



Oral History Panel on 5.25 and 3.5 inch Floppy Drives

Interviewed by:
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Abstract: *A review of the transition from IBM's 8 inch flexible disk drive standard to smaller drives, as the personal computer market emerged. Panel members participated in establishing first the 5.25 inch FDD standard, and then the 3.5 inch FDD standard, as dozens of companies scrambled to establish production.*

Jim Porter: We're here to carry on what I think will be a very interesting discussion about how the floppy drive business progressed from just 8" floppy drives, to 5 1/4" and then to 3 1/2" after a few possible directions off and different sizes and different formats. The floppy drive business got started courtesy of IBM because they wanted, first, to load microcode in the controller for a Merlin, which was a disk drive and for a couple of models in the system 370 and then, of course, in 1973, they brought out the key to diskette system, the 3740 key to diskette which, by the way, replaced the tabulating card, which had been the computer industry's method of loading data into computers since the 1890 census. So, in '73, the floppy drive got started. It turned out to be a big hit, to replace those tabulating cards, and it got into other applications, word processors, simple small business systems, et cetera, all over very quickly. And very quickly there was a flood of companies into the business making floppy drives. And what happened, though, was that one company became the leader in doing those floppy drives, a company named Shugart Associates, which was started, I think, in '73, was it not?

Warren Dalziel: '72.

Porter: '72. Okay. But, by the mid-'70s, they become the world leader in making floppy drives and, to start this, what I'd like you to do is to ask each of the people sitting at the table with me to give a little brief background of their background and how they got started in this business and what they're doing now.

Dalziel: I'm Warren Dalziel, the only real engineer at this table <laughter> in that I've stayed true to that. I've been a design engineer my whole life, after starting with IBM in 1962. And I'm not sure but I think may -- I'm one of the few people that have probably worked on every generation of disk drive, starting with the original 8" at IBM. I'm one of the inventors on that, listed on that product. And then somewhat involved with the 8" at Memorex and I left with Al Shugart or shortly after Al left IBM to join Memorex and worked there from '69 to '73 and then went to Shugart Associates, where I met Massaro and George here and, of course, Al -- I knew Al and many of the other people: Herb Thompson, Don Wortner and that whole crew. Worked on the 8" drive there and then, actually, that company was not started as a floppy company. I think maybe people know that. Convinced they could never make it as a floppy company. Don may address that more. I was working on a printer because that was going to be a big part of our small business system. Ended up working on all the Shugart drives, including the 5 1/4". Left before -- just as I left, I first saw the Sony at a trade show in New York, and I remember being very impressed, we'll discuss that more, because of the way it solved some of the problems that I had been working on for years. And then, subsequently, I did work on 3 1/2" with Jugi Tandon, involved, I worked on the Tandon products, both hard disks and -- then I left. I formed my own company after Shugart Associates and, for 20 years, I was an independent contractor, worked on a variety of peripherals and printers and medical equipment

and optical drives and removable drives and a wide variety and recently semi-retired the last couple of years.

Porter: George?

George Sollman: My name is George Sollman and I got started, I guess, very, very early in all this business at MIT Lincoln Labs or as part of a group working on the Sage system and then they would spin off our division and become Miter Corporation, which was the chief tactical advisor to the air force and then FAA. Very interesting period of time for the kind of people who were there and people spun off. Then, in 1964, I left to join the early part of the computer industry at Honeywell Information Systems at Waltham, Mass. Enjoyed that immensely and then they decided to move the division to Oklahoma City. Didn't think that was such a great idea so I joined Control Data in Los Angeles, working on a new set of products called mini-peripherals, one of which was designed to be a floppy disk drive. So I also changed careers, in a sense, at that time from being a card-carrying engineer to being a wanna be marketing person so I was product manager there. And we would do battle with this strange little company up north called Shugart, and I was having a great time until they decided to move that division to Oklahoma City, at which moment I made contact with Don and we got together up in Sunnyvale for a short interview, starting at ten in the morning, went through 'til three in the afternoon, no lunch, just it was intense. And had such a good time that, when Don said, "Come on up", I said, "Okay, I'll do it" and I was the first product manager. And so I was with the company from '76 until 1984, gradually working in different marketing and sales roles. Then, in '84, I took a decision that I did not any longer want to be in the disk drive industry because I couldn't understand the economics. I just couldn't understand how you made money. I was convinced the Japanese were going to take it all over and it was all over. I just didn't know how to deal with that. And so I decided to jump over to an industry that used disk drives, and that was the voice messaging industry. So I went in as CEO of a company called Centigram Communications. It was a turnaround opportunity. We later take that public in '91 and I stayed on 'til 1997. I then left to do a raw startup called At Motion. The early working name was Arabesque Communications but, when we went public with it, it was called At Motion, which would later be acquired by PhoneDotCom, later known as Open Wave. And then, after that, had been involved in a number of smaller companies, more in advisory and a board role. I'm on a board of a public company that's in the video conferencing area and a private company that's in enterprise software. And also trying to do my part with the local universities at Santa Clara.

Porter: Don?

Don Massaro: I'm Don Massaro. I started right out of Berkeley in 1967 at IBM in disk drive. I was in the file technology area, really responsible for doing a simulation, theoretical simulations of air bearing systems. And, in 1969, Al Shugart, who was at IBM, left and went to Memorex, put Memorex in the disk drive business and he pulled a bunch of engineers over. Warren was one of them, I was another one and I think, ultimately, Al took 200 engineers out of IBM and got Memorex sued, which was a big lawsuit. <laughs> Anyway, at Memorex, I started out doing recording head design but then I became the

engineering manager for the 3670, which was IBM's equivalent to the 3330 and Warren was a mechanical engineer at Memorex on that. And then, in 1973, Al and myself and a couple other individuals, one being Finis Connor left and went and started Shugart Associates. And Warren was right when he said it really wasn't started as a floppy company. We were a startup and we're doing floppy disk drives and we're doing a printer and Al Shugart says, "Geez, well, if you're doing a floppy disk drive and a printer, we might as well be doing a small business system." So, anyway, Al was the CEO. I was vice-president of engineering and manufacturing, got all these projects going on. We're burning money like mad and VCs came in and the VCs were not nearly as sophisticated as they are now, okay? There really actually weren't any real VCs around, you know? Bill Hamber could run around, give you a couple bucks here and there but there was no Sandhill Road where you could drive up and down and get VCs. And, anyway, the VCs wanted Al to cut back and Al refused to go do it so they fired Al and they made me the president and CEO. I think I was 28 or 29. I couldn't even read a balance sheet at the time. So we ended up, we had to fire -- within my first week, we had to fire half the people. So we fired half the people and never touched anybody that was working on the floppy disk drive and we focused on the floppy disk drive and, even though there were 13 competitors and we were technically the flakiest, we ended up owning the market. We had somewhere around 80/85% market share. And it really was due to our focus, due to the fact that we kept improving. We were always improving that. If you think about it, as you mentioned, Jim, it started out as an initial program load device. So, as a program load device, if the thing did 200,000 passes over the disk in its lifetime, that was great. We had to design this thing and redesign it and reengineer it so it could be used in a word processor or a small business system where you're talking about millions of passes and that head and that media and that mechanism was not designed to do that. So I would say the reason we were successful is we had nothing else to work on and we literally kept improving it, improving it, improving it. The other thing that helped a lot is we made our own head. We manufactured our own recording head. And the real technology, the tough part of the technology was that interface between the head and the media. And we had a real genius there, a gentleman called Herb Thompson, and Herb was one of the real great engineers of all time and he just understood the physics of it at the fundamental level and Herb lived in that head lab really understanding the wear mechanism and the interface between the head and the media and just kept improving it. And that's basically how we ended up, like, owning, like, 80/85% market share. The other joke is the reason why Shugart was very successful is that Sollman was our first hire in marketing and we never brought one marketing guy on until we knew what we wanted to do and established ourselves in the marketplace. If we had brought the marketing guy on early, he probably would have never made it kind of stuff. <laughter> Anyway, I shared George's view about the disk drive, the future of the disk drive industry so, in 1978, we sold Shugart Associates to Xerox for, like, 50/60 million dollars, which was probably the biggest financial mistake of my life because, a couple years later, we could have gotten ten times that. And, anyway...

Dalziel: 100 times that.

Massaro: Yeah. I know. Xerox asked me if I would go be president of the office products division in Dallas and I went and did that because I actually wanted to get out of the disk drive business and I wanted to get into the systems business and that was an entry point into that. And that was kind of an exciting

experience because, at the office products division, I got to take all that technology out of Palo Alto Research Center you see around this museum today the whole Ethernet and the Star, which was the first metaphoric computer and so forth. So, since then, I've been in basically the systems business and I'm on my fifth startup, okay? And this one is in the network securities base so I'm just kind of a serial entrepreneur and I just, actually just love starting up something from nothing and, you know, building it up. They're not all successful but this is simply the 21st century version of wildcatting. So we are. The entrepreneurs in Silicon Valley are a bunch of wildcatters, you know? We're not drilling for oil, we're drilling for markets and we're not using drilling rigs, we're using technology and sometimes you hit some and sometimes you don't.

Sollman: Kind of jump in a little bit. I just want to pick up one point...

Massaro: You want to defend yourself on the marketing comment? <laughter>

Sollman: No, actually, you brought up an interesting point that I don't know that we quite realized at the time. We had a very interesting customer in Apple Computers, Steve Jobs, who was special, still is special, and I think Don interchanged a lot with Steve and one of the things that came out of that is initial vision that PCs or computers would be an appliance. We went through those previews more than a few times. Like, that was one of the initial driving visions back then, it should be an appliance. What is interesting is that Jobs, this week at MacWorld, explained how he was delivering the first real computer appliance. So it took a long while to come from a terrific vision to a product. I think actually some people are ahead of that but, you know, I think that was the interesting vision of trying to understand how to drive it into an appliance product that would serve a lot of functions.

Porter: So here we are in 2005 and Steve Jobs has finally learned to understand the market. <laughter> I should mention that you mentioned that AI Shugart brought, supposedly, 200 people in. The number varies when he went to Memorex in '69. I was there at the time, working on the media side at the company and, in questioning AI over the years later, he always disputes the 200 number but who knows? He learned how to deny all of that in court. Okay. Those were the days of the 8" floppy drive. Now, in the mid-'70s, I heard this story about how the people at Wang Laboratories, out in the Boston suburbs, which were making small business systems and word processors and using 8" floppy drives from Shugart Associates, how they wanted to do this revolutionary thing of putting a computer on the top of a desk and they wanted a smaller floppy drive. And the story I heard, and I'd like to understand whether this is correct or not, you mentioned, I think, Jimmy Adkisson earlier.

Massaro: I was there. I was there the day that Dr Wang requested that product. Jimmy Adkisson and I were back in Wang Labs and I was one of the very few vendors that could ever get in to see Dr. Wang and that's because I had an engineering background, although Warren's right, he's the only true engineer <laughter>...

Dalziel: Practicing.

Massaro: The rest of us turned into either marketing or general manager sluts in <laughter> and Warren stayed true. I was still, in Dr. Wang's eyes, an engineer, okay? At least more of an engineer than the other CEOs...

Dalziel: Card-carrying engineer.

Massaro: ...that he saw. So we're in his conference room, which was an incredible conference. It's a big long table and he had a blackboard that was longer than that and 99% of that blackboard was all technical. In the lower right-hand corner, he had a couple of financial <laughter> share numbers kind of stuff because Dr. Wang was an incredible guy. He was the inventor of core memory, we just saw it here. And, anyway, Dr. Wang said, "Lookit, doc..." and, by the way, Wang Labs was our biggest customer. It was also our fist major customer and we became profitable just on the Wang business and turned Shugart around, which almost didn't make it. So we had a special relationship. And he says, "I need to come out..." and this was just as people were starting to talk about PCs. They didn't quite know what it was. "I want to come out with a much lower end word processor. It has to be much lower cost and I can't afford to pay you \$200 for your 8" floppy, I need a \$100 floppy." Now, that was interesting because, for the previous six months, Steve Jobs would show up in my office at least once a month telling us that he needed \$100 disk drive because, at that point in time, Apple was using cassettes, as hard as this is to believe, they were using audio cassettes and they were using them for storage. So Steve Jobs would show up. Nobody knew Steve Jobs and he was a mess. He had holes in his pants, he looked like a wreck, okay?

Sollman: Actually, Don, you got the time sequence a little wrong. We did the Wang Labs deal, we got the product pretty well product-fied or whatever you do and I took it to the Home Brew Computer Club meeting, we talked about it there. After that, the following Wednesday or so, Don came to my office and said, "There's a bum in the lobby." <laughter> "And, in marketing, you're in charge of cleaning up the lobby. Would you get the bum out of the lobby." So I went out to the lobby and this guy is sitting there with holes in both knees. He really needed a shower in a bad way but he had the most dark, intense eyes and he said, "I've got this thing we can build" and...

Massaro: I thought he approached us before we met with Wang. Was he after?

Sollman: Well after.

Massaro: Well after.

Porter: But back to Wang.

Massaro: So, anyway, so, when Dr. Wang wanted something and he had money, was a very successful company. I mean, Wang Labs owned the word processing industry in the mid-'70s, mid to late '70s. So Jimmy and I were scheduled to fly to Mohawk Data Systems, okay? By the way, Mohawk Data Systems actually funded us doing the first low-cost hard drive.

Sollman: Yeah.

Massaro: So we get down to Logan Airport, we get on the plane. It's snowing like a son of a bitch. It's just snowing, okay? And they're de-icing the plane but we're not going anywhere. So they finally cancelled the flight. So Jimmy and I rent a car and we're going to drive, in this blinding snowstorm, up to Mohawk Data Systems. Now, anybody that is in a car with Jimmy Adkisson for more than 15 minutes better find some way to shut him up, otherwise, you're going to commit suicide. <laughter> So literally we designed the 5 1/4" floppy drive in terms of the overall design, what it should look like, in a car driving up to Herkimer, New York to visit Mohawk Data Systems, and we stopped at a stationery store and we got some cardboard and so forth and so on because we're trying to figure out what size diskette this should be. And we ended up with 5 1/4" and it's real simple, the reason why it was 5 1/4". 5 1/4" was the largest - - was the smallest diskette that you could make that would not fit in your pocket. <laughter> We didn't want to put it in a pocket because we didn't want it bent, okay? So, anyway, we designed it up. We made a little cardboard mockup and then we actually came back to the company, right? And we gave it to the engineers.

[Editors Note: In subsequent a conversation Massaro agreed the statement is not exactly true].

Dalziel: That's not exactly true.

Massaro: Okay. Go ahead, George. <inaudible>

Sollman: You had just hired -- you had...

Massaro: I'll let you rewrite history. Go ahead.

Sollman: You had hired me about two weeks before that and you said, "Here's kind of what we want to do and you're supposed to be a marketing grunt, would you go get an analysis of all of the tape drives that are out there because it's got to fit in a tape drive format..."

Dalziel: I vote with George.

Sollman: And you've got -- you're going to have...

Massaro: <inaudible> Jimmy Adkisson.

Sollman: Okay.

Dalziel: This size, though. You're talking about this size was the tape cassette.

Sollman: Okay.

Massaro: Oh, I wasn't talking about the media. I was talking about the size...

Sollman: Yeah, the media.

Massaro: ...of the diskette, not the size of the drive.

Dalziel: Like this.

Sollman: Well -- but that's where we got to. We did an average and you looked at it. I think Warren and definitely Dave Brown looked at it. We looked at all the various tape drives that were out there. We said we had to replace them and that this is the size and we said, "How big can you make the diskette?" It turned out to be 5 1/4. It was not -- I think this is, like, 6" and this is 5 1/4"...

Massaro: I'm telling you, George, that might have been...

Dalziel: It might have been.

Massaro: ...I'm telling you, Jimmy Adkisson and I cut out a cardboard mockup of a diskette...

Sollman: That's true.

Massaro: Right? And we came back with it.

Sollman: That's true.

Massaro: Now, wasn't it 5 1/4"?

Sollman: I don't remember whether it was 5 1/4 or not but the more important thing is you got Norm Dion to go do a mockup of that...

Massaro: Right on.

Sollman: ...he could take back...

Massaro: That's true.

Sollman: ...to Dr. Wang. Show him it's a real thing.

Massaro: We had to get Norm -- we needed somebody -- and it could have been IBM, to make the media first and we did that.

Porter: We should explain Norm Dion...

Sollman: Oh, excuse me, that was ITC at that time, though.

Porter: We should explain...

Massaro: <inaudible>

Porter: Let me explain some of the names being thrown around here. Norm Dion, of course, he'd been at the old Memorex. He had started a company called Dysan, which became a media company and was making diskettes. Now, I should mention that Jimmy Adkisson had a different version of this whole story. <laughter>

Sollman: What was his version?

Porter: Jimmy said that you guys got together with the guys at Wang in a dark bar one night and, after a discussion, you decided on the size of what the smaller diskette should be and there was a cocktail napkin on the bar which was 5 1/4" square <laughter> napkin <inaudible>. That's Jimmy's story.

[Ed. note: Contacted in 2009, both Adkisson and Massaro stated that there was never any such meeting in a bar with Dr. Wang]

Massaro: Yeah. <laughter> Well, anyway, the thing we all agree on is the catalyst was Dr. Wang.

Sollman: Yeah.

Massaro: And the reason that he was the catalyst is, yeah, you might have had guys like Steve Jobs wanting a cheap \$100 disk drive and so forth but he didn't have any money and nobody ever heard of personal computers and nobody would think it was right and so forth. Anyway...

Sollman: Especially the CFO.

Massaro: Right. Well, we can talk about that but... <laughter> but Dr. Wang was serious, okay? And if Dr. Wang wanted something, he was very proper, you would go do it. And we went and we did it. We turned this thing in around, it must have been three months.

Dalziel: Yeah. And, again, I think the reason -- I doubt if you ever considered anything but just...

Massaro: Scaling down.

Dalziel: ...the eight inch, scaling the eight inch...

Massaro: Scaling it down, right.

Dalziel: ...which, you know, is the only way you could do a product that was a develop, purely development, not technology development...

Sollman: No technology. It was done very quickly.

Dalziel: And you're saying you made a diskette probably Norm made it by taking a pair of scissors and cutting down an eight-inch one.

Massaro: He did.

Sollman: Absolutely.

Dalziel: And...

Sollman: We didn't go spend \$10 million on development.

Dalziel: ...again...

Massaro: That was a buck 50.

Dalziel: I don't know if you've covered the history briefly but, I mean, and it evolves from this but this was about the third or fourth generation of the floppy, the disk package and then the key is the wiper in here. But when I started on the floppy and they had looked at other technologies then, Dave Noble had started that. They had a team. But when I -- the first floppy that I worked on was a piece of Mylar glued to a piece of foam and the head...

Massaro: Right. I remember that.

Dalziel: ...and the head pushed down into the foam. Foam is not a good engineering material.

Massaro: Yeah.

Dalziel: The only thing worse is the little pad that we use for a load pin. But, anyway, so then -- and then we went to a rigid, relatively rigid cartridge and we kept getting defects on it and then Herb Thompson's the one, Herb and Wayne Mullners put the wiper...

Massaro: While you were at IBM.

Dalziel: Yeah, while we're at IBM and we already had a head load thing so...

Massaro: So you didn't have a wiper in there?

Dalziel: No, no wiper and we kept get -- we'd run -- I can remember. You'd run, like, six hours and you'd start getting -- and they called them creepy crawlers.

Massaro: And then that was the beginning of the end.

Dalziel: Yeah, and the beginning of the end. You get a -- you get some contamination and I wasn't there that night. Herb was one to really work late at night and I think they put some Kimwipe or something in a cartridge and we had the head load solenoid so they put a piece of foam on top of that and that came down and compressed the wiper on both sides...

Massaro: And it worked.

Dalziel: ...ran all night. That's probably the first time it ran all night. We came in the next day, everyone was ecstatic.

Massaro: Herb was great at that stuff. He would just...

Dalziel: Yeah...

Sollman: <inaudible>

Massaro: ...sit there by himself and try all this stuff and he was very meticulous.

Dalziel: Actuators, too -- well, I don't -- get into the detail, you can tell I'm a technical guy but the first actua -- we had some interesting actuators on those first ones. There was a -- called a V-2, the double solenoid with -- and ran a lead screw and the first Minnow, which is out -- there's an example out here was a lead screw that we did.

Porter: Okay. So the net result was, in September of 1976, Shugart Associates introduced the SA400 5 1/4" floppy which became the model for the whole industry.

Sollman: I'd like to back up, if it's possible, to talk a little more about the interaction with Wang. As a matter of fact, Jimmy and Don did have this paper mockup but that was not appropriate for Dr. Wang. He

had us put together a set of flip charts before the days of PowerPoint and so Don and I are going through this flip chart, you know, what it has. And some charts got applause and some charts got raspberries. And one thing I was going to introduce is Dr. Wang was not a casual customer, just as Don said, and he was a highly involved customer. And the proposal we came back with is this would have a motor that was an A/C motor in it and he just went nuts over it. He said you cannot have an A/C...

Massaro: An engineer ...

Sollman: ...and A/C drive motor because it's going to cause the screen to shift back and forth. And Don said, well, I just...

Massaro: A/C drive motor?

Sollman: That's D/C. But it originally was going to be A/C.

Porter: Well, the 8" was A/C.

Massaro: The 8" was A/C but that was below.

Sollman: Yeah. But this was going to be...

Massaro: He wanted to put it next to the screen.

Sollman: Right. This was going to be A/C also.

Massaro: Ah, that's right.

Sollman: And Don said, "Well, I can't get my engineers to sign up for that because they think they're all crummy motors." He says, "Don't worry about it." He says, "I have a General Motors car. There are four different sources for every part in my car, including the tape cassette player and, Don, you can find it there." And so, I believe you and Dave Brown started going through all the catalogues to find the motors that were used.

Massaro: I don't remember that.

Sollman: Yeah, exactly.

Massaro: I don't even remember why we made it D/C.

Dalziel: I thought it was size. I actually thought it was size because, with the A/C where the capacitor was as big as the drive motor.

Sollman: It would have been yeah but Dr. Wang's objection was over the fact it would...

Massaro: Destroy the monitor.

Sollman: ...destroy the monitor. So I think the positive thing is that was just one of several interactions that Don was able to promote with Dr. Wang.

Massaro: Tell them the story about Apple because now, he's right on Steve. I always thought Steve was always asking for it ahead of time but you could be right. Anyway, so we announced the product in September and it exploded, okay? You see, we owned the 8" floppy disk drive. We were putting up a new plant every three months and we were selling every one we could make for 200, 250 bucks so why do a 5 1/4? Okay? Theoretically, the market leader doesn't go in and change it. And I would say that we were a bunch of young people. We weren't smart enough to know you weren't supposed to do that. We weren't smart enough to know that, if you own a marketplace with an 80% market share, you come out with another product, that's going to destroy your market share.

Sollman: But there was an older, wiser person who understood that. His name was Finis Connor.

Massaro: Oh, come on.

Sollman: Because we had...

Massaro: All Finis...

Sollman: We had...

Massaro: All Finis cared about was when his commission check was coming.

Sollman: You got it. Okay. So we had a huge...

Porter: Let's just mention that Finis Connor was a sales executive for Shugart Associates <inaudible>

Sollman: In the office next to Don. And so he found out that we were going to price this at 60% of the price of the 8" drive and he came ripping in to Don...

Massaro: I remember that.

Sollman: I was in a meeting, and he said, "This is complete idiocy. I've got all of these mortgage I got to <inaudible>

Massaro: <inaudible> his commission.

Sollman: ...and all the rest. And said, "This is pure idiocy. You do not have to price it at 60%." And Don said, "It's better we eat our own children than someone else do it." Quote/unquote.

Massaro: Yeah, that's true.

Sollman: And fine...

Massaro: We weren't smart enough to know not to do this, okay? So, anyway, we announce it and, you know, we had 80% of market share on the eight. We had 100% market share on the 5 1/4 and it exploded. And then you can tell the story about Apple. He brings -- he shows Steve Jobs this and Apple takes -- comes back with a P.O. the same day, didn't he?

Sollman: Well, no. It took a little bit longer but the part of it that was upsetting to a lot of people is that he took a look at it and said, "This is really elegant but I have to tell you, if you got this many components on here, you don't have a very good engineering department. So, Don, I'm going to give George a P.O. with a mechanism only", so a major catastrophe in engineering, and <inaudible> was there, right?

Massaro: Right.

Sollman: And as it -- we can't sell it just...

Massaro: 100 bucks.

Sollman: For 100 -- yeah. It'd be for \$100 with just some wires hanging...

Massaro: Just the mechanism.

Sollman: ...off it. He said, "I've got a guy..."

Massaro: But we did a minimum board for him, didn't we?

Sollman: No, we didn't. He wouldn't even let us do that. So he had a guy there who he said together Wozniak could put the whole thing in five chips, which they did.

Massaro: Oh, right.

Sollman: And they did have a five -- but they had to have all the fancy...

Massaro: No, we had to do the read channel for them...

Dalziel: Yeah.

Massaro: We did the read channel.

Sollman: Okay.

Massaro: We did the read channel. They did all the control logic because we ended up...

Dalziel: ...they couldn't handle the read channel. It's a very...

Massaro: ...very low level signal.

Dalziel: They couldn't have tested it.

Massaro: <inaudible>

Sollman: Well, but that was the whole argument. We can't test. It's got to come all the way out here and he said, "I got a guy named Rob Holt and Wozniak, they'll do the electronics in five chips or less, don't give me all this B.S." So we had to make a major decision, which a lot of people in the company were opposed to, starting with the engineer organization...

Massaro: Right.

Sollman: ...of selling him just the plain mechanism.

Massaro: But, by the way, they turned out within a very -- relatively -- within a couple years, turned out to be Shugart's biggest customer. We were doing about \$25 million a year in floppy disk drives to Apple Computer at 100 bucks a pop. That's amazing stuff.

Sollman: We'd be selling 30,000 to 50,000 drives a month and they were not very good at negotiating, maybe if you don't have enough, so if they needed 45, you had to deliver 45 no matter who you had to beg, borrow and steal the allocation from. And the worst time of our life was when the shipping van going over to Apple burned up over here. And we had to replace 30,000 disk drives within 48 hours or they couldn't make their quarter.

Massaro: You're making all this stuff up. <laughter>

Sollman: Okay. I'm making it up.

Massaro: Here's an interesting side note and I'll get off of this, okay? Steve Job was so appreciative of the 5 1/4" because it changed -- there are two things that made Apple go. One was the 5 1/4" floppy and the other one was VisiCalc, because there was now a real application for this stuff. That he came in and he offered to sell me 100,000 shares of his stock for a dollar a share, okay? By that point in time, we had been acquired by Xerox. I called Xerox lawyers and they said, "Don, you can't do this because Apple is your largest customer." Okay? And I had \$100,000 because we just sold the company. When that company -- when Apple went public, that was worth \$58 million. <laughter>

Sollman: That was your second mistake.

Massaro: <inaudible> Yeah, so selling Shugart when I did was small comparison to not even asking the lawyers to go do that, okay?

Sollman: I'd like to interject...

Dalziel: You're not as smart as I thought you were.

Sollman: ...one other point...

Massaro: I know.

Sollman: ...in this. That, as Don gets into the 100,000 share problem, what he did also is he started talking with Abe Zerum, who headed up the venture capital arm of Xerox and he said, "Abe, I can't touch it but what about Xerox?" So Xerox bought these shares, I believe.

Massaro: They actually put two million dollars in. They bought a lot more.

Sollman: Okay. Either two or three million in the company and, as part of this, he said, "Well, we've got to get on Steve's good side so, Don, I want you to take him over to Park." So I was there on that first contention, we went to Park and Steve's looking at Star and...

Porter: <inaudible>

Dalziel: <inaudible>

Sollman: Palo Alto Research Center. And Steve Jobs looked at this stuff and said, "I don't believe this." And that's when the light went on.

Massaro: That's right.

Dalziel: When he first saw the mouse and the...

Sollman: Oh, absolutely. The whole thing.

Dalziel: Yeah.

Sollman: And then he left.

Massaro: So when he left there from that point, he was convinced of what he wanted to do. Now, by the way, when Apple went public, Xerox made \$40 million from that stock that they got from Steve Jobs.

Porter: Which they never appreciated as a contribution from Shugart Associates. <laughter>

Sollman: I'm sure...

Porter: But to give you an idea, since you're quoting numbers, 5 1/4" shipments. 1977 got up to about 44,000.

Sollman: Yeah, that was the first year we introduced them.

Porter: Then the next year, in '78, 128,000. Then, in '79, 497,000 drives. Then, in '80, 866,000. And, in '81, 2.2 million. The next year, 3.6 million and then, in 1983, 10.5 million of those drives. And it was, by that time, 8" floppies in 1983, when you shipped those 10 and a half million, 1.6 million were 8". So the biggest thing in the industry became that.

Massaro: Interesting data point. When we were trying to raise money at the Shugart Associates in '73, the VCs, there was a weak, they weren't formalized, okay? They actually went out and commissioned a study on how big the floppy disk drive market was, okay? I don't know if you ever heard this number but the study came back that says that the -- and it wasn't 8" or 5 1/4", they said the whole floppy disk drive market will peak out at 35,000 units a year.

Sollman: Yeah. It was 100,000 total in five years.

Massaro: Yeah. It could have been 100,000 in five years but the peak was 35,000 in one year.

Porter: But something happened called the personal computer, which changed all of that. You were there just in time for the advent of the PC.

Massaro: Yeah. That's what made it a multimillion but it was significantly larger than 35,000 just from word processors and small businesses.

Porter: Sure.

Sollman: But the -- really a couple things were going on. I'd like to kind of build on Don's vision of the appliance because that started to really coalesce. You had a lowest cost per function input/output device. The microprocessor got extremely inexpensive. We even had some theory about having very, very inexpensive rigid disk drives. So, with the costs coming down, it got to a point where it got to be very interesting, like \$3,000 or less to become a personal computer. And I think that economic piece was happening right around us, very advantageously.

Porter: The other thing is you set a standard. That drive was 3.25" high, 5.75" wide, 8" deep. Those became sacred dimensions in the industry. So, in 1980, when the first hard disk drive was shipped by Seagate Technology...

Dalziel: The first 5 1/4" hard disk.

Porter: The first 5 1/4" hard disk drive...

Sollman: It should be the first 14" hard drive.

Porter: No, no. The first 5 1/4" hard disk drive shipped in 1980.

Dalziel: Exact same dimensions.

Massaro: Yeah, it had to be.

Porter: The ST506. It was in the exact same dimensions as that.

Massaro: Because they would go side by side.

Sollman: And the holes were already there.

Dalziel: Yeah. But I thought, at the time, and I may be wrong but I think the 5 1/4 that we did at Shugart was the first time that anyone other than IBM had introduced a removable standard.

Sollman: Yes. That's a good point, excellent point. The engineering people are bringing up the marketing significance because I can remember you and Dave Brown said, "Do you realize this is the first time anyone has successfully introduced a product that was not an IBM standard?"

Dalziel: Yeah.

Massaro: Just leave it to the engineering to play out the marketing importance. <laughter>

Dalziel: But that was significant because it's very -- as you see how long they last, that also -- it's very hard to introduce a new one. The world didn't like new, removable standards and...

Massaro: But you were right. The market was right. The market -- there was a need.

Dalziel: The market was right.

Massaro: In other words, there was a need there and they didn't care, and the marketplace didn't care who satisfied that need, it was there.

Dalziel: As a startup, we probably wouldn't have been able to do it as a 5 1/4 but, having had the background of a reliable 8" company, you were able to do it.

Massaro: Right.

Dalziel: And you're right, the first 8" was pretty crappy.

Massaro: It was.

Dalziel: And I can remember you were -- I used to say our good friend, Don Wortner, who passed away many years ago, you'd continue to have to rub his nose in it because he was such a optimistic, easygoing guy, he would tend to overlook problems and Don would come out there and...

Sollman: But your problems were not unique at Shugart, speaking as someone who came in, because the first day I showed up for work, I sat down with our VP of engineering Al Chow and I said, "Al, I just came from Control Data. We had the world's worst engineering group. We had all these problems. Can you share with me the kind of problems you're dealing with?" And he goes down this litany of about 50 problems, which are the same ones we had at Control Data, which, in my mind, proved that, any time you go into new technology, you have to go through the same learning process.

Massaro: But the difference is, we had nothing else to work on.

Dalziel: We were focused and...

Massaro: We were so focused. We had nothing else to work on. We had one product, which was the 8" floppy, and we had nothing else to improve.

Sollman: It was life or death.

Dalziel: The fact even we made a second one was good and the fact we made almost the third one and the hard drive was pretty good because companies have a hard time doing -- as the Tandon shows and, again, that our friend, Jugi Tandon isn't here.

Porter: Well, now that you mention Jugi, let's mention that one of the other guys who was at the old Memorex when a couple of you were and I was, was a fellow named Jugi Tandon. However, he didn't go to Shugart Associates, he moved south and went to work for Pertec and then set up his own company, Tandon, and became a very competitive floppy drive maker.

Sollman: Well, he started making heads.

Massaro: Making heads.

Sollman: He started out making heads.

Porter: Exactly right. After making heads. But he also did something else. He and some of his friends came out with a patent on a way of making a two-sided floppy drive, the bipolar head system. Now, when you looked at higher capacities, doing two sides of that disk, whereas you started with just one side. And here's a article from 1980 in which -- I'll read the first paragraph, "Talks between Shugart Associates and Tandon Magnetics concerning manufacturing licenses for Tandon's double-sided read/write head

assembly for floppy disk drives remain at a stalemate." Now, that patent of Jugi's was something that affected the whole industry going to the right kind of two-sided head production, didn't it?

Massaro: Right. Now, you see, we tried to buy Jugi. In other words, after Shugart was a purchase by Xerox, I actually tried to buy Tandon Magnetics. So I went down...

Dalziel: As far as a head supplier.

Massaro: Pardon me?

Dalziel: As a head supplier.

Massaro: As a head supplier because we had a design which actually mimics IBM's design where they were both floating and we couldn't get it to work and Jugi took a simpler approach and it did work. And so we tried to buy him and we came very close and, at the last minute, he decided not to do it. I think we were going to pay him \$2 million for his company and it would have been cheap to go do that. And then what happened is that, once Shugart got acquired by Xerox, then Jugi got into the drive business and he ended up owning the 5 1/4" business because Xerox kind of screwed it up by putting the unions in and doing other things kind of stuff.

Dalziel: Yeah. The head -- the history of the heads and interface, always a big problem with floppies. Again, I mentioned, at IBM, we tried foam and then actually several other things. I had some other -- I had some designs that almost worked but what we ended up with was a spherical head on one side and actually I borrowed from the tape drive business. It was kind of controversial and Don used to -- I forget what he called it. Our whole company depends on a little piece of fluff or something or a little piece of -- because we literally used a little felt pad that pushed on the other side to get compliance in an area but it's tricky because you had wear problems and that. And one of our big problems, you remember you mentioned the heads and solving was gap erosion.

Massaro: Right.

Dalziel: Because it is contact, there is wear.

Massaro: And it's such a...

Dalziel: The amplitude would degrade after usage and...

Massaro: It was a tough problem.

Dalziel: And that almost killed us and then we -- it worked, again, Herb and Dave, and got the glass gap, which obvious now but, at the time, it was...

Massaro: Wasn't, yeah.

Dalziel: ...wasn't. And when it came time to do the double-sided, we actually didn't take the lead there. IBM came out with it and one of the biggest mistakes of my life...

Massaro: Which we copied.

Dalziel: ...professional was we copied it, again, maybe being from IBM, I had so much respect for the company...

Massaro: <inaudible> copied it.

Dalziel: We thought it was good.

Massaro: No, no. The reason we copied it, because I remember, any time that you didn't copy something from IBM, you got in trouble.

Dalziel: Yeah.

Massaro: So we said, look, guys, this is real tricky so let's copy it.

Dalziel: And we had confidence in IBM.

Massaro: So we copied it and we got in trouble and Jugi had the right answer.

Dalziel: They -- and he -- because he says he didn't have enough resources. This was a very difficult head to make. It's too hard, too complicated. It's a case where simpler is better. If you look at that, it looks kind of odd but it's really -- what IBM did and what I believe is, when they wanted to do double-sided, they hired a bunch of guys that had been designing Winchester suspensions and, for them, how do

you make a head? You put a slider on a gimble suspension. And you put two of them on each side and, in some ways, it's very nice. It works well for rigid but it's absolute disaster for...

Massaro: Just by reference.

Dalziel: Yeah, and one of the biggest things so obvious now is, as a disk goes out of plane, the heads shift relative to one another so you got off track and there was really no way to solve that.

Sollman: Wear.

Massaro: It's terrible.

Dalziel: Wear and cap tap and we had these things to try to make it load gently.

Massaro: I don't know how IBM ever made that work.

Dalziel: I don't think they did.

Massaro: They <inaudible>

Porter: <inaudible>

Dalziel: What?

Porter: Eight inch.

Massaro: Yeah, but I don't think they made them.

Dalziel: No, they never made -- well, they -- but I don't think they ever made double-sided work. It's fundamentally flawed technology and we...

Sollman: And we copied it exactly.

Massaro: We copied it.

Dalziel: We copied it and we probably did as good or better than IBM but...

Massaro: <inaudible>

Dalziel: ...the fundamental...

Massaro: And Jugi figured it out.

Dalziel: When we first saw Jugi's, I think we were all skeptical because, again, you're pounding two rocks together. We tend to say, "How can that work?"

Sollman: That was an expression you guys used, too.

Dalziel: What Jugi did was Jugi kept the solid bottom head, changed it from spherical to essentially flat with blended edges and then just fluted the top one. Obvious. <laughter> And so you get around the problems of the shifting because you've got a solid place. But that wasn't without its problems, too, because you do remember the tap, tap issues and the wear and that but, of the solutions, obviously, it's the one...

Massaro: One who won.

Dalziel: ...one that worked. Oh, here's a felt loading pad. I don't have -- but these are just literally a little piece of felt.

Massaro: Right. It was from pool tables.

Dalziel: Yeah. Yeah, it was essentially pool table felt and then the one thing I did, which I see Sony copied, well, anyway, made the replaceable button one and then also, because of that, it was natural, you could rotate it to optimize the compliance.

Massaro: Yeah, change the read signal.

Dalziel: Yeah. Oh, yeah. You could twist this little piece of felt around and it would change how the heads...

Porter: So did you take a license with Tandon?

Massaro: I don't know. I had Don onto the office products division in Dallas so I wasn't at the -- sure, you must know that?

Dalziel: No, I had left...

Sollman: I think we did take a license...

Dalziel: I went to work for Jugi.

Sollman: The thing I'd like to bring back on Jugi, the thing that was very interesting there from my side, from a business perspective is he started out making head cores. He had almost no money to start the company so he started making head cores in his kitchen and then people got the head cores. They said, well, look, it's a lot of work...

Dalziel: Cores are the...

Sollman: Right. The little read/write thing.

Dalziel: ...recording filament, not the...

Sollman: The itty bittiest elements. He said, why don't I put those in an assembly? I'll sell you the assembly. People said, yeah, it is a pain in the neck putting them in. I'll sell you the entire assembly. So he sold the button assembly. And said, why don't I put in the carriage for you? And then, pretty soon -- I'll do you the whole assembly and, pretty soon, he had people come to him, can you drive? Yeah, give me a little front end money and I'll do the entire drive.

Dalziel: Like IBM.

Sollman: So he incrementally walked himself right...

Massaro: Right. With no VC funding.

Sollman: With no VC funding, owning 100% of the company, right into the marketplace. His -- I wish he was here to talk about it. But then he made, I think, the one strategic mistake, he then decided to go into the systems business and go head to head with IBM, who didn't have a valid business model themselves, which is about as bad as we talked right here on the double-sided heads.

Dalziel: He went from cores to heads to sub-assemblies to drives then he went to hard drives and then I did a tape drive for him. Then, in the small systems, a very...

Everyone: <inaudible>

Dalziel: ...motors <inaudible>

Massaro: ...hard drive business to Western Digital.

Dalziel: That's right.

Porter: Now, let's stay with the floppies.

Dalziel: Yes.

Porter: Let's stay with the floppies because, of course, Jugi and his brothers had manufacturing capability in India so Jugi was one of the first off-shoring entities in the disk drive business.

Sollman: Also the first to set up in Singapore, I believe.

Porter: Well, early in Singapore, but very early manufacturing in India. So he was an early manufacturer in India of floppy drives with his brothers' capabilities.

Sollman: I think that was kind of brand new for a lot of us. We couldn't spell the word offshore but he had a brother who lived there so that was okay. And I think we kind of missed that. Now, what would later happen is we had drive costs down at Shugart and Don -- I don't know if you want to talk too much about this but Don went against the chairman of the board of Xerox and opened up Mexico.

Massaro: That's right.

Sollman: Remember the blowup that we had on that one?

Massaro: Yeah.

Sollman: Don made a decision and I was there when he said to McCulloch, he said, "You told me to run a business. That's what you told me to do. And we've done it." So they started up in Mexico. Lots of push...

Massaro: That's right. I forgot about that. We had a head plant.

Sollman: Right. And on top of that, they then had people come back to explain how we were exploiting people in Mexico because they had the union people from Rochester go down and take a look at the working conditions.

Massaro: That's right. Yeah.

Sollman: Remember that? But the point I'm trying to drive at here is, in our own evolution of the floppies, we were stymied big time after doing five separate proposals to move the business to Singapore because Xerox had an arrangement, a legal...

Massaro: Sweetheart arrangement.

Sollman: ...agreement with Fuji Xerox, which is Fuji Photo Films. They could only manufacture offshore if they had their approval. So, because Fuji Photo Films had all their Japanese friends, they stymied our ability to do that. We could never understand. We'd go back to Xerox with a business plan and it kept getting turned down again and again and again.

Massaro: Right. Killed the business.

Sollman: And then we finally found out why that occurred.

[video off then on]

Porter: Let's talk a little bit more about the difficulties you had in making this thing work, Warren.

Dalziel: Well, I just -- there were a myriad of problems and we mentioned the gap erosion and many others. A few though that were kind of design choices and caused their own set of problems was, mechanically, they're interesting devices. You're moving the head, you're moving the disk, you're clamping the disk, unclamping it, raising it and lowering it. Probably a follow-on from IBM, the 8" and the 5 1/4", this is 3 mil Mylar, relatively stiff material but still just a thin plastic material with a hole stamped in it and putting that in and centering it was always a problem. And people solved it various ways, not always successfully. Following IBM's lead at Shugart, with the 8", we had, I guess I'd call it the male hub and we don't have an 8" disk but the disk went over it and two functions: it has to center and clamp. And what we had was the designs we had, it was clamping before it was centering and, if you -- and you would curl up the edge here and then, of course, you're eccentric and you can't read it. The solution that we came up with was this -- had various names, a spring-loaded assembly that would -- the disk is moved onto here and then it gets slid -- pushed down and it actually gets centered before it gets clamped. So that worked very well. I can remember -- who was the great big guy in field?

Massaro: Paul Curran.

Dalziel: Paul Curran. The biggest guy in the company with the fastest hands. I don't know if you...

Massaro: Right. Right. And he could always catch the disk.

Dalziel: Yes. I'd come up with a solution and I couldn't get it to fail. I'd go get Paul Curran. Paul had this, I don't know where -- he just would flick the door closed and I'd take the disk out and it'd be crumpled. So I'd go back and design something else. Finally, I got this. Paul could not damage the disk. So we knew we had it. That solved that problem. And, when we get into the 3 1/2...

Porter: Well, before you do 3 1/2...

Dalziel: No, but I will say how we really -- how that was finally solved. 5 1/4, again, because there was -- the disk doesn't move. You slide it in a rail and it stays there so that uses a female, a hole and then a hub gets pushed in. Well, various types of hubs and this is one of them, I'm not sure who's this is, it might be a Tandon, but a wedge-shape. So, again, you'd tend to center but it's kind of the same problem. You start clamping before you really center. But those worked quite well so just little things that you wouldn't think would be a problem were with that because you're dealing with this Mylar.

Sollman: Well, it didn't work then.

Dalziel: No, it didn't work. It never did work that well.

Sollman: As a matter of fact, one of my more interesting sales calls at Apple was they had to do a field retrofit to replace 100,000 hubs.

Dalziel: Yeah. Well...

Sollman: Little minor problem.

Dalziel: Well, yeah, little too much friction. Little too much friction. Again, you see, fundamentally, from an engineering standpoint, this comes down. It does -- not until it's clamping does it really spread out and center and you're fighting against itself. It doesn't want to move then. So this is actually a better solution but it had its other problems. The other thing briefly, I know, being an engineer but actuators, to me, it's fascinating. The original 8" was a lead screw and a step motor and we stayed with that. This is similar to what Memorex used and then we used on the first 8" floppy. I don't have the motor but this is the rotor of a big motor. So it was this big and you can see the size of the lead screw. On the 5 1/4, we were mentioning we should have the actuator there, we went to a much cheaper type of step motor called a tin can step motor, flatter, which also helped, and -- but not very accurate. So not really suitable for a lead screw but what was -- and Dave Brown, I think, came up with this or Harold or someone, I didn't really work on that actuator, came up with a molded plastic cam with a stylus groove on it.

Massaro: A stylus. And a stylus that was...

Dalziel: And a stylus, a little spring-loaded, beryllium copper stylus and it only worked different materials. I think we ended up, you know, with a Teflon-filled polycarbonate type of -- and it was stable and pretty good. Turns out if you really...

Massaro: And it was cheap.

Dalziel: In absolute precision, it wasn't that good and I think we had some -- if you were interchanging with Shugart drives, fortunately, most of them were, it worked fine.

Massaro: You're okay, yeah.

Dalziel: But it wasn't a particularly accurate device but was low cost and did serve the function.

Sollman: It was very hard for people to change to...

Dalziel: Yeah, yeah. People...

Massaro: This is an interesting point. The tooling was not exact in terms of the spiral going in.

Dalziel: No.

Massaro: So it made no difference if you were exchanging from Shugart to Shugart drive because it was the same spiral. Somebody else who tried to come out with another technique had a real serious problem. This is one of these cases where a design flaw can be an advantage.

Dalziel: Yeah. It did hurt people because, obviously, you've got to take something that's written by our drive and read it, even though...

Massaro: It was off-center.

Dalziel: It was off...

Sollman: It was a way to consolidate market share.

Dalziel: Yeah. <laughter>

Sollman: By your engineering department.

Massaro: It was all planned. <laughter>

Dalziel: But, interesting, from an actuator standpoint. Then the band actuator was actually developed -- I did it for the hard drive but then adapted it to the floppy and it was subsequently used on many floppies, including, I think, this Canon drive.

Massaro: Correct.

Dalziel: But then people did go back to lead screws, the Sony drive, and one I just want to -- here's -- compare this lead screw and this lead screw. That's -- and now they're even smaller.

Massaro: What is this? This is a 3 1/4"?

Dalziel: Yeah. But look at the lead screw. I mean...

Massaro: Oh, my god.

Dalziel: I mean, the motor -- so, obviously, everything's scaled down. It sometimes makes me feel, I mean, to have designed something this big and this crude...

Massaro: Actually almost embarrassed.

Dalziel: Yeah. <laughter> Almost embarrassed.

Porter: Okay. Now that we're talking about sizes, let's talk about how 5 1/4 was starting to seem a little large to some people. And so we had another wave, at this point, not just one company successfully building a floor mat, like Shugart Associates did with the 5 1/4. When we went to the micro drive to be smaller than this 5 1/4". Canon brought out a drive at the end of 1980 which is using a 3 1/2" disk, smaller than this. And then Sony brought out -- they announced a drive, they announced it actually in early '81. They didn't ship it until November of '81 using what became the micro floppy. Company called Dysan, which was mentioned a few times, subsidized a company called Tabor that did a 3 1/4" disk, not in a cartridge but separately, separate like the 5 1/4, and a company called IBM brought out a drive sometimes, which is this diskette, sometimes called 3.9 or 4.0. And, in Japan, Hitachi and Matsushita, in '82 and '83, brought out 3" diskettes. And, suddenly, we had a small, I say that charitably, a small, confused circle of products which made for big confusion in the market as to which was going to be the standard in the way that the Shugart Associates 5 1/4 had quickly become a standard.

Dalziel: Well, it just halted all market development because of that, that confusion.

Porter: Yeah. Or for quite a period of time.

Sollman: Yeah.

Porter: So a micro floppy industry committee was set up, starting in May of '82. How did all that happen?

Sollman: In April of '82, Bill Harry called me, Bill Harry at that time being Executive Vice President of Dysan, and so we got to have lunch, so we got together over at the sports club over here, I can't remember the name of it. Anyway, he said, "We got a serious problem." He says, "What do you think about these standards?" I said, "Well, look, we think three and a half is not bad. What do you guys think?" He said, "We think it's not bad." "What about the rest?" He says, "The rest will absolutely crater what we've done with 5 1/4. It won't go any place. We've got to band together. Would you be willing, as the leading drive manufacturer, to support a standards committee because we'll support it from the media side and it'll take \$50,000 to get this thing kicked off." We both threw in the 50 grand and that started the standards committee and we had enough meetings going, we had to meet with a lot of people in the back room to try to get them to go to it and then we had trouble with people coming together on it. So we got our ad agency, the same people who did the Apple ads in those days, to come out with a full-page color spread saying, "3 1/2" is the winner." Preemptively. Just it is the winner.

Massaro: But which three -- the Sony...

Dalziel: <inaudible> 3 1/4?

Sollman: 3 1/4. The Sony format.

Porter: The Sony.

Sollman: Okay. Meanwhile, what's also going on, that I don't know if many people know, is Mike Scholhoff, who is president of Sony U.S., shows up on the scene and he wants to buy Shugart from Xerox. So he's out here with the Sony corporate check and he's got all the people roaming through Shugart because they really, really want it. And he had a engine -- a physics degree from Harvard so he thought he was a great engineer and he says, "This has got to be possible." So they got in a big discussion back at Sony to see whether their future would be in hardware or software. In other words, the contact. And he then went to the board of Xerox to have a discussion about would you sell off the division. And they weren't sure. They weren't sure. 1982, I believe. They were not sure that...

Massaro: Plus they had Seagate wanted to buy it, too, in '84. They didn't sell it, either.

Sollman: '82, '83, you know, they're willing to buy it and I think some pretty interesting numbers got thrown around. We're talking about in the 50 and 100 million dollar level, no problem. And some people at Xerox thought they'd get a lot more for it. Anyway, netting it all out, the push Sony away. Scholhoff then made a strategic decision, I don't think influenced at all by this discussion, to go off in the content business. The rest is history.

Porter: Well, okay, the Micro Floppy Industry Committee, however, with a fellow named Charlie Payne as the chairman, finally worked out a compromise. Now, the 3 1/2 Sony drive, as originally announced, had a different file organization, et cetera, different interface, from that 5 1/4".

Sollman: Correct.

Porter: So what are the reasons why Sony ended up being the industry's choice by that ad hoc committee? Wasn't this the reason? That they made a new version of the drive in which the file organization was the same as a 5 1/4"? So that, from the point of view of the systems maker, who had to use these floppy drives, he could use either a 5 1/4 or a 3 1/2 without changing anything on his PC. Wasn't that the truth?

Sollman: Well, there was a lot to that. The engineering organization at Shugart fell in love with this product because it solved a lot of the problems that Warren referred to earlier. These were long-term bugaboos that we could not solve as an industry, let alone as a company, and it looked like Sony did a pretty good job on that side. They were totally incompetent relative to the systems organization and so I think basically people said they can organize their system's file structure however they want but we're going with the physical design. And eventually we got Sony to come around.

Dalziel: I remember most of the fight being over -- well, Dysan, actually, was promoting for a long time, as I recall, essentially a small version of this.

Porter: Which was this?

Dalziel: Well, except this has -- I'm surprised to see this because this does have the metal -- he did incorporate this, which, again, maybe having fought the battles for so many years, I can distinctly remember seeing the Sony drive in New York, I think it was the old NCC show and that was in '80, now this brochure is '81 but it could have been '81 and I saw this and I did. I fell in love with it. I said -- and I didn't appreciate, at the time, the subtleties of this hub design. It is the way -- it isn't a pin fitting in this hole here, which you might first think. It's a pin that gets forced over to the edge so it's a V-groove design, which is, if you're a mechanical designer, you know that's the most accurate way to locate something, you locate a cylinder on a V and there's a little pin that picks up this slot here that forces it over to the V. So that just solved all these problems and then the shutter was so much better than the open design. I mentioned that we put the wiper in here to wipe off stuff but it's so much -- you still can put your fingers on it and that and people don't put them back in the container. So this just, in so many ways, was so good. I think Norm's, Norm Dionne's objection, "Oh, it's too expensive, too expensive" but, in volume, you buy them now, I mean, what are they? A few cents?

Massaro: Because Norman's a very NIH guy.

Dalziel: Yeah. Well, he was. So, anyway, that, again, that became the standard.

Porter: Sony published their standards agreement in January of '83, agreeing to change the drive to be consistent with a 5 1/4" at the interface, which made it easy for system makers. The rest of these people - a 3" stayed in production for several years in Japan but -- between Matsushita and Hitachi, most of the others dropped off the map. IBM's dropped off the same year it was announced. This was a monster. So it became the standard and, in '83, it did 400,000 drives, all the 3 1/2. The next year, it was 1.9 million in '84. In '85, it was 3.2 million. '86, it was 6 million. '87, it was 12 million. '88, it was 18 million. '89, it was 23 million and so forth. So that...

Sollman: Where did it peak at?

Porter: About 120 million a year.

Dalziel: 120 million.

Porter: At the end of the '90s.

Sollman: Of the 3 1/2"?

Porter: Yeah.

Massaro: Wow.

Sollman: Wow. Amazing.

Porter: So it became the standard. But the 5 1/4, as we said earlier, maintained a peak up in the -- between about 15 million a year plus or minus a little bit for more than 10 years, mainly because it had gotten off to such a good start. It had become the standard. So, during the second half of the '80s, most PCs shipped with both a 5 1/4 and a 3 1/2" disk drive. Not one but both because there were floppies coming from all around. And remember software was published, first in 5 1/4" disks, then in 3 1/2". So that some of Bill Gates' software might take 25 diskettes.

Sollman: Oh, it did.

Porter: Easily.

Sollman: Yeah. The 3 1/2 got up to 50 diskettes before they went to CDs.

Porter: And I might point out that the diskette production on 3 1/2, at its peak in the '90s, got up to more than five billion diskettes per year. To go along with 125 million drives.

Massaro: So do you have on that page somewhere the total number of flexible media drives built from day one of all sizes?

Porter: Not...

Massaro: 8", 5 1/4...

Porter: Not a cum. total because they got thrown away after a few years, in many cases. No, I don't have a cumulative total.

Massaro: That'd be an interesting number, huh?

Sollman: Yeah, because it has all to do with learning curves.

Dalziel: And, again, just to be complete here, these were all open loop devices and modest TPIs, Tracks Per Inch. I think the first Minnow was 35 TPI...

Sollman: Then 48.

Dalziel: ...then we went to 48...

Porter: The first 8" floppy.

Dalziel: 8" was 40. Yeah, the first 8" floppy.

Sollman: Then I think we went to 96.

Dalziel: Then they went to 48, then the double was 96. Sony was 135.

Massaro: Sony was 135?

Dalziel: Yeah. And the reason you can do that, again, no more after positioning, it's more than just the size because the media is not stable, thermally and hydroscopically, yeah, so just being smaller, you have less distortion at the outside so that, really, it kind of scales. 96 is pushing it. You did have to get pretty accurate and, again, like most of these, they really didn't work worst case. If you...

Massaro: Right.

Dalziel: And they were all a trim erase of some type where you write, tunnel erase. That was the other head technology...

Massaro: Tunnel erase.

Dalziel: ...that people did various things.

Massaro: That helped a lot.

Dalziel: Various ways of trimming the track down so that you could be off track and not pick up the adjacent track noise. There were various attempts, I might add, to make closed loop drives and just another aside on the head thing. Some people never even did -- still didn't believe in Jugi's head. If you remember Herb, our good friend, Herb, flogged the gumball heads, the offset two, two spherical heads offset. Interesting compliance things. And I don't think anybody made a successful closed loop drive.

Massaro: But isn't a Zip -- wasn't a Zip drive a flexible media closed loop?

Dalziel: It is.

Porter: Now, and let's just mention -- you mentioned the Zip drive. The company called Iomega produced a Zip drive which was a high capacity drive later on.

Dalziel: It was closed loop.

Porter: That was after this era.

Massaro: Right. But that's closed loop, right?

Porter: Yeah.

Sollman: I think there's one other historical thing we didn't introduce that I think had a major impact and this was in the early '80s where NTT let -- put out an RFP where you had to come back with a 5 1/4" floppy, I'm backtracking a little bit, 5 1/4" floppy. You had to have 10,000 per month in production to bid on this so you had every Tom, Dick and...

Massaro: Who was this?

Sollman: NTT.

Porter: Nippon Telephone and Telegraph.

Sollman: Okay. So that you had become the key -- they would select. They told the world they would -- I think the Japanese world, you would select two suppliers. You had to be building 10,000 a month. So every Tom, Dick and Harry in Japan decided they could do this and, by the way, the banks would loan you the money to set up the production line. So they're all offsetting at production lines. Guess what? At the end, NTT kept their word. They selected the two and the other 24 companies showed up on our shores at Comdex that year and I'm going to say that was -- Comdex, '82? I think so.

Massaro: Who'd they select?

Sollman: It was, like...

Porter: Probably TEAC?

Sollman: TEAC and Matsushita, I think.

Massaro: Matsushita was the Shugart?

Sollman: Yeah. So, you know, they selected two and they built up all this surplus capacity which they could never chew up in the Japan market. There wasn't enough demand for it so it showed up over here, which suddenly dropped our prices down. Tremendously. I mean, like a factor of two overnight, you know? That was kind of good news/bad news because the good news was, the people putting in the systems could drop their system prices where systems PCs were sold. But we couldn't figure out how to make money after that.

Massaro: So what was the 5 1/4 selling for in that '83/'84 time frame when these all showed up?

Sollman: Well, I last have a memory that picks that up, it was, like, about \$125.

Massaro: You could still make a little bit of money at 124.

Sollman: This was the double-sided.

Massaro: Yeah.

Sollman: With all its problems. At \$124, \$125?

Massaro: Close.

Dalziel: And what were we saying? You can buy a floppy now...

Porter: Well, you can get a floppy drive today in quantity for about eight dollars.

Dalziel: Yeah.

Porter: But you're talking quantities of companies and I should mention that, in the early '80s, the number of floppy drive producers in the world got up to a peak of 63 companies and, by the end of the '80s, in '89, it was down to 52. And then, of course, by the end of the '90s, it had gotten down to close to a dozen. And, by the way, the U.S. companies basically were just a few specialists and that was it at the end of that time. Now, the Japanese companies you mentioned became predominant but even they have gone offshore to China in more recent years for...

Sollman: Yeah. Earlier, it was Korea and then they went off to China. I think the other part of the story that we probably ought to introduce is -- since we all came out of Shugart is what happened "at the end"? In December of 1983, there was a meeting in Xerox in Stanford, a company had bought Kerman Foster a major insurance company which they bought at the top and it's about right at the bottom, they need cash like crazy and we needed some cash to grow. We couldn't put production over in Asia because that was blocked by Fuji Xerox so the decision comes up, are we going to continue to finance Shugart? And the answer back was we can buy drives from other people now. The reason we bought Shugart was...

Massaro: They were the technology.

Sollman: ...the supplier. Well, now we've got all these different suppliers. We don't need them. So, at that meeting, the proposal was made by the vice-president of strategic planning, let's cut it back. Corporate staff said take engineering down to 25 people. They had 250 people at that time. And so I came back from that meeting totally discouraged.

Massaro: So you rode it down to the end?

Sollman: Well, actually, no, I didn't. I went in to see Bill Bayer in January of '84 and I said, "I want out of here. Cut me a check. I'm out of here." And, 13 months later, 3,600 people were gone, \$100, \$250 million a year business was gone. They attempted to sell the business and completely screwed that thing up, too, but that's another issue.

Porter: Shugart was closed down in '85. We should mention that, following Don's role as president, Jim Bochnowski was there in '79 and '80.

Sollman: For 13 months.

Porter: 13 months. Then Jim Campbell replaced him in July of '80 through May of '83. Then Bill Bayer from May of '83 to April of '85. And then Dan Starkey, from out of Xerox...

Massaro: Who?

Porter: Fellow named Dan Starkey basically came in '85 to close it up. And, in '85, it was closed up and a fellow down in Orange County bought the rights to make a few drives and the company who became the standard, the leader, was gone.

Massaro: Yeah.

Sollman: Right.

Porter: But, still, there were dozens of other companies making floppy drives.

Sollman: Let me take a more positive construction line. I think that one of the things that it taught a lot of us was that you can have a lot of fun in starting a business, a lot of fun growing these businesses and starting them and I don't know if anyone's ever compiled this but there's a whole family tree of not less than 40 or 50 companies that came out of Shugart because of the training you got and the vision and the excitement. There we go, I'm sorry.

Porter: Where'd you get that?

Dalziel: Oh, I'm sure...

Sollman: Did you make it yourself?

Dalziel: No, no. This was in one of the magazines.

Porter: Just explain that because it's hard to see.

Dalziel: <inaudible> hard drive but it kind of parallels the -- yeah. You know, we're all in there, various -- here's Shugart, associates back to Memorex and IBM and...

Porter: Yeah, the companies, the people that work in companies and then spun off and did others.

Dalziel: Yeah.

Porter: Yeah. Shugart Associates was a great training ground and -- as Memorex had been for many of the same people before.

Dalziel: And I have to say personally it was one of the most fun places I've ever worked and I give kudos. I probably enjoyed working...

Massaro: Even though you're pissed off at Shugart?

Dalziel: I worked for Don -- oh, we had more fun, Don, you know that. He'd drive his managers crazy because he was a very much hands-on managed by wandering around guy. He'd come in my office and tell me what to do and my manager wouldn't even know what I was doing. <laughter> But we'd get it done and working out on the line together, salesmen, everybody working <inaudible>

Massaro: It was a real team effort.

Dalziel: ...to rework something. I remember, in the early days, too, Don, we'd -- everyone knew exactly what our PG&E bill was, what our expenses were. I don't think I took a turn but guys literally mowed the laws because we cancelled the landscaping service. Do you remember that, Don?

Massaro: Yeah.

Dalziel: We'd come in on Saturday and mow the lawns. And...

Massaro: You see, Al had raised \$3 million and went through that in about a year and a half.

Dalziel: Boy, did we have good parties, though. My wife still talks about those.

Massaro: We had fun. They weren't expensive, either.

Dalziel: No, but the parties Al threw and then always gave Christmas to the wives.

Massaro: Yeah.

Dalziel: Always.

Sollman: I think there was really -- it was a tremendous learning experience for a lot of people and a lot of people in disk drive companies started -- I think the one problem Don -- Don only made one problem but, yeah, one problem he created is he made it look very easy. I think he shared only about 10% of the problems we were seeing in that funny corner office and, for a lot of people, looked really easy. And there was some people...

Massaro: I think there was -- if Don can make this work...

Sollman: Well, that's...

Dalziel: I think Dave Brown said that more than once. <laughter>

Porter: Well, you also, earlier in the discussion, made a point that, far from being just a successful company, doing nothing but presiding over your 8" floppy drive lead, you then brought out the product which would then eventually replace the 8" but you did it -- you replaced your own product.

Dalziel: Right.

Porter: Now, the problem was that the product that was going to replace that one eventually, again, the 3 1/2", turned out to be a mob of companies doing all of that, even though you had a leadership role.

Sollman: Yeah. But we had -- we were gone by then.

Porter: Even though Xerox was taking away, I think, during that period, a lot of the entrepreneurial spirit of the company, wasn't it?

Dalziel: Yeah.

Sollman: I'm going to argue to a fundamental business point. Everybody had offshore production. We were not allowed to have offshore production. And, without that, you lost the basic business fundamental. We even created a small separate division that Yoshi Narahara headed up just to develop the 3 1/2" drive. They successfully developed it but, when it came time to go back and propose building in Singapore, that was stopped. So as far as I'm concerned, it was really a case of a misunderstanding of what it took to be successful.

Porter: <inaudible>

Dalziel: ...was perceived as a leader any more at that time. I think Jugi had taken over the leadership.

Sollman: Jugi -- it was...

Dalziel: In the floppy business.

Sollman: ...very close.

Dalziel: Yeah, yeah.

Porter: And, of course, Tandon had offshore manufacturing.

Dalziel: Yeah.

Sollman: Oh, yeah. I think it was beating on price and then with his head technology he was beating on that and, since neither one of us invented...

Dalziel: He could do whatever he wanted to do.

Sollman: Yeah.

Dalziel: Yeah, it was a different time.

Sollman: Yeah, I think the other thing that Don didn't maybe fully explain here is that Xerox came in to take a look at our labor structures and, if you weren't earning enough, Don was told, you got to up Warren's salary.

Massaro: Not Warren.

Dalziel: You never told me that.

Sollman: Oh...

Massaro: Warren was making more than most of the people in the line.

Sollman: Okay.

Massaro: Now, we can't -- you know, who knows? You clearly can think of a lot of things that Xerox did that really caused a quick demise but, you know, so maybe it wouldn't have collapsed in '85, okay, but when you take a look at this product here, Warren, I don't know if you looked at this. This is the first time I've actually looked at the inside of one of these 3 1/2". There's nothing here. I mean, I didn't realize -- I thought there was a stamping versus a casting until I looked at it more closely. It so thin walled. You know? Now, you've gone from a drive that we could sell for 250 bucks to something that had -- this probably has a manufacturing cost of under \$10.

Porter: Must have if they're...

Massaro: Well, I don't know the vintage this is but that's under \$10. There's nothing there. So, you know, the question is, where's the value headed when it goes -- you see, I don't think Silicon Valley is very good at "commodity" type businesses.

Dalziel: And very high volumes.

Massaro: Yeah. We're not...

Sollman: We've proven that one.

Massaro: We're not good at commodity businesses. We can't handle commodity margins. We tend to look at the development investment required as being significantly more than what the consumer-oriented companies are doing. I don't know if we could have ever competed in this. We have a problem today competing.

Dalziel: Yeah, we do.

Sollman: Here's another story I should introduce. Don, at one moment in time, I'm going to say this is, like, February or March of one year, and I'm going to have to say it was -- must have been about 1980, took roughly 20 managers from Shugart to Japan and walked us down through the lines of Matsushita. We spent a week over there.

Massaro: That was in '79.

Sollman: '79. We spent a week over there looking at how the Japanese approach things.

Porter: We should mention that Shugart Associates had made an arrangement with Matsushita Communication Industrial to produce their half-high 5 1/4.

Dalziel: I thought they started with the 8"?

Porter: <inaudible> And 8".

Massaro: We licensed them on the 8" first and then followed the 5 1/4. We were shipping products to Japan, don't forget Shugart's the leader in the 8", we're shipping products to Japan through Matsushita. Matsushita is taking the entire machine apart when they get it there, re-plating the brackets, redressing the lines and so forth, the wires for the Japanese market. The quality was perfectly acceptable here but, over there, it wasn't. So we ended up licensing them and they were very successful over there with that product.

Porter: I went through that plant. It was very impressive.

Massaro: Yeah. MCI.

Porter: MCI.

Sollman: But Don not only took us through their disk drive area, which was actually a pretty small, minute part of that operation, we looked at all the other high volume production lines...

Massaro: Yeah, that was pretty impressive.

Sollman: ...and I think Don said, "This is the vision we've got to adopt here. Oh, wait, it's okay if you don't because we'll die." It was kind of black and white conversation.

Massaro: Well, we went through their stereo. You look at their stereo place, you know, Panasonic is their brand name and you just get blown away what these people are able to do.

Sollman: These automated screwdrivers and so forth.

Porter: Well, that complex outside of Osaka is very impressive. It's got all kinds of manufacturing, including the MCI, yeah.

Massaro: Japanese are very good at their manufacturing and engineering. They're very good. They're not great design engineers but they are great manufacturing engineers.

Dalziel: They are the world's best and that's, I think...

Massaro: At manufacturing and engineering?

Dalziel: ...both Joel and Dave Brown learned from that and I remember them saying that, you know, the world doesn't need two manufacturing countries and so, you know, they're -- Quantum's strategy was to...

Massaro: Offshore.

Dalziel: ...offshore from the start, essentially.

Massaro: Subcontracting. They subcontracted to MEI.

Dalziel: MKE.

Massaro: MKE.

Dalziel: Yeah, which was another division of Matsushita.

Porter: Okay. I think it's time to introduce a thought that we've talked over most of the angles here and I'd like to ask each of you, in turn, to give me a short summary of your thoughts about having participated in this stage of the floppy drive business. Warren, what do you think about having been a part of all of this?

Dalziel: Oh, I think it was tremendously exciting. I just, you know, you look back on a career, just kid from Oregon and stumbling into IBM, which was a wonderful company. And get the training there and then just happened, at the end of my time there, to work on the floppies. Then get taken over to Memorex and wasn't on the floppies. It just -- and then to work with Don, like I said, that was -- in fact, two of the most fun people I've enjoyed or people I've enjoyed working with are Massaro and Jugi and I wish Jugi was here, I could tell him to his face. A lot of people misunderstood Jugi. Very, very warm person and Don was just a lot of fun to work with, always joking, very sharp, always kept you on your toes. And, you know, being at Shugart, again, the first time I went to Japan was on that very trip there and I've been there many times since but learning about that, it really opens your eyes as a young engineer and gave me the

confidence and the contacts to go off and, since I wanted to stay as an engineer, I actually got out of the drive business because they were getting boring. I could go in how they've all -- there is an evolutionary action. You look at hard drives today, you can tell one from another. Actuators are all the same. When I was working on them, we had everything from rack and pinions to lead screws to bands to everything. So, for a mechanical engineer, that's exciting. Floppies were a great training ground because they're relative - - we used to say they're deceptively simple because a lot of companies weren't successful because they underestimated them. There is some real technology there but they're cheap and they look, you know, even the name, a floppy, used to have a badge. "Real men don't use floppies", you know?

Massaro: That's right, yeah.

Dalziel: And to be part of an enduring -- now they're fading out. It's sad to see that you can buy a computer now, it doesn't have a floppy but they won't be gone. I'm sure they'll be alive when I'm dead so it was exciting. There have been a lot of -- there have been some hits and misses along the way but that was definitely one of the highlights of my career. Shugart Associates was a terrific company and, like I say, I was able to work successfully for over 20 years just from many of the contacts that go back to that company. And rightfully or not, when you're associated with a successful company, people somehow think you must know something. It's not always true but... But they gave me a chance to design some fun products, also, of course, it wasn't mentioned but Don had the foresight and we got into the, really, the first low-cost Winchester. Seagate gets the -- because they did the 5 1/4 form factor, we had a customer that wanted a -- and we did the...

Massaro: We were the first ones to take a floppy actuary, which was Warren's actuator, and put it on a hard disk drive, cut out all that cost for closed loop servo and that was the creation of a low-cost hard drive.

Sollman: That's what we did for Mohawk.

Massaro: Yeah.

Dalziel: Yeah.

Massaro: And everybody said it couldn't be done.

Dalziel: And then, of course, then they went and did the 8", again following the floppy format. It's interesting that, up until sub-3 and a -- every hard drive was the size of a floppy. Floppy made a half inch floppy, hard drives came out half size. So it wasn't until recently -- even though there's no real reason for a long time to do it, they did. So long-winded answer to your question. It's been a great trip. I look back

fondly with a lot of it, both technically and the personal relationships that I had with some of the leaders in the industry and the people in it and I feel very fortunate.

Porter: Good. George, your thoughts?

Sollman: For me, it was extremely helpful in providing a basis of expectations, both of what I should expect out of management as well as what you should expect out of a market experience. The thing that was really crazy is, when you went to look for market survey reports, you know, there weren't any. We then started to deal with the personal computer industry. There were no market research reports. The best we had was when Trip Hawkins came walking through after he just got out of business school, he's going to do the first study of personal computers. And yet we had 40 companies show up at our doorstep, each of whom was going to have 10% of the marketplace. The only thing we knew, someone was not going to get their fair share. So that plus a lot of things gave me comfort that, as I've gone further, if you have a situation in the marketplace where there's all these market studies, you probably don't belong there. There's not a lot of opportunity. But if you go to place where it's not clearly laid out, there's huge opportunities to make money, to create product, to change people's lives, if you want to get very broad. And I think that's been very, very exciting. It is not a case where I did something or we did something that was great in the corner of a room but we had a lot of impact in the entire world of how we communicate, even today. And I think we probably will have left the world a little bit better for that experience. But I think that experience then inculcated itself into the people of the organization. A lot of us want to go back and recreate a lot of those same feelings again. I went off to the voice messaging business. There weren't any researchers. We had to do that one from scratch and then more recent stuff started up in the internet voice portable area. Absolutely green field. And I'm comfortable going into a green field kind of opportunity because I know you have fun, you make money and it gives you a chance to feel out who you are, if that's the way you want to be. And I think Don helped us a lot in getting that kind of feeling about ourselves.

Porter: Good. Don?

Massaro: It was a great experience. We were all young at the time. We weren't smart enough to know you couldn't do this stuff, okay? A big company would have never gone out and tried to create another standard because they'd have all these people standing around saying you couldn't do it.

Sollman: Corporate staff.

Massaro: What we had is we had some good people. There are people in the industry that know Warren, many of them said that he's the greatest mechanical engineer that's ever designed a disk drive. I happen to agree with that and you'll get a lot of other people in the world that will agree with that, okay? Herb Thompson might have been the greatest engineer in terms of designing heads and media and so

forth, okay? You get a couple of people like that together, a young environment, we got nothing to lose, okay? You know? If this doesn't work out, we'll go try something else. And we just -- we were in the middle of this very exciting thing. Warren and I were talking in the bathroom that, you know, we were fixing all these problems but, while we're fixing all these problems, we got a production line to keep up because, if we don't ship the product, we don't get any money. And if we don't get any money, we don't pay anybody kind of stuff. So those were kind of the rugged days, okay? And when you look back on it, god, it sure is a lot of fun, okay? And, you know, we all worked together as a team. We were all well motivated. There wasn't any politics going around, you know? It wasn't about fancy offices and titles and stuff like that, you know? You were just kind of working hard and we created an industry and it really is nice to go back and take a look and say, yeah, you know, we didn't hang the moon but we created a market. And Warren's other point, too, is we actually created the low end hard drive market. When we said we were going to put a floppy actuator in a hard disk drive and that we were going to be able to avoid a closed loop servo because we were going to compensate for the thermo expansion, everybody laughed at us. They said it couldn't be done. And we went out and we did that and, you know, prior to Shugart doing the low cost hard disk drive, they were all \$5,000 to \$10,000. So I think it was a lot of fun, you know? And that's -- I think you had to be young to do it. We were all young, okay? I mean, we didn't have a big marketing organization. We had George, okay? <laughter> No, I'm serious, we had George and I think the day you hired one product manager later on and so, you know, he didn't have a staff of 100 and go out and analyze you, you know? He'd go out and say, yeah, this looks good, let's give it a try. Why the hell? What have we got to lose, kind of stuff. That was the attitude.

Sollman: Let me jump in on that one a little bit. I think the one part we probably didn't talk enough about, we started down one track was our customers. We ended up having some incredibly interesting customers that influenced all of our visions, everything from Steve Jobs and Don talking about the appliance industry to someone as straightforward as Dr. Wang saying, that pig doesn't fly unless you do the following five things. And the guy is brilliant. And he's right on the mark.

Massaro: This is excellent point George brought up. Because we didn't have a big marketing staff, because we didn't have all these resource consultants out there, if you wanted to find out what you should do, you had to go out and talk to the customer. Not a bad idea, right? And we probably did a better job of talking to the customer and finding out what he wanted, okay, than anyone else.

Sollman: But listening to the customer.

Massaro: Yeah, that's what I'm talking about, listening to the customer. Yeah. That's an excellent point.

Porter: Well, it's a wonderful way to end this session, that the customer has the final word which, in many cases, the customer is overlooked and guess what happens? Those companies end up doing something

else or they're gone. So it's been a real pleasure, gentlemen. It's always nice to talk about people with people who had an enjoyable time starting an industry. Thank you very much.

Dalziel: Thank you.

Sollman: Thank you.

Massaro: Thank you.