CHEMICAL HERITAGE FOUNDATION

JULIUS BLANK

Transcript of an Interview
Conducted by

David C. Brock

at

Los Altos, California

on

20 March 2006

(With Subsequent Corrections and Additions)

ACKNOWLEDGMENT

This oral history is part of a series supported by grants from the Gordon and Betty Moore Foundation. This series is an important resource for the history of semiconductor electronics, documenting the life and career of Gordon E. Moore, including his experiences and those of others in Shockley Semiconductor, Fairchild Semiconductor, Intel, as well as contexts beyond the semiconductor industry.

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Oral History Program
315 Chestnut Street
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JULIUS BLANK

1925	Born in Manhattan, New York on 2 June

Education

1950	B.S., mechanical engineering, City College of New York

Professional Experience

	Babcock-Wilcox Company
1950-1951	Engineer, steam drums
	Goodyear Aircraft
1951-1952	Research and Development Engineer
	Western Electric Company
1952-1956	Engineering, manufacturing toll crossbar equipment
	Shockley Semiconductor Laboratory
1956-1957	Senior Staff Engineer
	Fairchild Semiconductor
1957-1969	Co-founder, Facilities, Engineering Services, Division Manager
	Xicor
1978-2004	Director and co-founder
1969-present	Consultant; Director of several companies; Investor

ABSTRACT

Julius Blank begins the interview with a look at his childhood and early education. He graduated high school at the age of fifteen and began taking classes at the City College of New York while working various jobs. When Blank turned eighteen, he enlisted and was sent to Europe to serve during the end of World War II. When he came home he finished college with the aid of the GI Bill and received a degree in mechanical engineering. Blank worked as an engineer at Babcock and Wilcox Company in Ohio, and then moved to Goodyear Aircraft. After two years, he and his wife moved back to New York where Blank got a job at Western Electric. In 1956, Blank was asked to join Shockley Semiconductor in California. He and his family moved to Palo Alto, where Blank worked on crystal growing for Shockley. Blank met Gordon Moore at Shockley, and eventually joined Moore and six other Shockley colleagues to form Fairchild Semiconductor. Blank first worked on crystal growing and research and development at Fairchild, but later helped set up assembly plants overseas. In 1969 Blank left Fairchild to become an independent consultant. Blank concludes the interview with some final thoughts on Gordon Moore.

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: **Los Altos, California**

DATE: **20 March 2006**

BROCK: This is an oral history interview with Julius Blank conducted by David Brock, on 20 March 2006 in Los Altos, California. I understand that you are a native of New York City [New York]?

BLANK: I was born in Lower Manhattan, to be precise, on 2 June 1925.

BROCK: Tell me a bit about the household that you were born into and about your parents—what they did and what their life was like?

BLANK: Nineteen twenty-five was just before the Great Depression, right in the middle of Prohibition, and my parents were immigrants. My father came from Russia and my mother came from, I believe, Austria, although the boundary has changed a little bit since then. I have two sisters, and my father and my sisters worked. I'm the youngest in the family of three. Next week my eldest sister is going to be ninety-three, and my other sister is eighty-nine. So, we're still hanging hard. [laughter]

BROCK: What kind of work did your father do?

BLANK: My father made musical instrument cases and luggage. In those days they used big steamer cases. He was also a translator. He translated articles from several different languages. He spoke Russian, German, Polish, and Hungarian. He got papers and articles from foreign newspapers and translated them into the local idiom.

BROCK: How did he acquire so many languages?

BLANK: I don't know. I never really asked him that, but he was one of those young guys in Europe that had an affinity for it. As a matter of fact, later on he was in the Luggage Workers Union where he was a trustee for the pension fund. One time I came to visit him and I noticed he was looking at the New York paper called *La Prensa El Diario*. I said, "Dad, why are you looking in Spanish newspapers?" He said, "Well, the membership in the union has changed. We've got a lot more Hispanic people so I decided in order to deal with them I should learn a little bit about Spanish." He taught himself Spanish at that age. [laughter]

BROCK: That's pretty impressive. With your father's work—both craft work and this work doing translation—were those aspects in the home: education, learning, and craft?

BLANK: No, not really. I never knew much about what he did at work. I had a peripheral knowledge of his translating at that time. I learned about that much later. I was busy growing up on the Lower East Side in Manhattan, which is an education by itself.

BROCK: Tell me a little bit more about your experience growing up?

BLANK: We lived in a neighborhood. Across the street from our house was a building run by the Children's Aid Society. It was a group of volunteers that served lower income people for the purpose of educating young kids whose mothers were working. They had a lot more teachers than they had students and I was rounded up literally off the streets when I was about four years old. They took me to this school and they taught me to read, write, and color. I remember they used to have naps in the afternoon and they gave us cookies and milk. It was a fun thing, and I learned how to read and write at a very early age, compared to the kids that didn't have that experience. I remember being five or six years old and walking three or four blocks to the library all by myself. My mother was terrified. [laughter] I did it anyway.

BROCK: Did they let you check things out?

BLANK: No. I was there just looking through books and at the wealth of stuff that was there without any particular interest. It was just at random.

BROCK: Did that experience help you once you became school aged? Did you go to public schools?

BLANK: I went to public school right after that and they tried to put me into kindergarten. I was five years old. They said, "You don't belong here." They kicked me up to first grade immediately.

In those days, the airplane was a very new development—in the late 1920s. When we saw an aircraft or a dirigible flying overhead everybody stopped and looked. It was not a common experience.

BROCK: Was that something that really caught your attention?

BLANK: Oh yeah. I was a very big fan of [Charles Augustus] Lindbergh when he flew all by himself across the ocean. He was one of my heroes.

BROCK: Were you interested in airplanes and aviation?

BLANK: No, just anything, projects of large—I remember we had a radio. We didn't have television in those days obviously. I remember listening to broadcasts from Berkeley [California] when they were performing experiments with the cyclotron. They used to broadcast these events whenever they happened and I was a very avid listener. I didn't know what I was listening to, but just hearing these people talk about that kind of stuff while it was happening, I'll never forget those early broadcasts.

BROCK: Did that peak your interest in technology?

BLANK: In technology and engineering. I was always interested in how things worked. I was fascinated with Mack trucks especially. In those days Mack trucks were chain driven. They had these big open chains—a chain drive. No guard over them. OSHA [Occupational Safety and Health Administration] would be horrified today. [laughter] They used to coat these chains with black grease and they were always dripping. They were used mostly as coal trucks, delivering coal down to the basement. I was always fascinated watching this big honking equipment work. They had no tires, they had solid steel wheels with thick rubber glued onto the rims. [laughter]

BROCK: How did your developing interest in technology play out while you were in public school? Did that lead you to pay attention in science and math class or did it express itself in your hobbies?

BLANK: Not much in the way of hobbies but I was always curious about things technical and practical. We were taught in junior high school—I remember they used to give shop classes. I don't know if they still do anymore.

BROCK: Sometimes.

BLANK: We used simple woodworking tools. We learned how to wire an electrical plug or a switch, simple trivial things like that. How to make some primitive plumbing fittings and things of that—this is at a very early age. Those kinds of things always interested me.

BROCK: Were you building things outside of school?

BLANK: No. With what?

BROCK: That would be the question. [laughter]

BLANK: Didn't have much to build with.

BROCK: Did your family live in an apartment?

BLANK: A small apartment. A walk-up. That building still exists to this day. We were just visiting there a few years ago and they had gutted it and turned it into a series of condominiums and they actually put an elevator in there, which was a big joke.

BROCK: I was reading somewhere that you went to a technical high school. Did you go to Brooklyn Tech [Brooklyn Technical High School]?

BLANK: No, I went to Erasmus Hall [Erasmus Hall High School, Brooklyn, New York]. It was an academic kind of school.

BROCK: Was Erasmus Hall a school that you had to apply to in those days?

BLANK: No. I just expressed an interest and I qualified for it, and I lived on the border between a normal high school and what they used to have in New York, an academic or a technical school. Somehow or other I got selected for that one.

BROCK: What was the distinction between the neighborhood high school and the academic or technical high school?

BLANK: Well, they used to call them commercial schools and in academic schools you had a larger smattering of things like Latin and Greek and classical learning. The commercial schools would be more into accounting and commercial subjects.

BROCK: Was it around 1940 that you started high school?

BLANK: I graduated in 1940.

BROCK: You were young when you graduated then?

BLANK: Fifteen years old.

BROCK: So being bumped up to the first grade—

BLANK: And then bumped up a few times after that.

BROCK: Okay.

BLANK: Graduating in 1940, the war had just started in Europe. I was fifteen years old at the time and I went to college but I couldn't afford to go during the day so I went to work. I started to go to college at night, taking night courses. It would take a little longer but that's what I had to do in those days.

BROCK: Where were you going?

BLANK: City College [The City College of New York]. It was uptown. We used to call it "Subway Tech." [laughter]

BROCK: Let's go back to your high school experiences. How did your interest in technology and engineering develop in those years?

BLANK: Couldn't tell you. I had a wide range of interests and I was always curious about things. I was interested in geology for a while so I did some work in that area. But there was nothing technical that I focused on. Mathematic—I had a full gamut of that. I did study Latin, for whatever reason.

BROCK: Was that enjoyable?

BLANK: Yeah. I liked it. I wasn't very good at it but I liked it anyway. [laughter]

BROCK: At fifteen years old in 1940, you start going to City College in the evening. What kind of courses were you pursuing?

BLANK: Whatever I could get. Whatever was available in the time frame. There were a lot of prerequisites to take. It was mostly history, mathematics, or whatever fit the schedule.

BROCK: Were you working during the day?

BLANK: Oh yeah, I was working full time in a factory.

BROCK: Making what?

BLANK: I had a series of jobs. The first job I had was in a factory. My father got me a job through a company that he knew about. I was just an entry-level factory hand, doing whatever had to be done. That got to be a chore because I had to work a lot of overtime. It was cutting it close, by the time I got out of there and got on a subway to go uptown, I got home at eleven or twelve o'clock at night. I left that job after about a year.

This was after Pearl Harbor when I left that one and I went to work in an office, figuring the hours would be a little better. It was a company called the Interborough Construction Company in Manhattan. They owned office buildings and they did repair and renovation. I was working for the headquarters there and that was where I learned about Wall Street. In my entry level position, they used to send me down to deliver checks at the closings whenever they bought or sold a property. The lawyers were downtown and they called up and said, "Make out the check for this amount and then have it delivered." I was the one that actually brought the check to the closing so that this deal could happen. I learned a little bit about the way Wall Street and the finance guys—I learned about debenture at a very tender age. [laughter]

BROCK: Did you do that then for—

BLANK: I did that for a while.

BROCK: Working and going to school?

BLANK: Continued. Then I decided I needed to get a little bit more knowledge about practical matters and I wanted to become a machinist. While I was going to school I went to another school at night at Brooklyn Tech where I learned how to operate lathes, machines, read blueprints, and that kind of stuff. I got a job as a machinist after that. I had a job at an interesting company called New York Testing Labs, where I was making machine parts for the testing of steels, metals or whatever they had. Right next door was a big chemical lab where they did the chemical analysis, that smelly place. [laughter] We had a lot of different projects, one of which was they were doing some work on making synthetic rubber in that lab. I got hauled in to deal with that one. But I couldn't handle the ammonia. [laughter] It was nasty stuff. But I learned a little bit about what the chemical processes were. Not formally but some of it rubbed off on me.

BROCK: Right. Had your coursework, after a couple of years at City College, gravitated toward a major?

BLANK: Not even close. One time someone came to the school in the evening and was touting a new program at the military. I was getting to be about seventeen at the time. They said, "Well, if you join the ER, Enlisted Reserve Corp, you'll go right into this program called ASTP, Army Specialized Training Program."

BROCK: Okay.

BLANK: The Navy had the equivalent called the V12.

BROCK: I've heard of that.

BLANK: This was the Army equivalent. They took students and they sent them to colleges. They had several hundred thousand GIs that they spread out throughout the country. I enlisted to avoid the draft, so to speak. Sure enough on my eighteenth birthday I got a letter in the mail, "Please report for active duty on 5 July 1943." which I did. Immediately I was sent down to Alabama to take infantry basic training that was a prerequisite.

BROCK: Okay.

BLANK: I found this camp full of hundreds of guys that were in the same boat as me, from New York and New Jersey and all over the place, and there was a big group from the South, students that were from the Virginia Military Institute or the Citadel, that were drafted on the same thing. Sure enough, after finishing basic training, I learned how to operate all the tools of the trade, machine guns, mortars, BARs [Browning Automatic Rifles], whatever they had—they sent us to school. They shipped us out. I fortunately went to City College again. [laughter] But I couldn't get out. Most of the time I was stuck there. I was there for about six months and then all of a sudden the directive came down canceling the whole program.

BROCK: What sort of coursework did you do for the Army?

BLANK: Engineering, physics, chemistry, the usual. Mathematics. A semester and a half isn't very much. When they cancelled the program I found myself back in an infantry division in Louisiana. Then I got sent overseas as a replacement in October of 1944.

BROCK: For how long were you in Louisiana?

BLANK: A couple of months, and then we got transferred. We went on divisional maneuvers, which was a trip all by itself. This was simulated combat where they took four or five divisions and they engaged in a mock war. It was surprisingly realistic when we got to the real thing—confusion of brain totally. I went overseas as a replacement and I was assigned to the 8th Infantry Division as a rifleman. Then they found out I could operate a machine gun so they put me in as a machine gunner.

BROCK: Where did you go first?

BLANK: Europe.

BROCK: Did you go to England first?

BLANK: We took the boat from New York to Greenock [Scotland], which is outside of Glasgow [Scotland], and docked, and then we went to shore. We didn't walk across. [laughter] We got on a little boat that took us to shore and then we went through about a week's additional training and we got our rifles zeroed in, and then we went on a train to Southampton [England], and then across to Omaha [Omaha Beach, Normandy, France].

The fighting had moved inland, but it was still a sobering experience climbing up the same cliff. We were sweating bullets carrying our stuff, but nobody was shooting at us. I had great empathy for those poor son-of-a-guns that did that under real fire. Then we drove past—on the way to the railroad station—we drove past a cemetery which was a shock because that was the first time I really knew that there was a war going on. When we passed a cemetery with fairly fresh graves, it hadn't been built the way it is now. We saw this huge expanse of headstones.

BROCK: Then you pushed—

BLANK: We went in through Belgium, and Luxembourg, and into Germany. I was wounded in December of 1944 in a nasty place called the Huertgen Forest. You probably never heard of it.

BROCK: I haven't. Is it in Germany?

BLANK: Yes. If you go to the World War II memorial in Washington you'll see on one sign there, a list of all the nasty, big battles and the Huertgen Forest is etched in granite. [laughter] It was a nasty one. I survived it.

BROCK: Were you sent to a hospital?

BLANK: I went through a whole series of hospitals. Just about then the Battle of the Bulge started and they had a lot of wounded. I was in the Paris hospital at the time, and they evacuated us to England. The first airplane ride I ever had in my life was on a hospital plane flying from Le Bourget where Lindbergh landed across the channel to an airstrip near Salisbury where they had another hospital that I was in for a while. The upshot of it was that when I got out of these various hospitals I woke up one morning and they said that we were being transferred. A whole group of us, maybe five or six hundred of us, were transferred to the Army Air Corp. They figured we were not in good enough shape to get sent back so they moved us into the Air Corp. They found out I was a machinist so they put me to work on an engine lathe making parts for airplanes.

BROCK: Replacement parts?

BLANK: Yeah. Whatever needed to be done. Then they found out that I knew something about metallurgy. My knowledge of metallurgy—

BROCK: In the testing lab?

BLANK: From the testing lab, I knew the difference between 10/20 steel and 41/30, so I became their local expert. [laughter] They put me in charge of the storeroom.

BROCK: Were the other people who were transferred to the Air Corp also doing support jobs?

BLANK: They were doing all kinds of things. They put them in offices and in various jobs, whatever they needed. At the same time they took GIs that were stationed there for many years and gave them rifles and sent them over to replace us. It was a very nasty time. But we managed to survive that.

BROCK: That must have been a fairly rigorous pace with all those air missions that they were flying out of there?

BLANK: Oh yeah. That was one of the biggest engine overhaul base for radial engines in the world.

BROCK: Okay.

BLANK: All the radial engines for the European theater were overhauled in that one base in the Midlands. They were running those test stands; it looked like literally hundreds of them. We were running the engines in before they put them out back into service.

BROCK: Okay. It must have been a huge operation?

BLANK: A huge operation. I didn't have much to do with the whole thing but I learned a lot about engineering and the way things are made. For example, the British used to marvel at the way we would take all the parts from the engines, put them in a big tub, clean them, fix them, throw away the bad ones, and pick them back up again and assemble an engine as it came by. They couldn't believe this because in England, every part had to be matched.

BROCK: Oh. [laughter]

BLANK: They weren't interchangeable. They didn't understand the way that we did it. It wasn't that difficult. It was just a trick. What they did was divide all these parts into zones. It didn't matter what the number was. As long as all of them were in the same zone, they would fit.

BROCK: Okay. It was like tolerance zones or something like that?

BLANK: Yeah. That was a quick and dirty way of doing it because we had no other way. Otherwise we would have gone crazy.

BROCK: For how long were you—

BLANK: Until they dropped that lovely bomb on Hiroshima.

BROCK: Were you in England that whole time?

BLANK: In England that whole time. As a matter of fact, at the time the war ended in Japan we were packing up the whole base to move to the Pacific.

BROCK: The whole engine—

BLANK: The whole engine operation. They flew a B-29 in for training to show us. Those engines were a little different—they were radials but they were different styles. They had hydraulic systems that you had to learn to deal with. We were very happy that we didn't have to deal with that.

BROCK: To where were they going to move it?

BLANK: I don't think anybody knew where, but it was just—we were just packing up all this equipment in big crates and they were moving it to a staging area to get on a boat at Liverpool, which was close by.

BROCK: Was it then back to the States by boat?

BLANK: I had to wait until I had enough points. [laughter] You had so many points depending on how much service you had, whether you had a combat badge or a purple heart, or whatever it is.

BROCK: To prioritize who got home first?

BLANK: Right.

BROCK: I didn't realize that.

BLANK: Oh yes. They called it ASR Points. I still have my discharge paper. I had forty-seven points and the guy said I'd been in—you get more points for the longevity in the service. A guy with five years had a better shot at getting home early than a guy with three, or two.

BROCK: What was your rank at the end?

BLANK: At the end I was Corporal.

BROCK: Okay.

BLANK: I had too many transfers. My service record, the last time I saw it—it doesn't exist now because it got burned in a fire in the early 1970s. They had a big fire in the Records Center in St. Louis. I remember I was in the Army for a total of thirty-three months and I had thirty-two endorsements, which meant that they endorse your record every time you'd get transferred from one place to another. [laughter]

BROCK: When was it that you were finally able to return to the States?

BLANK: I came home in April of 1946.

BROCK: Back to New York?

BLANK: The boat landed in Staten Island.

BROCK: Okay. What happened for you next?

BLANK: Then I tried to get back into school. My father wanted—he offered or told me I could get a job as a trainee in the union to operate a special machine that, in those days, was only handed down from father to son. He knew a guy that didn't have any children so he was going to sponsor me. I said, "No. I'd rather go back to school and finish." I came back a little late. This was in 1946, and most of the schools were overloaded. I wound up going back to City College. Actually, I went to Brooklyn for about a year and a half.

BROCK: Brooklyn College.

BLANK: It was an automatic transfer to City after that. At the same time, I got married.

BROCK: In 1946, when you got—

BLANK: In 1948. In between semesters.

BROCK: Okay. [laughter] Was your wife someone you had known before?

BLANK: No. I met her the day I came home. [laughter] A friend of mine was dating her at the time and he came to see me when I got out of the Army and he brought her along, and that was the first time I saw her. Then my friend got involved with another lady and I called her up and the rest is history. [laughter]

BROCK: Did you have to work when you went back to City College or were you on the GI Bill?

BLANK: I was on the GI Bill. Actually under PL-46. You may not have heard of that.

BROCK: I don't know what that is.

BLANK: It was similar to the GI Bill except if you had any kind of a service-connected disability, you got a full forty-eight months instead of one month for every month that you served.

BROCK: Okay.

BLANK: They gave you a little bit more of a stipend for allowances and that kind of thing. I qualified for that. I had a 10 percent disability, which was enough to get me under that program.

BROCK: You were there from 1946 until—when did you graduate?

BLANK: June 1950. I went straight through the summer. It didn't matter, I just wanted to get finished with it.

BROCK: When did mechanical engineering emerge for you as what you were going to concentrate on?

BLANK: I looked at it and I decided after a while that it was probably the broadest one of all the engineering disciplines. Since I didn't have any particular fondness for chemical, mechanical, electrical, or civil, and I figured that's the mother of all of them anyway. [laughter]

BROCK: Describe your training in mechanical engineering at City College.

BLANK: It was a very broad-based training. In fact, in talking to some of my contemporaries that went to other schools we had a much broader curriculum at City than many other people had. I had enough electrical engineering—which was not electronics in those days—that if I took another semester I could have gotten another degree, which a lot of people did—electrical and mechanical. Civil was another one: they taught everybody enough about basic civil engineering to pass the New York PE [professional engineer] exam, which most other schools didn't do. You learned about fluids, and gases, and mechanical engineering covered a lot of the chemical stuff too. So, I learned enough to be very careful about surfaces, which was where all the action was anyway, in metallurgy, and mechanics, and fluids, and also in chemistry, and in semiconductors too. I was pretty well-grounded. I also had a lot of work in manufacturing engineering. Then I had experience as a machinist, which showed how things got made.

BROCK: Is manufacturing engineering also sometimes called "industrial engineering"?

BLANK: At that time industrial engineering was not a full curriculum. It was a minor. Now they give you a degree in industrial engineering, which they didn't have then.

BROCK: I see. But manufacturing engineering—I'm just wondering what sort of issues were covered in manufacturing engineering?

BLANK: There were a lot of issues involving economy. We learned how much things cost and the economy of metals, the economy of labor, the economy of power, most of what gets made is eaten up in power. [laughter]

BROCK: Right. Okay.

BLANK: There's some statistical—we had an interesting course called "Engineering Economy," in which we learned how to finance large projects like power plants. [laughter] How to finance a big power station, where bonds are issued with a life of forty years, how to pay for that and how to put that into the structure to recover in the rate structure. This is an engineering issue as much as an economic one.

BROCK: It seems that emphasis on manufacturing and on the economics of technology—do you know if that was common in the training of a mechanical engineer?

BLANK: Not in many schools, no.

BROCK: I wouldn't think so.

BLANK: I also knew what a debenture was because of my own experiences. [laughter] I knew what a sinking fund was too.

BROCK: I don't know what that is.

BLANK: A sinking fund is something which pays for itself during the life of the project, and which repays the owner of the debenture during its life, with the proceeds from the project.

BROCK: I see.

BLANK: I don't know if they do that anymore. They had other things which were called "equipment trust certificates" which were very interesting. A railroad could mortgage a track length, the right of way; they also could mortgage a tunnel, a bridge. But when they had the fiasco with New York Central, the Penn Central, I was visiting a guy who had a bunch of bonds in Penn Central and he had an equipment trust certificate. I said, "Which one did you get? That dead end line out in Long Island or the Hudson Tunnel?" "The Hudson Tunnel I think was a good bet, but the dead end in Long Island I don't know about that. "

BROCK: When you graduated in 1950 what did you want to do and what did you end up doing?

BLANK: I wanted to get a job. At that time there were none or very few.

BROCK: Really?

BLANK: I looked for months and the pickings were very slim.

BROCK: Was that because of the transition from the wartime economy?

BLANK: Who knows, it just was lousy. Just plain awful. In fact, I was contemplating taking a job with the—going to Venezuela with the Orinoco mining. I'd just gotten married and I didn't want to deal with that. Eventually, I got offered a job as an engineer for the Babcock & Wilcox Company.

BROCK: I haven't heard of them.

BLANK: They're an old company. They've been bought and sold a few times, but at that time they were one of the premier central station boiler companies in the world.

BROCK: For power generation?

BLANK: Big central station generator. This was located in a town called Barberton, Ohio. Now that's really smokestack America. You work in a big boiler factory like that and it's mind-boggling to watch.

BROCK: The scale of it?

BLANK: The scale of it. I was working in what they called the "drum squad," which was designing big steam drums. The steam drum was something that was seventy-two feet long and about seven or eight feet in diameter. A big drum. [laughter] These spend their whole lives sitting under pressures up to 1500 psi or maybe even higher, and temperatures were around two thousand Fahrenheit. They were running white-hot throughout most of their lives. Watching them make a drum like that was really a thing to behold. At that time there was a race going on, not dissimilar to the race in silicon wafers when they went from four, to six, to eight, to twelve, and up. Gordon [E. Moore] told me he had a sixteen-inch wafer sitting on his desk.

At that time the state-of-the-art at Babcock & Wilcox was an eight-inch plate. They'd take an eight-inch thick plate, a sheet twenty foot square, and bend it into a circle, weld it, and take two more like that and weld it to each twenty-foot square that means it's sixty feet, and put end caps on it, so it was seventy-two feet. The only reason seventy-two feet came out was because that's what would go through most railroad tunnels.

BROCK: Oh gosh.

BLANK: If you made it longer it couldn't negotiate a curve. This was a practical limit. Their competitor, Combustion Engineering [Combustion Engineering Incorporated], had just completed a press capable of bending ten-inch plates, so they could handle bigger pressures and temperatures. Babcock & Wilcox at that time was going to upscale them, and we were working on a press to bend thirteen-inch plates.

BROCK: That must have been a huge press?

BLANK: Yeah. The problem was getting the raw sheets. A sheet of steel twenty foot by twenty foot, thirteen inches thick.

BROCK: Then having to move it?

BLANK: Yeah. There again twenty-foot square—moving it limits the size that you're going to make it. At that time they had a group working on the Nautilus, the first nuclear submarine. The reactor was made right in that factory. I didn't have anything to do with it, but it was built there. I was in a carpool with a guy who was an old-time engineer with B&W. We used to talk to him quite a bit and we'd ask him to show us around the place, because he knew everybody.

I went to my boss and I asked him if I could tour, he looked at me and he said, "You know, I've been here for twenty-eight years and it's the first time one of my engineers has asked me to take a tour of the factory." [laughter] He said, "By all means, go ahead and do it." [laughter] He knew the guy, they were old buddies. Once a week we'd go down and tour a different part of the factory. This was an education all by itself. Bending plate was one thing. Watching them weld these things—they used a welding rod which was an inch thick. [laughter] The coil—it looked like a hose pouring metal into it.

When they got all done with it—with the whole machine—before they did anything else, they had to x-ray every inch of weld. So, GE [General Electric Company] made them a huge x-ray machine sitting on a crane that was moved around. They moved the drum into this place and they would take pictures all along it. As soon as it had everybody's blessing they'd send—one copy the company kept, one went to the customer, one went to the state that it was going to be delivered to and one went to the insurance company. Just to make sure everything was right. Then we stuck it in an oven for three or four days to stress relieve it.

BROCK: The entire boiler?

BLANK: The whole drum.

BROCK: Wow.

BLANK: I watched them make coal pulverizers, which is another trip all by itself. Most of the coal-fired furnaces burned pulverized coal. They got this big wheel, ten feet in diameter, which was a big gear driven with a 150-horsepower motor on it, and they got these steel balls, that look like oversized bowling balls except they were bigger, only solid steel. There was a little press that was making these things. They cut a slab of white-hot steel, shoved it under into this die and overhead, whack, would come down and out would pop a white-hot ball. [laughter] Then they took this scale off and that was what they used to run around this track to make coal into very fine powder with water. When it was pumped into a boiler it looked like oil.

BROCK: A lot of surface area for firing?

BLANK: It burned much better. Then they got the water which added more to it anyway. That was a chore. I decided I wanted something different so a job came up shortly thereafter, at Goodyear Aircraft.

BROCK: Also in Ohio?

BLANK: In Akron. I went to work there in an R&D [research and development] department and it was an interesting group also. They had a big project with the Navy making the newest blimp, which was what they called their N-Ship. They had to replace the older ones. They were working on different types of fabrics and adhesives to hold the—

BROCK: For the skin of the—

BLANK: For the skin. They made structural elements for aircraft and for blimps out of—to save weight—out of layers of aluminum over balsa wood, or honeycomb aluminum, or in high temperature applications they would take stainless steel in thin sheets, over honeycomb stainless that would handle high temperatures. The adhesive they used in that was also an interesting material. They developed that in conjunction with Chrysler [Daimler Chrysler Corporation] that just came out with new bonded brake linings. Most of the brake linings were riveted in those days. Then they had this bonding variety which used a very high temperature adhesive.

Again, between the adhesives and the smelly stuff that went around—well when I got to work, I got an assignment one time to make some helicopter calculations. I had a boss who was a professor of aerodynamics at Guggenheim Institute [Guggenheim Institute of Technology]. I said, "Yeah, I can do these calculations. Nothing much to it, but I'd like to know what I'm doing." The one thing I neglected was aerodynamics. He said, "I'll give you some references to go look at in the library." I looked and I came back and did the calculations. He said, "I'll tell you what, since you really want to know, why don't we sit down for an hour, whenever we can. I'll give you a mini lecture on these things and pretty soon you'll be up to speed with what you need to know." That was almost worth a master's degree right by itself. When I did the rotor calculations he said, "Remember a rotor is a propeller." He said, and I'll never forget this, “The most efficient propeller is one that’s infinitely long, infinitely thin, moving infinitely slowly.”

BROCK: The “slowly” is very counterintuitive isn’t it?

BLANK: Most efficient. I said, “That’s very interesting. How come these props that I see nowadays, the turbo props, have chopped off edges?” I told him I used to see props in England that started out with the long slender ones and towards the end of the war they were squaring the edges off. It turned out that the tips, in a dive, become supersonic—it’s going this way and the plane’s going that way so there’s a vector in there which runs slightly above the speed of sound. Those tips take a lot of beating anyway so they square them off because they’re useless. He said, “Now you’re beginning to understand the difference between efficiency and effectiveness.”

That’s a lesson that’s hard to learn. You get so imbued with one thing you forget what you’re really trying to accomplish. We had a number of other things like that. I was doing a propulsion project one time moving an object through water. He said, “You’ve got two choices. In any given system you can move a small amount of water through a large delta V, or a large amount of water through a small delta V.” I learned later that the same thing is true whether you’re handling water, air, oil, data, or electrons. You have two choices, moving small amounts very quickly or large amounts slower, depending how much capacity you want to devote to the system.

BROCK: You were just doing all sorts of mechanical engineering work?

BLANK: All kinds of different projects. Coming from any place. We had a parachute project where we dropped scale-model parachutes from the inside of the air dock. Our lab was in an air dock similar to the one at Moffett Field [Moffett Federal Airfield].

BROCK: A huge space?

BLANK: There’s 200 feet of daylight in there. We had a crane put up on top and we would drop these chutes with bags of lead on them of different sizes, different configurations—ribbons, panel chutes—and take pictures on the way down. We put little lights on different parts of the shroud lines, and, then put them on a little plotter and from two different angles so we could see what the path was like with different configurations.

The early drag chutes came out of that project, and the cargo chutes came out of it. It was fun climbing in the middle of the night up to a hundred feet above, halfway above, to a stationary eight-by-ten camera, one on either side of the hangar, and every time they had a flight we took another picture. We put one sheet of film in there and the shutter rotated around. It would expose the film and we could catch the lights as it came down. They took two pictures, and from that they could determine the path. It was a lot of fun.

BROCK: These seem like they must have been government contracts?

BLANK: Most of them were government. Some of them were funded by private companies under government contract.

Then my wife got tired of Ohio and we decided to go back to New York.

BROCK: Is she a native New Yorker?

BLANK: The Bronx. My cousin's mother-in-law owned some apartment buildings and I said, "I'll move back only if I have an apartment first, then I'll look for a job." [laughter] She found us an apartment in Queens. I decided I wanted to go into manufacturing engineering to round out whatever else I was doing. I wound up at the Western Electric Company in Kearney, New Jersey. I don't know if you're familiar with New York? It's right across the river on the Pulaski Skyway, before Newark.

BROCK: Okay.

BLANK: There's a ramp that you'd take down—there used to be a big Western Electric sign on the Passaic River. I don't know if it's still there anymore.

BROCK: It's adjacent to Newark?

BLANK: It's between the river and Newark. Right across the water. They put me to work as an engineer in the manufacturing shop making toll crossbar switching equipment. This was the first automatic long-distance dialing equipment that was built. In those days if you wanted to make a long distance call you had to get the operator, who patched through to different cities, and then the local operator would take you through to your party.

They decided that if they continued that way there weren't going to be enough women born to man all the switchboards. [laughter] They developed the switching equipment and the main element was a crossbar switch, which was developed by Ericsson [Telefonaktiebolaget

LM Ericsson], a Swedish company, made under license by Western Electric. They had a huge factory in Chicago building these things, and that was the main switching element. Of course they used relays of different varieties in addition to that, but this was faster and they had a whole series of equipment aimed at dealing with traffic management. That's when they started with the area code business in the early 1950s. I was an engineer in that shop and started out among four or five other engineers handling all the different types. After we got a new frame as part of the equipment we had to learn if anything strange had to be built for that and take care of all the engineering issues.

Now, that piece of equipment was the first time semiconductors were used commercially in the crossbar equipment. There was a special card translator cabinet which used an array of germanium phototransistors to help them route calls. This was a kluge of a system but it was a deck of oversized IBM punch cards. We took an IBM punch card and had four of these stacked up. It was a stainless steel card about the size of four IBM punch cards. Each one was perforated with a different set of codes. There was a stack that was developed for different areas where if you added another central office into the system you had to add on more pads. These things would go up and down on cams and they'd shine a light through them, and at the other end of the light was this array of phototransistors. As soon as a connection was made, that path would get clamped, the connection was enabled and it was no longer available for anybody else until it was open again.

BROCK: I see.

BLANK: This was a kluge of a system. I didn't know what they were at that time, this mode of transistors. I heard about them, but that was about it. Another job I had, while I was working there—there was a toll crossbar gang and there were two other small shops that the same supervisor handled. One was a common parts shop where they made nuts, bolts, screws, washers, things like that, with automatic equipment and so on. Right next to it were a couple of guys that ran the metal finishing shop, which did plating, painting, whatever it was. They had huge automatic plating equipment for plating nuts, bolts and screws plus relay cores, and armatures. These all had to be chrome nickel plated and relay covers had to be zinc iridite plated.

When they had some new equipment and they needed some help but they didn't want to hire anybody because it was only going to last for a short time, I was drafted to help these guys out. First I was curious enough to want to do it. I was the only one in the group that had a chemistry background anyway, and it was fun. I helped these guys out and I learned a little bit about plating, pumping acids around, and neutralizing the tanks. We also had a nasty problem one time where a lot of our switches out in the field, for switching equipment, were getting contaminated with rust spots, and even the stainless steel fingers were getting corroded. They traced it back to the plating shop and the exhaust duct. The first time I saw it I said, "This doesn't make any sense." They had an exhaust fan in the shop itself pushing air up the stack. I thought, this is heresy, that's not a good idea. They should have the fan up on a roof pulling and not pushing. This had been done a long time ago. The upshot of it was they found that the duct was not a homogeneous duct. It was an angle iron framework and it had transite slabs stuffed into the corner. Transite is cement asbestos. That stuff is not made anymore, but that's what they were using. A lot of contaminated air was leaking through there and getting into our shop. Again when they had to deal with this program I was called on to go ahead and make measurements. We had some guys from Bell [Bell Laboratories Incorporated] come out to show us how to deal with it and how to take test samples. They punched out a bunch of filter paper where they punched holes.

BROCK: Like a hole punch.

BLANK: A hole punch. They had a Lucite thing made and they dimpled a bunch of holes in there, and they gave us reagents to put in there, one to wet down and put on the equipment, and another one to see what the—I had to do this myself, take periodic tests of this thing. I didn't train anybody else to do it because they weren't going to be doing it long enough. When they designed the new fan I said, "Look, you're not going to run this thing past the shop anymore. You're going to have to put it up on the roof." They did that and they put—I didn't want any holes. I wanted this duct to be made out of something that wasn't going to get holes in it. They finally made a duct out of a plastic material which was supposed to withstand the chemicals du jour. [laughter] They called it Boltaron and to this day I don't know what it was. It was some kind of epoxy duct or something like that. We were debating what kind of motor. I said, "I want to push that stuff up as high as you can get it." They were thinking about putting a scrubber on there. One of the other engineers who was a chemical engineer went to visit the company that made the scrubbers. He came back horrified. He said, "The residue from that—there's no known way to dispose of it."

BROCK: From the scrubber?

BLANK: From the scrubber. They decided to get it up and to mix it. The poison, it depends on the dose. They had a test run and model made at NYU School of Engineering of Aeronautics, to see how far up the air had to be pushed to get it to mix to a point where it's diluted enough so it's not going to hurt anything. They actually made tests and they made recommendations. We got a huge motor on there, much bigger than what someone would normally put on it, and then put a Venturi to choke it down and get some velocity in it, to get the air up, mix it, and get it out of the way. In addition to this I was working on switching. [laughter]

BROCK: I want to ask a little bit about the Kearney operation. Was it a large Western Electric factory?

BLANK: A very big one.

BROCK: Okay. This was to assemble the switching unit?

BLANK: Assemble, wiring, and test. One of the things I was part of was a cable gang, which made a switching frame, if you don't know anything about it—at that time the central office had these ceilings with railings on the top, and the switching frame is eleven foot six inches high, and anywhere from twenty-four inches to six feet wide depending on what was put in it. We had a capacity of about seventeen hundred switching frames a year or a single shift, and we were running two and a half shifts. We also built another plant to build the same equipment for a military program called the SAGE Program. SAGE is Semi-Automatic Ground Environment, which was the precursor to World Wide Web.

BROCK: To interconnect those?

BLANK: All these interconnections, or inputs from different areas connected, they thought they were getting input from different radar systems and they wanted to switch them to a loop.

That was it. We didn't have enough capacity to do it so they had to build a separate plant in Fairlawn, New Jersey to do that. That was only going to last for a couple of years anyway. It was a self-contained thing, but it had a relay shop in the building where they would assemble relays, which we used hundreds of thousands a year in addition to the switches. The switches were made in Chicago and shipped in.

BROCK: Where did they make the germanium phototransistors?

BLANK: Allentown. They would get assembled; we didn't make the card translator. We got most of the parts from another Western Electric factory, I think, in North Carolina, and we would do the finished assembly, wiring, and test. We also made the stainless steel cards which were heat-treated and ground flat. We had to make sure they wouldn't twist and warp and go through all kinds of things. It was an interesting thing, one of my buddies in the plating shop wrote a paper on hydrogen embrittlement. I think it's interesting because we used to find that plated screws that were under high stress tended to break. Well, as a mechanical engineer I understand highly-stressed parts don't wear out. They break before they wear out.

One of the pieces of trivia that came back from—if it's lowly stressed it's going to wear out before it's going to break. It will never break. They found out that one of the reasons it was breaking during the plating process, they would entrap hydrogen on the surface, and the hydrogen would react to whatever, like if they were near a seaport, there was going to be a little chlorine to get hydrochloric acid. Pretty soon it started winding its way through. We started a process of hydrogen embrittlement relief, which was taking these plated parts, sticking them in an oven at four or five hundred degrees Fahrenheit, for a few hours to drive the hydrogen out. This was a surface effect. When I got to the semiconductor world they start talking about it, I'm thinking, "Well, this is nothing new here."

BROCK: When did you join Western Electric?

BLANK: In January of 1952.

BROCK: You were there in Kearney through 1956, is that right?

BLANK: Through April of 1956.

BROCK: Okay. The story I've heard is that in 1956, was it Dean Knapic who called you?

BLANK: Dean Knapic was one of our—we were working together.

BROCK: At Kearney?

BLANK: Yes. He was in a different lab but his project was on wire wrapping, which I had an interest in also because it was my shop that was going to do more wire wrapping than anybody else. They also started for a short time an Engineering Development Group at Kearney in which they set aside to work on manufacturing engineering projects that would go across the lines for the whole company. I was selected to be in that group along with Dean Knapic, and [Eugene] Kleiner was also included. But then, one of the guys back in the crossbar gang died and I was reassigned back to that that one.

[END OF AUDIO, FILE 1]

BROCK: We were talking about Western Electric and working with Dean Knapic, making that connection. You also mentioned that Eugene Kleiner worked at that same plant?

BLANK: He worked at the same factory. In fact, Gene and Knapic and I were in the same carpool together for many years.

BROCK: I didn't realize that. Were you all living in Queens then?

BLANK: No, I was living in Queens, and Gene was living on the West Side, up near 80th Street, and Dean was living on the East Side of Manhattan, and we'd alternate. Gene, some days, used to drive, and some days I used to drive. Knapic didn't have a car so he helped pay the way for the tolls. We did this for a number of years. That's how we got acquainted with one another.

BROCK: Were you guys particularly friendly with one another?

BLANK: No, we were just involved with each other at work. On the job I didn't have much to do with Gene except he was working four rows of desks up ahead of me in the relay gang, and I was a few rows behind them in the crossbar crowd. Dean was in a separate section doing some, as I say, generic work and he had a wire wrapping project that he was trying to get put in to spread throughout the whole company. Kleiner had to get involved in it because he had to change the shape of the relay terminals to accommodate the wire wrapping.

BROCK: This was how to wrap the wire around the terminal?

BLANK: Around the terminal without soldering. We wired up enough pressure so that the corners formed a metallurgical bond with the wire, a gas-tight metallurgical bond. I was told a good electrical connection is a good mechanical connection. [laughter] It required a massive change of form factor for all the terminals that we were building. We did start to introduce this and in the beginning they wouldn't let us ship equipment without solder. We had to do the wire wrap and do the solder, and after we collected I don't know how many reams of data supporting that they were good, then we had to test run certain amounts, many hundred thousand. They were good at collecting supporting evidence before they went into anything. Western was an interesting place too. The first time I saw a cleanroom was at the shop they had at Hillside, New Jersey where they were making the underwater cable. This was a project to behold. They were building these repeaters.

BROCK: They would go under the sea?

BLANK: It was spliced into the cable and it went underwater. The repeater, in those days, was an amplifier that was made out of vacuum tubes. They used to call them "rocket tubes." Each tube was designed to have a service life of twenty years and at least double full-rated power. They didn't want to have to change tubes in the middle of the ocean. This cable would handle power and transmission lines simultaneously. This was a trick by itself. Anyway, they were building these things in the cleanroom. The first time I saw the guys with hats and bunny suits building the amplifiers.

BROCK: Okay. Because they didn't want anything in there that could—

BLANK: They wanted to make sure there was no—and they even had a fetish of keeping vibration away from it. I couldn't understand why because the thing sits in the ocean, it's weightless, right? I saw pictures of how they were laying this cable. They had this huge reel maybe twenty foot in diameter or more, it could have been more like a hundred foot. I couldn't tell from the scale. With this cable wrapped around it and they were paying it out, and as soon as they emptied that one, they clipped on another one and kept on going with this thing. On a calm sea it was one thing but every once in a while there was a pitching sea and this thing would go up and down and this cable whacked into the water with a shock load. They calculated how many Gs it was. It was pretty striking. It had to survive that. If it could survive that it would last forever. Because it had no stress under the water.

BROCK: When did Knapic leave for the West Coast? Did you talk with him about that?

BLANK: No, he kept me—he was a very talkative guy. He told us he was being interviewed by Bill [William] Shockley, and of course we knew that he was an exaggerator, so you know, "Okay. Interesting story." [laughter] Well, it turned out Shockley, when he set up his lab, was looking for some mechanical or manufacturing people because he knew that most from the scientific community of the day didn't have much experience with that. They were not always practical and they needed somebody to do things in a practical manner. He called one of his buddies at Bell Labs. I think the fellow's name was Rudy Molina. He was a friend of Shockley's, and he knew Dean because he worked with him on this project, and he gave him a call. He mentioned it to Shockley, and Shockley got in touch with him, and invited him out. So he went. He actually went and took a look, and he had to go and take this psychological test. You've undoubtedly heard about this one?

BROCK: I have heard about it.

BLANK: He gave them the authority to go ahead and find two more engineers to help round out this project. He picked yours truly and Gene Kleiner out of the whole gang. Not only did he pick me, we were the only ones that showed an interest in going. Most of the fellas wouldn't touch it with a ten-foot pole.

BROCK: Because they were established where they were?

BLANK: Yes. All of the—they didn't have any courage. We talked about going to the West Coast anyway at one time but we were looking for an opportunity where we had some recourse in case it didn't work out. Eventually I got interviewed by Shockley and he flew in. I met him at the Newark airport at the restaurant up there and we chatted for a couple of hours over lunch, and I got a letter offering me a job out there, and the same thing happened with Gene Kleiner.

BROCK: Knapic must have been one of the first people out there?

BLANK: No, there were about ten people there when he got there.

BROCK: Okay.

BLANK: Maybe, some technicians and a few guys. I think it was Smoot Horsley, Bill Happ, and Leo Valdez , and a couple of technicians. There were not very many people. Vic [R. Victor] Jones was there.

BROCK: Had Smoot Horsley been at Bell?

BLANK: I don't know. I didn't know much about him.

BROCK: Okay. But Leo—

BLANK: But Leo Valdez had been at Bell. I didn't know him. I didn't know very many people at Bell Labs, so he didn't mean anything to me. But he left Bell and worked with Pacific Semiconductor [Pacific Semiconductor Incorporated] making diodes in Los Angeles, and Shockley picked him up to work there. A real physicist, a Bell Lab type physicist. Nice fellow, actually, but not too practical. But that's another story.

BROCK: That was early 1956 then when you met with Shockley at the airport?

BLANK: Yeah, it must have been January or—it was early 1956.

BROCK: Did he describe to you then or early on in the conversation what he wanted to do with Shockley Semiconductor?

BLANK: Not really. I don't think he knew. He was just—his main thrust was silicon. He wanted to work on, focus on the silicon and ways to make devices out of it. They weren't sure whether they were going to do alloy or diffusion—but they were exploring to find out what the best way was. He didn't even know what to make—just to make a transistor with silicon. That was the thing that he was focusing on, because he felt that germanium had its limitations, and although silicon was harder there was more of it in the universe than there was germanium, with which I agree.

BROCK: Did you come to California to see the operation before you decided?

BLANK: No. We just packed up, sold whatever furniture we couldn't deal with and sold the car. I actually had the guy that I sold the car to drive me to the airport. We had our first child, who was ten months old at the time. We went to Idlewild Airport, it wasn't JFK then, in New York, and got on a Constellation and flew to California in April of 1956, almost ten years to the day that I got out of the Army.

BROCK: Did you have some time to do apartment or house hunting before you started?

BLANK: We had a few days. We went to California on a Wednesday and by Saturday we bought a house, having looked at what was available. We discovered there were no rentals around, or apartments—and no rentals or houses that would take young infants. We went to buy a house and we bought one. We stayed at a motel in Palo Alto until our furniture arrived, at which time we took the delivery and moved right in.

BROCK: Did you buy a house in Palo Alto?

BLANK: Yes.

BROCK: What were your first impressions of the laboratory when you got there?

BLANK: Having come from a sophisticated place like Western Electric, this was kind of primitive. It was strictly laboratory equipment. There was a small machine shop that was not going to be adequate, because you had to build everything.

BROCK: All the equipment?

BLANK: They had nothing, even little fixtures had to be built. They already had a couple of people there but I could see that wasn't going to be enough capacity. So we expanded the shop. The first job I had was to build this fancy crystal grower.

BROCK: Okay. Was this the one that Shockley and Jones had devised?

BLANK: Yeah, and Leo Valdez. It was a kluge, in my opinion, but "Okay, we're going to build this crystal grower." Unfortunately it was a project that got much bigger than we really could handle, to the point where it was going to take a while before we could get crystals. We decided that, "Look, we're going to need silicon," and Shockley was there so we'd get silicon from Bell, and we could buy some once in while from Sarkes-Tarzian [Sarkes-Tarzian Incorporated], just to do experimental work.

BROCK: I haven't heard of that—Sarkes-Tarzian?

BLANK: Yeah, I think they were in Indiana but it was a company that was growing silicon crystals that they would sell. This was a hit-and-miss kind of a thing so we decided that we ought to make our own crystals because it was going to be a while before this fancy grower got going. We could buy a crystal grower from a company in New England or New York. I've forgotten which. But it was expensive and there was a long delivery time, and it was an RF heated device. It took a twenty kilowatt generator. They wanted a lot of money for it. Because of the time delay I decided, "Look, we could build one of our own and have it running by the time these guys would even think of delivering it." One of the pacing items was getting the generator itself anyway.

BROCK: Just purchasing it?

BLANK: And having it shipped and getting it delivered was a big job. So we decided to go ahead and build a crystal grower, which I did. Gene and I sat around and we decided to build one and we designed and built a mechanism to pull crystals.

BROCK: A simpler one than the—

BLANK: Just one that was going to work had a quartz envelope, and a graphite pedestal to hold the suceptor with the quartz bowl. It had a chuck with the seed—you mount the seed on and rotated and pulled it, and so on.

BROCK: Did you pull it under a gas?

BLANK: Yes, you had to use an atmosphere of as pure nitrogen as you could get, with a little argon in it, which was a trick—we learned that from Bell. Just a few percent. I forget, maybe it's two or three percent argon in there was all it took to make life a little easier.

BROCK: Now that sounds like—well, I have a couple of questions about the big grower.

BLANK: You really don't want to waste time with that because it was a story by itself.

BROCK: I think it is interesting in terms of the Shockley Semiconductor experience. It seems like there must have been—in terms of the early days of the lab—a lot of people working on it. Was it on a large scale physically?

BLANK: Very large.

BROCK: Very complicated? It must have been expensive?

BLANK: Not that complicated. But expensive. We built a double-walled steel tank that could keep water on the outside just to cool it down, with covers on it so it looked like a little mini boiler, which was right up my alley. Inside was a crucible that was going to be heated by a resistance wire element wrapped around radiation shields. There were two or three layers of radiation shields around there. The outer one had a molybdenum wire. Actually it was three phases. We had three-phase wire wrapped around the outside with stand-off insulators to keep it from shorting out through the molybdenum, the molybdenum radiation shield, and the whole idea was to heat the whole thing up to just below the melting point of silicon. The point was to melt it first and then back off just before it gets fluid, which is a funny phase.

I knew from my thermodynamics. I thought, "This is a very unstable barrier." Then the idea was to put in a separate heating element with a piece of tantalum wire as a heating element to melt a puddle inside of it from which to pull the crystal, which was supposed to not have contact with the quartz crucible. The theory was not to get any oxygen in there.

BROCK: You'd pull it under a vacuum?

BLANK: Under a lot of negative pressure, let's put it that way.

BROCK: Okay. [laughter]

BLANK: We were not going to get a thing like that to anything that was called, in my book anyway, a vacuum. It was under as much negative pressure as we could have gotten out of it.

BROCK: Okay.

BLANK: I wasn't too happy with either. I'd rather put it under positive pressure with a known gas, but who was I? I was just a blacksmith engineer. [laughter] There was an interesting fiasco with that thing. We were going to build these stand-off insulators with high temperature like that, 1400° C which is pretty toasty, the voltages were not so big, maybe 300 volts or thereabout. Not so terrible. I said, "The only thing that's going to handle this is aluminum oxide insulator," which I knew because the mufflers in the furnaces were all aluminum oxide. Like the furnaces, if they could handle that all day long that's what they should use. Leo Valdez said, "Absolutely not. It's not pure enough we have to use sapphire." I said, "Sapphire? How do we get that?" He said, "Well, they now grow sapphire rods about a quarter inch diameter and about two or three inches long." Sapphire. This is hard stuff. Gene and I argued with him, but this was futile. We had to use diamond saws to do anything with it. It really was machined. We just cut grooves in it and hoped for the best. Leo insisted. I think that was a pacing item because the delivery time on that was lengthy. I don't know what it was, but it wasn't instant delivery. Then when we got it we had to fiddle around with it and try to figure out how it was going to be cut and designed.

We did it anyway. We got the thing fired up, everything was running smoothly, and all of a sudden bang! The whole circuit breakers, I thought they were going to fly off the wall. It turned out, to make a long story short, that Vic Jones showed me that at a certain temperature sapphire—I think he said it was like a Curie point, but I don't believe that because Curie has to do with the magnetic properties. What happened was that at a certain temperature the sapphire loses too much strength. At that temperature it doesn't hold itself up anymore and the wires sag and short out against the shield. That was a major fiasco and we had to redesign the thing, and we went back and did aluminum oxide, like we said in the first place. Aluminum oxide comes like high-strength chalk. We cut it up, milled it, did whatever we wanted with it, and then we fired it up, heated it up, and it became a ceramic. There were a few little tricks we had to learn. We got some books out from the manufacturer that told us what kind of shrinkage allowances to make. It was not a big part so it really didn't matter very much. We're not talking about a big scale. Anyway, we got this thing working like a charm, but by that time they had lost interest in it and it sat idle for a long time, and I—it was about then that I left the company anyway. In the meantime we were busy working on the real crystal grower that was actually making crystals.

BROCK: That sounds like one similar to the design of Gordon Teal and John Little. Or, where'd you get the—

BLANK: No. I knew it was a tube of quartz with a little viewing port, bolted onto it, in between two plates. I decided to make it like a tensile testing machine because I built a four-poster to hold this. I wanted a rigid platform, and I wanted to draw this thing up so I had two lead screws pulling the platform up. I didn't want any gears in there because I didn't need any noisy stuff, or clutches, or shifting. I didn't want to be bothered with that. I didn't think we needed the complications. What I found was a very large DC variable speed motor, which could go from 1 or 2 RPM up to 1800 smoothly. It had enough torque in any range, so it was not—it was oversized for the job but I was more concerned with the speed range than anything else. I had two worm-gear transmissions on each side turning these screws. For pulling we needed a very slow rate. There was another motor on top turning the chuck rod.

We drilled a hole and they had to go ahead and introduce the gas, and on the bottom we put a radiation pyrometer, which was made by Leeds and Northrop with a controller—the best of its kind. The only one of its kind in those days, and there it was. [laughter] I remember we were drawing this thing up. I had a draftsman doing the drawings and he tried to put a dimension on this plate to hold the table up. I said, "Don't waste your time because I don't even know what that is yet." He said, "Why? We have to put a name on it." So I said, "First of all. I don't want to wait six months for somebody to ship it out from God knows where just because it's that dimension, I want to see what's available first." I went to a shop we were working with and he said, "No, you got to go to a place that has a big—" I said, "Do you know anybody around that has a Blanchard grinder?" He said, "Yeah, there's a guy in Redwood City you can go to." I went to see him and sure enough he's got this nice Blanchard, and I said, "I need a couple of plates." I told him what it was. And he said, "Come on in the backyard." This was not engineer to engineer, this was machinist to machinist now. I went in the back and he had some boilerplate sitting in the back, and I said, "Well, this looks pretty flat." I said, "All I want is enough of a table to hold it up. Give me at least a half-inch, five-eighths, three-quarters would be fine." So, he had a couple of pieces of boiler plate an inch and a half thick. I said, "That'll do fine." He said, "Wait, I don't know how much you're going to have left by the time because it's not flat." We had it picked up. We brought it to the Blanchard. I asked, "How are you going to deal with this?" He said, "Okay, the first thing we're going to do is not going to put—"

A Blanchard grinder is a big table with a—it's basically a magnetic chuck, with a huge magnet that rotates, and right above is a big spinner with a big grinding wheel. This rotated and that rotated and pretty soon we generated a flat surface. We first put it on there and just brought the wheel down to just kiss the edge of the steel and slowly take off a little bit until you got enough of a flat. Then we turned it over and we did the same thing on the other side, and we kept on—I mean this was craziness but that's the only way we were going to get a piece of flat metal. Then when it got flat, we put the power on and finished it off, the magnet, because we didn't want to warp it. When we got through taking the magnet off it's going to go spring back again. We didn't want to do that.

This was the kind of thing that we dealt with. I didn't want to waste a lot of time waiting for things to get shipped out from New York, or Chicago, or Dallas, or Boston, or wherever, unless I had no choice. A lot of things we did were not the best practice but in the interest of saving time I think the trade-off was worth it because we got the thing up and running.
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A friend at Hewlett Packard was working on making silicon diodes for their own use, and we used to visit back and forth. He bought one of those crystal growers that we were looking at. We got ours designed and up and running before his arrived. We were passing seeds back and forth. "You want one of this?" "Okay." "We'll give you a piece of this. You'll give me what you got." That was the way it worked. He was there doing it all by himself. But his was a flimsy machine compared to ours.

BROCK: Did you go look at the commercial one when it came?

BLANK: Yeah. His was a single column with a cantilever, holding this rod in there. You probably have seen pictures of that one.

BROCK: I'm not sure. I didn't realize that there was a commercial crystal grower.

BLANK: Sort of commercial, with Semi-Metals [Semi-Metals LLC], or something. I don't even remember the name of it. Or maybe a General Semi, someplace back east that had these things. They wanted a lot of money for it, and the delivery time was terrible because they had to be hand-built. No, I designed it and had it built in less time than it took to ship it out of the East Coast or wherever it was.

BROCK: In your second crystal grower design, you raised up a platform?

BLANK: No, we had a platform that was just at table height. On top of that we set the quartz tube, and we pulled the quartz. It was maybe about fifteen inches high. Then the pulling rod was above that.

BROCK: How was it connected to the motor?

BLANK: There was a separate motor pulling sitting on the platform where the pulling rod motor was. The platform that had the chuck for the pulling rod went through a bearing and this was driven by a small variable speed motor again, a little Bodine [Bodine Electric Company] motor geared down so you could have some control over it.

BROCK: Okay. You dipped the seed into the melt?

BLANK: To get the thing started. Then it was turned on automatically and it started pulling up.

BROCK: It pulled directly on that rotating rod?

BLANK: We watched it as the melt changed the heat input. That was what the controller was doing, an optical pyrometer looking at the bottom of the crucible and changing the input setting to the RF generator.

BROCK: To keep it a semi-constant?

BLANK: Now, the RF generator was very expensive too. We decided we were not going to have a room full of these things. Every time someone turned around they got to throw a big twenty kilowatt load, or actually more than that, online. We developed a resistance heating device. We actually made what was going to hold the crucible, instead of a suceptor for coupling, which was made out of the same reactor-grade graphite. I learned about reactor-grade graphite. [laughter] We actually cut a double helix out of graphite and split it. We drilled holes in there and put bolted clamps of tantalum and fed through the bottom of the plate, and heated it up and we got this. When graphite is cold there's a nice spring. We heated it up and that was also used for a while too, because we didn't have the expense of an RF generator. This thing took a much smaller amount of kilowatts instead of twenty or thirty.

BROCK: You made a resistance heated crystal grower there?

BLANK: We made it. I don't think we actually built it. I did it later at Fairchild. In fact we built a fancier one with a three-phase. We made a triple helix, a bigger one, and that ran for many years. Those crystal growers were pumping out day and night. I talked to some of the maintenance guys about that. They said the only problem he had was that he heard a squeak in one of the motors. One time they figured out that one of the transmissions had never been greased. So, he got a grease gun and he gave it a couple of squirts and from then on it was happy as a clam. They never failed us. They were so over-designed.

I learned with manufacturing equipment, when something is built, no matter how delicate it is, we had to make sure it was built in such a way that it will withstand the rigors of the people that are going to use or abuse it. This is reality. We really had to go over the top. I saw a movie one time of a company that built wire-wrapping tools. It was a company called Gardner-Denver [Gardner-Denver Incorporated]. They built mining equipment. One of the things they built was hand drills for drilling rock and stuff, and they made a special electric wire wrapping gun for us out of magnesium. They recommended against it. They wanted to use something sturdier. We felt that, "Look, these things are going to be handled mostly by women and we want to eliminate as much weight as possible." They were making these pneumatic tools, and their main business was for Detroit. They had these nut drivers on a pneumatic hose and they ran a few screws on one side and they took this thing and flung it underneath of the car carrier to a guy on the other side who picked it up and used it to do the same thing on the other side. After running these things back and forth on a concrete floor—they showed me pictures where they wore out right through the skin. I said, "No, this is not that kind of environment." [laughter]

BROCK: For how many months did you work on the Shockley, Jones, and Valdez team?

BLANK: In addition to another project—this was not the only project. One year we were making—well, we had to make everything. We were making four-point probes and these lapping jigs to lap the silicon down to measure diffusion depth. Bobby Noyce wanted to do some work to figure out how to make aluminum contacts so we built a little shutter for him to evaporate aluminum on the contacts. Any number of things. We worked on how to make contacts. First we had to put the silicon on a header of some sort. That had to be developed. Then we had to make a contact to that. Then we had to make the interconnect from there to a pin on the header to the outside world, and then we had to encapsulate it. Each one of these required some work. In addition to that we had to slice silicon. We went and got a surface grinder and adapted it to cutting slices of silicon and then lapping it to the right thickness. There was that piece of equipment. Some of it we could buy and adapt and some of it we couldn't. For evaporators we would buy a bell jar. We had to do our own tooling inside. And then diffusion furnaces. When I got there Smoot Horsley and Bill Happ were working on a project where they were doing closed-tube diffusion. Have you ever heard of this?

BROCK: Closed-tube?

BLANK: Closed-tube diffusion. They take a small piece of silicon and they put whatever doping they wanted in there and sealed it in a quartz tube. They took this and put it in an oven for so many hours at such and such a temperature. They took it out, broke the quartz, lapped it, and measured the diffusion depth. I said, "Well, that may be an interesting way to do it in the lab, but for production purposes you have got to be kidding?" [laughter] There was another group working on open-tube, what we still do today. So, there was that consideration. Then Knapic called me one day and he said, "Look, this RF generator has to have water running through it all the time. They're dumping it down the drain and they're having a problem, because there was no sewer there." We were on a septic tank. I said, "You've got to be kidding?" He said, "We need a cooling tower to cool the water so we can recirculate it. Go get me one," because I studied air conditioning at one time so I understood what that was. I said, "I don't want to do this, but I have no choice." What we wound up with was a wooden tower, which I hated because it was about the only thing we could get in a hurry. If we wanted a real cooling tower we should have got Baltimore Air Cooler, which I'm more used to—a metal thing that I knew all about, that's going to last and is going to do the job, and can be measured. But the wooden ones, who knows? They were not built for this kind of work.

BROCK: How do you make a cooling tower out of wood?

BLANK: Just squirt the warm water on top and it dribbles down this cooling tower and comes out the bottom. It's just a simple device with a fan in there, but it's all redwood.

BROCK: So the water ran on the interior sides of it?

BLANK: Right. It was terrible. We had to clean it because it got dusty around there. But it was the only thing I could get in a hurry. For a while it was sitting on the roof and for a long time it was the highest spot in all of Mountain View. [laughter] They've since taken it down. That was one of a number of things that we did.

BROCK: In all of the crystal growing work, and crystal production work that was going on that you were just describing at Shockley, was Sheldon Roberts involved in that at all?

BLANK: Oh yeah. Sheldon Roberts was involved in it, and Vic Jones. Mostly Vic Jones. There were a few fellows that were involved in it. In fact, they were trying to get materials with different dopants in there.

BROCK: You mean in the growing process?

BLANK: Just to make seeds so they could use that to propagate. They wanted some arsenic in there. I said, "You know, this is nasty stuff. You don't want to deal with this." I made them get the gas masks and stuff like that because, I don't like to deal with gaseous arsenic. By the time you smell it it's too late.

BROCK: Yeah. [laughter]

BLANK: Then we had a deal with getting rid of the acid. There was not a lot of it, but some small amounts of pretty nasty things like aqua regia, fuming nitric, sulfuric, HCl, all the usual suspects. Then they were dealing with solvents—acetone, alcohol, MEK, trichloroethylene, carbon tetra—all the nasty things, but in small amounts. Fortunately there wasn't enough of a volume to cause anybody any great grief. Dealing with gases: how to get hyper-pure gases, and how to distribute them around the place? That was my problem, how to deal with the fittings and how to—

BROCK: The gas service for the lab?

BLANK: Yeah. From there evolved the fact that when we went to Fairchild, since I was the only one that had any experience at all with air conditioning, I was—

BROCK: Got that job again?

BLANK: I got that job. And electrical power distribution. Nobody knew from beans about that or the distribution of gases, chemicals, air, electricity, water. DI [de-ionized] water was another problem. In those days we were buying distilled water and running it through a little laboratory ion exchange column. The reverse osmosis stuff didn't exist then. In fact, I think such filters were classified. I think they were only using them for the military—they became available later. It was a problem getting hyper-pure chemicals, water, and gas, and distributing it to make sure it didn't get contaminated. Because every time you break the seal—

BROCK: Right.

BLANK: This was a mechanical problem that became a chemical problem.

BROCK: To go back to the Shockley experience then, was it mostly you, Eugene Kleiner, and Dean Knapic tacking all these things together?

BLANK: Yeah. Dean Knapic was the manager. He would hand us a project and between Gene and I, we decided who was going to do it, whether I would do it, he would do it, or we would both deal with it together. It was a very fluid, open relationship. It was one of those things. We were not dealing with—there were no politics here; something had to be done and who was the best guy to deal with it? If we didn't know we better get some help from someone who does. The important issue was solving the problem in a timely fashion. Anytime we had a disagreement we'd work it out until we both agreed that, "This is the right way to do it." Or, "If it isn't the right way, we're doing this way because of other reasons, like we don't want to wait six months for it."

BROCK: Right.

BLANK: Because otherwise we would never get anything to happen. [laughter]

BROCK: Did Dean Knapic leave Shockley before you did?

BLANK: About the same time. He formed KEP, Knapic Electrophysics, where he was growing crystals. He used the same crystal grower that I designed.

BROCK: The same exact crystal grower?

BLANK: Same exact crystal grower.

BROCK: Did he take that same machine with him or did he reproduce it?

BLANK: It's not that complicated a machine, it's a generic thing. So, he asked me to look over the drawings to see if he missed anything. [laughter] I don't care. As far as I knew it was public domain anyway. A Czuchralski puller is a Czuchralski puller no matter how you do it. In fact, Fairchild bought silicon from them.

BROCK: I had heard that.

BLANK: Yeah. They pulled their own silicon for a while. If they needed extra ones or if they had a resistivity which wasn't in the normal mill, they'd buy it ready. We were a big customer of his, as a matter of fact.

BROCK: I know that Jones and Valdez left Shockley soon after that big kluge?

BLANK: I think Valdez lost favor with Shockley over that. Jones just couldn't handle that kind of atmosphere and wanted to get back to an academic environment. He told Shockley that he wanted a change. Shockley said, "Well, I'll call Les Hogan," who was a professor at Harvard at the time, "and tell him about it to work a deal." So, he called Hogan and Hogan hired him while he was a professor. I met Hogan years later. I said to him, "You know Vic?" He said, "Of course I know Vic."

BROCK: I didn't realize Hogan was teaching.

BLANK: He was a professor at Harvard after he left Bell and before he went to Motorola [Motorola Incorporated].

BROCK: Let's talk a little bit more about Eugene Kleiner in those days, as a person, as a close coworker, and engineer.

BLANK: Kleiner's experience mechanically was as a tool maker and mine was as a prosaic machinist. He worked at a higher level. Between the two of us we could operate almost any machine known to man. He was better at—he liked to do welding so I left the welding to him. [laughter] Whenever we'd have a peculiar product and we were working with molybdenum, for example, for the first time, I did the research and I did the procurement. I was the purchasing agent at the time because I didn't want to start educating a clerk purchasing agent to buy technical stuff. It didn't make any sense, because by the time I wasted doing that—I just needed to know where to get it. When we worked in these radiation shields, how were we going to get sheets of molybdenum? At that time I found out that there were two guys that made sheets by two different methods. One was sintered and one was arc-cast. I just wanted something that was relatively easy to bend and drill holes through and deal with. Then we had to make little rivets to fasten the thing together. I didn't want us machining screws. We just drilled a hole and popped it—just to hold it in place is all. It was not going to do anything else. Just to hold this envelope together. Some machining we did—a feed through required machining. For certain things we got the arc-cast, and some we got the sinter, depending on what it was.

When it came to machining we both got together on the lathe and he was on the lathe and I was looking at the book that talked about how to deal with this stuff, all about feeds and speeds. I said, "Oh, it recommends using kerosene or turpentine as a lubricant." Why that material I don't know, but that's what they were—so we got a jug of that and we put it on there. It worked fine. We actually machined some screws out of it. Gene did it, and we had a long debate on the feed, on the feeds and speeds. "Let's stay within the realm of what they say." We did the calculation and we double-checked one another. The machinists were standing around watching us, the guys that were working. So, when we finally did it, they now knew that it worked, "This is the right thing to do, and this is how you do it." I think it was turpentine that was used as a lubricant.

We were basically interchangeable. If someone had a problem, his desk was right opposite mine anyway, so there was not such a thing as "my project." It was our project. If I needed him, if he put his words in it, fine. If I looked over his shoulder and I could say something, fine. Nobody ever took any offense over it.

BROCK: Did the two of you socialize outside of work or did you need a break from one another?

BLANK: We socialized a little bit. He used to live up on the hill above us, until he and Rose—they're both gone now. I remember when he bought the land. He took me and scouted it, driving up to show it to me. I had no idea of buying a piece of property here. A few years later, when this land became available, it turned out that he was right up there but I didn't pick it out that way.

BROCK: While at Shockley Semiconductor, did you work at all on building open-type diffusion furnaces?

BLANK: Oh yeah.

BROCK: Was that something that you worked with Gordon Moore on?

BLANK: Gordon and I worked on this fiasco of the platinum winding, which turned out to be—

BROCK: I heard about that.

BLANK: We worked for a while but then the platinum sort of gave out. We went in his car up to a company in South San Francisco, we had bought the platinum wire together. But we came upon this material, this molybdenum disilicide made by this Swedish company called Kanthal [Kanthal Global]. They were capable of doing that job. I think they still use it to this day. We ordered some of the first elements from them, custom wound, and we used the same thing at Fairchild as well.

BROCK: Was Gordon taking care of the glass blowing aspect for the furnaces?

BLANK: Gordon did the glass jungles, which were what was used in those days. I can remember watching him do this. He taught Art Lash to do it and he finally got rid of that chore. But with some of the early work, everybody had to do a little of everything.

The diffusion furnaces were sensitive so we built these electric controllers. We bought them from Barber-Coleman. They were always dying for some reason or other and I got a hold of Vic [Victor] Grinich. We looked at them and said, "This is crazy. There's no reason why this thing shouldn't last." So, we opened it up and looked inside and I said, "I can't believe that these components are that cheesy." Between the two of us we changed a capacitor, upgraded it two grades. Instead of 150 volts we made it 350, or whatever it was, and a bigger one, and a higher temperature one. The transformer to drive the electronics was just marginal. I found one for him that was bigger, so that it was not a problem. As soon as they came over we retrofitted all of them. We wrote to Barber-Coleman and said, "Look, why don't you make this change so we don't have to do it?" About ten years later they sent us a message back, "Guess what? We decided to incorporate these changes." [laughter] I learned at Western Electric that when you specify components, electrical components, you really have to know what you're doing. You can't believe what the manufacturer tells you when he puts a rating on a component, because he means that as a middle ground of where it ought to be. [laughter] If you're really serious, you have to really measure it right. In order for a piece of equipment to get qualified at Western Electric you had to give a KS number, which was a Kearney Spec. Once you got blessed with that number then you could supply that.

[END OF AUDIO, FILE 2]

BROCK: I wanted to talk about the general atmosphere of the laboratory. Was it a fast-moving place? Did everybody feel that time was of the essence?

[END OF AUDIO, FILE 3]

BLANK: Well, I think that the thing that precipitated the departure was the fact that after Shockley got the Nobel Prize he began to do a lot of traveling to different labs. Every time he came back he got the lab together and gave us a lecture, and embarked us on a new set of programs. It was interesting for a while but it came to a point where some of the things that we were really interested in dealing with we were never able to finish. We felt they were important, and then it was shunted off to try something else, which we didn't know how important they were. He went on a kick one time where he wanted to do zone refining. Well, you're not going to do zone refining on silicon so easily. This was a massive program and we couldn't do it like germanium. Some time was wasted on dealing with that when that time should have been spent on resolving important issues like diffusion, for example, making contacts and things like that. He had this fixation with this four-layer diode, which had nothing to do with chemistry but it was really a cross point. It was the cross point of a crossbar switch. I told him, "Really it's an interesting problem but that's not the problem. I don't care how little you make it I still have this massive wiring effort to go ahead and wire the switches, and then wire the frames together, and then wire the offices together one way or another. So, you can make these as small as you want but, that's not the problem. That's not the real problem." I had been working with Western Electric on a program to deal with printed wiring.

BROCK: What is printed wiring?

BLANK: It was the beginning of the printed circuit and there was a program going on where they were actually going to print resistors and capacitors and some kind of inductors. The chemical guys wouldn't know that kind of stuff. But there was some effort going on along those lines, to make sure that the interconnections were consistent, instead of having them to be done by hand every time.

BROCK: Okay.

BLANK: Because, I understood completely the tyranny of the interconnect. [laughter] That was my whole job, interconnecting. [laughter] How do you connect all this and test it?

BROCK: Right. [laughter]

BLANK: But my voice didn't matter. I'm not a physicist, so who was I going to argue against it? Besides, I felt also that maybe if I solved that and learned how to make it maybe it would help make something else that's more useful.

BROCK: But you weren't too enthusiastic about the four-layer diode just from a marketing, systems—

BLANK: Just from a practical point of view as to what are you going to, now what?

BROCK: Right.

BLANK: Now you still have to connect it. I could understand if we were talking about replacing a big and heavy hot vacuum tube with a little bitsy thing in here—that's another story. We could eliminate that much heat. As a thermodynamics freak, I could understand the value of that. [laughter] I think there was too much dabbling in making things too quickly.

BROCK: That urgency and focus was something that brought the eight of you together?

BLANK: We couldn't finish what we wanted to do. That's what led to it.

BROCK: I want to run through a list of names of some of your coworkers from this time, and ask you to reflect on them as people and what they did at Shockley. We didn't really talk too much about Sheldon Roberts, the metallurgist of the group?

BLANK: I didn't have too much to do with him, but he was working on contacts and evaporation.

BROCK: Okay.

BLANK: Later on I guess he got involved with crystal growing.

BROCK: When you moved to Fairchild?

BLANK: Yes.

BROCK: What about Gordon Moore?

BLANK: Gordon was involved in the chemical processing and in the gas handling, the bubblers, and the funny little things that you see in a chemical—

BROCK: What about Gordon as a person? Does anything stand out in your mind from those days that typified him as a scientist?

BLANK: No, he was just one of the guys that we used to go to lunch with periodically. We were always having the same problem with young families and trying to get by with a seemingly unstable situation.

BROCK: How about Robert Noyce?

BLANK: I also worked with him. He had the most semiconductor experience of anybody, from a nuts and bolts point of view. He was always hanging around trying to get things made and he was always amazed at how quickly we could make them for him.

BROCK: In terms of equipment or whatever he'd need for the—

BLANK: Anything he needed. I told him our purpose was to go ahead and make life easier for them so they didn't have to waste their time on things that didn't require Ph.D.s that could easily be done by people who were specialists. I remember he used to come all the time and we talked and sat in the cafeteria and he drew something on the back of a napkin and said, "If I could get something like this I could start working on this thing," and then a few hours later I said, "Is this what you were talking about?" He said, "Almost." We'd go back and make it. He said, "You know, at Philco [Philco Corporation] a thing like this used to take six months." I said, "Well that's the way—we have to put a stop to that to make sure that you have it, so that you're not wasting a lot of time, because time is of the essence."

BROCK: Did he share your appreciation of the need for speed and urgency?

BLANK: He was amazed that things could actually get done that fast. [laughter] Most of these lab things happened at a very leisurely pace. This was probably a shock to most people, that you could actually move a lot faster than that. We got to like speed after a while. [laughter] Speed became addictive.

BROCK: How about Vic Grinich?

BLANK: I liked Vic. We had fun together. We were always dealing with electrical equipment and I remember we used to have to go through the same nonsense on the electronics. They were always the same thing. Most of these guys didn't know how to design electrical equipment, or if they did they forgot about it. They never picked the right components. They never made them strong enough or they didn't make them with enough capacity. They were always trying to downgrade them to save a few nickels and it winded up costing them fortunes later on. We looked at it and saw if there was anything obvious that needed to be changed. The thing became acute because in a situation when we were dealing with processes like diffusion which take eight, ten, twelve, sixteen hours, with controlled temperatures and controlled atmospheres, we didn't want to have to deal with flaky things that could ruin all eighteen hours worth of effort. It made it important to make sure that it was rock solid.

BROCK: In essence you were checking on the designs of the off-the-shelf equipment that you guys purchased?

BLANK: By necessity. This is not something that we liked to do, but we had to deal with it.

BROCK: Next on my list was Jay Last.

BLANK: Jay Last was the optical guy in the crowd and we used to make stuff for him too. The first mask that we made, he wanted to put dots on silicon. He said, "How small could you make a hole in a mask for me?" I said, "Well, the best thing we could do, I think we can, the smallest drill I know is two mils, maybe one mil if I'm lucky but I don't know how long they're going to last." We found some very small drills and we actually made, not easily but with great difficulty, we perforated a bunch of holes in them and he used them to make his—to get these black dots in there so that they could use wax as photoresist. Well, not as photo, but as resists. Eventually we found some place that could etch them, because I knew you could silkscreen these things and etch them. But we didn't have the equipment at our facility so we went and found other people to do that.

BROCK: To etch the masks?

BLANK: To etch. To make the masks for us.

BROCK: Okay. What about Jean Hoerni?

BLANK: Jean Hoerni was mostly sitting making mathematical calculations. He was a very quiet guy, and that data that he reduced is still used to this day.

BROCK: On the diffusion?

BLANK: On the diffusion. We'd take a few—to get one point on a curve we had to diffuse a piece of silicon with a specific resistivity and a temperature for so many hours, and we lapped it and measured it, and this was one point at this temperature, and then we got to do it for another temperature. We built a matrix like that. We didn't want to do this forever. So, we took a couple of points and we made a mathematical curve to fit that. That's what he was doing, making tables of diffusion constants. The whole thing—taking probes down, actually measuring resistivities at different depths. It was mind boggling, but that's what we had to do.

BROCK: It was a huge experimental effort, to come up with those?

BLANK: Yeah. And it was grunt work really. It was something that had to be done, by people who were careful. They turned it over to technicians, but he actually did the mathematical curve for them.

BROCK: What about Tom [C.T.] Sah?

BLANK: I didn't have much to do with him. He was just a quiet physicist that worked by himself. I guess he worked with Noyce on some projects and everybody was milling around. If they needed something done they would see me or Gene—it was kind of an open environment.

BROCK: Harry Sello?

BLANK: Harry Sello came later.

BROCK: Okay. Right, almost right before you left?

BLANK: Very shortly before we left, so I didn't get to know him very well.

BROCK: What about Dave Allison?

BLANK: Dave Allison was hired about the same time I showed up. A few months later he showed up from—he was working at IT&T I believe. He was a neighbor of mine in Palo Alto. He lived up the street. We weren't close friends. He was a quiet, reserved guy that was doing his work quietly.

BROCK: The last name I had was Sam Fok.

BLANK: Sam worked at Shockley. In fact, he sat right next to me for a long time. He was working on—I can't remember. He may have been working with Jay Last.

BROCK: I'm not sure.

BLANK: I'm not sure either, because I know later on at Fairchild he was working on the special aligning equipment and the photo cameras and things like that. But he came later at Shockley. They had no place for him so they stuck him next to Gene and myself.

BROCK: Let's talk about your interactions with William Shockley over the period that you were there. Did you deal with him often?

BLANK: No, only once in a while. He called me in his office one time and said, "I want you to do me a favor. We have to give these tests to everybody that shows up, and it is very expensive so we'll reserve that for the senior people, but we want to do the same kind of testing at the other levels like technicians and office help." He said, "We located a service right here in Palo Alto that does it, and I really want to hire them. I want to make sure I get some kind of a correlation between what they do and what the other firm does. What I'd like you to do is I want you to go down and take all their tests, to qualify them because you have the broadest experience. You've worked in offices and factories and the results that we would get from you would be more correlated with what we would expect."

[END OF AUDIO, FILE 4]

BROCK: Shockley said, "Go down and take the tests?"

BLANK: He said, "Go down and take them all because if they correlate with what your test results were, we have a better chance." I said, "Okay. I'll do that." I was there for almost every day in the week. Some of these tests would go on all day, four hours in the morning and two or three in the afternoon. Towards the end of the week I was cross-eyed. I couldn't believe it. Finally they were just half days so at the end of it I finally got through it. He called me because he wanted to thank me profusely, the correlation was very good. He said, "There's no point in having someone else come down that never worked in a factory. For them to take the test it wouldn't be meaningful." He said since I worked in factories before and in offices, my experience would work all around. I said, Okay. [laughter]

He interrogated me at some length about switching equipment—the crossbar switches. What I explained to him was that the problem was really pulling all this stuff together by making sure that it worked. He didn't understand too much about telephone equipment, which was odd. The first two years that we were at Western they gave you a tour, like an indoctrinization program. We spent a few days at Bell Labs and a few days at Long Lines in Lower Manhattan and at AT&T [AT&T Corporation] and in different parts of the system to get to know all about it. We learned some of the basic elements of that system. They had to build equipment in those days for a forty-year life because it had to interact with so many other systems that in some cases you cannot justify upgrading it because the activity is too low. We had to keep the old stuff working but we still had to be able to interconnect it with new stuff. It was an issue that most people don't have a clue of. Not only that, even if we designed the greatest whiz-bang, we couldn't make it all happen instantly. It's going to take ten or fifteen years to go through the whole thing, by which time we got to start something all over again, maybe. In the meantime we had to pick spots, what to do first. In some areas like some sparsely-populated areas that were never going to get any more than a plug board, they were not going to justify an automatic piece of equipment, because it would take forever to just to pay for the installation. [laughter] That's why they had that restriction, which was something that most people have no clue about.

BROCK: Did the Bell Labs technical staff have to do a similar sort of orientation or not?

BLANK: I don't believe so. We had to learn about patents. We had many hours of discussions with the AT&T patent people especially about the antitrust case that had been going on. Euphemistically known as a "divorce case." [laughter] We had to learn the difference between transmission and switching, components and apparatus. It was mind boggling. They used to send their people to MBA school from time to time.

They had two levels, a promising engineer or a first-line supervisor was selected as having potential. They would send him to an internal school known as "charm school," which was a Western Electric–AT&T series of programs where the courses were given internally by professors from Columbia, or Harvard, or wherever. If someone passed that and was considered a really good candidate for higher work, they would send them to Harvard to get an MBA after they had their charm school, plus ten or fifteen years in the business as an engineer. This was a different type of student than a kid that got a BA in business then went right through a Harvard MBA. This was a whole different animal. After that much experience they really understood the difference between what's fantasy and reality. [laughter]

BROCK: Let's talk a little bit about the beginning of this dissident group, the eight of you at Shockley Semiconductor and how that unfolded and why you were coming together.

BLANK: It just evolved to a point where the senior people, Noyce and Moore, and the physics crowd were becoming—they had a problem with being shunted from one project to another. Gene and I had no problem of being able to jockey back and forth, because one piece of equipment is like another. It doesn't matter. But I could sense their frustration of not being able to follow through on a project, of switching before they got something resolved that said either we should forget about it, continue it, or go a different direction. It just happened that when we started private discussions among us in small clumps, the clumps coalesced around the eight of us, at which time I think Gordon was assigned the task of making contact with Arnold Beckman, because Gordon came from Caltech [California Institute of Technology]. He had the closest connection. So, that was how that developed.

BROCK: In your discussions with the other folks, did your concerns become more pronounced, from what you were hearing from them?

BLANK: From my point of view, if they were going to disappear then we didn't have a job. If they were going to leave, then this thing wasn't going to happen. It became important to collectively stay together and finish what we started out to do, one way or another, if at all possible. Then we started these series of discussions with Arnold Beckman, a few dinner meetings. He came up here several times and he agreed and then reneged.

BROCK: That strikes me as a pretty bold maneuver for the group of you to call Beckman up?

BLANK: It was.

BROCK: Did you have a conversation together beforehand about doing that?

BLANK: Oh yeah, we already decided.

BROCK: Tell me a little bit about that?

BLANK: It's been so long, I've forgotten how it happened. It just happened that we decided, "Well, we have to give it a shot. Since Shockley is not around the lab anyway, maybe Beckman can see that Shockley's not a really good manager and maybe he ought to continue his voyages around and let us—let the lab stabilize.

BROCK: That was because Shockley traveled so much?

BLANK: We thought he could continue traveling and then have him as a consultant but not continue as the moving force behind it.

BROCK: Okay.

BLANK: Well, this was not to gain—there was nothing punitive or negative about it. We just wanted the lab to succeed. That's the way we looked at it. That's the way it was presented to Beckman. He understood that, because he knew that Shockley was not a good manager particularly. He knew that going in.

BROCK: He did?

BLANK: Yeah. He said so.

BROCK: From what he had heard from Bell Labs?

BLANK: And from what he had observed. He was certainly a good recruiter.

BROCK: A great eye for talent. What was Arnold Beckman's initial reaction? He came up after some phone calls?

BLANK: Well, the upshot of the discussion was that he decided that he would find a way to get Shockley a chair at Stanford or something like that, and get a manager in from, I think, there was a fellow by the name of Joseph Lewis that he proposed, and eventually he suggested Maurice Hannifin from the Spinco Division. A nice fellow who became the interim head of the lab. But then at the last minute he changed. He reneged on this whole deal.

BROCK: And Beckman gave no signs to the group of you that he was changing his mind?

BLANK: No, not until the last minute.

BROCK: In a public way? At a meeting between everybody with Beckman there and Shockley?

BLANK: No, Beckman was there but Shockley wasn't.

BROCK: Okay.

BLANK: When he did that it took the wind out of everybody's sails and then he did in fact move Maurice Hannifin in and Noyce took on the job of being the technical head of the lab while Shockley was moved to Stanford. I don't remember exactly how that happened but Shockley didn't show up very much after that. It was Maurice Hannifin who was there day to day. It became very strained after a while. That's why we considered getting together and finding a different way to deal with this, since we had burned our bridges behind us. It was almost untenable.

BROCK: Did Beckman give you any explanations for why he switched his mind?

BLANK: No. None that I remember.

BROCK: And then did—

BLANK: We knew what happened later. We found out that he got a call from Jack Morton who was the head of Bell Labs at the time, who got wind of it, and told him, "You can't do this."

BROCK: "You can't do that to Shockley?"

BLANK: Right.

BROCK: Just because of Shockley's stature? Or why would they care?

BLANK: I don't know. My own personal feeling is it was probably what was known as the "Bell Labs mafia." Arnold came from Bell, Shockley came from Bell. It's like a club.

BROCK: I can see that.

BLANK: I could understand that. But, in retrospect, he was really cutting his nose off.

BROCK: Because Beckman told Shockley about the whole thing, is that right?

BLANK: He had to.

BROCK: Right. I can understand why things would be tense with Shockley afterward.

BLANK: That's why he wasn't there very much.

BROCK: At what point did you all decide that you needed to resign?

BLANK: We first decided we were going to see if we could do something together. We began this contact with Hayden & Stone [Hayden & Stone Incorporated]. Gene Kleiner wrote a letter to one of the guys at Hayden & Stone who his father knew very well, who then passed it along to Bud Coyle who was the manager of that office at the time. They looked at it and they decided to go ahead and come out and visit the group. There were going to be seven of us because Noyce hadn't made up his mind. We invited him to come along with us to join.

BROCK: Was Noyce involved in the discussions with Beckman?

BLANK: Oh yeah. Sure. But he said he made a commitment to Beckman that he would remain as technical head of the lab for some period of time. When we went up to the city to see Bud Coyle, the first time that I knew that he was going to come was when he showed up in the car.

I didn't even know he was going to go. I knew they invited him and I think it was Sheldon Roberts' station wagon and he was sitting in the back seat. I said, "Oh, I see Bob Noyce. I'm glad to see that you're here." He said, "I'm glad to be here." [laughter] Noyce was always showing up late for some reason. [laughter] Well, he showed up anyway, and—

BROCK: Was it after they had made the connection to Sherman Fairchild that you guys decided?

BLANK: We had another visitation from Fairchild when Dick Hodgson came out here. He had the task of evaluating this. He said he was going to recommend it and shortly after that we executed these papers and we simultaneously handed in our resignation.

BROCK: How long did that whole process take, between meeting with Arnold Beckman to—

BLANK: I'm guessing from March through September.

BROCK: It happened fairly rapidly when this thing unfolded? Did you have a final meeting with Shockley?

BLANK: No.

BROCK: Did you see him again after that, in later years?

BLANK: The next time I actually saw him was when that book came out that Carolyn Caddes [*Portrait of Success: Impressions of Silicon Valley Pioneers*] made.

BROCK: I don't know it.

BLANK: She made a book of all the people in Silicon Valley, and she had his picture in there and she had a book signing at somebody's house. I think it was her house in Atherton [California] and he was there. I think that was the first time I'd seen him in years. It was in 1984, something like that. He actually signed his name. I asked him to autograph his picture, which he did. I was standing with Andy [Andrew S.] Grove. I said, "Andy, did you ever meet Shockley?" He said, "No I haven't." So, I said, "Come on over. I'll introduce you."   The first time he'd ever met him. [laughter]

BROCK: Let's talk for a little bit about the early days of Fairchild. We talked a little bit about the electricity and the air conditioning being your initial responsibilities there.

BLANK: I had the whole building responsibility.

BROCK: Okay. And I understand when you first—

BLANK: It was a shell. Initially they wanted to give us power from a little transformer mounted on a pole in front. I said, "Come on!" We actually bought a twenty-five kilowatt RF generator just to get going for crystal growing. I said, "That's not going to last. We're going to get a bunch of furnaces. That transformer isn't going to last." I got them to put in a big transformer pad in the back, which was a problem because we were dealing with the City of Palo Alto not with PG&E [Pacific Gas and Electric Company], which is the power company. It's a city-owned utility.

BROCK: Oh, I see.

BLANK: They had to push this pipe underneath the building to get out in the back. It was a zoo of the highest order. [laughter] We got it done and we piped the place for gases, and whatever we could deal with, and had the place air conditioned with units mounted on the roof. It wasn't really a first-class environment. There wasn't enough room for anything more elaborate. All of the drains came into a neutralization tank, neutralized with sodium hydroxide, which was appropriate. I remember having discussions with the guy that ran the sewage disposal plant nearby. I would call him up and I said, "Hey, are we doing anything that's going to cause you a problem?" I told him what we were doing. He came around, and he said, "No. As long as you put plenty of water down there to dilute it as required it's not going to bother me.

There were only certain things that were going to foul up his digesters in there, and you're not doing any of that stuff." He used to come around, at my invitation, "Tell us what we're doing wrong and we'll fix it."

The power was another problem. We had these crystal growers working and the diffusion furnaces working and all of a sudden around five or six o'clock in the evening there'd be an "Rrrrrr"—everything would go down and then back up again. I couldn't figure it out. Finally, I went to PG&E because the Palo Alto people were not helpful. They said, "Oh, Ames Laboratory across the street in Mountain View has a wind tunnel which they generally turn on in the evening because that's when demand is low and they have enough juice." [laughter] This was a 60,000 horsepower fan. [laughter] I said, "Now you're telling me this." I decided, "Well, we're not going to do anything until after they turn it on." We had to call them and find out when they were scheduled to operate so we would work around it. [laughter]

BROCK: That's amazing.

BLANK: Dealing with DI water was always a nasty problem. We used to buy a tank car load of distilled water from a company and then run it through the lab and polish it.

BROCK: And they would deliver that on a—

BLANK: On a tank truck, and put it in a polyethylene tank that we had built, and draw down that and then come back every once in a while and top it off. All the drains were above ground because I didn't want to bury anything.

BROCK: Why not?

BLANK: First of all, drains will leak. If they leaked I wanted to see where they leaked so we could fix them. Secondly, since we didn't know what we were going to do from one week to the next, we had to be able to tap into them at various places. I didn't want to have to dig up the lab to go ahead and find it, and add another outlet, or another fitting.

BROCK: Oh, I see.

BLANK: Because we were always expanding and changing. If they were accessible we had the chance to deal with it. This was not rocket science. All the pipes were exposed. We could see what we were doing and get at them.

BROCK: Was that infrastructure and facilities your major push in the early days?

BLANK: One of them. I still had the equipment to build. I became what we called Engineering Services. Mechanical design, equipment, that kind of thing. Gene was more or less handling personnel and manufacturing, beginning to deal with that. We would still help each other out, but that's the way it evolved.

BROCK: On the equipment side of things was it very much still like the situation you faced at Shockley Semiconductor in that you're going to build your own crystal growers and you're going to build your own furnaces?

BLANK: No. Except where we couldn't get it built by the outside. Wherever someone else could build it, sure we'll go the either way.

BROCK: What things did you end up buying and which things did you end up building?

BLANK: The assembly equipment we built for a long time and eventually when it got to be automatic we bought it. You know the automatic stichers, we didn't bother with that. We didn't have enough—couldn't justify handling the talent for it. Exposure equipment, masking equipment. When they became available we bought it. Furnaces eventually became available. Evaporators. Little by little, wherever it made sense. But, some equipment, until I left, we were building our own.

BROCK: Would that be things like the growers?

BLANK: The growers they kept building for a long time and eventually they ran out of capacity. I had built them big enough so they could take two upgrades, but then they physically ran out of room.

BROCK: Oh, I see. In terms of the diameter of the crystals?

BLANK: Sort of the size of the crucible. I think we finally got up to fifteen kilograms and that was as much as we could handle. We couldn't get any bigger than that. Power was no problem because we just built a bigger helix. There was enough power in there for all of that. But they ran out of physical room. Then they bought some from the outside. That was after I left that particular part of it. Then they told me they had more trouble with the store-bought one. They looked prettier but they were breaking down. They had more time offline than online. [laughter] The ones that we built would last, they'd just run and run. They got rid of them because they ran out of capacity.

BROCK: Did you work with Sheldon Roberts? He took over responsibility for the crystal growing operation?

BLANK: For a while and then he moved on. He didn't stay there very long either. He and Jay Last left after a couple of years.

BROCK: In 1961 I think?

BLANK: Yeah, in 1961.

BROCK: You essentially transferred the design that you had begun—in terms of the resistance heating crystal grower—Shockley Semiconductor?

BLANK: No, I don't think we actually built one at Shockley.

BROCK: But you had started to plan?

BLANK: We built the prototype.

BROCK: Okay. You prototyped it and then—

BLANK: We actually built one there, of a whole different design. Nothing like the original one.

BROCK: So you had this facilities and equipment role and responsibility. How did that change over time?

BLANK: Kleiner was assigned to work at R&D, when they built the new R&D plant. He left and I got assigned to take over his job at R&D and also to handle all the facilities for the whole company in addition.

BROCK: When did this happen?

BLANK: About when he left. It was about 1961 or 1962.

BROCK: I didn't realize Kleiner left that early.

BLANK: Yeah. He left just after the—

BROCK: The Amelco [Amelco Corporation] group?

BLANK: Just after they left, I got another job. They asked me to transfer a division from another Fairchild division that was in Southern California up to here. This was their Transducer Division. They were making solid-state strain-gauge transducers. We made the chip for them and they had put this die on a Kovar beam and that was part of a piezo resistive element. You deflect the beam and it changes the resistance and that tells you how much pressure there is. That decision wasn't working very well. They were having a lot of trouble with it losing money. The powers that be decided they wanted to move it close to the source of silicon. They didn't have anybody else in mind so they called me one day and they said, "Well, how would you like to?" I said, "Are you asking me or are you telling me?" [laughter]

I went down there to look at it and it was a total zoo when we finally moved it up here. And it—they had a big program with Gemini. They were building these pressure transducers that were measuring the pressure in the—I can't remember if it was N_2O_4, or if it was nitrogen tetra-oxide or hydrazine. One or maybe both. They were having a lot of trouble getting them qualified because they had to pass a very strict environmental test. A vibration test, which is unreal, like $8G^2$ RMS, if that means anything to you. If you've every seen a shake table like that at that level it's mind boggling. I finally moved it up here with great pain. I took a look at this product and I said, "You know, this is not going to fly," because the thing was made rather flimsily. It was not really done right. Besides that they put so much effort into trying to save weight that they made the nozzle that attached so flimsy it would deflect when you torqued it into the machine. I got the customer to go ahead to invite us to redesign it to make it work, at his expense. The guy that ran it before said, "You can't do that." I said, "Just watch, because it's not going to fly like this." I redesigned the nozzle—simple mechanical engineering. I knew what the problem was. I got another guy, one of the fellows from the other Fairchild labs to redesign the circuit board to be more stable. After we got it to fly, they were passing with flying colors. They never really made money on it but they got back most of what they lost. [laughter] It was considered a great triumph.

BROCK: When was this happening?

BLANK: 1962 to 1964. Somewhere in there. In the meantime I got a call one time from Noyce. He said, “Why don’t you go to Hong Kong, because we want to do assembly work over there. See if it makes sense.” Charlie Sporck and I got on a plane and we went to Hong Kong. We checked the place out and from that we built this big factory in Hong Kong and helped them out with designing that facility.

BROCK: As you were doing this?

BLANK: Yeah. Eventually I transferred that facility back to the division somewhere else. I got to do all the facilities because at that time we were building plants and all over the world. We wound up doing it in Hong Kong, Korea, Australia, and then with our SGS facility I used to go to Europe because they were building in England, France, Sweden, and in Germany, not to mention a big expansion in Italy.

BROCK: What about the fabrication? What sort of expansion was going on through 1965 in terms of domestic Fairchild Semiconductor?

BLANK: In addition to R&D over here? We added a couple of buildings in Mountain View. We actually built a big plating shop in Mountain View to plate the headers and the frames for the integrated circuits. That place is still going, by the way. I just drove by there a couple of weeks ago and it’s still there. It was state of the art at that time, and everything was done correctly.

BROCK: That’s still a plating shop?

BLANK: That’s still a plating shop but someone else owns it and they’re running it. The equipment was built according to the highest standards—this is going to work twenty-four hours a day seven days a week, forever.

BROCK: Was it in 1961, around there, that you came to have general responsibility for facilities?

BLANK: It was 1964, I think.

BROCK: Okay.

BLANK: It started and then I transferred the transducer thing back to the other division.

BROCK: Then that became the real focus?

BLANK: That became my role.

BROCK: What sorts of issues were you dealing with there in terms of facilities expansion? Location?

BLANK: Location. We had the issue that newer technologies required more capacity, better air treatment, water treatment, effluent disposal, that kind of thing. Most of it, the thing was evolving at a rapid pace. We needed flexibility worse than ever. As the geometries were getting tighter and tighter, vibration became more of an issue. We started building fabs with waffle slabs you could punch holes anyplace you wanted to get stuff in and out, up and down at anytime, anyplace you wanted. We had a grid that we could run power, or in addition signal from computers would just be coming online so we could run cabling from that and telephone lines and other wires, and God knows what else we needed at that time, throughout the lab, without major disruption anytime you wanted to make a change.

There was also the issue of switching the equipment. After a while it got to be such that capacity becomes a problem, the power distribution. We started to buy high voltage power and distribute it ourselves internally. Because there was so much of it and we had to build it in such a way that we could plug in a big transformer without shutting the whole plant down. That was the main issue. Just about the time that I left, the company was starting to deal with changing over from copper to stainless steel for gas lines.

BROCK: Okay. When did you leave?

BLANK: It was 1969.

BROCK: What led you to leave?

BLANK: Noyce and Moore had left and I had just recovered from a nasty bout of pneumonia. I decided I wanted to get out of the rat race and do something that was less physically demanding.

BROCK: Because you're traveling to all these sites, all over the world?

BLANK: I had enough of that.

BROCK: I would imagine that equipment relates very much to the facilities?

BLANK: Oh yeah.

BROCK: There must have been a lot in your work about deciding what equipment to use. With that first group of the original cofounders, who left in 1961, it seems by that time there was a hierarchy amongst this group of sort of equal cofounders. Certainly Noyce had a very prominent role. Was that ever an issue for you?

BLANK: No, not for me. Gordon was happily running the R&D lab, and Vic Grinich was co-manager with him for a while, then he moved to the main facility and became involved with analog circuits. He and [Robert J.] Widlar—I don't know if you know Widlar at all?

BROCK: I've heard the name.

BLANK: They were the ones that were really pushing the linear integrated circuit. Vic Grinich used to have a lot of trouble getting wafers from the Mountain View crowd. When he was there, he used to ask them—I was in R&D—"could you get some wafers from the R&D for me?" We smuggled some. It was a bootleg operation in the beginning until they finally decided to get serious about it.

BROCK: The linear integrated circuits? I didn't realize that he was so involved with that.

BLANK: Yes.

BROCK: Let's talk about your reactions to—in the earlier period at Fairchild—these two signature developments of the planar process, and the planar integrated circuit?

BLANK: When they filed the patent, we forgot about it for a while. We decided that it was the way to make these devices. I, from a device standpoint, didn't have much to contribute because that's the way it evolved. All we had to do was figure out how to make connections to it, but nothing worked. [laughter] I knew that the integrated circuit was a winner because from my own experience with interconnect I knew that this is what had to be done. I was gratified to see that. I knew that was the way. That, in my opinion, became the biggest cost-reduction case that we ever had: the integrated circuits. The fact that it kept shrinking, it could become more complex—I knew that it had to be winner.

Now, whether we could make it or not was another story. Our early ones were somewhat of a bear to make, until they finally figured out how they got epitaxial growth on there. When someone worked with double metals, two metal layers, multiple layers, I knew that that was in the same line with the issue of interconnect. They had the same tyranny of the interconnect.

BROCK: What was the position that Kleiner had had at the R&D facility that you stepped into?

BLANK: He was the mechanical engineer resident handling the equipment and facilities for the whole lab.

BROCK: Why did he leave?

BLANK: I don't know. I think he was disappointed because he really wanted the manufacturing job at Fairchild, and when it was apparent that wasn't going to pan out he decided to move. He never occupied that office. He left before. I had to occupy it.

BROCK: Did you have a whole group of people working with you and your own shop on the site?

BLANK: We had a whole resident machine shop downstairs.

BROCK: Okay.

BLANK: They did work at the main factory. They had their own shop and we had ours, and we would do work for each other sometimes. We bought a slightly better class of equipment than they had over there simply because some of these were getting into required movement or precision.

BROCK: But it was that same—

BLANK: Same sort of thing. Building jigs. Little gadgetry before we decided on the major change of making a piece of equipment. I think they did a lot of work on masking equipment, with all the exposure boxes, the big high-intensity light, using, in the early days, contact masks. Then they were looking at a stepper, and we built a one-to-one lens, laser-driven device which never really worked very well. This was a big huge block of granite that this thing was driven on. That was a long story. [laughter] That was a job that Sam Fok was working on. He showed me a one-to-one lens that he made. It was perfect for a two-inch lens and he was going to make an exposure device for that. Then it became apparent that other people were specializing on that and then they eventually lost interest and bought them from the outside.

BROCK: More and more optical groups were getting involved?

BLANK: Mostly spin-offs, people that had worked at Fairchild before. [laughter] The same way with the furnace people, they came from there too.

BROCK: Right. Was Art Lash one of them?

BLANK: Yeah. A lot of those fellows left.

BROCK: Was it from 1964 to 1969 that you took on the sort of worldwide—

BLANK: It started in 1962 but it didn't really take off until 1964.

BROCK: What were your feelings about the strategy—that quickly became emulated—in setting up the test and assembly operations in foreign countries?

BLANK: Labor availability and cost.

BROCK: Did you have any concerns about it or did you think it was a good strategy?

BLANK: The only thing that concerned me was the availability of infrastructure, like the availability of gases, water, chemicals, power, and the reliability for all of the above. If we didn't have a reliable source of water or power I didn't care what we were going to make, it was not going to fly. If we had enough labor but we didn't have enough power it didn't matter.

BROCK: Let's talk little bit about your thoughts while you were over at R&D about Gordon Moore at Fairchild and him running the R&D facility. How would you characterize his evolving role?

BLANK: We had a very open environment there, I must say.

BROCK: Can you say more about that?

BLANK: His office was always open and one time he and Grinich's offices were right next to each other. Mine was just around the corner from that. In fact, for a long time we shared the same secretary. It was not a formal place at all. It was a lot of fun. I used to complain to Gordon that the more people he hired the less work that's coming out of there. [laughter] It seemed to take a lot longer. But that was a complaint of mine anyway.

BROCK: About transferring things out of there to manufacturing?

BLANK: Yeah. They'd take a little longer or they weren't done well. Sometimes—this is not any reflection on anybody—but sometimes things were over-engineered. To learn the sweet spot of when it's right to do it requires skill luck and perseverance. There's no formula for that.

BROCK: How would you characterize Gordon as the man who was leading an organization and directing technological development?

BLANK: Gordon was a very easy guy to get along with except every once in a while he'd get his dander up. I could see the look on his face. It was just a very imperceptible wrinkle that showed that there was something he didn't like or didn't sit well with him. But normally he was a very easy guy to deal with.

BROCK: What did you do after you decided to leave Fairchild? Was it roughly nine years later when Xicor started? You got involved with that? What did you do in that period of time?

BLANK: I worked for a while with a company that was doing consulting and I was investing in a number of different companies.

BROCK: In the semiconductor area?

BLANK: Electronics. Not necessarily semiconductors. In those days some of the early computer peripherals were starting to come online. We dealt with some companies that were making some special time-measuring equipment, and then another one that was making power supplies for high-resolution CRTs and another one for electrostatic color copying machines. There were a number of others that—oh, another one we did with a company that was doing electronic computer control, rudimentary wheel balancing equipment.

BROCK: Oh, for automobiles?

BLANK: Yeah. Automobiles and trucks. Jack Gifford was involved in that one. Now he runs Maxxam, but in those days he was in sales and he was one of the guys that started AMD [Advanced Micro Devices]. Before that, he was involved and there were a few others that I can't think of off of the top of my head now. It was also semiconductor transducers—spin offs from the pressure transducer operation. There were a couple of those. Some of them got sold and made out, and some of them went and disappeared into the never-never land of failures. We had our share of ups and downs.

BROCK: What was the name of the organization that you were working with in this period?

BLANK: Ness Industries, for a while. Then I left there and I got involved as a director of a number of these companies. I sat on a number of different boards.

BROCK: Has Xicor been a big involvement of yours?

BLANK: Well, in the beginning, no.

BROCK: No?

BLANK: A little bit. I ran a small semiconductor company. I was CEO for about a year, until they got a permanent manager in there. After I left he took over. Eventually I think they got sold or sold out or something after that. I lost track of them.

BROCK: It has been a mix of consulting, investing, and serving on boards?

BLANK: Yeah, that's been the mix.

BROCK: Since that time?

BLANK: Lately I've gotten off boards since the Sarbanes-Oxley [Act] was instituted. It's become more of a nuisance than it's worth.

BROCK: With Xicor, were you involved in founding that company?

BLANK: Yeah. I was invited to become one of their early founders. They wanted to start in semiconductors in 1978, I told them, "You got to be crazy." [laughter] Eventually my objections were resolved and they started it. It was a big roller coaster for twenty years. We finally sold it two years ago. Sold it to Intersil.

BROCK: Which was Jean Hoerni's?

BLANK: That is the company that Hoerni began. [laughter] But now that's in name only.

BROCK: Okay.

BLANK: It was sold to GE, who sold it to Harris, who took it private and then an investing group got a hold of it and took it public again a few years ago.

BROCK: So it's—

BLANK: Spruced it up but the name is the same. Almost like an incestuous relationship. [laughter]

BROCK: Just one last thing. Give me some stories about Gordon Moore as a technologist, a business person, an individual—any other reflections you might have about him or his contribution.

BLANK: Well, at Fairchild when we first started we were trying to make up our minds whether we were going to make the first device a NPN or PNP. There was a big duel going on between Jean Hoerni, who was a devotee of PNP devices, and Gordon who was assigned the NPN device. For a while, although it should have worked out NPN hands down, it didn't. It didn't look so great in the beginning, because the equipment was so ratty and we really couldn't get good results. Eventually sanity won and we decided to go with our strength instead of our weakness. To this day we still don't know how to make a PNP device as well as we know how to make a NPN device. [laughter] That's mother nature having the last word. I remember we used to have barbecues at Gordon's ranch—or his father's place over on the coast.

BROCK: Pescadero?

BLANK: Pescadero. We had venison. [laughter] I miss those barbecues. They were very good. I remember he came to my house one time and he saw my library. I had a book in the library, a textbook that I kept. I don't know why. One of these little thin ones. The thin ones are always the nasty ones. This one was labeled *Steam Turbines*. He was surprised by that. Gordon was a great punster.

BROCK: I learned that at some of the device conferences he was in charge of limericks or something like that?

BLANK: Oh yeah. He was very good at that. One that I'll never forget, when he started Intel [Intel Corporation], I don't know whether I was with him when he told me this or with a group. In the beginning they were making semiconductor memories which didn't look all that hot in the early days. [laughter] At that time the big thing was core memory. He said that, "We've decided to be rotten to the core." I'll never forget that one. It was prime. [laughter]

BROCK: You were part of the initial group of investors in Intel with the other—

BLANK: We got a call from Noyce and he invited us all to participate, which we did.

[END OF AUDIO, FILE 5]

[END OF INTERVIEW]

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