The Development of the Hydrogen Bomb

Nuclear weapons are of two basic types. Atomic, or fission, bombs, such as those used in World War II, split uranium and plutonium atoms. Hydrogen, or thermonuclear, bombs fuse hydrogen isotopes. Edward Teller and Enrico Fermi first studied the possibility of a hydrogen bomb in 1942. Based on Hans Bethe's research on thermonuclear reactions in stars, Teller and Fermi believed that atoms of deuterium, an isotope of hydrogen, could be fused into helium with a simultaneous release of energy. Because such a process required stellar temperatures, then unobtainable on earth, Teller originally doubted that a hydrogen bomb could be built.

Edward Teller

Despite his original doubts, Teller continued to study thermonuclear reactions and became increasingly convinced that a hydrogen bomb was possible. However, it had been decided that the United States would concentrate its World War II nuclear efforts on building fission bombs at Los Alamos. A thermonuclear weapon, it was believed, could not be developed in time to assist the war effort. Despite their wartime concentration on the fission weapons, Fat Man and Little Boy, Teller and a small group of scientists did conduct some elementary research on the hydrogen bomb while working at Los Alamos. In particular, Teller and his colleagues found that much less deuterium and tritium would be required than originally thought, thereby making a hydrogen bomb more realistic.

Technical Issues

With the end of World War II, the whole country, including Los Alamos, demobilized. Los Alamos faced severe shortages of manpower as senior scientists returned to their prewar university positions and younger staff left to enter graduate school. As a result, very little research and development on the hydrogen bomb took place. Among the technical accomplishments during the late 1940s was the improvement of fission devices, the use of computers and computational modeling, and development of cryogenic technology to produce liquid deuterium fuel.

The ultimate success of the United States thermonuclear program rested on five factors. First, was the discovery of a method to overcome the fundamental problem that thermonuclear systems lose as much energy as they create. Second, Los Alamos had to significantly increase the size of its scientific staff. The hydrogen bomb problem required complex interactions among physicists, chemists, and metallurgists. Third, to start a thermonuclear fire, smaller and more efficient fission bombs were needed. Fourth, computational ability had to be greatly enhanced. Fifth, the political decision had to be made to marshal the resources necessary to accomplish the task.

Computing

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The design adopted for the first hydrogen bomb did not come easily or quickly. Unlike fission weapons, scientists did not have a clear idea of the range of physical constraints governing thermonuclear weapon design. Extensive mathematical modeling and simulation were required. The need for better and better computers was compelling. During World War II, all computing at Los Alamos was done with desktop calculators and a variety of IBM business machines. Such machines were not capable of handling the complex modeling required for developing the hydrogen bomb. Beginning shortly after the war, true computers started to become available, beginning with the ENIAC, IBM's SSEC, and the National Bureau of Standards SEAC. Because these machines were on the East Coast, many of the thermonuclear calculations actually took place far from Los Alamos. Although the first hydrogen bomb could have been developed without modern computers, such development would have been substantially delayed.

Final Development

Because hydrogen bombs require stellar temperatures to ignite the thermonuclear fuel, the only possible way to ignite a hydrogen bomb was by using an atomic bomb. For the development of the hydrogen bomb to go forward, fission weapons had to be improved. The two wartime fission devices, Fat Man and Little Boy, were crude prototypes not capable of being adapted for use in a hydrogen bomb. A new class of fission bombs had to be designed, built, and tested. This process took years. The first testing of new fission devices did not take place until 1948, with more design improvements following in 1950.

Shortly after Truman's directive, hydrogen bomb research began to bear fruit. Edward Teller and Stanislaw Ulam came up with a promising design, radiation implosion, which was translated by Richard Garwin into a working design. Once the design concept was reviewed and approved, work began on constructing the Mike device and planning for a full-scale test at the Pacific Proving Ground in the Marshall Islands. Every atmospheric nuclear test was a major undertaking.

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