INTERNAL COMBUSTION ENGINES

Outline

- Gas Engines
- Oil Engines
- Diesel Engine
- Petrol Engine

Gas Engines

- Huygens
- Papin
- Etienne Lenoir
- Alphonse Beau de Rochas
- N. A. Otto
- Crossley Brothers

Huygens & Papin

- Huygens (1629-1695)
  - Pre-Steam
  - Small Quantity Of Gunpowder In Cylinder
  - Explosion Raises Cylinder
  - Power On Downstroke
- Denis Papin (1647-1714)
  - Same Concept

Etienne Lenoir (1822-1900)

- Resembled Horizontal Double-Acting Steam Engine
  - Cylinder, Piston, Connecting Rod, Flywhee
- Gas & Air Replaced Steam
- High Tension Spark
  - Battery & Induction Coil
- Return Stroke
  - Expelled Exhaust
- Slide Valves
- Water Cooled

4-Stroke Cycle

- Lenoir
  - 100 ft³ Of Gas Consumed Per hp-hour
  - No Initial Compression Of Mixture
- Alphonse Beau de Rochas (1815-1891)
  - Patent (1862)
    - Protected Invention Of 4-Stroke Engine
  - 1. Explosive Mixture In
  - 2. Mixture Compressed
  - 3. Burning Mixture Drives Piston
  - 4. Burnt Gases Are Exhausted
N. A. Otto (1832-1891)
- German Engineer
- Vertical Atmospheric Gas Engine (1867)
- Horizontal Gas Engine (1878)
- Based On Beau de Rochas Cycle

Otto (Continued)
- Otto Never New Of Earlier Patent
- Produced 35,000 Engines Within Several Years
- Very Few Used Electric Ignition
  - Most Used A Flame Drawn Into Cylinder
  - By 1878 - 28 ft³ per hp-hour

Early Flame Ignition
- Dual Flames
  - External
  - Internal
- Internal Is Extinguished During Ignition
- Incorporated Slide Valves

Other Developers
- Dugald Clerk (1879)
  - 2-Stroke Engine
  - Single-Acting Lenoir Engine
- Griffin
  - 6-Stroke Engine

Crossley Brothers
- Built Many 4-Stroke Engines Under Otto Patent

Oil Engines
- Hock & Brayton
- Dent & Priestman
- Hornsby
Hock & Brayton
- Gas Producing Plants Limited Development
- J. Hock (1873) - Paraffin (Kerosene)
  - Pressurized Air Broke Up Jet Of Oil Into Mist
  - Incomplete Combustion - Unsatisfactory
- Brayton (1873)
  - Two Cylinders
    - Compression Of Mixture
    - Actual Working
  - Air Forced Through Oil Soaked Absorbent Material
  - Double-Acting, 2-Stroke Cycle
  - 1890 - Single-Acting On Otto Cycle

Dent & Priestman
- Used Vapor Of Heavy Oil
- Otto Cycle - Horizontal & Vertical
- 100 hp
- Portable Model

Hornsby Oil Engine
- Vaporizer
- Oil Lamp To Heat Mixture Prior To Starting (10 min)

Diesel Engine
- Rudolf Diesel (1858-1913)
  - Patent (1892)
  - Based On Otto Cycle
  - Basic Principle
    - Compression, Air, Fuel, Piston
    - Higher Compression Than Other IC Engines
    - Injector, Pump To Add, Swirl, Burn By, & Oil Into Combustion Chamber
    - Ignition: Spark Plug, Boost, Contact With Air
  - Worked With All Types Of Petroleum Oil

Diesel Engine (Continued)
- 11% Greater Efficiency Than Any Other Prime Mover
- Disadvantages
  - Heavier & More Solid Engine
  - Roughness At Low Speeds
  - Cold Starting

Petrol Engines
- Gottlieb Daimler
- Karl Benz
- Electric Ignition
- Float-Feed Carburettor
- Hot Tube Ignition
- Opposed Pistons
- Balancing
Gottlieb Daimler
- Father Of Modern IC Engine
- Premise
  - Small & Light
  - High-Speed Motor
  - Power By High Speed Rotation
- Patent (1884)
  - High-Speed Gas Engine
  - Hot Tube Ignition
- Patent (1885)
  - Single Cylinder, Enclosed Crank & Flywheel

Gottlieb Daimler (Continued)
- Patent (1885)
  - Surface Carburettor
- Patent (1889)
  - V-Type Twin Cylinder
    - 19th Century
    - Connecting Rods, Common Crank
- Used On Motor Cars On Both Continents
- Sold In Large Quantities
- "First Modern Day IC Engine"

V-Type Twin Cylinder

V-Type Twin-Cylinder (Operation)
- First Down Stroke
  - Carburetted Air At Atmospheric Pressure Through Mushroom Valve
  - Light Spring Closes Valve
- First Return Stroke
  - Mixture Is Compressed (3:1)
  - At TDC, Charge Is Fired By Hot Tube Ignition - Gases Increase In Pressure (20:1)

V-Type Twin-Cylinder (Operation)
- Second Down Stroke
  - Driven By Exploding Mixture
  - Mechanical Valve Opens To Release Exhaust To Silencer - Remains Open During Return
- Second Return Stroke
  - Completely Drives Out Exhaust
  - Exhaust Valve Closes
- Cycle Repeats

V-Type Twin-Cylinder (Properties)
- 2 to 1 Exhaust Valve Gearing
- No Exhaust On First Return Stroke
- Governor Controlled
  - Keeps Exhaust Valve Closed If Speed Exceeds Maximum
- Flywheel During Non Power Stroke
  - Pistons Don't Oppose Each Other
- Cylinder & Valve Casting Is Water Jacketed
  - Radiator
Karl Benz
- "Father Of First Motor Car"
- 3.5 hp Single Cylinder Petrol Engine (1893)
  - Otto Cycle
  - Slow Speed
  - Primitive Surface Carburettor & Mixer
  - Electric Ignition - High Tension System
    - Spark Principle, Used By New Vehicles
- Patent (1885)
- First Motor Vehicle By Benz

Benz (1885) - Electric Ignition

Electri Ignition - Operation
- 4 Volt Accumulator In Series With Primary Winding Of Induction Coil
- Trembler Switch
  - When Core Energizes, Interrupts Circuit
  - Switch Springs Back Till Core Energizes
  - Cycle Repeats Rapidly Making a Buzz
- High Tension Winding Delivers A Series Of Sparks
- Rotary Switch Makes Sure Ignition Takes Place At Correct Time

Float Feed Carburettor
- Wilhelm Maybach (1893)
- Daimler Engines
- Petrol Fed By
  - Gravity
  - Pressure
- Needle Jet
  - Air Suction Mixes Petrol
- Float Controls Petrol Level

de Dion & Bouton
- 1895
- Light, High Speed
- Single Cylinder, Air Cooled
- Otto Cycle
- 1500 rpm
- Surface Carburettor
- New Ignition System
- Precursor For Many Engines To Follow
de Dion (1895) - Electric Ignition

Electric Ignition - Operation
- Primary Battery
- Plain Induction Coil
- Cam & V-Shaped Notch