A.M. Turing Award Oral History Interview with Frederick ("Fred") Phillips Brooks Jr.

by Gary Bishop

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Bishop: It's March 12th, 2020, and we're in the home of Dr. Frederick Phillips Brooks, winner of the ACM Turing Award. Among other honors, he has received the National Medal of Technology from Ronald Reagan. He received that along with some fellow IBMers, Bob Evans and Erich Bloch, along with Steve Jobs and Steve Wozniak, and Lockheed for orbital satellites. We are interviewing Dr. Fred as part of the Turing Award interview series that ACM has sponsored.

Fred, tell us about your early life. Where were you born? Where'd you grow up?

Brooks: Well, my folks were living in Chapel Hill here when I was born. My daddy was teaching biochemistry in the medical school. And shortly after that, he decided to go to medical school himself. He had done a couple years while he was teaching. So he went to Michigan and studied medicine, and when he finished, because he had an MD–PhD, he had a lot of attractive drug company offers. But he decided that he was going to move back home and raise his children back in eastern North Carolina where his folks were.

So he took a compass and drew a 25-mile circle around Kinston where he had grown up, because, he said, "A doctor's just 'that boy' if he's in his home town." And he drew a 75-mile circle, because being driving distance to get to Kinston for weekends, and he picked the town of Greenville in that because it had East Carolina's Teachers College and had the strongest public system in that zone. So I grew up in Greenville, all the way through high school. Greenville was then a town of about 20,000 people, the county seat and farm town for the world's greatest tobacco county. It was a very happy place to grow up.

Bishop: What role did your parents play in your education?

Brooks: Well, first place, they thought a lot about it. Every year they would have the teachers for the three of us, three boys, to dinner, and we weren't there, and they got to meet the teachers. They also in one case where the teaching wasn't so good, they intervened and persuaded the superintendent to let us go to another one of the schools in town. They gave it a great deal of attention.

But the most important teacher I had in my life was my daddy. We ate together. We came home from school, he came home from work. We ate together three meals a day for 18 years. And he had a phenomenal knowledge and we asked

lots and lots of questions. I don't recall him being stumped by questions we asked about science, about world affairs, and about what was going on. So it was probably the most important single factor in my education.

Bishop: How about your teachers? What important teachers or experiences did you have in elementary school?

Brooks: Well, the most important one was the first-grade teacher, Miss Anne Redwine. I had a happy experience with her. When I was a fifth grader, I was riding to town with her and one of the other teachers, and she asked how things were going, and I was bragging about how I had done on the standardized test and had done better than anybody else and so forth in my class. And she said, "Frederick, you don't need to compare yourself to anyone else. Just do the best *you* can." That stuck with me all my life and I've never been competitive really since.

Bishop: Great. How about high school?

Brooks: Oh, I had a great high school experience. Mr. June Rose, the superintendent, had built what was staffed with first-class teachers, and really, in spite of the small town, it was one of the five top high schools in the state. We regularly competed with the best in sports and public speaking and Latin contests and play performances, etc. And I had really first-class teachers in high school. Our high school was grades 5 through 12… was 8 through 12, so students from all over town, from the three elementary schools came together for eighth grade.

Bishop: What were your non-academic activities, including summers?

Brooks: Well, most important thing in high school was public speaking. When I was in eighth grade, I had the nerve to try out for the four-person varsity debate team. And because this was 1944 and all the big boys had gone to war, they had taken early graduation and gone, so I got on the four-person debate team. We didn't win any debates that year, but it was the start of a very fine teaching experience by the history teacher, who wasn't paid anything else to be the speech coach, Mr. Robert Sterling. And he built the public speaking program in that five-person high school till a hundred different students were participating in the public speaking club. And we did all kinds of public speaking – debates, a weekly radio program, legislative assemblies, extemporaneous oratory, the whole bit. That was probably the single most formative thing of my high school education, was a lot of training in public speaking, chairing meetings, parliamentary procedure, the whole bit.

I also had a good physics teacher, and he encouraged us to do all kinds of ad hoc electrical things. And we formed a little electrical engineers' club of six of us who ran the movie projectors for teachers and did the stage lighting for drama and all that kind of thing. So those were my principal high… And I was in the

student government. I was treasurer my senior year and wrote them a new constitution and so forth.

Bishop: How about summers?

Brooks: Well, as soon as I was 14 and could get a work permit, my daddy put me to work in his side business of making tobacco-curing equipment, especially tobacco flues. There I was working in a hot warehouse with… The crew consisted of two Afro-American men, and Mr. Frank Humphrey, the elder one of the two, was the skilled tinsmith. He taught us the trade and he made the flue elbows and the tees, the things that took a great deal of skill, and Jake and I made the straight joints. Then two years later, papa bought a side business in Stantonsburg, 30 miles away, and sent me every morning with a trailer load of rolled iron to be hammered into flue joints and sold to the local farmers. So on a typical day, I would hit 50,000 hammer licks on a steel rail, hammering rib seams and then rivets into the flues and repairing old flues and all of that.

Bishop: Wow. How'd you get interested in computers?

Brooks: Well, I had been interested in manual business data processing kind of in late grade school, early high school. So I made myself an imitation McBee Keysort system for my map collection. And lo and behold, when I was 13 I read in *Time Magazine* about this Harvard IBM Mark I computer, which Howard Aiken had been the architect of and IBM had been the designer of. As far as the world knew, it was the first programmable computer to actually run. We didn't know about Konrad Zuse's machine behind Hitler's iron curtain that had run a couple years earlier. And this really impressed me. *[0:10:00]* This was a… The drawing of it was an Artzybasheff monster with… The machine itself was 60 feet long, 8 feet high, a couple of feet deep, with rotating counters for storage and electrical clutching, and programmed with a punched paper tape. It operated at three operations a second, but it ran from… the time I went to graduate school in '53, it was still being used by the Air Force because it had 24 decimal digits of precision. For things like some Earth orbital calculations, that precision was needed.

Bishop: Tell us about your undergraduate years at Duke.

Brooks: Well, the Duke experience was also very fine. I've been blessed at every turn. I majored in physics and mathematics. I had one physics teacher at least every semester of my four years, and that was Harold Lewis. He started as an instructor when I started as a freshman, and he became provost after I was long gone. [chuckles] One of the most useful things, Dr. Nielsen, our department chair, wanted his best physics majors to go to Harvard. So when I was a senior, Harold was counselling with me on what I was going to do next. I said I wanted to go to Harvard, and he said he wanted me to go to Harvard. He encouraged me. And I said, "But I don't want to go in physics. I want to go study computers with

Aiken." And Harold said something that was prophetic. He said, "Fred, you're too young to get in on the ground floor, but you can catch the first landing." And that describes my career pretty well. I was a half-generation behind the pioneers, and so I got to know many of them, including Aiken and Wilkes and Grace Hopper, many others. Eckert and Mauchly. So I did catch the first landing.

Bishop: What other activities did you pursue at Duke?

Brooks: Well, we had an organization called the Freshman Advisory Council in which pairs of sophomores or juniors would go visit with freshmen in their dorm rooms and counsel them every week or every two weeks, and I was active in that from my sophomore year through my senior year and was president of it my senior year. And I was in the student government and become attorney-general my senior year. We did politics.

Of course I was… my parents were strong Christians and I was raised in the church, but I wasn't a real Christian at that point in time, but I was faithful going to a local church and the Sunday school. Matter of fact, part of my Duke education included a year-long course in Old and New Testament taught by a preacher who thought it was his mission to correct all our childish Sunday school understandings, and the general net was to destroy what faith I had had. Yeah.

Bishop: You were a house master as well, isn't that right?

Brooks: Yes. My roommate and I, Tom Sanders, became hall counsellors our junior year for our freshman dorm of 87 boys. So we… But about in October, the house master – and normally that job was a graduate student job, but he was faculty – became dean of freshmen and moved out of the live-in apartment. Rather than recruit a new house master, they asked us to take over as house master. So we moved down to this luxurious apartment with its own bathroom and bedroom and living room on the first floor, and took charge of counselling 87 freshmen boys who were meeting Duke standards of academics for the first time and many of them meeting alcohol for the first time. It was a learning experience for Tom and me.

Bishop: Who were your mentors or role models there?

Brooks: Well, I've talked about Harold Lewis. The other one was Joe Weatherby, who was professor of English and was the debate coach, and I was on the debate and did public speaking there all four years. So Joe was a very important teacher and influence there too.

Bishop: Did you have any internships?

Brooks: Yes. Starting my junior year, I had an internship with IBM in Endicott in their physics department as a physics major, and I did acoustics and vibration

studies. That was educational, getting to see how a company ran. And Jerry Brophy, Dr. Jerry Brophy, who was chairman of… who was manager of the physics department was an important mentor there, especially teaching me instrumentation, which I had not had a whole lot of in college. And Albert Irwin, another one of the physics majors and I went and bached together in this little town of Endicott and had a really great summer. New York in the summer, New York State in the summer is a very pleasant place to be.

The next year, I got an internship offer from Bell Labs in Manhattan, and the lady who was in charge of career placement said, "Well, there's another boy here who's going to Bell this summer, an engineer." Well, I was in the College of Arts and Sciences and I didn't know all the people in engineering in my class. She said, "Why don't y'all consider living together?" So I met Bill Wright and we bached together in Greenwich Village and explored Manhattan every which way all summer long, and had interesting work at Bell. I was in a local signaling group number 2 that was concerned with dial tones and busy signals. I was building a contraption that my boss had invented on paper and had patented to distinguish which of four parties on a four-party line was making the direct distance dial call. So this meant getting the phone modified suitably by the machinists and then building the system and then testing it against every which way of defrauding it, so…

Then the third summer, the first year after graduate school, Bill Wright and I, who did not room together in graduate school, each got jobs with North American Aviation in the Los Angeles vicinity. So they offered to… they were not used to having interns, so they accidentally offered to move our households to Los Angeles. We said, "We'll swap it for roundtrip rail fare," and two boys can drive an old Plymouth a long ways on roundtrip first-class rail fare. So we did 19,000 miles on that car that summer. We went to Los Angeles by way of North Carolina and Seattle, and we came back by way of San Antonio and New Orleans. *[laughs]* Bill being an electrical engineer, we hit every dam I think along the way to inspect it. *[laughs]*

And, the IBM summer, the most useful thing that happened was they closed the lab and factory for two weeks for everybody to take vacation. Well, what are going to do with interns? The answer is they put us in school and they taught us among other things how to program the forthcoming IBM 701 computer. Well, I fell in. That was it. It was before assembly programs. We programmed in octal absolute. And I continued the next summer… two summers later at North American. They had it. When I was at IBM, the 701 had not been delivered yet. It was coming in November, alright? At North American, they had a 701 and we were still programming in octal absolute. But I was doing missile data reduction, and that was very, very educational.

Bishop: Tell us a little bit about that computer.

Brooks: Well, it had a 12-microsecond memory cycle. It had two thousand 36-bit words of memory. It was kind of the premier scientific computer available at the time. It did not have index registers or floating points, so we programmed in fixed-point. That meant that you were always shifting to make sure the divides would go. *[0:20:00]* And the machine was not physically where we were. Our laboratory was in Downey and the machine was over at the airport at Inglewood, so we sent cards over in a station wagon and we got memory dumps back when our bugs had… *[laughs]* our divide check would fail. So that whole debugging process was kind of one shot a day.

Bishop: Lots of desk checking.

Brooks: Lots of desk checking. But the other interesting thing is that summer I was assigned to a program manager for a radar system who had 10,000 drawings and he wanted to build a punch card database system for keeping track of the drawings, their update status. And he wanted a printout that in fact had goes into indent for the parts as well as the latest update status and all that. Well, doing that pure on punch card machines with no computer was an exercise, and I learned something very important. Every morning… I got the thing running in about two weeks, and then I would take the printout and he would look at it and he would change his mind about what he wanted. So I would go and redo all the plugboards and figure out how to accomplish what he wanted, and next morning I would take it to him and he would change his mind about what he wanted. This went on for two weeks. Every morning he would change his mind about what he wanted. And at first I got very disgusted with this. Why didn't he make his mind up? But then I came to realize that the most useful thing I was doing for him was, by building the prototypes, I was helping him decide what it was he really wanted. So I learned a whole lot about how to work with a client and what you're doing for the client from that man. I forget his name, yeah.

Brooks: And that last summer internship was at Marathon Oil Company in Findlay, Ohio, another little 20,000-person town but the world headquarters of one of the largest oil companies in the world. They were converting their punch card system to a computer, an IBM 650 computer. And their treasurer had come through Harvard recruiting full-time people, but I had been assigned to write a dissertation by Aiken on designing a custom computer for payroll calculations. So when he explained this project to me, I said, "This is a priceless opportunity to learn about payroll operations and their computation."

And it was. It was a 40-state payroll done centrally in Findlay, and that meant I encountered all the kinds of complications with taxes and incentive pay and all the different things that real payroll computing had to do. Now the 650 had 2,000 words of memory, 10 decimal digits each, and so there were challenges in getting the whole payroll on. And it did not have disk or tape. It was purely "punch card in, punch card out, printer out."

It was a great team to work with. They had put together a task force consisting of a fella who had been in charge of the punch card department and a fella who'd been in charge of the payroll department and a fella, a bright young accountant who was going to be the computer heir and was learning, and an old fella who had had about every job in the company. He had rousted pipes in the oil field, he had worked in the refinery, he had worked in a filling station, and was now at the headquarters, and he knew more about the Marathon Oil Company probably than the executives did.

Bishop: How did you decide on Aiken's Computation Laboratory at Harvard for graduate school?

Brooks: Oh, that was easy. When I finished high school, there were no places to study to computers. When I finished college, there were five places in the US and two in the UK, and Aiken seemed to me like the right person and Harvard like the right place. And that was an inspired choice. The Lord has led me in some wonderful ways at many turns, and the gift of studying under Aiken and with Ken Iverson at Harvard was one of those real blessings.

Bishop: What was entering Harvard like?

Brooks: Well, it was like jumping into an unexpectedly cold swimming pool. In my complex variables class first semester, 25% of all the National Science Foundation Fellows in these scientific fields, physics, math, applied math, engineering, were in that room. And they were a lot better prepared than I was because I had not done a lot of advanced physics and math. I had spent my Duke years getting a liberal education. And I made B-minuses that year, and C's were failing, and I failed one course first year. So that was very strenuous, yeah.

Bishop: Tell us about the state of computing in 1953.

Brooks: Well, the 701, *[laughs]* which I'd used the summer of '54, was kind of state-of-the-art. There were, umm… [pause 9 secs] Let's see if I've got my years right. Yes, I've got my years right, because Wilkes had made the first running stored-program computer in Cambridge in '48… '49. IBM had essentially copied that design. And in school, we had a computer systems semester in which we went through in detail the circuits of the UNIVAC 1, which was a serial decimal character-oriented machine, and a classical parallel binary computer built not by Honeywell but by a predecessor of Honeywell. And we went through both of… we had a great teacher who took us through the circuit diagrams. *[laughs]* So we had learned a whole lot about what you could and couldn't do with computers, to make computers with the technologies available.

Bishop: Tell us about your mentors at Harvard.

Brooks: Well, besides Aiken and…

Bishop: You want tell us a little bit about him and working with him?

Brooks: Well, Aiken had come up with the concept of the Mark I when he was I think an assistant professor of electrical engineering. He had founded his own lab, had gotten funding for it, had built a succession of four computers – the Mark II was a relay machine, the Mark III was a magnetic drum machine, and the Mark IV was a vacuum-tube machine with magnetic drum storage. That had been put into operation the year before I got there. So that was the running machine in the machine room along with the Mark I, facing each other.

Aiken had a very strong personality. I would say he was a domineering character. All during the years when the Navy was operating the lab during the war, he was the commander, and then thereafter all the rest of us called him "the boss." He was "the boss," and there was no question as to who was the boss. He was a superb thesis advisor. He aimed us each at a problem, but then he turned us loose on how to go at it, and he came… if he was in Cambridge, he came to my office every day and wanted to see fresh prose. This was true of Peter Calingaert and Bill Wright and the other graduate students. And this meant that *[0:30:00]* I finished in three years, because there always was fresh prose every day. *[laughs]*

After the summer, the spring of my first year there, Aiken had as a new instructor, not even an assistant professor, one of his PhD students who was finishing that term, Ken Iverson. He had three that year, and he told Ken, "I want you to teach a course in business data processing." As far as we know, there was not a course in the world in business data processing. All the computers were built for science and were used for science. But Aiken thought they would be more important for business than for science, so he was foresightful in that direction. Well, Ken had done his dissertation on solving input/output system, helping use computers to solve what economists call input/output systems, matrices with thousands of columns and hundreds of rows. And he was a mathematician by background. Never went to high school, *[laughs]* but had gotten his master's and his PhD.

And soon as I heard that, I ran over to him. Aiken had coffee for the whole team in the machine room every day at five if he was in Cambridge, and we all chatted for a half hour or so, and then he would go to supper, we'd go our several ways. This was happening one of those afternoons. I ran over to Ken and said, "Can I be your teaching assistant?" He didn't know what else to say, so he said yes. So for two years, we shared an office and we put together this first course in business data processing. Since I had punch-card experience and training, I taught that part of the course. He had worked on algorithms and a way of representing algorithms mathematically, which got more and more complicated as it went but was very powerful.

Aiken taught me a lot, but Iverson maybe taught me more, including how to write. Every time I have a draft, Iverson would tear it apart and really did more for my writing. We were allowed to dictate our dissertations, and I started out doing that, and I realized it came out a lot more words than it needed and it took more time to edit than to write it. So then I moved to a typewriter, and I still found I could type faster than I can think. So I moved to a dip pen, and that was geared to my slow rate of thinking. *[laughs]*

Bishop: How did you come to write *Automatic Data Processing* with Iverson?

Brooks: Well, as a result of the two years we… Of course the next year we redid the course. You always need a second year from which you learn the first year. Then we said, "Well, we ought to write a book," and so we set out to write a book. When we sent it off to the publishers to review, their reviewers came back and said, "This needs to be two books." So we split it into two books. The mathematical language that had been refined by this time and tested pretty thoroughly was described in Ken's book *APL*, and then the joint book, *Automatic Data Processing*, covered everything else in the course – manual data processing, punch-card data processing, algorithms, sorting, machine language, programming, all of that.

An interesting story is that Ken did not get tenure after five years at Harvard. Needless to say, he went to see the dean and ask him why he didn't get tenure, and the dean said, "Well, you haven't published anything except one little book." Ken later got the Turing Award for that one little book and nothing really more. *[laughs]*

I think I may be the only person who's shared offices with two different Turing Award winners, because at IBM I shared an office with John Cocke for a year. And John was an immensely inventive person who did instruction pipelining with Harwood Kolsky and global optimization compilers with Fran… escapes me at the moment, and reduced instruction set computing and a few other inventions. And John was a North Carolina boy and had joined the company the same day I did in 1956, so we got along real well.

Bishop: Before we go along to IBM, how'd you meet your wife, Nancy Greenwood?

Brooks: Well, during orientation week at Harvard, all the first-year graduate students were on campus and all the others weren't, so they gathered us together. And during that process, I had surveyed the crowd and there were two really attractive-looking women in the entering class. Being a good churchman, when Sunday night came, I made my way over to the Wesley Foundation where the Methodist graduate students would be gathering. And lo and behold, here was one of those attractive women. So I moved towards her and we visited. Turns out, she had been born in the same hospital I had six months apart,

because her daddy was teaching at Duke but then the family had moved away in the war, and she had majored in physics and music at Rochester and Eastman School of Music. So we found a whole lot in common. Then next morning in a complex variables class of only 30 students, here she was. *[laughs]* And so that started a three-year courtship.

Bishop: Did she find the complex variables class easier than you?

Brooks: I think both of us found it difficult. *[laughs]*

Bishop: *[laughs]* What were your extracurricular activities at Harvard?

Brooks: Well, graduate students don't have much time for extracurricular activities. But I was on the Graduate Student Council and then president of the Graduate Student Council, which meant among other things I negotiated fellowship wages with McGeorge Bundy, who was a tough negotiator. *[laughs]*

But had one interesting opportunity for an evil practical joke, and that is one of our responsibilities was publishing the confidential guide to graduate student life at Harvard, the little red book. In it, among other things, we said that one of the local newspapers was rarely seen in the hands of graduate students compared to the other two. So I got an angry letter from the editor threatening to sue us, so I had to write him back. Well, the president of the Graduate Student Council had an office in a building with other student offices called Phillips Brooks House, named for the famous Episcopalian bishop Phillips Brooks, whom I wasn't named for. So I wrote the editor back and I explained that truth was a perfect defense against libel, and besides, we didn't have any money so we were judgment-proof. But I signed it, the only time in my life I've ever signed my name this way, "F. Phillips Brooks," and because it was on the letterhead, "Phillips Brooks House," etc. Well, he wrote back an angry letter saying my esteemed ancestor would be ashamed. *[laughs]*

Bishop: *[laughs]* How did you decide to work at IBM Poughkeepsie? Why not academia?

Brooks: Well, I didn't seriously consider academia at that time. I wanted to build things. I was a computer architect and I wanted to do computers. Moreover, an IBM project manager named Steve Dunwell came through Harvard recruiting and said, "I'm going to build the world's fastest computer." That sounded like fun, and so I went and interviewed there and at Sparry Rand and at some of the other companies, and that was clearly the most attractive of the options. Nancy interviewed there too and she was offered a job as a physicist working on the… Stretch was IBM's first transistorized computer, and so she was working on transistor circuits in the circuits department, and I was one of the three doctoral-level architects on the Stretch. *[0:40:00]* That was a very exciting project. In fact, we built nine of them, we sold them for $10 million apiece. The sales got cut off

at nine for complicated antitrust reasons, but the Justice Department claimed that we were selling them below cost at $10 million apiece. And it reigned as the world's fastest computer for the next two years until one of Seymour Cray's machines came along at Control Data.

Bishop: Did you know even then that you might become an academic sometime?

Brooks: Well, the summer, we had commencement Thursday, wedding Saturday, went to IBM after a two-week honeymoon, settled out in the country, living upstairs over a one-car garage. And I went out on the hills one summer day with a pad and I sat down and thought through what possible career ends might be feasible and reasonable. Being a newly married Methodist, I ruled out pope very quickly and I ruled out President of the US very quickly. And I came out the crack that there were four possibilities. One was… Two of them were in industry, two were academia. One was, in industry, an IBM Fellow – purely technical, not managerial. One would be IBM vice president. In academia, it was university president or university technical teaching, not managing. And given my gifts and graces, I thought, "Any of these are conceivable and they would all be fun. So the question now is how do you keep the options open?"

So Nancy and I discussed that and we came to the conclusion that, well, in the first place, moving from academia to industry is easy, moving from industry to academia is not easy; moving from technical to managerial is easy, moving from managerial to technical is not easy. But just for the chasm between industry and academia, we concluded there were two things we would have to do to keep that option open. One was I would need to maintain a publication program, which the company allowed but didn't encourage or give you any time off for. And we had the book – Iverson and I had our books on the way – and I had done some papers in graduate school, so that was straightforward. And we would need to live on an academic salary. That was essentially two-to-one between industry salaries then and now. So we lived on Nancy's salary and banked mine for the nine years we were at IBM. Even after she quit work to do child raising, we lived at that level. So when the UNC offer came years later, it was almost exactly half of my IBM salary, but that was not a factor in the decision because the discipline had bought freedom to not think about the money in saying what to do.

Bishop: Yes. What was your first job at IBM?

Brooks: One of the Stretch architects. Yeah. Werner Buchholz was the chief architect. Steve Dunwell was the project manager. And there was a product planning group from the marketing side, including John Cocke and Harwood Kolsky, who were highly technical, and then there were those of us who were the so-called system planners or architects.

Bishop: Isn't that where you met Gerry Blaauw?

Brooks: Yes. After I had been there about a year, this young Dutchman joined the team. Had gotten his PhD under Aiken the year before I got there and then, since he was a Fulbright Scholar, had to go home for a couple of years. And Gerry turned out to be, as indeed did Werner Buchholz, a first-class, a world-class computer architect whom I came to respect very quickly.

And Gerry was really the most important mentor and friend in my life, became… One day Gerry and I were talking about our weekends, and he and Paula had been up to a Shaker settlement in upstate New York, kind of a museum sort of thing. And I said, "That's a fundamentalist sect, isn't it?" and he said, "I'm a fundamentalist-…" He explained what the Shakers were, and then he said, "You know, so now I'm a fundamentalist." Well, that's not true. Gerry was an evangelical but not a fundamentalist. But that shocked me. I thought, "You've got good sense. How could you be a fundamentalist?" I mean he had a really good sense.

A couple of weeks later, Gerry and Paula invited us and some of the other young couples working in the group, "Would you like to come to our house for a Bible study?" Well, as Nancy said, we would have gone if it had been a Shakespeare study. It was something to do together. It would be fun. So for the next several years, we had a weekly Bible study taught by the inductive Bible study method where you study the text without commentaries or anything else, just seeing what it says, what it means, and what it means for me. And I came to realize, as did Nancy, that we were not Christians, that we were not believers and followers of Christ even though we were faithful churchmen. So that was really a challenge to us.

At the end of the Stretch project, I went to the research division. We moved to Mount Kisco, and during our year in Mount Kisco, Nancy became a Christian. And after we moved back to Poughkeepsie, through the prayers of many people in the Bible study and me and a lot of reading and studying and thinking of the evidence, I became a Christian.

The problem for me with my scientific education and my Duke theological putdown was the miracles. I just wasn't sure I believed the miracles. I came to the logical conclusion that if you can believe the resurrection of Christ, all the other miracles are finger exercises, and if you don't believe the resurrection of Christ, as Saint Paul says, forget the whole thing, it's not worth a hoot. So now the question is, is the resurrection true? So I studied the evidence carefully, of which the most powerful is the changed lives of the apostles I think, but all the other evidence, and came to the conclusion, gift of the Holy Spirit, totally unexpected one day, I knew the resurrection was true and I have never doubted that since, that Jesus Christ was raised from the dead, yeah.

Bishop: Now back to IBM activities, wasn't the Stretch computer augmented with some kind of cryptanalysis engine?

Brooks: Yes. Most of the machines went to Atomic Energy Commissions or Weather Bureaus, but one, number 2, went to the National Security Agency, and for them we built a cryptanalytic, what today you would call a plugin card. Stretch was 15 feet long, 5 feet high, 5 feet deep. Since it was a transistorized machine, it was smaller than a vacuum-tube machine. And the Harvest plugin card added another 20 feet *[laughs]* and about two-thirds more transistors than the Stretch proper.

It was a fascinating machine. It was a data streamer. You can think of it as two belts bringing bytes in, going through an arithmetic unit or a powerful table lookup unit, and then one data, one thing coming out and then small boys putting things onto the belts and the two going in and taking them off and stashing them back in memory and coming out at four million bytes a second. And it ran for 16 years as a matter of fact in the basement at Fort Meade.

Bishop: Now why were you involved with that?

Brooks: Well, there was a group of Harvest architects and then a group of Stretch architects, but I was the go-between because neither Gerry Blaauw nor Werner Buchholz were clearable for CRYPTO clearance. So I was one of the Harvest architects. I'm doing things like the automatic fix-ups instead of taking interruptions and programming fix-ups for missing characters and things like that. And the Harvest is described in a chapter in Buchholz's *Planning a Computer System [0:50:00]* that described the whole Stretch project. That's the best description of the machine, a really interesting machine.

Bishop: After Stretch was developed, what then?

Brooks: Well, after it was released into the factory, I went to the research division. Stretch had started in the research division, moved to the product development division, and so I thought, "I'll go back to research," which in the meantime had moved to Westchester County. So we moved to Mount Kisco, and it was during that stay that Nancy became a Christian then.

And so I was working on a book in between all other activities, but I had very special assignments. NSA wanted IBM engineers to be exposed to their problems, and so those of us who were cleared were kind of sent to NSA. I was sent for six weeks to work within their research division on just learning cryptanalysis techniques and working on crypto problems. So we lived in a motel at Fort Meade, and for six weeks put the baby in the kitchen for night. *[laughs]* And since Nancy's people lived in Falls Church, Virginia, that was a convenient time.

Another assignment was the President's Science Advisor had asked for a study of the state of Russian computer technology, and the CIA had assigned a person to it who was an expert analyst but didn't know anything about computers. So they asked IBM to furnish a person to collaborate with him on working up this report for the President's Science Advisory Committee. So I went to Washington and it was operated out of the Executive Office Building of the White House. I stayed in a hotel there and we'd work on it three or four days at a stretch, and then two weeks later another three or four days at a stretch. Well, that was very interesting because he had access not only to all the travelers' reports and press release clippings and all that but also all the classified information that we had. So we worked up a report and we concluded that from the beginning Russian technology had been almost exactly seven years behind American technology in computing, and that was an interesting result.

But then it became my job to present that to the President's Science Advisory Committee. So, here's this young man about 30. The person on the committee… The committee was made of very distinguished scientists, but the person on the committee who asked the best questions was Ed Land, the head of Polaroid and the inventor of the Polaroid film and the Polaroid camera and polarized sunglasses and all that. But he had very penetrating questions about a technology that he didn't really know. I was very impressed.

The other exciting thing that happened was one day we were working in the Executive Office Building and the word came, "Come over to the White House lawn next door. The President" – it's Eisenhower – "is seeing Churchill off." And Churchill was making what we knew would be his last visit to the US, and it was very touching. The whole crowd of us gathered and watched and clapped while the President escorted Churchill into his limousine and all that. The interesting thing is Eisenhower stood at least a half a head taller than anyone else in the crowd, and I had not realized that. Churchill was in his eighties and was walking with difficulty and so forth. It was a very touching moment.

Bishop: Neat. Now those sound like interesting activities that you did there in research. Why did you go back to a product development group?

Brooks: Well, it was clear that the product lines of at least the upper machine division – there was a high end of the market and low end of the market, two divisions – were running out of gas and something had to be done. They were organized functionally at that point, so they put together a task force and asked me to chair it and we produced a report. Then they asked me to come back to that division and become manager of architecture. There was an engineering manager and an architecture manager and a commercial product planning sales coordination manager. So "Come and work on developing a totally new product line." That sounded like fun. So we did. So we moved back to Poughkeepsie, and it was after we moved back to Poughkeepsie that in fact I became a Christian.

We had underway… Gerry had been working on a machine which was principally a business machine. It had scientific capabilities, but not real strong. It was well along in the design and had many of the desirable features from Stretch included in it. And he had been in that division the whole time working on this. So we put together a product plan for a whole series – so a machine faster than that one with accelerated floating point and all that kind of thing, and one smaller than that would be cheap in the office and so forth – called the 8000 series. So his machine we rechristened the 8106 and we had a running engineering model of that and put together a whole product plan – cost estimates for all the machines, market forecasts for all the machines, schedules for all the machines, pricing for all the machines, performance measures for all the machines, the whole…

In January of ’61, we had invited the corporate brass, etc., to Poughkeepsie and did a one-day presentation of the whole thing. One of the problems is it was going to be somewhat cheaper because the memories had gotten cheaper and cheaper… These were core memories. They’d gotten cheaper and cheaper to make, and so the systems were going to be cheaper, and most of our machines were out on rent. Replacing them with cheaper machines is not a really good thing for your revenue, so the question is “How do we create new market that will generate enough revenue to more than make up for the technological improvement?” Our concept was by essentially teleprocessing, attaching terminals to machines. That included of course the banking terminals, the grocery store terminals, all the… That was the key new concept, was widespread telecommunications attachment and the software to support it.

So we did the presentation. It went very well. Everybody approved of the plan. All the pieces hung together well. We went through each of the phases. Except one fellow sitting in the back of the hall just looked unhappy all day. Well, it was Vin Learson, the executive vice president of the company. And that night, my boss got moved from Poughkeepsie to Colorado. *[laughs]* A new boss was brought in from the small machine division and he was told, “If this plan is right, make it happen, and if it’s wrong, change it.” That was Bob Evans, the greatest boss I ever had. And that started a six-month fight as to whether we were going to go with the 8000 series or not, because after two weeks of looking at it, he concluded that it was not the right thing to do. There was a new technology coming along – this is ’61 – that would be there by ’65, and what we ought to do is… he came up with a plan of build warm-overs of each of the existing product lines, one more model to hold the market until we could get to the new technology, but do a product plan for the new technology.

Well, I felt very strongly the competition was eating us and beginning to really eat us, and that was new. *[1:00:00]* We had done very well previously. And I felt like we had to do something now and we had a plan. So we fought. Now this is clean fighting. It was about what the policy should be. It wasn’t about personalities. And it got to the point that Bob was reporting to his grand boss who was in favor of his plan and I was reporting to my grand boss who was in favor of my plan. And one

day he called me on the phone in February and said, “Fred, I want you to know you got a raise.” I was startled and I said, “Well, thank you, Bob.” He said, “I want you to know I had nothing to do with it.” *[laughs]*

So we fought, it went to the corporate management committee in April, and my plan won. Bob didn’t quit. He went back to the corporate management committee a month later, and we were each recruiting allies all around the company, and his plan won. So he had a meeting to reorganize the Poughkeepsie lab because his plan said, “Kill all these 8000 machines. Build warm-overs of the scientific and commercial lines we had.” He had a retreat up at Saratoga Lake of all the engineering managers in the division to reorganize everything. So I went. I figured, “I’m going back to research, be done with this,” but I went to Saratoga to make sure my boys landed on their feet in the reorganization.

And Thursday of that week, Bob came and said, “I want you to take the new product line.” You could have knocked me over with a feather. This is the family jewels, not building warm-overs but be responsible for the new product line. I was amazed. I wasn’t sure I wanted to work for Bob, because we’d been… I mean it had been back and forth. So I went and talked to my boss, and he said, “I never knew anybody that regretted working for Bob Evans,” and that turned out to be really true. Bob was phenomenal to work for. He really cared for his people. He was never parochial. He always was concerned with what’s the best interest for the company. Not for my division, not for my group, not for my people, but for the company. And he was a really great leader.

So I signed on with him and I thought, “I’ll go with this a month or so and see how this goes.” Well, came budget time and the fella in charge of the warm-overs came in with his $15 million or so budget and Bob cut it to 11, and I came in with my $9 million or so budget and got every penny of it, and I decided, “This is going to work. He’s really…” I thought this was just sham. No, he’s really with the new product line.

Then in the meanwhile, Don Spaulding, an advisor to Learson, had decided what the company needed was a single product plan across both divisions instead of two product plans. So a task force was formed and we spent several weeks in a motel in Connecticut coming up with what is known as the SPREAD report, which essentially was the 360 project. As project manager, I was then given corporate responsibilities for all the computers. And there it was.

So we had machine… the first machine was being developed… well, the architecture was done in Poughkeepsie with representatives from the different divisions. The first machine was being developed England. John Fairclough was the manager of that one. Then there was one being developed in Endicott, then there were three being developed in Poughkeepsie, and then there were two follow-ons, one being developed in Germany and another one, a very high-end, top supercomputer in Poughkeepsie. So we had a seven-machine product plan.

Bishop: Now this idea of a single architecture was new, wasn't it?

Brooks: Well, and moreover, Bob asked us at one point in the SPREAD meeting, "Can you make them binary-compatible so the same software will run on all the models?" And Gene Amdahl – who was also on the task force – and I said, "That's hard. It's easy to make them upward-compatible. Making them downward-compatible, putting floating point on your littlest machine, putting character arithmetic on your supercomputer, alright, I mean those are not easy. But we'll try." So we went off and studied it, came back, and said, "Yeah, we'll do that." So they were made upward and downward binary compatible, which meant we could have one software plan.

Bishop: Now I seem to remember a controversy around the successor to the 1401 and the 3-…

Brooks: That was later. That was later.

Bishop: That was later, okay.

Brooks: The first big fight was 8000 versus new product line. The second big fight was in the 360 group, we originally came up with some machines that were based on… [pause 6 secs] Blank. Pushdown. Pushdown stacks.

Bishop: Stacks.

Brooks: Pushdown stacks.

Bishop: Yes, stack machine.

Brooks: And they worked great from the middle-priced ones on up, but they didn't work for the small ones because all the registers turned out to be in memory and you were doing memory fetches everywhere. So I called a design competition and said everybody in the 20-person architecture group in pairs or groups could turn in proposals, and the decision of the judge would be final, and they had three weeks to put together sketches. Meanwhile, a group including John Cocke and Elaine Boehm had come over from research and Gene had come over from research and were part of the architecture group. Turns out when the three weeks were up and I looked at the plan… meanwhile I had done a little sketch and stuck it in a desk drawer just to see, and Gene's plan, Gene's little group's plan and Gerry's little group's plan were clearly the strong ones compared to all the others, and they differed in only one important respect. Gene's was based on six-bit bytes and Gerry's was based on eight-bit bytes. So now the question became, which way do we go?

They had strong technical arguments each way, and it turns out when you think about it, I think the six-bit byte format… I mean it affects your instruction lengths, your number of index registers, your input/output system. Everything hinges on that decision. And the six-bit bytes are really… the formats and all are really better for scientific computing, and the eight-bit bytes ones are really better for commercial computing, and each one can be made to work for the other. So it came down to an executive decision, and I decided for the eight-bit byte, Gerry's proposal. Werner Buchholz had seen to it that Stretch had variable byte length from one to eight. *[laughs]* That was an extravagance that nobody wanted to repeat. But it was imposed on us essentially because of the NSA machine. Okay. Gene appealed this to Bob, and Bob upheld me, so then we went back to work doing eight-bit bytes.

So my most important technical decision in my IBM career was to go with the eight-bit byte for the 360. And on the basis of… I believed character processing was going to become important as opposed to decimal digits. So yes, we did put decimal arithmetic into 360s, but the character string, the variable-length character strings were much more important. And we wouldn't have word processing. In fact, we had a person who built a word processor on the six-bit 709 and 7090, and during one of the fall festivals where we heard all kinds of debates about what the architecture ought to be *[1:10:00]* from the engineering and marketing and all groups, he had a new manual for us on our table every morning with yesterday's decisions reflected in it, and that was a very impressive demonstration of what he could do.

Bishop: That was the second big fight I think.

Brooks: It was the… Yes. The third big fight was John Haanstra, who by that time was head of the small machines division, had personally been the project manager for the development of the IBM 1401 office computer. It was the first machine in the world to sell more than 10,000 copies. They sold 20,000. It was very profitable. And John was never convinced of the 360 plan, so subterranean, under the table, he had a group in California developing a 1401 successor. This was dead quiet until January before 360 announcement in April in which lo and behold, there's a meeting in White Plains and he fetches out his machine and said, "We don't need to do the Model 30 and the Model 40. We'll do the low-end with the 1401-S, and y'all do the rest." Well, it was clear who was going to get the integrated circuits as they came along. Uh-huh. This was the end of 360 essentially.

So we had a vigorous, vigorous all-day debate before the brass. But meanwhile, some Britishers and then we had… One of the decisions was to use microprogramming, and one of the IBM engineers in Poughkeepsie had shown that you could emulate an IBM 7090 on a 360 with microcode up through Model 60, which had microcode. Model 75 didn't have microcode. So we had put a little team together to see if you could emulate a 1401 on a Model 30, and Bill Wright

and Gerry Ottaway and… name escapes me from Endicott, had worked on it. And I flew to Poughkeepsie where they were working that night after the first of the debate meetings, and we worked through the night and did all the inner loops and the key operations – plus, minus, times, divide, branch, load, store…

Bishop: Set word mark.

Brooks: Set… Well, no, we didn't have wo-… Yeah, set wo-…

Bishop: Yeah, 1401. Yes. *[laughs]*

Brooks: 1401 had set word mark and all that for the variable-length arithmetic. And we had shown that we could make a machine… that a Model 30 would run four times faster than a 1401. Well, the 1401-S ran six times faster than a 1401. So I flew back to White Plains the next morning and presented these results, and the meeting adjourned after a few hours, and there was going to be another meeting the next day. When I went back the next day, Haanstra had sent his lieutenant instead of himself to represent his group and I knew that overnight we had won. But this was only three months before announcement. I mean talk about an up… "Whew." That was the biggest, that was far and away the most important fight.

Bishop: How did you manage your family life during those years?

Brooks: Well, at the very peak, the stress was very great. I'm not a… I'm generally a fairly tranquil person, but I was on tranquilizers and I was working 60 hours a week. But this was after Evans had gotten promoted and I had another boss, and he was in the habit of calling six o'clock afternoon meetings. Finally I went to him and I said, "Max, I'm not going to go to any six o'clock meetings. I'm going to go home and have supper with family and feed my two boys and sing to them and put them to bed, and I'll come back at eight o'clock and I'll meet with you till midnight. But I'm not…" Okay. Well, he didn't like it, but he didn't have much choice. So that was the key way of managing the family life. I had two little boys then, and, you know.

Bishop: Alright. Now somehow you end up moving from hardware to managing the software on the 360. Tell us about that.

Brooks: Well, an announcement was scheduled for '64. In the summer of '62, I had been approached by Carolina and had turned down the job of director of the computing center. In the summer of '63, they had invited me back to talk about starting a computer science department, and I had ended up accepting that but said, "I can't come till fall of '64 when the machines are out." So I went home and told Bob Evans, and Bob and I agreed to keep it secret, because a project manager who's a lame duck doesn't have much umph. So the idea was to keep it secret until announcement at least.

And amazingly enough, we did pretty well. At one conference I was asked, “I hear you’re going to Carolina,” from a UNIVAC person who had heard it from Carolina. Alright. I said, “Where’d you hear that?” *[laughs]* But inside the company it was not known. Okay.

In late ’62, the software had been split off from the rest of the project and put into that division’s software house. Somehow they were preoccupied with building a software for the warm-over machines which had early deliveries, so they hadn’t put the strongest team on it. And they hadn’t gotten the point of that we were going to a lot of trouble to build up/down binary compatibility, so they came in with four different software plans that were not mutually compatible but were fit for different memory sizes. This came in in December of ’63 before announcement in ’64, and we said, “That won’t do at all. We got to kill that.” So it was clear that something had to be done. It was politically impossible to put the software back in the project.

So I went to Bob and I said, “I’m here till September” – and the machines were released to the factory – “I’m not needed anymore on the hardware side. Let me go over and see if I can bail out the software side in the nine months remaining.” That seemed like a good idea to him, so that’s how that came about. And in February we put together a task force that put together a whole new software product plan that was compatible up and down, a single operating system and 16 different compilers for many different languages and different memory sizes, because we had three Fortrans for different memory sizes for example, because you do things totally different on a compiler if you’re wheeling everything in and out on a disk as opposed to doing it in memory. So…

Bishop: What’d you do in those years besides work and family?

Brooks: Well, Ken and I had gotten our book out… our books out. Nancy and I continued to be active in Gerry’s Bible study. We went to Gerry’s church down in Beacon, in Peekskill, where Gerry and I taught an adult Sunday school class after I was converted. *[1:20:00]* And we raised family. *[laughs]*

Bishop: Earlier you mentioned… you began to mention the transition to UNC. Let’s talk about that now. How did you come to UNC and academia as your next career?

Brooks: Well, the Lord works in strange ways, his…

Bishop: Wonders to perform.

Brooks: …wonders to perform. Turns out UNC didn’t have a computer program but they had a computing center that had been financed through the Census as an alternative to their Washington facility in case of nuclear accident. And they

had a computing center director who was able and who taught elementary programming in the math department, and he left to go to University of Pennsylvania. So they needed a new computing center director, so they went to UNIVAC, because they had a UNIVAC 1105, and said, “Help us find a computing center director.” UNIVAC didn’t want to lose one of their employees, so they went to an alumnus of theirs named George Cramer who was working for IBM. George was one of the Harvest architects, got his PhD in mathematics, and was my father-in-law’s roommate at the University of Missouri when they were in graduate school getting their PhDs. So George I knew well because we were working together on the same machine, but he had known Nancy before she was born. *[laughs]* And so George said, “I’m not interested in that job, but I know a young man who might be.” So he gave them my name and they called me and said, “Would you come interview for this computing center…?” This is 1962, yeah.

So we packed up the young’ns – by this time there was still just two boys – and came down to Carolina and interviewed. It was the first week in April and the dogwood and the flowering cherries were in bloom, and they had a babysitter sitting the boys on the grass out in front of The Carolina Inn. And for Nancy, it was coming home too. Meanwhile in Poughkeepsie, the lakes were still frozen over and the old slush for the snowplow has piled beside the road and blocking the driveway and all that. And oh, it made us want to come.

But the job was pretty dull, so regretfully we packed up and said, “No, thank you,” and went home. But if you do an interview for anything, they want you to give a talk in the university, so they asked me to give a lecture. The lecture I chose was “Ten Research Topics in Information Science.” The people who came to the lecture were the principal clients of the computing center – the chairman of physics, the chairman of statistics, the chairman of mathematics, the chairman of chemistry, etc. And Hugh Holman, who was a professor of Southern literature but was dean of the graduate school, was the person to whom the computing center reported. As a consequence of the lecture, Hugh appointed a task force to decide whether there should be a department of computing science. They spent the usual academic year that committees do and came up with a report saying that there should be. Nancy and I had gone home regretfully and forgotten the whole business, and in the summer a year later they called and said, “Would you be interested in coming and talking about starting a department of computer science?”

Well, Holman, even though his field was English, was Southern literature, was a broadminded man and he had in fact had some scientific background. So this was his push, and the committee came in and said yes. And so we came down and interviewed again, and now that was a more interesting proposition. There was not a freestanding department of computer science in the country. It was being taught. When I went to graduate school, it was being taught in five places, but in some places it was being taught in EE departments and in some places it

was being taught in math departments. But the problem with being taught in these other departments is your faculty is judged by those standards, those disciplinary standards and not by computing science standards.

So we negotiated and they ended up making an offer which I accepted on the conditions that I couldn't come till the fall of '64 when the machines were out, when the machines were announced then. As I said earlier, so Bob Evans and I agreed we would keep this secret, and came back to Poughkeepsie and went to work in the software piece.

Well, it turned out that the soft-… the operating system… the compilers were coming along great, and that was half the work, was the 16 compilers, but the operating system was in deep trouble. So in June, Tom Watson Jr. asked me down for a one-on-one lunch in the executive dining room. Well, you know what that is. That's an arm-twisting session. So he tried to persuade me that I didn't want to go to Carolina at all, and he said, "We don't make promises, but it looks like you might have a good career at IBM." It was a very interesting conversation. He asked, "Why do you want to go to Carolina?" and I said, "I like to build things. I like to make things." And he said something unforgettable. He said, "I do too. Have you looked at Poughkeepsie recently?" And suddenly I realized this 10,000-person plant and laboratory enterprise was his personal creation against the wishes of his father, who was CEO. But I never would have thought of "making something," "Have you looked at Poughkeepsie recently?"

Then he said, "Well, if I can't persuade you, let me ask you if you will stay another year working on the software package. And if you will, we'll do the following. You'd be at Carolina one week a month organizing your department. We'll send a person at our expense to teach your courses. And when Carolina needs a computer, we'll help." So that's what we said. Okay. Well, it was in trouble and I thought I could help another year, and by another year we would be through alpha test. So said yes. So that's what we did for the transition year. And the person they chose to come and teach the courses was George Cramer, the computer architect and my father-in-law's roommate, *[laughs]* who had wanted to retire to North Carolina anyway and this was his last assignment before retirement. And he rented the house we had bought in anticipation of our… this house in anticipation of our move in '64, and I rented a room from him for the week of the month I was here, and we came and got the department started.

Bishop: Did you find an academic welcome at UNC?

Brooks: Yes. Very much so. The committee that had decided we ought to do this had mostly been associate professors, but their department chairs clearly thought this was something that ought to be done. So they were very welcoming. The statistics department said, "We'll fund you a graduate student." Another department said, "We'll pay for your copier." I mean it was "Yeah, we want y'all to come and succeed."

The first week I was on the one-week thing, I went to Hugh Holman and I said, "We need two things – some letterhead and a department secretary." He said, "You don't need a department secretary while you're getting started." I said, "We need a department secretary." *[1:30:00]* So he said, "Nah." Well, before the week was over, he called me. He called me Thursday night, said, "I've got a person for you to interview for department secretary." So this turned out to be a young woman who was a Carolina graduate, had been editor of the annual *The Chanticleer* when she was an undergraduate. She was working at Duke and was in a situation where she… And she had worked in the chancellor's office here and she had gone to work at Duke, and was in a situation where she was looking for a job. So I interview her. Her name was Lib Moore. And I looked at her résumé. She had never held a job more than two years at a time, but I thought, "Okay. Well, this may not work out long-term, but we'll see."

So Lib came and became the mother of the department, really a major force the weeks I was here and the weeks I was not here. She made every student feel important, every faculty member feel important, established good relations with the other departments' secretaries, was really a major force, enough so that when we built the new building, one of the classrooms is the "Lib Moore Jones Classroom." Another one is the "Hugh Holman Classroom." So one of our named classrooms is for a professor of Southern literature and another one is for a secretary.

Bishop: How did such a small faculty teach all the classes?

Brooks: Well, we couldn't. We couldn't cover all the subjects you needed to have a full curriculum. But we early on said that the only way a relatively small department is going to be able to do anything significant is in collaboration, and one of the strengths of the Triangle is we have Duke and NC State all within easy distance of each other, 12 miles to Duke. So we established a three-way collaboration, and immediately with Duke we put a microwave link between the Duke Chapel and the Bell Tower at Carolina and I started establishing video classes between the two. And we had some students who commuted. So in my computer architecture class, about half of them were Duke students.

Then we established, the three of us got some money from various businesses and established North Carolina Educational Computing Service, and we established a joint computing center, the Triangle Universities Computation Center, which the three universities owned equally. Then we offered… The Educational Computing Center decided our job was to evangelize computing in North Carolina education, so we offered any school that wanted to a hundred jobs a month, a teletype connection, and we had two circuit riders who went around teaching teachers how to teach programming and how to use all the equipment and all that. And at one point we had 72 institutions in the state using the Triangle Universities Computation Center. And they could use more than a

hundred jobs a month, but they got those free, paid for by the… This was a separate organization, but one that was closely allied to the Triangle Center and using their facilities.

Bishop: Alright. How'd you manage the administrative burden of running a department?

Brooks: Well, the first full year I was here, so starting in '65, I was teaching a lot of subjects but could manage, started a research program but could manage the administration.

About five years later, about 1970, Washington was making more and more rules and Raleigh was making more and more rules and the paperwork was getting heavier. And we had Aiken down for a visiting lecturer. So I took him aside and I said, "Boss, this job is getting out of hand. How do I manage it?" He said, "Get yourself an associate department chairman." I said, "There are only five of us on this faculty. We can't spare another one for this mess." He said, "No, no! Not a computer scientist. Get you a businessman."

Well, we had a businessman who had retired as vice president of Continental Telephone Company and come to work on a PhD. He was an engineer, he had founded a manufacturing factory up in the western part of the state, and he had a son who was here in the graduate program. After a year, he decided a master's degree would suffice and he didn't want to go through all the PhD, and so he was available. So I offered him the job and he took over. Well, he was a man in charge and he really streamlined and made things work great. When he went down to deal with the university bureaucracy, it was different from a department secretary going down, good as she was.

So that took the load off. But how did I get the money for it? Well, I went to the dean, following Aiken's advice, and I said, "I know where you can get, I can get a half-time first-class computer scientist for $20,000 a year." And he said, "Who?" and I said, "Me." *[laughs]* I explained the proposal. And so that's what we did. So he gave me the money. He laughed and gave me the money. *[laughs]*

Bishop: I have heard the department is described as having a special spirit. Tell me about the spirit of the department.

Brooks: Well, our university, in contrast for example with Harvard and MIT which every year hire twice as many assistant professors as they plan to keep, our university has a policy of "If you get promoted, your slot gets promoted," so there's no competition for slot. Therefore it's easy to encourage an enterprise in which everybody wants his colleagues to succeed. That's something we've worked at pretty hard, and we still do that. When we hire new people, we try to make sure they're not overburdened with beginning classes and they get their

research program off to a start and they're able to start teaching something that's in their specialty and so forth, and we cheer each other on.

Some years ago Henry Fuchs, a colleague and collaborator, suggested, "Why don't we get together for lunch every Friday?" We were having two faculty meetings a year. So we started doing that and in the process we transacted whatever department business it was. That turned out to do more for the sociology of the department than anything else we've ever done. So when we built the annex to Sitterson, we designed a faculty conference room that's horseshoe-shaped, copying one we'd seen in the business school, in which we face each other. I think that really helps a whole lot. And each week we have a research review by one of the faculty members drawn at random of "What I've been doing in my research area," so we get to know each other's research areas and get to know each other better.

Then I chaired the department for 20 years and really worked at a collaborative spirit. Then Steve Weiss chaired it for the next 15 years and he worked hard at maintaining that. So we had a 35-year head start at trying to maintain a strongly collaborative and friendly spirit. And the chairs since have worked at maintaining that.

Bishop: How did you come to write *The Mythical Man-Month*?

Brooks: Well, in that conversation with Tom Watson, that "Won't you stay another year?" conversation, he… No. At the end of the year, we had another lunch conversation and he said, "You're the only person in the company who's managed both a big hardware project and a big software project. What's the difference?" I was kind of stunned and I said, "Well, that's too hard. I'll go home and think about it." So I went home and thought about it, and *The Mythical Man-Month* resulted. *[laughs]*

The quick answer is the two are a lot more alike than most programmers would believe, and they are a lot more different than most hardware managers would believe. The big difference is *[1:40:00]* one is development, period, and the other you're going to have manufacture and deliver multiple copies. And one of them is purely labor-intensive.

Bishop: Why did you pursue research in graphics, a new area for you, when you got to Chapel Hill?

Brooks: Well, the areas I had been actively writing and publishing in were computer architecture and software engineering. In computer architecture, you really need the feedback of a factory that will estimate what your proposed changes are going to cost, because cost performance is a critical parameter. So I didn't think academia was the right place to pursue computer architecture research. And in software engineering, you need a client community of people

who are actually writing software. And so Vic Basili in Maryland has got the Washington Beltway group of client communities to work with and give him feedback on his ideas, but we didn't have in the Triangle here a software community at all. So I decided that wasn't the area in which to pursue research, even though I was doing the book, but it was based on experience, not new research. And I had been interested in computer graphics and had programmed the graphics terminal on the 704 and had seen to it that we announced with the 360 the 2250 graphics engine and delivered it.

So graphics seemed to me like it had two advantages. One was it not respectable by either mathematics or engineering standards, so there was very little competition. And the other was it was fascinating. So I picked that and said, "This is what I want to do my research in." And IBM lent me free a 2250, so we had the equipment. We hooked it up to the mainframe two floors below and installed it in our classroom here, and there we were.

Bishop: How did you choose proteins and building the GRIP Molecular Graphics System?

Brooks: Well, my long-time buddy and colleague Bill Wright had left Harvard to go to IBM without finishing his PhD. Some years later, IBM agreed to send him back to graduate school to finish his PhD, and he chose to come to Carolina. So I went to the provost and I said, "I now have a really super bright graduate student and a hardware graphics display engine. I want to build an intelligence amplifying system for somebody. Who on this campus most deserves to have his intelligence amplified?" This was Charlie Morrow, a chemist, and he said, "Deserves or needs?" and then he said, "I'll have to go think about that." So he went home and he came back with a list of about 12 campus entities that made a lot of sense. One of them was in city planning. One of them was in the highway safety folks doing car, driver simulation and… Okay. And one was a young chemist who was working in proteins. So we started out working with him.

Then later I made, had a contact from Duke who was interested in working on… We started building a system. He was interested in working on transfer nucleic acid, and he introduced me to another couple, Dave and Jane Richardson, who were protein crystallographers. We started a collaboration with them that lasted 30 years and was very effective for both of us. So in fact the first protein that was ever solved without building a brass model was solved on our GRIP system in our laboratory by Dave and Jane Richardson.

Bishop: Why virtual reality research?

Brooks: Well, in 1965 I went to I think it was the Spring Joint Computer Conference, and there was a person who gave a lecture that was absolutely stunning. It was Ivan Sutherland and the lecture was called "The Ultimate Display System." He said, "Don't look at that thing as a screen. Look at that thing as a

window, and through the window one looks into a virtual world. The challenge to computer graphics is make the world look real, sound real, move realistically, and maybe even feel real." He described the concept of a virtual reality system, which in fact he later built the first one of, and in which you track where the person's eyes are so you know which way they're looking and you have a model of the world to see and you have a graphic system that displays it in real time. That sounded like good fun to me, and so besides the protein work, we started working on that.

I got an application for a faculty position from a young man at the University of Texas at Dallas, who had done his PhD at Utah on Sutherland and in graphics. That looked absolutely fascinating. That was Henry Fuchs. And so he came and talked, and we hit it off. We both had the same vision, and so we said, "Let's make that happen." So we've been working on that ever since.

Bishop: Alright. Rumor has it that you were instrumental in helping attract IBM to build a plant-laboratory out at the Triangle. Is that so?

Brooks: Instrumental, yes. I didn't do it, but the people in the Research Triangle Foundation who own the land and the 5,000 acres of Research Triangle Park made the sell. But I got the vision that I knew, had heard that they were looking for places for two new laboratory-plant combinations. They were growing. Because of 360 sales, they were expanding hand over fist. And I heard that Manassas, Virginia and Boulder, Colorado were in the front-running. I thought, "There isn't any reason why Research Triangle Park shouldn't be in the front-running." So I went out to the foundation and talked to their salesmen and got hold of literature and I studied the airline schedules and the rail schedules and everything.

I heard that Tom Watson was going to come to Poughkeepsie for a two-day meeting and would be staying in the executive… where they bring business executives to pitch IBM to that night. So I knew he wouldn't be in a meeting that night, so I asked for an appointment after supper. This was February 24th, 1965, and so I said, "You said when we needed a computer, you would help. Well, we're starting our Research Triangle Computation Center, and the way you could help most would be if you pick the Triangle for one of your laboratory locations and rented night time on the Triangle University Center computer, because we won't be using it during the daytime, instead of putting in your own big computer in your laboratory." He listened to me for more than an hour. I had the charts, I had the maps, I had the airline schedules, the whole thing. And at the end, he said, "Fred, the IBM company is not in the habit of locating laboratories for the convenience of one person," but he said, "I'm going skiing this weekend with the head of the real estate division. I'll get him to come take a look."

Well, so when he came and took a look, the Research Triangle Foundation people, who (a) had a good package to sell and (b) were prepared to sell it,

made the sale. So in fact they did pick this, and at one point it was the largest IBM installation in the world with 13,000 people here. It has since shrunk, when they sold off the PC business. So all I did was get them to come look.

Bishop: Tell us about your professional service with the Defense Science Board and the National Science Board. *[1:50:00]*

Brooks: The Defense Science Board is a very interesting enterprise. It's made up of half civilians and half retired four-stars, and gives advice to the Department of Defense on all kinds of scientific and technical issues. I won't go into a lot of detail, but the most important thing I did was I chaired a special task force on military software. That report is still out and around, and still… I got a request last week for a meeting to talk about military software *[laughs]* from people who are picking up where that report left off. They said, "We're still making the same mistakes." *[laughs]*

Bishop: *[laughs]* Aren't we all?

Brooks: But one of the fun things about that job is we visited military installations to understand what the problems were. One was visiting the first computerized aircraft carrier. That was fascinating because the main computer for the admiral to manage the whole 200-mile-radius battle plan in the heart of the thing wasn't working. But we went around and talked to people. Turned out the most useful thing was email, because there were 3,000 airmen and 3,000 flyers on that ship. Alright. That's a small city. Talked to the chief petty officer in charge of maintaining the four elevators that bring the airplanes up from the hangar deck. All four of them are different. He had a parts inventory problem. He had used drink machine money to buy himself a computer. He had written a little database system to keep track of which parts had high usage and which ones had long lead time and all that, so he could manage the parts for those four elevators. We encountered this in I think three other places on the ship, homemade systems "just to do my job." And I became convinced that our biggest advantage over the Russians was the independence and ingenuity of the average fighting man. It was very impressive.

Bishop: Interesting. You had sabbaticals in your time at UNC. What'd you do on your sabbaticals?

Brooks: Well, the first one, Gerry Blaauw had left IBM to go and start a computer science department at the Technical University of Enschede in Eastern Netherlands. He and I were working on a computer architecture book, so I went and spent that semester and our family lived on campus there in faculty apartments. It's one of the few Dutch universities that has a campus. It was reclaimed from a forfeit by a former Nazi collaborator who had this big, fine estate. A beautiful, lovely campus, and a very interesting new department. So

Gerry and I worked on the book that semester and we put our kids in Dutch schools, and by that…

Oh, the night I talked to Tom Watson about Research Triangle Park was the night our daughter was born. It was a very eventful night. *[laughs]*

Bishop: *[laughs]* Wow.

Brooks: Yeah. So by that time, we had three children in Holland, and the youngest was in kindergarten. Yeah.

Bishop: Okay. So that was the first.

Brooks: Then I spent three sabbaticals in Maurice Wilkes' laboratory at Cambridge, two one-semester ones and one whole-year one, and working with a graphics group there and soaking up the atmosphere and learning a lot from Wilkes himself. The last time I was there, his founding colleagues had died and his wife was sick, he was lonesome. He was 94 but he was in the department every week, and he loved to talk about old times. So I went back and read some of his papers from 50 years before and it was incredible how accurate his predictions as to what was going to happen in computers and technology had been. And his engineering judgment was still sharp. He was still interested in which way is forward. It was absolutely a delight to sit and talk old times with Sir Maurice.

One fun conversation, very British, on one of my other sabbatical visits, he was very proud of St John's College, and he was walking me through the St John's Fellows' Garden. It had been announced at the Queen's List in January that he was to be knighted, and [this done one-on-one 1:55:30] during the next semester. So I asked him, I said, "Maurice, when do you go to Buckingham Palace?" and he said, "On that subject, I have received no command." *[laughs]*

Bishop: *[laughs]* What were your extracurricular activities while at UNC?

Brooks: Oh, I had two more sabbaticals.

Bishop: Oh, okay. Two more sabbaticals. We're back to sabbaticals, yes.

Brooks: Back to sabbaticals. Spent one at Duke working in Dave and Jane's laboratory and trying to learn something about proteins and crystallography and protein models and their representations. And they spent a semester in our lab when they were on sabbatical, learning about computer graphics. So Dave now has I think the most popular computer graphics program out there that he's personally written. And they had a 50th anniversary celebration of their work at Duke over at Duke last month, and half a dozen of us from Carolina were there to

help them rejoice in the anniversary. They're still running the lab, still solving science problems.

Then the other sabbatical was at London in Mel Slater's virtual reality laboratory. That was absolutely exciting. He's the best thinker in virtual reality, best theoretician, and one of the best practitioners anywhere. So that laboratory was very educational, and that's when I got to make small progress on a book. All the books have happened during sabbaticals, really.

Bishop: Tell me about extracurricular activities while you're at UNC.

Brooks: Well, I've been on university committees. Okay. Not…

Bishop: The usual stuff.

Brooks: The usual stuff. Chaired the Chancellor's Advisory Committee for two years, dealing with promotions and tenure and reading dossiers. But outside the university entirely, I've taught an adult Sunday school class since 1965, reading C.S. Lewis books together and alternating with scripture books. And 25 years ago, Nancy was one of the founders of a Christian school, Trinity School of Chapel Hill and Durham. And after she served on that board nine years, I served on that board nine years, and I'm back on it again and chairing the education committee.

Then some years ago, four years ago, the Lord sent us an able young man with a vision for a study center on the Carolina campus modelled after the one at University of Virginia, which had been the pioneering one. We formed a committee, a board of trustees, and incorporated and got a generous mortgage from the Baptist State Convention and bought what had been their student center and had gone out of business, an antebellum house once inhabited by a president of the university called Battle House located right at the very edge of campus, across two dorms at 90-degree angles to each other. So we've started a Carolina Study Center, and I've chaired that board since it was started. That's about a meeting a week, and the Trinity School one's about a meeting a week, so that's kept me out of mischief since I retired.

Bishop: Alright. And…

Brooks: But what I've done for fun was I've always loved the ocean and spent many happy childhood weeks at the beach. So pretty soon after we moved to Chapel Hill, we started looking everywhere from Wilmington to South Carolina line *[2:00:00]* for oceanfront lots. We bought one and had a shell put up on it and spent the next 25 years, the children and I, building the house inside the shell. We got it campable pretty quickly, then we plumbed it and we wired it and we put in partitions between the rooms and hung doors and did cabinet work and

sanded the floors and finished them and all of that. So for 25 years, we built house for recreation, and that's great recreation.

Bishop: Great. When you turned 74 and had been at UNC for 40 years, why didn't you retire?

Brooks: Well, people asked me that then, and I would say, "What can I do in retirement that's more fun than this? I've got really brilliant students. I've got really first-class equipment. I've got great colleagues and exciting problems." So I didn't want to retire. I was in good health. So I struck a deal with the dean for half-time for five years, renewable for another five years *if* my colleagues by secret written ballot concluded that I was still able to work at full level. When the five years was up, they did, and so that carried us till I was 84, and I decided then it was time to really retire. So I've just been doing those boards since then.

Bishop: Alright. Anything else you'd like to tell us? Any other stories come to mind while we've been talking here?

Brooks: Well, I have been blessed with opportunity after opportunity after opportunity. Saint Paul says in 1 Corinthians, "What do you have that you were not given?" That's true of family background, education, native brains, wife and children. All given, given, given. So I would say that's what I'm thankful for every morning.

Another thing I'm thankful for every morning is… David says in the Psalms, the normal lifespan is 70 and the exceptional lifespan is 80. So every morning when I get up, I say, "Thank you, Lord, for bonus days."

Bishop: *[laughs]* Yes. Bonus time, bonus time.

Brooks: Bonus time.

Bishop: Yes.

Brooks: So I've written some… I'm not writing any more books. *The Design of Design*, which summarized… essays summarizing my design experiences across many media is the last one to be published. But I've written a set of essays for the grandchildren, autobiographical essays, and I'm calling that, following David, another David psalm, "The lines for me have fallen in pleasant places." Just at every point, things have been really, really good. And I'm very thankful for that.

Bishop: Yes. We are too. Alright. This has been a Turing Award interview with Dr. Frederick Phillips Brooks…

Brooks: Junior.

Bishop: …Junior…

Brooks: *[laughs]*

Bishop: …on March 12th, 2020, in his house in Chapel Hill. Thank you.

[end of recording]