Oral History of John Blankenbaker

Interviewed by:
Lee Felsenstein

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Lee Felsenstein: -- 14th 2007. We are in the home of John Blankenbaker, in Chadds Ford, Pennsylvania. I'd like to start by asking you, John, first of all, where were you born, and date of birth? And tell us something about your family.

John Blankenbaker: Okay. I was born in 1929 at the start of the Depression, in Oklahoma. My family was a farming family, largely in dairy and cotton. Of course, for the dairy business, we grew alfalfa, corn, wheat, for feed for the animals. And times were not easy, but we did well enough. Perhaps the severest limitation on the family was that we did not own the land. It belonged to a Native American. So in 1937, the family decided to move to Oregon to a farm that belonged to a cousin of my father. And so for the first seven years I lived in Oklahoma, and then for the next sixteen years, I lived in Oregon.

Felsenstein: May I ask something about your parents… about their background?

Blankenbaker: My father was always a farmer, though he had a strong interest in becoming a minister. And as a matter of fact, he did one year of work at a seminary, started a second year but fell ill, so seriously ill that continuing the year was impossible. My mother was a schoolteacher and they met at the church in the nearby town.

Felsenstein: And so your upbringing was a farm upbringing for the first seven years?

Blankenbaker: Very definitely.

Felsenstein: Yes.

Blankenbaker: [laughs]. We lived on a farm. The only knowledge that I had of town life was at my grandfather's in Apache, Oklahoma, population several hundred. So not a very sophisticated town, but that was my alternative, but basically as a farming family.

Felsenstein: Was the family comfortable or was it hardworking or both?

Blankenbaker: Well, it was hardworking. Dairy farming is twice a day, seven days a week. Now, since we left there in 1937, when I was seven years old, I was never involved in that work level. But my father, my older brother, my mother, were very heavily involved in work. And though there was free time for activities, my mother was active in a club, did a lot of quilting, and they were very active in the church.

Felsenstein: How many brothers and sisters did you have?

Blankenbaker: I had one brother that was ten years old than I was. And so I was almost the start of a second family. And then I was followed by a younger brother two years after my birth. So there were three of us, three children in the family, but as almost two families.

Felsenstein: I see. You attended school, I imagine, before you moved from Oklahoma?

Blankenbaker: Oh, that's correct, I did start in Oklahoma in a four room school, divided in pairs of grades. And when I moved to Oregon, I was then in one and two room schools, until I graduated from the eighth grade. And I have some admiration for those one and two room schools. I enjoyed them very much because as long as you did your work, and didn't make any noise, got your homework done, you could do anything you wanted to do. So I took advantage of the library, read quite a bit of history that was one of my favorite topics to read. And to this day I enjoy reading.

Felsenstein: Farming is always, I wouldn't call it a technology intensive occupation, but nonetheless there's a fair amount of technology of different levels. Can you remember any of the technologies that were used around the farm then?

Blankenbaker: Oh, yes. First off, we had no electricity. So for example, this meant the cows were milked by hand. Okay, we did have a telephone, and it had a coded signal -- four longs and two shorts, the old party line. Later in life, when we had a telephone that rang only when the call was for you, I was very puzzled. How'd you know it was for you? [Laughs] So, the technology on the farm was mostly power: tractor, bailers, hammer mills for grinding grain.

Felsenstein: And so the major power source was not electricity, since you didn't have that.

Blankenbaker: That's correct.

Felsenstein: And so what was it?

Blankenbaker: It was tractors and horses, the major power source.

Felsenstein: Okay. So it'd be a gasoline tractor, and there was a power takeoff or something like that.

Blankenbaker: Right. It was the Fordson tractor, as I well remember. And my brother just sent me this last Christmas a model of such a tractor.

Felsenstein: You would have lived through the Dust Bowl of 1935. Do you have any recollections of that?

Blankenbaker: I have no recollections of that. And in western Oklahoma it was very severe. Where we lived some years maybe the rain would be insufficient. The real problem was that prices for farm goods were low. They were very low. And though we were never hurting, it was impossible to get ahead. I think my parents would've liked to build a new home, but it was just impossible to get that far ahead.

Felsenstein: So are there any particular memories that stand out from that time, which may or may not have any relevance to your later years?

Blankenbaker: Well, there are four events that I remember from those days in Oklahoma, that show that I did have a natural curiosity. One, I'd observed that a jar of water, that the water level went down with time. And I filled the jar up again and made again another experiment and found that it went down. And

so I asked my parents about "Where was the water going?" Could've been that the dogs were lapping it up or something of this nature, but it had enticed my interest.

Another time I was curious as to what was inside a .22 bullet. And the obvious thing to do was take it apart and find out. So, on the concrete porch, I laid the .22 bullet and started beating it with a hammer. It went off. I ran around the house one way and my family ran the other way, until they caught me. They found that I was quite safe, but it had been a little bit of excitement. It never discouraged any investigations, but perhaps I should've been a little more cautious about it.

Another thing that was a puzzle at the time was the Bon Ami can, that was a powder cleaner, and you may remember that on the Bon Ami can there's a picture of a girl carrying a Bon Ami can. And the Bon Ami can of course had a picture of a girl carrying a Bon Ami can. So this recursion went on indefinitely, and I was very puzzled about how far it could go. And it's not how far they carried it out, but it seemed like to me that it was sort of never ending. I didn't understand the word "infinity" then, but I was very bothered by this whole concept.

Another thing that has had a big influence on me is that some summers in Oklahoma it's very warm. So warm that it's better to sleep outside on the ground. So we would spread the blankets on the ground and we'd go to sleep there. And looking up at the sky I'd see these stars. Now we were far enough away from any big city that you had good visibility. I was very, very impressed at that time, and I remain impressed today, by the Milky Way, and the number of stars in it, and what that represents, and where we are in this larger picture. And perhaps that had some influence on me, I don't know.

Felsenstein: Did you parents encourage your explorations in any way?

Blankenbaker: My mother was a very strong advocate of education, of reading, and something of this nature. But they didn't particularly encourage physical things. They were tolerant. At a later time, I took my mother's washing machine apart, to see how it was assembled, at least a portion of it. And put it back together again. But my mother who was aware of what I was doing didn't raise any objections, so there was a certain tolerance on their part to my experiments, my efforts and explorations.

Felsenstein: So you were seven when the family moved, is that right?

Blankenbaker: To Oregon, I was.

Felsenstein: Okay. And so then what was that environment like?

Blankenbaker: [laughs]. Well, we moved to a farm that was sight unseen. We found out when we got there that it was half a mile off the road through the woods. And it had no electricity and no phone. Perhaps we knew that, but I don't think we understand clearly that it was so far off the road. So at seven years old, I was marching through, or walking through the woods to get to school, had to walk to school about a mile-and-a-half. Not all of it through the woods, but it used to scare me a little bit.

Felsenstein: Well, certainly there're not many woods in Oklahoma, I imagine.

Blankenbaker: Oh, not to the extent that there are in Oregon. But there are definitely woods. We owned a farm in Oklahoma, had woods, and --

Felsenstein: So, my stereotype is of complete pool table surface and so forth, not true.

Blankenbaker: Yes.

Felsenstein: In Oregon, how are things different aside from the physical environment?

Blankenbaker: Not a great deal different. Still, it was, on this poor farm, it was pretty hard making a living, and so we did a lot of work off the farm. And let's see, I guess when I was still seven years old, we picked hops one summer. Hops, as used in beer, which at the time had to be picked by hand. And my younger brother and I, while we were on the hop-picking venture, had to pick a basket, which is about four feet tall, full of hops every day. Our pay for this was an ice cream bar each.

Felsenstein: But were you four feet tall at that time?

Blankenbaker: [laughs]. I was four feet tall, but we were just barely above it, the basket. And we could hardly move the basket.

Felsenstein: I see.

Blankenbaker: We picked the hops one at a time, which was hardly the way to get rich fast.

Felsenstein: Then so you attended a slightly larger school, did you say?

Blankenbaker: No, slightly smaller schools. They were one and two room schools. The first one in Oregon was two rooms. On another move that we made, it was a one room school, where I went for three years, I think, skipping one year.

Felsenstein: When was the skipping? What year was it?

Blankenbaker: Fifth grade.

Felsenstein: Okay. So you were, your family was still renting?

Blankenbaker: At the time, we were still renting, until 1943. So for six years, we rented, and not all of that time were we farming. But then in 1943, my parents bought a farm, and all of this is in very much the same neighborhood.

Felsenstein: What was the town?

Blankenbaker: Albany, Oregon.

Felsenstein: In the Willamette Valley.

Blankenbaker: You're right, very good.

Felsenstein: My sister lives in Portland, and my father lived in Eugene. Okay, so tell us more about your own intellectual development, and your interest in technology, how that developed in your upbringing.

Blankenbaker: Until I was in high school, I have no clear recollection of any outstanding event. In high school, it was fairly typical. I did work on automobiles, on our automobile. I tore an old automobile apart, down to the last nut and bolt. I started driving to school as a licensed driver when I was age 14, because the high school did not provide bus service. You had to get to school on your own. So I drove the family car and the head of the school board signed a certificate stating that I needed a license to get to school. So, it was very typical. I read "Popular Science." I built battery powered radios, but we did have electricity by that time. Such activities were fairly typical. Other activities and high school, I was in two plays, enjoyed that tremendously. I tried running the mile in track, which I did not enjoy. Came back the next year as manager, which was a more pleasurable activity.

Felsenstein: The tearing the car apart, why did you do that?

Blankenbaker: Well, the car was so old that it was of no value and I was curious, a little bit, about the parts of a car. I'd basically understood by then how an internal combustion engine worked, and among the things that I read during this period of time, are the college textbooks of my older brother. The one that I found most enjoyable was Business Law, when I was probably ten or eleven years old, not even in high school yet. But I read other books about mechanical engineering and so on.

Felsenstein: So that was an exploration, just to sort of see what the car was made out of, is that correct?

Blankenbaker: Oh, that's correct. Yes. How the parts are put together, the parts of it. And I saved the nuts and bolts and segregated them as raw material for future projects.

Felsenstein: Okay. The radios you worked on, tell us something about that, and I would like you to be as technical as possible.

Blankenbaker: The first one was just simply a one tube radio, battery powered, nothing complicated. Then I tried paralleling the two tubes to see if I couldn't get more power. And strangely enough, no it didn't. [Laughs] The radio basically brought in, I think, two stations, the local stations, though once when electricity failed, I brought in Salt Lake City, which was just an amazing, to me, my one tube radio, would bring in a station from that far away, when the local stations were off, were blacked out.

Felsenstein: You'd need an external antenna of course. How long was yours?

Blankenbaker: As I seem to remember, I went to the roof of the barn and ran a wire down toward the house. And I had done that earlier because I'd tried building a crystal radio, and I put that antenna in for it. The crystal radio didn't work, in part I think because the earphones sold to me were bad, and non-functional. I never did make it work. But the one tube radio receiver had a very conventional circuit.

Felsenstein: Was this a regenerative circuit or just a grid detector?

Blankenbaker: It was a grid detector, yes.

Felsenstein: Okay, and what was the tube number in it?

Blankenbaker: I have no recollection. [Laughs]

Felsenstein: Oh, okay. Did you follow it with other radios, or that was it?

Blankenbaker: No, that was the only one. Having built it and saw that it worked, I wasn't that much concerned to go on and do anything more elaborate.

Felsenstein: And there was the failure of the parallel tube experiment.

Blankenbaker: [laughs]. I asked around some people that I thought, my physics teacher and another student in the school who did a lot of work with radios, as to why it didn't improve the volume. They gave me quite unsatisfactory answers, they didn't know. Of course it was a question of impedance matching. And it really didn't change much of anything.

Felsenstein: So, proceed and talk about your education in high school, for instance. What were the main areas of study, or did you get any choice in it?

Blankenbaker: Oh, yes, there was a choice, and I took the curriculum that was called "College Preparation." There were even choices within that, but I'd had the science electives, which meant biology, chemistry, physics; I took all of the mathematics that was offered, which went through calculus; three years of English and then Social Studies.

Felsenstein: So you elected the kind of scientific sub-curriculum of the college preparatory curriculum, is that correct.

Blankenbaker: I did, yes.

Felsenstein: Why?

Blankenbaker: That just seemed to be of most interest to me. Though when I was in the ninth grade, I wanted to be a draftsman; as I went further my sights were then a little bit higher, though it was by no means clear how I was going to afford college. In the spring of 1946, when I was a senior in high school, and thinking about college, and not knowing how I was going to afford it, a Navy recruiter came to the physics class and explained that the Navy had an Eddy Test and that if you passed the Eddy Test, they would send you to eleven months of electronics school And you could sign up for only two years. And at the end of that, you had four years of college. Obviously, I took the Eddy Test, I passed it very easily. I was enlisted in the Navy, and so began a new phase of my education.

Felsenstein: Okay. So tell us about that, for instance the Navy and the technical school.

Blankenbaker: Okay. They sent me to Great Lakes, north of Chicago-- that was boot camp for two months. Following that, we commenced about seven months of what was called Primary School, and there was a lot of fundamental work: resistors, circuits, vacuum tubes. The ultimate event was that we build a radio receiver. And so we studied radio receivers and transceivers and built a radio receiver with several tubes. That was followed by another school in Washington, D.C., that was about three months long and we studied there the advanced equipment: radar, sonar, loran, and some other things of this nature. So, 15 months after I had joined the Navy, I was now ready to go to work for the Navy.

Felsenstein: As an electronics technician?

Blankenbaker: As an electronics technician, third class. And this was besides the technical experience that we had in school, it was an eye-opener to me in several ways, for this farm boy that had never experienced the big city life, to visit Chicago, the art museum, Museum of Science and Industry, Washington, D.C., The Capitol, the White House, Williamsburg, things of this nature. All of these were broadening of my experience, besides the technical training that I was getting in the Navy.

Felsenstein: Did you learn much from your fellow sailors?

Blankenbaker: Nothing much from that, it was the school that was basically responsible. Many of them were very interested in radio, and so on, but I observed that their knowledge, their experience, was really very limited. And it was all swamped out by the technical characteristics of the equipment that we were learning. And so after 15 months, and I was ready to go to work for the Navy, they assigned me to a destroyer in England. An American destroyer, it just happened to be in England. They got me there eventually, and I commenced work largely on radar. It turned out I think there were five third class electronic technicians onboard the ship, and no one any higher than that in the electronic technicians. So, there's very little direction, it was left to you sort of to find the work to do and to do it. And I had no problem. I worked on all kinds of radars, had a lot of fun about it. I even worked on the fire control radar, until they told me that that wasn't my responsibility that was another department, the fire controlman. I worked on electronics; I worked on mechanical aspects of it, and so on. But we were back in Newport, Rhode Island, and altogether on that destroyer was not more than about five months. And then the destroyer was slated to go on a midshipman cruise to the Mediterranean. I volunteered to stay in beyond my enlistment, if they would just let me go on the Mediterranean cruise, give me a bunk and food; they didn't have to give me any pay. But they said no. They said if I wanted to sign over, sign up again, they'd give me a promotion, and I could go on the midshipman cruise. But I said no, I joined this navy to go to college, and I was going to go to college. So, it was back to home, back to Oregon State College.

Felsenstein: One question, you were apparently the most competent technician of the five, would that be fair to say?

Blankenbaker: I think that's true.

Felsenstein: And did there arise any, I want to say hierarchy, but that sounds too official, but I'm saying, did you rise to the top or was it a matter of your just keeping to yourself?

Blankenbaker: Everyone was independent. I kept to myself. I did my work; I didn't attempt to influence anyone else. Most of the others did really nothing. And so the electronics officer, who was not involved on a daily basis, did tell me later that he had, in the report of how long it had taken me to adapt to or become a useful member, had given me a period of two weeks, and he said he had never given anyone that short a time. So, I perhaps made some impression on the officers from the very beginning because the first project that I worked on was a wire tape recorder. And the wire had broken, but there were instructions about how to fix the wire. And I did so. The officers found out about it, took it up to the wardroom, and had great fun playing with it, broke the wire, would bring it back to me the next day, ask me to fix it. They'd take it up to the wardroom, the wire would break again. It was not a highly technical--it was not a good product.

Felsenstein: Not rugged.

Blankenbaker: Yes. But I worked on some transmitters and some receivers. There were some electronic countermeasures. I was studying the Morris Code a little bit. I did once, listening to a very slow sender: B-O-S-T-O-N, Boston! I got so excited I never returned to the subject. But again, yes you could send information this way. I had proved it, I had received the word Boston, but I sort of lost interest in it then. Just typical of many things that I did. After I proved it, one tube radio receivers, I lost interest. After I received the word Boston, I lost interest.

Felsenstein: So that should keep you moving in some direction. So where did you go? You went to college next, right?

Blankenbaker: Yes. I returned home and I went to college, and I enrolled in physics. The question was "Should I be in physics or should I be in electrical engineering?" I took aptitude tests on two different occasions, and the net result is, they said, "Oh, yes, yes, those are good choices, but have you thought about architecture? Have you thought about chemistry? Have you thought about teaching?" Which didn't help me at all because I was trying to get some guidance as to what I should be doing. So I had enrolled in physics, I stayed in physics. It would have been possible to switch to electrical engineering without any difficulty. In general, I liked the concrete a little better than the abstract, but I could stay with physics until we got to particles [laughs] got to Schrodinger's Equation much later and so on. So it was in physics. I had a lot of credit from the Navy work. Oregon State gave me a lot of credit. So, I had no problem at all in piling up enough credits for both physics and mathematics. And I was interested enough in mathematics to be taking it. I still had credits left over and I had taken some more German, I could've had a B.A., also. And I was so interested in other subjects that I wanted to sample them: philosophy, psychology, sociology, religion. I did take some German. All of these things, but I didn't pursue. Again, I sampled, find out what they were about a little bit, and then sort of lost interest.

Felsenstein: Now this was OSU, where was the campus?

Blankenbaker: Oh, the campus is at Corvallis, Oregon, there in the Willamette Valley, not far from Albany where we lived, so it was only 20 miles to college, though I did live on campus all the time.

Felsenstein: Good. And you were enrolled in Physics.

Blankenbaker: I was enrolled in Physics.

Felsenstein: And did you graduate in Physics?

Blankenbaker: I graduated in Physics and in Mathematics, two Bachelors degrees.

Felsenstein: And you could have had a third there, you said?

Blankenbaker: I could if I worked a little bit harder and had a third. I did try some stupid things like taking too many courses. One semester, or term, I tried 21 hours. 16 was normal, 18 was outside, and I tried 21. I had such conflicts that I couldn't even go to the chemistry lectures, which resulted in my only C. But I didn't get all that many A's. I wasn't that great a student. I was interested in a lot of things, but I wasn't entirely, that I'd want to go into things in that much depth.

Felsenstein: Tell me a little about any extracurricular interests.

Blankenbaker: I was in a couple plays. That was about the extent of extracurricular activities. Oh, aside from playing chess, or something of this nature. I debated one term, I guess it was. One thing that was extracurricular my freshman year, is that I happened to read, in I think it Popular Science, about this new computer, as they called it, this roomful of equipment, with thousands of vacuum tubes, and only two numbers, zero and one -- strange combination. Well, the thousand vacuum tubes didn't discourage me too much, because when you've worked on a radar that's got maybe a few hundred in it, it's not a far stretch of the imagine to thousands of vacuum tubes. It was a little stretch of the imagination, though, only two numbers, zero and one. I'd never heard of such a thing. So, going to work, I figured out how I could write a number with only zero and one; how I could convert that to and from decimal; how I could do arithmetic in binary. This wasn't entirely just an academic exercise, because in the Physics lab, we had to do a lot of computations, and they wanted you to use logarithms. Now, most engineers and most physics students carried slide rules. Usually we faked it, that is we got the first three digits maybe from the slide rule, and we added a fourth digit or something of that nature at random. But here was a computer, maybe I could make a computer. So this was my motivation for studying this binary number system, and I think I went so far as to work out how I could make an arithmetic unit. And though I don't remember all the details of it, I do remember that it had a novel device in it. I say novel in the sense that something I'd never seen before. I was thinking of electromechanical devices because that's something very concrete. Vacuum tubes are a little bit abstract, the relay seemed very concrete.

My novel device was based upon a rod which had two stable positions, and it could change positions by rods that came this way that were energized by electromagnetic coils. I didn't realize it at the time; I learned later that it was a JK flip-flop. The memory was to be relays, and it was not a stored program computer. I was perfectly willing to turn a crank, to select the operation, to turn a crank, to select the memory, this bank word that I was talking about. So it became time to add up the cost. Now, remember, that all I had basically was my GI Bill, which paid books and tuition and something towards living expense, and I had maybe $1000 that I'd saved from the Navy. Well, it was obvious that I couldn't afford this device, and so I lost interest in it, and never did anything more with it. But I was impressed by computers as an intellectual exercise. It was something to be interested in.

Felsenstein: And you essentially developed binary arithmetic just from the concept of ones, the basis of one and zero, or did you read up about it?

Blankenbaker: Oh, no, no, everything I worked out just on scratch paper myself. I had never read anything about binary numbers, and I don't know that I ever did, really, so to speak. They weren't taught in school, and it was not a subject that a lot of people talked about. No, it just, by how do you write a number with zeros and ones, how do you do arithmetic, how do you convert it to decimal? To and from decimal? So, it was just, I worked it out. And I'm embarrassed, though I smile at it happily now, how long it took me. It really took me several days to work out these simple things, which now I guess grade school students understand -- or some of the better ones do. But at the time, I didn't know that it was taking me such a long time to do this. [laughs]

Felsenstein: Well, it would seem that, I can certainly attest that I would never even have tried, because I had an older brother to instruct me in everything.

Blankenbaker: [laughs]

Felsenstein: But your older brother was far beyond you, so you had to do it yourself, so I congratulate you for that. Alright, before we approach your employment years let's try to concentrate on what more you can say about your college experience.

Blankenbaker: Between my junior and senior year, I applied for a summer intern job, with what was then called the National Bureau of Standards. And I did get a position. There were a hundred of us interns, and four of us were assigned to something called SEAC, which stood for Standards Eastern Automatic Computer. This was based, I guess, upon the EDSAC. It was operational. It'd been operational about a year. It was probably the most useful computer in America at the time -- the most powerful, and the fastest. A serial machine, still yet, but it was in use seven days a week, 24 hours a day, lightning permitting. It was sensitive to thunderstorms. It was during thunderstorms that private individuals could maybe try a program, if they understood that sometimes it might not get any result.

Felsenstein: Where was this job?

Blankenbaker: Oh, this was in Washington, D.C. It was at the Bureau of Standards main campus, which is north part of part of town, northwest part of town. And I felt so lucky that first I even had the intern job, and that I was one of the four chosen. And I wondered, "Why was I one of the four chosen?" So when the personnel office in the course of the summer called me in for an interview about how it was going and this, that and the other, I was bold enough to ask, "Why was I selected for this job?" because I felt so lucky. He says, "Oh, you had lots of chemistry." [laughs]

Felsenstein: [laughs]

Blankenbaker: Well, first his logic was wrong, and I hadn't had a lot of chemistry. [laughs] And I thought, let's just drop it, maybe they'll take me out. [laughs] I was anxious to stay there. The work was trivial, the assigned work that we had, but the opportunity to learn a little bit, of course, was great. We were introduced to Boolean equations, logic, and I did get late in summer my opportunity to write a program.

Felsenstein: [John holds up a portrait] Let’s take a look at the picture of you at age 18 That was just prior to discharge, you said from the Navy.

Blankenbaker: That is correct.

Felsenstein: Okay.

Blankenbaker: I was at Newport, Rhode Island. An artist in the USO made this drawing. And I sent it home and lost track of it until my brother found it and sent it to me just, oh, less than a year ago. And my wife liked it so much that she asked for it as a Christmas present. .

Felsenstein: Okay. Now, where we left it was the summer intern position with, you said, was it National Bureau of Standards?

Blankenbaker: Well, that was what it was called then. And today it is called National Institute of Standards and Technology, I believe is the modern name for it.

Felsenstein: You said that the work you were doing there was trivial, but the work that was being done there was what?

Blankenbaker: Oh, they were solving problems for everyone else in the government. I imagine that the Atomic Energy Commission was there with a lot of work for them to do. But as I understood it, it was for all kinds of agencies. Incidentally, the computer was still having a few little problems. They had to trim up the signals in the delay lines, and sometimes they did not quite have the trimming just right. Debugging, as I understood it was very difficult. It had to be done with an oscilloscope. You could not look at a word in memory. You could not study anything that way. All you could look at is those wave patterns on an oscilloscope, which meant that it was a little bit difficult to do.

Felsenstein: Tell us about the design of that computer. I think you mentioned a serial.

Blankenbaker: Oh. The original machine was serial based upon mercury delay lines for the memory. There were 512 words. They were very long words, some where in the order of 50 bits. I am not sure about the exact number. It was a four address instruction, alpha, beta, gamma, delta, two operands, a result, and the location of the next instruction. And it was binary all the way, of course. Input teletype, output teletype. Later they decided to try a new memory, or add a new memory, 512 words of CRT memory, or Williams tube memory, where the information was stored as a spot in the phosphor on a CRT. And a screen on the exterior of the tube could detect, when you tried writing again, whether there was any information there already. There was a slight difference, but it was not reliable. At first the programmers rapidly converted all of the programs over so that they take advantage of this random access memory. It was much faster than the serial memory of delay lines, but it was unreliable. And later on they went back to the mercury delay lines as being reliable.

Felsenstein: My understanding, which is no doubt imperfect, of the Williams tubes, was that it was a refreshing memory. It was a dynamic memory.

Blankenbaker: That is correct.

Felsenstein: And that I thought that the information was simply scanned sequentially in a raster pattern and then repeated.

Blankenbaker: Well, that was the refreshment would probably be that way, but if you wanted to access any one word for operations, you could go directly to that word.

Felsenstein: So you could, in effect, direct a beam to a particular bit, I suppose.

Blankenbaker: Yes. In parallel to all the bits of the word.

Felsenstein: Right. So there would be N tubes if there was an N width word.

Blankenbaker: That is right. And the room where they were stored, all the faces of the tubes were staring right at you, or you were staring at them. Actually, it would have been, if they wished, it could have been the modern pixels with a display on the tubes. They could have done that. The 512 words, let's see, that is 2 to the 9^{th}, so 5 by 4 is another 512 positions. You are right, which would have been 5 by 10, or something of this. Yes.

Felsenstein: Yes. Alright. And in fact it was not like the IBM version, where there was a metal plate over the face, the tube. You could actually see them.

Blankenbaker: There was a wire screen.

Felsenstein: I see.

Blankenbaker: It was still visible. The dots were still visible. Yes.

Felsenstein: But you say they were not reliable because other effects, lightening at the very worst.

Blankenbaker: Yes. That made everything unreliable, not just the Williams tube.

Felsenstein: Right. Okay. So the main memory was delay line or Williams tube.

Blankenbaker: Yes.

Felsenstein: And there was a mathematic logic unit of some sort clearly.

Blankenbaker: Yes. About which I really know nothing that I could say, except that it was a serial machine, and it was fixed point.

Felsenstein: Okay. Your duties in regards to this were what, anything?

Blankenbaker: The interns, the four of us, were building packages that had these little delay lines, a fraction of a second, you know, and sometimes packages of diodes for the logic. I was given the assignment out of the four of building a tester for these diode packages, so that you could plug in a package and test whether all the diodes were working.

Felsenstein: So you were in the most fundamental level building logic modules, not very sophisticated, I imagine.

Blankenbaker: Yes. All of them were passive modules. There were vacuum tubes, but we had nothing to do with vacuum tubes. We were building the passive components, logic modules.

Felsenstein: What year was that?

Blankenbaker: 1951.

Felsenstein: You graduated with your bachelor's degree when?

Blankenbaker: 1952.

Felsenstein: And then where did you go to work?

Blankenbaker: Okay. At the conclusion of a senior year, I still had the job at the Bureau of Standards if I wished to return there. I applied one other place. I applied to Hughes Aircraft Company because they had a very special program that you could go to school half time and work half time, and get a master's degree. It was at UCLA. So I applied to Hughes Aircraft Company. They were into many kinds of activities, but I very fortunately, again, was assigned to a digital computer department. And that was an eye opener in itself, because they had a digital computer that was the size of a small suitcase, and it was for aircraft, for flying aboard aircraft. So after the roomfuls of equipment that I had seen in pictures or had seen at SEAC, which was several rooms of it, this was very impressive. And the machine was fairly easy to understand, too.

Felsenstein: This was military equipment?

Blankenbaker: Yes. MMAX 79. I think I can repeat the number today safely enough, can even remember it.

Felsenstein: This is very interesting. I mean, we should not be surprised but, in fact, in 1952 they had a computer of that size, vacuum tube or transistor?

Blankenbaker: It was still vacuum tube. At that time it was a little peanut tube, which was even smaller than my finger right here and diodes. Incidentally, diodes were still considered so valuable then that at night you had to make an inventory of the diodes in the lab, and all the free diodes had to be returned to the safe. And that is how valuable diodes were at that time.

Felsenstein: These are geranium diodes. Is that correct?

Blankenbaker: I think they probably were. That was still at that time. You are right. And Hughes was building geranium diodes. They were in the business of doing that. They were a leader at the time in that geranium diode.

Felsenstein: Were they point contact?

Blankenbaker: I think they were. They must have been. They mush have been. I just do not have a clear picture in my mind.

Felsenstein: Okay. So what was the work you were doing there?

Blankenbaker: The first few months was nothing much. I was introduced to several things, but after about three months the Hughes Aircraft Company formed a department to build a business data processor. "John, you would like to work on that?" "Yes." "Well, you will design the arithmetric unit", a binary coded decimal, serial machine, drum, magnetic drum memory, vacuum tubes. Even that, you see, still vacuum tubes, diode logic. I had no experience designing arithmetric units really, in spite of my interest in it. But no one else did, either.

Felsenstein: So that would answer the question of why you. The answer is, no, there was no one else.

Blankenbaker: That is right.

Felsenstein: And you had studied something about binary.

Blankenbaker: I knew something about binary, yes. And many of the other people had some knowledge and, again, it was another one of those luck of the draws, like being assigned to SEAC, going to Hughes, assigned to a digital computer project, then on the business data processor, being assigned to do the arithmetric unit. So it was learning on the job, and these were big, expensive machines. This machine had a motor generator that was like this in diameter, the motor and the generator. [John holds up his hands very wide]

Blankenbaker: And the whole object of this was merely to filter the power in that because it took 60 cycle power in, and it generated maybe 400 cycle power or something, but it made the task of filtering the DC power a little bit simpler, because you had such a high frequency AC.

Felsenstein: The 400 hertz was the military standard, at least for aircraft.

Blankenbaker: I am just taking a guess. I do not know what it was. But that was the whole object of this. So this was the scale of the operation. Because they were not available on the market printers, card readers and such. IBM had card readers, but we were trying for much higher speeds than that. We were trying for magnetic tape units. All of these were a part of the project. It was consuming quite a bit of money, and it was a pretty large department.

Felsenstein: I note that this was pushing a number of technologies.

Blankenbaker: Oh, it was. It was. And when a new manager came in he said, "Well, how many of these are you going to sell?" And they said, "Well, our estimates think maybe 20." And he said, "It's not worth it." So the project was canceled. The return just did not seem to him to be. It was costing so much to get to the first one, and then to sell only 20 of them, so the project was canceled.

Felsenstein: This was in line with Tom Watson's estimate that there might be a requirement for five computers in the world, or the nation, or something.

Blankenbaker: It was very similar to that. That was the idea. I do remember that one of the companies that we were talking to was a large department store. I will just say May's, but I do not know that that was exactly the case. And it was really underpowered in the sense of a short term memory, that is the magnetic drum. Just to do a payroll program would have taken all of the space that was available on the drum. Now this is in the days when 100 bits per inch was hot stuff. And someone estimated that with a flying head redesigned that we might get up to 150 bits per inch.

Felsenstein: So you were using contacting heads at that point.

Blankenbaker: They were what?

Felsenstein: Contacting?

Blankenbaker: Flying.

Felsenstein: Oh, but you were using flying heads?

Blankenbaker: Yes.

Felsenstein: Okay.

Blankenbaker: Yes. The original was started with a fixed head at a space distance than flying heads were recognized that you could get a little bit closer, and that it would compensate for changes in dimensions if things heated up and so on. But 150 bits to the inch. All along my life everyone, and especially myself, have underestimated what was possible. It has been unbelievable what we could eventually do.

Felsenstein: What was the storage capacity of that drum?

Blankenbaker: I think it was 1,000 words, a four address machine. So, again, like SEAC, two operands, a result, and the next instruction, so 1,000 words, something like that, fixed point.

Felsenstein: Okay. Was that the bulk storage, or was it tape for bulk storage?

Blankenbaker: Well, the large volume of storage would have been by tape. And we were doing two things. We were having loops of tapes, so that you could access any piece of it within maybe 20 seconds, or something like that. But not random access by any means at all.

Felsenstein: Yes. Tape never is. How many tracks were those tapes?

Blankenbaker: I have no recollection of that point.

Felsenstein: Now how far did they get on that project before they cancelled?

Blankenbaker: We were laying it out. We were committing it to hardware, like the logic equations were being committed to packages of diodes. The flip-flops had been built. They were being tested and things of this nature. Nearly all of the equipment was in early test, something of this nature, the line printer, the card reader. Some problems were being found, being corrected. It was a very expensive thing. The head of the department said, "Well, every flip-flop that you add, I think that adds $500 to the price." That was three vacuum tubes and a package. I felt a great pressure to try and eliminate the flip-flops, or to do things more simply. And in some of my free thinking, which even was not devoted to the project, but how simple could you make a computer? And I read the comments another man had made, and he had suggested that a flip-flop might not be an actual physical device, but might be a magnetic spot, the image on a drum, for example, a zero or one, that both represent a binary two-state device. So I thought about this for something. Could you make a computer where some of the flip-flops were on the drum? What I came up with was a simple machine which had actually only one flip-flop itself, and a special memory, about 25 diodes. And in this memory you stored the description of another computer, and the problem that it was to solve. And you asked this simple computer, now, what would the target machine do in this case? And so you would evaluate it step by step.

Felsenstein: And this is very much in line with Turing's thinking. Not that I know his thinking, but have you heard of his work?

Blankenbaker: Yes. People are always making a comparison to Turing machine. I had a finite amount of memory. He had an infinite tape. With my machine the internal state of the machine itself was besides the memory only this one flip-flop. Yet in spite of that severe limitation, I knew that I could take any computer and any program and that I knew a decided procedure for translating it and executing it. With the Turing machine I never felt that I could program one.

Felsenstein: Turing only really talked about the existence proof, or about its completeness proof, or something. I do not know. He did work on it, but.

Blankenbaker: Yes. I just never felt happy that I could solve a problem with a Turing machine. I never doubted the Turing machine, but I felt that it was a very, very awkward machine to work with, whereas the machine that I was working with was very straightforward really. It was not difficult, though it was very slow.

Felsenstein: Now, you were doing this outside of your work duties?

Blankenbaker: No, no. It was in both. Both. In part because I was motivated to try and do something simpler at work, but I was fascinated by it and I did do some work outside, too. I could not have argued that it was done outside work hours. No, not at all. And incidentally, when I took it to the Patent Department, thought that they might be interested in it. And I said, "This machine, right here, can do what any other computer in the world can do. It is not general." Well, he says, "If it is not general, there is nothing unique about it."

Felsenstein: So alright, maybe if you are a hedge.

Blankenbaker: And I will not claim that I was the only one that arrived at this solution, either. But what it left me with is that you can make a simpler computer.

Felsenstein: Now this was a paper design, right?

Blankenbaker: It was a paper design. I do not think anyone ever implemented it in that form right there. No.

Felsenstein: And so it was strictly internal. There was no publication of it, right?

Blankenbaker: Yes, there was a publication. I wrote an article for IRE Transactions on Electronic Computing that appeared in 1958, but they were running several months behind so that may not be the year that is on the magazine cover. But it appeared in 1958. The title of the article was "Logically Micro - Programmed Computers." Because essentially it was micro programming, I will admit. Perhaps you would have said nano programming, or something more even, and it is fully described there.

Felsenstein: Now was micro -programming, it clearly was underdevelopment at other areas. Had it appeared by that time?

Blankenbaker: Micro- programming?

Felsenstein: Yes.

Blankenbaker: Okay. [Maurice] Wilkes in England, who advocated micro-programming. Matter of fact, he was very upset that I had used the words "logically micro-programming", because he was talking about small elements of hardware that could be put together, and I was talking about little bits of logic that could be put together. I felt that my title was perfectly justified, but he was very upset.

Felsenstein: He probably felt that micro-programming implied what he was doing.

Blankenbaker: That is correct, apparently, yes. So this led to some other thoughts, too. This was essentially a one-bit wide machine. The output of the data memory was one bit at any one clock time. So you were talking about one-bit wide processing. This led to some thoughts. Well, instead of representing a number as N bits wide, maybe we could represent a number by the probability that the next bit is a one.

Felsenstein: Now that is interesting.

Blankenbaker: Okay. If you had two such numbers, and fed them into an AND gate, the output is the product of those two numbers if the two inputs are statistically independent.

Felsenstein: Yes.

Blankenbaker: Well, that was a fancy thought that a multiplier might be as simple as a AND gate. That led to a need, of course, for random numbers to ensure some independence of that. Addition was a little more difficult than multiplication, but still you are led to the thought, see, what happens if you get two bits together on an OR gate for addition. Well, you lose one bit, you see. So instead of getting A plus B, you get A plus B minus the probability of A and B. So there was a slight error, unless you scaled carefully or juggled the bits. But it led to a lot of thoughts that maybe there was an alternative to N-bit wide processing and could be by one-bit wide processing.

Felsenstein: Except the bit would have a sort of depth.

Blankenbaker: A time depth. But what we are talking about here and everything is we are trading time and space. And you can carry this to an extreme. Vast amounts of time or vast amounts of equipment. And so you can vary the degree of this, too, but there are always these two considerations. Today most people think in terms of lots of equipment, as opposed to lots of time.

Felsenstein: But you must admit that they also think in terms of higher and higher clock speeds.

Blankenbaker: That helps. Now, especially with this statistical computation I am talking about, you want a very high clock speed because there are errors. But the law of large numbers, right, probability is that over the long haul you are right. So you want a very high clock speed to compensate for the errors that occur clock by clock. But on the gross, yes, you are right, would be right.

Felsenstein: Now where did this thinking lead you?

Blankenbaker: I tried applying it to some things, some questions, because after this business data processor at Hughes was canceled, I still worked for Hughes, and they assigned me to air traffic control. And I was thinking about the CRT's and where you have the tracing of an aircraft's flight. Nothing moves very fast there, though the plane outside is moving at 100's of miles per hour. Across the field of interest it is not moving very fast on the CRT. This kind of processing that I speak about might very well be used for following the paths of aircraft. So I have thought about it some from that standpoint. There may be problems that could be solved that way very well.

Felsenstein: Okay. Did it go any further than that?

Blankenbaker: No. No one else ever had the interest in this that I did. And always, of course, through trying to reduce cost. It was $500 a flip-flop. That was expensive. I envisioned things like dominoes. You can build a computer with dominoes. Okay. Two streams of those that merge into one stream is an OR gate. Change the path a little bit and you got a, what do they call it, A and not B. Course you got a

little delay, which is always necessary in any device. Even though you want to be fast, some delay is necessary. So just at every clock time you had to stand the dominoes back up again. But maybe if you thought this way, this could lead you to some other ways of implementing it that would automatically set the dominoes back up and so on. So in those days, I spent a lot more time thinking about some of the possibilities.

Felsenstein: That leads to the impression that you could work at a certain pace that would allow for this extra thinking. How was the job structured in a way that that was possible?

Blankenbaker: Well, the main thing was that if you got your job done, they were fairly tolerant. And I must say in the first two months that I worked at Hughes Aircraft Company, I had been on loan from one man to another man, and about three months into the job one of the men said, "Well, can I get John back again?" The other one said, "I thought he was still working for you." So in other words, I had floated between two men keeping myself quite busy and quite happy, and they never noticed the difference. I was not trying to cheat them, but they were tolerant.

Felsenstein: Okay. The position was engineer. Is that correct?

Blankenbaker: I guess that what it was called.

Felsenstein: Oh, do you know what the name is?

Blankenbaker: No. I do not remember.

Feinstein: Which is interesting in its own right? So the structure there, how would you describe it? It does not sound particularly rigid.

Blankenbaker: No. It was not. It was not rigid. There were several of us in the Logical Design Group. That is the group that basically I was in. I was in the arithmetic unit. Other people were on other things. The head of the group retired. I became head of the group. And things were dragging a little bit. But I set up targets and inspired some of the other people to produce towards this final result in a more straightforward way and show some results.

Felsenstein: You were a new, recently hired. I do not know how newly hired. You had been working for a little while there. How long before you became managing the group?

Blankenbaker: About two years. But we were all new.

Felsenstein: Yes. My point.

Blankenbaker: There was one man that had some previous experience in computers.

Felsenstein: So there was a group of young guys working on new problems that had never been faced before really, and pushing various technologies that had not been particularly developed. And there was nobody who knew what they should do. It sounds like a very interesting situation.

Blankenbaker: It was, and that applied not only to the logic but it applied to the mechanical devices that were involved, too, the tape drives, the printers, the card readers, and so on. By and large they were fairly young people. There were some older people, but many of them were very young people. Yes.

Felsenstein: So young means in their 20s. Would that be right?

Blankenbaker: Yes. Two and three years out of college some of them, some of them four or five years out of college. But there were others that were more experienced. Yes.

Felsenstein: Okay. So continue with what you were working on there, and the direction that went.

Blankenbaker: Well, I was at Hughes for a total of four years. And after the business data processor, I did work for about a year on air traffic control. And I did build a digital differential analyzer. Hughes was very interested in machine tool control. They were a manufacturing organization because they had built several mechanical devices.

Felsenstein: I believe originally that it was oil bits was what the company came from.

Blankenbaker: Well, those were the basis of the company. Yes, yes. Though the aircraft company had nothing to do with that part of it, though the aircraft company did build some unusual devices, the flying boat, a giant helicopter, of course special planes for Howard Hughes. But in later years it took a technical direction, especially electronics, airborne radar, missiles. They built missiles. They built airborne radar. They built digital computers for aircraft. So this venturing into the business data processor was an attempt at some civilian business.

Felsenstein: So the machine tool aspect of that, was that at all?

Blankenbaker: Because they were manufacturing and they wanted to automate the process. And there were some devices that are rather difficult to build mechanically, like the blades on turbines, which have complex curves, and the thought was that things like digital differential analyzers which could solve differential equations might be the way to direct the path of the tool.

Felsenstein: So the digital differential analyzer you built essentially took lots of numbers and it gave lots of numbers out. That correct?

Blankenbaker: Lots of numbers. It might take lots of numbers in, but in the proposed machine tool control, basically X, Y and Z plus on and off kind of thing.

Felsenstein: I see. So it was really built to be a controller of the machine tool.

Blankenbaker: It was a, as artists say, an artist's sketch. Okay. I mean a sketch, a preliminary sketch. The eventual machine they built called for a pallet to which the piece being manufactured was attached. This moved around from work station to work station to another, maybe a drilling operation, a boring operation, and things of this nature, all automatically, and to produce very standardized pieces without a lot of manual labor.

Felsenstein: And so the control was that control of the positioning of the pallet on its base? Was it done that way?

Blankenbaker: What they did eventually was after I left, and I was not involved in it and, again, my feeling is that the early direction was very novel and no one knew quite what to do. But eventually they did build a device, multi station controller.

Felsenstein: I would like to look a little bit more at the early direction aspect, because that was your contribution, right? Would you say that?

Blankenbaker: To which?

Felsenstein: The early direction of that, the digital differential analyzer.

Blankenbaker: The digital differential analyzer was realized that it was a way of solving differential equations which might be some complex parts might require, though the traditional machining operation does not require differential equations. But I mean it was all straightforward, linear motion or rotary motion. And I do not know that they ever used digital differential analyzer in the machine tool control. It is not a really general purpose device like a general purpose computer is so easily.

Felsenstein: Of course, I recall that there were mechanical DDR's, DDA's, analyzers, in development. Vannevar Bush was working on it. Was it Harvard or something in the pre-war era.

Blankenbaker: That was analog, Yes.

Felsenstein: And so this is kind of a continuation of that. In fact, was not ENIAC supposed to be a kind of digital differential analyzer?

Blankenbaker: I cannot vouch for that statement. But the weather forecasting that was done on some of these early machines; again, it was the differential equation. A lot of things can be formulated as a differential equation.

Felsenstein: Right. Alright. So you did work on that on paper. Is that what you said?

Blankenbaker: Well, I built one.

Felsenstein: You built one.

Blankenbaker: Yes. We used the leftover components from the business data processor, the magnetic drum, the logic and so on. And I generated a sine wave, and again that was the end of it sort of. I was not interested in carrying it any further and there was not anyone in the company. There was one, that was the first piece of hardware, computer hardware, that I really ever built and made work, and it was embarrassing how many mistakes I made. Somewhere along the line, I made clerical mistakes. The process I used was very good, but somehow mistakes crept in and it shows that you need to have it approved by someone else. I mean, you need to go through it and get it verified. It is like programming. You make mistakes.

Felsenstein: Well, the direction of that, one might conclude that you took the opportunity of having, knowing about the work that had been done, to do the design of the digital differential analyzer. Somebody must have said, yes, that is the right thing to do, or there was some process of getting approval for that, right?

Blankenbaker: The company was committed to trying to do something in numerical control. Some people recognized that a part of this might be differential equations. And so it was not difficult to get the company or those in charge to agree, since that was not involving a lot of money, to use some of these parts that we had and build a digital differential analyzer.

Felsenstein: Okay. So that kind of qualifies as a design from the junk box in my view. This is my statement, not yours. And I just wanted to put that out and see how you responded to it. I think I see.

Blankenbaker: What was the word that you used?

Felsenstein: Design from the junk box.

Blankenbaker: Yes.

Felsenstein: Okay. You worked for Hughes for how long?

Blankenbaker: For four years and the work was now not as interesting at Hughes. I did feel that maybe more education-- I had thoughts of a doctorate might be nice, be good.

Felsenstein: You took the job at Hughes in part because you would be able to continue your education.

Blankenbaker: That's right. The Masters program had been a factor. I did get a Masters degree in physics at UCLA, and now I was thinking more electrical engineering, rather than physics. I thought it may as well be a pretty good place, so I applied to MIT, and they said "Well come and we'll see how it goes," and so in 1956, the fall of 1956 I started at MIT in course six, electrical engineering. Now that's undergraduate. I started at a graduate level taking a mixture of some make-up courses at the undergraduate level and some graduate courses, and that went for two and a half years; elapsed time three years, but I had one semester out for consulting. Eventually I got an EE degree, professional degree as they call it. They're one of the few schools that offer that professional degree.

Felsenstein: How would you describe a professional degree?

Blankenbaker: <laughs> it's awkward. When I was later at Lincoln University and in the graduation ceremonies and you have to robe, I wasn't sure what I wore, so I told them what my history was and they said "We'll research it," and it turns out that you wore a doctor's robes, but you're not entitled to be called "doctor," so it's a halfway, in between situation kind of thing.

Felsenstein: So that was a full time effort? Were you working at the time?

Blankenbaker: When I was in school it was a full time effort. As I said, I did take out one semester to consult and I did work in the summers. One summer I worked at Thompson Ramo Wooldrige, and one summer I worked for Litton in Beverly Hills. So, two summers. The consulting job was, I believe the company was Librascope ,they had a contract with the FAA for air traffic control equipment, particularly for some terminals, so I helped them on terminal design and I suggested that why didn't they store this logic on a drum, and it was very simple logic. When you store this logic on a drum and that one drum could process for several stations, and it's changeable.

Felsenstein: This was a continuation of the thinking you had done on the logical micro-programming.

Blankenbaker: That's correct. It was a continuation, and I think that they implemented it in that way which was a novel idea to them. I had a great difficulty in explaining to the man I worked with whom I did admire, but he was an older man and it just didn't strike him that you could describe a machine on the surface of a magnetic drum.

Felsenstein: And the idea of having one drum serve multiple terminals was probably pretty confusing to him.

Blankenbaker: That upset the FAA when they found out about it, because it was a common element that might fail, and it was a valid concern on their part.

Felsenstein: Now Librascope, I knew the name as manufacturers of drums and disks.

Blankenbaker: General Precision is the name I think I should be using instead of Librascope, but some of these companies pass from one to another and I don't even remember, but I think General Precision is the one.

Felsenstein: Are these different companies?

Blankenbaker: The company that it was really, I guess General Precision. I said Librascope and that was probably a mistake. Librascope was building the LPG30, and General Precision was into other activities, but they did get this contract and I did help them. When I started with them they were thinking about having one big computer and it would take time cycles out to process for the terminals a la Whirlwind because one of the men involved was from the Whirlwind process and he was going to do that, but there really weren't enough cycles in the computer to do that.

Fleckenstein: You mentioned Librascope LPC30. Just explain what that was please.

Blankenbaker: Well the LPG30 was a simple digital computer; desk sized quite early on and was often used in an engineering environment with a flexowriter and programming mostly I think was assembly language on a magnetic drum.

Felsenstein: What year was this?

Blankenbaker: It was probably about 1956 that it came out. It was called the 30. It was priced probably in the $20,000 something of this nature. It was a good buy actually.

Felsenstein: It sounded like an early mini-computer.

Felsenstein: Well it was. Definitely.

Felsenstein: And you were working for General Precision. Was there any relationship between General Precision and Librascope or was that just a slip of the tongue?

Blankenbaker: If there was, I had completely forgotten it, and even mentioning Librascope was probably a mistake.

Felsenstein: Irrelevant, but interesting. So that was part of your consulting that you took off from MIT. So you graduated with an EE degree when?

Blankenbaker: 1959. I had to write a thesis. I had noted a novel structure and novel method of analysis for the prediction of filtering of binary sequences. When I even presented these ideas to my thesis advisor, he stormed in and said “You can’t do that!”

Felsenstein: It sounds like digital signal processing.

Blankenbaker: It was, sort of, on a logical basis, bit by bit. But he eventually became convinced that the equation that I was using could be interpreted in another way, arithmetric so that you really were getting the least means squared error, or whatever that phrase is. So it was a novel approach, and I don’t know that it ever had any value, but again it was a novel idea.

Felsenstein: So then at that point you’re back on the employment market.

Blankenbaker: I was, but the first summer-- Oh, in that same spring that I graduated I acquired Eleanor, my wife.

Felsenstein: Please tell us a little bit about how you met, and so forth.

Blankenbaker: She was going to Harvard Radcliffe, and I was going to MIT, and we met at a church, which was entirely an accident in itself that she was even there, but that’s where we met, and I had a convertible at the time, Corvette, and she used to get very sick riding cars but she found this car was no problem, that she could ride in it very well. So, she’s always been kidded that she fell for my car.

Felsenstein: I was about to make a joke like that. Usually there's some sharing of interest but never a complete overlap.

Blankenbaker: She was an art historian, and her family, her father, was a professor at Bates College in Maine, and for years the family had taken college students to Germany. They'd made a whole semester out of it. It was like ten and twelve weeks. Things were cheaper then. Still, it cost several hundred dollars. But he gave a course in Florence, Italy for several weeks. So the first summer that we were married we were invited to join along because my wife was one of the leaders as an art historian, and so we put off a job for three months.

Felsenstein: Well you could do a lot worse things than that, especially as newlyweds in Florence.

Blankenbaker: When we came back we picked up our belongings and put them in a trailer and towed it with the Corvette down to Princeton, New Jersey.

Felsenstein: And what was happening at Princeton?

Blankenbaker: I just decided that I would be a consultant and that was halfway between DC and New York City so maybe that would be a good place to be. She got a job and supported us. I spent some time studying alternatives in computer design. I did come up with one that I worked out pretty well, and then I had a call from Curtis Wright, who was building a fleet ballistic missile trainer. They were in a little trouble. They built great analog simulators for airplanes. That was their main business. They hadn't done anything in the way of digital work, and the man who got this fleet ballistic missile job probably was acquainted with my article, and logically micro-program computers, and he said "Really, that's a logic problem, not a numerical problem." You had thousands of inputs and switches and lights and people pushing them and so on. So what we really need is a logic trainer.

Felsenstein: Now a trainer was to train people.

Blankenbaker: To train people, yes.

Felsenstein: To run the system.

Blankenbaker: To run the system, right, and I suspect, though I've never had any proof of it, but that he had seen my article on logical micro-program computers and thought that he knew something of that nature. So, it had a drum memory, but the instruction was maybe 16-bits wide, and the data memory was not one flip-flop, but was a small core memory, but the operations were the basic-- how many different ways can you operate on two logic variables? That was the basic construction set, and the people who were doing the job, digital computers were new to them and they were having some problems.

Felsenstein: The prior technologies that they had been acquainted with were analog. Is this correct?

Blankenbaker: That's correct, yes, and so some of the people came from the analog world. Some of them were new. None of them were totally well acquainted with digital computers. I was supposed to design a way of loading the data onto the drums, the magnetic drums from paper tape, and I, for example

found out immediately that they assume that you could just write one bit in the midst of any other bits and it wouldn't disturb any of the other bits. So, we had to reorganize, and I suggested that the best thing to do was to take a lot of the other components that were being used, digital components, and turn them into a simple minded computer-- again, not numeric, but logically oriented-- and have it control the loading process. Namely, you would have to read in the old track, insert the new information, and then write everything back out again. So, things weren't going all that well between Curtis Wright and the Navy, and I hesitate to put blame on anyone, but maybe a lack of experience on both sides. But, I was able to help them and restore the faith of the Navy and that the job could be finished, and it was all installed up at Groton, Connecticut at a submarine base there and I helped to get it working. I had to debug a lot of it on site while it was being installed. We encountered several problems, and electrical noise, self generated, was worse than any thunderstorm that you could think of. But, we solved it all eventually, and eventually they bought another one.

Felsenstein: So how long did that take?

Blankenbaker: It was a better part of a year.

Felsenstein: And I've sort of lost track of the years now. Which year was it?

Blankenbaker: Married in 1959. I got this job started in 1960, so it was up to about the late part of 1960 I guess it was when this ended. At the start of 1961 I got another consulting job. Somewhere in here I've slipped a year, I'm sorry. At the early part of 1962 I had another consulting job helping design a message switching computer. I can remember it because very early on that job my first son was born, so that was 1962, and that was ITT, it was the main company. They had formed a division for this purpose. It was largely modeled on the PDP series of computers, but they built their own equipment and again, like all projects, it grew and it grew and it got over budget and they felt they were far enough along that they would dispense with me, so I left. I held a year's contract but they asked me if I could leave early, and I had no objections to being let out early.

Felsenstein: So in this case most of the work the all end user was the government, was the military?

Blankenbaker: Actually it was the State Department. Well no, I'm sorry. The first customer was the State Department for a message switching system. The reason I remember that is that for purposes of real-life traffic to work with, we got samples from the State Department.

Felsenstein: The cable traffic and so forth?

Blankenbaker: Yes. That in itself was an eye opener and gave you one set of opinions about how the government operates and about how efficient it is. Some of the messages that we had, which I was reading, was like to the Embassy in London, "When I come over I want to get some more of those socks, and can you recommend a tailor?"

Felsenstein: Yes, very illustrative.

Blankenbaker: I don't know how they eventually ended up. As I said it wasn't really complete when I left. I think that they did go through and fulfill a few of the contracts that they had.

Felsenstein: So a message switching system like that would have been...

Blankenbaker: It was teletype speeds. And just the sheer process of taking data in and out and recording it on tape was like 75 percent of the cycles, but there wasn't a lot of analysis. You just had to look at the header and see where it went and send it along when time permitted.

Felsenstein: They probably can say the same thing right now about the Internet.

Blankenbaker: Even more so <laughs>.

Felsenstein: So, on you went from there, and what did you do?

Blankenbaker: I remember that that was in the fall of the year and we took an extended vacation, but we wanted to be back in Princeton to vote in November, and I got back and there was a phone call waiting from me from Montgomery Phister and he seemed to be in New York City, but last I knew he had been in California.

Felsenstein: Tell us how you met him.

Blankenbaker: I met him at Hughes Aircraft Company. We both worked on this business data processor, but he had gone on to Thompson Ramo Wooldridge [TRW] and when he called me I found out that he was working for a small company, Scantlin Electronics. He was at that time in New York City because they were taking prices from the stock exchanges, the bond exchange, commodity exchanges. They were compiling this into summary information and sending it out to brokers on demand. So you punch in "GM" and you might get the opening high, low last price, net change and the volume of trading.

Felsenstein: It sounds like at the time that it was a very radical advance in the information system for stock trading.

Blankenbaker: It was, and Jack Scantlin, the founder of the company had already had a first generation device in which he had installed in the brokers offices a magnetic tape loop, in which it recorded the ticker tape, and if a broker asked for a last price, he read the tape backwards until you came to that stock symbol and that was hot stuff. But then it was realized that you could so something more if you did it in a central processing place, so it was a communication system based on 2400 baud high speed stuff: lines, subsidiary distribution centers which were special purpose, but in New York City it was based upon four Control Data, 160A computers that had all of 8K words of memory in the computer, but they were bit words, 12 bits. Two computers could share a larger memory that had 6 banks of 4K each, so it had 24K. So each computer had in essence access to 32K of 12 bit words. Now, the genius of Jack Scantlin was that he figured out how to encode the data so that it would fit in these machines and could be processed by them at a fast clock cycle of 6 microseconds per instruction.

Felsenstein: 166 kilohertz.

Blankenbaker: That's right, and it was really amazing. Now the job had to be split up among computers a little bit; one of them took the data in and stored it in the common memory. The other went and

answered the broker's request from the common memory. Another part of the job was that UPI wanted stock reports send over teletype for distribution for setting stock market tables. So I went up to have lunch with Monty, and by the time I went home I had taken a job with him.

Felsenstein: Doing what?

Blankenbaker: Well they wanted me to work in New York City because they really were in California and they needed some people in New York, so it would be in operations, it would be in programming, but in a few weeks I could transfer to the engineering department out in California.

Felsenstein: And what happened?

Blankenbaker: Well, things didn't go all that smoothly in New York City. For example, if you were writing new programs you had to write them after hours, because the computers were all busy during the day doing the work, and this UPI job was so awkward that I couldn't really turn it over to a technician. I sort of had to do it myself, and carry it through and I was writing code to try to automate the procedure a little bit better. Then there were operations during the day supervising the people. We had to have people who were correcting the data that came in from the stock exchange; there were lots of errors in it. As an example of the computers, I had promised the "correction desk" as we called it-- that was about four or five people correcting entries-- that if they could ever agree with the stock exchange about the ten most active stocks of the day, including their volume, that I'd buy them dinner. It went on for quite a while, and I trained and we tried developing, and one day they showed me that they had done it, but what had happened is the stock exchange had installed computers too, so for the first time we had some chance. They had been rather sloppy before. There had been people who were just adding the numbers up by hand and maybe not noting the corrections that appeared on the tape and so on. So, as other points - we computed the Dow Jones average. We had it available in a minute of the time. Dow Jones published it periodically during the day, but we had it on demand. As a matter of fact, at first when you asked for it we'd go and compute it right at that time. So it really was instantaneous. But again, to show how accurate and how much improvement computers brought to it, there were days that the Dow Jones people said the stock market was down, and we said it was up, and this led to many arguments with our salespeople because the sales manager would say "Change it." Who's going to believe us against Dow Jones? Well, there were interesting problems along the way like this, and it was a lot of night time work, living in Princeton having to stay over in New York City. We lived in Greenwich Village one summer, a year in Brooklyn in an apartment there. Finally we were ready to go to California and to the engineering department.

Felsenstein: Ok, what happened there?

Blankenbaker: In the engineering department there it constantly seemed like we had to improve all the time. More speed, we got more brokers, more customers you had to improve. We had boards that displayed commodity prices on it. If all the brokers had asked for the same commodities it wouldn't be so bad, but everyone had his specialty, and so we were sending stuff that took up time on the lines, but maybe only one or two people were asking for it. How do we increase the speed of the lines? How to increase the speed of the equipment? We had conflicts between the brokers who had the desk sets, because maybe only one of them could be active at a time. So, we'd try to have some server, special purpose equipment that would stack the requests and send them in automatically, things of this nature. And all the way along the line, because we were such an early pioneer there were people coming around

with their problems. "Could you solve this, could you do this?" and these were some of the most interesting things because you learned a lot. We had the small loan people, finance companies; the small loan officer.

Felsenstein: There's a Small Business Administration.

Blankenbaker: No, this would be like a company that loaned money against your furniture. But they had special requirements. It was required that the records always be maintained in the office where the loan was made, so that you could always access it right there, which led to a lot of requirements. We had Howard Johnson room reservations. We had Hilton room reservations, and I remember visiting even the central reservations for Hilton hotels as to where they made. I guess it was New York City, a great big room and a battery of people on telephones down there, and up on the walls, two to three stories high were a listing of all the hotels in the system, and if a hotel didn't have space they would block out a date. So someone would call in and say "What do you got in Banff on such and such a date?" "It's open." They'd make a reservation and they'd even send a message to Banff saying "We've sold a room for three nights June 26th." The only problem was that they sent the message so slow that the hotel might sell out before they got the message that the system had made a reservation on that night. You know, we say "Couldn't you send a telegram? Couldn't you make a phone call if this is your problem?"

Felsenstein: You mean they'd send it on paper?

Blankenbaker: Yes, mail. So, but these are the kinds of problems that you face. You saw the kinds of problems that people had in their business. It was interesting to see that. We proposed ideas to them and it was a fun project. We worked with-- a little bit later we worked in Los Angeles at the police department on a system which detected whether people were wanted; a warrant system, and it was fun to do all those various things. But there was a lot of tedium in the engineering department.

Felsenstein: What kind of things were you actually doing there? You're describing the systems here, but...

Blankenbaker: There was equipment. Improvements and equipment, trying a faster way of communicating, a better way of communicating. It was monitoring a lot of people. Supposed to be doing a little design work too myself, and I never have liked the conflict of monitoring other people and of doing work yourself. It was always in conflict, that kind of thing. I never did enjoy that. The tedium of it got to me after four or five years, four years about, and by then Jack Scantlin and the president of the company were at loggerheads. That is the typical founder; the typical person that's been sent in to run the company and it had been set up so that the founder was isolated in a special research activity, and sort of operating under a certain budget. The conflict got to be so bad, and I sort of got caught, but I decided to go back to the engineering department, and I did. Not too long after that the founder, Jack Scantlin, arranged with the board to fire the president and to hire another man. They had the man hired before they fired, and it was obvious that Jack Scantlin was going to try to exert himself in the new organization in ways that he hadn't been able to previously, and I didn't appreciate what it meant for me, so I resigned, and the board said "Well, you have done some good things for us," and the new president already recognized that there's some due cause that I had for resigning, and in the first two weeks he began to realize how severe his problem was. But they gave me $6,000 as a gift in going away. So I was unemployed, $6,000 in my pocket, and a little bit of other resources, and here I had been saying for 15

years, computers can be built much more cheaply. Maybe this is the time to think about it. So, as a proprietor I started thinking about what I would do, and that's the start of the Kenbak computer.

Felsenstein: Now you have come to the point where you had a little money, you had a little time, and you have decided that you wanted to do something about your thoughts about low cost hardware. I'd like to explore first of all where those thoughts came from. We've already been doing that to a certain extent by just finding out what you did but I want to invite you to kind of recap some of the thinking that went on in your mind that led to that decision to develop the Kenbak-1 and there'll be some things that'll be repetitive. It doesn't matter.

Blankenbaker: Well, for 15 years I had been thinking that much cheaper computers could be built and so when the time became available to me, which mainly was how many hours in a week I wasn't working, I got out the parts catalog, Allied or Newark or something of that nature, and looked around at what parts were available. I knew of course that many parts were available but I looked for some more, what was available in cases, what was available in memories, some things of this nature, and what I saw was that well, maybe if I took the serial memories which are pretty cheap and pretty good storage. I knew all about the ICs, input, output. Now I can't spend much money there. It'd just have to be lights and switches. So what I need is maybe a logical design and I'll have to translate that to a printed circuit board. So these are steps that basically I'd all been through in work so now what was the logic of the machine going to be given these parameters.

Felsenstein: But then the question of why do it? Explore that a little bit, please.

Blankenbaker: It's just that for 15 years I'd been saying it could be done. I'd been telling my older brother it could be done, others too. I had to admit that I didn't know what I was going to do about the memories but I was confident that it could be done and I felt that it would serve a very useful function because when I was doing my first programming, when I was designing computers, here I was designing an arithmetic unit for a big computer and what did I do. I'd written one program so far. It didn't work. I'd never designed anything before. Though it would be a very elementary system, still it'd be a step up towards thinking about some of these things. No one understood computers then very well. Let's see. This is 1970. There were certainly some professionals that did but the lay public did not understand so let's just go on to the name. I got to have a name for this.

Felsenstein: Before you go to that, I'm still going to loop back a little bit and explore. It sounds as if you wanted to create a computer that people could learn to program on at the most elemental level because you wished you'd had that.

B**lankenbaker:** Yes.

Felsenstein: --and you saw the need for it of sorts. Right?

Blankenbaker: That's true.

Felsenstein: So you had decided that you knew technologically what was possible and you felt that it would be a good thing to have the device so people could learn things that you had to learn the hard way.

Blankenbaker: True. And I'll continue by the choice of the name and this gives some insight into it. Blankenbaker of course is too long and people can't spell it, can't even pronounce it, but looking at the subset of letters in it there was a group of six letters, k-e-n-b-a-k. Hey, that starts and ends with a "k" just like Kodak does and what did George Eastman want to do? He wanted to make a camera for the mass market, to make it popular, not for the professional but for the amateur. I said, "That's exactly what I want to do." So I said, "That's the name that I'll take." My wife warned me that no one would be able to spell it but that was beside the point so that's how I chose the name and you see some of my motivation in the choice of that name. I was trying to reach a mass market.

Felsenstein: I see. You were approaching it from I'd say the bottom up—

Blankenbaker: Yes, that's correct.[laughs]

Felsenstein: --and talk about the way the design evolved, assuming it did evolve.

Blankenbaker: Yes. I did know that as a programming device or a device to teach programming that I wanted to illustrate as much as I could about the possibilities within programming. I saw right away that thought interrupts is one thing that might be difficult to do and I made no attempt to do interrupts but I did decide it should have multiple programming registers, there should be all the addressing modes that I could think of, jump conditions, and I even had some unusual instructions in there, set any bit in the memory to 1 or 0 or test any bit in the memory for 1 or 0 and the shifts and the rotates and so on. So I could put those in rather easily. It didn't take any great amount of effort to see that those weren't difficult to do and by choosing to put all the registers into the main memory and giving them addresses it even permitted a few more unusual instructions, not that they were useful but they were illustrative. For example, A minus A, which was register 0 minus register 0, would clear the A register but it wasn't worthwhile really to say clear the A as some computers did but I had it. It illustrated something.

Felsenstein: You had A minus A or you had clear A?

Blankenbaker: A minus A would clear the A register.

Felsenstein: And therefore you did not have a clear A instruction.

Blankenbaker: No. I didn't even give that mnemonic in the assembly language that I used. It just wasn't worthwhile but you could show people that such things were possible but no, I didn't have it—

Felsenstein: So the design was basically the virtual micro-program design that you had started thinking of a long time ago—

Blankenbaker: Oh, it wasn't that extreme because the- logically micro-programmed computer triggered a vast amount of equipment for a long period of time. It wasn't a reasonable thing to do nor did I really have the memories to implement that. On the other hand, a parallel machine, 8-bits or 16-bits and so on, was I felt overkill. In other words, I didn't need to process anything that fast. Even if it counted slowly, that was in essence good if the students could actually see the counting so to speak so there was no value, no merit, in being a high speed device or being a powerful processor. If it added and it took a little while, it's all right.

Felsenstein: --the pushbutton switches for input and lights for output and you knew that this was intended to be a kind of learning or a training device.

Blankenbaker: That's correct and I knew that one of the necessary ingredients or one of the necessary parts of it would be instruction manuals and as a matter of fact that probably is what I called the laboratory exercises which started on the assumption you knew nothing about computers. There was a programming reference manual. If you understood computers you could start with it and that would give you the details of this machine but there were no new concepts in it except how they applied specifically to this machine.

Felsenstein: Let's talk about the structure that developed around this. I was about to say you had only yourself to be responsible to—

Blankenbaker: Yes.

Felsenstein: --but you did get investors.

Blankenbaker: Well, much later.

Felsenstein: Much later so let's not jump there and let's keep working with how the design came about.

Blankenbaker: Okay. I am a believer in state concept and Boolean equations and schematics mean nothing to me really. Okay. It is true that I did generate a set of schematics after the machine was all built but the design in the machine was a state concept. By a state, it was a particular function like find the next instruction to execute, and the equations were how do you go from state to state and what were the conditions. And when you were in the mode which said "execute," you did what was required like add or subtract which was about the two most complicated things that I had in present operations.

Felsenstein: I have to keep remembering here these were all represented by patterns in memory, not by any pieces of hardware, and you had only really the minimum hardware to try to deal with them.

Blankenbaker: Well, no description of the machine resided in the memory as opposed to a logically micro-programmed computer. This was a computer that was directly implemented with no substitution of another stage. There was only one level but I chose a level that was pretty simple.

Felsenstein: Talk a little bit about that if there is anything much to say.

Blankenbaker: Well, the machine has somewhat less than 32 states for all the things that it does do and the choice of what I was going to include as instructions was influenced by several things but I knew that the command portion of the instruction would be eight bits because eight bits or the second part of the instruction would be the address so the command was limited to eight bits. This meant I was limited as to what I could do. Okay. I didn't quite use up every possible combination but I used up most of them. I always had that in mind: Can I do all of these things in eight bits of command? And where I had some space left maybe I would add another function or two.

Felsenstein: You were developing the op codes basically, the-- I'll avoid using the word "state" here because I'm on unsure ground personally but you were designing it as a computer is presently designed with the definitions of the bit layouts of the op codes. Is that correct?

Blankenbaker: I don't think I understand your question entirely—

Felsenstein: The instruction set. Start with that.

Blankenbaker: Yes. The instruction set-- There are basically of course certain things that you want to do in any computer that is going to be used for educational purposes to which I added a few things as the bits and the command code permitted and I tried to use up all the combinations that I could. It didn't quite make it but I tried to use as many so the fact that there are three registers works out as three of the four combinations of two bits kind of thing and—

Felsenstein: Was anything done with that last combination?

Blankenbaker: It would probably have been another set of instructions entirely and maybe that didn't even pertain to the three registers so the- I tried to be very generous on the jump codes. I was very generous on the jump codes. There are five conditions that I test that can be applied to any one of the three registers plus unconditional. Addressing could be direct or indirect and you could deposit a return address in a memory location so that took up quite a bit of the codes.

Felsenstein: You had an ALU that was one bit wide—

Blankenbaker: Yes. It was made up from gates, small gates. Yes, you're right. It was one bit wide. The arithmetic logic unit was one bit wide, made up from logic of small, discrete ICs.

Felsenstein: The flip-flop was the output register of that I would assume. Am I correct or is it too simple to say that?

Blankenbaker: Actually, generally you read the bits from memory and a register did the processing and wrote it right back into memory.

Felsenstein: Without going through the flip-flop.

Blankenbaker: Yes, without going through a flip-flop. The only flip-flop would be the carry. It is probably not best to compare this too closely to what I described in logically micro-programmed computers. The connection is that logically micro-programmed computers led me to believe that computers could be much simpler than what was being built and that was my motivation. That was that it can be done, something simpler can be done, but I didn't go all the way in simplicity because it'd take forever to solve a problem so I chose something in between.

Felsenstein: To repeat something you have said maybe twice so far, the Kenbak-1 is not your proof of concept although maybe it's a simpler concept you're proving which you have discussed here—

Blankenbaker: Yes. Well-- Yes. Logically micro-programmed computers were more of a motivation than a guideline as to how to do it. I have in some other work used the concepts of the logically micro-programmed computer to a greater extent than I did in the Kenbak-1.

Felsenstein: Maybe we'll get to that. Now concentrating again on the Kenbak-1, how long did it take you to get the design working?

Blankenbaker: Well, I started in September and we went on vacation and I came back. I cleared the desk in the bedroom and went to work. Within a month I had the paper design. I'm pretty sure of that. I started translating it into hardware and I got to think now about physically what kind of a configuration am I going to have so I purchased several cabinets that might potentially be it. The rule was don't pay for any special tooling. Try to take advantage of standard stuff as much as possible. I picked on this cabinet from Baud cabinets and that determined basically the size of the print circuit board that I could use so I had to spend time on the configuration question before I could start actually designing the printed circuit board but-- And as I designed the printed circuit board I often changed the logic a little bit because at the point- I did not come to a point where I needed an inverter but what I had physically on the board at that point were NAND gates so I- to double up the inputs and you got an inverter so other points even more extreme than that. I modified the basic design a little bit to take advantage of the layout on the board and the- very conservatively designed the board. There were 50-mil-wide traces. I didn't run any traces between tenths. Okay. The density on that board is about 1 IC per inch and it's a two-layer board so it just goes to show that when you take all of the job into your own hands and don't have to report to a committee or a set of specifications that sometimes it pays. You can achieve things that you couldn't achieve otherwise. I had a little bit of help in that my brother laid tape on the actual mylar. And along about March I took the mylar to the vender and he made up a sample board for me and I made some tests with a power supply which I designed. It seems to work but I won't brag about it at all. I'll say only I think that the two regulator transistors have never failed in any of the machines. Things were so over-designed. They're very, very conservative. I could run on power down to 70 volts AC. That was really excessive, which meant that I was dissipating more power inside than I needed to.

Felsenstein: It had to have been dissipated—

Blankenbaker: Yes, and having decided upon the cabinet and counting up the number of ICs and how much power they took, it looked like about 60 watts of dissipation so I put a 60-watt bulb in the cabinet overnight and see what happens. It got hot, so I said I got to have a fan. I didn't want a fan but I got to have a fan so it was a rather small fan and it's not very big and it's not too noisy and so many questions were decided as I went along but the logic design was completed basically in not much more than a month except that I did revise it as we were laying out the board to take advantage of the actual configuration on the board.

Felsenstein: The shift registers-- Who made those?

Blankenbaker: If I'm not mistaken, it was Intel but I'm not positive. They're MOS. That's all I know.

Felsenstein: Intel did exist then. You're right. I'm sorry. And they are MOS.

Blankenbaker: Yes.

Felsenstein: They are dynamic?

Blankenbaker: Yes. Yes but they're continually shifting. Yes, and of course that keeps them refreshed all the time. The shifting itself refreshes it.

Felsenstein: Then this is a direct-- I want to use the word "throwback" but that doesn't sound right. It's directly in line with the mercury delay lines and so forth, the serial storage methods that you had had experience with before.

Blankenbaker: Oh, yes, definitely. I have done more- far more work with serial memories than I have with parallel memories and so the drum memories were serial, the mercury delay lines were serial. I was well acquainted with serial memories. Serial machines have always been something that I'm very familiar with and have never been a problem. One man though on the internet now is saying that debugging these are very difficult because it's so complicated and I've always regarded it as very simple but that's the difference from where we came maybe.

Felsenstein: Absolutely. Then you had a working board and by definition you knew what size it had to be and I don't know when you finished the power supplies but something had to power the board--

Blankenbaker: Yes.

Felsenstein: --and then what was the next step?

Blankenbaker: I had done paper drawings knowing how things were going to fit together. I had the power supply. I had the printed circuit board. I populated the board and put everything together and see if it worked. No, it didn't work.

Felsenstein: What did you do?

Blankenbaker: I found out why. The first and simplest problem was that the bit counter, which is generating the clock pulses, wasn't working and an embarrassment to me is that I, who advocates state design so much and thought that I had proven that there were no states that would lock up and not go anywhere, overlooked that in the bit generator and it locked up.

Felsenstein: It seemed that the bit generator was kind of at a lower level than—

Blankenbaker: Oh, it's the start of everything, Yes, the start of everything. Yes. Unless it's working you don't get anywhere. Well, one R1C fixed that problem but-- Okay. But there are relatively few problems, very few really, remarkably few, remembering that this is the first time I've built this. It is on the printed circuit board that I've already paid for but yes, there were things that were corrected before we got to revision 2 or B. Yes.

Felsenstein: Which is what you had to do before you could build any more.

Blankenbaker: Well, I could have built them on the basis of that first board. It wasn't that bad but it would have been very desirable to change it. I'd only bought one to start with so—

Felsenstein: Do you remember how much that cost you?

Blankenbaker: No, I don't. It really wasn't that bad. It was a little slow in the PC board business at the time and they were I think all too happy to see me come in the door It was $30 or $40 but today it'd be produced very easily. It's silk screened. It's not anything fancy, 50-mil lines.

Felsenstein: Silk screened?

Blankenbaker: I didn't silk screen it but the board people--

Felsenstein: --did that. Yes.

Blankenbaker: Yes, they did. I put a lot of etch on for component numbers. I didn't silk screen any components or orientations or anything.

Felsenstein: What I'm thinking about here is of the technique they used for fabrication. I believe at that time it mostly was silk screening--

Blankenbaker: That was very common. That was very popular, Yes.

Felsenstein: They didn't have dry film?

Blankenbaker: And my thought was that anyone can do it. If you were a PC manufacturer, you could build this board.

Felsenstein: So it would be a relatively inexpensive board to build.

Blankenbaker: In a volume I thought it would be. My aim incidentally was I wanted to do it for $150 of parts and in volume I might have made that. More in the volumes that I bought, which at 50 was the most, was about $250 for parts cost.

Felsenstein: What was your thought about what's the market? Is it intended to be sold? I assume it was.

Blankenbaker: Yes it was, and in my very earliest thinking, I had visions of a newsletter. In other words, private individuals, a fun device, and that the newsletter might have games and programs to do and ask readers for their solutions and some ideas from them and in other words an exchange of information to make it into a fun device. So at that point I was thinking very strongly of private individuals. Right after the computer was built I was aware that there was a mathematics convention coming up, high school teachers, and I said, "I'll go to that and show it," which I did. That was the first public showing of it.

Felsenstein: Where?

Blankenbaker: It was at Anaheim I believe and still- yet I wasn't really sure where the market was laying- lay but I early on compiled a list of private secondary schools and mailed the letter to them and that resulted in some sales and as a matter of fact that's the first two machines that I sold and so I thought then maybe educational market was the place to be but due to my lack of experience I didn't appreciate marketing problems in schools, which is even though they like it it'll be two years before they can buy- one kind of thing. And that was one of the handicaps and I never really tumbled back to the private individuals. I sold some to private individuals because my first big ad was in The Scientific American and that brought responses from everything, private individuals, companies, you name it and so on, overseas, domestic and so on. And I should have in retrospect emphasized again the private individuals, going back to this idea of a newsletter and fun activity and educational, but directly by the individual, not in a school environment.

Felsenstein: So you did not actually create the newsletter. Is that correct?

Blankenbaker: I never did. No, I never did. No. That was a dream that I had in the early days that got bypassed just to show that at first that's what I was thinking of but somehow I fixed upon then the idea of schools as the market but- and it took a little while for me to realize the difficulty of selling to schools, not to these private schools where the teacher probably had a direct say, right, with the head of the school or something, "Yes, go ahead," kind of thing, but as a public school or so on, no, and unless the teacher himself was really interested, you didn't make any headway- already interested you didn't make any headway and then he had a hard time getting money. And I did sell four into one high school in New York.

Felsenstein: At which high school?

Blankenbaker: It was upstate. That's all I can remember. I have seen some mentioned on the Internet about this since then but he was really actively and strongly into computers I think already and he gave me a bit of a shock after he did have the computer when he said, "Well, I let the kids take it home." And well, I never intended for it to be really portable or so on. I wanted it to be safe but to carry it home on a bus was something that I really hadn't envisioned but he did buy four in several months before he had the money, about a year before he had the money, but it was a very popular program in that high school.

Felsenstein: You were about to say something.

Blankenbaker: Go ahead.

Felsenstein: I'm going to change the subject slightly. Did you try to investigate any other markets?

Blankenbaker: Not really. It was 80% educational market that we were thinking about and in retrospect that was a mistake. I never did have a sales manager. I thought I'd hired one once and he made away with $3,000 and returned nothing. I have a low opinion of sales managers.

Felsenstein: Yes, and one might say welcome to the computer industry at a different level. At some point you say you got some investors—

Blankenbaker: Yes.

Felsenstein: What was that point and when?

Blankenbaker: Oh, okay. After I had the working model and had demonstrated it to friends, taken it to this high school convention and so on, had what I believed was a product, then I sought investors by simply writing to a lot of friends and five of them responded, something over $20,000, and I felt confident enough and that was about the time that just the first orders were coming in.

Felsenstein: What did the terms sheet look like for that? What was the deal?

Blankenbaker: With what?

Felsenstein: What did the investors get for their money?

Blankenbaker: Stock.

Felsenstein: In the corporation.

Blankenbaker: Yes.

Felsenstein: So it was a corporation.

Blankenbaker: Oh, I should have said--I'm sorry—that--about this same time, yes, that I had the working computer that I did incorporate, yes, and I did sell stock. Okay. Correct.

Felsenstein: It was a total of about $20,000?

Blankenbaker: I forget the exact numbers. I might be able to reconstruct it if I thought about it but it was about $20,000 or just slightly over.

Felsenstein: What did the $20,000 get you?

Blankenbaker: Twenty thousand?

Felsenstein: What were you able to do with it and was there enough?

Blankenbaker: Well, I bought-- What I did with the $20,000 is that I bought the parts for 50 machines. I still had something left over because they were about $250 each. Fifty machines at $250 each is-- you tell me. Less than $10,000 so—

Felsenstein: It's $12,500 I believe.

Blankenbaker: Oh, is it? So I bought the parts for those and we were making a few sales but advertising expenses which I tried and most of which were bombed completely. It was just trial, live and learn, and then you find out that it was just wasted money. Scientific American is the one that really paid for itself.

Felsenstein: How?

Blankenbaker: Even though that was the most expensive ad, you had the better class of readers.

Felsenstein: Where else did you advertise?

Blankenbaker: Many high school magazines, some of the computer newspapers and some things of that nature—

Felsenstein: The responses you got, what do you think was the most noteworthy one?

Blankenbaker: The one that said, "Here's $750. Send me a computer." There was only one of those. The typical response is that they wanted more information. All right. So it involved an exchange of information. Okay. It was impossible for me to make a sales call except I said, "If I thought you were really interested, I will send you a computer for ten days."

Felsenstein: On approval.

Blankenbaker: "And if you want to buy it, okay. If you don't want to buy it, send it back to me." And so I sent a lot of machines out that way some of which were bought, some of which were returned.

Felsenstein: Can you guess at a ratio?

Blankenbaker: No, I don't know. No, because so many people bought sight unseen that it confuses the issue in my mind just a little bit but the cost of sending one out if they paid the way back was less than $10 in those days and as a matter of fact it's interesting to note the only way you could send it--I wouldn't use the mails, I wouldn't use USP- Postal Service--was to some states you could send it by UPS and in other areas you could send it by bus. That was the choices but the cost in both cases was under $10 anywhere in the United States.

Felsenstein: I wasn't aware that bus delivery delivered to a doorstep.

Blankenbaker: They don't.

Felsenstein: You have to go pick it up.

Blankenbaker: You had to go to the bus station to pick it up, Yes.

Felsenstein: Tell us about what happened then—

Blankenbaker: Okay. At the same time the money came in and I bought the parts, by accident I became aware that some space in the San Fernando Valley was available at a fairly reasonable rate. It was a generous enough space. So I rented it.

Felsenstein: How was this configured? Was it just a garage kind of thing or—

Blankenbaker: I beg pardon.

Felsenstein: What did you rent?

Blankenbaker: Oh. It was an industrial type building that had work benches in it and one or two offices. It had had a previous life I believe as a printed circuit manufacturing facility so there was one area that wasn't of great interest to us but it was a one-story building, work floor, work benches, a few offices.

Felsenstein: So—

Blankenbaker: We were there four months and then it was obvious that we weren't selling at a rate sufficient to do this and we moved back to the garage. I had one man that was assembling computers and I had to let him go. It's interesting to note that he had a son or a daughter--I forget which--and spouse who were programmers. He took one machine as part of his pay. He reported to me that as professional programmers that they carried this with them on their vacations and their trips and played with it so- which is sort of a—

Felsenstein: But you had to be a programmer first.

Blankenbaker: On the time schedule I mentioned that I had started work in my bedroom in September along in the winter time we modified the garage and made an office out of it. By spring probably about March, maybe April I had the printed circuit board, probably it was in May that I gave a public demonstration of this to the high school teachers and I was making plans for the future and with a working computer I started seeking then the investors, it takes a little because of regulatory requirements and so on. I finally ended up limiting the appeal to California residents only to make it a little bit simpler and the money from these investors did not come in probably until July/August time frame, probably about July not necessarily all at the same time. The five people that invested were all people that I had worked with up to that time. I guess all of them I had worked with at Scantlin Electronics, they were Montgomery Phister, Christopher Kamp was a programmer, James Dougherty was the Vice President of Finance for Scantlin Electronics, John Blatner a programmer, Vance Holdem was the President of Scantlin Electronics who had been disposed by Jack Scantlin and I don't have a clear recollection of their investments. The only thing that I might note is that they were all friends who had worked with me and we, when I say we, that's the royal we, nearly always it was my sole decision. The involvement of the investors in the company was very minimal and chiefly limited to annual meetings or something of that nature. The parts were ordered late summer and they came in September. The first two units that I had sold I handcrafted the cases myself. But I think after the second unit then they were all using the standard cabinet which was custom made or custom modified by Buds Cabinet and there was some question about assembler language and there never was a formal assembler language for the Kenbak-1 that I had control of or did. I encouraged students to write in assembly language but the assembly process was manual. Now at the high school where they had bought four computers, they had a larger

computer and one of the students wrote an assembler to run on that computer to assemble programs for the Kenbak-1 so I'm not sure now how I used the word assembler but I never was involved in writing one except I encouraged the students to think in terms of assembly language. There was one for which I was not responsible.

Felsenstein: It would be rather interesting and I don't expect you to do this here, to follow up with that person who wrote that and see what happened to them, but that's another interview. So the management structure was essentially you?

Blankenbaker: That's correct, the employees of the company, I did say that for a few months my brother assisted me in taping, okay he wasn't even considered an employee, I was still a proprietorship, yes I gave him some money but I gave him board and room too, it was a little strange. About the time that the investors came in I did have a secretary and then when the parts came in I had a man to help assemble, he was with us just about three months. When we moved to the garage, the secretary moved with me and she stayed I don't know, some period of time, there was a while when I was just again all on my own. Business, let's see end of 1972 I was looking for a buyer for the company and I did go to a educational conference in Chicago and there I met CTI, don't ask me now what it stands for, CTI Educational Products.

Felsenstein: What did they make?

Blankenbaker: They made all kinds of products for vocational training especially, junior colleges were a lot-- community colleges more exactly, community colleges were their market in technical programs for a variety of products. They saw the Kenbak-1 and we reached an agreement that called for the sale of basically the rights to the computer. I think I probably delivered a few computers to them because I had sold about 44 out of that 50 and so I delivered some to them. They went into a production run which I believe called for 50 machines. They had very little success, most of what they sold was to a community college in Canada to which I had made several sales already and they expanded and bought more but they were supposed to pay us some cash and they drug their feet, drug their feet, in the end they said can we turn back in our stock of products, parts that we bought and so on, that seemed like that was the best they were going to get out of them. And so it was never very profitable for Kenbak Corporation or really for CTI and when we moved to Pennsylvania I threw the parts away, sad to say.

Felsenstein: You're not the only one. Okay when you were doing Kenbak when you were in Southern California because you mentioned San Fernando Valley and we talked, previously Scantlin moved their engineering department out west right?

Blankenbaker: Well the Engineering Department of Scantlin Electronics had always been in California okay I had been hired in New York City to work there temporarily and then to move to California, yes I moved to California and that's where the Engineering Department was. So for several years I was with Scantlin Electronics in California and so I didn't move anywhere as I went into the Kenbak phase, I stayed in the same house. Kenbak Corporation was paying me a very, very small salary and I was actually renting a house and the owner came around and said "I want to sell it." My next door neighbor was kind enough to say "You were in the Navy weren't you, can't you get a VA Loan?" So I investigated and I did get a VA Loan but financing the purchase of the house was not easy, it was a frightful time there.

Felsenstein: You bought the house you had been renting?

Blankenbaker: Yes I did buy it with a VA Loan Yes.

Felsenstein: So the end game on Kenbak Corporation and the Kenbak-1 what can you tell us about that?

Blankenbaker: Well there was that CTI did buy and we turned all rights over to them, I sent them all the drawings they needed, the manuals that they needed everything of this nature. I think they did do some more additional training material, I think they made some video tapes, I'm not sure that I was impressed by video tape to teach about a computer but I think they did do that. So then there were several years of limbo while status was most uncertain because CTI didn't pay up and for several years until we finally in desperation took the parts back that they had bought. So meanwhile I had to go to work and earn some money.

Felsenstein: Okay so that was basically for you the end of the Kenbak experience?

Blankenbaker: Yes, we never filed for bankruptcy, we owed a few debts when we went out of business but we never filed for bankruptcy we just terminated operations, the corporation ceased to exist yes.

Felsenstein: Taking the overview, retrospectively and analyzing that whole experience, what comes to mind?

Blankenbaker: One thing is that we didn't choose the right market to market to, we didn't choose the right market, we should have emphasized the private individual and we should have hit these popular magazines from the public. Some people thought maybe I should have made a kit, I never agreed with that, it was too difficult but at $750 that was in the reach of private individuals and if they wanted a time payment plan I could talk to them yes. Incidentally the one bad experience, business experience out of this is one private individual bought a machine with a check no good, it bounced and never did pay and it was hardly worthwhile to go after him, he was across the country but that was the only bad experience of that nature that I had of a private individual but I did sell to private individuals, sold a lot to schools. We sold I think four altogether outside the United States, one to France, one to Spain, one to Italy and one to Mexico. So that put me in the international business which led to an interesting story. I had to go down and find out some rules about export and of course you don't ask a lawyer you go do it yourself right, it's cheaper. So the rules said that if the computer had 2048 bits in its memory or less, it did not have more than 2048 you didn't have to have an export license that was their limit. I had exactly 2048 so I got into a conversation with someone in the commerce department and they're "I don't care, you got to have an export license" I mean even though clearly I had just made it by one, you know, but that's cooperative the commerce department was for exports. I just went ahead and shipped them overseas and never worried about it.

Felsenstein: One of these days they'll catch up with you.

Blankenbaker: They may yet.

Felsenstein: Let's follow your career post Kenbak, there may be reasons to refer back but, you know, what did you tell the next employer that you had done previously?

Blankenbaker: Oh there was no secret about what I had done, he was well aware of it, it was a start up corporation, the entrepreneur was someone that I had known from my experience at Scantlin Electronics and he had been our AT&T representative in communications and he wanted to make some products for communication and he first started by asking me to design a very simple computer for a piece of test equipment but then he changed his mind and thought there was a better product and so the aim of the company became that product. The company was International Communication Sciences, you never heard of it?

Felsenstein: No.

Blankenbaker: They observed based on some work done at AT&T Labs that you could reduce voice to a digital stream of 2400 bits per second by doing a lot of processing on it. In essence you did a FFT, fast Fourier transform to find out a filter that would generate the voice and so you sent the description of the filter down the line. The hard part was you had to say whether it was voice or voice synthesis, which is very hard for a computer to tell but it could be reduced to 2400 bits. That meant over a 9600 bit modem, which was hot stuff then, you could send 4 voice conversations and at the price of telephone lines at this time, which is say 1973 it caught the attention of people as a product. It took a lot of processing to analyze four voice conversations and to take the data coming from the other end and recreate four voice conversations so it was my job as the computer designer, again I was basically a one man department to create a system and what I came up with was a system that had four computers identical, they were each executing instructions I think at 8 megacycles, 16-bit word and they shared a high speed arithmetic unit which was a vector processor and the programmer specified that operation by specifying the starting address of the vectors and whether the address incremented. And so what it basically did is the programmer with five words could specify a vector operation, multiply vector A times vector B, that is the components of them. Add the components of vector C and store that in vector D and when it was all done you got an interrupt in back at the computer that had requested this. So instead of a lot of instructions about multiply, add 1, multiply add 2 for the end direction and so on. It was just a very simple operation that gave them really in their repertoire a vector operation as opposed to arithmetic operations on the components. The basic problem of the system or the company was that the theory was weak for the speech. Sometimes it came out great, sometimes it came out like Mickey Mouse or Donald Duck, maybe is a better example. It never was possible to solve that completely. I was really proud of the computers because for the cost it was really a lot of processing that I generated in the system. The weak point of the computers was that to speed things up they had the layout done by a computer which placed the IC's and did the routing.

Felsenstein: At that time the programs for rudimentary…

Blankenbaker: Well you're right, at that time it was terrible and when I went to review the results about laying out a board, 6 layers and the 4 IC's making up a register were scattered all over the board, it was just complete nonsense and I said "Look put the IC's in this location and now do your layout." Well it resulted in a great improvement on that board and what I should have done is imposed more manually but management was in such a hurry that we let some of it go through that was just machine generated, it was terrible. It worked, our other little technical problem is that we used a 256 bit ram chip from Fairchild that did not meet the specifications. They had said that if you do such and such that it would work but eventually it would prove that in some cases it didn't work. In other words there was a race condition in the chip and so even though you had a little margin going in, that got all chewed up and so you lost bits in the memory, that was a little bit of a problem.

But the real problem was just the weakness of the theory, it was good in the sense that really getting speech down to 2400 bits is not easy; I mean that was an accomplishment, but the quality was not good. We sold some to people who were very anxious to keep their voice conversations private. For example commodity traders working between America and Europe, some of them were very anxious to keep the conversations private so some of them used it. Other people did use it to save some money but it never was a success and the company after 7 years or so went bankrupt. I had left it just before it went bankrupt but in some ways I remember comparing it to the Burroughs Scientific Computer, another room full of equipment, but they had a longer word length and in some ways but the ratio of what they achieved to the amount of equipment they were using was, you know, the two weren't at all in keeping, they weren't proportional. So that was seven years of work and they tolerated me, I was just a single man department and I didn't revise and change the computer a little bit but they allowed me to do things like well you can come to work at five in the morning and I can leave at two in the afternoon so that I can go home and add a room to the house so they tolerated things like that. So it wasn't entirely unhappy but we should have been more of a success. It was on a good track but overall we were too weak.

Felsenstein: Okay what then, what happened next?

Blankenbaker: Well one of the people that had been at International Communication Sciences as a Vice President I believe was Robert Adams and he was taking a class and came in contact with Russell Noftsker, the two of them discussed some ideas, the class they were in was something about patent law so you get some idea about their orientation to life. Russell Noftsker said "I know of a computer back there at the AI Lab at MIT that's ripe for production" and so Symbolics Corporation was formed. Several people were involved in that company, I guess I could be considered a founding member of it along with many other people, several people from the AI lab at MIT.

Felsenstein: So this was based upon LISP?

Blankenbaker: You're right yes it was a LISP processing computer, it was designed especially for LISP and there was a lot of discussion of what route to take. The machine at MIT of which few had been built was wire wrapped, it was a 6 feet tall, maybe you've seen them I don't know it was rack mounted, wire wrapped all the way. It just didn't strike us that that was a producible machine in any production, you could build a few, it was not what you'd want to do to build a large quantity. There was a lot of discussion by the people about the route to go, not all of them agreed and Richard Greenblatt was one that didn't agree and he wanted to stay with the wire wrap machine. He also wanted to be in charge so he went his way and Symbolics and most of the people went another way. For the first month there was not a lot to be done, concentration was upon getting a producible machine that was assigned to me. I worked so to speak in Bob Adam's basement there in Santa Monica and converted the design over to something that could be produced in quantity and the technique I used and I forget the exact name for it now but wire was laid on the printed circuit board in a soft substrate, are you familiar with that?

Felsenstein: I am familiar with that, Kollmorgen Technologies Corporation specialized in doing that as a fabricator but I'm trying to remember the name for it which was something like, I can't, it had wire in the name but that was about it. [Multiwire]

Blankenbaker: It actually made a very good board, it was a little more expensive than a printed circuit board but it made a very good board. The characteristic impendence of the transmission path of the wire was rather ideally suited to the TTL circuits and it actually was very good. So over the course of a year

where the production department consisted sometimes of myself, one summer my son assisted me and for maybe the last 6 months another engineer came on board so we completed the design and that included the cabinets, the hardware, everything and the conversion of the logic all down to these boards. So just about a year later we had a producible machine which was called LM2 LISP machine 2.

Felsenstein: What was that year?

Blankenbaker: See I started in 1980, that should be it was 1981 that we had the first machine to sell or available, it went actually to the people at Symbolics, the very first one.

Felsenstein: So the design was done in what MSI level or higher?

Blankenbaker: Yes SSI, MSI, not much LSI. I guess there were a few chips, the so called programmable logic chips, there were a few of those in there, kind of thing but no nothing really fancy, nothing fancy, it was basic stock material and it had been what they had used a few years earlier, we didn't change the chips really except a bit, nothing like that it was just the implementation.

Felsenstein: So the design was more of a re-layout, was that it?

Blankenbaker: Well Yes it was repackaging Yes, it was totally new package to what they had, we didn't have wire wrap anywhere in the system when we finished and it turned out without any difficulty to be an extremely reliable machine. Some salesman who's trying to sell maintenance package to Fairchild and they said "Why should we buy it, it never fails?" So I've always taken that that it was a very successful thing, was accomplished on schedule more or less and on time and it worked. I think the machine was debugged at the AI lab in 3 days. I mean we put it together, shipped it to AI, went with, checked out in 3 days. So they sold a large number of those and that was the start of Symbolics, they got a very good name for that. Then they went on to make more advanced models and I was responsible for some of the design there, by then they'd grown quite a bit and they had the 3600, was one of their machines. I was responsible for the cabinet there and got a lot of flack about that because that was at the time that all of a sudden everything had to be-- you couldn't detect any radiation from it. So no one knew exactly what that involved so I was responsible for the cabinet design in the face of this uncertainty. I was too conservative so it got to be too large and too complicated but we did-- that was the initial package.

There was other uncertainties and we had to allow space for it. We just too many questions that were unknown but in working with the people from the AI Lab, I found them very hard to work with them. They just generally sometimes weren't even pleasant people and I just didn't care for that and I had become vested in a certain amount of the stock and I said "Forget those people, I'm not going to put up with this." So I left and they went on to some success but they too went bankrupt in the end and they had management problems at the very top level and throughout the organization because you had very talented people but you had conflict and there never was a way that they could resolve that adequately.

Felsenstein: No one there had a talent for resolving conflict or if they did it was never used.

Blankenbaker: That's correct. When we started it was Bob Adams in California that was president and Russell Noftsker was Vice President and I went back once for I guess it was when I took the first LM2 machine back for check out and I arrived and they said "We've got to get rid of Bob Adams" they had no

idea what in the world how they were going to even do it. I said "You've got to talk to Bob Adams, you've got to make him an offer, you have to set him up so I called Bob Adams and told him the story, Bob Adams came in so they worked for a long time trying to reach some settlement and again Montgomery Phister an investor was appointed as referee of this dispute between Bob Adams and the rest of the crew and so Russell Noftsker became President. I noticed in the Web when they talk about Symbolics there, they don't even mention Bob Adams now but he was President for a year.

Felsenstein: This is common in the industry.

Blankenbaker: It is, I mean I've encountered this many times, I've mentioned already that Jack Scantlin was a difficult soul kind of thing. Bob Adams was pleasant and nice enough but maybe he was.

Blankenbaker: Okay about 1983 and my memory is not exact there but I did leave Symbolics and took with me some stock. If I'd stayed around longer I could have taken more stock but it's just that sometimes in life money isn't everything. I went over to Quotron which was the new name for Scantlin Electronics okay, the new president that I had spoken of when I left had come to realize what kind of a problem he had and he promptly went to work to sell Jack Scantlin for seven million dollars or something like that to Citibank and he succeeded, great accomplishment, solved lots of problems, they needed the money and they needed to get rid of Jack Scantlin.

Felsenstein: So they got the money and Bank of America got Jack Scantlin.

Blankenbaker: Jack Scantlin who owned some stock of course probably got something for it and part of the deal was that they would rename the corporation and no longer use the name Scantlin. So it was an entirely different situation, they were going through the throes of a new generation of equipment which I had a large measure in setting the characteristics of it while I was still with the old Scantlin Electronics and but I went back and asked about a job and they said well, you know, we need a new manager of communications which is not a trivial job because there were 13,000 private lines that they had, telephone lines and even though lines were shared a lot, still there were a lot of tail lines that they had. So I went on board as Manager of Communications and I remained with them two years and we went through the throes of divestiture of AT&T and there was a period of time that we couldn't even order a line, couldn't even get a line, I mean that went on for three or four months and of course that leaves our customers very frustrated too besides ourselves and so that was a very frustrating thing.

But by 1985 my wife's parents that lived in Maine were getting quite elderly, not the best of health, she would have liked to have been closer to them, she never was entirely happy about California because the trees just weren't big enough and so we reached an agreement that we would move, I would retire, we'd move east and probably settle somewhat closer to her parents without being that close. Though we did look at real estate in Maine, we looked at real estate in Massachusetts, we looked at real estate here and I had suggested Chester County the local county here because once I had interviewed Univac, not Univac, Burroughs who had that scientific computer, based upon that business I'd done for Symbolics I thought maybe that that would have some appeal and I spent a whole day looking at real estate here in the county. So we added that to the list of places to look, spent a whole day looking at real estate and culturally there's a lot that we like about the area here, Randy Winn River Museum, Winter Tour Museum, Longwood Gardens are three of the bigger names in the area and this is the area we decided on, we bought the home and have lived here since.

Now I've engaged many other activities besides work, 1980 or 79 I started writing a weekly letter of stock market commentary called *A Non-Random Walk*. This exposure to the stock market that I got at Scantlin Electronics can't help but rub off on you as is there any pattern to this set of prices and of course there's a big contention there. Most people say that it's random, the prices are random, a lot of people say, that's why I chose name a non random walk because I didn't believe that they were random. So for 7 years I wrote a weekly letter stock market commentary, a very limited distribution like 10 people, it was written as much for myself as for anyone else. But it was the start of a long writing career. After moving, I tried to augment our savings by stock market trading with mixed success, and again it's one of those things as learning on the job, and had I known at the beginning what I came to know later I might have been successful, but some of the time when you're learning on the job it's not always successful.

Felsenstein: The letter you wrote-- a stock market letter with ten subscribers-- this is strictly an amateur effort?

Blankenbaker: Strictly. It was based on technical factors, and I'm still impressed by some of the predictions that I did make. For example, in 1987 the beginning of the year, January 1st issue made a prediction for the year, and it's that a good buy point would be-- what was it, September or October?

Felsenstein: October is when the crash happened.

Blankenbaker: Okay. I gave the Friday-- I said the good time to buy was the Friday that we had the crash. Actually the best time to buy was the next Monday, so I missed by one day, but then my unit of time was weeks, not days, so you've got to forgive me there just a little bit.

Felsenstein: So you didn't cause the crash.

Blankenbaker: No, by no means. I'm still impressed by what I believe can be done in technical forecasting, but I've long since abandoned that. I haven't even purchased a stock now in many years. But I did go back to work to earn a little money, and did some-- a variety of things. One of the more interesting ones is I worked for Science Products. You've never heard of it. It's a company founded by a blind man making products for the blind. The man was still active in the company even though he was 80 years old. He was the head of the purchasing department and using a computer, and kept his records all on a computer, totally blind. Well that was the story of his life. He did all kinds of things like that. He used to go rowing on the ocean, but he was an amateur radio operator, he had built receivers, transmitters and so on, so he had rigged up two beacons, and he could locate himself by these two beacons so he knew where the dock was so he could come back to shore. His antennae wasn't working on the roof, so he climbs up on the roof to fix it, and as he slides and loses grip he realizes that he better grasp the gutter before he went over, so he got himself turned around so he could reach the gutter before he went over. That's the characteristic of his life is examples like that, and I think when he was about high school that he had a Model A car which he took apart and put back together again. Now he never did drive but he knew how a car worked, he knew what the parts were of it.

Felsenstein: What was the job?

Blankenbaker: Making products for the blind. They did a lot of work with cash registers. They did a lot of work with health instruments; blood pressure, blood testing like the One Touch that so many diabetics

use. There were audio recorders, scientific calculators, business calculators. Some of these had to be checked out, but all the new products, audio tape was required because you had to explain the operation of the device to the blind person who was the owner of it and the user of it. So I would make believe that I was blind, shut my eyes, get the feel of it, write a text, describe it and record a tape. For a cash register it took eight half-hour tapes. That's how complicated cash registers are today, but I tried not to omit any feature at all. For blood testing, where you jab your finger and so on I used to go through these procedures, you know, put a sack over your head, jab your finger and see what you could do. It was in a sense quite a bit of fun. The most notable thing and the one I feel even the best about was a little device called Sure Drop. We have in testing blood the requirement to prick your finger and to put one drop of blood on a little piece of a test paper. You seem to be familiar.

Felsenstein: My wife does this.

Blankenbaker: And the problem with the blind is they didn't know where to put the finger. So, it had been observed by Mr. Blenham's wife that maybe a mechanical device could be built to fit over the instrument and you put your finger on that, scrape the blood off on it, and it would run down and fall onto this drop. So, with that as an idea, I got aluminum, a file, shears to cut things up, bend up a piece and so on, and it looked pretty good. To make the blood run a little bit better we got special coatings for it. So I made up a few sample pieces, and we sent them out to the field. I never have had such a positive reaction to anything I ever did as to a letter from one woman. She says "I've always had to keep my husband home because I couldn't do the test by myself, but," she says "With this I can do it, and now he's free to do his own things." and she went on like "God bless you. You're my salvation." Well they went on to sell those things by the ten thousands. They're really a very popular device, and so that was-- I felt very good about that, and just simply describing a cash register in all of it's complexity today is- is not that trivial, and the implementation they made-- they added audio to the cash register including to read out the journal that has been kept of all of your transactions during the day. You didn't know they could do that, did you?

Felsenstein: I never thought of it.

Blankenbaker: They're very sophisticated. They're really accounting machines. They are, very much.

Felsenstein: I know the mechanical ones used to chatter away endlessly printing that stuff out.

Blankenbaker: Yes, they still do, and you can get a read out of it too, an audible read out of it too. Well I left there because my wife's mother was an Alzheimer's victim.

Felsenstein: Where were they located?

Blankenbaker: Well they were in Maine, but her father had died...

Felsenstein: I mean this company that you had left.

Blankenbaker: Oh, Malvern, right up here in Chester County. It was twenty minutes and five stop lights. That's what the county used to be. It's much different now. It's rapidly changing with development. But I left them to care for my mother in-law. She wasn't that bad yet, but she needed care. As Eleanor said, I

ran a day camp for doing things, keep her occupied and so on. And also, somewhat during the same time I was tutoring students at Lincoln University, and then I was asked to teach part time and I was asked to teach full time in physics; some in math too, but this came to a draw when a number of physics instructors was larger than the number of physics students. It got to be that point.

Felsenstein: What year was that?

Blankenbaker: The last year I think that I taught there was 2002, and there was just no need for me then, and of course I was getting along in years and I was the low man on the totem pole. I was the last in and first out, right? That's the way we worked it. So, those were the last jobs that I've held. Now actually, my wife worked a while longer than that and she was doing very well, and it afforded us the luxury of a couple trips to Germany.

Felsenstein: I understand that you are involved in genealogy and history?

Blankenbaker: I am. I've been involved in quite a bit, and some of this is all throughout this period and so on, and I'm going to have to almost look at a list in order to see some of the things that I was involved in of a non-technical nature. I have mentioned the *Non-Random Walk* that I wrote for seven years, and about 1986, that was one year after we moved here, I became a member of the Township Planning Commission, and that was for about nine years. Starting in 1989 and going for 15 years I wrote a bi-monthly newsletter journal entitled *Beyond Germanna*, which is a story of history and genealogy, and I did a lot of the research and a lot of the articles, though as an editor I was publishing also other people's work. Anyway, there was a total of 917 pages that were published, so it was a stack of paper about like that, and it gets to be rather expensive for people to buy in that quantity, so I did make a CD of it, PDF formats so you can get all of that now for $30.00 and you get automatic searching too. My biggest writing job though was that starting about 1995 I wrote a daily column of about one page per day distributed over the Internet, again dealing with these Germanna people that I have been mentioning.

Felsenstein: Just for the record, what does Germanna imply?

Blankenbaker: It's a combination of two words: German and Ann; Ann from Queen Ann, and the Lieutenant Governor of Virginia had built a fort there, and in order to gain the response perhaps of Queen Ann, he had called it Germanna, so Germans of Queen Ann. Not quite; she wasn't responsible at all for sending them over, but he was hoping to win favor with her. He did that on several occasions, including incorporating her name into projects to improve a little bit. So 2,500 notes. Now, I only stopped that this past spring. It was getting a little hard to find something to write about, but it was very popular. The whole object was to increase interest in this exchange network on the Internet of people interested in Germanna. So, perhaps a thousand people subscribed to it, and, to get their daily dose so to speak, or something of that nature, and it was very popular, but it began to drag after a while. A little bit more than ten years, 2,500 notes. For about ten years I've been a volunteer at the Germanna House in Lancaster County. Now that's Mennonites. I'm not a Mennonite, never have been. It so happens my son-in-law is a descendant of Hans Herr and his house, but that has nothing to do with it. That's just an accident. What I liked about it was that historically it was interesting and the place is run essentially by volunteer labor, and I always appreciate the people where volunteers put forth their effort; it encourages me to put forth a little bit of effort. The easiest job I had was I was vacancy officer for the township for two years.

Felsenstein: In charge of nothing?

Blankenbaker: Almost. The state law in Pennsylvania requires that a township have a vacancy officer in case that any office in the township is remaining vacant that the vacancy officer is authorized to go to court to compel the position to be filled. So I just had to keep my eye open, was there any vacancies and were they being filled? It wasn't a very difficult thing to do. I never had to go to court to get them to approve something. I've been member of the township zoning hearing board. After our trips to Germany in 2000 and 2002 I made a CD of the journey. Again, it's emphasizing the Germanna villages that people would like to know more about.

Felsenstein: Villages of origin. Is that what you mean?

Blankenbaker: Yes. In some cases we're still looking for the villages, yes. Along the way I wrote a couple small booklets, 64-pages; The Hebron Baptismal Register, the Hebron Communion Lists and Culpepper Classes of interest basically to genealogists. My interest, like the Baptismal Register and even the Communion List are intellectual problems. You don't realize it at first, but in the baptisms, there were sponsors for the child being baptized, and they were often related. As a matter of fact, in the few cases they were known to be related. Now what about the unknown cases? So you study and you study. My object was to put on by each sponsor the relationship to the parents. It nearly always was a sibling, spouse of a sibling, a first cousin or spouse of a first cousin. It was not parents, it was not friends; almost never friends. The only possible exception to that being some people had no relatives in the neighborhood, so they had to make some other choices, but I succeeded in getting about 90 percent of those relationships established, and the communion list, you might say "A list of people taking communion? What in the world is the interest there?" The interest is that in this Lutheran church there are very proscribed ways about taking communion. You took communion in the order in which you were seated. Who did you sit with? You sat with your relatives-- is most likely what you sat with, and in one communion service at the first 16 people (that is eight couples) they were all descended from the same woman. So, now you can go to work and say "Why are these two people sitting together?" or you might rephrase it "Who's the wife of Peter Weaver?" and low and behold you can find out by studying who people sat with, so it's an intellectual problem both in the baptismal registers and the communion lists, and I had great fun working on those. I am the treasurer of the Delaware Photographic Society and I got involved in that because when we went to Germany we bought cameras and we studied photography a little bit just to have a record of it. We probably brought back 4,500 pictures from the two trips. I extracted some of the better ones and put them on a CD, and that got us involved with the Photographic Society, and very quickly we got promoted to treasurer and Eleanor was promoted to secretary. But again, there was like 200 people were members and a large fraction of those were doing some job to keep the organization going, and there is a lot of work to be done. They run an international exposition every year. Their 75th one is coming up right now. So it take a lot of volunteer labor, and though we're now not so interested in photography, we're doing our duty for a little while just to help a nice worthwhile organization do its job. I am a board member of the Pennsylvania Chapter of Palatines to America [American German Genealogy Society], and I am the Webmaster for their website.

Felsenstein: Palatines?

Blankenbaker: Palatines is a word that the English use that means "German" because many Germans came from the Palatine, or the Palatinate, the English call them all Palatines, and it became synonymous with German, and so the word is used as that. The other things that I work on of a private nature, like housework, carpentry, adding a room to a house. I cleared 10,000 feet of land down the hill. My priority right now is to get that stump out of the ground, so somewhere along the line I've lost interest in some of the things that I worked on. I no longer write notes; I no longer do much with computers. I'm trying to

learn a little bit about websites though, and so on, because I'm I involved in so many now. I've got to learn something.

Felsenstein: There is a great deal to learn.

Blankenbaker: I'm finding out that around the world, people who are writing programs to display web pages and so on are not following the same rules. I mean, there's a set of rules in theory, but not everyone implements all of it, "Well we're going to do this, we're going to do that," and so you really have to try your results on as many browsers as you can to see if you got some fraction of them covered, or to find how to write it in such a way that perhaps you violate the fewest rules.

Felsenstein: I asked you about your family background, and I wanted to ask about your family as it's developed. You have grandchildren?

Blankenbaker: My family consists of my wife, three children and one grandchild. We're a little disappointed that it's only one grandchild, but that's the way that sometimes things work. We have one step-granddaughter. The oldest son, another John, different middle name, has a Doctorate in mathematics and is in operations research in the travel industry; worked a long time for Delta until they went bankrupt, and then he switched over to Travelocity, and he spends a lot of time on what I would call operations research; how to improve the operation, what's wrong, why is it not better, things of this nature, of which he seems to succeed pretty well. He lives in Dallas with a wife and her daughter. Our second child Ann lives in Connecticut, just outside New Haven. Her husband is quite a bit older, and they do not plan any family. He as a matter of fact is a grandparent. So our son-in-law is a grandparent, so that makes us in a certain sense step great grandparents. She's very involved in many things. By training she's a research librarian, but like myself she's got involved in many things. She was a disc jockey at two radio stations for a period of time, quite a number of years. She and her husband are book collectors and dealers. She's working right now very hard on a folk festival which she has done for several years in New Haven. She's a registered songwriter too.

Felsenstein: I didn't know you could register.

Blankenbaker: Well you register with ASCAP to collect your royalties. Now, she's never collected any yet because until you get to a certain minimum amount they give it to charity, but she is a registered songwriter, and so she has many talents that I don't have, but at least we both have a certain amount of diversity. Our youngest child David has a Masters Degree in philosophy; degrees also in mathematics. That's his principal field of interest. It's unfortunate that he doesn't have a Doctorate because he loves teaching, and that's almost a requirement this day to teach. He was teaching in Albuquerque very successfully and with a technical school, but his wife was going to medical school and she's now a research resident at the University of Wisconsin, so they had to pack up and move to Wisconsin. They have the daughter. He's still having some difficulty finding a full time teaching position that he's happy about. He's only been there a year so it's not that, but he's still trying to find a good solution to that problem, and she's trying to get through residency. She's one year into it now and has three years to go.

Felsenstein: She's not out yet.

Blankenbaker: She's in that branch that deals with dead bodies.

Felsenstein: Pathology?

Blankenbaker: Yes, and so she's done autopsies and she does, you know, lots of studies-- a microscope almost as much as anything, but no diagnosis of living people.

Felsenstein: A pathologist told me that that this doctor knows everything but can do nothing. This doctor knows nothing but does everything. A pathologist knows everything, and can do anything, but too late.

Blankenbaker: So she had chosen that because she thought maybe it would be more family friendly than some of the other fields, but so far I don't know that it has. She's on call and has to go in at some strange hours. You never can predict just when the problems will arise, and sometimes they require pretty immediate action. So anyway, that's the children. They're all doing nicely, but they're not really interested-- well my daughter among other things is responsible for the webpage at the library, and my son, the oldest one, is very well versed in computers. He was about 8 years old when the Kenbak-1 was built. By the time he was in high school he was working part time in programming and building computers and so on, so he knows more about computers than I do, that's for sure.

Felsenstein: Did he learn from this?

Blankenbaker: Not a lot, but he did eventually before long program it and do it some. The youngest boy was five when I was in the business of selling them. He was about five years old. I remember once that I had a visitor at the house from Italy who was interested in the computers, so I left him on the kitchen table with the computer and the manuals and he got a little bit confused about something. David was home with me; that's the youngest one, and I said "Do you remember this David?" The question was "How do you store a number in a particular location?" and I can't say that David understood, but he went through the correct steps and stored the number in the location that was required, which I have to give credit probably helped sell the computer to Italy.

Felsenstein: Now is the time for the overview, whatever you want to say in terms of looking over the whole story you just told, if anything.

Blankenbaker: I've spread myself too thin because I've been interested in too many things, so while I've done some nice things in different areas, I've never concentrated in one area. For example, I don't know half those acronyms in a popular computer magazine anymore. It's Greek to me. I do better asking my children. So, while I may have done some good work in computers, it hasn't been that much of my life. It's been a good part of my life, but it hasn't been that much. I've done some work in history, genealogy, and some of that's been very good work, but again it hasn't been a major amount of my life. So, I've spread myself around, maybe a little bit too thinly, but I've always made it a point to spend time with the family and the community, as you can see here some of the things.

I taught my youngest son to read by the time he was three years old, which we made into a game. It wasn't a chore, it was a game. Incidentally, I'm not sure that that was the best thing to do, to teach him to read at such an early age. He did used to wait for my wife in the school office when she was working in the school office until she could go home, so he would amuse himself by reading books, and administrators from the district might be visiting the school and see this little boy reading the book and

they would make some fun and they'd poke around a little bit and they'd find out that really he was reading that book, and so they took great claim for their school system, but it was entirely a private effort. Our idea of a family out was to go to the library, and so each child would head in a different direction so to speak, and maybe read a few books there and pick up some books to take home. So, that was our idea.

A lot of our life with the children we've never had television. For a long time I just sort of refused to buy a television. Sometime someone gave us a television. We'd watch some things with the children, but it got to the point once where one of the grade school teachers said "Maybe you should have a television. Your children are missing something." We didn't feel that they were missing all that much, but most of the time probably yes, we did have a television, but it was not a major point with us. Playing CDs and DVDs, especially DVDs I guess it was. Well, we had to buy a player a year ago when someone had made DVDs of my work for that television station. I sort of liked seeing myself. Had to go buy a DVD in order to see that. So we played them, we put the player away and we haven't used it since. So, we're not that technical. We're not technology people. I don't own a cell phone. I don't own a laptop. I do have a computer though. Anyway, that's my outlook on life.

Felsenstein: Well I think we've covered a good deal of it here and I think people will draw some conclusions that aren't too uncomplimentary. Thank you very much.

END OF INTERVIEW

