or not something had gone wrong. Because usually when a machine gets into one of these endless loops and spinning its wheels, you'll hear the same thing over and over and over again and you know the program has been lost somewhere. But this was a very rough diagnostic.

Kirsch: I'd like to perform a little experiment since Bob is interested in music, I'd like to whistle something to you Bob, and you tell me the name of what I'm whistling. Okay? [Whistling] Do you recognize that?

Elbourn: No.

Kirsch: Ruthie, do you?

Cahn: Fiba fiba foo.

Kirsch: Fiba fiba foo. That was what Sid is talking about, the mercury delay line memory test program, which would run at one megahertz. So, you tune the radio in to the one megahertz signal and the envelope, which was an acoustic signal, is what was the sound that Ruth says was called "Fiba Fibba Foo."

Cahn: It also printed it out if it went correctly.

Kirsch: Yes. So, we had many different ways of testing the computer. Including the audio tests. Can we talk about the other memory, the electrostatic memory? As I recall, Bob, you did the great design of the last of the great electrostatic

memories at a time when they were unfortunately obsoleted by transistors.

Greenwald: …By ferrite cores.

Kirsch: And ferrite cores, yes.

Elbourn: No.   I don't think I designed it.

Cahn: Bill Davis did
Elbourn: Bill Davis…
Kirsch: Bill Davis built the original electrostatic memory. I was referring
          to the last version that you did, Bob.

Greenwald: Oh oh. That's what Ruth and I worked on. What happened
          was that the memory, this cathode ray memory in which
          one digit is on one tube and there are 45 tubes actually.
          What happened was that the, the machine on this memory
          was notoriously prone to error. I mean, it would work one
          day and the next day it wouldn't work and then there'd be a
          lot of scrambling and so on. It was finally I think a fellow,
          Davis left and I think Holt left or he went on to something
          else and Ruth and I were given the job of trying to make
          this thing really, really work. And, we went through
          everything we could think of. We went through the
          amplifiers, we went through the grounding, we re-wired
          things. Do you remember the various things

Cahn: Not really.

Greenwald: We looked at them. We looked at the power supplies looking
          for transients. We had a whole long list of things. But
          when we finished the thing really worked and then became
          and that was, I think our pride joy. I think Ruth doesn't

remember that. But, I remember very well.

Cahn: I remember working…

Kirsch: What you may remember was that in maintaining the electrostatic memory, since the information was stored on 45 cathode ray tubes, each binary digit being one spot electrostatic storage on the face of the cathode ray tube. Occasionally there would be blemishes on the phosphor, which would cause one binary digit to fail. John Rafferty, had a mysterious ability to change the deflection amplifiers on all of the 45 cathode ray tubes simultaneously so as to move the raster off of any of the defects, any of the blemishes on the face of the tube.

Greenwald: And he kept a map of the known defects.

Kirsch: And he kept a map of where the known defects were on the face of these tubes. Then later on, you managed to use some new tube designs that RCA came out with which seem to have fewer defects on the phosphors, but again it was a good design too late, unfortunately for the technology.

Greenwald: Yes, in 1950 I think a fellow at MIT came out with using a magnetic core memory and Jay Forester changed the whole complexion of memory and from then on the mercury memory and the CRT memory became obsolete.

Kirsch: So, a lot of the technology of the SEAC became obsoleted by progress. And, that may possibly account for why so few people know that the SEAC started everything.