Oral History of Robert Everett

Interviewed by:
Gardner Hendrie

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Gardner Hendrie: We have with us today Bob Everett who has graciously agreed to do an oral history for the Computer History Museum. Thank you very much for taking the time to do this Bob.

Robert Everett: Thank you very much for asking me.

Hendrie: One thing would be good to get on the record. Do you remember whether you have done any other oral histories? Any come to mind when other people have done this just so a researcher might have a chance to go find it if he wanted to?

Everett: MIT [Massachusetts Institute of Technology] did. A well-known professor, whose name I can't remember, did an oral history, which was not a video history but just...

Hendrie: Just on audio?

Everett: Yes. And MITRE [Corporation] did a couple of video histories of the early days at MITRE, which I don't know what ever happened to them.

Hendrie: All right, good. Let's start with the chronological part of the interview. Maybe you could tell us a little bit about where you were born, a little bit about your family, siblings, what the environment was like when you were just young and just growing up.

Everett: Well, I was born in Yonkers, New York where my father and mother and older brother lived. And my father was a civil engineer, waterworks. He graduated from Dartmouth in 1906, and he was a very successful professional civil engineer. Among the places he worked for are Cambridge, and Portland, Maine, and Springfield, and Des Moines, Iowa and Bogota, Columbia and places like that. So I grew up expecting to be an engineer. And, you know, on weekends his amusement was to drive over to one of the places where he was the engineer and see how things were progressing. And I went with him and look at all that machinery and everything. So my rebellion was to be an electrical engineer and not a civil engineer. It's in some ways amazing because he had a heart attack, and in those days, you stopped work when you had a heart attack. This was back in the 1930s. And he said he would keep his professional organization going for me if I wanted to be a civil engineer, and I said, "No thanks, I think I'll be an electrical engineer." Which I now look back on with amazement. So my schooling was rather mixed. I went to public school for a couple of years, skipped a grade, and then my brother went very sick with pneumonia and various complications. He'd stay home. But if I went to school, I'd come back with a cold and he'd get a cold and he'd very ill. So for…

Hendrie: About what age was this would you say?

Everett: This was about third or fourth grade. So for three years we had tutors at home. And then went to small – I went to six different private schools, or five of them and one public school, in the next six years. One a year.

Hendrie: Is that because your parents were dissatisfied with them or you didn't like them or what kinds of things caused the...

Everett: Well, we went to a small private school in Bronxville. By this time since I'd skipped a grade, my brother was only a year older than I, we were in the same grade. And that didn't turn out too well. So my father sent us to Riverdale, which was a big well-known school in New York. And the next year and he still had problems. And so the following year, he went, we went to Florida, actually went to, spent the winter in Sarasota. He stayed in New York and worked and we, my mother and the two of us, were in Sarasota. Went to a private school, and that next year we tried again to say home in Yonkers. Went to the public high school. I gave up and went back to Florida. Coconut Grove first, The Gulliver School and then that following year to Coral Gables and then I went to another, very small school, which it turns out one of my daughters-in-law went to. So…

Hendrie: How did you feel about, or looking back, obviously there's some, there are problems in making long lasting close friendships if you're only in school for one year?

Everett: That's true. There's social disadvantages, but as far as learning it, you know, it's all in the books anyway so. Actually I probably learned more this way because, for instance, a small private school we went to <bell ringing> when I was a senior, my brother went to a different school, there were two teachers: one was a history teacher, and one was an English teacher. And when it came to mathematics neither one of them knew much about it. So I used to help the teacher prepare for the class for the other children.

Hendrie: Oh, that's great.

Everett: And there's no way to learn, but it's better than teaching.

Hendrie: Exactly. Because you have to explain it to somebody, that's really hard.

Everett: That's right. You can't just say well I answered so and so. So then I went to Duke.

Hendrie: Well could I just roll back? I want wanted ask about, now your brother what did he end up doing just so I have a little bit of perspective?

Everett: Well not very much. He went to photography school, and he did photography. And then the war started. The war started in 1941, you know, while I was still in school, and he worked over in New London at one of the, my family lived in <inaudible name of town> by that time in Connecticut. And he worked at one of the laboratories over there, and then he did, he studied accounting after the war and did various bookkeeping jobs and accounting jobs for people. And so then his wife got very sick, and he had a very troublesome life. So she finally died, and then he died about ten years ago.

Hendrie: Oh, my goodness.

Everett: So, I was the lucky one.

Hendrie: Yes sort of a sad story. Okay. Well let me, when you were in these, all these different schools, do you remember when you did…when you called your rebellion, called not civil, “I’m going to be an engineer but not civil, electrical,” and why you picked that as opposed to mechanical engineering or chemical engineer? I mean, there are lots of engineering fields.

Everett: There are lots of engineering fields. But I was interested in electronic, electrical, and it seemed to me that it was the future for real electrical engineers was very great. And although my father was a civil engineer, he knew of all kinds of engineering. That was when he went to school, you know, there really was only one kind; well there were two kinds, military engineering and civil engineering. And so he did things; he built radios and wired up things, designed stuff and control systems for filter plants and things. And I found that fascinating, so I decided to go in that direction.

Hendrie: All right. So you had some exposure in home through you father in what he did in electrical engineering? And didn’t pull the idea out of…

Everett: Yes, there were engineering magazines and things in the house, and as I say he took me around and visited the things he was working on, which I found fascinating. And he had a shop in the basement, and he could make anything. He was a remarkable man. And I’d go down and sit on a stool and watch him work.

Hendrie: So he was clearly the significant role model for you…

Everett: Yes, he was.

Hendrie: …as opposed to some people have a role model as a teacher in their scholastic…

Everett: No, he was the role model for me.

Hendrie: All right.

Everett: I still remember one – I don’t know how old I was, ten or twelve or something – and when he was working, he use to talk about his problems at work and his design problems and things of that sort, you know. And I was just an audience, you know. And one day he was describing a problem, and I popped up with a solution. I remember how astonished he was. <laughs>

Hendrie: Really? Oh, that's good.

Everett: Yes. My father was a great man.

Hendrie: Yes. Now did you get involved in amateur radio or any particular area of electronics or as a hobby?

Everett: No, I never did.

Hendrie: Okay.

Everett: No.

Hendrie: Now when it came time to graduate, what high school did you actually graduate from?

Everett: This little high school in Coral Gables. My God, I can't remember the name, but it might pop up.

Hendrie: Okay.

Everett: It had ten students in the high school.

Hendrie: In the whole high school?

Everett: There were two seniors, myself and then a young lady. And towards the end of the year, the head mistress called me in and with some embarrassment she said that Lois, was the girl, had spoken to her and was concerned that if the two of us graduated together it would look too much like our wedding. And she asked if I would mind not going to the graduation. And I said of course, I wouldn't mind. <Laughter>

Hendrie: Good.

Everett: It's funny that that was my graduation from high school. My graduation from college, that was 1942, the war was on, and they speeded up the engineers by a month to get them out and get them doing something useful. So I went home, and I wasn't going to go back to North Carolina for the graduation. So I didn't go to my Duke graduation. And then the next year was MIT graduation, and the war was on and they didn't do anything particularly for the graduation. So I went through my educational career without going to any graduations. <laughs>

Hendrie: Very good, very good. Well now when you're about to graduate for high school, what schools did you consider going to? Did you just apply to Duke or...

Everett: I was suffering at the time from sinus problems, and the doctor said it would probably be a good idea to go to a school in the South, and Duke seemed the best opportunity in the South. And, of course, with this checkered career, I had to take a lot of SATs and things. But really anybody who can pay his way could probably get in anywhere that was those days. It was 1938, and there's still a depression going on. So I only applied to Duke, and I got accepted.

Hendrie: Good. So now when you got to Duke what did you…you knew you were going to be an engineer. What kinds of courses…did you have to specialize in electrical engineering, or was the course load give you some electronics and some power, all the different kinds of…

Everett: Well the program was fixed essentially. There were two electives in four years. In the freshman year you had a choice between religion and economics. So everybody took economics. And in my senior year you had an electric election but the, they were going to stop the class a month early. So you could only take a course in the engineering school. So there really was not much choice. It was basically power engineering but, you know, the mathematics and AC/DC theory and stuff like; it's almost standard. There was one two-hour course in electronics which was taught in the physics department.

Hendrie: Wow, okay.

Everett: And there were no graduate students at Duke at that time. There were about 200 in the, well about 200, in the graduating, in the total school of students. And there were ten electrical engineering students in the class.

Hendrie: All right. So it was a very small, small class.

Everett: Yes, and when I got to MIT, you know, they sort of looked down their nose at me that I had gone to this small school. But I rapidly discovered I knew as much as anybody else.

Hendrie: All right. Now did you decide to, when did you decide you wanted to go on and get a master's degree and tell me a little bit about that sort of decision process?

Everett: I was, in the spring of senior year, it was customary to interview with people who came around for students or look for graduates. And a well-known man, whose name again I can't remember, who was a famous recruiter for General Electric, and MIT had a 6A program which you alternated semesters at a company and at MIT and took five years or something to get a, and it went all year round and it took five years to get a bachelor's. And he said I was a very good student at the top of my class, and he said I should go on and get a degree, a higher degree. So he said that GE would take me on in a 6A. So I never thought of going to…a bachelor's degree seemed like quite a lot to me. But, you know. I talked it over with my father, and we agreed it was a good thing. So I went to MIT and of course, the war was on, and so I never did get to GE. The first term I went to MIT and by that time I was working in the labs at MIT and never did get to GE.

Hendrie: That part never came to pass.

Everett: Never happened.

Hendrie: And you didn't actually apply to any place other than MIT?

Everett: No.

Hendrie: This was the program and sounded good so you went…

Everett: That's right.

Hendrie: …and did it. All right.

Everett: Never regretted it.

Hendrie: I'm just going to pause for a second. Now when you got to MIT, what was the program there to get a master's degree? What did you do at MIT? What courses did you take?

Everett: We started out taking, at that time, the summer session consisted of two six-week sessions. And so ordinarily I would have taken three courses I guess or subjects. And but the MIT people, fearful of my supposed inadequate instruction in my bachelor's degree, advised me to take only two subjects. So I took only two subjects the first six weeks, and I didn't have anything to do. You know, you're going to class two hours a day and doing homework for a couple hours a day and then go home every weekend. And by the end of the term, the pressure was on, and they told me that if I didn't want to go to work in the labs at MIT that I would undoubtedly be drafted. So I said, "Of course I would love to go to work in the labs." And Jay Forrester interviewed me and hired me as a graduate student in the servo lab where he was working. So I went to work for Jay.

Hendrie: That's how that association started.

Everett: And I was able to finish my – I was supposedly working half-time at the lab – and the next year I finished my master's degree and went to work full-time. Half-time was funny because we were paid 75 cents an hour, and us graduate students were bringing, you know, 30, 40, even more hours a week. And

Gordon Brown called us in and said, “Look fellows, the Institute is complaining. You’re supposed to be on half-time and here you are working 40 hours a week.

Hendrie: You’re using too much money.

Everett: We were making $30 a week and more. And so he said, “I don’t care how much time you work. Work as much time as you want, just put in only 20 hours.” So we kept on working 40 hours a week, but everybody was paid 20 hours. <laughter>

Hendrie: That doesn’t seem exactly right.

Everett: Oh, I thought that it was a very sensible position on his part. He didn’t want to interfere with our work; he just wanted to get the Institute off his back.

Hendrie: So when you originally went to MIT you, the draft was not, I was going to ask about the draft, and you indicated that that wasn’t particularly a problem.

Everett: It wasn’t a problem with me; I was young. I was actually, well, I turned 21 just after I graduated. But by the time the summer came along and I was 21; I was grist for the mill. And during my time at MIT, there were occasional flurries of being put in 1A and one thing or another. Now Jay was working on – he wasn’t working on an electronic program; he was working on a servo program. This was in the servo lab, which was run by Gordon Brown. And the particular program he was working on was a stabilized mount for search radar for ships. Ships roll and pitch, and so if you had a fixed antenna, sometimes it would be looking down in the water and sometimes looking up at the sky. So they, the early search units had a very high, narrow beam, this way, and a very wide beam vertically. So as they moved, they still could see ships on it. So this was a stabilized mount, hydraulic servos, and that’s what we worked on during the war. And it was put into production by Westinghouse Air Brake in the spring. And just going into, just starting to come off the line when the war was over, and it was stopped like everything else. So our efforts during this time resulted in two sets that went on two of the big carriers, but were eventually replaced by standard units.

Hendrie: I see.

Everett: But I learned a lot.

Hendrie: Yes. Was this, what kinds of work did you do on this project? Were you – sort of an area that you worked on or did you work on the mathematical calculations or the...

Everett: No I worked covered in servo oil in the lab on the servo pumps and motors and the control mechanisms, which were also hydraulic. About the only electrical things were selsyn motors, which were part of the system. So that's my career in the war.

Hendrie: Okay. Did you ever get a chance to go on any ships or to actually see this in action?

Everett: Well, the only ship I went on was the Lighthouse in Portland, which had one of these on it, one of the prototypes we'd built. And Raytheon provided the radar. So, this thing was sick, and so one of the Raytheon service guys and I went up to the ship in Portland Harbor. I had to change this drive…the servos, and he worked on the electronics.

Hendrie: But this was testing it on a light ship, which, of course, bounces around a fair amount too.

Everett: Yes.

Hendrie: Okay. Good. So what happens next? What do you do next? The project is done?

Everett: Well, it was still going on but, you know, it's the end of production so we…

Hendrie: Yes, it isn't a full time job.

Everett: Yes. So I've forgotten, I guess, the details of just how it came about, but Jay and Gordon Brown got mixed up in this business of building an airplane stability control analyzer. That was one of things that were subject to great development during the war. And Luis de Florez who ran the special devices center in the Navy, built a lot of these simulators and among them were aircraft simulators. Now they were…they had a cockpit, usually a fixed cockpit. And then there was an array of servos of one sort and another, and vacuum tubes, and flashing gas tubes, which approximated the equations for what the airplane would do based on what you did with the controls. And somebody had the bright idea that if you built a much more accurate computer for it that you could build a simulator which would simulate an airplane that had not yet been built or at worst a modified airplane. See, they set all the controls on these things to make them act pretty much like the airplane. But it was quite a step to ask for you to build a simulator that was good enough so that you could evaluate the air flush performance. But this was the idea. So we got involved in that, and the problem was how to build this computer. And we started out to build an analog computer with ball disk integrators and similar things and gears and whatnot and…

Hendrie: With a lot of mechanical parts, a mechanical analog computer, not an electronic one?

Everett: Not really, not an electronic one. Although these things were all connected together by wires and with little motors and things running things. And there were two problems, one is that you had to change it to fit different kinds of aerodynamics and whatnot. So it had to be a much more flexible device, the other,

other, one of the other problems was a matter of the dynamic range of these things. So Jay went to a meeting of some people, where he was encouraged to go by a friend of his from when he was in school, and he came back all excited about the possibilities of using digital electronics.

Hendrie: Do you remember what the meeting was or where it was?

Everett: I didn't go, and I don't remember. He would remember, but I don't.

Hendrie: Okay.

Everett: There's something about it I think in the recent *Technology Review*. There's a page about Jay and his getting started.

Hendrie: All right.

Everett: Anyway so we started in <inaudible> to build a digital computer and this was right back in the beginning. At this time the ENIAC [Electronic Numerical Integrator and Computer] was just about running. Now that was a very different machine.

Hendrie: And this is maybe 1946 or something like that?

Everett: Yes, yes, 1945.

Hendrie: 1945. Okay.

Everett: And it demonstrated you could put together a lot of vacuum tubes and make something work. So it turned out there were a number of people working on digital, electronic digital computers in the country. And in fact, in England, and in fact, the English had built some things along that line, which were too highly classified for anybody to know about. So our special problem was that based on its intent for this simulator, it had to be a real-time machine, which required it the high speed and high reliability because the idea was that if you were building a number cruncher and it made a mistake you back up and start over. But you can't do that when you're running a simulator or we rapidly started thinking about digital computer control systems. And so it had to be highly reliable; it had to be very fast. So it turned out to be a different machine from all the other ones being worked on. So we worked on that and then in the course this the airplane's stability control analyzer went away. And Whirlwind was intended as a prototype. It was only 16-bits long, but we found out many, many useful things you could do with that. So we gradually built it. The biggest problem was the memory, which we had a storage tube that was developed in the lab to Jay's ideas, and it was a real problem. A problem of maintenance, a problem of cost and life, problems of performance, like the time it takes to store and recover.

Hendrie: Well before we get into, further into that story, that particular piece of the story, I was wondering whether when you're thinking about building this digital computer, how much contact did you have with some of the other people? Did you go, there was a famous conference in Philadelphia in 1946, that some people from England came and talked at, with people doing EDVAC [Electronic Discrete Variable Automatic Computer] talked at, Von Neumann was there. Did either you or Jay go to that or…I'm trying to understand how you learned whatever you learned about…

Everett: Good question.

Hendrie: …building a digital computer before you said, "Okay that's what there is to know. Now we got to figure everything else out ourselves."

Everett: Oh, of course, oh we had to go and find out what everybody, what anybody knew. And that was a famous conference and Jay and I went at first. He stayed a week I think and then went back. I stayed two weeks. And then we sent, the thing lasted eight weeks I believe, and we sent several other people to cover the rest of it. And we made a set of notes of our own notes and then a set of notes came out from the meetings. So that was a very good way to learn what everybody was doing. It was a fascinating experience.

Hendrie: Did you ever go to Princeton and see the...

Everett: Oh yes, we went to Princeton and saw Rajchman and those people.

Hendrie: Did you see the people doing the IAS [Institute for Advanced Studies] machine at Princeton?

Everett: Yes.

Hendrie: Okay.

Everett: Yes, everybody went and saw everybody.

Hendrie: So you went, basically went and saw it, picked everybody's brain.

Everett: It was a small community. I mean about everybody who was working on digital computers could get in one room. <laughs> And there was a fellow named Alexander who worked for the National, what's now…

Hendrie: Bureau of Standards.

Everett: …Bureau of Standards. And he use to travel around regularly and visit all the places, and he'd kind of carried the story, you know. He'd come in, and he'd tell you what everybody was doing. And you'd tell him what you were doing, and he'd go out there and carry it around

Hendrie: Then he'd go around and be back in another three months.

Everett: And Von Neumann used to come around once in a while and talk to us. He talked to everybody. So and then everybody would get together once in a while.

Hendrie: Okay and just share experiences.

Everett: Yes. We use to say that the only thing that everybody in the business agreed on was the use of Allen-Bradley resisters. They didn't agree about anything else. <laughter>

Hendrie: Everybody was going their own way.

Everett: Everybody was doing their own things.

Hendrie: That is funny. In terms of working on sort of the basic block diagram, the basic organization of the machine, what were some of the alternatives? How did you sort of narrow down to the specifications of what you eventually, in block diagram, of what you eventually built?

Everett: Well, we started out thinking we would build a serial machine, but we rapidly discovered we couldn't get the performance that we needed. So we had to build a parallel machine. And I did the block diagrams for Whirlwind. I sort of sat down and did it, you know.

Hendrie: Yes, you just said "Well…" and the decision had been made that 16-bits was a long enough word for a lot of the arithmetic and a long enough word for the instructions.

Everett: It was long enough for the instruction. It was enough for five, 32 instructions and 2K addresses in memory. And we did enough programming and just figured you could do a lot with that. I used to say that the 16 wasn't two to the fourth; it was the sum of two prime numbers. <laughter>

Hendrie: I like that. Yes, very good. So you just made some basic and then plowed ahead and figured out what you had to do.

Everett: Yes, we wrote a report, R127 I think it was. There's a copy of it in there someplace.

Hendrie: Oh, really?

Everett: Which was, it was in two volumes: one was a volume of drawings, sketches and plans for the machine, and the other was a volume of words that went with it. So you could read the book while you were looking at the plans. And that was done in 1947. And so then, you know, there were a number…you had the problem of whether you're going to use a lot of gates. Whirlwind was done a really quite straightforward business, flip-flops with gates on them and things passed around. And so then we started building things. Other people did the circuit design, I never did any circuit design.

Hendrie: Did you build prototypes of gates and the different modules in house?

Everett: Oh yes.

Hendrie: And then did you actually build the assemblies when they were lots of repetitive things I would think in arithmetic…

Everett: No, they were subbed out

Hendrie: Those were subbed out. So you'd build one and get a design that you could specify to somebody else and let them do the work of building it.

Everett: Yes. You've seen pieces of Whirlwind I assume.

Hendrie: Yes, I have.

Everett: And you know how it is with design, there are all kinds of problems that crop up, and you have to find solutions to them.

Hendrie: Absolutely.

Everett: And I sort of worked on almost everything, depending what was going on.

Hendrie: Yes, what needed to be done.

Everett: Yes, what needed to be done.

Hendrie: The electrostatic storage tubes: what led to the decision to actually sort of design your own? Hadn't Williams in England used just regular cathode ray tubes?

Everett: Yes. I think the reason was, and I think this was primarily Jay's decision, the tubes we used had a flood gun, which held the picture on the face of the tube, and you could select and erase and so on with the regular gun.

Hendrie: With the regular beam. Yes.

Everett: Yes. And this enabled you to…essentially the thing was permanently stored because the flood gun would keep the storage, the picture fixed.

Hendrie: Oh, so it avoided the problem of…

Everett: Of restoring.

Hendrie: Of refresh.

Everett: Refresh.

Hendrie: Using the beam.

Everett: Yes.

Hendrie: Okay.

Everett: Now then the storage tubes were known. They were developed for radar use for…

Hendrie: Yes, with the long persistence phosphors.

Everett: Yes. And the problem was that, once again, if it were serial then the refresh rate wasn't too bad because you could read a line. And if there were 32 lines on the thing it only had to go back and refresh it once and a while. But once again, then you had a slow machine. If you wanted to do it in parallel, then each of these individual dots had to be maintained. And so you had to find out, had to go back and refresh them at a rate, which was determined by what pictures, what you were actually doing with the tube. We were in, as I remember it, I think it was IAS.

Hendrie: Can I interrupt you just for a second? Just remember that thought. I need to change tapes.

Everett: Yes.

END OF TAPE ONE

Hendrie: All right.

Everett: As I say, we were, I think it was IAS, but it might have been RCA. And the fellows there had just come back from England where they had talked to Williams. And they had set up a Williams tube, and it was a parallel. And, so I remember looking at it and saying, "Well, the problem is how many times you can write a round of spot without destroying it, and that'll tell you how often you have to refresh." And they went out and tried it. And it turned out it could read or write around the spot, maybe somewhere between eight and sixty-four times. As far as I know, nobody ever improved that estimate. <laughs>

Hendrie: Wow. Okay.

Everett: So, now if you've got 1024 on the thing, and you don't know where you…if you do it eight times, you may destroy something; you've got to refresh every eighth time, and then they have to refresh the whole thing and you've only read eight. Anyway.

Hendrie: Becomes a monumental task.

Everett: It becomes a....

Hendrie: Yes. Doesn't work.

Everett: …a breaker. Anyway, so, we decided not to go that way. We were already working on the other two. And we made them work, but it was a Herculean effort.

Hendrie: Okay. Now, Rajchman at the time was working on his Selectron?

Everett: That's right.

Hendrie: Did you ever consider using that? No.

Everett: No. I'm not sure he ever got it to work properly.

Hendrie: You were suspicious about that.

Everett: Yes. It didn't seem right. And we were more enthusiastic about our storage tube than was warranted. <laughter>

Hendrie: Okay. So the combination of the two things makes it...

Everett: The whole thing was, you know, you read about the Russian system. And the Russian system, to get anything done, they had to get the people above them to agree. In fact, they practically had to go all the way up to Stalin. And they'd end up with one or maybe at most two groups, and they had a fixed schedule, and they had a fixed price, and they had a fixed sign. And you know, the United States, there were a half dozen of these guys who were all doing something different. And the amazing thing that essentially all of them got a working computer out of it.

Hendrie: Got it to work right.

Everett: Yes.

Hendrie: Well, Johnniac even got Selectrons to work.

Everett: Yes.

Hendrie: Okay. All right.

Everett: It was a great experience. It really was.

Hendrie: Besides the memory problem, what were some of the other problems that you had to deal with in just getting either design problems or just implementation problems that caused you trouble?

Everett: Well, there was a great worry about tubes and tube life. Tubes were supposed to only have a life of a few hundred hours. And if there are thousands of them in the machine, you have the people making estimates that you have to replace a tube every couple of minutes or something. That was impossible. And we, not me, but our group discovered that the problem was a buildup of a layer in the source, in the tube.

Hendrie: Yes, on the cathode?

Everett: In the cathode. And once that got fixed, these tubes lasted a very long time.

Hendrie: How did they fix that?

Everett: Well, they put their cathode together different ways, different – they were coated, the cathodes. They were metal cathodes with coats, proper coat on. You just changed the coat, and the material, the base material, and you could get something...

Hendrie: You get it, yes; it was a material problem.

Everett: It was a material problem.

Hendrie: You needed to get fixed, and so you worked with the manufacturers of the tubes.

Everett: That's right.

Hendrie: Okay.

Everett: And they made special tubes for us. They cost, I don't know, several dollars a piece as opposed to 30 cents or something. <laughter>

Hendrie: But they were worth it.

Everett: Yes. And the other thing was the intermittent trailers. So, Jay invented marginal checking. Really what this was, if you had the field in which you're plotting voltages and repetition rates and things, if the spot you found where it would work all right was surrounded by a very narrow area of working so that as it drifted any way, it would drift into an area where it wouldn't function. First of all, you should design the thing to have as much space around it as possible. The second thing is that by changing usually the screen voltage, you could move the spot over, and you could find out whether you had enough space around it for it to work properly and to get rid of the tube if it started to drift over to one side when you – as you discovered that it was drifting too much out of the way. And you'd replace that tube before it failed. And this had a very, very positive effect. So, we had failure rates of vacuum tubes being measured in hundreds of thousands of hours.

Hendrie: Okay. Through fixing the cathode problem and then do marginal checking, so you didn't get failures while operating. Good.

Everett: Well, and just an endless number of things like that. We had to build our own test equipment, for instance. Nobody built test equipment for us. They had synchroscopes that were used for the radar business. They could be modified for looking at these pulse range and so on.

Hendrie: So there weren't really any commercial oscilloscopes because there wasn't any electronics?

Everett: There were some.

Hendrie: There were?

Everett: Yes. But, you know, not for the kind of thing we were doing. And they were looking at radar things and whatnot. And the television was coming along, and they were looking at television wave forms. So we had to build the preamps and whatnot to go with it.

Hendrie: Okay.

Everett: And I had some thoughts which escape my mind. Oh, yes, another thing was we built – we developed and built a set of components which did flip-flops and gates and counters and so on, in which you could assemble into a module which would generate a kind of pulse range you were interested in for test purposes. These led – and Ken [Olsen] started out with Digital. He put out a line of those. They were transistor based, not – the original ones were tube based, of course, so big they made them. And, all those things had to be done. And we were concerned about the power supplies and – this was in Cambridge – and Cambridge Light and Power was given the considerable movings around and voltage and shocks and whatnot. So, we had to build a system with rotating machinery which drove a...

Hendrie: So you did a motor generator set too.

Everett: …motor generator to isolate from the power lines. And then build the power supplies. You know, SAGE [Semi Automatic Ground Environment] actually had – I can't remember exactly now but – had a pretty much close to a farad of capacitors in its power <inaudible>.

Hendrie: That's amazing. <laughter>

Everett: Yes. I can't remember what fraction of it, but it was sizeable.

Hendrie: It was close to a farad.

Everett: Sizeable fraction of a farad. And so all those things had to be done. And so they were. And Jay wanted the thing spread out so he could get at it. So that's why Whirlwind is such a big thing. It's a two...

Hendrie: That's why no use was made of module, of more compact design.

Everett: No.

Hendrie: It was designed to be everything ...

Everett: At the rip rights used in the machine the distances were not a problem. So, they remained on panels. There's one around here some place. So he could replace one or even to get at the tubes and replace them. Or you could get at all the wiring and put a test probe on any point in the machine.

Hendrie: Okay. Good.

Everett: So it took a lot more space for things like that.

Hendrie: That wasn't...

Everett: That wasn't a problem.

Hendrie: That wasn't important.

Everett: That wasn't important, that's right. Yes, it seems to me that there's a lot of similarity between the satellite business and the computer business. People said of computers, "Well, those tubes are so unreliable; you'll never get the thing to run." And it turned out everybody got it to run. And they've said about satellites, you know, that, "You're going to make this thing, and you've got to put it up there, and it's got to last long enough. You can't get at it. You can't maintain it. How are you ever going to get it to work?" Everybody got it to work. And the difference was that in the computer business and in the satellite business, reliability was the number one requirement. If it was a choice between reliability and more performance, you took the reliability.

Hendrie: You just made all the engineering decisions with reliability at the top of your list.

Everett: That's right. And that was not what happened in the Army avionics business. I used to say that the way the Air Force went at it, they called a gang, everybody in and said, "Now, look, we're sick of this business. It doesn't work. We want it to be reliable. You got to have reliability. You got that? Now, let me tell you what we really want." <laughter>.

Hendrie: Yes, exactly. So, any other stories come to mind about the things that went on during the construction and debugging of the original Whirlwind I?

Everett: Well, I'll tell you one thing. The circuit designers, Norm Taylor and these guys, capacitance coupled the flip-flop to the gate. And this worked fine until you put a whole stream of bits through it in which case it would charge up the capacitor. And this wasn't discovered until they got something together which ran a long enough chain of pulses to create the problem. So what to do? Well, we said, you know, what could you do? It's a refresh problem. How can you make these things, if you all go to zero, where do you store the <inaudible>? And I had the idea that you turned over all flip-flops in the computer at the same time. So now they still contained the information. So you turned them over and you turned them back. This refreshed it and kept the information in the flip-flops. It was built that way. And it worked. I didn't think it was one of the more...

Hendrie: You didn't think you deserved a Nobel Prize for that?

Everett: Well, I didn't think – I thought that was an act of desperation, that's what I thought it was. <laughter> We would have had to redo the circuit design in order to avoid it.

Hendrie: And so all the flip-flops were designed so they were triggerable?

Everett: They were all triggerable. They're a standard design which you could trigger or you could set it to one way or the other.

Hendrie: Yes, so then trigger input, a set and a reset.

Everett: Yes, so you could just put in a line and <inaudible>.

Hendrie: So you just sent out a pair of trigger pulses, and then pause, send out of pair of trigger pulses, and proceed.

Everett: Yes.

Hendrie: Very good. That's a great story. Any other?

Everett: Oh, I'm sure there are thousands of them, but... well, we were the first people, as far as I know, to put a cathode ray tube on the computer. And that's because we were looking at it from the point of view of the simulators and things of that sort. And, so we made…we had some big cathode ray tubes, and we needed a stand to fit them in. And it turned out that wooden stands were cheaper than metal ones. So we had an outside cabinet outfit make these things. And they were very nice. They were all well done and finished and very nice. And we got complaints about this from the Navy. It looked like we were spending money unnecessarily to make these fancy cabinets.

Hendrie: Oh, my goodness.

Everett: When we made them because they were cheaper. So they had to be painted. <laughter>

Hendrie: Rather than the nice wood grain.

Everett: Yes. They had to be painted. Yes, but the cathode ray tubes were a great thing because not only could you do all kinds of things by <inaudible>. For instance, they would show you a picture of – this was not from the ones in the cabinet but a little one – which was connected in parallel with the storage tubes. And it would show you where the computer was working, you know. Bright, very bright spot down here where it was sitting out and scattered ones were around it. And it would tell you a lot about it. For one thing, if you were running a test program, and it started to go wrong, you could tell instantly by looking at the picture, which would change, and your mind is very good at judging.

Hendrie: Remembering the normal pattern.

Everett: Yes, knowing the normal pattern.

Hendrie: Wow. Okay.

Everett: And, let's see, some others. One of our guys, Ron Meyer, he came around and said he had this idea for hooking. There were five flip-flop registers, and the machine was built, initially, with something called test storage. It had 32 registers of switches, and it had five registers of flip-flops, which could be inserted anywhere you wanted.

Hendrie: But, each register is 16-bits.

Everett: Each register is 16-bits. It's amazing what you can do with that little. Anyway, it was a great thing for testing. And he said he got this idea. He wanted to hook an amplifier on one of the flip-flops in the register and use it to play music. And I said, "Music? With all our problems and you're going to take time to do that?" So we compromised. He could do it on his lunch hour. It turned out to be a very useful thing. Not only could you play Christmas carols at Christmas time with it, but it was another thing. This is a thing which you could tell by the sound what was going on.

Hendrie: And so people would get used to the sound.

Everett: Yes, you'd run the test program, and it'd make a particular set of sounds, and if something changed, you knew instantly.

Hendrie: Very interesting. That's fascinating.

Everett: And then we had the problem of how do you select the spot you're interested in, the particular piece of information that the computer's working on? We didn't think of the mouse. The original thought was a joy stick, which moved…as you moved it, moved a set of micro switches, and these would feed into these flip-flop registers, which ended up being used for input devices. And that would make a spot, and you could move it around. But then, we thought of the idea that when the spot comes on the tube, the machine knows what it's doing. It knows that it's just put that spot there. And if you put a photo cell over it, it would tell the computer that you were interested in that spot. And that's how what's called a light pencil or the light pen. And SAGE used those. And enabled the operator to pick out a particular airplane or whatever. All those interesting things. We used Flexowriters and paper tape. Started to have trouble, discovered that the paper tape we were using was slightly transparent to the light. <laughs> We had to get some different paper to make the paper Flexowriters work. We bought some magnetic tape drives from Raytheon. And people were…

Hendrie: Now, why would Raytheon have magnetic tape drives at this…

Everett: Raytheon was in the computer business at – it was developing computers.

Hendrie: Oh, yes, they developed the RAYDAC [Raytheon Digital Automatic Computer]. I remember.

Everett: They developed the Hurricane, was it? No, that doesn't sound right. Anyway, they developed a machine, and they developed these magnetic tape drives. They were five lines wide, five spots wide.

Hendrie: Five bits wide.

Everett: Five bits wide and about 200 bits per inch long. Something like that.

Hendrie: Okay.

Everett: Very coarse compared to today's standard. Anyway. But the problem was that the tapes were not very uniform. I mean, they had lumps in them once in a while. And people had various schemes for dealing with that. Our scheme was to – oh, I guess they were six bits wide. And we hooked them together. This one would skip over and hook with this one. This one would connect with this one and this one would connect to this one. So they were three spaces wide between the pairs. Now, this was based on the assumption there were no dropout…there were no extras. They were all dropouts caused by a lump of some sort. And it turned out this worked very well. And, it cost you half the tape density, but that's not a problem, very much of a problem. Anyway, we had this idea, and wanted to test it. So, we wrote a program in test storage: 32, 16-bit numbers with five flip-flops amongst them. And what it did was it ran the tape and wrote the number of the tape and a block of all ones of considerable length, and then a space, and then the same thing. And then it ran through, and it read all these things. And then if there was a dropout, a zero in it, it stopped and printed out a picture of the block on the Flexowriter with the number of the block.

Hendrie: Oh, my goodness.

Everett: It was all done in 32.

Hendrie: That was done in 32? 32 words?

Everett: That's what I say; it's wonderful what you can do when that's all you've got.

Hendrie: Yes.

Everett: We had tubes but they weren't working well enough to run programs with. So they were used to store the picture, so that you could then print it out. So one of these blocks might have, you know, hundreds of spots. Anyway, lots of fun things.

Hendrie: That's great. Those are great stories.

Everett: It was wonderful. For one thing, nobody knew anything about computers, so you didn't get any trouble from anybody. I mean, they make you paint the cabinet, maybe, but what else? So, you were on your own. You didn't have any way of getting somebody to tell you what to do. But at the same time, you didn't have anybody telling you...

Hendrie: You didn't have any critics?

Everett: You didn't have any critics.

Hendrie: Who thought they knew how to do it.

Everett: It was wonderful. I was talking to a friend of mine, Bill Davenport, who was another division head at Lincoln, and he said, "You guys are spoiled." He said, "Nobody knows about computers. They let you do what you want." He said, "Radar, there are a lot of people around who think they know what to do and there's a lot of trouble." He said, "Communications." He says, "Everybody thinks he knows communications." <laughter> He was a communications guy.

Hendrie: That's funny.

Everett: Yes. You know, looking back on SAGE, you probably couldn't do it today. Probably couldn't do it today. The bureaucracy is too tough and the power of the – back in those days, the Air Force had a lot of power.

Hendrie: So let's continue with the Whirlwind story a little bit more.

Everett: Okay. Well, as I said, the storage tubes were a marginal device at best. And Jay had been thinking about three-dimensional memories for a long time. And he'd heard about the thin film cores and also the ceramic cores. So, it was now SAGE days, and we had money and one thing or another, and so we started out, I decided the thing to do was to just build one and stop fiddling around. So we started building one. Ken worked on it and various and sundry other very good guys. And we eventually succeeded in getting cores that were useful, had the proper characteristics and were consistent enough to make a memory.

Hendrie: Did you try to make them yourselves or did you...

Everett: No, we got them from General Ceramics.

Hendrie: You worked with...

Everett: We subsequently got a ceramicist of our own who worked on it and helped a lot. But the first cores came from General Ceramics. There's a gentleman there who was instrumental in inventing that material.

Hendrie: You remember his name?

Everett: No. <laughter>.

Hendrie: Okay. That's fine.

Everett: Anyway. So, I was over at – we'd expanded and moved into the Whitawar [?] Building – and I was out of the Barta Building at that time, because I was working on the new SAGE machine. And Pat Hughes who ran the tube shop came over to see me. And he says, "Bob," he says, "We're having trouble making the tubes. We're down to a one-week supply."

Hendrie: Now, do these tubes burn out so that you have to keep making them?

Everett: I don't know. All kinds of things would happen to them, and they just would stop working.

Hendrie: Yes. All right.

Everett: And I'm sure that if there weren't any other way to do it, we would have made them better over a a period of time. But, I said, "Well, you know, we've got this core memory thing. We've built a memory, and..." Well, let me back up and say that we'd found out in the storage tube work that it was very important to have a proper test facility to generate the various signals that ran the core memory, storage tube memory. And then we'd put them in the machine, and I discovered that, or it was obvious that the computer was a much better test of the machine than the test rig we had built in the basement. So, as a part of building the first core memory, we built a computer called "The Memory Test Computer," which as far as I know was Ken Olsen's first computer. And it was largely made of these test boxes that I told you about, the flip-flops.

So, my story about that is I told Jay that I wanted to build this, and he says, "You just want to build another computer." I said, "No, I want a good test rig." So after some kind of argument, he agreed that I could go ahead and have this built, but as long as it couldn't multiply. <laughter> So, Ken built the computer, and I told him it shouldn't multiply. And after this was all going, I mentioned to Jay that everything was going well and couldn't we make it multiply, and he said "Sure." And so I call up Ken, and I said, "You can make it multiply," and I used to say that in a half an hour or so it was multiplying. But he eventually told me that it had been multiplying all along. <laughter> Anyway, we had a memory and it worked. So, my proposal was that we move that memory over to Whirlwind and build a duplicate and get rid of the vacuum…the storage tubes. And that's what we did. We made another memory and arranged to put it in Whirlwind and got rid of the vacuum tubes…the storage tubes. And it did a number of good things for us. One is that it roughly quadrupled the speed – no, it doubled the speed of the machine, quadrupled the speed of transfer between the secondary memory and the internal memory. It reduced the amount of maintenance time from two hours today to an hour every two weeks. And it freed up the tube shop, could then work on the displays for SAGE. And this all happened, just first ordered – oh, yes, I forgot. The mean time to failure instead of being three hours was measured in weeks.

Hendrie: My goodness. Now, approximately what time, when did this sort of happen?

Everett: '53. 1953.

Hendrie: 1953. All right. And when was Whirlwind I sort of "operational" in its first instantiation?

Everett: Well, it happened gradually over a period of time. It was running with test memory about 1949 or so. It was running with storage tube memory by 1951. And this was early 1953. So we'd been running with storage tubes for a couple of years.

Hendrie: So, it took a long time from the test memory phase to the storage tube phase.

Everett: Well, it took a year or so.

Hendrie: And this was mostly the issues...

Everett: And that happened gradually.

Hendrie: ...with the storage tubes, or was this still debugging the rest of the machine?

Everett: The rest of the machine was running pretty well, but we were starting to put things on it, more displays and operator consoles and all kinds of stuff which were adding to it. So there was all that had to be done. And it came along just in the nick of time, shall I say, because we were building what we called a Cape Cod System, which was the prototype air defense system in New England, which various radar scattered around New England were brought into the machine, and the Air Defense Command sent a colonel and a whole squadron of people to operate it, all those things that made a first order difference in the reliability of it.

Hendrie: What I'd like to do is maybe we could go back a little bit in time, and you could trace the metamorphosis of Whirlwind I and its uses up to the talk about the evolution of the idea of the SAGE system and that becoming a project. And then it will meet the core memory coming into the machine on the machine side.

Everett: Well, as I say, the original intent of Whirlwind was the airplane stability control analyzer. But by 1947, we had thought of many other applications for it, including tracking aircraft and intercepting. We were still working for the Navy at that time, and so, we had a simulation, which had <inaudible > been done, you understand. These things were planned out, reports written about them. Communication system, which used the computer to manage the communications. Simulator for anti-sub warfare that, you know, ran destroyers around and dropped depth charges and calculated the probability of damaging the submarine. This one for running a task force which we might be attacked by enemy airplanes, and so they... so, it was really a SAGE system in miniature, not very much of a miniature. And it had all the pieces, and these pieces were described in reports, not built.

Hendrie: Yes. Okay. And so, at some point...

Everett: But, we did see lots of things with the computer, things we invented ourselves. It was set up as a facility in which people could bring in programs and run it on the computer some of the time. And, you know, for instance, the Museum of Science was putting in a planetarium, and Whirlwind computed some of the gear ratios and so on for it. And it did a lot of other things, you know. So these were brought in by people from the outside, and our guys would help them with the problems, teach them how to do it. There were lots of people I'd met from <inaudible> who told me that their first experience with a computer was Whirlwind. First learned how to program on it. So, if the Air Defense problem had not come along, I don't know what would have happened. It probably would not have justified the machine for calculating what people brought up. I don’t know. Anyway, just about the time the Navy got sick of putting up the money. The air defense problem came along. The Air Force came along and rescued us and gave us money.

Hendrie: About what time did that transition occur? What year?

Everett: Oh, 1950?

Hendrie: Okay.

Everett: Started in 1949, then went…1950.

Hendrie: Okay. So then the...

Everett: Lincoln was started in 1951. And Lincoln was set up to do air defense. And, you know, basically, the creation of Lincoln is dependent on Whirlwind because it was the existence of this computer, it could be used for managing the tracking and intercepts and data gathering and everything, of an air defense system. Luckily the Air Force would be willing to support this.

Hendrie: Now, when Lincoln, when this SAGE project started receiving more funding and Lincoln Lab was set up, was Whirlwind moved? Was Lincoln ever running at MIT before it had its own facilities out at Lincoln?

Everett: Well, Whirlwind was built in the Barta Building on campus, and we never moved it. Eventually, Bill Wolf <inaudible>moved it.

Hendrie: Okay, so it always stayed at the Barta Building, yes.

Everett: MIT <inaudible>.

Hendrie: Yes.

Everett: And so that we kept the Barta Building. <inaudible>.

Hendrie: Okay.

Everett: And, in fact, I started a small piece of …I was unhappy about losing the contact with the campus, and the graduate students that were the heart of the digital computer lab staff. So, I set up a group at MIT to continue doing research on computers. And we kept that up for a while, but it didn't work out very well, because the professors on the campus wanted to do their own thing, and I wanted to do something that was useful to me. So, the result was that we decided to call it quits, stop funding it and they got funding somewhere else.

Hendrie: We need to take a pause and change the tape.

END OF TAPE TWO

Hendrie: Let’s see. Where did we leave off?

Everett: Where did we leave off?

Hendrie: Well, we were talking about whether part of Lincoln still resided at MIT because the Whirlwind was not a highly movable piece of equipment.

Everett: We kept it until about 1956. At the Barta Building.

Hendrie: Could you maybe outline a little bit more of the experimental work that Jay Forrester did or theoretical work that led to the idea of the core memory, which then you proceeded to try to build one. I’m just trying to tag on the introductory piece to the part you told about building one and then figuring out how to test it.

Everett: Well, he started out with a plasma memory, which was a bunch of intersecting wires, which broke down and set up a plasma for storage. And it turned out that – I didn’t pay much attention to it – but it turned out that it did not have the characteristics he wanted. And then he heard about this square loop material. A square loop was what he needed. And so he got some of these thin film wound cores, and he set one of our guys, Bill Papion, who’s still around, to work measuring it and things like that and laying out the loop characteristics and how square it was. And then he got some of these ceramic cores and did the same thing. And this went on at about that level until we got enough strength – we had so many other things to do – that we had enough money and people to actually start in to build one.

Hendrie: So there was a sort of a long tale of research leading up to deciding we know enough; we think it will work; let’s go try to make one. Did you try to make a…what size memory did you try to make as your first try?

Everett: Well, we made some, you know, two by twos, four by fours, and things like that. But the first memory that we built was 32 by 32. That’s one of the planes for the first memory. <Pause. Camera pans to a core memory plane framed and hanging on the wall> So it was an all out memory, in the memory test computer, which could be taken physically and put in the Whirlwind.

Hendrie: That was the whole idea, to build a…

Everett: It wasn’t the whole idea, but it was an idea. That is, if we were going to build a prototype to test, let’s make it one that would fit in a Whirlwind. Seemed an obvious thing to do. We had to double it, because Whirlwind had 2K words, 4K bytes, think of that.

Hendrie: Oh wow. Could Whirlwind address a 4K by 16? Oh, you had to build – oh, I'm sorry, it was 32 by 32, so it was only one. The planes were only…

Everett: There were two planes, two 32 by 32 planes. And we later added a 4K memory, and that required some changes in the article. If you want to use the 4K, you had to do something to tell it to use that instead.

Hendrie: Right. Get another bit in the address.

Everett: No, you couldn't add a bit, but you could borrow one.

Hendrie: Borrow one from some other place. Exactly.

Everett: There were 32 places for instructions, I mean, 32 different instructions. Originally it started out with only 16 or something, we always kept some extras. And every once in a while somebody would come up with an instruction that was sufficiently valuable to put in permanently, but people put special ones in for special purposes sometimes.

Hendrie: Then you do the logic wiring and all of that and make it work?

Everett: Well, Whirlwind had a picture outside that shows a couple of us looking, me and a couple of other guys, looking at it. There was an array of several instruction sets, a 16-way – er – 32-way switch that picked up one of these 32 wires, and then vertical wires that led to gates that fed off into various places on the computer. So if you wanted to put in a new instruction, all you had to do was pick one of these wires and then put diodes in to connect the horizontal wire with the vertical ones that you intended for, which were intended to go places. So it was very easy change the…

Hendrie: To make changes.

Everett: …to make changes.

Hendrie: And it was of course all in an open frame. Also made it easy…

Everett: Yes.

Hendrie: I read somewhere that Whirlwind had some polar…some coordinate…some instructions that changed coordinates. I was just curious.

Everett: Changed coordinates?

Hendrie: Yes, to do coordinate transformations, from polar to rectangular because of the changing a radar – no?

Everett: I don't remember anything at least. Nothing like that. You'd have to put in a special subroutine to do something like that.

Hendrie: What were you doing – you talked about when you were sort of supervising getting Whirlwind going. Talk about your personal role as you progressed to working on the SAGE system. What were the things you were doing. Back a little bit to your personal story.

Everett: I guess I was sort of Jay's lieutenant. Special assistant, whatever. And so I worked on whatever had to be worked on. I was sort of more like the chief operating officer, and he was the chief executive officer. Worked on whatever needed to be worked on. On the crew, sent them off, decided who worked on which specific jobs. I had to oversee the graduate students and make sure they got their TCs done and things like that.

Hendrie: So a wide range of things.

Everett: Yes. Which is fun, because you knew what was going on.

Hendrie: With the transition to working on the SAGE system, what were some of the issues or problems that had to be solved, maybe in larger space than just working on the computer itself?

Everett: Well, there were several things. As far as the computer was concerned, we needed a new and larger and more higher performance computer, which had to have somebody build it. So it was necessary to get a contractor, some industrial outfit, who would do the detailed design and manufacturer the computer. Then there was the question of the software. A program for air defense meant hundreds of thousands of instructions. And we never…most of the things we wrote was a thousand instructions or something. So this is, you know, this is an order of magnitude which meant having to build all kinds of tools and so on. And then there was the system engineering of hooking SAGE up with the outside world, and with the processors at the radars, dealing with the telephone company, getting standards set for sending bits over the telephone wires, dealing with the Air Force, learning about how you do air defense and what things are necessary, solving all the problems of displays and communications, and design of the SAGE system. And then, you know, we pretty much did Whirlwind by ourselves, including the Cape Cod System. But SAGE involved all kinds of people, including the telephone company; Western Electric was hired. The Air Force set up a SPO Assistant Program Officer, overseeing or managing the program, and then Western Electric was hired to build the buildings and put in the telephone gear and do detailed hooking up. And various companies. IBM, of course, was hired for the computer. And there were organizations working on the radar monitors and people built the display scopes which were special display scopes, which used <inaudible> technology. And Hughes built the storage displays. So there was a whole mass of things, so it became necessary to sort of invent our way into the system management of all this business. I think what happened was that we were used to designing things ourselves, and we get all these people, and it was a matter of taking the Lincoln people out of things and giving them away to somebody else to do. So we'd get enough Lincoln people to do the new things that hadn't been started yet. And that led to the problem that it seemed obvious that by the time we got through we would have exhausted the basic work of the laboratory, and it all disappeared into this vast maw, this thing. So I took a group, one group, about, I don't know, one-fifth of the division or something like that, to continue doing R&D, and they're the ones who built the transistor computer and TX-0 and the transistor driven memories and TX-2 and the 256 x 256 memory computers and all kinds of things that they worked on. So that they wouldn't be swallowed up in the day-to-day problems of getting the whole system done.

Hendrie: So the TX-0 and TX-2 were not sort of directly in linear path to doing the SAGE system?

Everett: No.

Hendrie: They were independent research?

Everett: And this 65,000 instruction memory turned out to be needed very badly. We started out…we thought we were going to have 8K of 32 bit words and ended up with 74K or something like that.

Hendrie: In core memory? In the machine?

Everett: Yes. Which seemed like a lot at the time. <laughs> But it was 256K bytes of core memory.

Hendrie: Tell me a little bit about the decisions of having IBM be the people who would build the machine. And how the production processor got specified.

Everett: Well, once again, this is kind of an extraordinary thing when you look back on it. It was obvious we had to have somebody like that. So Jay started out with me and Norm Taylor and Bob Weiser to go around and talk to the various outfits who were building computers.

Hendrie: Yes, might be capable.

Everett: Might be capable. Raytheon really didn't seem like they were very interested, and then they didn't have much capability. The telephone company wasn't interested. And this meant that the competition was really between IBM and Sperry Rand. Sperry Rand had bought Eckert-Mauchly and also the Engineering Research Associates [ERA] gang at Minneapolis. So we just went around and talked to them, and they showed us what they had and what they could do. And we went home and sat down around the table and each evaluated the people we'd talked to. IBM came out way ahead, and Jay gave them a contract from Lincoln and the Air Force gave them a bigger contract, a bigger contract still. So we picked IBM for this billion dollar contract. <laughs>

Hendrie: Going around talking to people and then sitting down…

Everett: Yes. I think of what a processor would be today. The entropy has gotten a lot smaller.

Hendrie: Yes. Exactly. How did you deal with the programming problem? A little bit of an analogous problem, a really big one.

Everett: Well, when we started out…

Hendrie: You weren't going to do it with grad students probably.

Everett: When we started out we were doing the programming ourselves, I don't know, fifteen or sixteen engineers. Engineers could do anything. And they were doing the programming, and it was obvious this wasn't going to hack it. So the various possibilities were: one, MIT could let us get bigger to do it; they didn't want to do that. Can't blame them. IBM. We tried our best to talk IBM into it. We said, "Look, golden opportunity here. You're going to learn all about this thing. You're going to get all kinds of trained people at the Air Force's expense." And they said, "No, we don't do our customer's programming. We help them do it, but they set up their own plug boards and things like that." So then we talked to Rand. Rand was working on air defense, and what they were doing was they had a group under a fellow named Kapler [?] who was working on the manual system to try to make it better, to improve training and so on. And he was very interested, and he had a lot of programmers, a lot, a dozen or something, who were using computers to help in this training process. And so he expressed a willingness to do it. And Colban[?], who was running Rand, said – shades of the future – that it was all right with him as long as they spun off the whole operation; he didn't want it at Rand. So this led to the formation of the System Development Corporation [SDC]. And they got the job of doing the programming. Now, the people who knew something about this program was, of course, the Lincoln people. And we hired hundreds, literally hundreds of people. There weren't any programmers you could hire, so these were teachers or God knows what, or mathematicians, or fresh graduates in mathematics and whatnot. And we had a system for evaluating them, and we had exams to give them and tests and one thing or another. And we hired them by the hundreds and turned them over to the SDC, and SDC wrote the program. But our guys really were in charge. So you'd take the guy who was a staff member at Lincoln, and he'd have 50 of these SDC people working for him, and so that's how…and nobody, nobody understood the size of the software problem. Just took an enormous number of people. Things haven't gotten much better sense.

Hendrie: And you only found out as you went along how big the problem was?

Everett: Yes. And the telephone company, the Bell Labs people, they had a job of running evaluation tests on SAGE, and they looked down their noses at us, all these problems we were having writing this program. So it was a great pleasure to me when they got the electronic switching, which was a computer driven switch, you know, and they got into the same kind of trouble. And that was years later, and they should have known better. We didn't have any way to learn, but we learned about it. But they didn't pay any attention to us. <laughs> And IBM, of course, ended up with tons of programmers. But it was done.

Hendrie: How were the specs on the machine itself done? Was that pretty clear, what you needed to do? You said there was some mis-estimating of how big the memory needed to be, but other than that, did you work out relatively clear specs for IBM up front that stuck? Or was there a lot of issues there?

Everett: Well, it wasn't a case of writing a set of specs and giving it to IBM. It was a case of starting to design the thing. The general spec for it was that this is a general purpose computer, and it's got to the fastest, most capacious thing that we think we can build. And so the original block diagrams and so on were done by the Lincoln people, and we worked with the IBM people. And the picture I have is that it starts out with all of the thinking being done by the Lincoln people, and it gets less, less and less, and the IBM people got up and up and up, and they took over. And at first, as this thing was starting, there was a certain amount of argumentation going on, because the IBM people were competent, and they'd built computers, and they were proud and confident. And so there was a lot of head bashing going on. For one thing they used square steel pipe for making their racks and we used L-shaped aluminum. And that was a matter for argument. <laughs> And we'd get together and – these were all meetings, they were called, I can't remember now. But we'd get, you know, dozens of Lincoln and IBM people together and thrash out these problems.

Hendrie: Was the work at IBM done in the group that was doing the 701 and 702?

Everett: No, they set up a new group with a new building, High Street in Poughkeepsie. Poughkeepsie is where these other things were going on, and I'm sure that some of the people came from there.

Hendrie: They would move some of the people over there.

Everett: But not the leaders. There were new people. I don't mean new to IBM necessarily.

Hendrie: Yes, but they weren't – they didn't – people like Nat Rochester, etc., did not move over to this project.

Everett: No.

Hendrie: Okay.

Everett: So anyway, one thing I remember is we went to visit the manufacturing people. IBM had built this big new plant in Poughkeepsie where they were making 604s or something, and you could eat off the floor. It was clean – I was used to – my previous experience with a manufacturing plant was the

Westinghouse Air Brake people, where it was covered with dirt, grease everywhere. So, we sit down with these guys, and Jay in his usual way had ideas about everything including how you manufactured stuff, and was telling them what he expected them to do. And finally one of the IBM guys says, “You can go back and run your damn university; I’ll run my damn manufacturing plant.” <laughing>

Hendrie: Wow. That’s great.

Everett: Oh dear. A lot of funny stories. We had drum memory in Cape Cod, which we got from ERA. And so we told, well, IBM had drums that they were making, but their drums were not oxide coated drums. They were a steel mandrel – or aluminum mandrel – I guess, with a wire, a magnetic wire wound around it, and then they’d grind it off on the top so it was smooth more or less. And this had the interesting feeling that they’d buy this wire you know in big coils from the wire people, and they’d be winding away and suddenly a knot would appear where they had hooked the wires together. Anyway, I remember that story. So IBM, by George, was not going to put ERA drums in their machine, no way. So one day they invited us to come up to Endicott, and they had developed a new drum; it was an oxide coated drum. And you know, it looked like the typical drum, with bonding bars and it had…each little head had a screw you could turn it and get the head closer and closer to the drum until you got the right signal. So they had this all carefully laid out, and the guy showed us this thing and how it‘s built, took the pieces of the head and put them together, and put the thing in. And he put it in, and he starts to turn down the thing but there’s no signal. There’s an open in his head someplace. Well, he had gotten a little flustered by this, but he says, ”Well, we’ll put in another head.” So these heads had a mounting, there was a mounting hole here and here that went into the two bars. And he starts to take this screw off, and he’s nervous. And he drops the screw and it caught, got caught between the head and the drum, and sparks flew out of it, this great stream of sparks. And it makes a terrible screaming noise. And he looks absolutely crestfallen. And a senior IBM guys says, “I think it’s time for lunch.” <laughing> So we went off and had lunch. And we came back, and he had recovered, and he put a new head in and showed us how it worked and everything. And we decided to go with the IBM heads, their IBM drums. The other part of this is that they then took the drum and gave it to the manufacturing people. Now, the guys who had developed the drum, they knew about the importance of this tiny gap, so they had made the drum out of all the same material, band bars, everything. Everything was made out of, I think, aluminum.

Hendrie: Yes, and all the same aluminum. So it had all the same co-efficient of expansion.

Everett: So it goes to their manufacturing people, and they say, “What the hell did they use that stuff for?” And they changed the end belts to something else. And that result was production drops start coming, and they’d start up with it and adjust them all right, but as they got warm, they’d quit running. <laughter>

Hendrie: All right, I have to go fix that problem.

Everett: Yes, it was easy for us. We just said go back and fix it; we don’t care what you do. It’s funny how much power Lincoln had in decisions. We had all these various organizations and when they would come together in a meeting, which we invented. Actually Jack Jacobs is the guy who set this up, and there’d be there'd be a problem, and a decision would have to be made among alternatives. And we'd do all the homework, and then we'd come in to this 100 people, 100 man meeting, and we'd describe the alternatives and the pluses and minuses, and how we wanted it, what we thought ought to be done. And they'd accept. We figured out the major reason they would accept is that none of them wanted to be held responsible for what was going on if they didn't. They held us responsible, and that was fine. We were happy to be responsible. Somebody had to be responsible.

Hendrie: Exactly.

Everett: You can't…this isn't the U.S. Congress. Anyway, lots of fun.

Hendrie: Tell me a little bit about the communications side of this. Obviously, lots of digital data going over telephone lines and presumably eventually had to go over the air to the – probably not initially – the interceptors were voice controlled initially?

Everett: They were also data links, which Lincoln was involved with.

Hendrie: There were data links? So you could send digital data to the aircraft, even in the earliest versions of the system?

Everett: There were a couple of different communications systems that the Air Force had. So, well, it was obvious that it had to go over the telephone lines.

Hendrie: What was the state of the art for doing that?

Everett: There wasn't any, really. So we, the first thing we did was we had to get a telephone line so we could do some experiments. So we ordered a telephone line and the telephone company came in and put the line in, and then they had a handset. And we said, "We don't need the handset." They said, "Sorry, every telephone line comes with a handset." <laughs> Anyway, so we built our own digital modems; as I recall a lot of that was done by Jack Harrington. And so then we had to learn about telephone lines. There was a question about what kind of data rates you could get. Also it turned out that the telephone lines had a lot of switching transients in them which didn't bother people who were talking on them, but it sure bothered when you sent bits over them. So we had to work with the telephone company to fix these lines so they didn't have these sharp signals on them. That had to be done. And at the time of SAGE, they were all special lines because…

Hendrie: They all had to be conditioned this way.

Everett: Now, we were getting, I don't know, 1800 bits per second or something across these lines, which of course is nothing at all today.

Hendrie: But still. Did you do it with the modem…did the modem do tone signaling, or do you remember what scheme…

Everett: I think we just sent…we'd have a point-to-point line from the radar to the computer, and you'd just dump a pulse, and out it would come on the other end.

Hendrie: So it was a direct – the telephone company provided copper-to-copper connection.

Everett: Yes. But then when it came to build a system that was a different matter. So the telephone company designed their own modems, which was what they should do, and so they took care of that. Then there was the issue of backup lines and whether you could use switch lines for this and things of that sort. And all that stuff had to be worked out.

Hendrie: Did you end up learning how to use switch lines as the backup?

Everett: Originally they were all dedicated lines but I believe – obviously they use switch lines now – somewhere along the line they learned…

Hendrie: Somewhere along the line they did figure it out.

Everett: They figured it out, yes. But in the beginning, they were all dedicated lines and trimmed up to make the…to fast digits.

Hendrie: Okay.

Everett: Now, the telephone company had built a thing called Missile Master, which was a control system for [US Army's Project] Nike's surface to air missiles.

Hendrie: Yes.

Everett: And they used digital transmissions. And they used 750 bits per second. So it was funny, this was deemed to be a terrible problem. They used 750 and we used whatever it was, 1700 or 1400, I can't remember any more. And, of course, we knew that wasn't a problem, but the real problem was between the Army and the Air Force in who was going to tell what, who was going to tell who to do something. And they finally got that settled. And a week after they got that settled, the 750, the 1400 problem was solved. <laughter> But then when we finally hooked up with this new system, it turned out that one end was the big Indian and the other was the little Indian. <laughter>

Hendrie: Oh no.

Everett: Isn't that something?

Hendrie: And that problem still plagues people today.

Everett: Nobody ever thought of the question, you know.

Hendrie: I know. Things that just couldn't be changed got set before anybody knew that there was a problem.

Everett: Well, we managed the thing pretty well because none of this existed, you see. So everybody had to do something, and they might as well do the same thing, if you could have arranged for it. And so the rule was if you want to talk to SAGE, you've got to use SAGE standards; don't use SAGE standards, you can't talk to SAGE. Since SAGE was in the middle of everything, everybody had to use SAGE standards. Except the Missile Master. <laughter>

Hendrie: Which got built earlier probably. Got speced before SAGE?

Everett: Yes.

Hendrie: All right, let's take a break now.

END OF TAPE THREE

Everett: Okay.

Hendrie: Could you tell me a little bit about the displays in SAGE?

Everett: Well, the original displays we put on Whirlwind were simply ordinary TV-type cathode ray tubes, and there was a dot map. But the ones in SAGE, we didn't have the time to get all that done if we'd had to spell out every pixel. So we used a tube that had been developed by…

Hendrie: Was it Stromberg-Carlson?

Everett: Stromberg-Carlson, that sounds like it.

Hendrie: I believe the character drawing was done by them.

Everett: Yes, which had a…

Hendrie: But it wasn't done for SAGE, was it?

Everett: No, we picked it up. We were always looking for something. And that used, as you know, a screen with numbers and things, and it passed the beam through the screen and gave you a little letter on the surface. And those really worked pretty well. There was a complicated problem. We wanted the phosphor to stay; we wanted persistence in the phosphor. We wanted a flash that would operate the light gun. So the whole question of the lighting, and how it was done with louvers to keep any reflections off the surface of the tube, and the color of the screen across the tube, which had to be such that a flash could get out, but that the reflections were kept. Anyway, this is a result…

Hendrie: Conflicting requirements.

Everett: Conflicting requirements. Which meant that a lot of work went into that by IBM and ourselves to make that work.

Hendrie: IBM eventually also built the displays for you?

Everett: Yes, they did. They built the whole machine, and all of the drums and all that stuff, and all those racks with connections in them tied up all the hundreds and thousands of buttons all over the back end of the computer. A lot of stuff. And it turned out to be a lot more than we expected, too. It cost a lot more money than we expected. We found out such things as: if you wanted to change the nameplate on a switch, it cost a lot of money. They had to change the drawings and the specs and all that stuff to go with it. Changing the nameplate was easy. Keeping the paperwork up to date was hard.

Hendrie: How many of the SAGE machines…

Everett: How many of them were built?

Hendrie: …were built, at least of the original model that you were involved in?

Everett: There were twenty-something. Maybe twenty-eight or something like that, and they were all duplexed. And the command centers had two machines in each, although they didn't have all the extensive operating rooms and things like that. So, at a guess, sixty FSQ-7s were built.

Hendrie: Yes, because two in every center and then…

Everett: That was an issue at first because a computer's an expensive thing, and the original idea was that if something happened to one center, that the adjacent centers would pick up the load. And that continued and was part of it, because if a center was destroyed then the adjacent centers would pick up the load. But it was clearly necessary to put a duplex in them, because you not only had to worry about the reliability, but you had to worry about training and putting new programs in, and all kinds of things of that sort. The thing was a living center, which it wasn't really thought of being in the beginning, and it was always in change. There was always a new software thing coming out. There were new weapons coming out. There were new procedures and communications devices and radars. So there were always new things coming in, and the center had to be modified to accept those.

Hendrie: So the concept of having a duplex…machines proved much more valuable than just for the redundancy and the uptime?

Everett: Oh yes. It gave you the time to test this and to do maintenance on the machines, to put in new changes, to do training, experiments, simulations.

Hendrie: Add new software and make sure it really worked as opposed to what SDC said?

Everett: <laughter> Yes. Well, they had a machine. That's how they actually ran it there, but…

Hendrie: Of course, they had to have their own machine to test.

Everett: After all, not only that, but each one, each center had to be set up to fit the details of that sector, like where the airbases were, things like that, where the radars were. Each sector was different, and so each sector had to be modified to fit the details of that sector, and then had to be tested to make sure that it was all right.

Hendrie: Were the bases – I'm sure it's in one of the books about SAGE – but were they up near the DEW Line [Distant Early Warning Line] or were they more back in the continental United States.

Everett: Oh, they were back in the continental United States. It was a continental system. It extended into Canada, but there was one system, one center.

Hendrie: And it was never tied into the new system at all?

Everett: No.

Hendrie: No. That was a completely different effort?

Everett: The DEW Line, however, and the Pine Tree Line across Canada were used for alerting, so that that information went into the system, but it did not go in digitally.

Hendrie: Didn't have to get communications lines from the DEW Line, did it?

Everett: Well it did. It did have a communication line, so…

Hendrie: Yes, but not digital. You didn't have...

Everett: Not digital lines.

Hendrie: You didn't have to have date links. Do you remember over what period roughly the systems were deployed, from the first operational one to when they more or less finished?

Everett: Well, the first operational one was 1958, and they went in, starting every three months or something, and then two months, and at the end they were supposed to go in one a month, but whether they actually did it, I can't recall. But once they started, they went in…

Hendrie: Went in pretty fast.

Everett: There were changes made. One of the questions of course was what did this thing do about ICBMs [Intercontinental Ballistic Missile]? Not attacking ICBMs but surviving ICBMs? So one of the things that people said about SAGE was that it won't last because the ICBMs will come in and take out the SAGE system, and the airplanes will fly in. And that led to things like the BUIC System [Back Up Interceptor Control System], which was a miniature SAGE at the radar. And so…can't remember what I was going to say.

Hendrie: We were talking about how many there were, and you said there were some other issues about what would happen if ICBMs came in.

Everett: Oh yes. The first centers were hardened. That is, they had concrete cooling towers, and the buildings were massively made out of concrete. Certainly not proof against an ICBM. I mean, not a nuclear weapon.

Hendrie: Not a direct hit but…

Everett: But then, after the first dozen or so they changed the building design so that it had a normal cooling center, and the building was much less hard. I guess on the principle they were saving money, and since the nuclear weapon can take out the hard ones, there was no point in spending money on the hard ones. That was a decision I was not privy to. But things like that went on.

Hendrie: Yes. I remember reading something about a much smaller version of the SAGE computer, a transistorized version. Was that ever done? Did that replace the tube versions in operation? Could you talk a little bit about that? What you know about that.

Everett: No. There was a proposal to put in a so-called “Super-SAGE,” which was a transistorized machine, which originally was intended to be underground. And it was made out of transistors, not the kind we have today but individual transistors. And a decision was made not to go ahead with that program. Now there was also the BUIC System, which was not made by IBM. It was made by, I think, Burroughs, which did the tracking and so on at the radar site. And the idea was that then there were more of them.

Hendrie: And so a little bit less vulnerable?

Everett: BUIC stood for "Backup Interceptors something". So that was the idea. It's funny, the first BUIC machine came to MITRE and was set up and turned on. And they found out – it was very interesting – that when it started running it used up all the computer time available without any airplanes or interceptors. It was all overhead <laughter>. It was much faster than the SAGE system, so here was this computer with five times the capacity or something and only supposedly ten percent of the airplanes that…it didn't have any capacity at all <laughter>. Partly it was written in a higher level language. SAGE was written in machine language.

Hendrie: That was a question I had. Could we pause for just a second, and I'll get that question? <Pause> I had a question about what kind of software was available. Maybe going back to the Whirlwind, were there any assemblers, or any math libraries? The development of standardized or reusable software that would help people write their programs? And then maybe you could continue the comments into the SAGE system.

Everett: Well, I can't recall all the details, but there were growing amounts of these things. At first, people just sat down and wrote it. And then if one person could do a thousand instruction program, and keep it in his head and get it right. But when you get twenty people for a fifty-thousand instruction program, that won't work. So there were all kinds of things that were invented, and there were certainly standard sub-routines for various functions, that you could use. And there were assemblers, I guess you would call them. The original SAGE program was written with, not instructions or something, but with the names of the things you wanted. If you wanted some interceptor base, you could put it in the interceptor base. And then the assembler line, the support line would just…programs would put them in the right places, and things like that. So, it was called a Compool, which contained all that information. And people could go off and write it, independent of where it'll end up, could write it. And then this thing came in, and they put it all together and made sure it was all right. But it was not in a higher level language.

Hendrie: So it was one-to-one. You wrote a line and you got an instruction, but you at least had symbolic addresses and so you didn't have to keep track of memory locations and things like that?

Everett: Yes.

Hendrie: That was sort of the level of the technology at that time.

Everett: In fact, the guys really did some great stuff in preparing for it, a lot of which was reinvented later. Have you seen the issue of the *Annals* [IEEE Annals of the History of Computing] about SAGE?

Hendrie: Yes, I think I have seen that.

Everett: That's got an article in it by Benington, which I think talks about some of these things.

Hendrie: I'll take a look at it. I don't think I've read that article. Another software question. I'm flashing back again to Whirlwind. Do you remember whether there was any sort of word processor that operated on Whirlwind I? There was a fellow by the name of Jack Gilmore who allegedly wrote something for Whirlwind I that allowed people to do rudimentary word processing.

Everett: Well, Jack lives in Mashpee.

Hendrie: He does?

Everett: Yes, he lives in – once again I can't remember the name of it, but it's off 151. As you leave Mashpee Center and go out 151, there's a sign on the right for Seaport or something. Anyway, he's alive, and…

Hendrie: He's alive? I've tried to locate him a few years ago, and I could not find anybody who knows…

Everett: Oh no, no, no. I'll give you his address and telephone number.

Hendrie: You probably have his telephone number?

Everett: Yes.

Hendrie: All right, I'll get that when we're done. Good. That would be wonderful.

Everett: Jack's a very smart fellow. He did a lot of interesting things. That may be true, but I wasn't aware of it. It wasn't a thing that SAGE needed, and there were all kinds of things, as I say, written by various people because lots of people had access to the machine.

Hendrie: Can we talk a little bit about some of the testing that went on on SAGE, in terms of real-life simulations or actual tests in the genre of the ICBM interceptor tests that are going on now? Was the Cape Cod System the first system that actually tried to fly airplanes, and find them, and track them?

Everett: It was the first system that used a general purpose digital computer for that purpose. But of course people had been using radar sets to shoot at airplanes for a long time. Well, yes – let me think of what I was going to say here – would you say the question again?

Hendrie: Yes, we were talking about testing.

Everett: Testing.

Hendrie: Yes, real world testing.

Everett: The first thing was that there was extensive simulation. A lot of work was done to write programs that would simulate the outside world, and which could see how the SAGE itself reacted to those things. Secondly, in fact there was a room in the SAGE center for training and battle simulation. Then there were real tests run all the time. The Air Force arranged to have the SAC [Strategic Air Command] people, the SAC bombers which were flying all the time for training purposes, to come in and attack the SAGE system in the northeast. And SAGE would track these airplanes and order interceptors out of the bases, and the interceptors would go out and try to intercept the SAC bombers. And that took place every week for a long, long time. And that gave you some real experience under real conditions because…

Hendrie: I assume lots of things were found…

Everett: Oh, lots of things were found.

Hendrie: …in the software.

Everett: Lots of things were found. And there were always a set of proposals for making things better, which had to be winnowed.

Hendrie: I guess there wasn't enough time or money.

Everett: It was funny. I'll tell you another anecdote. There was Division II of Lincoln, which was run by Bob

Bob Weiser at that time, which was working on farther out stuff for SAGE, and doing other things as well, and then there was Division VI which had the responsibility. And then there was the telephone, the Bell Labs people, who were supposed to be doing evaluation. And then there were the Western Electric people, who were supposed to get this thing built. And I discovered that anywhere you stood in this sequence, if you looked to the right you saw the most high-bound, immovable bunch you ever saw in your life, And if you looked to the left, what a bunch of chaotic, undisciplined people. It doesn't make any difference where you were. That's what you saw. And from our point of view in Division VI, these guys in Division II had all these crazy ideas, and we were never going to get them in. And we'd look to the Bell Labs people, and the Bell Labs people thought we were nuts to try to put anything in <laughter>.

Hendrie: And it was just – you went down the road – everybody.

Everett: And that fits a lot of things.

Hendrie: Isn't that interesting.

Everett: Yes. You can do that with people too. People sit in a row in the political spectrum: hard right and hard left. And you can line the people up between them. And everybody knows that out there there are crazy right-wingers, there are crazy left-wingers, but everybody in the middle thinks he's got the right place. <laughter> So when he looks to the right he sees miserable, greedy, no-goods, and when he sees to the left he sees crazy, brains-turned-to-mush people. It doesn't make any difference where you are <laughter>. Well, that's digression.

Hendrie: I love it. That's good.

Everett: Anyway, there was a lot of testing.

Hendrie: Are there any good stories from the testing? Just fun anecdotes where, "The strangest thing happened and, whoops!"

Everett: Well, nobody flew into anything or got killed in this testing. A lot of strange things happened of course, but I can't remember them. I remember one thing was a joke on me. We had these big tapes. It was a roll about that big and about that wide, and it recorded all the inputs to SAGE. And we ran these tests. The SAC airplanes coming in, and the Air Defense airplanes, and everything else. And they were all recorded on this thing. And these tapes cost $200 a piece. And I discovered that they were erasing them and using them over again. And I said, "My God, these tests run hundreds of thousands of dollars, and we've thrown away the information we've got available, and we ought to save them." So they said, "Okay, you say so, we'll save them." And then years later somebody came round to me and said, "Hey boss, we've got this warehouse full of these tapes. We didn't use them any more. Can we get rid of them?" I said, "Holy smokes, I'd forgotten all about them." <laughter>

Hendrie: And so the order got changed from "erase" to "keep forever."

Everett: Yes, that's right.

Hendrie: There's no in-between point.

Everett: No, no judgment allowed.

Hendrie: Exactly. Oh, that is funny. Now, was SAGE capable of detecting low-flying incoming planes? That would've seemed to have been one of the hardest problems. Just because of the radar, not because of the computers or anything.

Everett: The curvature of the earth.

Hendrie: Yes, the curvature of the earth.

Everett: The idea, in fact the original idea for SAGE, was to have small radars and multiple <inaudible> close enough together so that they can see small airplanes at low altitudes. And this changed to big radars with gap-fillers in-between. And the Cape Cod System had gap-fillers. And they were brought in and used, but it was still a very difficult thing to do. Once the airplanes got in, and presumably within the cover of these smaller sets, they could be detected. And then you'd have to carry it along through those until they got close enough to a big set to be seen. Two things were done. One is, there were ships anchored out…

Hendrie: Picket ships.

Everett: Picket ships. Because the worry was: if the airplanes had got in through the outer reaches of the…

Hendrie: The system.

Everett: …the system. Then it was a serious matter anyway. So, you wanted to detect them far enough out so you could do something about them. So they put ships out there, and they also had Texas Towers, which were essentially drilling platforms with radars on them, which were put out. And then later there were aircraft, radar aircraft, and an early version of the AWACS [Airborne Warning and Control System] plane. And those, we built equipment for putting in them and transmitting the data back to the ground. And those can fly up and down to give it a proper alerting, because they were expensive to keep all the time. So there were these various attempts. What would have happened if the Russians had really attacked us? I don't know. Certainly some of them would have gotten in.

Hendrie: The system just didn't…there wasn't enough time or…

Everett: It's too difficult a problem.

Hendrie: Too hard a problem for the…

Everett: It also depends on the weapons. There was a weapon system called Bomarc. Are you familiar with that?

Hendrie: Yes.

Everett: Especially the second Bomarc, Bomarc Three or something it was called, which was a Mach 3 airplane really. And it had a look-down, shoot-down radar on it. And you could fire those out quite a ways. I mean, they'd go a thousand miles out or something, searching for low-flying airplanes, or any airplanes over quite a wide area, because they were flying at…

Hendrie: Very high speeds.

Everett: …thirty or forty thousand feet. So, a big swath, that if they saw something they could actually get it. And that was quite a machine, I thought. But they never…I don't think they ever made any of them, any production. They took out the Bomarcs after a while. I don't know what would have happened. I'm glad we didn't have to find out. But we'd have got some of them. And you know the same problem comes up with ICBMs. If you want to write a spec for the ICBM, what did people write? They say, "Hundred percent kill." Well, you can't have one of these go through and kill a million people in a city. You've got to get them all. And from my point of view, if you can save most of the cities, you've done a good thing. And to say "Well, if you can't save them all, I don't care if you save any," doesn't make any sense to me.

Hendrie: Yes. And it's just totally unrealistic again to say you are going to get them all.

Everett: Yes, and that spoils the thing, because then the spec becomes meaningless. And then you can do anything you want to with it, because it's basically just nonsense.

Hendrie: Yes, and that doesn't serve anybody any good sooner or later. You can spend a lot of money on it though. What other things do you think might be interesting to cover during this SAGE period?

Everett: Well, it was the first of the large computer-based command and control systems, and I admit there was a lot of admiration for the people involved. Air Force's willingness to stick its neck out for a thing like this, and to put up the money and push things along. As an example, there was a lieutenant-colonel over at the base who was a representative of the Air Force R&D Command, and he thought he was in was in charge of the program. And there was a colonel in down at, the program office was in Manhattan, and there was a colonel down there from Air Defense Command, I mean, AR in DC, who represented the Research and Development Command in this program of ours. And Lamontaine [sp?] used to object. He used to come around and talk to us. We'd talk to him, and he used to try to tell us things, and we wouldn't pay any attention to him. And so he finally went to his boss, which was Al Shiely [sp?] in New York, and complained. And Al told him, he said, "Yes" – what was his name? – "You are responsible. And the Air Force in its wisdom has provided the Lincoln Laboratory to do this job for you. Now relax and let them do it." <laughter>

Hendrie: That's good.

Everett: As I look back on it, it's incredible the power we had. And we did a good job. Had a lot of help.

Hendrie: Yes, but the things basically turned out pretty well.

Everett: Yes. And a lot of other things.

Hendrie: So, exactly. Let's move a little bit on, beyond SAGE, and talk about what happens next?

Everett: Well, as I said earlier, one of the problems with SAGE was it was not a fixed thing that you built, like an automobile or an airplane or something like that, but was in a state of flux all the time. So, the commitment of MIT was to the completion of the first unit of SAGE, which was the first command center and three direction centers, and that was all. And they didn't want to take any responsibility beyond that. And one thing that MIT quite understandably felt: they weren't in the business of doing system engineering on air defense. They were in the business of teaching people, and they had a lot of relationships with companies who essentially were the customers for their product. And having Lincoln Lab pushing these customers around and telling them what to do is not making them happy about MIT. So they didn't want to continue this. And the Air Force did not have the capability of doing it. So the Air Force went around and tried to get somebody else to do it. IBM didn't want to do it. SDC wanted to do it, but nobody thought they were the right option. There was a proposal to have a consortium of companies. That is, all the industrial people would get together and jointly man an organization to do that. None of us thought that was a really great idea. Finally they went to the telephone company and said, "Look, you've been working on this. It's your responsibility to carry it on." And they said, "No, go back to MIT and tell them that they started it. Let them finish it," or something like that. So they went back to MIT and said, "We've looked at everything else, and we can't figure out anything else. Will you continue to do it?" And Jim Killian was president of the Institute at that time, and Jim said, "Well, I'll tell you what we'll do. We won't do it, but we will spin off the part of Lincoln that does that into a separate non-profit organization which you can take, and it will be a permanent support to you." So that's what happened. They spun off Division VI, or most of Division VI, and some other pieces that were working on SAGE, and formed the MITRE Corporation. And the initial job was to continue to attend SAGE. Now those of us who went to the new corporation knew that wasn't our lifetime's work because ICBMs were very important, and it looked like Air Defense was a losing business. But there were obviously lots of other things. So MITRE Corporation was formed, and has since been working on information systems of all sorts for everybody. And has gotten a lot bigger, and still

And has gotten a lot bigger, and still works on air defense, mostly for overseas. And it's worked out very well. MITRE's doing very well.

Hendrie: But it still is the same status? It's a non-profit?

Everett: That's right. It's what's called a Federally Funded Research and Development Center [FFRDC]. So it's a non-profit, and it has special relationships with its government sponsors with the terms of engagement. And it'll do about a billion dollars this year.

Hendrie: Really? Wow.

Everett: About 6,000 people. Close to 4,000 members of the technical staff.

Hendrie: I didn't realize it was…that it just keeps on going.

Everett: Well, its biggest sponsor is still the Air Force, but the DOD work is…we work for all the other parts of the DOD as well. And we work for the FAA, and have been for the last 50 years. And we work for the intelligence community. And we have an FFRDC that works for the Internal Revenue Service. And we have also work for, or have worked for, practically every part of the government because everybody has an information system. And they all have problems with their information systems, and we can be helpful to them.

Hendrie: As you proceeded at MITRE supporting ongoing support as a SAGE system, what was the first area that you diverged into?

Everett: You mean beyond...

Hendrie: Yes, beyond directly SAGE.

Everett: Well actually the first one was air traffic control. The digital computer lab had actually done some work on air traffic control very early in the game, back in the 1940s, and it was clear that this nationwide surveillance system was useful for air traffic control. So I took a few very good guys, and took them off SAGE – this was when SAGE was still going strong – and sent them off to think about air traffic control. And the Air Force supported this, because they fly in the airspace. And so these people worked on it. And there was a proposal to use SAGE for that purpose, which didn't have a great deal of support, but it was supported by some people. In fact, one of them – I think he was a secretary to the Air Force – said using SAGE for Air Traffic Control was something like coming to Washington and trying to rent a condo and being offered the Smithsonian Institution. <laughter>

Hendrie: We have to pause now. And we want to continue from that comment.

END OF TAPE FOUR

Hendrie: You just had mentioned the joke about using SAGE for air traffic control.

Everett: So anyway, there was some effort in that direction and that led into other things, to work for the FAA. At first it was all done for the Air Force. But after awhile, it transferred, and we worked directly for the FAA, and that's been going on ever since. We, in addition to holding the SAGE's hand and modifying it and improving it, there was the Super-SAGE thing to work on. And the SAC used some Super-SAGE Q32s, I think they were, the transistorized SAGE machines for managing the offensive business. We did some work on that. Then other things came up, the virtues of having a computer, a digital general-purpose computer, in the middle of these command and control systems was obvious to people. So people started building those things, and we gradually started picking up work for different people in the Air Force and others. It just grew from there. I used to think of it as a two-dimensional matrix: in one dimension were the particular technical skills that you had, and in the other direction were the particular skills that you had in the applications. So if you had Air Force Air Defense Command with the technology that we had for that, you could move over and do something else for the Air Force and fill that in. Or you could take some of the technologies you developed for the Air Defense Command and go pick some new sponsor. So by moving in this exact fashion you could gradually fill this whole matrix. And we've done pretty well at that.

Hendrie: Do you think the FAA would have ended up with more success in their air traffic control system if they'd adopted the SAGE system even though it looked incredibly expensive at the time, considering the amount of money they've spent since then?

Everett: I doubt it.

Hendrie: Just wasn't applicable enough.

Everett: I think we did air traffic control out of a SAGE sector up in the North. And it worked. It could have been done. But the technology was moving rapidly enough so they really made you start over.

Hendrie: Okay. I know you read a lot about the difficulties the FAA has had managing their…

Everett: I thought you were going to say, “Would they have been better off without the MITRE's help?” I could never say that.

Hendrie: I wasn't going to ask you to say that. I assumed that there probably…if MITRE had been able to do it in the Lincoln Labs mode with just lots of really smart people and complete control, maybe it would have gotten done right at a much more modest amount of money and been better done.

Everett: That's true. I think that is really true. The FAA has a different product than the Air Force. The Air Force is not at war right now. And so you could start over, as it were, and you could make big changes in it and things like that, and then didn't harm in what's going on. But the FAA runs all the time, and making changes in it is difficult. It's like rebuilding the traffic circle at the bridge over here while eastern traffic is going over the bridge. So that's a big problem in itself. And then the goal in the FAA is not so much efficiency and capacity. It's safety. So if you want to do anything to it, the first question is, "Oh, well we're handling that now, and what's going to happen to the safety if we make this change?" There's a big bureaucracy which is built up. And the FAA consists largely of air traffic controllers who grow up through the system and become more and more important, and then get into the center and have to work on these things and so on. And they're reluctant to make changes. So the Air Force looks at it, "You know, there may be a war. And if so, we're going to have to do this efficiently."

Hendrie: We are going to have to be able to win.

Everett: Yes. But the FAA says, "Well, we don't care whether it's efficient or not. Well, we care but we better not crash any airplanes or there will be hell to pay."

Hendrie: Right. Which I think you can see their point of view.

Everett: You can understand.

Hendrie: You can understand that.

Everett: There are similar problems throughout the government.

Hendrie: In terms of motivations that lead to reluctance to change.

Everett: But I think the model, which I <inaudible> what invented, of having a not-for-profit organization, outside the government organization. I'll give you another analogy. One of the problems the government has in having qualified, efficient organizations is that when the government started, fundamental to the democratic ideas, every once in a while you throw the rascals out. We've just done that. Then the new rascals come in and fire all the old rascals. I mean the political ones come in, and they fire out all the guys and put in their own guys. So now you've got a new operation filled with people that don't know what they're doing. And it turned out that it was so bad that we replaced it with a system by which you can't throw everybody out – in fact you can't throw anybody out – called Civil Service. And I think the FFRDCs and their alternate invention for dealing with this problem because they are outside the government and therefore they don't lose all your skilled people every time the administration changes. But at the same

But at the same time you can fire them if you don't want them or need them, if they don't do the proper jobs and so on. And so these people are not buried in a bureaucracy with very strong tenure rules. You can fire anybody you want. You have to pay them, but you can fire them. So I think it's an alternative solution to that problem. I've tried it on various people, and they've said, "Oh, yeah. Uh-huh." But it makes sense to me.

Hendrie: It would seem there might be one other advantage in that I would suspect a MITRE might have a better chance of recruiting and maintaining unusually talented people.

Everett: Oh, it does. That's one of my points. The government…

Hendrie: Well, the government. Who wants to work…if you're really smart why are you working for the government?

Everett: There are some very smart people working there, but they're scarce unless you can get up to the top where the rewards and power and accomplishment are great enough to make up for the troubles and lack of money and whatnot. But that's right. And that's the fundamental thing. You want a strong organization that has to be flexible. Strong, flexible organization. It's very difficult to get it in the government. Now the industrial people say, "We can do that. We've got great people." But it turns out that it's very difficult for them to do that at the same time that they're competing for business. It's like getting your house built by your architect. <laughter>

Hendrie: Usually doesn't work out so well. There are exceptions.

Everett: There are exceptions. The right kind of skilled person or outfit can do that. Particularly if they are successful enough to be snotty with people who want them to do things that don't make sense. But the trouble that industry has is that government is always asking them to do something silly, and they don't have the steel in them to refuse.

Hendrie: You spent the…after you moved on to MITRE, you initially worked on the SAGE portion of MITRE?

Everett: Me?

Hendrie: Yes, you.

Everett: I was the technical director.

Hendrie: You were the technical director for all of the technical…

Everett: For the whole technical organization. After a couple of years, I became vice-president for Technical Operations, and then a few years later I became executive vice-president, and then president.

Hendrie: And then you became responsible for the business?

Everett: Yes. I felt pretty responsible before because the technical organization was most of it. As an FFRDC and a non-profit and so on, the emphasis is on the technology and the job you do for the customer. And the finances and things like that in marketing and whatnot are a different matter.

Hendrie: And much more modest than in a conventional business.

Everett: Yes. I don't know how MITRE would do if it had to compete in an industrial world. I think it would depend on how rapidly we could build the skills that are necessary to live in that world before technical people ran out of work and collapsed.

Hendrie: I don't believe, I actually don't know whether they are non-profits but other primarily technical organizations that have tried to foray into the commercial world, such as BB&N [Bolt Beranek & Newman] that have found it very difficult.

Everett: Another thing that I think would make it very difficult, if that happened and you sat down and said, well, it isn't that I have a company that hasn’t got all the things that it needs. It's that I own this tremendous technical organization. And MITRE is like a huge multi-billion dollar organization. It's like the engineering arm of this organization. It just doesn't have all the production and the marketing and all that jazz, service. If you're going to make any money, you don't make it out of an engineering organization you make it out of production. So the thing to do would be undoubtedly to combine with somebody that had the production capability in a worldwide service organization and so on. Then provide them with a strong, coherent, know-how-to-work-together technical organization. That would give them a better chance, I'd think.

Hendrie: And make some great products.

Everett: Yes.

Hendrie: Because you make more money repeatedly selling the intellectual…the fruits of your intellectual endeavor rather than just selling it once and going on and doing another thing. <laughter>

Everett: People make a good living by giving advice, but companies don't. Individuals do. <laughter>

Hendrie: There are a couple of other things that I wanted to touch on. I read somewhere that you, in your

your many, many things you did, probably earlier rather than later in your career, you had a couple of patents. I'm just curious, could you just touch on those?

Everett: I had a patent on the display system in SAGE which was the only part that might conceivably have been any value was the light gun. I think the light gun was proper for its time, but it's obviously not the time now. So, I never worried about…the people that were fortunate enough to work in the computer business in the early days; everything we touched was new. And if you spent all the time patenting things, I suppose you could have made some money, but I don't know. Jay made some money out of his core patent, and he deserved to. But all the other things, I think he had a couple of other patents, but I don't think they made him much money. I never bothered about patents. Probably should have.

Hendrie: Were there any others? Was there one that had something to do with drums or was that not a – I just found some reference somewhere.

Everett: I don't know…I don't know what's patentable.

Hendrie: You don't know what you've got patents on. And then is it really a valid patent is always the second question.

Everett: The only reason I've got the display patent is that IBM made a deal with MIT that they could patent anything they wanted and give MIT a license and the Air Force a license. I don't know what they – they patented a lot of stuff. I don't know what ever happened to it.

Hendrie: When did you start becoming involved in Digital Equipment? I know you have obviously known Ken for…

Everett: I've known Ken for a long time. He worked for us at Lincoln, and he left about the same time Jay did and started this company. And I didn't know – I mean – I knew Ken. I'd see him every once in awhile, talk about what he was doing and so on. But I never had anything to do with it until I retired, and then he asked me if I'd serve on the board. And, of course, I said yes. Delighted. So that's what happened.

Hendrie: That's how you joined the board.

Everett: Yes.

Hendrie: I don't know whether you have any comments you would care to share or not. I'd understand if you don't. I'd be perfectly happy to turn off the camera if you wanted to share some not on camera about what happened in the late days of Digital when Ken clearly ran into some trouble at Digital.

Everett: Well, I'd rather not have that recorded.

Hendrie: A couple of other questions, a little bit more general. When you think back over your long career, what are the things that you're proudest of or feel best about of the many things that you've accomplished?

Everett: I don't know. I feel good about Whirlwind and the part I played in it. I feel good about SAGE. I feel very good about MITRE, which I had a lot to do with, and it's a pleasure to see it thriving. It seems to be doing good things and pretty much the way I wanted it to. So those are things. I've known a lot of great people. That's been a great pleasure to me over my life. I'm very happy with my family. I have six sons, you know.

Hendrie: I didn't realize that. That's wonderful. Are any of them engineers?

Everett: No, but I have a grandson who's an engineer, and he actually works for Lincoln.

Hendrie: Very good.

Everett: He has a master's from MIT, and he works in Division VI and doing very well.

Hendrie: Very good. Do you have any advice to give young people who might be thinking of an engineering career today?

Everett: I don't know. I think the thing to do is to find a job where you have opportunity for experience to learn things, to do things. Let the future, after that, take care of itself. You don't want to get stuck in a bureaucratic organization. I was very lucky. I don't know how many opportunities there are like I had. It wasn't me, it was the opportunities. But I've been lucky all my life. And so being lucky is a good thing. But my grandson seems to be doing well. He's getting lots of experience. He's working on an exciting program. Very smart. That's my feeling about it. Engineers like to build things. Find something you'll want to build.

Hendrie: Okay. Good. Well, thank you very much, Bob, for agreeing to do this oral history for the Computer History Museum. It's been a pleasure.

Everett: It's been a pleasure talking to you, Gardner. I wish the History Museum the very best.

Hendrie: Thank you very much.

Everett: I was somewhat involved in the start of the one out in this end, and I certainly hope you all do very well. I'll try to get out to see it.

Hendrie: Very good. Now, I just thought of one more thing I'd like you to talk about.

Everett: What?

Hendrie: Just tell me, tell on camera, the story of the end of Whirlwind. You were telling me a little bit earlier. I'd just like to get that for the record.

Everett: Well, Whirlwind was sitting there, and it belonged to the Navy because the Navy spent the money to build it, although they had a lot of additions paid for by the Air Force. And Bill Wolf who used to work for us – not the one at the National Academy – he had a building in Concord, and he thought it would be useful to him. We thought he was crazy. But he arranged for the Navy to take title to the computer and various and sundry other things and move it out there and to use it. And when he was finished with it, to give it to the Smithsonian. So he did that. And he got some of the Whirlwind technicians, and he wrapped it up and took it out, and he made it work, and I got to hand it to him. Eventually he didn't want it anymore, and he offered to deliver it to the Smithsonian for $100,000. The Smithsonian wasn't about to pay anybody $100,000, and so nothing happened. Then, in fact, one of the stories was about one of the guys that we were dealing with at the Smithsonian because they were talking to us about what we'd done, came out to look at the Whirlwind in Concord. And they had a date with Wolf. They went and he didn't show up. They waited awhile, and then they walked around the building. And then they found an open window or something, or an unlocked window, and they climbed in. They wanted to see the thing, and Wolf was watching and called the police. <laughter> Which is a picture of how relationships were between Wolf and the Smithsonian. Anyway, so that calmed down and then one day Ken called me up, Ken Olson, and he said, "Bob, Wolf just called me, and he is scrapping the Whirlwind and throwing it out in the junk heap. And he's told me if I wanted a souvenir, to come over. What can we do?" So we agreed. He'd go over there with some of his summer students and a couple of trailers and salvage as much as he could. I'd get hold of the Smithsonian.

Hendrie: Now, Ken's at Digital now.

Everett: Yes, oh yes. And so I spent a couple of hours trying to find anybody. It was summertime. I couldn't find anybody at the Smithsonian who had any interest in this whatsoever. The people I was dealing with were all of for the summer and God knows where. So Ken put it in the trailers and took it away. And then sometime after that, a year or two, he moved it into a warehouse. I got to thinking about it again, and I said to myself, “Well, why don't we take it and make a display out of it. And then we'll call Smithsonian and see if they want it.” So the Smithsonian wasn't very encouraging about this. They thought that… they had seen a lot of amateur displays, and they didn't think much of it, but after all these were the people that built Whirlwind. <laughter> So, they loved the machine. Anyway, so we did that. We went over with Ken, and they picked out a selection of stuff for this display and took it back to MITRE. And John O'Brien, one of the old Whirlwind hands who worked for us, he put it together, and we set it up in the lobby and asked the Smithsonian people to come. And they looked at it and said, "Gee, that's great. We'd great. We'd like that." So, we held a big party of Whirlwind people to come and say farewell to Whirlwind. And then we took it down at MITRE's expense and put it up in the Smithsonian, where it stayed for some years. We had a welcome Whirlwind party in Washington for it. And it stayed there until Smithsonian did a big computer display. And then the display we provided it disappeared. I think there is some pieces of Whirlwind, and I imagine that they've got some others. And Ken kept a lot of pieces which I think went to the Museum.

Hendrie: They probably did. I think we do have pieces of Whirlwind.

Everett: So that's the story of Whirlwind. It's still around. <laughter>

Hendrie: Still around in different places.

Everett: I assume you have a copy of the Whirlwind book?

Hendrie: Yes. All right. Thank you.

Everett: You're very welcome.

END OF INTERVIEW

