



Oral History of Mary Allen Wilkes, part 1 of 2

Interviewed by:
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Recorded July 28, 2021
Cambridge, MA

CHM Reference number: X9522.2021

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Brock: Well, Mary Allen, thank you so much for agreeing to do this interview with us. We really appreciate it.

Wilkes: My pleasure.

Brock: And I would like to, I think, I make a habit of saying “Let's just start at the very beginning” and talk about your youth. I read that you were born in Chicago in 1937. And I wondered if you could tell us a bit about just your family background in general.

Wilkes: Okay. I don't remember much about that first bit. But I lived in Chicago until I was about four. My father was an episcopal clergyman, and he had a church in Evanston. And my mother had a degree in Christian education, and she-- I'm not sure whether she was working while we were in Chicago. I was too little to know. But we left Chicago, as I said, when I was four. And he took a different parish in Florida, in Coconut Grove, Florida: Saint Stephen's Parish. And we were there for seven years. And my mother started and ran a very large, active church school, Sunday school.

And then in 1949, my father transferred to a church in Baltimore: Grace and Saint Peter's, in Baltimore. And that church had a small parochial day school for little kids, for babies. Really a daycare center. And my mother took that over and turned it into a quite successful and excellent, in my opinion, day school through the sixth grade. And that, in fact, was active until just last year. It was partly a victim of the pandemic. So she was an educator, he was a clergyman.

His first love had been the theater, and in fact he was in the theater and he taught speech and drama at Northwestern before he went into the seminary. And he continued this love of theater throughout his life, and put on-- did a little theater, did shows in Baltimore with members of the congregation. I was in some of those when I was in high school. That was fun, and it was a big treat to go to New York with my dad and go see a show or two and go to the automat. Nobody knows what that is anymore, but I remember the automat. You put nickels in and out came your food. It sounds horrible. It probably was horrible. Anyway, so they were good sorts.

And my father was also a kind of intellectual. As a theologian, he-- when I was in high school, he had seminars on Sunday nights for a group of about ten people. Most of them were graduate students at Hopkins or the Peabody Conservatory. And he would assign readings. And so they read T.S. Eliot, they read Wallace Stevens, they read Christopher Fry. And I read all that stuff. I was allowed to go to the seminars. I think the message was mostly I shouldn't talk, but I could attend and listen to the grownups discuss all these things. So I loved that. That was great fun, and that was a big influence in my, I think, my intellectual development.

Brock: Were you ever-- it sounds like looking at your ages, that you might not have had the chance to attend the school that your mother had created. Is that right?

Wilkes: That's right.

Brock: What was your education like, in those different places?

Wilkes: In Florida, I went to something called the Merrick Demonstration School. It wasn't really a magnet school. It wasn't a good school. It was a public school, but it was one of the better public schools. But I didn't get very much education in grammar school because I was sick a lot. I had rheumatic fever twice when I was a kid. And in those days, what you did for rheumatic fever was put the kid in bed and just-- they stayed there, which was really very bad for your bones and your muscles and everything else. They don't do that anymore. So I missed a lot of school, couple of-- and I had it twice. Anyway, when we moved to Baltimore, which I was in the sixth grade when we moved to Baltimore, and I was enrolled at Baltimore Friends School, the Quaker school. An excellent school, and I loved that school, and I went to Friends through-- I graduated from Friends in 1955.

Brock: It's just interesting, your father being a clergyman in a different-- what would you call it?

Wilkes: Fishbowl.

Brock: Fishbowl is a great word for it.

Wilkes: We called it the fishbowl.

Brock: Thank you for saving me. But I was just interested, was there any sort of family connection to Quakerism before that?

Wilkes: Yes. Yes. My mother was a Quaker. My whole mother's side of my family was Quakers, and very devout Quakers. Not just in name, but yes, very devout. And my mother, accommodatingly of course, became an Episcopalian when she married my father,¹ but at heart I think she was always a Quaker.

Brock: Interesting. I mean, certainly it sounds like maybe...theology certainly sounds to have been kind of a theme in your household, and I guess art in the aspect of the theater, but were there other-- if somebody had gone into your household, were there any other prominent themes that they would have experienced there, like music or politics or books?

Wilkes: A lot of music. Mostly-- well, I was exposed of course to a lot of church music. But I also studied the piano, and for a number of years a graduate student at the Peabody, a wonderful pianist named Shirly Ling, who went on to have a professional career as a pianist, she lived with us. She got room and board living with us in exchange for making sure I practiced the piano, which of course was a very tough assignment for her, but she survived it very gracefully.

Brock: And could you describe what your experience was like at the Friends School in Baltimore, what things-- what was gripping your attention, what were your interests your activities?

Wilkes: Yeah. Well, it was an excellent school and I just loved going to school. I mean, I still remember several of my teachers because they made such a profound effect on me. And it's hard to-- I don't think one can overestimate

¹ I have since learned, just serendipitously reviewing old family documents, that my mother in fact had become an Episcopalian several years before she met my father.

the effect that a good teacher has on a young person. We all know that now. I certainly know it now at my age, but at the time I think my mother was just grateful to have me in a good school and a Quaker school. She knew that was - education had been a very big thing in the Quaker side of the family. So yeah, it was mostly the education. And I made some good friends there and even tried to do some of the sports. I was not very good at that.

Brock: And what about in the classroom? Were you gravitating to one area more than another?

Wilkes: Well, I loved math. And they had-- I guess my last year, or maybe my junior year, our geometry teacher decided he wanted to teach-- we'd all had regular geometry and he wanted to teach a class in solid geometry. Three-dimensional geometry. So I took that. There were just three of us in the class. I remember that because that was so much fun. And with just the three of us, it was just like a tutorial, which for a teenager at that time-- I mean, we are not talking differential equations or anything. What the kids get now is fabulous in high school. That's not where we were in the 1950s when I went to high school. But there were some experiences like that that were memorable.

Brock: I think I read somewhere that in your junior high school years, that a teacher made a comment to you that you should get involved with computer programming. Was that..

Wilkes: It's true.

Brock: Yeah, it seems like..

Wilkes: Yeah, it's true. Mr. Legg. Sam Legg, L-E-G-G. He taught French and geography. Doesn't have a lot to do with computer programming. I had him for geography in the eighth grade. And I don't remember the context, but I must have been giving him an argument or something about something. And he just looked at me and he said, "Mary Allen, when you grow up, you ought to be a computer programmer." Well, I guess it shut me up, because I didn't know what he was talking about, of course. And it wasn't for many years that I wondered how he knew what he was talking about, because nobody talked about computers or computer programming. This would have been approximately 1950, maybe '51. That's what he said. And the moral of that story, I think, is not only that I went on to become a computer programmer, but as I said a moment ago, you never know what influence an important teacher is going to have on a young kid. And I think one of the reasons that I remembered that was not just that I was curious about what he was talking about. I think one of the reasons I remembered that was that it was something positive that he said I could do. I was a girl, and I was getting a lot of mixed messages about what girls could do, when most of them were things you couldn't do. You couldn't do this, you couldn't do that, couldn't be a lawyer, couldn't be a doctor, couldn't do all of this stuff. But this was something positive that he said I could do, a girl. And he didn't say a girl could do that, he just said, "You should be a computer programmer." And I said, "Oh, okay. I'll check that out."

Brock: Had you been at all familiar with the idea of computers and electronics?

Wilkes: Heavens no. That may have been the first time I ever heard the word. I don't know that one way or the other. But certainly the first time I remembered it.

Brock: Was there anything-- looking back to that era of your high school-- well, high school and before, is there anything that you see in your youth that prefigured or maybe led to your later involvement with computers or computer programming?

Wilkes: Well, certainly nothing direct that you could point to by way of any childhood experiences. I mean, we weren't playing computer games or anything like that in the 1950's. I think the main thing is probably I loved math. I had that kind of mind. And that's helpful. And the other thing I think would be reflected, perhaps, as I've mentioned, I love to argue. I like the logic of it. I like the give and take of it. So the logic, the geometry, solid geometry, all that, it's all reasoning. Argument is a form of reasoning if you're good at it, and geometry is a form of reasoning if you're good at it, if you can do it. So is mathematics. So that would be the predisposition. Nothing to the level, I think, of configuring, as you put it.

Brock: Yeah, that is really interesting, the idea of structured argument. It is in all of those things that you mentioned: a proof, a program, a debate.

Wilkes: Yeah, it's all in there. It's all-- it's the same mind. The same kind of mind that does those things.

Brock: Well, while you were-- I guess at least for part of your high school years, the Korean War was going on. And I was just wondering how things like that, or the sort of high Cold War, were making an impression on you, if those-- those events on the world stage at all?

Wilkes: Not really. I knew they were going on. I had no relatives involved in the Korean War, so what I knew about it was just from what was in the news. I didn't feel personally affected by it. And the same, well, the Cold War we lived through for a very, very long time. And it depends on what you ask and when you look and what you were trying to do at the time. Yeah.

Brock: And as your high school career was coming to a close, what were your ambitions? What were you wanting to do and thinking about doing next?

Wilkes: Oh, I wanted to be a lawyer. I had wanted to be a ballet dancer. I always wanted to be a ballet dancer, no questions asked, for about a decade until I got to be too tall and had bad knees. Then I said..

Brock: Had you done ballet training?

Wilkes: A lot. A lot, yes, when I was little and right through high school. And then-- but I finally accepted the fact that that was not going to happen. And so I said, "Okay, I have a pretty good mind. Think of-- what can you do with your mind?" And I wanted to be a lawyer. Do you want me to tell the story of how that happened?

Brock: Please.

Wilkes: Okay. That happened-- I don't have any lawyers in my family, so it didn't come from that. But in high school, I think I was a junior in high school and we-- a group of us were sent to Washington for-- this was from Baltimore, so it was a short trip. And we went on a civics trip to Washington for a couple of days and visited various

branches of government and our congresspeople and so forth. And we had some free time one afternoon, and I decided to-- and we had to go to one of a certain number of preselected things.

So I picked the Supreme Court. I was just curious about the Supreme Court. So I went to the Supreme Court, and my memory of it is that-- well, in those days you could just walk in. There was no security, no-- you could just walk in and sit down in one of the front rows and listen to the argument. And so I did that. And I sat down and I listened to the argument, and I just fell in love with the whole scene. I was blown over. It was so-- well, the setting is magnificent, of course. That's on purpose, so that you'll think of the justice as being the high-and-mighty ruler of the land or what have you. So yeah, that gets you in the Supreme Court.

But the other thing that totally engaged me was the argument. Again, back to this reasoning thing, this structured argument, talk about structured argument. I had no idea what they were arguing about. It turns out they were arguing an antitrust case. Well, antitrust is still incomprehensible to most lawyers, let alone a teenage girl. So I had no comprehension of the points they were actually making, but it was the intellectual back-and-forth, the give-and-take, and the, "Well, but what if this?" "Well, but you said that, but then what if you change this assumption, then don't we get a different result over here," and that sort of thing. And I just said, "Wow, I want to do that. You can do that for a living?" That was a surprise to me. Yeah, that's where that comes from, and that was a dream that I held onto my whole life. And it was just like that. It was like an epiphany. Yeah.

Brock: And so how did that epiphany shape what you were thinking about doing for college.

Wilkes: Not too much. I mean, I had a good liberal arts education in college, and that would-- I mean, I studied philosophy and I studied-- I didn't focus particularly on political science or government. So it didn't really affect those choices very much.

Brock: Did it affect your choice to attend Wellesley versus something else?

Wilkes: No. Wellesley was just somebody's-- I was told by the principal at Friend's School-- the headmistress at Friend's School and my mother discussed where I would go to college. And so I was told you can-- in those days, it wasn't any-- this is going to sound a bit funny, but what I was told was you can go to either Wellesley or Smith. But you have to bear in mind that in those days, this was not a competitive thing like it is today with kids. And you didn't have to apply to 15 different schools to hope you would get into one regardless of your grades and so forth. And the headmistress, of course, knew which schools would take me and what wouldn't. And so those were her choices.

Brock: So the first time you had been to campus was when you arrived as a student?

Wilkes: I don't remember maybe we went-- did we go for a visit before then? I don't remember. Possibly, it was the first time.

Brock: And you were the class of 1959 there?

Wilkes: Fifty-nine, yes.

Brock: And could you talk about, I guess, your continuation of studying theology, the continuation of your readings from when you were in high school attending the Sunday seminars, how did you come to major in philosophy? How did that..

Wilkes: Well, it's very closely related. My major actually was philosophy. They didn't have a major in theology. But there was a biblical history department, and you could certainly read-- in philosophy or the biblical history department, you could read theologians of various stripes. So that was-- and that was, as you point out, directly an outgrowth of my exposure when I was a teenager, and my exposure to my father. I went off to college and said, "Well, I think I'm going to look into this."

Brock: And in studying philosophy, you were telling me earlier that you studied symbolic logic or mathematical logic. And so did you find a connection there to your previous love of mathematics?

Wilkes: Sure. And the geometry. Yeah.

Brock: Let's see. And outside of academics, what were your interests and activities during your undergraduate years?

Wilkes: The theater was one. I was in a few plays. Not major roles, but just fun to be part of the theater scene and work with friends. I didn't do sports. We had to do-- athletics were required in those days. They aren't anymore. But I did things like fencing and golf. I didn't try anything too heavy.

Brock: And was there anything that you were doing-- I guess you already answered that. There was nothing specifically that you were doing that was feeding into your interest in becoming a lawyer other than..

Wilkes: No, no. And also, it wasn't something that girls did. Classmates also weren't doing premed. They weren't doing pre anything, because there were very few who would go on to a professional school.²

Brock: Right. So there was no kind of path to follow.

Wilkes: You were literally supposed to be educated so that you could carry on an intelligent conversation with your father³, and make sure your sons had a good education. I mean, that was-- I don't want to get into that.

² During my last year or so of college, I looked into the prospects of becoming a lawyer, but I was so soundly discouraged by mentors and the one lawyer I knew that I abandoned the inquiry. I was told that because I was a woman I wouldn't get into law school, or, if I did get into law school, I wouldn't graduate, or, if I did graduate, I wouldn't be able to get a job, and, if I got a job it would have to be in trusts and estates law (where all your clients are dead, I thought). Or maybe I could be a law librarian. But I not only wanted to be a lawyer, I wanted to be in the courtroom and try cases. This, of course, was virtually unheard of for a woman in 1959. I realized that, if I pursued the legal path, I would have to be a pioneer, and I knew that being a pioneer - breaking a lot of barriers - would itself be a full-time job. I didn't want to be a pioneer; I just wanted to practice law. The irony of course is that now people say I was a pioneer in the computer field. But my path in the computer field did not require breaking barriers.

³ I meant husband.

Brock: Well, given all that, as your undergraduate time was coming to a close, what were you thinking of doing next?

Wilkes: I was thinking that I might do something in the sciences, but I hadn't-- I didn't really-- I would have to take more courses at some point, and I wasn't sure what. But something in the sciences interested me more than, say, something in the humanities. I decided in my senior year that I did not want to go on in philosophy. Well, had I gone on in philosophy to get a doctorate, you-- what are you doing? You teach philosophy. I didn't think I would be good at that, so I didn't want to do that. And so I thought, "Well, maybe something in the sciences." But I didn't know what, and I knew I'd have to have more education, maybe a masters in something to go on in that direction. So I thought, well, maybe find a job in something quasi-scientific, or an assistant somewhere or something and learn a little more about it, expose yourself to the field. And that was as far as I got when I-- and I applied for a couple of assistant-- I guess you would call them research assistant positions at a couple of the universities. And then, of course, I applied for a job as a computer programmer.

Brock: Could you talk about that, your experience applying to be a programmer.

Wilkes: Yeah. I had-- remember back to my eighth grade geography teacher saying, "You could be a computer programmer." I said, "I should look at that. I should look at that. That's something he thought I could do." So the day I graduated from Wellesley-- this is my memory now, but it was a long time ago, but the day I graduated from Wellesley, my parents drove me from Wellesley right here into Cambridge to MIT. And they had an employment office. I guess you didn't have to make an appointment or anything. My recollection is I just walked in and asked if they had any jobs for computer programmers. And in those days, you didn't really have to have any qualifications to be a computer programmer, which was fortunate because of course I had none. Well, nobody did. Anyway, so they sent me to Lincoln Lab to interview there. And the rest is history.

Brock: So had you had any kind of further exposure or any exposure to computers during your time at Wellesley?

Wilkes: No. We didn't have-- we didn't even have electric typewriters. I mean, maybe toward the end I had an electric typewriter.⁴

Brock: So could you describe the Lincoln Laboratory at that time, and what it was like to get there, to start as a computer programmer there.

Wilkes: Right. Well, I got a job working as a neophyte programmer in the speech recognition group under Oliver Selfridge and Ben Gold. And they had a much more senior programmer, Connie McElwain who took me under her wing and not only taught me programming but gave me rides from Cambridge to Lincoln Lab every day. So that was a win for me. And Lincoln was as I think it still is pretty much, it's a large, MIT-housed defense research facility. And it has several divisions and within each division there's several groups depending on the focus of the research that's going on. Most of the people who work there have very strong ties to MIT. Some of them teach at MIT and they go back and forth. So that was my first job at Lincoln was working in the speech recognition project. And then I learned or I learned programming on, of course, one of the big IBM machines.

⁴ No, I didn't.

Brock: Was the IBM mainframe there at the laboratory?

Wilkes: Yes, at Lincoln. Yes.

Brock: And could you talk a little bit about Oliver Selfridge and Benjamin Gold and their efforts at speech recognition.

Wilkes: Yeah, they had been working-- they were, I think, some of the early, the first people really working on early, early speech recognition. And it was pretty rudimentary what we were doing. We were breaking down words into consonants and vowels and syntax. I don't remember exactly what we were doing. I had a low-level job doing whatever Connie McElwain told me to do. And Oliver was a very gifted mathematician and also he loved puns. He loved riddles. He loved crazy riddles where once you hear the answer, you say, "Of course. Why didn't I think of that?" One of those. And he used to pose these all the time. That's how he interviewed me. He gave me all these riddles. I couldn't answer any of them, but they hired me anyway. And Ben was an engineer and a lovely man. Both he and his wife, Sylvia, were very active in the arts. And she was a dancer and played the piano and I think-- I don't remember whether Ben played an instrument. But anyway, he was-- and I don't really know myself how far they got with that work. But they were with it for many years.

Brock: And was there-- and you worked with them for how long?

Wilkes: A year.

Brock: A year. And was there a lot of-- what am I trying to ask? -- interaction between you and Connie doing the programming of their efforts? I guess what I'm wondering is how interactive was it between them and the two of you?

Wilkes: Oh, it was very interactive. As I recall, we were in-- Connie and I shared an office and I think they were right next to us. I think you went into an area, we were there and they were just beyond there. No, we were in and out with each other all the time. Yeah. And we had lunch together and it was very congenial.

Brock: Did they also do programming, or was that something...

Wilkes: Not that I recall. They could have, I imagine, but not that I recall.

Brock: Okay. Interesting. And so your first year working as a computer programmer, at long last, how did you find it?

Wilkes: Oh, I loved it. I loved it. I didn't like the punch cards and the big reams of-- in order to debug a program, what they did was print out-- they did a dump, a memory dump of your whole program. Of course, it never ran. There was always a bug, if not more than one. And so the computer facility would do this printout on these big, wide, green sheets that accordion-folded, and that's what they would hand you back. And you had to go through it line-by-line to find-- and mentally play computer to find the bug. And you'd find it, then you'd change that one punch card or have the card-punch person change the one card and then take those same cards back to that big

computing facility and try again. So it was tedious. The programming was fun, but the execution and the protocol was mind-numbingly tedious.

Brock: And what was the programming proper like? Was it pencil and paper or coding sheet?

Wilkes: Pencil and paper. I think maybe we did that on big green sheets, too, because you didn't type your own cards. You didn't punch your own cards. You gave these sheets to a punch card operator and it was always a she. She typed them onto punch cards and I think therefore you had to have-- you needed a structured thing to enter the code on so that she could tell one line-- one instruction per line sort of thing. It was assembly language programming, so pretty basic.

Brock: And I know-- I believe at that time that this project of speech recognition was seen to be part of a broader effort at artificial intelligence. And I was wondering if you came across any of the other researchers who were interested in AI?

Wilkes: Not really. Not really. I mean, eventually I met Marvin Minsky and I met some of those people, but I wasn't working with them and I wasn't really, except very generally, aware of what they were doing.

Brock: They were at Lincoln Laboratory during that time?

Wilkes: I don't even remember that. I don't remember.

Brock: And I believe I saw that, I guess, after that year working on the speech recognition project, that you then took a year to live in Vienna. Is that correct?

Wilkes: I did.

Brock: Yeah. Could you talk about your decision to do that and what that was about?

Wilkes: Well, I still didn't know what I wanted to do when I grew up, and so I had two friends who were-- well, when I took the job at Lincoln right out of college, I had college loans to pay off. So I had to have a job. I mean, I loved the job, but I had to have a job. So I had paid off my loans, and I had two friends who were going to go to Vienna to study music. How did I end up deciding to go with them? I know. I meanwhile had not totally abandoned the idea of getting a doctorate in philosophy. And so I had-- I thought-- and I was interested in metaphysics, and if I was going to go on in philosophy, I wanted to do more with Kant particularly. That was going to require some time, if not-- in Germany just because of the language. I had studied German in college partly because of that, and then went-- in any event, so I guess I must have applied to someplace in Germany. In any event, I was thinking I would go to Germany and study philosophy. And so I applied to the Rotary Club in Baltimore. They had fellowships to study abroad. And I went for my interview and that went well, and then I got a letter from them saying, "We thought you were the best applicant, but we couldn't give it to you because you're a woman."

Brock: As plain as that?

Wilkes: Back to that.

Brock: I mean, as plain as that.

Wilkes: Pretty much as plain as that. I mean, I'm probably paraphrasing a bit. And so I said-- that happened a lot to girls, to young women just out of college. If you were reaching for something that-- and I hadn't even thought about that in connection with a fellowship, I mean, the fact that I was a woman would be an impediment. Anyway-- but meanwhile these two friends were going to go to Vienna and study music. And my mother, probably very wisely, said to me, "Well, don't worry about the fellowship." She said, "I frankly would rather you go to Vienna and study music than go to Germany and study philosophy anyway." And I think she thought I was too serious, I needed to get out and have some fun and so forth. And the good news about a story like this is that had I been a guy, had I been a boy, I would have just gone straight to a professional school. But partly because-- at least partly, if not in good measure, because I was a woman, I didn't do any of those things. I didn't go straight to professional school. I went in a computer field, and then I went to Vienna for a year. And then, well, I guess we're going to get to the rest of it. But I had adventures. I had a lot of adventures that young men would never have had, because they would have been on the straight and narrow, got to get this professional degree and so forth. So I did. I spent a year in Vienna to study music and learning German. I still learned the German, and by the time I came back from that, I had abandoned all thought of going to graduate school in philosophy. My mother was pleased.

Brock: Why was that? Just from what you had been reading?

Wilkes: I don't know, but I know I really never entertained the thought again.

Brock: And so when you returned, did you return to Cambridge from there?

Wilkes: I did. Well, I went back-- I had a good experience at Lincoln Lab. And so I went back there or I wrote them or something. I don't remember. And they said-- well, I don't even know whether it was an option to go back to Oliver and Ben's-- it probably wasn't or I would have. Anyway, so they sent me to Wes Clark's group, to the advanced computer design group. They said they need "a programmer." Again, we were fungible. Programmers were all women and they were fungible. They need a programmer, send her here or send her there.

Brock: And that was in 1960?

Wilkes: Sixty-one. That was in May or June of 1961. I was in Vienna for an academic year, September to May or something like that.

Brock: Well, could you describe the group and what it was working on and what it was-- just what the whole scene was like.

Wilkes: Well, the whole scene the day I walked in, was pretty spare. Because I didn't meet-- Bill Papian may have been around. Yeah, I must've met Bill Papian first. He was the head of the group, I believe. I won't have everybody's title straight anymore. But the head of the project, which turned out to be the LINC development project, was Wesley Clark, but he wasn't there. He was at home designing-- I was told, he's at home. He's working at home,

because he's designing this new computer. Okay, I said, wonder why do they need a programmer when he hasn't even designed the computer yet. But they gave me an office, or maybe I was sharing one. I don't remember. The only person I remember who was actually there the first day, the first few days, was Severo Ornstein who was a mainstay of our development team. And so he sort of took me around and introduced me and what? I don't know, just indoctrinated me into what little there was to indoctrinate me with, because nobody knew what was going to happen when Wesley Clark showed up with whatever he was doing at home.

Brock: Now, was the TX-2 computer, was that part of that group's laboratory or under its control?

Wilkes: It was. It was. The TX-2 wasn't exactly part of that group, but it had been designed by Wesley Clark, who was part of that group. And I think he and Bill Papian had started that group in mid-1950s, and he designed the TX-2 later, like 1957. I don't want to be too eager to put dates on things, but around that time. And so it was always-- within Lincoln Laboratories it was always regarded as Wesley's computer, even though it wasn't. It was MIT's computer, but if you wanted to work on the TX-2, you talked to Wesley.

Brock: Okay, which is kind of astonishing given that that computer at that time was certainly one of the world's most powerful computers.

Wilkes: It was.

Brock: If not the most.

Wilkes: At the time, it was. It was the biggest in terms of memory, and it was the fastest by far. It was an outgrowth of-- well, it was the realization of a real computer built with transistor logic. The first one had been the TX-0, which was also done with Bill Papian. And so this was the manifestation of what you really could do with core memory and transistor logic. And that's why it was so fast, and why it was the fastest at the time, because there weren't very many of those around. The big IBM machines were still being built with vacuum tubes at that time. So the TX-2 was a huge breakthrough. And of course it was astonishing because it was a computer that you sat at and worked at interactively with a scope⁵ in front of you and a keyboard and a console with switches and whatever you needed. And that, itself, was, "Oh my god!", completely.

Brock: Was it nearby to where this group and your office was located?

Wilkes: Yeah. It was right there.

Brock: It was down the hall, so to speak.

Wilkes: I don't know, around the corner or down the hall or something. Yeah.

Brock: And it itself was a room-sized?

⁵ A display, a graphical interface

Wilkes: It was room-sized. Yeah. It took up the whole room. And it also had great big, I mean, it had other components. It had great big, huge, magnetic tape reels. I mean big, like this. And like sometimes you see them in IBM photos of the big 704, 709 machines. Yeah. It also had a fire extinguisher in case the tapes caught fire. There were certain--

Brock: Yeah, I was reading somewhere about this. There was also..

Wilkes: I think it was the tapes.

Brock: I think I heard the story that there was a fire extinguisher, also, for the xerographic printer for the TX-2 that sometimes--

Wilkes: Oh, well that-- maybe it was the printer.

Brock: Yeah, something like that.

Wilkes: There were some hazards. There were some hazards in working with it, yes.

Brock: Was this soon after you arrived that this new computer that was being designed came into focus? And could you describe how it was, or at least what kind of computer it was going to be was described?

Wilkes: Focus is a stretch. <laughs> It did, of course, eventually come into focus, but not right away. And Wesley did eventually show up. I don't know, I suppose it was not more than a week after I'd been there. Seemed like a long time. And what he had was some sketches and I don't know exactly what. It was a control unit and mostly it was kind of like a flow chart of some sort. I actually have-- my job, the first day I met with him and Severo and whoever else was there, was to try and capture what he was saying. And I still have the drawing from that day, and I didn't bring it with me. But anyway, I should have looked at it before I came but I didn't. But anyway, so yeah, he had ideas about-- I mean, he was very focused on what he wanted to accomplish, which was to design a small, relatively small for the time, smallish computer that would be used in biomedical research labs, integrated right in with the experiment. So that it would have a scope display, it would have a keyboard, it would be highly interactive. And you could program it so that it would interact with your experiments while they were running, and you would be able to modify the experiments while they were running. And this dynamic working environment that you find in a biomedical laboratory, which is working with living matter, frequently, was something that he recognized just was never going to happen-- I mean, computerization was never going to happen if you had to use the great big IBM behind closed door, sealed, punch card environment. Because everything had to be done offline in that environment. And the biomedical research is data-driven. And what is the data doing while it's doing it? Not what did it do last week that's important. It's what is it doing right now, and how can I modify that or interact with it or influence it. Influence maybe is a better word. So that was his vision. But what we had that first day on the blackboard wasn't quite there yet. So anyway, and then Severo and I were tasked with the job of trying to come up with an operating code, an instruction set for what the programming would be like. And I said, "Ah, I am a computer programmer. That's why I'm here." <laughs> Anyway, I jest, but it was all-- it was fascinating. And so we were all part of that design process right from the beginning. And we would get bulletins from Wesley about how it was going.

Brock: Were the two of you, you and Severo Ornstein, were you looking at the instruction sets of other computers? Like were you looking at the TX-2 instruction set to come up with the LINC instructions?

Wilkes: Oh, that's a good question.

Brock: How were you doing that?

Wilkes: Well, that's what I said to myself. How do you do this? Why Wesley thought I had any qualifications for doing this at all, I found astonishing. But he worked that way. He just figured anybody could do whatever they needed to do. Whatever needed doing, if you were on this team, you could do it. And that was good. It was supportive. It was good for morale. And so you said, "Okay. If you say so." So anyway, no, I remember that. That's a very good question. No, we did not look-- I mean, I was not yet familiar at all with the TX-2 instruction set. The IBM instruction set was pretty useless. What we had to have were instructions that manipulated the tapes. Instructions that manipulated the character handling for the display. Those were-- you didn't need any of those when you were doing stuff for the IBM machines. Yeah, you needed add and subtract and so forth, but the other instructions were all unique to the LINC pretty much. And so we had several-- there were several go-rounds with the instruction set. And they didn't-- I'm trying to think. I had one drawing. Again, I drew it up from June of 1961 of what we called the alpha LINC. What we were calling the alpha LINC, LINC at that point standing for Lincoln Laboratory-- of the instruction set, which is where we were as of June of 1961, which was very early in the process. And the ultimate instruction set I think doesn't look very much like that. So it was an iterative process over the next several months.

Brock: But were some of these key aspects of the computer already expressed in what you were working on with the instruction set, in that for, I guess, both programming and operating this new computer, it would be real-time, online editing and interaction, I guess, drawing from the TX-2 experience, and also that it would be so oriented-- it seems highly oriented also to the tape drive system.

Wilkes: Oh yes, yes.

Brock: And those two aspects, the sort of screen or scope orientation and the tape orientation were there right from the outset.

Wilkes: Right from the beginning. Yeah, we knew they had to be there, because of the vision. The vision was always what drove us. And of course, if you have the vision and it's imparted well, which it was of course by Wesley, then as part of the team you can further that vision technically by saying, "No, that-- where we need to end up is over here and not over here. So let's try this. We also had to have instructions to read the keyboard.

Brock: Sure. Right.

Wilkes: Hello, yeah.

Brock: Well, it's just very fascinating to me. Well, two things that were fascinating to me in reading about it. One was, to pick on particularly this problem of biomedical computing or biomedical experimentation, biomedical

laboratory, because you could think that-- well, I was wondering, would not the same conditions apply in terms of the need to interact with the kind of experimental setup in real time and everything. Wouldn't that also apply to things like a chemistry laboratory? Or maybe other kinds of engineering laboratories. It seemed to me kind of a general laboratory issue, but that--

Wilkes: It might.

Brock: ...is especially tuned to biomedical.

Wilkes: It might. Certain disciplines in chemistry might lend themselves to it. But as soon as you verge toward the mathematical or the formulaic side of the research, you lose the need for this interactive, online facility. What you need, if you are working on some living matter that is changing all the time and that itself interacts with the environment and is influenced by the environment, it's not something you can put a formula on and define parameters, because they're going to change. What you need is to have a computer-- if you want to use a computer in your work, the computer has to be able to react to that. It has to take that into account and say, just a simple little example, this sampling rate is too high, we can't separate the signal from the noise. We can't see what we want to see because-- or maybe it's too slow. Or maybe something else. I don't know. My mind is getting foggy about that. But yeah, it's not something that-- I mean, if you were working in physics, for example, you can define everything by formulas. And it's static. I mean, the physical world isn't static, but the way we understand it scientifically is formulaic, and that lends itself to a static way of using computers. Whereas biomedical research and perhaps some chemistry research is fluid. It's dynamic. It's changing all the time, and you need to be able to capture that. And you may play around with it.

Brock: And it's also-- the other thing that I thought was very interesting was you could think of, okay, you need this system that can interact with the dynamic system in real time and everything that you've just described. But then does that necessarily mean you have to be able, also, to program it dynamically in real time to create the software to do that sort of interaction. It seems like-- could you-- do those things have to go together?

Wilkes: Yeah.

Brock: They do.

Wilkes: Oh, absolutely. Yeah, they do. And the LINC had lots of ways of doing that. And the-- well, the main thing, it had analog to digital conversion, so it gets built in, so that you could wire your experiment-- you could run your electrical signals from the experiment directly into the computer. And what the instructions said-- I don't remember what it was called mnemonically, but it was something like "sample and convert to digital." And so you're sampling-- and you could set the sampling rate by the way you looped the sample loop. And but you could also change-- there were knobs, potentiometers on the face of the computer, on one of the console boxes, that you just turned and you could sample those knobs as an interactive-- where the user would turn the knob and the sampling rate would increase or decrease or something. Tell the program, slow it down or speed it up. The same with the displays. If you're sampling, maybe you want to store your data, but then you may also want to look at it while you're sampling it to see if you're getting what you want. A lot of the rudimentary stuff you have to do is separating the signal from noise. There's an awful lot of noise in biomedical experimentation. And so you want to be able to watch it on the

display to see if there is a signal that's emerging from this noise. And so again, with one of these knobs, you could just change the parameters of the display, so that you could see what parts of the data were useful to you. Collapse it, expand it, shrink it, whatever. There was lots of that kind of interactive thing to aid the biomedical researchers. And of course the LINC itself was interactive. I didn't do the applications software. All the biomedical researchers did their own application software, but I had the same issues writing an operating system for a machine like the LINC, because you knew that that machine was constantly going to be interacting with a human being. So you were reading the keyboard, you were monitoring the scope. You were constantly monitoring what the user was doing.

Brock: I see now. Right, right. Because the machine is going to be in constant operation while the program is running. It's not just off doing a calculation on its own, that then all of these facilities have to be there for that constant, real time interaction like that.

Wilkes: Yeah, they do. They do.

Brock: I see. So was it then as the work went along to develop the instruction set for the alpha LINC, I guess, was it then that you started working on creating an instruction set simulation of the computer on the TX-2?

Wilkes: yes, I started on the simulator in 1961, in the summer while the whole design, the instruction set everything was still totally fluid, I started designing and programming a simulator which would run on the TX-2, which would simulate the operations-- the functionality and the operations of the LINC. And that would make it possible to write programs for the LINC before we had a LINC, because you could write them on the TX-2 with a LINC simulator, and you could run them on the LINC simulator and debug them so that you would have operating programs ready to go when you finally had a LINC. And I did start that in the summer of '91. And it was in fact almost finished by the end of-- I keep-- am I saying '91 all the time?

Brock: You said '91, but I knew.

Wilkes: Yeah, 1961, of course. No, not '91. It was a millennium ago. So we had the first demonstration of the very first LINC in March of 1961⁶ at Lincoln Laboratory. And the simulator was done by then, and then we had some programs running for it. But of course, since the design kept changing during that eight-month period, six-month period, I had to keep changing the simulator. It was back and forth to Wesley and Charlie Molnar, his righthand person, sometimes several times a day. And again, as I mentioned before, if you know what the vision is, you can feed back into that and say this is going to work or this isn't going to work and why. And so there was a lot of that, because I would be doing things with the simulator that they didn't have any other way to do. And then I would go back to them and say, "We need-- this is too cumbersome or I think this--" whatever. Lots of back and forth along those lines. And so we changed some of the instructions. We changed the instruction set. We added different instructions, we took some out and it was a very fluid process.

Brock: Could you tell me a little bit about what it was like to do that programming on the TX-2. You mentioned before, you're sitting at a console, toggle switches, keyboard, larger-sized screen.

⁶ Should be 1962

Wilkes: A wonderful big screen.

Brock: I was just curious about what it was actually like. How did you do it? Did you write it out on paper and then input it? And was there an editor on the TX-2? How did it work?

Wilkes: That's a good question. And you know I remember very little about what it was like to program the TX-2. I remember the environment which was as you described. Of course, it was my first experience with an interactive, online, "hello, it's responding to me," computer. So it must have had some kind of-- my recollection in terms of program preparation is that I wrote it out. And maybe-- it had, I know it had a punch paper tape input-output. So I may have had this instruction, my coding on a paper tape. I wasn't punching the tape. Somebody must've been punching the tape. I assume, but I really don't remember. I could be wrong. I assume I used that for most of the input. I think the-- it didn't have a really sufficient editor, as I recall, in terms of being able to do a lot of online debugging. But you could, however, when the program was running, I remember you could step through it to find a bug. You didn't have to go offline every time you had a bug. So I used to get the graveyard shift on the TX-2 so that I could get big blocks of time and then work through until I had made some significant progress on whatever it was I was working on.

[Break in recording.]

Brock: Well Mary Allen, we were talking about your experience programming on the TX-2.

Wilkes: Yes.

Brock: And I know that there weren't-- the community of TX-2 users was not that large and I wondered if you got to know some of the other TX-2 users like Ivan Sutherland or Larry Roberts.

Wilkes: I did, yes. And I knew Larry, but not because of the TX-2, we worked on it at different times, but I knew him later because of his association with ARPA, A-R-P-A. But I knew Ivan, I met Ivan on the TX-2 because he was writing Sketchpad, his famous graphic design breakthrough program the same time I was doing the LINC simulator. And he also had the graveyard shift, so we would schedule big blocks of time and I would meet him, either I was going off shift and he was coming on or vice versa. So that's how I got to know Ivan. We're still friends, we've been friends all these years. But it was fun because I got to know a little bit about Sketchpad when it was in its infancy and he got to know a little bit about the LINC when the LINC was in its infancy. So he's been a close colleague and he was a very close colleague of Wes Clark's too.

Brock: I wanted to ask you about the sort of culture, if you will, of the LINC Group, just my sense of it is it seemed that there was a kind of a humorous streak and that it seemed very closely knit, am I right about those?

Wilkes: Absolutely, absolutely.

Brock: Could you tell us more about that?

Wilkes: It was very close knit, it was very collegial, yes there was a lot of humor. Wesley had a wicked sense of humor as did Charlie Molnar, the engineer that came on board that worked very closely with Wesley on the design. So we were laughing all the time about something. Wesley was very, he was very not reticent, not retiring, but he was very collaborative, you always felt like you were working with him, you weren't working for him, you were working with him. And the whole team felt that way and so it was a very collaborative kind of team and we were very collegial, we all believed in his mission, his vision, and so that was a big motivator. And we all became very good friends, we were also very young, we didn't know any better, we were just out to do something wonderful and go for it. And so there was high energy, there was a lot of camaraderie and we're all still good friends, I mean those of us who are still alive, but yes, we were until-- we remained friends, all of us, until people died.

Brock: There's a photograph of the group that you have that I have seen that shows several women in the picture and I was wondering about the different roles that those women played and also there is a Black man in the photograph and I would love to know about who he is and what his role was on the project.

Wilkes: Sure. I just happen to have the photograph with me. Funny you should ask. Would you like me to show the photograph?

Brock: Well I've seen the photograph, so yes, I would-- but if you...

Wilkes: I don't have to.

Brock: Okay. Well I'd just love if you could just describe those people.

Wilkes: Yeah. The Black fellow was Bill Gomes, he was one of our technicians. The photograph you saw which is of a very large group of people was taken in the summer or toward the summer of 1963, we really had to ramp up to get the LINC's ready and all the programming done and everything done before the LINC Evaluation Program began that summer. We haven't come to that, but that was coming up, that was a big deadline, so we had expanded the staff quite a bit. The other women were either secretaries or-- they were all secretaries.

Brock: Okay.

Wilkes: Yeah.

Brock: And was Bill Gomes you said his name was, he was a technician.

Wilkes: He was a technician, yeah.

Brock: Was he doing things like working on the physical creation of the LINC hardware?

Wilkes: You know, I don't know, we had several technicians who did that and I'm sure they were all to some extent involved with some of that. I was personally not involved with it particularly, I was running back and forth to Lincoln Lab. By this time we had moved to Cambridge, I should mention that, we had moved from Lincoln Lab into MIT proper for various reasons, but I was still using the simulator at Lincoln and writing the first LINC system

software at Lincoln, so I was away during the day a lot of the time, I was back in the lab here at MIT in the afternoons and evenings because we worked late. But I wasn't directly involved with exactly what each of the technicians was doing.

Brock: Sure. Okay. Well let's see. I'm just looking at the question list and crossing out the things we already talked about. Oh, so you were just talking about the first system software for the LINC once you had the simulator going and you could work on such a thing. Could you talk about what that first system software was like, was it just an assembler, was there more to it? I wasn't quite sure.

Wilkes: Well I don't remember specifically anymore what the first version was like and the second and third and so forth, but right from the beginning you had to have an assembler, you had to be able to type in your lines of code, you had to be able to prepare programs on the LINC, so that involved typing and editing and converting programs to binary, had to be able to store them, had to be able to run them. So the first assembly-- and that's why LAP6 is called LAP, LINC Assembly Program, that's what it stood for, it just tells you what the provenance was. So yeah, even the very rudimentary ones didn't do much more than that, but they did the basics.

Brock: And so from the very beginning it had to have a rudimentary editor if you were typing in your programs.

Wilkes: Yeah.

Brock: And so I would love to hear you describe just the experience of creating that first system software for the LINC, how difficult was it? Were there other colleagues that were particularly important for you in terms of bouncing off ideas? Yeah, just if you could characterize that experience.

Wilkes: You think I would have drawn on lots of resources, I didn't. <laughs> My colleagues were all too busy doing other things trying to get these LINC's ready and I really didn't have any other resources to draw on in terms of how to do this. I just took the LINC, or the definition of the LINC, that's not quite the right word and figured out how to do it. Some of what you have to do is suggested by the structure of the machine by the order code that we'd worked so hard to get to be a really functional order code instruction set. And then from there you'd just say, "Okay, what will fit in the memory?" We only had at that time 1,000 12-bit words of memory, core memory. So that was a challenge, huge challenge, very limiting in what I could do. And the editor was just a rudimentary, I think you could only type one line at a time and I think if you wanted to-- but you could generate what I called a "manuscript," your collection of lines of code and you could save it on the tapes. I think you had to tell it what block number on the tape you wanted to save it in, the magnetic tape-- the tapes were pre-marked, fixed block and each block corresponded to a quarter of the memory, so you could map from this tape right into the memory or vice versa with the instruction set. But I think with the first assembly programs, you had to keep track yourself of what was on the tape and where it was stored and how long it was and therefore what blocks were free. So it was awkward, but it worked and we got things done that way. And the editing as I recall, you could edit your manuscript, you could edit it one line at a time, but the changes, I had to save the changes in a separate quarter of the memory, I couldn't make the changes right in the manuscript while I was looking at it on the scope, I had to type them in and then the assembly program saved them in a separate quarter of the memory and then when you left the computer it moved those changes to the tape. I called it a deferred storage technique or something like that I think a deferred...

Brock: And then it compiles the changes at the end?

Wilkes: Well the assembly program that the LINC Evaluation Program members took with them when they left in August of 60-- <laughs> I just can't deal with these dates. The LINC Evaluation Program took place in the summer of 1963 and the date, the only reason I know this is that I looked at the date recently, the date on the programming manual, on the user's manual for what was then LAP3, LINC Assembly Program number 3, the date on that is August of 1963. And that one describes-- is also a command, a meta command in the operating system in the assembly program that was "Pack," which packed those changes into the manuscript on the tape, so you could integrate all those changes into the manuscript by using this command called Pack.

Brock: When you were making those changes to a manuscript on the screen and the changes were being stored in this different part of the memory, were the changes-- did the changes appear on the scope, on the screen?

Wilkes: Yes, yes.⁷

Brock: Okay. I see.

Wilkes: No, you could-- I don't remember exactly how you did that, I don't remember in terms of what the user saw first and then next and then next.

Brock: And for doing this sort of screen-oriented real-time online editor I mean there simply weren't other examples for you to draw on for example in the literature or something like that, so this was just you exploring on your own how to accomplish it.

Wilkes: Yeah. Had there been other examples in the literature, I don't know that I would have even known to look for them. What we knew we were doing with the LINC was something so new and my only prior experience with computers had been with the big IBM 704 and then 709 which didn't involve any of this kind of use of a computer. So as I say, it wouldn't have occurred to me, who was I gonna-- I wasn't gonna talk to the IBM guys. And as it turned out of course, in the '60s during that same timeframe that we were doing the LINC and a little later most of it, there were several people doing various versions of editing with a display scope and a keyboard, there were parallel things going on, they were maybe a little bit later than what we were doing. But everybody was I think at the same starting point at about that time and certainly in 1962 or 1963, that has to have been one of the early starting points of that kind of use of a computer.

Brock: So clearly the primary use for that editor was to prepare programs.

Wilkes: Yes.

⁷ You always saw on the screen, in real time, everything you typed as you typed it - lines of manuscript, insertions to the manuscript, meta commands, deletions. You could "scroll" the manuscript up or down to look at other parts of it by turning a knob (potentiometer) on the console. This enabled you to identify where to insert lines, which, with LAP2 (1962) and LAP3 (1963), you did by using an "INsert" meta command. All the versions of "LAP" functioned as true graphical interfaces.

Brock: Did it have a facility such that you quickly thought about using it to create other sorts of documents?

Wilkes: No, not at that time.

Brock: Okay.

Wilkes: Not at that time, we were so focused on just getting the work out and getting it so biomedical people could use it and already talking about doubling the size of the memory which was going to change my work hugely and that sort of thing. So everything was still evolving too much, it wasn't until later that people began to use the-- and mostly they used the more advanced operating system, the one I finally ended up with and they would use that for other kinds of things, recipes or whatever. <laughs>

Brock: Reports.

Wilkes: Reports, yeah.

Brock: And to get a paper copy of a manuscript, of ink on paper, I know at some point the LINC was attached to a teletype for paper output, I was wondering when that happened, was that early on that that was happening or...

Wilkes: I don't know.

Brock: Okay.

Wilkes: The LINC did not come with any kind of printer and some people did attach a teletype so they could print out, not necessarily program manuscripts, but maybe data or something to do with their work, so I know people did that. And in fact the operating system has commands, you know, meta commands, I don't what they call them today, but I called them meta commands, for printing various things, a manuscript, you had several things you could print out. I don't remember ever using a printer, which sounds crazy, but I know I used flowcharts and I used handwritten program listings. And I don't remember ever using a printer.

Brock: Wow, okay.

Wilkes: It seems like I must have used one when I was using the simulator at the TX-2, you'd think I would have printed out my program manuscripts and taken them back to Cambridge with me to work on, but I don't remember doing that.

Brock: One thing that I thought in addition to-- well what's so interesting about the LINC is that by being intended for use by biomedical researchers, the LINC was therefore intended for use by what I think-- and I heard you in a different interview call "lay people," so people who aren't computer professionals, but sort of lay researchers with respect to computer professionals. And I would be interested to hear your thoughts about how that intended user of the non-computer professional, how that shaped how you were developing the LAP3 and LAP6...

Wilkes: The software, yeah.

Brock: ...and all of the LINC software.

Wilkes: Oh yeah, it did, it was foremost in my mind. Well the design of the whole computer, that was foremost in everybody's minds and so it went hand in glove with the logic design and the console design and the tape design and the keyboard and why you pick this particular keyboard over another keyboard and so forth. You wanted to minimize how much the user had to know about what was behind the façade of the computer, how much help did they get from the façade from what they could do at the façade and what they could see on the façade and how easy it was to use. All of those same constraints applied to the software that I was doing. Yeah, that was a big factor, the user computer interface. <laughs> Now that's all taken for granted now, but it wasn't then. Yeah, we used to have discussions about, "Well-- " some aspect of the equipment or some aspect of the program, do we want to-- should they have to take two steps to save a manuscript or can we do it in one or can we do it-- that sort of thing. Can you imagine having a discussion like that today, save a program or save a document? This operating system in that respect worked the same way as our laptops work today. You have a 'save somewhere' up there in all those menus, you have a save command and you just tell it what you want to call it and you save it. Well that's what you did then, but at that time, "Oh well, do you want to make it that straightforward or do you want to make it cumbersome and abstruse?"

Brock: Were you aware of the efforts-- you know, I should have checked the timing better of it chronologically, but I was wondering if there was any relationship to the effort to create the BASIC programming language at Dartmouth which had...

Wilkes: Oh yeah.

Brock: ...a kind of a similar aim, a programming language for the sort of layperson if you will.

Wilkes: Yeah, I didn't know that, I don't know anything about BASIC, so I guess that answers your question.

<laughter>

Brock: It does, very simple.

Wilkes: I remember hearing about it, I don't know if I heard-- was it in the '60s, was that around in the '60s?

Brock: You know, I am horrified to say I don't know exactly what the timing is.⁸

<overlapping conversation>

Wilkes: Oh, I'm sorry, you're the one asking the questions.

⁸ According to Wikipedia, the original BASIC was created in 1964 by John Kemeny and Thomas Kurtz at Dartmouth.

Brock: I can get away with not knowing an awful lot by asking questions. I think it's roughly around-- I think it may predate this...

Wilkes: Oh, okay.

Brock: ...effort on the LINC somewhat, but I'm not certain of that by any means. Well let's see. Could you talk a little bit about why the LINC group left the Lincoln Laboratory and came to Cambridge?

Wilkes: Sure, yeah. As I mentioned before, the Lincoln Laboratory was a defense research lab and it was funded almost entirely by the Department of Defense and the LINC was such a departure that it really had nothing to do with defense, it was that simple. And NIH was very interested in it because of the biomedical research aspects, the National Institutes of Health, and ultimately became our funding agency. But there came a point early on, well this must have been some time in-- it was 1962, it was 1962 after the demonstration of the first LINC that we were informed that Lincoln Lab was not going to punch our dance card any longer. So we left Lincoln, let me see, I think we left Lincoln at the end of 1962, I think we moved into Cambridge-- that was provided by MIT, by the mother ship if you will, here in Cambridge in early 1963.

Brock: And I was reading somewhere that you were in a space above a health food store...

Wilkes: That's right.

Brock: ...in Kendall Square...

<overlapping conversation>

Wilkes: Yes, we were by the health food store in Kendall Square next to the F&T Restaurant and the F&T Restaurant-- and we had these quarters above the health food store and we were there night and day in 1963 because of getting the LINC Evaluation Program ready. And by this time we had NIH funding and so forth. Yes, and the F&T Restaurant, which is no longer there, none of it's there anymore, but anyway the F&T Restaurant kept body and soul together for us for the whole-- all of 1963. We would eat there morning, noon and night. <laughs> We would run into each other. We were working such incredibly long hours, it was a godsend to have them there. But now there is-- there's no plaque for the LINC Group over there at Kendall Square, but there is a plaque for the F&T Restaurant. You can go see this historical plaque that's been put there by the Cambridge Historical Society, right where the-- so I know right where it was. Now it's right at the T stop. At that time I took a bus. <laughs>

Brock: You mentioned this LINC Evaluation Program. Was that something that the NIH wanted you to do or was that something that the group needed to do to really develop the LINC further?

Wilkes: Yeah. I think, well both. I think it came together, it was initiated by a fellow at NIH named Bruce Waxman who was very instrumental in getting our funding and getting us through the system. But the whole NIH funding thing began because a fellow named Robert Livingston who was Head of the National Institute of Neurological Diseases and Blindness at the time had heard about-- this is back in 1962, he had heard about the LINC and he invited Wesley to come to NIH and bring that prototype LINC that I've mentioned for a demonstration at

NIH. And Wesley and Charlie Molnar took the prototype LINC that we had demonstrated at Lincoln in March of 1962 and they went to Washington in April of 1962 and took it to NIH. And this is an aside, but it's a good story. LINC had been working fine and Charlie-- and we had sent them off with programs that would run on the LINC and Charlie had as he expressed, he had confidence of certain programs on the running on the machine and he of course could fix the machine if they weren't running. Anyway, they got to their hotel and they were, I guess they must have had the LINC in the hotel room, it was not small, I mean it was a lot smaller than the IBM machines, but nevertheless. So they were working on it and they could not get the LINC to function, they could not get it to function and it just wasn't running, it wasn't working right and so forth and so on. And Charlie who was a brilliant engineer could not figure out what was wrong. He finally did something and they got it over to NIH the next morning and it worked fine. They learned later that their hotel room was right in the shadow of a huge radio tower and there were radio frequencies that were totally interfering with the running of the LINC. So they spent an all-nighter on that. I mean they didn't need that. But anyway, so they got it to NIH and they had a general demonstration and then Livingston wanted them to use the LINC with an actual experiment and so Livingston, there was a fellow in Livingston's lab named Arnold Starr who was doing work on auditory-- how the cat's brain learns to distinguish sound. And he just could not do these experiments offline. And so Wesley and Charlie-- LINC worked fine at NIH because it was out of the radio tower, away from the radio tower-- and so Charlie wrote a little program to sample the signals coming from the cat's brain and a little program that would click something in the cat's ear and then the program also sampled the signals coming from a wonderful cat named Jasper, a beautifully cared for, wonderful cat. And in about two hours, Arnold Starr could see on the display scope the signal rising out of the noise I talked about earlier, could see the signals he had been looking for for months. And so that was the big selling point. There's a very famous quote from Robert Livingston that's quoted a lot, I'm gonna misquote because I don't have it in front of me, but, "It was such a surprise," that's the wrong word, "that we danced a jig right then and there around the machine. Nobody had ever been able to see what we were looking at." It was the first time they could actually see their data, the actual data while it was being created. It was exciting. It was exciting. So NIH funded us after that. And then I think it was partly Bill Papian's idea and partly-- I'm not sure whose idea it was to put the LINC Evaluation Program together, it was to get LINC's out there into as many biological, into 12, they picked 12 biomedical research laboratories around the country in all kinds of different disciplines. And they put a little ad in Science Magazine saying that this was going to happen in the summer of 1963 and that you would come to Cambridge and get trained and then you would take your LINC back with you to your laboratory and you had to be part of this evaluation program for I think it was a minimum of two years and report back and stay in touch with us, so we could keep interacting, improving on things and that's what happened. So they had they put the ad in Science and they had 72 applications from people who...

Brock: That's a lot.

Wilkes: Seventy-two and from people who had never had a computer in their lab, nobody had computers in their lab, this was it. And so the evaluation board, there was a board that ran the evaluation program, they picked 12 of these labs that were engaged in substantive research and that was how that came about.

Brock: And part of the proposition there was that the NIH would be buying them a LINC, is that correct?

Wilkes: Yes.

Brock: Okay.

Wilkes: Yes, NIH funded the whole evaluation program. And we had some funding from NASA. NASA was interested, "Oh, you're talking about small computers, interactive small computers, we could use one of those on board a spaceship." The LINC would sink the ship because it wasn't that small yet, but that was the direction. So yeah, we had some funding from NASA, those were the two main, it was mostly NIH.

Brock: And it was feverish work leading up to the arrival of the 12 groups.

Wilkes: Feverish, yes.

<laughter>

Wilkes: That's a good way to put it, good way to put it.

Brock: But in the end it's proved to be extremely successful, is that right?

Wilkes: Yes, yes, yes. Not with all 12, a couple of them just never got it, but most of them did, I think about ten of them, I think there were just a couple who their work wasn't really suited to this or something or they didn't expect to have to do so much work of their own. They had to write all their own application software. But the ones who were successful which was I think at least ten of them, they not only wrote the software, they swapped software, they had the operating-- I didn't realize how important this was at the time, but now with everybody writing apps everywhere for their cell phones and everything, you could do that with LAP6, the ultimate operating system. You could write your own apps and that's what they did, their application software and integrate it right with the operating system, so then you just ran your applications right from the operating system, you didn't have to load new tapes or anything. So they did all the application software and as I say they-- and they started writing journal articles about their work and it was huge. We knew if we could pull this off and get the thing running and get enough at least rudimentary software so it was useable and that kind of thing, we knew it would be a real revolution and it was.

Brock: What I was astonished to read about was how it seems like almost-- to me it seemed almost right after that evaluation program, the NIH was interested or in fact maybe even committed to creating, investing a huge amount of money, many millions of dollars in 1963 or 1964 dollars which it's probably on like a 250 million dollars or something like that level today to create a biomedical computing center around your LINC group. So I mean it seems like that is a very positive evaluation if you will. So I was wondering if you could talk about those developments.

Wilkes: Yeah. No, they did and there was to be for a brief period a biomedical computing facility or center housed here at MIT, but that would somehow involve biomedical researchers from other universities and hospitals and so forth, not just MIT. And the focus of that was to be on biomedical computing starting with the LINC work and that would I guess have continued to fund developmental research into the computing part of biomedical computing. But that didn't happen because of disagreements between Wesley Clark and his colleagues and the administration at MIT that wanted to centralize the control over all of this facility. And this idea of central control over any

computers was exactly what was totally anathema to one Wesley Clark, he was definitely one man, one person, one computer, that was his mission and it still was. And there was also-- I only know all this second hand, but since you asked, I'll tell you what I know, but it's all subject to correction by if there are any others who still remember. But there was also a concern that the group, the LINC Group, didn't have anybody with any academic positions, which we didn't. I mean we didn't even have doctors' degrees. <laughs> We were a bunch of college kids. Wesley had started for a doctorate in physics and decided that was too risky because he was having to work with radiation at Hanford in Washington State and that sent him in another direction, namely here. But anyway, so they said, "Well, we'll give your people faculty positions," and they offered, they told Wesley they would make him a tenured professor here at MIT if Wesley agreed that MIT would administer this center. And Wesley said, "No." He was so opposed to that kind of-- he said, "It will just turn into another centralized computing facility that's difficult to access and it won't happen." I mean it was a huge, huge risk that he took. He had people working for him. I wasn't part of this as I say, but I think at that point, yeah at that point I had left after we got the evaluation program started, I was on a long trip and so this was going on when I wasn't even here. But, you know, he had all the others working for him and it was a huge-- it was very courageous on his part. Anyway, so he turned it down. And then the funding that had come or was to come from NIH was 35 million dollars which was huge as you say at that time. And NIH-- so it was Wesley who had control of that 35 million, which was of course what was bothering <laughs> the powers that be at MIT. So Wesley turned the money down and NIH actually picked us up again after we left MIT and went to Washington University, NIH kept funding us.

Brock: Thank you. It's an amazing turn of events.

Wilkes: It's sort of remarkable to me, remarkable history, yeah.

Brock: It is. Could you talk a little bit about first what specific role you played in that summer evaluation program, what you were doing and then about your decision to travel right afterward?

Wilkes: In the evaluation program mostly what I did with respect to the students, if you want to call them that, the participants was teach, we taught them programming, how to program the LINC, how to familiarize themselves with the LINC. And I think at nights I was back out at MIT, I mean back out at Lincoln with the simulator finishing the assembly program.

<laughter>

Wilkes: Everybody else was here in Cambridge at night scrambling to get-- because when the program started, the LINC's weren't actually ready, <laughs> they were almost ready, but they weren't quite ready. And Charlie had the brilliant idea of saying, "Well why don't we have the LINC program participants assemble their own LINC's?" Wesley said, "That's brilliant." So that's what they did. But my main job with regard to the program itself was teaching.

Brock: And so then maybe about your decision to leave the project, to travel, which I imagine would have been not the easiest decision given all the camaraderie.

Wilkes: Well serendipity in life. In something like May of 1963 I had inherited, out of the blue, I inherited 1,000 dollars from a woman I barely knew, she had been a very close friend of my mother and for some reason, my mother was still alive at that time, I don't know why she didn't leave my mother 1,000 dollars, but she left me 1,000 dollars. And that was very generous of her, for 1,000 dollars in 1963 you could buy a round-the-world plane ticket on Pan Am 1 or 2, Pan Am 1 went in one direction around the world and Pan Am 2-- Pan Am was an airline.

<laughter>

Wilkes: Anyway that's what it cost and you could make unlimited stops, okay? So I didn't have the idea out of the blue just to do that, but I was sharing an apartment at the time with a friend who was getting her master's I think in Chinese studies and she had just gotten a grant to study in Taiwan for the fall semester of 1963. And she said, "Why don't you come with me after you finish the LINC Evaluation Program and we'll go on around the world to that?" So that's how it happened. And so I put my 1,000 dollars into an around the world plane ticket and went off. I did join-- Emily meanwhile by the time I got through with the evaluation program, she had gotten another grant to stay another semester in Taiwan, so she was going to be there until like June of 1964. And I said, "I can't wait for you, I'm just going to keep going around the world." So I originally was going to be gone for about three months, but I kept-- the world was fascinating so I kept extending it and you could postpone up to a year with your Pan Am ticket. And so I did that and I kept staying longer in many places, a lot longer. So I came back just under a year, just under the wire.

Brock: Wow. So I'm sure there were many, many memorable experiences on your trip.

Wilkes: Oh yeah.

Brock: Are there any that really stand out that you could share?

Wilkes: Oh yeah, there were many, there many. I spent a month in Nepal which was meeting Peace Corps people and journalists and also met and was squired around by the King's brother, Prince Birendra Bir Bikram Shah Devi, that was their names, those people are all dead now. So that was very interesting, the whole history of Nepal at that time, I won't go into that, that's not what the purpose of this interview is. <laughs> But it had just really just come out of a place where the country had really been closed down for several decades for political reasons and it just started to open up again and the royal family had just returned to Nepal from India where they'd been in exile for a number of years, so it was-- anyway, that was totally fascinating. But that was one of the most foreign places that felt foreign to me that I was in.

Brock: I think I was reading somewhere that an offer letter to join the LINC group that had kind of decamped to Washington University, St. Louis that an offer letter for you to join the group found you on your travels?

Wilkes: It probably did.

<laughter>

Wilkes: I don't remember. I know I had an offer, but I don't remember. Yeah.

Brock: Had you intended to rejoin the LINC group after your trip?

Wilkes: I hadn't definitely intended to do, but I knew-- I had stayed in touch, you know, snail mail in those days, that's all we had, but I still stayed in touch with the group and so I knew they moved to St. Louis, I knew that they had doubled the memory of the LINC, which had long been an apple in my eye or a bee in my bonnet and I knew that what I should do was go back and write a really decent operating system. Now that we had the experience with the people in the field and now that we had a somewhat, a larger memory, it was the next step in the logical progression of all the work I'd been doing for these however many years it was at that point was to do a much more sophisticated operating system with a better editor and that sort of thing. So I very much wanted to do that and I was obviously the person to do it if anybody was going to do it because I had this history.

Brock: What was the group doing during the year of your travel? For things like continuing to develop the systems software or work on--

Wilkes: They weren't doing anything about the systems software. No. It was being used by all these researchers. Not just the 12. There were several other LINC's. The LINC's were manufactured by DEC, by Digital Equipment Corporation. And there were several other people who bought them at the same time, laboratories that bought them at the same time. So there were more than the original 12 out there. But they were all using LAP3 and writing their application software. And the group itself, as I understood it, was fielding questions and occasional issues with the equipment. There weren't very many. It was extremely reliable. It was designed to be reliable because it wasn't going to be maintained by computer professionals. And so it had to be-- but there were that kind of things. I think there was one meeting during the time I was gone with some of the participants in the group, the core LINC group, to just kind of brief each other on how things were going. And the group itself spent a lot of time in the fall and early spring-- all fall of-- no, not fall of 1963. I left in November of 1963. All right, shortly after, it must've been early 1964 they were going around interviewing homes, wherever they were going to move to, various medical schools or whatever. And so they were busy. And the future was quite uncertain from their standpoint. Well, yeah, from all of ours. But by the time I came back, they were happily housed at Washington University, the medical school there, warmly welcomed by George Pake and Jerry Cox and those powers that be there. And so they were carrying on with the rest of the work.

Brock: Yeah. You mentioned that DEC was manufacturing LINC's. Were they doing that under contract with NIH or for NIH, or had they kind of made the LINC into sort of a product of their own?

Wilkes: I think both. The prototype LINC's, the 12 link evaluation program LINC's, were paid for by NIH as I recall. The components, the logic circuitry-- at this time Digital Equipment Corporation was not really into making its minicomputers. It had the PDP-1, I think, but I'm not even sure that was commercially out. But they were making these building blocks, these modular blocks. I do this because they were boards like this, with the circuitry on them and the transistors. But I mean, that's twice the size of a cell phone. So there were these logic boards that had certain logical properties. And that made it actually pretty easy to design computers and design the logical functions of the computer. And so the boards all came from DEC, for all those prototype machines. And they were paid for-- and the other components came from other places. It was a kind of a gradual thing. DEC did start making the tapes. And they used the same tapes in several of their minicomputers in later years. And then they undertook the manufacture--

somewhere along in there they undertook the manufacture of the whole machine. NIH didn't keep paying for all those machines, of course.

Brock: Well, just on that theme of the DEC modules, I know at some point, I believe it was before the group left Cambridge for Saint Louis that the idea of the macromodule program had been articulated and was something that I guess the NIH was going to also support. Were you involved in those discussions about that?

Wilkes: No. I was in Timbuktu or somewhere.

Brock: Okay, that was happening-- okay. So that was something that you would learn about once you would get to St. Louis.

Wilkes: Well, I probably learned about it just by correspondence during the year that I was traveling, but no I wasn't part of the discussion about it.

Brock: Could you describe the fundamental vision there of what the macromodule idea was about?

Wilkes: Yeah. It was building blocks. The idea that you could build computers from modules that performed different functions, and you would cable them together to make the kind of computer that you wanted. And this all was going to depend on miniaturization and everything, all the transistors becoming not only smaller but disappearing. That was part of Wesley's vision was that all of this was someday going to become much, much smaller, and you'll be able to-- well, as he liked to put it, you'll be able to paint it all on some handy surface. He'd whisk his hand like he was painting something. And he was right, of course, you know, because we have cell phones and they're very thin. And so the macromodular thing, also, when I finally rejoined them I did work some on those, but they were big. The LINC was big, relatively speaking, but the idea was that you could put these modules together in whatever configuration suited you and make your own special-purpose computers. One of the challenges was that these modules were to be able to perform asynchronously. You didn't have to have a central clock that pulsed that told every part of the computer what time it was, basically, and namely what to do next. And so you wouldn't have those classic timing cycles to work with. And that was a challenge. So that was the main, very simplified, summary.

Brock: And that just as the idea of one person, one computer, real-time interaction was a radical departure with the LINC, it strikes me that for the macromodule project, of a kind of choose-your-own-computer, asynchronous logic, that is another radical departure from-- everything else had a clock.

Wilkes: Yeah, it was. It was.

Brock: Well, maybe we can talk about your return to the States and your return to working on and making a system software for a LINC with the expanded memory.

Wilkes: Yeah, sure. No, I came back in November of 1964. And I wasn't-- I wanted to do that, as I have described. I didn't think I wanted to move to Saint Louis. I wasn't sure what I wanted to do. I liked Cambridge, but I was happy to have a job, because I needed-- again, I'd spent all my money traveling, so again, I needed-- after my first trip.

Anyway, so I needed a job and they wanted to hire me to do the operating system. And so I said to Wesley, I said, "I just don't think I want to move to Saint Louis." And he said, "Well, no problem." I was at that point living with my parents in Baltimore because I had given up my place in Cambridge, obviously. And so he said, "Well, that's no problem. We'll just send you a LINC and you can work at home." I said, "Oh. Okay." So they did. And two guys showed up, I think it was two, with a van and a LINC, and installed it in my parents' living room in Baltimore. And I spent most of 1965 writing what became LAP6 on that LINC in my parents' living room.

Brock: Wow.

Wilkes: Yeah. It was-- we didn't really think very much of it at the time. I mean, we had LINC's all over the country. They were out there, and they had to be the kinds of machines that didn't need air conditioning, because nobody had air conditioning in those days. That were very reliable, mostly made of off-the-shelf items that you could easily replace if you had to, nothing complicated about the-- and so we had them in all these places, why not have one in my parents' house in Baltimore? So there we were, with the LINC in my parents' house in Baltimore. And it was quite a topic of conversation in the neighborhood. Most of the-- I mean, people hadn't seen it. They'd never seen a computer before, any kind of computer. And my father just thought this was the cat's meow. He thought this was the best thing that had happened. And he would tell everybody he saw-- he was a clergyman. He was all over town a lot. He was out there with the people. And he would say, "Did you know I have a computer in my living room? I'll bet you don't have a computer in your living room. I have a computer in my living room."

Brock: And so how did that development go? I mean--

Wilkes: It went fine.

Brock: Well, but also in terms of what you wanted to make LAP6 into. Had you developed-- did you already have clear ideas about the sorts of things that you wanted to add to it?

Wilkes: Yeah, yeah. I had a lot of ideas that I couldn't realize with the smaller machine that we had before-- up through the LINC evaluation program. There were-- I knew pretty much exactly what I needed to do and what I wanted to do. I refined those ideas by going and visiting about ten of the labs that had now been working with the LINC for a year or maybe a year and a half by that time. That would have been in early 1965, yeah, that I made those trips. And getting further ideas from them, little things that were annoying or little things they would like help with, help from the operating system. And sometimes some bigger things. More program sharing among researchers and stuff like that. Any event, it was fruitful. Those trips were also fruitful. So those were the two main sources.

Brock: Were you having to travel the country by airplane to do those visits?

Wilkes: Yes, airplane.

Brock: Or were there concentrations of--

Wilkes: No, I went by plane. I got caught in a blizzard over Wisconsin. I stupidly was trying to get to Madison, Wisconsin, the University of Wisconsin Medical School, by plane. And instead of-- I had to go through Chicago,

and instead of driving from Chicago, I decided-- I just had gotten the plane ticket from Baltimore, through Chicago to Madison. And then Wisconsin got hit with a blizzard. We took off and then we were in this blizzard. And I ended up in Fargo, North Dakota.

Wilkes: In any event, I ended up in Fargo with a whole plane load of people and we couldn't go anywhere. And so I didn't even get to Chicago until the next day. And I remember that because Joe Hind who was running the show at the University of Wisconsin, the medical school, was waiting-- had been expecting me. And of course we didn't have cell phones. I had no way to contact him to tell him what had happened. He figured it out, I guess, from the weather. But I remember that particular trip was especially challenging. I finally got there, but it wasn't pleasant. But no, I traveled-- I went by plane.

Brock: And when you were developing LAP6 on your LINC at your parents' home, were you kind of bootstrapping LAP6 into existence? That is to say, would you modify the operating system that you were using and add features?

Wilkes: I think I just used LAP3. Well, there was one after LAP3 that apparently I did in the first part of 1965 called LAP4. Wow. That I have no memory of it or how it differed from LAP3. I have the programming manual from LAP3-- I mean, the operating-- whatever, but I don't have anything from LAP4. But I may have been using that. But no, my memory is whatever the current operating system was, I was using that to write LAP6 and then I was writing LAP6 from scratch. I wasn't trying to modify the old one. I undoubtedly used some of the routines, but I would have pretty much started with a clean slate and picked and chose what I wanted from the earlier system.

Brock: Right. Okay. And then at what point-- so were you sending tapes of LAP6 to Saint Louis for your colleagues?

Wilkes: At some point in 1965, I did send-- at that time it was called LAP5, what now would be called a beta version. We didn't have that term in those days, but a beta version. I did send LAP5 to Saint Louis and a number of people in the labs there were using it for several months. Yeah.

Brock: And if you could, how would-- are you able to characterize the changes that you made in LAP6, the enhancements, I guess, that you put into LAP6, what generally these kinds of things were? What were-- yeah. Can you characterize them as a whole or is it more individual things?

Wilkes: Yeah. Well, the operating system, right from the beginning, up through and including LAP6 was primarily used for program preparation. And that was still the case with LAP6. So you still had to provide all the same basic functions of program preparation, conversion, saving, etc.. And so the main changes in terms of functionality were-- there was a huge change in the editing algorithm, completely different editing algorithm, because I could use the larger memory, the double memory, which I badly needed. You needed that to hold the manuscript. And so that was the biggest change. And that was also the biggest change from the user's standpoint, because it's just smoother, and your changes were made directly to the manuscript while you were looking at the-- you could see what your changes were right while you were typing. And that was it. I mean, you were done. And then it just got saved automatically whenever you wanted to save it. And so that was a big change. But there were also-- I was able to do more with error tables, if you hadn't-- when you were writing programs, you used mnemonic codes, of course, but you could assign labels to certain lines in your program. I called them tags. You could tag lines. You could have comments on

lines. You could have headings. All of that got to be a little richer in terms of what you could do, because I had a little more memory. And the error-- and also was able to provide more debugging tools. Like as I said, showing you if you used the same label more than once, same tag more than once. You could also define certain constants as what I called equalities. You could say DOG equals 270 or something. And there again, if you had failed to define an equality or you had defined it twice or something, just flag those. They were still pretty-- it was still very rudimentary compared to what came later. But for what you could do with 2000 words of memory, I looked at what was most helpful to the people who were using it. And the debugging aids were all-- they were all helpful. You could do a lot of debugging right at the console on the LINC, because you could-- well, one thing you could do if you had long programs, you could build HALTs. There was an instruction called HALT, and you could just put those at certain places in your program, so when you were debugging, your program would stop at the first HALT. So if it got that far, you said, "Oh, maybe that part's working." And then you just raised a switch and it would go to the next HALT. Or you could step it step, you know, instruction by instruction and read in the lights exactly what the computer was doing, what calculations. Because there were a lot of debugging aids right at the console, and so they were already there. So I was able to help out with that. And I don't-- I think the manuscript, the filing system was a little more sophisticated. I was able to provide a little more flexibility with the filings-- on the tape-- filing stuff on the tapes. Oh, and index-- I'm not sure the earlier assembly of programs had an index. Now, there was an index on the tape. You could just look at it and see, "Oh, my program called DOG is here and my program called CAT is here." And you could delete things just by deleting them from the index, like you would today. But that was-- everybody appreciated these little, tiny things that we take for granted. It's strange to think that those things were all so new.

Brock: Yes. Well, it seems like the memory afforded you to do, it seems to me, a lot more with the editor, which to me still seemed to be the centerpiece of the operating system. And you could do, for example, almost like page up and page down. You could do that by hitting a keyboard command. And I saw you could also move line by line, up and down with the keyboard commands. So it seemed that that ability to kind of scroll through the manuscript and find exactly what you wanted and read it, just kind of instantaneously from memory.

Wilkes: You could. You could. Yes, there weren't even commands on the keyboard. I just assigned key combinations right under the finger. This one would take you up a page and this one would take you down a page and that sort of thing, and up one line and down one line. And yes, and you could see-- well, the tapes were little magnetic tapes that were just this big around, just under four inches around. And they-- there were two tape units. So you could have the operating system on one tape unit and your data on another, or your manuscripts on another if you wanted to, so that you could minimize the tape motion. Everybody who used the LINC got to know what the efficient way was to do certain things. And when you were working with a manuscript, you were seeing on the scope exactly what was on the tape head at that time. And if you moved-- it didn't always move. Because I could hold enough manuscript in the memory so that it didn't have to move with every line. It would move with certain-- well, it's too complicated, the whole algorithm, but it would-- the tape would move occasionally. And that was-- oh, it's doing its thing. That was just the operating system moving the string into the memory and back out onto the tape as you worked on it. And anything that was in the memory, you could work on. You could edit. You could insert or delete. I mean, that's all you're doing when you're editing. It's very simple. But you just did those things directly. And yes, it was very-- completely responsive.

Brock: I thought it was fascinating that you could have the ability to append one manuscript to another or insert a whole manuscript into another.

Wilkes: The whole concept was to just work with a broken string. Not to have special areas of the memory where you had to put inserts or keep track of deletions or any of that. You just treated the whole manuscript, no matter how many blocks long it was-- block being a block on the tape-- no matter how many words long it was, as a continuous string. And so whatever you were looking at, you could see where the manuscript was broken. It was called-- I called it locating the manuscript. Now, it's where that little cursor goes on your screen, when you move it because you want to insert something or delete something. You have to first position that cursor. Well, that's what you did with the manuscripts on LAP6. You positioned-- it wasn't a cursor, that's just what you saw was where it was broken. I called it broken. And that meant that you could do whatever you-- and that right there, in the middle of the manuscript, you could give it a meta command that would say, "Add manuscript DOG," and you would tell it, like if you were working from unit zero, then you could say, "Add manuscript DOG, which is on unit one." And it would go-- you would see and hear unit one, the tape on unit one start to scroll. And it would find DOG on unit one and it would pull it into the memory right there at that breakpoint in the manuscript and add it right in. And if it filled up what little memory I had to play with there, it would just go right back out on the tape and then come back to that point and break it again right where you left off, and continue adding that manuscript into the middle of the old manuscript.

Brock: And then at some point, did-- so the sequence of the string sometimes would get fragmented across noncontiguous blocks of the tape?

Wilkes: The string was only fragmented in the memory, in the core memory. It was never fragmented on the tape. Whatever was in-- there was one block's worth, which was 512 6-bit words of memory. One block, one quarter of the memory I used for that-- what I called the playground. And that was where you did your additions and your deletions. And it was just-- it was very simple. It was just pointers if you were deleting the pointer, move back. And if you were adding, you added your text and the pointer moved along with you. I mean, it wasn't a pointer you saw on the scope, but the computer was keeping track of a pointer. And then if you moved, then-- if you wanted to see a different part of your manuscript, maybe further down-- I point because that's where it's going to be on the tape-- then the operating system would just put those two strings together. It had the next piece of the string that needed to join right over here in another block in the memory. And it would just feed that into the string. And as soon as the playground filled up, it would go to the tape. And then it would just keep repeating that process until-- and it would carry it right down. And it would incorporate those changes from the memory as you moved to the next thing you wanted to see in your manuscript. So it was constantly being updated. Every time you moved the manuscript, any changes you had made would automatically fit right in.

Brock: Fascinating.

END OF THE INTERVIEW