Oral History of Berry Cash

Interviewed by:
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Rosemary Remacle: Berry, let's start the discussion with a little background information…where were you raised, who were your parents….

Berry Cash: I was born in 1938 in Houston, Texas. At that time, my father was what was called a doodle bugger. He was a geophysicist and was running a crew out in southern Texas, southern Louisiana, Mississippi, looking for oil. So we-- as a little baby, I lived in a different town every month or so as we moved. Then the war came along and we moved to Washington, D.C. And I actually started public school there. The schools were very crowded. I only went a half a day in my first grade. And then after the war, we moved back to Texas and he resumed his career with Texaco. And we lived in Houston, Tulsa, Oklahoma and then New York. He was promoted to work in the New York office in international and did. Basically, at the end of his career, he ended up executive vice-president of Texaco, responsible for all their operations in the eastern hemisphere. So he traveled constantly from New York to the Middle East.

Remacle: How did he influence how you got to where you are today?

Cash: In ways that I have become-- it's become more obvious to me now than it did at the time. He was an electrical engineer and he went to Texas A&M, as I did. I've always said that that's not why I went, but I'm sure it had a big impact. Ironically, in his day, he graduated in 1933 with an electrical engineering degree and it was difficult to get a job. And certainly-- and the jobs that he wanted were either in the power industry or the telecommunications industry, and they just didn't exist. So he sent resumes out to many companies. And after four or five months of just waiting, he received a job offer from Texaco. It's kind of a cute story, and it was told at his passing, actually, that he had been out driving a combine all night long and he returned home. And his father met him on the front porch and he said, "Son, you've gotten a telegram from Texaco." And he said, "But I'm afraid there's a typo in the telegram." He said, "They are offering you $15 a week, but I'm sure they mean $15 a month." <laugh> But they didn't and he went to work on a geophysics crew. They called them doodle buggers.

Remacle: Why were they called doodle buggers?

Cash: Because they moved all the time. They carried their life's possessions in the back seat of the car, and maybe a little trailer, —and so they were kind of nomads of that time. And relative to how it influenced me, there was another way. Each of the oil companies had their own geophysicists, and then there were some independent companies that would do that for hire. And one of those companies was based here in Dallas, actually, and it was called Geophysical Services, Inc., GSI, founded by three buddies that had all gone to MIT together. And that company, of course, evolved to be Texas Instruments. And so growing up, I had heard of Erik Jonsson, Cecil Green, and those guys were all friends of Dad's and Mother's in this little town. In fact, Mother says that Mrs. Green helped teach her how to change my diaper, so this was a very mobile little community that went around. So I knew of T.I., though not by that name, from very early days. And I ended up graduating from high school in New York, a suburb of New York, and then choosing Texas A&M as a school, which usually takes a lot of explaining. And the truth was I went there for-- the engineering school was great, and there was never an issue about that. And at that time, I was really interested in track. I was-- I had done well in high school and won some state meets in track. And I went there because they had an excellent track coach and I thought I was going to be an Olympian, hopefully. But my freshman year there, we ran against the

University of Texas. And my specialty was the quarter mile, one lap around. And, there was a guy that was a senior at the University of Texas, and I was a freshman, and he had just won the Olympics in 1956 in Melbourne, Australia in the quarter mile. And so I got on the track with him, and I was a freshman. He beat me by so much-- and I thought I was pretty good-- that I decided I needed to study harder and become a really good engineer and not worry about this track stuff.

Remacle: Brothers, sisters?

Cash: None. I'm an only duck, only child, I got all the love. In those days, you had to do something about the military. And Texas A&M has a-- it's basically an aggressive ROTC program, but you leave with a commission. So I had a commission in the Air Force and looked to a three-year stint, and did, in the Air Force. If you did five year-- if you flew, you had to commit to five years, and if you didn't, three. And I wanted a short tour, so I was a ground electronics officer. And most of that three-year stint was spent in Michigan at an Air Defense Command headquarters. And I traveled around Canada and the northern states, inspecting radar sets and working on the communications kind of stuff.

Remacle: Let me loop back to your childhood. Were you, as a child, interested in gadgets and electronics under your father's tutelage? Or in school, did a particular teacher--

Cash: Yeah, my father was a tinkerer and a handyman, not so much electronics, but just everything. I mean, Dad was a fix-it guy. So early on, I learned how to use tools. And yeah, I took a radio apart and put it back together and it sort of worked. I mean <laugh> It wasn't like I was really fascinated by that, as much as I was sort of [fascinated by] all things mechanical. So it was clear. I was good in math and science and, you know, language, foreign language, especially was a challenge. So I knew early on I needed to be an engineer. There's another story that-- relative to my childhood and the electronics industry. As Dad went in to do his service-- and we lived in Washington, D.C.-- he was assigned to the Signal Corp. Headquarters, working for the general that-- a General Back that ran the Signal Corp. And his coworker, as it turned out, was a man named Bill Hewlett. And Dad and Bill were assigned the responsibility to coordinate all the R&D programs that the Signal Corp. had let to both universities and research and companies. And Dad took the east coast and, of course, Bill took the west, because he was still actively involved with his partner, David Packard. And so Dad and Bill became best friends, and neither one of them, at the time they checked in, had an apartment. We ended up in apartments, right next door to each other for the three years that they served together. Actually, it was four that were served together in Washington. So Bill Hewlett and Flora were the next door neighbors for all that time. And I mean the embarrassing thing is it took many, many years later before I connected Hewlett Packard with Bill Hewlett, but I finally did. And it was one of the companies where I interviewed, because of that relationship.

Remacle: So when you got out of the military, you had to find a job someplace?

Cash: Right, yes.

Remacle: What was the process for doing that?

Cash: Yes, and it was a little more difficult because, of course, when you graduate and you are at a campus, companies come to that campus, but I was at an Air Force station in Battle Creek, Michigan. No one came to try to hire you, and so you had to more aggressively interview. And I interviewed three companies. And as I was telling Dad, I've got to go interview people, and he said, "Well who do you want to interview?" and I said, "IBM, Texas Instruments and Hewlett Packard." And he said, "Well our next door neighbor runs the eastern sector for IBM," and I didn't know that, so that was an easy interview to set up. And then he said, "My old friend, Cecil Green, of course, was a founder of TI," and I didn't know that, but that was easy. "And then you know Bill," and I said, "Bill who?" and he said, "Bill Hewlett, of course." And that was the day I realized "oh, <laugh> that's who that is". So I got those three interviews. The interview with IBM was stuffy. It was not a pleasant-- I didn't want to-- they didn't make it attractive to go to work there. The interview at HP was great. Mr. Hewlett was very warm and made me feel almost like a son. And the interview was great, but every person I interviewed had a degree from Stanford and I didn't, and so I thought hmm… that might be a problem. I loved Palo Alto. That looked good. And then I came to Dallas and I interviewed TI, and they also were very nice and cordial. And every person that interviewed me had come from Georgia Tech, Purdue, California, Colorado, all over the country, and they seemed so excited to be working at TI. And right at the end of the day, as I was completing the interview, I heard a Dixieland Band in the hallway. We went out and one of the programs had completed their project on schedule, and to celebrate, the project manager had hired the band, and bought a keg of beer, and they marched through the plant, and everybody fell in behind them and we went out in the parking lot and had beer and celebrated. And I thought this would be a fun place to work, so I came to work at TI in the late summer of 1964.

Remacle: Are you married, [do you have] children?

Cash: Just married. I got married and went to work, you know, in a hurry, <laugh> like we all did then, within about three weeks. So got married, went on a honeymoon and came to work. And I had gone-- while I was in Michigan, I had gone-- it was cold up there, <laugh> and it was sometimes boring and dark in the winter, so I went to Western Michigan University, which was, or is still a relatively small school. And they had just started a Masters [Degree] in business program. And I thought well, you know, it's something to do, instead of sitting around the Officer's Club and drinking, so I got an MBA during the three years that I was in Michigan, which—so I graduated with an MBA, got married, honeymoon, went to work all in about three weeks, I think, something like that. Yeah, hurry up, hurry up.

Remacle: What was your first responsibility at TI? What area were you hired in?

Cash: I had-- I felt, and I still feel that it's a good thing to get a checkmark in some squares on your resume as you proceed through your career, and I wanted a checkmark by engineer. And so I went to work at the most practical electronics I knew, radar, because of my experience in the Air Force and so I went to work. And TI, at that point, had what was called then the Apparatus Division, and later, the Equipment Division, and now they've sold that to Raytheon. But they had a number of airborne radar programs and so I went to work in the Equipment Division on a radar project called the APQ-99, which was a terrain following radar put in the nose of the McDonnell Douglas Phantom. It was a great experience and very-- <laugh> the program had fallen behind and it was very intense. They approached us--

Remacle: At which date are we?

Cash: This is the fall of 1964.

Remacle: Okay, so this is well after the hoo-ha about Jack Kilby's IC?

Cash: It was about the same, actually. So I worked-- I actually worked on that project only for a year or so. And we were-- <laugh> TI, at that time, was kind of up in the tulies from Dallas, and so there weren't really that many places to go and eat, so you ate in the cafeteria. And in the cafeteria, you would meet people from other projects. And I actually met some guys that worked for Charles Phipps in the IC Department. And I had heard about what a nice guy he was. And so I decided that a year and a few months was probably long enough to get the checkmark in the engineering thing. And this integrated circuit technology was clearly fascinating, going to grow like crazy and I wanted to be a part of it. So I went over and interviewed Charles for-- to see if he had a job and he did. And the job was they had successfully won a big program for the Minuteman Missile for the integrated circuits on the Minuteman, and were in the process of completing those, and were trying to-- they had the right to sell some of those chips to the commercial market, though the truth was they didn't-- they didn't fit all that well. But there were three circuits, three chips that were analog. They were amplifiers, turned out they weren't all that good a amplifiers, but they were amplifiers. And so when I interviewed, I knew what a DB was. <laugh> None of the other guys did…. they were all digit heads. And I knew what a DB was, so Charles said, "How would you like to be the marketing/application guy for those products?" That's great, so that's when I transferred over to the Integrated Circuits Department and worked for Charles Phipps, and worked with a lot of other young guys that were-- it was exciting. Jack Carsten was at the next desk. Dietrich Erdmann, who's still a close friend, was next to me. So we were all energized and it was very exciting.

Remacle: Did you have any interchange or interface with Kilby, himself?

Cash: At that point, he was still-- so we were in a product department, and he was over in what was called SRDL, Southern Conductor Research & Development. You saw him and met him, but he wasn't day-to-day at that point. I did later, but not at that point.

Remacle: Was he considered to be a big deal?

Cash: He was a big man. <laugh>

Yeah, the patent had already been issued and well publicized. And I think everybody knew it was important, but I don't think we all grasped how incredibly important it was. And he wasn't-- his personal best friend is-- was Charles Phipps, and so Jack was the technologist and Charles was the business visionary. And Charles always had a great insight into where all this was leading and helped shape the industry, and especially TI's role in it. So Charles has been a great mentor to me, still is. I mean he's a dear friend now.

Remacle: So you moved into Charles' IC Development Group.

Cash: Right and then things evolved. Charles was sort of reassigned and ran, SRDL. And at that point, Southern Conductor Research & Development had a number of programs.

Remacle: So let me clarify.

Cash: Okay.

Remacle: Kilby reported to Charles at some point?

Cash: No, they worked as peers at-- in the SRDL group. When I say ran it, I'm not totally clear. I actually think a guy named Willis Adcock was responsible for SRDL, and I'm pretty sure Kilby worked for him. And Charles ran the --- so the idea was we'd do the development, and then we're going to try to make businesses out of this. And that's what Charles was--

Remacle: Charles was part of the business part.

Cash: Yeah, exactly. And so there were at least four or five that I can think of, technologies that were trying to spin out into businesses. And Charles--

Remacle: And those were?

Cash: Yeah and one was MOS. One was Discretionary Wire, TTL, where you just built a big old wafer full of gates and flip flops, and then bonded and it looked like hair was growing out of the surface. <laugh> One of them was plated wire memories. There was a thin film program. I'm not sure what else, but those were the ones that come to mind. Charles thought, and rightfully so, that the one technology that sort of had the most promise and the shortest time to commercialization was MOS. And so he knew me from having worked for him before and asked me to come over and help make a business out of that. And so I became the marketing applications guy for MOS products. And that's--

Remacle: And the MOS products at that point were?

Cash: There weren't very many. <laugh> The MOS work began actually when TI and others would take a contract to build a custom device. In fact, Charles—one of my early lessons was Charles said, "We're not going to make a serious business unless we identify, specify and then build standard products." And so he was-- that was on me all the time; “where are the standard parts”?. So that's what we did. Sort of a quick sidebar, L.J. Sevin, who had worked at TI, at that point, probably for six or seven years as-- and he was noted as the MOS expert at TI. Ti had, in the early days of transistors-- not only integrated circuits, but transistors-- had understood that they needed to educate the user base about all this new technology. And so they had a deal with McGraw-Hill where they encouraged engineers at Texas

Instruments to write either papers or, better yet, a book about-- I'll make this up-- gallium transistors. McGraw-Hill would publish them and then they would sell them cheaper, give them away to customer's engineers to learn about these technologies. Well L.J. wrote a book about MOS transistors and then, obviously, later, MOS integrated circuits. I think ultimately, it was published in seven or eight different languages. It was clearly one of the most popular, if not the most popular, book in that series. And he was pigeonholed, I guess, as the MOS guy. And as he said, he felt like he had MOS engineer tattooed on his forehead. <laugh> So I met him. And ironically, the sort of fun story is that-- so I had been at TI at that point, I guess--

Remacle: You were the marketing [guy]…..

Cash: And I was working for him and LJ was the engineering guy in MOS.

Remacle: And he worked for Charles, also.

Cash: Yes. <laugh> And so it-- but just prior to that, maybe just prior to going over to work for Charles in the SRDL business part, I had a baby, or my wife had a baby. And so we go to the hospital and I'm standing there looking through the window at my son. And there's a guy standing next to me looking through the window at his daughter. And he's got a TI badge on, and I do, nerds, we are. I don't know if we had a pen protector or not, probably did, and it was L.J. And so we shook hands and met, and then a matter of-- it seems like weeks, maybe months, we ended up working together. So we brought-- his youngest and my oldest child were born within a few days of each other. And L.J. and I just hit it off right from the beginning, and he is still-- he and Charles and I all office together, still, and enjoy telling old man stories, and so it's a great way to end your career and remember.

Remacle: What were the major accomplishments when you, Charles and L.J. all worked together?

Cash: I think MOS was still was recognized as the technology that would enable the highest density, the most functions per square nanoacre of silicon that you could do, because the bipolar technology was a diffused technology and took more space. But at first-- <laugh> people would talk about it: "So the biggest problem here is, it's always going to be slow, because it has real high impedances, as you looked into these things, these big impedances, so it's going to-- going to be really-- always going to be slow". And then in those days, the process technology, the processing techniques used to make these circuits were similar to the ones-- I mean you still use mask, you still _____, and you still did diffusions, and they were similar to the ones that were used for bipolar circuits. A bipolar circuit is far less sensitive to contaminants than MOS. I mean for an MOS device you-- metal oxides, or you're working right at the surface. So any dirt, anything that happens up at that service affects the performance of the device; whereas, with a diffused device, it's all down in the body of the silicon. So it took us, meaning the whole industry, arguably, a decade, maybe not quite that bad, but a lot of years to figure how important super, super, super clean processing environment was to make things stable and make things yield.

Remacle: Would it be fair to say that MOS was a key factor in the driving of the really clean fabs--

Cash: Oh yeah, no question.

Remacle: --the more precise equipment, and, overall, the cost of a fab?

Cash: It absolutely was, is even. And the <laugh> Holy Grail, as you know, of semiconductor manufacturing is yield. I mean if it was perfect, I have 100 percent yield, that'd be great, but the closer you can get to that, the better. And what I don't think any of us really appreciated until we began to achieve much, much higher yields was that cleanliness was really the path to that. A good yield was directly proportionate to how clean you could keep the facility. So we all became-- and then of course later, you know, in the '70's, the Japanese got really good at it and taught us something. Us, the U.S., I think. Anyway, at that time at TI, MOS was not stable. The process that we were all using-- and I say we were-- Intel started in '69, we left and started Mostek in '69. Actually, Intel may have started in '68.

Remacle: I think '69 is the right date.

Cash: Okay, we started late in '69 and maybe they started early. AMD started right about the same time. So there were was no doubt that everybody was going to go chase the MOS market. But at that point in time, the process we all used P-channel. It was called high threshold. We wanted to be lower. But it was a P-channel device. The orientation of the crystal at the surface was 111 and the lattice showed you that 111 face. And the oxide thickness yielded a threshold voltage, a voltage at which the transistor would switch of around 5 volts. And that was part of the problem. Some days it was eight. Some days it was two. <laugh> And you didn't ever know exactly when. We had a process lady that used to plot threshold voltage, Mary Anne Potter. She plotted threshold voltage versus day of the week, which was a joke, but it wasn't too funny when you were trying to design a circuit and you didn't know when-- where it was going be.

Remacle: Which day it was going to work.

Cash: Yeah, exactly. <laugh> So that was the nature of the process technology at that point in time. And so, you want to know why we left TI? TI, in our view, was trying to foster all these different technologies. MOS was certainly one of them, but many of the others actually never came to fruition, or they certainly didn't have the customer traction that we were beginning to get. And TI, at that point, needed to move more jobs out of Dallas. There were way too-- they were too concentrated here and they knew it, which was true. And so they-- we came to work one day and there was a big banner hanging over our cubicles saying: Houston, where the action is. And the deal was basically you get to keep your job if you move to Houston. It was the first time TI had ever really tried to move.

Remacle: But you guys hadn't heard anything about it before?

Cash: A lot of rumors, a lot of rumors. It was-- but TI did the right thing. They were trying to move functions to Houston, and then later, Lubbock and other places that would have growth. They moved all the con-- most of the consumer stuff--- to Lubbock later, so they-- that way, they'd have to move fewer people and you'd grow in these other locations. And they moved MOS to Houston, and it grew there and

that was good. So it was a wise thing for them to do, but they were still learning how to move people. So for an employee in that group, you weren't getting as many dollars and [weren't able to] hire people that you thought you should. They didn't seem to appreciate the technology you were working on.

Remacle: L.J. characterized you guys as being kind of the stepchildren.

Cash: We felt that way. We felt that way. And that, coupled with the fact, "oh by the way, you're going to have to move to keep your job", everybody said "well, I might as well go out and interview, see if there are any other jobs". Well when we did, there were. I mean I got offered a job to work at Motorola in Phoenix, and others the same thing. But two guys that had worked at TI--

Remacle: At that point in history, though, TI was really the only semiconductor company here in Texas?

Cash: Oh yeah, absolutely. So that's the part of the move. You couldn't stay here and work in the semiconductor industry unless you worked at TI. So if you wanted to work in the semiconductor industry, you're going to have to move. So at that time, there were two other-- there two guys named Dick---Dick Hanschen and Dick Patritz---, who had both worked at TI for years, Dr. Dick Patritz in research and Dick Hanschen in sales and marketing. And so they left and started a venture capital fund in Dallas. And not only did they do venture capital, but they did consulting work for other people, and one of the companies they consulted for was the Sprague Electric Company. Now Sprague, old, old east coast capacitor manufacturer, but one of the grandsons, a guy named John Sprague, had a Ph.D. in physical chemistry from Stanford. And it was his charter to get Sprague in the semiconductor business. So along come these two former TI'ers that say put a little money in the startup and we'll move their fab into the Worcester Manufacturing Facility of the Sprague Electric Company, and you can't own them all, because these are entrepreneurs, and thus Mostek was born. We-- I look back now and we raised, I think, $4.5 million, which was by today's standard, nothing, but back then, a lot. But the truth was besides the money, they gave us two things, two assets that I guess when I think back I certainly appreciate them, but I don't think I realized, probably couldn't have done it if they hadn't afforded these two things. The first one was a fab. I mean to have all the clean rooms, all the steppers, all the depositions, everything was right there. We had to be reconfigured a little bit for our process, but not much. So Bob Palmer, who of course, later ended up running DEC, and was our chief wafer fab guy, went up there and had it up and going in months, almost weeks.

Remacle: Let's step back a step.

Cash: Okay.

Remacle: Let's talk about how did the team coalesce? How did they decide to leave TI? What was the response at TI? What did the rest of the world say? Talk about that whole period of time.

Cash: So there were really four of us that helped put the business plan together, and then when we left, there were a total of six, I guess it was. But L.J. was the design know-how guy, and a guy named Louay Sharif was a process know-how guy. And they left TI and wrote a business plan to start Mostek and got

that business plan funded by Sprague. So that took kind of the summer of 1969. The rest of us, we were told we were going to have to move, I think, in October or November, so we were all interviewing or trying to figure out what to do. And TI got word or figured out that L.J. and Louay were trying to start a company. They didn't like that at all. At that point, it's kind of hard to imagine, but there had never been a spinout from TI in any technology staying in Dallas. There had been people leave that would go to California and start a company, but nobody stayed here. And I'm sure TI felt very threatened by that. I mean who wants-- you know who-- being the only semiconductor guy in town was a good thing, so they didn't like it.

Remacle: Particularly for recruiting people.

Cash: Exactly. And so we-- actually, while we were there still, we-- now L.J. and Louay were gone, but the rest of us were there. We were told-- and this was, you know, terrible-- that they, TI were going to crush L.J. and Louay like a bug, you know, that kind of stuff. And they were trying to intimidate and scare us, and they did. We were convinced that TI was going to sue us, so that as we left, we all first went to see a lawyer, and they said do not take even a pencil. "Don't take anything. Don't make a list. Don't-- nothing. Don't hire anybody else. You know, you guys are going to come and go do your business. And when you hire somebody, be sure they're-- that means you're going have-- probably have to move them in from out of town, but stay away [from TI]".

Remacle: As I'm listening to you tell this story, it sounds to me like you guys were in communication with Louay and L.J.

Cash: Oh yeah, we were. It was a fluid situation. They were trying to start the company and hire as many of us as they thought they could get away with, and it ended up being five. But you know, they weren't sure they were going to get the money for a while, and oh my God, you know, what if TI sues us, and what if they sue us bef-- or sue those two guys before we leave. You know, who knew? But they didn't sue Louay or L.J., and they did start the company and we did leave. I don't-- it's funny now. I don't remember the precise date, but it was in early July, I think, or late June, possibly, and well before we were going to have to move to Houston. I d-- I remember the date for a funny reason is that-- I may have the wrong-- it was-- did we land on the moon on-- it was July 11th?

Remacle: It was sometime about then….

Cash: Yeah, well anyway, that was within a few weeks after we started the company, and I think it was the 11th. Anyway, that's when it happened, because I remember Vin and I went down to a downtown hotel and bought copies of the *New York Times*. We bought-- he had two kids and I had two. We bought four copies and saved them for our children with the man on the moon. So that's when we started. We started--

Remacle: Speaking of children, what were wives and families saying during this period?

Cash: It was interesting. You know, there was a certain amount of-- fear is overstated-- but nervousness.

Remacle: Concern.

Cash: Yeah. But I felt, and I know Vin felt, and L.J. too, that we were in a really, really good technology at a good time, and if this failed, we could get a job. I wasn't worried about a job. I might not be in Dallas, but I could get a job and, you know, moving wasn't the worst thing that could happen to you. So I never feared for, you know, employment, but I wasn't sure that Mostek was going to get funded.

Remacle: How well did this play at home, though?

Cash: We were young. I mean, you know, we-- who cared? I mean who cared? If we're-- <laugh> My wife said, "If we're going to move, give me a little heads-up on that," you know, a little one. But I think we were all-- we-- so to counterbalance that, we were so excited about what we were doing that I don't think the fear lasted long at all. Ironically, a couple of things happened.

Remacle: You were working for Charles [Phipps], so you had to resign to Charles?

Cash: Yeah, and Charles moved to Houston- well Charles went to Houston, but he never sold his house in Dallas. And so you know, that whole physical movement of the employees at TI was-- well it was difficult. It wasn't as easy as I think they thought it was going to be, but they-- you know they-- TI moved their MOS group to Houston and they did okay.

Remacle: What was Charles' reaction when you walked in and said “we're out of here”?

Cash: I think he was disappointed but, you know, Charles is a very <laugh> focused, disciplined guy, and said “if that's the cards I've got, I'll deal with them, so you guys have a nice life”. It wasn't-- there was nothing, no ill words. It wasn't a personal-- I mean there's a part of me that still loves TI, and a lot of the things that I learned and applied later, I learned there, and I don't forget that. There were some ill feelings, ironically, at the [Fred] Busey level. You know, he was-- you were a traitor or something. It wasn't quite like that in our mind. But that passed. And the ironic thing was with-- you know, so they were really upset when we left. And then within-- so that was the summer of '69, and by the beginning of '71, so like 18 months later, they were laying people off in the MOS curve. So you know, you guys left, but then the guys we kept, we were like-- I mean they were laying people off across the board.

Remacle: How do you start up a company when you have never done it before?

Cash: I think having done that, having started a company gives you great empathy when you end up at the end of your career in the venture business, understanding what the guys and girls that are starting a company go through, because you've been through it. I mean this is a silly story, but I remember, you know, at TI, when we needed a data sheet, I would write down the specs and so forth, and back would

come from the art department, a layout. The art department, when-- Mostek was my kitchen table, you know, you just-- you make do. In fact, I have a friend that tells a funny story, I think, a cute story. So in a big company you go to the bathroom and there's toilet paper in there. And if you are in a little company and there's no toilet paper, that might be because you forgot to stop on the way to work and get some. So that-- you have to put many hats on and do many things at the same time--

Remacle: Who were the officers of this new company?

Cash: So as we start up, L.J. is president. There was no doubt about it. Louray was the fab guy, the manufacturing guy, and he quickly hired, I mean immediately, Bob Palmer, and so Bob was a founder. And Bob was—- Louray was Ph.D. and certainly understood physically what had to be done, but Bob was the go-to, get-it-done guy, and so that was their relationship. We hired three design guys that we knew from TI that were really good, and they had all worked for L.J.

Remacle: And they were?

Cash: Bob Palmer-- I mean excuse me-- Bob Proebsting, Vern McKinny and Bob Crawford. And so they were all experienced, and it was one of the quick, funny stories. L.J. was their boss at TI, so we're starting out, he's president, and I was going to be, and was, the marketing guy and have applications and go figure out how we're going to put a sales force together and all that. And one day I said, "Hey L.J., are you going to be VP of engineering too? Are those guys going to work for you?" He says, "No, they're going to work for you." I said, "What?" I said, "I don't know how to design a circuit." He says, "No, you don't need to. They do." He said, "But I want to be sure that we don't have this argument that you and I used to have," because at TI, I was always selling stuff he didn't want to build or couldn't build, and he was always building stuff I couldn't sell. So he said, "I don't want to ever hear that again." So really, for the first five years of Mostek, I had all the development guys working for me, and I had the marketing guys, so I had to decide what are we going to build, and then okay, guys, let's go build it. And that was the best job I ever had. And that was “wow! How good is that?” So that's how we started, and Vin was-- Vin was always-- I mean it's oversimplified, but L.J. was always the leader, no doubt about it. It was just obvious, no question, had the intellect for it and the personality for it. We all loved him, followed him and trusted him. Vin was always Mr. Inside. He had finance and all the manufacturing control and stuff. And I was Mr. Outside, the, you know, sales, marketing, where are we going stuff. Back to the Sprague thing, so we got a fab from Sprague, as we did that. But the other thing we got that was really, really important, and I knew at the time it was, but I didn't appreciate it, so the Sprague logo was a rectangle in blue with a little blue border around it in a font style-- I don't know the name of it-- but it was Sprague. And so for Mostek, I chose the same rectangle, the same blue line, the same font, Mostek. And then down at the bottom, in small letters, an affiliate of the Sprague Electric Company. The power of that was you sat across from an engineer or a buyer and say “who are you guys?”.

END OF TAPE 1 / BEGINNING OF TAPE 2

Remacle: How much input did you get from them?

Cash: Very little. We were in a technology they knew almost nothing about. The other job I had to do was establish a sales organization. As it turned out, Sprague had a big sales organization for capacitors and passive devices and a small sales organization for the few transistors and they made some bipolar circuits. Those guys of course saw us coming and they wanted to be part of that. That caused Sprague a little trouble because we were going to take their guys and make them our salesmen.

Remacle: You were doing something much sexier.[than Sprague]…

Cash: Much sexier. The way that worked actually was we got a few of them, some we didn't get, some that maybe we didn't want. Time took care of that. Several of those guys stayed with us the whole way and became valued employees.

Remacle: You started Mostek with MOS at the heart of the company. How did you figure out what the products were going to be? What were your big product successes?

Cash: One of the markets that was just obvious for MOS from way back, the very beginning, was memory, semiconductor memory.

Remacle: Why was that?

Cash: Because, as I said a minute ago, MOS was the obvious way to get packing density, so you knew you could put more bits or transistors per square silicon acre than any other technology. The dominant way memories were made prior to the mid-'70s probably -- I'm not sure when the magic date was but somewhere in there -- was core. That's what everybody did. Core memory was nonvolatile. You pull the power off, it keeps its data, but it had other problems, most of which it was relatively slow and big. It took a lot of space to make those little donuts hang together. So everybody kept thinking eventually, semiconductors will be the way memory is made. So we knew that maybe as early as the late-'60s but certainly in the early-'70s, it became more and more evident. The first semiconductor memories were actually shift registers, just a long string and actually Intel dominated that with a 1,024 bit string. Then people said "That's okay, but that's really slow because it's just a string. So this random access array of bits is probably the way to go". The industry built 1K versions to a format that Intel, 1103 I think was the part number, started. So we all built those and they were not totally compatible with each other but sort of. But clearly, and this is the easiest marketing job in the semiconductor industry that ever has been, is to be the marketing guy to determine what the next memory will be. It's simple. It's four times bigger every four years. So immediately upon introducing the 1K, you started the 4K, and after that, the 16K and so on. To say K now to people, the thousands, is "God, you really made those?" Now it's megs. But a problem existed, and I think, looking back at all of the different patents that Mostek was given, this was one of the most significant. As you increase the bit density, the number of pins necessary to access any one bit increased. And as they increased, that meant the package had to get bigger and therefore the density, which was one of the benefits of semiconductor memory anyway, was lost. So at the 4K level, there weren't enough pins to keep it in a 16-pin package. We, Mostek, figured out a way, the way was simple, which was to multiplex the address lines so we could do that, to keep it in a 16-pin package.

Remacle: How did you get to that?

Cash: The way that happened was, here we are as an industry and this was LJ's good thought. We are as an industry trying to build a component that will go into a memory system and none of us knew a damn thing about memory systems. So he somehow was put in contact with a group -- they were in either San Diego or Orange County -- and they were memory systems consultants. If you think about it, at the time, you're going to build a bomb site piece of equipment for the Air Force, there will be a memory in it and it's got to be this big and that's what those guys did. They would design a memory system for--

Remacle: A specific application?

Cash: Yeah. And so they were really good, but [they were] core guys. They didn't know anything about semiconductors. So they came here and we were sitting in Dallas and were eating sandwiches over lunch and they said "It's a shame you can't get that thing in a 16-pin package." Bob Proebsting, who was the design guy, says "Well, the only way you could do it would be by multiplexing the address lines." In other words, in one time slot, look at half of the X lines and in the next time slot, look at the other half. These memory systems guys said "That would be easy because the addresses come out of the processor that way anyway." So it was like "whoa". Everybody put their sandwiches down, went to the blackboard and I was there. I think I bought the sandwiches. It was just an "Uh-oh, this is a big deal." By that evening, I think Bob had started drafting a patent. We just said "Oh, this is a big deal." So fast forward. A little cute story. We fought so hard to keep that as a secret. When we announced it, most of the world thought "no big deal."

Remacle: How long between the "ah-ha light bulb moment" and--

Cash: Announcement was six months maybe ,so it wasn't all that long. The more we thought about it, the better idea it got, not weaker. So we announced it. The memory systems guys got it immediately. It was "Uh-oh, that's a good deal." At that point, I had met Bob Noyce -- but I didn't really know him -- when he was being interviewed someplace, and he said, and it was in the press, "Well, that's a cute idea," and that really pissed us off. "Cute" my ass. This is really -- and he knew it. So years later, as I got to know Bob really well – he was a wonderful man -- I said "You said something one time that really got us and really made us even more determined." He said "Yeah, I know what it was," and he did. He said "I said cute but what I meant was 'Oh, shit.'" That was a great idea and it certainly propelled us into the business that we became most famous for.

Most people think Mostek - memories. But the other invention that we received a patent on probably was far more important and had a much more far-reaching impact on the industry, and that was the use of ion implanting in the manufacturing of MOS devices. So we started the company, and the first year or two, we were making P-channel devices and the threshold voltage was 5 volts. It was actually -5 volts from ground and that required you to use -12 and -28 volt power supplies, when the rest of the electronics world was running bipolar circuits that worked on ground and +5. So you have an MOS device in the system so there was a whole bunch of circuitry necessary to do that trans-- You're coming out of one into the other and it was a mess. What we all knew -- duh! -- if you could drop that threshold voltage down to a volt, volt and a quarter kind of range, then you could redefine ground and make it +5 ground and -5. Now you could run not straight but pretty straight across. So everybody's trying to do low threshold.

Remacle: Who is "everybody" at the time?

Cash: It's interesting. Intel, and even though they were very much a startup and their revenue was very small, because of the nature of the founders -- Moore, Noyce and the guys -- they were given instant credibility. And they were using a silicon gate technology to lower the threshold but it really didn't quite get them there. The other company that actually, at that time, was very well thought of and had a good market position, was General Instruments and they were using a nitride layer rather than oxide, which has a better dielectric constant and they could lower the voltage that way. And then AMI was trying a different crystal interface rather than 1-1-1 facing. They used 1-0-0 and that has a different mobility and therefore lowers the threshold. None of those worked all that great. They were better. So we were trying to figure out what the hell to do and we were experimenting with nitrides and doing all kinds of stuff.

The Sprague Electric Company had an R&D facility in North Adams, Massachusetts and some guys there working on -- LJ and I were trying to remember the names. McDougal was one of the guys and he was probably the lead guy I think. Sprague was very active in passive components and one of the uses of resistors is to build a lattice network with different resistive values in the lattice and that's used mostly in A to D converters. That's the application for it. They were trying to build an integrated resistive lattice so that one piece of silicon would have all these different values in it and they were trying to do it with ion implantation. And this is laboratory stuff. This is not anywhere near production. The problem they had was "How do we know when we shoot this ion stream at a wafer, how do we know what resistive value we've obtained at these spots?" They serendipitously, I guess, discovered that if they put an MOS transistor right alongside it, the threshold voltage of the MOS transistor varied and therefore, you could correlate threshold voltage with the resistance you were trying to get. So Bob goes in there and he looks at that and he says "You mean you guys were just kind of changing the threshold voltage?" They said "Yeah, but that's not..."

Remacle: They had a totally different application in mind?

Cash: Exactly. Bob was in an hour time difference and he had to drive from Worcester, and this was in the winter. He had to drive over there on these terrible-- It was the Berkshire Mountains. It's beautiful but [there are] tough roads. He was driving over there and called LJ at night and LJ tells the story at home, saying "You're not going to believe what these guys are doing." Again, it was the "ah-ha moment". We immediately took some parts we were already making in high threshold and sent them up there. They could only do one wafer at a time in this lab and Bob would drive over from Worcester back and forth. We were able to build those parts that we were making with a 5 volt threshold and we could pick the voltage we wanted, and it was just "oh, my god". So that was a huge deal.

Remacle: How did you announce that to the world?

Cash: There wasn't a one day-- I think if we had fully appreciated how important that was, we would've had a bigger release about it. But we were more -- I was especially -- anxious to not announce it as a technology but announce a part and let's show the world we not only can do it but we can make things with it. I don't remember the first device that we announced with that, but I can tell you the ones that made the most impact the fastest. We immediately started doing all the shift registers in low threshold, all the memories in low threshold. So those were the standard parts that you could say "This works. Take it and test it."

Remacle: Your customers said?

Cash: "Yay. That's great. Terrific." And the world wanted this, needed this. You didn't have to sell it. It was obvious. An integrated circuit switch, a simple switch, has basically two elements. The switching transistor sits there and you have to put a higher or lower voltage and you put it on there on what is called the load which is the pull-up part of the switch and we used a transistor for that as well, rather than a resistor. MOS and transistors had two ways of operation. They operate in the depletion mode or in the enhancement mode. The enhancement mode is where they switched. The depletion is where they're on all the time. If a transistor is on all the time, it looks like a constant current source and has a lower resistance, so that if you took the top transistor and drove it with ion implantation into the depletion mode, it stayed on all the time, looked like a constant current source, and it improved the speed power product of that switch or the whole circuit dramatically. We got a request to quote on three custom chips from Hewlett Packard Labs. The year now is '72 I think.

Remacle: So you're [Mostek] three years old roughly?

Cash: Yeah, and we're credible enough to be included on the bid sheet from HP. It was funny. They sent the chips to us, the logic diagram, and they said "This is a really big instrument we're doing and we don't feel comfortable to give one vendor all of the chips. So we'll just let you look at three of them." They were labeled "Flower 3," "Flower 5," and "Flower 8" or "9" or something. "There are others but you're not going to see those." Okay, fine. So we start looking at this and they said "We want the lowest possible power you can bid on this. We're not that worried about speed so just make the power really low. So we came back and we bid and we said "We can make all three of them under a hundred milliwatts and they said, "What? How are you doing that?" So they flew down here and we showed them an ion implant. They said "Who else can do this?" At that point, the only other company that could was AMI. We said if the power was that important, we might even make it a little bit lower and they said…. Unbeknownst to us, there were only three chips in the system and the system was the HP-35. The problem with the HP-35 is, based on their assumptions of using older technology, the battery life for an HP-35 was about 35 minutes, which wasn't too good.

So as we began to bid the program out and show them dramatically lower power—they, in turn, let two contracts for all three chips, one to AMI and one to us, identical contracts. It was such a serendipity thing. One chip was the arithmetic unit. Today we call it CPU. One chip was the logic unit, which was basically the glue that held the <unintelligible>.. And the other was the memory chip and they were read-only memories. Basically, that's where they stored the algorithms that did all of the math. So we and AMI go marching off to go build this and of course, they don't want us to talk to each other or anything like that. We assigned Bob Paluck, who's still a friend and a venture guy down the hall here to the arithmetic and he was just a kid at the time. He worked so hard and he's so good at being able to focus on the circuit. Anyway, to make a long story short, it worked right the first time, which was almost a miracle. And our read only memory also worked right the first time but our glu chip, the random logic chip didn't work. Serendipitously, AMI's glu chip worked and their other two didn't. The goal of the project was to go to an HP board meeting -- I don't remember the date of the meeting but I think it was the fall -- with an HP-35 to give to Bill Hughes. This was Bill Hewlett's pet. He challenged the HP Labs to build this and they came to the board meeting. I think actually, they built enough to give one to every board member, which was a big deal. And it was just luck because they used our chips and AMI chip. As time went on, through the ensuing years, the business was split, but we were really good at that point in life in manufacturing. So

we got the lion's share of the business and it was a terrific relationship that lasted until HP built their own semiconductor facility up in Corvallis.

Remacle: Talk about Mostek's foray in the calculator business.

Cash: This was very early. We started the company and we were building shift registers and trying to build memories and we were looking for applications that had some volume for custom work. We took a number of custom deals that we probably shouldn't have taken. This was back to Charles' lecture to me: "standard product, standard product, standard product". But one application that clearly had big volume was calculators at this point in time. We started in the summer of '69 and that winter of '69/'70, a man that we had come to know through one of our engineers, named Jim Imai -- he was a Nisei Japanese, still a friend, lives in the Bay Area and he had really great relationships with Japanese companies. He had actually worked for Philco in their microelectronics labs and knew about MOS. To make a long story short, Jim and I went to Japan and it was winter. I don't remember exactly the month but he took me to Nippon Calculating Machines, NCM, [later Busicom] and Mr. Kojima, who had the dream of building a pocketable calculator. The smallest calculator at that time was a little desktop that was half a shoebox, not too bad. They were actually MOS devices but there was a register, a bunch of flip-flops. It was not LSI. It would be MSI probably. So he had a logic diagram--

Remacle: MSI being--

Cash: Medium scale integration. So he had a logic diagram of that desktop calculator and said "Here, can you put this on one chip?" In his mind, it was important to get it on one chip. "I don't know if we can or not." So I went back to the hotel room and I counted gates and flip-flops and it was just a big drawing and it was all partitioned the way it was because of the MSI chips that he had to work with. So you could start seeing "why do we have this? If these were all on one chip, there'd be fewer—". One of the major issues in all of these chips was what package does it go in. The fewer the pins, the cheaper the package, the cheaper the circuit. So anyway, sitting in a hotel room and trying to repartition it a little bit and counting gates and flip-flops and all that stuff. I was pretty sure we could get it in a 28 pin package which at that time was one of the standards. And that was going to be really important. I wasn't that positive, so I was calling back to LJ. It was a big drawing and I couldn't fax it so I'm trying to describe it.

But Mr. Kojima wanted an answer before I went back home, so I said "I'll tell you what we'll do. We will try to build this in one chip and if we can, it'll be in a 28 pin package and we will sell it to you for $60 a piece. If we can't, we will put it in two chips, each a 28 pin package," and I was sure we could do that, "We'll sell each one of those for $30 a piece." He said "I'm not sure I want to buy that." I said "I need to go home." Anyway, he said "okay". Within a week, back home, we knew we could do it. By those standards, the standards of the day, it was a pretty big chip. It was 180 mils on a side, which by today's standards is nothing. To make a long story short, we put two engineers on it, redesigned the logic really to be better partitioned and had it done in six months which even surprised us, and it worked right the first time. We got those wafers back and we went in late one evening in the lab and in those days, you didn't have Teradynes that could sit there. You didn't have much test equipment so they had literally taken that old desktop calculator that we were supposed to make the chip look like, run a cable out the back and hooked it up to our probe set; I went down on the first wafer and turned it on and it multiplied 12 times 12 and got 144; and I screamed and hollered and popped the beer cans and that was history. That was over

a year in advance of TI's single chip calculator and later in a lawsuit between Bowmar and TI, our work invalidated the TI single chip calculator patent.

Remacle: TI still today talks about having the first calculator.

Cash: Not true. And anybody in the group there, they knew it. There are a whole bunch of little sidebar stories. I would go to the consumer tradeshows in those days just to see how this stuff is selling. I was with Mr. Kojima at their NCM booth when the Bowmar guys came by. They were introduced to me and they said "Can we buy that chip?" and I said "no because they funded the development, but we could build one for you". They went off and huddled and said "Oh, that's fine." The truth was they had already contracted with TI for TI to build them and the lawsuit later was about the exclusivity or not, and I think the issue spun around whether they bought enough of them for the Bowmar brain if you remember that. But the NCM calculator was out well over a year before--

Remacle: What led to the decision to have your own inside calculator business?

Cash: Bad logic. The logic was, and I'm sure it was similar to the logic that led TI into the business, led Intel into the logic business, is you have these consumer gadgets, if you want to call them that, or calculators and most of it's stuff we make. So why don't we just get in the real business and make calculators. Of course, the fundamental reason why that's a stupid idea is we knew nothing about the distribution channels and selling issues associated with the end product. So we started a wholly-owned subsidiary named Corvus and I was the lucky guy who got to run that and it was a life altering event for me. It was the first time I had failed at something and it was a good experience, but a tough one. And it was just all about the mentality, and the logic and the distribution channel of consumer electronics was a total mystery to us. I felt like at the end of it -- we did it for three years -- that I understood it. I was about to say I learned it. I don't think I ever did, but I did understand it, and we were getting better at it. But it was also, we were engineers. Consumer electronics is almost fashion. Let me ask Steve Jobs. Is there something-- Fashion, here? Yeah. And we could build great ones. There was nothing wrong with the product. It was fine. But it was a business we were not comfortable with. And all over a three year period, I think we made a couple of million bucks but it was painful, painful, painful. Hard lessons. A lot of kind of funny stories.

Remacle: When the light bulb go on that you should shut this down?

Cash: I have a couple of stories. One is, the day I was walking in New York City past those electronics stores on 42nd or 43rd or wherever they are and I saw one of our calculators for sale in the window of one of those stores, right next to an electronic sex device. So I thought "this is not a business that I need to be in or know anything about". We made the decision to get out, but we had a lot of inventory we needed to work off. So the way Mary Kay Cosmetics, which is located here in Dallas, the way they incent their salespeople, is to give them a gift if they have a party and sell so much cosmetics. Their company color is pink and so of course, if you're going to give a calculator away, it needs to be a pink calculator. And we had a calculator model that was perfect, just what they wanted, but we didn't have pink skins. So I had to go out and buy pink plastic. You don't buy plastic in just a few pounds. You have to buy hundreds of pounds. To make a long story short, it was a very successful program. They gave away thousands of

calculators and relieved our inventory. But at the end of the day, we still had a big flat of ground up pink plastic.

Remacle: What did you do with it?

Cash: I'm not sure. Wrote it off, I know.

Remacle: What did you personally do after that got shut down? That was in '65?

Cash: No, that's later. That's the late '70s. So we got in the calculator business sort of in '74 or '75 and we were out by '78. Toward the end of the '70s, here come the Japanese and the memory business.

Remacle: And your revenues are now about what?

Cash: We were in several hundred million. We were making money, [were] public company, [the] stock [was] doing okay, but we could definitely see "here come the Japanese into the memory business". So LJ orchestrated the sale of Mostek in a very astute way. We were able to get two companies interested in buying us and ultimately, we sold it to United Technologies. Harry Gray was running it.

Remacle: Who was the other company?

Cash: Elvasicker [ph?] was the guy's name and it was Schlumberger. It was a weird time but we saw the difficulties coming. Not only were the Japanese coming into the business and they were predatory in their pricing and good-- They were making very high-quality chips. They were very competitive. But we also saw the necessity to make the memories especially. You had to use multilevel masks. The tolerances got tighter and tighter and tighter. And to build a fab to manufacture those things got more and more expensive. We were used to building a fab for a few million dollars. I think the one we built here in Dallas -- LJ would know -- it was in the $10 to $15 million range probably, all in. We saw it coming into the hundreds and ultimately as it is today, around $4 billion. So we saw that coming and we saw the Japanese coming and we thought we either need a partner that's a strong financial partner or we need to find a home. Harry Gray said "Do you have any idea what it costs us to tool up a new jet engine at Pratt and Whitney? It's $10 billion". We said, "You're the man."

Remacle: Did you continue to work?

Cash: All of us did for one year.

Remacle: That was contractual?

Cash: There was no contractual agreement. We just thought that was the right thing to do and we all did, LJ as well.

Remacle: LJ left before the rest of you?

Cash: Yes, he did but I was very close behind him, within a week or two, I think. Vin Prothro stayed on a long time and ran the company for United Technology. Bob Palmer stayed on for awhile. Some of the other guys got hired away and Bob Paluck left. He was running design engineering at that time. So LJ was the first, I was the second and I think Bob Paluck was the third. LJ and Ben had become friends. Ben was an analyst for Morgan Stanley. Ben is a Louisiana guy and so is LJ so they became personal friends back when Ben was covering for the semiconductor industry. So Ben and LJ started Sevin Rosen and it was officed here and in New York. LJ had a couple of spare offices and as soon as I left, I went and hung out with him.

Remacle: Before we get too far, I want to go back to Mostek. My personal impression is Mostek is about memory and solving the ion implantation threshold problem was the heart of what Mostek brought to the industry. Would you agree?

Cash: Yes.

Remacle: What impact did Mostek have on the building of the Texas semiconductor industry?

Cash: I thought about that quite often since then, but at the time, we were doing it with our head down not really thinking about it. But if you build a family tree of Texas semiconductor as the Bay Area has done of Silicon Valley, clearly TI is at the root of all of that and we're one of the first branches off, the first branch in Texas. There is a guy who a good friend. His name is Mike Callahan and he had worked at Texas Instruments and then joined Mostek. He was not a founder but he was early, within the first year or so. And Mike and I were sort of friends because I knew what a DB was and I'm a linear analog guy and so is Mike. Mike went to the University of Texas so he has orange blood in his veins. Then he went to Berkeley and got his Master's and is a really talented mixed signal analog designer. So at Mostek, he undertook a standard product and wrote some patents that most people aren't aware of but Mostek offered the first DTMF chip that would generate the beep-beep-beep for touchtone dialing and receive it at the other end. So we did a lot of business. All the early touchtone phones had our chips in them. We wrote big time patents there that have stood up in court for years and years and years. And on the other end, the receivers back in the central office that would decode the analog signals coming over the lines with those-- Each time you touch a button, it's actually two different frequencies and Mike figured all that out. And he also built clocks. He built some analog circuits that others really weren't doing yet. We were first with all that. The margins were great, better than digital circuits. Early on, I thought that was a great place to go and it's certainly proven in my personal career a great place to invest. So Mike is one of the first spinouts. We sold Mostek in 1980 and in 1979, he wanted to go back to Austin and get a little closer to the mother lode at the University of Texas. So he left, went down there and started a design company, just design, for hire called Texas Microelectronics. He mostly did very low power analog designs in CMOS for pacemakers and all that kind of stuff.

Remacle: He ended up in the Bay Area as CEO? Or is that a different Mike Callahan?

Cash: No, he's still in Austin. Different Mike Callahan. You couldn't get him out of Austin. But he started Crystal Semiconductor. I was chairman and he ran it. We sold that to Cirrus. In Austin, Texas, there are probably, without exaggeration, 10 or 12 companies that have all spun out of that. Motorola moved to Austin from Phoenix. AMD moved from the Bay Area, but the mixed signal stuff that goes on down there-- I'm on the board of a company called Silicon Labs. It's very successful. All that came from that Mike Callahan branch out at Mostek, TI before.

Remacle: Are there vestiges of Mostek still in UTC?

Cash: It's part of TSMC now, but it's still over there. I don't frankly know how much work is still being done here versus other places, so there's no one over there now that I know. There is, a couple times a year, a group of ex-Mostek-ers that have a party, lunch thing, and I go. I hardly know anybody because so many of them went to work after we sold it. But it's still out there and they still do semiconductor work.

Remacle: What made you finally decide "it's time to do something different"?

Cash: Selling Mostek happened at a time in my life where there were a couple of other things going on. So this was late '79. The deal actually closed I think in January of '80. I discovered in the fall of '79 that I had prostate cancer and I had that to deal with, which I dealt with at MD Anderson with surgery. And I also discovered over a period of years prior to that that I was not in a good marriage and so I got divorced. I got divorced, I had cancer and we sold the company. Everything happens at once and then you go on. So that happened and so I was single and living here in Dallas, healthy, thank goodness.

LJ and Ben had started Sevin Rosen and I needed something to do, so I hung out with LJ. I was there when Rod Canion and the guys came up with the business plan for Compaq. LJ asked me to talk to TJ [Rogers] before they put money in Cypress and so it was kind of fun. And Ben was still writing his newsletter and selling it. He was no longer at Morgan but he was still writing that thing. I actually helped him write one on solid state memory, so I was just kind of-- It was fun but I knew that I wanted to be in venture capital. Remember, think where we are. We're in the early '80s and so there were a couple of things on the horizon that were clearly going to happen and were going to be big. Semiconductors were part of all those things because they were the guts, the fuel but the businesses were totally new and different. I was single so I decided that I wanted to be a venture capitalist but I wasn't broad enough. I was semiconductors only. So I took a period of about two years to try to broaden myself. So I did three things.

Back at the end of the Mostek days, late '70s, '77 or '78 or something, I had become friends with Steve Jobs. The reason we were is that it turns out that Mostek was the first company to give Apple terms. Everybody else was making Apple pay COD and that was because Steve was wearing flip-flops and t-shirts. I just met him and thought he was one smart dude and was fascinated with what he was doing and what his thoughts were. So we gave them credit and Steve thought that was great. But every time I'd go to the Bay Area I'd want to go see Steve, so we became friends but business friends. The minute it was announced that I had left Mostek, Steve called me and said "You've got to come to work for Apple." I said

"Steve, no. I'm divorced. I have two children here. I've got to stay in Dallas. I can't do that." He said "But we're doing the coolest thing. I've got to show you. I can't tell you over the phone. You won't get it." I said "Steve, it doesn't matter. I'm not moving." I was living alone in a little house and within an hour of saying no, there's a knock at the door and there was a courier with a first-class ticket to San Francisco the next morning and it said "Call me." So I called Steve and said "Okay, I'll come. But I promise you, I'm not moving." So I climb on the plane, fly to San Francisco. This was before all the high security. There's a guy at the gate. "Mr. Cash, go get in the limo. [Let's] go down [to Cupertino]," and we go right by the Apple campus and we go to an intersection in Cupertino where there had been a Texaco filling station and behind it, there'd been a dentist's office. Steve has rented the dentist's office and it's the Mac. It's a crew of I think 13 or 14, two teenagers. And the reception area of the dentist's office was a big ping pong table with the net taken down and all the circuitry guts were on it and a keyboard and a box with a button on the top of it -- a mouse. I'd never seen a mouse. So I sat down and within certainly minutes, I was grabbing stuff and moving it and I was blown away. He said "I want you to come out and be the marketing guy." I said "Steve, I am the wrong guy for this." So rewind. In the '70s, I'd gotten to know Bob Noyce pretty well and his wife. She at that point was the Vice President of Personnel for Intel.

Remacle: Intel, and then she went to Apple.

Cash: I said it wrong. She was at Apple then as VP of HR, Ann [Bowers]. Anyway, she sought me out and said "We would really like it if you would kind of help Steve." I think he was chairman but he wasn't running the thing then, and he hadn't hired Scully yet. But they had kind of taken much of the operational stuff away from him. Anyway, to make a long story short, I agreed to do it but I said I've got to commute. I've got to spend the weekends with my kids. So I flew out there and back for 10 months, 10 and a half months. What I ended up doing -- and Steve had to ask me to go with him every Monday morning, so it got me out there early enough, to the executive committee meeting. And so here's all the guys sitting around and every Monday they said "What about this program do you know?" I said "We don't know what we're going to call it but for now, we're calling it the Mac." "What software is it going to run?" He said "It'll run whatever it takes." "Who's going to buy it?" "Everybody." He said "Tell us more about it?" He said "You know the kitchen? You've got a Cuisinart. This would be the Cuisinart of your desktop," and everybody kind of groans.

Anyway, of course, it was a wonderful success. They were trying to implant some of the disciplines in Apple that many of the people they hired had had at HP. So one of the documents that they wanted Steve to create was called a PIP, which was a Product Introduction Plan. We would call it a business plan. It had everything about a business plan except manufacturing, which I just turned over. "Steve, where's the PIP? Where's the PIP?" So to make a long story short, I got to accumulate, compile -- I didn't write anything. It was all out of Steve's [head]. The problem was---Steve had --- he's got an attention span on a great day of about 20 minutes. So he'd have an idea and it would be a great idea, but then he was onto something else. So I kind of compiled the PIP and left. Steve was very upset when I left, but I really needed to get back and tend to being a father. Years later, when he married and had kids, he actually called me one time and said "All right. I finally get it." But it was a wonderful experience. I should've paid them to let me do that, look over their shoulder.

At that time, Sevin Rosen, the guy in Boston who did the software company that replaced Lotus-- So I introduced Lotus to HP and that didn't take, but it was okay. It did up in Seattle. So that was one thing I did to try to broaden myself and that damn sure worked.

Also back in the '70s, I had been asked to go on the board of a company here in Dallas called Communications Industries. They were an acquirer and operator of radio common carriers, which were the precursor to cellular operators. They also ran paging companies. And during those years, some guys came to me and I agreed to act as CEO and then quickly hire Jackie Kimsey to be the CEO of a company called ProNet, which was a successful paging company. I actually wrote the business plan for ProNet. It was a service company. We didn't make anything. All we did was make a beep and that was good. That was a good experience and certainly a precursor to all the stuff that was going on in the cellular world. It worked, made money. Sevin Rosen backed it. Jon Bayless was the guy on the board. Actually, LJ came on the board later, so that worked, so I did that.

In addition to that, I had friends here who had met through years in the industry who had started a company called Intecom and it was the first integrated voice and data switch, telephone switch. They had worked at Nortel before and came out and started that. The president, Mike Bowen, asked me if I would come to work there and I said "no. I don't want a real job". He said "How about if you consult?" So I did that again and basically helped them go public. We got Lehman to take us out and then helped them find a company to do the maintenance for them, which was GE. I negotiated that; helped them find a Vice President of Sales, which took awhile to get that; and then helped them find a partner in Europe. So I took projects on.

Remacle: When did you convert to be a real VC?

Cash: Right after that. Because here I am now. I'm sitting in Dallas, Texas. Sevin Rosen is wildly successful and I'm pals with all those guys and I have been pals with the Apple phenomena. I'm a semiconductor guy which is still good and Dallas was beginning to be known as a telecom town. So my goal of broadening myself worked. Those jobs worked over about a two year period. So the first thing that happened was that California-based VCs came to me and wanted me to open a Dallas office and join them, Kleiner and Mayfield. So I went to my buddy LJ and said "Should I do that?" He said "If you're going to do that, why don't you join us. But if I were you, I wouldn't."

So basically, LJ said "Why go to work for anybody? Why don't you start your own fund? So about that time, Interwest, in the form of a current buddy -- Scott Hedrick -- came to me and said "We'll help you raise a fund. Focus on Texas and just allow us to co-invest with you." So they introduced me to all of their limited partners as well as they put $4 million in the fund. I raised a $25 million fund with their help in three weeks. I was thinking "how hard is this"?

Remacle: It seems to be pretty easy.

Cash: Yeah. So that's 1983, actually the very end of '82. So I started investing in a cleverly named venture fund, Berry Cash Southwest Partnership. I'm proud of this. We got that all invested and realized a return to the LPs of about 23%, which is not bad in that period of time. Interwest only invested in the good deals. In about the middle of that, in '86, they came to me and said "We're going to raise our next fund. Would you consider joining us?" I had to make a decision. Do I want to do a Berry Cash II or join them? About that time, I had come to appreciate the value of West Coast window, understanding what's going on out there and they, by that time, figured out I was well enough connected down here that it would be a

good marriage and I'd been at that ever since and it's worked well. We've done some great deals, some out of here and some out of theirs.

Remacle: If you look back on your career, what period was the most exciting and fun?

Cash: No question, that. I often tell entrepreneurs the most fun you'll ever have is doing it yourself and the second most fun you'll ever have is if you're a VC and you help another guy do it and you stand real close. Goose bumps are contagious so if you've got a case of goose bumps, it's probably because you did something great. And if you helped a guy do it, you'll get a mild case and that's good.

Remacle: What are the biggest business lessons you've learned? One you mentioned was standard products.

Cash: Yeah, that was very practical. I think the other skill, if you don't develop this, you will fail and that is to be able to judge character in others. Clearly, the best asset that I have in my life are my real smart friends, so try the best you can to be pals with smart people, because no one is smart enough to know it all. So the broader scope of friends and the broader areas of technology and business, the better off you'll be.

Remacle: If you could change or redo something or identify the biggest mistake you made, what would that be?

Cash: I think a couple of things. I don't think in terms of regret so I'll modify your question a little bit. Maybe what are the biggest lessons you've learned. I think that one in the consumer electronics thing. Just because you're good in one business doesn't mean it transfers to another. There are business principles that do, but there are so many unknowns in some businesses that are totally foreign to you that unless you've grown up there, you won't get them necessarily quickly. So that was one. There was another one that I think so many VCs don't get or they don't get it quickly enough. So we, us electronics guys, are used to an industry that changes like this. Hell, at one point, Compaq was obsolescing a model every six weeks and so you're selling chips into that. So the velocity of what goes on is like this. You step outside of this crazy world and invest, say, in a company that makes power generation equipment, it may be the slickest, most fascinating power generation stuff the world's ever seen but that industry will not accept it, make the change fast at all. It's, by our standards, _____. So in your mind's eye, in the business plans you put together, you've better be prepared for that kind of a growth rather than that kind of a growth.

Remacle: What was one of the more interesting or fun things that you remember**?**

The two giants of integrated circuits, Bob Noyce and Jack Kilby. And you'll relate to this. In the late '60s and early '70s, there was no American Electronics Association, but there was WEMA, Western Electronics-- The powers that be out there wanted that association to become AEA, which it did. There was another trade association that came out of RCA and kind of the East Coast guys but it was totally different. So the WEMA powers that be said "Let's move east and those guys in Dallas seem like good

guys. Let's open a chapter in Dallas, Texas." So they did. First of all, they wanted TI to join and TI wouldn't join. So they needed another guy now. So yours truly got to be the first president of the Dallas branch of WEMA. At that time, for a three year duty cycle, Bob Noyce was president of WEMA. The really only hard job, when you're president of the local office, you go to their board meetings, a couple times a year which is painless, but you've got to put together a program and I think we were meeting once a month for the winter months. Maybe it wasn't quite once a month. So six programs you've got to think of somebody to come in and speak and let guys eat rubber chickens. I was straining to come up with this agenda and that agenda and we ended up with 30 guys in the Marriott hotel over here eating bad chicken at round tables. Then I was at one of the national meetings and I said "Bob, would you come and make a speech?" He said "Yeah, I would. But I'm not sure how interesting that would be. What would be really interesting is if we could get Kilby and I both to talk." I said "Have you ever done that?" He said "Never." I said "Geez, I don't know."

So I called Charles. Charles is best friends with Kilby. I said "Jack, Bob Noyce is coming to town. Would you be willing just to stand up. This will not be an argument about which is more important or any of that. It's just 'tell the story of how you came to the patent and the invention'." He said "I'll have to get approval from the lawyers." I thought "oh, shit". He did. And so that night -- I'm cutting this a little short; he didn't get it right away. They had to be sure there was not an argument. I said "I promise you, I'll be the moderator. That won't happen. Bob doesn't want to do that, either."

So the fun part was, they each stood up. First of all, rather than 30 people and rubber chicken, we had 200 people, a lot of TI-ers, but a lot of other people, too. The hell of it is, the press-- I should've called the press. It should've been video'd. So they both stood up and Bob is so articulate and fun and funny and Jack is, bless his heart, just an okay speaker and stoic. But he did convey what was the thought process? How did you connect the dots? The amazing thing they both said -- and they said it in a very non-threatening way, was "I, Jack Kilby, knew we should be able to interconnect active components on a piece of silicon to make a function, a circuit function. And it seemed obvious to me that the way to do that is with a planar process." Duh! So Bob said "Well, it seemed to me that if we had a planar process, it would be obvious that you could hook <inaudible>" And they wrote these two patents, which are basically the same damned idea and yet, they still do. They're old now, but total separate pillars. Isn't that cool? The most fun was going out for a drink afterwards.

Remacle: Is there anything we haven't laid down?

Cash: That was the cute story, the fun story.

Remacle: All right. We're done. Thank you.

END OF INTERVIEW

