# Nevada Test Site Oral History Project
## University of Nevada, Las Vegas

# Interview with Duane Sewell

**May 20, 2004**
**Livermore, California**

Interview Conducted By
Mary Palevsky with Carol Gerich of Lawrence Livermore National Laboratory

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**Mary Palevsky***: OK, we're going. So you can tell me your name, et cetera.*

**Duane Sewell**: My full name is Duane C. Sewell and my birthday is August 15, 1918.

*Where you were born?*

Born in Oakland, California.

*And what were your parents' names?*

My father's name was Earl and my mother's name was Hazel.

*Oh, it just occurred to me. I wasn't going to ask you this, but had they been in California for a long time or—?*

Well, yes, they had, but they were from the Middle West. My father was from, I've forgotten, Nebraska, I think, and my mother was from Illinois, and they met one another back there and got married, came out to the West Coast. My father was a traveling salesman and he was a good salesman. He really made the rounds. He eventually sold concrete pipe that he helped design the machine that made the things. And we ended up one occasion was interesting. He had a job in Elizabeth, New Jersey. We went back and I ended up the last, oh, three or four weeks of grammar school back there because he was at a job of installing a pipe machine in the prison in New Jersey, the state prison, and then did a good job of that so they sent him down to the prison in Raleigh, North Carolina to install one of the pipe machines.

*Wow. So he was technically-minded and good with his hands.*

Yes.

*So you probably got some of that from him, I imagine.*

Yes, I could have because he was—he never finished college but he went to the University of Illinois and he was a kind of a self-made man and was a *good* engineer. He could really design things well. And then we came out to the West Coast and he got involved in an ironworks out there.

*Yes. So we think of traveling salesmen like someone going around with, you know, household stuff but this is really an industrial—*

Big piece of machinery that he had designed and was selling to people that were going to install—yes.

*Now where were you in the family? Did you have brothers and sisters?*

I did not. I was the only child.

*You were the only child.*

And my first wife was an only child because her father died before she ever knew him.

*What was her name, your first wife?*

Elizabeth. Ruth was actually her first name. Ruth Elizabeth.

*Ruth Elizabeth, and you called her Elizabeth.*

Yes.

*OK. So you're in Oakland and you go to high school and you end up, what, being interested—?*

No, I never went to school in Oakland. My folks moved down to Los Angeles and we were out in the western part of Los Angeles before it was a big town at all, and it was the days when I remember we could go down to Venice Beach and there was nobody on the beach and we could go swimming. We lived just a few miles back from that and there was nothing between where we lived and the beach.

*Yes, I know that area.*

Yes, it's in the Baldwin Hills. In fact my folks were the first ones that moved out into the Baldwin Hills. I don't know if they still call it that or not.

*They do. They do.*

Yes, we were the first house out there.

*Wow! Now at Venice Beach at that time, we're talking what, the twenties?*

Yes.

*Was it—I mean do they have the people on the beach with the different entertainers and all that sort of—?*

Oh no, no, no.

*No. It was just empty then.*

It was just empty then.

*Yes. Because I think in the 1930s during the Depression I've heard stories of other things happening out there.*

Yes, that's right, but no, there was practically nothing out there at that time.

*Interesting. Interesting. So you go to school at public schools in the Los Angeles area?*

Yes, I went to public school in the Baldwin Hills area and then back on the East Coast for a short time in Elizabeth, New Jersey, then came back up to the West Coast. We moved down to El Segundo because the Depression hit when we were on the East Coast. In fact, my mother and I arrived in New York on the day that the Depression, the big bust, occurred.

**[00:05:00]** *You mean the stock market crash?*

Yes.

*Wow! Do you have any memories of that or—?*

I sure do. It was a real shock to obviously everyone and I didn't know the importance of it because I was just a kid at the time. It was actually Christmas Eve that we got back there because the train we were on coming out from Los Angeles, they had a train wreck ahead of it and so we sat on the tracks down in Texas for twelve, fourteen hours, went down to New Orleans and changed trains there. We were twenty-four hours late getting into New York City. And that was the first long train trip I ever took.

*Yes. Yes. So you're in New York and then—*

Then we came—my dad was given the job of driving one of the company cars back there, so we came back by automobile cross-country. Came down the southern part of the United States, down through Texas. In fact it was interesting. When we were going back there, it was the days when the Harvey Houses were in full swing, and we stopped to have all our meals. The train would go along for three or four hours and stopped, everybody would get off the train, go in and sit down, have a meal, get back on for a few hours. We didn't make very fast time but we sure got good food.

*Yes. So you're driving at this point?*

No, he left the car in Chicago.

*OK, I got it. So was that down through the Southwest?*

Yes.

*Oh, that must've been amazing in those days.*

Oh yes, it was wild country then. And the Harvey Houses were quite something, and the Harvey Girls.

*Yes, absolutely.*

It was interesting. Well yes, you don't want to get into this.

*No, it's OK because it's interesting because I was just at the Grand Canyon and they had a whole exhibit about that era and the Harvey Girls. It's part of history; we get to put that in, even if it's not about testing.*

Yes, I see.

*We're allowed, because a little bit of life history is always—you know, helps people in the future understand who you were and what era you came from, so that's all to the good.*

Yes. Yes. OK.

*So then you get back to California—*

And then we moved over to Pasadena. I went to two—well, let's see, I went to, of course, one school in Los Angeles and then when I graduated I transferred into junior high, then I moved to a junior high in Pasadena, and then I moved to another one, second one. That was in the days when junior high in Pasadena was the ninth and tenth grade. I went to tenth grade and then the eleventh grade I went to Pasadena Junior College which was the start of the high school or going into college. And then we moved up to, oh, skips my mind right now, a town just north of Stockton, and I went to school then—I tried to go to school in Lodi but they didn't have the classes that I needed for the last year of high school. So I drove every day for a year over to Stockton and went to high school over there and graduated over there. Then I stayed there for four years—because I could go to school at the College of the Pacific because the first two years of that, of junior college, were put into the colleges like that around the state. And that made it cheap enough so that I could afford to go. Then the last two years I went to the College of the Pacific because I was there, settled, had a job, and from there I went down to Cal [University of California. Berkeley] and started in immediately at Cal. When I got down there, and about, oh, I guess it was a couple of weeks after I got into Cal, I asked one my companions there, we were part of the

teaching **[00:10:00]** group, how I could get in the Rad Lab [UCB Radiation Laboratory] because I was always interested in that. That was interesting. I picked up the phone, called his office, and got a hold of his secretary—

*This is [Ernest O.] Lawrence's secretary now?*

Yes, who later turned out to be Glenn Seaborg's wife.

*Right. Right.*

And Helen said, `Well, just a minute, I'll see if he's busy.` I asked if I could see Ernest. She stuck her head around the corner and said, `He's not busy now. Why don't you come on up?` So I went up, I talked to Ernest for about ten, fifteen minutes. The end of that time he said, `Well, let me see if they've got a job for you over at the rad lab.` It was then the old lab, the old French Building, I think they called it, which was the old thirty-seven-inch cyclotron. And so he called over there and called back and says, `You go over and see Cornelius Tobias,` who was the head of the thirty-seven-inch cyclotron at that time. And so I went over and saw him and half an hour after I'd made the decision to go over and talk, I was working in the place.

*Unbelievable! I mean the contrast. Here you have Ernest Lawrence. The contrast for the way things would be today, I mean to a young scientist today, that would almost be an impossible scenario.*

Yes, that's right.

*Impossible scenario.*

But it was interesting and Ernest was very friendly and came around to see me in the lab and checked on people. I walked in the place and they wanted to know what experience I had and I said well, I didn't have much experience, and so Toby gave me the job of going out in the

courtyard with a Simpson meter and checking the grounding hooks. I remember that and I thought, boy, is this ever a wild goose chase he's sending me on. They must do this to all new people here. But I got out there and it was a valid statement because what they had, the grounding hooks, when you're starting to work on a high voltage piece of equipment you always hung a grounding hook on it to start with, to make sure it was off. If it wasn't, you grounded it before you went through yourself with it. And the Simpson meter was a continuity meter to tell if the grounding hook was hooked in solid to the ground.

*Well, thanks for explaining that, because I was going to ask you what that was. So you must have been interested in science already.*

Oh yes, very much so. Yes.

*And just both for the layperson and just sort of also historically, you've got Ernest Lawrence and his cyclotrons. Can you explain simply what a cyclotron is and then what your particular interest in what he was doing with them that made you want to work with him?*

Well, it was the dawn of the—really the radioactivity and the study of radioactivity. But what he did, he devised a way of using a low voltage to add, add, add, add steps [gesturing] to get to a very high energy which was high voltage. So it was getting to quite a high voltage with the acceleration of hydrogen atoms and helium atoms. And then they would use these as atomic bullets to bombard, to shoot at, other material and turn it into radioactive material, and then study that. And he had also a sixty-inch cyclotron which had been supplied to him through, I've forgotten who supplied the money, but that machine, I don't know if it's still in use or not, but it was used for making radioactive material for medical applications. And of course Ernest Lawrence's brother John came out to work with him. He was an M.D. and he was working in the medical field with nuclear materials to experiment with them. And so that turned out perfectly. I

got to know John quite well too, and he did a lot of good things with radioactive material in medicine. It was really the dawn of that era.

**[00:15:00]** *Right. So you've got the cyclotron on which you're doing sort of pure experimental physics in a certain sense.*

That's right, yes.

*Then you've got applications such as medicine.*

Yes.

*And then eventually that—OK, well, I'll stop there. I'll let you talk, not me. I'll ask you something.*

OK.

*So would you eventually work on the cyclotrons themselves?*

Yes.

*Not just the grounding.*

No, no, we actually took them apart and put them back together. I got one bad shock on that. This is on the thirty-seven-inch cyclotron, which was one of the earlier ones. And I went in there one day and they said they wanted me to take some stuff out, so I did. And there was a condenser which is—I don't know if you're familiar with them or not, but it is a can of metal essentially that stores an electric charge. And so I got in and I was taking things apart and I grabbed a wire in the poles of the thirty-seven-inch cyclotron and the next thing I knew I woke up across the room. It really *shocked* me. Fortunately a condenser is just one shot of electricity. Otherwise it would've killed me if I had gotten it because it was several thousand volts. That taught me a lesson. Be careful around the place.

**Carol Gerich***: Is that maybe the start of your safety career?* [Directed to Mary Palevsky]*: Duane is known as our safety czar, if you will. He was always careful about safety and made sure everybody else was.*

**Mary Palevsky:** *Yes, I got that from the Carothers interview. You talked to him about that too, that much later at the test site when you decided not to let a shot go. [Duane C. Sewell, interviewed by James Carothers, 1981. Lawrence Livermore National Laboratory archive].*

Yes.

*Because it was the last shot of Hardtack II? [1958]*

It was the last shot. I had about two thousand people that wanted to kill me that night. But no, actually that night I was afraid that we were going to break plate glass windows in Las Vegas, which they had done earlier. And the weather conditions were just right. We were shooting off high explosive shots at the test site to check for that. And the reason I did it, what convinced me that we had to—one last shot, we had every piece of dynamite we could find on the place, set it off. It was about a half a ton of dynamite, and one of the fellows about twelve miles downwind from where we were came with, `Wow, what was that you set off?` and it really practically knocked him over. And what happens is you can get conditions where the winds are just right, that it focuses and it hits the ground, bounces, and focuses again, and I was afraid it was going to focus on plate glass windows in one of the main streets in Las Vegas, so I turned it off. But there were a couple thousand people that were sure mad at me that night, I know.

*Yes. Yes. Yes, we've skipped ahead but that's OK because it's to the safety issue and your actual physical experience of what an unsafe condition can do, which you said, it could've killed you if the circumstances had been different.*

Well, I watched, frankly, some of the things when I started the safety down there [NTS], watched some of the things that Los Alamos was doing *at* Los Alamos and read over some of the safety reports. They killed a number of people with high explosive accidents, that sort of thing, and I was really concerned. I didn't want to have somebody's blood on *my* hands, and so I really started looking into that as kind of a side issue. It wasn't a career goal.

*Right. So this is at Nevada, you're saying, at the test site.*

At Nevada, at the test site, yes.

*So you got access to Los Alamos reports or you talked to people there?*

Oh yes. Yes, met the people there and talked with them. And that's where we learned the testing business, and they were still young in the business because this was back in 1952 when we started, but they—you want to turn that off? I've got to get some water on my throat.

*Sure. Sure.*

**[00:20:00]** End Track 2, Disk 1.

**[00:00:00]** Begin Track 3, Disk 1.

*I'm curious how it was—what kinds of ways had been people been killed or injured at Los Alamos that you were committed not to have happen at Livermore.*

Well, they had had some accidents, and I remember one accident very well. Four fellows went out in the burn area where they burn the old high explosives and somebody stepped on something and it went off and it killed all four of them, and that really shocked me and I didn't want to have that sort of thing happen at Livermore if I could help it. And so that impressed me to look into some of the accidents and to worry about how you phrase things and talk with people to convince them to be careful and not get themselves into a bind like that. And so I worried first when we got together out at Livermore. See, when we first started at Livermore, it really was

somewhat of a mirror image of Berkeley, in which the departments were all separate, or tied together at the top with Ernest. And we moved to Livermore. Well, Ernest had asked Herb [York] to be the—he didn't ask him to be anything, he just said, Go out and put a lab together, and that's what he told me too. There were no titles then. Ernest hated titles.

*OK, that's what it was. Yes.*

Yes. And I asked him one day, I said, Why do you abhor titles? He said, Well, let me tell you, Duane, whenever you get a title I find it takes the flexibility out of an organization. If I want to move a person from place A to place B, I want to go ahead and do it and I don't want a situation where everybody in the place is looking, did he go up or down on an organization chart?

*Interesting.*

So nobody has a title. And finally Herb went to Ernest and said, Well, what do I call myself when people call up? and he said, Well, why don't you call yourself Director? And that's how [laughter] the first title got started. And he was the only one that had a title for a long time.

*That's interesting. So that fits with Lawrence's sort of looking to maximize a person to a task and feeling that the title would have been—*

Yes. Well, what he was worried about is this: if he took John, moved him from job A to job B, he didn't want any hindrance of the title that would say, Well, in moving him from job A to job B, he went up or down on an organization chart. I want him to move there; that's the best place for him, that's best for the laboratory.

And so that's the way it was for a long time. It made it very difficult for people coming in: Who is this guy and where does he fit in? Should I listen to him or should

I not? And finally we got so big, you *had* to have some sort of an organizational structure so people understood where an individual stood and should they or should they not listen to them.

*Right. Let's tie this back a little bit. I think that where this little strand started was the notion of how you communicate—we'll stay with Livermore for a while, since we've gotten here—how you communicate the safety concerns in an organization that's as, I don't know what the word would be—that doesn't have an organizational chart. So what kind of challenge was that for you then, in those early days?*

Well, it was a tough challenge because there were really about six organizations that were all partially responsible for safety. And so the first thing I did was look at that and pull them all together. That was a tough job because it meant that certain people actually had to be stepped on and moved around and responsibilities taken away from them, but then put the safety organization together and with the responsibility, You are responsible for teaching safety to the laboratory. You're not responsible for safety *per se*. So you couldn't use them as crutch to say, **[00:05:00]** Well, he's responsible for safety. That wasn't my responsibility, if somebody got hurt. The point was, you go to them and find out what's the right way to do it but *you* are responsible, each and every one of you are responsible. It was hard to beat that into some of the people. I remember one time early in the game we had a fellow who wanted to check something on a high voltage supply and it was in a room about this big [demonstrating] with tubes and everything in it. And he couldn't get his meter in the right place, so he went inside and sat down with all this high voltage around him. And fortunately I caught that in time and we turned it off, and then I used examples of things like that to say, This is foolish. Think about it. *You* are responsible. In fact, we had one case out in Enewetak later on, where we had a nose cone on a missile on Johnston Island that we were going to launch. It had a

warhead, or an explosive, nuclear explosive in it. And we were keeping dry nitrogen pumped into it so the moisture out there in the humid Pacific climate wouldn't get in and short things out. And the instructions were, if you want to do anything in there, you shut down, kick the voltage down, and get the nitrogen out. And in fact, I have a feeling that nitrogen is one of the most dangerous things we had, which is nothing but an inert gas. But they looked at it and they knew what the problem was and all they had to do was make one little adjustment and they had to take a meter and measure it in the nose cone, and right there somebody's standing on the ladder, `Oh, we don't need to take it down.` So one of the fellows stepped in, held his breath, and then he forgot at the end of it, took one breath, and it turns out you take one breath of pure nitrogen and bang! [Hits table] You're out, you don't know what's hit you. He collapsed in the nose cone and—then people had a hold of him right there but they couldn't get him out. You don't realize how hard it is to move a limp human body when he's kind of tangled around some stuff. And it scared the living daylights out of the people. Well, then I took the foreman of that group and took him around and had him give a lecture to several groups in the laboratory to impress on them: Be careful. Don't make decisions like that, because you can't depend on human beings to think safety at all times. Well, I kind of got off the track there but—

*But I think that's really interesting and actually really, you know, it's making me understand something more clearly than I had before. You can correct me if I'm wrong. But what I'm getting from this is you're dealing with powers and energies and materials that are so potent, and you've got a little human being, you know, who in their kitchen might say, I'm going to reach back here, even though I shouldn't, and plug that thing, and maybe my arm'll get stuck. But the consequence of sort of that natural—let's get it done, or let's be efficient—or not even taking*

*into consideration the pressures you all were under, that to balance that with some kind of safety program is no small task.*

No, you have to preach it all the time. In fact, later on when I came back out to Livermore I gave a lecture once a month, of an hour, and also to teach them to be prompt and not slop over. I had a one-hour from eleven o'clock till twelve o'clock, just before lunch, and I started at eleven and I ended at twelve. And I got people to come on time and they could leave exactly when they knew they could. But there, for example, what I did is take the foreman of the job out in the Pacific where they'd had this trouble and bring him in to that meeting to put the *emotion* into it that only he could, almost killing somebody on a crazy idea that they knew what the dangers were but human beings fail.

*Right. Right. Thanks, I think that's important. Go ahead.*

**[00:10:00]** *Well, we're jumping a little bit but that's OK because I think this is important information. So let's just back up a little bit —just so we have it on the record—to how things developed at the lab and with you from—and we won't take a long time on this—from Pearl Harbor, let's say, and then how you end up at Oak Ridge and what happens postwar.*

OK.

*Is that too much?*

No. Pearl Harbor of course was a shock to everybody. Something like that just never went through my mind, it would ever happen. And it came along on the seventh [December 7, 1941] and on the eighth Ernest came to us and said, `We got a real job to do,` and he talked to a number of us, so on the eighth I was working on the Manhattan Project which was just started. It wasn't called that then, but that was the start of it, at the lab in Berkeley. It wasn't in Livermore because we weren't going full blast in Livermore. And it was a question then of what type of

organization you set up and how you meld it from what we *had* into what would meet the *wartime needs*, and that was up to a number of us to worry about, and that's what we did when we worried about the question of Oak Ridge and getting Oak Ridge started.

*Did Lawrence tell you?—I mean you were aware of the discovery of fission, obviously.*

Oh yes.

*But did Lawrence tell you right up front about the atomic weapon or—?*

Oh, it had been talked about and of course we knew the potential that was there if you could make it work. And so we immediately started working, the Berkeley lab did, on separation of uranium-235, which is the fissionable form of uranium, and separating it from the other uranium. That was the main job that I worked on, and that was what Oak Ridge was set up for, to actually invent a way of doing that and collecting that material. So that's what I concentrated on during the wartime years, and of course it was a success. Los Alamos was put to work on the job of generating enough plutonium and checking it out to make sure you can make a bomb out of it. The reason plutonium's better is because it's a much smaller critical mass, so you can make a much smaller bomb, than you can with uranium. Uranium was a sure fire. In fact, it was never tested before it was fired out in the Pacific. It was the first bomb that was set off out there in wartime.

*The Hiroshima bomb was the uranium bomb. The Hiroshima bomb.*

Hiroshima, yes. And there was the question then of going and selecting some way of doing that, and Ernest had— actually he put a number of us to work in Berkeley on several different ideas, and he got us all together one day, the people that had been kind of in charge of these things, and said, `How about this method? How about that method? And what did we learn?` so on, and finally he came to the conclusion of the electromagnetic wave separating the U-235 from the

U-238, and that was the one that I happened to be working on, so we immediately made the decision, then on the basis of that experimental data, we'd go this way and concentrate on that. We're going to Oak Ridge to set up a plant, if we can make it work, and then several of us started working on a prototype in Berkeley, up on the hills in Berkeley, and that's when California Research and Development, a subsidiary of Standard Oil of California, got into the **[00:15:00]** business. Because they were put in as far as the contractor and operator of the plant that we were going to build. And in a matter of a few months we designed a plant from scratch and set it up down at Oak Ridge in Tennessee. And then Ernest—well, he didn't ship us down there immediately. The first "race track", they were called in those days, of electromagnetic separators was built, put together, and they turned it on and it failed. And you've probably had this story also—

*I have it from Herb York but you can—yes, he told me that story.*

Oh, OK, well, Herb was down there, yes. That's when we found all the banana peels and apple cores and lunch bags and everything else in the [laughter].

*He didn't tell me that part. So you go down there and you find stuff in the—*

Yes, in the coils because the electrical coils were set up with oil around them to cool them and they had, of course, tanks around them then. And the Tennessee workers, it was a good place to throw garbage, so that's where their garbage went. [laughter] They shut the plant down and people at that time said, `Ah, this thing's a failure.` So we went down and had to clean all that garbage out of the coils and then turned it on and then we got it to work. But it didn't work exactly like we thought it would because it didn't separate as cleanly as we thought we could do it, and it also didn't separate as much. So instead of one racetrack we ended up with one, two three, four, five, [counting] I think it was, and then went to a second stage which was a smaller

system of the same thing and then purified it one step more before we were able to get the U235 to a pure enough level so it would do the job that we wanted to do. So there were the alpha plant and the beta plant, and all of that was done in a matter of, oh gosh, what? Months then, not years. And of course General [Leslie] Groves was set up so that if we needed something he made up his mind. He told me early in the game who he was going to depend on and if they said they needed this, he went out and got it. And an example of that is we needed wiring for the coils down there. Herb probably told you this. It ended up that we couldn't get enough copper because we were using it for the copper shells, and so he [Gen. Groves] came back and said, `Well, will silver do?` and we said, `Sure, it's even better than copper,` so he raided the national stockpile of silver and we were told at the time, the way it was put together, we were not allowed to cut any of that or file any of it or drill any of it because it was the country's silver supply. But we then devised a way of clamping the bars together. But I'd never seen so much silver in my life piled up in one place! Of course it was guarded just because of the monetary value of it. But it worked fine. And then of course when the war was over, it had all to be disassembled and taken back to the national stockpile.

*Right. You're talking about the speed at which you're working and Groves's responsiveness. One question I always have with, you know, technical people is you're doing this technical work during the war. In the back of your mind, are you aware of what's happening from day to day during the war? Are you aware of your direct involvement in the war effort?*

Oh yes. Yes, in fact, that was the nice thing about the jobs that those of us who went back from the rad lab—excuse me. [Telephone rings.]

*Sure.*

**[00:19:38]** End Track 3, Disk 1.

**[00:00:00]** Begin Track 4, Disk 1.

*If there's any particular other memories you have of Oak Ridge—oh, I know what it was, we were talking about getting ready for getting the material, which I guess you didn't even call uranium in those days. You had a code word.*

No, it was called—I've forgotten what we called it now.

*There's two. There's tube alloy and ore alloy.*

Tube alloy and ore alloy. And this was ore alloy, I'm pretty sure. Tube alloy was—

*Was plutonium?*

No, no. No, it was the U235—well, the standard uranium.

*OK. It occurred to me while you were talking, and I wonder what you think of this, that really the first test of that notion of the uranium bomb was the actual use of the bomb in Hiroshima.*

That's right. Because it was such a certain thing from the standpoint of calculation, then from the measurements that had been made, that the only question was, could you assemble it fast enough, a large amount of it fast enough, so it wouldn't go off prematurely and just kind of "*ffft*" instead of making a big bang? And when we finally got through with it, we'd made enough tests and measurements on it that it performed essentially as we had calculated it to do.

*Now at Oak Ridge—Herb tells a story—he's told it and he's written about it—of there was this point at which you were asked to ship everything that you had, as opposed to waiting till the end of the month when you would normally ship the material?*

Yes.

*And that was a shift that made you aware that maybe something was happening?*

Yes.

*Do you have a similar memory to that?*

Yes, I do. In fact, we knew when things were going to be put together and approximately when it was going to be tested. A few of us did. Not very many people, of course, knew. And they carried everything together and put it together and shipped it off to the Pacific.

*Of Trinity? Of the Trinity test? At Oak Ridge?*

Yes. Yes.

*Oh. OK.*

Yes, yes, Ernest told a few of us of that and the fact that it had worked and it was successful. And so a few of us were kept up to date on what was going on and where it stood.

*Besides you, do you remember who else that was?*

Certainly Herb and there were about half-a-dozen of us that were in on it.

*OK. So you had Lawrence's confidence and he would report to you on these things?*

Yes. Every time he saw us. He felt that a few of us, I think, needed to understand how it was going to keep the enthusiasm and excitement in the group. And it was an interesting environment that we were working in because the Southern environment—of course we were all damned Yankees from the North. And that really made a difference down there because, for example, there was a certain amount of, I wouldn't say hatred, but certainly dislike for us. And I remember that when you bought a dozen eggs, you never bought a dozen eggs without finding at least one rotten one in it, and it was little things like that that impressed on you, You're a damned Yankee and we want you out of here.

*Really?*

Yes. But then once the bomb went off, then we couldn't have been nicer people.

*You were heroes then?*

Yes. But it was an interesting environment to be working in.

*Sure, culturally, just having never been in that environment in the South.*

That's right. And I remember one of the first things that happened, I got on the bus down there and the bus driver said—I sat down and he says, `There's a damned nigger. Let me see if I can get him,` and he *vroom!* and headed right towards the guy. I don't know whether he would've hit him or not when he got to him, but he missed him. The blacks weren't as high as dogs, I think, on the social scale when we first went down there. Of course, it was still the period **[00:05:00]** where you had a "white" and a "colored" for restrooms and drinking fountains, everything.

*So you must've had black people working at the lab in some capacity.*

Yes, we did. They were—I can't remember, I don't think we had them on the payroll. Tennessee Eastman had them on their payroll and they assigned them to us.

*So that you would have the segregated restrooms and—*

Oh yes, restrooms and everything else. They sat in the back of the bus and you didn't treat them like human beings because if you did, then you were labeled as, `one o' them thar black people.` It was a different environment then and very distasteful. [pause] OK, where do we go from here?

*Well, we have Hiroshima and so then you know the war is soon going to be over.*

Yes. Well, we hoped it would be. We thought that would do it, and it wasn't until we fired the second bomb, and then that convinced the Japanese that it was a hopeless deal for them to compete with that. And so they signed the armistice and that stopped the war, which was certainly a wonderful feeling after four years of going through the hell that we were and with bodies coming back. And of course we were out there in the Pacific and planes would land,

bodies would be carried off of the thing and put in ambulances and taken to a morgue and dressed for home. I still have vivid pictures of that.

*So just before we leave there, what was your thinking, having participated in bringing what obviously was distress—is still distressing you to think about, bringing that to an end? Did you feel pride? Did you feel relief? Did you feel—?*

Ah, it was a certain amount of pride, although a certain amount of *grief* to feel that you had to kill that many people, innocent people, to shake up the powers that be to turn off this stupid business of killing one another, which was actually getting nowhere. And it was very surprising to me how quickly the Japanese people turned around. And they're very bright people as a race, of course, and started picking up some of the technical things that were involved in pursuing the war. For example, in the cameras, they very quickly became number one camera makers in the world, and it just went on from there. And actually there was some hatred of the Japanese after the war, but it didn't last very long. It was surprising how quickly that disappeared. Because in general they're very nice people, and of course we had put them in concentration camps essentially, which people now say, `Well, it was a horrible thing to do,` but when you're fighting a war and you don't know who's going to shoot and who's not, I think it was the right thing to do. But I know a lot of people today feel that's not correct, but it was the only thing, I think, that the United States could've done, and some of the Japanese people of course are really hurt by what was done and I feel sorry for them but those were wartime conditions. OK, now where—?

*OK, now something that's just sort of interesting to me historically is there's this whole legend, or not legend, that after the war's over, many of the Manhattan Project scientists go out back to their universities and don't continue to work in the weapons world.*

That's right.

*And then you are a person, and I know there are particular circumstances of your life that make this happen, that are among a group of people that worked on the first atomic weapon and they continue into what then becomes the Cold War.*

Yes.

**[00:10:00]** *But when you're first leaving, say, Oak Ridge whenever you do and coming back to Berkeley, you're thinking about finishing your education. Are you thinking of nuclear weapons and nuclear testing as something that you want to pursue, or are you thinking more of pursuing science?*

I was thinking of pursuing my education and I was on the track to do that. And I remember very well, Ernest got a hold of me one day when we were actually working up on the cyclotron, which we were in the process of building and in fact had it going. The first thing he had me do when I went back was to tear the Calutron apart that was in the big magnet up on the hill, which had originally been built for a big, high energy cyclotron, and start to put the real cyclotron in there. And that went on, I've forgotten, it took about a year. And he came to me one day and he said, Duane, I've got a proposition for you. He said, You're good at organizing things and there's a job that I want you to be aware of that I see as necessary and I think you're good at it, but it'll require you to give up your quest for a Ph.D., which is what I was working on that that time. In fact, I'd taken most of the coursework for that. And I remember we walked around the cyclotron building up on the hill about three times while we talked. In essence, what he said was, If you want a job and give up your work for a Ph.D., near as I can as a human being I'll offer you a job for the rest of your life, if you want it. And that's when he said he wanted me to put together a group of people to finish up the cyclotron and operate it and act as the head of that, versus just

letting that go for another two or three years while you get your Ph.D. work done. And I'd been married a short time before and it was very attractive because the salary was much better in the job than in the work if I were just going to school. So I chose to go there. I like to work with my hands anyhow, I'm like that. So I took on the job of putting together and running the first crew on the 184-inch cyclotron. And once we took care of that, then we started working on other things, and he assigned me to various jobs. And of course when Livermore came along, he came to Herb for the scientific part and me for the mechanical and organizational part of things. We formed a team then to operate essentially as the director and deputy director. We weren't called that, of course, nobody had a title.

*So to understand this, when he asked you to do the cyclotron work, the cyclotron is going to be for scientific experiments to understand the nature of the physical reality that you're studying?*

Yes. That's right, and for making various radioactive materials, and it was really a scientific instrument.

*Right. Once Livermore comes along, you move into then Livermore's mission [which] was to be developing nuclear weapons, better, different. I'm asking. I'm saying it as a statement.*

Yes.

*So it moves you back into the weapons world?*

Well, yes, and that's right, directly back into the weapons world, and of course Edward Teller and a couple of others that come along with the H-bomb, and he was pressing hard to develop that. He convinced Ernest of that, that that was important, and so that's the way Livermore got started. It originally got started, Ernest told me, I remember when we first got going out here, that **[00:15:00]** we would use Los Alamos ideas and we were not going to get into the testing business. And we were just going to do scientific work to help Los Alamos understand and

proceed with the H-bomb. Well, that didn't last very long because of the scientific mind and difference of opinion of how to do things. So we started out and cursed with Edward Teller. He definitely wanted to be on his own and—excuse me.

*Sure.*

**[00:15:41]** End Track 4, Disk 1.

**[00:00:00]** Begin Track 1, Disk 2.

**[00:00:00]** Begin Track 2, Disk 2.

*Tell me a little bit more about this original idea of Lawrence's that you would be "helping," for lack of a better word, Los Alamos with the science. That meant you wouldn't be getting into the testing business initially?*

No, we would not. Well, in a sense, we would, because we would design experiments and the measurements to be made on the Los Alamos-designed bombs and evaluate that and then turn that information over to them so they could put it all together with the information they were getting on a particular trait of the design that they were looking at.

*Right. Now another sort of social or political question, so I understand the context. You've got World War II, this real race to get the A-bomb for lots of reason that we won't go into here that historians argue about. Then you have what you all are taking on at Livermore, which is the Cold War. So when this first starts up with the hydrogen bomb, the Soviets exploding their first A-bomb in 1949, how much in your own consciousness personally are you thinking about a connection between your work and the political situation, the need to keep developing weapons?*

Well, that of course was on the minds of practically everybody that was in the business at that time. And the fact that these were such *horrible* weapons and they changed really the magnitude of the amount of damage that a handful of individuals could create and the number of thousands

of people that they could kill if you put these things in the right place. But then you ask yourself the question. I did: If you don't do it, well, you've got the Soviets doing it and it's obvious that they're not very far behind because they've been picking up the information from us, and therefore what's the best way to go? And I made the decision, personal decision. I really worried about this—made the personal decision—it's better to have a matching of power against power than it is to back away and say you shouldn't do this and hope that the other side would do the same. I wasn't convinced that that would happen. And that would put an unequal amount of power in the hands of a small group of people in the world, *separate* from the United States and Britain. So I made the decision, no, it's better to go ahead and get a balance of power than it is to back away from any power at all.

*So when you say you worried about it, were you saying you were worried about the decision or you were worried about—at this point we're talking about Stalin.*

Yes, I worried about the people, the amount of power that you can put in the hands of one individual. And the fact I didn't trust what those people would do with that amount of power. And certainly Stalin looked to me like a very *vicious* character and didn't mind killing thousands of people if that gained the objective that he was after. [Pause]

So I decided to stick with it.

*Right. It seems to me the way you describe it that there's—this is not a brilliant insight on my part, I'm just noticing it as you talk—that with World War II you have this goal of this* one weapon, *first that will deter the Germans, and then will hopefully end the war.*

Yes.

*But what you're talking about is this continual matching—there's sort of an open-endedness.*

That's right. And it's there, no matter how you look at it. At least I couldn't see any way around it. It was going to happen. Because if you know something can happen, it will happen. People will put it together and the ingenuity of the human mind will develop it. So that's why I **[00:05:00]** decided to stick with it and keep the United States, hopefully, stronger than anybody else in the world, certainly no less than equal as far as strength is concerned. And I still worry about it. I'm surprised that there's been practically no explosion of a nuclear character since, well, I predicted originally it'd be by 2000.

*Did you?*

Yes.

*When were you thinking in this way? Can you remember how far back?*

Yes, it was back in the mid-1990s, because it looked to me like powers were building up then and I was really worried about it, and the one thing that really worried me is nuclear explosion in the middle of New York. And there you would kill not thousands but hundreds of thousands of people. And that worried me and it still does.

*So thank you for clarifying that about the open-endedness, because that's the sense I had. So there's a shift, though, [it] looks like you're saying, back to this notion of Lawrence talking about sort of innovation, scientific and technical innovation, to the idea that Livermore will be actually testing designs of their own for the purpose of weapons into the stockpile, I guess.*

Yes. Yes. In fact we really started that after the moratorium in late 1950s—well actually the late 1950s and into the 1960s. [pause]

*I'll take you back a little further. Let's go back to—were the first tests that you participated in in Nevada?*

Yes.

*OK, do you remember going down to Nevada for the first time?*

Yes, I sure do. And in fact there were two of us that went down there [NTS], a fellow by the name of [James] Kilpatrick who was head of the electronics group here at Livermore, had come from Berkeley, and I went down to the test site to take a look at it and see what it was like. And Los Alamos had assigned certain areas to us, and the question of how you fit into the firing site and so on, the myriad of things that you have to get into, and we looked at that down there. So we came back then and the two of us decided on how we would structure an organization here at Livermore to go down and put these things into place and fire them and make the measurements on them.

*Is this related at all, when you say "put things together," because one of the things I've read about you is this whole notion of a "matrix organization" that differs from Los Alamos. Does that fit in there when you're talking about how you're going to organize the test site?*

Yes.

*Can you explain that to me a little bit?*

Yes, well, a matrix organization is one that has specialties that come from different parts of the organization. For example, the major teams that were put together down there consisted of mechanical engineers, electrical engineers, technicians, so on. But each one of those specialties comes from a different part of the organization, so it's a matrix that you bring these together in a team to do a specific job, then you disband, go back to your regular home, essentially, and ready for the next job. And that really was brought about by Ernest Lawrence's idea that, if I want a special person to do a special job and he or she is the best one to do that job, I don't want to be hampered by an organizational structure that says no, you can't do that. And so I tried to set it up as flexibly as we could and still keep the expertise that we needed. And the other thing that I had

**[00:10:00]** in mind is, it was obvious that you cannot take, say, a scientific organization and make a good engineering organization out of it. It just doesn't work. Scientists don't think like engineers think. And also from organizational and operational standpoint, that's not the expertise of a scientist. So you try to put a team together, a matrix, where you use the specialties and expertise of each group to do their thing and form a team that puts together an organizational concept that will produce a single product.

*Oh, OK, so does that mean that on a particular test of a particular weapon, that you would do this kind of drawing of the best people?*

Well, we left it up to the various expert organizations to pick and choose and assign their people. And even during the development of a particular experiment, you would change people because you get to a certain point you have no longer any need for that individual but you have two people over here, the same organization and one in another organization, and you can bring them in to do the job that needs to be done. So it's a *flexible* organization.

*I was just going to say, that's what it sounds like. So the job description doesn't start defining the person and the process.*

That's right.

*Which can happen.*

Yes, it can. And then you can't use, as Ernest said, if I have a need for a given expertise, I want to get that person that's the best that I have available, and so that enables you to do that.

*Was that ever difficult for personnel in that their job description wasn't maybe as neatly defined as they would want?*

Oh yes. That's right. And it took a while to get that ingrained in the organization. But once we did, people were very enthusiastic about it and cooperated with one another. So we put the teams

together out of picking and choosing individuals and not organizational, but you use the various organizations to essentially create and maintain the experts that you needed. And then if you only needed one expert in the laboratory, fine, you could have that person and be perfectly happy in his own organization and move them into the temporary organization to match the job that you had to do.

*Right. So this would play out in the testing arena then when you're deciding who goes, I guess, down to Nevada to perform these certain jobs?*

That's right. That's right. Yes. And the people that went down there of course were the people that did the work in generating the designs, making the pieces, so on, so that you had the best people you could have put things together.

*Now, your weapons designers then would go down to the test site.*

Yes.

*Was this true at Los Alamos, do you know, or—?*

Well, Los Alamos was at that time an entirely different organization, and I think in the sense that you're saying, yes, they did.

*OK. You can't help when you're reading oral histories of Livermore, which I've been doing to prepare to see you, that these first two tests that Livermore had, named after Herb York's godparents, I guess, Ruth and Roy?*

**Carol Gerich***: Ray.*

*Mary Palevsky: Ruth and Ray [Operation Upshot-Knothole, 1953].*

**Carol Gerich***: Although I should tell you as you say that, and Duane, maybe you can help, I was reading Wally Decker's autobiography and he claims that they were named after secretaries at*

*the lab. Ruth and Ray. And Ray, he claims, was Rae, R-A-E, and people didn't get that and they just renamed it Ray, R-A-Y.*

**Mary Palevsky***: Well, then you've got different legends.*

**Carol Gerich***: You've got different legends, yes.*

**[00:15:00] Mary Palevsky***: Folklore.[laughter]*

*So was that the first time, then, you had actually witnessed an atomic test is at that time?*

Yes. And it wasn't much of a test. Where did it go? [laughter]

*But something happened. You saw—?*

Oh, it happened all right but it wasn't very much and then this tower at the end of that. I used the picture of that tower. Los Alamos took a picture of that and sent it down to me. And in fact I've still got a copy of it around here. I'm sure you've seen it. But it was on my wall all the time I was at the laboratory, lest we forget.

*So you're not the kind of person who would waste too much time feeling bad about that? Were you disappointed at all or—?*

Oh sure. Very disappointed. But it's an experiment and you got information out of it, and then we redesigned and the information we got wasn't good enough for us to do any better the next time, but at least we were smarter. It was only a hundred-foot tower instead of the three hundred-foot tower. In fact, that first bomb, that was the only arming party I went on in all of them that we fired. And I can remember getting in the elevator and it was a steel tower and it was windy that night, clanking, so on, and the guy wires holding the tower were kind of pulling up and stopping it, and it was cold, it was below freezing. Riding up in this open elevator, we hit the top of the thing and it was fixed so that the elevator had a metal top on it and it hit the floor and knocked it. Scared the living daylights out of me when we did that. It poked up through and then

stopped so I could get out. But I can remember sitting there with this tower swaying, really swaying several feet, and this great big bomb, five-foot-diameter bomb, thinking, What in the devil am I doing here?

But that was the start of the testing period. And then went out to the Pacific. The next shot was as much of a fizzle, because I was in charge of putting that together and firing it and I gave the OK to go ahead and fire it. But it was a sloppy, rainy morning, which it was a lot of the time out there, and I thought, Well, it'll be a big enough bang. We can see it and make the measurements. And I remember Herb reported, he said, `Did it go off?` Because it wasn't much of a flash.

*Now were you in the Pacific for Castle [1954]? Did you see Bravo, or no?*

No. No, I didn't go out for that test.

*Yes. And the one thing I did want to ask you about, and we should probably be careful about the time now, because of the safety issue, is something that Carothers spoke to several people about but I didn't see it in your interview, which was Baneberry. Were you involved in Baneberry? Baneberry was the one that vented, the tunnel shot, was it, or a pit that vented out at Nevada. And in some of the histories he [James Carothers] does with other people that Carol gave me, Erv Woodward and some other people, he's asking questions about how and why that happened, and I wondered if you had any particular knowledge about that. And if not, we can go on to something else.*

I was there at the time we fired that. Let's see, Baneberry was the venting—

*Nineteen seventy.*

Yes, that occurred on the crack that opened up in the—Yes. And yes, that was a real scary thing because it vented for quite a while and this black, dirty gas coming out. Yes, what did you want to ask me about that?

*Yes, I just wanted to ask you sort of your thoughts on it or what you think was the problem or what your reaction was, just something to help us understand that event a little better than we do.*

**[00:20:00]** Well, the thing was that we didn't understand the geology well enough of that particular area when we fired that. And after that then Carothers became the head of the group that evaluated each one of the placement positions for the bombs that were put underground. [Containment Evaluation Panel (CEP)]And looked at the geology to make sure we didn't get into another Baneberry, because that was sure a scary thing that morning, I remember, this thing went *whoosh!* and it was just really shooting a lot of black dirt out and obviously a lot of radioactivity along with it.

*Yes. You were expecting it to be contained underground?*

Yes.

*And so you reached the point where it goes off and this other thing occurs.*

That's right. There was a crack in the geology there that we had not detected, and it made us understand that we had to be more careful in our evaluation and understanding of the geology so we didn't get another Baneberry accident.

*Yes. Now as a manager—I'm not quite sure what your title is at that point, but as a person in charge, do you then bring in geologists? How do you practically deal with a problem like that on the ground?*

Yes, that's right, you do that. You bring geologists and look at the particular area and places where it isn't so radioactive. You can't get back into it to look at what had opened up, and it was easy to see what had opened up, and you went out there, got fairly close but not right on top of it. And after that then there was a—I've forgotten the name of the group of people [Containment Evaluation Panel (CEP)] that was put together for every shot, and Carothers actually ran that and gave the recommendations from the group that had been put together, and the way he ran that was very clever and worked very well. They weren't required to arrive at a unanimous decision. They talked about it, they kicked things around, they agreed and disagreed with one another. When he got through, he asked each of them, `What is your opinion?` So we had, I don't know, half-a-dozen people, we had a half-a-dozen opinions, and on the basis of that he would then put a recommendation of whether we should or shouldn't go ahead and use that particular site. And I know when I was in Washington, [as Asst. Secretary of Energy for defense programs in the Carter administration] when I had the responsibility for giving the approval or disapproval of actually firing those shots, I always would read each one of those individual things before we fired. And on several occasions I would pick up the phone and call two or three of the people individually and said, `Why did you say this-and-so?` because it would give a better feeling for how sure it was that if I gave the approval to go ahead and fire it, that it wouldn't leak.

*That's interesting.*

**Carol Gerich**: *It was called the containment group, right, Duane?*

Yes, containment group. I had forgotten. There was an alphabet soup that went with it.

**Mary Palevsky:** *Yes. So once you're in Washington as, was it assistant secretary?*

Yes.

*You actually are then giving approval for shots?*

Just because I wanted to. I didn't want to turn it over to anybody else because I figured I had the experience and it was easy to make a mistake, not having been there. If you were just—you'd read about it and had never seen one of these things, it didn't appear to me that that was a good route to go. Maybe that was egotistical but I just felt I had enough experience and background, and I sure didn't want one of those things to vent if I could help it, on my shift.

*Right. So this was just with Livermore or did you also review things for Los Alamos?*

No.

*So it was because of your prior relationship, or with your continuing relationship?*

That's right. Yes. Well, yes. I can't remember—did Carothers's group look at Los Alamos shots?

**[00:24:43]** End Track 2, Disk 2.

**[00:00:00]** Begin Track 3, Disk 2.

*So we were saying that that was a—when you went to Washington, you kept this relationship with Livermore as far as—*

Well, it wasn't really a relationship with Livermore. It was the responsibility I had for the overall operation, and that's the way I chose to carry it out.

*OK. Well clearly, you know, you can't tell a whole life story in a couple of hours, but we've got maybe fifteen minutes left and I know that Carol may have some questions. But before that I'm wondering if there's anything that you're thinking about at this moment in time that's popped into your mind that you think might be relevant to sort of an understanding of Livermore and testing that you would want to share with me, and if not there are other things we can talk about.*

Well, nothing pops into my mind right now. It's typical. [laughter] When you leave, yes, I'll have a dozen things.

*Yes. That's OK because what I like to do after an interview is follow up. We'll transcribe it, you can read it, and after that we can talk on the phone or we can correspond, and so we can fill in gaps that occur to you then.*

OK.

*Carol, did you have anything that you specifically wanted to ask?*

**Carol Gerich**: *I just wanted to ask you, Duane, a little bit more about when you were at the test site, how differently Livermore worked versus Los Alamos. . . . Were they very different? I mean they had different places they did the testing. Did you mix with them at all during the testing, or how did it work in terms of those relationships?*

Well, they were two entirely different organizations, of course. And as far as working together, there wasn't any animosity to speak of it, that I detected, except the usual kind when you get a group of people together. But they had different ways of doing things. For example, the sling that we used to pick up the test package with, which had the bomb in it, were entirely different between Los Alamos and Livermore. No reason why we should do that, but we allowed the two labs to do it the way they wanted to do it. And it didn't cost that much and it gave a feeling of individuality to each one of the groups. But in general the two groups got along quite well, I thought, with one another. Oh sure, there were the usual disagreements about how we should do it. But I tried when I had overall responsibility, fine, let each group do it their way unless you could find a *reason* why that particular way wasn't the right way to go.

**Carol Gerich**: *But there was no talking and sharing ideas.*

Oh yes, there was.

**Carol Gerich**: *There was. There was sharing of ideas.*

Oh yes. Oh sure.

**Carol Gerich**: *So if Los Alamos had come up with a better idea for the sling, let's say—*

There was no problem about taking it over and using it.

**Carol Gerich**: *OK, you'd use it.*

Yes.

**Carol Gerich**: *Obviously Mary talked to you about Ruth and Ray, and even our third test wasn't that good. When did we [Livermore]reach parity with Los Alamos in terms of testing? Was it in—?*

In the 1950s.

**Carol Gerich**: *We did in the 1950s.*

Yes, it was actually the fourth test, I guess, where Johnny Foster—well it wasn't the fourth test. The fourth test we took apart and brought home. But then Johnny Foster had an idea that would enable the labs to do a better job on a warhead for a submarine-launched missile. In fact, it was Edward Teller coming to Johnny when we were in the process of designing, and asking him specific questions about size and weight of a warhead and the yield. And Edward then used that on **[00:05:00]** Rickover, of convincing him that, well, that was a good enough warhead for a submarine-launched missile, and gave the order to go ahead before we'd ever tested the thing. And I remember the people in the lab saying, `Edward, what have you done to us?`

**Carol Gerich**: *[Laughter] They said that over the years, often.*

And it turned out that he was wrong in what he had projected and people thought he'd gone way too far. Turned out he hadn't gone far enough. It gave more yield, it was lighter weight than the prediction that Edward had given Rickover to convince him to go ahead and design and build the underwater-launched missile.

**Carol Gerich**: *That must've been, then, the Redwing [Operation Redwing, 1956] test series, I bet. That was in 1956.*

I think so, but don't take my word —

**Carol Gerich**: *But it was more that we started getting better ideas, not that our testing techniques got better. It was that we started having better ideas at Livermore.*

That's right. Yes.

**Carol Gerich**: *OK, now that's clear to me.*

Yes. Well, we tried to stop being quite as *inventive* and stick to what looked like was really possible, and more people were checking and double-checking on things than had originally been the case. And it wasn't so *far out* as far as design of the warhead. It was kind of one of those things, Well, maybe it will work. If it does it'll really be innovative.

**Carol Gerich**: *OK. One last question. Was the role of the engineer different for Los Alamos or Livermore? Did they use the engineers the same way?*

The impression we had was no. But the scientists, I remember thinking and seeing instances of it where if you had a Ph.D. you were essentially God. You understood nobody questioned what you came up with. Of course that isn't the case at Livermore. And it was the scientists who had complete control of things. It appeared that way anyhow for Los Alamos, where it was scientists' ideas, and certainly had the veto power, but the engineers actually designed it.

**Carol Gerich**: *That's helpful. Thank you. That's what I thought. You clarified it for me.*

**Mary Palevsky:** *Just one quick thing, a question that came up when you were answering her question about moving from being so inventive, to looking at what would actually work? When you look back on the first two tests and the reason they didn't produce, are you saying that that was your analysis, that maybe you were trying to do too much on those tests?*

Well, it wasn't too much. It was kind of stepping too far out ahead of the knowledge we had and trusting the theoretical calculations that they would do what we thought they would do, and the didn't. We just didn't understand it well enough.

*Great. So that's a nice way of putting it. Just taking maybe a giant step over something that you needed to check out first.*

And we knew it was a giant step. We were taking a bigger chance. That was what Edward wanted to do and so we went ahead and did it.

*Great. OK. I think we can stop here. It gets tiring to have to sit and remember these things, too, so we'll give it a stop. Thank you very much.*

OK.

**[00:09:05]** End Track 3, Disk 2.

[End of interview]