



Oral History of Bill Saperstein

Interviewed by:
Douglas Fairbairn

Recorded December 14, 2022

CHM Reference number: 2022.0175

© 2022 Computer History Museum

Fairbairn: We're recording this oral history with Bill Saperstein. It's December 14th, 2022. We're at the Computer History Museum, and Bill, we're delighted to have you here. My name is Doug Fairbairn and I'll be doing the interview. So, Bill, we like to start these interviews out with going back to the very beginning. Where were you born and raised? What was your early family life like? What were some of your influences in terms of steering you the direction that you eventually took? So, let's just start there.

Early Life and Education

Saperstein: Sounds good, and it's a pleasure to be here and to meet all of you guys. Yeah, look, to start off here, I was born in Tampa, Florida, 1949, and which says I'm 73 years old. Very much in the country, so I really never even saw anything but a two-lane highway for most of my high school life. Yeah, I still remember my mom used to tell me-- she used to remember me taking my dog to school, and that's the kind of the way it was, a true country environment. The schools were not the best, as you can imagine, at that time. The schools in the South were, I would say, pretty behind in the maths and the sciences. My father was a cartographer, and my mother was a teaching aide So, I had a little bit of exposure to the mathematics of what my father would do as a cartographer, as a civil engineer, but he didn't have a college degree. He learned most of what he did when he was in the service.

So, I was interested in a number of things. I really liked to write, but mathematics came pretty easy to me at that time through most of junior high and high school. Science was interesting, but there wasn't a very good curriculum, so I really gravitated more towards math. Then I was always into water sports. Since my father was surveying a lot for the coast, I was almost always in the ocean, either swimming, or surfing, or fishing.

Fairbairn: You mentioned the-- surfing was one of your great loves, if you will, but I didn't know you-- there were <laughs> enough waves to surf in Florida?

Saperstein: Yes, on the West Coast of Florida where Tampa is, very, very minimal amount of surfing there because of the Gulf. But on the east side, Cocoa Beach, the surfing is pretty good. As a matter of fact, the best surfer in the world, at least the last few years, Kelly Slater, is actually from Cocoa Beach, , where I used to also live.

So, my father got transferred up to Washington D.C. the last few years of high school. So, when I went up there, I had never seen snow before. I'd never seen a four-lane highway, but the main thing was I had never seen the Smithsonian Institute and some of the museums that were up there. Of course, the high schools were phenomenal. I had teachers that had PhDs and they really encouraged doing independent studies. I had a great lab in physics and in chemistry which I never had when I was in Florida, and that piqued my interest. Although I still was really interested in writing, literature, and I was also interested in music a lot. I was not a trained musician; I was more just learning folk music on my own. At that time, that was the big thing, was the--

Fairbairn: Was that-- did you play guitar then?

Saperstein: -Bob Dylan thing. I played guitar then for quite a lot. Coffee shops and stuff like that. I was up there for two years, beared the snow, and the cold weather, and the water <laughs> up in Maryland area, when I would go to Ocean Beach, and then applied to some schools for college. I would have been the first one to go to college in my family and got accepted. The first one that accepted me was the one I took, which was Georgia Tech. I thought about trying to get into an MIT or a Caltech, but I figured I probably didn't have the grades, or the level that was in those. But Georgia Tech accepted me right away, so I went down there.

Fairbairn: Before you get into that, did you have any siblings? Did--

Saperstein: I have one brother who's actually older than me, and that's it. He still lives in Florida. He's retired. He's six years older than me.

Fairbairn: So, were there any of your teachers, for example, at high school, that steered you in a particular way? Or did anybody have any major influence on you?

Saperstein: My physics teacher in high school was very influential in making me really enjoy experimental physics. We did things a lot in his lab. Besides learning the fundamentals, he would basically say "Well, let's do experiments to really understand these laws." In that last year that I was there, a lot of the physics I did was out of the classroom because they had both a regular classroom and an independent study program, which allowed us to go into advanced physics. At that time there was no AP stuff, and allowed us to do calculus in high school. At that time, there was very few schools that had that.

This was amazing because I was going to school in Montgomery County, which was probably one of the best counties in the United States, they said, for high schools. Not that we were living in a great place. We were living in a small apartment, but we just happened to be zoned in the right place. So, we had this great high school. I can remember building telescopes, we built a GPS system, and we did a lot of experiments that-- just our own concoction. But you got to remember that at that time there was a lot of defense research going on. So, the Naval Research Lab, and Goddard Research Lab were all totally around us, right? My physics teacher, who had a PhD, had these connections because he was a real avid astronomer, and he was actually really well known in the area at the Naval Observatory. So, we would be able to go there and then we could get equipment, and so we would build up something like a GPS system by borrowing from the Naval Research Lab, the antennas and whatnot. We were the only place that I know that was setting up this giant antenna on the roof of the school and pulling in GPS data. This was back in the early '70s.

Fairbairn: Wow.

University Education: Georgia Tech and Stanford

Saperstein: It was pretty amazing. So, yeah, it was a total shock and it really made me appreciate education much more than what I had seen in the South. And also then made me say maybe I should go to college. Although I was really not that into college because I just really could not stand being away

from the nature that I loved, which was really being in the water a lot. So, with some trepidation, accepted the offer at Georgia Tech, which is landlocked in Atlanta. I had never lived in that much of a city. I was kind of in the suburbs of Maryland, outside of Washington. So, at least I was able to see trees and not to have a sidewalk around me all the time. But in Atlanta we were-- Georgia Tech is right in the middle of the city, and it's kind of a different type of school in that it's like a factory for engineers. But it's got some really great discipline on the engineering process.

I wasn't sure I wanted to be an engineer, but I signed up for aerospace engineering, and an opportunity came for me to co-op down at Cape Kennedy, Cape Canaveral, Cape Kennedy, which is a work study program that they had. Since I didn't have a lot of money, I wasn't on any type of scholarship at Tech, I had to figure out how I was going to pay for the place. So, the work study worked out really well. It was going to take me longer to go to school, but that wasn't my real worry. So, I would go down there and the beauty about that was it was right on the beach.

Plus, the beauty of being in a fenced-in area that was run by the Air Force and NASA was that you had the beach to yourself because nobody else could go in there and go surfing. So, I could bring my surfboard in there and have a blast, although the guards didn't like it too much and sometimes kicked me off the beach. So, I did that for all the Apollo programs, I worked on every one of them. Not heavy-duty engineering, but I started there on Apollo 7, which is the one that had the accident on the pad, all the way through all of the launches of Apollo, working in the vertical assembly building, and basically doing more engineering grunt work, where I was checking the data logs from-- that they were running during all their tests on pad and off pad tests.

Fairbairn: So, you were there for every launch?

Saperstein: Every launch, yeah. Every launch when I was-- if they were happening in the summer and in the winter, I was there, and then fall and spring I was back in school.

Fairbairn: Tell me about being next to a Saturn V launch.

Saperstein: The first one that happened was unbelievable. You're three miles away and you can still feel the vibration. The windows of the trailers that were out there for the press were being knocked out by that launch. It's pretty amazing, and the astronauts were there, you got a chance to meet them. But you really learned how triple redundancy was necessary, especially after Apollo 7. It was a whole year lost on realizing that they were not as safe as they should have been.

Fairbairn: This is the fire in the capsule?

Saperstein: This was a fire in the capsule, and on hindsight, yes, it was definitely a big mistake. But then they started to also realize that god, we were successful in Gemini when we probably should have had the same type of mistake. At least it grounded NASA a lot more. It's not to say that the other accidents were going to be preventable. It's just most people don't realize how risky space flight is, and even with the redundancy that you have. I mean, right now we did all of Apollo with 8-bit microprocessors. It's just hard to believe, right?

Fairbairn: Slow ones, slow, they--

Saperstein: <overlapping conversation> Yeah, what's running in your microwave is more than what we had in those, and just the ability to do things, the engineering feats. The transporter in its own right was-- I can remember the Society of Automobile Engineers gave that vehicle the Vehicle of the Year when that was finished-- I mean, rather than any car made. That was phenomenal, right, that vehicle. The civil engineers made-- gave the award to the-- not the-- what is it? The few mile pathway from the VAB to the Pad 39, because it couldn't be more than an inch off, or something like that. Otherwise, the rocket would have tipped, right? So, it was amazing. A lot of people there, a lot of cross-functional communication and interaction. There was a lot of vendors, a lot of people that were subcontracted. So, just that communication, and that it all worked together is just hard to believe back then. So I did that, and then after Apollo, I was assigned to Launchpad 37, which is the old Saturn 1B launchpads, which were used for the launching of the Space Lab. The first one, that was basically—the early sky labs were just the second stage of the 1B <laughs> rocket. Although I wasn't involved with any of those launches, because I finally graduated about that time when they were just about to launch those, I was actually there maintaining the launchpad. It was kind of fun because it was just myself and two other people had this—these two launchpads, 37A and B, that we were able to just do whatever we wanted. We could go out there and hunt rabbits if we wanted to. It was, again, still pretty amazing that all of that stuff still had to maintain and keep working even though you were right by the salt water, and it was rusting every day. So, you would just have to go out there and sandblast it and paint it on a regular basis, and keep the electronics working, even though the electronics, like you said, was very old, 12-inch CRTs, stuff like that. So, it took me six years—

Fairbairn: Back to Georgia Tech. <laughs>

Saperstein: Yeah, it took me six years to get out of Tech, and even though I started out as an aerospace engineer, I realized that I didn't want that much rigidity in engineering. I wanted to do more math and then I got hooked on physics when I started taking some of the undergraduate physics classes. So, I switched over to applied physics, which is more experimental physics. The other reason was that Georgia Tech's applied physics program gave you the opportunity to do a lot of electives besides your main core.

So, the engineering courses I was really interested in, I could just take those as my electives. So, things like material science was really very interesting to me. Electrical engineering was really fascinating to me because at least at that time, Tech was really big in electromagnetics. So, the tie between electromagnetics and physics has always been beautiful for me, because, once you learn Maxwell's equations, you realize the beauty of physics, and the beauty of nature. So, I was really just enamored by E&M theory. So, after I did the theoretical aspects in the physics side, I took all the EE courses, because I really said "You know, this is probably what I want to do. If I can't do what I really have a real passion for, probably I should go into engineering." Like I said--

Fairbairn: Passion being the physics?

Saperstein: No, the--

Fairbairn: Or--

Saperstein: -passion being--

Fairbairn: Or music? <laughs>

Saperstein: -the music. Also, since I had been raised in the country, and my parents not wanting to see me leave the homeland of Florida, they said-- because they had moved back down to Florida from Maryland. They said "Well, you love it out here, why don't you come back? You like animals, why don't you go into veterinary school?" I said "Yeah, I do love animals, but I don't know whether I can get into veterinary school." So, actually, my last year, that year that I was deciding what I was going to do when I came back from Europe, I was teaching labs in Atlanta, and I worked in a veterinary hospital to see whether that's what I wanted to do. So, I was put on a waiting list to get into a Georgia veterinary school. You have to wait for two years because you're not a resident. I was a resident of Florida. Florida doesn't have a veterinary school. So, I said "I'm not going to-- I can't wait that long." So, when I came back, like I said, Stanford was there, and so I went to my professors at Georgia Tech and at that time the President of Georgia Tech, Dr. Pettit, was-- well, he used to be--

Fairbairn: Oh, he was from Stanford.

Saperstein: He was from Stanford.

Fairbairn: I remember that, yeah.

Saperstein: So, I went to him, and I said "I'm being offered this assistantship there. I really love E&M and microwave design." He said "Oh, then this is the place for you to go. They've got a microwave lab there, they've got Varian labs there, they got Raytheon." The foundation of a lot of the funding for Stanford was--

Fairbairn: Yeah--

Saperstein: -the microwave. So--

Fairbairn: -right.

Saperstein: -you probably know it from when you were there.

Fairbairn: Yeah.

Saperstein: So, I did that. I said "Okay, well, that's encouraging. I guess I'll accept it." But before I left, I went to one of my physics teachers, and I said "I'm going to go to Stanford." He said "Oh, okay, that's good. I know a few people that I went to school with at William and Mary. I'll put in a good word for you." One of them was a professor here, now he's passed away, but he was professor emeritus at Stanford called Bill Spicer. So, my professor and friend at Georgia Tech put in a good word for me. So, I go out to California. It wasn't my first time out, I had been out to California on a surfing trip and fell in love with the

surf out here, but I had never surfed up north. I was always surfing in the southern part. I was just a bum then. I was just kind of working my way down through there. That was one summer.

So, I go into Stanford, and I check in, and I say "Okay, I want to go to the microwave lab and talk to some of the advisors there." He said "Well, there's no more microwave lab. We've stopped the microwave program, and there's really no more microwave programs going on. There's some basic E&M at the graduate level, but Varian is not funding, and Raytheon stopped their program." So, I kind of said "I came 3000 miles to go to school here and now you're telling me that?" They said "Yeah, well, you can go to the microwave lab," and that was called the Ginzton Lab, and "They've switched over and are totally doing laser technology." I said "Well, yeah, I've had one laser class when I was an undergrad. Very interesting, but I'm not that-- I don't know whether that's what I want to do."

So, then I contact Bill Spicer and I say "I'm come over here, I have an assistantship, but a research assistantship, not a teaching. But the field I want to do research in, there's no more field here. So, I can go and do research under one of the profs for a laser, but I don't really want to do that." So, he was saying "Well, why don't you work for me?" I said "Well, what do you do?" He said "Well, we do solid-state." I said "What the hell is solid-state?" He said "What do you mean?" I said "What is solid-state?" I mean, he said "Well, it's semiconductor technology and electrical properties of materials." I said "I studied vacuum tubes and I had maybe a chapter on the transistors, and that's about it, even as a physics student. So, he said "Oh, you can learn this." I said "Is it experimental?" He said "Yeah, that's all we're doing is experimental. It's not theoretical," although he had a great tie-in with the theoretical group. So, I said "I'm not going to go back, I'll give it a shot." So--

Fairbairn: Yeah, there's a lot of good physics there, anyway.

Saperstein: Yeah, it was. So, he said "Okay, here you go." So, I was an entry level graduate student there and, of course, I had to take a lot of the courses. I had no knowledge at all of solid-state. So, I took as much as I could. I passed his classes pretty well, and so he was really quite happy with me, but I was not really wanting to go into that type of physics as much as really applied stuff. He was doing a lot of work that was at SLAC [Stanford Linear Accelerator Center], so it was really experiments that were reinforcing some of the theoretical work. So, he was working with the Synchrotron, and I was working as support there. Synchrotron, you kind of get your time slot, so my time slot was like two o'clock in the morning, and we would run our experiments. A lot of interesting vacuum technology. But I was more interested in the EE application, so I took a lot of double E classes.

And then my interest in E&M, since it wasn't there, I was able to get some of that by-- at that time, there was a big thrust in acoustic. So, acoustics is very similar to E&M, a lot of the theory is. I took all the acoustic courses I could. Kino was teaching it then, and Bertram Shaw. So, they were the experts in the country, so I would just go in there and they said "What are you doing here? You're not doing research for us." I said, "I like this subject, and so I'm just going to take it." So, I did that, and then in the middle of all of this, I met John Linvill, who was the head of the EE department, and I really was enamored by his entrepreneur application of his knowledge. He had done Telesensory Systems at that time for his daughter's vision, and so he said, "Would you be interested in doing some experiments with me to develop these materials that we can use for the Opticon?" I said, "That sounds really cool." So, I asked

my true advisor, Bill Spicer, I said "I'm going to split my time. It may take me a little bit longer to get my degree." At that time, I was on the PhD program, even though I told Dr. Spicer "I have no intention of probably getting my PhD, but I want to take all the courses, and I want to get into research." The only way that I was guaranteed I would be able to do research is if I told them I would be on the PhD program.

So, that's what I did, and I spent half of my time in Linvill's lab, which they were building up as a semiconductor processing lab, if you remember? And then half of it working for Spicer. The good thing was once I got out of the SLAC thing, Spicer gave me an Auger system, and then I said "Well, I want to study the materials, but I want to study how they apply to devices." So, I said "I'm not really satisfied with understanding even how a Schottky diode works, and nobody's told me how. So, let's look at it from a true physics point of view, and let's look at the spectroscopy. Let's do Auger but let's make a Schottky diode in a vacuum chamber," and actually not have any contamination at all, and really see what an ideal Schottky diode would look like. So, that's what I did, I designed the experiments, and we did that. It was the first that had ever been done and it was really fun because I had experts in Ojay, I had experts in vacuum technology, but I was the guy that wanted to apply it to a semiconductor device, not just a semiconductor material. Then Linvill was saying "Okay, I want to make this. I want to make a device that can actually"...

<pause in thought>

Saperstein: "Tickle the fingers for the Opticon." That's what it was. It's a Braille reading device. If--

Fairbairn: I remember the name, I was trying to remember what it was.

Saperstein: Probably something that you may even have in your museum. It was a reading aid for the blind. His daughter was blind and a true inspiration for all the engineers was-- he never said he was playing god, but he was saying "This is what engineering is all about, is giving something to society, and what better thing to do than to do for my daughter?"

So, he invented this device while he was there, and then he started a company called Telesensory Systems which did talking calculators, and this, and that. He was actually well known. It was the starting of the entrepreneurial aspect of a carryover of what Terman started with Hewlett and Packard. He actually went to Congress, when he was my advisor, and presented to them saying "You guys got to give this seed money to the universities to be able to start companies, like Telesensory Systems. These students are able to do that." Because he used to hire a lot of kids to work in there.

So, he asked me to do this device, but he didn't want me to use piezoelectric ceramics, which is what he had right now. At that time, I found some plastic piezoelectric, and with his help we developed a cantilever design for this plastic which was used for speakers by Pioneer at that time. But, of course, we couldn't get the movement that- a normal ceramic piezoelectric. So, we had to make the structure, basically design the structure in the plastic that would do that. Well, I said "Gosh, you've got an IC lab here. Let me try to use lithography to do this." So, we developed that, we patented it, he started using it. It lowered the cost immensely for the Opticon, and that's when I got introduced to Jim Plummer and all the guys in the IC lab. I said "Golly, this is a really neat place," <laughter> and--

Fairbairn: <laughs> You really went from several--

Saperstein: That was my biggest problem, was that I was like a butterfly flying around saying "God, all this stuff is so neat." But the beauty, Doug, is that it's all fundamentally based on physics. The beauty, to me, was almost everything, even Linvill's understanding of the way we looked at semiconductors, and Spicer's too, it's all Maxwell's equations. It's those basic equations that go all the way down to the atomic level, they don't go down to the subatomic level, but the atomic level. Maxwell's equations makes it so beautiful, right? So, I just felt like I would go to Spicer or Linvill, and say "Yeah, I can understand this by writing this," by taking Maxwell's equation and going one step further. He would say "Oh yeah, you're absolutely right."

But learning the properties and the processing of silicon, which was the big thing then, was the big thing that Stanford was doing. Berkeley was doing more of circuit design and from integrated circuit. You had Gray up there that was doing analog IC design courses. But at Stanford it was semiconductor technologies, semiconductor processing, semiconductor physics. So, I really got into that; it was really interesting. Took my qualifying exams for the PhD and passed them. So, everything was all set, I finished all my classwork, and I said "I just cannot spend another two years, three years doing my thesis. I'm going to go out and get a job."

Fairbairn: So, you were there for two years?

Saperstein: I was there for two-and-a-half years, yeah.

Fairbairn: Two-and-a-half years.

Saperstein: In that time, I also did some work at Varian, at a work study type thing in Lab 7, which was their research lab that was doing semiconductor-- mainly 3-5 semiconductor research. It was basically people that were from Bell Labs that didn't like the weather in New Jersey and came out to California. They were all Bell Labs people. So, it was very unique in that it was really pure research, more than any other place in the Valley at that time. So, I went to Linvill and I said, "I don't want to get my PhD." He said "But you did everything?" I said "Yeah, but I don't want to-- I'm not good enough to be a professor, and I don't think I need it to do what I want to do. I just want to work and apply some of the stuff that I know." So, he says "Well, what do you want to do?" I said "Well, since I can't be a professional jazz musician, I would really like to work for Hewlett-Packard." At that time, Hewlett-Packard, in the '70s, was the epitome of--

Fairbairn: Yeah, I know, it was--

Saperstein: So, he said--

Fairbairn: -the ultimate.

HP Labs: Semiconductor Processing and HP-PA RISC

Saperstein: Yeah. So, he said "Why?" I said "Well, they're just the gold standard." He said "Oh okay." So, I <laughs> was in his office and he dials up the head of HP Labs. He said "I got a student here that doesn't want to finish the PhD. He wants to work at HP Labs." So, it was just kind of like no interview, just "Okay, have him come on over to Deer Creek and we'll talk to him if there's anything interesting." So, that's the way it was back then, everybody knew everybody in the Valley that was tied into-- especially with Stanford--

Fairbairn: Yeah, Stanford HP, yeah.

Saperstein: -and with Berkeley. Yeah. So, I went over there, and this is where it started to get really interesting for me. Because, Deer Creek was really the epitome of an IC lab at that time, around the mid '70s to the mid '80s. It was very automated. It was only a two-to-three-inch lab but that was still state-of-the-art. They had projection lithography, they had ion implantation. They invented plasma there. All of this stuff. I was, of course, in HP Labs, so I was the only guy without a PhD in this, but I had a lab to myself. I could go in there and I could say I want to build any device I wanted to build, and those guys were not so much into circuits, they were more into studying devices, and processes, processes and devices. Of course, the head of that lab, my boss's boss, was John Moll from the Ebers-Moll model, right? So, you could go in there and you could talk to a science foundation fellow right there. But the interesting thing was also everybody in that lab. You know the chronology of the Valley for silicon. It started out with Shockley's company and then went to Fairchild--

Fairbairn: Yeah, Fairchild, and--

Saperstein: -and then--

Fairbairn: -exploded then.

Saperstein: -and then it exploded. So, a lot of the people there were ex-Fairchild. The ones that didn't go there, a lot of them went to Intel, of course. So, Fairchild was right down the road from Deer Creek. Of course, Moll was a big attraction for a lot of people to come there, and so they had a great conduit to Stanford, of course. At that time, I was surrounded by people that understood device physics 10 times better than I did, but I still had that desire to be an experimentalist. So, I was the one that was in the lab all the time. I was experimenting a lot with ion implantation, which was just starting to get really used a lot. Varian was about the only one that was making ion implanters at that time, and so we had an old ion implanter from Varian, and I rebuilt that. The type of stuff that I had learned to do when I was back home in the country, right? You tear apart your engine or whatever. So, this was doing a lot of vacuum work and setting up the scanners for the ion implanter.

Fairbairn: At Stanford, or there, did you work with Jim Gibbons at all, or...?

Saperstein: Oh yeah, Jim Gibbons was my-- when I was working at Varian doing ion implantation, he was my advisor. What was interesting, when I was at Stanford-- or when I was at HP, I was there with a slight overlap with Jim Sansbury, who was Gibbons's key student who wrote the book on the ion implantation tables. Who eventually went out and started Altera. He was the founder of Altera. So, yeah,

like I said, these guys were just members of technical staff. So, Gibbons was a really sharp guy. Him and Plummer were the two skyrockets at Stanford. They were the whiz kids, the young guys that just became full professors like that. They were really, really bright.

Fairbairn: He taught my first-- my double E 101 class <laughs> at Stanford -- and we did an oral history with him, and he described, you know, how he discovered-- how he-- whatever, ion implantation. You know, somebody presented him with this thing when he was in Europe, he says "What do we do with this?" "Well, let's try this," and, so--

Saperstein: Yeah, and he furthered that besides just that. I mean, of course, he was consulting for a lot of the companies in the Valley. But then he also had students that were-- that really were doing cutting edge technology on laser annealing, because his group was doing that also. So, it was pretty-- I mean, he-- amazingly respected. Plummer was just the-- he was just always into new technologies at the process and then applying those to circuits. So, he had a really good foundation in circuit design and a really good understanding of devices. He was really great, and I really liked working with him. And this was really before we had the CS Department taking over a lot of what was going on. Like, Hennessy was not that big at that time, and he was I think still a junior professor. So there wasn't that much of computer architecture and even there wasn't even the CS Building there. And I think CS was actually not a separate-- It may have not even been a separate degree at that time. It may have just been underneath EE and then later it became part of the curriculum.

Fairbairn: Anyway, back to Deer Creek. What was that?

Saperstein: Yeah. So back to Deer Creek. I was learning a lot there. I became the guy that was willing to do the experiments and also willing to do the test circuits, because nobody wanted to deal with circuits. They were all physicists or material scientists and everything. So, I had a lab to myself to play around with. I learned all the processes. And at that time, you put on your white suit and you'd go into the clean room and the majority of it was still wet technology. There was most of the etching was still done wet. A lot of the oxidation and the furnaces and everything were all manually run and everything else. But there were people that were developing a lot of these technologies, so I got kind of interested in the stuff. At that time also, MOS was not-- NMOS was the only real technology for circuit design. I started doing bipolar actually there, because it was that popular and it still had much more performance. It just was very high-powered.

And so at that time, HP tried to do NMOS computers. But, you know, doing a 32-bit NMOS computer, it was like a heater. It was they couldn't do it. They actually had to drop it down to a 24-bit computer their first MOS base. And so, but Deer Creek was doing CMOS experiments for the calculator group up in Corvallis, and so I got exposed to CMOS at that time. And so, I started doing some experiments there and also doing-- seeing how we could use ion implantation and self-aligned gates, and also trying to do silicon nitride gates to improve the current gain on a device.

So, it was great. I think that I could have stayed there. I was there for five years just at Deer Creek. And the thing that I would probably say in looking at the Valley at that time and looking at Deer Creek especially, I was just amazed at how many people were just so passionate about what they did. You

know, like right now, I think about people saying, well, you got these startups here or you got-- Back then, you had a lot of people starting companies, but we called them "spin-offs." We never called them startups because what it was was the person was doing something in the company and they were passionate about it, but the company decided that's probably not our business model. Especially at HP.

Like, Sansbury proposed Altera to Hewlett Packard to do that type of programmable logic. They said it's not our business. But they gave them some money and he did it. So, it was a spinoff. SEEQ was that way. You know, the guy that was right next to me help start SEEQ. We had done experimentation in, nonvolatile memory, and he was a really bright guy and he said, "Why don't we do this?" And they said, "It's not our business." And then, you know, the other guy, my boss help start LSI Logic, Conrad Dell'Oca. There was Steve Combs who started Maxim. You know, IDT was started from HP. You had all of these people that were spinning off not because of, you know, they weren't young people, they were people that had experience at HP that HP said, "Well, we're not really in that business." I can remember even Trimble Navigation was a spinoff of the work that HP did to do navigation systems that they eventually dropped and so they just said, "Okay. Go ahead and take our technology. We'll license it to you, and you can start a GPS navigation system." Because that was originally started in HP Labs.

Fairbairn: Yeah. To me, the biggest difference is today people start with the idea of I want to start a company and then try to figure out what to do. They aren't necessarily passionate about it, but they just want to start a company.

Saperstein: They just want to start a company.

Fairbairn: Whereas in our day, so to speak, you only started a company if you had a great idea and the current company didn't want to pursue it.

Saperstein: Exactly. And that's what I said. It was often called a spinoff. And sometimes your mother company would help fund it, or at least give you some seed money. But, yeah, the passion was there. And the whole idea of making a lot of money was not really in your mind at all. <laughs> It was really, "Gosh, I'm really interested in this. I want to do it," you know. And that was, that was really cool. And also at that time, there was some, you know, you talk about things that were ahead of their time.

Many people don't realize that the facility that's the spaceship for Apple used to be an HP-- a giant HP facility. It used to be an integrated circuit facility. It was the Cupertino facility that was doing silicon on sapphire. It was one of the-- I mean, they had spent millions of dollars developing that technology on 3-inch wafers. For all the reasons why it's now popular, it's just it was ahead of its time. It was the technology and the processing was not quite as reproducible. But they saw the desire for doing it for power reasons and for performance. And then, HP had that philosophy. HP was probably, it was truly the engineer's engineering company. The CEO and the CTO were heavy duty engineers, but they were also smart businessmen. They were very approachable. They were-- they could easily get lost in an engineering conversation. And it was, I can remember when I first started there, I was working away in my little 8 by 8 cubicle and Dave Packard comes in and says, "What are you doing?" And that's amazing, you know. His whole idea of walking around was very-- And we were lucky, because we were, yeah, he was in 1501 [Page Mill Rd.] and we were...

Fairbairn: Two blocks away.

Saperstein: Yeah. And so he would do that. And Young didn't do it as much as Bill and Dave. So, I was 5 years at the research lab. I mean, it will take me a lifetime to say everything that was going on there. But I learned a lot, but I still wanted to make circuits. And I didn't know how to make circuits that much. You know, I had taken a few courses. And I said, "How do I do that?" Well, the beauty of HP is that they just let you make a tangent in your career. So there was a guy there who-- probably retired or maybe even passed away now-- called Chuck House at HP.

Fairbairn: Oh, he's associated with the Museum. He's--

Saperstein: Oh. So I wrote Chuck and I said, "Chuck, I'm a senior MTS now in the IC Lab. I've been 5 years here, but I really want to design circuits. And I want to make a product." He was a strong believer in you don't have to have that experience. You'll learn it on the job. The thing that HP should be doing is give you the opportunity. So he said, "Okay, let me see what I can do". So I went from a senior-- He called up a guy that-- God, I forget his name now. But he was heading up an IC design group also in Palo Alto that was associated with the labs but going to transfer the technology to Cupertino. This was the circuit design technology, not so much the process stuff. And so, he called him up and he said, "I got this guy here. Will you take him on?" So, I went there, and he said, "Do you know anything about this?" I said, "All I've done is test circuits. You know, ring oscillators and very simple gate arrays." And he said, "Okay, well, we're doing a computer chip. You'll just be a designer. You'll have to learn at the entry level." So I went from a senior to an entry level, which was fine with me. It just didn't bother me at all because just given the opportunity, I thought that was the greatest thing that HP did. And Chuck was great, you know. He said, "Okay, I got this set up. Tell me how it goes." And he was the true spirit of what HP was. What the HP Way was all about was embodied in him.

Fairbairn: In Chuck House?

Saperstein: Yeah. Definitely. He was not only a smart person, but he knew where the company should invest money, because the HP Way had its 7 or 9 goals and one of them was you don't invest in things which you really don't think you're going to make money on. I mean, the labs did a lot of stuff. We did a cabbage picker once, an automatic-- It never made it, but, you know. Well, they said, "That's neat, but you know, let's not make it into a product." But Chuck was really an offspring of that type of thinking, you know, and--

Fairbairn: Well, Chuck's been a longtime associate and actually was on the board of trustees.

Saperstein: Oh, yeah, he--

Fairbairn: For quite some time here at the Museum, so he's--

Saperstein: Yeah.

Fairbairn: I think he lives in Central California someplace.

Saperstein: Yeah. I mean, he used to live out here along with you probably heard the name Barney Oliver and those guys.

Fairbairn: Yeah.

Saperstein: So, you know, Barney was right up from Deer Creek, you know, along with Bill Hewlett. They lived up there. So I went to this group and this group was, it was started out of 1501, so which is in the Main Building. And then I found out that it was going to be doing a RISC processor. <laughs> And I said, "What the hell is a RISC processor?" You know, because again, I didn't know anything about computer architecture. But, I got put in there and I understood devices pretty well and I understood semiconductor processing pretty well. But, I had never done an ALU or a layout that was really 14 layers or anything like that. So, I go in here and I find out that it's the first HP-PA RISC chip. And what it is I don't know whether you're familiar with the history of that, but the 801 team that was at IBM, you know, Birnbaum took them and he had the 7--

Fairbairn: So Ruby Lee was involved here?

Saperstein: Ruby was my boss.

Fairbairn: Okay.

Saperstein: <laughs>

Fairbairn: So we did an oral history with Ruby also and got her part of the story, so.

Saperstein: Ruby was my mentor. She is a brilliant lady, and she took me under her wing. I can't say enough good things about her. She was fantastic. And so, I was there, and I was the only guy that understood how to make this, you know, even though it wasn't really important, I would be able to go in and say, "Well, let's not lay this out on a total field of oxide because it's not going to be easy to do lithography. Let's group this stuff together." But all the other stuff I was pulling it from them. So Ruby was teaching me architecture, you know, what is a virtual-- a virtual address, and all these other things which I didn't know anything about. And then the circuit designers were all crusty old engineers that had designed, you know, that's the typical pattern for what HP was. You know, they weren't a computer company.

So Birnbaum's team was unique in that they didn't have computer architects in the rest of the company, but they had a lot of good circuit designers and IC designers. And so, they merged that and we were pretty much locked up right above the Credit Union on Porter Drive. And I'll never forget, it was a secret thing, you know. We were locked into the place rather than being able to go out. They put a little cafeteria in and everything. And we were working, at that time they actually had a reduction in the days that we could work and the rest of the company, they were working 4 days a week getting paid for 4. And they said, "Well, you guys can work 6 days and we'll pay you for 5." So they had us work 5 days a week and 1 Saturday a month or 2 Saturdays a month and they would pay us for the week, right. So that it wouldn't

be a lot of disgruntlement with the rest of the people and they'd say, "Well, why are these guys getting 5 days," you know? Well--"

Fairbairn: Right. Because they're actually working more, right.

Saperstein: We were working more. And it was a critical project. And so, yeah, Ruby went from, you know, Ruby and [Bill] Worley went to Cupertino to get this technology into the main, the minicomputers there, like the HP 3000, to convert that over. Ruby went one step earlier and said, "Let's make the chips, okay?" Because what Worley was doing was he was basically doing TTL versions of the HPPA, okay.

Fairbairn: Right.

Saperstein: And so, so Ruby didn't know anything about circuit design or about IC processing but she knew the architecture. So we did the FTL at that time, Faster Than Light modeling. They didn't have Verilog back then, they just had this and/all [ph?] tool which was called FTL and then we used the Daisy Systems which were used for PCB design, we used them for IC design. And so by the time-- So we did one iteration and it was stopped and then we started-- Well, let me see. No, we did the first design, I was given multiple blocks to design including the IA, CSR, and I/O blocks. It ended up I had maybe about 4 blocks that I had to design myself. And that was a real education.

Fairbairn: Four logic blocks?

Saperstein: System blocks.

Fairbairn: System blocks, okay.

Saperstein: Yeah. Which was really exciting. And so I was taking classes via video at Berkeley, just as fast as I could to try to understand how to do an IC. Then the second chip we moved to Cupertino and Ruby headed up that whole group then. And I was underneath her as a senior lead and so I was the senior architect, which I thought was putting a lot of responsibility, but it was fun because then I architected the second HPPA chip. And that was a lot of great experience. I designed one block but I had about 15 or 20 other people that I led and that was very-- that was really cool. We never taped out that chip unfortunately because we were competing with Fort Collins at that time and they were doing a similar HPPA chip, not the same low end that we were, but they basically when the management said, "Fort Collins is going to take over your-- Is going to manage your group," well, that was like the kiss of death for us. And so Ruby left and then that's when I also left HP after 10 years. And so, after that, I mean, it's I know it's a long spiel. But it was great. I mean, I still look back at HP as probably the best company, the best run company I've ever worked for. Even when John Young took over, he managed it well. And the HP Way existed for a really long time.

To give you just like an anecdote, I can remember, you know, there was a lot of different divisions at HP but like there was a division on the East Coast that was I forget what it was doing. I know they had the med-- they had some medical stuff there and everything. But the ultrasound group and the medical instruments group was on the West Coast. It was here. And there was one lab technician on the East

Coast that her son was critically ill and the hospital, did not have the instruments to actually diagnose him. And I can remember that that word got back out to California, right. And so they just asked Dave Packard, "Can we use your jet? Can we give this instrument?" And so they just plopped that instrument in his jet, flew it over there, you know. That was really the way that company was. Pretty amazing.

After HP, I went to a few companies that were smaller. And I wanted to learn more about-- the last time that I was, when we were doing our final chip at HP, I was using a program called HILO which was the predecessor to Verilog, by it was Morrissey. And so, I wanted to really design chips totally from that without having to do any schematics. And so, I got a job at a company called Force Computers, which was doing VME systems and I-- we got a contract to do a future set of three chips and I told them I would design all 3 chips in Verilog and--

Fairbairn: In HILO or Verilog?

Saperstein: Verilog.

Fairbairn: Okay.

Saperstein: And use Synopsys to synthesize it. <laughs> And they said, "You're out of your mind." I said, "Get the contract and I'll work with a semiconductor company that's going to do the circuit validation and the processing." And so they said, "Who?" And I said, "Well, if we can get TI, that would be great." And so, I made connections with TI and we did this 3-chip set and we sold it to the Navy and it worked the first time. They couldn't believe it! Even TI couldn't believe it, you know. Because they had never used Verilog on an IC before. They were jelly bean company. So I did that and then Apple called me up. And--

Fairbairn: So were you a full-time employee there?

Saperstein: At Force, yeah. I was a full-time employee. I was the only guy that was doing the ICs.

Fairbairn: Had you used Verilog before? Or what--?

Saperstein: Never.

Fairbairn: You just knew that was the right path to go?

Saperstein: It was the right path to go. And I had version 1 of Synopsys. <laughs>

Fairbairn: So that—

Apple Computer and the 68000

Saperstein: I was debugging that and debugging Verilog. At that time, Gateway was taking over that and they had a facility in San Jose and I would go to that high rise and we would go over the test methodology

and everything else. So, I became pretty good at writing Verilog and testing it and mentored a lot of engineers on how to do test benches and everything.

Then I was called by Apple to be a Senior Scientist, to work on their CISC processor, work with Motorola in developing their next generation CISC, processors for their-- for their personal computers.

Fairbairn: Was that the 88000?

Saperstein: No, no. This was the 68040, 68060, 68050.

Fairbairn: Okay.

Saperstein: And so I went over there and, you know, I would say, "Gosh, you know, I'm a RISC guy, I'm not a CISC guy." He said, "Oh, it's okay." And I said, "You know, I'm really a UNIX guy. I mean, PCs are toys, right?" And they kind of frowned on me.

<laughter>

Saperstein: But I said, I didn't know the Apple way. Apple was a totally different culture. When I went there, Jobs was still there. Sculley was on the peripheral about to come in. But Jobs was still running it for a while until he got kind of kicked out.

Fairbairn: So this is in '89, '90?

Saperstein: This was in, yeah, '89, I think, '88, '89. I'm really bad with exact dates, but yeah, it was like a year before Jobs left. But the writing was on the wall that Sculley was going to take it over and so I was in there and I was working as a, you know, I had a cushy job.

I was working with Motorola to define what we needed for the next generation Macs. They had just done the Quadras, the 040s, and since I didn't know much about the Macs and their architecture at that time, I volunteered-- I mean, Gregg Zehr was in the same modular Mac group and so he had a group that was doing the Quadras. And I said, "I'll do a chip for you if you want," because they didn't have an audio chip. And I said, "Well, I know how to do chips if you-- I'm not supposed to be doing this. My boss is Steve Manser, but he'll let me do this for you."

Fairbairn: <laughs>

Saperstein: And so--

Fairbairn: Steve Manser bought my house in Saratoga.

Saperstein: You're kidding me.

Fairbairn: <laughs>

Saperstein: It's a small world, Doug. So, Steve was my boss, and he was the one that hired me and I told Steve, I said, "Steve, I'm helping Gregg. Gregg works for you. I'm going to do this chip for him." And so he says, "Okay, but, you know, you're supposed to be doing-- You're a--" You know, because he was competing with the RISC guys and he wanted the-- The RISC guys had an architect and so he wanted to say, "You're my architect. They have an architect that's doing the RISC stuff; I want you to do the CISC stuff." So I said, "I'll do that but, you know, I got to understand what the Mac is." And so he said, "Oh. Okay."

So, I was into Gregg's group as a, I don't know what the-- a token individual contributor, whatever it's going to be, you know. So he wasn't my boss. But that's where I met Jano, okay. So, so Jano was straight out of school and he said-- And he was just, you know, gung ho young kid and everything straight out of Stanford. And he was, he was assigned to work on one of these chips. And I said, "Well, Jano, I want to present something to you. We're not going to use schematics for this chip--" Because at that time, all the chips were done with schematics and they were using VLSI-- VLSI Semiconductor Company, right. Because they had the tools--

Fairbairn: That was my company.

Saperstein: Pardon me?

Fairbairn: That was my company.

Saperstein: Oh, is that right?

Fairbairn: Yeah. <laughs?

Saperstein: So they were using Compass tools.

Fairbairn: Well, they became Compass tools.

Saperstein: Yeah.

Fairbairn: But before that we developed them as part of VLSI.

Saperstein: Yeah, a part of VLSI.

Fairbairn: Right.

Saperstein: And, you know, Apple was a VLSI-- It was--

Fairbairn: Yeah.

Saperstein: All VLSI, right. And so I said, "Ah, come on. We can do this. We can do this without having to do schematics." There's no self-checking. You can't simulate at the--" So I told Jano, I said, "I'm going to

do the whole damn thing in Verilog. I'm going to generate all the block diagrams in Verilog. And I'm going to test it and simulate it in Verilog, and then I'm going to synthesize it. You're never going to see a schematic at all." And he said, "No, you can't do that. It's not going to work." I said, "Believe me, we can get it to work." And so that's how he got to know me.

And so we developed that chip along with a guy named Doug Farrar who was the audio guru there and I ran this past him. The chip eventually went into the Quadra and went into the LC. It worked the first time, and they were just kind of blown away. And then after that, everybody started using Synopsys and Verilog, you know. So we bought, a lot of Sun workstations and what not and it became the big thing. Although I could see at the-- from the beginning that you know, we were a system house. We weren't a silicon house, and we should never go into making silicon just like we should never expect VLSI to know all the things that we needed from the silicon side. You know, they were a silicon house, they weren't a system house; we were a system house, we weren't a silicon chip design house.

Fairbairn: Yeah, yeah.

Saperstein: And so, the funny thing was, you know, you talk about moving and going, so I was working with Motorola, but in the process of doing this chip, I learned about the Mac. And I got all the disks for the ROM and I started writing assembly code for the Mac because I said, "Man, this is a toy, but it's a lot of fun." And then I started talking to the software guys and I started to understand what the toolbox was doing, what the ROM was doing and what the basic architecture was. And so then I said a very controversial thing to Manser. I said, "You know, the Mac is basically just a computer architecture. If you want, I could run DOS on this thing." And he said, "What the hell are you talking about?" I said, "I can run DOS on a Mac. And I can actually run it really well." And he said, "Do you seriously-- think that you could pull that off? I'll give you 20 percent time to just play." I said, "I can pull it off." And so, I went to the Apple library and I tried to check out books on the IBM PC, the AT. There wasn't a single PC book at Apple. There was only the Macintosh, you know, "Inside Mac" and everything.

So I went to Stacey's, I bought every PC book that I could find, and I read about the BIOS and everything else. And I said, "I can make the Mac run DOS, not as a VM machine, as a true hardware machine. And I just had to emulate for the drivers an interface that uses the Mac's hardware. And so, what started out as just a fun thing, I got everybody pissed off because I was really going against the grain at Apple. I mean, if you mention Microsoft, they even hated you.

So I said, "The best way to do this is I'll do an ASIC." And at that time, I couldn't have-- They wouldn't pay for an ASIC, so I did a programmable logic ... and a giant programmable logic device. And basically, it was the interface from an X86 to the Mac's IO and to the Mac's memory. And the beautiful thing is that Apple already had what was called a coprocessor interface slot. And that coprocessor interface slot talked to everything. <laughs> Everything on the board.

Fairbairn: So you put an X86 in parallel with the 68000--?

Saperstein: Yeah. And I made the 68000 the master. And what it did was it basically carved out a memory slot in memory and said,, "Okay. Reserve this. I'm not going to touch it." And then I mapped the

X86... is IO mapped. It's not memory mapped. The IO is separate from memory. And I mapped that into memory for what the Mac did. And I put a TLB in there so that I didn't have to change any software on the PC. It thinks that everything's starting from 0 <laughs> and but it isn't, it's starting from somewhere--

Fairbairn: Yeah, it--

Saperstein: In--

Fairbairn: In your allocated memory.

Saperstein: And so, everything was controlled by the Mac as the master, but they were autonomous. They were running their own processes, okay. And when you wanted to run something like a keyboard, I emulated the 8041. So, basically, when I touch something, the Mac said, "Okay, this is-- I'm going to convert it into 8041 code and send it back to the X86. And so it was all just reversed engineering because all of that code wasn't-- You couldn't get the BIOS code, you know?

Fairbairn: Yeah.

Saperstein: And so I did that--

Fairbairn: Yeah, people had to reverse engineer the BIOS.

Saperstein: I reverse engineered all that. At that time, we were just running DOS, and so I went to Manser and I said, "Okay. Here. Here it is." And I put it in one of the pizza boxes that we had. I used the chips and technology graphics controller and I could just switch between the two. You know, the screen, I just had a Y cable and I would switch from one controller to the other and I wouldn't lose a step. You know, one would keep on going and the other one would keep on going and then if I wanted to cut and paste, I could cut and paste across in memory.

Fairbairn: Yeah.

Saperstein: And he was floored, you know. And then I got some PD guys and I said, "I'm going to take your pizza box and I'm going to put this in there." And the... I called the project Royal Scam.

Fairbairn: <laughs>

Saperstein: Because I was-- because I was a big Steely Dan fan and I said, "This is by far the biggest scam that Apple will ever--" And so, I presented it, and Manser said, "Can you actually productize that?" I said, "I'm going to get killed if you-- You're going to have to be my front man,--"

Fairbairn: Yeah.

Saperstein: "Because I am not going to go in front of everybody because I'm going to get shot down by everybody."

Fairbairn: Right.

Saperstein: So he said, "I'll protect you. Go ahead and productize it." So at that time, God, Dave Deitz was straight out of MBA school from Stanford. He eventually did really well as a, I think, a VC also, and I think he was also one of the execs at Symantec. But he was straight out of school, and I said, "I've got a project for you. Tell me whether this system will actually sell." So, he did all of the studies, you know, with the user studies. And, we gave him a mockup and everybody loved it. Because at that time, and even now, you know, the PC, everybody hated the PC but all the software was on the PC.

Fairbairn: Right.

Saperstein: And all the schools did not want to buy two computers.

Fairbairn: Yeah.

Saperstein: So he said, "We can sell this. We can sell it. You just have to-- We have to somehow convince Apple to do this."

Fairbairn: Yeah.

Saperstein: And so I said, "Well, that's your job, right?"

Fairbairn: <laughs>

Saperstein: So the way he convinced Apple, I don't know whether this was the right way to do it, but at that time, they had Comdex, if you remember Comdex?

Fairbairn: Yeah.

Saperstein: That's the precursor to CES, right?

Fairbairn: Yeah.

Saperstein: And so, at that time, Jobs was gone and Sculley was in charge and so we came to Comdex for the first time that time and he introduced the Newton, if you remember it.

Fairbairn: Yeah, yeah.

Saperstein: The Newton was the big thing and the PowerPC, at least introduction of the PowerPC. And so, he would do the presentation, he's going to do it and then we... Dave got me a corner of the Apple booth, just a little corner smaller than this, and we set up probably about 5 what we call, we didn't call it the Royal Scam anymore, we called it the Macintosh DOS Compatible. And he set those up and I said, "Just let people have one person right there telling them how to switch and just let the people play." Okay. And so, I set those things up like at 12:00 at night right before Comdex opened up and when all the guys

were going around and looking at the systems. So, I get a call, I'm in the hotel after that long night and I get this call from Dave and he says, "You will not believe this, but your product just won Comdex. It's the best system of the year by *Byte* magazine."

Fairbairn: <laughs>

Saperstein: I said, "Oh, my gosh. That, you know--" He said, "You got to come over. You got to shake Bill Gates' hand. He's going to give you the award." I said, "Yeah, because, you know, Sculley wasn't going to take the award." And so, I go there--

Fairbairn: Sculley knew that it was there? He--?

Saperstein: Yeah. He knew it was there, but it was, this little thing.

Fairbairn: Yeah. He was doing the Newton and that was the big, big thing, yeah.

Saperstein: Oh. It was! It was as big as the Intel booth. It was gigantic what they did. So that was not really-- It was kind of embarrassing for Apple at that time. It's the only award I've ever won for Apple where they let me keep it. It never went into the glass case. But it was, it was probably one of the most prestigious awards they could have ever won. The first time at Comdex and they won System of the Year.

-

Fairbairn: Yeah.

Saperstein: We were in *Byte* magazine, everything. And so begrudgingly, they let us make the product. And so, I think we made the product for \$780,000 dollars. That was the total investment by us to build these systems. And I think we made something like the first 3 or 4 months we made, like, \$21 million dollars on that. And so, the return on investment was unbelievable. So, they couldn't stop the project even if they wanted to, right.

Fairbairn: Yeah.

Saperstein: And so, I got kind of stuck with that and then they said, "Okay, well, we're going to continue this, but now we want you to run the silicon group," at Apple that was doing their own RISC. And they said, "And you'll be architecting that, because they realized that PowerPC was the way they wanted to go. They wanted to stop doing CISC stuff." And since I knew how to do that, I had relationships with IBM a little bit and Somerset. And so I started doing that. And then about halfway through that I said to the management, I said, "No. We've got to just stop doing silicon. It's a dead end for us." This was before, you know, they got the Racer X guys and started doing their own. This was long before that.

I said "Let's use IBM," and "Let's use Somerset." We got to just be better at defining what the system is and rushing them to do the stuff. So that was one of the hardest jobs I had. I basically was the one that disbanded by own group, the silicon group there. It had a lot of people in it and at that time, there was no follow on to that. Some of them went into verification groups, but the majority of them left Apple at that time.

So, I basically started another project to do a cross-platform, but this time, we would run Windows and the big problem with the Mac was you couldn't run Doom on the Mac, but you could run it on a Windows machine and we had people that wanted to use the Mac, but they wanted to run Doom and so, we were-- we did a version with the Cyrix part, which was cheaper.

Fairbairn: The x86 part from Cyrix, yeah.

Saperstein: This was like a-- what is it, the dual-- the D-version and so, they were as good as-- what's that, the 486DX or something like that and so, we built this and we got-- the interesting thing was to get Windows, I had to go and present to Ballmer and get the approval from Microsoft with a Mac and so, it was interesting because Ballmer, Gates, Andy Grove, they all wanted to get into Apple. Even when I was doing the first one, Intel, Andy Grove said "We'll sell it to you as if you're a tier one." I said "Our volumes are going to be nothing." He's like "I want to be inside a Mac." So, it was really good. So, I was doing that and again, I was just managing a small group and we were really kind of like the...

Fairbairn: You were managing a small group, but doing major strategic changes with it.

Saperstein: Yeah. It was kind of interesting and then at the same time, the group that was working on Pippin. I don't know if you remember what Pippin was. Pippin was Apple's approach to doing a videogame and it failed, but the software team I knew were really good. So, my boss was Jack McHenry at that time. I said "We've got to get those guys and we'll find work for them," and so, in the middle of the night, we basically packed them up from their offices and moved them into our office and told their boss "They're no longer working for you." You've got to remember, Doug, that is the way Apple was.

Fairbairn: I was about to say this is a little different than Hewlett-Packard.

Saperstein: Very, very different than Hewlett-Packard and I was pretty much the cowboy at Apple a lot, even just doing the DOS-compatible was-- even in a place like Apple, to do that was crazy.

Fairbairn: What did Jobs say about that or was he gone by then?

Saperstein: Well, Jobs was already gone, but actually, I'll jump a little ahead. I was doing another project, which I'll get to in a minute, but that Windows compatible project was really selling like mad and we didn't have to do anything because the schools were buying it, especially the community colleges and-- but Jobs...

Fairbairn: What was that called?

Saperstein: It was called-- it was originally called the DOS Compatible, then it was called the Cross Platform, the Mac Cross Platform and it was certified Windows, and it was originally certified DOS. So, when Jobs came back, he found out that we were selling this and he wanted to kill it. But he couldn't kill it, because they had backorders for so many of them. So, what he did was he basically got Orange Micro in LA to basically-- he licensed it to them, and he got out of the business.

At that time, I wanted to do something else anyhow and so, I had now the whole team. So, what I did was I basically said "I want to make an under \$900 Macintosh." At that time, even the iMacs were more than

that. I said "I want to make a full-blown Mac that's going to only cost us \$400 to build and we can sell it for under \$1,000," and I said "And I think I can make it with an architecture that is totally different than what we're doing right now." This was before Jobs came back. This was even before [Jon] Rubinstein came in. This was right kind of in the middle when we were doing the 630-based, the high-end PowerPC stuff that they were doing. So they had about two or three projects, towers and desktops that were using this really high-performance PowerPC from IBM, but the problem that they had was that it was-- its memory hierarchy was slowing it down. It was running very-- it was all based on-- it's fetching from a memory that was running at one-fourth the speed of the CPU and so, I said "Come on, guys, you know what RISC is. If you starve it, it's not going to be performing."

So, I went to IBM and I said "I think we can design something that's cheaper, but much more performance and lower power than what you're currently providing, and you guys can do the architecture so that you can license it to Motorola and you can use it to other customers. It doesn't have to be exclusive," and since my group was the C-players, McHenry was giving-- he also had the higher end computers under him in modular Mac and so, he basically just said "Go ahead and do whatever. I'm not going to give you anything. You've got a software/hardware team,"

And so, we stopped doing the Cross Platform, but then we started doing this really low-level, entry level project, which I called Gossamer at that time, which meant light as a feather, right? So, we were doing Gossamer and it was basically a total departure from Apple also. We were buying PC parts. I said "I'm going to make it a mini-ATX." He said-- everybody in the PD department, "What the hell are you talking about?" I said "I'm going to do a standard size. I'm going to use a standard power supply. I'm going to use PC 101 DIMMs. I'm not going to do anything custom for us except the processor."

So, I go to Gregg Zehr, who was running the personal computer-- the laptops at that time and he was trying to put PowerPC in the laptops and I said "I will architect a low-power chip for you, with a bridge chip, if you pay for my project because my boss won't pay for my project." Again, this is Apple, right? So, Gregg said "Yeah, because I have no architects. I have nobody to do this," And so, I did the PowerPC based on Camelot, which had backside cache, which now everybody does, right? It had a dedicated cache that was not lookaside from the memory, and we designed that with IBM and designed the module-- I designed a module with IBM in Carolina and...

Fairbairn: So, IBM had to design this new chip based on your architecture.

Saperstein: Exactly. Yeah. It was a backslide cache, which was running at 300 megahertz compared to 90 megahertz, which was what the high-end was running. So, long story short, we came out with this board that-- the whole idea was "I'm going to put this mini-ATX in a tower, in a pizza box, and in a modular." Okay. So, nobody is going to know what the damn board is. I'm going to put four disk drives in the tower, but I'm going to use the same board that I'm using in my pizza box, because that's what the PC guys do, right?

So, again, totally against-- if you're familiar with Apple and now, of course, Apple does everything custom to them. But at that time, I didn't want to qualify every DIMM that was-- the power supplies, we were spending twice as much for our power supplies as I could buy them that were for the PC world. So, we did this and then Jobs-- and then Rubinstein becomes my boss and I'm saying "Oh, my god, here's this

guy from NeXT. I know he's got this ego and I know he's-- if he's not going to get involved with this, he's just going to cancel it because he's got too many projects anyhow." Because he takes over now all the modular Mac and all of the entry level, which was called the Performa at that time.

So, I go in to talk to him and I say "This is what I'm doing," and he said "Okay, keep doing that. Don't report to McHenry anymore. You report to me." I said "What does that mean?" He said "I just want to talk to you once a week or once every other week." I said "Oh, okay." I had never worked for Ruby before and so, I go and we finish up this system and I go to IBM. I go back east and we finish up, or figure out most of the bugs and the first one that comes out-- so, we do a competition with the high end. Here's this \$400 system to a \$4,000 system. We're four times the performance and that's when Ruby tells Jobs and Jobs basically says "You're making all the computers for next year."

So, he basically lays off all these other guys, which was really bad for me because they were my friends. I tried to find them other jobs, but it was basically-- it's all based now on Gossamer. So, for that one year, I did the tower, the desktop, and the education products. Just the Gossamer by itself and the modular Mac, they got \$5 billion in one year, the most they had ever gotten, and Ruby told me you basically saved the company. We were losing \$1 billion a year and then Jobs was able to do the iMac with that architecture, a modification I made for that, and then he had enough money to do the iPod.

Fairbairn: So, the chip that you architected for the Gossamer went into the iMac, the jelly bean...

Saperstein: It was, basically, it went into the jelly bean with the-- but what it had was a PCI bridge chip that I got Digital to basically build for us. That's how I got Digital into Apple. I made I-Squared, the company that's a distributor down in San Jose, rich for that. So, yeah, that was the big difference between G3 and G4 was the expansion. But they used the same backside cache chip.

Fairbairn: So, G3 and G4 were the public names of this chip for you.

Saperstein: Of the systems, yeah.

Fairbairn: You did that chip just as a-- I mean, it was your project. It wasn't top-down authorized.

Saperstein: It wasn't authorized. Matter of fact, it wasn't authorized.

Fairbairn: It wasn't on the project plan. It wasn't...

Saperstein: No, matter of fact, the interesting thing was they were based on the high-end chip from IBM, 604, I think, it was called. They didn't have anybody to do the servers. So, I can remember meeting with the VP of marketing. She took me out to dinner in her Mercedes and she said, "We really need somebody to develop these servers, because we don't really have a good entry into the servers based on this chipset, and it's a big hole in our portfolio," and I said "Well, what would my group do after that?" They said "Well, we really don't have anything else after that," and I said-- this really pissed her off-- I said "I am not going to ask my team to fall on their swords for Apple. You guys have not been the nicest to us right now. You guys are losing money. Unless I'm told to stop what I'm doing, I am not going to stop what I'm doing," and that pissed her off because she didn't have any control over the group. But it was under the-- it was what you would call a G-job under the radar. I would go and-- this was the first thing that we ever--

we also offered it for the education market. It had a video-- it had two PCI slots and one of the slots had a card for video input/output, which the teachers loved. It was the first Mac that had this capability, and it was great. We had a remote control for the TV, the whole nine yards way back then and so, for the education market, it sold like mad. But it won Macworld, all the subdivisions of Macworld, we won hands down, but I never got to keep those trophies. They went into the trophy case.

Fairbairn: But IBM did this chip based on some G-job at Apple. They didn't...

Saperstein: Oh, absolutely. Yeah. Actually, the G-job on Apple and the funding of Gregg because Gregg knew we needed this for the portables. He couldn't use the 604. It was too power-hungry. But he didn't know how to do it. So, it was kind of like you scratch my back. I'll scratch yours.

Fairbairn: Who had to authorize IBM to go do this?

Saperstein: It was Gregg.

Fairbairn: Okay.

Saperstein: And then I basically made something for the rest of Apple because see, Gregg didn't utilize the chip to its maximum. I used it so that it just beat the pants off of it.

Fairbairn: He just needed something low power for the laptop, right?

Saperstein: Yeah, exactly.

Fairbairn: So, he cranked it down a little bit.

Saperstein: He only used the internal cache. He didn't have the outside cache. I made the outside cache, which made it scream and then I said "Okay, I'll develop the north bridge for you to talk to memory," because he had none of that and so, that one was done by Motorola. I sat down with Motorola and said "Okay, guys, it's pretty straightforward to do this bridge. You're going to be able to get the license to make the processor, but you'll get sole responsibility for the bridge," and so, they sold the bridge for the desktop and for the portable and so, they did really well for that year.

So, that quote-unquote "saved" Apple. I mean, Ruby still says that if it wasn't for that product, they wouldn't have turned around the company and so, they gave me a decent compensation I could probably go into some really interesting-- probably the most interesting story, Doug, was there were two issues with doing the G3. One of them was we found a bug in the chip. It was due to an IBM design issue where they had two-- their pull-ups and pull-downs were too weak and so, in the floating point unit, we, meaning Apple, my team-- because I had the performance team underneath me also-- we had done some random code sequences and we found a bug in their FPU.

Now, we didn't think that these-- this was a random instruction stream, but it was still a bug, right? So, I went to IBM and I said "Go ahead and see if you can do a screen so that we can-- it's not a design. It's the strength of the pull-up and pull-down. So, if we can screen it at the ATE tester, then we could get

good chips out that we know didn't have the problem. Meanwhile, I'll go out and I'll see how serious this problem is."

So, knowing that it's an FPU, I basically went to all of our beta sites that were doing math, like China Lake Naval Observatory, you name it, NASA, you name it. I said "I'll give you a machine. Just beat the hell out of it and if you find a bug, I'll give you a brand new machine that's production quality." So, that was like two months before or three months before we were going to go and introduce this worldwide. I had three or four factories running simultaneously around the world to produce it. It was the first worldwide intro for any Mac computer since Jobs was there. So, then I go into the meeting with Phil Schiller, who was the VP of Marketing that Jobs brought in. He was, I guess, an ex-NeXT guy also, and at that same time, Intel had their floating-point bug and they didn't tell anybody about it.

Fairbairn: Right.

Saperstein: Then they got rammed on the Internet, right? So, I told Schiller-- he said "Well, we've got to stop. We can't do anything." I said "Well, I'm going to check with-- I don't think IBM is going to be able to do anything about this, but I have the data from all of these beta sites. They've never been able to reproduce this bug. Don't forget, we're the ones that found the bug with a random program." Schiller said "No, no, it's not going to..." I can remember being in that meeting-- I remember, I said "Look, I know you're paranoid about what happened at Intel, but let's just when we introduce the product say we have a bug and if anybody can reproduce it, we'll give you the machine free," and Jobs said "Yeah, that sounds good." So, that's what we did. So, the second half of that story is Jobs meets with IBM and he says "This is your bug. You're liable for this chip. If anything is wrong with this, you've got to..."

Fairbairn: You'll have to replace them all.

Saperstein: "You've got to take on financial responsibility." IBM-- this is the CEO, he's in his suit and tie and Jobs is in his turtleneck-- this is right at the Peppermill...

Fairbairn: Yeah, the Peppermill, right next to Apple, right?

Saperstein: Yeah. I wasn't at that meeting, but I heard what went down and Jobs said-- the IBM guy said "No, you're not even profitable for us. The number of chips-- we're not going to take liability for that." So, Jobs said "Then we're not going to buy the chips," and so, that word comes to me that "Don't buy any chips from IBM," and of course, we can't buy them from Motorola because they don't have the process for copper aluminum to make these chips that can handle the electromigration, right? They were going to be developing that. So, all of these first runs were going to all come from IBM.

Motorola said "We'll take on the liability." They wanted the business. I said "You don't have the chips." So, I get the word that Jobs has basically insulted these guys from IBM. I'm saying "Yeah, that sounds right." So, I get the word also that no orders to IBM for production. I've got 60,000 units being made, going to be made for introduction. I've got to build six weeks of inventory, right? I've got almost 100,000 units that I've got to build up right away.

Fairbairn: Where were these being built at the time?

Saperstein: They're built in Singapore, Cork, and in Sacramento, all sites. That was the first time that we had done that in a long time. So, I was going around the world for EVTs-- in other words, I took my team and we just-- we had a lot of frequent flyer miles and so, I was given that order and I said "Okay, how do I get around this?" So, what I did was I told my coordinator, I said "Okay, we cannot buy production, but these are production parts. We can buy for development, right?" They said "Yeah, okay." So, we're going to do 100,000 development builds and so, they said "What do you mean?" Because normally, a development build is 1,000.

Fairbairn: Two-hundred or a thousand.

Saperstein: "We're going to build 100,000. Can you get that approved?" and so, it got approved and that's how we-- then of course, Jobs eventually caved in and said "Okay, we'll buy from IBM. I don't know whether he-- I never found out whether he was pissed off at me or what, but at least I didn't get fired and we were very successful with that, but that was some of the stuff that we had to deal with.

Fairbairn: What was the machine-- what was the name of the end machine?

Saperstein: Gosh...

Fairbairn: It was not the iMac or...

Saperstein: No, this was the one before the iMac. We had a tower and we had the outrigger box, which was a desktop and then we had the education, which was the all-in-one. So, those were the main computers that we developed, and it was pretty much the whole product line.

Fairbairn: So, did IBM ever fix this bug or was the bug ever discovered by anybody outside?

Saperstein: It was never discovered. I don't know whether they ever changed the mask. They would have had to change the mask to do it. They probably did. What turned out when they put the screen in, the yield dropped down to only 10%. So, we couldn't use their screen. We wouldn't have gotten any chips. So, that's when I really said...

Fairbairn: You had no choice. You've just got to go.

Saperstein: We're just going to roll the dice and then when-- I told Schiller to do this, he was freaking out, but like I said, at that time, I was such a cowboy. I basically said "Come on. This is Apple. We can do anything," and I had already kind of fallen for the culture and the folklore and drank the Kool-Aid, I suppose.

Fairbairn: It fit with your personal style.

Saperstein: Yeah. It was...

Fairbairn: So, when it was announced, Jobs actually announced that there was a bug and that they would...

Saperstein: Yeah. It was announced that it was a bug, but it was kind of like if you could find-- it wasn't-- I don't think he announced it. It was just, I think, one the webpage that if you could find this-- if you can reproduce this bug, then we'll give you the machine free and that was kind of fun. That was kind of fun. So, yeah, it was a strange time.

Vanguard and TSMC

Fairbairn: So, how did the ride at Apple come to conclusion?

Saperstein: I had done about 12 Macs and so, I go in to Ruby and I say "It's time for me to go," and leave and a real good friend of mine was doing a startup, Design Center for Vanguard Semiconductor in San Jose and he asked me to partner with him and so, this was funded by TSMC and Vanguard, TSMC mainly, and so, we did a design-- we hired about 50 really experienced designers, IC designers, and we had a foundry in Taiwan and...

Fairbairn: TSMC...

Saperstein: Pardon me?

Fairbairn: TSMC was the foundry

Saperstein: Actually, it was Vanguard, which was funded by TSMC.

Fairbairn: Oh, I see.

Saperstein: So, Vanguard was a RAM company, a RAM semiconductor company, but they basically were bought eventually fully by TSMC. But they were funded and we were developing RAM technology and specialized silicon devices, specialized ASICs. So, at that time, we were looking at Rambus, which was a bad mistake on my part. At that time, having seen that Intel pushed PC 101, the RAM technology, they were driving it. They were qualifying it. For their next generation, they were saying they were going to use Rambus and so, everybody was saying "That's crazy because that is a very expensive technology and it's hard to qualify." And I said "I agree, but if Intel is committing to that in its plan of record, then we have to go along that path because otherwise, we're not going to get any business if we're going to be at least making some of our portfolio being RAM." So, I spent \$10 million for the license for Rambus and going to those meetings with Intel and seeing that Intel was getting harder and harder for them to qualify and Rambus was not really following through and then we had the technology for DDR. But Intel wouldn't buy into DDR. If you remember, it was not the technology that they wanted to push. Eventually, they did push DDR. That was after Via basically had the violation of their patents or-- it was an exchange of stuff. But we didn't do DDR and that was a real big mistake on my part. So, we eventually came back and developed the DDR chips that started selling. But on the ASIC side, we wanted to do CMOS imagers because at that time, the only imaging technology was CCDs. So, my friend, who was from Bell Labs, he said "I think we got some interesting circuitry that we can use to make these CMOS imagers really very low-leakage and so, the white balance would be much easier and they would be really low power and so, I got a team together and we developed the imager chip and..."

Fairbairn: Also made at Vanguard?

Saperstein: It was made at Vanguard, and the beauty of it was we used RAM-- since they had a RAM process, we were able to use the redundancy capabilities that they normally use in RAM with laser programming. So, the big problem with imagers is if you've got bad pixels, then your chip is bad, right? X-number of bad pixels. So, what we were able to do is we were able to mark the bad pixels and then reprogram the redundancy just like they do for RAM cells and basically, it looks like there's no bad pixel. We would just average on either side, plug that in-- just plug the map into the redundancy and then the logic would just basically say "Ah, this is a bad pixel. Take both sides and dither it and get the pixel value there." So, we were always making 100% perfect arrays even though they weren't perfect-perfect. And having the technology, especially the testers at Vanguard, it was no extra overhead cost for us so, we were way ahead of everybody. We were ahead of OmniVision with this technology. We had all the patents and we were probably leading in CMOS imaging. Sony was so scared that they were dropping the price on their-- they were having to drop pricing on CCDs because they saw that CMOS was going to kill them. It's got random access capability. It's low-power and it's low cost to make. So, they were still prominent in the CCD business with their cameras, but CMOS was going to be there.

So, the first application I did was a semi-disposable digital camera. At that time, the batteries on a digital camera would last for maybe an hour or two, at the most, using CCD technology. We designed a camera that would last for two weeks on a battery charge with the CMOS.

At the same time, since you're interested in the flops just as much as the successes, besides the Rambus thing, at that same time, we were using Kyocera to do our substrates for the imagers, right? So, Kyocera comes to me and to my friend, Bob, and he says "We're going to do a flagship cell phone. We're using these guys chips, but there's going to be the ceramic substrates of ours inside there. We'd like to put a camera in it. Would you guys want to help us put a camera because you've already got our substrates?" And of course, I said "Who in their right mind would want a camera in a cell phone? We've got this product. It's going to be used for video conferencing and disposable camera. This is the future, guys, not in a cell phone." So, we said "No, we're not interested." A year and a half later, we closed down shop. We just-- we just couldn't keep it going.

Fairbairn: Would that have been successful at that time?

Saperstein: It would have probably been successful. Cell phones were not smartphones, but the beauty would have been it would have competed directly with the digital camera. Don't forget, at that time, the digital quick shot cameras were really prominent, but they couldn't keep a charge. They were only good for like an hour worth of charge. Here, we were basing it off of how long would a cell phone last-- a cell phone would usually last at least a day. So, yeah, it was-- that was...

Fairbairn: So, what year was that?

Saperstein: Oh, gosh...

Fairbairn: Maybe '95, '96, '97?

Another Startt Up: BroadOn

Saperstein: Yeah. It was-- I'm horrible with dates, but yeah. That was a big mistake. After that, then I went to work with, again, some intermediate startups but then Wei Yen called me up, who was an ex-SGI guy, the head of SGI, and we started a company called BroadOn, which was supposed to do...

Fairbairn: Called what?

Saperstein: BroadOn, B-R-O-A-D-O-N, which was broadband on-demand, eventually turned into a company called iGware, but what our idea was he was-- Wei is probably the third guy on the list of mentors that was very influential to me, at least, and he was the VP of Engineering at SGI during its heyday. He made all the work with Nintendo, doing the reality machine, etc., the 64-bit reality machine. So, he had an agreement with @Home and AOL to stream video from the Turner library because AOL had the Turner library and so, they had the content. So, he said they agreed if we could set up a secure streaming system-- because at that time, it wasn't called streaming. Nobody had anything like that. So, we did the device. It was the first AP that had a hard drive in it. So, we designed an access point with a hard drive that the person would want to download a video and so, you would set it up and go to work and then you come home and it's on your hard drive. So, we're not streaming live. Nobody had that capability at that time. Then we had Wi-Fi, which was not that reliable. We had Ethernet and we had PhoneNET capability to hook it up to your TV. So, we had a satellite box on the TV. We had the AP and we thought this was great because the AP is where you wanted to put the streaming device close to where you were connecting up your computer.

And so, we had this setup and we had it-- it was very secure. We had set up all the authentication, our own development. We had our certificates and then @Home-- AOL got cold feet. They said "We just can't trust digital over the-- sending digital..." We said "That's our whole business model. What the hell are you talking about?" So, they said "No, we just can't do it." So, we eventually sold those devices to Acer for their networking service since it was all controllable from a central office. They didn't have to go there to do any of their configuration of these APs. So, we did that and we said "Okay, never again will we go in there."

Nintendo and Video Games

But then the other thing was Nintendo, because of the connections with Wei, they wanted to enter the Chinese market with gaming, but they were very concerned about security and so, Wei pitched to them, he said "Look, I'll make a Chinese videogame box that you can't duplicate. Our security will prevent that," and so, Sony said "Okay." So, Wei set up a company...

Fairbairn: Sony said okay or Nintendo?

Saperstein: Nintendo. I'm sorry. Did I say Sony? I'm sorry. Yeah, Nintendo said okay, and it was his connections with Nintendo. That's a very interesting company. I could spend a day just discussing how their structure is. The culture there is very, very unique. So, Wei set that up and this little startup called Broadcom, now we switch from doing streaming. We basically said "Okay, we're going to do a gaming device." So, we got the rights to the [Nintendo] N64 and we took the three-chip set and we made it into a single chip. So, we had to do this, and we got NEC to do all of the certificates in their fab, which is what made it secure. Now, everybody does that, but we were the first. We put servers in the NEC fab to download the certificates and I had the write to code, it was straight out of "Mission Impossible." We'd

send them a disk with all their certificates and then it would self-destruct. It was funny. So, we did this and Wei set up a company called iQue. You can still get on the web and actually look at the iQue player and it was only sold in China. It was built in China by a ASUSTek factory in Suzhou. And we set up a design studio in Suzhou to localize all of Nintendo's games into Mandarin. It was the only videogame player in China that was authorized by the government to sell because it was pirating proof and it was really a lot of fun to do. It was the hardest project I think I've ever done because we had almost nobody and we had to do silicon, we had to do system, we had to do software, and we put all... We had cartridges for the games and you'd go into like the 7-Elevens in China and we made these kiosks where you could take your little cartridge and drop it in and you'd download as many as five games. You'd either rent them, you could buy them, or you could try them because they would also self-destruct after like one try and...

Fairbairn: You had to do kiosks?

Saperstein: Everything. It was unbelievable. Probably the best accolades I got was first from Nintendo because Nintendo was really impressed. They had very good engineers. The quality of their work was really good. So, they complemented us. We had really good relationships, even after-- it didn't sell great in China, but it opened the door for Nintendo to get into China and sell the Gameboy and all their other games. But on top of that, some of them came back into Japan, and some of them even came into the United States and people took them apart and they basically said "Yeah, you can definitely tell this is Nintendo quality. This is Nintendo design." So, that was probably the best compliment that we could have ever got. Nobody even had the foggiest idea that this was built in China.

And that's how I got to work very closely with Foxconn, worked with Terry and all those guys. And that's how Foxconn got the Nintendo business for the Wii. So, every time I go to Foxconn now, they wine and dine me because they said "Gosh, you made us millionaires on just this one contract." But the funny part about it is I'm at this startup that Wei starts and I'm saying "You're VC-funded, we had these great ideas..." and the beauty about Wei was he would throw out an idea and it was just different than Apple. It was different than HP. It was basically he was a very smart guy. He wasn't worried about the details. If you went into the details, he would ask some great questions, but he wouldn't scold you for failing. He would say "What about this?" and then if you saw that there was some really neat stuff associated with that, you could take and go with it and he would just support you.

It was totally different, right? HP, you could fail, but you were not supposed to fail because you had all these other smart people around you that were going to boost you along. At Apple, you were always worried about the other team because Jobs always pitted one team against another. That was his way of getting the A team to surface to the top. With Wei, it was "I'm going to surround you with-- I'm going to get a lot of really bright people together and we're going to try to do something innovative."

But after five years, I said "Wei, we don't have any equity. I mean, this is a startup. We can't go five years without having any equity." We had millions of shares that were-- we thought they were useless and Wei had just come out of-- he had 3Dfx, which he sold to ATI, and then he became pretty much the runner of ATI and then he sold it to AMD for-- I forget how many billions of dollars. So, Wei was no poor guy. Some of BroadOn he was funding, but he had Acer, he had venture coming in, had @Home, had AOL, but I said "Nah, this is-- I'm going to probably go and try to do something else." So, he said "Well, what are you

going to do with your stock?" I said "I'm not going to buy the options, just forget it." He said "But you did all of this work. This is not right." So, I said "I'm not going to spend that much money on the wallpaper."

So, then one day, he just called me up and-- I mean, I used to have a lot of fights with him because I was strong-headed and luckily, my wife was the mediator between us. She's really good at that, and Wei was just the nicest person to my wife and would always go through her to get to me, right? So, I guess in some ways, psychologically, he was really a good psychologist there. So, when I get a call from him, I say "Well, I bought all the stock options in your name." I said "What are you talking about?" He said "You did a lot," and at that time, I was-- I had left. I said "Well, that's very nice. I'll pay you back." He said "No, it's done. It's okay." I mean, it wasn't-- probably in the big scheme of things, it's not a lot of money, but it was a lot of mortgage payments on my part at that time. I was not well off, still even after all of these successes. At Apple, Ruby gave me a lot of money, but I left it on the table. After the G3, I said "I got to do my own thing," and Ruby got mad. He said "Haven't I been good to you?" I said "You've been great to me, but I've got to do something else." So, I had Apple stock at \$8 a share, thousands of shares that I just said "Take it. It's okay. It's never going..."

Fairbairn: "It's never going to be worth anything."

Saperstein: "It's never going to be..." That was right. It was \$8 a share. I said "If this gets to be \$40, it's going to be-- you guys are going to go out like-- it's never even going to get there," and when it got to be something like \$80, my wife bought it. I said "Why are you doing that? You know the history." She said "You sold all your stuff. You got rid of it. Let me do it with my money." So, I said "Okay." What she did was she sold her Intel stock and bought that and I said "Okay, well, it's your money."

Fairbairn: Good choice.

Back with Rubinstein at Palm and another CES Award

Saperstein: Then that's history. So, long story short, with Wei-- I did this. Then I go and Ruby-- I have a few startups in between that don't succeed and then I go to-- Ruby calls me up and he says "I'm at Palm now. I could use you to come on over and do some work for us," and I said "Okay. I'll do that, but only two years. I owe you for what you did for me. It's the least I can do, but you've got to give me independence and I'll deliver for you." So, he said "Okay, come on over. You can be a director and go."

At that same time, I get this call from one of the guys that was working at BroadOn. He said "Have you read the Wall Street Journal?" I said "No." "You better read the Wall Street Journal or at least pull it up on the web." So, I pull it up on the web and Wei has sold BroadOn to Acer and I said "What does that mean?" He said "That means that all that stock is worth something, plus you're going to get cash on top of the stock." I said "Golly, that's amazing." So, that was really the first windfall that I ever really got, totally unexpected. So, you kind of-- again, it's that type of thing that I was saying Doug, that when you did this, you never expected to get any money and fortune sometimes comes to you, sometimes it doesn't. But if that's your main reason for going to do it, then it's the wrong reason.

And later on, I found out that Wei actually made a deal that the money that was quoted in the Wall Street Journal was only half, so that if they were profitable after four years with the technology that BroadOn

gave them, they would pay the other half. So, my wife used to tell me “I got the letter on that and I was just wondering whether I should tell you that the other half of the money-- you’re going to get another half of the money or whether I should have just pocketed it without you even knowing.” I would have been wondering why she was playing more in the stock market.

Fairbairn: Buying more Apple stock.

Saperstein: I know this is getting long. I don't know how much time you have left. Then I went with Ruby and I did the Pre with him, which was a direct competitor to the iPhone. At that time...

Fairbairn: At Palm?

Saperstein: At Palm-- and at that time, Palm was outsourcing everything, all their stuff. They didn't have any design group in-- they were writing specs and giving them to HTC and I said “I don't want any part of that. We'll develop this all in-house. I'll get a small group...”

Fairbairn: Giving them to HTC-- HTC is...

Saperstein: The design house in Taiwan that's also a contract manufacturer.

Fairbairn: Oh, I see.

Saperstein: So, HTC was developing all of the Palm...

Fairbairn: Oh, I see. They were designing the specs and everything and saying “Okay, you do it.”

Saperstein: Yeah. So, I had a small team. We were in the basement of Palm, about five of us, ironing out the architecture, even the industrial design, everything. I presented it to Rubi and said “Okay, this is what we're going to do.” And then I worked with Chris McKillop, who was ex-Apple, and we developed the software. I made the hardware work with the software. My old TI friends, I basically went to them and I said “On a handshake, Rich, give us these chips. We're not going to use Qualcomm. We will use the OMAP,” and so, we had the whole thing, and the Pre was great. It was the first in a lot of aspects. We just didn't have any apps for it.

But we introduced it at CES. It was the second CES award I won of the best product of-- that was a real great thing. But it was also the only product that won an award that did not live up to its expectations. We had developed that product for all carriers and we had developed it for AT&T and Verizon and Sprint, but we wanted Verizon because we knew that Verizon couldn't get the iPhone. But they negotiated-- the negotiations with Verizon, Palm just played too hard to get and Verizon said “Okay, we're not going to do it on your terms.” If we were to have done Verizon, we would have probably been a really strong competitor to the iPhone. Instead, we were with Sprint, which is a very small carrier and it just-- eventually, it just died and that's unfortunate.

Barnes & Noble: The Nook and Bill's 3rd CES award

So, after that, I retired again and then Barnes & Noble contacted me through some weird way or some referral from, I guess, some person that was working there and they asked me if I would head up the

Nook development in Palo Alto and I said "I'm retired. It's going to take a lot to pull me off of this." And they said "What is it?" and I said "Total autonomy. I don't even want to report to anybody except the CEO and I..."

Fairbairn: "Send me a paycheck and I'll do you a product," right?

Saperstein: Yeah. That's basically it. "I will go down to setting up the labs, buying everything-- just give me a blank check and the reqs and we'll make it work for you," and they did because, I mean, it was the logical thing for them to do because they were a book company. They knew nothing about..."

Fairbairn: I was about to say. So, that was the Nook. I mean, you developed the Nook and...

Saperstein: Yeah.

Fairbairn: I was always wondering "How the hell did they get this-- they're a book company. How the hell did they get this?" and the answer is they hired you.

Saperstein: I did the cherry-picking of the people that used to work for me. We did at one time as many as three products at the same time. We were doing software, hardware, reliability testing. I developed the team in-- we eventually took over the PARC (Xerox Palo Alto Research Center) building and we revamped it to be the Nook building where the cafeteria was and everything else and we did that. I set up a...

Fairbairn: Which PARC building?

Saperstein: The one that was down-- not the one on the top of the hill, the one on the bottom. That was the white building-- that was the second building. It wasn't the original PARC that was on the hill. This is the one that was right down below it. You go down the stairs from the hill and I think that's where the cafeteria was, on the second floor.

Fairbairn: There was a cafeteria up in the top building. I don't even know about the lower building.

Saperstein: Well, when you say the top building, you mean the...

Fairbairn: 3333 Coyote Hill Road? It's sort of the main-- it's where they are...

Saperstein: This was on Hillview Road. The one on Hillview, there's the two entrances. There's the one that's-- the first entrance was PARC, but that was built after the first one, which was the-- it's kind of built...

Fairbairn: It had this layered thing-- yeah, yeah, yeah.

Saperstein: Yeah. The other one was more conventional, but it was two-story.

Fairbairn: I didn't even know about that. That was after I...

Saperstein: That's an older one. I mean, newer as far as timescale goes. But we had that, and we developed all of those products. That was my third CES. The Nook Color won CES best...

Fairbairn: You won three awards?

Saperstein: Yeah, three awards.

Fairbairn: Best product at CES in three different...

Saperstein: It was the consumers' choice at CES, yeah, for that year and it was really interesting because that was the year that I think Bezos or somebody said, "Why would anybody want a color reader?" That's when he was doing the Kindle in e-ink only. So, we did the color version and it just beat the pants off and later on, they did the Fire and after we did that, then Gregg Zehr, who was running Lab 126, he comes to me and says "You want a job at..." I'm having too much fun running this place. So, then we did the e-ink reader with the built-in light, not with the extension light, but we laminated a light on it, again, a year and a half ahead of Amazon. That's when Gregg comes by again and he says...

Fairbairn: It was backlit?

Saperstein: This was front-- top-lit, which was very unique. It was very unique. But I had a very small team. I had a team in Palo Alto, I had a team in Taiwan, and I had a team in China. So, I basically was really vertical. We were embedded in Pegatron. I made them a lot of money. I had a-- we ran at a facility in Taiwan and then we had the one in Palo Alto and so, we could control the whole thing.

Nest Labs

When I went to Nest-- well, when they closed down Nook, I had to find jobs for all my people. I had about 30 people here and I had maybe 20 people in Asia. So, I just started beating the bush around my Apple network. I knew people at FitBit. I knew people that had gone to Nest from Apple and so, what I did was I just started to go and ask these people "Hey, I've got some really talented people. I'm going to go retire again. Can you take these guys?" So, Nest actually had an open house just for the Nook people and it was really good. They were very nice. This was when they were on Hansen Way and Tony [Fadell] was in charge and they brought them all in. They had a few positions for some of the PD and the EE people, system engineers that I had and I think-- and the GSM and reliability people. So, I just went there to make sure that everything was cool and then one of the VPs pulled me over and said "What are you going to do next?" and I said "Man, I'm going to retire. I don't get a chance to surf as much as I want to. Now, I'm just going to go in the morning and that's fine," and they said "Well, we could really use an architect. You don't have to put in full-time. Do your own hours and we just don't have anybody that understands the system architecture and the silicon," and I said "Well, I'll come by and I'll talk to whoever is in charge." So, I talked to them and I said "This is not part-time. This is at least going to be full-time for six months or more," and they said "Yeah, but after that, whatever you want to do." I said "Okay," and so, I went through that. I did four chips for them.

Fairbairn: Is this when they were doing the thermostat?

Saperstein: Thermostat, the smoke detector, the security product and the cameras.

Fairbairn: So, they did custom chips for all of those?

Saperstein: Tony wanted custom chips.

Fairbairn: Yeah.

Saperstein: We developed custom chips for the thermostat, which we never used. I did one custom chip for the thermostat, which we did use. I worked with NXP to do a custom chip that we never used, but I have some really good relationships with NXP, and I said "Look, there's no exclusivity. You can sell this chip outside." So, they basically sold it to Garmin and they made millions. It was great for them. So, I'm happy for them, but it was a year out of my life designing this chip. I worked with Dialog doing their 154 Bluetooth chip that we were going to use also. It was a custom chip to be used in a smoke detector and then we decided not to use it, but...

Fairbairn: You went with standard product?

Saperstein: Yeah. We went with standard products. Then I went with Qualcomm to develop a chip, an all-in-one processor for the smoke detector that had all the radios and the processors in it. They were going to do a wearable chip and I said "No, let's do this chip because it's an IoT chip," and so, they developed-- they set up an IoT group and they built this chip. It's the 4020 [QCA4020], which again, we didn't use. We pissed off Qualcomm immensely, but the irony of it is Qualcomm sold it to Ring to compete directly with the Nest cameras and it beat the Nest cameras because it had a feature which I designed into it, which we couldn't get off the shelf.

Fairbairn: Which was-- what was that feature?

Saperstein: It was the ability to do pre-roll. In other words, before the trigger event, you could capture... So, it was an integrated three radio plus a M4 MCU inside of one chip with a lot of memory. So, that lot of memory was the big win and also, the direct connection. You don't have to wake up anything to stream back to the cloud. So, I got-- Qualcomm didn't talk to me for at least six months after we did my-- I said "Look, it's not my fault. At least I enabled you..."

Fairbairn: Then they made a lot of money anyway.

Gossamer Engineering: Doing design for others

Saperstein: They did make a lot of money and that was good. So, yeah, that's kind of been a strange history and I started another company on the side, which we called Gossamer Engineering. It was a design house purely. I had a bunch of people that used to work for me in the Valley. They liked the old way that we used to do things, whether it was at Palm or whether it was at Nook and so, I said "Well, what I'll do is I'll help you organize and I'll try to make the contacts, but I want you to run it." A legacy is only as good as what you can hand down. If there's a vacancy there and you don't know how to take over from that, then that's not the right legacy you want. So, I said "I'm going to put you in a position where you're going to have to make hard decisions that are not only technical. They're going to be business decisions also."

So, I started this and I basically said “I really don’t want to run any day-to-day on this. I’ll set this up. I’ll try to make some of the contacts. I’ll give you hints on the directions that may be the most-- the best financially.” What it was set up to do was be-- since we had all these contacts in China, it was going to be to support startups, real startups, these startups that basically don’t know what the hell they’re doing. It’s not like the old spinoffs. These are guys that just want to start their own company but have no idea how to make a prototype and worse, they have no idea how to make it into production. So, this group was a bunch of seasoned designers and production engineers. I had them in Taiwan, China, and I had them here in San Jose, right where the airport was, and we would just basically say any startup that wants our help-- so, there were startups. There were even larger companies. We did it for Google. Google, their research group, ATAP, didn’t know how to implement. So, we had contracts with them. We had contracts with Facebook. This group designed the Portal for them and got it into production for them, the first one because they were all experienced designers. The Peloton treadmill was designed by us.

So, these guys enjoyed it and from day one, we were profitable. We never had to go to VCs or anything like that and I had some VC contacts that we would get some crumbs from the VCs that realized that they were funding a company that didn’t know how to do their idea. But eventually, it was hard for the team because you’re always having to try to get gigs, right? These guys want to just work as engineers, and I didn’t want to do that. I was getting too old to just go out there and try to get work or to come up with ideas like that all the time. So, we eventually sold the company to Peloton. So, they bought it. Again, that was a surprise. I said “Holy mackerel,” but it’s...

Fairbairn: What years did you do that?

Saperstein: That’s been fairly recent. I mean, the sale to Peloton of Gossamer Engineering was-- I guess it was a year and a half ago.

Fairbairn: Before they had their own dive.

Saperstein: Right. They were doing great and the reason why that happened was because the CEO of Nook that was based in New York became the CEO of Peloton and so, he called up and I said “I’ll leave it as a vote to the team. If they want to do it, I won’t blame them, then that’s fine.” There’s no hard feelings there because I did this for them anyhow.

Fairbairn: Right.

Saperstein: So, they did well. They got a lot of stock options and hopefully they vested before things went down. But, it’s been a great-- the Valley has given me a lot of experience. It’s humbled me a lot. I’ve been surrounded by a lot smarter people than myself. I’ve always been the stupidest one in the crowd, I think, and it’s given me the opportunity to learn, and to learn from very smart people, sometimes very weird people, but still very smart. It’s taught me a lot about how the business of technology is so different than almost any other and to be successful, you can’t just have a great idea.

Lessons from Silicon Valley

I can remember when some startup guys come to me that are actually very smart, had some great ideas, but when I would tell them “You know, there’s a gravestone on 101 of a company that did this five years

ago,” what’s different from you than what they did? They would say “We think we’re smarter than those guys are,” and I said “Well, unfortunately, that’s the wrong answer. To get my vote, I can’t give you that. You’ve got to tell me technically why-- it could be the technology. It could be the timing, but just saying that you’re smarter than those people five years ago is not the right answer.”

Long before I graduated from college, there were some really smart people out there doing some amazing things and it’s kind of ironic that today is the anniversary of the transistor at Bell Labs. This is 75 years ago it was invented and so, you and I both were at Stanford when Shockley was there and got the Nobel Prize for that. So, the Valley will humble you, but it can also blow up your ego. It all depends. I always think that it’s the greatest place to understand technical history because-- also, to try to follow your passion. But when so many engineers, they don’t realize that the Valley is not a place to be comfortable. It’s always a place that if you’re uncomfortable, then you’re doing the right thing in your career.

This is not like working for the Post Office, right? You don’t want a comfortable secure job. You want to be pushed because the Valley is-- that’s the whole thing about the Valley, but it’s also the passion that it brings. You’ve got to have the passion, not just the urgency of getting rich or doing something. I think that was the really interesting thing about the time when I was at [HP] Deer Creek. It was the perfect storm. You had all of these people that were very bright and that they wanted to do this neat stuff that was process-related or silicon-related or design-related and so, it was just natural for them to spin off.

It wasn’t the same like it is now. I think that I relate it back to the time when being a physics major, back during the time of quantum mechanics. For the longest time, Newtonian physics was the Bible, but it could not explain a lot of things, right? So, when you look at the theory of quantum mechanics, it’s so different. It’s so non-intuitive, right? But if you read history of physics and the history of that time, you had a group of 40 or 50 really outstanding physicists that their minds, it was the perfect storm. They said “Something needs to happen to explain this,” and so, that’s...

Fairbairn: I just saw a picture of this group that...

Saperstein: Yeah. It’s that group. It’s exactly that group. Any other time, that would have never flown. There would have been so much bickering amongst that community, but everybody realized that the time was right for invention. That’s the way it was back in those days at Deer Creek and in the Valley in general. Everybody was doing a RISC chip-- Fairchild, AMD, Intel had their own little thing, HP. Everybody was experimenting on new devices.

Fairbairn: Even ARM, the predecessor of ARM.

Saperstein: Yeah, even the predecessor...

Fairbairn: Acorn RISC...

Saperstein: Acorn, right. It was a great time to be an engineer. You just couldn’t help but get caught up into it and it wasn’t-- nobody was talking about how rich the company was. They were just talking about how fantastic the technology could be.

Fairbairn: Exactly.

Saperstein: It was-- I'm hoping that it comes back. It will. We've lost a lot of momentum when we lost the semiconductor business and I thought that it was going to come back with the system business, but even that didn't do as well. Software has been kind of like the-- filled the void, but it's different. It's a different thing, I think. I love doing software, but the motivation, the mindset is a little bit different than the guys that were doing systems and hardware, I think. So, it's kind of different. I think I've taken up a hell of a lot of your time.

Fairbairn: Well, this is what we came for. I suppose we could dig into any of these stories to a much greater depth, but I think it's been a fabulous couple of hours and I really appreciate it and great contribution.

Saperstein: It's been fun.

Fairbairn: It's been a great education for me because I knew about these various things, but I had no idea that they all came from you.

Saperstein: Well, I wouldn't say all of them came from me. I was part of the team or of the process. I think probably the more interesting thing is that behind the scenes, it wasn't as well-organized or planned as it may have seemed. Nobody would have thought that the G3 was a skunkworks, that it was...

Fairbairn: Yeah. I mean, that to me is a revelation.

Saperstein: I think that I was-- even though I always knew that Apple was a shoot from the hip cowboy compared to HP by a long shot or IBM. I probably was at the end, the most rebellious of all of them, and probably that's why Rubi was not happy when I left, just because he was trying to compartmentalize more. And I said "I don't think I can do that." I can even remember when I was doing the review for the iMac and Jobs had done the ID for that.

He had talked to Jonathan and Jonathan asked me to come in and review it, Jonathan Ives, and I'm looking and I'm saying "Jonathan, why do we have triangular shaped PCBs? You know that that's going to be more expensive to panelize. Why the hell-- and why is it this color? Why do we have to have this color on the cord? You know that your cord is going to be \$2.00 when I can buy it for \$0.25." But he said "Steve wants that," and I said "Okay. I understand." That's where I realized that I wouldn't have the freedom that I had when he wasn't there. But it was definitely a great learning experience. It was good and I think that you just go around ... Probably if you look at this museum and you see what people have done, it's still, I think, amazing to look and say in this short period of time, look at this advancement. Do you realize that one of my office mates at Deer Creek was David Lam.

Fairbairn: Oh, Lam Research.

Saperstein: Lam Research.

Fairbairn: Yeah.

Saperstein: Dave and I used to eat lunch together. He was a young kid with a PhD that said, "I think I can make this react in a plasma," and I said, "That's pretty amazing," because at that time, nobody could

etch-- there was no plasma etching. It was all wet etching, and you could never keep the geometries. I must admit, at that time, I was saying "Dave, you're going to electrocute yourself. This is crazy." But the nicest guy in the world and physical electronics. The same thing-- who would have ever thought that some of these companies that were starting out doing semiconductor equipment would rise to the level that they were. It's amazing. I think that you look at the history that you guys are trying to archive and it's a very short span. It's almost mind-boggling if people kind of realize that just in that timeframe of the 80s, I was dealing with 5 micron-technology that was cutting edge. It was bleeding edge. Nobody ever thought about doing a million transistors.

Fairbairn: Been there.

Saperstein: It's just amazing.

Fairbairn: All right. Well, that's a great way to wrap it up. It's certainly been a great ride and a great interview and we really appreciate it. Thank you very much, Bill.

Saperstein: I thank you for the time.

END OF THE INTERVIEW