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Oral History of Michael Mallary

Interviewed by:
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Yamashita: This oral history interview is with Doctor Michael L. Mallary, who was originally trained as a high energy physicist at Caltech but found his way into the storage technology field and credited with numerous inventions, patents and publications in the field over his illustrious career. Doctor Mallary began his career in storage technology at DEC, Digital Equipment Corporation, starting in 1980 where he worked for 14 years. He made many contributions there, solving highly technical problems with DEC products and inventing very innovative recording head designs, which are still used today. In particular, he invented the shielded pole perpendicular writer. This is US patent 4656546 in 1987, which allowed supporting engineering developments to double areal density. It (Perpendicular Magnetic Recording) has been predominant in the industry since 2005. After DEC was purchased by Quantum in 1994, Doctor Mallary remained with the company and made critical contribution to the acceptance of perpendicular recording in the disk drive industry through his contributions. He was a key contributor in the National Storage Industry Consortium, or NSIC, effort to increase areal density in storage using the shielded pole architecture and pushing down the grain size to the limit imposed by thermal decay of the magnetization. He continued to make his contributions felt through the industry while working for Maxtor Corporation, which took over the Quantum operation in Shrewsbury. After Maxtor, he has worked at Seagate and Western Digital working on advanced high density recording concepts such as heat-assisted recording, or HAMR, microwave-assisted recording, or MAMR, and two-dimensional recording, or TDR. Through his 165 issued patents and 57 technical publications, Doctor Mallary is considered one of the key innovators in the storage technology field. This interview will be conducted by Grant Saviers and Tom Yamashita, myself. We both had the privilege of working with Doctor Mallary in the past, myself with Mike in NSIC and later at Western Digital; Grant was with him at Digital Equipment Corporation. So, with that, I'd like to begin the interview process, first by I'd like to ask Doctor Mallary about your family background, where you were born, grew up and received your early education.

Mallary: Okay, well, I was born in Berkeley, California, and my family on my father's side lived in the Bay Area. I still have relatives there. My grandfather taught at the university, sociology, and he had a lot of influence on me, because he encouraged my development in science. And I'd say that my interest in the world of mind really had a lot of roots in his interest in that world and transmitted through my father and directly from him. I also found out recently actually that my grandmother on my mother's side was also very interested in education. She was an educator, and in fact, I just became aware that she was in an article in the Boston Globe in 1929 for having gotten two degrees from Boston University in one and a half years while simultaneously raising a family of five children in Brockton, Massachusetts, and then they considered it newsworthy and published an article in the <laughs> Boston Globe about her. Anyway, she was also very interested in education. She saw that as a way of women getting a leg up on reality, and she was like the original feminist really. She was outraged that boys could get sent to college and girls would not, and so she ended up going back and getting two degrees.

Saviers: Interesting.

Mallary: And anyway, that interest in education was transmitted then through my mother, and then she was interested in my father because he was of an intellectual bent. And he became a sculptor, and he also was interested in music. He composed and played the piano beautifully, classical and jazz. And I helped him with his sculpture at times. I taught him welding actually <laughs>, and he did some welded sculpture, and at one point I actually collaborated with him on the first computer sculpture, and it's called Quad, and a version of it has been recently purchased by the Tate Modern Museum. [1]

Saviers: That's pretty impressive.

Mallary: Yeah. <laughs> Anyway.

Saviers: Something in the Tate.

Mallary: Yes. Anyway, and I'm taking care of his art actually, and I have a big project to try to preserve his art. He passed away 20 years ago, and I'm preserving his art. But this whole thing about being involved in the world of mind is very much a family thing, and I got it from my grandparents and through my parents, and that, I think, is really important. I became more aware of it as a result of reviewing this whole-- by my own biography of this thing.

Saviers: <overlapping conversation>

Mallary: And anyway, I grew up in LA, and my mother was in advertising. She supported the family really. She was also one of the original feminists. She had to make her way in a man's world, and she was a very successful advertising executive. In LA, my father worked in the garage, and I was kind of underfoot. And I did my little projects while he was doing his sculptures, and I'd carve little statues out of wood and did my own woodworking projects, and that gave me this hands-on experience of working with my hands, building things, and that was very important; I always liked building things. And I also got into reading books of how things worked, and I got fascinated with how various machines worked. When I learned how an internal combustion engine worked, that was really great. But then that led to an interest in how reality worked, and ultimately, I figured out, oh, physics was where it's at, atoms, and, well, atoms are made out of neutrons and protons and electrons. Well, how do they work? And so, I ended up ultimately getting into high energy physics, going down to the fundamentals of reality.

Saviers: You built some pretty impressive things as a high school student.

Mallary: Yes. <laughs>

Saviers: What were they? Tell us about them.

Mallary: Well, I'd say the most impressive thing was my science project to make an electron microscope, which it kind of worked. I did the whole thing, the vacuum system, electron beam, focusing magnets. I got some help from people at Philips Electronics. They gave me a tungsten filament so that I could build my electron gun around it, and I learned machining as a result. I went to the local high school. I went to

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[1] [Editor's note] Robert Mallary, (Dec. 2, 1917-Feb. 10, 1997) American sculptor and pioneer in computer art. https://en.wikipedia.org/wiki/Robert_Mallary

Archbishop Stepinac High School in White Plains, but they didn't have a machine shop there, so I went to the local high-- joined the high school science machine shop club and did my machining there and learned machining to build things. I learned to weld. I went halfsies with my father on a gas welding kit, 'cause he wanted to do steel sculpture; I wanted to do my electron microscope. And the first version of it leaked like a sieve, so I had to learn to weld better, <laughs> and--

Yamashita: Well, this is extraordinary. You have a vacuum system; you need high voltage power supplies, phosphor screens. For a high school kid, this is--

Mallary: Well, for 25 dollars, I bought an old x-ray machine to get a 70,000-volt transformer for the high voltage, but then I got some rectifier tubes that I put in series. They were only 15,000 volts each, but I put a couple of them in series and immersed in oil, and I ran the filaments off of just D cell batteries, and I immersed the whole thing in oil, and then I built a capacitor out of sheets of plastic and aluminum foil. And so, yeah, I built a high voltage power supply for that.

Yamashita: How much voltage was--

Mallary: Well, I think I was operating at about 25kV, and I ended up--

Yamashita: Sounds quite dangerous.

Mallary: Pardon me?

Yamashita: Sounds quite dangerous.

Mallary: Well, yeah. The thing is I knew about how to take care of myself, because I got my first shock when I was nine years old, and I never got shocked after that. <laughs>

Saviers: It's a learning experience, isn't it?

Mallary: <laughs> Yeah. Anyway, I learned my lesson when I was nine. <laughs>

Saviers: Now, did you win any awards for this effort?

Mallary: Yes, I got an honorable mention in the Westinghouse science talent search in--

Saviers: That was kind of a predecessor of the Intel one now I guess it is?

Mallary: Yes, yeah, yeah. Anyway, later on I used that transformer for a hack that I collaborated with a friend on. His father was a dentist, and he had a transformer, too, so we built a huge Jacob's Ladder, which appears in all the "Frankenstein" movies where, when Doctor Frankenstein appears, you see a spark rising in the background, <makes buzzing noise>, and it's called a Jacob's Ladder. Anyway.

Saviers: You said this is a 10,000-watt--

Mallary: Yeah, it was.

Saviers: That must've put the whole neighborhood out of business.

Mallary: Well, we were blowing fuses with it, yeah, and we built it outside so it wouldn't burn the house down. And it had a gap of about this big at the top, and it was <laughs>--

Yamashita: This electron microscope, how far did you get? Did it work?

Mallary: Well, it kind of worked. I got a beam going, and I got a little bit of magnification going, but the trouble was, though, that at one point I blew out the fuse in the house. Let's see, what happened was-- oh, yeah, I remember now. I decided I'd let it get a little better vacuum or something, and my cooling lines coming in from the garage froze up, and so the diffusion pump didn't get any cooling. And then the vacuum was no good, and the next time I turned on the high voltage, I got a discharge, blew out the fuses in the house, and then the fore- pump stopped, and then all the oil in the fore-pump got sucked into the diffusion pump along with air, and then that all burned in the diffusion pump and contaminated the whole system. I never got a decent vacuum after that, so that was the end of my electron microscope. <laughs> Anyway.

Saviers: But good experience for your start in experimental high energy physics, right?

Mallary: Yeah, right, and also it informed me that I really need to back up systems and ways of-- I should've had a solenoidal cutoff or a valve. I should've had some safety mechanisms to shut off the vacuum system so that the fore-pump oil wouldn't get sucked into the diffusion pump. <laughs>

Yamashita: Sounds like you were quite resourceful getting all these parts from dentists and Philips--

<overlapping conversation>

Mallary: Oh, yeah, yeah. Yeah, I had to go down and scrounge up parts from all sorts of places. I got the diffusion pump chimney exactly for a dollar. I bought a couple of chimneys on Canal Street where you can get used parts. I got them for a dollar each. I was walking around on Canal Street. I just thought "Oh, yeah, yeah, that's a diffusion pump chimney." I got one of those. <laughs> Yeah, that was great. And I built a diffusion pump around that, and I got a fore-pump on Canal Street in New York. Canal Street in those days, they'd sell all sorts of surplus equipment right on the street. You could just go down there and buy it off the street.

Saviers: All gone now.

Mallary: Yeah.

Yamashita: So, we talked about your father. I understand that he was actually a quite well-known artist. I looked it up, and he's considered a neo-Dadaist. Is that the right word?

Mallary: Yes, yes.

Yamashita: Could you talk about him a little bit?

Mallary: Well, yeah, he was an interesting person, and neo-Dadaism was part of what he did. He became relatively famous for that, but that was a period of time when he was doing his tuxedo art where he would buy used tuxedos down in New York City. I don't know if that was-- I don't think that was Canal Street, but it was down in Lower Manhattan. And he would take them back to his studio in Manhattan and stretch them out with elastic bands into grotesque shapes and then freeze them in polyester plastic. And he was very much into the corruption of Western civilization and the fact that we were going down the tubes in a cultural and moral sense, that we were really losing our anchor. And you can see that very much in our modern reality, both the fact, for example, that the world is cooking and no one cares, that global warming represents an existential threat to our species and people are turning a blind eye to it. That's just one symptom of the corruption of our reality, just one symptom, and Bob saw that in 1960. And he had a famous piece in the World's Fair in New York City, I think it was '64, called Cliffhanger. You can Google "Cliffhanger" and "New York World's Fair." It was in the New York State pavilion, which was a whole bunch of these tuxedo figures that were hanging in various states of falling off of a ladder that was horizontal[2]. And I have Cliffhanger at this time, and I have to figure out a way of preserving it, 'cause I can't throw it away. And so, I've figured out that I'm going to purchase a bunch of shipping containers and pack them with Bob's art and store it that way.

Saviers: So pretty interesting creativity and construction projects in high school, so this leads to going off to university. And tell us a little bit about how you got there, what you considered what the alternatives were.

Mallary: Well, let's see. Like I said, I was interested in how physical reality works, and I wanted to get to the fundamentals of it, and I figured out physics was it. And so, I had offers from MIT and Caltech. I decided I think I'd like to go to MIT for undergraduate. I did well there, and I had a lot of fun there. I got into the hacking scene there in various ways. Hacking in those days was-- computer hacking was a minor subset of hacking in general. Hacking was any kind of practical joke that involved technology that would twist people's brains, and it was supposed to be nondestructive and just something that was supposed to create a mental <laughs> knot in people's heads <laughs> based on technology or whatever. Anyway, and so one of the-- and I learned physics there, and I'd learned the scientific method and the importance of mathematics in terms of defining what the scientific theory is and what the predictions of the theory are and so that you can compare that to experiment and that whole process of defining your theory mathematically and then comparing it to experiment mathematically. And this is one of the things that modern reality is very deficient on, and it's one of my big pet peeves with modern reality is it seems as we are going into the future, we're becoming less numerate, not more numerate, and I think

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[2] [Editor's note] http://www.robertmallary.com/Art/gallery4_found_materials/the_cliffhangers.htm

it's really a shame. And it's one of the reasons why we're unable to come up with genuine solutions to the global warming situation, because most people who are trying to deal with the problem will not deal with the numbers of it. It's fundamentally an engineering problem, and they will not deal with the numbers of it.

Saviers: What was your most successful hack at MIT?

Mallary: Let's see. Well, okay, I had a couple of really nice ones. One of them was Can Magazine, which was the first magazine in a can, and that was just a literary hack. It was a spoof on pop art where we put a magazine in a Campbell's Soup can. It was art, literature and poetry, student art, literature and poetry. It was kind of a way of meeting girls. "Would you like to be published in a--" <laughs> anyway, we put it in a-- so we had this magazine rolled up in a Campbell's Soup can. We had a run of 1000 of them, and it got an article in Time magazine actually. And my mother, who was in advertising in Madison Avenue and stuff, she had some contacts with Andy Warhol. She got us an interview with Andy Warhol, and he actually signed one of the cans. We went down and interviewed him for the second edition, which never actually happened, so that was quite--

Saviers: Any visits to the dean's office in terms of "Don't do that"?

Mallary: No, no, no, though I could've had some--

Saviers: It could've happened.

Mallary: It could've happened, but I--

Yamashita: Interesting--

Mallary: But I did do a neon sign hack where I altered a neon sign, a gigantic neon sign, but I won't go into the details on that. <laughs>

Saviers: We all have those little bits of history which we're glad are not preserved on YouTube now.

Mallary: Yeah, that could've gotten me into the dean's office. <laughs> But anyway.

Yamashita: So, what were some of the projects that you did at the undergraduate level?

Mallary: Oh, well, I did have a senior project where I tried to observe a microwave line of silicon hydride, because the radio astronomers were looking for it in clouds in space, and they needed to know what the frequency was. And so, I tried to generate silicon hydride and measure a microwave frequency of it, but I didn't actually get it. But that was interesting from the point of view of getting my hands dirty with building the apparatus and learning some microwave technology.

Saviers: And this is the MIT machine shop for students and so on?

Mallary: Yes, and I worked in the machine shop, and I did some microwave work as well, and so I'd learned a lot of electronics, yeah.

Yamashita: Who was the professor you worked with?

Mallary: That was John King[3]. He was my senior advisor, yeah. Anyway, so that was on the academic side, yes. Oh, yeah, there was a technology hack that I did. I attempted to make industrial diamonds in my dormitory room. I had a 20-ton press-- I still have the jack in my garage actually-- and the idea was to try to come up with a process for doing it at a lower temperature and pressure than people normally work at, and the idea was to use a chemical reaction that would precipitate carbon at a lower temperature and pressure. Rather than trying to get graphite to transmute into the diamond structure, precipitate carbon into the diamond structure at a lower temperature and pressure, and so the apparatus for that would be a lot cheaper than to work at the higher temperature and pressure. And so, we were at 20-- let's see now. I think I got about-- I think I was getting about 50 kilobars, and so we made the pressure vessel, and we heated it to 500 degrees C, and every now and then it would blow up in the room, but it was contained within a steel structure, but it would go bang. And we maintained the pressure by putting 50 pounds of barbell weights on a two-foot-long steel pipe on the jack, and so this would be maintaining the pressure, and as the reaction proceeded, we'd have to keep cranking it up. But if the pressure vessel blew, then the thing would come crashing down to the floor, and then the guy downstairs would come running up. "What the hell's going on up here?" I said "Oh, we're just making diamonds." <laughs> Anyway. But we got a highly amorphous form of carbon. We probably were generating vitreous carbon well before its time. Now people make vitreous carbon for dental implants, but anyway, we did an x-ray analysis of it, and it was probably vitreous carbon. <laughs> But anyway. <laughs>

Yamashita: So, after MIT, where did you go?

Mallary: Oh, well, yeah, I decided to go to Caltech. I could've gone to MIT for graduate school, but I decided to go to Caltech. It had a better reputation for high energy physics, and I had a full scholarship there, and so I decided to go to Caltech. And there I did the first year doing coursework in Pasadena, and then I went on to start working at the Lawrence Radiation Lab in Berkeley on an experiment following that year. And that first year actually, one of the things I wanted to talk about a little bit was that Professor Charles Barnes[4] had mentioned in a lecture in the physics course that I was taking something that knocked my socks off at the time and got me going onto a thought that went on for 50 years and is alive today and I'm still talking about it. And he mentioned that in the fusion process that operates in the sun, two protons come together, and they stick together very temporarily, and then most of the time they fly apart. But every now and then, one of them turns into a neutron by the weak interaction, and now you have deuterium, and then the deuterium can go on to fuse into helium and produce the energy of the sun over billions of years. But most of the time they fly apart, and in fact they stick together for about a hundredth of a trillionth of a second. But if the nuclear interaction were about half a percent stronger than it is, then they would stick together permanently and form helium-2, and then the sun could burn much

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[3] [Edito's note] https://en.wikipedia.org/wiki/John_G._King_(physicist)

[4] [Editor's note] https://www.caltech.edu/about/news/physicist-charles-barnes-dies-47561

more vigorously than it does, and in fact it would burn up in the period of a million years instead of billions of years, and that we would have absolutely no opportunity to evolve, and there would not be the possibility of anything like us evolving anywhere in the universe. And that just knocked my socks off: if the nuclear interaction were half a percent stronger than it is. Okay, well, I went on to think about this, and I've identified now 17 aspects of physical law, including this one that I've just stated, that have to be more or less exactly the way they are in order for anything like us to have evolved anywhere in the universe, and I've written a book about it called "Our Improbable Universe[5]." Anyway, that's something that's been a life's work, and it's been very important to me, and it's phenomenal that we have come into existence. We have this precious reality, and we really should be taking better care of it than we do. <laughs>

Saviers: So I've read parts of the book, and it's very wide-ranging, and it's very interesting, and you've kind of got some speculation in there about maybe there are a lot of choices how you might have a universe, and maybe we're just the lucky one.

Mallary: Right. There's two hypotheses as to how you could get these 17 things just right. Some people call it the Goldilocks Universe, and there's been a lot of-- and one would be a deistic hypothesis that involves a creator manipulating the physical parameters to get things just right, in which case you've got to say "Well, this creator went to a lot of trouble. You just can't throw it away," <laughs> which we're doing, <laughs> we're showing every sign of doing. The other hypothesis is that it was a random happening that got these 17 things just right. Well, people who plug in the numbers, what is the probability? How many times do you have to throw the dice in order for a random happening to generate? You're talking about numbers like 10 to the hundredth. We've got the one universe in 10 to the hundredth, and some people propose that we may in fact exist in a larger meta-universe in which the dice has been thrown 10 to the hundredth time, and we have this one universe in 10 to the hundredth. That is just right, which makes it a very special place. And so, my position is reality is special either way, <laughs> and you have to treat it as sacred either way. <laughs> Anyway.

Saviers: Right. Good point.

Yamashita: Comes from a particle physicist's point of view, understanding of reality.

Mallary: Yes, and that's my whole position is that we have this incredible reality, and we really have to treat it much better than we are. <laughs>

Yamashita: Now how about for your thesis work at Caltech? What did you work on?

Mallary: Well, that also turned out to be part of the book, 'cause it turned out to be part of the 17 things, and I didn't really appreciate it at the time that I was working on it. And one of the reasons why I wrote

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[5] *Our Improbable Universe*, Thunder's Mouth Press, Michael Mallary,2004. 2d edition 2018 http://improbableuniverse.com/ and see video at http://vimeo.com/35172497 in 2012 at the Forum meeting of the Silicon Valley Humanist Community.

the book was, when I realized its connections to reality, it also motivated me to do the book. But the thesis was to look for a violation of a symmetry principle in physics that physicists thought applied to reality, and it's called CP, that is, charge conjugation parity. Those are just the terms that he used, and what it corresponds to, the symmetry principle that they thought existed was that, if you changed all the particles into antiparticles and looked at the system in a mirror, that the equation should be exactly the same. Okay, that's called CP symmetry, that is, all the particles turned into antiparticles. Look at it in a mirror; equation should be exactly the same. Turns out they aren't, that there's a tiny violation at the level of parts per billion. Good thing turns out, and I only found this out many, many years after I did my thesis. And I did my thesis on this topic, because if CP symmetry were an exact symmetry, we could not exist, because the Big Bang would've produced an exactly equal amount of matter and antimatter if CP symmetry were exact. And then in the first few minutes, all the matter would've annihilated with all the antimatter, and the universe would've been nothing but a ball of photons and neutrinos expanding to infinity forever. There would be no stable matter at all in it. But because CP symmetry is violated at the level of parts per billion, a tiny excess of matter over antimatter was generated in the Big Bang. We are that tiny excess.

Saviers: So, it wasn't the Big Poof; it was the Big Bang.

Mallary: Pardon me?

Saviers: It wasn't the Big Poof where it happened and that was it.

Mallary: Right. Well, it's possible that it's cyclic. We don't know, but the cyclic thing is not favored at this time. But at any rate-- but when I found out about the implications of the CP violation and the existence of matter, then that was another motivation. My thesis project was to look for a large CP violation in a particular interaction. I did not find it; it did not occur. The small CP violation had already been observed by Fitch and Cronin a few years before, and they later received a Nobel Prize for observing it. Anyway, at that time, no one appreciated (when they saw it) this connection between the CP violation and the existence of an excess of matter. That existence of the excess of matter over antimatter wasn't figured out until about 1971 theoretically, but that also depended upon something else, too. It also depended upon the existence of at least six quarks, and I was also involved later on with the discovery of additional quarks. In my work in high energy physics, I was involved with a discovery of the fifth quark. An experiment that I was involved in in the mid '70s at Fermilab when I was working at Northeastern University teaching physics there, we were doing an experiment at Fermilab where we were looking for evidence for the existence of a fifth quark. At that point, evidence had existed for a fourth quark. In the original quark model, there were only three. Then evidence for a fourth was discovered. Then at that point, it also became apparent that quarks occurred in pairs, so that if there were a fifth, there had to be a sixth. Well, if there were six, then that allowed the CP violation to conspire with the existence of six quarks to produce this excess of matter over antimatter[6]. Anyway, this experiment we were doing, we

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[6] Dr. Mallary states that this should have been more correctly stated that, the existence of 6 quarks allowed the CP violation which allowed the excess of matter over antimatter.

found about a hundred upsilon particles at a three-sigma level, but Leon Lederman[7] at the same time was doing a much larger experiment. He got about 10,000 of these particles, and he published on that. He did present our data as backup to his, and anyway, he got the Nobel Prize for the fifth quark.

Yamashita: So, if you had better equipment, you might've had a chance.

Mallary: Well, anyway, but if there are five, there's six. Anyway, the sixth was discovered about 20 years later, and anyway, 1995. And when I found out about all this stuff, then that really motivated me to put this all together and write the book.

Saviers: So, the career goes from Caltech with a PhD to high energy physics and teaching at Northeastern University, Boston.

Mallary: Yes[8].

Saviers: So now going beyond Northeastern, what does a high energy physicist do in the future?

Mallary: Well, the problem was at Northeastern, I had to cross "Ripoff Park" every day on my way home. I got mugged once, and I got away, and my daughter was going to a daycare where the kids hit, kick and spit, and I decided I needed to earn a living wage, and so I decided to go into industry. And I had a lot of experience with big magnets, so I figured I could use my background with Maxwell's equations to do magnetics. So, I got a job with Magnetic Corporation of America doing large magnets for various purposes: fusion, high energy physics, magnetic separation and power generation, various other things.

Saviers: They were in Boston or Cambridge?

Mallary: That was in Waltham, Mass.

Saviers: Waltham, okay.

Mallary: And anyway, they had some financial backing from venture capital, and that was a nice job. I liked that. I was doing a lot of different things. I was getting experience in a lot of-- it gave me experience in the power industry, and this is also part of my involvement with global warming and stuff. I understand how to make electricity and what the parameters are of the electric power industry. Anyway, after a couple of years, though, they started having financial difficulties; they weren't getting the backing anymore, and so I decided I'd better look for another job, and I did some looking around. I could see there was excitement in magnetic storage, and I asked my headhunter to get me an interview in the disk drive industry, and he did. And, well, so I got an interview with Digital Equipment (Corporation), and I was being interviewed by a mechanical engineer named Mitch Szymanski. And at that time, I didn't really

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[7] [Editor's note] https://en.wikipedia.org/wiki/Leon_M._Lederman

[8] [Editor's note] Dr. Mallary went to Rutherford Laboratory in Chilton, Didcot, UK as a post-doc after Caltech for 2.5 years before going to Northeastern University.

know-- I did a little bit of research on magnetic recording, and I knew about longitudinal recording. I didn't know about perpendicular recording really, and I didn't know about Iwasaki-san[9] in Japan doing perpendicular recording with a monopole head. I forget whether it was-- I'd gone home and come back for a second interview, but at some point I told Mitch "You guys are doing this thing all wrong. You shouldn't be doing it with longitudinal recording. You ought to be doing perpendicular, and this the head you ought to use," and I sketched the shielded pole head for them. <laughs> That was in the job interview. Well, anyway, I got the job, and then I joined Digital Equipment to work on thin film heads and doing magnetic analysis with thin film heads, and while I was doing that, developing the thin film head for the RA90 disk drive, I also continued analyzing the shielded pole head that I'd sketched out for Mitch. And it looked pretty good in terms of analytic calculations, and I did some finite element analysis with it and still looked pretty good. And so, I applied for a patent on it, and the patent issued in 1987, and that's the one that Tom referred to in the introduction. And then I continued working at Digital on refining the thin film head and produced a number of insights into the functioning of that head. I think one of the valuable things I did was to figure out how the flux conducted during the read-back process, and it was important, because in the read-back process, you don't want any noise from what's called Barkhausen noise, which corresponds to domain wall motion getting hung up on defects in the structure and then jumping suddenly. You want to conduct flux by rotation of the magnetization and not by wall motion. Well, I figured out how flux could be conducted by rotation without wall motion, and people thought, up until then, that that always required some degree of wall motion. I figured out how to do it without any wall motion. As long as the rotations were small, you didn't require wall motion. Well, read-back doesn't require big rotations; it's only small rotations, and I was able to show this analytically and all that. And it was important, because when you design the magnetic structure and you burn in what's called magnetic anisotropy, you want to put it in in a way such that you can conduct the flux through the entire structure by rotation without wall motion. And I got patents on how to do that and how to put in the-- you plate the magnetic films in a plating field. Anyway, so that was one of the contributions I made to the theory of flux conduction. And I also did a number of things in terms of understanding problems in producing the thin film heads and then how to improve the design and improve the write process.

Saviers: And this is all occurring in the DEC [Digital Equipment Corporation] facility in Shrewsbury?

Mallary: Yes.

Saviers: Yeah, Bob Rottmayer[10] was running the film head group there.

Mallary: Yeah, and I had a lot of fun there. I've been thinking about why it was that things were so synergistic, and it was the managers were all technical people; they all were hands-on technical people, and so we were just all on the same wavelength. It really helped a lot. <laughs>

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[9] [Editor's note] Shun-Ichi Iwasaki, Perpendicular Magnetic Recording, https://en.wikipedia.org/wiki/Shun-ichi_Iwasaki

[10] [Editor's note] Robert E. Rottmayer.

Yamashita: Is that the same Bob Rottmayer that went to Seagate and Read-Rite[11]?

Mallary: Yes, yes, yeah, and he was a very hands-on technical person.

Saviers: The first physicist I ever hired is Bob.

Mallary: Right, right. Yeah <laughs>, yeah. Yeah. Anyway, I was talking with Bob yesterday actually.

Saviers: Oh, okay, great.

Mallary: I went up to visit him yesterday, and--

Saviers: Oh, terrific, wonderful. That's on my to-do list, but I haven't done it. So, the goal I think, if I put something in here from my memory, was that DEC's going to catch up with IBM's areal densities, and the RA90 I think was the attack at that. So, you were working on that project. Was the goal achieved do you think?

Mallary: Well, I think we were being competitive. We got competitive with IBM for sure, yeah, yeah. But then what happened is IBM came out with the magnetoresistive read-back head. They had developed that, and we were still on inductive head technology, and so I came up with a concept that could extend inductive read-back called the diamond head, which was really cute. It was really a nice invention where normally in read-back you conduct the read flux through a coil, and that stimulates a voltage in the coil. So, the magnetic yoke structure takes the read-back flux off the disk and channels it through a coil, and then that creates a voltage in the coil. The idea of the diamond head was, instead of running the read-back flux through the coil once the way a yoke normally does, the diamond head ran that flux through the coil twice so that the effective number of turns was the number of coil turns times the number of yoke turns. Normally the number of yoke turns is just once. In the diamond head it was twice, and I figured out a geometry that you could execute in thin film technology where you could get the yoke to pass through the coil twice, and it was really neat. I nearly fell off the chair when I realized what I'd <laughs> done. Anyway, it was a really cute idea, but it was only there, though, to provide us with more read-back signal to buy us a little time to develop MR (Magneto-Resistive) technology to catch up with IBM again, and so it was only for a couple of generations that the diamond head was useful, but it was really a nice, neat idea. But at the same time, though, we also got involved with NSIC, National Storage Industry Consortium, where the idea was to collaborate with other corporations in the disk drive industry to advance magnetic recording as a group, because we all were using each other's patents anyway. We might as well collaborate on the fundamental developments of the intellectual property to begin with. And so as part of NSIC, though, we wanted to extend recording past the limits of what longitudinal could do, and we figured out that the way to do it was with perpendicular recording and that the shielded pole head was the way to do it. In the early '90s timeframe, I worked with NSIC and other people like Mason Williams and Roger Wood, and we figured out that we could extend perpendicular recording to a terabit per square inch using

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[11] [Editor's note] Read-Rite Corporation, http://www.fundinguniverse.com/company-histories/read-rite-corp-history/

the shielded pole architecture and perpendicular recording. And we pretty much put a stake in the ground in the early ‘90s timeframe, said “This is what we can do, and this is what we ought to be doing,” and that created a whole impetus to do the developments both in the disk technology, the head technology, and to realize what this architecture could achieve. It took a huge team effort. It wasn’t just the idea of the shielded pole head. It was also this huge team effort, and one of the things that I’m very much into is the idea of collectivity of mind, team effort. That’s what makes this world go around: lots of people working on this stuff together and working on the ideas and working on making things work together. Anyway, we figured out in the early ‘90s a terabit per square inch was feasible. That was achieved in about 2013 in product shipped.

Saviers: Wow.

Mallary: <laughs> And it actually hasn’t gone much further than that. <laughs>

Saviers: Twenty-five years almost.

Mallary: It pretty much stalled at that level. That’s where we’re at in hard disk technology today.

Yamashita: So, you and Mason William from IBM and Roger Wood-- I don’t know whether he was at IBM already or not-- you’re responsible for road maps and modeling for the NSIC. How was that teamwork like? Did you collaborate extensively to do that, or was it just at the meeting?

Mallary: Well, we would meet frequently, and we’d go back home and do our own calculations and come and present. It was a very collaborative process. It was a lot of fun, and it was a great example of teamwork. It really was, and it is how things should work. And so we’d shown what the path into the future should be, and then by the early 2000 timeframe, when longitudinal really was running out of gas and it became clear that we had to switch over to perpendicular, well, that patent from 1987 was running out, and so I was asked to do a picket fence around it, and that is to create a whole bunch of subsidiary patents. And so, I went back and patented a whole bunch of-- submitted patents on a whole bunch of other ideas, and I ended up getting about eight more patents on the basic shielded pole type technology.

Yamashita: This is at still at Digital.

Mallary: Pardon me?

Yamashita: Still at Digital?

Mallary: Well, I don’t know. I’m not sure. I think they probably were submitted when I was with Quantum, and, I don’t know, then it was inherited by the next corporation <laughs> that took over. I’m not sure exactly who owned what when. <laughs>

Saviers: There's a couple instances where the scientific method was failing the engineers, and they had no clue as to what was going wrong, and you were asked to come down out of your physicist ivory tower and fix stuff on the production line. Can you tell us about some of those experiences?

Mallary: Oh, right. Yes, I remember that there was an erase problem in the I think RA81 disk drive, and there was a problem where the disk drive was losing its memory.

Saviers: Not a good thing.

Mallary: Yeah, <laughs> yeah. Anyway, over a period of time, the data would gradually corrupt, and it was driving people nuts of course, and the product was on ship hold. Very expensive. Anyway, this is where my experience at Magnetic Corporation of America helped a lot actually, because I had been involved in magnetic separation of fine particles, so I knew particles. Anyway, I figured out, after getting involved with the problem, that it was magnetic particles stuck to the edge of the slider were erasing the disk over a period of time.

Yamashita: How did you come to that conclusion?

Mallary: I forget exactly, but I think with all these things, it's kind of an intuitive-- it kind of comes to you in your sleep or whatever. <laughs> I'm not sure exactly what stimulated me to think that it was magnetic par-- for one thing, the sliders at that time themselves were magnetic, and so the fact that magnetic particles could stick to the magnetic slider magnetically--

Saviers: Right, they're ferrite sliders, right?

Mallary: Yeah, yeah.

Saviers: Right, right?

Mallary: Yeah. But then what I did, though, was I figured out a technique for figuring out where the particle was on the slider by writing a bunch of test tracks on a disk. Write a bunch of test tracks, stop the disk, and then I'd pushed the slider across the test tracks to varying degrees. And then I'd take that slider away, and I'd spin the disk up and read it again and look for the corruption of those tracks that had been pre-written, and based on the corruption of the tracks, I could figure out the location on the slider of the corrupting particle, and then having figured out the location on the slider, I was able to look for that particle in a SEM (Scanning Electron Microscope), find the particle, and use EDX (Energy Dispersive X-ray) to identify the material that the particle was made out of. If it was made out of samarium cobalt, aha, it came out of the positioner motor, because that was samarium cobalt; that was a source of samarium cobalt. And, yes, we found out that the positioner magnets in the positioner motor were only epoxy coated on let's say five of their six sides. And so what we did then was we said "Oh, <laughs> we got to coat them on all six sides," because what was happening was that when they were being put in the ultrasonic bath to clean these positioner motors, that was shaking loose particles, and those particles are getting all over the place and contaminating everything. And so anyway, we--

Saviers: Disk drives have all these magic little things that are going on that are not very intuitive until you really start getting into it and looking and looking and looking.

Mallary: Yeah, but anyway, by finding the particle and identifying it, I was unambiguously able to show it was the positioner motors and solve it, yeah.

Yamashita: It's a huge problem--

<overlapping conversation>

Mallary: Oh, yeah, it was a very expensive problem, yeah.

Saviers: Yeah, it was the flagship large disk product at the time and, I don't know, hundreds of millions of dollars a year in revenue, so it was a big deal. And of course, if you didn't have the disk drives, you couldn't ship the computer.

Mallary: Right. <laughs> Oh, yeah.

Yamashita: Were there other problems like this that you solved?

Mallary: I think there were. I don't recall. I can't recall exactly what those others were, though, at this point, but I think that was the big one. But I did end up troubleshooting a lot of things, and I always considered those Sherlock Holmes things to be a lot of fun.

Saviers: Sure. Later you were talking about how corrosion was happening in a recording head that was flying.

Mallary: Oh, yes, yes, that was one of those, yeah.

<overlapping conversation>

Saviers: One of those. Say a few words about that.

Mallary: Right, well, that had to do with understanding a wide range of physics, too, because we were seeing corrosion of the pole tips, and, well, why were these pole tips corroding? Where's the water coming from? These disk drives are dry. Why is it getting wet? And, well, it really is a no-brainer, because the pressure at the air bearing surface is many, many atmospheres, so if you have a relative humidity of even five percent and you compress that air to 20 atmospheres, you're at a hundred percent humidity. That's wet. <laughs> And so that's what the problem is, is that even if you're in Arizona, <laughs> right where the pole tip is, it's wet. <laughs> It's a very wet environment, because the pressure is so high, and so, well, that's why the pole tips corrode. <laughs> And so what would happen, though, is that contact with the disk would gradually scrape away the carbon on the pole tips, and then they became susceptible to this corrosion from the wet environment, but no one could understand where the corrosion was coming from, because no one’s throwing water in the drive, you know what I mean? But anyway, I was able to-- <laughs>

Saviers: So, when the physicist interacts with the production people and the engineers, how does that go?

Mallary: Let’s see. I’m pretty patient I think, so it takes a while, but you have to say the same thing many times--

Saviers: Yeah, yeah, but you got through.

Mallary: Yeah, yeah.

Saviers: So, the math and the science eventually wins.

Mallary: Yeah, yeah, and that’s the nice thing about science is that it’s true whether or not you believe it. <laughs>

Saviers: So, DEC gets acquired by Quantum, right? That’s kind of a big deal. But you staid in the Boston area?

Mallary: Yes, yeah. Yeah, and I used to joke that I’d just stay in the same place and the corporations would keep moving through. But anyway.

Saviers: So how did that work? You developed some further evolutionary advances at this point? Was the perpendicular recording being shipped?

Mallary: Well, yeah, but we started shipping perpendicular around 2005 I guess, and with the shielded pole architecture.

Saviers: Right, so it’s--

Mallary: And there, though, the task became to actually get all our vendors to produce a shielded pole head, because one of the things about the shielded pole head is it’s not easy to produce, okay? It does have a lapping criteria that is stringent, and so you have to lap it accurately to a certain tolerance, and so that’s the one difficulty. And at first you got a no-can-do attitude, but then when people see the advantage of it, then they--

Saviers: Figure out a way.

Mallary: They overcome it. And now it’s been standard practice. It’s been in every disk drive now since 2005 pretty much.

Saviers: Pretty much, yeah, right. So that gets recording to a terabyte per square inch? Is that about right?

Mallary: Yes, a terabit.

<overlapping conversation>

Mallary: But we're pretty stuck there, and it's difficult to get beyond. Now, NSIC was pushed in the direction of HAMR as being the preferred technology for the future beyond that.

Saviers: And what is HAMR?

Mallary: Oh, yes, sorry. HAMR is heat-assistant magnetic recording where you actually heat up the disk where you're trying to record the bits, but the temperatures involved are very high. You have to heat the disk above what's called the Curie temperature, which is about five, six hundred degrees centigrade. My experience with materials science and I actually learned this in my diamond-making project <laughs>-- was that you go above five hundred degrees centigrade and everything has trouble, and my diamond-making vessels would explode at five hundred degrees centigrade. <laughs> Anyway, materials have a lot of trouble above 500C, and so HAMR really does have a lot of difficulty with material reliability, and I've not been a big enthusiast of heat-assisted magnetic recording for that reason. It's always scared me.

Saviers: What problem does the heat solve?

Mallary: Well, the heat enables you-- that's a good question, and what it is, is that you have to reduce the grain size in order to record finer bits. You need an adequate number of grains in each bit so that you have a decent signal-to-noise, and so if you want to make the bits smaller, you'll have to make the grains smaller. Well, if you make the grains smaller, they lose their ability to stay magnetized against thermal agitation unless you increase what's called their magnetic anisotropy. Well, their magnetic anisotropy is how much magnetic field it takes to switch them, and if you increase their magnetic anisotropy too much, you can't provide enough magnetic field to switch them with any magnetic material that you can come up with in nature. There just aren't any magnetic materials that have enough magnetization to switch high magnetic anisotropy materials.

Saviers: It's a write problem. You can't write the bit.

Mallary: Yes, you're right, so the way to overcome that is to heat the materials up, and when you heat them up, that lowers their magnetic anisotropy so that you can write them so that when you cool down, then their magnetic anisotropy goes back to a high value, and then they retain their magnetization in that magnetized state at the low temperature, and so then your bits become thermally stable at room temperature, and they retain their magnetization. And so, yeah, the heat assistance allows you to write very high magnetic anisotropy materials that will retain their magnetization even when the grains are very tiny and otherwise would decay thermally.

Saviers: Where does the heat come from?

Mallary: Typically, from a laser, but you could do other ways, but a laser.

Saviers: So that's a laser in the recording head?

Mallary: Yeah, you would have some kind of light pipe to concentrate a laser beam down to a very fine point and try to create a tiny spot on the disk that records your bit. It's very hard to combine the laser light with a magnetic field, but the fundamental problem, though, is the very high temperatures; and the fact that you need disk lube in order to be able to fly your head at a very low spacing, and the lube itself gets corrupted by the heat; and again, you have to have a seal job to keep water out, because again, at the high air bearing pressures, water will condense, and then that becomes a problem in the write process, and you get pole corrosion associated with the high temperatures plus the water <laughs>. And not only the poles corrode, but also the ceramic surrounding the structure, they dissolve at the high temperatures <laughs>. It's really a horrendous materials problem, and it just scares the hell out of me from a reliability point of view, so--

Saviers: Is there product shipping with it?

Mallary: No. <laughs> No.

Saviers: Not yet. Interesting.

Mallary: Not yet, no. No, that's my understanding.

Yamashita: Supposedly, though, Seagate's supposedly shipping, but it's not so clear.

Mallary: I made an inquiry on that subject two days ago, and the answer was no, by someone who knows.

Yamashita: You had worked on this when you went to Seagate for a little while.

Mallary: Yes, I did work on that at Seagate for a while, but also at the same time I'd started working on microwave-assisted magnetic recording, and that's why I worked on microwave-assisted magnetic recording, which turns out to be problematic, too. It's not as easy as I had hoped.

Saviers: And so now you've gone to Quantum, and then Maxtor acquires Quantum, and now you move to the Seagate research center in Pittsburgh. Is that right?

Mallary: Yeah, then Seagate acquired from Maxtor, and then I had to move to the research center in Pittsburgh. But then they closed that, the research center in Pittsburgh, so I decided to retire from Seagate and go back to Massachusetts, because my daughter said "Oh, good, we can go back to Massachusetts," and so I said "All right, yeah."

Saviers: So, I had visited the Seagate research center. Bob Rottmayer was running it, so you're working for him again in Pittsburgh, right?

Mallary: Well, let's see, I don't think I was working for Bob at that time actually, no, no.

Saviers: Okay, but that was kind of this huge investment that they made in this research center and then shut it down. What happened?

Mallary: Right. I wasn't really aware of what was going on at the higher levels. Mark Kryder[12] was the person who wanted to set up that research center, and I suppose his political situation wasn't as good as it might've been. I don't know. I don't know details of that.

Saviers: So, is the research thread going on somewhere else now in Seagate?

Mallary: I'm not privy to those issues, and so I just can't--

Saviers: So how long were you in Pittsburgh?

Mallary: I think it was about two years.

Saviers: Two years, okay, short stint.

Mallary: Yeah.

Yamashita: You worked on MAMR (Microwave Assisted Magnetic Recording) at Pittsburgh as well?

Mallary: Well, yeah, I was doing some work on MAMR at the same time, too, yeah, and I'd been working on HAMR and MAMR, and anyway, I decided to take a retirement package. I went back to Massachusetts, and then I got a position with Western Digital working with them on MAMR.

Saviers: And so, this was a consulting relation? They're in California and you're in Boston?

Mallary: Yeah, and I was traveling out to California, and I ended up commuting to Japan, too, and I had a gigantic carbon footprint there for a while, pretty unconscionable actually <laughs>.

Yamashita: Japan with Western Digital?

Mallary: Yeah, that was with-- well, let's see now. No, wait, hold on. No, initially it was with HGST (Hitachi Global Storage Technologies). Initially it was with HGST. No, initially I believe I went to work for HGST. No, hold on. No, I went--

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[12] [Editor's note] Mark Kryder, https://en.wikipedia.org/wiki/Mark_Kryder

Yamashita: It was Western Digital first and then--

Mallary: I went to, yeah, Western Digital, and then--

Yamashita: And then they acquired HGST, so if that's--

Mallary: Yeah, yeah, and then they acquired HGST, and then I was working with HGST on MAMR.

Yamashita: On MAMR.

Mallary: That was it, yeah, yeah. Okay.

Saviers: And what is the theory behind MAMR? How does it work?

Mallary: Okay, well, the idea there is that if you have a magnetic particle and you apply a microwave field to it, you can get its magnetization to start precessing around in response to the high-frequency applied magnetic field and so that you can get it to switch with a lower applied field than you otherwise would take, because you can get it to start precessing around to larger and larger angles with this applied microwave field. And when you go to a magnetic resonance imaging system, the electrons in your brain or whatever is being imaged are precessing around in response to that magnetic field, and, well, similarly the magnetic grains in a disk would be precessing around in response to this applied magnetic field, and that would make it easier to switch them. And the trouble is to get a strong enough applied RF (Radio Frequency) field in combination with the write field of the head, and then you have microwave-assisted magnetic recording, and they call it MAMR.

Saviers: And what microwave frequencies are typically used?

Mallary: You're up around 20 gigahertz. That's pretty high frequency, and in order to do that, you need what's called a spin torque oscillator in the head. And Jimmy Zhu[13] at Carnegie Mellon University has been a big proponent of that, and I did a lot of work using his software and a lot of his concepts. I built on a lot of his concepts in what I was doing.

Saviers: So, what's your bet for that being something for the future mainstream?

Mallary: I think I really have to at this point self-censor on that, because I'm actively consulting on the issue, and I really shouldn't comment on it.

Saviers: All right, wonderful.

Yamashita: So still reasonably active right now in these advanced topics?

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[13] [Editor's note] Professor Jian-Gang (Jimmy) Zhu, https://users.ece.cmu.edu/~jzhu/

Mallary: Well, we're working on it, but it's--

Saviers: So, what's your average week like?

Mallary: Well, I've been staying busy somehow. I'm glad I'm retired. The consulting I'm doing for Western Digital at this point isn't that much. It's not that many hours per week or anything. And I rock climb twice a week just to stay in shape, and I do give talks on global warming, because global warming's my hot button. I view it as an existential threat to our species. And-- say, well, if you want me to sew a probability on it, maybe it represents a five or ten percent threat. That's way too large. <laughs> And considering what it took for us to get to where we are where we can now pretty much accomplish all the things our ancestors prayed for, we can do now, <laughs> to throw it all away is just ridiculous. Anyway, so I give talks on global warming, and I've stayed busy. <laughs> I don't know.

Yamashita: What other hobbies? You have many it seems.

Mallary: Well, let's see. Actively right now, it's mainly those things actually right now. I've had other hobbies in the past. Let's see. I used to do sculpture, but I'm not actively doing that now. I promote my book. I'm working on my--

Saviers: Yeah, so I wanted to give a plug for your book here and have you talked a little bit about it.

Mallary: Oh, yeah, right, okay. Oh, okay, well, this is "Our Improbable Universe." It was a life's work, and I'd mentioned that I started thinking about this in graduate school. And it identifies 17 aspects of physical law that have to be more or less exactly the way they are in order for anything like us to have evolved out of the raw energy of the Big Bang anywhere in the universe. So, it took 14 billion years plus these 17 things being more or less just right, but because of our addictions to fossil fuels and to playing surreal Russian roulette with nuclear holocaust, we threaten to throw it all away in the blink of a cosmic eye. It's just absolutely outrageous. And so, I give talks on it, and I've been talking about it for 15 years, both of the book and global warming[14]. And one of my things about global warming-- and a lot of Greens will consider me to be-- I don't know. They don't like it, but I--

Saviers: A traitor to the religion?

Mallary: Well, I view nuclear power as essential to dealing with the global warming issue, because when the wind don't shine and the sun don't blow, we burn. <laughs> And I can show in my presentation that I do on this we need a 60 percent reduction in carbon emission to stop growing carbon in the air, and we just can't get there with pure renewables. For example, in 2013, there was a whole week when wind and solar across all of Europe were at 10 percent of nominal capacity, 10 percent. So, there's no energy storage that can bridge that gap at this time, okay? Now, batteries are getting better, but they're nowhere

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[14] [Editor's note] Dr. Mallary has given many lectures on Global Warming. http://vimeo.com/53999586, http://vimeo.com/35172497. A 2011 lecture on his book *Our Improbable Universe* is at https://www.youtube.com/watch?v=59gNQ9LqBl8&feature=youtu.be

near good enough to bridge that full week. <laughs> Yeah, there's a couple of videos on global warming, and there's also a video on the book.

Saviers: So, you're trying to educate audiences to look at this I think analytically and by the numbers. Are you successful in getting people to bridge that from their kind of inherent biases and kind of historical beliefs? Do you think you're making conversions? You're getting folks who believe what you believe?

Mallary: I would say based on the feedback I get from the people I talk to when I give presentations, yes, but of course I only reach maybe a couple hundred people a year <laughs> directly. But maybe they talk to their friends, and hopefully-- but one of the encouraging things is that people are paying a lot more attention now than they have in the past. I certainly felt like a voice crying in the darkness in the past, but now people are really paying attention to this global warming issue. The wildfires in California are causing people to wake up. The extreme weather in the Midwest are causing people there to wake up. The fact that we've had the wettest year ever in America is causing people in the Midwest to scratch their heads about whether or not the propaganda from the fossil fuel industry has not been a lie. In fact, it has been a lie. They've known that they've been lying for 42 years. James Black, senior scientist for Exxon Mobile, told management in Manhattan in 1977 that there was scientific agreement at that time that the continued burning of fossil fuel would lead to global warming. That was 42 years ago. <laughs>

Saviers: Have you pondered ways of leveraging the message into the political chattering classes?

Mallary: Well, I talked to my Congressman about it two weeks ago, but he was already well on board on it, and he in fact was one of the first sponsors of a bill that's in Congress right now, HR763, which is the Energy Innovation and Carbon Dividend Act, which in fact is a carbon tax actually, but it's a revenue neutral tax, but 80 percent of people would actually gain financially from it, and 20 percent would lose. But it's being criticized as being revenue redistribution.

Saviers: So, getting folks to embrace nuclear power? I think I looked. I don't think there's a single presidential candidate with that part of their policy or their message.

Mallary: Well, I'm looking for candidates that don't pan it overtly. Anyway, yes, because people are absolutely phobic about it, the average person thinks that nuclear is a million times more dangerous than coal. The factual reality is exactly the opposite. In the time that nuclear has been around, coal has killed almost a million Americans from air pollution, and coal has yet to kill a single American.

Saviers: Other way around.

Mallary: Yeah.

Saviers: You got the words backwards.

Mallary: I'm sorry, nuclear has yet to kill a single American. Yeah, I'm sorry, I misstated, yeah, yeah, and thanks for <laughs> correcting me. Yeah, right. Anyway, so I'm dealing with a phobia, and the media has really played up the Three Mile Island thing. And Three Mile Island released a negligible amount of radiation in the environment, because the Nuclear Regulatory Commission in fact did its job well and required that the containment structures in America have filters on them, which the Japanese regulatory agencies did not require, and therefore Fukushima released 10 million times more radiation than Three Mile Island did. <laughs>

Yamashita: But there is Fukushima, too, and that's certainly on lot of people's mind.

Mallary: Right, and that's because they did not have filters on their containment structures.

Saviers: On my vacation, I read "Midnight at Chernobyl," which is a real eye-opener of a book, and wow.

Mallary: Right. And I've read about Chernobyl recently, too, and my position is that the Soviet Union should not have been allowed to make nuclear reactors to begin with, because being a totalitarian state, they had no ability to correct anything, because everything was considered to be a state secret, and so they had no ability to correct anything 'cause of that phenomenon. Now unfortunately America is heading in that direction as well. <laughs>

Saviers: So if you go back over your career and think about-- and I think one of the things that was kind of in our preparation, you'd said you actually had an opportunity to work with Richard Feynman or at least take his classes. That must've been kind of a dramatic experience given what I've seen about him. So when you look back at and say "Well, here are the big things that kind of made me successful in all the things I did," what do you kind of look at as the major milestones along the way?

Mallary: Oh. Well, it was really great to have taken courses with Richard Feynman and been exposed to that person. I don't know that I can identify that as being that formative, though. It was just a nice experience.

Saviers: Sure, sure, right, right.

Mallary: He was just a fine human being, and I remember one of the things was just a reminiscence that he had. He just stood aside during a lecture once, and then he was talking about the aftermath of the Trinity test and how 90 percent of the scientists were celebrating, "Oh, this is wonderful," but 10 percent were going around, "Gee, what did we do?" <laughs> And we really were thinking about what the--

Saviers: Unleash the genie.

Mallary: Yeah, yeah, yeah. Anyway. <laughs>

Saviers: What would be your advice to, say, high school students thinking about a career in physics as a for instance?

Mallary: Oh, I think it's a really nice thing. But discoveries are hard to come by in physics, and you just have to accept the fact that you're going to be participating in a huge team effort and be satisfied with just being part of moving this ball forward a little bit in general. You might be the person who makes a Einstein type discovery, but probably not. But just be satisfied with being part of a collective effort that is moving the overall understanding of physical reality forward by a lot and the excitement of just being at the forefront of what's going on. I found it very stimulating, both in terms of the just excitement of the moment, but then it also got me going philosophically big time and understanding reality on a philosophical level, too.

Saviers: How did your early experiences of making things kind of help you in your career?

Mallary: Oh, a lot. I think that was one of the very-- actually I think that's one of the things that really-- people usually thought of me as being a theorist, but the fact that I could get in there and get my hands dirty and understood stuff down to the nuts and bolts I think really helped a lot. The reason that I was able to get to the heart of those magnetic particles as a source of erasure had to do with the fact that I was so hands-on, that I could intuit what was going on there pretty much right off the bat. So, I think the hands-on stuff was very important, and I learned that working in the garage with my father. <laughs> That's where I got my start on that hand-- and that actually kind of was how things work and working with my hands. It's extremely important, and that's unfortunate a lot of kids today are just pushing buttons.

Saviers: Right. You can't go fix your car anymore.

Mallary: No. Yeah, and that's a real big problem, yeah, yeah, yeah. Yeah, I tried to rebuild a car at one point. Didn't succeed, but I tried, and I learned a lot by trying. <laughs>

Yamashita: Talk about your family, your children, what they're doing.

Mallary: Oh, yes, yeah. Well, my oldest daughter is a psychiatrist now with the Veterans Administration, and she has two daughters, and let's see, I guess they're about seven and nine, Maya and Noor. And let's see, I have a daughter named, let's see, Caroline. My oldest daughter's Elaine. And Caroline is studying general relativity at University of Massachusetts at, let's see, Dartmouth. And let's see, she's about to wrap that up, and let's see, my youngest daughter, Joanna, is a senior at University of Connecticut, and she's going to do a PsyD (Doctor of Clinical Psychology) in psychology, and she wants to do therapy and psychology like my eldest daughter actually, who's a psychiatrist, but Joanna doesn't want to be a psychiatrist. She wants to just do a PsyD and go out and do therapy. Yeah.

Saviers: So graduate degrees and PhDs run in the family.

Mallary: Yes, yeah, yeah, and again, I would trace this whole thing back to my grandparents as being the people who really got those balls rolling. <laughs>

Saviers: I think it was Richard Feynman who said, "We're trying to understand time by smashing watches together and looking at the gears and the springs that pop out of that."

Mallary: Oh, yeah, that's high energy physics experiments, yes. Yeah, that's basically what we're doing, yeah, yeah. When we crash protons together, yeah, to-- a proton is very complicated. Yeah, it's like throwing two Swiss watches at each other and trying to understand how they're made by looking at the pieces that fly out. Yeah, it is, it is. Did Feynman say that?

Saviers: Yeah, I believe so.

<overlapping conversation>

Mallary: Okay, that's about right.

Yamashita: It's a good analogy.

Mallary: That's about right. He's good at that kind of stuff. Yeah, he's very good at expressing things in an understandable fashion.

Saviers: So, we talked a little bit about-- there's more to discover in high energy physics, smashing particles together and so on, so you think there's another whole evolution of what we understand about the fundamental nature of matter?

Mallary: Oh, yeah, there's definitely a huge reality underneath what we understand already, yes, a gigantic reality under there, and the trouble is it might be that the energy level of that reality might require an accelerator that's the size of the orbit of Jupiter around the sun, and we may not be able to access it experimentally. And that could be a real fundamental problem, because the scientific method has always relied upon the ability to experimentally verify your theoretical hypotheses. Without that experimental verification, you end up in the woods very quickly. And so, it's not clear that science can progress without-- if you need an accelerator that big in order to get to that next level of reality, we're in big trouble from the point of view of moving it forward.

Yamashita: Now, how about some favorites stories that you might want to recount or stories about your favorite teacher?

Mallary: Well, yeah, when my family was in transition from Los Angeles to New York because my mother got her big break in advertising and a job on Madison Avenue, Mad Ave, the family had to move back from LA to New York. I was temporarily moved to Berkeley and stayed with my aunt, my father's sister, Jean, in Berkeley, and I went to Garfield Junior High School there for about a half a year for seventh grade. And there was an excellent science teacher there. He just had all the great science toys. He had a Jacob's ladder, and I told you about the Jacob's ladder I made. Ultimately his ones was little one, but I-- anyway, he had a van der Graaf generator, which makes sparks, too, and he had a Tesla coil. He had a cloud chamber where you could actually see radioactive particles shooting through from a hunk of uranium ore he had. And at one point, he had a contest between the girls and the boys as to who could wire up a lamp fastest. And I represented the boys, and they had a gal here, and I had my razorblade to strip the wires with my razor, and sometimes I'd cut my finger open doing it. <laughs> Anyway, but she had the right tools. She had the thing wired up in no time <laughs>, and I was still stripping… <laughs>-- and the class was rooting for me. Anyway, she beat me hands down. <laughs> But anyway, he really did stimulate my interest in science, because he just had all those great science toys, and he taught very well, and it just got that excitement, that fundamental excitement going. And I was already interested in science, but this really confirmed that this is what I want to do. And anyway, I was back in Berkeley in the early 2000 timeframe, and I was visiting my cousin Dirk who lived there, and his significant other, Patricia, was there at the time. He ultimately married her, but she's passed away since then. But anyway, I was telling Dirk about this science class, and Patricia said "Oh, yeah, I went to Garfield at that time, too," and it's since been changed to Martin Luther King Junior High. Anyway, I said "Oh, well, do you know that science teacher? Did you ever go to--" "Oh, yeah, he was hitting on me last week in Berkeley here." "Oh, he's still around? Wow." She knew his name, and so I dial 411. I got him on the phone and said "Thank you for being such a good science teacher." Well, he was really appreciative, and he said he remembered me, and I got the impression that maybe I was the only student who ever called him up to say thank you, which is an awful shame, and it really informed me of just how important it is to give positive feedback. It costs you nothing. Anyway, I just made it an important thing to say thank you whenever I have the opportunity. I wish I'd called up Charles Barnes, too, to say thank you to him for telling me about the nonexistence of helium-2 as being an essential ingredient to our reality and stuff like that. But anyway, that guy was just a real important person to me. Mentors are very important, and it also informed me of the fact that some of the most important things you do with your life, you actually never get that positive feedback on, and you just have to do the right thing and know that you're doing the right thing, just have the maturity to give yourself that positive feedback and pat yourself on the back, whatever it takes to do it, because a lot of the time you just don't get it back the way you should, because in mass society, people go their separate ways. And I've told this story to people, and they've said "Yeah, I wish I'd phoned that back, and I've even thought that I'd like to call this guy back, but I've lost track of him." And that's the problem with mass society: You don't have that opportunity to get back to them. And I just happened to run into Patricia, and she knew the guy's name, and I was able to get back to him.

Saviers: Terrific.

Yamashita: Terrific story.

Saviers: We should all do more of that.

Mallary: Yeah, yeah, and that's why I tell this story, because just to encourage people to-- doesn't cost you a thing. <laughs>

END OF THE INTERVIEW