



Oral History of Robert Norman

Interviewed by:
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Fairbairn: Okay. This is an oral-history interview with Robert Norman. Joining myself, Doug Fairbairn, in this is Dave Eggleston, who's worked with Bob through the years and is going to be a joint interviewer.. Today is Thursday, July 16th, and 2020, and we are all sheltered in place at our respective homes, and so we'll start the interview with that.

So, Bob, in these oral histories, we're obviously going to spend the majority of the time talking about your professional career and the contributions and interactions you've had over that period. But it adds to the richness and the fullness of the story if we can have you describe a little bit about your early years. Where were you born? When were you born? What was it like growing up? Tell me a little bit about your parents and the environment that you started with. So I'll turn it over to you with that.

Norman: Yeah. I was born in Gettysburg, South Dakota. That's about 60 miles from Pierre right in the-- almost the dead center of the state, little farming community, about 2,000 people in the town. My dad was in construction work for most of his life, and my mom everything from working in a bank to having her own dress shop kind of things. As a kid, both parents worked, and in those days, you didn't worry about your kids. You just turned them loose, so a typical summer day for me would be to get up in the morning and go find a buddy and figure out what you were going to do for the day, and I lived by one rule with my parents. That is shortly after dark, I better be home, and that was the extent of what I had to take orders from or to-- the rules of the house. So, it was pretty flexible.

Fairbairn: Kids learned a lot of self-direction in those days. You had to plan your whole day out, right?

Norman: Yeah, exactly. But you'd get up in the morning, and it was either baseball or go out fishing or stuff-- where we grew up, it was great fishing and everything. So as a kid, it was-- it really is a kid's dream to grow up out there. Business-wise, that's another story, the cold and the winters and the business climate. Unless you're a farmer, it's a terrible place to live, but as a kid it's wonderful.

Eggleston: Bob, didn't you have a Huck Finn/Tom Sawyer-like story of building a raft?

Norman: Yeah. Yeah, I sure did. About first or second grade, the buddies and I-- well, this was when I was living in Fort Pierre at the time. My dad was working on the dam building, the Oahe Dam, and my buddies and I decided to build a little raft, and none of us could swim. But we built this raft and jumped on it and floated down the Bad River, which is a pretty good-sized river, and we just had a blast all day long going down the river. We realized it was dark, and we had no idea where we were, and so we were floating, deciding what we were going to do, because there's no way we could go back upstream. It runs fast enough. So, we floated until we saw lights, and I was able to-- or my buddies and I, we got to shore, and we walked towards the lights, which is the little town, and we didn't know what to do. None of us had money. God forbid money in those days, couldn't make a call or anything. So we flagged a cop down and said, "Could you make a call for us?" and I called my dad and said, "Can you come pick me up?" and he said, "Well, where are you?" and I had the cop give him directions, and we were 60 miles downstream from where we had gone on the raft out floating all day.

Fairbairn: <Overlapping conversation>. Sixteen or sixty?

Norman: Sixty, six-zero. Yeah, we made really good miles. Like I say, the river runs pretty fast, so we made good headway. It was 60 miles by land but not sure on the water route, My dad kind of checked out of the house and came and got me, and he said, "Well, we don't tell Mom about this, but don't do it again."

Fairbairn: So, is this a log raft, or what did you build the thing out of?

Norman: Yeah, we had some scrap boards that we found. Actually, nobody had nails or anything. We found some twine and stuff and tied it together, and away we went. It was very crude, especially very crude considering none of us at that point knew how to swim. But it was fun. But that's very symptomatic of the kind of days I had as a kid. Very free, do what you want, no holds barred. Get home at night was Rule 1, and Rule 2 is don't get hurt. That was basically it. So, yeah, no, it was great growing up there.

Fairbairn: What did you do in the winter? I mean, it's fine to float down the river in the summer, but there's the long winter to deal with.

Norman: Yeah, there was a lot of sledding and that kind of thing. But by and large out in the cold areas like that, they have very good indoor sports, a lot of basketball and stuff that they keep the kids busy with. So that's very good. I enjoyed basketball. As a matter of fact, I had planned to be a coach, and everybody always said, "Well, Bob, you got to study harder," and, "No, I don't need to study. I'm going to be a coach," and I lived with that dream for a lot of years. And then I got hit with rheumatoid arthritis as-- when I was about eight years old and had various bouts with that over the years. I'd have remissions, and then I'd get bad and remissions. I finally faced reality when I got into high school that the coaching is out, that the physical side of things just weren't going to happen. So I said, well, if I want a future and take care of myself and a family, then I'd better get serious about school! I always liked math and science, so I started hitting the books and kind of turned the academics around, if you will, changed my attitude, and I ended up going to engineering college and got a start in that.

Fairbairn: Were your parents encouraging you on the academic side, or did they just..

Norman: To be real honest, not really. My dad, I think, had an eighth-grade education. I'm the first Norman that ever went to college and graduated. Like I say, it's a farming community, and everybody works for a living and very few people go to college. But then on my mother's side, there was a lot of people that went to college, so I have to take that back somewhat. But my mom was, I don't know, very sort of uncaring or just, "Do what you want, long as you're happy. Find your path and go." So, yeah, as far as encouragement goes, it really wasn't there as a kid. Everything I got was kind of self-motivated in life.

Eggleston: How big was your high school, because I remember a story. You went back for a reunion, and people had done quite well for themselves, but it was a small class.

Norman: My graduating class had 54 in it, and out of those 54 there's 4, maybe 5, millionaires out of that group. As a group of people, that's a pretty good hit rate. So, I grew up with some very different people, And I have to admit that. I look at most people, and I had a very unusual class of people. I don't know what you'd call them. They're just unique personalities I guess is all you can say. In a way I was fortunate, because they all kind of had different drummers, and you got to see a lot of things, or think about things that you normally wouldn't with a normal class. We got guys that wanted to be writers, way down in school, and just would write all the time and do those kinds of things. Just a real different group of people.

Fairbairn: So what year were you born?

Norman: I was born in 1948. Getting old.

Fairbairn: So you must've graduated in about 1966?

Norman: Exactly, yep, '66, and I went to South Dakota School of Mines right after that, and I graduated in 1970. So with four years I was able to get through pretty quick, and..

Fairbairn: What area did you study? You said you were interested in science and math, but what was your degree in, and were there..

Norman: I had an EE degree, but what I took mostly was power and control systems, which was almost totally opposite of what I ended up doing. I did control all my life but control as far as memory controllers and disk controllers, that kind of thing, but not the motor controllers and the kind of things I studied for. Actually, I was in the years when they were still teaching tube design. So, when I started, I spent a lot of time studying tubes and everything, and we were switching over to transistors kind of as we went, where we saw quite a bit of that when I finally was a senior. But a lot of the things related to building things like transistors or tubes was tube-based. That's basically worthless by the time I got out of school.

Fairbairn: So do you get into like amateur radio or any hobbies associated with electronics?

Norman: Played with a little bit, but, to be real honest, that never captivated me. I'm not a video fan, either. I don't play games. I don't know. Seems like I enjoy working on things. I enjoy inventing, making things work, but as far as just hacking around, that's never been an interest of mine. I know that's counter to what most engineers are like, but I never said I was like most of them, I guess.

Fairbairn: So as you were going through college, did you have any ideas to what you would do with your degree or where you would go or..

Norman: No, not really. When I was interviewing, I really interviewed a wide range of type of jobs, everything from computer design to the railroad design to....Burlington Northern out of Chicago offered me a job on Grand Central Station down there, and I took one look at it when I was there and said, "Nope, not going to do it." So then I had an offer to manage a pump station for the gas lines and oil lines, where I would basically have a crew under me of about 10 guys or so that would... Responsibility were to keep

that up, and that would be in Nebraska, and I kind of attempted to stay close to home. But that was kind of a dead-end job, I could see. Besides, a 20-year-old kid telling a 50-year-old guy that he's got to go do this or that.... I worked for my dad in the summertime managing a crew.

One year we put up grain bins, and I had a crew that was responsible for putting up grain bins. The Butler bins, the round metal ones that they put up, and I did really well. I had the top crew as far as what we produced and everything, but to be-- I maintained that level of efficiency by keeping beer at the site, and I said, "Long as you guys are producing, I'll buy beer." I ended up almost spending my whole summer wages on beer, keep those guys going. I remember in the fall my dad asked me, "Well, aren't you going to buy a bunch of new clothes and stuff for school?" Well, I'm broke, and he couldn't figure out where my money went. My money went for beer to keep the crew happy.

Eggleston: Now I understand why we had the beer fridge in the lab at MQD. That makes a lot of sense to me now.

Norman: I can't take no credit for that.

Fairbairn: So, going back to your earlier comment, was it your goal to stay around South Dakota, or was it your goal to get out?

Norman: I wanted to stay close. All my friends and everything were there. When you grow up in a small area with a small group of friends, you're kind of sheltered, and you're afraid to take that first big step. And so I was kind of motivated just not to go too far from what was familiar for me. But later, in later years, I kind of regret that, that I didn't-- wasn't a little more aggressive in viewing the kind of options I had at that point in time. So I..

Fairbairn: You told us about the jobs you rejected. What was the job that you accepted coming out of..

Norman: Well, my first job was at Sperry UNIVAC. I had a job offer from UNIVAC and Control Data, both mainframe houses in Minneapolis, and I couldn't tell the difference between the two. My sophistication as far as looking at the job and analyzing it was basically zero. So, UNIVAC offered me \$10 more a week, so I took it. I mean, that's really a poor thing to say, but that really tells you how unsophisticated I was in the electronic world as far as what's involved, the jobs and everything. I was what they call really green.

Fairbairn: So had you traveled much outside of South Dakota before you went to..

Norman: No, hardly any at all. So that was part of my reluctance to do that is the comfort factor. It's basically just stepping outside your comfort zone, and at that point that was outside my comfort zone. I think back now, and it's laughable, but as a 20-year-old kid, that's the way you looked at things.

Fairbairn: So, you accepted a job, you say, at Sperry?

Norman: Yes, that's correct.

Fairbairn: Tell me about that move. What was it like going to Minneapolis? What was the nature of the first job?

Norman: Well, it started out horrible. When I was moving from Rapid City, where I went to school, the movers came and packed everything up, and when I got to Minneapolis, the union was on strike. I had a buddy that was also going to UNIVAC, so we got together and said, well, let's help each other load and unload and everything. So, we were down to the last item, which was about a 400-pound freezer that we pushed onto the truck. In those days, I didn't have a hoist. You had to push them up the ramps. So we finally got it on the truck, and the whole time the union guy was sitting there, smiling, and I was wondering, "What the heck is he smiling about?" And soon as it was on the truck, he walked up and said, "We just went off strike about five minutes ago." So that was kind of my start in the world at that Minneapolis.

I started out on the test floor checking out computers, the mainframes and stuff. The design job I wanted wasn't open, and so I had to start out in test, and I worked that for a little over a year or so. But looking back on it, that was probably one of the best things that could've happened to me. In college you don't get really good hands-on experience for troubleshooting and using sophisticated equipment and stuff. You learned really fast in that environment, because that's the name of the game is tracking down things with good use of the equipment.

So, I learned a lot of the practical side of things by taking that job, and then after I was there a little over a year, my boss went over to the design engineering and said, "You're wasting this kid's talent. He's too smart to be testing-- doing the kind of testing he's doing." He said, "You need to hire him as a designer." So, they transferred me into the memory-design group, and I've been in design ever since.

I actually started out working on drums, which-- most people don't even know what that is. It's predated disk drives, and so I worked on drums for a while, and then I got into testing plated-wire memory. I found all kinds of problems with it, and that was one of the reasons they put me over on the design side: "Okay, now fix them." But it worked out, actually, pretty good.

Fairbairn: Did you have any introduction to computers or programming or anything at college before you went to Sperry?

Norman: I took Fortran, the basic Fortran course they had in those days, but that was essentially it - nothing real major. So, I was learning as I went on just about everything I did in life. It seemed like driving a tractor up and down a field all day doesn't really prepare you for the computer world, and so it was learning on the fly. But luckily, I picked most things up pretty fast and did okay.

Fairbairn: So, it must've been quite a shock moving from this small town to the world of electronics in Minneapolis and so forth. Are there any other memories from that time about what that transition was like?

Norman: No, not really. One amusing incident that did happen when I was still over in test, is they had what they called a FASTRAND, which-- I don't know how many tons it is. It was their biggest drum that they made, and they were shipping-- going to ship it out to some site. And they had a guy with a-- had a little light electric cart with a little motor on it that you put underneath, jack it up, and it's got little wheels that-- I don't know what they call them, electric-- little movers, or—anyway. He was bopping down the hallway headed towards the dock area, and I realized too late that he was going way too fast. I started yelling at him to stop, and he couldn't stop. He put on the brakes and everything else, and that FASTRAND just kept moving, and fell right off the end of the dock. Back in those days it took about a month of solid engineering work of building and tests to make one of those. So it was a major loss to the company, but that was quite a sight seeing it go off the end.

Fairbairn: So, you moved over to design in Sperry, and you started working on memory design. How long did that go and tell me a little bit about that experience.

Norman: Yeah, I did, as I mentioned, some of the cleanup work on the plated-wire memory. But that was relatively short-lived, and they were in production with that. The next thing I did is I designed front-end controller for a backing store for a two-wire core system. Again, most people don't know what that is, but I worked on a two-wire core. UNIVAC was on hard times, and they called us all into a room one day and said, "Well, we're going to have layoffs, but we're going to do it technically based," said, "We picked two teams, and we're going to have a design-off between Team A and Team B, and whichever wins gets to design that product, and the team that loses, we show you the door." The project was DRAM memory, the first one that UNIVAC was going to do, and so I had a lot of bills and stuff, and I didn't want to lose my job, because it was a bad market in Minneapolis at that point. So I basically..

Fairbairn: These 1103 memories from Intel?

Norman: Yes, it was. Yes, it was. For about two, three weeks, I locked myself basically in my house and designed, and then when we had the presentation to the big guys, I blew them away. I came up with a radical concept that they really liked, and we won the design. And I was in Team B, and Team A was all the-- what they considered the top talent in the company. Team B was young guys that are expendable, and we won it, and they didn't hold their word, though. They didn't lay those old guys off. They found places for them, but the fact that we won it saved all our jobs.

So, I got to go ahead and implement the concept of what I came up with, and there was a guy that helped me on the ECC portion of it doing the Hamming code. And other than that, that was basically-- it ended up being kind of a one-man design, and I had something like 40 plugin boards, the big-size boards in a refrigerator-size unit. When I plugged it in, it ran! When I debugged it, I ended up with two backplane miswires and a cut and an add on one of the controller chips. So out of all of that, essentially about a three or four changes to get it up and ready for production, unheard of as far as-- in those days.

Fairbairn: Designing with 1103s back then was-- those were tricky parts to make work reliably.

Norman: Yes, they were. I spent a lot of time playing with them in the lab before I cast the controller in concrete, I had a couple of technicians working for me that I gave a whole raft of things I wanted to know and test, and then they did a very good job. So I wasn't surprised by really anything by the time I got the design complete. But you're right. It was a challenge. But that also reminds me of-- we had a big meeting when everybody found out how well the memory was working and how easy it went together.

They called a big meeting, and some of the head guys from Blue Bell, Pennsylvania, which is corporate headquarters, flew out, and we had a meeting. The topic of the meeting is, "Should we buy Intel?" We talked everything through, and there was one guy from Blue Bell, one of the executives, that voted yes, and I voted yes, and everybody else in the room voted no, which-- I laugh about it now. UNIVAC buying Intel, because UNIVAC was just barely hanging on. It would've killed both companies. The culture was so different between the two that it would've been bad for both. And I think Intel never would've turned into what Intel is if they had been under the UNIVAC umbrella. And UNIVAC didn't know how to manage it. So, I suspect they would've played with it a few years and then dumped it or something. I just didn't see it ever working, but it was interesting that I got the vote, and..

Fairbairn: Interesting story there.

Norman: Yeah, no, it..

Eggleston: Bob, what was it about your architecture that was different?

Norman: I did pipelining, which in memory had never really been done in those days. When we did the architecture, I went wide and then pipelined everything down narrow for the channel. And I did some things timing-wise that were very unique. Everything was asynchronous design, which, again, is-- you don't do today. I was very good at that kind of design, and so I came up with some novel ways of doing clocking and things, where we got the most out of it. When we set out as our design goal, the spec for the product for the memory is-- I had 650 nanoseconds to take a request in, get it down the channel. 16 channels coming in, and do the priority select on the channels, go to the memory boxes and get it back out and all of that in 650 nanoseconds. You say, "Well, that's a piece of cake," but in today's speeds it is.

Back in those days, that was a real challenge. I was able to do it in 400 nanoseconds, and my boss at the time said, "Don't you dare tell them that you've got 400 nanoseconds," and we'd go to a meeting, and the processor guys would just beg us for-- "We just can't do this. We've got to have five more nanoseconds that you've got to back off on the"-- so we could make our time, and he would growl and, "Well, we'll look at it." Then he'd go back in a few days, "Yeah, we found a way to do it, but you owe us." I heard that for about a year, and when it came-- and it worked out really good.

By making them do that, they actually cleaned up the design very considerable, and they were able to pull it way in themselves, where if we'd given them the time, they'd probably just called it a day, and everybody's happy. So, my boss was right. He was smart in holding back and making them do their job. But when we first plugged it in and it ran, I was running 100 nanoseconds faster than what they expected, and they thought, "Man, this is a screaming computer," and then they thought they did it all in the

mainframe, and then they did forensics on it, and lo and behold, it was all memory time that saved the day as far as performance.

Eggleston: Any notable patents come out of that work?

Norman: No. I can't think of anybody that got a patent at UNIVAC. That was just something that wasn't part of the language back in those days. I look back on it now, and, geez, there's a lot of things I could've patented. I designed a logic box that converted error locations to physical locations so that the field engineer could walk up to the box, dump the error codes, and it would tell him which chips were failing and what the probability of failure was. That all popped out in lights that they could read. I think about that now, and back in those days that was very patentable, and, yeah, just never thought of it. Nobody ever brought it up. Yeah, it's kind of strange, actually, but I guess people weren't really patent-- as patent-aware or didn't think about them in the same way as they do today. By the way, my boss did kick me under the table once. I started to say something about the memory, and he knew what I was going to say, and he kicked me, "Shut up. Don't tell them," and so I learned to be very discreet and cautionary in what I say in meetings. I learned the hard way.

Fairbairn: So how long were you at Sperry? Any other..

Norman: UNIVAC, yeah.

Fairbairn: <Overlapping conversation>, yeah, UNIVAC..

Norman: Yeah. I was there for a little over five years. I was actually the youngest engineer they had. They had a bunch of old-timers, and when they put the freeze on hiring, all the young guys just didn't come in for a lot of years. So everybody called me the kid, which I loved to think of those days. But, yeah, I was the young guy for the longest time. But UNIVAC had a very stodgy culture in that you wore a work coat and suit and tie every day, and you were nine-to-five, and what's your problem if you're here after five o'clock? That shows you're not doing well in your job. So, people were nine-to-fivers and just totally different than what I ran to in my next job. It was just the opposite of that.

For example, one day the air conditioning broke down. I took my tie off. It was 90 degrees in there, and I was sitting on my desk doing some design work, and my boss came up and said, "Where's the tie?" and I said, "Well, it's hot," and he said, "Yeah, it's hot where you'll get fired," and he said, "We wear ties here." He said, "Please go put it on." I was told in so many terms that that was unacceptable, and nowadays it would be laughable. But, again, that was the culture back in those days.

Fairbairn: Interesting insight. So, were there other major programs you worked on after this memory-system design, and what was the-- how did you wrap things up there?

Norman: Yeah. The memory was the last thing I did. It's 1134, I believe it was, for their 1100 series computers, and I actually have seen that box going into some old computer centers. I've actually seen it sitting there, so believe it or not, there's still a few of them around. And, God, I don't know why, because, I

mean, it took refrigerator size to be a quarter of a megabyte of memory. I don't know, but I have seen them.

Fairbairn: Yeah, yeah, things live forever. So, what finally caused you to move on from UNIVAC on to-- and what was your next position?

Norman: The two things that motivated me to move on: the cold weather in Minnesota, and I wanted to design with microprocessors. That was the new, greatest thing. I designed on the side a tester to demonstrate how it worked and stuff to the management. I did it on my time and got it done, got it working, and I took three huge cards out of the tester. It was the great, big, huge cards, and plugged in a little half-size card, and it did twice as much functionality-wise and everything. And they wouldn't let me put it into production. They said that's too radical a jump for us. They had a lot of military contracts, so they were very keen on fit rates and that kind of thing. But they held off and said, no, maybe in two, three years we could get that approved, where you can-- we can look at using it.

And two, three years seemed like forever to me when the-- I could tell electronics was taking off and starting to really move from the old mainframe days, because the minicomputers were starting to come out and stuff. My motivation was to go find someplace that had processors and minicomputers so I could learn about what they were all about

And so I found a job with Texas Instruments down in Austin and moved down there, and the first day on the job I was filling out paperwork, and my boss come in and said, "You come with me," and the guy said, "He's not done with his paperwork yet." He said, "He can always fill that out," said, "I need him now," and he took me back to the lab and said, "We've got a system that-- it's not working. It's our new prototype. We've got to ship in a day or two. I don't want you to go home until this is working." I hadn't seen the schematics or nothing, and..

Fairbairn: What kind of system was it?

Norman: It was a disk system for their small operating system, their 990 computer with-- that they had, for the minicomputer and disk attached. And so I rolled up my sleeves, and I left at two in the morning, and I had it working, but I was like, welcome to TI. The culture was way different than UNIVAC, and it was-- they expected a lot. They threw a lot at you and expected a lot, but I probably learned more in those two years than I had at five at UNIVAC, easily, because they.

Fairbairn: You said you'd worked with drums before, but had you ever seen a disk-drive interface before you.

Norman: No. I had not. When I started debug, it was like, "Okay, what does this do?" Dig out the parts, and you're like, "That's a processor. Okay." I had no idea what I was looking at, but I got it to work.

Fairbairn: Is it a hardware or a software problem?

Norman: Actually, it turned out to be a coding problem. They had a couple of states that they were missing their timing of their code, and I was able to spot it on a looping function that I set up.

Eggleston: So it was a real problem and not just a new.

Norman: Yeah, it was a real problem.

Eggleston: It was not a new-hire initiation stunt that they were pulling?

Norman: No, no, it was a real problem, and I got it to work, and they said thank you. But I went home to my wife and, I said, two o'clock, first day. Come on. I caught a little heck over that. Like I say, they gave you a lot of responsibility. There was three people in the company that had stamps or had the ability to shut the line down, and I was one of them. I was a pretty young guy to have that responsibility, considering what was all going on. But if I didn't like what I saw on the line, I could go shut it down, and I was the only one that could turn it back on if I was the one that shut it down. So, they did give you the responsibility, but you better be right. So..

Fairbairn: So what was the project? After you got this debugged, what was your major project there at TI?

Norman: Yeah. I bounced around a little bit. They were looking at CCDs, and I built a controller for the CCDs, but that was the old alpha days that nobody understood, and finally they threw up their hands and said, "Well, maybe someday we'll build it, but not today." So they put that on hold. But I learned a lot about CCDs and how to make a controller for it, and then they jumped into bubble memories. I built a controller for bubble memories and learned a lot about bubble memories and the technology, and we had them working in the lab. But we could tell right away that that's not a marketable product, considering the speeds and the cost and everything. It wasn't going to fly.

So they canceled that, and then I got my teeth into a real good project. I did a disk controller for the DX10 system, which I'm told by some of the old-timers that I met afterwards that that was their biggest seller ever that that had the highest run rate of any product that they had sold. Essentially it was a disk controller with a SMD interface, and bit-slice processors. The kind of standard for what was done in those days, and I get to write the firmware for it, and everything was mine. It was like, design it. Build it. Test it. Write the firmware. So, it was a great project to get your teeth really into a processor type of environment and understand what many computers are all about.

I quickly discovered that you have to be a switch-thrower if you wanted to be in that environment. The interface was just so terrible that you entered most things by switches and threw a bunch of switches and toggle, throw a bunch of switches and toggle, enter the data, very poor, and that drove me crazy. So I said there's got to be a better way, and I started looking around for something else that was a little bit more meaningful than that. I could see that the minicomputer market was not really going to take off. It just lacked too many things. I did get a real appreciation, though, for OTP memory in that back in those days when you went to the lab, you'd load your firmware up. You'd either load it with tape, or you would

load it with a card reader, and I could never keep my cards from folding and the ends and stuff. So I'd always eat my cards, and it would take me half a day to load my code. So, on the side I built a OTP array that I fed my data into, my board with. I had the only one there, but it was fast-loading. I could take my little OTP down to the lab and load it up within seconds, and everybody else would take half-hour to an hour to get up and going.

Fairbairn: What is OTP?

Norman: One-time programmable. So I got a real appreciation for what you can do with programmable memory, and that kind of carried forward from then on, where I put that in a lot of my designs and stuff. So, about that time, a friend of mine that had worked at Texas Instruments had gone to Colorado and had gone to work with Storage Technology. He put my name in the hat to say, "This is a good disk guy." They were looking for a disk guy, and so I went out there for an interview, and I fell in love with the project. It was everything I'd been looking for, and so I have-- I was there at Texas Instruments about two and a half years, and so I left and moved to Colorado, and..

Eggleston: How big was Storage Tech at that time, how many people?

Norman: It was right around 15,000 or so. It was a decent size. The project that I was working on was the 2700. If you go to Colorado and mention that, anybody associated with that project, the 2700, would know all the stories. What we built was we took a 8-inch disk and a 6801 processor, and we had 2 PDP-11 ports on it. We had a floppy connect on it, and we had a big array of DRAMs with our own operating system, and essentially it was a computer on a disk. And that was before the-- anybody else had a mini-computer on the market, and we had a lot of people lined up that wanted the product, but we just couldn't make it run.

What the problem turned out to be is it had a really weak base plate. See, we had a major customer down in Texas that had to have one up and running, or it was going to impact his business. We were looking at a major fine, and so they said, "Bob, hand-carry this one down and get it going for them, because we know they work here in the lab. So we can't find out why they're dead on arrival."

So, I hand-carried about a 200-pound system down there. I think I still got marks in my hands, where the plastic cut in from the handles. But I got it down there and set it up. Lo and behold, it was dead on arrival, and so I started tapping around the drive, and every once in a while, I'd see a servo burst. I fixed it by taking computer cards and shimming the chassis. Finally I could shim it to where it worked just fine. I ended up by putting a big rope around it, "Nobody cross this line. If you want to use it, call me. I'll fly you out. We'll talk about it."

They ran for months in that mode. It worked fine, but it had to have the shims, and nobody got to touch it. So we found out what the problem was, and for a lot of time we spent trying to filter out resonances with the microprocessor, where we would detect vibrations, and we would look at those vibrations, and we would change our servoing and stuff to match our filters and stuff. But you'd get the next batch running, and the heads were a little different. The spindle was a little different. The resonances were all different,

and we could never get enough of symmetry to-- where we could come up with an algorithm that worked every time for the variations that we were facing.

So I think management threw up their hands and canceled the project. But to me, that was probably the most interesting project I ever worked on in that it really was a minicomputer. I'm hesitant to say this, but my boss at the time went out to California and talked to some folks -- at a company called Apple, and they wanted to buy the design for something that they were building that was the Mac. And management got wind of it and basically walked the guy out to the door. They said, "We don't mess around with little companies. You shouldn't have done that." So kind of an interesting little tidbit that most people don't know about, probably half a dozen people or less, but it could've been. We had the makings of the first minicomputer, and we marketed it wrong. If we had thrown the drive away and just marketed it, we would've had a great-selling product.

Fairbairn: Interesting.

Eggleston: How much capacity was that drive?

Norman: It was 20 megabytes. Yeah, it's really small.

Eggleston: DRAM cache? Using..

Norman: No, the DRAM actually was what we operated out of, not caching, God forbid. In those days you never cached a drive. The speed is what you got in and out, but the memory was for the servo control and the PDP-11 control.

Eggleston: Got it.

Norman: ... and all that kind of thing and the operating system that we had that-- some of the basic commands had some things that we were supporting.

Eggleston: Main competitor for Storage Tech at that time was IBM?

Norman: Right, right. Yeah, go ahead.

Eggleston: I seem to recall a customer visit you went on, where they had a couple Storage Tech drives in the corner and a field worth of IBM drives, and..

Norman: Several related to that, similar kind of things. We were installing our first 8370, which was a knockoff of the 3370 from IBM, and we installed it in an office building in downtown Denver. We installed it and got it running and stuff, and the IBM guy was over there sweating with manuals and everything, and he couldn't fix the problem. So finally, he came over and said, "You guys obviously know about this. Can you help me fix this?" We looked at his problem. In short order we fixed his problem and made a real friend in the process.

And, lo and behold, we had IBM boxes at Storage Technology that we used to look at stuff, and in theory you're not supposed to open them up and look at them, but we did it all the time. I remember the guy came in, the same guy one day, and he came walking over to me and handed me a card and said, "I think that capacitor is yours." We had put a capacitor across the component looking at something and forgot to snip it off when we were done. Being the good man he was, he handed it to me and said, "I think that capacitor is yours." Didn't turn us in, because we could've had a major fine if we had-- so it was-- good deeds go rewarded at times.

Fairbairn: That's great. So, I'd like to step back and just sort of set a time frame. You graduated in '70, and you went to work there at UNIVAC, and you left there in '75 or '76? Is that right?

Norman: Yeah, right in there.

Fairbairn: ... and went to work for TI for a couple years. So, what year did you join Storage Tech?

Norman: '77 kind of comes to mind. I think it's right in...

Fairbairn: Right in that time frame.

Norman: Yeah, right in that time frame. One of the things I do like to blow my horn about a little bit is, starting at the 2700, I did the servo control with the microprocessor. Nobody's been able to beat my date as far as when they had a working servo processor controlled. So I'm still making the claim that I was first, which was a big thing in those days to control a voice coil with a little eight-bit processor. It took a lot of work and a lot of algorithms and stuff, but we got it working. It was kind of the template for what a lot of people did. Also, we came up with diagnostics that allowed us to hook an RS-232 into your drive and debug, where you could issue commands and stuff, debug.

We turned that actually into a full-blown test capability at manufacturing. It worked out so well, and when guys at Seagate and MiniScribe broke out and started doing the small drives, they basically picked that software up from us and turned it into the diagnostic software that they use today. So we kind of pioneered the whole area of diagnostics also on that project. After the 2700, even though it had an ill-fated, and the servo actually worked good as far as the control. The concept of how to do it was entrenched and had a lot of advantages. So in the follow-on products I did of the 8370, the 8375 and the 8380, all three of those projects had servo control by the processors, and I did the design for all of those, and it ended up working out very well.

Fairbairn: So going back to Dave's earlier question, did you get any patents out of any of your work at TI or at Storage Tech?

Norman: Nope. No, at TI it was the same story. At Storage Tech it should've been, because some of the AMD guys came out, and I drew pictures on the boards that they later turned into chips. Some microcontroller chips and stuff that they were doing but no patents there, either. All my patents came

quite later in life, and it was just-- I'd never even thought about it, just something that never crossed my mind, because it just wasn't part of the company's culture in any of those places.

Fairbairn: So how long did you end up staying at Storage Tech, and any other major programs there before you moved on, and what was it...

Norman: I was there a little over five years. If you look back, Storage Tech went into Chapter 11, filed bankruptcy proceedings, and they finally got out of bankruptcy, and I was told that the 8380 that I designed was the product that got them out of bankruptcy. That was their big seller that saved the day. In that design I just-- because it was my third pass at a disk drive, I banged that together pretty fast and had it up and running very quick.

So they threw the head of string controller at me, where it was two processors running in parallel, where you compare byte-by-byte operations so that you can detect errors by a mis-compare on one of them. It was-- that was about 10 big boards that-- required to do the head of string controller, and I designed that, and that worked out really well, too. It was a big success. So I kind of got more-- a little bit away from the drive development then into more of the controller and processor environment. So, I learned a lot in that process also.

I was always looking at learning how things worked. I used to read magazines voraciously, where-- not necessarily word for word, but I studied the pictures, where, "How're things put together? What're the key building blocks?" I found that very useful, and that extended my design life by a long time, essentially. Because most engineers don't take the time or the energy to stay abreast with the changes, and I did. I really spent a lot of time studying, and I read a lot of books. One year, just for grins, I wrote down how many books I read, and I read 100 books that year. So it gives you an idea of how much I read. I still read a lot today, but that's what I find keeps you up and keeps you abreast of things.

I was invited to go out with a startup, MiniScribe, where there was a lot of millionaires built out of that. I was in the belief that men have 14-inch drives. Boy, was I wrong, and that taught me the lesson that I never forgot, is, having seen that take off and everything. I said, "Boy, you need to understand the market better than you do. You might be a great designer, but you don't know squat about marketing." So I went out of my way after that experience to understand where the market's moving and what's really needed in the market to be a success. Because building something that you think is great and works great, it don't mean anything unless it sells! So I kind of put a new hat on about mid-career, I guess you'd say.

Eggleston: Was it at Storage Tech you either took or threatened to take a forklift-driving class in order to have a backup plan? I seem to remember something about that.

Norman: I kept signing up to learn how to drive the forklift and the box that lifts people up for the lights and stuff that the maintenance guys all had. I did it kind of as a joke for my boss, and he kept rejecting it, said, "You don't need to know that." I said, "Well, I got to have a backup. I got to have a backup," and he'd always laugh, but next month when it was time, I'd go sign up again, and he never did let me go, but it was a fun joke.

Eggleston: Well, maybe that came from your experience at Sperry UNIVAC, where somebody didn't drive a forklift very well.

Norman: No, it was more of a kidding thing with him, but I always told everybody that my retirement plan was to work at a parking lot, where I had a radio and a TV and a little heater. That was my retirement plan. Shoot for the stars, I always say, but...

Fairbairn: So what did take you out of Storage Tech?

Norman: Well, like I say, they were on hard times, and I did a career evaluation again and said, "Well, I'm doing really good here," because that-- at that point I had attained the title of-- what do you call it? The top engineering ladder you can get on. Geez, I forgot the name of it.

Eggleston: Fellow or something?

Norman: Fellow, yeah, basically the same thing, where there was no place for me to go, technically, and at that point I wasn't sure I wanted to be a manager, and I said, "Well, to come back and do meaningful products, it's going to take five years before the floodgates open again and we can go do things." So I kind of looked at all that and said, "Maybe you should move on. You don't know anything about semiconductors, so you've been a system man all this time, so go to California and see what semiconductors are all about."

So I decided to do that, plus-- Advisory Engineer. That's what it was called. That was the top spot at Storage Technology. When I got to be an Advisory Engineer, you didn't work for anybody. You consulted, and the vice president asked if I would do him a favor and go and evaluate products and tell him which ones weren't going to cut it, either technical, or the team is bad. Technology isn't right for what we're doing, just basically evaluate each product.

And basically I had the ability to kill products, and I learned real quick never get into that mode. People would see me coming down the aisles, and they'd scatter. "Don't talk to Bob. He's liable to cut your product." So that was very uncomfortable, and it taught me never to get in the life-or-death decision path with anything, if possible. It's good if you can be in on the decision-making, but just to walk in and say, "We're shutting this down," don't do that. That's bad.

Anyway, I made the decision that I was going to go to California, and just out of the clear blue about that time I got a call from Monolithic Memories, and they were looking at getting into the disk world. They wanted somebody to come out and do specialized FPGAs and disk controllers and various things. So I interviewed, and it was a product-planning job, where I was-- I came in as a manager of about 25 people, where we defined logic products, sequencers, disk controllers, that kind of thing. It was going along pretty good, and when I hired on, they didn't tell me that it was-- again, naïveté on my part that it was-- three groups would be informed, and one of them was going to make the cut. They had a communications group, and they had a, I'm sorry, DSP group that they were looking at getting into, and then the storage products. So once a month I would put together a business plan and go over to the executive row and

give all the VPs and stuff a presentation on my thinking and my plans. What kind of things we ought to build and what markets to chase. Got into the total available memory, share of memory, all the marketing buzzwords and worked all of that out, and I learned a lot in the process. But it was going actually very good, and when we got down to the decision point, I found out by then that it was-- that I was skating on ice again, that one team was going to be picked. And they told me that I was picked and that I would be a director shortly and had my own division in that area. But lo and behold, about a month later, AMD bought us, and that-- and best-laid plans, as they say. So we...

Eggleston: At MMI, was that when Federman was leading the company.

Norman: Yes, it was.

Eggleston: ... and did you interact with Irwin at that time?

Norman: Yeah. Actually, I knew Irwin pretty good, good guy, really good guy. So, yeah, Irwin and I talked a lot, and he asked very good questions. He was always very friendly, and he threw good Christmas parties and stuff. So it was a very nice atmosphere in that I got along with those guys very well. So, that paid off later, actually getting into SanDisk. Irwin was the one that recommended me. But, anyway, when AMD bought us out, they threw a bunch of stock at me. I had to stay there for a year, and-- as part of the buyout agreement, they picked 10 people that had to stay for a year to soak up the knowledge that they wanted, and otherwise the deal was off.

So, I worked there for a year, just a little over a year, but it totally changed. Once you're into a culture of a company and you're the person that gets bought, the world changes. I could see right away that, yeah-- I don't know. The culture didn't seem to fit me, and besides, the first week I was there, they said, "Bob, you're taking over this group." They gave me 150 people to manage, and then the next week they came around and said, "Bob, we're having a lay-off. Lay these people off." And it was like, thank you very much.

So, you know, I had a bitter taste in my mouth about that. And I decided that I needed to move on. And that was about the time that Eli Harari called me. Federman had told him that, you know, there was a good-- this guy that you know, showed some real innovation and stuff, on the product planning side, and he ought to interview me. And so, I started talking with Eli. We met down on Tasso Street., which was Federman's office area, down there, on Saturday. And Eli, Sanjay and I would meet and talk about what we wanted to build. a disk, is it a big disk, is it a little disk? You know, that kind of thing. What properties has it got to have. It was early on that we knew that the memory was going to have real problems early, so we had to plan on heavy error correction, and that kind of thing.

Eggleston: Doesn't Eli tell the story that the original plan, at SanDisk, was like a mainframe storage system? I seem to remember that--

Norman: Yeah, yeah, it was. Yeah, actually, that's what Eli had come up with. He wanted to be a mainframe guy. And we very quickly realized that that just didn't hold water. From not only a technical point of view, but also, from a speed parameter kind of view, that the flash was too slow to fit into the

mainframe market. And so, we needed something that was a little bit more forgiving. And so, we chose to go to the minicomputer. Or, I'm sorry, the PC market, basically. And that was a good move.

So, I ended up working with Eli, and we worked out the business,, plans. I helped him with the business plan, and I helped develop the technical roadmap and stuff that he presented to VC people, and everything. And it was off to a good start. And, very early on, I wrote a couple of big thick specifications that defined what a flash controller and flash system ought to look like. And just about everything that's in that document turned out to be what we built. And it was the foundation for all the patents that we did. It turned out to be very valuable.

But, anyway, I came in, and started working, actually, with Sanjay, quite a bit, on defining the memory, the memory interface, that kind of thing. . Eli kind of let me run wild. And I think it worked out well, in that, originally, they had made a partnership with Western Digital. And my job was to oversee that interface, and make sure that we understood what they were building. And so, I traveled down to the LA area, once a week, and I learned what they were doing. hey were doing a fixed design, with FPGA, where the processor controlled everything through management software. And it just wasn't right. I could tell that they were going to crash and burn, because they couldn't make real time changes.

Sanjay would come up to me and say, Bob, I need this. Can you change the controller to do this? Yeah, no problem. Because, what I had built was a software-based design, that was, RAM-loadable. So, I could make a software change, and we could be up and running in 15 minutes, where Western Digital, if we made a change they would-- they could be down anywhere from three days to a week, making that change. And so, I could see what was happening, and they weren't keeping up. And Sanjay was a little bit frustrated.

So, I went into Eli's one day and just said, Eli, do you mind if I develop my own controller? And he said, do what you want, Bob. Just take care of what needs to get done, that's all I care. If you want to build a controller, have at it. So I did. I got a couple of guys in place, and we built the product. I designed the Actel-based, FPGA kind of design, and got it running. And then, we hooked in an Adaptec front end, to be an ATA front end. And then, the back end was the Actel design that I did, the sequencer. And that, literally, took a month or two months. And we were up and booting DOS, and Western Digital wasn't even close. So, we beat them by a long way, in having something that we could exercise and run. And so, once we were there, the shine was kind of off Western Digital. And things didn't go quite as smooth after that. And Eli decided that we needed to be in charge of our own destiny, and do controllers and stuff. And--

Eggleston: I remember, you and Eli toured Japan at one point, and he-- with one of the two working prototypes, and he gave you rather a scare.

Norman: Yes, he did. Yeah, we were visiting-- I believe it was Canon, and that was when we had our first PCMCIA card that plugged into our two-and-a-half inch disk. And we were taking that around, showing everybody how it worked. We were sitting in the head guy's office, having a little tea and a wonderful time, and the guy was telling Eli, well, this looks good, but we're really concerned about ruggedness. Our cameras are rugged, and we don't think that you might be able to stand up under some-- you know, those

kind of environmental conditions. And Eli said, Bob, give me that card. And I handed it to him, and he threw it against the wall across the room. He said, plug it in and show them that it runs. It was like, oh, god. And I plugged it in and it ran, but I mean, this was hand-carried, we just hand-soldered everything. It wasn't hardened at all, as far as environmental ruggedness, or anything that-- you know, later things that we added. But yeah, I was almost sick, plugging it in, thinking, oh, if it fails. But it worked. And then, that was a master stroke on Eli's part, because the Canon guy was very impressed.

Eggleston: Did you win the business?

Norman: Yes, we did.

Fairbairn: I'd like to back up again, as an important set of developments. So, when did you first meet with Eli? What was the time/month/year, whatever?

Norman: Actually I started talking to Eli in '87, and I-- '87 or '88. I think it was '87. And I believe I joined in '88. And became a full-time employee. I had to make the one-year period at AMD before I quit, otherwise I would have messed up the whole business plan by quitting. I had the right to walk out. So, I told them that I was going to leave-- I was working with Eli, when my year was up, I was going to quit, did they have a problem with that. And they said, no. Go ahead. Just be discreet about it. And I was. And so, I put in a lot of work doing planning and architecture and stuff, and spec writing, patent writing for what we-- you know, later turned out as products.

Fairbairn: So, when you started on this, was it clear, what the direction was? And how much did you know about Flash?

Norman: I had used Flash a little bit, its storage technology, in the couple of the products. But they weren't in the mainstream products. It was more some of the testers I designed, to support us and stuff. But I was aware of it, and from a black box point of view, Flash is pretty easy to use. You got the interface where you go by the rules, you should get the data in and out. And so, from that point of view, to a system guy, that's all you really need to know. But, when you have Flash as your media, and you've got to manage bad columns, bad bits, it's a totally different animal. But-- so I was aware, but I can't say I had an in-depth knowledge at all.

Fairbairn: So, when you were helping write the business plan, working things out initially, was it clear, what the end goal was? Did you know you were going to try to make a disk-compatible product, and was there a question as to whether you could make that work?

Norman: No, no. It was an evolutionary thing. We knew, relatively early on, that it wasn't going to be a mainframe memory. And then, we struggled with what it was going to be. The cost of the memory was such, and the write speed was such, that we didn't really fit in well anywhere. And we had low power, we had ruggedness, everybody loved, but we struggled for a number of years, where we had to refine the product and get the write rates up, and you know, the reliability up, better than it was, by hardening the

firmware and stuff. But to say we knew what it was-- what was going to win, we really didn't. And it was really a product that was ahead of its time.

We had to basically live pretty meager, as a company, for a number of years, until the phone market came along, and, you know, the camera market, and the-- PC started using cards as plug-ins and stuff. So, until that occurred, things were pretty meager. We were lucky enough, in the early days, to get IBM to buy our two-and-a-half inch drive. And that was a very good occurrence for us. It gave us a money flow. But IBM really put it through the ringer. We would run a few hours, when they first plugged our units in, against their tough software, before we would fail. And we asked them how long it would take before-- how long do we have to run, before you're happy? And the guy said, if you can run over a weekend, you've got a solid product. And it took-- memory's a little shaky here, again, but it took us six months of constantly changing things, firmware, hardware, to basically harden the memory to the point where it would last that long. But that was great, in that without IBM beating us up, in a friendly way, of course, but showing us the errors of our way, we wouldn't have had such a good product early on. So, it was very valuable.

Fairbairn: So, this was a compatible product with a two-and-a-half inch disk drive, that you were replacing?

Norman: Right, this was a disk drive that had two plug-in cards, the PCMCIA cards. That was the product that we sold to IBM.

Eggleston: And didn't that go into a trucking computer, or something like that, is what I recall? Something that was mobile--

Norman: Yeah, there-- that was one of the applications. I spent an incredible amount of time on the phone, supporting people, everything from heart defibrillators to the black box in, you know, the jets. They put them in that. And I spent a lot of time talking to the Navy about torpedoes. Want that contract, go start a war, go sell a lot. But, yeah, talking through the issue with a lot of customers actually turned into being a pretty big part of my job for a while, sort of after the first wave of the design stuff was done. Then it kind of turned into support, for a year or so, that-- it was almost full-time explaining to customers what they had to do, and what they were doing wrong.

Eggleston: Wasn't one of the missed opportunities with Polaroid, who looked at digital photography?

Norman: Yeah, it was. Actually, we had two really missed opportunities. When I came aboard, my first day on the job, Eli and Federman were there, and they said to me, "Bob, I want you to do two things. And I want you to do it religiously. He said, call Polaroid, and call Apple. And keep calling them daily, until we got some sort of deal with them."

And so, I used to come in, get my coffee, go to my desk, and dial Boston. And I mean, that was my morning routine, is dial Boston. And got a very good working relationship with those guys. And finally, they said, yeah, okay, we'll come out and talk to you. And they did. And they were quite bullish on the

technology, but they just thought that a digital camera would sell more chemicals for them. The paper-- that people would print out more. That that was a way of upping their volume in printing, because people would shoot pictures everywhere and want, oh, I got to have a picture of that, oh, I got to save a picture of that. And we could never convince them that, long-term, that that's not the way to look at it. And so, they just basically refused to look at that as part of their business plan. They only wanted to look at a camera with Flash as a way of downloading and printing pictures. And they totally missed it.

Fairbairn: So was a PCMCIA card the first successful format or product that you had?

Norman: I guess you could call the IBM product a success, in that we sold, I think, \$3 to \$4 million worth of them, and it helped us really debug everything and make it good, solid. But, yeah, the PCMCIA card was-- I would say, was the marginal. And it didn't really start taking off in volume until we got down to the ATA. And even that was too big. But you could see the interest grow, as the smaller we got. So, the roadmap was obvious, was get small, you know, as fast as you can. That's where the real interest was, and that's where the company went.

The other thing that Dave mentioned was Apple. I called Apple daily, and finally made a breakthrough there. And I met-- probably drive out to Apple about once a week or once every two weeks, sometimes. And we had it going pretty good. Our product was going to go into the Newton. And they had a proprietary S-bus, they called it, and I had one of my guys, Joseph was the guy designing it. He designed a controller with an S-bus on it, specifically targeted for Apple. And we were actually exchanging simulation between Apple and SanDisk, to make sure that the two ran, before we both taped out. And things were looking really good, and then, we had a big executive meeting, and marketing stood up and said, well, you guys are doing it wrong. You don't want an S-bus, you want to have the standard product that everybody's going to buy. That'll give you more sources and volume.

And so, he was pitching the PCMCIA, or whatever after that, the ATA, or mini-card, or whatever. Mini-card wasn't ready at that time. But Apple went back and thought about it and came back and said, yeah, I think you're right. We're going to go that route. The project's cancelled. And when we walked out of the meeting that day, I knew exactly what was coming. And it hurt. We basically, you know, gave it away. I think you can argue, long-term, that was probably best for both companies. But, again, I had a short-term survive hat on, that we still were deep in the money, as they say. And yeah, it hurt, to walk away from what I thought was going to be a real winner. Because I thought Newton was going to really catch fire. As it turned out, that wasn't the case. There was a few years ahead of where it needed to be, both in software and battery life and things. So, it probably wouldn't have flown, no matter what.

Fairbairn: So, were they not interested in the product, even with a different bus interface?

Norman: Yeah, no, they were. They said, we'll-- when it comes time to-- we're going to redesign, and when it comes to buy, then we'll come back and talk. And to be real honest with you, I don't know if that ever occurred. I don't think it did. I'm sure marketing and stuff had talks, but by that time, there was other people with other offerings and stuff, and the-- they embedded a lot of stuff, too, that kind of changed the way they were, you know, looking at things. So, the whole picture kind of changed. So we-- in a way you

could say, I guess, we screwed up. But I don't-- I think, for the good of both companies, I don't think that was the case. I think we both would have gone down the road a little farther, spent a little more money, and we would still be where we are today, with neither of those products existing.

Eggleston: I think that was one of the very few times Apple did not use a proprietary interface.

Norman: Yeah, it is.

Eggleston: And so, maybe they learned their lesson the hard way.

Norman: I don't know their thinking, all I know is that we proposed they go away from us, which I thought was crazy at the time. But looking historically back on it, it wasn't a bad move, in the scope of things, long-term.

Fairbairn: So, what did turn out to be the product or the customer that really turned things around? Was there sort of one big breakthrough that--

Norman: I think it was the cell phone cards, that-- where they think the real volume kicked in. That was about the time I left SanDisk, was when we were at-- right at that point, of going to the really small cards. So, I didn't see the massive ramp that they went through, manufacturing-wise.

Fairbairn: So, getting back to the original design of this, was there a time when you thought that, boy, I don't see how to make this work, or you had a breakthrough in terms of insight, in terms of how to make it work? Or was it sort of gradual improvement over time? Or how did that--

Norman: No, actually, what I needed to make it work, I realized very early on. You know, the fact that we had to do bad bit replacement, bad column replacement in the controller, that we needed to do some wear leveling. We sort of knew that that was the case, but we didn't put it in the initial product. We wanted to see how good the memory was initially, but it was in the back of our minds. And so, you know, thinking of caching and various things. Knew very early on, what it was going to be. And I don't know, I mean, I slept with this stuff for probably six months, coming up with what it is we all needed to do, and it worked out really well. Some of the patents that we have in that area have stood the test of time. There's three patents that Eli, Sanjay and I have that-- I think they made the company somewhere around \$2 billion or more, in royalties. And a big, big part of that is the system aspects of those patents, the header structure, and how we did things with the controller and stuff. Those are very valuable patents.

Eggleston: Do you see those ideas tying back to one of your prior company experiences, whether in the drive business or even back at Sperry, or-- where did some of those ideas come from?

Norman: I would say that some of the ideas came out of Storage Technology, in that it related to disk stuff. Like IBM has what they call count key data. There's fixed-block architecture, and count key data, where the key is-- they skip over bad areas on the disk. So, nothing is set in stone, as far as the format on the disk. You go out and you find a sector header and know where you are, and read that header. And

then, you kind of lock in on where the data is. You have to skip areas of byte counts and stuff that you skip over. So, the concept of doing a lot of that kind of was, you know, filtering in my mind. And when I realized that Flash had a lot of bad stuff that we had to skip over, I said, well, you know, it isn't the disk. I'm not going to do it that way. But the concept, I would, you know, pick it up and use kind of what they-- the end result was, in a different way. And so, the disk experience definitely helped.

Fairbairn: So, what-- how long were you at SanDisk, and were there any other sort of major highlights, or interesting customer interactions there, that you think might be worth talking about?

Norman: Well, it seemed like every day was something going on. It was a very busy time. No, I have to admit that I ended up managing more people than I wanted. I enjoy designing, architecting things. And I don't enjoy managing. And I had good people, not that I'm complaining about the people. It just detracts from the time that you have to do the fun things. In the early days at SanDisk, I had a lot of meetings, and things I had to go to. And I would go to those meetings, and then, about five o'clock, when things would start slowing down, and people would start filtering out, that's when I started doing my design work and stuff. And so, it was a lot of hours. But, I enjoyed spending those hours, because it was the fun things. And I could see the future in it. I was really a strong believer in what we were doing. It was just a matter of finding the breakthrough product to get us there, to achieve the right power, density, and that kind of thing. So, very bullish on it, and you know, still am, today. I think it's an incredible industry, that we started.

Fairbairn: That's for sure. One of the customers, I understand, that you worked with was Grid Systems?

Norman: Yeah, yeah. Trying to think of his name, Scott-- yeah, anyway, we worked with Grid. I went out there quite a bit, and they were a good customer. But they would plug our card in, and they had it working in relatively short order. There wasn't too much hand-holding with them. They seemed to be doing okay. But the software was not ready for having a product like-- they had like a Grid Pad out on their desk, out front, where they were going to have people sign in on the Grid Pad. And it took so long, to retry, retry, retry, that they very quickly had to remove that. And it was bad publicity. And do it the normal way. But they had the right idea. They had the great concept. Again, it was a matter of software, battery life, you know, the kind of things that held everything back, those early years.

Fairbairn: Was John Ellenby at Grid, still, at the time?

Norman: Who?

Fairbairn: John Ellenby? CEO--

Norman: I don't recall--

Fairbairn: Okay, that's fine.

Norman: I don't think so.

Fairbairn: All right. So, what caused you to move on from SanDisk, then? You obviously had a huge contribution there and made a major development.

Norman: Yeah, I was employee number five, and that was only because I couldn't join right away. I would have been three. But I had a real good opportunity come along. Micron approached me and offered me the VP of their system engineering group there. And so, I decided to take it, and I went over to Micron. And, you know, that's when Dave came aboard. He had turned into my firmware guy. We made a firmware guy out of Dave.

Fairbairn: At Micron?

Norman: Yeah. He--

Eggleston: Yeah, in absence of qualified resources, you use what you've got.

Norman: Exactly. Dave was doing a good job. So, we--

Eggleston: But I learned a lot about NAND from that, so--

Norman: Yeah, no, that's the important thing, is if you're learning, it's all worthwhile. Because it-- the more you learn, the more it pays back in the future, and makes your next job easier.

Fairbairn: Is that the first time you had met, or worked together, was at--

Norman: No, actually, Dave and I knew each other from SanDisk. And, as a matter of fact, the day that SanDisk went public, Dave and I were sharing a beer at Birk's.

Eggleston: That is true. Celebrating that event.

Norman: Yeah, celebrating the event and watching the TV and the ticker go across. So, yeah! Knew Dave well from SanDisk.

Fairbairn: How long did you work together at SanDisk?

Norman: When did you come aboard, Dave?

Eggleston: Yeah, in '90. I was-- my employee number was 32, so it was 1990. And then, when did you depart? Maybe I left-- we overlapped for probably three, three-and-a-half years, something like that.

Norman: Yeah, that sounds about right.

Eggleston: Again in '95--

Norman: Yeah, I'm trying to think when I--

Eggleston: At Micron.

Norman: Yeah, '90-- I think '94 or so, it was right around there, is when I left. '94, '95. So, yeah, we had a pretty decent overlap.

Fairbairn: So then, you moved on to Micron, and he joined you there, shortly thereafter. What was the major task or challenge at Micron, that you were given? Were they getting into new area? Or what was the--

Norman: No, it was basically put Flash in place for Micron, was our goal. And they-- you know, that's what we did. We built Flash, and were building a controller, and putting things in place.

Fairbairn: I mean, as a competitive product to SanDisk?

Norman: Yeah, more or less, it really was. Only it was a totally different structure on the memory, at that time. So we had to take a different approach with the controller. But, essentially, we'd be in competition. Nothing wrong with good competition. But the hardest part of Micron, I found, was interfacing the Boise. They don't have a Valley culture. And once you get kind of used to doing things in a certain way, there's the Boise way, and there's the Valley way. And they're not a good match. And so, to me, the-- a big part of that whole experience was managing the culture between the two.

Fairbairn: What was the biggest difference, or-- in the compatibility?

Norman: We ran everything on a real shoestring. I kind of thought, when I went aboard it, well, Micron's got some deep pockets, you know, we're-- we'll be able to throw people at things that-- it'll be easier, this time around. And that wasn't, it turned out, to be the case. We had less resources, and resources was always an issue. And, like, I spent almost all my time designing a controller, and very little management work, there was really nothing to manage, you know. A few people here and there, that you could catch in the hallway and be caught up in, you know, a few minutes. So it didn't really require management, it was figure out what they needed, and kind of go forward.

Fairbairn: So, in that case, was the product direction very clear, and you just had to execute on--

Norman: Yeah, I think, in general, the product direction was clear. They wanted Flash to run in their fab, and oh, by the way, let's build a controller, too. That was kind of a-- I'm not sure they were too committed to that. I think it was, well, SanDisk is doing that. Let's go down that path, until we see where we're at. And that was one of the things I struggled with, the whole time I was there, is what was the commitment level for that. And I never was sure.

Fairbairn: And is commitment level to a system-level product, versus just being a--

Norman: Yeah, to a system-level approach, right. So, yeah. It was-- I'm trying to think how long I was there. That was two or three years, I guess. Anyway, the-- what-- we had a gentleman's agreement on a buyout, that they wouldn't buy us until we passed the knee of the curve, as far as evaluation. And the guy that made that handshake left the company, or-- trying to think if he left or if he died. Anyway, he was no longer there. And the guy that took over said, what contract? What are you talking about? And so, they bought us out at what I consider an extremely low price.

Fairbairn: What is the buyout? I don't understand--

Norman: We were Micron Quantum. We were funded as a separate company.

Fairbairn: I get it.

Norman: And so, the deal was is that, yes, eventually, when we had it brought inside, when things were working and stuff. But from a business point of view, and accounting, and all of that, they wanted to keep it separate, which made sense. And so, anyway, the buyout occurred, and I think I was probably the most disgruntled person there. I was the last holdout, I think, to sign, just because it was way too cheap. But I took the buyout, eventually, and it turned out to be a fairly decent amount of money, and everything. But nothing like it should have been, in my opinion. But I don't think I'm a greedy person, but maybe I am, I don't know.

Fairbairn: Want to get what you deserve.

Norman: Yeah, yeah. Anyway, so, it was a good experience. I like Darrell. Good guy. Keep in touch with him and everything. So--

Fairbairn: Darrell, who is this?

Norman: Rinerson, he was the president. He was the guy that hired me. Head of Micron Quantum. Good guy. So, I left Micron, and I formed a partnership with Frank Lee. Frank has worked for me at SanDisk, and he's a ECC expert. And we did consulting work. We did a lot of consulting work for Zilog. And then, along the way, I caught up with Jim Rubino. Rubino was Seagate's interface to SanDisk. Al Shugart was on our board. And when we had a deal with Seagate, Rubino was the interface. And I met weekly, or twice weekly, with Rubino, managing the Seagate interface was part of what I did. And so, I knew Jim pretty well.

Actually, it was funny. I have some pretty good Asian friends, and I was able to really get some incredible prices on our controllers for-- even though our controller costs a lot, but there were EEPROMs and stuff that I got, were basically really low-priced. And they brought their head buyer over one day to-- they were going to show us how to buy parts. They brought over their big book, with prices and everything, and he said, well, okay. I brought my book and said, okay, this is the breakdown of our part-- what I pay for it. And he said, okay, let's go down them, line by line. And we pulled up the first item, and he said, okay, I pay \$3.50 for that. And I said, oh, that's interesting, I get it for a buck fifty. And we went down the list like

that. And I beat him on just about everything. The only thing I didn't beat him on is individual resistors and capacitors. They buy those in such mass that there's no way I'm going to get a price. But, for the bigger components, I had them beat. And they were absolutely shocked, that we could do that. Just a sidebar, I thought of.

But, anyway, I met up with Rubino. And Rubino said, you looking for doing some work and stuff? And I said, well, always looking for work. And he said, well, how about a partnership? He said, I'll put part of my company in it, and you put you two guys in it, and we'll come up with a product, and eventually, we'll form a company called Tango. And I said, okay, okay. Then Jim said, well, I'm talking to Intel. Intel needs a serial interface, and can you help us out there? And Frank said, oh yeah, I know how to build a serial interface. So, he went off and wrote the draft first spec of a serial ATA interface. And kind of my part of the role was to go up to Oregon, here, and sell it.

So, I got to know the Intel guys up here pretty well. And, you know, showed them the spec, and what it did. They liked it, they bought into it, and wanted to push that as the standard. So, things kind of took off through the serial ATA. And Frank built the first controller that they showed at-- what do you call it, Intel development days, or whatever it is. And showed the product, the serial ATA working. And it got into the standards, and I attended some standards meetings, and things were going good. But Jim and I could never come to an agreement on terms. So, Frank and I just walked away, and let that drop.

But that was about the time that we got a call from Silicon Image. They do the HDMI serial interface for the TVs and stuff, and they were looking at expanding, and getting into the disk market. So, they wanted us to come in and build them a prototype, and teach their engineers how it worked, and, you know, everything. And they wanted me to put a five-year plan in place, for product definition and roadmap and everything. And so, I come in, and I worked on that quite a bit. And, as it turns out, I found out I'm a good contract guy. I was working with the business guys, and I ended up making a first draft of a lot of their contracts. They'd come in and say, Bob, we're talking to A, B, and C over here. This is the framework of what we're doing. Can you make a draft of a contract? And so, I'd draft up a contract. And it stayed pretty close to what I came up with, always. So, I did a lot of that kind of work for them.

Fairbairn: So you branched up into legal work, along with your technical work, huh?

Norman: Right, yeah. Actually, it is. I found out, I've got a real knack for that aspect of things. But, anyway, I ended up doing that. And I think I gave them a roadmap that I consider worth millions. But we all think wonderful things of ourselves, don't we? But, we got the first product going, which was kind of bridge chip, adapters, and stuff, that-- that's what they asked for. And we taught their engineers how it worked, and they were able to pick it up, and built beta parts. And we got them going.

Fairbairn: So, you designed a custom chip for them? Or is it a--

Norman: Yes, we were part of them-- we were employees, at that point. We quit the consulting. And they actually bought our company for a nice, sizable tune. That-- I'm almost embarrassed to say how much they bought us for. But, anyway, that did pay off, in that regard. And we got everything in place, but things

weren't flowing quite right. So, Frank and I sat and talked about it, over a beer, and it was obvious that they got out of us what they wanted. They didn't see us as employees-- excuse me, employees. They were, by and large, mostly a Korean engineering house. And we didn't fit in too well. Sounds like I'm repeating myself on all of these. I think I must be hard to get along with.

But, anyways, so we decided that, well, we lived up to our contract. We gave them a roadmap, we gave them a-- you know, working parts. We taught their engineers how to do it, and they were very capable of it. So, both Frank and I kind of moved on. And I spent about-- close to a year, trying to get a startup going. I was working with Jim Birkner I don't know if you know Jim or not. He was Mr. PLD, at MMI. He's famous for-- they gave him a Porsche.

Fairbairn: Yes--

Norman: Yeah, that Jim.

Fairbairn: Was it John Birkner?

Norman: Yeah, John Birkner-- what did I say?

Fairbairn: You said Jim.

Norman: Jim, oh, I'm sorry. John Birkner. Yes. So, we tried, for about a year. And the market was bad for venture money, about then. And we could just not click. We just-- seemed like we always missed. And I think it was that we didn't have a CEO that Sand Hill Road likes to see. You know, PhD kind of thing. I think that was part of our problem. Because I think we had a good idea. Basically, what we wanted to do was do programmable devices with a whole array of mini-processors, RISC processors, that we would run at gigahertz kind of speeds, and emulate everything. And then we would have drop-in code for, oh, you want a USB part? We drop that code into the processor, and we got-- that processor runs USB. And initially, from our die size estimates and everything, we thought we could get 64 processor cores on a chip. People are kind of doing that nowadays, but back then, a lot of the people basically said, flat-out, that-- you're crazy. Said, the software effort alone is, you know, \$50 million. Because we were asking for \$10 million, as our first round. And that alone-- plus, we're not sure you can do it. That's a hard task. And, in my mind, it was very doable. I had no doubt that we could have done that. And I had--

Fairbairn: Emulating this functionality in each one of these cores, and--

Norman: Right, yeah. Doing hardware emulation through firmware. And I think it was a good product. I had the busses worked out, as far as 64 cores talking to each other, over a high-speed bus, with two clock latency between all of them. I had that all worked out, and absolutely convinced it would work. But people were very hesitant that that was too complex to put in silicon at that time. And, since that time, people have done it, and, you know, there are things out there like that. But, anyway, we played around for a good-- oh, about a year, in that regard.

Fairbairn: What was this timeframe again? What year was that?

Norman: This was 2002, I think, right around there. And so, you know, we worked at it for a while, and we just went our separate ways. And so, we both kind of went our separate ways. And I ended up going to work for a company called Neo-Axiom, which was a guy I'd met at Silicon Image. He had a little company that got bought out by Silicon Image and he had quit after a little over a year, basically for the same kind of reasons that I cited. They had some early funding, and so we had a small team of guys going. We were basically building a serial ATA switch. I'd always used schematic capture, up to that point, so that was the first time I used Verilog, and I loved it. I should have been using Verilog my whole life. But-- designed it. And we were right at the stage of tape-out, and we had magically run out of money again. And the VCs weren't anxious to hand us money. Which, looking back, it's obvious. Why would I fund major dollars to a switch company that's a one-trick pony, that there's no real meat and potatoes there, as follow on growth business? So I understand their motive.

But we ended up selling the design to Acer, and they bought it out, and took it over, and turned it into a part. And about that time, my body was breaking down pretty bad, and I retired in 2004. My wife had moved up to Washington, and we were-- I commuted back and forth for five years, and we went really long stretches without seeing each other. So, the retirement was a real welcome thing, in that I got to get back in touch with my wife again, and just take life a little bit easier.

Because, at that point, I was just barely walking. And so, life had gotten pretty hard, to get up every morning and get out there and get after it. So, it was a real welcome change. And, actually, that got me into stock trading. And I've stock traded now for-- well, since 2004, up until now. I trade stocks daily. And I make as much at that as I do engineering. I can do it in my easy chair at home. And it worked out pretty good.

Fairbairn: So, are you still doing engineering?

Norman: Yeah, I am. About a year and a half, closer to two years or so ago, Eli Harari called me. He has a new startup going, Sunrise Technolgy.

Eggleston: Getting the--

Norman: Or Sunrise Memory, I'm sorry. Sunrise Memory.

Eggleston: Getting the band back together, after all these years.

Norman: Got the band...

Eggleston: It's the whole crew.

Norman: The whole crew is back there.

Fairbairn: Are you involved, Dave?

Norman: I'm sorry?

Eggleston: No, no comment. I'm an independent consultant.

Norman: That's right. Yeah, we got the crew, and I wish I could tell you about it, because I'm-- to be real honest, I'm probably more excited about the potential of what we're doing right now than I ever was at Flash. So, I think Eli has a real good chance of having lightning strike twice.

Eggleston: Plus, it's just a fun team to work with, let's be honest.

Norman: Yeah, it is. Yeah, it's very-- it's very pleasant. And, right now, I've been working on the architecture for the last year or so. And that's been, actually, quite interesting. I think I'm close to ten patents, filed on that already. Some of them are actually pretty good patents that I-- one or two that are going to be very valuable. But, you know, a few weeks ago, I was asked to design a controller, and so I rolled up my sleeves, and right now, I'm working on a controller, where what I need to do is-- and I type with one thumb, anymore, and not much else.

But I do a detailed spec of what that controller is, what the product is, and I detail it down to almost the gate level. And I'm looking at having somebody else do some prototyping on an FPGA for me, and then a team of guys, if that looks good, to pick it up and go to an ASIC. So, yeah, I'm knee-deep in a design. I'm doing as much as I ever did. And again, I don't have to get up and drive to work, and I make my own hours. I actually find that I'm getting more done than I used to. With all the meetings and, you know, things that normally come up at work that keep you away from the design side and the development side. So, development-wise, I'm very efficient, at this point.

Fairbairn: Another person discovering that working at home is the most productive way to work, huh?

Norman: It really is. I mean, you know, if a person has any self-discipline, boy, there's no better way to let a guy work than at home, because it is efficient.

Fairbairn: So, how long before we-- the grand unveiling-- we get to find out what's going on in your head?

Norman: Well, it's a new technology, so it'll be a while. I'll just leave it at that. It's-- can't say too much. But it's an exciting technology, very exciting.

Fairbairn: Glad to hear you're still interested and motivated and so forth. So, you live in Oregon? Where-- what part of Oregon are you living?

Norman: Pendleton. I had a house on the ocean, up in Washington. Just absolutely beautiful. I had the-- looking out my front windows, the front of my house was all glass, and I could sit there at night and see

Point Roberts, the lighthouse and everything. Absolutely beautiful. But the damp, cold weather just killed me.

So, my daughter has got a farm down the road, about a mile from here. And their neighbor was looking for a buyer. So I bought the farm. Bought the farm, literally. And moved here. And, you know, continued stock trading and stuff. And then, I'm doing less and less and less of that. I find that you can do almost all your trading from six-thirty to nine o'clock. So, I can get all the stock trading in I need, and then I switch over to Sunrise work. And if I can work-- they'll let me work 'til midnight, no problem. So, it works out pretty good.

Fairbairn: So is this stock trading day-trading? You're--

Norman: Yeah, right, I'm a day-trader. Yeah. I actually made a big dollars one year, trading. But I was going crazy. I mean, I couldn't get five feet from the TV or the radio, to get the news and what was going on. I'm real big into options trading. That's what I do now. There, for a while, I was doing heavy stock trading, and buy, sell, buy, sell, buy, sell. And you're going to be a nervous wreck. I did it for about two months, and said, whoa. I'm done. I mean, it's murder on your nerves. I did real good. I was bringing in 20 grand a month, doing that. But, Jesus. It's not worth it. Life's too short for putting up with that. I'm just amazed that people can do it all the time. But I make a good salary on options trading. And that's-- you know, buy an option and go to sleep. So, you check it every couple days, is all you have to do. It's a very forgiving kind of thing. So, I enjoy that. That's kept me busy for the last-- since 2004.

Fairbairn: And a good source of income, as well.

Norman: Yeah, yeah.

Fairbairn: Is there anything we missed here, in sort of covering the arc of your career? What's the standout achievement day, event, product, you know, what do you look back on--

Norman: In 2005, I did get the Flash Achievement Award. Yeah, that was a nice thing to get. I'm at 220 patents, and going. My goal was 220, and I've passed that. So, I've met my goal. And the way things are at Sunrise, I could write another hundred patents--

Eggleston: I was going to say, Eli's got you signed up for another 200, I'm sure.

Norman: Yeah, it's--

Fairbairn: It sounds like you didn't even start filing these patents until SanDisk. Is that correct?

Norman: That's correct, right. There's a period I left out. When I was doing consulting work, I worked for Darrell. He had another startup, doing 3D memory. And he had me hired as a patent writer. And so, I wrote patents for him. And I think I had something like 50 patents that I got for-- trying to think of the name of the company. I'm struggling, here. Dave, do you remember what Darrell's company was?

Eggleston: No, I can't remember that one.

Norman: Yeah, I've forgot the name of it--

Eggleston: Well, there was Unity Semiconductor--

Norman: That was it, Unity, yeah.

Eggleston: Yes, for Unity. Oh, okay.

Norman: Okay, so, yeah, I worked for Unity as a patent writer.

Eggleston: Got you.

Norman: And it was 50, 54 patents or so, I got from him. And I got about 80 patents with SanDisk, and about-- I don't know, 50-- about 50, 60 patents with Micron, and one or two patents with AMD. I did get, you know, their delay line thing that I did, programmable thing. And a couple at Silicon Image. And then, like I said, I've got about two granted so far, and about another ten in the works, with Sunrise.

Fairbairn: So, out of all those patents, is there one or two that really stick out and say, boy, that was a huge insight, or that was a--

Norman: Yeah, there are two SanDisk patents, the 948 and the 096 or something like that--

Eggleston: Wasn't it 987?

Norman: 987, there you go, yeah. You know the stuff better than I do, Dave. But those were two really valuable patents that basically cornered the market for SanDisk, as far as the system aspect of things, how we did things--

Fairbairn: Those were the \$2 billion patents?

Norman: I'm sorry, those the what?

Fairbairn: Were those the \$2 billion patents?

Norman: Right, right--

Eggleston: And by the way--

Norman: Yeah, the vast majority--

Eggleston: Yeah, by the way, Doug, that was \$2 billion in the royalties that were paid to SanDisk, not to mention protecting SanDisk's own multi-billion dollar business. So, it's even-- he was just being modest, in talking about the direct income from those patents.

Norman: Actually, it was funny, back in the early days, when we first came out with our first controller, we had a lawsuit filed by Intel for infringement, and the guy cited on the patents was the guy that I had worked with in Colorado. I did the hardware and he did the firmware. It's a small world. But we counter-claimed, and they backed off real quick, because our portfolio was much stronger in that area than what they had. They didn't realize we had so much.

Eggleston: Quick side story-- oh, go ahead.

Norman: No, go ahead.

Eggleston: No, I was going to jump ahead-- the reason I remember the 987 patent, was when you and I worked at Micron and designed the controller there, SanDisk, later, after you had left, sued Micron. But not on the 987 patent, but on the improved-- new and improved successor to 987. But we were able to fight them to a standstill, because we--

Norman: I'll be darned.

Eggleston: Obviously knew what was in that one, and could design around it. So--

Norman: I'll be darned. I hadn't-- I was not aware of that. Nobody had mentioned that to me--

Eggleston: That was a couple years after you had left, yep. That's why I remember that one so, so well.

Norman: Yeah.

Fairbairn: You're obviously still on very good terms with Eli, after leaving and going to a competitor, filing patents against him.

Norman: Oh, yeah, no, there's absolutely no animosity there. Eli and I are very good friends. He calls on a regular basis. And yeah, I consider Eli a friend of mine. And--

Fairbairn: Nice to be working with him again.

Norman: Yeah, exactly. A good relationship. Yeah. The whole patent thing was quite interesting. I find the depositions were most interesting. We had a big patent fight with Samsung, and they were basically trying to-- one of those two patents, they were after trying to break it. And I could tell my lawyer was nervous. And so, I kept thinking, what's he nervous about? Because I was answering the questions, and I thought I was doing good, and, you know, everything was rolling along. I think we were into the tenth hour of the deposition, and all of a sudden, it hit me that they were trying to... On the patent, I didn't put down a

specific interface. I put a universal kind of interface to it, that you hooked like an ATA or a SCSI or whatever to. I didn't want to make it interface-specific.

And so, just as I thought he was going to say, okay, we're done, and then he would have had us. Being a bad lawyer, never ask a question you don't know the answer to. And he had one more time-- you know, stab at the knife. And he asked me something about the interface. And I used that excuse to jump through a big hole and say, oh, you misunderstood. And he said, oh, I'm done. And then our lawyer jumped in and said, no, you've got to let Mr. Norman speak. He's not done yet. And so, I got to totally explain how I broke the patent down, and why it was like it was. And it totally countered everything he had up against me at that point. And we ended up winning the lawsuit. But we were literally within minutes of losing it. And that stands out in my mind, as a big moment, because that was major dollars.

And so, yeah. Things can turn on a dime, real quick, in that environment. It's interesting and they're almost fun, because it's a cat and mouse game of wits, with the lawyer. But when there's that many dollars attached, it loses its fun real fast. But, yeah, there were several other ones that were a little bit interesting. But that's one that stands out the most.

Fairbairn: Right. Well, it's certainly been a very interesting discussion. Is there anything else we missed that you'd like to highlight? Dave, do you have any things that you'd like to maybe ask him about further?

Eggleston: No, I think we've covered quite a few stories there. Like I said, some of them might actually be true. So, it's been a real pleasure. And Bob's just a super pleasant guy to work for and with, so that's--

Norman: Yeah, no, I enjoy working with Dave, so--

Eggleston: Great to reconnect.

Norman: It's mutual.

Fairbairn: Beyond what you're currently doing, whatever that might be-- so, you had worked together at SanDisk and Micron. Were there other times when you also crossed paths?

Eggleston: No, that was really those areas. But it's very likely we're still both working in and around the same general space--

Norman: We're circling the drain, as they say.

Eggleston: Same kind of end goals, here. Maybe with different sets of clients, so--

Norman: Yeah, there-- they just-- they're a little hiring here, is-- pay it some attention, Dave, it's going to be valuable. It's going to be a game changer, just like Flash was.

Fairbairn: All right, well, that's an exciting note to close on. We'll have that phrase in there, and we'll come back in another year or two or whatever it is, and see what the magic is.

Eggleston: More than a year or two, I think a few more years than that, but out there a little bit farther.

Norman: Yep, I think so. Very good.

Fairbairn: Thank you very much.

Eggleston: Great to see you, take care, Bob.

Norman: You bet, nice to see you again, Dave.

Eggleston: Great to catch up. Bye-bye.

END OF THE INTERVIEW