Chapter

16

George T. Reynolds, Russian espionage, shots Ruth and Ray, 1953

Ensign George T. Reynolds, USNR

Ensign George T. Reynolds, USNR, contributed significantly and uniquely to the reports and analyses of the Port Chicago explosion prepared under Captain William S. Parsons' direction at Los Alamos during the several months following the explosion, which reports and analyses were transmitted by Captain Parsons to Atomic Bomb Military Policy Committee member Rear Admiral William R. Purnell. At Los Alamos, Captain Parsons was Ensign Reynolds' commanding officer.

On 24 April 1944 George Kistiakowsky wrote to James Conant and named Reynolds among eleven men from among whom "we would like to have a minimum of six men." George T. Reynolds was then at Princeton University working under Professor Walter Bleakney in National Defense Research Committee (NDRC) Division 2, Structural Defense and Offense. On 25 April Conant requested Vannevar Bush to instigate Reynolds' transfer to Los Alamos; Conant added, "There will be a kick here." By 9 May Reynolds had not agreed to the transfer.

Ensign Reynolds was never a "happy camper" at Los Alamos. In one undated letter mailed from Santa Fe 14 February 1945 to NDRC Chairman James Conant, Reynolds asked Conant to find some means to arrange his transfer from Los Alamos. Reynolds was discontent at

Los Alamos because he found he was inconveniently subordinate to men of higher military rank than his own but men of inferior scientific and technical accomplishments. Furthermore, his assignment at Los Alamos did not provide enough important work for him to do. In this letter to James Conant, Ensign Reynolds wrote:

"Since I am here entirely at your request, I feel it is about time to submit an informal report. Frankly it is only just recently that I have overcome my initial disappointment at missing my Ft. Pierce [Florida] assignment, but I can now say I am trying to make the best of it . . . part of my trouble has been in not having enough important work to do . . . it has been difficult to find myself in my own field with in [sic] my own work, unable to move with the freedom that the NDRC accorded me as the result of my experience & PhD in physics . . . after 7 months I am beginning to feel the limitations of the rank of Ensign. I am extremely fortunate in having a fine Navy Commanding Officer here [Captain Williams S. Parsons]. He has been very understanding & I would not want him to think I am discontent, & so would appreciate your confidence in the matter. I realize this request borders on being presumptuous, but am making it after several weeks deliberation. I would very much appreciate hearing from you, as I am trying to maintain as many of my old contacts as possible." Signed, *Geo. T. Reynolds*

Ensign Reynolds would have preferred to spend the years of his World War II military service with Professor Bleakney on the beautiful beaches at the U.S. Naval Amphibious Training Base at Fort Pierce, a few miles south of Vero Beach on the Atlantic coast of Florida where, no doubt, Ensign Reynolds would have made an unremarkable contribution to the nation's war effort, as his contribution to the nation's war effort at Los Alamos would have been unremarkable, except his definitive contributions to analysis of the Port Chicago explosion.

In an interview with Reynolds for the Rutgers Oral History Archives of World War II, conducted by Sean D. Harvey and Shaun Illingworth in Princeton, New Jersey, 29 October 1999, Reynolds narrated the events and process that led to his assignment at Los Alamos:

> ". . . Back in 1943 [sic, 1944], I had been 'asked' by Vannevar Bush, who was head of the OSRD [Office of Scientific Research and Development], and James B. Conant of Harvard University, who was head of the National Defense Research Council [sic; Committee], to go West and work on a project that several of my acquaintances here had already gone to work on. Everybody knew what that was. However, I didn't want any part of it. Not for any moral reasons, it was all right with me, but I wanted the action that the amphibious warfare training promised to me. But I made a mistake. I was summoned to Washington, and I was interviewed by Conant, and he said, 'You know, you're the only one that we've been trying to get that has refused to go there. And I don't think you're very patriotic.' And that's where I made my slip. I said, 'It's not that I'm not patriotic. I've got myself a commission in the US Navy.' "

Reynolds' "slip," by which he made known to James Conant his status as an ensign of the United States Naval Reserve, resulted in immediate Navy orders that Reynolds proceed within four days to Santa Fe and there report to Captain Parsons. Ensign Reynolds did not, apparently, present himself to James Conant at that Washington meeting in Navy uniform. The investigator must wonder if Ensign Reynolds could have foreseen the consequence of his "slip"—an unwelcome assignment to Los Alamos—would he have permitted James Conant to hold the false perception that he, Ensign Reynolds, was a civilian rather than an officer of the United States Naval Reserve?

Ensign Reynolds was 27 years old and "very egotistical." He considered that his Ph.D. in physics that he had received from Princeton University one whole year earlier, and the abundant scientific and technical experience he had accumulated as a graduate student at Princeton entitled him to much more authority and respect in the overall scientific and military community at Los Alamos than he had been accorded. Being then "very egotistical," Ensign Reynolds must have felt he was amply justified in evasion of at least one military regulation at Los Alamos that he reckoned inconvenient to his own purposes. One military regulation in force at Los Alamos required that all his personal mail that would be sent off-base be first submitted to Los Alamos U.S. Army censors. On 14 February 1945 Ensign Reynolds mailed his complaining letter to James Conant from the U.S. Post Office in Santa Fe, by which evasion of military regulation the

Army censors at Los Alamos and his commanding officer Navy Captain Parsons were unaware of his complaints. As he wrote to James Conant, "I would not want him [Captain Parsons] to think I am discontent, & so would appreciate your confidence in the matter."

James Conant, however, ignored Ensign Reynolds' request for confidence in the matter and in 1981 caused Ensign Reynolds' letter to be reproduced in the "Bush-Conant File Relating to the Development of the Atomic Bomb, 1940-1945." Ensign Reynolds' letter, the envelope in which Reynolds mailed the letter from Santa Fe, Conant's office acknowledgment of receipt of the letter made 17 February by Ruth E. Jenkins, and Conant's own responsive letter of 9 March are all reproduced on Reel 10, Group 156 "R" of that 14-reel collection produced by the National Archives.

On 9 March 1945 Harvard University President, National Defense Research Committee Chairman, Atomic Bomb Military Policy Committee Alternate Chairman, and member of the British-American atomic bomb Combined Policy Committee James Conant wrote his temperate response to George Reynolds' chummy letter of 14 February:

> "Dear Ensign Reynolds:
>
> "I am sorry to have been delayed in replying to your letter and sorry that I was not able to see you personally and talk over your problem. I can readily understand some of the difficulties under which you have labored. I wish I could do something to help you out, but I am afraid I am not in a position to remove the limitations of which you speak.
>
> "After all, I think you would have to find consolation in the fact that these limitations would have been quite as severe in your work at Fort Pierce if not more so, but in this case you would have been dealing entirely with commissioned personnel and not mixed up with a civilian organization.
>
> "I certainly hope that in the future your work will prove more interesting than in the past and that you will feel in the long run that your transfer to this particular task was not too great a sacrifice.
>
> "Very sincerely yours,

"James B. Conant"

In the Rutgers interview Dr. Reynolds reported his attitude and frame of mind when he arrived at Los Alamos:

> "I wasn't happy. I was assigned to the group that I knew were after me: a Harvard chemist, George Kistakowski [sic], a very colorful fellow, who is well known to the history of the atomic bomb. He recognized immediately that he had an unhappy camper there. I went to his office at Los Alamos as soon as I arrived there. He said, 'Hello, I'm glad to see you.' And I said, 'I'm not glad to be here.' He said, in his Russian accent, 'Oh, God! . . . What's wrong?' And I told him I'd gotten married, and my wife, Virginia, was down in Santa Fe on a street corner with our luggage, and I'd been taken by MPs [Military Police] into a car and brought up to the hill."

Reynolds did acknowledge in this Rutgers interview, "I was young, very egotistical . . . and of course, we thought the civilians knew more than the Navy." In the Rutgers interview Reynolds does also acknowledge that his commanding officer Captain Parsons "was a fine gentleman." Princeton University Professor of Physics Emeritus George T. Reynolds is 58 years older than in 1944 when he was young and "very egotistical," but assessing my interactions with the man these last 20 years I have found that only the qualitative degree of the adverb that he used predicatively in his self-description is less fitting today than in 1944 and would be better qualified now as "somewhat less than very egotistical." Professor Reynolds is member emeritus of The New Jersey State University at Rutgers Board of Trustees; he has spent much of his time since retirement at the Woods Hole Marine Biological Laboratory and Woods Hole Oceanographic Institution on Cape Cod, Massachusetts.

On his work in analysis of the Port Chicago explosion Professor Reynolds explained in the Rutgers interview:

> "I went to Port Chicago, and spent about a week there doing every kind of analysis I could think of to estimate the blast effect of the ammunition ship. Using collapsed oil drums, knocked over telephone poles, windows dished in miles away, sides of railroad cars, all of which could be analyzed physically, mechanically. I came up with a ridiculous answer, which was that fifteen hundred fifty tons of

> TNT went off. I said, 'Fifteen fifty, plus or minus fifty.' Today, knowing what I know about physics and the experiences that I've had in the field, I would have said, 'Well, it's somewhere between 1000 and 2000.' But not me, I was very confident of my work. When it was all said and done, and they got the bill of lading out, it turned out that there were fifteen hundred forty tons, so I was immediately considered an expert, purely by accident."

The compete Rutgers interview is available at:

http://oralhistory.rutgers.edu/Interviews/reynolds_george.html

Fort Pierce, Florida; the DOLOC Committee

In August 1943 Commander in Chief (COMINCH) Admiral Ernest J. King, USN, asked the Navy's Coordinator of Research and Development Rear Admiral Julius A. Furer to set up within NDRC a project to study the Demolition of Obstacles to Landing Operations (DOLOC). John E. Burchard, Chief of NDRC Division 2, Structure Defense and Offense, was DOLOC Committee chairman. DOLOC members included Princeton University Professor Walter Bleakney who was Deputy Chief of Division 2 and George Kistiakowsky who was Chief of NDRC Division 8, Explosives. The committee representative in England was H. P. Robertson. John Burchard's 29 July 1944 report to Rear Admiral Furer, "Damage Survey at Port Chicago, California," is reproduced in Chapter 11. The work of the DOLOC Committee began at an orientation meeting with the Navy on 22 September 1943 at which Admiral Furer presided.

The investigation of obstacles to landing operations, and their elimination by explosives, was undertaken principally in anticipation of the Allied Forces June 1944 Normandy landing. The DOLOC experimental obstacle demolition programs were conducted at Fort Pierce with large explosive charges—aerial bombs, individually placed mines, and explosives-laden remote-controlled boats—to determine the size and placement of charges that could accomplish the destruction of shallow water and submerged obstacles emplaced by the German defenders. However, the submerged craters that resulted from detonation of those necessarily large demolition charges could trap and likely would drown heavily laden Allied troops slogging ashore through the otherwise low-tide shallow water access to the beaches. Studies made at Fort Pierce determined the explosive charge weight necessary to destroy expected landing obstacles, the depth of craters resulting from those charge weights, the elevated lip of the resulting craters, and the time required for wave action to remove the stumbling-block crater lip and refill the crater.

The largest experimental charge detonated statically in the course of DOLOC investigations at Fort Pierce was 64,000 pounds, under shallow water on 3 February 1944, which cleared underwater obstacles within a circle 160 feet in diameter. On 4 October 1943 a charge weight of 6,800 pounds of TNT was similarly detonated, which cleared obstacles in a circle 80 feet in diameter. The experimental underwater detonations conducted at Fort Pierce confirmed a previous rough equation that the diameter of cleared circle in feet would equal approximately twice the cube root of the charge weight expressed in pounds—the “cube root law.”

Twice the cube root of a submerged demolition charge weight (pounds TNT) best described the crater results of the submerged demolition experiments done at Fort Pierce, but 3.70 times the cube root of the charge weight (pounds TNT) best described the results of crater experiments done on the surface of clay soil, also done by NDRC Division 2. Generally speaking, 3.70 times the cube root of the charge weight best predicts the diameter increase of all physical effects that result from a ground surface explosion, chemical or nuclear. Because the depth of the water beneath the exploded Liberty ship SS *E. A. Bryan* at the Port Chicago Naval Magazine pier was slight compared to the charge weight of the explosion, the Port Chicago explosion is usually defined as a ground surface explosion.

Measurements of the crater formed in the Suisun Bay bottom beneath the exploded Liberty ship SS *E. A. Bryan* at the Port Chicago Naval Magazine pier were immediately used by Los Alamos to confirm applicability of the cube root law to multi-kiloton explosions. **Enclosure (B)** of Captain Parsons’ “Port Chicago Disaster: Final Report” to Admiral Purnell, dated 16 November 1944, is Dr. Maurice

Shapiro's "Analysis of crater in bottom near ship pier." In that report Dr. Shapiro wrote:

> "A comparison has been made of the crater in the Port Chicago explosion with those created in a large number of TNT explosions in clay soil. In experiments performed by Division 2 of NDRC* (*'Effects of impact and explosion,' Sheet No. 3B-1, September, 1943), with charge weights ranging between 100 and 4000 pounds, the following empirical equation relating crater diameter D (feet) to charge weight W (pounds) was deduced for explosions occurring at the surface of the ground:
>
> "$D = 3.70W^{1/3}$
>
> "Applying this to the Port Chicago explosion, we have D= 3.70 x 146 = 540 feet. The crater diameters in the NDRC experiments exhibited approximate cylindrical symmetry. They were measured at the original ground surface between shear shoulders. The diameters estimated above for the Suisun Bay crater, namely 600 and 300 feet, were similarly measured at the original bed-surface under the SS E.A. Bryan. The qualitative agreement between the crater size predicted by extrapolation and the actual size is surprisingly good if one considers the distribution of charge in the ship, the location of the center of gravity of the charge 20 feet above the bottom, and most significantly, the considerable energy absorption by the intervening water."

In his Port Chicago damage survey to Rear Admiral Furer of 29 July 1944, John Burchard wrote in paragraphs 1.a, 1.b., 13, 15.a. and 15.b.:

> "1. Purpose of Survey.
>
> "a. For information it might yield as the effect of very large charges when used in bombardment. The location of the charge below the water line was of course one which would be expected to result in less damage to structures than might arise certainly from air blast in the open and probably from earth shock if the charge had been buried in earth.
>
> "b. For information as to the effect which the detonation of a large underwater charge near the shore might have on enemy underwater obstacles and nearby shore fortifications. A simulation of underwater obstacles was available in the piling supporting the piers and of shore installations by adjacent revetments used to protect loaded

freight cars. These were of standard construction of piling with earth-filled walls and might be taken as reasonably representative of a bunker, though on a large scale. On the other hand, the charge was not located for optimum results as it was supported well off the bottom by the hull of this ship.

"13. Underwater effects. Crater not yet measured. If we take [the Port Chicago] charge as 4,000,000 pounds and compare with 64,000 fired at Fort Pierce, we would expect crater radius of circa 320' from cube root law."

"15. Conclusions.

"a. The detonation of such a load among enemy obstacles would neither:

(1) guarantee a satisfactory passage, or

(2) stun the enemy long enough or cause enough casualties to impair his defenses. Our own personnel rallied immediately.

"b. The radii of positive and worthwhile damage to be expected from such charges will not exceed those postulated by the $W^{1/3}$ rule and will probably be less."

Russian espionage and the uranium hydride bomb

As shown in Chapter 13, in his letter of 5 February 1939 to physicist George Uhlenbeck, J. Robert Oppenheimer first proposed a uranium hydride nuclear fission bomb to utilize the deuterium hydrogen isotope in a U^{235} metal-deuterium compound. In development at Los Alamos, Oppenheimer's 1939 concept of a uranium-deuterium fission bomb would be named the Mark II by James Conant on 4 July 1944.

On that date in memorandum to General Groves, Conant forecast the Mark II would yield an energy of explosion equivalent to 1,000 tons of TNT; the Mark II was successfully proof fired at the Port Chicago Naval Magazine the evening of 17 July 1944. On 17 August 1944 by memorandum Conant informed General Groves of the decision taken at Los Alamos, in consequence of the Port Chicago explosion, that the Mark II should be put on the shelf, and Conant's memorandum of 17

August 1944 to General Groves acknowledges that the then known upper limit of effectiveness of the Mark II could be improved somewhat and developed for combat use in 3 or 4 months time. The Mark II uranium hydride bomb was the first practicable and proven nuclear fission weapon.

Despite all that historical significance, in his comprehensive review of the Manhattan Project history, *The Making of the Atomic Bomb*, Richard Rhodes mentions uranium hydride only on pages 610 and 611, in discussion of Otto Frisch's bench-top critical mass experiment which Richard Feynman described allegorically as tickling the tail of a sleeping dragon—because of the distinct hazard that the experiment in progress could accidentally go awry and propagate a violently explosive nuclear fission energy release, lethal prompt radiations in the immediate area, smoke and fire, as of an aroused and angry fire-breathing mythic dragon.

On February 5, 1939 Oppenheimer proposed what would become the Mark II. On 21 August 1943 the Atomic Bomb Military Policy Committee informed Vice President Henry Wallace, Secretary of War Henry Stimson and Chief of Staff General George C. Marshall, "There is a chance, and a fair one if a process involving the use of a [uranium] hydride form of material proves feasible, that the first bomb can be produced in the fall of 1944." Eleven months later the Mark II was successfully proof fired at Port Chicago.

On 16 March 1945, eight months following the successful proof of the Mark II, Russian nuclear physicist Igor Kurchatov wrote an assessment of the technological value of materials recently obtained by the NKGB from spies inside U.S. military bases and war plants. Among those materials that on 5 March Kurchatov was provided to review was information that the U.S. had the uranium hydride bomb concept in development. In his 16 March report to NKGB chief Lavrenti Beria, on the technological value of those materials Kurchatov had received for review on 5 March, Kurchatov wrote that the materials were of great interest. Kurchatov noted two particular ideas mentioned in those materials to be of especial interest: 1) the use of uranium hydride 235 instead of metallic uranium 235 as the active material of an atomic bomb, and 2) implosion as a method to detonate an atomic bomb.

An English translation of portions of Kurchartov's 16 March 1945 report to Beria is found as Document No. 8 in Appendix Two, pages 458 and 459, of *Special Tasks* by Pavel and Anatoli Sudoplatov with Jerrold L. and Leona P. Schecter (New York: Little Brown & Co., 1994; updated edition June 1995).

The copyrighted translation of that report, commissioned by the Schecters, reads in part:

> "The utilization of uranium-hydride 235 instead of uranium 235, as the materials suggest, is based on a great degree of probability of the absorption of low-velocity neutrons by uranium, which provides for diminishing the critical mass. The introduction of hydrogen, however, retards the entire process and may drag it out to impermissibly long periods of time. Besides, because of the low density of the substance, the critical mass needs to be increased. Therefore, it is far from obvious that the use of uranium-hydride instead of uranium will yield that significant (almost 20-fold) gain with regard to the mass, which the materials suggest.
>
> "The proposal in question can only be gauged after a stringent theoretical scrutiny of the matter. . . [Schecters' redaction].
>
> "It seems exceptionally important to establish whether the system described was studied through calculation or by way of an experiment. If the latter, that would mean that the atomic bomb has already been executed and that uranium 235 has been separated in major quantities. The materials contain a remark that seems to suggest that. In describing the implosion method it is pointed out that no experiments have yet been carried out with active material. . . ."

Because the Schecters have deleted part or parts of the whole text from their English transcription of Kurchatov's 16 March 1945 report to Beria it is impossible to know certainly from their text if "the system described" by Kurchatov is in fact the uranium hydride bomb concept, although contextually "the system described" appears to be the uranium hydride bomb concept. The Schecters have not responded to a request to obtain the deleted part or parts of their commissioned translation of Kurchatov's report to Beria. Kurchatov's 16 March 1945 report to Beria was published in the Russian Academy of Sciences journal *Questions of History of Natural Science and Technology,* No. 3, 1992 (*Voprossi Istorii Estestvoznania i Tekhniki*). The Schecters' book *Special Tasks* was lambasted by the critics in 1994, but some of the criticisms made of that first edition are addressed in the updated 1995 edition.

Joseph Albright and Marcia Kunstel in their book *Bombshell. The Secret Story of America's Unknown Atomic Spy Conspiracy* (New York: Times Books/Random House,1997) detail the life of the Manhattan Project physicist Theodore Alvin Hall, apparently known to his Russian handlers as "Mlad." Albright and Kunstel believe Mlad was the person who provided the Russians with the information that Los Alamos was working on a uranium hydride bomb. Albright and Kunstel wrote that, in the course of their interviews with Hall in the 1990s, he didn't recall knowing anything about the uranium hydride bomb, but Albright and Kunstel comment editorially, "at the time he probably did know of it."

Albright and Kunstel on page 125 propose their reasons to believe that Hall provided the Russians with information about development of the uranium hydride bomb at Los Alamos:

> "A second clue pointing in Ted Hall's direction was that the raw document that so interested Kurchatov stressed the possibility of making a bomb of uranium hydride. Because of the odd history of the uranium hydride bomb, it is possible to triangulate a sixty-day period during which that information most likely passed into the hands of the NKGB. That window lasted from late November 1944 to late January 1945—a period that contained Hall's meeting with [Saville] Sax in Albuquerque. It was only in this brief span, Los Alamos records show, that the laboratory possessed enough U-235 in the form of uranium hydride to make a critical mass. Starting in November 1944, metallurgists had converted twelve kilograms of U-235 into 1,350 small cubes of uranium hydride. The cubes were for the critical assembly experiments carried out by Otto Frisch's G-I group. Twice in those two months Frisch and his assistants did stack together enough hydride cubes to reach a chain-reacting critical mass. Very likely it was this same pile of uranium hydride cubes that [Vsevolod] Merkulov had in mind when he wrote to Beria on

> February 28: 'The Americans already have the necessary amount of active substance for two or three bombs of lesser effectiveness.' "

Albright and Kunstel were not aware in 1997, nor were Beria and Kurchatov in 1945, that the Mark II uranium hydride bomb required only 9 kilograms U^{235}, nor did they know that at least that minimum quantity had been produced by Philip Abelson at the Naval Research Laboratory during 1943. Albright and Kunstel are, therefore, incorrect in their statement that only during the 60-day period between November 1944 and late January 1945 did Los Alamos possess "enough U-235 in the form of uranium hydride to make a critical mass."

Albright and Kunstel wrote that only during that triangulated period of 60 days from late November 1944 to late January 1945 would information about the U.S. hydride bomb "most likely" have passed into the hands of the NKGB. But information about the U.S. hydride bomb concept and development could have passed to Russian intelligence anytime after Oppenheimer first proposed that concept to George Uhlenbeck in his letter of 5 February 1939.

After distribution of the Atomic Bomb Military Policy Committee report of 21 August 1943, which noted the fair chance that the first (uranium) hydride bomb could be available by the fall of 1944, the British and Canadian members of the Combined Policy Committee knew certainly that the U.S. had the uranium hydride bomb in development.

Following James Chadwick's visit to Los Alamos 29 July through the morning of 3 August 1944 the British and Canadian members of the Combined Policy Committee knew that the first uranium hydride bomb had been successfully proof fired at Port Chicago 17 July.

Information about the U.S. uranium hydride bomb development could have reached the Russians from American, British or Canadian sources. One possibility in Canada was Allan Nunn May. "The event which unraveled the spy network in Canada was the defection of Igor Gouzenko, a code clerk in the Soviet embassy in Ottawa, in early September, 1945. This led directly to a physicist-spy, code-named "Alek" engaged in wartime nuclear research in Canada. Gouzenko's

Soviet documents revealed him to be an Englishman named Allan Nunn May, a person who had had many leftist connections in prewar years. Nunn May, never at Los Alamos himself, nonetheless obtained information of interest to the USSR. He informed them of the nature of the Trinity and Hiroshima bombs, the U-235 output of the plant at Oak Ridge, and of Pu-249 at Hanford, and passed a small sample of U-233 to Soviet agents" (T. M. Sanders, University of Michigan;

http://www-personal.umich.edu/~sanders/214/other/handouts/chr_spy.html)

Klaus Fuchs should also be considered as one person who could have provided the Russians information about the uranium hydride bomb development. Fuchs worked closely with Edward Teller at Los Alamos, and the uranium hydride bomb was dominant among Teller's program interests and efforts. No mention of the uranium hydride bomb was made in Fuchs espionage trial in England, but Fuchs had no reason to mention another particular instance of his espionage than those that were before the court.

Someday in the clouded future the Russian Foreign Intelligence Service archives may locate and release the documents that Kurchatov reviewed for Beria from 5 to 16 March 1945; it will be possible then to ascertain what remark suggested to Kurchatov that the uranium hydride bomb had been tested, and it may then be possible to ascertain the source of that information. Very few persons were cognizant that the Mark II had been successfully proof fired 17 July 1944.

According to Albright and Kunstel, Vsevolod Merkulov wrote in his 28 February 1945 report No. 1103/M to Beria:

> "There is not any definite schedule for producing the first bomb because so far the design and research works haven't been finished. It is thought that a minimum of one year and maximum five years will be required to produce the first such bomb.
>
> "As for bombs of somewhat smaller capacity [i.e., the Mark II], it is reported that already within several weeks one can expect the manufacture of one or two bombs, for which the Americans already have available the necessary quantity of active substance. This

> bomb will not be so effective, but all the same it will have practical meaning as a new kind of weapon by far superior in its effectiveness to all the currently existing kinds of weapons. The first actual battlefield explosion is expected in two or three months."

Merkulov's 28 February information about U.S. production of smaller capacity bombs "within several weeks" and the first actual battlefield explosion "in two or three months" does not correspond to any forecast in James Conant's Los Alamos site visit reports to General Groves of 4 July and 17 August 1944, nor is that information forecast in his "Report on Visit to Los Alamos – October 18, 1944," nor in his "Summary of Trip to Los Alamos, December 1944." Merkulov's information of 28 February did not come from James Conant nor anyone in his office at the National Defense Research Committee.

Albright and Kunstel continue discussion of the uranium hydride bomb on page 126:

> "By the time Sax met Hall in Albuquerque, Oppenheimer and his division leaders were indeed toying with the option of trying to make several 'bombs of lesser effectiveness' out of uranium hydride. Edward Teller's hydride-gun idea had gone into and out of fashion, but it remained a live possibility until the end of December 1944. But after Sax' visit, the picture changed overnight, making the hydride bomb a dead letter. On January 1 [1945] Oppenheimer froze the design of Little Boy [Mark I], a bomb that needed all of the Manhattan Project's stock of U-235 in the form of pure uranium metal. Oppenheimer's metallurgists were ordered to convert all 1,350 hydride cubes into metallic uranium. By early February 1945, the uranium hydride cubes were gone and the option of making several small bombs "of lesser effectiveness" had disappeared."

In fact, on 17 August 1944 James Conant reported to General Groves the decision taken at Los Alamos to put the 1,000-ton TNT equivalent Mark II on the shelf, with recognition Mark II could be taken off the shelf and developed for combat use in 3 or 4 months time if required, and with the possibility of some energy yield improvement. The **option** of making several small bombs of lesser effectiveness, i.e., the Mark II, had not "disappeared" by early February 1945; that **option** was remitted after 17 August 1944 and was not revisited until 31 March and

11 April 1953 in shots Ruth and Ray of the Upshot-Knothole series of tests conducted at the Nevada Proving Ground.

Shots Ruth and Ray, uranium hydride experimental devices

After the war Los Alamos physicists were skeptical of the usefulness of uranium hydride in weapons. Edward Teller remained interested in the concept though and, as he had at Los Alamos during the war to assure development of the Mark II uranium hydride bomb, Teller used his prominent position to push hydride weapon development when the University of California Radiation Laboratory (UCRL) weapons lab opened in Livermore, California. Ruth and Ray were both uranium hydride experimental devices designed and produced by Edward Teller and Ernest Lawrence at UCRL, later the Lawrence Livermore National Laboratory (LLNL). Ruth was the first device fielded by UCRL and was detonated 31 March 1953; Ray was detonated 11 April 1953. Both yielded an energy of explosion equivalent to 200 tons of TNT, which is the same energy of explosion produced by the proof detonation of the Mark II uranium hydride experimental device at the Port Chicago Naval Magazine 17 July 1944. Review of the reported ionizing radiation effects that resulted from shots Ruth and Ray permits approximation of the probable ionizing radiation effects that resulted from the 17 July 1944 proof detonation of the Mark II.

Ruth, named Hydride I, was detonated at 0500 hours, 31 March 1953 atop a 300-foot tower at the Nevada Proving Ground. The energy yield was 0.2 kiloton (200 tons TNT equivalent). The Atomic Energy Commission (AEC) objective was to evaluate the nuclear yield, blast, thermal and radiological phenomena produced by this experimental device. The Department of Defense (DOD) objective was to measure the effects of the detonation and evaluate the military applications of the device. The top of the cloud reached an altitude of 13,600 feet.

Ray, named Hydride II, was detonated at 0445 hours, 11 April 1953 atop a 100-foot tower at the Nevada Proving Ground. The energy yield was 0.2 kiloton (200 tons TNT equivalent). The AEC objective was to evaluate the nuclear yield, blast, thermal and radiological phenomena produced by this experimental device. The DOD objective was to evaluate military equipment, tactics, and doctrine; to measure effects characteristics and evaluate the military applications of the device; and to orient military personnel in the tactical uses of nuclear weapons. The top of the cloud reached an altitude of 12,800 feet.

The public report “Shots Annie to Ray” (Defense Nuclear Agency report DNA 6017F) does not identify the active material employed by the devices detonated in shots Ruth and Ray, but elsewhere in the Department of Energy (DOE) literature Ruth is identified as “Hydride I” and Ray is identified as “Hydride II.” Both were necessarily U^{235}-enriched uranium hydride devices. The degree of U^{235} enrichment is not reported. The popular literature, without any documentary reference, reports only one difference between the Ruth and Ray devices: the uranium hydride active for shot Ray (Hydride II) was, specifically, a uranium deuterium (^{2}H) compound; by implication the uranium hydride active for shot Ruth (Hydride I) was either U^{235}-enriched uranium compounded with the naturally occurring abundance of hydrogen isotopes, or the hydrogen (^{1}H) or tritium (^{3}H) isotopes.

It seems improbable that Edward Teller and Ernest Lawrence would have spent time, money, effort, and a quantity of separated U^{235} to develop and test a uranium hydride device, Ruth, that would employ a compound of uranium and natural hydrogen or a compound of uranium and the ^{1}H isotope. From February 1939 it was known that a uranium deuterium compound would be the most efficient uranium hydride active material. For that reason, the Mark II employed a uranium deuterium active, and the proof detonation of the Mark II effectively demonstrated the efficiency of a uranium deuterium device. Hydride I (Ruth) was intended for use as a primary in a compact thermonuclear bomb system; conceivably the test of a uranium tritium device would have provided information and data useful to that design and purpose.

However, all we know certainly is that active material of Hydride I and II, Ruth and Ray, was uranium hydride and that the test detonation of the two each produced an energy of explosion equivalent to 200 tons of TNT, which is the TNT energy equivalent produced by the Mark II uranium deuterium Mark II experimental device proof fired 17 July 1944 at the Port Chicago Naval Magazine.

Projects done in conjunction with both shots Ruth and Ray evaluated the nuclear yield, blast, thermal, seismic, electromagnetic radiation, initial gamma radiation versus distance, radioactive fallout dispersal, airborne sound, and indirect damage. Shot Ray also included cloud penetration, cloud sampling and radiochemistry analysis of the obtained samples; shot Ruth did not. In addition to the same projects done at shots Ruth and Ray, shot Ray included troop orientation and indoctrination—71 DOD personnel positioned as observers 16 or 18 kilometers from ground zero. The principal DOD exercise that accompanied shot Ray was to provide Marine Corps operational tests designed to investigate factors that might affect the use of helicopter assaults under the conditions following a battlefield nuclear detonation: flash blindness, overpressure, and ground and airborne radioactivity. Three helicopters were employed in the exercise.

The radiological effects measurements obtained from detonation of the uranium hydride devices Ruth and Ray provides information sufficient to assess the probable radiological consequences of the proof detonation of the uranium hydride Mark II at the Port Chicago Naval Magazine 17 July 1944.

Ionizing radiation consequences, Ruth and Ray

Ionizing radiation survey data for shots Ruth and Ray were reported as roentgens/hour (R/h), which is equivalent to Roentgen Equivalent in Man (REM). Many different systems and units are employed to measure and quantify ionizing radiation. The published DOE ionizing radiation survey data for shots Ruth and Ray are reported as roentgens/hour and are so reported here. Following the discussion, below, of the Ruth and Ray ionizing radiation survey findings, information is presented which correlates ionizing radiation exposure levels with short-term human health effects and mortality. One week continuous exposure to 1 R/h would be expected to produce no medical consequence. The ionizing radiation survey data obtained immediately following shots Ruth and Ray permit the conclusion that no adverse effect to short-term human health was probable in consequence of the proof detonation of the Mark II at the Port Chicago Naval Magazine. Long-term human health effects that may result from one-time or intermittent exposure to low levels of ionizing radiation is a subject debated with the same want of definitive conclusion as the debate to definitively settle the Origin of Life.

Ruth

The Ruth device, Hydride I, is reported to have been 56 inches in diameter, 66 inches long and to have weighed 7,400 pounds. A betatron is reported to have been used for initiation. The weight and dimensions of the Ray device, Hydride II, and the initiation mechanism for shot Ray are not available.


Shot Ruth – Remains of the Tower

Ruth was detonated atop a 300-foot tower in the open air. Only the top 100 feet of the steel tower were vaporized, so the fireball of shot Ruth did not exceed a radius of 100 feet and therefore did not contact the ground. Ground surface material was not vaporized by the Ruth fireball, which limited the material entrained by the Ruth fireball and rising cloud that could be distributed as radioactive fallout.

The Mark II was detonated 10 feet below the waterline, within the hull of the Liberty ship *E. A. Bryan*. The fireball generated by the proof of the Mark II at Port Chicago did contact steel portions of the ship as it initially formed, but probably did not contact Suisun Bay water. More radioactive debris was certainly produced by the proof of the Mark II—and available to form radioactive fallout—than was produced by shot Ruth, but the quantitative difference of vaporized material and particulate matter generated by the two detonations was small. The amount of radioactive fallout that resulted from the proof of the Mark II at Port Chicago was greater than that which resulted from shot Ruth, but the difference was so slight that the radioactive fallout from the two detonations can be considered to have been effectively the same.

The prompt gamma radiations emitted by the detonation of Ruth were attenuated only by the surrounding atmosphere, and earth immediately beneath the shot. Much of the prompt gamma radiations emitted by the Port Chicago proof of the Mark II was attenuated by the steel hull of the ship before it disintegrated.

There was an insignificantly greater amount of radioactive fallout available to be deposited over a wide area downwind of Port Chicago than was available to be deposited in consequence of shot Ruth, but significantly less prompt gamma radiations affected the immediate area of the Port Chicago explosion, within 1,000 feet, than affected the immediate area of shot Ruth.

One B-25 aircraft spent four hours tracking the Ruth cloud at 12,000 feet, and encountered a maximum radiation intensity of 0.1 R/hour. That reading was made at the cloud periphery because aircraft did not penetrate the Ruth cloud.

The gamma radiation spectrum of residual contamination and initial gamma exposure versus distance data were obtained by the U.S. Army Signal Corps Engineering Laboratories to characterize the gamma radiation resulting from the Ruth detonation. The initial gamma exposure data from shot Ruth have not been published, but were probably a composite measure of prompt and delayed gamma.

During the first 80 minutes following the Ruth detonation a radiation ground intensity survey was made by an H-5 helicopter at heights ranging from five to 50 feet above the ground. The highest radiation intensity, 1.0 R/h at a height of ten feet above the ground, was measured near ground zero. One C-47 and two L-20s surveyed fallout radiation intensities as far as 320 kilometers offsite at heights ranging from 500 to 800 feet. Those aircraft detected negligible amounts of radiation.

On the ground surface within a radius of 50 meters of ground zero for the Ruth detonation the radiation intensity was initially 10.0 R/hour. At 24 hours, 1.0 R/hour. At the end of 72 hours radiation intensity on the ground was 0.01 R/hour to a maximum radius of 150 meters from ground zero. The onsite fallout was minimal; intensities exceeding 0.1

and 0.01 R/hour were found as far as four kilometers from ground zero in a narrow band to the south.

Ray

Shot Ray detonation, 11 April, 1953

Radiation surveys done following shot Ray were not so thoroughly conducted as for shot Ruth.

In one of the Ray DOD exercises conducted immediately after the shock wave passed, one of the three helicopters in the exercise proceeded toward the shot area and then landed about 150 meters from ground zero. A radiation monitor disembarked and during a period of ten minutes recorded radiation levels on the ground, 150 to 1,000 meters from ground zero. The highest radiation intensity recorded on the ground was 10.0 R/h, 510 meters from ground zero. All recorded intensities except the one made at 510 meters were less than 10 R/h within ten minutes after the detonation. The maximum intensity of onsite fallout encountered 30 minutes after the shot was 25 R/h, five feet above the ground in one isolated spot. An F-84G aircraft penetration of the Ray cloud was made 45 minutes after the detonation. A peak intensity of 40 R/h was detected. The Ray cloud was not tracked by aircraft. Low-flying aerial surveys conducted offsite, up to 320 kilometers, encountered a maximum intensity of 0.05 R/h.

Ionizing radiation exposures, short term human health and mortality effects

Short-term (several days), whole-body exposure in roentgens, probable effects. Source: “Emergency Exposures to Nuclear Radiation,” TM-11-1, and “Medical Aspects of Nuclear Radiation,” TB-11-24, Office of Civil and Defense Mobilization.)

000 - 100 R	No obvious effects
100 - 200 R	Minor incapacitation
200 - 600 R	Sickness and some deaths
Over 600 R	Few Survivors

An exposure of 1 R/h for 6 hours/day in the open air is considered “safe.” Persons exposed to one month continuous exposure at 1 R/h would be expected to suffer 50 percent dead; 15 days continuous exposure to 1 R/h would be expected to produce 5 percent dead; one week continuous exposure to 1 R/h would be expected to produce neither medical consequences nor, therefore, deaths.

Using the ionizing radiation survey data reported for shots Ruth and Ray as measures of the probable ionizing radiation levels produced consequent to proof of the 200 tons TNT-equivalent uranium hydride Mark II experimental device conducted at the Port Chicago Naval Magazine it is readily apparent that even the two men who survived the Port Chicago explosion at 1,000 feet under the rubble of the Joiner Shop, at the shore end of the pier, would probably not have suffered adverse short-term health consequences as the result of ionizing radiation exposure, prompt gamma nor subsequently from any local radioactive fallout. Neither of those two survivors showed any immediate effect of short-term ionization radiation exposure and one of the two, interviewed by the news media 55 years later, neither evidenced nor claimed any adverse health effect in consequence of the otherwise brutal drubbing to which he was subject 1,000 feet from the center of the Port Chicago explosion.

Those personnel in the Port Chicago Naval Magazine barracks and administration areas 1.5 miles from the detonation of the Mark II were in no way affected by the immediate gamma radiations produced by the detonation, nor were hazardous levels of radioactive fallout probable at that distance. Similarly, civilians in the adjacent town of Port Chicago were not subject to immediate or subsequent ionizing radiation hazards. Comparison of the survey data taken of the intensity of downwind radioactive fallout from the detonations of Ruth and Ray clearly shows that no widespread hazardous intensities of ionizing radiations from fallout were probable from the Mark II detonation at Port Chicago, although local hot spots may have occurred in the then remotely populated Sacramento Valley.

Those personnel who immediately entered the area of destruction at the shore end of the destroyed Port Chicago pier to conduct search and rescue were not exposed to any substantial radiological hazard. The men who subsequently recovered human remains and who did metal fragment plots and fragment recovery in the near vicinity of the detonation of the Mark II were not exposed to any radiological hazard of consequence.

Final remarks

Twenty-two years ago at a church rummage sale in Santa Fe, New Mexico, I recovered the “History of 10,000 ton gadget,” a document that Los Alamos photographic technician Paul Masters had purloined from the Manhattan Project laboratories at Los Alamos in winter 1944-1945. The bottom line of that document predicts that the ball of fire that would result from the 16 July 1945 nuclear bomb test at Trinity Site would occur in “typical Port Chicago fashion.”

A few days study of the “History of 10,000 ton gadget” persuaded me that if competent Los Alamos scientists had characterized the Port Chicago explosion fireball as having been typical of a nuclear fission explosion then the Port Chicago explosion had, according to the doctrine of necessitarianism, necessarily been a nuclear fission explosion. I subsequently learned that the men who had written that characterization of the Port Chicago fireball, Joseph O. Hirschfelder and William George Penney, were not just run-of-the-mill competent Los Alamos scientists but were brightest among the luminaries of the Manhattan Project scientists working at Los Alamos in winter 1944-1945.

In autumn 1980 Los Alamos National Laboratory Director Donald M. Kerr, now director of the Federal Bureau of Investigation Laboratory Division, challenged me to prove, if I could, that the Port Chicago explosion had been a nuclear fission explosion. *The Last Wave from Port Chicago* is my response to that challenge.

My critics demand that I produce a "smoking gun" document in proof of the work made here, so I venture to compose that document, which is a signed and handwritten direction from President Franklin D. Roosevelt to the Secretary of War Henry Stimson, dated July 7, 1944. Because that document would be substantially redacted if it were ever available to the public, I also provide the document as it would be redacted by the appropriate Government authorities.

> "By the authority vested in me as Commander-in-Chief of the Armed Forces of the United States of America, and additionally granted to me by the Congressional Declaration of War against the Empire of Japan, I hereby direct you to authorize the Joint Chiefs of Staff and Rear Admiral William R. Purnell, USN, the Navy member of the Atomic Bomb Military Policy Committee, in cooperation with appropriate civilian scientists and Armed Forces personnel assigned to the Manhattan Project laboratories at Los Alamos, New Mexico, to secretly detonate the prototype Mark II experimental uranium hydride nuclear fission bomb at the Port Chicago Naval Magazine as soon as practicable in order to prove the feasibility of large scale nuclear fission weapons, which are essential to the present and future national security, and by that proof detonation to determine by scientific analysis of the physical consequences of that proof the anticipated military consequences that will result from such use of an atomic bomb of comparable energy in the particular circumstances of an enemy harbor or maritime port and, moreover, to utilize detailed analyses of the consequences of that proof detonation to be made at the Port Chicago Naval Magazine to establish the anticipated military effects that will be realized from the use of the more powerful militarily-decisive nuclear fission bombs now in development by the Manhattan Project, in similar or other circumstances of combat. The exigencies and imperatives of the present War require

> that the proof detonation of the Mark II prototype atomic bomb here ordered shall be made by the parties without consideration of any physical consequences to property and persons which shall inevitably arise from execution of this order."
>
> Signed, *Franklin D. Roosevelt*

The administratively redacted text of President Roosevelt's direction to Secretary of War Stimson, the "smoking gun" document, would read:

> "By the authority vested in me as Commander-in-Chief of the Armed Forces of the United States of America, and additionally granted to me by the Congressional Declaration of War against the Empire of Japan, I hereby direct you to authorize [SENSITIVE INFORMATION DELETED] to determine by scientific analysis [SENSITIVE INFORMATION DELETED] the anticipated military consequences that will result from [SENSITIVE INFORMATION DELETED] use of an atomic bomb [SENSITIVE INFORMATION DELETED] now in development by the Manhattan Project [SENSITIVE INFORMATION DELETED]."
>
> Signed, *Franklin D. Roosevelt.*

Photographs and illustrations credits.

Shot Ruth, remains of the tower. Source: Lawrence Livermore National Laboratory.

Shot Ray, detonation. Source: Lawrence Livermore National Laboratory.