CHEMICAL HERITAGE FOUNDATION

ISY HAAS

Transcript of Interviews
Conducted by

David C. Brock

By Phone

on

24 and 25 June 2010

(With Subsequent Corrections and Additions)

CHEMICAL HERITAGE FOUNDATION
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ISY HAAS

1934 Born in Istanbul, Turkey on 18 June

Education

1955 B.S., Electrical Engineering, Robert College
1957 M.S., Engineering, Princeton University

Professional Experience

IBM Research Labs, Poughkeepsie, New York
1955-1956 Superconductivity Research in Lead

Remington Rand Univac, Philadelphia, Pennsylvania
1957-1958 Circuit Design

Fairchild Semiconductor, Palo Alto, California
1958-1959 Device Evaluation
1959-1961 Microcircuit Development

Amelco Corporation, Mountain View, California
1961-1966 Device Development
1966-1968 Director, Research and Development

Inmet, Inc., Los Altos, California
1968-1978 President, IC Design

General Instruments, Inc., Chandler, Arizona
1978-1980 MOS Device Research

Semiconductor Engineering Corp., Inc., Tempe, Arizona
1980-2001 President, IC Design

Honors

1955 Summa Cum Laude, Robert College
1956 Orson Desaix Fellow, Princeton University

ABSTRACT

Isy Haas was born in Istanbul, Turkey. He and his parents were Jewish and Polish citizens, not automatically Turkish. They spoke French and German until World War II, when they ceased speaking German. Haas attended a French Catholic grade school and the English High School for Boys. He was always interested in physics, and at Robert College, where he graduated summa cum laude, he settled on electrical engineering.

Experiencing Turkish anti-Semitism, Haas wanted to go to the United States. He matriculated into Princeton University, where he obtained a master's degree in engineering, though his classes were mostly in physics and mathematics. His mentor and advisor was George Warfield, who recognized Haas's "feel" for the way things happen or work, his "physical intuition." One summer he worked for IBM, where he first became interested in computers.

Haas accepted a job at Remington Rand Univac in Philadelphia, working on positive-gap diodes under Josh Gray. Haas obtained his first patents there. Remington helped him gain his permanent residence, important because the military was his field's main customer. He left the Northeast for California, where he went to Fairchild Camera and Instrument (later Fairchild Semiconductor); there he worked with Gordon Moore, Robert Noyce, Victor Grinich, and Jay Last. Calling himself a "cynical circuit designer," Haas preferred evaluating devices. He developed Avalanche switching and wrote "a few" papers on four-layer diodes.

When Last founded Amelco Corporation, Haas left Fairchild for Amelco and stayed there about seven years, including the years after Amelco was incorporated into Teledyne Technologies. He worked with Lionel Kattner on diffusion, and they evolved a proof of principle for diffused isolation. Haas designed and evaluated most of the integrated circuits originating at Teledyne. Assuming Last's position when Last left, Haas became knowledgeable in many aspects of design and evaluation. He spent a year trying (unsuccessfully) to raise capital for his own company and then went into consulting.

At the end of the interview Haas discusses his patent for a two-collector transistor; Teledyne's military work; and the sources and development of equipment and materials. He talks more about Sheldon Roberts and Lionel Kattner. He explains how his move to Chandler, Arizona, improved the quality of his life. He concludes the interview talking about his work on MOS devices for General Instrument Corporation, which finally convinced him that he wanted to be his own boss. He took up what he liked best and did best: developing integrated circuits of all kinds. He had very little competition at first, so he did quite well. Eventually the field expanded and computers were developed to aid with design and simulation. Computers were too expensive for Haas at first, and a gradual decline in work led to his retirement. Haas says he is now attentive to the stock market.

INTERVIEWER

David C. Brock is a senior research fellow with the Center for Contemporary History and Policy of the Chemical Heritage Foundation. As an historian of science and technology, he specializes in oral history, the history of instrumentation, and the history of semiconductor science, technology, and industry. Brock has studied the philosophy, sociology, and history of

science at Brown University, the University of Edinburgh, and Princeton University (respectively and chronologically). His most recent publication is *Understanding Moore's Law: Four Decades of Innovation* (Philadelphia: Chemical Heritage Press), 2006, which he edited and to which he contributed.

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INTERVIEWER: **David C. Brock**

LOCATION: **By Phone**

DATE: **24 June 2010**

BROCK: Okay. It looks like I've got these recorders going. So, I thought I could just begin by asking you, Isy, about…I learned from my background research that you were born and raised in Istanbul in Turkey.

[…]

I was wondering if you could tell me a little bit about when you were born and the family that you were born into, your father's occupation, things like that.

HAAS: My what?

BROCK: Your father's occupation.

HAAS: Oh, okay. I was born in Istanbul, Turkey […on] June 18, 1934. And I was born and raised…lived in Istanbul, raised in Istanbul until I left on September 23, 1955. I went to a French Catholic grammar school [Notre Dame de Sion], actually a nun school. Even though my parents are Jewish—we're Jewish, I'm Jewish—the school was one of the better schools. And it was almost next to our house . So that was convenient, and I also got a good education.

And from there I went to an English high school [English High School for Boys][…] I guess it would be the equivalent of our high schools. And from there I went to an American college in Istanbul: it was, at the time, called Robert College, which is an American college established under a…I believe it's a Presbyterian Trust operating out of New York City, and started during the Crimean War, with some connection to caring for the wounded coming out of the Crimean War. [An American minister started a bakery to make bread for the wounded returning from the war]. The details are really sketchy now in my mind. But that school…by the way, Robert College is now known as the Boğaziçi University, or University of the Bosphorus. [It] is, I believe, nationalized, but I'm not sure.

BROCK: Interesting.

HAAS: From there, […] I came to the States and did my graduate work at Princeton [University]. I got my master's degree and completed my Ph.D. classwork. And then from there I went to work for Remington Rand Univac in Philadelphia. [Remington Rand Corporation acquired the UNIVAC corporation].

BROCK: Could I ask you some additional questions about…

HAAS: Yes.

BROCK: Your life and your education in Turkey. What was the language that you spoke in your household?

HAAS: At home, I spoke [German and French, but mostly French after the age of six, which is when we went to grammar school. My parents chose not to speak German and to teach us French instead, trying to distance themselves from the Germans!]

BROCK: Yes.

[…] **<Time: 05 min>**

HAAS: And so I speak German as well […as] French. And we spoke French at home.

BROCK: Were your parents also born in Turkey or had they…

HAAS: Yes. My parents were born in Turkey. But, according to Turkish law, you are not a citizen automatically, as one would be in the United States. You can apply if you want to become a Turkish citizen, which I did when I became eighteen, but I was refused Turkish citizenship, the official reason [being] that I only wanted Turkish citizenship to be able to leave the country and come to the United States, which was quite true […]. As a Turk you could come to [the] States and get [foreign currency from the government]. Your parents [apply and get permission for] foreign exchange [in order to send] you money to support you […].

BROCK: Yes.

HAAS: If you were not [a citizen, you] were not allowed to send money out of the country.

By the way, I was a Polish citizen.

BROCK: You were a Polish citizen.

HAAS: And my parents were Polish citizens.

BROCK: That's interest[ing]…that was my…going to be my next question.

HAAS: Yes. So…

BROCK: Because that was…

HAAS: I decided that I was going to try to come to the States without any money, and I applied to nine universities, got accepted by eight, rejected by one. Would you like to know who rejected me?

BROCK: Please.

HAAS: [Polytechnic Institute of Brooklyn]. I don't know why they rejected me. I got accepted by Harvard [University], Purdue [University], MIT [Massachusetts Institute of Technology], [University of Illinois], Stanford [University].

[…]

BROCK: Yes.

HAAS: …by Harvard, MIT, Purdue, Stanford, [University of] Illinois […]. Oh, eight of them, I forget who the others were, but Brooklyn Poly decided I was not good enough.

BROCK: Now that is quite an impressive array of acceptances. Was this applying for electrical engineering for a doctoral program?

HAAS: It was […]

BROCK: Okay.

HAAS: And financial assistance. I got financial assistance offered by, I think, four. I forget. [The largest amounts were offered by the University of] Illinois in Urbana, and Princeton. Illinois offered me a little bit more, but Illinois was…I'm sorry, Princeton was a little less, but I said that's for prestige.

BROCK: Why did you…at the time that you were, I guess, finishing up your studies at Robert College, could you tell me a little bit about what your thoughts were about your goals and your career that led you to want to go to graduate school in the United States?

HAAS: Well, there were two primary goals. The first and the most important was to leave Turkey. I was a foreigner and a Jew. And I was very sensitive to anti-Semitism and other discomforts that I felt. I don't think that everybody felt the same way I did at my age. But there were quite a few of my friends and acquaintances who felt the same way—and all of them by now, have left Turkey. At the time, that was my primary reason.

BROCK: Okay.

HAAS: And I was a little bit of a maverick at home. I wanted to go and get [out] on my own, and make it "on my own." And […] <**Time: 10 min**> coming to the States for graduate studies was both an aspiration and a way to leave Turkey.

BROCK: Right.

HAAS: It was not…at the time—to put things in perspective: […] getting a master's […] was a ticket to a better life. Today it is not anymore. When I came to the States to get a master's degree—I'm just going to throw this number—I believe that maybe 10 percent of college graduates were going for graduate studies. Today, everybody gets a bachelor's degree. So, a much larger percentage goes on to a master's degree. And at that time getting a master's degree was the equivalent to today [of] getting a Ph.D. […].

BROCK: Right.

HAAS: If you don't have...but many people [have a] master's degree today. If you wanted that extra thing, [that] extra benefit, you get the Ph.D. In my case, after I finished my master's thesis and my Ph.D. course work, the desire to become a permanent resident was much stronger than any other academic or financial aspirations.

So I decided to take a job, which, also, if you're interested, I applied to roughly thirty companies. And one of my requests was that the company would have to help me get my permanent residence. Only one company agreed to that. But also, the type of work that I wanted to do at the time, even though my major was solid state physics, in addition to electronics, my interest was in servo-controlled systems. All that work was military classified work. So because I did not have my citizenship, I got maybe thirty refusals, rejections, […] if I remember right. […] Most of them said that they're sorry, but they cannot hire me because I'm not a citizen.

BROCK: Right.

HAAS: Now, I worked for one summer at IBM [International Business Machine] Poughkeepsie Research Labs in superconductivity.

BROCK: Oh, on cryotrons or…

HAAS: Yes, cryotrons. Now, at the time—I have to use my Wikipedia here—cryotrons were still not on…not thought of. What we were doing was [producing] our own liquid helium…

BROCK: Okay.

HAAS: …and also doing superconductivity research measurement and related things on lead. Lead, because, at that time—I forget now the literature, the history: there was quite a bit of [superconductivity research being done on lead].

BROCK: Yes.

HAAS: …but the relationship between magnetic field, electric field, the electric current going through a lead film or filament were not too thoroughly researched, and so that was my, primarily, the research on lead, not the generation of liquid helium.

BROCK: Right. And that was sometime in that 1955 to 1957…

HAAS: That was the summer of 1956.

BROCK: Summer of 1956, okay <**Time: 15 min**>. Yes. So that would have been right before the cryotron, I guess.

HAAS: Yes, yes.

BROCK: Interesting. But I guess they must have been—at IBM, of course—interested in all sorts of magnetics. I guess it was probably in the magnetic basket.

HAAS: I'd say…yes, right. I remember the use of memory media.

BROCK: Right.

HAAS: Yes, I guess.

BROCK: To…let's see, so a couple questions. Did you have any family in the United States?

HAAS: No.

BROCK: When you came, so…

HAAS: Oh, I…yes, I had an uncle living in Brooklyn.

BROCK: Okay. Was he able to help you in any way in coming…once you came to the States?

HAAS: Sorry, I am getting emotional.

BROCK: Oh, sorry. We can…we can skip it if you're prefer.

HAAS: Oh, no. No, he's…he was a very nice, poor man. And I owe him a lot.

BROCK: Well, let's see. So, when you applied to Princeton, were you applying to the physics department or to the electrical engineering department?

HAAS: Well, I was applying…I applied to the electrical engineering department, even though I found out later—which doesn't make any difference to me—that the degree, the master's degree, that Princeton gives is engineering…

BROCK: Yes.

HAAS: …not electrical engineering, but engineering. So I got to have a master's degree in engineering, even though […] most of my classes were physics and math. When you enter…I guess when anyone enters the program at Princeton you have a fairly lengthy interview with the Dean of the School of [Electrical] Engineering, and that was Professor [Ernest] Johnson […]. And he went through…we went through my background [of courses] I had taken at Robert College. So he told me what classes he suggested. And I said, "Well, you know, I think maybe I should take another couple of classes on this and that." And he said, "Ah, yes, you probably need that. But you can do that on your own. You can do that on your own." They really pushed. They were really pushing to make you work hard, and I really appreciate that now.

BROCK: So where did your interest in solid state electronics and solid state physics come from?

HAAS: Well, it just came. I had a professor called George Warfield as my teacher in solid state physics, and he was my thesis advisor as well. And I, at the time…I didn't know that, but looking back now, I can see that what appealed to me was his approach to education, or to physics, which was to get the feel for what is happening, physically happening at the […] quantum level […]. And diffusion, what is diffusion? Well, why do we talk about diffusion? What does a diffusion profile look like? Why does it look like this or like that? And, you know, at the time I wasn't thinking of it in the same line [as] your question […].

BROCK: Yes.

HAAS: I guess that appealed to me, because later on (meaning maybe even decades later) I realized that the reason I was successful at Fairchild [Semiconductor] and Teledyne [Technologies, Inc.] was because I was always looking at […] what was happening. If I can make you visualize <**Time: 20 min**>, what was happening in the P-N junction or what was happening electrically between the P-N junction and the characteristics of the transistors…I was always interested in much more than the equation justifying beta or recombination or lifetime. I went much more into, "What does this really mean? What does this represent?" And I think that there are very few people that did that at the time.

BROCK: Would you call that a sort of a physical intuition for what was happening?

HAAS: I think I did. Yes, I think I did have it. But that's the way I worked. And that's the way my mind worked. Jean [A.] Hoerni was teaching a class in solid state physics at Berkeley in the graduate program.

BROCK: Yes.

HAAS: And after he taught it a couple years, he asked me to teach it. And I think that now—at the time, I thought he asked because he was impressed with how smart I was, [but] now I think he had me teach it because he thought I knew what I was talking about, which I'm looking at as an indication of what I just said earlier: that I enjoyed the physical understanding of what's going on.

BROCK: Right. Well, what sort of—two things: what sort of work, then, did you end up doing for your master's thesis?

HAAS: It was—I'm going to snow you now, right—hole mobility in silver chloride. Oh, my God.

BROCK: Hole mobility in silver chloride.

HAAS: Right. In other words, the hole mobility was significant [because] electron mobility was [much smaller]. So it consisted of me designing and having […] built a piece of equipment that would hold a silver chloride crystal—in the dark, of course, because [you had to shine a beam of light on the crystal to generate carriers].

BROCK: Right.

HAAS: And this would have to be AC measurements, so I had to [design] equipment [to cool] the crystal, cooled it down to liquid nitrogen temperature, and included a gear, a mechanism, [a] piece of equipment that provided a chopped beam of light.

BROCK: Okay. And then the incident, chopped beam of…

HAAS: And make electronic measurements.

BROCK: Of the hole…of…

HAAS: Of the current flow.

BROCK: Of the current flow. And then, was…the holes were the carriers in this? Was that why you chose the…

HAAS: Yes, yes…

BROCK: …material?

[…]

Was it…what was the reason for the choice of the material, that material in particular? Was it because it was dominated by holes more so…?

HAAS: It could be because there was previous work on this. And it was work that George Warfield had done or supervised, I believe, at RCA Princeton Research Lab [RCA Laboratories at Princeton, New Jersey].

BROCK: Yes.

HAAS: I think he was a consultant there […]. And this was one of the subjects that was available for master's thesis and it excited me, what was involved and why. And so I said, "Okay. That sound[ed] like [something I would like to do!]"

BROCK: Mmm. And did you […] have to prepare your own crystals or did you get…?

HAAS: No. He got them for me from RCA.

BROCK: I see. Well that's a nice segue into one of the other questions that I had written down which was, what were your…did you have exposure to any of the nearby industrial labs that were interested in solid state physics? RCA was certainly right there <**Time: 25 min**>, but…

HAAS: No, I didn't.

BROCK: No, you didn't. No. My other question then, was in the…in your years at Princeton, did you have any exposure to or interest in digital computers?

HAAS: I don't think…. Oh, well, not at Princeton.

BROCK: Okay.

HAAS: I don't remember any talk/indication/knowledge of any computers at Princeton. When I went to IBM that summer of [1956…], I think it was for three months, either, two or three months, I'm not sure—IBM put you through a two-week both indoctrination and education course. The indoctrination was to kind of prepare you for, or encourage you to come back as, an employee. And also, a class in computer programming and you had to program a problem, and load that program on a computer. I forget now which model. It was before the…was it 370? It was before…it was a computer where you fed the cards in the front and […] could also turn a bunch of buttons in the back.

[…]

[END OF AUDIO, FILE 1.1]

[…]

BROCK: Okay, so yes. We were talking about your two-week introductory course at…

HAAS: IBM.

BROCK: …at IBM, yes, and that being your first real exposure to computers. What was your…well, what was your…did computers really grab your attention? Or, you said that you became interested in servo systems, servo controls. Could you just talk about, I guess, the development of your interests while…?

HAAS: Right. I need to…again, I guess it's a question of me getting a feel for these things. I really enjoyed the servo/math combination of the class I was taking at Princeton, and did very well at that. So I thought I had a good feel for the servo systems, because that's all understanding the relationship between math and electronic systems. So I thought I'd enjoy doing that. But I…well, yes. I started wondering, "Well, why did I go into solid state physics?" Well, at the time there was…you couldn't get much of a job in solid state physics.

BROCK: Right.

HAAS: And this is where…you know, transistors were available, manufactured, but they were fairly expensive and certainly not too common. And you know, Sprague [Semiconductor], I'm not sure who else. RCA [Radio Corporation of America] probably. I think Texas Instruments was working with [grown junction transistors] at the time. […] You know, after I went to Fairchild, then everybody wanted to go into the semiconductors.

BROCK: Right.

HAAS: You know that's…Fairchild put semiconductors on the map.

BROCK: Well, when you…so when you decided to, that it was time that you wanted to, basically, secure a position in order to establish, you know, get your permanent residency and you applied to those thirty companies, it was the…

HAAS: I think…I think I know what you're getting at. Let me fill you in.

BROCK: Okay.

HAAS: I just realized myself, now, what happened.

BROCK: Yes.

HAAS: I got the offer from Remington—at that time, UNIVAC used to be called Remington Rand Univac.

BROCK: Right.

HAAS: You probably are familiar with the history. And the job that they offered me was "device application," which was [the study of] new electronic components and researching or analyzing their application to computers. […] It was a one-man department, my boss [Josh Gray] and I. He hired me to do the footwork and he was the brain. And my first job was to work with a device called the "positive gap diode," which is—actually, was (I don't [think it still] exists)—it was something like the Esaki diode.

BROCK: Okay.

HAAS: Are you familiar with that?

BROCK: Yes.

HAAS: […] The current voltage exhibited a negative resistance in the zero to one volt range. So there was a possibility of <**Time: 05 min**> using [the diodes to build] various computer applications and come up with computer circuits, […] like memories. And so I played with that, and [I applied for and got a couple of patents on these applications: U.S. patent number 2,966,599].[1]

[1] Isy Haas, "Electronic Logic Circuit," U.S. Patent 2,966,599, filed 27 October 1958, issued 27 December 1960, assigned to Sperry Rand Corporation.

BROCK: Who was making those?

HAAS: Pardon?

BROCK: Who was making the positive gap diodes?

HAAS: I think it was Sprague, but I'm not sure. I forget now.

BROCK: Okay.

HAAS: […] I came up with the idea of two, either two or three applications. One was a half adder and the other [was an oscillator (obvious stuff)], an And-gate or […] a Nor-gate, a Nor-gate and a half adder. And I got patents for that, or Remington Rand applied for patents. They were granted. But what I was really getting at [was that] that was the time when I realized that I enjoyed that type of work, the device…the solid state device work.

BROCK: Right.

HAAS: […] After a year at Remington Rand Univac, I decided I wanted to get [away from] the East Coast. I just didn't like the East Coast society. I didn't fit in at all. I applied to…no, I didn't apply. I hired a headhunter in California and told him I was looking for a job in semiconductor […] devices. And he came up with Fairchild and we met in Columbus, Ohio [(Ohio State), where a meeting of the IRE (Institute of Radio Engineers) Solid State Circuit Conference was being held].

BROCK: In Columbus is Ohio…

HAAS: …Columbus.

BROCK: …State.

HAAS: Yes.

BROCK: I think that's Ohio State.

HAAS: Next to the prison. Yes. That's where they, Jay [T. Last] and Gordon [M. Moore], interviewed me […].

BROCK: Well, before we get to that, if you don't mind, I'd like to ask you a few other questions about your UNIVAC experience.

HAAS: Sure.

BROCK: I was looking…in one place I saw that it was in 1955 that Remington Rand merged with Sperry [Corporation], and it became…

HAAS: I don't think so.

BROCK: No, that's a wrong date. It was Remington…

HAAS: Sperry came much later, after Remington Rand. Yes. I think that Remington Rand bought UNIVAC. And then Sperry came in, I think while I was at Fairchild.[2]

BROCK: Okay. Well, my question would be…so it was based in…the facility where you worked was the main facility, would you call it?

HAAS: It was the only facility, yes.

BROCK: Okay. And it was in Philadelphia.

HAAS: Yes, yes, on Allegheny Avenue.

BROCK: On Allegheny Avenue.

[2] Sperry Corporation bought Remington Rand in 1955.

HAAS: Right. Next to the subway station or, [rather], the railroad station (I'm sorry).

BROCK: Okay. Did you…now how many…about how many people were in the operation when you were there?

HAAS: I would have to guess. I would [say] it was a few hundred, because that building included everything from design to manufacturing…

BROCK: Okay.

HAAS: …manufacturing computers. And a lot of research. They were doing some research on magnetic storage like drums, magnetic drums. And I think the one that was a hot item at my time was an 80-kilobyte drum. Can you believe that?

BROCK: Oh, my gosh.

HAAS: Everybody was excited over the 80-kilobyte drum <**Time: 10 min**>.

BROCK: Now, did you have much interaction with the…with [John P.] Eckert or…?

HAAS: No.

BROCK: Okay.

HAAS: Never met them [Eckert and John Mauchly]. Never saw them.

BROCK: Okay. So…

HAAS: I knew about them, yes.

BROCK: Yes. So your…but your interest was more…well, you apparently had an image that you would fit in better in the culture of the West Coast than the East Coast. What was it about your image of the West Coast that you had thought would be a better fit for you?

HAAS: No. It was my image of the East Coast…

BROCK: Okay. You didn't really know what the West Coast…

HAAS: I wanted to get as far [away] as possible. You might laugh at that, but at the time, you know I was [twenty-four]…

BROCK: Yes.

HAAS: At the time…. No, I was less than that, twenty-four, I think. At the time you're not very rational or sophisticated in your thinking. I had a situation, several situations there. I was living on the Main Line [just outside of Philadelphia] with a classmate who was staying with family on the Main Line, right near Bryn Mawr [Pennsylvania].

BROCK: Yes.

HAAS: And I decided that this is not the way I want to live the rest of my life. You know: getting dressed for Sunday brunch was not my idea of living the rest of my life. So I decided I'm going to get as far from it as I can, and it was a very, very non-sophisticated way of choosing locations.

BROCK: Well, could we then talk about this meeting that you had with folks from Fairchild in, I guess it was 1958, in Columbus.

HAAS: Right.

BROCK: Was that in connection with one of these device research conferences or…?

HAAS: Yes, it was. I think we're talking about the same thing with the…it's not called the Device Research Conference anymore, is it? […] In my day it was called the [IRE] Solid-State Circuits Conference.

BROCK: Yes, right.

HAAS: It was usually held in Philadelphia.

BROCK: That's right.

HAAS: It was, wasn't it? Yes.

BROCK: Solid State Circuits Conference…

HAAS: […] I guess they tried several places and one of them worked. At that time, they […] held it in Columbus. And I think it was May or June…

BROCK: Okay.

HAAS: Roughly. I moved in July.

BROCK: Okay. And could you tell me about those discussion…the discussions you had and if you…what you recall of meeting with the Fairchild folks in Columbus?

HAAS: Yes. I knew that I liked devices by that time. […] I just remembered, now, more details about Remington Rand. His name was Josh Gray, my supervisor. But three months into my working for him, he quit and went to teach at the University of Pennsylvania. So I was transferred to a circuit design department, and I designed the [magnetic] core read/write amplifiers. And I wasn't too good at that, or too excited, so that was part of my [decision] that I would prefer devices rather than circuit design.

BROCK: Okay.

HAAS: And when I met the Fairchild group in Columbus, I spoke with Vic Grinich, Gordon Moore, and Bob [Robert N.] Noyce. Bob was really the one that dominated the conversation with me; [we] met in their hotel room. And he asked me a little bit about what I was doing, and told me about some of the micro…I'm not sure what word he used, micro-work that <**Time: 15 min**> they were into at Fairchild. I don't remember whether he said they were working with or were thinking about it or what. And he said, "Would you be interested in that?" And I said, "Oh, sure." But, you know, I didn't know what I was talking about, but I said, "Oh, sure." And they made me an offer, […] which I accepted against everybody's advice.

BROCK: Who was advising you against it?

HAAS: […] I went to [talk to the] Remington Rand […] purchasing department.

BROCK: Yes.

HAAS: Purchasing department. And they had a guy there that was a semiconductor purchasing agent. And I asked if they'd heard about Fairchild Camera [and Instrument Corporation], and naturally he said, "Oh, yes. You know, they're a new company. They're gonna go broke any day now." I said, "Oh. I like that. I liked the challenge." Believe me, on that basis, I turned around and accepted the challenge.

BROCK: And how did…what was the job as described?

HAAS: Device evaluation for Vic Grinich.

BROCK: And…

HAAS: And what did I do?

BROCK: What did device evaluation mean?

HAAS: There were two or three…actually, I should say, three or four different areas being worked on under Vic Grinich at the time there. Some engineers working on evaluating DC, AC, and very high frequency performance of the devices, the different devices that came out of

development at Fairchild. Like…what'd they call them? Small signal parameters. But this was both DC, AC, and the type of measurements you made for the plumbing, you know microwaves.

BROCK: Okay.

HAAS: Then there was another group: […] one or two persons. One was Ray Kikoshima, the other was Bob [Robert] Beeson. Ray had worked for IBM in the core memory design. He was evaluating the 2N696 and 2N697 performance with regard to driving cores, reading and writing […] for memories. Bob was working on that, plus he started evaluating the—I forget the part number—the gold-doped device when it came out. And that…oh, yes, and before that he was doing evaluation work. He was doing the 696, 697, and the current steering logic applications that IBM was using at the time.

BROCK: Okay.

HAAS: And then there was me. I was working on evaluating/understanding [the characteristics of] new devices worked off of [the] Fairchild line. [There] were two in particular: one was the Avalanche breakdown and switching of the various transistors: why, when, where, how they go into Avalanche. What the different processes affected…how did the processes affect the Avalanche switching? The different Avalanche switching modes, based on circuit configurations like low impedance base/high impedance base connections, different voltages, different processes under the same circumstances. Now, I gave one or two papers at the Solid-State Circuit Conference <**Time: 20 min**> relating to that. And the other was the four-layer device, which was kind of a byproduct at Fairchild. You know the Fairchild guys had to work on four-layered diodes at Shockley.

BROCK: Right.

HAAS: When they started making PNP [transistors, they were having problems because of the soldering to the headers. The gold alloy they had been using to attach the NPN transistors to the TO5 headers were creating a P-N junction between the PNP collector and the metal header, creating overall a PNPN which exhibited a negative resistance situation as a function of voltage as the voltage increased].

BROCK: Okay.

HAAS: So […] I worked on both, [the] development and [the] evaluation of the [effects of the] different […] alloys and/or […] the bonding [temperature] of the chip to the header. And also, working at understanding the switching—which was not new by the way. […] Shockley and others had done most of the theoretical work. So, my take on this was using the history and background to understand and apply it to these devices and see what laws they obeyed, what they followed. And also, one of the objects was to see if we couldn't come up with a new application for a product that did switch.

BROCK: Right.

HAAS: […] I got intrigued about using this for very high current applications in the amperes [range] on a pulse basis, because you couldn't dissipate amperes in a little, small chip DC-wise. So I wrote a couple of papers on that too.[3]

BROCK: Now, what sort of applications would those have been, where you're dealing with those high levels?

HAAS: We didn't come up with much practical…many practical suggestions. It was mostly [determining] what the capabilities [were]. There was interest in Europe: that's why [large] versions of this [device made their way into] electric trains, and [the like].

BROCK: Oh, wow.

HAAS: […] At the time, like I said, […] Fairchild never was very interested in power devices.

BROCK: Right. Well I read a very interesting paper. I can't remember the exact date, but it was a paper that was written, well, that has your name and Vic Grinich's names as authors about these four-layer devices…

HAAS: That was the one.[4]

BROCK: And what I thought was very interesting in there, if—and I have to confess, I didn't understand everything in the paper—but what I did see was, essentially, discussion…

[3] Vic Grinich and Isy Haas, "Applications of PNPN triode switches," presented at the International Solid-State Circuits Conference, 1959.
[4] Ibid.

HAAS: You've been reading a lot, haven't you?

[…]

BROCK: I try to. I think it's…

HAAS: Good.

BROCK: …good to be prepared, I think. But, in my previous looking into <**Time: 25 min**> stuff at Fairchild in this early period, you know I saw repeated references to computer systems houses being interested in using these four-layer devices as switches for use in computers. And what was interesting in this paper that I read by you and Vic Grinich was you were describing different possible uses for these three-terminal, four-layer devices. And one was for…that the device could act as a memory itself. I thought that was…that it could form basically a memory element.

And then I thought it was interesting that you also described using them as…using them in circuits for driving magnetic cores, like reading and writing and magnetic cores, and then, also for making things like a flip-flop. So, they seemed pretty versatile.

HAAS: Yes. My memory of that, or for those specific things you're mentioning, is very, very vague. But what I do believe I recall is that other than showing, demonstrating, that these things were capable of switching very high currents, the results that we got in applying these things to different applications were not impressive.

BROCK: Okay.

HAAS: Not even to us.

BROCK: Okay.

HAAS: I believe that those things were put in […], primarily, to appear as if we were not wasting our time.

BROCK: Okay.

HAAS: You know, […] I didn't have any interest in pursuing those. I wasn't sold on the idea that this was going to replace core drivers and driving cores and stuff like that.

BROCK: Okay. And just…you mentioned a name of a person who also worked in Device Evaluation who had come from IBM, and was working with Bob Beeson. I didn't…

HAAS: That was Ray Kikoshima, great guy. So was Bob. Yes, both passed away.

BROCK: Okay. And he had worked at IBM with core memory. Okay.

HAAS: Right.

BROCK: Well, let's see. So, it looks like you worked…doing that work for about a year, is that correct?

HAAS: Which?

BROCK: Doing this work on studying the Avalanche switching and the four-layer devices.

HAAS: I can't give you specifics about that. We can work that out backwards. If you go through my…if you go through my history working with Jay…

BROCK: Yes.

HAAS: […] Before working for Jay, I worked for Bob [Robert H.] Norman. [But] before working for Bob Norman, I worked for Vic Grinich. And that was […when] I worked on the Avalanche switching and the PNPN [switching]. And my last…I believe that my last periods with Vic already included working on integrated circuits. I really don't know how long these took. It was more in terms of months and not…

BROCK: Okay.

HAAS: …because 1960…you can work that out.

BROCK: So […] Vic Grinich then hired Bob Norman to take <**Time: 30 min**> over Device Evaluation, is that right?

HAAS: Right. Correct.

BROCK: And did the program expand then under Bob Norman? Or how did things go with his arrival?

HAAS: Okay. I remember what happened now. Vic was in charge of evaluation and application, device application, device evaluation. And the stuff that […] I described to you that I did under Vic Grinich—device evaluation—that was both the device applications and device evaluations. At some point, at the time when Vic hired Bob Norman, [Vic] hired […] Bob Schultz.

BROCK: Okay.

HAAS: And Bob Schultz took over device applications, and Bob Norman took over device evaluation.

BROCK: Okay.

HAAS: And that's how I went to work for Bob Norman.

BROCK: Okay. Well, let's see. Maybe we could talk just a little bit about your impressions around this time, let's say by 1959, after you had been at Fairchild for a bit, your impressions of the major people in the R&D organization, like Vic Grinich, like…well, who else was part of it? Vic Grinich, Gordon Moore, Jay Last…

HAAS: Hoerni.

BROCK: Jean Hoerni.

HAAS: Yes.

BROCK: Just your…if you wouldn't mind giving me your impressions of those folks at that time.

HAAS: I was very impressed by most. But I worked with all of them. There was another gentleman that you have left out, and you may or may not have heard of him, was Dave [David] Allison.

BROCK: Dave Allison, right, who worked in diffusion.

HAAS: Well, he worked on devices.

BROCK: Right.

HAAS: Not to say devices. I'm not…I don't know if [Dave] is still alive or not, but he was a great guy, [very helpful], very practical, hands-on experimentalist. […] I've heard your talk about him […] so you know all the deal about Jean. Jean had [a practical] side to him also, which came in [very handy in due course with] his inventions.

BROCK: Yes.

HAAS: You know he wanted to prove what was in the pudding, so to speak. And so, you might call him an experimentalist in the later years. But I really loved and respected Jean a lot at Fairchild. And he and I went to Teledyne, and our relationship continued, but it was a very professional 'love and hate' relationship, if you know Jean. [laughter] He was a great guy, but he could disagree and be dramatic. [laughter]

BROCK: Yes.

HAAS: But our paths crossed […] a lot at Teledyne. At Fairchild, he was…he was really one of my mentors.

BROCK: Okay.

HAAS: Dave Allison to some extent also. Vic Grinich was…he was a great, very solid electronics engineer. If you needed any…you had any questions, you could go ask him. He understood you thoroughly. But he didn't like being a manager. When he was through with you, he'd want you to leave. But, you know, he was very helpful with making [suggestions. When] I had a problem, [I would] go to him […]. He was usually right on, and I'd go do my work, and he'd leave me alone. Julius Blank and Eugene Kleiner, I knew, but had no interactions to speak of. [C.] Sheldon Roberts <**Time: 35 min**> the metal…is he still alive?

BROCK: I believe so.

HAAS: I guess he is a metallurgist. He was very helpful in answering questions, helping me out, because I was very much involved later on with the processes involved in laying metals on the front and on the back of ICs [integrated circuits]. He was very helpful in helping with the theory and the fundamentals behind it. But he was not a practical person. To solve a problem, he would recommend a two-month study. And we didn't have two months. We needed a solution by the end of the week […].

BROCK: Now, did he come to…over to Teledyne also?

HAAS: Yes, he did. He came over at the same time that I did. Jean and Jay started, or were in talks with Henry [E.] Singleton and Art [Arthur] Rock about starting the semiconductor division. And when the die was cast, they resigned and it was announced that they started Amelco.

BROCK: Yes.

HAAS: [When I found out about Jay leaving, I went to see Gordon and told him I was resigning and that I would ask Jay for a job]. He told me I was crazy, that Jay might not hire me. I said, "That's okay." So […] went to Amelco and at some point Sheldon also left and joined Amelco.

BROCK: Well, I guess we'll get to Jay when we talk about the micrologic effort. What about Bob Noyce and Gordon Moore as people you were interacting with at this time?

HAAS: I interacted much more with Bob Noyce [mostly during] weekly staff meetings…I think it was weekly or monthly. It was a staff meeting. I think it was Monday mornings, but I'm not so sure. Gordon was in charge of R&D, so I interfaced with Gordon occasionally, when I ordered equipment and we needed his signature […]. Occasionally, I'd go to Gordon with questions, technical questions […].

BROCK: We were just talking about your…

HAAS: Gordon…

BROCK: …Interactions.

HAAS: Oh, Bob Noyce. Bob, yes, Bob Noyce at some point really impressed me with his insight, and after that I thought Bob Noyce was God. He was really able to [suggest] reasons for what was happening. In my days, [this] was, in relation to the four-layer device and I think the Avalanche switching…I wrote a paper on the thermal, either behavior or dissipation of the chips, in the chips. And that was mostly <**Time: 40 min**> mathematics, which was not my forte. So I leaned a lot on Jean for that. Sah, you know Sah, Chih-[Tang] Sah?

BROCK: Yes.

HAAS: Sah. I think Sah was just a brilliant mathematician, and Gordon. I'd go to them with various aspects of the paper and what I was trying to formulate into mathematical models. But […Gordon] was very supportive. […] Historically, he's always been supportive of engineers in his company.

BROCK: Right. Well, at what point then did you make a shift from…well, was it while you were working for Bob Norman that you became involved with this effort towards a microcircuit?

HAAS: Well, definitely. When I got involved in the electronics of microcircuits, I was definitely working for Bob Norman. But when I started…when I started this, I'm not sure if Bob…I've got to change that. I'm not sure whether I had been working already on this before Bob came or not. I wouldn't be surprised if I was not working on this before Bob came, because I believe that Bob designed all the circuits that we applied to the microcircuit program. […] The flip-flop […] was the key first element that we started working on.

BROCK: Right.

HAAS: […] Well, I didn't design it. You know, Jay didn't design it. So it must have been Bob who designed that [as well as] all the other circuits.

BROCK: I believe that's correct.

HAAS: I must have started working on microcircuits after Bob came and I started working for [him].

BROCK: The only thing I could think of was, I think that Jay, initially, as part of that program, made a hybrid circuit, I guess you would call it.

HAAS: Yes. But that was after Bob designed it.

BROCK: That was after Bob designed it. Okay.

HAAS: We put four transistors—not me, they—put four transistors on a ceramic handler. And you probably heard the concern about drawing in resistors?

BROCK: Right, with the…

HAAS: Between metallic paths to make the [connection]. I think, that was two resistors.

BROCK: Yes. And so was that the…that was the first kind of microcircuit that you were working…?

HAAS: Very first, right.

BROCK: Now, did that—just to stick with those hybrid circuits—did that become a line of activity in its own right, even as you were…even as the project expanded, to include the planar integrated circuit? Was there…?

HAAS: Why don't you start all over. I didn't get…

BROCK: I was saying with the hybrid circuits—you know, putting these discrete devices together in one package—did hybrid circuits sort of continue as a line of development even when you guys started working on the planar integrated circuit?

HAAS: […] I would have to say no. But I believe that Jay made one of these to take back and demonstrate at one of the Solid-State Circuit Conferences, I believe. But I'm not sure. I don't remember that very clearly.

BROCK: Okay. And so your initial role in the program was evaluating this hybrid circuit that was made <**Time: 45 min**>?

[…]

HAAS: Oh, no. I don't remember doing anything with that hybrid circuit.

BROCK: Okay.

HAAS: After I started on the program, I started with a big picture: "What are we trying to do?" You know, "how [was this] going to evolve?" "How can you possibly build circuits blindfolded," so to speak? We knew that transistors could come off the line with a current gain of plus or minus a 100 percent, VBE voltage (the base [emitter] voltage) ranges of you know, 30, 40 percent or more […].

So I started working on the whole gamut of all aspects of the relationship between the manufacturing process, circuit requirements, statistical probabilities, some of which you know, you mentioned, […] or Jay mentioned in his presentation. And so I got more and more intimate with how this was going to work, […] what this was going to involve, what the chances were of being realistically successful, assuming we made circuits. At that time, in the beginning, we didn't even have any working circuits using the Lionel Kattner and Sam Fok approach of pulling circuits apart or, really, etching them apart and then gluing them back together.

BROCK: This is the physical isolation with…

HAAS: Yes, right.

BROCK: Well, so let me just make sure that I'm understanding—because I think it's very interesting—it seems that there were…when you were going to undertake this program to try and make planar integrated circuits that one of the arguments that you could make that the things would never work, would be you could never…that there would be this problem of yield. That once you summed up…

[…] That was part of this high level analysis that you…

HAAS: Right. And if you go through my notebooks—the engineering notebooks, not the patent book [at…] CHM [Computer History Museum]—[you will see how I was trying to get a feel for how likely it was to expect a circuit to work well over the entire range of variables].

BROCK: Oh, with the materials you gave to the Computer History Museum, yes.

HAAS: You know, I have all that in there, the percentage yield, what [the effect of] temperature was, different methods of selecting transistors, all kinds of combinations that at the time were very intriguing and/or questionable.

BROCK: And so part of your examination was to see if there was a way around this argument that you would never achieve yields by…

HAAS: No, I don't think so. I think…

BROCK: No.

HAAS: [The] psychological attitude at the time was it will work. So, it's not a pie-in-the-sky type of intention or project. It [might not] work occasionally [but] it was reasonable to assume that the processing/engineering would improve with time […]. <**Time: 50 min**> I did not conceive a conviction that this would be a slam dunk. That, yes, it had problems, but considering…put yourself in the position of the guy doing this way back: […] I pick a hundred transistors at random out of the box of rejects—literally rejects—and put them together at random, and you get working units. [This was a significant departure from the way transistors used to be specified for designing circuits].

BROCK: Now, can you explain to me, like, one, how you thought of doing that? And two, how the work…why the units worked once you made them from rejects?

HAAS: Wait. What was the first part?

BROCK: Why did you even think of doing that, grabbing all these things at random out of the box of rejects?

HAAS: Oh, because if that worked, anything could work. I'm serious.

BROCK: Yes, yes.

HAAS: I mean, if you could show that garbage made good flip-flops then [there has to be] some weakness in the [premise] that the only way to build a circuit is with very tight tolerances on beta resistor match, VBE match, VCE sats, and [the like. You have to understand that that was the belief among the circuit designers we expected to become our customers].

BROCK: So you had an intuition that you could make circuits without these sort of tight, tight…?

HAAS: Right. [Actually it was our hope (at least it was my hope) that we could make viable circuits without abiding by restraints set by the establishment].

BROCK: Okay.

HAAS: Now you have to keep [in mind], that I did this because I was not a good circuit designer. I was a cynical circuit designer.

BROCK: Interesting.

HAAS: And I thought, you know, […] "Let's see what happens." And that's where […] I was coming from when I was confronting circuit engineers working at the Burroughs [Company of Detroit], and Sperry, and the like, and they were telling me, "Look. […] How can you tell me

that you're going to make working, reliable circuits taking…connecting transistors on a chip [without] making measurements? Will that guarantee anything […]?"

BROCK: Yes.

HAAS: That was my state of mind.

BROCK: So, what was it that…I mean, if it's not too crazy of a question to ask you, but what was the weakness in the argument of those circuit designers, their argument that you needed these very tight tolerances for all the components, why did it work?

HAAS: There was no weakness.

BROCK: There was no weak…

HAAS: No, there was no weakness.

BROCK: Oh.

HAAS: The issue was that when Remington Rand Univac put out a—this is the first time I've thought of this question; thank you for asking me—…

BROCK: Oh…

HAAS: [The weakness was in the idea that they were designing circuits and we were thinking of *selling* circuits. So the issue became: "how does one test a function and NOT how does one design a function"].

BROCK: Yes. I got…

[…]

HAAS: [When an engineer] was designing a current steering of circuits [at] IBM […], or TTL [(transistor-transistor)] or diode-translogic at Remington Rand and Burroughs, […] <**Time: 55 min**> their obligation was to have the circuit designer design the circuit, and then write a specification for every single component […]. They would then [submit these requirements to the likes of] Fairchild, […] TI [Texas Instruments], […] Siemens, Philips, Sprague, […].

BROCK: Right.

HAAS: So, […] they had to decide or determine what parameters they had to [specify] how tight they had to fit inside the promise, parameters, so these various devices could work together. Now, when you went away from this approach to where you are buying a function from Fairchild, you're not going to be looking at the transistor. You cannot look at the transistor.

[I started looking at catastrophic reasons for failure. As a matter of fact there were very few instances where "function failure" was due to parametric failure].

BROCK: Yes.

HAAS: [Eventually, when we did get into the marketing of the circuit on a chip], the engineers did start specifying […] different limits than they were before. They started specifying fan out, fan in, output voltage, input voltage, so that when you bought a gate, you could assure yourself that this gate would be able to drive so many other gates and/or that the output voltage of that gate would be within a certain limit so that you could do other things with that output voltage.

BROCK: I see.

HAAS: And same with the input voltage. They [were now using] different parameters; but they were specifying limits, but different types of limits.

BROCK: I understand.

HAAS: And it took them a while to readjust.

BROCK: So that was an insight that you were developing, for example, when you were making the…putting together circuits out of the rejects. You were coming to see that while you

basically had a random distribution of the characteristics of these individual transistors, that you could put them together and yet that combined function would still work within a certain setting.

HAAS: Right. And that's where Bob Norman [came] in. He […] devised the different techniques and measurements we needed to put a functional block through to measure and evaluate the performance and distribution. […] One thing that comes to my mind is he devised a way to sweep the input and output voltages and currents of gates…

BROCK: Yes.

HAAS: …and [study] the distribution, and <**Time: 60 min**> [for us device developers to understand what process parameters were affecting the distributions]. Is the distribution too […] loose? […We were studying every] single device that came through different processing to evaluate if any one was better than others. [It] usually [turned] out that metallization was extremely critical to…

BROCK: This is putting the metal…layer of metal inter-connect?

HAAS: The interface between aluminum and the surface of the silicon.

BROCK: Okay.

HAAS: And the bulk…the resistivity or resistance of the bulk on the output voltages…. You know what an IR drop is, right?

BROCK: Yes.

HAAS: Current times voltage.

BROCK: Right.

HAAS: Because sometimes it is…you know that in the bulk of integrated circuits affects…we're going to probably get into this later. [The] lateral flow of current in the body of the chip [creates a] significant voltage [drop] relative to the […] theoretical saturation voltage of

transistors. And I'm being very [emphatic] about making […] this point, because later on in life, I came up with an idea that was patented to get around this IR drop. That's at Teledyne, after Fairchild.

BROCK: Okay.

HAAS: And we'll get into that later, I'm sure.

BROCK: So that was another issue was essentially about the quality of the bulk material in addition to this…

HAAS: […] The shape, the thickness, and the length; that's […] one of the problems [that] was […] significantly altered by […] growing a thin [epitaxial] layer of practical resistivity [and] doping selected areas […].

BROCK: Right.

HAAS: And so it's decreasing that resistance very significantly.

BROCK: And these were…so these were…you were seeing, using, this testing process of sweeping through these…

HAAS: [Yes: observing the base and collector saturation] voltages, yes.

BROCK: Yes. Then…

HAAS: [The base to emitter and the collector to emitter voltages in the saturated mode].

BROCK: You could…then you could basically diagnose whether different process and materials conditions were making…

HAAS: Better or worse…

BROCK: Better or worse integrated circuits.

HAAS: Right.

BROCK: And by better or worse integrated circuits, it would mean that they would fit within…you know, whether they would fit or whether they would not fit these new sort of definitions of the proper limits for these…

HAAS: Right. See Bob came up with the way to relate these distributions to how many gates can be driven…

BROCK: I see.

HAAS: […] If you have multi-input […and] output distribution, [you would plot the two and predict a] yield, or [a] theoretically expected yield of that process.

BROCK: Wow, okay. So it was a very important measure.

HAAS: Yes.

BROCK: Interesting. So, did you also…so this is, this was…I guess all of this sort of work that you were doing is addressing, <**Time: 65 min**> you know, the issue of, you know, that you could indeed make these devices. But were you also getting other information that was making you more confident that you could make them economically, that you could get, eventually, you could get an okay yield on these things?

HAAS: You want the honest answer?

BROCK: Yes.

HAAS: We didn't have the slightest idea. I remember a meeting we had at Teledyne. This was years…a couple years after […] Fairchild, a couple years after that. We're at Teledyne making integrated circuits—it was the same integrated circuits. Yes, by that time Teledyne really had

the brains and not Fairchild anymore. So our circuits worked better. Yields were better. But we had an IRFQ [Informal Request For Quotes] from the military for gates. And was either that or Apollo. I think it was Apollo. And we were talking about 30 dollars a gate […] or for an RS [(set/reset)] flip-flop.

And our costs were humongous, much higher than 30 dollars a gate. And we all knew it. And Jean was…Jean and Jay, you know it was coming out of their pocketbook, […] it was going to cost them money if we screwed up. So Jean was jumping up and down, "No way are we going to sell this for 30 bucks. […] This thing is costing us hundreds of dollars. We're not…" And we decided to go ahead anyhow because of, well, either you are looking at that…to borrow Bob Noyce's approach to costs versus marketing, "If you build them, they will come."

BROCK: Yes.

HAAS: And that's why eventually the cost […] did come way below market prices.

BROCK: Right.

HAAS: [But in the beginning we] knew it was more expensive than what we could get.

BROCK: Okay.

HAAS: We had to compete with nickel [(5 cent)] transistors and nickel resistors and the assembly costs. [But] we had the advantage of mass processing, [and] labor costs eventually lost. So, integrated circuits prevailed.

BROCK: Well, maybe we could go through then…just maybe we could go through now the sequence of, you know, the efforts to tackle isolation by this physical isolation approach of the epoxy and all that. And then the move of you and Lionel Kattner into doing diffused isolation.

HAAS: Yes. I'm going to make your job much easier.

BROCK: Okay.

HAAS: I was involved with all electrical aspects of the physical isolation [techniques, while] I was working on […] all the other stuff: […] the [evaluation of results due to] betas, temperature, this and all that. I was working with Lionel on making measurements of his circuits, but all I was really doing with those circuits was, [determining] if they were working or not working, and life-testing <**Time: 70 min**> them…[eventually] they would all fail.

BROCK: They would all fail the life test.

HAAS: Yes, eventually, they would all fail. But I digress a little bit. Lionel can give you all the answers […] to all your questions about the processing […] of those isolation techniques. The gluing together techniques: they tried sugar—carbonized sugar; they tried epoxies; they tried gluing down without any epoxy. But eventually, when you think about it, the only […] weak point was…by far the Achilles' heel [was that] the whole thing was held together by four fringes of oxide and a metal [film]. And you know, sooner or later somebody was going to walk by and make it vibrate and crack.

BROCK: Okay.

HAAS: And that was what was frustrating me and drove me to think of another way. But Lionel is, you know, the main guy. He and Sam Fok—Sam was a chemical engineer that was working with Lionel on the equipment to spray, edge, and separate the chips and stuff like that. […] I was also working […] with Lionel because he was processing the different transistors that I was evaluating.

BROCK: Earlier with the Avalanche…

HAAS: Same time.

BROCK: Okay.

HAAS: I think so. I'm not sure. I think so. But I was taking devices from him, and from Dave Allison who was making different gold-doped devices. We knew they would have to be gold-doped to keep the switching times down. So, you know, I'm not sure I remember how much of this Lionel was building. Once we started…once the die was cast we did away the physical isolation [and worked only] on the diffused isolation. Then Lionel was making all the devices.

BROCK: And…?

HAAS: At some point, either you ask me…whenever you want me to, I'll tell you how this whole thing came about, which is my main whining point.

BROCK: Well, maybe could we talk about it now?

HAAS: Do you really want to put that on record?

BROCK: I would.

HAAS: Okay. I think we've had a very good introduction. And I think I sent you an email yesterday. I went through the [Kurt] Lehovec and Bob Noyce patents,[5] and I'm not sure I have the whole picture. But one of the things about these patents that…I was not at all familiar with the Lehovec patent. I knew it existed, but he wrote a lot of papers.

BROCK: Yes.

HAAS: So I was not familiar with this patent […] until you gave me the patent number yesterday and I downloaded it.

BROCK: Yes.

HAAS: And the first I heard of a reference to a patent by [Lehovec was at David Laws' interview. Also, bear in mind that Bob Noyce applied for his patent on September 11, 1959, and Lehovec on April 22, 1959. Furthermore, if you look at Noyce's patents you will notice that mounting those chips on a metal (conducting) substrate would short-circuit some junctions].

BROCK: Okay.

[5] Kurt Lehovec, "Multiple Semiconductor Assembly," U.S. Patent 3,029,366, filed 22 April 1959, issued 10 April 1962, assigned to Sprague Electric Company; and Robert N. Noyce, "Semiconductor circuit complex having isolation means," U.S. Patent 3,150,299, filed 11 September 1959, issued 22 September 1964, assigned to Fairchild Camera and Instrument Corp.

HAAS: I didn't know. [Maybe] Jay knew. Jay said, yes, he knew about it. But when I looked at them yesterday…and the Bob Noyce patent…I was only familiar with Bob Noyce's patent. The thing is that [they were] good theoretical ideas […] they got patents on, but there's no way you could mount those on a conductive support without shorting out the P-N junctions.

BROCK: Yes. That's for sure in the…<**Time: 75 min**>

HAAS: […I knew] I was the only guy that understood solid-state physics, electronics, and processing in that group. They didn't even know how to use a curve tracer. Lionel did, but only to check a transistor. And you know, if it weren't for me being there, Fairchild would not have invented the integrated circuit.

So I [told Lionel], "Why don't we do this?" And he said, "Well, it would take twenty-four hours. And not only that, we would have to etch the wafer…." Being naïve […] , I said, "Well, so? We'll make it fit." And some of the people ridiculed me. The others tolerated me and explained to me why it was not feasible. [One of the lab's chemistry gurus was] Eugene O'Keefe, who said, "You're crazy. This'll never work. You put the oxide through 1200 degrees centigrade for more than three hours and it will evaporate, crumble, and crack." So, since I didn't know anything about diffusion or chemistry, I said, "Well, I'll do it, I'll make it better." I was very naïve. I was very gung-ho and believed in my infallibility and brilliance.

BROCK: Now…

HAAS: […] In fact, I really was very naïve. [I did tell Jay, and he said, […] "Why don't you give it a try." And so at that [point] Lionel didn't have any choice […]. He was going to have to do the whole work […]. I [did] the calculations for the diffusion. That's how I learned the diffusion calculations, with Jean's help. That's no big deal, just using curves and a slide rule. [And so we started by learning to etch the wafers down to 75 microns]. That was a terrible job, but I think it was two weeks and we made an existence proof. [Actually, Lionel could have refused to support me, but he did not and was very cooperative]!

BROCK: Now, let me walk you through that again, with just a couple questions. So, you're saying that you're frustrated…

HAAS: Can you speak up a little bit, please?

BROCK: Yes. Sorry. I was going to say if I could just walk you through this, because this is a very important sequence. I'd like to walk through it again with a couple questions. So, if I'm

hearing you correctly, you're saying that as you're doing this testing of these physically isolated circuits, some of them work, but they all eventually fail.

HAAS: Yes.

BROCK: And that this leads you to say this physical isolation is not going to work. We need to try something different. And then you get the idea of basically using P-N junctions to isolate the pieces of the circuit from one another. And to create this P-N junction isolation by diffusing all the way through the wafer.

HAAS: From both sides.

BROCK: From…yes.

HAAS: From the unmasked back of the wafer, and the masked top of the wafer.

BROCK: Right. Now, so…and I believe from our correspondence on the email, I sent you these…think I sent you copies of these two patents that eventually were issued to Bob Noyce that he filed.[6] I guess they were filed right…well, maybe in this period, because he filed these patents in September of 1959. And they were…these two patents were about different schemes for using P-N junction isolation in integrated circuits.

HAAS: Can I…may I ask your patience to give me another three minutes, so I can relax and get into this interesting conversation more relaxed.

BROCK: Of course. Of course…

HAAS: Just one second please.

BROCK: Yes.

[6] Robert N. Noyce, "Semiconductor circuit complexes," U.S. Patent 3,117,260, filed 11 September 1959, issued 7 January 1964, assigned to Fairchild Camera and Instrument Corp; and Noyce, "Semiconductor circuit complex."

[END OF AUDIO, FILE 1.2]

[…]

HAAS: Where were we?

BROCK: Yes. So I was just going to say that we were going to walk through this diffused isolation start. And I was remarking that in September of 1959, Bob Noyce filed some patent applications on a very similar concept, which was P-N junction isolation for a planar integrated circuit.

HAAS: Now is that the patent you sent me yesterday?

BROCK: I think there were two of them that I sent you by email (as attachments) yesterday. There's one that everybody is more familiar with…

HAAS: I have them. I have them.

BROCK: Yes. Now, I was just wondering…so it sounds almost as if it may have been a case of both you and Bob Noyce kind of coming to this idea independently around the same time.

HAAS: No.

BROCK: No.

HAAS: No. As I say in my patent book, [page 127 on August 31, 1960],[7] I was under the impression that I was…that I had seen this in the literature somewhere. I did not claim ever that it was my idea. [You have to realize that Noyce filed his patent on September 11, 1959, and what I saw I knew was not practical because the IC chip could NOT be mounted on a conducting header like the TO-5 package or similar].

[7] Isy Haas, "Micrologic diffused isolation," located in the Computer History Museum Collection, doc-481baa943366b.pdf.

BROCK: Right.

HAAS: I just wasn't sure what my subconscious had seen before. All I knew for sure was that when I [made my suggestion], everybody said, "It's stupid. It's not going to work. It cannot work." But you know, I don't care who invented it […].

BROCK: Right.

HAAS: …just was dead set on trying it.

BROCK: Okay. Well, could you…could we then talk about…. Now, of course the great advantage of this would be that you would avoid all that sort of mechanical fragility of the physically isolated one. As I suppose you'd avoid other problems of alignment and things like that with this diffused one. Now, could we talk about the people who said that this is either extremely hard or ludicrously hard?

HAAS: Sure.

BROCK: It was…part of the issue there, [as] I understand it, was that for this boron diffusion, it would really attack the wafer. Was that the main concern?

HAAS: No.

BROCK: No.

HAAS: You know, it is…at the time, it just seemed to everybody that there was just a totally impractical approach. The boron…first time I heard of this boron thing [was] when I heard your thing which…wasn't it Jay mentioned that boron? [I think that Lionel figured we would cross that bridge when we got there]!

BROCK: May have been.

HAAS: Yes. No. The…well, you understand that I didn't know anything about diffusion or chemistry at the time, right?

BROCK: Yes.

HAAS: So: "I'm going by just the calculations. It's going to take twenty-four hours or twenty-eight hours at 1,200 degrees to do this with the wafer […]."

BROCK: Right.

HAAS: The diffusion experts at Fairchild laughed at it, said [it would never work].

BROCK: Okay.

HAAS: […] Gordon [saw] me in the lab one night working on God knows whatever. […] I was the only one in the lab, […] and he [asked what I was] working on, so I told him about the integrated circuit thing, and he said, "Hmm, good, let me know. Keep me informed." And he walked away <**Time: 05 min**>. If I remember correctly, Jay said, essentially, "What the heck, we can't do worse than what we have now."

BROCK: That sounds like a very Jay comment.

HAAS: […] Jay was always very supportive […]. Always.

BROCK: Yes.

HAAS: One small item [that I] skipped by is [that] I resigned [from] Fairchild […] because I could not tolerate working for Bob Norman anymore.

BROCK: Oh, I didn't know that.

HAAS: And ten minutes after I submitted my resignation to Gordon, Jay came in and said, "You're not going anywhere. You're going to work for me."

BROCK: Wow.

HAAS: And that was the beginning of a long love affair, but…

BROCK: Now is it…

HAAS: So, Jay was always totally supportive of me, except until the press got involved and we all went our different ways, and I never got credit for anything in Jay's eyes.

BROCK: Yes. He feels that you didn't get the proper credit.

HAAS: Right.

BROCK: Yes. That's certainly…that's certainly…

HAAS: Maybe we can get into that some other time. Right now, we were talking about the…

BROCK: Okay.

HAAS: …the diffusion […].

BROCK: So…

HAAS: Lionel…

BROCK: Yes.

HAAS: …and I bootlegged this because we didn't have the masks for it. So we dreamed up combinations of other masks to double-mask and […] essentially get the same etched pattern to shortcut having new masks made.

Am I over your head now?

BROCK: No, no. I'm just trying to…

HAAS: Okay.

BROCK: paint a picture of…

HAAS: He and I collaborated on this. He checked my calculations. He made whatever changes needed to be made. And after that it was a very, very close working relationship between Lionel and I, because he understood what was going on in the furnaces, knew how to modify the gas [flows], the gas mixtures, the oxide thicknesses, the defects created by photoresist, and temperatures. And I would be the one who would then test the junctions and the transistors […] and providing the answers as to why they were not working, what went wrong: [namely] diffusion [depth], pin holes, defects in the masking.

So that was the way I learned about processing, because I had to do the chemical work, the wet chemistry to etch oxides, stain junctions, etch silicon, grind silicon down to expose different junctions, different places. And I was the only who knew the relationship between the electrical curve (on the curve tracer) and what you see under the microscope.

BROCK: Interesting. So, it was…it sounds like it was a very intense period while you were…

HAAS: Oh, I loved it. I loved it.

BROCK: Because you were…you must have been in some ways…you must have been encouraged in part by things that you were seeing to keep at it so intently. Or…

HAAS: [That's the] way […] I have always been. And I want to give credit publicly to my wife for putting up with me.

BROCK: Well…

HAAS: The days before […] getting married to Lynda [Haas], I used to sleep […] on a restroom couch at Fairchild's.

BROCK: Wow. Just because you were working such long hours…

HAAS: Oh, it…I was a bachelor. I didn't have anything better to do.

BROCK: Well, when did…so as you and…you said earlier, but the timeframe escapes me now, that within a relatively short <**Time: 10 min**> period of time, you and Lionel Kattner had achieved a good proof of principle for the diffused isolation, is that right?

HAAS: Yes. I think it was two weeks.

BROCK: Wow.

HAAS: I think so.

BROCK: And so this proof of principle was you had a wafer where you had diffused all the way through and it was…you had a circuit or what was it…?

HAAS: We had a flip-flop.

BROCK: You had a flip-flop that worked.

HAAS: Essentially we used the same masks that he had been using for the etched isolation. But we managed to generate a top diffusion mask from the old mask.

BROCK: I see.

HAAS: I *believe* so. I'm not sure if we did that or [if we found another way]. Eventually we did have a new mask made. But when you talk to [Lionel], he would know better.

BROCK: Okay. Well then, once you have this quick proof, how did people react to it when you showed them it? How did Jay react? How did some of these…how did some of the highly skeptical diffusion experts react?

HAAS: You want this answer in Arizona speak or Princeton speak?

BROCK: Whichever you would prefer.

HAAS: How about, [*********]?" Yes, it was amazing.

BROCK: They were just stunned.

HAAS: […] You know Gordon knew […] right away, and Bob knew […] right away. And so there was a lot of small talk about, "Well, is this something that's practical or not?" Because […] even after we solved all the chemical problems, you have to visualize that Lionel was working with seventy-five micron wafers.

BROCK: Now was that much thinner than you were…

HAAS: Oh, yes. […] I think we were starting with hundred micron wafers. But ask Lionel. I think we started with standard N-type wafers. I think it was 5 ohm centimeter wafers. The only thing we had to do [to the standard wafers was] to polish the back as well.

BROCK: Okay.

HAAS: And then etch them uniformly, so we have a…wait a minute. No, we didn't have to polish the backs. […] No, I don't think we polished the back. […] The top was mechanically polished. We etched them, and we had the best etchers we knew of at Fairchild do the etching for us. And so the wafer had to be as nice as possible. This was a manual etching [using] CP8, [which is a mixture of] hydrofluoric [and] nitric acid […].

BROCK: Yikes.

HAAS: And down to about say 75 microns. [These wafers were then processed through 4 or 5 photoresist steps and] were breaking […] like crazy. The photoresist [operators] would [place the broken] chips on the chuck—the alignment chuck—and […] eyeball them first and then line

up the mask visually, not mechanically like they were doing the planar. It was very hard. [Gordon and Bob knew that the processing was very dicey but there was no choice]!

BROCK: No other choice. No other approach to microcircuits.

HAAS: […No]. The physical isolation was, [but it would have been impossible to find] <**Time: 15 min**> a material with the [right] thermal coefficient […]. It probably had to be close to .001 percent, coefficient of expansion, to match the silicon, otherwise it would eventually crack.

BROCK: Right.

HAAS: Well, based on that, they had no choice.

BROCK: Well, so they had to…so with them not having a choice, did you get some more resources so you could kind of tackle the problem head on and try and make it more…

HAAS: You mean financial?

BROCK: Or just in terms of manpower or…

HAAS: Oh, yes.

BROCK: Yes.

HAAS: Yes. The whole psychological and the physical emphasis was behind me at the time […].

BROCK: And…

HAAS: As for Bob Norman, he still hated my guts.

BROCK: Now was that just a personal animosity between you two? Or…

HAAS: I believe so.

BROCK: Yes. I guess you were…I mean, I guess you were both…had similar sorts of…

HAAS: No, I don't…

BROCK: …interests.

HAAS: I think it was personal on his part.

BROCK: Just a personal thing on his part. Well, so you…so then how did the…so what were the next big steps then in the story? I mean, what was the next chapter? Was it making the process, improving the process? And what was…just how did it unfold from there?

HAAS: I'm trying to think. The only intelligent answer I can give you was [that there was a lot of] hard work in all areas. The hard work was on Lionel's part. Mine was analyzing why it wasn't working. He came up with a double-masking technique to eliminate pinholes. We...I'm going to start confusing my work at Teledyne now with the last work I did or had done at Fairchild. Because eventually, you know, even though Amelco was started making matched pairs and field effect transistors, mostly Jean spearheaded projects, eventually, we [got] into the micrologic [in] competition with Fairchild. I was totally immersed in the development of those. By then I was in charge of R&D. […] I was still working in the lab. Lionel stayed at Fairchild and [then] went to Signetics. He was [one of] the founder[s] of Signetics. Eventually, he came to Teledyne as well.

BROCK: Oh, I didn't realize that.

HAAS: Yes. I think [that] the last couple of years [at] Fairchild he took the job of production manager […]. But he had the production of microcircuits as well. At Teledyne, we already had the epitaxial of process. So the problem was somewhat different there. We didn't have the long diffusion processes.

But there still were a lot of unique problems associated with the production of microcircuits that I had to [solve and fine tune] the relationship between performance and

process <**Time: 20 min**>. And now…you know, it is very, ongoing tedious work. And how much of that I was involved…well, I was involved with all the electronics work until I left.

BROCK: Which was when…

HAAS: At what point, I just don't remember.

BROCK: When did you leave Teledyne?

HAAS: I think it was November 1961.

BROCK: That's when you left Fairchild.

HAAS: Right.

BROCK: And then you were with Teledyne for how long?

HAAS: Seven years, till March of 1968.

BROCK: Till March of 1968.

HAAS: Right.

BROCK: And then where did you go next?

HAAS: I left to become rich. Everybody that had left [to start] a semiconductor company had become rich, so I said I'm going to do it also. I left and got busy, working at raising money to start an analog microcircuit company, IC company. And found out that [I was a bad salesman]. So that took one year, and I said, "Okay, enough of that." [I then started doing] contract IC design work for […] the semiconductor industry: Fairchild, Teledyne, RCA, Harris [Corporation], you name it, everybody, Motorola.

BROCK: Analog integrated circuits or…?

HAAS: Pardon?

BROCK: For analog integrated circuits?

HAAS: No, everything, analog and digital. [By then] I had a reputation for…I had made myself a reputation for being an analog IC design whiz […]. So, once I realized people thought that, I did the best I could.

BROCK: And for how long did you do that sort of work?

HAAS: I started in California from [1969 to 1978 after trying to raise capital from] 1968 to 1969 […]. We came to Arizona and I continued that in Arizona, except for a small interlude [in which] I worked for eighteen months for General Instruments in Phoenix. And we…the reason I left California was because I really was hit hard by the [1974 to] 1976 recession…

BROCK: Oh.

HAAS: …and I got scared. So I took a job, supposedly head of R&D at General Instruments Semiconductor Division here in Chandler in Arizona, [but] that was a big fiasco. I didn't get along with my boss here either. So after my contract [ran out], I went back to the same thing. I continued that until, I think, about […] 1995, give or take. […] I had a gold mine until two things happened. [First], the world recognized that, hey, it could be done. Initially I had a terrible time trying to convince people that I wouldn't take their secrets and sell them to someone else.

BROCK: Right.

HAAS: So it was very hard to get business. Then, I guess, [that the companies] decided [that it was] big deal. Not everybody's looking for secrets." So other companies started doing the same thing. Then computer work started […] <**Time: 25 min**>. The use of computers in association with design, […] simulation, circuit simulation, design simulation, […] computers were starting to [be used more and more]. I just couldn't afford the investment for computers. I did what I could using computers on a timeshare basis. [Eventually], when my phone stopped ringing, I just stopped working. That was it. I retired.

BROCK: Well, did Lou Beckman….I would be interested to know…in some ways it seems that at Fairchild in 1961, you and the other folks working with the integrated circuits could have thought of yourselves as being on top of the world. You had, really, a very technically sweet thing there that was, you know, going. And yet, it seems that all of the key people leave from the micrologic program very quickly. You know, you, and Jean Hoerni, and Jay Last leave in 1961. And then, I guess, Lionel Kattner must have left Fairchild with the Signetics people in what, just the year after or something?

HAAS: Right.

BROCK: And then Bob Norman and his group leave in 1963 to do…

HAAS: Right.

BROCK: So that's really, seems to me like a lot of the key people…

HAAS: Yes.

BROCK: …leave, one, two, three. Could you talk about why that happened?

HAAS: Well, I can tell you my take on this, my input, my point of view…

BROCK: Yes.

HAAS: But I'm not even totally familiar with the point of view of other people. Not even Jay. All I know about Jay and Jean is what they told me, which I am sure is not the whole story. Over the years, […] Jay used to tell me a lot about Fairchild, his time at Fairchild, and his relationship with the other people, and [William B.] Shockley, [Jr.]. […] I don't know the real reason, if there was a real reason why he and Jean left. One of the historical events that in my mind where…are you there?

BROCK: Yes, I am.

[…]

HAAS: At some point it became public knowledge that the "Fairchild Eight," each made a quarter of million dollars from Fairchild Camera.

BROCK: Yes.

HAAS: And I believe that that became a big, big thing in the Bay Area. Everybody thought, "Oh, God. We start a company…the way to get rich is to start a company." […] I didn't think that then at the time, until after I had worked for Teledyne for a while. And I left. And I saw what everybody […] had been doing. I was late in figuring all this out. But today I believe that was a turning point in Silicon Valley in making the valley population realize that, "Hey, starting a company is the way to become rich <**Time: 30 min**>."

I wouldn't be surprised if […] Jay and Jean [felt the same way]. I believe that Jay [and Jean had their own reasons].

BROCK: Well, why did you feel that…you know, once you heard that those two were leaving…?

HAAS: Why did I leave?

BROCK: Yes. Why did you…I mean, it seems like, I mean that…

HAAS: […] I liked Gordon Moore and Bob Noyce. [But I had a lot of discomfort with many of the "luminaries" of Fairchild's Integrated Circuits Program. I felt] there was a lot of politics […]. I got along very well with Jean and Jay, [so it was] a slam dunk [decision for me to go with them]!

BROCK: Okay.

HAAS: I figured I'd be much happier than playing politics […].

BROCK: I understand. Well, let's see. Where do you think we should go from here? You're phone is running out of battery. Should we…would you like to switch phones or should we pick this up again at a later…?

HAAS: I don't have access to another phone.

BROCK: I would like to talk to you about your experience at Teledyne for sure.

HAAS: Well, how about tomorrow…?

[…]

[END OF AUDIO, FILE 1.3]

[END OF INTERVIEW]

INTERVIEWEE: **Isy Haas**

INTERVIEWER: **David C. Brock**

LOCATION: **By Phone**

DATE: **25 June 2010**

BROCK: I don't have…I don't have a set of questions as detailed as the ones that I prepared for our conversation yesterday. So, maybe I could…we could just begin by talking about the, you know, your Intersil [Corporation] experience, the shift from Fairchild to Intersil. And I'll just ask questions as we go along.

HAAS: [Amelco and Teledyne].

BROCK: From Fairchild to Teledyne, I'm sorry. Yes.

[…]

And you were going to tell me the distinction between the Amelco and Teledyne.

HAAS: The Teledyne. When […] Jay and Jean were discussing the possibilities of starting a semiconductor company for Teledyne, […] the middle man was Arthur Rock again.

BROCK: Right.

HAAS: […I had a great deal of respect for Art! He] knew Henry Singleton from the Litton [Industries] days. Henry Singleton and George Kozmetsky left Litton. But I'm not sure whether George Kozmetsky was at Litton as well […].

BROCK: Right.

HAAS: […] George had been at Harvard Business School, so whether he had gone to Litton first, or whether he joined Singleton, after Singleton left Litton, I'm not sure. But at this time, Singleton and Kozmetsky were co-heads of Teledyne Holding Company, which was a company

that they and Art Rock formed with cash, and they were going to buy out companies that […] were good companies to buy.

Singleton was a whiz at—even though he was an electrical engineer—was a whiz at knowing how to find companies that had a combination of the right potential product, but usually a good balance sheet, and a low stock price. So when he acquired a company, he improved his [own] balance sheet, and he bought it with stock that [had a high P/E (price to earnings)] ratio…he bought a low P/E ratio stock with a high P/E ratio stock, so the earnings kept [going up] and up astronomically by just buying good companies [with good financial sheets with stock].

And so, going back to Jean and Jay and Art, they got together with Singleton, and Singleton was interested in or liked the idea of starting a semiconductor division, because he figured that would work in well with his plans to form a large high-tech […] company, […] doing a lot of government contract work, like Litton. […] At that point, Teledyne Holding Company had acquired just one company in California, in [Hawthorne…]. The name of that company was Amelco. […] They made transformers.

[…] <**Time: 05 min**>

BROCK: I see.

HAAS: And so [Jay and Jean started Amelco Semiconductor]. I quit Fairchild and applied for a job with Jay, and he hired me. I enjoyed all those famous stories about guys starting a company in your garage: you [set up] a table in your garage and a phone, and you start ordering parts, books, and desks and stuff. It was fun, I thought. […] I was doing the electronics and […] some of the diffusion equipment—the furnaces, the sinks, the hoods. Jay was taking care of the optics, the photoresist, and the mask-making parts of the endeavor. The agenda was basically to continue Jean's project from Fairchild at Amelco. Jean had some pet projects that he just loved. The first one was matched pair transistors.

BROCK: Could you take…could you explain what that was all about?

HAAS: Which - matched pair…?

BROCK: Yes, because I've…

HAAS: Okay.

BROCK: …I've heard a couple of people mention that.

HAAS: [In the designing of] analog [transistor] electronic circuits, […] you very often have a differential [pair of transistors at the input of the circuit. With a signal at each input]. One input is a signal input, and the other input is [usually a] reference or another signal whose difference you want to measure from the first signal. It's a very, very common thing. If you wanted to look up a little bit of it, look up "Darlington pairs."

BROCK: Okay. I've read about the Darlington…

HAAS: That's another application.

BROCK: Yes.

HAAS: There are [many] applications […] in analog circuits that […] use a pair of transistors that need to be as identical as possible, because they are usually at the front end of the amplification…

BROCK: Okay.

HAAS: And see, now my servo background decided to talk. […] These [input] signals get the most amplification before they reach the outputs on the circuit. So you want the error portion of the input signals to be as small as possible, because those error signals are going to be amplified just like the input signal.

BROCK: Okay.

HAAS: So, you want a matched pair handling this input signal, and, you know, if they're identical then [there] will not be an error signal on top of the actual "information signal." […] The most important parameters are the <**Time: 10 min**> VBE match […].

BROCK: Well, I see "VBE" all the time, so that is the…

HAAS: That's a base-emitter voltage.

BROCK: Okay.

HAAS: […] It's always referred to as VBE, and the VBE match [is the difference between the two VBE's of the two transistor at the same current. The ideal case is where the two VBE's are identical at the same current]!

BROCK: Okay.

HAAS: […] Now, if the current gain of these transistors is also equal, then that [is] even better.

BROCK: Okay.

HAAS: So, the most important thing […] was the VBE and then the beta and […] I don't remember what else. […] The way Fairchild was making this product was taking transistors out of the basket, […]measuring the VBE at the given currents […and sorting the transistors into one of ten (or so) different bins for different VBE voltage ranges]!

BROCK: Okay.

HAAS: […] At the end of the day they would take all the transistors with the matching VBEs and resort them [to] make sure they were well matched, et cetera, et cetera, and [market] them as matched pair transistors. This brought a very good price, even though the labor that went into that selection was [considerable].

BROCK: So, these would be in two separate packages?

HAAS: Yes, right. And that takes us to the next step, and that is Jean said, "Well, if we take two transistors that are located, geographically […] side-by-side [on the wafer], chances are that because they're next to each other […] they will probably be much closer to each other than two transistors picked at random. And he was right. […As a] matter of fact, [this] was part of the thinking behind integrated circuits, [namely] that transistors on the same chip are probably more like each other than not alike.

BROCK: Right.

HAAS: This was Jean's pet project […], and he worked on that for a while at Fairchild and they went his way. They would slice the wafer and keep all the chips together [and] they were […] separated in pairs, […] assembled in pairs, and tested in pairs. And the yield turned out to be better […].

When we went to Amelco, he revived the project, and we started making and selling the matched pairs. We also started making a field effect transistor, not a surface-type field effect, but a bulk-type field effect [where] the current path was in N-type material sandwiched between [two P regions]. Anyhow, it was [essentially…] the <**Time: 15 min**> Shockley patent or idea.

BROCK: So, is this the so-called unipolar field effect transistor?

HAAS: I think so, yes.

[…]

BROCK: All the testing and…?

HAAS: The testing, the device application, the device evaluation. I was working on hare-brained ideas on clever microcircuits as well, because by then I was quite familiar with the idiosyncrasies of semiconductor devices in […] the IC environment, what's good and what's bad about them. I tried to come up with simple but reliable amplifiers, analog amplifiers, oscillators. I don't know what else, but they were all interesting. But they were all failures.

BROCK: Failures in the market sense?

HAAS: […] There were good ideas, but no applications. But it kept […] my hand in the IC challenge. And then at some point, we started getting back into ICs. We hired a couple of good circuit designers, one of them […] had been at Fairchild [but had gone back to] IBM. […] He chose to join us at Amelco: that was Ray Kikoshima.

BROCK: Oh.

HAAS: He [had both linear and digital experience]. He designed most of the […] ICs that Amelco produced and marketed over the years. There was a couple of very, very good linear, high-gain linear amplifiers. We [also] started with the Micrologic second-sourcing right away […]. [But now we also had the epitaxial capability].

BROCK: Right.

HAAS: We started making micro[circuits] of all kinds. […] Ray designed a family of what [became known as] high noise immunity logic [(HNIL)]. [But it] didn't sell very well, [… except] in some [military] applications. […] For years afterwards, people would still come to Teledyne and ask for more of these circuits.

[…] <**Time: 20 min**> After a while, Teledyne Holding Company just put their name on the corporation and called themselves Teledyne, Inc., [and we became] a division of Teledyne.

BROCK: Right.

HAAS: We were Teledyne Semiconductors. […] After two years or so we moved to a large facility […] we had built […] on Sterling Road in Mountain View [California]. I think it was about [fifty] thousand square feet.

BROCK: Wow…

HAAS: Fifty or a hundred. Yes. At some point later, [we doubled the size]. You can check that with Jay, I guess. I was in charge of electronics under Jay. Jay was in charge of R&D. He had my group and then other people who worked on vacuum depositions, some hybrid circuits at work, some packaging, some chemical processing things like oxide deposition for insulation, and stuff like that. […] And either in 1965 or…so that's 1961 [and mask making].

BROCK: Right.

HAAS: […In 1966 Jay decided to move to Los Angeles]. You can ask him. […] He got a corporate job working for Singleton, […] and promoted me to director of R&D, so I took over all his jobs, his responsibilities. My main activities, especially after we moved to the new building, were […] circuit development and […] applications…

BROCK: Right.

HAAS: …and device development, and processing. We […] hired a guy [from Fairchild] called Owen Hatcher, who was a processing guru. […I was also] measuring, evaluating, debugging what was coming off the different steps of the processing, diffusion, analyzing, testing, and…but really finding out […] the problems [on the IC production line].

BROCK: Right.

HAAS: Finding the problems, feeding it back to the right place in the ladder, and finding a solution. And that really developed me into a very broad-based person; […] I was […] familiar with the device, the design, the process, the whole works, which really helped me tremendously later on in selling myself as a consultant, because I was able to handle almost anything […].

BROCK: Right.

HAAS: So, yes. And <**Time: 25 min**> in…we were […] second-sourcing all of Fairchild's micrologic family. Our regular circuits had a very good reputation, but we were unable to compete with the Fairchild […] UA709 amplifier […]. It was very good, but very simple, very basic, very inexpensive. And they were everybody's favorite.

BROCK: Right.

HAAS: […Getting] started second-sourcing the Fairchild micrologic [...] was easy, because I was already an expert on the [details] of the whole process. […But] the biggest problem affecting the quality of [the] Micrologic [line was the] lateral IR-drops in the bulk of the transistors.

BROCK: Right.

HAAS: Am I losing you?

BROCK: No.

[…]

HAAS: [The flow of the collector current was through the silicon sandwiched between the base and the "P" substrate. Even with the selective N+ doping in the epitaxial layer in the collector (to increase the conductivity) the IR drop was significant enough to cause complications. I wrestled with this problem a very long time until one day I saw the light!! I conceived the "two collector" transistor, this device being optimal for applications like DCL (direct coupled transistor logic). I was issued a patent for this invention].[8]

[…] In the DCTL […] type of logic, [when] the transistor is turned on by an increase in input voltage […], its output voltage [(collector)] drops down to the [collector] saturation voltage. And because the voltage is much lower than the base voltage, it holds off the transistor or the base that it is driving. Are you with me so far?

BROCK: I think so.

HAAS: Okay. You have a transistor gate, okay. A gate is either on or off. And the DCTL, which is the traditional way micrologic is described, direct coupled transistor logic. And in DCTL one gate drives another.

BROCK: Right.

HAAS: […] When the driving gate is off, its collector rises [and "turns on" the transistor whose base it is connected to; the collector voltage of the driving transistor will be held at the base voltage (VBE)].

BROCK: Okay.

[…]

HAAS: […] When current flows into the base, it turns on this […] transistor […] and that transistor saturates.

[8] Isy Haas, "Transistor with elongated base and collector current paths," U.S. Patent 3,284,677, issued 8 November 1966, assigned to Amelco, Inc.

BROCK: Okay.

HAAS: So when a transistor saturates, current flows out of the power supply through the resistor, into the collector, through the base to ground.

BROCK: Right.

HAAS: And it saturates, and [the collector voltage goes to the theoretical saturation voltage to which you have to add the lateral voltage drops].

BROCK: Okay. <**Time: 30 min**>

HAAS: […The] transistor that's turned on is connected to another base (of another gate), [but no current will flow into the base of the "driven" transistor because the voltage at its base is held below the voltage at which the base turns "on"].

BROCK: So, in essence if they're…the transistors are wanting to be in the opposite state from one another.

HAAS: Right, right.

BROCK: Yes. I got it.

HAAS: […] The transistor that is turned on holds ["off"] all the bases connected to (it's connected a number of gates); that's called the "fan out."

BROCK: Okay, yes.

HAAS: […] No current is flowing into the transistors that it is connected to. So, I said, "Oh." So, we split the collector into two…into two collectors, one on the north side of the transistor next to the emitter, and other on the south side of the transistor next to the base contact.[9]

[9] See Ibid.

BROCK: Okay.

HAAS: The one on the base contact side goes to the resistor, to the power supply, and the other one […] is the contact [(the output)] that goes to the [next] base […].

BROCK: I see.

HAAS: So, because […] the load will not take any current from that transistor when the transistor is turned on, the voltage at that point next to the emitter is going to be the "absolute" theoretical VCE sat [(collector to emitter saturation voltage)], which is in the millivolts. It's very, very low. [In other words, the collector saturation voltage will not be affected by IR drops].

BROCK: And so then it won't tend to have this dampening effect on the ones it's connected to.

HAAS: Right, right. […] It's a very simple thing that's a combination of circuit operation, transistor theory, and geometry.

BROCK: So there would be a collector on both the…on the opposite faces of the transistor structure.

HAAS: Say again.

BROCK: So, there would be…the collector would be divided…

HAAS: Yes, right, right, right.

BROCK: …and…

HAAS: Opposite side of the transistor.

BROCK: On opposite sides of the transistor. And…

HAAS: I mean, I can…if you'd like I can give you the patent number, and you'll see the pictures and stuff in there.

BROCK: Yes.

HAAS: And…

BROCK: Well, did this become…did this become a popular transistor form for DCTL logic?

HAAS: Of course not. As far as I know, only one company used it, and that was Signetics and Philips bought Signetics.

BROCK: Right.

HAAS: What am I looking for? Okay. Okay. It's…I think this is it. Yes. Ready…

BROCK: Yes.

HAAS: [U.S. Patent] 3,284,677.[10]

BROCK: I'll look it up.

HAAS: Yes. […] You'll be able to visualize [better how this works]; it's very difficult to explain it without the pencil and paper.

BROCK: Yes.

[10] Ibid.

HAAS: So, as far as I know, Signetics did. […] They did use it. I know because I did some consulting work for them after I left Teledyne and I was working on my own, and…

BROCK: Right. <**Time: 35 min**>.

HAAS: […] I don't know of anybody else that used it other than Teledyne. It's a very clever thing.

BROCK: It is.

HAAS: So you know that…I also patented […] at Teledyne the idea of being able to place any number of resistors into the same N-type pockets […] so long as the pocket is tied to the most positive voltage in the circuit.[11]

BROCK: I see.

HAAS: […] Teledyne had some fantastic patents.

BROCK: Yes.

HAAS: But they didn't know their value. And rather than exploit them like Fairchild did, they made deals with other companies like Fairchild and TI, and said, "Well, we'll let you use our patents if you let us use your patents." […] I believe that's what they did. They never exploited these patents.

BROCK: Well, could I go back through and just ask some questions about…

HAAS: Sure.

BROCK: …the sequence that we just discussed?

[11] See Isy Haas, "Integrated circuit having active and passive components in same semiconductor region," U.S. Patent 3,363,154, issued 9 January 1968, assigned to Teledyne, Inc.

HAAS: Sure.

BROCK: One was when you were first setting up…first setting up the Amelco Semiconductor, where exactly was the facility and where did you go on your first day of work?

[…]

HAAS: […] Moffett Blvd. We were on Moffett Blvd.

BROCK: And had…what had been in the space before you? Was it just an empty building or…?

HAAS: I think it was already a spec building, empty building.

BROCK: Okay.

HAAS: There was another building next to us […]; that was part of Rheem Semiconductor […]. Just…just disregard that. I don't…yes. Yes, that's what it was.

BROCK: When…and so one of your first jobs it sounds like was to set up the process line, you know, with you handling certain things, and Jay handling other things. Is that right?

HAAS: Yes.

BROCK: Now, were you able to basically—this is 1961—were you able to buy a lot of the equipment commercially or were you buying the most important pieces and then having colleagues make the equipment?

HAAS: We bought most of the equipment. By that time furnaces were an industrial business. Neither Fairchild nor us were making our own furnaces anymore. The guys that left Fairchild…the guys that were making the furnaces at Fairchild left and started a furnace company. It was something "glass"…

BROCK: Electroglas [Inc.]?

[…]

HAAS: Electroglas, right. And I think we bought our…we either bought our furnaces from Electroglas or from Thermco [Instrument Corporation].

BROCK: Oh, right.

HAAS: I don't remember now. There were some vendors that were building hoods, your laminate flow hoods.

BROCK: Right.

HAAS: We bought those from them. The only thing that I remember that we built <**Time: 40 min**> was the mask making equipment, mask making and photomasking equipment.

BROCK: Right.

HAAS: They had hired an optics guy, Bob [Robert E.] Lewis, that he and Jay got along just beautifully. Bob was a very nitpicky optical engineer, and that's just what was needed […] to make masks.

BROCK: Right.

HAAS: And Jay knew exactly what he wanted, how to get it done. If I remember right, I think that one of the keys was that he had a huge granite block, and [he bolted] all the optical equipment onto the [granite].

BROCK: Right.

HAAS: I never saw it. I never went into the photomask-making facility, because that was very, very dust-free and stuff, and I didn't want to even bother vacuuming myself or changing my clothes.

BROCK: Gotcha. Now, where did you get your silicon? Were you growing it yourselves or buying wafers?

HAAS: Oh, we were buying it from Monsanto [Company].

BROCK: Buying wafers from Monsanto.

HAAS: Yes.

BROCK: Were you buying epitaxial wafers from Monsanto? Or were you or did you make your own epitaxial reactor?

HAAS: […] I know we were buying epitaxial wafers from Monsanto. I forget now at what point we started making…I believe we started growing our own epitaxy after we moved to Sterling Road, after we built our own facility.

BROCK: Right, so about 1963.

HAAS: Right. And we still bought epitaxial wafers from Monsanto for the transistor manufacturing, [but] the epitaxial […] work was for our IC work, I think. Okay.

BROCK: Right, that would make…

HAAS: I may not be right, totally right. I just don't know for sure.

BROCK: Now, did you—this is kind of an obscure question—but I know also at this time that Merck was selling epitaxial material. Did you ever buy material from them? Or was Monsanto the supplier that you really remember?

HAAS: Don't know. I don't know.

BROCK: Okay. And then we mentioned that, initially, the idea was to pursue these…continue Jean Hoerni's work on these matched pair transistors, and this bulk field effect transistor.

HAAS: Right.

BROCK: Now, was there also a continuation of the hybrid circuit works that Jay had been into early on in the micrologic program at Fairchild?

HAAS: Would you rephrase that question again?

BROCK: Oh, it was just that, you know, these hybrid circuits that Jay had started out with…

HAAS: Yes.

BROCK: …I understood that that became a business at Amelco.

HAAS: Yes. […] I had nothing to do with that. […] Like I said earlier, especially once Teledyne got established and started buying all kinds of companies, […] their headquarters in Los Angeles was military electronics.

BROCK: Right.

HAAS: They bid on contracts. They got contracts, et cetera, et cetera. And one of the biggest contracts they got, and maybe it was the biggest, was a contract called the IHAS Program, the Integrated Helicopter Avionics System.

BROCK: Okay.

HAAS: I told them they misspelled. It should be with two A's, but they <**Time: 45 min**> wouldn't listen to me. […] The whole idea behind that project…Singleton's idea was, "We will go after this project because it's a helicopter navigation system, and we will be the best supplier

because we will make the microcircuits for that. And what we cannot make as chips, we will assemble in hybrid packages."

BROCK: I see.

HAAS: And these were very, very complex circuits that at the time [were] absolutely impossible to make in single chips. They were about, I think, inch and a half by two inch, or inch by one inch and a half, flat ceramic packages.

BROCK: Wow, so big.

HAAS: [The package] had the printed circuit board-like metallization, metallized on one side. And the chips were die-attached in there, some capacitors were put in there, IR resistors were put in there, and some ICs were placed in there. [They were] assembled and packaged, life tested, burned in, and all that, by a separate group run by a fellow called Joe Welty.

BROCK: I've heard his name before.

HAAS: Pardon?

BROCK: I've heard his name before.

HAAS: Oh. I had nothing to do with it. I didn't want to have anything to do with it. I could see the problems involved in that thing from ten miles away.

BROCK: We had mentioned…well, we were just…you were just mentioning the issue of packaging and assembly for the Amelco integrated circuits, and these matched pair transistors, and field effect transistors. Were you doing all the assembly and packaging there in Silicon Valley? Or did you send things overseas?

HAAS: Very good question. I don't remember. Yes. We did all the assembly up to a point. Then at some point, we set up our facility in Hong Kong, and a fellow by the name of Myron Weintraub went there and headed it.

You know, you mentioned the field effect transistors…

BROCK: Yes.

HAAS: I'm really bothered by that. I don't…I'm confused whether I did that there or General Instruments. So be careful where you […]

[…]

BROCK: I think that the timing would be…the timing would make sense, if you worked on unipolar field effect transistors around 1961, which they were more, I think in…there was a lot of that….there was more activity on them at that time. And then, maybe when you were at General Instrument, which was…what's that, 1976 or so?

HAAS: Yes, 1978. It was 1978.

BROCK: Then that was probably the MOS [metal oxide semiconductor]…

HAAS: Oh, I know I did there, because they wanted to involve a big power field effect transistor, a huge one. I worked <**Time: 50 min**> on that there. But it must have been because I already had the experience at Teledyne.

BROCK: Yes.

HAAS: I'm just not very clear on that.

BROCK: When we mentioned yesterday that Sheldon Roberts came over to Amelco.

HAAS: Yes.

BROCK: What did he do?

HAAS: I don't know. I can only theorize, if you want me to do that, but…

BROCK: Sure.

HAAS: […] I would definitely not be certain, it'd be assuming.

BROCK: Yes.

HAAS: I know I worked with him at times on alloying. […] You know he did a lot of metallurgy. […] And I didn't know anything about the theory behind these details. So, I used to go to him to get educated. [Aluminum acts as "P" type material when alloyed to silicon, but one can also have many complications depending on the surface, temperature and alloying times, including heating and cooling rates].

[…] I used to have a lot of yield problems with microcircuits at times because [we…] did not have any production engineers following the product […]. We did not have [a] sophisticated production, product transfer process. I developed the IC, and then turning it over to production was a verbal thing.

BROCK: I see.

HAAS: "Okay, Joe, it's your problem now." And we would train the operators to do things the way they were supposed to. They would write their own procedures if they wanted to write their own procedures. But there was no engineering manual or product manual that I turned over with a product. So, the production line did not have any engineering to <**Time: 55 min**> baby the product. I'm not sure what the right word is.

BROCK: I know what you mean.

HAAS: […] We told them [the process but] they would […] create the documentation they needed to keep things running smoothly and as expected. But when they had a problem, they called Isy. I would figure out [the problem], solve it, tell them how to solve it, until the next problem. And metallizing used to be a recurring problem, because it's the fundamental weak point in the process, aluminum is P-type.

BROCK: Right.

HAAS: We connect aluminum to P-type and N-type services on the circuits. And even though […] it's no problem on the base, usually, because the base is P-type, but the emitter, even though it's very highly doped, [it] still often [did not] make a very good contact. That's bad enough. The aluminum [did not] make a very good contact [to] the base either, even though it's a P-type, because of many, many reasons. One is you have to have it at the exact temperature, for the exact, correct time, in the right atmosphere. And the rate of […] warming and the rate of cooling are very important. So that used to get out of whack very, very often.

And I used to go ask Sheldon for his help, consulting, explanations. And you know, he was always a big help. My only problem with him was that, like I said yesterday: Sheldon's was one that'd start a project to evaluate the situation, the conditions and take a couple of weeks, a couple of months to evaluate what is happening, how it's happening and how to solve it. And my attitude though [was], "I've got to solve it by tonight, because the production line is stopped."

[Today I sometimes wonder how much of these problems were the result of my lack of experience and how much due to the process].

BROCK: Was he…did he stay at Teledyne for your whole time, while you were there?

HAAS: [Yes], that's when I was there. […] He left after I left.

BROCK: Okay. And you also mentioned yesterday that Lionel Kattner came to Teledyne. When was that?

HAAS: I…I'll throw out the number 1965.

BROCK: Okay.

HAAS: I am not sure.

BROCK: Now…

HAAS: I don't know why he left Signetics. He came to Teledyne and he had the job of integrated circuits production manager.

BROCK: Okay.

HAAS: So, yes.

BROCK: So, you worked with him in that respect for…while you were director of R&D, he was heading up the production.

HAAS: Right.

BROCK: Let's see. I had…when…well, yes. So there was this second-sourcing of the micrologic. Was that…when you started to get into that, was…did you have to do a deal with Fairchild to do that? Or was that second-sourcing something that you know had to be official in some way? Or did you just produce parts that were the same?

HAAS: As far as I know, we didn't make any deal with Fairchild. In those days, you didn't make deals with anybody until they sued you. Everybody was copying everybody else.

BROCK: Right. Okay.

HAAS: So, there…yes, everybody copied everybody else.

BROCK: Right. And then, I wanted to…you know, as the Amelco Semiconductor was going and you're getting into things like <**Time: 60 min**> second-sourcing the micrologic, was there a tension between things that the other parts of Teledyne wanted for this military equipment, as we were discussing with the hybrid circuits? For you guys…

HAAS: I think…I should yes there was some. I think Jay would know best if there was, and what there was, because I suspect that some of the tension never filtered down to my level.

BROCK: Okay.

HAAS: There were a few situations where Teledyne would send out a couple of troubleshooters up to [visit] with the intention of coordinating the progress being made on

the…either, the IHAS Program or other things that we were doing for them. And they were always a pain in the butt. And, you know, you can tell I used to be a prima donna. I still am, but nobody else is suffering from it, except my wife. But they […] did not affect my work at all.

BROCK: Okay.

HAAS: So, there was you know, some run-ins, but the day they left…the moment they went out the door that was the end of the problem.

BROCK: When…for how long…so, when in the early years of Amelco, Teledyne, Jay was head of R&D. What was Jean Hoerni's position?

HAAS: I think he was Assistant General Manager or even General Manager.

BROCK: Okay.

HAAS: Yes. He was Number One.

BROCK: And so was…did that mean he was the one who was mostly interfacing with Singleton and Kozmetsky and all that?

HAAS: I don't know, David. I think it was Jay, and I'm only saying that because I was more on a friendly basis with Jay, than I [was] with Jean. Jay and I were not buddy-buddies, but […] occasionally we would talk as friends and not as employee and boss.

BROCK: Right.

HAAS: With Jean that never happened. We were under very good terms, but very formal, polite terms, Jean and I.

BROCK: Right. When did he leave?

HAAS: Oh, he left…I don't know. I think it was 1965-ish.

BROCK: And what was…and that was when he went to do Intersil, is that right?

HAAS: […] He didn't leave to start Intersil. He left because he left.

BROCK: Okay. Do you know what was behind his leaving?

HAAS: It was probably me.

BROCK: Oh, dear. What do you mean?

HAAS: I really don't remember, except that I know that he and I [sometimes had differences]. You know, I was microcircuits, he was [discrete devices]. By that time we had hired Jim Battey to be General Manager. So [Jean] was not General Manager anymore. […] Jim came on board before we built the building. Jean left after Jim came onboard. […] I really forget why <**Time: 65 min**> Jean and I had a fight. But […] he left soon after, but I believe that there was probably a lot of other things going on between Jean and Jay and corporate that had nothing to do with me. I wouldn't be surprised if his departure and my problem, my difficulties with Jean coincided in timing.

BROCK: Okay.

HAAS: I know that Jean and George, George Kozmetsky, used to go at each other in meetings. George told me [so himself] after I left Teledyne. I worked with him…I should say, I asked him to help me organize my efforts to start a semiconductor company. And he helped me for a couple of months at that; we talked. He used to tell me stories about he and Jean. Jean was a very emotional, dramatic person. George was a very […] cool person […].

BROCK: Yes.

HAAS: …in control of situations.

BROCK: And did it…what was the impact of his departure?

HAAS: None.

BROCK: How about when Jay went to Los Angeles?

HAAS: None.

BROCK: And so, as you…you're leading things there in Mountain View. You're troubleshooting. You're…you know, you have this overall responsibility. When you…I guess it would…what was it in 1968 that you were, or 1969 that you were thinking of leaving?

HAAS: I left in March of 1968.

BROCK: You left in March of 1968. So, was there a particular…

HAAS: Yes.

BROCK: …development that you wanted to create a new company to exploit?

HAAS: No, no. You'll have to rephrase your question: "Was there a particular thing that lay behind your departure?"

BROCK: Yes.

HAAS: The answer is yes. And now, we're talking about the [1966 to 1968] era of tough times, tough economic times. When everybody in semiconductor industry was pumping big money into the business, Singleton was not about to put any [cash] into anything. We were expected to grow from earnings and pay for our expenses through earnings, and that was very, very difficult to do. We were not very profitable. I forget the exact time, I think it was sometime in [1967], Jim Battey called me and said, "We have to layoff. Everybody's going to lay off 10 percent of their staff."

BROCK: This is 1967.

HAAS: Must have been 1967, yes. What'd I say?

BROCK: 1977.

HAAS: Oh. Yes. So he… "I'm asking you to give me the list of 10 percent of your staff, and we're going to lay them off." And this was very hard for me, because […] I ran a very good department. There was no excess baggage.

BROCK: I <**Time: 70 min**> see.

HAAS: They were all very bright, good people, very, very good people, all of them. No, I had [already] culled out the ones that didn't work out. We both agreed they weren't working out. They left. The people I […] had to let go were very good, very good people. [But] I knew I had to do what I had to do. I gave Jim the list of people we had to lay off, and I don't remember who these were, but I mentioned Bob Beeson to you.

BROCK: Yes.

HAAS: He was one of the people that I had to lay off.

BROCK: Who you had worked with previously at Fairchild.

HAAS: Right, right. Then, you know […] things went back to normal, kind of, [but then] again [in] March, I think it was either, March or February 1968, same thing happened all over again. Jim called me and said that, "I'm sorry, but we have to lay off again." And I forget now, whether it was, I had to layoff so many people or there was a percentage, but I gave him my list, and I put my name at the bottom.

BROCK: Oh, wow.

HAAS: Because I was laying […] off/firing people who I had tremendous respect for. I couldn't lay them off. So I fired myself.

BROCK: And just to…and just like that. And so, it was then after that that you've, I guess, thought about…

HAAS: Right, right…

BROCK: …starting your own firm.

HAAS: Right. So, I'm out of a job, so what am I going to do? So, it's…you know, it took me ten minutes to decide what to do. They acted as [if they wanted me to stay and make me a deal, but I] said no. They offered me the job of running Hong Kong, and I said, "No, I don't want to."

BROCK: For…with whom?

HAAS: For Teledyne […]

BROCK: Oh, okay, yes.

HAAS: …Semiconductor operation in Hong Kong.

BROCK: Right.

HAAS: [We] had a Hong Kong assembly operation.

BROCK: Yes. So, they offered you the job of running that.

HAAS: Yes.

BROCK: Okay.

HAAS: And I didn't want that.

BROCK: And so, well, as you were then thinking of starting your own semiconductor company, what sort of…what was your idea? What was your plan? What sort of a company were you interested in creating?

HAAS: Analog circuits.

BROCK: Analog circuits. And that was because of your experience with them, and…or because you felt that they had even greater potential? Or what was…?

HAAS: Yes. Yes.

BROCK: Why did you…?

HAAS: Yes. Yes, to both. I was extremely comfortable in the analog…in the analog integrated circuits' process and all, all the […] tricks and the whatever. And there was no other analog IC company started yet. They were all digital companies, digital manufacturers. I think…yes, Bob Norman had started his company. Intel had started…oh, no, no. No, Intel was about to start their company. They had left Fairchild. Everybody knew that. [As a matter of fact, Bob Noyce and I] discussed the possibilities of joining our efforts. [But] I thought not. I wanted to be my own boss […].

BROCK: That was with Bob Noyce.

HAAS: Pardon…yes. And <**Time: 75 min**> in case you are curious, I have never been sorry about those decisions. They were all the right decisions, including leaving Fairchild, leaving Teledyne, and not going with Bob.

BROCK: But…and you say that because you're pleased with how it…with what came next?

HAAS: A combination of two things. I was pleased with the way things turned out for me and my family. And if I had stayed in the Bay Area, my life would […] have turned out very, very different from what it is today. And it would have been a much worse life. Our quality of life today is much better than I think it would have been in the Bay area, […] if I had stayed [there].

BROCK: Right. Well, so…well, maybe we can talk a little bit about your efforts to start up this analog circuit company, and then your decision to stop trying.

HAAS: Decision to what…?

BROCK: Your decision to stop trying to create…

HAAS: Oh…

BROCK: …a company.

HAAS: I…when I decided to do that, and started working a little bit with George Kozmetsky, and […] a few other people, just talking about generalities, I realized that I had to make two decisions. One, if I start the company, if I'm successful at starting a company, I would have to know that I will be able to sustain myself for two years, take care of my family for two years without income.

BROCK: Right.

HAAS: And allow myself one year to get the financing and start the company, and if I didn't get the financing in one year, I would stop trying.

BROCK: Okay.

HAAS: So, one year for that, and two years for the company. So three…I had the finances to take care of my needs for three years. […But] I wish I had a computer at that time. I [would] spend my whole time preparing spreadsheets, monthly expense and income, project income and expenses, different expenses, […] listing all of the salaries, capital goods, materials in use, inventories, all that. You had to do all these by hand, and add all the numbers. And if they didn't balance, do them all over again until they balanced.

If […] did that and I started talking to the various [individuals/groups] who […] had money for this sort of thing. There was no venture capitalists [to speak of]. […] Allstate Insurance had a group that had tons and tons of money that they put into various things, not necessarily new ventures, but just all…and there was groups all over the country, and brokers,

stockbrokers, or I should say brokerage houses. I […impressed] Sutro, a [brokerage firm] in San Francisco. […] And I was trying to raise two and a half million dollars…

BROCK: Yes <**Time: 80 min**>.

HAAS: I worked with Sutro, made lots of presentations to different groups of individuals [but] was not able to raise any money even though I gained the support and confidence of Sutro [who did offer to put in a million and a half if I could raise the rest].

BROCK: Yes.

HAAS: And I couldn't even raise the one. So after one year, I gave up and I asked myself, "Well, now I've got to go into business. What am I going to do?" My train of thought or strategy at the time was, "I'm going to go into a business that I can do with my hands tied behind my back." And, well, there's only one thing that I can do that with, and that's integrated circuits. I [went] into consulting [on] integrated circuits.

BROCK: Could you tell me just about some of the work that you did consulting? Who…what was the nature of the consulting, and for whom you were consulting?

HAAS: I did a little bit of consulting with Stanford Research [Institute]. Oh […] there was a number of groups that…oh, yes, American Microsystems [Ltd.], [Fairchild, RCA, Harris AMD, LSI and many others]!!

BROCK: Right, which was an MOS company.

HAAS: Yes, right, Bob…

BROCK: Howard Bob.

HAAS: Howard Bob […].

BROCK: Oh, yes. Yes, yes.

HAAS: The SRI [Stanford Research Institute] work was more along […] IC. They had a couple of special situations of products. They were both financing and developing. But they were [in] the medical and electronics field. They had the knowledge of the medical field, the design, and the circuit design, but they didn't have the IC knowledge. So I interfaced with them for the…not interface, but I worked with them on the IC issues. And the others were […] due diligence [work]. You know what that is, right?

BROCK: I think so, if you're going to…

HAAS: A company wants to raise money, the investor says, "Well, I want a third opinion, an unbiased opinion to tell me whether it's a good […] product or whether it's real or not, or whether the market really like they say it is." I had a few of those. And I designed ICs for […] the existing semiconductor companies.

BROCK: Linear integrated circuits.

HAAS: Pardon?

BROCK: Analog integrated circuits.

HAAS: Linear and analog. There was a company called Qualidyne [Systems, Inc.], a company called […] MicroPower Systems, a company run by John Hall.

BROCK: Okay.

HAAS: Qualidyne was run by Ward Gebhardt from Fairchild. Harris Semiconductor, RCA, Texas Instruments, Signetics.

BROCK: And they would call you…did they call you in for a particular…when they were having difficulties of a particular kind? Or was it when they didn't have enough horsepower…?

HAAS: Mostly <**Time: 85 min**> when they didn't have enough manpower themselves.

BROCK: Right.

HAAS: On a couple of occasions, Fairchild called me because they had problems with…I forget whether it was a linear or digital circuit. And interestingly enough, I had just built that circuit for another company, for Qualidyne. It was a Fairchild circuit, but Qualidyne wanted to second-source. So they told me that their customers "were having problems with the Fairchild circuit. Would I take a look and see if I could see the problem and fix it?" So I did. And Qualidyne made the product and took the business away from Fairchild. So, lo and behold, Fairchild calls me and said, "Okay. We give up. Why don't you fix our circuit?" [But] I said [I couldn't do that because that would not] be ethical, would it? So that was great satisfaction for me, to experience that sort of thing. But, having done that, I [also] gained Fairchild's respect, and they gave me a whole bunch of other circuits after that.

BROCK: How long with the average circuit design consulting job…how long would that usually be?

HAAS: I don't know if I should ask you to turn your tape off or not, because that was the secret of my success. I was extremely good. I could do the jobs much, much faster than they thought it would take. I used to charge them what they thought it would take.

BROCK: Well, let me just ask you what…how long did they think it would take?

HAAS: Oh, some were…I'm going to say the average over time…because the circuits kept getting larger and larger and larger.

BROCK: So, they took longer.

HAAS: And so they took…but I think the average was six weeks for me. […] What I would do is quote them three months and go get two jobs, and work on two jobs at the same time. And after…once I established my reputation, I started charging what I was making, and prorating that, and adding in a little bit for G&A, and stuff like that. [Initially] my quotes came around two, three, four thousand dollars per circuit. But you know, when I realized that I had a real service to offer, [I had no problem raising my fees appreciably]. And they all paid it. I had very good relationships with most of these companies.

BROCK: Did…were there many other people doing this…?

HAAS: No. No. No, there were not. Initially, there was none. I was the first one, and they would say […] they didn't think [it was a viable] service, because, you know, they didn't trust you. […] They suspected you'd take the idea, their process, and everything. They had to give me their process.

BROCK: Right. To do design the chip, you needed to know their process.

HAAS: Right. And they were afraid I would sell them to their competition. But then, when I became […] known, when I was successful, and [people knew] how much I was charging, quite a few other engineers went into that same area, and same field, same business, [but by then] <**Time: 90 min**> I was ready to retire.

BROCK: When would you say the other designers started getting into that consulting/design act?

HAAS: What years?

BROCK: Yes, or generally.

HAAS: In the 1990s.

BROCK: In the 1990s.

HAAS: Yes.

BROCK: So, you were alone in it for quite some…or relatively alone in it for quite some time.

HAAS: Yes.

BROCK: And was it a question of…it was really a question of a personal reputation that got past these concerns, eventually, that you were going to steal their process and all that sort of jazz.

HAAS: [You can] say that again.

BROCK: Was it really a question, do you think, of the reason why you were able to be successful at doing this, despite the client's concerns that you might give away the design or the process, was just because they came to trust you personally?

HAAS: Yes. I think so. I think there […] were two sides to this. One was what you just said. And, you know, often they still didn't trust me, but didn't think that what they were having me do was of any competitive value. For example, Fairchild and Texas Instruments were producing the same line, the same [circuits].

BROCK: Yes.

HAAS: …the same [logic family]. […] I [designed a number] of circuits for Fairchild, [but] I think it was just one for Texas Instruments. I'm not sure, one or two. But Fairchild knew that the other competitor was TI, and more often than not, they were asking me to duplicate one of TI's products. So, [I would refer to the TI] catalogue and design the circuits to the Fairchild [specifications. They started giving me a lot of latitude]!

BROCK: Interesting.

HAAS: And, yes, the other aspect, the other side of the coin was that some of the companies, some of my customers would choose to second-source a product that they did not have. They would give me the product that they wanted me to second-source, and I would analyze it, make measurements, and […] sometimes I [would] actually extract the circuit diagram. They didn't even have that. And then give me their process, and I would adapt the circuit to their process.

BROCK: So, you'd sort of reverse engineer and then adapt…?

HAAS: Yes, yes.

BROCK: That's interesting, because I guess that goes back to device evaluation.

HAAS: Yes, right. And you know, I was…I was very, very comfortable doing that and I was very fast. I guaranteed all my work. If it didn't work, I would fix it free of charge, which I never had to. [That did help my reputation].

BROCK: Now did you do this work in your own facility or at the customer's facility?

HAAS: Mostly at my own facility. There [were] two instances, [maybe] three, when [some companies started generating mask by computer (computer-aided design, or CAD) <**Time: 95 min**>. I would go to their facilities and they would teach me to use their system. […] I did that for Fairchild, for Motorola. [At that time the cost of the computer was in the one million dollar range and I could not afford that. Eventually I did] acquire a PC-based, IC design software around the early 1990s, I think. That worked fairly well, and I used that.

BROCK: So would…you would be supplying people with drawings essentially.

HAAS: Yes.

BROCK: And then, from there they would have to…

HAAS: Some drawings and some computer tapes. In the latter days, it was computer tape and indirectly their masks as well, because I would undertake the ruby […] generation, as well.

BROCK: Okay. So, you would basically subcontract that.

HAAS: Yes.

BROCK: Okay.

HAAS: Right.

BROCK: So, in terms of facility you really…it was not that intensive of what you would require…a place to think and design.

HAAS: Right.

BROCK: Yes.

HAAS: I had…I had offices, and…I'm trying to think. I had some for the graphic capability, crews for the graphic work, and I had some good optical capability to take accurate measurements off the chip.

BROCK: Okay. Well, we talked about that you phased out of that work in the mid 1990s, as I guess circuit design became more computationally…

HAAS: Right.

BROCK: …intensive.

HAAS: Right.

BROCK: How have you spent your time since? Have you had particular interests that you've been following?

HAAS: No, no business, no external business projects. My main interest is, has been, always…way, way back, […] the stock market. […] So after I retired, it's basically [been] my primary occupation.

BROCK: Is investing and following…

HAAS: Yes.

BROCK: …finance?

HAAS: Right.

BROCK: Well, I think exhausts the questions that I had. Is there anything that you can think of that I should have asked you that I [haven't] or any important aspect that we haven't yet discussed?

HAAS: I don't think so. There probably is. I can…you know I can get back to you, if you would like. If you would like me to get back to you if I think of some ideas, holes or [other] things that I have left out. Well, let me ask you this. Are you…have you found what you have heard interesting?

BROCK: Very much so.

HAAS: All right. Did any of it…was any of it a waste?

BROCK: No.

HAAS: So, if I thought of things that appeared to me to be holes that I left out, I could call you and update the record.

BROCK: I think that would be an excellent idea.

HAAS: Okay.

BROCK: Let me just switch off these recorders for a moment, or I'm just going to…

[END OF AUDIO, FILE 2.1]

[END OF INTERVIEW]

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