Oral History of Marvin Rudin

Interviewed by:
David Laws

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Laws: Good afternoon, it's Friday, April the 14th, 2017 and we're here at the Computer History Museum in Mountain View, California. My name is David Laws, I'm Semiconductor Curator at the museum. And we're going to interview Marvin B, Rudin (Marv) about his life and career in Silicon Valley. Marv, could you tell us about where you born and about your childhood?

Rudin: Well I wasn't born in Silicon Valley, so my life outside of Silicon Valley started in Glendale, California. Actually we didn't live there, we lived in the north end of Los Angeles but the hospital was in Glendale, White Memorial Hospital. And my parents, after a couple of years, moved to a place that was busy, one of the busiest streets in Los Angeles called Fletcher Drive, My dad was working for the Los Angeles Police. And to make extra money, this was back in 1929 and there was a crash and so people needed more money, and my mother put up a market in front of our house. Later on, when I was only seven, I was selling papers out on a busy corner of San Fernando Road which was the north south road to San Francisco from Los Angeles. It was the highway, there were no freeways, none, no freeways. Other notable things were that I broke a leg with my neighbor who was quite a sports guy, Kenny McTaggart up in the Verdugo Hills nearby. That got patched up of course. Then at 13 I had appendicitis and was in the hospital. But the big thing came when I was just about to turn 15, World War II started, the Japanese attacked Pearl Harbor It was a big shock and I was selling papers in Glendale at the drugstore there, I believe it was Thrifty Drug, it might have been Sontag. Anyway, it was a big shock. It wasn't like today where you'd hear about it right away, people were asking, "What happened?" and I couldn't tell them as it wasn't in the newspaper, it had been printed the night before. I had to come home to find out on the radio that we'd been attacked at Pearl Harbor. Also when I was in first grade there was a big earthquake. It shook down our school in the middle of the night. They had a shortage of classrooms and they had those tented type that they use in the military with a wooden foundation and a tent top. They couldn't find a space for me in my class so they moved me ahead a half a grade. I managed to do well enough to survive and in 1944, I got into Caltech. When I got into Caltech, I didn't know that it was going to be hard [to get in] so I only applied there. I got to learn later that there were 350 qualified kids, it was boys only then, so qualified boys who were authorized through their high school record and they only were going to take 50 because Caltech was almost all full with the Navy V-12 program. So they only take in 50 for the freshman class and luckily I managed to get i.

Laws: What year was that?

Rudin: It was 1944, when I graduated from Franklin High.

Laws: You graduated from Franklin High in 1944.

Rudin: I forgot to mention that at Franklin High I wrote a column for the sports page. The editor of the sports page didn't want to write it anymore, so he asked me to do it. I took journalism at the time. I guess

that made me notable there and so I ran for office for the Boys' League President. Boys' League at that time was a sexist outfit that held assemblies only for boys and there was another one for girls for the Girls' League. So that was practice for me in public speaking.

Laws: What did you enjoy doing at school, any particular subjects? Math, I presume, based on your later career?

Rudin: Yeah, I was good at math and it kind of goes back to when I was in the fifth grade. I was walking home and I remember thinking that day that something had transpired, I was up at the chalkboard and it seemed like I was the only one in the class who understood. I can't remember what it was, but I was the only one who seemed to understand it right away. And so I was walking back and I was thinking nobody ever told me that some people are smarter than others, I just thought all kids were about equal. And at that time I thought, "I wonder why they didn't get what I got?" And then gradually I began to see like in junior high, they used to give us math quizzes when we first came into class. There was a five minute rule and you had to solve all the problems in five minutes and submit them. They were all arithmetic and if you could get it done in five minutes and they were all correct then you got a star or whatever. At the end of the semester, I was far ahead of the other people and I won it almost every day, probably did every day. So then I began to realize there is a difference, and then it became more apparent in high school. At Franklin High, high school was three years and junior high was three years. And when I went to Franklin, I had an older brother, three years older than myself and he had a car. It was three miles away, so I went with him. When I got to Franklin, in my very first English class, I was quite sure that several girls there were doing better than I was but at midterm, the teacher said, "I'm only giving one A out and it's Marvin Rudin." And I was reading a book which I normally don't do but I just did it because there was time to kill while she graded. I just about fell off my chair, I couldn't believe it. And then gradually as time went on, I kept getting As and ultimately I graduated first in the class scholastically.

Laws: . Were there any particular teachers that encouraged you in one subject or another?

Rudin: Yes, Hitchcock in the fifth grade wanted to advance me another half year.

Laws: Okay.

Rudin: And I and my parents decided that I wasn't physically mature enough to be in a class a whole year advanced. But I think maybe I should have because it would have gotten me out of Caltech even sooner.

Laws: Well it doesn't seem to have hurt you too much Marv.

Rudin: So I applied in Caltech in 1944 and then I went in the Navy for a year and a half. Oh, and why did I go in the Navy, because half of our class nearly, 24 all enlisted in the Navy for the Eddy program which was going to teach us to be electronic technicians for the Navy.

Laws: Etty, E-T-I…

Rudin: E-D-D-Y.

Laws: E-D-D-Y, okay.

Rudin: And we were going to be electronic technicians and they needed them because there were new things that people who knew ham [radio] and all that couldn't handle, namely radar and sonar. Those were big things for the war, important things.

Laws: Okay, so you applied to the Navy and you were enrolled in the Eddy program.

Rudin: Yeah, I enrolled in the Eddy program that was to teach us electronics for the Navy, their kind of electronics. And the way it worked was we first had to go to boot camp, everybody who goes in the Navy goes in boot camp first, maybe for no good reason but that's the way they do it. So in the company I was with, my great buddy from Caltech was Bill Bittner and he had gone in too but he didn't appear on the train that took us all to Chicago and to Great Lakes Naval Training Center where we went to the boot camp. And I was really upset about that, that he wasn't there because we were really close. But in any case then I didn't have a buddy in the boot camp, so on weekends, I'd go up to the recreation center and they said they were having a ping pong tournament. Well I'd played a lot of ping pong both at Caltech and also before Caltech, so I was fairly good at it. We used to play for money, so you had to be good because you didn't have much money. So anyway, I entered and there were 2,000 men in the boot camp I learned later but I managed to win that very first tournament. And the guy I was playing, he won the first game, we had to win two games out of three and he won the first game easily, I struggled but barely won the second game and then the third game, game was 21, and he was ahead 20 to 15. I said to myself, "I'm going to throw caution to the wind and I'm just going to whack every ball, try to kill every shot," and I did seven in a row, I've never done that before or since and won the tournament.

Laws: Good for you.

Rudin: Yeah, and then after that there was a tournament every week. Some little guy came up to me after I'd won and he beat me, and then for the next four weeks, he beat me in the finals. And then he left, and I won again, so I won two out of six.

Laws: Good for you.

Rudin: And then I tried boxing as well. I'd never boxed before and I was scared to death on the first bout because the other guy had knocked out somebody the week before. I put my arms up to shield and I thought, "I'm going to show him I'm not afraid of him," so as he came out of his corner I started punching him early. It turned out it was an easy fight, because it turned out I had a reach on him and I just put my left into him. I said, I'm not going to back up because I saw this other kid back up and he got knocked out of the ring by this opponent last week. So I quickly came up with a strategy and it won for me and from then on I didn't lose a fight, I had one draw.

Laws: Good.

Rudin: Yeah, I mean that was really thrilling because I'd never done these things, probably never would have if I hadn't gone in the Navy.

Laws: What did they teach you at the boot camp? Was there any electronics training?

Rudin: Well one of them was to recognize Japanese planes for one thing. No electronics, no.

Laws: No electronics at all.

Rudin: No, no, this was a general boot camp for-- well these were special people, from Yale, Harvard, the crème de la crème mentally. And they gave us some kind of a Navy IQ test and I didn't score highest in that, the guy from Yale did, a Jewish guy from Yale. But anyway, I did all right but not like some of them. And yeah, so the Navy finally discharged us [from boot camp] and some of us were sent to what they called pre radio I think. One of them was in Chicago, they took over a high school [Marv Rubin's note: it was Manley High School] that was on California Street in Chicago I remember, I don't remember the name of it but they took it over for the Navy. It was a great chance to go out and have fun when we weren't studying. We were heroes in Chicago in World War II. In the coast there were more sailors and whatnot but in Chicago, a uniform was everything, I found out. So I had a lot of good times there, it was only about, I'm not sure, it might have been four or six weeks. And had a chance to go visit relatives in Ashtabula, Ohio that I probably never would have seen otherwise and I experienced some strange place to me in the Midwest. Ultimately I got sent to Treasure Island here in the Bay. When, let's see-- wait a minute, no, I'm wrong. First we went to Del Monte, California where they had the hotel Del Monte, that was in…

Laws: Hotel del Monte was in Monterey.

Rudin: Monterey, it was in Monterey, right, I'm sorry, not Del Monte, but it's the del Monte Hotel. And I remember, while we were there, one of my classmates from Caltech came through the lobby and he said, "Hey, everybody, guess what," he said, "They dropped this big bomb in Japan and the war is going to be over quickly." He didn't know it was an atom bomb.

Laws: Sure.

Rudin: A couple of huge bombs. The hotel was interesting, they used the stables for electronic labs, the stables by the polo field there at del Monte where we used to march to Colonel Bogey, if you know that march, and they used to sing, <singing>, "Horse shit, it makes the grass grow green."

<laughter>

Rudin: And like that. And then we went up to Treasure Island for the final schooling.

Laws: Okay.

Rudin: And there we saw huge amounts of sailors coming back and marines coming back from the war. And also we saw, and this is an interesting thing, German captives from the Africa Corps. They were the cream of the crop, I guess, they were all over six feet and they all marched in rhythm beautifully, and they served in the scullery dishing out the food, and then us eggheads would be marching like stragglers, nothing like that.

Laws: Interesting memory, Marv. So you were out of the Navy in 1945?

Rudin: I got out just in time to go back to Caltech.

Laws: Okay.

Rudin: So it turned out that I was in for a year and a half in the Navy. Oh, I also got a surgery done on a hernia I had that would have kept me out of the war but nobody wanted to keep out of the war in World War II because you would have felt like you were disloyal to the country. So I went in anyway and they never could detect it, I could hold up the hernia so the doctors couldn't detect it. And anyway, I got it taken care of with surgery before I got out of the Navy. Oh, the other funny thing in the Navy after we got through the electronics school, even though the war was well over, they assigned me to repair movie cameras. , -- Help me on this, the 16 millimeter, 16 millimeter.

Laws: Sixteen millimeter, the wind up clockwork driven type?

Rudin: Sixteen millimeter, well they were expensive ones for the Navy. And it turned out all we did was throw darts because nobody cared and then the captain came in and caught us throwing darts and we thought, "Oh, now we're going to be in trouble," and he said, "Hey, those feathers are a little ruffled," he said, "I need to get you some new darts." <laughs>

Laws: Interesting.

Rudin: And one of the officers went off with one of the WAVES, that was the females' Navy, the WAVES, ran off with one and there was no discipline, it was sort of like MASH only real. So anyway, I got out and went back to Caltech and I did better than I did as a freshman for three years, with my grades. And I moved closer to the school, for a long time there I actually drove from my home to the school.

Laws: And so you graduated from Caltech in?

Rudin: Graduated in 1949.

Laws: You graduated with a BS in electrical engineering?

Rudin: Right, and I had a professor in the senior year mathematical physics [Robert Langmuir]. I scored 100 percent on his final and so he thought I was absolutely sensational and he wrote a letter for me to Simon Ramo, also a Caltech grad (PhD) who ran engineering at Hughes Aircraft. They had this giant contract with the Air Force to make fire control radars, or fire control systems, excuse me. And so that was a great place to get a job, and I thought, oh surely they'll make me an offer with that recommendation to Ramo. Instead the human services, or human resources or personnel as they were called then, lost my letter.

Laws: Oh no.

Rudin: I couldn't even get it back from them, didn't invite me in for an interview and on top of that, I couldn't get in touch with Professor Robert Langmuire again…

Rudin: I couldn't find him because he'd gone off on a sabbatical to Spain and so I couldn't get another letter., There were no jobs then, for whatever reason, all these guys came back from the war I guess and they occupied the jobs. And although my classmates got on with Hughes Aircraft, so who knows. So I was driving along in Burbank and I saw a little place that looked pretty run down and it said, Goslin [ph?]

Engineering, so I stopped to see what they did, and he hired me. But he hired me at a rate that was like 60 percent what I would have gotten at Hughes Aircraft. I designed magnetic components for him for a year. And then I went back to Caltech to get a master's degree because some of the other guys I knew did that and I thought, well maybe I should do it too. So I did and I even tried to do something stupid and tried to still work for this guy who started paying me more after he saw I could do everything he needed, this Goslin. And so I worked for him at nights and still tried to go to Caltech in the daytime but it didn't work out after one semester, I had to drop that and just concentrate on Caltech and I got a master's degree with a specialty in feedback control systems [under Professor Wilts]..

Laws: What year was that?

Rudin: That was in 1951.

Laws: Fifty-one, okay.

Rudin: And I joined a company called Coleman Engineering. Owner Ted Coleman was a graduate of Caltech and Caltech had an employment department that led me to his company. I worked for them for two years on all kinds of strange R&D projects [e.g., a Navy anti mines wave generation study] and then I thought I'd rather get into electronics. See they think a Caltech graduate is like a physics graduate, he can do anything technical. <laughs> Right? So I went to RCA and I was with RCA five years. After I was there about two years [with 4 engineers under me], they gave me my first supervision level title as a group supervisor [Marv Rubin's note: I hired Bob Graham, later Intel's first market manager then]. We were working on a secret project for the Air Force which I'm sure isn't a secret anymore, so I can tell you. It was a Doppler radar that hones in on the Doppler effect of targets that are moving. They had the contract, I found out later in competition with another company that had the same contract, Westinghouse. I was responsible for one part of it, the stabilized local oscillator [or STALO] which was not very big but it was like the foundation of the Doppler radar because it provided the foundation frequency that had to withstand airborne vibrations. So I came up with an idea of using two frequency-offset microwave cavities physically opposing one another with their end plates in between them forming a cavity containing hydraulic fluid so they could flex to make the center frequency of each going up and down in unison. [The hydraulic fluid dampened vibration. You could offset them with a screw at the end of one of the cavities to change its frequency a little bit from the other one. So by subtracting the two signals that came out, you had to first rectify and then subtract them, you got a curve like this versus frequency that held a Klystron oscillator tube in the center between the two frequencies at around zero in the frequency differentiator curve. And I got a patent on that. Then it turned out we lost the contract after about four years, maybe four and a half, to Westinghouse, the final contract. So then they started putting me on things, which I hated, like countermeasures where you have to imagine what the enemy is going to do and then imagine what you can do about it, which is like playing chess with yourself. <laughs> So anyway, I did it for a while but then I decided to leave.

Laws: And where was RCA located, is this in Los Angeles?

Rudin: Oh, it was RCA on the West Coast, it was on Olympic Boulevard on the west side of Los Angeles, not far from Santa Monica.

Laws: Yes all right.

Rudin: Yeah, so it was a great location to have fun., And by the way, I would never take overtime because money wasn't important to me, I knew that there was an atomic bomb that Russia could throw at us and so I said, "Have fun while you can," and that's what I did off hours, I was very serious on the job and then off hours, I didn't want to work overtime because I wanted all the rest of the time to myself and to fool around with ladies and play games and whatnot.

Laws: On the beach at all in Santa Monica?

Rudin: Yeah, oh yeah, I got to be a pretty great two-man volleyball player on the beach, yeah. Oh yeah. And oh yeah, Muscle Beach.

Laws: Sure.

Rudin: Yeah, and I hung out at Muscle Beach and I knew the guy who ran it and he sometimes had an extra girl for me and things like that. And sometimes the girls didn't like the musclemen, they like a skinny guy. <laughs> Oh, it was interesting. Oh, and I met my wife, that all ended when I met my wife there at RCA, she was the secretary to the personnel manager.

Laws: At RCA.

Rudin: At RCA

Laws: And what was your wife's name?

Rudin: Her name's Jan.

Laws: Jan.

Rudin: His name was Russ Javens but that doesn't matter in this story. So anyway, we lived on the Sunset Strip for a while after we got married and I even started a TV repair store on the Sunset Strip next to Bublitsky's [ph?] and that was interesting, all the types of people, Hollywood actors and so on. And there was a place next door called the Aware Inn where like Marlon Brando would have hamburgers or whatever there. Yeah, we met all these kind of people. You said I had an interesting life but you don't know the half.

Laws: Didn't know the half of it.

<laughter>

Rudin: Anyway, I got a job at Aeronutronic, the Ford Motor Company got a bee in their bonnet that they should go into aerospace.

Laws: So we're about to about 1958 now I believe.

Rudin: Yeah, I went to RCA in '53 and then '58 was five years later and I left and I went to Aeronutronic. By the way, almost every job I had didn't take advantage of what I knew before, of course I'm a Caltech guy like a physicist so I can do anything! So they brought me in and they wanted me to, what was it, analyze telemetry. It was interesting, they had executives and they were using the old Grand Central Air Terminal in Burbank and the females there up on the upper lobby there were all working for these executives and then us peons who were high level engineers were downstairs working. And that went on long enough for them to get their big wonderful sensational campus built down at Newport Beach. So they got it built in about six months and we all moved to Newport Beach in Orange County. I did the telemetry study, they got a contract for a telemetry study for the joint services to analyze the different competing forms of modulation that were being used to send missile test signals from the missiles to stations along the missile ranges. So it turned out that ultimately PCM is the best when you think of everything involved even though PCM once it drops out, it drops out completely whereas FM or phase modulation or amplitude modulation, they don't die suddenly, at least you can go a little lower and gradually the noise comes in. But PCM, once the noise drops it out, it's very rapid, a little more noise and it's gone. So that's what we discovered, we got data on it and turned in a report and so on. And at the end of that, there wasn't much to do there. I had a buddy there who had the radar department and he asked me to come and join him but we really didn't have any contract to work on. So I realized that isn't going to last so I started looking to take advantage of my knowledge of telemetry and the company that hired me was a missile telemetry leader Radiation Incorporated [in Melbourne, Florida]. They hired me, I think it was like 1959, at the end of '59 or…

Laws: Nineteen-sixty I think you told me.

Rudin: …maybe the beginning of '60.

Laws: Right.

Rudin: And they didn't treat me too well it turns out. Dick Hultberg hired me and I told him, "I don't want to work on proposals at all because when I worked on proposals at my last two jobs, I didn't run the proposal, somebody else did and they lost it." I said, "I hated working on something that long and thinking all about it, and then you don't get a chance to actually prove you were right." <laughs> So I didn't like that, you know. I hired a very, very bright guy from Italy, Fiorino Fiorinni. And they also had me take over supervision of the engineer responsible for A to D and D to A converters [at Radiation]. What a surprise. Robin's edit: I didn't know then but that would lead me to push through the creation of the first 10 bit IC D/A converter 12 years later]. After I was there about maybe four or five months, I was pressed into service to work on a proposal and I said, "Look, you told me that you wouldn't give me any proposals." And he said, "Oh yeah, but the upper management is insisting on it." So I said, "Well, okay. I'll work on this one if you let me run it. At least I'll have myself to blame." <laughs> So he said, "Okay." It was like instrumenting monkeys in test sleds to see what happens when you shoot them at high speeds like, I guess in a space shot. I remember going out to a company in Hollywood, California, that was expert in medical pickups and got their input. I wrote the proposal and we lost it not because we didn't have the best proposal because we did have the best proposal. But a college with practically no overhead won the contract. <laughs> One more way to lose proposals. But then the next three proposals I wrote, not only one, but they got the contract. So <laughs> I didn't have a loser on these proposals. One of them was where Fairchild was a subcontractor and I was able to line them up as a subcontractor. There were 90 people at the bidders conference, engineers. Probably more than one from one company, but I was the only one from Radiation and I said, "Oh, my God," you know. It was all these people, and I thought, "How can I win this?" Then I remembered that Bob Graham had come out to Radiation and I had got some of the key people from Radiation in a room to hear his pitch on Fairchild's new IC chips, and I thought, "Oh, I'll contact him and see if he can line them up. After all, he's a top marketing guy," and he did. He lined up for me to visit Gordon Moore and Vic Grinich, both founders of Fairchild, as you may know, and I talked to them. Fiorini went with me and he was mainly enjoying the fact that he could get these wonderful California artichokes.

<laughter>

Rudin: But anyway, he was a smart guy and I relied on him on anything new or complex, he was terrific. Even quantum mechanics. And we used to play chess together all the time. He was pretty good. Anyway, to make a long story short, I won the contract. Oh, and one of the things I did that we wouldn't have won it if I hadn't was [to find low cost competitor for the RF circuits]. We had an RF division at Radiation and we had a Data Systems division. The Data Systems division was bidding it but the RF division didn't know how to get a RF integrated circuit. Oh, did I forget to say that that telemetry system had to be all integrated circuit if at all possible?

Laws: In 1961?

Rudin: Yeah. Because in '62 is when we won it.

Laws: So you didn't have a lot of choice of circuits. You had Fairchild Micrologic and some stuff from TI, I guess.

Rudin: Was Motorola.

Laws: Motorola.

Rudin: Wait a minute, no. Motorola wasn't there yet, no.

Laws: Right.

Rudin: And TI didn't have a real planar capability. So who was the other one you mentioned?

Laws: Well, the only two that came to mind were Fairchild with Micrologic, that came out in early '61, and TI's planar circuits, about a year later

Rudin: They couldn't build-- nobody else could really build planar _____, but there was one other company [joining with the telemetry companies]. I think it might've been Motorola. Yeah. Motorola, yeah. So they probably had something, and in any case, no. There had to be other companies. Oh, I know what it was. The other telemetry companies that were bidding it were planning to bring in an IC company like Fairchild, if they won it.

Laws: I see..

Rudin: Whereas I had Fairchild from the beginning to give me, ideas on it. And so in any case, what I did was we had an RF division. I think we bid, total bidding was, would've been, like, 500,000. Or a little more, and so I thought, "Their [plus $100k] bid is too high." So this was the last day to bid and I had to get it done, and it was not only the last day but it was already like three o'clock in the afternoon. <laughs> So I said, "Wait a minute. TRW [in California] has an RF capability and I can still call them [in California]," <laughs> and I did, and they gave me a quote over the phone for what I needed for the transmitter, and it was only like maybe $10,000. So I saved, like, a hundred thousand dollars and I believe that made the difference, in getting the price down to where we got the contract, and then the story changes that after

that -- I got those contracts but they wouldn't let me manage them. They wanted me to get more contracts.

<laughter>

Rudin: Like a bird dog. Go out and get us more <laughs> birds. You can't eat the birds. So… <laughs> So I said, "To hell with that," and within two weeks I had a job at one of the companies I beat out for a telemetry synchronizer R&D project at Huntsville, Alabama. With NASA. I didn't get the job with NASA. I got the job with the outfit that lost out when they thought they were going to win it. A guy named Parker Painter who ran a company called Dynatronics, so when he heard I won that contract, he hired me instantly. <laughs> He couldn't figure out how I beat him because he was always getting work from them, he knew them, <laughs> and so I went to Dynatronics to run the Data Systems division there.

Rudin: So I had to move to Central Florida, which I did and I moved on to Lake Killarney. Went on the lake surface where they had the water skiing championships that year. I got a contract for them but NASA wanted us to take half the cost of it because we were going to pioneer and make some miniature modules, like, airborne modules, and Pete Petroff, who was an ace over at Radiation, had come to me and asked me if he could join our airborne section and he had this idea already, I think, and so he and I, I hired him, and he and I went to I think it was Washington, D.C., and talked to NASA and they said, "We're ready to give you this contract, but you'll have to foot half the cost." Well, Parker Painter wouldn't hear of it even though they were falling on hard times. Well, that was another thing. It didn't look like they were going to be able to hold up as they were, because they were starting to run out of work, and I was getting blamed for laying people off <laughs> when I just got there, you know. In other words, I was almost like [I was hired] for that purpose, I don't know. But anyway, so my wife said, "Well, let's goes back to California." "Okay. If I can find the right job." Well, I was hired by Hughes to run the Advanced Techniques Department in their Ground Systems Division. [Rudin's edit: Actually their biggest contract by far was for US Navy carrier's "Hat Box Radar" that tracked everything, sea or air around the carrier and required state of art computer and radar technology. In advance techniques we had two contracts: moving ferrous wire domains memories for the army, and Associative memories.]

Rudin: [At Hughes] I had the interesting experience of discovering I had a imposter working for me. <laughs> Who had been a technician in another company nearby and he was running back and forth but he had this wonderful resume that he'd stolen and I began to think, "He can't be." <laughs> "He's not the one he says he is," and I went to my boss, and he said, "Oh, you can't let him go. He's a Ph.D. and he's--" and I said, "Maybe he is but he's lost his brain power or something." <laughs> And then sure enough, somebody discovered [Rudin's edit: he's stole the resume of another guy he was impersonating where he worked at Beckman], and that was another interesting experience. So I got the job at Hughes, a nice job working for a Caltech Ph.D., running the Ground Systems division. Oh, and on top of that, one of my profs at Caltech, Norm Enenstein, was there and he thought I was a, you know, great guy. So everything looked very great there but then all of a sudden they cut off all the cost-plus-fixed-fee contracts in the

military. So new times were <laughs> coming in, and my department was eliminated <laughs> and the people were just reassigned, and so I was reassigned. Somebody I worked for at RCA found out about this and he said, "We could use you over at Space Systems," and I barely got to Space Systems when I got a call that Gordon Moore wanted to see me. <laughs> From Bob Graham. So that worked out. <laughs> Actually, I wrote a proposal for Space Systems before that happened though, and guess what? <laughs> They won it.

Laws: <laughs>

Rudin: And guess what? They didn't give it to me to run. <laughs> Again. And other engineers who didn't work on it, they were on the contract and then they kept coming to see me and asking, "What did you mean by this?" and, "How do we do--" <laughs> I'm supposed to explain, like, I wrote the proposal in 10 days. I'm supposed to explain to them over weeks on end what I figured out in 10 days. That's… <laughs> So anyway, I thought, "And the coming thing is semiconductors, right?"

Laws: Right. Had you been using semiconductors at all in any of these other designs?

Rudin: Not yet, but I was assigned, when I was running the Advanced Techniques department at Hughes to the Semiconductor committee and I used to go down to Newport Beach where they had a research lab there, and hear what the latest was that they were doing. They were actually developing ICs. Yeah.

Laws: Hughes were a big factor in diodes in those days.

Rudin: Yeah.

Laws: They had very high speed diodes.

Rudin: It's hard to remember now, but I used to go down there once a month to see what they were doing.

Laws: So now it's 1966 you're hired by Fairchild.

Rudin: I came up, my wife took a trip to Scotland with the kids, because she had relatives there, and I went out and stayed on Arastradero Road, [in Palo Alto] at the apartment there. And what I found out was really amazing. They'd had that contract for four years. <laughs> I think the contract probably was already done but the contract had been there four years ago.

Laws: Sorry, what contract was it?

Rudin: The one that I won with Fairchild [when I was at Radiation] to make an all IC telemetry system, and the only exception was the RF, and maybe the D-to-A converter, but the Air Force certainly hoped to have amplifiers developed even though no amplifiers had existed in 1962.

Laws: Right.

Rudin: And so I get there and that's what I find. When I interviewed Gordon Moore that I wouldn't come unless he got me a secretary like I was used to <laughs> and so he knocked out the walls and everything and <laughs> reshaped the office, so I could have an office like that. <laughs> Got me a secretary

Laws: So you arrived at Fairchild in 1966.

Rudin: Yeah, I arrived there. I saw- that it was ridiculous. They hadn't accomplished anything. Nothing they'd done that I could find had transferred into production.

Laws: But they did have some kind of a differential amplifier they were building up there, didn't they?

Rudin: No. [They weren't building anything salable. Dave Philling told me former manager Daveand Hilbiber was working on a differential input amplifier front end]. The only thing that maybe I had no quarrel with at the time, [was] the processing, and that was half the people. So it really left half the people, six, that were supposed to be doing the other part. But I think at the time they didn't think of themselves as circuit designers, they thought of themselves as IC technology people. Processing technology, chemists and physicists and so on. Dave Pilling was the processing engineer who was [taken from Harry Sello's Physics Department and] assigned to me, and he was a really nice guy. I told him right away, I said, "Dave, I know nothing about the processing." I said, "Actually, I've never really designed circuits [either I am a systems guy]." I said- "Gordon Moore asked me that when he interviewed me." He said, "Do you design circuits?" I said, "No. I don't believe I've ever. Maybe once I designed a circuit." I did help people to design circuits but I didn't personally design the whole circuit. But I showed them how to mathematically analyze it. <laughs> And he said, "Well, what will you do?" and I said, "I can guarantee you that I can do the job. I'll hire circuit designers and I definitely have experience in hiring people who are good, that know their stuff. I know how to do that," and he said, "Okay." <laughs> Sent me an offer and the offer was about, like, 10 percent more than I was making and my wife said, "Yeah, I think I like the San Francisco area," <laughs>. So we took his offer, if he would give me a secretary.   So [when I arrived] I couldn't find anybody <laughs> who knew what they were doing and people started quitting. You know, like a palace revolt. That was the best thing that ever happened to me. <laughs> Because that gave me the chance to hire people, so I was told, "When the middle of the year comes, we're interviewing Masters in EE, and you'll be able to hire two of them." Well, guess what? <laughs> They all

wanted to come with our department, because I'm like a young guy. Do you notice that? I'm not even old at all. I don't even think I'm old. I don't now and I didn't then <laughs> for sure, and so I know that they like me. You know, I can interact with them and, you know, and I'd ask them questions. This is my technique. You ask questions that are not easy to answer, but they're not hard because of ignorance. They're only hard because they can't think well <laughs> and you just see how they think, and the other one is you ask them to describe what they've done that they're proud of. That was really good to see if they can describe it to you so you can understand it, and if they can do those two things, that shows they're smart and they think rationally in terms of how to explain something and they think about how it looks to the other guy. Because when you work at a company if you can't work with other people, you're never going to get anywhere. <laughs> I mean, you have to interact with other people. It's not just enough to be smart. So that worked out for me, and besides, I can actually understand circuits. I mean, if they tell me something that doesn't make sense, I'll know right away and I'll say, "You just said what?"

Laws: Who were some of the people you hired, Marv? Do you remember their names?

Rudin: Oh. So I hired, I hired Ken Stafford. I hired a guy, I'm going to call him, I'm not sure if that was his name, but I think it was Morrison [Rudin's edit: the correct name of this person is Dave Oberlin]. He was from Ohio State. Ken Stafford was up from MIT. [Rudin's edit: Also Chuck Botchrk, who helped me to design what may have been the world's first 16 channel MOS multiplexer considering that Fairchild R&D was probably the earliest researcher for MOS digital ICs].

Laws: Did you hire Garth? Was he there already? Garth Wilson?

Rudin: Oh, Garth is a special case. I actually found him, looked for somebody, and found him. I wanted somebody to run circuits. I wanted two people who knew enough, to run the engineering work in both areas, circuits and process. So I hired Garth [for circuits leadership]. I found him in the IEEE Proceedings, a recent issue. He'd written a paper and I looked him up and he was from Cal, and I found his phone number. He was working at a microwave company in the East Bay. I called him and said, "I'm interested in talking to you about a job supervising design engineers for linear integrated circuits, and if you're interested, I'd like you to come over and talk to me a certain night when you're available," at a bar in Palo Alto. He came and I talked to him, and then I made him an offer and he took it. Then the personnel guy at R&D said, "Boy, were you lucky to get Garth." <laughs> He didn't even ask me how I got him. "Boy, you were lucky to get him," and by the way, his professor said that he was the best Ph.D. that he'd had at Cal.

Laws: That was a good hire.

Rudin: So I made sure before I hired him.

Laws: Right.

Rudin: Yeah. When hiring, I don't care if they're smarter than I am. I go for the best. I seldom meet anybody smarter than I am, frankly. I won the chess competition at Precision Monolithics against [George] Erdi and the other engineers who played every day.

Laws: Did you hire George Erdi into Fairchild as well?

Rudin: Yeah, George Erdi I hired from University of California. He was a friend of Andy Grove, by the way, and they're Hungarians, and so is Leslie Vadász who helped me design a multiplexer with MOS.Another one I hired was from Caltech, was, as you may know, was, you know, your friend. <laughs>

Laws: Ted.

Rudin: Our friend, Ted Jenkins. And from Stanford there was the one whose name I can't remember and one of the reasons is that he couldn't design. <laughs> He certainly couldn't do processing. He wasn't a chemical engineer, and he couldn't design. The thing I liked about him was that he told me stories about his father had told him this and that, but later I realized that he needed a father to tell him what to do.

Laws: Interesting.

Rudin: And so I got him a job down in-- I can't remember his name. It might've been maybe Edwards or-- anyway, I got him a job down testing in Mountain View rather than letting him go. But just think, a guy with an MS from Stanford ought to be a good tester in Mountain View.

Laws: How about Dave Fullagar?

Rudin: Dave Fullagar, yeah, I interviewed and hired. Yeah, he looked good. Very good, because he was very personable and he could definitely explain what he'd done, <laughs> and smart at answering a puzzle question.

Laws: What kind of circuits did you have these people working on?

Rudin: Oh, that's where I came in. I was a system engineer and I knew the kinds of things that were needed to replace these, these bulky modules.

Laws: Right.

Rudin: It was amazing the difference in size <laughs> that you could do with a dual in-line package. And so I had them working on a comparator amplifier, which I need for A-to-D conversion. An instrumentation op amp you need for very low-level signals, like microvolt signals, without a chopper, by the way.

Laws: Was that the 725?

Rudin: 725. And that's what Dave Fullagar was on until he was reassigned when he cleverly found out he could take the 709, redesign it better -- he was enterprising. He knew that we had a process in production for a capacitor on-- board. And so one day I'm down in the lab, which was in the basement of R&D, the Electronic lab. Of course, Gordon Moore, being a chemical engineer running it, <laughs> the electronics went down in the basement and the processing went up on the main floor. Anyway, I was down in the basement like I tended to do, walk around and, you know, see how people were doing, and there's Dave Fullagar and he says, "Marv," I said, "What are you up to?" "I got something to show you," he says, "Look, I've just put together a bread board of an amplifier that could replace the 709 because it has a capacitor built in." And so there's a story I'm going to tell that he never told, which kind of annoyed me. He told the story that he had a design that could replace the 709 and immediately there he was in Gordon Moore's office, and the next thing you know he's sent to production. Wasn't that way at all. It was like this: I told Gordon Moore that Dave could overcome what [Bob] Widlar had done at Fairchild and then also at National.

Laws: Right.

Rudin: And I said, "Gee, that's terrific." He said, "But they want me to go to Mountain View to work in production [to make it happen there]." He said, "I want to stay in R&D," and I said, "Well, if you do that and you're successful, you'll be famous. You can name your ticket." I Said, "You'll be able to come to R&D if you want, stay there, or, you know, whatever you want, even go outside the company and name your price. It'll be that important," and you see, I wanted [him] to do it because I hated Widlar because of the way he acted toward me when I asked him what did he need, and he just laughed at me. Because he was getting ready to leave.

Laws: Right.

Rudin: But the point is, you know, Widlar wasn't civil, and I'm always civil. I mean, who would be otherwise, you know, only a nut. I'm coming to him and say, "What could we do to help you make better circuits?" and he wouldn't tell me anything. I said, "Well, let me tell you this. I'll be successful with you or without you," and I was. That's what PMI [Precision Monolithics Inc.] was.

Laws: Let's finish off the story about Dave Fullagar and the other work that you did at R&D.

Rudin: So what happened was in order to get him to go [to work in Mountain View] , I said to Gordon Moore, "I think you should give him a raise as a incentive to go," and he said he would. Then I brought him into his [Moore's] office. It was all staged.

Laws: Okay.

Rudin: He wasn't forced to go but he was offered a raise by Gordon Moore if he would go. Okay. So that's a story worth telling, because he never told it, and that annoyed me. I gave him good advice and got him a raise and got him a promise from Gordon to take him back to R&D after he finished that project.

Laws: Good.

Rudin: Now, I never told him that, but he knew part of it. He knew he wouldn't have gotten that raise. I mean, unless he thought Gordon thought of it, I suppose. All right. To go on, the other circuits were of course a D-to-A converter, and it was done with film resistors because we didn't know that we could do it with diffused resistors without trimming them and it's not known how to trim diffused resistors because heat causes the impurities to move in unforeseen ways so you can't do that. You can do it with film by just taking away film, you know. Can't do it by adding film. Okay. So then what were the other functions? . I don't think we went for an audio amplifier because they already had one and they don't have to have great DC performance at all. There's no DC in audio, so what else? Let's see. There was a high impedance input as well as a low impedance input [amplifiers]. Oh, and another thing I did, even though I didn't design circuits when Erdi said, "I can't get the 725 to get a low offset voltage at the input," and I said, "Why not?" he said, "The heat from the output somehow flows unevenly back to the input." I said, "Well, why don't you put the output further away by making the chip rectangular?" He said, "They don't do that." I said,"Why not?" He didn't know. I said, "Look, why don't we ask them." <laughs> Since then, it's a rectangular chip.

Laws: Right.

Rudin: <laughs> That came from me. I don't remember all the other ones, so…[1]

Laws: That's okay. We've got a sense- of the kind of products that were coming out of R & D.

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[1] During the editing process Marv Rudin added the following note: "I wrote papers in '66 and '67 stating the kind of A/D design and the kind of functions needed for telemetry. They in effect, stated the linear products we needed from Fairchild R&D engineers, such as: A/D precision high speed comparator; low drift, high impedance, low noise instrumentation op amp; low noise, high impedance, high slew rate op amp; junction FET input op amp.

Rudin: Yeah.

Laws: And so you did this for three years?

Rudin: I did it for two years, yeah, almost three years [Rudin's edit: two years and 10 months], and left in, like, October or November, but that was after the Motorola people came in. And that alone was a good reason to leave.

Laws: They came in about September of '68.

Rudin: Oh, and Les Hogan, acting all gruff, comes down into the lab Jerry Sanders with him. <laughs> And Jerry Sanders is saying, "How come you haven't got more out?" Well, I got the 741. <laughs> That was plenty. Let's see. So he said, "Is that all you did in three years?" <laughs> something like that.

Laws: No.

Rudin: Actually, we kept trying and trying. Was hard to do linear things in R&D because their process wasn't any good and they didn't know it.

Laws: So the Hogan crew came in.

Rudin: Well, we were kind of plotting to leave.

Laws: I see.

Rudin: And they came in and that put the cap on it. <laughs>

Laws: Okay, okay.

Rudin: First it was my processing engineering chief, Dave Pilling, who reported to me for processing, and he said he wanted to go with me and Garth and start a new company and he even invited me [and Carth] up to the mountains to his father's cabin. It looked like sure he was going to go and then he got cold feet. Then it was another guy whose name I can't remember who was at Fairchild and he said he, he wanted to go and then he got cold feet, <laughs> and so we just went anyway. <laughs>

Laws: We being you and Garth?

Rudin: And Garth came anyway. Without anybody sure to come with us for processing.

Laws: Did you have a very well developed idea of the products you wanted to make?

Rudin: Oh, absolutely. D-to-A converter obviously was needed because our process [at Fairchild], wasn't good enough. Even though we had a 10-bit chip it was sort of like some midget thinks he's going to win the high jump contest. I mean, it was a 10-bit chip but was only accurate to 7 bits from 0 to 80 [degrees C] and the big market right then was for military if you wanted to get everything military, [you needed a temp range of minus 55F to 125F.

Laws: Sure. And the products you were competing against were discrete modules?

Rudin: Not only modules, but many were built by engineers on circuit boards with other things.

Laws: Got it.

Rudin: They were hidden.

Laws: Yes.

Rudin: We, when we went to form Precision Monolithics and get the financing, a management consultant was assigned, named Jerry Frank, from the San Fernando Valley. He said, "Well, what's the market?" and I said, "I don't know what it is because the hidden market is being designed by circuit engineers [together] with other circuits all on the same board. I said, "So you don't know either." Told him point blank, "You don't know either," and he had to admit it. He said, "No. We can't find any way to find out how many are used."

Laws: Now, this management consultant, you hired him or he was hired by the--

Rudin: No. No. The people, Bourns [Inc. of Riverside, CA], that was considering backing us.

Laws: Okay. So you approached Bourns and said you wanted them to fund this company and they hired a management consultant.

Rudin: Yeah. I had a cousin make a call to them named Martin, and I asked him if he would help me out and make a call so nobody'll know. He said, "I have some people," and he told them what kind of people, and they said, "Yeah," they were interested, and then I said, "Okay," and well, I also got Beckman, the ones who backed- Shockley.

Laws: Right.

Rudin: Dr. Ballhaus, the president of Beckman, met me at the airport clandestine to see if they would back me and he was gung ho about it. He realized this was different than what happened with Shockley, but Beckman, Arnold Beckman didn't, and I never met Arnold Beckman. But I think I could've persuaded him that he was making a mistake, but so I had to drop that one. But Bourns came through. I also had people in San Francisco, Hambrecht & Quist, but they didn't treat me very well when I went up to see them and made me sit around and I didn't like that. And then there was another guy who really was nice and he wanted to back me but he said he didn't have the money yet, that Sears Roebuck was going to put up money to put into high tech. I wish now I'd waited.

<laughter>

Rudin: Because I didn't like the backers, as you well know by now. We could've really done fantastically. <laughs> I mean, we could be doing the two billion a year that Analog Device is doing.

Laws: How much money did Bourns put up?

Rudin: They only put up three million. And they were so stingy, you know, equipment costs a lot in semiconductors.

Laws: Yes.

Rudin: Semiconductors. Because of the equipment costs we couldn't do it on our own funding, Anyway, they put up three million but it was, it was credit. It wasn't even money. They signed up for the credit on it. <laughs>

Laws: Right.

Rudin: Oh, I didn't say I got a contract in between when we first took off from Fairchild. I got a contract with Pete Petroff, the one that went off with me to get that contract from NASA. He ended up working for NASA in Huntsville, and he got me a contract to design a micropower amplifier for space shots. Garth and

I worked on that and it paid our expenses for a while, but Garth was getting antsy about how long that was going to last. <laughs>So I loaned him some money and I didn't have a lot at the time, but I loaned him some money, and he paid me back later after we started the company, but all of that in order to keep him from bolting, because I thought he'd get nervous and wouldn't hang in there, because I wanted to wait for the guy from Allstate who, you know, he was going to have a lot of money. Unfortunately that was a decisive point <laughs> in my life, so to speak, because Bourns bought everybody else out, which was foolish. It was stupid. You don't buy people out. <laughs> I mean, when they're ace contributors to the company.

Laws: So you formed Precision Monolithics.

Rudin: So we left on our own. We took that contract. Then ultimately we got the funding and we made offers to Wadie Khadder. He knew thin films well and he was a stop gap in case this new guy [Jerry Bresee, below] didn't work out for the processing. Wadie Khadder was good. He was from a top school in England,. Cambridge or one of the two top ones, Oxford or Cambridge.

Laws: Sure.

Rudin: And so he hired in. They all got beginner stock.. Garth got half what I got and we got 30 percent altogether.

Laws: Earlier you said you hired a process guy? Tell me the story behind that.

Rudin: Okay. Jerry Bresee was a, really a serendipitous case. He called me after an article came out in Electronic News that said a company called Precision Monolithics was starting up in Santa Clara County. They actually said in Palo Alto, because originally we were going to start in the hills in Palo Alto in the high-tech company district there behind Stanford.

Laws: On the Stanford Research Park?

Rudin: Yeah. The Stanford Research territory, only up in the hills there.

Laws: Where Xerox ended up?

Rudin: Yeah, right. Xerox ended up there. Overlooking Fairchild R&D. <laughs> Kind of funny, and then later we changed our mind and decided that we didn't like the restriction that you can only get a lease there. You can't get ownership. So we ended up on Space Park Boulevard in Santa Clara While we

were putting up a building we moved into a real estate office on Scott Boulevard nearby that was just big enough to take the people we hired, which were about maybe half a dozen. Garth, Bresee, Khadder, and I found Dooley through Garth. Garth didn't know Dooley, but he knew somebody who did and somebody he went to school with, and I called that guy and he didn't want to come with us, but he told me about Dooley.

Laws: That's Dan Dooley, right?

Rudin: Dan Dooley.

Laws: Yeah.

Rudin: So I called Dan Dooley and asked him to come and when he interviewed he said he had an ace technician who knew thin film really well. It was the same outfit that could do the RF for that contract I got at Radiation, TRW Microcircuits. I think it was, I think the power was probably all one, but maybe not. Might've been separate but so anyway they both hired in and so we had them and then we had Erdi, and who else would there be? Oh, and I talked to Bresee a lot when I interviewed him to find out why his process might be so good. I felt we weren't sure yet.

Laws: Where did he come from, Bresee?

Rudin: He came from Tektronix. And when we interviewed him I asked him a lot of questions and I found out that he lays the wafers down, I said, "Oh, that might give laminar flow and that might give more uniform [layers] that we could get impurities to go in to than we were able to do at Fairchild R&D." So I thought I had a reason then to hire him, and he said he had six more processes that were good that he'd played with. So I thought, "Gee, he's like a walking process machine if we need it. So we've got to hire him," <laugh> and we did. He talked me into putting liquid epoxy floors in. It's where there's no tiles, it's all a liquid coating on the floor, so there's no cracks to hold dust.

Laws: Got it.

Rudin: He wanted me to do that, to make sure we'd done everything we can to minimize the dust. That was another secret, trade secret. <laughs> Epoxy floor. I knew what was important, you know. So and anyway, we're at that real estate office and then guess who comes to see me but Ray Stata and Emil Rechsteiner [from module maker Analog Devices]. Why I remember Rechsteiner, because I was told later that he'd been a fry cook in New York City and somehow he became president of Analog Devices at that time because of financial reasons.

Laws: Okay.

Rudin: He was trusted by, yeah, I guess the backers for the money, to see that the money was properly handled. So why did they come to see me? Ray Stata was nosing around to see what we were up to because they had just bought a company called Pastoriza Electronics that was in A-to-D and D-to-A converters, and James Pastoriza was a key guy from then on at Analog Devices, ADI. He joined them the same year that we started Precision Monolithics in '69. So naturally it was very important to see, "What's the state of the art?" Stata had the chutzpah to come out and visit us at the real estate office.

Laws: They were building modules at that time, right?

Rudin: Only modules. Oh, they might've been using some of Fairchild's linears, although they weren't very good, but it may be the 725 they might've used, and so they were out there nosing around about the D-to-A converter. He told me, "Well, the way we build them," he said, "what we do is we build four bits at a time and then we hook them together." Well, I knew if you do that, you got a nightmare of a problem trying to align each group of three so that they don't occupy more than a minimum bit of the full scale. They'd have to do some trimming and things like that, you know, so it'd be a lot of trouble compared with [our approach], "We're going to build it all at once with no trimming, the whole circuit. "And for a D-to-A we'll have the output amplifier all on the chip, and the resistors, and we might have to use thin film resistors. We're not sure yet." That was my message.

Laws: So he came to see you before you had introduced or built a product?

Rudin: We were building the building. Our process guy was buying the equipment and having it installed. Everything was new, and it had to be new.

Laws: Right, right.

Rudin: When we finally started to run things, our guys from Fairchild were wowed by what they saw [from Jerry's process]. You know, by the tests and the uniformity. We had some test patterns and so Dan Dooley knew we could build a 6-bit D-to-A converter like rolling off a log.

Laws: So the first product you brought out then was?

Rudin: An op amp [operational amplifier] designed by George Erdi. he designed all the op amps.

Rudin: Dooley designed all the D-to-A's. And then when the A-to-D's were built, that was a bit later, I managed to hire the absolute best person in the country who knew linears. The guy who'd worked in telemetry and systems and data acquisition named John Bowers.

Rudin: He did the modules and he wrote the application material and he really knew his stuff, and he was, he was nitpicking to the finest degree. Which you want in an engineer.

Laws: <laughs> Absolutely.

Rudin: Yeah. He had worked for me at Dynatronics. In the Airborne division. The same one that I hired Pete Petroff into.

Laws: Yeah.

Rudin: So he didn't find me to be a bad manager. He took the offer and everything. Everything went just great. He went with me and the sales manager to New York to demonstrate our first D-to-A converter, 2-chips, in a dual in-line package that would run 10-bit accuracy to a half bit over the full military temperature range from minus 55 to 155. Analog Devices wouldn't have a chance to do that.

Laws: So this is 1970 when you brought out this two-chip, 10-bit D-to-A?

Rudin:, I don't recall whether it was right at the end or right at the beginning of '70, but it was right in that time zone. We only built the 6-bit one because sales heard that JPL wanted an IC D-to-A converter if they could get one, to put on their space shot to the moon. They still hadn't got to the moon with a man, but they were shooting things to see what it's like there, and of course, they found out it's moon dust. <laughs>

Laws: And so you built the 6-bit for JPL?

Rudin: Yeah. -- The 6-bit wasn't a big seller, but I'll tell you what was were the amplifiers.

Laws: And what were the model numbers of those amplifiers?

Rudin: Well, some of them were [popular industry standard] amplifiers we wanted to get into sockets with [like upper end ua741s and ua725s]. Say, we've got a better one, and you can put them right in the same socket.

Laws: Go it.

Rudin: Because those are in production. That's why it was important. So all those, the SSS, for superior second source amplifiers, were built so they'd get into sockets that are already there.

Laws: Right. And you can generate revenue more quickly that way.

Rudin: Because they're in production. Takes time in that market, unfortunately, so then we had other ones like OP-01 for the future, that we had designed in, but we'd have to wait for production on those.

Laws: Yes. Right.

Rudin: And I would swear that we had an 8-bit converter that we brought out. I can only say that maybe we knew at the end of '71 that we were going to bring out a 10-bit in '72, and so, so we stopped doing the 8-bit. [An 8-bit application can always use a 10-bit chip]. It's the only thing I can think of, because I remember that Dooley told me, "Hey, I can easily do 8-bits." And they were untrimmed, the 8-bit used diffused resistors. So we had a 6-bit and I believe he had an 8-bit and the thing I'm puzzling about is why wasn't it in the 1972 buyers guide? And I believe by the way those guides came out the end of the previous year just like cars do, you know, what are we going to have next year? So some of the things they said, "We're going to release them in this year," but they weren't out yet at the beginning of the year, and we had the aimDac100. I remember, being in New York City and demonstrating it when it wasn't a product yet, that was released. —By the way I coined all those names, and how to name the products. Keep it simple because it'll stick in people's memory. OP-01, OP-02. <laughs> DAC-01, DAC-02. Why get complicated?

Laws: Right.

Rudin: And AIM stood for Analog Integrated Microsystems, which meant not IC, not totally IC, but rather an assembly of ICs and maybe even some discrete components if needed, but they couldn't be very big because they fit inside a dual in-line package.

Laws: Right.

Rudin: Oh, and by the way. <laughs> Here's a human interest part. There was a guy named John Webber who worked at Fairchild with us in our department, but he was like a do-it-all kind of technician without any formal training. He could've just as easily been a insurance man. <laughs> He was very nice guy and strong guy and well built and everybody liked him. I said to him, "I have to be in New York City

the next day," and he said, "Our people [in New York at rge IEE show] don't have that aimDac100 ready yet," and so I said, "Well, okay, I guess that's the way it goes," and he said, "No, Marv." He said, "We're going to work around the clock." The guys have promised. "We'll work around the clock and we'll have it." <laughs> And they did.

Laws: So you're able to go back to New York and demonstrate this.

Rudin: I felt strange because I didn't feel like I had in any way tried to make them work all night. <laughs> But they did. It was amazing, and I went back there with Wayne Peacock who was the sales manager. I had the marketing role, which is creating ads and giving talks out in the boondocks, wherever, and so I went to New York to give the talk, and to be on a panel with Ray Stata and Bernie Gordon. Bernie Gordon, he had his company [Analogic Corporation], and he designed very high end D-to-A and A-to-D converters, up to like 14, 15 bits, maybe even 16. I don't know. You know, he'd trim resistors or whatever it took. Then there was Ray Stata sitting next to me and he said that, "We're doing it with," like I told you earlier, "four bits at a time and we're putting them together and we're putting them in a module." <laughs> And I said [to a full auditorium panel audience], "Well, you've heard how it used to be in the olden days." <laughs> I was nervy, and I said, "And then you heard what's it's been until recently, and now you're going to hear how it is now and into the future." <laughs> Somebody told me they've met more than one person who was there <laughs> and they still remember it 20 years later. Because it's like saying to you, "This is a new D-to-A roadmap." You know, I wanted to be the usurper of the market, because we needed to be, even if they didn't like it. Ray Stata might be a customer and so might Gordon, but the volume of a guy building super high accuracy A-to-D's and D-to-A's is not going to be very large and his price per unit is going to be way up. Ray Stata's modules, they can't make them as cheap as you can make chips and put them into an IC package, and so yeah. I could sell them to them, but my idea was to take over his market. We should be able to do that. It should take us a couple of years to get the best ICs, During that time we can start putting out modules that will fit into his sockets, and maybe even smaller ones that don't have to fit in his sockets that people would prefer if they're starting from scratch, and that was my thinking. And that's why later on when he wanted to buy from us, I wouldn't sell to him, and so that's why you'll see that he's gone out of his way to belittle my company by saying they did six bits and they did a two-chip converter. But he never said we did a 10-bit in '72, but we did. . Even a little A-to-D converter in a dual in-line package.

Laws: Sure. So let me get this straight. You did a 6-bit with diffused resistors?

Rudin: Six-bit with diffused, and eight-bit with diffused, but the big thing was the ten-bit that even got eleven-bit accuracy with some yield.

Laws: You did a two-chip solution first and then you did a monolithic?

Rudin: Yeah. When we found out we could do it with monolithic, we stopped offering the 10-bit aimDac.

Laws: Right.

Rudin: Because nobody would prefer the aimDac if you could get the monolithic.

Laws: And that was 1972.

Rudin: And that was in '72. In the '72 buyers guide at the beginning of the year it said, "We will release this year a 10-bit."

Laws: Sure.

Rudin: And I remember that we were getting 10-bit yields at the end of '71.

Laws: And how well was this received by the market?

Rudin: It was a sensation.

Laws: Okay.

Rudin: Yeah. But so were the amplifiers. It's just that the amplifiers just don't seem as unique. Our arameters were better than others could build, at the time. It was a trade secret. It wasn't patented. Why would you patent a trade secret when you can't look at the product and see how it was done?

Laws: Yeah, sure.

Rudin: There's no way you can tell. Somebody from National came over, an engineer, and he wanted to buy our chips, and the lady out in the lobby went in and got him a chip and sold it to him. But she shouldn't have.

Laws: So roughly, what was the revenue of the company by '72? Do you remember?

Rudin: No, I don't remember. It wasn't enough to break even yet.

Laws: Okay. So how were you financing the company?

Rudin: Using Bourns' three million.

Laws: Okay.

Rudin: We still hadn't used it up. So yeah, that's a good question. They might've been loaning more money. Think that might've been it. Now, by '74 I would say we should've been at break even. And Jim Grugan, who had the financial, was my friend, but he didn't have to worry about money if we were short of it.

Laws: It was the Bourns line of credit then that was basically supporting you. Right.

Rudin: It was.

Laws: Okay. And what other products came out after the 10-bit monolithic?

Rudin: Oh. There were absolutely loads of amplifiers. It's amazing how many George Erdi got out and that he had a patent on. He was terrific and he knew amplifiers by then. He started knowing very little at Fairchild but by this time it was after three years at Fairchild. And now he could actually work with a processing engineer to manipulate the process to optimize it.

Laws: Right.

Rudin: And so he just did wonders. I mean, those amplifiers, you wouldn't say superior second source if they weren't superior or the designers who were buying, they'd laugh at you. Then on top of that, we even had better ones that had their own name, like OP-01 and OP-05.

Laws: You had two really star designers.

Rudin: Two stars.

Laws: Dooley and Erdi.

Rudin: Right. That's all we had. Nobody else.

Laws: Is that right?

Rudin: And then Garth, brought in somebody and I told Garth he shouldn't hire him because he didn't score well on our intelligence test. See, we were looking for ne plus ultra people.

Laws: Right.

Rudin: Obviously a lot of people are quite good and can hold a lot of positions, but we needed to make all our money count <laughs> and get as much as could be done, you know, all of that.

<laughter>

Laws: Okay. So by '74, the company is probably breaking even now?

Rudin: No.

Laws: Did Bourns buy out the whole company? What happened?

Rudin: What happened was I had a five-year contract to see that I wouldn't leave in the middle before we were worth the investment. <laughs> So did Garth. But I left, in 1974 and they didn't offer me anything. But I didn't want to work for them anymore and I left anyway. I figured if it has to be, I know how to build another company that'll wipe out Precision Monolithics <laughs> I felt, although that wouldn't be so easy. <laughs> But anyway, I was feeling brave and so when they wouldn't offer me anything I called a legal outfit in San Francisco. I called a couple of them. And one of them turned out to be the biggest and oldest and best. <laughs> And I can't remember their name. Maybe I'll think of it later. Maybe my wife will. And the attorney handled it pro bono. He said, "Let's get on a plane and go down to visit Bourns." And I said, "What for?" He said, "Well, we think we know how to handle this." <laughs> And apparently just the sight of this ace big legal outfit from San Francisco caused Bourns to want to settle. I'm not going to tell you how much it was, but it was adequate. And especially since the market had crashed. <laughs> And I thought that was a good time to get that money and put it in the market, like for Intel stock.

Laws: Right.

Rudin: Intel, I think Intel had gone below 10.

Laws: So basically you were getting payment for your share of the company?

Rudin: Right. And then I gave the attorney $5,000, even though he didn't ask me for anything. Wasn't that interesting that he just thought it isn't fair what happened to me after what I did that for them, But I had a case if I wanted to make it because they made us use their advertising in Europe. Their sales force in Europe only sold little potentiometers, not active circuits.

Laws: Right.

Rudin: Not even vacuum tubes. I could've gone after them and said, "You forced us to use bad marketing in Europe so how could we do as well as we should've been able to do there? And you also made use your reps in the US when we probably could've gotten better reps. Very likely we'd have won anyway. Those attorneys could've turned that trick.

Laws: Right.

Rudin: 'Cause people usually would feel sorry for a guy who accomplished all that and they don't offer him anything: So that's how generous Bourns was.

Laws: Okay.

Rudin: I could laugh now because I ended up with quite a bit. I really didn't have to worry about working.

Laws: What was the eventual position of PMI? They were purchased by Analog Devices?

Rudin: PMI, Precision Monolithics was bought by of all things Analog Devices, the one that I wouldn't sell chips to.

Laws: Right.

Rudin: -- in 1990 though.

Laws: So PMI continued for another 15 years after you left.

Rudin: They were still around for another 15 years. So obviously they had to have done very well. And they should have. I mean nobody could touch their products.

Laws: Sure. So what did you go on to do after you left PMI?

Rudin: Well, after that I invested about two-thirds. And I invested one-third in forming a company to make inventions. And I called it A-U-T-E-L, Autel, the invention I first had in mind was a plug-in auto clock that goes into the cigarette lighter socket and it has a power tap for other things that we might think of later. I started to do that and I found an engineer and he bought part of the company and invested his money. And but it took too long to get the auto clock built. And he had an idea for a timer. And I said, oh I could sell that timer because I used to feel that meetings were taking too long. That if you told everybody that each person at the meeting has like five minutes, up to five minutes, and that way we can get it done in an hour whereas it was going in like two and half hours.

Laws: Yeah.

Rudin: And so I thought with a count-down timer that you could put into a standard shirt pocket. I can show you a picture of it. [trademarked Memotime]

Laws: Sure.

Rudin: Oh, I failed to show you a lot of things that I had here. This is the picture of Precision Monolithics that was going to b built up in the hills like I said. <laughs>

Laws: Oh yes.

Rudin: Artist conception. And then let's see, this is something I should've read. [Shows a document] Can I read it?

Laws: Yeah. Sure. Go ahead.

Rudin: Okay. Precision Monolithics, also known as PMI, was an American company based in Santa Clara, California, that developed and produced mixed signal and linear integrated circuits (ICs). It was the pioneer in the fields of digital-to-analog converters and operational amplifiers in IC form. The company was founded by in '69-- 1969, by Marv Rudin and Garth Wilson, who had both left Fairchild Semiconductor at the end of 1968. Wilson was circuit design manager under Rudin who managed Linear circuit R&D at the Fairchild Semiconductor R&D Laboratory in Palo Alto from 1966 to near the end of '68. At the beginning, Wilson was Vice President and responsible for Engineering and Production, and he reported to Rudin who was President, and Marketing Manager. Jim Grugan was hired from Fairchild and joined shortly after incorporation as Vice President Administration was responsible for Finance, Facilities,

and Purchasing. Immediately after financing and incorporation, they offered founder stock and hired IC designers George Erdi from Fairchild and Dan Dooley from TRW Microelectronics. They also hired Jerry Bresee, a chief process engineer from Tektronix, who developed a semiconductor process far superior to what they were able to access from the Fairchild R&D processing services department, with the exception of nitride passivation technology low noise that was known by the founders from Fairchild. In 1969, Dooley designed the first fully integrated D/A converter, the 6 bit DAC01, using diffused resistors, which can't be trimmed. He recruited his thin film technician with precision resistor fabrication skills that were essential for improving the accuracy of D/A converters, which became the biggest selling product that helped launch the company. Semiconductor and materials engineer Wadie Khadder was hired with founder stock from Fairchild to support Bresee.

PMI pioneered the design and manufacture of the first 10 bit semiconductor IC D/A converters on the market. In March 1970, during the IEEE Annual Convention in New York, PMI caused a major stir in engineering circles by introducing the aimDac100, the first 10 bit 2-chip D/A converter in a dual in-line DIP semiconductor package. —It was far more compact and reliable than the modules that were state of the art at that time. By 1972, Dooley and Bresee, PMI's chief process engineer who developed process uniformity never before seen in the semiconductor industry, continued to design and produce a full 10 bit D/A converter on a-- on a single chip, the monoDac02. At that point PMI's linear process uniformity and products capitalizing on that uniformity put PMI in a class by itself. It would be several years before any other company could match the Dac-02.

Bresee's superior processes, and George Erdi's outstanding design expertise enabled PMI to establish itself as a superior source of linear amplifiers, including operational amplifiers, some of which garnered US patents. With layout and circuit design made possible by Bresee's and Khadder's process uniformity, transistor performance, and surface passivation, Erdi was able to design and achieve breakthrough advances in microcircuit design..

Laws: This gives a good sense of what you accomplished at PMI.

Rudin: <laughs> It's obvious what I'm going to say. Yeah. We're like that song <singing> "You're the tops." From the '20s.I don't know if the camera can zoom in, but this is what it looked like from the top. And then right on the first two pages are the aimDac100 and the 6 bit.. And then on the next page, Erdi's outstanding design expertise amplifiers.. This is the comparator amplifier. This is the other comparator amplifier, each with different specifications. Here's a 725 SSS, meaning superior second source. We wanted to sell those where Fairchild's725 had been used. And the mono OP 8. It was supposed to replace the National LM108 that Widlar had done only but do it better. Just like I told Wilder when he wouldn't cooperate, I said, I'll do fine without you. And that's what we did. We set out to do so fine without him that his circuits were secondary to the users. Kind of a nice guy, wasn't I? <laughs> Okay. And then here's the OP 1 fast slewing Op Amp., the superior second source [to the Farichild] 741. The well, this is for custom chips, so if they tell us what they want, if they are enough of them, we're going to make them.

Laws: Okay.

Rudin: And. And over here are the modules that John Bowers was able to make. He found out how to make modules, although he didn't come from a module company, but he knew how to design circuits. I didn't even find out how they were getting them made, but they were quite compact. One of them was quite noteworthy, a 13 bit D/A converter in a module. And here's a very high-speed 10 bit converter in a module.

Laws: What was the year of this catalog, 1972?

Rudin: Well, some- some of these were designed in '71 and the rest of them were ready in '72.

Laws: Thank you that offers a good review of the all the PMI products at that time.

Rudin: Yeah. And then we ran these brazen ads that said things like, "How many 10 bit D/A converters cost only $15.95 and give you all this?" And then down here it says, "Only one." That was my idea. 'Cause, you know, we were saying we're unique.

Laws: Yeah.

Rudin: If you want to find a second source you won't find one. <laughs> And this one said, "Precision Monolitics is number one in linear IC technology." And then gives the examples of products, why we say that here. Okay. And then this one was selling a mono OP 01 and giving specifications that were, you know, tremendously good, knowing that the designers would compare them and figure out that this was better than they could get anywhere else. And then these said, "How many precision comparators can match this performance?" And it gives the performance and it says, "Only- only one, the mono comp 01CJ." I guess it was an especially good one <laughs>. Don't remember that one.

Laws: Could we look at the timer picture you were going to show us?

Rudin: Okay, here's what the timer looks like. It was a quite a classy looking thing that was designed to fit exactly into a standard dress shirt pocket. You could read the end of it.   So you could look down to see what the time is without anybody noticing, hopefully.

Laws: And who were you selling this to?

Rudin: To executives at first. However the designer of it told me that it would sell to pilots, private pilots to use as a timer when they do a countdown before landing.

Laws: Sure.

Rudin: They have a limited time and if they don't see the airfield they're supposed to peel away and try again. And they call it a countdown timer. And the red LED number stood out in the dark. And it was classy for an executive. So for the two uses, we sold some in "The Wall Street Journal" with ads to executives and we sold some in pilots' magazines to pilots. Okay, and- and it turned out the- after we sold a thousand of them, we had to quit because unfortunately LCDs were ruining the market for LEDs.

Laws: Uh-huh.

Rudin: LCDs use less power.: And they could be seen well enough.

Laws: Sure.

Rudin: So we had to drop it. But it turned out that this product led to another product that worked for over a decade. Namely a pilot called and said that he had an idea for a mount for it, to put it up on the control yoke instead of down on a pilot's lap. The pilot could put this in front of him where he's looking at the instruments. So that worked out great. That mount, called Quick Clamp" started to sell. Gradually sold but not super high until electronic [GPS] navigators came out [and stimulated a volume market to hold the units].. And so it was a small business that we were unique in the market with. We had a couple of employees that were part-time students. We got the assembly done by Goodwill, they have a place where they manufacture down in San Jose.

Laws: Sure. Goodwill Industries.

Rudin: So we showed them how to make them. Okay, the other product, the pilot's mount for a timer out to be great because I had this idea of adding a chart board to it, so the pilot didn't have to look at his lap. He could look at the chart on his yoke, on his control yoke. And so that was a lot safer. He could glance up quickly to look at the sky.

Laws: Yeah.

Rudin: And that worked out great over a long time and we got them made. At first, we didn't sell huge numbers so we got them made at the Goodwill. And- and so there's not much more to say other than our sales ran up to between a half million and a million dollars in the best year.

Laws: Okay.

Rudin: And they didn't cost much to make so that was, you know, good.

Laws: Okay, so what was the next adventure you were involved in, Marv?

Rudin: I got into other activities, namely I became active in the Libertarian Party. I'd become a libertarian in 1980 and- when somebody told me that there's a party that believes in freedom of both kinds, business and financial and social freedom. And said, well, I believe that way. I didn't know there was such a party. I said, well, wait a minute, there are about five parties. Two-- three of them don't amount to anything, so if I see a party that I like it's close enough to what I like you don't need to say- tell me more about it, so I joined the party. And the first thing I did, it was right near the elections, so I went down and saw Ed Clark. He was the presidential candidate that year and he was at a hotel in Los Angeles in the auditorium. And I listened to everything they were saying and then- and then I went out into the lobby. And as they came out, one of the candidates was one of the Koch brothers, Charles Koch, and he was running for vice president. And I walked in <laughs> and I walked up to him and I said "Keep it simple". I said just tell them they'll have money, they'll have more in their paycheck <laughs> in their take home pay, if they go Libertarian <laughs>. And then I walked up to Clark and I said- I said when you're on camera, look at the camera. Don't look at the audience in the auditorium. So <laughs> I said "'cause there's a much bigger audience out there than there is in the auditorium". That was good advice <laughs>.

Laws: <laughs> Right.

Rudin: But it's I was quite a- sort of brassy <laughs> and- and that's how I got started. So now it was 15 years later and I'm 70 and- and I'm wondering what's wrong with this party, they don't seem to grow at all in 15 years. I said so I've got to find out why, so I'm going to start going to their meetings and I learned why <laughs>. But it took me- it took me like several years, about five years to really. I sort of saw why but I wasn't-- I thought what, surely there's a way for and entrepreneur like myself, which I realized I was by then, having taken such a big chance with PMI. So surely there's somebody like me could get it growing, that's what I thought. What they need to do is to start doing some clever things, putting ads up on U-Hauls that say, "Freedom, Choose It Or Lose It, Libertarian Party." And put that truck in a busy thoroughfare and then keep moving it.. So by the end of the year, a whole lot of people have seen that truck all over the county <laughs>. And I'll bet that'll cause our- our registrations to increase.

Laws: Mm-hm.

Rudin: Everybody yawned <laughs>. Just like Marlan Bourns yawned when I told him we could take over the whole modular industry <laughs>. Same thing, nobody could see it. Not even one person could see that there were things like that we could do that were creative and didn't cost much <laughs>. And I could give you more but that's a good example. I looked into radio stations and different things that you could use it cheaply at night, and nobody appreciated any of that. It turned out, what it was, was a club who were critical of anybody who wasn't a pure libertarian <laughs>. And they felt proud of themselves because they really knew and it really didn't matter whether we could win votes, even though they ran for office every time, some of them did. Oh, they got their name on the ballot, you know, like an ego trip it was for them. So- so anyway, at first, I was publicity chair. Then I became chair, I got elected. I got elected to publicity chair then chair. Then I thought, well, I can reach libertarians by doing a newsletter. So maybe that'll work and I'll get them moving the direction I want. That didn't work either <laughs>. I put out beautiful newsletters and every month for about two and a half years. And I could not get even one person to say, "Yeah, I want to join in doing these things, these creative things." And all they wanted to do was just meet every once- once a month and there were only like 30 of them out of 600 who had joined.

Laws: There were 600 members locally?

Rudin: Six thousand registered voters, and about 600 dues paying members. And the most that would show up at a meeting was 10 or 20. And I got the biggest meeting attendance they ever had, over at Coco's in Sunnyvale, I just called a lot of the paying members <laughs> and invited them to come and there was standing room only. And they said they'd never seen standing room only <laughs> before. So I realized I'm a different kind of person and nothing is going to move them and I'm wasting my time <laughs>. So I left and I never went to anymore meetings.

Laws: But you continued to support their aims.

Rudin: I still am a libertarian 'cause I believe in their principles. And I still vote Libertarian.

Laws: So what else did you do with your time, Marv?

Rudin: I was going to the gym. I was playing tennis.

Laws: I think you said you were skiing at one time, right?

Rudin: I was skiing every winter, yeah. Yeah, I taught my son how to ski.

Laws: You have just the one child?

Rudin: Four children, one son, and three daughters. And I was dancing [the West Coast Swing], by the way, with my daughters at my 90th birthday over at the Blue Pheasant. The only birthday party I've ever had was with my family, by the way. My 90th, I just said would be nice to do one when I'm 90 and my son fixed it up.

Laws: Good.

Rudin: He's- he's a board certified: Orthopedic surgeon. Interestingly, some guys at the bar said, "Oh, you're really popular with the girls" <laughs>.

Laws: <laughs>

Rudin: My daughters were all pretty good but they're in their 50's now but they still look pretty good.

Laws: Good.

Rudin: But and I said no, no. It's my- it's my 90th birthday and it's my family and my daughters and daughter-in-law.

Laws: Marv, you've had a lot of interesting experiences throughout your life. If you were advising a young person today and, say, they were studying science and technology, what kind of advice would you give them as to how to pursue their career?

Rudin: Well, it depends on what ultimate goal they have besides being smarter than everybody and making a discovery that nobody else has thought of.[If they want to be happy in their careers they should take an aptitude test and find out what the opportunities are, and then see what opportunities they would best fit].

Laws: Mm-hm.

Rudin: I wasn't like that. I wasn't raised in a family that exalted pure knowledge. I only went to Caltech because my math teacher kept talking about Caltech. And I wasn't knowledgeable enough and didn't have good enough advice to know that I might not get in and I better go- look somewhere else, as well. So- so I went there just to be an engineer, not be a physicist. Physicists [and other scientists], I think, were the smartest people, although it's not always true. But I mean tended to be.

Laws: Sure.

Rudin: And so maybe that's why I got B-pluses the rest of my Caltech three years and still was high enough in grade to get into *Tau Beta Pi. Considering that w*hen I was a freshman [competing with science majors], I was a B-minus. Or maybe I just got better [with more college experience because my high school wasn't as good the people who were in high schools around the suburbs.

Laws: Is there anything else you'd like to say?

Rudin: I didn't realize that I might make a good manager and a good supervisor. I just wanted to be an excellent engineer. I can write extremely well and say exactly what I want to say. And that's been a big benefit, and why as a marketer I did so well and why as a manager I did so well. Nobody- nobody left me not understanding what I had to say to them.

END OF THE INTERVIEW