Oral History of Fred Brooks

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Grady Booch: So I am here today outside Cambridge. What little city were you in?

Fred Brooks: We're in Little Eriswell.

Booch: Little Eriswell where Dr. Fred Brooks is here on a sabbatical. And it worked out well for us to get together for this interview so I am delighted to have this opportunity to spend [time] with you. We're here for an oral history for the Computer History Museum. We'll be taking a look at the far-ranging things you've done and maybe get some insight from you for the generations to come in terms of advice and lessons learned. But I'd like to begin back at the very beginning. Let's sort of walk through this chronologically here, Fred, and tell me where you grew up. Where were you born?

Brooks: I was born in Duke Hospital because my father was teaching chemistry at he University of North Carolina and that was the nearest hospital at the time. And I then when I was about six months old he decided to change careers, went to medical school and after finishing medical school at the University of Michigan we settled in Greensboro, North Carolina, a town in the center of the coastal plain in the eastern part of the state. And I grew up there, and it was a great place to grow up because of the superb school system. It was the home of a teacher's college and so all the teachers we had in school and in high school had master's degrees and supervised student teachers. And so I had a really excellent education. I think it's interesting that one person a year ahead of me in my high school; our graduating class was about 100 students, was John Mayo who was later head of Bell Laboratories. So it was a little backwards town but never mind, we got good educations in Greensboro.

Booch: Marvelous. And another small world story we'll get back to there was someone else very special born in that same hospital...

Brooks: Yes.

Booch: Around that same time.

Brooks: Yes, Yes.

Booch: We'll come back to that. Were you one of many children?

Brooks: One of three, three boys.

Booch: Youngest, middle?

Brooks: I was the eldest. I am the eldest.

Booch: And tell me a little bit about growing up. What did you like to do as a kid? What do you remember? What did people say about you?

Brooks: Well I enjoyed school and we had a great neighborhood with three kids on either side of us and they matched ages so there were only four ages for nine kids. And we had a half-acre yard and we lived

next to a railroad track that had trains going by on it to watch and enjoy. And we fought World War II in trenches dug in the backyard and jungle gyms and whatnot in our yard because we were just barely too young to be seriously engaged. And I always had a fascination with business equipment and so when the local corset factory went bust I bought a comptometer and filing cabinets and stuff, you know, I paid $4 a piece for the filing cabinets and I think I paid $35 for the Burroughs touch operated adding machine. And made my own McBee keysort system for keeping track of my map collection. So I've always been fascinated with the kind of machines that process information.

Booch: A map collection because I see maps on the wall here. What did you collect as a child in terms of maps?

Brooks: Road maps, state maps, "National Geographic" maps.

Booch: Marvelous. So this Burroughs machine was your first computer, so to speak.

Brooks: Yes.

Booch: Excellent. And you spent most of your childhood growing up in that area then?

Brooks: All of it. We moved there when I was four.

Booch: I'm just curious. Are you in touch with any of your childhood friends still?

Brooks: Oh yes. We had a high school reunion not long ago and I'm in touch with several of them. Five of my class of 90 some odd became university professors. As a matter of fact, one of them has just retired from Chapel Hill where he founded the Institute for Arts and Humanities.

Booch: Small world. What was your favorite subject in school?

Brooks: Physics.

Booch: And what was your least favorite subject?

Brooks: Physical education.

Booch: Did you do much sports as a kid?

Brooks: No. I'm clumsy and awkward.

Booch: Physics. Tell me about the state of physics back then? This is gosh, the time of Feynman and Oppenheimer and all that.

Brooks: Well, but the state of high school physics hasn't changed much. It's essentially Newtonian mechanics, electricity and magnetism, a little bit of acoustics, a little bit of optics, you know.

Booch: And that's what began to fascinate you that eventually led to your doctorate in physics.

Brooks: No, my doctorate was in computer science. But I did my undergraduate major in physics.

Booch: That's right.

Brooks: But I knew I was— when I was 13 in the little town library, which was given by a native son who went north and made a fortune in shoe machinery. I read in *Time Magazine* about the Harvard Mark I. It had this great cartoon <inaudible> on the cover of the Mark I Machine and I knew from then on that that was what I wanted to do.

Booch: Wow.

Brooks: So in college, in addition to doing a physics major and a math major, I did economics, I did accounting, and as well as the humanities because I knew that was my interest. And the head of the physics department was determined that his best students should go to Harvard and study physics and so two of us did. But I told my advisor, I said, "Well what I really want to study is computers." And he said, "Fred you're too late." He said, "You can't get in on the ground floor. He said, “You can catch the first landing." And that's the story of my life, because I caught the first landing. And that means that I had a chance to meet and really get to know Pres Eckert, John Mauchly, I met Konrad Zuse, I didn't have much of a talking with him. We had to talk through translators. I never got to meet Von Neumann and Howard Aiken was my thesis advisor. So I got to really know the pioneers even though I wasn't in that generation. And that's been a great joy.

Booch: So Eckert and Mauchly, what was your interaction with them? How did you two connect?

Brooks: Conferences. And back in those days conferences were run on much lower budgets and they'd put two of us in a hotel room. And I got put in the same hotel room as Pres Eckert at the conference even though he was Univac and I was IBM.

Booch: Well this jumps ahead a little bit to your IBM career; let me go back to college for a moment. Your undergraduate degree was from...

Brooks: Physics. Duke University.

Booch: Duke. And what year did you graduate there.

Brooks: '53.

Booch: What were you focusing on in your physics study? Anything in particular or just general physics?

Brooks: No just general. And then you know mechanics, electricity, thermo, modern physics, the usual stuff.

Booch: And it was at Duke that you met this young lady that was born...

Brooks: No.

Booch: Oh it was later then.

Brooks: No, that was at Harvard.

Booch: Okay, so you went on to your undergraduate degree then your graduate degree, your master's degree in physics as well _____.

Brooks: No.

Booch: Okay.

Brooks: I went to Harvard. But instead of going into the physics department, I went into the computation lab, which was part of a division of engineering in applied physics.

Booch: Who were some of the people that were in that department at that time?

Brooks: Well it was a very small group. There was Aiken, which we knew as the boss. And he had some friends on the faculty that participated in all the Ph.D. committees and we took their courses. But there were two young instructors, Ken Iverson finished a year ahead of me and Bob Minnick finished a year ahead of me, Bob Ashenhurst and Peter Calingaert and I finished the same year. No Peter finished a year ahead, but Minnick and Iverson, Aiken swore in as instructors and so the whole crowd gathered at 5:00 everyday in the machine room which by now had the Harvard Mark I on one side and the Harvard Mark IV on the other side. Each machine about 60 feet long, for coffee. If the boss was in town coffee at 5:00 was *de rigeur*, and we'd talk for a half hour or 45 minutes and then he'd go home to supper and we'd go back to work. And so at the end of my first year he, at coffee, he told Ken Iverson who was finishing that year "I would like for you to prepare a course on the application of computers to business." And nobody had ever taught any such course anywhere in the world. And so I had had trouble with a course in boundary value problems so I wasn't continuing my NSF fellowship next year so I went to Ken and I said, "Can I be your teaching assistant because that's right down my alley?" And so they housed us in the same office and Ken and I then, he prepared the course and I was his teaching assistant and helped. Out of that came our book *Automatic Data Processing*, which went through an edition based on the IBM 650 and then four or five years later an edition based on the 360. [The dates are 1963 and 1969]. And Ken was fully as important in my education as Aiken was. Aiken was a very impressive person and he did something I can't do with my students. He came to my office every day and wanted to see the prose that had appeared since the day before, the year I was working on my dissertations. And guess what? Some had appeared since the day before.

Booch: And tell me about the choice of topic for your dissertation. What did you finally end up with?

Brooks: Well he said, "I want you to design a machine specialized for payrolls." And I said, "That sounds like a good topic." I was interested in the design methodology; he was more interested in the machine. In the <inaudible> the two together and so the dissertation ran about 500 pages including the things I was especially interested in and how you get from the requirements, as it were, to the machine. His hypothesis was that by specializing a machine for payroll you could make significant improvements in cost performance. That turned out not to be the case. It turned out that by specializing a machine for serial file processing—master file in, transactions in, new master file out, routine orders out—you could and that was essentially the machine I designed for my dissertation. But there were no further economies to be had by making it specialized for payroll.

I had a tremendous advantage of getting offered a summer job at Marathon Oil Company, Ohio Oil Company it was then, now it's a division of U.S. Steel or vise versa in Findlay, Ohio. Their treasurer came through talking to Aiken about how to mechanize his payroll. And I indicated I was interested in that. He offered me a summer job. Well, there was a little group, Ohio Oil Company operated in 40 states with a centralized payroll in Findlay, in this little town of about 20,000 people south of Toledo. And the headquarters of this worldwide oil company, strong in production in Libya and many other places as well as the Marathon brand of gasoline that you see in refineries and pipelines, the whole works. Well this little group consisted of the manager of the punch card installation who was on leave on a special task force, the manager of the payroll department on a special task force, a bright young accountant who had joined the company recently, an old timer who had worked in every division, he had started as a roustabout in the oil fields and then walked the pipeline and then worked in the refineries and me.

My job was to—- they had decided on a 650 and so I was the computer scientist to help them figure out how to get in on the 650 and that was priceless experience with a real multi-state payroll, seeing all the complications. And I got hold of similar kinds of detail data from three other outfits so I had a spectrum of payrolls to analyze and understand. And the complexities in business data processing are the fact that you're trying to lump a wide variety of cases under a single process and so typically on the 650 when it was doing business applications, half of all instructions would be conditional branches. And that's not true in scientific computing for example.

So this helped me a whole lot. And it helped me as a computer architect because I was also doing scientific computing and spent a summer at North American Aviation doing missile tracking and database building and so forth. And a summer at Bell Labs trying to identify which party on a four party line was dialing this call. And a summer at IBM in Endicott where I learned punched card machines and I was in the physics department doing acoustics. So the order was IBM, Bell, North American Aviation, Ohio Oil Company. But those four summers were a priceless part of my education. And they exposed me to radically different corporate cultures and radically different geographies. And I knew by the time I was finishing my Ph.D. that I didn't want to go into the missile business, that it was too up and down and in and out. And at North American at least at that time the relationship between the management and even the professional staff was colored by the heavy unionization of the plant. And so it was almost hostile. Whereas at IBM and at Bell Labs you're part of a team. And at Marathon you were in this little five-person group, that was just really great.

Booch: So back to the Mark I and Mark II for a moment. Did you program those?

Brooks: No I never programmed the Mark I. The Mark IV we programmed starting the first semester. I mean that's what we learned, was to program the Mark IV. And my present colleague Bill Wright [ph?]

and I, he had come from Duke too. So we undertook for our first year project to write a program that would analyze melodies and create synthetic melodies using a eightfold Markovian process. And that took us three years to get done but when—- and the problem is what do you use for a sample. What we needed is a big a corpus as we could get. So we chose common meter hymns because we could find a lot of them that already had the same metrical structure. We transposed them all to the same key then we analyzed the transition probabilities of the melodies. And the interesting question was, is there some order at which you get something that sounds like a human could have written it and yet doesn't replicate a chunk of your sample. And what we found was that at orders five and six that did happen. At seven and eight we replicated sample halves, and at two and three and so forth you wouldn't have mistaken it for human music. But at five and six we got stuff you could pass off on any choir.

Booch: Amazing.

Brooks: That was one of our first papers.

Booch: Are you a bit of a musician? Do you sing? Do you play instruments?

Brooks: No, no, no. We were using this as a model language.

Booch: Oh, okay.

Brooks: We were interested in doing this with English but that takes too many samples. So we picked these just melodies as a model language to try the methodology on and see how it would work.

Booch: So what was the nature of programming back then? What languages, what tools did you have?

Brooks: The machine, the Mark IV was programmed in decimal absolute. It had 230 registers and 10,000 words of program storage and 4,000 words of backup drum storage. So it wasn't an assembler. But Aiken had designed a relay box that enabled you to encode it algebraically and so Bill and I did part of [the] encoding on the relay box and part of our encoding in decimal. Our first program for determining the Markov frequencies ran about 2,500 instructions. We were allowed two shots on the machine in the semester and each one hour and it's the only big program I ever wrote that ran right first time.

Booch: So to what do you attribute the fact that it ran right the first time?

Brooks: Extensive desk checking.

Booch: Marvelous. Wow that's not a lot of time to test and debug because you had to get it right. Wow marvelous. So let's proceed on then. So you finished up your master's degree then.

Brooks: Well the master's was an *en passant* on the way to the Ph.D.

Booch: Oh got it. On the way to the PhD. The machine that you had proposed, the one you designed for doing payroll was it ever built?

Brooks: Oh no, no. It was a thesis project.

Booch: Got it. Got it. So you were clearly very influenced by those four summers.

Brooks: Oh very much so.

Booch: Do you have much contact with the people you were working with back then?

Brooks: No. They— most of them have died.

Booch: So in fact what was the state of computing for businesses because what you and Ken were doing had to have been incredibly revolutionary?

Brooks: Well the 650 came out in 1956, I believe. [Announced in 1953, delivered in 1954]. No, I programmed the— there was a 604 plugboard programmed machine [that] had gone into a lot of punched card installations. And I programmed the 650 at Ohio Oil Company in the summer of '55. So the 650 came out in '54 I think. And it was very popular. It was the first machine to sell more than 1,000 copies.

Booch: What would it sell for?

Brooks: $2,000 a month rent. [$3,250/mo for 1,000 words of storage and $3,750/mo for 2,000 words].

Brooks: Yeah. And it was very popular. It was the first machine to sell more than a thousand copies.

Booch: Wow. And programming was, not unlike per the Mark IV, there weren't a lot of tools or anything <inaudible>?

Brooks: It was decimal absolute

Booch: Yeah.

Brooks: But because it was decimal, you know, I can tell you op codes today.

Brooks: Twenty-four store distributor.

Booch: Oh my.

Brooks: [Laughter].

Booch: That's remarkable.

Brooks: [Laughter].

Booch: Did you have any contact with the designers of that machine at all? Were you just <inaudible>?

Brooks: I did later. It turned out that Ernie Hughes who was responsible for the Model 30 360 was one of the design engineers on the 650 a decade before.

Booch: Marvelous.

Brooks: Yeah.

Booch: So then after you graduated from— finished your- your Master— or your Doctorate, then you went on to IBM. But there's a promotional story I want to come back to because I heard you say that shortly after you defended your thesis you connected again with that young lady that was born in the hospital back then.

Brooks: Well, we- we met the first Sunday night we were at Harvard. Each of us were raised good, Methodist churchmen, even though neither of us was a converted Christian at the time, that happened later. But we both made our way to the Wesley Foundation facility for Methodist students for Sunday night. And we met there that first Sunday night and had a three-year courtship over our stay at Harvard.

Booch: Marvelous. Nancy, where had she <inaudible>?

Brooks: She had done her undergraduate work in physics. She had grown up in Durham. And then when World War II came along, her daddy went into the Navy and they were located in Patuxent Naval Base and then in Washington. He's a mathematical statistician and so he ended up in Washington. So she went to high school in Washington and they lived in Falls Church [Virgina]. So she went to the University of Rochester with a major in Physics and a minor in Music. And then went to Harvard and got a Masters in Physics and did another year of Music. And then we got married the Saturday after commencement on Thursday. We both went to IBM. She was working on transistor circuits for Stretch— simulating the circuits with matrix calculations. And I went into Stretch architects, under Werner Buchholtz.

Booch: Big wedding? Small wedding?

Brooks: Middle-sized.

Booch: And you just celebrated your 50th wedding anniversary?

Brooks: Yes, last summer.

Booch: Fugitives of the laws of averages. Congratulations. So, IBM? How is it you got the job there? Did you— did they approach you? Did you approach them?

Brooks: Well, Steve Dunwell, who was project manager for Stretch came through Harvard looking for people. And what he had to offer was very attractive. Here's a chance to work on the world's fastest computer. And that sounded good to me and so I leapt at the opportunity.

Booch: An amazing opportunity for a husband-wife team to work on.

Brooks: Yes, yeah.

Booch: So your wife was working on building the transistor end of it. You were working on the...

Brooks: On the architecture.

Booch: ... architecture?

Brooks: Yeah.

Booch: Who are some of the other architects you worked with?

Brooks: Well, Werner Buchholtz was the boss of architecture, Jerry Blaauw, John Cocke, Dura Sweeney, John— name escapes me, was part of the market planning group here. He had a strong background in scientific computation. Harwood Kolsky who, with John, devised lookahead, instruction lookahead. That's part of the Stretch Project. Harwood's background is Los Alamos. He was a theoretical physicist, computational, who had done part of the computations for the H-Bomb tests and in <inaudible>.

Booch: So he was on the Manhattan Project? Wow. Where he— so he worked with Feyman and- and all those kind of folks, I'd imagine. So, where were you in the beginning of— where was Stretch when you joined it? Has it— had it just begun? Was it along the way?

Brooks: It- it was— it had been— the team doubled from forty people to eighty people in July of '56. They had been underway thinking about it about a year and had just signed the Los Alamos contract… and had just signed the contract with National Security Agency to build a Harvest. And I was the only one of the Stretch architects proper who was native-born and could be cleared to work on Harvest. And so I was the go-between between the two architecture groups.

Booch: You needed an above Top Secret Clearance...

Brooks: You needed...

Booch: ... I'd imagine.

Brooks: ... a communications, intelligence crypto clearance to work on Harvest.

Booch: So as the go-between you then were responsible for looking at their requirements and feeding them in or <inaudible>?

Brooks: Well and working on some of the architecture for Harvest. So, Jim Pomerene was Engineering Manager for Harvest. George Kramer and Paul Herwitz were two of the architects along with Jim. And I worked on the real-time adjustments because Harvest is a streaming machine and you want to not stop.

Booch: Is Harvest unclassified now?

Brooks: Harvest has been described in the literature.

Booch: Okay.

Brooks: Yeah.

Booch: So I can ask you these questions without getting into trouble?

Brooks: That's right, yes. [laughter]

Booch: Good.

Brooks: And Harvest is now out of commission but it went for some twenty years.

Booch: Wow. What was Harvest's mission, primarily?

Brooks: Breaking- breaking wirewheel crypto codes.

Booch: Wow. So kind of following along the path of what Colossus did?

Brooks: Oh, yes. Yeah.

Booch: And this is a path they hadn't expected. Was there much influence from the work from Colossus and the folks that <inaudible>?

Brooks: Oh, the whole crypto community is [a] very close knit, secret community, especially between the British and the Americans. So there're hardly any secrets between those two.

Booch: So do you have to talk...?

Brooks: So we— I was assigned one stretch of [a] six week assignment in NSA, working in their advanced development group on algebraic techniques for wirewheel machines.

Booch: Wow. Marvelous. So, I'm trying to understand then the parallelism between that work and the Stretch work. Did this happen at the same time or...?

Brooks: Harvest was a plug-in card for Stretch.

Booch: Oh, I see, got it.

Brooks: So Stretch was the host and it was about 15 feet long and five feet high and five feet deep. Harvest was the plug-in card. It added another twenty feet of specialized electronics.

Booch: Marvelous.

Brooks: It's a wonderful machine. I mean, the whole concept is just radically different.

Booch: So what makes it so wonderful? You speak with almost a dreamy passion about it.

Brooks: Oh, yeah. You can think of it as having two conveyor belts and they come together into a logic unit and then a conveyor belt goes back to the memory. At the end of each of these conveyor belts is a small boy who takes things out of memory according to quite complicated patterns and puts them on the belt. And going back in there's another small boy that puts things back in memory in quite small and quite complicated patterns in addition to the logic unit which is one byte wide and does all the Boolean things plus addition and subtraction. There's a table look up, a streaming table lookup, that allows you to take an arbitrary base, shift a bunch of bytes in to make up an address, go to memory and either count in memory OR in memory or bring back from memory a chunk of stuff which then gets extracted and put on the conveyor belt. And this thing ran about 4 million bytes a second, all this going and it would take a half day to write an instruction for it. It had about 250 bytes of instruction to set it up. You can think of it as an electronic plug-board, if you want to think of it that way.

Booch: How many Harvests were actually built?

Brooks: One.

Booch: Just the one. Interesting. And it was used, you said, for 20 years?

Brooks: Yeah, something like that.

Booch: Amazing. So <inaudible>...

Brooks: And it— and it had a very powerful tape system, used wide tapes with automatic robots fishing them out and mounting them to keep the data flowing.

Booch: Way ahead of its time. <Inaudible>.

Brooks: Way ahead of its time.

Booch: Wow.

Brooks: So it's more like today's graphics processes. As a streaming machine than like anything else today.

Booch: So back to Stretch then what are you most proud of in your contribution to the Stretch architecture?

Brooks: The notion of going from a hardware console to a programmable console, [an] operating system- driven console. That was so that we could have multiple programs. Stretch's big contribution was all the supervisory facilities to enable multiprogramming. And to enable you to keep your programs apart. Dura Sweeney and I had the patent on the interrupt system. It was not the first interrupt system, Univac 1103 had that. But ours was the first one that had maskable and vectoring interrupts and that and so that and the programmable console. I was responsible for the instruction sequencing chunk on the architecture.

Booch: So this was the sort of the era of the rise of the machines in which there was a lot of experimentation.

Brooks: Oh, yes.

Booch: <Inaudible> sections.

Brooks: And we made our share of the mistakes. But the purpose of Stretch was to make the fastest machine we could, cost no object. And that's both liberating and tempting. And we didn't...

Booch: Did you succeed in that goal?

Brooks: No. Dunwell had set out to make a machine 100 times the 704 but the memories available were only six times the 704. The circuits were about ten times the 704. And the idea was by using more of everything, we could get there and you can't. It turns out that with a memory bandwidth like that, you can't do it. So we got to 50 times. It was declared a disaster and withdrawn from the market at 13. Nine of them were built I guess. And later then they [IBM] recognized that it was the thing that— in the first place the Stretch technology enabled the 7090s, 7080s, 7074. And in the second place, the concepts became crucial for the 360s. So Tom Watson, to his credit, went back and got Steve Dunwell out of disgrace and made a special award to him recognizing the important influence the Stretch had had on the company's welfare.

Booch: Where were you doing this work?

Brooks: Poughkeepsie.

Booch: Okay, Poughkeepsie.

Brooks: Yes.

Booch: And, wow, that's amazing. So it was to Tom Watson's credit because this was a- a leap of faith he took for this project to proceed. And then— so Stretch, you know, then wound down. Where did IBM find you next?

Brooks: I went to the Research Division in Yorktown and I worked on this book some.

Booch: The book being...

Brooks: No, not that book...

Booch: Oh, a different book?

Brooks: ... the *Automatic Data Processes*...

Booch: Oh, the one with Ken.

Brooks: ...360 edition. Ken and I had done the 650 edition and then he was kind of fully occupied with APL so I did most of the 360 edition of *Automatic Data Processing*.

Booch: In fact, it's set it in historical time when it was Ken working on APL when did it?

Brooks: Oh that start- started at Harvard in the course.

Booch: Oh, okay.

Brooks: When we were doing the automatic data processing course, he started looking for ways to describe sorting mathematically. He was a mathematician by nature and by training. And he'd found that there were many available notations but they were inconsistent with each other. So he undertook to develop a consistent notation that would serve. And here's the kind of problem you encounter: in ordinary algebra, the letters represent variables and the numbers represent data. In machine programming, the addresses, the names are numbers and the contents are letters. And so you have to start thinking in much more general terms. And Ken did a magnificent job of fashioning APL as a thinking language with complete freedom to use any characters you please as a thinking language. Then later when it went mechanizeable, the characters was a great handicap and he later developed the J language that uses a standard character set.

Booch: Did he ever write many APL programs?

Brooks: Oh, oh sure.

Booch: Very good.

Brooks: It's very powerful.

Booch: It is.

Brooks: I once did a pension calculation for a Methodist conference between supper and bedtime.

Booch: All in APL?

Brooks: All in APL.

Booch: Marvelous.

Brooks: We were doing actuarial work for 150 retired pastors.

Booch: So back in your tent, who's the lab man, lab director back then? Do you remember?

Brooks: John Gibson was lab director in Yorktown when I...

Booch: And the labs hadn't been around that long, had they?

Brooks: Oh, the big lab at Yorktown wasn't built. We were in the Mohansic facility where U.S. [Highway] 6 crosses the Taconic [State Parkway].

Booch: What other researchers were there at that time? I mean, IBM has about 3,000 researchers, but you were much smaller back at that time probably.

Brooks: Oh, I- I can't...

Booch: Hundreds.

Brooks: Yeah, it was— the division, the research division had been in the 701 building and, matter of fact, Stretch was in the research division when I joined the company and then it got moved to [the] product development division after the first year. And so, going back to research was a natural for me and for John Cocke. And John and I joined the company the same day, July 10, '56. And John had his Ph.D. from Duke so we quickly became friends, yeah.

Booch: Did you have much contact with Tom Watson back then? <inaudible>...

Brooks: Oh, no.

Booch: ... all the labs occasionally?

Brooks: Yeah. And Tom Watson, Sr. would come through the labs, yeah.

Booch: Any memories of Tom Watson, Sr. at all?

Brooks: Well there was this wonderful tale, I didn't see it. I'd been down the hall in the research lab and encountered this tall Scotsman who was wearing his kilt. And Mr. Watson Sr. turned to the lab manager and just said, "Get some pants on that man."

Booch: Very good.

Brooks: So there was a pretty strict dress code and kilts apparently didn't fit. They didn't fit— kilts and ties. [laughter]

Booch: So you remember wearing ties and- and white shirts back then?

Brooks: Oh, yeah.

Booch: So then the 360 came to be. How did...

Brooks: Well, there's a long story there.

Booch: Yeah, there is.

Brooks: While I was in research, the data systems division, which was the middle of the market up in computers, recognized they had a product line problem. They had the 7090 line, the 7080 line, the 7074 line, the 1410 line and so, Charles Decarlo, who was vice president for engineering, appointed a committee to study what a successor product line architecture might look like. I chaired that committee on loan from research. It was called a May Day Committee because we would need to report the first of May.

Booch: In what year would this have been?

Brooks: Well let's see, the year I was in research must have been May of '60. Meanwhile, Jerry was working on a machine called the 70AB, which was a business data processing machine [in the] upper-middle range, incorporating a lot of the Stretch concepts.

Booch: Had Stretch gone out of production by then?

Brooks: It was at the lab, still in production.

Booch: Okay.

Brooks: It was being manufactured in Kingston. Copies went, you know, to France, England, [a] lot of places. And from this came the concept that we needed a new product line for the data systems division. So at the end of the summer, I was asked to come back to the Data Systems Division to Poughkeepsie as manager of architecture parallel to Don Pendery, who was manager of engineering. It was functionally organized at that point. And we then undertook to design a new product line which was called the 8000 series. Built around Stretch concepts as reflected in the 70AB and the 70AB would be our first engineering model because it was up and Larry Canter was Engineering Manager for that particular machine. It was coming along great. Larry had been one of the inventors and engineers of the channel, the notion of an independent I/O processor running on a business data processing machine, very good engineer. So we designed this 8000 series consisting of a small, binary computer. A small [computer] that was scientific— a small business machine, this middle-sized 70AB and then a grown up version of that for high-performance things like insurance companies and utilities. And a grown-up version for scientific computing, the 8108. And then we worked very hard on that and in January of '61, we had zero-level cost estimates and zero-level market forecasts, had a marketing plan that involved creating new markets by making these machines communications-oriented.

Booch: Interesting.

Brooks: Okay. Because we had— you don't eat your own business. Just replaced them because most of our business was rental business. And, you don't make any money displacing your own rental machines.

Booch: Right.

Brooks: So, [we] had to do something that would create new computer applications. And we saw communications as the way to go.

Booch: Let me hold that for a minute because we need to switch out tape here, I think. And I'm going to ask you a question about the May Committee and we'll pick up right there.

END OF TAPE 1

START OF TAPE 2

Booch: So the question I was asking is back to the Mayday Committee in terms of, you know, its size and you said there are about 30 people, and you got selected because I think you said you are research and-

Brooks: I was available.

Booch: You were available. But you said while you were in research there were a number of things you were doing that sounded fascinating.

Brooks: Yes. Whenever I wasn't doing anything else, I was working on the *Automatic Data Processing* 360 edition book. But one assignment was six weeks at the National Security Agency. They had asked

IBM to assign some of their people into their research division so that they would have some in-house competence in the crypto field. Because IBM had built them a lot of special-purpose machines and would again. So I was one of a group of people assigned one after another into that.

Booch: And you were assessing the Soviet—

Brooks: No, no no.

Booch: Was that later?

Brooks: This was purely a crypto assignment, and what I was worried about was whole inside literature community, [?] and stuff Turing had done on the Enigma. All that has since been declassified.

Booch: Right.

Brooks: Then another time I was assigned four weeks to the executive office of the President. This was in the Eisenhower administration.

Booch: And the Cold War was raging.

Brooks: Yes, and I was in Washington when Khrushchev came to town.

Booch: Oh, my.

Brooks: And saw the parade and I thought I would never live to see that. That was just incredible.

Booch: So you saw Khrushchev from a distance.

Brooks: He came up while I was standing at the curb, and the car is going down the road to Blair House. Yeah, I mean, that kind of distance.

Booch: Wow.

Brooks: And I was in the executive office building one day on this assignment when the word came to everybody, "Come over to the White House." Eisenhower was seeing Winston Churchill off after his last visit, and so we all came over and stood on the lawn, and here came these two old cronies who had been through so much together. Churchill was in his 80s, and was clearly feeble, and you had no trouble imagining that this was the last time they would see each other. One of the things that surprised me was that Ike stood a head taller than everybody else on the lawn. Okay? I just had not been aware of that. But it was a very moving— you know, there were maybe 150 of us from the executive office building and the White House staff saying goodbye to him. So that assignment was to the President's Science Advisory Committee, George Kistiakowsky was the president's science advisor at the time. And I reported to them after the study of the materials to see I had collected, which included a lot of open literature material, a lot of newspaper clippings, a lot of interview reports from American scientists who

had been on tours of the Soviet Union, and a lot of material that was gathered by communications intelligence methods, and that was why.

Surprisingly enough, the person on the president's science advisory committee, who had the best and most penetrating questions. By the time I reported it, it was the Kennedy Administration. I remember my shock when I went back to Washington and here is all this playground equipment set up on the White House lawn for Kennedy's kids. And it was Ed Land, the founder of Polaroid; he had much the most penetrating questions. Not a computer person at all, but a great mind, and I was very impressed. He never finished college, either. He's the one who quit Harvard. So you can probably talk about it now, but..

Booch: What was your assessment of the state of—

Brooks: They were about seven years behind in all respects.

Booch: Software, hardware, everything?

Brooks: Everything.

Booch: Interesting. Interesting. Wow.

Brooks: And that had been true— I tracked it over some years, and the lag had been pretty constant.

Booch: So, wow, fascinating assignment.

Brooks: Oh, yeah.

Booch: This is amazing.

Brooks: Then another one was a group of us was assigned to go out on what's called a 438L contract to look at the intelligence processing at the Strategic Air Command underground in Omaha. So we went out and spent a week watching how the briefing was done; how the data was processed in the sub-room in the underground where the commanding general had his general brief on logistics and operations and personnel, and so forth, and then he retired to the tank and got a little briefing just on intelligence. And they were using our machines for processing that data and needed some advice.

Booch: Wow. What did you advise them on, what did you suggest; if you can say?

Brooks: I don't remember, fortunately.

Booch: So, then, this brings us back to— we were talking around 1961 timeframe, then, when things were really—

Brooks: In January, we presented the 8000 series in what we call the winter carnival. It was an all-day thing, we had the brass up from Armonk and White Plains, and we went through the forecasts. We went through the estimate; we went through the performance figures; we went through the communications or attachment concepts; what we saw, and this is creating a new market because you can really run terminals and things like banking, and so forth. Teleprocessing was the term invented at that time for the purpose of…

Booch: Was that an IBM marketing term or a term out in the atmosphere or…

Brooks: That would be [a] marketing term.

Booch: Okay.

Brooks: And the whole program was very well received, except for one fellow sitting in the back who just got glummer looking as the day went on, and that was Vin Learson, and that's not who you want to get glummer as the day went on because he was executive vice-president of the company. Well, that night he fired my boss, Max Ferrer, he shipped him out to Colorado, to Boulder, to outer Siberia, to work on tapes. He brought in Bob Evans from Endicott, from the other division, because this was our division's plan. He told Bob Evans to look into it; if it's right, make it happen; if it's wrong, turn it around. Bob spent three weeks looking into it, took me out to dinner at a fish place in Poughkeepsie, and told me he had decided it was wrong, and was going to turn it around. And it was his plan. His plan was to do— we were losing market. We were obsolete.

Booch: Who were you losing market share primarily to?

Brooks: The Seven Dwarves. Everybody was out after us. We were fundamentally address size-limited. We couldn't attach more memory to the 7090, we couldn't attach more memory to the 7080. And the applications were hungry for more memory. So, the problem was that he proposed to wait for a new semi-integrated circuit technology that was going to be three years down the road, and the problem is how do you hold the market in the meantime, whereas I had a plan that would get out there now. It had some fundamental difficulties, and he was right and I was wrong. But we fought for six months, and at one point, at the end of February, he called me up, he said, "Fred, I want you to know you got a raise." And I was quite surprised. I said, "Bob, thank you." Then he said, "I want you to know I had nothing to do with it."

Booch: So here's a silly question, if you don't mind me asking you a personal one. What did an IBMer get back then, in the sixties?

Brooks: Huh?

Booch: What was a typical salary back in the sixties for an IBMer?

Brooks: I don't know. I don't remember. Well, when I left, I was hitting the twenties.

Booch: Yeah?

Brooks: Yeah. Matter of fact, after the 360 came out, Tom Watson, Jr., called for our pay cards for Gene and Jerry and me and Bob, and he said, "Do you mean we bet the company on people we don't pay any more than this?" We got instant $10,000 a year raises.

Booch: Straight from Tom.

Brooks: Straight from Tom. Yeah. Yeah.

Booch: That's marvelous. So, I want to go back to the heads rolling from the one gentleman being fired.

Brooks: No, he was exiled.

Booch: He was exiled.

Brooks: He was given a managerial job at the Boulder laboratory, and not in the main line of where the action was.

Booch: Got it. Interesting. But let me also understand this stage of the Seven Dwarfs and programming back then, because we also saw them derive some of the higher programming languages.

Brooks: Yes.

Booch: This is during the time of Fortran and Cobol and the like, as well, too.

Brooks: Right.

Booch: Did you ever run across John Backus?

Brooks: Oh, yes, sure. When I was in research, I knew Backus and his team, because they were working on Fortran. As a matter of fact, I had been impressed with Fortran, which came out when I was a graduate student, winter of '56. And that Fortran I was a marvelous accomplishment, because John understood that to break the hold assembly language had, he had to have running times that were competitive with best assembly coding. It didn't matter how long it took to compile for that market, for that lead scientific market. So Fortran compilation would take 20 or 30 minutes, but then you ran production for 40 hours, and so the optimizations, that team that John had put together, was really brilliant and did a phenomenal job on Fortran.

Booch: Did you have much interaction with them professionally at all, while at the labs?

Brooks: I tried to keep up with what they were doing, but I was doing machine architecting and he was doing compiling.

Booch: Got it. Got it. So you said earlier that, you know, your boss was right and you were wrong. In what way? In what sense what that?

Brooks: Oh, he had two parts of the vision. One was, we ought not to do a new product line for the data systems division, we ought to do a new product line for the IBM Company, big and little, and he was right and I was wrong. The other was that we ought to make the new product line coincide with the new technology. And the reason that was right was the 70AB, then rechristened the 8106, used the same memories the 7090 used. Now, by this time, these memories were coined in pure gold. The margin on them must have been 85, 95 percent profit. The manufacturing engineering had gotten down to they could make these core memories, and so the pricing people told us, well, look, to come out with a system profit margin that's appropriate, we'll take it off from the processor and get it back on the memories. Well, it turned out that if you went through that exercise, you needed a negative price on the processor. And, you know, pay people to harden your processes away, so that was a fundamental flaw in building a second generation technology new product line. And Bob did not understand that then, and I didn't either, but it became clear in the ensuing fights. And we fought back and forth, and we went to [IBM's] Corporate Management Committee in March, and I won, and that did not slow Bob down a bit. Bob is unstoppable. And, so, on some morning he went to the Corporate Management Committee in May, and he won. And that was over.

And, then, this meant stopping all the projects in the Poughkeepsie lab. They were all 8000 series projects. And reassigning all the people, and his plan was to do temporizing machines, the 7094; the 7080 model 3, etcetera, etcetera, to hold the market as best we could until we could get there with the new product line, with the new technology. And, so, all these engineers had to be reassigned to these temporizing machines. Max Paley was in charge of the temporizing machines, and, to my utter amazement, Bob asked me to take the new product line. I had gone to— he had a retreat up at Saratoga Springs to spend a week ironing out who is going to do what, and I had gone to make sure my boys landed on their feet in the re-assignment. But I was going back to researching. I was on the way out. And Thursday of that week he asked me to take the crown jewels. And I was dubious. We had been fighting pretty hard, but I went and talked to Jerry Haddad who was Bob's boss at the time, and Jerry had been engineer and manager for the 701, and Bob had been an engineer on that. And Jerry said, "Well, Fred, I never knew anybody that regretted working for Bob Evans." So I thought, "All right. I'll give that a try, we'll give it a go and see how it goes." And it went really well. And we clicked and we fought shoulder to shoulder, side by side, the rest of the way. And Bob is one of four great bosses I had in my life.

Booch: Who were the other three?

Brooks: Aiken, Tom Watson, even though he was not my direct boss; and Sam Williamson, who was dean at Carolina, and later president of the University of the South, Sewanee.

Booch: So it sounds like the reason you and Bob clicked so well is, I mean, you both had a professional yet adversarial relationship in the sense that you could—

Brooks: We respected each other.

Booch: — speak the truth to each other.

Brooks: That's right. And we respected each other.

Booch: Yeah. This sounds too negative, but you wouldn't—

Brooks: Oh, we were fighting.

Booch: <Inaudible>

Brooks: We were fighting. It was adversarial. We were advocating different product strategies, and product fights in big corporations are major.

Booch: They are indeed.

Brooks: And each of us was swearing in all the friends we had from all the divisions, and he had friends that went— I mean, folks like Clarence Rosell [ph?] who had no official position in this decision at all, but was a very influential figure in the company. He was running a factory somewhere, but, you know.

Booch: Wow.

Brooks: So the fraternity system affects things.

Booch: So true. So what resources did he give you to proceed with your job? He said, you know, Fred, go forth and do this, and then…?

Brooks: This happened in early June; come August, it was time to come in with the annual budgets. And Max came in, I think, with a 12 million dollar budget for the next year, and Bob cut it to 10. And I came in with 9.6 and got every penny of it. Now, Maxwell is famous for padding his budgets, and mine was honest. And, apparently, that was detected. And, so, once I saw him give me the resources, and he said he would go get the people. All right, so I had drafted, and he brought in a first class engineer, Peet Fagg, from Endicott, to work for me as my engineering manager. And, so, we started to work.

Then, the Spread Committee. Don Spalding stimulated Learson with this idea of having a corporate wide thing. The problem is John Haanstra [of] the 1401, which was doing great. And Haanstra wasn't eager to do anything that would upset his market. So they made Haanstra the head of the Spread committee.in hopes of co-opting him. But halfway through that, John, who was engineering manager of the general products division, got promoted to be a division manager, and so he had to go off the Spread Committee, and from then on John was an adversary to the 360 project all the way through until the final shoot out in January of '64.

Booch: Interesting. So what did that 9-plus million buy you in terms of resources, how was that kind of spread apart in terms of the hardware and software, people side of things?

Brooks: At that point it was all hardware. We had a small program. I had Paul Herwitz, the village grover on my team, and product planners, to figure out what we ought to be doing, but then there was a big program in house that was supporting all these interim machines. Okay. So SOS was going along great, and on the scientific side, there was Autocoder and all these things on the commercial side, Cobol.

Booch: Ever run across Grace Marie Hopper and what they were—

Brooks: Oh, yes, as a matter of fact, I ran across— Grace visited us at Harvard occasionally, in Chapel Hill, where she came and gave a lecture series for us. And I rode across the continent with her on the airplane once, because she hired my first two Ph.D. students, as a matter of fact, to work in her office at the Pentagon after she went back as Admiral.

Booch: I still have my nanosecond from Grace.

Brooks: Yes, I had my nanosecond.

Booch: Okay, back to the 360. What was the— a couple of lines of questions here. What was the first major internal milestone when you guys met, for which you could say, you know, 'I'm confident we're going to actually pull this off.'

Brooks: Oh, Lord, that's too involved. What happened architecturally was we had started out in the data systems division pursuing a stack architecture.

Booch: Which is what Burroughs had—

Brooks: Which is what Burroughs had done. Turns out that works great if you've got a real show off transistor register for several levels, and it doesn't work great if you've got it all in memory, and you're having to pull it and push it and pull it and push it. So when we started, after the Spread Report came in in December of '61, then we faced the question of now making a whole product line with this architecture. We had accepted the assignment of making it upward and downward compatible, one architecture.

Booch: Now, let me go back to that decision if I may. Who made that decision, was that yours or was that your boss, was that Bob's, to just come out?

Brooks: I don't know whether Bob brought it up or whether Spalding suggested it; Spalding was very smart. And, so, in the Spread Committee, Bob, Gene [Amdahl] and I were kind of the chief architects; John Fairclough from Hursley [U.K.] was the third one who was a professional architect and engineer, and later Sir John, a really wonderful person. So Bob said, this is what we want to do and can we do it? Gene and I said, not evident, looks hard. And the problem is addressing, if you put addresses big enough on the littlest machine, your littlest machine is serial by byte and that means you spend a lot of cycles fetching address bytes that you're never going to use, and that compromises your performance. So, the stack architecture was a way of addressing that by not fetching as many addresses, but it turned out that when we went through the performance and cost estimation cycle in March of '62, the stack machine was working fine from the middle up but they weren't competitive down below because of all this pushing, reflecting things in and out of memory. So we scraped it and had a design competition, which was an idea Gene suggested, and we said form internal teams as you please, and I think there were 12 or 13 teams, mostly of three or four people in the architecture group, and I said the decision of the judge will be final. And it turned out that Gene's team and Jerry's team came in with essentially the same concept, which was use base registers that Philco had introduced in a machine a year or so earlier.

Because the base registers meant that we could get by with short addresses and expand them in the registers and that got us over the hardest technical problem. There was one very big difference, and that is Gene's machine was based on the six-bit byte and multiples of that so 24-bit instructions, 48-bit floating part <inaudible> and Jerry's machine was based on a 8-bit byte and 32-bit instructions, 64-bit, and 32-bit floating point, which is not a real happy choice, but… there are strong arguments each way. And you want your architects to be consistent. You're not going to have an 8-bit byte and 48-bit instruction floating point word. And, so, then came the biggest internal fight, and that was between the six and eight bit byte, and that story has been told. Gene and I each quit once that week, quit the company, and Manny Piore got us back together. He was the senior scientist in the company and a person of great wisdom.

Booch: And the 8-bit byte prevailed.

Brooks: Yes. I had made that decision, and Gene had appealed to Bob; and Bob confirmed it, and, of all my technical accomplishments, making the 8-bit byte decision is far and away the most important. And the reason was it opened the lower case alphabet. I saw language processing as being another whole new market area that we weren't in and couldn't get into very well, as long we were doing 6-bit character sets.

Booch: So the design decisions that really shaped the beginning of this, we can enumerate.

Brooks: We flushed the stacks, went to the base registers, went to the 8-bit byte.

Booch: And the fact that you had the same instructions architecturally taught—

Brooks: Oh, oh, that was made in the Spread Committee.

Booch: Oh, yes.

Brooks: What we said was, look, we don't know whether we can do that or not, but we'll go try to do that and we'll come back and tell you whether we have to break the architecture into two fragments or three, or whether we can do it. And so we went off to do it, and it turned out that with the base registers we could do it, and so we didn't break it. Now the Model 20 is a subset. Model 20 is not a perfect 360.

Booch: It's a proper subset.

Brooks: It is a proper subset.

Booch: So tell me one or two decisions that you regret having made, if there are any.

Brooks: Well, one that we knew we were doing wrong, but we couldn't see how to pay for it, that far ahead, was in the input/output control, where it limited the address sizes so that we could get all the information in one control, and we knew we would outgrow that. As a matter of fact, we published a paper in '65 that said we will have to go to 32-bit addresses from 24 during the life of this product, but we can't do it now because it would have— and one that we did just by mistake, just overlooked, was branch and link, which use the high-order 8 bits of some address to stash data in and when you go to a 32-bit

address, that's the only place in the whole— you had to have control words, but we knew we would have that problem and we finally went to 32-bit addresses. But branch and link was just a goof.

Booch: Interesting.

Brooks: The other thing that I would— the SS format for character processing. We had a choice of do we go with a fixed word decimal format, 650 style, or we knew we needed this variable length format for character processing. The question is whether you do the decimal that way or whether you do the decimal more fixed, doing the style of fixed point binary, that was a toss-up, and it might have been needed to go the other way, but, on the other hand you have some knowledge that you don't get before <inaudible>

Booch: So in the beginning of this project, this was, you know, really down at the harder level of the architectural decisions. When did the software elements of the project begin creeping in and start dominating? Where did that fit in the life cycle?

Brooks: Well, in '62, we formulated the plan to have four software levels, known as Romans I, II, III, IV. And they were fundamental because we had hardware compatibility, the software levels only had to be distinguished by the memory size. And McWhirter, who was the division president, took the software away from us and put it in his software house that was doing the software for the makeshifts for the market holders. Well, they were busy, and they didn't give the 360 software much attention. But by the end of '63, we had definitions for Romans II, III and IV, maybe even Roman I as well, but it was a mess, it was an awful mess. And, so, in January of '64, we had the final shoot out with Haanstra where we got the go ahead to do the 360, and that was a little technical *tour de force* by three bright engineers who overnight came up with the 1401 emulation on it, on the Model 30.

Booch: <Inaudible> who that is?

Brooks: Yes. Bill Wright, Bill Hale, Jerry Ottaway [ph?]

Booch: Overnight?

Brooks: Yeah, well, we had this meeting in White Plains, and Haanstra was saying, I've got this 1401S, it's made of the 360 technology, it's six times faster than the 1401, it's the same price as the 1401. I've got more than 10,000 machines out there in the biggest single revenue producer there owned and Honeywell to eat me with its Liberator and okay? And things were not going real well in that meeting. So I had Bill and Jerry Ottaway [ph?], my technical cavalry, they were real bright engineers, and were dispatched to wherever the trouble was. They later went to Germany, well, earlier, and done the Model 20, okay. So we got on an airplane and flew to Endicott, Bill Hampf [ph?] was kind of the Model 30's representative on the architectural team, a real smart lad, so he was resident there. And knew the mircocoding backwards and forwards, and so I brought him coffee and encouraged him all night and we decided, you know, which of the central loop and typical operations that would make up a performance mix. We had to have the microcode fully detailed for that. And the next morning we had a machine that was four times the 1401, and could switch back and forth between being a 1401 and a 360. Well, the Model 30 already switched back and forth between being a 360 processor, a selector channel, and a 256-way multiplexing channel. And, so, the notion that one implementation can take on multiple architectures

was an insight Jerry had had some years earlier that was just crucial to our thinking. And [the idea] that one architecture can have many implementations was crucial to our thinking. And, so, I went back to White Plains and brought in these results. And, yes, it's not six times the 1401, but the customer can start by running his 1401 programs, not have to convert a single thing, and bit by bit, code new applications or reconvert old ones to the 360 and get into next generation stuff, the last one. Well, that had an impact, but I still didn't know how things were going to be. The next morning I went back to the political meeting, and Haanstra wasn't there. He had sent his engineering manager instead. I knew he would. And, sure enough, John Opel representing the whole marketing force had come in overnight and said this is what we've got to have. And, so, but look, this is three months before announcement and the whole program is hanging in the balance because what Haanstra said was you do all of it except the Model 30. All right. If we had just taken the 1401— of course, we'll take the chips, and we'll take that big chunk of your forecast, all right.

Booch: Three months before announcement?

Brooks: Three months before announcement it was hanging in the balance.

Booch: That's pretty tough.

Brooks: That was pretty tough. But we knew then that we were going to make it. And that was the first time we knew for sure.

Booch: So give me your memories of the announcement. It happened in New York?

Brooks: It happened in Poughkeepsie first, and then— no, it happened in New York first, and then, oh, we drove to Poughkeepsie and then we did it again, essentially for the press corps there. I had a sharp ear ache come on that day. I remember that vividly. One of them inflamed things that you have to have lanced. But it was a glorious day; it was a glorious day in New York. It was a glorious day in Poughkeepsie, April the 7th, 1964. It was picked to be the 7th to match the Mark I, August 7th, 1944.

Booch: Interesting. So, was Tom Watson there?

Brooks: Oh, indeed. He did the pitch.

Booch: And you were sitting in the background?

Brooks: Oh, I helped. I mean, several of us had something to say.

Booch: What was your feeling, then, you know, toward the end, as you realized, wow, we've really done something pretty amazing. Could you sense that, the reaction of the press?

Brooks: Well, the thing I said to my team is "Tonight the lights will be on in the other guys' offices."

Booch: Do you think you took them by surprise, the Seven Dwarfs?

Brooks: It had been kept pretty well secret. Not quite, but pretty well. There'd been surprisingly few leaks.

Booch: Yeah. And then the orders started pouring in.

Brooks: And then the orders started pouring in. Meanwhile, the software <inaudible> and so I said to Bob, look, the machines are being released to the factory. The hardware part is done. The road to announcement of the data processing division is rolling on. Since McWhirter won't roll the two together, let me go over and leave the hardware part and go work on the software. I was already scheduled to go to Chapel Hill in September. Bob and I knew that. I don't know when we told the public that, but I think it was— it wasn't until about announcement, but he and I knew that.

Booch: So, in effect, you were ready to move on from IBM.

Brooks: I had accepted the job in Chapel Hill the previous August.

Booch: Well, why Chapel Hill, I'm curious.

Brooks: Well, that's a long story, but— and I won't go into it, but I had in the meantime become a Christian, and the Lord was leading in very clear, not easy to explain, ways. This was something that back the summer we were married, I had plotted out full possible career paths, university-technical and university-administrative, Industry, technical-industry-administrative, so industry-technical is your job, fellow, and the administrative is the vice-president kind of thing, and similar in the university, a dean or, you know, or just a professor, which is in my job. Okay. I had asked myself, in that scene, I had discussed, what do we— all four of these are attractive end points, being newly married and a Methodist, I ruled out being Pope, and lacking the talents, I had ruled out being President, and then just come up with these four end points. What do we do to keep the options open, came to two conclusions that governed our lives. One was we would live on an academic salary, and so we lived on Nancy's salary and banked mine, and we did that for years until she quit, and then we lived on what had been her salary with normal progression. And that meant that when I had the opportunity to go to Chapel Hill at half salary, we were disciplined and had bought freedom. We were free to make that choice. It was not a change in standard of living, and moreover, there was money enough to put down more than half on a house.

The other decision was to keep the academic option open, one has to maintain a publication program. And the IBM company encouraged publication in principle, but they didn't make any time available for it in practice. And, so, when something like the interrupt system, did a paper and followed up computer conference, on when there weren't anything that we could talk about fresh out, did review papers for, you know, review of I/O systems of computers and things like that, so that when the opportunity in Chapel Hill came up, I had an acceptable, professional record for an appointment as full professor. And that was bought with weekend labor and night labor over the years, too.

The opportunity in Chapel Hill came about this way: the head of the computer center left to go to Pennsylvania, and they had a Univac, and, so, they went to Univac and said "Find us one." Well, Univac didn't want to tap any of their people for that kind of job, but they had an alumnus who was working for IBM, and they went to him. Well, that was George Cramer, he was then a Harvest architect, and he had

been Nancy's father's roommate in graduate school at the University of Missouri. A small world, they were both mathematicians. And, so, George said, "Well, I'm not interested in that job, but I know a young man that might be." He had known Nancy since before she was born. George and Daddy Greenwood had been close all along, and so, this was the summer of '62, we went down and interviewed for the job and, you know, it was April, and the grass was green, and the dogwood and flowering cherries were in bloom, and the lakes up north were frozen, and the old muddy snow was very wet, but the job didn't fit. It just didn't fit. And, so, I declined, and we sadly trudged back north.

My people were still living in North Carolina. That was an important attraction, for my kids to grow up knowing their grandparents. But, as part of the interview process, one gives a lecture. And the lecture I chose was ten research topics in computer science, arguing that there should be a discipline, and there wasn't. Okay. And, so, since there wasn't anybody, the heads of the departments that use the computations all turned out for the candidate's lecture, and the dean of the graduate school, who was professor of Southern Literature, Hugh Homan [ph?] assembled a committee after I'd gone back, to study the question of whether Carolina should have a computer science department. And they came back to me a year later and said, "Would you be interested in coming and talking about starting a computer science department?" That was the summer of '63.

Well, that's a different proposition. And these elders of the several scientific departments were all for it, so you felt this immense feeling of support for getting off the ground. And that was when, after a lot of prayer and guidance, I accepted the job, and then I went and told Bob, and we agreed that since lame ducks in industry don't have a long half-life, we would keep it secret for the year until appropriate, so this was August of '63, and the announcement was due in April of '64, and I was due to go to Chapel Hill in September of '64.

Booch: Let me hold that here and change the tape.

END OF TAPE 2

START OF TAPE 3

Booch: Our decision to move on to lead the software side of things where you had this opportunity at Chapel Hill on the Chapel Hill side for a moment. That was kept secret for the longest time.

Brooks: That was kept secret for a long time.

Booch: How did IBM and you manage to keep it a secret?

Brooks: Well, Bob and I knew and I guess he told a few of his bosses but generally we didn't tell people.

Booch: Wow.

Brooks: Now the word got out at Univac and I remember a Univac person coming up to me at a conference and saying, "I hear you're going to Chapel Hill." I said, "Well, where did you hear that?"

Booch: I think your daughter was saying maybe a little off on the time here you even had a house in Chapel Hill.

Brooks: Oh, yes, well no that—

Booch: Was that a little later?

Brooks: The house was bought when we still felt we were going in the fall of ’64 but, yes, that’s a little later. We bought it in the spring of ’64.

Booch: So it must have been a tough decision.

Brooks: It was, yeah.

Booch: I’m going to go down the software…

Brooks: Yeah, well no. The tough decision was to go to Chapel Hill, but look it’s February. Announcement is in April. The machines are on the track. Everything’s rolling. The software is in an utter mess. So I went to Bob and I said, “Between now and September when I leave, let me go over there and bail and just see what can be done with the boat.” So we changed the team. Some projects were ending up, like the— well, one of the operating systems, the 1410/7010 disk-based operating system the first. Ted Codd had built a disk-based operating system for Stretch and he was working for me. I had inherited him when I took over the architecture job in DSD [Data Systems Division] and so I sent him to school to get his Ph.D. which was the other wisest thing I ever did, after he finished the Stretch operating system. That was not the operating system delivered with Stretch. There was an official one and then Ted was doing this research project in multi-programming, I think the first multi-programming operating system running, but then we had this, so I changed teams and we had a retreat off in the woods in February of ’64 and came back with a totally different product plan which involved then these memory levels but compatibility among them, a variety of language processes, two Fortrans, a card-based Fortran, a report program generator, two levels of Cobol and a modular operating system that would start at 16K of which you got to leave some space for the application program and so we said the operating system has got to be resident in 4KB and it turned out we couldn’t do that so we ended up making 32KB the minimum size of OS. And sure enough we had a tape-based operating system for the smaller and a card-based operating system, a little disk operating system called Basic Operating System, and those got delivered on schedule in February of ’65 was the first one, okay.

The big operating system was in trouble and so we patched and baled but by summer it was clear that we were still in trouble. And so Tom Watson invited me down to Armonk for one of these one-on-one luncheons in the executive dining room and the two questions were ‘why don’t you stay here?’ And I said that I really wanted to get back closer to the technical level.

Being a corporate processing manager for the system was— it’s a great level because you’re three levels from the bottom and three levels from the top, which means you know your people and the bosses know you, okay. It’s a really good job but I was ready to get back to more technical work. And I said, “I like to make things.” And he said something I have never forgotten. He said, “I do too. Have you looked at Poughkeepsie recently?” And you suddenly realized that this whole thing that had started as a typewriter

factory and was now this manufacturing center for the computer industry was Tom Watson's creation. "I do too. Have you looked at Poughkeepsie recently?" It just raised my sights most wonderfully. But then he said, "Well, will you stay another year and keep on bailing out the operating system? If you will, here's what we'll do. We'll send somebody to Chapel Hill to teach your courses. You go one week a month to get your department organized. And when you need a new computer in Chapel Hill, we'll help." Well that turned into $900,000 later on. It became the foundation for the Triangle University's computation center and the negotiations around that became the basis for IBM to choosing the Research Triangle Park for a location and it is now at 13,000 people, IBM's largest single location in the world.

Booch: You built something.

Brooks: No, he built something but that was a good offer and so I said yes and we worked out that I could have a— this took some fighting with the corporate organization folks because that I could have an associate manager of the operating system, Dick Case and Dick and I worked like that, had all along. The corporate people didn't want that kind of structure, but never mind, it worked. And so that's what we did and so to find a person to go teach my courses, lo and behold, George Cramer [ph?] was getting ready to retire from IBM and he wanted to retire to Asheville, North Carolina when he got through anyway and he loved to teach and he had taught mathematics before he went into the computer industry, so he would love to go and teach in Chapel Hill for a year. So we had bought a house. We rented it to George. I rented back a room in it and I commuted back and forth. When I was in Poughkeepsie, Dick and I were in charge and when I was in Chapel Hill, Dick was in charge and we got the thing turned around and on track.

Booch: Marvelous. So the size of the 360 OS how big was that? How many folks are you talking about?

Brooks: It peaked at about 1,000 but that was a fairly narrow— I mean it built up and it went down and it was— one of the strangest things I ever tried to do was to organize an Orthodox synagogue. It turned out I needed to move the 110 programmers from the Time Life Building to Poughkeepsie and a lot of them were Orthodox Jews and they wouldn't move unless there was a synagogue. Well that meant I had to get, what do you call it, a *minyan* of ten Orthodox men and I searched the Hudson Valley and I could not put together an Orthodox synagogue but that was one of my stranger adventures.

Booch: Amazing.

Brooks: You know what a manager does.

Booch: What's that?

Brooks: Whatever needs doing.

Booch: There you go and you did quite a few things. So from the time you began to turn around the OS until you delivered how long a period of time was that?

Brooks: We delivered the first version, did deliver in April or May of '65 but it was slow and it was November really before a respectable version was delivered. It was November of '65.

Booch: So in that process, sort of a threefold question: what was the best decision you made? What is the worst decision you made? And I'll come back to the third one.

Brooks: Well the worst decision is documented in *The Mythical Man Month* and that was the decision to take the architecture away from the architecture group and give it to the operating system manager. As I document there he said, "It'll be so much late and it'll cost so much" and Marty Belsky the architecture manager said, "If you leave it with me, it'll be the same amount late, it will cost the same, but it'll be right" and he was right and I was wrong and that was a multimillion dollar mistake.

Booch: Right.

Brooks: The best decision in the whole program was certainly the eight-bit byte. The best decision in the operating system, well, the assembly language, surprisingly enough, posed a lot of technical problems because there were two entirely different schools of thought had grown up in the scientific and the commercial sides. On the commercial side, the assembly language served as a platform on which high priests in any different corporation wrote macros and the troops programmed in the macro language and so Eastman Kodak was a proponent of this and had done a really good job of that and various others. In the scientific community, the scientists would write their own macros and they programmed in assembly language, macro enhanced. And so the question of how to resolve all this led me into technical thickets, the thickest technical thickets I got into in the operating system. The other set of technical decisions I made had to do with PL/I and the whole question of do we use equal for assignment following the Fortran tradition or do we use a colon-equal [:=] kind of thing? But the more serious question is do we do independent evaluation of expressions so that you can factor out common sub-expressions?

Booch: Exactly.

Brooks: And the answer to that was yes, but that leads you to peculiarities such as one divided by three equals zero because of data typing.

Booch: Right. I'm going to come back to the language issue for a moment and the third question of that genre is and you may have already answered it, what was the hardest decision you had to make during that time, one that you just remember laboring over?

Brooks: During the operating system too?

Booch: During the operating system work.

Brooks: It's always people and I won't go into personalities.

Booch: I understand. It was a matter of staffing on the site.

Brooks: And removing them, yeah, yeah.

Booch: Interesting, so on the language side for a moment, PL/I, and I'm not going to go into great detail on the OS 360 stuff because this has been documented quite well elsewhere, but tell me about the

evolution of the languages that came along and paralleled this. Who were some of the principals you worked with on the PL/I side?

Brooks: Well, PL/I, SHARE put together a team. Jim Cox from Oak Ridge I believe, George Radin from IBM, there were six of them in all that made the SHARE committee doing PL/I, one from England, I forget who. I don't remember the names of that committee, but they worked on the language. The basic concept was to make a universal programming language that would meld and displace Fortran and Cobol.

Booch: Was ALGOL a factor in that?

Brooks: ALGOL was not really a factor. Now part of our product plan included delivering an ALGOL compiler. We had to. We had to for government reasons but ALGOL was popular in Europe and ALGOL had a lot of important concepts in it, particularly having to do with subroutine calls and parameter passing, that whole business, that we had to master and adopt. What we saw as the most important steps forward in PL/I were the unification, the provision of compile time mode, just like macro assembler but if we'd been smart we would have done a schedule time mode instead of doing JCL, all right, but we weren't smart. That's the worst mistake we made was JCL.

Booch: Splitting JCL and languages.

Brooks: Yeah. Well the existence of JCL was a mistake. Building it on a card format was a mistake. Building it on assembly language was a mistake. Thinking of it as only six little control cards instead of a language was a mistake so it had no proper sub-routine facilities, no proper branching facilities.

Booch: JCL was sort of an expeditious decision wasn't it, that kind of blew up?

Brooks: It kind of grew. It kind of grew but when you end up with your data definitions doing all the verbiage things because you've limited yourself to six verbs that's a language mistake.

Booch: So in some ways JCL—

Brooks: We didn't see it as a language was the fundamental problem. We saw it as a set of control cards.

Booch: Got it.

Brooks: And lo and behold they're still around, the dusty decks that nobody dare touch because they run and nobody knows what's inside.

Booch: And people found ways around the simplicity of the language. It was incredibly complicated.

Brooks: Incredibly complicated, the keyword parameters and the set goes on and on and on and on.

Booch: Interesting. Who led the JCL development effort?

Brooks: Casper Scalzi, but that's not his fault.

Booch: No, no it was a strategic decision having JCL in the first place.

Brooks: Yeah.

Booch: He probably did a fine job given the constraints.

Brooks: Yes. So the important thing in PL/I was to incorporate in the best modern knowledge and character processing as a—

<crew talk>

Brooks: Incorporate character processing as an integral thing, so the sub-string, the endfix operator, these character-based operators. The other hard question then is operator precedence because as you get all these levels of operator precedence solution is very simple. There is no operator precedence There is none whatever at all and so you better use parentheses or you're in deep water. In PL/I we put in operating precedence but it gets quite complicated and I think the hardest technical decision was the question of shall you consider targets in evaluating expressions? And the answer was no because of optimizing compilers.

Booch: Yeah. I remember you writing someplace that IBM had a waffle about its support for PL/I.

Brooks: Absolutely, absolutely that killed it, yeah.

Booch: Interesting.

Brooks: Back and forth, back and forth. Now where they didn't waffle was in the U.K., Rolls Royce I think may still be using PL/I, it took off in the U.K. partly because it was being built in the U.K. at the [IBM] Hursley laboratory and so there was enthusiasm but IBM did the same thing with APL, on again, off again, on again, off again when a wholehearted support would have made it happen. Now, could you have displaced Fortran? No, I now think that would have been impossible but I still deal with chemists who are using Fortran.

Booch: Could you have displaced Cobol, maybe so.

Brooks: Yeah, I think you could have displaced Cobol and that community is more coherent. It's more top down oriented and PL/I is a better substitute for Cobol than it is for Fortran.

Booch: Yes, yes. So things finally shipped and the orders for 360 were still pouring in.

Brooks: Yeah. Well if you look at the annual reports the company goes and then it goes like that.

Booch: Yeah and the Seven Dwarfs go in the opposite direction.

Brooks: And the Seven Dwarfs go in the opposite direction.

Booch: Right.

<crew talk>

Brooks: We invested a fortune in that operating system.

Booch: How much did IBM pay for that or spent on 360?

Brooks: Well, it depends. My hardware development budget was about $100 million. That doesn't count all the I/O devices, the disks, the tapes, the new keypunches to accommodate eight-bit bytes and the larger character set and all that stuff and it doesn't count capital tuning for the factories and all that, so what the whole program cost billions. The software budget for OS, not counting DOS, I think was somewhere in the neighborhood of $400 million in 1964 dollars, which would be $4 billion today roughly.

Booch: Yeah. I'm sorry, go ahead so quite a bit.

Brooks: Yeah.

Booch: So in your management then how long did you continue as manager for the 360 work?

Brooks: Through alpha test which was April of '65, something like that.

Booch: And then you passed the torch onto—

Brooks: To Fritz Trapnell.

Booch: Got it, got it. So I'm not going to belabor your experience there because your marvelous book goes into so much detail on that but give you the opportunity. Are there any untold stories from that period that come to mind?

Brooks: None that come to mind. I unloaded.

Booch: You unloaded there, so we'll move on from that. So from the time of the alpha period and then on did you have much customer contact or were you kind of buried deep in the labs around this time?

Brooks: Well I was doing a lot of sweeping up and we had customers. We did customer calls all during the program.

Booch: So it was a matter of telling the customers what's coming up.

Brooks: We did customer briefings, confidential briefings before announcement, two and three a week to the major customers.

Booch: Any memorable ones, any memorable customers that you just kind of blown away?

Brooks: Well, one thing impressed me very much. I did a customer call on St. Paul Insurance Company and they wanted to present to us their computer forward plan. Who presented it? The resident IBM system engineer.

Booch: Fascinating.

Brooks: She had an office there. She went there 40 hours a week. She was a part of the St. Paul team. I had seen the same thing at Ohio Oil Company. I was called upstairs one day. They had an executive meeting with the president and the vice presidents on what computer to buy next. Included in the executive meeting was the IBM salesman who they played poker with across the street for 20 years who had had that account and Homer Barton [ph?] was part of the decision and the decision was do we buy another 650 or a 7070? All right and I understood more about how that— I never regretted the 25 percent of my price that the marketing division took. I never begrudged them that because of what they did.

Booch: Yeah. These were heady times.

Brooks: In terms of real support, I mean this system engineer for St. Paul I'm sure was getting paid more than St. Paul paid any of their people. She had a higher degree of competence and she was an integral part of St. Paul's team. She was an integral part of IBM's team. She was feedback to us as to what the customer needed, a strong advocate for the customer, and this was true of system engineers all over the company. It was a very strong, very strong, two-way street.

Booch: Did you have a sense when this was happening of the amazing role you had played or were you just so happy working with the technology?

Brooks: I was happy. I was happy.

Booch: Good. And from peers in the Seven Dwarfs by now their lights must have been burned out by being on so late. Were you getting calls from them saying, "Fred, I want to work for you?"

Brooks: No, because by the time all this was happening I was on the way out.

Booch: True, yeah. You were made Fellow when in this timeframe? I'm trying to remember the history there.

Brooks: I never was made an IBM fellow.

Booch: You were never made an IBM fellow?

Brooks: No.

Booch: What a travesty!

Brooks: I was a line manager.

Booch: My goodness. Because the Fellow program had started in '60-something, if I'm not mistaken.

Brooks: Yeah, but typically they're mutually exclusive.

Booch: Right they are indeed.

Brooks: Yeah.

Booch: Interesting, so after the alpha work then, then that's finally when you moved on?

Brooks: Yeah.

Booch: So was it a difficult transition? Were you happy to move on?

Brooks: No. I was happy to move on and it was not a difficult transition. I love to teach and as I say the atmosphere and the support at Chapel Hill in terms of my colleagues could not have been better, so the head of the statistics department gave me one of his graduate assistants and he was funded and I didn't have any money to fund a graduate assistant, so he funded one out of his budget. It was that kind of attitude everywhere. The problems are different. In the management job, you have 13 people lined up outside the door with insolvable problems. In the teaching job, you had the inexorableness of tomorrow's lecture coming ready or not; so there are pressures in both cases but they're quite different kinds of pressures. In the last year of the 360 program, both the hardware and the software, I was on tranquilizers but I had a working pattern that worked. My boss was in the habit of calling six o'clock meetings.

Booch: Six AM?

Brooks: No, 6:00 p.m. and I finally went to him and I said, "I'm not going to do this. I'm going to go home and have supper and put the boys to bed and I'll come back and meet with you from 8:00 to midnight but I'm not going to come to a six o'clock meeting." So he was kind of shocked at this frontal assault but I did that. And then I'd come back and do the paperwork because there was a lot of correspondence in those days, a lot of little yellow slips and route this and handle that.

Booch: No email back then.

Brooks: No email. I'd do the paperwork and then about midnight I'd go down to the machine room when they were doing the shift change. Well, when they're doing the shift change they were working four shifts and debugging the machines, the status is known, okay and they'll tell you and the bosses aren't there, all the intermediate bosses, and so what they tell you is the truth. Okay, well this isn't working and this is

and so forth, so I'd get a real good picture of how things were coming in the machine room every night before I went to bed.

Booch: Those were long days.

Brooks: They were long days, long days.

Booch: So as you moved to Chapel Hill then, what did you love teaching the most? What was your favorite thing?

Brooks: The software engineering lab. I love teaching computer architecture and I still do that. I did the software engineering lab 22 years but I don't do that anymore.

Booch: And that was around that time that you truly began to start writing on computer architecture?

Brooks: Yeah, well I started writing on *The Mythical Man Month*. See Tom Watson asked me this question at lunch. He said, "You've managed the hardware program. You've managed the software program. What's the difference?"

Booch: In all sincerity he asked that.

Brooks: In all sincerity. I said, "Well I can't answer that one but I'll think about it." Well that's where *The Mythical Man Month* came from.

Booch: Wow.

Brooks: And so I went home and thought about it and thought about it and thought about it and five years later I had a book draft. Now, as I say in the book, managing software is more like managing hardware than most software people believe and it is less like managing hardware than most hardware managers believe. It has its own set.

Booch: Did you ever circle back with Tom and have that discussion on the answer to that question?

Brooks: No, I dedicated the book to him.

Booch: Tell him read this book.

Brooks: So it's dedicated to Tom and Bob.

Booch: Very good, marvelous. So what did it mean to teach software engineering back then, because here we're talking late '60s, early '70s. What did the software engineering course look like?

Brooks: I thought it was a problem as a project course and so there was one lecture a week. Then I divided them into teams of typically four, advertised around the campus for projects, had them build stuff, met with each team each week and I insisted that they choose a producer and a director separate for each project, so the producer is the boss responsible for the schedule and for resources. The director is responsible for technical content to get them into the habit of thinking that way on larger projects. I think that's— I copied the terms from the movie industry but I think it is the same as architecture manager.

Booch: Right. There's a delightful book by Jim Coplien, *Organizational Patterns of Agile Development*, in which he's studied the organizational structure of hyper-productive projects. He doesn't use those terms but in his analysis of many hyper-productive projects you see that same binary star relationship. So you were one for the first people really teaching software engineering then around that time?

Brooks: Yes.

Booch: Who were some of the other folks that orbited in the academic space that were even thinking about that topic?

Brooks: Oh, I think Corbató at MIT was because they had built the Multics system and faced many of the same problems. Barry wasn't in the academic field. He was still at TRW but he—

Booch: Barry Boehm.

Brooks: Barry Boehm, he was thinking hard about all those issues. Vic Vasili [ph?] has been thinking hard about all those issues. And Harlan Mills, then at IBM, was probably thinking as hard. I consider Harlan and Barry and Dave Parness to be the three giants in the field.

Booch: So tell me your interactions with those guys. Did you and Harlan ever cross paths?

Brooks: Oh, yes, oh yes. Harlan's one of my heroes, sweet man.

Booch: I met him a couple of times. He's a gentle, gentle man.

Brooks: Yes, a godly man.

Booch: And Dave Parness.

Brooks: And Dave Parness, well I hired Dave.

Booch: I didn't know that.

Brooks: He was on our faculty. That's an adventure and David and I jointly taught the software engineering course lab. That's an adventure.

Booch: Where was this relative to his A7 work, before, after, during?

Brooks: During I think. I think he had started it and then he hired Paul Clement [ph?] who was one of our graduates whom he picked up in our program to continue on with that work.

Booch: Dave's not far from you. He's at the University of Limerick now.

Brooks: No, he's being forced to retire and he's moving back to Canada.

Booch: Really? I didn't know that.

Brooks: Because he hit age 65 or whatever the mandatory retirement age is.

Booch: What a travesty. I thought he was just getting going there doing good stuff. Oh, well that's another story. And then Barry Boehm what were your interactions with him?

Brooks: Oh, I'm an admirer of Barry's. I didn't know Barry until this book came out. Oh, mercy that's the kind of book that you don't expect to see a successor to. That's a 25-year book.

Booch: Yeah, that's amazing.

Brooks: And since then I've gotten to know Barry well and Barry is a person I like very much.

Booch: Wonderful, wonderful. So, back to Chapel Hill then. The program started from nothing and grew to where it is. I mean how many folks did you have on your staff teaching, how many professors?

Brooks: We have about 40 faculty. That includes some research faculty, grant funded. We have about 160 to 170 graduate students. We have a smaller undergraduate program. We started as a graduate only program and since we always saw ourselves as a middle-sized department, not a big one, we chose to specialize in our research areas.

Booch: And then so let's jump ahead to the '70s, the microprocessor hit.

Brooks: The micro world.

Booch: How did that hit your department? Did you see it coming?

Brooks: No, but I saw it when it got there. I saw what it— that it was what I absolutely had to know, so I put up my own money and went to a short course held in Florida, taught by the fellow at Livermore who was the microprocessor provider for all those instrument people and it was a hands-on course. We programmed microprocessors and interfaced them with stuff.

Booch: What year was this?

Brooks: It was a weekend. I don't know.

Booch: Mid-‘70s sometime?

Brooks: It was quite early on.

Booch: Okay, okay.

Brooks: And out of that—

Booch: It was like the 4004 or the 8080?

Brooks: It was the Motorola, the 6500.

Booch: 6500, oh yes, yes, yes, got it.

Brooks: No, wait a minute that’s not right, the 6800.

Booch: Oh, the 6800.

Brooks: The 6502 is the knockoff of the 6800.

Booch: That’s the one the 6800 right.

Brooks: And I was immediately impressed and so as a matter of fact I wrote a paper that I gave at IFIPS about what micro meant and how it related to all the other computers, and that paper was incorporated in the architecture book as the introduction to Chapter 16. And the thing is that conceptually it’s more like the spaceborne computers than it is like the other computers because it was so restricted in memory and weight and so forth and it was designed originally for control purposes rather than computational purposes. And so it is kind of a nephew to the classical computer but a direct descendant of the spaceborne control computers. I do not know of anyone in the field that would have at that time anticipated that the production of any kind of computer would vastly exceed 100 million a year.

Booch: In fact, during that timeframe you made a statement when we were talking earlier you had also seen the rise in minicomputers which fundamentally changed the business as well.

Brooks: Yes.

Booch: You used a great phrase in terms of from the—

Brooks: Sociology.

Booch: Exactly so describe that to me again.

Brooks: All right. The minicomputer was made possible by diode transistor technology but it was made important by Ken Olson realizing, and Gordon Bell, that there was a market for an instrumentation computer and the register, the RTL I believe it was called logic that meant that you could easily interface your instrument to this computer [which] meant that it opened up all kinds of laboratory applications. It was a descendant of the MIT LINC as a matter of fact. But the sociological thing it meant for both business and for universities was that you could have a computer that you controlled in your department instead of a glass house at the center that a high priest had controlled and you stuck stuff through the slot and got stuff back. And the sociology of this is very important. At the university scene, it meant that all the central campus controls on the purchases of computers didn't apply because you bought a chromatograph and it just happened to have a DEC PDP-8 as part of it. Well once you had the PDP-8 you're off and going.

Booch: The cost thresholds were different too.

Brooks: The cost thresholds were 50K instead of 500K. And so the minicomputer revolution was tremendously important.

Booch: And a similar sociological impact was the microcomputer.

Brooks: And then the same thing happened with the micro. Now you can have a computer on your desk that you control instead of the department controlling, so I consider those sociological forces. The technology enabled it. The sociology drove it.

Booch: Right and the next one I believe you mentioned is the technology of the embedded computer and what's the sociological implication there as well, having machines embedded all over the place?

Brooks: I don't know.

Booch: Good answer.

Brooks: I think it's kind of like how many electric motors are in your house.

Booch: True. What was the first minicomputer Chapel Hill got? Was it a PDP?

Brooks: The first one we got in our department was a PDP-11. Well, no, we got a— I don't even remember the name of it.

Booch: But it was a DEC machine.

Brooks: No. The PDP-11 was a DEC machine and it was for general purpose applications.

Booch: You mentioned Gordon Bell. Where did you and Gordon first connect?

Brooks: It's hard to say. I was very impressed with his book, his computer architecture book, and did a review of it. I was invited to Carnegie Mellon and gave essentially an oral review of it there and I think that's when we first started having serious conversations.

Booch: When did you begin to start teaching courses on microcomputers at Chapel Hill?

Brooks: Oh, right away.

Booch: Were you one of the first ones to do so?

Brooks: Well, if you teach computer architecture when the micro comes along you start teaching the micros.

Booch: Any memorable students from that era that you mentored that have gone on to do some great things or too many to mention?

Brooks: Too many to mention. John Crawford went on to Intel and became the chief architect of the 386 and 486.

Booch: John Crawford.

Brooks: John Crawford and Dick Sites, who did the Alpha [microprocessor] at DEC, was a student and friend and still is.

Booch: So we're moving from the '70s to the '80s, this little company nobody thought about much, Microsoft was starting to pop up. Were you involved in I think you mentioned some stories about the whole IBM decision of the operating system going on to Microsoft and the like and what a really bad decision that was.

Brooks: That was a really bad decision.

Booch: Do you think they could have known a-priori, or was it?

Brooks: Yes. As I say, the technical advisory committee, the pressure from Opel to get something out to compete with the Apple II was very great and the lab that Don was running was a closed lab, stay home, leave us to do our business kind of thing. A technical committee got there kind of late on the scene and the decisions had been made. They were very bad decisions.

Booch: You mentioned the Apple II. That was your first personal computer, your first PC?

Brooks: Yes.

Booch: What did you do with the Apple II? What did you use it for?

Brooks: Just messing around.

W1: He didn't use it.

Brooks: But she did.

W1: I played on it.

Booch: The boys program on it.

W1: The Apple II Plus.

Booch: But then you have the story jumping ahead a little bit where you got your first Macintosh. Tell us how you got your first Mac.

Brooks: Well, after having a good, happy experience with the Apple II, I had bought an Apple III. The Apple III was not a marketing success and the field of maintenance support for it was weak and I couldn't get it to run regularly and reliably. But Jobs, Wozniack and I were at the White House in 1985 for the first National Medals of Technology and they had us in the back room before the ceremonies.

Booch: Who was president back then?

Brooks: Reagan.

Booch: Reagan, okay.

Brooks: Oh, very impressive. And so we got to chatting and I said to Steve I was having trouble getting my Apple III fixed could he help? He said, "I'll tell you what I'll do." He was so proud of the Macintosh. It was brand new. It had been out about a month. And he said, "You send me your Apple III and I'll send you a Macintosh." So we did and that sold me on the Macintosh. It was right. It was right in so many ways.

Booch: And you've been a Mac user ever since.

Brooks: I've been a Mac user ever since.

Booch: Your current machine is a?

Brooks: Is a Mac laptop.

Booch: The Intel version or the PC?

Brooks: No, I'm not up to the Intel version yet.

Booch: Okay, very good.

Brooks: My eldest son is because he's a full-time computer consultant. He moved on. I'm merely a user.

Booch: So here we are now in the '80s and this madness called the web began. I had my first email address in '79 when it was the Arpanet and I remember reading, having a little book with everybody's email address in the world. When did you get your first email address?

Brooks: I don't know. It was quite early. Steve Bellovin was one of our students and he's now a professor at Columbia and his dwell time at Carolina was quite long in graduate school because he did all kinds of other things including originating Net News. He took a year off to teach on our faculty. So he got us on email quite early.

END OF TAPE 3

START OF TAPE 4

{The transcripts reflect all the audio available on the video tapes. Unfortunately, the beginning of tape 4 is not seamless with the end of tape 3.}

Brooks: And so I asked Tom for an appointment to cash in my chips. And he was going to be in Poughkeepsie that night spending the night anyway, staying in the homestead and so he let me have his evening. And so I went to him and laid out the case for the Research Triangle as a place to consider for one of these two lab plant sites. And I said then if you do that instead of outfitting it with its own computer you can rent time on the Triangle one, and enable us to get The triangle one off the ground. That's what near then happens. They rented three years worth of shift for $900K and that in fact enabled us to get the thing going. And he listened patiently and he said "Well," he said "Fred," said, "we're not in the habit of locating laboratories for the convenience of one person." <laughs> But he said "I'm going skiing with Whiz Miller [ph?] this weekend, head of the real estate division and I'll bring it to his attention." And so Whiz and his team came down and looked at it and the people at the Research Triangle found the foundation did a superb job of making it clear, the advantages at that site. And a year later we had an IBM plant and lab there.

Booch: Wow, and the rest is history. That's remarkable.

<crew talk>

Booch: So here we are in the '90s and the Web begins to hit. And how did that begin to change what you were teaching from a software prospective? Did you see it coming, when it was going to change?

Brooks: No my prophecy is not very good**.**

Booch: And nowadays you've been moving in the direction of virtual presence, virtual reality kinds of things.

Brooks: Well for many years one of the areas we picked for emphasis when we started the department was computer interactive three-dimensional computer graphics. And so I worked for 30 years with protein chemists so, and building tools to enable them to construct protein structures from crystallographic data. And then when the virtual reality concepts came along this is a natural extension of 3D interactive computer graphics. And we've been doing that for some years, looking mostly at serious applications as opposed to entertainment applications in training and things like that. And we got a good team of people now who are carrying on that work.

Booch: And some fascinating things you're doing. I remembering reading some of the research papers which others can take a peek at, just the notions of devices, glove devices, head devices and all that. So, where do you think that's going to head if you were to project another generation ahead? Do you think its all going to come together?

Brooks: To every day use in the home, no. The industrial use is important already and there are hundreds of big installations that are used for design review and tasks like that. And those are going to continue to be important. I think the projector-based technology is going to dominate the head mounted display technology. The things you can do with the little digital light projectors are just absolutely incredible, and work my colleague Henry Folks [ph?] is doing work, Wharton [ph?] people in Atay [ph?] how Zurich are doing just really nice

Booch: The work in digital paper even. Amazing stuff. So let me ask one general questions on the software _____ space, and go to some sort of ending up philosophical questions.

Brooks: Can we open the door?

Booch: Yes. It's getting kind of warm in here. How have you seen the nature of software engineering changing over the years, I mean, with the 360 work you sort of built those ideas from the ground up.

Brooks: Well, we recognized that building big systems is building is different from building programs. And I think the distinction between a program, a programming system— a program and programming product and a programming system product is a fundamental distinction. And we got that far the— your work in object-oriented programming, has just changed the field and entirely for the better. Right.

Booch: I'm not sure entirely, but thank you.

Brooks: I think so, it- it of course incorporates Dave Parness's information hiding concepts in an elegant fashion in the concepts from Norway. There's still an awful lot we don't know about how to build complicated systems and keep them under control.

Booch: In fact you talk about in terms of the essential complexity of software systems. Are you still pretty convinced that essential complexity will never go away?

Brooks: Yeah, we will always undertake things at the edge of things we can do.

Booch: So there truly is no silver bullet.

Brooks: There truly is no silver bullet. But what I argue in *No Silver Bullet* is not that there is not but that there cannot be. Right.

Booch: Right**.** It's like proving that certain things are totally impossible although, you spoke on notions of Ada might give us some things, Ada never quite got there. But Ada certainly has influenced a whole generation of languages certainly ahead of its time.

Brooks: But then a whole list of contributions. What I said in *No Silver Bullet* is in 10 years there won't be any single one that will give us an order magnitude improvement. It isn't in the cards, well the 10 years have come and gone and another 10 years have come and gone. And don't know whether we had order of magnitude improvement or not.

Booch: So for the generations after us, it's still going to be hard.

Brooks: And still the best answer is buy, don't build. And unfortunately some many of the commercial off-the-shelf products do not lend themselves to aggregating with others. And the whole questions of who's got central control, means it's real hard to take an off-the-shelf database system and do anything other than build your application on it but melding it with another system is difficult today.

Booch: Do you think perhaps this is one of the reasons that service-oriented architectures are gaining some traction?

Brooks: I don't know. I haven't tried to follow software engineering for the last decade. I no longer even read the literature.

Booch: There is so much of it.

Brooks: Well, my whole intellectual life has been one throwing interest overboard. When I was a graduate student you could know it all. There were two annual conferences and there were two quarterly journals and you can know the whole of computer science. And I can get progressively more ignorant in my own field for the last 50 years.

Booch: So what are you focusing on these days? You're here on sabbatical in the UK, to finish up a book I understand.

Brooks: On the process of design.

Booch: So, in fact, this is a theme you mention earlier that you were really fascinated about I think as you called it the design of designs.

Brooks: That's the title of the book, yeah. I lifted that from a mechanical engineer at Cambridge here that I met many years ago Gordon Blake [ph?] wrote a little book called the *Design of Design* and it exactly describes what I want to talk about.

Booch: Very good. As you look back over your career where were you having the most fun?

Brooks: I have no complaints. It's all been fun.

Booch: That's a great answer. And to somebody who would be considering a career in the computer field, how would you advise them?

Brooks: Look at the intersection between the computer field and biology. The ablest young people today are often opting entirely [to] go totally into biology instead of computers. I think the intersection between the two— first place that may not be a bad choice, the biology field offers the same promise today that the computer field did to me in '53. The wonders that are going to happen there have just begun to be tapped. On the other hand, the key to much biology is information, where is the information hidden and how is it processed. And so for the information scientist and therefore the computer scientist the interaction with biology and biologist is the golden opportunity. And for any young person today I would say go there, go there. That's where the fun's going to be.

Booch: Very good. And the last question is you're a man of faith and unashamedly so and I admire that. We could go into a long history on that but you along the way have probably had to make some hard moral and ethical decisions in what have you done in the hiring and firing. How would you say has your faith shaped your career and the decisions you've made? Is that a question we could go into?

Brooks: Well, since the hardest decisions are about people you can't give very many concrete examples**,** unless you do as my great-grandmother said and don't tell name and tales both. <laughs> But yes, you try to seek the leading of the Lord as what to do. And He's been amazingly good, so the lines have fallen for me in certain places.

Booch: So even with your career and working on software and such you felt that was the path you should be taking. Wonderful.

Brooks: And I hope it's been useful.

Booch: I think history will prove that to be a, resounding yes, Fred. So the last question, are there any questions I should ask you?

Brooks: Afraid not.

Booch: Thank you so much. What an amazing interview this was.

Brooks: I'll ask the one you didn't ask, and that is how did I become a Christian?

Booch: Yes, please.

Brooks: And the answer is when I was about 30 years old, Jerry Blaauw invited Nancy and me, he and his wife to a group bible study in their home, a group from the Stretch team. And we started going and

we started facing the scriptures head on. And I had had bible at Duke. And I had a background but I had been educated away from belief. And coming on the scriptures Jerry insisted that we not use commentaries or secondary materials, just look at the scripture and see what it says, and what does it mean, and what does it mean for me. This is a pattern of bible study emphasized by Intervarsity Christian Fellowship. And over two years I came to see that the intellectual difficulties I was having as a scientist with Christianity were secondary, that the real question was am I willing to completely yield to the Lord Jesus. And, you know, you worry about the miracles, well if you believe in the resurrection all those other miracles are finger exercises. That's not hard for the Lord to do. If you don't believe in the resurrection there's no point in any of it. So the real question is do you really believe that Jesus was raised from the dead and that he was the Son of God? And after a period of more than two years, both I and Nancy got converted during that time.

Booch: She was part of those studies as well?

Brooks: Oh yes. These were couples. And many friends praying for me, and me praying for a clear indication one way or another. Then suddenly I was given the gift of faith. And it has never departed.

Booch: What church do you go to here in the UK, if I may ask?

Brooks: St. Lawrence down the road here, St. Lawrence of Eriswell, that's where we've been going. So, Anglicans.

Booch: What a great story. Thank you so much for sharing.

Brooks: Well I'm sorry. I have been in better shape.

Booch: But if I'm in as great shape as you are when I'm your age I'll be dancing.

Brooks: Well I hope you don't have the hiccups.

Booch: Thank you so much.

Brooks: You're welcome.

END OF TAPE 4

END OF INTERVIEW

