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

Interview with Robert Brownlee

September 10, 2006
Las Vegas, Nevada

Interview Conducted By
Mary Palevsky

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Produced by:

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

Director and Editor
Mary Palevsky

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

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

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Mary Palevsky: *Robert Brownlee, thank you very much for meeting with me this evening. If you could begin by giving me your full name, place of birth, and date of birth, that's a good start.*

Robert Brownlee: Well, Robert Rex Brownlee is my name, and I was born in 1924, so I'm eighty-two. I was born on the farm in central Kansas, and I was the oldest son, only one son, and I had two sisters, one five years younger and the other one much younger. So I grew up on the plains, the prairies of Kansas. And I was pretty much shaped by a few events that happened when I was young, quite inadvertently, I didn't know it at the time. So what I am is a product of that youth in Kansas, I think.

Both of my grandfathers homesteaded, and the environment was one of homesteaders. And there was no government, so they took care of each other, and that attitude, practice was common when I was growing up. It never occurred to you to call somebody. The neighbors took care of you, took care of each other. And so I look back upon that as an ideal way of growing up. Nobody ever had locks on their doors or anything like that. The whole community was a community of wonderful people.

What kind of farming was done there?

Wheat. One of my grandfathers, my father's father, homesteaded in a place where you can also raise cattle, so we had wheat and cattle, but most of our neighbors only had wheat.

So in the Depression, we went through some very bad [times]—there was no money, but you worked on a barter system. But we had cattle and our neighbors did not, so when the neighbors were out of food, Dad [Clarence Brownlee] would say we must butcher, and he would call that neighbor say, `I need to butcher. Could you help?` Well, the practice was when they helped, you sent meat home. And then my father would say, `I think that family is out of food. I'd better butcher.` Because they didn't have cattle and we did. So I grew up in that—and what that meant was, with no money. The meat spoiled, too—no money, I had a nice beefsteak every morning for breakfast.

So you had to eat it.

Yeah, it was great.

Now when you said things shaped you, this is one of the things you're talking about?

I asked my father—I asked question after question after question. When I was five, I asked my father, `What makes the sun shine?`

And he said, `Nobody knows.`

And I said, `But Uncle Mason will know.`

And he said, `No, no one in the whole world knows.`

So I discovered my first question for which there was no answer. Then I tried to invent other questions that would have no answers. So then I asked utterly stupid, incredibly opaque questions, trying to find other questions for which no one in the world knew the answer. But that answer, what makes the sun shine? No one knows. I'm going to find out. Someday I will.

And then I mentioned that I was in my early teens, I'm not sure, thirteen, fourteen when I made lists of what I wanted to do with my life. I decided, I don't want to be rich, although that's tempting, but no. I don't want to be famous; that's not what I—what is it you want to do? I wanted to understand everything, and the reason for that, I was curious about everything, so I always asked my father question after question after question. So Hans Bethe was the guy who got the Nobel Prize for answering that question [“What makes the sun shine?”], and he was working on that problem when I was asking that question, that was in 1929, and he really didn’t solve the problem till maybe 1936 or ’34, along in there, still a young man. He only died, you know, within the last year.

Yes, I knew Bethe.

Subsequently I got my degree in astronomy and astrophysics and my **[00:05:00]** interest was in models of the sun, and so I spent a year doing a model of the sun at one instant in time. But when I got my degree, there were only a couple places in the world where you could go and get your hands on material as hot or hotter than in the center of the sun, and that’s what I wanted to do, and so I applied to Los Alamos and got that job. And loved every day and would’ve worked there for free.

The interesting thing of an astrophysicist then being the person who knows about containment [of underground nuclear tests] is a fascinating one. But let’s back up a little bit because I want to hear about your World War II experience.

My father was a very intelligent man. He was a college man. My grandfather was a graduate of college. And out there on the prairie, that was rare. And he was very interested in world affairs. We had no electricity, no running water, anything like that, but my father kept current on what was going on in Europe. He said, I would guess in 1931, maybe, or 1932, If Adolf Hitler ever comes to power, there’ll have to be a war. So when Hitler became Chancellor in ’33, I knew there was going to be a war because my father had said so. And I vowed, when I’m eighteen I will enlist. And when war started in 1939, in Europe—World War II started in ’37, but at any rate—

Why do you say that?

That's when the whole thing, shooting started in China. The Japanese were occupying China and then China just rose up in revolt at the Marco Polo Bridge, and that was the start in '37, because then they sacked Nanking, and that was a slaughter, a terrible slaughter. So at that moment we knew we would ultimately have to have a war, my father did, with Japan.

So your father talked about that, too?

Yes. But I vowed I'd enlist, and when the war started in Europe in '39 I said, `Do you think it'll last until I'm old enough to get in it?` Because I was only fifteen. And he said, `Wars are very easy to start and very difficult to stop, and so I'm afraid this will be a long war and you'll be in it.` So he did not like my plan, but when I was eighteen I enlisted. And you won't believe this. I read. I read a lot. And I've forgotten the number now, but in World War I, I think there were forty million horses in Europe. Millions anyway. And they were used by all combatants. They used horses for everything. And I grew up on the farm, had my own horse, and I [was] so stupid that I thought, well, if there's a war, there are going to have to be horses, so I enlisted in the cavalry. And you've probably never heard of the cavalry.

I've heard of the cavalry.

But not in World War II.

Yes, I have.

I enlisted at Fort Riley, Kansas, which is a cavalry post. And the guys who enlisted with me were disillusioned right away, but I was not disillusioned until the following day. I was a slow learner. And I went through training in a tent with six of us. I was ten years younger than the next guy and twenty years younger than the oldest guy. They could not imagine anybody as dumb as I was. So they taught me well of the three armies. There's the army of regulation, and in any kind of a crisis you devolve to that army. And then there's the army the way the officers run it, and they are unaware of the army the way the top sergeants run it and so forth. And that's the old army that existed for all time up to the beginning of World War II. You didn't pick that up in other elements of the Army but you did in the cavalry because they were old. When I got there, to my disgust they only had mules, and I realized this was a big mistake.

I put in for transfer to the Army Air Corps and my cavalry friends were outraged **[00:10:00]** that I was not loyal to the cavalry and that I could be so idiotic to want to go to the Air Corps. And they said, `The Army has you and it's futile for you to put in an application. It'll never work. And this way you've demonstrated your disloyalty.` And my transfer came through. And I was in the Army Air Corps for a few days when I realized this is a big mistake. I should have put in for application to the cadets, to the aviation cadets, so I put in for that. And they told me, `Well, you're already in the Air Corps. They take aviation cadets from universities and colleges. And so this is a big mistake. You'll never be accepted.`

But I was, and so finally I went from the cavalry to the Air Corps and then the aviation cadets. And I was happy, but in aviation cadets our officers were all ninety-day wonders, and the things I'd learned in the cavalry, how to go AWOL [Absent Without Official Leave], how to avoid long marches, how to do incredibly complicated things almost within regulations but not—the officers in the Army Air Corps didn't know any of those things, so I was considerably too well educated to make a good aviation cadet.

At any rate, I grew up out there on the prairie. We had a sea horizon; flattest county in Kansas. And if I stood in the same place, the same star arose at the same spot every night. I knew all that. So I was interested in the sky and my father could answer my questions pretty well. And so I wanted to be a navigator. That's what I wanted to be. I was always good at math. And so my goal in aviation cadets: I was going to be a navigator. Well, they ask you what you want to be and they didn't pay any attention to that, but that's what I wound up.

So when I graduated from navigation school in Hondo, Texas, to my great surprise I was selected as a navigation instructor. So that saved my life because everybody in my class went off to Europe and most of them got killed. But I was delayed and then when I finally did go, I went to the Pacific.

And what year was that?

In '45. I joined in '42. And I got to the Pacific—oh, when we were selected, all of a sudden we were selected as a crew, B-29s, and when we got together for the first time, we discovered each one had been an instructor. The pilot had been a pilot instructor, the bombardier was a bombardier instructor, and so on. How come we're all instructors? Well, it turns out we were the general's crew, so we had this special—we were treated better.

Now what does it mean that you were the general's crew?

We had a general who when he needed to go somewhere, that was his B-29 and his crew and we did—yes. And he selected—he wanted for his crewmembers to be really experienced or knowledgeable, I should say "knowledgeable" rather than "experienced."

So we went off to the Marianas, but we got there just right at the end of the war. So I'd never flew to Japan in a combat mission, but I did have some missions when they were still shooting. But I got there at the end of the war. However, we knew that the probability of living through it was not very good, because you had to fly so many missions and the loss of planes. They were getting better. And the invasion of Japan was coming. And on Tinian they built a hospital on the island for people injured in the invasion. And they were just building that, getting ready for the invasion, and the longest corridor in the hospital was just a mile long, with buildings off of it. And there were many corridors. And so you knew this was going to be a terrible slaughter.

[00:15:00] And I was in the 504th Squadron; the 509th were the guys who dropped the atom bomb. And the 509th had a fence. Nobody else had a fence. And they didn't do things. They didn't seem to do anything. And so we were puzzled about that. And then it was the 509th that dropped the bomb.

Harold Agnew was there. And I sent him a picture taken, I think, by one of our squadron people, and I sent him a picture last summer, I think, which he'd never seen, of Tinian. And I got it at that time when I was over there. And I have it digitized. It's a magnificent picture of the whole island.

I would like to see that.

And at any rate, I sent that to Harold. And so Harold and I were there at the same time. I had no idea—well, that's not true.

By this time I knew about nuclear energy and I knew what made the sun shine, and so that's why I wanted to go to Los Alamos. I didn't get there of course until after the war because I had to get my degree. So the question, what makes the sun shine, my decision to understand everything combined to aim me at Los Alamos.

As a young mathematically and scientifically gifted person, had you had any conception—you're saying you knew by this time of Bethe's work—I'm asking a question about the bomb. So when the bomb was dropped, do you remember what your response was, both personally and—. Was there a scientific understanding?

They said the flash in the sky that everybody saw in the southwest.

You saw this flash.

No. But the flash that everybody saw. This was with the Trinity shot, which is in July. See, if I remember correctly, Trinity was July 6th.

Sixteenth.

Sixteen. August sixth was Hiroshima. Think of the short time, the incredible short time, and eerie, that flash with Trinity—the Army said an ammunition dump had blown up. And I remember we were skeptical about that. Ammunition dumps don't do that. There's something odd about that. And I was smart enough to know that. However, the moment we heard [about the] atom bomb, I understood how that could be. Not in detail, of course.

And we were all convinced it saved our lives. In the years since I learned some other things. At the time we knew that the Japanese had taught everybody to commit suicide when they saw their first soldier, but this was in Guam and Okinawa. I hadn't realized that they had been very successful in indoctrinating everybody in the homeland. And so there isn't any doubt in my mind at all, none whatsoever, that the first atom bomb saved millions of lives, most of them Japanese. We'd killed four hundred thousand people, I think, in fire bomb raids without a hint of it making any difference. And also England. Germany bombed the dickens out of London and nobody in London said to surrender. And so I was under the impression that bombing doesn't do any good except to destroy—it doesn't destroy their will. That was my view. And so I thought we were going to have a terrible long war, and I didn't expect to live through it.

You didn't expect to live through it, really?

I didn't expect to live through it, because it's going to be too long. I saw an intelligence report. As a second lieutenant I could do that, and I would go in and look at these things, and one of them was the plan for what we were going to be doing in 1947. I thought, I'll not live through another two years of this. And so the atom bomb for me was, oh, suddenly it's over, and I hadn't expected that.

[00:20:00] I still think it was necessary to stop that invasion. However, this book [indicating Kai Bird and Martin Sherwin, *American Prometheus: The Triumph and Tragedy of J. Robert Oppenheimer*. New York: Alfred A. Knopf, 2005] has taught me that the feelings against using the bomb in Los Alamos were much stronger than I had thought. I was aware that there were people there who did not want to see it used except as a demonstration. But there were people who said, `But it might not go off.` What if we have a demonstration and it doesn't go? We had better set it off first, but not announce it as a demonstration. And the decision to use it in a Japanese city was a Washington [D.C.] decision, not a Los Alamos decision. I think if you'd asked the Los Alamos people, they would've said a demonstration test.

But there was another wrinkle. The scientists in Los Alamos were heavily European. They were there to get an atom bomb before Hitler did. Their concern was not Japan. When Germany surrendered, their goal had been achieved. They'd beaten Germany. So they were not interested, for the most part, in dropping it on Japan. The military people were well aware that even though it would appear that Japanese [Japan] was defeated, that we were going to win, the real goal was to stop the war. It was not to win the war; it was to stop the war, because we'd perhaps already won it. And I think that was a legitimate goal, whereas many Los Alamos scientists did not feel that way, I think. That's how I understood.

I was told that in those early days, there were a few people whose family had been killed by the Nazis and so on—tend to be Jews—who when military people would come in from Washington, they would tremble when they saw a uniform. So they'd been traumatized in Europe, and so anybody in a military uniform frightened them badly. So there were a number of people in Los Alamos who were anti-military, and I can understand that. And their interest was science, and in effect they got outvoted by the military, which I think I understand.

From my point of view, being there on Tinian, fearing I'm not going to outlive this, to suddenly have the war end was—you can't imagine what that meant.

How did you actually hear about it? Was it announced?

Oh yeah, everywhere. In those days the blacks were segregated from the whites. We had a kind of a ridge and we lived over on the side closer to the ocean. There was a ridge and blacks were over there. And we were all armed with .45s and everybody shot. But we noticed that blacks tended to shoot over the ridge. An unusual amount of stuff didn't come from up there; it came from over the ridge. I remember that. And they were celebrating, but they were also expressing something.

Growing up on the prairies out there, we had no black people or Italians or Greeks or anybody. We were all Northern Europeans. I had no prejudice. I was brought up not to have prejudice. I didn't have any prejudice. I got in the Army and I discovered amazing things. And one of the things was, we had a Jewish boy from Flatbush in our outfit. And he would go not to the immediate supervisor but to the next guy up and tell him he was being discriminated against because he was a Jew, and he would get out of whatever assignments we all had. And then he would brag to us how smart he was compared to us because he got out of the work and we didn't. And he always complained that he was **[00:25:00]** discriminated against because he was a Jew. And I asked this guy from New York, Are all Jews like that? He said, Only in Flatbush. [Laughing]. And so I remember those kinds of details of discrimination, which was novel to me. I was really dumb. I was from a unique part of the world and a unique period of time and I needed to be educated on every front.

Brownlee, is that a Scottish name? That would be my guess.

Scottish. And we were Scottish Presbyterians. And the Presbyterian Scots had a very clear eye, and they had the ability to say it. And so growing up in the old Scottish Presbyterian environment was good for you. You had to think. And in my family you were allowed to escape if you were clever, so you were questioned but if you were bright you knew how to—I'll give you an example. My grandson just came back from Iraq last week, Sunday night, week from tonight. He's been over there a year. He was in the 101st Airborne. And his girlfriend met him there, and we were there. And she'd talked to him on the phone.

And I said, `How come you've talked with her any number of times, and you never called me?`

He said, `Well, I'm twenty-two.`

Now that's a good answer. And I said, `You've answered well.`

And our kids have had the ability to answer, and it comes from the old Scottish genes, I think. There's always a way to evade the question. How in the world did we get off on this?

Well, that's interesting because it tells me something about your directness, but yeah, that's a great point you're making: the import of the question is avoided by a very clever answer in your grandson's case.

Yes. I gave a lecture in China on what's in an empty box. It was at Fudan University in Shanghai. And I had three of the grandsons with me, and so they heard that.

And when they got home, my son said to my grandson, `You heard your grandfather give a lecture.`

And he said yes.

`What was it?`

And he says, `What's in an empty box.` And he said, `But we knew that. We knew that. We didn't need to hear the lecture.`

And my son Wayne said, `Well, name three things that are in an empty box.`

And my grandson said, `Actually I've been taught to think outside the box.`

I said, `You pass.`

But that's the kind of interaction we always had in the family, and I'm pleased to see it coming up, that there's always a laugh associated with it. But that's how to evade—it's hard to put it to a test. They always pass.

That's very good.

But I was that way. I think we were taught to be that way. It's probably genetic.

Cultural or genetic or some combination thereof.

But I got a very good education. Let me explain. In the Depression we had no money. Two things cost money: coal—there was no wood; it's just out on the prairie—coal for the fire and gasoline for the lantern. That cost money. We didn't have any money. So in the wintertime we ate and went to bed. That avoided having to heat the room, and no lights. We'd go to bed, and then I'd ask my dad questions and he'd tell me stories until I went to sleep. And I so I heard the history of the Romans and the Greeks and the Egyptians and Genghis Khan and the Civil War, an enormous amount of information about the Civil War; I would ask Dad questions and he would tell me these histories. And so I got an education that transcended the school system because I learned what I wanted to know from my father on those long winter evenings in the dark. And he would talk to me until I went to sleep. I could not have had a better education, because he would **[00:30:00]** go into—now let me make a point. He would give me all kinds of information about the Civil War. I was telling one of the grandkids the other day about Pearl Harbor. The time between Pearl Harbor and now was the same length of time from the Civil War to when my father was telling me those stories. Isn't that amazing? The Civil War was not that far in the past.

That's right. That's amazing.

And in 1929 when I was getting this education, from the end of the Civil War in '65, that's thirty-five plus twenty-nine is sixty-four years. From Pearl Harbor to now is sixty-five years. Isn't that amazing?

It's amazing.

But that's why I know so much about the Civil War. Did I learn it in school? No. I learned it at home. So I had an exceptional opportunity to learn beyond my years because there was no electricity, no money—all the food we needed. I didn't think we were poor. And my father educated me. You can't beat that. You cannot beat it.

And what was your father's name?

Clarence Brownlee.

And had the family been in the country during the Civil War?

Yes. My ultimate ancestor came over in 1642, and they had fled from King Charles I [spending some years in Ireland before coming to America]—and they were Protestant. And the king came by in a hunting party and the boys threw rocks at him, and he came back with troops; and they fled to Glasgow, the two Brownlee brothers, and made it across to Ireland. And one of them stayed in Ireland, and the other one came on across to this country and moved into Pennsylvania. A generation later, the son of the man in Ireland came over, so the Brownlees came a generation apart but the second one was the nephew of the first one. And so they got chased out by King Charles. Then they lived in Pennsylvania, and then a number of them came west when you could get land.

So what were their loyalties during the Civil War, the family?

North.

The North. Because I know that Kansas was contested.

Very, very heavily North. Kansas was populated by people who were in the North. Missouri favored the South. That's the reason why we had a war between Kansas and Missouri. Remember [the] Quantrill raid in Lawrence, Kansas.

That's right, I'm thinking of Lawrence.

And one of the Brownlees was there, living in Lawrence at that time; Quantrill set the house on fire, and then they shot the men when they came out of the burning—so his wife put him under the carpet and drug the carpet out from the blazing house, and he was in the carpet—and that's how he didn't get shot. Isn't that something?

Amazing. That's something.

So we had those kind of Civil War stories. So I grew up with stories, and I asked lots of questions, so it wasn't enough to hear about Genghis Khan; I wanted to hear all about Genghis Khan, and so on. And I couldn't have had a better upbringing. Could not have done better. I'm sorry that kids nowadays are so poorly educated. We have great-grandkids and my problem is I can't get my hands on them. They're too big a generation gap.

I'm sure something trickles through. That's all very interesting, but given the—

[00:35:00] Beside the point.

No, it's not beside the point because as I said, one of the things that oral history does that nothing else does is it gives you these individual personalities.

Yes, and you need to know that.

And you need to know these things, and it helps put you in context.

One of the things you notice is that I enjoy those stories because there's always some humorous aspects to them that I really do like, and that's true of the things here at the test site. What do I tend to remember? The fun things.

So when the war is over, how soon is it that you get to come home, to get back on our time line here?

I came back, got the degree, college, majoring in both math and physics and a minor in education. Then I taught high school for two years, and I knew this was not—I enjoyed it. I was a pretty good teacher, I think, but I need to go back to school. And I decided I can go to graduate school and do just as well as I can teaching high school. So I went to Kansas University and got my master's degree and then went to Indiana to get my Ph.D. And by that time we had three kids and not anything like enough money. I got $111.00 a month, I think. And so I worked and did extra things to make a living. So it took me four years to get my degree in Indiana, so I came out of there very late. But then when I arrived at Los Alamos, I was thirty-one years old with a brand-new Ph.D., but the average age of a staff member at Los Alamos was thirty-one when I arrived there in '55.

Interesting. In '55. OK.

I got there ten years after the war. But meanwhile I went to graduate school and did all those things. Finished college.

So explain a little bit how an astrophysicist ends up at Los Alamos, even though we're not into containment [of underground nuclear tests] yet; we're still in atmospheric. Well, what were they looking for in someone with your education?

I was an astronomer in astrophysics. My degree at Indiana was in astronomy and astrophysics. But it was a combination of math and physics, always. And astronomy, because I loved astronomy. And navigation, I loved astronomy. But I had my eye on Los Alamos because an atom bomb is hotter than the material in the center of a star. Well, I wanted to know all about that. I wanted to understand that. I didn't have a motive of killing Germans or something. My motive was to understand everything I could. Well, they put me in the Test Division. Well, that's exactly where I wanted to be. And I started off every day doing really well. I enjoyed every day. And I arrived in '55. I saw my first nuclear explosion in February of '55 [Wasp]. And that was one kiloton.

Where was that? That was here [at the Nevada Test Site].

Here. And then in '56 I saw my first thermonuclear explosion. Now let me describe this. In Kansas out on the farm we had dynamite and during the drought we would blow big holes that would fill up with water because the water table was close to the surface, and we could take dynamite and blow holes and have water for the cattle. And I loved it. Well, I knew what a pound of dynamite was. I knew what six or seven pounds of dynamite was. So the first shot I saw was one thousand tons of high explosive, HE, not just explosive but high explosive. Ahhh! Breathtaking. And I never saw a fission explosion that I didn't like. Think what you could do with those out on the farm. You could move real estate.

And then fifty years ago last May, I saw my first thermonuclear explosion [Cherokee]. And it's hard to believe but it was 4,200 times bigger than that first. You have no idea what a factor of 4,200 is multiplied by one kiloton. At any rate, my first thermonuclear explosion kind of turned me into a peacenik. This is not—we don't want to go there [we do not want to go to the use of thermonuclear weapons of such size]. There's nothing—I'm not mad enough at anybody, I'm not that mad at **[00:40:00]** anybody, to use this in as an instrument of war. And so when I saw one kiloton, I was like a kid; I loved it. When I saw four megatons, what I saw were all kinds of questions that needed to be answered, and we didn't even know what to ask. But for example, we see it over here, and then you look over there and clear air is glowing a color you've never seen before. I want to understand how come that air is glowing like that and what's going on is over here, what's happening over here. And if I'm going to understand everything, I suddenly realize why there's an infinite number of things to learn, and until we learn that, we don't know whether we want to do this again or not. Does that make sense?

It does. I have some questions about it.

So what I'm saying is, my experience, the difference between a fission explosion and a fusion explosion is all the difference in the world. But that was its effect on me, and there were others, I'm sure, who weren't affected that way. But I saw questions that I had no idea how to answer, and anytime I had a question I had no idea how to answer, that bothers me.

Yes. So the one-kiloton test you saw is a relatively small fission test.

It was one big explosion.

But it must've been a big explosion.

Oh, of course, a kiloton, you have no idea. It's wonderful.

I don't. I have no idea. But somehow that wonder turns into something else when you see something that huge as the—?

Seeing something 4,000 times bigger than that, that's a number, 4,000, a multiplier of 4,000 is an incredible number to multiply by. And it's a different event. Every aspect of it is different, from a scientific point of view. "Wait a minute. Boy, do I have things to learn."

Which test was this and where were you relative to it?

The first thermonuclear was on May ninth and I've forgotten the name of the test.

I'll look it up.

I think it was May ninth of 1956. At any rate, it's the first few days—you know, that's wrong. The first test we did in the operation was May first, and so the first thermonuclear came some days after that. It wasn't May ninth, I think.

OK, I'm going to look right now.

You have the book with you? [DOE/NV—209-REV 15 December 2000].

I do.

Let's look it up because I think I can tell you—.

It's four megatons, and it's Operation Redwing.

I thought it was Redwing.

And let me see, let me go back here till I can get there It's pretty close to the front, isn't it?

It must be.

Castle, Teapot, and Redwing. Lacrosse was May fourth and that's the first test and that's the one I did all the—I was working on that test. And the first thermonuclear was—oh, here it is. It [Cherokee] shows here it's 3.8, and it was on the twentieth. And that was my first thermonuclear. And the thing I remember at the time was we thought it was going to be 4.2. Well, it shows here it was 3.8, but that's where I get my 4,000.

Now there was another one there which was Navajo and that was 4.5 megaton. And Navajo, I was working on the bunker close to Navajo—and we had a camera station and built a great big bunker, huge, thick walls. And then they reduced the yield, and everybody said we had to move the bunker closer. We couldn't do that. And then, but oh dear, we're not at the right distance. And the building was built before anybody knew what the bomb was going to be, what the yield was going to be.

And this is a lesson I learned. When it came time, there was a thunderstorm, a perfectly ordinary thunderstorm for the Pacific. Cloud wasn't very high, it's lightning, it's raining and moving slowly along. And it's coming toward ground zero. And my **[00:45:00]** boss—I said, he's not going to shoot that with that rainstorm over the shot site because that's going to cut down our visibility. We're not going to be able to get the data we need. And here came that rain cloud and it came in and it was at ground zero and we went four, two, three, one, boom, and the cloud lit up on the inside something tremendous. And I thought four megatons would blow that cloud to smithereens. And that cloud burped and belched and moved on, only now the falling rain is tremendously radioactive. And so we quick did the calculation and realized that Mother Nature's expending four megatons of energy every so many seconds. And that's when I learned, you may be awed by four megatons but Mother Nature isn't. And that was a profound lesson for me because I thought it would blow that cloud to smithereens. And it burped and did things but it moved on raining. That was a profound lesson for me as a scientist. I said OK, I need to understand thunderstorms better. If you're going to understand everything, there's no place to stop.

Correct. But I'm hearing two interesting sort of themes here. One is that the weapon, that the explosions, the detonations and what their consequences are, the phenomenology of them, causes you to realize other questions that need to be answered. And then there's the one that's connected more directly with what it is, which is a weapon, which is it should never be used. So I think a question a lot of people have when they are thinking about people who worked on these huge weapons during the Cold War is, was the science separate from the war concerns? How do you think about those things?

They were pretty much separate, I think. That's a function of time. On occasions it was separate and on another occasion it's not, perhaps. But I think I was always interested in the science, not so much in the politics, if that's a way to say it. I'd been in the Army four years, and in World War II all the information was on the clipboards; a ship arrived with supplies and they handed you a clipboard with what they had on board and that's the first you knew. And so on Guam one time a ship arrived and they had a whole lot of winter uniforms. Well, we don't need them. And so the military in World War II was a kind of a random walk. Despite all the planning, what happened was a consequence of things that weren't in the plans. And I kept seeing that everywhere. And as a scientist, with an experiment coming up, we weren't interested in how this explosion might someday be used on somebody. We were interested in why is that not making this not work like we calculated or whatever.

There's another point to make. I happened to get started with computers right at the beginning because it came naturally. In graduate school. And all of the computing which is enormously important for those initial atom bombs in the fifties was made with a memory of 256K. Your cell phone has infinitely more. And so our calculations were incredibly primitive. And was that bad? No. That was stimulating because you had to use your brain. There was no alternative.

[00:50:00] And so you had to outwit Mother Nature. You were constantly trying to outwit her. "Outwit" is the wrong word. Let me see if I can tell you what I have in mind. Mother Nature does exactly what she calculates at every instant in time. She follows the rules and the laws and it's that way because that's what her calculation was. And when she makes a calculation, it's perfect for that moment. In Kansas, before harvest, the wind blows across the wheat, and you can see the individual puffs of wind. These stalks go down and the next and the next and the next, and then they stand up and here comes the next, and right next to it, when this was down, this was up. And you could see the size of the puffs of wind. And if you put an instrument to measure the wind it'll give you the velocity. But when you look at the wind moving over the wheat field, you can see the complexity of that wind, even of a steady wind, and you can see the trueness. Occasionally there might be a tree or a little building or something, and the wind right behind that, the wheat is moving a little differently. You can see that. And you say, oh. And so when that wheat moves, Mother Nature has calculated the effect of that little building, whatever it is. It's all there. OK, the moment I do a machine program of the wind blowing over a wheat field, I certainly do not put in the little building or the extra tall piece of rye. I can only gloss over that.

So Mother Nature can beat me every time in the detail, but I can outwit her because I can see that that wind is going to get there before she knows about it, and I can put something there that affects that. So let's use a bullet. The bullet is fired and she's calculating exactly what the trajectory of that is, but I can put something in front that she doesn't know is there until she gets there that stops that bullet, and I can put it thin or thick and I can calculate what that is. And so I can do her calculations, I can do some of the calculations she does ahead of time, and that gives me the ability to outwit her. I think that's the correct word. She can outthink me but I can outwit her. I think that's the best way to say it. At any rate, so the challenge is, do I have the smarts to outguess Mother Nature? She'll make the calculations which I can't make, but that causes me to have to be really clever because I've got to outwit her. OK, that challenge transcends politics. "Politics" is the wrong word. Transcends strategies or something. Does that make sense?

Yes.

So if you're really curious—I gave a talk on global warming the other day, and it was about Al Gore's movie, *An Inconvenient Truth*.

I haven't seen it yet.

I haven't either. That doesn't bother me. I can still talk on the subject. I don't know anything about global warming, but I do know about machine codes and computer models. All truths are inconvenient. All truths. That's why you leave almost all of them out of a computer model, because you can't put them all in. Mother Nature puts them all in, but you only put in some. All truths are inconvenient. So I'm convinced that much I hear about global warming, it's nonsense if it comes from computer models, because the models don't mean a darn thing. I learned early on in the containment, the computer models taught me how to think, but you should never pay any attention to a number on the page. It's the concept of what's important, et cetera. And so we used those early **[00:55:00]** computer models to teach us how to think, but we were not so stupid as to believe a number on the final page. Well, today they believe the number on the final page, but I'm smart enough to know that they do not understand how many truths are left out of the calculation, if you can see what I'm saying.

We're off the subject but not really. Because in containment, we had to outwit Mother Nature by doing an experiment that would give us a hint of how to do something in our favor instead of the way she did it, and so in containment it was vital. We had to understand myriad of things and pick out which were the important things and now how do we block against those. So every time we had a containment failure, we said, OK, we'll not do that again, because that taught us a way we could go wrong. And then we had this failure, ah, we hadn't thought of that, so we'll stop that. And so many of our containment failures will never happen again because we deliberately were smart enough now to know, we don't have to go there. So the next containment failure is going to be a surprise. It'll be something that we've not considered before.

I didn’t mean to do it but I made our HA [Hazards Assessment] guys very angry because I said, The containment surprise that’s coming is one of human error. We’ll make a human error.

And so they said, Like what?

And I said, Well, you stem the wrong hole.

Well, they were angry, that they would never stem the wrong hole. What I was saying is, there’ll be some silly human error that will creep in because you’ve never done that before and that didn’t get looked at. And I just used that as an example. And so if you continue to do underground testing, you can have new errors, new surprises, but you will learn and then say that that will never happen again. So all the while our containment was getting better and better because the new failure was a surprise and we learned from that. And you have to have those surprises, however, because Mother Nature is outthinking you, because there’s some inconvenient truth that you didn’t have in your calculation. Does that make sense?

It does make sense. Let me stop for a moment.

OK.

[00:57:42] End Track 2, Disc 1.

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

OK, I’m turned on again.

I arrived [at Los Alamos laboratory] in ’55. My division leader was Alvin Graves. I have an enormous, enormous admiration for Alvin Graves for many reasons. He was very farsighted and so he would anticipate problems before other people had come to grips with it. And I saw him functioning in that way for a long time. I always had an enormous admiration of him. And in ’56 he said, One of these days, we’re going to have to go do our tests underground because we can no longer put the radiation in fallout and around the world.

And we're going to have to learn how to do nuclear tests underground, so Brownlee, would you just look into that?

What did you think when he said that? Did you think he was right?

[I said] I don't know. Well, I don't know. I don't know anything about it underground.

[And he said] Well, we're going to have to go underground, so work on it.

So the assistant division leader was Bill Ogle, whatever his title was. Maybe he was an alternate division leader. At any rate, he was like me in the sense that he had an early history similar, was interested in everything. And so he and I would design a nuclear test and we'd put it down a hole and we'll see what happened. And the first thing we did was just put it in an open hole, and we discovered that if you set it off in the ground and then did the same thing in the bottom of a 400-foot hole, you could cut the fallout by 90 percent. Well, isn't that interesting? So the next thing we did was put a great big plug in the hole, halfway down the hole. Well, that cut it by another factor of two. And then we put the plug at the bottom, right next to the bottom, and we discovered that that was the best of all. And I know this sounds silly, we discovered you can put a piece of paper over the bomb and cut the fallout. And well, isn't that interesting? Now all we have to do is put a plug at the bottom and then fill that hole with sand and everything'll be fine. Well, we knew that wasn't true because the temperature of the bomb and the pressure of the bomb is—the temperature of the bomb is greater than the center of the sun, and it has pressures that no ground in the world can contain. So the question is, why does anything stay down? Because the pressures are too great. Well, some of them did and some didn't.

So there were a series of events and the first real tests we did, which were just our experiments, were in '57. And we had a panel that we said, here's what the next test is like.

And one of the guys on that panel said, `Well, this is the craziest experiment I've ever heard of. It looks like it's been put together by two old farmers.`

And Bill Ogle said to me, `How did he know we were farmers?`

Because he and I had grown up on a farm and it's just what two old farmers would do. We laughed because it was an attempt to learn and the only way we knew to learn was to do something.

So we had a whole series of experiments in which we learned a lot. And we had the moratorium in '58, the test moratorium, and we discovered—we had discovered in '57 that none of our weapons—I'm going to talk about weapons now, devices—are you onto the language of the laboratories? A nuclear device is not a nuclear weapon.

Yes.

OK. We discovered that the weapons in the stockpile, none of them were safe. None of them were one-point safe. And we got badly frightened. It means that any one of these can go off. Oh, what we had learned in the '56-'57-'58 time frame, I learned from—I'm **[00:05:00]** trying to say his name. He's still in Los Alamos, I think. Know him well. At any rate, I went to talk to him one day and he said, `Brownlee, you have to understand, these things want to go off. The trick is to keep them from going off, except where you want them to.` And we had tricked ourselves, the first thermonuclear was, what, eight feet in diameter, twenty feet long, eighty-five tons or something like that, sixty-nine tons, I've forgotten. [Technically, Greenhouse/George was the first to get some thermonuclear yield though Mike gets most of the credit.]

And we were under the impression that in order to get a thermonuclear, it was hard. And that was in '52. In '56 when I saw my first thermonuclear, it was about that size [indicating size].

So how big is that, would you say? Four feet by—not even.

No, it was that wide and long. It's not much different than that. At any rate, so in two years' time after Mike they'd gone from twenty feet long and seven feet in diameter to a few cubic feet. Well, what we didn't realize is that we'd honed and shaped them until they wanted to go off accidentally. All you had to do is kick one. And we found that out.

OK, the moratorium comes. What are we going to do? We've got all these up in the stockpile and we don't know that any of them are safe. So if Los Alamos came out to here to do those tests, the Russians would assume we were violating the treaty, so we just did them at Los Alamos. And so we drilled holes and put the stuff down there, just fired it. And one day all the stemming fell in. And so we said, well, of course it should. Of course. We understand how that could be. It'll fall in. And then shortly after that, it didn't fall in. Oh, why not then?

So we did those experiments at Los Alamos in '59 and '60 and '61. And that's when I started learning containment. Because we wanted to contain then, right there in town. And that was the most secret thing I ever saw.

Now let me ask you something. This is related to safety concerns of the stockpile, these tests that you were doing?

Yes.

Whatever you were doing was mimicking in some way something that might happen to a stockpile weapon?

Right. We were trying to figure out how to make the stockpile thing safe. If a guy went by with a .22 and shot it, it didn't mean it'd go full yield. It just meant you'd clobber everything with radiation.

If you shot the weapon itself?

Yes, it'll just go off. So how do we make them? And since 1957, half of all the money we spent out here has been to keep things from going off.

Really!

Yeah. They're easy. They want to go off. That's the lesson you learned: They want to go off. That's the reason why I believe that the next incident will be an accident where terrorists get their hands on a weapon and it goes off in their cellar because they're not smart enough to know that they want to go off. My guess is the next atmospheric nuclear thing will be an accident by people who don't know better. It takes a wealthy nation to make sure they won't go off. What happens is you have this curve, here's the probability, what we want is flat here, peak here [diagramming curve]. We don't want a bell-shaped curve. We were willing to reduce the probability that anything will happen in order to police it, but that took enormous skill and money. And the average country, I wouldn't expect Pakistan or India to spend any money doing that.

So let me understand this a little better just in layperson's terms. You're doing experiments of some size. What size are the experiments you're doing at Los Alamos?

We started out with tons. We did twenty tons and ten tons and two tons and things like that. [The experiments in Los Alamos never were to have a nuclear yield, just to find out how NOT to trigger them. The reference to tons is commenting done in Nevada.]

But they are nuclear reactions that are happening.

Yes, and then very quickly we were doing a few kilotons.

And this is because?

We started out just to reduce the fallout. Now we were doing underground tests at the same time we were doing atmospheric tests because when we went back to testing, we were doing tests in the atmosphere. But I was still very interested in all the underground tests because I was trying to make sure that we kept it in [bounds]. Interestingly enough, the radiation at the test site was large enough, high enough that we'd have a shot and we **[00:10:00]** didn't know whether there was any radiation coming from that or not because the background radiation was larger than what was coming out, if it was coming out.

Of the underground tests. Yes.

And so sometimes we did the test and we didn't know whether it leaked or not because if it leaked it was less than the atmosphere was. So we were doing both tests at the same time: underground tests, trying to contain, while we were doing atmospheric tests. Because we were getting ready for the time when we're just going to do underground tests.

So let me understand a little better this connection between making sure the stockpile is not going off accidentally and containment. So it's sort of like you're not trying to contain a reaction in the weapon; you're trying to actually prevent it from occurring.

Yes. You were trying to learn how to not have a nuclear explosion, just have the HE go off. But suppose you did get a little bit of the nuclear explosion, you don't want that coming out. So they're connected. You have different motives but for this test, suppose we get a little nuclear yield. Well, we don't want that coming out on the wives and children who are living right over there [in Los Alamos].

Incidentally, I'm going to change the subject. The guys at Livermore were doing the same kind of things we were. As I understand it, the only statistical significant thing we had at Los Alamos that was significant was thyroid cancer. A number of people at Los Alamos had thyroid cancer, including my own son, who asked me, `Dad, did you do this?` And I don't know. Livermore, doing the same things, had melanoma. To my knowledge there isn't anybody that can explain why Livermore specialized in one kind of problem and we specialized in another. We lived in a different environment at different altitudes. They were at sea level, roughly; we were at six thousand feet, seven thousand feet. Because we were at high altitude, we should've had more skin cancers than we had. But we had thyroid cancers. I have no idea. And the problem is, the number of cases were too few to draw conclusions. The truth is, no matter what you hear, the truth is, the number of people radiated are so few that we haven't been able to trace. And also I said no two brains are wired the same. No two bodies are wired the same either. So you and I can have the same exposure and you'll be affected and I will not. I got a lot of exposure on one event in the Pacific, and all of us who were exposed to that—I don't know, got killed in automobile accidents and died of old age and things. I don't know any of us—and yet there are people who've had trivial, utterly trivial amounts who sue the government claiming it's obvious that we caused it. I don't know that.

And then my own son, he gets thyroid cancer, and was it because he lived in Los Alamos? Well, maybe. I don't know. Because there's not enough data. You can't prove or disprove anything. And people think, oh, and the same thing is true of Hiroshima and Nagasaki. You see when they celebrate, after all these years they celebrate Hiroshima and Nagasaki, and they get the people out who've been exposed? How come any of those guys are alive? Wait a minute. Doesn't that prove that all that radiation doesn't necessarily kill you when you're young? There they are. Just like me. And too few—they are too few.

Yes. Which test was it that had the exposure in the Pacific that you mentioned, or what year was it, do you recall?

It's the last one. It was awesome. It was Tewa, done on the twentieth of July of '56.

So it was part of Redwing still.

Part of Redwing. Five megatons. And I was on Enewetak and it was in Bikini two **[00:15:00]** hundred miles away. We went out, saw the sun rise. The distance was such that the fireball size, when it came up over the horizon, was about the size of the sun, so it was as bright as the sun, so it looked like the sun rising. And we were two hundred miles away and we watched, it went up, and then part of the cloud, it was this way, we were looking there, part of the cloud goes off to the north like it was supposed to be and part of the cloud just didn't change azimuth, it comes right straight at us. And it arrived, and I don't remember how long afterwards, we watched it, and then the fallout was like dirty snow, it was foamed coral; I don't know, we had fractions of inch of the foamed coral over us. It would rain and the radiation levels would go up and it would rain and the radiation levels would go down; we were in a metal building, and we had Geiger counters but none at high levels because we were two hundred miles away. And we would walk to the wall and it'd go off scale, and we'd hold it up over our heads and it'd go off scale and over here it'd go off scale. So we all wound up on the floor in the middle of the building and I stayed there until the next day. And I don't know. At any rate, we got eight years' worth or something in that one, and we were a couple of hundred miles away. And they said, Well, we don't have time to come and get you right now, and the reason for it was our last shot was the next morning at Enewetak, so we didn't leave until we did that shot [Huron]. That was the end of the operation.

So I've never had any, other than just being stupid, I've never noticed any effects. But I think it's changed. I think it's in the genes. You can argue with me about that but—

I'm not going to argue. I'm going to—when we talk later, it's reminding me of one of the—someone who worked on exposure said to me something similar to that, which is it's an individual sensitivity and it's very difficult to prove who that person is.

Yes. And there've been too few people exposed to the same thing to believe the data.

But in your own case, how old was your son when he got the cancer and what was—

He was twenty—oh, that was in '56 and he was conceived in '58. He was born in '59. And so that came after that exposure that I had. But is there cause and effect? Nobody knows. It could be. I wouldn't say it isn't, but there's no real capability of saying it is.

Right. So the possibility in his mind and your mind—I'm asking, I'm saying this as a statement but it's really a question—it's not what you guys were doing in Los Alamos; it's a possible genetic thing from the Pacific?

Perhaps, yes. I have to just tell you a story. He was a paramedic in Oklahoma City when he had the thyroid cancer. And we went and the doctor said, I think it's too late. I don't believe that I can save him. The tumor he has, I cut it open and it's totally black on the inside, and any tumor that's black, I lose them. But the only hope is to give him as much radiation as I can possibly give him. And I don't dare give him more than that because then that'll kill him, but I don't dare give him any less than that because he's going to die anyway. So that was the bleak word. So I sat with him and my wife and my older son, and we were sitting in the room, and my older son says, Chip, you know if Dad could have this in your place, he would have it four or five times over rather than have you have it. And that's the lowest I've ever been in my life, I think. I had tears. And Wayne says, Chip, if I could have this in your place, I would have it. Wayne says, And Chip, if you could have this in our place, you would have it. Thanks for having it.

[00:20:00] And we all laughed. The family laughed. It was just what we needed to pull us up out of that terrible mood. I get tears when I think about it. But what I'm telling you is that's what our family is like, because in this terrible time, Wayne tried to make us laugh. And I never was that low again. But it tells you something about the tribe, but I'm reminded because when I think of that, what do I remember? Thanks for having it. Totally unexpected thing.

Now I have to ask what happened to your son?

He's doing fine. He takes medicine for it all the time, but he's survived splendidly, and what is he—he's forty-eight now or something. He's forty-seven. So he's done fine. He was in his late twenties when he had it. But whether it's related to me or not, I have no idea. But it is peculiar because Los Alamos had a significantly higher amount of thyroid cancers than the control groups. But we don't know why.

And that raises a question about the Livermore and the skin cancers because again it's a question of where one might imagine, if there were to be a correlation, where exactly it is: the kinds of work, where the work was.

It's just a mystery. If it occurred out here [Nevada Test Site], well, Livermore—we came here, so we share that in common.

That's what I'm saying, yes.

But, on the other hand, maybe it was the radiation levels in Los Alamos are quite a bit different than Livermore because, first of all, the natural radiation is different, and then we had a lot of stuff right on site that they didn't have at Livermore. And so it's too complex to sort out. But we had similar work. We didn't have similar cancers. Isn't that interesting? I don't know.

It is interesting. It's a question. But it seems that there—I guess, again I'm asking, do you think that one can draw general conclusions that some people are affected in some ways by this excess radiation?

Yes, I think you can. There isn't any doubt about some people are more sensitive, I think. For example, Al Graves. Just as I go to say names—this is old age—I go to say a name and it won't come. The guy at Los Alamos who was killed by radiation because he had two pieces of [beryllium]—

Well, there's Louis Slotin.

At any rate, his screwdriver slipped and he got a—.

Al Graves was standing right behind him, and he died but Al survived. And we had—oh, let me—here now is my spin, my prejudice. Every new industry, it takes a while to develop the safety rules to keep people from dying. So when they first did solar panels, the number of people who died in the manufacture of solar panels started right where all other industries start, and in a few years they got it down. But I use solar panels as energy as opposed to nuclear. Nuclear never did have that curve. It was always down here. The number of people killed by nuclear in the labs was trivial: four, five people, six, seven people. Nothing compared to every other industry in the world. Why was that? One of the reasons was Al Graves. In World War II, all military people—it was a way of life—you sacrificed as many men as necessary to achieve the military objective, including everybody. When those first atom bombs went off, Al Graves in the Test Division said, `Nothing we do is worth the life of one of my men.` There were no women then. `Nothing we do is worth the life of one of my men.` And in an age where everybody was sacrificing people, Los Alamos refused to sacrifice people. He said, `If it looks like we might kill somebody,` [snaps fingers] `let me know and we'll stop it until we revise the plan.` And that's when the military want these tests tomorrow. And he says, `No, it won't go tomorrow if there's a question raised.`

[00:25:00] I was on the committee that sat under his armpit to hear what was going on and to bring to him word different from the military chain of command. And if NASA [National Aeronautics and Space Administration] had had that same policy, they never would've lost the *Challenger*. But that's due to one man who said, `In this business, nothing we do is` `worth the life of one man.` Now that's not a military—it's an anti-military thing. OK. So Los Alamos, we had industrial accidents, a guy would get killed with electrocuting himself, but the guys killed by radiation are just a handful. And no other industry can come anywhere close to that.

It reminds me of when I—I had a chance to talk to Duane Sewell a couple of years ago and he expressed similar kinds of—

Is Duane still alive?

I think he's still alive. He was not at all well when I spoke to him.

Last time I heard, he was in bad shape.

Yes. But he talked to me about safety, and how he was so scared of accidents and the kinds of things he tried to train his guys to avoid, so it's reminding me something of that. But is that a separate question from the fallout question? The industrial safety question is a separate question from fallout, from actual explosions.

Yes. It's a different question. Al had the authority to put that into effect where he was. He didn't have the authority to do other things. But he says, `Nothing we do is worth the lives of one of my men.` And that meant if any of us saw a hazard, [snaps fingers] you could stop things like that. And other organizations didn't have the power to do that.

I wonder if also—it's a question that's raised; I wonder what you think—if it also had to do with the newness of the work, that it hasn't become a bureaucracy yet, so you were trying to figure out—?

That's right. That's precisely correct. And when Al says that eventually we're going to have to go underground, he was looking ahead and saying we can't do that. We can't have that fallout. So all of a sudden it became very personal. And how he chose me, I don't quite know. First of all, there weren't very many of us. But I was young, and he just said, Go find out how to do this. And I have no idea how much money we spent to do that. Huge sums.

Now it's six o'clock but I do want to ask you a few more questions before it gets too late.

I haven't really told you about containment at all.

I know, but that's where I'm going to ask you some and then, maybe I'll have to follow up on the phone or something. But at this point Livermore exists, so is Livermore doing similar things?

Yes and no. During the moratorium, they had come to the conclusion that the future was in peaceful uses of nuclear energy. Los Alamos never did that. Los Alamos said no, our responsibility is the stockpile. And so Livermore started doing tests with a different flavor than we.

Gary Higgins at Livermore had the same kind of role that I did. He at Livermore was looking at things something in the way I did at Los Alamos. And the two labs, anything you want to say about the two labs is true and false at the same time. There were people in the two labs who hated each other and would not have anything to do with each other. There were people in the two labs who would cooperate and share. Gary Higgins and I found each other. I don't know when, but maybe in '61. Maybe in '58. And I would go up there [to the test site] to see Livermore things in the tunnels, so I started learning from them, and I was sharing what was going on with us. And Gary Higgins and I, he finally devolved into being kind of the guy responsible for containment in Livermore, and I was the guy in Los Alamos.

And the difference between the labs is rather striking. At Los Alamos, on a couple of occasions I said, I don't think we ought to do this test. And my bosses accepted my opinion and we didn't do the test. In Livermore, the guys who had the same responsibility I did, on occasion said, I don't think we should do this test, and Livermore went ahead and did them anyway. So I had more authority—that's the wrong word. I didn't have any authority. My bosses took my word for it. And Livermore bosses **[00:30:00]** did not always take the word of their experts in it: `For political reasons, we have to get this test off next week and we're not going to postpone it.` But my bosses, thanks to the pattern of behavior set by Al Graves, `if Brownlee thinks it shouldn't be fired, we just won't fire it until changes have been made.`

Right. Now another question I had about this, it sounds like some of the tests that you did when you're figuring out containment are specifically to figure out containment.

Yes.

And then there must've been other tests that were being asked of you to do that you had to contain, is that correct?

That's correct. Yes. The people who tested in the atmosphere, all their diagnostics were looking optically, detectors and so on, and seeing is believing. So when we first talked about going underground, there was weeping and moaning and whining and carrying-on. And so the first underground test, they wanted to look in and see them, and so my containment problems were, the guys wanted to look down the hole and see the thing go off and then close the hole, then contain.

See with photographic equipment.

Yes. Because that's what they had done in the atmosphere. But after we'd been testing underground for a decade, I was alternate division leader, and one day I said, `OK, suppose now we, in the next few months, decide we need to do a test in the atmosphere.` The same guys, ten years earlier, who wept and moaned and wrang their hands and carried on, they did this again. They said, `We can't go into the atmosphere. We won't be able to get the data.` Because underground we had all of that shielding. And so they learned to get everything we wanted better underground than in the atmosphere. It just tickled me. I enjoyed asking the question to see them throw their arms in the air, because I remembered, whether they did or not, that they did the same weeping and moaning we just talked about. So people, scientists included, want to do what they've been doing, and when you ask them to make a change, they are against it. And so forcing the system of experimenters to make those changes was always tough.

And Baneberry happened in '70 and we had enemies in the AEC [U.S. Atomic Energy Commission] who were very jealous about all of the money that went to the nuclear tests. And we lost half a year of testing, and so from that time on they halved our program: `You can have only half as many tests.` They won. No, they didn't. Because if we only have half as many test, we'll do twice as much on each test. So tests went from frequent tests, fairly easily accomplished, to few tests, enormously difficult to accomplish, because we put everything on one test. I shouldn't say "everything" but you know what I mean. And so at no time, scientist or taxpayer or politician, do people not be human. We're human beings.

Oh, I was going to amuse you by telling you when I said no two brains are wired the same. When you see a thermonuclear bomb, every brain has exactly the same conclusion, comes to exactly the same conclusion when he sees his first thermonuclear bomb.

Which is what?

Some idiot has miscalculated and we're standing too close. And what I'm saying is, the human reaction is to blame somebody else because you think you've been set afire, you think your clothes are going to go in flame, that's what the sensors tell your brain: I'm going to flash into flame. And everybody blames somebody. The first thought that comes to your mind is, some idiot is responsible for putting me here. And I say, well, **[00:35:00]** in times of crisis, human nature wins: Put the blame somewhere else. And to me that's a very enjoyable conclusion. We are built in such a way that we want to avoid personal responsibility in times of great surprise. It's somebody else's fault. And I find that amusing.

But you also raise an interesting point which is an obvious one but human beings in general have not ever been exposed to anything like that ever, so—

Yeah. Well, let me tell you about that. When the brightness of an object—say they're all the same size—goes as a fourth power of the temperature, so if the sun was twice as hot, it would be sixteen times as bright. OK, the sun is only 3,000 degrees. A thermonuclear—well, a nuclear explosion is a million degrees. So let's say it's 300 times brighter than the sun, if it's the same size. Well, when the bomb first goes off, it's, let's say, the sun's half a degree, so I can be at some distance where the bomb goes off, so it's half a degree, the sun. OK, if it's 300 times brighter than the sun, it's eighty-one billion times, 8.1 billion times brighter. The atmosphere won't let through that much light. It becomes opaque. So when the light first starts up that light curve and it gets brighter, and then it goes dim, because the atmosphere won't let the light through. But meanwhile, the thing is expanding and cooling, so when it gets enough for the light to come through the atmosphere and gets bright again, it's a million times brighter than the sun, eight billion times. At any rate, the goggles we wore cut the light by a factor of a million. That's what we needed because that's all the atmosphere would let through. So you watch with your goggles. It's a million times brighter than the sun. And so your eyes, you can see it. Now it fades from view because it—and you rip off the glasses. Well, it's still enormously brighter than the sun, and so you can still take—so they say, `Don't take your glasses off too soon.` Well, people quit seeing and they take off their glasses, and they take it off too soon. So what you do is take it off looking this way instead of that way. OK, but when that light is a million times brighter than the sun, it shines on your clothes and your skin, and that sends a signal to the brain which says, whoa! Because it's never had that before, and your thought is, I'm going to flash into flame. That's the thought that occurs to you, and it's somebody's fault, which is the fun part. But what I'm saying is, we've all had that experience of suddenly your skin—well, say your clothes are exposed. What happens is it drives the moisture off and your clothes are always damp, and so if you take a video picture of a guy standing there, the flash of light comes and he smokes. All of his clothing is smoking because—I shouldn't say "all." The part exposed to the light is smoking. That's a pre-ignition—and your skin tells you [snaps fingers], your brain tells you, I'm done. And well, that's a fun experience to have because you learn a lot from it.

But you also said earlier that it made you a peacenik.

The thermonuclear did. Yes. A fission bomb is still many times brighter than the sun. Yeah. But that's what the atmosphere lets through. That's what you see. Now—well, I don't know the classification of that. I'm going to let that go.

All right. Good enough. Yeah, well, there's so much to talk about but let's do this—

Let me see if I can give you a quick summary.

But I have one question, though, before you summarize, and maybe you can incorporate it. Because there were these ventings, these unexpected releases—Eagle, Pike, then **[00:40:00]**

Baneberry you've already mentioned; there are others, right? But if you can, in your summary, giving me some kind of understanding of—without going into classified things—what kinds of things are missing or what is it that happens that you didn't expect when these kinds of things happened?

Well, Pike was ours [Los Alamos], and at that time I knew what Pike was; I knew how deep it was supposed to be and how deep it was and what the yield was supposed to be, and the yield was supposed to be 850 ton. It was 400 feet deep. And I thought that's probably all right. It's less than a kiloton; it's probably going to be all right. But I could've said no, but I didn't. It was in '64. And unbeknownst to me, because I didn't ask, Don Westerfeld had a pipe looking at x-rays, but it didn't come to the surface; it just came partway. I didn't know he had a pipe with—looking at the x-rays to come up partway. I just didn't ask. I didn't know about that. And when that pipe came up to a level—a layer in the soil which was hourglass sand, and when the guys drilled the hole, sand kept dripping in from that layer, just little streams of sand like an hourglass, just kept pouring in—and they walled it off. And that pipe ended right at that level of sand, so the x-rays came up, all that energy came up, and went through the sand of zero strength. It had no strength. It was zero strength. And the energy came out and did this [gesturing], and then—

Went horizontal?.

Yes, and then it's so close to the surface, the surface cracks and it comes up in a big, long line. And it took a minute to do that. And Al Graves was the scientific advisor. I became scientific advisor later, but I learned a lot in those early years. So he comes back to me and I said, `Well, I didn't know it had a pipe on it.` [And he said], `Well, from now on, you will know everything about every shot, because if it's got a pipe on it, you need to know, Brownlee, because I'm counting on you.` OK, so I got my marching orders. And that moment we had to coordinate. But I also had to talk to the drillers because they didn't tell any of us at the lab that they had a layer of hourglass sand. And from that moment on, we had to make sure that we understood what the data were when they drilled that hole. And then, instead of it going 850 tons, it went 1.15 kilotons, so it had substantially bigger yield than I knew about. So from that moment on, I had to go to the bomb designers and we had to set a yield such that it cannot be higher than that yield. OK? So Pike was when we put our act together. From now on, Brownlee, you'll know every detail about every shot before we fire it, and then you tell me if it's safe to fire. Never mind that I'm standing there as an astrophysicist, having to learn geology, having to learn everything else. But the challenge was great: Make those things stand. Well, that was Pike.

Eagle you mentioned. Eagle was a line-of-sight to the surface, and I knew the guy who designed it because we were talking prior to the shot, and he had, in this line-of-sight pipe all the way to the surface, he had four baffles. There was a big baffle here and here and here and here. And we'd learned by putting in a baffle, you can see through the center, but when they—every one of those baffles, it loses an awful lot of energy. And our guys, Los Alamos guys, went out to watch them put this in the hole. The guys in Livermore, the guys [who] lived in Las Vegas were Livermore people but they never worked at Livermore; they worked here, lived in Las Vegas and worked there. The guys in Livermore said this is how it's to be, but they weren't the same people. In Los Alamos **[00:45:00]** we were the same people. The guys who designed it came out here and put it [down and said], Yeah, OK. So our guys said, We saw them put it down, and they put all the baffles together right on the bottom.

Oh, they weren't separated.

They weren't separated. They were all right on the bottom. So what they did was hold the pipe open. Great big baffles, so they had a big cylinder with a hole in the middle at the bottom. OK, the energy that came up immediately blew the whole surface away, but there was no radiation in it at all. That first explosion was just pure energy, no radiation. And then here came the radiation in the form of steam, and that started coming out of the pipe and that was heavily radioactive, and that continued until it collapsed, when it shut it off. And so what we learned there was what we had—oh, and Livermore never admitted this. They denied. They said no, it was built just like it said. My guys told me, no, it was not. All the baffles were in the bottom. So Livermore does not agree with what I've told you but I believe my guys. And so I think all those plugs were on the bottom and that just held it open. OK, so this confirmed to us that we had to have the same guys [from the laboratory]. For example, I'll give you another example. I left a get-lost hole in one, which it was underneath the bomb and I wanted to make sure that radiation went down and got away.

"Get-lost hole?"

Yes, it was just a hole underneath—here's the pipe and there's a big like a washer that with a big hole in it underneath, and I wanted that hole left so that the radiation could get away from the bomb. I went out when they were putting the thing down hole. Well, the last thing one of the guys did was take all the extra cable and coil it up and put it in that hole. Wait! That has to be an empty hole. [They say], `Oh, we didn't know that`. OK. So you have to have that kind of attention to detail, and that requires somebody from the lab being there when they put it down, or the guys understanding that no, we have to have that hole here. You've got to tell them there, that hole is for a purpose.

So we learned from all those kinds of things. And so we kept getting smarter and smarter about what the other guy was doing. And then there's a fact about containment that is overwhelming. The way radiation comes to the surface is through the cables, and it's not until you finally gas-block the entire cable at enormous cost that you can stop that. But in the early years, a little radiation out, the background radiation at the test site was such that it didn't matter. Well, the experimenters got in the habit of saying, Oh well, it's only going to be a few mR [milliroentgen] out of the cable. But Al Graves said in 1963, not—well, I was complaining about the treaty because the treaty was different in Russian and in English. The Russians were allowed to have bad—they kept bad atoms from getting out, but they defined what was bad, and our version was not to let them out. And so I'm complaining bitterly about this and Al Graves said, Look, not one atom out. That's the way we're going to do it. Forget the Russians. That's the way we're going to do it: Not one atom out. Well, "not one atom out" meant that you had to gas-block those cables, and it took Livermore a long time to finally gas-block their cables. We were shouting at them all the time, You've got to do a better job of gas-blocking the cables! Because they had a lot of leaks. And so the truth is, suppose North Korea does a nuclear test. They will not gas-block their cables, and so you'll be able to sample their test. And I suspect that holds for Pakistan and India and everybody else, because third-world countries simply don't understand the incredible cost of achieving complete containment. The cost is not just money. It's time and manpower and brains, and most countries aren't interested in that, and we were only interested in that because a few people insisted on it. We were ahead of the country. We were trying to do the job right before the political pressure, because that started—we had years of testing in the atmosphere when we were trying to learn how to test underground.

Now, let me give you a quick summary. The moratorium, we did tests at Los **[00:50:00]** Alamos where I was learning a lot, and those data came from the coal mines in Great Britain. One man, Bob Newman at Los Alamos got into all those and started teaching us what the Brits knew about coal mines collapsing. And I finally got right into that and started learning. Then we went back to testing and the only tests we were prepared to do were one-points, which is not what the President of the United States wanted; they wanted us to do a big test like the Russians were doing. We had no capacity to do that because we were not ready in any sense.

"One-points" being one—?

One point—you fire the HE just at one point and see if you get a nuclear. And so it's a one-point safe, it's called. So if I fire a gun at it, it goes at one point in the HE but it won't go nuclear.

Now the Russians just announced to us, We're going to start testing tomorrow, and up until November—that was September 1st [1961], so October to sometime in November, they did fifty-some tests in the atmosphere.

Huge number of tests, I know.

Yes. And the biggest was 58 megaton. And the only thing we were prepared to do was a one-point test. And so they fired September first to September fourteenth; I think Livermore fired one. We [Los Alamos] did, September fifteenth, something like that, and ours, if it was a success—I mean there was nothing to feel [because of low yield]. And this did not please anybody in Washington because we went out and did nothing. We returned to testing and you could stand on ground zero and not know it. And so we didn't go to test then until the next April or—atmospheric test. Meanwhile, the Russians had stopped and brought all the pressure on us to stop. Their test series, they planned all that time during the moratorium and did a splendid job. They had a first-rate test series. They got the lead on us. They've always known—we never did go back to do those series. We were going to do them in '64 and then we had the Limited Test Ban Treaty in '63. So we never did do those tests, and our last tests that had the opportunity to learn what the Russians did, we never had, and we've never had any since. And—country's insane. At any rate—

What country's insane?

We are. The last delivery, the missile delivery system tested, was in ’63. It’s been forty-some years, so this is Brownlee speaking. If the military was going to do a nuclear test on a delivery system, I’d go find the biggest hole I could find, because they’ve never been tested in forty years, and we have no idea how they’re going to behave until you’ve tested them. That’s me speaking. Now, I can speak with some authority because I was in charge of a number of joint tests between Los Alamos and SAC [Strategic Air Command] when we did Minuteman tests, so I know a lot of that that I’m talking about. And I recognized that the crucial tests that we needed, we never had the opportunity to do, in ’64. They had never been done. And now what they do is have committees that certify on a piece of paper that all is well. And if that doesn’t work, they’ll get another committee who will look at it and come to the same conclusion. This is a skeptical old man speaking. Trust no one, until you’ve had the experiment.

But doesn’t it also—it’s a function of how really complex all these things are.

Oh yeah. We had some tests at the test site in very late years that were vastly more complex than the shuttle launches, but they were classified, done in secret, without anybody being able to talk about it. And the nation does not know the enormous cleverness, ingenuity, and cost of some of those magnificent experiments that we did. They were magnificent things. Cost money, but they were addressing questions that were **[00:55:00]** really crucial, and they had to be done underground. But if you want to test a real missile, you can’t do that. So you can see I’m an old tester. Until you’ve tested it, I don’t know. And it’s because all truths are inconvenient and that’s why you’d leave most of them out of your computer modeling, if you understand what I’m—it’s an old man’s view. It’s not the current world view.

No, it’s not. We should stop because it’s been two-and-a-half hours and maybe we can, hopefully we could continue at some point, but let me clarify one thing. You were just talking about these *secret tests that were done later that were so complex and such amazing accomplishments. When you say they needed to be done, give me a sense, without going into anywhere you can't, what that need was. Was it a particular kind of weapon or particular kind of delivery system or—*

I have to be careful—see—[because of classified information]

Or tell me you can't answer it. Generally what does one mean when one says that they needed to be done?

In today's world, what is the technology that provides us with all of our information about the other guys? Can you answer that question?

No, I can't.

Well, think about it.

What is the technology—

It's satellites.

OK, satellites. Yes, of course.

Yeah. And so if you are doing an experiment to make sure you can see and not be blinded, then that's crucial to today's world and not to the past world. I think that's fair to say.

OK, well, the child crying in the hall is a good indication that it's dinnertime [interview took place in hotel room].

They don't belong to me [laughing].

But one last question. Can you tell me, because I hear things, can you tell me how large the largest cavity at the test site is from an underground nuclear explosion?

I can't. I should be able to answer that question but I've just forgotten.

But I mean what scale are we talking about? Can you give me that sense?

The largest one we did, I think, was Bilby, in the flats, and the Bilby crater, you can go look at it.

We went down into Bilby. They drove us down that thing.

But you may notice, if you are careful, the road comes in and you go down a very gradual little bit and then come to the crater. Did you notice that way out you start in a tiny little—there's a tiny little slope down—?

I don't know. I'll have to look next time.

You didn't notice that. Will you go again?

Yes, I'll go again.

OK, there's the crater but look, there's a dish and the crater is in the center of it, but there's a dish shape, because the ground shock compacted that alluvium, and so the initial ground shock had a dish shape, a concave dish shape, in the valley floor, and then later the cavity came. That dish shape is the size of the cavity.

OK. So I'll get a sense of that scale.

And it's big.

Yes, it's big. I'll pay more attention next time we go.

And I was there on that event and I was responsible for getting the hydrodynamic yield. We had a trailer, and as soon as they allowed me back in I drove my car and spent a couple of hours in the trailer to get the number for the yield. And when I came out my car had settled into the dirt to the frame, because the dirt had been fluffed with the shock, and I drove in and the car settled low. It was hopelessly stuck. I mean all four wheels into the frame. And they brought a big crane in and lifted me out. One of those huge cranes, it came and lifted my car out and I drove away. But that big—in spite of the ground being fluffed where I was parking, the fact is it was fluffed but it was inside that dish shape. So **[01:00:00]** when you go out there, find the dish and then you measure it and that's the answer to your question.

I will do that. We'll see how close I can get my tape measure out. Well, thank you. We should stop and I will—

Well, I'm glad to do this. I still haven't given you the real story on containment.

I know you haven't but we've begun—

Let me give it to you shortly. In 1961 when we went back to testing, Al Graves said, You know, it'd be a good idea if we met with Livermore about each one of their shots just to see what they're doing, so we know. And we'll tell them what we're doing and they can tell us what we're doing. OK, so Al and I went and met with a guy who later became director of Livermore—I'll say his name in a minute—John Nuckolls. At any rate, those two and we two sat and talked. And then two or three weeks later, we had another opportunity two weeks later, and somebody said, You know, this'd be good to do on a regular basis. Let's just plan on meeting. And the Test Evaluation Panel [TEP] was created; we discussed the tests and shared information. And then after Baneberry they said all the emphasis has to be on containment, so the Test Evaluation Panel, the TEP, became the CEP [Containment Evaluation Panel]. And so I was at the first meeting of the TEP before there was ever a piece of paper. And so I was there for the first CEP meeting and all that sort of thing. So I've been associated with the TEP and the CEP ever since 1963. So I missed a few later on when I was a division leader. There were some I missed, but since then, I'm still chairman of the CEP, and so I've been fastened and fascinated by containment on a basis since '63.

What do you mean by that basis?

If something went wrong, it was my fault.

Oh, so now it's your head. OK.

And Bill Ogle told me that it was a delight to have me because he wanted it fixed so that he could fire me after every failure, and then he'd hire me back the next Monday. But the system, anytime you had a failure, Washington wanted to have somebody pay for it, and he thought it'd be a great pleasure to fire me after one of those events. I laughed because I knew he could do it.

It's an amazing stretch of time, over forty years.

Yeah, and all that while I've been concerned about containment, and the intricacies of it, and the question is, can I outwit Mother Nature because she can outthink me? And I got to learn how to do that. But that's a wonderful challenge. So I think that's the summary of containment. You try to outwit her. And it's just an intellectual challenge. It has very little to do, from that perspective, of why somebody wants to do a test. If they're going to do it, let's contain it. If we're going to contain it, how do we do that? What do we have to know about the geology? What do we have to know about the other lab? Because every containment [failure] that Livermore had, I paid a price. Every containment failure. I had to do something different because of those dunderheads. So I needed to know what they were doing, because I also had to outwit them or help them outwit Nature. And so Gary Higgins and I built a pretty good bond, and that continued with others, so the containment people tend to work together because we needed to know what the other lab was doing. And that was fun. You got to meet them and find out what was going on. And you were always learning. Always learning. That's wonderful. So I could look at containment strictly as a scientific challenge and it's great sport. I can look at containment as an activity that required money, and that's not nice at all because it required lots of money. "Not one atom out" was a terrible charge. I mean that's tough. Nobody's smart enough for that. What I'm telling you is if I look, I can find one atom. If I know how to look, I'll find one.

Yeah, that's a whole other question, finding those atoms.

There's another thing I've got to say to you. No, I don't have to say it but when I say it I **[01:05:00]** hope you'll just be amused. If they give me enough money, I can do an experiment that will blow their hats off, which means they don't dare give me that money. But I'm smart enough to ask for the money for another reason, and then blow their hats off, because the guys who are doing some of these experiments are so clever that the experiment they're really doing may be different than what's down on paper. And so you need to not just know what the other lab is doing; you need to know how some of those guys think, and that's true of your own lab, and so you've got to understand people's brains. I'm speaking now as perhaps a division leader. I trust that guy, but I'm clever enough to know that he's clever enough that I'm going to have to watch him. Now, I've been told that Edward Teller had a jillion ideas a month, but you had to have somebody with him who was really bright to pick out the good ones.

Yes, I've heard that, similar things.

And one of the delights about the laboratories is you meet guys who are bright and clever, and you want to be careful about giving them the money they say they need. Does that make sense?

It does. OK, I think we'll leave it there, though.

OK.

[01:06:53] End Track 2, Disc 2.

[End of interview]