DOUBLE ACTING ENGINE

Steam Inlet Mechanism

- Large Engine of Watt Used Condenser
  - For Cost Reasons
  - Steam Entered Steam-Jacket
  - Entered and Evacuated at Bottom
  - Exited Towards Condenser
  - Condenser Connected to Suction Pump

Steam Distribution Device

- Watt (1778)
  - Steam Enters Cylinder at Bottom - Piston Rises
  - Steam Evacuated To Condenser - Piston Lowers
  - Newcomen (7 psi), Watt (10 psi)
- Watt (1780)
  - Led to Double Acting - Reversed Operation
  - Constant Steam Pressure Under Piston
  - Alternating Pressure & Vacuum Above Piston
  - Did Not Change Operating Principle
    - Vacuum, Not, Still Driving Force
  - Not Satisfactory - Led to Double Acting

Double Acting Engine

- Steam Inlet Mechanism & Distribution Device
- Experiments by Other Inventors
- Principle of Double Acting
- Planet Gear & Parallel Motion
- Cutoff Valve & Governor
- Industrial Uses of Steam
- Summary - Development of Engine

Inlet Mechanism - Single Acting Engine

Steam Distribution - Watt (1778)
Steam Distribution - Watt (1780)

Experiments by Other Inventors
- Jacob Leopold (1724)
  - Two Newcomen-Type Cylinders
  - Four-Way Cock
  - Steam Pressure Higher Than Atmospheric
- Jonathan Hull (1736)
  - Paddle Wheel in Continuous Motion
  - Ratchet Mechanism
  - Opposite Direction With Counter Weight

Experiments by Other Inventors (continued)
- Continuous Movement (competing with Watt)
  - Keane Fitzgerald (1759)
  - John Stewart (1777)
  - Matthew Washborough (1779)
  - James Pickard (1780)
  - Thompson (1793) & Sherrats (1794)
  - Double Acting - Two Alternating Cylinders
- E. Cartwright (1797)
  - Closed Circuit
  - Two Gears - Flywheel

Atmospheric Engine - Leopold (1724)

Atmospheric Engine - Hull (1736)

Rotary Engine - Cartwright (1797)
Planet Gear & Parallel Motion
- Planet Gear - Watt (1781)
  - Crankshaft & Connecting Rod
    - Matthew Boulton, (1779)
    - James Pickard, (1780)
  - Epicyclic Gear Train
    - Watt’s Sun and Planet Gear
- Parallel Motion - Watt (1784)
  - Tried Rack & Pinion
  - Chains Previously
  - “O” is Center of Beam
  - “A” is Fixed
  - “B” & “C” are Attached to Piston Rods

Planet Gear - Watt (1781)

Parallel Motion - Watt (1784)

Cutoff Valve
- Previously Steam Pressure Was Used Throughout The Stroke
- Watt (1769)
  - Stop Supply Of Steam Before End Of Stoke
  - Utilize Steam Expansion For Last Portion Of Stroke
  - Absorbed Shock of Piston At End Of Stroke
  - Total Power of Engine Decreased
  - Economy Of Steam To Produce Same Work
- Patent - Watt (1782)

Governor
- Last Of Watt’s Great Inventions
- Speed Governor
  - Limited Opening Of Valves
  - Controlled Steam Flow
  - Slowed Down Engine
- No Patent - Used In A More Primitive Form In Grain Mills

Governor With Fly-Balls (1784)
Industrial Uses of Steam

- Boulton & Watt (1773 - 1800)
  - Soho Factory - Built 500 Engines
  - 1/3 Were Pumping Engines
  - 2/3 Were Double Acting
  - Averaged 15 hp
  - After 1800 Watt's Patents Went Public
- Great Britain & Ireland (1817)
  - 20,000 hp in Cotton Mills
- Glasgow (1825)
  - 310 Steam Engines

Double Acting Rotative Engine - Boulton & Watt (1787 - 1800)

Summary of Development of Steam Engine

- Papin (1690)
- Savery (1698)
- Newcomen
- Watt - Condenser (1769)
- Watt - Double Acting (1784)
- Woolf - Double Expansion (1803)