Oral History of Barry Schechtman

Interviewed by:
Tom Yamashita

Recorded August 8, 2019
Mountain View, CA

CHM Reference number: X9137.2020

Yamashita: This oral interview is with Dr. Barry H. Schechtman, who held numerous positions at IBM in research, technology development and manufacturing, and then he went on to become executive director of INSIC, the Information Storage Industry Consortium. Dr. Schechtman obtained his Ph.D. from the electrical-engineering department at Stanford University, working under Professor William E. Spicer on photoelectron-emission spectroscopy of organic solids, a relatively unexplored area at the time. His graduate studies at Stanford were supported by fellowships from the Hughes Aircraft Company and the National Science Foundation, or NSF. Upon completing his Stanford degrees, he joined IBM as a research staff member at San Jose Research Laboratory. At IBM, his initial technical interest focused on modeling and experimental characterization of the charge transport in photoconducting polymers, as well as the use of process-control computers to collect and analyze data in physics laboratory. Many of these studies were done in collaboration with various colleagues in IBM research. After three years of research in these areas, he moved into management positions, where he had opportunities to impact IBM's product engineering and manufacturing operations. A one-year assignment in IBM headquarters working with the chief scientist and science advisory committee further steered his technical interest toward IBM's product areas. From 1995 to 1999, Dr. Schechtman served as the executive director of the National Storage Industry Consortium, or NSIC[1]. At NSIC, he added to and managed a product portfolio that grew to more than two hundred million dollars of storage-related research conducted jointly by the industry members with numerous universities. This effort led to accelerated technical progress of the storage industry, and it also generated trained students, who were excellent candidates for hire, into the sponsor companies. In addition, NSIC's very detailed technology roadmap studies gave the storage technology community and its customers a consistent 5-to-10-year outlook for future technology improvements and the specific challenges that have to be addressed to achieve those improvements. Dr. Schechtman ensured that NSIC's research programs maintained a pragmatic perspective so that technology improvements did not occur in isolation but rather were focused on addressing the needs of the customer applications. My name is Tom Yamashita, and I will be conducting the interview today. So, with that, first of all, thank you very much, Dr. Schechtman, for coming out here. We're in a recording studio in the Computer History Museum, located in Mountain View, and Dr. Schechtman came all the way from La Jolla, California, which is near San Diego, for this interview. So, let's begin by please telling us about your family background. Where were you born, grew up and received your early education?

Schechtman: Thank you, Tom. I come from a very urban environment in New York City. I was born in New York and had all my early years of schooling in New York. I was born to parents who were not educated, not highly educated at all. They both individually stopped going to school after the fourth grade so they could help with financial support by working for their family. My father emigrated from Russia, and my mother emigrated from Hungary, in both cases in the early part of the 20th century. There was a theme, kind of — in our family, where my parents considered that their poor financial status was largely due to their lack of education, and so they wanted to make sure I didn't fall into the same trap, and it became a mantra in our family to talk about getting us educated as much as possible or staying in school

[1] NSIC or National Storage Industry Consortium was later changed to INSIC, Information Storage Industry Consortium.

as long as possible. So, I was kind of hooked into that as a master plan without really having any kind of a master plan, without yet knowing, of course, in those early days, of what I wanted to do.

Yamashita: Were you speaking different language at the household, Russian or Hungarian or mostly English?

Schechtman: We're a Jewish family, and my parents spoke Yiddish but primarily when they didn't want me to understand.

Yamashita: I see.

Schechtman: I guess that's not unusual, and so I had to counterattack as a kid, so when I had to pick a language to study in high school, I chose German. Of course, the vocabulary and the sentence structure of German is very similar to Yiddish. It's mostly the pronunciation is different. But I never became fluent in any language other than English. Sometimes I've regretted that. [Of] course, it makes it harder to connect with colleagues and other people. So, in the early going, I didn't have much direction about what to emphasize in my studies and what I was interested in. I didn't have much exposure to it. My interest kind of went down the path of taking care of myself. The other thing I didn't mention is both my parents worked. After all, they had quit school to work, and they worked in jobs that were pretty demanding, but didn't require much education. My father was a technician in the NYU College of Dentistry, and he worked in a lab, where they basically put together appliances and fixtures for false teeth, and the students at the dental college would work on patients that came in, and the students would practice on them and write prescriptions for the teeth that had to be made and basically learned that — my father learned as he went, and I think he became pretty good at what he was doing, because he wanted to earn more money, and he found that he could moonlight by working for private dentists who sent their orders for teeth out to a special laboratory. So he got an evening job with a laboratory, and an interesting thing for me is that, that connection he made with dentists in private practice turned into the first summer job I ever had when I was about 15, and I worked — I sat more than I worked. I sat in the office of a dental lab, and when orders came in, I was basically the delivery boy to pick up orders and bring back the parts to the dentist, and I think my father connected me up with that dentist's office or that lab with the hope I would learn something the way he did and adopt it as a career direction. But I don't know if he was disappointed about this or not, but I was not interested in making teeth. I didn't know what I was interested in yet, but it wasn't that. But one of the side-benefits of that summer job — well, two-fold actually. I got to do a lot of reading, because I was traveling all over the five boroughs of New York City to pick up and deliver, and I got to — in addition to the reading, I got very familiar with the transit system in New York, and that boded well for me later on. It was a pretty complicated situation. My mother worked in a neckwear factory and in the Garment District on the West Side of Manhattan, where fabrics came in, and they got turned into clothing, in this case neckties. The job she had was kind of towards the end of the assembly line. She was paid on a piecework basis, and she would get batches of ties, and they were — all the stitching was done on the ties in the factory on the inner side of the ties, and the next-to-the-last step, which is what she was responsible for, was to use a very crude instrument with a stick to reach into the necktie and pull it inside out, so then it became right-side-up, and it was finished. For each bundle of parts, of fabrics that she had to deal with, there was a little ticket that she tore off, and then at the end of the week or the end of the month, she got paid by how many of these tickets she had collected. But probably more significant for me was the fact that — an unusual fact, in those days, when we're talking about the early '50s, the unusual fact that my parents were two working parents. There weren't too many like that. Mostly the women in that area stayed at home, and so I learned to be more independent early. We didn't have the term that we use now. I think we use the term latchkey kid, latchkey child, but — where the youngster lets himself in and out of the house, because nobody's there. I remember my mother would get up extra early before she went to work, and she would prepare breakfast for me, and breakfast would be some kind of hot cereal in a vacuum bottle, a thermal vacuum bottle. So I got to do a lot of reading, and I had to — I got to spend a fair amount of time on my own, and it developed kind of a taste for independence and certainly developed a taste for learning, and I did have the beginnings of some sparks of interest in mechanical things. I enjoyed getting a hold of issues of Popular Mechanics, and there were all sorts of things that they could build. There were plans for things you could build there. I never did much follow-through. I just liked reading them. The other thing I remember about my room as a kid — so we were not too much — not too far past the end of World War II. We were maybe 10 or 15 years past it, so there were a lot of demonstrations and publicity of military equipment, particularly the latest aircraft, and I had my room — and the aircraft companies were into public relations pretty well in those days, so they — you just had to ask them for these, and they'd send you huge posters with beautiful photography of their airplanes and so on. So, I had the walls of my room covered with that. Speaking of my room, we lived in a residential neighborhood of the Bronx, which is one of New York's five boroughs. It's a neighborhood that had a mixture of private homes and apartment buildings that by New York standards were not very tall apartment buildings. But we were not downtown, so the apartment buildings typically were five or six floors high, and you got to interact with your neighbors quite a bit just going up and down the staircases or the elevators and so on. But as a whole, the neighborhood, as probably still goes on today, had certain ethnic characteristics based on the last wave of immigrants to move in. So, my parents came, as I mentioned, from Eastern European countries.

Yamashita: When was that, by the way? When did they come?

Schechtman: They came in the early 20th century, I think about 1920, and they didn't come together. They met after they were in the — in New York. So, I think that set the theme for my personal surroundings and our personal characteristics. I would say this mantra of, "Get as much education as you can," now when I look with hindsight, it certainly worked out well for me, in a way, coming from that immigrants background and turning out to do what I did. It's not unlike a lot of other American success stories. But even though I say it worked out well for me, I think my parents were looking for shortcuts to figure out how to do well in the system, and they were always — when I had a question that they couldn't answer, which was often, they kind of revered teachers, just like they revered getting more education, and they would always say, "Ask your teacher." The implication was teachers know everything.

Yamashita: Did you have brothers and sisters in the household?

Schechtman: No. I'm an only child.

Yamashita: Only child, okay.

Schechtman: I didn't have a brother or a sister. I didn't have a pet.

Yamashita: Did you have extended families nearby?

Schechtman: Yeah, we did. My mother was 1 of 8 siblings from Hungary, and my father was 1 of 10 siblings from Russia, and so I had lots of uncles and aunts, and I had a lot of cousins, their kids. I'd say that was truly all extended family, but some of the people lived close enough together that they would get together frequently. So there was some fraction, half or a third, of those 18 people that I saw regularly, and a bunch of others were just names to me, because a lot of them settled in Brooklyn, another 1 of the 5 boroughs, and not too many in what we would call Queens today and not too many in Manhattan. The Bronx was where my parents ended up. I think what happened is their parents came over to the U.S. from Europe in small bunches. They didn't come all at once, and they didn't come onesie-twosie. They came 3, 4, 5 at a time, with the lead person being 1 of their parents, my — I'm not even sure about how that went on my father's side, but on my mother's side it was definitely her mother that took the lead, and so they kind of found places to live, and then over time, over 5, 10, 15 years, they moved a few times. They aggregated, and they had centers of more of them being together. So, we'd have Sunday events, where somebody would host a dinner at home with 6, 8, 10 people, and they'd bring their — my uncles and aunts would bring their kids with them. So, I had some sense of extended family, and in the end, even to as recently as 10 or 15 years ago, I still was getting together with some of those people, but they were kind of the last of the surviving relatives.

Yamashita: I see. Just say something about your schooling there, high school, for example.

Schechtman: Yes. So, in those days, New York City had a very fine public school system, and for the most part, most people just went to it, and we were — this is before the days of specialty schools on certain topics or what we call magnet schools today. Most of the schools were equal to each other. I think you went to — you typically went to the school that was closest to where you lived, and because our neighborhood in the Bronx was pretty high-density, there were quite a few schools nearby, so you could pick — I think they'd assign you to a school based on which was actually the closest, but I think that was negotiable, if there was a reason you wanted to go to a different school. But the schools I'm talking about typically, not always, were eighth-grade schools, from kindergarten up to eighth grade, and typically the distance from where I lived to where I went to school was a five-minute walk, which worked very well for my parents, two working spouses situation, because they knew I wouldn't have to roam the streets very far. Our neighborhood when I was growing up probably had ethnic characteristics that were — if I had to pick one, I would say it was mostly — had become an Italian neighborhood at that stage, although the Italian people who had succeeded in business or whatever jobs they had were typically in private homes, and the people who were working in the kinds of jobs my parents had were typically in the apartment buildings. I mean, there —

Yamashita: It was pretty well-mixed ethnically, socioeconomically.

Schechtman: Yeah. Yeah. Yes. Yeah, and there were phenomena associated with being in these apartment buildings that would be hard for somebody to relate to today, because it's so different. But our apartment building had a coal-burning furnace in the basement that provided the heat for all five floors of the building, and once every so often they'd get a coal delivery, and as kids we would — so a big truck would back up to this hole in the wall that went down into the basement, and the truck would dump its coal, and so in the basement there'd be a huge pile of coal that the superintendent of the building would have to go physically and shovel some into the furnace every so often. But as kids, when the — haven't thought about this for quite a while. As kids, our slightly mischievous thing to do, which we loved getting away with, was to go play in the coal pile, and the more adventurous of us would actually go play in the coal pile on the truck and accompany the coal down the chute into the basement.

Yamashita: You'd get very dirty.

Schechtman: Very dirty. I'm actually surprised I ever got away with that.

Yamashita: So, all these buildings are burning coal. The air must've been horrible.

Schechtman: Yeah, although we probably didn't think about it that much then.

Yamashita: Didn't notice that much.

Schechtman: At some point while I was still young enough to be living at home, they converted the heating system for our building from coal to oil.

Yamashita: I see.

Schechtman: So, then they just had a truck with a pump, no place for the kids to slide down. So, a little bit more about the local education: For the most part, you — at around four or five years old, you went into prekindergarten or kindergarten, and you stayed in that same school for eight years or so. But the beginnings of my interest in science and engineering I can trace back to the last of the eight-year period in my time scale, my seventh- and eighth-grade kind of time, mostly because I had a physics teacher. I'm not sure if we'd call it a physics class or a science class. I had a physics teacher who I liked so much in terms of what I was learning from him that as soon as he announced that he was interested in doing a club for after-school — school typically went until about 3:00 P.M., and he was going to do ham radio in the club, and the people who participated were going to get their license to do short-wave radio and so on. I would've probably signed up for anything this guy announced he wanted to do, because I liked him as a teacher so much. But he was an unusual guy, because he took on learning what you had to, to do the ham-radio stuff without knowing much about it, so I think he kind of set an example for me of a way to proceed and take risks and follow through, and, in fact, several — not myself, but several of the other kids in the class became — one of the tests you had to do to get a license was to telegraph key — with a telegraph key, do a certain number of words per minute. It's kind of ironic. I mean, if one wants to poke fun at that federal government, here's a good example. The license was a federal license. In order to get the license, you had to be proficient at 13 words per minute with the key — with the telegraph key. But once you got the license, you had earned the right to speak by voice instead of having to use the telegraph. So, somebody wasn't talking to somebody when that was set up. But the eighth-grade teacher

I was referring to, Mr. Levy, quite a few of the students in the club — I don't remember how many we had. It wasn't very large, maybe six or eight people. Quite a few of the students became proficient at the 13 words per minute to get their certificate, their license, and he did not, and a couple of the other kids did not, and I did not. So, we were in a five-words-per-minute group, and we had to use only the keying. We weren't certified to use voice, and the people who had gotten the certificate that demonstrated 13 words per minute, they could use voice, and to me that was kind of exciting to — because we had short-wave radios then, where if atmospheric conditions were okay, you could get overseas broadcasts, not very clear and not very understandable, but just the idea of making that connection was kind of exciting with all the static.

Yamashita: Do you think your interest in electrical engineering started using the ham radio?

Schechtman: I'd certainly say it started from that club. The ham radio, maybe. It's a little hard to say, because another thing that happened when I was about 13 or so was there was a company, and it's still around, but they don't do the same stuff anymore. They were the Heath Company.

Yamashita: Yeah, the Heathkit.

Schechtman: Heathkit, and we scrounged together — I think it was about $30 or — to assemble a Heathkit transmitter. So for the short-wave radio there were separate boxes, one for transmission and one for receiving, and I think I learned — I did get my interest in engineering stimulated by these experiences, but I think I also learned something about myself of not being really good at any hands-on stuff at the bench. It was very hard for me to go back to my parents and say I just blew something up that they had scrounged the $30 for.

Yamashita: So, it wasn't the ham-radio club. It was your own money or — for yourself?

Schechtman: Yeah.

Yamashita: So, $30 back then must've been a lot of money.

Schechtman: Yeah. That's an interesting comment, because I have this very strong impression that I remember. So in a five-story apartment building, you didn't take the trash down by yourself, but there were — in the hallways on each floor there was a chute that you opened up, and you dumped the — there was no recycling or anything. You dumped your trash, and it went down to the basement and somehow got collected, I guess. But I remember my mother. She was so upset about this, rightly so. In this case, it was $50, not $30, but she didn't stay attentive while she was throwing the trash down the chute, and she ended up holding the trash bag and throwing $50 down the chute, and that was a very hard thing for us. So up through the eighth grade I was — my education was in the public school system. I was pretty young at the end of the eighth grade, because it was the practice then to pick a few students who were doing really well and accelerate them by one year. So, I never went in the sixth grade. I finished the fifth and went to the seventh, and that's a mixed thing. I'm not sure how I feel about that, because I remember later in high school, where supposedly our background was to learn certain things in elementary school and then be ready for high school. There was kind of a hole in my background from the sixth grade, not having attended, and one specific area that I always felt like I didn't know what I was talking about — but it's not a complicated area. It's just the concept of specific gravity as a unitless measure of mass, and I never had any lessons in that, so I didn't — I never went and got myself straightened out on it.

Yamashita: I see. Or you must've still done quite well academically to be moved up a grade.

Schechtman: Yeah, I did, and now we get into somewhat specialty schools. So, within the public system in New York City, there were several high schools, each with their own flavor of emphasis but all being somewhat unique and special. There was one in the borough of Brooklyn called Brooklyn Tech, Brooklyn Technical High School, and that, as you might guess from the name, had some emphasis on technical things. There was one in Manhattan called Peter Stuyvesant High School, and I don't recall if it had any emphasis. It probably did. I didn't know many people that went to that, and then the school I went to was in the Bronx, but it still involved a two-bus commute from home to the school, so no longer the five-block or the five-minute walk, and that one was called — nowadays it's called the High School of Science. It was called the Bronx High School of Science, and that's the way it grew up, and that was clearly — these three schools and certainly the High School of Science were clearly for students that were pretty sure they were going to go on to college, and it was like a college-prep school. They worked the students pretty hard, and for me it was a no-brainer to want to go there because of the mantra, "Get as much education as you can," and they had entrance exams. I remember they were on a Saturday, and they took the whole day, and that was part of the selection process, who got in, and you got to be on a waiting list and so on, and then when I went to undergraduate college, it was a similar situation, but it was no longer part of the public school system in New York. I went to a college called Cooper Union in the Lower East Side of Manhattan, which is a fascinating neighborhood. It's an ethnic neighborhood that has had a lot of turnover over the century, and the Cooper Union was a very highly regarded school. They only had two schools within the union, had nothing to do with labor unions, but they had one school on art and architecture and another school on engineering, and the two schools didn't interact very much with each other. The engineering school established a very good record over the years of accomplishment on the part of its graduates after they were out for a while, and the other thing that made — so like the entrance into that special high school, the entrance into the Cooper Union involved testing, extra testing. So we had the testing that everybody trying to get into college had to take, the SAT-type testing, and then based on doing well at that, we had to take this second round of testing that's specific to the Cooper Union, and the reason it was so competitive — two reasons. One, there was a — were fairly — it's a small school. There were a fairly small number of openings, 100 for the year divided in — for the engineering school, divided up into 4 branches of engineering: civil, chemical, mechanical and electrical, and the other reason it was so attractive to apply to is it was a tuition-free school. It was fully endowed, just like what the big schools are getting back to now.

Yamashita: Is it like tuition, room and board, everything?

Schechtman: Yeah. Well, tuition and supplies, but it was — in terms of the way you lived, you didn't go to a campus. You lived where you lived during your high school years, in my case at home with my parents.

Yamashita: I see. You can just commute.

Schechtman: Yeah. So Cooper Union was established in 1859 by a fellow named Peter Cooper, who was a very bright guy and very successful industrialist, and he made a lot of his fortune in steel and in particular in steel — it was the emerging time in the 1850s of railroads, and he was a guy that had a flair for showmanship also. He could sell you an idea, and he staged, with a lot of publicity, a race between a thoroughbred racehorse and a train engine, and he wanted people to get it into their heads that the train was the coming thing. Forget about the horses. But he made his money in steel, and he built this fully — he built one building in Manhattan, which still stands today as the primary building of the campus, and he built — in 1859, he built a five-story building, which doesn't sound very high, but it turns out at that time it was the tallest building in Manhattan. There were no real skyscrapers here.

Yamashita: Really?

Schechtman: Yeah. One little side thing is that he tried to be creative at every turn. No buildings had elevators yet at that time, but he left a shaft in this new building in anticipation of elevators, and he kind of guessed wrong. He didn't understand that elevators would be built with rectangular or square cabs, so his shaft was a cylinder, but that was a detail.

Yamashita: So, anyway, the competition to get into this — it must've been fierce.

Schechtman: It was. It also —

Yamashita: How many people do you think applied every year?

Schechtman: I think it was probably — I happened to hear some numbers, current numbers, for Stanford now, and they're taking in something like one-sixth of their applicants, and it was probably similar in this case as well. But it also put a bit of a bias on the nature of the students. There were students, who, if they didn't get a chance at a school like this, their families probably didn't have sufficient funds to go to other well-known colleges. So, it was a bias here, where the students were not necessarily from poor families but not, either, many examples of people from wealthy families.

Yamashita: Do you think it was mostly local people?

Schechtman: Out of that class of 100 in my graduating year, I only can remember knowing a handful of people that moved to Manhattan to go to Cooper Union, but there were some of those. But they used to look for opportunities to live with a relative nearby and so on. Now, what happened in the last — so the school goes back to 1859. What happened in the last few years is the area around the school became way too expensive for the students to live, and the school couldn't afford the full tuition. They didn't manage the endowment well enough to keep it funded. So, the school built some dormitories. That was new. So over this 150 years or so, they went through cycles, where just about everybody lived at home, and more recently they went through cycles where there was a dormitory, and then they had to discontinue the dormitory, and the last 20 or 30 years the whole area is getting, way they say it these days, gentrified, and that's happening all over, though, not just in Lower Manhattan. Neighborhoods are being rebuilt for people with more money.

Yamashita: So, this has become more local school again, back like when you went?

Schechtman: There's been a lot of controversy. There are people who feel the trustees of Cooper Union did not do their job to let the endowment fail, and it didn't fail completely. They cut back from free tuition to half-tuition support, but — so, actually, we the alumni had some votes in the last few years, and we got involved with the state government in New York State to try to resurrect the tuition-free program, and..

Yamashita: With such a small class, you must've got to know everybody in your class. Hundred people is tiny.

Schechtman: You did. You did, and then there was a social structure. Even though there was no campus with houses to live in, there was a social structure of fraternities. Cooper Union, when I was there, had five fraternities.

Yamashita: Is this you just get together group?

Schechtman: So, they would rent a place. They had a —

Yamashita: I see.

Schechtman: … quote "fraternity house," but it wasn't like a fraternity house on Fraternity Row at Stanford, right?

Yamashita: They just got there together, meet and so on?

Schechtman: Yeah. There was a process, which is probably similar to what takes place at bigger schools. There's a process at the beginning of the new school year with the new freshmen coming in, them being invited to gatherings from each fraternity, each of the five fraternities, and it's funny. They call those smokers, those gatherings. These days you would never call something a smoker, but —

Yamashita: We used to call it Rush, Rush Week at Stanford. It must've been similar type of thing.

Schechtman: Yeah. So some 5, 10, 15 people for a given fraternity would rush, and at the end of the first academic year, as you got into May and June, we've — you would figure out which ones are going into which fraternities, and that would — you're right when you say everybody knows everybody in your class. There's some extent of that, and then on top of that there's a social structure with the fraternities, where the people in a given fraternity — now, I was — in those days, I was very active, and by the time I was in my senior year, I was the president of my fraternity. I'm not that much of a — these days of a party-going guy, so I'm trying to notice how I was different then. But academically I did very well at the same time, and I ended up graduating first in my year. Now, the one thing I would add: The students who come out of

Cooper Union do very well, in my opinion, not because the teaching is so great there or the curriculum is so great, because they started out as students who could get through that filtering process of the extra testing. Most of them were going to do very well, whatever they did. With hindsight, and when I went to Stanford later for graduate school, I got to see what a real, big university, big to me, looked like, and I found that the teachers that I encountered at Stanford — so this was after my bachelor's at Cooper Union. I was working on a master's and ultimately a Ph.D. at Stanford. I found that maybe not 100 percent but a very good fraction of the teachers at Stanford were very accomplished teachers, either — they all were very good in the depth of their knowledge, and many of them were very good in their way to convey it to the students. So, after I had that experience, I became a little more critical of the teachers not being that way at Cooper Union.

Yamashita: Really? Is this because they — did they do research, or were they mostly into teaching?

Schechtman: In those days they didn't do research. More recently they did a little bit of research. They were supposed to be into teaching, but I don't think they were particularly good at it.

Yamashita: Interesting.

Schechtman: I'm not sure if they were paid as well as at other universities. I'm not sure. Most of them had night jobs, too, I think.

Yamashita: So, in Cooper Union you chose electrical engineering as a major. So why did you choose that?

Schechtman: So, we're talking about 1959, June of 1959 was when I was graduating from —

Yamashita: High school.

Schechtman: — high school, right, the Bronx High School of Science, and if you remember back — I don't know if you can remember back to 1959.

Yamashita: You're very young.

Schechtman: So, I was young for where I was. I was 16, and it was an exciting time, technically speaking. Computers were emerging. 1957, the Russians put the Sputnik satellite up, and the U.S. felt very challenged. By the time you got into 1960, I think that was when John Kennedy put the goal of a man on the moon on the books. So I think it was good public awareness of science, even if the public didn't understand the details, and it was good funding, and electrical engineering seemed to me, I guess, to be a field, which was overlapping with physics some, and you do — you had tools in that field, mathematical tools, and we could tackle almost any kind of a problem. I'm not sure I went through that kind of thinking at that stage, but it may have partly had to do — so in the High School of Science that I was just finishing up with there, I had whatever impressions got made on me of how much I liked chemistry versus civil engineering and so on. But it seemed to me a very exciting time for — again, I probably should qualify that comment by saying I didn't have a clear picture. I didn't hardly have any picture of what an electrical engineer did once they got out of school. So it's this, "Get as educated as you can," that kept me going like a flywheel, whatever — and I probably was just — I wish I could say I was a big planner and had this master plan, but probably I was just making choices between two or three possibilities at every branch point and — that presented themselves. At the end of Cooper Union four years later, that's clearly an effect I had and why I ended up at Stanford for graduate school, and there's a whole story that goes with that, but —

Yamashita: Was there some particular professor that had a big influence, you think, at the Cooper Union?

Schechtman: Not so much, actually. There were some I felt very negative about. It's interesting.

Yamashita: But you were directed to go further, Ph.D. What made you decide to do that, just more education, the better?

Schechtman: Yeah. That was something that — my parents didn't ask a lot of me, but they would've — I would've probably had a big argument with them, and they would've been very disappointed if I chose to stop schooling at that point, even though — same thing I just said about electrical engineering I can say about the Ph.D. I didn't know what a Ph.D. person does when they finish their degree.

Yamashita: There weren't any people in your extended family that went that way, or were there?

Schechtman: Far from it. I had one uncle who was good in math, and he liked math, but he never pursued any research or any academic stuff. He ended up doing everybody's tax forms for them. That's what he did with his math.

Yamashita: So, from Cooper you decide to go on Ph.D. Did you consider many other schools? Why Stanford?

Schechtman: Well, if we back up for a moment just a little bit, I had a few choices I was considering before I went into Cooper. Maybe you could view that as my hedge position in case I didn't get into Cooper. I had partial-tuition scholarships promised to me from MIT and from Rensselaer Polytechnic, and then because my father worked for NYU in the dental lab, I think I could've gone tuition-free to NYU, which — it wasn't a fancy school, but it happened to be a school in those times pretty high tuition. From what I could learn and read about things, I didn't want to go to NYU just because my father was connected there, but I probably, if I didn't get into Cooper Union, would've ended up at Rensselaer or MIT. Now, when I talk about Rensselaer today, most of the people I know actually don't know much about it. It's not in the same class as MIT, I think, in terms of public awareness. So, the choice of going to Stanford after Cooper Union, it's kind of a personal element to it. The dean of engineering at Cooper Union towards the end of the third year, junior year, had made a package deal with some of the aerospace companies. The aerospace stuff was really starting to build up then. I'm not sure when NASA got started, but they were doing a lot of — there were industrial companies that were in groups that had sub-companies that were all aerospace-related. So the dean of engineering at Cooper Union made an agreement with somebody high up in these aerospace companies to take five students from Cooper Union and give them summer jobs, and there were different companies, and mostly they were sprinkled around the L.A. area or Orange County, and I think the dean just took the top five based on how we were doing as students in our academics, whatever our grade point average was — took the top five, and this one went here; this one went here, and deals were all worked out. So, I was really excited. I was going to be working for a company named Autonetics[2], and probably you would recognize better their parent company's name, but I can't remember it myself now, and they were in Anaheim. So, I was going to go to Anaheim. I was going to be working within a mile of Disneyland. I was going to be working in the L.A. area, which had a certain feeling to it, and it turns out my then-wife's sister also lived in the L.A. area, and, in fact, her husband was a Cooper Union graduate in electrical engineering four years before me. I had all these motivations to go to the West Coast, and something got fouled up with my paperwork, and I didn't get to go. The other four guys got to go, and I was pretty upset. So, I think a couple of things happened out of that. One is I had to find a summer job. The bottom fell through. It was already close to summer when we got the news, and I — there was a guy, a VP-level guy at Bell Labs in New Jersey, who was a Cooper Union graduate, and he would come every year and recruit one or two Cooper Union electrical-engineering students for summer positions at Bell Labs. So, when my Southern California deal fell through — and he also would just look at grade point averages and maybe interview the students a little bit. When my Southern California thing went south, too far south, he came and promised me a job, a summer job, and it was a great thing to be in Bell Labs, even just for a month or two, because you have Nobel laureates walking around the hall. They really were probably the best industrial research lab. It was a shame when they got broken up, in a way.

Yamashita: You had any inkling what Bell Lab was all about back then or learned when you got there, or how did that work?

Schechtman: Yeah. I didn't know much about circuits and electrical engineering, despite the fact having been —I knew how to do homework problems in a textbook, but in terms of real applications, not so much, and I was put in a group. Turns out the transmission of long-distance telephone communications in the — we're then talking about 1962, I think. It turns out they were all still analog-based, no digital, and so I was put in a group, which was kind of a researchy group. It wasn't going to be a product next year, but they were going to replace the analog transmission with something called PCM, pulse code modulation, which was really — I guess the C in pulse code modulation, the code, is the critical thing, because they would represent one analog value if you had a signal coming in, and you sliced it into different levels. They would represent 1 analog level by, I think, a group of 7 pulses. So, you could get 2 to the 7th possibilities of equivalent to analog levels out of those 7 pulses, and 2 to the 7th, I think, is 128 or — I think it's 128. So they could slice an analog signal into 128 points and represent it by just 1's and 0's, 7 1's and 0's, and they didn't have to have anything to do with the amplitude, and the summer job they gave me, which turns out if you have 7 pulses where you used to have 1 waveform, your circuits have to operate at high frequency now and have the bits coming through 7 times as fast, roughly, and they were — in another group — that's another thing about Bell Labs at that time. They were very integrated. They

[2] Autonetics was a division of North American Aviation, later became part of Boeing.

not only knew what business they were in and connected their research to it. They needed transistors that would operate at higher frequency than the ones that existed commercially, and transmission — in transistor characterization there are parameters, and one parameter is frequency value, and it's the transistors' — it's a roll-off curve, and you get out to that frequency, the transistors' response falls off, and so they were making — and that's called a beta factor, and I'm surprised I remember this. It's a long time, and it turns out that they needed somebody to make lots of measurements on the in-house transistors they were making to see if they would be suitable for these new long-digital communications links. So, I had a summer job, where mostly I was learning about how to characterize high-frequency transistors. This is almost up in the microwave frequency range, and I was learning about that stuff, and I was doing routine work of plugging all the test samples in and collecting data, and another reason it happened — this was just fortunate for me. Another reason it happened to be a great year to be working — a great summer to be working at Bell Labs was that they — the first satellite — so you have to put this in context about how fast things started moving in the space race. So, Sputnik went up from Russia in '57, and we're talking about the summer of '62 when I was at Bell Labs. It's five years later. They built the first satellite. So, there were a bunch of other satellites after Sputnik as part of the space race, but Bell built the first satellite designed for communications, not military and so on, and you might remember this. It was called Telstar —

Yamashita: Right, Telstar.

Schechtman: … and we had a big celebration, and they did a live test, and there was somebody who used to work at Bell Labs but was now nearing retirement and was on the faculty at Cal Tech[3]. I can't remember the guy's name now, and so the — Bell Labs has several locations in New Jersey. The one I was in was in Murray Hill, which was their centerpiece location when they want to present things to the public, and they had a pretty fancy auditorium in that building, and I remember they squeezed as many of us as they could from — the building as a whole probably had 2,000 workers in it. They squeezed as many of us as they could into this auditorium, and they threw the switch, and we heard the first voice communications coast to coast from the professor at Cal Tech to the guys in the lab at Bell Lab, and it —

Yamashita: Did —

Schechtman: — wasn't quite as thrilling as "one small step for mankind — for man," but it was pretty thrilling, actually, to be part of that. Nothing I was doing on my job was directly related to the satellite stuff, but it was just an exciting event.

Yamashita: So, it's like your first job like that, right, to —

Schechtman: Yeah, I had —

Yamashita: University doesn't provide jobs like that.

---

[3] John R. Pierce, developed pulse code modulation (PCM) at Bell Labs, he was instrumental in starting Telstar. Later became professor at CalTech, and became chief engineer at Jet Propulsion Laboratory.

Schechtman: Right, and one of the — in doing this exercise of preparing for this interview, I picked up some patterns in my career, patterns of choices and behaviors, and they say sometimes you can't see the forest for the trees. There was nothing that was really a surprise when I picked up these patterns. It wasn't like, "Hey, I never realized that." But even though I realized it, it was kind of a background realization. It wasn't like something I was thinking about day to day, and so what grew on me through this period, summer jobs starting in 1960 or '61, was how much I liked the industrial research environment compared to universities. So, I think the seeds were planted for me at that stage of going down the path of not teaching.

Yamashita: So, this Bell Lab job was like your senior year or what? Was it a junior [year ?].

Schechtman: The Bell Labs job was taking the place of the one in Southern California that was going to be after my junior year.

Yamashita: Junior year, right. Okay.

Schechtman: Yeah. But I had one before that, and — after my sophomore year in '61 working for a government lab. It was in Washington, D.C. There was a lab called DOFL, D-O-F-L, Diamond Ordinance Fuse Laboratories, and Diamond — it was named after a guy, Harry Diamond[4]..

Yamashita: <inaudible 01:05:58>

Schechtman: … and that was my first technical summer job, and there, again, they gave — they had some gadgetry that they were building. In this case it was somewhat military funding. They were building a new way of detecting missiles coming in. Apparently when missiles come through the atmosphere, they generate a lot of charge. They get charged up, and so there were electric field lines coming out of the charged missile, and they — the group I worked with was attempting to prove that they could detect a missile from some distance, not proximity by right near them, to detect the missile from some distance based on sensing these electric field lines. None of the gadgets that the military was using in those days was particularly taking advantage of this effect that the missile gets charged. So that was my first real technical job, and my supervisor — in the cases of my summer jobs, I felt fortunate that my supervisors, they weren't senior managers. They were either guys working at the bench as researchers or maybe first-level managers. But I was very fortunate that whoever they were, they gave me enough time, they managed me and they taught me stuff, and they taught me by example attitudes about research and how to do it, and so I was just a kid when I had this Diamond Ordinance Fuse Labs job. It was part of the — we used to call it the National Bureau of Standards, the NBS, and then they changed it to NIST, National Institute of Standards and Technology. The building I worked in in Washington was owned by that group, which —

[4] The Harry Diamond Laboratories (HDL) was a research facility of the Ordnance Development Division of the National Bureau of Standards and later the US Army, most notable for its work on proximity fuses in World War II.

Yamashita: By NIST?

Schechtman: By NIST, which itself is a part of the Department of Commerce. So, yeah.

Yamashita: Very good labs, I mean, right? As laboratory goes, very good laboratory, so —

Schechtman: Yeah, and my third and fourth — I've had four summer jobs. My third and fourth ones were also comparably positive experiences, because the third one — where was the third one?

Yamashita: That wasn't the Hughes?

Schechtman: Yeah. That's right.

Yamashita: That was —

Schechtman: You've got it right, Tom. It was bundled with the Hughes Fellowship.

Yamashita: So that was your senior year before —

Schechtman: That was when I was graduating from Cooper.

Yamashita: — going to Stanford?

Schechtman: Right, and the bundling — the fellowship that Hughes gave me put together one year of Stanford tuition. I think there was some room and board.

Yamashita: So how did you get that? I mean, that's a pretty good deal.

Schechtman: Yeah. The combination of Cooper Union having its good reputation and me being the first in my class in the GPA, it sort of became automatic.

Yamashita: Being number one helps. Number one helps. That's great.

Schechtman: So that was the Hughes summer job, and that was the least-interesting of my four summer jobs, but it was in Southern California. I finally got there, and my fourth year — after a year of graduate work with — and I wasn't yet working with Bill Spicer[5], but he was aware of who I was, and we were talking about my coming into his group. He had a buddy at the General Electric research labs in Schenectady, New York, a fellow named Virgil Stout[6]. I think you know this. Bill kept up his connections with industry even after he came to Stanford. He did that pretty well, and so Virgil Stout was an old

---

[5] William E. Spicer, 1929-2004, Stanford University Electrical Engineering professor. Co-founder of Stanford Synchrotron Radiation Laboratory (SSRL).
[6] Virgil L. Stout, 1921-2009. At GE from 1952 to 1983. Responsible for development of CAT scanner and MRI for GE.

colleague of Bill's. I mean, Virgil was at a GE lab, and Bill was at RCA Labs, I believe, before he came to Stanford, and the GE lab, in its own way, belongs up there with Bell Labs and some of these other special places just because of it being, in a way, the granddaddy of industrial research labs. It was started by Thomas Edison and some other famous figures in physics and other sciences. There's someone, Charles Steinmetz[7], who was a well-known physicist at the time, and there's another guy that was interested in plasma discharges. So, it was kind of a special environment. It didn't quite generate the Nobel laureates that Bell Labs did, but in terms of industrial research, it was also a fun place to be for the summer, and, again, it was funny. Course, earlier I was disappointed that I didn't go to California for a summer job, where we had relatives, and then I was in California working with Bill, and I got a summer job at the GE labs in the East Coast, being near my other relatives. But, yeah, I think, in going through this process for the interview, the business of how much I liked industrial research compared to other — I liked — I found that I — this is hard to benefit from as a summer student, but in terms of once I laid my career out in terms of industrial-lab research, I found it much more appealing to be working on something, where if it went well, it was going to get used, and there weren't lots of links down the chain before it was going to get used. I think, looking back over my career, I'm not sure when that got clear to me, but I think — I'm not sure when I put it into words in my head, and you could say it, but I do think that after I settled down in a particular job at IBM for many years, working on something kind of at the researchy end of the spectrum but it being something that we were trying to get used in a product or to solve a problem, that's — those are the kind of opportunities I seem to subconsciously be seeking out.

Yamashita: Okay. So, could you say a little bit about how you chose Stanford? You must have other choices.

Schechtman: Yeah. I'm not sure I remember that part very well. Let me think. I'm sure —

Yamashita: You got your Hughes scholarship. You say it was bundled with Stanford.

Schechtman: Yeah. I'm not sure, but I think it could've been bundled with any other school, maybe. The people on that summer program for Hughes — so this isn't a direct answer to your question, because we were talking about the summer jobs versus the long-term choices or the graduate school choices. They treated us very well as summer students, the Hughes Fellowship participants. Hughes at the time had a pretty showy research lab that would be their Bell Labs, if you like, and it was in a very —

Yamashita: Hughes?

Schechtman: Yeah, Hughes did, yeah —

Yamashita: I see.

---

[7] Charles Proteus Steinmetz, 1865-1923. German born mathematician, electrical engineer and professor at Union College.

Schechtman: … and they took us for show-and-tell one day a week. I think it was Wednesdays, one day a week through that whole summer of six or eight weeks. They would load us into a bus and take us to one or another of the Hughes facilities, and people would make presentations to us, so they were clearly trying to get us interested in working for Hughes.

Yamashita: Sort of a recruitment activity for them.

Schechtman: Yeah, and so they had this very fancy research lab, which didn't belong to any of the product organizations, that was in Malibu, practically on the beach in Malibu in the L.A. area, and following in the footsteps of IBM and a few others, they had a very fancy building, lots of glass, very future-looking. But I can't remember. I mean, finishing at Cooper Union, maybe I just asked for — why would I have not asked for — maybe it was no university that had the same track record as Stanford at that stage. Again, coming out of Cooper Union, being first in my class, you're right with your premise I must've had other choices. I think the Hughes Fellowship could've been applied in other places.

Yamashita: When you got to Stanford, sounds like at least a year you were probably looking to see who you like to work for. Is that true?

Schechtman: To some extent, yeah. I was in for a shock when I first got to Stanford, because — and this — my earlier comments about not being thrilled about the quality of the teaching at Cooper Union come in here, because I found there were deficiencies in my background from my four years at Cooper Union. There were topical areas that I didn't have enough background in to be comparable to the other first-year graduate students. I remember in particular — I could see this guy as if he were sitting here, for some reason, an Asian fellow, and I don't remember his name, but I — he was coming from having done his undergraduate work at MIT, and he came to Stanford, so we were both at Stanford at the same time, and he was starting to talk about this thing and that thing and that thing, and I had never been exposed to those, and this was not real electrical-engineering stuff. This was math, basically, but the use of certain Laplace transforms and this and that. So the shock I was in for was one needing to patch up some holes in my background, and the second was to realize, aside from the topics that I was missing, that some of the teachers in Cooper Union hadn't done a great job at teaching these topics, and, in contrast, I remember I took a — what was considered an undergraduate course at Stanford in the math department in complex variables, and we were — in Cooper Union we did a few homework problems with complex variables, but this was a quarter course, a course for a quarter or two quarters, and the professor was very deep into it, and we didn't have examples like that at Stanford — at Cooper Union. So, I'm thinking —

<pause in thought. Transcription resumes at 01:18:56>

Schechtman: — I'm thinking it was fortunate that I caught up with — I had a red flag waving for me, "Hey, you're missing some stuff" —

Yamashita: Soon as you arrived <laughing>.

Schechtman: — as soon as I arrived. But fortunately, if it would've been a year or two after I arrived, I would've wasted some of that time. Course, I might not have been able to get through the Ph.D. process, the qualifying process. But I'm going to have to puzzle over this question you asked of how did I choose Stanford.

Yamashita: So, why don't move on, then? So, after a year looking around, you chose Professor Spicer. So how that come about? I mean, the little that I know of him, he's more like an applied-physics guy than EE guy, so he's very much into fundamental science.

Schechtman: Yeah, and Bill Spicer actually had a dual appointment. You were in the materials engineering, I think, material science department, but he also had an appointment in the EE department. Spicer was kind of interesting to me. Well, in the first place, I took — another area that I got exposed to a possible guy to work for was with Bob White[8] at the —

Yamashita: Bob White, okay.

Schechtman: — also in the EE department that maybe also was dual-appointment, not sure. It was funny. I was totally snowed by Bob's class. He was teaching quantum mechanics, basic first course, I think, in quantum mechanics, and mostly I was snowed, because he went too fast. Bob, if you remember, liked to talk pretty fast, and I was feeling a little miserable at my not being able to keep up in class, and I happened to have a very old car, and it needed some repairs, and I took it not very far from here. It's probably within two miles from here to a shop to get this thing done, and I remember I'm in the garage there, and the car's — my car's up on the lift, and some guy's looking at it underneath, and Bob White's there, and he was having some car-repair thing, and he also had his arm in a cast. He had fallen or something, and so we started to chat socially in a way that I never would've been comfortable if it was in the classroom. We were just both there in the garage, and I decided to be kind of brave and tell Bob that I like the content of his class, but I didn't like the speed at which he was teaching it, and I probably had gotten similar input from a few of my peers that were taking that class. So I don't know if that comment got him to slow down a little bit, but he took it in pretty well, and by contrast, at I think about the same time or maybe shifted by a quarter I took Spicer's class, which was Optical Properties of Materials or Optical Properties of Solids, and Spicer didn't go too fast. I wouldn't have that complaint, but it was hard to understand him. He had a Southern accent, and he swallowed his words, but I liked him, and his group was kind of new and just building up, and he had selected the first two or three graduate students really carefully, so they were pretty advanced students. They were not your ordinary cut, and they had to build up Spicer's lab. Spicer had only arrived in '62, I think, or '61. They had to build up his lab from scratch. As an aside, my wife, my current wife, Marjolaine, was Bill's secretary at the time.

Yamashita: Oh, I didn't know that. I see —

[8] Robert L. White, Stanford Electrical Engineering Professor, Emeritus.

Schechtman: She knew I'd been thinking about this stuff and relating to the questions you gave me and so on, and when I started talking about the first students in Spicer's group, a fellow named Neil Berglund[9] and a second one named Neal Kindig[10], she could have a good conversation with me about it, because she remembered them from when she was a secretary. But basically, Spicer went from 0 to 60 miles an hour pretty quickly in building up — I think he gathered a lot of support to support different students, and before you knew it, he had 8 or 10 students and a couple of post-docs and so on. I personally liked him as a person, which probably influenced my decision, but in particular the fact that he was connecting the quantum mechanics that I was learning in Bob White's class, which gave you the band structure of solids, the electronic structure of the electrons and the holes, and relate that to the physical properties of the solid, why they're shiny or colored or conducting, and I found that part very interesting. Again, it tapped into my underlying interest in working — doing research on something that could be applied or useful, which —

Yamashita: The fact that he came from industry research, do you think that might've influenced you also?

Schechtman: It might've. It's a good insight. If it did, it was probably more at a subconscious level, because I don't remember telling myself that. But, in fact, it's interesting, because I mentioned a few minutes ago that he kept up his ties with the people in industry. You probably remember this. A very important part of the photoelectron-emission studies that all of the people in Spicer's group were doing was to have the samples prepared in an ultra-high-vacuum chamber and to keep them clean for some reasonable amount of time so you wouldn't be dominated by surface effects. So, Spicer was connected with the people just down the street from Stanford, the Varian Company, who was at the leading-edge —

Yamashita: — Vacuum technology.

Schechtman: — yeah, of ultra-high vacuum, and, in fact, he would bargain with them. We ended up in my research of building a dedicated chamber just for the sample category that I was working on, which was organic solids or molecular solids. Everybody else had been applying the photoemission studies to semiconductors or metals pretty much. I lost my track here a bit.

Yamashita: Anyway, so why chose Professor Spicer?

Schechtman: Professor Spicer's group? Yeah. Yeah, yeah. So, this doesn't answer that. I mean, I think liking the topics that he was emphasizing was really a big part of it, and thinking that he would be a very supportive adviser was part of it. But under the category of him staying connected well with the industrial labs, he had a guy, a colleague at Bell — not at Bell, at RCA Labs in Princeton, who turned out went on to

[9] Neil Berglund, President of Northwest Technology Group, Founded Eteq, a laser based lithography company, now part of Applied Materials.
[10] Colonel Neal Bert Kindig, 1928-1988. After West Point and a career in the Army, Kindig taught electrical engineering at University of Colorado from 1957 to 1988. He took a leave of absence from 1962 to 1964 to earn his Ph.D. under Professor Spicer at Stanford, working on photoemission.

pretty big jobs, a fellow named George Heilmeier[11] and George was a researcher at the RCA Labs in Princeton, and Spicer liked to have these guys visit him at Stanford if they wanted, and I knocked on Spicer's door one day, and this guy is sitting there., I didn't know who he was, turned out to be George Heilmeier, and he had some test tubes with some materials in them, and one of his boxes had actually single crystals of some pretty purple-colored stuff, and it turns out George Heilmeier and his colleague, a guy named Sol Harrison, at that era in RCA Labs were trying to deposit transistors instead of using silicon and germanium and so on, using these organic materials. So, Spicer called me to his office, and the guy was sitting there, and he introduced me to George, and George's first question is, "You're in the group? What're you working on?" and I didn't know what I was working on yet. So he started telling me, well, what he was working on in RCA, and I said, "If we could figure out how to get you — how to get me some of your samples from RCA, I could apply photoemission to study them and see if we learned anything special." So, the fact that I worked on organic solids was not by a big plan. Spicer didn't need to have me work on a particular topic in order to get support for me. With some of the other guys in the group, the funding came from Varian, and they had to do this, and they had to do that and so on. I was somewhat independently funded with the Hughes Fellowship and then after that the two years of NSF fellowship. So, I was the guy Spicer had a lot of flexibility with.

Yamashita: Could do anything.

Schechtman: Yeah, he could assign me to whatever.

Yamashita: Yeah, okay. That's a pretty good deal.

Schechtman: I don't know if he thought about it much ahead of time or if it was just a coincidence that I knocked on the door when this fellow, George Heilmeier, was there, but that led to my working on organic materials. When I say Heilmeier went on to big things, he became the CTO of Texas Instruments, I remember.

Yamashita: Wow, CTO?

Schechtman: Yeah, and I think he had a position in one of the government agencies like DARPA [Defense Advanced Research Projects Agency] for a while, because people from industry and from universities kind of rotate through those positions.

Yamashita: Professor Spicer had all kinds of connections to industry people.

Schechtman: Yeah. Another guy in your department, Bob Huggins[12], you probably remember him, I think, he was another guy who worked for the government. He definitely did have a DARPA job. Yeah, so

---

[11] George H. Heilmeier, 1936-2014. Formerly with RCA Labs, CTO of Texas Instrument from 1983-1991. President and CEO of Bellcore 1991-1996.
[12] Robert Huggins, professor, Stanford University Materials Science and Engineering, emeritus.

these guys who had been in industry, and we could throw in Bill [John] Linvill[13] and John Moll[14] brought some special flavor to at least the EE department, and it contributed to Stanford's uniqueness in the long run, and some — and, interestingly, some of them had motivations — some of the professors had motivations not only to do useful things but, in some cases, to do useful medical or health-related things, which when you're an 18-, 19-year-old graduate student, you have a choice between getting blind people to see with the device you're working on versus doing stuff in the military in Vietnam. It's a no-brainer what professors you're going to work with, and Linvill — you probably know this, but John Linvill, who was the head of the EE department for quite a few years, had a daughter who was blind, and he developed this very clever device that could read a page, could scan the images, and then the device itself was a bunch of needles or pins that you put your hand on, and it — the scanned image would turn into an image in these pins, and — that somebody who knows Braille like a blind person could actually read without having sight. So, I thought personally it was very attractive that there was this interest in medical applications. Bob White had a project with a transplant in the ear that had a bunch of different electrodes on it, and depending which electrode you fired, you'd get certain patterns, and he — so Linvill was trying to make blind people see. Bob White was trying to make deaf people hear, and it was a very welcoming environment, in a way.

Yamashita: I see. So maybe it's a good point to talk about — little bit about your actual Ph.D. thesis now.

Schechtman: Okay. Yeah. So, in a way, I got to take advantage — see, I started working for Spicer probably in late '64 or early '65 after — and I had some trouble getting through the qualifying orals for the department. I, at the time I wasn't as comfortable explaining things on my feet, and the format of the orals at the time is you had to see 10 professors all in one day. You marched around to their offices.

Yamashita: So, one at a time?

Schechtman: Yeah, one at a time, and you were alone with the professor, and depending on who they were and what their interests were, you spent 10 or 15 minutes with them, responding to their questions, and some of them would throw you pretty tricky questions, and in any event, I wasn't that comfortable ad libbing on my feet. You know, I would much rather respond from charts and stuff like that, so I didn't make the cut the first time I took the EE Department orals, and I felt a lot of pressure to — typically if you fail them twice, you're not going to — you're going to end up with a master's degree and be happy and that's it. So, the second time what actually happened is Bill Spicer and I had decided to work together. We had agreed on that, and for me that was a good thing in the end because I was — apparently the way the faculty would deal with who gets past the qualification, excuse me, and who doesn't, that they would, like, the upper third would automatically get passed and the lower third would automatically get rejected and they would spend all their time arguing about the middle third, and if you had a connection already as a student with one of the faculty, they would go to bat for you, and if you were in that middle group, and apparently I was very much right at the middle, and the second year I passed because Bill spoke up for

[13] John G. Linvill, professor, Stanford University Electrical Engineering Department
[14] John L. Moll, was at RCA Lab from 1944-1945, Bell Labs from 1952–1958, Stanford Electrical Engineering Department professor from 1958–1970.

me, and so that's the background. Now, how I — and what I actually did in the work, I don't know if you had much interaction with what we call, in the ERL building, what we call the tube lab, which was a bunch of guys who knew glassblowing and could make contraptions.

Yamashita: Mm, little bit.

Schechtman: Yeah.

Yamashita: Not so much.

Schechtman: So, by the time I came, in the sequence of Spicer students, there were six or eight of them that had come before me, and I don't know if Bill imposed this as a requirement or it just happened naturally. Some of the students got to take the equipment that the previous students developed and apply them to their problem, and some of the students had requirements for some uniqueness that none of the already built machines could do, so they are the generation that built new equipment. So it turned out, once George Heilmeier and Bill Spicer had agreed that I was going to work on these materials that he had brought the pretty crystals of, we started thinking about what I was going to do and how was it going to be different in terms of requirements, compared to the studies of photoemission with semiconductor surfaces and metal surfaces. Because the semiconductor and metal guys, the theory was pretty filled in pretty well, and you — or the band structure and indirect, or Bill liked to call them non-direct transitions and direct transitions and so on, so there was some pretty fair understanding of how all that worked with the semiconductors and the metals, but nobody had tried looking at that for — or these organic crystals, which were basically molecules put together, and they did have a crystal structure but it was very loosely coupled. The strong bonds were within each molecule, and the — it turned out, when we thought about what we were going to do, these materials, they were called phthalocyanines. First thing I wanted to know, where was I going to get samples if the guy in RCA, Heilmeier, wasn't going to keep feeding me samples or what? Turns out, with a little bit of reading, it turned out that in the paint industry, if they wanted to make colors that were either a very deep blue or very deep green, these molecules were used as dyes in the paint industry to give those colors. So <laughs> I was trying to figure out samples, and I ended up writing to the Sherwin-Williams paint company, and I connected with some guy there. In the business Bill was in, you didn't need very much quantity of materials. You're working in ultra-high vacuum. You have a thin film or whatever. This guy wanted to ship me cartons of this material with one-pound jars in them, and the reason they were of interest, as a material to study with photoemission, is they were pretty stable. So, it was pretty clear from the literature that you could heat these up in vacuum and instead of the molecules breaking apart they would go from the source to the target or to the substrate with keeping the molecule intact, without breaking up the molecule. So that was — I think you had to get up to $500^{o}C$ or $550\,^{o}C$ to start damaging the molecule, and you didn't need to do that to just transfer the molecules from a crucible to a substrate. So that was one of the reasons — so, George Heilmeier's interest was one of the reasons we got into the phthalocyanines. The fact that I could get a lot of samples easily, and the fact that the materials were very stable, thermally stable, all — and finally, if you looked at the molecule itself and where the carbons and hydrogens were and so on, it was very similar, the phthalocyanines were very similar, to some biologically important molecules. They looked almost the same. Chlorophyll and hemoglobin. So, there was some hope that we'd get some insights from the electronic structure of the solid that might even be useful to the guys worrying about the biological connections, like photosynthesis and oxygen take-up and so on. So to make a long story short, the reason I asked you about the tube lab is I spent probably the first year of my lab work over in the tube lab, and this guy, Phil McKernan], he was pretty old, he was pretty shaky, <laughs> but he was mechanically a great expert and he was a very skilled glass blower, so I spent a good part of my first year kind of standing at his side and he was on his stool at his bench and he was coming up with ideas way faster than I was, because he knew what he could build and what he couldn't build, and in the end we built a whole system for the organic samples, where we deposited them. We — well, first we had to purify the carloads of stuff coming from Sherwin-Williams, and we basically found that the properties of the phthalocyanines were intact when you heated up these powders and just collected them on a cold substrate. But you collected a lot of stuff too that was coming out of the — or coming out of the paint samples, and it turned out I had an incident. It's kind of amusing, I guess, now. So about 35 percent of what was coming out of the phthalocyanines when you heated them up was useful for your experiments. Was clean and so on, and the other 65 percent was full of crud, and so, again, a simple thing that this fellow, Phil McKernan did, we built a huge U tube that we could surround with a thermos bottle, excuse me, thermos bottle of liquid nitrogen, and we did one round of purifying the phthalocyanine powders by evaporating them and trapping the lower — the lower energy stuff that came off first would come off and get trapped in the cold trap, and the rest would be reconstituted, so we developed a chamber in which — well, first we developed an offline purification process for thin film deposition, and then we built this chamber where we could evaporate and inside the chamber we can move things around without breaking the vacuum and wheel the chamber up. This was true of several of Spicer's equipment. Wheel the chamber up to a deep UV spectrometer and do the photoemission experiments. I made a good connections — so it was kind of of interest — as a generic set of experiments it was of interest in its own right of, "Can you do this photoemission on organics for the first time? Are there organics that are interesting to study?" and I made a connection with a guy named Charles Weiss at the UC Lawrence Berkeley Laboratory, who was doing calculations of what the electron ring structures look like in the molecules, because he was interested in hemoglobin and chlorophyll,. So, basically it was pioneering work and it also was used to validate some of the theoretical work they were trying to do. At the same time, we didn't answer any earthshaking questions, I would say. We laid some groundwork that if somebody wanted to take the next steps, that we had probably given them a good shortcut.

Yamashita: Well, you evaporate this thing on — as a thin film form. Is it a — was it crystalline or monolayer? What was it?

Schechtman: You could get — it wasn't monolayer. It was reasonably thick, and you could get an x-ray diffraction on these.

Yamashita: it was crystalline. It grew — ?

Schechtman: Yeah. Probably crystalline.

Yamashita: Oh, I see.

Schechtman: You know, it had a grain structure. So yeah, and I think we even had one more feature in this chamber. I was going home nights and having nightmares about how complex this thing was getting and what if something ever happened to Phil, the builder? <laughs> Needed an insurance policy.

Yamashita: <laughs>

Schechtman: But —

Yamashita: That’s a valid concern. <laughs>

Schechtman: Yeah. We had one more feature built into the chamber that after we had deposited the sample, if the chamber for some reason sat overnight waiting for its turn to be wheeled up to the spectrometer, we had a heater behind the substrate we were depositing the films on, and there we did a little surface cleanup. We were probably heating just enough not to break up the molecules, certainly, but to drive off any impurities again. So finally, originally, we did that in the big macro scale with the glass tubing, and then in the chamber we did cleaning up a little bit before measuring the spectra. But the spectra were kind of boring, because if you do it on silicon or if you do it on copper, you got sharp peaks in the density of states versus energy, which is what came out of the photoemission measurement, but we just got one broad peak of these organic samples. But we did find where that peak was. It did move with what the specific details of the molecular structure were, which atoms were varied. So we believed that things were working pretty well, and in the process I measured the complex index of refraction, n and k, for these phthalocyanine films, and nobody had published anything, even though they were used as dyes in the paint industry, nobody had published anything on their optical properties over a spectrum, over a frequency range. So that was a contribution, I would say, just in terms of raw data that belongs in a catalog somewhere.

Yamashita: And you learned a lot about putting vacuum equipment together. <laughs>

Schechtman: Amazing amount. Not that I could do it. I learned about it.

Yamashita: Okay. So, after Stanford, you went to IBM. Could you tell us how that came about?

Schechtman: Yeah. I finished my Stanford work in 1969 in January, but basically I was available for employment a few months earlier in late ’68, and that was a very good time to be job hunting. Again, partly because of the Space Race and NASA and some other things. People were creating positions in the technical areas, so once I had my research results and my well-practiced presentation on what they meant, I probably, I haven’t counted this, but I probably went and visited 10 or 12 different places that I might end up working. So it was kind of a real push for a few months, and in the end, I was most interested in some of the IBM places and Xerox, not here in Palo Alto, but a Xerox lab in New York, and there were some places that were interested in me, but I wasn’t so interested in them. So, in the end, I kind of narrowed down to IBM and Xerox, because they were both — basically both high-quality industrial research labs. I didn’t have any special reason to look forward to spending the winters in Rochester, New York, but Xerox was doing interesting stuff, and in the case of IBM, I had three locations I got offers from, one in their semiconductor development area in East Fishkill, New York, and one in their research lab in Yorktown Heights, New York, and one in San Jose, and since I was already, at the moment, a resident in San Jose and pretty comfortable in this area, I was certainly somewhat prejudiced towards looking to see if the San Jose offer would make sense for me. But it was really an offer for a post-doc position that would have to be putting me back on the market a year later looking for a job, and it was a position in very basic science, spectroscopy of molecules, where maybe it was more similar to what I did with my work with Bill Spicer, but certainly was not in any way connected with IBMs products or technology. So, because none of the three of those positions attracted me, the IBM positions, I was about ready to say "Yes" to the Xerox offer in New York, and I got a call from IBM. I had rejected IBM in San Jose and I told them why, and I got a call from them indicating they were just forming a new group and there was one position in it they had created, a permanent position, as opposed to a post-doc, and would I like to come back and talk to them about that? And I did that and the pendulum swung from it being hard for me to be interested in the IBM job to where it was all of a sudden quite a good match for my interests, and they wanted to put the physics of electrophotography and the discharge of electrons through a photoconductor, they wanted to put that physics on a firm footing and wanted somebody to not only model that but to characterize some materials they were studying for the purpose of getting into the electrophotography process. So this was very attractive to me, and I said, "Yes" right away and it turned out that IBM already had a relationship going with some engineers in Japan who had come up with a way to improve the photoconductor deposition by about a — improve the sensitivity of the resulting films by about a factor of two, which they achieved by sandwiching the photoconductor with a dielectric, and basically when you charged up the — when you discharged the photoconductor, the charges went onto the dielectric and got saved there so then on the next pulse you got the additional charge you were applying, plus the charge you had put in the bank in the dielectric, so called. So they were, they, the Japanese collaborators, were preparing samples like this, and my job was to evaluate them, and at the same time inside IBM we were preparing samples of other photoconductors and trying to compare them, or put them into this sandwich configuration with an extra dielectric. IBM —

Yamashita: Was this an organic [photoconductor] or — ?

Schechtman: Well, yes, and no. IBM — in the first place, the trendsetter or the sort of the leading-edge work on photoconductors for electrophotography was being done at Xerox, and most of Xerox's work was based on selenium alloys as the photosensitive material. They were interested in phthalocyanines because of some of the same properties I talked about. So, it's ironic. I went to IBM, who wanted to study Xerox's process, and I didn't go to Xerox, although I might've, and they wanted to study what I had studied already. <laughs> It was kind of a three-way loop there. I think Xerox was doing something with organic photoconductors. In IBM, we had a project in the Chemistry Department, and we had a candidate photoconductor, which apparently we couldn't come up with a clever name for, so <laughs> it was called OPC, organic photoconductor, a missed opportunity there, and so they were using the photosensitive materials with the sandwich structure from Japan to see how our own in-house materials compared. We also had people in our group doing things with the Group 6 of the periodic table, chalcogenides, like selenium and tellurium and others. Sulfur. We were — so we had a fellow in the group, an inorganic chemist. Some of these materials were pretty dangerous to work with and pretty toxic. Who was generating his own samples and we were comparing them. But basically IBM's underlying motivations were to recognize the physical limitations they were going to encounter with their current line of printers, which basically involved mechanical hammers hitting ribbons, like typewriters, and they were much more interested from very high-speed printing in some noncontact process, like electrophotography, and so that was a good project to get involved with in my early days at IBM, because it had several elements to it, working with several groups, and both the organic and the inorganic samples, and it also had a big modeling component. A fellow that joined IBM more or less the same time I did, named Inder Batra[15], was more of a theoretical person and was doing modeling calculations to describe the distribution of charge inside the photoconductor as the charges moved and went from one plate to the next plate, and he and I did a lot of modeling work and published five or six papers on this, and so it was a very nice team effort, and I think it'd come — we weren't tasked with coming up with a photoconductor that was better than everything else before. We were more tasked with laying some groundwork and developing fundamental tools for evaluating these materials, and it became a serious thing for IBM and they shortly, in the next few years after that, they put out what I think was their highest end printer. I think it was called the 3850[16], as I recall, which was almost a room-sized copying machine that could really spit the paper out in an enterprise computing and printing environment. So, IBM did, in fact, get into that field, and we had provided, no startling breakthroughs, but enough of a set of tools that we could evaluate one material versus another, which I think proved useful.

Yamashita: I see. So, who hired you into IBM and which group did you work for?

Schechtman: I think there were three names involved that should be mentioned here. My immediate manager was a fellow named Haj Seki, and I think this was his first management position, and he had a small group to support the electrophotography effort, and one of the reasons Haj was in the mix was that he was fluent in Japanese, and he was the one making the trips over to visit the collaborators in Japan.

Yamashita: This is Hajimu Seki, right?

Schechtman: Hajime.

Yamashita: Hajime or —

Schechtman: H-A-J — H- <laughs> A-J-I-M-E.

Yamashita: Hajime, okay.

Schechtman: Yeah, Hajime.

Yamashita: Yeah, okay.

---

15 Inder "Paul" Batra, became Professor of Physics at University of Illinois at Chicago, head of department from 1998-2004.

16 [Interviewee's note] The correct model number for the printer is the IBM 3800.

Schechtman: Yeah. He's a fellow that he had almost no trace of an accent. I think he came to the States when he was about 10, and he did a pretty good job of, you know, some people can be learn — can be taught this and some people have to learn it, and he did a pretty good job of keeping his own technical work going and managing the group and supporting the group. Good mix of that. What he didn't have a lot of knowledge of, which later I cared about more, was the technology side of where all this would fit into IBM products and stuff like that. That was — he had some probably fairly generic ideas about that, but was not very expert in it, so that's one name. Haj's boss is a fellow named Eric Kay, and by the way, just as an aside since I'm seeing Denis Mee today, Eric lives in the same retirement community that Denis lives in, and I don't stay in touch with Eric very much, but he's still active with conferences, but his name should be mentioned, because the way the IBM San Jose research lab was at that time, it was at Eric's level of management, the second level, that they kind of accounted for and kept track of slots to hire and how many people they could keep on board and so on. So, he wasn't at all — Eric was not at all involved with it, specific to the work on the photoconductors. He himself was trying to do leading-edge work in surface science and ultrahigh vacuum, but he was supportive of our group, and he was the one who had the ability to sign off and hire me, and I would say even though Haj and Eric were my first and second-level managers, Paul Grant, who you know from the museum interactions, I believe, was my officemate. We didn't have enough office space in that building when I joined IBM, and so they squeezed two of us into an office, and Paul's the one I got really educated by on various aspects of how IBM worked and IBM's history, and his father worked for IBM. I think his mother worked for IBM. They were a real IBM family. Plus, Paul was really smart, and he knew a lot of stuff technically that I hadn't been exposed to, some of it relating to how IBM could use the technology and some of it relating to his own measurements. He gave me a little bit more perspective than either Haj or Eric could on how these — how materials he was looking at, which were magneto-optic materials, optical storage materials, basically, how they could behave in the applications environment where IBM might use them. So that was a whole separate piece of work that I was not involved with, but when Paul and I, sharing the office, had conversations, I always came away from those feeling like I had learned something, either about IBM technology or quantum mechanics or... So Paul was very good at that, and so he actually made it a point to make two or three visits over a period of six months to Bill Spicer's group at Stanford when the group was having a one-hour seminar session or something like that, and he was trying to — Paul was trying to set up similar apparatus for photoemission studies that Bill had in the group at Stanford. But mostly, Paul came away from those visits to Bill telling his boss — his boss was Eric Kay also — even though Eric was a second-level manager there was no intervening first level between Paul Grant and Eric. He came back from those visits to Stanford encouraging IBM to go after me, to employ me.

Yamashita: I see.

Schechtman: I think he thought I was good and I think he thought I would come in the door with some knowledge that would be helpful in setting up the photoemission at IBM. So that's the story of how I got hired, and that sort of was my stable configuration in the hierarchy at IBM for the first two or three years, I'd say.

Yamashita: So, you mentioned that after few years, I guess, you started to work under the Science Advisory Committee in IBM? Could you talk a little bit about that?

Schechtman: Sure. That was a fairly special opportunity. So that's an example, relating that to what we talked earlier, about my making choices as opportunities presented themselves, versus having a real master plan, which I didn't. Apparently, the way the process was working, is the corporate headquarters, including Lewis Branscomb[17], who was a chief scientist of IBM, had a way of — they wanted to bring young, aware researchers into that environment to work with Branscomb for a year, and mostly Branscomb wanted to be in touch with physicists who he could relate to from his own lab experience. So, every once in a while, every year, year and a half, I think it was time to turn over that position, who worked with Lewis Branscomb. The position was called Executive Secretary to the Science Advisory Committee. So I think names get put in once there's an opening, and usually the names came from the corporate Research Division, which means that San Jose research lab, or the Yorktown Heights research lab, and my — so I think Eric Kay got asked, "Do you have any names of people in your organization that might do this temporary assignment for the next round?" So, I'm imagining that's what happened, and Eric put my name in. I loved — I loved it. I mean, I loved the job, because I could — I made connections on behalf of the Science Advisory Committee. I made connections with senior management in different lab sites at IBM. Got to hear from them about their strategies, and then got to deal with people at the working level to see where the goals were and the progress and what their challenges and difficulties were in whatever topic they were working on, and the way the Science Advisory Committee worked is that Lewis Branscomb assembled, mostly through his personal connects, assembled a collection of 6 to 10 prominent scientists, prominent meaning Nobel Laureates or heads of universities and pretty senior guys, and Lewis would treat them as a committee that he would march around once a quarter, on a quarterly basis, and visit some IBM geographic site where most of the work was going on that topic, and they would do an A to Z review of everything going on in that site relating to that topic, and my role was to arrange those meetings, both the logistics and where to take these guys out for dinner and so on, but also to make sure the senior managers at each of these locations that were getting visited were, as you might understand, they'd be motivated to put their best foot forward and look like they really have things in good shape and they're on track for the next generation, whatever gadget it was. But Lewis wanted me to play the role of poking at that and not accepting it immediately on face value and make the agenda of the quarterly review, with the outsiders, be potent enough to expose any weaknesses. A good way to do that is if there're two groups competing inside, in-house, for — the way to move, let's say, from 1.5 nanometer wide lines to 1 nanometer wide lines in lithography. If there were competing groups, that made the job easier for me, because each group would like to talk about what the failings of the other group's approach was. So I could basically put the meetings together and my role was not to be very involved technically with the discussions but to keep the meetings on track and to make sure when the visitors, these very senior guys, asked a question, that it wasn't ignored, that somebody was following — after the meeting following up on it, and so on — so it was not just a few years after I joined IBM though, it was about seven years. I joined in —

Yamashita: I see. Quite a while, time it took place.

[17] Lewis M. Branscomb (born August 17, 1926) is an American physicist, government policy advisor, and corporate research manager. He is best known as former head of the National Bureau of Standards and, later, chief scientist of IBM; and as a prolific writer on science policy issues.

Schechtman: Yeah, I joined in late ’68, and I took this assignment with the Advisory Committee in June of ’75. About seven years after I joined.

Yamashita: Pretty heady job, sounds like.

Schechtman: It was — and a fun job too. Well, it depends. I should take it back a little bit, because there were topics that Lewis wanted to review that I could feel comfortable with as an EE material scientist. For example, “Should IBM get into solar energy and make devices for solar energy?” was a topic, and that’s one I could get comfortable, when I could at least understand the words that people were speaking. But some of the topics that Lewis wanted to cover were system-level stuff, like you were talking during the break, I think, about groups here at the museum would cover systems-level stuff instead of just piecemeal stuff. Lewis wanted to cover the systems-level stuff, and sometimes it would relate to stuff that didn’t have a lot to do with my physics background or anything like that. Like we did one meeting where IBM was contemplating getting into the banking machines business, an ATM thing, and there were a lot of systems issues and counterfeit bills issues and stuff like that. So, it’s the kind of thing that presidents of universities talk about that I don’t get to talk about it very much, so — but it was really fun interacting with these guys. A few of them were caught up in their own fame a little bit and not so easy to talk to, and several of them, many of them, were down-to-earth people, and at the same time, Lewis wanted to treat them very royally when we had these meetings, in terms of when I arranged — the meetings were usually a day and a half long and it was the intervening evening meal. Usually I had to go all out in putting something really big together, so — but it was a great job in terms of the doors were open to me, because if any of the site managers didn’t want to participate, I’d basically have to go back to Lewis, my boss, and say, “I can’t get cooperation from that site. Would you give this guy a call, please?” and so —

Yamashita: It had some power. <laughs>

Schechtman: Yeah, yeah. It opened doors. It had some power, and it opened my eyes as to — also to things going on in IBM that I didn’t know about, that in some cases they were just exploring whether they want to get into a given field or not.

Yamashita: And how long did you do this?

Schechtman: It was typically one year. I did it for one year and two months. It’s a job you can get burned out on too.

Yamashita: High pressure also.

Schechtman: Yeah. Yeah, things had to be done right and you had to gently, you know, the guys doing the actual work in the labs, in the various IBM labs, and kind of pouring their hearts into doing it right, you hate to have to be the one that says, “Did you consider this? Did you consider this?” but it’s better if I do that. With these meetings, we usually did dry runs of the presentations, or at least outlines of the presentations. It was more constructive for me to poke holes in what the guys were reporting during a pre-session or a practice session, so I didn't have to do it in front of the committee.

Yamashita: So, this must've been — how best to put it? A very quick introduction or exposure to many aspects of IBM and people and various projects going on within the company.

Schechtman: Very much so, yeah. It was a, I mean, it was — now, let me think how to say it. It was a real gem of an opportunity. Let's put it that way, and I didn't mention that Lewis ran his own advisory committee, which didn't have these famous guys on it. They were internal IBM guys, IBM fellows or just high scientists, and he ran — that was called the CTC, the Corporate Technical Committee, and sometimes he would run meetings on topics like the ones he did with the SAC committee, but on something he wasn't ready to talk about to outsiders yet. But the same things we commented a few minutes ago about doors being open for me and my getting exposure to a lot of stuff applied equally well with these. I didn't have as much responsibility with setting up the CTC meetings, but sometimes we would merge a SAC meeting and a CTC meeting and it'd turn into a 18-person meeting or something, but we'd have good coverage of the topics.

Yamashita: Well, what sort of work did you get into after this assignment?

Schechtman: So I came back from the East Coast in 1976, and we, at that time, still had parts of the San Jose research laboratory that were more leaning towards pure science and parts that were leaning more towards products and applications, and I came — I left from the pure science part and I came back to the pure science part, but I left as a — I left the position of being a first — after Haj Seki was my first-level manager for two or three years, then I became a first-level manager in San Jose, and I left that position to go East for the SAC position. So I came back and they found an opportunity for me to come back to a second-level management position, and that was kind of exciting for me, because I don't know how much credit IBM was giving for this, but — because you need highly technical companies, I think the technical stuff is emphasized as a main area to make your achievements in, and it's probably what it should be. But being a second-level manager now, when I came back, I had to coach other managers on how to deal with their people and how to get the most out of them, and so I enjoyed that as well, but it was a mixed thing. So, it was a new challenge for me to be a manager of managers, but at the same time there I was again in the fundamental research side of the lab. It was almost like my very first chance at IBM where I got the three positions, but the one that was in San Jose was just fundamental science. So, it wasn't very satisfying to me. So I did okay but wasn't enjoying that second-level job very much, and then we had some movement of positions, and the lab director of San Jose research at the time, a fellow named Don Rosenheim, he offered me the position of a guy that was going East for an assignment, so that was a third-level position, and —

Yamashita: Third-level manager.

Schechtman: Third-level manager, yeah, and it had most of the applied parts of the research at the San Jose research lab under it. So, we had things related — we had a big polymer department, polymer chemistry department, and they were doing things on resist technologies. We had optics guys. We had mechanics guys working on InkJet printers. So, it was a lot of — it was fun stuff technically. It was lot of proof of concept kinds of stuff, and that's a position I was in from about —

Yamashita: Third-level manager, my understanding of IBM, is a fairly high-level management position; is that correct?

Schechtman: Yeah. In terms of number of people you're responsible for, it's fairly high-level. It's... We talk about departments as the second-level manager and the departments were typically, at that time, 30, 35 people. You'd have maybe three of those. You'd get up near a hundred people for the third level. I'm trying to think what branched me off. I'm drawing a blank here.

Yamashita: So, is it during that time or afterwards that you got involved in some special assignments or was that all in between?

Schechtman: Yeah, I think it was during that time. We're jumping a little bit now from the late '70s to the early '80s, I would say, and again, at that stage, IBM research in San Jose, IBM research in Yorktown Heights, New York. There was a third lab, IBM research in Zurich, Switzerland. Now, I haven't kept up, but I think there's between nine and a dozen small sites that are part of research at IBM. So during that period, there was a lot of occasions where there were some problems with product that was about to come out, and until we got into the '80s, it was more or less on an ad hoc basis we'd pull a few people together and see if we could respond to the product divisions. Sometimes if we had unique capabilities to respond in a given situation, we would, not in a high-level way, but we would create a small group of a few people from here and a few people from here and give them a task of just dealing with that problem. If it had anything to do with polymer chemistry, we, in my organization, had the unique collection of people that knew that stuff, so having — generally, the product development parts of IBM looked to getting help from the research parts, if for no other reason, because there were a bunch of bright people in the research parts and might as well get them to help. But in certain cases, the ability of research to contribute came because of uniqueness, that you couldn't get it anywhere else, and the polymer chemistry is a good example of that. So, we had a second-level manager sized department. Larger than 30 or 35, maybe 40, that worked on anything having to do with polymer materials, and it was — inside IBM there was a contention for resources and a contention for credit and fame between the Yorktown Heights lab in New York and the San Jose research lab, and it was kind of a contention that was never going to leave San Jose satisfied no matter how it came out, because the whole power structure was in Yorktown and everybody in San Jose reported through the Yorktown structure. So, they controlled the resources, so —

Yamashita: Yorktown Heights did?

Schechtman: Yes, yeah.

Yamashita: I see —

Schechtman: So — and the guy who ran the research division, they turned over every few years. They, during that period in the '80s and so on, they all were coming from Yorktown Heights.

Yamashita: I see.

Schechtman: So — but at the same time, despite the minutia and the quirks of how we were organized, the overarching goal that came from Yorktown Heights to themselves and to San Jose was to become a world-class research — industrial research laboratory, because IBM research wasn't fully on the map when these other more mature organizations like Bell Labs and GE labs really were well established. IBM research goes back to the 1950s, I would say.

Yamashita: They wanted more Nobel Prize winners and — is that how?

Schechtman: There were a couple. There was —

Yamashita: Way back then it was just Leo Esaki. That was —

Schechtman: Okay, you remember. Yeah.

Yamashita: Yeah, that was about it then.

Schechtman: Right. He was the first, but then I think the scanning tunneling microscope, the STM —

Yamashita: Was much later, so —

Schechtman: Yeah, but not much later than the '80s, was it?

Yamashita: Late '80s, perhaps?[18]

Schechtman: Okay. I'm not sure.

Yamashita: Yeah. So anyways, striving for the excellence was one of the driver.

Schechtman: Yeah, and interestingly, the lab in Zurich was, of course, a bit more isolated from day-to-day observation by the management, and their local management in Zurich did a good job of protecting the groups that were doing fundamental science. Some of their science was, in the end, very relevant to products, the stuff that relates to codes and signal processing of — with a data channel. They have a, I think still, probably, a really powerful bunch in the Zurich lab.

Yamashita: So, what were some of these product firefighting that you worked on?

---

[18] Gerd Binnig and Heinrich Rohrer from IBM Zurich were awarded the Nobel Prize in Physics in 1986 for the invention of scanning tunneling microscopy.

Schechtman: The one that I remember some details well about had to do, and one that ended up being quite a bit of my time involved, had to do with really last-minute hiccups in trying to get the first high-end hard disk drive product with MR heads in it. At that time, the diameter of the enterprise hard drive products for IBM, the diameter of the disk was about 14 inches, and everything IBM did at the time, they weren't making small hard drives then. Because everything they did at the time was relating to these high, large-diameter disks, and we had a number of issues, but one of the ones that required detailed material analysis and microscope analysis and so on, kind of stuff that you're very familiar with, we needed to apply those kind of tools to unravel what was going on in, and an issue that I remember pretty well, I think this stuff eventually got published. I'm sure it's old enough that it doesn't matter anymore, but in the early products we built in the lab for the MR heads with hard drives, we were getting shorting out of the sensor element because we were smearing — well, let me back up a little bit. So, you needed shields in the MR head that needed to have good magnetic permeability, and then you needed a sensor stripe in the reader part of the MR head that needed to be noise-free and to have a sizable MR effect. I mean, magneto- resistive effect in the presence of a field, and the easiest thing for them to do when they started was to use permalloy as the material. Nickel 80, iron 20. They didn't anticipate — not sure we could've expected them to anticipate, the fact that, okay, the permalloy is now exposed at the head disk interface. Permalloy is a mechanically soft material, and so the contacts, we like to talk about the HDI, the head disk interface, as if there's no contact and we're just flying lower and lower with each product's generation. But the reality is there's lots of contact, and the — in the case of — so this was the first time we had a combination of a head structure that was passing current through the element at the exposed surface of the head, just because the permalloy sensor was a stripe and you had to have a current running through it. It was the first product where we had a combination of that with a disk material that you're very familiar with, some metallic disk alloys, and what was happening, with hindsight now, when they did all the analytical work, what was happening was the permalloy in the sensor was mechanically smearing from the contact with the disk and it was shorting the current, giving current a shorting path, without it going through the full stripe, in the best of cases, and in the worst of cases, there was enough current going through the wrong places that you would just — the stripe was becoming a fuse and you were just blowing up the element. So, one of the guys, I think rightly, got credit for this idea. A material science guy you probably know named Kent Howard, who became an IBM fellow in that era. He introduced the group that was not — well, Kent was basically going to all the material science conferences and they related to storage and so on. He introduced the group to the idea of using a mechanically hard material for the shields around the permalloy to protect it, and also not being a material — being mechanically hard. Not being a material that could smear out in a way that it would short to the element carrying the current, and so Kent recommended sendust. Sendust[19] was the nickname of the magnetic alloy, which is mechanically, I mean, magnetically soft, so it makes it for a good shield, but mechanically hard, so it's not going to smear very much. I'd say, as I recall, it's an iron, aluminum, silicon, maybe something else, nitrogen alloy. So that was — this came out of a lot of brainstorming and a lot of weekly meetings of what was going wrong, and then once that idea was introduced, this was a pretty good success story because there were people nearby in-house that could intercept the head making process and put the sendust in place of the permalloy shields, and I like to talk about that one because it was — it held up the shipping of that product by I'd say one to one and a half years, and —

[19] Sendust composition is typically 85% iron, 9% silicon and 6% aluminum.

Yamashita: That's a big deal.

Schechtman: Yeah, it's a big deal, and not only for the technical aspect itself but for the bragging rights of being the first to get that hard disk drive out with the MR head, because Seagate was very active at the time as well publishing.

Yamashita: What was the — with the MR head, IBM being the first, they leapfrogged everybody for little while. So, it was a big achievement, right, to get it out?

Schechtman: Yes. It was not a secret that everybody was working on that. Seagate was publishing a lot in addition. They were putting work out at conferences. We had some stuff in our first MR heads that I'm pretty sure we didn't publish for the first couple years after the head was in products. What I'm thinking of is one of the real challenges with — let me back up a little bit, and we had, two or three years earlier, successfully put out a new category of tape product, part of what was new being the use of an MR head in this new 3480 tape product. That MR head had a stripe width across the track. I can't really remember, but it's probably in the 200 or 300-micron range, and the hard drives at that particular era, we're probably, I think, talking about 10 nanometer wide tracks[20]. So it's just like — that sensor is just like a bar magnet, and if you wanted to not have magnetic noise contributed by domain walls jittering around and moving around, you want that bar magnet to be rock stable with — its moment pointing in a certain direction and not moving around, except by virtue of detecting a magnetic field from the disk. It would move its angle. So, it turned out, as with a bar magnet, the rectangular shape, the longer the better of the bar, gives a contribution to keeping it noise free by not having domain walls in there. The shape itself dictates along a long magnetic piece with no walls in it.

Yamashita: So, the shape anisotropy kept the Barkhausen noise from showing up, I guess, huh, yeah?

Schechtman: Exactly. I mean, I think another way to say that might be it not only kept it from showing up, it kind of squelched it. There was no Barkhausen at all.

Yamashita: Held it [domains] in place.

Schechtman: But we went on to the MR head for hard drives with, let's say, a 10-micron track width, then the sensor, instead of being a long rod, looks closer to being a rectangle. Not very long aspect ratio. If we wanted a 10-micron track, the height of the sensor stripe might've also been about 10 microns, so it'd be more like a square, in which case there was nothing about the geometry to give it stabilization, and it was a very major contribution and a fairly simple one, although the guys who make the heads would say they had to practice it a lot to get it under control. A fellow named Ching Tsang, in the heads area of San Jose research, contributed the idea of putting two permanent magnets, one on either side of the track, that were forcing — they were permanent magnets in which their own moments were in a certain known angle and position and they were helping to induce anisotropy in the soft magnetic stripe that was the

[20] Should have said 10 micrometer tracks. First HDD with MR head had areal density of around 100 Mbit/in^2, at around 3000 TPI, (8.5 micro-meter track width).

sensor of keeping it single domain. So that was a very major contribution by Ching. Ching has a Stanford connection too. He was a student of Bob White.

Yamashita: Bob White. Yes.

Schechtman: Yeah.

Schechtman: So —

Yamashita: Who were some of the other people that you worked with during those time period with the MR heads?

Schechtman: Yeah, it's interesting. I'm going to mention some names now. It'll be interesting to see how many or not of them are familiar to you, because sitting there in the same building as those guys being in San Jose research, but on the what we've been calling in this conversation, the pure research side of things, the pure science side of things, I didn't even know who these guys were at the time. But in addition to Ching, there was a very important contribution by a Swiss guy. I think he had spent some time in the Zurich lab, but he was now in San Jose research, named Otto Voegeli, and he's a guy that published a bit but he came from a lot of experience in manufacturing processes, and he made a very tangible contribution to the introduction of the MR head by designing a test chip. He called it a test chip, that would go through the head processing line once every n chips, and there were also clever devices built into this thing when you put it in a DC field or when you — DC magnetic field or AC magnetic field or he did this to it or that to it, and he tricked up the devices on this test chip to give you lots of essentially physics feedback on the device was working and what was working well and what wasn't, and this test structure got incorporated into the product to go through with every wafer. We dedicated some small number of sites on the wafer to this test behavior. So that's another name, and a guy who was always very valuable but didn't do much work at that stage, but was very valuable in a consulting mode, was Dave Thompson.

Yamashita: Dave Thompson, huh? Okay, uh-huh.

Schechtman: Yeah. I've got a picture on my wall at home. It's a hard question to answer, to name some names in the MR head and to be worried about leaving somebody out and so on, so I got a picture on my wall at home where I think there are nine people in it. But it was very painful of who to include, who not to include, and this was essentially for the introduction of the MR head. Another guy who has been part of this and does publish a lot and is active in the conferences, or was, is Bob Fontana.

Yamashita: Oh, I see, mm-hm.

Schechtman: So, he may be familiar.

Yamashita: Mm-hm.

Schechtman: I have to say, this whole process of preparing for this interview was like a nostalgia trip down memory lane. It triggered some things that I hadn't thought about for a long time, and the amazing thing about how our minds work is that once you trigger some of that, it comes back pretty clearly. I'm trying to think of a few more names for you.

Yamashita: This is time period when you were second-level manager or third-level manager? Or in between?

Schechtman: This particular stuff we're talking about occurred in 1988, '89, and I became a third-level manager when I came back in 1976 from my Yorktown — no, my Armonk headquarters assignment, and then I became — then my boss, who was a fourth-level manager, fellow named Heiner Sussner, he went back to Europe shortly after that, those years, but he was taking a sabbatical I think in France, in fact, and so I was filling in for him as a fourth-level manager, and he came back, and at that point we — at that point the pendulum swung back from the pure science and pure technology groups in the lab to where we were trying to make impact with everybody, and so in — probably in '88 or '89 is when we were doing the firefighting on these problems. The problem was the product was going to be a 14-inch hard disk drive with the MR head in it, and the problems occurred in it, and the firefighting, in the time frame of about '87, '88, the last year before shipment, and it delayed shipment to I think '90 or '91. So, it was pretty big impact. The tape was —

Yamashita: — was earlier.

Schechtman: Yeah, the tape — the product shipped in 1984, and just to — it's always helpful to refresh ourselves about how much data we talk about today and how little we did relatively speaking at that time. That product was a big deal, that 3480 tape cartridge, with the cartridge capacity being a hundred megabytes. The kind of capacities that if you find a hundred-megabyte flash drive in your desk drawer you throw it out.

Yamashita: Hm, tapes are terabytes.

Schechtman: Yeah, in fact, it's very interesting, having a fair amount to do with the NSIC work, we raised the consciousness of the communities that, by gosh, tapes and hard drives really are in competition, and if you look closely, tapes are better for some applications and hard drives are better for some applications, and there were people trying to build companies and businesses where they weren't really going after the right application. I'm thinking, for example — can't remember the name of the company. They were based in Colorado, and I think it began with an "A," but they were intent on using hard drives, small diameter hard drives, for long-term archival stories, and they had to really go out of their way to make it even plausible, so they had to exercise the hard drives every so often because they were worried about which ones were still alive, which ones might've had heads sticking to surfaces and things like that. It was not a very natural marriage, but some guys have an idea, if you work hard enough at something you can probably make a bad idea work, but yeah. I particularly — we started helping the tape guys when we realized that they were being the subject of lots of commentary and speculation about tape being dead, when in fact they were quietly advancing their technology like mad at about the same rate of progress, of capacity or areal density, as what —

Yamashita: As the disk drives, huh?

Schechtman: Yeah, the disk drives had a really hot period in the second half of the ‘90s, where they were — products were doubling every year on areal density, and see, the tape guys, in fact, during that era, IBM and Fujifilm became kind of aware that it’s a useful thing to make the world be aware that tape is still advancing. So, they jointly did lab demos, but lab demos had become commonplace in the hard drive communities now. People leapfrogging each other with the latest high-areal density figures. The tape — except for IBM and Fujifilm collaborating on a couple of demonstration densities, that was not a common thing to practice in the tape drives. But the tape — I know we might get into that on some of the other questions — my answer, before being asked, is tape will be around for a long time, because there are some things it does better than anything else. You hear a lot of criticism of tape, but it’s coming from places where somebody has something to gain.

Yamashita: Right. Well, there’s various things being said about tapes. Maybe we’ll get into that later. Let’s talk about 1990s then. What were some of the things that you were doing then?

Schechtman: Okay. In the ‘80s is when we mostly got involved with building up the joint programs between research and the product development people.

Yamashita: You mentioned you were working with the product division, introducing the heads into Japan, for example.

Schechtman: Okay, okay, and then when we get into the early ‘90s we’ll also be talking about the formation of NSIC, I think.

Yamashita: Right, right.

Schechtman: Yeah, so the Japan thing was an example of IBM trying to act internally like the big company it was and trying to get one part of IBM storage activity collaborating with or taking direction from another part of IBM storage activity to kind of integrate the whole, but it turns out when you talk about the small diameter disk drives at 3 1/2 inch at a time, IBM was building those in its lab in Fujisawa, Japan, and I think that same number — <laughs> it’s interesting. I think that same number I was mentioning for the cartridge capacity in 1985 with the tape product the 100 megabytes, the one you were going to throw away from your drawer, this story about the Fujisawa use of the heads from San Jose or not, really relates to products, hard drive products that Fujisawa was building, I believe, at a similar capacity or similar density to what we were talking about with the tape. So, tape in ’84, ’85, was delivering a cartridge a volume capacity of 100 megabits, megabytes, and Fujisawa was building hard drives later in —

Yamashita: They’re all smaller form factor, right, that’s what they were focusing on back then?

Schechtman: Yeah, the 3-inch form factor. I'm just sort of trying to compare. In '84, when IBM's tape division went over to the new format, they were also taking — if we talked cartridge capacity, they were doing some tricks in there to get that up, like putting longer amounts of tape in and so on. If you don't talk about areal density you can get into trouble. I was just sitting here thinking that in 1992, '93, Fujisawa was building 3-inch diameter hard drives with capacities of 100 to 200, I believe, megabytes. Same ballpark, maybe a factor of two more than what tape was doing five, six, seven years earlier. So that's an indication that tape, you know, it was their market to lose, tape, because they were way ahead on areal density, if they were there at that capacity six or seven years before the small hard drives.

Yamashita: Everybody else, uh-huh.

Schechtman: Yeah, so that's an interesting thing to look at.

Yamashita: Well, Fujisawa was quite independent of all the other IBM storage division, right?

Schechtman: Yeah, and something changed —

Yamashita: They're doing their own thing.

Schechtman: Something changed about that. They changed the organizational structure so that Ray AbuZayyad[21], who was the head of the storage division in San Jose, basically they, on the organization chart it was a dotted line, but Fujisawa was now reporting to AbuZayyad.

Yamashita: Oh, I see. That was the change.

Schechtman: So — and the local people here in San Jose, I'm not even sure because I'm not aware of whether any of this occurred with respect to the disk itself or if it was only a head issue, but I was involved with the head issue. The head organization at the time, again, still swings up and back all the time. In the early '90s, the head organization in San Jose, I'm not talking about research now, I'm talking more about the product engineering and product manufacturing. The head organization became fully integrated, so one manager named Barbara Grant was given the whole thing.

Yamashita: The heads?

Schechtman: The whole heads thing, right, from development to manufacturing, and she and I knew each other pretty well. She had worked for me when I was a second-level — when I was a third-level manager, and she had worked in San Jose research as a second-level manager, and I was very impressed with her management skills, and she had a big problem getting San Jose and Fujisawa to work together on putting San Jose's product, MR heads, into Fujisawa's hard drives, and she basically asked me to leave research and take an assignment reporting to her to kind of be, the way she described it, kind

---

[21] Ray S. AbuZayyad; General Manager of San Jose IBM site in 1982, President of General Products Division in 1985, President of Storage Systems Division in 1990, General Manager of ADSTAR in 1991.

of be the account executive for Fujisawa representing Fujisawa's interests and being the — Fujisawa being the internal customer for the heads, San Jose product area being the internal supplier for the heads, and it wasn't going well. It had been going on for a year or two. AbuZayyad had ordered Fujisawa to use the MR heads, which were technically better, and would give the hard drives that they built an advantage, and Fujisawa had pretty comfortable relationship with Japanese vendors for earlier generation type heads, which were ferrite heads. They had —

Yamashita: Was it ferrite or thin film heads?[22]

Schechtman: They had thin film.

Yamashita: It must've been thin film.

Schechtman: It depends how far back you go. I guess if I say ferrite I'm going pretty far back. Course, the, I think the thin films — you're probably right.

Yamashita: Yeah, so TDK and Yamaha perhaps, and Alps?

Schechtman: And Alps was a big one.

Yamashita: They were the main [suppliers]?

Schechtman: Yeah.

Yamashita: Maybe not Yamaha. Alps and TDK were certainly their major vendors.

Schechtman: Those were the ones I remember being most often mentioned, and Fujisawa basically had the attitude, "This has been working really well all along. Why can't we just keep doing it?" and basically AbuZayyad told them they just have to do what San Jose says, in this case, and to stop, you know, whining about it, and Barbara knew that there was a lot of dissatisfaction on the part of Fujisawa, not so much on the specific parts we were delivering to them, although there were some issues with that as well, with the quality control, but more on just, you know, human nature. If you're told you have to do something and are forced to do it, you haven't maybe signed up really.

Yamashita: Relationship issues, huh?

Schechtman: Yeah, and of course, the — so she asked me to be their account executive, and there was a fellow over on assignment to the Fujisawa lab from San Jose named Murray Hill. I don't know if you knew him.

---

[22] [Interviewee's note] The evolution of head designs used in Fujisawa's hard disk drives followed the sequence of ferrite heads first, then ferrite MIG (metal in gap) heads, and then MR heads. They did not have products with thin film inductive heads.

Yamashita: I've heard the name, yes.

Schechtman: Yeah. So, he was — the Japanese can be very — what's the word? Very not telling you everything they dislike or, you know, very playing it close to the vest[23], and so Murray was — he was not part of the heads organization. He was really part of Fujisawa, but he and I had enough of relationship that when Fujisawa was telling me that something is okay or something is not okay, I would check with Murray to find out if he thought so also. But in the end, I feel very proud of how that came out, because with Murray's help — and there was a second-level manager in Fujisawa named Ino-san, and he, he finally came over. He crossed the bridge to realizing and accepting that Barry was over there to help them. <laughs> Not to be the enemy. I just — it was an exercise that was frustrating with how long it took for me, because I knew I was there to help them from the beginning, and when Barbara asked me to take the assignment, she said, "If you have any conflict with my heads organization here and have a different position about what we ought to be doing compared to what we are doing, you tell me and tell me who to march into my office from the manufacturing operation and tell me what you want me to tell them and I'll tell them," and she made good on that. We had three or four of these — over a period of maybe six or nine months — we had three or four of these escalation discussions where the head of slider fabrication, which puts the air bearing on the head, for example, was somebody I would disagree with based on quality control questions I had or based on could they ship the volumes? Fujisawa's, in some cases, just unhappy with the quantities they were getting. So we had three or four of these escalation meetings in Barbara's office and the guys in San Jose product engineering for the heads, when they saw every time I went in with them they lost, <laughs> they lost, and they figured it out that it was a stacked deck.

Yamashita: <laughs>

Schechtman: But —

Yamashita: Ultimately you succeeded.

Schechtman: Yeah, and it just had to do with them — with building the trust, and this was a great experience for me in terms of learning, even though it was inside IBM and my customers that I represented, but I had never had to deal with customers in the Japanese culture, and it was different enough that it was a great experience for me, and from the frequent trips I had to make over there I learned a little bit about Japanese life and this thing that we say so easily here, the Japanese really live it, like that the customer's always right and you're going to do what needs to be done for the customer. I had a — when I tell people about it, it's an amusing meeting, but when I was there it wasn't so amusing. I got — there was a first-level manager who was my point of contact with the Fujisawa lab. Oh, I can't get a name right now. I'm close to getting a name, <laughs> and he was my point of contact officially with Fujisawa, and I got ordered by him or just asked by him, but again, if you treat the customers the way the Japanese like to, being asked is enough. It's like an order. I got asked to go to a meeting that they held once a year. It was an IBM confidential meeting where they got all their suppliers in and they disclosed,

---

[23] Japanese are often accused of being "inscrutable" for not expressing clearly what they are thinking and being difficult to read (their thoughts).

IBM disclosed the plans for the next year in terms of the volumes and which products they're going to go into and what the specs are going to have to be on the heads, and they wanted each of the attending suppliers of heads that came to this meeting, it's all in one big room, they wanted each of them to kind of salute and say, "Yes, we want to participate in that plan. We want the business. Let's go forward together," and it turned out that way for us as well, coming from San Jose during —

Yamashita: Even though it's internal, <laughs> basically.

Schechtman: Yeah, that's right. But it also — it also, the meeting, when I got asked to go to the meeting, <pauses> I'm pausing because this guy, this manager's name that was my contact, was on the tip of my tongue and <laughs> I can't quite get it. This meeting had a Japanese name. It was a certain type of meeting that they had every year, and I had a couple of people who spoke Japanese in my group in San Jose, and I asked them, "What does this mean, the name of this meeting?" and the first gal didn't know. She hadn't heard of it, and the guy I asked, he said, "It literally means 'to confess guilt.'"

<laughter>

Schechtman: So, the customers in Japan were running meetings where basically the suppliers have to talk about how they fouled up and how they're going to do better next year, so —

Yamashita: I should know that word, but I don't remember myself. <laughs>

Schechtman: I — the guy who might remember it, you probably know him, because he went over from IBM to Hitachi GST. Yoshi or Yogi. Yoshi, I think.

Yamashita: Tadashi Yogi.

Schechtman: Tadashi Yogi. He was the guy in my group that told me what it meant[24].

Yamashita: I see. I should ask him then, yeah.

Schechtman: Even might be fun to just ask him.

Yamashita: I think —

Schechtman: If he remembers anything I'm talking about.

[24] Type of meeting referred to might have been "hansei-meeting" (反省会議) which nominally might be translated as "review meeting" or "post-mortem meeting", but in Japanese, the word "hansei" has much more deeper meaning, to honestly express regret for mistakes made, or things that had gone wrong for example, and provide path for doing better in the future.

Yamashita: I've been to these meetings myself, so I should know, but yes. Literally it's like what you say. <laughs>

Schechtman: Yeah, well, the other part of this is one time, at least when I got asked to go to this meeting, I had a little notice, a week or two's notice, and I had a written request, but I was going to visit Fujisawa about — for a 1 1/2 or 2-day visit every six weeks. That was my pattern, and usually I had — I think I got the name. It's <laughs> on the tip of my tongue. Something like Kakuta-san, K-A-K —

Yamashita: Kazuta?

Schechtman: No, I think K-A-K-U-T-A, Kakuta. It's pretty close to it anyway. <laughs> Now I'll be able to relax. <laughs> I — oh, yeah. But normally when I came, unless there was some special topic to discuss, I wouldn't interact with the senior management like Ino-san, but it turns out a period had been going not well with the delivery of San Jose heads to Fujisawa. This was one of these quantity issues, not quality issues, that you couldn't manufacture enough, and I didn't expect to have to explain it to anybody. I was just there at the working level to help the guys resolve issues, but I get told by somebody, "Follow me." They took me into a conference room and there was at that time a quite senior manager of the Tucson IBM site named Glenn Larnerd, and he was the main executive contact to the main customers for these small hard drives from Fujisawa. The main customers were Apple, and Apple, if you've dealt with them in these kind of contexts, they're very tough. They have guys who know their stuff and they ask good questions. <laughs> So I got marched into this room not having planned to go into any meeting, and in the room was sitting this IBM VP Glenn Larnerd and two first- or second-level managers from Apple wanting to beat me up about what's going wrong.

<laughter>

Schechtman: So that was not one of my most pleasant experiences. But when the Japanese are very demanding about something as a customer, they're usually trying to be nice about it when they communicate. The Apple guys weren't trying to be nice. It was culturally different.

Yamashita: I could see what that was like. <laughs>

Schechtman: Yeah, you can relate to it?

Yamashita: Yes. <laughs> So after this period of time, you start to get into the NSIC activity. Could you tell us how that got started?

Schechtman: Okay. I think I should tell you first some quick interim assignments I had, just because they kind of laid some groundwork —

Yamashita: Relate to — okay. Sure.

Schechtman: — some groundwork from being available to work with NSIC. There were three things that come to mind, actually. I think when I came back from sitting in as the fourth-level manager in ’89 or something like that, when my boss Heiner Sussner had taken a year sabbatical, and I had been a third-level manager, now I was temporarily a fourth-level manager. They didn’t quite know what to do with me. I didn’t have an actual —

Yamashita: Even though you were a fourth-level manager in —

Schechtman: Well, right.

Yamashita: — in practice.

Schechtman: Right. I was a fourth-level manager while this guy was on his leave, and he was coming back.

Yamashita: Oh, I see.

Schechtman: So, he took his fourth-level job back and they weren’t sure what to do with me. So, because my interests are pretty broad, they kept coming up — I think during that period from let’s say ’89 to ’94 or ’95, they must’ve come up with three or four assignments, special assignments.

Yamashita: These are the special assignments.

Schechtman: Yeah. Lab director at Almaden research was Juri Matisoo and he — they needed to have somebody coordinate a liaison between IBM San Jose research and Lexmark, which was a spinoff company from IBM —

Yamashita: The printer.

Schechtman: — to get into printing, and based in Kentucky. So, they wanted me to manage that relationship. There was a group called Storage Manufacturing Research, which I found very interesting, but they had — they were a small group with a dotted-line management responsibility to a more senior person in Yorktown Heights. There’s one more thing that maybe I can’t think of right now, but I basically was given a potpourri of assignments, and it’s a little frustrating because you can’t get very good at any one of them when you’re splitting your time that much, so — Oh, yeah. I remember, another one I was given. So, IBM, in addition to forcing sites like Fujisawa to use the San Jose heads, they had major production capability of the previous generation thin film inductive heads, and they wanted to find customers for those heads. They wanted to sell them as components they weren’t going to use anymore in IBM drives, and I got asked to manage — these were all challenging assignments, actually, but they were kind of fun too. I got asked to manage the relationship between IBM’s heads organization and Conner Peripherals hard drive, and I think somewhere in there, there must be something that you were familiar with from KOMAG, because — or maybe it's just that the guy I'm thinking of is Keith Gooodson.

Yamashita: Keith Goodson.

Schechtman: Yeah.

Yamashita: He was at ReadRite at one time then.

Schechtman: Okay. He was the one who I had a deal with at the time with Conner.

Yamashita: Oh, I see.

Schechtman: Yeah and other stuff?

Yamashita: Yeah, he moved around from maybe there to he was at —

Schechtman: He was at Western Digital at one point.

Yamashita: Western Digital also, yeah. Or he managed the media operation for Western Digital.

Schechtman: Right, right. And in the context of my assignment to help San Jose sell heads to Conner, he was working for Conner as the customer for the heads at that time.

Yamashita: I see.

Schechtman: And I remember the dates pretty well on that one because the meetings I was going to and we were discussing specs of the heads and quantities were attended by some pretty senior people. Conner, I guess, had merged with Seagate at that point.

Yamashita: I see.

Schechtman: And the Seagate President, Bill Watkins — So the point I'm wanting to make is that there were people who cared about contractual relationships there and lawyers and stuff like that. It wasn't purely technical meetings. And Chris Bajorek was representing IBM at these senior meetings and I was doing the technical work and the liaison work down at one first and second level management of making sure that the heads organization was able to deliver on what Conner wanted. And Bill Watkins, I don't know if you know him, he has a, let me say a bombastic personality.

Yamashita: <laughs>

Schechtman: And so does Chris Bajorek at times, so it was kind of an interesting room. And we had a number of times where we postponed continuing the meeting because we got into fights. I shouldn't say "we" because I was just quiet in these meetings. And one time, one time the fight was really a big explosion and it looked like IBM, you know, Watkins, Watkins walked out of the room. Just turned his back and walked out of the room. "I'm not going to deal with you guys anymore. You're wasting my time," and so on, pounding on the table. And so, <laughs> and Chris, Chris Bajorek was my immediate manager at that point. I didn't manage a group or I just had these mini staff assignments. And I called Chris at home that night and I said, "Chris, I have this offer to be Executive Director of NSIC and I have the feeling if I don't take that that I don't have any other jobs anymore. <laughs> Because I think I kind of got dismissed by Watkins." So, Chris, I had asked him several times, you know, could I be on his books as an IBM employee on leave and leave of absence and do the NSIC job for a while. And he had been resisting. You know, he didn't want to use me for that. And he kept saying, "I'll come up with something for you. I'll come up with a good assignment." But practically speaking, he was too busy to even spend much time worrying about it. So, it was Halloween. It was October 31st that this happened when Watkins stormed out of the room. And I had had several discussions with Chris about going to NSIC and he always said, "Just wait. Just wait." So, I tried to push one more time on the same evening that we two hours ago had broken up the meeting and he said, "All right, show me some paperwork. We'll discuss it." And from that point on Chris was supportive of my going to NSIC. So, you can see, there's a lot of backstory here.

<laughter>

Yamashita: I see. I didn't know. I never heard that story before. I think I read that —

Schechtman: And I don't know after I went to NSIC if Conner and IBM San Jose resumed the relationship and the discussion about buying heads. I don't know what happened after that.

Yamashita: I do remember that IBM was trying to sell heads and I don't remember now whether anything came of that.

Schechtman: I don't know. I was — I don't know if there was anybody else besides me in IBM working on the problem. As I recall now, I wasn't trying to do it in general in the abstract, but maybe we were trying to use Conner as a pilot case. If we could work that out then we could maybe go on to others. But I think you're right. There's nothing I can point to. And as soon as I started my NISC leave, I wasn't being exposed to IBM confidential information anymore, so I never found out what happened.

Yamashita: I see. So, who in NSIC?, NSIC already existed at the time, obviously. So how did they recruit you?

Schechtman: It came about almost by happenstance or by coincidence. Tom Howell, who again, there's always a little back history here <laughs> to put it in context. Tom had tried to leave IBM for another company a few years earlier — I'm not — Probably.

Yamashita: Is this for Quantum or something before that?

Schechtman: I'm not aware of who it was. I never found out who it was. But he put in a resignation letter and I felt he had used dirty tactics a little bit because he and I had discussed it once and I assured him we really valued his contributions and I might have even arranged for a bigger raise or something like that and he — and I had talked him out of leaving at that point. And then I was on a trip in fact to Fujisawa for a few days and a second resignation letter came in.

Yamashita: Oh. And he went to Quantum.

Schechtman: That's when he went to Quantum. And obviously, he didn't want me to have the opportunity to talk about it, I guess. <laughs> So he did it while I was 6,000 miles away. So, so I was unhappy about that, but he and I didn't speak about it and we just let it go — let it go. Then a few years later in '94, the Intermag Conference was in Albuquerque and Tom and I ran into each other in the cafeteria or wherever the meeting was and I asked him, "Are you with anybody for lunch?" He asked me and neither of us was with anybody, so we decided to sit together at lunch. So, I didn't bring up the sore point of him <laughs> having bailed out during my absence but I asked him, "You've been at Quantum for a while now. How do you like it?" And he actually misunderstood why I was asking. I was asking because I wanted him if he had things to share about how Quantum manages people better than IBM or something like that, I was hoping to learn from it. In fact, I explicitly asked him, "What do you like better about Quantum than you did at IBM? And are there stuff that you like about IBM better than Quantum?" And you know, he answered. He was open. But then a light bulb went on for him and he assumed that I was thinking about leaving IBM because I asked. And I wasn't. <laughs> I was pretty happy at IBM at that stage. And so, he said, "If you're thinking about leaving IBM, they've been looking for an Executive Director [of NSIC] for some time and you would be a great match for that job." And I knew very little about NSIC at that stage, so it planted the seed in my mind. And then either that night or the next day or that night they had a conference banquet and it was a horrible situation for the banquet because it was pouring, and we were under pop up tents and we didn't have shelter except where the mud was. So it turns out I worked my way around, so there was a buffet, a barbecue buffet, I worked my way around to talk to Denis Mee, because I knew that Denis, I knew Denis pretty well and I knew that Denis knew a lot more than I did about NSIC and how NSIC was running. And I asked Denis — They got my predecessor, you know, John Simonds at NSIC really wanted to get out of his job and I asked Denis, "Do you think I should consider taking this job? Because if I say yes, they're going to grab me and it's going to be a done deal." And we talked in the splattering mud and Denis said, "Yeah." If it sounds interesting to me, he thought I could do it pretty well. And that's, I think he called John Simonds because John Simonds showed up in my office on the IBM plant site the next day. He flew up from San Diego.

Yamashita: Just for this purpose?

Schechtman: Yeah. He had been trying to get out of the job of Executive Director for two years.

Yamashita: <laughs> Oh, I see.

Schechtman: And he finally —

Yamashita: There was his chance. <laughs>

Schechtman: — finally had a candidate. So, yeah, <laughs> he actually came in. He didn't worry about disrupting my calendar. He just sat in the visitor chair in my office telling me all about NSIC till I didn't want to hear anymore. So, at that stage I was kind of excited about doing the job. And so, so then my role was to go back to Chris Bajorek and really this time convince him to let me go. And we worked out the deal where I was on leave of absence from IBM and the HR people insisted that I do that leave of absence one year at a time or they didn't want to grant a multi-year on leave. And then after three of those one year extensions of the leave of absence, I reached the age for being able to take my retirement and that was my main point of staying on the NSIC [IBM] books to get to that point — Of staying on the IBM books. So, yeah, after that NSIC was my full-time job as soon as —

Yamashita: Were you under IBM payroll also at the time?

Schechtman: No.

Yamashita: Oh, no?

Schechtman: Yes and no. I was on their books so I looked like an employee but there was no pay involved. NSIC made me a — John. <laughs> I wonder how much he would have gone for if I pushed. He made me an offer that was okay. I think I asked that I be making the same salary as I was making at IBM and there was some difference in the benefits. But he made me the offer.

Yamashita: Well, at least you had the IBM retirement.

Schechtman: Right.

Yamashita: Here so you made that, so that was a good deal for you.

Schechtman: Right. And John having come from a large company, Kodak, he was pretty familiar with their benefits for their employees, so he actually gave the NSIC employees before I got there pretty decent benefits too.

Yamashita: So, you joined NSIC about four years later after it got started.

Schechtman: Four or five years later.

Yamashita: But so maybe still talk about what was the inception, the reason for why the NSIC got started.

Schechtman: Okay.

Yamashita: And how did that come about?

Schechtman: Okay. An important part of the answer to that has to do with the success the industry had during the eighties in establishing some research centers first at the universities. I mean, there were the two main ones at CMU [Carnegie Mellon University] and UCSD [University of California San Diego], but there's another four, five, six small ones all relating to storage or trying to relate to storage. The centers established at first in the eighties are kind of a mixed bag in terms of how satisfied or not the industry people are with them. So, for example, they really liked the idea for being able to access students who come out of the university program with some knowledge and some training related to storage so they can get up to speed pretty quickly. At the same time, the way the university centers, the main ones, were operating, yes, the industry sponsors could come and hear student presentations on studies they were doing, but there wasn't a real close coupling between the desires of the industrial people and the topics they wanted to dig deep in. There wasn't a real correlation between that and the centers. You know, the centers support the faculty. The faculty have generally an idea, a good idea, of worthwhile work to do and good quality work to do, but there wasn't the sense of hands on connection between the sponsors and the research being done. There were some exceptions, but so my understanding was that the key industry people from the larger companies were quite satisfied with the university centers in the eighties such as they were, but they thought there was now that they were established and the professors were all I think pretty much tenured professors, I think the feeling got built up that we could use that as an existing structure to start from and do even more with them. And one of the areas to do more in was to make more concrete connections between the industry needs and the student research. And another area to do more in mostly came up by comparison to the semiconductor industry and Denis Mee was very much part of that, was that the semiconductor people had gotten tremendous amounts of government money to support their joint activities to the extent of having built two sites, SRC in North Carolina, Semiconductor Research Corporation, with their own building and everything, their own staff, and that was kind of the research oriented part for the semiconductors; and the other one was SEMATECH. It was based in Texas, I believe, and has more recently expanded, which is the manufacturing issues of the semiconductors. And they got huge sums of money and the storage people were wondering how do we get some government money into storage. I don't think anybody expected dollars in the amount that the semiconductor folks get, but something more than these little bits and pieces. So these deliberations were going on in 1989 and '90 and in the meantime, the Department of Commerce under NIST said it was in the process of setting up a program called ATP, the Advanced Technology Program, which was going to be aimed specifically at commercializable results and what results where you wouldn't get them without additional investment, that the additional investment would be necessary, and yet the investment would have to be matched. The government would pay for 50 percent and the sponsors would pay for 50 percent. And there was a whole infrastructure about to be set up, but the storage companies were a little bit early, so, you know, they had their existing centers and they didn't move on. They were a little bit early and a little bit late and they didn't move on yet to the next step. And while these discussions were going on, ATP became law. Congress passed the ATP Creation Act. But it was very unfinished business to put structure into it and rules and how people were going to pay for what and what kind of proposals you have to. So basically, I'm not sure, I think John Simonds, my predecessor as Director of NSIC, was instrumental in connecting with a particular guy in the ATP program, George Somebody[25], I haven't met

[25] [interviewee's note] George Uriano directed the ATP program from its establishment by Congress in 1988 until his retirement in 1995.

him. And I think John Simonds helped see a white paper get developed for why storage is so critical to the country and how much more is left to still be done in storage in terms of advancing the technology. And so, they got a white paper submitted and we put together a quick infrastructure for how the companies and the universities would all relate under an ATP project. The government had very specific rules that needed to be followed. But in the government, it's almost like you comply with the rules and you worry about the details later, but you did the big stuff first. So, the people who were in the original meetings and it was obviously Kodak and John Simonds and IBM and a few others, I'm not sure exactly who. They basically were ready to go. They put two project proposals together and they asked the ATP people, "Where do we have you send the check?" And that's what they wanted to know. They wanted to know if we have an organization and they can send the check. And as it turned out, the two projects were totally reasonable projects. One was to move to the next stage of MR heads, the GMR heads, totally different structures than the original MR heads, and to try to get everybody working together on those. And then there was more for the optical storage community, a project on creating blue laser light by frequency doubling red laser light. And the GMR heads project was very successful to the point of the people moved on after that to discuss different topics, you know, after that phase of the NSIC activity because everybody was already succeeding in putting GMR heads in their products not very long after the concept was first published, 2-1/2 years I'd say after the concept was published. There was one that the outside world was ready to receive the technology quickly. The other one with the blue light, there was clearly a need for blue light to move on to the next generation of optical disk density, but there was a lot of active programs, a couple at universities and a couple at companies, to create blue light more directly by making the semiconductor diode structure of different dimensions and different materials. So, it compared, to essentially work like a normal LED, but to move all the dimensions in the specs to the blue part of the spectrum. And these other activities, there was a company called Cree, C-R-E-E. There was another company, I can't remember their name right now. And there was a researcher at the — a researcher from a company in Japan that came here and got a faculty position to continue that work at UC Santa Barbara[26]. And those activities, especially the guy at Santa Barbara, basically made progress faster than our frequency doubling effort in the NIST program, the ATP program. So, we succeeded in generating blue light but if people could invest and grow the semiconductor structures to give you directly blue light emitting diodes, then it was a much simpler approach. You just slapped two electrodes on it and figured out a blue light source. And that's now, you've seen that in a lot of places now, that they were being produced in high volume.

Yamashita: How about the other sources of funding? DARPA?

Schechtman: Right.

Yamashita: How did that come about?

[26] Shuji Nakamura, joined University of California, Santa Barbara after leaving Nichia Corporation in 1999. Nobel Prize winner in Physics in 2014 for the invention of blue light emitting diodes with Isamu Akasaki and Hiroshi Amano.

Schechtman: So, so my impression is that in most cases other than ATP, ATP tried to be extremely clean about this and to treat everybody equally, everybody has an equal chance, but in most other cases, including the NSIC ones that I'm aware of, it was required almost like we talked about Fujisawa and developing the relationship with the contract people in places like DARPA, it was important to develop the relationship between the researcher, the expected researchers and the contract managers that had the money in DARPA. And my sense is that you have to have that relationship sort of be present as an ongoing thing so that all of a sudden some event happens and one of the contract managers has money to spend and very similar to ATP asking where do we send the check, you got to be ready with proposals. Now and the ones you asked about, the two holographic proposals that were already funded and just about getting started in terms of work when I joined NSIC in early '95, were the two holographic one They basically split the problem into a material science problem with materials people working on the materials needed for the holographic storage and that was called PRISM [PhotoRefractive Information Storage Materials] and then another project called HDSS [Holographic Data Storage Systems] to put all of systems together.

Yamashita: So, you managed the PRISM and the HDSS?

Schechtman: Yeah. It was up and running. I mean, I took over from John Simonds and it basically became part of the NSIC portfolio.

Yamashita: Now how about the disk drive side?

Schechtman: Right. So, we had somehow, again, the general point I want to make is that it was important to have ongoing relationships with the contract managers in the government agencies. So in the case of hard disk drives, NSIC got used to thinking about the topical areas for hard disk drives as five different areas, you know, heads, media, head media interface, signal processing its channel and whatever, one other I'm leaving out[27], but there were five, basically. And we were covering the heads aspect pretty much with the ATP program so there were I think three or four others that needed coverage and DARPA, I'm not sure who on our side made the connection, but around 1994, DARPA had some money to spend. It's a little strange how these things operate. The money came in a category or a bucket that was supposed to support research for display technology like flat screens. Somehow the guy who had access to the money didn't have proposals in hand or good ideas to spend the money on and somebody on our side, I'm guessing it could have been Mark Kryder[28], but I'm not sure, somebody said, "We could put together a proposal on advancing hard drive technology. And by the way, that's going to be crucial to future storage and to the military and DARPA cares a lot about the military one." So we were, it was more a matter of timing. We were there. We had already — We had already generated this white paper on storage which we could take out of the drawer and submit. And we basically got the funding for

---

[27] [Interviewee's note] The additional topical area was servo and track following.

[28] [Interviewee's note] Mark Kryder was a professor at Carnegie Mellon University (CMU) who was the director of CMU's Data Storage Systems Center, which became the largest of the industry supported data storage university centers. He played a significant role in connecting the INSIC industry community with the government funding agencies. In the 1998-2010 period, Kryder was the technical director of INSIC's Extremely High Density Recording (EHDR) program, which was a follow on to the UHDR program.

the program we called UHDR, Ultra High-Density Recording, from this guy who had money for display technology. And the first year or so that I was there was the first year that NSIC was running that project for DARPA at UHDR and we only saw that contract manager once where I would have expected to see somebody maybe quarterly. And he didn't seem all that interested in the details of what we were doing.

Yamashita: But the money was substantial, so.

Schechtman: The money was substantial and it persisted for two or three years. The renewals we had, I mean, the other good thing about the government contracts is if you do a good job on setting them up with the initial proposal, then from a technical point of view you make certain amounts of progress and you reach milestones and then you've already defined what the next round is going to be like and the renewal process is pretty uneventful and smooth. Whereas with something like ATP starting a new research program there's a lot — the startup phase involves a lot of overhead at least because of having to deal with how you're going to handle IP and stuff like that.

Yamashita: As funding goes, so from the Department of Commerce is for research, is that unusual or is that just —?

Schechtman: I think it was unusual then. The mission statement of the ATP program, I think I have it almost verbatim, is to enhance the competitiveness, or maybe it says to enhance the worldwide competitiveness, of the digital data storage technology with emphasis on the U.S. in the case of the Department of Commerce. In fact, later on we got to where we were including some foreign companies on not on new proposals but on ongoing ATP projects and we had to go through a little bit of extra bureaucracy to deal with that. The trouble with ATP is, and you go up to NIST and then the Department of Commerce and then you're at the Cabinet level, the Secretary of Commerce, it's pretty political, that whole environment. And for whatever reasons, the ATP was first implemented in the early nineties under Clinton, under Bill Clinton, and he and his supporting people were very positive about ATP and they created the whole thing and they funded it at first. But it was very, it caused a lot of detraction from the Republican community and they said things like, "The government —" Well, this is probably under the umbrella of, "Big government is no good. Make government smaller," and so on, which tends to be a Republican theme. They came back and said, "This is not what we should be spending government funds on because we're getting these proposals and we're deciding who to fund so we're picking winners and losers and we should let the marketplace do that." So I guess Clinton was in office until — Well, I guess the Congress — I think Clinton got elected in '92 but then two years later in '94, Congress swapped and was more heavily Republican and they actually — It's just like what's happening with Obamacare now. They actually wanted to kill ATP and there was a lot of attention and energy in the Congress on killing ATP. And it took them — You know, ATP had done some startup and had funded 100 or 200 projects. They spent quite a bit of money and now it was all going to be undone.

Yamashita: But it took a while.

Schechtman: Yeah. Well, we felt the impact of it because as late as — It did take a while, but as late as 19 — late 1990s, 1995-97 or '98, we were still getting new proposals funded, but by '99 and 2000, we had what I thought was a terrific new proposal on holographic storage and ATP didn't want to hear about it anymore. And the reality was, I mean, they put in criticisms about why they're not funding it, but the reality was they weren't going to be funding anything because Congress was killing the program. So, they did like with the HAMR [Heat-Assited Magnetic Recording] program, I think we first got our funding as a five-year program in 2001. So, they actually kept renewing. That's one thing about government, it's contractual. You get it nailed down and just you got it for the next five years.

Yamashita: Then you could keep going for a little while.

Schechtman: Excuse me?

Yamashita: No. So, kind of changing the topic a little bit.

Schechtman: Oh, okay.

Yamashita: But IBM played obviously a very big part in getting the NSIC going. And could you talk about what was their motivation for doing this?

Schechtman: Okay. And I would talk from a perspective, again, not having been part of the startup process for NSIC, I talk about this from a perspective of my insights from how IBM works from my years there. But IBM has always been a company among technology companies that likes to push as much as possible to get university help and university involvement on topics of interest. Typically, there's not a direct connection between a product area and what the universities are doing, but IBM likes to be part of the discussion of choosing areas that are generically likely to be of use. Now that's, I just said that I could apply it to other parts of IBM, not just storage. That's sort of the way they operate. And in fact, for reasons I'm not sure how, how or why this happened, a lot of the money they spend on universities, they spend by the overseas arm of IBM which has most of their activity in Europe. And but there are all sorts of — Well, IBM has a pretty active program of bringing post-doctoral people over to work in the labs here one year or two years, San Jose, Yorktown and so on. So, there's always been the history of close ties to the university. Sometimes it's a marketing motive underlying. In general, it's a marketing motive of where they want to develop relationships with key professors and institute heads in places in Europe, for example, where they will vote positively for acquiring new IBM equipment and stuff like that. It's almost like lobbying. But having said that, from an NSIC point of view I would say if IBM probably has the attitude if they're well enough staffed technically that if they support some stuff with other companies, even with their competitors, they, IBM, will be in a position to get at least their fair share out of the results, maybe even more than their fair share because they have so many technical people to interact with the university work. So I think there's that underlying thing that — And in fact, in the NSIC programs, the ones we organized ourselves that didn't have the constraints of the government like ATP, but the ones like EHDR [Extremely High Desity Recording], in those programs we encouraged the professors doing their work to publish and the only constraint is that they present the results in one quarterly meeting before they publish it. And a company like IBM and some of the others in order to benefit from EHDR, they have to be closely enough engaged with the people doing the research in the universities that they are ready to take advantage of the results and are ready to give feedback and give direction for the next quarter of what’s worth doing. So, I think IBM correctly so I would say judged that we can share the risk of the new technology and not be owned by us and we can share the ability to license it to each other as long as we stay scientifically engaged with the university work and influence it as best we can. And I think that's a judgment they make consciously, and I think it mostly works for them. So also, like, in EHDR, we did not provide for intellectual property. We just let everybody publish. And again, those who can run with the results and turn them into something are the ones that will get the best benefit. So, so in a way, even without government money, IBM probably was very well positioned at the start of NSIC to get the benefits of it, at least as much as any of their competitors.

Yamashita: Well, they were well vested in centers also, right?

Schechtman: Right.

Yamashita: Having provided a lot of funding to CMRR in San Diego.

Schechtman: That's right.

Yamashita: Or the other one, Professor Bogy's[29] lab in Berkeley.

Schechtman: That one and CMU.

Yamashita: CMU, so.

Schechtman: That's right. And they did get — IBM and the other sponsored companies did get what they expected out of it and NSIC became a way to just get more, given the —

Yamashita: More participation.

Schechtman: More participation and more coupling from the sponsors almost to the point, like in EHDR, we're not paying the overhead of the universities but we're giving direction to the graduate students who are working for world's best scientists in that field and all the IBM or the other company people have to do is, and it's not trivial, they don't do this easily, is to spend enough money to support one of their own in-house people to interact with it all. That's the way they get the leverage.

Yamashita: So that was a strategy. It was a correct one because it benefitted not only them but a lot of other companies as well, so.

Schechtman: Yeah. And it was interesting to me, being somebody inside IBM, that I vaguely knew a little bit about NSIC but they kept it fairly partitioned away from all their other IBM stuff. And I think they made a conscious decision —

---

[29] [Interviewee's note] David B. Bogy, University of California, Berkeley Mechanical Engineering Department established CML, the Computer Mechanics Laboratory, as an industry sponsored university storage center.

Yamashita: To do it that way.

Schechtman: Yeah, to do it that way. And when they participated to participate with pieces of the research that wouldn't necessarily expose too much of IBM's secrets. Like for example, in the heads area, do you know Mason Williams maybe? He did a lot of modeling for NSIC for the GMR heads program, but only modeling. IBM never let the other companies get some of their parts to do characterization on. So, it was reasonably well thought out. And I think another thing is to get, and this applies to all of them but I think IBM did it pretty well, is to pick not a lot of numbers of people but a very few but very precisely defined people who are just right in the combination of skills. They understand the technology. They can mix it up in discussions with their competitors in the room. But they don't — they have good enough judgment to know what not to talk about. So, and Mason was an example of somebody like that.

Yamashita: I see. Can you talk about some of the early issues with NSIC, you know, some of the difficulties that you had getting companies on board? I mean, you were doing a lot of recruiting, too, trying to get companies to come on board, things of that sort.

Schechtman: Yeah. Once we got past some of the government programs where the funding came pretty heavily to the tune of 50 percent, now we were leaning towards models of how the program should be structured more like the EHDR example, where see in the government funded work, even the universities had to come up with their match of 50 percent. Now we kind of worked, we legally worked around that by the companies giving more than their 50 percent and giving the credit for the extra money they donated to the universities, so the universities didn't have to actually come up with extra dollars. But the best way to take advantage of NSIC being formed and the people — The people went through a pretty good two or three-year learning process from '91 to '94 of sitting in the same room with their competitors and working together. It didn't come so naturally. And for example, a company like Kodak coming from the chemical industry, they believe in trade secrets, not so much in cross-licensing. That's typical of the chemical industry. So, they don't —They have more resistance do doing things with their competitors. They would love being in a project where they're the only ones generating the materials and all the other companies are the potential users of the material and can evaluate their samples and so on. That would be from a Kodak or a DuPont perspective kind of an ideal configuration. And we approached that a little bit in the Tape program where we have the drive companies there and all the media companies competing for their attention. But going back to us recruiting NSIC membership, I think especially after I left NSIC in terms of being the Executive Director, I left in '99 and up until that point — I'm losing track on what I was going to say about this.

Yamashita: How many companies were —

Schechtman: Yeah.

Yamashita: I mean, you brought in many, many companies yourself, but —

Schechtman: Yeah, I did, and most of them in the context of being interested in one of the programs or another one of the programs. If they were very small companies they were hoping to end up with some funding. The big companies were kind of mixed on whether they wanted the government funding or not because if you take it there's all sorts of extra overhead and accounting stuff you have to do and some of them felt it wasn't worth it. But yeah, to make NSIC operate well in a business model without government money because we were trying to figure out how to do that, the more sponsors, the better and we had I think to the very end, NSIC had a tier structure depending on the amount of revenue from storage the company had. There were, like, three tiers of membership fees and that determined how much you had to put in and also, it defined how many people you could send to the technical review meetings. They were one, two and three, something like that.

Yamashita: A lot of the structure was decided by the board of the NSIC, right?

Schechtman: Yeah.

Yamashita: So how easy was it or difficult was it for you to, you know, get the board on board, I should say, or, you know, to get anything done?

Schechtman: It was actually, once we had gone through a few proposals and a few iterations on it, we were starting to become kind of better at it, what I found was working in the first place, NSIC's interests were kind of portioned from one technology to the next, so the same sponsor, I think mostly the same sponsors or a given company might put money into hard drive stuff but wouldn't put money into tape or vice versa. They were the enemy, in a way, the other guys. So within if you compartmentalize, let's say we want to get more companies added so we can strengthen our hard drive technology activities, I found NSIC was having enough success that I found if I can get one or two senior people to stand up and say, "This is going to work well. We would like to do it," then after one or two, numbers three, four, five came much more easily because pretty soon you get into a regime of the sponsors thinking or the potential sponsors thinking, "If some good stuff's going to come out of this we don't want to be left behind," so. And the more companies that joined, the more results you get per sponsor dollar because the pool grows. So I think, so in the example of hard drives and EHDR, I remember we have a picture of a meeting that was hosted by Ken Lee at Quantum at the time where we had most of the senior people we were working with or wanted to work with in hard drive technology and the two that kind of stuck their necks out and said, "Let's do this" were Ken Lee, himself, from Quantum; and at the time there had been a shuffle at IBM of who was CTO and who was responsible for what and Chris Bajorek had been, but Bob Scranton had that position. So, Bob Scranton — well, Ken Lee said, “Let’s do it.” I remember the meeting pretty clearly. In fact, the picture we have I think it must have been inside Quantum, but I don’t know the inside of Quantum very well. It had a spiral staircase and people were standing around it on different steps. So, Ken Lee said, “Let’s do it,” and Bob Scranton said, “We waste too much time and energy with negotiating and contractually writing down the IP rights. So, let’s come up with as easy a process to write down and to use for IP as we can do and minimize the lawyer stuff and all of that.” So, it was Scranton who said, “Let’s just encourage all of the professors to publish,” and again, like I was saying a few minutes ago, we had the feeling that the bigger company sponsors, sponsors who could assign their people to go to NSIC meetings and get the most out of them, would benefit the most. If everybody published, the NSIC sponsors would have a one-quarter lead on seeing the results before his stuff gets published, and he also will have had direct influence on the researchers including some projects where they actually collaborated with the researchers. They may have had samples from a company, and they were going to try out a new measurement technology or something. So, yes, I think — and then on the other hand, if they use — so, once Ken and Tom [Bob Scranton] stuck their necks out, NSIC wrote down the IP policy of the EHDR program in one short paragraph, five or ten lines, and basically, we had to do something. I wouldn't say it was not legitimate, but I would say maybe it was a little bit in a gray area, and what I'm talking about I'm willing to be documented on this since we are recording. What I'm talking about is the faculty members who we valued very highly for being the best at what they do and we had selected them for doing the research, they were under attention from NSIC to publish and from their university development offices to patent, and most of the people we were dealing with didn't care much about the faculty people. A few exceptions, but most of the people didn't care about patenting. They were perfectly happy to do the work and get it published in peer-reviewed journals. So, basically, NSIC's policy was playing into the strengths of what the faculty guys wanted anyway and so they didn't resist. But we put them a little bit at a risk because their contracts office and IP office, especially for aggressive universities like Berkeley and Harvard and Stanford, they make a business out of going and getting patent licenses. For most of them, everything was okay as far as the professors went but we didn't publish licenses very much so there were not too many grumbles from the contract offices. But we were undermining their efforts. All we did in the end to implement the policy was when we decided on a researcher at a university to fund, we had them sign and send back to NSIC a four- or five-line paragraph that said, "I am aware that it's the strong preference of the sponsors that the results of this work be published rather than patented," and —

Yamashita: That was sufficient <laughs>.

Schechtman: Yes, it was sufficient because I was very confident from the beginning that that would work because it's playing into them wanting to publish. We're all on the same side and the guys in the patent's office are on the other side, in a way, and we basically — they had a reasonable level of fear that if they didn't go along with this there wouldn't be money coming for other projects in the future. Now, the reason the university's contracts' offices were unhappy, one, we talked about already that they wouldn't get the IP ownership. But the second one is they wouldn't get overhead. They wanted us to treat the projects as contracts and there would be sometimes 50, 60 percent overhead from the big universities on contracts and we said, "This is not a contract. We're not requiring any deliverables. This is a gift. It's a gift to the group of Neal Bertram's because we like what they're doing, and we don't expect anything in return in any —" That's what's documented in the written stuff.

Yamashita: But the reality is that the NSIC had a very big influence on what they did.

Schechtman: That's why I say we were kind of in a gray area. We didn't expect contractual deliverables yet we didn't pay for them to cover their —

Yamashita: For the contract.

Schechtman: Yes, to cover their piece of salary, and the student's salary, and so on.

Yamashita: Well, for the participating companies it was a pretty good deal because we could see that you could get a great deal for the value of that money you put in.

Schechtman: Yes, and Paul Frank had some charts he used from time to time. He developed some very nice charts that basically showed how much leverage there was in sharing the risk and sharing the cost.

Yamashita: It was very successful for all of these very competitive companies to come along and actually try and force us.

Schechtman: Yes, and it's even more dramatic than what happened in the tape program, in the tape industry, because there we had exactly the case of the drive companies that wanted to integrate the technology hearing in the same meeting from the media companies in the tape business and media companies are basically chemical companies, and I mentioned before that traditionally IP is handled by chemical companies by keeping things secret not by cross-licensing, and the fact that we had three or four or five of the drive makers in tape in the room and three or four or five media suppliers and it was even finer than that. There were substrate suppliers and there were particle suppliers. The media suppliers were — they had to break with their history and they couldn't say, "We're not going to share any secrets." If they wanted to take advantage of being in the room and giving direction to the research or having their samples evaluated and getting a fair report back, they basically couldn't afford to not be at the meetings.

Yamashita: But they had to be open also.

Schechtman: Yes. So, what we did with the tape program is when we wanted to get the companies in, especially the materials companies, we invited them to one quarterly meeting and so they could see the process from start to finish. They would sit in on the director's part of the quarterly meeting where we'd make comments privately from the researchers on how we thought the progress was and do we want to steer the project in another direction and so on where they asked this professor to provide these samples so that this guy can measure the polymer characteristics, and so on. So, yes, I think it worked pretty well. The trouble with the tape industry, maybe hard drives eventually also, was in hard drives, in EHDR, we had enough of a critical mass of sponsors that we could divide them up into the five topical areas. You know, heads of media, and channels, and so on, and we could assign a research person from one of the companies to head each of the five topical areas and that was really a way to ensure that there was this close coupling between the company's interest and what the universities were working on. But in tape, we never reached the critical mass. We wanted to create a similarfive groups, but we would've only had one person per group. We would not have had a team from industry, and it had some good things and some bad things. It meant when we had our general discussions of which is making the most progress and where do we have to invest a little more. We had the whole team of sponsor organizations and their technical people all in the room at the same time, and hearing the same messages and influencing it. But we didn't have an ability to turn each of those technical topics into a team effort where we could fund three or four things at three or four universities the way we could in EHDR.

Yamashita: So, during your tenure, the NSIC becomes or was it backward? INSIC becomes NSIC[30].

Schechtman: It was after. Yes.

Yamashita: Can you talk about that change? What caused it?

Schechtman: Yes. Right. It occurred in 2002. So, Paul Frank had been at NSIC for about two years. So, we have to start by recalling that the earliest projects had government funding and were concerned either about US competitiveness economically or military developments in the case of holographic storage, and if that was our starting point — let me think.

Yamashita: You had a company like IBM very concerned about Japanese participation for example. So, there were a lot of reasons for trying to keep that all domestic.

Schechtman: Yes. So, I think the simplest way to answer the question is the way NSIC was structured it became apparent that — well, two things became apparent. First, the domestic progress motivation for keeping it US really wasn't where the companies were coming from. Yes, they liked the idea of getting the money but no they didn't like the idea — there are two factors. They didn't like the idea of having to work on whatever. They didn't want to behave like a university researcher who will totally steer their project directions depending on where the funding's coming from. The companies in the storage business knew where they wanted help technically and trying to couple it to government money had a positive aspect because if you succeed in getting government money you can get some pretty big dollars. But it had a negative aspect in that it really constrains and restricts what you aim to work at. So, instead, the big companies, in particular, HP and IBM but particularly HP started complaining about, "It's not worth getting the government money. It's too much overhead with it. It's too many reports," and so on, and they didn't say where the extra money was going to come from if we cut off the government money, but they said they wanted us to evolve over time into much less dependency on government money, and so we still got one or two government projects funded after that point. But if you look by the 2002 timeframe when we made this decision to open-up internationally, if you look then we had already become 80 percent of the projects' funds were not government funds anymore. So, we made the transition on that part pretty quickly and then about US competitiveness we kind of had to recognize that the storage industry, especially the hard drive industry, to some extent the tape industry was becoming global and we were missing things like a Korean company bought Maxtor. Samsung opened a major development lab in San Jose. There was lots of evidence that we were missing the boat if we were going to insist on being US-only and when you come to the tape business it's even more interesting because the tape drive companies were pretty much US companies. At the time, we were talking about IBM, HP, and Seagate. They were US companies but the whole infrastructure of the tape industry once you got below the drive level and you got to substrate materials, particle materials and so on, that was all in Japan. It wasn't anywhere else, and some of the best — the US had kind of given up research in tape. Some of the best research and researchers that we could go after were in Japan as well. So, we actually got a strong pressure at a few of the board meetings, the NSIC board meetings to become international, and the only

[30] NSIC became INSIC (Information Storage Industry Consortium) as it became a more international organization.

resistance was from some of the small start-up companies that were participants in the ATP programs where they didn't seem to think of where their money that they were going to lose is going to come from. So, that was a bit of an issue.

Yamashita: Even IBM didn't argue for it at the end. For keeping it domestic.

Schechtman: Did not argue for it?

Yamashita: Yes, I mean —

Schechtman: Right. Even though it was on the material side of the tape program that I described, the activity being in Japan, at the same time the sponsors like IBM of the drive parts of the program very much appreciate — NSIC did something you might call extracurricular. In the first place, we got to the point where the tape program had three or four drive companies and four or five, six media companies. A total of about nine sponsor companies involved. We basically felt that just for public awareness in their companies, that they're spending the money from. So, we started to hold one of our quarterly meetings per year in Japan and we had basically big rooms where there was not much restriction on the number of employees they could send to the meeting. So, the American companies obviously didn't pay for a lot of their employees to go overseas to this meeting because they could wait for one quarter and catch up. But the Japanese companies, I think, really appreciated a lot the fact that we were making all of the information that was hot off the press available to their employees. Their working-level employees and we went a step further. So, we had four years of I think in 2007, '08, '09, and '10 where we had a quarterly meeting in Japan.

Yamashita: This isn't a tape that we're talking —

Schechtman: It's a tape, yes, and then tape was sort of special with the way the companies are bunched up together and where they are, and the interdependency of one company's work on the next company's work. So, we had one quarterly meeting per year in Japan and then on the third and fourth of those four meetings we enlarged the concept and we invited professors from all over Japan who were candidates to work on our stuff. Most of them were not already working on it and we also brought in people from the sponsor companies to talk about the industry in general and the results of our roadmap. We haven't talked much yet about the roadmap studies, but I think that was very crucial to delivering value from the sponsors to the community. So, I or somebody else would get up and present charts, and so these special meetings, the last two of the one-per-year meetings, we called a tape technology forum, and it was really like an open conference but by invitation. But we covered stuff within the NSIC programs and stuff that we were just thinking about doing, and the roadmaps, and the companies in Japan who weren't building the kind of tape drives we were mostly doing research on but who were interested in catching up about what NSIC was doing. They came out in pretty large numbers. We had the last of those meetings, which was in October of 2010, we had over 100 people at and we had — I don't remember. I think Fujifilm was the company that provided the meeting room and the supporting lunches and whatever. They felt it was very worth their while. So, in a way that's a part I'm sad about that's gone away.

Yamashita: So, you've passed the baton to Paul Frank and you kept the tape part.

Schechtman: I wore two hats. As the director of — well, the agreement I had with Paul was, and he was fine with it, when he came in as executive director he basically told me he was so happy with what I was doing that he would define my job, whichever parts of the job I was doing already, I could put down that's my performance plan, and he would do the rest. So, I could pick — so, if there were things that I didn't find fun like the NSIC internal office budget, he would worry about it. So, that was a terrific deal for me and I think — and so, I wore two hats. So, one was being typically is what I did is I would be a project director or a program director of a given technical program and I would oversee it. So, for example, in hard drives I didn't do that and we anointed Mark Kryder to do that but in tape, I did that, and I did it for optical storage also. But the thing I liked about tape is that there were these layers and a hierarchy of participation. Like today's tape media is still not all metal. It's still metal particles in a polymer binder and coated onto a substrate, and we were dealing — we had really good projects. I'm thinking of one now at the University of Vienna by a researcher, a magnetics modeling guy named Joseph Fidler, and he would model the tape about supposing the particles got smaller by a certain volume? Or supposing the particles they started out being kind of cigar-shaped. Supposing they became closer and closer to round and we get a lot of results and on the part of the sponsors, they were the drive companies who were interested in the whole thing. But there were companies like Sony and — I'm not going to remember all of the names now. But there were companies that were specializing in — they had to have a substrate for the tape that was better than commercial mylar, which is what they were using so far. The same stuff your polyethylene phthalate. The same stuff that your soda bottles are made out of. Not developed for high tech but they were — Sony was doing stuff where they were making a layered structure of the cheap mylar with a metal film to get stronger mechanical properties so it wouldn't — when the tape expands, you'd lose your track registration. At the same time, there was another company. I remember now one of the names. A company called Teijin that was trying to get the industry to switch over to a polymer that was much more rigid. The molecules were much more rigid than the polyester and Dupont named one of those polymers as aramid and —

Yamashita: Are these a polyimide type of a <overlapping conversation>.

Schechtman: Aramid is in the polyimide family. That's right. A very high temperature. But we didn't care about the temperature so much, but we cared about the mechanical rigidity. But it cost three times as much, the aramid, as the polyethylene. So, we were trying to use the NSIC program to define what were the key parameters if you wanted to do a cost versus benefit analysis of switching to the new polymers or not? So, we did stuff like that and then the particles, there were several different kinds of particles, the most recent lab demonstrations that I mentioned between IBM and Fujifilm a few years ago started using barium ferrite particles and now that's becoming mainstream and we talked a little bit about magnetic anisotropy earlier. The barium ferrite particles that are going into the most advanced tapes now are like hexagonal platelets. So, you're already getting a natural orientation. The hexagonal platelets where the magnetic moments of the particle — if this is a platelet, it's perpendicular to the flat part of the particle by using particles that are going to want to be recorded in at least partially perpendicular recording mode. So, there's a lot of advances the tape people can do. They're nowhere close to anything like the superparamagnetic limit. So, I think they have plenty of stuff they can do but they don't have enough money to spend it on NSIC.

Yamashita: Well, by now, I mean, there's so limited number of companies involved making the tape or the drives and so on. But maybe for necessity, they needed to band together maybe. Is that fair?

Schechtman: Well, yes and no. You want to probably separate that discussion into two pieces. IBM, I know these days their name is Oracle. They were StorageTek and they were Sun, but the old StorageTek that's been around for a long time, they and IBM occupy a piece of the market which is tuned for the high-end enterprise and they get a little more capacity in the cartridge and they get a little higher data rate transferred. The rest of the market has had the bottom go away. There were all sorts of tape drives. A quarter-inch cartridge was one. AIT from Sony. Advanced something interactive tape and there were a lot of, also from Sony and HP, DDS, digital data storage, and they each had their own mechanical figurations. The bottom of the market has dropped out because it's been replaced. The capacities are such that you can do it with flash drives now and put them in your drawer. You don't have to have an elaborate tape system, and the middle of the market is where the action is. So, you got at the high-end IBM and let's call it StorageTek, and at the low-end nothing because there's no real good uses for tape at the end or at the personal-computing level, and in the middle they have this LTO Consortium which has three drive makers and other licensees which has — it was very nice for NSIC to have that to work with because the LTO Consortium published roadmaps not defining their technology pieces but defining data rate and cartridge capacity and so on. Pretty much a two- to three-fold improvement per year. Not a two- to three-fold improvement. A doubling every two years. You have to be careful with tape about whether you're talking about capacities or areal densities because they trade one off against the other. They sometimes just put more tape in the cartridge, which is not trivial when the tape is four microns thick and you want to start and stop it at 10 meters a second and it's all pretty impressive. So, anyway, with the original comment, yes there are quite a few smaller numbers now of drive manufacturers and some of them manufacture for each other. IBM does some stuff, I think, for Oracle and at the mid-range, there's some stuff being done between HP and Quantum. But the fundamental underlying technology we've tried to look at it. We're not ready. We don't think the industry is ready to move to metal tape. So, it's still going to be particle-based and the roadmap — we didn't talk about the roadmap. So, the roadmaps, in my opinion, especially for tape but also for HDD, is one of the most valuable things NSIC did both in terms of the process of the roadmap, of getting people comfortable with talking about the five- to ten-year out stuff in a same room, and plus providing the results of the roadmap in a compact report where the people who have customer contacts for the drives can go take that report, make presentations, and ensure the customer that there is a future for tape.

Yamashita: It certainly was, from own experience, been part of NSIC meetings many, many times. The roadmap was the valuable activity because it kind of pointed the direction and the exercise of seeing the modeling people or basically from drive companies doing the exercise was a very valuable component of being in that NSIC group. So, I think you're very, very correct in that statement that the roadmap was one of the most important — sorry for the comment.

Schechtman: No, in fact, I appreciate it and even when the NSIC tape program shut down and the drive makers kind of stopped working together on sponsoring university research —

Yamashita: Just to have the roadmap.

Schechtman: They did work together and they've written two more roadmaps since I left and they did them kind of on a budget-level without as many people involved.[31]

Yamashita: So, I remember that one of the critical meetings in EHDR, that the roadmap meeting took us into the perpendicular. So, it was a seminal moment. <laughs>

Schechtman: Yes, and I think Roger Wood, in particular, contributed. Well, when you talk about perpendicular it was not only Roger but Roy Gustafson and a number of other people <overlapping conversation>.

Yamashita: Mike Mallary...

Schechtman: Yes. You're going to do something high-risk so you reach a consensus and people are sharing the risk. I think Roger Wood made a major — I don't know if his is the only name that belongs, but made a major contribution on this, what do they call it? Two-dimensional recording, where they write the next track on top of the previous track partially?

Yamashita: That's not 2-D. I forgot the term for it[32].

Schechtman: Yes, me too.

Yamashita: Anyway. So, Mason Williams, Roy Gustafson, <inaudible>, and Mike Mallary. Those are the modern guys that kind of led the effort and I remember one day put the perpendicular and that sort of set in motion our future for many, many years.

Schechtman: Right, and I remember when it was a big deal to talk about reaching one terabyte per square inch and we ended up with several ways to do it, I think.

Yamashita: So, I was going to ask you what you think the biggest impact that NSIC activity had? Certainly, the roadmap is one of those things. What were some of the other big accomplishments you think that the NSIC had?

Schechtman: Yes, I would say one thing is, and the roadmap is a sub-piece of that or is a piece of that, just developing and supporting the process of getting the people together, getting different people to do

[31] [Interviewee's note] INSIC has conducted tape roadmap studies approximately every 3-4 years since 1994. The most recent edition was published just one month prior to this interview in July 2019.
[32] Shingled recording

different pieces of the work, comparing, and having the industry move towards consensus. So, it’s a very efficient use of resources for the industry. Other than that, one can pick one’s favorite technical results and I think there are quite a few of those. One thing we haven't mentioned I instituted — this came from my IBM background. IBM likes to give recognition and achievement awards for certain technical accomplishments. So, I instituted two categories of awards that we gave at the annual meeting at NSIC each summer, and one was for a piece of outstanding technical accomplishment and one was for a piece of I think we called it the NSIC outstanding leadership award, which really meant for program management, and we had a committee that would decide who would get those awards each year, and there’s quite an impressive list of names and accomplishments that goes with that.

Yamashita: Anything else as far as the NSIC program is concerned?

Schechtman: Let’s see. I think stuff you touched on, Tom, about the modeling and all of it is a major contribution. One of the more tangible contributions came — I always like to talk about some of what NSIC did was develop tools. Measurement tools or things like that that they could put back in the hands of the sponsors and the sponsors can use it on their own proprietary stuff on analysis without being public about it. One of the best examples, maybe the best example, of the technical level award, outstanding technical achievement award, a researcher named Jon Wickert[33]. He was a student of Cal Berkeley in mechanical engineering; he was not Dave Bogy’s student. But he was at CMU and he was the mechanics guy at CMU, and he developed a software model to treat all of the variables in a mechanically moving tape path, properties of the tape, properties of the rollers, the drive, and so on, and that would’ve been a great accomplishment right there but he didn’t stop there. The guy must have had an unusual amount of energy because he, I would say probably over a four-year period, each quarter he came back and he made improvements to the model, and he also put a new version of the model out. He would distribute it on a CD every single quarter. Some updates with some notes. So, he basically was doing the software support work of a delivery software product and he was volunteering to go visit the companies if anybody needed some hand-holding using that software. So, that’s an example of — now, in other cases, like I mentioned a few minutes ago, Joseph Fidler in Vienna he had a model that he and colleagues at IBM in Europe had developed for magnetic recording calculations and he didn’t choose — it wasn’t secret, but he didn’t choose to put it in the hands of the sponsors because these things, unless you’re phenomenal and unique like Wickert, need a lot of continuing support that aren’t readily available for most professors. Wickert, by the way, while he was doing those four years of supporting this software and delivering new versions, he also got two promotions during the four years. He moved from CMU to Iowa State University and I’m not sure, but I guess he might’ve moved from associate professor to professor. He’s a fairly young guy. But then he moved, still within those four years I believe, to a department head of mechanical engineering on the first move and then he became the dean of engineering at Iowa State. So, he’s a phenomenon.

Yamashita: Yes. Well, having raised a lot of graduate students was a good accomplishment too. I mean, we hired many, many people out of the NSIC programs.

[33] Jonathan Wickert, Senior Vice President and Provost at Iowa State University since 2012.

Schechtman: I think relative to the initial programs at the university centers, the incremental additional ones we hired because of NSIC. Maybe not up to what I hoped.

Yamashita: You thought we could've done better?

Schechtman: I thought with the trouble we went to, to run NSIC and that being one of the major goals, I thought maybe not we could've done better but it would've been nice to do better.

Yamashita: I see.

Schechtman: But most of the companies, the same bucket of money went for creating slots to hire people as went for participating in the NSIC. Paying sponsor fees in the NSIC program. So, the companies basically had to cry poverty because they couldn't get it out of both buckets and still keep going.

Yamashita: Well, for smaller companies, especially like one that I work for, the exposure to good students was much, much better, being a part of NSIC.

Schechtman: Yes.

Yamashita: Maybe not quite so with the larger companies.

Schechtman: No, and the smaller companies liked getting the government money as well. In some case, they were still in start-up mode and it was a matter of survival for them.

Yamashita: There were a lot of other topics that I wanted to cover, but time is running short. So, I would like to ask you what is your viewpoint of the storage space now with your experience in the hard disk and the tape?

Schechtman: I think both will at some point approach some limitations where they just can't keep advancing in density. I may not be smart enough to know when and what those limitations are, but we conjecture about it a lot. But I think the thing that's going on in parallel and it will happen for both, it will happen for hard drives in particular, for tape maybe, is as you can't advance on the one parameter of density very much, we got decades of enjoyment and benefit from advancing the technology in terms of density, there are other things you can advance. You can apply manufacturing skills to lower the cost of the product if you have enough volume. You can package the product in many different forms. I mean, this doesn't have a hard drive anymore but at one point in the original iPod, it did. You repackage things in a way that the customer cares about. They don't really care what's under the covers very much. So, I mean, there have been mistakes. There will be things that are taken over by solid-state storage and it's happening already. But I think if one keeps a focus on the customer's end application and which variables are most important to the customer, that can help you make the right choices, and I think there's room enough in the technologies where the natural performance parameters or the different technologies will just naturally fit in certain applications. Like as I mentioned earlier, it was crazy to me that a company was trying to use hard drives for long-term archives. If you're going to keep them spinning, it's one thing. He was not going to spin them. He was going to spin them just once in a while. There's overhead there with other stuff if you can match. I think tape is such a low-energy technology and the benefits of the low-energy usage become greater as the total amount of data gets greater and the archives get bigger. So, I would say there's room for all categories of storage. I think the place that's not going to succeed are the ones that are coming up with totally different ways to make ones and zeros. It's not needed right now. I would say some of the holographic storage work, it's very nice work technically. It's very elaborate, and they solved a lot of problems in terms of putting a holographic system together. But other technologies — I mean, they evolved, the holographic projects in NSIC and also there was a company InPhase[34] that was a spinoff from a very good Bell Labs group. All of those people, including the NSIC researchers, solved a lot of problems to make the technology work and they performed a very impressive demonstration at Stanford with the group's results. But there was no cry in the marketplace for why you need holographic storage. It really didn't prove out to be higher capacity or higher density. It wasn't read-write because they evolved to — there's another topic we can get into. Do we need read-write capability for all of the configurations or do you tune the projects or the performance or the products to be write once read many? Which is really great for archive where you don't want the data to change. It's remarkable. That's kind of ironic. The senior people in the magnetics' community, both hard drives, and tape were criticizing optical storage because at that time the writable ones weren't rewritable. They didn't yet have good enough phase-change materials to make them rewritable. So, they were write-once and the executives who wanted to protect the magnetic recording product lines said, "See, it's never going to be any good if they're only write-once." So, now, high-end tape products, like IBM's and StoragTek's, they put software in to make their rewritable technologies turn into write-once because the application wants write-once. It's a little bit crazy but in the optical stuff it was kind of natural to do write-once and there is a real call for it. So, yes, I'd say the emphasis has to be on making the technology — I usually talk about it and didn't today, making it easier to use. It's just that's where such a good job was done on this thing and there's room for that everywhere. Cost, energy savings, easier to use, and I think all of the three main technologies will co-exist for at least another decade. I don't know where I'm going to be in another decade <laughs>.

Yamashita: We should probably be closing. Time is up. So, maybe last question. What are you doing now? Do you have children? What are they doing now?

Schechtman: Quick answers. I'm trying to exercise a fair amount and my wife and I adopted a hobby called pickleball, which among seniors is probably the fastest growing sport in the country. We're hoping it's something we can continue to enjoy together. We play bridge and I've done some volunteer work with adult illiteracy as part of the San Diego Library. So, that keeps me out of trouble. It's my second marriage and it's her third marriage. So, between us, we have a blended family of three adult children together. I mean, individually, but her daughter is a school teacher in Reno. My one son is an MD in San Jose. A family practice MD and my other son is a consultant in the foodservice industry and he lives just outside San Francisco in Pacifica. That takes care of what I'm doing and the kids. What else was there?

[34] InPhase Technologies, Longmont, CO, spun out of Bell Labs in 2000.

Yamashita: I forgot to ask one question that I always ask. What advice might you give to a young person starting out now given your experience?

Schechtman: I think my comments relate to industry probably not so much to academia. So, if they end up heading towards industry, I would tell them to emphasize flexibility. Learning more different things and being good at more different things instead of getting deeper and narrower in one specific specialty and as part of that looking for opportunities to work not individually but in team structures where people are used to working in groups is also very important and not emphasized in academia, and then probably if they're given choices for accepting this assignment or accepting this assignment after other parameters are dealt with one that they will feel like they're learning in the assignment is always better. Because it'll just make them that more able to contribute. So, I think that's what I would say.

Yamashita: Great answer. This concludes our interview. It's been a long one but hopefully, it's worthwhile. Thank you very much.

Schechtman: My pleasure. I guess I would like to add that this is a great group and you're doing great stuff, and having been invited to do the interview I consider it an honor. So, really thank you for that.

Yamashita: You're welcome.

END OF THE INTERVIEW

