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

Interview with Robert Brownlee

August 6, 2007
Las Vegas, Nevada

Interview Conducted By
Mary Palevsky

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

Robert Brownlee: The first lecture I give at these courses [for UNWTOP, Underground Nuclear Weapons Testing Orientation Program] is just pure history, and my theme is, how do we happen to have nuclear weapons? And so then I start with the desire, with our fright that the Germans might get in [with an atomic bomb during World War II]; I describe the guys at Los Alamos [National Laboratory] in those early years, who tended to be Europeans, in interest if not nationality, and their fear of Hitler, and their desire to make sure that he was defeated, and so they were working night and day to do that. And then suddenly, Germany was defeated. So, in Los Alamos there was among those scientists, an appreciation for what nuclear explosions might actually be, and so some of them, once Germany was defeated, were not very enthusiastic about continuing. But, I'm going to say the military—but I'm really talking about the administration in Washington [D.C.]—they saw the necessity to stop the war essentially at any cost, because those—and I was in the Pacific, so I was aware of the fact that we were facing a really gosh-awful future with Japan. And as time has gone by, I appreciate even more how close that was. The Germans had given Japan all the necessary information for jet airplanes, and Japan had the capacity to really do things quickly, and it was a close call. So I say, OK, we fired three nuclear explosions, when we only had enough material for four, but why did we do that? It was to stop the war. And so we fired those three things, and the war stopped, and so that's that.

And then I bring in the fact that it's much more complicated because there was a war between the Army and the Navy, a tremendous thing. First of all, it was just historical; the Army and the Navy made sure they didn't get along. The Pacific was a Navy lake, and they felt that the money spent on the Manhattan Project was a complete waste, because it should be given to them; they controlled the Joint Chiefs of Staff [JCS], [Franklin Delano] Roosevelt was a Navy man, and so they were dead set against the Manhattan Project. This is particularly true of one admiral, and I'll say his name in a moment [Admiral King]. He'd been in ordnance all his life, and he was on record as saying that it was ridiculous to think that they could get that much energy from something, and so he regarded the Manhattan Project as a complete waste. And I was in the Twentieth Air Force, and we were aware that we were surrounded by Navy, and they controlled everything, except the mail. Air mail.

At any rate, they were scornful. And, lo and behold, the Army Air Corps dropped two bombs, and the war ended. And the Navy was astonished. And so they felt—they were after all in control—they felt obligated to find out about this new weapon; they were convinced that it couldn't really bother them, but they wanted to find out. So the [Operation] **[00:05:00]** Crossroads test in '46 was strictly a Navy deal, and it was bungled in about every way you could bungle it.

Mary Palevsky: *Can you give me some sense of some of the bigger bungles?*

They put the fleet of about 198 ships, I think, in Bikini, and the first thing was an air drop. The only plane that could drop an atom bomb was a B-29, so that was the Army Air Corps. B-29s at high altitude never, ever hit the target that they aimed. The reason for that was we didn't know that the atmosphere was layered and every tacking of wind was going this way, so when you dropped a bomb, it did that [demonstrating], and as a result, the commander of the Twentieth Air Force said, We'll go in with two incendiary planes and drop a great big X. And then everybody bombs on the X, and no matter where the bombs go, it turns out you create a fire storm, and that's much better. You couldn't hit the target anyway but you could get it with fire. So, traditionally, we never hit anything we aimed at.

Well, I use this as kind of a joke but, on the air drop, of course, Crossroads Able, we missed the target. The Army Air Corps did not hit the target. You see almost no pictures from that event, and the reason for that is the bomb went off above the ship that had all the cameras. It's bound to happen. [Laughing] And so the amount of information we got from that was not much. There are almost no pictures. I have two or three pictures that I dug up, the only decent pictures that exist of that event. [R.Brownlee 2007 1-4]

Now were you involved in Crossroads?

No. And then, in Crossroads Baker, the bomb was placed underwater, in the center of the fleet. But the Navy did exactly what the Navy always does. They have a sheet of paper that, at time plus one minute, you do this; time plus five minutes, you do this; time plus ten minutes, you do this. So immediately as the bomb went off, they followed their sheet, and they put men on those ships. And those ships had been—a water wave came over them, that was intensely radioactive. And so the Los Alamos people were saying, `Don't put anybody on the ships until we find out.` But they followed the plan. So they put a lot of people back on the ships, and when they got there they discovered that the radiation levels were so high, everything was off scale, so it took time to pull them back. So they exposed unnecessarily huge numbers of people.

Another other interesting thing to me about that [was] the number of people there to watch were forty thousand or something. There were a whole lot of people in the Pacific with nothing to do after the war, and they all went to see this shot because it was the only thing going on, so there were huge numbers of people there, which by our standards, AEC [Atomic Energy Commission] standards, was silly. They were there. And I think they were there because they were bored. So there were huge numbers of people there, and a lot of exposure that was unnecessary. And they were convinced that their ships would survive. And so, when they saw the devastation, which was much more than the radiation: they put an aircraft carrier and the bottom fell out of it, and ships sank for some days. So the chaos was just so great that that they cancelled Crossroads Charlie. They were going to have three. So they only had the two tests.

Well, this came as a shock to the Navy. I'm saying that with the bias of being an old Army man. It was really a shock to everybody, because the other things happened with nobody **[00:10:00]** watching. I mean you dropped it in Japan but we weren't there, if I may put it that way. So when we did it ourselves and looked, then we learned. And the "we" there is mostly military, because they were the ones that did not understand or appreciate the magnitude of what was going on. I think the guys in Los Alamos understood the magnitude of it, but the others, you have to see it to believe it. And so they learned an awful lot. And as a result, they said, OK, we have to have a big program, we have to have a series of tests, we have to understand what this effect is on us. And so, the goal at Los Alamos was stop the war, and once we'd done that, the Los Alamos scientists, many of them said, "That's it."

But the nation, I'll put it that way, said, We have to learn more about this. So then we embarked upon a whole program, which eventually became just an AEC program, and in the earliest days, I've been told that when the military showed up at Los Alamos, there were people there who would tremble when they saw a man in a uniform, because they'd been so traumatized by the European things. And so, in my day, when our deputy director was Jane Hall, the military would come to Los Alamos and want to have tests for their purpose, and Jane Hall would serve them tea and say, We're very busy right now and we just don't have the time to do that. So one of the reasons for [Lawrence] Livermore [National Laboratory] was they needed a responsive organization. And so I think you know this story. I probably don't need to say more about that.

But, in my talk to the UNWTOP people, I try to give them this feel of history, and then I show them our atmospheric tests, and all the things that we did, trying to understand, and then I describe the evolution into the underground part of our experience, and I played a significant role in that because, in 1956, my boss, Al [Alvin C.] Graves, said, We're going to have to go underground, so Brownlee, find out how to do that.

So that was as early as 1956.

Fifty-six. Yes.

And what were his reasons for saying we had to, from your understanding?

He recognized that we can't go on testing in the atmosphere because of the fallout. We're going to have to go underground. And so the purpose of going underground was strictly to eliminate the fallout.

Now this is a question that may require some retrospect on your part, so at the time and in retrospect, do you think Al Graves was saying, the fallout itself is a problem, or the perception of the fallout, or some combination?

The fallout itself is a problem. Al Graves was in Chicago [Manhattan Project's Metallurgical Laboratory, University of Chicago] under the stadium when they did their first thing [nuclear chain reaction]. And Al Graves was a genius of the first water. I don't think he was necessarily seen that way, at the time, because his role was different, but when I say "genius of the first water," I'm saying his ability to look ahead and see the future. He was way ahead of a lot of the others. And so he took it upon himself to do things.

Let me give you an example. In the war, and I participated in this, you were permitted to sacrifice as many lives to achieve a military objective as needed. It was standard. So you are to achieve this objective, and you sacrifice whatever to do that. And Al, in those days, felt that you must preserve human life. I went to the same church he did in Los Alamos. He was an elder in our church. It was not a denominational church; it was an interdenominational church. But he was a Christian and had certain Christian principles that I admire because I'm a Christian. And so as division leader of the Test Division, he said, Nothing that we do is worth the lives of one of my men. And at the time there were only men. And therefore, he created a system in our task **[00:15:00]** force. It was an out-of-the-record way to get information from anywhere in the ground floor to the top guy. And in the military system you can't do that. So what he did was create a Hazard Evaluation Group, an HEG, and they sat under his armpit, and if anybody in the task force was concerned about tomorrow's shot from a particular point of view, they could talk to us because they weren't on record and they weren't held responsible. If we thought that was important, we would go to Al and say, We think tomorrow's shot should be postponed until this problem is solved, and he'd postpone it. And then we'd go back to that guy and we wouldn't proceed until that guy felt we had solved the problem. Had NASA [National Aeronautics and Space Administration] built a system like that, we would've saved the *Challenger*. But we had a system whereby, if somebody was really worried, you could call it off. This drove the military crazy, because it was the civilians controlling the joint task force of running a test in the atmosphere. But the civilians were almost invisible, and it all focused on the deputy commander who would say, No, I can't do it.

There's something I will tell you that does not exist in any history book, but I don't think I'm violating any classification at all. But in 1962, when they were at Christmas Island, Admiral [Lloyd M.] Mustin was—there was going to be a test, and Bill Ogle was the scientific deputy commander. And Bill Ogle said, We're not ready to do the test, and it was, I think, a safety problem, and therefore we can't do the test.

And the Admiral said, I'm in charge and we're going to do the test.

And so Bill Ogle said, Well, certainly, you're right, you are in charge, but I can't have any of my men there, so we will just call and have the planes come from Honolulu and we'll evacuate all of the Los Alamos people while you do the test.

So the Admiral capitulated.

And then I became the scientific deputy commander of the task force. And Bill Ogle told me this story. It had never gotten out anywhere but he said, You as scientific deputy, you just say, "Fine," to the military, you go do what you want, but we will not participate. And then evacuate your people, and you have that right. And he did it once. And of course he didn't have to do it, because the Admiral capitulated.

Al Graves started that kind of a policy: Whereas the military, had a decades-long habit, well, seven years' habit, of sacrificing people for objectives, we are not going to do that. We are not going to do that. So therefore, we could stop a test if we were really worried. And the concern was not money, it was not schedule, it was lives, of our men. Now, if he had that about us, he had that same feeling about others. So that's why I'm convinced that he, an old Los Alamos guy did not want to do things just to kill Japanese.

So this thing I've told you has never—I've told a few people this story, in recent years, but you'll not find it in any history. It was totally off the record. But it was a very significant event when the deputy commander says, Fine, you do as you want to do, but our people will not be there.

[00:20:00] *Right. I have several questions about this but do you recall, did that test eventually go?*

Yes, it went. It went when we were ready. I believe I'm the only person who knows it happened, who's alive, and I don't know the event.

You don't know the event, but it was a '62, Christmas Island test.

Yeah.

The other interesting thing I wanted to comment about was that you seem to be indicating the mindset of World War II that you're talking about, of sacrifice everyone for an objective, and then the war ends.

But in the ending of it, I think there were people at Los Alamos who still had this idea, `Let's do a demonstration test. Let's not actually drop it on them.` And then the question arose: `Yes, but we've only had one test, and let's have a demonstration and have them look, and suppose it doesn't go off?` And that's a sufficiently profound speculation that, I think had I been on the decision I would've said, OK, let's not have a demonstration. I think I would've come to that conclusion. We're trying to stop the war. Oh. Two-thirds of all the people killed in the Pacific from the beginning, the beginning being '37, two-thirds of all the people killed in the Pacific were in the last ten months of the war. And every day the slaughter was bigger. And so we killed four hundred thousand people with those fire raids. Not a hint of surrender. If you look carefully, this is my opinion, the Germans bombing London didn't bring the British to their knees. Their resolve was not to quit. It brought them to their knees in 1938, but when they bombed London, it went the other way. And so all of our bombing raids never tempted anybody to surrender, no matter what the devastation was. The nuclear thing [was] an awesomely different thing, and that did bring them to surrender.

So, I think had I been part of the business, I would have voted to go ahead and drop it on Hiroshima, or drop it somewhere, rather than ask for a demonstration test. But, there were people in Los Alamos at that time, and I was not there then, who said, `Our object is not to kill people. Our object is to stop the war. Stop it.` And the hope was that it would stop it.

Do you know where Al Graves was on that question?

No, I don't. But his behavior, subsequently, was always consistent with demonstration tests, but he never told me that.

Now, just briefly, what was your role when you were in the Pacific?

I was in the Test Division.

No, I mean during World War II.

Oh. I was a navigator in B-29s. So I arrived there just at the end of the war, and so I got there and saw the end. And then I got out, so I was back at the university in graduate school, at the time of Crossroads tests.

Now, when you were a navigator on the B-29s, did you go on bombing raids?

No, I got there just at the end, so my missions were—we were hoping we'd be shot at, just for the record, but we never were. We flew over one island, hoping they would shoot us, but the Japanese were saving their ammo and they didn't have much. So I got there right at the very end. But, you know, the guys there were aware that Iwo Jima had been captured, in order to save our B-29 crews. And I mixed with those guys. And they were kind of in awe that all those Marines **[00:25:00]** lost their lives just for us. It wasn't for our planes; it was for us. And they didn't have enough B-29 crews. They had to keep them. Plenty of airplanes. And the guys in Iwo Jima didn't know that they were taking Iwo Jima to save Army Air Corps lives. It's a great oddity. I still, as an Army Air Corps person, am in awe of the number of people who were sacrificed to save us. That's very humbling. Because they didn't know it. But the B-29 crews knew it, and they were landing on Iwo Jima before the place was completely captured. At any rate, a strange war.

Well, let me come back to the subject. And the subject is, how did this unfold? And I try to give the classes that. And then I show them that, early on, we said, OK, we're going to have to go underground, but how do we contain underground? Because the object of going underground was just to contain. And the experimenters didn't want to go underground at all, so they wept and moaned and cried and carried on, because they were going to have to go underground. And the reason is, they were used to seeing, and seeing is believing, and all their detectors were to see. And so if we do it in a hole in the ground, we can't look at anything. So their first goal was, Let's put it in the ground but let's still look, so we want to have an open pipe, which allows us to look in. And the containment people said, No, we want to close that pipe off. So, at the beginning, we said, OK, we'll let the light come out, so that people can look in, and then we'll close everything off. And then we had to learn how to do that.

I'll go back. I got my clearance in '55 so I've had it fifty-two years, and so the first test I saw was in February of '55, here [at the Nevada Test Site, NTS]. But it's incredible. Two of us, just out of graduate school, were given the job of measuring the opacity of uranium. And the reason you needed to do that was—a reason—the radiation from the primary flows down the channel to implode the secondary, but the channel has uranium gas in it. How does that radiation flow to do that? So, the opacity is the determination of what happens to the photons as it tries to go through that cloud of uranium. The theoreticians needed that.

Well, two of us just out of graduate school were given the job: Measure the opacity of uranium gas. So, we were, I'm going to say theoreticians—that's not true, close to that—and so we did calculations, and then we said, Well, we'll need this and we'll need that and we'll need this. And so starting in '55, we said what you need for that experiment. And that experiment was Lacrosse. And it was a forty-kiloton bomb. Device. Not really a bomb. You understand the difference.

I do.

Yes. It was a forty-kiloton device in a hohlraum, a tank, which came to the same temperature. And then we had portholes, looking in, and we had forty lines-of-sight, forty portals, and in each porthole we put an sandwich of material, so the same energy, light, trying to come through that, would come through different than it did through that sandwich, which was different than through the other sandwich. And we had uranium in there, uranium gas and various things, and so we were measuring how the light came through each sandwich, and we had forty of them. And then we had vacuum pipes coming from there, for a long ways, to an array, and then the light came through to an array of cameras, and the cameras sent the light **[00:30:00]** down the lagoon, to where—I'm sorry, the mirrors, where we had an array of mirrors, to cameras, where we could record—capture the film. So we had to have the cameras far enough away that it would be effective.

I found out later that that experiment cost forty million dollars, in 1956, and they did anything we told them. We need this, we'd like to have that, OK. So I describe it as a golden age because at no time was money ever discussed with us, and yet I was only thirty-one, and the other guy was thirty.

And who was he?

Art Cox. Now we had help, don't misunderstand me. We had very great help from a theoretician. I'll say his name in a minute [Burt Freeman]. And so he should be named too if we're remembering. But the remarkable thing was the engineers: We had the finest engineers in the world, we would wave our hands and say what we wanted, and they built it. So when we arrived, that was the first test in 1956, because we had to get that out of the way before we could do the other atmospheric test, because this had to be perfectly aligned, all that, so it was the first.

So when we went out in ’56, we had to do that shot first. That was very successful. And since that was the first shot, then I worked and started—in graduate school I had run an astronomical photography lab, so they said, `Go help with the photography.` So I started developing film and doing all of that sort of thing. And then, I hate to share this on record because it’ll sound like I’m bragging, but it’s a part of the record at any rate. And then Al Graves came to me and said, `We’re terribly impressed by the job you’ve done, so here’s a big raise.` And he gave me the raise just in the middle of the year, but he gave it as so much a month. And, for the rest of my career—sometimes you got raises of a percentage, or whatever, but I got that raise without, and it was big at the time; I have no idea how much that was worth to me but in my career, a million bucks or something. At any rate, so the job we did on that caused Al to have a lot of confidence in me, I think, so from that time on, every so often, he would tell me, `OK, so you go do that.` Well, I was an astronomer, an astrophysicist. I didn’t know anything about geology. And he said, `Well, you go find out how to do that.`

Well, so let me explain the problem. The pressures and temperatures from an atom bomb are so huge, how can anything stay in the ground? How can the ground possible contain that? So the question is not how do you—was, how does anything stay in the ground? So when we first started, we had no way of knowing what would happen. And we learned in very short order, that if we just have an open hole, put the bomb at the bottom, don’t do anything, you can cut the fallout by 90 percent. Now that’s a significant lesson. Then we put a plug halfway down the hole, and we could cut the fallout to 95 percent. We put the plug at the bottom, but still an open hole, we could cut the fallout by 98 percent or something like that. So what we recognized was, we could enormously reduce the fallout if we just put a bomb in the bottom of a hole; you don't have to fill the hole.

[00:35:00] But then, it didn't take long until the goal was "not one atom out." So when we got ready to do a limited test ban treaty, there were two versions of the treaty, one in English, one in Russian. And the English version read, `Not one atom out.` Now I'm not being literal but the only sensible interpretation was not one atom out. So we hollered, and said the two versions were different. In the Russian version, essentially, it was `You can't have any bad atoms out,` but they get to decide which are the bad atoms. And there is a practical reason for that. We were shooting in the only place in the world where we had a chance at keeping everything down. I say "the only place in the world." It's almost literally true. And [with] the Russians, there was no possibility of them keeping every atom down. So they were fighting for that. Well, Harriman was our ambassador, so we got word to Harriman that the two treaties, the two languages are different. And he said, `Oh, pay no attention to that.` And so Al Graves told me, `Brownlee, quit complaining. Our goal is not one atom out. Don't worry about the Russians, just us. Not one atom out.` Now, the problem. So we could cut the fallout by 98 percent or 99 percent, but how do you cut that last 1 percent? And we spent millions and millions and millions of dollars to try to make sure that not one atom came out. All the while the Russians have stuff out every time. And I just said, `This is totally unfair and irrational,` and Al [said], `Forget that. Not one atom out.`

The first learning process was while we were still doing atmospheric tests, so therefore it was all right to have something out. That was not illegal. And what we recognized, we'd really been successful at keeping a lot of the fallout. And then it's true that, no matter what the yield, I can built a hole of the diameter that you need, deep enough that I don't need to fill it. It'll close itself off. Nobody wants to go that deep. It's too expensive. But you can win complete containment by just spending money, namely by putting a really deep hole.

Like what would be really deep?

Oh, six thousand feet. You know. But, when I think of the cost of such a—well, at any rate, so, if you're going to do an experiment at a reasonable cost, and that doesn't mean cheap, a reasonable cost, to keep one atom out you're going to have to be clever. And so we polished and honed and did all kinds of things for years, trying to learn how to do that. We were, I'm going to say, enormously successful, almost all the time. When we failed, it was because there was a brand new something, which we hadn't spotted, before. And so each failure, we analyzed the failure and said, `OK, we're now smart enough to know we won't do that again`. So, the failures got rarer and rarer, but each one we studied and said, We'll never repeat that kind of a failure. So the failures were enormously educational, because we made them that way. And, what that meant was, as long as we were testing here, in a region where we had thousands of holes and knew a lot about it, then I could sit like this and say, `This shot ain't going to come out`. It's fine. This business of pretending it's going to come out is nonsense. You don't need to do that. We're not going to be surprised here. But, if we had gone over to the next valley, then I would have said, all bets are off. I don't know. I've not learned anything about that valley. So the importance of the **[00:40:00]** test site was, when I say, we have essentially the only place in the world, it's not true, but the only known place in the world where we can do an underground test with enormous confidence, you don't need to worry about this, because we're deliberately putting it in a place where we've understood the surprises. Does that make sense?

Yes, it makes a lot of sense and I have a couple of questions. Containment becomes important in and of itself, as part of the testing program, separate from the developments of the devices that will become weapons for certain military purposes.

Containment, dependent upon the treaty which says not one atom out. And that has nothing to do with the experiment, nothing to do with what anybody wants to do. And so therefore us containment guys were despised and hated, because we were always sitting there—

With your thumbs down.

Thumbs down. No, you can't do that. And we were given the power to stop any event. And why? Originally because we wanted to reduce fallout. Then by treaty we were forced to reduce it to zero. So we were absolute. So there was a hard core of us, who met regularly, and voted on every test. But anytime we wanted we could stop a test. And we were told to make our decisions without money being a factor. So it didn't matter how much it cost to stop the test, we were allowed to stop the test.

I'll tell you another story. One time, we were getting ready to do a line-of-sight-pipe test, and I got to worrying about it. And my division leader is now Bill Ogle. And I went to Bill Ogle and said, `I don't think we should do that test there.`

And he said, `Why not?`

And so I told him. I would guess we talked an hour, or so, and I said, `But I'm on the Containment Evaluation Panel [CEP], and if we bring this test to the Containment Evaluation Panel, I would have to vote no.`

And so he picked up the phone, called out here, and said, `We're going to move that shot.`

Now, we had already spent maybe three million dollars and they were working night and day, preparing it. And they said, `What?`

And he said, `Find a new place for this event.`

And there was a fault, I didn't want it there, and he said, `Get it away from that fault.`

And they said, `OK.`

And so I, as a person, had the power to stop any test without regard to the money. My equivalent at Livermore never had that power. His guys would override his recommendations. But not at Los Alamos. Both Al Graves and Bill Ogle would not ever take a test to out here, unless we ourselves were entirely for it. I had to be for it, or they'd never bring it out, never propose it, out here. And that's not true of Livermore.

And who was your parallel at Livermore? You told me before but say it again for the record.

It started out as—oh, I hate being old. Actually I love being old. I just hate the memory problems. I'll say his name in a moment [Gary Higgins]. And then, it became Larry Germain. But the originator at the same time, who had the same job at Livermore that I had at Los Alamos, was—he's dead now, of course.

You know, we have your index from your first interview and I think you mentioned him there, so we'll just look at that at the end.

OK. The name will come to me in a bit.

Now, another question about the decision-making process. Does the nature of the particular way a device functions, how is that factored into your decision-making?

Let me give you an example. One of our tests, the yield I was told was ten kiloton. So, I buried it **[00:45:00]** at a depth for ten kiloton. It went seventeen. At that time, all I had to do was go ask, What is the nature of this test? And had I seen the nature, had I asked the question, somebody would've told me, You know, it's possible that this thing will go quite a bit differently. It may go lower or higher. And the reason for that was, it was an old-fashioned gun-type device, and there you can't predict accurately. But it was early in the game, and I didn't ask the right questions. But I did not have the authority to ask that question at that time. But from that time on, Al Graves said, You will know about this. So then I would go to the theoreticians, and they would lay out in great detail this particular thing. Is the output mostly x-rays? Is it mostly gamma rays? Is it mostly neutrons? What is it and what effect? And then I have to say, They don't care about the geology. So I have to ask, OK, if there are a lot of neutrons, what's that going to do to the area, to the geology around, and how might that affect it? So from that day forward, I talked to the theoreticians and the bomb designers, to make sure that I knew.

Now I can tell you a funny story. I thought it was funny. Al Graves had a temper, a terrible temper, and I may have mentioned this before. And his face would just flush red, and the sky would fall. And I was in my office one day and there was a man in the neighboring office. And Al Graves walked in and said, I told you [not] to do thus-and-so, and you did it.

And the man said, Yes, but, but—

And Al said, I made myself very clear.

And the guy says, Yes, but—

And Al said, You didn't do what I told you, and you're fired, and I want you out of here by four o'clock this afternoon.

I was just in awe. I didn't know you could fire a guy. I never saw the guy after that day. He was in the next office. But Al's face would flush, and then you knew.

So, Livermore had a test, and I remember it because that was the joke. At that particular time, the code names were for materials, so Tapestry was one, and Gingham, and Ticking was one. And this test was Ticking. And Al was on the Containment Evaluation—actually it was a different thing then, different board, didn't have that name, but it was the Test Evaluation Panel.

He was there and I sat behind him. And so he said at the lab, What do you think about Ticking?

And I said, I think the yield is too big for the depth of the hole, so I think it's not a good thing.

So he said, Well, look into it.

OK.

It came time, we were out here [in Las Vegas], it came time to vote, and they went around the table to vote. Yes, Livermore thinks it's fine. And then they ask Al, How do you want to vote? And Al looked and I said, OK. So Al said, OK. And then at the break he turned to me and he said, You told me you thought it was too big.

And I said, Yes, but as long as it's Ticking, it won't go off.

And he flushed red. And I realized, I am about to be fired. And so quickly I said, I consulted with our designers at length, and they told me that in order for it to get that yield it had to have a higher efficiency than any bomb has ever had, and if we have a normal efficiency, which is almost certainly what's going to happen, the yield will be this, and if the yield is that low, the depth is OK.

And so Al thought that over and decided it was funny. And I was saved. The shot went off with the correct yield as our designers said, and it was contained, because the yield they had on it was unrealistic for this **[00:50:00]** design. So Livermore's number was too big, and at Los Alamos, I told Al, vote yes, it's OK, because it's not going to give that yield. But I didn't phrase it that way. I said, As long as it's Ticking, it won't go off. Well, I never did that again because I saw his face flush. And he thought about it and decided it was funny. Whoa! Close.

So what I'm saying is, even for the Livermore devices, I would consult our theoreticians, to see what they thought about the possibility of that bomb functioning in a different way, that device functioning in a different way. So the answer to your question is yeah, those details were important to containment.

Now this is the Test Evaluation Panel [TEP], which is constituted to include lab scientists from both labs on everybody's tests?

Plus other people. Yes, any test. So USGS [United States Geological Survey] had a member and there were other members.

But it seems to me that if you're evaluating a test of someone else's design and expertise, that makes it extremely difficult for you, no?, if you're not dealing with the actual nuts and bolts of that test.

So our TEP meetings were just something. And the lab would come: If we were asked this question, we'll have to be prepared to give this answer, and what if we're asked that question? So on one of the occasions when Livermore came, everything was fine, so I said, `I want to see your viewgraphs that you've brought, to answer the questions that we haven't asked.` And they went, Oh. So from that day on, they had to be prepared for a non-question, which required them to show what they were concerned about. Does that make sense?

Yes. Oh, let me make sure I'm understanding. You want them to reveal to you what they're concerned about, absent your having thought of it.

And they didn't do that at the beginning. But one day I said, `Show me the viewgraphs that we have not asked questions about.` And from that day on, that was a part of the presentation: Here's what we have that's concerned *us*.

So this says something to me about the possible question about the culture of the panel. You want it not to be, "You didn't catch one of our concerns, therefore we don't have to justify it." That would be one kind of culture, I guess.

The cultures in the two labs were quite different. And Sandia [National Laboratories] had a third culture. They also had a member on the [panel]. But, at Los Alamos, I or my successors had an absolute veto power. A member of the CEP [Containment Evaluation Panel] didn't come to Nevada unless he supported lab stuff. He didn't get here. That wasn't true of Livermore. The Livermore guy would pass me notes under the table, for me to ask a question that he couldn't ask. So, the people at the table felt a responsibility that transcended their laboratory jobs. And at Los Alamos that was clear. As a CEP member, I was in the clear. In Livermore, the CEP member had to be careful. But, it still worked because he would suggest to me things that they were worried about, that he felt needed to be exposed.

Interesting.

Yeah. It says that the lab's people did a pretty good job of exercising their responsibility, even though politically they had problems at home. I learned to trust the guys on the panel, with a few exceptions.

But is there ever a test where there is no atom out?

Oh, yeah.

There are some where nothing comes out.

[00:55:00] I have to qualify that, by saying this. The definition of containment was: Not one atom out for twenty-four hours. So if at the end of twenty-four hours not one atom out was not one atom out, and you quit looking. It's probably true that with the atmospheric pressures of highs and lows coming by, weather highs and lows, they pumped the gases in the ground. So when a high comes over, air is pushed into the ground, at the surface. A low comes out and that air comes out. And that goes on at depth. So if you allow me to have a bad atom, which never decays until it gets to the surface, years after the test, that atom can emerge. And so eventually, the earth is built in such a way that eventually everything comes out. But by the time that happens, it's already decayed and is no longer a bad atom. But our definition of containment was, not one atom out for twenty-four hours. And at the end of twenty-four hours, if we hadn't seen anything, we shut down the detectors and the guys go home. And if there is an atom out the next day, we don't know it. But we were not saying no atom is going to come the next day. We're just saying, from here on it's utterly trivial. So I think that answers your question.

Yes. And the other kind of general question that arises from what you've told me, which is all very educational to me, is the question of whether, from the exercise of containment, because you mentioned how originally the weapons designers didn't want it, does knowledge come forth that actually serves design purposes, or are they really on two separate tracks of science?

I would say they're separate. I don't think our knowledge ever affected a design. I don't think it did. It's not our knowledge. Our need to do things affected the design. So when we did the tests in Colorado, I laughed hard because when they first said we'd go underground, I said, You know what this means. Eventually we'll design a bomb to fit a hole. And everybody laughed. And with our tests in Colorado, we designed a bomb that would fit that size hole because that size hole is what the drilling industry used. So we did indeed design a bomb that would fit a certain size hole. Now that's funny. Think how far you've come from ending the war. I mean you've evolved in a fascinating way. And so now we've evolved to using nuclear energy to help give us gas or some oil or something. And it no longer has anything to do with the war.

And so it's therefore perfectly logical that eventually you'll design a bomb to fit a certain size hole. So those kinds of changes did happen.

Right. And what about, related to this, the question of the weapons designers and their military customers, let's say, have certain requirements of what that weapon will be like eventually. And then at the same time, they have to spend time and thought about containing that.

They don't spend the time and thought. They just assume that somebody will see to it that that's contained. I think that's fair. I'm smiling because I learned early on, I have to disbelieve the bomb designers. They're theoreticians. They understand their trade perfectly. They're devoted to that absolutely. And therefore they don't know the difference between 70 degrees and freezing, **[01:00:00]** because that's not part of their—and so, I learned, I have to get into their heads, in order to make what they say useful in a real world. Does that make any sense at all?

Yes.

And so I don't mean to put the theoreticians down, but they are a peculiar lot. I'll say it in another way. Edward Teller had ten new ideas every fifteen minutes, but you needed somebody with him who was bright, who could sort them out, and almost all of them you needed to throw away. They were no good. But you needed somebody with him to filter, who was smart enough to see the good ideas. And Edward was the epitome of my view of many theoreticians. You'd better have somebody with them who has common sense, meaning very bright because he's got to filter what he hears. So when I talked to theoreticians, I had to filter their words and their views, to make sense in my world. Does that make [sense]?

Yes, it does.

And so I always smile. Oh, no, I've got to go talk to somebody. This is going to be one of those days where he's going to give me lectures in things that are irrelevant, but I have to understand them because if there is relevance, I have to find it.

Right. Now this question I'm going to ask you is somewhat off the subject but, you know, Teller is known and criticized, by some, for putting into the system ideas that could never work, and lots of money and time and energy being spent to do that. Do you think that's a fair criticism?

Edward was, in my experience, two entirely different people. When he was with scientists, just scientists, every idea was interesting and valuable and rational and so on. And the moment a certain kind of person would walk in the room, a person who was outside the family, and therefore might take tales back, a press person, Edward would become a wild man. He would be showing off for the press or for the visitor, would say things that would make you do this: *This guy has absolutely lost it, he's completely crazy*. But it was an affectation which he put on when somebody came. So the press, whenever they interviewed him, carried away with them a strange view of Edward. When he was just with us kids, he was not that at all. So when you could talk with Edward with the people right there, it was entirely different than having a stranger in there, because the moment that stranger arrived, Edward became another person. And it had something to do with publicity—I don't know a better word for it. There must be a better word for it. But I learned that despite what everybody else at the lab said, Edward's value had to be determined independent of his personality. He was extremely valuable, but nobody liked him because he was, every so often, totally flaky. Does that—?

But to follow up on that, yes, that makes sense. But as far as actual programs that are implemented at Livermore, from his ideas, there is a lot of critique that, could they work or were *they, you know, Star Wars and x-ray lasers and things like this, that seems to be an example that some critics say, things could never work, but they were these sort of wild ideas.*

[01:05:00] My own personal sympathies are with Edward on those kind of things, because when people say that something can never work—even genius people say that I think—they've indicated that their imaginations are limited. And over and over and over, the technologies that come, a new technology emerges, and to your amazement you discover that something you could never imagine having worked, will work. And so my experience has been, if you say that something cannot be, Mother Nature hears that, and immediately starts a demonstration to prove you wrong. And so you should never say that something cannot be. It's a plot, by nature, to make you wrong when you say that. So I will never say that something cannot be, and therefore I fault people who say that something cannot be, because that says they've lived too long in the past. They're not looking ahead. And so there are many things that cannot be, but you'll not hear me say them, because I don't want to be made a fool of. And Mother Nature's principal job is to make a fool of you. [Laughing] She keeps doing it over and over. May I speak to that for just a moment, though?

Yes. Please do.

I've said it at the [Atomic Testing] Museum, but I'd like to say it again. Mother Nature does her calculations infinitely well, infinite detail, in real time. And she does them perfectly. We can never match that. We can simulate it in a variety of ways and we're getting better, but we can never match what she can do. But she's always in real time. She cannot predict tomorrow until she gets there. And we, as people, can outwit Mother Nature, because we can see ahead. So here's a bullet that's fired, it's spinning, and Mother Nature calculates gravity, and air resistance, and wind, and she does everything correctly, but she does not know that I've put a screen up in front of that bullet, she doesn't know that till the bullet gets there, and then the bullet calculates that perfectly. And so, our role, out here, was not to calculate as good as she can—we can't—but to anticipate what she would do if we did this and if we did this, because we can't outthink her in terms of calculations, but we can outwit her, because we can look ahead as she does all her calculations in real time. And this is true, [it] has nothing to do with nuclear things. I'm talking about the whole world, all of nature, she's calculating at every instant and doing it correctly, but she doesn't predict tomorrow, and we can, and we can therefore build something so that tomorrow, when she goes to do this, we can outwit her. And so, I think it's a terribly important concept, relevant to your question. Something cannot be done. If I'm clever enough, I can think of a way to outwit her, by doing something that she hasn't done before or hasn't experienced before and hasn't anticipated yet. I can put something ahead of her. And so that's a reason why I say I will not say that something can't be done because, if I'm clever enough, I can probably find a way in which we can do it. But it may take a technology that's not going to exist for another hundred years.

[01:09:33] End of Track 2, Disc 1.

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

OK, we're recording again, and while the machine was turned off, I asked if we could talk a little bit about some of the unanticipated problems with containment.

Yes. The first one I've already mentioned, what if the yield is completely different than you expect? So you're surprised because—and we've had several of those. One of them we were expecting forty kiloton. It was a very deep hole, line-of-sight pipe on it, and it went forty ton. So it was down by a factor of a thousand. Now the behavior of everything in the pipe is built for forty kiloton, and so forty ton is entirely different. So, the containment process, I think it contained all right, but all the details were utterly different. So I learned a lot from that experience, not because of something I should prevent, but I learned that expecting forty kiloton, I had to be better prepared for forty ton. And so, sometimes the yield is—a few times the yield is high, sometimes low, and that changed the behavior of everything. So that's the first kind of an experience that you need to have. You need to prepare for almost anything as opposed to what the designers tell you, in terms of the amount of energy involved.

Yield-wise. Now do you recall the name of that test that went low?

I could give it to you. It starts with a P, and I could look it up. But it's easy to do. In the book—do you have that book with you? [Referring to DOE/NV—209-REV 15 December 2000]

I have it. Let me get it out.

Let me just quick look again, and we'll have it right now.

That would be good.

I'll turn here to—all I have to do is look to see a yield of forty ton, I think.

Under P?

OK. I had the habit of line-of-sight pipes starting with a P, and so as I look down there's Pipefish and so on. It wasn't Pliers Isn't that strange? I'm not seeing this. See, I thought it was just going to say forty ton. No, they just say less than twenty kiloton.

That's right.

And so they don't say forty ton. Two hundred, yes. Pipefish. I can't do it because there are a whole set of them say less than twenty kilo—but I have it at home, and I think I can recover it at home.

Great. When I send you the transcript, we'll just fill that in.[Information on available]

Yes. At any rate, that's one kind of thing. The next thing we learned was—I shouldn't say the next. We learned that the nature of the geology is terribly important, and when you put down an explosion, you're making instantly a cavity, and it's first of all vaporized; and then the pressure is so great it expands, and around that you have a compression. But what you do, whatever stress field is there, you change it dramatically. And Mother Nature likes to put that back, the stress field back. Oh, the secret to containment is this: the explosion expands, and then it overshoots, because it has momentum, and you get a vacuum in the center, and it comes back; when it comes back it sets up a tight stress field, and that's what contains. That goes away in **[00:05:00]** time. So, you're nothing if you don't use your head. And I said, I wonder how that works, having a stress field that Mother Nature wants to put back. Is there any place in the world that they do that? Yes, there is. The diamond mines in South Africa, they mine down, and then Mother Nature tries to put everything back and they have rock bursts, and it kills anybody in there because the rocks at the site explode, and Mother Nature is trying to put that stress field back, and I wonder how that works. And furthermore, they have seismic network down hole which tells them when they're getting ready to do that. We have seismic nets on our—I wonder how that works. Do you suppose I can get a trip to the South African diamond mines? Gold mines, not diamond. Well, why don't I look into it? Well, at that time, South Africa was getting ready to do their nuclear tests—so anybody from Los Alamos. So I said, I want to go down in your gold mine, to look at your stress fields. And they said, OK. And when we got down there, there were two of us, and when we got down there, I discovered that they never let anybody into their gold mines, except the workers and the management. Their politicians are not allowed to go down. Nobody in South Africa, nobody in government, goes down hole. But they let me in there. And we went to a depth of 11,600 feet below the surface, and then we skinnied down the stope for an additional four hundred feet, so we got to twelve thousand feet below. The temperature of the rock was 140 degrees. The air temperature was 120; they kept it at 120. But the wall was 140. And they had the seismic net.

And they had—I've never seen the like of it. It was as close to slavery as you can possibly imagine. The blacks that were in there wore kind of thongs but it was so hot they didn't wear clothes. And they couldn't afford lights, so they had 10-watts light, and you could barely see. You could see the men because of the perspiration on their bodies. They worked twelve-hour shifts. They signed a contract for eighteen months. They were down there twelve hours, I think six days a week but I'm not sure of that. And they were given a little money, but [most of] the money they earned at the end of the eighteen months was sent home, to them, separately from them. That money that went to those other countries was their principal exchange, what do we call it, their money that came into the country was mostly coming from these guys. And so their governments didn't want to protect them. They wanted them to stay the full eighteen months. They didn't get paid if they didn't stay the eighteen months. They had camps to keep them. And they were just slaves.

And then I asked a whole series of questions, about the temperature and the lights, and the guy was frustrated with me and he said, `You Americans are so rich, you can afford to be safe.` Oh, well, I hadn't thought of that. But they didn't have the money to spend that we would've spent.

At any rate, I went down there to learn about stress fields and learned an awful lot, and found it useful, but I must admit, nobody told me I had to go do that. It was an idea of my own and it paid off. So I've been to twelve thousand feet below the surface, and that ain't bad for one of us here. I enjoyed the trip immensely, but I learned a great deal.

What year was this, about, would you say?

It must've been about '73 or '74, something like that. Seventy-two, maybe. At any rate, it was fabulous. And I'm smiling because I had this idea, I wonder if I can get a good education out of this. And the answer was yeah, I got an education that I never imagined. But, I was introduced to—by an old friend, who I hadn't seen in years, and he introduced me to a guy. This was last summer, last fall. And he said, `Let me tell you about Brownlee.` So I'm listening. And he said, **[00:10:00]** `He thought up things that he wanted to do, and then he got somebody to pay him for it.` [Laughing] And I laughed, because there's some truth to that. What is it? It's not just what I want to do. What do I need to do? I need to find out about this. And so I'd convince somebody to pay us to find out about that. It was a golden age because we were allowed to do it. And so I don't think I was ever—I think I was always given the money I asked for.

There was something else that happened. A guy who lives here in Las Vegas retired, recently said, `Let me tell you about Brownlee. He never asked for anything he didn't need.` And I thought, Now that's a very complimentary thing. But the other guy said I was using the system to get what I wanted. But those things are the same, in a sense.

Right. I think so. That's very interesting. Two different perspectives on the same phenomenon.

Yeah. But at any rate, I thought back and I laughed because my trip to South Africa was to look into the stress fields. So, understanding the stress fields and what happens after the shot is important. Let me go on to the next one. I have to understand the behavior of the medium, the geologic medium, as it's vaporized, crushed, stress released, et cetera, and so you have to learn all kinds of things about geology. And we had some failures strictly because of that. Pike was a failure because there were aspects to the test that I knew nothing about, and I should've known.

But that was before we were asked to know. And so it had an x-ray pipe on it that came up partway, and I didn't know there was an x-ray pipe open, because there was no open pipe to the surface. But the x-ray pipe was open for a long way up. And then it came to a stop there, and unbeknownst to any of us, except the drillers, they hit a layer of hourglass sand right there. So where that pipe stopped, by pure coincidence, the geology had zero strength. No strength at all. It was hourglass sand. And so the energy went out this way [demonstrating].

Horizontally.

At that level, horizontally and that, and that's what erupted, because enough energy got there that it had more pressure than the overburden, and so it cracked and out it came.

And the other wrinkle with Pike was we were expecting 850 tons, and it went 1.15 kilotons. I hadn't expected that. I think it might've been all right at 850 tons. So it had the wrong yield, a pipe I didn't know was there, a geologic layer that I had no—I had had no experience with a layer of hourglass sand. I hadn't asked that question. The drillers know that every once in a while they hit a layer of hourglass sand. I didn't know that. That was March [13th] of '64. Look up Pike and see if that's right.

I'll look up Pike. And it just occurred to me, if you want to draw me a little picture, feel free, while I look up Pike. You're right. March 13, 1964.

Friday the thirteenth.

And it says—exactly. And all it says is less than—let's see, what does Pike say? Less than twenty kilotons. And you're saying it's 1-point-something kilotons.

Yeah. It was 1.15. And so I've written here—my writing is bad now—.85 kiloton, no, 1.15 kiloton. Here's the line-of-sight pipe which came to there [showing on drawing] and lo and behold, there's that funny little layer. And so it went up like this, out here, and then up [showing on drawing].

Hold on to that [paper] in case we want to do anything else.

OK. So this is Pike. OK, and then there was the next P, which was—it was sixteen instead of ten.

It's '64 still?

Yes. Was it '64? No, I don't think it's '64. Let me look for that. Brownlee, you idiot, you should know these things.

No, no, I'm asking you to go so far back. It's almost fifty years ago.

Yes, but my brain is such that the only things I remember are in the past. I can't remember yesterday.

[00:15:00] *But it's that name memory part of the brain that goes. That's what's so frustrating. The other thing we could do is look in the sixties.*

Yes, that's a good idea [looking through DOE/NV—209-REV 15 December 2000].

While you're doing that, I'm going to get a sip of water.

OK.

Well, it's once again less than twenty kiloton, and I'll say it in a little bit.

At any rate, then we had a series of things in which the collapses didn't go right. And so one time, everything worked fine, but when it collapsed, part of the pipe broke open and that allowed a leak. And so then I said, OK, I have to do that different. I have to design everything different so that it'll still work if something goes wrong in the collapse. But finally, and ultimately, it's this: no matter how clever you are, the radiation promptly will find a way out through your cables. So as soon as you have a cable that's bringing you information, even your firing cables that you don't need anymore, the radiation comes out through those cables. So, we learned that the radiation has to be gas-blocked. In order to keep every atom out, every cable that goes down has to be gas-blocked. And sometimes that means all the way. Sometimes that means you gas-block it here and there and there. But suppose I have a gas-blocked cable to here [indicating on diagram], so it can't go beyond this, but that blocks it and the stuff leaks out there, at that level. Now, if collapse time, even though you've got it, it's not in the cable anymore. It's out in this, and that can also come up. But usually, it depends on your stemming. So, on the stemming, what we did was have coarse stemming and fines, like this [indicating on diagram], so this is coarse and this is fine. So the stuff comes up and then takes a lot of time and comes up. So you buy time every time you do that. And then we had a superstition about stemming. And so everybody had his own superstition. If I put a layer of something, it'll have a different effect. And if I just put gumdrops there, it'll be entirely different than if I put dirt. And so whatever I put here, if I have a mind that is complete flaky, I'll put powdered soap there, and it'll have a different effect and I'll buy time in some way. So we had whole cultures built up about what the stemming should be like, and the variations in the stemming, because I'm going to let the energy come up to here, so I won't try to stop it down here but I'll stop it up here [indicating on diagram], and then I'll put a big stop here, and then on collapse time it's going to be different. So, here this hole up here, the stop down is like this, and so the hole is stemmed but what's the stemming around the casing? And do you have a casing down here or do you not? So, all kinds of ridiculous things emerge from the stemming, and the secret is gas block.

So I got asked, a year ago, about the North Koreans, and I said, `But of course they will have a cable leak, so when they do a nuclear test, you'll be able to, if you're there, you'll be able` **[00:20:00]** `to find the gas coming out.` And so they had their test, and I'm told they had a general who said, `There's no hope of doing this,` and he wouldn't even let them sample, and they said, `Let us sample one more time,` and that's when they found it. Whereas, on my side, I said, Well, of course, it'll come out. All you have to do is keep sampling and you'll find it. Because they are not clever enough to have invested enough research to understand how to gas-block cables. So if everything else fails, their cables will leak, and so you'll get a sample. And they did, and of course, because North Korea can't do that. And neither can anybody else, unless they've invested enormous amounts of experience. And so, ultimately, ultimately, in today's world, the only way you can hide a test is to gas-block your cables. And they don't know how to do that. And they're not going to know how to do that for years.

Now, help me understand the gas-blocking of the cables in layperson's terms that doesn't go over into classified information. Is it a physical something that you put in that cable?

Yes. You can order them—you can order—manufacturers can order it made, but they want a lot of money. They research it. You tell them that, OK. And then, suppose you can't do that, what we do is physically cut the cable, put in a transition—here's a wire or something bearing the information we want—and we separate that cable out and spread it and put all the stuff around it, and then it goes back together. So you can physically gas-block these ten feet of it by taking it all apart, and not allowing the stuff to go through it, and putting it back together again. So we did that several times. But meanwhile, we'd have cables that are continuously gas-blocked by the manufacturer. And they're continuously gas-blocked, so you order three thousand feet, let's say for one test you order a thousand feet of gas-blocked cable, for that. Then, if it's perfectly gas-blocked, you probably only need twenty feet of it. So what you do is test this ten feet, test that ten feet, test that ten feet, and if you have several things of ten foot that was OK, you used the cable. But you tested it. And so you have continuously gas-blocked cables that had to be tested every so many weeks, because if you just lay it out on the surface in the sun, it's no longer continuously gas-blocked. So you had to test. And so you kept testing the cables that were continuously gas-blocked. And then where you needed to, you broke the cable apart, and physically took it apart and did these elaborate blocks. But that's a science all its own, and I'm glad there was somebody else who did all that. But all we asked was, have you tested this, and are you convinced that this is really a good cable?

Now when we were in the tunnel, a year or whenever it was ago, and we would come to these areas and there would be kind of this gooey stuff that the cables looked like it went through, was that also—?

That's part of it, yes.

And what was that called? I can't remember. I just remember it being pointed out that this had to do with preventing gas from coming through the cables.

Oh, I don't remember. Yeah, it's a gooey stuff. And it's this, cornflakes and, you know, you design something.

Let's see. I think I was the first one to use that kind of material, and it was called something epoxy, and it was kind of an epoxy, and it didn't set up right. So here was the hole [indicating on diagram], and we poured this stuff in, to make a block here, and when we met back the next day, it had just dribbled all away, had gone away, so we had to dig it out to redo it. The test was Finfoot. And we had this epoxy that we moved out, and piled it out beside the hole. It was a vast pile of epoxy that hadn't set up. And then the guys called in to the CP [Control Point] and said, Guess what? This pile of epoxy is moving towards the CP. So we called it Son **[00:25:00]** of Finfoot. And so Finfoot, I think, was the first one to have that kind of an epoxy. So let me see when that was. Why do I not find Finfoot?

I just saw it. It's there.

There it is. Sixty-six. And that's the first time we used that kind of an epoxy. And the last time, too, I think. We made it different after that. It would fill half of this room, and more. It would probably fill this room. And we dug it out of the hole to redo everything, and then this jelly-like stuff started migrating downhill, which happened to be towards the CP. So we said, Well, that's Son of Finfoot over there.

At any rate, so stemming became important. Gas-blocking cables, imperative. What additional kinds of surprises? Suppose what happened on Baneberry. We had water and there was a hydrofrac. And the hydrofrac opened the ground in a little slit, and a lot of the energy went over there, and hit a fault and came up the fault. Ah. We had not thought of hydrofracing, and we were fairly close to a fault. So when I said, Move the thing away from the fault, I was concerned about that sort of thing. But from that time on, we looked at water.

Now I'm going to say something. It's not classified. It has to do with legal problems. Turn it off.

[00:26:50] *All right, I will pause this.* [Recording stopped for of the record remarks].

[00:26:55] One of the lessons we learned from Baneberry was that the CEP did not have all of the information at shot time that they needed to properly assess. We'd assessed the shot before that. So the events that happened between the time we assessed the shot, and the time it was fired, figured into the containment problems but, we didn't know that. So, that's another thing we learned.

And then we had a whole series of experiences where, in early times we saw the leakage stop when it collapsed. So there'd be a little leak and then it collapsed and that would shut it off. And so we got to thinking that way. And then we experienced the opposite: nothing until you got collapse, and then a leak. And so the moment we saw that, then we had to think differently about the collapse process. So every one of our failures was a learning experience. And then we vowed, We'll not have that experience again.

So I think currently, if we were testing where we tested, I have to say that, in the valley, that I would be willing to say, if there is a leak of any kind, it's in the accident mode, we don't have to prepare for it. It's an accident of the order of one chance in ten to the five [10^5], and therefore we can do it safely and we don't have to put a lot of people out looking, assuming it's going to leak. And so I think that's an important—I'm not sure the system will ever buy that, but I'm saying there are designs such that, the probability of a leak is, I'm going to be extreme and say one in a million. It's probably ten times that high. I'm overconfident, super confident and overconfident, perhaps, because we put it there, and I know everything around it because we have thousands of holes, we know that area. And I used to say—

Oh, on Baneberry, I was a member of the—there were three of us who were investigating the whole thing, and then we had to testify before the five guys who were in the AEC, commissioners. Gods. And they said, You have to dig the hole one radius deeper than you're going to put the bomb, one cavity radius, so that you know—and I told them, No. If you make me dig the hole deeper, I will still put the bomb at the bottom of the hole because that additional **[00:30:00]** depth is greater, gives me greater assurance. So no matter what hole I have, I'll always put the bomb at the bottom, because the additional depth helps much more. So, I won't go with your rule. And the lab, present at this hearing, were horrified that I would say no to the commissioners, we won't do that. But I convinced them. So we never did have to dig deeper. And the way I summed it up was, I don't need to dig, for those kind of events, I don't need to dig extra deep just to look for a dead whale. I'm not going to find a dead whale. So I don't need to do that, and if you do make me have a deeper hole, then I'll put it at the bottom of that hole. And that won, because ultimately, [as] I told you at the beginning, if I go deep enough, I don't have to do anything.

Now what was their reasoning for the radius deeper? In case there was something down there that you missed?

Yes. That was their logic, and I could understand that. But I just said, No, we won't do that. And people were horrified. I had no power to say, We were not going to do that. They had the power to say, We'll be happy to do that. No. I was making my own argument. My own argument is, if I have a deeper hole, I'll argue to put it at the bottom of that hole, because I can demonstrate that that gives me a lot of additional safety, and more than overpowers the knowledge. I have other holes to tell me what's below that. I don't need to go deeper. I don't need to look for a dead whale. And come on, guys. And that carried the day.

This is my own personality. I never hesitated to say no or whatever. And the bureaucracy doesn't like people like that, which I'm well aware of. But I claim if you understand something, you've got to be honest about it, and not just do what the bureaucracy wants. The lab was prepared to do anything the commissioners said, and so they were horrified that I said no, to them, to the commissioners.

But the commissioners finally agreed.

They agreed with me. I was able to articulate how strongly I felt about that, and so they went along with me.

Can you talk a little bit more, since we're on Baneberry, about the experience, as a whole, for you? Now this is a Livermore test, but you're on the panel, and you have to learn things about what happened. But testing has stopped for a significant period.

Well, I was on the investigating committee, so we stopped for six months. And we had enemies in the AEC, to nuclear tests, and it was greed. I told you that anything we wanted, we got the money to do. And there were people in the AEC who wanted money for other things, and the test guys always got what they wanted. So they were envious.

Now this is the AEC commission or the AEC staff.

AEC staff. So the staff said, We've got those guys where we want them.

Just to stop you for a second, what kinds of other things would they be wanting money for?

It's a dumb question to ask because I'm talking about a bureaucracy here. Who knows what kind of things they had? Who knows the pots they wanted to put money in? I have no idea.

OK. So the first thing they did was, it [Baneberry] came in December, so it cut our year in half. So, we were testing, I forgot, forty tests a year, something like that. So from then on we could only test twenty because the next year, they gave us half of our budget money, and they cut the test program in half. And they were jubilant. Now, the consequences of that were predictable but the bureaucracy didn't understand. When we only had half as many tests, we did twice as much on each test. No. We did three times, four times, five times. So instead of having twenty cables down hole, on a test, we would have two hundred cables down hole. Now, the moment I have a **[00:35:00]** hole like this, filled with two hundred cables, stemming can almost be irrelevant. You're stemmed with cables, so they're all leaky. OK. But, what we did was increase enormously the amount of information we got from each test. So by limiting the number of tests, the mind of man, it's like taxes. If they put a tax against luxury yachts, the luxury yachts industry moves to somewhere else. So, if the number of our tests is less, we'll do more on each test.

So, Baneberry fundamentally changed the number of tests, the things we did on each test, the things we looked at. It was profound because we had to work around a new set of rules and a new set of understandings, and we took it from there. And so, if I look—suppose I'm in Russia somewhere, say, Curse those Americans. They have a disaster, and they're much better off ten years later because of it.

But am I understanding you correctly that—no, I'm going to phrase this differently. Do you think the action taken by the AEC was unjustified and simply a result of these bureaucratic political things, or would you have thought some kind of action would've been commensurate with the level of the accident? I guess that's my question. Testing is stopped for half a year. Was that unjustified, given the seriousness of the accident?

Bureaucracies—what they did was perfectly rational, if you have an IQ of 100. Maybe even an IQ of 85. So what they did, in their eyes, was justifiable and rational, and I would agree, the way they think, that's fair. That's a fair assessment.

Well, what would you have done, then? Maybe would be the question, given—

I would've said, having the number of tests at the rate we were doing is the most efficient way to use our abilities and knowledge, and therefore from an efficient use of our resources, that was a better way. But they're not interested in the efficient use of resources. Good heavens, if you did that, you'd have to put them out of work, so that doesn't work. So, from a point of view of efficiency, of our routine, we were better off with the procedures. But when we had to work around their rules, we found ways. But we paid in time and effort for that. So there was a cost.

So there was a cost to Baneberry in several levels. But I guess the question I'm asking is, what would've been your response, from your point of view, to this accident, in that you didn't want it to be repeated? So there had to be some kind of investigation, right? And so what would have been a rational response from your side of the world to this thing that happened?

Make sure that we never have that accident again. And we are going to make sure that that accident doesn't happen again, that the circumstances that caused that, we'll never do that again. And therefore, to use that as the prediction for what the next one might be is totally fallacious. From that day on, every shot we used the Baneberry as the prediction of what this shot might do. And the one thing I knew was, it was not going to be like Baneberry because we learned how to prevent that. So using that as the model for venting—we spent decades with total irrational behavior—using Baneberry as a model, when the one thing I knew it was not going to be like Baneberry. We're not going to have that leak again and we never did and we never will. And why then do we tell the public that that's what we expect? And more than that, we taught our own guys at the test site that that's what they should expect. And so we miseducated ourselves from the word go, because of this idiotic behavior. So, what are the consequences? The **[00:40:00]** consequences were years of devilish misinformation to our own troops. We taught people the wrong thing. We used Baneberry as the model for the next vent. And the one thing I knew, we're not going to have that again. So the damage was just enormous.

Now were you thinking that way at the time?

Yeah, I think so. Maybe I wasn't, but I remember being outraged. But then I enjoyed being outraged by bureaucracy, so maybe I didn't think the same. But I think I did. Where I get in trouble is when I tell them this. I'll tell you what the problem was. I had convinced almost everybody but the manager of NVOO [Nevada Operations Office]was scared to do it. He was better off with his superiors if he just let it go. So it was a non-decision, that kept us doing this. And ultimately, if the manager had had the guts to stand up and fight, he could've won it, I think. But so our problem was right here in Las Vegas, and the manager just—and it's a sequence of managers. They never had the guts to attack this issue.

So you're saying, if I'm understanding you correctly, that into your system, then, comes an unjustified concern that Baneberry will be repeated, when you have diagnosed why it was repeated [why it happened]?

Yes, and we said, `We know this. It's not going to be like Baneberry. Whatever it is, it's not going to be like that`. So using that as a model—oh, and then the other problem. What is a better model? That might be one that's harder for them to deal with.

Who?

NVOO. Suppose I said a better model is that it starts a slow leak after four or five hours. That means we have to sit with everybody longer and it's better to just have a zero time leak, and plan for that, than it is to plan for one that starts later. So they didn't want to venture into a new world of predicting. I understood that. But still, they're teaching our own people at the test site that this might come out, and it'll be like Baneberry. Nonsense. So I hope you can see my side of it. But I'm sitting there, as a guy who knows about containment and not the politics, and they're dealing with the politics of it, so I have to give them a nod. The manager has to deal with the political side. I don't. But from a scientific point of view, to pretend that it's going to be like Baneberry is immoral. Funny I should add that word.

Well, I'm glad you said that scientific point of view because I'm trying to imagine if it were another kind of scientific experiment, with less public and large-scale consequences, you would go into an experiment with a hypothesis, you would try to design it in such a way that you predict as much as you could, and then if there were an error—

Let's give an example. Suppose we decided to do a test at—where all those people live just southwest of the test site, in the valley there. Pahrump. Suppose we started to do a test in Pahrump. And it's going to be very similar to—Pahrump has a water table clear to the top. We'd have to put the device in a submarine, to keep the water out of it. It would be a whole new world. And under those circumstances, the Baneberry model might be a tame model, because I'm in entirely different circumstances. So the moment I go to somewhere else, anywhere else, I've got me, Brownlee, has to pull back my horns and say, Look, this requires a whole new way of behaving, and the Baneberry model is not the model to use. It's some other model, but it might be worse. So I think that answers your question.

But I think I'm saying, if you're looking at the practice of science, suppose you're doing an experiment that's not a nuclear device test, just any experiment in any laboratory, you go forward, something happens that's unexpected, you analyze it, and you continue to go forward, **[00:45:00]** *taking that into account. It seems to me what you're saying is, "That's my way of doing things as a scientist". So, socially, there's all sorts of things that come into play because of all sorts of other factors surrounding it, that mitigate you acting as you would. Is that fair?*

Yes. That's fair. It's fair. I nodded to the manager, after shouting at him. He has political problems that I don't know anything about, and I have to acknowledge that. I don't have to believe in them, but I have to acknowledge they're there.

And personally, what was that period of time like for you when you were on this investigative—? Because you—

I wasn't home for three months.

Were you physically here?

We went everywhere, looking into contractor stuff, and—I'm going to give you answer that I shouldn't give you.

My favorite kind of answer.

I'm always happy when things are as bad as I predicted. And so I enjoyed much of it because they were as bad as I predicted. And so as I think back, was I really having a good time? Some days I was. I felt pleased with our final encounter with the commissioners because I won a number of my points, when I didn't have anybody with me. And so, I enjoyed learning, and that aspect of the long-time investigation, I enjoyed because I learned a lot. I got to look into a lot of things. But when I saw the penalties that we had to pay, I thought they were quite irrational, and quite—they looked to me—for example, at that time, public flogging was legal in Nevada. So I said, `The AEC staff, what they really want is a public flogging, so why don't we have it? They want to see somebody suffer, and they don't care who that is, so let's arrange that. Let's pick somebody and flog him, publicly, and then they'll be satisfied, because that's what they want.` And that's not much of an exaggeration. They wanted a public flogging. Public floggings were legal in Nevada, so I proposed that. Well, everybody laughed, but in doing that, I released the pressure a little, in proposing seriously that we have a public flogging, so the AEC will be pleased. Then the AEC stood down a little from the public flogging that they wanted. And then my boss helped. He said, `Brownlee, what I would like to do is just fire you after every containment failure, and that way they would be happy, they'd see somebody fired. And of course I'd hire you immediately back because it would be so much pleasure to fire you after every failure.`

And who was your boss at the time?

Bill Ogle.

It was Bill Ogle.

Yes. And so he said—but he too saw the need to have somebody to blame. And it is true, in a bureaucracy you can't find anybody to blame. It's just true. And, in these things, was there somebody to blame? Baneberry, maybe. But mostly, it's not the fault of one person. It's the lack of communication or whatever and it’s hard to fault that. So if something happened, if this guy had known about it he’d change it but he never heard. And setting up a system that allows the right guy to hear the right things at the right time is next to impossible. You hope you’ve done it but it’s hard.

Now were you involved in the lawsuits? Did you have to testify in those lawsuits?

No. And I will say they were very careful to not have me testify in the lawsuits at all.

Because?

I knew about this other, and it was fine with me not to be involved. Because if they’d put me under oath, I would have to say that. That would’ve been—and so, at least, they knew that I knew.

[00:50:00] I’m not sure I’ve by any means reviewed all but the important things that I’ve talked about: the yield, the nature of the medium, the nature of how the pipe is stemmed, the importance of gas blocking, and the importance of being surprised by something brand new, and then making sure you never do that again. And those are the critical elements of containment. And I’m not saying it’s not possible to be surprised because I’ve already told you, if you say that can’t happen, Mother Nature is going to get you. But you can still be confident that it has a level of happening which is exceedingly small.

Do you have any feeling at all of the difference between one in 10^{10} and one in 10^{6}? One chance in a million, and one chance in ten billion?

Well, there’s a big difference.

There’s a huge difference. And anything—this is me speaking—anything with a chance of one in 10^{10} is a miracle. The average person regards one in 10^{6} as a miracle but that’s not true. All kinds of things in science have a probability of one in 10^{6} of happening. They’re not miraculous. But when you get something one in 10^{10}, that's different, in my experience. So I'll tell you this story. I was a member of the JHEG. I've already mentioned the Joint Hazards Evaluation Group. And we were getting ready to propose a test of the Navy, to drop a bomb from their plane, antisubmarine, and have it go off. And they had a set of data which they gave me—I was chairman of the JHEG—that demonstrated the probability of missing.

And I said, I'd like to see these data confirmed.

And they said, How would you confirm them?

And I said, Take this plane, with this bomb rack—that was the important thing, with the atomic bomb rack—and fly off of a carrier in the Pacific, and demonstrate that these data are OK. I need some confirmation.

So the Navy said, OK, we'll do that.

And so they flew off and the pilot triggered and nothing happened. The plane flew on. It finally banked and when the wings flexed it fell out. And when I compared that with the data, there was one chance in 10^{10} of that happening.

So I said, I'm never lucky enough to see a miracle, and therefore this demonstrates that these data are irrelevant. The data are irrelevant. Therefore, you can't do the test.

So an admiral called Bill Ogle. Bill Ogle called me down to his office.

What have you been doing lately?

I told him. And he said, I got a call from an admiral over here that wants you fired.

And, Well, fire me then, but I explained to him.

And he said, Well, keep doing what you're doing.

And so the Navy wanted to do this test. So they formed a group of eight captains, Navy captains, to visit every aircraft carrier, in the world, and talk to the pilots about this.

And then one day I got a call: Come to Albuquerque. We want you down here for a meeting. And I walked in, and there in the center were, I think, six of the eight captains; the walls were lined with everybody else, and I was the only non-Navy person there. So I realized, They are going to have my head.

So they said, Sit down, Dr. Brownlee. We have been to every carrier in both fleets, and you're right. The data were collected with a different rack because the pilots know that the atomic bomb rack is no good, and when they fly for the record, when they're flying for the record, it's against their careers, so they always use the other rack. And therefore we have to completely redesign this rack because you said the rack is no good.

And I didn't. That isn't what I said. I said the data did not support this. But I had made them go do it to demonstrate that the data fit and it didn't. And this whole thing came about **[00:55:00]** because I said, I'm not lucky enough in my world to see something that has a probability of one in 10^{10}. That's too lucky for me. It's miraculous. Therefore, there's something wrong. So I tell this story, to say that I have a sense of the big difference between 10^{-6} and 10^{-10}. And 10^{-10} is in a category where you're never lucky enough to see it, because that means they'd have to drop a hundred billion of those things for that to happen. And so my perception of math was always a factor in my decisions. And so I'm smart enough also to say that 10^{-10} is not zero. There's always a chance that something—right. But the probability of it, of you living to see it, if it gets to 10—but I've seen things with 10^{-6}.

In February I went to Antarctica with my family. And on the ice continent, if you find a rock, it fell from space. Right? There's no place else for it to come from. And then the rock gets buried, and eons pass, and then a glacier flows, and then there's an iceberg that goes by, and it has one rock in it. I have just seen a meteor, probably, going by me at one mile an hour, horizontally. What's the probability of my seeing a meteor go horizontally at one mile an hour? Well, I've done that, I think. I saw it in an iceberg. So, it's possible to see incredibly rare things. But two things. You've got to be in the right place, and then you've got to have an eye that recognizes it when you see it. Look at that, I said, Look at that! That's a meteor. You know, I was all excited and everybody is looking. It may have been. But to have a single rock in a big thing of ice, is almost certainly a rock that fell from space. At any rate—

Wonderful, though.

I know. I laughed. Who would've ever have imagined I could have seen this? I was as happy as you could be when I saw it going by. At any rate, what I'm saying is, you can indeed experience incredibly rare things. But you have to understand that the probability of that is not anything like as low as one in 10^{10}, because rocks are falling on Antarctica all the time, and there must be countless individual rocks in the meteors on their way to the oceans, so it's not that improbable at all. It's only you imagine it's improbable. What is improbable is that I was there to see it.

So, at any rate, what I'm saying is that, I always had a sense of the possible, and I think that made me a good containment guy because I could think of really dumb things. For example, I insulted our guys something terrible. I said, I think we've got the containment problems down to where the bigger threat is that they will stem the wrong hole. Now what I was talking about was a manmade error, a man error, where, despite everything, somebody does something really wrong, and I chose the words "perhaps they'll stem the wrong hole." Well the guys who stem holes were just horrified that I would say something like that in public because that reflected upon them. No, I'm not talking about them. I was using that as an illustration of a human error, and I thought we'd had all the errors down to where, it's the human error that we have to anticipate. But I hurt their feelings. I didn't mean to.

And when was this?

Oh, when would that—? That would've been about 1980, I think.

So the state of the understanding of that particular problem had evolved to the point where you felt confident that the kinds of things that could happen in that geography were—

We had pretty good control of it. So the problems you look for are human error and a meteor strike, something that is highly improbable that can still happen and get you, but you have no control over and no expectation of, and that's a real surprise, and that's in the category of one in 10^6, maybe. And therefore it's ridiculous to send everybody out expecting a Baneberry leak. Absolutely ridiculous. A complete waste of effort and money. A misuse of funds. So I think you can see what I'm saying.

[01:00:00] *Yes, I do. I do. And it seems to me to border on this larger problem in our age of, besides the bureaucracy which you mentioned, but I wonder if it also has to do with understanding things, technical, scientific, and engineering-wise, if you're—*

I worry about that, because there's no way I can teach the things to anybody. I wish there were. You have to experience it, I think, and we haven't had an atmospheric test in forty, what, forty-five years. Nobody knows about that anymore. And the technology for doing the underground gas-blocking has died. They're not doing it anymore. There's nobody alive that knows how to do that in the industry. There's nobody at NVOO—I still call them NVOO—who's smart enough to teach them how to do it. So I think you can't do that anymore, without starting over. So I have almost no faith in our ability to transfer knowledge. It has to be learned by individuals and I don't know how to do that. And the current business of doing everything on computers is nonsense. Computers, I believe strongly, teach you how to think but you should never believe any number you see. So when they want to confirm everything by computers, I think they're kidding themselves. But that's an old man, a crotchety old man, speaking.

But this does bring us a little bit full circle to what I talked to you about before we started recording, which is the fact that you're still, as a self-described old man, training some people about some aspects—

I share with them my experiences. One of the things I do to this group, I say, OK, I'm one of the few left who's seen an atmospheric, multi-megaton shot from up close, and here's what that's like. Then I go through a whole of series of being knocked to your knees and doing all these things, and trying to explain why we have those effects. And so I say, suppose there's a bomb sitting in the corner of the room, and if it has the temperature of the sun, it's as bright as the sun—anything with the temperature of the sun is as bright as the sun—and it's sitting in the corner of the room. OK, that, when it goes off, is three hundred times hotter than the sun, and the brightness goes as the fourth power of the temperature. So when it's three hundred times hotter, it's 8.1 billion times brighter than the sun, in the corner of the room. And the atmosphere won't let that much light go through. It starts but the atmosphere becomes opaque and won't let that much light—it can't pass that much light. But the bomb is going off and it's expanding. And as it's expanding, it cools enormously, and it's this big, and when it's that big, it's eight billion times brighter than the sun, but it expands. And when it's a million times brighter than the sun, the atmosphere lets that light through. So I only need to wear goggles that cuts the light by a factor of a million, because the atmosphere keeps the brighter from coming through and if I have the goggles, I can look at it, because I only see it when it's a million times brighter than the sun. So I have goggles that allow me to see a million times brighter than the sun. And then it gets dim and I take the goggles out. Wait! It's still hundreds of times brighter than the sun. So I take the goggles off too soon.

So what I do is give them a whole series of sensations and explain why, from a scientific or a technical point of view, why that happens. And I've told the guys here that when I'm giving the lecture on this stuff, it's not relevant to the present world, it's not relevant to anything they'll ever see or do, and so it's a waste of their time for them to hear me say this. The class has told me repeatedly, `This is not a waste of our time.` But I'm still curious: Why isn't it a waste of their time? Because I'm describing something that I don't think has much relevance to their job. And so I've mentioned that several times privately in conversations and they go out of their way to say, `No, no, this is exceedingly valuable.` I haven't figured that out. Why is that valuable? And perhaps the answer is, they see that you can think in a technical way about these things, and that **[01:05:00]** allows you to apply some technical thinking to current things. But it's the nature of how you think, as opposed to what you're thinking. Maybe that's the value.

Now, can you tell me what the purpose is of this training as a whole?

They're the guys who are looking at other countries, and you're supposed to help them understand what they see. For example, I tell them about the atmosphere coming through. OK. When you have something, you have a spy satellite, and it sees a bright flash, and it does this, it has a blink, and the moment it has the blink, you know it's because the light that's coming through the atmosphere was too much for the atmosphere to let through, and so you know that's nuclear because a meteor can't do that. A meteor doesn't get that hot. OK. So the Africa test, on the satellites it blinked, and we knew instantly it was nuclear. So there was a meeting in President [Carter's] office, and they declared it a meteor, because they didn't want to admit that it was somebody's nuclear test. But all of us knew it was a nuclear test.

The Africa test?

Yes. The South Africans and the Israelis did a test off southeast of the tip of Africa, and we declared it a meteor. It wasn't a meteor. It was a nuclear test. And they went to the correct place to do it.

But that could've been—President who, that would've been?

[Carter]**.** A meeting in his office and they declared it a meteor. And I tell these people that and said, Look, it blinked at us, and meteors don't blink because they don't get that hot. And we're talking millions of degrees. And meteors are only thousands of degrees. The temperature of the sun. So I give them some insight into that kind of a problem. If they see it blink, I tell them, that's a nuclear thing, not a meteor. And so there are relevances. But by and large, I'm entertaining them, I think, instead of educating them.

I wonder, it would be interesting to know if they're perceiving some value in the historical evolution of these things. I think that would be the other question to ask.

There probably is. There probably is some—in the whole course we're educating them and a lot of it is relevant, but some of what I tell them is, I think, entertainment. I'm always a little embarrassed. But on the other hand, we get enormously powerful feedback from that. They all like that. They all want it. So these guys have me do it again. But I'm always—if I haven't really wasted the time.

It doesn't seem so. But the purpose is to educate intelligence people about what to look for, regarding nukes?

Yes. Whatever you see, how do you interpret it? And they need to know what we did and how we did it so they have some background for judging what they see.

Are they scientists themselves?

A lot of them are, but a lot of them aren't. They're technical people in the intelligence community, so they're well educated and they're very bright. Is it not really true that everybody is self educated? Don't you educate yourself? You don't really–you educate yourself. And so no matter what your training and background is, if you're educating yourself all the time, then you're useful. And I think these guys are in the category of educating themselves in a useful way, and we help with that. What we do, I think, is show them patterns of thought, as opposed to the—they can read books for the information. What they need to do is see how the system thought and what it was thinking when it did these things, because other countries will go through that same process. I think that's a fair way to look at it.

That's interesting.

But you can put the details in a book, that isn't how they learn. That isn't all they learn. That isn't enough of what they learn, I think.

[01:10:23] End of Track 2, Disc 2.

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

Ralph Waldo Emerson said there's no such thing as history, only biography. And I think that's true. In order to understand history, you have to understand the role of every individual who participated in that history, which is impossible. But with the nuclear, the history was imbedded in the minds and hearts of fifty people. And now, getting a glimpse of their personalities, actually reveals a lot about the science, Edward [Teller] included. So I think when you talk about the nuclear, you can indeed talk about personalities. You can talk about individuals, and the role they played. So, I mentioned Al Graves. He said, Nothing we do is as important as the lives of one of my men. That was said at a time when the military was sacrificing everybody. So that was contrary to popular behavior. But he established a precedent for the nuclear business to be super safe. So the truth is, relative to any other industry we've killed almost nobody.

I saw the data for the manufacture of solar panels. The number of people killed in plants creating solar panels is greater than we ever killed in Los Alamos and Livermore and Sandia combined. Odd.

Now would you say that Al Graves's point of view is reflected—?

His point of view carried the day in Los Alamos activities. I think that's a fair way to say it.

And would you say that there's something of that in the way that you have operated on these various panels?

Yes. It was an attitude. It was a perception of the world. And it played a big role, I think. And some of us young lads learned it. Saw it. We saw it, and adopted it for ourselves. I think that's fair. Not everybody did that, but some of us did.

Now one question that comes to mind from the point of view of those who might see any kind of nuclear weapons activity as harmful, would be: How, in your own mind, that played out, and let me say a little more about that. Because clearly if you're thinking realistically and you're saying, "We have a deterrent role to play, in our work as nuclear scientists," and yet what you're potentially creating is so dangerous, is there some kind of cognitive dissonance there for you between Al Graves saying, Nobody is worth sacrificing, and yet the result of what you're creating would be terribly harmful? And that harkens back to your point about seeing the hydrogen bomb and becoming a peacenik, too. [See interview dated 09/10/2006]

Have I told you in the previous one [interview] about my giving a talk to a class of fifth-graders?

No. I don't think so.

Don Pettit was an astronaut who was up in the international space station when the *Columbia* shredded. He worked for me at Los Alamos, and I was kind of his ersatz father because his—when my wife and I went somewhere, he always asked if he could go along, so he was kind of family, and he adopted us, we didn't adopt him. But he wanted to become an astronaut and I told him how stupid that was. But he dreamed on and, to my surprise, got to be an astronaut. And then he was up in the international space station. But he invited us down to see him launched and so on, and we were treated as family for that, so that was nice.

And Don was up, and my grandson was in the fifth grade. And he told his teacher that I knew that astronaut, so the teacher invited me to come and talk. And I gave the kids—we talked astronauts. And at the end of the hour, she said, Would you just say a few words to the class as to why we spend all that money up there in space? And she screwed up her face. And I realized she'd been reading NEA.

And I said yes, so I turned to the class and said, Of all the fifth-graders **[00:05:00]** who've ever lived in the world, you are the most fortunate because in your lifetime, you're going to see man venture into space and do things that are just unthinkable, because, I said, it's the destiny of man to go into space. That's why we're here, and we'll do that. And we won't just go to other places in the solar system. We're going to go to other stars. And the way we're going to do that is with nuclear energy that gives us the wherewithal to do these things. And we can colonize the entire galaxy, our galaxy, in sixty million years, and this has been studied by a good friend of mine, and in the lifetime of the universe, [snaps fingers] sixty million years is just like that. And we can colonize the galaxy. And that means that everybody in the galaxy will be speaking English, and it'll be a bad English because they'll be taught by astronauts, but nevertheless, this is the role we have, and in your lifetime, you're going to see steps in that direction. Now, notice, I said nothing about money. I said nothing about why we're spending money, all that money. I just said it's the destiny of man to go into space. We're going and you're going to get to see a lot of this, and nuclear energy is the way it's done. And this little boy sitting there, like that. Each one wrote a letter to me, and he wrote, "Dear Mr. Brownlee, when your team builds a city on the moon, Stansbury (the name of his school) will be there. Over and out." [Laughing] That fifth-grader got a glimpse, right? When your team builds a city on the moon, Stansbury will be there. Over and out.

I got the biggest kick out of that because that little guy got a vision. And, what I'm saying is, nuclear energy gives us the vision, gives us the capability to envision these kinds of things. And therefore, every sacrifice that we make is justified. Every sacrifice. I would hope they were sacrifices that they choose to make. But nevertheless, every sacrifice. And wars are a temporary curse that eventually we'll outgrow. Now, having said this, you will see an inherent optimism that I have. It's genetic. There is no supporting evidence that allows me to justify being this optimistic. I'm optimistic genetically. But that little guy sitting there is also genetically optimistic. And we will persevere.

Now, let me say it this way. I happen to believe from a scientific point of view that the universe was created with a purpose. And the reason I say that is because the probability of this universe having these constants are vanishingly small. If I see a man, knowing nothing else, immediately as I see him, I know the speed of light and all the constants of nature I know, because if any one of them changes, the man can't exist. As an atheist, my atheist friends, in order to get around saying the universe was created with a purpose, say there's an infinite number of universes and we're one and therefore it's all by chance. And my attitude is, well, yes, that's entirely conceivable that there are an infinite number of universes, but I don't invent an infinite number of universes just to avoid saying—just so I can say it's all by chance. So I prefer to say, it has a purpose. Now we can debate what the purpose is, but I think man has a destiny, in this universe, and we are in pursuit of it, and I think nuclear energy is a part of it. And why do I think that? It's because I learned that bombs want to go off, the energy is there, an infinite amount of energy is there, we have to be clever enough to get it out at a rate that we want, but we've already learned how to get it out quickly and cheaply and easily. We've just found no way to convert that to the useful side. But we will. And our destiny is tied up with that because our destiny is not universal health care. **[00:10:00]** Our destiny is colonizing the galaxy. And I'm glad to have been a part of that.

But I think any sacrifices that we make is worthy, if that's our objective. And I recognize it's not the objective of many people, but why do we spend all that money up there in space? It's because it's part of our destiny, and nuclear energy and money in space go together to do the things that I think are coming in the future. So I would like to hang around for another fifty thousand years, or whatever, to see that process begin to unfold.

So, what I'm telling you is, I have a view that's pretty broad, and therefore when you ask me this question, which I understand, about nuclear, I say, Ah, but the problems that you're asking me about are temporal. And I'm seeing beyond that, and therefore it's enormously easy for me to excuse people who don't have that vision. Is that fair? I can excuse them if they don't have that vision. I can understand they're not seeing it the way I see it. But I prefer my view, because it's much more fun and I enjoy it.

Yes, I think I was also harking back to what you said in the first meeting, when you saw the bomb of that size, that hydrogen bomb, who would ever—I'm paraphrasing you now—who would ever *want to? So there is the reality that the weapons program was about weapons, not about nuclear energy, although I take your point clearly that the advancement of this knowledge is won, in a sense, ultimately. So I think I had a more mundane question about how you as a thoughtful person understood these things and understand these things now.*

I was horrified by World War II. I could not believe that I was alive in a time when in four years' time fifty million people lost their lives. It boggles the mind and you can't—and so I thought the deliberate use, of killing, whatever, to stop that, was justified. I still think that. The moment that war stopped, I think we, to our own astonishment, discovered that the end of World War II, instead of achieving our goals, we suddenly realized that Russia was the enemy. Now, when I say that, that's not true for me. My father said in maybe 1930, If Hitler ever comes to power, there'll have to be a war. So from that moment on, when Hitler became chancellor in 1933, my father said there'd be a war, therefore I know there's going to be a war, and I believed that. But, by 1934 or 1935, my dad was saying, Stalin is an enemy that when we defeat Hitler, we're going to have to defeat Russia. There's no other way out of it. So I bought that, too.

And therefore through the Cold War, I had this feeling that somehow it's completely nonsensical. We're building these things that nobody in their right mind wants to use, but the only reason we're building them is so they won't use them. And therefore deterrence was why they were there. And when I give this talk to the guys, I tell them that the justification was deterrence, and I believed in that deterrence.

I still think a legitimate role of nuclear is deterrence for war. But I believe that's a temporal situation. I never imagined, I never realized—oh, I had gone on record as saying, Russia can't survive, and I had trivial reasons for it. I said, Any country that spends that big a fraction of their total national output, looking, keeping watch on each other, can't survive. But it **[00:15:00]** never occurred to me that they were going to go completely away in my lifetime, or than that, in a few months. I never imagined they could collapse like that. I saw Germany collapse like that. I saw Japan collapse like that. I never expected Russia to collapse like that. Having seen that, I recognize that we can collapse like that. And so, I think the role of nuclear things as a deterrent was a correct policy, as a deterrent.

Could they still be used as a deterrent? I think so. And so if I were President of the United States, I would look at the possibility of doing a demonstration test on the border between Iraq and Iran out in the desert and say, Look, guys. I would consider doing something like that as a demonstration because we can do a demonstration without harming anybody really. We can build a bomb where the fallout is trivial and so on. But we could do a demonstration test. It's dangerous to do a demonstration test because you're threatening, but on the other hand, that's preferable to us losing.

And so, in the current situation, I would be willing to entertain a variety of things, but, having said that, I regard that as temporal. Our real goal is utterly different and we need to take the longer view, and therefore, we ought—for example, in the Vietnamese war, my solution at that time was, why don't we just buy it? Why don't we just go over and give every Vietnamese enough money to move to Paris, preferably to Paris, and just buy them out, because we had the capability to do that, why don't we just do that? So I didn't want to bomb them with nuclear. I thought the solution was buy them. I still think that would've been a good solution. I think you can't buy the Muslims, with money, but maybe there are other ways to buy them.

So I think in different ways than the political people. And I understand that we've got a crisis, we've got to get out of that, but that's not our purpose. Our purpose in the world is not to end the Iraq War so that we can save the money for health care. That's not my way of thinking. I'm saying no, no, we should keep our eyes on colonizing the galaxy. So I just think different. And I can't help that. I was brought up to think broadly, because my father did, and I saw that and emulated him, and wish he was around so I could discuss these things with him. But I think what I'm trying to share with you is, I have a vision of the destiny of man, which transcends local politics and local times. I also think it's possible for this country to go like that. And I shrug because I'm happy when things are as bad as I predicted. And so what I'm really saying is, I think we're in for a big surprise. Let me tell you about global warming for a moment.

"In for a big surprise." You have to tell me what you mean by that.

I think, the reason I talk about global warming, I think the surprise that's coming is going to be a disease that we have no cure for, and all of a sudden millions of people in China and here and elsewhere will die. This started in World War I, in my experience, when my father was telling me about it, the first time we had a lot of troops together in this country, and the flu epidemic killed everybody; it was solved by dispersing, because the end of the war came and the Army dispersed and we no longer had all the soldiers dying from the flu.

Population densities everywhere have gone up. Bangkok, since World War II, the population is up by factors of three or four, and that's true of Cairo, that's true of the Chinese cities, unbelievable. Here the other day you may have heard, the price of gasoline has gotten so big in Alaska, that the individual villages in the interior cannot—it's eight dollars a gallon and they can't run their generators. And the only thing—they interviewed a kid and I heard what he said: There's nothing to do here except to watch television, and we have no power now, so I'm going to the city. And a hundred thousand natives interior to Alaska are now, within the last six months, on their way to the cities in Alaska. And so, all over the world, people go to the cities.

[00:20:00] And so I'm saying, Oh, you know what's going to happen one of these days? We're going to have a medical [crisis] that'll take the populated cities of the world. And I look for that surprise. And I'm saying global warming is not the fear. The fear is that more, in the near term, we're going to lose millions of people because of diseases that we can't cure. That's my prediction. So maybe you see what I'm saying. And so I think the kinds of surprises that we're in for are not the kinds that people are making a big fuss about. It's going to come quicker, and it's going to come in more painful ways, because we put everybody into the cities. China is unbelievable. And the consequences. I had an uncle, with three boys, and they decided they'd make their living raising turkeys. And the more turkeys they had, the better they did, and they kept them all here and did all the correct things for turkeys. And the moment they put one extra turkey into so many turkeys per square meter, they caught a disease and all died. If they kept the population density of turkeys lower, they did all right. But the moment they put in the extra turkey, bang. I think people are no different, really. And so my prediction is, oh, are we going to be surprised about the consequences of population density. And so maybe I'm with the environmentalists. The only solution to the world's problems is to get rid of four-fifths of the population of the world. But I'm not that angry at anybody, so I don't want to see that happen. I still think that our destiny is not here. Weird, I know.

No, it's your view and it's very interesting, and it's already 10:30, so we should stop, but thank you very much.

[00:22:12] End of Track 2, Disc 3.

End of interview.

R.Brownlee 2007 Photo 1
Crossroads Able June 30, 1946

R.Brownlee 2007 Photo 2
Crossroads Able June 30, 1946

R.Brownlee 2007 Photo 4
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R.Brownlee 2007 Photo 3
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