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

Interview with William Mayer

July 20, 2004
Las Vegas, Nevada

Interview Conducted By
Shannon Applegate

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Produced by:

The Nevada Test Site Oral History Project
Departments of History and Sociology
University of Nevada, Las Vegas, 89154-5020

Director and Editor
Mary Palevsky

Principal Investigators
Robert Futrell, Dept. of Sociology
Andrew Kirk, Dept. of History

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Shannon Applegate*: And now we're recording.*

William Mayer: I was born in Milwaukee, Wisconsin. Went to school there. Got out of high school. Enlisted in the Army. Came back and then, on the GI Bill, I went to college. I went to Marquette University, and in 1960 I got a degree, a Bachelor of Electrical Engineering.

The first job I had was with a small architectural firm, and would do the electrical portion of whatever: banks, churches, schools, that sort of thing. But being a small firm, it just didn't seem like I was being able to get ahead very much. So I found another job with Dow Chemical and spent about a year working there and learning about chemical plants. Then I moved to Cleveland for a couple years and worked for a very large architectural firm. They had about eighty people. And when I was with them, there was an opportunity to go to Sudan. We had a contract with the government to provide architect and engineering help. So I got to spend two months in Khartoum. It was very interesting. I really enjoyed it.

Then I came back and wanted to go into private practice, so I wrote the exam in Ohio, in Michigan, and in Wisconsin. Passed all three, and went back to central Wisconsin and opened up a consulting firm. But there wasn't very much business. At the time, the local junior college was looking for somebody to set up an instrumentation program to train instrument mechanics for the paper mills in that area. So I taught during the day and did my consulting at night. And we set up an instrumentation program, and I wrote some of the manuals and designed some of the equipment. But I wasn't really happy with teaching. If somebody wanted to learn something, that was fine. But if they were in there, like some of them were, merely to avoid the draft and going

to Vietnam, you can't teach them. They don't want to be taught. They just want to avoid the draft.

So anyway, I saw an ad in an engineering magazine, from Holmes and Narver, and sent in my résumé and they invited me out in May of '69 to interview. I interviewed there and they made me a job offer, so July 1, [1969] I went to work at the test site.

And the test site was different to me because there was so much *politics* involved. I had never been in that sort of a situation. And with Holmes and Narver, the fellow that was my boss, who was head of the electrical section, I found out, didn't have a degree in electrical engineering. He had a degree in mechanical engineering. He had gone to work for Bell Labs and found out that only the electricals were getting promoted, so he just decided to be an electrical. Without the training. But he was a great guy. We still talk. But anyway, he got a chance to move over to EGG [EG&G, Edgerton, Germeshausen, and Grier] and work for them. And the problem was—not having been trained in some of the electrical things—he had a hard time on his first job because he *really* didn't know how to do the calculations to come up with what he needed. So the control room at the CP [control point], the calculations for that, were done on my kitchen table. I showed him how to do it.

[00:05:00] And the way Holmes and Narver was set up back then, is they had a group in Mercury that primarily supported the AEC [Atomic Energy Commission] people and their little projects. Then they had a group that supported the Los Alamos people, they had a group that supported the Livermore people, and they had a group that supported DNA [Defense Nuclear Agency] or DoD [Department of Defense] up in the tunnels. I stayed with the group in Mercury that supported AEC people and did their projects. And then budget restraints came along and there wasn't enough money to keep me full time there, so I transferred out and I went to work in

the group that supported Livermore in Area 2. And it's sort of a *strange* relationship. The AEC at that time had two people in Mercury, two electrical engineers. One was power, one was cable communications. They had counterparts downtown that had the same thing, and they were supported by the downtown H&N office.

But the power engineer set me up to do a project—they were doing an event, I believe it was called Scissors—but moving equipment around, you'd have to take it down to get it underneath the power lines. So what I basically did is I designed a little loop that went underneath the road, and we used high voltage cable, and that way you didn't have to take cranes down and all that sort of thing. And that seemed like a very straightforward job, to me. And what I later found out was the high voltage cable actually had been installed in Livermore's area, and then they moved the camp so it sat empty. It was just two poles along the road, with these cables hanging there, not being used. Well, the laboratory feels that that was *their* property because they requested it, they justified it, and it was out of their budget. AEC feels that because they paid for everything, that it was theirs, and they could use it where they wanted. So during the summer, when the electrical engineer from Livermore went on vacation, the AEC man got REECo [Reynolds Electrical and Engineering Company] to take that cable out of there and put it over into this Los Alamos event that was going on. So that was the sort of things that went on.

Did you get caught in the middle?

No, and amazingly, later I went to work for supporting Livermore, and I was with the guy that was on vacation when they stole his cable. But he got even.

He did? How'd he get even?

They needed a building up in Area 12, Livermore needed a building, that they would use, sort of the stage when they did a reentry into the tunnel. And they didn't have one. Well, traditionally,

Los Alamos painted their buildings light green. Livermore painted their buildings a dark blue. So one weekend, the Livermore people got REECo to bring one of these doublewide trailers, and they picked up this Los Alamos building, which was like twelve by forty, hauled it up to Area 12, repainted it dark blue, and put a security fence around it.

So they stole their building. Oh, that's funny!

Oh, yeah. But anyway, I worked as a senior engineer, doing design, and then, in order to get ahead, to get more money, I went into project engineering. Well, that kind of dilutes it because you're trained and you're good in one area. Now, you're going into areas where you **[00:10:00]** got to do surveying and landfill and whole lot of other things. And then beyond that, the only way to get ahead would be to go into management, which I did. And now I can look back and say it's a mistake, because I went into it primarily to get more money, and I don't appreciate management. I don't like having the kind of people problems. Give me a good engineering problem.

And anyway, we had our shortcomings, and some of the—not my boss, but *his* boss, *really* felt I shouldn't have been in management, and I finally got out. And I went to support the Los Alamos people. Well, the Los Alamos people hadn't had an engineer out there for some time. The one they had committed suicide, and then it was just sort of nobody was there. Whatever they needed, they got back from Los Alamos. And the fellow back in Los Alamos and I worked quite well, and he liked my work, so he finally talked the group leader into recreating the position out at the test site, and so I interviewed for that, and it was great. I now got rid of all the people problems and back to doing engineering. And it's the best job I had in my forty years of engineering.

So what would you do, as the Los Alamos engineer? You were the Los Alamos engineer on site at the test site, right?

Right. My job is being responsible for the power systems; that they have adequate power for all the trailers and everything they need. Also for the grounding, which tends to be rather important. We worked out a design so that we had what we call a single point ground. Everything referenced to that one point. And *really*, you got to do that if you're going to do a lot of instrumentation and look at a lot of things. But then I also was responsible for the lightning protection system, and we worked with the weather people down here [Las Vegas]. We actually developed a system whereby we could sit and look on our monitor and watch the lightning storms move across the test site. There was a couple occasions where we would be emplacing a device, going down hole, as we called it, and these storms would come up, and we'd watch it on the monitor. When they got so close, we'd just say, `OK, shut it down,` and we'd back off about fifteen hundred feet and wait, and then we'd go and check the monitor and make sure where the storm was, and then resume with our operations.

And at the beginning when I came in, the high voltage that we ran around to get to these event sites was 4,160. And with power, the further you got to transmit it or get it, the higher you should be with your voltage. So what we found out was at the 4,160, if we had a very long line and the event out at the end, what would happen is the drillers would come in halfway in between and get onto the line. Well, every time they'd stick a drill, there would be such a surge that the event would lose power. And the problem there is when they set up these trailers to do their diagnostics, they have to calibrate each of those scopes, and if you lose power, you lose calibration, which means you spend a lot of overtime with EG&G technicians, recalibrating these things. So we began a program whereby, I redesigned the Los Alamos power system, and we

[00:15:00] went to 12,500 volts, and *only* at the test site will you find power lines laid on the ground. That's against every code in the world, but we did it, and we have some 12,500-volt lines. As much as I could, I wanted them buried, but there were times and places that we couldn't.

Did you have any problems due to that, that it wasn't—?

No. The worst problem I can remember—and it was before I went to work for Los Alamos—they needed a power line and they ordered the cable and laid it out, and then they put up a little wire fence on either side of the cable. Well, during the hot, dry summer, the tumbleweeds would get in between these two fences and get trapped. And they would send laborers in with pitchforks to go and pitch it out. When they ordered the cable, they didn't tell the manufacturer that it was going to lie in the sun. And one of the types of insulation was called crosslinked polyethylene. If you expose that to sun without putting inhibitors in that cable, it will revert back to its previous form, which is methane gas. So you had laborers with pitchforks, and this cable blew up. It was swelling like a snake had swallowed a rabbit. And it's full of methane gas and you've got a sharp pitchfork?

So they punctured it and it blew up?

Luckily, they didn't get it, but—

So what was wrapped around the cable? Is it like a plastic? Because I would think that would crack or—?

No, each conductor has an insulation, and then there's an overall jacket on it.

And then that jacket is more weather proof to heat and all that.

Yeah.

Where did the test site get their power from?

I don't know exactly where it is today. But there used to be a substation up on Durango and Charleston called the Westside Substation, and Nevada Power ran a line from there out to Mercury; another line going through the rural electric group, the power line goes around and goes up to Pahrump. And Pahrump has a line running over into the old NRDS [Nuclear Rocket and Development Station] site. So you got Nevada Power and REA [Rural Electrical Association] power coming into the test site. And the test site main loop, it is a loop, but you got two people coming in. Primarily, the power comes from Nevada Power. And Valley Electric is sort of a backup segment.

So in case something happened with Nevada Power, it's like having a battery on or something.

And originally Nevada Power ran a line out there at 35,000 volts, and that was just too far. Eighty miles is too far for that kind of load. So it was rebuilt to 138,000. And one of the things when I was supporting Livermore is when they would move a drill rig—now, I don't know if you ever saw a picture of what that looked like.

I've seen a big bit of how big those drills are.

But they usually would put three Caterpillar tractors in front, pulling, and three behind, pushing, and they would just skid these rigs to the position where they were going to drill the new hole. Well, if you had this power line in your way, you had to painfully and expensively lower that rig and dismantle it, get it underneath, and put it back up. So one of the other things that I did, like I did for that one event, I designed—it was supposedly going to be an underground **[00:20:00]** crossing, but it didn't turn out that way. But it was a set of structures such that we could turn the power off, detach the wires, skid the rig through, put the wires back up. A lot less effort. I mean one five-man lineman crew, as opposed to a whole bunch of people trying to tip over—I think

drill rigs are about 150 feet tall. But anyway, there are two of those crossings out there that I put in. That was a fun thing.

How long did it take you to come up with that design?

The design wasn't that bad. Getting people to agree to it my original design, I was using a cable and going underground. REECo very much opposed that.

Why?

Well, for one thing, the REECo engineer thought that you'd have to have a vacuum pump for that. He didn't understand that they had come out with new cable that is solid. You don't need the vacuum system. Now, as it turned out, ALCOA, who came out with the cable, it only lasted about two years, and then it went bad. So it was a good thing we didn't do it.

The cable went bad?

Yes. They had numerous failures across the country with it. When you get to that high a voltage, things become very tricky, and little minor flaws start to get at you. And I remember going up in a bucket rig because there was a problem, and somebody had put a nail in a power pole, and that nail was just causing an arc to form.

Just a nail in the actual wood pole itself would have an effect on the—?

Yeah.

I didn't know that.

And so we found the problem, got rid of the nail, and the problem went away. But it was a lot of different little projects that were very interesting, very different.

When you came up with the design for this new way for these drill rigs to cross over power lines, you said—the other engineers—you had to sell that idea.

Yes, you could—DOE [Department of Energy] had asked that this be done, but then we would get together with everybody—the laboratories, DNA, and REECo—and say what we're doing and discuss it. And there was what we called a power management group that had representatives from each group, and I was the Los Alamos representative. And we would get together and discuss problems, which way we were going, things like that.

You'd said that you supported Livermore and then you ended up working for Los Alamos. Was there a big difference in working for the two different labs?

There was a rivalry between those two, and if one does something one way, the other one *must* do it a different way. And once or twice, I'd slip, when I first started, and say, `Well, the way we did it over in Livermore country…` and they'd jump down my throat, `You can't do that.` But the interesting thing is when I was the resident engineer supporting Livermore, I hired a young fellow who came up from the Kennedy Space Center. And his name is also Bill Pittman. He was my electrical engineer, and then I made him my design chief. And then when I got crossways with management, I was going to go to work for Livermore. Well, my boss's boss found out about it and went over and told the Livermore people that I was no good, unreliable. By the time he got through assassinating my character, there was no chance. So I encouraged Bill, my engineer, to take the job. And he did. So even though the labs were opposite and all that kind of rivalry, Bill and I were friends, co-workers, and we shared a lot of things.

Well, that's nice. So you had a comrade on the other side.

[00:25:00] Yes, and we did things quite differently as far as—on one shot the ground motion knocked some things loose, including a power conductor, and it went into the frame of the trailer. Of course, the way they shock-mount these trailers to survive, you end up either putting Plexiglas down, which is an insulator and what Los Alamos uses; you go to Livermore and they

use a Styrofoam, which is an insulator. But anyway, on the reentry, it was a telephone trailer, after the shot, the guy went up to inspect the inside of it, and when he grabbed the door handle, he grabbed 120 volts, and it knocked him down.

Was he OK?

Yes, he was OK. But we looked at designing equipment such that we could see if anything had been electrified that was isolated like that. And Los Alamos had H&N design a set of relays such that on reentry, I would go in with the REECo electrical engineer, and one by one, we would identify each of the trailers and structures and make sure it was OK and restore it to normal. During the actual shot, we would kind of remove this protection so that that trailer floated, which was a requirement for instrumentation. But we could do this from the substations that were *in* the trailer park. Over in Livermore, they had a totally different way of checking the grounding, and they sort of physically ran a harpoon into the ground and then checked against the frame. And it was, to me, a slower, more drawn out method, but both of them accomplished the same thing. It's just that, we have got to do it differently.

So how often would you encounter the Livermore side when you were working at Los Alamos? I mean were you just in two different playing fields?

Yes, we were pretty much—we did have a couple of joint shots. Kearsarge was one of them. And there was a Livermore trailer park and a Los Alamos trailer park, and then off to the side was the Russian trailer park.

Was this during the JVE [Joint Verification Experiment]?

Yes. Bill and I did the reentry; we did mine first and then we did his.

What's the reentry? Is that going back into the trailer?

Yes, after the shot. They'll go back in and get whatever they have record[ed]. In the old days, it used to be pictures that they would mount on a scope, and I think it's probably now CDs [compact discs] or some kind of removable media.

Did you work with the Russian counterpart at all?

Not too much. When they came over, I gave them a couple of lectures on how we grounded and what we did and what our theories were on that. And we had a couple sessions, and make sure that they didn't interfere with us and we didn't interfere with them.

What were your impressions of them?

The workers were OK, but the bosses seemed to be more politically orientated than the actual scientists that were there. If I'd be giving a lecture and answering questions, and we had just the scientists in there, there was one atmosphere. But if the boss walked in, it became very cold, stick strictly to business sort of thing.

When you would talk to them, did they know as much about electrical engineering as you?

Yes.

So it wasn't like they were real far behind in technology or anything?

No.

How was the language barrier, or was there a language barrier?

They had interpreters for some of them, but a lot of them could understand English, so it wasn't **[00:30:00]** that bad. And then the other thing I enjoyed was working with the British.

Did you work on, was it Icehouse?

Icecap?

Icecap. Yeah. You worked on that?

Yes.

So they were fun to work with?

Oh, yeah. And their first shot was with Livermore, when I was supporting Livermore. And then the second shot—and then they started alternating. They'd have one with us [Los Alamos] and one with them. There were some of them that I knew for at least ten years.

So the same people would stick—

Yes, same people would come back, and same trailers, and the interesting thing is somehow they ended up with EG&G designing the trailers along the Livermore line. So it was a little different but with the relationship I had with my counterpart there, there wasn't much to worry about. They were neat people.

So what made them particularly fun?

Just their sense of humor. And there was one poor fellow, I think four times on four different shots, he tried to get data, and he never did. And Icecap was going to be, I think, his last chance, and then President [Geroge H. W.] Bush shut it down.

He would have to be thinking he was cursed after a while. What would they do? Would they come to you and say, We want to record this type of data, and then would you have to make sure that the electrical work could get that, or how would that work?

I never really got into what data they were recording, but their power system in England is not the same as the United States. They tend to use fifty cycle current and we use sixty cycle. And when I say that, you know I'm an old man because in 1958, we stopped saying "cycles" and we started calling it "hertz." But no, we found ways to be very compatible and it worked out well.

So you would just make sure everything was hooked up to this trailer and that it was functioning and that it wouldn't lose power.

Right.

Did you ever have an experience where before a shot you lost power?

Yes.

What was that like?

I'm trying to remember why—we had one where we had an earthquake about three minutes before shot time, but it wasn't that—but something went wrong and we had to go back out there to reestablish the power. And, of course, the EGG technicians, if they can have a chance to redo it, recalibrate—everybody wanted to go back to their trailer and check it. The test director said, `If you're going to do that, then we'll just cancel the shot.` And so we and one small group went back in there and reestablished—and I just can't remember the details. Because we would have a central power station at the back of the trailer part, where we would come in with our 12,500 volts, and then go out to little distribution units at 480 volts. On that big substation, I had a re-closing mechanism such that if that thing tripped, I could then send a signal from the control room to reestablish it.

Automatically or—?

Yeah, we sent out a signal and it would re-close. If it would trip again, then we'd know we definitely had a fault.

You'd mentioned something about lightning. Did you ever have problems with wind out at the test site? With it getting real windy and—?

[00:35:00] Not really. The test site power system was relatively stable to winds. The problem was the feed, from Mercury to Las Vegas, of Nevada Power. And they used a different type of structure, and there were four points coming back, that when you had a strong wind, you probably would lose the power. One of the things I did early on at DOE's request—in a power system you put these protective devices and you want them to open up if there's a fault. But you

want the device closest to the fault to open, not one way down the other end. Well, one of the ways they achieved that is what's called a distance relay, and by how the distance relay is set, it will look and say, oh, that's in my zone. I open up. Or it'll say, that's not in my zone, let the other guy open up. And I did this study which included all the major substations at the site and where their settings were. Also I worked with Nevada Power, and I went back to Texas, to the engineering outfit that designed the line that goes up to Pahrump and over. And came up with essentially a coordination scheme that says, OK, everything's fine, it'll work. *Except* everything wasn't fine. In going through, before I actually got to the test site, they had hired General Electric [GE] and a man by the name of Fisher to do a coordination study. He did the study and presented this paper, along with some recommendations, which pretty much, when I read it, it looked like, get rid of the Westinghouse relays and put in all General Electric, which is impossible because REA uses Westinghouse and we use General Electric. But anyway, when you figure out how to set these distance relays, you have to take into account how that structure—and the geometric relationship of the conductors. Well, at the test site, you have two poles with a cross member and these three conductors hanging down, and you go through and calculate the geometric mean factor, and that determines your settings. Well, in the report that Fisher did, he used the same settings on the test site as he did on the line going back to Las Vegas. Well, Nevada Power uses a single pole and they got what they call a lazy V, and they hang the conductors this way [demonstrating]. So the calculation for that setting would always trip the Westside Station and it would never trip Mercury.

And Mercury was GE?

Yes. And that confused me because I presented this to AEC and I showed them what the problem was, and they were happy, but they didn't do anything.

They didn't fix it?

Not as far as I knew. It never got changed.

So how would they work around that if it would—?

I don't know. AEC [Atomic Energy Commission] was worried that they might get sued for causing somebody an outage here, so they wanted to make sure that *they* weren't at fault. And as it is, if the power dumped, it was always going to be Nevada Power Company's fault.

I didn't even think about that. Was there ever tension between if the test site used up too much energy, that it could cause an outage?

I don't think so, really.

Not the way it's structured, with the grid and everything?

No. And having the second feed in there.

The majority of energy was used during a test, right?

No.

No? When would—oh, you said when drilling was going on. Was that—?

Yes. And see, drilling used to be self-sufficient. They'd have diesel generators. Then we had the oil shortage in the seventies and they said, `Cut back on the diesel and use the` **[00:40:00]** `electric power that's there.` So then, when they did that, then we had the problem with the trailers losing power.

Would there be drilling going on, on some parts of the test site, while a test was going on?

Not while the test is going on. When you have test, basically you shut everything down except that one site. So only the one site is going, so you're not using maximum power. When you *don't* have a test, they'll be ventilating the tunnels with these—I don't know if you've seen these 400

horsepower motors that they ventilate all the tunnels with. You'll have drilling going on. You have all kinds of activity. And that's when you use the most power.

And that's when you have to really watch where people are getting power, because you could cause an outage, right?

But outages were very rare. The chief power dispatcher and I were very good friends and went to the same church and things like that. He was good about making certain that things were very adequate and worked out.

When you worked for Los Alamos, were you the liaison between the test site and the lab? So would you have to work with Reynolds Electric people and—?

And H&N people.

Was that difficult at all?

No.

No? So I'm just trying to get a better understanding of what your job actually was. Would the lab say we need you to do this project, or they would come up with a problem and you'd have to solve it?

I would look and see what we needed to do, and do it. And that's what made the job so wonderful. And, you know, I was the only electrical they had for a long time. So yeah, we'd determine that we're going to have an event here and we need power, and I would get out a drawing of how that power line would be routed, put in there. We'd work up maintenance schedule sheets and go through maintenance on all the generators and all the equipment. Every piece of electrical equipment had a worksheet, a maintenance worksheet, and we checked it off each and every event. And there really just weren't many problems.

And that equipment belonged to Los Alamos.

It was *assigned* to Los Alamos. Now, technically, everything at the test site belongs to AEC or DOE. Their money bought it. But yeah, the equipment for Los Alamos and Livermore is different, but it was both bought by DOE and then just assigned to those laboratories for their use.

Did you have a preference on who you enjoyed working for, Livermore or Los Alamos?

I enjoyed Los Alamos.

You did? What reason?

Well, for Los Alamos, I was *the* electrical engineer. Livermore always had two engineers working their events. One would be a civil and one would be an electrical.

One would be—what was the first one you said?

A civil.

What's that?

Oh, dirt, bridges, dams.

I see. Civil engineer. I got it.

So every event, and there must've been, I think, about five teams, so there would be five electrical engineers. Plus the one that didn't worry about events worried about all the other stuff. And see, this way I could worry about everything.

Sounds like you got to do more.

Oh, yeah.

Well, I have a question about—you said you joined the Army originally?

Yes.

When did you join the Army?

August of ’52. And I got out August of ’54. Spent about five months in California, at Camp **[00:45:00]** Roberts, and about another five months down in Fort Benning, which is just outside of Columbus, Georgia, and then thirteen months in Korea.

And what did you—where were—?

I was a radio repairman.

And so would you repair the radios on the bases or…?

I didn’t get to do much repair. It was more maintenance, and if you really needed a repair, you sent it to a facility somewhere back there. But we kept the radios going. We had little generators that broke down. Those things used to be a maintenance headache. They’d run for about four hours and then they’d plug up on the exhaust, and you’d have to disassemble them and clean it all out and put it back.

And then how were you able to go to Sudan? Again, you said you went there for about two months?

The firm in Cleveland had a contract under the USAID program, and they had two engineers and two architects that went to Sudan as part of a permanent party. But then they also agreed to the government that they would furnish a mechanical on occasion and an electrical on occasion. And I was the newest member of the firm there, but the oldest guy had just gotten back from a trip to Liberia. The humidity there is so bad that when you get back, you throw all your clothes away. And he didn’t want to go. And the next guy said, `Well, my wife can’t drive. She’ll starve to death.` So *he* didn’t want to go. And just somehow I lucked out that I got a chance to go to Africa.

Part of the government program said once you start going to your site, you’ve got forty-eight hours to get there. So we had a plan where I would fly from New York to Rome, Rome to

Athens, Athens to Cairo, Cairo to Khartoum. But they couldn't get a confirmation. And since you only had forty-eight hours, the alternate plan took me down to South America and across. But at the last moment, they got the confirmation and we went like that.

And it was a hectic time because Labor Day, September 1, I went to a ball game and my eight-year-old daughter got sick. And we didn't know what was wrong. And Tuesday, I went back to work and the wife tried to find a doctor for her. Well, she had an appendix that turned gangrenous, and she was in the hospital for twenty-eight days. And she got out like the twenty-eight, twenty-ninth of September, and we took her to the airport, put her on a plane, and she flew to Milwaukee, which is less than an hour's flight, while we drove. Picked her up in Milwaukee and went up to the farm in central Wisconsin. Dropped her off. Turned around and went back to Chicago, got on a plane. And it was just a lot of driving.

What year was that?

Nineteen sixty-four.

So your wife got to go with you?

No.

No. She drove you back so that you—

She drove me down to Chicago to catch the plane. But the good thing was, coming back from your job, the government said you got all the time in the world, so we left Khartoum and spent overnight in Cairo and climbed the pyramids and went to a couple of shops. Somewhere I got a picture of me, in front of the Sphinx, on a camel. And then went up to Athens, and my wife met me in Rome. And another strange thing is the week before she was coming over, the airline flew **[00:50:00]** into the mountain. The traffic controllers in Rome don't even tell you there's a cross wind or anything. It's the pilot. And they had a new pilot, and the cross wind got him at the end

of Fiumicino and into the mountain. So they decided then that they would make the pilots fly to the alternate airport. And the mechanical was Frank and I were going from Athens to Rome, *we* didn't know *which* airport, *where* our wives would be. But anyway, I went to Fiumicino and he went to Ciampino, and as it turned out, my wife came there and his wife came there.

So you got lucky.

Yeah.

When you were in Sudan, what did you do?

Basically wrote a set of codes. They really didn't have an electric code that the contractors could follow. So I wrote one, based on the English way of doing things. Here, an architect or an engineer will do plans and specifications, and the specifications tell you the quality, quantity, and that sort of thing. English-wise, you don't have specifications. You have provide-and-fix, and every paragraph starts out with P and F. And then we'd just put in a bunch of rules. Construction in the Sudan is very strange. They pick a site, say, for a school. The first thing, they go out and they'll bring in a drilling crew and drill a well. And that well has to produce so much water. If it doesn't, they abandon the project. But if you get one that builds so much water, then you go out and you build the wall around the outside of the building. Then you build the building and you build the quarters, because the teachers live within the compound. But what will happen is the general contractor will come in and do his cement work and all that sort of thing, and the general will paint the walls. Then the mechanical will come in and install his heating and ventilating equipment, tear up the walls, and then paint them over again. And then the plumber will come in and install the pipes, tear up the walls, paint them over. And electrical is last. And they come in, tear up the walls a little bit, and paint it over.

So it's just not a real efficient way of getting something built.

And the housing—a senior teacher gets a three-room house and three electrical outlets.

In a three-room house?

Yeah. The middle teacher gets two rooms and two outlets. And the junior gets two rooms and one outlet. And that was the way they'd been doing it for years, and you couldn't change it.

Even if you wanted to add more outlets, they weren't going to have it?

Yeah. But my question was, what three things does the senior plug in? Couldn't come up with an answer.

Status, right? That he has the three outlets. The other thing I was going to ask you was, you had said that you had these cables out at the test site and they were above ground and you would've preferred that they were underground. Why weren't they placed underground?

There's an argument, and I know it happened, but if you'd buried a cable, *invariably* somebody would come along and drill a hole and drill into the cable. The other thing is that if you bury a cable and you have an event, the ground motion will—. So the way I had them buried is it was a very *wide* trench, and then we would take sand, fill up a cement mixer, take the sand, and drive down and lay a bed, then lay the cables on it, then back again with more sand. And that **[00:55:00]** thing was, oh, four or five feet wide. But what we were trying to do was avoid having rocks next to that cable because *that*, during a ground motion, would probably injure the cable. And I don't recall from the time we started doing that, after we had the new system, that we ever lost an underground cable. Now, I've had cables lost *in* the trailer park. That was the dumbest thing I ever heard of. The electrician superintendent that ran his cable out, the cable was too short, so he put a splice in it for the last seventy-five feet. Well, when the event went off and we had the ground motion, the splice broke. If he'd have been thinking, he'd have put the cable and the splice back at the other end, where there wasn't going to be ground motion.

But he had probably already laid it. He didn't know that it was short. How long would you have to set up the trailer area if an event was…?

Probably from the time we start till the event would be like three or four months. Now, *some* events—now, I spent well over a year in Ledoux, which was an underground shaft. Very interesting. Got to do a lot of good shielding down in that one for the cables.

What kind of shielding did you come up with?

In the main room, we put a trench down and then put the scientific cables, the coaxial and that sort of thing, down. And then I put steel shot, which would give me a magnetic shield, and then lead shot for the radiation shield, and then we put steel plate over the top of the little cove that we had.

How'd you come up with that?

I don't know.

I guess I took enough courses that—and it was effective. None of the scientific people ever informed me of having lost data because there were eruptions.

Frankie Lou Mayer: Have you told her of the book you wrote?

No.

You wrote a book?

I wrote a thesis on grounding to get my master's degree.

Where'd you get your master's?

Columbia Pacific.

How long did it take for you to do your thesis?

Oh, I'd work on it and then I'd work a little more. It probably took me well over a year. And there were other courses that I had to take. Columbia Pacific is run by an M.D. He has a doctor's

degree from Harvard Medical School, but he can make more money as president of the university. But he pushes holistic things, and so I took a bunch of those. But they gave me credit for all the conferences and seminars and things like I'd done for—now, let's see, graduated in '60, so I probably had thirty years' worth of going to different meetings and seminars.

So is that how you kept up to date with new things, is that—?

Right.

Would the test site send you out?

Yes, I went out both from Holmes and Narver and from Los Alamos.

You'd go to different seminars and—?

Yes.

Would they have like certification training? I know that with computers, everything changes so much that you have your basic degree, but then you get certified on other technologies.

They didn't have it *then*, but they did give you something which essentially said you had so many hours of training. And if I was going to keep my professional license, I would have to have thirty hours of training every two years.

So that's how you stay licensed.

Right.

[01:00:00] *That's how that works. It's not like you just take classes on being an electrician and then you're an electrician forever. You've got to keep that going.*

Right.

Oh, all right. You did try to do private consulting, you said?

Yes.

Did you like working for the test site better, or did you like the consulting?

I liked the test site. Liked Los Alamos much better.

Why?

Uusually, I would consult *to* the architect who would get the project. On one project I laid out the school, and it was a Catholic high school, and then the archdiocese said, `We don't have the money. We're not going to build it.` Well, if they don't build it, then you don't get your fee.

So you did all that work for nothing.

Yeah. And I had one kind of kooky architect that he designed one building and I did all the electrical, and then he decided he didn't want to design it that way, so he re-did the whole thing, so I ended up designing twice. And Los Alamos is just so much better.

Were you more of a collaborator with the architect at Los Alamos?

I don't follow that—

Would the Los Alamos architect ask your opinion on things, or I mean would you have input into how a particular event was structured?

You really don't have architects. They're all engineers, and mostly they're civil. But no, they would just tell me we're going to have this trailer with this many cables, and that's it.

And then you did it.

And then I'd go over to my drafting machine and I'd lay out all these trailers and draw in all the feeds and all the grounds, give it to REECo, and say, `Build it.`

So it was real straightforward, with not many changes?

No, and generally if a trailer is used in one configuration, it stays that configuration, and that's what made drafting so easy, is we could make the little templates for these trailers and then you just pick them up and plunk them down and connect the dots. It was good.

Now, did you drive out to the test site, or did you take the bus?

Both.

You did both. How long did you drive?

It takes me a little over two hours. My preference is to get on the bus. But a lot of times I couldn't get my work done in time, so then I would drive in at night with a government vehicle and drive back out the next day. Or if it was *too* late, I'd just go down, get a dorm room, go over to the Steakhouse, have a great meal, and stay overnight. But that left her [referring to his wife] alone, so that's when I bought my first dog.

To be the protector?

And something for her to have at night, I guess.

When you were working, how many hours would you work a week? It sounds like you put in a lot of time.

We tended to work more than forty hours. It was a little strange because the people back in Los Alamos, if they worked overtime, they didn't get paid for it. They were salaried. We were salaried, but if we worked overtime, we could work up to ten hours overtime and be paid for it.

So that was even you, as a Los Alamos employee.

Yes. So when I had to, I had to. When I didn't, head for home.

And how long did you work at the test site?

I worked thirteen years for Holmes and Narver and eleven plus for Los Alamos.

And all that time was spent out at the test site.

Yeah. Well, two months weren't.

Oh. Where were those two months?

When I was with Holmes and Narver, Livermore was short in their plant engineering section, so **[01:05:00]** I got lent out, and I spent two months living in motels up in Livermore.

But for the most part—. Did the commute ever drive you crazy?

No.

How was the road? I've heard a lot of people call it the Widowmaker and that it was a real tough road.

Yeah, that was prior to '69 when I came. When I came, it was four lanes divided already.

Would you ever have to go out to the forward areas, or were you mostly in Mercury?

When I was supporting Livermore, I was in Area 2, way forward. When I worked for Los Alamos, I was in Area 3, and that's forward. They're all beyond the control point.

So you would drive an hour out to the test site and then another hour once you got there, pretty much.

Say that again, now.

Well, you'd drive an hour from Vegas to Mercury, and then would it take you another hour to get out to your area?

Yeah, sometimes.

And you'd have to take your own lunch, I would think. Was there a cafeteria out there?

There is a cafeteria at the control point. We ate there. When I was with Livermore, we went up to Area 12 and ate.

[Discussion of the commute to NTS during break] H&R Block and I did income tax for about three years. But I had people come in that worked in Area 12, and of course, the union people couldn't ride the bus, so they'd get a van and take four or five people out, and then this guy showed me his receipts for gas, and he would put 45,000 miles on a car in one year.

I wanted to ask you, too, from all of my interviews, it seems like that it was a real tight knit group out there, that people enjoyed the work and enjoyed who they worked with, and that was your impression, too?

Yes.

So you liked all the guys that—? Did you build this strong friendship from what you were working on? Because there just seems like that there was such a camaraderie that is quite unique.

Yeah, it is. There was something special that you're one of the group sort of thing, and it was very enjoyable. Tight knit and tightlipped. And that was sort of a thing that you never gave more information than what you absolutely had to, and you hoarded information. And that was something that I had to get used to at first.

Because that's not normal in other situations.

No.

I know that you didn't work for REECo, but were you ever aware of labor issues or anything that was going on at the test site with workers?

Oh, yeah.

What were your impressions of that? Did you have any?

I don't know. I went—there was a couple strikes where they'd be picketing out there and stuff like that. The last one I remember, they simply took the non-union people and put them to work. And the thing was that if we were having a strike, we were going to get an event off, just to show you we could do it. And I'd seen people that usually sit behind a desk and they're doing strange things, like running a backhoe. I remember one strike, I was out there, and one of these giant water trucks, I looked up to see who was driving it and here it was the head power dispatcher.

`Fred, what are you doing up there?`

Did you ever encounter any protesters?

Yeah, they were marching out there and they'd try to stop the buses, and I thought some of them were particularly stupid because if they got run over, I couldn't care that much, but they had their kids with them. And you see a five-or-six-year-old kid, he's got no place being out in the desert to begin with.

Right, especially for something that he doesn't know. And then when you started working there, you said it was a political environment. What did you mean by that?

Oh, just everybody had their own little empire that they wanted, and it was something I was not used to. You know, here's a problem or here's something that needs to have electrical work done, do it and get it over with. And you couldn't just be straightforward. And I'm kind of naïve. I think everybody is being honest and telling me the truth and they don't mean something other than what they say. And it was kind of hard getting adjusted to that.

And was that due to the fact that there were different groups vying for resources or…?

Yeah. The Los Alamos Area 3 was known as Bonneyville. **[00:05:00]** And Bonney was the REECo manager of that area. And he absolutely insisted on knowing every person that was in his area. And he had a little spy network, and, `What are you guys doing out there?`

Right. So it was definitely when they say "areas," it was "areas" for a reason.

Yeah.

Did you keep in tune with politics? Did you ever feel budget [constraints] due to the different presidential administration that was in power, would you really feel it on the test site, as far as cutbacks or spending?

We would have a budget meeting—well, we'd have it like every month, and I would come out and we'd sit down and look at where we are and if we got money to buy something, buy it, and if

we don't where do we cut back, that sort of thing. But then, there would be projects that we would write up a proposal, write up a justification, and then try to get them included into the budgets. They were—build like new dorms and all sorts of things. And one that I did, the substation in Area 3, they put in a drill hole relatively close, and the drill hole was 1500 feet. At that depth, that would be a pretty good size test that they were going to do, and based on what I would assume would be the yield of that test, I could predict major damage to that substation. And the substation would have to be energized to get the event off. And so there'd be no way to shut it down, do the event, and then turn it back on. So anyway, based on that, we wrote up a justification for building a new substation, and it didn't get into the first budget. Somebody got a dormitory and somebody got a new crane. But it stayed in the system, and eventually it got into the budget and got funded. Now, that's a problem. That substation probably ran between ten and twelve million dollars. The hole in the substation that would've been damaged went away when we stopped testing. The new substation was built four years *after* we stopped testing. But once you get a government budget going and things identified and justified, you can't shut them off.

You can't stop it once it's in there. I had no idea.

If you ever do it once, then, you know. And even back—I forgot if that was Nixon or somewhere back there, they came out with an idea called zero-based budgeting. So instead of taking this year's budget and then adding on what you need, you go back and re-justify the entire program every year. It took us about two years to figure out how to get around all that. But once something is proposed and agreed to, you can't suddenly say, well no, I don't want that anymore, because you've lost faith.

Right. Because then they're going to question everything else you send down the pipe.

Right.

So was that difficult to figure out how to work with the budgeting system?

No.

No? Was it a pain, or that was just how you had to work it?

It's just part of the job.

That's interesting. When you started working there, what were your opinions about nuclear energy or weapons testing at the time, or did you have any?

I really didn't have an opinion at the beginning. The longer I was there, the more I was in favor of it because it wasn't just the tests, but we were learning other things. For instance, I think **[00:10:00]** Elmer [Sowder] mentioned directional drilling. If you take a drill rig and put hydraulic jacks on the corners, and you raise it up this way [demonstrating], the drill will go that way. So they really developed directional drilling. Up on the north slope of Alaska, the oil companies would go to sink one hole, and then go in directionally and hit pockets, so you didn't drill twenty wells; you drilled one and did these little directionals. So it's an efficiency to the oil industry. And there are so many spin-offs that came off of things that we learned and developed and shared. And so I was glad that I was a part of it.

Do you have an opinion on Yucca Mountain at all?

Yeah. I have an attitude, and it's shared by several of us. DOE is self-defeating, and if anybody shuts down Yucca Mountain, it'll be DOE. And they're talking now that, you know, 10,000 years isn't long enough. Just realize that 2,000 years ago, English wasn't a language. And now they want signs, that'll last for 10,000 years, warning people what's there. In ten thousand years, what is the language going to be?

Right. I heard an article on NPR [National Public Radio] that they were saying that they had to have, what is that, the unilanguage that anybody could read, and somebody brought up the point

that, well, if they're intelligent enough to be able to drill into a mountain, you'd think that they would be able to know what's in the mountain.

The thing is, you have the Nevada Test Site here. It's got over nine hundred holes where we put nuclear devices down and detonated them, and the debris is down there. That's a dump. We have Beatty over here. During the seventies and eighties, every electric company that couldn't clean up their equipment that had the fire proof pyrenol oils in it sent that contaminated stuff to Beatty, and it's piled up. Beatty is 3,500 feet. It's over a 100 degrees in the summer. It snows in winter. And being at 3,500, if this contaminated oil gets into the ground, does water run uphill or downhill? Las Vegas is at 2,500. It's a 1,000-foot drop. So there's the Beatty dump and there's the Nevada Test Site dump. Now, somebody wants me to get worried about the one in between, which it's concrete, it's got steel jackets. Neither of these things have anything. So I feel it's a political issue. It was started by Senator [Richard] Bryan, and he had these pictures of him and his family sitting out there in the desert. In twenty-five years of riding the bus, I never saw a black Cadillac with license plate 1 parked anywhere, or anybody picnicking out there. So I think it's the only place that we can contain that waste, and certainly putting it in one place is a lot better than having it scattered and trying to protect a hundred sites. And it doesn't bother me. I think it's a good idea, but I think DOE will defeat itself, or whatever they're calling themselves today. I don't even remember the initials. It's something—they've gone beyond Department of Energy, and it's the Nuclear Something-or-other.

I can't remember.

[Showing memorabilia] When you start out, it'll say Atomic Energy Commission.

Oh, that's great. So this is your old badge?

Yep. And then they went to the Energy Research and Development [Administration] [ERDA].

Oh, wow.

And, of course, they go to the Department of Energy.

The progression of the badges.

[00:15:00] And when I was on loan to Livermore, I was like that [showing another badge].

These are great. What was your clearance?

Q.

You had a Q-clearance. Oh, there, there they are. Oh, these are great.

And then after I retired, I went and did some things. They recorded a history of how we did things, so as a consultant, I had that. And to figure out how to have the electrical equipment go through the ground motion, the shock. We decided that the people down at NASA [National Aeronautics and Space Administration], when that rocket takes off, must get all kinds of shock waves. So anyway, we went down to NASA, and in the vertical assembly building, there are different areas, and you have to be authorized for the area that you're in.

And so the days that are open, those are the days you can—well, what does that mean?

No. There's a physical area inside the building, and this is Area 17 and—

So these were the areas you were allowed in.

That I was allowed in.

That's interesting. So the area thing is just pervasive throughout our government.

Yeah. And it's interesting that all of these are Department of Energy Nevada, but the last one I got is Albuquerque.

Why is that Albuquerque?

I don't know. Unless it was requested through Los Alamos, which would work out of there.

They're getting fancier with their badges. That is interesting. Now, I was going to ask you one more thing, and now I can't remember what I was going to—is there anything else that you can think of?

Well, one thing that I thought was kind of a neat, fun thing on the side, for each and every event, somebody back at the laboratory would come up with a patch for that event.

These are great! So you would get a patch for every event you worked on?

Right. And then a couple of the fellows in our group, once we'd get the patch, they'd go down to an embroiderer here and have hats made, and we had caps for every event.

I've seen some of the hats, and I've seen some of the certificates.

I've got a big box.

Do you have all the hats? These are terrific. Could I scan these and have these for our—?

Sure.

I'll give them back. But I could use the scanner and scan them in. Because these are terrific. Same with your badges. Would that be OK?

OK. Yeah.

That's great. So was Ledoux the name of a [shot]?

Yes. I believe it means "pretty woman" in some language. Besides having the fun of the shielding, that was a shaft that was dug, and it's sixteen by thirty-two. Half of it is elevated; the other half is what we lowered down into it. But down at about 960 feet, we ran a shaft to put Ledoux in. And it was very complex. It had hardware and stuff in there that I've never seen before. And we came up with a whole new operating system. We got ready, and they put the device in there, did the backup, and started filling up the shaft. And when they got completely

filled, something failed down in there. So we dug a second shaft all the way around it and came into the instrument room and they fixed whatever went wrong, and then we shot it.

Oh! That's scary. Because the device is in there. And when you're saying they filled it, you're talking about the second—wasn't there like a second tunnel that they'd have to fill with concrete? Is that what you're talking about?

[00:20:00] There was no concrete in that shaft. It was dug into the sand and we had steel sets in the wooden boards. But then when they built it, it was filled with sand, and we had some plugs in there that we pumped in. But then we had to do the second one and fill the second one back up, and that's why the event took so long.

How long did it take?

Well over a year.

Oh, really? Why was that one so much more complicated?

I'm going to say that—I don't want to explain what that event was. It was complicated, but they proved what they wanted to.

Well, that's interesting. When you were on the test site itself, were you ever concerned about radiation or safety or—?

No.

No? Felt real safe?

My film badge always came back good except for one time. And the one time it came back with a reading on it, I had gone over to the Holmes and Narver home office in Anaheim. Landed—it wasn't Los Angeles airport; it was one to the south. But anyway, I had my badge in my suitcase, or handbag, and they ran that thing through a Pickering Model 1 X-ray machine, and that's what was on the badge. So the only radiation that I ever recorded didn't come from the test site.

And when we were rebuilding the system, we put out bids for transformers, and there was a company in West Virginia that got the bid. And I went back there, and they asked me about, `Well, aren't you scared out there, with that radiation?` And my answer was, `I'm more scared to go to the grocery store on Saturday, seeing these idiots driver over speed bumps with a cell phone, than I am about anything out there.`

And I was on Midas Myth/Milagro, and that was the tunnel that collapsed. In every job where *I* was in control, I never had anybody killed, hurt, major loss of equipment. The worst accident that I can remember is there was an apprentice lineman and she was up on the pole and when the took the tension off—they were putting in a fiber optic cable, *in* with the power cable—when she released that one clamp, the thing flipped around and it cut her in the lip. That's the worst I've seen. On Milagro, I didn't know that there was an entire reentry party ahead of *my* reentry party. And of course, I'm supposed to get there first and make sure you don't get electrocuted when you grab these things. When I got there, the first party was up on these platforms and making measurements and doing all kinds of things. And I was standing there, watching them. There's always a worry that radiation can come up some of these cables, even with the gas blocks in them. So anyway, on that event, they had electricians working over the cable hole, and they were cutting the cables and dipping them into a sulfur compound, which would seal it. And we were watching that, and then I got a call and it was from somebody at the CP who called and said that the fire alarm was going off in one of the buildings. And I says, `How can the fire alarm go off when we've got everything disconnected?` Well, they forgot to tell us that they had a separate line for the fire department that wasn't disconnected. So anyway, in the time it took me to walk over to where the phone was and get back, that's when it collapsed. And I and the REECo electrical got knocked down, but that was **[00:25:00]** it. But my

foreman on that job was right at ground zero, and he's the only person killed as a direct result of a test. But DoD was in charge. And incidentally, that was Elmer Sowder's first tunnel shot. He was the test director.

Oh, really? Why did the tunnel collapse? Did they ever…?

They just determined that it was normal, and it should have been deeper, or something like that. DOE reports are something that I can't read and understand what they say. When I was out supporting Livermore, we had a shot named Baneberry. And that was fun. It was a Friday, it was the day of the Christmas party, and we were going to be paid. And the paychecks went out to the safe on Thursday. Friday they shot it, Baneberry went up. Nobody could get into the area.

Oh, so you couldn't get your paycheck.

They reissued, and distributed them at the Christmas party. But I read the Baneberry report, and DOE will write it and take a swipe and say, `REECo did this wrong. F&S did this wrong. Holmes and Narver did that wrong.` Never once did DOE do anything wrong. And it's not a smooth discussion of what happened. It's punching, back and forth, different people.

Besides Baneberry, I was also on Peninsula [October 1975], which is the one where Livermore put the wrong size bolts and it dropped. And I forgot what the third disaster was. Oh, they didn't grade the ground zero right, and on the weekend, there was a very heavy downpour, rain. And the Wackenhut guard reported that he saw a river of water running and going into the hole. Well, all the water, and some of the looseness of the thing, it was too much weight, and it tore the bomb loose from the cables.

What test was that?

I forgot the name of it. But luckily, we were in a steel liner, so they lowered a guy—and they had already poured this epoxy plug to seal. Cut a hole in the plug, sent a guy underneath, reattached the two wires that they needed, and then detonated the device. But they lost all the information.

Livermore had three major disasters. And the last one took the head of the mechanical engineering department. I don't know where he got transferred, but he was never heard from again.

So he was sent away?

Yeah.

When the tunnel collapsed, would you have been close to that? Are you saying you got that phone call and that got you out?

That got me out of the way.

So that was luck that—

Yep. The only unlucky thing is one of the guys was injured. And we were carrying him on a stretcher towards the helicopter, and I was at the back end and I had one hand on the stretcher and the other one I was holding the IV for the guy. Nobody said a word, and there was a fissure in the ground, and I walked *whoomp!* And the medic behind me grabbed the IV. So I ended up getting a little scrape on my leg, and that was the extent of my injury.

Were they digging people out? How did—?

People weren't really buried. It just dropped. It dropped about like fifteen feet. And people had back injuries. The one electrician I saw went into shock and just turned white. We put the pressure suit on him, and that's when they found out that suit must've been twenty years old. The medics found out that they had bandages that were so old and they never got used. But no, I lucked out a number of times.

[00:30:00] *So did that ever make you nervous? Did it make you nervous on your next test?*

No. And in fact, the next week, I forced myself and went back into the tunnel.

Did a lot of people quit or—?

Not that I know of. The only emotional one I know of was on Peninsula. The crane operator, when that bomb dropped, that was the last day he ever operated a crane. He wouldn't go near it.

About DOE. One of the tunnel shots, we needed a generator down in the tunnel, and we just automatically assumed that it would be destroyed with the shot. Well, it turns out it wasn't. One rock hit the side and there was a little paint scrape. But now we've got a generator that, as far as inventory says, it's destroyed. And for years, I had a spare generator that wasn't on an inventory.

Didn't exist. And would you try and reclassify it or no?

No. Don't disturb it.

Well, that's interesting.

[Looking through memorabilia]

Yeah, that was us, Livermore, and the Russians.

So that's during JVE. Now, who designed these? [Certificates]

People back at the lab.

Oh, this was Kearsarge. Did Livermore come up with patches and things, or did they do their own thing?

I don't remember.

That is interesting. This is great, if I can get these scanned in. This is terrific.

Frankie Lou Mayer: —the above ground testing, and they would ask us not to look in that direction, at the mushroom cloud. Why, I don't know, but we looked anyway.

Yeah, I've talked to a lot of people that witnessed the atmospheric tests and how interesting that was. Well, thank you. That's perfect. Well, is there anything else that you can think of?

No.

OK.

[End of interview]