Oral History of Alan B. Grebene

Interviewed by:
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Laws: My name is David Laws. I am semiconductor curator at the Computer History Museum in Mountain View, California. Today is Monday, November the 5th, 2012, and this afternoon we're going to interview Alan Grebene. Alan was a pioneer in analog design and has spent most of his career here in Silicon Valley. We will talk about Alan's career, the things that interested him, the things that excited him and the challenges he faced along the way. Alan, let's talk a little bit about your early days? I understand that you were born in Turkey.

Grebene: Yes. I was born in Istanbul, Turkey and grew up there till I finished next to the last year of high school at Robert College. It's an American school in Istanbul.

Laws: A little bit about your childhood prior to that? Are there particular subjects at school that interested you?

Grebene: I was interested in math and physics and felt pretty good about both of those subjects, so that sort of led me in my mental planning at the time to engineering and more specifically electrical engineering. Electronics was sort of an offshoot branch yet, and it wasn't a separate major by itself.

Laws: Were there any people in the family or relations that mentored you?

Grebene: No. No, not really. I came from basically a military family. My father and his father were all in the military, the Turkish military or the Ottomans before that. So I'm the first one to break the mold and go into essentially a field outside of military.

Laws: Interesting.

Grebene: The opportunity came when I was my junior year at high school at Robert College where I got a scholarship from American Field Service, or AFS.. It was an exchange program that had started shortly after the Second World War mainly to bring European students to the US. To have them spend a school year, the senior year in high school, and take back the experiences that they gained, sort of a cultural attempt on the part of US to show US as a country to young people in Europe, who may eventually be the leaders there. And it's what brought me to US in 1956. I ended up at a prep school in Connecticut called Choate, a very lucky break again, because it's one of the top-notch schools, which I did not know till I got their brochures. And, yes, it looked a little unusual that the whole school had 23 tennis courts where the city of Istanbul had three tennis courts. So, anyway, this is where I ended up as a senior, at Choate, and graduated the following year, in June of1957. I was also awarded a scholarship to Cornell University in electrical engineering, for the 1957-58 school year. This is the first time I really got into electrical engineering as a subject.

Laws: Did you pursue specifically electrical engineering to go to Cornell?

Grebene: Not really. It just sounded exciting. I looked at the other engineering choices, and it's just luck of the draw that electrical engineering sounded more enticing. After my freshman year at Cornell, which went very well, I had visa issues. I could not extend my stay in the US, so I had to go back to Turkey and finish college at Robert College. I received my bachelor's degree in 1961 in electrical engineering. Again, at that time electronics was just a subset of the basic electrical engineering curriculum. The following year, I was awarded a scholarship to UC Berkeley to do my master's work where I chose electronics as my field of study. That was the up and coming field. It was my first introduction into the world of semiconductors, because what I had studied in Turkey involved only vacuum tubes. I spent two years at Berkeley and basically finished my master's.

Laws: What was the subject of the master's?

Grebene: The master's subject was control systems, essentially developing a model for non-linear behavior in some of the control systems due to delay times and all that. But most of the courses I took also were in circuit design, along with the system theoryl. I took my PhD preliminary exams and passed those at UC Berkeley. Then, I started job-hunting, because my visa was expiring and I had to get my green card. Just as I started my job interviews at Berkeley I realized I had a fatal flaw in my otherwise nearly perfect design. The good jobs in the systems area, which were plentiful at the time because this is the heat of the Cold War and space race, all those wonderful jobs that were exciting required US citizenship, which I wasn't. So the remaining job interviews at UC Berkeley did not prove to be very fruitful. Instead, I decided I would do my own freelancing and took my car and started interviewing around the Bay Area, primarily in the South Bay. I interviewed at Hewlett-Packard. I interviewed at a few other companies whose names I don't remember. But in one of my adventures of that sort driving around, I saw the name of Fairchild. I knew from my engineering classes that they were making transistors, and that sure sounded interesting, and knocked on the door and went in.

Laws: Which branch of Fairchild was this?

Grebene: This was the R&D labs.

Laws: And they were in Palo Alto?

Grebene: By Arastradero Road and what is now the Foothill Expressway. It was the Junipero Serra Boulevard at the time.

Laws: Got it.

Grebene: So turns out I was at the very high-tech end of a high-tech company by going into R&D just because I happened to drive by, and they were nice enough to take me in. Gave me a brief on-the-spot interview, and a quick tour of the facility,and told me what they were doing, showed me what an integrated circuit is.

Laws: So you just knocked on the door?

Grebene: Yeah, I did. I did and said "I'm from Berkeley finishing my master's." And those were the days when jobs were plentiful, and Fairchild was "If you have the right education or background you're welcome" kind of thing. It was open-door. And they showed me my first integrated circuit under the microscope, which, for me, was total fascination. I had not seen one. I didn't quite understand what small meant. I think it was a couple of differential pairs and whatever or simple circuits, but it was sort of a love at first sight on my part. They said "Okay, we'd like to talk to you more," invited me back for a detailed interview, at the end of which they made me an offer to be an engineer in their device development group at R&D labs. And that was my entry through the wrong door to the right place at the right time.

Laws: So this was middle of 1963?

Grebene: This was June of 1963.

Laws: Do you remember who your boss was when you started?

Grebene: Yes. My boss was a gentleman by the name of Heinz Ruegg. He was Swiss, and he was heading the small circuit research group within the device development department, which then reported to Pierre Lamond.

Laws: Quite an international cluster you had there.

Grebene: It was. And my officemate was Bob Polata. Bob was from Czechoslovakia. And of course our boss in the R&D labs was Gordon Moore. So it was a kind of incidental entry to a perfect spot for getting into high-tech for me. That's how it started. I fell in love with integrated circuits and fell in love with analog as a field. It seemed more challenging and back in those years, and it was almost more art than science. I spent a year and a half at Fairchild.

Laws: What were you doing during that year and a half?

Grebene: My first project was designing a custom circuit, which they thought they might later make into a standard product. I don't remember the part number. It was some µA number, but that never quite got into production. But it was a very high-tech circuit for its time, relatively simple, a couple of differential pairs and an output stage kind of thing. It was being designed for aerospace use for a company called Radiation Inc. in Melbourne, Florida, which later became Harris Corporation. As it was to be used in nuclear weaponry it had to be radiation-hardened. So I ended up being at the cutting edge of the technology. It was the first time to my knowledge of an analog circuit using dielectric isolation process and at the same time using thin film resistors, nickel chromium. So I was the designer of the circuit, but really the real challenge was in the technology.

Laws: Who was working on the process aspect of it?

Grebene: The person that worked on the dielectric isolation was a fellow by the name of David Hilbiber. And the fellow that did the nickel chromium was a fellow by the name of Bill Lehrer. These are all Fairchild R&D guys that graduated from there like I did and went on to other things.

Laws: Both of their books are in the museum’s collection of Fairchild Semiconductor Patent and Laboratory Notebooks.

Grebene: But this was my step number-one into IC design, and...

Laws: Were there any tools? Did you use a slide rule?

Grebene: The slide rule was it. That's about the scope of the tools. Calculators weren't really around yet, and whatever calculator we had-- and there was only one -- was a mechanical calculator. You cranked it and it made divisions for you. This was about the limit of the tools. The rest was intuition and some process data, but no design tools. It was pretty much what you knew about transistors and so forth. But in the process I got to learn a lot about the semiconductor processing, what needed to get done, how it was done. And of course Fairchild was at the leading end of it. Most everything was empirical. We had notebooks that showed you the curves and graphs for certain processes, and you got involved with the process by specifying what junction depths you had to have, what beta, what breakdown voltage they should be designed for.

Laws: Jean Hoerni created a set of diffusion of curves for this purpose, didn't he?

Grebene: Yes, he did. We would kind of read through those curves and find out which were manufacturable and use those. It was a great way to get to know about semiconductor process without really doing it hands-on. And that opened up other doors for me. About a year and a half at Fairchild

being a rather young upstart myself I felt like, gee, I knew a lot about semiconductors, and I was open to offers from others that wanted to learn about semiconductors, sort of a self-proclaimed or declared source of knowledge, which you do when you're in early twenties. And I got an opportunity to go to Sprague Electric Company in North Adams, Massachusetts, where they were trying to go from transistors into integrated circuits. My job was to help them to build basic op amps and so on, integrated monolithic chips. I was there with a friend of mine from Berkeley, Bob Pepper. I took his courses during my Master's study at UC Berkeley.. He had gotten his PhD a year before me, and we became friends in the process. So I spent about a year and a half to two years at Sprague, and in late 1965 I had an opportunity to go and teach analog circuit design at Rensselaer Polytechnic.

Laws: What did you do at Sprague? Any particular products or devices?

Grebene: Yes. I was involved in designing analog chips. My primary product that I was involved in was an analog multiplexing switch. It used bipolar and JFET technology together. The basic circuit really was two emitter-follower inputs for differential input and a JFET between the two emitters. They could turn this on and off, let you do multiplexing or analog modulation, and then that connected to an amplifier stage and a bipolar output. It was an interesting circuit that essentially did a lot of gain control, which was needed for AGC applications, without really affecting the bandwidth very much, which was unusual, because most AGC applications change the bandwidth as you go to lower gains.

Laws: Now the process of design was pretty much the same at that point in terms of identifying specific devices from a set [of characterized geometries].

Grebene: Pretty much so. We were doing essentially JFETs by adding an extra diffusion step so that the top gate of the JFET] was a little deeper than the bipolar transistor base diffusion, and would give you a junction field-effect transistor. The control came from the bias applied to the top gate of the JFET.

Laws: What kind of worst-case analysis could you do? You knew the range of parameters probably.

Grebene: Not an awful lot, frankly. You'd run a couple of test runs of individual devices and look at repeatability, but most of the stuff in those years was by the seat of the pants. You had the diffusion curves. You knew roughly what controlled what parameter, and we had Shockley's field-effect transistor paper as the one that we used for the JFET parameters; and some very basic models for the bipolar transistors. Things like Gummel-Poon models for bipolar transistors weren't available at that time.

Laws: And then you got the opportunity to go to Rensselaer and teach. And this would've been in...

Grebene: Late 1965.

Laws: '65. Okay.

Grebene: So I was about a year and three months plus at Sprague. And we had a couple of publications on gain control. There was a paper that I presented at what was then called the Philadelphia conference, the ISSCC. That seemed interesting and, quote, "got some attention" for me, and led me to essentially be invited to be an instructor at RPI, help them with their semiconductor lab and work on my PhD in the meantime. So I started there in fall of 1965 and finished at the beginning of 1968 or end of '67. My work there was on primarily field-effect transistors, JFETs. And it was primarily trying to work on the behavior of the junction field-effect transistors beyond pinch-off, the channel with modulation effects, and the residual conductivity that would remain. And that led to a thesis on that subject, and I did my doctorate and also gave a paper on that at the 1968 ISSCC. That was the closure of my academic work. Then I decided to go back to California, where I felt that things were happening. I was keeping in close touch with the people I knew in California through mail, and conferences, and following their technical articles and so on. And I knew that that's where I wanted to be. I got hired at Signetics as a member of their circuit design department, which turned out was just me. The purpose there was to find new circuit techniques, primarily in analog. And one of the techniques suggested there, if we could ever find a way of doing it, was the phase-locked loop as a frequency-selective method of signal detection. Because we were all trying to do active filters and stuff, which barely work, and really were not that useful outside the laboratory. So I started working on the phase-locked loop as an idea. And right about that time I was joined by another engineer by the name of Hans Camenzind, whom I'd known by name earlier. Not only did Hans join the company, he ended up being my officemate in the same office, and we became a two-man design group working on phase-locked loops.

Laws: I believe you had some previous contact with Hans, via something you'd published.

Grebene: Yes, one of my publications, and I believe it was in the Proceedings of the IEEE, and was a circuit technique for increasing high-frequency performance by isolating certain device pockets on the chip from the IC substrate. It was a technique that worked, but it was more or less esoteric. A couple of weeks or a month after the article was published, I got a scathing review on it from an engineer by the name of Hans Camenzind working at Mallory Labs saying this would never work, etcetera, etcetera.

Laws: This was in a letter form?

Grebene: No. This was a letter to the editor.

Laws: I see, to the publication.

Grebene: And I wrote my answer back saying "This is why it works, and here's what I've done." And so the matter was closed till Mr. Camenzind happened to be my officemate suddenly at Signetics. So we

became friends and it was a very productive couple of years we worked together. He worked at lower-frequency circuits using phase-locked loop techniques, and I was working in higher frequency. Back in those years high-frequency meant like IF detectors and so on, FM detection, frequency synthesis, etcetera. And those were productive years. We presented a paper together at ISSCC 1969 that sort of put the phase-locked loop into the IC world. The phase-locked loop technique was known back in the 1930s as a method of synchronizing power generators. Later it was known as a method for systems design in the aerospace field for synchronous signal detection, etcetera. An expensive technique, it used an oscillator, an amplifier, etcetera. Once we were able to put all these together into a single chip it both improved the performance and made it extremely cheap, so a circuit technique that once would have been a big black box now became a monolithic chip that was worth maybe at that time $10 or $20.

Laws: And you were replacing hundreds of dollars worth of components essentially?

Grebene: We were. We were really, and opening up new applications where you would not use a phase-locked loop before.

Laws: What sort of applications?

Grebene: Oh, well, things like IF and FM Detector sections of FM radios, replacing vacuum tubes and all that by a phase-locked loop that picked up the 10.7 megahertz IF frequency and directly gave you a demodulated audio output and a lot of noise rejection in the process. Meanwhile, we also worked at the lower-frequency end of it to make tone detectors. Touchtone dialing was just coming of age. It was done using active filters, and Bell Telephone had just come up with the touchtone-dialing phones. We thought we could do that with a phase-locked loop, and Hans Camenzind worked on a tone detector for that application, which eventually became a Signetics product. And I worked on a general-purpose high frequency phase-locked loop which did a multiplicity of functions. This was my primary project at Signetics, phase-locked loops and applications.

Laws: Would you have had much involvement with customers in those days? Did you ever get a customer requesting something with particular features or characteristics?

Grebene: Not very much. We were more sheltered from it, except phase-locked loop was so new that that brought in customers. All of a sudden I got involved with customers because the technique was brand-new and few people knew about its applications, so we had to educate the customers on how to use phase-locked loop circuits. And we could do certain things with it so they were willing to pay premium price to get a custom circuit. Mostly in the aerospace area and some high-end communications. So I was involved with the customers in saying what can or cannot be done and then helping the design group, which was in the main engineering department, put it together because they'd never seen a phase-locked loop either till we made some. That gave me an idea that eventually phase-locked loop could be a

method that could be commercialized broadly. Very much like an op amp that was well-known, but when it became available through Bob Widlar's designs (as the µA702 or the µA709), and new fields of applications opened-up when they could be manufactured for a fraction of a dollar. We thought the phase-locked loop showed the same potential. And this is what led me to break away from Signetics to start a company called Exar. In those days you did not start companies easily. There was no venture capital. There were no doors to knock on. We tried to raise money here [in the US]. There really wasn't an interest, because although my name and reputation was somewhat known, and money was available for people like Gordon Moore who started Intel, we just weren't in that league at all.

Laws: Exar would've been about 1970, '71.

Grebene: The idea started in 1970. The company really got incorporated in '71.We were able to find some funding from a Japanese company.

Laws: Who were your co-founders?

Grebene: There were two other fellows, [both from Signetics], A fellow by the name of Paul Davis and a fellow by the name of Ken Greenough. Ken was more the process guy, and Paul was overall process plus administration, and I was the design engineering guy. And we were able to make this connection with Japan through Paul Davis, who had quit Signetics and was looking for another job and at the same time trying to raise money for Exar. Well, the Japanese company that hired him for transistor yield improvement and so on, when they were told about the phase-locked loop and we're looking to raise money for a company they said "Oh, we'll do that for you." The company was Rohm Corporation. They were then called R.Ohm and were the number-one manufacturer of carbon resistors, trying to get into transistors and to leapfrog over to ICs. And we told them "Gee, not only could we help you do that, but we'll give you this brand-new technology called phase-locked loop. You can get into communications and consumer circuits," because they're interested in FM detection, radio on a chip and the like for the Japanese consumer market.

Laws: So you hadn't patented any of this information that may be proprietary to Signetics?

Grebene: We had several phase-locked loop patents at Signetics, but the technique has been known before, and those were for specific circuit configurations, and we were able to work around them.. So, yes, it was patented, but on the other hand it's like patenting an op amp. You could attempt to patent only little blocks within it, which is what gave us the right, we felt, to go start Exar. Signetics did not think so, and very shortly after that we got sued by Signetics. And just about that time, as I was starting Exar, my officemate, Hans Camenzind, had also left and started a company called Interdesign doing semi-custom analog chips, analog arrays customized with metal masks, something we did at Signetics for quickly bread-boarding our circuits in silicon. And Hans wanted to make a business out of it. When we started

Exar and started working on phase-locked loops we looked at the idea of what he was doing and thought "This is great. We'll use our test chip approach that we used at Signetics to do semi-custom designs as well." That brought on the second lawsuit, by Hans Camenzind's company, Interdesign. So we became somewhat notorious in the Valley as running away with this technology that everybody claimed was so unique and this and that. Turns out this lawsuit eventually died of old age, never quite went to trial, and we went through 100's of depositions, and eventually Signetics gave up and left, and Hans Camenzind's company was really relying on Signetics both as their customer and also the one that would pay the expense of these lawsuits. It all kind of went away, and this was year three or four of Exar. We pretty much came into our own, primarily doing semi-custom circuits using arrays or communications circuits using the phase-locked loop techniques.

Laws: And the semi-custom circuits were all analog?

Grebene: They were all analog at the time, because that's what we knew and that's really what the world was. The processes were not compatible between analog and digital. Analog at that time was basically a process that required high current gains and certain breakdown levels and etcetera. Digital was primarily using TTL, which required gold doping to reduce the storage time, which is a perfect killer of performance for analog because the leakages go up. So they really weren't compatible, and frankly digital was pretty cheap to buy and add onto as an external IC to our analog section to make a board-level design. So the pressures weren't on us for mixed signal.. Analog and digital circuit functions were not mixing much on the same silicon chip. And one of the other things we did was designing oscillator circuits. The heart of a phase-locked loop is really an oscillator, which then gets synchronized to an outside signal, and the combination of the two signals are mixed together and used for detection or synchronization. In turn I developed good techniques of designing oscillator circuits, and we made some oscillator IC products. Phase-locked loop also requires a phase detector, which is usually a circuit to multiply two signals, and then the low-pass filtered output would show the phase difference if they were at the same frequency but different phase. So we made some multiplier circuits. By that time a fellow by the name of Barrie Gilbert had come up with an analog multiplier technique, which really was very brilliant and very useful technique for exactly what we wanted. So we would combine multipliers and oscillators to make essentially analog signal generators, because with a multiplier you could modulate the oscillator output, and we had developed a unique sine-converting technique at Exar, which was essentially using a triangle generator driving an emitter-coupled-- basically a differential pair, which is slightly overdriven so that you would round the corners. Turns out a slightly overdriven differential pair with some emitter degeneration between the two emitters really did a very good job of rounding a a triangle curve into a sine curve. It sort of generated a hyperbolic cosine and hyperbolic sine, which for small deviations are very similar to a sine wave, so we can convert a triangle wave into a sine wave, and modulate it. So it kind of gave you a signal generator on a chip. In fact we went so far as selling two of these chips on a PC board as a kit to do your own signal generator that generated AM, FM and every waveform under the sun, because you could generate triangle or square and modulate them with triangle and square in every which way. So one of our successful products was the signal generator [model] XR-205. It gained a lot of attention, big magazine covers and all that, but commercially it was not that successful, because function generators are sort of like laboratory equipment. They're used one or two in the laboratory. People don't buy them

like op amps and phase-locked loops. So we gained a lot of notoriety at Exar. But the product really other than being esoteric did not really do much. We did a good amount of business with semi-custom circuits using analog arrays and custom communications circuits, more specifically T1 repeaters, and the company grew around that. I was there for about 11 years, from 1971 till 1982.

Laws: About how big did the company get?

Grebene: It was a medium-sized company by Valley standards, $30 million, $40 million business.

Laws: And how many people roughly?

Grebene: I think we had about 200 to 250 people.

Laws: As you say, a mid-sized Valley company in those days.

Grebene: And the Japanese company that had financed us, they owned majority interest by the time the other founders had left, and I owned most of the remaining minority interest in the company. They wanted to have Exar be a wholly owned subsidiary, because they wanted to take the Japanese company public in Japan, and Exar would be a feather on their cap if they bought it out. Great opportunity, so they made me an offer, which certainly was very nice, and I took my chips literally and moved on.

Laws: I believe you were doing some teaching during this time as well.

Grebene: Yes, I was. I was teaching at University of Santa Clara in what was called "The Early Bird Program". I did this for about four years. It started when I was] at Signetics in 1969 and went on till 1973 or '74. It was fun. I was enjoying it. The class was primarily for professional engineers working mostly in the IC business and doing their master's study in these morning classes, so it was a good group of people who knew the technology.

Laws: And were highly motivated.

Grebene: Highly motivated, highly interested and sort of was really a class unique to the Valley, because that technology was directly applicable to here. Eventually the management end of the IC business took more of my time, and I gave up teaching and spent full time at Exar after, say, 1974 on. Teaching was really a couple of days a week and in the morning, so it really was a sideline, but an enjoyable sideline. After I left EXAR I decided to do an IC startup of my own, trying to benefit from what I learned at EXAR. I had no employment contracts that would limit me, and it was a very friendly parting. So, I put together a

team of good analog design engineers from the valley and so on and went out and raised venture capital. We got Micro Linear fully funded in 1984. It was a very good group of engineers. Paul Gray, who was a professor at Berkeley, was going to take his sabbatical leave so he joined as one of the initial key people. And off we went to do primarily custom analog design. By that time the CAD tools were coming on stream so we were no longer cutting Mylar tape and doing it by hand. Our plan was to use these CAD tools in our semicustom arrays made up of not individual devices but tiles of building blocks to build custom and semicustom circuits and eventually going to standard products with that. And the company developed fairly well. We went through a couple of rounds of financing.

Laws: Who financed the company?

Grebene: Initially it was seed funding form Fred Adler of Adler and Company.

Laws: Sure.

Grebene: And a number of local venture-capital companies. I'm trying to remember the names but anyway it was well funded and kept getting well-funded. It never quite became profitable; it came close but it got big enough, we were about maybe $12-$15 million business level with about 80 to 100 engineers. At that time I realized that I was in over my head -- so I hired a CEO and became pretty much the Chairman and outside face of the company. That worked fine for a while, except that the chemistry wasn't right. So the time felt right, since all my stuff was vested, to go ahead and freelance again. I got involved with the venture capital business. I became an associate with Sequoia Capital where Pierre Lamond and Don Valentine, both of whom I knew from earlier years, were the principals, to look at their deals, bring in deals and so on; that was sort of a part-time activity. I'd be doing consulting on and off and doing some expert witness work for various lawsuits. By that time the lawsuits in the Valley had become fairly standard and law experts were in demand to defend this or attack that patent. It was an interesting set of years. In my expert witness activities I also kept running into my old friend Hans Camenzind. Each time on the opposite side of the table - representing the other side. They were interesting and fun years on their own merit. I had several startups get funded and several startups get acquired. As I said, those were really active years in the semiconductor business and the software industry was just beginning to come into its own. The PCs were becoming more of a tool rather than a toy. And in 1989, I started another company just on my own funding called Symmetry Design Systems. The idea was to make models of both devices and ICs with analog content for board level design. Simulation, primarily various flavors of SPICE, had become quite popular and the board level guys wanted to now go beyond bread-boarding to simulate the whole board, and they needed SPICE models for each of the analog chips on their system board. I was able to connect with some very good engineers in software and device modeling and we were able to acquire the commercial rights to modeling software developed in China in Tsinghua University because one of my junior partners was a Chinese engineer. He had graduated from there and knew the right people, and the university wanted to gain some notoriety through our reputation. Tsinghua is sort of like MIT of China.

Laws: Okay.

Grebene: These are the years where China is just coming on but it's still 1989 and they wanted to basically have some external markets that they can get familiar with through this software. So we signed a licensing agreement to have the world rights to it with future royalties to them as we sold it to a maximum of certain amount; essentially a bootstrap bargain. It was a parameter extraction program; essentially extracted bipolar Gummel Poon parameters or MOS parameters for device modeling. You would do that by either -- in the case of the transistors, we would take a particular commercially available transistor and would use this tool to extract all of its electrical parameters, mostly from the data sheet. You can scan in the data sheet. Click on the characteristic curves on the scanned data sheet image for breakdown and AC performance et cetera and out would come the Gummel Poon models.

Laws: So, here you were bringing technology in from China. Quite a reversal of what people usually think of.

Grebene: Yes, we were. China was hungry for technology but interestingly enough our technology was flowing this way which later on pretty much phased out because all the stuff then became more involved with China operation. In fact, I had a visit from an FBI agent who wanted to interview me because of our interaction with China and the Chinese engineers we were bringing to the US, to make sure that none of the classified technology from the US was flowing over. He promptly found out that no, the flow was backwards and felt very comfortable with it.

Laws: Good.

Grebene: So that was…

Laws: Sorry, what year was it you started Symmetry?

Grebene: Symmetry was 1989 started in my home. It became really an officially incorporated company by 1990. We got the Chinese software by the end of '90 and essentially became commercially visible in the US from 1991 on through 1996.

Laws: How were you selling the tool?

Grebene: Well, initially we were selling it directly ourselves and sales reps that basically would have demo version of the software they'd show.

Laws: Did it run on a PC or a workstation?

Grebene: Back in those days, no. It was Unix-based, and ran on Sun workstations. PCs weren't quite up to speed.

Laws: Sure.

Grebene: Although our macro models ran on a PC using P- SPICE which was available at the time. The company was self-funded primarily by myself and a few years into this became financially independent doing quite well mainly because it was small and playing in a niche. It was what I call at the time a "point tool", used to supplement a whole array of tools supplied by major CAD companies. The technology is changing and being a point tool is only temporary, you really have to go in something bigger, and fortuitously for us a company in Oregon, Analogy, who we had dealt with and our device models for their analog simulator. They knew our software well, wanted to buy us and made me a very good offer which seemed like the right time to essentially cash out of that business. In 1996, I sold the company to them.

Laws: So you've been doing that for about six or seven years then, I guess?

Grebene: Yes, and then I went off doing more of my start-up consulting work, got involved with a couple of companies which were either trying to raise money again or find a way of growing. My involvement, typically, would be on an essentially gratis basis. I'd have some equity in the company but beyond that I'd devote my time to getting that company grow and eventually be acquired. . I was helping a group of Chinese engineers, this time all from Taiwan, very bright group of guys that had started a company called Ultima designing so-called "physical layer" circuits for Ethernet networking, same thing that Level One was doing. But the Ultima guys were very successful in selling their products in the Far East because of their Taiwanese connections and the company was pretty much self-funded and profitable, but still living hand-to-mouth. Along came Broadcom and wanted to acquire the company because Intel had acquired Level One which kind of left us as the only one that was available with this technology that they could acquire. And they made a very good offer and we sold the company. That was sort of my last adventure. By that time it was year 2000 but from 1996 on I was really semi-retired.

Laws: You've published a few books along the way, Alan?

Grebene: Yes.

Laws: So, how did you ever find time to write books with all this other work going on?

Grebene: Well, the earlier years were very active. There was a lot of energy boiling in me. First one was started with the phase-locked loop technology and the course I taught at the University of Santa Clara. Notes for that course became the source of this book. Actually I was thinking of writing a book with my office mate, Hans Camenzind, but after trying various outlines we couldn't quite agree how the book should be written so he decided to write his own book and I decided to write my own book, with different publishers.

Laws: Yes, he did publish a book on a similar topic.

Grebene: Yes, and part of it was the competition. If Hans was going to write a book, I wasn't going to stand still, right? That made us very productive, it turns out. If I'd started to write a book I'm sure Hans would have done one too. But that was the first book called *Analog IC Design,* which was published by Van Nostrand back 1971. It did quite well. It went through several printings and all that, several translations to Japanese and various European languages and so forth but basically became dated fairly quickly because it was heavier on review of the existing circuits of the day and not as thorough in the basics as it should have been because well, I was more enamored by specific hands-on circuit design and I was communicating more toward the IC designers as opposed to want to be IC designers.

Laws: Right.

Grebene: And in 1982, my last year at EXAR, and, in fact, 1981 I started thinking of writing a new book. There was a book that was out by Paul Gray and Robert Meyer from UC Berkeley that was quite popular on bipolar and MOS design but it was written not from the point of view of a circuit designer but more as a college textbook. I thought I could do that similar book more aimed at the practicing engineer with the same publisher, McGraw-Hill at the time; and they said "Great, go ahead and do it. Send us an outline." They liked the outline; and off I went. Out of that came the second book in 1984 called *Bipolar and MOS Analog IC Design*; a very successful book. It was about oh maybe a couple of inches in height, a good doorstop.

Laws: Getting close to the Jim Williams book.

Grebene: Yes. That did make a hit. That became together with the book by Gray and Meyer the two standard books that have lasted a good 10, 15 years.

Laws: Is it still in print?

Grebene: It was as of three years ago. Now, it's available on special request and costs a few hundred dollars and all that. I think McGraw-Hill finally sold the rights to the minor publishers but it did quite well.

It went, I think, over eight printings over its lifetime, which was, I would say, about 15 years at least. Then, by about 2004, 2005 that it becoming outdated. And that's how that book came about.

Laws: Interesting.

Grebene: It was fun doing it and I enjoyed it and I had some free time; this was when I was conjuring the plans for my Micro Linear startup.

Laws: You've met some interesting characters along the way, I imagine. Earlier you mentioned Jean Hoerni. You met Jean?

Grebene: Yes, I met Jean. In later years, he had retired but he had some young engineers that he was trying to help develop a high voltage IC design technology which would be a specialized niche circuit business and I was involved helping that company get funded which turns out it came close but didn't happen. Through that experience, I got to know Jean Hoerni, a very delightful person; strong and opinionated but he had mellowed out by those years.

Laws: I believe you mentioned that in your Rensselaer days that you met with L J Sevin?

Grebene: I did. I'd met him through ISCC this is when LJ was a department manager at Texas Instruments and had recently published a book on junction field effect transistors.

Laws: He was at Texas Instruments then?

Grebene: He was at Texas Instruments. I went knocking on his door for some device samples from him that I could use for my Ph.D. work, device samples plus the corresponding manufacturing data on them; channel lengths, diffusion profiles, this and that, which he was willing to supply to me on a non-disclosure basis so I could do my Ph.D. thesis. That worked very well. I was grateful to him. He was heavily acknowledged when I finished my Ph.D. work which was on the behavior of junction gate field effect transistors for operations beyond the so-called "pinch-off" part of the IV characteristics and how they varied at different gate bias levels and why. The same behavior that basically was used very shortly thereafter in modeling short-channel MOS devices for so-called velocity limited current flow beyond the threshold voltage.

Laws: Hans Camenzind is another industry character we have talked about. You kept up with him over the years through various lawsuits and other activities, I understand.

Grebene: We did, we did. It was an interesting creative relationship and a tangled relationship in the sense that we had high regard for each other professionally but personally we had different personalities. He tended to be, in my opinion, overly patronizing and in turn he probably saw me as a young upstart that knew less than he thought he knew. And it was a competitive creative period but as creative periods go, you know, it was an unstable equilibrium and we sort of went our different ways, remained sort of friends, but more professional friends than personal friends.

Laws: You also mentioned Don Valentine and Pierre Lamond.

Grebene: Yes, Pierre Lamond, of course, was my boss for a while at Fairchild R&D and Don Valentine was VP of Sales and Marketing at National later on. I did not know him from Fairchild although he was from Fairchild but a lot of Fairchild people later went to National. When I was trying to start a company and looking around, they wanted to hire me as an engineer, made very good offers because they were interested in the phase-locked loop technology at the time. Don was there. I met with him and he put the arm on me saying "Hey, we could do great things," this and that and that's how I got to know him, from that. Later on when Pierre Lamond asked me to get involved with Sequoia Capital, Don and Pierre were the two principals. They had done some very big deals and grown rapidly but still small in number of people. They'd just taken Apple public, for example; that was their big pride and joy. And I was trying to hit them for financing Micro Linear; unfortunately they had funded Cypress just before. There was a conflict. Also they weren't as enthralled by the custom nature of our business which turns out they were right in the long run because really the growth in Analog was in standard products because it's very design intensive and custom was not really a good use of top engineering talent because everything ended up being once or twice but that talent could have been put to better use.

Laws: Sure.

Grebene: Which, by the way, about the same time a company like Maxim had gotten started, has done very well. So that was their reason for not being involved in Micro Linear but they were able to direct with various other people that would be interested in it so the deal did happen.

Laws: Okay.

Grebene: I enjoyed my years there; it gave me an inside look at venture capital and…

Laws: What would you do for them? They would have a problem with a company and say "Can you go sort this out, Alan?" or…

Grebene: That would be one. What I would do is I'd sit in their partnership meetings on Mondays where the deals would go through and those that fell into areas that would be closer to my expertise, I would be assigned to go look and see and do a due diligence to see if it merited an investment, or if there was a temporary need for somebody to be overseeing them for a while. If it's a troubled company, I'd be called on it but more often it was primarily working with the deal flow and asking to bring potential deals in through my contacts because in venture capital business, deal flow is everything and they were sitting pretty high up to the source so they had a good shot at deal flow but you could not have enough of it. So that was my dealing with them. Later on I got calls from other companies. Kleiner Perkins approached me to help turn around a software company called Simucad at the time, doing essentially logic simulation. I ran that company for a year and then hired a president and we finally sold the company to Daisy Systems around 1989.

Laws: Yes, okay, I remember Daisy.

Grebene: But those were the kind of things that I would do with venture capital. None of them were full-time. They were essentially individual opportunities. Sometimes this would help me identify a particular group of people that I can later work with to help them either get to a stage where they could be funded or if they were funded, help them temporarily in product planning, business planning. And eventually these activities were like a halfway-house for me from going out from actually running a company to eventually drifting into semi- and later full retirement.

Laws: Were there other particularly memorable characters that you came across that impacted your direction or your decisions?

Grebene: There were a lot of them. Bob Widlar joined Fairchild three months before I did and I got to know him quite well mainly because Bob was designing new and novel stuff at the Fairchild manufacturing operation in Mountain View. We had processes that were better than theirs and better controlled so he would be at Palo Alto R&D Labs half the time trying to fabricate his first product, the µA702 Op. Amp. that he was working on. We became friends over the years. Then he and I teamed up and gave some lectures at SLAC on IC design; and basically stayed friends. We'd run into each other at conferences and go out drinking.

Laws: Bob would do most of the drinking, I imagine.

Grebene: He would, yes. I would sort of be a very distant second to him but it was a fun relationship. I enjoyed him and his quirks; very good designer. Those were the fruitful years of analog design, the field was just sort of bubbling up with talent. Because it was new there were no fixed methodologies. We were all designing with just sheer intuition or what we learned from each other and stayed close to each

other. That's how I met people like Barrie Gilbert, who was a close friend, because we were all in that small oasis of analog talent.

Laws: He was at Tektronix in those days?

Grebene: He was at Tektronix. Then he went to Analog Devices, but came up with some ideas which became pretty much the cornerstone for many of the designs we did later. Jim Solomon was another. Jim was a year ahead of me and he got his master's at Berkeley and when I came back after my doctorate, they wanted to hire me at Motorola but I was interested in Silicon Valley. We stayed friends and periodically got together through conferences. He was heavily involved with ISSCC and Journal of Solid State Circuits, which I was too at those years; a very colorful, very pleasant, very knowledgeable person that also knew when to move from circuit design to design tools and started Cadence.

Laws: Did you have any time for a family with all this that's going on?

Grebene: I have a wonderful wife, Karen, that I've been married to for almost 50 years; she also came out of Berkeley, graduated about the same year I did, 1963, and one son is named Alan also; he is an intellectual property attorney. He went through Berkeley and later through NYU Law School, and practiced with Cooley Godward for a while, he's an intellectual property attorney, and now he's the general counsel and the Senior VP at a successful software startup called Medallia Corporation or Medallia.com, which is growing very rapidly and he's happily sitting at a very good seat there.

Laws: What do you do outside of consulting?

Grebene: Well, I don't consult anymore because technology has sort of passed me by. It's hard to be part-time in this Valley. It's a very fast-moving environment and you either run as fast as you can on the treadmill, or you get left behind. And I decided I had my fun years doing it and, frankly, my knowledge of the technology was beginning to get dated. It's time to watch the field from the sidelines, if you would, rather than to play in it.

Laws: How do you spend your time now?

Grebene: Well, I do a lot of stock trading. I manage my own funds.

Laws: Okay.

Grebene: Fund, rather.

Laws: And you ride a mountain bike, I understand?

Grebene: Yes, I'm an avid mountain biker for the last15 to 20 years I've been at it. It's a fun sport and this area has beautiful trails to try it on. Santa Cruz Mountains, up to Skyline and so forth.

Laws: So, you can ride up to Skyline?

Grebene: We do. We don't ride on the pavement. We usually run through-- right through the Stevens Canyon and up although I must admit age does slow you down after a while and you find that you do well with your own group which are those of us that are in their early to mid-70s and the younger group goes passed us. Usually all we see is-- they say "On your left," and off they go but it's still a fun sport. You're fighting gravity and you get to feel that, at least, in theory the gravitational constant is not really a constant but it goes up with age.

Laws: Interesting observation.

Grebene: It does. You feel it when you get to 70s.

Laws: You've been to the museum, I believe, a few times?

Grebene: Yes, I have.

Laws: Is there any particular exhibit that you enjoy?

Grebene: Well, I've enjoyed really all of them. Initially it was more like a warehouse full of old equipment that I have worked with. All the IBM computers that I've punched cards for and the like. It was fun, very nostalgic but when I brought my friends over who weren't technical, they couldn't quite follow. The second time around was with friends, again, when the museum had gone through a reorganization and had gone up-scale. The displays and the exhibits were changed and it was a different world all together. People that weren't technical could really enjoy it. And that's when I really fell in love with it. I've come in a number of times since then just to wander around, look at the old familiar things, the new familiar things; it's been fascinating experience and frankly, many thanks to you for being a driving force to bring it to where it is.

Laws: Well, it's certainly been fun to do and I get lots of opportunity to meet folks like you and talk about the good old days…

Grebene: Well it also is a good way of presenting past history. Things become past history very quickly in The Valley. The shelf life of any idea is quite short. So it takes an organized display such as the museum to put those into perspective.

Laws: Well, the rule used to be we didn't put anything into an exhibit until it was at least 10 years old.

Grebene: Yes.

Laws: But 10 years is a long time now and I think the first thing that broke the rule was when Google offered us their server after it was about six years old.

Grebene: True. You're right. The half-life of new ideas or their shelf life is very short, and the rate of their bubbling up is increasing very rapidly.

Laws: Sure.

Grebene: So, I think it's a great organization with s wealth of information here to keep everything in chronological perspective and displayed beautifully in the process.

Laws: And trying to make it relevant.

Grebene: True. Well, plus you talk about certain personalities and the way, you know, Ted Hoff and Andy Grove and Gordon Moore these are the names that we all know. Here you kind of bring them into the picture as individuals that have come in at the right time and done the right thing. That makes it much more personally interesting, not just looking at hardware but looking at the people behind it.

Laws: Sure, and the challenges they faced.

Grebene: And the challenges.

Laws: What was the toughest challenge you think you faced in your career? Is there something that stands out?

Grebene: Good question.

Laws: Starting companies is always challenging. There are always a zillion things to be done.

Grebene: Yes, that's challenging but it's challenging in a different way. It's challenging in having to go knocking on the doors. And it's challenging attracting the key people that would be financeable along with you. And every time you do it, it's challenging because, no matter how many times you've done it, you still get haunted with the fear of failure that really lights a fire under you and it makes it a lot more challenging. On the other side, professionally challenging, I found my first job at Fairchild very challenging when I was thrown into a new technology, I didn't know much about it but neither did anybody else and it was the cutting edge of the cutting edge at the time; building a radiation hardened IC with that dielectric isolation technology, just conceptually done a few months ago depositing thin films on it not yet commercially done and myself designing the circuit. It was fascinating. It was enticing, exciting and a very steep learning curve where some of the things were learned by making mistakes. And sometimes they were expensive mistakes. I give Pierre Lamond a lot of credit for putting up with some of the earlier mistakes in the design where I just didn't know enough about the technology but neither did most people.

Laws: Right.

Grebene: Kind of think it's like-- now it's getting a little deeply technical but collector contacts need an N-plus diffusion to make good contact. Well, the examples I looked at I did not see it and my first circuit that I developed with this technology did not have those. So an aluminum contact to the collector actually becomes a Schottky diode.

Laws: Yes.

Grebene: Okay, and the circuit sort of works but not quite; that was a learning curve of what was not shown in the literature that you learn by doing. Expensive mistakes, but in those days when you're sitting at peak of the technology mountain you could do it and live to tell stories about it and not get fired.

Laws: True. Well, you've certainly lived to tell a lot of good stories, Alan. I'd like to thank you very much for joining us this afternoon,

Grebene: Well, thank you very much and thank you for the opportunity. These are good memories.

END OF INTERVIEW

