CHAPTER I

PREMORATORIUM INTERNAL READINESS ACTIVITIES

The AEC, the weapons laboratories, AFSWP, and the other components of the nuclear weapons "complex" had been intimately involved with the national actions toward a nuclear weapons test ban since the subject was first raised. The early Lillienthal group had several members from that complex. The complex was continually consulted on the subject through the early years, and an appreciable amount of "in-house" effort went to those considerations.

After the exodus from Los Alamos at the end of WW II (and from other portions of the system), the new weapons complex consisted of people who probably, on the average, felt that the continued design, testing, and production of nuclear weapons was a necessary element in the United States defense posture. When a test ban, as a prelude to other disarmament moves, began to be considered seriously, the nuclear weapons complex spent some effort considering the effects of such a ban on the weapons system, what capabilities should be maintained, and what moves, ahead of time, might "safeguard" the system capabilities.

While there were some early opinions expressed that in order for a CTB (Complete Test Ban)* to be believable to the rest of the world, the weapons complex would have to be completely dismantled, including the dissolution of the weapons laboratories, these opinions were never taken very seriously. Rather, the feeling seemed to be that any such agreement should be entered into gingerly, that the Russians were not trustworthy, and that therefore, the weapons complex should be maintained, at least for a few years. The stockpile needed "care and feeding," and further advances in nuclear weapon system design could clearly be made, and might become necessary were the Russians to act in some inappropriate manner.

However, the aims of "maintaining the weapons complex capability" or "maintaining a nuclear test capability" did not, in general, lead to clear-cut and generally agreed upon suggested actions. There was clear agreement that the internal health of the AEC weapons laboratories had to be maintained (the point was not so clear with respect to the DOD laboratories), but what did that mean? Should the people be kept at work on weapons design and production problems, or should their capabilities be exercised by putting them to work on other subjects? Without nuclear testing, would it be possible to keep them on weapons work very long? Would good people stay to work on problems that could not come to fruition? To maintain a testing capability, was it necessary to maintain the proving grounds? Were cadres representing the major field contractors (EG&G, H&N, REECo, etc.) necessary, or could these organizations be allowed to disappear? Was it necessary that the in-house weapons test organizations be maintained as entities, or could they be absorbed into the other parts of the laboratories? If they were maintained, what work should they do?

These questions were not taken particularly seriously over the years 1946 to 1956, but began to use up more effort as the moratorium approached. The separate

*Today, July 1979, CTB means Comprehensive Test Ban.

organizations, as was to be expected, took somewhat different tacks in answering the questions. However, once in a while there was consistency. In June 1954, Teller* (Livermore) and Bradbury** (LASL) sent their joint opinions to Ken Fields (General Manager, AEC) in response to a query by John Foster Dulles. They felt that a CTB would work in favor of the Russians because the United States would observe the treaty -- but it might be circumvented or openly violated by the Russians -- and because the Russian intelligence (due to the difference in societies)*** was better than that of the U.S., so the only way the U.S. could stay ahead was to work harder and faster, which it could not do under a CTB. They further commented that a TTB (Threshold Test Ban) would have the following effects:

a. If the threshold were zero, there would be no tests, and hence little or no progress, accompanied by a loss of sense of urgency.
b. If the threshold were 5-10 kilotons, the U.S. could do tactical weapon development. They recommended that at least this be allowed for any condition short of complete and satisfactory atomic weapon control.
c. If the threshold were 50-100 kilotons, they could do weapon component testing for large bombs. They recommended that the threshold be at least this high.
d. If the threshold were 1-2 megatons, they could develop lightweight thermonuclear warheads. They opined that such a threshold might impede the Russians, who seemed more interested in very large yields.
e. If there were no limit, the laboratories would increase their capabilities in the high megaton field.

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*Edward (Ede) Teller--born January 15, 1908, Budapest, Hungary--Inst. of Tech., Karlsruhe, Germany, 1926-1928--Ph.D., U. of Leipzig, Germany, 1930--numerous D.Sc.s, etc.--Rockefeller fellow, Copenhagen, 1934--Lecturer, U. of London, 1935--immigrated to U.S., 1935--Prof. Physics, George Washington U., 1935-1941--naturalized, 1941--Columbia U., 1941-1942--U. of Chicago, 1942-1943--Site Y (Los Alamos Laboratory), 1943-1946--U. of Chicago, 1946-1949--Los Alamos Scientific Laboratory, 1949-1951--U. of Chicago, 1951-1952--Livermore Laboratory, 1952-1975--Retired, June 1975. Participated in the early 1939 American work (Szilard, Tuve, Rosenfeld, Wheeler, Hafstad, Zinn, Fermi, Anderson, etc.) showing the possibility of a uranium 235 bomb--with Szilard visited Einstein Aug. 2, 1939, to obtain his signature on the letter to Roosevelt that led to the establishment of the "Advisory Committee on Uranium" (Oct. 1939)--consultant to that committee 1939-1941--with Fermi (fall 1941) calculated the feasibility of a thermonuclear bomb--assisted in production of world's first nuclear chain reaction, Stagg Field, 1942--presented the thermonuclear concept to the June 1942 Berkeley conference on atomic weapon progress--Group Leader, T-1, Los Alamos, 1944, hydrodynamics of implosion, Super--member, Los Alamos Tech. Board, July 1944--Group Leader, F-1, the Super and General Theory, Sept. 1944--Group Leader, T-7, Super, Nov. 1945--Observer, Trinity, July 1945--Asst. Director, Los Alamos Scientific Lab., 1949-1951--led conceptual work that invented "secret" of the thermonuclear bomb 1951--pressed for second nuclear weapons laboratory 1952--joined Livermore 1953--Assoc. Director 1954-1958--Director 1958-1960--opposed complete test ban and proposed underground testing as alternative 1957-1962--pressed for "clean" weapons. Member, USAF Scientific Advisory Board--fellow, American Nuclear Society--fellow, American Physical Society--member, National Academy of Science--others--Albert Einstein Award 1958--Fermi Award 1962--others.

**Norris Edwin Bradbury--born Santa Barbara, Calif., 1909--Whiting Fellow 1931-32--Ph.D. (Physics), U. of Calif., 1932--NRC fellow in physics, Mass. Inst. Tech., 1932 to 1934--Asst. Prof. Physics, Stanford U., 1934-1937--Assoc. Prof. 1937 to 1942--Prof. 1942 to 1950--Prof. Physics, U. of Cal., 1950--active service, U.S. Naval Reserve (Commander), 1941 to 1945--Dahlgren Naval Proving Ground (exterior ballistics) 1941 to 1944--joined Site Y (later Los Alamos Laboratory) July 1944--Interdivisional Weapons Committee (responsible for all phases of nuclear weapon work peculiar to combat delivery) 1944--Group Leader X-1 (implosion research) Sept. 1944--Group Leader X-6 (weapon assembly), Mar. 1945--Technical Deputy, Project Alberta (activities concerned with combat atomic weapon delivery), Mar. 1945--Group Leader, TR assembly Project TR (Trinity), June 1945--Director, Los Alamos Laboratory, Oct. 1945--member, USAF Scientific Advisory Board--member, Science Advisory Committee, Office of Defense Mobilization, 1955-1957--retired, Sept. 1970. D.Sc., honorary, Pomona--D.Sc., honorary, Case--LL.D., honorary, U. of N.M.--fellow, American Physical Society--fellow, National Academy of Sciences--Phi Beta Kappa--Sigma Xi--Navy Legion of Merit 1945--Special Certificate, U. of Cal. Regents, 1960--DOD Distinguished Public Service Medal 1966--AEC Citation 1968--Fermi Award 1970.

***Author's comment.

They further opined that explosions below 5-10 kilotons yield could be concealed in Russia, that one megaton would be observed, that long-range detection would *not* give the size of the explosion (to any reasonable accuracy), and that therefore (if a low threshold were to be chosen), close-range surveillance and observers would be necessary.

Lastly, they agreed that a temporary moratorium would not seriously damage the weapons program, but that if it went beyond January of 1957 (2-1/2 years), the detrimental effects would be serious, and that beyond that time the effects would be rapid and cumulative.

By the beginning of 1958, several main paths of effort, with respect to a possible moratorium or test ban, were evident within the weapons complex. While there was real-time interplay between the subjects, they were roughly as follows:

a. information, participation, and "guidance" to the centers of government concerned with treaty-related questions,

b. changes to the test and design schedule to accomplish as much as possible in the time remaining,

c. consideration and actions on those subjects that might maintain the health of the weapons complex post-treaty, and

d. possible post-treaty "readiness to test" considerations.

As mentioned before, the separate components of the complex attacked the problems differently. Briefly, Livermore, still trying to "prove itself" as a laboratory, was hawkish. It emphasized the need of continued testing, warned of possible Russian cheating, proposed alternatives such as underground testing, worried (both theoretically and experimentally) about seismic detection, and pressed for some of those alternate activities that would maintain their competence, such as Plowshare (peaceful uses of nuclear explosives), Pluto (an air-breathing nuclear propulsion reactor system), and testing below an observable threshold. Los Alamos, "old tried and true," took a somewhat more relaxed view. Having been through so many "scares," they really did not believe a moratorium would actually come about, and resisted external pressure to act as if it would. Bradbury and a large portion of his staff thought that a moratorium might actually be good for the laboratory, that some means of coming to agreement with the Russians had to be found, and that further weapon development might not be particularly "cost effective" to the country. LASL seemed to feel that between Rover (space nuclear propulsion program), the compilation and analysis of old test data, and the peaceful contemplation of genuine new weapons concepts, they could be well employed for several years.

The AEC tried to fight a bad situation as best they could. Like Livermore, they resisted a treaty, tried to find alternatives, and urged the accomplishment (at least for the AEC) of as much as possible before such a treaty might come about.

The Department of Defense shared the AEC views and moved in a similar manner. Unfortuntely, AFSWP was in the throes of a possible reorganization (or even deletion) and could not put substantial effort on the subject.

During the year 1958, before the moratorium went into effect, the various test organizations expressed their future needs, through appropriate channels, to the upper echelons, usually with the attitude that they must be ready to test again soon, or that it really wasn't going to happen and life would go on as it had before.

We will now take up separately some of the facets of these activities in 1958, even though the subjects were, in general, not actually separated at the time.

AEC Laboratory Health in the Light of a Possible Moratorium

Partly because of continual questions on the effects of a moratorium, and partly because of just general worrying about the weapons program, Bradbury gave Starbird* some of his feelings on the subject on January 8, 1958. After expressing concern that the laboratory (LASL) had "lost control of its own destiny" since it no longer chose what it felt best to work on in the light of its own knowledge, but rather responded to external pressures from the AEC and DOD (brought about partly by the growing strength of Livermore and AFWSP),** he commented that he felt the laboratories were now making very little progress per dollar invested, and that perhaps a moratorium would be a good thing in a certain sense right now:

> If we had to sit down and think, if we had time to sit down and think, we might think of something. It is very unlikely that with the press of affairs as they are, and with the general attitude of the Commission what it is, and with our own response what it is that we will have the intellectual fortitude to say "No!" to any proposal, nor will we, with the continual workload (which we will partly bring upon ourselves) find the elusive "new" idea if it exists at all. ...A moratorium followed by the possibility of further testing would at least force us to take stock of our whole situation. ...It is my own impression that LASL has let itself get slightly too bogged down in mass production of weapon designs, and that we should try to take that aspect of our life a little easier and work a little harder in general research--which is thought to be good for the country too! It is for reasons like this that the thought of a moratorium, cast in the proper context, is not too painful.

Livermore, however, was not so pessimistic. In March 1958, Teller (who had recently assumed the position of director of Livermore) gave Starbird a thick document listing all of the work required in the major problem areas, and concluded:

> The above enumeration clearly indicates that there is far more useful work to be done than a laboratory of the present size of UCRL can possibly do in the immediate future. This poses the difficult and dangerous problem of choosing the ultimately most useful and desirable ideas from among the many promising and in some cases unexplored candidates. We feel that, at least at the present level, limitations of funds should not be the determining factor in our ability to pursue some of this work.

As a result of the growing pressure, the AEC commissioners called the laboratory representatives into Washington on May 28, 1958, to discuss the effects of a moratorium, but they never got around to the question of the laboratories, spending most of their time on the values of underground testing.

However, Bradbury continued to seek guidance, and it finally came (copy to Teller) on July 11, only a few weeks before Eisenhower announced the moratorium, in a

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*Alfred Dodd Starbird--born April 28, 1912--West Point 1933--Army Corps or Engineers--Col. 1944--Instructor, United States Military Academy, 1938-1942--War Department General Staff, 1942-1944--Commanding Officer, 1135 Engineering Construction Group, European Theater, 1944-1945--Operations Division, War Department General Staff, 1945-1950--Secretary, Supreme Headquarters Atlantic Powers Europe (SHAPE), 1950-1953--Office Chief of Engineers, Department of Army, 1953-1955--Director, Division of Military Application, U.S. Atomic Energy Commission, 1955-1961--Director Engineers, Northwest Pacific Division, 1961--Commander, Joint Task Force Eight (Dominic), 1961-1962--Director, Defense Communications Agency, 1962-1968--Director, Defense Communications Planning Group, 1966-1968--Safeguard (Sentinel) System Manager 1968-1970--retired from the Army (Lt. Gen.) 1970--Asst. Director for Test and Evaluation, Defense Research and Engineering, 1970-1975--Asst. Administrator for National Security, U.S. Energy Research and Development Administration, 1975-1978. Four Distinguished Service Medals, Legion of Merit, two Bronze Star Medals. (Ed. note: Deceased 1983).

**Author's note.

letter from Libby* (acting AEC chairman). The answer was in two parts, as follows:

1. Laboratories as excellent and experienced as Los Alamos and Livermore are national assets and whatever our future holds there will be important work for you to do. Consider two of the possible types of moratoria or disarmament arrangements.

   (a) Test ban only. Then your job--on atomic weapons--would be to digest and collate the results from Plumbbob and Hardtack, which are rich sources of basic weapons science that when fully understood and analyzed will enable us without additional tests to materially improve our weapons designs. A period of eighteen months or two years probably could be most profitably employed in this way. Experimental work at subnuclear yields probably would be involved.

   In addition, we hope that whatever the nature of a test ban, there would be special exception made of the nonmilitary applications of nuclear explosions so this potentially important development could be continued, possibly under the aegis of the test ban authority conducting the inspections and control of the ban. Particularly in the case of Livermore, but also in the case of Los Alamos, this would serve as a meaningful and challenging project to which the weapons design experts might turn their talents to designing Plowshare devices, i.e., devices especially designed for nonmilitary application where consideration of cost, diameter, fission to fusion energy release ratios, neutron escape efficiencies, etc., are dominant as compared to weight, yield to weight ratio, and similar considerations dominant for military applications.

   (b) Full disarmament with present stockpile frozen except for reworking and continued maintenance and Plowshare continued under the aegis of the disarmament authorities.

   The reworking possibilities are large and the full consideration of our present factual knowledge may well reveal significant and important stockpile changes that could be made safely by reworking and without testing at full yields. In any case both the tasks outlined above under (a) would remain.

2. The second part of our guidance would be to advise you to make plans on a strictly confidential basis which you would hold in readiness to reorganize your work and reslot people should a cessation actually occur. The existence of such plans we believe should be closely held by you to prevent there developing in the laboratory a feeling that you, and we, believe a moratorium or cessation is immediate. Neither of us, of course, so believe.

   The plan should be to get the laboratory in the best possible scientific trim beginning immediately so that its ability to perform a wide variety of scientific tasks efficiently and wisely will be at a maximum. Probably the stratification or separation into development groups for weapons or atomic power, etc., on the one hand and into pure research groups on the other which appears to be taking place should be reversed so that the rule would be that all scientists at the laboratory are expected to have research of good quality underway and to be fully conversant with a broad field of scientific literature outside their particular field of development concentration.

   This might lead to more people working on weapons by the addition of part of the personnel from the pure research groups but with everyone being expected to spend part of his time in basic research, the net effort in the development program as a whole would not be greatly changed in total manpower. Of course, there are always individuals who are constitutionally unable to do development work and basic research simultaneously and provisions for exceptions in these cases should be made, but it would be our hope that the shift in trend described be made so that the natural tendency toward stronger and stronger preoccupation with narrow fields and development interest be counteracted so our weapons laboratories can be kept young and scientifically agile. In these ways we think you can plan wisely for the future, whatever it holds.

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*Willard Frank Libby--born Grand Valley, Colorado, 1908--Ph.D. (Chem.), U. of Calif. (Berkeley), 1933--Other Hon. degrees--Staff Berkeley, 1933-1945--Columbia U. War Research Div., 1941-1945--Inst. of Nuclear Studies, U. of Chicago, 1945-1954--AEC General Advisory Committee, 1950-1954--member USAEC, 1955-1959--Prof. Chem., U. of Calif., Los Angeles, 1959 to death in September, 1980. Helped develop gaseous diffusion method of uranium separation--invented carbon-14 dating technique--as Commissioner and as member of the GAC urged Civil Defense, the development of the Super, understanding of fallout radiation hazards, establishment of a second weapons lab. Many awards, including Willard Gibbs Medal, 1958; Albert Einstein Award 1959; Nobel Prize for Chemistry 1960.

However, the situation changed as soon as the President announced the moratorium (August 22, 1958). On that day the President (Eisenhower) sent the following letter:

> Dear Dr. Teller:
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> I am today announcing that the United States will suspend nuclear weapons tests for a period of twelve months and, under certain conditions of progress toward real disarmament, continue that suspension on a year-to-year basis.
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> It will, of course, require an extended period to negotiate and install a genuine and assured disarmament arrangement. Even though we will not be doing any weapons testing, it will be necessary that we maintain our weapons development progress during the period and with no less urgency than in the past. It is necessary, in the interest of our country's defense, that the staff of your laboratory, and that of the other weapons development laboratories, continue their research and development in this field with their current vigor and devotion.
>
> I am instructing the Atomic Energy Commission to develop plans to see that these essentials are met and that the vitality of our laboratories is maintained.

Similar letters went to McRae (Sandia) and Bradbury.

John A. McCone, by now chairman of the Commission, emphasized to the laboratories on August 22 that they must maintain the capability to return to testing with a minimum of delay, since the Soviets might not fulfill the conditions set forth by the President for the moratorium. He furthermore pointed out that Plowshare was not included in the moratorium, so that experiments on the peaceful uses of nuclear explosives should be scheduled for firing during the forthcoming year.

In spite of their general support, the Commission worried about laboratory size. The question was apparently triggered off by the growth of the Sandia Laboratory, but the discussion usually concerned Livermore and Los Alamos. Libby had the feeling (early August) that Los Alamos had grown too large, and that Livermore was at just about the right size. Budget reductions because of the proposed moratorium were already being proposed, but on August 27, after Colonel Stewart of DMA* had commented that "the proposed reductions in weapons budget would adversely affect weapons laboratory personnel," the Commissioners stated that "any underruns from other programs would be allocated first to the weapons program." Libby again suggested, on September 17, that the laboratories be held to a limit of 3,000 persons, but no action was taken because of the President's statement that the laboratories should be kept at peak efficiency, and that every effort should be exerted to maintain the morale of the laboratories.

As the moratorium approached, there was time for one more round. In October 1958, McCone requested that the laboratory directors inform him of the status and plans for activities of the laboratories during the moratorium. Teller, for Livermore, replied with their plans to work on Pluto, increase their efforts in pure research, continue with Sherwood (controlled thermonuclear reactors), investigate nuclear weapons using new channels and perhaps methods of testing, study seismic detection with nuclear or high explosives, look at nuclear experiments other than testing, weaponize already proven weapon designs, and expand Plowshare. He pointed out that nuclear explosions might be permitted at high altitude, and that at least theoretical work and nonnuclear experiments should be permitted. Bradbury, for Los Alamos, outlined a program, for a short-term moratorium, of weapons development, improvement in diagnostic techniques, and other means of furthering weapons progress without actually testing, but emphasized that if the moratorium were to continue more than a couple of years the role of LASL in the national picture was not obvious and

*Division of Military Application, AEC.

should receive very careful consideration at that time. He also pointed out the possible diversion of laboratory effort to Rover, Sherwood, and Plowshare.

Premoratorium 1958 Nuclear Test Operations

It is not here intended to go into any detail on the 1958 test operations, but simply to outline some of the interplay with respect to testing that occurred as the testing community gradually became aware during the year that the moratorium was approaching reality.

At the beginning of 1958, five test operations were in sight. Hardtack, to be conducted in the spring at the Eniwetok Proving Ground (EPG) had been approved for construction by the President, and preparation was well under way. Project 58A was a small operation in the winter at the Nevada Test Site, to include only a few one-point detonations. 58B, soon to be called Millrace, would be a small fall operation at NTS, to include some four Livermore underground tests and several one-point safety tests from both laboratories. Trumpet would be a full-scale operation in the spring of 1959 at NTS, in which Livermore intended to concentrate on underground shots, but LASL would continue its undisturbed way with tower and balloon shots. And planning for Willow, a 1960 EPG series, was just beginning.

Clearly, by this time, Livermore, spurred by Edward Teller, Gerry Johnson,* and others, was well down the path toward going underground for most of their nuclear testing. They had conducted the "Rainier" shot, Ex.(b)(3) [redacted] at 1.7 kt underground in September of 1957 and were well satisfied with the results. In early January, Livermore planned to fire a shot at 40-kt yield underground in Millrace, and "By increasing the yields of devices tested by a factor of 20 or so each time, it is hoped to reach the megaton range in underground testing by 1959." Teller was to spend a great deal of effort during 1958 attempting to convince the AEC and the President, with some success, that we could accomplish the main purpose of a test ban, the reduction or elimination of fallout, by going underground. Los Alamos, however, was less than enthusiastic. Bradbury felt that it was most unlikely that good yield measurements could be made underground, or that multimegaton device development could be carried out there.

In addition to the "normal" AEC development shots, planning had started in mid-1956 by AFWSP, assisted by the AEC laboratories, to include three "high-altitude" shots in Hardtack. The three shots were to become Yucca, a balloon-lifted, 1.7-kt Ex.(b)(3) to be fired at 87,500 feet; Teak, a 3.8-Mt Ex.(b)(3) to be lifted by a Redstone missile and fired at 76 km altitude; and Orange, also a 3.8-Mt Ex.(b)(3) to be lifted by a Redstone missile and fired at 40 km altitude. The experiments were planned to document the effects of such shots because of the growing interest in antiballistic missile systems. The major portion of the experiments was to be done by the DOD (radar effects, ablation, etc.), but the AEC laboratories would participate (small rockets, nuclear and optical measurements).

*Gerald W. Johnson--born Spangle, Washington 1917--B.A. and M.A. Washington State 1937 and 1939. Ph.D. (physics) UC Berkeley, 1947. Navy 1941-1946 (Lt. Commander)--Active duty, AFSWP 1951-1953 (participated in Operation Buster-Jangle)--Lawrence Livermore Laboratory, 1953-1961, Associate Director for Plowshare and Test--Test Director NTS mid 50s--Livermore Task Unit Leader, Operation Redwing (1956). Chairman Military Liaison Committee & Assistant to the Secretary of Defense for Atomic Energy, 1961-1963. Returned to Livermore 1963-1966--Director of Navy Labs, 1966-1968--Secretary of Defense Rep. SALT and CTB negotiations 1977-1979. Appropriate Navy and DOD awards.

On January 22, 1958, the AEC approved Hardtack (25 tests) and Millrace (4 tests and up to 10 one-point safety tests), and arranged for execution authority to be requested of the President. Approval for Hardtack was received from the President on January 31, but he did not approve Millrace.

Several complications to the test plans began to appear in January and February of 1958. As a result of the Livermore conviction that "clean" weapons were a boon to mankind, a proposal was made, and accepted by Eisenhower, to include a demonstration "clean" shot (Piñon) in Hardtack. The 14 member nations of the U.N. committee on radioactive fallout were to be invited. They were to be furnished "samples" of the radioactive cloud on which they could do their own radiochemistry. CJTF-7 (Luedecke*) had not yet included this shot in his plans. The idea seemed to be to convince the U.N. that nuclear tests could be conducted without serious fallout hazard to the world, and perhaps that clean weapons would not hurt noncombatants.

Late in 1957, N. C. Christofilos, of Livermore, proposed that electrons from a high-altitude shot such as Teak could become trapped in the earth's magnetic field, and offer a possible AICBM** mechanism, in addition to producing an appreciable amount of radio noise. A long conference, held at Livermore February 10-21, 1958, and attended, amongst others, by J. R. Killian, chairman of the President's Science Advisory Committee, concluded that Teak would not produce serious effects on military radar and radio systems, but that a properly optimized shot might cause difficulties for several months. Because of the large uncertainties in the calculations, the group recommended that a small shot be fired to establish the facts. This was to become Project Argus.

Project 58A had started in December of 1957 with two LASL safety shots. Unfortunately, one of these, Coulomb-C, gave a yield of 500 tons, producing observable fallout on Los Angeles. The project was completed with the Livermore Venus shot on February 23, 1958, and Uranus on March 14.

Further difficulties began to appear. Teak and Orange had been planned to be launched from Bikini Atoll, and construction of the Redstone launch facilities was mông rapidly on Bikini Island during February and March 1958. The question of a possible eyeburn problem had been raised during 1957 planning, but was dismissed as not serious by the DOD planners. However, when the Task Force began to seriously look at the question early in the year, the answer was not so obvious. By March, they were convinced that the eyeburn hazard would extend some 350 miles from Teak, an area including 2,000 to 4,000 Marshallese natives. It did not appear practical to the Task Force to control 4,000 natives over such an area. The alternatives were to cancel the shots, take the chance, or move the launch point. It was estimated that moving would take a minimum of five months. Complicating the problem was the fact that some of the needed measurements were to be made from an Army satellite, launched for that purpose during March, which might no longer operate if Teak were delayed the necessary time to move the launch point. During late March, Starbird urged the

*Alvin R. Luedecke--born Eldorado, Texas, Oct. 1, 1910--B.S. Chem. Eng. 1932, Texas A&M College--2nd Lt. Army Field Artillery Reserves 1932--Wings Feb. 1934 (Kelly & Randolph)--Army Air Force (regulars) Oct. 1938--Military Attache for Air to Central America 1939-1941--U.S. Air Force Jan. 1947--Exec. Sec. Military Liaison Committee to the AEC 1948-1949--Deputy chief AFSWP 1951-1954--Chief AFSWP 1954-1957--Maj. Gen. USAF, Commander Joint Task Force Seven 1957-1958, immediate administrative head of the Hardtack Operation at the EPG--retired from Air Force 1958--General Manager, AEC, 1958-1964--Deputy Director Jet Propulsion Laboratory 1964-1967--Associate Dean of Engineering in charge of research, Texas A&M, 1967-1970--Acting Pres., Texas A&M, 1970--Executive Vice Pres. for Texas A&M system 1970-1976--retired Aug. 1976. Distinguished Service Medal--Legion of Merit (two clusters).

**Anti-Intercontinental Ballistic Missile.

Commission to approve firing the shot on April 16 as planned, trusting to the Task Force to protect the natives. But the Task Force had already proposed alternate sites (Wake, Midway, Christmas, Johnston). Luedecke, JTF-7 commander, discussed the problems with the Trust Territory officials, and Louis Strauss, chairman of the AEC, discussed it with John Foster Dulles. Frank Shelton,* AFSWP chief scientist, Al Graves,** Dodd Starbird, and Herbert Loper, Assistant to the Secretary of Defense for Atomic Energy, jointly agreed (March 2) that it would be wise to move the detonations. On March 22, 1958, "even though he thought the Hardtack test series would be the last in the Pacific and he could appreciate the need for this vital defense information, the chairman (Strauss) questioned the element of urgency, inasmuch as the Commission had known nothing of the development six months ago." In early April, the Commission decided that they liked Johnston Island (Strauss had been there) and told Starbird to seek DOD concurrence on the move and/or concurrence in canceling the shots. Starbird discussed the point with Herbert Loper, who determined, early in April, that the JCS did not wish to delay or move the shots. On April 7, 1958, Strauss and Killian met with State and Defense on the subject. Dulles agreed with Strauss that any case of eyeburn could jeopardize the rest of Hardtack, and hence the recommendation was made to move to Johnston Island. On April 9, the President concurred, with the usual admonition to hurry.

Livermore had proposed their 40-kt underground shot in Millrace as a step toward proving the feasibility of underground testing, but construction difficulties, as they appeared in February and March, made it appear that it could not be accomplished in Millrace, but would have to wait for Trumpet. However, by March, two other pressures were beginning to develop. The Commission was beginning to suspect that the future held only underground testing, if any, so there was need to gain more experience with the technique. Furthermore, the need of further seismic data was becoming apparent. Thus, in early March, both Starbird and Libby argued the need of an early (December 1958-January 1959) test at the NTS of at least 40 kt underground.

While the possibility of a CTB was becoming more real, it still, in early March 1958, was not the only item of concern to the testing system. Over the last several years, there had been a growing feeling, largely fostered by Livermore, that short-time "operations" were not conducive to maximum efficiency in bomb development, and

*Frank Harvey Shelton--born Oct. 5, 1924--Flagstaff, Arizona--Ph.D., Calif. Inst. Tech., 1953--Sandia Corp. 1952-1955--Armed Forces Special Weapons Project 1955-1959--Kaman Sciences Corporation 1959 to present. Participated in blast and thermal measurements, Operations Tumbler-Snapper, Ivy, Upshot-Knothole. Associated with AFSWP (Kirtland) in preparations for HA event of 1955. Military effects test planning for Teapot MET (1955). As AFSWP Technical Director directed planning and arranged funding for DOD effects tests for Redwing, Plumbbob, Argus, Hardtack I and II. Participated in U.K. Buffalo series, Australia, 1956. Participated in decision to move Teak and Orange from Bikini to Johnston Island. Assisted in White House considerations leading to 1958 test moratorium. Prepared test plans for Willow, including planned high-altitude events. Assisted in formulating high-altitude test plans for Dominic (1962), and participated in tests.

**Alvin Cushman Graves--born Washington, D.C. 1909--Ph.D University of Chicago, 1939--U. of Texas, 1939-1941--U. of Chicago Met. Lab., 1941-1942--Los Alamos 1943-1965. Participated in first nuclear reactor construction and operation at Stagg Field 1942--moved to Los Alamos with first group from Met. Lab. 1943--operated displacement seismographs at Trinity--Group leader M-4 (electric method) 1945--Associate Division Leader M Division 1946--involved in major radiaton accident (over 200 R) while in M Division--Associate Division Leader of temporary J Division for Operation Sandstone (1947-1948)--Division Leader, J Division 1948-1965--Deputy Commander for Scientific Matters (or variations of that title) of Joint Task Forces 3, 132, and 7, Operations Greenhouse, Ivy, Castle, Redwing. Scientific Advisor (or similar title) to the test manager, all Nevada Test Site operations 1951-1965. Deceased 1965. Exceptional Civilian Service Award, Air Force, 1951--Certificate of Achievement, Army, 1954--Distinguished Service Award, FDCA, 1955--Senior Reviewer, AEC--Fellow, American Physical Society.

that "continuous" operations should be considered. Starbird began to investigate this subject by inquiring of the laboratories as to their opinions on continuous operations at the EPG with intermittent underground shots at the NTS, as opposed to continuous operations at the NTS and intermittent large-yield shots at the EPG. Ken Street for Livermore and Bradbury for LASL both preferred continuous operations at the EPG with intermittent operations at the NTS, but Bradbury again expressed his unhappiness at the underground concept for the NTS.

Other evidences of the growing pressure to get problems solved while there was still time appeared in March and April 1958. The DOD, following their growing interest in x-ray effects, were contemplating the design of an underground x-ray simulation shot Ex.(b)(3) and began conversations with Livermore and Sandia concerning a forerunner experiment that might be done on the proposed Ex.(b)(3) to establish some of the techniques. Livermore, represented by Gerry Johnson, needed an immediate commitment (April 3), while Sandia simply did not have the effort for a fall experiment.

Now that Teak and Orange were delayed, Commissioner Libby, who was trying to keep worldwide fallout from Hardtack to a minimum, proposed in April that the Ex.(b)(3) warheads for those shots be replaced Ex.(b)(3) Bradbury (LASL) replied that Ex.(b)(3) might be available by 1960.

The Air Force proposed (March-April) that systems tests of the Nike Hercules and the Ex.(b)(1) be conducted as soon as possible. Since it seemed too late to get the shots into Hardtack, they proposed that the shots be done at the NTS. The Commission felt that the NTS was too small to be shooting nuclear weapons at drones, so the Air Force proposed Eglin Air Force Base, which was accepted as a basis for study.

The Argus concept began to take hold. As a result of action by the Armed Forces Policy Council on March 11, Livermore was directed to undertake the necessary further theoretical work and to submit recommendations as to the nature of any nuclear test to be conducted. In order to effect close coordination between the Department of Defense and the Atomic Energy Commission on the subject, the Deputy Secretary of Defense on March 24 designated AFSWP the responsible agency for the DOD, in coordination with the Advanced Research Projects Agency (ARPA). By memorandum April 4, the Deputy Secretary of Defense assigned the overall responsibility for the management of this research and development program for the DOD to the Director, ARPA. During March, the conclusion was reached that it was practical to conduct the experiments, but because of the uncertain future of nuclear testing, the experiments should be done quickly, not as a part of Hardtack, but rather in the Atlantic, with a ship-based launch. The requirement was for 2-10 kt at 500-800 miles altitude and 30°-45° geomagnetic latitude. The Commission approved the concept in principle during April, but worried "that if the shot were carried out at the proposed location, the U.S. would not be in a position to object to weapons testing by the U.S.S.R. in international waters." Teller informed Starbird that there would be no eye damage to observers and, in fact, there would be no perceptible effects at sea level. On May 1, the President approved the nuclear test, to be called Argus, to be conducted before the end of Hardtack, and specifically before September 1, 1958.

On April 28, the first shot (Yucca) of Hardtack was fired. Presidential pressure had led to an initial proposed finishing date of late June, but now, because of the move of Teak and Orange, late August appeared to be the earliest possible end of Hardtack. Additional shots were beginning to appear for Hardtack, but the only further solidification of plans for Millrace was the statement of the intended starting date, September 15. Livermore concluded that by really pushing construction, they might get a 40-kt underground shot ready by November or December, but

otherwise the largest shot planned was 5 kt. LASL still planned only a few one-points. The Commission, on April 16, asked its GAC* to consider the question (at their May 5-7 meeting) of how testing might be conducted if only underground testing were permitted. They approved a number of 20- to 40-kt underground shots for Trumpet (early 1959). The crisis had not yet been recognized.

May 1958 was a comparatively static month. The laboratories and field staff organizations were up to their ears in actually conducting Hardtack and preparing for Millrace. LASL had finally broken down (largely as a result of the furor about fallout on Los Angeles from the December 1957 one-point shot) and decided to try some of their proposed Millrace one-point shots underground. Contracts were let to produce the holes (36 inches by 500 feet) between June 8 and July 19, so that, under pressure, operations could start as early as August 1. Tunnel work for Livermore continued. The Commission declassified certain information about Piñon, which was now definite, even though the Task Force had not figured out how to handle the foreign observers. They also approved the Eglin tests, to be conducted by the DOD with AEC review of safety and operational plans. Dulles had stated that such tests should be finished by September 1, in view of a possible moratorium, and Starbird worried that accelerating too many weapons tests to meet a September date might tip our hand internationally, making us appear over-anxious to enter a moratorium. The laboratories requested two definite additional shots for Hardtack and one contingency. The Commission worried about the President's concern with additional fallout Ex.(b)(3) [redacted], but concluded that he might accept the additional shots, since Hardtack might be the last test series. They requested (May 28) the additional shots, and also requested approval for Millrace. If Millrace were not to be approved, then they requested two more Hardtack shots, one to be a one-point safety shot. No additional Millrace tests (except for the 40-kt underground) were yet contemplated.

The picture began to change in June, however. J. B. Fisk, R. F. Bacher, and E. O. Lawrence, now appointed by the President as U.S. delegates to the "Conference of Experts," discussed with Strauss the urgent need of seismic data from a larger underground detonation than Rainier, and were told that such a shot might be possible in October. The field test system started another round of "what can we do?" discussion immediately. Libby (June 12) offered the opinion that some of the disappointing results from Hardtack were coming about because the laboratories were not properly studying data from earlier experiments, but since Hardtack might be the last test series, any tests the laboratories now considered important should be carried out without regard to the number of shots. Starbird moved rapidly, asking the laboratories on June 13 to consider finishing Millrace by November, assuming no monetary limitations. Bradbury, Teller, and Hertford** (ALOO) all answered that they could meet the date, assuming extra funding. By the 18th, the President had approved the additional shots to Hardtack, and had approved Millrace, requesting that it be accelerated to begin before the end of Hardtack. LASL now began to take the moratorium possibility more seriously, and suggested to Starbird that a new set of tunnels to allow some full-scale LASL shots in Millrace might be practical. Starbird said to go ahead, and by the end of June, the decision to start two LASL tunnels had been made, even though it was estimated that the 3,000-foot tunnels could not be completed before December.

Task Force 88, commanded by Rear Admiral Lloyd C. Mustin, was activated for Operation Argus planning purposes June 2, 1958, and for operation on July 14.

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*General Advisory Committee

**Kenner F. Hertford, Manager, Albuquerque Operations Office (AEC).

On July 2, 1958, Eisenhower told State to inform Mexico and Cuba of the possible Eglin shots, with the comment that if either government objected, the tests would be reconsidered. The operation was canceled on July 24, 1958.

By now (July 1958), the system was moving in all directions. Commissioner Libby had forced the movement of at least one EPG shot to "reduce" worldwide fallout,* the Piñon shot to demonstrate weapon cleanliness was coming closer, the possible moratorium was becoming more real; and Teller was convincing the Commission to argue for a treaty limiting testing to underground only, rather than a moratorium or CTB. The word was going around that only underground testing would be allowed from now on, and Kenner Hertford (ALOO) proposed that in order to guard against Millrace being canceled, it should immediately be publicly announced as an all underground operation. The laboratory directors and Starbird had a go-round on the subject in mid-July. Starbird had just informed the directors that Trumpet (spring 1959--NTS) would have, in his planning, about 18 shots (Bradbury was worried that Teller would want more than nine, but was uncertain as to whether to argue about it or not, because he was not sure LASL needed even nine). Teller (July 11) felt that DOD, Plowshare, and safety tests should all be separated from weapons tests and that all 1959 weapons tests should be underground (although, were the decision different, Livermore would do a few above ground in order to conduct "special" diagnostic experiments). Bradbury and Graves resisted, but were willing to move toward underground and balloon shots, eliminating tower shots. Starbird (July 17) agreed with both, but would not go along with an immediate limitation to only test underground, suggesting instead "to limit our testing to the degree possible without impeding weapons development." At a lower level, LASL J-6 canceled their tower construction plans for 1959 and began working on six underground locations. Reflecting the now real pressure, LASL tunnel construction was halted (presumably temporarily) since the proposed devices could not be ready before December. Bradbury's information was now (late July) that Millrace would have to be finished by November 15. The LASL test division reaction to all this was relief at not having to rush underground for Millrace, and disappointment at having to do "expensive" testing underground in 1959.

With the additional shots and the move of Teak and Orange, Hardtack was beginning to stretch out, threatening to become a possible embarrassment with respect to a moratorim, and eating into the time that the test experimenters had to prepare for Millrace. Luedecke, JTF-7 commander, who had just been approved as the next AEC General Manager, pointed out (mid-July) that the intended "open" clean shot, Pinon, would stretch the operation an extra two to three weeks. Starbird, on July 10, in Strauss's last few days as AEC chairman, suggested reappraisal of the program. Some 3-4 million of the estimated 10 million dollar cost of the program could still be saved. Six of the fourteen nations invited (Sweden, Brazil, Canada, Belgium, Australia, and France) had accepted, but the Soviet Union, Czechoslovakia, and India had declined. The Commission agreed it should be canceled. But a week later, at John McCone's first Commission meeting as chairman, the subject was chewed over again. The OCB (Operations Coordinating Board), including State and CIA, were all opposed to canceling the shot, on the basis that it would be embarrassing to the President, and that they felt the AEC had not told them all the real reasons for cancelling the shot. The Commission (July 17) changed its mind, agreed that the demonstration should be held, but asked Starbird to try to get Luedecke to accelerate the shot. On July 26, the President canceled the shot.

*During Redwing and Hardtack I, Libby tried to reduce the solubility of radioactive fallout by arranging that large amounts of silica sand be emplaced within the fireball region of Pacific shots and/or arranging that the shots be on a coral reef. If the solubility could be reduced, the hazard of ingestion would be lessened. No effect was noted.

Teak was fired on August 1, 1958, and Orange, the other major high-altitude shot of Hardtack, on August 12. Both detonations occurred at the wrong position in space, and, due to cloud cover, the detailed photographic coverage was almost nonexistent. Hoerlin,* on behalf of LASL, managed to get a request for a repeat of Teak through channels to Starbird even though the DOD said they were satisfied with the results, but the argument was not sufficiently convincing, and (August 14) the request was denied, Starbird agreeing with the DOD decision. (In retrospect, considering the surprises of Dominic, one can speculate on the probably strongly different course of events had the Teak repeat been approved.) At about this time, it became obvious that Argus could not be finished by September 1, and the deadline was extended to October 31.

In spite of all the flurry, in early August the plans for the Millrace operation, to begin September 15 or earlier, still had not changed significantly, Livermore still intending to do a few low-yield shots underground, and LASL intending to do a few one-point safety shots.

On August 18, the last shot of Hardtack, Fig, was fired. Instead of the originally intended 24-25 shots, some 35 detonations took place during Hardtack.

Four days later, the roof fell in. On August 22, President Eisenhower announced a one-year moratorium to begin October 31, 1958. As Bradbury put it, "It was time for the troops to fall out and fall in again." This time the initial question from Starbird to Teller, Bradbury, and Hertford was by telephone: "Give me the possibilities for tests than can be conducted at the NTS before October 31 as soon as possible."** The laboratories, after conferring with ALOO and other parts of the test organization, answered on the same day. LASL had just been given the responsibility for the XW-38, 3,000-pound, Ex.(b)(3) ICBM warhead, a decision still debatable to Livermore, and proposed to do it by October 10 at the EPG. In addition, they could begin one-point safety tests at the NTS within three weeks, and offered a further list of low-yield devices of interest to the military that might be accomplished by the deadline date. They proposed to fire, in general, in the atmosphere, by any means that could be arranged. On the other hand, Teller answered that Livermore could finish out its work underground. Starbird put it together quickly, and managed to get out the same day the information that Millrace would now be called Hardtack Phase II (for political reasons), that it would include as many as nine small nuclear tests at the NTS, probably one shot at the EPG, and up to seven one-point safety tests. He directed that as many (pertinent) shots as possible be fired by October 31, postponing research, development, and production where necessary. He could not resist, however, telling the laboratories that they must be prepared to reinstate Trumpet at any time, and to continue planning for Willow at the EPG in 1960. The final words were, "We should eliminate projects directed toward conducting operations with greater economy, capacity, or content at either location" (NTS and EPG).

The next few days saw further solidification. On the 25th, Starbird listed seven tests for Livermore, but showed three as balloon tests, explaining that there

*Herman Hoerlin--born 1903, Schwaebisch-Hall, Wuerttemburg, Germany--Ph.D. Stuttgart--immigrated to U.S. in 1938, naturalized in 1944--Chief Physicist, General Aniline and Film Corp., Binghamton, N.Y., 1938-1953--Los Alamos Scientific Laboratory 1953-1972--visiting professor, Cornell, 1959 to 1960--retired 1972. As Group Leader of J-14 and later J-10, participated in all U.S. atmospheric test operations from Upshot-Knothole to Dominic with the exception of Argus. Concentrated on fireball yield, optical, and high-altitude phenomena. LASL Task Unit Commander for high-altitude shots, Hardtack and Dominic. First ascent of 24,500' Tongsong Peak (Tibet, Nepal) 1930 (highest peak climbed to that date). (Ed. note: Deceased 1983.)

**Inferred quote.

was no necessity to limit the tests to underground as yet. On the 26th Bradbury reaffirmed LASL intent to do the ICBM warhead at the EPG, but warned that the date was already slipping. On August 28 the President approved an accelerated Hardtack Phase II, but disapproved any further EPG shots, wiping out the XW-38 test.* The next day, McCone and McElroy (Secretary of Defense) publicly announced Hardtack Phase II, describing it as about ten low-yield nuclear detonations, several of which would be underground. But Sandia** was already moving rapidly to prepare for balloon shots.

The first Argus shot was fired August 27, 1958, not particularly satisfactorily, being followed quickly by the second on August 30, and the third on September 6. The "Argus" effect was not so serious as feared.

The Nevada Planning Board met on September 9, 1958, at Mercury, Nevada, being chaired by Duane Sewell*** of Livermore. The plan for Hardtack Phase II discussed was for six tunnel shots, one tower shot, up to four balloon shots, and several one-point safety shots. Among the agreed upon assignments were: Jim Reeves, Test Manager; Gerry Johnson, Deputy Test Manager; Duane Sewell, Scientific Advisor; Col. W. S. Hutchinson, Deputy for Military Matters.

Hardtack Phase II was a wild operation. It began September 12, three days before the earlier planned date, with a LASL one-point safety shot, Otero. Instead of the earlier planned four underground and seven one-points, there were 37 detonations in all. The largest underground detonation was Blanca, at 19 kt. The detonations took place underground, in the air (balloons), on various height towers, and even in "Gravel Gerties." The laboratories even traded firing sites on occasion to move faster. The last shot was Titania, a Livermore detonation, at 1:34 p.m. on October 30, and one shot, Adams, was left hanging in the air as midnight, local time, went by. The period was one of continual changes, requests to the President, DOD proposals, etc.

But the operation seemed hard to kill. On October 28, since the Soviets had indicated that they might continue their testing beyond October 30, Starbird asked the laboratories for plans to continue testing beyond October 31, what could be done in three months, six months, etc. Bradbury (LASL) came close to rebellion, pointing out that it was time to quit for a while and survey the situation, politics or no politics. He did weakly mention a few things that could be done, if really necessary. The October 31, 1958, meeting of the AEC resulted in the following note:

Ex.(b)(3)

[redacted]. However, in the afternoon, when the test was scheduled, the atmospheric conditions were such that some blast damage would have occurred over the Las Vegas area and so the test was delayed. At 11:00 p.m., the

*The W38, reassigned to Livermore, entered the stockpile in 1961-62 and was retired in 1965. The W38 was never tested.

**Sandia Laboratories, Albuquerque.

***Duane C. Sewell-born Oakland, Calif. 1918--Graduate student under E. O. Lawrence at Berkeley 1940--Manhattan Project, Oak Ridge (Y-12) During WWII--Assisted in development of 184" cyclotron at Berkeley, 1946-1950--MTA accelerator development of Berkeley 1950-1952--Became Director of Scientific Operations of UCRL (Livermore) in 1952--Senior operational member from Livermore for Operation Upshot-Knothole, 1953--Managed Livermore's nuclear test operations for Castle (1954), Teapot (1955), and Redwing (1956)--Scientific Advisor to the Test Manager for Hardtack, Phase II (1958)--Associate Director of LLL for support, 1959--Deputy Director LLL, 1973--Asst. Secretary for National Security, DOE, 1977 to 1980. U.S. AEC Citation, 1971--ERDA Distinguished Associate Award, 1977.

weather seemed to be clear and an additional high-explosive test was held to determine the blast prediction. This indicated that the last shot could safely be fired and a test was scheduled for 11:30 p.m. and General Starbird said he approved proceeding with the test at that time. Subsequently, the weather changed and it was decided the test would have to be delayed until 2:00 a.m. Starbird said he then conferred with Department of State officials and was told that U.S.-U.S.S.R. discussions were scheduled to begin in Geneva at 9:00 a.m., EST, October 31. He stated he decided at this point that in view of the probable political and psychological repercussions of holding a test at this late date the final test should be canceled. Starbird said there will always be a question as to whether the final shot should have been fired in view of its importance Ex.(b)(3) Ex.(b)(3) but that he believed that the other considerations were of overriding importance. The Commissioners unanimously agreed that General Starbird had made the right decision in canceling the final test.

Plowshare

Concepts concerning the possible use of nuclear explosives for nonmilitary purposes were discussed even before the first successful nuclear detonation. However, the program really began to move in the late 1950s with the establishment of the *Plowshare* (or PNE, Peaceful Uses of Nuclear Explosives) program, largely pressed by the Livermore Laboratory (then UCRL). Since the program grew at the same time as the worldwide pressure to ban nuclear weapons tests was growing, several emotions contributed to its approval. The program, if successful, would counteract the fear of nuclear detonations to some extent. It would (or would not, depending on the debater) allow some investigation of nuclear explosive design, especially clean design, under a nonweapon guise. It might actually be of some value to the human race. But most important, in the light of the subject of this book, it might be helpful toward keeping nuclear explosive design and experimental work continuing during a moratorium or test ban period.

In early 1958, whatever the reasons, Livermore and DMA were attempting to expand the program, with some help from Sandia, but essentially no interest on the part of Los Alamos. The main promoters at Livermore were Edward Teller and Gerry Johnson. Agreement had been reached with the Commission that the first attempt would be to conduct a harbor excavation experiment near Point Barrow, Alaska, in mid-1959. A four million dollar 1959 budget was approved in April (1958) for that purpose. In addition, conceptual planning was beginning for industrial application tests directed toward power production, mining, and isotope production. By May, the estimated cost was already up to seven million, and Starbird was looking, without success, for additional funding from the Departments of Interior and Defense. By June, the harbor project had been named "Project Chariot," no site had been chosen, but the detonation was now delayed to the second half of 1960. A second definite project, "Gnome," at 10 kt, to investigate power production, was now planned for early 1960 in New Mexico.

The August 22 announcment of a moratorium engendered a strong defense of Plowshare. On August 28, Teller wrote to Eisenhower and McCone, "All of us are anxious that the great possibilities of using nuclear explosives in peaceful pursuits should be fully exploited. We feel that if we do not succeed in carrying through this work, the United States will, in the long run, suffer in its power and its influence in a decisive manner." McCone answered the next day, " . . . The Commission believes that Livermore and LASL should give a high priority to this project. . . . Useful experiments can be scheduled . . . during the year's suspension (October 31, 1958-October 31, 1959) as well as for later periods. I request that your revised program be submitted. . . ."

By October, Teller had convinced the Commission that Plowshare work should not be confused with nuclear weapons work and had increased the scope of Livermore

studies to include the following items:

a. a channel through the reef at Kapingamarangi,
b. a harbor at Cape Thompson, Alaska,
c. a harbor at Katalla, Alaska,
d. a sea-level canal across the Alaska Peninsula at Port Moller,
e. oil excavation for Tar Sands,
f. a second power and isotope production-type shot,
g. the creation of artificial aquifers,
h. mining by leaching, and
i. excavation of oil from oil shale.

He further assumed that Gnome would be fired in FY 1959, and that three other experiments would be conducted in FY 1960, all to cost 5 million dollars in FY 1959 and 14 million dollars in FY 1960.

In mid-October, McCone suggested that the Operations Coordinating Board establish a Plowshare Advisory Subcommittee to stimulate wider interest in the program. But by the same time, the question of how to conduct "open" Plowshare shots under a treaty, convincing others that these were not really weapons tests, and still not revealing weapons design data, had already raised its ugly head. No immediate answer was obvious. McCone commented, however, on October 15, that "any competent scientist in the weapons field could determine simply from observing the instruments whether they were intended to record a weapons or a Plowshare test."

Nevertheless, Livermore entered the moratorium with this active, apparently funded, program that could "legally" keep some of their design and experimental people busy for a while.

Low-Yield Testing

Another concept that showed some initial promise of helping the nuclear weapon design and testing community came up not long before the moratorium began. Again, the question was raised by Edward Teller, who was convinced that the Russians would cheat, if possible. He therefore argued that, in essence, any test that was not detectable should be legal. On August 29, 1958, he wrote to Starbird that, as a general rule, any experiments with designs in which the nuclear energy production was not more than the energy production by the high explosive were obviously not tests of the nuclear weapons and should be permitted as experiments. Furthermore, since tests of a kiloton and smaller could not be detected and identified, he suggested that "explosions of military significance below a limit of at least 100 tons be permitted. These explosions will be important for our future weapons development." He further suggested that any future international agreements should not prohibit tests, but should simply put a limit on the effects. During this time, he also made the point that one-point safety shots could not be considered nuclear tests.

Starbird answered (September 4), agreeing that one-points were not tests, that planning should continue to conduct such experiments, but that Presidential approval would be required. Yields would have to be limited to a few pounds or less. However, he felt that announcing that 100-ton and below tests were legal would not be politically acceptable, although he would take it up at a higher level. Starbird followed up, and informed Teller and Bradbury a little later that the U.S. would strive in the forthcoming negotiations for authorization to conduct safety tests up to a yield of 10 tons, and hydrodynamic tests with nuclear material, but producing zero yield. The idea was that the safety tests might produce a small nuclear yield,

but would just be conducted for safety reasons, not to develop new weapons. The hydrodynamic tests might be valuable to weapons development, but would not produce any yield.

Bradbury commented (October 13) that a one-point test resulting in a nuclear explosion of any yield would violate the spirit of the President's moratorium, that diagnostically one-points could not be distinguished from any other explosion so that policing would be essentially impossible, and "From the general philosophical point of view, we believe that if a moratorium is worth entering at all after considering the balance between technical loss and diplomatic gain, this balance will not be in the least changed by the trivial addition, even if one knew how to enforce it or make it effective, of a one-point safety test program." Furthermore, he suggested that the question of hydrodynamic tests not be brought up at all, since they would produce no nuclear yield, but "we, of course, intend to pursue weapons development by any means we can which does not involve nuclear explosions."

On October 16, Teller included in his laboratory plan one-point safety shots and experiments using nuclear materials but not leading to a nuclear yield.

While the argument shows in the higher-level record only late in the game, Livermore had done their homework. They had early in 1958 requested the AEC in Las Vegas (Max Smith) to study the design of a vessel to hold an explosion as large as 300 pounds of H.E., with provision to recover active fissionable material. Appreciable work had been done on the design by the time of the moratorium.

Teller raised similar points during this period with respect to undetectable deep space testing. Were one-points to be allowed during the moratorium, many of the test capabilities could be exercised and maintained.

Physical Test Readiness

As might be expected, actual moves toward establishing a postmoratorium readiness to test were rare up until the time (August 22, 1958) that the President announced the moratorium. After all, there were at least two proving grounds in operation, competent people were already in the system, and the moratorium ground rules had not been established.

The first formal moves came, not surprisingly, from within the testing organizations themselves. In early May 1958, AFSWC (Air Force Special Weapons Center) began to prepare a plan for their operations in the event of a moratorium. AFSWC furnished the major effort for TG 7.4, the Air Task Group of the Joint Task Force operating at the EPG. They also furnished air support for NTS operations. They (Col. James F. Crosby) concluded that their job would be to support operations at either test site on six-months notice, and therefore the 4950th Test Group would reduce to half strength, and keep its space. The 4926th (sampling) would be needed to monitor possible foreign tests, and hence would stay at full strength. The 4951st, at Eniwetok, would have to maintain capability at Eniwetok and hence would stay at full strength. The 4935th (NTS) would stay at full strength for similar reasons. The 4952nd would be reduced to one office and one man. Little did they know!

Col. Wignall (Deputy Commander, Task Group 7.4) worried (May 19) about even this much reduction, at least for the first six months, and suggested that some effort could be used preparing a detailed record of the procedures developed over the years of testing. Col. Kieffer, Commander, TG 7.4, had digested all this by July 30 and recommended to Luedecke, Commander, Joint Task Force 7, that no reduction below normal testing interim levels be accomplished, on the assumption that a six-month readiness after November 1959 would be required.

Barney O'Keefe,* at Edgerton, Germeshausen, and Grier, Inc., proposed (June 17, 1958) a basic policy to the company. He first stated, giving the appropriate political reasons, that it was a virtual certainty that a moratorium would be declared, and assumed October 1, 1958, as the magic date. He then predicted that the contractors would be told to maintain a six-month readiness to test, with the immediate consequence that the AEC would stop procurement on items of less than six months lead time, and would insist that personnel in slots that could be filled in sixty days or less be fired. He further assumed that facilities required for the test program could no longer be justified. He then proposed an 11-point program to meet the situation, including restricting hiring and facility procurement, developing alternate programs, and vigorously entering into a readiness program, assuming Starbird's and Hertford's cognizance of their situation. The plan was followed, and in 1961, EG&G was there to help.

CTG 7.2 (U.S. Army Col. Stanley Sawacki) suggested to Luedecke (August 4) that TG 7.2 also would need its normal interim joint table of distribution if a six-month readiness after November 1959 were required. But he also suggested that TG 7.2 be eliminated, with its functions being picked up by other Task Groups. His interim joint table of distribution was 1,100 personnel.

The Air Force Scientific Advisory Board, the membership of which included Harold Agnew, John Foster, Dave Griggs, Al Latter, and Edward Teller, took up the subject on August 8, 1958. They recommended, "Planning for future tests should be conducted intensively and with periodic reviews." They did not mention funding for the field organizations.

The subject got a lot more attention on and after August 22, however. On that date, Starbird started down the path that was to so infuriate the laboratories over the next three years. Stating that we should be prepared to revert to testing on short notice if the situation warranted, he went on, "We should be prepared to reinstitute Trumpet at NTS *limiting major expenditures to those essential to readiness, and approved individually by DMA,*** and include in our plans the possible conduct of a spring 1960 series in the Pacific. Our budget should be based on and tailored to such an approach." McCone wrote to Teller (August 29), "Your efforts should be so oriented that, in the event the test suspension is not extended or is canceled, we can revert to testing and ensure consequent advancement of our developments with a minimum of delay."

On September 8, Ogle (then Scientific Deputy, JTF-7) wrote to Luedecke, defending the continued participation of military personnel in Task Group 7.1. Over a hundred people were involved.

Other parts of the system began to respond, in spite of the pressure of testing. Jim Reeves,*** Nevada AEC, met with Holmes & Narver, Inc., on September 19 to help

*Ed. note: Bernard J. O'Keefe has been Chairman of the Board, EG&G, Inc., since 1972.

**Emphasis added.

***James Edson Reeves--Born Atkinson, Illinois, 1906--M.S. Hydraulic Engineering, Univ. of Iowa, 1930--Army Corps of Engineers (civilian) 1930-1952 except for a year (1944-45) at Tennessee Eastman (Oak Ridge), Mississippi River nine-foot channel 1930-1938; third lock for the Panama Canal 1938-1942; trans-isthmus sea-level canal 1942-1948; Greek rehabilitation projects 1949; flood control, navigation, and military construction in the Pacific northwest and Alaska 1949-1952--Deputy Director, Office of Test Operations, Albuquerque Operations Office of the AEC, 1952-1953--Director of the same office 1953-1957--Assistant Manager for Field Operations, Albuquerque Operations Office of the AEC, 1957-1962--Manager, Nevada Operations Office of the Atomic Energy Commission, 1962 to Dec. 31, 1968--Assistant Test Manager, Upshot-Knothole (1953)--Test Manager, NTS, 1955-1968--Participant, Operation Ivy, Eniwetok Proving Ground (1952)--Commander, Task Group 7.5, EPG, 1955-1958--Commander, Task Group 8.5, Dominic, 1962--Retired Dec. 1968--Army Certificate of Appreciation 1954--AEC Honorary Superior Performance Award 1959--AEC Distinguished Service Award 1961.

them put together a "state of readiness" plan for Eniwetok. Based on ALOO guidance, they planned for a capability to resume full-scale testing in nine months, and developed the costs, H&N personnel, and procurement necessary. But the situation was still confused. Reeves wrote to Graves (September 29) that, "As you can undoubtedly appreciate, we are in a state of considerable confusion regarding the degree of preparedness for testing which we will maintain following the moratorium, if it comes to be on October 31." Starbird had given him, verbally, three criteria:

a. Within three months to be in a position to conduct three to four quick and dirty barge tests in the Pacific with a minimum of diagnostic measurements.
b. In the Pacific, start testing on a light diagnostic series to develop into the continuous type of operation of 10 to 12 shots per year within 9 months.
c. In Nevada, be prepared to start low-yield and safety-type testing as soon as possible.

But he (Reeves) pointed out the second major difficulty of the next three years by commenting that the Bureau of the Budget was already tying up most of the construction funds for the two test sites, and putting on pressure to reduce the maintenance and operations costs.

Eisenhower sent a message to Congress on April 3, 1958, proposing reorganization of the Department of Defense. For the next five months, AFSWP was busy trying to help define their own future, and had little time to consider "readiness." They did their homework well enough that when asked for their views on August 6, they responded within a week with the plan that was to lead to the eventual establishment of their follow-on agency, DASA (Defense Atomic Support Agency).

Nevertheless, on October 1, 1958, Chief AFSWP (Rear Adm. E. N. Parker), forwarded his intentions to the Assistant Secretary of Defense (R&E) as follows:

a. AFSWP intends that test planning during the suspension period be directed towards conducting an overseas operation first, when the suspension is lifted.
b. AFSWP has requested authority to expend funds from $2,000,000 already allocated in the FY 1959 budget for preliminary planning for Operation Willow. AFSWP has tentatively estimated that an additional $4,000,000 will be required in FY 1959 for preplanning Willow.
c. *First-priority high-altitude requirements*: Ex.(b)(1) [redacted]

ALTITUDE	YIELD	APPLICATION OR REASON
Ex.(b)(1)	[redacted]	[redacted]
Ex.(b)(3)	[redacted]	[redacted]

d. *Second-priority high-altitude requirements*: Desirable, but of lower priority are:

ALTITUDE	DEVICE	APPLICATION OR REASON
Ex.(b)(1)	[redacted]	[redacted]
Ex.(b)(3)	[redacted]	[redacted]

He further suggested that interest would be shown in another set of experiments, which he had not yet coordinated with the services, as follows:

a. *First-Priority Requirements*

Ex.(b)(1)

Ex.(b)(3)

[redacted]

b. *Second-Priority Requirements*

Ex.(b)(3)

[redacted]

c. *Third Priority*

Ex.(b)(3)

[redacted]

One of the earliest moves toward a different way of thinking came when Don Shuster* (Sandia), then Commander, Task Group 7.1, wrote to Luedecke recommending a captive balloon shot facility at Engebi (EPG) to reduce the costs of maintaining a readiness capability and to shorten the time from notification to operational status. LASL and Livermore were not particularly enthused. Luedecke forwarded the suggestion to the JCS and to McCone with the recommendation that the capability be developed and maintained during the moratorium. Starbird asked ALOO to consider the proposal, and provide funding estimates if they concurred.

Luedecke, soon to be General Manager, AEC, asked Ogle (October 21) to comment on his intended recommendations to the JCS and AEC concerning the possible capability to resume nuclear testing. Luedecke first reviewed the political situation, commenting along the way that:

> Our experience indicates that the U.S.S.R. will resume testing at such a time as the Kremlin considers that it is in their best interests to do so, progress of negotiations or agreements notwithstanding. However, it appears possible, or even likely, that their interests would best be served by cooperating in negotiations to the extent necessary to cause the United States to refrain from testing for an extended period of time.

He proposed that the AEC and DOD could maintain a capability to conduct a limited number (3-4) of proof tests at both test sites within three months, and 10-12 developmental tests within nine months, if (a) continuous plans were maintained; (b) continuous capability to activate a test organization were maintained; (c) necessary

*Don B. Shuster--born 1921, Santa Fe, N.M.--Attended New Mexico Military Institute--U.S. Army, 1941-1946--joined Sandia Laboratories, 1946--Manager, Instrumentation Department, 1951--Full Scale Test Department, 1955--Director of Field Testing, 1959--Director, Aerospace Programs, 1963--Director, Special Projects, 1965--Director, Advanced Systems Development, 1966--Director, Exploratory Systems Development, 1968--Director, Exploratory Project, 1973--Director, Advanced Planning Analysis, 1973--Director, Exploratory Weapon Systems, 1975. In charge of High Resolution Telemetry, Operations Ranger and Greenhouse (1951)--Cryogenic Monitoring Instrumentation, George shot, Operation Greenhouse--High Resolution Telemetry, Operation Buster Jangle (1952)--Commander, Sandia Task Group, Operation Redwing (1956)--Associate Test Director, Operation Plumbbob (1957)--Commander, Scientific Task Group (7.1), Operation Hardtack (1958)--Deputy Scientific Deputy, Joint Task Force Eight, Operation Dominic (1961-1962).

plant, equipment, and funds were adequate; (d) provisions were made for "normal service support" by appropriate AEC and DOD agencies; and (e) studies were conducted of alternate means of conducting test operations to effect simplification and economy. He went on to recommend that the JTF-7 responsibilities be assigned to AFSWP (he came directly from AFSWP), who would work closely and continuously with the AEC on these subjects. He recommended deactivation of JTF-7 and its subordinate units. EPG would be taken care of by the AEC. He recommended that the U.S. maintain a capability to test within three months.

Ogle could not see the broader points, and could not stand the idea of AFSWP being responsible for future test planning (they might not even exist six months later). He proposed that the important items were the maintenance of the AEC laboratories and AFSWP, the proving grounds, and the appropriate communication channels, but that a central active planning organization was of secondary importance and, in fact, would bore the people "involved in the continuous and thankless job of maintaining "war plans" that must be changed continually and may never come to fruition." He strongly urged a point of view that AEC diagnostic measurements were up to the AEC and its contractors, and were not within the cognizance of AFSWP. Two years earlier, Luedecke as Chief, AFSWP, had been trying to convince Ogle that AFSWP measurements were none of the AEC's or Task Force's business. Depends on your point of view.

On September 19, 1958, the Secretary of Defense promulgated the guidance that limited test operations might be initiated by February 1960, but that extensive test operations would not be initiated before mid-1960. Following that guidance, Chief, AFSWP (October 26), requested funding to continue Trumpet projects and to initiate a complete moratorium weapon effects program. Any Trumpet agency in need of immediate funding to prevent collapse was requested to submit details and would be provided assistance as soon as possible. AFSWP would develop a complete and comprehensive moratorium period program as soon as feasible.

Ex.(b)(1)

[redacted]

Within a week (October 28), the program had been laid out. [redacted]

Ex.(b)(1)

Ex.(b)(3)

[redacted]

Apparently the contractors could. Just the day before, Nevada AEC had called a meeting of its contractors (H&N and REECo) at the NTS-CP to discuss their readiness. In addition to Reeves and Bill Allaire of the AEC, Sam Howell (H&N), Lew Reynolds (REECo), and Carol Tyler (REECo) attended. The guidance was offered that capability to resume testing promptly would be maintained, continuity of personnel would be required for balloon handling crews, microbarographic and seismic measurements, B and E tunnels would be reopened, etc. In addition, the following general guidance was offered:

> (a) DMA (Starbird) has requested that we clear with them on any major engineering studies or programs which might be initiated concerning future test activities; (b) if and when testing at NTS is resumed we should assume that the tests would be on a continuous type basis rather than the short operational periods which have occurred

in the past; (c) that any future test program would probably involve a heavy diagnostic effort; (d) that during any interim period it is contemplated that there would be periodic meetings of the Planning Board on about a three-month interval; (e) that there would be a relatively large effects effort, both DOD and civilian, in any future test program; (f) that it would be entirely possible that criteria would be developed during the interim period with the result that such criteria would be dropped into the laps of the architect or the construction contractor practially overnight when the decision to resume testing was made. This would result in a high abnormal work load.

Starbird, as Director of the Division of Military Application, closed out the period nicely in his October 31, 1958, message to the General Manager, AEC, on readiness. In reviewing the political situation, he commented:

The danger to our national security lies in the strong likelihood that the U.S.S.R. will protract negotiations and "cooperate" only to the extent necessary to cause the United States to refrain from testing for an extended period of time.

He went on:

. . . our readiness to resume testing, should the President so direct, must be adequate to permit the following:

Ex.(b)(1)

[redacted]

The maintenance of a capability to resume testing on the above time scale will require, as a minimum, the following:

Ex.(b)(1)

[redacted]

Finale

And so, the testing community entered the moratorium with some optimism. The President, the Secretary of Defense, and the AEC had all indicated their support of a strong and viable readiness program. It appeared that Plowshare detonations, one-point safety shots, and conceivably even shots with "just a little" yield might be allowed. Rover and Pluto could continue. There were lots of data to be analyzed, and time to do it was welcome. In fact, to most testers, the moratorium was welcome. The testing system was tired, tired, tired. Duane Sewell pulled down his balloon (not without some trouble), and everyone went home.