H-bomb tests

Scientists detonated the first H-bomb in 1952, creating an explosive force greater than 10 million tons of TNT. Later tests miniaturized such weapons to fit inside an aircraft or missile in a dangerous arms race with the Soviet Union.

Text

The world entered the nuclear age on July 16, 1945, when American scientists detonated the first atomic bomb at the Trinity test site near Alamogordo in New Mexico. This A-bomb converted a tennis ball-sized mass of plutonium into an explosive force of 20,000 tons of TNT (20 kilotons). A few weeks later, on August 6, America dropped "little boy" on Hiroshima. The explosion devastated the city, instantly killing 66,000 of its 343,000 inhabitants and seriously injuring many more. On August 9, "big boy" fell on Nagasaki and killed another 25,000 people. The next day Japanese Emperor Hirohito (1901-1989) began surrender negotiations to end the Second World War.

Beginning in 1941, the "Manhattan" project to build the atomic bomb was the biggest single military construction operation of the War. Costing over two billion dollars, it collected thousands of America's best scientists in the town-sized Los Alamos military base in Northern New Mexico. The director of scientific operations, physicist J. Robert Oppenheimer (1904-1967), personally recruited many of these people to work on the bomb. Notable participants included Niels Bohr (1885-1962), Hans Bethe (1906-), Richard Feynman (1918-1988), John von Neumann (1903-1957), Edward Teller (1908-2003), and Stanislaw Ulam (1909-1984). Although Bohr already had his Nobel Prize, Bethe and Feynman would earn theirs later.

The end of the War put military planners in a tricky spot over what to do with the vast resources for building the A-bomb. One scientist in particular, Edward Teller, suggested that they should continue their research into nuclear explosions to build a device of unprecedented destructive power. Called the "super," Teller claimed his bomb would be hundreds of times more devastating than the atomic bombs dropped on the Japanese. This super bomb would fuse hydrogen into helium similarly to the nuclear processes inside the Sun. Whereas scientists detonated the A-bomb with conventional explosives, they would need an A-bomb to trigger the fusion reaction inside the Super.

Initially, the U.S. government was unwilling to supply the money and labor to build the Super bomb. Its focus was set on projects such as post-war reconstruction. On August 29, 1949, an event occurred that dramatically changed this view—the Soviet Union detonated their first atomic bomb. One month later President Harold S. Truman (1884-1972) announced to a shocked audience that the Soviets had caught them up. Teller immediate responded by pushing for the Super, even though Oppenheimer and others called it "a weapon of genocide" that "should never be built." President Truman listened to the advice of his military and on Jan 31, 1950, he announced that America would continue work on the Super, or H-bomb.

The Mike test

Just after Dawn on November 1, 1952, American scientists detonated their first H-bomb, nicknamed Mike. With an explosive force of 10 million tons of TNT (10 megatons), its fireball expanded to 3 miles across and shone as brightly as 1,000 suns. It gouged a crater 2 miles wide and several hundred yards deep, completely vaporizing its test island in the Enewetak Atoll of the South Pacific. Mike's destructive force was more than 500 times greater than the atomic bomb dropped on Hiroshima

Mike was not suitable for military device, though, mainly because it weighed 70 tons and was larger than a bus. In particular, it needed a cryogenic refrigeration plant to liquefy the hydrogen nuclear fuel. This fuel was stored around a stick of plutonium. Conventional explosives encasing the hydrogen started the reaction by compressing both the hydrogen and plutonium. The plutonium then exploded like an atom bomb, which started a thermonuclear reaction in the hydrogen. This fusion reaction spread through the nuclear fuel in an uncontrolled explosion with the energy of our Sun.

Scientists use a particular type of hydrogen in H-bombs that is well suited for thermonuclear reactions. Hydrogen atoms are naturally found in three forms, or isotopes, which have the same chemistry but different masses. The two heavier forms, deuterium and tritium, make particularly good nuclear fuel. In the nuclear reaction two nuclei from the cores of either deuterium or tritium atoms fuse into the nucleus of a helium atom. Scientists cannot use normal hydrogen because the mass of two of its atoms is less than one helium atom, unlike the heavier isotopes.

Military H-bombs

The next step in developing the H-bomb was to create a device that could be dropped from an aircraft. American scientists completed such a bomb, called Bravo, in Operation Castle. On March 1, 1954, Bravo vaporized several miles of coral reef in the Bikini Atoll near the Marshall Islands. Yet the scientists had an unnerving surprise—Bravo's immense explosive force of 15 megatons was more than three times the expected blast. Islanders on Rongerik, 135 miles distant, saw the detonation illuminate their sky. On a ship 30 miles away U.S. physicist Marshall Rosenbluth (1927-2003) described the explosion: "There was a huge fireball with turbulent rolls going in and out. ... It spread until the edge looked as if it was directly overhead. It was a much more awesome sight than a puny atom bomb."

Bravo's main difference from the Mike test was that it used a solid nuclear fuel rather than liquefied hydrogen. This meant the bomb was smaller and lighter because it did not need a bulky cooling facility. The solid nuclear material was powdered lithium deuteride, a chemical compound of lithium and deuterium. (In the energetic explosion, the lithium also converts some deuterium into tritium to also help the fusion reaction.) Weapons designers packed this powder around a plutonium detonator to make a relatively small and compact device about the size of a conventional bomb.

Following the successful detonation of Bravo, the U.S. military put their efforts into building lightweight, solid-fuel, H-bombs for battlefield munitions. Throughout the fifties these were carried by the B-52 bomber, or stratofortress. First introduced in 1952 as an atomic bomb carrier, these huge aircraft had eight jet engines and were 160 feet (49 m) long. Each bomber could deliver several H-bombs to targets many thousands of miles distant from were they took off.

Another military use of H-bombs was as a warhead on an Intercontinental Ballistic Missile (ICBM). These rockets can transport the nuclear device across continents in less than an hour. American scientists tested their first ICBM, called Atlas, in November 1958. This was more than a year after the Soviets had used their own to put the first artificial satellite, Sputnik 1, into orbit.

The Soviet-American arms race

On August 12, 1953, about a year after the first American H-bomb, the Soviets detonated a thermonuclear device at a secret base in Kazakhstan. Their bomb was called *sloika* (for layer cake) after its design of separate folds of uranium and lithium deuteride. While their first H-bomb had a comparatively small explosive force of 400 kilotons of TNT, it was small enough to fit in an aircraft. In principle, the Soviets could therefore use it as a deliverable weapon. Two years later, on November 22, 1955, the Soviets exploded their first megaton-sized hydrogen bomb. The United States and Soviet Union were now on an equal footing.

During the years of the Cold War, the Soviets and Americans both developed in excess of ten thousand nuclear devices. Since each H-bomb was able to destroy a city, these vast arsenals could literally obliterate both super-powers several times over. Fortunately, the threat of "mutually assured destruction" meant that these weapons were never used.

After effects of nuclear testing

The bravo explosion of March 1954 alerted the world to another effect of nuclear weapons—radioactive fallout. Ash from the blasted coral reef fell on a Japanese fishing vessel the *Lucky Dragon* sailing 80 miles downwind from the test site. The 23 crew became severely ill from radiation sickness and one person later died. In response the Japanese media demanded that the Americans "Tell us the truth about the ashes of death."

Since *Lucky Dragon* there have been several further incidents of dangerous radiation exposure from nuclear testing. In addition to its immediate effects of a severe sickness, radiation also increases the risk of cancer in later life and can cause genetic defects in future children. Soldiers practicing operations in the aftermath of a thermonuclear explosion and nearby residents have successfully pursued compensation claims against the U.S. government. Moreover, several islands and areas in both the former Soviet Union and United States are still highly radioactive fifty years later.

Box: A-bombs and H-bombs

Both A-bombs and H-bombs create their immense explosive force from the energies within the nuclei of atoms. However, they work in very different ways.

The A-bomb, or atomic bomb, uses nuclear fission. The nuclear core of a heavy atom splits into two or more smaller nuclei. In practice, these heavy atoms are usually uranium or plutonium, while the two atomic fragments are lighter metals like silver. Since the total mass of the final fragments is less than that of the original atom, this "missing mass" is released as energy. The energies are typically huge, as predicted by Einstein's famous relation $E=mc^2$ (c is a large number called the speed of light).

The H-bomb, or hydrogen bomb, instead uses nuclear fusion. Two nuclei of hydrogen, the lightest atomic element, fuse into helium, the next lightest. This helium nucleus is less massive than the total of the two original hydrogen nuclei, which again releases energy. Our Sun burns through the same nuclear reaction as an H-bomb.

H-bombs are about one hundred to one thousand times more powerful than A-bombs. This greater power is mainly because hydrogen is about two hundred times lighter than uranium or plutonium, making it easier to store. Moreover, the fusion reaction is very efficient at fusing most of the hydrogen atoms into helium, whereas the fission reaction misses many heavy nuclei. On the other hand, H-bombs are more difficult to ignite than A-bombs. An A-bomb detonator is the only practical way of exploding an H-bomb.

Box: Inventors of the H-bomb

Although American physicist Edward Teller is known as the "father of the H-bomb," the scientist Stanislaw Ulam also played an essential role. Both Teller and Ulam immigrated to the United States from Eastern Europe in the late 1930s. Teller was known as a talented atomic physicist. Meanwhile, Ulam was more mathematical in outlook.

Teller first became interested in the hydrogen bomb after a conversation with the nuclear physicist Enrico Fermi (1901-1954) in September 1941. Fermi speculated that an atomic bomb might set off a thermonuclear reaction in deuterium to create a much larger explosion. At first Teller thought it impossible, yet after some calculations became convinced by the idea. Even so, work on the device would have to wait until completion of the atomic bomb.

After tireless campaigning by Teller and the Soviet successes with the atomic bomb, President Truman gave the go-ahead for the H-bomb in early 1950. However, calculations by the mathematician Stanislaw Ulam soon showed that the original Teller design could not work. For several months the project was stuck. Finally, in early 1951 Ulam suggested that the atomic bomb detonator should compress the nuclear fuel while setting the bomb off. This Teller-Ulam design led to the first H-bomb, Mike, in 1952.