IN SITU COMBUSTION
or "Fireflooding"

This method is sometimes applied to reservoirs containing oil too viscous or "heavy" to be produced by conventional means. Burning some of the oil in situ (in place), creates a combustion zone that moves through the formation toward production wells, providing a steam drive and an intense gas drive for the recovery of oil.

This process is sometimes started by lowering a heater or ignitor into an injection well. Air is then injected down the well, and the heater is operated until ignition is accomplished. After heating the surrounding rock, the heater is withdrawn, but air injection is continued to maintain the advancing combustion front. Water is sometimes injected simultaneously or alternately with air, creating steam which contributes to better heat utilization and reduced air requirements.

Many interactions occur in this process, but the accompanying drawing shows the essential elements. The numbered statements below correspond to numbers on the drawing.

1. This zone is burned out as the combustion front advances.
2. Any water formed or injected will turn to steam in this zone because of residual heat. This steam flows on into the unburned area of the formation, helping to heat it.
3. This shows the combustion zone which advances through the formation.
4. High temperature just ahead of the combustion zone causes lighter fractions of the oil to vaporize, leaving a heavy deposit of residual coke or carbon as fuel for the advancing combustion front.
5. A vaporizing zone that contains combustion products, vaporized light hydrocarbons, and steam.
6. In this zone, owing to its distance from the combustion front, cooling causes light hydrocarbons to condense and steam to revert back to hot water. This action displaces oil, condensed steam thins the oil, and combustion gases aid in driving the oil to production wells.
7. In this zone, an oil bank (an accumulation of displaced oil) is formed. It contains oil, water, and combustion gases.
8. The oil bank will grow cooler as it moves toward production wells, and temperatures will drop to that near initial reservoir temperature.

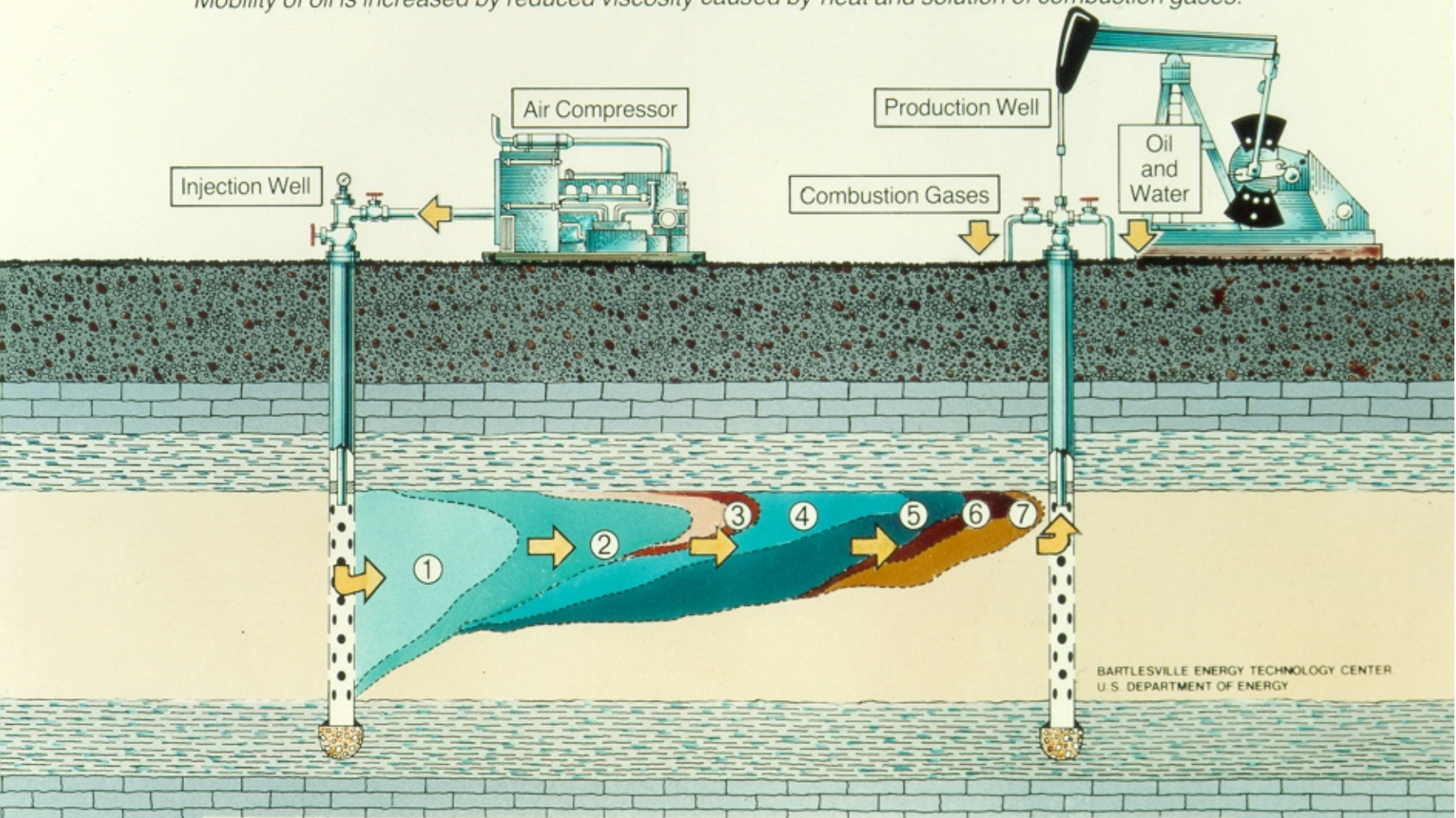
When the oil bank reaches the production wells, the oil, water, and gases will be brought to the surface and separated - the oil to be sold and the water and gases sometimes reinjected. The process will be terminated by stopping air injection when predesignated areas are burned out or the burning front reaches production wells.

Notice in the accompanying illustration that the lighter steam vapors and combustion gases tend to rise into the upper portion of the producing zone, lessening the effectiveness of this method. Injection of water alternately or simultaneously with air can lessen the detrimental overriding effect.

IN-SITU COMBUSTION

Heat is used to thin the oil and permit it to flow more easily toward production wells. In a fireflood, the formation is ignited, and by continued injection of air, a fire front is advanced through the reservoir.

Mobility of oil is increased by reduced viscosity caused by heat and solution of combustion gases.



1. Injected Air and Water Zone (Burned Out)
2. Air and Vaporized Water Zone
3. Burning Front and Combustion Zone (600° - 1200°F)
4. Steam or Vaporizing Zone (Approx. 400°F)
5. Condensing or Hot Water Zone (50° - 200°F Above Initial Temperature)
6. Oil Bank (Near Initial Temperature)
7. Cold Combustion Gases