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## September 19 1957 nuclear test

The Operation Plumbbob was a large-scale nuclear testing program conducted by the US military from May 28 to October 7, 1957, at the Nevada Test Site. The series consisted of 29 tests and aimed to improve tactical weapon design, conduct bio-medical experiments, and test safety protocols. Operation Plumbbob was a series of nuclear tests conducted at the Nevada Test Site in 1957. The tests produced significant radiation exposure for civilians and servicemen, with over 3,000 exposed to high levels of radiation. A survey in 1980 found elevated rates of leukemia among these servicemen. Pascal-A was a US nuclear test designed with a small maximum energy release that could only initiate detonation at one location, adhering to the "one point safe" criterion. Although planned to be safe by current standards, the test in an underground shaft deviated from expected safety protocols due to unanticipated yield of 50,000 times greater than predicted. The actual explosion was much larger than anticipated, causing a significant radiation release despite being conducted underground. Calculations using normalization data suggest a yield of approximately 55 tons for Pascal-A. First-hand accounts from physicist Robert Campbell and astrophysicist Robert Brownlee recount the test's unexpected success, highlighting the challenges encountered during its execution. There were numerous issues during this period. The object finally fell into place, I believe it happened around ten o'clock at night. There wasn't much time to return to Mercury and go back to bed before having to try again the next morning. Someone suggested, "Why don't we just launch it now, and then head in?" And indeed, the most impressive firework was lit, as it was visible from night on. The blue flames shot hundreds of feet into the air. Everyone gathered around and jumped into their cars, rushing to leave without counting who arrived or departed the area. Of Dr. Robert Brownlee, an astrophysicist who in the summer of 1957 faced the challenge of containing a massive underground explosion, equivalent to several hundred tons of dynamite. The blast was placed at the bottom of a 500-foot vertical tunnel in the Nevada desert, sealed with a four-inch thick steel plate weighing hundreds of pounds. Brownlee expected the lid to be blown off, but not exactly how fast. High-speed cameras captured the giant manhole cover as it soared into history, with Brownlee estimating its velocity at six times the speed needed to escape Earth's gravity. This experiment, though unnamed in the article, was significant as only two shaft shots were fired before the Soviet Union launched Sputnik on October 4, 1957. The nighttime Pascal-A shot couldn't have been involved due to the absence of a fireball streaking into the heavens. However, Pascal-B, which took place in the summer, was confirmed by Dr. Robert Brownlee as the likely candidate. The feature that made Pascal-B possible was the placement of the collimator close to the nuclear device, allowing for extreme velocities when combined with the vaporization of a 2-tonne mass into a superheated gas expanding up the shaft. This turned it into a giant gun, propelling the steel plate off at high velocity. To illustrate this physics and estimate the speed, consider that if the collimator absorbed a substantial part of the explosion energy (say a third of it), it would have been heated to temperatures far higher than any conventional explosive, reaching temperatures 50 times higher. The maximum velocity achieved by an expanding gas is determined by the equation  $u = 2c/(\gamma - 1)$  where  $u$  is the final velocity,  $c$  is the speed of sound in the gas, and  $\gamma$  is the specific heat ratio of the gas. The actual speed of the steel plate was not calculated due to insufficient data. Brownlee never publicly challenged the Soviet's claim of launching Sputnik first but has expressed doubts about their achievement. The steel plate from Pascal-B was never found after being propelled into the Nevada sky, leaving behind a fascinating piece of unexplained history. The speed of sound in vaporized gases from high explosives is approximately 7 km/sec, calculated as the square root of 50 times the value of  $c$  for explosive combustion gases, which is around 1 km/sec. Using a  $\gamma$  value of 1.25 for explosives, we can estimate the velocity:  $u = 2 \cdot 7 \text{ km/sec} / (1.25 - 1) = 56 \text{ km/sec}$ . This velocity is roughly five times Earth's escape velocity of 11.2 km/sec, similar to Dr. Brownlee's calculation of six times. However, it's unlikely that an object could escape Earth's atmosphere at such a high speed without significant deceleration. Hypersonic projectiles and incoming meteors face the same problem, with objects under 8 tonnes losing their cosmic velocity in the atmosphere. Only larger objects can retain a substantial fraction of their initial velocity. The disappearance of a projectile doesn't necessarily imply a successful space launch, as even ordinary artillery shells can travel far beyond search areas. Additionally, the "Thunderwell" project, proposed but never executed, aimed to launch a spacecraft using nuclear-heated steam, involving a deep shaft filled with water and a nuclear explosive detonation at the bottom. Other projects, like Franklin Prime, tested nuclear devices, such as the XW-30 warhead, with varying yields and designs, including the UCRL TX-41 thermonuclear design. The Smoky test system was reportedly a two-stage device, utilizing a boosted primary within a thermonuclear mockup setup. This design potentially mimicked the first two stages of a full three-stage system. The secondary stage contributed to some thermonuclear yield, which was estimated at 45-50 kilotons. Dimensions for Smoky included a diameter of 50 inches and a length of 126.2 inches, weighing in at approximately 9408 pounds. The Mk-41 eventually became the highest-yielding nuclear weapon ever developed or deployed by the United States, boasting a yield of 25 megatons. It held the record for the highest yield to weight ratio among known weapons, reaching about six kilotons per kilogram. Smoky gained notoriety in the 1970s due to radiation exposure received by over three thousand servicemen participating in Desert Rock exercises near ground zero shortly after the test. This led to Congressional inquiries and epidemiological assessments of affected veterans. A 1980 study involving 3224 participants found an elevated number of leukemia cases, with ten occurrences compared to the expected base number of four for a similar unexposed population (Health Effects of Exposure to Low Levels of Ionizing Radiation: BEIR V, 1990, p. 375).