Oral History of Joseph Cherney

Interviewed by:
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Dag Spicer: Well, I just wanted to say ... I think we got cut off there ... what a thrill it is for me to interview you today, and to think that you are the fellow who is standing in that ENIAC picture [in CHM's Revolution exhibition] is really remarkable. So thank you so much for speaking with us today.

Joseph Cherney: I'm privileged to do that. I'm pleased with it.

Spicer: Now, do you mind if I record this conversation?

Cherney: Recording is okay.

Spicer: Okay, and thank you. I'll go ahead and start that. So what I'd like to do is ask you a little bit about your life; not just ENIAC, but really starting out when you're very young: where you grew up, what your parents did, and that kind of thing, up to as far as you'd like to go ... maybe up to your retirement, or further, if you'd like. So with that said, if you're ready, I think we can begin.

Cherney: Okay.

Spicer: Okay. So we're here today with Joseph Cherney. This is Wednesday, December 2nd, 2015, and we're speaking via Skype, and we're going to explore Joe's life and achievements. So, Joe, could you tell us a little bit where you grew up, and what part of the country, and what your parents did?

Cherney: I grew up in Flandreau, South Dakota, just north of Sioux Falls, South Dakota. I have an older brother, two sisters, and a twin brother. So we're identical twins, and grew up. My father was an automobile mechanic ... independent automobile mechanic ... and so during the course of growing up, between sports and working in the garage, we did that. My high school started 1940. My older brother went into the military through the National Guard. My two sisters ... when the war started, my two sisters left home and married two military officers. And so we finished ... *I* finished ... high school at that time. My older brother came home. He had been ... had a bad leg. He'd come home in 1944, and we were to be 18 in 1945, where we'd be drafted. So he talked us into going in and joining the Navy, in order not to get into the Army. And so we then joined the Navy in August of 1944, went into the Navy ... were called in to the Navy in September of 1944. In boot camp, we took the Eddy Test, which was a special test that they had for training technicians in the Navy. And so, finishing there, we went to Chicago for two months for a preliminary course.

Then we went to Gulfport, Mississippi, for three months, of which they went through the technical aspects of how electronics work, and the technical basis for it. And then we went back to Chicago for nine months with a specialized training, each month being a different training, and so forth, from that standpoint. And we were in Gulfport when the German war was complete. We were in Chicago when the Japanese war was complete, and so we were celebrating that on the streets of Chicago at that time. We then ... we were in for the duration. But at that time, then, we were assigned to the USS Missouri. There's a story behind that. I won't take time to tell it, but it turned out to be that they arranged for us both to be aboard the same ship. So my brother was aboard the ship as a radar technician. I was aboard the ship as a wireless ... as a radio technician. And so we were there until... 1946.

So in 1946, we entered the South Dakota State College, and my aspirations had been to go to Berkeley, because I was interested in the cyclotron back when I was in high school. And somebody from South Dakota ... I contacted him. He sent me a book on it. But with the GI Bill, you went to your home state. You couldn't get into any other school. At that particular time, they started a new course ... engineering physics ... which had the theoretical of physics along with the practical of engineering. As I mentioned in my note, a year ahead of me in that particular one was Gene Amdahl. So Gene Amdahl and about five others of us were the engineering physics group that went through, from that standpoint.

Spicer: When you said you were born in Flandreau, Gene's name immediately popped into my head, because ... yeah.

Cherney: Yeah. He lived on a farm outside of Flandreau. Yeah.

Spicer: "Flan-*drew*." Sorry. Can you tell us a little bit about the kind of training you received in the Navy? What specific systems and technologies were you learning there?

Cherney: Well, I mean you have to recognize the fact that the technology in the 1930s was mostly high-frequency radio. They still hadn't got to the ultrahigh frequencies. The tubes were not capable of handling the large frequencies, which would be necessary for frequency modulation type units. The... a lot of work was being done by amateurs ... amateur radio people ... and they were building different tubes, and so forth, that would keep the cathodes closer to the plate, and would get into that higher, higher frequency, and they were doing exploration there. When the World War started, what they did then was to go ahead and... started doing all kinds of theory here. So here we are with vacuum tubes, mechanical type things. Radar was a rumor. And the public press was very ... in fact, it was during the '30s, at the Roosevelt Fireside Chat, and reported exploits. Most of our knowledge of the war was through the newsreels in the movies. So you didn't have the broad expression of things there. Amateur radio was very important.

In fact, one of the ... we first took this Eddy Test after hitchhiking to Sioux Falls, and failed it. And the reason we failed it was because we were not quite that knowledgeable about amateur radio concepts, and so forth ... antennas, and so forth. And... but we did better in boot camp, and got into this. The radios had moved from battery radios, in the '20s ... all transformer-driven. Then, in the '30s, they came out with the ones where they went ahead and ... AC/DC radios, they called them, of which they got rid of the transformers, and then just put resistors in line with that, and they converted 100-percent AC to that. One of the problems that you had with that was, it was ... you could get a shock off of it. And aboard ship, one of the officers asked me to go ahead and take the shock out of it. All I could do was wire the chassis to the ship ground to prevent the operator from shorting it and getting shocked.

So anyway, radar was talked about in the news, and so forth, but nobody knew exactly how it worked. When we came home from the Navy and *did* know how radar worked, we tried to explain it to my father, who was a very capable man, but we couldn't get past explaining an oscilloscope to him. The concept of an oscilloscope was beyond the normal thinking of the people, at that particular time. It wasn't until TV came, after the war, that the concept of an oscilloscope was there. So it was very difficult to go ahead and explain it when you couldn't explain the oscilloscope, of how the ... you end up with the face of an oscilloscope, and you ended up with a dot in the center, and a line going around, and then a blip showing up where there was an object there. So, went through, from that standpoint. During the primary years, we ended up getting into power electrics ... electricity. We got into radio basics and many of the things that I had taken. I was able to take a comprehensive test in college because of the things that they did there. In the Chicago one, we just went through ... each month, we were taking a different thing. We'd take radio receivers. In fact, when we were troubleshooting receivers, the World Series was on in Chicago. <laughs> So we quickly looked for the bug that they'd put into it, and then listened to the radio. <laughs>

Transmitters... navigation systems, when they were using the system for the navigation. Sonar... and radar... and then antenna theory, and so forth. And so we got a good, comprehensive picture of this. One of the ... during the course of this, we also got into closed-loop servos. And during World War II, the closed-loop servos concept was not seen ... it was not used by the enemy, either Germany or Japan. And that's a consequence ... so, you know, where you had the closed-loop servo, where you got power steering today. But the mathematics of that had not been available to them, and so what they had to do was, when they aimed their guns ... antiaircraft guns ... they had to use wheels. Two people on that. One of them was up and down, and the other one was rotating, and that's one of the reasons that they did the low-flying hedgehop type bombing: because the operators couldn't travel fast enough in order to get the airplane flying by. And the ... so they ended up, then, with a Norden bombsight up for high length. A Norden bombsite was kind of a mechanical, analog type system, and they had to go ahead and keep in track for... I don't know, five, ten minutes, in order to do it, but it was very accurate.

When we went to college, most of the things that we had learned in the Navy were still classified. And so as they ... so we were learning ... in college, we had teachers who had been taught in the 1920s and the '30s, and they had not had some of the training we'd had: for instance, AC circuits, where you return from three phase to two phase ... to... three phases to one phase, and so forth ... those conversions. And so we did, in the Navy program, because that was part of what we needed to do, because of ... in that particular case, what they were using was three-phase extenders and receivers, to be able to do cycling from one end to the other. They would end up with ... using that. You would have the three phases hooked up together, like a motor, and then you would go ahead and turn the stator, and that stator would turn at the other end. So you now have a remote change to what you were doing, from a magnetic standpoint. So we ended up, then, being able to ... in college, we were able to go ahead and take credit for the work that we had done: the mathematics. So we didn't have to take gym, or anything like that, so we had time for extra courses. I joined the Physics Society. I joined the Sigma Tau for the Engineering Society, the Blue Key for the Service Society, and my brother and I were drum majors in the band... from that standpoint.

Spicer: Wonderful.

Cherney: And so... but we went on and enjoyed the engineering physics, from that standpoint. Korean War... when we graduated, the Korean War was on, and jobs were hard to get. So my brother decided that he was going ... we had four years of GI Bill, but we went ahead and worked our way through one, so we saved one year of GI Bill for graduate school. And... during the summer, I ended up working with an electrician, to wire farmhouses. The Rural Electrification Administration came through, and so the farmhouses were being wired for electricity. So I had ended up, during college, in the summer, and so forth, so I got a lot of experience with wiring houses, from that standpoint. The... I ended up sending an application to the government, and they gave me two offers. The one offer was to go to a Navy boat facility in Virginia, I think it was, and the second one was an offer to go to Ballistic Research Labs in Aberdeen Proving Grounds. I accepted the one with Aberdeen Proving Grounds, not knowing ... in those days, you didn't travel just to go get an interview or anything. Airplane flight was really nonexistent at that particular time. But trains were going east and west in our part of the country, and buses north and south. And so we were at the beginning of the airplane, at that particular time. When I got to Aberdeen Proving Grounds, they introduced me to ... they came in [and] showed me the ENIAC, and I frankly did not understand. I was having a little bit of difficulty kind of grasping that. Aboard ship, I'd been working with the wireless, working with... big transmitters, so the electronic racks didn't scare me. But I frankly didn't understand what was going on, and that bothered me. Well, as it turned out to be, I left for a week and came back, and when I came back, it all clung into space, and all of a sudden I started to realize that we were solving the problems, and so forth. From then on, I grasped what was going on very quickly. My boss told me, he said, "I was worried about you before." But he says, "You seem to have it right now." And...

Spicer: Sorry, what was name of your boss? Do you remember?

Cherney: I'll think of it. I've been ... I'll think of it when we go through with this.

Spicer: Okay. Right.

Cherney: So, being single, I went ahead and worked the shifts. I'd work a week, day shift, then I'd work a week of evening shift. Then I'd work a week of day shift, and then I'd work a week of midnight-to-morning shift, and that was regular. And... one of the times I was on evenings ... I was on the evening shift ... President Truman came and visited us. I was glad I wasn't there, but I saw him going by on the train. <laughs> heard about how friendly he was to all the people, and so forth, but...

Spicer: Now, what was the nature of your work at this time, on ENIAC?

Cherney: It was broken down into two things. One was that the mathematicians operated the machines, and they were self-sufficient.

Spicer: Okay.

Cherney: So when I went in, I found them sitting at the desk ... a small desk, temporary desk ... and they had the control box. And they had a layout sheet, because the way they did the problems was to go ahead and lay it out on the spreadsheets. And they had flow diagrams and spreadsheets. They had gone through this by hand calculators. They had put the information on the function tables, and they ... on the function tables, and then they would go through ... some of them would go ahead and do sum checks. But all of them would go through, step by step, until ... for the first time, they would go through and make sure the things were doing exactly the way they were responsible to do. The ... when something happened, the engineer who was in charge ... at this particular time, they required engineers to be the troubleshooters. And so when the engineers were there, they would get the engineers in, in order to go ahead and follow through with what they did, and then they would run a deck of flashcards. We called them flashcards, but what they were doing was IBM cards, which had specified programs on them, and they would put these programs into the relay storage. They had 100 lines of relay storage. They would then operate the programs on the relay storage so that they could ahead and check every accumulator, all 20 computers, and all of the other logic that were available to it. Then, while we were watching the flags tests, we would watch the displays. For instance, accumulator number 15 was the designated central processor. The 19 and 20 were the ones where the final products would usually show up. And so we could watch the patterns of lights, and especially during the 10-digit-by-10-digit multiplications, they would go like waterfalls. They would then go in other different kinds of patterns. And we got so we kind of recognized what those patterns were, and we sometimes could go ahead and identify what the answer was.

Spicer: Wow.

Cherney: The ENIAC had been in operation since 1948 ... the later part of 1948 ... and my boss...

Spicer: Sorry, this is at Aberdeen, you're talking about?

Cherney: This is at Aberdeen.

Spicer: Yeah, right.

Cherney: And the ... remember, they put it into full service about ... let me interrupt for just a second. The history of this was that they had set up the thing at Pennsylvania ... the Engineering School at Pennsylvania. Homer Spence was the name I'm searching for. Homer Spence was my boss, and he's listed in the records, and so forth.

Spicer: Yes. I've seen his name before.

Cherney: Yeah. And he ended up, then ... they ended up bringing it there. Back in the 1940s ... most of the men in the '40s wanted to ... most of the men had been called into the military. So the women mathematicians, then, were called upon, in order to perform these things, and they came up with solutions to the partial differential equations and the differential equations using 10-digit desk calculators. And, for instance, if you were going to go ahead and study what a curve was for a ... you know, you've got a jet, and what you want to do is to go from the 600 pound per square inch coming out of the firing, and you're going to end up with it having it expand. Well, ideally, you want it to expand until finally the end of the cone is at room temperature; or, in case of the ... at 60,000-foot temperature ... you know, pressure ... whatever it is. So now you get the maximum efficiency. So in order to run that, it's a nonlinear curve that goes up. But what the operator would do would be [to] go ahead and just take a small movement ... maybe a tenth of an inch. They would then solve it as a linear triangle, and that set the new conditions themselves in a linear triangle. And so what they would do is end up doing the same problem a thousand times, and the error that came about by the approximation was negligible, because they could up, then, with multiplication. So repetitiveness was one of the key factors in the ENIAC, or the electronic vacuum tube computer. They were limited by physical scale in the case of analog computers, and with the relay computers ... we had one downstairs ... they could do the reiterations, but it would take them a week to do what the ENIAC could do in an hour.

Spicer: Right. So I want to ask you a couple of things. One is to describe to us how ENIAC worked. And I know that's kind of a long answer, probably. And then my next one after that is, how did you program it? So you can blend those answers, if you like.

Cherney: Yeah. Well, keep in mind that the operators then were using 10-digit calculators. And so, according to one estimate in the literature, they could go through and ... and go through and make a trajectory calculation in two days. What they would do then is use that as the baseline, because you have to put in moderations for the shape of the bullet, the temperature, the wind, and other conditions that come about. So what you want to do now is to go ahead and go through those things so that the person that's firing the gun can then go ahead and know ... have a matrix of what to set the gun at. This is ... the internal ballistics create a movement and positioning on the bullet, so when it leaves the gun, the external ballistic people will start out with a velocity, a shape, and how they're going. They will then run another trajectory, and then another trajectory, and then what they will end up doing is interpolating between these as they would modulate the temperature, or as they'd modulate the wind, or as they would modulate some of the other variables.

I can't find it in the literature, but I think that's the reason that they made the ENIAC function tables with 104 rows, and with two six-digit numbers horizontally, each with a sign. And that was in order to support ... and there were 12 instead of 10. So here we end up with a bigger than a 10-by-10. We ended up with a 12-by-12 matrix, and that was for... so that they could go ahead and use those stored trajectories, and not modulate them.

All right, the pattern of the ENIAC, then, was on that basis. So the heart of ENIAC was to go ahead and build a 10-digit ring, which could store ... it was a 10-position ring of tubes. And then they would put 10 of these rings side by side, and they would then put a sign number on the end. So you ended up, then, with a row of 10 by 10 ... 10 horizontal, 10 vertical ... and then a... just two ... on/off, minus/plus ... on the side. They would then build into that three inputs for data, and two outputs for data, and then they would put in programmable type of capabilities in that accumulator. They ended up with six transmitters and four receivers. The transmitters would go ahead and receive a signal. When they finished with the product, they would end up sending out a signal. The receivers would only receive a signal. And then they end up with one channel which would ... they would just receive the signal, and then they'd pass it on. So the capability was there, in order to go ahead and program that. One of the examples that I had sent was, then, if you want to go ahead and add two numbers together, if you want to multiply, what you can end up doing is putting the one number in, say, register accumulator number one, and then you've got accumulator number 15, which is the central one. So would you then command ... accumulator number one ... you'd put a switch setting and the cables on number one, that it would go ahead and transmit the signal six times. You would then go ahead and set the 15 so that it would receive for 6 clock cycles. So now you've gone ahead and done that. Now, how would you do that? You'd do that by patch cords. You would set the switch, and you'd put a patch cord on that, and then you would hit the patch cord. It would then transmit from the transmitter over to the 15. It would then say, "I'm sending. Receive it."

So what they did then was to go ahead and put together ballistic routines by hooking up the patch cords, they ended up with a square-rooter and divider, and they ended up with a multiplier. And then they accomplished the shifting they had to do by mechanically shifting of the data lines. So you'd move one channel and send it through another channel, and you'd have different shifting – this is the mechanical shifting. You'd end up with a cable which had the pins shifted, and then you'd end up using other computers to go ahead and decide how much shift you wanted to do, and so forth. And so, under those circumstances, it was easy to do. The problem was, in order to have an array of shifts, you had to have an awful lot of different combinations in order to do it. So anyway, what they ended up doing then is to go ahead and set these up. They put in a programmer ... a pre-programmer ... which told it which would be the initial one that they would use; in other words, which of the 17 do you want to run, that you have programmed in there?

And then they had a cycling unit, which would set up the 200 microsecond clock. And so if they wanted to transmit a number out of accumulator number one, what they would do is to open it up so that it would count 10. That meant it would overflow, go back to the same number, and 15 then would receive ... they would have a gate, which ... you would gate how many of the ones that were actually stored in there, so that you now could transfer the storage from one accumulator to the other through that cycle servo. So they had the storage ... they had the gates, and so forth, in the ENIAC's accumulators, which would allow them to only punch ... read out the number of pulses that were actually stored, even though they were stored around.

Spicer: Right. Now, how long did a typical setup take for a problem?

Cherney: I don't know. Well, before they put in the codes in this particular case that we're talking about, what they would end up doing is have specialized setups for every program. And setups would take probably two days, and then they would run through. And if the machine was bad, they had no way of knowing whether the machine was the problem. So according to literature that I've got, it could be three or four days before they actually had a program running. Once they had a program running, they could calculate the trajectory faster than the bullet actually traveled. But that was clearly inefficient. So what they ended up doing then, then, is putting in the codes they set it up so that they could take two digits off the functional table, move it over to a cycling unit, decode it, and then perform the product, and then go back and get two more, decode it, and they called that the basic cycle. They would go get the two digits. What they'd do is read out a whole line ... 12 digits ... of the accumulator. They would run it through a special-designed, two-at-a-time type selector, which would count up, and then they would go perform the first result and that would send it to the cycling unit, which was ... which had a capability of 00 through 99, 00 being nothing. Zero-one meant that you were going to add ... what was in register 15 would now be added to one. And then, number 2 ... what was in 15 would be added to 2, on up through 10. Then 11 was, what was in one would be sent to the 15. What was in 2 would be sent to 15 for 12. And so they went through those kinds of shifts. This was then followed by performing the second result in the same way.

When they got to a divide ... they would put the numbers in the quotient and the divider elements, and then they would just go ahead and give a command to the divider, and it would go through, dividing. When it finished, it read out a signal, and said, "I'm done." And then they would put the results in a specified accumulator and get the next code to continue. ... now, when we finally ... when I got there, in about a year... and let me take an aside. During the original design, they had gone ahead and selected a predetermined number of tube types. When they were running the computer, they ended up, then, always going and pinpointing which tube it was, in a typical engineering fashion... if you excuse the expression. <laughs>

Spicer: Okay.

Cherney: And so it ended up taking time. So when they sent it to set it up there at Ballistic Research, Homer [Spence] said, “No way.” He said, “We’re not going to take the extra time to go ahead and figure out which tube it is. What we’ll end up doing is we’ll remove all of the tubes that are in the area of doubt, and then we will send those to our tube-checker, Katie, and she’ll decide which are the bad tubes.” So under those circumstances, all we had to do was to kind of put it within one or two decades, and then pull the tubes.

Spicer: Now, this Katie that you mention ... was this a full-time job of hers, checking tubes?

Cherney: Yes. This was a full-time job of hers. So she was doing the tube-checking, and so we ended up with another man, which was Murphy, who was the mechanical technician if you wanted something, he could find any place on the base, or make any changes needed.

Spicer: Oh, yes.

Cherney: Those kind of people.

Spicer: One of those guys.

Cherney: <inaudible> enough.

Spicer: Right.

Cherney: Homer, then, had gone ahead and established that particular practice. This became more apparent to me, because when the ORDVAC came in, they wanted to pinpoint every tube, and he finally moved over to the ORDVAC, and said, “No. We’re going to go ahead and start to replace multiple tubes, and not do...”

Spicer: Now, what was the reliability of ENIAC, at this point, hours before failure ... that kind of thing?

Cherney: I can tell you what the literature tells. It’s hard for me, because we were the engineers, but all of that was figured out by the programmers, and there wasn’t always agreement as to when the program ... the computer was not working or not.

Spicer: Well, whether it was ...

Cherney: The answer came back is ... the literature shows people that were doing this thing; that out of a 160-hour week, 8 hours were set aside for troubleshooting.

Spicer: Okay. Oh, that’s very low.

Cherney: Out of that 160 hours that they had, they had about 100 hours of operating time. So the reliability was about 100 out of 160. And this is for the period of time between 1953 and 1955. I'd say 1950 and 1955.

Spicer: And how long would a typical repair take, would you say, if you encountered a problem?

Cherney: In general, I got to the point, and some of the others, also ... the engineers did ... where we could go ahead and fix a problem in just a few minutes.

Spicer: Oh, wow.

Cherney: Now, sometimes those were makeshifts. For instance, we didn't have very good oscilloscopes. But when I put an oscilloscope on a transmission line, which were the trays, what happens is, -- let me get a little technical now.

Spicer: Sure.

Cherney: The ENIAC called for a pulse that had a ten microsecond risetime... It would rise to 50 volts, and hold it at 50 volts, and then come down. Because of the trays, now, were metal trays, inside there were metal kind of channels, and a wire went from end to the other. These, then, were terminated. These were driven by cathode follower circuits. You're familiar with cathode follower circuits?

Spicer: Right, like a 6L6, or something?

Cherney: A 6L6. Two 6L6 cathode followers, driven by a 6V6. And at my boss's request, I went ahead and measured the actual thing. And what we were doing with the 6V6, we were actually pulling ... the amount of signal we're getting was related to the size of the grid. So in other words, it was pulling positive grid currents, and even cathode followers, they didn't do that. But in this particular case, they were using that particular thing. Now, they were then driving a 220 ohm resistor.

Spicer: As a termination resistor?

Cherney: As a termination for the tray.

Spicer: Right, right.

Cherney: Now, because of the capacitance in the tray, it ended up being, then, that the... you would end up with a capacitive load and a resistive load. So what they did was to go ahead and put in a small choke on top of that, and the combination of the capacity and the choke then gave us standing waves.

Spicer: Ah. Uh-oh. That's not good. <laughs>

Cherney: It was not bad.

Spicer: Oh, just ... it wasn't bad to have standing waves in the trays?

Cherney: No. It ... but what had happened is that sometimes I'd move the load, in order to get the standing wave. So I'd get the peak at the suspected accumulator, and get them back working. <laughs> That's why I'm going through all of the explanation. But in most cases, it was tubes. And in the case of the accumulators, it was tubes. In the case of the divider/square-rooter, it was tubes, *but* they were so seldom that you'd go ahead and tell that, because the filaments were out. They weren't. The tube has the life expectancy because of the pulling of the electrons off of the cathode. And what happens is that the ... as you get a smaller and smaller area of the cathode on the 6L6s, you get less and less signal. Now, which fails first? Well, it gets back, now, to the fact that the pulse is going to drive another receiver, and if that receiver went as weak, then that's the one you'd change, instead of the 6L6.

Spicer: I see. Right.

Cherney: So the flash tests were very good, because I would say, on the average ... there were exceptions, but on the average, I would say we would have it back online between 30 minutes or less.

Spicer: Wow. That's impressive. I read somewhere that higher-reliability vacuum tubes were available as of about 1948. Do you know anything about that? Did you encounter that at all, or...?

Cherney: No.

Spicer: Okay.

Cherney: They picked the vacuum tubes, which are the most common, that we used for radar.

Spicer: Right ... radio.

Cherney: When I went through radar school, I asked a technician who had been on the field, and he came back for radar training. And I said, "How in the world do you go ahead and repair a radar in the field?" He says, "It's almost 100 percent tubes." And he said, "What we end up doing is, when we don't have ... we're not fighting," he says, "we go around and we pull out a tube, put another tube in, check to see if it works. If it works, we mark it to that socket."

Spicer: Right. <laughs>

Cherney: And so they had few enough tubes that they could go ahead and do it, from that standpoint.

Spicer: You're right. Right.

Cherney: Now, the... okay, go ahead.

Spicer: Oh, I was just going to ask if you interacted with the ... now, I want to get this right. The women who set up the problems ... were they called programmers, or were the...?

Cherney: They were called computers, originally.

Spicer: Computers. Okay. And ...

Cherney: Yeah. But when I got there, they were called programmers.

Spicer: I see. Okay.

Cherney: Because they ... you now had a program, where before, they were actually doing the computing.

Spicer: Yeah. Now, this is still before it was a stored-program machine, right? When it was still patch panels.

Cherney: Human computers.

Spicer: Yeah. And did you interact with these ladies very much, and do you think they were ...?

Cherney: A number of them, yes ... the men and the ladies. I interacted with the programmers. George Reitweisner... I interacted. His ... ultimately, his wife, Homey, I reacted with. Most of my reaction was with the two of them. I can remember George telling me that he'd gone ahead ... one of the papers ... you probably have it; if you don't, I can send it to you ... had listed all of the programs that they'd run. And George had run one for pi and for E, which are series. And so he came over to me and told me that he ran it to 2,500 places, but he said the man who did it, he spent his whole life doing it. He got lost at about 1,400. <laughs>

Spicer: Oh, yes. Yeah, it's very humbling. Must have been very humbling back then, to see. Now, with these women programmers, how knowledgeable about the machine do you think they were? There's some material out there that say the mathematicians didn't know how to express the problems, so the women had to translate their ideas.

Cherney: They were very knowledgeable about the machine. They knew the switches, they knew the cables. Now, what ... and they knew how the machine would work. Ask them a lot of electronic ... say, "How would a vacuum tube work?", they probably couldn't tell you. But the mechanization of the problem actually was their baby, and they knew it better than most of them.

Spicer: Wow. I want to ... I think what we'll do is, if it's okay with you, is make this a two-part interview, because we're just ... you know, we spent an hour, and we're still just on ENIAC. So why don't we just go till eleven ... another eight minutes or so ... and then we can pick up again next week, maybe, or whenever it's convenient for you. So I just had a couple more questions.

Cherney: Well, let me give you a little more background.

Spicer: Oh, sorry. Go ahead. Yeah.

Cherney: Homer (my boss) asked ... I got moved over to the EDVAC. I was off the ENIAC. And this is after about four months. So I moved over to the EDVAC, and was working with the people. Now, the EDVAC was a serial machine. It used a mercury delay line type memory. It used a standard power supply, and we were troubleshooting it. And it was using a four-position coding scheme. You would say, “Where’s my” ... first address would be, “Where’s my ... where’s the command?” The second one was, “Where do you want to get the two digit code the two words for it?” And the third one was, “Where do you want to store it?” And then they ended up with a simple command for what was the operation that they wanted to perform. Now, we were fiddling around with that, and in the same time, they were talking about putting a rotating drum on there, and one of the fellows was developing the drum memory electronics, What they did was they were actually gating one microsecond pulses with one microsecond pulses. That’s not normal. Normally, you gate a pulse with an open gate. So we ended up having to time the signals in such a way that they got there, so we used old delay lines that were from the military, and put in delay lines to do this. One time we were troubleshooting, I went ahead and measured the voltage, and I found out that the voltage was varying from 90 volts to 150 volts.

Spicer: Wow.

Cherney: The computer was running this program. The ... when we checked it, we found out that there was a Pi filter in the power supply. Capacitor, inductor, capacitor. And what was happening was that the repetition of the program was exciting the resonant frequency of this capacitor parallel circuit

Spicer: The choke. Yeah.

Cherney: So what we ended up doing is taking out the initial capacitor , and putting in just a resistor. Now the point I want to make is that one of the things that we ran into with computers was that repetition could go ahead and cause problems by themselves. Now, the ORDVAC people, reportedly, were programming programs in such a way to play Christmas carols. They’d put the earphones on the data line, and then they would play Christmas carols. But what I was trying to say is that Homer then asked me ... I think this was when he was going back to the... there. He asked me if I would take over the ENIAC maintenance. Well, this is ... this became kind of a dividing line that I had there. I was moving out of pure research, and moving into management, so to speak. So I said yes. And I said, “That’s on one condition.” And he said, “What’s that?” I said, “Those engineers over there are doing a technician’s work.” And I’d been a technician in the Navy. And I said, “I want you to go ahead and transfer them over to do an engineer’s job.”

Spicer: Right.

Cherney: And he said, “Well, wait a minute, now. They’ll never be able to troubleshoot all the problems.” I said, “What, for instance?” “Well,” he said, “the square-rooter and divider.” I says, “I’m single. I’ll put myself on 24-hour shift. Anytime they get into trouble, I’ll do that.” So the big job I had was training these people. The first thing they wanted to do ... and this was the problem they had ... was try to memorize a fact and problem. And I had to train them, saying, “No, you have to memorize the procedures by which you go through and *isolate* the problem.”

Spicer: Right. Right.

Cherney: And most of the problems were tubes. We’ve got exceptions. I did write one exception. When I came home from a trip, Homer came to me, and he said, “The computer is intermittent. I just can’t figure out what in the world's going on." So I said, "Okay. Send everybody home. Give me a chance." So I ended up having a technician go ahead ... we ended up with a 20-stage ring, which created the sequence for the word position. All other ring stages were removalbe, most of the rest of the rings were all plug-in, but this one was not. So I just asked the technician to go ahead, and with the power connected ... what we ended up doing is, from history with Homer, we never turned off AC power, but we did turn off DC power, and it would automatically go off if there was a fault.

Spicer: I see.

Cherney: So I said, "Leave the DC power on. Take out all the tubes." And I showed him which pins to go ahead and give me measurements of those. Well, the ring is a very ... it's a bunch of 6S triodes, and they're all balanced in such a way that they disturb one, it'll move to the next one, and so forth. And then I said, "Turn off the DC, and then take resistance measurements of these." And the resistance would show if there was a leakage in the capacitor. The voltage would show if there's an unbalance in the voltage. Well, sure enough, there was. A microcapacitor was bad. So between the two of us, we were able to get in there and replace the capacitor, and went on and worked on, from then on. So, as I said, most of the problems were tubes, but that was one of those areas in which a couple hours in order to troubleshoot it, and we had it back online, so...

Spicer: Wow. Well, can you ... just before we wrap up for this session, can you tell me ... I've seen Homer Spence referred to as a "PFC Homer Spence," and he's in uniform. Private first class? Is that correct? It seems like, from your discussion, he would be a more senior rank than a private.

Cherney: Yeah, he was not military. That had been before he got into the government employ.

~~**Spicer:** So he was never in the military?~~

~~**Cherney:** I can't say that.~~

~~**Spicer:** Oh. Okay.~~

Cherney: I'm just saying is that he wasn't in the military at the time I knew him. He was a GS ... I think he was a GS-11. I was a GS-9. My next raise, when I got one, was to a GS-11. And then the GS-12 was the one that was in charge of the section. The GS-13 was the one in charge of the department, and the GS-15 was in charge of all of Aberdeen Proving Grounds, and Congress-appointed, and so forth. So one of the reasons I left, because I wasn't sure what it was. But anyway, no. He ... at that time I knew him, he was one of the key members of the program there.

Spicer: That's fascinating.

Cherney: I think the time that he would've been a private first class would've been back when the military was developing the ENIAC.

Spicer: Yes.

Cherney: So then I suspect he left the military, and had come back for a job with the Army.

Spicer: Right. Do you know how many of the women from the Moore School, in the initial days of ENIAC, moved over to Aberdeen? Do you know?

Cherney: From the literature that I've seen, and from the ... I didn't know the people in Pennsylvania.

Spicer: Oh, yeah.

Cherney: But I would suggest that about half of them.

Spicer: Okay. Right.

Cherney: At least half of them had moved over. Now, part of the reason it's hard for me to answer it is because some of them had moved on to the EDVAC or to the ORDVAC. And I didn't interface with them nearly as much as I did with the ENIAC.

Spicer: Yeah. Right. Okay. Well, let's leave it there for today, Joe, and this has been fantastic. I'm so glad we recorded this. This is so wonderful. As you know, we're going to be producing a transcript of this, and putting that online, and you'll have an opportunity to review the transcript, of course, and make any changes that you want, and that'll be in the next ... probably a couple of weeks after our last interview, you'll start getting some material.

Cherney: Let me add one additional thing...

Spicer: Yes, certainly.

Cherney: I think. The Korean War was going on, and two graduate engineers had been drafted. And the two that were there were assigned to the ENIAC. One of them was so upset that I talked to him, and I said, "Wait a minute, now. You're an engineer. You can get unusual experience here in this computer lab because of the fact that you're here." Well, he said, "No." He says, "The government ... I'm worth more money than the government's giving me. I'm on a private's salary, and I'm working at an engineer level."

Spicer: Right.

Cherney: The other one was quiet, an innovator, and he's the one that came up and discovered the fact that a copper dioxide ... remember, now, I'd gone to the school on transistors, and so forth, but nothing was available for us. But this young man went ahead and saw that they put a signal ... copper dioxide signal. Now, the reason this is important is because the oxide had too much capacitance. But this one had been built so that it was a stack of these, cutting down the capacitance, but still getting the bidirectional signal. So what he did was to go ahead and replace the one mega-ohm resistors that we had for isolation purposes in the function tables, and put those into a function table which used one-tenth of the power that was required for the other one.

Spicer: Wow.

Cherney: In addition, instead of using the switch signals... he ended up having plugboards that had been developed by industry, and these pluggable boards now would go ahead and set up the signals the same as switches were, and they were removable, so the operator could go back ,reuse, And do it, from that standpoint. Now, it's this diode which then gave me the capabilities of going in and building a shifter. So I said, "Why not go ahead and set up a 20-output signal counter, and a 10-input, and then go ahead and build up a gate so we could select which of these 20s that signal was going to go to?" And the diodes were necessary, in order to go ahead and complete the design. And the literature says that that improved the shift. Well, what I ended up doing is changing them. I've got the programming thing, but I just changed the programming for the shifts, so that all they had to do was to go ahead and receive the 10-digit number, which was the command, and then it would shift it from the source to 15, or to ... it usually shifted to 19 and 20. And so they did it, in one add cycle, what had taken about 30 in the previous ones.

Now, that was ... those items ... the movement of the engineers and the technicians, the addition of the function table, the addition of the shifter, and then the installation of the magnetic static memory was credited as cutting the cost enough so they were extending the life of the ENIAC past the date that they had, which was 1955. I left in 1953. But from then on, they were using technicians, and so forth. So that was kind of the influence that I had on the ENIAC, which helped out. It also became ... here's why I wanted to tell the story, is because I seem to have been one who has been picked by my superiors to help introduce new technology. And so the rest of my career, as you can see, was kind of one of moving in new technology, and working with ... between engineer ... getting engineers and production people to work together.

Spicer: Right. Right. Yeah. Well, that's a wonderful way to end it. Thank you very much for that. And do you want to do this at the same time next week? Does that sound...?

Cherney: That's fine. Sure.

Spicer: Yeah? Let me see. Let me just check my schedule here. That would be next Wednesday. Yeah. That sounds good. So we'll just do it at the same time, and thanks again, Joe. This has been fantastic.

Cherney: Well, one last question.

Spicer: Yes.

Cherney: I have a number of items, and I'm... that I'm wondering if you would ... in the museum, do you actually display hardware?

Spicer: Oh, yes. Absolutely. Yeah, we have pieces of ENIAC on display, actually.

Cherney: Which panels do you have?

Spicer: There's a function table, and it's actually on load from the Smithsonian. So let me think. You know, I'm going to have to get back to you on that. I can't quite recall. But we have a whole display ... a whole gallery ... on ENIAC, actually, and I'll send you some pictures. You can have a look.

Cherney: Okay. Well, first is I've got some boards that were used in the VERDAN. I've got the schematic. I've got the drawings, but I assume that somebody's got the drawings.

Spicer: No, I don't think we do. We would love anything you want to donate. This is such an important chapter.

Cherney: But I also got involved in home computer. I've got a Macintosh.

Spicer: Good choice.

Cherney: It was the second Macintosh, but I've got an Osborne computer, so, as I said, what may happen is then if we get serious about some of the things that I have I may want to make a trip up and visit you. That's it. We'll see.

Spicer: Wonderful. We'd love to have you visit.

Cherney: But, as you can see, back when I was in analog stuff I got involved in IEEE, but I haven't quite found a place in the IEEE. I think we have a IEEE presentation on the reliability of the VERDAN years back, but, anyway, I'm extending it beyond the need, but that was just a thought.

Spicer: Oh yes. Anything from that era that you want to consider donating is just gold to us. It's fantastic stuff, and we would love to accept it, so please keep us in mind.

Cherney: Okay.

PART II:

Spicer: I think where we left things off you were still at Aberdeen of course, and I would like to ask you about the conversion of ENIAC to the stored program machine using the Burroughs memory. Could you talk about that?

Cherney: Yes. When I was on the EDVAC one of the engineers there was trying to convert a rotating magnetic drive drum, and they were planning on adding the drum to that. Homer Spence sent me on a trip to I believe it was RCA and MIT to look at the possibility of the core matrix memories that they had, and in both cases they were not ready to make the memories. One was discussing or really concentrating on how to address it, and the other one was concentrating on what's the core mix material for the unit. And so Homer then came back and said "I did get ahold of Burroughs business machine, and they said that they would build one, and they would use a magnetic wire that was wrapped and potted." So the specifications were set-up by Homer for that, which would be 100 lines of code. Now, the function tables had 104 lines of code, and they were 12 digits long with two signs, one for each six half. I'm pretty sure that this was designed on the basis of extrapolation so that one of the steps that they did was to go ahead and put in trajectories and then change a parameter and then extrapolate between the two of them. In this particular case we did a 10-digit number, so it would be 100 lines of code and 10 digits long with single sign. I didn't follow the progress too much on it, but then I was sent up to Philadelphia to the Burroughs company in order to review it, because they said they were ready to deliver it to us.

Spicer: What year would this be?

Cherney: This would be 19 ... I think it was '52 or '53, because I left ENIAC ... it was in '52 I'm pretty sure, because I had left ... I've got the date someplace, but it's important. And so I got from them what the interface requirements were, so they described the program to me, which was fine. I then asked them ... I said, "Are you sure that you can go ahead and drive our digit trays?" And they said, "I've gotten a measure of what the digit trays are. They are a 220 ohm resistor with an inductor on top and a 0.01 [microfarad] capacitor equivalent, and you have to drive that in one microsecond up to 10 microseconds." The reason I asked the question was because they told me that they were going to use a brand-new circuit. We were using cathode followers. They were going to use a circuit that was becoming popular in the digital world, which was a ... what you end up doing is driving a transformer, and then one section of the transformer was feedback, so you end up with positive feedback back, and it gives you very sharp signals, but they were using a miniature beam-powered tube that became popular in the radios at that particular time. I don't remember exactly what the make was, but it wasn't important. So they went back and came back and said "We'll have no problem driving it." Well, being a skeptic I went home, talked to a man by the name of Murphy. Murphy was my mechanic. He could get anything done. And I said "Okay, we've got to go ahead and set ... we're going to put it at this location. We need to go ahead and have cooling air, so you need to go ahead and hook up a pipe at the top of this unit" ... and I had the requirements for it ... "and hook that up to our air ducting system up above. The second thing, you need to go ahead and get the power," so we had the power there. And then I said "I don't think they can drive our 40-foot of tray."

Spicer: Wow.

Cherney: I said "Let's get a four-foot tray. That'll reach from their machine over to ours" and then built another shaper that we used, where we ended up being able to amplify the signals. It was 11 because 11 contacts in the tray, 10 digital decimals and one sign. And so we ended up then putting that four-foot tray over there and then hooked that up to one of these amplifiers to drive the rest of the 40-foot tray. It maybe wasn't quite 40, but it was in that range. And so then I went back and looked at the programming, how to program this. In the past the people who were the programmers went ahead and did this, but I had no problem in going ahead and understanding how the machine was programmed. What you end up doing is taking 12 decimal digits off of the function table or off of the relay unit, depending on whether you're running a write program or you're running a flash test. You then put it through a counter, which counts off six digit pairs, and then one at a time it'll send those to a cycling unit, which will go ahead and register those on a counter, which goes from zero to 99. And so all I had to do from this standpoint was to go ahead and duplicate exactly what we did for the other. I just went ahead and set-up an available ... we were only using about 60 positions on that particular 99 set, so I just ended up using the same basic one that was five add cycles. It would go through and decode that, and then it would give out a command, and so I ended up sending the command to the machine. There were three steps. The first one was to go ahead and send a command which would identify the address of the machine it was. Then the second command was to go ahead and tell it to read, and the third command would tell it to write, but I set-up those three commands and had those all set-up and fed the program signals over to the interface that they gave me from that standpoint. They brought the machine in on day one. By the end of day two we had it working and so forth, and on day three they actually were using it for programming purposes.

Spicer: Wow. That's excellent.

Cherney: But that was the planning ahead. Murphy asked me whether or not they were able to do it. I said "They barely got the four-foot." <laughs> But it worked out well, because we were able to pick up the signals from them and then re-amplify them, and it worked out really well.

Spicer: Now, this was using magnetic core, not thin film or anything else like...

Cherney: This was using magnetic core. I didn't go into the details on it, but they told me that they did have some problems. When they potted the core they changed the magnetic characteristics, a little bit longer, but from the literature that I've seen all the time I was there then, which was probably almost a year, everything worked fine. The programmers were pleased with it.

Spicer: Can you talk about how that changed the way the programmers did their job, being able to store the program in the ENIAC?

Cherney: Okay, yes. Initially all the programs were put in by switch setting on the function tables, and there were three function tables. Now, the programmer would go ahead and prepare the signal flow. He would prepare the commands. He would then run through a dry run with a desk calculator to make sure that it was doing the things that he wanted. They would then have that set-up, and they would be using the commands that the ENIAC would be using, so then what we would do ... they would call for help.

So usually six people came in, two per function table, and then they would go through and set the switches. Then some of the people used a small program for a sum check. Others did not. So for the first step the programmer would sit down and using the controls that we had, which was a cable coming down with a little control panel, you had the ability to run, stop, run one instruction, stop and then one pulse at a time, and these were done in the programmer channel, and so they would then step through the programs watching these things going through the same as they had done from a desk calculator standpoint. Then they would then go into productive runs, and only when they ran into problems would they call us technicians to come in, verify what they had done and then figure out ways in order to get the repair taken care of, which normally was watching what they did, secondly running the flash tests. If it was in the divider square-rooter, if we determined that it was, we would just go in the back panel, we'd find a filament out and we'd replace it. We never did much troubleshooting there, because it was just strictly a logic unit. If it was a marginal one in a accumulator we would identify which digit sets it was, and then we would go in there and mass-change tubes and get it back online as soon as possible. So now the fourth function table was brought about that I had mentioned, and on that they used plug wire, because plug wire had started to be used by business machines and so forth, where you ended up with just an array of a punchboard, and then you would push wires in to connect the different ones, and then you would place it into the function table and put it into home, so instead of the switch settings you now ended up with a 10 by 100 array of punch holes and you then were able to go in and identify that. There again the storage memory was the same as they had before. So this became the way that they had programmed it.

Now, when we ended up with the static memory there, they would put all of their programs from the relay. We went from the card reader to a transfer set of relays and then into a storage bank of relays, which used 1224 as the code, and so if you look at the master cycle it uses the 1224 code, so we didn't have to have 10 relays. We used coded decimals from that standpoint. They would then feed that anyplace they wanted in the machine. In this particular case if they wanted it done with a static memory they would then just use the commands to feed it into the static memory and the same way feeding it out. Now, the accumulator was set-up in such a way the central register was number 15, and so accumulator number 15 was the one that most of the commands would relay to. 01, for instance, was to transfer what's in accumulator number one to 15. Eleven was transfer what's in 15 to number one, clear and then transfer. They also had non-clear commands and so forth. So this was the approach they took. Now, because this new function table that had been added and designed by a drafted soldier that was there I used the same technology. I'd gone to the technology school in Pennsylvania that the designers of the transistors had conducted, so it was a two-week course, but it was clear at that particular time that we did not have available to us transistors, and these were transistors that used spring...

Spicer: Point contact.

Cherney: ...point contact, but this soldier had recognized the fact that during World War II they had come up with a diode that generally were used for detectors used a triode that would go ahead and get a one-way through the triode so we could decode signals from that standpoint. The diodes that we had were only 6A6 dual thermal diodes. Well, to try to put in that many diodes for isolation purposes in the ENIAC would've been totally impractical, but they later in the war came up with a copper oxide, and what they did was to cut down the capacitor effects they stacked them. They stacked quite a few of them in there, and now that particular diode then gave us conductivity in one direction and a high resistance in the other direction. So when he had a matrix of selectors he went ahead and used those diodes and cut the ... in the case of the function tables we used one mega-ohm resistors, so if you take one mega-ohm resistors and you've got 100 of those as the load you find out that it takes a high voltage on the input in order to get the best particular selection set, and with these diodes it was very simple. We just put a small voltage in, and it would be recognized, so this then became an approach. Well, he said "Okay, then I can go ahead and design a unit which will select a digit, and then it'll shift it from twin outputs." Well, the big problem with it was that since we had negative numbers as nines the big problem that came back was backfilling the nines if you did that. By using these diodes we're able to go ahead and backfill, so we now could go ahead and shift a positive number or a negative number, and we'd have the backfill for those. And the literature of ... some of the people I knew there had talked about it. They said that cut down the average shift problem from 30 add times to one add time, right, because I went ahead and programmed it in such a way that I took the command that they had and set-up the register, set it up so that the register within this little shifter would identify what shift they wanted, and then it would come out on two 10-digit channels or 11-digit channels counting sign. And sometimes they wanted to throw away the remainder, sometimes they wanted to save it, and so we had commands both ways, but it was very simple to just go ahead and do that, because it was just a matter of programming an accumulator to receive it.

So that was why this particular author, Barkley Fritz, had commented the fact that it added benefit because we had replaced engineers with technicians, which saved salary costs ... as an aside, I was kind of puzzled. They said they used six technicians on the ENIAC in the latter years. Well, at the time I was there we usually used just one person on each shift, so I couldn't quite reconcile the six, but secondly it ended up being that the static memory increased the ability to be able to go ahead and easily use solutions of one problem or one part of a problem into the next problem. They did not have to go ahead and punch it out on punch cards and then feed it back in, so we now ended up with a memory that could actually become readily available, one of the solutions.

Spicer: Did they frequently use subroutines and those kind of things in the static memory?

Cherney: Well, they did in all of the memories. In other words, initially they put those, quote, "subroutines" that they did for their problem ... they would program the punch wires. They then set-up a bunch of standard arithmetic type of subroutines and then kept in their actual programs with the switch settings their own selected subroutines, and now by putting them in the punch table during the course they had to change those by hand-change or they had to change those by punching out cords and feeding them back in, but now they could go ahead and set-up a routine, change it, repeat it, change it, repeat it all in the read-write memory, so it gave them tremendous flexibility now in order to do these kinds of things, which increased their efficiency tremendously. So the combination of these things, according to one of the articles that I saw, extended the use of the machine into 1955. One of the things that I was a little disappointed ... I sat down with Dr. Stern and was commenting on the status that we had. He was the director of the labs, and so I commented the fact that my objective was to go ahead and keep the machine working properly and let the people loaf. He said "No, no. Your objective is to keep the people busy regardless what the machine's doing." And I said "I'm not for civil service." <laughs> What he really meant I won't tell you. I have no idea, but what I understand is these were the objectives that we had from that standpoint, and I got a chance to talk to ... one of the questions that came back with ... a programmer ... he said "People are saying that the ENIAC is not a computer because it cannot make decisions." So the two of us worked together. He wrote the programs and I did the wiring in which we set it up in such a way that you would set-up the test program so it would flip the signal change, plus or minus. In other words, if it was a negative number or a positive number. I then went ahead and plugged it in such a way that if it came out positive, which ... you'd see an actual sign, it would flip the device, which ... remember I told you it was counting the number of commands and it would skip to the next memory to operate instead of that one. So we did demonstrate, though I'm not sure ... we didn't put it in permanently, but it was capable of doing that kind of thing...

Spicer: Like branches.

Cherney: Yeah.

Spicer: Taking branches in a program.

Cherney: Yeah, so that you could go ahead and branch the program based upon a test that you ran for it, and so there was no question that the ENIAC was a digital computer instead of a digital processor.

Spicer: Did the team do marginal checking on ENIAC?

Cherney: The answer is yes. What we would do ... the failures at the ENIAC retirement were predominantly end-of-life type failures where the vacuum tubes' signals would decrease. Now, when the signal decreased it could show up in weakened tubes in the receiving end. In other words, what happens is that we would take the 6L6s, and we were pulling them very, very heavily. They would give us a signal. Now, if that 6L6 would now reduce the amount of that signal that signal would go through a matrix of some kind. It would then come to a sensor, a 6AC7 or other tubes and it would go ahead and expected to get a half a volt signal, but if the input came down that half a volt may be a little lower, and if this particular tube was weakened so it didn't have the amplification capabilities that it did then you'd end up with a marginal error, an intermittent error. And so that's why once in a while if it looked like it was that kind of thing where it just failed once in a while I did on occasion get an oscilloscope, which was a very old oscilloscope, look at the line either on the driving line or on the back where we distributed the thing and move the load resistors in such a way that the accumulators which were having the difficulty got the stronger signals, and sometimes we could go ahead and continue operating. Our objective was to do whatever we had to do in order to get operating until Sunday.

Now, on Sunday what we would end up doing is peaking the repetition rate up to 125 KHz, and then we would troubleshoot the machine replacing tubes until we finally had the thing operating with the flash tests trouble-free at 125 KHz. Then when the programmer came in he would set it at 100 KHz, and as he ran into problems he would slowly move the frequency down, and if it got below 60 KHz it was turned back to the technicians in order to troubleshoot. Now, that's the way the margin was worked into the unit.

Spicer: Right. Kind of a frequency or clock rate margin.

Cherney: Right. Rub rate, yeah.

Spicer: Did you do power supply margining, or just look for weak tubes?

Cherney: No.

Spicer: Did you screen tubes before you used them?

Cherney: Yes, yes. They were screened primarily by the designers. They said "We want to cut down the number of tubes." Secondly, they went and looked for the most popular tubes, and I was familiar with them because during the Navy we were using the same tubes for radar and for radios. They then went ahead and ran life tests on them, over-stress, and they sent them out for examination in order to find out what the problem was, and mostly it was the oxide on the cathode, which'd either wear out or it made blocks that may go onto the grid, and so they ended up looking at it from that standpoint. They went ahead and operated at Pennsylvania troubleshooting every program down to the actual tube that was failing and confirmed what had caused it and so forth. When they finally delivered it to ... they were turning the power off and power on, because they then ended up with experience with what happens when you turn the DC off. Generally not too much. What happens when you turn the AC off? Then you get a lot of problems because the cooling down of the machine and then bring it back up was the problem. So when they put it into operation in 1949 they went ahead and said "No, we're going to go ahead and operate it seven days a week." Now, that was a serious decision, because we're talking in terms of 180 kilowatts of power and keeping it on all the time, so we ended up with that. Now, people were kidding us about the reliability of the machine, but they said "Well, we got the Bell relay machine downstairs. It's got multiple capabilities. It's got tapes." It was run by these punch-hole paper tapes, and if they run into a problem they ended up with another with a backup, and they would continue on, but they pointed out the fact that that particular machine, that tape machine, which was very reliable, operated for a week. The ENIAC could pick that up in two hours, <laughs> so the contrast that took place.

The second problem that they ended up with that Homer was worried about was the fact that it seemed like during business startup, six o'clock to eight o'clock, we end up with random errors that wouldn't repeat, and he was convinced that it was the spikes coming in from the line, because one of the things about a digital computer is when a spike comes in and it flips a relay or flips the tube's number everything goes to pot. In analog it degrades, but not in a digital computer then. Now, I ran into that same problem with the ENIAC when I was working with it, because we had put in the unit, the ENIAC, and we were using a disk magnetic memory, so we didn't have the jump of pickup heads and that kind of thing, and what it was was a disk that was within microinches of the oxide, but we put in a sensor to sense alpha particles. When the power supply ... when they got that it would trigger it off. If there's nothing more within two milliseconds they would go ahead and turn it back on.

Well, this became an indicator of fault, because what was happening was that the lines ... they would come in and trigger it, and over a period of time it triggered it in such a way they stored away the 30 or so critical ones, turned off the power, and then if nothing happened they went back, got the 30 or so critical ones, put them back in the registers and then moved on. It turned out to be the head of manufacturing in the missile system division asked me ... he says "How come you can't go ahead and design that so it doesn't give all that flak?" I said "That was put in in order to protect you." I said "Go look at your line and see how much there is static that's on it." And I said "Don't use one of those old Dumont oscilloscopes. Get a brand-new oscilloscope." Next time I saw him he says "Boy, you're right, is that dirty power," and then I think also in Minuteman II when we introduced mini circuits we used transistors and resistors in Minuteman I.

When we went to Minuteman II we went to mini-circuits. In other words, they were the kind of surface-mounted things that we could design on a drafting board, so everybody was doing that. Motorola had put out some, and others were putting out those kind of things, and they were sensitive to that power, because we'd moved down in power from five volt down to three volts, and so all of us had to go back and redo our power from that standpoint. So what Homer did was to go ahead and ... several years he told me he had tried ordering a motor generator with the idea in mind that the inertia in the motor generator would filter out the high peaks, and so then in I think it was '52 he said "I finally got it." So we installed a motor generator on the second floor ... we're on the third ... on the second floor in the same area as this relay machine was and hooked that up, and that seemed to cut out interruptions we had no problems while we were there of these kind of intermittents coming through, one of those things that it's hard to measure, and we had only one problem with the motor generator, and that was because as delivered the little exciter that they had on the end of the alternator end up with a bent shaft, so we finally had to get them to come in and replace the shaft, but otherwise nobody ever really worried too much about what that was, and it went on, and I think it improved the power tremendously.

Spicer: Do you have a sense for how much it cost to operate, either just the electricity alone or the whole operation with staffing and...

Cherney: Some of the literature does go ahead and go through those kind of estimates. I don't remember them too much, but what happened was that if you look at the across-the-line diagram for the AC they did go ahead and when they came to the critical power, which was into the DC power supply ... remember now when we talk about 160 kilowatts we're talking in terms of the power to go ahead and run the air conditioners. We're talking about everything that was necessary, all the lights. Air conditioning at that particular time was bad, so what we ended up doing then was enclose the ENIAC and then put in two self-standing air conditioners, which were room air conditioners. We air conditioned the room, and then on top of the ENIAC cabinets we had the platform, where we put in furnace fans in order to circulate the air and bring it from the floor on up past the tubes and out, and I don't know how much was put to the outside world and how much was just re-circulated within the room itself.

Secondly, they used magnetic regulators, saturable reactor regulators. What they ended up doing is ending up with a three-position transformer. In the center leg of that particular transformer they would put DC in it, so they would go ahead and decode the signal. If it was too high they would go ahead and saturate the transformer so it couldn't pass quite as much electricity, and if it was low they would go ahead and desaturate that thing and give you a better coupling, so it changed the coupling, but of course here we're talking in terms of milliseconds. We're not talking in terms of digital-type speeds and so forth, but that did pay off. And I did go through ... I started to ... running an analysis of the power. I think about 35 kilowatts, almost one-third of the power, was for filaments that we had. Secondly, for the DC regulation they did not have the regulators. If you're familiar with it, we first got radios with batteries. We then put in battery eliminators, but they still used the heavy transformers and the vacuum tubes and so forth, and then we went to AC/DC, where we went directly off the line using a current-limiting resistor and just rectified that and used it in the radios. This is in the '30s.

Spicer: What's the difference between a battery eliminator and a power supply?

Cherney: A battery eliminator is a power supply, and what it does is a battery eliminator ... the standard voltages that were required for the radios in those days was 150 volts for the plate...

Spicer: B-plus?

Cherney: B-plus. About 75 volts for the screen, minus 14 volts for the inputs, the grid, and then zero volts for the plate. Now, these could be modified. You could go ahead and put a resistor in the cathode, put the grid at zero and put a resistor in the cathode, and that would give you a negative voltage on that, and you could go ahead and use a dividing resistor to go down to the screen from that standpoint. So they had 45-volt batteries, 90-volt batteries that we used to go ahead and use on those radios, and then we had a six-volt battery, which was used for the filaments, and we also ended up with a minus-14-volt battery, but most of the people didn't use those. They could get them to operate without it. So they came out with battery eliminators. They generally would have one which was good for the DC voltage, the plus voltage, and then they'd use a battery for the filaments. My brother bought one of those back in that particular time which was a portable radio which ... we had to put a 45-volt battery in it and we had to put in a six-volt battery to operate it, but these came through.

Cars, what they ended up doing in order to get the high voltage was to put in a mechanical switch that would go ahead and go on-off and a chopper, and it would chop the flow that would make the DC electricity going through a transformer, and then we'd use it from that standpoint. In order to get voltage regulation we used gaseous breakdown diodes, and so it's the same thing as just a gaseous tube, so we ended up with generally about 60 volts from that standpoint. So those then became in our cars. It wasn't until we got to the transistor that we were able to get away from that mechanical mess, but, anyway, aboard ship I did end up with one officer who asked me to go ahead and try to solve the problem of the AC/DC radio, but all I could do is to give him a wire from there to ground.

So in the ENIAC we ended up using this approach. Now, one of the problems they had was since they had decided they were going to use direct coupled that they weren't sure that if they used capacitor coupled they would be able to hold one pulse at a time type of operation. They felt like the capacitor would discharge and you'd lose data, so they said "What we need to do then is to segment every circuit so we have the three voltages they require for the circuit, but we have to go ahead and then have enough power supplies so that we can go ahead and service it." So they ended up like 12 ... no, about 10 ... I could count ... about 10 filament levels. In other words, every tube was hooked up to a filament level, and they selected the signal that was available that was on the outside of the machine to go from zero to 50 volts, and everything was either [higher] than that or lower than that, and so they ended up then with the need for these multiple ones.

Well, instead of building a power supply for each one of those what they did was to go ahead and build 28 different power supplies, all the way from three-volt ... I mean three-phase high-powered ones to a 5U4 small vacuum tube power supply, and they put it on a ribbon bleeder, and then they would put the power supply where the power was needed. In other words, they would end up with one power supply at the top, and then down another tap they'd put another power supply, and all of those were geared for the amount of current that was coming out, so the bleeder ended up having probably used up more power than the vacuum tubes did for regulation purposes, and so that eliminated regulators.

Now, we didn't have much problems with the power supplies. At the time I was there I think we only ended up with maybe two or three occasions that the filter capacitors burned out. Now, we did have a machine. We could go ahead and we could take a one mega-ohm resistor and put, say, 500 volts on it down to an aluminum capacitor. I was looking for the word, and it would correct the capacitors, because what happened was what it does is to build up that interface between it, and if it fails that got broken, but we didn't have too much problems with that. That was there. Secondly, we did not have too much problem with the vacuum tubes. One of the things that the designers did was to make sure that they had them well within the ratings. They also made sure from a worst-case standpoint ... they said "You have to have margin between what the extremes are of the voltages," and this became one of the practical things that came in Minuteman and the others, is you say that it's capable of this. Now go ahead and cut it down to, say, 75 percent of that so that you make sure that if all of the tubes in a string were in a worst case they'd still come out right.

Spicer: I've heard of Eckert especially being very conservative and very clever with the way he achieved that. Can you comment about how his circuit designs were designed for absolute worst-case scenarios?

Cherney: I have some of the literature on that in my file, but the answer come back is during World War II we started to end up with designs of digital sensors, radiation, so we had the Geiger counter. So in the Geiger counter they started to come up with counting circuits. Well, in the Geiger counter generally you wanted to sense ... it was a matter of few and more and most, but it was not precision.

Spicer: Not calibrated.

Cherney: Yeah. So what he did was to go through a tremendous amount of design, both analytically and mechanically, in order to get a good, solid, stable ring. Now, if you think of a second you have two triodes. Now you have them hooked up in the standard way with a load resistor at the top, and now you've got them side-by-side. Now, what you end up doing is taking the output of number-two triode, positively feed it back to the input to number-one triode. You now take the positive signal of number-one triode, the plate, and feed it to the triode of the other plate. Now you end up with a situation of which both of them can't be that way, and the cathode's sort of hooked up in a common manner. So it's going to be one tube is on and two tube is off or two tube is on, one tube is off.

Spicer: A flip-flop.

Cherney: Yeah, and now you come through and disturb that balance, and it comes out with the fact that the one that's off has a better advantage to turn on than the other one, so we have a flip. Now, put multiple of those together and you've got a ring, and he did a lot of work of designing the ring to make sure...

Spicer: You mean connecting them serially.

Cherney: Connecting them...

Spicer: In series.

Cherney: Actually in parallel.

Spicer: Oh, okay.

Cherney: I think parallel would be better, because when he had all 20 of these triodes together only one could be on. All the rest of them were off. Now if you went ahead and forced that one that was on to go off then the next one would go on and the rest would be off, and you now end up with a counting ring, and it totally depends upon the balance of the circuits. In other words, if you ended up with a little resistance value it would tend to always go to that one when you disturbed it, because you weren't feeding it directly into the stage. What you're ending up doing is feeding it in, for instance, the cathode, which would then upset it, and then it would go to the next one. So he spent [a] tremendous amount of time coming up with a ring which could do that, and then that same design was used in the nine counter on the programming section of the accumulator, it was used in the 10 counter for other places, and it was used as a 20-stage counter in the signal generator, the one that set-up the 200 microsecond word time. That's the one I had discussed last time about repairing. So this became that then.

Now, in addition to that they did use some flip-flops, like in the places in order to go ahead and show what the status was of the different units, so it was based upon this. Now, the second thing was that he did a lot of work in order to find out exactly [about] a 6L6. Well, a 6Y6 is equivalent to a 6L6, but it's got a little more push power, but they were used interchangeably, and then he went back and, as I said, he picked out the five tubes. Now, what kind of tubes did he need? Well, he needed a power tube, which is 6L6. He needed a driver for that, which is the 6V6 driving the 6L6s into a cathode follower mode with a 220 ohm load. He then needed an amplifier stage, which would take a small signal. It'd come up and shape the signal properly, and then he ended up with multi-grid ones that could be used for logic purposes, so he used a five-grid tube for logic purposes. And then the 6SN7 being dual triodes was used for the signals there. Now, what they would do is to go ahead and hook up a gaseous indicator tube, like a neon, at each of these stages that were off and then one of them that was not so that the neon, which was on, would brighten up on the face of the accumulator and would indicate, and they used that as an indication of the value. Now, if you take zero and subtract one from it you now end up with nine all the way across, and a negative number's indicated on the side. If you add one to it, it goes back to zero. If you add one to that, then you get one with zeroes going all the way across and the sign showing as positive. So this became the logic that we're using within the machine itself, and, as I said, they ended up using multiplier counters in the logic in order to indicate the status of the program as it was going through. Now, we had no problems with the neons. They were very stable and so forth, though...

Spicer: Did you use sound at all to diagnose the system?

Cherney: We did not. My understanding from Homer and from some of the others ... that they did use sound as a signal in the ORDVAC. Now, that was the third machine they had. Now, that was on the Princeton principle, which they ended up with ... it was the ILLIAC-type equivalent, but what they ended up doing is having parallel registers like we talked about. To transfer from one to the other they would lower the common signal, and then based upon the analog sum of those particular one they would decide what the addition or subtraction was between these two parallel ones. So in at least the version that I had understood with the Princeton machine they were using an analog gatherer. Now, the second thing, Homer then wanted to get me on the machine, because he wanted to go down with them in order to go ahead and get them to quit trying to troubleshoot the exact tube. Now, they also used wiring. That was the age in which point-to-point wiring came in. Remember, we used cable wiring in the ENIAC, we used cable wiring in the EDVAC, <phone rings> but now they were using point-to-point wiring in that machine. Now...

Spicer: Do you need to get that?

<non-interview conversation>

Spicer: It's basically 11 o'clock anyway. Do you want to just close for the day and leave it at this point? We can pick up in January.

Cherney: Okay. Yeah, I think it'd be a good idea.

Spicer: Okay. This has been just wonderful, and we got lots of great stuff today, so thank you very much for that.

Cherney: Okay. Now, I am interested in your museum. Right now I'm making temporary plans to maybe come and visit you in the Easter vacation.

Spicer: Fantastic.

Cherney: My daughter's going to be free, my son is kind of interested in coming, so we'll see what happens, but I'll work with you.

Spicer: Great.

Cherney: But when I was aboard ship we were over in the Mediterranean area, and the operators would call down and said "Would you go ahead and set-up your 200 watt transmitters at such-and-such a frequency?" We would. And then they'd say "Would you change it this?" We would. And finally we ended up they said "Fine." Well, anytime we lost power what happened was the Teletypes in Washington, DC, started to clatter, and they said "Keep those on in order to stop the machine from clattering, because if they start to clatter they'll turn them off." So, secondly, we ended up then with modulation. We were using audio signal modulation, so I was setting-up machines so that you'd end up with something like 1,000 cycles and then 5,000 cycles, and now you would go ahead and use that as a binary-type thing in order to run these machines, the Teletypes. Now, I have a Teletype machine, and in fact I used it as my first machine on my first home computer input/output, and I do have ... I have not used it, but it was given to me by a friend who was a ham radio [operator], and it is a electronic tube pattern that goes ahead and could receive these signals from other hams and make the telenet work. The question that come back is "Are you interested in that teletype one or the electronic panel? Do you have it?"

Spicer: So that sounds like an RTTY. Is that right?

Cherney: It's an RTTY.

Spicer: Yeah.

Cherney: RTTY.

Spicer: Okay. I don't think we have one in the collection. Could you maybe send me a photograph and the model number and manufacturer?

Cherney: Yeah. Sometime in the future I'll do that.

Spicer: Yeah, but potentially yes, we are interested. We do have a lot of teletypes, the ASR-33 style, but...

Cherney: I tried to find out exactly what the model on this one was, but I don't know. It may not be in that good of shape, but it still works, and what I ended up doing was building a relay return box so that you can go ahead and type on it by itself. In other words, you can type on it, and it feeds it out, but there again I have no qualms one way or the other. It's available, so I just thought "Okay." We can talk more about it.

Spicer: Yeah, that sounds good. It would be great to get a picture of you beside our ENIAC, an old friend.

Cherney: <laughs> Yeah. Yeah. It would be nice to have been able to get something from the ENIAC, but then they weren't giving that away to people like me and so forth. <laughs>

Spicer: Right, right. Well, thanks again, Joe, and let's connect again in the New Year.

Cherney: One last question. I did send you a email whether you've seen it or not apologizing for not being able to describe very well how the ENIAC worked.

Spicer: Oh, you did a good job, and I did see all those references, so thank you. I'll be pursuing those.

Cherney: Yeah. So I've got copies if you need to have me send them to you. I've actually copied them on a copier machine and put them on a CD, DVD, but, anyway, I just was curious, so that's good. Then you've got that in order to go back for. Secondly, the last thing I'd say is that we haven't talked about the ENIAC, but there has been a face interview on the ENIAC ... I'm sorry ... the VERDAN computer, and it was done by people back in Washington that were doing that particular thing. If you're interested I can give you the reference to that.

Spicer: Very much so. In fact, you might remember the Ballistic Research Labs digital survey document. We actually have that online. It's scanned. I can send you a link if you like. And I looked up the VERDAN, and they mentioned a VERDAN II, so I don't know if there was a I, but...

Cherney: That would be the II.

Spicer: ...I would love to hear more about that. Let's definitely do that. We've spent two hours just covering your ENIAC work, so we've got a ways to go if you're still up for it. <laughs>

Cherney: Oh yeah. Now, one additional thing. As I told you, I kind of got moved from program to program, so we had designed a field artillery computer, the FADAC, and we had gone through all of the field trials and so forth with the FADAC, and that used similar memory to the RECOMP computer, which was a commercial computer that Autonetics had put out. When we got to the production they had put me in charge of the FADAC computer for the production computer, and so I worked with the Frankford [???] Arsenal back in those days on the FADAC computer to go into production. Now, the standard practice at that time was to go ahead and give the developer one production contract, but according to the man that I was working with in Philadelphia ... he said they were threatened, that their practice was they would do one-third research, they would do one-third development and one-third production within the Army, and the rest would go to contractors, but he said that they were talking about shutting down some of the arsenals, and so as a consequence they were going to go ahead and put out the first production bid for competitive. Well, we were kind of at a disadvantage, because we'd been through all of this high development for reliable type of components, and another company that had went ahead, and they didn't have our technology for the memory, nor did they have our technology for the resistors, but they had a price we couldn't match, so they got the contract. It's interesting. Almost two years later or three years later they called me up and asked me some questions about how in the world to get the FADAC working, but I'd gone over to England and I'd gone to other places to see if there was interest in us building it for them, but their comment came back was "No, we need the United States ... the arsenal to go ahead and give us that information," you know, programs that they developed and everything, but, anyway, the FADAC if you go on the Web site is a beautiful machine that is really paying off in the field with what it did as soon as they got to the field. What it did was to give the capabilities of a good first shot, and as the Web emphasizes, as we've emphasized, the first shot is the only surprise shot. All the rest of them are ... but, anyway, that's enough.

Spicer: Okay, well, have a wonderful holiday. Merry Christmas to you, Joe.

Cherney: Yeah, merry Christmas to you.

END OF INTERVIEW

