

An Interview with  
GENE M. AMDAHL  
OH 107

Conducted by Arthur L. Norberg

on

16 April 1986  
17 January 1989  
5 April 1989

Cupertino, CA

Charles Babbage Institute  
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#### Abstract

Amdahl begins the first session with a description of his early life and education. He recalls his experiences teaching in the Advanced Specialized Training Program during and after World War II. Amdahl discusses his graduate work at the University of Wisconsin and his direction of the design and construction of WISC. He concludes the first session with a brief discussion of his work at International Business Machines (IBM). In the second and third sessions, Amdahl discusses his role in the design of several computers for IBM including the STRETCH, 701, 701A, and 704. He discusses his work with Nathaniel Rochester and IBM's management of the design process for computers. He also mentions his work with Ramo-Woolridge, Aeronutronic, and Computer Sciences Corporation.

GENE M. AMDAHL INTERVIEW

DATE: 16 April 1986

INTERVIEWER: Arthur L. Norberg

LOCATION: Cupertino, CA

NORBERG: Dr. Amdahl, can you tell me something about your parents? I know you're from South Dakota originally. Were they a farming family in South Dakota?

AMDAHL: Yes, my grandfather homesteaded in South Dakota prior to it becoming a state. So the homesteading would have occurred sometime in the early '70s. And on my mother's side, they homesteaded also on and about the same time, also in South Dakota.

NORBERG: Now, was this a very large farm by the time you were a boy?

AMDAHL: Well, he acquired several farms, altogether probably 5, say 5 quarter sections. These were divided between his children.

NORBERG: I see. That's a reasonable size. Was it dairy farming or wheat, or a mixture?

AMDAHL: No, it was at the edge of the corn belt so he raised corn, oats, barley, alfalfa, some grazing land, pasture land. He raised some flax. We also fed a lot of animals. Each year we'd feed about 50 cattle, bought them essentially as fairly well developed calves and feed them until they were ready. Initially they'd start out on pasture land. Or we'd plant rape along with the small grain and after we'd harvest the small grain, we'd let the cattle graze on the rape that would then come up.

NORBERG: Now, was it...

AMDAHL: So there'd be about 50 head of cattle a year we would raise. We had brood sows and raised about 100 to

110 pigs every year. We would buy and feed somewhere between 300 and 600 sheep every year and we raised about 2,000 blooded chickens every year. Besides that my father's farm farmed a little over 200 acres and we had a few milk cows, like 4 or 5.

NORBERG: Now each of those type of animals doesn't take very much work in each instance. It would seem to me the aggregate is quite large here.

AMDAHL: The aggregate is large and then we raised most of the feed for them.

NORBERG: Which suggests that there were employees on this farm as well as family.

AMDAHL: When I was young we had one hired man normally, and, of course, during the harvest season we would join with a numbers of neighbors and all would assist in the threshing all around. But normally one or no hired man.

NORBERG: That's an efficient operation.

AMDAHL: That's a lot of work.

NORBERG: How many others in the family besides yourself?

AMDAHL: I had three brothers and a sister.

NORBERG: And are you the youngest, the oldest...

AMDAHL: The next to the youngest.

NORBERG: Next to the youngest, so the other boys would have been working right along with you at the same time.

I read one interview with you done by Bro Uttel for *Fortune* in which he made an offhand comment about some mechanical activities that you engaged in while you were, I presume, a young boy from the tone of the paragraph. What sorts of things did you do on the farm?

AMDAHL: Well, I guess I was always interested in high technology, but high technology depends upon your frame of reference.

NORBERG: It certainly does.

AMDAHL: And at that time, until high school age, we didn't have electricity. The rural electrification came in about the time I was a freshman in high school. So, basically high technology as I saw it was largely mechanics. Of course, we would repair, sometimes even make our own farm equipment when times were difficult, even made our own paint to paint our out buildings. I remember still the formula for making paint. And it was interesting enough to be worth repeating it. It was skim milk mixed with Portland cement, pure, no sand, and ocher (a red pigment).

NORBERG: And this would provide a sort of a white wash, I take it.

AMDAHL: Yes. It lasted almost as well as an oil-based paint.

NORBERG: I'm impressed. What about the mechanical side of this? Were there tools available, and how extensive was the tool situation?

AMDAHL: Well, tools, you know, things like hack saws and wrenches, things like that. And we would make things like wagon boxes, hay racks, buildings. We would repair our own plows, sometimes make some pieces to go on the plows instead of buying them, because it was more expensive to buy than to make if you had something you could make it out of, and we always had... When I first started out, when I was very young on the farm, tractors weren't in yet, so we used horses. And our first tractor was a Fordson, with big, wide steel wheels. And when the rubber tire

came in, we got an Allis-Chalmers. When I got access to a lathe, I made a big jack that was capable of lifting our tractor so we could rotate the wheels, take them off and turn them around so that instead of being close together they were farther apart. So they'd be proper for row cropping, for that activity, and when put in closer they were proper for pulling equipment.

NORBERG: Very clever. Now I'm struck with the time period here, because as I know you were born in 1922. And if this was taking place, that is plow horses were still being used, well, when you were six or seven that's 1928 or '29.

AMDAHL: Well, I was older than that. I would have been at least 10.

NORBERG: All right. In the early '30s. So this seems like a long time after gasoline engines were available on various kinds of mechanical equipment.

AMDAHL: But not for normal farm equipment. They were available for... The Fordson, for example, was not very useful as a normal farm implement. It was useful for driving a threshing machine, which is what we used it for. We acquired a threshing machine and it had, as I recall, it was a 15/30, which would mean it would be 15 horsepower drawbar and 30 horsepower running belt-operated equipment.

NORBERG: Let me ask just one incidental question. Were your neighbors essentially in the same sort of situation in that they had the same kind of equipment...

AMDAHL: Yes.

NORBERG: ...using a plow horse, etc.

AMDAHL: Yes. We might have been slightly above the average, but not much.

NORBERG: Can you tell me something about your early education in South Dakota? Did you attend a rural school or a city school?

AMDAHL: Yes, a rural school. We were 11 miles from the town we normally went to, six miles from the nearest one, which was really a village. I went to a rural school which had one teacher, one classroom. At peak, we had some 36 students there, although normally our average during my attendance there was probably more like 15.

NORBERG: And throughout all grades, I assume.

AMDAHL: Yes, all eight grades. We had some excellent teachers, really motivated, really, I think, well equipped in terms of understanding the things that they were teaching very well, which probably didn't require a great deal of understanding, but quite a bit more than they had to call upon to teach the class because they could answer questions very well. One particular teacher was from a neighboring farm, almost neighboring. He bought a lot of music and taught a number of different instruments. He'd always put on a class or a school musical, things of that nature. So one even had, I think, as much exposure to cultural activities of that sort as one would get in many city schools today.

NORBERG: What were the range of subjects as you remember them up until the eighth grade?

AMDAHL: Well, they were, of course, the standard range. One of them was current events so I was aware of what was going on in Germany, a little less so, since the papers didn't carry much about what was going on in the Orient prior to World War II in terms of Japan's problems, what kind of frictions that were developing. I was aware of the fact that the British, for instance, had effectively blockaded Japan, so that Japan did not have access to raw materials. They were at that time occupying Manchuria and so they were viewed as kind of an outlaw country. I was aware of the rise of Hitler during that period. I talk to kids now about the same age and they seem blissfully unaware of what's going on in the world.

NORBERG: Yes, that's a good observation. What other subjects? Do you recall anything about science and mathematics?

AMDAHL: We had mathematics, arithmetic I'll call it. And we were taught arithmetic, very basic arithmetic, and taught it well so I understood it. Could do everything in long-hand. Applied it to some simple computational problems, what you would call probably first-level algebra. The very basic part of algebra. We learned to do things like take square roots manually, which was going fairly far for a grade school. We had a course in civics, and it was there, of course, where we had to keep abreast of what was happening in the world. We had english. We had to write some themes and some poetry, read books and report on them. We had spelling competitions, things of that nature, things that would increase our vocabulary. We had history. In civics, of course, we learned about government -- the structure of it. Oh, science and hygiene, those two went together, came under that title. Our science was really an extremely basic sort of thing and was involved with hygiene in the sense that it was very important that people understood since access to doctors was not that easy. How to take proper care of ourselves. Understanding the spread of communicable diseases, all that.

NORBERG: Now, was there a library close by that you could get access to?

AMDAHL: We had our own little library, which probably had maybe a couple of hundred books in it. There was one in our town where we probably had a thousand books, but we very seldom got into the town. But I would take out books in the town library.

NORBERG: I'm fishing to see where the first interest in things like electricity and electronics and so on came from.

AMDAHL: Well, my mother had been a teacher and she wanted to make sure that we had stimulation so she bought an encyclopedia. The particular one was *Book of Knowledge*, which was very readable. It was some 20 volumes. And I think most of us in our family read almost all of them.



NORBERG: Interesting. Do you remember anything from those?

AMDAHL; Oh yes, I remember the particular descriptions of the transmission of an automobile and differentials and all those sorts of things. And I read about the countries. It's hard to remember how many things I read about. I read about people...

NORBERG: But the examples you chose are, I think, indicative of the sort of interest that would have developed at about that time. I take it if the town was ten miles away that the family had an automobile.

AMDAHL: Yes, we did.

NORBERG: Did you ever try to take it apart or toy with it in any way?

AMDAHL: Not until I got my own. I got a Model A Roadster when I got to college and that I took apart and I would like to say I rebuilt it, but I only did a little bit to it. But I took it apart and put it back together again.

NORBERG: You say your mother was a schoolteacher. Did she continue to teach school when you were young?

AMDAHL: No, she had taught until she got married.

NORBERG: I see. So she was working on the farm, essentially, from that time on.

AMDAHL: Yes.

NORBERG: Where was the high school?

AMDAHL: The high school was at another town that was really on the verge of being a village, but not either of the

first two I referenced. It was a consolidated school. That is, they consolidated a number of rural schools together at that one place and had bus service.

NORBERG: That's early. Now what do you remember about this school? How large was it in terms of student body, programs?

AMDAHL: The student body there was approximately 400 for all four high school grades. I went there for two years. Then I went to a church academy, Augustan Academy, a Lutheran Church school for my junior and my senior high school years.

NORBERG: Now where was that in relation to your home town?

AMDAHL: Down in Canton, South Dakota, which would have been about sixty miles south.

NORBERG: Which meant you would have to board there.

AMDAHL: Yes, I did.

NORBERG: What was the attraction of the church academy for your parents and yourself?

AMDAHL: My mother wanted to make sure that I was exposed to good influences.

NORBERG: Good influences on the moral side or on the intellectual side?

AMDAHL: On the moral side, because I think actually on the intellectual side I did better at the consolidated school.

NORBERG: I see. Again, I ask you the same questions that I mentioned in the case of the elementary school: what

was the education like? Let's confine ourselves to the academy first of all.

AMDAHL: To the academy? Well, it was, I would say, a very weak school academically. People that were dedicated, teachers and a lot of dedicated students, but not enough teachers, not enough experience on the part of the teachers. I went, for instance, to classes in biology and one new class they put in, physics, in which the teacher was basically one jump ahead of the course he was teaching, of the particular subject that he was then in. And I had very little mathematical background and ran into these formulas in physics and they really didn't make sense to me as a formula except that I could see that if a variable occurred in the upper side of the expression it increased with the variable, if it was in the denominator it would decrease. And in terms of just thinking about the subject, I ended up getting one of the best grades in the class even though I had not had the algebra necessary to work it.

NORBERG: I take it then you did not get the necessary mathematical background until you got to college?

AMDAHL: That's right. So I took one year of... or I guess one quarter of remedial algebra the first quarter I was there.

NORBERG: Do any of the teachers in either the consolidated school or the academy stand out as having had any influence on your thinking?

AMDAHL: Not intellectually. In grade school this one teacher that I mentioned that was from a neighboring farm had a lot of influence.

NORBERG: This is the man with the music.

AMDAHL: Yes. But he was equally versed in every area. Skilled at hunting also, which helped. He had a .22 target pistol with which he would hunt gophers. Most people had more trouble hitting a gopher with a rifle than he had with a target pistol. I watched him from a distance about here to that post drive a nail with a target pistol. There was

one other kid I went to college with, same class I was in as a freshman. He was good like that with a rifle. You could throw a walnut up in the air and he would shoot and more than 90% of the time, he would hit it and it would shatter.

NORBERG: Are there any of the students who emerged from the academy or the consolidated high school that you have kept up with over the years or who have made a name for themselves in society in the same way you have?

AMDAHL: Not many. I really don't know of any.

NORBERG: Because I think of people like Ernest Lawrence and there were several people...

AMDAHL: There was nothing like that that came out.

NORBERG: ...who came out of his group in North Dakota in that case.

AMDAHL: I guess until I got to college.

NORBERG: We'll come to that in a minute. I need to get some chronology straightened out here because it's not quite clear to me the next sequence of events. The way I interpret what happened next is that you did not go directly to college at that time, but went into the service instead or stayed on the farm.

AMDAHL: No, I stayed on the farm for one year. At that time my father really couldn't quite afford to have one more student in until one graduated. I couldn't go. But one year afterwards I went in.

NORBERG: That would be in what year?

AMDAHL: That would have been the fall of 1941.

NORBERG: And then after one year, into the service and then came out and finished. Let me go back then to that first year of college. What sort of objectives did you have for yourself in terms of higher education as you were coming to the end of high school or during that first year? And particularly who influenced any decisions about it?

AMDAHL: Well, my parents wanted me to go to college. I wasn't so terribly motivated myself at that time, but after being home on the farm for a year I was motivated to go to school because I didn't like to be a farmer. And I would not have been successful as a farmer, because I really didn't basically like that kind of activity. I liked the outdoors, the openness of a farm, but I didn't like being dependent on the weather, particularly I didn't like being dependent on South Dakota weather.

NORBERG: It was a question of weather and not a question of the type of work that had to be done or the...

AMDAHL: No, I also didn't like the kind of work. I had a stomach problem and when I would have to bend over too much apparently I would release too much acid into my stomach and I would end up having to vomit. That gets old very quickly.

NORBERG: Yes. And there's certainly a lot of bending doing farm work. All right. So you were motivated, but what sort of objectives did you have?

AMDAHL: Well, I decided I wanted to get into high technology, because I had become very interested in science even though I didn't have enough course work to really get me excited from the standpoint of really having a good understanding. I was excited and I understood mechanics very, very well so I thought I'd be a mechanical engineer. So I went to... Oh, by the way, the same guy who taught physics, who didn't know physics, he let me look at his book in trigonometry. And even without adequate algebra, I was able to do that trigonometry. And geometry I had taken and was relatively a whiz at that.

NORBERG: This is plane geometry or plane and solid?

AMDAHL: Yes. Plane.

NORBERG: All right. So you had developed this interest in science earlier.

AMDAHL: Yes. And I would say that physical things that I could see and that had nice physical relationships that I could visualize, I was very good at.

NORBERG: I take it if your parents needed to wait until one of the children was out of college before someone along the line could go in that this would have dictated where one could go as well, it wasn't possible to go across the country perhaps.

AMDAHL: No, that's true. But they went to a church college and when I went, when it became my turn to go, I wanted to go to the state college where I could get technical training, technical education.

NORBERG: Did they just agree to this or did they endorse it?

AMDAHL: My father didn't want me to. My father wanted me to go to the other school. His reasons, I think, were really worthy of note. He said that he considered education not a basis for learning how to make a living but rather for learning how to get the most out of life.

NORBERG: Very astute. So how did you convince him otherwise?

AMDAHL: Mostly by being stubborn. He really felt that I would get more for myself out of the other one. But I found I got a lot out of his remonstrance; it did affect me and so I did deliberately try to get more out of the non-scientific subjects.

NORBERG: And how did you do that? What things did you take?

AMDAHL: I got very excited about ancient history, for example, and of course, I took both english and literature courses. I was no good at music -- being about the only one in the family who wasn't, I always sort of lagged in that aspect. But you can't do much with a tin ear.

NORBERG: My son is like that. I sort of sympathize with the situation because he's desperate to do it and yet he cannot. I would assume that the first year would be a fairly standard program of english and history and maybe one of the sciences and certainly mathematics and so on.

AMDAHL: Yes.

NORBERG: Now what occasioned going into military service before finishing your degree?

AMDAHL: I went to my second year and there I got involved with some guys that were a little more wild than usual, so I was kind of late for my morning classes because I would stay out a little late at night. And I ended up... Well, the two guys I was going with were flunked in the course because they didn't attend enough classes. I missed the same amount of classes, but I got an A.

NORBERG: How do you account for that?

AMDAHL: This just happened to be in trigonometry. I studied that book on my own in high school and every time she'd ask the questions for somebody in the class to come up and put an example on the board I'd raise my hand and I'd go up there and I wouldn't know what the proof was in the book but I'd work it out right in front of her. And she decided it really wasn't terribly important whether I attended the class or not, because I think on only one occasion did I not get the answer right.

NORBERG: Okay, you got an A in the course but the other fellows failed. What happened with this threesome?

AMDAHL: Well, they had to retake the course. But that fall, in that second year, Pearl Harbor occurred. And that's how I ended up... But the second year it was kind of a hiatus, everyone had gone into the services.

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AMDAHL: And so I wanted to go into the service, too, but the draft board wouldn't let me because they'd drafted so many of the youth that there weren't enough people to harvest. So they would not let me join. So I worked for that summer, tried again in the fall and they still wouldn't let me. And then I had an opportunity to get into the Eddy program in the Navy, which was where they taught electronics.

NORBERG: Well, I think I misunderstood something then, if that's the case. You talked about the course in trigonometry in the fall, which would be the fall of '41?

AMDAHL: Yes.

NORBERG: Okay. Then it makes sense. And then tried to get into the service during the summer of '42.

AMDAHL: Yes. And I couldn't. So I stayed on with school. I had a job in a hospital there where I stayed in the basement in a small room there and I got my meals. So board and room and \$15 a month for doing all of the floor cleaning and waxing, helping with odd jobs all around just general handyman.

NORBERG: Now when were you allowed then to enter the service? Was that...

AMDAHL: In the spring of '44.



NORBERG: That late! Had you been helping with the harvest all that time or had the draft board been...

AMDAHL: Oh yes, but in the fall of '43 they started the ASTP, Advanced Specialized Training Program, for the Army, and a whole bunch of those came to South Dakota State -- they didn't have teachers. So they invited me to come and teach physics laboratory. So I...

NORBERG: That's quite an accomplishment. Why do you think they invited you to do that?

AMDAHL: Because I had taken a course in physics and come through with flying colors.

NORBERG: What sort of experiments did these young men set out to do?

AMDAHL: Well, just sophomore physics.

NORBERG: With the usual pulleys and inclined planes and electrostatics and so forth?

AMDAHL: Yes, and the heat of vaporization and things of that nature.

NORBERG: Tell me a little about the electronics school in the Navy.

AMDAHL: That was a very highly condensed course where they started out with a month of math, teaching you to do computations basically in alternating current using vector analysis. And so we learned that, how to use a slide rule, and a refresher course in algebra, which I didn't need. But the rest of it was all really quite new to me. Then the next set of courses were on vacuum tubes. While I was teaching physics laboratory, one of the physics professors was taking a graduate course by mail on vacuum tubes. And so he let me look at the text and I ended up solving all of the problems that he solved. As a matter of fact in some cases he used my solution.

NORBERG: Do you by any chance remember the title of that book and the author?

AMDAHL: No, I don't remember the title of the book and the author. But it was principles of vacuum tubes.

NORBERG: Back to the Navy again.

AMDAHL: So back in the Navy then we got into vacuum tubes there, we got into radio circuits, including the theory of heterodyning, the equations for gain through the transformer coupled resonant circuits. We could learn enough to understand all of the feedback and I could generate the equation and solve it. I'm not sure how many in the class could but it sure came through nicely to me. And then when we finished... Oh, we also learned about such things as flip-flops, one-shot multivibrators, and were all set up for the next set of courses which were on actual radio equipment. The various kinds of radars that were available then. They were relatively new. And the dead reckoning equipment used by the Navy for plotting course and intercepts, things of that nature.

NORBERG: Now, did you put this to use at all, during the years of the war?

AMDAHL: Well, I was all set to go to sea, as a matter of fact, there's an interesting little side-light there.

NORBERG: Be my guest.

AMDAHL: My brother was killed in Germany just about three weeks before the end of the war. He was an armored car commander leading his army into the town across the first bridge which was over the river separating France and Germany.

NORBERG: Yes.

AMDAHL: And he was shot by a sniper. Because of that, I was asked by my parents if I could get a leave to go

home for memorial services. As background here, I might say that shortly before this, there had been rumors going around that somebody was assigned, not somebody, a Bosun would be assigned to watch over us whenever we went to sea, and if we were in danger of being captured it would be the Bosun's duty to shoot us so we couldn't be captured because of our knowledge of the radar. And I just sort of laughed...

NORBERG: Chuckled at that.

AMDAHL: ...and then when I was applying for my leave they agreed to it and as they were getting the papers ready I was about from here to your papers from that Dutch door to the desk in which the papers were sitting and there stamped in big red letters was "THIS MAN MUST NOT BE CAPTURED." At that point, I decided there was probably almost 100% truth in the rumor.

NORBERG: I'm a little surprised that late in the war that that sort of...

AMDAHL: This was '45.

NORBERG: ...that that sort of situation still persisted.

AMDAHL: Well, I think they didn't know how much the Japanese knew about it and didn't want the Japanese to be able to get anything from us.

NORBERG: Where had you been stationed? Had you been in South Dakota all this time?

AMDAHL: No, oh no. The first course was at Wright Junior College outside of Chicago. The second course was downtown in the heart of Chicago, 190 N. State Street. The third course that I talked about was at Treasure Island in San Francisco in the San Francisco Bay.

NORBERG: Was that the first time you'd come to San Francisco?

AMDAHL: Yes.

NORBERG: Yes. Okay.

AMDAHL: Then I ended up being assigned to be a teacher, because of my record. So I was sent back to Chicago to teach, to go to teacher's training and ended up after a couple of weeks of teacher training teaching at Hertzl Junior College in western Chicago. And then down to Gulfport, Mississippi, where I spent the most of the last year that I was in the Navy.

NORBERG: You mentioned something a little earlier about the Army and I've forgotten now what the relationship between...

AMDAHL: Army Specialized Training Program.

NORBERG: Yes.

AMDAHL: I was a civilian at that time and I was teaching Army students.

NORBERG: That's right. Now is that after 1945 then?

AMDAHL: That would have been...

NORBERG: Or before the Navy altogether?

AMDAHL: It would have been before the Navy.

NORBERG: Before the Navy. I have that clear now. All right. So you went back home for the memorial service. Did you go back to active duty after that?

AMDAHL: Well, yes, I went back. I still wasn't quite done with the third course, so I still had all the teaching ahead of me yet. I didn't know what my next assignment would be. I knew it would be either sea duty or that.

NORBERG: So you went to Chicago when, in about... that is, the second time.

AMDAHL: I went to Chicago early in the summer of 1945; it probably might have been June.

NORBERG: '45?

AMDAHL: June of '45.

NORBERG: '45. And how long did you stay there?

AMDAHL: About three months. Maybe less. Maybe it was... I guess the course itself was 2 1/2 to 3 months. And then I went down to Gulfport, Mississippi, and was there until June or late May of '46.

NORBERG: '46. And teaching all that time in the Navy?

AMDAHL: Yes.

NORBERG: Now, all this time you must have been thinking about what you were going to do after military service was completed. Do you recall those thoughts at all?

AMDAHL: Yes. I wanted to be in electronics. I decided I really was fond of electronics, but also wanted physics. I decided I wanted to go back to school, but I couldn't get into the University of Minnesota which was the one I wanted. They were filled up with so many returning servicemen that they had no openings at all. They were only taking Minnesota residents and I was really a South Dakota resident. So I actually moved into Minnesota to try to see if that would help but it didn't help. So I missed the first quarter of the fall of '46. And I applied then to South Dakota State College. I got married just after getting out of the service and occupied myself during that quarter constructing a small house, portable one, because there was no place to stay at South Dakota State College. All of the rooms for let had been let already. And I decided well I can build this little house. So I proceeded to work on that and then I looked for a place where I could set it up well, I could get a little lot, but I couldn't get any of the fixtures necessary to attach to city water. I called all of the towns for several hundred miles around. Nobody had those things. So I thought about that a while and decided I'd go down to the trailer court outside of town. Not a trailer court, it was really a motor court. And they had excess space there and I asked them if they'd let me put my house there and connect to their water, because that didn't require this legal fitting. So yes, he was willing to do that. He gave me a very reasonable price. I got that all set up -- just the rough exterior -- in time for the start of the winter quarter. And then I lived in it and finished it off on the inside while I went to school.

NORBERG: And your wife was living there, too?

AMDAHL: No, it wasn't good enough for that yet. But by the spring quarter it was. So one quarter she stayed at home while I did that.

NORBERG: And where was home in relation to South Dakota State?

AMDAHL: About 30 miles away.

NORBERG: So not so bad. Did you own a car by that time?

AMDAHL: Yes, I had a 1935 Plymouth.

NORBERG: My uncle had one of those. Delightful car.

AMDAHL: But the very next winter it was so cold in the state, every day it got below -35. For a whole week. The daytime never got higher than about -30. And even though I had antifreeze, it still froze and cracked the block.

NORBERG: All right. So you finished the program and obtained a degree in electrical engineering as I recall.

AMDAHL: Not electrical engineering. I decided I wanted to continue with physics. So I went into physics but I also took electrical engineering courses. I took physics courses, I took courses in advanced chemistry, and math. I ended up I could have had 4 degrees. I had to choose which one I wanted, because they wouldn't give me more than one and I chose engineering physics.

NORBERG: Engineering physics. I guess I misread the entry in *Who's Who* where I thought it said B.S.E.E.

AMDAHL: It should be B.S.E.P.

NORBERG: I probably misread it. All right. That sort of sets the stage then for what you wanted to do after that.

AMDAHL: At that I got so interested in physics I decided I wanted to become a theoretical physicist.

NORBERG: Why? What was the attraction there?

AMDAHL: Why should somebody choose to be a monk, I don't know.

NORBERG: Okay.

AMDAHL: It was really that I was so excited about it intellectually that the thing I really wanted to do was to understand how the world worked. And at the time I made the decision, I talked it over with my wife, explained to her that this probably meant that we would have to live on a very limited income for the rest of my life, because at that time I was not aware that physics had come back into vogue and that scientists were going to be commanding large salaries. I thought in fact I was doomed to be sort of on the same scale of income that my professors were on.

NORBERG: Obviously she agreed that that was acceptable to her.

AMDAHL: Yes.

NORBERG: How did you come to choose the University of Wisconsin?

AMDAHL: Well, I tried three schools and University of Wisconsin accepted me. I tried Yale and Princeton and they didn't. My background was not really adequate for... You know, I'm sure I couldn't compete with the students who had gone to first class colleges and first class high schools. I'm not sure that my college background at that point was a great deal better than some of the really good high schools.

NORBERG: I see. All right. So you arrived at the University of Wisconsin in 1948.

AMDAHL: Yes.

NORBERG: What was the program like in 1948?

AMDAHL: Well, I arrived there in time for summer school and I elected to take a course in the mathematics department. The course was on non-Euclidean geometry; it was essentially matrix theory for relativity. I didn't really have an adequate background, but I managed to get my A out of that by really working at it. And I really got a good



feeling for it. Learned all about how to deal with the Jacobins. Anyway, I probably should go back to my college. I wanted more courses than I could get. So I got the dean of engineering, who was quite a good physicist, dean of the engineering school and he gave me a special course on relativity. And so I learned about the advanced and retarded potential and things of that nature. Here was the chance to get to the real thing. And at Wisconsin I should have really waited and taken that after a year, because I was the only one who just came to graduate school and took that course. Most of them had been in the graduate school for a couple of years. I think I took every course that I had felt there was a certain romanticism about in quantum mechanics. I still remember the opening lecture in quantum mechanics where my major professor explained to us that theoretical physics was really very much like a religion in that it really was based on faith. Faith that there would ultimately be a simple description of nature. Somehow or another that stuck with me through all of those years.

NORBERG: Who were some of the faculty at Wisconsin at this time?

AMDAHL: My major professor was the head of the theoretical physics department there. His name was Bob Sachs. He just retired a couple of years ago as director of the Fermi Institute in Chicago. One of the leading theoretical physicists in the country, say at least among the top twenty.

NORBERG: Who else was there besides him?

AMDAHL: Well, the leading man in construction of Van de Graaff generators for high energy particles... I'd give you his name if I could think of it easily here.

NORBERG: I don't have it either.

AMDAHL: I'm very poor on names.

NORBERG: I didn't look up the faculty of Wisconsin before I came over. Some of those people were still there by the

time I got to Wisconsin so the names like Sachs come to mind quickly.

AMDAHL: This was Herb. Professor Herb. And when he retired he started his own company building Van de Graaff generators. Made a very successful business out of it. So he was really first class in that area. Then there was one that came in a little later in theoretical physics was a man by the name of Powell. What years were you there?

NORBERG: Oh, I wasn't there until the late '60s.

AMDAHL: Powell wouldn't have been there any longer. One of my fellow students who is still there was Converse.

NORBERG: Oh yes.

AMDAHL: He and I and two others shared an office. Three others. Five of in one office.

NORBERG: Did Sachs give you any assistance, shall I say, in developing a dissertation problem or did you select this by yourself?

AMDAHL: No, I was starting a dissertation, done quite a bit of work on it in getting the mathematical background all set up so I'd be able to do quantitative calculations. I developed a set of orthogonal functions that had the characteristic that as you took the sequential states that you were describing with those functions the expectation volume of the nucleus would grow such that these states would represent the nucleus of that many particles. So if you took the state for a given classification of the... Is it the Mendeleev tables?

NORBERG: Yes.

AMDAHL: You would calculate a volume that went proportional to the number of particles, basically.

NORBERG: Now how far did you get with this problem?

AMDAHL: Well, I got that ready and was going to analyze... What I was going to analyze was the contributions to the magnetic moments of heavy nuclei due to spin anti-symmetry and velocity-dependent forces.

NORBERG: Typical Wisconsin problem.

AMDAHL: And had gotten that far along at the time that my major professor called me in and said that he had been asked by the head of the electrical engineering department, Harold Peterson, if my thesis subject could be changed to a recording of a proposed machine that I described in a special seminar.

NORBERG: That you had described. Now how did you come to describe this special machine?

AMDAHL: Let's move back in time here. This would have been late 1950 that the head of the electrical engineering department asked my professor to do that. In '49 I'd worked in that office with Converse, I and two other graduate students, Norman Austern and a man by the name of Volcov were asked to determine whether opposed forces between nuclear particles could describe the simplest three body nucleus, tritium, hydrogen-3. We spent thirty days using a desk calculator and a slide rule to hold the two most significant digits. And we mapped the energy levels for all values of the parameters and found the lowest energy state which was not quite bound. It was virtually bound but not quite. So we concluded there was no way that that could actually describe a nucleus. Thirty days to do that. I decided that there had to be a better way to do it. So I began to invent computers.

NORBERG: Invent or investigate?

AMDAHL: Invent. There was nothing... There were no computers around. We had an analog computer over at the electrical engineering department. So I went over to find out what they had and I audited a class on this analog

computer, which used electronics and operational amplifiers. And I went over to see what they had at the mathematics department. They had there a 602A, which was a multiplier. You could put in a card with two numbers on it and punch into the same card the product of the two. And that's all they had as computers. I decided neither of those met my desires so I thought about what I might do and the first thing I thought of was a digital differential analyzer, which would be the digital equivalent of that electronic analog computer and I was quite excited about that. My major professor suggested that I go to summer school at the Aberdeen Proving Ground. Not school, get a summer job, because I needed a job anyway. So I went there and worked for the summer. They didn't really have any computer, but they had one they were trying to make, which was the EDVAC. And they had the ENIAC sitting there, which wasn't a programmable computer, of course, you plugboard programmed it. So I looked at those and I decided I really didn't like either one of those, but what I thought I would be interested in though, was designing one of my own. So I began to think about it. And as I worked during the summer there I thought about what I would do and I ended up figuring out one that used a magnetic drum and that would have serial revolvers. At that time, I called them recirculating registers, because I thought that they were new. I didn't know that they had been invented yet and patented by I guess it was Engineering Research Associates in Minnesota. So I had this idea in which I had these recirculating registers and utilized a 50-bit...

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AMDAHL: ...floating point word with a 40-bit mantissa. And could have 32 copies of that in memory and yet 40 copies of just the mantissa in the recirculating registers for doing the arithmetic. And I called that integral synchronization. And that's how I came up with the name of WISC (Wisconsin Integrally Synchronized Computer). I've got it here.

NORBERG: I will look at it before I leave. How much time do you have, by the way?

AMDAHL: I have until... I need to finish by four.

NORBERG: Fine. Okay. That's what I had thought when we talked to your secretary before. I want to drop back just a little bit in that story and ask you about two other things that probably are related. One of them is, before you went to Aberdeen, when you were thinking about what sort of machine or some mechanical device that might do this task, what sorts of principles do you recall using to guide your thinking? Were you thinking back to the flip-flops in the Navy electronics? Had you learned anything about counter techniques and so on at that time?

AMDAHL: Well I learned about counters and I learned about flip-flops in the Navy, but nothing that went beyond that. I did invent some things like that. I figured out how to make a shift register using flip-flops that were connected with capacitors not diodes, which was an interesting discovery. If you look on the two sides of the flip-flop as being two voltage dividers, you pulse the power supply and the conducting side has a very low pulse appearing at its plate and the other one has a good size pulse almost at the amplitude of the original one. And both sides coupled capacitively to the next stage would set that succeeding stage into the same state the previous one is in.

NORBERG: And clear the preceding one at the same time?

AMDAHL: Yes. The preceding one would take the state of whatever was ahead of it. So that was going to be my storage mechanism.

NORBERG: The second thing is the statements that you made about going off to the engineering department and learning about analog machines and seeing what they had in the math department and so on suggest to me that you might also have either gone to the library to see whether anything was available.

AMDAHL: I went to the library afterwards. We didn't have any books. The only text on computers that we had, the only book on computers, was a book of pictures that were of the dedication of the Harvard Mark I. It didn't explain anything about the Mark I, just pictures. So that's all we had in the library. So I did go to the library, and there was nothing there. The only thing available... At that time, I thought any information on computers was classified, because they were all being done under government contracts. So I didn't know anything about them. I'd read about

them in a book called *Giant Brains*. I don't know if you ever read the book.

NORBERG: Edmund Berkeley, yes, I know it.

AMDAHL: Yes. That's the only text that I had access to before I went to work at the...

NORBERG: Aberdeen. Were any papers floating around? Copies of papers that had come from various symposia that had been held.

AMDAHL: No, not a thing.

NORBERG: What then did you encounter when you got to Aberdeen in terms of either papers or books...

AMDAHL: I explained my... The only plans that they had in mind were for the EDVAC, that's all. They didn't have any more.

NORBERG: But what about the Goldstine and von Neumann papers that you quote in your dissertation? The reports to the Army from 1946?

AMDAHL: I only referenced those as being there, I never saw them.

NORBERG: How about the Hartree book then, had you seen that from 1947?

AMDAHL: I didn't know about that one.

NORBERG: It's the first entry in...

AMDAHL: Did I put it in? I got them out of the... I did see... Oh I know what I did. By the time I wrote my thesis, I had read one book, but that was read in 1951, early '51. And that book was by Engineering Research Associates on *High-Speed Computing Devices*. And that was a real text. But that all came after I'd made all my plans.

NORBERG: I take it that none of the mathematics people had mentioned *Mathematical Tables and Aids to Computation* to you then, which began to have things in 1946, late '46 to be sure, about computing devices and techniques.

AMDAHL: Since our library had nothing in it, they didn't have any reference to that, either.

NORBERG: This is at the University of Wisconsin?

AMDAHL: At that time that's all there was.

NORBERG: I'm amazed, considering what they had when I arrived, a major collection of scientific and technical material.

AMDAHL: Oh yes. You've got to remember this was the very beginnings of it. There was infinitely less information in that library on computers than there was on this new thing called strange particles.

NORBERG: All right. You started the tale by telling me that the head of the electrical engineering department had come to ask if you could be relieved. Now was that on the basis of what you had learned at Aberdeen and therefore had presented when you came back?

AMDAHL: Well, I designed my own computer while I was there, you know, planning the ideas for it, which was very different from what they had at Aberdeen. You know, it was floating point. Aberdeen was all fixed point and there was a four-address thing; I had a three-address one. I had overlap, which didn't occur in any of the others. So I had

four instructions in course of execution concurrently, including figuring out a way to divide at the same rate, generating one bit of quotient at a time by either adding or subtracting the next time. And I was going to patent that and found out that it had been patented earlier by von Neumann, but I didn't know it until the patent application went in.

NORBERG: Oh, I see. Were you trading off the information about the EDVAC while you were designing your own?

AMDAHL: No. Because I didn't see anything about the circuitry. I got a look at it in the sense that they showed me some mercury delay lines, but I never saw anything on the circuitry board.

NORBERG: Okay. Interesting.

AMDAHL: But I did see the instruction manual.

NORBERG: Who else was at Aberdeen at that time, while you were there that summer.

AMDAHL: Only mathematicians, that's all I met.

NORBERG: Any of them interested in the EDVAC machine?

AMDAHL: Yes, most of them were involved in doing programming.

NORBERG: Who were they?

AMDAHL: Oh, let me think. I can't get their names at the moment.

NORBERG: They may come back to you. When you left Aberdeen then and came back to the University of



Wisconsin, had you thought anything about building that design?

AMDAHL: Yes. Building what I had in mind to do. But I just talked about it to one of my classmates and somehow or another he got enthusiastic about it and he went and started talking to the electrical engineering department, because he was an EE. His name was Davidson. And he really thought he could get the electrical engineering department interested in it and that would give me a chance to build it maybe, or at least a chance to have it evaluated. And so what he effectively arranged was a chance for me to give a lecture, or seminar, on this proposed computer of mine. I had nothing in writing, it was all in my head. So I described the computer and apparently in that one lecture they got excited enough so that their... they'd heard enough about this new thing called computers so they decided they had to train graduate students. And probably the best way to train them would be to have a project going. So that's how the head of the engineering department went to my major professor and asked him to have my thesis subject changed so they could have a record of it to build.

NORBERG: That's interesting. This seems sort of a remarkable change considering that you went there to do theoretical physics and now the electrical engineering department is asking for something else. How did this sit with Sachs?

AMDAHL: Well, fine. I was always an inventor and I don't know that I would have been a very top grade theoretical physicist, because in the course of doing something I would get very interested in something that I can do with it. But I wouldn't have been a good experimental physicist either, I would have been a... I don't know what I would have been. I was getting excellent grades, you know, but it was quite clear that I kept taking off in these unusual inventive tangents.

NORBERG: So when exactly were you at Aberdeen? Was that '49 or '50?

AMDAHL: The summer of '50.

NORBERG: And then in the next six months it was essentially developed and then you took some time to write a dissertation which is dated June of 1951.

AMDAHL: That's right.

NORBERG: As I remember the article by Davidson and some of his colleagues on the applications of the WISC later on, where they describe the entire machine in a publication, Davidson made a comment, or the authors made a comment, five of them, made a comment that this was the only known machine at the time that had been invested in by the university without any government funds. What sort of investment did that require? Did you ever learn about that?

AMDAHL: I don't know what the total investment was. I was put in charge of the project, which began in January of 1951. And during that time I wrote my thesis, negotiated for a magnetic drum with Engineering Research Associates. One of the people I negotiated with was vice president of that company at the time and his name turned out to be the same as the man who started Control Data. So Norris was the principal that I negotiated with at that time.

NORBERG: How did you come to choose a drum for this purpose?

AMDAHL: The lowest technology level so we would have the maximum chance of really being able to make it.

NORBERG: So this is part of the design philosophy of reliability that was built into WISC.

AMDAHL: Yes. Let's say it was scaled down to what my expectations were of what we could do with the technology there.

NORBERG: Had you looked carefully at the other technologies, just for completeness here?

AMDAHL: I'd only observed the mercury delay lines and I decided that would be too hard to master for the things that we really felt we could do. The speeds of it would be faster than we could make with the flip-flops and all of that. In fact, I reached the conclusion that the electronics would have to stretch just as far as the other technology in order to make it work. And they didn't make the EDVAC work, ever.

NORBERG: That's true. Also, had you visited any of the other sites where machines were being constructed or not?

AMDAHL: Never.

NORBERG: When you first contacted or, let me ask that question differently. Who first contacted Engineering Research Associates about a drum?

AMDAHL: I did.

NORBERG: You did. On what authority? Was the university willing to pay for this drum or were you asking for the company...

AMDAHL: This was after I was put in charge of the project in January.

NORBERG: So you had a budget then?

AMDAHL: Yes. I had a budget. Well, not strictly a budget, it wasn't a fixed amount. I was just told to go ahead and do it. They may have had a fixed amount, but they never told me what that limit was. And I went out and I bought the vacuum tubes it was built out of. I bought them as war surplus from the air base near Madison. A whole mess of 6J6s. That's what it's populated with.

NORBERG: All right. Did you ever go to Minneapolis to look at the drum?

AMDAHL: Yes.

NORBERG: You did. And who did you deal with beside Norris?

AMDAHL: I don't remember the names of the other two. Two engineers that worked in the magnetics part of it.

NORBERG: This was 1951 so it was still an independent company at the time.

AMDAHL: That's right.

NORBERG: Do you think they gave you a good price for this drum? Just out of curiosity?

AMDAHL: Yes. I don't remember what it was.

NORBERG: I can look that up, the records are available.

AMDAHL: I was really excited when I saw the quality of what they did. You'll see that yourself here.

NORBERG: You stayed then as head of that project through to '52 as well?

AMDAHL: Yes, until June of '52.

NORBERG: I want to ask you...

AMDAHL: At which time I left to go to IBM.

NORBERG: Let me ask you one question which struck me as a little odd here and it's in a section of this article by Asmuth, Davidson, and others. In the flip-flop section, it describes the type of tubes that were used -- the 6J6 for the most part and then 12AU7s. And they make a statement, "should subsequent change-over be desired, these tube types can be replaced with any of several recently developed computer type tubes." I haven't any idea what they're talking about.

AMDAHL: IBM also used a 6J6 that they developed themselves to give it much better reliability, much longer life.

NORBERG: So it's a question of reliability, I see.

AMDAHL: Yes. IBM built its 604, its electronic calculator using their version of the 6J6.

NORBERG: Did the procedure of orthogonal coordinates as applied to nuclei ever get developed fully enough by you to be published?

AMDAHL: No, I haven't looked for my notes since. I'd have to go back. It was just a simple tour de force sort of thing. You set up what you wanted to describe and it had several parameters in it so you could set the parameters so that the volume would have the characteristics you wanted. I wanted to do this instead of using the wave functions that... they weren't really wave functions they were using  $e^{-ax^2}$  which...

NORBERG: Falls off very rapidly.

AMDAHL: ...falls off very rapidly. I instead chose to use one which had an expectation volume, because the other one I felt wouldn't really describe it adequately.

NORBERG: I was just trying to ascertain whether you had completed that problem, too. As you were coming up to the middle of 1952 and directing this project on the building of WISC, what were you thinking about in terms of the

future?

AMDAHL: Well, IBM had talked to me about the end of 1951.

NORBERG: How did they learn about you, do you know?

AMDAHL: It came out in the newspapers about this thing that was being done at the University of Wisconsin. And the branch manager in Madison, Wisconsin, for IBM read about it and he decided to come over and see. He talked to me and he went back to IBM with it and suggested that that was somebody that they really ought to hire. And so they invited me to come back to IBM. I went back and visited there and they made me an offer, an offer that I basically couldn't refuse.

NORBERG: Is this the end of '51 now?

AMDAHL: Yes. So I had the offer in place for about the last six months. I got my Ph.D. in February, but I stayed on until June just to make sure that the project was brought along as far as I could.

NORBERG: So they offered you a position and you went there. Before you arrived was there any indication of what sorts of things you would be doing when you got there? Had they hired you for a specific purpose in other words?

AMDAHL: Well, they'd seen the thesis. I had gone around with a man from the Wisconsin Alumni Research Foundation to see if we could... We'd applied for patents on the machine and we wanted to see if we could sell it. We visited RCA and we visited IBM. And IBM was very interested, but not in getting the machine, they were only interested in hiring me.

NORBERG: Well, does that suggest there are two routes by which IBM learned about you, one from the branch manager and one from the approach of WARF to the situation?

AMDAHL: Yes.

NORBERG: Had they invited you before the WARF visit?

AMDAHL: No. The WARF visit... Yes, they had invited me before the WARF visit, okay. But the WARF visit took place before I went there for the interview.

NORBERG: What was the interview like? Do you recall it?

AMDAHL: It wasn't a very grilling interview. It was, you know, they asked me about the computer and of course I told them all about the computer. And they showed me what they were doing and that was very exciting to me. They made an offer which was bigger than I expected and I managed to retain my calm and point out that it had been a very expensive proposition to go to school and I had a young son that was just born and they increased the offer. And I took it. If I had gone as a theoretical physicist to teach as several of my classmates did, I was earning at that point twice as much. If I had gone to industry at that time, I would have earned about as much as I was first offered.

NORBERG: I see. Well, that's very effective negotiating. Who were the people who did the interviewing? Especially on the technical side.

AMDAHL: One was Nathaniel Rochester. He and Morton Astrahan.

NORBERG: Oh yes. Now you came...

AMDAHL: And of course I also was interviewed by Ralph Palmer and Jerry Haddad.

NORBERG: Now were each of these people in a position to hire you to do different sorts of tasks or were they

making a general assessment?

AMDAHL: They were all I think making a general assessment.

NORBERG: Now do you have any idea about why you were placed under Rochester when you first went there?

AMDAHL: Well, Rochester, when he saw the thesis, he wanted to have... anyone who could write like that he wanted. And I think in fact it turned out to be about the best place I could go, even though he wasn't really in charge of any of the projects. He was sort of the intellectual leader.

NORBERG: So what sort of projects did you work on when you first went there?

AMDAHL: When I first went there, the first project I worked on, while I worked on a number of other projects a little later, was Rochester's attempt to do what he called the Conceptor, where he wanted to write a program that would simulate a neural network according to the theory in a monograph by Dr. Hebb from a Canadian university.

NORBERG: That's early. I didn't realize he was working on it that early. Can you tell me something about this design? I don't know much about it at all.

AMDAHL: Well, we were able in the memory space available in the 701 to simulate approximately 1,000 neurons of our simple model. And after a short while I was able to convince Rochester that the model was not adequate. We had to have something that was equivalent to forgetting. But even introducing that didn't really still come up with anything that I felt represented learning. The conclusion that Rochester had at that time was that one really had to have a much larger network. And I think that one needed more than one mechanism for learning.

NORBERG: How long did you work on that project, Gene?

AMDAHL: Oh I must have put in about six months in that before we added another program which is character



recognition, which we worked on for about another year. During that time at the end of that year, I'd been involved in several meetings on what might be done to make a follow-on to the 701.

NORBERG: Yes. Can we hold that for a minute? I'd like to learn more about the character recognition project.

AMDAHL: We worked out the method of lakes and bays, which effectively decided the... Oh, what do you call it... I want to say just geometrical, the topological properties of the character. Whether there were inlets or whether there were enclosed areas. And that together with some information on the number of crossings, we were able to do an excellent job of reading characters. And we built up a nice unit for getting the data and we were getting excellent results, getting 95+% recognition of three standard type fonts. And we even had 80-some % results of reading wire printing. And then all of a sudden the program was over, because IBM at that time decided that they had to put in projects of greater intellectual interest at Endicott. One of the things they decided to put there was character recognition.

NORBERG: Well, why couldn't you just go to Endicott?

AMDAHL: I wouldn't have gone to Endicott on a bet. Neither would my two people.

NORBERG: So then by this time you were engaged in the assessment of the 701 to see how it could be improved.

AMDAHL: And also on my own there I was doing something. I wrote an emulator program, which allowed me to write a program which would use 701 instructions. In it I could call for floating point operations and do floating point computations. I could call for integrations and operate like a digital differential analyzer including a curve for getting variables in effectively by averaging four-point interpolation.

NORBERG: Was this distributed by IBM in some way?

AMDAHL: No. I used it at the laboratory and with the 704 I converted it to run on the 704 and it became much simpler.

NORBERG: As I recall it, one of the objectives of the study of the 701 to get some sort of, as Bashe calls it, some feasible improvements was to develop features that could be installed in the field, apparently in response to the need for...

AMDAHL: Yes, it was going to do the 701A. I was the only one with floating point experience, since I'd done the WISC. So I figured out how to introduce floating point and indexing into the 701 without much of any additional hardware except a pot full of diodes and wires. Not much of anything else. And of course, we also came to the point where magnetic core memory was going to be available. So that allowed some changes again. So that the number of vacuum tubes involved probably became a little less than the 701 because we didn't need a regeneration counter and things like that. Well, it wasn't less, because I had to have three index registers.

NORBERG: When did the whole idea of doing a 701A get dropped in favor of what came to be the 704?

AMDAHL: The 701A went on for about one year in which case I'd done all of the stuff for the 701A. All the 704 did really was clean up the halfword-fullword structure by going to only fullwords.

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NORBERG: ...little bit further than that and say chief designer as well without question. Who else served on the project with you?

AMDAHL: One man from New York, the same guy that developed FORTRAN. Backus.

NORBERG: Backus. I didn't realize that he...

AMDAHL: He was going to do his FORTRAN and whatever I put there had to be something that he could deal with in FORTRAN. And he was a very bright fellow.

NORBERG: Were there other people besides Backus?

AMDAHL: Not in terms of planning the machine. It was just me.

NORBERG: Just yourself. What sort of supporting mechanisms were there in IBM for this sort of...

AMDAHL: I wrote down a complete list of what it was that had to be put into the machine and the program steps that had to occur and what interconnections had to be done at each stage and any conditions involved. The engineers did the calculation of the resistor values and where they would put them, where they'd run the wires, and

NORBERG: Did it require...

AMDAHL: ...to determine the development time.

NORBERG: Did it require a tremendous selling job, well...

AMDAHL: No. They essentially gave me my head on it.

NORBERG: And then picked up the design and decided they were going to do it.

AMDAHL: Well, they told me to figure out what to do and do it. They also put me in charge of the engineering model of 701. So I had the field engineering that had to be done at headquarters, you know, for any engineering changes and that, plus this, the 701A activity. And so I had those engineers involved in doing the detailed logic

implementation while I did all of the definition of what they were to do in detail.

NORBERG: And where did Backus fit into these discussions?

AMDAHL: He just met with me on probably a half a dozen occasions.

NORBERG: One last question, we're getting close to the time when you need to leave and I was looking for a place to bring this to a reasonable conclusion for this afternoon. When did you get involved with manufacturing and marketing, if at all, on the 704?

AMDAHL: Only in presenting to the customers. The day the announcement occurred in Endicott, at their homestead, where they brought together the 701 customers, I presented the machine.

NORBERG: The machine? Was the machine already in...

AMDAHL: No. No. Just a description of it.

NORBERG: Just a description. And after that it was somebody else's responsibility to manufacture it?

AMDAHL: Well, engineering always moved it off to manufacturing. Manufacturing engineering had been involved late in the design part. We went through such things as rebuilding our own engineering model to a 701, at the same level as the manufacturing units and built our 701A by modifying that. We decided that that was really quite a nightmare. And then the decision came through that, yes, we could make just a 704. I was very happy to get rid of those complications.

NORBERG: Good. That's a good stopping point.

DATE: 17 January 1989

TAPE 3/SIDE 1

NORBERG: The last question that I asked you in our first session was, "What sort of projects did you work on when you first went to IBM?" And you answered by describing two early ones: Rochester's conceptor that he had put you on, the simulation of the neural network, and then "character recognition."

AMDAHL: That's right.

NORBERG: And you mentioned that you decided not to go to Endicott when the character recognition project was transferred there.

AMDAHL: I was not really offered...

NORBERG: Oh, you were not.

AMDAHL: No. The people had elected not to go to Endicott. I had two people working for me on it. They elected not to go to Endicott. I don't know that I was specifically asked myself, because I had other activities as well. And one of the activities that I had at that time was a charge by Mr. Palmer, Ralph Palmer, that I should see what I could do about putting floating point into the 701, since he knew that I had floating point in the WISC. So I began my planning for the 7... This was meant to be a field upgrade on the 701. But it became quite complicated. I was able to put in the floating point rather readily by just making a controlled break in the arithmetic unit, the adder, so that I could deal with the exponent separately from the fraction. Actually it was a fairly modest set of additions that could be done. But it turned out, to do it in the field, it wasn't modest.

NORBERG: What would have had to have been done in the field?

AMDAHL: I think you would have had a machine that would have been unreliable. I also, in the course of time, decided that we could add in indexing at no cost in time, because with the way that they had the cycle partitioned in time, I could get information out of memory. I barely had time to run it through the high end of the adder into a register by the end of the clock cycle. And so I concluded we could have indexing. This was in the days of the "B box" in England, and there was some work going on in indexing in the ANFSQ7, which was the SAGE system, which was being done in Poughkeepsie. A secret project. I think not secret, but it was at least confidential, saying that we couldn't have access to it. So our indexing was different than what we believed existed anywhere else.

NORBERG: Just an incidental question, was there a significant amount of compartmentalization in IBM at that time among projects, whether they were government classified or not?

AMDAHL: They were really practically isolated in the sense that people who worked on them would get together and have coffee or something like that, but they didn't cooperate.

NORBERG: This is from one project to another?

AMDAHL: Yes. We sat next door to the 702 project, when we were doing the 704, and we weren't too cognizant of what they were doing on the 702 and they weren't very cognizant of what we were doing.

NORBERG: Yes. But yet, Bashe mentioned something about, I think it was the 701 project in which there was a shortage of office space, and four people had to share an office, people who had different responsibilities for the 701. And the project directors like Palmer felt that that was an advantage in the design of the machine. Was this true only within a project and not across projects?

AMDAHL: Are you asking it in terms of the design of the 704, the planning of that?

NORBERG: Well, I was asking a more general question, actually, trying to get you to reflect on IBM's policies at the time.

AMDAHL: I shared an office with two people that worked with me. [interruption]

NORBERG: You were just starting to say that you shared an office with two other people.

AMDAHL: Yes, Elaine Boehm and Jacob Johnson...

AMDAHL: A brilliant woman. The first woman in the engineering area of Poughkeepsie and I hired her in over considerable worry on the part of other managers that it was a woman technical person. There were continuing problems in trying to keep her salary advanced at the same rate the men were being advanced.

NORBERG: Where did she come from, Gene?

AMDAHL: Let's see, what's the college that's associated with Harvard, the woman's?

NORBERG: Radcliffe?

AMDAHL: Radcliffe.

NORBERG: Thank you. I'm sorry, I didn't want to deflect you.

AMDAHL: A woman who had developed a fear of mathematics, so that she just couldn't really... It seemed strange, because she was a marvelous programmer, a marvelous logician. She could think so logically, but just a psychological fear about mathematics. I'm sure that with her mind she would have been a great mathematician.

NORBERG: So you shared the office with these two people. What sort of interaction went on among the three of you?

AMDAHL: We talked about lots of things. Well, first, Jake Johnson was involved with the character recognition project, as was I. But I was always kind of directing his work. I'm trying to think of the name of the other guy who really worked for me. Jake directed what he did, but the other guy worked for me. I keep thinking Schmidt, but that's not quite right. Anyway, they were doing a character recognition project and Elaine Boehm was helping in something that I was involved with, which was running for the Poughkeepsie plant the computing center, which used the engineering model of the 701. I had several other people working for me too, one of whom I tried to let go, because he just wasn't sharp enough to perform at the level that he was hired at. And when I went through all of the steps to let him go from IBM, he got snapped up in another project in IBM. In my area he was given the task of determining what size wire and diameter of a spring to make for a given requirement. Return springs for typewriter keys, things like that. Well, he was unable to get the solution to converge; it was really just a cubic equation. And finally, after it must have been 60 days of him trying to get that thing to converge, I asked him if I could see the problem that they had given him. I looked at it, and all of a sudden it stood out: the thing was separable. It had a double root. We didn't need the computer at all to solve it.

NORBERG: So, he left the group, I take it, at that point.

AMDAHL: He left the group.

NORBERG: So, there's still now just the three of you.

AMDAHL: Yes, the three of us. I was working on this putting floating point into the 701, and Elaine, who was doing some programming on the 701 for me, was a good foil. So he began to bat back-and-forth about what ought to be in there. And so she made quite a contribution to what was the 701A and renamed the 704. Actually, when the 701A started out it had both the 701 instructions and the subset of the 704, most of them, but not quite all. In looking at



the amount of change that would be required, we decided that it couldn't be done in the field. And if we couldn't do it in the field, it'd be put out as a new machine. It was concluded also by others that we'd talked to that the value of having the 701 instruction set available was only a modest benefit, because there weren't that many applications developed yet. And it would clean up the structure a lot if we could just drop the old 701 and put in only the 704 instructions.

NORBERG: Now how was this decision made? Was it made within the group?

AMDAHL: Yes.

NORBERG: That is, to recommend to higher management, say, Palmer, or maybe even beyond.

AMDAHL: Yes. Actually, the input about the change being too big came from outside. That came, I think, from either field engineering or the factory, one or the other.

NORBERG: That suggests that you had some contact with the factory people.

AMDAHL: Oh, yes.

NORBERG: Can we go back for just a moment. When you arrived at IBM in, what was it, late '52? The fall of '52, or was it in '53?

AMDAHL: That was June of '52.

NORBERG: June of '52. Were you aware soon after you arrived what the production level of 701s were at that time?

AMDAHL: Yes. When I arrived they either had just shipped the early ones or were about to ship them. And in the

course of the time I was there I... When I was given the charge by Palmer to see what I could do, I was also shortly thereafter put in charge of the 701 engineering group itself, not only for the computing center, but also just to manage the debugging activities for the field. If they'd have a problem, we'd model it on the engineering model to determine what the fix was. And then we could fix them out in the field.

NORBERG: But at that point then you're skipping over the manufacturing aspects; that is, you didn't have any responsibility...

AMDAHL: Well, we hadn't started the 704. I had no responsibility in the 701 itself. It was all designed when I came on board. I didn't really have responsibility for any other manufacturing aspects. I only ended up managing the group that was handling field changes.

NORBERG: Was there any activity either among your group, or perhaps a special group, to develop new applications for the 701. Or was that left to the customer primarily.

AMDAHL: It was left to a large extent to the customer; however, since we used our engineering model for a computing center, we did quite a bit of development work ourselves. In fact, along with Nat Rochester, who I reported to, and so had purview over everything also, he had become interested in what we would call an assembly program -- being able to write things not in specific locations, but be able to use symbolic addresses. And he wrote an assembly program that did that. I ended up writing some things like conversion from binary-to-decimal and decimal-to-binary, and a few things along that line. Later, after the 704 came in, I wrote a program which made the 704 behave as though it were an analog computer; that is a digital differential analyzer. Those were useful tools. On the 704, I and a number of the people that worked for me wrote loading programs, things of that nature, so that the machine could load programs and check them in the process.

NORBERG: Did you go out in the field yourself?

AMDAHL: We had contact once in awhile with customers, not too much. On the 704, the contact with customers really started largely after we completed the design. Then we had more contact with the customers on the 704 than they did on the 701. And the reason for that is we started an organization called Share. Share was begun for the 701, but late in the game. We had the 704 ready to go out, and the beginnings of Share, then, were really aimed at getting the 704 supported. This was when John Backus, for instance, began to work on the FORTRAN compiler.

NORBERG: You mentioned Backus the last time we talked. When did you begin interacting with Backus?

AMDAHL: On the 704, when he was going to work on that compiler part.

NORBERG: Was he already at IBM when you came?

AMDAHL: I don't know. I got to know him through the applied science part of the activity, which was headquartered down in New York and run by... I shouldn't have any trouble getting his name. I can see his face so clearly. He lives here in Palo Alto or... I can't think. [Cuthbert Hurd]

NORBERG: So that suggests that Backus wasn't up in Poughkeepsie very often.

AMDAHL: No, he came up three or four times.

NORBERG: In the course of a year?

AMDAHL: In the course of about six months.

NORBERG: How did you two interact with each other? What were the topics of discussion?

AMDAHL: We'd go over what I was putting in the machine. He would comment on some of it. A few changes were

made because of him. On the whole, though, some of the things went in the way I wanted to put them in. For instance, the indexing started with the maximum number and went down to zero -- my way of doing it. That gave me an automatic determination of when you'd completed the count.

NORBERG: Now, did Backus have some other idea about this?

AMDAHL: He wanted it all to be additive. And we made it so you could get his too.

NORBERG: How was that done?

AMDAHL: We added another instruction.

NORBERG: I'm not very familiar at all with the actual design activity at that period in the 1950s. I remember reading a piece that you wrote for the *Annals* in which you cited two letters that had been submitted to Hurd, I guess it was, in IBM.

AMDAHL: Cuthbert Hurd is the one who ran Applied Science, by the way. The name I was trying to remember.

NORBERG: You listed the various changes that you thought might be appropriate for the 701A. Now, from what you've said this morning, it appears as if that became the basis for the 704.

AMDAHL: Oh, yes. The 704 was just dropping the 701 part of the 701A.

NORBERG: Now, did that mean you had to construct a new instruction set to build in the changed instruction set that you thought was going to go in to make the 701 the 701A?

AMDAHL: Well, the 701A, as planned originally, was not implemented.

NORBERG: Yes.

AMDAHL: It was planned on paper. And so going to the 704 from that meant that we dropped a number of instructions that were meant to bridge between, and then we'd drop the 701 instructions themselves entirely. That left us with a clean instruction format. We just took that instruction format, and we then had plenty of room to put more things in. So we put in a number of more things.

NORBERG: Well, I guess what I was trying to get at is, how much is the 704 like the 701? From the bottom up.

AMDAHL: If you look at it from the standpoint of instructions, you see almost nothing other than the fact that it had similar I/O handling. If you look at it from the hardware, the hardware was almost identical, except for where we did the splits in the arithmetic unit. Oh, then we also did a core memory. Near the end of it, I proposed channels, but it was too late to do that. My memo on that got lost.

NORBERG: Why was it too late?

AMDAHL: Because we were too close to shipment date. I didn't like the way we were doing I/O. Never did like it.

NORBERG: What sort of interaction was going on then among the people that you were dealing with in IBM? For example, Bashe describes when a design is available, there's discussion with the Future Products Group, the Applied Science Group, the manufacturing people, engineering, field engineering, and so on. When did these steps occur, do you recall, about the 704?

AMDAHL: Well, on the 704, since the hardware was so similar, it was really just a rewiring that had to take place. We had started the first CAD system. It was very simple at the time we had it. It merely gave where the wires ought to be interconnected. So there wasn't much of a release from the standpoint of our CPU. There was really no

addition other than three index registers, and part of the space for that was provided by removal of the special counter that was determining how often you had to refresh the CRT memory. So basically, we added three registers and took out one. You know, it would have been about one bank of pluggable units that went in over and above what was in the 701. But there was a lot more wiring. The 701 was simpler internally in terms of the amount of wires. My guesstimate would be we had about twice as many wires.

NORBERG: Was the increased amount of wires due to core memory, or were there other connections being made too?

AMDAHL: No, it was for doing the fixed point and the floating point and indexing.

NORBERG: You said you put in three new banks and took out an older one.

AMDAHL: Three new registers took out an older one.

NORBERG: So that in itself would increase the number of connections. Did negotiations have to go on with engineering and with manufacturing?

AMDAHL: Since we had no new technology on the CPU part, there wasn't anything there that had to go on with manufacturing. We had to, of course, go through the same... Basically, it was the same channel we were using before for field changes. We also had a joint project with the 705, I guess it was to do the core memory. And although I contributed a number of the engineers to that, I didn't really handle the interaction between the memory and manufacturing.

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AMDAHL: I never, at that point, ever had the full interaction with the plant for manufacturing or for maintainability

and serviceability.

NORBERG: Who did?

AMDAHL: I'm not sure who was handling it on the other side. Oh, it would have been "Red" Dunwell. He had the 705 project.

NORBERG: And he would have also had responsibility for seeing the 704 through manufacturing?

AMDAHL: No, not the 704 -- only the core memory.

NORBERG: Did your group begin to grow as the 704 project came on?

AMDAHL: Well, my group that I inherited when I got it were the ones that were working with manufacturing all the time... with manufacturing and field service all of the time... That was their normal role.

NORBERG: Had they been working on the 701 then...?

AMDAHL: Yes.

NORBERG: ... or 702?

AMDAHL: Yes, that's what it was, the 701. It was maintaining engineering changes for field support; so they were working hand in glove. So we didn't have any new kind of interaction; it was just a continuing interaction between the same people. Now there was some new subjects in it, but not what normally went on where an engineering group would engineer and then start an interaction with quality control, field engineering, the manufacturing questions about tooling and all of that. Those would have been a new, big, different kind of activity to enter into. But for us, it

was just a natural continuation of what we had been doing in everything except the somewhat relatively small shift in the intensity.

NORBERG: As you said, there was no new technology involved in the 704, these people wouldn't have to gear up to do any new tool design, that sort of thing.

AMDAHL: That's right.

NORBERG: Was there interaction with the SAGE group or other groups connected with core memory?

AMDAHL: I'm sure there was, but the core memory design that we were using was quite different than the core memory design that they were using in SAGE.

NORBERG: How did they differ, Gene?

AMDAHL: Well, the kind of drivers that were used were controlled differently. The vacuum tubes we used to be the drivers were different vacuum tubes. Ours were, in some respects, quite a bit simpler. Well, you can't say anything was more reliable than what they did for SAGE, because SAGE was really a very reliable machine. But ours was much more economical, and near it in reliability. The man who headed the memory design is the man who is now Science Advisor.

NORBERG: Bloch?

AMDAHL: Erich Bloch.

NORBERG: But we ended up with an answer to a different question there, and you said that one of the differences between the two were in the drivers, the drivers from the in the 704.



AMDAHL: We used drivers that had a transformer feedback, where the transformer would... when a current built up to the right amount, the flux would have all shifted to the far side, and that determined how long to drive one. So it was magnetically controlled for time and intensity.

NORBERG: Yes, and that did not exist in the SAGE?

AMDAHL: Not to my knowledge; that was not used in SAGE.

NORBERG: And the other half of the answer seemed to have...

AMDAHL: And also, I believe... I don't know whether it was the case in SAGE, or if they used the same technique that they did at RCA. Ours was not that way on the sensing circuit. On the RCA they did an integral to determine how much flux was switched. On the IBM one we sensed a pulse.

NORBERG: The other half of the answer had to do with quality control, and I don't see how that fits into the story.

AMDAHL: Well, quality control...

NORBERG: You said that the 704 was almost as reliable, but not quite.

AMDAHL: No, I said the core memory systems were almost as reliable as the ones use in SAGE.

NORBERG: Yes, but more economical to produce.

AMDAHL: But much more economical to produce.

NORBERG: Okay, now, to what...

AMDAHL: We couldn't have made a viable, commercial entity at the expense level of the SAGE system.

NORBERG: That I understand. Was it your design that produced this lower economic circumstance?

AMDAHL: No, that would have been Erich Bloch.

NORBERG: Now, was he doing that for a range of machines?

AMDAHL: He was doing it for the 704 and the 705. So he handled those interactions with the factory and the field engineering, quality control people.

NORBERG: But you weren't concerned with that, I take it.

AMDAHL: No, I had several people from my organization that were on loan to him to do our particular version of the memory. And the 705 had some people on loan to do their particular version of the memory. And Erich had his own organization, which was designing the fundamental parts, and overseeing how each of these others were put together.

NORBERG: Pugh talks about that aspect of magnetic core memory development. Did you have other projects going on at this same time besides the 704?

AMDAHL: Yes, we were still doing a little bit on the conceptor, but I wasn't devoting much time to it. But we were doing some other work at the moment that escapes my memory of what it was.

NORBERG: Let me probe a little bit more deeply then. Was it the practice in IBM at the time to ask people for advice

on a range of other ideas or projects that were going on in the company? For example, let's say that Future Demands is interested in a slower machine, a faster machine, a bigger machine, and so on. Would you be likely to be called into discussion on a regular basis for that sort of thing?

AMDAHL: Not on a regular basis. But we'd get called in every once in awhile to go off for a week and determine how a particular area should be served. This is all a long time ago.

NORBERG: I realize that this is. I have the advantage that I've looked at a lot of this recently.

AMDAHL: One of the things that we were involved in was trying to determine what was going to be done as a follow-on for the 604A, 605. And at that time we had either a 4 or 5 day session on it. It was a group that was proposing something called MAC and another group proposing something called CAM.

NORBERG: Do you know what those acronyms stood for?

AMDAHL: I know that CAM stood for something like Calculating Accounting Machinery, Computing Accounting Machinery.

NORBERG: Could the other one have been Management Accounting Machine, or something like that? I can look these up, certainly, but I'm just trying to make sure that I understand what you're talking about.

AMDAHL: Something... Accounting Calculator, I think...

NORBERG: Okay.

AMDAHL: Modular Accounting Computer. MAC was plug board controlled, and the CAM was to be controlled by a programmed drum. You could put a program on the drum. Werner Bucholtz was one of the protagonists for CAM,

and I can't remember the name of the people, but probably related to a group that was working... had worked with Woodbury, Toben and Wheelock.

NORBERG: What happened during this meeting? You seemed to remember this one, so let's proceed with it.

AMDAHL: Well, I was really quite convinced that if one wanted to follow on to the 604, one really should take into account the fact that the people who used the 604 were accustomed to using plug boards. And if you're going to do a follow on to that, probably the plug board was a reasonable way of doing it. The CAM, on the other hand, really was a stored-program machine, but really not one that you could modify by having the program itself work on itself. And so it wasn't a very general purpose, stored-program machine either. So from my viewpoint, I decided that it really didn't make much difference which way it came out. There were some interesting things about how they'd organized CAM. The MAC, I thought, they were carrying about as far as it could go, and probably it ought to end after that one. And I think MAC carried the day.

NORBERG: Was it produced and sold?

AMDAHL: I think it was, but not very many. The one big protagonist for it was a man that was from Northrop.

NORBERG: That would make sense, wouldn't it? Yes. What sort of interaction went on during the meeting? How intense was the discussion? Did people feel that they really had a stake in this, and therefore, they were out to win?

AMDAHL: Yes. You're asking me what really went on. I think management was aware of most of these projects. And they probably had already selected who was going to win, selected who would be coming on the committee.

NORBERG: Committee for what?

AMDAHL: Committee to make the decision; you know, this group that met and worked for these several days. I

think it was a foregone conclusion as to how it would come out. Probably some of the battling was quite intense, because it was an attempt of CAM to upset what would appear to be the inevitability of the MAC program.

NORBERG: Do you think that participants in the meeting understood that the...

AMDAHL: Oh, no.

NORBERG: Well, they're not supposed to. But I asked you, do you think they did?

AMDAHL: Well, I think people had the feeling that that's the case. But one of the purposes of having those committees go through this exercise is so that management is alleviated of the responsibility for having made that decision over the better judgement of whoever the opposing parties were.

NORBERG: Yes, sure. All right, now, if, as you say, management had already decided, at least, had a bias in favor of one project or another, who is this "management" we're talking about? How high up in the scale were the people making these decisions?

AMDAHL: This would have been about as high as Jerry Haddad and Palmer.

NORBERG: From Haddad and Palmer, what were the next steps between them and Watson? Were there one or two levels, three levels?

AMDAHL: There was the Vice President of Engineering -- what was his name again? His wife was a sorority sister of Watson's wife. Well, anyway, he was in the chain, but I don't think he was a strong determiner of what would be done. And then, of course, there were people that would get interested up there later from the financial and marketing end, but they weren't really involved in these meetings, not at this time. IBM was not yet well enough organized to have as much representation from the marketing side as you have from the engineering side.

NORBERG: Well, isn't this about the time when IBM decentralized? Somewhere around '54 or '55, at least, the first time, decentralized. Before that it was rather hierarchical when Watson, Sr., was in charge, was it not?

AMDAHL: Yes. That's right, it was very hierarchical. And along about '54 we saw the first change when Learson came out to manage the laboratories. I didn't notice much change down at the level I was at, except that I did notice that my old friend, Applied Science, became part of marketing. That changed some interfaces that I was dealing with on the 704.

NORBERG: In what sense?

AMDAHL: When I had something new, I wanted to see if they thought it would be worthwhile for the field. There wasn't really much of anyone to talk to. One of the things that we... I had done the work on the channels. Elaine and I did a lot of work with those channels before I left. The 704 wasn't out yet, but we had done all of the planning for the 709, and we'd determined that we could do sorting by setting up the control words in the channel program, and that way we could use all of memory as a buffer without having to move things back and forth. We could just bring them in whatever order they were on the tapes, and pick them out of order to the proper order to be written on the output tapes. And we established that we could do this on a 704 more economically than could be done on the 703, which was a tape sorter/collator developed at Poughkeepsie, and sold to the Treasury Department. I think they sold three of them.

NORBERG: Now, you mentioned the 709 in that answer. How did that project get involved...?

AMDAHL: The 709 was the list of things that I had on the 704 that we couldn't put in.

NORBERG: Couldn't put in. I see. So you were constantly making these long lists of things that you think are possible for a given design.

AMDAHL: Yes, and I'm selling them originally to Applied Science to try to get their excitement and imprimatur on it, so I can sell it to management as the next project.

NORBERG: As the next project. Why not put it all into the 704?

AMDAHL: Because we couldn't meet the delivery date if we did that. We'd just have to push it back and push it back and push it back. We had a competitor that was doing those things, and they suffered severely because of it.

NORBERG: I presume you're talking about Remington Rand. [Amdahl nodded yes.] Did these potential changes occur to you as the project was going along, or is your style to do this right from the very beginning?

AMDAHL: No. A lot of these changes were new ideas.

NORBERG: That had come along during the process of evaluation of the old ideas, I take it.

AMDAHL: Yes, and one of them was the conversion programs that allowed you to, for instance, read in one format and convert it to another. I was able to show that with that you could read in teletype, or something like that, characters converted into the 6-bit format with table, so that you'd get all of the character shifts and all of that properly taken care of. That's what you'd do between tables. I was able to show that you could take binary coded decimal numbers together, add them in binary, do a convert, and carry out the "carries" for you, and reconvert the result to the binary coded decimal again. Including you could put checking in.

NORBERG: When do you think your first discussion about the 709 occurred with Applied Science?

AMDAHL: It was before Applied Science ended.

NORBERG: Before it went into marketing.

AMDAHL: Yes. And after it went into marketing, the stuff on the sorting... I was dealing with the man who had been in Applied Science -- not Hurd, but a younger man that left IBM to become president of a girls' college... a women's college, not too far from New York. (Charles de Carlo.)

NORBERG: I haven't the slightest idea who that is.

AMDAHL: He was fairly famous at the time, but apparently a little too politically active in the internal politics.

NORBERG: In the internal politics of IBM.

AMDAHL: Yes. And so, he got thwarted and decided to leave.

NORBERG: That kind of decision. I would have said that the politics of the meeting you just described between MAC and CAM must have been horrendous during the course of the discussions before and during the meeting.

AMDAHL: Oh, yes, and there'd be all sorts of caucuses that would go on. That was IBM's way, one would have thought, of shaking out who's to win. But generally, the winner was pretty well determined before the meeting.

NORBERG: Well, do you have any guess as to how the winner was selected then? I don't mean a specific case...

AMDAHL: Well, it would have been the lab manager. Many of these things have presentations to management before. And of course, you'd have adherents on each side. But the side that got the most powerful adherents was generally... particularly if you got the one who put together... who had largely put together the selected participants in the meeting and set the agenda for them, that was really the clue as to which side was going to win.

NORBERG: Can we step back a minute, and can you tell me a little bit more about the style of working, as you



observed it, of people like Haddad, and Palmer, and Dunwell. I'd like to talk about Dunwell a little bit more for obvious reasons, I think. I have not met any of these people; some of them are not alive. What was Haddad like, as a co-worker, now?

AMDAHL: Well, I can't say I ever worked with him as a co-worker ? ...

NORBERG: Well, observing him, I mean.

AMDAHL: Observing him, he seemed very urbane, seemed to be technically very competent. He knew his engineering very well. He listened well to you. He had his own agenda, but he very carefully did not display it. But he was very reasonable, rational, a very nice guy.

NORBERG: Yes. Now, how did he compare with Palmer?

AMDAHL: Palmer was very much of the same ilk. Palmer, though, you felt always held his cards extremely close to his vest, more so than Haddad, affable. You couldn't really tell whether he was an accomplished engineer, although from what I understand, he was. But I never really got a chance to see that for myself.

NORBERG: Do you have any idea what the relationship between those people and somebody like Learson was?

AMDAHL: Learson was like a bull in a china shop. Smart as a whip, listened long enough to decide, and then you almost couldn't shake him after that. To a certain extent, you had to be extremely careful that you apprised him of the facts very quickly, and very cogently, or you'd run into the problem that if you made it too long-winded, or too many interlocking details, that he might arrive at his conclusion a little too soon.

NORBERG: Now, how would one learn that? Could you deal with him enough, or observe him dealing in others?

AMDAHL: I think after about two conversations I understood that, but I didn't understand in the sense that I could have told you this at that time. At that point, I was just telling him very directly exactly what I thought the problem was, and how I thought this other approach gave us the capability we needed, and maybe something more. I tried to keep it that short.

NORBERG: Was there a fairly direct access to these people? That is, could you see them on a reasonable calendar?

AMDAHL: I didn't see him very often. I saw him maybe five or six times.

NORBERG: In the course of three years.

AMDAHL: No, he wasn't there more than the last year.

NORBERG: I see. Then in the course of the last year. How about Haddad and Palmer?

AMDAHL: Oh, Haddad and Palmer, I would see very often.

NORBERG: Did you continue working with Rochester?

AMDAHL: Yes. I was, I guess, nominally working for him all of the time, although most of the time he wasn't doing anything with me. You know, he wasn't managing me, but he did have my card.

NORBERG: So there was you and people working for you, Rochester, then Palmer, say?

AMDAHL: It was either Haddad or Palmer.

NORBERG: Haddad or Palmer, and then Learson, and then up to Watson. Okay, so we've established a reasonable

hierarchy. I would guess from what you've told me here about the interaction among these people, and the intensity of people like Palmer, and Haddad, and Learson, that this would create a good deal of not only competition among project managers...

AMDAHL: There was.

NORBERG: ... but also a good deal of tension, I would think, among people.

AMDAHL: Yes, if you had a good idea sometimes and tried to sell it, you couldn't get anywhere. For instance, on the 705, Red Dunwell, who is quite a master politician, as well as very technically competent in the sense that he could organize the ideas very, very well. He wasn't so competent on just technical matters himself, but he could organize... He could get to the heart of something fairly well; very quickly organize the thinking about it, and put together a program. He really was outstanding at that. He had the 705, and he decided he would invite me, and I brought in Jake Johnson and Elaine Boehm to look at what we might propose for the 705.

TAPE 4/SIDE 1

AMDAHL: We'd just finished the 704, and we were knowledgeable about what was in the 702, how they'd use memory as an accumulator. And we got what I think were brilliant ideas. Who in our group got which of them I don't know, but all three of us were contributing very significantly to it. But we worked out a way to put those accumulators in memory control all with indexing, which allowed multiple accumulators, all of the functions that you would have gotten from a 702, plus all of the benefits of the indexing, for all of your data sets, and all of that. And it worked much faster. The number of memory cycles required to achieve it was reduced probably to less than half. We presented it to Dunwell, and Dunwell listened to our presentation, and said that we had done a very nice job, but the people in the commercial marketplace were not sophisticated enough to deal with indexing so that was it.

NORBERG: That was it. What machine was the first one that had the indexing in it then?

AMDAHL: 704.

NORBERG: 704. Okay, and you were trying to sell it to be on the 705, as well.

AMDAHL: Yes.

NORBERG: Was it on every follow-on machine after the 705, do you think? 709, 7090?

AMDAHL: 704, 709, 7090 was all one family. They all had indexing. It started with the 704.

NORBERG: Yes. And the 360 series had indexing.

AMDAHL: That's right. So did STRETCH. The last year I was there, I was working on STRETCH.

NORBERG: Before we get to STRETCH I'd like to go back to something you said earlier, and that is that you were never satisfied with the input/output equipment on these machines. Were many changes needed in the peripherals for 701, 704, 709, as you were evaluating the input/output schemes for those machines, or not?

AMDAHL: The peripherals were the same, except for the controllers. The controllers were different for each of them.

NORBERG: Did you try to get changes in the input/output system without any new controllers?

AMDAHL: Not very much. We generally had a drum on our machines to have fast input and output, and not many of the others, I believe, had it.

NORBERG: What others? Other IBM machines?

AMDAHL: Others. The 702, the 705 may or may not have had a drum. I'm not aware of it. We had a drum, though, in the 701 and the 704. We did not strive too hard to get our own peripherals, for a very good reason: that the scientific marketplace was not viewed as nearly as large as the commercial marketplace, and if we could use the same one, we would get a much lower cost for the product pricing. The pricing could be possibly higher, but at least it wouldn't be forced to be so high that it wasn't really salable. And if it was set higher, it gave us more profit, because as a product manager, we didn't have full responsibility for profit yet, but that came later. But we certainly got kudos for being profitable.

NORBERG: Yes. How were prices decided upon for the 704? Did you have anything to do with that? That is, were you involved in the discussions about it?

AMDAHL: I was involved in the discussions with respect to the size of the market. The first time they came to me they were estimating there would be six. I wouldn't even listen. He came back with 12, and again, I told him, you know, everyone that got a 701 will want one of these. More people want 701s than we had 701s. So he came back with 18 -- the number of 701s. I said, "It's going to be much larger." So they came back with 32 of them, and I accepted that.

NORBERG: On what basis were these decisions being made? What is the difference between, say, 18 and 32?

AMDAHL: Forecasting, we were not allowed to participate in that.

NORBERG: But do you know how they were making the decisions in the forecasting group?

AMDAHL: This was kept quiet. This was something that IBM did not want anyone outside of that forecasting group to be influencing. They were looking at information coming back from the field, and they didn't want others to be able to twist their arms with excessive pressure.

NORBERG: Well, that I can understand, but it seems to me that there must have been some... What do I want to say?  
... Some general view among scientific and engineering personnel about who was going to need these things, and who might be able to buy them.

AMDAHL: Yes, at this time, I really think there was a conflict between Applied Science and Sales, or Marketing. And because of that, I think it was hard to decide what kind of input, whose input to give what weight to. I'm sure Applied Science was thinking there would be more than six. But commercial sales probably thought six was an exorbitant number.

NORBERG: But you would think in terms of something like the 701, six is relatively small.

AMDAHL: Yes, but you know, it's original name was the Defense Calculator.

NORBERG: Yes, I know. So they saw the market as largely government, and largely the Defense Department.

AMDAHL: Yes, and largely very special high-profile projects.

NORBERG: Yes, did you watch any of the other projects going on simultaneously, things like the 650, or the NORC?

AMDAHL: The 650 was in Endicott, and I'd see it a little. I didn't get very close to it. I knew they had SOAP -- the Self Optimizing Automatic Programmer, or something like that. And the NORC, I visited once. My brother worked on the NORC. Did a lot of the logic design for that system, including what he was assigned in redoing somebody else's.

NORBERG: When you visited the NORC, was that in any way connected with your assignment of STRETCH?

AMDAHL: No.

NORBERG: All right, can we return to STRETCH then? How did you become involved with discussions about STRETCH?

AMDAHL: Well, Nat Rochester was sort of viewed as the man who would control what was going on in the scientific computing area, even while he was always doing his own little research. I shouldn't say "little," but his own research; none of which was really... It wasn't very well publicized, what he was doing. Whether he was just keeping it under his hat, or whether... It was always a little bit far out, and I think to a certain extent the lab management thought it might bring down some negative reaction from the top of the company to have them think that far out research was being done there. And so Nat told me that it was about time for a new machine, and this would be my baby and I should go ahead and work on it. So I did. I started out doing something on my own first, and had an interesting concept. Then I talked with John Backus on it two or three times. And John thought what I had proposed initially, he couldn't do a compiler for. So we went ahead and redid it. And we came out with the thing that was the look-ahead structure of the STRETCH. I worked and got all set to make a presentation to Los Alamos. I went down there and presented it, got a very nice reception. Then, along in the summer, procurement of a computer was put out by Livermore. They wanted something developed that would be high performance. And that's when "Red" Dunwell came in. And "Red" Dunwell immediately saw the possibility of government financing, and decided, "Well, now, this is an opportunity to get money in for really doing something of benefit to the commercial world, as well." So he came and looked at my structure. He decided, "Well, the front-end part of that was close enough to being a commercial machine," he thought. And so he could make a commercial machine out of the front end, and the back end would be the big, floating-point engine. I kept telling him it would get too complicated. I began to get more and more frustrated, because I couldn't see that it was possible to do that and have anything that would either work well for the scientific end, or work well for the commercial end. We had a running battle going on, and I was feeling, of course, betrayed, because here I had been given the charge, and I had done all of this work. Then later in the summer, along came a plug board one again [laugh] to do this. And somehow or other, they couldn't get it through their heads that you couldn't even get the signals to the plug board fast enough to be a supercomputer. But that muddied up the water for at least six weeks. Then "Red" Dunwell engaged some others in coming into the

commercial end of this thing. I was really getting very, very frustrated. Then they decided to change the organization of the lab and brought me in, sat me down, presented what they were going to do, and there was "Red" Dunwell in charge of this machine. And I only had the specification of the logic, the architectural design. I left there that afternoon, went back to my office, and wrote a resignation letter.

NORBERG: There are some complicated elements in there. Do you think that people like Dunwell, and whoever it was that he was aligning himself with, saw a market for STRETCH as being relatively large, say, a dozen machines. We're not talking about a big number here. A dozen machines, or did they see it as a potential crossover, where you design something for this machine, and sell it to Livermore, Los Alamos, and whoever is interested in a half dozen models. And then you go on and use the technology that you learned from that, as they did with the 701 and build another situation. [interruption] I was asking you about Dunwell, and his attitude toward the STRETCH idea, anyway, and whether or not he and the people aligned with him might have seen this as a crossover technology, and therefore would have had a good deal more support within the company because of the commercial possibilities of it.

AMDAHL: Yes. I think he saw two things. I think he saw the chance for government funding, and that would bring in the opportunity to really get transistors into the high end. And I think he legitimately thought you could build a combination commercial and scientific processor that way, where the commercial processor was the front end to the scientific. What happened, though, is it got designed to be too complex. And so its cost got out of hand, size got out of hand, performance was down.

NORBERG: Why did you see this as a threat to yourself, and therefore felt so strongly about resigning right away?

AMDAHL: Because I couldn't do what I wanted to do. I had been having this running battle on trying to make two processors in one. I looked at it and I was convinced that it wasn't possible. And it wasn't possible, it turned out. At least no one figured out how to do it.

NORBERG: Well, how long was this running battle going on?



AMDAHL: From maybe early summer through about the middle of November.

NORBERG: So, four or five months. I guess, from my point of view, looking back on this from the way you've described it to me, it doesn't seem quite so earth-shaking as it must have seemed at the time. Many times, as I understand it anyway, IBM shifts people around in this way, and there are times when really talented people don't get the projects that they had hoped for, or wanted, or thought that they were best for...

AMDAHL: That's right.

NORBERG: ... and so on. And they sort of bide their time and wait, and some of them are successful in getting later projects. Did you feel this was not possible for you within the company?

AMDAHL: Well, what I felt was that with that kind of an organization I'm not going to be in control of what I want to do any time in the future. It's going to be a much more bureaucratic structure. I'll work in one area of it, and that's all I'll get experience in. And I decided that I didn't want to have that kind of life, basically. It wasn't just Dunwell. It was the way the structure was set up; I was going to be a peg-in-a-hole.

NORBERG: Well, had you been contemplating this question for some time, then, within IBM, so that this decision turned out not to be just the result of one action?

AMDAHL: Well, IBM had been becoming more bureaucratic. And probably the reorganization was one of the things, the earlier one where marketing and applied science disappeared. Before that, it was kind of a collection of inventors, and it wasn't remaining that way. The cost of having a collection of inventors was too high, I'm sure. But that was the structure that was really exciting to me. And I liked the competition. And at this point, that seemed like the death knell.

NORBERG: Before going on with that issue, I'd like to get something else in here, even if it's a negative answer. In this period, '53, '54, '55, while you were working on the various 700 machines, and then getting the ideas that came out in part in STRETCH, did you evaluate the machines coming from other manufacturers, say in '54? Did you look at the UNIVAC I? Were you interested in the RCA machines, and the NCR machines that had come out of California, and so on?

AMDAHL: I was familiar with the UNIVAC machine; I was familiar with one of those from California, the...

NORBERG: CRC, or Logistics?

AMDAHL: I don't think it was either of those. It was one that was bought up by Burroughs.

NORBERG: Bought up by Burroughs? ALWAC?

AMDAHL: No. I had one of the ALWAC engineers working for me at a later point in time, so I know it wasn't that. No, this was one where the people that worked in that program eventually were the ones that did the B-5000.

NORBERG: B-5000. I should know that, but I'm sorry, I don't.

AMDAHL: Anyway, it was a drum machine.

NORBERG: How did you learn about these things?

AMDAHL: Mostly published literature.

NORBERG: Did you attend professional meetings at the time?

AMDAHL: I attended them. Not religiously, but I attended maybe one a year, or something like that. I would listen to the talks and decide most of the stuff I was listening to was not going to go anywhere, but every once in awhile something very interesting would come out. I remember the very first one I attended. It might have been the fall of '52, or the fall of '53, I think more likely '53, held in Toronto, Canada. At that time, the part that I remember was something that wasn't presented as a paper, but just a discussion going on around the attendees about a universal computer with only three instructions: subtract, branch-on a plus or minus, and store. And with this, they had been able to program the shifts, and everything like that [laugh]. Really, the truly original RISC machine.

NORBERG: I see. Who had done this?

AMDAHL: Although the WISC was pretty close. That was done at the University of Ontario or Toronto?

NORBERG: I see. One thing I didn't ask you before is, had you ever met with Watson, Jr., in this period?

AMDAHL: I met with him on at least one occasion when I was making some kind of presentation on the 704, the 709, in which I was presenting, among other things, to a top-marketing exec, Red something. I don't know what his...

NORBERG: Another Red, besides "Red" Dunwell.

AMDAHL: Yes. He was a much older Red.

NORBERG: The meeting obviously doesn't stand out very well.

AMDAHL: No, I can't remember what I was talking about, but I think it was related to the subject of the sorting that we were able to do, that Elaine and I were able to work out for the 709, the proposed 709. And I was trying to get the proposed 709 to become a project 709.

NORBERG: Yes. Did anyone approach you during this period '53 - '56 to leave IBM and go to work for them?

AMDAHL: One guy inside did. Yes, also a guy from Burroughs.

NORBERG: Had you considered them seriously, or not?

AMDAHL: I considered the one seriously from inside, to start our own company. That man's name was Bob Evans.

NORBERG: Oh, yes. Evans was contemplating going out on his own? Which he never did, as I recall. What did he have in mind?

AMDAHL: He and I would form an engineering development company. An engineering company first, where we would do engineering, and then we would grow into doing development, and then get our own products.

NORBERG: Yes. All in the computer field, I assume.

AMDAHL: Yes. He was working for me at that time. He was doing a peripheral device on the 701, the 704, which was the first CRT display, a very precise display. It was a contract development, where the contracting agency was the Rand Corporation in Santa Monica.

NORBERG: I take it nothing came of this in any serious way.

AMDAHL: No, Bob...

NORBERG: You didn't discuss any of the financing, or any of the...

AMDAHL: Bob... His capabilities began to be more recognized, and he got promoted to a position with more

management content. Suddenly, he was so excited over that that the idea of being on his own disappeared.

NORBERG: How did you learn about the job at Ramo Wooldridge?

AMDAHL: I just called Ramo Wooldridge and asked them if they had a job.

NORBERG: Had you made a number of those calls?

AMDAHL: No. I just called. Before I wrote my resignation letter, I picked up the phone and called Ramo Wooldridge, and asked them...

NORBERG: Why them?

AMDAHL: My brother had worked there, was working there. It was a new, exciting company.

NORBERG: Had he left...?

AMDAHL: He had left...

NORBERG: He had left IBM, then.

AMDAHL: Because IBM wouldn't let him come to Poughkeepsie because I was there.

NORBERG: So you called Ramo Wooldridge, and what was the result?

AMDAHL: I called my brother and first got who I should talk to and called him. He said, "Come out here. We've got a job." "We'll make a job for you," is what he said.

NORBERG: That's interesting.

AMDAHL: He did make a job for me. And it turned out it was a made job. I guess the only way they could describe me was as their "utility outfielder". [laugh] I ended up writing most of the proposals for the computer division there, and all of the contracts that came in went to other groups. They were highly organized, and turned out very much like the IBM Lab was being reorganized. And they already had a hardening of the arteries.

NORBERG: Were they mostly dealing in government contracts?

AMDAHL: Yes. Government, or they'd get some commercial contracts, but they weren't doing any development of their own.

NORBERG: But it was commercial contracts with, essentially, other defense contractors, was it not?

AMDAHL: No, they would do it on their own.

NORBERG: I see.

AMDAHL: The RW400, which I did the initial work for, was to control a cement plant.

NORBERG: Were there other people working for Ramo Wooldridge at that time that you remember who in one sense became significant in the computer business later?

AMDAHL: I don't think so.

NORBERG: This doesn't seem like the ideal that you had in mind when you left IBM.

AMDAHL: I didn't really have that as an ideal in mind, but I did know I wanted to be in California.

NORBERG: How did you come to that?

AMDAHL: Well, anyone who is born and raised in South Dakota gets to the point where they recognize sooner or later that getting to California is having one foot in heaven. [laugh]

NORBERG: Well, I didn't quite see it that way, but that's all right. [laugh] So you wanted to get to California, and this was...

AMDAHL: This was one. It wasn't an overpowering thing to go to California, but there was a lot of activity going on in southern California. When I got out there I realized it was almost all government contracting, and I didn't care much for that. As a matter of fact, I have quite an antipathy towards government contracting yet.

NORBERG: Why?

AMDAHL: I just don't like the way the whole thing operates. You can't make any reasonable profit the way they have it set up, so that you can't ever support anything that you want to do for yourself.

TAPE 4/SIDE 2

AMDAHL: ... and at the same time, to even make out and break even, you have to do things that verge on violations of regulations. They don't allow you to charge all of your expenses, and at the same time, everyone goes into it realizing the only way they are going to make out is as a big contractor. I mean, the contractor and the contractee. Anyway, if the agency in the government changes the specs, now you've got a chance to recoup your money. That's about the only way you can make out.

NORBERG: Yes. Now this would be under cost plus, fixed fee contracts that we're talking about.

AMDAHL: Now, even in cost-plus-fixed-fee, it was cost plus a certain percentage. The percentage was not high enough to cover the running costs of the company that couldn't be chargeable on the contract.

NORBERG: What do companies do under those circumstances? Do they look for commercial business that can carry the slack that isn't provided by the...

AMDAHL: Well, if you have a large enough organization, what you find is that you can borrow some time to write proposals that only a little bit of time the writing part really gets charged as cost for the proposal. The thinking time is from a contract that they're working on already.

NORBERG: It's essentially the same as the academic world.

AMDAHL: You buy facilities and you have them, and then you rent them. You don't write them off; you rent them. By renting, you can have a continued income from property, basically that can help support you. But you have to be a pretty big operator to be able to pull that one off.

NORBERG: Certainly in the computer business at that time that was difficult to do.

AMDAHL: Yes, they wouldn't buy a computer. They would make you rent computers because you could get paid for a rental, but you couldn't get paid more than depreciation if you bought one.

NORBERG: Was Aeronutronic any different when you went there?

AMDAHL: No. But it didn't have hardening of the arteries yet. It didn't have a fixed structure that really had no



place to put any new ones, because, you know, what IBM was putting in place was a matrix organization. Now there's no place to put somebody, except adding them to one of the squares that's already in. Similarly, that's what they had in the Computer Division of Ramo Wooldridge. They didn't have that at Aeronutronic, and so there I was free to range over a wide variety of things, which I enjoyed.

NORBERG: What sorts of things was Aeronutronic doing at the time?

AMDAHL: Well, most of it was for bidding. We'd bid on a vote tallying machine to be used by the State of California, which we lost, but which was a beautiful concept, magnetic tape. You'd take and mark a dot. We were expecting we'd mark it with ink that was, let's see... you'd shine ultraviolet light and then you'd check the different frequency of it with that... I don't know what you would call the effect (fluorescence).

NORBERG: Well, this is for general voting procedures, not for the legislature, or something of that kind.

AMDAHL: Yes, general voting, and would accommodate different formats. You can vote for so many in this group. You can vote for less than that, or up to that number, but not more than that. And the thing worked in that you had a strip of tape in it that you'd pull with a handle. The tape went by, and you read the ballot and what was on the format and recorded the stuff on the tape. And then when you let the tape back, you had accumulated everything, and it was ready for the next ballot.

NORBERG: Who got the contract? Do you remember?

AMDAHL: IBM. Reading cards. They still do it that way.

NORBERG: They tried a computer system in Minneapolis this past election, and they broke down more often at the polling place than not in the counting process. So, I don't know what the problem has been.

AMDAHL: I think when you get right down to it, the voting technique used now is very nearly as foolproof as you can get. You can make mistakes in punching the ballot, but that's about all.

NORBERG: I would assume that there was no development money for that sort of a proposal.

AMDAHL: No.

NORBERG: So the company was bankrolling that.

AMDAHL: Yes. Ford Motor Company was its backer. They were in aerospace, nuclear physics, electronics. And then they had enough power in our group so they maybe put a computer group in there.

NORBERG: Yes. What sorts of other things did you work on?

AMDAHL: The FAA. We did the flight plan... Let's see, the device... first CRT terminal where we would display up to six formats, and you had an automatic cursor -- the first cursor, by the way -- and we had trouble proving that, so we couldn't break the... Somebody else who had come in later got the patent on the cursor. But we had the cursor in this thing, and the cursor would jump to the next... what do you call it... a slot for a character. It would jump across part of the format to the next blank that you're to fill in, and then show each character you're filling in. It had a five-by-seven display character. And there was an eighth row of five, which was the teletype character to be transmitted over the...

NORBERG: So this is for inputting data about the proposed flight plan of flight x.

AMDAHL: Yes. The pilot would fill it out.

NORBERG: Now, did any of this information later get displayed on some sort of a screen indicating where the plane

was at a given time, and...

AMDAHL: No, it was part of the FAA system that they were putting in as a test system right near Atlantic City, New Jersey. The name of the machine was FLIDEN -- Flight Data Entry.

NORBERG: Now that I assume was contracted for. It was constructed.

AMDAHL: Yes, and I headed the project.

NORBERG: Did that mean trips back and forth to the East Coast from here?

AMDAHL: Not many; a few.

NORBERG: Or was it just installed and it ran by itself?

AMDAHL: During this period, of course, lots of trips back to the East Coast, and lots of different proposals. One of the proposals was for an interceptor. This one occurred while I was at Ramo Wooldridge. The interceptor computer for determining how to vector, to outmaneuver another fighter plane. It was one of those. Then at Aeronutronic we went for one that was to be a digital differential analyzer. Actually, the idea that it would be a digital differential analyzer was mine, but it's one where I had to do a lot of solution of differential equations in time for control in an aerospace environment. Yet it had to be fairly low power. So what I constructed was the digital differential analyzer with what I called a sentry system. A sentry system was a very modest computer that just was monitoring the environment. When the environment showed the threat it powered up the digital differential analyzer. And we needed, if I recall right, something on the order of 40 integrators, something like that. And they had to be done with delay lines, because the time line, the rate at which you had to operate was very fast. So that was another one; we didn't win the proposal. There was another proposal which was to be instrumentation for monitoring the test-firing at Fort Wachuka... No, White Sands. And this was a mathematical analysis. And I went through the mathematical

analysis part, and ascertained that if I overspecified, I could get rid of the nonlinear terms. And by getting rid of the nonlinear terms, again, a digital differential analyzer could handle it with very high precision, and very economically. Still didn't win it.

NORBERG: Is it my personal prejudice here that these seem like less interesting problems than the ones you were working on at IBM, or, would you agree with it?

AMDAHL: They were less... Well, I had a great range of things that I could invent on, which was the thing that I found exciting. But I hated to not see them go anywhere, and I also hated that when we got them, generally speaking, somebody else was doing it. They wanted me writing the proposals, because they had a problem getting proposals that had anything new in them. Anything I touched seemed like it came out with something new. I remember the president of Aeronutronic being questioned by one of the generals as to whether or not -- there were three or four of us there who had written a proposal -- we would be devoting our time to these projects. The president carefully explained that there were many things going on in the company. The company had to make sure that it didn't "eat its seed corn." It satisfied the general.

NORBERG: When the proposals were made, then, to wherever. Let's say the FAA or the Air Force, whoever was looking for a new design...

AMDAHL: Then they'd start a project. Sometimes I'd be a consultant to it for a while, but I never got to really work on the interesting parts.

NORBERG: I was going to ask a different question. When you lost the proposal, that is, the project did not come to Aeronutronic, was the design allowed to be picked up by a competitor and built?

ASPRAY: I don't think so. No. To the best of my knowledge, the agencies did preserve the proprietary content. I understand now there are leaks, and I am sure there were then too. But they weren't leaks that gave away the other

party's proprietary technology; they may have given away the bid.

NORBERG: I guess what I was trying to ascertain for myself was whether or not there was a requirement by, say, the Department of Defense that the designs became their property and they could contract with somebody else to build such a product or not.

AMDAHL: No. Since they had not funded any of it those were not theirs. At least, I was never under the impression that they could do anything with it.

NORBERG: Other than say yes or no. Thinking back on the 1950s now, from the WISC machine through to the ultimate 709 project, which did go on in IBM, how do you now assess the changes in the computer field? Were there significant points that you think were overriding in the design stage of the computer field?

AMDAHL: Well, let's see. I'd say the biggest changes that I was observing was what you spent your time designing. In the beginning it was largely circuits. You had a very simple machine. You started doing things that were a little more complex, but you were doing those only when they had pretty well established, basically a pluggable component. And then, pretty soon you could get functional. When the medium scale integration came out in semiconductors, you could get functional things like an adder, or a counter. Then design became more of a design of the function you wanted. Now, instead of trying to make sure that all the components would talk to one another with really high reliability... Nowadays, for instance, here, we don't design circuits at all. We have functional statements that we make in Pascal and we simulate the machine to prove that it's compatible by running these Pascal subroutines linked to one another. And when we are satisfied with that, then we have a compiler we wrote that compiles into logic for the particular technology we're using. We apply a program that optimizes that, and then a program that times it, to see whether or not we have to go back and restate the functionality of...

NORBERG: And this is fairly standard across the industry, at the moment, isn't it?

AMDAHL: We're the only one that's doing it.

NORBERG: Is that right? Are the others still doing the earlier technique?

AMDAHL: Yes.

NORBERG: That's interesting; I didn't realize that.

AMDAHL: Logic design by logic blocks.

NORBERG: Do you think that your style of design changed during the '50s? When you went back to IBM, for example, in 1960...

AMDAHL: When you get right down to it, most of the time, I was one of the fortunate ones who got to always work on, "What is the function that we should be doing?" "What is the problem we're trying to solve?" "How can we make this thing most applicable?" The 704 was the first real chance I had. The market size there went from being just six scientific to going to and being 32. It got a lot into the commercial arena, not dealing with banking, but other parts of commercial activities. And we sold 140 of them. We captured much of the market that the 705 was expected to capture. The sum of the two forecasts were fairly close, I believe, to the sum of the two sales. But my sales went up by about a factor of four over the forecast, and there was about a corresponding reduction, not a factor of four out of the number of machines reduction in the 705 forecast.

NORBERG: So, your style, in the say middle '50s, was essentially the same style you just described as going on here at Andor Systems at the moment.

AMDAHL: Yes. That's right.

NORBERG: So, it did not change in any significant way. Having left IBM, considering the reaction you had to the Dunwell appointment to head the STRETCH project, what changed in your view of IBM that encouraged you to go back there in 1960?

AMDAHL: Well, I had wanted to be in commercial computing. I had tried to get Aeronutronic into it. We had the Autotron 500 that we made a proposal on to the Naval Supply Center in Oakland. We didn't win it; we did a first class job, but it was proposed and we decided we'd try to market it to the Ford Motor Company for use on an automobile end of their business. And we had our first rebuff there. The head of the computing activity for the Ford Motor Company listened to our presentation and thought it was really very exciting. But he took me aside afterwards and told me that, "You know, if I were to buy this from you, even though you're part of the Ford Motor Company, if anything went wrong, it would be my fault. If I go with IBM, everyone would agree that I went with the best and I would not have any fault."

NORBERG: Even then? Even in 1959, or so?

AMDAHL: Yes. That was about '58, actually. No, it could have been '59. And so, that was one. The other one was that in talking with the other part of top Ford management, it came out that they would not invest in developing that, because they never made any capital investments that they did not get returned in 24 months.

NORBERG: Well, how does that explain some of the things they did when they acquired Philco, in the computer field, that is.

AMDAHL: Well, I think what was going on in Philco in the computer field ahead of time was already set in concrete, so they couldn't change that. And afterwards, I think, it became only contract funded.

NORBERG: So only 24 months would apply.

AMDAHL: Actually, nothing much happened.

NORBERG: Well, did IBM approach you, or did you go back to approach IBM?

AMDAHL: IBM had been working on me all the time I was gone.

NORBERG: Oh, they had? I see. What sort of inducements were they making?

AMDAHL: Finally, Manny Piore came... I left Aeronutronic and was thinking of starting my own business. The only way I could think of doing it was to start as a kind of consultant, and I began talking to another firm that we just ran across, people that had worked on the original software support we were going to have for the 704. They happened to have a firm out in California. A group for them from a number of different companies had formed a software firm. And they wanted to get me to head up the hardware end of it there. I talked with them a little bit, and finally, it just came to me very slowly that what I'd be getting into there was something where we'd be doing proposals, maybe not to the government, but the same kind of contract proposal, for contracts there.

NORBERG: In a sense, customs projects.

AMDAHL: That's right. That was Computer Science Corporation. And that's the way it worked too, afterwards. So I decided, well, it's the same mill. And at that time, Manny Piore, Dr. Piore, vice president for research, was sicced onto me. And he took my wife and me to dinner at Romanoffs, and it turned out he was related to the family that runs Romanoffs -- his wife was. And so, of course, they rolled out the red carpet for us. And that convinced my wife, who was looking for a little more security. So I went back. I agreed that I'd go back east for a minimum of five months and a maximum of seven.

NORBERG: As what, a consultant?



AMDAHL: To work in research there for a bit. Well, when I got there, he immediately put me... Well, not immediately... Well, almost immediately, he put me in charge of something to be the next scientific computer. I was to begin to work on that. And then he put me in as director of experimental computers. And so I ended up being in research for a year. And during that time, I was being pressured to come in and head up... It was near the end of that time, I was called in to head up the design of the 360.

NORBERG: Now, when you arrived, was the discussion about the 360 going on at that point?

AMDAHL: No. There wasn't a 360 envisioned at that time. The 8000, or something like that was what was being designed. The one in charge of the project was the man who became my boss when it went to 360. The guy that was doing the design, was his choice to be the designer, and I got forced in between the two by Evans.

NORBERG: Yes, I see. Essentially the same thing that happened to you with Dunwell in the previous experience, as I look at it anyway. Where were the people that you had been associated with before? Where was Haddad now; where was Dunwell; Palmer, and so on?

AMDAHL: Haddad was at corporate headquarters by this time.

NORBERG: So these people had moved up the ladder, in a sense.

AMDAHL: A few of them had or they were on corporate staff. Actually, the majority of those that were my peers were in less influential positions.

NORBERG: Can you give any reason for that?

AMDAHL: Put on staff, because there were new up and comers that had displaced them as the management, and they were too high up to be put under them. There wasn't really a management level above to put them in. So they

went to the side. They could serve a function there of overseeing, because they did have the experience to bring to bear, and could spot people who were about to relive some sequence again, unless they changed what they were doing.

NORBERG: Well, thank you. Let's stop there for today.

DATE: 5 April 1989

TAPE 5/SIDE 1

NORBERG: In our previous session, you mentioned your return to IBM just as we were coming to a conclusion. One of the things that you said in telling me about their wanting you to come back, and Piore coming out to see you, and talking to you and your wife, you indicated that your first assignment when you went back was concerned with the next scientific computer. What did that mean? What does "next scientific computer for IBM" mean in 1960?

AMDAHL: They called it Project X. It was Piore's conviction that IBM had to put out a scientific computer, because the Stretch 7030 had not been as effective a product as they had expected. In fact, the program for Stretch had been a loss. It was a loss at that time, although they were still installing machines, because they had I think it was seven machines to install altogether. There looked to be little or no hope that it could ever turn black. However, some of the technology development expense was assessed against the 7090 which used it, and somewhere along about three or four years later, maybe five, it turned out that, in fact, with the other write-offs and the last tailing end of the revenues coming in, the program actually turned from red to black. By the time I came in, the spirits were pretty low among the scientific computing center people.

NORBERG: How long then did Project X last if it took four or five years to get it into the black with the 7090?

AMDAHL: Well, Project X was undertaken by the research laboratories, which meant it was on an extremely limited

budget, basically two or three people.

NORBERG: What sort of procedure was involved here in terms of developing such a project? Clearly with IBM this was an investment by the company to see whether or not there was a possibility of extending the technology in this case.

AMDAHL: I think you have possibly made it a little more formal than you should have.

NORBERG: All right.

AMDAHL: It was planned by Dr. Piore, with probably only his discretionary budget. And I came in. I was to carry that out. Those were not my only duties. I was also made director of experimental machines -- one of the six directors of the research laboratory. In the experimental machines area, they had just closed down the work on superconductors as applied to a machine. It had been ascertained that since they were not power amplifiers, that the likelihood of being able to do a machine was pretty dismal. They decided to cancel that -- the weakness really being the lack of power amplification in the device, which is the same thing that affected the more recent ones in superconductors.

NORBERG: When you say six directors of the laboratory for six different activities, what were the others?

AMDAHL: Semi-conductors, for one. I don't recall what they all did, but that just gives you an idea of how spread out... And then there was, of course, the director of all research. I had another computer project under me and some individual researchers. The computer project that was under me was one that was headed by Rex Rice to do his ADAM computer.

NORBERG: A-D-A-M.

AMDAHL: Yes. And this was all to be operating on a high-level language. I was following that fairly closely and began to insist on getting some specific determination of what are the execution times for some fairly commonly appearing programs. And I was never really able to get that information. I finally decided to recommend closing it, and it was closed.

NORBERG: Why were you unable to get the information?

AMDAHL: I don't think they had ever got quite gotten to the point where they could determine it, but it had run on for several years. And it seemed inappropriate to continue it, if they weren't going to be able to ascertain some of those very simple things about it.

NORBERG: How long did this aspect of director of experimental machines go on?

AMDAHL: Approximately one year.

NORBERG: And what other things did you explore in the meantime?

AMDAHL: I, along with John Cocke and Elaine Boehm, worked at trying to structure what we felt might be an appropriate form for the Project X. After looking at it for a bit, we decided that the push-down store was very attractive from that standpoint. And we began working on that quite seriously, got it developed to a fairly high degree of detail, at which time I was called to go to Poughkeepsie.

NORBERG: What ever happened to the push-down store? Was it used?

AMDAHL: Well, the story continues. At Poughkeepsie, they had been doing computer development. I can't remember what the name of it was. It was the one that just preceded System 360. And it was a fairly complex machine with a lot of registers in memory and quite a few registers in hardware. Apparently there were problems at

Poughkeepsie in determining whether or not that ought to go through; it seemed to lack some of the economic requirements that they wanted. And they brought it to me at research, made the presentation so I could make my recommendations. I concluded after listening to it that it was a machine that really could neither be significantly speeded up or significantly cost reduced. The reason was really too much complexity in the structure, and complexity which required that a lot of the registers that you used had to be in memory, for you couldn't put that much hardware together, that is the amount that you had to have in hardware to get any degree of performance. It was really very costly. And so I recommended that that approach ought to be abandoned, and a simpler approach taken. Then I got, of course, wooed then to come there and head up such a thing. And about the time that I was being wooed, we started the corporate-wide Spread committee. When I say corporate-wide, it was only representatives chosen from each of the divisions in corporate; I believe none from research. That committee began its deliberations just shortly before I agreed I would go to Poughkeepsie. An interesting thing happened as I was being wooed. Evans was the one who tried to get me interested in coming. And what he did was he invited me to a budget meeting where he would have some time in between listening to presentations for budgetary requests, and he could talk to me in those in between times. In the meantime, he invited me to sit and listen. So I sat and listened. I got the message he really wanted to get to me, which was that for every machine family if you wanted to introduce, say, tapes, or disks, you had to have development programs for each machine family, and software support for each machine family. Worse than that, the members of the family were only upward compatible, not upward and downward compatible. So that we had to have a different support for each member of each family as well. It was quite clear that they had about reached the end of their rope.

NORBERG: Did Evans express that to you?

AMDAHL: No, he just let me see it for myself. He did point out that it was doubtful that they could get enough engineers to do all the things they would like to do. That's the closest he came to letting me know what his real motivation was. He had an upward compatible family in mind. But I told him that from what I observed there, one thing was crystal clear, if we were going to do a family of machines, which is what he wanted to do, that their proposal that it be upward compatible was really inadequate. It could not be upward compatible. It had to be upward

and downward compatible. And I would take the job only on the basis that it was to be both.

NORBERG: I understand the upward compatibility technical issues, I think. What are the technical questions that have to be overcome in achieving downward compatibility.

AMDAHL: You have to pay a great deal more attention to how it gets realized in the hardware, so that your costs can be low at the low end, and yet your performance be able to be made high at the high end.

[INTERRUPTION]

AMDAHL: I think I could say a little bit more about being able to...

NORBERG: Please do.

AMDAHL: ... get this variation in cost and corresponding performance. The structure had to have a philosophical approach, and the philosophy formulated for that was that none of the mechanisms that we were to employ in the complete line should be anything that was linked specifically to a peculiar capability of the technology of the time, because that would only be useful in one machine and all it could do was distort part of that line. The general approach had to be one of having the number of registers limited to the number that you could reasonably put into hardware registers at the top end of the line, and which could almost all be restored into memory at the low end, suffering only the performance losses that one would get as a measure of the disparity of reference speeds.

NORBERG: Well, I can understand why one would want to reduce the number of development programs that need to go on for separate products. It would be nice if you could plug in the same peripherals, for example, into a range of different CPUs. But what I guess I don't appreciate is the downward compatibility. If one believes that the company is going to continue to... any company, the purchaser in this case, is going to continue to expand their need for information processing, then they would always be moving up the scale anyway. And so as long as it is upward

compatible that would seem to be sufficient, wouldn't it? From a marketing point of view, I guess.

AMDAHL: From a marketing point of view, you're absolutely right, to a large extent; not entirely. It is easy to sell, but it is not easy to support, because you find if you have it incompatible going downwards there must have been a reason for that. Something functioned much more efficiently because you had that additional capability. If it functioned more effectively, that meant that that was not available to the smaller ones. And so you would have two sets of software, therefore it wouldn't in practice be compatible. Also, we were concerned that many companies had more than one location, some of which had small machines, some of which had large. And to have those be compatible, there you have your marketing situation.

NORBERG: Can you place that budget meeting for me in time, with respect to the Spread deliberations going on in the company?

AMDAHL: I am not that familiar with its exact start, because I wasn't in one of the operating divisions at the time. All I can think of is that the meeting at Jug End occurred, in my memory, somewhere around June.

NORBERG: Of 1961? 1962?

AMDAHL: Of 1961.

NORBERG: You would be back about a year then.

AMDAHL: No, the summer of 1961 I was out on the West Coast. I am not sure... it must have been... It might have been late 1961... late in the summer of 1961.

NORBERG: All right. That raises another point that you mentioned last time: that you went back to the New York area for four or five months, ostensibly as a consultant.

AMDAHL: That's right.

NORBERG: And now you just mentioned that you returned to California, rather than going to Poughkeepsie, or...?

AMDAHL: Just on a short assignment, and if I recall... No, I can't recall what the assignment was.

NORBERG: So you were out here just a few months, then, sometime in the middle of 1961, and then returned to Poughkeepsie after that.

AMDAHL: No, to Yorktown...

NORBERG: Yorktown Heights. All right...

AMDAHL: Maybe my memory is tricking me. When I first went back to research, the new research laboratories had not been completed. So we started in Yorktown Heights, rather than at Yorktown. And I think we were at Yorktown Heights during that winter and then that summer I came out to California for a month. I went back, and the move had taken place from Yorktown Heights to Yorktown. It was at Yorktown that I was director of experimental machines.

NORBERG: Is it that way, or is it the reverse? Coming from Yorktown to Yorktown Heights? I am trying to remember now ? ?...

AMDAHL: The big new facility... We were in just ordinary development facilities when I first came back. We moved into the new laboratories when they were available, which would have been sometime around May of 1961. And I was there close to a year. So it would have been 1962 when the Jug End (?) conference took place.

NORBERG: I see.



AMDAHL: The Spread Committee started.

NORBERG: Before we go into the Spread Committee, and then your activity in 360, I would like to return to another matter, and ask you what IBM was like on your return. And the reason I want to do that is because earlier in an interview -- gee, it's two sessions ago now? Maybe it was the beginning of the last one -- you said to me that you left IBM in 1955, because IBM was becoming too bureaucratic. You mentioned that the context... you described the context at IBM prior to 1955 as a sort of collection of inventors in many ways...

AMDAHL: That's right.

NORBERG: ... and that was disappearing, and that, therefore, you saw that as not very conducive to the type of work you wanted to do. Then why return? And what did you find when you did return?

AMDAHL: Well, the reason I returned was that I did not find the situation materially better where I went in California. The first company I went to, Ramo-Wooldridge, had the same kind of organization that they had just put into Poughkeepsie. And there was no room for me... They had a role for me to do, but they explained my position as being utility outfielder. That's not necessarily all that emotionally rewarding, because I had the responsibility to write all of the proposals, but didn't get to be involved in the execution of any of them.

NORBERG: The same thing happened at Aeronutronic too, as well, when you went there.

AMDAHL: To a large extent, yes, although there I had big hopes that being associated with the Ford Motor Company that they were a commercial company, and therefore would be interested in getting into commercial computing. It turned out that their interests in Aeronutronic was to get into the military business, not into commercial. And so, I really sort of misread, and certainly misjudged what I could accomplish in terms of getting them to make moves in the commercial direction.

NORBERG: Did you make any conditions, then, with IBM when you agreed to return?

AMDAHL: Well, the only condition that I got them to agree to was that I would be on the East Coast for a minimum of five months and a maximum of seven.

NORBERG: Each year, or for that return?

AMDAHL: No. For that return.

NORBERG: Yes. And that turned out not to be the case.

AMDAHL: That's right.

NORBERG: Now, what was IBM like then when you returned, in contrast to 1955?

AMDAHL: Well, in the research area, things were still, you know, loose; it wasn't so bureaucratic there. In some respects, I had a high enough position in IBM so that I was less affected by bureaucracy, but it was bureaucratic now that I look back. But the particular project I had, when I did undertake System 360, was one in which we were really given a fairly free hand to make a lot of the decisions. Later, one of the decisions I wanted to make they wouldn't permit.

NORBERG: We'll come to that in a moment. Then do I conclude from that that the work you did on 360 architecture was done in the research facility? It wasn't a project separate at Poughkeepsie or somewhere like that?

AMDAHL: No, I went back to Poughkeepsie in 1962 to do that, so it was all done at Poughkeepsie. And we brought stuff from Project X along in terms of the plan at the time. In fact, Dr. Piore charged me with carrying the

responsibility for Project X, that was fine, but I had no budget.

NORBERG: (laugh) Was this a typical behavior pattern in IBM to try to woo somebody away from a project they were working on and into a new project, as Evans seems to have done with you?

AMDAHL: Yes, I don't know that it was any more serious than wooing people away from another company.

NORBERG: Any more serious. I would have thought that that's an interesting way to proceed inside a company.

AMDAHL: Yes, it is. You could get your hands slapped, and possibly Evan's hand was slapped by Piore. I never knew.

NORBERG: Did you work for Piore during those two years -- 1960 to 1962, directly, or was there somebody between you?

AMDAHL: No, the one who was director of research was between us. He was vice president of research.

NORBERG: Who was, Piore?

AMDAHL: Piore.

NORBERG: Yes.

AMDAHL: In fact, he had the director of research under him. Under that were more directors. There might have been a slight difference in the title, but I don't recall. I recognized that that man was my superior. I can't think of his name, but I think he was there at [?] recently, still. Very capable guy.

NORBERG: Now, in 1977, Bro Utall, of *Fortune* magazine, claimed that you were the architect of the 360. Do you agree with this statement?

AMDAHL: Yes, far more than anybody else.

NORBERG: Well, maybe you could describe for me then what the objective was that you were given in 1962 to work on 360.

AMDAHL: There were four categories of activity to take place under Fred Brooks. There was architecture, engineering, software, those were under me for initial planning, then there was market requirements, which wasn't under me.

TAPE 5/SIDE 2

NORBERG: ... market requirements.

AMDAHL: We talked about market requirements. Market requirements was to be staffed with some people with marketing backgrounds experienced in the field. The software was to be the operating system, that is, the general structure from the standpoint of what was the environment in which this thing was to operate, and specify the software, but not to do all of the software development. It was just to do the specifications. The engineering was to do the timing of the data flows structures for all of the members of the family, and at that point to pass it on each one to a different engineering manager, for carrying out the actual engineering projects. But the structure to be defined to have the performance and cost goals that were to be set for each of those machines. And architecture was to be a continuing activity.

NORBERG: What do you mean by continuing?

AMDAHL: Well, architecture had to define how the machines were supposed to function, the interface that that machine would present to the user, and to all separable parts of the system like the peripherals. Define the instruction set and the access that you had to that system for debugging purposes, for example. It did not specify an interface between memory, because the memory was considered too different between models.

NORBERG: I guess I would have used a different word than continuous in this case.

AMDAHL: No. It's a continuing function that still exists today.

NORBERG: For 360? Or... continuing function in that sense. Yes, I would have seen it as the overriding group where most of the things in the other three are defined by what happens in architecture...

AMDAHL: Oh, absolutely.

NORBERG: And therefore, they become sort of, oh, I don't whether I want to say, the management group, in a sense of the design.

AMDAHL: Well, I think that's what Bob had in mind, and Fred Brooks had in mind, but it wasn't what I had in mind.

NORBERG: I see. Why not? What is it you had in mind?

AMDAHL: I had in mind that we should be looked on as helpful to engineering, helpful to software development, not controlling.

NORBERG: Why not? Wouldn't it seem effective to control them?

AMDAHL: Because you don't make anything happen in IBM very effectively, if they view you as a threat. You'll

start to have power struggles. That's the last thing I wanted to have to be involved in was power struggles, because the whole undertaking was basically a power struggle within the corporation. Each of the machine families could see where, that is, the managers responsible for them could see their empires coming to an end when the 360 took off. And this forced them to do some of the bitterest internal battles you could imagine, particularly between divisions, which now no longer had independence in the product that they were to develop, because we were in one particular division and three of the projects were in different divisions.

NORBERG: I would have thought for a project as complex as 360, or any machine design of a substantive kind, you need to have some group which is, or some person, maybe even, that is making the final decision about, "We'll go this way and not that way."

AMDAHL: Well, that was my responsibility.

NORBERG: It was.

AMDAHL: Yes.

NORBERG: So it's not a consensual business that we're talking about.

AMDAHL: No, that's right. But what I did was I brought in representatives. I did the data flow first, with some kernel like a person or two in each area. And I did the data flows with them for those machines. But they were not the managers that would come in to take it over. They came in when the time was right to pass it over, which was probably a year and a half later. And those organizations kind of got built up during that period a little bit. And then the managers took over the individual machine models. But they were all brought in with the recognition that they had to be compatible. If they had a problem, they had to resolve it. At the same time, we had established a relationship so that their problems could come to our immediate attention and we would work together to resolve them. And we would work between the members of these groups. Now, many times I was asked to hire more people

and I told them it wouldn't work. I wouldn't be able to play the role that I was playing.

NORBERG: Did this group have responsibility... these four groups that you just mentioned to me: architecture, software, engineering, and so on. Did these groups have responsibility for only one of the machines in the 360 family, or every machine in the 360 family?

AMDAHL: The market requirements really interfaced only with architecture. Architecture interfaced, and I had the responsibility for data flows for all members of the family, and the interface to them from that time on, even in World Trade, as well as the General Products Division.

NORBERG: How did this work with, say, Hursley, which had the low-end machines too?

AMDAHL: I used to travel over there quite regularly. And had people that worked over there for quite some time with them. Some people came over and worked with us on data flow. And we talked a lot with them about their technology, and found a lot of that very interesting, tried to spread the gospel in other places about some of the useability of some of that technology. Each project, however, ended up using a different technology for the control store, which was inefficient. They had already tested their technology and so had the most experience with it. We also found their participation very effective. And so they were represented in architecture, just like people from the General Products Division during the Model 30 definition. We had two people that went over to Germany and worked with them doing the model 20. They were over there for over a year. In retrospect, model 20 could have been totally compatible, but it wasn't. They elected to do a subset. And we ended up having to do another machine, the model 25 to fill the gap.

NORBERG: Well, it seems to me this is defeating the purpose that the company set out to do.

AMDAHL: That's right. At that time it was impossible to convince people over there.

NORBERG: Over where? In Germany, or in corporate?

AMDAHL: In Germany. I think it was in Germany. It was impossible to convince them to try, because they viewed it as verging on the ridiculous.

NORBERG: How did they express that? (laugh)

AMDAHL: They didn't really have a discussion with me; they had it with my two people there. On the other hand, it was corrected in the model 25 from that time on ?

NORBERG: Was Model 20 eventually dropped? Or did that continue for some time?

AMDAHL: I don't know.

NORBERG: Can we go back to the... Well, there is one other question that I should ask. How large, then, did the architecture group get?

AMDAHL: We got up to about... considering members that were also members of engineering, we were about 20 on the CPU, and probably another 10 on the channel, I/O.

NORBERG: That doesn't seem like a lot to me.

AMDAHL: It wasn't.

NORBERG: But these people were spread all over the world as well, in five facilities, I guess it was.

AMDAHL: Yes, and there were about 15 of us that were headquartered in Poughkeepsie all of the time.



NORBERG: Can we talk a little about the group itself? The architecture group. How were the tasks divided? What were the principal problems to be overcome? And how were they overcome?

AMDAHL: Well, the first thing that happened, I guess, was something that you might well expect. The previous machine program had been headed by Fred Brooks, had one of his favorite designers, a very bright man, a very thorough man by the name of Gerrit Blaauw. From Holland. When Bob Evans put me in between the two, it was sort of forcing me down...

NORBERG: Now, in between the two... in between Brooks and Blaauw?

AMDAHL: Yes.

NORBERG: Now, were they working on something in the 8000 series, or in some other machine?

AMDAHL: They had been working on the 8000 series. That was the number I couldn't remember. So they were the core of this, the organization that I was inserted into.

NORBERG: Now, excuse me for interrupting again, but was Brooks then head of a whole series of other projects as well?

AMDAHL: No, he was my boss, and he had two responsibilities... I'll have to say three: he had me... I had three of those. I had programming, engineering, architecture. And he had responsibility for marketing. Or he may have had another man in charge of it, but that was his responsibility. And then his major responsibility was to interface to corporate management and the rest of the company.

NORBERG: Now, where was Evans in this?

AMDAHL: Evans was his boss. He was president of a division.

NORBERG: Okay, now I understand. Let's go back to the architecture group. So Blaauw comes in to work for you now.

AMDAHL: Yes, and although nothing was actually said, it was quite clear that he was doing his own thing in competition.

NORBERG: You mean, continuing the 8000 series while you people were supposedly working on something else?

AMDAHL: Well, the 8000 series was dead, but he was using that same kind of basic structure. And he was proposing this structure. I had brought in the stuff from Project X. And the thing we both learned was neither one was really the right answer.

NORBERG: Why not?

AMDAHL: His couldn't be made fast enough. The other one couldn't be made inexpensively enough. If you tried to make it inexpensive it would have been too slow. And then it was kind of difficult to get any cooperative agreement of what to do. So I recommended to Fred Brooks that we have a competition, let anyone in architecture propose what they wanted to do, and then we would evaluate them, and decide which one ought to win. Fred was to be the evaluator.

And it turned out, not only did proposals come in from marketing, architecture, and engineering, but also research submitted one, which in my view was a very far out machine, interesting, but not really implementable to achieve anything.

NORBERG: Was this a standard procedure with IBM to allow this sort of thing to go on? How much time did you give these people to present such a proposal?

AMDAHL: I think there was about two weeks. Then the evaluation was made and the team that I was on consisted of Elaine Boehm and Jacob Johnson.

NORBERG: Two people who had worked for you before.

AMDAHL: Yes. They had worked for me way back...

NORBERG: In the early 1950s.

AMDAHL: And we put together one. Gerrit Blaauw and some of his people put together one. One came in from research and there was one or two more. And we programmed three sets of data processing applications that we were to compare. And we were also to point out the general capabilities that we were trying to achieve with the architecture. He selected ours as the approach that appeared in the system 360.

NORBERG: Now was this a foregone conclusion before you even got into the evaluation?

AMDAHL: No. As a matter of fact, I assumed that Gerrit Blaauw would win.

NORBERG: I see.

AMDAHL: But I felt that it was really the only way we were ever going to make sense out of that organization.

NORBERG: Now, was this proposal that your group made in this competition different than the approach that was being taken in Project X?

AMDAHL: Yes.

NORBERG: You had developed a new one. So you had gotten over the problem of it being too uneconomical?

AMDAHL: Yes.

NORBERG: And how did you get over that problem?

AMDAHL: Well, we had used a push-down store in Project X. It didn't complicate high-speed operations. It had the effect of being related to formula evaluation. It had been worked out differently I believe at Burroughs at that time, and maybe if we'd taken their implementations things might have gone a little more effectively at the low end, but the high end wouldn't go as well.

NORBERG: Were you aware of Burroughs' activity at the time?

AMDAHL: Not in detail. We knew roughly what they were doing.

NORBERG: How did you know that?

AMDAHL: They did some papers. They had some machines out in the field.

NORBERG: Now you have approval to go ahead with your design. Did this win over Blaauw and others who didn't feel that it was...?

AMDAHL: Yes, they understood why we had done what we did -- the combination of both base registers and indexing, so that the addressing structures registers along could be made up of an origin and a sequence count using

base registers and index registers, but out of a common register set, which allowed the reduction of the number of registers required.

NORBERG: Now, did you feel at the time that this would cover the whole range of machines that were planned?

AMDAHL: Yes, because we had been looking at how we would do the high end and how we would do the low end. We estimated performance, which wasn't very accurate for any. We didn't do the intermediate ones; they were assumed O.K. So we were set then at that point knowing what we would do with the Model 75 and with the model 30, the two machines we were looking at. We were not looking at the model 20 at that time. That one hadn't even started yet and we weren't looking at Project X, because that wasn't in the Data Systems Division plan, even though I still had this verbal charge from Piore to keep Project X alive.

NORBERG: Had the Hursley people taken part in this competition as well?

AMDAHL: Oh, yes. There was a proposal from them and some of those people participated in the architectural planning.

NORBERG: How well expressed was the proposal that was put to these groups for competition? Was it two pages, 20 pages?

AMDAHL: I think it was just a verbal announcement.

NORBERG: And would this have come out of the Spread Report as the objectives for the program?

AMDAHL: It had nothing to do with the Spread Report.

NORBERG: I realize that, but didn't the Spread Report propose objectives to be achieved?

AMDAHL: Oh, yes, the Spread Report did have those objectives, although I never saw the Spread Report.

NORBERG: That seems strange.

AMDAHL: It was kept quiet, because they didn't want to give it out to the world.

NORBERG: Well...

AMDAHL: I heard... I was told certain things about it, but I was never shown a copy of it.

NORBERG: I find that a little puzzling if you were one of the principal people... It doesn't matter who "you" is in this case. It turns out to be you as Gene Amdahl, but...

AMDAHL: It may have been if I had asked for it I would have gotten it.

NORBERG: But how are the objectives transmitted to someone to know exactly what they were doing?

AMDAHL: Fred had them, and he was my boss, presumably that was the way I was shown them. He had implemented them in such a way as to make recommendations to our group regarding byte size and addressing.

NORBERG: How much interaction then was there between you and Brooks?

AMDAHL: A fair amount. After this shootout, if you like, on the designs, Fred was very much concerned that I was going to put Gerrit in a meaningless role. We had kind of limped along at one point, because of format weaknesses, and I wanted to make a change at that time, which would have been a violation of Spread. And I wanted to go to 24/48 words, which would allow us to go to either six bits or eight bits. That, of course, was verboten. I presented

that, Fred said no, and I said, "I don't think we can do an effective job on the floating point." Somehow or other, his response made my hackles rise. Probably still over his concern about Blaauw. His not wanting to be there in the first place. Blaauw having suffered what he had to suffer. Anyway, he gave me a direct order and I said, "I want to talk to higher management. I can't really do that." So the next thing that happened I had a meeting in Bob Evans office, just the three of us. Bob put on the blackboard the pros and cons, and he rated the 8-bit byte as having a weight of 60 percent because it was different from other vendors.

NORBERG: Why? Why not 40, or 100, or whatever?

AMDAHL: It was more than 50%, that's all that was important.

NORBERG: I see, okay. (laugh) So in effect, you lost at that point.

AMDAHL: Yes. Anyway, I sat there and listened to what he had to say and what went through my mind was that one thing was quite clear I can lose and I won't have anything, or I can accept this and go this way. I won't get a machine as good as I would have liked, but at least I'll have had a chance to do it, which is a lot better than becoming a nonentity. So it was about the only choice I could make.

NORBERG: Now what sort of problems did you have to overcome to do it that way?

AMDAHL: There were problems with how you split the exponent. I wasn't really all that happy with hexadecimal and normalizing. You lost definition on truncation. Your truncation error accumulated a little faster. And your range on the exponent wasn't as wide as I would like.

NORBERG: What sort of calculations would that have affected?

AMDAHL: I think it would have made the computer a much more effective scientific computer. When I say much

more effective, I don't know that IBM really very seriously went after the scientific computing. At that point they wanted to do something that was reasonably good for engineering, and could be presented as a scientific computer, but recognizing that not very much money was spent on the scientific end of it. Probably some hang-over from Stretch days when you got neither a scientific nor a commercial computer.

NORBERG: But I would think that IBM at that point would be looking at the commercial market as the bigger one, and therefore, in Evan's view, the truncation probably was not very serious.

AMDAHL: It turned out that had been determined at the Spread meeting, although it had been told to me that it was to be 8 bits, it wasn't really clear to me that that was a requirement at this point.

NORBERG: But that suggests the Spread committee had gone rather deeply into architectural considerations in the system.

AMDAHL: Oh yes, that's right. But only as to whether or not you could control with microprogramming. Except for byte size and addressing, they didn't go into how a machine should be structured internally. I recall those kinds of implementation concepts were left open.

NORBERG: After this meeting, since this is after the proposal evaluations as well, was it a clear path then to the rest of the solution of the problem of developing the architecture for this scheme?

AMDAHL: Well, the next part in that particular story was that we had one more meeting with the group vice president, which I thought consisted of...

NORBERG: A follow-on to the...

AMDAHL: ...only five dollar words which didn't really say anything.



NORBERG: Was this a follow-on to the Evans Brooks meeting?

AMDAHL: Yes.

NORBERG: And was it needed?

AMDAHL: Well, it was needed to show top management that the rift was healed. Then Fred also was still not satisfied. He came to me and wanted to clear up what kind of role Blaauw would have. I thought Blaauw should have the role of defining decimal. This was agreeable to Brooks.

END OF INTERVIEW