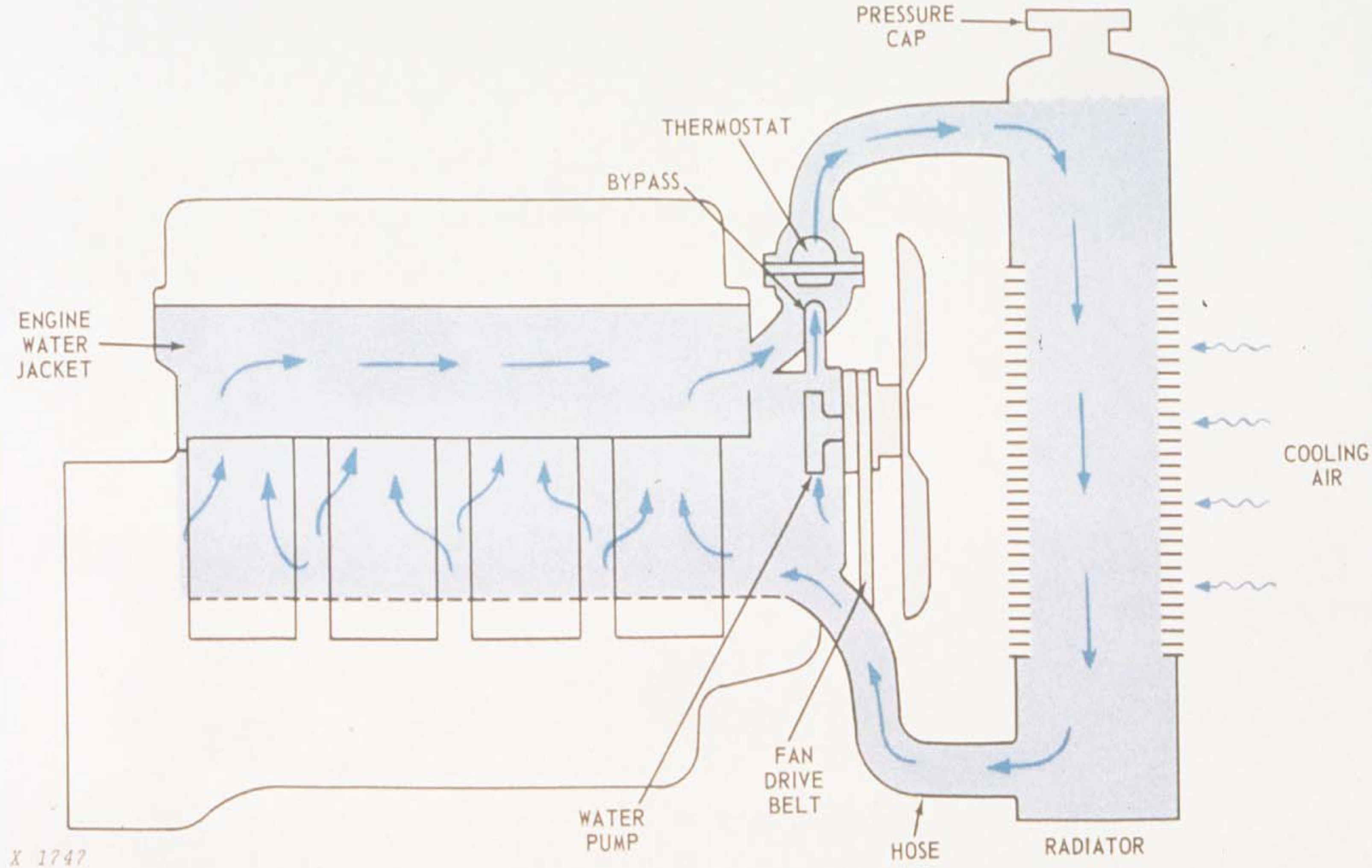

Fig. 1 — Liquid Cooling System

Cooling Systems

- Prevent Overheating:
  - Excess Heat generated in engine
  - Peak temperatures exceed melting point of metal
  - Cooling removes excess heat

- Regulate Temperature
  - Regulate Temperature
  - Allow engine to warm up in cool weather
  - Cold engine less efficient
  - Cold engine allow corrosive compounds to form
  - Maintain engine in optimum range.

Consequence of engine running to hot:

- Pre-ignition
- Detonation
- Knock
  - All result in very high pressure rise and possible damage to engine

- Heat Fatigue of components
  - Burnt Pistons
  - Burnt Valves
    - »
- Failure of lubrication system
  - Oil breakdown
  - Oil film at cylinder destroyed at 200C
    - Scoring of piston & sleeves
- Warping & fracture of components

Consequence of engine running to cold:

- Unnecessary Wear
- Poor Fuel Economy
  - Incomplete Combustion
  - Lower coolant Temperature
    - More energy transferred out of cylinder
    - Energy from is wasted & not available for work (Power)
- Promotes corrosive conditions in engine
  - Water of combustion reacts with sulfur oxides in exhaust
    - Forms acids
  - Allows water & sludge to accumulate in crankcase
  - Over time, fuel diluting the oil will accumulate
    - Normally lighter volatile fuel will evaporate as temp. rises

Cooling Systems

- **AIR COOLING SYSTEMS**
  - Use air to dissipate heat directly.
  - Transfer of heat to air more difficult.
    - Require fins and baffles to increase surface area
    - Fans used in large engines to blow air around engine
  - Used in small engines and some large engines
  - More Difficult to control temperature
  - Most vehicles are water-cooled

- **LIQUID COOLING SYSTEMS**
  - **Liquid cools engine, air cools the liquid**
  - **Engine heat absorbed by liquid**
  - **Liquid travels to radiator**
    - Airflow through radiator cools liquid

Cooling Systems

- **OPEN-JACKET SYSTEM**
  - No pump
  - Water open to air, not pressurized
  - Evaporation cools water
  - Convection draws cool water in bottom
  - Hot water rise through engine to outlet
-
- **THERMOSIPHON**
  - No pump
  - Close cooling system
  - Cool water enters bottom of engine
    - Water heats up, small vapor bubbles, density decreases
    - Less dense hot water rises
    - Colder water entering bottom forces hot water in radiator
  - Fan pulls air through radiator

Cooling Systems

- MODERN COOLING SYSTEM Similar to thermo siphon but pump added for positive circulation. Thermo siphon is still present in modern systems but not major factor.
  - Radiator
    - Heat exchanger to air
    - Coolant reservoir
  - Fan
    - Forces air through radiator
    - Fan requires energy
      - Belt driven, direct to engine (Continuous Energy use)
        - » Stationary, slow vehicles under constant load
      - Belt driven, thermostatically controlled clutch
        - » Many larger engines
      - Electric Motor, thermostatically controlled clutch
        - » High speed vehicles, normally no fan needed
        - » Many cars, fan only runs when car stationary
  - Water pump
    - Centrifugal pump circulates water through engine & radiator
    - Draws cool water from bottom of radiator, into engine
  - Thermostat
    - Temperature controlled valve (more later)
  - Coolant
    - Antifreeze
      - Prevents freezing in winter
      - Helps prevent overheating in summer
      - Anti-corrosion

Radiators

- RADIATOR
  - Cellular type core
  - Tubular, Tube and Fin type
- Pressurization
  - Increase boiling pinot temperature
  - 1^{o}C for each 4 kPa increase in pressure
- Operation of Pressure control Radiator Cap
  - Prevent coolant loss under normal temperatures
  - Pressure relief into overflow chamber at high temp & pressure
  - Vacuum valve when liquid cools, allow air into radiator
    - Suck in liquid from overflow chamber
  - Check cap for excessive pressure and vacuum

- **WARNING: OPEN CAP ON HOT ENGINE OPEN SLOWLY, CARFULLY WITH LARGE THICK CLOTH**

- FANS
  - Suction Type
    - Smaller, high speed vehicles
  - Blower Type
    - Slow moving, dirty environment
  - Shrouds
    - Improve airflow

RADIATORS

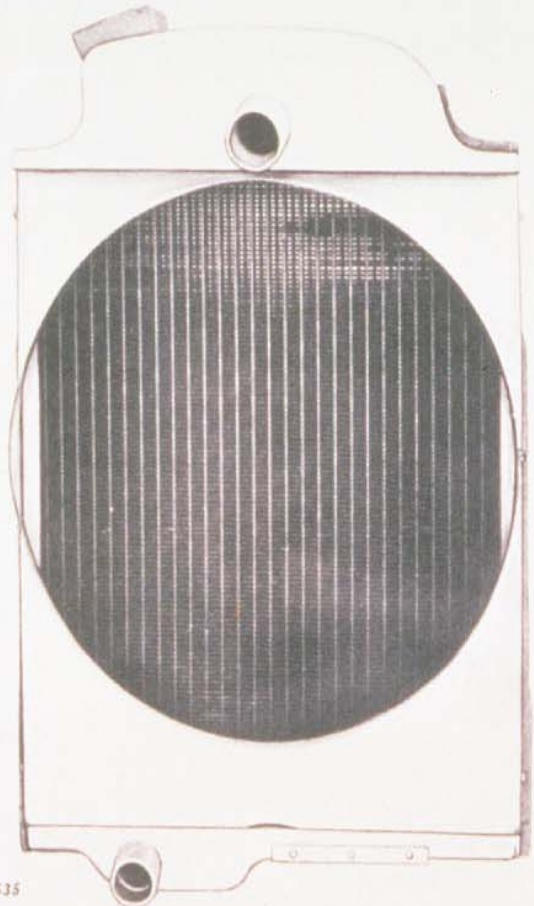

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Fig. 2 — Typical Radiator

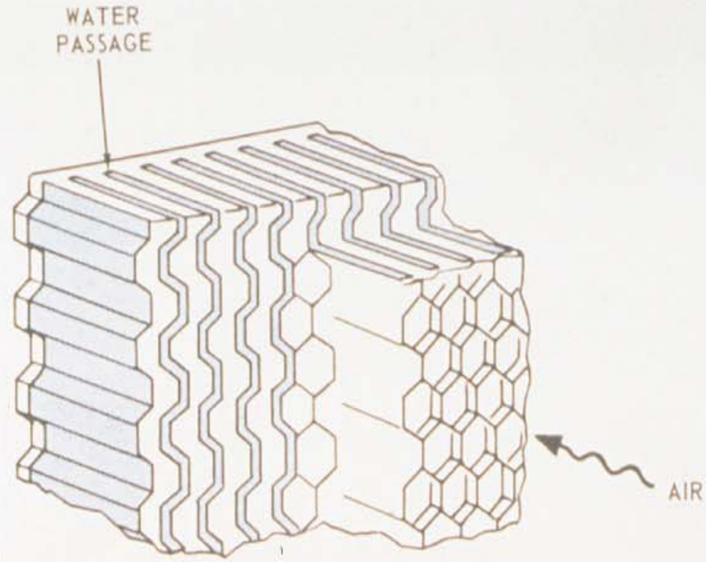

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Fig. 3 — Cellular-Type Core Radiator

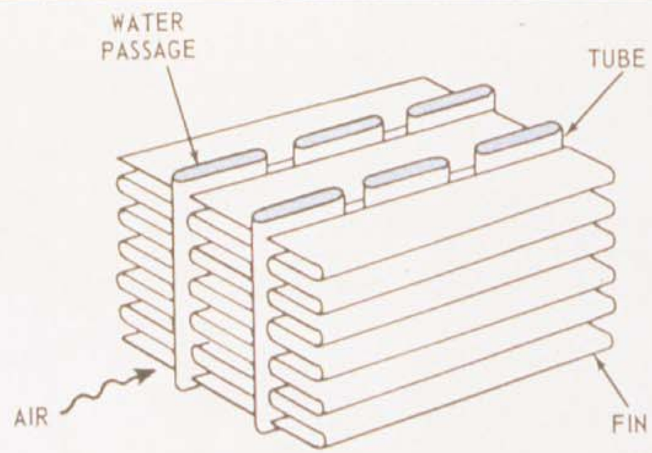

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Fig. 4 — Tube and Fin-Type Core Radiator

RADIATOR CAP

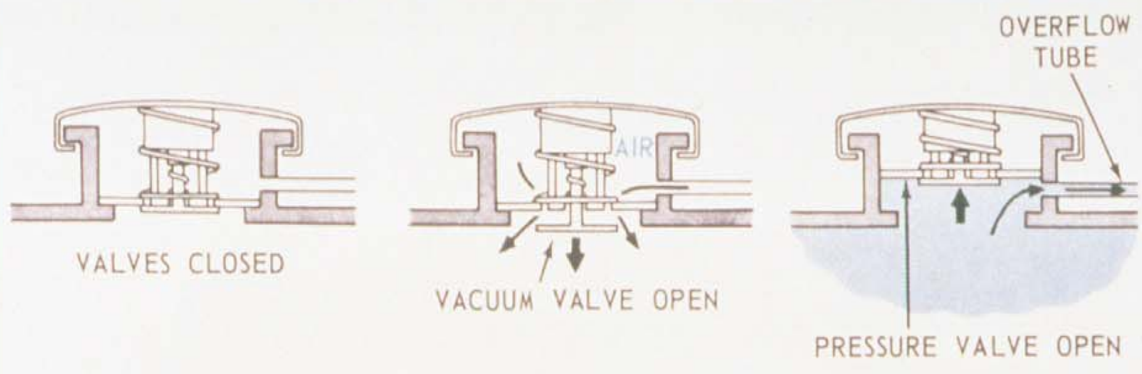

Fig. 7 — Pressure Control Radiator Cap

TESTING THE RADIATOR CAP

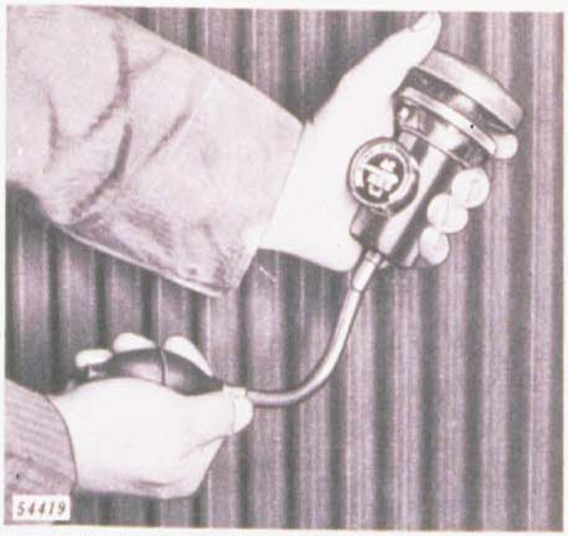

Fig. 8 — Testing The Radiator Cap

THERMOSTATS

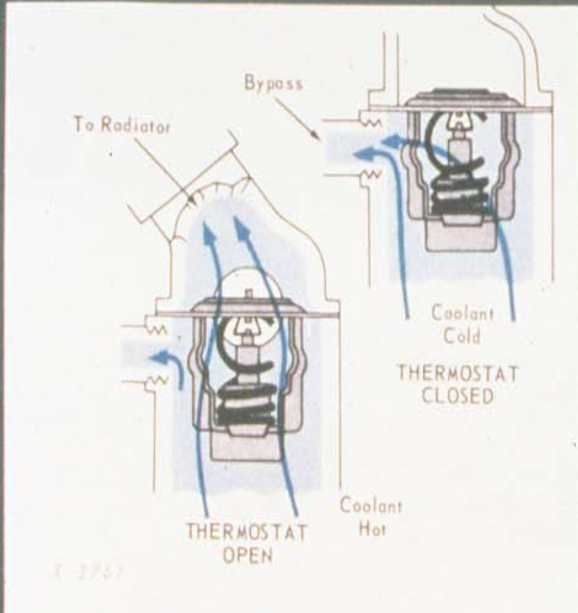

Fig. 14 — Cooling System Thermostat

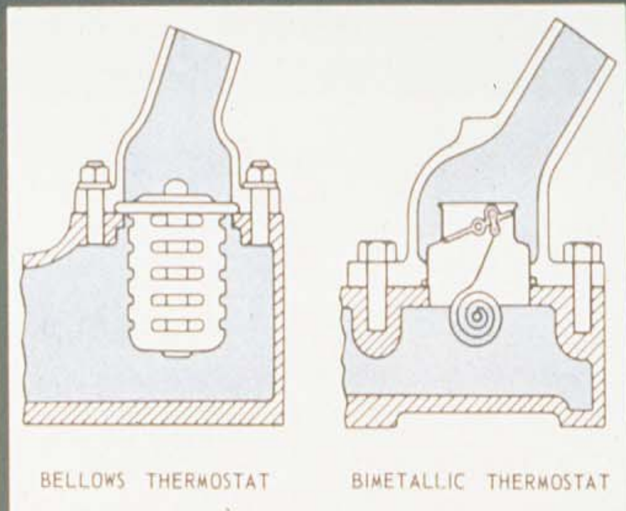

Fig. 15 — Types of Thermostats

Fig. 16 — Testing A Thermostat