Combustion & Explosions

Combustion

Two types of combustion, classified by their speed:

Deflagration

Rate of combustion slower than the speed of sound.

Most combustion is deflagration.

Candle

Firecracker

Detonation

Rate of combustion is faster than the speed of sound.

Only with high explosives.

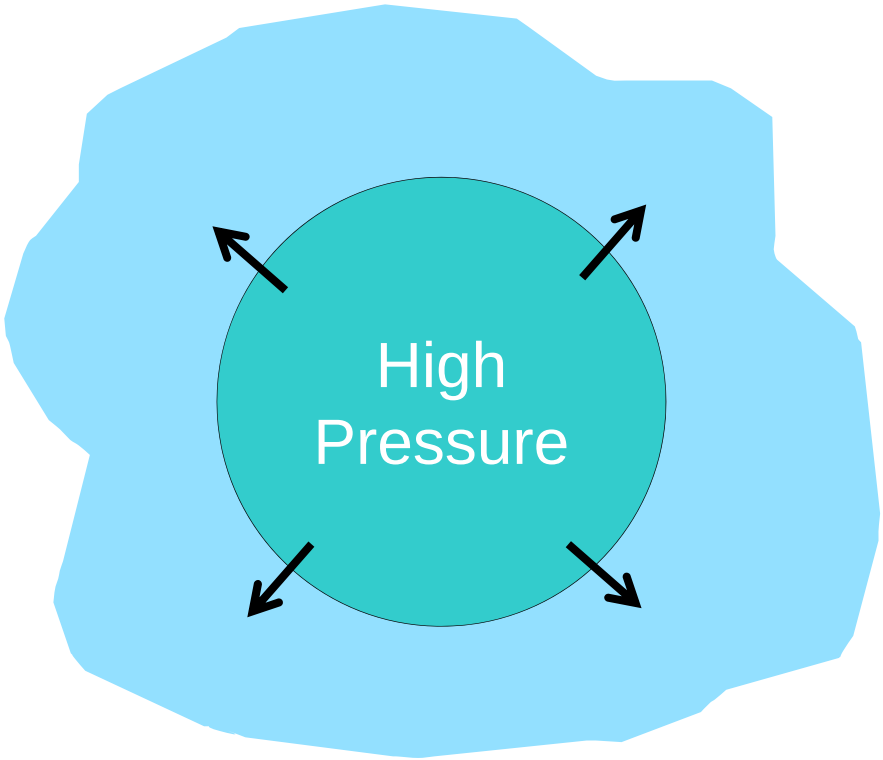
Dynamite

Atomic Bomb

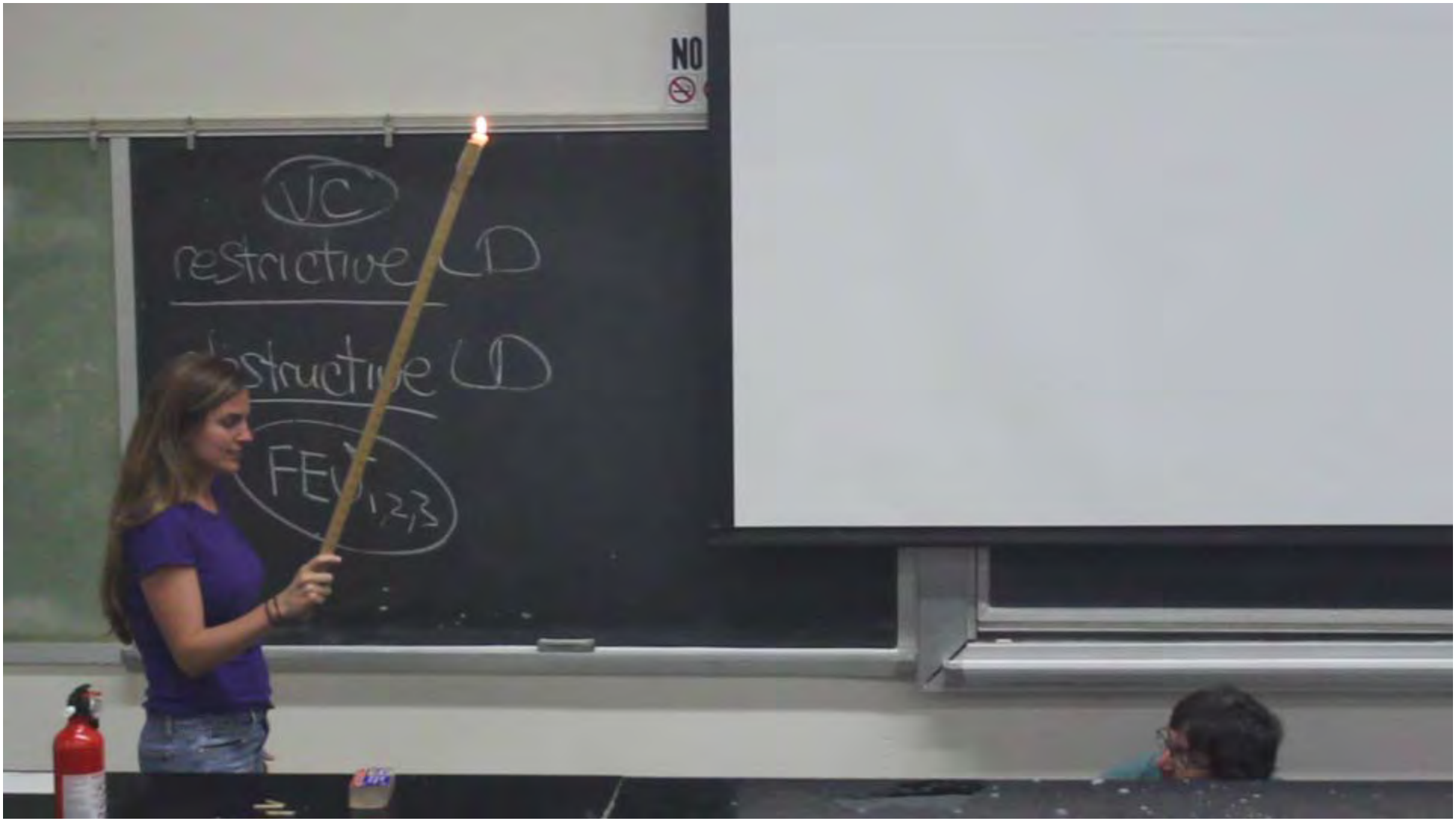
Propane Foam Combustion

Explosions and Waves

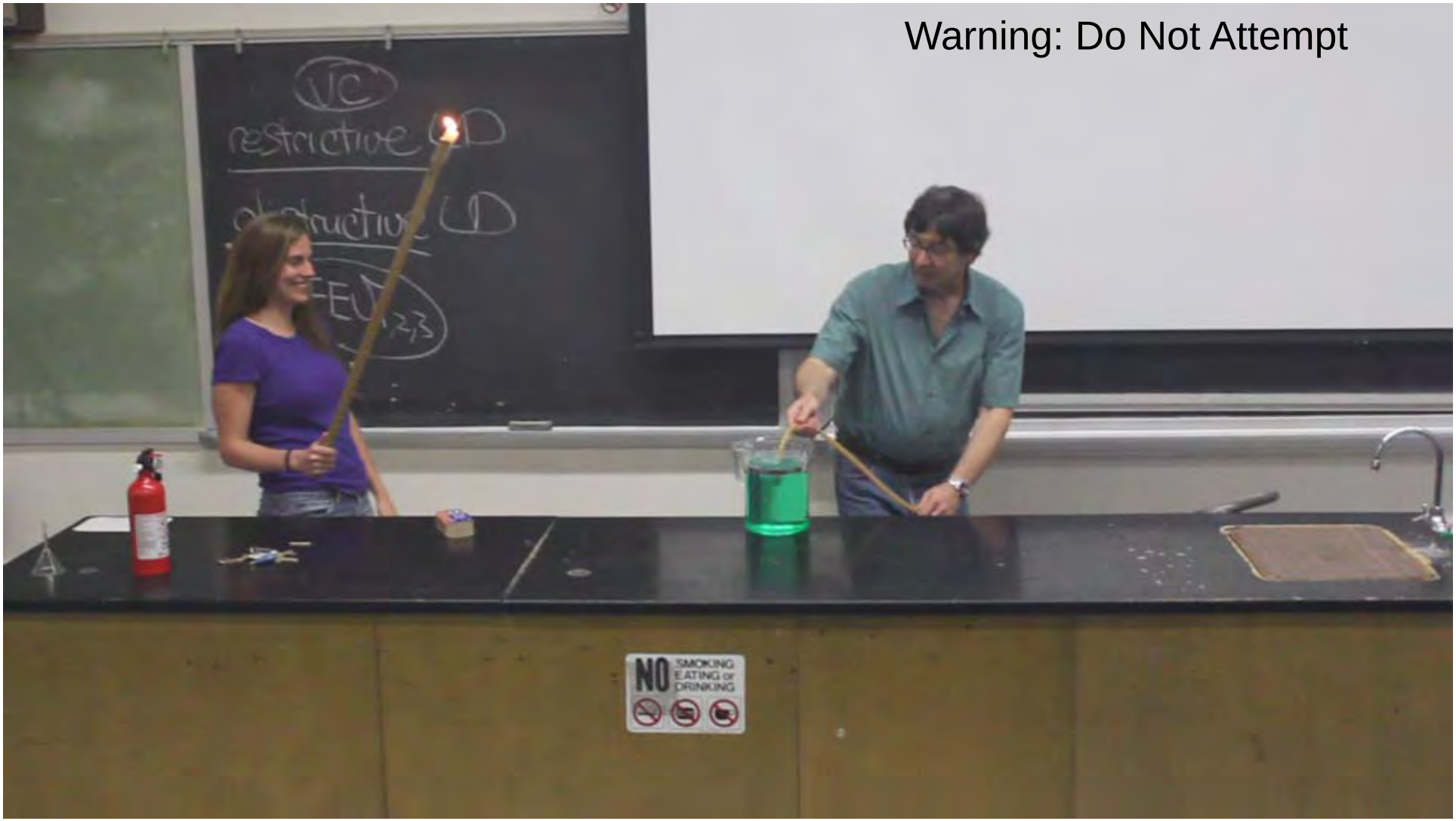
Explosions produce pressure waves due to differences in pressure



Hydrogen Bubbles

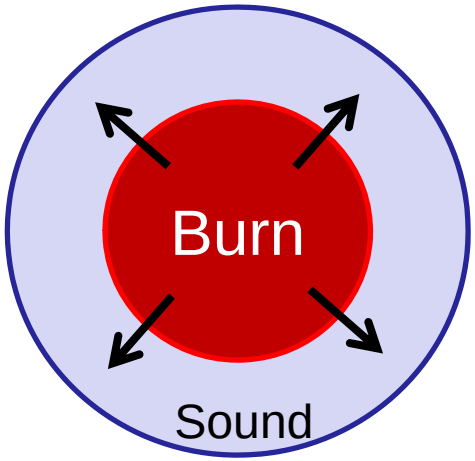


Hydrogen Foam Combustion

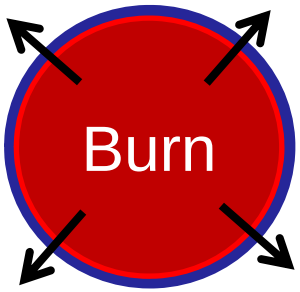


Combustion Waves

<u>Deflagration wave</u>
Sound of the explosion may be loud but is *not* a shock wave.



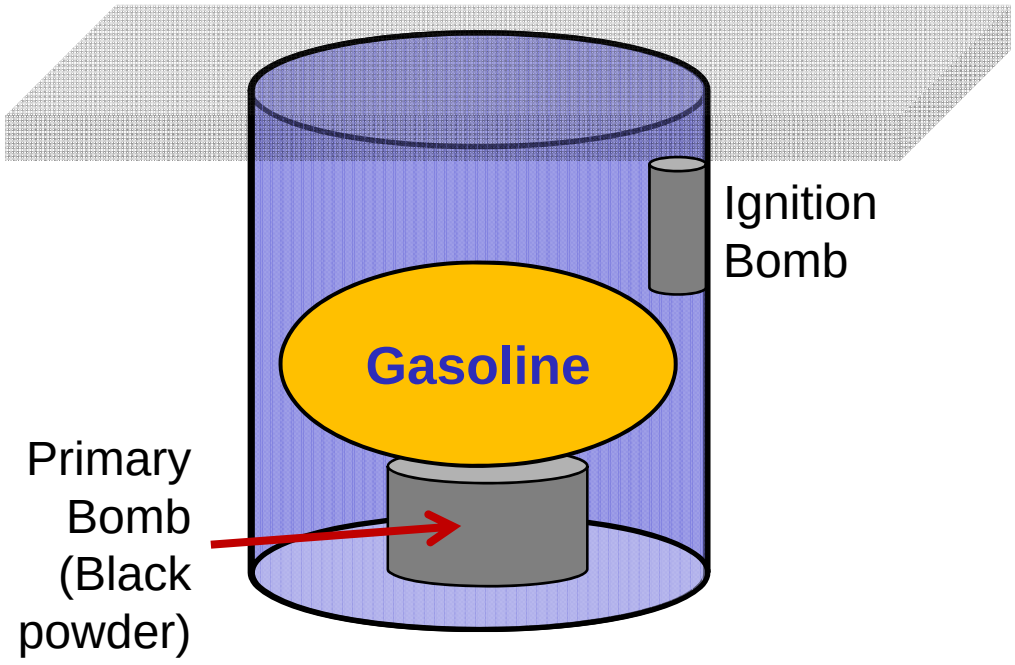
<u>Detonation wave</u>
Dangerous shock wave is produced by the blast



Trinity Atomic Test

Live-Action Pyrotechnics

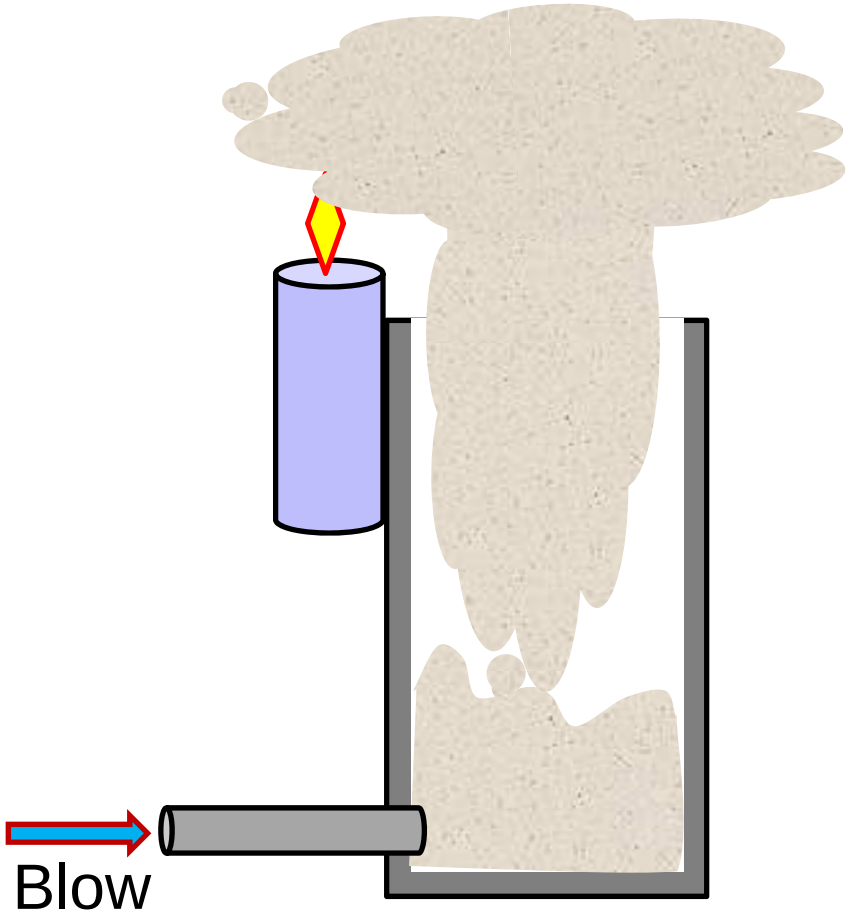
Explosions in movies are commonly produced by blasting a balloon of gasoline into the air with one bomb and igniting the vapor with a secondary bomb.



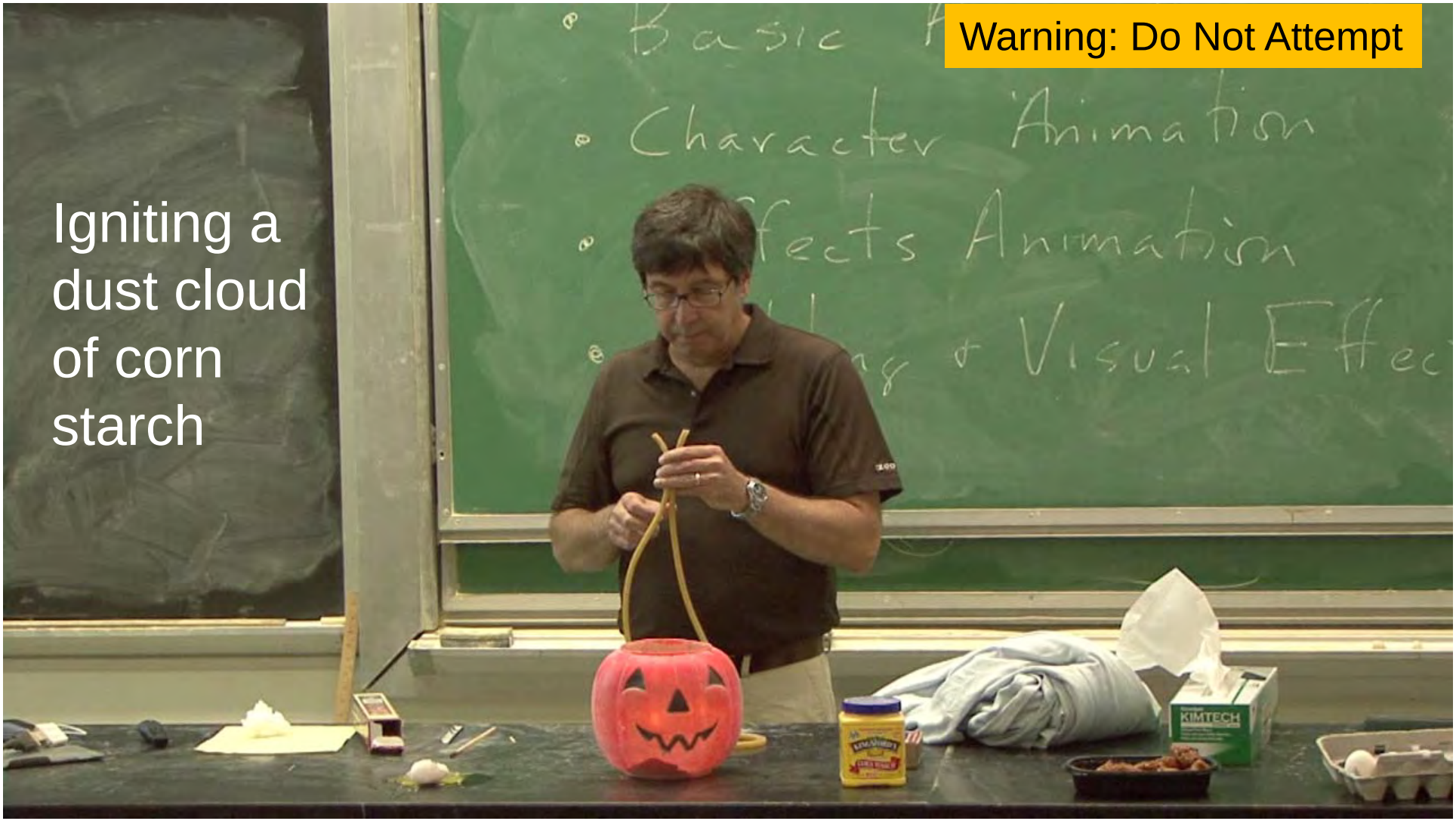
Dust Explosion

Cloud of cornstarch combusts rapidly due to the large amount of oxygen available to each grain.

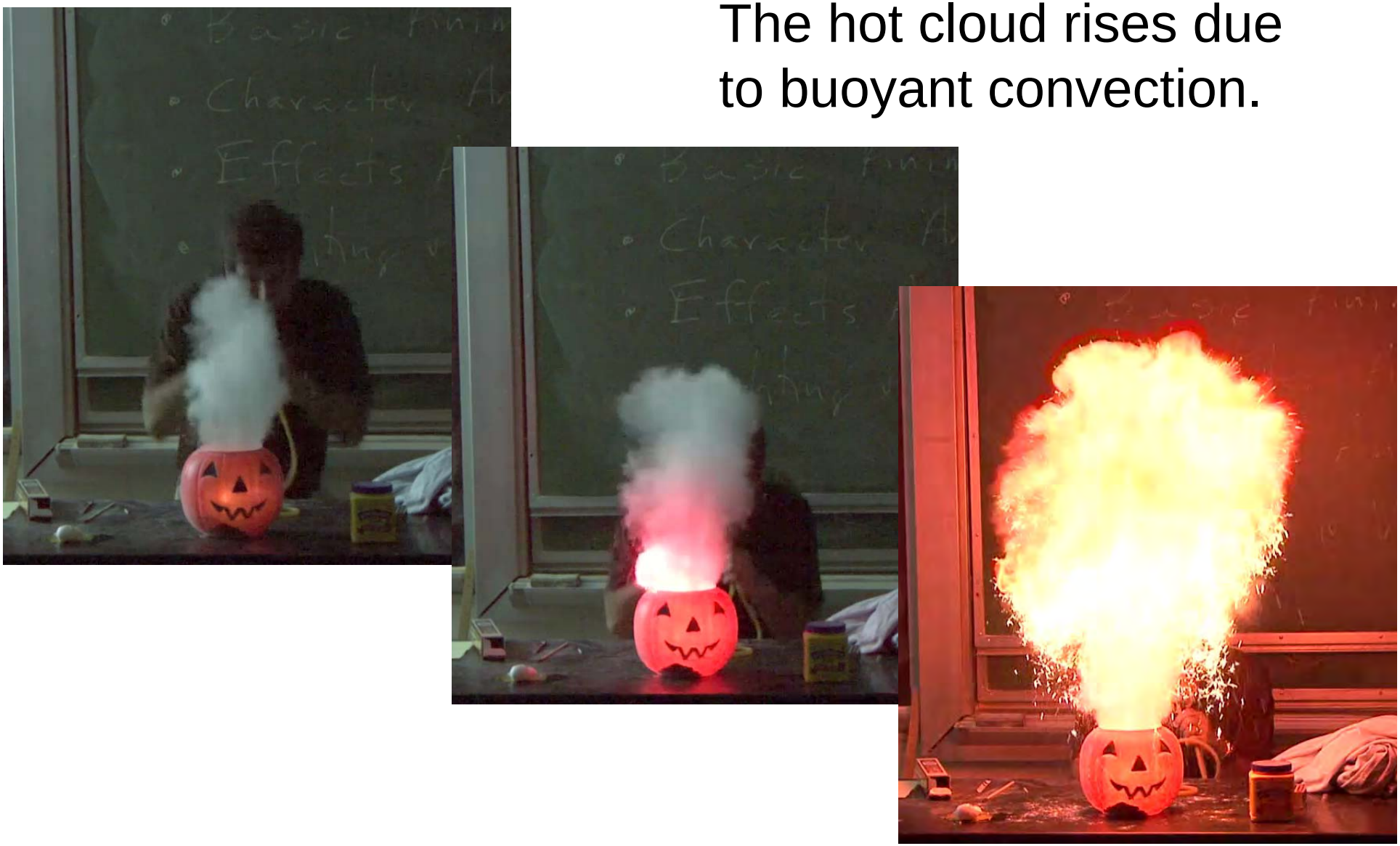
Example of a rapid deflagration.



Dust Explosion



Dust Explosion



The hot cloud rises due to buoyant convection.

Dust Explosions

Grain silo explosion

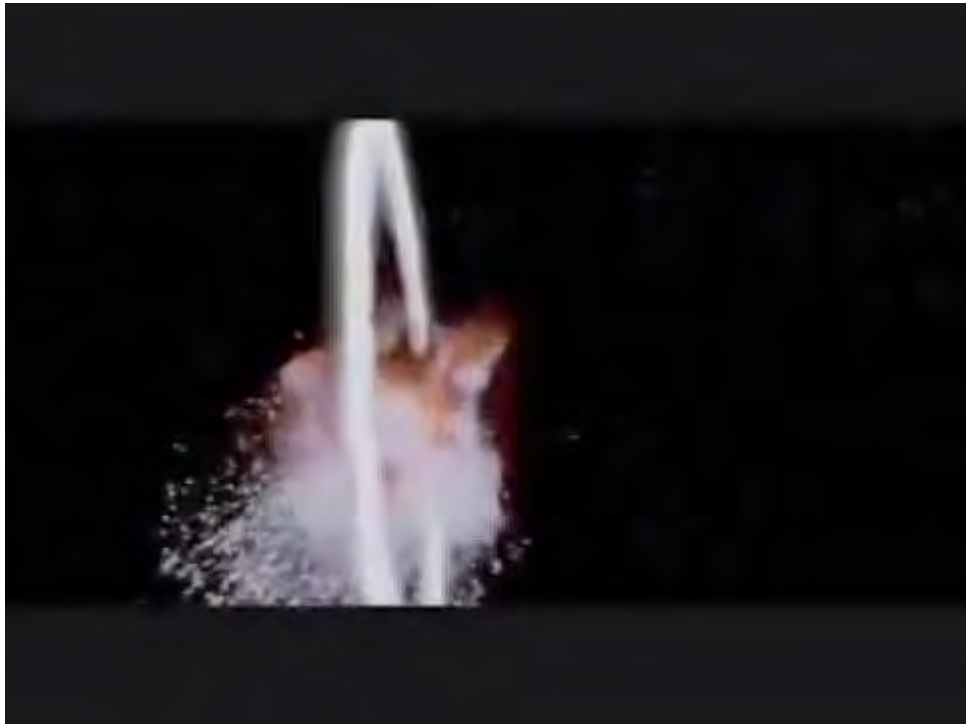
Coal dust explosion

Explosions in Space

Star Wars (1977)

Camera is on the floor, looking up at the explosion

There's no buoyancy in space so explosions expand but don't rise.



http://www.youtube.com/watch?v=z2jPCQbl0Lc

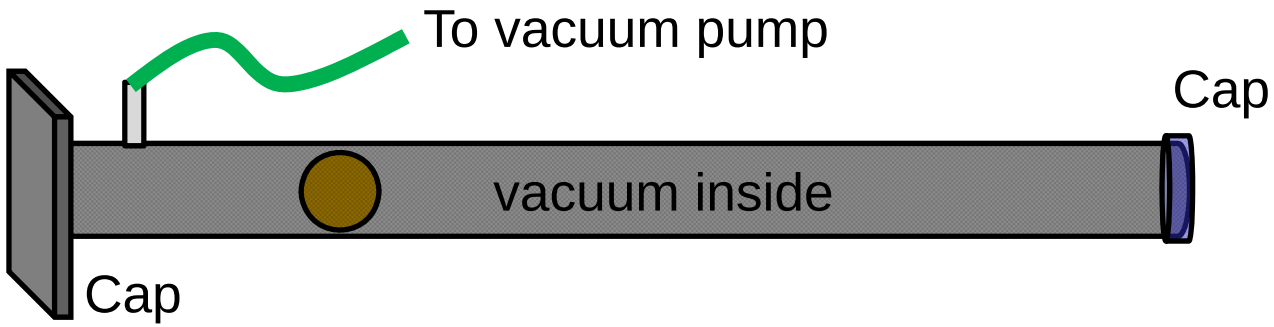
Blast Waves

High explosive detonations produce blast waves, invisible, high pressure shock waves that travels faster than the speed of sound.

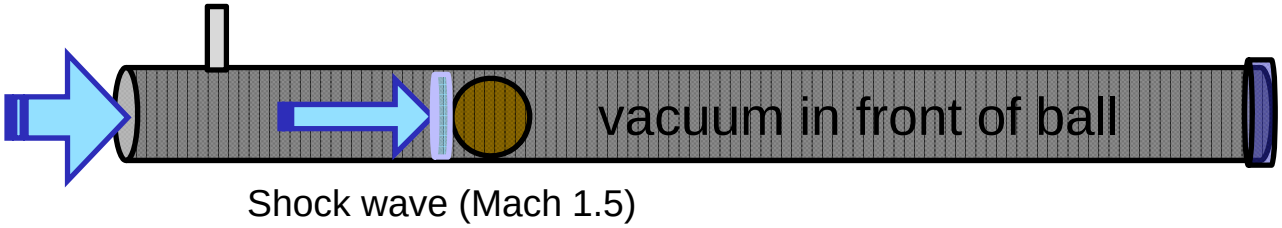
Detonation of a 500-ton TNT explosive charge produces a blast wave that churns the water near the ship.

Shock Tube Cannon

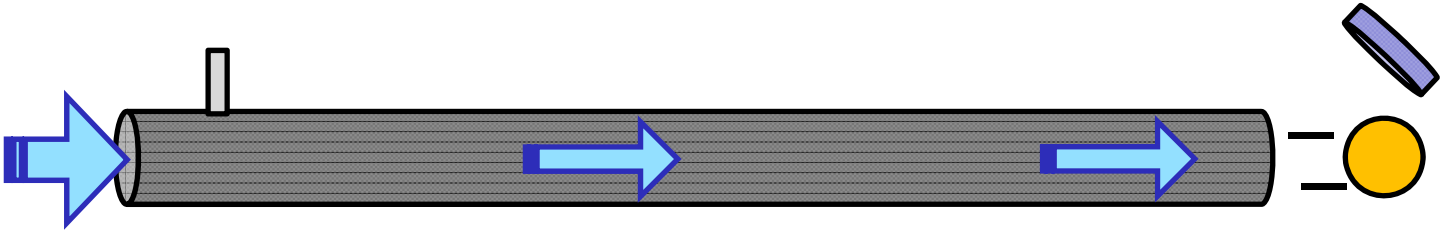
Seal the tube and remove the air inside



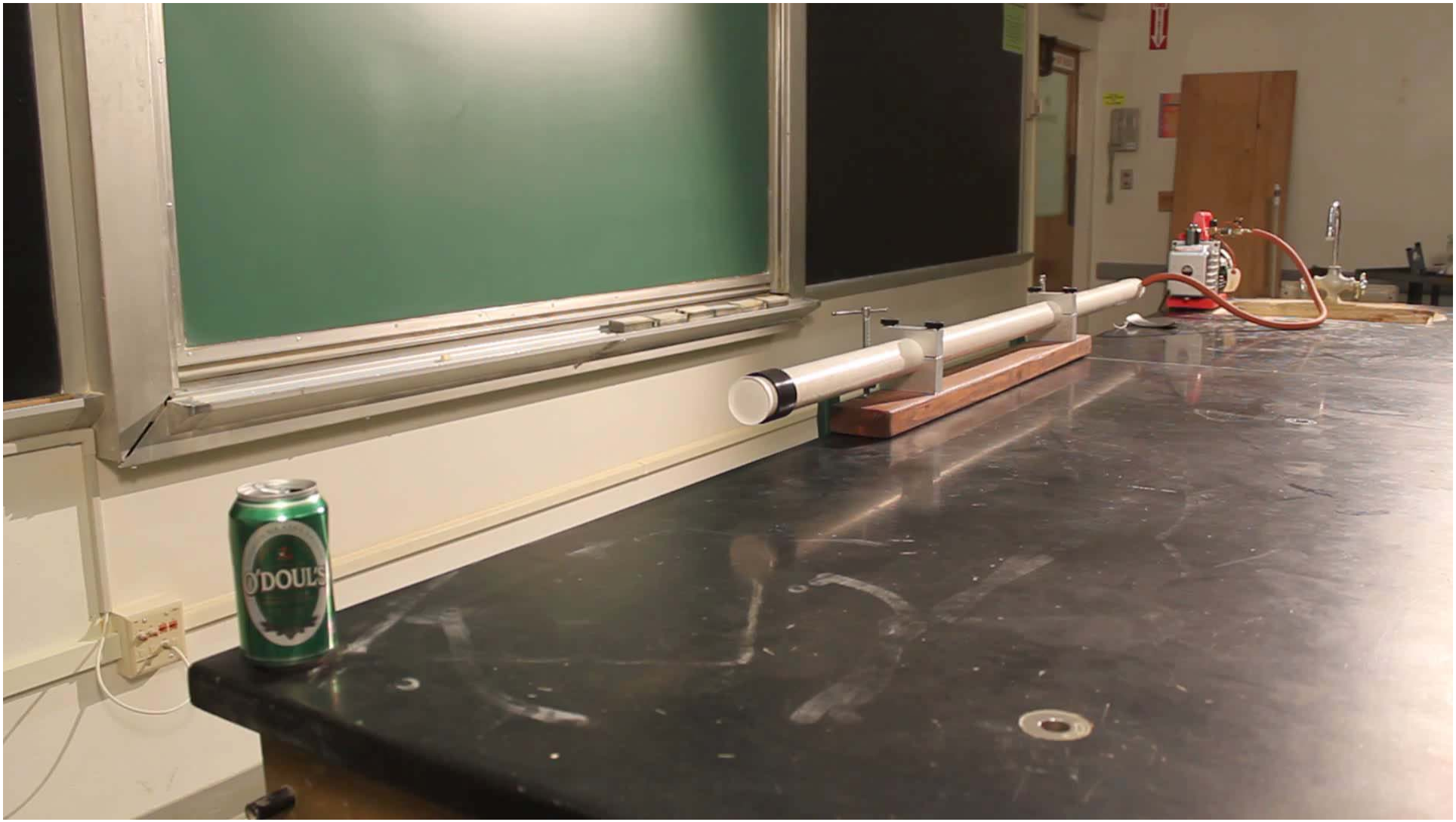
Open one end; air rushing in forms a shock wave behind the ball



Ball is fired at high speed



Shock Tube Cannon



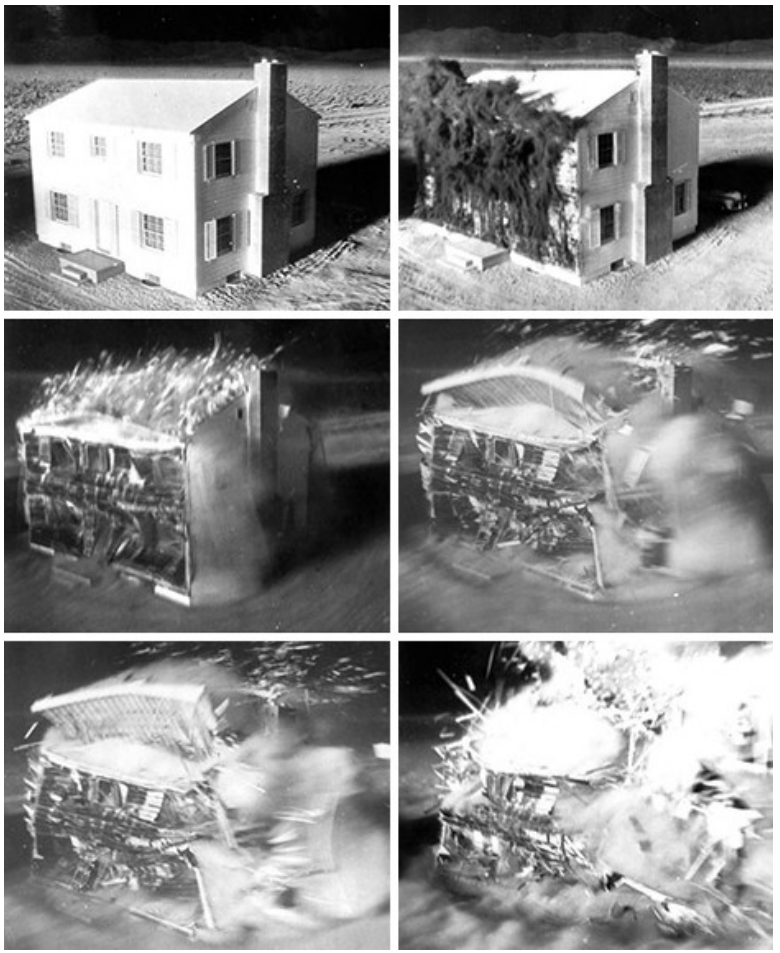
Shock Tube Cannon

Nuclear Blast

Light from the blast sets houses on fire even before the blast wave hits.

Intense force due to the high pressure shock wave.

Even after the blast wave passes there is a strong wind, causing further destruction.

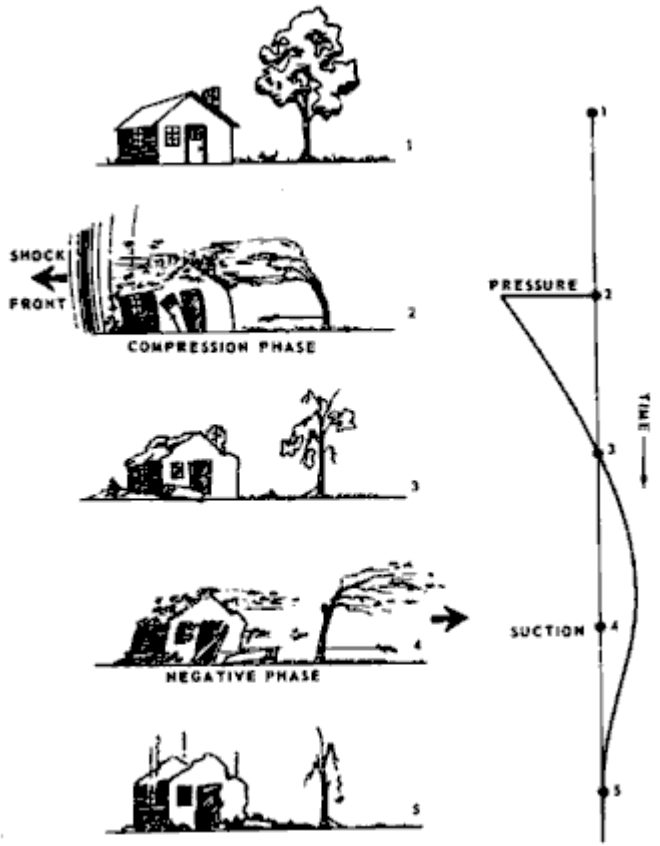


Operation Upshot-Knothole (1953)

“Survival Town”

Notice how the pressure first jumps as the blast wave hits then reverses and causes a back pressure suction.

Operation Teapot; Apple-2 Test (1955)
29 Kiloton yield



Indiana Jones and the Kingdom of the Crystal Skull (2008)

Indiana Jones (implausibly) escapes the "Survival Town" nuclear blast by hiding inside a refrigerator.

Summary

- There are two types of combustion: deflagration and detonation
- Deflagration is slow combustion, such as flames, fires and gasoline explosions.
- Detonation is rapid combustion, such as high explosives and atomic blasts.
- Large deflagrations used in special effects are often dust or vapor explosions.
- Detonation explosions produce dangerous high-pressure blast waves.