The Evolution of Nuclear Technology: Thermonuclear Weapons

Thermonuclear weapons, sometimes referred to as Hydrogen, or "H-bombs," utilize both atomic fission and nuclear fusion to create an explosion. The combination of these two processes releases massive amounts of energy, hundreds to thousands of times more powerful than an atomic bomb.

Origins

Development of the hydrogen bomb dates to the 1940s during The Manhattan Project. Edward Teller, a physicist studying nuclear fission, developed an interest in scaling up a nuclear explosion using hydrogen as fuel. He and others referred to this yet-to-be-discovered invention as the "Super," due to its unprecedented destructive potential.

Debate about the possibility, and even the morality, of the Super caused many to shift their focus toward smaller fission devices. That is, until August 1949, when the Soviet Union tested its own atomic bomb. Just six months later, newly elected President Harry S. Truman ordered the development of the hydrogen bomb.

Stanislaw Ulam, a mathematician working on the Manhattan Project, partnered with Teller to design the first hydrogen bomb. The largest theoretical hurdle for the two was figuring out how to trigger nuclear fusion before the shockwaves from the fission blast reached their secondary device. Their breakthrough occurred a little over a year into their research, and in 1951 the Teller-Ulam design was approved for testing.

The bomb (code-named "Ivy Mike,") was detonated on the island of Eniwetok Atoll in the Pacific Marshal Islands on November 1, 1952. The blast produced an equivalent of 10.4 million tons of TNT, or about 700 times more powerful than the bomb the United States dropped on Hiroshima in 1945.

How it Works

Exact designs of this type of weapon remain a state secret, but most experts believe that the bomb is set up in two stages: The primary stage, fission, triggers the secondary stage, fusion. The result is an extremely powerful, and theoretically limitless, explosion.

- **Stage 1: Nuclear Fission**

  Thermonuclear bombs rely on a primary process called nuclear fission, in which a conventional explosion triggers a chain reaction that splits the nuclei of large atoms, resulting in a nuclear explosion. For this to occur, weapons-grade fissile material — either uranium or plutonium — must reach critical mass.

  In thermonuclear weapons, an implosion bomb achieves critical mass through the inward compression of fissionable material, such as plutonium. The device is typically spherical, with the outermost shell being made up of conventional explosives. The innermost portion contains a hollow plutonium pit filled with some form of hydrogen fuel — most likely Tritium in gaseous form. As the outermost layer of the sphere explodes, heat and energy are directed toward the center using a series of explosive lenses, and the plutonium pit begins to shrink into itself. The density of the particles rapidly increases, spitting out additional free neutrons and causing a chain reaction that results in a nuclear explosion.

- **Stage 2: Nuclear Fusion**

  Nuclear fusion creates energy by combining two isotopes of hydrogen — deuterium and tritium — to create helium. When fused, the extra neutrons within the nuclei of these isotopes are released in the form of energy. A compound known as lithium deuteride, which is created by combining lithium and deuterium, is used as the fuel in modern thermonuclear weapons.

  The primary fission explosion produces high energy gamma and x-rays, which are channeled downward, and reflected toward the fusion device. The polystyrene foam that fills the inside of the devices' containment shell then melts into a plasma, and begins compressing the cylindrical casing. The outside of the casing contains a uranium tamper, meant to absorb some of the x rays to prevent an early reaction within the core. Next, a "sparkplug," usually made entirely of fissionable material, compresses and fissions, releasing outward explosive energy.

  The heat and pressure from the explosion cause the "fuel" (lithium deuteride) surrounding the sparkplug to react, releasing tritium. The tritium then fuses with the deuterium to form helium (nuclear fusion) and more neutrons. The free neutrons cause additional fission reactions, which creates more pressure on the lithium deuteride, producing more fusion reactions. The positive feedback loop between fission and fusion continues until a massive explosion occurs.