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Vin Scheinman

An interview conducted by
Peter Asaro
with
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Q: Why don't you just tell us your name and where you were born and where you grew up?

Vic Scheinman: Okay. My name is Victor Scheinman. I was born in Augusta, Georgia, on December 28, 1942. My father was in the U.S. Army at the time, stationed there, and so that's what brought me to Georgia. But at a young age, when the war was over, World War II was over, and we moved to Brooklyn, New York. And I lived there in Brooklyn until I was about 12 years old. And I guess if you want to call it –

[TAPE CUTS OUT]

– I was interested in space and rockets and things like that, and science things, I loved it. And I would say my first contact with robots occurred when I went to see the movie "The Day the Earth Stood Still," as a kid maybe about eight years old or maybe nine years old. And I was terrified by the robot in that movie and had nightmares over it. In fact, one night I woke up and saw the robot standing in my room. I'm convinced it was there. So I hid under the covers after that for many weeks. And as part of that process, I remember my father encouraging me to maybe make a wooden version of the, what was it, Tobar or whatever his name was.

Q: Kind of as therapy?

Vic Scheinman: Yes, kind of therapy, right. My father was a doctor and so I did that. I remember it was all silver and it was made out of wood and about this high, and it had a little shield. He had this shield over his eyes and I had a little string I could pull in the back, and the shield would go up and down. And of course, I was always into trying to build spaceships and things in the backyard that we would climb into and things of that sort. I remember in fifth grade, I had a friend who liked trains a lot, model trains, he was into trains. And I remember talking with him one day and he says, "When I grow up, I want to go to MIT." And I said, "Well, what's MIT?" And he explained, he gave me the initials of Massachusetts Institute of Technology. Then he started to tell me a little bit about it, and the only reason he knew about it was his father had gone to Harvard and had mentioned MIT, and his father was a Harvard man. I had never heard of MIT at the time, but he did. And so, I said, "Well, I want to go there, too." So ever from the fifth grade on, I sort of dreamt about, "Well, that's where I want to go." I went to a private high school in New York. We moved to the Bronx. It was a small high school, and it had a science program, but not an intensive science program. It was more of a liberal arts school.

And in fact, I did go to MIT and I was the first student in this school ever to go to MIT, so it was sort of unique for them. And in fact, I don't think any other kids in the class went to what I would call an engineering science school. The first years were hard for me, the first year was just because I didn't have what I would call the AP courses that they have today. This was in 1959 when I went to high school. When I went to MIT, I was 16, I was young, too, when I started. But I liked the environment and I liked the science and I liked the labs and I liked just wandering around the campus and talking to people, researchers, faculty people. I felt very privileged that I could talk to professors as a young kid and they would talk to me. And in fact, the early professors, my first physics lectures were all taught by full professors, not grad students. And I still remember them being very influential and just how I thought.

Q: Did you know at that time you wanted to do robotics?

Vic Scheinman: No, no. And in fact, generally at MIT in those days, you spent the first two years taking general subjects, math and chemistry and physics. But I actually was more interested in aerospace at the time, and I actually went and became an aeronautics and astronautics major. And in fact, my Bachelor's degree is in aeronautics and astronautics, not in mechanical engineering. And I was in aero and astro, and that's really what I enjoyed. I had my first summer job, I had between my junior and senior year. I was just 18 at the time and I worked for Sikorsky Aircraft in Stanford, Connecticut on their helicopters. And it was a very nice, interesting job. More data processing and things of that sort, but I got in experience of being able to wander around the plants where they were building the helicopters and got to ride in. I wasn't allowed to fly in a helicopter, but I was allowed to get into the helicopters while they were doing ground taxi tests and things like that. So they would run me around on the field, and while we were getting ready to take off, you've got to get out. But it was a good experience, a great experience.

My senior year, I did a research project. We had to do Bachelor's thesis in those days. My senior year was my Bachelor's thesis, it was on hydrofoil boats, fully submerged hydrofoil boats, and I did tests in the towing tank at MIT, and also worked on control systems for controlling hydrofoils, and built an ultrasonic height sensor for looking at wave heights and allowed the foils to run at a fixed distance under the surface of the water. I had an interest in electronics at the time, too. I was a Ham radio operator. I got my Ham license in high school when I was about 13 and I had a little Ham radio station at home. I wasn't gung –ho Ham, but I did have this radio station, and so I knew about electronics, and got interested in control systems at the time. I was very much a hands –on guy, I was president of the model airplane club, if you want to know that. And in fact, it wasn't then just about building model airplanes, but we did do work on radio control and other control methods for model airplane. In the winter at MIT, you can't go outside, so we used to fly planes indoors in the armory there. And we even had worked on light controls where essentially you could flash a spotlight on the airplane, and then the photocell sensor would allow you to control the direction of the plane. Let's see, for my work on my ultrasonic sensor and the hydrofoil stuff, I was always interested in tinkering and building things at MIT. I was active in the hobby shop and learned how to use machine tools. I did win, it's called the Louie de Flores Award. It's for outstanding ingenuity or whatever, I can't remember what the title is. And the $500 was a very significant amount at that time. It was essentially a semester's tuition, and it was one of the larger undergraduate awards that you could win, and so I felt that was a nice going away present from MIT. I graduated in 1963 after four years.

I went to work for Boeing for a short term, for several months. And my faculty advisor at MIT actually guided me, his name was Holt Ashley. He was a professor of aeronautics and astronautics. He's not alive anymore, but he kept telling me, he said, "Vic," he says, "what do you want to do?" I said, "Well, I'm not sure what I want to do." He says, "You know what I want you to do? I want you to go work for Boeing for a while, and then go to Stanford." I said, "Well, why?" He said, "Just trust me, just do that." So what I did, I was young, I was only 20. I was very lucky that I was young enough. And we had the draft at that time, military service in the Vietnam War was building up at the time. And all of my friends knew that they either had to stay in school or work in the aerospace defense industry to keep out of the draft essentially. And we had a test, you took the Selective Service test in those days, and if you got above a certain grade, you got so many years of graduate school deferment. And I got high enough grades that I had the graduate school deferment, if I was in grad school. But what I did was I took a year off from my studies. I went to Boeing, my faculty advisor, Ashley, had gave me a good letter of recommendation, and I sent it to the right people. And when I arrived at Boeing, I mean I was this young kid. They put me in an area called "Mahogany Row," which is, in those days, they had bull pens where they had hundreds of engineers working in these big, open office areas. And around the edge were all the managers in their mahogany wood –paneled offices, and I was in the wood –paneled office area, looking out. And a couple of the people in the group there had added me to the Boeing employee chart, which is this sort of pyramid, and of course at the top was the president.

And I come in there and I look at me, where am me, I'm just this little name third from the top of Boeing. My boss reports directly to the president of Boeing. And he said to me, the first day, "Well, Vic, here's what we're going to do with you. Here's my card. You have a budget which pays you for whatever you want to do. Take this card with you and wander around anywhere in Boeing. I'll give you some people to talk to. And if you like what you see, go work with them." And I was not there permanently, I spent about four months just going from group to group, working on projects that were interesting to me. And it didn’t cost the groups anything, because I had my own funding. It was sort of like your own funding and you could just go around, and it was very interesting. I worked on them, let's see, I worked on a lunar gravity simulator, which is a giant elevator, and did some analysis and studies on that. And in fact, got familiar with programming analog computers, where the programs were essentially done by adding resisters and capacitors and things like that in chains essentially to process or to do computations, analog. I worked on missile –carrying submarines, aspects of that. Mostly these are sort of advanced proposals. The group that I was in at the time was advanced ballistic missile systems, and I worked on some rockets. But I learned a lot, and I sort of saw what the aerospace was like. And after that, I decided I wanted to take a trip.

So I took a trip, I took my backpack and I started out around the world, visiting MIT alumni in various countries. And my first country was, well, it wasn't MIT alumni, I ended up going down to Tahiti and New Zealand and Australia and Philippines and Thailand and Malaya. And I essentially spent most of the year doing that, visiting some alumni in various places, and seeing that they were doing in their countries, and getting appreciation for the breadth and width of engineering around the world. I was in India at the time and I got called up for my pre – induction. My draft status was 1A at the time, which meant that I was eligible for the draft, but I was too young. Unfortunately, they started lowering the draft age because they needed more recruits, and I was called up for my physical exam when I was in India, and I realized I'd better come back to the United States soon and go to grad school. So I was out a year. I had been previously admitted to Stanford, but I had asked for a deferment for a year. And they had said, "Well, we can't guarantee it, but chances are good you could come a year from now." And so what I did is I came back to Stanford and I started Stanford in the aeronautics and astronautics department. And rapidly realized that since they didn't have an undergraduate program at Stanford, they had only a graduate program at Stanford in aeronautics and astronautics, I had a lot of the coursework already. And I really was interested in taking more courses in the mechanical engineering department. And so what I did is I asked Stanford if I could switch departments. And mechanical engineering said yes, you can join in any department, so I did that, so I moved into mechanical engineering. But I took a lot of courses in aeronautics and astronautics, and my Master's degree is an ME Masters, but I had a lot of fluid mechanics. In fact, they took propulsion courses, I was really interested in rocket and electric and nuclear propulsion in those days. And so I did a lot of course work in the aeronautics and astronautics, but got credit in mechanical engineering.

I guess I missed a couple of summers, I had some summer job experience, I worked on the Apollo program, which was the moon mission. I spent two summers working on that, one when I was at Stanford. Again, so I was in aeronautics and astronautics, sort of in the summers, working on the Apollo program and building the Saturn rocket and also the lunar lander. One summer was in the theoretical aero thermal dynamics group, which was looking at the heat shield on the Apollo reentry module. And another one was in the Saturn rocket group, where I worked on turbo pumps for powering the rocket engines. Both were very interesting jobs, and again, I really got a sense of what the whole process is, not just the engineering, but the making of the system, in other words fabrication. And on lunch hours, I'd spend my time wandering through the factories, the manufacturing areas, and just talking with the people. But the trip around the world convinced me that I really should be more in mechanical engineering, where I could do projects where an individual could make more of a difference. I always felt in aerospace that you're one sort of small tooth in the giant gears of industry. And after I got my Master's at Stanford, I got my Master's in one year at Stanford, I stayed on and started working on the engineer's degree. I really wasn't focused on the PhD at the time. And the engineer's degree is sort of a post –Master's degree at Stanford. And I got a research assistantship, working in the artificial intelligence lab, the AI lab at Stanford. I worked with Bernie Roth, he was associated with the lab at the time in the group that was sort of looking at hands and arms for the computer. And my work started to be into robotics at Stanford.

Q: At that time, did they already have a mechanical arm and hand?

Vic Scheinman: Yeah, they had a mechanical arm, which they had bought, and in fact, some of the work that I did early on was maintaining that and keeping it running. It was called the Rancho arm, which they had obtained. It was a prosthetic arm that had been converted, from Rancho Los Amigos Hospital in Downey, California. And it was an electric arm, which was essentially made as a prosthetic arm for a person, originally controlled by tongue –operated switches, among other things. It didn't really have any computer interface. And essentially what we did was, when I got there, they had started work on getting it interfaced with the computer, and much of that work on that arm was done. But it was not an arm that was easily – <audio cuts out briefly> – it had all sorts of problems, it wasn't very accurate. You could move it around, but as far as doing tasks of manipulation, it was very difficult to use that, even with the computer. And there was some other issues that we learned very early on. We learned about the importance of simplifying the arm solution, the computations required to deal with this arm, which didn't have orthogonal axes and the kinematics configuration was not ideal for computer control, especially in those days when the math was not as well developed as now and the computation speed was slower. And so I was involved in working on some new robot designs. One was what's called the ORM project, which was like a little snake robot. I worked on it with another grad student, who was a little bit ahead of me, Larry Leifer, who's a professor at Stanford now. And this was a little snake –like arm. Essentially, the idea was that this was a digital arm to be controlled by a digital computer. And design involved a stack of plates, you can see that arm at the Computer History Museum in Mountain View, California, right here. I think it's on display now. I don't know if you guys have been there?

Q: I've seen the museum.

Vic Scheinman: Yeah, right. It's a stack, it's only a stack about that high. And essentially what it was is a pneumatic arm. It had a bunch of plates, and these plates were controlled by essentially inflatable actuators, which could either be inflated, call it a one, or deflated, a zero. And there were four actuators between each set of plates. So imagine a stack of plates, with four actuators between it. And so imagine a four –bit word positions, although there was some amount of overlap there. But you could have a four –bit word theoretically defining the positions of each plate. And this arm, the goal was originally to make a big stack and maybe have it do things, and being controlled directly by the computer, direct digital control. It carried a little light bulb at the end, that was the target, that was the end effector, if you want to call it that, and a camera could look at that. The programming of that and description of that is written up in Don Pieper's PhD thesis, Donald Pieper. These were still all in the 1960s we're talking. And we rapidly learned that there were some problems with dealing with this arm. First of all, it was one where the path control was very difficult because in going from one state to another, there's an indeterminance condition as the actuators inflating and deflating. It's sort of like in electronics, when you have a digital component, there's a data ready line usually, which essentially says "I've switched and now the data is valid." So there's an invalid state, and during the invalid state when it's switching from zero to one, the arm could flail around in random positions. Not only that, in binary words, the states of many of the bits have to change, to go from one number to the next increment. And of course, gray code coding is a way of coding words such that the state change is only one bit at a time. Unfortunately, in the real world, it's very hard to have what I would call a truly great coded arm, such that it has very discreet changes from one position to the next. And so we had problems in controlling the arm.

Then, we said, "Hey, computers are fast, let's build a fast arm." So I worked on what's called a hydraulic arm, there's a write –up on that, as well. And we spent a fair bit of time working on the hydraulic arm. The hydraulic arm is also at the Computer History Museum. That's not on display and they don’t really have much documentation on it. But I found it while rummaging through their inventory and it was sort of stuffed into a barrel, and it might still be there. I should get over there and give them more documentation on it. This was a high –powered arm that was supposed to be very fast. We spent a couple of years working on that, and it ran at the AI lab. It was so powerful and had so much power to it that it would shake the building when it ran. And we ended up having to actually build steel structures into the floor to hold the thing up, because it was originally built on the computer floor. The mainframes had special floors for them, where you could pump cold air around, underneath the floor and then into the machines, which are generating a lot of heat.

Any event, we used that, we learned a lot about that. It was a robot that ran in what's called space war mode, which is it needed real time computer control. And running it with a timeshare machine was very difficult, because a timeshare machine doesn’t necessarily give you guaranteed real time, except if it runs in what we call space war mode, which is where it's dedicated to you. And that's because the servos were all dual –loops and the servo mechanisms were closed within the computer. The PDP –10 at those days, early on we were using a PDP –6, and then we went to a DEC PDP –10. And it wasn't compatible with the computer environment, because it had hydraulic oil, it had leaks, and the floor got sticky. We had to keep it in a separate room to keep people away from it. It needed this real –time full –time control to run it, but there were a number of problems with it. But it was an arm that could be controlled. Then, I was asked to design an arm that really could be used by the computer, and I designed an electric arm. And essentially, I was given sort of carte blanche to do something, and this arm here, the Stanford arm was the sort of product. And I did that as my engineer's degree thesis, just the design of the arm. I didn’t build it at the time, or I started to sort of build parts of it, but it really wasn't building it. And of course, it had the orthogonal axes. I tried to incorporate various other features, which were interesting to me. I was a prismatic axis just so I could design that, and a <inaudible> joint degrees of freedom. It's a six –degree or freedom arm, with a one –degree of freedom proportional hand, so it's a seven –degree of freedom robot, all electric. And it had brakes on the joints, such that we could run it in space war mode, but then you could turn it off and then the arm would sort of sit in a static position until you've finished your computations for the next move, and then it would go on. Whereas the hydraulic arm, if you turned off the computer, it would collapse. This one didn’t. And it sort of became a sort of a workhorse.

I left Stanford at that time after my engineer's degree in 19, I don't know, '69, I think it was. I left Stanford and went to work at a company called Raychem in Menlo Park in automation engineering. And at that company, I chose that company, actually I committed myself originally to go work for IBM at their research centers in Los Gatos, California. And I said, "Well, look, I need several more months to finish my work at Sanford." When those few months were up, I called IBM and I said, "I'm ready to start." They said, "Well, we have a complication. The fellow you were going to be working for is on sabbatical for the year, and so we're going to have you work with another person directly." I talked to that other person and I wasn't as excited about what his group was working on. And this opportunity to work locally without having to move at Raychem came up, and so I went to work there. And our job was to essentially design automatic machinery that would use Raychem products, which were essentially shrink plastic products, like shrink tubing. You're familiar with shrink plastic tubing, you heat it up and it shrinks? Well, they had a lot of products that were based on that, and they were the developers of this shrink tubing. It's a radiation cross –linked plastic product. And our job was to develop machines that would use Raychem products, which we would give or sell to companies so that they could incorporate Raychem products in their finished assemblies. And I essentially, since I had an electronics background as well, I did a lot of the controls for these machines, as well as the mechanical engineering designs. And I got to work with some very experienced engineers, learned a lot, spent a year there. Stanford asked me to come back after a few months and said, "Hey, we want to build this Stanford arm." So I went back to Stanford and I started building that arm.

Q: Who contacted you about that?

Vic Scheinman: Who contacted me? Well, at Stanford, I would say I had always been in contact with people at Stanford. I worked with John McCarthy, of course, was running the AI lab at the time and I was very close to him. Who contacted me at that time directly, I would say Lester Earnest. And you might have met Les, I don't know. He was sort of like the administrative director of the AI lab. McCarthy was the faculty director and he was the sort of faculty head of it. Les was the administrative head, and I guess Les might've done that. I remember at the time sort of discussing, "Well, what's my title going to be," and a few other things. And I've kept close to him, he's retired now, of course he lives in Los Altos nearby. So I came to the AI lab and I started working I was called an employee of the AI lab. I also went back and started taking some courses on the side. At that time, I thought, "Well, maybe I should work on a doctorate." I wasn't that enthusiastic about it, but it seemed like a thing to do. And so, I started working on a PhD, in the sense of just taking some of the courses. And I built this arm, I also worked on other aspects at the AI lab. But the thing that happened is that, we got this arm working, the gold arm, the gold version of this, and then Stanford said, "Well, we need a second arm," so I built the blue arm. There was a third arm that was started, but never finished, a red arm, because we decided we don't really need three arms. Other people got interested in these robot arms, because papers were starting to come out based on projects which Richard Paul, Lou

Paul, have you talked to Lou Paul yet? Richard, you know the name? He lives in the Santa Cruz area, not far from here.

Q: He's in Fresno.

Vic Scheinman: He's in Fresno now, well, he was in Santa Cruz and now he's in Fresno. So you're going to see him there?

Q: Yeah, we've been talking to him.

Vic Scheinman: You have, okay.

Q: Just on email, yeah.

Vic Scheinman: Yeah, okay, all right. He insisted he's out of robotics, or at least maybe he's said that to you, right, okay. Anyhow, Lou wrote his book and sort of described the Stanford arm and the computations and the math and all of that. Other groups wanted that arm and so I made some kits. Again, I'm trying to remember now, I'm getting a little bit out of phase here maybe. But anyway, at some time around that time, I made an arm for SRI. SRI wanted an arm. This is the one for SRI. I didn't actually physically build this arm, I didn't have any way of building it outside of Stanford at the time. And so, SRI found a small company locally who had a machine shop and they built the arm physically. So I worked with them and gave them my drawings and all that, and they made the arm.

Q: Who at SRI wanted the arm?

Vic Scheinman: It was in Charlie Rosen's group. This was Charles Rosen, the AI lab and David Nitzen. Neither of them are alive now, but it was the AI lab there. And at the time, Charles Rosen was the director of that. Also, JPL wanted an arm and so I worked with them. Again, they built the robot, I did a lot of the drawings, they did some of their drawings to adapt it, and they mounted it on a mobile vehicle for a lunar rover simulator. And there were a few other people who wanted some arms, and I made some kits. Boston University, actually, I can't remember at the time, so there was a time there also. This was in the early '70s now, and in '70, '72, I think it was, Marvin Minsky at MIT said, "Hey, you know, we want an arm, too." And he had had some money to do his own robot from DARPA, DARPA had given him some money. So I went to MIT, essentially Stanford loaned me to MIT, but I worked at MIT for a few months in the summer. I think it was in the summer of 1972, something like that. And Marvin said, "What we want is we want an arm," and he had some specifications. It was sort of like a mini –robot. He said, "Make the smallest robot you think you can make that can do some of these tasks," and he had written up this proposal, a multi –page proposal, which he showed me. And I have it somewhere in my files, but I can't remember where, which described tasks like doing remote surgical procedures, where essentially you'd take this robot and you'd put it into some clinic thousands of miles away and maybe have a nurse or somebody like that with the robot and a surgeon hooked up in the Unites States could run this robot arm. And it would be able to do some simple procedures and other tasks of that sort. That was his idea.

And so, I sat down and I started designing another arm, and that was the little 260, well, it became the PUMA 260, but it was the one that you have on the dining room table there. The prototype actually was a little simpler. Well, that's the second batch. The first prototype, MIT got a couple of those. And I think I built three for MIT eventually. So I designed that arm at MIT, and essentially my whole process of design wasn't to design a part and build it. It was like I sat down and I spent several months designing every part of the robot, from beginning to end, all the calculations, all of the studies, all the detail drawings. And in those days, we didn't have CAD, so I had either a drafting table or I would work at my desk on vellum and do all the machine drawings. And I sort of decided that was the smallest arm I could build that was practical, or at least that I felt that I wanted to build at that time, and would fit this task. And that was the configuration that I chose. He wasn't specific about what it had to look like or anything. And it incorporated a number of features that I wanted to try out. It was sort of like it was an opportunity for me to experiment with what I could do. It had a shell structure, which was like most robots in those days had sort of like solid beams and things of this sort. This had a shell, which was a thin sheet metal structure, lightweight shell. It had a number of other features in it. Backlash was an issue, it had some interesting ways of controlling backlash and it had a lot of other features that I felt were new to me. And it gave me an opportunity to design gear trains and work with frameless motors. In other words, I wasn't buying motors off the shelf anymore. I was actually buying components of motors and designing the motors themselves.

Q: So what was the problem with backlash?

Vic Scheinman: Well, it affected the positioning accuracy and the repeatability of the robots. And it limited the ability to do fine motion tasks. And in addition, it wasn't just that, but that was the main reason for backlash control in gear trains. But I did want to have a six –degree of freedom arm and a proportional end effector, if you want to call it that, an end effector that wasn't just pneumatic open and close. Although, if you notice on these arms, there are some pneumatics here, because for industrial applications, people want sometimes pneumatics, although the original one had proportional end effector. The other feature of the arm, the original arm, was that I knew that it was going to be used in a setting where vision was going to be involved at the time. And vision in those days was more binary vision, and the feature extraction capabilities of vision were somewhat limited. So I wanted simple features to look at in the arm, so the vision system could actually look at the robot and determine its position and orientation by just looking at it, rather than having this very complicated thing with the wires and cables and things dangling all around. I wanted everything inside, so that in the case of having a camera, look at the end effector at the robot itself. It would have a simple image, which could be processed quickly.

In any event, I did that at MIT, I started designing that. I came back to Stanford, got cold, I said, "Hey, I want to go back to Stanford." So I came back to Stanford and continued to work at Stanford. MIT says, "Well, we want you to build these robots." And actually, while working at Stanford, I was able to build some of the robots on the side. And I actually realized that to build them for MIT, it wasn't practical to build them at Stanford, I had to do it on the outside. So I found some outside people to work on making parts, but I also bought a small machine shop. And I actually started a little office in Mountain View, California, and I called it Vicarm or Vicarm. I started saying Vicarm, but then people said, "Why say Vicarm?" We used to say Vicarm so that they wouldn't associate it directly with my name. But I had a little machine shop and we set up electronics, I had everything there. After a while, I hired Brian Carlisle to work for me, and Bruce Shimano, both of them. Bruce was working on his doctorate at the time. By then, I sort of kept putting off the PhD more and more and more, and then eventually never finished it. And I had actually given a couple of papers based on my PhD at that time, but never handed in the thesis. Bruce was working on his doctorate, and on the side in the evenings we would work on the software and the control. And are you going to talk to Bruce at all?

Q: We talked to him, yeah.

Vic Scheinman: You did talk to Bruce, okay, all right. Well, he might have stories about working on the floor at my house in Palo Alto, in the days of paper tape and all these other things. But Bruce developed most of the software, and Brian's job was to help to make the robots and get them delivered. And I guess in the case of Bruce, he had been working at the AI lab. In the case of Brian, he was one of Bernie Roth's students, and Brian had no real experience in robotics, prior to coming to work for me, and so I sort of started him out, I guess, on the right track, because he kept going. All right, so much for Brian and Bruce at that time, but they worked for me. And then, we sort of grew. I got in these orders to make robots this size arm and the Stanford arm and the MIT arm for various people, mostly research organizations, General Motors, National Bureau of Standards, AT&T, some universities. Naval Research Labs bought a little MIT arm. I had a little brochure, I don't know if you've seen that, somewhere I have the Vicarm literature, and it shows the arms and describes them.

Q: How much did they cost?

Vic Scheinman: Well, the very first arms that I sold, I started out at the very beginning just selling the robot with the software, and the customer had to supposedly had to build the computer interface, because it needed a mainframe computer. So I showed them how to do it with PDP –11 mainframe computers. And I think the very first one, it was $4000 for a little MIT arm, I had said something like that. But that rapidly went up, I started realizing what it really costs me to do these things. And once I had hired Brian and Bruce, and they were working full –time, Brian was full –time, I started realizing the costs involved and I had the little business there. It got to maybe 15,000 or something like that, I can't remember. I have the price list somewhere from years ago. And then I started offering the controller. When DEC came out with the LSI –11, which was essentially a PDP –11 minicomputer on a one –board on one or two boards, I started designing controllers that would have that all incorporated. So not only did it have the microprocessor, the processing capability on it, it had the software and everything, so I could deliver the whole software package.

And that's when we started developing VAL. It had, let's see what else, and of course, I got carried away and we started having not only that, the micro controller couldn't do the servos, it wasn't fast enough to do the servoing in real time on its own. And so, we actually made software servos and we used these little 6502, it was an 8 bit microprocessor, single chip microprocessor, that was used in the first Apple 2 computers, not in the Macs, but prior to that, and a few other things. It was made by this company called MOS technology back in the '70s, a one chip microprocessor. It was sort of like the Intel 8080 or Zilog Z80, but it was a 6502, and we used one processor to do the servoing for each joint. So the first arms in there, there was essentially eight microprocessors, one for each joint and one for the end effector, one for each of the six joints, one for the end effector, and then the LSI –11 for doing the trajectory and the path control and the arm solutions.

Vic Scheinman: Okay. So I started making some arms. I made some robots. We made a bunch of these – of those over there. By that time General Motors had been playing with my Stanford arm and there were various people there at GM. I don't know if you talked to – if you talked to Steve Holland at all. Has he come up? He's –

Q: He has come up.

Vic Scheinman: His name's came – come up.

Q: Uh huh.

Vic Scheinman: Steve Holland was maybe more recent. There are other people, Mitch Ward. There are a few others but I would say the closest person I've been to in more recent times – I don't know what's – Lothar Russell – Rossol. He was a name. GM had a – essentially a research group at GM research and they wanted to get into robotics too. Okay. Oh, I have to go back further. I forgot a big part of this whole thing. Can I jump back a few years?

Q: Of course.

Vic Scheinman: All right. I have to give – all right. In 1968 or something like that maybe or '67, '67, maybe '66, I can't remember, there were a couple of guys. One was named Joe Engelberger and another one was named George Devol. George was an older man to me in those days – I was in my twenties at the time – who had a company called the Devol Research

Company and he was interested in robots and robotics and so was – and he had funded this company called Unimation which he had been – he had a number of patents and things which he had licensed to a guy named Joe Engelberger who had this company called Unimation, and George came wandering around. He wanted to give some money to somebody at Stanford as a fellowship to work in robotics and Stanford picked me so I had a fellowship for a year at Stanford which funded me for a year during which time I got to travel with George and with Joe to Unimation in Connecticut and around the country looking at early robot installations in factories and finding out what was available. Okay. Unimation was – had some of their robots out which were these hydraulic arms. Okay. There were some other robots out there. The Unimation robot was actually sort of somewhat of a digital arm. It had a rotating memory in it; it had digital memory, didn't have semiconductor memory. It had actually a magnetic memory if you want to call it that. There was another arm called the Versatran by AMF Corporation and we saw a number of these in the factories and companies were using it and mostly in Detroit it was used, both of these arms for loading machines and unloading machines and material handling primarily. Also Unimation was starting to try and do some welding with it where they were lifting up heavy welding guns, spot welding guns. The –

<crew talk>

Vic Scheinman: The AMF Versatran was an electric arm and – but it had an analog programmer – controller, essentially a whole series of potentiometers which you would set each joint angle with a potentiometer and then a stepper which would just physically step from one set of pots to the next set of pots to the next set of pots to the next set of pots. And it could go through maybe a dozen positions and that was it, which was sufficient to load a machine or unload a machine, but it was a good experience for me to sort of see that. There were other pneumatic arms that would just load – move in and out or left and right and things of that sort. There were a few other arms. Okay. So there was that. There were – but I met Joe Engelberger at the time and I sort of saw the company, Unimation, in Connecticut and it was a good experience for me then and I sort of established sort of long –term contacts with those – with George and with Joe. I guess there's other things that I'm forgetting. Oh, I started Vicarm and then in the very early days of Vicarm – once I got my little microcontroller running on this LSI/11 I had this box. It's smaller than that. It's about a third the size of – that box is a bigger box 'cause it's running a bigger arm and it was a little more advanced; it had more features to it. I was able to take it places. I could take the whole arm with me, the whole robot, everywhere in an airplane, fly it with me, even carry it on board in those days 'cause the arm weighed 15 pounds, the controller and everything weighed maybe 25 pounds, and so for 40 pounds I could carry it with me and when I made a trip I'd take it with me.

I went to Engelberger and I showed him in Danbury, Connecticut. I plopped it down right on his desk. This was in the '70s, maybe a number of years later, but I had these names so I plopped it down on his desk and I programmed it up and had it running, doing real time straight-line motion and all these things that his – he could only dream about with his big robots. They couldn't do that. And I took it to other places. I plopped it down on the desk of the head of Digital Equipment Corporation, same thing, and brought all his engineers in to watch it – to look at it running, and I also went to the very first robot show I guess it was. I brought it there but I didn't have a booth and I guess people – I had talked to you about that. I was a little bit – I wasn't a mainstream guy. I had a full beard at the time and long hair and stuff like that and wandering around at GM in Detroit where everybody was very stuffy with their coats and ties was quite a shock to them. <laughs> And so I came to the robot show and I had my little robot with me, the very first one. There were only seven or eight exhibitors there. This was at University of Illinois in – I don't know when it was, early '70s.

Q: In Champaign or Chicago?

Vic Scheinman: Yeah. It was in – I think – no, it wasn't Champaign. It was in Chicago but –

Q: What year?

Vic Scheinman: I can't remember.

Q: <inaudible>

Vic Scheinman: Yeah. Right. Right. Right. Robots One I think it was called. Anyhow, and I had this robot and of course these – all the other companies had these big things they were showing and I had this little thing and I – they said, "Well, that's a toy. You can't show it here. You can't have it in here," so I took it out in the front steps and I had – got an extension cord and I was able to run the whole thing on extension cord and then people would come around. They were all crowding – all the young people would be crowding around and in fact the people who were researchers and science – engineers and programmers all came and were interested in it because they realized that it was one – it was sort of one that had this programmability that nothing else – not – the others didn't and it had the control and it had the real time processing. It wasn't just a step, step, step, step thing. It had a whole programming language, which was Bruce's – the VAL language. Joe Engelberger invited me to bring the robot in to his booth. It caused some controversy and I showed it in his booth but it sort of became – it got me into the show. People complained about it, saying, well, it wasn't part of it and all this, but anyhow it did that and it sort of was my first sort of experience at a robot show. In other years then I'd just buy a booth. I bought a booth later on, all of it sort of funded – just personally funded. In this case, I didn't have outside financing or anything like that. Okay. GM got a robot, a Stanford arm. They came to me and they said, "You know, Vic, we really want to – we have this idea for a – an automation system. We've seen the Vicarm, the little one that looks like these, and what we want is we think we could – we would like to have a bigger version of that which would work on our assembly lines and be sort of like a human replacement, human moves, human speech, human space but we're worried about your ability to make these arms, build them and deliver them to us. So maybe you want to talk to other people," and then they had some suggestions. Other people had talked to me about the same thing, "Hey, Vic, think about joining with somebody else who can build it."

Q: How many arms do you think you'd built at that point –?

Vic Scheinman: Ten or fifteen and it wasn't – I was building it for research groups. I wasn't trying to market to factory floor applications. That's what it was. I built six of the – I had the first prototypes of those Vicarms at six. I built six of those and I had maybe four or five or – I don't know – something like that of these things here. It was a small operation at the time and so I made a deal with the help of Charlie Rosen at SRI, said, "Hey, talk to Joe Engelberger at Unimation," and I did. I talked to Joe and we talked to GM and Joe of course knew people at GM and they had a working relationship because they were selling robots there, and I made a deal with Joe Engelberger at Unimation where essentially became the West Coast division of Unimation. I sold out to him. I had a royalty arrangement with him on the technology and I also said, "Well, I still want to work on my doctorate at Stanford," and so I had some arrangement on doing that although unfortunately I spent so much time at Unimation working on the West Coast division. I grew it and so Bruce and Brian – Bruce was finishing his doctorate so he came on full time then. Brian was already full time with me and he moved over with me to Unimation. We essentially just changed the name on the door one day but eventually within a few months we moved to a bigger facility and started designing the – I started designing the bigger version of the two – of the robot for General Motors and that was our focus for a couple years to design and build that and a controller and prove things and upgrade it all. And so in Mountain View we had the West Coast division Unimation and we built the prototypes there. We even got in a big hydraulic arm in California and started hooking up the software to that to try and make that into a – and call it a real robot <laughs> rather than just a stepping simple thing and started working on other technologies, other areas. I started on the direct drive concepts and things of that sort and I did that for a couple of years. I had an employment agreement with Unimation for a few years, maybe two years or so, during which time we delivered the bigger PUMA to General Motors and we started moving the manufacturing of the PUMAs, we – the design to Connecticut and they started building them in Connecticut.

Let's see. So anyhow, I did that. I guess at that time Unimation was – Bruce was working in Los Angeles. I moved him down to L.A. after his doctorate and he worked down at Consolidated Controls Corporation offices which were part of Unimation and Unimation was owned by – was a subsidiary of Consolidated Controls and Pullman Corporation in those days so Bruce worked down there and he's probably told you that and he worked in L.A. and in fact – and so I commuted down and I'd meet with Bruce there. He had been working on his own originally and then he hired – we got a couple other people to work with him in that. Lou Paul got a couple of – Cliff Geschke and there was a few people who came and worked for him – with Bruce and then of course Brian was up here in Mountain View with me and I brought in some other people as well and we were up to maybe ten or so in Mountain View. I then – when my employment contract was up and I decided I wanted to move on I had been – I had given the – I had the opportunity to get involved in a startup. Okay. And Unimation at the time I really just had – I didn't have stock or anything of that sort. It was sort of owned by these other companies and I realized that maybe I should just try – look at these – this other opportunity and so I moved and got involved in starting up Automatix, all right, and with a fellow named Phil Villers and – but I wanted to stay in California. He was located in Massachusetts and this was sort of a venture capital-funded startup from day one. We wrote a business plan and I helped put him – I helped put the technical team. He had the business team together. Don Pieper became VP engineering. Have you talked to him? You haven't talked to him yet? Okay. All right. He lives here in California too now down the coast near Santa Barbara and Don came so I talked Don into leaving Continental Can. He was in Chicago and joining in the startup group. I got Gordon VanderBrug, another – he was at National Bureau of Standards essentially. He came on board and I helped sort of put the technical team and made the technical contacts and we started this company with venture funding from the beginning. There wasn't any sort of personal seed capital or anything. It's sort of like day one we got the money; we'll just start doing this. I worked out of my house, not this house, another house down the street here –

Q: What was the idea –?

Vic Scheinman: All right. We were going to do everything. We were going to have sort of like turnkey robotic systems and what we were going to do was we were going to do three product lines, welding robots, assembly robots, and vision systems, and we were going to design and build the robots and vision systems and do the applications as well onto the factory floor, turnkey robotic automation and so we started out with the three separate product lines, the welding. We made agreements to buy welding – robots. We bought robots and we were going to do arc welding, not spot welding, which is continuous path motion control, and we were also going to do vision-based arc welding, which was seam welding using vision and sensors or I would say we – you call it vision but it wasn't just vision but there were sensors to adapt the weld paths to the real conditions, which were – which was a problem with seam welding and that is that the seams aren't always identical in production. The material warps and bends and things like that or there's gaps changes, things of that sort, in other words make smart welding robots. In the assembly systems we were going to build assembly robots and we were going to do small part assembly and we had some contracts and business things like making keyboards, putting in keys and keyboards and things in those early days and a lot – other assembly tasks.

And then in vision systems we were going to use – we made a deal with SRI, which is in the public domain software, to use the SRI vision algorithms and I essentially was able to work with SRI and our first vision boxes were essentially we took a lot of the SRI vision software and a lot of their electronics that they had, which is – you didn't just buy off the shelf boards. You had to design your own boards and logic and we built them – I built them right in my house essentially. Well, we contracted out various PC board fabs but essentially did a lot of the prototype stuff of starting to make an industrialized version of that – of their vision system and incorporate that into our vision product and SRI also had – there was a spinoff from SRI, Machine Intelligence Corporation, which was trying to do the same thing – which was doing the same thing although they didn't last very long. That was Charlie Rosen's thing on the side but they didn't – they weren't – I think they wanted to go after the research market more but we went after this other market. Okay. So we started doing that so we had the three product lines and we had customers that were buying our vision systems and eventually we moved all the manufacturing to Massachusetts. I was just doing some of the advanced development in California. I did the vision, brought the vision into Automatix, and then transferred it to Massachusetts and they were able to run with it and develop more vision algorithms but we were using essentially the feature extraction capabilities of SRI vision work, which was done under DARPA contracts, and so I had that access and I had been – had a long-term relationship with SRI and so I knew who to talk to and who to work with there.

Okay. So we did that and that became one of the product lines. I also worked on assembly and I had some ideas on assembly which I wanted to work on in advanced development and that was the robot world, which was scaling robot tasks – the robots to the size of the tasks. If you were making – doing small part assembly, why not – why have a giant robot doing small part assembly, and the concepts involved – as I said, robots work in a robot world and people work in a people world and that was to scale the whole world down to an environment that is conducive to robots whereas traditionally robots were working in people world. They had to have aisles. There were safety issues. Everywhere I went people were, "Oh, robot hitting a person," things of that sort. In this case here I was able to move the robots, make them really small so that I had robots that if you stuck your hand in there they were small enough that they wouldn't hurt if they hit you, but even then you weren't intended – just naturally you were looking in from the outside. The world was a separate world and the heights – why have an eight-foot high or ten-foot high ceiling when the robots are working on parts that are only a few inches high. You could have ceilings that are only that high. So I had also been familiar with some other technologies, in this case Sawyer motor technologies which had been used in some plotters and I worked a relationship with a company here in Silicon Valley, Xynetics, which doesn't exist anymore but it was a company that was making what's called Sawyer planar motors. And I incorporated their technology into this robot world system and we – I started developing that and there was also a multi-robot system, naturally multiple robots working in coordinated fashion, so I had multiple robots. You could put in two robots, three robots, four robots, six robots. It was more of a Cartesian-based system.

It wasn't anthropomorphic in the sense of looking like an arm but the – it wasn't a gantry type of Cartesian robot. The gantries have some limitations on the number of robots you can put in, the number of arms you can – or manipulators you can have in a gantry system 'cause they start colliding. In this case you could put multiple robots in. It was based on the fact that vision is an integral part of the robotic system. The concept was as you – anything that came into the system could be presented in sort of not a precise manner. Vision would acquire that and determine its location and position and – its position and orientation accurately and you could do precision tasks on non-precisely placed parts because you had the vision system that was inherently incorporated to the system and in fact it was a vision system with manipulation capability rather than a manipulator with vision capability. And that's of course because we – vision in those days and still today requires a lot more computation, or call it processing power if you want to call it that, than manipulation, and so I started building Robot World. My first customer was – well, I did it as a research – advanced development here in California, same thing. We grew out of my house. I started having – I had a facility down in Redwood City near here down at the waterfront. We had a group of people there working on again the mechanic – the mechanisms, the electronics, the sensors and the software, the whole cross-section, a small development group, and again the goal was transfer the technology to Massachusetts. Our first – we did deliver several systems out of California here.

Eventually, it moved to Massachusetts, the first customer again General Motors, and they had some specific application in this case here, small part assembly. Most manufacturing – most assembly in car assembly is small part assembly. It's not the final assembly that you see that everybody knows. It's making those subassemblies that is where a large part of the assembly goes, the fuel pumps, the windshield wiper assemblies, the fuel injectors, the distributors, the – all the little parts that are part of the bigger assemblies, have to be assembled in some ways. And so we developed that for – we developed a – we sold a Robot World to General Motors and then Hewlett-Packard bought a bunch of Robot Worlds for inkjet cartridge manufacture and it had this – because it had the vision built into it they were able to actually – at HP they actually were able to run these Robot Worlds from Silicon Valley here but they could be all over the world. Because of the high-level software and the communication capability they could see what was going on, they could diagnose the problems, and in fact it enabled them to – they developed their own communication interface if you want to call it that and control interface, which enabled them to run these Robot Worlds remotely. And of course the built – having the built-in vision they could also see what was going on too. This was precision vision and the robot had very good accuracy. It had – it's sort of like micron capability from micron resolution and – let's see.

So at Automatix I had other roles there too. We worked on – there's more – I have more wrists and mechanical arm parts that developed here in California. I would develop them for Massachusetts and we built some assembly robots as well. Let's see. That went on for quite a few years, California, and we sold – eventually Automatix grew. We grew to a company of something on the order of 350 to 400 people in – mostly in Massachusetts but we had offices in France and we had relationships and we were buying our robots' components with – some of the welding robots and some of the assembly robots were coming from other countries as well, Japan, Germany. We would build controllers – we would buy the mechanisms in many of those cases and put our own controllers on it which were – had vision capability and they also had this real time sort of high –level control. We had our own operating system but we were spending a lot of time developing our own operating system, which was called RAIL, Robot Automatix Incorporated Language or something. We called it RAIL and at some point we decided we were spending so much effort developing this operating system; maybe we could find – and our sort of computer. We were building our own circuit boards, everything – maybe we could find some sort of commercial product and we actually did. We made a deal with Apple <laughs> and what we did with Apple – Apple agreed to sell us their processor and the Apple operating system. This was the old Apple, where it was based on the 65, the 6800, Motorola 6800.

Q: Pro Dos, was it?

Vic Scheinman: It was operating system six, and five, and four, and three, the early Macs, you know, Mac's. The Mac, we bought Mac. And essentially they started to try and sell us boards, but it was easier for them to sell us the whole computer as the price of the board, with the agreement that we would destroy everything else. So we would take these Mac 2-ci's or whatever it was. I can't remember what it was, pull the boards out of it, the processor board, which was a mother board, pull the mother board out, and then smash everything else up, you know, just have it destroyed, because that was the agreement. It was cheaper for them to do it that way. So we did that, and we used their operating system. It was embedded in our product for a while. Let's see what else happened.

So, and at some point, essentially we found that the problem with Automatix was that we were trying to – we found that to expand further, we really needed to have people who were going to do system integration as well as us. We couldn't do all the applications on our own. And so we had this line of system integrators. Unfortunately, the system integrators generally felt that we were competing with them, because we were building all the systems. We were building the – we were the supplier to them, and they were doing the applications, but we were also doing the applications. And so we had trouble expanding our system integration, our integrators, and that became a difficulty. And I would say that we started to realize that it wasn't practical for us to do the applications, and yet the integrators weren't willing to come on board as much as we would like, because we sort of had too much control over them. And so after a number of years, we had built the company up to maybe selling a hundred million dollars, or so, of – well, I'd say, let's say we sold – I can't remember what the numbers were, but let's say at some point we had sold fifty million dollars' worth of robotics, but unfortunately it cost us a hundred million to do it. And we slowly divested some of our product lines. We sold off Welding. We sold off Assembly, if you want to call it that. We made some deals with Yaskawa, for instance. They bought Robot World, and they bought some of the assembly robots, and Welding, as well, a Japanese company. And we moved more towards Vision, because we felt that that was one where we had more control over it. It was potentially more profitable, and rather than the robotics end. There were too many – we were always in the position where we were competing against the low bidders on the applications. And the low bidders, in general, were people who couldn't do the job anyhow, but they didn't know that they couldn't do it.

One of the big problems with robotics has been that in application engineering it seems so simple. And people say, "Oh, I can do that." And the customers were not educated enough to realize that the people they would choose wouldn't be able to do the job. It's not a matter of buying parts, and putting it together, and then delivering it. It's a matter of getting it all to work.

That's the hard part, on the factory floor, in the actual real world case. And we were always competing against these low bidders, who were other system integrators, who weren't part of Automatix, who would say, "Hey, I can do that for less." And so it was hard to make a profit in many of those areas, and it still happens today. The cost of an application is, like, four to five times the cost of the robot. The robot's only, like, twenty or twenty-five percent of the typical application. And, in fact, the other problem is, is that we found that in each case, we would do an application thinking that there were additional follow on orders, but they were always less, because people would want to have changes each time. In other words, there was a lot of follow on applications work, which was involved. And the applications weren't where we were making our money. We were making it in selling the robot, the basic robots and the systems. In the Vision systems area, we had much better margins. But even then, we found that even if we could make the Vision systems for free, for free, we had to charge ten or twenty thousand dollars for every Vision system that went out the door, just to do the support for the customers, because there was a lot of customer training involved. It's now gotten a lot easier. Now it's twenty, thirty years down the road, and you just buy a board and a camera, and you're off and you're running with some software. In those days, it wasn't the same.

Anyhow, we eventually became a smaller company, sold off a lot of the technology, and the company essentially doesn't exist anymore, and closed, sold off the West Coast. The work that I was doing became part of Yaskawa. I went to work for Yaskawa as a consultant for a while, and we moved down to Mountain View, where they had a little office. And I worked on some robotic stuff for them, and incorporating the Robot World technology. And Yaskawa, of course, used that, built Robot Worlds, where it has that they go close to seven or eight hundred of them, of these Robot World systems. Lab Automation, a lot of biotech automation, uses Robot World's HP, bought a bunch of the company's for small part assembly, bought them. And if you want to talk to somebody about that, John Payne. I don't know if you've talked to John Payne, P-A-Y-N-E. He's at Yaskawa. He lives in the L.A. area, and he essentially – he was at Automatix, and he became – he moved over to Yaskawa, and he sort of ran the Robot World Division, but now he's doing other things, because Yaskawa, in the last couple of years, they stopped selling the Robot Worlds. They were very expensive systems, but they made them in L.A., in the L.A. area, out near Newport Beach area. I can't remember the town actually, but, yeah. But any event, Yaskawa, and he can talk to you about that. A number of Automatix employees went there. And I worked for Yaskawa for a few years doing that. And then I went to Stanford just on a volunteer basis initially, became a consulting professor there, spent maybe about ten, fifteen years there. I can't remember.

And a couple of years ago, I sort of retired. And now I'm doing well. I'm meeting with – I have a high school group that meets. It's a high school robotics group. I do some consulting, not just in robotics, but in mechanical engineering, and have been working on some other projects. You saw the little mobile vehicle, those little scooter-like things there. We sponsor the project at UC –Davis, a student project, to look at characterizing some if the motors in that, and we're sort of looking at some high tech handicapped aids, and just a number of various other little projects at the moment. I'm an investor in, obviously, Unimation. As you know, the Unimation West Coast Division, when I left, Brian took over. He ran it for a while. Unimation sold out to Westinghouse Corporation, which was – of course, it didn't directly benefit any of us, because we didn't have any stock in it. It was only a few guys back in Massachusetts, in Connecticut, and it was an opportunity for Bruce and Brian to spin off and start Adept, to sort of follow on the work we'd done in the West Coast Division. And, of course, Adept grew, and I don't know. Have you've been to Adept at all? No. Okay. All right. Well, and they, of course, ran that for a number of years. And, of course, the same thing, you know, the ups and downs of the industry. Adept got into financial difficulties, unfortunately. I would say some people who didn't have the same philosophy got involved, got onto the board of directors of Adept, and, you know, Bruce and Brian one day were shown the door, sadly. The company now has gone through some restructuring and, of course, I've still been a stockholder all along, from the beginning to now. And they're in the East Bay. And a very, maybe the largest, still the largest American robotics maker. And they founded Precise Automation. I'm an investor in that. And let's see, what else? What else do you need to know? I probably skipped other things. I've given you a long story. I'm trying to remember all this stuff.

Q: Yeah, yeah. So all these robots that you built, which ones to you think were the most important?

Vic Scheinman: Well, the most important one, I guess, became the PUMA Robots, the whole series, Programmable Universal. See, GM had this concept of Programmable Universal Machine for Assembly, all right. And in their case, they had sort of misguided ideas that the robots would be like people, and you could – the robot was doing only a task that a person could do. And unfortunately, that's a little bit misguided, because, yeah, maybe the robot can do a task a person can do, but the robot can do many different tasks. And the philosophy for GM was, okay, you've got this seventeen inch, or twenty-four inch, width between workstations, so you have these people all along these assembly lines. They wrote some articles on that. The robot had to fit in this space a certain wide, do certain motions that a person would do. Parts are coming down the conveyor belt, you know. And if the robot broke down, you could put a person in there, and he could take over the job. Right? The line didn't have to stop. You just unplug it. In fact, the first robot, you just pull him right out and put a person in there. They didn't realize that the person, you'd have to have people waiting for these robots to fail. Not only that, they would have to know all the tasks that all the robots were doing, because you never knew which robot was going to fail. Whereas, if you put another robot in there to do the job, would take a few seconds and you could reprogram it to do whatever task was required at that station.

And so they started to realize that after they got these robots on line, and they never really made the machine for assembly that was using the PUMA robots, but we called it the PUMA Robot Program of Universal Manipulator for Assembly. But they bought a lot of them, and they used them in dedicated, in various applications. And, of course, a lot of other people bought them. I and we, I would say, were generally pretty open with the software, and the hooks to the robot. And as such it got a wide following in the research community, the university community, the research community, because people could interface to the robot. They could build their own controllers. I did a controller for Stanford a number of years ago, a few years ago, where it's interfaced to a PC. Okay? So get rid of the original controller, just interface it to a PC now, but you could interface it to – because the interface was very well characterized, whereas most other industrial robots, it's hard to – the companies don't want to talk about it. They don't share it as much. This became sort of more one where people wrote about it. People could learn to use it, and it became very popular among the research community, which is what I felt strongly about, that you want to share. So I'm maybe most proud of that.

Q: Do you have any idea how many PUMAs were made?

Vic Scheinman: Several thousand.

Q: How long did the production go for?

Vic Scheinman: Well, the production still goes, if you want to call it indirectly. The company that makes what I would call the PUMA follow on, is Staubli, S-T-A-U-B-L-I. It bought the Westinghouse, the Unimation name, and the Westinghouse line of robots. And the robots there use the same, I would say, kinematic configuration. The innards have changed, because it's now thirty years, forty years later, since the 1970s, but they make a whole series of robots, very, very good quality robots. They, for a long while, actually used the Adept controllers in their robot. And they also kept the Unimation name for a while. Now I think they've moved away from that, but they make a whole series of robots, small ones starting about this size, and going up to giant ones, much bigger. And, of course, the PUMAs came in larger sizes, too. There were some big ones that were, you know, big ones, 700 series, sort of like, well, this is the 200 series. The others were the 600 series, 5 and 600 series, and then there was the 700, a bigger one. So Unimation had, you know, we made larger ones, too.

Q: Did you have any connection with when Unimation sold some of their line, I think, to Kawasaki?

Vic Scheinman: Yes. Well, well, no. Kawasaki was a partner. The PUMAs were made at, I believe, three places. We made them in the UK. We made them in the United States, and Kawasaki had a license agreement and made Unimates, made PUMAs, all right, Kawasaki Unimates. And they also did some of their own engineering, as well, but that relationship was actually pretty long term with Unimation. The Kawasaki became – after I'd left Unimation was when they started actually making the PUMA robots, but they had the relationship with them, because they made the hydraulic ones, as well, earlier on, in Japan, in the Kawasaki on that.

Q: So, you know, the fellowship when you were traveling around the field with Devol, George? Like, what were some of the other places you visited?

Vic Scheinman: Well, I'll tell you. You know, the one I remember the most was we went to GM. Well, two things I remember. One is, first of all, George always liked to travel first class, so we always sat in the front of the plane. We went first class everywhere, which I liked. I was a little kid, you know, twenty-one, or something, at the time, you know. And so that was the thing I remember. The other thing was that we would always go into these places, and they had the robots. There was always some problem with the robots that he was going to show me. And one day I was there. We went to this plant. I think it was at Ford or GM, River Road in Detroit, and the robot – we went in there, and he was going to show me this Unimate robot, Unimation robot. And we get to the plant, and we're going into the plant, and there's this huge stamping press, a big, sheet metal press, what it is, and the robot is supposed to put pieces of sheet metal in there. The press comes down and forms a hood, or something like that. Then it can take it out. And, of course, the advantage of having a robot is some of these parts are pretty big and heavy, and people have to do it otherwise, and the robot can do stuff that's sort of heavier and dirtier than people want to work with, and there's oil that's spraying around.

Well, we get there, and the robot's not working, and the press is not working, and all these engineers around it. And what they show me is it's a robot. Something went wrong, and the robot stuck its hand in there, and the press came down and squashed the robot's hand. And I'm looking at it, and they have this pile of stuff, which is – you can imagine. It's like when you go to a car crushing, you know, they take the whole car and they squish it. Well, the robot's hand has been squished there, and there's sort of this pile of mooshed stuff, metal. You can see springs, and little pieces, and bearings in it, all smashed. The end of the robot has been smooshed in this press, and the press has been damaged. The dye has been scored because of the robot getting stuck in there. I still remember that image <laugh> of the robot. And they don't know why it's done that, but, of course, they had this little action the night before. So that was one of the things I remembered. The big thing I remembered there was the spot welding. Again, in those days, the advantage of it was just – I got to play with the spot welding guns. They're on cables, and they're counterbalanced from the ceiling, so that you're holding this gun, which might weigh a hundred or two hundred pounds. Some of the big ones did like that. It's sort of like holding a big, big machine. And there's the probes at the tip, and you're trying to position it, as the car comes by, to weld, to do spot welds. And although you're not necessarily having to lift the welding gun, because it's on this counterbalance that's holding it up, you have the inertia of the gun, so it's massive. And just moving it, displacing it, accelerating and decelerating, and bringing it to a stop without a lot of overshoot and oscillation, takes a lot of work and planning, and getting an accurate positioning at the tips to do the weld. And so that was an experience for me to see that the robot could actually hold this thing.

And, oh yeah, it's big and beefy, but it's stronger and it's got the ability to apply more forces than a human does, and it can position these welding gun tips more accurately, and faster, so it could do more welds in a shorter period of time. And so it was a good experience for me to be able to see why you need, you know, why having a robot helps. In George Devol's case, we had a lot of meetings. He was interested in – George had an interest in patents a lot. I didn't. I felt that the way to – I wasn't interested in making lots of money, and things of that sort. In fact, when I started Viacom, I didn't have business. You know, I didn't feel I needed to have business cards and a big name, and all that. I've learned differently since. But in any event, George was very strong on documentation, you know, and always being interested in what can we patent? Everything I looked at, he said, "Look for patents. Look at this. Look at what you can do that we can create that's new and proprietary." And so we had a lot of discussions on that, and coders, you know, optical coders, and control methods, and stuff like that. Mostly it was just seeing the applications, but it wasn't just the robot applications. It was also processes that I got a good experience with. I remember looking at making car instruments, like the gas gages and stuff like that, everything from that to big presses. And just my opportunity to work on the assembly line and get a sense of what people were doing, and then how to convert that, how a robot might be able to do that, what I would say, with better quality control. And that was a big issue, and that is the repeatability, you know. Always used to be you don't want a car that's made last thing on Friday night or, you know, or Monday morning, when people aren't showing up for work, and they're putting substitutes in, you know. And I learned that. So robots aren't just for human replacements, I learned. They're really doing the work that humans can't really do well.

Q: Okay. We're almost out of time here, but any other people we should talk to?

Vic Scheinman: Well, I mean, there's millions of people you could talk to. You've talked to Joe Engelberger, have you?

Q: No. We're going to do that.

Vic Scheinman: You're going to get Joe. Good. That will be good, you know. He's getting old, and it's very important to get to him soon. I haven't talked to him. I was at his house maybe two, three years ago. Are you going to see him at his house? Try and go to his house if you can. All right? It's a museum. It's a nice thing. And don't feel guilty. I photographed all his plaques and everything around. I've just gone around with my camera, click, click, click, click, click, click, click.

Q: We can get back to you, since you seem to have also a lot of, kind of, documentation on various things.

Vic Scheinman: Yeah, yeah, right, right, yeah. For the PUMA robot, the first one, those documents, a lot, a number of my design calculations, I gave them all to the Smithsonian, or at least not all of it, but a number of files. And they hired some college student, who spent a summer as an internship. I think she was at University of Maryland, to work at the Smithsonian one summer, to sort of organize some of that. There's some errors in that. I've seen the report, the story, but there's errors in it, but I'm not particular about that. Errors are errors. So go see Joe Engelberger. I would say that's that. You might want to see some people at GM.

Q: Yeah. And we have Steve.

Vic Scheinman: Well, Steve Holland would be – now, Steve Holland came to Stanford. He actually got his master's at Stanford. GM sent him there for a year. He's a little later, but he would be a person to talk to, and he's at GM. I think most of the other guys might have left GM by now. The original guru there was Lothar Rossil, R-O-S-S-I-L, Lothar. He's older, and he would be a guy to tell you sort of like the early days, and he sort of founded the AI group at GM. Steve Holland was a little bit different. He was more in manufacturing development, but he did some of the work with the GM versions. I mean, at Unimation, Joe would be the big person to talk to if you're going to talk to one. I mean, there's a bunch of other people, but I don't even know if they're alive anymore, you know. But get Joe, if you can. He's good. You know, then Marvin Minsky. Well, maybe, you know, John McCarthy, he's more of an AI guy. He's here at Stanford. I see him regularly, but he's failing right now. I mean, he can talk to you, not about robotics as much as just sort of AI history, and all of that, but you're in computer science. You haven't talked to John, huh?

Q: No, not yet.

Vic Scheinman: Yeah, right. You'll have to do that probably in his house. He got his little oxygen, and stuff like that. He has a walker.

Q: Right. We heard it was <inaudible> right now, so.

Vic Scheinman: It's not – yeah, right, right. Well, I mean, I meet with him. Actually I've gone over for lunch a couple of times recently. Maybe about two months ago I was at his house, just he, and I, and Lester, and this other person. You could talk to Lester, and he's not a roboticist, or anything like that, but he was in Los Altos, and he can tell you the early days of the AI lab.

Q: That would be great.

Vic Scheinman: And he can talk to you about some of those things. And he could say a lot about – he can talk more in terms of what John's thinking. I mean, John was a guy who he dreamed of all sorts of things, and he was a little less flighty than Marvin Minsky was, but you should see if you can get him, Marvin.

Q: Yes. He's on our list.

Vic Scheinman: Yeah, right, right. They had different approaches in general. We were very deterministic type of approach here. In other words, all the motions of the robot were calculated, mathematically developed motions and motion capability. Well, Minsky didn't think about that. He said, "Let's build something and figure out how to make it run." And he wasted a lot of money trying to build a lot of hardware that never really ran, because he couldn't figure out how to control it, you know. They got into adaptors, and neural networks, and stuff like that, and with limited success, whereas we early on at Stanford realized that we could, if we designed the robots right, we could control them to do this real time core transformation and motion control. I'd say that was, I think, a key to.

Q: So combining the control with the design.

Vic Scheinman: Yeah. The planning.

Q: The planning of it.

Vic Scheinman: Yeah, right, right, right, right, right. And early on the problem with the planning was that it took a while. Now, of course, it can be done in real time, a lot of that type of motion planning, and that's what the PUMA, the little Vicarm, this is sort of like one of the first ones to really do a lot of real time. There was another company that also did – I can't say.