

# The Hydrogen Bomb

## Teller's Super

- **Nuclear fusion:** this is how the sun and stars must work
  - Two nuclei are combined to make a single, new nucleus
  - Nuclear fusion was known before fission
  - Only elements lighter than iron can undergo nuclear fusion and release energy
- Fission = heavy elements, fusion = light elements
- Some fusion reactions are more likely than others, hydrogen is the easiest, deuterium and tritium is even easier
- Individual fission reactions are >10x more powerful than individual fusion reactions but fusion atoms (hydrogen) are smaller, so there are more per unit of mass
  - 1 kg of fissioning = ~18kt
  - 1 kg of fusioning = ~50 kt
- You can put as much fusion fuel together as you want without risk of premature explosion (unlike fissile material). You will not hit a critical mass, unlike fissioning. You can make a bomb as big as you want!
- **Fission review:** nuclear fission - two very positive nuclei suddenly find themselves next to each other, repel violently
- **Fusion:** trying to force two light atoms close enough together to overcome the electrostatic repulsion, so that the nuclear force can kick in
- **Why does fusion release energy anyway?** Why push two things together to release energy? 1. If they are confined in a bottle, the odds that they will smack each other, it will occur. 2. This makes them very unstable because they are smashed together. This nucleus has too much energy in it. 3. The nuclei ejects it all with a bang.

## Edward Teller (1908-2003)

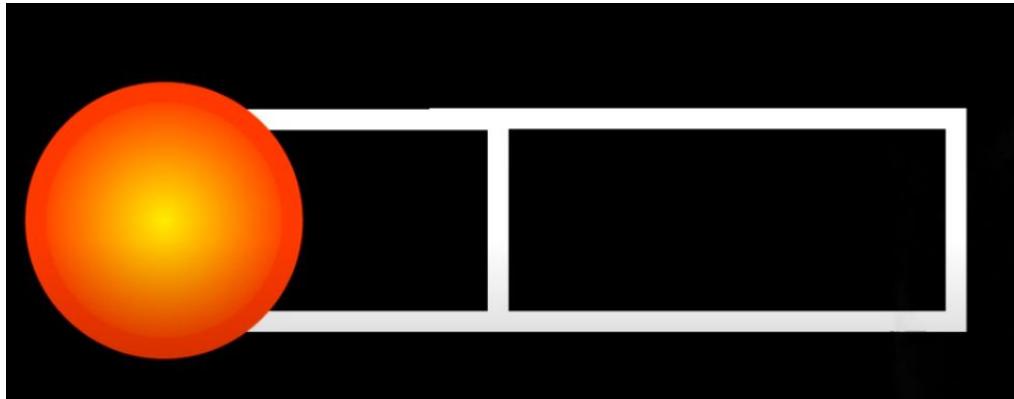
- Misunderstood, "bad" guy
- Hungarian martians. Theoretical physicist.
- Anti-Nazi, pro-US, anti-communist
- Gets very involved in weapon development. Finds it to be a stimulating experience.
- Almost every one of Teller's ideas was bad, but he had a few good one.
- Missing a foot, strong accent, model for Dr. Strangelove story

## The idea of the H-bomb

- Late 1941: Enrico Fermi and Edward Teller - fission ignites fusion - the "Super"
- Initial estimates on Super's explosive yield: 10-100 million tons of TNT (Nagasaki = 20 thousand tons of TNT)
- Teller fixated: Oppenheimer allows to work on Super during WWII, but seen as a future problem.
- He won't do his job, he is fixated on the Super. Oppenheimer lets him work on it.
- Reassigned his work to Fuchs

- During the war, very little progress on Super made: much basic information about fusion reactions still not known and much basic information about fission bombs not known. Super is considered one of the major reasons for international control but it is kept secret from the public. Not mentioned in the Smyth Report.
- Independently proposed by 5 people during the war (fusion).

### **“Runaway Super”/“Classical Super”**



- Conditions starting at one end will spread to the other end (hence, runaway)
- The appeal is that it is easy and you can make it as long as you want

### **Postwar Work**

- During post war, not much progress made: working on producing more and better fission bombs
- Manhattan Project remnants in disarray
- Computers are not powerful enough to do SUper calculations
- Still not a lot known about fission bomb energy/radiation output
- Some super work, but on the back burner so Teller is unhappy

### **The H-bomb debate**

- 1949: Joe-1 is set off. The detonation of the soviet atomic bomb drives the new discourse on the H-bomb
- What do we do to show the Soviets that we are more powerful than them
- What are we going to do to reassure our allies?
- **Post “Joe-1” resurgence of interest:** Teller leads the call for making a crash H-bomb program the US “Response” to Soviet test
- H-bomb would be a “quantum leap” in weapons technology - qualitative advantage
- Other scientists enlisted included Ernest Lawrence of UC Berkeley
- Major supporter is AEC Commissioner **Lewis Strauss**
- All lobby JCAE, USAF, to support secret program - not a public call
- The idea of the h-bomb is still secret
- Strong opposition to the idea by some scientists and administrators though
- Most prominent Robert Oppenheimer, David Lilienthal also opposes
- Opponents cite many reasons not to do it: technical arguments (don’t know how to do it), strategic (dangerous to US), moral (weapon of genocide) - no military target that large
- GAC report, October 1949, recommends against crash program
- General Advisory Committee to the AEC: Oppenheimer is the head of it, he was a chain smoker

### Kilotons vs. Megatons

- Fat man - 20 kilotons
- Ivy mike - 10 megatons
- How does the morality change if the explosive go up
- "Staten Island, who even cares"
- a 10 megaton nuclear weapon would just destroy the NYC area, all 5 boroughs, etc.
- These create nuclear fallout.
- With one bomb, have Chernobyl like contamination

### H-Bomb debate goes Public

- Until Nov 1949, debate is only between people with secret clearances in government
- Debate some issues on talk shows: "Is there too much secrecy in the atomic thing?" He said that it was not secret enough. He did this on live television. If you let the scientists talk, then they would be talking about this secret weapon they are making
- Pro-H-bomb JCAE member leaks on television game show, picked up by national columnists
- Debate is now public, most scientist lobby groups against crash program
- Public opinion is in favor of the crash program

### Truman and the H-bomb

- Truman does not know A-bombs from h-bombs; does not seem to care
- But once the debate is public, feels his hand is forced
- Demands that government scientists stop talking about the h-bomb at all (gag order)
- Asks national security council for their recommendation to build and majority of NSC says to build it
- Truman decides that h-bomb should be built for security pending an atomic pact.

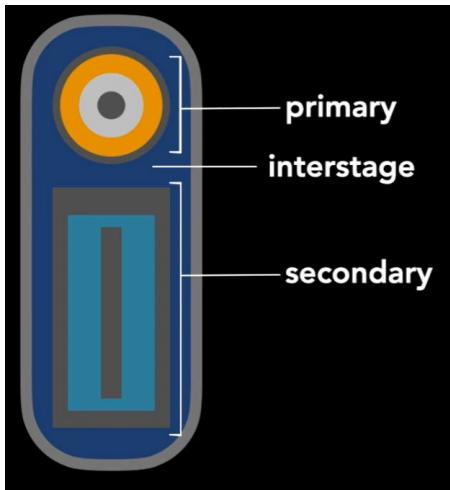
### Two days later:

- feb 2 1950: scotland yard announces that Klaus Fuchs has confessed to being a Soviet Spy (Truman got no heads up about this)
- Caught by top secret Venona program: decoding old soviet communications
- Us authorities caught off guard

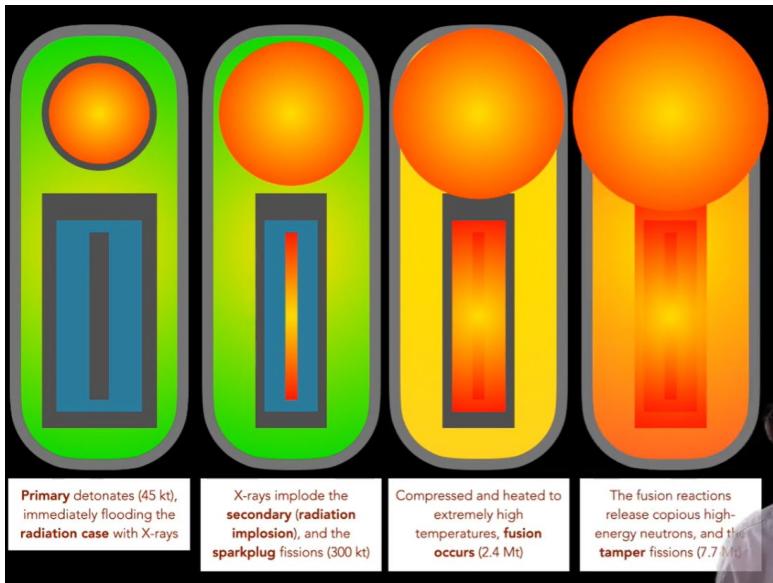
### The Teller-Ulam Design

- **The "Crash Program":** teller and los alamos feel pressure for h-bomb crash program
- But how to do it? Nobody knows
- Computer simulations finally, conclusively show in 1950 that Runaway super will not work
- This design does not work so they are back to square one
- In early 1951: Polish mathematician **Stanislaw Ulam** has a breakthrough: **bomb in a box**
- Teller extends: **radiation implosion**
- They call this the equilibrium super but better known as the Teller-Ulam design. Fuchs gives information only goes up to 1947-1948.
- *Basic idea:* instead of putting the atomic bomb right next to the fusion fuel, keep them separate (staging) but put them in a heavy box (radiation case)
- The radiation energy of the atomic bomb will fill the box and compress the fusion capsule = radiation implosion

- By pre-compressing the fusion fuel with radiation before heating it, it creates the conditions for fusion reactions



- Radiation case is around the whole thing above^
- The blue in the secondary is the fusion fuel (DD or LiD), pure deuterium at first, later they make it liquid. The thin rod is a sparkplug (made of Pu). The whole fusion fuel is surrounded by a tamper (U-238) -> the other thing it is going to fission the uranium in the tamper



- **Teller-Ulam paper 1951:** Talks about their general scheme and making the fusion fission secondary assembly. This paper changes the mind of a lot of people. Many people were convinced that this would work
- **Operation Greenhouse, Shot George: May 1951:** They tested a cylinder, 2D exploding device. Confirms radiation implosion can work, ends up being a very powerful explosion
- **Operation Ivy, Shot Mike: Nov 1952:** The sausage (the big cylinder), very large weapon, meant to just be a test; Not a weapon easily dropped out of a plane. You need a plane that is also a refrigerator
- You can generate lightning with nuclear weapons :O

- They destroyed the entire island

### **Implications of the h-bomb**

- Total destruction of nations now very feasible - maybe even civilization?
- You can make the bomb as big as you want
- You can destroy entire nations
- High-yields compensate for poor accuracy of rockets - ICBMs now seen as feasible
- New frontier of weapon design open - solid fuel, miniaturization to be studied next
- Those who long supported h-bomb work seen as vindicated, those who opposed it, suspicious
- But US does not announce test success for several years