# Oral History of Chris Bajorek and Dave Thompson

Interviewed by:
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**Allan:** We are here this morning to record the oral history of Drs. Bajorek and Thompson who individually and in groups contributed to a lot of technology, especially in terms of recording density. That's a whole bundle of things including heads, media, flying height and such like. Going back in time to when disk drives were new, every customer presentation had a horseshoe with wire running around it.

**Thompson:** <laughs>

**Allan:** We explained, "This is induction, and we pursued that in a little bit more elegant form on disk drives for years, but the smaller a head got, the harder it was to make. It was necessary to turn to transistorized technologies and come out with a thing called a thin film head. The first thin film head turned up in a disk drive that they led the project on.

**Thompson:** The research, please, I was never in the Product Division.

**Allan:** That's right. I should probably correlate there's a distinction between figuring it out and getting it to market. In fact, at one time, I sat in a room where two groups were trying to explain how they couldn't proceed.

**Thompson:** <laughs>

**Allan:** One was from Research and one was from Development, and it all came to a head when one manager got up and said, "Look, here's the problem. You guys go to work every day in Research expecting failure. You're doing something new, the probability of it working is quite low. We come to work every day to take the once in a lifetime event and turn it into an everyday event. That's a philosophical difference that makes it hard for us to absorb everything you have, because we have to base it upon existing technology and evolve it." He ended the argument, and it was rather exaggerated, but it did make the key point that there is difficulty in bringing technology to market, because the personality of the development groups is different. We went on from thin film heads and got into what we call magnetoresistive, and both of you were involved in that.

**Thompson:** Yup.

**Bajorek:** Yeah.

**Allan:** Magnetoresistive sensors go way back before disk drives adopted them. The technology first turned up actually in point of sale wands. There's a long history here, 40 years ago, more than 40 years ago, the first ones were used, and that means you guys knew each other before then. So taking a look at your backgrounds, what was it in your early years when you were at school, when you were at home, who were the influences and what were the influences that led you into this area?

**Bajorek:** You want to lead, Dave?

**Thompson:** All right, well, I'm the older guy, I guess. I grew up in North Dakota and I guess you could say that from grade school on I always wanted to be what I thought of as a mad scientist, you know, <laughs> a movie kind of mad scientist. A little later and more sophisticated, I wanted to be an engineer. I was already working with electronics a lot in those days, which was all vacuum tubes and stuff. When I finished high school and came time to go to college, we didn't have much money and the only way I was going to go to a fancy college was to get a good scholarship.

The only, actually the only school I applied to (other than I could have gone to the North Dakota universities) was Carnegie Tech. That was because their tuition was only $400 dollars a semester, and I thought somehow if I didn't get the scholarship, I could scrape that kind of money together. MIT was twice that, so MIT was out of the question. I applied to Carnegie Tech. They had a rule that you had to talk to an alumnus who would send a report back. They couldn't find an alumnus willing to go to North Dakota, <laughs> so they accepted me based on my tests.

This was before SATs were called that, I think, but I really aced those tests, and I did get a full National Merit Scholarship which made it pretty easy for me. You could work your way through school in those days. My wife got no money from home, she worked her way through Carnegie Tech while going to school full-time. I don't think you could do that today. I mean, there was no such thing as student debt.

Anyway, so you asked how did I get into magnetics. I went to Carnegie Tech which was a leader in engineering magnetism at that time. Things like giant motors, but the more modern stuff, magnetic amplifiers and nonlinear cores, that kind of thing was in fact a mainstay of the undergraduate EE course. The Introduction to EE was to understand and use nonlinear magnetics, so it was fairly natural choice when I finished as an undergrad and was looking for graduate work. A professor named Leo Finzi, the grand old man of magnetism, was willing to be my advisor, and that was it, I was in magnetism. Now what was the question? <laughs>

**Allan:** Oh. I was just curious how you got into magnetism and you came through.

**Thompson:** I came in because my favorite professor was a leading light in magnetism and one of the founders of the Magnetics Society and all that sort of thing.

  

**Allan:** Even simpler than that, it was economics, the school you went to was into magnetics.

**Thompson:** It was, but I think if you have an engineering mentality, you're looking for the problems, and the guys who know where the problems are the guys you want to follow, and that was magnetism at Carnegie Tech in those days. It was also semiconductors, by the way, and electrostatic precipitation, and a bunch of other things, but the one that drew me in was magnetism.

**Allan:** All right. Chris?

**Bajorek:** My childhood background is a little bit more complicated than Dave's. I was born in Tel Aviv, then Palestine, now Israel, in the middle of World War II of Polish parents. At the end of the War, we migrated first for a couple of years to Scotland and then my father, who was an electrical engineer, got a job with General Electric. Their operations were in South America, managing hydroelectric projects based out of Buenos Aires, so we moved to Argentina. After finishing high school in Argentina, we moved to the States, and I ended up with a kind of a double education, Polish at home and Spanish in Argentina.

The Polish generation of that day wanted to return to Poland and rebuild Poland after World War II and the end of Communism, but Communism hung in there for a long time. In preparing to go back to Poland, they insisted on teaching their kids rigorous Polish, giving them a rigorous Polish education. I ended up doing double duty in schools, <laughs> going weekdays to Argentine schools and weekends to Polish schools. At any rate, we came to the United States and knowing that we were coming to the States, I was forced to finish five years of high school in three by taking some of the years through examination.

By the time we landed here, I was tired of studying, and imagine a young kid landing in the States. I was 16. I wasn't very interested in studying at that point, so I went to Pasadena City College. Why? The Rose Bowl queen gets elected from the student body of Pasadena City College, so the best looking <laughs> girls in Southern California were going to PCC and it was always, obviously, a magnet, for young males. I spent four years at Pasadena City College to finish <laughs> two years because we were having too good of a time.

While at PCC I met my future wife, Janet. As I was finishing PCC I had to decide what to do next and I started thinking of applying to the traditional schools, Berkeley, Stanford, USC. By then I had a sense of wanting to do an engineering career and she asked, "Why not Caltech?" I was driving by Caltech daily from our home to PCC and she said, "Why are you applying <laughs> to all these distant schools? You should apply to Caltech." I walked in and by coincidence they were giving admission exams to students from Occidental College. Caltech and Occidental had this three-two plan where by going to both schools you could get a double degree, a degree in the Humanities and a degree in Science or Engineering.

They were considering two students from Occi-- you still had to pass a test to get in-- and they let me ride along with those two students on a grueling three-day examination, one day in Math, one day in Physics, one day in English Literature. I was convinced I had failed those exams. About a month later, Professor Langmuir from Caltech shows up at PCC and I'm called into the Dean's office and Langmuir has this brusque demeanor and he says, "Are you Chris Bajorek?" I said, "Yes," and he says, "Well, you got an A in Physics or Math, a B in the other science subject and you flunked the English exam, but if you're willing to take a year's of remedial English work, we'll give you a full paid scholarship to enter Caltech as a junior."

That was fabulous, I may be the only student, I don't know for sure, but I may be the only student who transferred into Caltech as a junior from Pasadena City College. I took a seniors lab course, it was mandatory for engineering students at Caltech. The professor who was teaching that course was Floyd Humphrey, who is also a magnetician. I got to know Floyd, he offered me a summer job.

<laughter>

**Bajorek:** I got to know their magnetics research effort, there was a small group headed by Floyd Humphrey and Chuck Wilts and I got hooked into applied magnetism by being part of that group. I was accepted to graduate school at Caltech, that was again an exception. They usually didn't want to have undergraduates stay on for their Ph.D. programs, but I was able to stay on and ended up selecting a thesis investigating spin wave resonance phenomena in very, very thin magnetic films. It turned out with the benefit of hindsight that that research turned out to be extremely useful for what I ended up doing later at IBM. The influence of deciding what to do professionally, well, it really came, probably from... You know, I'm not conscious of a moment when I realized what to do, like you wanted to be a mad scientist, right?

<laughter>

**Bajorek:** I knew my father was an electrical engineer and my mother was the first law school graduate from the University of Lwow (Lviv) which was at that time part of Poland and now it's in the Ukraine. The default situation in our family was everybody was going to be a professional. The question was not whether one would be a professional but what profession. Because my father was an electrical engineer, I became intrigued by that, and I imagine that's how I subconsciously ended up being interested in science and engineering.

**Allan:** Both of you pursued a Ph.D. Now one of the things I remember about school was even though, as you said, it was reasonably cheap, it was still a lot less money than you could make earning.

**Thompson:** No. <laughs>

  

**Allan:** Is that right?

**Thompson:** In North Dakota? Are you serious?

**Allan:** Wow. Okay.

**Thompson:** By taking graduate courses in undergrad I was way ahead of the game at Carnegie Tech. I came in in '58 and I finished my Ph.D. in seven years from that through undergraduate, and then I was an assistant professor for three years, so I was there ten years. Meanwhile, my wife was following two years behind, so it was just the natural thing. If they would let me stay, I was going to do it. Is that the question? <laughs>

**Allan:** Yes, because I did notice that many of the people that I knew who pursued a Ph.D. wound up staying in the academic life because although it wasn't as, let's say, as easy to make money as it was in the outside world, it was a comfortable, a very comfortable, enjoyable environment to work in and--

**Thompson:** It was-- As far as I was concerned, it was financially terrific. I mean, the minute I got my bachelor's degree my financial worries disappeared. I had always felt I was rich as a grad student because I spent less than I got. That's my definition of rich. <laughs>

**Allan:** Wow.

**Thompson:** And it's been true ever since.

**Allan:** Was it that easy for you also, Chris?

**Bajorek:** I also have that memory, yeah. As an undergrad, I got covered for tuition and some incidental expenses, but once I got into graduate school, I was fortunate to get fairly good fellowships and graduate teaching assistantships. I also as Dave, remember those days as the richest days of my life.

<laughter>

**Bajorek:** Because we were-- we were not able to spend what we got, you know, and--

**Thompson:** You didn't have to go into debt, you know. If you got enough money to live on and you were living the way you wanted to, it was great. I mean, he mentioned his two professors. I knew them all the way from Carnegie Tech because Wilts is a famous rock climber and Humphrey is, well, he's a scuba diver too, right?

**Bajorek:** Right, right.

**Thompson:** Humphrey was also one of the founding magneticians of thin film magnetics, and you asked how we drifted into this particular area. It's because people we knew and admired were in that area, and like I said, a good engineer follows where the problems are and these guys knew what the problems were.

**Allan:** You've reshaped my ideas on school--

<laughter>

**Allan:** After getting your degree and wanting to get out and make some money, I've got to ask, why did you leave that environment? Was that--?

**Thompson:** Okay. I will answer that. It was very simple. After three years as a professor with my wife finishing up, I loved teaching and I loved doing research, although I really hated the proposal and grant getting part of it. I couldn't do both, they were both full-time jobs to me, and it wasn't an option to just be a teacher. I mean, that was a dead end track in most universities, certainly at Carnegie Tech.

I had spent summers, two summers working at IBM, and I had in fact, towards the end of my thesis, I had two thesis advisors. One was Professor Finzi and the other was Professor Hsu Chang who was only a visiting professor. He was from IBM Research and that was his full-time job. I had two summer jobs out there and I just knew where I could go. They made me a fabulous offer. I only interviewed two places, IBM and Bell Labs, which were the premier industrial labs of the times, and I took the offer from IBM. They knew my wife too, and as a programmer she ended up making more than I did for a while, but that was okay. Again, the money was terrific with two professionals and no kids. How can you lose, right? We didn't go there for the money, we went there because IBM research in those days was a place you could do what you wanted to do, and you didn't spend your time writing grant proposals and sending them off to Washington for some bureaucrat to puzzle over.

**Bajorek:** I didn't have any inclination to stay in academia, somehow from the outset, early in graduate school, I decided that I would feel more comfortable by going out to industry. I don't know, maybe it was the influence of some of the courses. I was lucky to take courses from Carver Mead, who at that time was teaching at Caltech and he had very strong connections to industry, very short connections to Gordon Moore and <laughs> Andy Grove at Intel,.

  

We brought Andy Grove to teach our semiconductor physics class so early on, I was exposed to strong leaders who were visiting Caltech from industry and somehow I just became intrigued by the possibility of industry. I interviewed in about three or four places, IBM Yorktown included, and like David did, I judged Yorktown from those interviews to be, in an industrial sense, the richest possible, most fertile ground in which to get involved in projects. The spectrum of work going on at that time in the division and in that location was just phenomenal, you know. It was from lasers to X-rays to semiconductors to magnetic films for film memories. They were already active in magnetic bubble memories.

Dave's group was active in magnetic recording so it was like a candy store, the world's best candy store to go into. The last attraction, it was near Manhattan, and there's no city in North America that resembles Buenos Aires closer than Manhattan. I was a bit <laughs> homesick for Buenos Aires, so I figured if we could be an hour away from Manhattan in an environment like Yorktown, this would be Nirvana. That's what we did.

**Allan:** You've just described an environment that was totally different to my experience, which was in Development. In Development, you get a new project. You're told what project you're going to be on, and even if it's 180 degrees from the last one, you're supposed to believe just as much in this one. You make it sound like you had a menu to choose from in terms of what you could pursue. So were you able to--?

**Thompson:** Let me clarify that. At IBM Research in those days, you could work on what you wanted to do provided you could convince your first and second level manager that it was better than what you were already doing. If you didn't do that, you were told what to do, so I was never actually told what to do other than when I first arrived on the job. After that, every project I worked on was my idea and I went and I convinced the bosses that it was their idea, too. Managing your manager is one of the first things you learned. Right, Chris? He managed me for years when he worked for me.

<laughter>

**Allan:** When did you first sort of like strike each other? Because you had parallels in who you knew.

**Thompson:** Well--

**Allan:** And there were parallels and such, but when did you first sort of start to know each other?

**Thompson:** When I hired him. <laughs>

  

**Bajorek:** Yeah, basically-- When I came to interview at Yorktown Heights, I think Dave was the sponsor of that-- of the invitation to come and interview in that lab. I was quite impressed, you know, I obviously was interviewed by Hsu Chang and Dave's colleagues. Hsu Chang was at that time Dave's boss.

**Thompson:** I think I was just a first level manager about that time.

**Bajorek:** Right, right.

**Thompson:** So he'd be in my first group, yeah.

**Bajorek:** I may have been your first hiring chit for a professional, right?

**Thompson:** It's very likely.

**Bajorek:** I was lucky, Dave made an offer and a competitive offer, and for the reasons I mentioned earlier, it looked like the stars aligned to make it an attractive proposition. Of course, he gave me my first assignment, the first assignment he gave me was a printout of Hunt's paper about magnetoresistive heads. <laughs>

**Thompson:** ...which we had independently invented and were still looking for a good application for, because although Hunt's paper described the thing very well, there wasn't anything useful you could do with it. It was a sensor, which was fine because one of my primary interests and our group's interest was various kinds of sensors. Magnetic sensor, piezoelectric sensors and in addition to recording, we worked on things like magnetic delay line keyboards, magnetic actuators for printers and I'll think of others. We were just a sandbox full of ideas and we were looking around the company, which was a huge company, for various ways we could use our sensors.

**Allan:** So what year would that have been?

**Thompson:** Pardon?

**Allan:** What year was that?

**Thompson:** I think I made my first magnetoresistive sensors at the end of 1969 or early 1970. I have samples still lying around somewhere from 1970, so certainly we were into it by then. Maybe I should give you a little bit of background on my group and Hsu Chang, my boss and half of my thesis advisor. When I came into IBM as a full-time employee, IBM was in the midst of a great battle between semiconductor memory and magnetic thin film memory. At that time, it was not obvious which one was going to win. They had built a big facility in Burlington, Vermont to make magnetic film memories. Are you familiar with those at all?

**Allan:** No, they don't click.

**Thompson:** It was Fishkill where they were at that time building the semiconductor memories, and the magnetic memories had a lot of advantages. They were very fast, but the main one was when you pulled the plug, it just stopped and you could start up again when you turned it on again. It was completely nonvolatile, which none of the semiconductor ones were for decades after that. When there was a fault, because IBM big computers didn't actually get turned off, they stopped because there was a fault, you lost everything.

Whereas with the thin film memories, you stopped the memory and okay, fine, you're started again and it's all still there. They were by far the most reliable memories, maybe still the most reliable memories ever made until they got into fully error correcting ones. I've never heard of an instance of one of the film memory elements going bad. The semiconductors around them that fed them information and drove them could fail, but the magnetic elements didn't. They used magnetic-- first of all, I'm sure you are aware of ferrite cores.

**Allan:** Oh, yes.

**Thompson:** The magnetic film memories were a thin film version of those, okay, and this is right up the line of the sort of stuff I did for my thesis, so it was pretty straightforward. I was hired to help come up with a nondestructive memory cell. Are you familiar with how ferrite cores and memories, magnetic memories work? You get the information out by basically writing it and seeing what happens, so that's a destructive memory and it was a two cycle thing. You read it and then you wrote it back again. I was working on non-destructive cells as my first assignment, because exchange coupled films was one of the things that I had worked on in my thesis. Are you with me so far? <laughs>

**Allan:** Yeah, that's--

**Thompson:** The big battle occurred about a year after I got in and I still don't know whether it was technical or political, but the semiconductor guys won. The Burlington factory was switched over from magnetic film memory to semiconductor memory. I don't know if they're still making them there, I mean--?

**Bajorek:** Yeah.

  

**Thompson:** It's been a lot of years, 40 years they've been making semiconductor memory in Burlington. We were looking around for other things to do and the hot topic sort of going off on the side was Bell Labs magnetic bubble memory. Surely you're familiar with those.

**Allan:** Yes. I remember trying to convince the board of Sperry that the decision they just made to give our $5 million dollars to bubble memory was a very foolish one without calling them idiots.

**Thompson:** <laughs>

**Allan:** It was a very difficult task, people were enchanted by them.

**Thompson:** They were enchanted because you could look in a microscope and see them. I swear, it was the public relations value of magnetic bubble memories that kept that thing alive for all those years. Of course it was a nondestructive magnetic memory, so it had that advantage, and it was much sexier than magnetic films, which had already been killed. Hsu Chang became a big fan and the whole department was flung into magnetic bubbles. There were magnetic bubbles being done out in the Development divisions too, and I didn't like it because I thought that technology was being way oversold. I always get uncomfortable when I sit in the meeting and I hear my manager making promises about how great this is going to be. I mean, you're probably used to it in a product sense, but these were technological brags which I didn't believe.

Hsu was a very reasonable guy and I convinced him that I would like to veer my own research towards sensors and find some use for the darned things. I started making these magnetoresistive sensors and we had our big coup, our first big coup and a big patent, too, when we broke the Bell Labs monopoly on magnetic bubble patents. <laughs> In those days, IBM and Bell Labs, those guys, they didn't actually use patents as a source of revenue, they used patents for freedom of action. They would try to collect enough patents in some technology so that the guy who owned other patents would cross license with you. So far, so good?

**Allan:** Yeah.

**Thompson:** We had no hold at all on Bell Labs. Now if you didn't have any patents, then you would have to pay Bell Labs a significant licensing fee. Anyway, I invented and patented a magnetoresistive bubble sensor using this magnetic sensor that I had been working on, and this is about the time that Chris showed up, because we had some of those in the lab that we'd made--

**Allan:** Right.

**Thompson:** We'd actually made them for sensing magnetic stripes, but you just glued them on to a bubble chip and made them small enough, they acted as a bubble sensor. Bell Labs only had Hall effect sensors, and bingo, that patent was worth a million bucks at least to IBM, because Bell was forced to cross license this wonderful technology which I didn't believe in called bubbles.

**Allan:** I think that's called serendipity somewhere.

<laughter>

**Thompson:** Serendipity, but you know, the company loved it and it's the kind of thing that gets you noticed all the way at the top. I built this thing for reading magnetic stripes and I'd just hired Chris and I said, "Chris, let's use this for reading magnetic stripes," which is basically tape. With inductive heads, the signal you get is proportional to the speed at which you wipe it across the stripe.

**Allan:** Yeah.

**Thompson:** An MR sensor, it's speed independent and in those days they were just getting cassette tapes, audio cassette tapes, which ran very slowly because the slower they ran the longer, the more music you got. <laughs> We were looking for other applications, one of the magnetic stripe applications we had that IBM had worked on was the BART cards. Are you familiar with BART cards, the magnetic stripe on them? Those are generally read by popping them in a machine and the machine determines how fast you scan it.

We had visions of using hand scans for all sorts of applications so one of the first things I did after I hired Chris was I got a BART card. I handed it and said, "Chris, we're going to use a sensor to read this." At IBM Research in those days, the walls were thin sheets of steel., and we stuck our calendars and stuff to the wall with magnets. Chris took the BART card and <laughs> he stuck it to the wall with a magnet and that was the end of that BART card.

**Bajorek:** <laughs>

**Allan:** <laughs> He erased the data.

<laughter>

**Thompson:** Erased all the data, yeah. Chris immediately jumped in and we had some successes which Chris led about various handheld magnetic readers, and we got several of the Product divisions involved.

  

There was the--, I'll let him tell you about it., but in addition to BART, there were magnetic check readers. Magnetic characters printed along the edge of bank checks don't have much signal, and if you use an inductive head you have to run them through at lightning speed. With a magnetic thin film magnetoresistive head, you can run them through at any speed you want, and I'll let him tell you about the price tag readers.

**Bajorek:** He gives me Hunt's paper, "Let's go figure out what we can do with this." <laughs> That was my introduction to the subject, and there were two other things going on at about that time. First of all, I came in by the time the war between film memories and DRAM was over. <laughs> Right when the film memory stopped, but bubbles were going, in fact, were energized by the discovery of amorphous materials by Cuomo, Gambino, and Chaudhari. That was an IBM invention and there was a lot of hoopla in Yorktown Heights about amorphous magnetic bubbles, and later on, I was drafted from Dave's group.

My first managership was to manage a group of amorphous bubble developers to see if we could do something with that technology, and I won't digress very far, but we ended up killing <laughs> amorphous bubbles. I remember I hired an engineer, Bob Kobliska, and we proved why, with Bob's help, you could never make a practical memory out of the highly temperature sensitive ferrimagnets that these bubble materials were. I ended up killing that program.

**Thompson:** He's good at that. He's killed lots of programs, by the way.

**Bajorek:** <laughs> Coming back to it, Dave had another invention at that time which he didn't mention, which is the Hunt head, as described in Hunt's paper it was an unshielded device i.e. it by nature had relatively low resolution because it would sense fields <laughs> from long distances. To make it really practical you needed to somehow shield that device so it would read the data or the signals in a focused sense, and Dave had invented the idea of shielding Hunts' device, and a group that--

**Thompson:** Can I just explain the language on that?

**Bajorek:** Yeah.

**Thompson:** When you say shield you think that somebody put a Faraday cage around it or something.

**Bajorek:** Yeah, yeah.

**Thompson:** In magnetic recording, the resolution, how small a bit you can read, is determined first by the spacing between the sensor and the thing and basically, you're trying to get it as close to contact as you can. The second is for example in an inductive head, it's how big the gap is between the two halves of the horseshoe. With a simple stripe reader, it turns out the critical dimension is there's no gap so it's just the height or the width of the stripe, and it was very difficult to make it small enough. But...., if you put magnetic layers on either side of it you actually had a gap with a magnetoresistive sensor edge in the gap, now the resolution is determined by this narrow gap instead of the much bigger dimension of the width of the stripe.

That was one of the other three big patents that I got for IBM that was worth an incredible amount of money, because every magnetoresistive recording head ever made since then has used this particular idea.

**Bajorek:** That idea was beginning to be picked up at that time by a group of tape drive developers at IBM in Boulder, Colorado. That was a good thing because driven by that application, which was the early part of what became I think the 3480 tape drive product. They established a laboratory in which you could actually fabricate film devices, they needed to be able to make their own film heads. As we looked at the potential application of Hunts' head we needed a lab in which we could make real heads.

**Thompson:** A manufacturing facility.

**Bajorek:** A facility.

**Thompson:** You couldn't make them in Research, so this was a Godsend for us.

**Bajorek:** We could make improved prototypes, but we couldn't do something rigorous. As we focused on this consumer application, imagine, this would be the idea of having a company like Macy's use magnetic stripes <laughs> on every product they sell from ceramic pots <laughs> on one end to clothing on the other. You want it to be able to scan these at a cash register, or anywhere in the store, for inventory control and tracking, with a hand-held device that would be able to operate under a large variety of conditions, and by a large variety of humans. From young kids <laughs> who were hired as interns to cashiers, to customers in the store, so it turned out to be a very demanding contact recording application, <laughs> one of the few that ended up being successful outside of tape recording. At any rate, in order to make it successful we had to basically enable this device to work in unlimited **azimuthal** <laughs> configurations. We made the strip short enough so you could orient it any way between bits, and still read the data on the stripe. Because of the application, we had to basically learn how to make a single crystal sapphire substrate, only sapphire could withstand the rigors of abrasion in this contact recording application. Because it was a contact recording application, there was a lot of frictional heat generated in the process of reading data, which could sometimes be stronger than the magnetic signal from the device, these--

  

**Thompson:** And both of them would cause a change in resistance.

**Bajorek:** Yeah, resistance. You know, it's a thermistor as well as a magnetoresistor. We had to help the heat dissipation by laminating the sapphire to a single crystal silicon chip. <laughs> In the end we ended up creating this tip, spheroidal tip made out of the sandwich of sapphire and silicon that could read data on virtually any surface for this application. We got the interest of a laboratory in Los Gatos here in California, an engineer by the name of Charlie Coker who picked up the idea and ran with it. He was able to put together a whole consumer transaction system he built the ones that held this tip, the preamps, the data detection system.

He converted the entire library of the Los Gatos Lab into a system where you scan books in and out of the library via these magnetoresistive sensors, and through that, we managed to persuade what was then the Office Products Division to apply the technology into the retail sector of commerce. Eventually, I think in the '74, '75 timeframe, we were able to commercialize that and department stores like Macy's and other such companies deployed them broadly. I remember coming to San Jose in the early eighties and going to the central <laughs> shopping mall here at Macy's and seeing IBM cash registers with these hand-held scanners attached to them, operating ten years after we had prototyped them in Yorktown.

**Thompson:** Let me explain the technical issue here. When we got into this, there was still a battle going on about the UPC, the Universal Product Code. It wasn't really what the retailers wanted. When I was a kid, for example, I used to put price tags on merchandise, an after school job, because when merchandise came in, it wasn't priced. You had to print out a string of price tags and put them on each unit. With the UPC, what you did was you convinced the manufacturer to put the code on their labeling, every unit was the same. There was one number for every instance of that item. With the magnetic ones, each item you tagged was unique. It had when you printed up the label, it also told when you got it, when its expiration date was. The inventory control was much better, so in many ways, the magnetic price tag was vastly superior. It lost out in the end because of two things. One is that when they started putting UPC on the labels it cost you nothing as a retailer. That was a big plus, and secondly, you had inventory control when everything became online in computer networks within the enterprise. You didn't necessarily have to have things like an expiration date on the unit itself, it was all in the computer. Are you with me?

**Allan:** Yeah.

**Thompson:** It was an interesting thing, and it was a good example of the kind of sensors we made. Another one which lasted for years and was pretty much invisible outside IBM was the magnetic check reader. You know, magnetic checks, I mean the checks that you write have magnetic ink on them.

  

**Allan:** Yeah, the MICR (Magnetic Ink Character Recognition) code came in a long time ago and I remember dealing with situations when, let's say, the high speed passage of checks stopped with a screech.

**Thompson:** <laughs> Yes, and the magnetic thing isn't very magnetic and it has a small signal and you have to run it really fast to get a good signal out of the MICR head. With an MR head, you could run it by any speed you wanted and you could make it on sapphire as he [Chris] pointed out, because checks that have been in the public's hands are terribly abrasive. Paper itself is abrasive, because they put chalk and stuff in it to whiten it up, but after the people have handled it, it's full of really abrasive dirt and a sapphire check reading head had much greater life than the ones that were made out of steel, which was the predecessor.

**Allan:** Now one thing that you've both identified along the way is that technology needs two things. A certain degree of luck in the sense that it doesn't get hit by a political influence from somewhere else; and a champion to get it out the door and into the world of use.

**Thompson:** Well--

**Allan:** So with all the technology that you've been involved with--

**Thompson:** Yeah, but I think you left out what I think is the most key ingredient is, somebody has to recognize the problem. I always claim that recognizing the problem was, and finding it was, much harder than solving the problem once you'd adequately formulated it. In fact, I thought as a manager, if I could state the problem, I could get one of my guys to solve it. If no one had thought about it, or hadn't stated it properly, it seemed impossible, and unobvious. As my patent lawyer used to say, "If you figure it out and explain it succinctly, it's not patentable, because it's too obvious." I had a number of cases where I would write out the Invention Disclosure and try to help the patent attorney write it down. He says, "You can't do that! If you write it that clearly, it'll be obvious **and be rejected** for that obviousness." He would go back and make it unintelligible, or almost so, and we'd get a patent.

**Allan:** Well, but the flipside of that is--

**Bajorek:** It also helped to have links into, as you put it, the champion who had figured out the problem, was trying to solve it, and who would welcome your solution as the superior one to alternatives he was considering. I go back to, "We're trying to make the simple Hunt head as a consumer transaction device, the group in Boulder was headed towards applying magnetoresistance to a tape recording application. That was a really good one, and we didn't solve those problems ourselves, but I think we helped Boulder solve them. We capitalized on Boulder's capability to then help commercialize this consumer transaction one [application].

  

**Thompson:** That brings back a thing, so let me explain why it was so difficult to do a tape head. In those days a tape head was an inductive head, you know, a little ring-shaped thing with wires on it. In the tape business, you wanted lots of tracks, how you got areal density in large part was to get 20/30/40 tracks across a half-inch tape. If you tried to read more than one at a time, these inductive heads would all read each other, they were magnetically coupled to each other. The read heads were almost impossible to make, whereas with an MR head, each little stripe is independent, and they don't have that crosstalk to nearly the same extent. It was a huge advance for them, because it increased their read back data bandwidth. You could write 40 tracks in parallel, but you couldn't read 40 tracks in parallel until we got the MR head. You couldn't build inductive heads that would do it, so that gave IBM a big leg-up in the tape business for a while.

**Bajorek:** That became the second success in commercialization of MR heads, but as I said, that was driven largely by the spontaneous job at IBM Boulder. Later, this was transferred to Tucson, and the product was eventually shipped out of Tucson. In the meantime, we got involved, the real challenge for us was to try to come up with a sensor that we could use in a disk drive. At that time, the state of the art disk drives were using about one-mil/25-micron track pitch. It's one thing to try to make a tape track width which was 100 times wider, <laughs> or ten times wider. The consumer transaction track was a quarter-inch wide, right?

Developing or applying the technology to a hard drive application immediately required a device that was less than a mil in width, in length, and if you wanted to project it into the future, a fraction of a mil. We started to think in terms of microns, dimensions of micrometers for the length of the stripe. A fundamental problem in all these stripes and materials is a phenomenon that's well-known in magnetism, called Barkhausen noise, where the material itself, ferromagnet, doesn’t like to stay magnetized in a single domain. It's a high energy state. It can reduce that energy, the energy of the state if it breaks up into domains, and as you try to polarize it, magnetize it, and demagnetize it, it doesn't do so continuously. It does it discontinuously.

Every time you have a discontinuity you get a noise, a spike in the signal, which corrupts the signal you want to get out of the device. The next biggest challenge for us turned out to be to figure out breakthroughs on how to quench that noise, while simultaneously making the device operate also in a linear fashion. To be able to detect polarity in the data, we needed to be able to make this device respond in a bipolar sense, and magnetoresistors in their simplest form are not bipolar. They have a parabolic response about the zero excitation field, so we needed to also simultaneously provide linearization of the signal. We were lucky to come up with ways to linearize the signal, but for the first few years of trying it, we failed to come up with a solution to the Barkhausen noise. By the mid-'70s, I think, we went in different directions, right? I was-- you sent me off to Fishkill.

**Thompson:** I didn't send you. You ran away. <laughs>

  

**Bajorek:** No, you sent me off. You were tired of me, on a sabbatical assignment to work on-- and that was a great assignment. They were trying to introduce the newest semiconductor technology for mainframes, including the packaging technology where we could package a hundred chips on a ceramic module, and six to nine of those modules on a giant so-called Clark board. As often happens, the new technology had last minute surprises before it could be shipped in a serious way, and I entered Fishkill just at the time when they were firefighting the last minute surprises. I was able to get involved as contributing to solving some of those problems. I came back to Yorktown, then I was your manager.

**Thompson:** Yeah.

**Bajorek:** They promoted me to second-level manager, then he had to report to me in Yorktown.

**Thompson:** Well, I was a Fellow. I didn't want to be a second-level manager, so I was happy with that.

**Bajorek:** No, I understand that.

**Thompson:** As an IBM Fellow, I was slightly insulated from his craziness, because I could always walk away. <laughter>

**Bajorek:** All I'm trying to suggest is that we went into a several year hiatus, where we didn't make progress on the MR head for hard disk. In the meantime, a group had been formed in San Jose Research that was interested in magnetoresistive heads, with individuals like Ching Tsang and Otto Voegeli. Eventually, IBM made the decision that all of its applied magnetics work related to, particularly that related to bubbles and magnetic recording, should transfer from Yorktown to California, to San Jose.

As part of that transfer, I was asked to come to San Jose and take over. Being the senior manager was another promotion, running what was then called the Storage Systems and Technology Group in research. I inherited this new group interested in magnetoresistive heads, they were a part of that function. They had evolved the thinking from where Dave and I left it in Yorktown, enough to the point where by adding a couple more inventions we managed to finally solve the Barkhausen noise problem. It required applying what we called a longitudinal magnetic field bias.

**Thompson:** Mm hm. And a transverse bias too.

**Bajorek:** Transverse, the transverse bias that was needed for linearization of the signal. We had figured that one out, but we hadn't figured out how to do the longitudinal one effectively. That was a breakthrough that was achieved in San Jose in the early '80s. That breakthrough enabled us to basically conceive and prototype the first magnetoresistive head that fully functioned in a disk drive application at the dimensions required for a disk drive.

**Thompson:** It hit the world in I'd say in 1991.

**Bajorek:** Yeah, it took us what?

**Thompson:** Ten years. <laughs>

**Bajorek:** Took us nine or ten years until we managed to solve all the problems.

**Thompson:** But it was…

**Bajorek:** To commercialize it in any volume.

**Thompson:** Let me back up a little bit.

**Bajorek:** Yeah.

**Thompson:** ...and explain why there was a group in San Jose that could be interested in MR heads. Going back not ten years, but twenty years from 1991.

In 1969 at the end of the great memory wars, when I decided I really didn't want to get into bubbles, one of the things I did with a colleague called Luby Romankiw, who'll we mention again later, was try to come up with a thin film magnetic recording head for disks. At that time we were using ferrite heads, I'm sure you're familiar with those, and they were the mainstay, they had been around for a while. They'd replaced metal heads, and I thought we should be able to use our thin film magnetic expertise to make smaller heads that worked well: inductive thin film heads. We made some in our lab in Yorktown, and we sent them out to San Jose, and sure enough they worked in a research-y kind of a way, you know? <laughs> Good enough for research.

They set up a development group in San Jose to work on inductive thin film heads to replace the ferrite heads, and they ground away at that for a few years, and pretty soon they had a product. In fact, our key patents in that included one of the other big patents that I held for IBM. IBM had inductive thin film heads for what, three, or four, or five years, before anybody else got rid of their ferrite heads. The other people finally had to get rid of their ferrite heads, because they couldn't make them small enough. You know, every turn of the crank they get smaller, and we were by far the leaders in recording heads for drives. That was one of the things that the competitors had to do, they had to scramble to catch up when the ferrite heads finally ran out of gas.

They were manufacturing these things in San Jose, they had a nice production line, which looked like a semiconductor production line, making wafers for all these heads. They were making money at it, and so they were perfectly willing to consider now the MR head, which we had already transferred to the guys in Boulder for tapes. They were a much harder problem to do on disk drives for a number of reasons.

**Allan:** The interesting thing is that, looking back in time, there was always this fear, you might call it an inferiority complex perhaps, that we were going to run out of the ability to keep doubling the density and halving the cost every year.

**Thompson:** Yeah, for 40 years that was our fear, and it always has been.

**Allan:** Somehow that undercurrent really was blossoming in the era of thin film heads, because we thought we'd come up with a way to get past it, and suddenly we were running into barriers on thin film heads. The MR head came along almost like a savior, on where we were able to go.

**Thompson:** It may have seemed like that to an outsider, but in fact, when the MR head appeared we'd already been making them in Yorktown for 20 years. They just weren't ready and they didn't work well, but for 20 years in the back, turning the crank, and ten of those years with him [Chris] running in San Jose... That was invisible to the world, but when MR came out it was not a sudden jump. It had been supported all those years with money, because management knew they were going to run out of gas with the inductive head.

**Bajorek:** I think also he's describing that perception looking at it from the outside. The rest of the industry had to live without MR heads for another five or six years. You know, we announced them and shipped them in 1990. The rest of the industry didn't catch up to that till '96/'97, so it was a six/seven year period where industry had to live on extensions of the ferrite heads.

**Thompson:** Chris can fill your ear with reasons why it took ten years for the MR head to get out, because they ran into many unexpected-- or maybe even some expected--, problems that were tough to solve.

**Allan:** That was the thing that struck me at the time. I knew there was something else. It didn't seem to work, or it didn't seem to work well enough, because it wasn't coming. The thing is, it wasn't as if it was the concept, it was the packaging and the technology to put it into that environment that was the killer.

First, disk drives are another problem in the sense of wear, and I can remember arguments about recession which I never understood, because they'd get into esoterics which you needed to be in the game to understand. All of those seemed like, insurmountable barriers at times, but then they basically got knocked over.

**Thompson:** The MR head was by far the biggest revolution of any product I've ever been associated with, because..., the giant GMR head, you probably heard of it, that's the more recent MR head-- that was a drop-in. The head people and the guys who make the pre-amp with the wires going to the head, they had to change their stuff, but nobody else was affected. The people who make the air bearings, supplying the sliders, and the people who make the sliders, people make the disks-- they didn't have to change anything. It was just a drop-in. The MR head changed everything, you had to have a new channel, and new equalization.

**Bajorek:** A new pre-amp.

**Thompson:** You had to have more wires, and you had to have an electronic device. You talk about pole tip recession, the wear on the heads in those days in those days partly came because you landed the head on the disk. They didn't use load/unload back then-- you landed on a disk which the disk people had put abrasive particles in, so that it would wear the head instead of wearing the disk when you landed. <laughs> This is the old armor-piercing bullet versus the armor kind of thing, and those guys were just screwing up the heads.

**Bajorek:** Yeah.

**Thompson:** When the head did touch these particles, it produced thermal spikes, which drove the channel nuts, so the channel guys had to change everything. The disk guys ultimately had to change everything, the head guys were obviously changing everything, and the air bearing people had problems, too. It was a revolution of every component within the disk enclosure. I don't know of any other new technology development that required overturning the apple cart in that sort of way, and that's why it took ten years.

**Bajorek:** Yeah, it was probably even more complicated than the transition to perpendicular recording that the industry went through later. And the challenge--

<overlapping conversation>

**Thompson:** They changed the disk--

  

**Bajorek:** With the benefit of hindsight, you know, we can talk about these problems and their solutions, but there were extraordinarily challenging and we were helped by a couple of things <laughs> that came along the way. There were no silver bullets to fix these problems, you know. These required a concerted effort by large teams of engineers, and along the way we killed a couple of programs in IBM. We had a massive Josephson junction program in Yorktown heights, which--

**Thompson:** Superconducting computers.

**Bajorek:** Yeah, which were aiming at replacing semiconductors for the giant superconducting computers, and my sabbatical in Fishkill contributed to killing that program. At that time the industry did not know how to build a mainframe without using-- relying fundamentally on engineering change wires. I don't know if you remember engineering change--

**Allan:** Oh, yes.

**Bajorek:** We just couldn't do it. We needed them at the module level, we needed them at every level of packaging, right? The Josephson guys were very clever, but they had never thought of the need for superconducting engineering change wires. We would never been able to design a practical mainframe on that technology. Anyway, there were lots of other problems.

**Thompson:** The connection problems--

**Bajorek:** Yeah.

**Thompson:** -- were also terrible.

**Bajorek:** Terrible. I mention that because the Josephson program had gathered a very competent group of people who needed new assignments, and that was just the time when we were beginning to face these tough problems that Dave just described. We were lucky to transfer some of the best skills from the Josephson program like Hans Zappe, Tadashi Yogi <laughs> who's our friend here at the museum, to join the MR head program. I had come out to the West Coast and ended up having to kill IBM's magnetic bubble program, jointly with a colleague of ours, Jim Belleson.

Jim was on the product side, they had developed a fully working magnetic bubble memory with the goal of commercializing it, and we had advanced programs in that space in San Jose research. Jim and I had the distinction of doing our best to make bubble succeed, but we didn't, and that program had about 150 engineers and scientists. A highly interdisciplinary team of magneticians, semiconductor experts, packaging experts-- these magnetic memories require pretty sophisticated packages.

All of a sudden we had the ability to redirect that team of people. Having access to those skills and redirecting them from Josephson devices and magnetic bubble memories to magnetic recording, really gave us the bandwidth that enabled us to solve these problems. Even with that skill application, it took us another six years or so to overcome thermal asperities, shield smearing, the lead protrusion. I imagine--

<overlapping conversation>

**Thompson:** <inaudible>

**Bajorek:** We had the opposite problem. We had the stress of these multilayered MR heads on film inductive heads for writing were so high that if you had the wrong metallurgy, it actually extruded it from the head under the right temperature and humidity conditions as opposed to eroding it, right?

**Thompson:** Electro-migration also produces enormous pressures if you're bonded on all sides. You don't see that usually on a chip, semiconductor chip, because you're free in one dimension, but in that head, electro-migration would cause things to come squirting out.

**Bajorek:** Squirting out through the gap, and you couldn't look at these MR heads without them corroding on you.

**Thompson:** Yeah.

**Bajorek:** We had to learn how to passivate the air-bearing side of the heads.

**Thompson:** We also had to stop making disk drives the size of turkey roasters with air blowing through them, and we started by not quite sealing the drives, but at least controlling what little air did go into the drives. The old IBM in the early disk drives were actually air-cooled. We've wandered off, what was the question? <laughs> Oh!

**Bajorek:** I just want to come back and finish this story. The commercialization was enabled by redirecting these people. Denis Mee was a key partner in this endeavor at that time, because he acquired the resources that were in the product division devoted to bubbles. It enabled us to form a joint lab between research and the product division called the Magnetic Recording Institute. Dennis was the first leader of that institute, and the staffing in that Institute enabled us to have the depth to take the MR head technology from research and then transfer it into a product development environment. Without that skill it would have taken us much--

**Thompson:** Oh, yeah.

**Bajorek:** --much, much longer to solve these problems.

**Thompson:** This Magnetic Recording Institute was a paper construct, everyone in it actually reported to managers in their own division. I was the next head of that thing, and it was a perfect job for me, because nobody actually worked for me. I gave technical direction to like 150 people, and they had to listen to what I'd say, and they had to tell me what they were doing, and they had to nod their heads when I told them it was wrong. I didn't have to worry about their salaries, I didn't have to worry about their performance plans. Nobody actually worked for me. It was great!

**Bajorek:** At any rate, I just want to finish. That's how we got finally to the goal line. There was one phase to solve all these head-related problems, but then we had to learn how to integrate the technology into a disk drive. By the way, you couldn't buy the tooling necessary to build these devices, nobody made it, so we had to design and build the tools that were used for production. We had to completely modify clean room design to institute very rigorous electrostatic discharge control.

**Thompson:** An example. You know, people probe to see if a magneto resistor has the right resistance and so forth. You could give it a magnetic field and see if it worked, but if the operator moved her seat on the chair in her lab coat, the resulting electrostatics would blow the thing out. It took a long time to find out why our wafers, which started out with very high yield, would have very low yield after it was all done and tested.

**Bajorek:** Yeah, just the capacitance of an individual, right, in approaching one of these devices was enough to-- the discharge from that capacitance --

**Thompson:** You could blow them up with picojoules. It's amazing how sensitive they are as fuses.

**Bajorek:** It took another year to learn how to really put them together into a device. In fact what helped us was that with Jack Harker's blessing, who was still driving programs at IBM, he created a team to design a whole new disk drive, what became eventually the Sawmill disk drive. The five-and-a-quarter-inch ultra-reliable drive, he really aimed that drive as becoming the drive that would be the first to adopt the MR head, and it turned out to be the first drive that actually commercialized that head out of San Jose.

  

**Thompson:** Yeah, it was 1990. I was thinking of the one in '91 out of Rochester.

**Bajorek:** 1990, and then the second drive we selected was one that Rochester developed, the code name, the Corsair Drive, which was the first gigabyte size three-and-a-half inch drive. That turned out to be a very high volume product which took the MR head to another level of sophistication in terms of mastering production at very high volumes. At low volumes we could sort heads with less than ten percent yield, but you couldn't afford to do that at high volume. We had to master these technologies to the level where we could produce wafers and drives with yields in excess of 80/90 percent to make it an--

<overlapping conversation>

**Thompson:** That was the first PRML (partial response maximum likelihood) Channel right in that drive?

**Bajorek:** No.

**Thompson:** No? Where was that first done?

**Bajorek:** That was done in the Redwing drive out of Hursley.

<overlapping conversation>

**Thompson:** Okay, so <inaudible> it was also--

**Bajorek:** Well, that shift was about contemporaneously but it was a collaborative effort between Rochester and Hursley, where Rochester designed the chip for Hursley. Rochester was responsible for providing the entire technology menu for the Redwing drive.

**Thompson:** I got it.

**Bajorek:** The heads, the media and the channel.

**Thompson:** What brought it to my mind was the PMRL channel, which is really the first highly digital channel that gave people a much easier route for mating the channel to the head. The signals on the MR head were different, and the noises were different, and once we got into the PRML digital channels it took a big bottleneck out of the development process. The old channels had a long turnaround time.

**Bajorek:** Yeah.

**Allan:** You just touched on one thing there, because I was thinking that at the time, the PRML coding came out in the same era.

**Bajorek:** Yeah.

**Allan:** The thing was it's very hard to figure out what data is unless you've got an excellent coding scheme that will compensate. You have media, which we haven't discussed much yet, except the impact on media if you did it wrong. We've got the head. We've got the coding scheme. All of which are outside the tribology issues of just keeping above the surface as much as you can. When you look at this lexicon of issues, it's not just one discipline that has to be changed to get there. Like you said, everything eventually had to change to adopt this technology.

**Thompson:** If you were a company that used the design philosophy of buying your components, and buying your heads and buying your disks, and so on and so forth, you would have been very, very hard pressed to make all these changes at once. The MR head did change everything, and that would bankrupt a company if they tried to do that and it failed for any reason. You lose one turn of the screw in the disk drive business and you are out of business. There were like 20 or 30 companies making drives at that time, and IBM made money, but a lot of the others barely were treading water.

**Bajorek:** You're right. It required one of the most interdisciplinary efforts that I'm familiar with in my history in this field. We even had to draft 20 specialists out of Fishkill, because parts of the processing, the wafer processing and tooling that we had to use were very similar to the ones that had been mastered for semiconductor manufacturing. We didn't want to learn all of that from scratch in San Jose. I remember having to go and plead with headquarters to give us access to some good specialists from Fishkill that we imported. We were lucky to hire an individual by the name of Gabor Paal from Fishkill, who played a major role in helping us complete the processes that were necessary to make the wafers. Without that injection, this would have taken even longer.

It took some key innovations, but the execution and translation of those innovations into practical processes that we could use on a regular, high volume production basis was facilitated enormously by the access to essentially three programs. The skills from the failed Josephson program, the transfer of the skills from the bubble program/magnetic memory program, and the drafting of about 20 key skills from Fishkill.

**Thompson:** And a management that had deep pockets and was willing to humor us, because at one time hard disks were the most profitable part of IBM.

  

**Bajorek:** I was thinking about the factors that facilitated the commercialization of the MR head, and the last factor I can think of that was very important was the willingness of the Product Development Division to accept that technology. That willingness was very rare in product divisions, and where it existed, it was usually a result of the influence of key individuals. I'm thinking here in this case that people like Denis Mee and Jack Harker played a very strong role in influencing key product developers in the division to very seriously look at the MR head as an application. I think that materially improved our chances of success.

**Thompson:** Over on the research side, Ralph Gomory, who was head of research at that time, was to my way of thinking, the perfect Technology and Science Manager. He fostered the kind of freedom, focused freedom, but still a freedom to do what you thought needed to be done and get it done. My second level manager, Cliff Cullum was also excellent, and later Jim Eaton at supporting this kind of thing. I was lucky in my 32 years at IBM. I never worked for a bad manager, but I certainly saw plenty of them. <laughs> You knew, they were out there, but I was very fortunate, and I'm sure that has a large amount to do with my success. Chris, you had some good managers, too.

**Bajorek:** Yeah, well, I hate to say it, but you were my first experience. <laughs>

**Thompson:** Well, I worked for you, too. So that closed the circuit.

**Bajorek:** It was pretty good. It was very good, excellent. I was lucky to draw good managers all along, and they influenced what I did. You know, Jim Eaton brought me for sabbatical to Fishkill.

**Thompson:** Mm hm.

**Bajorek:** In turn , we formed the Interdivisional Advanced Packaging Technology Lab, we then formed this Magnetic Recording Institute, which again, stimulated collaboration between Research and the Operating Divisions, and finally, I was drafted to leave research and go into product development. The latter parts of the MR head program and the disk drive programs that incorporated the MR heads were programs that I was lucky to manage. The Sawmill project that Harker started, he gave it to me to manage. <laughs> He assigned Jim Makiyama, who was the actual product manager and designer of that drive to report to me, and I think that helped bridge the gap between the disk drive group and the head group that was responsible for the head. In the middle of that, once we saw that Sawmill was going smoothly, I was drafted to go to Rochester, and--

**Thompson:** Which your wife thought was the middle of nowhere.

  

**Bajorek:** Oh, yeah. As background, at one time the Justice Department was going to break up IBM as a monopoly, and IBM was preparing for that possible eventuality by essentially planning to be able to split itself into two entities. It ended up, purposefully by design, duplicating certain capabilities, disk drives included, so that the mid-range systems and entry level systems could be self-sufficient in disk drives from the high end, in the eventuality it had to be split, so at the time I was asked to go to Rochester where we had these new development groups, pushing new drives. We needed to figure out a way to make the entire company-wide program rational in some sense, because in the end, we didn't have to split IBM. We settled without having to do that split, but we now had these overlaps, and one of the problems with the Rochester products is that they were not able to duplicate the film head capability. They were relying on vendor components, and as such, they were more similar to the products that the rest of the industry was developing.

One of the goals I set out-- in going to Rochester-- was to see if we could enhance the leadership of those products by injecting some of the new technologies in there, and that's what drove the take-up of designing the first PRML chip. The chip was designed by the Rochester team, fabricated by Fishkill, and went into the Redwing drive. By the way, that worked with the metal-in-gap ferrite head and film disk, the Redwing drive had that combination. Rochester, ironically, turned out to be the first group that shipped IBM's film disk in the Lee five-and-a-quarter inch drive. It was an interesting drive, as you might recall, because it was the first and only drive that used a vapor phase lubricant.

**Thompson:** Hm.

**Bajorek:** On the disk, you know?

**Thompson:** It's still the best lube idea I ever saw, but it fell back out of favor again, partly because this was a product that was put into environments with high thermal gradients. It turns out vapor lubrication is more difficult to manage if you've got one hot side and one cold side on your enclosure. It's a dumb place to do it, but it's a great idea. During the break, we were mentioning that people's prejudices are partly to solve problems by using the methods of their previous success, or the technology of the previous success. The counter to that is when they've had a big failure, they remain resistant to that for a long time. IBM had a big thin film disk failure about the time I joined the company, and it was unfortunate, because the alumni from that ended up pushing the particulate disk long after the particulate disk should have been abandoned. This is one case where IBM, in particular San Jose, the big disks were not leaders with thin film disks because of that unfortunate history.

**Allan:** It happens. Politics gets in the way, doesn't it?

**Thompson:** It happens, and there were two big factors which could never be overcome. One was corrosion, because they hadn't understood carbon overcoats or anything like that, and because those big disk drives were cooled by running outside air through them, you never could really handle the corrosion problem. The other was that when you're using 14-inch disks, think about the machines you need to make thin film 14-inch disks, as opposed to a three-and-a-half inch disk. It's crazy. Actually, there were two programs, one was plated and one was evaporation. I was thinking of the one that used evaporating thin film disks, but the plated ones have even worse corrosion problems because plating incorporates elements from the plating solution right in the film. You're never going to get them out.

**Bajorek:** Yeah, being familiar with the history of film disks, I think that a very fundamental breakthrough was the discovery of diamond-like carbon with a bonded lubricant on it, polymeric lubricant. That really came out of DataDisk, right?

**Thompson:** Mm hm.

**Bajorek:** Once IBM learned of it, that's how the Rochester group succeeded in punching through its film disk. They were able to very quickly adopt the diamond-like carbon, but initially with a vapor-phase lubricant.

**Thompson:** Right.

**Bajorek:** Once the bonded lubricant idea surfaced, it adopted that, as well. The key disadvantage of the vapor phase lubricant was that at that time it added about 35 cents to a dollar of cost to the drive, which you could avoid if you didn't use it. Being a cost-sensitive environment, a lot of people rejected it just because it added this small amount of cost.

**Thompson:** Even though--

**Bajorek:** --it worked perfectly well.

**Thompson:** In fact, it's better, because it's self-renewing. When the head and disk momentarily contact, it scrapes off the lube, and instantly a mono-layer reappears.

**Bajorek:** Yeah.

**Thompson:** That's what it was, the vapor maintained a mono-layer of lubricant on the disk.

  

**Bajorek:** Once Rochester adopted and integrated MR heads in their products, they were able to punch out some very industry-leading, very competitive products, and the last group that adopted the advanced technologies were the groups out of Japan in Yamato and Fujisawa. Their claim to fame was to try to emulate the rest of the industry by building drives out of the merchant sources from the--

**Thompson:** Component industry.

**Bajorek:** -- component industry that was supplying the other 20 or 30 disk drive makers. They also learned how to integrate the advanced technology and shipped some industry-leading, two-and-a-half inch and three-and-a-half inch drives, once they themselves adopted the MR head technology. That completed the journey, but the rest of the industry relied on metal-in-gap (ferrite) heads, film disks, and they eventually were forced to switch to MR heads in the mid-'90s, in the '96/'97 timeframe. By then you had companies like Headway, which was purchased by TDK, and Alps mastered the MR head technology, so the component suppliers were able to provide those to the rest of the industry. I think that's the essence of the story of MR heads, right?

**Thompson:** As seen from IBM, at least.

**Bajorek:** Yep.

**Thompson:** We, of course, rejoiced when our opponents finally bit the bullet and tried to start making them, because they had all the problems we did. Of course they did hire away some of our alumni so they didn't have to relearn everything, but it was a tough job for everybody.

**Allan:** A couple of things that come to mind here, number one, IBM for a period had the best products at what appeared to be low buildable prices compared to the same capacities. Although IBM could have made it an OEM, the spirit was lost, it didn't exist.

**Thompson:** Right.

**Allan:** It wasn't like an HP who went in and when there was a need to decide who got what coming off the line next week HP leaned towards their OEMs because they knew they needed their business to keep going.

**Thompson:** Right. Right.

  

**Allan:** IBM never shipped to an OEM if there was an IBM need. Here was an opportunity in the market where the technology was way ahead, the packaging was viable, but the spirit was very, very weak because you couldn't get it to the customer.

**Thompson:** The big money maker in IBM in the drive business was out here in San Jose, and it made its money by selling the drives with IBM systems. All the way up to headquarters there was the mental attitude that if you have a good product it's an advantage for selling the system. If you OEM that product, it's no longer an advantage to you because the other guys will get to market, get the rest of the system out faster than you do. It might even be a disadvantage for the guy selling systems. Those were the guys at the top, OEM was never, never really looked at on paper [as a business] that I can think of in the storage division.

**Bajorek:** By the time the realization came that OEM could be important it was too late. We tried to penetrate the OEM market with the products out of Rochester and out of Yamato and Fujisawa, but as Dal said, it was not ingrained in our culture. That was not our business, and we really didn't do very well at it. We had good products, we could have sold many, many more, but we just didn't have the commitment, the energy behind it that OEM would have required.

**Thompson:** They didn't trust us for the following reason. Suppose you're an outsider wanting to buy an OEM component from IBM, and you've been through these cycles of shortages either because of some technological disaster or because you couldn't ramp up the new things like the MR head fast enough. If there's a shortage and you're getting your drives from IBM and IBM is getting its drives from IBM who do you think is going to get the product that's in short supply? It's going to be the internal people, so as an outside customer you just don't trust IBM not to favor the internal sources.

**Allan:** But they did trust HP which was the interesting anomaly between the two organizations.

**Thompson:** I don't think HP had the marketplace clout that IBM did in the system side.

**Allan:** I'm not thinking about disk drives when I'm thinking of HP, I'm thinking of HP and printers.

**Bajorek:** Yeah.

**Allan:** In their printer division, where they were very successful, HP made a commitment to the outside world which they kept. As you pointed out, when IBM made a commitment to the outside world they met all of the fears of the person they committed to.

  

**Thompson:** Yeah.

**Allan:** And that's…

**Thompson:** It's a way of doing business, but it's also a question of who is running the corporation? IBM was never run by technologists, it was always run by-- we think of them as bean counters-- and maybe occasionally lawyers but mostly bean counters. They would never do anything to threaten the profitability of the main line, and so there were technologies that were held back because it visibly threatened what was already there.

**Allan:** In fact, that was probably not a bad thing from industry's point of view because, guess what, a lot of those people who were quote held back split, and used that knowledge elsewhere.

**Thompson:** IBM was the greatest university for recording people in the world.

**Bajorek:** The other aspect that affected this was that the drive industry evolved into being highly commoditized and standardized. Never mind not trusting IBM to buy a drive from in terms of priority. No respectable OEM customer wanted to be dependent on one source whether it was IBM or anybody else. You needed to have at least two sources. In fact, that penchant for demanding two sources decreased the true value of a leadership product because…

**Thompson:** From an OEM point of view.

**Bajorek:** …you wouldn't be able to sell it until somebody else could offer it. The system manufacturers insisted on-- the Dells, the HPs who were buying drives, the Apples, -- insisted on having two sources. partly also to be able to negotiate pricing. Cost became such an important factor, and those were arenas in which IBM was not able to operate successfully.

**Thompson:** Plus..., there's significant information flow both ways in an OEM environment. IBM really worried about our confidential information flowing out to the customer, and I'm sure the customers didn't like the idea of IBM learning their plans too. You really can't keep these things secret. Rochester developed the reputation of bleeding our technology out the door to their suppliers, and there was some hard feelings about it. Celia Yeack never got over one of the leaks out of Rochester with regard to some of her testing techniques, but if you know a test and your customer needs it, you can't really hold it back.

**Allan:** Chris, one of the things you mentioned sort of countered or contradicted a thought I had of the word sabbatical. Around here the sabbaticals from Apple and Google and all of these other companies, the guys always came back talking about their wonderful time in India and this, that and the other thing. You talked about a sabbatical at Fishkill, which is not a tourist destination.

<group laughter>

**Allan:** What did the word sabbatical mean in research? Did it mean getting outside your field and into a different environment for a period?

**Thompson:** It depends on what you did for a living. My only sabbatical when I was back east was here in San Jose working for the boss of the manufacturing site, the development site, but people in other disciplines, of course, went to universities on sabbatical. I would guess that we were one of the most applied technologies, and there weren't many universities that were doing stuff that we wanted to do or needed to do. If you were in information theory or material science or something like that your sabbatical would logically be the university.

**Bajorek:** I think, with the benefit of hindsight, IBM called this a sabbatical but it was really a career development ruse.

**Thompson:** A temporary assignment.

**Bajorek:** They figured that if they exposed people from research to real problems in the product divisions that it would enhance the research division's ability, if they came back, to be more effective in technology transfer when working on relevant problems.

**Thompson:** Knowing what the problems are, like I said, as an engineer knowing what the problems are is more important than figuring out how to solve them.

**Bajorek:** I learned that if you truly want to find out what a division is all about, or a company is all about, go spend a few weeks in their manufacturing operations, and just get exposed to the day-to-day battles they had to deal with in producing products. To me, the Fishkill experience was very valuable in teaching me about a new field, but also in teaching me about how these units operate. What one would then have to do to really get their attention, if one wanted to move some new ideas that could be beneficial to them. One of the most difficult transitions for me in my career at IBM was going from research to development. The first couple of years I was absolutely-- I felt totally incompetent on the product development side. <laughs>

  

I expected that I would come in and find deep expertise on all aspects of disk drive design and manufacturing, and that would make it easy for us to transfer this MR head technology into production. I learned through baptism by fire that there was nothing of the sort. One literally had to step back and analyze the situation and guide those teams into taking specific actions. It was a brutal learning experience. Once I learned it though, I became more effective in being able to lead such teams, but at the beginning it was a very difficult experience. I think these sabbaticals were really there as a career enhancement, and the research division wanted to send people out for their careers. I was one of those booted out to go into the product side. <laughs>

**Allan:** You also extended your network, though. You knew that at Fishkill they knew stuff that you didn't know when you needed it in a different arena, and not even when you were in research anymore.

**Bajorek:** Oh yeah. In the end it did turn out to be a roller coaster ride of excitement, frustration, but big satisfaction in being able to --- imagine--- we created new technology from the ground up. Scaled it up. Commercialized it. Shipped it out the back door, the loading dock, from the ground up. We went from proof of principle to a scotch tape-held prototype, to a rigorously prototyped device, to a full product development scheme, and then full scale manufacturing.

**Thompson:** One thing it's done is made us very skeptical of demonstrations, technology demonstrations from research divisions elsewhere, if you know what I mean. Demonstrations in principle are usually not worth much.

**Bajorek:** Well…

**Allan:** The skeptical eye.

**Bajorek:** The other-- a couple of other lessons from this. One is dealing with these issues like "What do we do with Josephson technology or magnetic bubble memories, and how do those differ from MR heads?" It was learning the experience for an emerging technology to have a chance to compete against extensions of an incumbent technology. It has to be at minimum, an order of magnitude, preferably a couple of orders of magnitudes superior to the incumbent.

**Thompson:** Right.

**Bajorek:** For example, we killed bubbles-- we could prove very rigorously that bubble memories would be cheaper than DRAM memories by a factor of six. People would kill for a factor of six reduction in cost per bit in a memory, but that was measured against an incumbent that was running at full speed and we had yet to discover the problems we didn't know about. A slip of schedule of two years would have erased that six fold advantage overnight, so it was a brutal lesson to learn.

**Thompson:** You didn't mention the other big technology that was used against us which was optical storage, and it was always going to be 100 times better. Or maybe it was ten times better. Or maybe it was one times better. Or maybe it wasn't as good as magnetic recording. The reason was that we kept doubling [magnetics] every couple of years, and they stayed with pretty much the same wavelength of light, maybe within a factor of two. That determined their resolution through the whole thing, and so they started out with much higher areal densities, and now they're way behind. Who uses optical storage for anything other than consumer playback units?

**Bajorek:** It's very hard to understand that when you're competing against a Moore's law driven type of progress, where every year you go up one-and-a-half times. One of the best assignments I had after I retired from IBM was an assignment working for Eli Harari at SanDisk. He had asked me, "Chris, we were very successful with Flash, I need you to go find out what could threaten our future." I was given free rein to visit about 60-some efforts on emerging memory technologies around the world. Each thought it was working on a unique solution, it turns out they're working on about a dozen technologies. With one exception they all did not appreciate that they really had to demonstrate superiority by orders of magnitude compared to NAND Flash to have a chance to compete in that arena. I was astounded as to how many efforts were being funded under false promises, the investors were misled into the promise of this technology.

**Thompson:** Or were naïve.

**Bajorek:** Right.

**Allan:** That's why I've never understood, how did bubbles even get into the picture? If you look at it from 30,000 feet and say, "let's take this technology, every time we shrink it, it gets slower." Access time getting slower on a denser memory is the antithesis of progress in a disk drive arena. And so…

**Thompson:** Does it really get slower? I don't think-- I think it stays the same.

**Allan:** Yeah, it does. It's the circulation and the…

**Thompson:** Oh, you're talking about the fact that it's a loop. Yeah, okay, if the number of bits in the loop increases they are slower.

  

**Allan:** Going through the technology at the time and making the presentation to a group of people, and them not even conceiving that this was a dead end because the better you got at it, the worse it was for the user. They could not grasp that fact, and maybe it was the PR [Public Relations] principle, and maybe it was the fact that you could see it, but it sucked off resources.

**Thompson:** You could see it. I mean it didn't take me two months to decide to get out of that program when our whole department was re-purposed, but like I said, I worked for good managers. I said, "I've got some ideas, let's do these instead", and they said, okay.

**Allan:** The fact that the bubble memory project failed, failed at the right time in terms of financial boost, technology boost and everything else.

**Bajorek:** Yeah, it was…

**Allan:** For a different technology…

**Bajorek:** It was a silver-lining.

**Thompson:** It was the right time for IBM, but it wasn't the right time for Bell Labs. It wasn't the right time for Hughes and some of the other people who poured a lot of money into it, and had to walk away.

**Bajorek:** Even Intel made a major investment in bubble memories before they got out of it. Very unusual, but maybe we should turn to some of the other thoughts, other questions.

**Thompson:** Other questions.

**Allan:** Chris, one of the things that I knew about you long before I ever met you, for a period of time you were on the front cover of Electronic News every second week. You just referred to your resignation from IBM, and they're both closely coupled.

<group laughter>

**Allan:** At the risk of bringing up some difficult memories, can you give the background about how that had occurred, because it was a very important principle that was established here in California.

  

**Bajorek:** After completing various assignments at IBM I crossed the twenty-fifth anniversary. It entitled me to retirement, and I was intrigued by the possibility of tasting the world outside IBM. I'll take a slight detour. Tu Chen who I had met when I was in IBM Rochester under circumstances of a battle to try to qualify Komag's disks for use in Fujisawa's products, where Komag had run into a technical problem and Fujisawa as well. I met Tu Chen at that time and we solved those problems, and ever since he wanted to recruit me to go join him at Komag. I finally did that about five, six years later, and IBM was very upset that I had left. I was fortunate they thought well enough of me that they were upset but at that time IBM's standard operating practice was to claw back proceeds from stock options for someone who they weren't satisfied with for having left.

**Thompson:** Who went to work for the competition, in particular.

**Bajorek:** And they could-- they were sole determiners of who the competition were. It turns out at that point in time, Komag was a large supplier of disks to IBM, and one could have argued whether it was a competitor or not. IBM declared Komag a competitor, and the standard operating procedure for loss of leadership was to threaten the person who had left with litigation. To claw back those proceeds [from stock options], and shortly thereafter to offer them a return job and forgiveness for having left. That's what happened, I left IBM but a few months later I got this letter saying you've got to return proceeds of stock option exercises dating go back a year or six months to a year, and if you don't do that we'll sue you.

A month later I got a letter, "By the way, we'll be glad to take you back and you'll be able to keep the proceeds." I knew that was happening because a few other strong technical leaders in IBM had left under the same circumstances and some came back under the promise of a return job. I had analyzed the situation and concluded that the claw back of proceeds in California was illegal, that that would not succeed in California. IBM's offer to come back notwithstanding, as a defensive measure, I sued IBM in California because I wanted the issue resolved under California law. IBM immediately sued me in New York. This is at state court levels, and we ended up consolidating the case in federal court in San Jose but to be judged under California law. There was a first trial at federal court. I won that case. IBM appealed it to the Court of Appeals, and the Court of Appeals ruled that the case really should be tried under New York law which would have been advantageous to IBM.

By that time the matter had proceeded long enough that we decided to-- I was confident I would have prevailed in the end-- settle the case. Later my case came up in a related case and it went all the way to the California Supreme Court, and at that point, the California Supreme Court ruled that what IBM had attempted to do was illegal in California and settled the matter permanently. There was a period of hiatus, we didn't quite resolve it all the way in the litigation because we settled it along the way. I think I became known as IBM's bad boy, because I had the temerity to sue IBM.

**Allan:** You were only known as that inside IBM. Outside, you were seen as an anti-hero or a positive hero, taking on Big Blue. You know, there were opinions from "he's nuts" to finally "he's got his own problems." There was a huge range of opinions on this from people who didn't know you. I don't think anybody knew you or what you were fighting for. They just knew that it was this crazy situation that made headlines. I don't think it was ever explained, certainly not as succinctly as you just did, nor as perhaps as honestly as you just did.

**Bajorek:** The settlement terms of the matter are confidential, but I had anticipated that possibility because, as I said, at that time this was standard operating procedure for IBM. I managed to protect myself, so this had minimal financial impact on me.

**Thompson:** You mean Komag paid for the lawyers or something. He can't talk about it.

**Bajorek:** I came out of it okay but, I became, as you say, also famous in legal circles. All human resource law specialists got familiar with this case, but it was interesting. The local federal judge, Judge White in San Jose, saw instantly the right decision-- made the right decision. The panel I drew and the three-judge panel I drew in the Court of Appeals was a judge from Alaska, a judge from Utah and a judge from New Mexico. That's a territory of the Ninth Circuit. The concept of a stock option was totally foreign to them, they didn't consider it pay.

In California it's illegal to claw back any pay, period, and stock options are part and parcel of the remuneration system in California. These judges in the Court of Appeals had no idea what a stock option was, and they didn't consider it remuneration. At any rate, it was all straightened out when it ended up going to the Supreme Court of California, and what IBM attempted to do was judged to be illegal.

**Thompson:** That's peculiar. You started in the state court, you went to a federal appeals court, and then went back to the California Supreme Court.

**Bajorek:** No, another case that was being litigated, a similar nature, ended up going to the California Supreme Court, and they cited my case in that as precedent for the arguments. The Supreme Court rejected the case saying look you can't cite the Bajorek case because it was incorrect, it's illegal under California law to claw back stock options.

**Allan:** From the outside looking in that was really not part of the picture. Part of the picture was the right to work, right to continue in your career…

**Thompson:** In your profession.

**Allan:** …in your profession…

  

**Thompson:** Without using proprietary knowledge.

**Allan:** Yes.

**Thompson:** The proprietary knowledge was, I'm sure, the bone of contention.

**Allan:** But the way…

<break in recording>

**Thompson:** At that time you could hardly practice disk drive technology coming straight out of IBM without your knowledge of the work being also being full of proprietary stuff.

**Allan:** I was…

**Bajorek:** In my case none of that came out.

**Thompson:** None of that applied?

**Bajorek:** Absolutely not. First of all, there was no impropriety in that sense. And IBM never even accused me or had any basis for that. IBM was angry that I left.

**Thompson:** Okay. I got it.

**Bajorek:** IBM wanted me back, and they used the threat of litigation as a way to induce me to come back.

**Thompson:** That's understandable Chris because you'd been a manager for so long. You were probably poisoned as a technologist anyway. No one thought of you as having technological secrets.

**Bajorek:** Technological secrets....

**Allan:** Dave, you had a much easier time retiring didn't you?

  

**Thompson:** Yeah. I was with IBM thirty-two years, and I retired at the last minute under the old retirement plan which was a very good plan, determined benefits. It was quadratic for the first thirty years and then flat after that, so if you retired after fifteen years you got a quarter of what you got if you went for the full thirty, and it's a good retirement. About the time I'd been in thirty years I was sitting in the lab manager's conference room, you know, one of these HR talks that you have to sit through once in a while. This lady came out from New York and she said, "The IBM retirement plan is an intelligence test, and if you stay more than thirty years you flunk." She looked around, we all looked to be younger than that although I already had my thirty years at that point. I said, uh-oh, I better take notes.

They discontinued the old plan shortly thereafter and I retired at the last minute. I had also achieved what I wanted to and I was no longer at that time running any projects myself, I didn't have anyone working for me. It wasn't like the professors who have grad students they have to get through and that kind of thing, so I was happy retiring. I got a big wad of stock options that didn't vest for five years, so for five years the only technology work I did was for the universities, mainly technical advisory committees in Singapore, Carnegie Tech, that sort of thing. Other than some patent consulting, I've been really retired since 2000.

**Allan:** No expert witness or court cases that came up?

**Thompson:** Just some patent cases which I advised on but they weren't patent cases that involved me personally. They were just interesting cases, and I was there was an expert witness, but I never actually had to testify in court. They were all settled at the deposition stage.

**Allan:** Similar for you, Chris? Or did you wind up on a stand somewhere?

**Bajorek:** I ended up helping, as Dave did, with a few cases, but I had three major cases where I had to testify in court proceedings. One was a famous case involving GMR head technology. Siemens had sued Seagate claiming that Siemens had invented the GMR Head, and I worked on behalf of Seagate's side. Seagate got that court to declare the Siemen's patent as invalid, and the second case was a trade secrets theft case between Seagate and Western Digital. Again, I testified on behalf of Seagate. The most recent case was CMU versus Marvell involving a CMU patent in the data channel used in disk drives. CMU won that case and got the largest patent award in the history of academic patents.

**Thompson:** We're talking about billions here. Right?

**Bajorek:** The possibilities were billions but the case settled at $750 million. There were larger cases among private industry fights, particularly in the pharmaceutical industry area, but the $750 million award to CMU set a record. Of course, CMU got a fraction of that because the lawyers took a third off the top. The actual inventors, the faculty Professors Moura and Kavcic got another third under the CMU patent rules, but CMU ended up with $250 million contribution in the end, net, which was quite substantial for their endowment. I felt very good about that case, to see the white hats win.

**Allan:** Did they build a new wing in honor of you as a witness?

**Bajorek:** No. No. The patent was based out of their data storage system center which was an industry university collaborative effort. They, of course, felt they were entitled to the entire 250 million but you can imagine the university quickly found how to spread it elsewhere. They might not get any of it before it's all done. In the end I quit doing it because I found this work of testifying in proceedings rather stressful.

**Thompson:** It's very intense. Yeah.

**Bajorek:** Not all attorneys play the game ethically, and dealing with attorneys who are not ethical in their behavior is not a pleasant situation, so I quit doing that. I'm fully retired. I just play. The one exception is I do volunteer work and I'm on the same committee you are [Dal], the Storage Interest Group here at the museum. I find it ironic to be on the receiving end of the oral histories, I really appreciate you doing it.

**Allan:** This is it. You've both had a long time in the game and you've always made reference to somebody else as to how things happened. Like you've got a patent but it's not your patent, it's our patent in the sense of it wasn't gained alone. It was something that was done with other people.

**Thompson:** Oh yeah, always co-inventors.

**Allan:** When you're going down the list of people and situations that basically influenced you and perhaps guided you in different directions, you've mentioned never having had a bad manager. Now that's very fortuitous.

**Thompson:** It is.

**Bajorek:** Yeah.

**Allan:** That's not always the experience.

**Thompson:** There is some skill in not getting assigned to a bad project by making yourself unattractive to that assignment. Part of managing your manager is staying away from the tar pits.

  

**Allan:** That's an interesting skill.

**Bajorek:** It's a studied degree of incompetence. You have to practice studied degrees of incompetence.

**Thompson:** I learned it from my wife where I am thoroughly incompetent in the kitchen and she knew better than to ever ask me to do something in the kitchen. I'm no good at it, you could believe that.

**Allan:** Let's put that another way. You could choose to be useful in the kitchen but you've managed to set it up such that it's not acceptable to be in the kitchen.

**Thompson:** No one would choose me to assist them in the kitchen.

**Bajorek:** I'm sure if you had to you would learn, but I attest to the fact that you're absolutely masterful at avoiding the kitchen.

**Thompson:** You were headed somewhere with this question.

**Allan:** If you look back who were the people who influenced you most in terms of setting trends in the way you went, or in terms of what you did looking back over your time?

**Thompson:** You mean, before I left school, for example?

**Allan:** Yes. Because some way or another you wanted to be an engineer. Let's say you had a father who was an engineer, so when you look at dad's an engineer, and he's making good money. That's an easy decision to make, easier than not knowing anybody and having to get there, so there must have been influences there.

**Thompson:** Like Chris, I grew up in a family where it was just assumed that if you were smart enough you'd be a professional. You'd get the education somehow and you'd do it. My father was manager of the local JC Penny's store, but he had wanted to be a chemist. When the Depression hit, he had finished his sophomore year. He had to go home and look after the family store in Wisconsin, and he did put his brother through college, but he never got that degree. He always missed that, and my brother and my sister and I we all were expected to go to college and succeed, and we did.

In terms of influences, there were a couple of teachers in high school that were very important, an English teacher and a science teacher. Once I got to the university there were many wonderful teachers inspiring teachers, not just my thesis advisors but my first undergraduate physics instructor was a lifelong friend. Dead now, but very inspiring. When I got to IBM I was lucky to have good managers, not just good at management but also technologically learned which is important, because if you get some dodo making the decisions it's going to run off the rails even if the technology is sound.

Now, in terms of colleagues we haven't talked much about colleagues there's one colleague that stands out as different from all of the others and that's a fellow named Luby Romankiw or Lubomir, a Ukrainian. Electrochemist, but you could think of him as materials science wizard. If you want plating, if you want insulation, deposition, anything. He and I were together from the start making these little transducers of ours, and I would do the magnetics design. I knew what I wanted, I knew how to hook it up and make the electronics work but he knew how to make the things. He knew how to make them small, and he knew all of the tricks to make the materials work.

One of the reasons IBM was the first one to ship thin film heads is not because we were the first ones to think of thin film heads. The basic patents had been out there for a long time and a lot of people had tried. They had always failed because they never could find the non-magnetic elements and patterning techniques that would work with permalloy which was the necessary magnetic element. Luby could do that. He's the one who invented using photo resist as the insulator in a thin film inducted head which sounds easy enough, but everyone else tried to use something like SiO2 (silicon dioxide) and the resulting stresses made the magnetic films not work.

People think that photo resist is just another plastic. It turned out at that time it was the only thing you could pattern the coils with that would let the adjacent permalloy work. He was a master of deciding between deposition techniques and etching techniques. The coils in the inductive pad were the technologically hardest things besides the permalloy, and most people tried to etch those coils out of a sheet of copper, for example, or gold. They never could get the aspect ratios, but typically those windings are twice as thick as the windings are wide each turn. It's like you can't do that, or in those days you could not do that with etching. Ion milling hadn't been perfected yet, and he was the whiz that made this work by electroplating. He and I would bounce ideas off each other all of the time and he would solve my fabrication problems and I would solve his design problems.

**Bajorek:** I second that, he had also an employee by the name of Sol Krongelb who ran the thin film deposition tools at Luby Romanikiw's group. I look back on the combination of Luby and Sol as key to the early work we did. All of this, whether it's Dave's inductive film head work or the MR head work, whether they're the consumer transaction devices, all of that work would not have been possible without access to, and the creativity of, Luby and Sol.

**Thompson:** When IBM development tried to make inductive heads, they brought in a bunch of people from Fishkill, and the first thing they did was get rid of the photoresist and start using SiO2. Those heads never worked. Finally, they had to copy Luby's plating cells and all of his other stuff and transport all that out to the west coast.

It's sort of odd, one of the first things we did when we got our first head working in Yorktown was we put it in on a disk drive. A disk drive in those days was bigger than a washing machine, and there was a lab tour. I think Thomas J Watson Jr. was part of the tour, this may have been a few months before you joined us [Chris]. He looked at it, we showed him the demonstration, and we explained why we wanted thin film heads. His only question was "Why isn't this work being done on the west coast? Disk drives are done on the west coast". He turns to my manager and he says, "Why are you allowing this work to be done here?", and then he asked me. I said, "Because we have the ideas". He said "Fine" and went away.

**Bajorek:** In my case, the parental influence was very strong in picking a professional career, but the Caltech influence was there early on. One of the best courses and faculty I ever had was Richard Feynman, I was lucky to take quantum mechanics from him, and I would say Feynman's overall outlook on science and technology and life were very influential.

I learned my semiconductors from Andy Grove. Andy was-- I didn't know it at the time-- but Andy turned out to be a hell of a leader in the valley here. I took my solid-state physics classes from Carver Mead, and Carver Mead ended up being an extraordinary leader in various aspects of the computer industry.

At IBM there were executives and managers who really facilitated this. Frank Mayadas was one of our senior managers who early on pushed us in the direction of moving this technology into commercialization. Jack Harker on the receiving end, Dennis Mee, they were on the product side. Gomory as the head of the division was very influential. Lastly for me there was working for Tu Chen at Komag, it was an extraordinary roller coaster ride, and I never met anybody more maniacal in dedication to a goal than Tu Chen. <laughs> It was fabulous working with him, and this didn't influence my career, but the assignment with Eli Harari was a joy because working with Eli was very special. To have the opportunity to spend a couple of years working essentially one-on-one with him was very, very rewarding.

**Allan:** It doesn't sound like there's any regrets or any things that you can look back on and say I kind of wish. Are there any such things that you're looking back at times, at what one might call crisis?

**Thompson:** I have one regret. It must have been 1984 or so I took the internal sabbatical to work on the staff of the manager at the manufacturing site in San Jose. I was still in Yorktown and my wife and kids came out here, and we had a good time. In fact, that was a prime development in getting my wife to agree to move to the west coast which she eventually did. Anyway, while I was on his staff I was a trouble shooter and I sat down and I looked at some of the failure problems and I wrote a memo to file which I shared with the patent guys that essentially invented RAID except most people think the I in RAID stands for inexpensive, right? All I had experience with at that time were these giant strings of washing machine sized drives, but I was working on the how do you handle a drive failure? How do you stay online which is very important especially for the high-end machines? How do you recover from a failure and rebuild the redundancy?

I wrote all that up and it was rejected and I didn't push it. It was rejected partly because in those days the drives were stupid, all of the intelligence was in a control unit if you're familiar with that architecture. They weren't reliable either, so the redundancy and reliability of the string of drives was not as important as when you got a drive intelligent enough that you could pull a drive out and drop in another one. It had enough of its intelligence that the RAID idea made sense. At that time there already were five-and-a-quarter-inch drives in existence, there were interfaces, and I wasn't seeing that side of the equation. My biggest regret is not having pursued RAID, which would have put RAID out three or four years earlier and with me as the inventor instead of all of these other people.

**Allan:** What year was that?

**Thompson:** I'm trying to remember exactly. It was the year of my sabbatical. Do you remember, Chris?

**Bajorek:** I think it was early eighties, maybe '83, '82, '83.

**Allan:** We had a different problem as an independent disk manufacturer which was that our average sales per subsystem was five. In the days of the 2314 the average number was nine, eight plus one. George Jacoby worked with me, and we were trying to come up with a plan to apply tape technology to disk drives in the sense of them buying nine track tapes.

**Thompson:** Yes.

**Allan:** We wanted to have them buy six, seven, or eight track disk drives, so George and I were working actively on that. There were so many people that were coming up with the idea of how you could use the number of drives to help each other.

**Thompson:** And replace one that dropped out for some reason...

**Allan:** And replace the one that dropped out.

**Thompson:** Maybe this wasn't, in fact, the right time.

**Allan:** I'm not sure I meant the right time, I'm saying it was the wrong publication period. The world was not receptive to the idea for a long, long time until a RAID paper was written based on inexpensive disk drives. That was the catch phrase.

**Thompson:** In my case the drive was not the inexpensive part, it was the fact that these strings had to be up 24/7 and the full mirroring was the only reliability thing they had. They had to have every data on two strings, so it [processing] went on if one string went down. It was the continuous availability and not the cost that was the main driver in my mind.

**Allan:** You were fighting a different problem. You make a lot more money on two strings of drives than you do on one, plus a couple of extra drives.

**Thompson:** It would have been a tremendous competitive advantage if you had strings that didn't go down. For whatever reason, you asked if I have any regrets, that was the biggest regret I have, not having pursued that.

**Allan:** It would have been an interesting pursuit because the world…

**Thompson:** Or even published it. I probably could have gotten permission to publish it.

**Allan:** That would have been a real plus.

Thompson: In IBM it was hard to publish something that wasn't already out as a product, or wasn't just purely technology, but I could have-- I mean I was on the lab director's staff. I could have twisted arms until I got it out and I regret I didn't do that.

**Allan:** I regret you did not too.

**Bajorek:** More fundamentally, had you pushed it, you might have gotten IBM to be an early adopter of RAID. IBM ended up with the fundamental patents in RAID, but they were late to market. In fact, it's what destroyed... I think that IBM's tardiness in adopting RAID enabled competitors like EMC to bring it to market and then essentially relatively quickly take away IBM's dominant market share in storage systems.

**Allan:** [Dave], we just decided you're responsible for the downfall of the storage division at IBM.

**Bajorek:** See, you were just not aggressive enough. <laughs>

  

**Thompson:** We have two other things that we have witnessed as sort of watching a train wreck. One was the destruction of IBM's Boulder lab, the tape library, the robots and all of that stuff. The reason that that lab was moved to Tucson was due to some struggle at the top of IBM over optical storage and copiers. The copier division basically pushed IBM out of Boulder, took over the site and then proceeded to make terrible products and go under.

**Bajorek:** The Office Products Division.

**Thompson:** The Tucson lab... Most of the people who were in Boulder loved it of course, and a lot of them quit and formed STK. In the process of moving to Tucson they [IBM] basically gave away the robotic tape library business which was a huge business. We saw all of that, and, I guess, there was nothing we could really do because it wasn't a technology decision. When the Tucson lab was set up, the primary focus was optical storage, the tape guys were cast as a dying technology, a mature technology that wasn't going anywhere. "We'll move you guys down there and you continue to crank out some products" which was just absolutely wrong. It all goes back to IBM headquarters where some great visionaries decided that tape was dead, optical storage was the future, "Let's put all of our money there and let's kill these other guys". It was just awful. Do you have anything to add?

**Bajorek:** No. At that moment, the Office Products Division was viewed as a hot future, so they were given whatever site they wanted and they said "We want Boulder."

**Thompson:** They took Boulder.

**Bajorek:** And they were given Boulder.

**Thompson:** In fairness, from the management point of view, storage optical products, office products, in particular copiers, were big. They failed not because it wasn't a promising market but because they put technological morons in charge and they designed the products to be unreliable. The products failed in the marketplace, but it wasn't because they couldn't have competed with Xerox if they had put the right people on the project. Do you agree with that, Chris?

**Bajorek:** Yeah. I remember I was in Rochester when EMC started attacking the midrange system arena by selling storage for those systems. We had a big headache with Allstate being a major customer, and without RAID capability, without even mirroring capability, they were always a large number of Allstate agents down because of disk drive failure around the country. I remember that was a popular time for the Six Sigma quality programs that Motorola had pioneered. We got deep into Six Sigma in Rochester and mastered it and so on, but I quickly proved that even if we achieved Six Sigma quality disk drives, there would still be too many Allstate agents down on any given day.

  

We really had to adopt RAID technology to achieve a desirable outcome there, and I remember having to take this to the head of that division. He, in turn, took me to John Akers in Armonk to make that pitch to really drive from the top down the adoption of RAID. Here was an inventor-- one of the innovators in RAID, ideas, which was terribly late to market. In that regard It wasn't the only area, right?

**Thompson:** Anyone who has worked for the government or a big company can give you a long string of missed opportunities. I don't want to be a downer because, in fact, we did very well. Occasionally you would see some colossal bonehead decision made, and what can you do?

**Allan:** When you said tape was dead…

**Thompson:** That was in our purview because we, in research, owned the technology, the ten-year outlook it as called on where are we headed. I helped prepare those many, many times, and ten years later we'd look at them and we were almost always dead on as to where the product would end up. We were almost always wrong as to the technology stream that would get us there. The areal density ten years from now would be such and such, and yeah we got there, but we sure didn't get there with the list of things we thought were going to get us get there. Things like textured media, for example, which I never thought would work.

The people who draw these things up loved that kind of stuff, optical storage and so forth. Getting back to your point, we could have gone out there and fought harder for the right thing and sometimes we just put our heads down and let the storm blow over us when they made these bad decisions. The people that you put down never forget it. You do have to choose your wars.

**Allan:** Back in the early sixties somebody else made the same decision on tape, that it was a dead technology, but were going to fix it with disk drives. That was the invention of the Count, Key, Data (CKD) format which became an albatross of major proportions.

**Thompson:** Eventually, yes. Yes.

**Allan:** It's things like that which influence the entire course. That one was overcome by energy, but it took a lot of energy to overcome that and eventually it was dispensed with. Those concepts, once they get into a mind way up high, as you've said, they distract you.

**Thompson:** Oh they are. The fact that every track has to have same number of bits, that hurt us for years, but enough of that. We finally got over most of this and then we got old and we retired.

  

**Allan:** But you're still active.

**Bajorek:** The one thing I do want to go back to, is giving credit where credit is due. We gave credit to Luby Romankiw and Krongelb but to really get this thing through the goal line, remember Ching Tsang and he became an IBM Fellow. He made key contributions to understanding the micromagnetics of these sensors. Kochan Ju who really played a key role in getting the device into development. Mike Chang who then became CEO of Headway. Mao-Min Chen who then also became the CEO of Headway. These are all guys who were alumni, and made the MR head program.

**Thompson:** It' a long list.

**Bajorek:** I'm sure I'll forget the names of key people but I'm just thinking out loud how Hans Zappe came out, he was the designer of the devices with its tolerances and distributions to be able to help the channel guys design the pre-amps. Gabor Paal who came out from Fishkill, the list goes on. I really want to make sure whoever listens to this or reads this doesn't get the idea that just you and I made this happen.

**Thompson:** Back in the inductive head there were people like Ian Croll.

**Bajorek:** Ian Croll. It took the effort of teams of people and without whom, again, it wouldn't have happened as rapidly as it did.

**Thompson:** Our industry is very different from say the pharmaceutical industry where if you have a patent on a drug, a couple of people could, in fact, have done the initial discovery. Maybe it took a team to prove it out, to do all of the medical experiments to show it.

The disk drive is such an interdisciplinary thing, you need the magnetics, you need the electronics, you need the control theory, and you need the channel people. Then there's the tribology, and the corrosion, and on and on and on. There's all of the mechanical stuff having to do with the arm and the heads and the aerodynamics of the flying head. Literally a person cannot invent a disk drive, or even a significant piece of it. You need a team, and I don't know of any other technology that's as diverse. If you're in the semiconductor business you've got semiconductor physics and fabrication to think about, but you don't have hydrodynamics. You get the idea, don't think that we did that much ourselves, we were just sort of at the head of the crowd.

**Allan:** Your names are well known. I'm assuming that there are also awards that went along with the fact that you were involved with these teams. What sort of awards did you get while at IBM and elsewhere that people have recognized your contributions?

  

**Thompson:** I got many awards within IBM, but the most important to me was being made an IBM fellow in 1980.

**Bajorek:** I had to write the nomination for that. You made it easy.

**Thompson:** Thank you, Chris. There were a number of Outstanding Contribution Awards within IBM. On the outside, of course, the most important to me was being made a member of the National Academy of Engineering and an IEEE Fellow. I was also the president of the IEEE Magnetics Society and pretty much all of the offices that are below that as you work your way up.

Let's see, I was named inventor of the year by the New York State Patent Attorney Society, whatever it's called. I'm a member of the National Inventor's Hall of Fame, so I've had plenty of recognition. I don't feel overlooked at all, and a lot of my colleagues who worked just as hard as I did and were creative, didn't get that. It's interesting how, as one of the guys at IBM headquarters said, "Awards beget awards". Once you get an award other people start looking at you and pretty soon you're on a list for another one.

**Bajorek:** It's a similar experience, that is, I had several IBM internal awards. I earned an early IEEE fellowship position, and then a Reynold B. Johnson award and a Millennium Medal award, but I haven't matched Dave in terms of his recognition at the academy or the Inventor's Hall of Fame.

**Thompson:** If you're in the product side of things you don't get that chance. Most of the best stuff is kept secret, it doesn't come out until years later when it's all done, so it's really tough. Once you leave the research division and lose the ability to publish this stuff, it's tough to get these awards.

**Allan:** Both of you have referenced what I would call the relatively easy entry into school, the fact that you didn't have huge bills and such like, and the industry that we got into through applied magnetics blossomed.

**Thompson:** It was the right time and it was absolutely the golden age for that particular thing. I mean if I had been two generations earlier it would have been the golden age of steam locomotives. You just have to take what's opening up.

**Allan:** What advice can you give to a youngster today, somebody who is coming into the job market?

**Thompson:** That's easy. The first thing I learned, or one of the first things I learned when I went to college, was to get yourself into classes where you're taught by the right professors, the brilliant professors. The ones who know what the problems are. I didn't get into applied magnetics because back in North Dakota I expected I'd be in electronics, but I went for the brilliant professors and that's what they were doing. Chris at Caltech had even more brilliant professors than I did.

**Bajorek:** Yeah. I would summarize it as saying fight tooth and nail for the best education you can get, and get schooled in the fundamentals.

**Thompson:** Go for the instructors as much as the course.

**Bajorek:** You need to find what I would call good role models, and the right instructor can be very influential in what you decide to work on and how you look at the world. They can essentially teach you a way of looking at the world which you may not be able to pick up from the average instructor in an academic setting. Don't fall in the trap of coming up with a solution looking for a problem. <laughs> Work very hard at identifying a significant problem, and then apply yourself to try to solve it. I would say those are the two pieces of advice I would give a young person starting. It's hard to predict what career path to follow because the world has changed so much. You want to be equipped-- you can't go wrong with being well-trained and working hard at smelling out the tough problems.

**Allan:** Let's switch now and say, okay, what advice would you give to a leader in the storage industry today, and say where they should be going? The industry does have issues. What do you see as the challenges and opportunities that lie ahead in the business? When you're retired, you can look at it from a holistic point of view.

**Thompson:** I never considered myself a leader in the storage business. I was always a technology guy in research. He was a leader in the storage business so you should ask him.

**Allan:** You must have an opinion because you're in the business of "Wow that's going to be a hit, that's going to be a gain." That's going to be a benefit, because there's an opinion somewhere.

**Thompson:** If a student, a high school student came to me and asked, I would not twist his arms to get into the technology of magnetic recording. I wouldn't necessarily have a better option other than, as I said, to go to the right school and get the right professors and find the problems. They might be in bioengineering or something, I don't know. My daughter went to Carnegie Tech but she certainly didn't go into electrical engineering, she went into bio because that's where she saw the interesting problems being. You asked a more specific question, you said if I were a leader in the storage industry...

**Allan:** I was thinking, if you were counseled for advice from somebody who is leading today. He's in a CEO role of a major company in the storage industry and he's looking for outside counsel. There's so many things that when you're in the leadership position there's a number of people who echo your own thoughts back at you, so you feel invincible. You know in your heart that it isn't so good, and you want an outside influence, you want outside objectivity. That doesn't come from somebody you know well, but it's somebody you might respect. If you look at it and say what's your opinion of the industry today? What you see are its problems and its opportunities from the outside looking in as a knowledgeable participant at one time. Looking at it today, do you see anything that looms?

**Bajorek:** I think about it from time to time. We are right now in a world where Flash solid state memory and DRAM for main memory and disk drives coexist. I have yet to see an invention that surpasses any one of those technologies in their individual domains.

**Thompson:** They all have an end in sight in some sense. Always the end is in sight, but in this case, for magnetic recording it's the number of atomic diameters between the head of the disk and it's down to about ten now. They aren't making atoms any smaller, so you aren't going to get another factor of 100 by scaling like we had for so many years. We got many factors of 100 over the years.

**Bajorek:** First of all, I'll say that if you're a business leader in this space, keep an eye on those three technologies and their proper balance. They'll continue, they'll continue to coexist and the issue is how to most smartly mix them in future applications. All of the low hanging fruit in all three areas has been picked. In all three areas we need to reach much higher in the tree to advance the technologies for higher density and lower cost. There are no laws of physics that are stopping us, but it will be in large part dependent on the investment we continue to make in extending these technologies. Don't expect progress if you shortchange the investment in R&D. Unfortunately the industry has consolidated so much that I am concerned about, on the disk drive side, whether we're making adequate investments to sustain further progress.

**Thompson:** In the absence of an alternative it's probably not as pressing. If there were some.., for example, if electron beam storage were any good and it were competition. Electron beam storage is not any good, neither is optical storage.

**Bajorek:** No, but the mix of how you mix these existing technologies…

**Thompson:** Flash is creeping up.

**Bajorek:** If you let go of disk drives Flash will continue to penetrate the space that disk drives are serving, or vice versa. If you want to thrive in disks you better not underinvest. I would say that the leverage will come not from advancing key limits or reducing key limits, but the capabilities of these technologies are basically determined by the three sigma limits of the distributions of key components. It's not the fact that we are on average here, we really have to back off and set the head to disk spacing by the variance of these components. I think there's a lot to be gained from attacking and reducing the variance in the components because that would enable you to squeeze more out of what we have. Given that there are no inventions that could be superior, that's where there could be some fruitful ground.

**Thompson:** It will get you factors of two. It's not going to get you the factors of ten that we're accustomed to.

**Bajorek:** Correct.

**Thompson:** I think we have to resign ourselves to the fact that progress is slowing down and it's going to continue to slow down at least in the disk drive business, in the sense of areal density.

**Bajorek:** Yeah, that's true for all of the technologies here.

**Allan:** We counter that by saying there's no limit to the need for data storage, yet we are acknowledging the fact that our ability to meet that expectation which is infinite is…

**Bajorek:** Is becoming more limited.

**Allan:** Yeah.

**Bajorek:** It has slowed down. Progress has slowed down in all areas whether it's Flash, DRAM or hard drive, and I anticipate it will slow down even further.

**Allan:** Should we go back to magnetic films?

**Thompson:** Go back to what?

**Allan:** Try magnetic films again?

**Thompson:** No.

<group laughter>

**Thompson:** There are still people working on MRAM, you know.

  

**Bajorek:** Modern versions of MRAM are basically modern versions of magnetic film memories. We used to sense them inductively, now we sense them with a tunneling magneto resistor. I have to share one last story which you might find interesting. When I was in Rochester, we were invited, Jim Porter and a colleague ran an annual storage conference here in the valley. We got an invitation from them, from Jim in particular, to talk about the future of disk drive sizes. The world had just commercialized five-and-a-quarter and three-and-a-halfs were just introducing. Jim wanted to know what will happen beyond that.

We ginned up a quick project in Rochester to design a one-inch disk drive which we codenamed Squirt. We're going to design this disk drive to basically be packaged into a ceramic module, so it would look like a semiconductor device on a board. We put an array of these ceramic disk drives on a card and we had RAID on a card, and we put, I think, seven disks into it. We scaled down the Lee drive, leading 340 megabyte 5 1/4-inch drive into this 1-inch drive, and we went and presented this with a serious face at Jim's conference.

**Thompson:** IBM strategy is now revealed.

**Bajorek:** Of course. Remember Tom Porter, he was sitting with me and he was a leader of the Corsair drive that came out of Rochester. We had a lot of fun putting this whole thing together, and we gave the talk. Some people took it in a jovial sense and I didn't know this until later, that some people took it seriously.

**Thompson:** Particularly people from Japan who would never think this could have been a joke.

**Bajorek:** The bigger shock was HP announces Kittyhawk and…

**Thompson:** How long did that take?

**Bajorek:** It took about two years. Two or three years.

**Thompson:** I still have one somewhere.

**Bajorek:** Bruce Spenner comes to see me... Bruce was running the HP disk drive project in Boise and comes to see me and says, "Chris, I need MR heads. Kittyhawk in its current, I think it was a 20-megabyte capacity, isn't going anywhere but if I could double it my market study says I'd be extremely successful. Would you sell me MR heads?"

  

I took it up the pole and I was rejected. IBM not only wasn't reluctant, IBM could have made a big business selling MR heads on an OEM basis, they absolutely didn't want to do it. Two days later Bruce met with Komag, and agreed with Komag and Seagate to transfer the MR head technology from HP into Dastek. Komag had bought Dastek. The agreement was that Dastek would make the wafers and Seagate would turn them into sliders and supply itself and HP with the heads.

When Bruce came to see me he said, "Chris, the reason we did Kittyhawk is that presentation you made," and I said "Bruce don't tell me you took it seriously. We just meant it as a joke," and his mouth dropped. He says, "You mean you guys didn't-- you chose not to pursue Squirt?" Ironically, this joke precipitated the formation of what eventually became Headway. Kittyhawk turned out to be a failure, but Kittyhawk needed heads.

**Thompson:** It was a poorly designed product actually but not necessarily the components.

**Bajorek:** I understand. One could have never anticipated that a joke like that would create a product that then needed MR heads, and our unwillingness to supply MR heads would induce the creation of a new company making MR heads.

**Thompson:** The ball bounced back too. With a Kittyhawk product out there, IBM ended up with a one-inch drive that we sold because now it had credibility because they (IBM) were doing it.

**Bajorek:** I know it went around, but I found it interesting how these events could be precipitated by a presentation of that type. I never anticipated that.

**Thompson:** I can see you're getting squirmy. I'll give you one anecdote and then we can quit. How's that? It's called Typhoon Chris. Different IBM sites have different cultures, and I guess Blackjack Bertram had some culture back east.

There were a couple of managers in San Jose who were very abrasive to their subordinates, the kind of things when a slightly timid guy put up a chart he'd get yelled at and be reduced almost to tears. Mee and Croll came back one time, I remember, in very bad shape. That was just the style of a couple of the managers, and IBM had set up a magnetic recording facility for manufacturing and research in Japan. I think it was partly because at one time IBM wouldn't be able to sell its disk drives in Japan if they didn't have some kind of local manufacturing. This was common, India is famous for this kind of stuff. They were subordinate in technology to the U.S. and occasionally Chris would go over there to see what their problems were and fix them. He became known as Typhoon Chris <laughs> because when they made presentations to him he criticized in front of the whole room which you don't do in Japan, at least, you didn't do back then. You want to comment on that Chris?

  

**Bajorek:** It was true in that sense, but it was even worse than that. As a senior manager, in the Japanese culture you were not expected to sit through a review of a problem. You locked up the engineers in a conference room to argue it all out, and you sat by yourself in a separate room. At the end of a three or four-hour session among the engineers you were briefed on what the conclusion was.

**Thompson:** They would brief you, whatever.

**Bajorek:** I did it traditional North American style. I'd sit in the review and interact, and of course, this was very unusual for them. What really drove me crazy was that we had to solve some real problems. We had to dump Alps as a head supplier, bring in TDK as a supplier. Dump Komag as a supplier, and bring Asahi Komag on as a supplier because Komag had no capacity here. We had to make some very rapid decisions and rapid re-qualifications. None of the Japanese managers would help me do that, they would sit in that room…

**Thompson:** They listened to the engineers but hard decisions were put off.

**Bajorek:** I had to run out, go to the interior to Nagano, to TDK to negotiate a contract for rapid delivery of heads on an emergency basis, and none of them would come with me. I'd call where are they? They were on the golf course. I was just livid that I would have to go travel like a chicken with its head cut off all over Japan negotiating deals while these guys sat at headquarters or played golf.

**Thompson:** Nevertheless, I would occasionally come out as a technologist and I'd listen to the problem, I'd talk, this was usually at the engineering level. Then they'd say, "But Typhoon Chris is coming."

<group laughter>

**Bajorek:** We were very fortunate to have been able to have some very great careers and make some contributions along the way.

**Thompson:** Yeah, it was fun. Thanks.

**Bajorek:** Dal, thank you very much.

**Allan:** I appreciate it. I'm glad you came today.

END OF THE INTERVIEW

  