Oral History of Allen Baum

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Brock: Well, great. Well, Allen, thanks again for coming and sitting with us today and participating. I thought we could begin with just when and where you were born and if we could talk about your family of origin.

Baum: I was born on the East Coast. And we lived in River Edge, but I was technically born in Hackensack, New Jersey. It's just across the Hudson River, a few miles across the Hudson River from Manhattan. My father was from Brooklyn, and a lot of the family was there. My mother was from, originally from Berlin, and eventually she settled in Mount Vernon. And my parents met each other at a, I think a New Year's Eve party, and it turns out that my mother's family and my father's family are related through another marriage.

Brock: <laughs>

Baum: So there's-- there's sort of three families all in this kind of triangle, all married to each other. So I have cousins all over Manhattan on both sides of the family who all know each other and actually hang out together sometimes.

Brock: And was that family connection in kind of the New York City area? Or did that go to back to Germany also?

Baum: No.

Brock: Okay.

Baum: There was-- there was no one left in Germany, to say the least.

Brock: Oh.

Baum: My mother was a concentration camp survivor.

Brock: Wow.

Baum: So, yeah, there are very few relatives who are still alive. And having said that, the family did kind of scatter after a while. At least one family moved to California and then back. For a little bit, they were in

Tennessee somewhere for a bit. But most of the family except for that particular aunt, most of the family was New Jersey-New York area.

Brock: Did your mother get to the United States on her own or with other family members or?

Baum: Oh, boy. There's a book on that. <laughs>

Brock: Yeah. <laughs>

Baum: She survived by walking out of the concentration camp just before the Russians got there. Convinced somebody on the road, some soldiers on the road that she was French on the basis of her high school French, so they relocated her to Paris. She managed to find the rest of her family who were already in the U.S.

Brock: Wow.

Baum: And eventually was able to come over.

Brock: She had been separated from her kind of immediate family in the--

Baum: For, yeah, three or four years at least.

Brock: Oh, my goodness.

Baum: At least. And that isn't-- <laughs> There are more stories than that.

Brock: I'm sure. I'm sure. Wow. Well, was your-- was your household and your kind of extended family, was that, you know, a particularly religious family or?

Baum: No. Not at all. Now my grandmother, you know, kept kosher and stuff, but my mother did not. Didn't even try. We did do the usual things. You know, bar mitzvahs and things. But other than that, my father was, you know, he helped build the sound system at the synagogue, but other than that he never showed up there.

Brock: <laughs> Well, I know that from doing a little bit of background research that your father had an electrical engineering degree from Brooklyn Poly.

Baum: Mm-hmm.

Brock: I was wondering, you know, how much of his interest in engineering and electronics was in your household while you were growing up.

Baum: Oh, yeah. <laughs> The basement was his lab. He had, you know, an oscilloscope and a signal generator and shelves of switches and lights and capacitors and all sorts of stuff. Having said that, he didn't actually try to teach me much of anything. But it was all there to play with.

Brock: Were you allowed in his basement?

Baum: Oh, yeah. He didn't try to keep us out of anything.

Brock: Okay. Did you have siblings?

Baum: I have two brothers, both younger.

Brock: Okay.

Baum: And one of them <laughs> ended up at Apple technically before I actually worked for Apple. In fact, my father, my brother and I all worked at Apple at the same time.

Brock: <laughs> Well, we'll get to that. I'm sure that must have been interesting. What year were you born?

Baum: I was born in 1952.

Brock: And your father was work-- where was he working?

Baum: He was working at ITT Federal Labs, which was in Monmouth, New Jersey, and he did communications oriented stuff. He was an analog engineer.

Brock: Okay.

Baum: In backing up a bit, in 1939, the family was gonna take a road trip to the Coast-- we are the Coast.

Brock: <laughs> Okay.

Baum: And he was gonna get a summer job. And his father said, "No. There's gonna be a war next year. This is gonna be your last chance. Come with us." So he came out to California. They filmed the whole thing. I'm trying to get the film restored. And he really, really liked California. So when ITT Federal Labs got sold, he asked a friend who was here at SRI, "Hey, any jobs out in California?" And the friend said, "Well, yes."

Brock: <laughs>

Baum: And so in 1965, we moved to Los Altos and he worked for SRI.

Brock: And so I guess he was used to, you know, SRI, I think the majority of their sponsored research came from the government and the military.

Baum: Probably.

Brock: So that must have been--

Baum: He was--

Brock: A similar sort of to ITT?

Baum: Yeah, he was doing-- yeah, he was doing communications satellite kinds of things. And I'm trying to remember, he told me once. Something that was kind of packet based, maybe. I don't remember. But on that note <laughs> he took me into work one Saturday. The building was empty pretty much, but walked around and saw Shakey the Robot and other computers, and there was one other guy working there. And he's in an office, you know, so it's all the halls are darkness in one lighted office and we stop and he's got this giant TV screen and he's rolling this thing around the desk and showing me how the thing on the screen moves. It was Doug Engelbart. So I met him when I was about 14 years-old or something.

Brock: <laughs> You had your own private mother of all demos.

Baum: Yeah. That was, I believe that was before the mother of all demos.

Brock: Right. What was that-- Well, I have a few questions that'll take us back, but just staying on that experience, what was that a big deal for you? I mean, you--

Baum: I did not understand the significance of it.

Brock: Okay.

Baum: And I was at this, you know, this amazing place that had robots and giant computers.

Brock: Right.

Baum: So it impressed me enough-- it impressed me enough that I remember it, you know, 40 years later.

Brock: Well, to take a step back, you know, growing up in that kind of a Northern New Jersey in the 1950s, you know, what was that like for you? What was school like? What was life outside of school?

Baum: School was easy.

<laughter>

Brock: I remember 7th grade math class they started teaching us something and I went, "Wait a minute. I've been doing this since, like, 3rd or 4th grade, and it was just a waste of time." So school was, you know, like I said, easy. There was no challenge there. But got to wonder. And we lived right near what is now a county park with, you know, woods and trails and things, so I spent a lot of time just wandering around there.

Brock: Were you gravitating at that age to kind of technical things and science and math? Or more--

Baum: I would say more nature, but not science and math particularly.

Brock: Mm-hmm.

Baum: Math a little bit. I'd already started reading some science fiction by then. <laughs>

Brock: I was about to ask what you were reading. Was that a big thing for you, science fiction?

Baum: Oh, very. I've been pretty heavily involved with it, including helping out on conventions and being on some panels. Not writing.

<laughs>

Brock: Okay. You anticipated my question.

Baum: No, no. I'm strictly a reader, I am. Writing takes a different kind of mindset than I have.

Brock: Who were some of the authors that drew you into the genre?

Baum: I remember the first story that I can remember reading, and I might be mixing it up with something else. It was either Heinlein or Louis Charboneau, who no one's ever heard of. But, you know, at that age, I was reading Andre Norton, early Heinlein of course, probably some Asimov. I went to the library and basically cleaned out the shelves, so. Lots of short stories by lots of people, whoever I could get ahold of.

Brock: And so you moved, I guess, when you were what, 13 years-old?

Baum: Thirteen years-old.

Brock: Okay. And had you gone to the, for like grammar school or elementary school, was that to your neighborhood school?

Baum: Yeah. Yeah, yeah. I went to the local elementary school, local-- actually, there were two. There was one that was, like, K through 3 and then 4 through 6. And then finally, it was the junior high and I only was there for 7th grade, then went to Cupertino Junior High for 8th.

Brock: Okay.

Baum: And then Homestead High School for high school.

Brock: What was that-- Now, you moved to Los Altos? I can't remember where.

Baum: Los Altos.

Brock: Okay, yeah. Could you, you know, as a-- as an early teen coming to Los Altos in the middle of the 1960s, you know, what was that, you know, like as a place to be a teenager? What was the community like?

Baum: I'm not sure how I would characterize it. You know, I had friends in high school, friends in the junior high. You know, I went to Explorer Scouts, Boy Scout explorer camp, Boy Scout camp. I'm still in contact with some of those people. Most of them, actually.

Brock: Was it a situation where you could walk or ride a bike to somebody's-- to other people's houses-

Baum: Oh, yeah.

Brock: Before you could drive or have access?

Baum: Yeah, all the time.

Brock: Okay.

Baum: There wasn't any public transportation, so--

Brock: Okay. <laughs>

Baum: There wasn't a lot of choices there. But yeah, bike.

Brock: Okay. And was the-- was the change of-- was the change of schools, was that-- was it kind of more of the same? Or did it seem different?

Baum: I don't think I really liked the schools in New Jersey. I liked the schools in California a lot better. And I certainly liked the California weather a lot better. The climate was different then. It only rained on weekends at night kind of thing.

Brock: <laughs>

Baum: Just, it was really pleasant.

Brock: Yeah, yeah. And, you know, as you got into-- I guess, as you got into high school, you know, how were your interests developing and--

Baum: Well, my father-- I'm not sure of the exact order of these things, but my father took me to some evening presentation by HP on their HP 9100 calculator. And I was totally fascinated. They probably showed off their 2114 or something, but I was totally fascinated with this thing. And then, probably shortly thereafter, I was walking through I think it was the library. It was, like, before school started, every room was a homeroom for somebody. And there was a guy sitting in the corner and drawing all of these weird pictures on a piece of paper and I asked him what he was doing, and he said, "Oh, I'm designing a computer." "What? You're what?" And he said, "Yeah," and he showed me a Varian 629 manual. "Yeah, I'm designing this one." I decided, "Hey, I want to do that." That was Steve Wozniak.

Brock: <laughs>

Baum: And that's how I got my interest in computers, really. Shortly thereafter, there was a Tymshare installed at-- No, was it Tymshare? GE, somebody installed a terminal in the school so, you know, students could try to use it and see what they did. I was like a sophomore and all the seniors totally dominated it.

Brock: <laughs>

Baum: And I think they used up computer time, 'cause they took it out.

Brock: <laughs>

Baum: After that, someone's father offered to bring a bunch of students to Lenkurt maybe, where they had an IBM 1620 for us to play with. And I wrote my first-- I learned Fortran that night, or I thought I had. And you know, wrote a little program that could solve quadratic equations.

Brock: I didn't catch the name of where that computer was.

Baum: Well, I think it may have been Lenkurt. L-E-N-K-U-R-T. I think.

Brock: A company.

Baum: It's a company, yeah.

Brock: Okay.

Baum: I think-- I don't know if they still exist or not, actually. They made modems and--

Brock: Oh, okay.

Baum: Did telephone equipment kind of things. So I kind of learned Fortran and ran this program and discovered, oh, you could write bugs.

<laughter>

Baum: Which I had a lot of.

Brock: Could you talk about that evening program and that particular HP calculator? I'm not familiar with it, so if you could just describe--

Baum: Oh, there's one here in the museum.

Brock: <laughs>

Baum: At least one. You know about HP handheld calculators.

Brock: Yes.

Baum: And they had one and the first one they had was programmable. That was a 91-- HP 9100 that fit in your desk, in your pocket.

Brock: Oh, okay.

Baum: So the first one was designed, it was a very interesting machine. It was a calculator. It had a little CRT display. It had Reverse Polish. And you could-- it was easy to program. You just, you know, plus AB or AB plus, I guess, I don't know.

Brock: <laughs>

Baum: And you could write programs. You could store programs on magnetic cards. You could even plot them out and plot, you know, make graphs with them. The internal architecture is really interesting. <laughs> But I'm not sure you'd need to know that right now.

Brock: Is that something that you got into at that time?

Baum: No. I didn't know anything about what went on inside at the time. I found out years later because I joined the group that designed it.

<laughter>

Brock: Was it the programmability that captured you? Or I'm just trying to get at, like, what fascinated you?

Baum: Yeah. It was, yeah, the fact that you could just punch a button, and this thing would do something for you.

Brock: <laughs>

Baum: And do something that you would find hard to do of yourself.

Brock: When you met Steve Wozniak drawing, you know, his own designs for a computer, was he in your same grade in the school or?

Baum: No, he was, Steve Wozniak was two years ahead of me.

Brock: Two years ahead.

Baum: Steve Jobs was two years behind me.

Brock: Okay. <laughs> And so was it sort of you and Steve Wozniak kind of pursuing this mutual interest in computers together? Or were there other classmates that were part of the--

Baum: I don't remember any other classmates. And it was mostly he mentoring me.

Brock: <laughs>

Baum: He knew it all. And we used to, we had permission to go off campus every week to go to oh, boy. It was a company that was right along, well, along 237 and had lots of antennas whose name is escaping me at the moment.

Brock: <laughs>

Hsu: GTE Sylvania?

Baum: Yes. I think it was Sylvania. And they had an IBM 1130 that nobody was using on Wednesday afternoons, I guess. So we'd go in there and write programs and run them and just sort of learn how to program. And we wrote stupid programs. You know, powers of 2, prime numbers, badly, knowing now what I know. Knight's tour, and all sorts of things, just learning programming tricks and some idioms and things like that. And using immense amounts of printer paper.

Brock: <laughs> And were the people who owned the computer happy to, you know, have you using this? You know, was it-- they wanted to encourage other people within the industry?

Baum: I think they wanted to encourage high school students. I actually don't know. I mean, it was like somebody's father worked there. And, you know, we went in this room and we started using the computer and there was nobody else in the room.

Brock: <laughs> I'm surprised.

Baum: It was just us, the computer, and the printer and a card punch. That was it. Yeah, they weren't keeping watchful eyes on us to make sure we were[n't] doing something bad.

Brock: That's what I was wondering, if it was kind of instructional, it was just a kind of free form exploration.

Baum: Free form, yeah. We did anything we wanted.

Brock: Wow.

Baum: Which, you know, wasn't all that impressive, really. But you learn something.

Brock: But a pretty rare opportunity, I would think--

Baum: Yeah.

Brock: For high school students of that era. What was--

Baum: The other-- the other thing that Steve and I used to do is drive to SLAC. The SLAC Library, it was all open, so you'd just go in there. The computer room was open. They had this, you know, 360/91 with a front panel of about the size of that <laughs> screen.

Brock: <laughs>

Baum: And you'd just go in there and look at it. I have no idea what all the lights did, but it was pretty impressive. The library, though-- Oh, as an aside, that front panel is in the [Computer History] Museum. <laughs>

Brock: That exact front panel.

Baum: That exact front panel, I think, is owned by the museum now.

Brock: Oh, wow.

Baum: We'd go to the library and they had books about computer design. They had all the magazines of the day, you know, electronic, well, magazines, the computer design-- computer design magazine, I think. All sorts of stuff. And we'd just go there and read them and there were books and journals. And there was also a Xerox machine there and nobody was paying any attention. We copied whole books. <laughs>

Brock: Was it-- it wasn't a coin operated Xerox machine?

Baum: Nope.

Brock: It was just--

Baum: Yeah.

Brock: <laughs> Oh, wow. That's a great find.

Baum: Yeah. And we learned a lot there.

Brock: And it was just open stacks, nobody checking. You could just wander around.

Baum: Nobody paying attention to a few high school students that were in there reading.

Brock: Right. Yeah. Wow.

Baum: They probably thought we were young looking Stanford students or something, I don't know.

Brock: Right. Who discovered-- who was the one who first discovered that-- I would think it would be a discovery that the SLAC Library was so open and easy to use.

Baum: I have no idea. I don't remember that.

Brock: And it was mainly--

Baum: I don't-- I certainly don't recall it was me.

<laughter>

Baum: But how we found out, I don't know.

Brock: Was it mainly, again, the two of you doing--

Baum: Yeah. Just the two of us.

Brock: Okay.

Hsu: How did you get invited to GTE Sylvania?

Baum: It was the parents of somebody else in probably Steve's high school class, and he might even actually remember who.

Brock: So this would have been kind of in the 1960-what, '67 or so?

Baum: I graduated in '70, so that would have been somewhere between '67 and '70. And Steve was-- Steve was two years ahead of me, so Sylvania was probably when he was a senior and I was a sophomore, so that would have been '70-- Sorry. What did I-- That would have been '68, probably.

Brock: Yeah. Well, this is, you know, it's a kind of an interesting time in the world and in the Bay Area, <laughs> the late 1960s. I just wondered how, you know, the turmoil of Vietnam and the kind of various aspects of the cultural revolution were kind of playing into your life then.

Baum: We, with the exception of, you know, having to have a draft number, and my draft number was pretty high, we were kind of insulated. We knew about the protests and we also knew if we went to college, we'd be deferred. But, you know, I was reading the "Berkeley Barb," and going to Kepler's Book Store, so we weren't terribly sympathetic with that. On the other hand, you know, I was, you know 17 or 18 years-old and pretty politically naïve. Still.

<laughter>

Brock: Maybe it's a good thing.

Baum: Yeah.

Brock: Was there a lot of political activity in the high school at all?

Baum: No. Not a lot. I remember the most-- I'm going to the first Earth Day celebration in San Francisco, the only time I cut school. <laughs> But that was it, really. That I, personally, am and the other kids in the high school probably were a lot more politically active.

Brock: Was that a continuation of that interest in nature and the outdoors that we talked about a little bit ago?

Baum: I'm not sure it was that or, you know, like Country Joe and the Fish was gonna be playing live there or something.

Brock: <laughs> Yeah. Hard to disentangle. <laughs>

Baum: Yeah. I actually don't remember why I decided that I had to go to this. It seemed like a good idea at the time.

Brock: What about in the community, like, in Los Altos? Was it-- did it seem kind of a quiet and unchanged environment? Or did it seem touched by the sorts of things you would see going on in the evening news?

Baum: I'd say pretty untouched and quiet. And it's, you know, if you go to a city that has a Main Street and, you know, a university, that's one thing. We were far enough away from Stanford and we didn't see what was going on on Stanford campus. My father did. He saw some of that because they were protesting against SRI and eventually, Stanford was pretty much forced to sell off SRI. But he was, I think he was gone by then.

Brock: By the time of that divestiture or whatever?

Baum: Yeah. Mm-hmm.

Brock: Were there courses in the high school that allowed you to pursue this, you know, burgeoning interest in computers?

Baum: Well, there was computers, no. However, well, I mean, well, Mr. McCollum's electronics class, which was pretty well known, I think. I took a class with him, mostly, you know, putting together vacuum tube amplifiers and things. But De Anza College was right across the freeway. De Anza College had a [IBM] 360/40 and a [IBM] 1620. And, one of the operators was somebody we went to high school with,

and he graduated the same class as Steve [Wozniak]. So I actually, Steve and I and my father took a programming class at De Anza, mostly so we could just get computer time.

Brock: Was that while you were in high school?

Baum: While we were in high school.

Brock: Oh, interesting.

Baum: My father couldn't hack it and he dropped out.

Brock: <laughs>

Baum: Steve, on the other hand, could have taught the class easily. He knew more.

Brock: By the time he walked in the door?

Baum: Oh, yeah. He knew more than the instructor did.

Brock: <laughs> And that was, you know, that was all--

Baum: That would have been my--

Brock: Really self-taught--

Baum: Yeah.

Brock: For the both of you.

Baum: Yeah.

Brock: Reading, you know, just direct engagement with the--

Baum: Reading and doing.

Brock: Who was the high school colleague who was running the lab? Do you recall?

Baum: Well, he was just the nighttime computer operator.

Brock: Okay, okay.

Baum: And Larry, last name started with a "V" and I don't recall any more than that. I'm pretty sure.

Brock: So then--

Baum: So we used to go in. And we took the class and then we used to go after hours and he'd sneak some jobs in for us. I had a, you know, we had to do a project for a social studies class, and I actually used the computer in a project. It was actually pretty-- knowing what I know now, it was actually pretty ambitious. I was trying to figure out cliques in the high school. So I had everybody fill out who their, you know, nine-- who they hung out with, and then tried to do an analysis to see who was strongly connected. And, you know, found out that like all the cheerleaders were strongly connected, and that kind of thing.

Brock: <laughs> Their social graph was dense.

Baum: Yeah. Yeah, that's-- that's what it was. It was a social graph. It was actually kind of interesting.

Brock: Yeah. Where did you fit in on the social graph?

Baum: Oh, with the, you know, the math club.

Brock: <laughs> There's a cluster.

Baum: Yeah. I mean, it was, but I think I ignored any cluster that was, like, you know, less than four people or something. So no, I didn't have a really terribly strong cluster there with me in it, anyway.

Brock: And was that experience making your own vacuum tube amplifiers in McCollum's class, I mean, did that become important for you--

Baum: No.

Brock: Later on? <laughs>

Baum: Well, important in that I didn't want to have anything to do with vacuum tubes and 400 volt power supplies.

Brock: <laughs>

Baum: No. I mean, I learned some stuff that probably I should known much, much longer ago <laughs> than that. That's about--

Brock: About actually making circuits and things?

Baum: Yeah, yeah. And Ohm's Law and things like that.

Brock: Okay.

Baum: And sort of the idea of how vacuum tube amplifiers even work, and what transconductance is and things like that.

Brock: And was it in these years of the late sixties that Steve Wozniak was also doing this-- electronics projects like the Cream Soda Computer? Or was that later?

Baum: That, I think the Cream Soda Computer was several years later.

Brock: Okay.

Baum: I'm trying to remember. I think, God, [did] we have a project? We were trying to-- we had several projects. One was, like, to build a copy of the Data General Nova. But that was after he graduated. I was a senior in high school by then, so we were asking to go to Fairchild and say, "Do you have any cosmetic rejects we could have?" And, yeah, sometimes. They often did. And we got hold of them and that's how he built the Cream Soda Computer. And I think I was off at college when that happened.

Brock: Okay. And that was really walking in the front door of a facility and just asking for whatever was there? <laughs>

Baum: Pretty much. Yeah. Steve Jobs was not involved at that point. Steve Jobs would have just called them and convinced them to send him stuff. But, no, we just walked in. And my senior year, after I graduated I wanted a summer job, and Steve Wozniak and I just started driving around Santa Clara and Sunnyvale looking for some place that we could get a summer job. And we stumbled on some little company called Tenet, T-E-N-E-T, that was building a mainframe. We'd never heard of it before. And when we walked in the door we thought we were, like, next door at Signetics, or something. But they hired us both.

Brock: Huh.

Baum: And that was my first job.

Brock: Well, could you describe what that was like? What you did? What the--

Baum: Oh. I was writing mostly test programs for this mainframe, just stuff that would exercise it and, you know, see that it was working properly.

Brock: Diagnostics.

Baum: Yeah. Pretty much just diagnostics. I don't recall exactly what he was doing. Probably something a bit more ambitious. There's some literature about Tenet. Tenet sold one machine before-- before the-- some big recession hit. <laughs> And it was actually pretty well designed. The guys that designed it went on and had good careers other places.

Brock: What were you using the machine itself to-- Well, you couldn't have been using the machine to write the programs. How were you--

Baum: I think you could. I mean, there as at least one that was, you know, they're sitting there. They sold one production one, but there were other ones.

Brock: So you were using the machine itself to--

Baum: I think so.

Brock: And what programming language were you--

Baum: Fortran, I think.

Brock: Fortran. And, you know, what did you make of that experience? Was it encouraging? Did it--

Baum: Oh, yeah.

Brock: Yeah.

Baum: I got-- I got paid.

<laughter>

Baum: I got paid-- Wow. I forget if it was $125 or $250 dollars a week. <laughs> I thought that was pretty good.

Brock: When did-- now was Steve Jobs wasn't part of your kind of electronics and computer group at this time, was he?

Baum: Not at-- I've gotta think about this. I met Steve Jobs through Steve Wozniak because I had-- my father had given me his old car, except it needed the engine rebuilt and he helped me rebuild it.

Brock: Okay.

Baum: It was a very tiny engine. It wasn't like a huge job. But I needed, I had to get the steering wheel off and the steering wheel had some enormous nut, a bolt. A nut bolt. A nut. Recessed, so you needed an enormous socket to get in, and I thought, "God, how am I gonna do that?" And Steve Wozniak said, "Oh. Steve Jobs' father. He rebuilds cars for a hobby. He'll have all these tools. Let's go over and talk to him." And that's how I met Steve Jobs.

Brock: And did he have the socket?

Baum: Oh, yeah. He had it.

Brock: Yeah.

Baum: He had everything. He was quite a guy.

Brock: Well, then, did you fast become friends? Or what was he--

Baum: Yeah, we became--

Brock: What was he like in those days?

Baum: Always wanting to do something. Build some project. We actually had, we were gonna start a little company to build, like, frequency counters or timer counters. And I was doing most of the actual design. And it never went anywhere. I don't remember why, but partially because of engineers' disease is what I call it. Like, "Oh. We could just do this one more chip and add this feature." And then it just never ended.

Brock: <laughs>

Baum: And of course, yeah, we could have built these things, but we had no clue how to actually sell them or who we would sell them to or how to get them manufactured.

Brock: What did-- who would have been the kind of person who would have a need for a frequency counter?

Baum: Oh, engineers. I mean--

Brock: Engineers.

Baum: I mean, you could go to Hewlett Packard and buy a frequency counter, right.

Brock: Mm-hmm.

Baum: And, "Oh, ours will have this extra little feature that theirs doesn't have. And oh, by the way, they sell those for hundreds of dollars and we could sell ours for--" Because, well. We don't have to worry

about all the sorts of things that Hewlett Packard had to worry about to pay their engineers, and the factories to build it and da-da-da-da-da.

Brock: Right. I wonder if there's something inherent about, you know, being interested in electronics and being interested in computers at this time at that age where, like, starting a business or doing something commercial with it, like, was a natural fit? Because I don't know how many other high schoolers would necessarily have been talking about starting a small business manufacturing a product. You know, and--

Baum: Yeah. I don't think he thought that far ahead at that time. He was just looking at, "God, we could do this. We could make money."

Brock: Hmm. Did he particularly need money? Was that--

Baum: I don't know that he needed it, but I suspect he didn't have it. <laughs>

Brock: Yeah.

Baum: So, yeah.

Brock: So maybe that was a part of the-- Was that something that you had thought about? I guess I'm trying to get at, was that something unusual about him? Or was that something that was common to, like, you and Steve Wozniak also?

Baum: No. I think that was Steve [Jobs]. Steve wanted to make a mark. He wanted to do things. And we were just content with playing around, you know, building this thing for ourselves. But he wanted to do something more than that. And, yeah, I mean, it's pretty obvious seeing his career later, [that] he did it.

Brock: <laughs> Yes. Right.

Baum: But, you know, just like he-- He did lots of things-- he was always-- he was really a leader. I remember, he was, I actually was his roommate one summer up on top of Skyline [Boulevard]. He came to me and said, "Hey. You're back for the summer. I found this place up on top of Skyline we could rent. Let's do it."

Brock: <laughs>

Baum: And we did it.

Brock: That was while you were back home from MIT?

Baum: Yeah. This is when I was working at HP for the summer.

Brock: Okay. Well, before we move into that, I know I have read this lore about the pranks at the Homestead High School. And I wondered if you could just talk about the reality of that or the unreality of that.

Baum: No, I think the reality of that is correct.

Brock: <laughs>

Baum: There was-- I was never involved in any of the senior pranks. And of course, there's the famous-- well, there's the pranks at high school and there's-- Let's see. Where do I start? I did a-- I did one prank, and that's when, English class, the teacher announced she was going off somewhere for something and there was going to be a substitute teacher the next day. And we all knew that that meant that we would be watching some program on the closed circuit TV system. And me and a friend said, "Oh. We should-- we should jam it." So I went to my father and said, "How do you build an oscillator." Oscillators were around 200 megahertz. He says, "Oh, yeah. It's really easy. You just do this. You know, just coil, a capacitor, you know, a battery." Okay. And then I went and put it together and in my garage. And he looks over my shoulder and he says, "No, no, no. Not that way. This way." And I brought it into the class and, you know, and when the thing started, I took it out and tried to turn it on. And I tuned it. It didn't do anything. Ah, closed circuit TV, it's-- It doesn't-- It won't get jammed as easily as broadcast TV. And all of a sudden, I saw it flicker. And I went, "Oh." And I turned it back a little, much more slowly, and the flicker just, "Boop," the whole thing just off. So that was my prank. And then, Steve Wozniak was at the University of Colorado, Boulder then. I told him about this and he went, "Okay." And he went to town with it. I mean, and there are lots of documentation about that.

Brock: Oh, wait. Is this the thing where he was playing with it and then people, you know, he had them standing in weird positions or something?

Baum: That's the one. In his dorm, he had people, you know, he was, like, the ham radio guy. So he knew electronics, so when the picture went out he said, "Oh. It's probably a grounding problem. Just put your hand on top of the set," and then, "Oh. Uh, oh, maybe only one foot on the ground and then it'll work better." And, "Oh, no. You have to put your hand here."

Baum: And then, of course, they were sure it was interference from somebody and they formed a vigilante committee to find the guy, and Steve was on the committee of course.

Brock: <laughs>

Baum: And in class, he actually built one into a felt pen.

Brock: Wow.

Baum: And with the cap, you could turn the cap and it would tune it. And there was some class that was, you know, probably Introduction to Programming, just some big old class where they had monitors around and they might have even had an overflow room. And he--"pop"-- And then he'd wait till some guy got disgusted and left, and--"pop"-- And then all the TAs would say, "Ha. That's the guy."

Brock: <laughs>

Baum: He's very good at pranks. But not just pranks. Pranks where someone else would get blamed for it.

Brock: Yeah. That I imagine is the master stroke.

Baum: Yeah. But in high school, the other, the big prank, of course, was the one he put, made a ticking box and put it in somebody's locker to scare them. And he didn't want him to touch it, so he labeled the batteries contact explosive, because as everyone knows, contact explosive would explode if you touched it, so you better not touch it. Well, somebody heard this ticking in the locker and the principal cut the locker open and found this thing. Grabbed it. Ran it out to the football field and threw it out. And of course, nothing happened. It was just the ticking box. But they went to McCollum, the electronics teacher, and said, "Who could have built this?" <laughs> And he just-- "Steve Wozniak."

<laughter>

Brock: How much in trouble did he get in for that?

Baum: He was actually thrown in jail.

Brock: Oh, my gosh.

Baum: His mother was-- they were gonna charge him with, I forget what they were gonna charge him with. You know, a bomb threat or something. And he didn't call anybody. He didn't threaten anybody. He didn't say a word. He just stuck it in somebody's locker. His mother was not pleased with that and had him released. His mother was a force to be reckoned with. And but he was suspended. So he spent his entire suspension playing tennis on the tennis courts at high school.

<laughter>

Brock: Well, what was it-- Did you, you know, in kind of being friends with him and doing all these activities together, did you get to know his parents?

Baum: Oh, yeah.

Brock: Can you talk about them?

Baum: Oh, his father was an engineer. He worked at Lockheed. Very smart guy, you know, could have been, you know, this pipe smoking professor or something like that. I actually don't know what he did for Lockheed. But I know he taught Steve a lot. His mother was actually fairly politically active, and there's some early photos of Steve with Nixon or something.

Brock: Oh.

Baum: And she didn't stay a Republican very long.

Brock: Hmm.

<laughter>

Baum: Shall we say.

Brock: But in what way was she a force to be reckoned with? A strong personality?

Baum: Yes. A strong personality. Obviously, not stupid.

Brock: Yeah.

Baum: Yeah, she--

Brock: Was she humorous like her son?

Baum: Pranks and things like that?

Brock: Yeah.

Baum: No.

Brock: No. Or jokes?

Baum: No, she had three kids to raise, she couldn't do that kind of thing.

<laughter>

Brock: Right. Well, let's see. I guess it was later that the-- that the blue boxes and the telephone-- and the phone phreaking aspect began, was that--

Baum: Yeah. I wasn't-- I was at MIT when that was going on. And I remember coming back and them telling me the stories, how they'd met Captain Crunch and some of the things they'd been doing. And I remember him designing his blue box, which there's at least one in--

Brock: Yes.

Baum: In the [Computer History] Museum. And he was-- This was an example. At MIT, there were blue boxes, and they were complex and unreliable. And he built something that was just a marvel. I mean, he just used so few chips. It was, it never failed. And he carefully designed the PC board so that-- 'Cause you had to pay. When you had a PC board made, you had to pay for every hole that got drilled. So he made sure that, you know, he wired things up so he wouldn't have to have very many holes. It was-- And it was designed to use the cheapest-- absolute cheapest parts and the fewest number of the cheapest parts. It was incredibly well designed.

Brock: Well, maybe before we get into that, let's talk about-- I mean, by the time you are-- Well, at some point, you applied to and were accepted to MIT. Had that been a dream of yours for a time?

Baum: Not at all.

Brock: How'd that happen?

Baum: Okay. So I was at Homestead High School. Tymshare, Inc. was across the freeway, and there was a guy there that was looking for high school students to bang on the computer and make sure there weren't any security violations. Very interesting guy. Too bad he's not around to have an oral interview with because oh boy he could tell stories. He's, you know, two-digit serial number at DEC and all sorts of things.

Brock: Oh, okay.

Baum: He had been at some timeshare startup in Seattle where he hired some high school student to bang on up there, a guy named Bill Gates. I think he claimed he was the only person to have ever employed Bill Gates.

<group laughter>

Baum: So I was talking to him about my college choices and I had no idea where to go. And he said, "What do you want to do?" I want to learn how to design computers. "Oh, well, then you should go to some place that has lots of computers." Oh yeah, that makes sense. Who has-- which colleges have lots of computers? "MIT has lots of computers." So I applied to MIT.

Brock: Is that where he had gone?

Baum: Yes, that's where he had gone.

Brock: Okay. And do you recall his name?

Baum: Oh, Dick Gruen. Richard P. Gruen. And, you know, the [Computer History] Museum has some of his papers and they'll probably get more as we uncrate them.

Brock: <laughs> And he was on the-- was he part of the software side of Tymshare then? Or do you recall?

Baum: Probably. Yeah. He was not on the hardware side. So yeah he would have been on the software side. He was also, I think, Intel's first CAD manager. He knew all of the founders on a first name basis. Very, very interesting guy.

Brock: Well, what was that like having that job to, you know, kind of bash away at their computer?

Baum: You know, I bashed away. I found a bug. And then he sort of went, "Oh yeah, yeah, we know about that one." So it wasn't that interesting, really. I got computer time if I wanted it. But I can't remember-- I was-- at that time I was probably pretty busy. I was going to high school and taking classes at De Anza [College]. So I didn't have a lot of spare time. But it was kind of cool because I could go over there and look at all of their documentation. They had all of this documentation labeled, you know, confidential, private, secret. I'd go, "oh wow," and I'd look at it and I went, "why?"

<group laughter>

Brock: Were there other people who he was employing to do the same work that he had employed you for?

Baum: Probably yes but I didn't run into any of them.

Brock: Okay. So then you set your sights on MIT. And you applied…

Baum: Actually, I set my sights more on Stanford but was rejected. And Caltech-- I went to visit Caltech and I said I wanted to do computer design and they sort of went, "Oh, okay that would be like applied physics or something." So I went to MIT.

Brock: And did you-- was the financing of it a concern for you? Or was it about…

Baum: At some level I mean not cheap but I got some scholarships. And one of the scholarships and I actually didn't realize this until much later. The scholarship was paid by my work. So I had to get a job at MIT. I didn't know I had to do that but I did it anyway. And got this job and then found out oh that was part of the scholarship. And I worked at the-- I think it was called the Modeling Lab at MIT which was the next room over from the Artificial Intelligence Lab.

Brock: Well, maybe you could just tell us a bit more about what your experience was like at MIT and with computers and with this work at the Modeling Lab.

Baum: The Modeling Lab-- what I-- there are two things I remember doing and one was writing drivers for a Tektronix display. And they had an Evans & Sutherland graphics processor really. It did this thing and I was supposed to interface the Tektronix to that, I think. And there was also something they had called an ADS terminal, an A-D-S terminal which had a little like microprocessor kind of thing in it. And I was supposed to write an interface to that. And I actually met with the designers of it, I guess, and said hey, you should add this instruction because that would make-- something. You know, typical, know it all kind of thing. But at MIT I was in this room with PDP-10s and PDP-6s. and guys writing in Lisp and, you know, all of the people that are now big names they were- they were doing this stuff there. So I learned a lot about how to-- <sighs> how to work your way around a computer system.

Brock: Were there any people-- I imagine there was just so much going on in those years, are there any, you know, people that you met or worked with or learned from that really stand out for you?

Baum: Oh there's a lot of MIT people that stand out. Some of my professors, Marvin Minsky, [Seymour] Papert. A very interesting guy, who I'm not sure is a Fellow here, Ed Fredkin. I took a class from him and that was really fun. Not your typical class and I did something very atypical with it. At MIT you have to have the required humanities courses. You have to take humanities courses--English. Nobody wants to take those. Not true, but a lot of people they're just, oh yeah, we've got to take them. Ed Fredkin is an interesting guy. He was a professor at MIT that did not have a college degree. In fact, he was the guy that started a company called Triple I that sold the terminals that Stanford AI used. And he was teaching a class called problem solving, which was literally about solving problems and he'd just give weird things that like you'd see in XKCD, kind of analysis. And he actually had these boxes, briefcases built, full of TTL and with, you know, with chips on there and you could just wire them up to do breadboard things, little like breadboard briefcase. And it had speakers and lights and some bunch of switches. Like one of the homework problems was to build a machine that played Boogie Woogie baselines. What I did with that class is say, hey wait problem solving, there's a class in the psychology department called problem solving and it's good for humanities credit. I want humanities credit for this. I got it.

<group laughter>

Brock: That was your problem solving.

Baum: Yeah. But he taught me something about going around solving nasty problems like that. Yeah, so a lot of the professors were impressive. Some of the grad students—[Richard] Stallman was around then.

Brock: Can you talk about him?

Baum: I didn't know him. I just knew he was around then. I met him afterwards. Two of the-- MIT built some Lisp machines and the two-- the founders of two of the companies that spun out from that, Tom Knight, Richard Greenblatt were there. There was a guy named Bill Gosper who is-- I don't know he might be a Ramanujan Fellow or something. He doesn't think like the rest of us. Conway's Game of Life, he was the one that proved that Conway's Game of Life was a universal Turing machine. And he-- I think he was the one that came up with, there's some patterns in Life that's called gliders. I think he's the one that came up with those. I think. I'm not sure about that. But there were guys like that there. And more.

Brock: As an undergraduate did you have the sort of access to computers that you had had hoped for or was it-- well it sounds like through your job you had tremendous access.

Baum: Well, yes, that was just in the summers. Oh the first couple of summers I actually had a summer job at Stanford AI Labs.

Brock: Could you talk about that?

Baum: With what I remember doing is instrumenting their SAIL compiler. And then figuring out which operations were most common and then making those kind of hardwired in the compiler. And they were trying to teach me their schematic drawing system because they had a project there. They were going to build a PDP-10 that was ten times faster than the one that DEC actually had. That eventually went nowhere. I'm not quite sure why. And then my work for HP we actually imported that system to design our machines.

Brock: Through you?

Baum: No, not through me. But I had seen it. I thought it was pretty good and lots of people still think it was pretty good. It was the forerunner of many schematic capture and design-- electronic design systems. They did it before anybody did it. And I think a bunch of different companies had spun out from that like Mentor Graphics. So when the project folded DEC hired the guys that designed the schematic capture system.

Brock: So this was--kind of help me to understand it because I'm not quite sure that I exactly get it. So that, it's almost like a CAD type system for systems design.

Baum: It was a CAD system for electronics design.

Brock: Okay. And at the circuit level.

Baum: Yeah, at the component level I would say.

Brock: Okay. So which components you would use, how you would put them, lay them out.

Baum: You can draw the schematics with them. Yeah and actually there were-- there were a couple of different parts to that. One was just the, drawing the logical design. And then there was a separate section where you could actually do the physical design and put chips down. And then it did some auto routing. And it was-- for its time it was way ahead of what anybody else could do, I think.

Brock: And did it have kind of a simulation function too where you could kind of test if it would work right?

Baum: No. I don't believe it had a simulation function. That came later.

Brock: So it was two summers you worked at MIT and then two back here?

Baum: No, actually I worked for MIT during the semesters and came back here the summers.

Brock: That must have been a heavy workload while you were in Cambridge to be taking courses and working.

Baum: Yeah, I mean it wasn't like a fulltime job. I had other jobs at MIT. One was working for the Architecture Machine Group, Nicholas Negroponte. And I was supposed to design a fast multiplier for something they had. And engineer's disease, I kept trying to get it smaller and smaller and smaller. I'm not sure I ever-- I don't think I ever finished it. And then I applied for a job at HP, at HP Labs. And I got two different job offers. They had on campus recruiting. And they also had a program, a co-op program. The co-op program was pretty strict in the sense that you had to have a faculty advisor. And they had to give you meaningful work. They couldn't have you do grunt work. And a few other odds and ends and you got credit. And I got an offer, two offers one through this regular campus recruiting and one through the co-op for the same group. I'm not sure that they knew about the two offers and I picked the co-op version. And so that summer which would have been after my sophomore year, I worked at HP Labs right up the road, in the group that had designed the HP 9100 and the HP 35 calculator. And I got to the work on the HP 45 calculator. My summer job was to microprogram it. That was a pretty smart group.

Brock: Yeah. You hear just so many things about Hewlett Packard.

Baum: I've never seen anything like it.

Brock: Can you tell us about that?

Baum: So everybody was in cubicles. But the cubicles were not little cubicles. They had an eight-foot workbench with-- that you kept racks of equipment on. And then a desk and everything else. There were computers. And every-- it was very, very open. You could talk to anybody. Things were not terribly secret. The stockroom, which was pretty well stocked, was an open stockroom. If you needed something at home for your own little project, you could take it home. And that's how the Apple I got built and the Apple II.

Brock: Meaning taking parts or… test equipment and stuff?

Baum: Taking parts. Parts, parts. No, this is parts, not test equipment.

Brock: Okay. And that was kind of just an open benefit from being part of that environment.

Baum: Yup. Mm-Hm.

Brock: Well…

Baum: I think the guy that ran the stockroom there eventually went to work for Apple, if I recall correctly.

Brock: And had Steve Wozniak come to this calculator part of HP by that time?

Baum: So HP-- the calculator had turned into its own little division and moved to Pruneridge down here right off 280 [in Campbell]. And I told the guy that ran the group, hey I've got a friend who's been designing computers for years. And he said, <claps twice> "Tell him to come talk to me." So Steve Wozniak got a job in that group. And that's how-- and he was designing calculators for Hewlett Packard for years and years.

Brock: And that was-- this was during the summer that we were just talking about when you made that suggestion?

Baum: That might have been. I might have come back from the winter and worked for them then. I don't remember if it was summer or winter but yeah something like that.

Brock: In this timeframe?

Baum: Yeah, in that timeframe. And he had just-- he had left the University of Colorado. He had learned to play bridge and that completely creamed his grade point average. And he was working for a little company called Electroglass and I don't know what they had him doing but I suspect it wasn't as interesting as designing calculators for HP. So I suggested this and he jumped on it. And he was pretty happy there. I guess they were happy with him. He was happy with them. When Apple started they eventually hired the guy that had been his boss as head of engineering at Apple.

Brock: I had no idea.

Baum: Yeah.

Brock: So when you were this summer-- the summer when you were working at HP this was also the summer where you were living with Steve Jobs on Skyline?

Baum: There were several summers and that-- one of the summers, yes.

Brock: Okay. There were several summers working for HP, in other words.

Baum: Yeah.

Brock: Okay.

Baum: And probably winters as well. So my first thing I did was the HP 45 calculator. And then I came back and what were we doing? Lots of little things. There was a-- they were building an e-beam chip exposure machine. It was going to be really amazing all the way down to one micron features. They thought they could get that low which is funny now. But the problem is that these masks you just raster scan them.

Brock: Right.

Baum: The masks-- if you look at the number of bits it took were bigger than any memory system you could build. So somebody had the idea, okay, well the mask data, it's just rectangles. And we can just describe the rectangles and then we can, you know, expand them on the fly and then we can build a much smaller memory and decompress it and use that. So I built a little multi-processor that would do this expansion, microprogram machine.

Brock: It's almost like a PostScript for circuit elements kind of.

Baum: Maybe. It was very, very specialized. And by the time they got it finished and working, it was kind of weird because there's some bits of it had to be superfast and then some bits that didn't. And we built some of that out of TTL and some out of ECL and they didn't like to talk to each other very well. But by the time they got it finished and working someone had come out with 16K memory chips, CCDs, I think, not actual DRAMs. And that was perfect. So they just scrapped it all and built it out of CCDs. And around that time they were looking at sort of new computer systems. And they had some guy as a consultant who was really into AI programs and said that they should build-- you know, if you look at these problems, everything, memory is too precious, you don't need, you know, eight-bit things or thirty-two bit things. You might want seventeen-bit things. We should build bit-addressable processor. So we were building-- so we started to architect a machine that would bit-addressable. And then someone else came and said, oh you need security and you have to build a capability architecture. So eventually what we did is, I designed a machine-- it was actually a 64-bit machine which was designed to be extremely general purpose, it was microprogrammed. And the microprogram was designed to emulate other instruction sets. So the idea is, we're going to build this thing and then we'll program it to see what kind of instructions that we really want. And around that time RISC started to rear its ugly head. And HP had hired this guy named Bill Worley from IBM who had worked on the IBM 801 project. And they had hired Joel Rosenbaum [ph?] to be head of the labs. And so they started this project to build this RISC machine and I got myself on it.

Brock: That's very early isn't it? I mean what year was this…

Baum: Well, this was the PA-RISC, what turned out to be PA-RISC. It turned out to be not as early as some other projects. Okay. So HP had a bunch of different things going on at that time. They had the HP 2100 series, the little 16-bit minicomputers. They had the HP 3000 which are interesting business machines. There was a project called Vision which was supposed to outdo-- be even more complicated than a VAX, and they were busy trying to get it built. One of the HP 3000 designers or two of them, actually, said, "No, no, no, we should build something really, really simple." And it was a RISC machine and everybody said that's a stupid idea. They each went off to found their own computer companies. And then, while about a year later we got these IBM influx and we started building a RISC machine. And I think what finally killed Vision is-- and this was probably after I was gone. One of the young guys at the labs decided he'd take his vacation and build this machine that we were designing and he- and they eventually did, stuck it on an HP 3000 board, plugged it into an HP 2000 and it ran rings around HP 3000. At which point Vision was totally cancelled. It pissed a lot of people off.

Brock: Were you designing this machine as-- were you designing it, like, was the heart of it a microprocessor? Or were you doing it out of…

Baum: No, basically we were designing with gates. And how the gates would be implemented we could get standard packages of gates. We could build custom chips. There was a bunch of things-- it was

actually designed for ECL because there was an ECL gate array project. And then eventually they said, you know, we can't afford to do that. It had to be CMOS. But it was designed to be very, very efficiently implemented in ECL. So it was-- and- and we looked very, very carefully at data paths and how fast we could make it go. The goal was 10 whole megahertz, which was a big deal at that time.

Brock: What was your reaction to the extent that you were aware of them as microprocessors came out, you know, while you're at MIT? Did that create a stir? Or was that too small?

Baum: One of my first projects at MIT, it was a lab and we had to build a project, a final project. And mine was an eight-bit microprocessor out of RTL gates, which were obsolete even then but it worked. But I had access to lots of computers there. So microprocessors were little toy things. And they were still really expensive. Until that fateful WestCon where Steve Wozniak picked up a couple of $20 6502s and then you could actually build something. On the other hand, I was used to larger computers that had significant resources. They had disk drives. They had compilers. Operating systems. And these, you could build something that had lights and switches in the front but trying to actually do anything with them, that would be a lot of work. So I never really got too interested in it until, like Apple I where I could actually sit down. I didn't have to do anything. I could just start doing stuff. And actually couldn't really do that much. I could type in in a computer, on a keyboard, but all I could type in was, store this number into this location. And that's why I wrote the disassembler [for the Apple I] because I was putting all of these-- I was hand assembling things and probably getting it all wrong and I at least wanted to see if I was getting it right. So first step was, write a disassembler so I could type all of these in and then see, did I get it right? Yes. And then the second step was, okay now, let's do it the reverse, the assembler. And for the assembler, and by the way that [what] was significant about that is that whole disassembler took 256 bytes of code, maybe 255. So then I wanted to write an assembler which was a much bigger deal but I figured out that, oh, all I have to do is, just run through all of that-- if I want to say add this to that, I just type, add this to that, and then just start taking a count or basically incrementing it till I got the op code that said, add this to that. That was the assembler.

<group laughter>

Baum: So it was brute force, very simple and fit into 256 bytes if you already had the 256-byte disassembler.

Brock: Because they needed to work in tandem.

Baum: Yeah, so one of them was used basically as a tool for the other one.

Brock: Interesting.

Baum: Now, when I wrote it, it didn't take 256 bytes. By the time Steve Wozniak was finished with it, it took 256 bytes.

Brock: Well, let's-- maybe we could get into that whole-- that whole kind of story and that sequence. You know, you graduate from MIT. Obviously, HP invites you back. I guess you knew Steve Jobs much better after living with him.

Baum: Well, he spent most of the time with his girlfriend somewhere else. <laughs> I didn't see him around the house all that much.

Brock: Okay. Well, having been roommates is a certain kind of a bond. So I know that-- but you and Steve Wozniak then weren't working in the same building were you?

Baum: No, I was working in Palo Alto. I was still at the [HP] Labs and he was with the calculator division.

Brock: But he was getting into this TV terminal sort of project. Right? He was making like a video terminal.

Baum: Yeah. There was-- when was that

Hsu: [Computer] Converser.

Baum: Yeah, Call Computer. Yeah. And I don't remember exactly how that-- I know he designed this terminal for them. I guess he was still working at HP at the time. I don't actually know. But yeah, and I don't remember who it was exactly that connected them up-- connected him to them.

Brock: Well, I was reading in his memoir, Steve Wozniak's memoir, he talks about going over to John Draper's apartment and seeing him with a teletype, like exploring the Arpanet. And thinking, oh, I could make a video terminal so I could also…

Baum: Hmmm. Well, there were some video terminal projects like in Popular Electronics. So that might have been the germ of his idea also. I'm not sure if I was around much for that. I'm not sure where I was.

Brock: And then the Homebrew Computer Club starts to get going.

Baum: Yeah. And what happened there was, I went -- there was a little storefront in Menlo Park called People's Computer Company. And I guess I was over there and, because they had a book shelf full of science fiction, so I liked that too. And right outside-- on a telephone poll outside there was this little flyer for Homebrew Computer Club. And I took down the details and called Steve and said, hey, we really should go to this. So we dragged him to the first one. And we saw the Altair. Is it Bob Albrecht's house, I think?

Brock: I'm not sure.

Baum: Yeah.

Brock: Or is it in Gordon French's garage.

Baum: It was Gordon French's garage. Right. Bob Albrecht was the guy at People's Computer Company.

Brock: Okay. And was that now, because obviously you had had that attempt to make your own homebrew Data General computer.

Baum: Yeah, the paper designs. And also here's a real thing.

Brock: Right. And how was that? Did you know other people-- once you got there were there familiar faces?

Baum: None. I didn't know anybody.

Brock: Did it feel like other people there had known one another before? Or was it really kind of a coming together of strangers with this common interest?

Baum: I think a few of them probably did, but I don't know how many. That was a long time ago. I barely remember that.

Brock: Was it soon thereafter that -- Steve Wozniaks's interest in making a computer?

Baum: Making his own started? Yeah. I think so. I mean, between that and, he did this little video terminal and then he managed to-- and the video terminal had no microprocessor in it at all. And then he

started seeing ads for little microprocessors and we went up to WestCon and we bought one. And he figured out how to build a little microprocessor system with memory. And he had this video terminal. And he just, there's like one chip in between them that are like two separate sections. And that's how the Apple I started.

Brock: Wow. It was that much of an adaptation of his earlier project.

Baum: Yeah. Mm-Hm.

Brock: And what about you? Were you making your own computer?

Baum: No. I was off-- well I was, but like for HP. So I wasn't doing anything like that at home.

Brock: Okay.

Baum: Or maybe I was at MIT at that time. I don't remember.

Brock: I think it was '75 that that starts…

Baum: Yeah, okay, then I was working at HP designing bigger things. But I was getting parts for him out of the stockroom. And the-- when he was designing-- then after Apple I, I was writing software for it. I think the disassembler was first done on the Apple I. So it was put in the ROM of the Apple II but it was originally a little cassette tape you could get for the Apple I. He started designing the Apple II. And I was getting parts out of the stockroom and I suggested, hey, this is the way you should build your I/O system to really reduce the parts count and make it really useful. And that's how the Apple II I/O system was developed, with all of the slots. And each card could have its own ROM with a little driver on it.

Brock: Oh, well that was a major thing about the Apple II, wasn't it, I mean that, all of these available slots?

Baum: Well, there was-- yeah, the available slots was his idea. He wanted to be able to plug things in. But the way they worked was originally my idea.

Brock: Well, to go back, like what was your reaction when you saw Wozniak's project, when he had finished kind of the Apple I prototype or whatever you want to call it?

Baum: I'm not sure I saw any prototype. I saw it when it was a real board. And it's like, this is pretty cool. This is kind of, a little limiting, but you can do stuff with it and I played with it. I started writing a debugger for it. So clearly I was interested. The Apple II was way beyond that. That was [a] really nice piece of work.

Brock: When did you father's support for. I know he gave a loan for the Apple I.

Baum: I can't remember—I think it was either just him or him and me. They had an order for 50 Apple Is. And it was like presold, so it's like guaranteed money but they didn't-- they had no cash flow. So they needed money to actually get the parts. They were able to get some credit. So I told my father who was not working at the time, why don't you lend them $5000? We'll make a few bucks when they pay it back. Meantime, and it's a done deal. I mean there's no risk involved, really. So he said, okay, and he lent them the money and they built the parts and that's how everything started.

Brock: And I think I was reading in something that he maintained a connection with them? Or he started working with them?

Baum: Well, when they actually started Apple Computer he had been laid off from Lenkurt actually. He worked-- how did that happen? He was out of work for a long time. He had a heart attack and then the whole group was laid off. And if you're a 50-something, you're an old engineer with a heart condition. So it took a long time to find another job. He finally found another job. The first day on the job he had appendicitis. Anyway so he's out of a job again later. And he-- I can't remember if they asked him for advice or something and he said "Look you guys, I'm sitting at home not doing anything. If you guys need any help just let me know. I'll give you a hand." And I don't think he was expecting it but they hired him. And he worked there until he died.

Brock: Was that a long time then?

Baum: He was one of the first people to get a fifteen-year pin. And he was actually on his deathbed when they got the pin.

Brock: And did he have a variety of roles there?

Baum: He was mostly kind of-- he did power supplies and did more, almost technician level stuff. But he debugged power supplies. I guess he helped design them. He worked with Rod Holt.

Brock: Yeah.

Baum: And also when they failed, figured out why they failed. He might have done some video stuff too. I'm not sure about that. But he was a fixture at Apple. I mean he was the second oldest guy at Apple. Mary Reagan I think was maybe a year older. And a couple of years after he turned 70, Apple figured out, oh, we can't put money in your IRA anymore, because they'd never run into this problem before.

<group laughter>

Brock: Well, let's see. Well, do you have a question here, Hansen?

Hsu: Yeah. So you started writing programs, like the dissembler and the assembler for the Apple I, as soon as you saw the machine that Woz had built?

Baum: Well, as soon as I had one in my house. They lent me one. I can't remember why.

Hsu: So then they just-- did they just take the programs that you wrote and give it-- give it out to people? Where they shipped as part of the machine?

Baum: I'm not sure how that worked. Certainly, they gave it out because you could get a cassette tape with it on there and they probably published the code in Dr. Dobbs or something like that. So people had access to it. It wasn't a problem. And then eventually it went into the ROM of the Apple II. At some point the Apple IIe came out and the manual had the ROM-- I mean they had the whole disassembled ROM in there. And they had a copyright notice that didn't have my name on it like the earlier ones they did. Franklin Computer had, was starting to do clones and they were getting hammered on for copyright violations. And they noticed, oh look, his name is on that, but it isn't on that. And they called me and they wanted me to give them permission to copy the ROM. And I said, I don't think so.

<group laughter>

Hsu: So you were sort of doing this just in your free time after work.

Baum: Yeah. Mm-Hm.

Brock: Just to help out your friend in his new business.

Baum: Yeah.

Brock: Kind of pitching in. He's starting this…

Baum: Yeah, and also for myself because I wanted to use this thing and it needed stuff to be useful.

Brock: Right. So you were making what you needed for yourself.

Baum: And the Apple IIe came out, my brother convinced me that-- he was working there and he was working as a Developer Tech Support. I can't remember what he was doing there. But, you know, the IIe-- he knew the IIe memory system really well and he said, you know, we should design a memory card for this and convinced me to design this memory card. And we had a special twist to the way the memory card worked which worked like no other. The Apple II had-- the way that you get extra memory in the Apple II is you bank switch. You were using this part of memory and then "whffft" all of a sudden you're using this part of memory. But the display, you know, the frame buffer was in the original part of memory. And so when you wanted to switch you had to copy all of this stuff and then switch. So we designed it so that video accesses wouldn't switch but data accesses would. And that became-- we sold the card off and it became the bestselling add-on memory card for Apple II. And survived attempted clones because they insisted we get a patent on the idea. And I said, yeah, whatever. And then they went after a company that copied it. And said you've got to write a defense. And I said, okay. And I said I don't know what's really patentable and I started digging into it and decided actually, yeah, it really was patentable. No one had ever done anything like that before. So they had a, pretty much, monopoly on that kind of memory card.

Hsu: So you did that while-- but you weren't an Apple employee then either?

Baum: No. I was working at HP then. That was a bit of a conflict, designing a memory card for an Apple II. But HP was not competing in that market. There was no competition. So I convinced them that it was okay. I don't think they were really happy about it.

Brock: And then you sold that to Apple?

Baum: No, I sold it to Applied Engineering, was the name of the company that made it.

Brock: What did you think at the moment when Steve Wozniak was making his decision to leave Hewlett Packard?

Baum: Yeah, he tells that story. He was really reluctant because he had this, I wouldn't say cushy job. That's not the word I want; a kind of guaranteed job. In many ways working for Hewlett Packard in those days, you had a pretty secure job. That's it. And this is like really risky. He didn't know about starting a

business or anything else. And besides, if he's starting a business he'd be like a vice president or something and he wanted to be an engineer. He didn't want to have to manage people. Not fun. And I told him, well, nobody says you have to be a manager. You could just be an engineer even if you started the company. And oh, by the way if everything goes south HP will take you back. And that convinced him to go to Apple, evidently.

Hsu: Why did you decide to stay with HP?

Baum: I actually interviewed and Steve Jobs said, "Hey, come here I'll give you this. You'll have this much stock and everything else." And then I went there and talked to Tom Whitney, he's the guy I worked for at HP that they had hired. And Tom Whitney said, "No." And I said, okay, fine I'll stay at HP. Besides I'm doing what-- at Apple I would be designing stuff around microprocessors. At HP I was actually designing guts of microprocessors and that's what I wanted to do.

Brock: Let's see.

Hsu: You mentioned your brother joined Apple. When was that and how did that happen?

Baum: He was-- he should have had a three-digit employee number but they reserved some for Europe. So he was like in the 1100s or something. And I think he just went and applied for a job there.

Hsu: And that was when your father was already there?

Baum: It must have been. Yeah, my father was already there. So he probably knew that there were some openings and applied and got the job, in a totally different department from my father.

Hsu: And what year was that? Before the IIe came out?

Baum: Yes. Well, let me think about this now. That would have been around '79 or '80, maybe. I think it was his first job out of-- no. My brother actually worked for the calculator division also in Corvallis when they moved up there. I think he took like a gap--

Hsu: HP you mean?

Baum: Yeah.

Brock: He took a gap year and worked up in Corvallis for a year and then came back and I think then he went to school. And then worked for Apple. I think that's the order. We can get all of those details if we need them.

Part II

Brock: How did it seem for your two friends, Steve Jobs and Steve Wozniak, that whole... kind of birth of the company, and the Apple II project? I mean, did they seem stressed or excited? What was your impression of that?

Baum: Well, it got harder and harder to actually hang out with them, for one thing, because they were doing their thing, I was doing my thing. Eventually, it got-- you know, I used to be able to just walk into Apple, and just say hi, and do anything. And eventually, they had-- you know, you had to have badges and-- and besides, Steve Jobs was actually too busy to talk to you, because he was busy doing deals and... whatever. So that... but they were just busy. I think they were having fun. I don't think Steve Wozniak would've hung out if he *wasn't* having fun.

Brock: Yeah. What about the ways in which Apple, in general-- but Steve Jobs, in particular-- was talking about personal computers as this kind of revolutionary tool for the mind and creativity? He was speaking about it in very...

Baum: Well, Steve Jobs, but I don't think Steve Wozniak thought about it in those terms. I'm actually not sure how much that's what drove Steve Jobs, as that's how he thought he could sell the idea.

Brock: Did you think that at the time?

Baum: No, I didn't even think about it at the time. In retrospect, he might've-- I mean, it might've been something that, you know, somebody had said something, and he said, "Yeah, that's right, that's it." And then that's probably what-- because I remember the whole "bicycles for the mind" thing. I think that was something that really impressed him.

Brock: So it was something that he latched onto, as kind of a tool. Okay. In some accounts that I've read, people were talking about this time-sharing outfit that I think was in Mountain View-- Call Computer-- where everybody at Homebrew Computer Club was given an account, or maybe there were accounts there, and also that some of the early software development for Apple was happening on that system.

Baum: I... that, I don't know anything about.

Brock: Did that figure into the scene at all?

Baum: Not that I know-- except to the extent that Steve developed this thing which eventually turned into the Apple I, not that I know of. Some of the-- there was some guy that was at Call Computer that may have been involved in the Homebrew scene, as well, but I didn't know him.

Brock: Let's see. I'm just looking over my notes, here. Just to go back to that initial loan that your father and yourself gave to...

Baum: You can search for it online. It's-- somebody scanned it, and it's--

Brock: Oh, really? Oh, no! I'll have to look for that. I didn't come across it, but now that I know, I'll dig for it. Was that money that somebody else had been planning to give them? Who was that other person?

Hsu: Ron Wayne.

Brock: Ron Wayne was part of a partnership, and then got out quickly.

Baum: Yeah. He got out when it was... Ron Wayne-- there's lots of interviews with Ron Wayne that explains exactly his reasoning. He'd been burnt for something long ago, and he didn't want to get burnt again. He was too risk-averse, so he pulled out. But no, that had nothing to do with Ron. It's just they needed--

Brock: Oh, that was after?

Baum: Yeah. They needed $5,000 to build parts to deliver these boards, that they were then going to get paid $10,000 for, or whatever.

Brock: Got it.

Brock: When you were helping out with the Apple II, particularly this input/output design, and also the incorporation of both your disassembler and assembler into the ROM... there's that aspect of helping out your friends, who are starting this company. Did they pay you for that, or was there any...?

Baum: At that time-- God, was there even an Apple Computer at that time? Maybe not. Certainly...

Brock: Oh, maybe not.

Baum: Yeah. I mean, the Apple I was there before Apple started, right?

Brock: Right.

Baum: And the Apple-- I'm not sure how incorporation and when the Apple II design was finalized-- how those line up, exactly. But I'm sure the information is out there. But no. I mean, and... actually, with the IO design, it clearly wasn't, because Steve was still working at HP at the time. I got... yeah, he didn't-- they didn't have the parts in his stockroom, but I had it in my stockroom, so...

Brock: I guess you must've been part of the Homebrew when Bill Gates sent this letter that said, "Please stop copying my software."

Baum: I think I was in the room when they read that out, I *think*, but it's been a long time.

Brock: I'm interested just to hear about that context in which he'd feel the need to write that letter. You're writing programs to use on these homebrewed computers. Other people are doing the same thing. If you could you just talk about the culture around making and sharing software in this community?

Baum: Well, I mean, there was-- when you're a hobbyist, you depend on that, and you-- what you-- what goes around, comes around. So if you contribute something, you're building on the work of others, and that all helps. That changes when software becomes an industry, and in the homebrew scene, it was not really an industry yet. So I think that Bill Gates was, effectively, just ahead of his time.

Brock: What about software for the computers in your day job at HP, with the practices around software, around *those* computers? Was there the same thing of sharing, or had that become a business?

Baum: Well... I think that things like compilers and editors and things, you bought, but I didn't buy them. I never saw them. I just-- they were there on the computer. So that wasn't something I was really exposed to. And that was a much... you know, much bigger, polished, professional thing. It wasn't homebrew. It wasn't hobbyist. So what changed was, you know, software became-- software for PCs became a business, and that's what... well, you know, Bill Gates kind of spearheaded. But even with big computers, there was sharing going on. I mean, IBM had this user group called SHARE. Guess what? And then the same thing was true for lots of... you know, PDP-10 time-sharing systems. There were lots of programs you could just get; you didn't have to pay for. But if you wanted the compiler or something, you had to go to DEC and pay for it. That's a different thing. But that's... different class of programs. I mean, utilities

versus compilers-- you know, utility, it's a requirement. So operating systems, compilers, things like that, were usually-- you'd pay for. But things that were not for production work... special purpose-- you know, accounting software, something like that-- probably, you just got for free.

Hsu: So that was generally system software?

Baum: System software, you paid for, but--

Hsu: Applications?

Baum: Well-- sorry. I probably got mixed up in that sentence. Something like an accounting package-- professional accounting package. I mean, somebody would have their own little thing that they built and you could get for free, but if you wanted something that was professional and complete and supported, and all that, then you'd pay for it. But the industry-- the homebrew industry at that time was way too immature for that kind of stuff, until Bill Gates came along.

Brock: I guess your brother and your father were at Apple before their IPO, and there's this famous story about giving out the stock, or not giving out the stock. How did that touch them?

Baum: Good question. I don't know if my fath-- I actually don't know-- I think-- I'm not sure how or if my father got stock. I-- Steve Wozniak made sure *I* got some stock. I got a call from him. He said, "Hey, I need this information, because we're going to IPO, and I'm going to give you this."

Hsu: So that was just out of his own personal...?

Baum: Out of his stash.

Hsu: The Steve, the Woz Plan.

Baum: Yeah, the-- you're right. I mean, he had, what, 45 percent of Apple at the time, so... or some number.

Brock: Yeah. Well, that was... okay.

Baum: I still have one of those shares somewhere.

Hsu: Nice.

Baum: The actual stock certificate. Yeah.

Brock: Wow. There's this trajectory that the personal computer is going on, which would seem, to me, different than what you were doing professionally at HP, with a very different and interesting line in RISC microprocessors. Did those worlds diverge? How should we think of it?

Baum: I think they did diverge, because... I mean, the whole RISC thing was pretty much aimed at DEC VAXs-- you know, mini-mainframes, things like that. And it wasn't for a very long time before something that you would call RISC actually made it down into microprocessors. It was just that the scales were just too different. Although, eventually, Intel x86s became just as good, and that's when you really saw that sort of thing hit. But even-- well, PowerPC was a RISC processor, by some definitions.

Brock: Is there a necessarily hazy definition for a RISC processor, since it's relative to complex?

Baum: Yeah, "reduced instruction set computer." There's a... there are some definitions, and there is a trustee at the museum that can read you chapter and verse. But the idea is to make things-- well... hmm. You're going to get a whole lecture if you're not careful. The idea is that these really complicated things, they have all this complicated stuff in it, but the complicated stuff, when it's used, makes things better, but hardly anybody ever actually needs to use them. So if you just get rid of it all, everything gets simpler, and then the stuff that you *do* use gets faster. And in an era of... where every transistor really mattered, that was a big deal. When transistors are free, doesn't mat-- there's some principles that matter, but overall, it really doesn't make that much difference. And that's why Intel really won, is because the stuff that made it complicated was an increasingly small part of the processor, so it really didn't matter. Underneath it, actually, it looks like a RISC processor. And besides, transistors were free, so it didn't matter, and they were very well aware of where they should, essentially, spend their effort. And that's what the whole RISC thing was, is, don't just spend your effort because somebody thinks they need this. Actually measure it, and see if they really *do* need it. And by the way, if they do need it, figure out how much it costs, because it might cost more than it's worth. That's sort of the principle of RISC.

Hsu: You mentioned PowerPC. Would you say that RISC architectures in the '90s, like PowerPC, like PA-RISC, DEC Alpha-- with transistors getting cheaper, were they moving away from those original principles?

Baum: No.

Hsu: Or were they still--?

Baum: No. They were actually doing something a little bit different, which kind of negated their advantage, and they were going to multiple instructions at the same time, and-- superscalar or out-of-order [execution]. And it turns out, if you put superscalar and out-of-order in there, then the amount of logic-- the complex stuff becomes just a little nit on the corner, and it really doesn't matter anymore. And by the way, when you build those things, you basically have to use RISC principles anyway, so it doesn't-- yeah, even the complex stuff underneath is RISC. Now, let's see. There's more trajectory you're missing. I worked for Apple at one point.

Hsu: Right.

Brock: And was that right after--? No, you were at HP, and then you left HP and went to... Thesis [ph?].

Baum: Thesis. So I was actually interviewing at Apple, because the project that I was working for at HP-- PA-RISC-- was now set in stone. Division was going to take it over. "Let's look at what we want to do next." And they decided they wanted to do something next, and I said, "That's-- I don't want to work on that. That's-- egh." So...

Hsu: What was that?

Baum: Hmm?

Hsu: What was that?

Baum: It was some kind of networking project... connecting everything to everything, or something. I forget. I don't think it ever went anywhere. So I interviewed at Apple, and... had a very nice interview, and they were going to make me an offer, and there was a hiring freeze.

Hsu: What year was that?

Brock: Eighty-four.

Baum: Eighty... four.

Hsu: Eight-four? Okay.

Baum: So... Wendell Sander had heard that I was interviewing. He was one of the ori-- you know, really early at Apple, and he was working with a startup in Menlo Park, run by a guy he knew, named Rex Rice.

Brock: Oh, yeah, from Fairchild Symbol. Wow.

Baum: Yep. Yeah, that Rex Rice. And he was working for this little company, and I forget what it was called at that time, but they changed their name to Thesis Memory Systems [ph?]. And they had this great idea, it was to build-- you know, everybody was making these DRAMs. And a million bits on a chip-- that was really hard to make, so they were throwing a lot of these chips out. But, you know, if you just took all those chips and put them together in a memory system, wrapped them with error correction logic, you could use these bad chips, which you could get for free from the manufacturers, and then put a big battery next to it, and use it as a giant RAM disk. So they were going to sell these systems. A really bad idea.

Brock: Interesting. Why?

Baum: I didn't realize this at the time, but now that I know more about the business, they don't make chips-- one-million-bit chips don't have a million bits. They might have 11-- you know, 1.1 million, and the other 0.1 million are spares for when things go bad. So if you had a couple of failures, doesn't matter. They'd sell the chip anyway. It worked just fine. If they had a chip that *didn't* work, it was probably so bad, you couldn't use it even with ECC around it.

Brock: It had some sort of fundamental defect?

Baum: Right. So, something much worse-- if it was just a couple of bits bad, not a problem. That's the first problem. The second problem is, if you put these things on a tester, you want to figure out if they're good enough to use. Well, testers, they just sit there and go, "Good enough. Done." To do this, you had to say, "Exactly how bad was it?" Which took 10 times as much time.

Brock: On the same tester?

Baum: Well, we had to actually build special-purpose testers to do that, because the regular tester just tests "yes or no." And testers are expensive. It really-- test time is *really* expensive, because the testers are expensive. So that's the second thing. The third thing is, when they test in the factory, they take this wafer, put it on a tester, and the thing goes *duk duk duk duk duk duk*. It tests all the chips, and then spits some ink on the ones that are bad, and they slice and dice it, and ship it out. Well, if we were getting these bad chips, we got the ones that had already been sliced up. We had to take each one, individually, and put it on a tester, line it all up, test it, take it out, package it.

Brock: You were getting unpackaged die?

Baum: Yes. How else were we going to get bad die? I guess we could-- probably, they could've been post-packaging failure, but probably not very many.

Brock: Okay.

Baum: And again, post-packaging failure is probably something fundamental. It just didn't work at all.

Brock: Right.

Baum: So it was a stupid idea in at least three different ways. So they've changed their focus to do-- to actually use *good* DRAM, and just-- and it's the battery-backed-up part that they were selling. They probably sold one or two of those. Oh, and it had ECC around it, so that was kind of nice. And then... they started-- Lotus had this extended memory card, so they-- we designed a replacement for that, and I don't know if they sold any. And the company finally went out of business when-- I think the creditors found the secret bank account, or something, is what I heard.

Brock: Somebody was...

Baum: Yeah. The VCs found the bank account that they weren't telling about, and finally pulled everything away. By that time, Rex had left. Lots of people had left. And my brother calls me and says, "Hey, look. There's this job opening at Apple for microprocessor designers." Hey! So I interviewed there and got the job, and we started designing this microprocessor. It was a secret project. They-- you know, Apple bought a Cray, once upon a time, and built a special building for it.

Hsu: Oh yeah, I keep hearing about it. We never knew what that was really f-- they say it was to design computers.

Baum: It-- that was intended to help design this microprocessor. It turned out to be-- it was a Cray, and it should've been really, really fast, and it *was* really, really fast, but not for the things that we were doing. <laughs> It turned out that we had a bunch of Sun Workstations that interfaced with this Cray, and they were just as fast as the Cray were, for the problems that we were doing-- the simulation jobs. But that was... later, we found that out.

Brock: Before we get into that, may I ask you what Rex Rice was like?

Baum: Oh, great guy.

Brock: I've read about him and his career. Actually, he would be the antithesis of the [RISC], ultimately complex instruction set sort of thing, right?

Baum: Oh, yes.

Brock: Going back to IBM, in the '50s, he was doing stuff, wasn't he?

Baum: Well, he was also-- I thought he was a *mechanical* engineer.

Brock: I have no idea.

Baum: He designed... he designed the DIP package, among other things. He was a great engineer. I was working in the lab, trying to get this memory system working, and it was failing. And I was trying to debug it, and then it would stop failing. And this happened a couple days in a row, and I said, "I can't figure this out. Why is this failing?" And we had this board, and the idea is we were going to take these bare die and just glue them to a board, and package them up. And we had some of these... you know, samples.

Brock: Like a multichip module, in a way, or something?

Baum: More like a DIMM.

Brock: Oh. Okay.

Baum: Except DIMMs have actually packaged stuff on it. This was like game consoles when you get the ROMs. They're just-- they just have this chip face-down, and a blob of glue on it, and that kind of thing. So we had this thing, and it wasn't working, and I said, "It's not working." He goes, "Well, what's going on?" I said, "Well, it got all these failures. And in the morning, there're failures. In the evening, everything works." And he says, "Okay, let's think about this. What's different? The sun's shining through the window into this thing, and you got this plastic package which is not totally opaque. That's your problem." <laughs> Pretty sharp. Really-- nice guy to work for. Now, having said that, till the day he died, he thought Symbol was a good idea. <laughs> It was a terrible idea.

Brock: Yeah. Well, I was fascinated to learn that we have the Symbol in the collection.

Baum: Yes. I was in the... in the [Computer History Museum] warehouse [the other day] when somebody pulled out a box of these blue boards, and they said-- they came up to me and said, "What *is* this?" And it says, "Fairchild Computer Systems Division." And I went, "*Fairchild*? Fairchild didn't build any computers except for the Symbol, which I saw over there yesterday. Let's see if it fits." And it did. And then I poked around in the arc-- not the archives, the accession records, to see how it got there. Because, actually, they built some other things, as well, and I wanted to make sure it was the right-size board, and everything. And there was a list of all the people from the Symbol project. I looked at it, and I went, "Oh, my God. I worked with him. I worked with him. I worked with him." I worked with like half a dozen people on the project, at least. And...

Brock: In different companies?

Baum: They... a lot of them were at HP. One of them, I'm working with now. Let's see. Who else was on that project? One with-- I run with. <laughs> It's just-- it was just weird.

Brock: Stan Mazor was on that?

Baum: Yeah. Okay, yeah. There was some Intel names I'd recognize, as well. It was like, "Whoa!" I had no idea all these people I knew had worked on that project.

Brock: How about that? Was that at the end of Rex Rice's career, then, this project?

Baum: No. He went from there to a company called the Engineering Department, which was run by Wendell Sander and Peter Quinn, both of whom I had worked with at Thesis. Peter Quinn was my boss. I believe he might've also been my brother's boss, at Apple. Who else was part of the Engineering Department? There're a bunch of names.

Baum: The other founder of Apple. The guy-- the money guy.

Hsu: Markkula?

Baum: Markkula. I think Mike Markkula was also involved. I *think*. But I might be misremembering that. There was some connection there. I don't remember exactly what it was.

Brock: Well, that's really interesting. Thank you. When you did get to Apple in 1986, I think this is, correct me if I'm wrong, but right after the turmoil, and Steve Jobs leaves, and...

Baum: By total coincidence, I worked for Apple during the years that Steve Jobs wasn't there. Wasn't-- certainly not anything on my part. It just-- that's the way it happened.

Brock: Did you see him socially in those years?

Baum: No. He was too busy... no, hardly at all. Every once in a while, we'd come across, but not very often.

Brock: How about Steve Wozniak?

Baum: Steve Wozniak I saw more often. I'd make time, we'd go out and have lunch, and things.

Brock: Right.

Baum: But even he was off doing his own thing, too.

Brock: In this period?

Baum: Yeah. He was-- Wheels of Zeus.

Brock: I don't know what that is.

Baum: He was doing-- he had CL9, which stands for Cloud Nine. He invented the programmable remote control for TVs. And he also did... infrared remote control amplifiers. So you could sort of just plug this on your remote control. You'd be in another room and do this, and it would switch channels. Worlds [*sic - should be *Wheels*] of Zeus-- he was trying to do a GPS pet collar, like for geo-fencing kind of things. And then I think that was too far ahead of its time. But he did some pretty innovative stuff.

Brock: But he wasn't a strong presence at Apple, by the time you got there?

Baum: No. After... after his plane crash, things changed a lot, and he went back to school, and then started these companies. And so he's still-- you know, I guess he's still officially an employee. I think they still pay him.

Brock: And that things changed for him a lot, just because of his perspective, with that brush with death, things changed for him?

Baum: I'm not sure what changed, but, I mean, he'd already been... I think-- oh, God. Who's the Apple...? I'm trying to remember what changed. There was something.

Baum: When they started moving away from 6502s, maybe. I don't know. But he started-- it seemed like he was losing interest, and there were some other things he wanted to do, like... have a big rock-music festival, and go back and get his degree... which he did. And he worked pretty hard at it.

Brock: Well, then maybe we could dig into this microprocessor project that the Cray wasn't as useful for as it should've been. What was the project? What was the thinking?

Baum: It was called Aquarius, and it was started by a guy that had come out of the supercomputer world, and he was going to build a little multicore processor with our own instruction set. And the way it was originally designed, there was no cache, nothing. It was just little, tiny memories, and you'd run some little code, and if you're gonna branch somewhere, you'd say, "I'm going to branch somewhere in a bit. Go fetch that code into this other chunk of memory, and then I'll jump to it." So, totally software-managed memory. And he had a compiler team that had worked on some supercomputer compiler, and they would be able to figure all this stuff out. And it was going to be a stack architecture, too, so it was a really tiny core. But there'd be four of them, they'd run really fast, and the compiler team eventually came back and said, "We can't do *this*. This is crazy." <laughs> And they made it a much more conventional machine. I was complaining about it, and I was actually so pissed off that they wouldn't listen to me, that I was actually interviewing other places. And eventually, the compiler team said, "No, this can't be done," and they adopted the approach that I was pushing all along. So... you know, there's... much more to this story. <laughs> Eventually, the project was canceled, and in hindsight, very good reasons. At that time... developing a microprocessor is really expensive. If we designed this and built it, no matter how good it was, we'd then have to go design the next one and the next one and the next one. That was going to chew up an amazing amount of money. Whereas... Intel and Motorola, they designed these wonderful things, and sell not just to Apple, which was a small part of their business, but to lots of other people, and totally amortize the cost. So there was another project that was starting up, using a RISC processor, that said, "Hey, this is stupid. Don't do that. Let's go partner with somebody else." So that killed the project, and probably, in hindsight, rightfully so. And let's see. The first pro-- I know the people on the other project. They were using... first, they started using an AMD chip, and then they decided-- because that chip had actually been used in some graphics card for a Mac. And then somebody said, "Oh, no, we can't do that, or we'll just totally piss off Motorola, and that would be bad." And the pissing-off part-- I'll get back to that. And then they settled on the Motorola 88110, which was an actually pretty decent chip, and what they were-- they asked for a whole bunch of changes, it would've made it even better. But then somebody had a bug in their ear, and said, "You know, their volume isn't big enough, either. We can't compete with the likes of Intel. We have to go and work with somebody else." So I was actually in some meetings

where they were looking at trying to get Motorola and HP to collaborate, and finally Motorola and IBM collaborated to do PowerPC. So that's how that started.

Hsu: So you were in that pretty early.

Baum: I was not-- I was in the meeting where they were trying to get 'em together, but I had nothing to do with those other projects.

Brock: Oh, okay.

Baum: It was pretty funny, 'cause we sat down in a meeting with HP, and saw all the guys I used to work with. But the pissing off part, AT&T was gonna actually fabricate the chips. They were gonna lay it out and fabricate it. They were doing the same thing for the Newton Project. There was a variation of the CRISP chip called "Hobbit," and when our project got cancelled, AT&T Microelectronics was basically left holding the bag. They put all this investment in there. They were pissed. And then they went to the Hobbit Newton Project, and said, "You know, this chip we're designing for you? You're gonna have to pay for all the development now and forever." They went, "Wait, wait a minute. The idea was that you develop this chip. We'll use it, but you get to sell it other places, as well." They went, "No, no, no, no, no, no." So a bunch of guys in the Newton Project had been looking at the ARM processor, and originally Newton was gonna be programmed in a language called "Dylan." It was a very object oriented language, and CRISP chip wasn't optimal for that. The ARM chip, with lots of [ph?] bit twiddling things was actually pretty good, and they did a sort of head-to-head comparison and said, "Look, ARM is, like, three times faster, smaller. We can just buy it." And they told AT&T, "Bye." And, well, actually first, they went to Acorn and said, "You have this ARM chip, you have this group there. Why don't you spin them out into a separate company? You know, we'll fund them to begin with. They'll develop these chips. We'll buy them. You'll buy them. You won't have to pay for their development, and they'll sell the chips elsewhere. The chips will be cheaper for all of us. And Acorn said, "Okay." And that's how ARM started.

Brock: Wow.

Baum: And they went to AT&T and said, "Bye." Now it turns out that that comparison, that head-to-head comparison was just a little, tiny comparison, and if they looked at a big, huge workload, I think they would have found things different. But for that little kernel, you know, it was-- and by the way, they never did really ship production with Dylan anyway, 'cause it couldn't perform.

Brock: The code for the Newton couldn't perform.

Baum: Yeah, yeah. So the high level language they were gonna use to program everything was just too slow. Now with, you know, an Intel Xeon processor, it would be fast enough, but then it just wasn't.

Brock: Why were they developing this language?

Baum: Because it had all sorts of interesting properties, and it was an object oriented language, and it was-- you can add, you know. It was Lisp-like. Sorry. It had a lot of the same kinds of-- nah, it was just object oriented. It's hard to explain, but--

Hsu: You could add, could you add methods to any arbitrary object <inaudible> class?

Baum: Oh, yeah, you could do all that stuff.

Brock: What was it about the Newton that made that, you know, they wanted this programming language kind of innovation and tool for the Newton?

Baum: I don't know why they decided they needed that.

Hsu: That's interesting.

Baum: But they eventually had to abandon it.

Hsu: 'Cause it sounds like they were trying to do Alan Kay's "Dynabook," in a way, 'cause, you know, the "Dynabook" is a portable machine with a Smalltalk object-oriented language on it.

Baum: Well, have you seen the? There was, Sculley had this video of the personal assistant.

Hsu: The Knowledge Navigator.

Baum: Yeah. That was supposed to be a step in that direction.

Hsu: Oh, okay. Huh. So Dylan was the technology that the Knowledge Navigator was supposed to be written in.

Baum: Probably.

Brock: Huh.

Baum: And I have to say that the development environment inside the Newton was actually pretty cool. It was, you know, you could just set up, you know, windows, and it was really nice, and have it automatically resize things for you.

Hsu: Oh, so it had automatic layout.

Baum: Yep, yep, way too far ahead of its time.

Brock: Was that something you had a direct role in?

Baum: I joined--

Brock: Or were you trying to figure out where you were in all these things?

Baum: So after our project was cancelled, I was part of just normal Advanced Technology Group, and I was trying to build a micro--

Hsu: And so Aquarius was part of ATG.

Baum: Yeah.

Hsu: Okay.

Baum: And that was cancelled, so I started just trying to make busywork. I was trying to design a multiprocessor using 88K processors. And I don't know what was going on, but I was pretty unhappy, and I called up Larry Tesler and said, "Hey, do you guys need any computer-- any architects?" He said, "Oh, no, no. We have plenty. We have great architects here, but, you know, we're doing this thing with ARM, if you want to move to Cambridge for a couple of years and be our liaison there." And I went, "Yeah?" I called my wife and said, "Hey, I got this idea. I think we're gonna be moving to Cambridge." She said, "Oh, God, all the way across the country?" And I said, "No, no. The other Cambridge." And she said, "Oh." So we went to Cambridge for a couple of years. I was Apple's liaison to ARM when ARM was, like, twenty-five people.

Brock: Wow.

Baum: And I actually joined either the same month, or the same week that their current CEO joined.

Hsu: Wow.

Brock: And that was?

Baum: '91.

Brock: Nineteen ninety-one. How did that play out? I mean, what was the success of that collaboration between Apple and ARM? Like, how would you describe that?

Baum: Huge.

Brock: You know, and how does it relate to the outfit that they bought that was-- where were they-- that became the basis of all their processor designs nowadays.

Baum: Ah.

Hsu: Oh, PA Semi?

Brock: Yeah.

Baum: Oh, okay.

Hsu: That's much later.

Brock: Oh, it is later, but it's also an ARM company.

Baum: Okay. Yeah. I was involved peripherally with that, sort of. Well, ARM was ultimately extremely successful. I mean, the money that Apple put into it, and the CEO at the time, Robin Saxby, decided that's sort of the business model and the business he wanted to pursue. He said, "Our advantage is like,

really low power. Phones, mobile phones need this. We're gonna go after mobile phones." And he did it and was spectacularly successful.

Brock: Right.

Baum: Apple owned a big chunk of it, but when Apple was really having hard times, they sold off their chunk at quite a profit, but they sold off the chunk. And then-- oh, while Newton was going on, some people from DEC came to visit, and they said, "Hey, we were looking at doing a low power Alpha and decided that just couldn't be done, and then looked at the ARM. We think we can make an ARM which is really low power, really high performance, really tiny, and cheap, and we can do it in a year. Would you use that in your Newton?" Cause, you know, we were using ARMs in the Newton, and we all kind of went, "Phhht, yeah. You can't do it, but, yeah, if you could we'd use it." That was the basis of StrongARM, which became a very successful business for DEC. And then DEC sued Intel. Well, I worked on the StrongARM 1500, which was a very interesting product. It was an ARM and a DSP kind of highly combined. It was supposed to be like video processing using set top boxes, and things like that. And then we finished that project and our group in Palo Alto, we were just gonna start an Alpha project. And just then it was announced that DEC was-- no. No. Intel, at that time, Intel, DEC sued Intel for patent violations, didn't go to them and say, "Hey, pay up or stop using it." They just sued them. Intel was completely taken by surprise. There was a settlement. The settlement was you have to buy our Microelectronics Division and pay us a whole pile of money, and everything will go away. So they sold the Microelectronics Division, which we were part of, except for the Alpha Design Group, 'cause they didn't think that they could sell that to Intel and have the SEC approve, 'cause the two can conflict. So I went away on vacation not knowing whether I would be coming back and working for Intel, or coming back working for DEC. And it turned out they decided to keep the Alpha Design Group, so I was still working for DEC. Except the reason for the lawsuit was Compaq wanted to buy DEC, but didn't want to buy 'em with this Fab and Microelectronics Division. So by doing this, they got rid of the Microelectronics Division, and now they could sell themselves to Compaq.

Brock: Wow.

Baum: Five years later, Compaq took the Alpha Design Group, gave it to Intel, so they could sell themselves to HP, I know guys that worked for DEC, Compaq, HP, and Intel, pretty much without changing desks.

Brock: Wow.

Hsu:. So you had gone. So when you had moved to Cambridge, you had left Apple.

Baum: I was working-- no. I was working for the Newton Group in Cambridge.

Hsu: Okay.

Baum: Then I came back, and Newton was going downhill, and I called up Dan Dobberpuhl, who was in charge of the Palo Alto Design Group here, one of the principals behind StrongARM, and said, "Got any jobs?" And he thought he could squeeze me in, so I went to work for them, much shorter commute, very nice. And then when DEC sold everything off to Compaq, Dan left and founded PA Semi.

Brock: Oh.

Baum: Wait a minute. He founded two companies. I got to remember the order. It was PA Semi. There was something before that or after that. Now I'm not remembering. He did something. He started SiByte. No. He started SiByte, and SiByte was designing a MIPS, no, Power[PC]? I can't remember what they were designing, but he sold that off, and then he started PA Semi, and then Apple bought PA Semi.

Brock: And it had, I guess, its collaboration with ARM had closed with the Newton?

Baum: Well, they still owned a chunk, and then they sold off the chunk, but DEC had an architectural license. That's right. So Apple then went and licensed it separately, and probably got an architectural license so they could build their own ARM processors. And eventually, for a long time, they were being designed by Samsung, and I think they finally switched over to completely Apple designed cores, but I don't know that for a fact, and nobody at Apple certainly will tell me.

Brock: Was there anything in particular that caused you to leave Apple for DEC?

Baum: This was when Apple was going through really hard times.

Hsu: Oh, '96?

Brock: It was '96.

Baum: Yeah, '96, and it was pretty clear that the Newton project was gonna be totally axed. That's why.

Brock: Okay. And that was the only area for which there was kind of creative microprocessor work in the company related to...

Baum: Oh. Well.

Hsu: The PowerPC was being designed by Motorola and IBM, so that wasn't in Apple's...

Baum: And actually, yeah, the guy that was lead designer of the StrongARM actually joined the IBM-Motorola-Apple thing, and got disgusted and left. And I think that's when he started StrongARM. Working for collaborations turned out to be ugly, as anyone on the Itanium Project at Intel can tell you, or at the HP side. Both sides will whine about it.

Hsu: So I do find it fascinating, though, that there were these two completely different RISC processor things that Apple was pursuing, StrongARM on one end, and PowerPC on the other.

Baum: More than two.

Hsu: More than two?

Baum: I mean, there was, well, there was their homegrown thing, was Aquarius. They also tried something with the 29000, the 881K, PowerPC. One of the interesting things was very early on someone had taken, well, actually that's the basis of the PowerPC. Somebody took a, was it AMD 29K, stuck it on a board, plugged it into a Mac, and made it essentially emulate a Mac using just-in-time compiling, things like that.

Hsu: Oh. Was that the Star Trek project?

Baum: That sounds-- Star Trek, I thought Star Trek was something.

Hsu: To do Mac OS on the x86?

Baum: I thought it was x86. Yeah. No. That was, same guy; same guy, Al, Al Alcorn was, I think, the manager for both those projects. Now this was something where you actually picked up an instruction, instead of simulating it, you essentially compiled it and [it] actually ran pretty fast, which was surprising how well it worked.

Hsu: Huh. Was that?

Baum: That was the basis for a lot of things that happened at Apple after that.

Hsu: Yeah. So I was wondering, was that the basis for the 68K emulation on the PowerPC?

Baum: Yep.

Hsu: Okay.

Baum: Different people did it, but that was, you know, they decided they could make it work, I think, on the basis of that early work.

Hsu: Right.

Brock: I was interested in just the kind of DEC operation out here, you know, in the second half of the 1990s, like, how big it was. How it fit into the rest of DEC.

Baum: There were a lot of buildings in downtown Palo Alto that were DEC.

Brock: Okay.

Baum: There were several different groups. There was the group I was working in, the Palo Alto Design Center, which was just a west coast, you know, design center, just didn't do any-- they collaborated with other groups. There was DEC SRC, the Systems Research Center, I guess, DEC WRL, the Western Research Labs. There was PAIX. The group that did Alta Vista, I'm not sure where they-- they were up there, too, and I'm not sure if they were part of SRC or WRL, or that was part of PAIX. So there were a whole bunch of really smart people in those buildings.

Brock: Yeah, so hundreds of people.

Baum: Yeah. We probably had, I'm trying to count, maybe-- I don't know if we had fifty in our building, but, yeah. There were a couple hundred probably.

Brock: It seems like it's not prominently-- I mean, these groups had been here for some time, like since the '70s, correct?

Baum: Some of them had, yeah.

Brock: Yeah. So it's interesting to me how it doesn't, in terms of the historical writing, you know, DEC's presence is a little bit invisible.

Baum: These guys really-- I don't know if Dan Dobberpuhl has been interviewed by you, but he certainly should be.

Brock: I don't know the answer to that.

Baum: 'Cause, yeah, he was one of the architects for Alpha. He was on the SiByte, StrongARM, PA Semi.

Brock: Oh, yeah.

Baum: I'm not sure. He's now on the Board of Directors of Movidius, who are doing chips that people are using for self-driving cars, I think.

Brock: Huh.

Baum: I think.

Brock: Well, I wondered if there, you know, if we just pause at this moment that's right around 1999 or 2000. Just, you know, was there any, in terms of your community, was there any still, the people who had been in Homebrew, or who had been in this area in the early days of personal computing, you know, was there activity? Did people still get together? Was there a network?

Baum: There is some kind of network now. It's mostly centered around a couple of different conferences, the Hackers Conference, and probably the Asilomar, used to be the Asilomar Microcomputing Workshop. I don't know. I'm not sure if that's the exact title now. Might still be that title. And a lot of those people show up, and a lot of other interesting people.

Brock: And that's where that kind of group gathers.

Baum: Yeah. And it's much broader now than just microprocessors and homebrews [ph?]; all sorts of stuff. There's physicists, and chemists, and Makers.

Brock: I am familiar with that Asilomar, or I know of its existence, I should say. The Hackers Conference I don't know anything about.

Baum: That started thirty years ago, or something, and they've been going for thirty years.

Hsu: Is that the thing that Stewart Brand organized? He organized a hacker conference that Woz went to, and Andy Herzfeld, and Stallman.

Baum: Yep. That was the first one, I think, and it was at, not Point Reyes, but forget what that beach is on the other side of Golden Gate Bridge.

Hsu: Stinson?

Baum: No, not that far. It's, like, Roosevelt Beach, or something. If you go across the Golden Gate Bridge and go up just over the hill, there's a beach, Conkite, Fort Cronkite Beach? Something like that. It's there, and there's a facility you can rent, and, yeah. And it's morphed a lot since then. That particular one was mostly computer people, and now it's just all kinds of interesting folks, many of whom are computer people, but not all of them.

Brock: Is that something that you have gone to and still go to?

Baum: Yes, not regularly, depends whether I'm in town and whether I think I can contribute. Right now, usually I'm working on things that I can't talk about, because they're gonna be products, and then I retired briefly, and there was nothing to talk about.

Brock: So silenced in both aspects. Well, unless you have a question, Hansen, I was thinking about asking about, you know, moving over to Intel.

Hsu: No. I guess you just mentioned that Asilomar has kind of been, I guess, the Maker movement has been a really big thing in it?

Baum: Asilomar and Hackers even more, I think.

Hsu: Hackers, yeah, hackathons, and things like that.

Baum: No. It's called "Hackers," unless you're trying to get your company to pay for it, then it's called "The Think Conference."

<group laughter>

Brock: It has a cover name.

Baum: And it costs more.

Brock: If you're thinking or if you're a hacker. That's funny.

Baum: They have some pretty interesting people talk there.

Brock: Does anything stand out for you that was?

Baum: Oh. I'd have to go back and think. I wasn't there last year, 'cause I was somewhere else, or something. It's often in November when I like to take off on vacation.

Brock: It sounds fascinating.

Baum: You have to have a lot of stamina.

Brock: Just it's lots of ideas coming at you?

Baum: Things start in the morning, and keep going 'til the morning.

Brock: Well, you know, you were talking about your colleagues who worked for many different companies while sitting at the same desk. Did that happen for you when Compaq kind of transferred your group to Intel? Did you have to move?

Baum: No. Then, I had to move. Mostly the people that did that were on the east coast. For a while, HP was actually shipping Alphas for quite a while, there were obligations, so there was a building in Schulsbury [ph?] that was, like, half Intel and half HP. And then every few months, like, they'd move the wall as people transferred over. They shared the cafeteria.

Brock: Wow. What was the shift to working with Intel like for you?

Baum: Well, it wasn't too dramatic in one sense. I had to suddenly start commuting to Santa Clara, but the entire roof just went Pfft, and we had been working, I mean, we were part of whatever, some microelectronics group in the Alpha Design Group, which had two primary locations, one in Hudson, and one in California. And so they all sort of moved, to Intel en masse. Some of us actually had to move, they just stayed in the same buildings, and we started working on another project together. This project happened to be an Itanium project, and so different architecture, you know, but same kind of work, and there's a lot of work sort of integrating Intel design practices with, you know, DEC design practices, and arguments about which design language to use, and which simulator, and lots of other stuff. But it was an education for both of us. I think there was a bit of cross-fertilization. And eventually things drifted off, you know. That project got cancelled, lot of politics, and not politics-- outside of Intel politics, maybe for good reasons, maybe not. Eventually the group got the project they really wanted, which was to design a better x86 server processor. They were finally able to do that, and I think it was quite successful. It was the--

Brock: What was the external politics?

Baum: HP.

Brock: Oh.

Baum: Well, the whole Itanium product line, it was badly done. You're doing this really cool-- well, first of all, there's internal politics at Intel. People had just-- there were a lot of groups that just hated the idea, and they wanted to do a 64-bit x86, but, no, they couldn't do that, because that would detract from this other thing, and eventually AMD came out with a 64-bit x86, and that just opened the floodgates. They had designed x[86]-- 64-bit things, but they weren't allowed to do anything with them. Now they could. So that, because so many people were not happy inside the company, the best people were not working on Itanium.

Brock: I see.

Baum: So I think that's the story I heard. There was just lots of politics going around, and fights with HP. "This feature should be in there." "No. We can't implement that." There's lots of that going on. So finally HP said, "We'll do it ourselves," and they came out with their own chip, which Intel fabricated, but they were the primary. Hm?

Brock: And called it the same thing, called it—or that was the Itanium.

Baum: The first Itanium didn't work so well. The second one HP designed, it worked better. And then Intel started to get their act together, and the ones after that were better, but by that time lots of other companies were looking at this and thinking, "Intel wants us to buy this thing, but they're in bed with their biggest customer, who's always gonna get it cheaper, and get the features they want," so hardly anybody used it. That just killed the product line.

Brock: I had never-- yeah, thank you. I've never been really able to understand that Itanium story.

Baum: Yeah. Originally, I mean, the original Itanium story that I heard was that there was a project at Intel to build a 64-bit chip, RISC chip. What I heard, which I don't think I've ever verified, was they actually went to DEC and said, "We'd like to license Alpha." And DEC told them, "No." So they had their own chip, which I've seen the specs for, which is very Alpha like, and they were working on that. And HP came to them and said, "Hey, we have this wonderful architecture. It's better than anything else out there, and if you build it for us and collaborate we'll be your best friend, and we'll buy chips from you, guaranteed." And Intel went, "Wow, we have instant market success. Sure." And they flushed the other one, and the rest is history.

Hsu: So how much was Intel really behind the whole EPIC, you know?

Baum: They were behind it in the sense that HP came to them and said, "We got this great thing. Collaborate with us."

Hsu: But it wasn't originally their idea.

Baum: No, no, not at all. It was, like, Bob Rowe, and folks at HP Labs, I think.

Brock: Well, let's see. And you were with Intel. You were with Intel for about a decade. Huh? Is that right?

Baum: Yeah.

Hsu: So the chip you worked on, the x86 chip, was that the Xeon?

Baum: Yeah. There was a couple of different Xeon chips I worked on, but started with this Itanium chip, and it was supposed to be 16 Itanium cores, and with an interconnect that looked vaguely Alpha like. And one of the first things I did is I worked on the interconnect scheme between processors that became QPI. I was part of that team.

Brock: So was it the DEC group who did the Xeon, then, eventually?

Baum: Well, did the Xeon. The cores, we did the things around the cores, the Uncore, it's called, so all the interconnects, the caches, everything outside the core, which, if you look at the area on the chip is, yeah, fifty percent of it, at least. But Xeons were supposed to be really good, you know, servers, so it was important that you be able to build multiprocessors with them. That's what we were concentrating on, which is what Alpha did, as well.

Brock: Okay. And the cores were coming from a different group.

Baum: Cores were coming from Oregon.

Brock: Okay.

Baum: Or Israel, I guess.

Brock: Right.

Baum: Mostly Oregon, I think.

Brock: And was that importation, or those core designs, were they specific to Xeon, or were these essentially just common core?

Baum: They were the best cores that Intel knew how to make, and they went into desktop chips, and they went into servers. The stuff around them was totally different. And there was some influence on the server group, you know, for features that enterprise chips needed.

Brock: Yes.

Baum: But not too much, and wasn't all that much needed, really.

Brock: I'm just wondering, in the circuitry the Uncore part of these server chips, is there an echo or an influence from just this long period of expertise and RISC and that whole ARM world?

Baum: ARM world, no. One thing that was developed by the group that came from DEC is the ring interconnect on the chip. That went into servers first, and I think has migrated to desktop now as well. And everywhere else in the company. So that, and the interconnect between the chips. So the interconnect on the chips and between the chips was developed by people from DEC basically.

Brock: But it doesn't sound to me like there's anything very RISC-specific with that.

Baum: The RISC-- anything that's RISC, no there isn't. The RISC specific stuff would be inside the core, and that's, you know, been going on forever for Intel. I don't think much of that has come from the outside.

Brock: So it's more a talented group of microprocessor makers that, I mean, what's coming from DEC. It's not like bringing, making Intel more RISC-like or something like that.

Baum: Oh, no, no, no. It's other things than just that. There are some fiefdoms in Intel. And the core designs are part of that. And the people that do it know those cores inside and out, and know every little-- they're good. They're very talented people, but it's hard for some other group to come in and do an x86 core, that would be probably stupid. It would take them years and years and years and years to get up to speed.

Brock: What about as a work environment or place to do microprocessor projects, Intel compared to--

Baum: Well, in my position, what I tell everybody is Intel was not a particularly fun place to work, but boy, it sure wasn't boring! There's so much going on and you know, a lot of it, I think it's the nature of the business. It's nothing about Intel. There's stuff about Intel I think that's incredibly well-run in many ways. I mean, they walk the walk and talk the talk, they talk the talk and walk the walk. And there are a lot of platitudes that are platitudes at other companies that actually Intel managers really do it. So there's that. But it's a big company with a business model that requires them to build tens of millions of chips that work in amazingly high volumes and they have to work for everybody! And that's a very tough business really, and they do it better than anybody. But it's hard to do, and it really colors the entire work environment, and the way that projects get managed and everything else. They do it as well as they possibly can, but it's just-- it's hard to be creative in that environment. I mean, we start a project, like a Xeon [ph?] project, they say, "Okay, work week this, five years from now, you're going to tape out."

Brock: Wow.

Baum: And they do, usually. They come awfully damn close. And they'll get chips-- and if they miss that date, well the fab's already moved on to putting something else through the line, so they might delay them quite a bit. I mean, everything is really scheduled!

Brock: Yeah, yeah.

Baum: And then if they don't get that chip up and running Linux in a week, it's really bad news. I mean, they're very good. And they work like dogs for it! And they get results.

Brock: Yeah, as you're saying, it's a very specific kind of activity that they're doing on this massive scale--

Baum: The massive scale is--

Brock: Getting things to yield at mind-bogglingly high yields.

Baum: That, too.

Brock: The margins and the timing and the discipline of that--

Baum: Yes.

Brock: I can see how it would be a hard environment to explore some new idea about--

Baum: I mean, they have research groups that explore new ideas. But getting those new ideas-- and they build them, I mean, they explore them, they write papers on them. But getting them into production, that's most-- that's really difficult. It happens, but it's really hard.

Brock: Are there environments in, let's say the past 15 years or so in microprocessors. You know, looking out across the whole landscape of the kind of microprocessor game where it's easier to ship a product that embodies some new approach or new idea in microprocessors or is that more like the Intel story?

Baum: I've seen-- there've been new approach, I mean, Nvidia is a completely different approach. It's kind of more specialized but they're kind of branching out. Intel is trying-- has to try to compete with that. And it's causing quite a bit of disruption, I think. ARM, I mean, the ARM business model is so different than Intel's that they're having trouble competing in those markets, even if they have superior technology. It's still-- it's hard, just because of the, you know, they depend on the large volumes. And ARM depends on aggregate large volumes, but not individual large volumes.

Brock: I got it.

Baum: Because it's just a totally different business model, and whether it becomes more successful in the long-run, we'll see, but it certainly has been successful up till now.

Brock: 2012, you step away from Intel. Just curious about what the thinking was, or the timing was of that?

Baum: Oh! Well, Intel, that's a longer story. Intel has a Rule of 75. If you've-- age plus years of service equals 75, you get to retire. I thought that I was going to hit that mark in February of 2012. But they had a slight downsizing, and they offered everybody a deal, and I looked at it and said, "Could we delay it for like a month?" And they said, "No." And then I looked at it further, and it turns out that age plus years of service, if you're 50 and a half and have 24 and a half years of service, not good enough, because they truncate before they add.

Brock: Oh, no!

Baum: But there are actually three different retirement criteria, and I met another one, because when we joined up-- backtrack. When the Microelectronics Group was transferred to Intel, that included the StrongARM Group. A month later, everybody in the StrongARM Group had pretty much quit.

Brock: Wow.

Baum: And that was mostly in Austin, because that was the only site. For a bunch of different reasons, but Intel was left with this product line they had to support, and almost no one technical left to support it. So when our group came over, they were determined that wasn't going to happen again, and they treated us very nicely. So one of the things was that my prior service with Intel-- actually with Compaq, guess-was counted as-- not for everything-- but for years of service, it counted. So after ten years at Intel, I had effectively fifteen years of service.

Brock: Okay.

Baum: And that plus my age added up to be enough, I guess. No it had to be 55 or older, and I was. And fifteen or more years of service, and that extra five years did that, so I could retire.

Brock: And so you chose to.

Baum: Oh, yeah. I was-- my wife was getting sick of me being on the phone for 24 hours a day.

Brock: It was really that kind of environment?

Baum: Well, the reason it was 24 hours a day wasn't because I was working all 24 hours. It was because there's a group in Bangalore, and there's a group in Hudson. That was annoying.

Brock: Yeah. And you, I think a few moments ago you described yourself as only having been briefly retired.

Baum: Ah, yeah. So I retired and then immediately started a bunch of volunteer jobs. One of which was here [Computer History Museum]. Which was my favorite volunteer job of all time. I'm also working at the Friends of the Palo Alto Library. And I'm now Chair of the Technical Committee on Microprocessors and Microcomputers for IEEE.

Brock: Oh!

Baum: Which sounds like a much bigger deal than it really is. Trust me. But it means I get to go to conferences in Japan.

Brock: Oh, cool, great!

Baum: Yeah, there are four conferences I oversee. And then I ran into someone-- I'm not sure how much of this story I can really tell. Because of something I found in the [Computer History Museum] warehouse, I found a wafer in the warehouse, and I said, "God, I know who designed that!" And then a week later, I ran into him at Stanford! And I said, "I just found this wafer you designed!" At which point he says, "Oh, that's what happened to it!" <laughter> But then he said, "I have something that you might be interested in," because he was starting a startup. So.

Brock: Okay, and so you have a connection to a startup now.

Baum: Yep. And then there was another startup that I've been following that it's very-- it's pretty open. And they have a new microprocessor architecture, which is *completely* different than anything else that's ever been done before.

Brock: Wow, what is that called?

Baum: It's called Mill Computing.

Brock: M-I-L-L.

Baum: M-I-L-L, as in the Babbage engine, called The Mill. I sort of call it Itanium-Done-Right, but that's-- it's not. It's way different. There are a lot of things that are similar for similar reasons. But it's a very different architecture, and very, very security focused. So--

Brock: Would it be a special purpose or--?

Baum: Totally general purpose. And it's a family of architectures from small to large. It all can run the same code, even though they are not strictly binary compatible. It's a very interesting idea. And there is one other person I'm kind of advising, as well.

Brock: Is that Mill Computer local?

Baum: Yeah, they actually meet a block from here. It's kind of a virtual company, 'cause there's no headquarters. Everybody kind of works at home.

Brock: Hm. Well, I guess I have some just more reflective general questions, but I thought I might turn to you, Hansen, and see if there's something you wanted to ask.

Hsu: Sure. Yeah, I guess I was interested in your thoughts of-- I mean, did you have any contact when you were at Intel with the Atom group? I guess you were completely on serv-- enterprise processors.

Baum: Yeah, I was enterprise process-- the Atom group was a completely different group. I don't think I even knew anybody in the Atom Project, the Atom Team. It's a pretty spread-out company. It's, I mean, right now most of the core designs are being done in Israel. Right? And other groups are doing other things with them. There's actually-- I guess there must be-- not sure where Knight's Landing [ph?] is being done. That might be around here, but--

Brock: Oregon, maybe?

Baum: No, remember when they-- there's also, when you're working on this chip, you might be getting the core from here, and the interconnect from here, and the memories from there, and so it's hard to say.

Hsu: Wow.

Baum: It's a big company, and there's lots of expertise scattered in different groups.

Hsu: So would you say-- you mentioned earlier-- would you say the reason that Atom hasn't been as successful as ARM in the low-power mobile space is because of the way that Intel business works?

Baum: I would say it's more that than the technical aspects of the chip itself. And it's because, the way I characterize it is that, if you wanted some chip that has a core and it's got this IP and that IP and this IP and that IP, you can go to somebody who makes something with an ARM core, and say, "I want something with, okay, an ARM core. Maybe this ARM core, that ARM core, and A, B, C and D." If you go to Intel and you want something with a core, and it has A, B, C and D, they'll say, "Oh, well, we have A, B, C and X, will that do?" And you don't have any opportunity to get what you want. If you told them five years ago you needed A, B, C and D, maybe they would have developed something like that, but you're not going to start it now.

Hsu: Right.

Baum: So that's the business model, they do things in large volumes, and instead of having little bespoke SOCs.

Hsu: They can't customize it for--

Baum: It's much harder for them to customize. They're trying to work into that, and then eventually maybe they'll get to that. But it's very-- it means ripping up a lot of stuff that they know how to do well. <laughter>

Brock: Okay, well, I thought that just a couple looking back at the sweep of your involvement with a couple different areas, just in looking from, you know, the sweep of microprocessors, just some reflections on, you know, where they've come, some of the most important, you know, as you see it now as you look back, some of the most important changes or touchpoints in that story. Just interested in your thoughts.

Baum: In the industry in general?

Brock: The industry, or for you, or just looking back on this microprocessor story.

Baum: Well, first I have to characterize sort of my own career, which was, I've really been in the right place at the right time for a lot of the stuff, for Apple, I was in this high school room when I met Steve Wozniak, all that stuff. I think the industry has changed rather dramatically. Just for me, learning to design processors. Now if you're a freshman in college, you're taking a course and as part of that course, you're going to design a microprocessor, which was head and shoulders above anything I would have dreamt of designing, and you know, at the height of my designing career. Just things are so well known-- like out of order [execution]. And you get a freshman-- or superscalar, does a superscalar processor, and they do it now. Now some of it is because they've been playing with their laptops all their lives and learning to program, and they've taken that, so they have a head start. And some of it is just that we just know that much more now, and we have much better tools, that they can do that. So that's been a big change. I think that it used to be everything about the core. And now I think it's all about the apps. There's some hardware stuff in there, and if we can get special purpose things for neural nets. But a lot of that, you know, neural nets, VR, AI, Big Data, you may see much more focused efforts in those areas, but general purpose things, what we have is actually pretty good. And it's gonna be hard to get a lot better. Maybe Mill can do that, but we'll see. So it's all gonna be, you know, programming models, we can get 16, 20, 72 cores on a chip, maybe more. People have done more than that. I mean, Intel sells 72 cores on a chip, I think. And getting them to actually do something useful, using all of them, well, a) is impossible, because the chip would probably melt; but, b) nobody knows how to do that, just because there's other bottlenecks and they don't know how to program for it. People are starting to figure that out. So there's going to be a lot of interaction parallels to make that happen. And I've seen some papers recently that look like they have some promising approaches. The other thing that's different now is the power wall. That just hammered everybody. And everybody knew it was coming, and they were hoping there would be some miracle and the miracle didn't happen. So yeah, we can get way more transistors on a chip than we can possibly actually power. So something's gotta give there, and I just don't know what. That has colored lots of things. At Intel, we're designing microprocessors, somebody comes up, "Oh, we could do this wonderful thing that will speed up this and make this go faster!" And the first question somebody asks isn't like, "Okay, how many hundreds of thousands of transistors is-- okay, how much power does it add?" If it adds one percent, getting one-- a feature that adds one percent of performance to a chip is a pretty big deal. It's kind of hard to get that. All the whole, the low-hanging fruit's been picked.

Brock: Yeah.

Baum: So getting one percent, that's good. If it costs more than one percent of power, pfft, why bother? We're power limited.

Brock: Power limited in the sense of, now, when you say that it can't-- all these regions of transistors can't be powered, is that this idea that I've read about of like dark silicon, where it's just not called upon frequently enough? Or is it literally like you know, you couldn't-- you don't use the areas of silicon, because you don't have the power supply. Or you don't want to supply it with the power.

Baum: Well, there's a lot of all of that. There is dark silicon. If I have a multiplier on a chip, and I'm not using it to multiply, then I don't actually try to clock it, because that uses power. And there's clock-gating and there's power-gating. Two slightly different things. Both of them sort of have the same effect. One of them has more of an effect than another. Like clock-gating, the transistors aren't using any power, but they're leaking. So that leaking is power. Power-gating, you even turn off leakage, but if you actually need it for something, you'll have to wait before it turns on again. So there's lots of tradeoffs there. And Intel will put processors to sleep, and then wake them up again, but managing, "Okay, can I go to sleep now? Because if go to sleep now and then all of a sudden this thing comes in that I have to do, it's going to take me forever to wake up. And while it's waking up, I'm basically wasting power." So they don't want to go-- that transition has to be done as infrequently as possible. So there's lots of interesting design tradeoffs there, shall we say?

Brock: And this is all because we're carrying around these processors in something with an inadequate battery or something?

Baum: That's one reason, but not even that. We're, you know, data warehouses have lots and lots of processors. They put them next to dams so they can supply the power to them, and supply the cooling. That costs just a tremendous amount of money. So power is everything now. I mean, nobody, you go to a conference now and somebody has a new cute architectural feature, these grad students that write these papers, they don't ignore power anymore. They go quite a bit of detail about why this is better, and it will actually improve the performance without causing more power. That's a big change.

Brock: Yeah. What about the change of just where computing is in our society today? You know, from a time when it would have been-- you know, it would be you and your friend, Steve Wozniak, were unusual for being high school students who were really interested in computers to today. You know, just in terms of people's interactions with computing.

Baum: I think it's a different scale. We're working from a different baseline. I mean, before the baseline was nothing, right? Now the baseline is, "I've got my Raspberry Pi. I can put a web server on it, and I can do this. I can connect it to a camera, I can go to-- well, I used to be able to go to Radio Shack, not anymore-- but there are places you can just buy these things, plug them together." Now there's a lot-- you need to do a lot more in software to get this to work. *IEEE Spectrum* has a column about some guy who just decides, "Okay, I'm gonna do this thing." And he says, "Okay, I got to slap down a Raspberry Pi board. Oh, yeah, I'll take this out, do this. I'll just write some code, and--," that's where it is unless you know, really have that coding background, it's much harder to do anything, because you're-- once upon a time, you could think about wiring your own-- buying the chips and wiring them together, and making a little processor. But now, you're not gonna do a foundry in your garage. I know one person that tried. <laughter> She made some interesting-- she made transistors.

Brock: Home-brewed transistors. Huh. Wow! I've never heard of that!

Baum: Yep. And she's like, you know, used an old microwave to do annealing or something. She's quite-- she's a pretty impressive person, I have to say.

Brock: Whoa! Yeah, that's interesting, because now the minimum component is either a whole system, or the processor.

Baum: And it takes rather large teams of people to build those little systems.

Brock: Yeah. <laughs>

Baum: So that's something that—you know, kind of inevitable. But anybody can write a piece of code. You don't need to-- you know, you can get a compiler and you can start writing the code yourself, but you can't actually-- having said that, you can get gate arrays-- not gate arrays-- FPGAs.

Brock: Yes!

Baum: And you can actually design your own processor. And so you could do that, and people have done that, and people are doing that.

Brock: I'm interested in your thinking about maybe not the technically inclined people, but just like the general use of computing, or almost the-- what would you call it? Almost like the transitive use of computing. You know, for people whose lives are shaped by other people using computing.

Baum: Oh, it's ubiquitous computing. It's there, and sometimes you don't even know it's there. It's in some-- how many microprocessors does your car have? I've heard some pretty large numbers, which like kind of boggled me. Like what are they doing besides twiddling their thumbs?

Brock: Yes! <laughter>

Baum: I mean, people know that-- I think they know that cellphones have processors in them. I don't think they think about it. They think about the apps that's on it. And home automation. You know, it's like once upon a time you get a burglar alarm for your house. You didn't think about that in terms of microprocessors and they didn't have microprocessors. But now they do, and they can be much smarter and have cameras that sense whether it's your cat in the house or something else. That was an interesting homebrew project. Some guy was kind of sick of his cat dragging in mice into the house. So he set up a camera that actually recognized the cat's silhouette, and whether it had something in its mouth, and wouldn't let the cat door open. <laughter>

Brock: That's really funny! And I wonder if a cat would change its behavior.

Hsu: Right.

Brock: Yeah, that would be the interesting thing.

Hsu: Would the cat know that it was the mouse?

Baum: Oh, it wouldn't know it's the mouse. It would just stop trying to bring it in, 'cause it couldn't after a while, maybe. I don't know. I don't think our cats are that smart.

Brock: I don't think any cat I ever had would actually change its behavior. <laughs> What about just the whole, you know, trajectory of Apple, you know, since you've seen it go from, I don't know if it is still today, you know, the most valuable company by market capitalization, or it's certainly become this--

Baum: Close.

Brock: -- gigantic thing! I just wonder what you make of that, you know? <laughs>

Baum: I'm pretty amazed. Actually, when I first saw the iPhone, I was completely blown away. I didn't think anybody could actually build anything that worked that well that small. And they did it. So. But even conceiving that project, <laughs> that took some guts. I mean, that was such a difficult project. It was just so far ahead of its time. That sort of thing doesn't happen very often. I've seen it happen once before. HP came out with the HP 35 calculator. Two years later every slide-rule company in the world was probably out of business. It was that much of an advance. And a lot of the same-- that was an amazing project, too. I wasn't involved. I didn't start working for them till afterwards, but worked with the people that did it, and that was a one-year project.

Hsu: Wow.

Brock: Wowwww!

Baum: With custom ICs, custom keyboard technology, custom power supply technology, custom display technology. Everything was-- it was just an amazing project. Probably custom algorithms, too. It was very impressive.

Brock: Okay, and I guess then your impression of Steve Jobs when he came back to Apple in '96, what you made of watching your former high school friend, you know, in that role?

Baum: You know, all those things about him being a visionary are actually kind of accurate. I mean, he could see a much bigger picture. He could see connections between things that I think other people just didn't see, or he made connections that people never considered making.

Brock: Interesting.

Baum: But he did a lot of-- when he came back-- Apple was kind of organizationally messy when he came back, and I think he cleaned a lot of that stuff up, and just really streamlined things. I mean, he did have an artistic sense, and he sort of applied that in some very interesting ways. I would say it's almost a Japanese aesthetic, which is something I like a lot. So.

Brock: It resonated with you.

Baum: Yep, yeah.

Brock: And then just wondering if there's kind of an early Apple community for people who were, you know, today-- I mean, we talked about the Hacker Conference, and the Asilomar. Is that where that kind of people who were around at the emergence of Apple would be seeing one another and getting together?

Baum: There's been at least one re-- there was a 40th Reunion recently. And there have been some, like reunions, and they're parties! <laughter> And there's a guy that has sort of a yearly picnic, Ed Zotz. But other than that, not too much. There's, yeah, there was an event here. Some kind of anniversary party here a while back.

Brock: I think I've seen some videotape from that.

Baum: Hm. But there was one in downtown San Jose a year or two ago.

Brock: Hm. Well, I think that exhausts my list of questions, unless there's something you want to ask Hansen.

Hsu: I think I'm good also.

Brock: I'll just ask if there's anything that we really should have asked you that--

Baum: Oh, I'll think of it later.

Brock: <laughs> Okay, well, we can get back together. But I think then we'll just thank you very much for your time today.

Baum: You're welcome!

Brock: Thanks.

Hsu: Thank you.

Brock: Thanks so much!
END OF INTERVIEW