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Committee on International Security and Arms Control

60th Anniversary of Trinity:

First Manmade Nuclear Explosion, July 16, 1945

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CASET Associates, Ltd.
10201 Lee Highway, Suite 180
Fairfax, VA 22030
(703) 352-0091

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PROCEEDINGS 8:45 AM

DR. JEANLOZ: My name is Raymond Jeanloz, and I am the Chair of the Committee on International Security and Arms Control that organized this morning's symposium, recognizing the 60th anniversary of Trinity, the first manmade nuclear explosion.

I will be the moderator for today's event, and primarily will try to stay out of the way because we have many truly distinguished and notable speakers. In order to allow them the maximum amount of time, I will only give brief introductions and ask that you please turn to the biographical information that has been provided to you.

To start with, it is my special honor to introduce Ralph Cicerone, the President of the National Academy of Sciences, who will open our meeting with introductory remarks. He is a distinguished researcher and scientific leader, recently serving as Chancellor of the University of California at Irvine, and his work in the area of climate change and pollution has had an important impact on policy. Dr. Cicerone.

AGENDA ITEM: WELCOME: Ralph Cicerone, President, NAS

DR. CICERONE: Thank you, Raymond and good morning. I want to make a personal comment first, Because of the quirks of the calendar this is my first full week on the job as President of the National Academy of Sciences, and as luck would have it this is the first official meeting here in the Auditorium where I have the honor of giving a welcome. So, it is a special pleasure for me to be here to welcome you.

I want to say thanks, also, to the Ploughshares Fund and the National Nuclear Security Administration for helping CISAC, the group which Raymond chairs

for sponsoring this meeting and for making it possible

Over the years CISAC under the leadership of Pief Panofsky and later John Holdren has had what have come to be called sunrise meetings on a Sunday morning of the annual meetings of the National Academy of Sciences and on many Sunday mornings I got up early enough to come and listen to those discussions on nuclear energy, nuclear weapons and many related topics over the years, and I found them to be very, very enlightening.

It is a special honor today, also, to welcome Trinity veterans and some members of the Trinity family for this retrospective and perhaps some new perspectives on that day 60 years ago when the Trinity veterans detonated the so-called "gadget" of which there are some fantastic photographs outside and to hear some other presentations today on a lot of other events of the last 60 years and where we are now.

It is always appropriate to reflect on that particular event and related events for all of the forces both physical and geopolitical that it unleashed to contemplate on the balance of positive versus negative outcomes and future prospects.

So, I look forward to the discussion today. I suppose there are a lot of things that are unexpected in my new job and one of them is there is an unusual amount of activity this morning involving the Academy on the Hill, and I have to leave fairly soon, but I am going to stay as long as I can because this is a distinguished group of speakers with a very interesting audience, many of whom have not only supplementary but completely independent perspectives on the matters that will be discussed today.

The past leadership of CISAC is here. John Holdren will be here in a few minutes. So, it is a great cast and I once again welcome you to the National Academy of

Sciences and I look forward to the discussion this morning and to hear about some of the follow-up afterwards. Thank you. Raymond, thank you.

AGENDA ITEM: INTRODUCTION: Raymond Jeanloz, Chair, CISAC

DR. JEANLOZ: Very good. I have just a few introductory words myself, but first of all by way of logistics let me point out that we will have the opportunity for questions. We have microphones in the aisle, and for the next presentations we will ask that you wait until we have heard both speakers before asking questions.

I would like to start off by highlighting the fact that this morning features a panel of distinguished veterans from the Trinity event. These are exceptional colleagues, and their other contributions by themselves might well be celebrated quite as easily today: for example, the Nobel prize, former Presidential Science Adviser, former National Laboratory Directors, and so forth.

But what we are celebrating today is the anniversary in two days of the event 60 years ago when our species created a nuclear explosion for the first time. This is not only of great historical interest, but it is also a very contemporary topic.

The issue of the Trinity event and the Manhattan Project have come to insert themselves into our national dialogue as recently as in the February 24, joint statement by Presidents Bush and Putin identifying one of the greatest threats our two countries face as being nuclear terrorism. Indeed the bright flash of the Trinity event is something we hope not to see here or elsewhere around the world.

Nuclear terrorism and nuclear proliferation are very much in the headlines these days, and represent one of two ways in which today's symposium, looking back

historically to the event of 60 years ago, is also looking at the present state of affairs and the future of the nation.

For the second connection between Trinity and current events, I want to turn to another statement that was made just a few months ago. This was when General Cartwright, Commander of US Strategic Command, in testifying to the Senate Armed Services Committee closed his comments with a call for a national dialogue on nuclear weapons. Why do we have a nuclear arsenal? What is its future role in the defense of the country, and the security of the world?

It is in the light of such calls for a national dialogue that our program is very relevant to the present state of affairs.

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DR. JEANLOZ: We would like to ask the veterans to please come up and take their places at the table. While they are coming up here, I will make the passing comment that we all understand there may be differences of views. There are differences of views as to implementation that all of us in this room, from the veterans to the youngest, passionately share. The one concept that we are deeply worried about is the safety and security of our nation and the world, and we are talking about different ways of implementing that safer, more secure world.

We now come to the main event of this morning's agenda, and to start the panel discussion with our veterans we will first have a presentation by Wolfgang "Pief" Panofsky. He is, quite frankly, the source of energy that made this event happen, along with the members of CISAC and its staff.

Many volumes have been written by and about the men sitting on the stage

before you. They created history 60 years ago, and of course have continued to create history in their own fields since then.

Chairing this session, Pief Panofsky will start off with a brief presentation. He is a long-time member of the Committee on International Security and Arms Control, and indeed he is a previous Chair of the Committee and he currently chairs our group of Senior Advisers. Professor at Stanford University, Director Emeritus of the Stanford Linear Accelerator Center, I give you Dr. Pief Panofsky.

AGENDA ITEM: Roundtable discussion by Trinity veterans

Introduction: Wolfgang Panofsky, Chair

DR. PANOFSKY: Thank you very much. Scientists who worked on the development of nuclear weapons are often asked whether they have had qualms about their work because of the unprecedented power of nuclear weapons.

The people you see here were in their early twenties at the time of Trinity. They were working hard and schedules were extremely tight. They were motivated to counter the expansion of Nazism and Fascism in Europe and to respond to the Japanese attack on Pearl Harbor. People on both sides of the conflict at that time were dying by the hundreds of thousands. Under these circumstances not many of the participants in Trinity entertained profound thoughts on the basic revolution in military affairs which the advent of nuclear weapons generated.

Indeed many senior individuals directing the work on the bomb had divergent responses to the vexing questions which were facing them. Should there be a demonstration of the nuclear weapons before actual military use against Japan? Is one

weapon enough to end the war or should two be detonated? The answers to these questions are still debated today but in this session I suggest that we should accept history as it is and focus on the future.

The frame of mind of most young people on Los Alamos is well represented in the words of Richard Feynman when he was celebrating the successful Trinity explosion. "You see what happened to me, what happened to the rest of us. We started on the thing for a good reason and then you work very hard to accomplish something and it is a pleasure and it's excitement and you stop thinking. You know, you just stop." That is Richard Feynman.

My participation in military problems was at the California Institute of Technology on improving the accuracy of anti-aircraft fire by measuring the shock wave from the supersonic bullets traversing past their intended target. The Director of Los Alamos, J. Robert Oppenheimer asked Luis Alvarez the great physicist, to devise instruments to measure the energy released during the test explosions to be unleashed at Alamogordo and during the actual operation and use of the weapon.

Alvarez read our reports on measuring the shock wave and asked me to adapt, the device that was developed at Cal Tech for the purpose assigned to him by Oppenheimer. This was done but during the Trinity test because of bad weather and because of the unknown effect of the test explosion we were unable to release the measuring devices from the B-29 airplane in which we were traveling at a range of many miles from the test explosion. We made sketches of the mushroom cloud and estimated its height.

I was asked about my profound thoughts after landing the B-29 after the

momentous historical event and I replied truthfully, “I fell asleep immediately.”

The shock wave measurement devices were dropped by parachute both over Hiroshima and Nagasaki from a plane separate from the one that dropped the bomb. It was these devices which yielded the precise value of the explosive power of the two bombs which destroyed Hiroshima and Nagasaki.

The Japanese later recovered the devices and one of them is exhibited in the Peace Memorial Museum in Hiroshima, a very moving experience to actually see that device now.

You may be interested in the following event associated with the parachute drop over Nagasaki. May I have the next slide, please?

A group of physicists led by Luis Alvarez who worked at the Lawrence Berkeley National Laboratory then called the University of California Radiation Laboratory, wrote a letter which you see here projected which was addressed to Professor Ryokichi Sagane, a physicist who worked at the Berkeley Laboratory before the war. The letter explained the nature and power of the new weapon in general terms easy for a physicist to comprehend. The Japanese did recover the letter and it was delivered to the Japanese High Command and the Japanese surrendered the next day. It is not known to me whether this form of communicating with the enemy affected the decision to surrender.

Let me now turn to the sequel to Trinity from this historical personal account. Today the world has an inventory of about 30,000 nuclear weapons, about one-half of the Cold War peak. Each of these weapons possesses an average explosive power larger by a factor of about 20 than those which destroyed Hiroshima and Nagasaki taking

about 250,000 lives. The good news is that no nuclear weapon has again been used in hostility, notwithstanding that 100 or so wars have been fought since 1945, but this good news has its bad side effects.

The group assembled here has seen real nuclear weapons explode but today's decision makers have not. While they have been exposed through the literature and briefings to the awesome physical realities of nuclear weapons and the destruction and suffering they cause, nuclear weapons have to many of them, not all of them, become symbols of power and strength and prestige and tools for diplomatic bargaining.

Some decisions makers are even searching for new missions where conjectured circumstances might give advantage to nuclear weapons over conventional munitions, but such efforts endanger the now 60-year-old taboo against actual use of nuclear weapons.

The awesome physical facts pertaining to nuclear weapons are real. Whatever the means of delivery, nuclear weapons can multiply the destructive power that can be carried by a weapon of a given size and weight by a factor of about a million, a factor so large that it is difficult for people to comprehend. In consequence nuclear weapons allow fewer and fewer people to kill more and more other humans and to exact enormous economic damage. This leads to the ultimate danger that sub-national terrorist groups might acquire nuclear weapons and detonate them in populated areas.

The advent of nuclear weapons invariably changes the relations among nations. In some sense they have become the great equalizer between powerful and less powerful states.

The United States must recognize that our overwhelming military

strengths and demonstrated willingness to use that strength provides an incentive for lesser states to acquire nuclear weapons.

In the words of a Deputy Indian Minister of Defense: “Never negotiate with the United States unless you have a nuclear weapon.” Categorizing some of the world’s states as rogues or even evil is no substitute for an evenhanded international non-proliferation policy.

Throughout human history proliferation of any new technology for either peace or war, be it fire, gunpowder, steel fabrication, electronics or whatever has never been stopped; but, in response to Trinity, we must stop the proliferation of nuclear weapons, which violates historical precedent. How can we accomplish this? Treaties and other international agreements have been very successful in slowing proliferation but in the long run each sovereign state on this globe must be persuaded that its national security is better served without possessing nuclear weapons than with them.

Each state now possessing nuclear weapons must examine critically whether their stockpiles of these weapons and other materials to make them are really necessary and truly consistent with their national security, and as was discussed previously, not to meet some short-range contingencies but to serve the true long-range security needs of the nation. Above all, the emergence of nuclear weapons underscores the need to emphasize non-violent means for settling international conflict. Ignoring the reality of nuclear weapons demonstrated at Trinity or replacing or distorting scientific facts by policy or ideology results in grave peril to this nation. Thank you very much.

DR. PANOFSKY: I would like to proceed in alphabetical order. Now, we have very little time. We would like to have every one of you give first a brief account of

what you did at Trinity, followed by whatever thoughts, profound or not profound you wish to express.

AGENDA ITEM: Individual statements by Trinity Veterans: Harold Agnew, Hugh Bradner, Robert Christy, Val Fitch, Don Hornig, Lawrence Johnston, Arnold Kramish, Louis Rosen, Maurice Shapiro and Rubby Sherr.

DR. AGNEW: When Pief called and asked me to attend this I asked him why because I said, "I was never at Trinity." We had an argument. I checked with Larry Johnston. He thought I was at Trinity, too. I was not at Trinity.

Luis Alvarez wrote a very interesting book and on Page 141 he says, "Sometime after midnight we took off. Larry, Harold and Bernie were aboard, and Pief was our guest. The plane also carried Navy Captain William Parsons." I was not aboard.

And another point, the Enola Gay is out near Dulles. You can go see it. Now, that thing normally carried the following people. They had a commander, that would be the pilot, a co-pilot, a navigator, bombardier, flight engineer, assistant flight engineer, radio operator and radar operator.

Now, you look at that cockpit. They were all in there. Now, Luis says that he was in there, too. That is possible. Our instruments were behind the second bomb bay and there was a tunnel and you crawled on your belly and you could get up into the cockpit.

One person could kneel between the pilot and the co-pilot. There is no way the rest of this gang could have been up there watching, but he describes in great detail what they saw.

Now, at the back of the airplane there was a window about six inches in diameter because we had removed all the turrets from these airplanes because of the heavy load we were carrying. So, you could look out. One person at a time could look out that window but you couldn't see anything in front of you. So, I don't know how all those people saw all that they saw.

Now, when we knew that Trinity was going to take place I was measuring neutron cross sections and we were assigned to measure the yield. This was John Manley's group (using a Cockcroft-Walton Accelerator). Our technology was to take some large pieces of plywood, cut circular holes in the plywood, paste paper over these holes and we were going to place things at various distances from the ground zero and depending on which papers broke somehow we were going to determine what the yield was. This seemed to me to be very dull and I had heard that Luis Alvarez was asking for volunteers to attempt to measure the yield and we would go overseas. I ran down and volunteered and he accepted me. I think I was the only volunteer.

I worked, as Pief described, in developing these instruments, and we were told to go to Utah where we were going to leave to go overseas. I went there. We were told to carry only a toothbrush and any shaving equipment, nothing else except the clothes on our backs. We went there, stripped, put all our clothes in a cardboard box which was sent back to our family and we were issued uniforms. We had a duffel bag and everything. I was all of a sudden a first lieutenant.

I keep thinking that Luis Alvarez was with me. Anyway we put on these uniforms and had the shock of our lives when we went outside because all of a sudden people started saluting us and we didn't know what to do. We went back in the rest room

in front of a mirror and practiced saluting. I am not dreaming this but somehow that is what transpired.

Then I went to Tinian. Now I dug through some stuff at home and I found my boarding pass. We would call it a boarding pass today and it listed that I had paid up what I owed for being on the base that length of time. The lodging was 25 cents, meals for a day 50 cents, very reasonable and my boarding pass said I was on the Green Hornet and I was leaving on July 13. So, I left on July 13, to go to Tinian. I find it very hard to believe that Luis would let me go all by myself to set up everything that had to be done, pick out the airplane, starting, installing equipment, getting our gear and doing this all by myself because he was a very active individual and he was sort of always in charge of things. So, it is very hard for me to explain that he wasn't with me and one other thing I remember distinctly being taken into the teletype room in Tinian waiting for the results of the Trinity test and I remember this came over the teletype and yes, indeed it was successful.

I don't think I could have gotten in there at my rank and as really a single officer unless Luis had taken me and there wasn't anybody else. So, I am just baffled by history I guess as it is being written.

I would like to say one thing with respect to Linton Brooks' comment. I agree with him on all things except I wouldn't put anything in the stockpile if I didn't test it and I will give you an example. Every once in a while you have to have a key made. Keys are just to me two-dimensional objects. You take it to an expert. He copies your key. You bring it home and what do you do with it? You put it up on the shelf, right? No, you try it. One out of three times it does not work. You take it back to the guy that

made the key. He looks at it. He compares it with the original, shakes his head and cuts you a new one and throws the one that you brought back in a big bucket which is filled with keys and you say, "What are those?" He says, "Those are keys that I made that don't work."

Now, a key is a very simple thing. It doesn't have to move. It just has one function and so I say, "I agree with what we want to build for the future but don't put anything in if you are going to count on it unless you test it." Thank you.

DR. BRADNER: In the spring of 1941, when I completed my Ph.D. at Cal Tech the US was evidently preparing for war. So, I went to work at the Naval Ordnance Lab in Washington to develop magnetic mines. In the early winter of 1943, Ralph Gunnett, the laboratory Director offered me the opportunity to transfer to the Manhattan Project. Arthur Compton briefed me on the project and indicated that it would probably not produce a bomb during the war but might be significant at the peace table. At Los Alamos I simply tried to contribute wherever Oppie needed it most. Initially that meant expediting the construction of the town and the technical area.

When in 1943 Seth Neddermeyer suggested explosively driven implosion of a hollow cylinder John Streib and I, with a few military, became his group. It was a very low priority effort. We fired the first charge on Independence Day 1943, and spent several months trying to obtain reliable explosively driven critical collapses initiated by high-quality primacord.

By July 1944, it was realized that a gun assembly would be far too slow to work with plutonium. Simultaneous multi-port initiation was recognized as the great

obstacle; primacord was not adequate. Then Neddermeyer's efforts became top priority at Los Alamos, but he continued in his inventive, laid-back manner. Kistiakowsky arrived in late January 1944, impatient with Seth's approach. I became a member of Kisti's group.

Then Luis Alvarez arrived and worked on electric detonators; I became a member of his group fabricating the devices. I worked briefly on the Ra-La (Radio-Lanthanum) diagnostic experiment in preparation for the Trinity test. I was just an observer at the test. At the end of the war, I joined Pief and Alvarez' high-energy physics group at Berkeley.

Here I will give a few considerations. I am going to attempt to give somewhat different perspectives than Pief's magnificent opening comments. Mine will be hopefully at best, provocative but superficial.

I had been raised with a strong loyalty to our country. I didn't feel any moral concern about bombing an enemy. My reaction to the use of saturation bombing or poison gas, for example, would be measured by its effectiveness in winning the battle. I felt and still feel that people advocating world government without power are naive. I was in favor of using American dominance to prevent other nations from developing nuclear weapons. The threat of assured destruction might suffice. The destruction of a city by an atom bomb would be comparable to saturation bombing using conventional weapons. I did not expect the emotional trauma that occurred, or the size of the stockpiles.

Thus my reaction to the Trinity shot was satisfaction at a successful project. I feel that the past 60 years without major conflict can appropriately be credited

to the threat of inevitable retaliation including by the way the use of nuclear submarines

World peace also depends upon the rationality of world leaders. Today the threats of terrorism present a different set of dangers to society, and the vulnerability to attack by small groups of fanatics armed with chemical, biological, or nuclear weapons. Techniques for assembling such weapons and sources to buy them from the rogue states are becoming openly available.

Instead of progressing with nuclear peaceful uses of nuclear energy, more countries are working toward, or already have nuclear weapons. Violence appears to be the action of choice to resolve human conflicts.

This background plus fear of accidents and the unknown has impeded American use of nuclear energy to replace fossil fuels. Our reluctance to embrace it can force the US to become a second-class world power.

Our society should monitor things such as breeder reactors that could result in bomb production. There is a recent proposal to build large arrays that could detect every reactor in the world.

We may be at a point in history where a massive two-pronged project should be created to understand and accept peaceful utilization of nuclear energy and to develop a worldwide conviction that resolution of conflicts by violence is not acceptable to civilization.

How can religious hatreds be countered? How will Chinese (or Russian etc.) attitudes toward the safety of individuals differ from those of the Western Europeans and Americans? How can terrorism be made unattractive to the terrorists? What lessons might we learn from history? The past few hundred years actually are the anomalous

ones for personal safety.

Such a project would require teams of physical scientists working with teams of behavioral scientists. The physical science is nearly in place. Human attitudes and understandings are not. Political and financial commitment of the US Government would be essential. The rewards could be tremendous.

DR. CHRISTY: Thank you. My role at Trinity was that of an observer. I was bussed down there in the afternoon of July 15, with about 100 others and we were stationed on a slight rise with a good view of the shot site about 20-odd miles away.

My background and reason for being there was my involvement in the design of the Trinity bomb. I had spent a year before going to Los Alamos at the Met Lab project in Chicago working on the first reactor there and then I went to Los Alamos and worked in the theoretical division under Hans Bethe and later also under Rudolph Peierls where I worked on the design of a small reactor, finally I worked on the implosion designs of nuclear weapons.

In the course of that work, I proposed the final modification and design of the Trinity bomb and the Nagasaki bomb which led to the ultimate design of the final bombs which were in fact called the Christy gadget.

Now, that is why I was there. My reaction to the bomb was alike to that of I think anyone. We were observing these bombs through the very dense glass supplied to us, welder's glasses and the flash was awesome. Then on removing the welder's glass we could see the rising fireball, kind of a swirling orange with black and an interesting purple glow surrounding the fireball which could be recognized as ionization of the air

from the intense radioactivity in the fireball. This was a very remarkable spectacle and my impression was that I didn't need to be very much closer if I wanted to survive.

Later my reactions to the bombs evolved. A few days after the Hiroshima explosion, photographs of Hiroshima became available in the papers and it was remarkable to see that all that was left of a sizeable city were a few hulks of reinforced concrete buildings virtually destroyed except for the structure and the rest of the city was totally flattened.

Now, we had in fact calculated the radius of destruction expected from these bombs for typical European-type cities but to see the total flattening of a large city except for as I say a few relics of buildings made a very deep impression and subsequently in the last 20 years I have had occasion to be much more deeply involved with Hiroshima.

I became involved and was head of the US working group trying to establish, jointly with the Japanese counterparts the actual radiation dosages delivered at Hiroshima and Nagasaki. That is radiation of primarily gamma rays and neutrons.

It turned out to be possible even at this late date by techniques of nuclear physics and otherwise to make measurements on actual samples obtained from these cities to determine the doses, the radiations that were present at the time of the bombs.

This information has been used with very considerable advantage in order to compare the radiation doses there with the number of subsequent injuries or deaths, primarily from cancer.

Now, over 100,000 people have been followed in this project. It is a joint Japanese-US program in order to find out their subsequent medical histories. Of course

of these 100,000 more than 50,000 by now have died and of those more than 10,000 have died of cancer. Of those 10,000 a significant but smaller number have been statistically identified as being due to the atomic bombs by comparison with sample populations that were where the radiations were very small. So, this information has been very helpful medically.

In the course of these visits I have made many visits to Hiroshima and have had occasion to visit the Peace Museum there on quite a number of occasions. There I have been again exposed to pictures of what the actual effects of a nuclear weapon were on Hiroshima, and it is really a very emotionally powerful experience to see that, I recommend that those people who are contemplating using nuclear weapons in warfare expose themselves to in fact what the effects are.

As a result of that, it has become clear to me that if we now consider modern nuclear arsenals which on the average contain bombs 20 or so times as powerful as the Hiroshima and Nagasaki bombs and in numbers 10,000 times as many, it is now apparent that warfare using these weapons cannot be tolerated. Human societies cannot imagine doing that, and the problem is how do we maintain a posture in order to make sure that that doesn't happen.

In the course of this I want to make one comment to add to what Panofsky has said about the motivation for those who were at Los Alamos. The motivation that was quite prominent at Los Alamos was one of considerable fear that the Germans would develop atomic weapons before we did. We were very conscious that Germany was the world leader in atomic physics prior to the war and we had no reason to believe that they would not have organized a very good project for developing nuclear weapons.

We know now that this project in Germany was concentrating on use of heavy water as a moderator in a reactor and there were programs in Britain to attack Norwegian heavy water sites and this was one reason why the German project never came to fruition. However, we did not know that at Los Alamos and until Germany was defeated the fear of German success in developing atomic weapons was very real. This was particularly real among the fairly large number of refugees from Europe and Germany who had come to this country and were now playing leading roles in physics and in particular also at Los Alamos.

They were particularly concerned about the possibility of a German bomb. When Germany was defeated it became apparent that that was no longer a worry and we concentrated as others have mentioned on trying to finish a horrible war, which we did.

Regarding the future I should say my remarks now are not based on any expertise. They are based on some 60 years of worry about atomic weapons and trying to be aware of what the possibilities are for control of these weapons.

It has seemed to me in recent years that the paradigm that we have followed in nuclear weapons control is no longer really successful. That paradigm was based on a few states with nuclear weapons perhaps large numbers and many states without nuclear weapons. This “have” and “have-not” situation apparently does not work. Many of these other states feel that as a matter of prestige and in order to be able to sit at the same table they have to develop nuclear weapons and we have seen that happen in state after state not only for prestige but perhaps also for purposes of defense or deterrence.

This program then is no longer really working, and I think we have to look

if there is another program that we can imagine that could be successful. It seems to me that it is possible to imagine a program in which states with aspirations are allowed to develop under strict supervision nuclear weapons, a few nuclear weapons but only a very small number. This allows them to feel that they can now talk to the big states and it may be possible that an equilibrium situation among nations could be developed based on not some bombs on the one hand and zero on the other but based on a few, namely that nations are allowed to possess a few weapons but only a few.

The key I think to ultimate success of such an idea would have to be that we would have to join that group, namely be satisfied to have only a few weapons of our own. This would require major changes in our own posture and it would require a lot of education and thought to achieve that end.

However, we have been fortunate and have survived 60 years of a Cold War and large numbers of nuclear weapons in arsenals. I don't think we will have the luxury of surviving another 60 years without the use of atomic weapons unless we can find new policies to regulate their development. Thank you.

DR. FITCH: First of all, we are recognizing an event that happened on July 16, 1945 today, July 14, 2005. I am somewhat amused that this recognition of the anniversary is taking place in this Francophobic town on Bastille Day.

I was one of those drafted in the US Army in World War II and near the end of my junior year in college. I had been majoring in physics and chemistry and somehow I ended up working, basically as a technician, at Los Alamos. I believe my title was research assistant.

So, I was a member of the SEDs, the group that Harold Agnew had alluded to. We lived in barracks, ate in the Army mess hall but worked for civilians in the technical area. I was assigned to work for a member of the British mission, namely Ernest Titterton. I became his right-hand man and in this situation I was involved in the test at Trinity.

Titterton's group, there were five of us altogether, another SED, two civilian technicians who wired circuits for us and me. At the time of the test we had two prime responsibilities. One was to provide timing markers prior to the explosion to various experimental groups, for example, to open camera shutters. At the end we sent the signal that triggered the explosion. That is the reason why Titterton and I were in the main control bunker during the test. As I recall Don Hornig was also there as well as Rubby Sherr.

The other responsibility of our little group was to measure the simultaneity with which the 32 detonators fired. They were arranged symmetrically around the surface of the spherical gadget, the Christy gadget. The timing information was recorded remotely in a bunker which was about half a mile west of the tower on which the bomb was located.

The main control bunker, on the other hand, was 10,000 yards directly south of the tower and that is a bit less than six miles. About a minute before the moment of the explosion Titterton suggested that since everything was in an automatic mode, why not go out and get a good view outside the bunker. I was of an age that was infinitely curious with little regard for personal safety so, of course, I seized the opportunity taking a two-by-four inch piece of glass with me, the nearly opaque glass of the type used in arc

welding helmets. So, I sprawled out on the ground east of the bunker holding that piece of glass cupped closely in front of my eyes. I looked at the mountains somewhat to the northeast. I didn't want to be looking directly at the tower at the moment of detonation. Incidentally there were three or four other people out there with me. I remember in particular George Kistiakowsky. Then the explosion and you have all heard about that incredible flash of light even if you weren't looking directly at it and even if you had an arc welder's piece of glass in front of your eyes you were still blinded by this light, but after a few seconds I could move the line of sight to the tower and see the fireball and later the fireball starting to reach the ground.

So, I got up off the ground to get a better view of what was transpiring, this was maybe 15 or 20 seconds afterwards and then I remembered the blast wave had yet to arrive. It takes about 30 seconds for this sound to travel the nearly six miles. So I retreated to the ground again. With the blast wave there was at first a very sharp report, the gust of wind and the reverberation of sound apparently echoing off the nearby mountains for the longest time.

I should say that after 60 years one's memory can be rather faulty but the events were so tremendous you don't forget any of the details. I did write, many years ago, about some of my experiences at Los Alamos and I referred to that article in thinking about what to say here.

There was an MP at the door of the bunker, and he had turned totally pale. Apparently no one had told him what to expect. My remark to him at the time was, "The war will soon be over," and of course it was.

In a few minutes Titterton and I turned off the apparatus in the bunker and

drove back to the base camp which was about five miles further south and there was the great physicist I. I. Rabi pulling a bottle of Scotch out of a trunk of a car. We all had a hearty swallow of that and then headed for the barracks for a nap. It had been a long night.

I have been asked whether I wasn't afraid of the radiation at six miles and well, I guess I had made only one calculation, that is that the amount of air between me and the bomb was just about the same as the amount of air between me and the sun and that does a pretty good job of shielding.

I have been asked to comment about how science-driven enterprises, and of course the bomb was a classic case, fare as they enter the public domain, enter the political process and I am not at all sanguine about this. Those of us who have been scientifically involved have had little effect. There are still tens of thousands of these miserable gadgets in existence despite the best efforts of people like Panofsky who has devoted such a large part of his life to the control of these weapons.

Those with some basic common sense seem to abandon the political process. Apparently to be successful in modern political life it is necessary to be well endowed with arrogance and hubris and that is what takes over. Hard-nosed evaluation appears to be lost. Now, our government does many wonderful things and I want to emphasize that. On the other hand, it does evil things. I want to remind you of the vilification of Robert Oppenheimer who was, in my book, the real hero of Trinity and that happened of course less than 10 years after the Trinity test.

The government supports many activities that are terribly expensive and, in my opinion, totally ridiculous. The anti-ballistic missile efforts I find in this category.

I call them snake oils, modern snake oils. I remember the Safeguard system in the early 1970s, the SDI in the early 1980s and now we have a system being deployed that has not passed, with any credibility, any of the tests proposed for it. The objective apparently is to simply spend money.

I can't resist the old joke. Why are we building an anti-ballistic missile system? To protect ourselves from those governments that can't afford the suitcase. If you start thinking about that and the threat of terrorism, it is more serious than a joke. I could go on and on about the modern snake oils that are perpetuated by our government but I think I have probably used up my time. Thank you.

DR. HORNIG: When Pief called me I couldn't see what I could possibly contribute to this discussion other than to reflect on how a series of apparently random events led to some useful results. It all began for me in the spring of 1944, when my boss at the Explosives Research Laboratory at the Woods Hole Oceanographic Institution under whom I had recently completed my Ph.D. summoned me to his office to tell me that my services had been requested for a secret project at a secret location to work with an unnamed person on an important project. That was all. Then he asked me to think it over carefully. My recently wed bride, Lilli, and I discussed whether it made sense to abandon a household which we had just set up and the garden she had just planted. We asked ourselves why we should buy a pig in a poke and respectfully declined.

The next morning the phone rang with a call from Professor George Kistiakowsky in Santa Fe, under whom I had studied at Harvard. He asked me simply, "What the hell has gotten into you, Hornig?" That afternoon came another call, this time

from Washington. It was from James Bryant Conant, then the president of Harvard and Chairman of the National Defense Research Council. He asked, didn't I realize, and I quote, "That Uncle Sam is pointing his finger at you?" I was disgusted, but so much for secrecy. I still didn't know what it was all about, but I knew something about the people who had called.

Well, shortly thereafter we bought an ancient Ford coupe, packed up all our belongings, and instructed the moving company to deliver them to Post Office Box 1663 in Santa Fe. We set off for the only goal I had been given; it was 109 East Palace Avenue, Santa Fe.

We arrived at an obscure office and were assigned to the last available bungalow and told how to get to a place called Los Alamos which I hadn't heard of before, on top of a mesa in the Jemez Mountains. So off we went again, along a gravel road without any guardrails until we reached a guardhouse where we were admitted to a depressing olive drab military base.

Then the real story began. I was settled in a dismal office amid a pile of reports. I learned that my job was to measure the characteristics of shock waves from a huge nuclear explosion in order to determine its size. I was shown a small pellet of plutonium and that was a real shock. My qualification was that for my Ph.D. thesis I had measured the characteristics of shock waves from two-ton bombs. They were the biggest around then, and this was going to be 20,000 tons. The only trouble was that there was no plutonium, the test site had not yet been built and no one knew how to carry out the implosion anyway.

It was very discouraging and I hated the thought of sitting in my office

planning. I was very depressed. Fortunately I attended Oppenheimer's staff meeting at which the question of how to initiate the spherical implosion was discussed. The only idea at that point was to utilize an explosive switch to set off all the detonators on the periphery of an explosive shell surrounding the plutonium. The problem with the switch was that it would destroy the gadget. So, there would be no testing. You have heard about the importance of testing.

At this point I had an idea and made a suggestion. It was eventually my principal contribution to the success of the project. This was that we ought to be able to trigger a high-voltage spark gap within a fraction of a microsecond and use the spark gap switches to fire the detonators that would initiate the spherical implosion with adequate simultaneity.

Oppie immediately asked me to assemble a small group and give it a try. That was late in May 1944. After that I had nothing more to do with shock waves, although that was what I had come to Los Alamos for.

With the help of a group of SEDs who have been mentioned here earlier, bright science students who had been drafted, we went furiously to work. By fall I thought we had the fundamental problems in hand but most of my colleagues, including Kistiakowsky, were very skeptical as to whether this step could be entrusted to a 24 year old. I realized a decision had to be made in October. In her book Critical Assembly, Lillian Hoddeson says of the critical meeting of the Cowpunchers Committee, "At this point the issue of which to use was unsettled. Although Kistiakowsky strongly favored the explosive switch, Hornig boldly objected, arguing strongly then on 9 October against the explosive switch and in favor of his spark gap switch." The decision was made in my

favor. So we went back to work more furiously than ever to build a reliable firing unit, later called the X unit, for the bomb test scheduled for the next spring. From then on I was on the spot to produce reliable X units in time. By late spring 1945 we did have two commercially manufactured X units available.

Getting from there to Trinity was rough sledding but I won't go into that. The worst came at Trinity itself. The test was scheduled for July 16, and we were not ready, but President Truman was about to meet with Stalin and Churchill in Potsdam. So we had to be. Troubles persisted until the last seconds. On July 9, during bad weather, the X unit fired prematurely. That made everyone very nervous. Oppenheimer berated Kistiakowsky for entrusting the job to an incompetent like me. But we found the problem, which was a disconnected ground wire, and proceeded. The confidence level remained low, though.

On July 15 the assembled bomb was hoisted to the top of the 100-foot tower on which it would be detonated. That same day a spare X unit which was being used for intensive final testing of measuring equipment failed. There was panic and I was in deep trouble again. After a frantic all-night session it was determined that a glass spark gap switch that carried a current of several thousand amperes at about five kilovolts had shattered after being used for over 160 tests, although it had been designed to last for 10 firings. The decision by the high command was to proceed, although the confidence level was lower now than ever before. On July 15 the tension was enormous. The weather looked bad and was getting worse. The orders from Potsdam were to go ahead. Against this backdrop Oppenheimer held a meeting at about six p.m. Present were Bainbridge, Kistiakowsky, and I. He was terribly worried about the possibility of

sabotage on top of all these other troubles. He decided that someone who understood the details should stay with the gadget until it was locked for firing. We agreed and as the youngest I had priority.

I was given the first, and as it turned out, last turn. A violent thunder and lightning storm enveloped the site; I climbed to the top of the 100-foot tower, where I babysat the live bomb. It was a deeply philosophical experience to contemplate the monster beside me and what it was about to do to the world if it worked. My brightest, best moment came when the telephone rang around midnight and I heard Kistiakowsky say, "Don, you can come down now." No one went back up after me.

I still had one job to do. As proprietor of the firing unit I manned the one manual switch which would stop everything if a problem arose, the "chicken switch," because otherwise an automatic timer was in control. I was stationed just inside the door of the control bunker, 10,000 yards from Ground Zero. My console consisted only of four meters attached to the distant X unit and a number of red lights indicating whether the firing condensers were charged.

At minus 30 minutes everything went on automatic timer and I had the only override. I had no deep thoughts. Up to the moment of the blast my only thought was "Your reaction time is half a second. Don't blow it."

At 5:29 all the needles dropped to zero and the red lights went out. There was a brilliant light swirling around outside. That was the end of the war for me. In fact the war did end three weeks later. My own reaction then was to be terribly tired; I had hardly slept for 48 hours. My second thought was "We have really opened a can of worms, haven't we?" For many years I worked on the proposition, where do we go from

here? Well, I have heard lots of profound observations this morning and I don't have any more to offer. I only hope that as the product of this symposium we will hear some very good ideas. Thank you.

DR. JOHNSTON: I think I will start with a joke. A number of us who were involved in this project have been giving talks all over the place after the war when people wanted to understand what the atomic bomb was all about, but I think the best question that I ever had was, "Why did you wait until the end of the war to drop those bombs on Japan?"

When I arrived at Los Alamos in early May 1944, Luis Alvarez give me the job of creating the electric detonators that have been referred to by our previous speakers. These would be required to simultaneously explode the lenses that were on the outside of the bomb so that the implosion wave could be focused on the plutonium core in the center. That was quite successful and so I won't say any more about those detonators since they worked quite well.

For the Trinity test Alvarez decided that this explosion would be a perfect time for a dress rehearsal of our measurements of the later explosions over Japan. So, we were planning to be at 30,000 feet flying over the explosion of the bomb when it went off, but as we were about to take off from Kirtland Air Force Base Luis Alvarez got a call from Oppenheimer and he was having cold feet about some of their calculations about how much energy this bomb would put out, and I don't know exactly what he said but he was worried that we would be blown out of the sky and he would be responsible.

So, he ordered Alvarez to stay 25 miles away from the gadget when it

exploded. So, we were reduced to the role of just being observers, but we were observers. So, when we took off from Kirtland Air Force Base in the front pilot's cabin of the plane were Panofsky and Alvarez and I believe Captain Parsons was there, wasn't he? Okay, and in the rear compartment of the bomber behind the bomb bays were Bernard Waldman and I and a couple of crewmembers were back there and the tail gunner. So, we got a view. There was a storm outside but what I saw was just a flash in the small porthole that we all had to share to see what was going on, 25 miles away, but then we started flying towards the rising mushroom cloud and we all were able to see it.

I think one of the most common questions that I have been asked by interviewers was what was your first impression when you knew that that bomb had been successful, and I remember it well. I was saying, "Praise the Lord my detonators worked," and I am sure there were a number of other people who were having similar thoughts. If that thing had failed we would have thought "probably it was my fault" and the telegram to President Truman at Potsdam wouldn't have gone, or might have said, "It failed. So, don't play the nuclear card with Joseph Stalin," but it worked and we were all jubilant.

Now, for remarks on the present situation, I don't have any on nuclear proliferation but I think I can add this. With all the threats that are in front of us I think it is not a bad idea to do some praying, praying to "you know who" and this is a radical thing for a scientist to say perhaps, but I must say that I have been impressed with what my cosmology friends have come up with – the transcendent creation of the universe in the big bang. And I have also been very impressed with scientists who have written books about the Anthropic Principle, that this is a very nice universe that we live in. I

think this is a very good omen that there was a benevolent intelligence involved in creating all these things.

So, the electric charge on the electron and the proton were carefully regulated to within two percent. If they had been two percent different we would not have had any carbon atoms. You know how good carbon atoms are to make proteins, the thousands of proteins where carbon atoms will combine in so many different ways to make our bodies. So let me encourage you with something that Jesus said, "Ask and you will receive, that your joy may be full."

So, let us ask. So, what should we be asking? Well, I am asking that God will give us good ideas about what should be done and if I get any good ideas I think I will tell Panofsky and some of the other leaders that we have been listening to. And that is the direction of my hope.

DR. KRAMISH: Thank you. Like Harold Agnew, I also was not at Trinity. Perhaps the reason why will illuminate some aspects of Trinity. First I would like to explain the term SED, which stood for Special Engineer Detachment. I had been assigned to the Army Specialized Training Program (ASTP) at City College of New York. When that program was terminated, most of the GIs were shipped out to the Pacific. A few of us were interviewed by a jolly fellow named Dean Arnold. I did not know his first name at that time nor did I know his affiliation. My Trinity panel associate, Don Hornig came to know Dean Arnold at Brown University. Hornig eventually became president of Brown.

Actually Dean Arnold was sort of a covert recruiting agent for General

Leslie R. Groves, the head of the Manhattan Project. The Dean posed a few questions and then asked, "Where would you like to do your graduate work?" And I replied, "Brown University." He said, "Why?" I said, "Because I am interested in servomechanisms and Brown has the best applied mathematics faculty," and he beamed and there were no further questions.

The following day the ASTP commanding officer, a mere lieutenant came around and said, "How did you know he was from Brown?" Obviously I was a spy. I said, "Honest, sir, I didn't know that at all." In fact, I learned he was from Brown from that lieutenant, but I was already under suspicion for an earlier serendipitous moment. Before the Normandy invasion students had a pool of 50 cents each. I bet on June 6, 1944, winning about 20 bucks. The officer called me in. "How did you know the date of the invasion?" I replied, "June 6, was my 21st birthday." You can't win.

Soon I was transferred to Oak Ridge Tennessee. Usually, one was immediately assigned to an SED job at Oak Ridge or elsewhere in the Manhattan Project. But, 10 of us were kept aside. After about a week, we were becoming very concerned and felt we were going to be shipped out to the Pacific. We were invited to a hut where we were introduced to James Bryant Conant, President of Harvard and President Roosevelt's science adviser. Some of us recognized him. He said that he hoped we would volunteer for a task that posed some significant inherent danger, but we were not obliged. He couldn't tell us what the task was but he assured, "This is one which will hasten the end of the war." He then said that he would step out for 15 minutes and we could talk this over as to whether we wanted to turn down the task. This was very unusual for the military incidentally and we surmised that Conant was offering something

interesting. We could not turn it down. That very evening we were dispatched to Philadelphia without any travel orders, but we were ignored by the MPs on the platforms and train.

In Philadelphia we reported to the Philadelphia Navy Yard, after checking in at the Bellevue Stratford, to work for Phil Abelson, who had been a researcher with Glenn Seaborg on transuranic elements at Berkeley. We were assigned to the pilot plant for the thermal diffusion project for the separation of isotopes. The intent was, although Abelson didn't tell us, that the product was seed feed for the gaseous diffusion and electromagnetic projects at Oak Ridge to boost production efficiency to obtain material for a bomb sooner.

Again, I opened my big mouth. I volunteered to work in the transfer shack which held the most dangerous process, with two civilian employees, Peter Bragg and Douglas Meigs. Bragg was the senior technician performing the operation. He warned, "Now, if you don't do this right, it is going to blow up." I asked, "Did it ever blow up?" It blew up, and I got my answer. We three were bathed in live steam, uranium compounds and corrosive hydrofluoric acid, all of which were deeply inhaled, complicating the body burns. My two colleagues were immediately killed; I was laid out with the corpses, stripped of clothing, on the adjoining boiler floor. The Navy chaplain, having administered last rites to Meigs and Bragg, turned to me, as I was writhing on the floor in pain. I cursed the chaplain, not for the pain, but because he was violating my faith. At that moment, I lost consciousness. Some two weeks later the chaplain visited me in the hospital and he said, "My son, you cursed me; you cursed the Lord." I replied, "Well, Father, it worked, didn't it?"

Well, that accident got me to Los Alamos. I returned to Oak Ridge to work in the main plant. The operating gas, uranium hexafluoride was the same that I was exposed to at the Philadelphia Navy Yard. It is the same nuclear material being converted by Iran nowadays. There were leaks in the Oak Ridge plant, although not as bad as at Philadelphia, but I kept wheezing and coughing, etc., The Manhattan Project medical doctor, Colonel Stafford Warren decided to "Send me to a mountaintop for some fresh air," At Los Alamos I ended up working for Maurice Shapiro. He dispatched me to the Salton Sea where B-29 bombers, rehearsing for Japan, dropped dummy practice bombs on me. I calibrated their ballistics by radar. Some landed mighty close and I kept thinking, "This is healthy?"

After the B-29 crews departed for Tinian Island, their forward base, I was charged with sole responsibly for quality control of the Trinity and Nagasaki detonators, replacing Larry Johnston. I arrived late in the game. Transporting high explosives on my lap on bumpy roads, I continued to ask myself, "This is healthy?"

Well, to get to why I wasn't at Trinity. In June, I was invited, a mere corporal, to the Cowpunchers Committee. This committee was composed of the senior group leaders, called Cowpunchers because Oppenheimer had to round up all these crazy scientists going around with crazy ideas. There I received a good briefing on Trinity. Oppenheimer asked me only one question. He said, "Kramish, are all those detonators going to be simultaneous?" I replied, with some trepidation, "Yes, sir," and he said, "They better be." The command was seared into my mind. The detonators for Trinity and many of them for Tinian had already been shipped out but we were making detonators like mad. It was my duty to stay on site to test those detonators which were

destined never to be used in nuclear weapons.

I, also, was afraid that Colonel Warren who was in charge of health at Trinity would see me there and ream me out for possibly exposing myself to more radiation. Those were the reasons I was not present at Trinity.

I would just like to make a brief remark on secrecy. The Congressman noted that secrecy is increasing mightily in Washington and that has affected my present work drastically because records that were declassified in the sixties and the seventies are in the National Archives. If they seemed to have the word "nuclear" in them they are reclassified which is absolutely stupid. These records have already gone out to the entire world and it was part of the warhead phobia. We are not thinking of terrorism rationally in many respects as the actions have affected me, they are trivial but the actions as they affect the population in large measure are not thought out. Thank you.

DR. ROSEN: When Pief called me to participate in this symposium I told him I thought he was doing something really admirable but I don't qualify. I wasn't at Trinity. He said, "It is okay. I expanded the net."

So, here I am. In January of 1944 Dr. Triton of the Office of Scientific Manpower came to Penn State recruiting for various war jobs and he talked with the dean and they called me in and the dean said, "Dr. Triton has an important message to give to you," and the message was, "I am recruiting for a very important project which will shorten the war and I think you have the background that would be very useful."

"So, what is this project?"

"Well, I can't tell you what the project is. I can't tell you where it is, but

if you will just go to 109 East Palace Avenue you will get further instructions."

Well, I had been turned down for enlistment in the Navy because I was two pounds underweight, but Dr. Triton didn't worry about the weight of candidates. So, I arrived at Los Alamos in April of 1944, and was assigned to work in one of the groups working on the technology of assembling the various materials with sufficient rapidity to surmount the problem of pre-detonation, of pre-ignition.

This became a central concern following Segré's measurements of spontaneous fission rates. It was the development of this technology that the Soviets were able to bypass courtesy of Klaus Fuchs, the so-called "implosion" technology.

Explosive design configurations were changing continually and there were periods of waiting when we could do experiments of our choice. I chose to investigate the attenuation of electromagnetic signals by high explosives.

I had no indication that anyone was at all interested in the data. I was reporting first month after month and then every two weeks and then every week.

Preparations for the Trinity test were finally in place, awaiting results from an experiment by Ed Creutz's group involving a much larger scale mock up than previously used. The results were a showstopper. Oppenheimer asked Bethe to make sense of the new data. The following morning Bethe advised Oppenheimer that when the most recent data are corrected for the effects of the high explosives the results are consistent with previous measurements. A great sigh of relief. The data which I thought had gone into a black hole had not in fact escaped Bethe's attention. Almost nothing did. I believe that most of us would agree to the inevitability that a way would be found to achieve on earth the violent release of nuclear energy. That this was first accomplished

in a democratic society rather than by Hitler or Stalin or Saddam Hussein is surely one of the most fortuitous events in all of history. Hopefully the early success of the Manhattan Project is providing the leeway to manage the outcome.

The inevitability of the emergence of nuclear weapons foretold the now vital requirement for unprecedented international cooperation, collaboration and control if access to this energy source is not to result in dire consequences.

This is a major derivative of the nuclear event with obvious and enormous implications for the future. It is true that the past 60 years represents the longest period in modern history of about 300 years absent a war between the major world powers. Today even the smallest and poorest nations can aspire to access nuclear weapons in one way or another as can terrorist groups. Dr. Panofsky said, "Such weapons are becoming the great equalizer."

I have no credentials in the domains of international policy or politics but what we have witnessed in recent decades convinces me to stand with those who recognize that military capability by itself is no longer sufficient to ensure national security and international stability in the nuclear age.

It seems obvious to me that the most influential and most capable nations must now greatly and urgently increase efforts toward reducing the causes of conflict among nations and cultures as well as of the growth of terrorism. That is in my opinion the most demanding and enduring consequence of the Trinity event and once again time is of the essence.

The immediate result of Trinity was the termination of the war in the Pacific. Jubilation at ending the war masked the sorrow felt at the casualties incurred and

concerns about the future, but not for long.

I remain convinced that the evidence which has emerged from Japanese archivists in just recent months support the judgment that alternatives to immediate use of the bomb including a demonstration would have incurred far more deaths and injuries and destruction but today the opposite would almost certainly prevail. Investment of goodwill and treasure to avoid that scenario would have additional positive and vital consequences in my most humble opinion.

Finally, I express the hope that the Trinity event has taught us the importance of guarding against technological surprise militarily, politically and especially scientifically. Thank you.

DR. SHAPIRO: I had the pleasure of meeting Robert Oppenheimer when I was a graduate student of Arthur Compton's at the University of Chicago. Little did I suspect that, several years later, I would get an invitation from him.

In the war against Japan my initial assignment was to work in a field that I had no experience in. I had never even read Lamb's Hydrodynamics but I was assigned to a laboratory in Washington, the David Taylor Model Basin to study the physics of underwater explosions. A couple of years later, having become an "instant expert" on hydrodynamics, I was invited to meet with Richard Tolman who had an office in Washington, where he was recruiting on behalf of Los Alamos.

Now, contrary to some accounts, many physicists throughout the country had a pretty good idea of what was going on at some mysterious lab out West. Fission had been discovered, the couple of UK scientists, Peierls and Frisch, had already shown

that it would not take an enormous amount of uranium 235 to create a powerful atomic explosion. Moreover, it was noticed that a number of nuclear physicists were missing from their normal haunts, and were reputed to have gone out West

So my trip to Los Alamos was not shrouded in mystery. I had a fair idea of what to expect. Nonetheless, Ed McMillan, who introduced me to the project upon my arrival, had to assume that I didn't know, and he said to me, "Maurie, this is a sort of Buck Rogers project." He than asked me to lead a small group of which he had been in charge. He was urgently needed to work on problems connected with the design of the implosion "gadget."

So he turned over a small hydrodynamic group to me. Our job was to generate gravity waves by means of mini-explosions in a pool of water and to measure their amplitudes as a function of distance. The purpose was to answer a "delivery question:" Would it be a good idea to use some of the early bombs in water action against the Japanese in the Pacific, i.e. would the gravity waves be high enough to do significant damage.

We spent a few months doing some small-scale experiments. There wasn't much water on the Hill at Los Alamos. So in scaling up we had to extrapolate boldly. Nevertheless it became increasingly clear that the surface gravity waves generated, for instance, by a 10 kiloton explosion would not be high enough to warrant using the bombs in that way. So, I was able to give a simple answer "No" to that question.

I was then asked to take over a larger group to work on the external ballistics of the bomb. My friend sitting nearby has already described how we observed

drops of dummy bombs from a B-29 aircraft that flew from Utah, over about 600 miles, to drop their cargo over the Salton Sea, where we measured the trajectories with radar and motion pictures.

So those were my unexpected wartime contributions. I now want to share with you some experiences at Trinity. I shall not describe the site itself because this has been very well described by my colleagues here. Instead, I thought I would share with you some special encounters during the long night when we were waiting for the rain to abate so that the bomb could be detonated and, secondly, in a bus ride on the way back to Los Alamos.

While waiting at Alamogordo on the morning of July 16, I had a blanket with me which, on the wet sand, was shared by Hans Bethe. Our conversation was, for me, the most memorable experience other than the blast itself. We were about to witness the world's first explosion of a fission bomb, and what we discussed was Bethe's classical work on the nuclear reactions that power the sun and other stars. So here we were ready to witness history's first *fission* explosion, and we were discussing *fusion* in the stars, a conversation I will never forget.

As we were returning on a bus to Los Alamos I was sitting, during the first part of that ride next to Charles Lauritsen who had directed the rocket project in Pasadena. He subsequently became Uncle Charlie to Oppenheimer. Oppie had a number of advisers, among them Uncle Nick (Nicholas Baker otherwise known as Niels Bohr) and Isidore Rabi, among others. As Lauritsen and I were discussing what we had just witnessed, we wondered how many of those "gadgets" it would take to defeat Japan. We decided, having differing views, to make a bet; the winner would get a good bottle of

wine. Lauritsen's rocket project had contributed significantly to the success of our mission in the Pacific, and he guessed it would probably take more than ten of the new bombs to end the war. I felt it would take less than 10; that was all I needed to wager. So I think this story reveals how conservative physicists can be.

As a further illustration of this conservatism I cite another wager that I made on the same bus ride. That one was with Willy Higinbotham, who had been in charge of electronics on the Hill. At issue was the question, how powerful was the explosion we had just witnessed? Remembering an estimate of Hans Bethe, I felt it safe to guess that it was probably well under 10 kilotons of TNT-equivalent. Willy was willing to bet that it was more. I lost that bet.

DR. SHERR: I am quite an elderly person on this panel and therefore you can expect me to wander around a bit. First of all I would like to thank my son-in-law Robert Hess who brought me here, pushing me in a wheelchair over countless miles of carpet, and my daughter who recognized that my voice isn't always clear and sent me this container of lemon juice to make my voice clearer.

Well, I was immensely pleased to come here to see Pief again after many years and especially to see Harold Agnew because I am reminded of going fishing in the Valle Grande with him – he had got permission to go there. The Valle Grande is a volcanic crater a few thousand feet above Los Alamos and we went and looked at it. It was a big round crater that I guessed was a mile in diameter. I remember taking Phil Morrison up there to show it to him, and he also thought it was about a mile until he noticed what looked like a bunch of rabbits down below and wondered what they were

doing there. I gave him my binoculars and he saw they were longhorn cattle and so we revised the diameter to 20 miles.

Dr. Panofsky has clearly outlined the problems facing us here. I must say I was appalled when our President supported by Congress forgot the policy that for 40 years preserved peace between America and the USSR. Both had amassed thousands of weapons but the recognition by both of MAD, capital M, capital A, capital D, meaning Mutually Assured Destruction, discouraged any military confrontation.

Sixty years ago today I was in a dugout at north 10,000 making final adjustments to the wiring of some apparatus. The next morning at 5:30 a.m. I was looking at my oscilloscope waiting for the bomb to go off and to see what my measuring equipment would record as I listened to Sam Allison saying calmly, "four, three, two," and then not so calmly, "now." Then I bellowed, "Who the hell turned on the lights?" Then I realized my goof and I ran outside to see the mushroom cloud and the result. And when I saw the cloud I thought this was the world's greatest experiment. I will explain that. It was truly a great experiment to test the work of many people involved from Bill, my assistant who was a farm boy from Idaho, to Hans Bethe and Robert Oppenheimer and also to Maurice Kolodny my neighbor whose job was to electroplate the initiator that I had worked on. We didn't know what the other fellow was doing, so successfully was it secured.

I worked with Charles Critchfield in the Initiator Group from August 1944 to May 1945, and we tried various designs of a device which was supposed to emit neutrons at the moment of maximum compression of the plutonium sphere. We tested many designs with inscrutable names like Urchin, Nicodemus, Grapefruit, Iron Maiden,

Little George. On May 1, the Initiator Advisory Committee, of which Bob Christy was a member, accepted the Urchin design. We had done as many tests as we could think of but we could not make the crucial experiment. To quote Critchfield, "We had no way to prove that Sherr's design would start the chain reaction before the whole system disintegrated under the high explosives. It was a major justification for the Trinity test."

I think I will talk about one other thing. I live in a retirement community. Among our activities is a Current Events Club. One day I suggested for discussion a proposal of Total Armament to replace Total Disarmament. Let us give every country one identity-coded bomb and therefore have UMAD, Universal Mutually Assured Destruction. Since it would be security coded, if a terrorist got hold of it we would be able to know what country it came from and that should act as a serious deterrent. The response to this suggestion was utter silence. The reason was I think that people believe that a Saddam Hussein could go off his rocker and push the button. I don't think it is that simple to launch a nuclear bomb. I really don't know how many additional suicides it would require. My idea makes life a little bit easier for Bob Christy's suggestion. This would be the reductio ad absurdum of the colossal problem facing future generations.

DR. PANOFSKY: Thank you very much. Harold Agnew would like to give a final last word.

DR. AGNEW: I refrained in my talk from talking anything about philosophy or what we should be concerned about but there is one thing we should be concerned about and that is unauthorized use of a nuclear weapon by any country that has them. When Pakistan, India did their tests this government imposed sanctions. What we

should have done is offered them technology to make sure that there is no unauthorized use. I talked to a Pakistani general. He said, "Oh, we have a good system. We keep our weapons separate from our missiles." From the United States standpoint it would be better if they kept them on their missiles because of their limited range. What we need to worry about is unauthorized use because the physical possession of the nuclear weapons around the world is not with the leaders. They are in the hands of a lieutenant or a colonel and he may be planning for some sort of coup. So, I think we have to worry about transferring technology to prevent any unauthorized use. Thanks, Pief.

DR. PANOFSKY: Thank you very much.