REFLECTIONS OF A NUCLEAR WEAPONEER

FRANK H. SHELTON

Frank H. Shelton

THE NUCLEAR WEAPONEER

Dr. Frank H. Shelton is the ninth generation of Sheltons in America. He descends from the Shelton family that moved from England to Middlesex County of Virginia Colony in late 1600. Excellent records for this family and its early descendants are found in the Christ Church Parish Registry for Middlesex County. Twenty-six Shelton relatives are recorded as Revolutionary War veterans in Virginia Colony. Dr. Shelton's Great-Great-Grandfather and his Great-Grandfather Shelton were both surviving Confederate Civil War veterans. His father was a veteran of World War I, and Dr. Shelton was an Army officer in World War II.

Frank Harvey Shelton was born 5 October 1924 in Flagstaff, Arizona. After living for a while in Phoenix, the family moved in 1930 to Boulder City, Nevada, where his father was a member of the Bureau of Reclamation on construction of Boulder (now called Hoover) Dam. Frank graduated from Boulder City High School and was admitted in 1942 to the California Institute of Technology in a freshman class of 160 members. He entered military service in 1943; and after declining a principal appointment to West Point, he was commissioned in Armor at Fort Knox, Kentucky.

After World War II, Frank returned to CalTech where he majored in Physics and has a B.S., M.S., and Ph.D. from that institution. His doctorate thesis was on experimental-theoretical aspects of new particles in cosmic rays (under the tutelage of Dr. Carl Anderson, the 1936 Nobel Prize winner in Physics for discovering the positron in cosmic rays.)

While a graduate student at CalTech, Dr. Shelton worked during the summer months for North American Aviation, with an AEC Q-clearance on nuclear reactors. After graduating from CalTech, he was employed for three years in the nuclear weapons effects department of the Sandia Corporation in Albuquerque, New Mexico, where he participated on nuclear weapon tests at the Nevada Test Site and was involved in test planning for experiments on Pacific tests. Dr. Shelton became Technical Director of the Armed Forces Special Weapons Project in 1955 at the Pentagon, Washington, D.C. For over four years he was directly involved in nuclear weapon effects and test programs in Nevada, the Pacific, and with the British in Australia.

During the depths of the nuclear weapons testing moratorium that began in December 1958, Dr. Shelton resigned from the Department of Defense (DOD) and undertook nuclear weapon effects research in a division of Kaman Aircraft in Colorado Springs, Colorado. When the Soviets abruptly resumed nuclear weapons testing in September 1961, he returned as a contractor to the DOD and was engaged for nine months of nuclear weapons testing in the Pacific in 1962. During the atmospheric testing era, Dr. Shelton watched 65 nuclear weapon detonations.

THE NUCLEAR WEAPONEER (continued)

The Limited Test Ban Treaty went into effect in 1963; and since then, all United States' nuclear weapon tests have been underground. For the last 25 years, Dr. Shelton has participated on 36 DOD underground nuclear weapon effects tests at the Nevada Test Site.

Dr. Shelton joined Sandia Corporation in the summer of 1952 when planning for Operation IVY was underway for conduct in the Pacific that fall. Beginning with Chapter 5 of this book, "Operation IVY-1952," and subsequent chapters, Dr. Shelton presents his personal experiences in a historical account of nuclear weapons and their effects.

While the book could easily have begun with the contents of Chapter 5, a more complete understanding of the subject depends upon the presentation of the history of nuclear weapons that are given in the first four chapters. Hopefully, this transition from nuclear weapons history to personal involvement presents the reader with a more in-depth treatment of "Reflections Of A Nuclear Weaponeer" than simply beginning the book with the year of 1952.

This book spans the history of nuclear weapons, with emphasis on their effects, from the early pre-Manhattan days until about 1990. It has been written by an individual who has been continuously involved in the subject for forty years. This unique compilation of notes and pictures will, hopefully, leave a legacy into the twenty-first century for this phase of world history.

ACKNOWLEDGEMENTS

Although Dr. Shelton developed all the material in this book, he was ably assisted by the following: Amy Varney was proofreader and provided suggestions for all twelve chapters; Elaine Garcia provided document processing; Dave Beach was graphic artist and did the photographic paste-ups; Alan Gaddy provided the offset printing for the color representations; and Floyd Wright performed the general printing, collating, and presentation of the book.

INTRODUCTORY THOUGHTS

The day began gray and overcast with a prediction of thunder storms that afternoon in Georgia. Reading the local Columbus, Georgia, newspaper that Thursday morning, 12 April 1945, in the Officers Candidate mess at Fort Benning, Georgia, I noted a small United Press item that mentioned that President Franklin D. Roosevelt was vacationing at his winter retreat in neighboring Warm Springs, Georgia. My father had been killed in an automobile accident exactly one year previously; and my inner thoughts that day, as we went about our military duties, were of boyhood memories and the events that I had enjoyed with my father. I recalled the excitement in Boulder City, Nevada, when essentially everyone in town lined both sides of the main street as President Roosevelt's open touring car moved slowly along, so close that I could almost touch him. That was a long time ago, 30 September 1935, before World War II had started. Roosevelt, then serving his first term in office as we emerged from the depths of the depression, was in Boulder City to dedicate Boulder Dam. I can still hear President Roosevelt on that 30 September 1935, in dedication ceremonies at the dam, less than five years after construction started, saying:

"*This is an engineering victory of the first order--another great achievement of American resourcefulness, skill, and determination. This is why I congratulate you who have created Boulder Dam and on behalf of the Nation say to you 'Well done'.*"

My father worked for the U.S. Bureau of Reclamation; and we had moved to the Boulder Dam area in the spring of 1931, when early preparations of the dam site began. I grew up in Boulder City and received my schooling there from the second grade through high school. It was an excellent schooling system in a town administered by the Federal Government. I took the CalTech entrance examinations and was accepted in a class of 160 entering freshmen in the fall of 1942 at the age of 17. At age 18 I registered for the draft in Pasadena, California, while going to CalTech; spent about a year there before being drafted into the Army Air Corps in 1943. How did I happen to be in Fort Benning, Georgia, in 1945? That is a long story.(A)

Thursday, 12 April 1945, was business as usual at Fort Benning as almost everyone at that time foresaw a possible beginning of the end of the war in Europe. By evening, it had been an unusual day for everyone around the world. At mid-day, in Warm Springs, Georgia, while sitting for a portrait, President Roosevelt (in the sixty-third year of his life, and at the same age as I write these notes) was stricken with a massive cerebral hemorrhage. He remained comatose, with heavily-labored breathing, through the afternoon and died at 3:35 p.m.

In the spring of 1945 Roosevelt was in his fourth term as President, with the heavy weight of the final days of the war in Europe on his mind as he sat for his portrait that fateful day. Looking at his portrait, I realize how much he had aged under the heavy burden of the office since the day I had seen him ten years earlier in 1935. One of the many accomplishments that FDR carried with him to his death was his decision on 11 October 1939 to pursue the development of an atomic bomb, which was in part his early response to Hitler's starting World War II on 1 September 1939.

(A) Dr. Frank H. Shelton. Service men with appointments to West Point were assembled at Amherst College for academic training during the winter of 1944-45 and were moved to Fort Benning for final processing. At Fort Benning I decided to forgo exercising my principal appointment to enter West Point the summer of 1945. I was "itching" to get back to CalTech to pursue my first love--physics--after 39 months of military service. With a B.S., M.S., and Ph.D. in physics from CalTech, I went to work in 1952 at Sandia Corporation in their Nuclear Weapons Effects Division and participated on nuclear weapon tests in Nevada and in the Pacific for four years. Then as the Technical Director of the Armed Forces Special Weapons Project at the Pentagon in the Eisenhower Administration, I planned and participated in nuclear weapon tests for another four years. As a defense contractor, my participation in the 1961-63 atmospheric test series made a total of 65 atmospheric weapon detonations that I observed. Since 1963, all nuclear testing has been underground and my participation in the last 25 years has totaled 36 nuclear weapon effects tests. An in-depth familiarity with 101 nuclear weapon tests in the past 36 years has given me the opportunity to meet almost everyone involved in the subject--Presidents, Cabinet members, Congressional members, and their staffs, as well as Atomic Energy Commissioners, Department of Defense Secretaries, officials and contractors, as well as members of foreign governments. These notes that form "Reflections of a Nuclear Weaponeer" are reflections of the nuclear weapon testing community--so many of whom are now deceased.

Vice President Harry S. Truman became President after taking the oath of office in the evening of the day Franklin Roosevelt died. Following a brief Cabinet meeting, Secretary of War, Henry L. Stimson, remained to speak with the President on an important subject: the atomic bomb.

Stimson had just gone out to Oak Ridge, Tennessee, arriving at noon on 11 April 1945, for an inspection tour of the facilities that would continue through the next morning. Accompanying Stimson was Brigadier General Leslie Groves, Head of the Manhattan Project, and Colonel William Kyle, Stimson's military aide. Stimson was very impressed with the Oak Ridge operations of the Manhattan Project with its immense plant facilities that were required to obtain enriched uranium for use in the atomic bomb that was being developed at Los Alamos under the direction of J. Robert Oppenheimer.

Truman relates in his memoirs that, "*Stimson told me (that night) that he wanted me to know about an immense project that was under way--a project looking to the development of a new explosive of almost unbelievable destructive power. That was all he felt free to say at the time; and his statement left me puzzled. It was the first bit of (official) information that had come to me about the atomic bomb, but he gave me no details.*"

James Byrnes, Director of War Mobilization with an office in the White House, talked briefly with President Truman on Friday the 13th, but didn't relay very much more to Truman than Stimson had on the subject of the atomic bomb. (1: "Year of Decision," Truman.)

The first in-depth atomic bomb briefing was given to President Truman on 25 April 1945. Secretary of War Stimson placed a great deal of emphasis on foreign relation matters of atomic energy, and in particular on the Russian situation. Brigadier General Groves, head of the Manhattan Engineer District (MED) project, presented its history, present status, and the forecast of atomic weapon availability. "*The gun type of weapon using Oak Ridge enriched uranium will be available about 1 August (this year),*" General Groves related to the new President, "*and a second (gun weapon) will not be available before the end of the year. . . . While the first of three implosion atomic bombs (using plutonium from the Hanford plant) will be ready for a test in early July (1945)*"--which was called by the code-name TRINITY.

A LETTER FROM EINSTEIN--1939

While General Groves does not specifically say so in his memoirs (2: "Now It Can Be Told," Groves), he probably began his review of the history of the Manhattan Project with a brief reference to the letter of 2 August 1939 from Albert Einstein to President Roosevelt, which included a paragraph that predicted:

"*This new phenomenon (nuclear chain reaction) would also lead to the construction of bombs, and it is conceivable--though much less certain--that extremely powerful bombs of a new type may thus be constructed. A single bomb of this type, carried by boat and exploded in a port, might very well destroy the whole port together with some of the surrounding territory. However, such bombs might very well prove to be too heavy for transport by air.*"

Einstein was, however, much too conservative in his prediction--one of the early requirements that was established in the atomic bomb development by the Manhattan Project was that it would be aircraft deliverable.

A copy of Einstein's two page letter of 2 August 1939 to President Roosevelt is given in Figure 1-1. The letter (given here) begins with a reference to recent work by E. Fermi and L. Szilard. (B)

Before World War II began in September 1939, the community of nuclear physicists was small and intimate, and reports of an experiment or a new theory spread rapidly among the individuals--without regard to national boundaries. So, when a number of the outstanding European physicists came to the United States to escape the Nazi German and Fascist Italian

(B) A fairly detailed calendar is given at the end of this chapter to assist the reader in observing the chronology of world important events, particularly those concerning the development of the atomic bomb--the subject of these notes.

were certainly no sure-fire indications that the "gadget" would work; so, at Yalta Roosevelt had deemed it essential that the Russians attack the Japanese to bolster the success of the scheduled 1 October 1945 United States invasion of Japan.

During the Potsdam meeting on 24 July 1945, Truman casually strolled around the large conference table to Joseph Stalin, and through the Russian interpreter mentioned that the United States "now possessed a weapon of unusual destructive power." Stalin showed very little interest in Truman's statement, remarking merely that he trusted that "the United States would put the weapon to good use against Japan." When Stalin showed no unusual interest, Truman should have suspected that there was a spy-in-the-ointment somewhere in the Manhattan Project. The spying escapades of Klaus Fuchs and David Greenglass, while they were at Los Alamos, were not uncovered until 1950. (6: Hewlett, pp. 394, Truman -> Stalin.)

SPIES--DAMN SPIES

There were spies, damn spies, at Project Y, as Los Alamos was officially designated in the Manhattan Project. There were two individuals at Project Y, unknown to each other, who committed espionage by divulging sensitive, secret, atomic bomb design information to the Russians: Klaus Fuchs and David Greenglass. Fuchs, a physicist, was a member of the British atomic energy mission at Los Alamos in the Theoretical Division under Dr. Hans Bethe and had complete access to atomic bomb physics (and Teller's H-bomb considerations). David Greenglass was an Army Sergeant machinist working on high explosive lens molds in Dr. George Kistiakowsky's Division for the implosion bomb. He had limited access to bomb design, but he obtained a great deal of design information in discussions with scientists in the Technical Area of Los Alamos.

Harry Gold was the courier of the information obtained from Fuchs at several meetings in Santa Fe, and from Greenglass on rendezvous in Albuquerque. Easy access to atomic bomb secrets was just what General Groves was afraid of when he let Oppenheimer argue him out of strict compartmentalization of activities at Los Alamos. Harry Gold relayed written information, bomb sketches, and verbal reports on important scientists working at Los Alamos to the Russian KGB agent, Anatoli Yakovlev, in New York City, who promptly transmitted the atomic bomb information to Moscow.

On one of the courier runs, Gold met Fuchs on 2 June 1945 (just the month before Trinity, 16 July 1945) in Santa Fe and received a large envelop of written material from Fuchs--the "Doctor"; and on 3 June 1945, in Albuquerque, Gold obtained written material from Greenglass, three or four handwritten pages plus sketches of implosion bomb lens mold designs, which Gold labeled "Other" and delivered both packages to Yakovlev about 10 p.m. in New York City on 5 June 1945. We know that Gold met again with Fuchs in Santa Fe on 19 September 1945 (after Trinity). Again, there was a conversation and a package of written material from Fuchs on the atomic bomb and its performance at Trinity, all of which was transmitted by Gold to KGB agent Yakovlev in New York City. So when President Truman mentioned to Joseph Stalin that the United States "now possesses a weapon of unusual destructive power," Stalin probably knew more details about the atomic bombs than President Truman. (7, 8, 9, 10, and 11.)

It has never been publicly divulged what led the FBI in the autumn of 1949 to tip off the British Intelligence Service that there had been leakage of sensitive atomic bomb information to the Russians while the British mission was in the United States. Klaus Fuchs was not named by the FBI. The British sorted him out as the spy. Klaus Fuchs was arrested on 3 February 1950 (about 5 months after the Soviets detonated their first nuclear weapon on 29 August 1949) and his "confession" and interviews by the U. S. FBI led to Harry Gold, and to the other U. S. espionage agents, Julius and Ethel Rosenberg. The Rosenbergs, both U. S. citizens, were found guilty of conspiring to commit wartime espionage on 29 March 1951 and were sentenced to death. David Greenglass, Ethel Rosenberg's brother, as well as Harry Gold, testified at length as government witnesses at the trial of the Rosenbergs, and much of the above information on spying was obtained from complete trial transcripts that are available in the public domain.

During the trial of the Rosenbergs in 1951, Greenglass replicated the sketch (a cross section of the implosion bomb) and the written material that he had given to the Rosenbergs in September 1945 (after Trinity, 16 July 1945) while on furlough from Los Alamos to New York City. This very detailed sketch of the implosion bomb components was reviewed by government agencies, including the Justice Department, the Atomic Energy Commission, and the Joint Congressional Committee on Atomic Energy. The AEC authorized the release of the information solely for the purposes of the trial, and so that information is not in the public domain. However, Greenglass' verbal description of the sketch did appear the next day after his testimony at the trial, 12 March 1951, in the New York Times: (7)

Reading from the sketch, Greenglass described 36 high explosive lenses, each of which carried two detonators. He explained that two detonators were used to make sure the lenses fired if one detonator proved defective. He introduced the word "implosion" to describe an explosion focused inward instead of outward. He said 72 condensers were used to fire the detonators.

Greenglass then described a "barium plastic sphere" which he said acted to protect the high explosive from the plutonium constituting the bomb core. Inside the barium sphere, he said, a plutonium sphere was placed.

Inside the plutonium sphere, he said, a beryllium sphere provided a source of neutrons to discharge into the plutonium. At this stage, he said, the plutonium was "highly sensitive" because of the pressure concentrated against it. As the neutrons discharged, he added, "nuclear fission takes place."

On completion of the description, Judge Kaufman ordered the court stenographer not to transcribe that testimony. He said that the stenographer would read it from his notes to any defense lawyer, but that the court did not want the testimony made permanent in writing.

Greenglass added, under Mr. Cohn's questioning (Roy Cohn was one of the assistant United States attorneys), that the bomb switch was set off by a "barometric pressure device" and that the bomb itself was dropped by parachute. The latter statement went unchallenged.

Security was uppermost in the minds of Oppenheimer and Groves when they visited the Los Alamos Ranch School, about 35 miles N.W. of Santa Fe, in mid-November 1942 and selected that area as a suitable site for nuclear weapon development, design, high explosive (HE) testing and fabrication. Not until 1947, however, did the FBI become responsible for investigating project personnel in the process of granting Q-clearances. I have a very early Q-clearance, number BE-403, granted in the late 1940s to work on AEC reactor contracts at North American Aviation. Cleared personnel carry the same Q number throughout their entire professional career. (F)

Prior to the Atomic Energy Act of 1946, The Manhattan Engineer District had full charge of atomic development and handled security matters exclusively through its own officials. During the Manhattan Project, Los Alamos personnel wore badges at work that were the patriotic colors of red, white, or blue. Top level scientists (Klaus Fuchs, et al) with access to all information and Technical areas wore white; blue badges gave access only to the limited area required for their bearers' work (David Greenglass et al.); and red badges gave no access to classified information and were for the trades and support personnel. David Greenglass gave his wife the names of important scientists at Los Alamos in late 1944 during her visit from New York City in response to the request of Julius Rosenberg, Greenglass' brother-in-law. With only a blue badge, Greenglass should not have been able to give his wife the white badge names of Oppenheimer, Niels Bohr using the cover name of Baker, Harold Urey, George Kistiakowsky, Hans "Baker" (Bethe), a theoretical physicist, et al; and thus to give Russia awareness of who was involved and what all might be going on at Los Alamos. Los

(F) Certain Soviet responses in 1985 to United States plans for Strategic Defensive Initiatives (Star Wars) provides confirming evidence to a theory that I have long maintained as to what tipped off the FBI in about 1947. In interest of maintaining that channel of intelligence, an explicit revealing of the theory is not appropriate here, but clues will be sprinkled along the way, especially in Chapter 3.

experimentally certain that plutonium-239 would produce neutrons. The entire plutonium production program at Hanford was a pure gamble on the outcome of this experiment. The gamble paid off.

A water boiler experiment was designed to provide a strong neutron source. It was also an integral experiment to test a theory similar, in some respects, to that involved in designing an atomic bomb.

Chemistry And Metallurgy Division

The Los Alamos Chemistry and Metallurgy Division was assigned the tasks of purification and fabrication of active (fissile), tamper, and initiator materials for the atomic bombs. Before April 1944, the Division was loosely structured with Purification, Radiochemistry, Analysis, and Metallurgy groups being headed, respectively, by C.S. Garner, R.W. Dodson, S.I. Weissman, and C.S. Smith. The youthful J.W. Kennedy had been Acting Division Leader from the beginning; and with the 1944 reorganization, he became the Division Leader, with C.S. Smith being Associate Division Leader in charge of Metallurgy.

The problem of plutonium purification was primarily the job of the Uranium and Plutonium Purification Group, CM-5, headed up by C.S. Garner. It was not until early October 1943 that the first small quantities of plutonium had arrived at Los Alamos, with intensive work having begun not only on plutonium, but also with various stand-ins that included uranium, cerium, lanthanum, zirconium, and thorium.

Research on the physical properties of plutonium metal began in April 1944. These investigations proved to be of major importance because of the metal's unique physical properties. The puzzle of plutonium metal having inconsistent physical properties was resolved in July 1944. Plutonium's metal inconsistencies were explained by determining that it existed in two different phases, alpha and beta allotropes, with a transition from the room-temperature alpha phase to the beta phase between 100 and 150 degrees centigrade.

Between the time the chemistry building was completed in December 1943 and its full staffing in April 1944, about twenty men moved to Los Alamos from Berkeley, Chicago, and Ames, where they had already been doing research on uranium and plutonium purification. Four additional chemists came from the California Institute of Technology to the Los Alamos chemistry staff. Members of the Metallurgical Laboratory at the University of Chicago who had joined Oppenheimer at Los Alamos were: E. Teller, R.F. Christy, D.K. Froman, A.C. Graves, and J.H. Manley. Robert Christy became a member of Bethe's Theoretical Physics Division T-1.

The British Mission

Klaus Fuchs settled into room 17, dormitory T-102, in the sprawling new Los Alamos barracks on 14 August 1944, along with other members of the British Mission, some of whom had already arrived at the atomic bomb laboratory. Fuchs was assigned to Hans Bethe's Theoretical Division and worked directly for his old friend and benefactor Rudolf Peierls, who had taken over T-1 from Teller's role in June 1944. If one wanted to know all about the physics of atomic bombs, the gun weapon, the implosion bomb, and the Super, then T-Division was the place to be. (16) (Figure 1-14, Fuchs.)

FIGURE 1-14. KLAUS FUCHS, GERMAN/BRITISH PHYSICIST ON THE MANHATTAN PROJECT AT LOS ALAMOS

Within a few months of Fuchs arrival in New York City as a resident member of the British Mission to the Manhattan Project, he made contact (February-March 1944) with the Soviet spy courier "Raymond", real name Harry Gold. The sixth meeting of Fuchs and Gold occurred in June 1944. It was in early July that Fuchs learned that he would be moving to "somewhere in the southwest"--Los Alamos. After transferring to Los Alamos, Fuchs met with the spy courier Harry Gold in February 1945 when Fuchs traveled to visit his sister in Cambridge, at which time he passed considerable written information about the atomic bomb to "Raymond." They agreed to meet next in Santa Fe at the Castillo Street bridge over the Santa Fe River. The meeting occurred on a Saturday in early June 1945, one month before the TRINITY test. At that time, Fuchs indicated that the yield of the test was predicted to be the equivalent of 10,000 tons of TNT, and Fuchs told Gold at that meeting that the bomb was intended for use against Japan. As they separated, they agreed to meet again in Santa Fe on 19 September 1945, which was after the surrender of Japan. (See Chapter 3, Fuchs was arrested on 3 February 1950, about five months after the Soviets detonated their first nuclear weapon on 29 August 1949.) (+)

In the fall of 1943 President Roosevelt and British Prime Minister Churchill discussed closer collaboration to speed up the development of the atomic bomb. At the 19 August 1943 Quebec meeting, the secret Agreement Relating to Atomic Energy was signed, stating that the British and the United States would not use an atomic bomb against each other and would not use one against a third party without each other's consent. "*We will not either of us communicate any information about Tube Alloy to third party (meaning France or Russia) except by mutual consent.*" The arrival at Los Alamos of O. R. Frisch and E. W. Titterton in December 1943 marked the culmination of lengthy negotiations among the British, Canadian, and American governments to integrate the three countries atomic bomb research. (Figure 1-15, Quebec.)

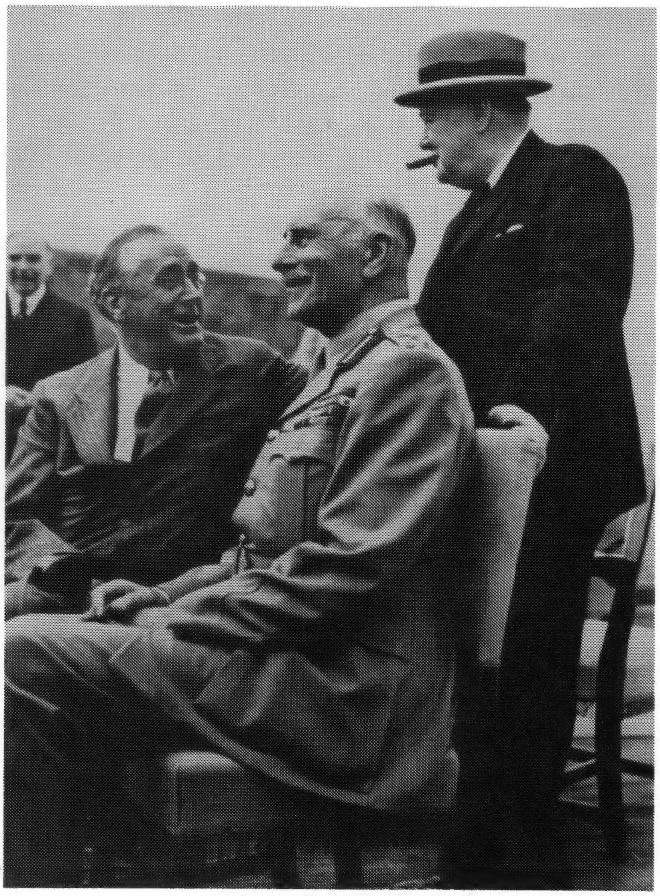

FIGURE 1-15. ROOSEVELT AND CHURCHILL AT QUEBEC ON 18 AUGUST 1943 FOR THE SIGNING OF THE QUEBEC AGREEMENT; CANADIAN GOVERNOR-GENERAL, EARL OF ATHLONE, IS IN THE FOREGROUND; CANADIAN PRIME MINISTER MACKENZIE KING IS IN THE BACKGROUND

Sir James Chadwick of the British Cavendish Laboratory, scientific advisor to the British members of the Combined Policy Committee in Washington, arrived at Los Alamos in early 1944

(+) See Calendar at the end of the chapter for prior activities of Fuchs and other members of the British Mission.

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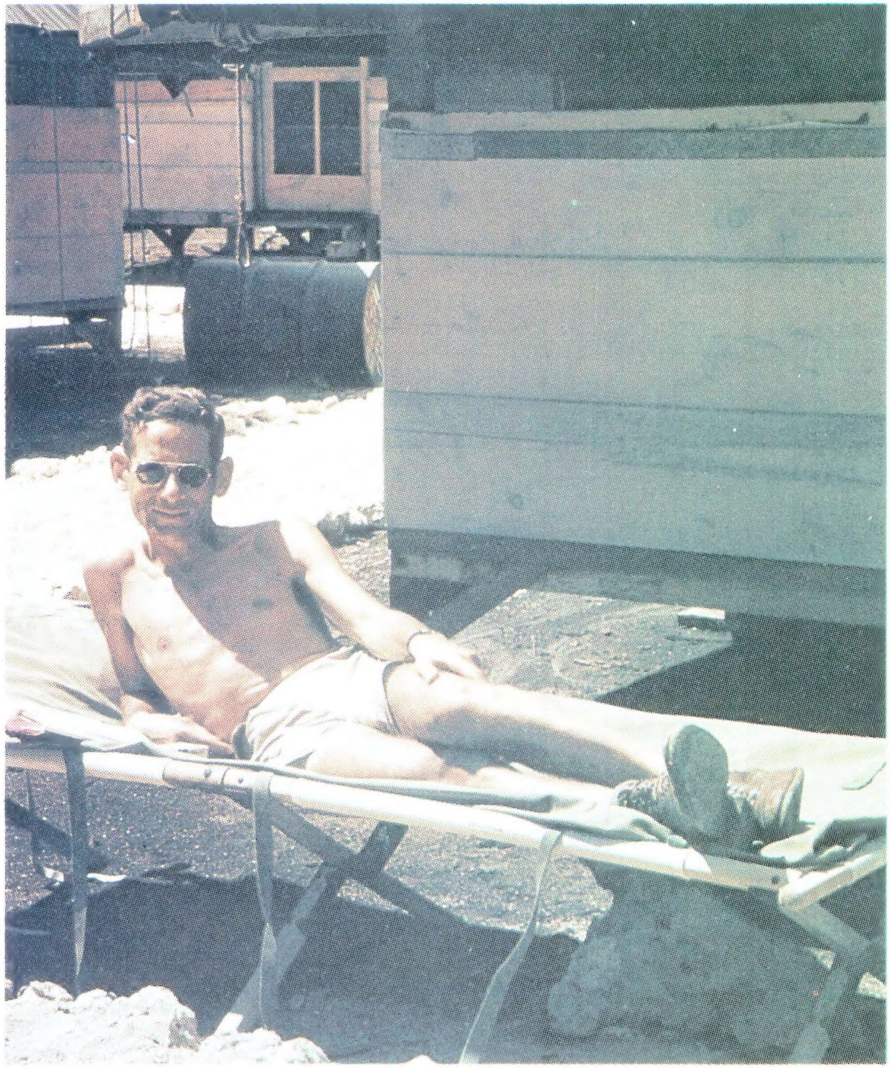
The mistake that was made at Los Alamos in breaking down compartmentalization was vital to Fuchs.

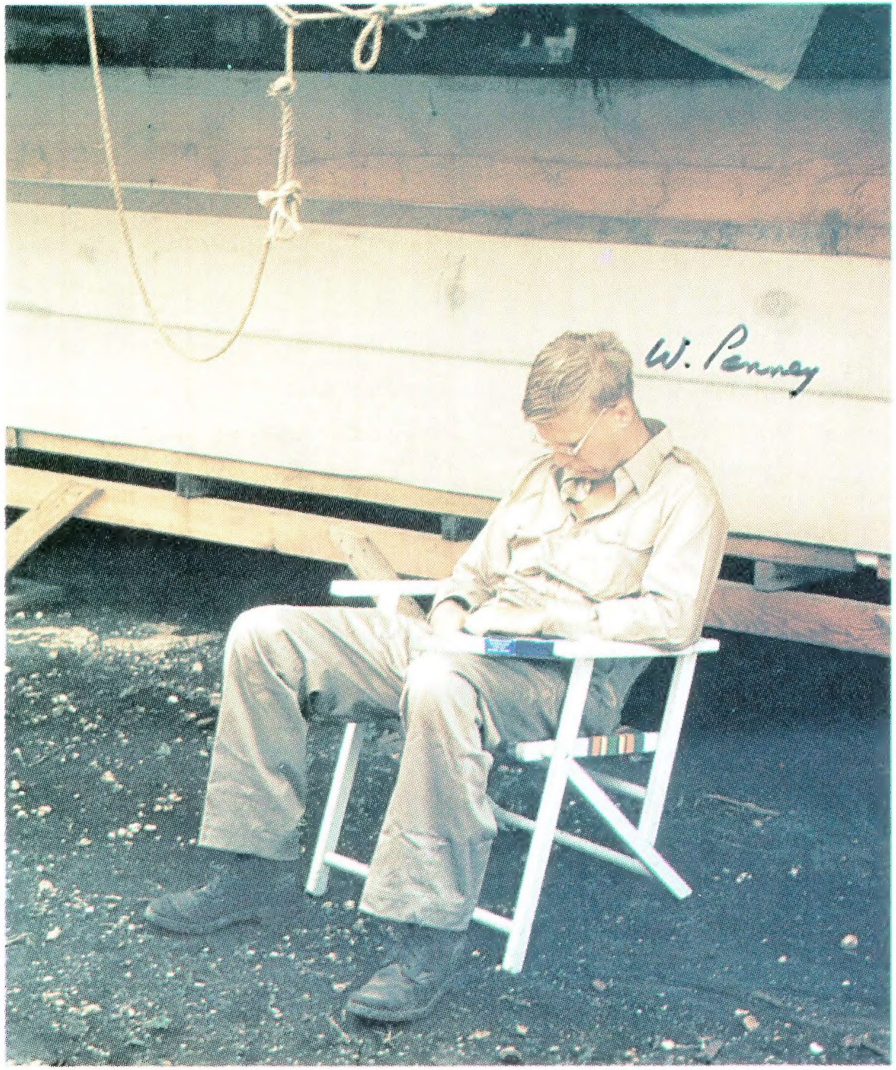
---General Leslie Groves

If Fuchs had been infinitely compartmentalized, what was inside his compartment would have done the damage.

---J. Robert Oppenheimer



BOB SERBER "WORKING" AT TINIAN ISLAND



BILL PENNEY "WORKING" AT TINIAN ISLAND

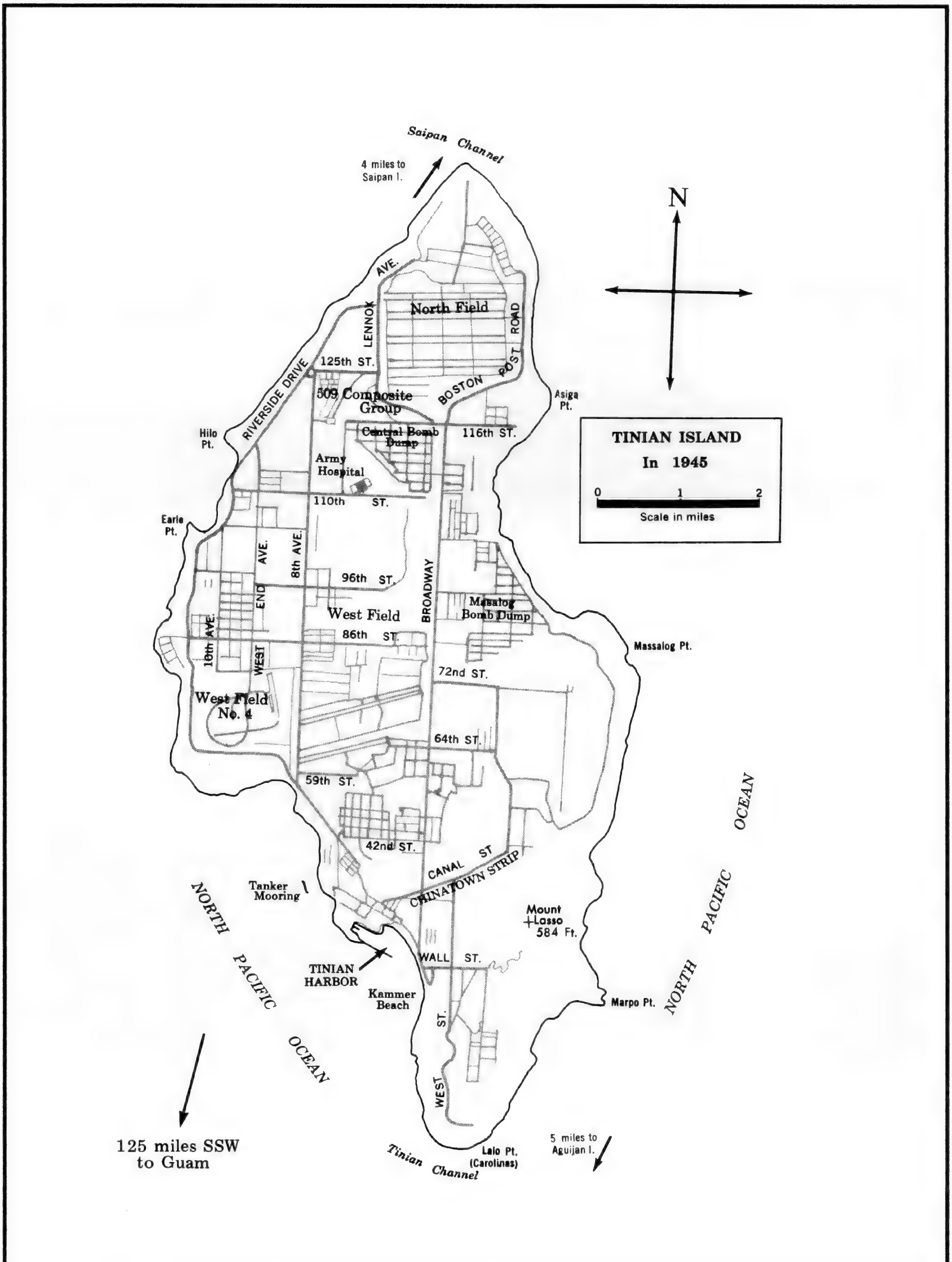
PHOTOGRAPHS AND NAMES COURTESY OF HAROLD AGNEW

509TH B-29 BOMBER WITH ORIGINAL TAIL "ARROW"

509TH B-29 BOMBER WITH CHANGED TAIL TO "LETTER"
BOMBER #89–INSTRUMENTATION A/C, BOMBER #77–DROP A/C FOR NAGASAKI

IN RESPONSE TO MY QUERY, HAROLD AGNEW RELATED THAT, "ON THE TAIL MARKINGS, THE 509TH HAD AN ARROW. ALL OTHER 20TH AF HAD A LETTER FROM THE ALPHABET. THE DAY BEFORE HIROSHIMA, TOKYO ROSE CAME ON AND SAID THEY WERE READY FOR US. SO, OVERNIGHT, WE CHANGED OUR TAIL INSIGNIAS TO LOOK LIKE THE REST OF THE 20TH (I.E., WITH AN ALPHABET LETTER).

PHOTOGRAPHS COURTESY OF HAROLD AGNEW



TINIAN ISLAND – 1945

509TH BOMBER WITH ORIGINAL TAIL "ARROW"

509TH BOMBERS AT TINIAN ISLAND NORTH FIELD WITH "ALPHABET" TAILS

PHOTOGRAPHS COURTESY OF HAROLD AGNEW

in a notebook belonging to a man who was one of those examined by the Canadian Royal Commission there did appear, amongst a long list of other names, the name of Klaus Fuchs . . ."

EFFECTS OF ATOMIC WEAPONS

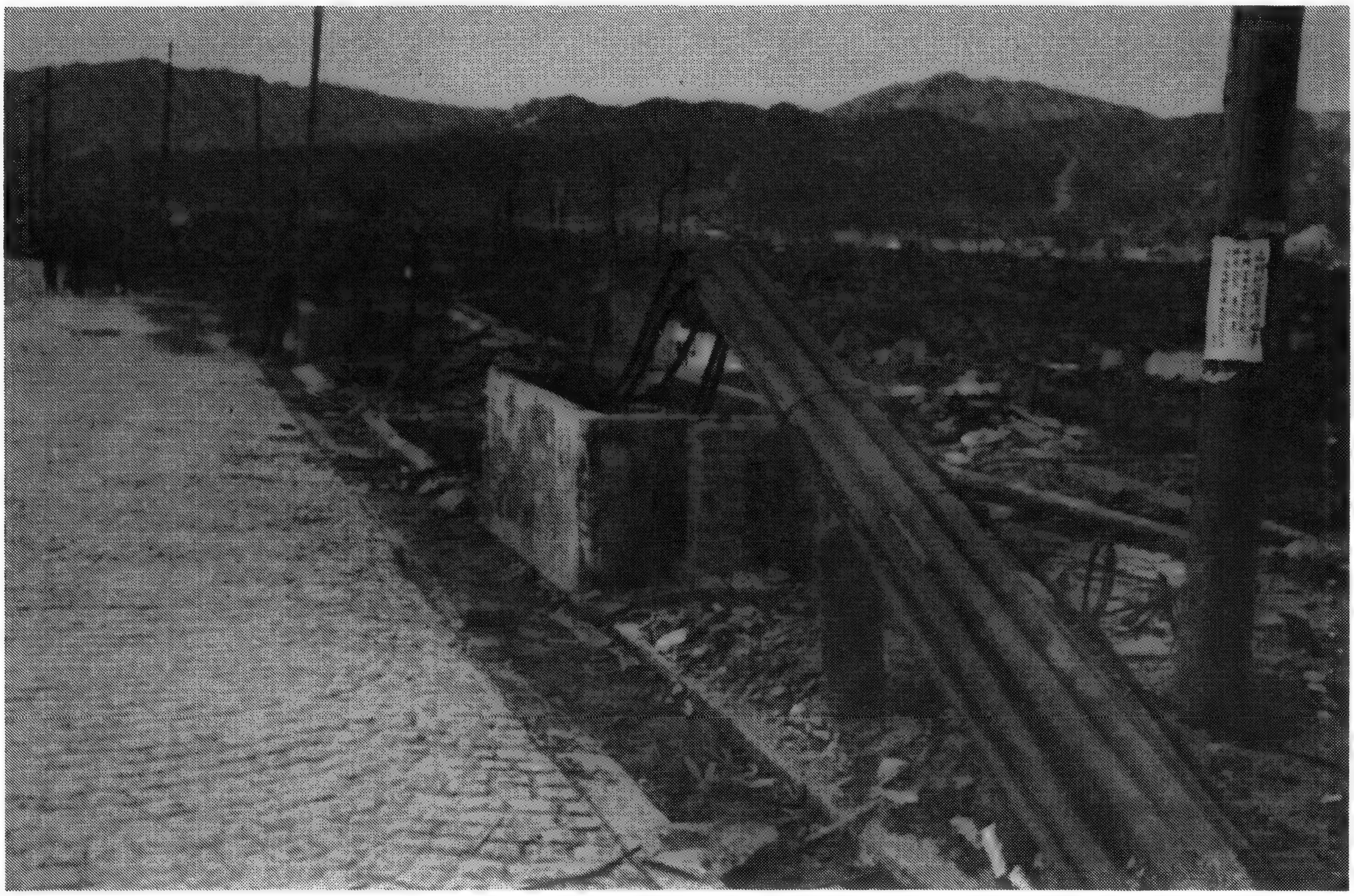
During the fall of 1945 and through the end of 1946, the Los Alamos Theoretical Physics Division was occupied with bomb physics research and also took on the work of thermonuclear systems that had formerly been under Edward Teller's Fusion Group. In the fall of 1945 T-Division leader Hans Bethe turned the attention of the division toward the complex hydrodynamical problems involved in interpreting the blast measurements made at Trinity, Hiroshima, and Nagasaki. Hans Bethe later resigned as T-Division leader, on 1 December 1945, to return to his former position at Cornell University. It is noted in Appendix A of these notes that Bethe testified at the Senate hearings on Atomic Energy on 5 December 1945 (5 days after leaving Los Alamos) as a professor of physics at Cornell. His successor as T-Division leader was George Placzek, who had been at Los Alamos only since May. Bethe and his eight group leaders, as of August 1945, had all left within a year. Richard Feynman was the first to leave, then Robert Serber, then Hans Bethe, et al. (5: Project Y.)

Following Trinity and the two nuclear weapon detonations over Hiroshima and Nagasaki, there was intense activity in the Los Alamos theoretical division, beginning in the fall of 1945, to interpret the measurements and observations. One of the efforts was the development of a theory for estimating the energy release of a fission bomb explosion by the measurement of the expansion velocity of the fireball in its early stages, called fireball yield determination. Consideration was given in the theory to account for the effects of the bomb mass, as well as the effects of the Trinity steel tower, its platform, and the cab that housed the bomb.

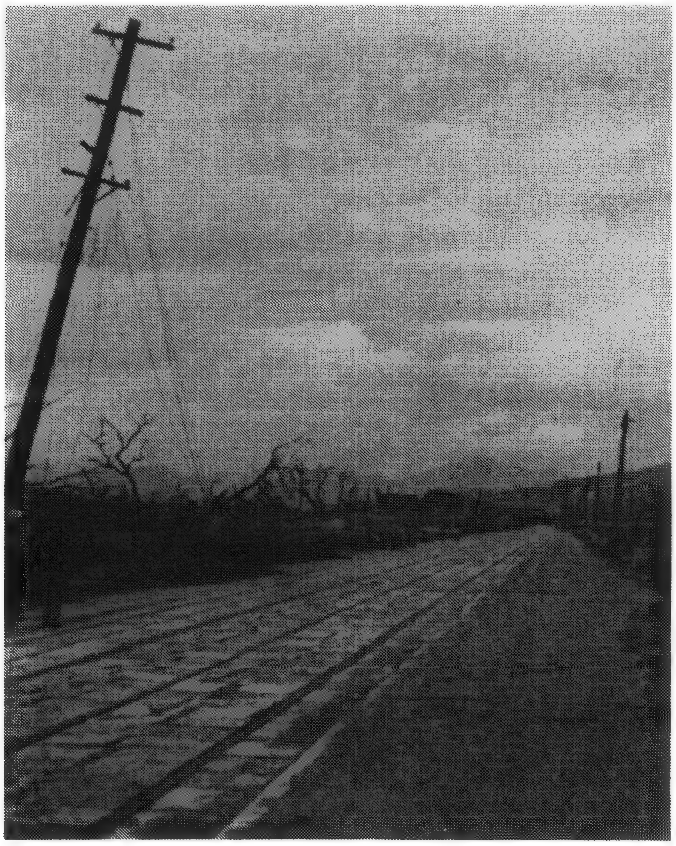
Early Los Alamos considerations on how a nuclear weapon blast wave develops over time and distance were compiled into a classified document entitled "Blast Wave, LA-2000" edited by Hans Bethe, who also wrote the introduction, and the "small gamma-minus-one" approximations to the blast wave equations. Rudolf Peierls and Klaus Fuchs wrote the section on the equation of the state of highly ionized air. Joe Hirschfelder and John McGee developed the material on thermal radiation. Von Neumann derived the "point source" solutions to the blast wave hydrodynamics. Klaus Fuchs wrote the chapter on the IBM solution to the blast wave called, "IBM Problem M."

One of my first tasks when I went to work in 1952 at Sandia Corporation in Albuquerque was to derive the equations in LA-2000 while developing a document for completion in September 1953 on "High Altitude Effects on Blast-Thermal Partition of Energy From Nuclear Explosions and Associated Scaling Laws." Analysis of the IBM "M" blast wave data allowed a determination of what portion of the energy released by a fission bomb is converted into blast energy. The blast energy from the explosion of an atomic bomb was found to be about one-half (50%) that from explosion of a corresponding amount of TNT, with about 35% of the fission yield appearing as thermal radiation, and the

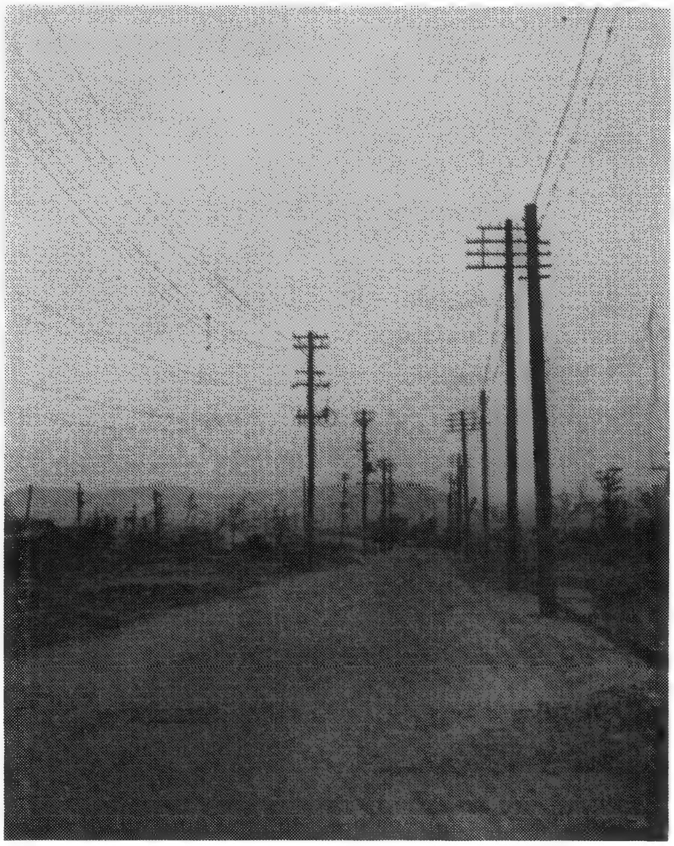
			Termination
Theoretical Division Leader		H.A. Bethe	Dec. 1945
T-1	Implosion Dynamics	R.E. Peierls	Jan. 1946
T-2	Diffusion Theory	R. Serber	Nov. 1945
T-3	Efficiency Theory	V.F. Weisskopf	Feb. 1946
T-4	Diffusion Problems	R.P. Feynman	Oct. 1945
T-5	Computation	D.A. Flanders	Sep. 1946
T-6	IBM Computations	E. Nelson	Jan. 1946
T-7	Damage	J.O. Hirschfelder	Aug. 1946
T-8	Composite Weapon	G. Placzek	May 1946



1,200 feet from GZ



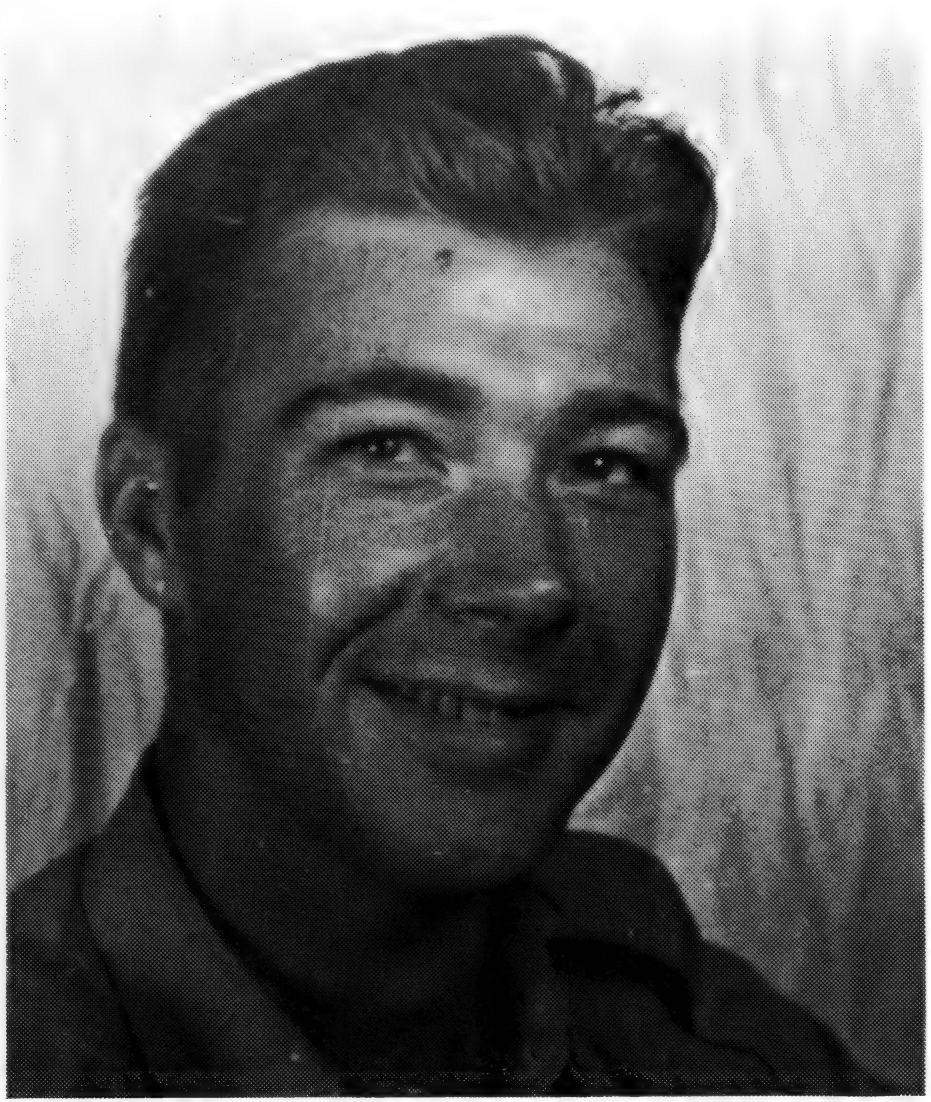
2,500 feet from GZ



4,500 feet from GZ

FIGURE 2-16. DAMAGE DUE TO THE DYNAMIC PRESSURE-BLAST WINDS AT HIROSHIMA

DR. WILLIAM G. PENNEY
BRITISH MISSION REPRESENTATIVE (#86)



JAMES F. MOULTON, JR.
U.S. NAVAL ORDNANCE LAB (#80)

PHOTOGRAPHS COURTESY OF JAMES F. MOULTON, JR.

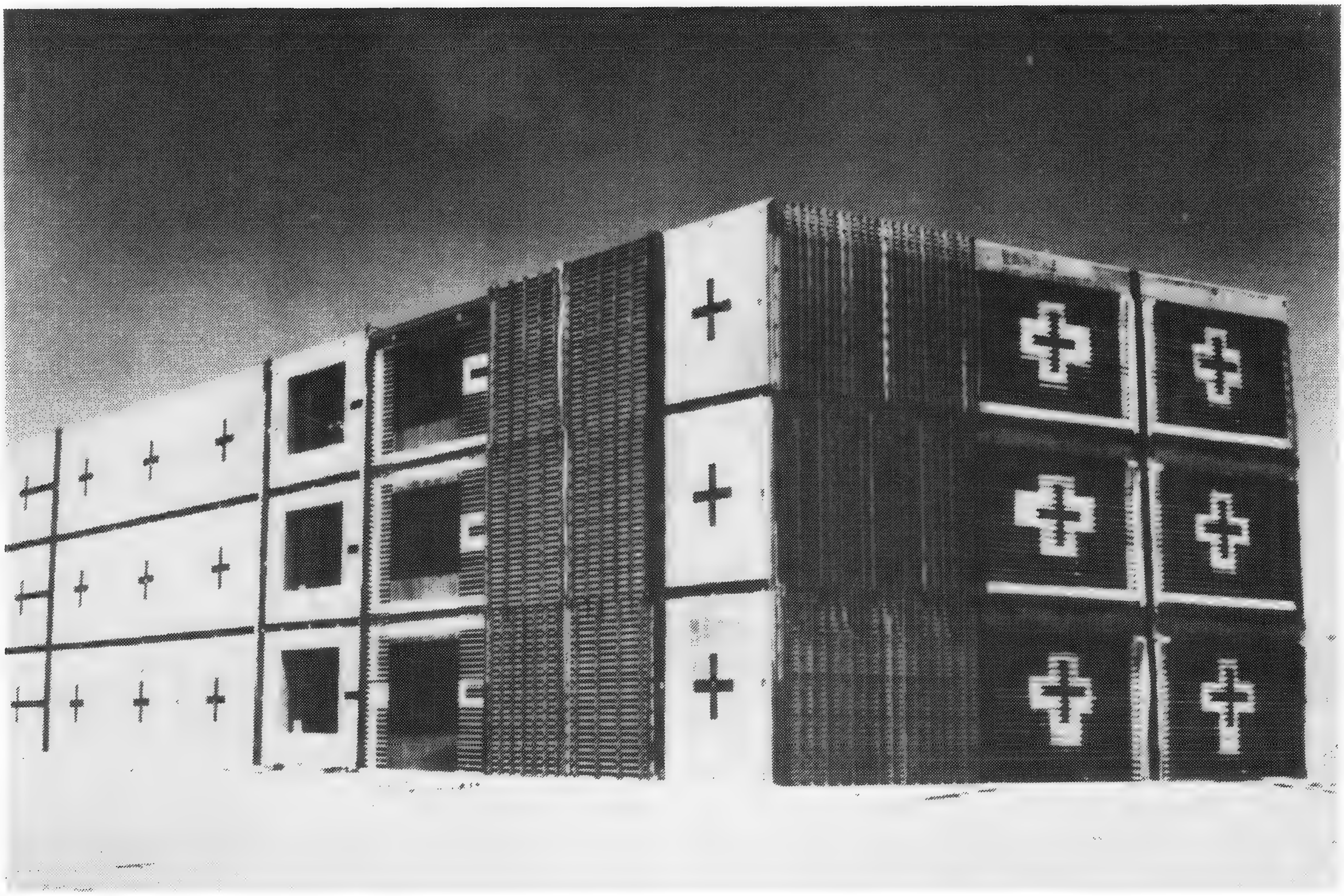


FIGURE 4-10. THE ARMY MULTI-STORY BUILDING COMPLETED, ENGEBI

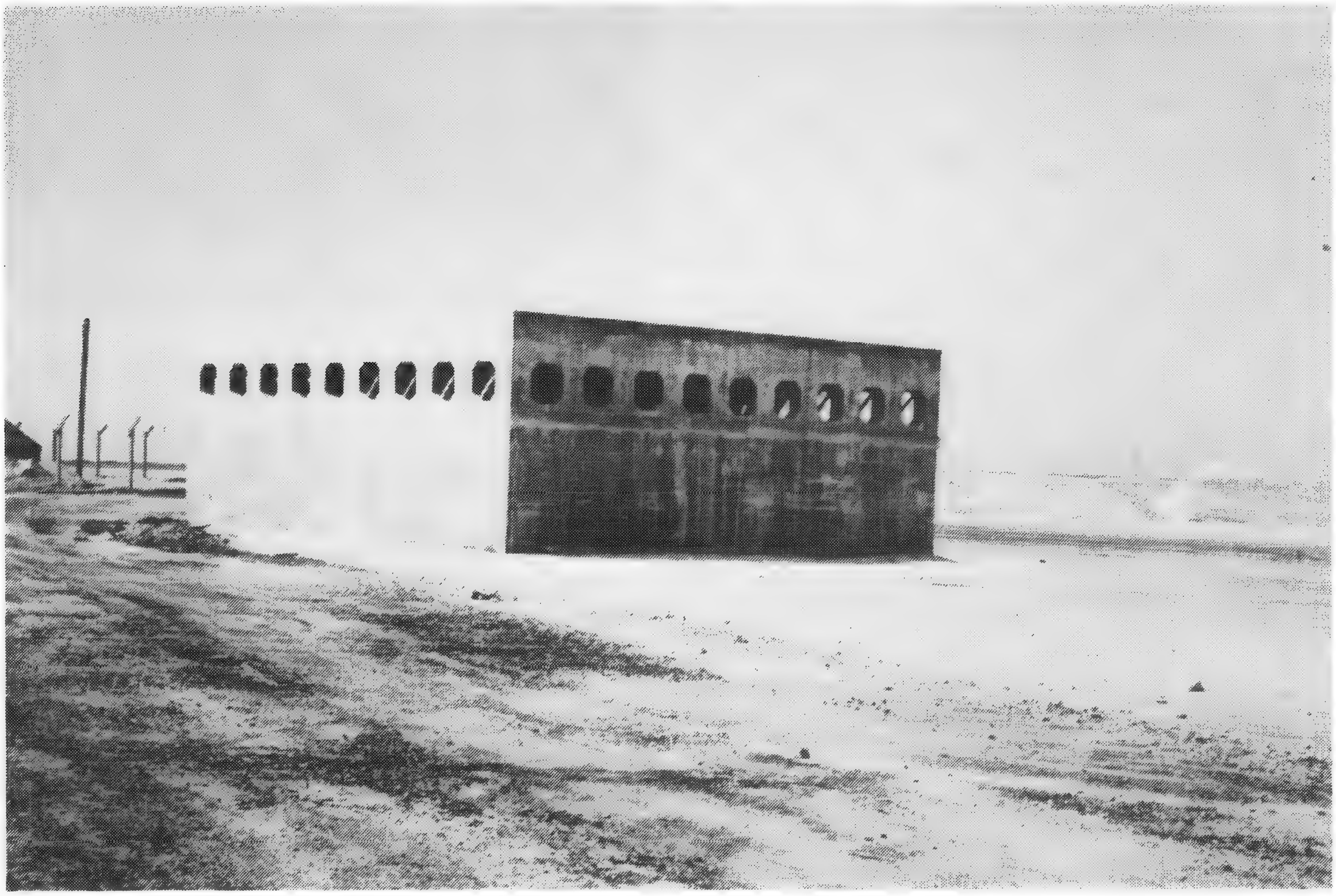
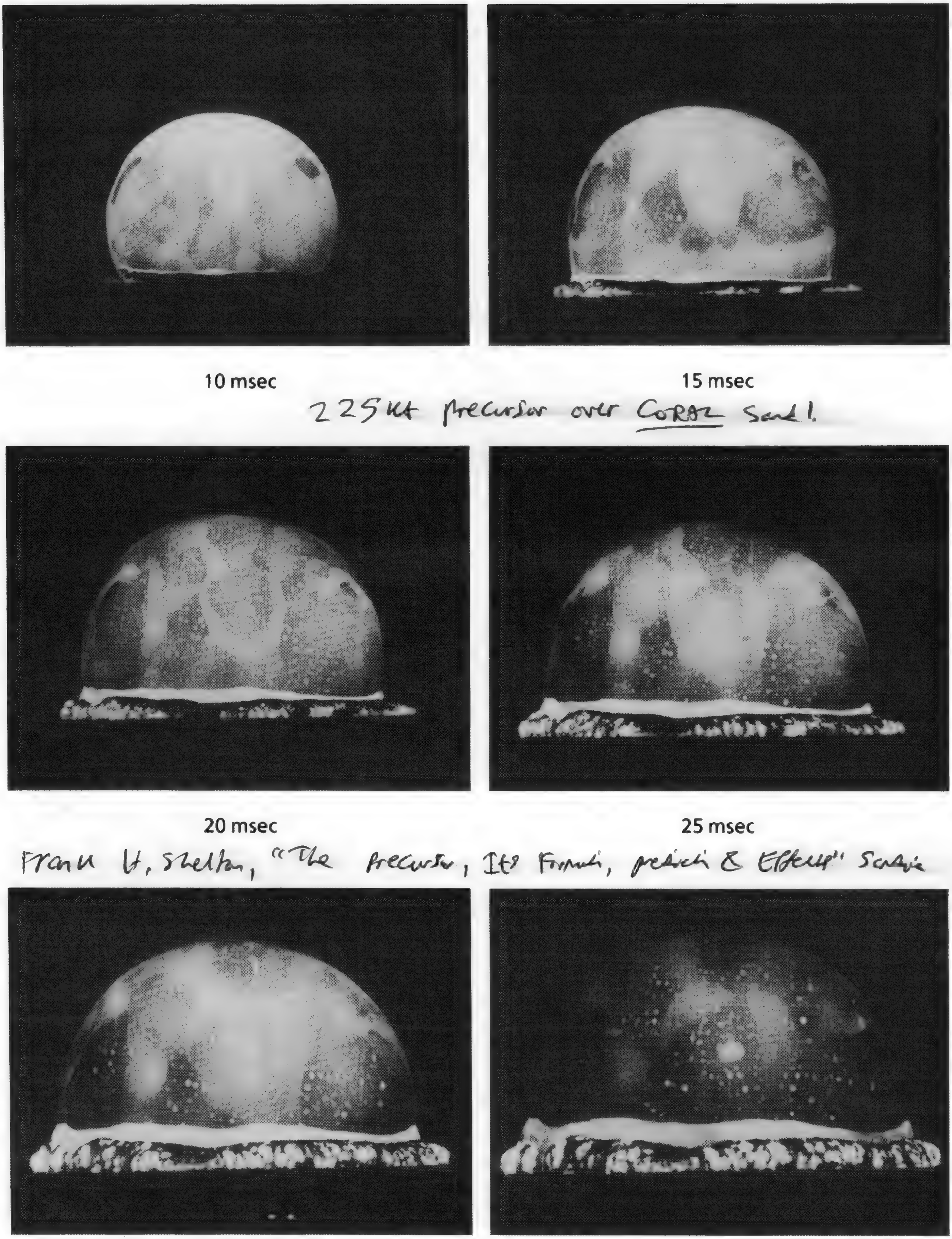


FIGURE 4-11. ONE OF THE NAVY BUILDINGS, ENGEBI



10 msec 15 msec

225 kt precursor over CORAL sand!

20 msec 25 msec

Frank H. Shelton, "The Precursor, Its Formation, Prediction & Effects" Sandia

30 msec 35 msec

FIGURE 4-21. EVENT GREENHOUSE/GEORGE SHOWING DEVELOPMENT OF MACH STEM

TABLE 5-1. EARLY STRATEGIC AND TACTICAL NUCLEAR WEAPONS IN STOCKPILE

Mark 1 - Production model of "Little Boy" gun weapon, 10 feet long, 28 inches in diameter, and weighing 8,900 pounds. Several were made in 1946 and retired in 1946. (See Figures 1-27, 2-10, and 2-15.)

Mark 3 - First production model of "Fat Man" implosion weapon, 10 feet 8 inches long, 60 inches in diameter, and weighing 10,800 pounds. Entered stockpile in 1947, retired in 1950. (See Figure 1-30.)

Mark 4 - Developed to improve the performance of the Mark 3. Entered stockpile in 1949, retired in 1953.

Mark 5 - Light weight (3,175 lbs.) tactical bomb, 48 inches in diameter. Entered stockpile in 1952, retired in 1963. (See Figures 3-19 and 3-26.)

Mark 6 - First mass produced strategic bomb, weighing 8,500 pounds, and was barofuzed so that the height of burst could be changed while airborne. Spoiler rings assisted in obtaining aerodynamic stability. Stockpiled 1951- 1962. (See Figure 3-20.)

Mark 7 - 1700 pound gravity bomb, designed for tactical aircraft, internal or external carriage. Entered stockpile in 1952, retired 1957.

Mark 8 - Improved gun weapon, entered stockpile in 1951, and retired in 1956.

Mark 9 - 280 mm howitzer gun weapon. Entered stockpile in 1952 and retired in 1957; replaced by W19 projectile from 1956 to 1963. (See Chapter 6.)

Mark 12 - In the stockpile from 1954 until 1962; a 1000 lb. bomb for supersonic aircraft.

review of the rest of Chapter 5 by Lauritsen, Bacher, and Fowler.

Dave Griggs was disturbed by three points that appeared in the introduction and body of the draft report. First, Oppenheimer had written a recommendation in the introduction, *"That the President of the United States should announce that the United States would not use the Strategic Air Force (Strategic Air Command, SAC), in the attack of enemy cities or urban areas, unless and until United States cities had been attacked first."* The recommendation for a Presidential announcement carried shades of a previous Oppenheimer recommendation that the President announce that the United States would not pursue thermonuclear weapon development. What disturbed Griggs the most about the Oppenheimer recommendation was the drastic impact it would have upon the plans and options for SAC operations in Europe.

A second point in Chapter 5 that bothered Griggs was *"A recommendation on the specific nature (mix) of the tactical nuclear weapons that would form the nation's stockpile."* The VISTA recommended character of the nuclear weapon stockpile was at considerable variance with the positions that the Joint Chiefs of Staff and the Air Force had taken on the composition of the future stockpile. Further, the VISTA recommended stockpile would be equally divided into three parts: Joint Chiefs of Staff reserve, Strategic Air Command, and Tactical air Europe. Tri-partitioning of the nuclear weapon stockpile would severely restrict the Air Force's options dealing with an emergency.

The third point in the November draft of Chapter 5 that Griggs noted was *"The present state-of-the-art makes it impossible to assess the capabilities of thermonuclear weapons with respect to their tactical use."* Again, Oppenheimer's opposition to pursuit of thermonuclear weapon development could be seen, in spite of the President's 31 January 1950 directive to accelerate the development. Teller had visited the Project VISTA study group in the summer of 1951, but his views were essentially ignored in the VISTA report. Elwood Quesada, an Air Force General who had been Commander JTF-3 on GREENHOUSE (see Chapter 4 of these notes), participated in the November 1951 meetings and was, of course, very familiar with the thermonuclear weapons developments that had occurred on Operation GREENHOUSE, but was unable to impact VISTA's downgrading of thermonuclear weapons.

With a draft copy of Chapter 5 in hand, four representatives of VISTA were sponsored by the Secretary of Defense, Robert Lovett, to visit Europe in early December 1951 to obtain an operational perspective from the U.S. military

UNCLE crater = 130 ft. radius, 53 ft. deep
SUGAR crater = 45 ft. radius, 21 ft. deep

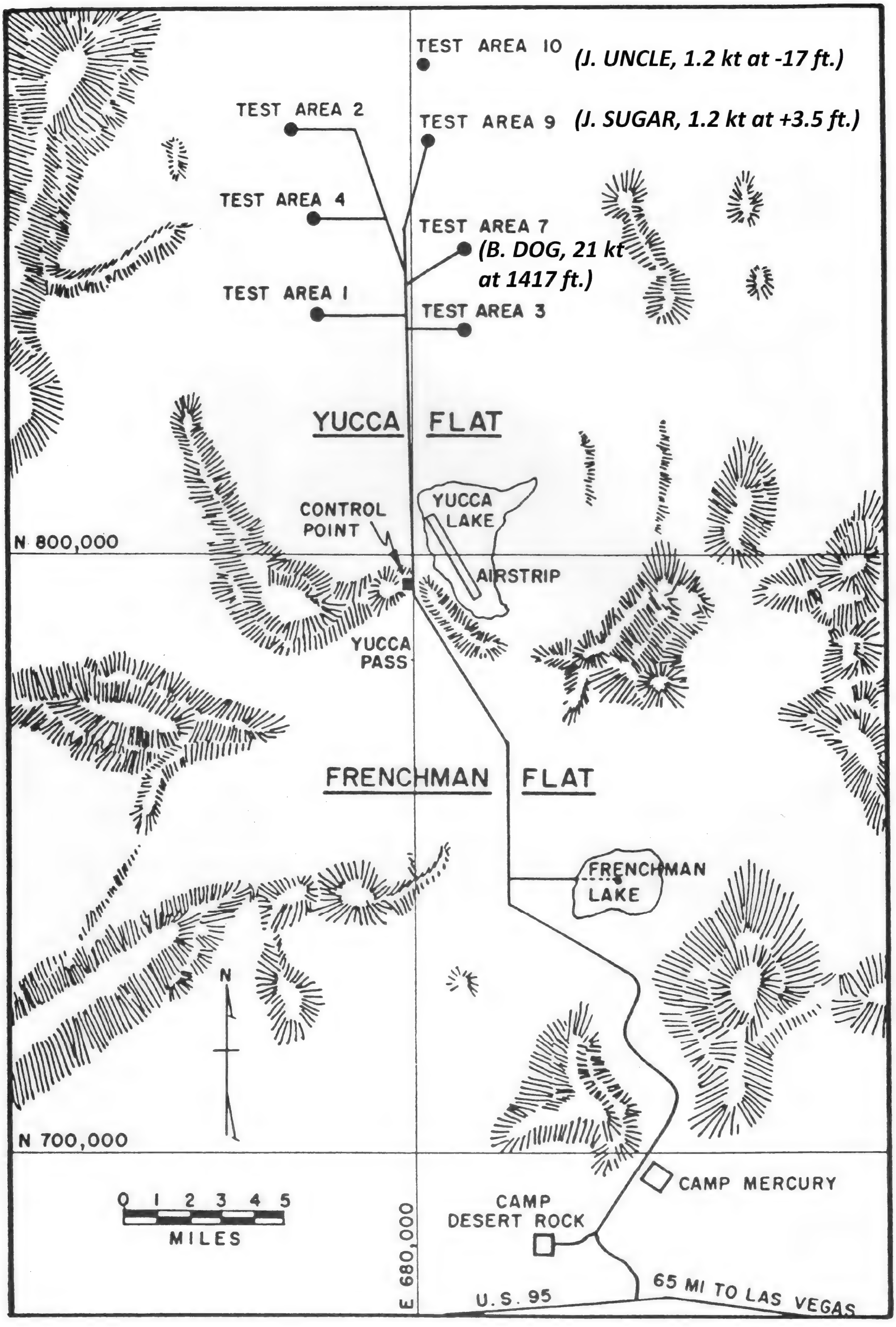


FIGURE 5-9. NEVADA PROVING GROUNDS

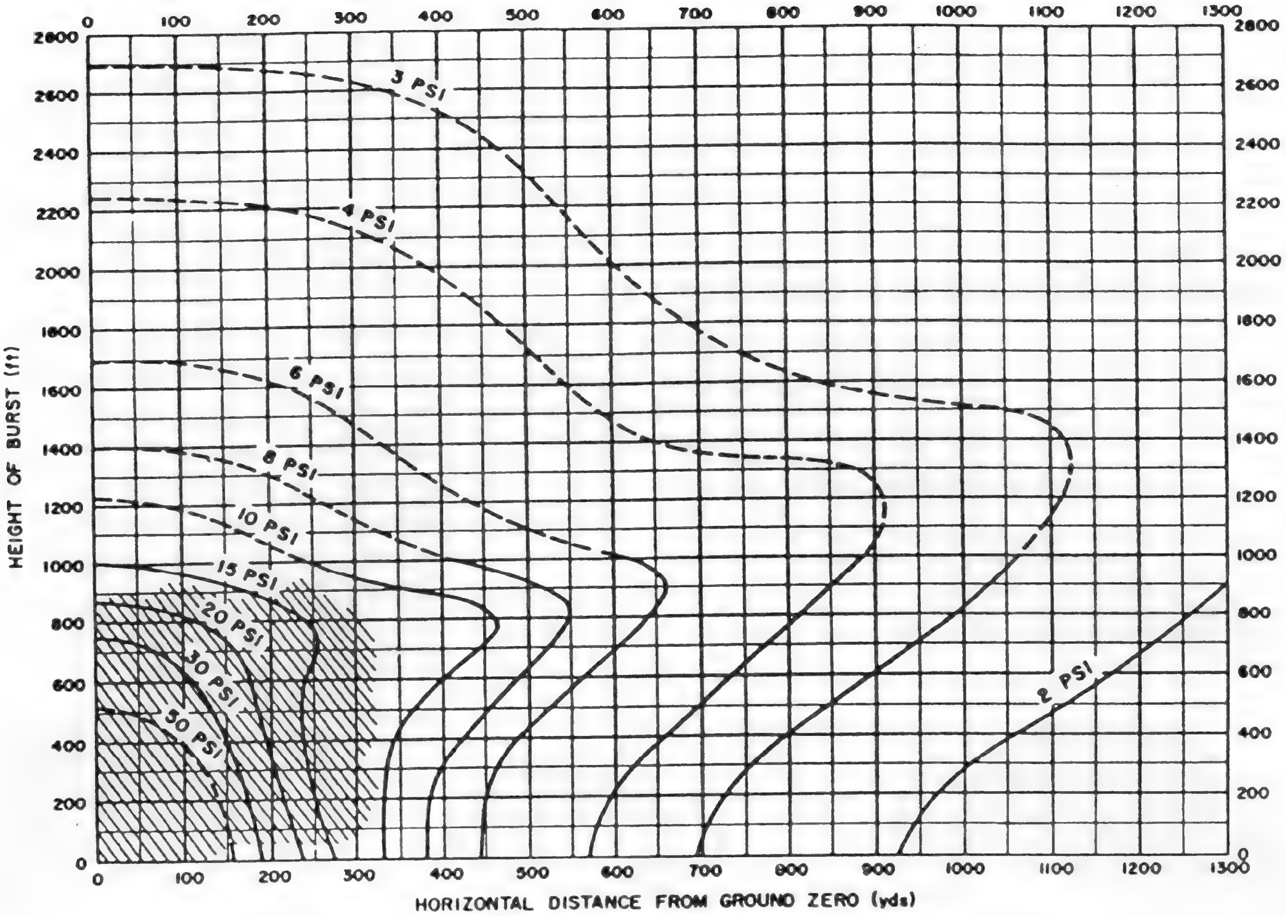


FIGURE 5-22. HEIGHT OF BURST CURVES (SCALED TO 1 KT AT SEA LEVEL)

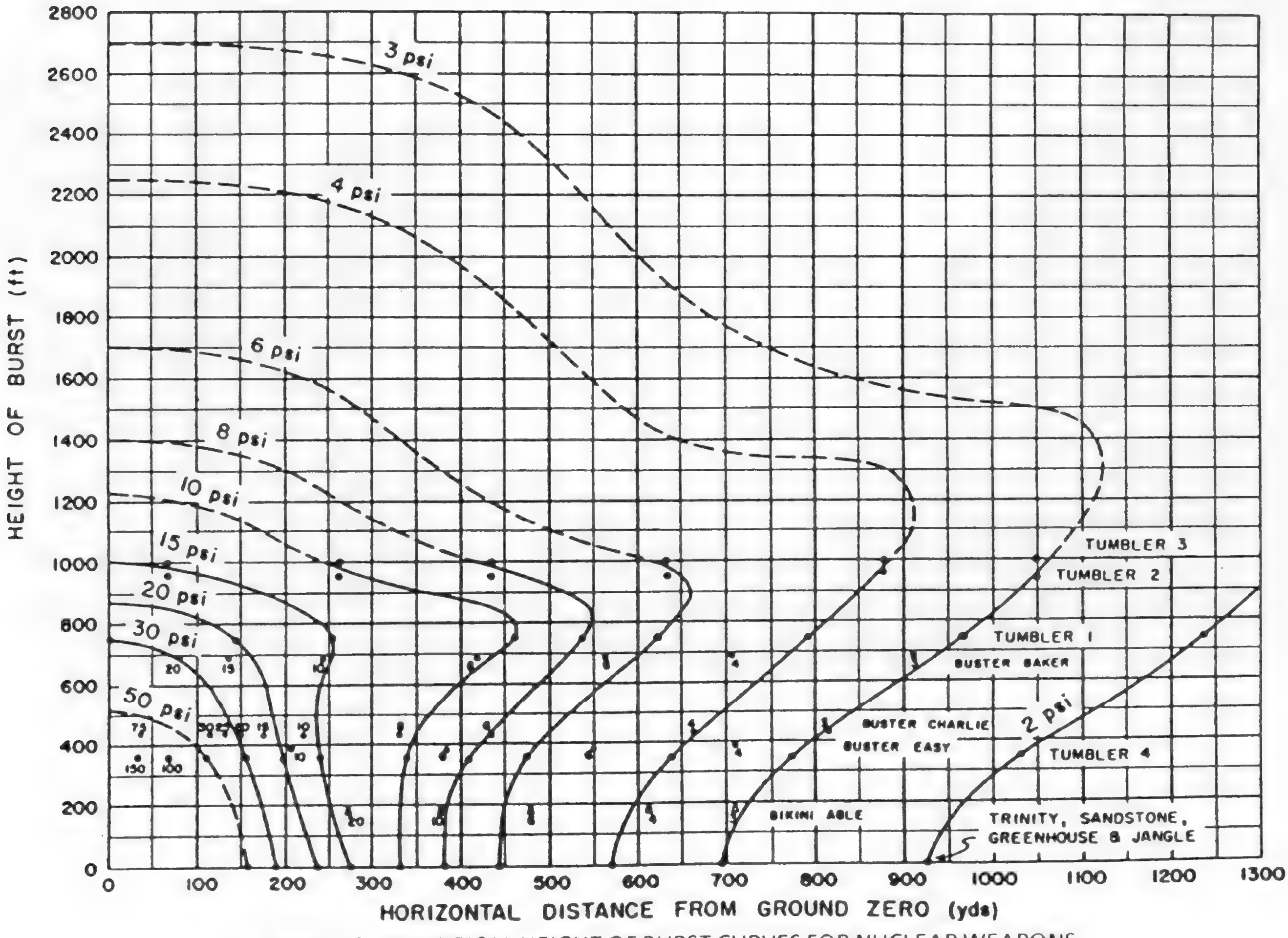


FIGURE 5-23 EMPIRICAL HEIGHT OF BURST CURVES FOR NUCLEAR WEAPONS

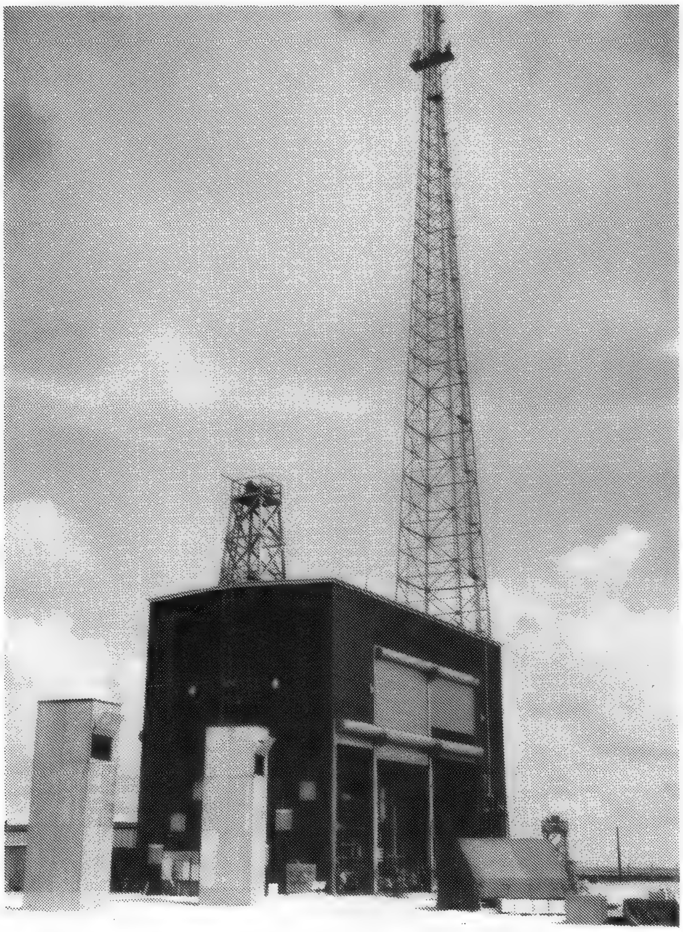


FIGURE 5-27. MIKE DEVICE CAB ON ELUGELAB ISLAND

Final Preparations For MIKE

Final assembly of the MIKE nuclear device occurred the afternoon of the day before the shot; this assembly was completed about an hour before general evacuation of Task Force 132 from Eniwetok Atoll was completed at 6:00 PM, at which time only the USS Curtiss and the USS Estes remained in the lagoon. Detonation of the MIKE thermonuclear device was scheduled for 0715 on 1 November 1952, Eniwetok time, which is on the west side of the International Date line (i.e., 31 October U.S. time). Sometime on 31 October, a P2V aircraft was sent to warn off a British merchant vessel, the SS Hartismere, that was sailing in the direction of Eniwetok and into the possible path of fallout from the shot. The P2V developed engine trouble and turned back. It made an emergency landing on the already evacuated Eniwetok landing strip at about 8:30 PM. The aircraft's crew was flown by heliocopter to the Rendova, waiting in the lagoon, after which the ship put to sea. About this time, six men normally assigned to the USS Estes could not be found but turned up on the USS Collins at about 10:30 PM. The British ship Hartismere was found by another P2V in the early hours of shot day and

FIGURE 5-28. KRAUSE-OGLE HELIUM BOX FROM MIKE CAB TO STATION 200

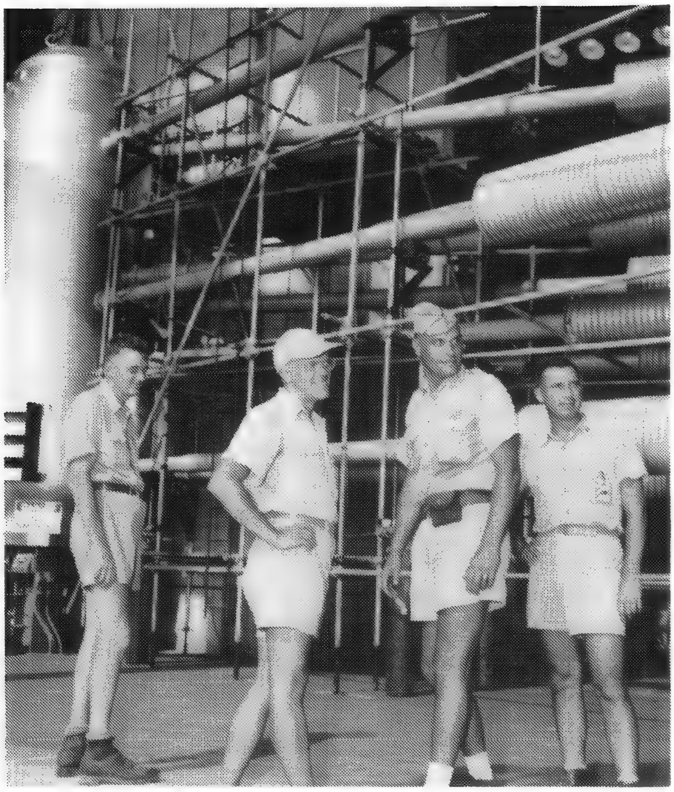


FIGURE 5-29. MIKE FIRING PARTY
H. E. Grier, S. W. Burriss, R. T. Lunger, M. D. Sprinkel

diverted to a safe course. The firing party departed the shot island, Elugelab, at 3:00 AM on shot day, departing on the last ship in the lagoon, the USS Curtiss, at 4:05 AM. (Figure 5-29, MIKE firing party.; 5-30, MIKE pre-shot.)

Weather had been a problem during most of October as the 1 November shot date for MIKE approached. Rain would compromise the collection of scientific data, but the winds aloft were the determining factor for favorable shot conditions. It was necessary for the fallout track to avoid populated islands to the east and south, as well as the task force itself. The weather briefing at 9:30 PM on 30 October indicated a very favorable picture for 1 November. The weather briefing at the same hour on 31 October, however, gave a poor outlook, and the weather conditions continued to deteriorate all day on D-1. Sometime around midnight the winds aloft shifted to a very favorable direction and speed at all upper levels, including the Krakatoes above the tropopause at 56,000 feet, making it possible to predict that the fallout track would be north and

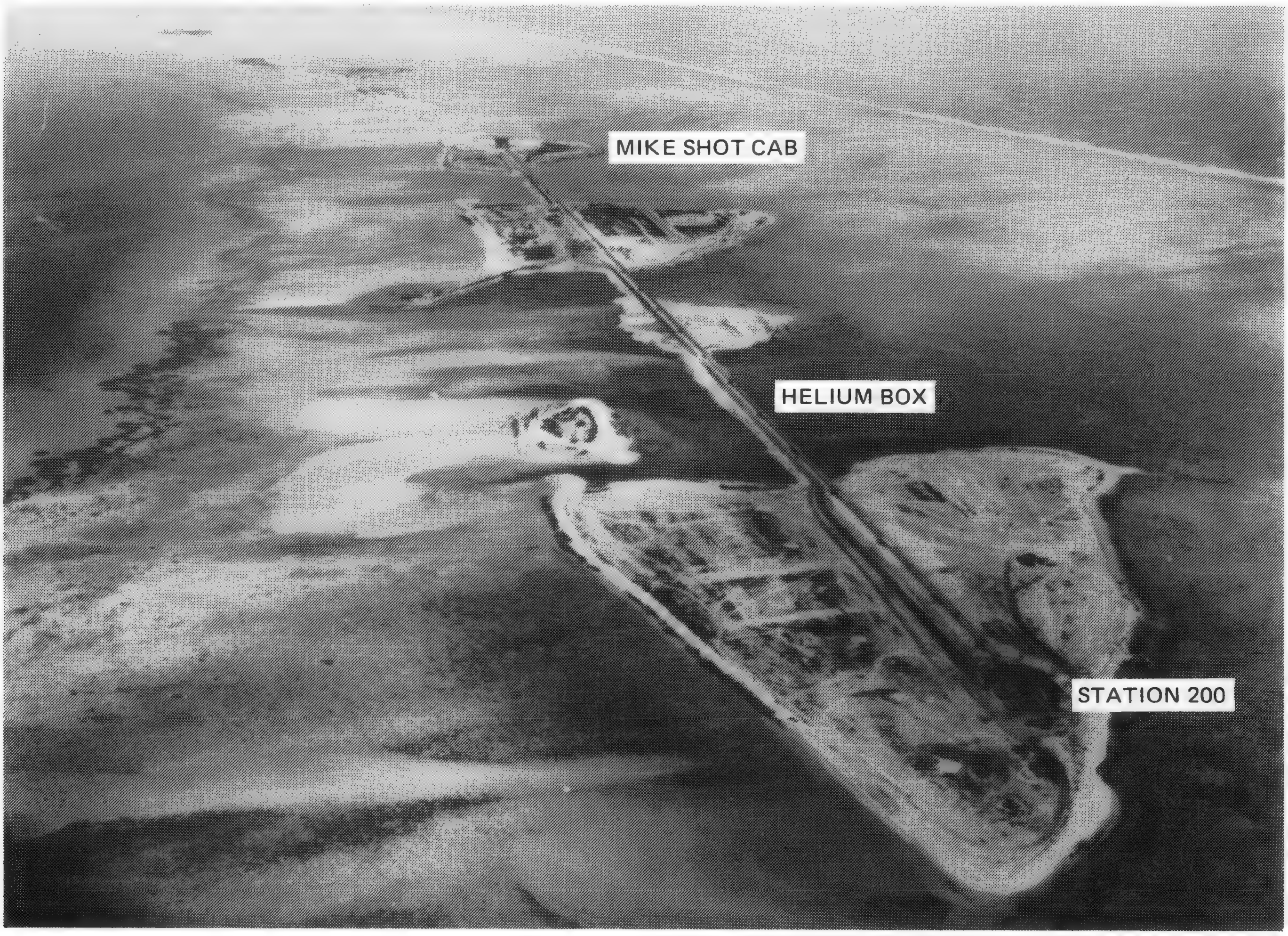
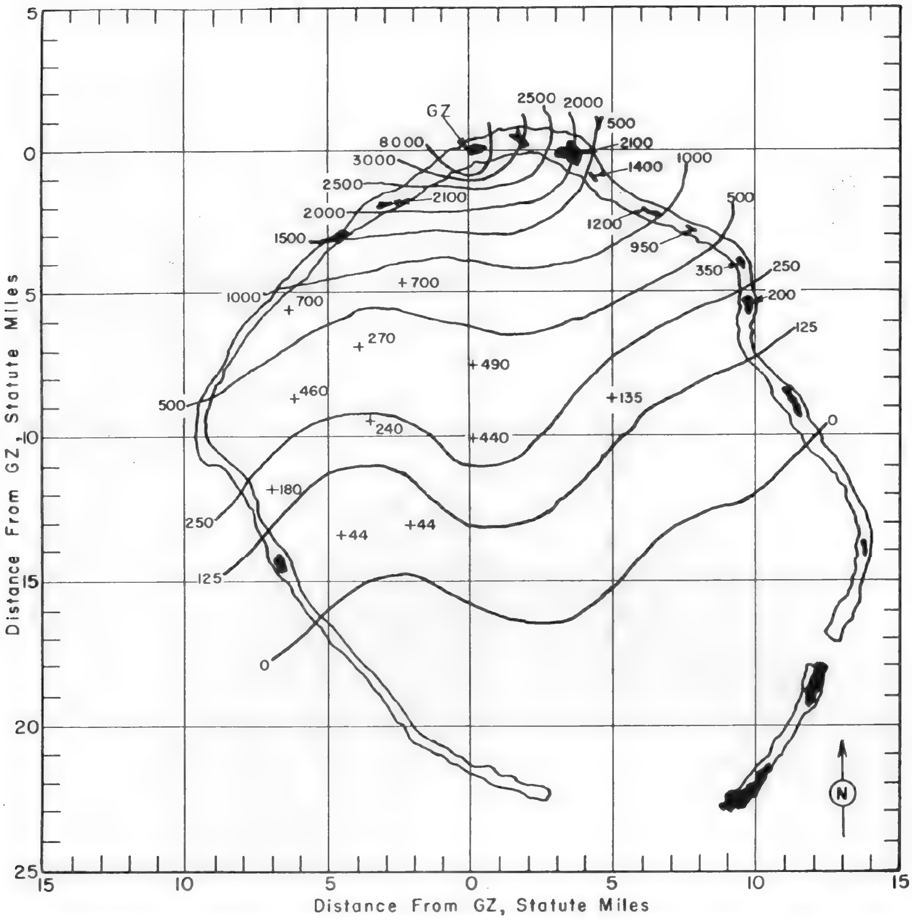


FIGURE 5-30. IVY MIKE SITE ON D-14 VIEWING NORTHWEST, HELIUM BOX EXPERIMENT FROM STATION 200 TO MIKE CAB

FIGURE 5-33. IVY MIKE D-1 (31 OCTOBER 1952) VIEWING NORTHWEST FROM STATION 200 TO SHOT CAB

FIGURE 5-34. IVY MIKE POST-SHOT D + 2 (3 NOVEMBER 1952)
VIEWING NORTHWEST FROM STATION 200, SHOT PRESSURE WAS 330 PSI



IVY MIKE - ATOLL DOSE RATES IN R/HR AT H + 1 HR

RUCHI ISLAND WAS 2.3 KM WEST OF GROUND ZERO AT ABOUT 3000 R/HR AT ONE HOUR

FIGURE 5-35. IVY MIKE POST-SHOT STATION 520 ON RUCHI ISLAND; JOHN MALIK ON REENTRY ON D + 4 (5 NOVEMBER 1952); DOSE RATE OF 3000 R/HR AT 1 HR HAD DECREASED TO ABOUT 12 R/HR. (30)

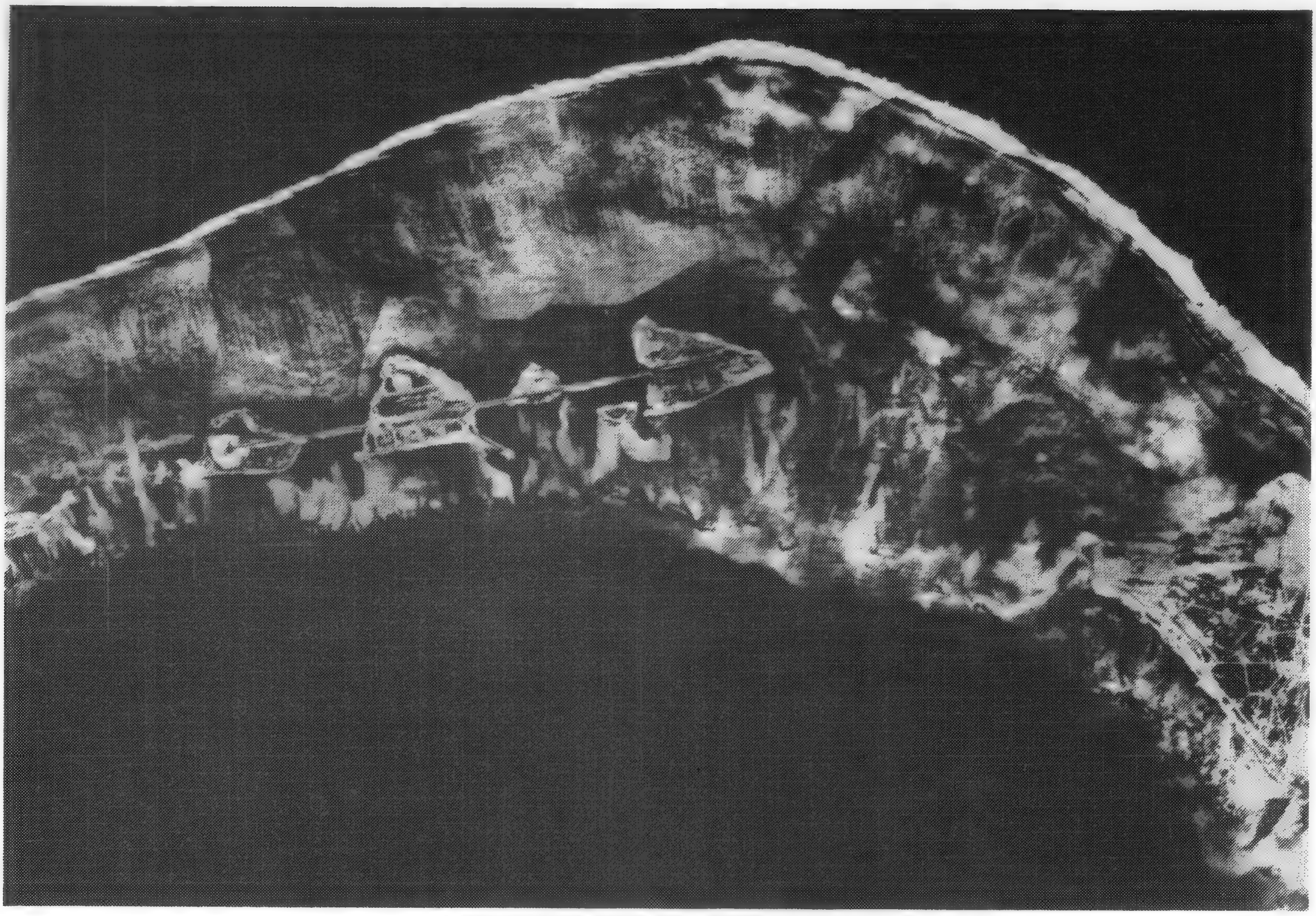


FIGURE 5-36. ENIWETOK ISLANDS PRE-SHOT ON D-9 (21 OCTOBER 1952)

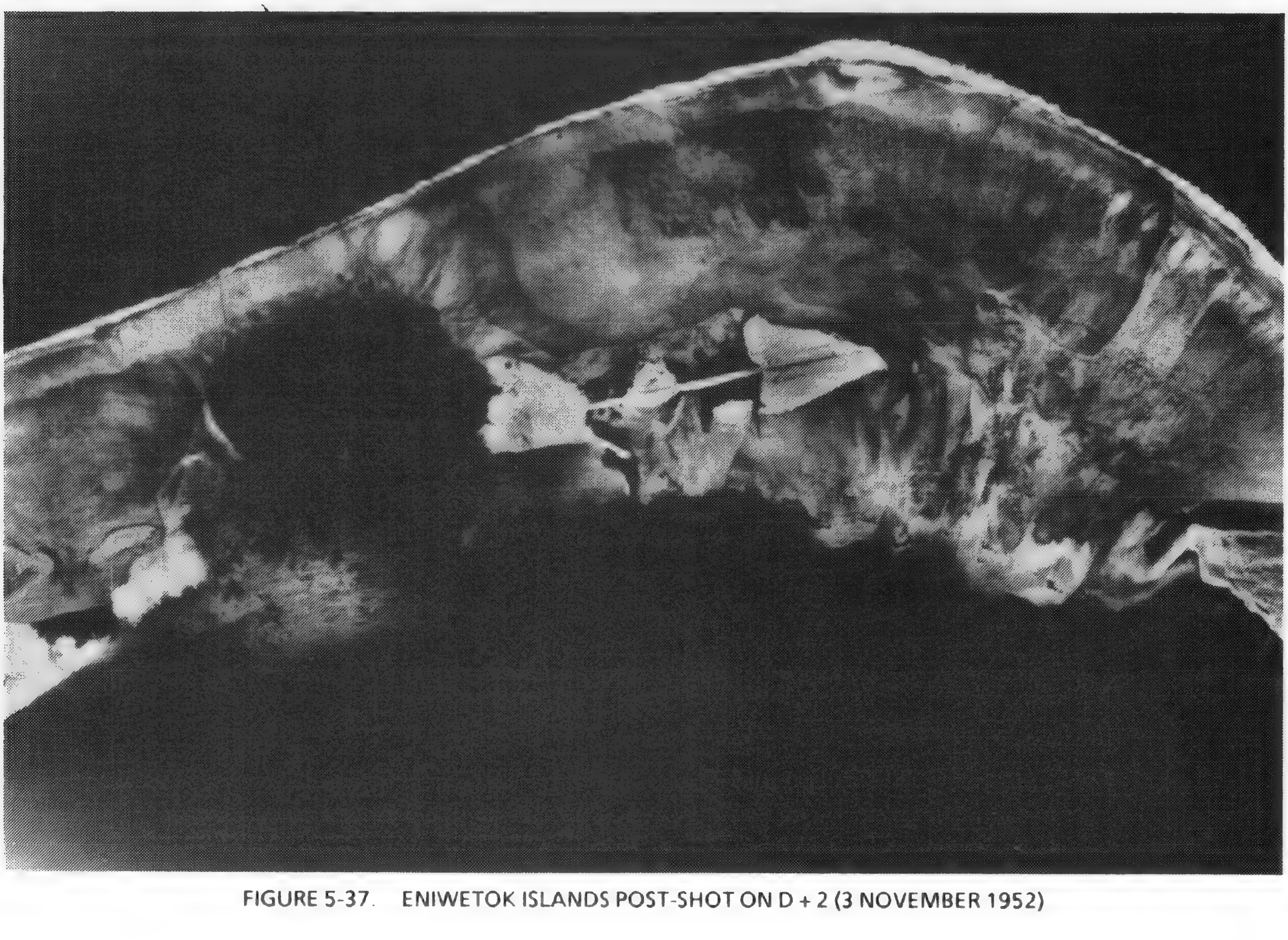


FIGURE 5-37. ENIWETOK ISLANDS POST-SHOT ON D + 2 (3 NOVEMBER 1952)

FIGURE 6-22. SHOT BRAVO - CRATER

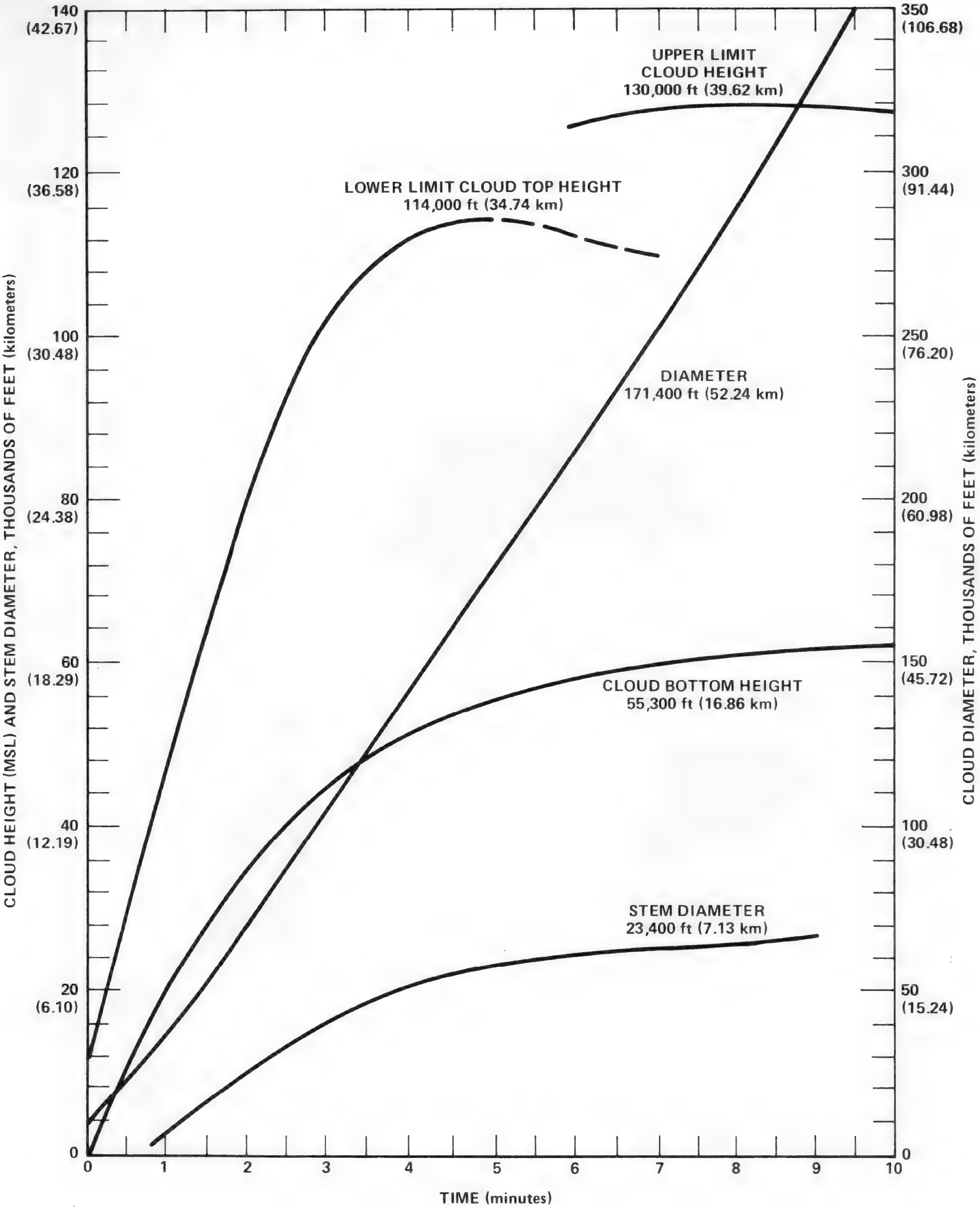


FIGURE 6-23. SHOT BRAVO - CLOUD DIMENSION

SANDIA LAB NEWS

published every other friday for the employees of sandia corporation, contractor to the atomic energy commission

Vol. 7, No. 17 ALBUQUERQUE, NEW MEXICO AUGUST 26, 1955

F. H. Shelton to Take AFSWP Post In Washington

Dr. Frank H. Shelton, who has been with Sandia Corporation since October, 1952, next month will become Deputy Technical Director for the Armed Forces Special Weapons Project in Washington, D. C.

—Frank H. Shelton—

A member of the Weapons Effects Department staff at Sandia, Dr. Shelton participated in Operation Teapot in 1955 and Operation Upshot-Knothole in 1953 at Nevada Test Site.

During Operation Teapot he was on loan to the Department of Defense and served as technical advisor to the Military Effects Director at the test site.

He has done extensive research in the field of blast and thermal phenomena associated with atomic explosions.

Born in Flagstaff, Ariz., Dr. Shelton was reared in Boulder City, Nev., and graduated from high school there. He attended college at California Institute of Technology and received his Bachelor of Science degree in 1949 and his Master of Science degree in 1950. He completed work for his Ph.D. degree there in 1952 and was awarded the degree in 1953 after arriving at Sandia. All three of his degrees were in physics.

Dr. Shelton saw three years of duty in the Army during World War II and was commissioned at the Armored Force School, Fort Knox, Ky., where he served as an instructor.

He is a member of the American Physical Society and Society of Sigma Xi. Dr. and Mrs. Shelton and their three daughters, Jill 5, Joyce 3 and Gwen 1, have been living on Sandia Base.

Boulder City Review Journal Spring, 1955

EX-BOULDERITE — Taking an active part in the current series of detonations at Nevada Test Site is Dr. Frank H. Shelton, research physicist in the Weapons Effects Department of Sandia Corp., Albuquerque, N. M. Dr. Shelton, son of Mrs. Jessie Shelton, (663 Ave. I) Boulder City, is serving as assistant to the Sandia supervisor-in-charge, R. S. Millican, at the Nevada Test Site, and also is assistant to the scientific director for military effects, Dr. E. B. Doll of the Department of Defense. Dr. Shelton lives with his wife and three children at 3001 W. Sandia Dr., Sandia Base. His brother, Warren H. Shelton, is a student at the University of Nevada.
(Joint Office of Test Information Photo)

FIGURE 7-15. SANDIA NEWSPAPER - F. H. SHELTON

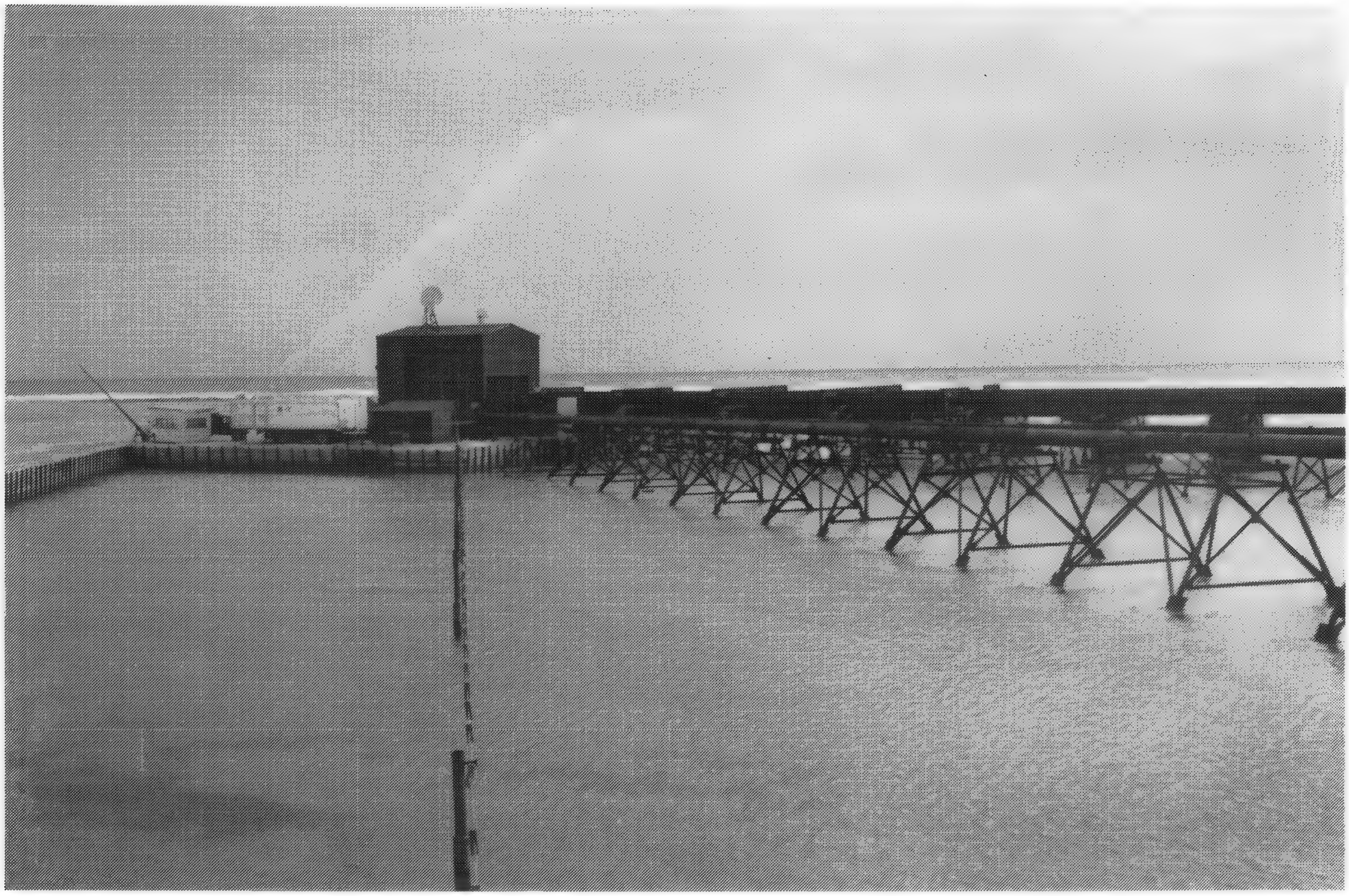


FIGURE 7-20. REDWING LACROSSE SHOT ISLAND (D-8, ENIWETOK SITE YVONNE)

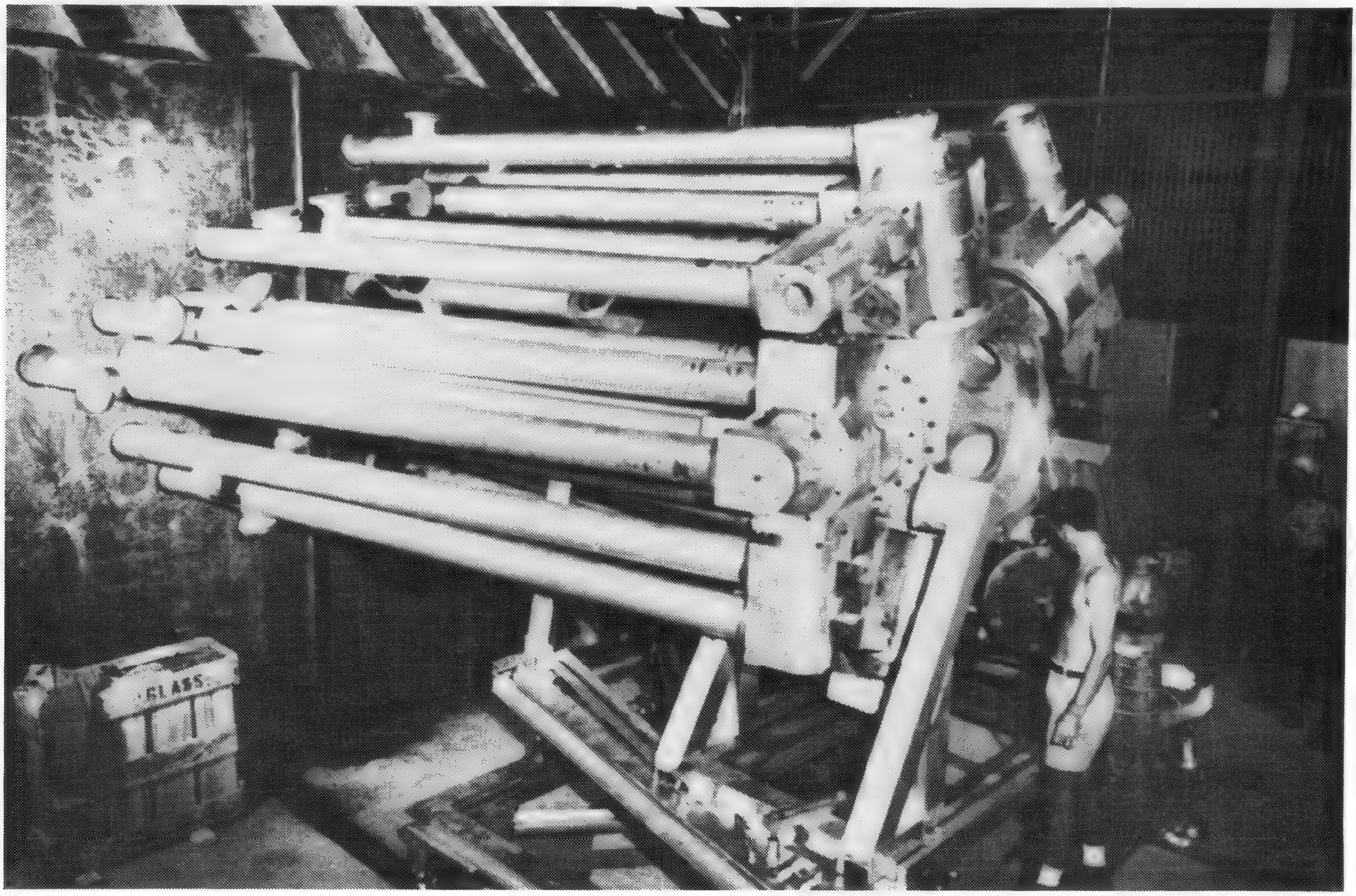


FIGURE 7-21. REDWING LACROSSE DEVICE (D-35)

In May 1956, members of a University of California Regents committee accompanied E.O. Lawrence to the Pacific Proving Grounds to review the ZUNI hydrogen-fusion nuclear weapon test. Left to right are: University of California Vice-President James H. Corley; UCRL Physicist Harry Keller; Regents Gerald Hagar and Victor R. Hansen; UCRL Physicists William McMaster and Gerald Johnson, in front of Brigadier General Alfred D. Starbird (person to Starbird's right is unknown); Ernest O. Lawrence; UCRL Physicists Carl Haussmann and Charles Blue; UCRL Director Herbert York; Regent Earl J. Fenston.

FIGURE 7-23. UCRL GROUP AT PACIFIC PROVING GROUNDS

that the CHEROKEE shot was off target somewhere to the northeast of Charlie island. He had arranged for a helicopter to take me, Colonel Woodward, and an H&N engineer with a surveying transit to go up island to try and triangulate the actual burst point, which was out to sea some place. We stopped at several islands east of Charlie, and it was noticed that the Air Force structures were still standing, but with some sidings removed to the north. Finally, on Charlie island it was apparent from various blast indications that the burst had occurred about 20,000 feet (about 4 miles) to the northeast. On return to Nan island, we prepared a message for Gaelen to send over to Headquarters JTF-7 at Eniwetok. (Figure 7-25, Gaelen Felt.)

I knew the message on the CHEROKEE bombing error would be forwarded by Admiral Hanlon to the Joint Chiefs of Staff in Washington. I also knew that my friend, Don Quarles, Secretary of the Air Force would be disappointed in the turn of events. He would probably have to go over to the White House and inform Eisenhower of the situation. I made a mental note to go by and talk to Don as soon as I got back to Washington and explain that Brigadier General "Blackie" Samuels had been on the radio to the drop aircraft continuously during the bombing run, giving direct orders to the bombardier.

A couple days after CHEROKEE, we were amused by the newspaper accounts of the shot, which described it as being "the largest ever conducted in the Pacific." Unclassified accounts of CHEROKEE surmised that the yield was 10 MT, which was fine with all of us who knew the actual explosive power, and we hoped that impressed Khrushchev.

ZUNI Event

ZUNI was a test of a large yield thermonuclear device, designed and developed by UCRL, that required an island to support the large amount of diagnostic instrumentation. Real estate was scarce in the Pacific Proving Grounds, ZUNI being the one event at Bikini to crater out a piece of the island on Operation REDWING. Because of its yield and island configuration, ZUNI was the primary event for fallout documentation on the operation. ZUNI event would turn out to be the most thoroughly documented fallout shot measured during all the United States' weapon

FIGURE 7-24. OPERATION REDWING CHEROKEE SHOT

FIGURE 7-25. GAELEN FELT

testing in the Pacific from 1946 (Bikini ABLE/BAKER) through 1962 (Operation DOMINIC).

About two weeks before the readiness date for ZUNI, we toured the shot island (Tare) and the shot cab with Walter Gibbins, UCRL Deputy on Task Group 7.1 (Appendix B, 7.1 organization). It was interesting to walk the area and note that ZUNI ground zero was near the old KOON crater produced by a UCRL event on Operation CASTLE. (Figure 7-26, ZUNI cab.)

Reviewing the fallout documentation plans for ZUNI shot, I spent some time on one of the three fallout collection ships that had been modified by the U.S. Naval Radiological Defense Laboratory (NRDL) at Hunters Point in the San Francisco bay area. With Commander Don Campbell, Program 2 Director, we visited the YAG-39 (USS George Eastman) which had been modified to permit operations in the fallout area from its heavily shielded control room and was to be positioned in the fallout zone (along with the YAG-40 and USS Crook County) prior to arrival of fallout. It was only after spending some time on one of the YAGs that I appreciated the potential contributions that ships could make in our all-out effort to document fallout from large yield thermonuclear weapon explosions. Paul Tompkins and Gene Cooper, heads of NRDL, and I reviewed their plans both in my office and in theirs for modifying the ships for fallout collection. I was more impressed with the AFSWP costs and long lead times for modifications in the naval ship yards. Out in the Pacific, the modified ships were truly technological innovations. Victor Van Lint spent a large part of his time out in the Pacific coordinating the plans for the Scripps Institute of Oceanography's boat (the MV Horizon) to service the 16 deep moored "skiffs" that were instrumented to collect fallout data in the area north of Bikini Atoll.

As shot day for ZUNI event approached, everyone was evacuated from Bikini Atoll, including those who had occupied the Control Point on Nan island during the CHEROKEE shot. The Task Group 7.1 Command staff and key scientific personnel were aboard the USS Curtiss when ZUNI was detonated by a radio signal at 5:56 a.m. on 28 May 1956. Ground zero was near the KOON crater that was made on Operation CASTLE. The yield of the University of California Radiation Laboratory (UCRL) ZUNI device was 3.5 MT. ZUNI, with its high yield and surface placement, formed a large crater that chewed out the western end of Tare island, and ejected material was pulled up into the radioactive cloud. As soon as we were able to make an aerial survey of the ZUNI crater, it was flooded by the lagoon waters. Crater dimensions were: radius = 1165 feet, depth = 93 feet (Figure 7-27, ZUNI shot).

The ZUNI radioactive cloud topped at 85,000 feet, with a diameter at that time of 75,000 feet. General cloud movement was to the north at 15 knots, but the lower portion of the stem moved to the west, under the prevailing easterlies, at about the same speed. The 30,000-foot winds turned to the southeast sometime late on shot day, causing light fallout on atolls southeast of Bikini. Heavy radioactivity was measured throughout most of the Bikini Atoll, with readings of 75 R/hr at 4 hours (H + 4 along the northern rim of islands). Fortunately, the living area on Nan was only lightly touched by fallout. An H + 4 value of 0.003 R/hr was measured. Fallout contours for the ZUNI event are given in Figure 7-28, with all readings being extrapolated back to H + 1 hour. Some hot spots of 150 R/hr were noted at about 50 miles north of the shot point. (Figure 7-28, fallout contours, and Figure 7-29, ZUNI crater.)

TEWA Event

(See Figure 7-30 and 7-31, Eniwetok and Bikini Atoll maps for shot locations.)

The UCRL 5 MT TEWA device was fired 21 July 1956 on a barge anchored on the reef between Charlie and Dog islands on the north rim of Bikini Atoll (Figure 7-32,TEWA barge). TEWA was a companion event to ZUNI for documentation of fallout from large yield thermonuclear weapons (Figures 7-33 and 7-34, TEWA device and shot cloud). In early Operation REDWING planning, the location of the TEWA event had been moved from deep lagoon waters to as near the coral reef as possible. I had always hoped that it could be anchored in water that was less than the 24.7 feet which occurred on the final placement. Total weight of the barge was 440,000 pounds, including 410,000 pounds of steel, all of which contributed to the fallout material, as well as the coral reef material created by the explosion. Crater measurements were: radius = 1915 feet, depth = 133 feet, with a total of 740 million cubic feet of material being ejected in the formation of the crater. The fallout pattern documented for TEWA is given in Figure 7-35. While the yield of TEWA (5 MT) was larger than ZUNI (3.5 MT), it was observed that the down wind "hot spot" for TEWA (1000 R/hr) was much higher than on ZUNI (150 R/hr). The difference was primarily due to the higher percentage of fission yield for TEWA as compared to ZUNI. (Figure 7-35, TEWA fallout contours, and Figure 7-36, TEWA crater.)

SEMINOLE Event

The SEMINOLE device was detonated on the western end of Irene island (Eniwetok Atoll) at 12:55 p.m. on 6 June 1956 during Operation REDWING. SEMINOLE was a LASL sponsored event with a low yield of 13.7 KT. However, because the device was detonated within a large water filled tank, it probably had an increased

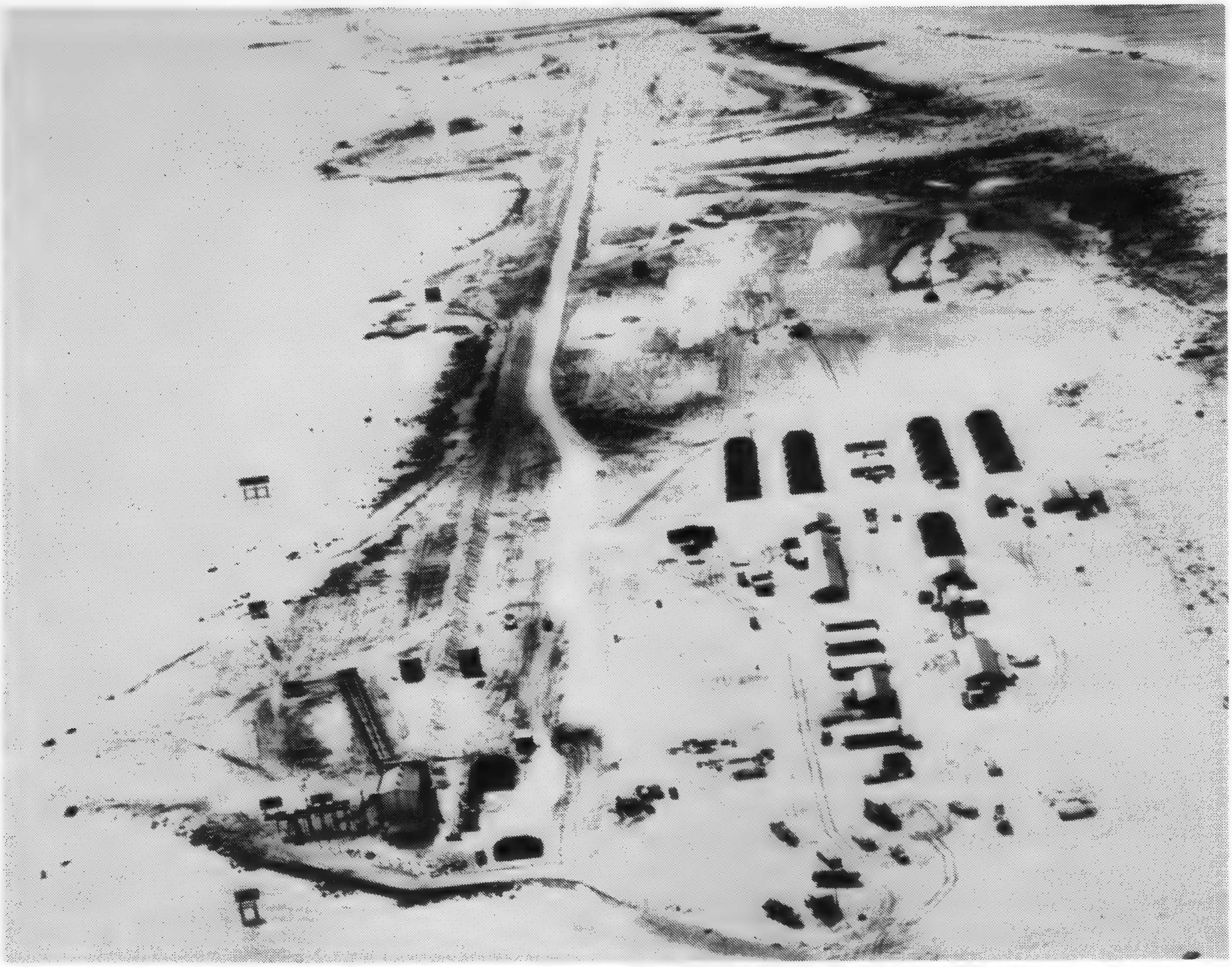


FIGURE 7-26. ZUNI CAB AND INSTRUMENTATION (D-30, VIEWING EAST, EDGE OF CASTLE KOON CRATER)

FIGURE 7-27. ZUNI SHOT VIEWED FROM ENEU ISLAND

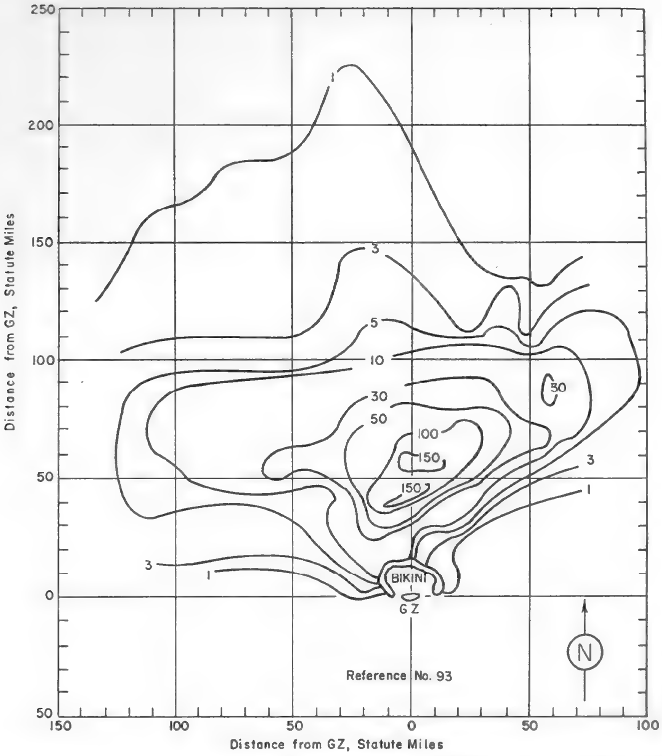


FIGURE 7-28. ZUNI FALLOUT CONTOURS

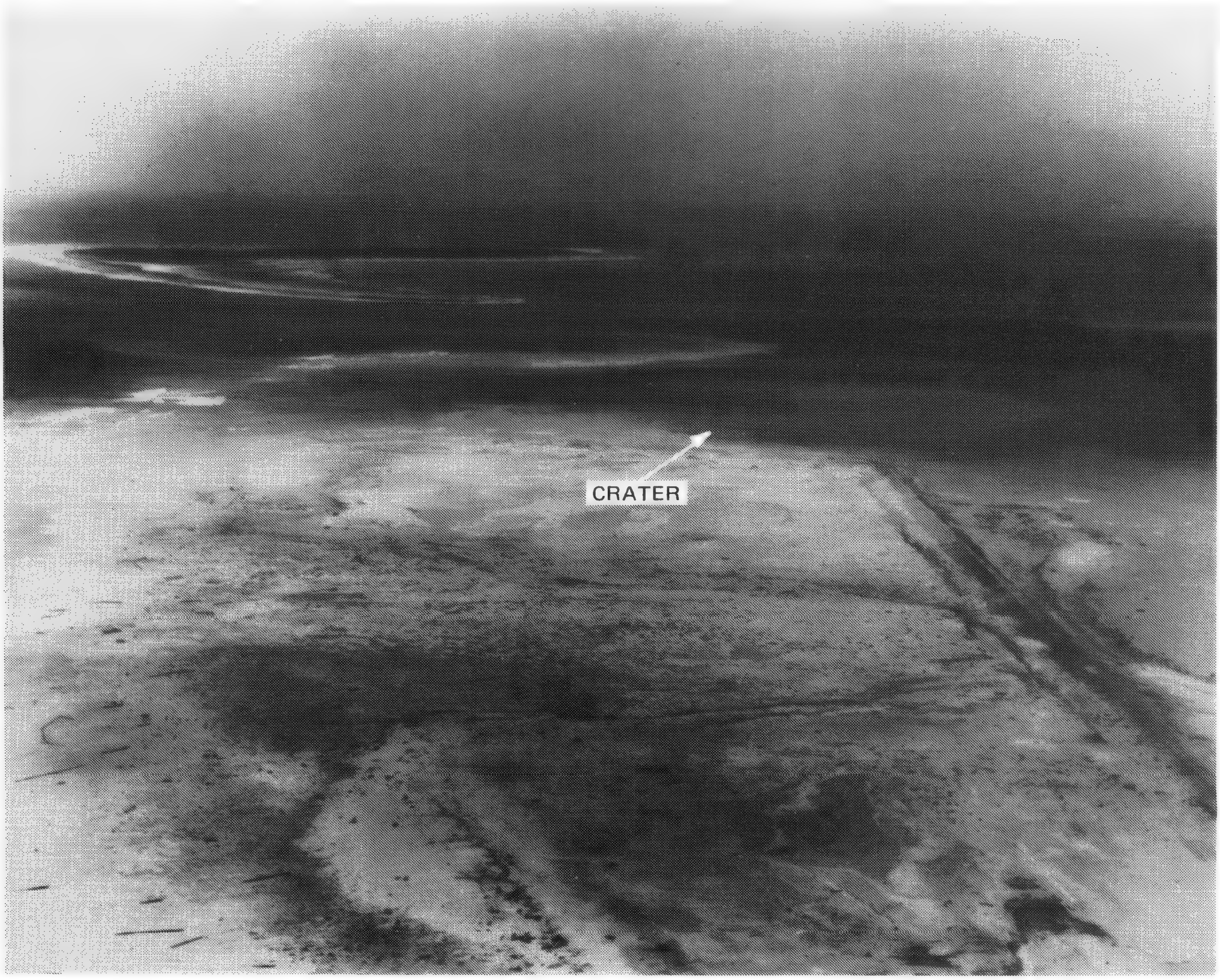


FIGURE 7-29. ZUNI CRATER (H + 10, LOOKING WEST)

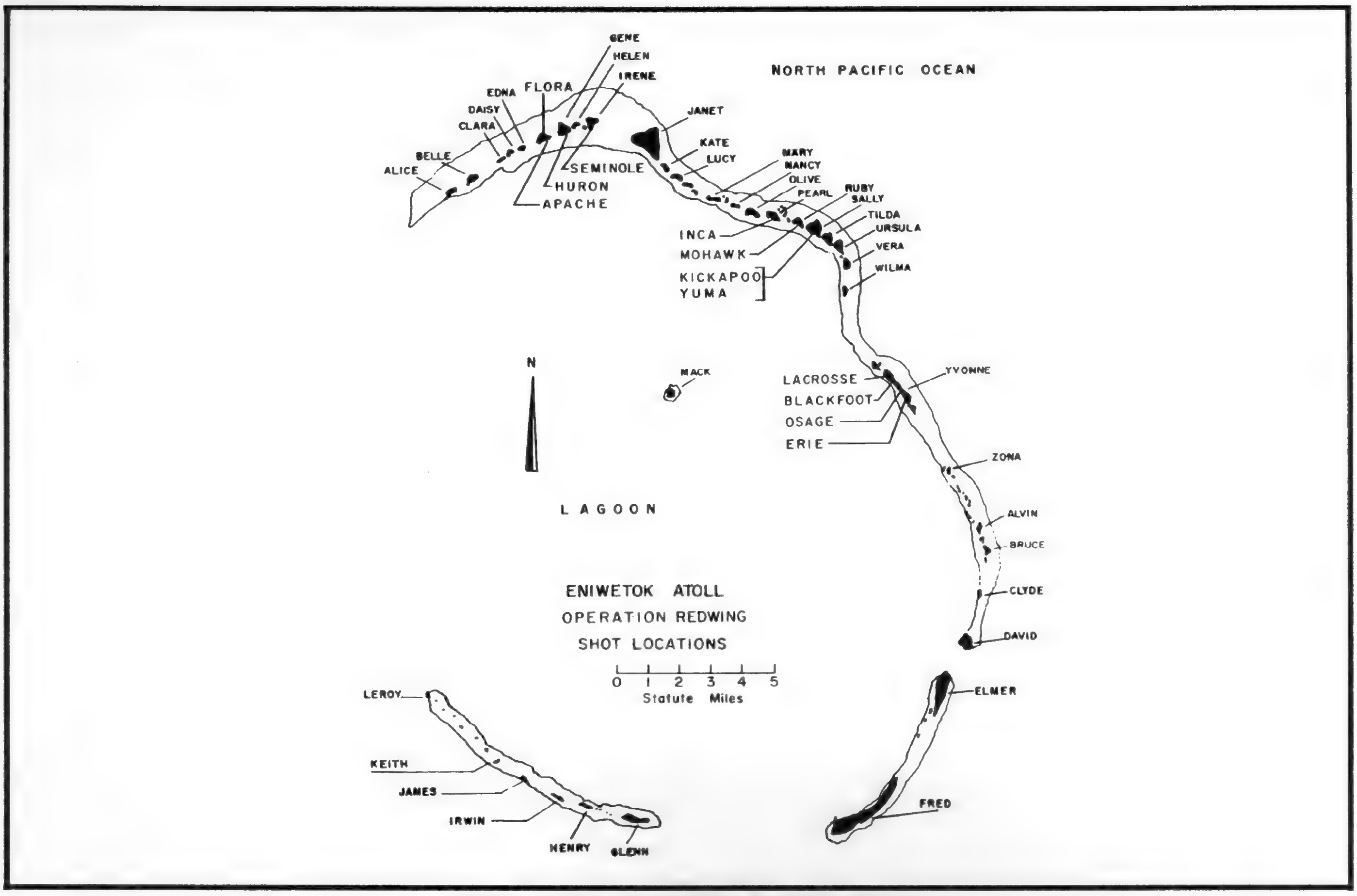


FIGURE 7-30. ENIWETOK ATOLL SHOTS

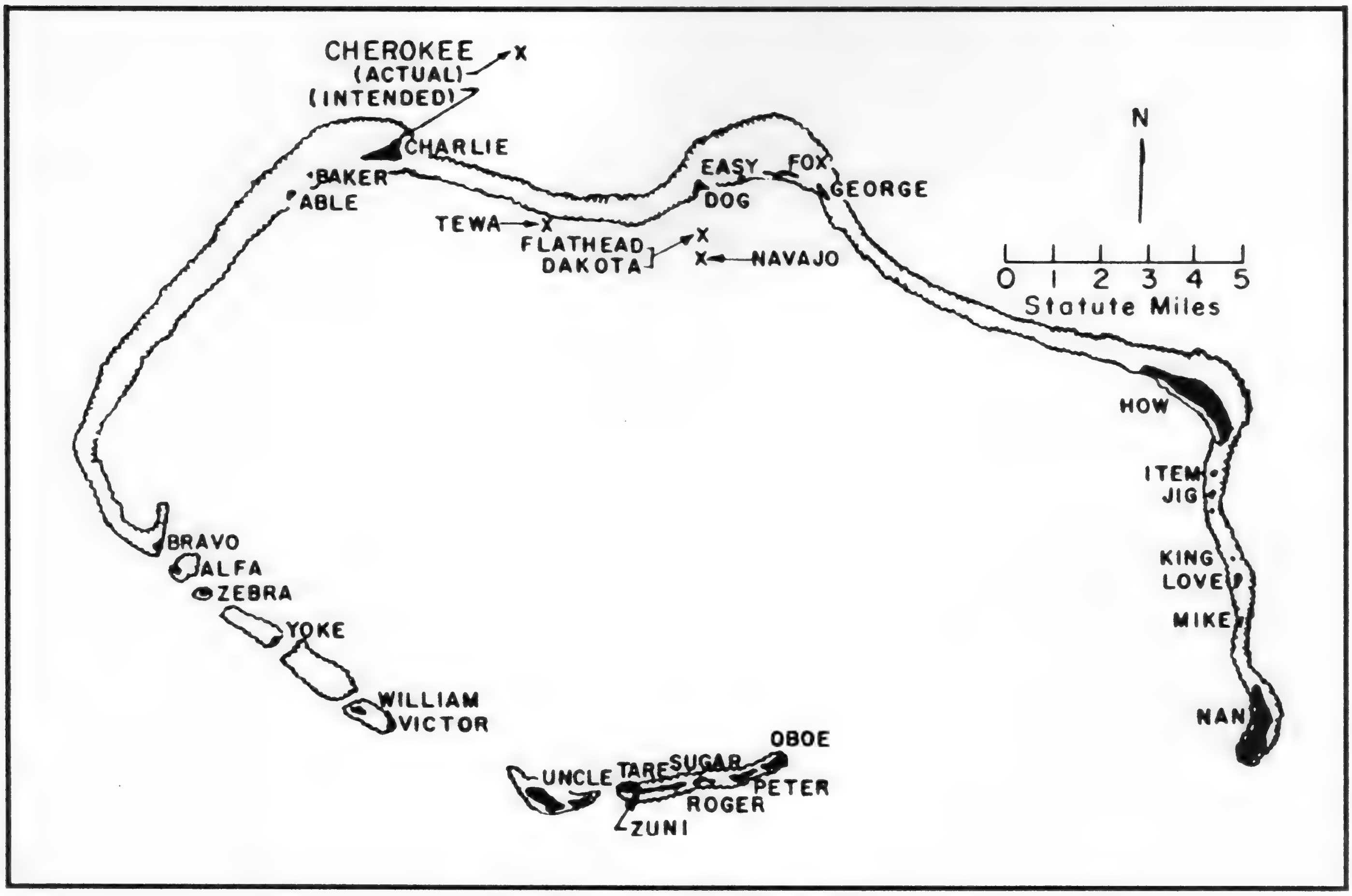


FIGURE 7-31. BIKINI ATOLL SHOTS

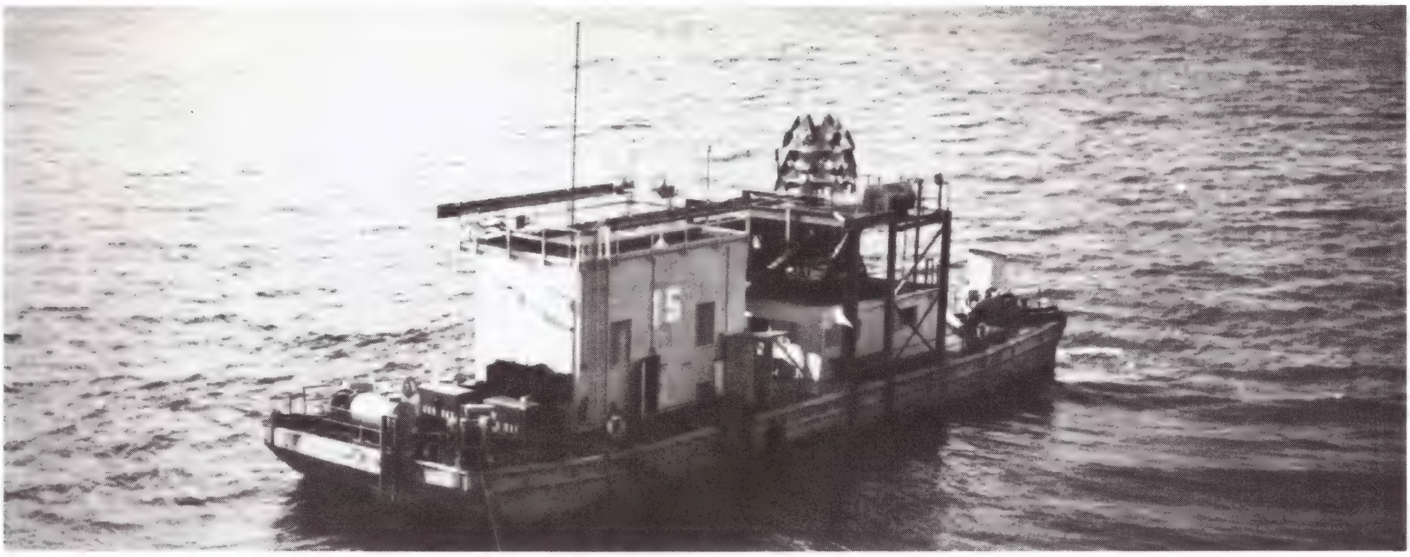


FIGURE 7-32. TEWA PRE-SHOT BARGE (D-1, BIKINI LAGOON BETWEEN DOG AND CHARLIE ISLANDS)

FIGURE 7-33. TEWA DEVICE (D-3, HOB = 8.2' ABOVE WATERLINE)

FIGURE 7-34. TEWA SHOT CLOUD FROM ENIWETOK

amount of energy coupled with the ground, resulting in a larger crater volume as compared with a similar device detonated in air at the same height of burst. (Figure 7-37, SEMINOLE water tank under construction; Figure 7-38, SEMINOLE device.)

The SEMINOLE nuclear weapon was placed inside a 15-foot diameter air filled steel tank, which, in turn, was inside and tangent to the diameter of a 50-foot diameter steel tank. The tanks were connected by a structural steel tunnel with water-tight doors. A 200,000 pound lead shield was positioned directly opposite the device between the two tanks. The total mass of sea water in the large tank, including the flooded access tunnel, at shot time was 2.9 million pounds. The station foundation was a 3-foot-thick concrete slab (1.3 million pounds of concrete and 200,000 pounds of steel). (Figures 7-39 and 7-40, shot and crater.)

SEMINOLE shot had an impressive amount of ejecta at zero time (see Figure 7-38), producing a crater that was: radius = 324 feet, depth = 31.6 feet. (Figures 7-41 and 7-42, pre-shot and post-shot.)

FLYING HIGH WITH A HALF-DOZEN U-2S

The fallout program on REDWING was designed to document local radiation levels for hundreds of miles down wind and for a few days after each nuclear weapon detonation. As the REDWING series progressed, I watched multi-megaton radioactive clouds rise to about 100,000 feet altitude. (Figures 7-43 and 7-44, REDWING shots DAKOTA and APACHE; Figure 7-45, MOHAWK shot.)

The documented local fallout was being carried back to earth on large, solid particles. While it was important to understand the local

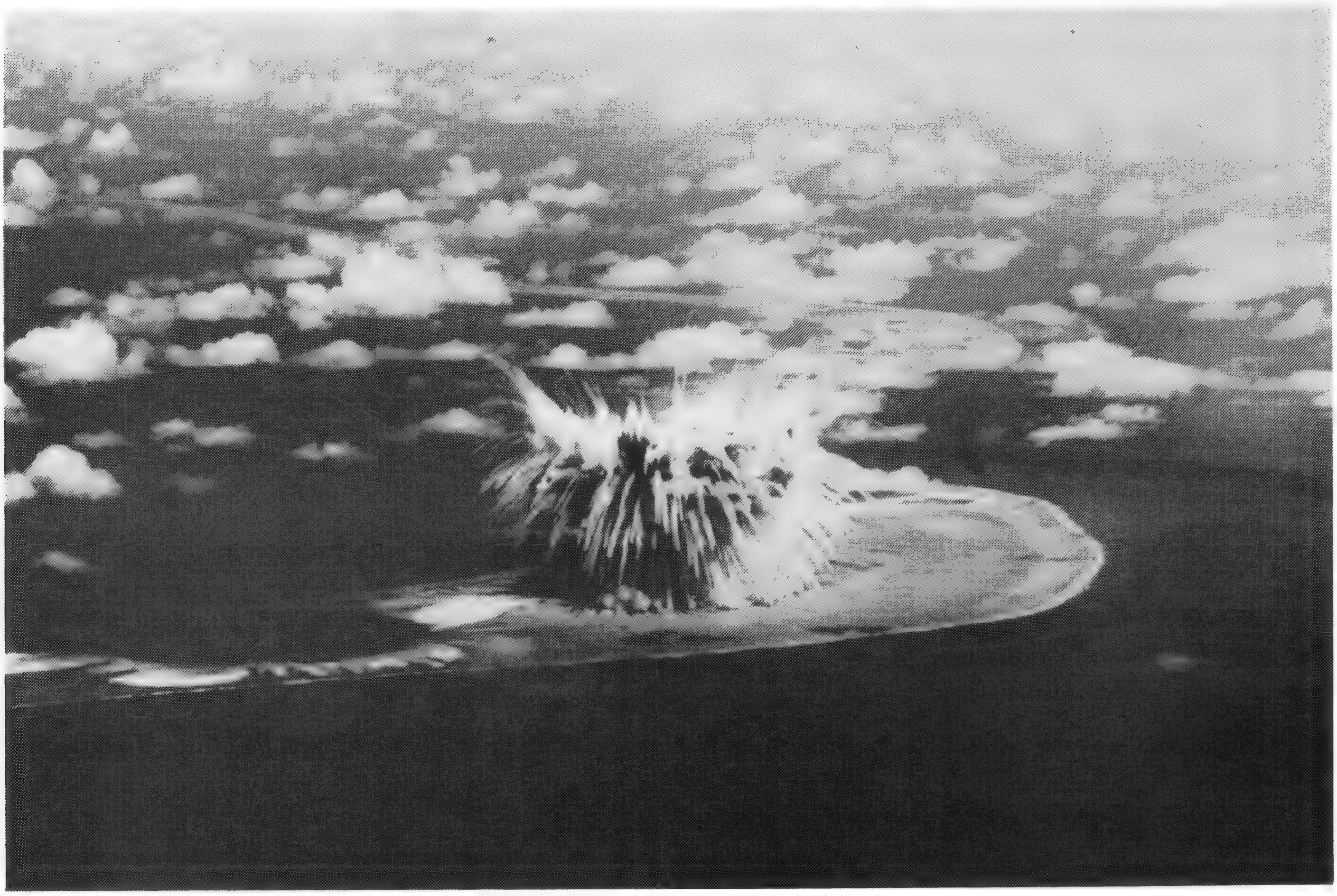


FIGURE 7-39. SEMINOLE SHOT

FIGURE 7-40. SEMINOLE CRATER (D + 19, VIEWING NORTH)

TABLE 7-7. SUMMARY OF PACIFIC CRATERS

OPERATION	EVENT	YIELD (KT)	HOB (FEET)	RADIUS (R) (FEET)	DEPTH (D) (FEET)	RADIUS (R)/(D) DEPTH
IVY	MIKE	10,400	10.0	2,910	187.0	15.6
CASTLE	BRAVO	15,000	7.0	3,255	200.0	13.0
	KOON	150	9.6	495	40.0	12.4
REDWING	LACROSSE*	39.5	8.0	200	55.5	3.6
	ZUNI	3,380	10.0	1,165	113.0	10.3
	SEMINOLE	13.7	7.0	324	32.2	10.1
	TEWA	4,600	10.0	1,915	133.0	10.4

* Originally, I thought that the small radius/depth = 3.6 for LACROSSE (Similar to Nevada craters R/D = 2.0) occurred because it was not heavily washed by waves after the shot, as the high yield shots were. Now, it is believed that the large R/D ratios in the pacific craters are due to pressure collapse of the porous coral material, and not due to ejecta from the crater. (See Table 7-3, Nevada Test Site Craters.)
(Reference 16: Table 1-1, "Geologic And Geophysical Investigations Of The Eniwetok Nuclear Craters," Capt. Byron L. Ristvet, September 1978, AFWL-TR-77-242, Unclassified. Most of the REDWING figures also appear in this reference.)

fallout portion of the total nuclear radiation that was produced by the large yield nuclear bursts, I was thinking about the other part of the fission debris that remained in the stratosphere for years and was spreading around the earth. How do you measure that part of the fission debris that slowly settles out of the stratosphere as worldwide fallout? At that time, there was only one kind of airplane that could fly high enough to sample the stratosphere, and that was Kelly Johnson's new U-2 aircraft being built to CIA specifications for overflight reconnaissance of the Soviet Union. (Figure 7-46, U-2 aircraft.)

The Joint Chiefs of Staff, realizing the seriousness and complexity of the worldwide fallout problem, requested in the fall of 1954 (after CASTLE Bravo in the spring of 1954) that the Armed Forces Special Weapons Project (AFSWP) study and evaluate the situation on a continuing basis. After considerable study during 1955, it was decided that the largest uncertainty in the prediction of the distribution and concentration of worldwide fallout debris on the surface of the Earth was the quantity of fission products in the stratospheric reservoir and the rate and mode of its transfer to the biosphere. The AFSWP program became known as the High Altitude Sampling Program or "Project HASP."

Soon after I joined AFSWP in the fall of 1955, Major General Al Luedecke (Chief of AFSWP) brought me into the Top Secret U-2 program that was underway at that time under the immediate supervision of Lieutenant Colonel Howard Rose, AFSWP Radiation Division. Development and availability to AFSWP of the new Lockheed U-2 aircraft made Project HASP a real possibility. It was, however, important to incorporate a sampling system into the U-2 aircraft using a new filter paper with low resistance to air flow, but high efficiency in collecting capability. A contract was initiated with the Institute of Paper Chemistry in September 1956 for development of the filter paper. Prior to the delivery of the six AFSWP U-2s in the summer of 1957, a contract was let in February 1957 with Isotopes, Inc. under the scientific direction of Dr. Laurence Kulp and Dr. Herb Feely. Professor Elliot Reid of Stanford University, one of this country's leading authorities on the application of aerodynamic theory to atmospheric sampling mechanisms, was consulted regarding the design and application of a filter-type sampler for HASP.

President Eisenhower wanted intelligence information from within the Soviet Union; especially early warning on mobilization of troops or aircraft. However, CIA, under Allen Dulles, had been unable to establish an effective spy network in Russia to obtain information on Soviet military build-ups. Eisenhower activated in early 1954 a "Surprise Attack Panel" to advise him on the Soviet surveillance matter. Chairman of the Panel was James Killian, President of MIT. Edwin Land, inventor of the Polaroid camera and winner of a

FIGURE 7-43. DAKOTA BARGE SHOT

FIGURE 7-44 APACHE BARGE SHOT

FIGURE 7-45. MOHAWK TOWER SHOT

MAY 1 0 1957

SCIENTIST DOUBTS FALL-OUT DANGER

Atom Tests Can Be Safe for 40 Years at Present Rate, Pentagon Aide Testifies

NY TIMES

Special to The New York Times.

WASHINGTON, May 9—Atomic testing can be continued at the present rate for another forty to fifty years and not create any serious danger from radioactive fallout, the chief atomic weapons scientist in the Defense Department believes.

This opinion was offered recently by Dr. Frank H. Shelton, technical director of the Armed Forces Special Weapons Project. He gave it when testifying before a House Appropriations subcommittee on the possible dangers to human health caused by the fall-out from atomic explosions. The testimony was released today.

Dr. Shelton was called before the subcommittee to discuss what had been described as a "great deal of concern" being expressed over the long-range effect on the human race of the fall-out. The subcommittee's chairman, Representative George H. Mahon, Democrat of Texas, had noted such "concern."

At one point during the closed door hearing, Mr. Mahon asked:

"Could you not say that at the present rate we could go on for forty to fifty years without serious danger in so far as you know?"

"Yes," Dr. Shelton replied.

Information 'Meager'

At the same time, Dr. Shelton conceded that information on world-wide fall-out from past atomic tests was "extremely meager." The Defense Department, he said, is taking steps to define more precisely the amount of radioactive debris in the air from atomic tests and the rate at which it is falling to the earth.

Dr. Shelton testified that it would require large nuclear explosions with a yield equivalent to 30,000,000,000 tons of TNT to bring the average concentration of Strontium-90 in human bones up to the maximum permissible concentration. This would be equivalent to 1,500,000 atomic bombs of the size dropped on Japan in World War II.

Strontium-90 is a long-lived radioactive product of a nuclear explosion. In human bones it can produce cancer or leukemia. The maximum permissible concentration of Strontium-90 for general populations has been set at one-tenth of a microcurie for a person. A curie is a technical measurement of radiation, and a microcurie is one-millionth of a curie.

Dr. Shelton said that the maximum permissible concentration was five to ten times below the concentration necessary to produce a "barely detectable increase" in the rate of bone cancer or leukemia. His statement was based on the assumption, challenged by some scientists, that extremely small doses of Strontium-90 will not induce bone cancer.

Dr. Shelton likewise tended to minimize the threat of external radiation from fall-out materials. To increase the world-wide external radiation exposure by 10 per cent, he said, would require atomic explosions with a yield equivalent to 5,000,000,000 tons of TNT. The 10 per cent increase, he said, would be equivalent to the greater natural radiation received as a result of living in Denver instead of at sea level.

In the event of war, Dr. Shelton said, exposure to radioactive fallout can be reduced "very effectively" by even the most simple shelter.

FIGURE 8-4. NEWSPAPER ARTICLE, NEW YORK TIMES, 10 MAY 1957, "SCIENTIST DOUBTS FALLOUT DANGER"

FIGURE 8-19. PLUMBBOB - HOOD SHOT, 5 JULY 1957, 1500', BALLOON, 74 KT (LARGEST)

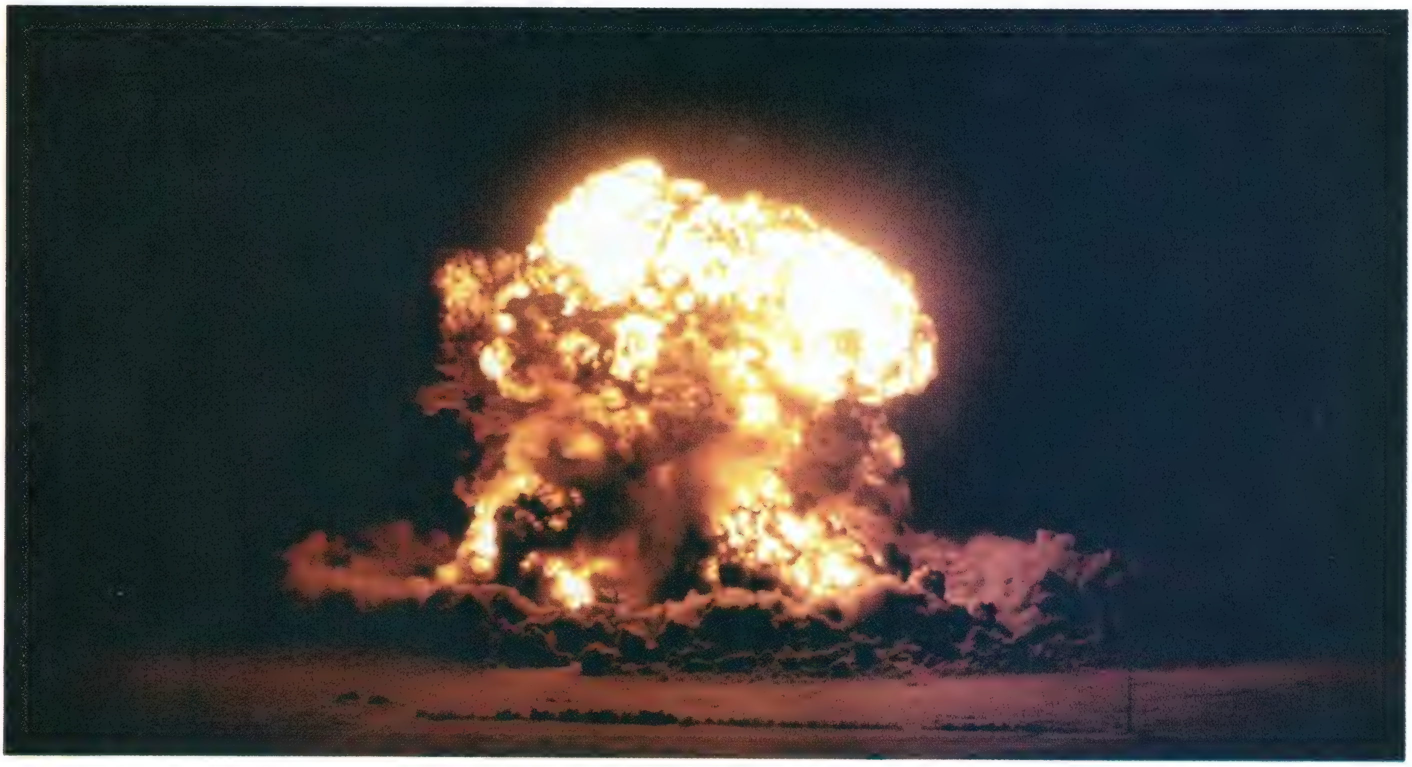


FIGURE 8-20. PLUMBBOB - DIABLO SHOT, 15 JULY 1957, 500', TOWER, 17 KT

FIGURE 8-21. PLUMBBOB - STOKES SHOT, 7 AUGUST 1957, 1500', BALLOON, 19 KT

FIGURE 8-22. PLUMBBOB - FIZEAU SHOT, 14 SEPTEMBER 1957, 500', TOWER, 11 KT

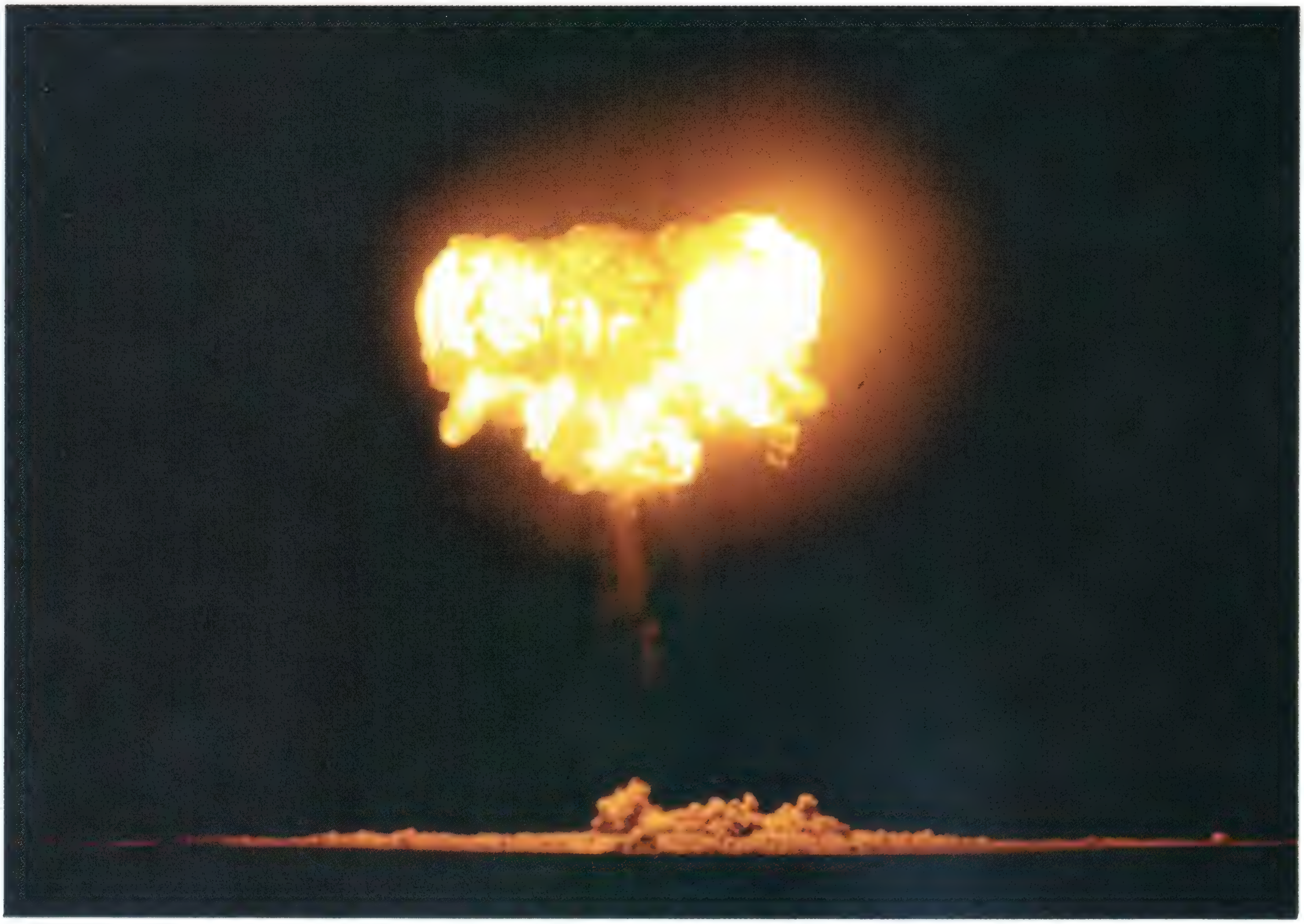


FIGURE 8-23. PLUMBBOB - CHARLESTON SHOT, 28 SEPTEMBER 1957, 1500', BALLOON, 12 KT

T-1 (M-101)
Weight, lb:
Loaded: 37,850
Payload: 2,650
Range, miles: 500
Diameter, in.: 66
Length, ft.: 62

In 1957 the T-1 missile was operational, but was also being used as a test vehicle for more advanced Soviet missiles. The T-1's liquid propellant engines were used as upper stage units in the T-3 ICBM.

The Soviet T-2 (M-103) surface to surface missile was an outgrowth of the German A-10 design, which never reached the production phase in Germany before the end of World War II. The T-2 was an IRBM, two stage operational missile deployed throughout the Soviet Union in 1957. With a 1,850 mile range the Russians put Western Europe and North Africa at risk with the nuclear warhead tipped T-2 missile.

T-2 (M-103)
Weight, lb:
Loaded: 110,000
Payload: 2,450
Range, miles: 1,850
Diameter, in.: 100
Length, ft.: about 66

Static testing of the T-2 missile began in 1951, and full-scale firings were observed in 1955. Using an inertial guidance system, operational testing of the T-2 continued at about the rate of five launches per month during 1956 and 1957.

By 1957 the Soviet T-3 (M-104) missile, with its 5,000 mile three stage system, was operational and in large scale production. The first stage of the T-3 was powered by a large 480 thousand pound thrust rocket motor, the second stage by a T-2 motor, and the third stage by a T-1 propulsion unit.

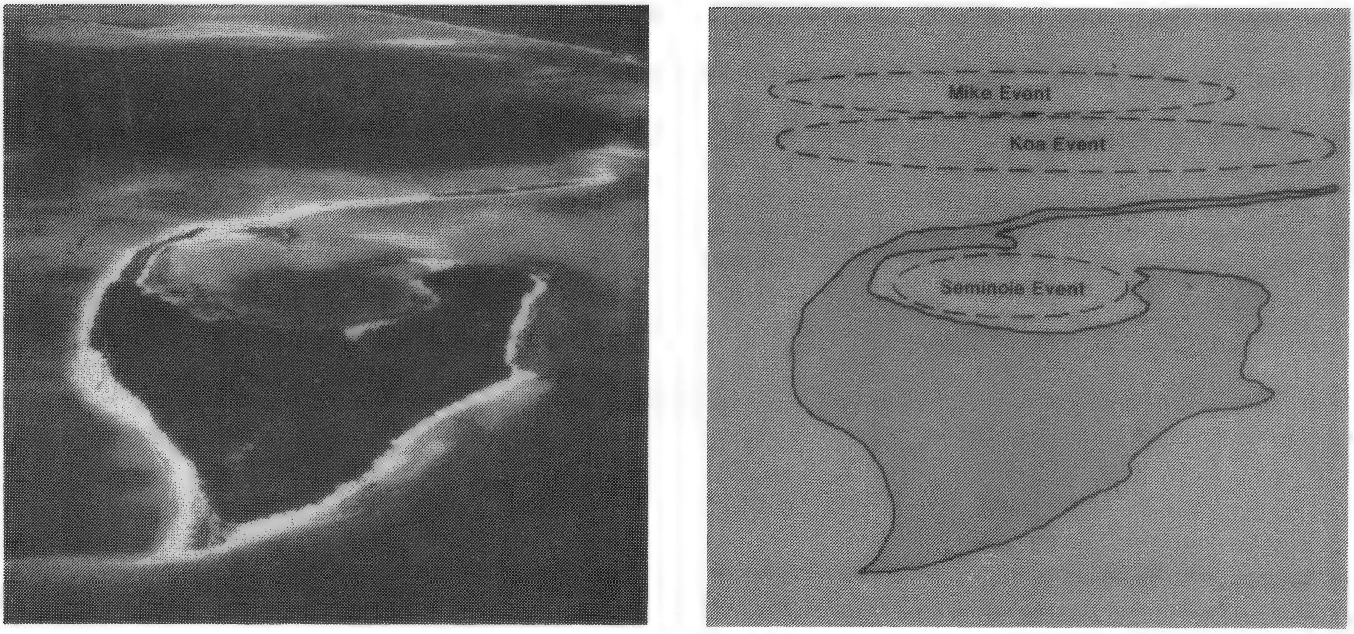


FIGURE 9-11a. PACIFIC CRATERS IN THE MARSHALL ISLANDS, CRATERS PRODUCED BY SOME U.S. NUCLEAR TESTS AT THE PACIFIC PROVING GROUND IN THE MARSHALL ISLANDS

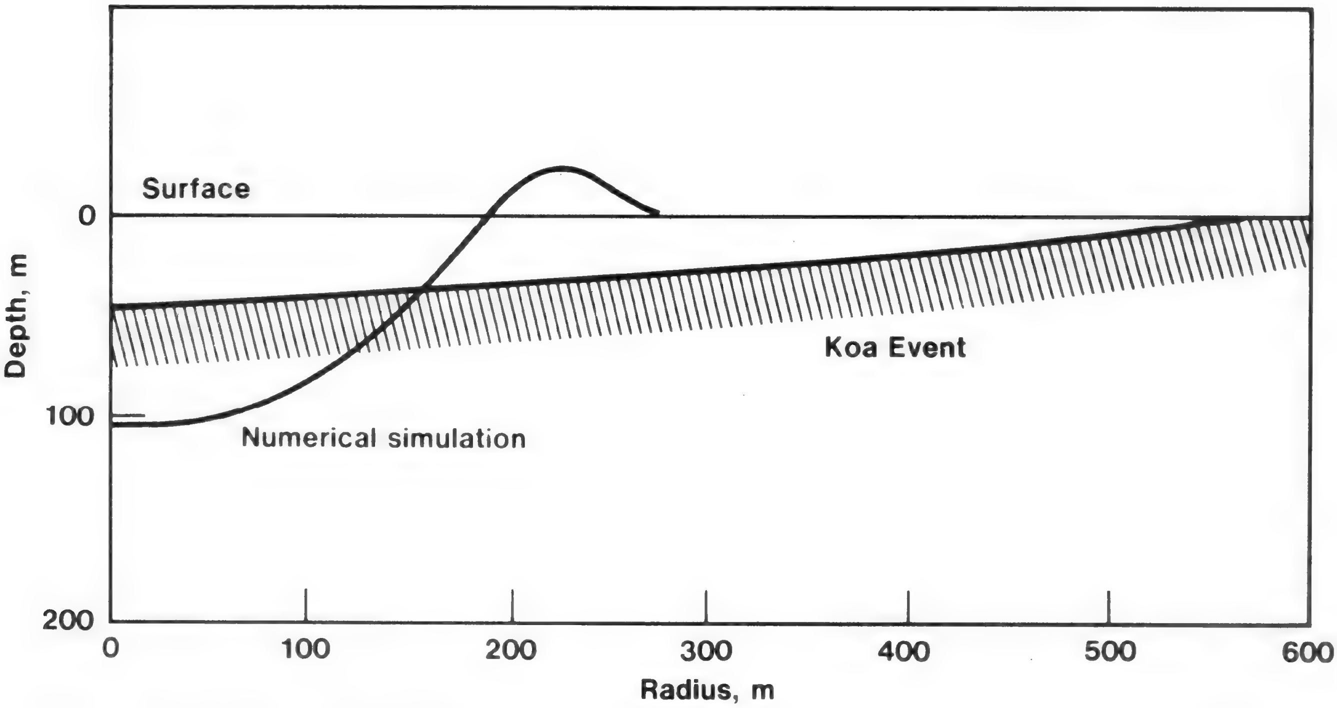


FIGURE 9-11b. PACIFIC CRATER CALCULATIONS, PROFILE OF THE PACIFIC PROVING GROUND CRATER PRODUCED BY THE KOA EVENT, CONTRASTED WITH THE CRATER RESULTING FROM A TYPICAL NUMERICAL SIMULATION

TABLE 9-2. CRATER DIMENSIONS FROM DETONATIONS AT ENIWETOK AND BIKINI ATOLLS AND NEVADA TEST SITE

OPERATION	EVENT	YIELD (KT)	HOB (FT)	RADIUS (FT)	DEPTH (FT)	RADIUS / DEPTH
CRATER DIMENSIONS FROM TEST EVENTS AT ENIWETOK AND BIKINI ATOLLS						
IVY (1952)	MIKE	10,400	10.0	2910	187.0	15.6
CASTLE (1954)	BRAVO	15,000	7.0	3255	250.0	13.0
	KOON	110	9.6	495	40.0	12.4
REDWING (1956)	LACROSSE	40.0	9.6	200	55.5	3.6
	ZUNI	3,500	10.0	1165	113.0	10.3
	SEMINOLE	13.7	7.0	324	32.2	10.1
	TEWA	5,000	10.0	1915	133.0	14.1
HARDTACK I (1958)	CACTUS	18.0	3.0	173	37.2	4.65
	KOA	1,370	2.7	2160	170.0	12.70
	OAK	8,900	5.8	2870	204.0	14.70
	FIG		1.5	18	9.7	1.86
CRATER DIMENSIONS FROM TEST EVENTS AT NEVADA TEST SITE						
BUSTER JANGLE (1951)	SUGAR	1.2	+3.5	45	21	2.10
	UNCLE	1.2	-17	130	53	2.45
TEAPOT (1955)	ESS	1.0	-67	146	96	1.6
NOUGAT (1962)	SEDAN	104	-635	640	320-	2.0

various contaminated islands in Eniwetok Atoll as a result of nuclear weapons testing through Operation HARDTACK in 1958. Although there had been over twenty years of time for the radioactivity of the fission particles to decay, the most troublesome isotope to still contend with in the clean-up was cesium-137, which has a half-life of thirty years. About 110,000 cubic yards of radioactive soil was gathered up from the various islands and dumped into the CACTUS crater. To stabilize the contaminated material, the crater was first lined with a water tight material; and after filling with the fission debris and other radioactive materials, an eighteen-inch thick concrete "dome" was constructed over the top of the material that filled the crater. (Figure 9-15, CACTUS Dome.)

KOA Event

The KOA nuclear device was detonated 13 May 1958 in a water tank at the west end of Gene Island, at the north end of Eniwetok Atoll, near the old IVY MIKE crater created in 1952. The KOA ground zero building consisted of a 10-foot in diameter, 8 foot high, air-filled steel tank containing the nuclear weapon 3 feet above the floor. The air-filled tank was located concentrically inside a 30-foot in diameter water filled tank 23 feet high. The concrete foundation weighed 278,000 pounds and there were 70,000 pounds of steel in the water tanks. When filled, there were 870,000 pounds of water surrounding the nuclear detonation. (10: Sea-Floor Observation)

The KOA yield was 1.37 MT and produced a crater with a radius (R) of 2160 feet and a depth (D) of 170 feet, giving an R/D of 12.7 (see Figure 9-11, Oblique of SEMINOLE, KOA, and MIKE craters). At the edge of the KOA crater was an Air Force concrete beam experiment 1830 feet from ground zero inside of what appeared to be the crater radius (see Figure 9-16, pre-shot beam). After the shot, the top of the concrete beam experiment was 6.5 feet lower than pre-shot

FIGURE 9-12a. HARDTACK, SHOT CACTUS, ENIWETOK, SITE YVONNE, 18 KT SURFACE, VIEWING S.

FIGURE 9-12b. HARDTACK, SHOT CACTUS, ENIWETOK, SITE YVONNE, 18 KT SURFACE, VIEWING N.

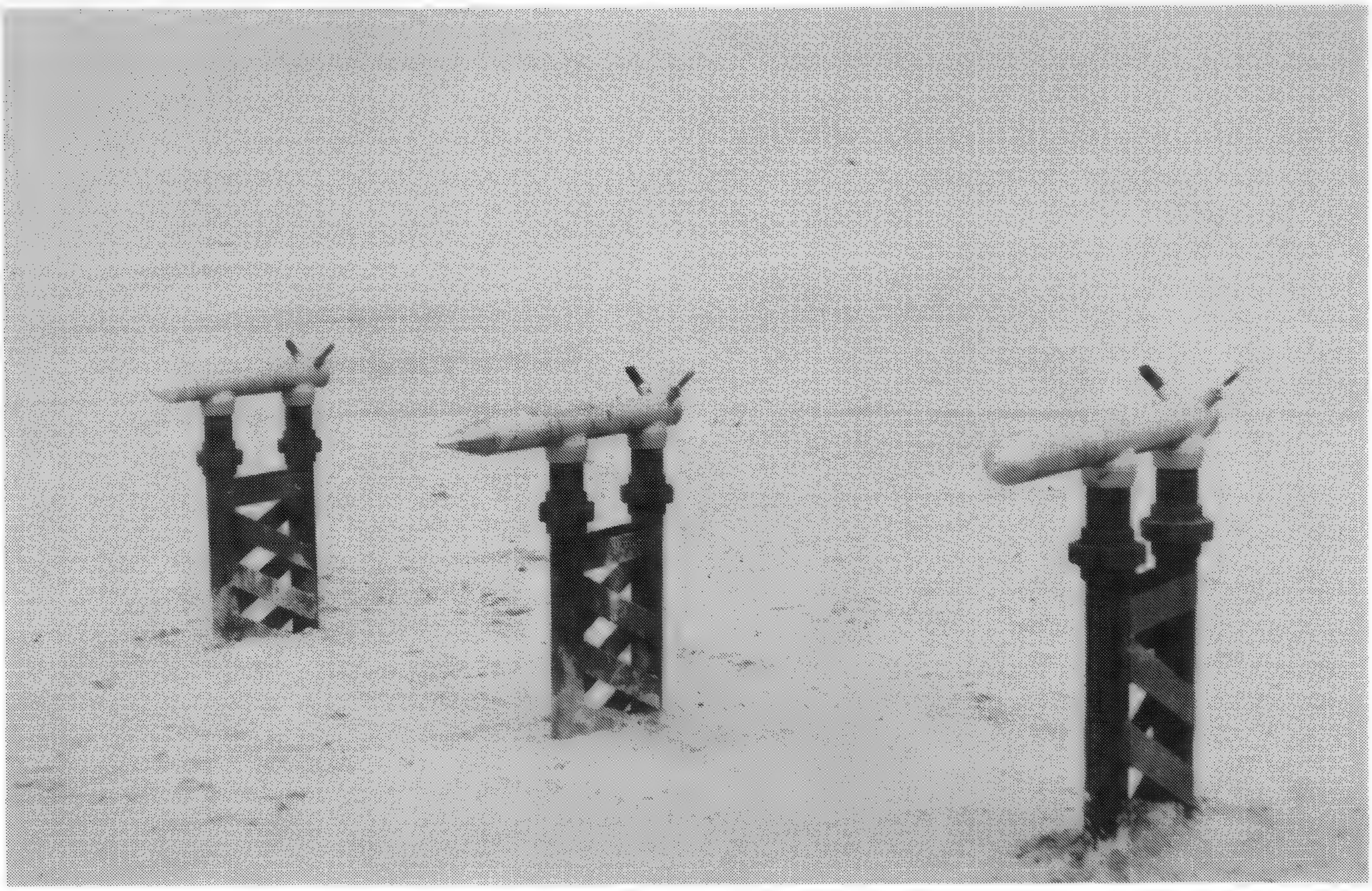


FIGURE 9-13a. HARDTACK, SHOT CACTUS, ENIWETOK ATOLL, Q-GAUGES, TAKEN 19 APRIL 1958

FIGURE 9-13b. HARDTACK, SHOT CACTUS, LOWERING DRUM GAUGES, TAKEN 28 MARCH 1958

FIGURE 9-14a. HARDTACK, SHOT CACTUS, SURFACE BURST, H + 3

FIGURE 9-14b. HARDTACK, SHOT CACTUS, ENIWETOK ATOLL, PHOTO: D + 3, VIEWING S., (LACROSSE CRATER ON LEFT)

FIGURE 9-15. CACTUS DOME COVERS MOST NUCLEAR MATERIAL AT ENIWETOK ATOLL

and the coral reef material around the concrete was compressed an additional 3 feet (see Figure 9-16). This type of data adds credence to the theory that the shallow saucer shapes of the Pacific craters are not due to ejecta cratering but due to compression and liquification of the coral, causing it to flow back toward ground zero under the high pressure air blast (greater than 1,000 psi) and long duration of the blast wave. (11: Geologic and Geophysical.)

OAK Event

OAK event, 8.9 megatons (MT), was detonated on a barge in shallow water (13 feet) on the west reef of Eniwetok Atoll (see Figure 9-4, Map). The detonation occurred at 0730 hours on 29 June 1958. The axis of the nuclear device was horizontal, three feet above the barge deck, and the barge deck was about 5.6 feet above the water line at shot time. The barge was composed of 446,000 pounds of steel and there was no sand ballast (usually equal to the barge weight) to provide a shallow draft for the barge. (See Table 9-2 for OAK crater dimensions.)

AEC Commissioner Bill Libby was the only technical member on the Commission during the planning and execution of Operation HARDTACK. Dr. Libby put a lot of thought and effort into reducing the effects of worldwide fallout, especially from the large multi-megaton thermonuclear events scheduled for the 1958 Pacific series. I had reviewed an early copy of his manuscript on "Fireball Chemistry" that explored the possibility of ballasting each of the barge shots with about 225 tons of silica sand, instead of the 225 ton of coral sand that was usually employed. The theory was that during the early fireball phase of the explosion the strontium-90 would be chemically combined at the very high temperatures with the silica sand to form a water insoluble strontium silicate. Insoluble strontium-90 would thus be eliminated from the food chain, especially

FIGURE 9-16b. HARDTACK, SHOT KOA, ENIWETOK ATOLL, SITE GENE, 13 MAY 1958, 1.37 MT, PHOTO: D + 8, 21 MAY 1958, POST-SHOT CONCRETE BEAM EXP, 6.5 FT. LOWER THAN PRE-SHOT AT 1,830 FT., PO = 1,130 PSI, RA = 2,160 FT.

the milk chain for children during their bone growth phase. The barge shots that incorporated silica sand as ballast on Operation HARDTACK are indicated in Table 9-2. Although the OAK barge event had an impressive yield of 8.9 MT, it was not the largest shot fired on Operation HARDTACK.

Incorporating thousands of tons of silica sand into the barge shots meant transporting it to the Pacific Proving Grounds from Hawaii. During a number of discussions, both in Washington and at Eniwetok Atoll, I had the distinct impression that Bill Ogle, Scientific Director for JTF-7, was annoyed by the silica sand subject since the new procedures would impact his immediate objective of getting the AEC weapons development shots off as quickly and easily as possible. However, Bill Ogle would not have to testify, as Bill Libby and I (and many others) would before the pending 1959 hearings in radiation to be held by a special subcommittee of the Congressional Joint Committee on Atomic Energy, which had already notified us that the subject would be "Biological and Environmental Effects of Nuclear War." The YELLOWWOOD events were typical of the barge shots with Silica Sand. (Figure 9-17, YELLOWWOOD Event.)

FIG And QUINCE Events

The FIG surface shot was the last event of Operation HARDTACK I (18 August 1958) on Yvonne Island at Eniwetok Atoll, a week after ORANGE shot had occurred on Johnston Island. FIG was a late addition to the HARDTACK schedule as a cooperative effort between the AEC's University of California Radiation Laboratory

FIGURE 9-17. HARDTACK YELLOWWOOD BARGE SHOT WITH SILICA SAND BALLIST

(UCRL) and the DOD's Armed Forces Special Weapons Project (AFSWP). FIG ground zero contained 130 tons of Nevada Test Site soil that replaced coral reef material in the shape of an inverted cone that was 8 feet deep and 30 feet in diameter at the surface, with an additional six inches deep out to a radius of 35 feet. The Nevada soil was compacted to correspond to original test site conditions. (5)

Exactly the same soil preparations had taken place on the QUINCE event, but that shot had a yield that was not expected, necessitating a repeat experiment on FIG. FIG crater dimensions were exactly the same as would be expected for a Nevada detonation--18 feet radius (R) and 9.7 feet deep (D), R/D = 1.9. This experiment showed that for short duration blast waves, corresponding to the small FIG yield, the crater shape was not affected by coral pore collapse and compaction that occurred on the large yield (long duration) blast waves.

Returning to Table 9-2 (crater dimensions), the dimensions of the CACTUS crater are to be noted. The radius of CACTUS should be about 10 times the radius of FIG--which it is; and the scaled depth of CACTUS should be 97 feet, which it is not, and fails to scale by more than a factor of two. So, for nominal yield weapons, like CACTUS, the Pacific coral reef craters fail to be deep enough; and for large yields like OAK and KOA, the crater diameters are larger than expected and the depths of the craters are shallower than expected by scaling from other geologies. One should not use the empirical, large yield Pacific crater data to confidently predict that Soviet Union missile silos would be within the crater radius.

Underwater Bursts--WAHOO and UMBRELLA

The two Department of Defense sponsored HARDTACK underwater nuclear weapons effects tests could be considered a continuation of BAKER test of the Operation CROSSROADS series at Bikini in 1946 and the WIGWAM test 500 nmi off the U.S. west coast in 1955. WAHOO shot was fired at a depth of 500 feet in deep Pacific ocean water about 8,000 feet south from the nearest island on Eniwetok Atoll. UMBRELLA was detonated at a depth of 150 feet on the bottom of Eniwetok Lagoon NNE of Henry island. (Figure 9-18, UMBRELLA Underwater Burst.)

It is noted that the Soviet Union had not conducted an underwater nuclear test prior to the 1958 testing moratorium. Upon abrogating the moratorium on 1 September 1961 (thirty four months into the agreement), the Soviet Union conducted its first underwater test on 23 October 1961, having a low yield range, south of Novaya Zemlaya. Realizing during the moratorium that it had no underwater effects data, the Soviet Navy must have had grave concerns, and underwater test preparations must have begun long before the Soviets broke the moratorium to allow their test to take place about six weeks after resuming nuclear weapons testing.

TEAK--High Altitude Shot

A Redstone missile lifted off its launch pad on Johnston Island, and its powerful rocket engine drove it straight up for three minutes before its megaton-range nuclear warhead detonated at 252,000 feet (76.8 km) at 11:50 p.m. on 31 July 1958. Beginning about that time radio communications stopped throughout most of the Pacific basin. Honolulu had difficulty maintaining military and commercial air travel services. Indeed, commercial air traffic had to be suspended for many hours because of a failure of long wave communications. There was, however, no interruption of telephone line communications on Hawaii. The electromagnetic pulse (EMP) produced by the TEAK detonation was not noticed anywhere in the Pacific except for a "click" at zero time on radio receivers in the vicinity of Johnston Island. (Figures 9-19 and 9-20, Redstone Missile at JI.)

When I left the Pentagon at the end of the day on 31 July, a communication had been received from General Luedecke, Commander Joint Task Force-Seven at Johnston Island indicating that the TEAK event was "go" for late that evening. This meant that the shot would have occurred before work began in the Pentagon the next morning (11:50 p.m., 31 July, at Johnston Island is 5:50 a.m., 1 August, in Washington, D.C.). However, when I looked through the communications at about 8 a.m. on 1 August, there was nothing from General Luedecke. Being responsible to both Chairman AEC and Chairman Joint Chiefs of Staff, he would have immediately notified them that TEAK had occurred, and there would also

FIGURE 9-18. HARDTACK UMBRELLA--UNDERWATER SHOT AT BOTTOM OF ENIWETOK LAGOON

FIGURE 9-23. TEAK INSTRUMENTATION POD SHOWING RADIATION EXPERIMENTS

Johnston Island the next morning preparing the launch pad for receipt of another missile the next day. Thus preparations began for ORANGE. As the ORANGE event Redstone missile passed through 125,000 feet altitude, the fire signal was sent, but no nuclear explosion occurred. It was immediately observed that one of the safety interlock switches in the control room at Johnston Island had not been thrown when the missile passed through a safe altitude above the island. ORANGE nuclear detonation occurred at an altitude of 141,000 feet at 11:30 p.m. on 11 August 1958. Although it was the same nuclear yield as TEAK event, ORANGE was somewhat less spectacular, and had little effect on radio communications in the Pacific.

Following the spectacular night sky display of TEAK, there was considerable public interest in Hawaii as the schedule for the ORANGE event approached. CINCPAC announced on Monday, 11 August, that a nuclear test was to be conducted at Johnston Island sometime between 2200 and 0600 that night (Hawaiian time is one hour later than Johnston Island time.) The ORANGE show in Honolulu was a disappointment compared to the TEAK display. There was a brilliant flash for about one second, which "dimmed to a rosy glow and faded away." From the top of Mt. Haleakala on Maui Island, the view was described as a "dark brownish red mushroom [that] rose in the sky. . . then died down and turned to white with a dark red rainbow." According to the Honolulu Star-Bulletin, dateline 12 August, this display was visible for about 10 minutes or so.

Figure 9-24 is a photograph of the ORANGE shot, as it would have been seen by an observer on the USS Boxer approximately one minute after the burst. [11: "United States High-Altitude Test Experiences - A Review Emphasizing the Impact on the Environment - A LASL Monograph," by Herman Hoerlin, October 1976, LA-6405, unclassified] The expanding nuclear weapons debris stopped as it snow-plowed into the ambient air, forming at first a spherical shell, and by one minute started to evolve into a torus (donut) with the bottom part of the shell having been opened up. Recall that the ORANGE nuclear weapon was "salted" with a tracer element that formed about three megacuries of radioactive rhodium-102 (half-life 210 days). The main portion of the nuclear weapon debris rose to an altitude of 150 kilometers, although observations from Mt. Haleakala indicated some debris was above that elevation. These were the initial conditions for determining the residence time of nuclear weapon debris in the stratosphere, extensively measured by the Armed Forces Special Weapons Project (later the Defense Atomic Support Agency) High Altitude Sampling Project (HASP) using U-2 aircraft (see Chapters 8 and 10).

OPERATION HARDTACK PHASE II PRE-MORATORIUM ACTIVITIES

As Operation HARDTACK Phase I wound down in the Pacific, Phase II was winding up for test operations at the Nevada Test Site. Even before the last shot was conducted at Eniwetok (FIG on 18 August 1958), members of Joint Task Force Seven were returning to their home bases. The "Conference Of Experts" had been meeting in Geneva and recommended, on 21 August, a 180 control station network to monitor a nuclear test ban that would be "effective" for yields as low as five kilotons, and "partially effective" down to one kiloton. E.O. Lawrence had returned from Geneva ill and died following surgery on 27 August 1958.

FIGURE 9-24. ORANGE EVENT SEEN FROM U.S. AIRCRAFT CARRIER AT APPROXIMATELY H + 1 MINUTE

On 22 August 1958, President Eisenhower announced that the United States would, on 31 October, consider a moratorium on all nuclear weapons testing for one year (and perhaps longer), while negotiations on monitoring a nuclear weapons test ban and disarmament agreements were being conducted, provided the Soviet Union did not resume nuclear weapons testing during the negotiations. Most of us in official Washington were keenly aware of the developing policy by the Eisenhower Administration, mid-way through its second term, to enter into serious nuclear weapons test ban negotiations with the Russians, beginning in the fall of 1958. Having followed the "Geneva Conference" messages to and from the U.S. State Department, it was clear that John Foster Dulles and his advisors were tilting strongly toward stopping all nuclear weapons testing, provided the Soviets followed suite. None of us were surprised when President Eisenhower announced on 22 August 1958 that the United States would halt all nuclear weapons testing on

The New York Times March 20, 1959

Argus Weaponeer

Frank Harvey Shelton

Special to The New York Times.

WASHINGTON, March 19—For a few minutes today Dr. Frank Harvey Shelton stepped out of the anonymity that goes with his role as the Pentagon's chief atomic weaponeer. From the way the young, retiring scientist nervously wet his lips, it was apparent that he did not like the unaccustomed glare of publicity.

Man in the News

As technical director of the armed forces special weapons project, Dr. Shelton is the principal Defense Department scientist responsible for developing military requirements for atomic weapons and for conducting atomic tests.

As project director he was also responsible for the overall scientific direction of last summer's high-altitude explosions that created a sheet of radiation around the world.

It was the latter role that today drew Dr. Shelton out of his closely guarded Pentagon office to participate in a hectic news conference on the novel experiments of creating man-made radiation in space.

Has Little to Say

Dr. Shelton had little to say about his role in what some have called "the greatest scientific experiment of all time" and when he did talk, his low mumble was virtually inaudible to reporters.

According to the person who knows him best, his wife, this quiet, shy manner is characteristic of the 34-year-old nuclear physicist.

"He talks more than he used to," she explains, "but he still doesn't talk very much. I do most of the talking, and he gets worried when I don't talk."

The quiet manner can perhaps be attributed partly to his training as a scientist more interested in research than in conversation. As one colleague described him today, "Frank is a very studious scientific fellow."

Part of the silent attitude, however, springs from the strict secrecy that surrounds his job as an atomic weaponeer.

"We have a very tough mission," he explains, of his project, "and we just don't like publicity.

Study of Cosmic Rays

Dr. Shelton was drawn into the secrecy of atomic weapons and the spectacular creation of man-made radiation in space through a study of the cosmic rays that are mysteriously created by nature.

As a graduate student at the California Institute of Technology, he specialized in research on the particles of cosmic rays. He had originally started as an engineering student but then "grew into" the field of physics.

Associated Press

"We just don't like publicity."

This research in nuclear physics—he received his doctors degree for his work in 1953—lead him into the field of atomic weaponry. He was employed by the Sandia Corporation, which carries out atomic weapons developments and manufacture for the Atomic Energy Commission. Then three-and-a-half years ago he came to the Pentagon to be the technical director of the Armed Forces Special Weapons Project (abbreviated to ASWAP within the Pentagon).

Won a Scholarship

Dr. Shelton was born in 1924 at Flagstaff, Ariz., the son of a former schoolteacher and a worker on the Hoover Dam. Most of his boyhood was spent in Boulder City, Nev.

Through the winning of a scholarship Dr. Shelton was able to go to the California Institute of Technology. His college career was interrupted during World War II by a period of service with the Army, during which he obtained a commission and spent most of his time in school.

While still an undergraduate he married the former Miss Lorene Gregory of Trinidad, Colo., in 1948. They have three daughters, ranging in age from 5 to 9 years.

The type of man who brings work home from the office, Dr. Shelton has few interests or hobbies outside of his work. He occasionally dabbles in collecting stamps and coins, but as he explained today:

"I have no real hobbies. I just like my work."

FIGURE 10-5. ARGUS WEAPONEER

Quarles Sets Policy on Data but Bars Full Publication of the Project's Findings

Special to The New York Times

WASHINGTON, March 19—Some results of the Project Argus experiment are being prepared for publication by the National Academy of Sciences through "normal scientific channels."

This was announced at the Pentagon today by Donald A. Quarles, Deputy Secretary of Defense, in response to requests for details of the tests last summer in which three atomic weapons were detonated 300 miles above the earth.

This policy was confirmed by Dr. Alan T. Waterman, director of the National Science Foundation, and Dr. Detlev V. Bronk, president of the National Academy of Sciences.

They said the plans were "well advanced" for "orderly publication" in scientific journals. In addition, they said a symposium would be held at the National Academy's annual meeting here April 27, 28 and 29.

Mr. Quarles emphasized plans to keep many of the results of the test secret. He announced that he was sorry that the project was no longer a secret.

In response to a question about the publication of news of the tests in The New York Times this morning, Mr. Quarles said that this was not "playing the game" the way he liked to see it played.

Mr. Quarles, however, would not confirm that he was, in effect, accusing The Times of a security breach.

Publication Withheld

The tests were conducted last Aug. 27, Aug. 30 and Sept. 6. In publishing the account this morning, The Times explained that it had withheld publication of its information until it became evident that the Soviet Union knew of the theoretical principles involved and that a high official of the Pentagon had recommended an official announcement.

The Defense Department decided this morning to hold a news conference after numerous requests for information resulted from The Times' accounts.

But Mr. Quarles announced that if it had been up to him there would have been no disclosure. He made it clear to those who attended that The Times' publication of the news of the tests had not been officially inspired.

Mr. Quarles said that the experiments had been classified because: first, they had substantial military implications; second, "we were probing a new science here" and that more time was required to assess the results.

"The results are not the property of the scientists," he responded to a subsequent question on the same subject. "Of course the scientists publish those things which we collectively judge to be in the interest of the American people to publish."

FIGURE 10-6
QUARLES SETS POLICY

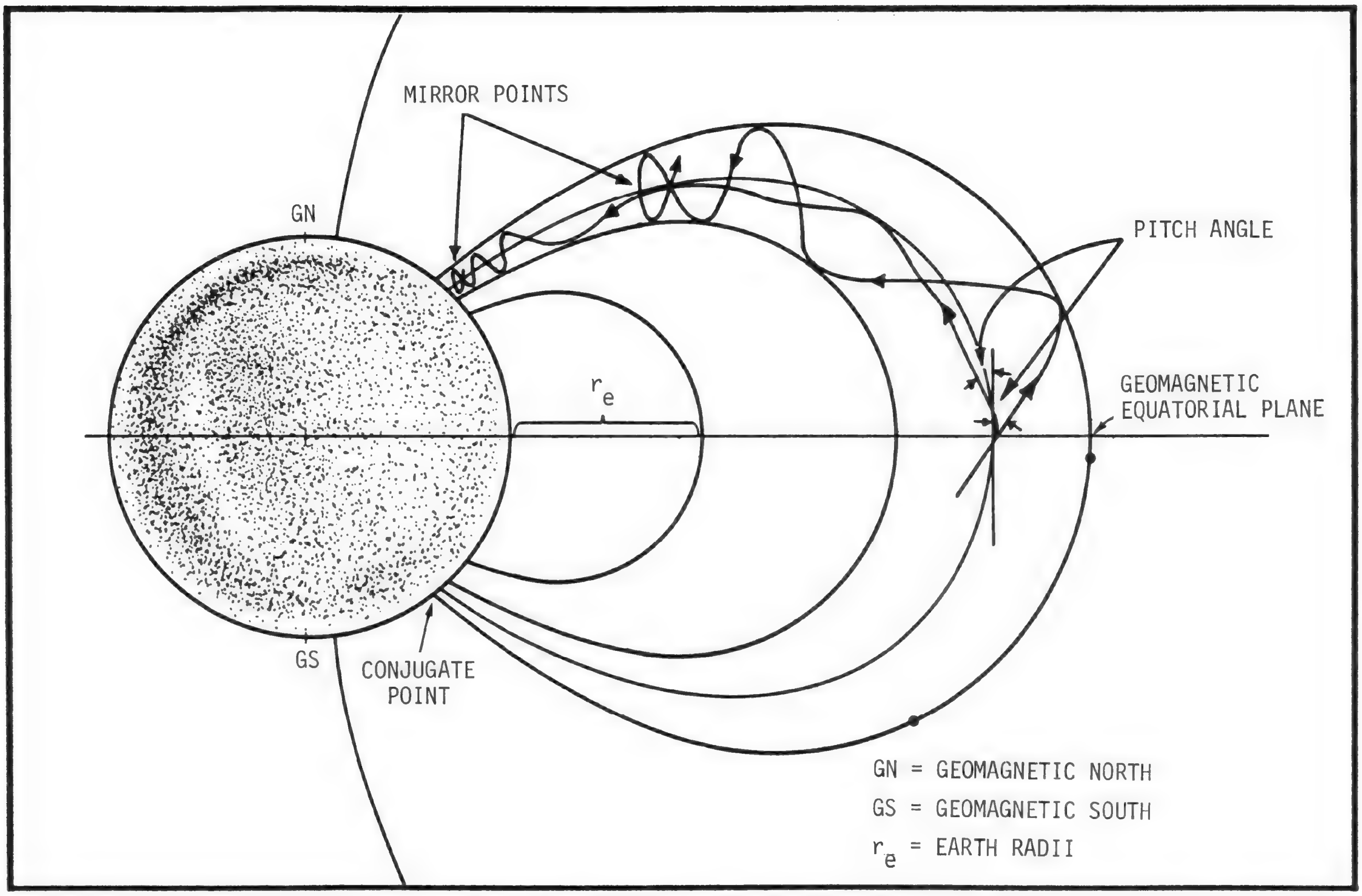


FIGURE 10-7. EARTH'S TRAPPED RADIATION DIAGRAM

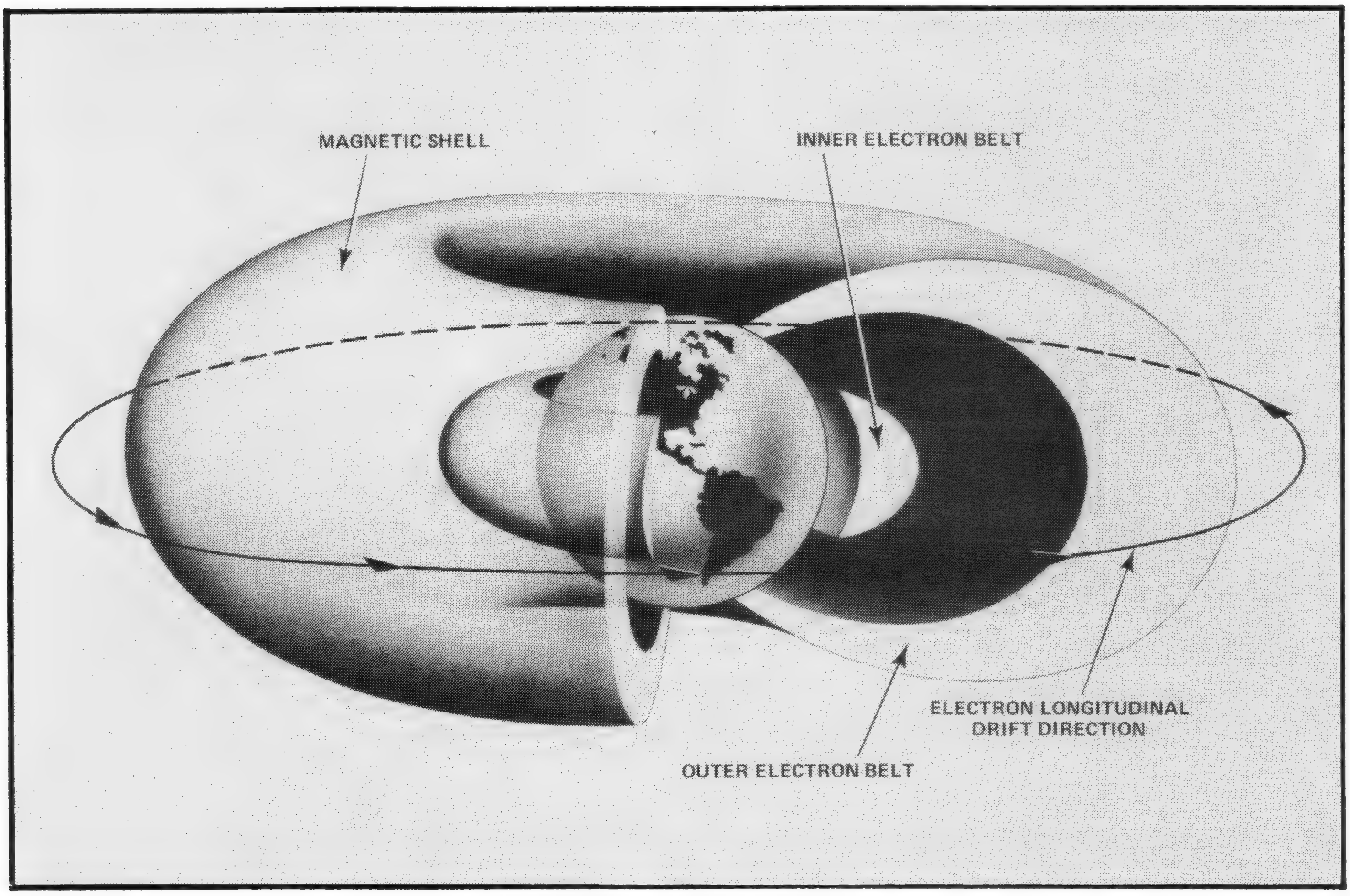


FIGURE 10-8. VAN ALLEN BELTS

The Evening Star June 22, 1959

World Would Survive Atom War, Expert Says

Congress Is Told Countries Not Attacked Would Suffer, But Still Could Go On

By RICHARD FRYKLUND
Star Staff Writer

The popular conception of a world population destroyed by fallout after a nuclear war, is mistaken, a congressional committee was told today.

Dr. Frank Shelton, technical director of the Defense Department's Atomic Support Agency, told a subcommittee of the Joint Committee on Atomic Energy that world-wide fallout would not threaten the survival of countries not attacked, even during a "large-scale" nuclear war.

The best-selling novel "On the Beach" is wrong, Dr. Shelton said, in picturing a deadly fallout cloud gradually encompassing the entire earth.

"Medium" War Postulated

The committee today opened a week-long series of hearings on the effects of a hypothetical war between the United States and Russia. The group envisions medium scale war in which the United States, Russia and some European countries are hit directly by large nuclear bombs.

Dr. Shelton said the radioactive strontium 90 in the bones of people around the world would rise only "slightly higher than the maximum permissible concentrations" set as a guide to radiation hazard. The added gynetic dose would be only the equivalent of the present natural radiation, he said.

Dr. Shelton concluded that other countries would survive handily even though they might have grounds to worry about an increase in cancer and defective children in future generations.

Death to All in 7 Miles

No person within seven miles of a large nuclear explosion would have more than a slim chance to survive, Dr. Shelton said.

The committee is assuming that Washington would be hit by two bombs, one of 8 megatons and the other of 10 megatons. A megaton is the equivalent in blast destruction of a million tons of TNT.

Dr. Shelton said that direct radiation from a 10-megaton bomb would kill everyone exposed to it within 2 miles of the blast. Even brick buildings would be destroyed in an area 7 miles from the explosion, crushing people who took shelter and leaving others exposed to fallout radiation and heat damage.

Persons within 25 miles of the explosion, Dr. Shelton said, would suffer second - degree burns on all exposed parts of their bodies. The bomb would make a 240-foot-deep crater, 2,500 feet in diameter.

Dr. Shelton said people downwind from the blast would be killed by fallout radiation in an area roughly 100 miles long and 17 miles wide.

Most wooden buildings would catch fire in an area 25 miles from the explosion.

Senator Anderson, Democrat of New Mexico, asked what these blast figures would mean in simple human terms. "What will happen to me, standing 10 miles from the Capitol downwind from the center of the explosion?" he asked.

Dr. Shelton said almost all wooden houses and most brick buildings in his area would be destroyed during the first minute after the explosion. The fallout effect would not come for a half hour, he said, but it would be strong enough when it arrived to give an unsheltered person a deadly dose of radiation in minutes.

Attack Date Assumed

The hearings, according to Subcommittee Chairman Holifield, Democrat of California, are designed to clear up the "considerable confusion" in the public mind about the effects of nuclear war. The hearings will assume that 224 cities, military installations and Atomic Energy Commission centers, will be hit by 1,446 megatons of large nuclear bombs. The attack takes place at 7 a.m. Washington time, in mid-October. The weather is assured to be that which actually existed on October 17, 1958.

Eugene Quindlen of the Office of Defense Mobilization said casualties and destruction will be based on an assumption that no cities are evacuated, that no extensive air raid shelter systems exist, but that people have enough warning to hide in buildings.

Chairman Holifield read a message to the subcommittee from Lt. Gen. James E. Gavin, former head of research and development for the Army, saying that the conditions of the atomic war assumed by the committee are "entirely realistic."

FIGURE 10-28. WORLD WOULD SURVIVE ATOM WAR, EXPERT SAYS

FIGURE 11-5. TRUCKEE EVENT AT CHRISTMAS ISLAND

FIGURE 11-8. FRIGATE BIRD THROUGH PERISCOPE

FIGURE 11-9a. SWORDFISH, ASROC LAUNCH

FIGURE 11-9b. SWORDFISH EVENT

Honolulu Star-Bulletin

Vol. 51, No. 189 HONOLULU, HAWAII, MONDAY, JULY 9, 1962 ★★★★ HOME EDITION 10¢

KGMB THE NEWS STATION CBS IN THE PACIFIC Radio 590, Channels 9, 3

N-Blast Produces Colorful Display

Color photos by Terry Luke show how last night's hydrogen bomb explosion looked from [illegible] Punchbowl. The first photo was exposed at exactly 11 p.m., the moment of ignition. The light was so intense that the sky appears blue as in daylight. The light spot in the sky [illegible] above the elevator shaft of the new First National Bank Building is the bomb center. Center photo was taken about 11.01 p.m. with the sky dominated by greenish colors. The right hand photo was made at about 11:05 p.m. just before the color faded.

Spectacular Test Shot Lights All Islands

[illegible] bomb at least [illegible] uranium atom bomb dropped on Hiroshima lighted the entire Central Pacific Ocean for an instant last night, then [illegible] running [illegible] for six more [illegible]

It caused worried phone calls to newspapers as far as 3,900 statute miles from Johnston in Auckland, New Zealand.

Sightings were also reported from Samoa, Fiji and planes between Hawaii and the West Coast.

Fired possibly 300 miles above Johnston Island it was a spectator show for thousands of persons in Hawaii but today scientists are beginning the task of collecting and analyzing data from around the world to determine its effects.

After a series of failures and postponements, it was a satisfying first success for U.S. Joint Task Force 8 in its planned high level test series.

An Atomic Energy Commission official at Pearl Harbor this morning described the explosion as "basically a scientific experiment."

He said he doubted whether scientists findings would be made known until "sometime in the future."

"They will be studying this for weeks and months to come," the spokesman said.

The spokesman added that the height of the detonation would continue to be kept secret. So would the yield of the nuclear device.

There has been no confirmation that a second test will be conducted from Johnston Island. Three and possibly four were scheduled.

Precisely at H-Hour as a short-waved countdown reached zero, the bomb flashed with instantaneous daytime brilliance in Honolulu's southwest sky.

It was perhaps 15 degrees above the horizon, indicating an altitude of several hundred miles. The bomb center registered a pinpoint of light on camera films.

The first flash was followed by the appearance of

Turn to Page 1-A, Column 1

★ ★ ★

Shock Wave May Have Put Out Lights

The City-County Street [illegible]

More Stories on Pages 2-A, 2-B, 24-B

[illegible]

Turn to Page 1-A, Column 4

Bulletin

[illegible]

The Johnston nuclear blast flooded the beach at the Hawaiian Village in Waikiki with an eerie light last night.—Star-Bulletin Photo by Amos Chun.

★ ★ ★

Blackouts Brief In Communications

The thermonuclear blast over Johnston Island last night didn't affect communications as much as expected but the Federal Aviation Agency said it experienced occasional blackouts for about two hours after the 11 p.m. blast.

But since then communication has been normal, an F.A.A. spokesman said.

Australia and Japan also reported similar brief interruptions soon after the blast.

The F.A.A. official in Honolulu said the "occasional short outages (signal going out) affected point-to-point communication in all directions."

He estimated the duration at 20 to 30 minutes, but the interruptions disappeared after about two hours and communication has been normal since.

He said communication between Honolulu Airport and aircraft in the air was perfect at all times.

Some Honolulu radio stations were washed out by interference but returned to the air immediately.

The Japanese Overseas Telephone and Telegraph Company reported transpacific telephone connections with [illegible] and Buenos Aires, Argentina, were knocked out right after the explosion but service was restored a short time later, Associated Press said.

In Sydney, Australia, an

Turn to Page 2-B, Column 8

Most Going Into Orbit

Little Fallout Seen From Test

WASHINGTON, July 9 (UPI)—Atomic experts expect [illegible] of any radioactive fallout from the nuclear explosions in space over Johnston Island.

Some of the bomb debris, perhaps as much as half, may be hurled free of the earth's gravitational field and wind up wandering through space in long orbits around the sun. A part of what is left is expected to go into orbit around the earth.

The remainder may well be [illegible] aloft, far above the weather [illegible] so long and be dispersed so [illegible] the time it comes down.

"There is no doubt," one [illegible] International, "that [illegible] above ground [illegible]

A Defense Department study [illegible] year ago estimated that half of the radioactive debris from a megaton bomb exploded at an altitude of 100

Turn to Page 1-A, Column 6

DIRECTORY

FIGURE 11-21. STARFISH EVENT -- HONOLULU NEWSPAPER

FIGURE 11-22. STARFISH PERSONNEL: (L TO R) HERMAN HOERLIN, JOHN KODIS, FRANK SHELTON, BILL OGLE, LEO KILEY

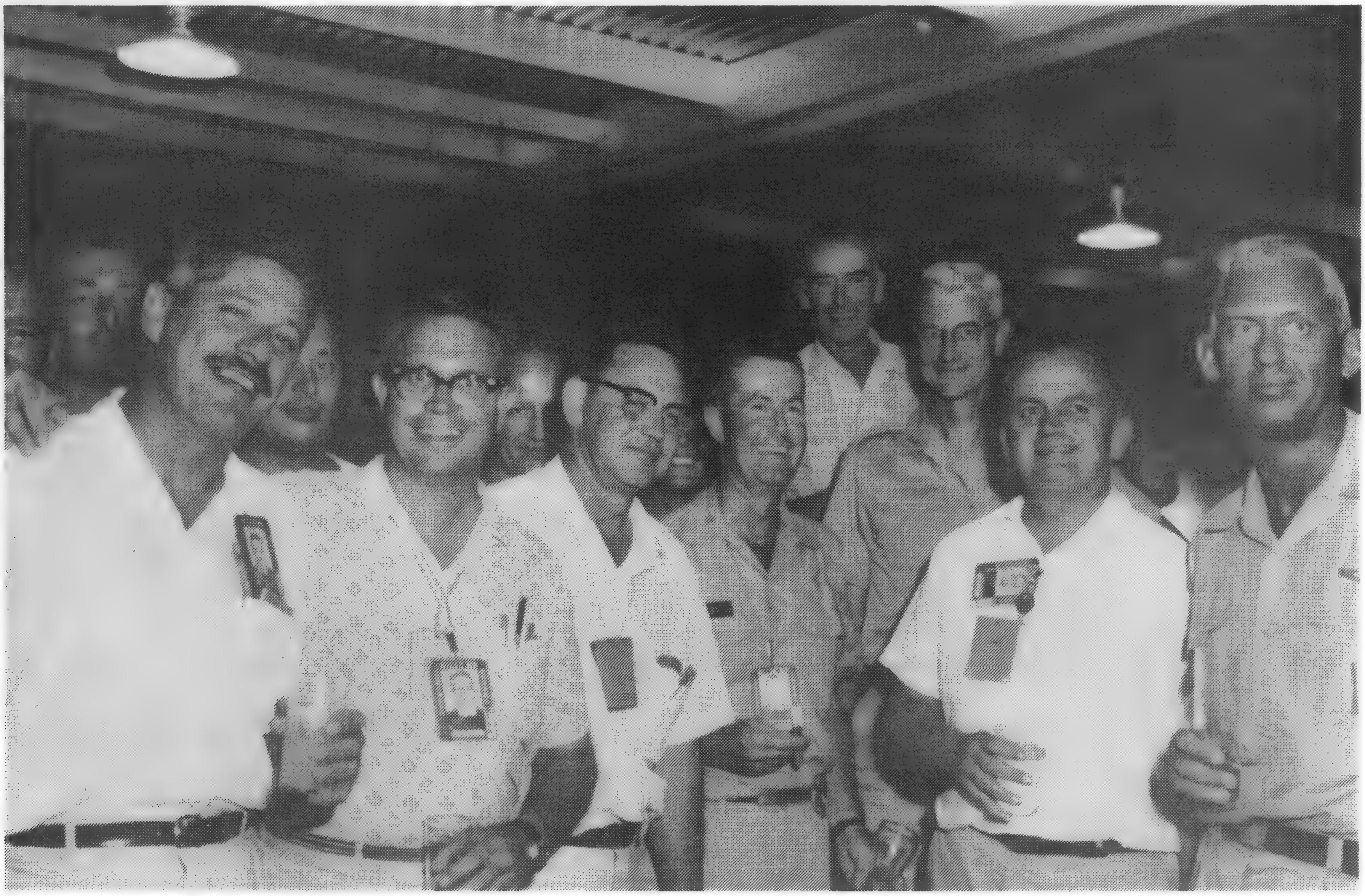


FIGURE 11-23. STARFISH PERSONNEL: (L TO R) JAY SOGGS, FRANK SHELTON, BILL OGLE, LEO KILEY, DODD STARBIRD, DON SHUSTER, MIKE MEYER

FIGURE 11-28. STARFISH EVENT FROM CHRISTMAS ISLAND

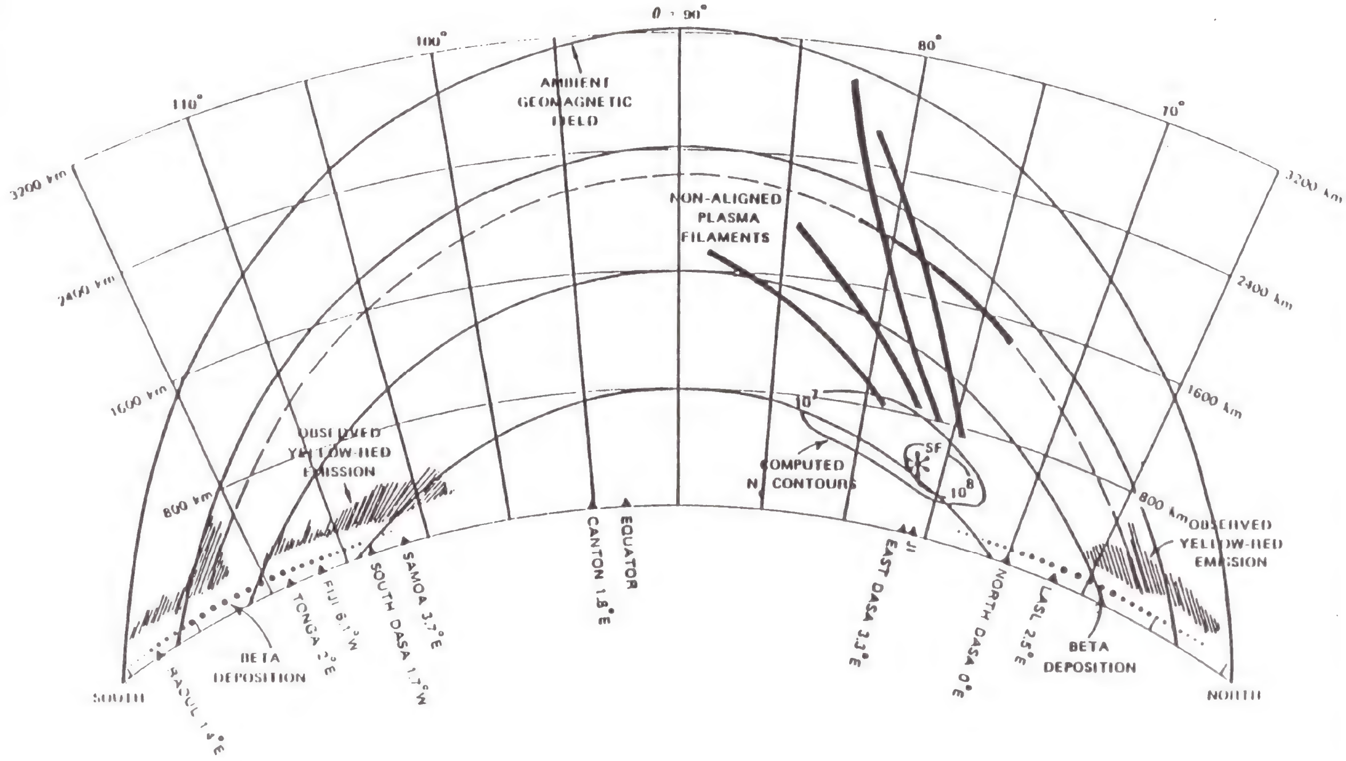


FIGURE 11-29. STARFISH EVENT FROM CHRISTMAS ISLAND (SCHEMATIC)

negotiations with the British for Christmas Island they were informed of our high altitude test plans for Johnston Island. It was the British scientist Sir Bernard Lovell of Jodrell Banks who was the first and the loudest in their objections to the U.S. conducting any high altitude tests since the trapped radiation would produce synchrotron radiation noise that would interfere with their radio astronomy.

STARFISH detonation had also caught the attention of the Soviets. On 11 August the United States received a message that the Russians were anxious about the safety of their astronaut, Nikolayev, who was scheduled to orbit the Earth for several days. The Soviet plea was for the United States to refrain from conducting any high altitude nuclear tests that would endanger the life of their cosmonaut. Secretary of State Dean Rusk assured the Soviets in a public announcement: ***"We wish Major Nikolayev a safe flight and a happy landing. The U.S. of course contemplates no activities that would interfere with him in any way."*** Dean Rusk did not say that the U.S. could not conduct a high altitude nuclear test at this time even if it wanted to.

On Monday, 13 August, I received a phone call from Lieutenant Colonel Billy McCormac from the Washington, D.C., office of the Defense Atomic Support Agency (DASA) asking me to attend an inter-agency meeting scheduled later that week to review STARFISH effects on satellites and astronauts. During that meeting in Washington, I presented some of the STARFISH phenomenology predictions that had been supplied to me on 15 June by Conrad Longmire, et. al., of Los Alamos. I also showed the assembled group some of the pictures of the STARFISH detonation (such as those given previously in this chapter) indicating that the fission debris was not confined to the magnetic field lines through the burst point, but had jets of fission debris that could be found at altitudes as high as a half an Earth's radius (L = 1.5). Pete Scoville, CIA Deputy for Science and Technology, asked me, ***"What fraction of the STARFISH relativistic electrons was trapped for reasonably long times in the Earth's magnetic field?"*** My response to his question was, ***"As close as I can estimate it is about 5%, but it could be as large as 10%."*** After years of analysis of STARFISH data, that is still a reasonably correct answer. Pete Scoville gave a fascinating briefing on recent Soviet satellite activities and their concern for radiation effects on cosmonauts. (Table 11-6 and Figure 11-35, Earth's radiation belts.)

TABLE 11-6. SOVIETS CONCERN FOR RADIATION EFFECTS ON COSMONAUTS

DATE	EVENT
09 JUL '62	STARFISH DETONATION
28 JUL '62	COSMOS 7 LAUNCHED - RADIATION MONITORS
01 AUG '62	COSMOS 7 RECOVERED
11 AUG '62	SOVIETS REQUEST HOLD ON FURTHER U.S. TESTS
11 AUG '62	VOSTOK 3 LAUNCHED APOGEE EQUAL TO COSMOS 7
12 AUG '62	VOSTOK 4 LAUNCHED PERIGEE OF COSMOS 7
15 AUG '62	VOSTOK 3 & R RECOVERED

The AEC issued our preliminary assessment of the STARFISH radiation belts on Monday 20 August. After some additional discussions and amplification of the first release, the AEC issued a more definitive statement on 1 September 1962. This statement included early results from the Telstar satellite launched the day after STARFISH and indicated that the distribution of the trapped radiation was above the altitudes of manned space flights. To placate the British, the release also said that the additional radio noise that might interfere with radioastronomy would soon fade away. The release did acknowledge that the STARFISH trapped radiation had damaged the solar cells of three satellites: Transit 4-B (a Navy navigational satellite), Traac (DOD), and Ariel (British scientific satellite launched by the U.S.).

The following are some of my notes that continued to evolve that summer - fall of 1962 on the effects of STARFISH on orbiting satellites. (See Table 11-8.)

ARIEL I: Ariel was a United Kingdom scientific satellite launched by the United States on 26 April 1962 from Cape Canaveral, Florida.

TABLE 11-7. SATELLITES DAMAGED BY STARFISH

SATELLITE	LAUNCHED	DETAILS
ARIEL I	26 APR '62	RADIATION COUNTER FAILED 11 JUL '62
TRANSIT 4B	15 NOV '61	LAST TRANSMISSION 2 AUG '62
TRAAC	15 NOV '61	FAILED 12 AUG '62
INJUN I	29 JUN '61	LAST TRANSMISSION 28 AUG '62
TELSTAR I	10 JUL '62	LAST TRANSMISSION 21 FEB '63
STARAD	26 OCT '62	LAUNCHED TO MEASURE RADIATION

Its ephemeris was inclined at 54 degrees, with apogee 1,209 km, and perigee 393 km. At the moment of the STARFISH explosion, Ariel was at an altitude of 815 km, and at a geomagnetic longitude about the same as the explosion, but situated in the South Pacific about 7,400 km from the detonation. Following the STARFISH explosion, Ariel located an intense radiation flux on the L = 1.12 shell which passed 400 km above Johnston Island. Ariel radiation detectors showed an immediate increase in relativistic electron count rate. Because of the westward motion of Ariel relative to the Earth, it was not possible to observe the eastern extent of the Johnston Island trapped radiation shell until 10 July, when the intensity was very much reduced. After 13 July 1962, four days after the detonation, Ariel operated only intermittently as a result of the deterioration of its solar cells caused by the STARFISH artificial radiation belt. (13: Section - "Data From the Aston 302 G-M Counter in Ariel I," pp. 93). (Ref. Nature 195, pp. 1245, 29 September 1962, "Satellite Observations of the Energetic Particle Flux Produced by the High Altitude Explosion of July 9, 1962.")

<u>**TRANSIT 4B:**</u> W.N. Hess reports that "*. . . on August 2 Transit 4B stopped transmitting . . . .*" which was 25 days after STARFISH. (Ref. J.

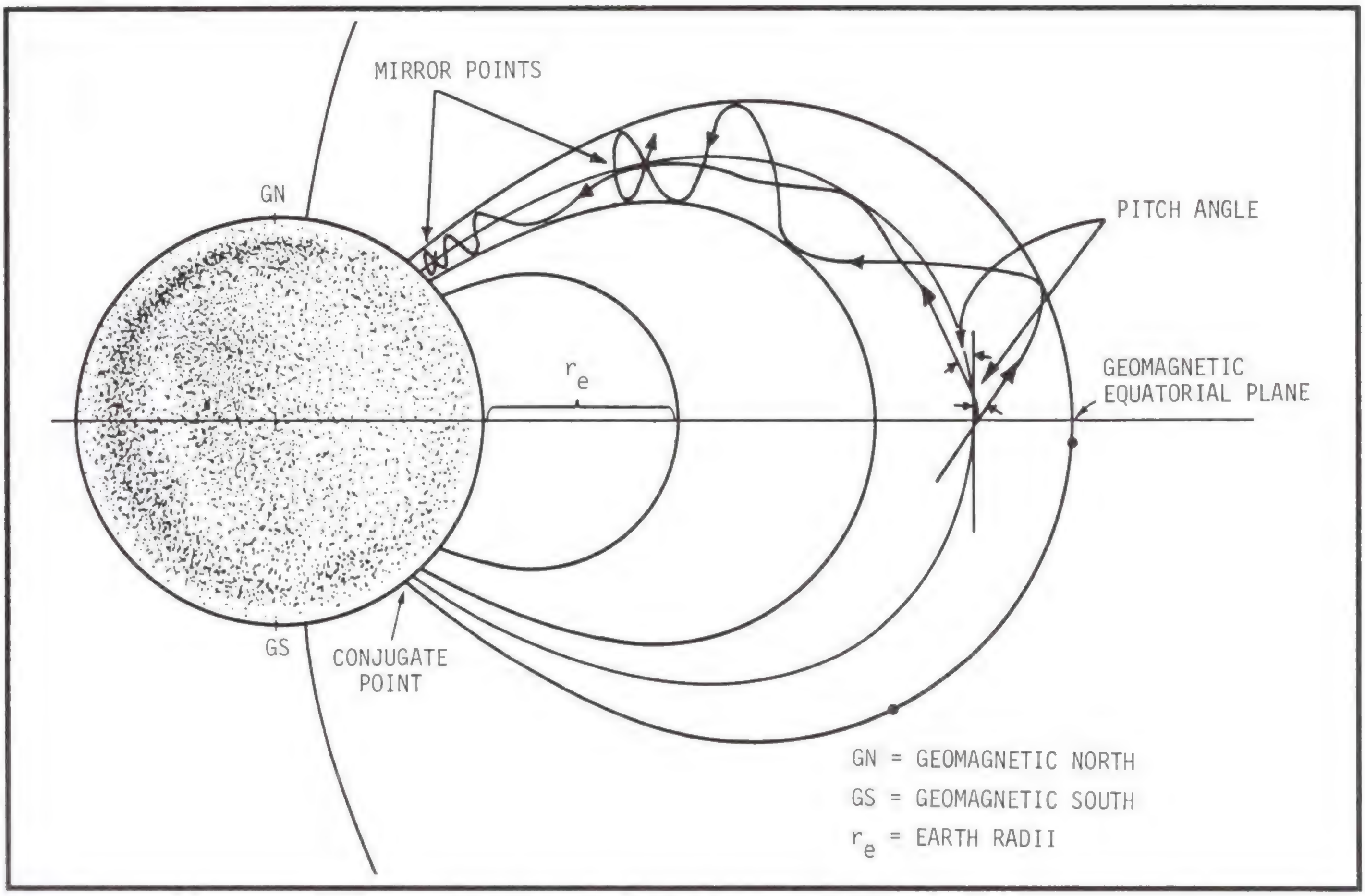


FIGURE 11-35. EARTH'S MAGNETIC FIELD

Geophysics Res. 68, pp. 667, 1 February 1963, "The Artificial Radiation Belt Made on July 9, 1962.")

TRAAC: Traac was a research satellite designed by Applied Physics Laboratory, Johns Hopkins University, and had been in operation 190 days at the time of the STARFISH detonation. The satellite had an inclination of 32 degrees, an apogee of 1100 km, and a perigee of 960 km. It was located in the vicinity of Easter Island at an altitude of 1100 km when detonation occurred. The first telemetry recording after the detonation was made 28 minutes later by the station in Southern Rodesia. The time corresponds to the westward drift of 1.5 Mev electrons from Johnston Island to central Africa, producing complete jamming of the Traac Geiger counter. Traac's solar-cell power system had already suffered some degradation in the natural space radiation environment prior to STARFISH. Following the detonation, data were transmitted on a reduced schedule between days 190 and 224 as degradation of the solar cells accelerated. Thirty four days after the STARFISH explosion, Traac stopped transmitting data on 12 August 1962. (J. Geophysics Res. 68, pp. 631, 1 February 1963, "Traac Observations of the Artificial Radiation Belt from the 9 July 1962 Nuclear Explosion.")

INJUN I: The Injun I satellite was designed by the Office of Naval Research in conjunction with the University of Iowa and launched on 29 June 1961 with an inclination of 67 degrees, an apogee altitude of 1010 km, and a perigee of 890 km. Useful radiation data were received following its launch, until its last transmission on 28 August 1962, more than a month of data following the 9 July 1962 STARFISH detonation. A useful aspect of Injun I was the extensive amount of pre-STARFISH radiation data obtained by the same detectors as the post-STARFISH measurements. (13: Section-Spatial Distribution and Time Decay of the Intensities of Geomagnetically Trapped Electrons From the High Altitude Nuclear Burst of July 1962," pp. 575-592, J.A. Van Allen.)

TELSTAR I: Telstar I was launched on 10 July 1962, one day after STARFISH. Its inclination was 45 degrees, with an apogee of 12,100 km, and a perigee of 7,330 km. It is not easy to evaluate the effect of the STARFISH nuclear detonation because of the meager amount of information on the natural electron distribution that existed before the test in most of the region of space that Telstar I actively explored. The changes in the distribution observed by Telstar subsequent to 10 July lead to the conclusion that STARFISH injected a large flux of relativistic electrons over a very extensive region of space. The last transmission from Telstar I was 21 February 1963 due to radiation damage. (13: Section - "Telstar I, STARFISH and the U.S.S.R. Tests," pp. 611.)

STARAD: The Air Force satellite Starad was launched 26 October 1962 for the specific purpose of measuring the trapped electrons produced by STARFISH. The satellite had an orbital inclination of 71 degrees, and at the outset an apogee of 5,580 km, and a perigee of 198 km, with an orbital period of 148 minutes. On 28 October 1962 at 04:41:18 (Greenwich Meridian Time) the Soviet Union detonated a nuclear device above the Earth's atmosphere. The Starad satellite measurements placed the geographic latitude at about 48 degrees North, and the longitude in the range of 54 to 80 degrees East. The yield had been reported as being in the intermediate range. (14: "Foreign Nuclear Detonations," Department of Energy, 22 May 1985.)

SHUTDOWN AND REGROUP

Rumors were rampant during the month of July that the President would end the current United States series of atmospheric nuclear weapons tests. However, before the disastrous launch pad fire at Johnston Island on 25 July 1962, the Soviet Union announced on 22 July that it was resuming atmospheric nuclear testing, although it had refrained from doing so following the conclusion of their series on 4 November 1961. But in light of the ongoing intense U.S. test series, the Soviet Union said it had no other alternative. The Soviets began a new series of atmospheric tests on 5 August 1962 with a detonation at Novaya Zemlya.

At his 1 August news conference, President Kennedy hinted that he would continue with the three high-altitude shots that remained to be conducted at Johnston Island: (1962, Item 316, pp. 593.)

QUESTION: ***"Mr. President, have you reached a decision yet as to the extent and timing of additional nuclear testing required by this Government?"***

Where To Find It

The Honolulu Advertiser

NEWS IN DEPTH

107th YEAR NO. 33,891 FRIDAY, NOVEMBER 2, 1962 10 CENTS

Soviet Suggests Red Cross

Castro Refuses UN Inspection

See Story This Page, Column 1

2:09 A.M. 60 Seconds Later 75 Seconds Later 120 Seconds Later 180 Seconds Later

FIGURE 11-39. KINGFISH EVENT IN HONOLULU NEWSPAPER

FIGURE 12-7a. SAGE CONFERENCE -- 15–18 APRIL 1975; HOMESTEAD AFB, FLORIDA

1ST ROW: DR. WILLIAM J. KARZAS (RDA), DR. FRANK H. SHELTON (KN), MR. BENJAMIN T. PLYMALE (BOEING), DR. ROBERT E. LeLEVIER, CHAIRMAN (RDA), MR. PETER H. HAAS (DNA), MR. WILLIAM B. WRIGHT (RDA).

2ND ROW: GEN. BRUCE K. HOLLOWAY, USAF (RET), DR. CARTER D. BROYLES (SANDIA), MR. CHARLES S. LERCH (SPC), DR. CHARLES McDONALD (RDA), LT. GEN. WARREN D. JOHNSON, DIRECTOR (DNA), DR. ROLAND F. HERBST (RDA), DR. WILLIAM E. OGLE (PC).

3RD ROW: DR. WILLIAM R. GRAHAM (RDA), DR. JAMES E. CAROTHERS (LLL), DR. HENRY S. ROWEN (STANFORD U.), MR. WARREN W. BERNING (DNA), DR. LOWELL L. WOOD (LLL), MR. RAY L. LEADABRAND (SRI), DR. DAVID C. OAKLEY (DNA).

FIGURE 12-31. LONG-RANGE SPARTAN MISSILE WITH A MULTI-MEGATON, ENHANCED X-RAY WARHEAD FOR THE SAFEGUARD DEFENSE SYSTEM

FIGURE 12-33. DIAMOND SCULLS PORTAL AREA SHOWING LARGE PIPE SECTIONS TO BE ASSEMBLED IN THE TUNNEL FOR SPARTAN MISSILE SURVIVABILITY TESTS

one man's walk along this trail. It has been an exciting time. Not that I would counsel a current Ph. D. to enter this particular arena. But, when I began in 1949, forty years ago, with the issuance of my Q-clearance to work on AEC nuclear reactors, it was a blooming era.

During atmospheric nuclear weapons testing, prior to 1963, I watched 65 nuclear detonations. Some of the events were small, some were large megaton shots, some were at the Nevada Test Site, some were in the Pacific. On various introductions to my presentations to Congress, I was touted as having observed more nuclear detonations than anyone in the "Free World." I never tried to run down the accuracy of those introductions, but I have the general feeling from discussions with "old" testing hands that the statement is basically correct. Especially, when my observations of United Kingdom nuclear weapons tests are taken into account.

Prior to the Limited Test Ban Treaty of 1963, I worked as an AEC contractor at Sandia Corporation, Albuquerque, New Mexico, in their weapons effects department; then as a Government employee in the Department of Defense, the Armed Forces Special Weapons Project which was responsible for DOD nuclear weapons and their testing; then as a member of a nuclear weapons effects and testing team in a public company - Kaman Corporation. These various positions, at various locations, with various relationships to the nuclear weapons testing community have given me an overview of this important facet of American history. I hope that an accurate, detailed perspective of nuclear weapons has been passed to the reader - present and future.

TABLE 12-20
ORGANIZATION AFSWP - DASA - DNA

ARMED FORCES SPECIAL WEAPONS PROJECT (AFSWP)
1 JANUARY 1947

DEFENSE ATOMIC SUPPORT AGENCY (DASA)
6 MAY 1959

DEFENSE NUCLEAR AGENCY (DNA)
1 JULY 1971

CHIEFS/DIRECTORS	TECHNICAL DIRECTORS
MG Leslie R. Groves, USA 1947-48	
RADM William S. Parsons, USN (Acting 1948)	
MG Kenneth D. Nichols, USA 1948-51	Dr. Herbert Scoville 1948-55
MG Herbert B. Loper, USA 1951-53	
MG Alvin R. Luedecke, USAF 1953-57	Dr. Frank H. Shelton 1955-59
RADM Edward N. Parker, USN 1957-60	
AFSWP -> DASA 6 MAY 1959	
	CHIEF SCIENTIST
MG Harold C. Donnelly, USAF (Acting 1960-61)	Dr. William P. Otting 1960-64
MG Robert H. Booth, USA 1961-64	**DEP. DIR. SCIENCE & TECH.**
LTG Harold C. Donnelly, USAF 1964-68	Dr. Ted Taylor 1964-66
VADM Lloyd M. Mustin, USN 1968-71	Dr. Fred Wikner 1966-68
	Dr. John Northrop 1969-72
DASA -> DNA 1 JULY 1971	
LTG C. H. Dunn, USA 1971-73	Dr. Jack Rosengren 1972-74
LTG Warren D. Johnson, USAF 1973-77	Mr. Pete Haas 1974-79
VADM Robert R. Monroe, USN 1977-80	Dr. Ed Conrad 1979-83
LTG Harry A. Griffith, USA 1980-83	Dr. Marv Atkins 1983-87
LTG Richard K. Saxer, USAF 1983-85	
LTG John L. Pickitt, USAF 1985-87	**DEPUTY DIRECTOR**
VADM John T. Parker, USN 1987-1989	Dr. Marv Atkins 1987-1989
MG Gerald G. Watson, USA 1989-1992	Dr. George W. Ullrich 1990-
MG Kenneth L. Hagemann, USAF 1992-	