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

Interview with John F. Campbell

January 31, 2006
Las Vegas, Nevada

Interview Conducted By
Charlie Deitrich

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The material in the *Nevada Test Site Oral History Project* archive is based upon work supported by the U.S. Dept. of Energy under award number DEFG52-03NV99203 and the U.S. Dept. of Education under award number P116Z040093.

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[00:00:00] Begin Track 2, Disc 1.

Charlie Deitrich: *I just wanted first of all to say thanks, and you're going to run us basically through the beginning to the end of an event, the Distant Zenith event [0919/1991].*

John Campbell: [A] nuclear test, the nuclear weapons test, and it was for Defense Nuclear Agency [DNA] which was a DoD, Department of Defense [test], and that's where our funding came through. And I worked for Reynolds Electric and Engineering [REECo] and their parent company was EG&G [Edgerton, Germeshausen, and Grier], and Reynolds Electric and Engineering did forty years of support of nuclear testing on the [Nevada] test site. Then I worked out there till 1994 when the moratorium shut us down or limited—the test ban treaty shut us down.

First they would acquire the funding and then you would have a Containment [Evaluation] Panel that would meet. They were usually a group of scientists that would determine what yield the device would be, how big it was going to be, and then what part of the mountain or real estate that we would drive the tunnel under to get the most overburden for containment. Overburden is the amount of earth above ground zero, see, because we're driving this portal, portal being the entrance to a tunnel, back into a mountain called Rainier Mesa. It was Area 12, Rainier Mesa, P Tunnel, "Papa Tunnel," P Tunnel, and the event was code-named Distant Zenith.

Let me ask you, as far as the funding goes, and I don't know how familiar you are with this, but does the idea for a test come first or does the money come first and how the money's going to be spent comes later?

Usually they had programs, and programs would entail several different tests to prove this type of device, or maybe they wanted a bigger yield, a lot of those determined the yield, and then the effects upon electricity, radar. They tested for everything. Communications. At one time they even hung a nuclear device and missile that was taken off of a Russian submarine off of Hawaii with the *Glomar* [*Explorer*], the Hughes undersea mining venture that they disguised as undersea mining. But what they did, they went off the coast of Hawaii, I don't know, several hundred miles and set up and reached down into the ocean and picked onto this nuclear sub that still had Russian people aboard and nuclear weapons, and pulled it right up into the bay of this huge ship. And they took that missile and took it to the test site in T Tunnel. And Mint Leaf would be—I'm guessing at this. It was in Mint Leaf, the code of the test [05/05/1970]. And I think that was T-02—Tunnel, 02 Drift in T Tunnel [actually 01 drift]. And they hung that whole missile inside of this line-of-sight pipe which was a test chamber, and exposed it to that flash of light that comes from a detonation, a nuclear device. All they want is more or less the flash of light.

I got you. "The shine," right, is that what it was called?

The shine. Yeah. And then as soon as the device—well, seconds after it's detonated, nanoseconds really, the closures start happening [slapping hands together rapidly], and that's inside of the line-of-sight pipe, they have closures that are built to contain the gases and any debris or anything that might come down the line-of-sight pipe. Test chambers.

But first they would establish the funding and then they would have the meetings and find out where, through core drilling and through surface drilling and through geology, they would determine where ground zero was going to be, and that had to be in such an area where **[00:05:00]** there was, oh, a minimum of somewhere around between 700 and 1,000 feet of earth above the event.

And that would be overburden?

That's what we would call overburden. And there were so many acronyms from the test site that most people look at you like, whoa, what kind of language is he speaking? Because all of them, they were acronyms and names for things that—we even invented names because there was no name for them, for the tasks and what we did and how we did it.

And the decision as to where to do the test would be based on the size of the test, is that right?

Yes. And that would be done by what they call a Containment committee. There'd be a panel of several of the scientists. In fact, Dr. Jim Carothers, I believe he was the chair of the Containment [Evaluation] Panel for many years. And they would try to portray a synopsis of worst case, what would happen here if it's this big, how are we going to do this and do that, and they all had to be reasonably sure that they could contain this device before we ever started going to driving the tunnel.

And then we would drive, oh, let's see if I can read this here, tunneling, there was about 4,400, say 4,500 feet of tunnels that would be driven for this particular event. Each event would take somewhere in the neighborhood of about four to five thousand foot of tunnel driving, of different sizes. They weren't all the same size. We'd start out somewhere around an eighteen-by-eighteen or a sixteen-by-sixteen heading and as we advanced the tunnel, we would mine for containment plugs. There had to be huge concrete plugs inserted into the mountain that we could get access in and out with our tunnel trains and locomotives. They were all twenty-ton diesel locomotives that would pull the mine cars for hauling the concrete underground and the debris or muck, we'll call it, outside.

OK. Now the portal already exists?

Well, we would have to mine the portal in the beginning, but they would do that—from the portal to the nearest test bed was somewhere in the neighborhood of 2,500 feet to about 3,000 feet, and then we would start what they call Y-off or branch-off with a test over here and one up there and one over here.

And so you'd be able to get several tests out of one?

Several. In one case, at N Tunnel, we even used the same drift, the same line-of-sight pipe. All they did was bring the ground zero closer to the portal, or closer to the entrance of the tunnel. I think the Miners Iron and Diablo Hawk, those two, they used the same test chambers, line-of-sight pipe, and all that stuff. Ground zero was, say, at seven or eight thousand foot from the portal. The next ground zero would have been probably 1,800 foot to 2,000 foot closer. Because the earth wasn't disturbed very much, the ground fall and the damage from the previous test was more or less contained back there, see.

And does ground fall mean—?

Cave-in.

So that's actually a word that means what it sounds like.

Right. Ground fall. It's a cave-in. Yes.

And so is P a tunnel or a portal?

P is the tunnel. They had several tunnels. In early days they had A Tunnel, B Tunnel, G Tunnel, E Tunnel, T Tunnel, I said N Tunnel, and then P Tunnel. P Tunnel was the latest, and that's the one that they keep in readiness today, if they were to go back testing. That was one of the requirements of the moratorium, that we could stay in readiness, and so there's a test bed already mined. All they have to do is start to field the line-of-sight pipe and the experiments for the scientists.

[00:10:00] *And that's P Tunnel that's [overlapping voices].*

That's right, P Tunnel, yeah.

I think the way it's worded now is it has to be ready to go within, what, two years, is that right?

They give us somewhere about two years before, and now they want to cut that in half.

I read that, too.

Yeah, they wanted to cut that in half, and so they've tasked all these engineers in the think tank to cut that in half. It's going to be tough. I guess they can do it, but they're going to have to do it different than we've ever done it. I don't know how they'd do it for sure but I'm sure if there's enough money behind anything, they'll figure out a way. The twenty-six years that I spent out there, that's how they more or less did some of these tasks, [it] was with nothing but manpower. They just threw manpower and ideas and money at it and kept her going. We never shut down. And somehow, someway, we figured out a way to do it.

Indeed. All right. Well, so we have the funding, we have the tunnel that's chosen—

The test bed has been chosen. And then we'll hire a cadre of [miners]—because we go three eight-hour shifts, so we're continually mining, most of the time, not all the time, you know. Sometimes they'd run one shift, but predominantly if they needed—they'd set a date somewhere out in the future of about eighteen months, they'd circle the day on the calendar that this is the event day, the zero time, and then we would be challenged to meet that date. And it was about eighteen months.

That was the average?

Somewhere around in there. A good average of eighteen months is what they'd give us, and that is to construct the tunnels, the mining the test bed, to field the experiments from the users or the experimenters, scientists, and then to execute the event, and then to reenter that test bed and capture their films and experiments. They would go back in and actually retrieve a lot of the experiments and films and stuff like that that were in recording alcoves.

So the zero time isn't necessarily the day of the event; it's when—

The second they push the red button.

Oh, that is zero time?

That's zero.

OK. And then there's some time between zero time and when you collect all the data and whatnot.

We call it X-minus-eighteen months, just like you were counting down, that's the way they do it. When it gets down to minus-ten minutes and then they get right down and then they count down the last twenty seconds, fifteen, ten, nine, eight, and all of what's done is then automatic. The control point must be somewhere in the neighborhood of twenty, twenty-five miles from P Tunnel, and it's done remotely from about twenty miles away. But there's cameras everywhere. They've got underground—they even have cameras right on the device, but there are very few people see that.

You ever see it?

One time.

Really.

Yes. I got to see two devices while the scientists were hooking them up, doing the wiring and the measuring and whatever they do, their part. They were, what do they call that, device engineers. They would bring it in. But once it went underground through the portal, the responsibility of the men's safety was my responsibility because I was the mining superintendent, so I would usually be on the team that would walk the flatcar in, pushed by a motor, with the pig on it, and a pig is a lead-shielded containment vessel for transportation of the nuclear device. And then they'd take it up to ground zero and there'd be probably a party of about, including security, there'd be, oh, ten, twelve of us that would escort this thing to ground zero, and then they'd have your industrial hygiene and RADSAFE, the radiation technicians, they would check for leaks and this and do their safety checks, and then take the device out of the pig, place it into A Box. And when they took it out of the pig and placed it in the A Box is when I was standing in a position that I could see what went on. And I waited for, what was it, **[00:15:00]** twenty-five years to see that. It was kind of disappointing a little bit because, is that all it is?

Well, yeah, a twenty-five-year buildup, it's hard to imagine it not being disappointing.

Because very few people got to see it. Very few people got to see it. Well, I knew that some of the scientists and the DoD people, your test engineers, because DNA, or Defense Nuclear Agency, was our main customer. It's got a new name now. They've renamed that. Something to do with weapons. I've heard it a couple of times [Defense Threat Reduction Agency (DTRA)].

So to go back to kind of march through our chronology here, when you say "field experiments," that means actually putting the experiments into the field?

Yes.

You weren't a part of the process of choosing the experiments. You were the people that somebody said, "we want to do this," and you make it happen.

And we did it. The scientists would come to us with the impossible. They'd want to put a ten-foot plug in a nine-foot hole. Really! And we did it. This is again at T Tunnel, they brought in a hunk of granite, probably weighed ten, twenty ton. Huge. And it was the exact same size as our drift that we drove. And there was a place where they had drilled them holes. And this was a huge piece of granite, you know, three times the size of a car, and they had strategically placed holes in this and holes all the way through, part of it was polished to high polish on it, it was shaped really weird, and that was put in ground zero and then all the experiment line-of-sight pipes were hooked up. And what that was for, I never did ever find out what it was for, but that's what they would do, the scientists. Sometimes we weren't on the same page; they were in their own little world. But they knew that we would get it done for them. Somehow, someway, we got that thing in that. It took us four or five days, but we got it back in that and placed into that tunnel.

And correct me if I'm wrong, but it seems like your job was to get on their page, or to make their page—

Fit ours. Yes. They already had theirs. Theirs was set in concrete or, you know, it was written in—so we had to figure out a way to accommodate that.

I don't know if we mentioned this yet, but what year was [Distant] Zenith? Do you remember?

I can find out. Let's see if I can see the—Distant Zenith. Let's see if I can find it. [Sound of pages turning]

If you're looking for that, I guess—I didn't want to break you from your chronology.

Oh, that's all right. Distant Zenith, September 19, '91.

And so the eighteen-month thing, you found out, what, early summer, late spring of—

We probably knew they were going to do at least three events at P Tunnel when they first started it. We knew that we had at least three test beds to do, so it was, oh, we knew in plenty of time to get ready for the Distant Zenith, because it wasn't the first one that we did. I think Disko Elm was one of the first we did at P Tunnel. Again, I'd have to go back and make sure because there were about five events that we did at P Tunnel. At N Tunnel there's must've been—because that went on for forty years. I mean it, oh, no, since 1958. They worked underground at N Tunnel

[00:20:00] forever. And I was one of the last human beings out of the old part of the tunnel. Now it's full of water. I was still employed there when they—we called it "button it up." They removed as much hazardous material as they could from the tunnel and all them miles and miles and miles, literally miles of drift that was in that mountain, they went out with big containment plugs, closed the doors, and turned the pumps off and virtually turned all of the power off underground.

So you literally were one of the guys that turned out the lights as you left.

I was the one that called the department office and got permission to call Dispatch and turn the power off at N Tunnel. It's kind of like putting an old friend to sleep, because I'd worked there fifteen years and had supported my family fifteen years with that tunnel. So I got to be there at the last, and there was no big fanfare, nothing. I just walked over to the telephone and called Chris Evans, the dispatcher in charge of Electrical, and I said, Shut her down. And so they got the lineman out and shut all the power to the transformers off, and she went to sleep. Started filling full of water. And that was ten years ago, so there's a lot of water in that mountain right today.

In fact. OK, so where were we in our—?

Well, I'll just read some of the statistics from this Distant Zenith, and the amount of tunneling that was done, there was about 4,450 foot of tunnel. It was began October '89 and completed June '90, the mining was completed. [Reading from Distant Zenith statistic sheet].

[00:22:02] End Track 2, Disc 1.

[00:00:00] Begin Track 3, Disc 1.

And we're back.

OK, where'd we leave off at? Tunneling?

Yes.

[Reading from Distant Zenith statistic sheet]. There was about 4,450 foot of tunnel. We began mining in October of ’89 and completed mining in June 1990. And the overburden or the ground cover over ground zero was 880 feet. Ground zero, distance from portal, 4,900 feet. Amount of earth removed, 29,496 cubic yards. Line-of-sight pipe, 800 foot long, diameter from six inches to twelve foot. The event bag, which was a nylon type of material that they filled full of exotic gases, it was 550 foot long.

What’s that for, again?

They filled it full of several exotic gases. For what, I don’t know. I don’t know exactly what they were after by filling it full of gas. And the diameter was fifteen-and-a-half foot to twenty foot. Volume, 138,300 cubic feet. And they filled this full of gas and I’m not sure what it was for, but it more or less virtually was just a big balloon inside of the tunnel, and it was 550 foot long and they filled it full of these gases. They had bottles and bottles and bottles of different types of gases, and a little bit of this and a little bit of that, and then that was filled up and kept full until zero time. I guess it’s the X-rays or something. I don’t know. Or the EMP, the electromagnetic pulse that comes from off the device when it’s detonated. I never did find out why they did that. And some things I knew better than to ask too much about.

And there was 400 miles of cabling, from fiber optic to coax cables, and there was 1,200 channels.

The budget was forty-seven million [dollars]. And that’s just the budget for this. The overall budget I know was bigger than that. The picture was a lot bigger than just here.

But the forty-seven million is just the budget for the Distant Zenith test?

Project. Yes.

Well, that's, you know, fifty million is fifty million. And adjusted for inflation nowadays, I mean, you know.

How much? What is it?

I don't know, maybe sixty, seventy million now.

I bet. Yes, seventy. And we couldn't afford to do business the way we did today because of safety and the rules on radiation exposure, that has changed tremendously. In fact, we couldn't do it. The way we used to do it, we couldn't do it. They don't have enough money to get it done.

Is that good or bad?

I'm going to say it's a little bit of both. It's bad in one sense because you lose out on the knowledge, but then if they're tasked to do it a better—get the same results a better, cheaper, safer way—and that was one of the things that we were challenged again and again and again was we got to do it cheaper, we've got to do it safer—and usually it was somebody paid for it in blood. It was usually something happened that we had to. We had to clean up our act. Or there would be a leak or something would happen. And that's how they learned, by doing, because they never knew for sure what was going to happen. In the early days, they didn't know how big the device was going to be. They just kind of guessed at it, see. Some of them went over yield; some went under yield. And there's no way they could figure out—in fact I had one scientist tell me that the device, it has a mind of its own. When it's first detonated, it goes out, trying to escape, you know, the path of least resistance, and then it goes back in again and comes out again with more power. If you can hold it that time, you got it. It'll contain itself then.

[00:05:00] *OK, so we're still fairly early in the process, right? Is there anything you want to say about the process of fielding the experiments?*

Well, the mining entailed, too, before we could ever field the experiments, the mining had to be completed and there were a lot of plugs, closures, places for closures that. If we had a picture, you could see it better, but for me to explain, in this series of drifts that we'd mined, there had to be places for closures, which would seal the radiation, the debris, everything off from going down the line-of-sight pipe. It had to be done in nanoseconds. And during the mining process, we had to superharden the ground, and that was done with ground support rock bolts that were fully epoxied up to twenty foot long—twenty-five foot long some of them, twenty-four foot long—which were fully grouted and they were on four-foot centers. Every four foot in that mile of tunnel or 5,000 foot of tunnel had to be supported so it wouldn't cave in because of the ground shock that would go through from when you detonated. It would do some funny things. I mean it would turn concrete to water under that much pressure. Concrete would flow just like water. One second ago it was hard, up to so many psi [pounds per square inch], say twenty thousand psi, and then close to ground zero where some of these containment features were, the concrete, the scientists said it would just flow just like water. I couldn't figure out how it did it.

Yeah, that's hard for me to wrap my brain around.

In fact, if you could get down in 15 Shaft, that was done in granite, at Pile Driver and Hard Hat, those code names. They did it for NORAD [North American Air Defense Command] over at Cheyenne Mountain in Colorado Springs, Colorado. This was a test to see if that communication complex would survive a direct nuclear hit. And they had a round drift, oh, I'd say ten foot in diameter, driven about, oh, eighty feet that I could see. And they lined that drift with concrete and rebar. Rebar was one-inch rebar on about four-inch centers, so it was just a solid mass of rebar and concrete. And when that device went off, it squeezed the tunnel down and took this round cylinder and flattened it. And I dare you to find a crack in that concrete. Now you know that if you take a round cylinder of concrete and [hitting hands together] crush it, it's going to crack and fracture, but under that pressure and that ground, it didn't do it. And I used to go take people back there and I'd say, `Now, look at this.` And you could put water on it, because you can usually see any hairline fractures or something, and I defy you to find a crack in that concrete. How that happened, I don't know. It's just one of the things that under that tremendous amount of pressure, in nanoseconds, just in quick time, it just did some weird things. And other places it just tore it all to billy goat. It did. But in this one particular drift, and it was—now when they were pointed right at it, they would survive, but when they were crossways, they would destroy it. They know that. So if they're looking right at the device or at ground zero, the shock waves coming this way, it would survive more so than if it was crossways. If it was crossways, it just wiped it out, like a tsunami. Same thing. It's much the same kind of energy that you'd get out of a hurricane, a tsunami, tornado. All that huge amount of energy that's released there in such little places that does weird things. It was. It was mind-boggling to me. And the geologists that did it, they'd shake their head, too, yeah, because you couldn't second-guess it. You couldn't get one ahead of them. That was fascinating, but it kept me going, because I **[00:10:00]** figured, how in the world would this stuff—? How and why. And in some places it completely failed. Other places it would stand like nothing ever happened. Like you wouldn't believe that two or I'll say five hours ago, there was all that energy and electromagnetic pulse and all that stuff was going down the line-of-sight pipe and then five hours later we're standing there without any protection. Just like nothing happened. No gases, no nothing. That's how good they got at it. Just like walking back into a laboratory that had a nuclear device go off in it, hours before, five hours before, and we'd walk right back in and no reading or nothing. I think Distant Zenith was one of them. We went right back in and it was completely clean. Everything worked like they knew what they were doing.

So I guess what comes first? Do you mine for ground zero? Is that what it's called?

Yeah, we go all the way to ground zero with both the line-of-sight heading—that's where the experiment is—and then we have what they call a bypass which is driven parallel, about eighty to a hundred feet away parallel, and so when once they field and put in the line-of-sight pipe and then concrete it in, because we'll pump. Let's see, concrete and grout in Distant Zenith, there were 10,953 cubic yards of concrete and grout used to seal that tunnel, because you'd put the line-of-sight pipe and that line-of-sight pipe would start at six inches. That's where the device would go, right here. And then it was like a megaphone. It would go all the way up to twelve foot in diameter. And then they would pump a vacuum on that. It would be down to I don't know how many microns. It would get right down to simulate outer space. That's what they were trying to achieve, the same conditions as outer space.

Is that on all the tests or this one in particular was supposed to simulate outer space?

Most all of them. Most all of them had a line-of-sight pipe in them. Now in the early days back in, oh, the late fifties, they did it many different ways. They were learning. Then once the moratorium [occurred] where they had to contain them and they had to go underground, they did things a lot different. Had to.

OK. So you start at ground zero with the line-of-sight pipe, and then kind of describe to me what the process is to field the experiments once you have ground zero and the line-of-sight pipe.

Well, the places for the experiments were designed when they assembled the line-of-sight pipe, usually in Spokane, Washington. That's where they made a lot of the line-of-sight for the test site was then in Spokane, by Boeing. And they would ship it to the test site. And in the pipe were certain grids and brackets and things that are already put in there, strategically put in certain construction stations, and once that was in and cemented up to the end of the pipe to contain it, then there were doors, much like pressure hatches. You would open that door up and scientists could go in and then they'd hang a warhead, a regular end of a warhead, they would hang them in the pipe, with the device in it. They even did that one time. They hung a live device inside of a warhead inside the pipe, because they wanted that shine to hit the warhead, because it does something to it. They disarm them. It disarms them. That's why they wanted, with the MX [missile experimental] system, if they did have a, say a submarine launched a missile into outer space or it come off of a satellite. They had missiles and warheads in satellites. They'd deploy ten at once, you know, just from wherever. And they could get close to that satellite and detonate a device and the shine from it would disarm it. Something in the circuit worked the electromagnetic pulse, and again this is way over my head but that's what they were trying to achieve.

Well, if it was over your head, it's a mile over mine. So with the line-of-sight pipe, is there only one line-of-sight pipe?

Note: Photographs and diagrams Mr. Campbell refers to are from The Containment of Underground Nuclear Explosions, *U.S. Congress, Office of Technical Assessment, OTA-ISC-414, GOP, October 1989. Page numbers indicate explanatory images.*

[00:15:00] The line-of-sight drift and a line-of-sight pipe—well, here, that shows you. See, there's the tunnel, see, and this is a piece of line-of-sight pipe. [pp. 22, 23] It had to come in in sections, and then the pipe fitters had to weld it all together, see, and then we would go and build bulkheads every so many feet and actually fill the whole annulus or the radius around there full of concrete. So you'd only have the pipe itself open on the inside, and that was open all the way to ground zero.

So you have a ground zero, you have the pipe, and then whatever part of the tunnel, the distance between the tunnel and the pipe would be concreted in.

Yes. Because here's the edge of the tunnel. Now here's one of your experiment stations. See all the little places for—? And this would be built and—

And that's the cross-section of a line-of-sight pipe?

That's a cross-section of a line-of-sight pipe, and all these places were for experiments, all the way around these things, and there were several places. There's one there in the middle, up here [p. 24]. And there were different ones, different kinds of them like that. Let me see if I can find a place here where it shows more of a line-of-sight. Yes, here's the portal, see, and there's one event, two events, three, four. There were four. That's at P Tunnel. And then there was one more off over here, and the new ones they did is off over here. It Y-ed off right in here by the old walker shack and went out that way. But on the tunnel entrance, there's a huge door about 1,700 foot in. They call it a gas-sealed door. That's metal. That swings into place, and the only way you can get back in the tunnel is to open a little hatch and crawl in until during reentry, then they'll take a crew of people and go in there and open this big, huge door back up. I mean it's inch-thick metal and it's a gas-sealed door. It seals all the gases back in. That's what it's for. There are several of these along the way. There's one here. There's one there. So you got the gas-sealed door, you got the gas-sealed plug, and then you got your overburden plugs and stuff back in here. But see, this here was the line-of-sight drift. See this straight drift right here? That was line-of-sight. This other one parallel to it was called the bypass. Ground zero would be right here. So once this is concreted-in with all this pipe in it, going out to about here, right in there, then these crosscuts in here, scientists can come up here and go over there and get in the pipe through a big door. [Sound of pages turning] Those are some of the closures. There's a FAC, fast-acting closure. [p. 44, Figure 3-7, c] This is part of the line-of-sight, but you're getting real close to ground zero because that's probably only about two-and-a-half, three foot in diameter. This is about seven foot from here to here. That's about a ten-by-ten drift. See the rock bolts that hold the ground and the wire mesh? [p. 47] I've got a picture that can really—

What was the main goal for the Distant Zenith test?

Ooh, I bet you that one's classified. I bet you why they were doing that was classified. It was part of a program. [p. 21, image and text scrambled], A lot of it had to do with communications, I know that, and it had to do with getting more channels out of the fiber optic, because fiber optic was fairly new yet and they were getting more and more channels from fiber optic, where they used to take a whole bundle of coax, it was that big around. The cables were, oh, half-inch to three-quarters of an inch in diameter, and there would be miles of them, literally just several miles, and then they replaced all that with fiber optic back in the eighties. And I can remember the first fiber optic cable. Man, they treated it like gold. Well, it was. It was more expensive than gold. And then mostly what it all is now, or in the latter years, it was most all fiber optic that they got their **[00:20:00]** information out of, and it was a lot clearer and more channels and a lot less chance of cable damage. Because that was our lifeblood, it was the cables, so we had to protect them, oh, all the time.

Pardon me if I'm being redundant, but I'm trying to wrap my brain around all this. So the first thing you do, is it the right terminology to say you tunnel in, create the test bed where the device goes, and then what comes next is you put the line-of-sight pipe in?

Yeah, once the mining is completed and all the ground hardening, ground support is done—

And that's where the rock-bolting comes in?

That's the rock-bolting and concreting. Then we start to concrete and grout. Grout, again, to seal any fissures or any watercourses that were in the mountain, that we'd have to seal them off, and if there was any water leaking, they would try to seal off as much water as they could, because water can cause you to have problems with secondary explosions, because of the steam. That tremendous amount of heat would cause a secondary explosion from water, and that caused them lots of misery in the early days. Some of the areas of Rainier Mesa have more water than others. T Tunnel was the worst. It had more water in it. E Tunnel and T Tunnel. A lot of water.

But like I said, once the mining was done and the line-of-sight pipe was installed, then would come your scientists and they would start to what we call field their recording stations and all of the instruments that went in and experiments that went inside the pipe would be installed. And then they would run several dry runs on the cabling, like full-system dry runs, so they'd start down a five-hour countdown where all the scientists would make sure all the little cables and all the idiosyncrasies that they had going on and little magic experiments that they had [been] playing with, that once they got them where they were happy or they could meet, again the Containment Panel and the Evaluation Panels would say all right. After they had a dry run, they'd have a meeting and say, `All right, well, we've got problems here, here, and here`, and they'd work on them, and then once they got a good dry run, then they would give us the OK to insert, and that's when they'd bring the device up, because she's all ready to go, and then the device goes into ground zero.

How does the device get into ground zero? Is that through the bypass?

Yeah, we'd go down the bypass. See, because it goes all the way to the portal. Because the rest of it's full of concrete. [p. 67]

And the other thing is, did you play any role in fielding the experiments in the line-of-sight pipe?

We supported. Our pipe fitters, our carpenters, our craftsmen supported the scientists. Whatever they needed, we were there to support them, putting them in, but they would do most of the tech work themselves. We had electricians and pipe fitters that would help them that were kind of specialists, trained. They would help the scientists. But mostly they'd bring their own people to do it. Sandia, Lawrence Livermore, who were some of the other ones? Los Alamos, Jaycor. There must've been at least twenty agencies.

If there's an eighteen-month from the time you get the go-ahead to the time of the actual event—

Well, now, there was the event and then reentry [that] was eighteen months. That was from beginning to end.

I mean how long does each of these steps take? Like how long would it take for you guys to kind of get to where you've created the test bed?

Right at about a year.

That takes a year to tunnel in there and do that?

To get all the things ready for fielding. Fielding is when the scientists come in.

OK. So that takes a year.

A year, to do the mining and construction and concreting.

Wow. This might be a dumb question but how is it that the tunnel didn't collapse on you guys?

[00:25:00] Because of the hardening, the ground, the rock-bolt supports.

So as you go, you're doing it?

Yes. And then we come back later and do some more. We can advance the tunnel so you can get all the mining done. And then we'd come back in and set up big rock drills. And they'd drill and just hundreds and hundreds and hundreds of rock bolts would go out into the ground twenty-four foot and then they'd put a plate on it, a big, huge rock-bolt plate. And they would torque it up and it'd pull that ground together, just a like a bolt would on a car, you know, it pulls that ground together, so when the ground force does hit it, it all goes together. It doesn't wiggle and fall in. It moves together, kind of like it was one piece.

Yes, I got you.

That's why if I would've had any way to do it, I would've taken a camera out there more to record some of the things. A lot of people, you know, you could talk for a week and it's hard to get through to them how you did it, without having pictures and actual—and I know that DNA has got video pictures of the actual Alpine™ mining and different sequences that we did.

What were some of the challenging things about that first year of the process of actually tunneling in and getting to the test bed?

[Telephone rings]

[00:27:39] End Track 3, Disc 1.

[00:00:00] Begin Track 4, Disc 1.

Well, so why don't you talk a little bit about what your role in the actual mining part, the first year. What were some of the challenges? What was your responsibility?

Well, when I was superintendent, you had to coordinate usually three shifts. They had a graveyard and a day shift and then swing shift. So we mined continuously. We always had, from Sunday night till Friday night, we had a crew working underground, mining. Probably a crew of men, oh, somewhere around thirty-five; with all your support electricians and radiation monitors and safety people, we had about thirty-five people to the crew on the back shifts. On day shifts we always had a bigger crew, had more pickup drivers, because everybody had a pickup out there. You'd think that there were 5,000 people working that one job, but no, it's because there's a hundred pickups outside, that's about how many people you've got.

Some of the challenges were—the biggest challenge we had as mining was the safety and the paying attention to detail as far as the size of drift, because the scientists were real particular about, especially in areas close to ground zero, that if it called for a five-by-seven, that's what they wanted. They wanted it within plus or minus a quarter of an inch. That's tough to mine. You almost can't do it with dynamite, but you can with an Alpine™. You can get it within a couple of inches, but then in places we'd have to do it by hand. We'd have to actually mine through that rock with air spaders, chipping gun, and you'd drive or advance your heading for about, oh, twelve, thirteen feet, because it was that critical. Right off of ground zero. You have to be right in there, because it was a containment. And I once found out why, and I don't—it was out at, if I can remember, I went to a meeting down there [DNA}, and I never could figure out why near ground zero would it matter, but here was your line-of-sight pipe [p. 45]. And this area right, say, from here to the device was here [p. 45]. When it went off, this area right here, they knew it was going to fail, most of it's going to be vaporized.

The pipe would actually—

Everything.

They knew that the pipe closest to the device would fail.

The ground and—yes. You're right in here [p. 46], which is going to be nothing but vaporized, and it's going to leave a cavity, one that it'll cave in later. But the reason that this drift right in there had to be exactly what they said, because in the end, after, and they found this out through shock waves, it resembled a woman's breast. So from here to right there, they knew it was going to fail. If they kept this drift exactly the size they called for, the scientists, then the rest of this energy would be dissipated up and out around. But they had to hold it right in there. And then right down here was your first closure, your FAC, fast-acting closure, and then they had closures, your MAC [modified auxiliary closure] and GSAC [gas seal auxiliary closure] and your TAPS, tunnel and pipe seal. Those are doors that would close within nanoseconds after the device went off. But this right here, the containment right there, Joe LaComb had it drawn on a board, and Byron Ristvet and those people, they had it, it resembled a woman's breast. And that's why he said it had, you guys, we've got to be right on the money for about twenty feet right in here.

Would the tunnel kind of do that shape, too, or would you just kind of go in and then have the—?

[00:05:00] No, it would start out down here. You'd have about a, oh, five-by-seven where you could walk through it, you know, you wouldn't have much clearance, about, oh, that wide [indicating width], and then it would megaphone out up to an eighteen-by-eighteen, sixteen-by-sixteen, according to how big a pipe and what they was going to put in it, determined the size of the drift, each line-of-sight pipe. I know that I've got pictures somewhere in there that has good pictures of line-of-sight pipe already installed, where you can see in the pipe and look down it. But it was all just graduated up and over, what, Distant Zenith was 800 feet? Yes, LOS [line-of-sight] pipe, 800 foot long. So it started out at six inches in diameter and went to twelve feet. Six inches in diameter was ground zero. That's where they put the device right in front of it.

How big is the device?

The one I've seen was not as big as a basketball but close.

Maybe a volleyball?

Yes, a small volleyball. Then it just looked like somebody had taken a shiny ball with a bunch of little gadgets hung on it here and there, and they put it in there on a rack, and then they had to adjust it right in. They had little, fine adjustments where they could get her perfect, wherever it had to be. There were two parts to it, A and B. It's much like a piece of pie. That's how the scientists explained it to me. Here's your device [drawing]. It's stable here. Take this piece of pie out, it becomes unstable, and you bring her back in, it comes critical. And they do that with electricity and maybe a, well, I don't want to use dynamite, but an explosive, to bring that together. Once it comes together, it becomes critical mass and goes. It's just like a pie. You got a piece of pie and it's OK there, but you pull that piece of pie out and it becomes unstable, and you shove her back together and it comes critical.

And so you saw the Distant Zenith device, or was that a different test?

No, I saw Distant Zenith.

OK. And that's the size of a shiny volleyball, essentially. Is it megatons?

Kilotons. A megaton is a million times that TNT. I'm going to guess somewhere around five. I think in one of the books it'll tell you. There is one of the containment books like this, it'll tell you [less than 20 kt].

Yes, I think I have one of those somewhere.

It'll tell you the size of the device, the kiloton, the yield. Let's see, let me look here. OK, here's Anchovy. Depth of barrow, purpose, yield, low, so it didn't tell you yield. Twenty to a hundred and fifty kiloton? Let me see. [Sound of pages turning] Let's find some of the tunnel ones. Disko Elm. OK, this was P Tunnel. Less than 20 kt [kilotons]. Weapons Effect. Depth of barrow, 875. Sponsor, DoD/LLNL, Lawrence Livermore Nuclear Lab. NTS, U12p.03. That means Area 12, P Tunnel, 03 Drift.

[00:09:14] End Track 4, Disc 1.

[00:00:00] Begin Track 5, Disc 1.

What comes first, digging the line-of-sight tunnel or the bypass, or both at the same time?

Both. Same time. You usually have two different crews, a bypass crew and a line-of-sight crew.

And what do you call the thing that's to go from the bypass tunnel to the—?

Crosscut.

Those are crosscuts. OK.

Crosscut 1, 2, or—if you look at a detailed map, it'll tell you, and then in some of those pictures I gave you, there is a detailed map of Crosscut 1, 2. And some of them we have to—let's see if I can find [pages turning], we have to take some of the closures in like a FAC and a GSAC let's see, I thought I'd seen a picture here [p. 67].

Are the crosscuts dug at the same time as the bypass, or do you come back later and do that?

Usually we would do most of the mining as we go in, see. We usually task one group to go right straight ahead and of course the drift gets smaller. And then the bypass crew will come in and when they get to these [indicating on diagram [p. 67]], they'll mine them through. Because we can have crews working ahead up in here, see, and you can have a crew in there doing some task, rock-bolting. Now when it comes to muck removal, then you've got a problem with congestion.

Are you mining, digging the crosscuts from the bypass to the other tunnel or from the main tunnel to the bypass?

Either way.

Doesn't matter?

Doesn't matter. Yes, it's whichever comes first and how bad they need it. Yes. But see, like, where these drifts are curved somewhat from the bypass over here to the—like that [p. 47]? Those are accesses to bring in late-time closures. Because the FAC, this one here, that's what makes it closed. Can you read that? It says, "Danger, high explosives." That's a sheet of explosive material. Have you ever seen composition C or—?

Like plastic—?

Same.

OK. Plastic explosives.

This is a sheet of plastic explosive.

And that's what makes the door close?

It's wrapped all the way around this pipe, and inside here is a certain kind of copper metal that's pliable and it'll seal off. It'll just squeeze it right down to nothing. When that goes off, of course this is filled full of concrete after this is done, but they have to come in and arm this at late time. The device goes in, then they got to come in and one of the things they'll do is arm this, because they have this high-explosive blanket in there plus the high-explosive det [detonation].

Did you say "late time"?

Well, what I mean by "late time" is after they insert the device, once the device is inserted, then it kind of changes the picture of everything we do.

OK, that's late time, from the time that—

Once they insert the device, insertion, from then we'll start stemming at ground zero right then, usually sandbags first so in case there's a grout leak or a concrete leak, it won't get back in and destroy the project. Because we've had problems in the past where grout did leak into a box, and so we have to be really careful about making sure that we don't. And they've got cameras; they can tell exactly when and what's happening in A Box. Because they've got two security guards camped on top of that device until we—and once we get the first pour made, then it goes back to you don't need security except in these places like this where there could be a problem with somebody going in there and not on purpose but things could happen where this explosion could go off, so they have to be careful with this.

And so it takes a year to do all the crosscuts, bypass, and—what's the name of the big tunnel?

LOS.

The line-of-sight tunnel?

Line-of-sight. Yes. LOS.

[00:05:00] *OK. Then you're not doing the line-of-sight pipe as you do that? That comes after all of the tunneling is done?*

After 99 percent of the mining is done, then they'll start fielding the pipe, or bringing the line-of-sight pipe in. And that is the sign to the craft, the pipe fitters, and miners support them. They bring the pipe in and position it, and then they take a laser beam and line it all up and get her perfect, and then they mount it, and there's mountings all the way up the tunnel for this pipe to stand on. We bring it in on the rail, take the car, the pipe dollies back out, mount this big line-of-sight pipe on pedestals. Then once it's filled full of concrete, see, then it's pretty well in place

And the rails, the track is only in the main, the portal tunnel, right?

Yes. And most of the track is taken out, especially in the stemming areas.

The stemming areas?

Stemming is where you concrete. Anyplace where you fill it back full of concrete is a stemming area. End of stemming is where they—you look on some of your maps, it'll say "end of stemming." I don't have any. Usually I can tell where end of stemming is on—see, there's your bypass drift [indicating on diagram p. 45], your HLOS [horizontal line of sight]. When the explosion is detonated, radiation travels down the HLOS pipe at the speed of light. These are all the closures, your MAC and GSAC, mechanical closure. MAC is maximum auxiliary closure. GSAC is gas-sealed auxiliary closure. And there's your end of stemming, a test chamber, end of stemming in the bypass, see, all that black is concrete, and that's where the end of stemming is. And the same here. Usually end of stemming in the bypass coordinates exactly the same construction station as end of stemming in the line-of-sight. It's usually real close together.

I would imagine that concreting in the bypass would be one of the last things you do.

Last thing. Yes.

Is that the absolute last thing you do

That's—yes.

The device is already in there. Because it's the point of no return, right?

Yes, right, that's the only way you can get in there. The only access you've got to get in there is through the bypass. And that bypass is sectioned off in different pours. We might have as many as ten different pours, different types of concrete and different volumes of concrete. But once the first pour is made off of ground zero, then they're always setting up or getting ready or pouring, for seven days. Usually it takes us about seven days to stem from ground zero to the end of stemming, see, from ground zero here [indicating on diagram p. 67], because this is already stemmed in or concreted in. All the experiments are in, so at late time—what "late time" means is anytime after you put the device in is late time, then we'll start right at ground zero and put in that first containment plug, and it's usually only about a twenty-or-thirty-yard pour. It ain't too much. So if we have to go back in and fix a leak or fix a problem, then we still can. But once we start pouring several hundred yards of concrete, you just—

How do you get back through the concrete? Well, you would just mine through it, right? That's probably easier than normal mining, I would—no?

No, it's harder.

Is it?

Yes. Because you've got so much metal, rock bolts and different things that interfere with you. Usually what we would do is drive a drift on the outside of it a little bit, another drift on reentry. We would go up as far as we could in the bypass, and then they—but places we had to follow the old drift line again because they had experiments imbedded in the tunnel rib or wall that we had to go by and they'd dig them out later, usually to do with ground motion.

[00:10:00] *So they'd have experiments not in the line-of-sight pipe but actually in the—*

All over the tunnel. Yes.

And would you guys be the ones to put those in there?

We would support the users or the experimenters, scientists. They had three names. They called them "users" until the drug culture come about and then they said, no, we can't use that, no, we can't use that name, so they called them "experimenters." Scientists.

OK. What was some of the goofy stuff that you saw as experiments? I mean I've heard some different stories about the different stuff that was in there.

Oh, let's see, the funniest—the one that was, they brought a gun barrel off of a Navy ship, one of the big gun barrels.

Like a sixteen-inch off of a battleship?

Yes. Yes. They took it underground on flatcars. And it was hush-hush about what was going [on]. And they laid it up in the drift. I can't remember exactly where it went. Frank Solaegui can really tell you about this because he was more or less in charge of it. I was just on the crew and heard the story later. And got to see it. I got to see it and everything. But once they brought the gun barrel after the event, they went in and captured the gun barrel again, brought it out and they tipped it up on one end and a piece of gold about that big around [indicating size] rolled out of the barrel. It had all kinds of little wires and, you know. But the gun barrel was, I guess, to hold it in place. But the gold was to take the full flash of light, the shine. And they rolled that gold out there and that, oh, that probably had to be—I'll bet you it weighed twenty-five, thirty pounds, forty.

The gold?

Yes. That's a hunk of gold big as a grapefruit. Pure gold. With little holes and wires and—

Just a measure of what—

If gold would be a good insulation, I think, or a good conductor, or what temperatures, or would the gold withstand this flash of light without changing in it somehow? Because that pulse does weird things to a lot of materials. The pulse goes clear through the mountain. It's actually a ray in a way, I believe, the way I understand it, that electromagnetic pulse has a ray that goes with it that will actually go clear through the earth. It leaves a signature that goes clear through the earth. But yet it's so small, it can go through your body and never touch a cell. That's hard to believe. The way the scientists explained it, your cells are about that far apart [indicating distance] and this ray goes clear through your body and never touches anything. Now I can't go with that one because I feel like I'm solid mass.

Yes, I do, too. That's yet another thing I can't wrap my mind quite around.

Quantum physics. There's something there. Well, there in Lead, South Dakota, in that gold mine, [Homestake Gold Mine] they had a tank of—what do they use for dry-cleaning fluid? That chemical [perchloroethylene (C_2Cl_4)]. But the scientist [Raymond Davis] was measuring rays [neutrinos] from outer space, and I think in the three or four years that they had that experiment going, they had captured two rays that had gone through—it was fourteen hundred foot underground, in solid granite, and they had a photographic path of this ray going through that big, huge tank, and it had to have several thousand gallons of this—well, they use it for dry cleaning clothes. Of all the weird things that they used for. But I read—I think it was in *National Geographic*, yes, about some of the rays that hit planet Earth, go clear through the earth and never touch anything. Now, how's that? How can you do that? I don't know. My mind's not that objective.

Well, yes, you know, I see something like this [knocking on table] and I go, this is solid, right? I mean here it is.

And it isn't. Not to that.

This is getting deep [laughing]. You know, one of the things that I think surprised me and I would imagine would surprise a lot of people is that these tests, and correct me if I'm wrong, they weren't testing the device, they weren't going, gee, is this device going to work or how can we make the device better? A lot of them were to see the effects of the device on various things.

[00:15:00] Yes. Communications. Radios. They even took a field command post like they'd use out in the field in the Army or Marines or something, where they had a command post with all the communication equipment in it and stuff, they took one of them underground and set it and actually had it bombarded by the shine.

Now would that go in the line-of-sight pipe, or that had its own—?

No, that had its own—yes, had its own place, a ramp, yeah, and in fact that was—

And this was underground they did this?

Yes. This was at P Tunnel, too.

So would that be like the device is like the hub and then there's spokes coming off and one of the spokes that the shine goes into was where the—?

They would come down smaller line-of-sight pipes. I'm trying to think how—I saw some of them here [p. 24]. OK, see, actually this flange would be removed and another piece of pipe would be put on there, and we can go on down the tunnel with it, oh, three or four hundred feet, and they put a Plexiglas cover over it, and at late time that cover, because there's a vacuum on this at zero time, there's a vacuum on inside this pipe somewhere to simulate outer space, but they'd take these off and of course there would be another piece of pipe going on down and it would be right in front of what they wanted to test. Actually that shine would hit what they wanted to test and that was that field command—it was like a, oh, it was big as, oh, like a work truck you see these guy go around with like a van almost, not a van but it come off of like a big pickup camper? Small camper shell? Not very big. But that would be a command post for all their communications from outer space and that was, I was trying to think, it was when I first got there or the second shot. I don't know if it was Disko Elm or Mission Ghost or Mission Cyber. It was either Disko Elm, Mission Ghost, or Mission Cyber. I think Mission Ghost was the first shot, so it would've been the second one, which would've been Mission Cyber [12/02/1987]. That's where they had that field command in there.

And so there's almost line-of-sight pipes in the line-of-sight pipe.

They come off of it.

We only have a couple of minutes, so I'm going to stop this CD and put another one in.

OK.

[00:18:17] End Track 5, Disc 1.

[00:00:00] Begin Track 2, Disc 2.

I don't have anything left of mining. [Sound of pages turning] We covered the containment plugs, the mining of the containment plug. Yes. OK. And there was probably about one, two, three, or four of them in the tunnel complex. It was the gas-sealed plug, so it pretty well defines itself. It was supposed to withstand 1,000 degrees, 1,000 psi for so many minutes. I don't know exactly the time but I know 1,000 degrees and 1,000 psi, and that's a lot of psi. That's a lot of psi. And I don't think that they've ever been tested to see if it did. One, Mighty Oak come the closest, and it held except for release of some gases in the atmosphere, but it was contained at the overburden plug, but everything else was lost. Everything back in the test bed area was lost. But the gas-sealed plug and the gas-sealed door did hold. Some gases come out. In fact, you can read about that. There's a lot of articles about Mighty Oak, T Tunnel. That was the worst one we had. In fact, I think it covers Mighty Oak in here in this book.

Let's see, mine, bypass mine, the gas-sealed door, gas-sealed plugs, and mine the LOS and bypass simultaneously, you know, we're mining both of them together.

And the crosscuts as well.

And the crosscuts as needed. Crosscut from LOS to the bypass. Overburden plug, gas-sealed plug, your FAS gate, your MACs, GSAC, TAPS, they're all acronyms for closures.

OK. Have we talked about the FAS gate? Is that just the—?

They're all the same. They're just different names. The FAS gate was the first acronym for GSAC, and they improved upon them, oh, and so they renamed them. FAC is fast-acting closure. GSAC is gas-sealed auxiliary closure. And then you would have the mechanical closure. TAPS is tunnel and pipe seal. GSAC is gas-sealed auxiliary closure. MAC is mechanical closure. MAC. There's still another definition for MAC, too. The M. Modified auxiliary closure. MAC. Modified. That was a FAS gate and then they called them a MAC, modified auxiliary closure. TAPS is tunnel and pipe seal. In fact, one of the tasks I had over at Pile Driver, when the scientists from Lawrence Livermore lab come down and we started talking this mining jargon and he was reading our logbook because we have to make a daily entry and we did this and this and this here, and so he tasks us to sit down and do a glossary of all the mining terms so he could understand what we were talking about. And I have that somewhere, but I haven't been able to find it. I know I've got a copy of that.

I think it might be in all that stuff [donated to UNLV]—

It's there. If you look in there somewhere.

I think I remember seeing that.

OK, there is a glossary of mining terms.

Well, it's funny because not only does the test site have a lot of jargon, it has a lot of jargon that doesn't really speak to one another, like you miners had a jargon, the scientists had a different jargon, and so it wasn't as if there was another language going on at the test site; it was like the Tower of Babel at the test site, it seems like.

[00:05:00] And each one of your crafts had certain tasks and things that they had their own language for. Like the pipe fitters, you know, they would have things to do inside the pipe that we weren't involved with a lot. We would go in and help support them if they needed, but most of the time they took their, the pipe fitters, they were—that was a negotiated deal, union negotiation. That was Baneberry there. I saw that [Containment of Underground Nuclear Explosions, p. 33].

You were out there for Baneberry?

I watched it come out of the ground. I was riding in the back of a van, going to work at Ledoux where U1a shaft is. They still got that going. And yes, I was with, oh, Jack Power, Wally Beaman. About four of them are dead now, five of them. I don't know if there's any of them alive but me. One, two—Pete Peterson is gone, Wally's gone, Jack's gone. Jack Severson is gone. I don't know of anybody but me that's still alive. Anyway, we were coming over Control Point Hill, CP they call it, control point, and Baneberry was in Area 2 about, oh, five miles as the crow files. And I was about half asleep. Cecil McMurtry, he's still alive. There's only two of us that I know of. And Beaman was sitting in the front seat with Jack, the driver, because we carpooled in vans, and he said, Holy mercy, look at that. I rose up out of the back seat and the whole desert floor just started to bubble. I mean huge bubble. And then it just kind of collapsed in on itself and come right straight up, and then this is what you see [indicating photograph p. 33]. You could see boulders flying through the air, big boulders, big as pickups, flying through the air. See, it didn't come up at ground zero. Ground zero was over here somewhere. It came up through a crack that intersected the drill hole. That was a drill hole. There wasn't mining done there. It was all done with a drill hole, forty-eight-inch cased hole, and then they'd drop the device down on a rack with a drill rig. That was different than the way we did it.

That must've put the fear of God into you when you saw that.

Yes. Beaman said, Hell, we're done for the day. Let's go to Indian Springs or Cactus Springs where you can get a drink. So that's where we went, to Cactus Springs. But man, it was pandemonium. There were security guards driving everywhere with their lights on. They didn't know what to do. They were trying to route people this way. That was in the day where they let people out fairly close to ground zero. And the last day, since Baneberry, there was nobody past Mercury, except for your scientists up in the control point. But there was nobody out in the forward area. Nobody. They swept all the forward area. And forward area would be beyond control point, or actually forward area is beyond Mercury, is called forward area.

OK. Well, it seems like that's how we most often learn lessons is from mistakes.

Yes. Hindsight. Yes.

Well, so was there anything else you wanted to talk about as far as the mining the first year of the work in a test? Do you want to like maybe describe a typical day for you?

Well, OK, that would be a good point, is to kind of brief—for safety reason, say we were mining a ten-by-ten drift, which is about one of the normal-sized drifts. We did more ten-by-ten mining, ten high, ten wide, than most of the other sizes. We got bigger than that but not a lot. Most of our mining was done in ten-by-ten, because you could get equipment down it, you could get personnel a lot easier instead of the small drifts. You've come in, say, and they would be advancing, either drill and blast or with an Alpine™ miner, a mechanized continuous miner, and you'd advance your heading about, oh, eight feet. At a time you'd mine, oh, about eight foot of **[00:10:00]** what they call ahead of wire, the chain link fencing that we use to support the ground, and rock bolts. That Alpine™ miner stuck out about ten to twelve feet, so your operator on the miner was always protected. He was under protected ground at all times. So then he would back that Alpiner out. It was on tracks, electric motors, and he'd back it out. Then we would go in there with jacklegs and miners and drill and install ground support rock bolts and then put the wire mesh up, and that way you could safely mine back. It wasn't dangerous. You had to be careful, because you could get a ground fall or a slab or something on you, a slab being a piece of rock that would fall on you.

Like how far would you go in any given day?

Oh, on an average, when everything was going real good, we would average, completed tunnel, about six to seven feet per shift of completed tunnel. Some days you'd do more, some days less, but then I think the average there was about six to seven feet a day.

When you're going with the Alpine™ miner, then you have to back it out in order to—?

You only back it out about twenty feet.

How fast is this thing?

Real slow. About like, you know, a real slow walk was it was going fast. Yes, it was like a crawler. It crawled on tracks and you could ease it up, but it was a real slow walk, and you can crawl on your hands and knees about as fast as it can go wide open. About the same speed.

OK. And this thing, I mean if you're running on three shifts, this thing is running semi-constantly, then.

Yes. You'd probably cut for an hour and a half, two hours, back it out, rock-bolt, hang your utilities, which the utilities would be your vent line to pull the dust out, air and water line, you need water line for fire, and to drill in rock with a rock drill, you need water to suppress the dust. And we needed atomizers on the Alpine™ miner that sprayed because this big head would create a tremendous amount of dust because it just chewed the rock up, the volcanic tuff, and that's very high in silica, so to control the rock dust and the diesel smoke and all the pollutants that we had underground, we did it through a ventilation system. So whenever you got to the end of a twenty-foot section of pipe, then you had to bring another one in and put it in place, and then they'd take a telescopic piece and shove down it, so when you advance you could pull this out as you go. And then once you got to the end of it, down come another pipe and you put your telescope pipe back in, and then you keep advancing that way. That's for your ventilation. And then you'd have to carry with you air and water: compressed air to run your jacklegs or your drills, and a lot of your machinery underground is air-driven, a lot of your concrete pumps, the conveyors to them are air-driven, your Moran cars, a Moran car being a car that contained concrete. It was a concrete truck on rail, is what it was, and it had a big air motor to it and you hook a two-inch air hose to it under ninety pounds of compressed air, turn a motor on, and that actually rotated that big barrel with concrete in it, twelve yards of concrete. And that's how we'd take a lot of our concrete underground is on rail, big rail like you see running up and down the Union Pacific, only smaller.

And run by air.

And run by air.

Is that because you don't want the fumes of—?

That, and no gasoline underground.

More combustible and stuff?

Diesel only, a number-two graded diesel. And then you had to scrub it, run it through, oh, percolate it through water with soap and stuff in it, soda and soap, and they put a—

The diesel fuel you would have to do this?

[00:15:00] Well, the exhaust, see, had to be scrubbed. And then you had to have so many cubic feet per minute of ventilation to meet the OSHA [Occupational Safety and Health Administration] standards and mine, health, and safety standards. So we were under a lot of [standards]—and then our own rules. The government, they had a rule book this thick [indicating thickness] and of course Reynolds Electric [REECo], they—whichever is the safest. Because for many years, no other entity could get out there except for who they wanted. We run our own safety program, and did pretty well. Finally in the eighties, when the Tiger Team—I don't know if you ever heard of the Tiger Team that Congress mandated to go around to all the nuclear facilities and inspect them? Oh, they came out and they tore us up. Oh! Because we weren't living by their standards. They did. It took us, I don't know how much money it took, which is OK. A lot of it was redundant, I mean because we had all kinds of exotic chemicals, gases, bottles and bottles of helium, hydrogen, all kinds of welding gases, you had epoxies, and all this, and when you take it underground, all kinds, and blasting gas from dynamite when you'd blast dynamite, that puts off a heck of a gas and it burns all the oxygen. So you've got to maintain your dust level, the level of diesel smoke, because there was a lot of diesel. You get six, seven, oh, we had one, two, three, usually about five motors, maybe six diesel motors. And I mean by "motor" that runs up and down the track, pushing them big twelve-yard Moran cars, or pushing muck cars to haul the dirt out, haul the material in, flatcars. There again, I wish I had some pictures or something to show you of how a tunnel train would be made up, because you had to pull everything. Mostly everything you had to pull in. You couldn't push a muck train in except for a Moran car, and that's the only one you could push in.

Moran car?

"Moran car" being the concrete hauler. They were called Moran cars, I don't know how—maybe from the maker? I don't know who made them. We called them Moran cars. And all they are was a twelve-yard concrete hauler that could actually dump the concrete into a conveyor belt, which would dump it into a pump, which would squirt it back into the pour. Some of the pours would go anywhere five, six, seven hundred yards. If you could pump a Moran car every fifteen minutes, you were doing really good. Everything was going clickety-clickety-click because, you know, you get one of them things off the track and they weight thirty ton.

Oh, geez.

That's just what I said, oh, geez. And it's going to get hard on you. You're under the gun for time, you know, you're under the gun. Once they put that device in it, it just—the thing gets just a little bit—they screw the old a little tighter. Which, to me, it was a challenge.

Yes. Wasn't it exciting, too, it seems like?

Oh, yeah, yeah, you'd get bored once in a while, but not very often. You didn't have time to get bored. It's kind of like this place around here, see, it was the same.

What was your title, mining supervisor, mining superintendent?

Mining superintendent.

How much time did you spend in the tunnels as opposed to an office or something like that?

OK, I would get to the job about 7:30 in the morning. There would usually be the graveyard walking boss, which was my assistant, that was there all night. I just showed up about 7:30 in the morning on day shift. And I'd talk with him, then I'd usually have a walking boss, which they were assistant superintendents, and there was one or two to each crew, so we'd always have two or, well, not two, we'd have one there all the time. That had to be a salaried supervisor **[00:20:00]** underground at all times. So when I get to the job, the graveyard walker would come out and tell me and the day shift walker coming on where they were at, if we were—OK, you're rock-bolting here, you're pouring concrete over here, you're doing this over here. We'd have several, oh, forty or fifty tasks sometimes going on at the same time in different parts of the tunnel. And then that would be for eight hours, and during the mining part there wasn't a lot for us to do, I mean as far as directing traffic, because it was repetitious, over and over and over. We just had to make sure that they were on target and had plenty of material because you know you're 125 miles from anywhere, or 105. From that front door over there to P Tunnel is 105 miles. And you know if you have to run to town to get a handful of bolts, you can't wait five hours for them to get back, so we had to have quite a warehouse system out there to keep us going. It was quite a storage area. In fact, N Tunnel, when they started demobbing it, there must've been fifteen to twenty acres of stuff.

Demobbing? Demobilizing?

Demobilizing. Yes. We started buttoning up and moving out and they give a lot of the stuff away, barrels and barrels of oil and antifreeze. It was fifteen to twenty acres, say, you take two city blocks right here in this neighborhood, and there were all kinds of material on it. Every kind of thing. Sheet metal from this thick to that thick [indicating thicknesses]. I got pictures somewhere of the lower yard at N Tunnel, and it was probably at least fifteen acres of stuff.

Was there one big place that serviced all the different tunnels or was there one per?

Most of it came out of Mercury, Warehouse Division, but we had our own people that ordered. They would order what we needed according to what phase of mining we were in. When we were actually doing the mining and construction, we applied a lot of gunite, and I never did ever cover that. That was what covered the tunnel walls with. It's sprayed on, much like a swimming pool when you gunite a swimming pool or pump the concrete on homes. It would be blown on. You'd blow on about, oh, anywhere from three to six inches of fibercrete or gunite all over the tunnel.

Is that after the rock-bolting?

After the rock-bolting, yeah. And again, sometimes the hardening came on after that, when you'd harden the tunnel. First you'd go through and support it so it wouldn't cave in on you. Then you'd gunite it. And then you'd come back and set up them big drills and they'd drill the twenty-four-foot fully-epoxied or full-grouted bolts on three-by-four or four-by-four centers all the way from the invert, which is the floor, all the way around to the other floor. They didn't harden the bottom too much. Some places they did. Not too much.

And the gunite's purpose, was it to harden the tunnel, was it to diminish dust, was it—?

To harden the tunnel, so when on reentry, when you come back in, you don't have ground fall or cave-in. Because it would, it would really bind everything together. Because that wire mesh or chain link fencing was in there and gunited through that, and that helped it, and the rock bolts helped it. You'd have places where it would ground fall, but that gunite saved our bacon a lot of times on how it supported the ground. And it kind of moved kind of like it was elastic; it moved together. Some places where you have a fault, you'd see a shear, and then you might have a problem over here where, oh, several hundred ton come out of the roof or even the bottom heaves up four and five feet, but the bottom just comes right up against the back. It's hard to tell where and when it's going to happen. The geologists, they had it pretty well figured out after a while, about which kind of ground, which conditions would heave on you during zero time from **[00:25:00]** the ground motion from the device, because your ground's going to move around in there three and four feet. Sometimes they just [claps hands together] close the tunnel up, just like you weren't even there, just a pile of rubble, and we'd have to mine back through that, and that got to be a little bit dangerous sometimes. They'd be careful, and it was slow.

As far as our safety record out there, we had as good in the industry as there was. We got lucky, though. Got lucky.

All you need is a little bit of luck, right?

Lot of luck. Lot of luck. Yes. Because I've even seen some close calls and I said, how in the heck did we ever get by it? But yes, if you could ever get out and go into that tunnel, see, this is your air and water line that goes up the tunnel. That's your ventilation. Big, huge 200-horsepower axle-veined fans, 100-horsepower axle-veined fans, four and five of them. I mean you could throw your hard hat underground and it'd suck it down that pipe so fast. Working around it, I've lost several hard hats. It'll suck it right off your head.

Well, so shall we move to maybe what happens after the tunneling, the mining—?

Well, I think we've pretty well got, you know, except going into the real intricacies of—we've covered that pretty much.

The final bit of mining and you get the—

Yes, the little assorted tasks that we would do, you know, required drilling and blasting. There was always something going on somewhere. And then a lot of core drilling went on, because from the bypass to the line-of-sight pipe, where there was cabling, electrical cables or coax cables or communication or scientific cables, data cables I guess you'd call them. They would drill from the bypass a hole, oh, say, from four to six inches in diameter, some up to twelve, fourteen inches in diameter, through the rock to the line-of-sight pipe, or to that line-of-sight drift, and then they would bring cables out and go to different places in the pipe for their experiments. But they would do a lot of core drilling, and then that was done by the operating engineers. They call them diamond drills, and where the diamond part come, because they had a diamond bit on it, a diamond core bit, diamond-impregnated, so it would actually core over the rock and you could bring the rock out. In fact that's what these boxes are right here [indicating items on shelf]. They're core sample boxes.

Oh, so they just can just take them right out?

Say they drill ten foot and they pull out the core barrel, they take and this box is sectioned off probably in a tray of one, two, three, four, four, I think it's about that big. I've got a little bitty core but I don't have any big ones [walking away]. That's a small core out of 15 shaft [walking back and showing core]. That's granite. That actually came out of 15. Pile Driver.

That seems perfectly symmetrical.

It is. And that's hard. That's harder—that's what they call bird's eye blue granite and it is hard. You can take a regular rock drill that hits and turns and you have water on it, and there'll be fire spitting out of that hole that far [indicating distance], with water in it.

And so these were smaller, I don't even know what you call them but core-drilling—

Yes, most of them they did for recovery samples. This was done for—that was recovery, to see if the—when they stored the nuclear casks from power plants, they stored them at Climax. There was a test called Climax or a test bed, it was in 15 shaft, they stored these radioactive caskets in these ground holes for a year, I think, and they were about 1,300 degrees, and there's some exposure, but then they went back in later and core-drilled into the rock different depths to see if **[00:30:00]** the radiation and what effect the heat had upon the ground structure. Did it move it? Did it twist it? Because they were measuring everywhere on that tunnel all the time. And they put I think it was five of those caskets that were full of radioactive material, and they did it for a year, and then they pulled them out. They were from Turkey Point, Florida, out of their nuclear reactor in Turkey Point, Florida. We had five of them onsite for a long time. Where they ended up, I don't know. I don't know where they took them to. Eventually maybe Yucca Mountain. Maybe. That's where it was supposed to go eventually because that's what Climax was, was the prototype for Yucca Mountain, in granite. Yucca Mountain's in the volcanic tuff. That come out of over by Pile Driver. Red Hot, Pile Driver, Hard Hat were three of the codenames and that was back in the fifties, '58, '59, '60, '61, '62, '63, maybe up to '64, they had three or four events in 15 shaft. Area 15. I bet I could find it in there. Pile Driver. [Sound pages turning] In '59 [1966], I think.

And so the line-of-sight pipe doesn't get put into the line-of-sight drift, tunnel. Is there a difference between a drift and a tunnel?

Same. Drift. Tunnel.

So are the crosscuts, bypass, and line-of-sight tunnel, are all those completed before you start putting the line-of-sight pipe in?

Ninety-nine percent. There's always little tasks here and there, you know. Mighty Oak. Mint Leaf, that was a T Tunnel, 1970. That's where they had that Russian submarine missile. That was Mint Leaf at T Tunnel and that was May 5, 1970. Mission Ghost, '87. OK, I believe that was the first event at P Tunnel. Nineteen eight-seven. I was there. Hard Hat, 1962. That was the first one at—Red Hot. Maybe it might've been Red Hot. That was before my time. I went out there in '67, so I don't—and a lot of them, all I ever heard was the stories and seen the aftereffects.

Good. Now why don't we maybe transition to what comes next. What happens after, you said it takes about a year, after you start putting the line-of-sight pipe in.

The mining takes anywhere from nine months to a year to complete the mining.

OK. So how does your job transition once you start putting the line-of-sight pipe in?

We're in support, and as soon as they put the pipe in, then our job as a mining cadre was to stem the tunnel. That means to grout or concrete the line-of-sight pipe into place and to construct and pour the containment plugs, and that was done with concrete.

Are there types of concrete?

They had a menu of concrete. I used to have a copy of it. There had to be over 150 different flavors of concrete. And each one of them had a name. Let's see, one of them I can remember was Midnight Zephyr Extra High Strength Groutcrete with ChemComp.

And that's how they would write it, MZEHSG—

Midnight Zephyr Extra High—and it seemed like every once in a while they'd have an event, like Midnight Zephyr, and so they'd name a concrete after it because Waterways Experiments [U.S. Army Corps of Engineers] and USGS [United States Geological Survey], they would **[00:35:00]** have quite a cadre of people working on concrete. Some of it they wanted—well, they had one concrete called Super Lean, and that was six yards of washed sand and one sack of concrete. So when you poured it and it set up in the better part of a day, you could actually pull the form off and take and scrape it with your fingers, it was so soft. But it held. It's not like pouring wet sand and then when it dries out it's going to fall. This Super Lean was just—that's what it was. And it was used in certain places along the tunnel. Now in your containment plugs they had to have a different strength of concrete. Some of it in seven days it got up to 25,000 to 28,000 psi. Some high, hot stuff. That one I can remember, Midnight Zephyr Extra High Strength Groutcrete with ChemComp. ChemComp is a retardant to slow down the hardening process of it.

Why would you want to slow down the hardening? So you would be able to work with it?

So we can work it, yes, because some of it was real hot. And we had to pour it at a certain slump. They had all kinds of inspectors inspecting us pouring concrete. And they checked every load that come in, because it had to meet the containment committee's standards for hardness, the ability to seal the rock, and yet be like the rock. See, they didn't want it to get any harder than the rock, so they wanted to simulate the natural volcanic tuff.

What would happen if it was harder than the rock?

In some places, from the power, from the device explosion, would get between the concrete and the rock and form a pathway. So if it's the same, it doesn't. It won't get between the interface, I guess I want to call it, where the concrete comes up against the side of the tunnel, and it can go right down that tunnel and get into where it's not supposed to be. And there was certain places they wanted harder concrete, but most of the stemming was to stay as close as they could to the rock hardness, the same hardness that the volcanic natural was, that's what we had to pump concrete in. But I used to have a blueprint with all those types of concrete, and there was about a hundred different flavors of concrete.

That’s crazy.

Yes, it was. And every time we’d have a new shot, they’d have a new flavor of concrete.

So this isn’t the type of concrete you can buy down at Home Depot or anything. This is like super-duper concrete?

Oh, no, no, no, no, no, no, no, this is all kind of exotic concrete. They had fly ash in it. They had all kinds of stuff in it. So it wouldn’t shrink. See, a lot of concrete will shrink, and once the water has dissipated, it’ll shrink. Well, that would leave a gap between the rock line, or the interface, there’d be a little bit of a gap. They couldn’t have that.

That would be bad.

Yes. So we’d even have to go in later and pressure-grout those places, set up big pumps with a real fluid type of concrete and pump it high, oh, 1,000 psi, 1,200 psi, 800. We weren’t going to get too high because that would again fracture the rock, see. You get too much pressure. So they’d make us go right up to a certain psi and then hold it right there. And sometimes we’d have to hold on them for hours because they’d bleed off and you got to pump them up again and they’d bleed off and pump them up. So it’s labor-intensive, and it goes on twenty-four hours a day. A lot of hours and hours and hours of pressure-grouting went in to seal the plugs, to seal the concrete and the rock interface. We couldn’t have any voids. Couldn’t. Couldn’t afford a void. That would get us into more hot water than we could get out of, because we did it several times. We left some of the pipes empty and we didn’t know it. On reentry, you know, when you’re mining back through it and you see one of the pipes that ain’t got—ohhh, boy! Here them inspectors are writing down—and then they have a meeting about it. Oh, yeah, that could really get us in somewhat of hot water with the containment.

Yes, I bet. Well, and if on a good day, let's see, you said about six to eight feet of drilling a day, that's what, eighteen to twenty-four feet a day, somewhere in there? Maybe just say an average of twenty?

[00:40:00] That would be a good figure.

How quickly does the line-of-sight pipe go? And which way are you going? Do you go from—?

We work towards ground zero.

Towards ground zero. OK.

Except when you retreat, you know, once you put the device in, all you can do is go out. So we start at ground zero and pre-grout or pre-stem, they'd call it pre-stemming. You pre-stem all the line-of-sight pipe into place. You do all the concreting you can ahead of time. That's so when they bring the device in, the only thing you've got to do is plug up your pathway, the bypass drift and some of the crosscuts. Most of the crosscuts are already pre-stemmed up for, let's see, the one into the FAC, we usually have to pour usually simultaneously while we're readying a pour in the bypass after they've inserted the device. We'll make a pour over here and then one over here and one there and one back here and then it all comes together, but we have to stagger our pours. What I mean by stagger them, you've got a pour here so it can be hardened and so they can be getting ready for another pour behind it, because the pours were about a hundred foot long, and you went back in there, say, a thousand feet, so we had ten pours, roughly. It varied from, I'd have to get a map and look at the bulkheads on there, the stemming bulkhead, but they're roughly about a hundred feet. Some of them, the anchor plugs, which would be the last plug in the stemming, we called that anchor plug, that's the one that's got to hold. Some of them up in there can fail a little bit, but that one better not fail or the tunnel's in trouble.

I'm sorry if I missed the answer, but like when you start the line-of-sight pipe and you're going towards the test bed, the device, the device is not in yet. No. How quickly are you moving on that? How quickly does that go?

OK, once they start fielding your line-of-sight pipe, it would take the fitters and the miners about, oh, I'd say anywhere from seven to nine months to install the pipe, because they come in in about fifty-foot sections, thirty-foot sections, so they had to be welded. You know, a twelve-foot weld all the way around is a lot of welding. And for the pipe fitters to get in there. They'd weld twenty-four hours a day. But it'd take to install, to line, because they had to line that pipe, you know, they shined a laser beam right down the center and they had crosshairs. They'd hang a crosshair on the pipe and they'd have to be right on, dead right, zero tolerance, putting that laser beam down that pipe. And that's how they could get that big pipe centered. And then we'd concrete around it so it wouldn't move. Because they had to pump a vacuum on it later.

And so you did the two things relatively simultaneously? You would concrete and go back with the—no, that can't be right.

No, we'd install the pipe—

And then you'd concrete.

Then we'd weld it, and once they—

So you'd install the whole pipe, then you'd weld. OK.

And then they'd pump a vacuum on it to make sure there were no pinholes and leaks in the pipe. And then they would say, all right, the pipe is sealed. Then we would go back in and build bulkheads about every hundred feet, and then we'd pump up a hundred foot and that'd hold that, and then retreat out and pump another hundred foot and another hundred foot until you get to the end of stemming and the line-of-sight pipe is there. It's encapsulated in concrete, different flavors and hardnesses of concrete, some that it's soft for a reason. And in fact there's even one section in one of the FAS gate or the MAC where they just blow sand in, just regular desert fines, because they wanted that little twenty-foot area for this high-det explosion to collapse that pipe. And then they wanted the gases to start to go out into the rubble zone, but then not to go beyond that. You can get out this far, but don't go beyond that. And they got to where they could target.

It's incredible, isn't it?

In fact, one of the things that used to get me about it, in the craters down in where you seen the pictures of the bomb craters, they'd come up and they'd take the laborers out there and they'd **[00:45:00]** build a fence around the area that was going to crater, and when that thing subsided, caved in on itself after zero time, oh, sometimes two or three hours, the whole thing would just cave in on itself. You could go right up to within about three or four feet of that fence and the rest of it was just a big crater. And how in the world do they know it's going to crater out this far?

They're good.

Because it know it wasn't the laborers that did that, but so many feet from ground zero they had to have a fence for later, and that's exactly—let's see if I have one here. This shows you a picture of some of the [sound of pages turning] at Baneberry.

Like if this is the main tunnel, and then this is the line-of-sight tunnel, right, if that's the main tunnel, this one, and that's the line-of-sight tunnel [indicating on diagram], do you concrete all the way back to here?

End of stemming. End of stemming can vary.

OK, so that's like the map you showed me somewhere. OK.

Yes, and they all vary different, according to what the size of the yield they anticipate to be, how much do we need, 800 feet this way, 1,000. See, you got 800 feet of overburden above you, you need that much here, and they'd usually go about 10 percent over. That was a rule of thumb that I figured, or at least we're going to give you another hundred feet to play with, at least a hundred foot on what they call the anchor plug or the end of stemming. Same thing.

And that end of stemming, that's where it really has to—

That's got to stop anything that might get away, other than if it comes down the line-of-sight pipe, and if it comes down the pipe and the pipe ruptures, there ain't much you can do about it. See here [sound of pages turning]. See all these craters? Those are old bomb craters. It looks like the moon.

It does look like the moon.

Yes. And they'd have a fence all the way around that thing.

[00:47:22] End Track 2, Disc 2.

[00:00:00] Begin Track 2, Disc 3.

All right, so we have the line-of-sight pipe in. Let me see if I get the terminology right. You've concreted back to stemming?

End of stemming.

To end of stemming. I was close.

End of stemming or anchor plug, either one.

Is the bypass tunnel still—?

Open.

Open. So that's the last thing you do, because you need some access to get—

You have to have access to insert the device and get your scientific people back in, and then as they come out, then they have to arm certain cables, make certain splices, or not splices probably at that time but they have to arm the FAC, MAC, GSAC, TAPS, they have to arm them. OK, they're already armed. You have to go into a firing box and put that in readiness, and then that firing box would be concreted in, but they have to pull the shunts out and all the safety devices, protective devices, and then get it ready to go, and then we retreat out of the bypass. But there's probably four places along there we've got to stop and let the scientists make their adjustments on the closures, because that's all done from the bypass side, or close to it, where we can get a firing box in there.

And right now, at this stage of the process, you can still go into the line-of-sight tunnel, right? Or pipe, excuse me. And go almost all the way back, right?

Well, you can go back till it gets too small to crawl. But yeah, you can go back, like I said, that far.

Do people ever need to do that, to tinker with the experiments or anything?

Yes, Yes, Yes, because there are gauges back in there, there are gauges and experiments that they have to get back in to be at, yeah. So actually they have big doors. I saw one on this one here. See, these are entrance doors. See that one? You can imagine one, oh, they looked more or less like, if you had your big line-of-sight pipe, they have just a big hatch that you would be able to seal it because they had big wing nuts, much like a hatch on a ship, a bulkhead hatch, exactly the same thing. So they could put a vacuum on that pipe, because it had to seal, because they had to put a vacuum on the inside of that pipe before zero time, down to I don't know how many microns. It got down to an almost perfect vacuum. Real close.

Was that one of the reasons why they put the vacuum on it, is to make sure there was no—?

Nothing.

Yes. So it's not so much to simulate outer space as it is to make sure there's no—or it's both, I guess, but to make sure there's no punctures or—

Because a lot of the testing was done for outer space, so they had to simulate that as close as they could.

OK. And is there a sense of, I would imagine that some tests needed to be closer to—at that point, does proximity matter, you know, the experiments in the line-of-sight pipe?

As long as the shine can hit them, because they all have to have a little real estate. In that one picture you've seen that they're this was always a good—

How did the welds hold?

Good. They got some of the best welders in the country, and they did it all with wire feed, heliarc. See all these little experiment stations? Anything back here or up ahead of it can't interfere with this shine. It has its own little—all the way to ground zero. Each one of these, even the stub pipes, and they're along the outside of the pipe. But each one of these things was placed in a strategic position to where when this shine comes down the pipe, you don't get a shadow from one interfering with the other. In fact, see, you couldn't put one right behind here. They all had to have—

They each had to get their own part of the light, the shine, the light.

Right. And that's why they got into the twelve-foot pipe, see, they could have more area down there, where if they put them all up front, they wouldn't. So the bigger the pipe, usually the more **[00:05:00]** experiments they had. And they usually had two test chambers. This is a major test chamber and then they'd have one—in fact, the door to that test chamber is right in front of this. Yes. I've probably been in this pipe right here. I bet I have [p. 24].

So where are we in the process? If the line-of-sight pipe is done, if the concrete has been poured to end of stemming, how many months out are we now? How close are we to the event and how far away from here?

We're within three to four months of execution. Whatever it takes for the electrical people, the techs to get all their stuff ready, their experiments all ready and in and tested, so they'll go through several dry runs. Probably every day they'll have three or four dry runs.

And the dry runs start occurring at that point where you have—?

Once all the fielding is done, what I mean by fielding, all the experiments are in, and then they've pumped a vacuum on the pipe, and then they'll have a dry run. Everything's working good, everything looks good. Then once they've determined that the experiments and the experimenters are done, all the recording stations are set to go, the computers, in big, huge alcoves or drifts, sometimes they call it a dance hall, too. It was about, oh, thirty foot wide, probably two hundred foot long, and it'd be plumb full of little trailers, a trailer much like a little square house trailer, only about, oh, about twenty foot long, eight-by-eight-by-twenty, fifteen, and inside these was all their recording stations and computers. Mostly recording stations. And then all the cables were run to them. And then there was a cable run from them on to the surface, into the mesa, because they had trailers sitting up there that would record, too, outside, up on the mesa, because they had a drill hole through from the surface down with cabling going up that they could connect to and put more recording trailers on the surface. But that was usually outside of the crater area.

But one time they didn't. RADSAFE went up there and they were in one of the trailers checking it out when it started to crater. Killed one of them. There were about four people went down in it. I think one was killed. One broke his leg. That was at T Tunnel, too, but I don't know if it was Mighty Oak or it was the one before Mighty Oak. But yeah, the kid that got hurt, I knew him in Pahrump. He died. He was a RADSAFE. And they have to go back. That's when they really come into focus is when on reentry, because of the possibility of radiation leaks, gas leaks and stuff. And there was always some, but most of it was minute. It'll tell you in this book here if there was any [DOE/NV—209-Rev 15 December 2000].

OK. And so if the dry runs have gone off without a hitch—

Then they give us the go-ahead and they order the device and bring it up on the job, usually about, oh, it shows up about seven in the morning, and we take it underground and they're ready to start pumping concrete or stemming, they give us the OK to start stemming.

Is there a tension when the device shows up?

Yes.

I mean are the same people allowed to show up at work, or is it—?

Usually no, except the need to know and the need to be there, you're escorted in and out. They got a visual authority, a VO. I don't know what that acronym means. VO is visual authorization. OK. So you had a badge. You wore your badge. And then they'd log you in and log you out. So you had to be on a list of some kind to get in there. And the number of cadre was at a minimum. Always at the bare minimum. We had people standing by down twenty miles away or ten miles away, or in a bus sitting at the bottom of the hill somewhere, all your craftsmen, but they were ready to go pumping concrete. As soon as we got ground zero buttoned up, then they would turn it over to us.

[00:10:00] *When the device came, how much time between that morning, that seven a.m. in the morning when the device shows up to where the event's actually going to take place? Are we weeks away? Are we months away?*

It took us somewhere on the average of seven days to button the tunnel up. We retreated and pumped all that concrete in about seven days. Then your gas-sealed containment plugs had to have a cure of about three days to reach the hardness to contain any possible leaks. It had to get somewhere around the 20,000 psi range, the hardness of the concrete.

If the device got there at seven, at what point would they leave and the device already, you know, how long would it take for them to show up, install the device, and then have you have your crew come back and be able to start working?

They call it emplacement. Three or four hours. Short time. It doesn't take them long to assemble it, but there'd have to be a protocol, usually a DNA or a Navy or an Army, DoD personnel has to be there. Usually it's the engineer in charge. You know, I knew several. On this one here, Ricky Richards, Lieutenant Richards, he was the [DNA test] engineer that I answered to, the first line of engineer. He kind of was the captain of the ship, well, in the engineering part. I would've been the captain of the ship and I had a boss, a project manager, which oversaw all of the—each one of the crafts usually had a superintendent. I was over the carpenters, the miners, the laborers, some electricians, and some pipe fitters. The pipe fitters had a superintendent and an engineer, and the electricians had a superintendent and an engineer, usually.

OK. And what was that called? Was it past time?

Late time.

Late time. And so we're here and then if the device shows up on a Monday, how long does it usually take before the event actually happens? I'm just wondering.

Seven to ten days. It took us about seven days to retreat, pump all the concrete, pull and close the doors. Only had one big door to close. I would say eight, nine days. About seven days to what they call button up. Final button-up would be closing all the little hatches. You had big doors that closed the tunnel, but you had little hatches that people could crawl in and out of to get up to the end of stemming, see, in case they had to go back in and go in the line-of-sight pipe; they could actually pull the vacuum off, open up the pipe—that was costly and it usually cost them time when they did it, a day or two—and they could go in and make an adjustment and go out and then pump the pipe back down, and that usually took about, oh, twelve to fourteen hours to pump this pipe down to vacuum. Sometimes longer, according to how big the pipe was, again. Because they had big roughing pumps and then they had finishing pumps that'd really get her down to however many microns they wanted to. And then once the final button-up was made, then we'd retreat to control point, which was CP, into the "war room," I think they called it.

What was the last actual thing you did in the tunnel before you left and went to control point?

Closed the hatch on the gas-sealed door, the last closure in the tunnel.

What's the line-of-sight pipe doing right now?

Sitting there with a vacuum on it.

But I mean is it open at the other end?

No, no, no, they've got a big dome on the end of it. It's all closed.

So you close that down, too.

Yes, it's got a vacuum on it. See, there would be a big dome fit on the **[00:15:00]** end of this. Say this was the end of the pipe [p. 24], there'd be a big dome fit on there, and then a bunch of stub pipes, them little pipes would be run off of it to various experiment stations.

Now at this point, is all of your attention as the mining superintendent devoted to this particular test? I mean has the next thing you're going to do come across your radar screen yet?

No, we're focused on execution and reentry.

OK. Are you out there—?

Here's your war room [p. 27]. This is where they actually say test control center, and I would get to be back up here, more or less in just readiness. I didn't have no function other than to watch it go on. Here's your test controller. That's Larry Ashbaugh or Joe LaComb there.

That looks like NORAD a little bit, or NASA [National Aeronautics and Space Administration].

In a way, because it's all weather stations. They can tell weather, they can tell everything, they can tell you what the line-of-sight pipe is, what the temperature is at ground zero, and they have to keep ground zero at a certain temperature, so there has to be refrigeration units run right up until zero time, then they shut all power off. They can do that remote, shut all power off, and put a key in, turn it, which they've already done that in the red shack, and then the countdown is done automatic.

What's the feeling like, being in that room?

Well, it just like, I think, much like a space shuttle or anything like that. Everybody's been working for sometimes three, four weeks, seven days a week. We don't shut down, you know, and it gets to where there ain't much left of you.

Well, I mean a year and a half total, right, in that neighborhood, and it all boils down to this single moment?

And then they can tell in a few minutes, because there'll be different places along the tunnel where they can tell if there was a radiation leak.

And so is it like a mechanized countdown, you know, ten, nine, eight—?

Yes. Especially the last thirty seconds, OK, how was it? Let's see if I can remember how it was. It'll be, OK, "time minus three minutes, T Tunnel, Distant Zenith," and then over the loudspeaker in another minute, "minus two minutes, zero time, Distant Zenith," and then during the real thing it gets down to the last—and even during the dry runs, it gets down to the last fifteen, twenty seconds, they count it down, ten, nine, eight, seven, zero time, T Tunnel, P03.

I mean is it anticlimactic? Because I mean with the space shuttle, you actually get to see the space shuttle going up or—

You don't see anything. If you're outside, you might get to see some dust come off the mesa.

OK. Because you can't hear anything, right?

No, nothing.

So the first time must've been kind of almost a letdown, somehow.

Yes. Here's your radiation monitors [p. 67], see, they're all up and down the tunnel, each one of them black spots, and this is ground zero. Here's end of stemming, right there. So if there's any leaks, all over this tunnel and clear outside the portal, out over the portal, because see our offices are over here. This is the portal. And all these are RAMS [radiation area monitoring systems]. Mission Cyber, December 2, '88.

So you know pretty much instantaneously whether or not everything is OK.

The temperature, everything, yeah, they can tell within, oh, twenty seconds whether they're going to have failure. And failure means that somehow radiation gas got out from something. And they can pretty well tell where it came from.

And you as a mining superintendent in the war room after twenty-one seconds after, what are you thinking now? What do you do?

We get to go home.

OK, so you go. And then what's the turnaround time between detonation and you going back?

I was on several of them in the beginning, but once the execution goes over, the authorities hand it over to DNA, to Joe LaComb and that type, the top dogs, they call the shots from then on. So we would have a standby group of reentry people, in case they have to go back in or go back in **[00:20:00]** and establish a fresh-air station at the portal. Right outside here, over here there's a big building, and that's where they establish a, OK, everything, the portal's clear, there's no radiation escape, there's no contamination, we're OK to go to the portal. But we can't go underground yet, but we can go to the portal. So you go up there and you assemble your reentry teams. You usually have three of them. You have a reentry team, a rescue team, and a standby team. And there are about six, seven men on each one of them. Then they can tell at all times by their RAMS or their monitors if there is any gas buildup or pressure buildup or if there's a problem, they can tell. But they physically go in there and check every foot of it and assess what they call scientific assessment. They look at the tunnel and they look at the rail and they make sure this is OK and it's all under microphone in a self-contained—like they went after them miners in Virginia, same thing.

And you're out there for all this. No? Yes? OK.

Yes. Usually we get to go home and shower and change clothes and get back up here by eight o'clock in the morning. Say this is two o'clock in the afternoon. They'll take, and I won't have any part of that, establishing a safe area at the portal. Once that's done, then we show up, usually the next morning around nine, ten o'clock. Reporting time is eight. We'd go up and assemble our rescue teams, and everything's pre-staged there, and then the test controller will tell us, `All right, let's advance to the gas-sealed door`. So we'll take a train and go as far as the first gas-sealed door is. Then they'll have a group of people under that little hatch I'm talking about. And then we'll open that up. And then they'll go on through and they'll go to the next plug. They'll open up another hatch in a little turn tube and crawl through it and go up to the end of stemming on both the bypass and the LOS drift, and they're going to check for radiation, any leaks, any gas leaks, any explosive mixtures. And once that's assessed that there's no problem, then we'll turn the ventilation on, the big ventilation outside, and that'll start ventilating the tunnel. And then usually that night we have a swing shift come on and we've got authorization to open the big gas-sealed door. So the iron workers will go in there and open that huge door, probably weighs thirty tons, forty tons, and pull it around, and lay rail back so we can get our engines in it. And then the next day, we'll go up to the next plug, which is the overburden plug or the gas-sealed plug, not the door, the plug, and they'll go through there. A lot of the scientists go back in. If they have to recover film right away, they'll take a scientific assessment team and it'll last usually two or three hours. They won't be underground over an hour and a half. And they'll go in and get their film or something and pull it out. And then they'll let us ventilate the tunnel, continue to ventilate and continue to hook up our ventilation, and then we'll start mining back through the gas-sealed plug, which is usually drilling and blasting. Sometimes they'll let us go through these trainways with an Alpine™ miner. In the early times that we had to do it, the drill and blast, but then once the Alpine™ come in, then we go right down through the middle of this plug and mine out the center of it. That way, we can get our trains back in and all of our personnel. Because on a busy day you would have 200 people underground, 250, on a shift, not usually a back shift so much but on day shift you would have anywhere from the bare minimum you're going to have is about fifty or sixty, and then however many watchers and tourists that you got, people with nothing else to do that want to come watch.

As far as the line-of-sight pipe, are you taking that whole thing out, or just the experiments out?

Both. Sometimes they reclaimed the line-of-sight pipe up to the end of stemming, took it out, sent it to Spokane or sometimes they'd do it onsite, sandblast it and clean it up and if there was **[00:25:00]** any radiation, you know, they'll decontaminate it, and then they'll reuse that, especially your test chambers, because they were a lot of labor in there. The regular bare line-of-sight pipe, they can probably make that easier and cheaper than redo it. But a lot of your TAPS, they would reuse the TAPS, the tunnel and pipe seal, and that probably weighed sixty tons, eighty tons, sometimes a hundred tons, according to how big it was. Huge.

Is there any reason for you guys to go back through the bypass tunnel?

We do go down the bypass as far as the end of stemming, and they'll set up a diamond drill and tag ground zero. I mean a core drill, like I'm saying, they'll actually core into, under special conditions, blowout preventers, you know, and full safety gear, they'll tag ground zero. I mean tag the melt or the molten rock or the area where ground zero once was.

Is there any ground zero anymore?

Well, it's where imaginary was. It's nothing but a big cavity, or that's usually cave—

Yeah, I was going to say, is there a cavity anymore or has it been caved in?

Just a chimney, yeah. In the early times, some of the events they had, the big megatons on the mesa, did leave a cavity. Benham [12/19/1968, U20i, 1.15 Mt] or Boxcar [4/26/1968, U20c, 1.3 Mt], I can't remember which one. Boxcar was the biggest, or Benham? They were the biggest megatons done on the test site. I think we only did two or three megatons. And the scientists said that there was a cavity there that you could put Boulder Dam in. That's 7,000 feet. Big as Boulder Dam.

A cavity of 7,000 feet, as big as Boulder Dam?

Yes. And then it would cave in, every once in a while you'd hear—you'd be down—I was underground at 19G and you could feel that. It wouldn't be a rocking, swaying motion. You'd feel the energy, I guess, through the tunnel wall because Benham was only about five miles away, but there'd be huge cave-ins inside that cavity for a long time, for two or three months. Every once in a while, we'd feel that cave-in. You can't hear—

From five miles away, you would feel it?

Yes. Underground. Yes. Because it had to be huge. I mean you got to have boulders flying around there, or falling. Not flying but falling. You know, as big as Boulder Dam, that's huge. And then, you know, it stayed a cavity, an open cavity, pretty much for quite a while, three or four months. And then every once in a while we—because we couldn't figure out what it was. So finally one of the bosses, they said, Hey, we're going to shut this thing down, and finally got some of the scientists and they started coordinating their geophones with the time it would happen and said, well, yeah, that's all that is, is whatever the codename was, Benham or Boxcar. But it was in the megaton range. A million tons of TNT. Most of them we did in the tunnels were kilotons. Fifteen, twenty kilotons.

We have three-and-a-half minutes. We can always put another CD in, but is there anything you feel like I should know about the post-detonation?

It's still the same mining for us except we went much slower and you usually had the scientists right there. When you got close to one of their experiments, oh, they'd be right there, well, we got to mine just a little slow and do a lot of it by hand with spaders and chippers until they got one of their gauges out and they'd let us go again. But we'd reenter down and they inspected every foot of it.

How long between the time you actually start the reentry process and the time where it's done, complete, you're ready to move on to the next task?

Three or four months.

That long?

Yes. By the time you get all the mining done, back, because we had to mine back in usually to the GSAC and MAC to check them out, and they'd pull them out and reuse them. So we went back within, oh, 300 feet, 400 feet of ground zero, with our mining. Usually down the same old drift. We just mined the old concrete out. Because they wanted to see how, again, if we did a good job of filling the tunnel. Because one time we didn't. It was at P Tunnel. I got my ___ chewed on a little bit. They said, hey! Oh, and I saw it. I says, oh, shit. Because I'd seen it first. I **[00:30:00]** said, oh, my God. What they call a top-off hole. Say this was the tunnel here [drawing] and every so often we'd have to drill a hole up in here, up in the back or the roof, oh, that big around [indicating size] and then stick a four-inch pipe in there. And then we'd pump on that last. That was the bleed to let the air off. And when this tunnel got plumb full of concrete, it would force it up in here and out this little pipe, because there would be a pipe in there, and then it'd be run clear out to the bulkhead, see. So this is a top-off number 2. Top-off number 2. When that got full of concrete, you knew that the drift was full of concrete. But not always. It didn't always run that way. See, there would be voids in it, and just sometimes the concrete would be up in there but yet this little bit would be void, see. You couldn't have that. No voids whatsoever. Because, see, once it—exponential numbers that went on, once that gas got into this, see, it could create more and more and more. Then it could get away from you. So we had to make sure everything was gas-sealed tight. Labor intensive. Hours and hours.

Yes, it sounds like it. Well, we literally have fifty seconds left. Sum up a test in fifty seconds.

Yes, that's it, sum up a test. Get ready for the next one. That's what we did.

Yeah. Would you get any time off or would it be basically done with this one, all right—?

Some. Well, yeah, the heat would be off once the reentry was established and we got back to the everyday way of doing business, mining the bypass and stuff like that, yeah, we'd get time off. It wasn't bad. But you didn't ask for none of that until after zero time.

We're at T-minus-10, so [laughing].

OK. All right, that's good.

Thanks, John.

[00:32:13] End Track 1, Disc 3.

[End of interview]