Oral History of William (Bill) Regitz

Interviewed by:
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Gardner Hendrie: So, a Computer History Museum, oral history session, and we're talking today with Bill Regitz in his home near Lancaster, Pennsylvania. Maybe the first place to start would be just to talk a little – if you could talk a little bit about where you were brought up, your family, your siblings, a little bit of the background as to where you were born and raised.

Bill Regitz: Okay. I was born about 80 miles north of Lancaster in a little town called Locustdale, Pennsylvania. It's a coal mining town, hard coal mining. My father was a hard coal miner. He worked there for about 40 years. Family, I was one of six children, I was number four in line and went to school for the first three years of my life in the same town I was born in Locustdale. Schools consolidated and went to a little town called Centralia and then in the high school another little town called Aristes.

Hendrie: Okay now how – you said you had – you were fourth of six.

Regitz: Correct.

Hendrie: Okay, how far apart were they and, you know, were they boys, girls?

Regitz: There were three boys and three girls. My older brother and older sister were relatively close together and then I think there's three or four years between me and my brother who was also relatively close together. We were two years apart.

Hendrie: Okay.

Regitz: And then my two sisters came about two years after that each two years after myself.

Hendrie: Okay.

Regitz: And, you know, I didn't really because my sisters and brothers – my older sister and brother is about four years to six years older than me, I didn't get to know them very well but my next brother that's one year older than me, two years older than me rather, we were both born on the same day, him and I played together and got to know each other very well.

Hendrie: Oh, very good. Are you still close to him?

Regitz: Actually, close to all my siblings. My oldest brother was a policeman and he ended up unfortunately passing away a number of years ago with colon cancer but the rest of us are alive. My mother and father also passed away. My father died when I was 15 and so my mother ended up raising the six of us in this coal mining town. My brother lives – my other brother lives only about two miles from here. One of the reasons I moved here was because of him. We found this home here because we

came to visit him and decided this is a good place to live in Lancaster County. My other brothers and sisters are all close to the area so we get together quite often.

Hendrie: Very good. Well, when you were growing up what did you think you might want to do? What are your earliest memories of what you thought you might want to do when you grew up?

Regitz: Oh, when I was growing up we came from a relatively poor family. With six kids in the family my mother and father, neither of them graduated from high school and their immediate objective was to make sure all six of their children graduated from high school. That was their goal in life which they achieved and so as I was growing up I wanted to be, I think, at one time a policeman, an Air Force pilot. My brother, I think, went into the Marines and at one time I probably wanted to go into the Marines and do things like that. But, as I came to high school their goal was not only have us get through high school but take academic classes, the academic program, so it was the more stringent of the school that needed to take the classes I needed to take. So, I was prepared for college but I couldn't see where the money would come from to be able to do that. My father had passed away a couple of years prior to that and we needed to go out and work. So, my initial goal was to go get a job someplace and all those other dreams, I didn't do anything from that standpoint. They went in that direction.

Hendrie: Okay, what did some of your other brothers and sisters do when they graduated?

Regitz: My brother because a Pennsylvania state policeman and he was in the service. He went to the Marines and then came out of that and became a policeman. My older sister ended up getting married. I remember that's a long time ago and at that time men worked and women stayed home, right?

Hendrie: Right, exactly.

Regitz: She didn't work but she went to New Jersey and she actually worked in a factory and she also ended up getting married. My next brother, one older than me by two years, he went to Stevens Trade School here in Lancaster and he went for three years there. That school at the time was for poor families and he got a scholarship to go there so it didn't cost anything for room and board so that was a good deal and my sister below me –

Hendrie: What did he do with Stevens?

Regitz: He was a carpenter.

Hendrie: Okay, he learned a trade.

Regitz: He learned a trade. He learned to be a carpenter and he stayed here in this area and has been working in that trade ever since.

Hendrie: Okay.

Regitz: My next sister she went to nursing school. Actually my next two sisters went to nursing school and my sister did graduate from college. I think both my sisters graduated from college and my one sister has an M.S. degree in nursing.

Hendrie: Oh, very good.

Regitz: So.

Hendrie: So, not a family – the parents, you know, didn't get very far through the school system but they clearly set the goals for their kids and in some sense the expectations.

Regitz: They did. Well, they did and my mother was certainly probably the driving light in the family from that standpoint and, you know, she knew what she wanted and she knew what she wanted for us and she kept us on track and, you know, gave us the discipline that we needed to be able to do those kinds of things that we ended up doing and, in the end, she actually did help out and the same as my sisters, I mean to go to be nursing school. You can get into class relatively cheaply but it still costs money to go to school and eat during that time frame and she worked hard enough to be able to support all those activities.

Hendrie: Wow. There was no – was there any thought that any of you would, you know, follow your father's occupation or was that sort of why your mother was pretty determined.

Regitz: I think both my mother and father was both pretty determined that, you know, we weren't going to follow him into the mines and he tells – I don't know if I should tell the story or not, but…

Hendrie: Sure.

Regitz: He tells a story that his father was a miner. He emigrated here from Germany from the mining regions of Germany and why he came and ended up working in the mines here and certainly his father, my grandfather didn't want my father to go to work in the mines because it's not a very healthy proposition. My father died of black lung and we watched him die of that and once you see that you really don't have any desire at all to continue with that profession in any way, shape, or form. And, he tells a story that when he came home from work the first day we were in the basement cleaning it up actually, cleaning the jar shelf off and we were sitting there and I noticed that this door that went outside had this big mark in it and I said, oh, what happened there? He said oh, well let me tell you what happened. Now, whether this is a true story or not I really don't know.

Hendrie: I understand but this is the story.

Regitz: This is the folklore anyway and he said when I came home from work the first day my dad through a double-bladed axe at me. He said, I told you not to go to work there. He was kind of a wild guy.

Hendrie: Oh, my goodness.

Regitz: Yeah.

Hendrie: All right.

Regitz: Whether he tried to hit him or not I don't know.

Hendrie: But he was really upset.

Regitz: But it made the point, right. But, you know, we did a lot of work in growing up. If we wanted something we had to work for it and we had a pretty good life compared to most people in my opinion as we grew up in the town. Everybody worked at the mine and everybody got the same amount of money and everybody worked the same number of days in most cases and, you know, so if you wanted something you had to work for it and save. And, one thing that I noticed when I was going through town you could see the difference between families who had something nice and who didn't have something and I always considered that we had something nice. We had lots of food, lived in a home, and clothes always looked pretty good and had nice lunches when we went to school and other people you could see that their dads spent a lot of time in the bars. There were something like six bars in this little town of less than 500 people.

Hendrie: Okay, so you sort of knew who did go to the bars.

Regitz: I knew who went to the bars and I could tell the families that were there. I could tell what they had and I could tell what we had, so if you stayed focused on work and earnings you could see it made a difference in life and that made a big impact on me as I was growing up.

Hendrie: You just observed that.

Regitz: Yeah, just observed that, you know, so we worked.

Hendrie: What sort of things did you work at when you were growing up?

Regitz: Oh, standard things that you would expect kids to do, you know, delivered newspapers. I cut grass, cleaned garages on Saturday. We had planted about an acre piece of property so, you know, during the summer months we had to cut bean poles, pull weeds, water, do the types of things that you

have when you plant a garden, mostly vegetables for that time frame. And then, I would sell the excess off the property. My brother and I we liked, he liked working in wood. Actually, I always liked working in wood too and –

Hendrie: He's the one that went to Stevens, right?

Regitz: He was the one that went to Stevens and so as we were growing up we ended up getting a couple of tools, you know, a table saw, a jigsaw, those kind of things. We used to make things and so he'd be making them and I'd be the seller. I'd be going off selling them and so we made like broomstick holders, a fence.

Hendrie: You figured out a design that worked.

Regitz: Right and then we'd go copy them and on my routes I would go bang on doors and sell –

Hendrie: Oh, you'd sell them off the paper route?

Regitz: Yeah.

Hendrie: Sort of.

Regitz: In this little town, yeah. So, that was like vegetables the same way. Depending on where we were we would go out and sell them so that got us into that kind of a business and we developed – his skill is a lot, much better than mine in doing those things but, you know, for making and putting together.

Hendrie: Yeah, he had a real knack for it.

Regitz: He had a real knack for it. I never had the patience for it.

Hendrie: Okay.

Regitz: So, those were the kinds of things we did when we were growing up.

Hendrie: Very good. Now, we obviously know where you sort of ended up. What courses in school did you particularly like and which ones did you hate?

Regitz: Those that I particularly liked was always the math and the sciences from that standpoint. I really enjoyed them. I did good at them. Math was always one of those things you could do and you knew whether the answer was right or not because it usually had a correct answer.

Hendrie: Yes.

Regitz: You know, English and history and things like that that you had to do a lot of reading, I'm not a great reader, and I never considered good classes to take in actual fact as I was in high school. Later on in life I understood why one needs those but they were not my favorite. I took them but I didn't do as well in those classes I did in English and history – I mean in math and sciences.

Hendrie: Okay. It is funny how we do well in things we like to do.

Regitz: Like to do, right, that's correct.

Hendrie: It's all through life.

Regitz: When you enjoy and you see that other people, some people like the other classes but my preference was math and science.

Hendrie: Math and science, okay. So, when you graduated what did you do? You said that you really couldn't figure – did you think about going to college or did you just –

Regitz: No.

Hendrie: How did your mother feel about that?

Regitz: She didn't pursue it from that standpoint. She didn't push me or anything toward that end. My teachers in high school wanted me to continue on into college in some fashion but as I said I didn't think there was enough money to go around to do anything in that arena and I was working. One of the last jobs I had in high school was working at a place called the Boulevard Drive-in, which is in the town next to where I was born and raised and I worked there my junior and senior years and so I finished the summer off working there and then I went –

Hendrie: What were you doing there?

Regitz: Short order cook.

Hendrie: Oh, okay.

Regitz: You know waiting at the window.

Hendrie: You were feeding people.

Regitz: Feeding people, waiting the window.

Hendrie: Okay.

Regitz: I don't remember what I earned but whether it was 35 or 50 cents an hour but something in that arena and worked quite a few hours at it and going to school but I finished the summer off and then I went to New Jersey. My sister lived down there and so I went down and lived with her during the week and then came home on weekends and got a job. My first job down there was working in a plastic factory on graveyard shift making screwdriver handles and other plastic parts running [inaudible].

Hendrie: Now this wasn't the same, you said she worked when she moved to New Jersey.

Regitz: Yes.

Hendrie: She worked in a factory too, was it the same one?

Regitz: She worked in a sewing factory.

Hendrie: She worked in a sewing factory.

Regitz: In Elizabeth, yes.

Hendrie: Okay.

Regitz: In Elizabeth.

Hendrie: In Elizabeth?

Regitz: Yeah, in Elizabeth, New Jersey, right.

Hendrie: Oh yeah, sure, okay. So you worked there.

Regitz: Yeah and worked on the graveyard. That was my first job. I was only there a couple of months and her husband, my brother-in-law, he worked at the GM factory, Hyatt Roller Bearing, and so he got me an interview over there and I moved out. I couldn't stand graveyard. I was getting sick especially in that plastic factory. It just didn't set well with me. I never worked on a graveyard shift before and, you know, it messed up my system. But, in addition to that, he got me into Hyatt Roller Bearing, oh, somewhere around, you know, 90 bucks a week I think if I can remember correctly.

Hendrie: Uhm.

Regitz: Which was a pretty good job compared to the plastic factory and my job –

Hendrie: A lot better than flipping burgers at the drive-in.

Bill Regitz: Yes and so I went to work there working on second shift, swing shift, and my job there was stamping bearings and roller bearings.

Hendrie: Okay.

Regitz: And in '58, there was a recession and what happens in the car business when there's a recession you get laid off and it was a pretty deep recession. I couldn't find work anywhere. I looked and looked and looked and I was out of work for about nine months.

Hendrie: Oh, my goodness.

Regitz: And my brother who had been living in this area here, he was working on a construction project building a school and he said he could get me in as a laborer. So, I decided that, well, he said come on down, live with me, so I did the same thing, went to live with him.

Hendrie: So, you came back from New Jersey from living with your sister.

Regitz: Well, actually I wasn't – it was when the job went away I came back and lived at home again.

Hendrie: Yeah.

Regitz: And then I came down here with my brother and lived with him during the week and went home on the weekends and working as a laborer in the school.

Hendrie: Uh huh.

Regitz: And about that time in history when electronics was becoming a big deal and it was pretty close around that same time I think when Kennedy decided they were going to put a man on the moon.

Hendrie: Uh huh.

Regitz: And, I was out in the middle of a field, what was a laborer doing, what you normally do is clean up.

Hendrie: Can you place a --

Regitz: This was about ’58, ’59.

Hendrie: Fifty-eight or ’59, okay.

Regitz: And, you know, I was a laborer on a construction site. You build scaffolds. You take care of whatever carpenters need and want, go get them this, go get them that, dig ditches, and I was out in the middle of this field digging this ditch and looking at my hands and seeing those blisters on it and it was hot. I said I’m not doing this the rest of my life. About that same time, as I said, I think Kennedy announced it’s time to, you know, we wanted to go forward and set the nation in building a – sending a man to the moon and electronics was big, just coming of age, and I got this brochure from DeVry Technical Institute talking about you can go to school, work at night, and work your way through the activities and so I decided to go talk to him and he came to visit me and it seemed like the right thing to do. So, he said do you like math and sciences? I said I love math and sciences. He said well then you’re going to like this.

Hendrie: Okay.

Regitz: So, it connected together and my mother says I think I can afford to pay the tuition but you got to work to earn your keep so I said that’s a deal and so off I went to school in ’59 and ’60.

Hendrie: Now, where was this?

Regitz: In Chicago.

Hendrie: Oh, it’s in Chicago.

Regitz: That was a big deal for a little kid from a little coal mining town in Pennsylvania.

Hendrie: Yeah.

Regitz: To go to Chicago, a big city.

Hendrie: So, where did you live in Chicago?

Regitz: Well, they arranged – we lived – they didn't have on-site housing but they helped arrange for people to live together and it turned out that another kid from the town next to me he also was going to school in the same school and we met another fellow out there and the three of us ended up renting a place to live.

Hendrie: Okay.

Regitz: So, we lived together in that kind of a dorm. Then for whatever reason I stayed in school for the two years. You could – they had classes I think every six weeks or every 12 weeks I guess it was so every 12 weeks you could drop out and then come back again but I chose to stay there for the full two years right in a row and the fellows that I started with they decided to take a break. So, we split up and then I lived by myself most of the time.

Hendrie: Okay.

Regitz: During the next year, year and a half, whatever it turned out to be.

Hendrie: Now, what did you do for work? Were the classes during the day?

Regitz: Yeah, classes were during the day and you could work weekends or work at night. And, I ended up doing a couple of things out there. One, I was a Good Humor ice cream man.

Hendrie: Okay.

Regitz: On weekends which is a pretty good deal. I could sell ice cream and be outside in Chicago. And, the other one after that I went to work for a place called Door-a-Matic door checks. They made door checks and I was in the packing and receiving department, shipping thing, so that got me some flexible hours and it was very good in helping me get through school.

Hendrie: Good. So, you graduated from school.

Regitz: Yeah.

Hendrie: Now, what do you – or, you're getting close to. What are you going to do now?

Regitz: Well –

Hendrie: Okay, we were going to say what did you – you're getting close to the end of school, what did you do next?

Regitz: DeVry, one of their things as most schools are trying to get you to go there they're going to help you find a job and it turned out that they're a pretty good technical school. I hired a fair number of people out of DeVry in my later years at Intel, and they brought companies in to interview and took you out for a job to do that. The places to go to work at that time, the number one place I think if you had good grades was Sandia, Bell Telephone Laboratories, Boeing, are the three places that I remember and since Sandia was the right place to go I said well I ought to go there to go to work.

Hendrie: Where is this located?

Regitz: That was in New Mexico.

Hendrie: Okay.

Regitz: So, they came in the school and picked who they wanted to interview and I interviewed with Sandia, Bell Labs, and Boeing, and got job opportunities from I don't know how many different places but definitely from Boeing and from Bell Labs and I considered Boeing as an opportunity because I heard a lot of people that I worked with in Chicago really said that Seattle really was a beautiful place to live. They were in the service and were stationed up there and good feedback as a city. But I ended up going with Bell Telephone Laboratories, it was the number two place to go to work and it was more commercial than military and for whatever reason I never really wanted to work in a – for an organization that concentrated solely on military. I think probably because it has its ups and downs. It had more layoffs than some of the other areas and I went to work for Bell Labs because they'd been around for a long period of time. They had a very good reputation. They had retirement programs and if you stayed there forever at the time. I was thinking am I really going to be there but I thought at the time I went there that I'd be there forever.

Hendrie: Okay.

Regitz: And so everything looked like it matched up. It was a good company and they never had a layoff and, you know, so it just seemed like the right place.

Hendrie: Seemed like a good idea.

Regitz: All lined up with what I thought was good.

Hendrie: Now, was the draft active at this time?

Regitz: The draft was active at this time. We were in the Vietnam War during this period of time. I was on the – I've always said that I was too young for the Korean War, which my brother participated in, and the Vietnam War I always said I was a little old, on the old side for that war. The other thing is, you know, I got married when I was in school and as long as you were in school and married they weren't really taking those people during the draft as well. And, I think while I was in school I always thought that maybe they lost my draft card in my office but I don't really know whether that's true or not but I've never been called and I've never been in the service.

Hendrie: All right.

Regitz: So that part of my life I didn't.

Hendrie: Okay, now at the school in Chicago I mean did you specialize in any particular field or was it just general electronics. Was this an electronics course or I mean how would you characterize the kinds of courses? What kind of courses did you take?

Regitz: This was definitely electronic class to be an electronic technician.

Hendrie: Okay.

Regitz: And they trained you in everything from TV repair all the way up to one of the last classes I took in the school was a six-week class of transistors. So, everything was on vacuum tubes prior to that.

Hendrie: Okay.

Regitz: There was a lot of lab work associated with it as a technician. You spend a lot of time in the lab, you know, taking data, collecting data, and perfecting those activities and so I took, I supposedly could repair TVs. I worked on radar systems and those kind of systems and microwaves and I decided I didn't really want to work on microwaves. The other reason I didn't want to go to Boeing or into the military because it just wasn't something that interested me that much.

Hendrie: Yeah, right.

Regitz: But, you know, out of 90 percent of the classes or even more than that, I said only one six-week class out of a full two years in the school was associated with transistors.

Hendrie: My goodness.

Regitz: Remember this was now 1959.

Hendrie: Yes.

Regitz: So, but they were around.

Hendrie: They were just a little slow.

Regitz: Well, you know.

Hendrie: There were transistorized computers being shipped but that's all right. Okay, good. So, you did decide, back to Bell Labs, you decided to go to Bell Labs and so what did you do, what did they have you do when you arrived there?

Regitz: I always considered Bell Labs as one of the – I don't know. I think the school was very good that I went to. It was a very difficult school. I did well in class from a grade point average and enjoyed working with the transistors and other things and the people that chose to work with Bell Telephone Laboratories was when the 101 electronic switching system and it was one of the first telephone systems that was made out of transistors at the time using transistor technology. And, the area that I went to work in was the people that developed the magnetic memories [inaudible] memories is what technology they used but it was the read/write memories, the permanent read/write memories for the system.

Hendrie: Okay.

Regitz: Not the permanent but the temporary storage. They used twister wire for the permanent storage within those systems but it was an outgrowth.

Hendrie: They used twisted wire?

Regitz: Twisted wire, yes, twisters as they were called but it was a permanent storage. You could turn power off and, you know.

Hendrie: I see in that sense, okay.

Regitz: In that sense and you could do the same thing.

Hendrie: So, if the power went down, oh yes you always worried about the power going down.

Regitz: Yeah, the call stores as they were called is where all of the temporary information was stored.

Hendrie: Right.

Regitz: But the permanent information in the telephone system that you did not want to lose under any conditions was in the twister wires, plate of wire.

Hendrie: Okay.

Regitz: Is where they were. And, so they had these two types of memory used in the computer and I was assigned to the [inaudible] sheet or the temporary storage if you wish.

Hendrie: Uh huh.

Regitz: The more transient storage that they needed.

Hendrie: Now, why did they have a different technology? Was one of them faster?

Regitz: Yes. Yes. The call store was – good question but it might have been somewhere in the area of even ten times faster.

Hendrie: Uh, okay.

Regitz: In the read/write transitions compared to what and the writes you could not do on the twister. The information was stored on a card that you had to program so you had to pull these cards out and put them back in if you wanted to change that information.

Hendrie: Ah.

Regitz: That's why it was called more permanent and temporary storage.

Hendrie: Oh, I understand now, yes. So, it was a –

Regitz: Actually it was the RAM.

Hendrie: It was fundamentally –

Regitz: The RAM.

Hendrie: Almost a read-only memory.

Regitz: It was the read-only memory.

Hendrie: Yes and you could just, yeah, you had [inaudible].

Regitz: Yeah, so that's where today in today's terminology the RAM write was the [inaudible] memory and your hard disk really was the twisted wire.

Hendrie: Yeah, okay. Okay, good.

Regitz: Okay. And that particular system was developed by the same group, now if I can remember correctly, that put together the controls, the control module, the computer control module for the Zeus, the Nike Zeus.

Hendrie: Oh, all right.

Regitz: module.

Hendrie: Okay.

Regitz: And that was quite an impressive thing actually and they had converted it to transistors and then this was a – the ESS was a commercial electronic time division multiple switch that they were using as an outgrowth of that work is where this came from.

Hendrie: Okay and using the same transistors and probably the same kinds of service.

Regitz: Well, they were updated. They were updated transistors by this time but they were – it was all semiconductor versus vacuum tubes.

Hendrie: Right, okay.

Regitz: Or, at least 99 percent of it was.

Hendrie: Okay.

Regitz: There were probably some vacuum tubes somewhere in those days.

Hendrie: Okay.

Regitz: But what I was involved in I was a technician working in the memory area and I worked with the engineer who was assigned the job of developing the sense amplifier for this module.

Hendrie: Okay. Now, could you just describe briefly how does this work?

Regitz: Most of the computer industry at that time was using cores.

Hendrie: Yes.

Regitz: Okay and a core is just like a donut and they're strung on wires. What the [inaudible] sheet is is a core of memory in a sense but it was made on a [inaudible] sheet kind of mass producing cores if you wish of about an inch, inch and a half square, somewhere in that size and it had an array of holes in it 16 by 16 so one sheet was 256 bits of memory.

Hendrie: Okay.

Regitz: And then we'd stack these sheets up and also on one sheet also had one plate of wire that was completely plated through all 256 cores and that turned out to be the sensor wire.

Hendrie: Okay.

Regitz: And the other three wires, the X wire, the Y wire for selection, and then the inhibit wire to be able to write into the memory was strung through more wires it was strung through the module and the modules were 4K and 8K bits of memory.

Hendrie: Okay, oh wow, all right.

Regitz: You know. No, 4K and 8K words of memory and each word was 16 bits, sorry.

Hendrie: Okay, 4K, okay very good so it was a 16 bit machine.

Regitz: Actually I have a couple of pictures of those upstairs.

Hendrie: All the other three wires strung, you know, did they stack the sheets? Were all the other three –

Regitz: They stacked the sheets.

Hendrie: They strung it straight up and down through the holes?

Regitz: Yes, that's correct.

Hendrie: And then they weaved different ways.

Regitz: Then they weaved different ways which wire you were doing.

Hendrie: Which wire you were dealing with.

Regitz: Correct.

Hendrie: Okay, so they didn't have wires, I mean, so it was a very straightforward scheme.

Regitz: Yes, you take a needle. Then they figured that it was, yes, and they were basically doing this to reduce the cost of putting the cores together rather than stringing cores that they figured this was cheaper.

Hendrie: Okay.

Regitz: Was it really? I really don't know but they picked the technology.

Hendrie: It was a homegrown technology, I'm sure they [inaudible].

Regitz: Bell Labs, yes, oh they sure did.

Hendrie: Exactly, okay. All right.

Regitz: So that was our job.

Hendrie: So, okay, so you worked on the sentan?

Regitz: Correct.

Hendrie: For this and built up – built memories, tested them.

Regitz: We built the sense amplifier, modeled it, designed it, put it together, built the prototypes and built the systems.

Hendrie: Okay.

Regitz: And then delivered those systems to the engineering prototype for the people that were putting the whole system together.

Hendrie: All right, so this job was doing design and building a working prototype. It wasn't necessarily Bell Labs didn't necessarily produce ten or 20 of these here.

Regitz: No, Western Electric was the manufacturing arm for AT&T at the time. Remember Bell Labs at that point was the engineering arm. Western Electric was the manufacturing arm and the job was not only to build but to build and put in production and I think that's one of the things that, you know, I've always stated that, you know, I got good schooling, book learning if you wish at DeVry Institute but the people there at Bell Labs were also very good. The discipline within the organization I think was extremely good and they taught me the engineering disciplines of how to collect data, how to analyze things, and how to put it together.

Hendrie: There we go. All right.

Regitz: But anyway Bell Labs I think I got my engineering disciplines, really understood the engineering disciplines.

Hendrie: Uh huh.

Regitz: And also they helped me or convinced me, if you wish, that I need to go to school and get my B.S. degree which I did at night so they were instrumental in being able to – the people I worked with to be able to do that. And, the other thing they gave you an opportunity, you know, to be an innovative technician. I mean it was really a good environment to work in and as a result I ended up getting a number of patents as a technician on the projects that I worked on at Bell Telephone Laboratories and did a number of good things throughout my life there.

Hendrie: So that, yeah, you working on the sensor and you came up with a circuit idea.

Regitz: Correct.

Hendrie: What to go do.

Regitz: Went over it with the engineers.

Hendrie: Went over it with the engineer. You'd go try it out.

Regitz: Right.

Hendrie: Bell Labs patents absolutely everything so.

Regitz: As a result we ended up with a – I ended up with a number of patents –

Hendrie: That's great.

Regitz: In sensor technology, inhibit drivers, and in regulators actually, in voltage regulators so it was – because of the memory area I was not a logic expert, right?

Hendrie: Okay.

Regitz: And I did a lot of linear work, if you wish. A sense amplifier is nothing but a big linear amplifier and the same as inhibit drivers that turned out because you had to be able to vary the amount of the current going into the modules and control it and you had to do that over temperature and, as a result, it needed voltage regulators to be able to regulate things inside there. So, I covered a very good parameter of circuits.

Hendrie: Yeah.

Regitz: As a circuit designer.

Hendrie: Exactly.

Regitz: As well as having good engineering discipline.

Hendrie: All right and while you were doing this they encouraged you to go to school.

Regitz: Right.

Hendrie: And you did that mostly at night?

Regitz: I did that at night.

Hendrie: Okay.

Regitz: During that time of my life. I was also married. I got married, oh, about two months before I graduated from DeVry Technical Institute and ended up having four children and a number of patents while I worked at – got my degree at night at Bell Telephone Laboratories.

Hendrie: How long did it take you to get your – where did you go to get your degree at night?

Regitz: I chose to go to a place called Monmouth College.

Hendrie: Monmouth?

Regitz: Monmouth College.

Hendrie: Oh yeah, okay.

Regitz: In West Long Branch, New Jersey. It was a college at the time and actually when I started there it wasn't even accredited as an engineering school but they were applying for their accreditation. The other place was Miller college of Engineering I think and it would have been a lot further from home and the second thing is, is that they didn't – would not have accepted as much credit out of my work from DeVry Institute.

Hendrie: Ah, so you would have had to go longer.

Regitz: Would have had to go longer, would have had to drive much further at a time doing that which would have taken away from my family. So, I chose to go to Monmouth College and they paid for all the activities and it turned out in my opinion not a bad choice. The school I think would have been maybe at the time better but the school did become accredited. I had very good instructors from Fort Monmouth and the timing of the classes I was taking I was able to put them to work almost instantaneously in work, you know in advanced math and circuit analysis and linear activities. So, it worked out extremely well for me from that standpoint. I never considered it, you know, a bad decision. I always thought certainly the degree was very helpful in the company.

Hendrie: Well, you were learning some of the theoretical things.

Regitz: Correct, I needed at the time to do the basic work I was doing.

Hendrie: Okay.

Regitz: And my goals, I've always been goal driven. I don't know. It must have been my mother that beat me into this but I've always been goal driven and my goals at that time really after working and going to school in DeVry for two years and then working for about seven years from '60 to '67 to get my degree in Monmouth College, I sure liked all of those engineers that came to work at Bell Labs and they were giving them a year off with pay to get their Master's degree.

Hendrie: Uh huh.

Regitz: Not a bad program.

Hendrie: That's not a bad program at all.

Regitz: Yeah, so one of my objectives was to be able to get, you know, into that program and certainly, you know, to be able to do that you needed to have a good reputation at work, do good work.

Hendrie: Uh huh.

Regitz: Which I had. I had some patents underneath my belt. The other goal you need to have at least an average greater than 3.5 which I did and so my objective was to get into that program and I applied for it and unfortunately I was turned down and not accepted into the program.

Hendrie: Oh, my goodness. Well, we need to stop the tape and we'll talk a little bit more about that when we get back.

Regitz: Okay.

Hendrie: I want to go through the story of with Bell Labs and the issue of going to get your Master's degree but you were mentioning when I was changing the tape about the difficulties that ferrite sheet.

Regitz: Yes.

Hendrie: Why it wasn't – why it didn't take over the world from this course.

Regitz: You know, what I remember you look at this a little bit differently as a technician versus a manager and you look back and remember certain things but I believe that it was not a cheap process to go through to make the the ferrite sheet to begin with compared to the little cores. I think what Western was trying to do was do more work in the United States than doing cores at that time was producing wired

overseas in cheap labor environments and I don't think Western wanted to do that. But, so they were looking for different ways of mass producing this activity but over time because the ferrite sheet you couldn't saturate the core. Like in cores you didn't have to do a lot of compensation of the currents used in the X and Y select currents and the inhibit currents. They worked exactly the same way as the core so you had to temperature compensate them and you had to carry them. So that gave you extra cost and, in addition to that, the readout circuitry was signals because you couldn't drive them as hard, therefore the signal that you were reading out was not as strong, therefore all of the circuitry I think was much more expensive than what it would be in a core memory.

Hendrie: All right.

Regitz: That's kind of what I remember as we put them together.

Hendrie: Yeah, there was a fundamental problem that there was a real tricky thing that you had to have enough drive to change some of the domains and that whole – but if you put in too much it would interfere.

Regitz: It would interfere.

Hendrie: And you'd start changing the ones that were near the next hole, so a real balancing act.

Regitz: Yes, right, so you signal to noise ratio that you're reading out became very sensitive from this standpoint.

Hendrie: And obviously you have to have all sorts of temperature compensation.

Regitz: Yeah.

Hendrie: To hold those drives exactly right no matter what.

Regitz: So, they were probably right on the trade off of stringing the cores together and making the core but then when you put the circuitry together I think that threw the balance in the other direction.

Hendrie: Okay.

Regitz: And no one else picked it up in the industry because the industry learned how to make cores and they became produced in a larger quantity than what the telephone industry was able to do.

Hendrie: Exactly and learned how to string them.

Regitz: And learned how to string them relatively cheaply and economically.

Hendrie: Okay, good. Now, at this time have you gotten your degree yet? Where are you?

Regitz: Yes. Because we are, you know, that's about where we're talking about.

Hendrie: Now how long did it take you to get your degree?

Regitz: I was in school from '61 through '67 in Monmouth.

Hendrie: Okay, so this is a –

Regitz: It was a seven year process.

Hendrie: Seven year process.

Regitz: Yeah, I was taking nine credits a semester.

Hendrie: Uh huh.

Regitz: I took summers off but so I was gaining at the rate of 18 credits a year to be able to do that.

Hendrie: All right, okay, good. Now what other – I wanted to just spend a little bit more time in this period of Bell Labs. What other things were you working on? You didn't work on this ferrite sheet? I mean that was just your first project.

Regitz: No, I worked at –

Hendrie: Or did you work on that for most of the seven years?

Regitz: No, I worked in memory most of the seven years that I was there. They had moved the division that I worked in from Murray Hill down to Homdell.

Hendrie: Okay.

Regitz: And they decided to move the division and the projects out to Illinois, Naperville, Illinois. I had only one year left to go in my schooling and so they left me behind one year to be able to complete that,

but so six years I worked on ferrite sheet stores, as I said started out working in the sense amplifying area and the last thing I did was a complete project of doing a ferrite sheet system store for – I forgot what system it was anymore but I had the whole system designed from the logic and everything put together to do the whole project.

Hendrie: Oh, all right, okay.

Regitz: And my job was also I put two or three systems in manufacturing at Western Electric during that same time frame and that's where I learned at least one of the things I was looking for was to be able to not only design something but I wanted my work to go to production. I liked the idea of doing something that goes into production.

Hendrie: Uh huh.

Regitz: I've seen a lot of people at Bell Labs. They hire a lot of people there and a lot of Ph.D.'s and working just purely in the research environment and not knowing that it's going to go anywhere never really interested me from that standpoint. I always like that satisfaction of production.

Hendrie: Okay.

Regitz: And that later I think affected how I worked from that standpoint. But the last year what they did there was this large system, that the product I designed the memory for going into was a military system and they had worked on this military system for many, many years and I must have had thousands of people for like six or seven years trying to put this telephone system together and the military decided they were going to deploy it and so what they left me behind to do was to do the training on that system.

Hendrie: Okay.

Regitz: Okay, and I worked about a year on that and just as I was getting ready to graduate and leave they cancelled the whole project.

Hendrie: Oh, my goodness.

Regitz: And what was this? This was a military –

Bill Regitz: It was a military communication system.

Hendrie: Okay.

Regitz: It was a four-wire part of the military telephone system and they were planning – I don't know how many systems in different areas at the telephone switching but it was a large telephone switching system installed to be in, you know, in a big plant, thousands of lines handling military calls. I think there was one going up in Alaska and along the whole eastern seaboard here.

Hendrie: Oh, my goodness.

Regitz: The military just decided –

Hendrie: Just completely separate.

Regitz: Yes, it was an updated system that probably prior to that time they were probably using step-by-step relay systems and this was the first electronic system that they were using.

Hendrie: Okay.

Regitz: Why they cancelled it I don't know but they cancelled it and all that work for many years down the tubes by a lot of people.

Hendrie: Oh, my goodness.

Regitz: It didn't make it to production.

Hendrie: Yeah.

Regitz: And that's about the same time that I got my degree and, you know, had applied to get into the graduate study program and learned that I was not accepted into the program.

Hendrie: Now, did they tell you why they wouldn't approve that or if you'd stayed longer would they have maybe –

Regitz: I never, you know, the things that I remember at that point in time whether they were the true reasons or not was not what I wanted to hear so I probably really wasn't too interested in understanding their reasons why.

Hendrie: Or exploring.

Regitz: Or exploring because I knew at Bell Labs if you came up through the line, which I did and got my associate member to technical staff, which was a step below the member of the technical staff, people that they came in at that level from college with a B.S. degree and I knew if you stayed there that you could be pigeon-holed in that position for a long period of time and never make member technical staff and that kind of says well I'm not going anywhere because they don't promote from AMTS people to supervisors or anywhere. I mean that's it. You know so I didn't want to hear that and that's not where I wanted to be and so, you know, whether it was the school I went to, which might have had something to do with it, you know. Monmouth College was not one of those schools that they hired from and seek people from. That's my thinking it was that. My reviews had all been good. I had been progressing faster than most people up through the ranks. I had a number of patents which most technicians don't get and I had worked on my own projects and, you know, they thought enough of me to let me behind to finish school so it looked like everything was in the right direction. So, it might have been the school I chose to prevent me from doing that but was it good or bad in my career, I don't know.

Hendrie: Sometimes these things are very fortunate.

Regitz: You know so it got me, it made me make a decision to leave Bell Labs.

Hendrie: Okay.

Regitz: That's what happened and then I decided that when I graduate that I'm going to go someplace else. I wasn't going to Naperville. If I'm going to move I'm going to move someplace different.

Hendrie: Okay.

Regitz: So, it forced me to get into that process of interviewing.

Hendrie: Okay, so what did you think about where you might want to move to?

Regitz: I had given a lot of thought to that.

Hendrie: Okay.

Regitz: I wanted to stay in memory and the people that – and I didn't want to be in an organization working for the military. I wanted to be commercial and my decision after looking out there was I wanted to go to work for IBM in their memory development activities.

Hendrie: Okay.

Regitz: So, I –

Hendrie: Now, where were those?

Regitz: That was up in upstate New York, Poughkeepsie.

Hendrie: Poughkeepsie, probably.

Regitz: Poughkeepsie.

Hendrie: Okay.

Regitz: And so going into this I decided well I'm going to interview a lot of companies and Monmouth College, like most colleges or universities, you know have their people come to campus and set interviews up and it was not a bad time for engineers coming out of college in '67.

Hendrie: Okay.

Regitz: And I had a lot of opportunities and I chose to interview a lot of people and I wanted to get well prepared for my interview at IBM.

Hendrie: I see so essentially some of these are practice interviews.

Regitz: Oh, yes they were practice interviews. No, Ford Motor Company, for example, was one.

Hendrie: Which?

Regitz: Ford Motor Company.

Hendrie: Okay.

Regitz: And they have a big plant in Metuchen, New Jersey and I wanted to see an assembly plant.

Hendrie: Uh huh.

Regitz: I was curious what goes in. I like manufacturing I guess so one of my interviews was there and I spent two days there interviewing and then I planned this big trip up the East Coast from Honeywell, 3C, who else was in there? Digital Equipment Corporation, anyway and on my way back my last stop was three days of interviewing at IBM.

Hendrie: Okay.

Regitz: That was my last interview and I figured that was enough to make up my mind where I was going to go.

Hendrie: Right.

Regitz: And I executed that plan.

Hendrie: Okay.

Regitz: And I got job offers from every place I wanted to, including IBM and I'm sitting there after going through those interviews. You do learn something, you know, you're supposed to at interviews, you know, learn – they're supposed to learn about you and you're supposed to learn about them and what goes on at their activities and after being at the IBM location and getting a job offer, even from the location I wanted to be in and the department I wanted to be in, I thought about it and I said, well, what am I going to be? Here I'm going to be another fellow with a B.S. degree working in the environment that has a lot of Ph.D.'s very similar environment like Bell Telephone Laboratories and I figured it's not really where I want to be.

Hendrie: Okay. You're still going to have this, yeah, problem.

Regitz: This problem that seemed like a problem to me at the time.

Hendrie: I understand.

Regitz: And I looked out there and I decided to go accept the position at Honeywell in the 3C organization.

Hendrie: Okay.

Regitz: One day we're working on computers. It was a memory job. All jobs were memory, working in memory.

Hendrie: Right.

Regitz: In every company I interview was in memory. I figured that was a good transition out of Bell Telephone Laboratories and I have something to bring to the environment and into the job and I chose to go to work for Royce Fletcher at Honeywell in the 3C division.

Hendrie: Did Digital Equipment not interest you?

Bill Regitz: I don't remember why I turned the job down at DEC. Honeywell interested me more, maybe because it was-- I don't remember why, maybe because they seemed at the time to be more in the computer business. DEC at that time was more in the module business. Although, as it turns out, as we both know, DEC and 3C started out in module business and built their selves into a-- built a computer business out of it. But there's no doubt at that time, Honeywell or-- not Honeywell-- well, Honeywell 3C Division, Computer Controlled Corporation, which was bought up by Honeywell, was the leader in that business. And they were the leader in the minicomputer business at the time. And I think that probably influenced maybe

Hendrie: Yes, they were bigger than DEC at the time

Bill Regitz: I think that influenced me to go-- to select that job over DEC. It seemed-- I don't know. I can't remember.

Hendrie: So you never really considered IBM? Was the work interesting that you'd be doing at IBM?

Regitz: Oh, the work definitely would've been interesting from that standpoint. But I don't know-- this interaction-- because I was probably frustrated with Bell Telephone Laboratories at the time, that they didn't accept me into the masters program, that I knew that I'd never had a desire to get my Ph.D. degree. I did have a desire to go on and get my masters degree. And that was one of my objectives and goals in life. But I knew that's as far as I wanted to go. And I just figured that this educational thing and this image that I had of what the people were doing and how they reacted and how they treated their employees-- because I knew at Bell Labs that as long as I was an associate member of technical staff, I'd go nowhere. But I'd made that transition. And somehow that put me-- that non-acceptance into that program at Bell Labs I think left a bitter taste in my mouth and I figured I-- decided I'm going to go try something different.

Hendrie: So it wasn't the work, it was you had this feeling that this could be too much like Bell Labs.

Regitz: Too much like Bell Labs.

Hendrie: _____ with the same prejudice against people and their education as opposed to what we all know is what really matters, is _____ after you've been at work for a while. It's what you do.

Regitz: Correct. What you do. But definitely I think that was one of the-- at Bell Labs that did matter. At least I perceived that it mattered. And I was not going to let that interfere with me at IBM. Now whether it did at IBM or not, I really don't know, because I didn't work there, but that definitely was my thoughts at the time I took that position.

Hendrie: So you move up to Boston, pick up the family.

Regitz: Moved the family. Bought a house down in a town called Franklin about a half hour south of Framingham, where we worked, and it was a tough year for me actually. I just had a child. My fourth child was born in '67. I had a job that paid $1000 a month, and I bought a new car, bought a new house, and made a movement. And financially, that first year was really tough in Boston. That was one of the-- my first time I really, really had a tough year financially. Lots of change.

Hendrie: Lots of expenses.

Regitz: Yes. I didn't understand the taxes. The heating bills were more than what I thought it was going to be. The taxes were more than the banks told me they were going to be. And in actual fact, balancing payments going out the door of more bills than what I had income. We couldn't deal with it. That's hard. That was really hard.

Hendrie: And your wife has just had a child.

Regitz: Right. And there was three others that was going along with that.

Hendrie: So we get to 3C, Honeywell, and so Royce Fletcher hired you. What do you do first?

Regitz: Rebel. That's interesting. Royce was an interesting guy. He did a lot of traveling. His business at that time was in building custom memory modules, some kind of OEMing memory systems. And when I came on board, he kept giving me these jobs of looking into this and looking into that and writing this up and writing that up and research over here and there. Read this, read that, and I wasn't too pleased with that assignment. I wanted to get into building it, design and build something. I said rebelled a little bit. He had, you worked at 3C as well, but one of the things that you did there, you had to fill out a timecard, at least we did anyway, I don't know whether you did. But we had to fill out a timecard of knowing what projects we worked on because they tracked the projects, especially in the custom memory area, because we're trying to see whether we were making money on them. And one thing he did not want me to do was put money on overhead. So I came back-- he came back, and I didn't have enough work to do. I was just bored sitting around doing nothing. And so I charged my time, most of the time that week, to his overhead account and turned in the time. And he came back, and he-- I knew I was going to get yelled at because I knew I wasn't supposed to do that, but I had nothing to do. Well, being an honest guy, I put down what I wanted to do. And I was testing the system anyway. And he came back and we had a discussion. And after that, that became no longer a problem. He's finally-- he began to assign me some reasonable projects to work on. But that was interesting. I said I rebelled a little bit. I worked on a whole bunch of very interesting products. One of them, I worked on the sense amplifier and finally finished off a drum memory that I don't remember what the system was in. But I put a drum memory into a production and designed a sense amplifier for the drum memory. And I think I got a patent or two out of that activity. Another job that I got..

Hendrie: Do you know whether the drum memory was for a 3C computer or for some special purpose?

Regitz: I don't remember, but it was a drum memory, big drum sitting there, and trying to get this data off the drum. And it had a lot of-- the circuitry was very similar, and the stuff I had done-- the work I had done at Bell Telephone Laboratories in sense amplifiers helped quite a bit in putting it together. It worked quite well. It was not a very large project. Because we were in that kind of a custom contract area, I don't remember whether it was a project for a customer or whether it was something that we were doing for a standard product at 3C or Honeywell even. And then another project, the last core memory design, and the only one I came close to completing was, I did all of the initial design work for the 319 minicomputer. I think it was the 319 minicomputer.

Hendrie: 316.

Regitz: 316 minicomputer. I think a fellow named Dave House was the project manager on the 316. and they were looking for a-- to reduce the cost. And they were looking for a low-cost memory solution. And kind of what I came up with was-- and they had all these pluggable modules. And I think the module that was going into that was like 2-inch by 3-inch cards. And they were stacked up in a connector stack of something like 3 high and maybe 8 or 9 wide if I can remember correctly. And what we wanted to do was use that hardware, rather than special hardware, and the same size modules to make the sense amps and the inhibit drivers and all the control circuitry that went into it, including the stack. So he came up with this idea of taking a 4K by 8 memory module and laying it out, stringing the cords together, and then folding it up into a folded stack and plugging it into the module. That made the module, the memory, pluggable, and also expandable in that activity. And I took..

Hendrie: So taking what would have been a core plane.

Regitz: a core plane, right.

Hendrie: But instead of just having it out flat..

Regitz: It would be folded up.

Hendrie: It would be folded up.

Regitz: Yes, into like a big W.

Hendrie: So multiple, actually 4.

Regitz: Yes, 4 folds, yes.

Hendrie: So there'd be 4 pieces of it, logically.

Regitz: Correct.

Hendrie: But physically it was all folded up like a W.

Regitz: Yeah, and when they were-- obviously, when you were stringing the stack, you want it to be laid out in one big location so that the needles could go straight through the stack and be able to accommodate that. And then you needed to be able to fold the wires together to be able to accommodate that and make the hinges if you wish around the module. So it was an interesting activity. And I got the stack up and designed into the module. I never did get time to complete that project. Another friend of mine at Honeywell, Hank Bodio, finished the project off, from the standpoint. I was transferred to a different project.

Hendrie: You did the design work on that, and then were these just conventional sense amps and drivers? Or did you need to do design work on the electronics going around this?

Regitz: I think the electronics that we used around that was modules that-- or components anyway, that was mostly in-- being used at Honeywell at the time in other memories. I don't remember..

Hendrie: You don't remember any significant technical problems related to the design of the circuitry.

Regitz: No, most of the technical problems there was in-- with putting the stack together. Because that was the biggest issue there, was bringing it down and then figuring how to make the cost. We may have used-- made all new modules for that memory, which I think we did. But I think it used all present-- it didn't expand on the technology. It used existing technology at the time because our job was cost..

Hendrie: re-layed out circuits you already know and understood.

Regitz: Yeah. It's all cost reduction designs that went into it. Now I, as I said, I did all of the proposals, put it all together, had it all approved, and had the stack designed. And the circuit modules were coming together when I was asked to do a different project.

Hendrie: you were working for Royce at this time.

Regitz: I'm pretty sure I was. I'm sure that was for Royce, yeah. I only had 2 bosses at Honeywell, and that was Royce Fletcher and Bill Jordan.

Hendrie: How much time has gone by since you arrived at..

Regitz: About a year I think. I was at Honeywell about 3 and a half years. And I think that was about a year.

Hendrie: You'd done some of these custom products and this was the last one you did.

Regitz: Yeah, that was the last one.

Hendrie: What did you get moved off this to do?

Regitz: Well, at that time, a fellow named Bill Jordan, which I knew but didn't really know him. I hadn't spent a lot of time talking to him. He was in the group. And-- or associated. He was in the same building anyway. And he was in the same-- I guess we both had the same boss' boss. I guess that's what it was. So yes, we were in the group or the division.

Hendrie: Who was that?

Regitz: I don't remember who that was. Burge Jamison, Rechert, both of them, but I can't remember who was over the division at the time. Doesn't matter. But-- so we had this big department meeting. Come hear what's going on. and there was rumors about reorganizations and stuff that was going on. and so we were sitting there-- I was sitting there looking at the-- listening to the presentation. And he said, we're forming this new semiconductor memory group. It's going to be headed up by Bill Jordan, and we're going to put Bill Regitz into the group. It'd be a group of 2.

Hendrie: And nobody had talked to you about this.

Regitz: No one talked to me about that. I looked back at Jordan, and he was sitting behind me. And I looked back at Bill, and he looked at me because I knew him. And he looked at me, and he said, well, I don't know. I didn't hear about it either. I was news to him, too. So that's the way you make-- I learned there's good ways to make organization changes. So anyway, that was the project. And I had to wrap up. And they decided to have Hank Bodio complete the project that I was working on and then move over working for Bill. And that was the start of semiconductor memories. There was no significant energy prior to that going on. Evidently Bill had been campaigning for a while for Honeywell to be-- put money into semiconductor memories. He believed that it was going to be the future. And he wanted to participate in the development of it. He must've generated some proposal some place or had some discussions or something. I don't know. But..

Hendrie: to get a semiconductor memory program going in the memory group.

Regitz: Correct. In the memory group. And so there was the 2 of us. And he and I got together, and we were talking about, well, what are we going to do? And he was telling me he wants to work on-- our job is to study how bipolar and MOS devices and come back and do some proposals. And so we're sitting there, and there was 2 things to do. There was MOS and there was bipolar and he had done a lot of work in bipolar at that time, evidently in drivers and-- x and y drivers for the core memories. He had helped work on integrated circuits both in the industry and put some standard activities in place. He had some very strong feelings about standardization verse to customization. He wanted standards, not

custom. And.. we don't want to end up with a custom chip. I think Honeywell at that time, there was a lot of custom designs going on in other divisions of Honeywell. And the stuff that 3C was doing was wanted to be more in the area of standard designs. They wanted to lead the industry, drive standardization, but select standard circuits versus a whole bunch of custom circuits.

Hendrie: I've had a chance to interview Bill, and that's exactly right. He had an experience with trying to do a custom driver for core memories- integrated driver. And it was very hard to get anybody to be interested because he didn't have enough volume. And so he then came up with an even better one, a new improved one, and he'd learned a lesson. And he went and cut deals that here's the product, it is your property. You don't have to pay us any license fee. All we want to do is get past all the early production so we can announce a product that has this in it at a lower price.

Regitz: Right. That was what-- that was his theory, but it seemed like it was coming from him at the time. And he believed that we could get a leading edge advantage on the technology by developing it, and in the long run, get the cost associated with it, of the higher volume lower cost. In the integrated circuit, the higher the volume, the lower it costs. That's just the way it is. So that was one of the things that he was driving for within the programs. And so as we looked at both those programs with that kind of a background and some of the things that we're trying to accomplish, which I had bought into, we decided that he was going to concentrate on bipolar and I was going to concentrate on MOS. So that's how-- the way we divided up the workload. And from there..

Hendrie: After you decide who's going which direction, what did you do first?

Regitz: Well, research. Started reading articles on MOS design. I'd never worked at MOS to integrated. I'd never did integrated circuit design, never worked in MOS. Everything I was doing was bipolar, so it was all new to me. So when-- did research on what was going on in the industry, reading papers.

Hendrie: When did this sort of start?

Regitz: Well, I went to work for Honeywell in '67, so my guess is about '68.

Hendrie: Worked in the fall of '67, or do you remember?

Regitz: No, I started there Thanksgiving of '67. this was '68, late '68. it was late '68. and at that time, there was semiconductor memories. I had used a number of semiconductor memories in some products that I had designed and worked on. The first one was at Bell Labs. And I was looking at them at Honeywell but didn't use any because we were all in core memory design at the time. But I was reading some articles on them. But the job was just to look to see how to make memory and to come up with a low cost solution, something that would be cost competitive to core, so our objective was..

Hendrie: Now these were all bipolar memories, these early ones that were available?

Regitz: Yes, that were available at that time. There was no MOS available at all at this timeframe. It was just coming into its own at that point in time. At least that's my memory from that standpoint.

Hendrie: So you're doing some research, reading papers.

Regitz: Reading papers, putting them together, learning how MOS transistors work, how they would store energy and learn how to make flip-flop memories, all on paper, just reading and working through the different configurations. I needed some form of a circuit analysis program. And there was something that was-- Defalco, John Defalco. I don't know if you remember a John Defalco. I think that was his name. I think he worked in another area up there. And there was a semiconductor group inside 3C's..

Hendrie: Yes, _____.

Regitz: Yeah, I think Defalco may have worked in that area. Or he may have worked someplace else. But I think it was some programs around there that started out that was very simply looking at MOS design and stuff. And I needed something that I could simulate to do some simulation work. We'd built some models in the lab, but just take them to work with the MOS to see how they worked and everything. So-- but then I worked on beginning to build a circuit simulation program to be able to analyze it. There wasn't anything available at the time in the industry that I could buy, that I could run on the computers. So those are the kind of things that we began doing. Also began looking at all of the new companies that was being start-- that was started up to find out who was doing what and what they were doing, companies like Advanced Micro Devices, Intel, Fairchild, Motorola, AMS. There was quite a few that was in the memory business. So we were reading and meeting with those people as well. Bill knew quite a bit of people in those arenas at that time, and he had some good knowledge about the semiconductor industry because he had worked with them on other circuits at the time. So we used that and then used the purchasing department to help put the things together. So exactly how it occurred I don't remember, but-- all of the details, but eventually, I ended up putting together a proposal for Honeywell to fund the development of a 512-bit memory-- MOS memory device. And by that time, we had worked up a design-- a system design, what it would look like, and we used a 316 computer, which was just going into production around that time using core memory. But we were using that memory and those modules and that format. I was very familiar with that, but used that as the basis to develop a semi-conductor memory version of that same system. So I'd done all the paperwork associated with pulling that together and then worked down to what the integrated circuit would look like and putting a proposal together to be able to take out to management to get approved and get funded. And we kind of proposed a program that would get 8 or 9 different companies doing a test chip, and then off of that select the right company to go into production with. And our thinking was similar to what we talked about earlier. We were not looking for a custom chip. We wanted a standard chip, built by 2 or 3 different companies, and we would give them the license to go build it and produce it. and what we wanted was some number of chips off the production line early so that we would have a head start getting down the learning curve and doing it.

Hendrie: This particular proposal for 512-bit chip, you had done proposed circuit design for the chip?

Regitz: Yes, we had a proposed circuit design for the chip.

Hendrie: Had you analyzed it with this?

Regitz: Yes. We did put together a simulation program.

Hendrie: How did you do that?

Regitz: Computer simulation. I wrote the computer simulation program and ran it on the computers on punch cards.

Hendrie: Was it on computers that were around at the..

Regitz: Yeah, it was Honeywell computers. I don't know if they were 3C or Honeywell at the time, but they were probably Honeywell computers that we were using and whatever is in the computer center to run the simulation programs. And they would run hours.

Hendrie: And then you figured out all the details of gate width and _____ thicknesses and all <inaudible>.

Regitz: Well, we were using-- no, we were using a program. The basis at that time, Honeywell was also developing some MOS circuits designs, and we chose also to work with Honeywell. I guess they have-- they had a _____ group, and there was-- did they-- was he the same one that had the facility in Minneapolis?

Hendrie: _____ had a facility in Framingham.

Regitz: In Framingham, right. But there also was another facility.

Hendrie: I think there probably was another facility in Minneapolis.

Regitz: In Minneapolis. Most of the work that I did was in Minneapolis because I spent many months in Minneapolis help putting together with-- who was the fellow? I don't know. I can't remember his name at the moment that ran that facility out there. He and I got to know each other very well during this same timeframe. So we were using his model of the MOS circuit that he had. And I integrated the model for-- whatever models we had into the circuit program and matched <inaudible>.

Hendrie: So he had transistor models.

Regitz: He had transistor models.

Hendrie: and then you would take those transistor models and put them into your _____.

Regitz: Plus the books-- yes, plus the books that was available at the time about the transistor model. I was looking at it from that perspective more theoretical in what was coming out of the lab than with knowledge of taking the parameters of the process itself and integrating directly _____. So we eventually did that, but it was-- became a very basic program and then kept getting more and more complicated as we kept adding more and more parasites and all of the complete model _____, the _____ and the capacitances and all of that. And so it was an interesting process, but it did lead us to-- did lead me to be able to convince quite a few people to be able to make the-- to take on this chip.

Hendrie: do you have a copy of that? Do you know whether in any of those things that you've saved you have a copy of that proposal?

Regitz: I believe I have a copy of that proposal or some of the works. I know I have some trip reports and stuff that I'd put together at the time it was there. I did save a couple of that-- some of that information has gone through life.

Hendrie: You made this proposal, 512, and this was a dynamic?

Regitz: It was a dynamic cell, meaning that it needed to be refreshed from time to time because in-- MOS is not like a core where once you _____ into the activity, the core would stay there forever. But in the case of MOS, because of the resistance that's across the capacitor, it would leak off over time. And periodically, you had to refresh your data. And the course that became a big controversy between core and semi-conductor. And of course once you lost power in semi-conductor, you also completely lose-- not only do you have to refresh it from time to time, which people talked about, oh, like is that going to be a problem and create me some access issues into the memory, etc, etc. but it also-- power went off, it'd lose everything that was in memory. Right? So not like _____. System point of view, you had to worry about that. So it gave you different design parameters.

Hendrie: We're talking about that you'd done these simulations and you'd worked with Honeywell up in Minneapolis to learn more details about the MOS processes. Had they built any before you submitted this proposal? Had any test cells been built? Or did you have anything physically to work on? or was this really all theoretical design which was tested with some simulation?

Regitz: This is all theoretical design tested with some simulation. Yeah. That the cell seemed to work, and supported by whatever work was going on in the industry at the time. And-- but the process at this point in time was to build a test chip and then go on and build the-- test the reliability, test the concept out, and then build the memory itself.

Hendrie: And when you said build a test chip, were you thinking that the first step would be to build just a really little test circuit that just had 1 or 2 of the memory cells? Or did you mean to build a test chip so you could have a fully loaded sense line and all the 512 _____?

Regitz: It was a test chip, if I can remember correctly, and then move into the-- but a simulated version of the test chip. And we were depending upon-- because we wanted to test some reliability activities about it as well as a result of that. And as we went to the different companies, what we wanted them to do was put their own reliability models that they were using to test their process out onto the chip itself. And then that would allow us to take and-- Tony Nezuti's name comes to mind, but I think he was the QA person that worked on the project. And he was assigned on the other end to work and put together the reliability studies that we would need to show that this would be a reliable process. So it was a test chip and not fully implemented it at all. And the second phase of it after getting through that then was to select the companies that was going to build the chip itself.

Hendrie: So you just built elements of the chip, the things you needed to do to test reliability and just understand how well it was going to work.

Regitz: Correct, to test reliability.

Hendrie: At this time, were there other examples of dynamic cells? Had you seen other dynamic cells? Or do you remember?

Regitz: No, don't remember seeing it. there was nothing physically available in the market at the time. This is definitely leading edge development technology.

Hendrie: Had they written anything about it?

Regitz: There was articles that was being published. And the question is who. And I hadn't looked those up in a long, long time. But GI comes to mind as one person that was doing some work in that arena. And I think there was shift registers that was being done out of memory at the time as well.

Hendrie: Okay, with dynamic nodes.

Regitz: With dynamic nodes no, that's right.

Hendrie: <inaudible>. Data was stored on the gate _____.

Regitz: Right. And data was stored on the gate to accommodate that. That's correct. And there was probably work being done on it in bipolar, obviously of static memory at the time. But MOS, I don't think there was very many MOS circuits that was out at all at the time. And there was MOS individual devices that was out there. But I don't remember very many integrated circuits that was out at the time. They were just coming into their own.

Hendrie: Where did you get the idea to do the 3 transistor cell?

Regitz: I think I was going through permutations of what you could do at the time. And there was some articles out there talking about doing it with 3 or 4 transistors and data being stored. So I don't think it was-- it wasn't that far off the wall that I can remember at the time. And the particular cell that we had come up with, we had analyzed a couple of different options, and we had chosen the particular cell which was a 2X1Y. I think it was 2 lines in one direction and 1 in the other that went into the 3 transistor cell to come up with it. and we chose that one because we thought, in looking at preliminary layouts, that it would yield to the smallest cell at the time. And it was smaller than the standard, if you wish, 4-wire configurations, 2 in the vertical and 2 in the horizontal lines, that went through to make the cell.

Hendrie: Four wire, four transistor configurations? Or is this_____?

Regitz: No, it's still 3 transistors. And so as we worked with the people in Minneapolis, we thought we could yield up with a smaller cell out of this completely configuration. But it had a disadvantage of requiring that the drive line, which was combined-- the read and write lines were combined. And to be able to do that, you had to have what we called an intermediate voltage generation. You had to generate a signal that was somewhere between on and off, about halfway-- about half value to read it out and then full value to write information back into the cell because once you read it out, it was a destructive read, you lost the data.

Hendrie: Fundamentally, you're multiplexing 1 of the logical lines to do a new job.

Regitz: That's correct. Yeah. We were combining the read and write lines in together into the cell.

Hendrie: So you did look at a bunch of different cell configurations and the layout _____.

Regitz: And tried to-- laid out-- lay out the cells. And so we did a fair amount of work in looking at the designs and the layouts to-- we-- I guess it was I and probably worked with the people in Minnesota to understand the layout rules, and with whatever facility and work I could get from people that I could sponge off of people in Framingham to learn how to do layouts because they were all new to me. I'd never laid out a transistor before.

Hendrie: so it was a combination of people that understood something about the semiconductor.

Regitz: Yes.

Hendrie: Layout process and the physical design _____.

Regitz: Yeah, and Bill had some knowledge in that area as well.

Hendrie: Do you remember who you worked with up in Minneapolis at this juncture?

Regitz: Ollie. Just came to me. And I couldn't remember the Andreko, but I couldn't remember Ollie just a little bit ago. But Ollie Andreko yeah. Now he was..

Hendrie: I'm thinking Ollie Andreko worked in Framingham, didn't he?

Regitz: Maybe he worked in Framingham and moved to Minneapolis. Don't remember. But definitely worked-- I worked a lot with Ollie.

Hendrie: He taught you about..

Regitz: Yeah, he did.

Hendrie: Semiconductors, about MOS.

Regitz: MOS and MOS processes.

Hendrie: And you knew circuit design.

Regitz: Right. You're right. From that standpoint, I knew circuit design. I felt very comfortable configuring things on paper, configuring things in the lab, combinations of things. The new here was learn how an MOS worked and then too, learn about layout rules in how you lay it out and how that would impact the cost because we all knew that we needed to get this down to a very small amount of silicon. If the chip got too big, the yields were too bad. If it got too small, the yields were-- your costs were too high. So we were trying to hit that window of opportunity there.

Hendrie: You did all this preliminary work and then you put this proposal together. What happened?

Regitz: Well, took it first internally to get it ratified. And asked _____..

Hendrie: _____ Bill Jordan about it.

Regitz: Well, yes, and then-- but I worked with him all the time. I think our relationship there, he left me alone in MOS and I did all of that technical work. And he did all the technical work he was doing in bipolar. But his knowledge of how the system worked at Honeywell and what proposals you needed and who you needed to talk to and those kinds of things, that he was very knowledgeable about that. And that's where we worked together quite a bit on that, putting the proposals together, getting them out, getting people to approve them. And he had-- as I said, he also had a fair amount of knowledge about purchasing and working with purchasing and what they wanted to be able to do that.

Hendrie: He had that experience on previous chips.

Regitz: He had that experience-- correct. We took that. And then after we got it approved, we already had selected I think at that time the companies that we wanted to work with. Then the next job was to go to purchasing and get it sent-- get the proposal sent out to customers-- I'm sorry, to suppliers, and then obviously go meet those suppliers and help them convinced that they needed to do this work and that we were funding them a small amount of money but nowhere near the amount that it was going to cost them to do it. so this was a joint development program between us and the suppliers.

Hendrie: Do you remember some of the reactions from different ones?

Regitz: No, actually, I think Honeywell at that time had a very good-- especially 3C had a very good reputation in the industry of working with suppliers. And the-- our message that we had developed, which was, hey, this is a joint program, and that you get to sell this thing. This is-- we do not want this just to be a product just for Honeywell. No royalties. We just wanted some early production. And that we were going to go to multiple suppliers. At that time, it was not unusual to get 3 or 4 different people to make the same product. Everybody required second sources. We were just talking about developing all at once and trying to bring on all these suppliers at the same time to go out and attack this big industry, which was memory. And there's not doubt at that point in time, one of the-- the usage of semiconductors was into the memory arena. The could-- we could see that the standardization and the large quantity of parts and everything else went to it, and Honeywell-- at this time 3C was a large usage of memory. And they were probably the largest single minicomputer supplier in the world at the time. And then that, coupled with all of Honeywell's business and the larger mainframe business, was a good force-- it was a good company to work for at the time.

Hendrie: You said GI had done some work. Were they interested in this?

Regitz: They were interested, but I'd have to go back and look. I don't remember working a great deal with them. I think we did a little bit of work in the beginning, but for whatever reason, they decided not to go on. The companies that I think that we put a lot of energy with was Motorola, Fairchild, Intel, AMS, Honeywell in Minneapolis. They wanted to be a supplier in this. They wanted to bring their-- do it. I-- there might have been a couple more.

Hendrie: Texas Instruments, were they in this or not?

Regitz: No. they may have done something in the beginning, but they were very big on bipolar not very big in MOS at the time. And I didn't work a lot with TI. Whether they did it in the beginning, they definitely was not in the initial people who did the design of the chip after we get through the test chip. They didn't participate. They weren't that interested in doing it.

Hendrie: of these people that you said you actually did spend some time working with them, which ones got as far as doing the test chip?

Regitz: I think all those that I mentioned did the test chip.

Hendrie: So they all had some serious interest in it?

Regitz: Yes, because to have-- to be able to do this, as I said, they had to put this test chip together. And that was going to be more money that what-- I think we were giving each person $20,000 or something like that. So it was not a lot of money, but a fair amount of money to show that we were interested in doing it and what we wanted to do. And then the-- we would test-- then we would do our testing and come back. And then-- but it was a-- really a partnership because without some company to be able to test the concept together and put the modules together and be committed to build a memory module-- semiconductor people did not have that expertise at all to be able to do that, no system expertise at all.

Hendrie: So you were in an interesting opportunity for them?

Regitz: Yes, we offered a lot into the-- we offered-- I think from Honeywell besides the money and the volume, the technical expertise that Honeywell had and our own expertise, what we brought to the table of being able to design and put the systems together, and committed to do that. And that was our commitment in the program, in the joint development.

Hendrie: Do you have any idea what timeframe we're in now? Are we into '69?

Regitz: Probably '69 by now.

Hendrie: Because it took a little while to do all this design work.

Regitz: Correct. And as the semiconductor companies were doing their work, we were building our test boards to burn the units in and then also begin to put together the system proposal to go around to build the chip itself, finishing off the design of the remaining stuff that we need to do there as well.

Hendrie: Tell me about the next step. Presumably, people start delivering their test vehicles.

Regitz: The people developed their test chips. And I can't remember who all delivered them, to be honest about it. But we delivered them, and we did our test, our reliability test. That was mostly what we did with them was reliability testing, did some testing in the lab on some of the chips to see what they looked like and how the cells worked. And in the meanwhile, we were putting together this proposal to build a 512-bit chip, and what the pinouts would be and what the signals would be and the specification of this thing that-- we dubbed it Intel the F30. that was a technical-- the technical description of the F30.

Hendrie: What's the 512?

Regitz: I can't remember whether it was 512. It was 512 when we went out and then later updated to 1024. but I don't know whether we used 2 different numbers or just updated or revised the… Eventually, it was the F30.

Hendrie: At Intel, it was the F30

Regitz: No, at Honeywell was the-- Honeywell-- at Honeywell, it was called the F30. That's the-- Honeywell's definition of it. and the documentation and stuff that went through it, the technical specification.

Hendrie: So you had gotten some of the test chips back before you made this proposal that you were talking about.

Regitz: No, no. we had-- the proposal at Honeywell was an overall proposal that started with a test chip. We were doing it in phases. The test chip was phase 1, then phase 2, and then phase 3.

Hendrie: And then the second proposal was the detailed specs for the F30.

Regitz: That's correct. Correct. After we did some more technical work, and also to prove out what was going on.

Hendrie: Of the people that delivered, who did you decide you wanted to work with?

Regitz: Well, we wanted-- we ended up with the-- Motorola, Fairchild, Intel, and I think AMS. I think so. I have to go back and read one of my F30 troop reports to find out who I visited, but for sure Motorola, Fairchild, and Intel, and I think AMS, were the people that was in the running at the time in building chips.

Hendrie: So what did you do next? What happened next?

Regitz: Well, we decided on what the printout was and what we wanted to do. And during that process, we had in mind that we wanted to make a 512-bit chip. And during that activity and going out and talking to-- and mostly Intel was the dividing-- was the driving factor here. They convinced us that we needed to upgrade it from 512 to 1024-bit chip. And..

Hendrie: What was their logic?

Regitz: We weren't quite big enough in die size to get the cost low enough. Okay. So the die size if you get it, as I said earlier, if you get it too large, your yield at-- at that time, they were 2-inch wafers I think. You just didn't get enough of the die off. The yields were too poor. If you got them too small, then the costs were too high. So we were trying to push that a little bit harder. And so looking at their data, and

they came back and said, this is what we'd like to do. Everything's fine. We just want to do a 1024 instead of a 512. and so we said, okay. Let's-- we'll switch ours over to a 1024.

Hendrie: and so you switched everybody over to a 1024?

Regitz: Yeah. We didn't have any real complaints from anybody about that. So it definitely was the right thing to do at the time.

Hendrie: Honeywell is out of the running to do this.

Regitz: No, Honeywell-- no, Honeywell continues-- and they build chips, too. Whether they-- I don't remember whether they worked or not anymore to tell you the truth. But no, Honeywell just followed right on into the-- they followed right along.

Hendrie: So now you've switched it to 1024, and all of these people are working to build chips?

Regitz: That's correct. We had firmed up what the spec would be, went over that with everybody, made the modifications to the specification. So our role in this was controlling what we called the F30 specification. We had all of the design activity, modules and everything, pretty well sketched out of what we wanted to do, at least from an architectural standpoint. And as we brought on some additional people at Honeywell to help do this. We brought on a fellow named Hank Bodio, which we talked about earlier, that picked up my 316 module design. He came over. And-- to do the-- to complete the system design. And so I took the interface. He did all the system work. And I kept the interface with the semiconductor suppliers and done the-- whatever chip design was going on and get the specs up to date and then kicked off the suppliers to be able to go do this and gave them some additional money spread out over time to deliver the activities with Honeywell's commitment to build a system and test a system as a test platform. And we proceeded to go on with that til about 1970.

Hendrie: Who delivered working chips first?

Regitz: Intel and Motorola I believe. Intel for sure. And I think Motorola did. And then I think Fairchild did. And I'm pretty sure Honeywell did, but I don't remember when.

Hendrie: By this time, you're working on the system design and PC boards that you can put the chips in.

Regitz: Correct. We had that system up and running ready to take the chips at the time that Intel had the first chips out. And as they tested some good ones, or semi-good ones, whatever you want to call them, that worked fine, they passed them over to us. We populated the system and began running them in the 316 computer. We had the computer set up in the lab. Hank did all of that and did the-- and was ready to do the testing version of it, with the logic added in to do the refresh and test it out.

Hendrie: Do you have any idea when you fired it up, got it going, with the first chips?

Regitz: Well, we gave the IEEE paper in '71, so-- and that was in February. The solid state circuit conference is in February. So-- and we needed to have that system up and running before anybody would allow us to do a paper anywhere. So that had to come together the end of '70 at the time that this was occurring, that we actually passed data and remembered things and ran a computer program and ran those memory test programs. We ran those memory test programs over and over again day and night in the lab.

Hendrie: To see whether there were any failures.

Regitz: Yes.

Hendrie: And you didn't find the alpha particle problem?

Regitz: No.

Hendrie: <inaudible>

Regitz: <inaudible>. Well, he found some problems, mind you, but not what-- not the classics that we later debugged in time, as the process varied, etc.

Hendrie: Did you populate different boards with different people's chips so you could try to <inaudible>?

Regitz: at-- when they first came out, Intel was ahead of everybody. Intel delivered first, yeah. And then later, Fairchild and I think Motorola delivered chips into the program. And by-- I think that was also after I left Honeywell and went to work for Intel.

Hendrie: So some of that occurred..

Regitz: After I left. Right. And Hank continued on doing everything. We had added a couple of more engineers, 2 or 3 more engineers, into the program. So we probably had 5 or 6 engineers working on the program at the time when I left Honeywell.

Hendrie: But the effort had moved from specifiying this chip to doing systems work and building the system.

Regitz: Well, the whole objective all the time was to build-- was deliver a system. Okay. And we needed to get people to design the system into computers because we were a memory group. And the memory

group all by themselves, we had to find a customer on the computer side to be able to do that. And the 316 was one that we selected. And the people that were designing the core memories were doing their cost reductions faster than what we could do our cost reductions. We had worked over the issues of power and some of those others. There always were concerned and timeframe, well, lose power, you're going to lose everything that's in memory. And the second one was this refresh issue. The refresh issue never really became a big deal. We figured out how to get around that with the right priority into it because you had to do the refresh at the time it was there. So that never turned out to be a real big thing, that the power and the memory was I think a-- it was a so-so problem, large in the scale of what people-- what I can remember people talked about and was hesitant to do it. But the real big issue was cost. Okay? No one wanted to pay any more money for it. And so as-- and at that time, as the core industry was going through its own changes, they could also see that they're going to have this big infrastructure out there. And the kept figuring out how to make core planes cheaper and cheaper and cheaper. And the work that we did on the 316 memory is low cost memory. Dana Moore and company, who was working on the memory side of it, kept figuring out how to do things with integrated circuits that kept bringing down the cost. If the cost kept coming down and we kept figuring out how to get more and more cost out of it, and-- but we just couldn't-- we could forecast lower cost in the long run. But you had to start somewhere. You couldn't deliver them at that point in time. And cost was always in the industry-- was a problem within the industry even when I was at Intel. So it-- we had to find some usages of it that needed something other than just cost to be able to get into some of the systems. And eventually, there was some. And eventually, some systems, they'd go into production, but I was at Intel long before that occurred. Beudio and company were the ones that drove that at Honeywell.

Hendrie: The 316 that you got working and started putting in memory tests and reliability before the solid state circuit conference paper was probably Intel chips to the best of your knowledge.

Regitz: Yes, yeah, it was Intel chips. I don't think there's any other in that box.

Hendrie: But Intel.

Regitz: Could've been. I just don't remember.

Hendrie: So now you've got a successful program; you've got some chips. Who authored this paper for the solid-state circuit conference?

Regitz: Joel Karp and myself put the paper together, and I worked very closely with Intel during this process, closer than with the other companies. A fellow named Bill Latin [ph?] and Bill Richardson at Motorola, they were the other two members that I worked fairly closely with. I can't remember who was at Fairchild, and I can't remember who I worked with, I think, at AMS, but Joel – I spent more time at Intel – we were much more involved together and working than what I was with the other two, although I had to keep all of this information that I had tactically how all the chips worked together from each other, and I didn't share anything across the board. The only thing that we had common was the pinout and the activity. All three were working on the same cell structure, so the designs were all similar - the design was all implemented, was all the same. Unbeknownst by me at the time at Intel, in addition to the effort that Karp, who was the designer, who was doing the technical work and putting the 1102 together –

Hendrie: That was their F30?

Regitz: That was their F30 – the 1102 was their F30. There was another program going on at Intel, and it was headed up by a fellow named John Reid, and they were working on 1103, which was another three transistor cell approach, The MOS was a 1K pin-compatible part to the 1102 or F30, but it had a 2X-2Y solution. Intel didn't like – they didn't think – not that they didn't think, they didn't have as much confidence in the intermediate voltage generator on the MOS design, trying to do that and control it over the processes – they thought that was going to be a problem, so they wanted a way out. They wanted to get in. They were very interested in getting into the MOS memory business, and they seen this as their opportunity, working with the customer. Because again, they didn't have the system expertise –

Hendrie: But they could build the part but –

Regitz: Then they had to go find a customer to use it, where here the customer was coming to them telling them what they wanted, so they worked all the system issues and pin issues out associated with that.

Hendrie: Do you have any idea of the timing of the work at Intel on the 1103 – did they start that after the 1102 was started? Did they look at the 1102 and they're working on it and they're saying –

Regitz: It was parallel efforts.

Hendrie: Uh?

Regitz: It was parallel efforts.

Hendrie: Yeah, so most of the time it was parallel – I was just curious as to what order they started them in.

Regitz: They had different design –

Hendrie: Well, probably the 3 had to start later at a higher number – it's the way it works, but I don't know that.

Regitz: Don't know that either.

Hendrie: You don't know that?

Regitz: Don't know that either. I mean, if we are talking –

Hendrie: Because you were there and you didn't –

Regitz: Right.

Hendrie: They did not disclose a second built one?

Regitz: And they didn't disclose that to me until later on in time. But as far as I could tell, it was done in parallel with it. They had two different engineers and they – probably both of them worked together on both projects. Both projects knew what was going on –

Hendrie: Right.

Regitz: - so there was a little competition they had established between the two engineers to accommodate that. But sort of different issues, but they both worked on them together.

Hendrie: Just an aside – did you ever keep track of Joel? Do you have any idea –

Regitz: You know, our families – we both lived in the same town, our kids went to the same school. He has two daughters and I had two boys and two girls.

Hendrie: This is when you –

Regitz: Yeah, we both lived in Cupertino, California. So we knew each other reasonably well. Actually my son and one of his daughters were married for a brief period of time –

Hendrie: Oh my goodness! That kept the family together.

Regitz: Yeah. So, he went through a divorce while at Intel, but over the time we've known the families for a long period of time – went to their kids' weddings, so yes, we –

Hendrie: So you were dirty as?

Regitz: Well, I do and I don't.

Hendrie: Okay.

Regitz: I haven't had much contact with him since my son and his daughter got married, and shortly thereafter they decided they didn't want to be together any more, so I don't – he lives in California. I know

that he'd gone on and done a bunch of things, and he worked for a company in Korea, the Korea semi-conductor memory company – what's their name, why can't I remember their name at the moment?

Hendrie: Samsung?

Regitz: No.

Hendrie: Hi- something or other.

Regitz: Slipping my mind here at the moment.

Hendrie: Yes, there is another one.

Regitz: There's a large semi – so –

Hendrie: There's another one.

Regitz: - he was over in Korea for a long period of time.

Hendrie: Hu?

Regitz: He was over in Korea for a long period of time. I don't know where he is. He's back in California at the moment –

Hendrie: But you're not sure where?

Regitz: Not sure where. I haven't had any kind of work for them for years. And John Reid, the same way. I mean, both of them worked for me when I went to Intel, both of them worked for me. So it was John Reid, Joel Karp, myself and a couple of technicians and some layout people – that was the memory design team for those products.

Hendrie: Okay. Well, that was sort of an aside. Let's talk about where you give the paper to the solid-state circuits conference?

Regitz: Correct.

Hendrie: So, now what are you – I get this impression that you aren't at 3C much longer?

Regitz: I had decided that I wanted to move into the semiconductor business –

Hendrie: Where the action was.

Regitz: Where the action was, because it seemed to me that memory design was moving – the design itself was moving from the computer industry and eventually it's gonna move into the semiconductor industry. The chips are gonna get bigger and bigger and bigger, so that was the trend that was going on. But I wanted to complete the program that I wanted to do and I had wanted to give a paper to the solid-state circuit conference. I figured that was a good technical achievement. So I was committed to do that and move on, and it was not good for companies to hire their customers either –

Hendrie: That's true.

Regitz: And being at that time considered a key employee at Honeywell, the timing had to be right to accommodate that, and I wasn't quite ready to move. I wanted to do it, but I wouldn't have done it in the beginning – I wanted to follow this project through. But long term my objective was to go, and after looking at all these semiconductor companies, you know, the one that interested me the most was Intel. I liked the people there the best; they had the best reputation; they had lots of money to work with – they didn't have those kind of issues. I liked the way they worked, and in the end –

Hendrie: They were clearly very good, because they were faster than anybody else, if nothing else.

Regitz: And they had the leading edge technologies out there, good processes. So after seeing all that data, more data of all the companies I ever worked with before, I could see that that's really where I wanted to go. It was my choice to accommodate that. Now I had to wait around for them to make an offer. We had talked about it a little bit from time to time, and sparred about it in many meetings I've had with them. My buddies over at Motorola, they'd wanted me to come over there, and some other people wanted me to come, but I wanted to go to Intel. So it was just a matter of timing. It was around the solid-state circuit conference and the chips had come out. We had put the system together. I had also learned that the 1103 was out and in the same stage, and they had given us chips to look at, and we said we would. And they informed me that they internally went through a review and they decided that they were going to make the 1103 and drop the 1102. That kind of was a bombshell on me.

Hendrie: That didn't feel so good!

Regitz: No, it didn't feel good, you know, because I'd put a lot of work and thought into design and activities that went on there, and all of a sudden I got this other thing which just didn't feel the same. But we had set this goal of having a standard part for multiple suppliers and we kept telling them we weren't trying to direct what was inside the chip – I did a lot of work on it and did a lot of concept designs with Joel and we have some joint patterns between Intel and Honeywell on the circuitry that's in the 1102 and using other chips, as a matter of fact. But they decided that the IVG generator was just too complicated to do, and so they were gonna do that. Shortly after that, they also offered me a job, and I decided I was gonna go. And that all happened prior to the solid-state circuit conference presentation.

Hendrie: Okay. Who offered you the job?

Regitz: Les Vadasz – Les Vadasz offered me the job.

Hendrie: Was he running –

Regitz: He was running memory – he was running engineering memory at the time. He was running all of MOS design –

Hendrie: Actually.

Regitz: Actually, whatever –

Hendrie: But there weren't any –

Regitz: Oh, there was lots of work going on the bipolar. Their first product was bipolar, so there was another HT Schwar [ph?] I think was his name that headed up the bipolar design activities, and he worked for Grove who worked for – Robert Noyce was running the company at the time. But I'd interviewed – I met Gordon a number of times - on planes, in traffic, in meetings. I knew Noyce – Noyce had come to the house, stopped in at the house a couple of times during the development of the program, in my house in Boston. And Grove I met in the activity. I was interviewed – I went through an interview process. My wife and I went out there - in addition to all the work that they know – we still was interviewed, and they offered me the job prior to the solid-state circuit conference. Honeywell knew that was coming, so they had already cleared that with Honeywell prior to that time. So Joel and I met down at the solid-state circuit conference. I was on a trip, because Joel and I, who'd put the paper together, we had agreed that we would do – we had worked on the presentation together; I was gonna give the presentation and I made a dry run at Honeywell and I was doing a dry run at Intel prior to the circuit conference, and then Bill and I was gonna meet down at the solid state circuit conference, and he was supposed to talk me out of going to Intel, but instead I talked him into going to Intel.

Hendrie: This is a –

Regitz: No, no – that time was in Philadelphia.

Hendrie: Oh, it was in Philadelphia?

Regitz: Yeah, it was in Philadelphia, down at the auditorium. That's a pretty impressive auditorium. Have you ever been to that auditorium? It's a large auditorium.

Hendrie: This is the main auditorium, it's over near University of Pennsylvania but it isn't part of it?

Regitz: I thought it was part of the University of Pennsylvania.

Hendrie: Yeah, there's a huge auditorium, at the convention center.

Regitz: Yeah, you're right, it's at the convention center. It is huge. For a little guy from a little town about 80 miles north from here, as a coal cracker, it's a scary thought!

Hendrie: To stand up there?

Regitz: Yeah, to stand up there in front of all your peers and give a paper was a good experience.

Hendrie: He says, afterwards!

Regitz: Well, I made it through – I don't know, I did get paper of the year, but I enjoyed giving the presentation.

Hendrie: That's good.

Regitz: That was a good experience.

Hendrie: Okay, very good. And by then you had decided to accept the offer?

Regitz: Yeah, not until after the – because I still had to have discussion with my family and kids, but it was after the solid-state circuit conference. I had the offer, but I had not decided to go. I don't think I told them until after the solid state circuit conference.

Hendrie: Okay, and so Bill Jordan talked to you about –

Regitz: Well, at that time when we were down there, we had talked about what's going on and where we wanted to go and what was happening, and we ended up – as I said, I think I convinced him that we ought to both go to Intel, and that we ought to put a proposal together to do a memory system division-

Hendrie: Oh, all right.

Regitz: - at Intel. So we left that solid-state circuit conference and agreed that we were gonna co-author a proposal and send it off to Noyce. I had not accepted my position yet –

Hendrie: Okay.

Regitz: - at Intel. We would send it off in the morning, and I knew they were gonna get it. I don't know however we got it out there, but I knew it was coming. I was laying in bed one night thinking, "Well, I wonder if Noyce – he should have gotten it by now. They haven't called, they haven't done anything." So all those things running through your mind, then the phone rings – I was laying in bed at 10 o'clock at night, and who was on the other end but Robert Noyce.

Hendrie: Oh my goodness!

Bill Regitz: And he said, "I got your proposal. We like it. We'd like to talk to you'se."

Hendrie: Very good.

Regitz: So, I said, "Fine." We went on and made an arrangement for a meeting and he talked to Bill –

Hendrie: You and Jordan went out there?

Regitz: No, I never went out there. I think Bill – I'd already been out there, so I didn't need to go out there any more, so Bill went out and we had proposed to start this memory development division, and we wanted to get the 1103 development and put all of this work into one group under the direction of Jordan.

Hendrie: I think we may have run out of tape, so maybe we need to just back-track just a few phrases back to – you were talking about going out to and sending Noyce a something –

Regitz: A business plan.

Hendrie: A business plan by snail mail.

Regitz: Right.

Hendrie: Okay, so you got –

Regitz: Not exactly sure how we got it there, I don't remember, but we did get their attention, and he did look at it, and as I said, I was laying in bed one night and wondering whether he had received it yet, and wondered why we hadn't heard back from them that day, and lo and behold, the phone rings and there's Noyce on the other end saying they received the plan, he liked it and he wanted to talk to us some more about it. So we had talked and they said, "Well, I don't really need to talk to you any more, I've already offered you a position. Let me talk to Jordan." So I got them hooked up together and whatever Bill did to his own process to go through that, and we had proposed, and I said that we do the development and market, make systems, develop systems like a custom memory system business out of semi-conductor memories, similar to what Honeywell was doing out of cores, and market those and take on the

responsibility of designing the integrated circuits to go with them, but putting all of that together seemed to me that was a good business –

Hendrie: And all the systems knowledge and everything gets reflected back into circuit design?

Regitz: Correct, right into the circuit design. But that was not Intel's idea and model; they had wanted me to come to work on the semiconductor side of the business, and they didn't want to integrate it together, they wanted to set up the memory system business as their own separate business. So this kept going on and on and on, and it was getting bogged down in this activity.

Hendrie: Well, I'm sure it wasn't convincing them.

Regitz: Evidently, and I wouldn't put it all on Jordan, but we weren't able to convince them, and he had a lot of discussions with them, more than what I did at the time, and he was not able to convince them, and I wasn't able to convince them, so finally after talking to them, I decided, well, okay, I've just to go to work for them and you do your thing and I'll do my thing. I did that; I accepted the position and started work there on March 29th, which was only like 4 weeks, 6 weeks after the solid state circuit conference.

Hendrie: This is 1971?

Regitz: '71, and Jordan went to work a couple of weeks after that. We crossed paths – I think I left the apartment and he moved into the apartment that I stayed in for the first couple of weeks at Intel.

Hendrie: Oh, my goodness. All right.

Regitz: Anyway, that got us both to Intel, and I went to work for Les Vadasz and my responsibilities at that time was MOS memory design manager, and had the responsibility of designing and putting into production the 1103 and doing all the follow-on chips. At that time we were contemplating a 4K-memory development program and all of the dynamic memory designs, not the static designs. I had two design engineers – Phil Karp, John Reid and two technicians and I think that was the bulk of people that worked for me at the time when I took the job.

Hendrie: Wow! All right. So, when you got there, what were the first tasks that sort of faced you?

Regitz: Oh, the first task was clear: that was to put the 1103 into production. Characterize it. Things worked a little bit differently then than what they do today. Circuit models were not very good, and a lot of the work had to be done through characterization of what the product is and control the parameters of the process, and try to align widths and do the kinds of things you needed to define to be able to keep the things together. We had to put the volume test equipment into production and get manufacturing up and running and get the customers up and running. In those days, the design engineer, who was not only responsible for the design but he was responsible for all the product engineering duties of running the

manufacturing organization, there was no technical marketing activities so you supported the customers, you know, so the job was a very broad job, as well as try to do the design energy and the next generation, and define it, put the design activity to work for the next generation, the 4K chip activity. So that was the job at hand. So the first job was to really do the characterization and find out if you wish where does the process want to run to make this a high volume device.

Hendrie: Okay. And you would actually – they would have a separate set of processes, settings, for this?

Regitz: No, it was the process settings versus a separate process.

Hendrie: Yeah, they'd have separate settings?

Regitz: Settings, right.

Hendrie: Yes, separate processes?

Regitz: Right, settings -

Hendrie: So, running 1103s, they sort of set it up this way.

Regitz: So we set out to get the manufacturing test equipment in place and characterized the 1103.

Hendrie: Now how do you test an 1103?

Regitz: We were doing it on homemade testers that we had produced at this time. There was no semi-conductor memory testers available, and we had designed one at Honeywell which we had given the specs to Intel to produce, Hank Bodio did the bulk of those designs there and the testing of it. And Intel, they had their own test department that was working on it, so it was a combination of what we were doing at Honeywell and what the people knew that they needed internally to test devices out, because we knew Honeywell didn't know that. But the system test came basically from Honeywell. That's the way I remember it.

Hendrie: Okay, the system tester, yes.

Regitz: Right. And the second piece of it, we had to characterize the 1103 over all of the process parameters, and that process, basically the manufacturing organization would make chips, you know, at the extreme ends and a couple sets out of here, and then what you call typical chips –

Hendrie: Seven different places in the recipe.

Regitz: Right, in the recipe as best they could define that, and the recipe. So the job was of taking - characterize the chip and then set the specification around the activity, with system knowledge knowing that it was gonna work in the system environment. So I did the characterization work, me and the design engineer – the technician, rather – did the bulk of collecting all that data, putting it together, drawing the charts over temperature from zero up to 95 – there was no temperature testing, everything was done at room temperature, so you had to correlate the extremes back to 25°C and guarantee the specification over the temperature range –

Hendrie: Over the wider range.

Regitz: - so all of the correlation factors that needed to be done, and it took quite a while. I don't remember how long it took, but the reports were generally in the inch thick kind of reports, with all the curves and stuff that you had to chart and put together. I think all of the work that came back out of my original work at Bell Labs was really very helpful during this whole process. And then doing that with what programs you need to run – what program sequence you want, and where do you find the worst case program and how you do all of that needed to be done and put together.

Hendrie: What were some of the problems you had to deal with, with the 1103 issue?

Regitz: I'm convinced today the 1103 really never worked. It was one of those things that you had to have it in this location, and no matter what you did with it, you would destroy data.

Hendrie: Is that right?

Regitz: Yes. Obviously it didn't quite – it did work in the end, right, but we had to put a lot of things in to be able to control the parameters, but if you did it wrong, you wipe data out within the memory. We had a whole – I don't know how many different parameters we had, but as we went through this, you know, besides being the product engineer at a semiconductor company, which means you control the test program, you had to test how the product flows in the processes that you're running, but then you define that with the help of the process engineer, to be able to put that together. On the other hand, you had to work at marketing. Your responsibility was the data sheet – you controlled the data sheet; you also controlled the parameters that worked in there, and if it didn't work out, you were technical marketing support, so you went out to the customers to be able to find the problems why this thing didn't work, right?

Hendrie: Yeah, exactly.

Bill Regitz: And the bulk of that work fell on my shoulders from that activity, because I had the system knowledge, and so the engineers did a lot of work internally and worked with the process people and the characterization work I'd done from that standpoint. So, we went out, we designed the systems and put them together, and Jordan was billing systems, and he had brought Honeywell – I don't remember exactly when Bodio came to Intel, but eventually Bodio and a couple of the engineers that worked in my group at Honeywell migrated to Intel working for Bodio. And they had put the systems together. So they

were over there testing their systems, and also getting the test results from the customers at the same time. There's one effect that came back. For the life of me I couldn't describe what it was to you, but we've named it the Bodio effect, which was one of the last effects that we found on the chip. But if you had the right overshoots on one of the lines –

Hendrie: Of one of the signals?

Regitz: Of one of the signals –

Hendrie: This is about driving the array of chips?

Regitz: Correct.

Hendrie: Okay.

Regitz: And because those coupling effects went into the chip, if you had the right overdrive, you would actually instead of writing data into the chip you would actually take all of the data out of the chip, and destroy the data that was there, convert a one to a zero, a zero to a one – I can't remember exactly which sequence it was in.

Hendrie: Oh, my goodness!

Regitz: So you had to control all these overshoots on the thing. So Bodio was testing the parts at the system level, and I had some of his makeup in the testers in the lab, and I was finding the problems – what did we need to do in the chip. Once we understood that, then we could come back and design the system solution, if you wish, or work around to prevent that from occurring. So that was the kind of activities that we went through. And we went through I don't know how many different one of those problems. As a matter of fact, this was so bad at one point in time we had DEC – DEC was one of the first computer companies to end up going out in the industry in producing the part.

Hendrie: Using them, using the 11 update?

Regitz: Using the part. And one Sunday night I was at home and had this call – actually it was a Saturday night, I had this call from Les Vadasz who was my boss at Intel, and he says that DEC system is out in the field and it doesn't work. He wants us to send someone to Digital Equipment Company on Monday morning. I said, "Fine. I have no problem – I'll go and I'll leave Sunday night." He said, "No, they want you there fresh," so I had to go out Sunday morning. So, it was a big deal. They end up – we never flew first class at Intel, but Vadasz says, "Since we're making you go out early and not in your timeframe, we'll upgrade your ticket to first class." So I went out Sunday morning – that was a Saturday night around 10 o'clock he called me, and I was on the plane Sunday morning flying to Boston. I got in that day and

was waiting the next morning for the salesman to come and pick me up, because I had no idea – I'd never been to DEC before.

Hendrie: You had no idea where you were going?

Regitz: I had no idea where I was going except I was gonna go to Digital Equipment. I knew who I was going to visit – I knew all of that, and there's a three-hour time difference between Boston and California. No salesman shows up at 7 in the morning.

Hendrie: Oh, my goodness!

Regitz: And here it's now 9 o'clock and he's still not around. So I finally decided, "I can't wait for him any longer" and I go call – I couldn't get Intel because it's only 6 in the morning –

Hendrie: Yeah – they're not awake.

Regitz: They're not even at the plant, so I called into DEC and found out who I was supposed to see and where I was supposed to go, and ended up driving a car over there, and I walk into this room with DEC – I'd been in a number of customer meetings prior to that, but never by myself – all alone, right. I walk into the meeting; there must have been 30 people sitting in this large room -

Hendrie: Oh, my goodness!

Regitz: And they explained to me – and here's just me!

Hendrie: Oh!

Regitz: It's kind of like that auditorium in Philadelphia, you know, and all kinds of things going through my mind. What – are they gonna slaughter me? What, run me through a ringer? But it was very clear from the beginning, though, that they had a problem and they wanted us to help. They explained what the problem was, how the problem showed in the field, how many systems they had out there, what they had built, and they wanted a solution to this problem. So we quickly got together and I was there all week, and by the time I left on Friday we had found out what the problem was, demonstrated the problem, showed them how to fix the problem, modified what I needed to do to the specification to get it work, had those changes implemented at Intel, and I could make those changes at Intel on the tester, because we had produced some parts. We had simulated the problem back at Intel so that the part would take – we knew the deals were okay. We're gonna throw chips out, but it was an acceptable loss and went home on a Friday night with a successful trip. But that was the types of things that was going on through the semi-conductor industry at this point of time.

Hendrie: Can you characterize roughly what the problem was?

Regitz: Again, it all relates back to this overshoot on drive lines that was removing charge, sometimes lots of it all at once, and sometimes, you know, when you're sitting there in memory, you only refresh I guess it was every millisecond at the time, and if you just pull a small amount of charge out, the refresh time would significantly reduce. So depending upon exactly how you read, how much overshoot was on the lines, the magnitude of it, and the duration of the energy in that overshoot was what was causing the problem. So I mean theoretically under the conditions that we'd specified, the cell didn't really work because of all the parasitic RAMS, but we understood them, we were able to get at them and define them and then pull it together. You know, and in the end the 1103 was the largest single volume chip that ever was produced in the industry at that point of time.

Hendrie: So how did you control the overshoot – did you damp the signals somehow?

Regitz: Damp the signals with diodes.

Hendrie: I was gonna say, put a diode on it.

Regitz: And also to control the rise time that was going into it, so the circuit background helped with the solutions that we did in the environments, you know. But at that time everybody wanted their own thing, you know. Reece Brown – Burroughs, he was a big deal with core memory; he was a big deal with semi-conductor memory. He was another big user, and he wanted his own spec. The people at Honeywell drove me up a wall. They wanted a separate spec – these were people in Phoenix. They wanted a separate spec, and they wanted a high voltage spec. So I had all these specs that was coming together within the industry to be able to – it was just the timeframe that was there. People weren't buying in the standards, basically. So they all wanted their special thing out, because they figured if they had their special spec, then they could get a special price, which could be cheaper.

Hendrie: The special spec, they definitely can get – it's the cheaper part!

Regitz: That was their theory, so that was going on. And because of all these special specs, and the 1103 being so sensitive and having such a narrow process window, it was hard controlling all of that. So I had to go back, and we had to re-characterize the 1103 for a higher voltage, higher, faster part. The activities it was coming down to, I would do these specifications, do the characterization, accept the specs, put them into production and release a tape. For example, Reece Brown on the other end, he was working with – I forgot the name of the memory tester company at that time – and he came back and he was working with this company to be able to test the memory trips coming in the door. And we were still working on these little automated boxes that we had produced internally – no big Teradyne tester or anything like that. And I had tested these devices and sent them out the door, and they got to him on the other end, and he said they didn't work. I said, "Well, what did you test them on? Did you do this, this and this?" He said, "Yeah, I put them on the tester; tested them under these conditions; they don't work – they all fail." I said to him, "No way did they fail, they work." We went through this for a day or two and he said, "This program's getting behind schedule", and he knew Gordon Moore. He called up Gordon Moore and said they don't work, and he wanted someone to come to Poughkeepsie – I think it was Poughkeepsie in New Jersey [New York] – so he could show what was going on. And he wanted me and Gordon to come to New Jersey.

Hendrie: Oh, my goodness!

Regitz: So Gordon and I got on a plane and went to New Jersey, but I said, "I'm not going there unless I take my test equipment. And I'm not going there unless I take the technician with me so I can show you that these things are gonna work and we can do this incoming test." He agreed to that, so we packed up our test equipment, we packed up the parts – some additional parts plus the ones we'd shipped out there – and we'd gone on down into New Jersey. We had dinner at his house – Reece Brown's house – that night we arrived, and the next morning went into the plant. We were sitting over there, taking them, and said, "Here, they work"; showed them what we did, and he said, "But they don't work over here." So we had his design engineer, his test engineer and the people who made the test equipment in, and after about – I don't know if it was a day, four days, one day – but after some period of time I showed them that the equipment was bad. It didn't work. The sense amp, when the signal was coming out of the device, the sense amp actually needed too much energy to be able to test the part.

Hendrie: I understand, yeah.

Regitz: So we had to go back and redesign that incoming device, their sense amplifier, made some modifications to it to be able to accept the pieces. So he ended up accepting that shipment, which was quite a few dollars on equipment that we shipped out from the other end.

Hendrie: Oh, wow!

Regitz: Then ADAR – I think was the name of the test equipment manufacturer – they came back and modified their equipment –

Hendrie: Modified the sense amps –

Regitz: They fixed the problem. We had issues in England, we had issues with testing on the floor. We had made a decision to go with Teradyne J941s or whatever the tester activity was, and I had moved out of design engineering during this timeframe. I could see similar things that came back to haunt me. We talked about Ph.D.s and where they are and what you know and what the knowledge is, and they had hired a fellow at Intel named Sun Lim Chow, and he came in with the knowledge of processes, he had his Ph.D., and he new processes and he knew circuit simulation. His job was to integrate the process and the circuit simulation together, and the thing that I really respected about him was his knowledge that he had about how the semiconductor worked and then be able to correlate that back in the processes. He's now VP of process development, and has been there for a long time. He owns all of process development at Intel, but I looked at him and I could see the knowledge that he had that I did not have relative to it, and I could see the knowledge that I had in the system manufacturing world and I could see that I was able to do much better work in that area. So they had asked me to go over and set up their product engineering organization at Intel, and I had gone over to do that, because we had problems in manufacturing. The design engineer just couldn't do all that work that was needed to be done. He brought in Dave House from Honeywell, and he set up the technical marketing group, and so I transferred some of that responsibilities over to Dave. And then they wanted to set up this product engineering group to offload the

design engineer from doing that, because while you're working on the customer's problems, while you're working on the manufacturing problems, there's no way you have time to put in–

Hendrie: You were in New Jersey for a week, that's why this is getting done?

Regitz: Well, you know, you're not working on the next 4K. So I ended up going over to set up the product engineering organization for Intel and during that process they had made this decision to use these Teradyne testers. There must have been eight or nine of them on the floor chunking out parts, testing parts, you know, 24 hours a day, probably 7 days a week, and what we call the ITR rate at that time was, you know, you'd come along, test parts, then you'd put them in storage and bring them back out again, you'd do a sample test on them, and the sample test had a bat, and they were very relaxed parameters in that sample test, and then you'd chip them if they passed. That was the quality control.

Hendrie: What does ITR stand for?

Regitz: Internal Trouble Report.

Hendrie: Yes.

Regitz: Meaning that the parts I tested once didn't pass the same programs of a relaxed version of the same program I did before.

Hendrie: The second time?

Regitz: The second time, right. And obviously, if you have a lot of those, you're doing a lot of re-tests, because the solution was re-test and then go to the other thing. And then you'd have an ITR of the ITR, right? So this was going on, and Intel at that time, almost all the revenue, 80 percent of the revenue, was coming from the 1103. Without monthly revenue, you go –

Hendrie: You're in deep trouble.

Regitz: You're in deep trouble. So we had all these ITRs. So I made the decision that the only way I'm gonna solve this problem is I've got to shut down the floor and I've got to correlate all of these testers. There was no other way – we tried everything else to do it - so we waited until the end of the month – probably the end of the quarter – got through that quarter, the first month of the quarter we shut the floor down. We were sitting there, and one day went by, a week went by, and I still wasn't able to correlate. I had Teradyne people, I had all the best test engineers, and we were going over all of the different tests, all of these eight or nine pieces of equipment, just trying to sort out the problem. And we finally did figure out what the issue was, and it was a similar very issue that we had at ADAR with Reece Brown, and that was that the testers just didn't have enough sensitivity to be able to slice the signal at the same time to look at the difference between a one and a zero, and that was what we were failing – the magnitude of

the one or the magnitude of the zero coming out of the chip. So we went back and we had to redesign a fix for all those systems and put them back together to be able to make them now uniform and be able to control them. We had to process steps in place, but those were the kinds of things that, because of the equipment, the capabilities of all of the new equipment that we had, both in the manufacturing line and the production line and with customers that we had to work through to make this conversion and bring the volume up in the 1103.

Hendrie: Just lots of things that would be very hard to predict?

Regitz: Yes.

Hendrie: And you'd just have to solve it in real time.

Regitz: Right.

Hendrie: Now, was the 1103A out yet?

Regitz: The 1103A, when we came into the process, we knew that the 1103 had these bunch of issues that we talked about, like the Bodio effect –

Hendrie: Yeah, like the world's smallest process window –

Regitz: Yes.

Hendrie: And critical timing.

Regitz: And critical timing.

Regitz: And all sorts of critical timing and –

Hendrie: Very hard for the interface designer.

Regitz: Yes, and multiple signals coming in that they had to come in precisely where they were.

Hendrie: Yeah, exactly.

Regitz: So we had set the design objectives of the 1103 to widen the process window and make it easier to use, okay, so in addition to working on the 2104, which was a product that Joel Karp was working on, I

took on the responsibility of redesigning the 1103 into the 1103A. We did complete that, and it did meet - its design objective. It was much more stable than the 1103 with a wider process issue and –

Hendrie: Much easier –

Regitz: - we fixed all the issues –

Hendrie: - and many fewer calls.

Regitz: Yes, and much easier to use. And the line was cut over from 1103s to 1103As.

Hendrie: Okay. Now, the 4K part, was that also a four-wire, four-connection part – it was still a three-transistor cell though.

Regitz: It was still a three-transistor cell, and it was a four-wire part, the 210.. actually, we did a 2104, we actually ended up doing a three-wire version of the 2104, so the 2104 went on as a second generation design of the original 1102.

Hendrie: Oh, okay.

Regitz: And not the 1103.

Hendrie: Did not use the 1103 set –

Regitz: Correct.

Hendrie: You used the 1102 set –

Regitz: Correct.

Hendrie: Because they felt they really needed, that they might be able to solve the voltage generation problem –

Regitz: Yes, and we switched from P channel to N channel.

Hendrie: And it was switched?

Regitz: Yes, it went from P channel to N channel.

Hendrie: Ah! So the 2104 –

Regitz: Is an NMOS.

Hendrie: Is an N channel part?

Regitz: Yes, correct.

Hendrie: Okay.

Regitz: And we put that together and Joel gave the paper down at the IEEE circuit conference the following year, I believe, if I can remember correctly. I think that ’72.

Hendrie: And he designed that part?

Regitz: Well, the both of us designed that. He was the design engineer –

Hendrie: You both did that.

Regitz: Yeah, we both worked on that.

Hendrie: On the 2104?

Regitz: Correct, but he was the lead design engineer.

Hendrie: All right. And the 2104, did that go through?

Regitz: No, that never worked –

Hendrie: So the 2104 is N channel, it’s the 1102 cell –

Regitz: Right.

Hendrie: And that’s three wires, three glides through the –

Regitz: We've got to be a little careful here about numberings, because I don't remember – I'd have to go back and really look that up. But the first 4K design was exactly as you described it, okay?

Hendrie: Yeah.

Regitz: Now, as we were going through that design, some of the same issues –

Hendrie: Came up.

Regitz: Came back up again, especially with process windows, and controlling the intermediate voltage generator. As a result of that activity, we never could hit the cost targets on that given design, okay. Also in the industry at that same point in time, I think it was AMS – there was a bunch of people that was working on the one-transistor cell, probably out of IBM, was probably doing some work in that arena as well. I think AMS and other people were doing work on the one-transistor cell approach, okay, and Intel brought in a fellow named Mike Guyhuefter [ph?], I think he was from AMS, and his job was to put together a one-transistor cell approach – him and Sun Lim Chow worked on a one-transistor cell, 2104, a version of the 4K chip. Whether it was 2104 or some other number, I don't remember any more.

Hendrie: Okay. Did that ever actually ship?

Regitz: That was the one that shipped and crashed.

Hendrie: That was the one that actually shipped?

Regitz: We shipped 2104s, but not very many. It's probably not worthwhile talking about. When you think of it in volumes, it was very small quantities.

Hendrie: Okay. And they made just a few 1102s because they decided –

Regitz: Yeah, very early on in the timeframe they decided not to make very many 1102s – they switched over to 1103.

Hendrie: Why don't you tell me a little bit more about what you did afterwards in your career? The thing I think from the Computer History Museum's point of view, the particular interest is the story of how dynamic – you know, how the memory business started to grow, but I'd like to hear it. Maybe you could just tell that, and think about what else you did.

Regitz: I tend to agree with you. But going back, following up on your comments first, there's no doubt that I think the conversion from core to semiconductor is a very interesting transition within the industry, and I think the relationship between Honeywell/3C energy, tying up with Intel and the other people, and

putting it together and bringing it up and making it work – I mean, it was the 1103 that came out as being that part that began the transition to semiconductor –

Hendrie: First high volume, really successful.

Regitz: Yes.

Hendrie: I should mention, Fairchild and Motorola had figured out how to make these parts. Do you know anything about why they did not pursue this – left the field open at Intel?

Regitz: I don't think that they really – remember this was a very sensitive part with a lot of issues, right, and the same issues occurred at some of these other parts, only there's less degrees and more degrees and other programs came back up, and their development programs were running late. And they quickly moved on into the development of the 4K, and into the 16K.

Hendrie: So they probably just ran into enough problems in the 1K.

Regitz: And Intel, they tied on with a company up in Canada, I think –

Hendrie: Yes, MIL.

Regitz: MIL, right, to make the 1K dynamic RAM as a second source, and that kind of helped that situation go away.

Hendrie: Yes, okay.

Regitz: I don't think anybody else, even though we wanted to be pin compatible, there was a common pin out but it was very difficult to get these manufacturers to be able to do that.

Hendrie: So it was a very hard part to make –

Regitz: It was a very, very hard part to make –

Hendrie: And to yield in any sort of volume –

Regitz: Correct.

Hendrie: At any sort of reasonable cost.

Regitz: I think that's correct. Intel was – I think one of Intel's strengths was being able to master how you make parts like that in very high volume and control the processes associated with it and to work all the issues.

Hendrie: Very good. Maybe you could tell me a little bit more about, you know, what you did later on in your career – I think that would be, you know –

Regitz: I think from a career activity, as I said, as we weren't as successful in the development of the 4K chip to go along with that and then bringing in other people to do the work on the 4K single cell approach, but Intel – my strengths, I think, really lined up better with the manufacturing and with the marketing, so I went over and continued to support the start-up of the manufacturing activities. I had an opportunity – Dave House, who also was – he was a 316 product manager at Honeywell at the time – was it the 316, was it the minicomputer –

Hendrie: I think it was –

Regitz: The 96?

Hendrie: It was a product that was going to be the X12 –

Regitz: Ah, yeah!

Hendrie: Yeah, the 316 I believe was –

Regitz: That was a different computer.

Hendrie: Yeah, I believe the 316 was the X-nutter, and it was sort of a – it was a unique machine that actually never got devolved in production, but yeah, he was a product -

Regitz: He was a product manager.

Hendrie: He was a product manager, product designer. He was designing and he was doing everything, just like designers at Intel _____ in those days.

Regitz: Intel was looking for a technical marketing manager at the time, and David moved from Honeywell to a company down in Southern California –

Hendrie: Microdata.

Regitz: Microdata, right, Microdata. In my conversations with the marketing manager over there, I said, "Why don't you go talk to Dave House; he'd make a good technical marketing fellow." So they brought Dave House in to staff, to technical marketing people, so now we finally at Intel are beginning to get the product engineer and the design engineer offloaded from all these techno-_____ and working with the press and working with the other people. So they brought Dave House on board, and Dave House had been there for a while, and they were forming a new division at that time to take on - the micro-computer had come out, the 4004 and the 8080 etc. etc. and Dave House went over to run that division which left a hole back in technical marketing in his position. The marketing manager, Jack Carsten, came up and asked me to go out, to leave the product engineering position I'd been in for about three years or something like that, to come over and run the technical marketing position. I looked at him and I said, "You want me to go where?" I said, "You know, marketing people, all they do is open doors for engineers." That's my views. But anyway, after thinking about it a while, I said, "Well, gee, now I've been in design engineering, I've been in semi-conductor memory systems – I mean, I've been in a whole bunch of system houses; I've been in design engineer – designed an integrated circuit and designed a couple which went into the - personally designed one, helped some others go into manufacturing; been in product engineering – why not try marketing, just broaden my career. So I decided I'm gonna go try this. So I went down to run the technical marketing organization which had all of the parts that Intel was producing at the time, except microprocessors which Dave House took when he went over to there. Now, I did that for about a year, and at this point in time Intel decided they're gonna form divisions. Up to that time they were one big semi-conductor company, except for the memory system division which Bill Jordan had come to Intel to run. In his division they had design marketing, you know, and all the pieces of the division, and the semi-conductor business was just one big company.

Hendrie: One big lump, yes.

Regitz: So they were breaking it up into pieces. And at that point in time I didn't have enough experience to be one of the technical marketing – not technical marketing but marketing managers which would have been the position of my equivalents at the time. So it was the first time that I did not have a job at Intel. I didn't have enough experience on the one hand and couldn't back up into my other positions because they were all filled. So, I decided that, in looking at the opportunities, that I was gonna go over and go to work in memory systems division where Bill had been working, and I went over there in the design engineering group and I looked at the design engineering group and I said, "Well, your problem is that you don't have a product engineering organization." So, I made a proposal to set up a product engineering organization and they gave me an opportunity to go set that up, which I did. So I moved out of design and moved over into their manufacturing organization. At that time – I was over there for about a year, set that up, so I give myself credit for, in addition to putting the 1103 into production and working those issues at Intel, setting up their product engineering organization and disciplines involved in the components in the manufacturing side, and they wanted to move to Phoenix and I did not want to move to Phoenix. So I helped them get established, find a building, get everything set up, helped them make the first move, and now I'm out of a job the second time at Intel with nowhere to go.

Hendrie: Okay. Can we take a break?

Regitz: Sure.

Regitz: The engineering organization he had taken over the bubble operation at Intel, right, and he was looking for ways to use the bubble.

Hendrie: Yeah.

Regitz: Okay, so my – so I moved, it was a temporary assignment. It was not a long term assignment but my temporary assignment was to devise methods and convince people Intel had some system product divisions besides the memory division. They weren't even using the bubble. They also had a big business selling computer development systems and other modules and so my job was to figure out a way of using it inside Intel. Okay, so I went away and worked and understood the bubble and came back with some solutions and came back and made a couple proposals to be able to accommodate that and in the meanwhile Bill Jordan had left the memory system business and they brought in a fellow named Mikellmount [ph?] to run the activity and it didn't work out. It was a really – Intel has not a very good track record of bringing senior people in. They digest them and spit them out pretty quickly.

Hendrie: Right.

Regitz: And so, Mikellmount [ph?] left and they didn't have anybody running the memory systems division at the time. So, I went to Grove. It was my 40th birthday as a matter of fact around that same time and I talked to Flat [ph?]. He was kind of a mentor there and I said well here's my idea. Why don't we do this with the memory system business and we were going back over it. He said why don't I just send that proposal to Grove?

Hendrie: Yeah.

Regitz: Is that what you want me to do? Yeah, send that to Grove. So, I sent it to Grove and he called me and I talked to him a couple of times about it and he called me on my 40th birthday as it turned out, He didn't know that but it turned out to be a nice birthday present for me, and he offered me the general manager of the memory systems division.

Hendrie: Very nice.

Regitz: So, I took that on. In the meanwhile, Intel had made the decision to get out of the DRAM business. So, now I'm sitting over here running the memory systems division, which is what I started out proposing to do with Intel anyway, not run the division but work there at the time.

Hendrie: Yeah, you thought it was a good idea.

Regitz: I thought it was a good idea and we used a lot of memory and they had – Bill had worked up quite a bit of – they got into IBM, got into Unisys, I guess it was Univac at the time, and a whole bunch of people that they were delivering lots of memory system businesses to and but now there's no memory

systems. So, I tied up my old buddy Ron Whittier [ph?] who was running the memory products division at the time and they assigned me underneath him. He turned out to be my boss. So, now we have the memory component business tied into the memory systems business, right?

Hendrie: Yeah.

Regitz: I was running the system side and he and other people running the DRAM side.

Hendrie: Right.

Regitz: So, I had a good supply of RAM and then they decided to get out, completely get out of that business and here I'm buying all these parts from NEC, Toshiba, you know whoever was making –

Hendrie: And no longer, this is no longer a vehicle.

Regitz: Right and you go out to the sales people and you try to get their attention and they didn't want anything to do with memory. Their focused someplace else and we only had one sales force. So, I looked at all of that and we had built a memory system business. I had grown it, I don't know doubled it, and made more money off of it and et cetera but it wasn't going to go anywhere and it began over the top going downhill and so I looked at it and made up my mind. I said, okay, we need to shut it down.

Hendrie: This is silly.

Regitz: This is silly.

Hendrie: Having a memory systems business if we aren't making memory.

Regitz: If we're not making memory.

Hendrie: Yeah.

Regitz: It doesn't match our activity.

Hendrie: Right.

Regitz: So, I convinced the organization to sell off the business, close it down, and I had to get up in front of an auditorium to tell people that this is what we're doing, in a very bad recession, and the activity.

I sold off the business to a company called Zitel and closed down everything else and transfered everything else out of the organization and, again, I was out of a job.

Hendrie: Uh huh.

Regitz: You know.

Hendrie: Okay.

Regitz: And so I took my first sabbatical at Intel after shutting it all down. That worked out fairly well, transferred the customers over, didn't lose any customers, had good feedback from customers, good feedback internally, good feedback from the employees and so I took my sabbatical. But before I went on sabbatical, I decided to go back to work on the component side of the business again in Santa Clara and they were just bringing up the – they had what they called TX manufacturing and TY manufacturing. TX was manufacturing plants for an oversee. TY manufacturing were like pre-plants producing parts in the United States, kind of what I ran when I – my last job in product engineering. It was actually a manufacturing job running a manufacturing line. And, but this was all associated with peripheral components.

Hendrie: Yes.

Regitz: Microprocessors and things that go make up the microprocessor line and they were in a big mess. The products coming into the organization was not documented very well. The production programs were there. There was parts that were designed waiting months before they'd even have a product engineering program assigned to them. It was just a big mess.

Hendrie: Oh, yeah.

Regitz: And, at that time, the 8080 was just coming out and what the heck came after the 8080, the 286.

Hendrie: Oh.

Regitz: Followed by the 386 was just coming out and those parts just needed to get out into production and there was a lot of energy going into them. And, I spent more money buying test equipment. We expanded the plants. We even went down and reopened the old Mountain View plant which had been closed by this time to put test equipment in to be able to sort wafers and test parts and I spent more money on manufacturing equipment and test equipment than what I had in income in my memory system business quarters before that.

Hendrie: Oh my goodness.

Regitz: And, so I did that for a period of time and then they decided that they're going to take that organization, break it apart into pieces, and I took another general manager position heading up Ethernet controllers, 586.

Hendrie: Oh, okay.

Regitz: Okay.

Hendrie: Uh huh.

Regitz: And I took that on plus I took on the design responsibility over in Israel, ran the design center over there with this activity. That's where the design activities were going on and did that for a period of time and then went back into the manufacturing side of the business running an organization up in Folsom, California and it was for peripheral components again. It was back running the pre-manufacturing, pre-engineering activities associated with getting the products out, transitioned over to the manufacturing plants. And then, my last assignment at Intel I shut that organization down, transferred it all out, shut it down again and now it was like three or four years and I said now what am I going to do? And, so I could have retired but I looked at it and said well, if I stay here a little bit more I get some more of these golden handcuffs of stock options that was available and I didn't – what I wanted to do, it turned out I wanted to be – I wanted to do something different. So, I went back to the system world and I looked for a job that was up in Oregon and I became the program manager. There was an old friend of mine from the manufacturing organization over in Panang had moved over to system manufacturing up in Portland and they wanted someone to come in to coordinate a program for GI. GI was called GI but it was for Sony.

Hendrie: Oh.

Regitz: And it was Grove's initial and the initial of the Sony guy who negotiated this deal. Intel was going to design a microcomputer box, a minicomputer box, for Sony.

Hendrie: Right.

Regitz: We were going to build it, okay, from Sony's design and ship it out the door and so I took on the project management of that job to ramp the box into production and then after that he said well – so it was an individual contributor job so I got out of all that management stuff.

Hendrie: Uh huh.

Regitz: And then the second thing happened was that they started producing these little modules, which I showed you earlier.

Hendrie: Oh, yes.

Regitz: The modules that go in the notebook, the notebook modules and they were having lots of issues of manufacturing with that. So, my last job at Intel, I ended up again being another program manager. I did take on some responsibilities with a co-manager, so I didn't do too much managing, if you wish.

Hendrie: Yes.

Regitz: Writing reviews and that kind of stuff and ended up putting those modules into manufacturing and took my fourth sabbatical from Intel and then retired.

Hendrie: Very good.

Regitz: After 28 years, 29 years.

Hendrie: Twenty-eight years, incredibly varied.

Regitz: Yes.

Hendrie: So, you got a chance to work on so many different things.

Regitz: I did.

Hendrie: So, it keeps you from being bored.

Regitz: It does.

Hendrie: When you have new challenges.

Regitz: Right.

Hendrie: And something you have to learn about.

Regitz: Yes.

Hendrie: Learn to solve them.

Regitz: Yes, every one of them.

Hendrie: We don't get bored.

Regitz: No, needed to go back and do a little research.

Hendrie: Exactly.

Regitz: To be able to move into the job and then the position, so I enjoyed it.

Hendrie: That's wonderful. Well, thank you very much.

Regitz: You're welcome. I thank you.

END OF INTERVIEW

