Oral History Panel on 8 inch Floppy Disk Drives

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Abstract: *As IBM established the initial 8 inch flexible disk drive standard, first with a specialized FDD used with mainframe computers, then with an FDD for personal computers, independent manufacturers such as Shugart Associates actively developed their own FDD models. Panel members were instrumental in establishing the industry standard for the 8 inch FDD market and in establishing sales leadership for their company.*

Jim Porter: We're here today to discuss how the eight inch floppy disk drive and diskette happened, and why, and what went into doing all that. It turned out to be one of the most influential product introductions over time that ever existed in the industry. The various generations did away with, in effect, the tabulating card, which would be the computer industries method of entering data for the industry for many, many years since the proper tools were introduced. One diskette could hold the capacity of about 3,000 tabulating cards. There was just no comparison and the world has many millions of trees still in forests that were not cut down because the floppy drive came along and made it possible to do all of this much more efficiently than cutting down all those trees and making all those tab cards. So, that's just one of the benefits. The floppy drive was used in many, many different kinds of equipment over time. And it was introduced originally in 1971 but it got -- the program got started by IBM several years before that and it went through, as I said, several generations. And, in this discussion today, we're really just going to talk about the events during the 1970s and just going to talk about the events mostly for the eight inch floppy disk drives, although I'm sure we'll take note that in '76 the smaller one happened, the 5.25 inch floppy, which became very popular on those newer computers that got generated at the end of the decade called personal computers. So, to start let's just start by having each of our gentlemen on the panel today give some background on themselves and their background in the industry -- Warren.

Warren Dalziel: I'm Warren Dalziel. I graduated from Oregon State as a mechanical engineer and was hired by IBM, went to work in June or July of 1962, a 21-year-old engineer and started in manufacturing work there for several years. And to give credit to the gentleman to my left, I worked with Herb on -- I was in test equipment and designing some test equipment for the data cell drive, automatic strip testers and that. I also worked on head and disk testers but I guess Herb saw something in me and arranged a transfer to development. Worked briefly on an improved 2321 but then was put on a program that had been started I think a year or two before possibly by Dave Noble. It was a very small group. I don't even remember who other than Dave and maybe Hal Hester who isn't here today. Who else was on it? Maybe Herb remembers. But Don Wortner, Brent Nelson, Herb and myself and a small group of others went to work on it. I was assigned most of the mechanical part and the Minnow there we'll talk about later I worked on. Then also followed Herb and Al Shugart to Memorex and then Shugart Associates, worked on various products but also got back and worked on the floppy at Shugart. And then in 1980 I started my own consulting company, incorporated and just

recently closed that after 24 years. And during that period I worked on a wide variety of products, including hard drives and printers and tape drives and tape libraries and optical drives and optical switches and medical equipment and quite a wide variety. And I'm very pleased to be included in this panel today reminiscing about the eight inch floppy.

Porter: Herb Thompson.

Herbert Thompson: My name is Herb Thompson. I graduated from the University of Colorado in August, 1957, immediately came to San Jose and went to work for IBM and there I worked initially on cleaning up problems with the original disk drive, the RAMAC, and once that was finished pretty well, why I went to work on the flexible disk file or flexible strip file and that was in 1958 we started that. And I worked with IBM until 1969, worked on the floppy disk program which Warren outlined and then went to Memorex, spent three or four years, then Shugart Associates and then I struck out on my own from there.

Porter: Jim.

James Adkisson: Well, Herbie gave the shortest of the resumes but he's the father as far as I'm concerned of this technology. I came from the dark side, which was a short stint as an engineer and a technician at IBM in the last '60s and joined Memorex in an entirely different area and was induced to get out of engineering and move into the marketing side where I might have a chance with a little more talents than the engineering side. But got involved again after that with the start of Shugart Associates and, of course, the launching of the floppy product line from Shugart Associates, which was essentially not the genesis of the fundamental invention of the product but was the genesis of the invention of the whole disk drive OEM industry with the eight inch floppy being the primary impetus to initiating that industry. So, my recollections are going to be much more towards the customer point of view, field service point of view as opposed to necessarily on the eight inch in particular the invention point of view.

Porter: Well, I think Warren mentioned the name Dave Noble. Dave Noble, of course, was assigned by superiors at IBM in 1967 to start the ICPL Program, the Initial Control Program Load Program and my understanding is that Dave worked by himself for a few months and gradually finally decided what that initial program mode would have to consist of. They were considering tape cartridges. They were considering a variety of other methods of storing data and loading data for these new things coming along using semiconductors that forgot everything they knew when the power went off. And, of course, a program load device was needed and it was Dave Noble who is I think generally regarded as the gentleman who decided, well it should be some kind of a disk

and let's use this little flexible disk. And so, out of this after a lot of development activity came an eight inch flexible disk inside a jacket and a drive which connected with this and made it work, made it revolve. But, what were the reasons why IBM really felt they had to have this kind of a device? Was it only just to load microcode or were there any other thoughts do you think that were going on within IBM during that period? Why did all this happen? Any thoughts on that?

Thompson: Yes, I have a few. I keep kicking myself because I didn't recognize the potential for the floppy at that point in time. I just recognized it for what it was defined to be. I think that spreads across the board even to personal computers. I guess I'm more like Thomas Watson when he said "What could we do in the United States with more than one computer?" So, in any event the market exploded with floppy disk drives once we got the people building their mini computers and that sort of thing. And so, that was the thing that should have impressed me and didn't and I consider it to be from an engineering standpoint really not a big thing like the 2321 was. That was a real tough one. But the floppy had a few challenges but it wasn't nearly as bad as the 2321.

Dalziel: Of course I was a low level and, you know, a staff engineer. I forget the title. But program load, and that was the only thing that I knew that it was being used for. I remember when it was first shown to us. The approach they were taken then was I think it was mil and a half Mylar bonded to about an eighth inch of foam rubber and there was no jacket or anything and they took a head that we bought from a tape drive, probably out of a tape drive and loaded that into the foam and the actuator mechanism was a lead screw but driving the lead screw was a fairly Rube Goldberg, we called it a V2 or two linear solenoids and a spring for the third position on a crank, so you'd fire one solenoid to get it to go part way, then fire the other solenoid, then turn it off and the spring would then bring it back to the final position. As I recall, there were some problems either with timing or centering or maybe if you started before it had totally settled it would go backwards. So that was the first and that didn't work very well. I don't think it took Herb very long. We didn't take long to figure out we had to do something other than the foam. Foam wasn't an engineering -- so, we joked. We substituted probably a little hunk of felt, right? I remember Herb saying that the whole industry revolved around this little piece of felt. But we adopted a more conventional approach is what tape drives in early days did too is to load the tape against the head with a felt load pad. Even until recent days that's been done, so that's what we did on that and that's what's on the original Minnow. And actually for years until the double-sided was perfected that was the technology for getting compliance.

Porter: Well now the project started in 1967 but the Minnow drive, as it became known when it finally turned into a drive project, the Minnow drive didn't ship in any applications until 1971. How much time before '71 was it really ready to go?

Adkisson: Well, in ’72 and I recall when you -- to sort of finish up with your question are what are you going to do with this thing? We had developed a program loader at Memorex which would have one of the disks and the terminology at the time and it was a marketing buzz was that this was to be the primary IO device and that was the time that there was this term called de facto standards starting to be kicked around. And a de facto standard was going to be a method by which diverse systems can interchange data. And so there was actually an awful lot of thought. It wasn’t simply as a program load device. If you had been in the halls of Memorex during the period that the punch card replacement version was just being introduced, long before it was being shipped, it was very clear that this was going to end up being the primary IO device that was going to enable through its standardized format and the de facto standards at that time were always assumed to be IBM that this de facto standard was going to be the IO device for various diverse equipment and, in fact, it did. The very first of these floppies went into a variety of customers, including many or all of the mini computer manufacturers and at that time DEC was dominant, Data General, Hewlett Packard. We even used it in the Intel development systems for the very beginning of a microprocessor. It was the IO device. It was being used in emerging processing of words, the Viatrons, et cetera. So, it ended up being recognized by the folks at Memorex and that team that was led by Al Shugart was pretty excited about IBM’s announcement because that was finally acknowledging that it was going to be an IO device, not simply a program load and that was the impetus for the team to be pulled together and the formation of Shugart Associates, literally within a few months after the announcement by IBM.

Porter: Okay. But, again, to go back to the fact it was introduced in ’67, the project was started, excuse me, in ’67 but it wasn’t shipped in actual applications until ’71. And the first Minnow applications were to load microcode in the controller for the IBM code name Merlin drive, the 3330, and to load the code also for a couple of models of the 370 computer.

Thompson: Yeah.

Porter: Now, to be ready for those introductions that drive must have been ready to go to production substantially before that ’71 date.

Dalziel: Well, I left in ’69 and at that time here I have a picture of an early Minnow on test and it’s essentially the same as this and essentially the same as in the picture in ’71. And before I left, what did we used to have at IBM, A, B, and C test products?

Thompson: A, B, and C that’s correct.

Dalziel: And we had gone through at least two levels. I think I had almost completed all of them. I mean that's when we -- I found -- I had problems with that coupling breaking and other things but most all the problems had been resolved. My recollection in '69 at least it was a fully functional, I think was C wasn't shipped yet so we probably hadn't completed that or maybe we had. But anyway we had definitely gone through B test. So what happened between '69 and '71 I have no idea, maybe that was delayed, either the Merlin was delayed, which it was I guess or the 370 was delayed but --

Thompson: Now when did the 370 ship?

Dalziel: Well, this is April of '71 is the announcement. I don't know if this is -- somewhere around there.

Porter: I think it was just on a couple of the models of the 370. It may not have been the first 370 that shipped.

Dalziel: When you see the picture it's identical to that unit right there, so right? We had working machines in when we left in '69?

Thompson: Yes.

Dalziel: Yeah.

Thompson: Well, I imagine Al Shugart probably made the decision when to start it.

Dalziel: Yeah.

Thompson: But he said, well they took eight years to do the 2321. Better give them three years for this.

Dalziel: Yeah.

Porter: Well, the--

Adkisson: But a formal first customer ship as I recall doesn't necessarily mean that there weren't any units in the field because what you're calling A, B, and C, there was also beta and there were …

Dalziel: IBM didn't tend to send units out before.

Adkisson: Before for customer testing?

Dalziel: No, they weren't like --

Adkisson: We did at Memorex.

Dalziel: Yeah. They put things out that worked.

Porter: Well, based on what you said with all those people having left IBM to go to Memorex there must have been a lot of good knowledge at Memorex about how to build such a drive also during that period wasn't there?

Dalziel: But that isn't why most of us left. We didn't go there to work on floppies in fact.

Thompson: Not for a period of time.

Dalziel: Not at Memorex. In fact, I never did work on them at Memorex. You--

Thompson: Dave Stoddard.

Dalziel: Yeah, Dave Stoddard did. It was a total separate --

Porter: So, the question then of what it took to get this kind of a program going in Memorex, first of all there were people at Memorex that had a lot of knowledge about the nature of such programs and when Memorex started working on such a floppy drive for the first time, it was actually I suppose before IBM shipped the Minnow itself for those applications we discussed for loading control, loading the code on the controller for the 3330 and for the models of the system 370. Memorex was actually working on a drive which could accomplish the same purpose at that time weren't they?

Dalziel: They were but not the same group of people actually.

Adkisson: And that's pretty obvious when you look at the mechanisms. They had media interface was the same because it had to be for standardization. But just look at the Minnow mechanism and now go and look at the first Memorex drive, which had a lot more similarity to the Shugart drive.

Dalziel: This is an early--

Porter: Let's make the point that the first Memorex floppy drive that was actually introduced and shipped, the Memorex 651, which was the first OEM floppy drive.

Dalziel: Right.

Porter: And that actually shipped in 1972.

Adkisson: Yeah.

Porter: And it was not compatible with anything else.

Adkisson: Right.

Porter: But it was initially and very quickly a successful OEM product because it was the first available OEM drive for the Wang Laboratories and other companies like that.

Adkisson: For the DECs, right.

Porter: And DEC that needed and wanted a floppy drive.

Adkisson: For IO to replace paper tape.

Thompson: You have to remember the IBM drive was read only.

Dalziel: Yeah, good point.

Thompson: And the first Shugart drive or Memorex drive was a read-write.

Porter: Yes, indeed.

Thompson: And even though at IBM we were building the right heads but were doing that for manufacturing in our limited requirements.

Dalziel: Your records say the 651 was the first one that shipped, so 650 perhaps? I mean I have a data sheet for the Memorex 650 here.

Adkisson: Which I remember as the first one.

Dalziel: Which isn't dated but it shows --

Adkisson: That's the one I recall.

Dalziel: Most of the things that ended up in the Shugart drive, the AC drive motor with a belt. This had I believe a Bulova step motor. This is not the identical lead screw but essential integral lead screw, whereas the IBM had a lead screw connected to a step motor through a coupling. This now attached directly to the rotor. It still had the relay type head load that we had on the Minnow, big capacitor for the AC start motor but this wasn't until, like you said, in the '72, '73.

Porter: Well, I realize there was a 650 project at Memorex but the drive that was eventually shipped and became the first successful OEM disk drive was the Memorex 651 and it had a life of several years because it was adopted and used throughout the life of those systems that it was used on by those various companies. And it was a great success for Memorex during that period. Of course, when you look at the longer range history, a year or two later when IBM introduced the drive which became the eight inch industry standard, Memorex was a bit late in following up on that and lost its position. And since we mentioned that we should mention that right behind the introduction of the Memorex 651 in 1972 IBM did introduce what they called the IGAR, the model 33FD, along with their 3740 data entry system. The 3740 data entry system, of course, was the system which provided the ability for a keypunch operator to sit down at a different terminal and enter the data directly onto a flexible disk and, as I pointed out earlier that flexible disk could hold the capacity of about 3,000 tab cards, so guess which was more efficient? And it replaced the tab card. But the 3740, of course, became -- that is the floppy drive used on the 3740 became the industry standard and was frequently known

around the industry as the 3740 drive, even though it was of the IBM 33FD drive itself. And, of course as I think was mentioned earlier, Shugart Associates happened to be the initial leader in bringing out an IGAR or 3740 compatible drive and that leadership position in OEM drives changed. But you went through all of that history both at IBM, Memorex and Shugart Associates I think you gentlemen, so how do you feel about the transition that occurred in such a short amount of time actually?

Thompson: Well, you mean the fact that the floppy disk took over the whole world as far as data entry is concerned/

Porter: For data entry.

Thompson: That's another thing I wasn't too impressed with. You know I thought that would be a better way to do it than with punch cards but it never occurred to me that it would explode the way it did, so I was taken by surprise by this.

Adkisson: I think I'm going to be a bit argumentative on your analysis but, again, looking at it from the point of view of having been in the field and calling on all of these customers, as I recall we had a very small percentage of our market was the data entry market. Decision Data was the biggest competitor to the 3740 and they used to make an 80-column punch card in '96. Do you remember those? I think that was back in Pennsylvania.

Thompson: Yes.

Adkisson: That whole market segment there was no question you had to build a 3740 equivalent with a soft sector format and the sectors were defined very clearly, which made the de facto standard issue very easy. But if you go back and look at the successes of Shugart Associates and the downfall of Memorex, which emerged with the first of the OEM products it had to do with the fact that this was the first real OEM solution for mini computer people to replace paper tape, for not only a -- but for all IO purposes. And there was emerging markets in what they call the small business system and like one of the biggest customers in those days was a company called Data Point, which doesn't exist anymore today. And, of course, Wang Laboratories, Data General, DEC, HP -- but the actual data entry, which is associated with the Enterprise 370 type computers and large systems to replace cards turned out to be an immeasurable part of the market from my point of view.

Porter: To amplify what you're saying let me quote from a market study published by Venture Development Corporation in 1974 at the end of the year. Here were their projections for 1975. "Data entry, 12,500 drives; small business systems 3.3 thousand; intelligent terminals and remote batch, 10.2 thousand; point of sale, 500; programmable calculators, 700; word processing, 800; control and test systems, 500; mini computer and micro computer peripherals, 3.1 thousand; system loader 1.4 thousand; a total for the world of 51,000 drives in 1975." So, Jim, to amplify your comments there was quite a diverse area of applications.

Adkisson: Right.

Porter: And, of course, this was before that product that we know now as the personal computer which later used a huge quantity of later generations of floppy drives. But, yeah, the applications there were not just data entry. It was the largest of them but it was maybe the pathfinder which made this available for all these other applications.

Adkisson: Those applications really made the product.

Porter: Yeah.

Adkisson: The standard IO. I would like to add one other thing, again from the perspective of somebody who dealt with the customer. Shugart Associates brought product design benefits that at that time were not being pursued by our competitors and that lays at the feet of the fact that Al Shugart was the consummate manager who believed in engineers and Al Shugart would believe an engineer's word over anybody else in the function any day for that. And, in the end, it always paid off because our primary competitors in those days were Memorex with the 650 and Control Data, Pertec and those folks tended to let's just stay close to IBM at the very early days and the Shugart team tended to innovate. And, Warren pulled out a couple of items but you can dramatically see the difference between the way IBM solved the problem and the way the Shugart engineers took that and re-engineered to use a similar media but the volume, product volume was about 25 percent of what this one was. The actuator issues having to do with linearity they solved. I mean I can tell you a lot of interesting stories about problems they didn't solve until we had them in the field. But, just the same, Shugart was the innovator. We tried new ways of clamping disks. We even had an innovative way of holding a pulley on to the shaft that was attached with a belt to the motor. I think after a number of cases where the pulley kept falling off, one of the engineering managers, and Herbie denies saying this, said "Well if it continues falling off what I want to do is extend the shaft, put the nut on it and bend the end of the shaft to solve the problem." That sounds funny but the fact was in those days that was what gave

Shugart the leadership was innovating for the customers, very quickly solving problems and we within a year went from a brand new start up company with some fairly sizeable corporate competitors, the Memorexes and Control Datas and everything to the dominant supplier of this device. So, no question IBM was the initial genesis of it but it was all that innovation that occurred in the very early '70s that moved the technology very fast and far, including pushing capacities and other functions as well.

Porter: And being a reliable vendor.

Adkisson: Reliable vendor.

Porter: Right.

Adkisson: With the exception of holes that were punched off center and hubs that fell off and everything. We make fun of that but that was the nature of any new innovative idea. It happens still today and so but the key was how fast the engineering response and how quickly the problem was resolved. There was another innovation that Warren should talk about, which was he developed a concept of a split band actuator. Well, that sounds pretty esoteric. I can tell you that when it was implemented in our product the customers were able to enjoy a much more reliable device than they were before with the lead screw actuator which had some linearity issues and supply issues. Those kind of things I think were very significant to set the tone for why it was necessary to become a successful supplier in the OEM industry. There's the hub.

Dalziel: If I hear that bent shaft story one more time! Jim makes a good story. Neither Herb nor I remember it and I defy him to find any product that has one. I see -- I don't even think we--

Porter: You're looking right at it.

Dalziel: This is the pulley he's talking about. We ended up with a zinc diecast pulley here and I don't doubt that they came off but I don't think we solved it by bending it.

Adkisson: No.

Dalziel: But it makes a good story. Just looking at this I'm reminded of a few other things that I think I -- well, again, it's hard -- this thing weighed 17 pounds. It's hard to

believe we designed something this -- or that I designed something this big and clunky and ugly.

Adkisson: Well, compare it to that.

Dalziel: Well, I mean it's improvement but still and this is a refrigerator door switch here that we used for that. Again, it's cheap and it was reliable.

Thompson: It became the standard of the industry.

Dalziel: Yeah, everybody used it and this was just a commercial relay that we adapted for head load. Shugart was -- we almost went out of business so that sharpened everyone's focus. We were a small company totally committed to just one product and Herb lived and breathed there. I think we were most all in every Saturday but if I ever missed one, Herb didn't. A lot of pressure to produce there. It was a tremendous amount of fun. When there was a problem I think Jim, I know we all were on the production line. I can remember more than one Saturday out there reworking parts because we found a problem and after the -- we would just get in and solve it and ship it out, total commitment to customer quality. And I remember one of the best things. Again, we all had grounding at IBM, which I think we all admit is a first class company and in those days certainly was but the commitment to quality and testing, do you remember, I think we had eight or 16 drives that we had running in the lab constantly. We had a cover over them so they were running at temperature. We just ran them until they wore out, analyzed them, find out what wore out, fix it, put them back on test. We continually were testing and improving and that really had an impact on me I know. And then we had the freedom to innovate. Again, we had problems when we started the double-sided, which again I'll let Herb talk about a little more or maybe you want to introduce that. That's the follow on.

Porter: Just to mention that in '76 IBM introduced their Crystal, to use their code name, which was their 43FD and that was the first two-sided floppy drive. It was the same recorded density but they went to two sides and that was in '76 that that came along and, of course, that became again another industry standard, which Shugart Associates and all the others followed.

Adkisson: Yeah. Well, a little bit about the head even and Herb was instrumental in that. A big advantage --

Dalziel: Well, I wanted to say something. I don't want to dominate here but as I recall, you guys correct me if I'm wrong, even the term floppy was a little controversial. It was somehow -- of course, IBM always referred to it as diskette and diskette drive. I don't think you'll ever find an IBM publication that mentions floppy. And I think, and I'm sure even we called it floppy but our customers always did and the button, maybe you want to put this on Herb.

Thompson: "Real men don't use floppies."

Dalziel: And then the code names, I don't think we gave code names to the Shugart products but IBM was always big on code names.

Thompson: Yeah.

Dalziel: Did we ever have any code names? I don't think so.

Adkisson: We did on the hard drives, the eight inch and 14 inch hard. I'd have to go back though.

Dalziel: I don't even remember those but I do know that floppy -- we finally all gave up and started calling them floppies.

Thompson: No, we called it Minnow on the front right?

Dalziel: No, but that was IBM.

Thompson: At IBM.

Dalziel: Yeah, at IBM definitely. IBM always had code names as I recall.

Thompson: Yeah.

Dalziel: Although I don't--

Porter: On most products they had code names.

Dalziel: Yeah, I don't remember what the 2321 was. But anyway so there was the -- and Herb perfected -- I think Don Massaro, or Herb, you say this is the most difficult low technology product in the world because there is a lot of technology in this little product and making that head, we had our own head. We were one of the few companies and, again, we were big on buttons in those times I guess. We were the headstrong company.

Thompson: You got a new one. The headstrong company.

Dalziel: And I think marketing would promote that, that we had control of our destiny because most companies--

Adkisson: It sounds like engineering is doing more marketing materials than--

Dalziel: I think that was a marketing BS thing. Most companies bought their heads. We made them and Herb had the lab out there. You perfected the way of -- what do you get those lens grinders to lap the …

Thompson: Yeah and a piece of rubber.

Dalziel: And just right the -- rubber.

Thompson: Yeah.

Dalziel: You and Dave Brown out there lapping heads and who were some of the -- you had some great women technicians there.

Thompson: They did.

Dalziel: They all tended to be women. We could turn around a prototype in days there.

Thompson: Yeah.

Dalziel: And solve a problem. Glass gaps, remember the gap erosion problems?

Thompson: Uh huh.

Adkisson: That all came about because it wasn't being used just as a program loader. It was being used in heavy duty cycle applications and the program loading device.

Dalziel: Yeah.

Adkisson: If you even attempted to use this device the way it was being used in the small business and mini computer applications, you could take a disk that was run in a Minnow and hold it up to the light and you could see that all the oxide was worn off of it just after a couple of days' usage, continuous usage.

Thompson: Well, let me explain something here. This disk is coated on both sides with ferric oxide and that's normally what we call rust. And when they make this oxide, they put it in a ball, what they call a ball mill. It's a big cylinder full of ceramic balls the size of marbles. And you pour in the ferric oxide, which is coarse particles and you turn this machine on and it sits there and rotates and it grinds, the ceramic balls grind up the ferric particles. Well, there's a little bit of the ceramic balls wear off also as it runs and, of course, that comes out of the ball mill then with a mixture of ferric oxide and aluminum oxide, which is what the balls were made of. So now that's coated on the disk and now when you load the metal head against this, it will wear that thing out very rapidly. And you can look at this through a high power microscope and you can see those little bits of ceramic in here and each one of those running past the head is cutting a chunk out of it. And so, IBM went to the ceramic head to get away from that problem and, of course, we did too. But, of course, we jumped on the people at Memorex, or at Dysan I should say, that were making the media and they developed a process whereby they don't use ceramic balls. And, of course, they worked on lubricants and that sort of thing. And so, that was sort of a big hurdle we had to overcome. And one of the -- the ceramic head, of course, was sort of a lifesaver for us at that point in time.

Porter: The ceramic head was started into use approximately when?

Thompson: When IBM first delivered that data entry station.

Adkisson: It was single sided.

Porter: Oh, with the Minnow?

Adkisson: It was spherical, right?

Thompson: Yeah.

Adkisson: It was the round screw hole.

Dalziel: Yeah but the original Minnow I thought had a metal in it.

Thompson: It did.

Dalziel: It had a metal head. It looked like a …

Porter: It had a metal head. I think the ceramic head was next generation.

Dalziel: Yeah, it was.

Thompson: That's right.

Porter: Yeah.

Dalziel: We weren't there. That was after we were at Shugart the ceramic.

Thompson: Hand me your lead screw and I'll tell you another problem we had.

Porter: Of course there was a problem on hard disk drives they didn't have because they used flying heads.

Adkisson: Right.

Dalziel: Yeah.

Porter: And they weren't hitting the surface like they were with contact reporting on the diskettes.

Thompson: Yeah.

Porter: Yeah.

Thompson: Well, this is a lead screw out of the floppy disk drive here and you can see it's threaded and there's a nut that resides inside of the carriage and, of course, as this rotates, driven by the stepper motor it moves this head back and forth from track to track. Okay, that's the first lesson. Now the second lesson is this runs right directly behind the magnetic head and the magnetic head is designed to detect very small magnetic flux changes. And in the drive we could recognize that if there were stray magnetic fields around that we'd get what we'd call asymmetry. The asymmetry would affect the way the head is reading the magnetic pulses and make them shift and we'd get data errors. And so that became a field problem.

Adkisson: Uh huh, big field problem.

Thompson: Yeah.

Adkisson: For interchange.

Thompson: And so we tried everything. We went out and kicked the electronics people to make them fix their electronics so we didn't have that problem.

Adkisson: The data separator ended up being one of the most costly and significant programs to help customers who were designing their own data separators. We ended up integrating that data separator if you recall.

Thompson: Okay. We finally found out what it was. This lead screw was getting magnetized some funny way. I can never define what direction the main position was. But when it would rotate that magnetic field would rotate around with it and so you'd only see it every ten tracks or something like that when that magnetic field would go up and wipe out the data from the end.

Porter: Hum.

Thompson: And so then we went out there and were degaussing all stepper motors we got. We build a degausser and put it on the line very quickly and each motor then was

run through that degausser. Now that's the sort of problem that we run into in some ways. I thought that was quite interesting.

Dalziel: Yeah. I had almost forgotten that. Lead screw was another mechanical problem.

Thompson: Yeah.

Dalziel: That when you step the friction would deflect the lead screw so that at the end of a step the screw is still vibrating.

Thompson: Vibrating up and down, yeah.

Dalziel: Yeah. The solution was a little pad on the end there, not very elegant but it worked very effectively. We retrofitted everything. There already was a point for when they turned this. So, that was one thing about real time solutions and a lot of times we'd have to solve a problem without changing anything or minimum change, so that's an example of that. Recognizing and finding the problems I think that was a real strong point of that engineering team and Herb was the leader in that, applying, always looking for a reason. There had to be a reason, he'd say. The engineering, do the fundamental engineering. Herb's a master at that.

Porter: A question about how all that was implemented. You were doing all of your own manufacturing too, weren't you in your own facility? So, engineering had a very close relationship geographically with them. It wasn't like today where you'd be off-shoring to some other country, et cetera. You had a very close relationship on a day-to-day basis.

Thompson: Yes.

Dalziel: I have a couple of pictures of that line and, in fact, that was kind of an innovation. This was -- nowadays, of course, it's nothing with the volume production but this was--

Thompson: The line was impressive for its time.

Dalziel: I think Harold Medley was involved in setting that line up with the conveyor belts and kidding back there and, yeah, and the engineering labs were just right next door.

Thompson: Yeah.

Dalziel: So, we were, I mean nothing happened on the lab that we didn't know about. And then final test, we had automated test stations at the end there. I remember Dave McDougal and others, I know I'm missing some names, so everything was thoroughly tested and it was a pretty automatic process there. Rejects would get recycled down through another line. This actually was a picture in '79, an article in '79 about towards the line there I think. I think we were --

Porter: Actually I think it was there then because myself and -- actually it was still there in the early '80s.

Dalziel: Yeah.

Adkisson: Really?

Porter: Because if you remember the DataStorage Conference, which my organization and a friend ran each year, we always had tours of factories in the early days in that conference. We put everybody in a bus from the conference location, took them out and I think the first or second year we did a tour of a Shugart Associates floppy drive manufacturing lines and they were there and we started that conference in '82. So, it was still there then in Sunnyvale, quite sizeable. We're really just talking about the growth in those periods. I would point out that by the end of the decade, we're talking about what happened during that period, in 1980 worldwide production of floppy drives had grown to 1.5 million drives. However, something else had happened in 1976 in addition to the introduction of a two-sided eight inch floppy drive. The smaller drive, the 5.25 inch was introduced. So, I should point out that of that million and a half floppy drives that was produced in 1980 about a million of them were 5.25, which came along just in time for the PC industry and for the desktop computer.

Adkisson: Word processing.

Porter: The 5.25 was a better size than one of these large things. But the eight inch floppy didn't die an early death because of the 5.25 inch floppy coming along for all those applications that Jim was talking about, that list I read.

Adkisson: Don't forget the 5.25 inch was in the middle of that obviously. That was introduced purely as a packaging solution and it had backed off on technology in terms of

densities and everything. And so, the eight inch was assumed that it was going to continue because it had a lot more real estate on that disk that it would continue driving the amount of capacity that's available on one removable piece of media. That was a pretty good argument to keep the ball, to keep the momentum going for a few years but it finally sputtered out because the packaging constraint of the eight inch was just too big a burden to overcome.

Porter: Well, the eight inch stayed in production for a long time. And I can tell you, you may find this hard to believe, the last of the eight inch floppy drives weren't produced until the end of the 1990s.

Dalziel: Wow.

Adkisson: Is that right? I didn't know that.

Porter: Well, I'll tell you who it was.

Adkisson: And who produced it?

Porter: There was one customer for them called IBM.

Adkisson: Oh, for …

Porter: They had large pieces of equipment which still they had service contracts for--

Adkisson: I see.

Porter: -- which used eight inch floppy drives and they had a contract with YE Data in Japan and YE Data was still delivering 5,000 to 10,000 eight inch floppy drives to IBM each year until the end of the '90s basically so IBM could properly handle the service contracts they had on old equipment.

Adkisson: Those were probably the most profitable floppies ever built.

Porter: Probably.

Adkisson: Yeah.

Porter: But so it had a long life.

Adkisson: Yeah.

Porter: We went through most of the '70s, the '80s and the '90s but, of course, production peaked on eight inch floppy drives in the early '80s and it started downhill because the newer things were being designed around 5.25"s after that period. But, nevertheless, the Shugart SA900 later replaced by the SA800 series to use the old Shugart Associates terminology. Those products and the competitors that copied what they were doing had a production life which went on in many cases for ten or 15 years.

Adkisson: Well, it was a very clear need to keep it because just using your data that you provided from your research, which I think your research archives are much better than my brain archive is. But, you know, recalling those days in 1976 we were launching a five and a quarter inch which was a 90,000 byte storage medium and it was very slow. In 1976 we were shipping a 568,000 byte eight inch that was much faster. So, this whole thing, I think they called it the sailboat effect, you know. Eventually steam engines wipe out sailboats but there's an overlap where the technology of the older technology is still rolling along for certain applications. And, as it's turned out and the whole industry has become packaging oriented it's cost per box and not -- and they're driving the packaging smaller and smaller and that's what the eight inch had to succumb to. Nobody was going to be able to ship equipment with 17-pound floppies in them.

Porter: And when they wanted a desktop computer they wanted something physically smaller.

Adkisson: Right.

Porter: Now, is it true, Jim, that the pattern for the 5.25 inch floppy was a cocktail napkin? You brought that in question.

Adkisson: Absolutely. There was no science. Most of the -- in those days I believe most of the innovations were serendipitous, not the engineering, the innovations in terms of -- but the engineering had a lot of engineering to it to make it work. But we had a lot of customers in those days that were complaining about the 17-pound eight inch drive and there was an emerging market that was called word processors. Now that industry

subsequently went away because the PC became a multi-function desktop device. But, there were a number of customers that were innovating the concept of a monitor to put your page on and a storage device and they were complaining about the eight-inch and simply having drinks with some folks with -- actually the Philips Company that owned Redactron and they were complaining. We got a lot of complaints about it. It's too big. And I just said, "Well, what if it was that size?" And took that size home and I made a cardboard markup. And did Dave Brown work for you at that time?

Thompson: <Shaking head affirmatively.>

Adkisson: It was Dave Brown that took that mock up and I remember a lot of grumbling. "Well, you know, there's no technology. We're not advancing anything you know. This isn't" -- and I just wanted them to use junk parts but build it smaller and whatever you had to trade off for capacity we didn't care. It's a word processor because 90,000 bytes is a hell of a lot of pages anyway. And Dave Brown turned around that prototype in like six weeks so that we could put it in a jewel box and take it to the NCC show and it was overwhelming. It shows that form over function always is better. That's why we like form over function today.

Dalziel: We ended up with -- the picked the leading cassette drive at the time and that's the shape. That's the size we used.

Adkisson: Actually, you're talking about -- well the actual mechanism--

Dalziel: It was eight inch by -- the actual dimensions of the drive.

Adkisson: Oh, the drive.

Dalziel: Yeah, the drive were the same as the leading cassette drive at the time.

Adkisson: I think Dave told me that he really was constrained by the motor that was -- and he'd gotten a motor out of a vending machine and it was this high because people always wonder, well why is it that? And Dave said because that's the motor I had in the scrap pile to do the prototype. So, serendipitous, just a little smaller.

Porter: It's 3.25 inches high, 5.75 inches wide, eight inches deep.

Adkisson: Well that obviously wasn't thought out.

Porter: It became the industry's sacred dimensions for all kinds of prototypes.

Adkisson: Yeah, it turned out that way. That's right. There was engineering though. I don't want it to sound like this was just an accident because there was this issue of ratio one over ratio two for the head guys to keep signals, strength up. Correct me if I'm misreading this.

Thompson: No, you're doing fine.

Adkisson: So there was a lot of engineering that happened in that six weeks but fundamentally the drive it was set up to be the size of a cocktail napkin.

Porter: But basically the TPI, the tracks per inch, the bits per inch, et cetera were retained exactly the same as 8 inch, weren't they?

Adkisson: Yes.

Dalziel: Same head.

Adkisson: Yes.

Porter: So, the technology was the same as the eight inch.

Adkisson: No. In order to reduce the cost the little stepper motor used a helical.

Porter: Okay.

Adkisson: And it was stamped wrong. It wasn't linear and that's how we maintained our lead because nobody could duplicate it.

Porter: I was referring to the recording technology, yeah.

Adkisson: Yes, the head media interface we actually used rejected heads for a while, if you may recall, for the five and a quarter. So, the eight inch was really -- it was the -- it was the spear of driving the technology and the 5.25 inch at that time was to follow and sort of a cheaper, smaller version of it. And then, of course, at the end form function was more important and the eight inch lost that.

Porter: Well, in '77, IBM introduced the 53FD which was two-sided but double recording density.

Adkisson: Density, yeah.

Porter: And that then doubled the recording capacity up again and became another standard which the rest of the industry adhered to at that point. So, those existing eight inch floppy drive organizations that were using it on their products they had a successor product to evolve to.

Adkisson: It had to be downward compatible.

Porter: Had to be downward compatible, yes.

Adkisson: That was the constraint and that's why you saw some of these funny solutions. We could have pushed the technology and the technical side much faster but you had this thing called backward compatibility which has plagued the industry up until recently where we're just sort of like -- you're seeing it even today with DVD, CDs. You have to make these big leaps and you were constrained. As soon as there was a de facto standard that a new product came out you had this backward compatibility issue to satisfy the customer.

Porter: Now, Jim, you were involved with the sales side of this Shugart program.

Adkisson: A lot of planning and sales, right.

Porter: Yeah. Who did you regard as your biggest threats competitively on all of this in eight inch floppies?

Adkisson: We always thought IBM was going to be a threat and we were always amazed as to how they were able to snatch defeat out of the jaws of victory. We actually

at Shugart moved ahead on the innovation side because Herbie was our innovator with the heads and the mechanism. Warren was the innovator with actuators and we did the innovation on data separators. So, IBM ended up not even being the de facto standard for formats after a while because they attempted to compete with the 5.25 inch with a format that didn't make it. So, always in the back our mind in those days if you were in a meeting, and I can't speak for what Don was telling engineering, but I know that we were always worried about IBM. In reality, our biggest threat was the dominant OEM company at the time, Control Data. And I think hubris and arrogance versus people who didn't know that we should be beaten to death by these guys defeated Control Data because Control Data had the resources. They had the prominence in the industry already and they beat us in some really important accounts like the Data General account. And we came back and they beat us at DEC and I mean how could you survive when you lost DEC and Data General to Control Data? But we came back stronger for that, very aggressive in our minds, price wise. In those days a disk drive was doing around 55 percent gross margin and we decided to cut the gross margins to 40 percent to capture market share. Today, if you can get a ten percent gross margin you would be thrilled.

Thompson: Yeah.

Adkisson: So, Control Data in reality and then behind them were a lot of -- the Pertecs had an innovative design that was made out of sheet metal. The favorite thing was to go up and grab it and show how you could twist it and ours was a casting. It was rigid. So, I would say Control Data was the real threat to us in those days.

Porter: So, the Japanese companies had not become major competitors at that point in time?

Adkisson: No, YE Data was -- everybody in Japan was trying to find licensing deals. The Europeans were all trying to do licensing deals.

Dalziel: I was working -- I think Tandon took over the market actually then, when Shugart faltered.

Adkisson: On the 5.25 inch, yeah.

Dalziel: Yeah and then lost it to the Japanese.

Thompson: So, we created the opening for Japan to get in and build floppy disk drives--

Dalziel: Yeah.

Thompson: -- by selling a license.

Adkisson: Licenses. A license to build it better.

Dalziel: Well, we taught them how to, yeah.

Thompson: And that started the whole ball rolling and pretty soon we lost it.

Porter: To give you the numbers, at the end of 1980 there were 25 U.S. based companies, both captive and OEM markets, making floppy drives. There were eleven Japanese companies at the end of 1980 making floppy drives and eight European companies making floppy drives. But, of course, later on in the '80s it basically shifted. Most of the American companies dropped out because they didn't like the pricing as it declined.

Adkisson: Margins.

Porter: And the Japanese companies became dominant in floppy drives.

Adkisson: Japanese, I think if we do some soul searching we weren't paying much attention to Deming in those days and there's this thing about engineering in the quality but the fact is that the Japanese really paid attention to what went out the door from a quality point of view and we thought we were doing a decent job but the fact is that if you looked at the warehouse of rejects, of course Jugi (Tandon) took this to the extreme. He was focused on cost per drive and that a customer didn't care if they had to reject a third of those drives. He's just going to return them anyway.

Porter: Well, but to be candid let's don't forget that Jugi had a brother in India who is quite adept at putting manufacturing things together, so Jugi was …

Adkisson: Quality wasn't there.

Porter: But Jugi was a very, very -- because of the family arrangements was very early in offshoring floppy drives.

Adkisson: Yes.

Porter: To India.

Adkisson: But the quality that came out of Tandon, I could go into a warehouse at Wang and I could see a Tandon reject pile and I could see Shugart reject pile and the fact is we lost sight of what cost is, cost of ownership and the Japanese didn't. And I agree that we might have slowed down things a little bit if we weren't as open with the licensing but I think we would suffer a little bit of the hubris that the auto industry did if we didn't sort of face the fact that we did not concentrate on quality the way the Japanese did.

Porter: Let me ask you what was the average OEM price in the latter part of the 1970s for a floppy drive, an eight inch?

Adkisson: Oh, gosh.

Porter: Hundreds of dollars.

Adkisson: Yes.

Porter: Two or three hundred.

Thompson: Three hundred and some dollars.

Adkisson: Yeah.

Porter: Three hundred and some odd dollars.

Thompson: I don't remember exactly.

Dalziel: It was more than that.

Adkisson: The lowest prices that we were selling were to Wang and to Intel -- actually Intel and those were the high volume guys and something.

Thompson: Three hundred and eighty or something like that.

Adkisson: Yeah, it was about.

Porter: About $380?

Adkisson: Something like -- you collected ASPs I think in your data and whatever you collected I know I sold cheaper than that, okay.

Porter: Okay.

Adkisson: Because we could not tell you what we had to take some of the business for and so you would get data that was--

Porter: So, we're talking about again what happened then back in that era. I might just point out as a footnote for the discussion that if you're a major system manufacturer in the last few years and want to buy a floppy drive, say it evolved into the drives that are there today, you'd have paid about $9 each.

Adkisson: Yes.

Thompson: Yeah.

Adkisson: If you took -- yeah.

Porter: And the production of floppy drives exceeded 200 million floppy drives per year.

Dalziel: Those two figures go together, high volume and low cost.

Porter: Exactly. But floppy drive production …

Adkisson: That's right.

Porter: … price is going into decline now because of CD ROM and other things have basically started to displace them in many application. We got past some of the thoughts that Herb had pretty quickly. Herb.

Thompson: Okay. I'll talk a little bit about the very early days here, regress back to that point in time that it was first recognized that they needed this control program load and so that task was assigned to an engineer at IBM named Dave Noble. And Dave Noble and Hal Hester was assigned to that program also. I don't know who else it was but that was before my time. But they started out by going out to WhiteFront, which was a Wal-Mart of the '60s, I guess, and buying a 45 RPM record player and then they put a turntable on it with foam rubber and they would lay the disk on top of that and they mounted a magnetic head in the arm of the record player and jury rigged the actuator that Warren was describing earlier and that's the way they ran the thing. And Hal Hester liked to talk about the episode of the creepy crawlers. They had creepy crawler problems with it and it took quite a bit of time to figure that out but I guess they finally did and that's -- when you write a track of data on the disk and then play it back in an oscilloscope where the display is one revolution of all those data bits, why on the oscilloscope it looks like a rectangle of a different color. And they'd see a little drop out in that, drop out being a little area where there wasn't any data. And they'd see that thing in one revolution. On the later revolution they see it move down to display and another revolution move a little further, so that's where the creepy crawler problem came from. And they finally found out that that was dirt on the disk or a hair or a particle of some sort and each time the head would roll over that thing it would push the media away and the signal would be lost but it would roll it down the disk a little bit. So, they'd run that little particle all the way around the disk. And that's the time that I first joined the program along with Don Wortner and Ralph Flores and Ed Charles and others that I don't remember, Ray Okiyama and a few other people.

Dalziel: Wayne Molners.

Thompson: Wayne Molners. And so, one evening Ralph Flores and I were in the lab working quite late trying to figure out how we're going to solve this problem and we said we just got to give up on trying to make a record player out of it. We've got to somehow trap the disk in the envelope of sorts. So, I run down to the local Safeway store and bought a roll of pink wipe and pink wipe is a material that looks like a roll of tissue paper we use today. But in those days the pink wipe was used in the household to clean, dust and that sort of thing and it picked up dust quite well. So, I bought a roll of that and went back and we got a file folder, manila file folder and cut it to size. We glued some pink wipe on it, cut the holes in for the head and the center clamping and all of that and we put that on and lo and behold the problem disappeared, clean as a whistle. Well, as it turned out the pink wipe wasn't very good and it was replaced by a different type of wipe that

was white and that's still used today after that little episode. Of course, as Jim has pointed out earlier, these things, I heard the number eight billion was the maximum yearly production.

Porter: Well, for diskettes it got up to from five to eight billion diskettes per year. The drives got up to about 200 million a year.

Thompson: So that became a big swinger.

Dalziel: I think you forgot one thing.

Thompson: Oh.

Dalziel: The other thing you did was that we had some type of head load thing. You put the piece of foam and then lightly pushed the pink wipe against the disk, right, lightly squeezed the disk?

Thompson: Yeah, right in this area preceding the head we have two little pads that are one on the bottom, one on the top. The top one had foam rubber on it and a solenoid that would actuate that. So, when we loaded the cartridge in the drive the solenoid would pick and clamp the disk, the cover against the disk. So, that turned out to be very successful and still used today, virtually unchanged.

Dalziel: Solved the problem.

Thompson: Solved the problem.

Dalziel: Yeah.

Thompson: By working late one night.

Dalziel: And, even, I mean every diskette has the white wipe. The 3.5 inch eliminated the foam pad but they internally in the cartridge they have a spring load that loads the white wipe but the exact same principle that you guys did that night. I can remember that I think coming in the next day and the drive -- and it was still running without errors and

quite an exciting time. And, Herb typically he was probably there until midnight. He was a late, late worker, I remember that, very dedicated.

Thompson: So, of course, we had a lot of other little problems, no real big swingers I don't think. We had a good head builder there. I don't remember his name though, a heavy set guy.

Dalziel: At IBM?

Thompson: Yeah.

Dalziel: Yeah, we had a little -- yeah, Garnier, Mike Garnier.

Thompson: Mike Garnier that's it, yeah.

Dalziel: Yeah.

Thompson: And he designed and built the heads for it. There were metal heads built out of mu metal. And, of course, we were one-sided recording and the drives we were building were playback. We were building magnetic heads for manufacturing so that they could put them into their writers. I don't know who built the writers but do you know?

Dalziel: They were built in manufacturing, yeah. I remember doing the original tolerance studies for them. They called that the -- there was a Minnow and Mackerel.

Thompson: Mackerel.

Dalziel: The writer was the Mackerel, do you remember that?

Thompson: Yeah.

Dalziel: But you didn't mention, I mean this was the predecessor to the one piece cartridge was the three piece. I think you and Ralph did this too, in fact, right?

Thompson: Well, see this is -- what happened --

Dalziel: A little better than your file folder.

Thompson: The file folder really looked similar.

Dalziel: Yeah.

Thompson: Well, it looked more like this.

Dalziel: Did it? Did it? Was it a three piece?

Thompson: When we went into production we thought, hey, this is a better way to do it. Essentially they're the same. This is just more economical that's all. You could do it with this very easily and it's a little more rugged than this one. But that's sort of the quick history of how we got the diskette the way it is, so I guess we could talk about heads now.

Porter: Good.

Dalziel: Yeah.

Thompson: Do you want to talk about--

Dalziel: Well, you were the head guy.

Thompson: Yeah, you did the analysis on them so you can talk about it better than I can.

Dalziel: I did the design. Shortly after -- as soon as we could get, I think we got one of the first IBM double-sided which unfortunately we don't have here. What was that model number? I don't --

Porter: For the first double-sided --

Dalziel: For the 43FD.

Porter: Was the --

Adkisson: Fifty-three.

Porter: The double-sided was--

Adkisson: Or, 43.

Porter: -- the 43FD …

Dalziel: I don't know if we had talked about how we'd do it but we waited and, again, we had extreme confidence in IBM those days. What they did and there's some history that IBM folks have written, what they decided on was essentially to take Winchester technology. They tried some other things that didn't work. What they did was take -- they went away from the spherical head, went to two flat heads and offset the cores, again to get away from this crosstalk.

Thompson: Yeah.

Dalziel: I think they're offset four tracks or, no, more than that.

Thompson: Something like that, yeah.

Dalziel: Right. The two cores are offset and they mounted them on flexures very much like Winchester flexures and, of course, you have to blend and everything to get it. We saw that in the IBM drive that we had and we said, well that's the way to do it. Boy, that's pretty slick and how are we going to do it and immediately set off to design our own heads and arms. At the same time, I guess, I wasn't … but I thought I think I'd like to design a better actuator than that lead screw. Again, whatever you're used to you know all the problems so you think you can design something new that doesn't have any problems. But I got involved with a German company with this little motor which, again, it ended up being used by the millions in hard drives. And, in fact, this whole actuator concept was used in both rotary and linear versions in a lot of millions of products. But the head it looks like it would work well and you don't have that little foam load pad that I mentioned before. This is a felt load pad that's here. You can't -- a little -- this was red that would wear out but it --

Thompson: Hold it still and he'll get a picture of it for you.

Dalziel: The little round load pad and this was a snap in load pad actually. That was kind of a breakthrough. You could replace them if they wore out but also they found in the snap-in feature that was left a little slot there so it didn't take long for the line to learn that you could take a screwdriver and turn that and tune the compliance so that you got the high point of the felt just in the right place. And so, we thought -- we saw the IBM one and we though, oh boy, all those problems go away. We'll just go to this. It was a problem from the start. This was a very, very difficult program. I don't know how much trouble IBM had but we just about went out of business on this, a lot of problems on this. I think we put them in the field and we had to withdraw them. Interesting side light, as a way for us to internally test we did what we called tap tap test. We would repeatedly load and unload these heads to see if we had the -- just as a way of engineering and optimizing the blends and things. Somehow that test got out to our customers and they started doing their own tap tap test. So, we got -- we would get rejects because they failed tap. It was the type thing that the number of tap taps you could do would be like 200 years of use. No one is ever going to load and unload the heads that much but that became our problem. So these heads did have compliance problems. There were stiction problems. There was singing problems. There were singing load pad problems too, singing being a self excited vibration or resonance set up because the friction of the media running. These would also develop that. But maybe the biggest problem of these was the fact that the two cores would get offset. As they complied with the media they would shift track position. So, they really never worked and were abandoned and Jugi at Tandon we might have discussed this in the 5.25. He had a small company and he always -- he said he couldn't afford to do this. It was too complicated, so he figured out a simpler way, which worked quite well. It was one fixed head and one, one gimbaled head much easier to produce. Herb later developed on his own even maybe another approach to two-sided heads that I think neither one was gimbal, the gumball heads. Anyway there was a lot of work done on this double-sided. The one that finally ended up working though in all drives is the Tandon approach with one fixed and one gimbaled head. I think this, again, if you compare it with the earlier lead screw approaches was pretty elegant. As Jim said, it was much faster. It was quiet, just kind of a nice design that people liked. It was interesting. This then became adopted by the hard drive people and the floppy people for various reasons went back to other designs and including eventually went back to lead screws, small lead screws. Shugart reinvented the lead screw and called it Helicam, I remember that. After we had left -- after we left they abandoned the band and while everybody else was going to the band they abandoned the band. So that's my recollection on the double-sided that it was a very, very difficult product to produce and just caused a lot of grief at IBM and a lot of problem for the field I'm sure and embarrassing to the company because it just didn't work very well. And, our defense was, well, it's just like IBM.

Adkisson: Again, the more capacity you put in it the broader the application, the higher the usage. If it was being used like the very first drives were used those applications probably would have been just fine.

Dalziel: Expectations were high.

Adkisson: But we ground up a lot of media.

Dalziel: Yeah.

Adkisson: Because of heavy usage too.

Dalziel: Yeah.

Thompson: Uh huh.

Adkisson: So, everything has to have a duty cycle associated with it, which is the reason why the hard drive is dominant. If it wasn't for that we'd be using floppies like hard drives now.

Porter: Well, it was a matter of capacity and access times were involved too.

Adkisson: They were on plan with metalized floppies that were incredible capacity to be driven from them though.

Porter: The floppy had a lot of large uses which you folks have very nicely talked about.

Adkisson: Yeah.

Dalziel: Okay, we had shown some things here but I guess pointed out. We didn't really identify them. This was an early diskette one, which I'm quite sure is a single-sided IBM diskette. It has a little different case on it and the oxide looks different. Let's see was this hard sectored?

Thompson: Yeah, those were sector …

Dalziel: But only single sector, so that was actually soft sectored. And diskette two looks much alike but slightly different vinyl case, the double-sided diskette. And then what I had shown here was a Shugart Associates 800 -- the diskettes, the double-sided, single-sided and this was actually Serial No. 868, so I don't know if we went sequentially but that's a fairly early one. I actually bought this at a junk shop I think for $5 and it's missing the drive motor here and the capacitor, so that's what this is. And then this -- the 800 had the lead screw and what was designed here was an exact replacement, used the same mounting holes as the lead screw but used a smaller, finer pitch step motor connected to what we called a split actuator. And maybe you can't see it -- I mean a split band. It's a single steel band with two legs on one end and a single leg on the other wrapped around the band and tensioned with a single spring in the back so that when the step motor rotates a step, depending on the diameter of the capstan, the head moves a precise one track. We showed that without really a lot of explanation, so that was that.

Porter: Okay, that's what you had, Warren, right?

Dalziel: Yeah, that's what I had.

Porter: We can move this back out of the way now.

Dalziel: All right. Not so good.

Thompson: Okay. I just wanted to show you one of the very early versions of the floppy disk. This is an example built by Memorex and it was nearly identical to the early diskettes that IBM built. This diskette was quite similar to what was eventually gone into production except they used three sheets of the heavier plastic material here and they would have an outside cover on one side, back side the same thing and separating those they had a third sheet with a big hole cut in it so that the disk could rotate in and they could put their wiping material in there. Here's the head cut out. On this side here's where the load pad pushed the disk against the head. This little hole here is the sector, where the sector light would shine through or the index as the case may be. And this little cutout here was a cutout that caused you to put it into the drive in a certain direction. And so that pretty well describes a very early version. The later versions are very, very similar. They didn't have the cutout here and they had two little cutouts here but it's essentially the same thing.

Porter: Okay. Thank you all.

Thompson: Yes, sir.

Dalziel: Thanks.

Porter: Well, I would comment that it's been a pleasure to have this session with each of you, who each made major contributions to one of the more important products the computer industry has had and it's been fascinating to hear your insights as to how and why and the ways in which you made it happen. Thank you all very much.

Adkisson: Thank you, Jim.

Dalziel: Thanks, Jim.

END OF INTERVIEW