CHAPTER-2 Power and Transmission

Introduction to Automobile Engineering

CLASSIFICATION OF INTERNAL COMBUSTION ENGINES

1. **Application**
2. **Basic Engine Design**
3. **Operating Cycle**
4. **Working Cycle**
5. **Valve/Port Design and Location**
6. **Fuel**
7. **Mixture Preparation**
8. **Ignition**
9. **Stratification of Charge**
10. **Combustion Chamber Design**
11. **Method of Load Control**
12. **Cooling**

CLASSIFICATION OF INTERNAL COMBUSTION ENGINES

1. Application

1. **Automotive: (i) Car**
   (ii) Truck/Bus
   (iii) Off-highway
2. **Locomotive**
3. **Light Aircraft**
4. **Marine: (i) Outboard**
   (ii) Inboard
   (iii) Ship
5. **Power Generation: (i) Portable (Domestic)**
   (ii) Fixed (Peak Power)
6. **Agricultural: (i) Tractors**
   (ii) Pump sets
7. **Earthmoving: (i) Dumpers**
   (ii) Tippers
   (iii) Mining Equipment
8. **Home Use: (i) Lawnmowers**
   (ii) Snow blowers
   (iii) Tools
9. **Others**

CLASSIFICATION OF INTERNAL COMBUSTION ENGINES

1. Reciprocating

2. Basic Engine Design:

(a) Single Cylinder

(b) Multi-cylinder

In-line

V -Type

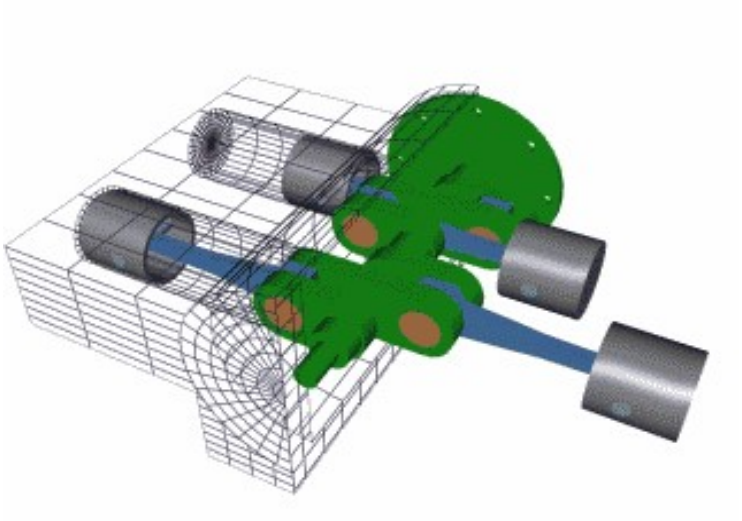
Radial

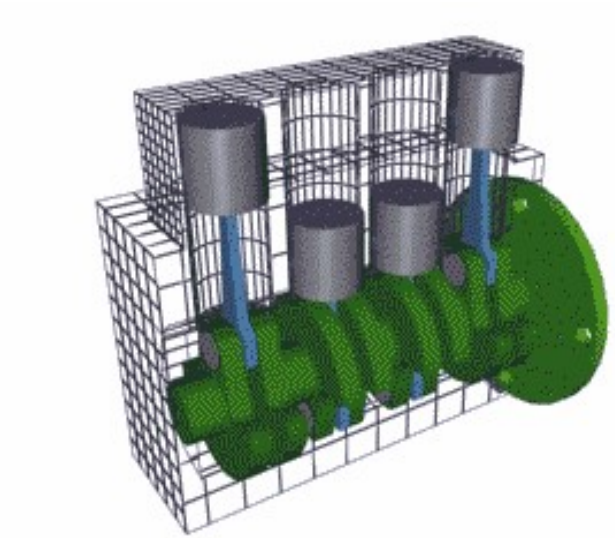
Opposed Cylinder

Opposed Piston

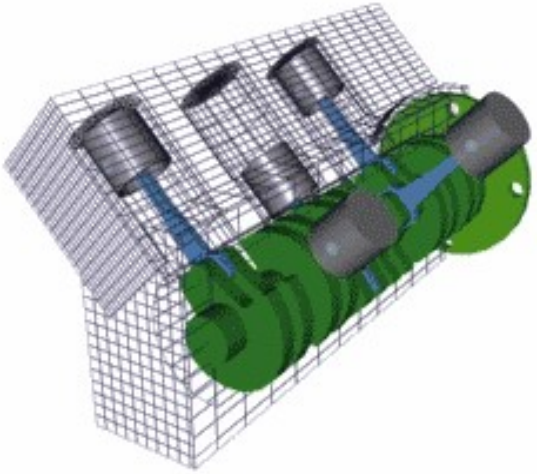
3. Rotary: (a) Single Rotor

(b) Multi-rotor

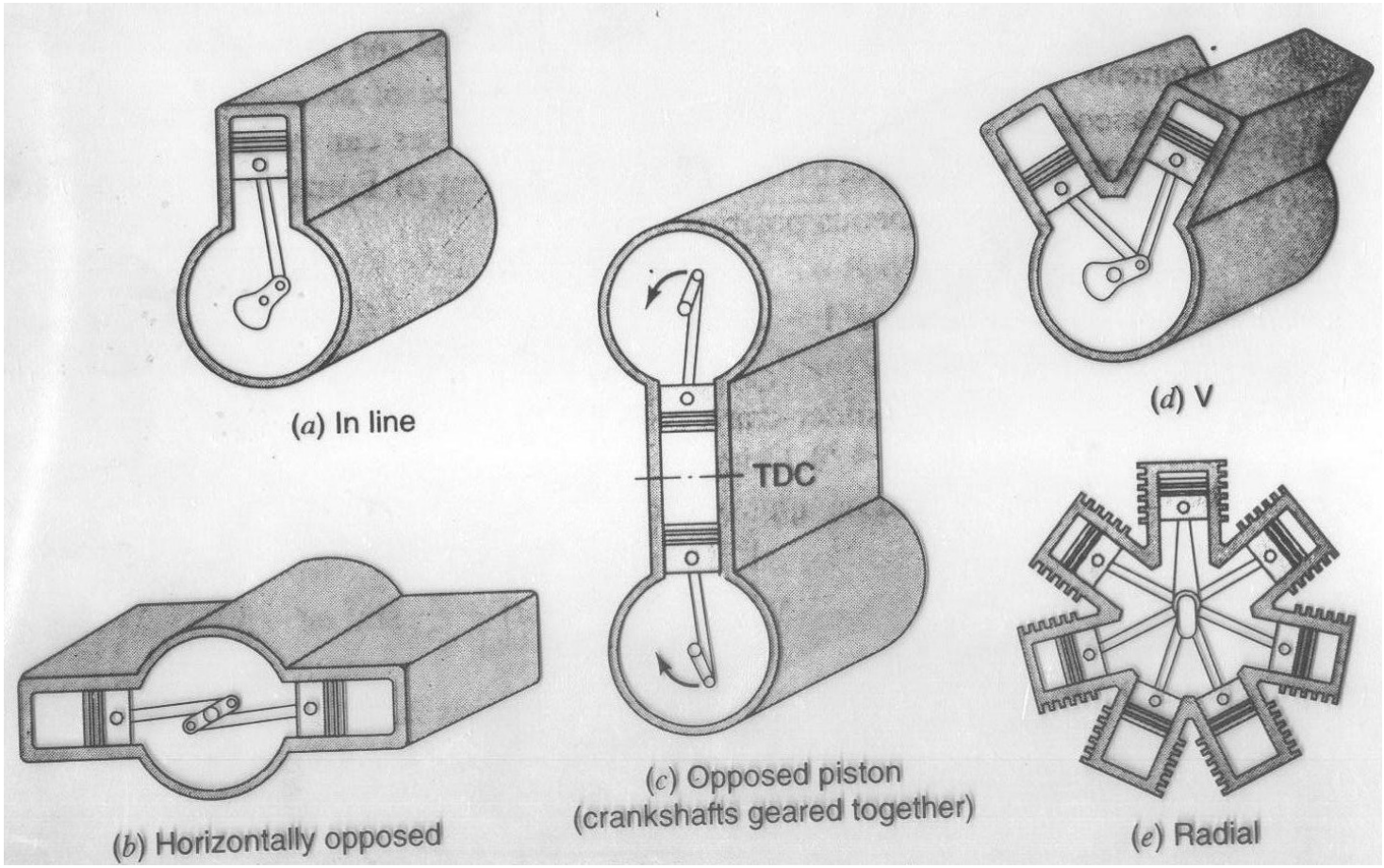




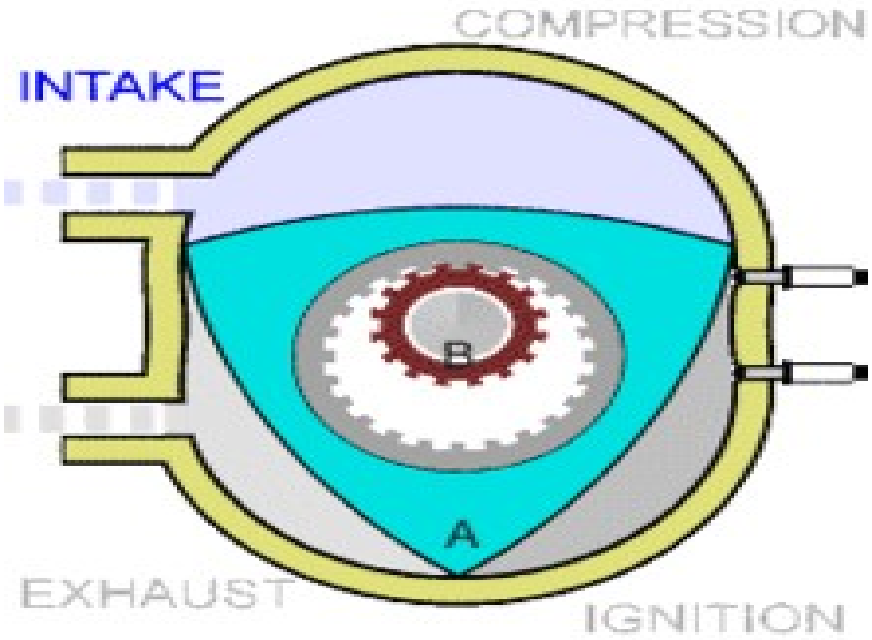
Flat - The cylinders are arranged in two banks on opposite sides of the engine.



Types of Reciprocating Engines



Wankel Rotary Piston Engine



Aircraft Engines
Automobile Racing
Motor cycle engine

CLASSIFICATION OF INTERNAL COMBUSTION ENGINES

3. Operating Cycle

- **Otto (For the Conventional SI Engine)**
- **Atkinson (For Complete Expansion SI Engine)**
- **Miller (For Early or Late Inlet Valve Closing type SI Engine)**
- **Diesel (For the Ideal Diesel Engine)**
- **Dual (For the Actual Diesel Engine)**

CLASSIFICATION OF INTERNAL COMBUSTION ENGINES

4. Working Cycle (Strokes)

1. Four Stroke Cycle:(a) Naturally Aspirated

(b)Supercharged/Turbocharged

2. Two Stroke Cycle: (a) Crankcase Scavenged

(b) Uni flow Scavenged

(i) Inlet valve/Exhaust Port

(ii) Inlet Port/Exhaust Valve

(iii) Inlet and Exhaust Valve

May be Naturally Aspirated Turbocharged

5. (a) Valve/Port Design

1. Poppet Valve

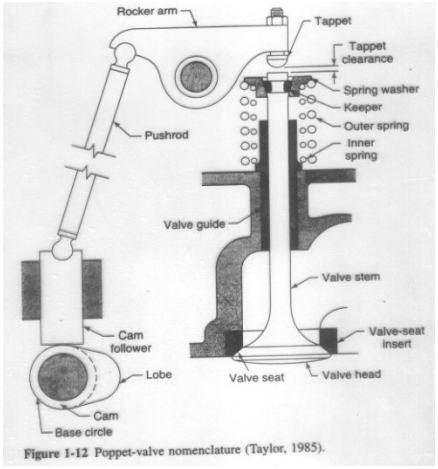
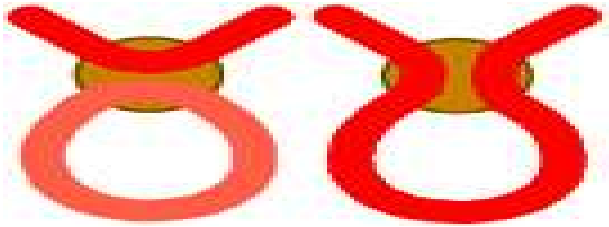


Figure 1-12 Poppet-valve nomenclature (Taylor, 1985).

2. Rotary Valve



- A **rotary valve** is a type of valve in which the rotation of a passage or passages in a transverse plug regulates the flow of liquid or gas through the attached pipes. The common stopcock is the simplest form of rotary valve. Rotary valves have been applied in numerous applications, including:
- Periodically reversing the flow of air and fuel across the open hearth furnace .
- Loading sample on chromatography columns.
- Certain types of 2-stroke gasoline engines.

3. Reed Valve

Reed valves are a type of check valve which restrict the flow of fluids to a single direction, opening and closing under changing pressure on each face. Modern versions often consist of flexible metal or composite materials (fiberglass or carbon fiber).

4. Piston Controlled Porting

5. (b) Valve Location

1. The T-head

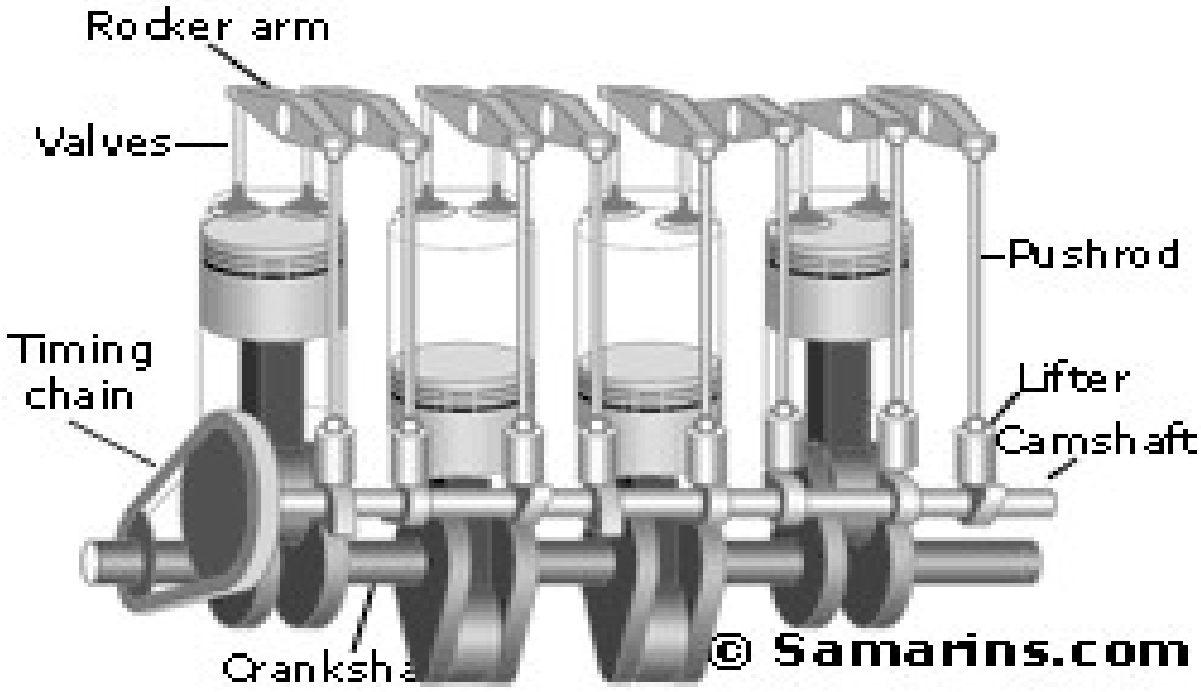
2. The L-head

3. The F-head

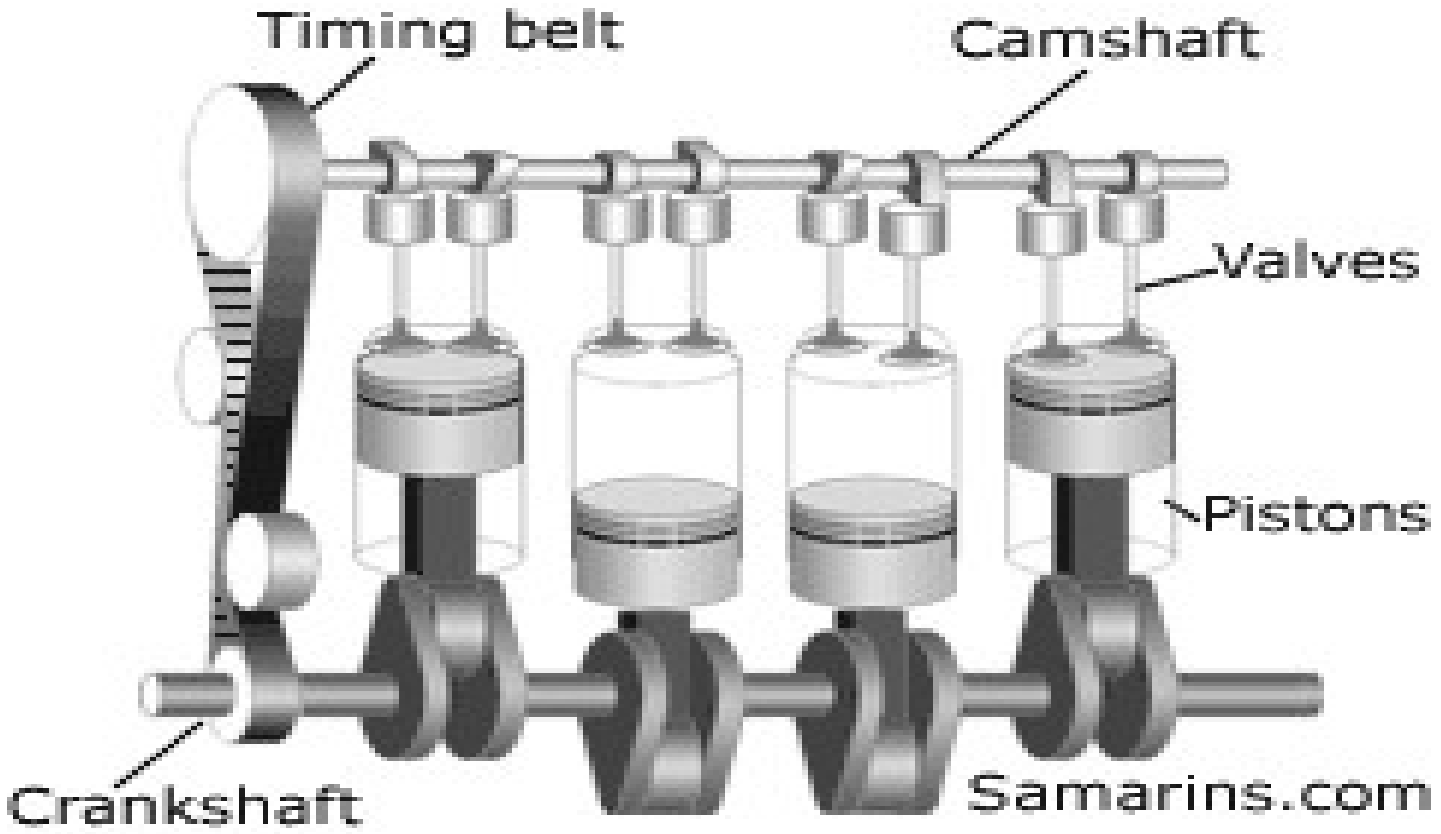
4. The I-head: (i) Over head Valve (OHV)

(ii) Over head Cam (OHC)

- **OHV means Overhead Valve** - an engine design where the camshaft is installed inside the engine block and valves are operated through lifters, pushrods and rocker arms (an OHV engine also known as a "Pushrod" engine). Although an OHV design is a bit outdated, it has been successfully used for decades. An OHV engine is very simple, has more compact size and proven to be durable.
  On the downside, it's difficult to precisely control the valve timing at high rpm due to higher inertia caused by larger amount of valve train components (lifter-pushrod-rocker arm). Also, it's very difficult to install more than 2 valves per cylinder, or implement some of the latest technologies such as Variable Valve Timing - something that could be easily done in a DOHC engine.



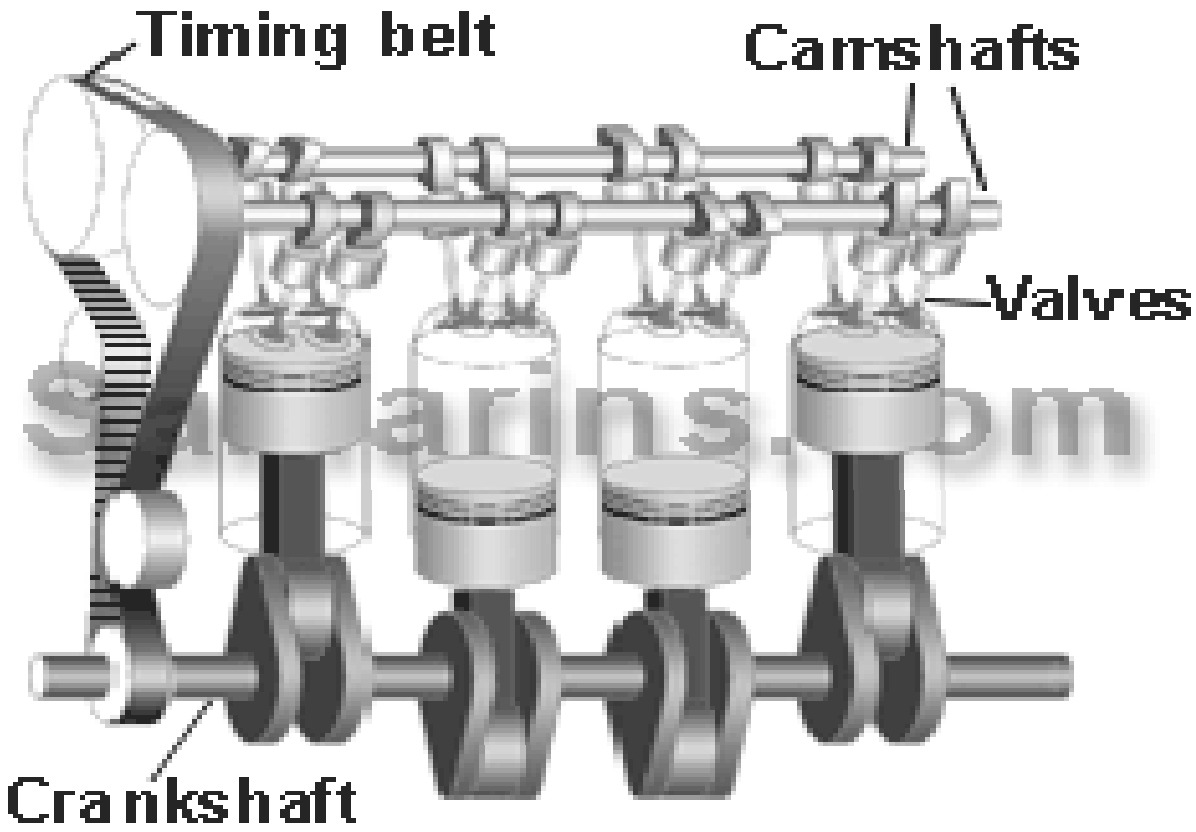
- OHC in general means OverHead Cam while SOHC means Single OverHead Cam. In the SOHC engine the camshaft is installed in the cylinder head and valves are operated either by the rocker arms or directly through the lifters (as in the picture). The advantage is that valves are operated almost directly by the camshaft, which makes it easy to achieve the perfect timing at high rpm. Also it's possible to install three or four valves per cylinder .The disadvantage is that an OHC engine requires a timing belt or chain with related components - more complex and more expensive design.



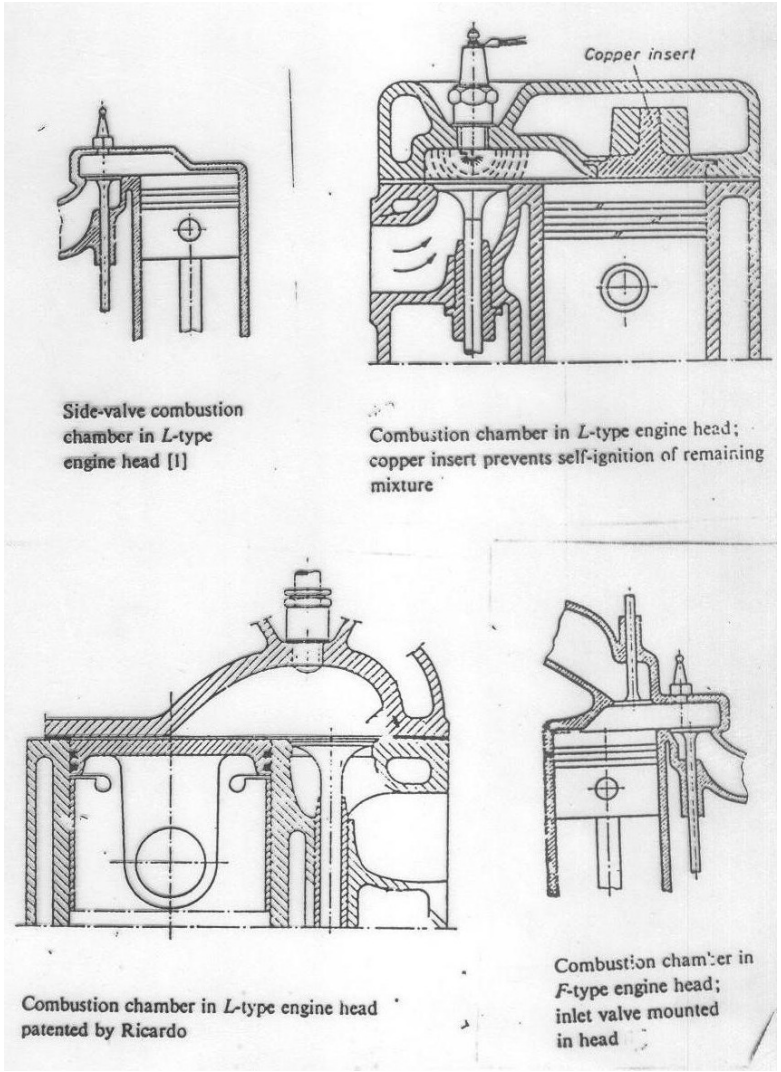
- **DOHC or Double OverHead Cam** - this setup is used in many today's cars. Since it's possible to install multiple valves per cylinder and place intake valves on the opposite side from exhaust vales, a DOHC engine can "breathe" better, meaning that it can produce more horsepowers with smaller engine volume.

Pros: High efficiency, possible to install multiple valves per cylinder and adopt variable timing.

Cons: More complex and more expensive design.



Valve Locations



CLASSIFICATION OF INTERNAL COMBUSTION ENGINES

6. Fuel

1.Conventional: (a) Crude oil derived (i) Petrol

(ii) Diesel

(b) Other sources: (i) Coal

(ii) Wood (includes bio-mass)

(iii)Tar Sands

(iv)Shale

2. Alternate: (a) Petroleum derived (i) CNG

(ii) LPG

(b) Bio-mass Derived (i) Alcohols (methyl and ethyl)

(ii) Vegetable oils

(iii) Producer gas and biogas

(iv) Hydrogen

3. Blending

4. Dual fueling

CLASSIFICATION OF INTERNAL COMBUSTION ENGINES

7. Mixture Preparation

1. **Carburetion**
2. **Fuel Injection**
   - **(i) Diesel**
   - **(ii) Gasoline**
     - **(a) Manifold**
     - **(b) Port**
     - **(c) Cylinder**

CLASSIFICATION OF INTERNAL COMBUSTION ENGINES

8. Ignition

1. Spark Ignition

- **(a) Conventional**
  - **(i) Battery**
  - **(ii) Magneto**
- **(b) Other methods**

2. Compression Ignition

CLASSIFICATION OF INTERNAL COMBUSTION ENGINES

9. Charge Stratification

1. **Homogeneous Charge (Also Pre-mixed charge)**

2. **Stratified Charge (i) With carburetion**

(ii) With fuel injection

CLASSIFICATION OF INTERNAL COMBUSTION ENGINES

10. Combustion Chamber Design

1. Open Chamber: (i) Disc type

(ii) Wedge

(iii) Hemispherical

(iv) Bowl-in-piston

(v) Other design

2. Divided Chamber: (For CI): (i) Swirl chamber

(ii) Pre-chamber

(For SI) (i) CVCC

(ii) Other designs

Combustion Chamber Designs

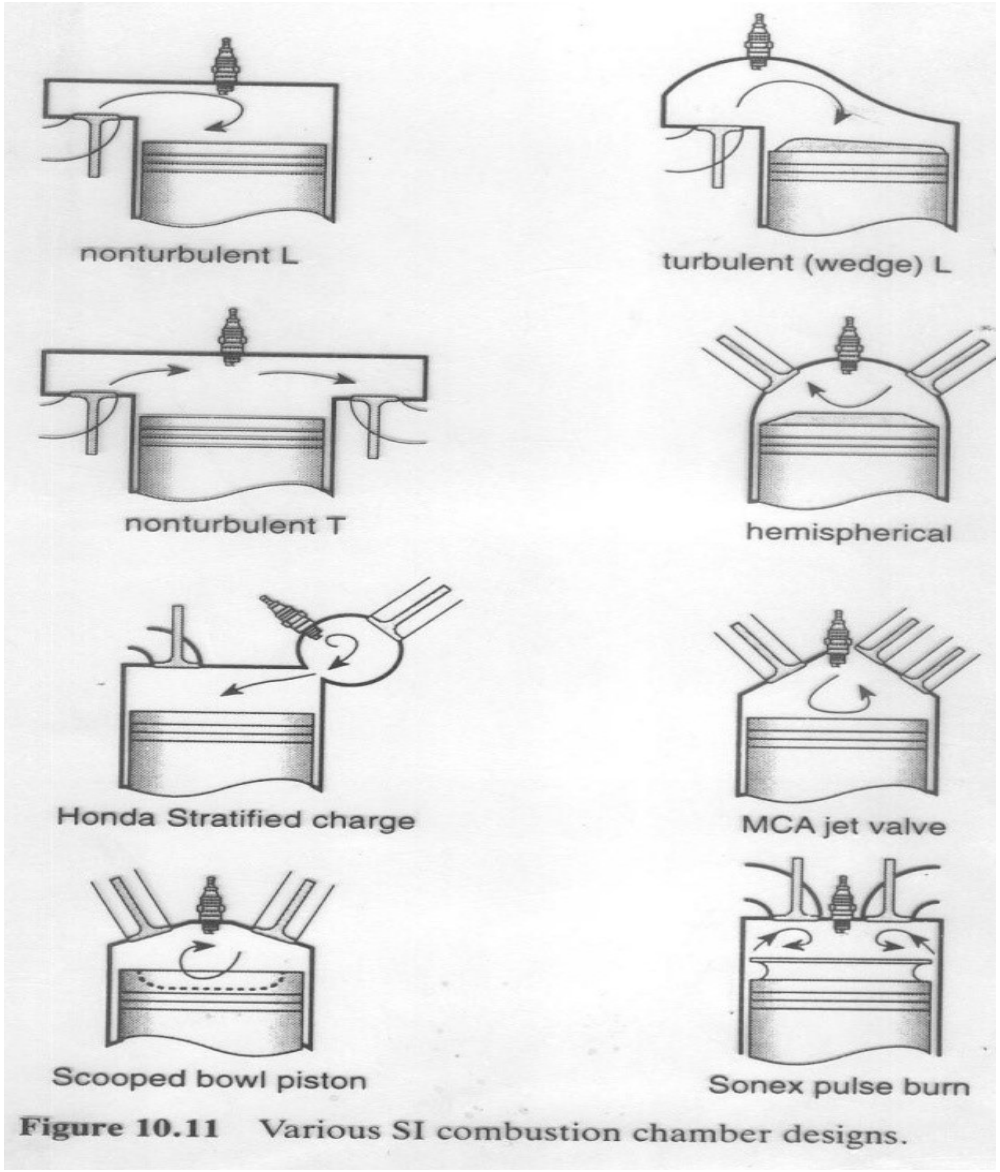


Figure 10.11 Various SI combustion chamber designs.

CLASSIFICATION OF INTERNAL COMBUSTION ENGINES

12. Cooling

1. **Direct Air-cooling**

2. **Indirect Air-cooling (Liquid Cooling)**

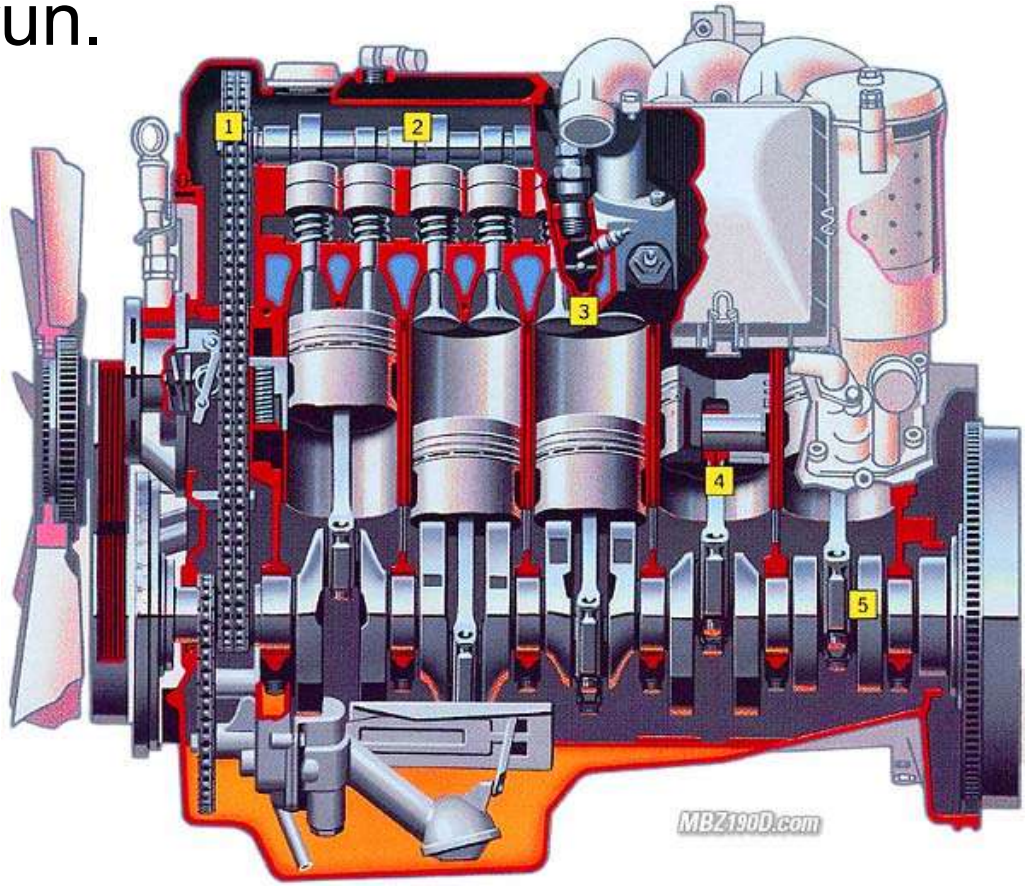
3. **Low Heat Rejection (Semi-adiabatic) engine.**

DIFFERENT PARTS OF INTERNAL COMBUSTION ENGINES

Engines

Internal combustion engine needs fuel, ignition and compression in order to run.

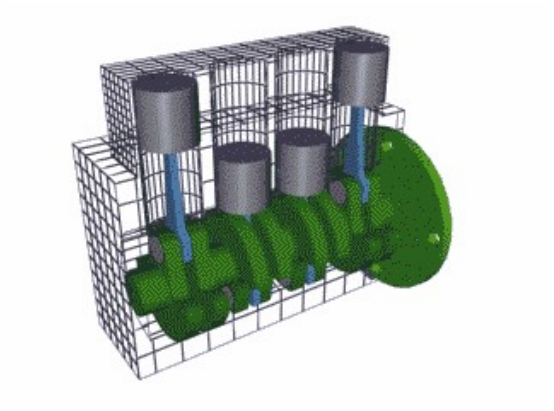
- Four-Stroke Gasoline Engine
- Two-Stroke Gasoline Engines
- Diesel Engine
- Rotary Engine
- Steam Engine



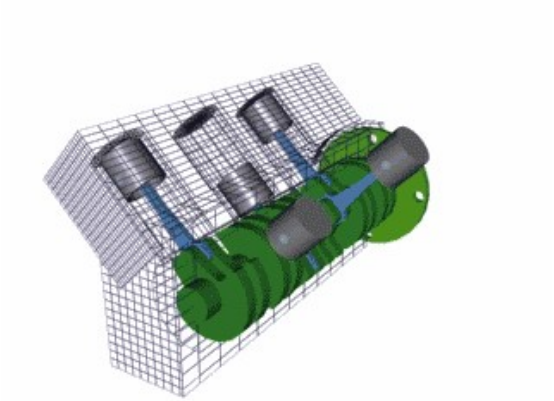
Engines

Configuration

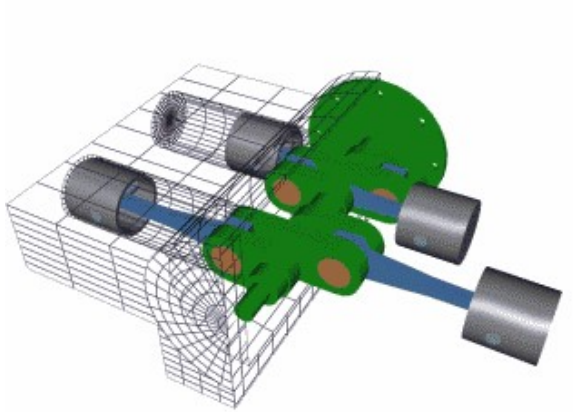
- Inline Engines: The cylinders are arranged in a line, in a single bank.



- V Engines: The cylinders are arranged in two banks, set at an angle to one another.



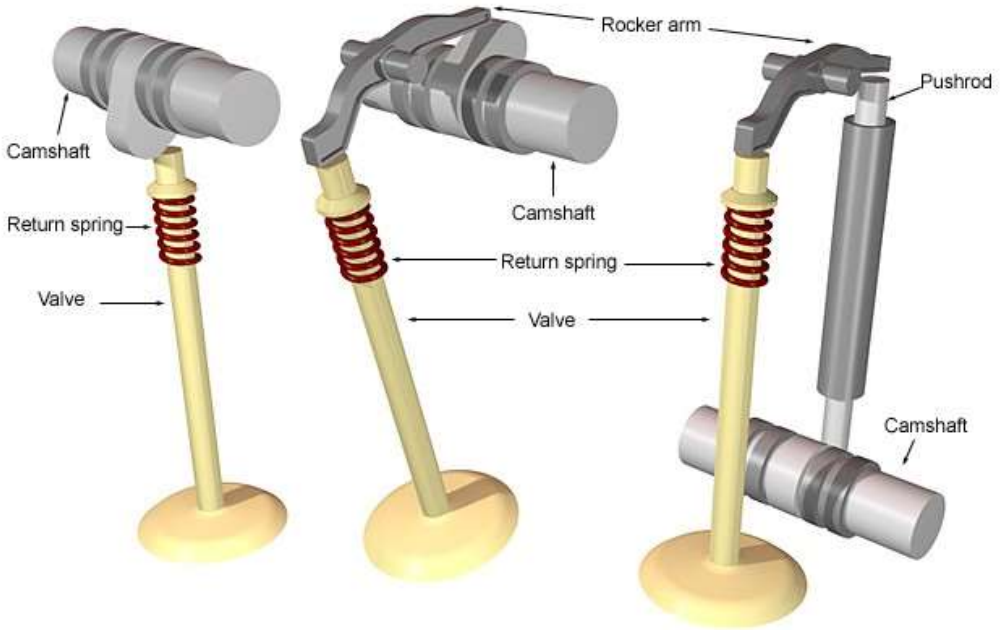
- Flat Engines: The cylinders are arranged in two banks on opposite sides of the engine



Engines

Parts

Valves: Minimum
Two Valves pre Cylinder

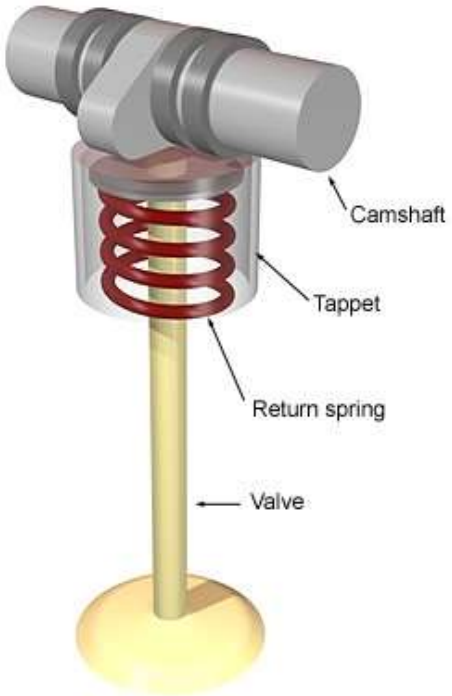


•Exhaust Valve lets the exhaust gases escape the combustion Chamber. (Diameter is smaller then Intake valve)

•Intake Valve lets the air or air fuel mixture to enter the combustion chamber. (Diameter is larger than the exhaust valve)

Engines

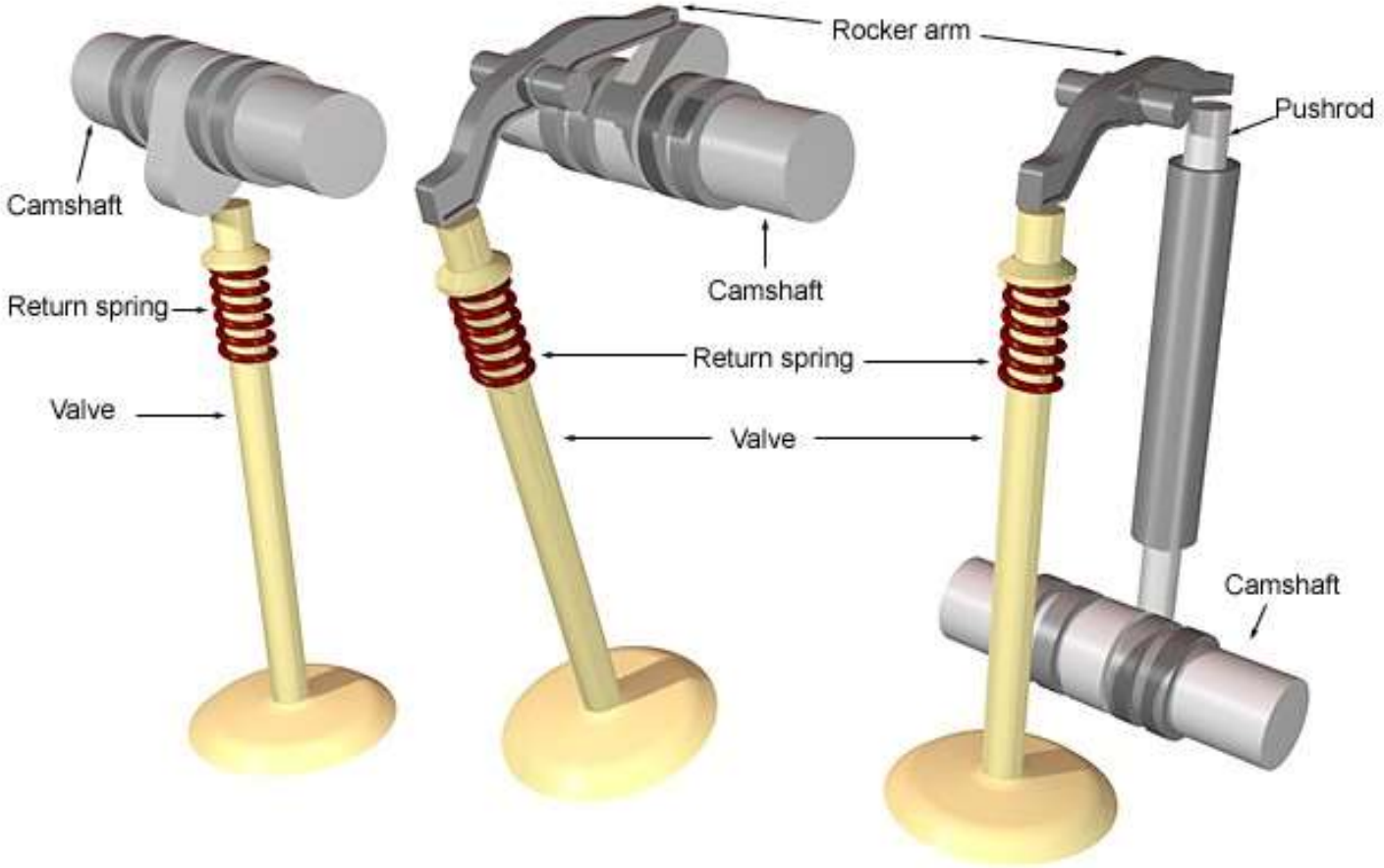
<u>Valve Springs</u>: Keeps the valves closed.



<u>Valve Lifters</u>: Rides the cam lobe and helps in opening the valves.

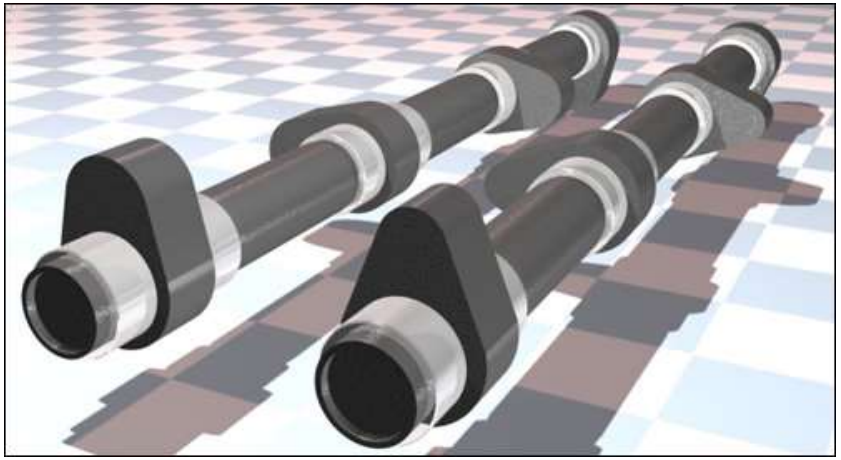
Engines

Different arrangement of valve and camshaft.



Engines

Cam Shaft: The shaft that has intake and Exhaust cams for operating the valves.



Cam Lobe: Changes rotary motion into reciprocating motion.

Engines

Spark Plug

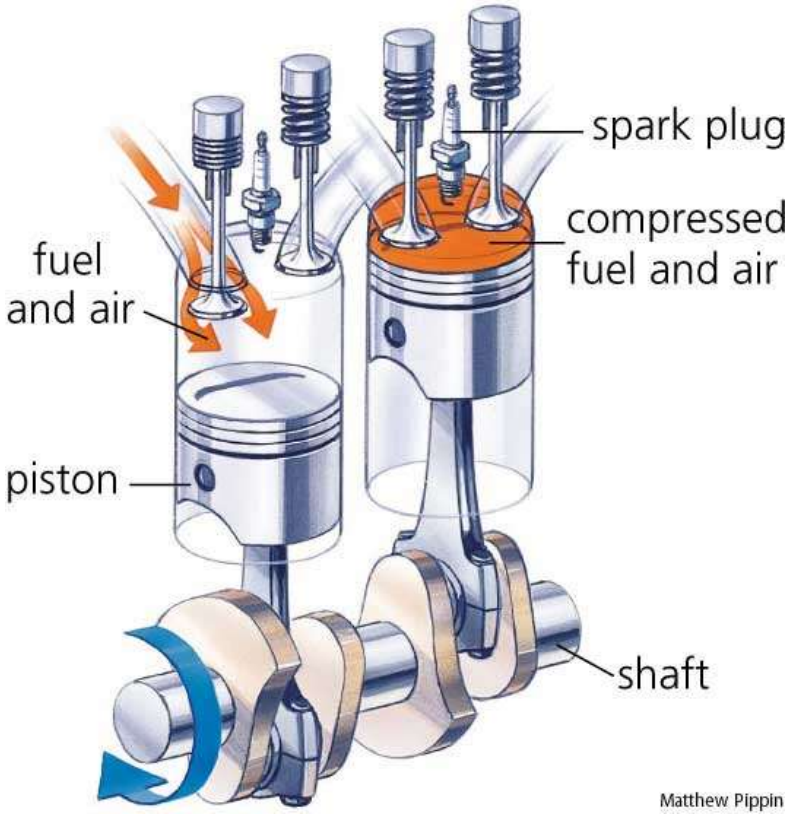
It provides the means of ignition when the gasoline engine's piston is at the end of compression stroke, close to Top Dead Center (TDC)

Engines

Piston

A movable part fitted into a cylinder, which can receive and transmit power.

Through connecting rod, forces the crank shaft to rotate.



Engines

Cylinder head

Part that covers and encloses the Cylinder.

It contains cooling fins or water jackets and the valves.

Some engines contains the cam shaft in the cylinder head.

Engines

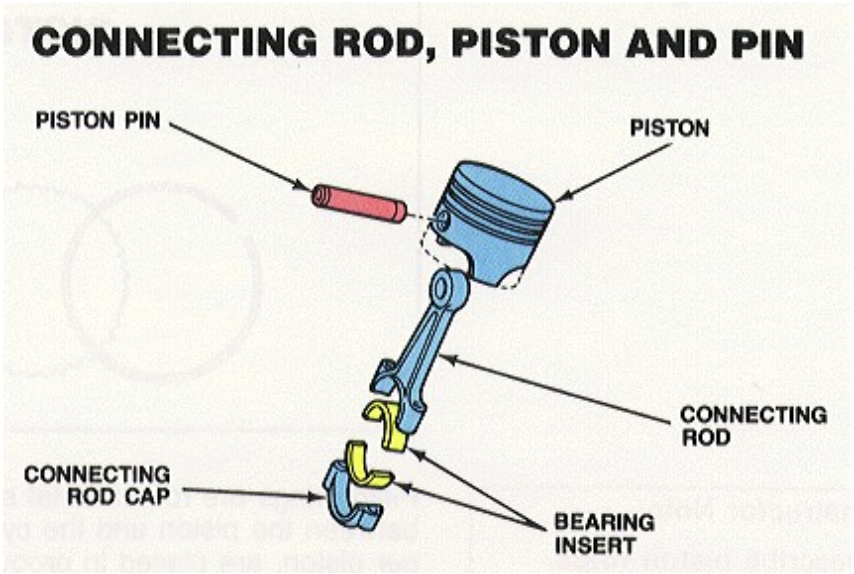
Engine Block

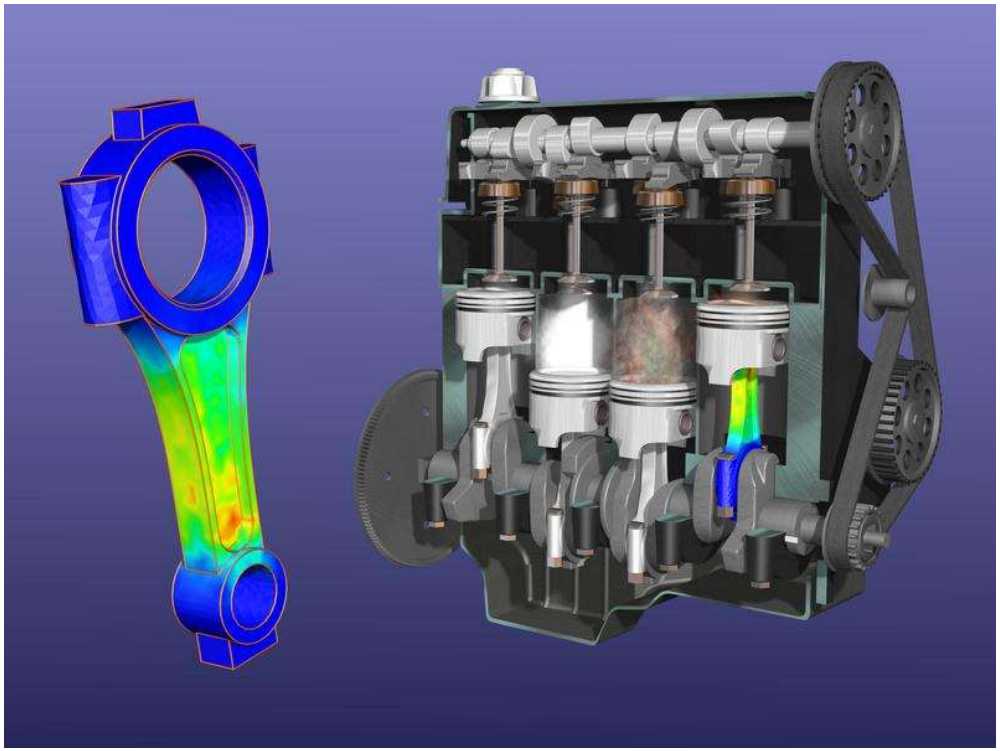
Foundation of the engine and contains pistons, crank shaft, cylinders, timing sprockets and sometimes the cam shaft.

Engines

Connecting (conn.) Rod

Attaches piston (wrist-pin) to the crank shaft (conn. rod caps).

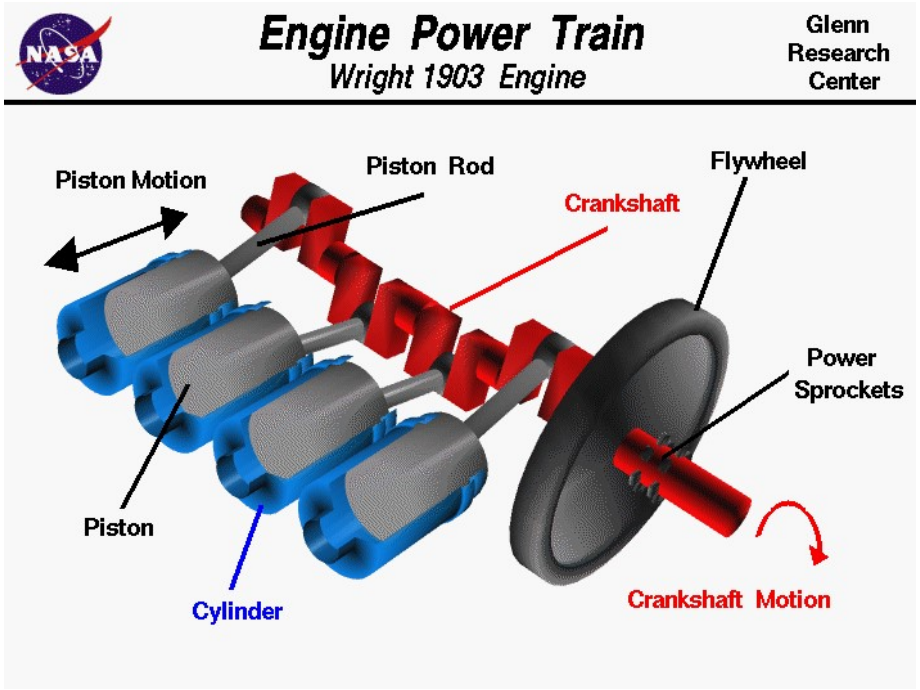




Engines

Crank Shaft

Converts *up and down* or reciprocating motion into *circular* or rotary motion.



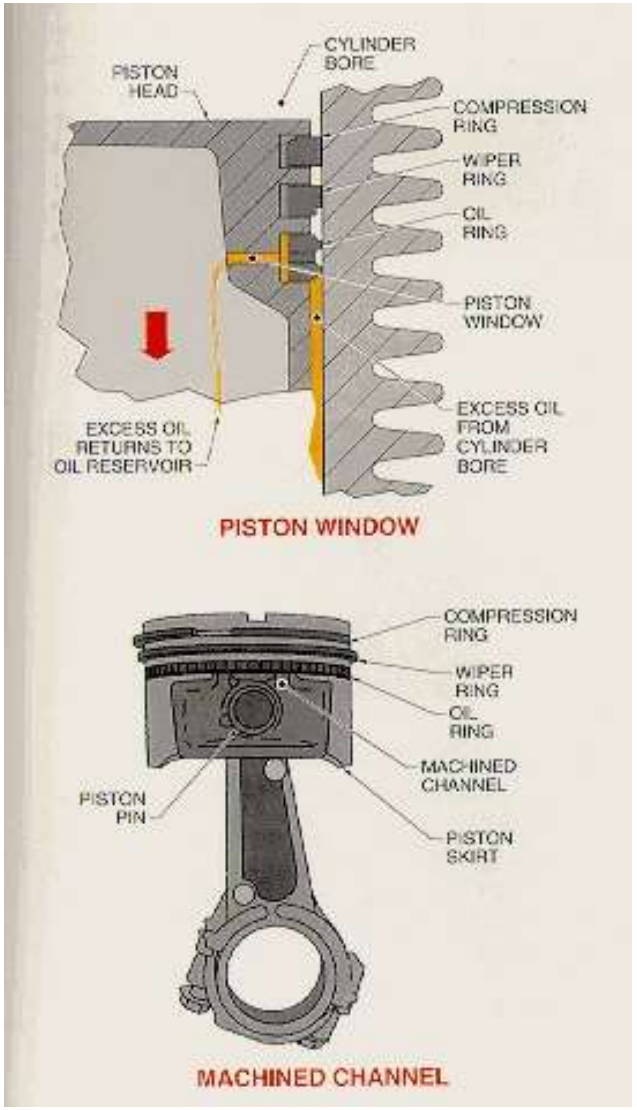
DAMPNER PULLEY
Controls Vibration

Engines

Piston Rings

Four stroke: Three rings
Top two are compression rings (sealing the compression pressure in the cylinder) and the third is an oil ring (scrapes excessive oil from the cylinder walls)

Two Stroke: Two Rings
Both the rings are Compression rings.



Engines

Flywheel

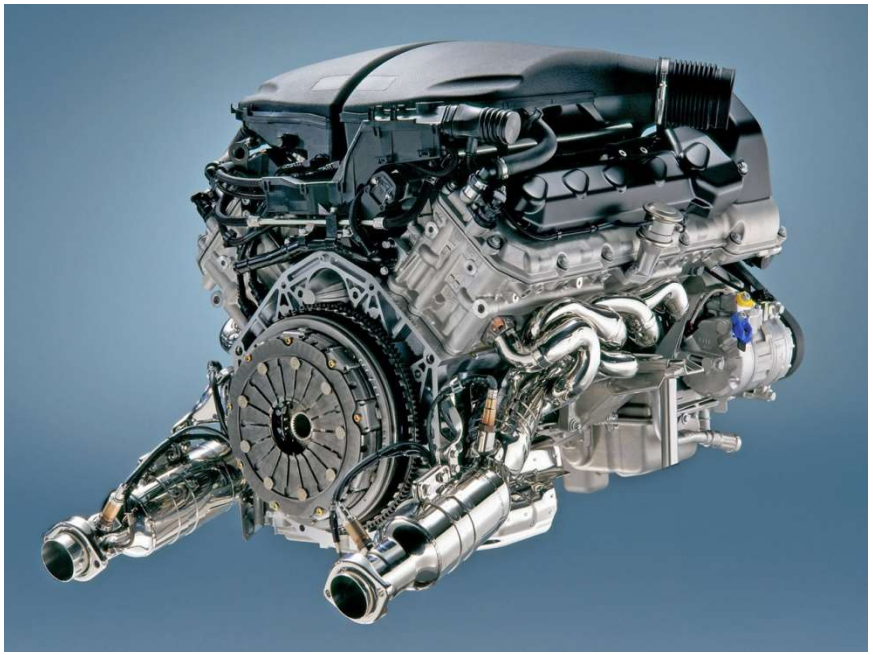
Attached to the crankshaft

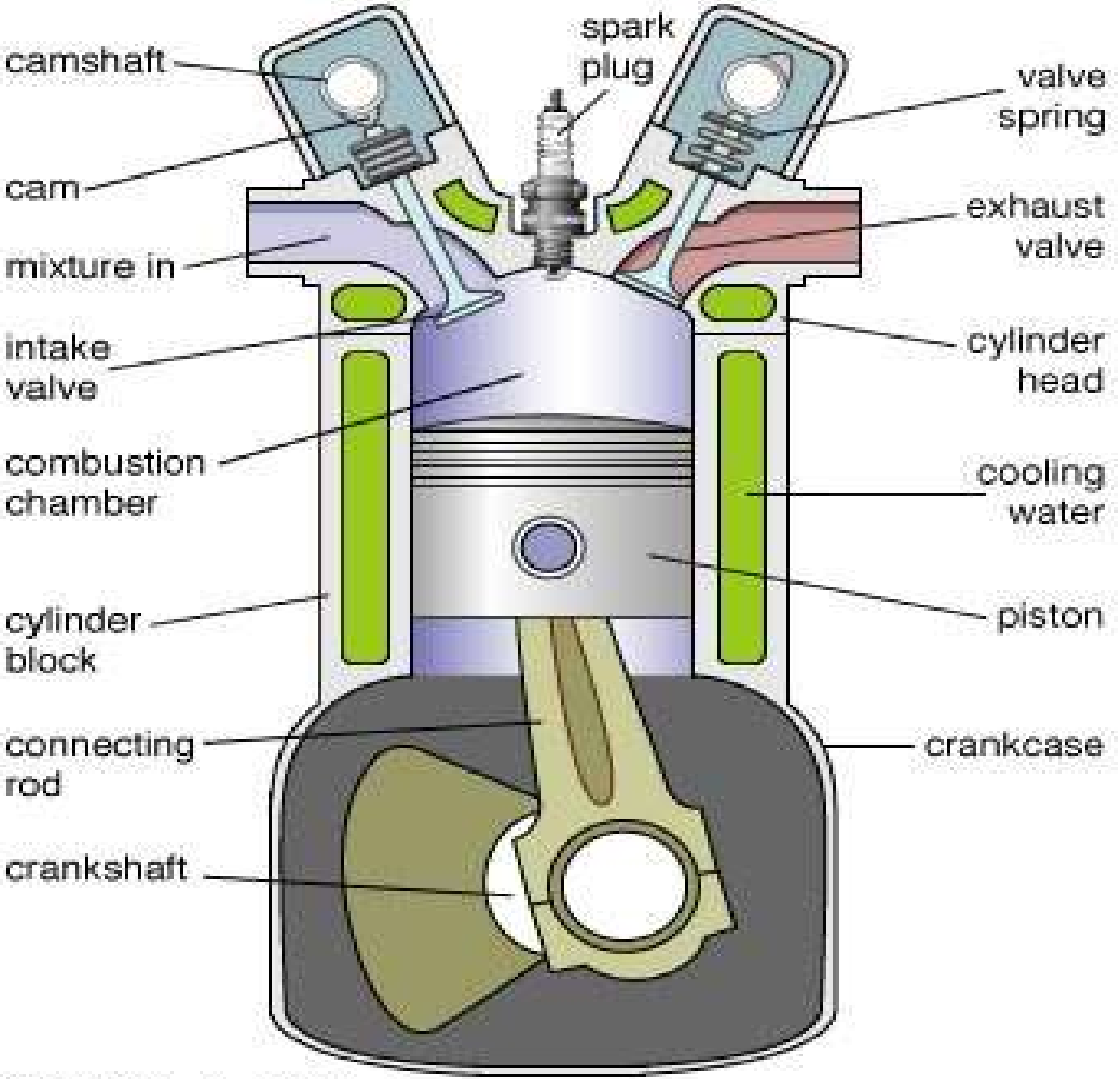
Reduces vibration

Cools the engine (air cooled)

Used during initial start-up

Transfers power from engine to drivetrain




camshaft
cam
mixture in
intake valve
combustion chamber
cylinder block
connecting rod
crankshaft
spark plug
valve spring
exhaust valve
cylinder head
cooling water
piston
crankcase
© 2006 Merriam-Webster, Inc.

Purpose of valves

Intake valve :

- Opens at beginning of intake stroke
- Allows the air fuel mixture to enter the cylinder

Exhaust valve:

- Opens just before the exhaust stroke begins
- Burnt gases escapes from the cylinder

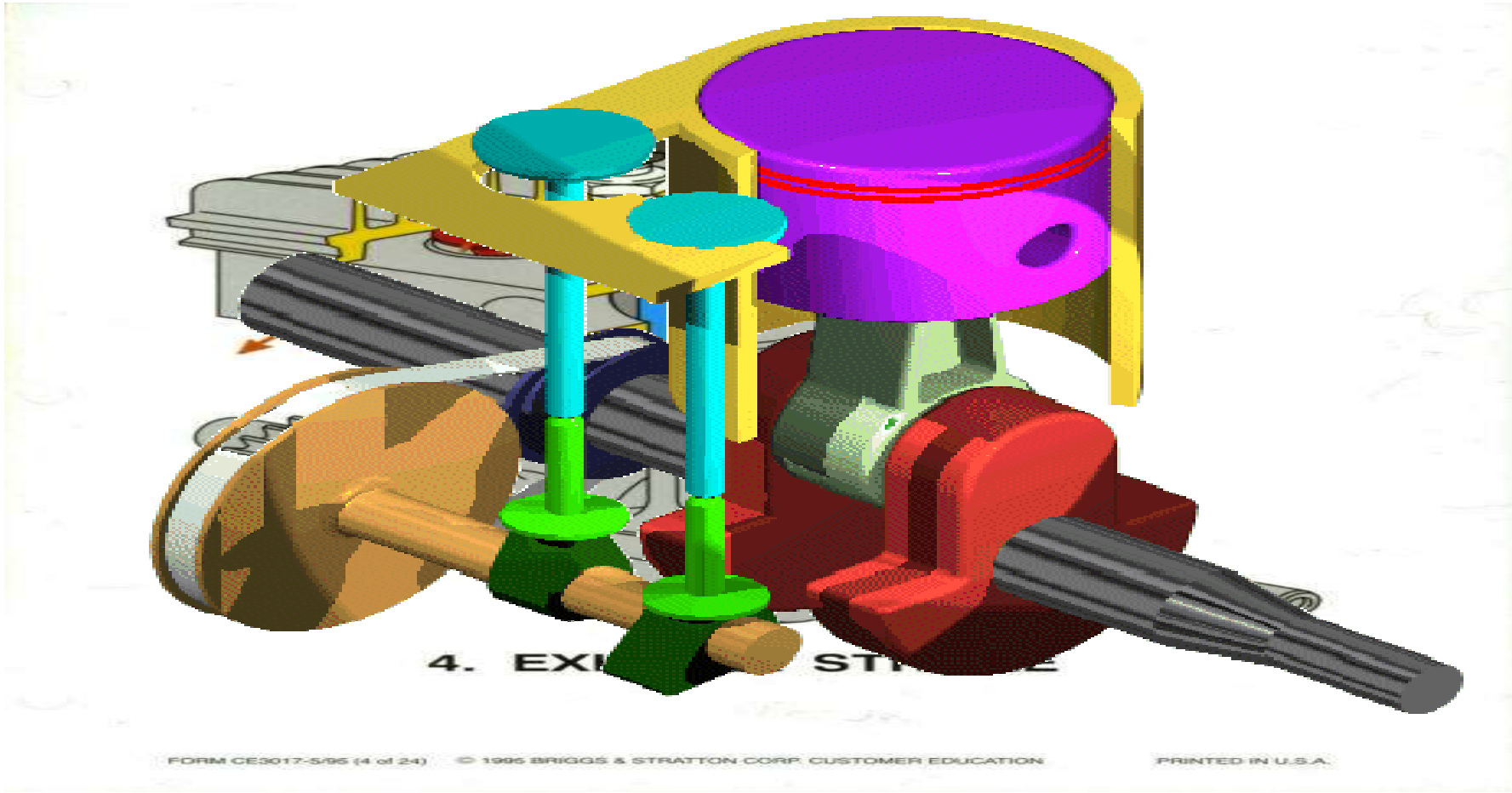
The valves are operated by valve train..

Valve and valve trains

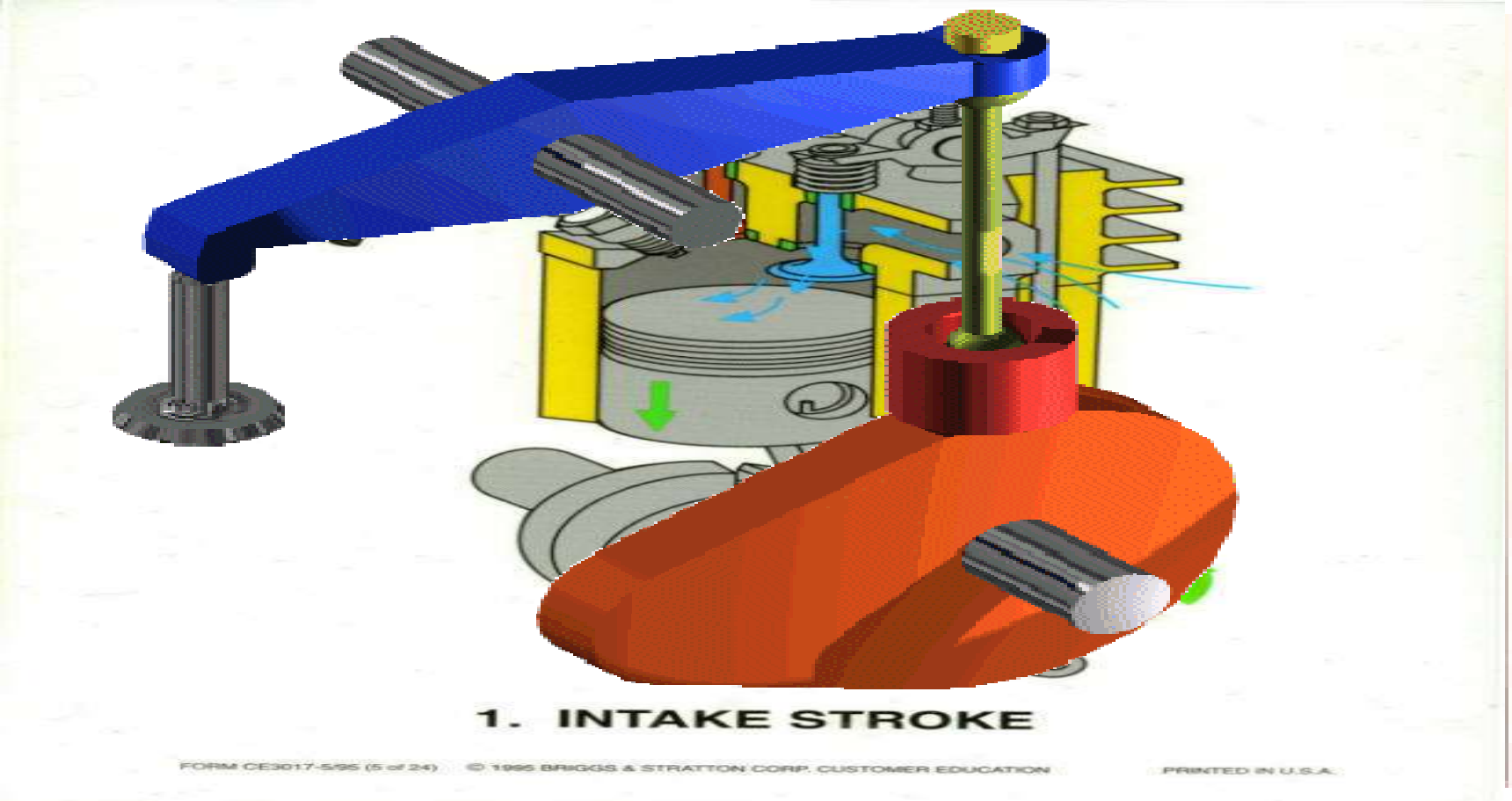
There are two basic type of valve trains

1. Overhead camshaft with rocker arms
2. Camshaft in block with pushrods

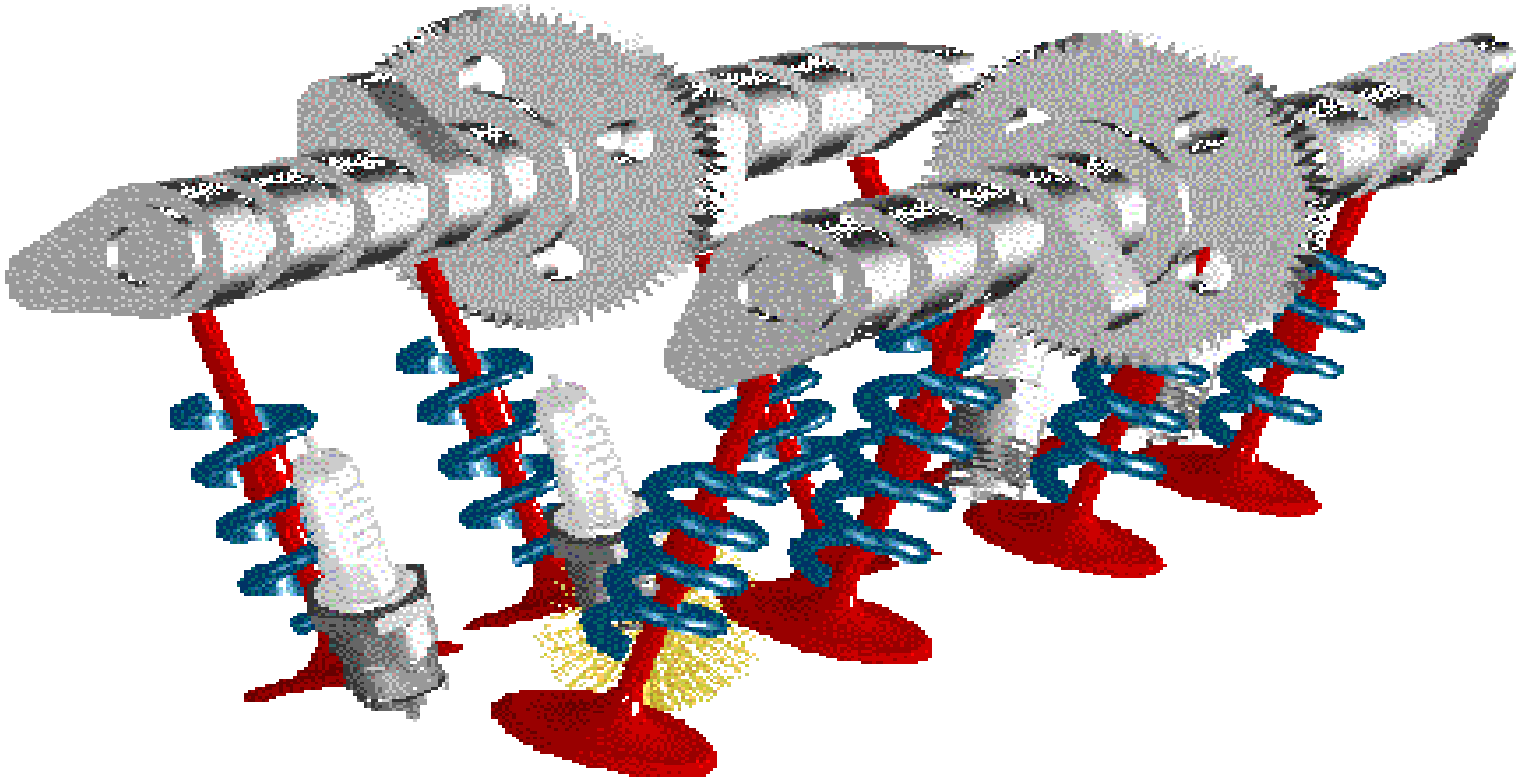
L head engines



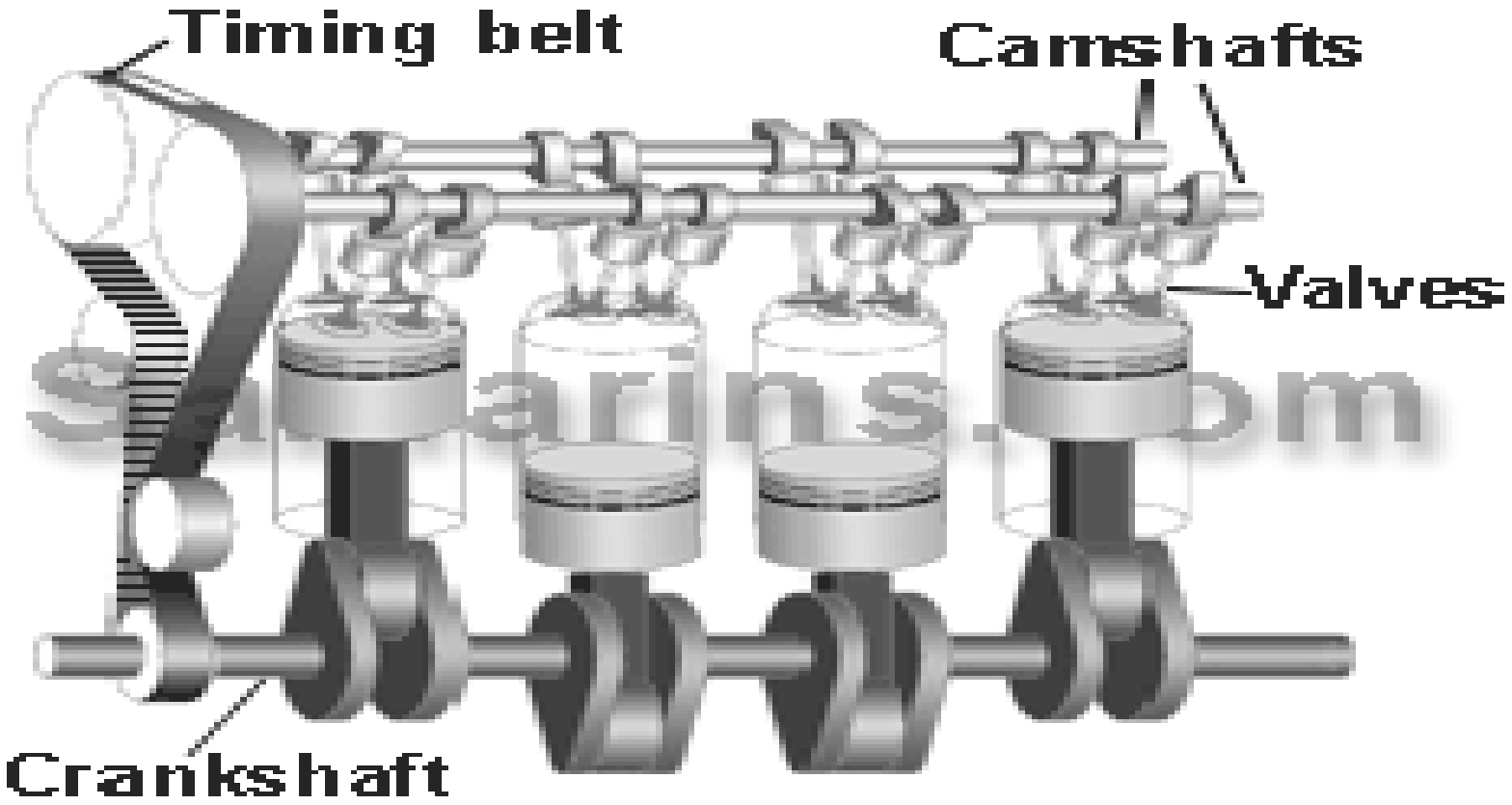
Overhead valves engine



Overhead camshaft



Multivalve engines



Valves

Intake valve is usually larger than exhaust valve
Why??????????

When intake valve is open, the only force moving air fuel mixture into the cylinder is atmospheric pressure.

Whereas when exhaust valve opens, there is still high pressure in the cylinder.
Smaller exhaust valve provides enough space for high pressure gases to escape out of the cylinder.

Valves

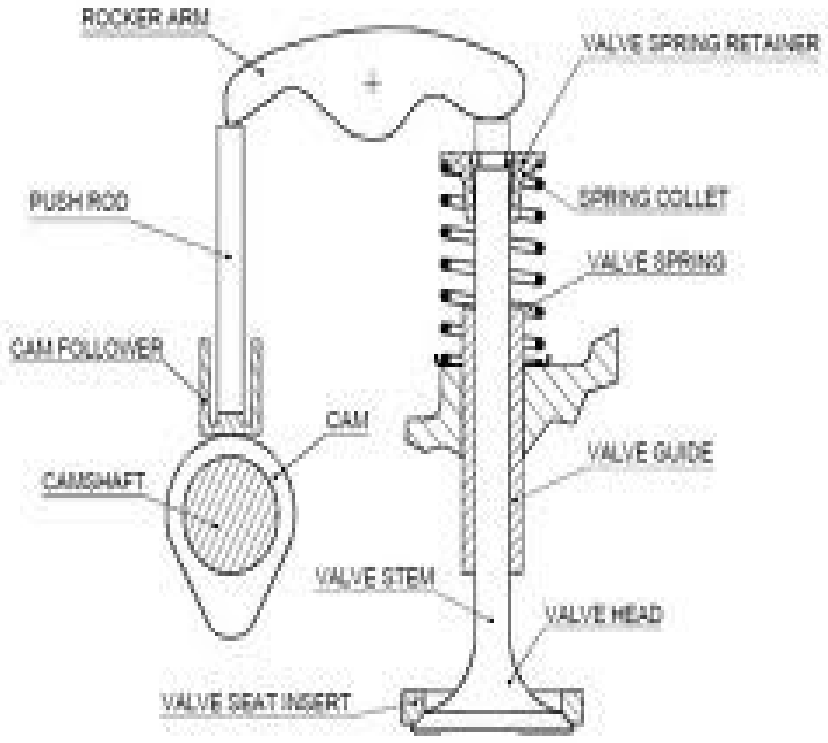


Fig. 2.2 Overhead valve drive

- Valve guides
- Valve seat
- Rocker arm
- Valve spring arrangement

What is important??????

- Valve cooling
- Valve rotation

Lubrication system

Purpose of Lubrication System

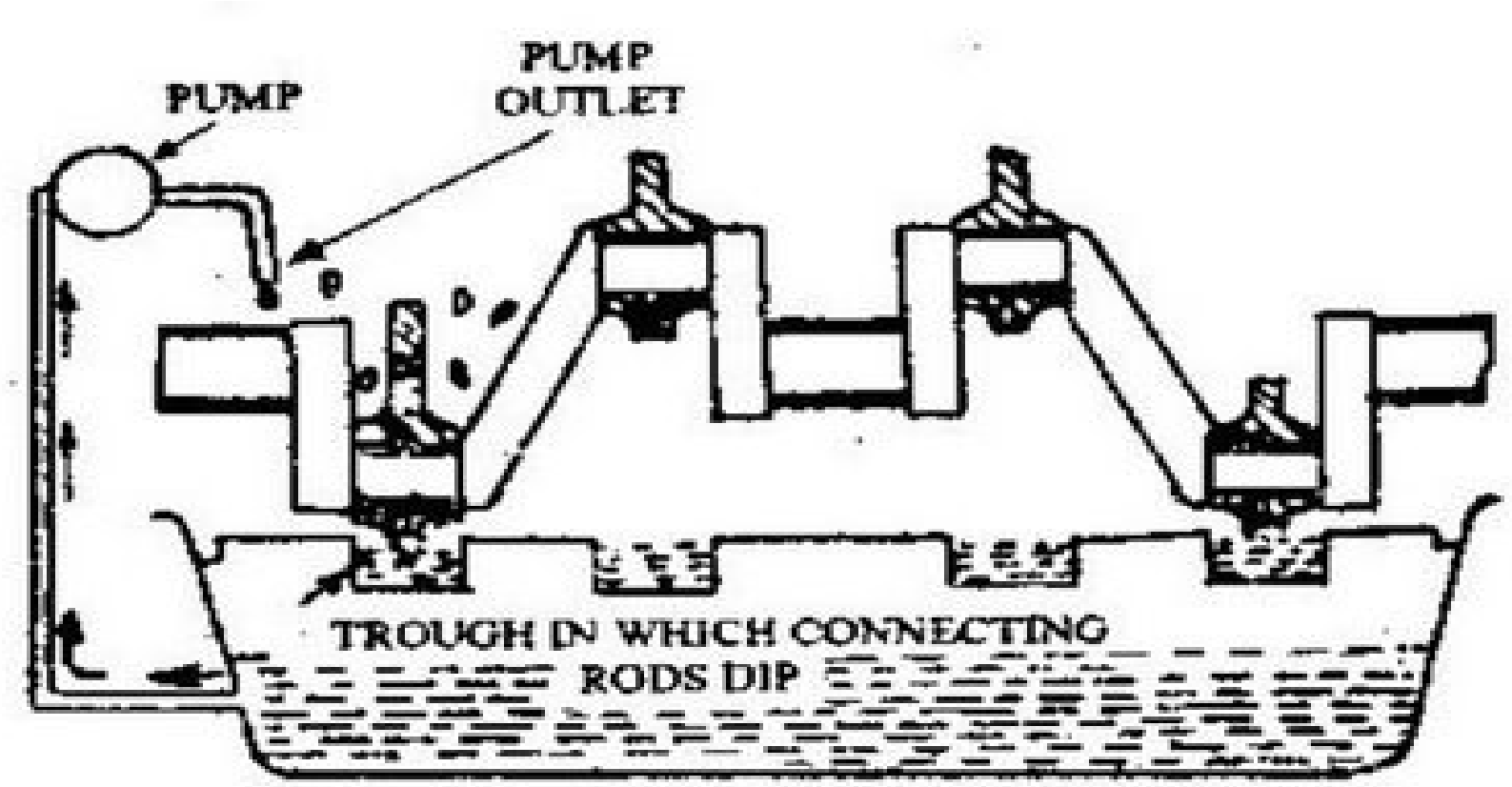
- Primary purpose is to reduce friction between moving parts(bearings and journals) by making a thin film.
- To insure that no metal to metal contact occurs.
- Friction and wear held to a minimum
- Oil film acts as a cushion between metal parts

Lubrication system

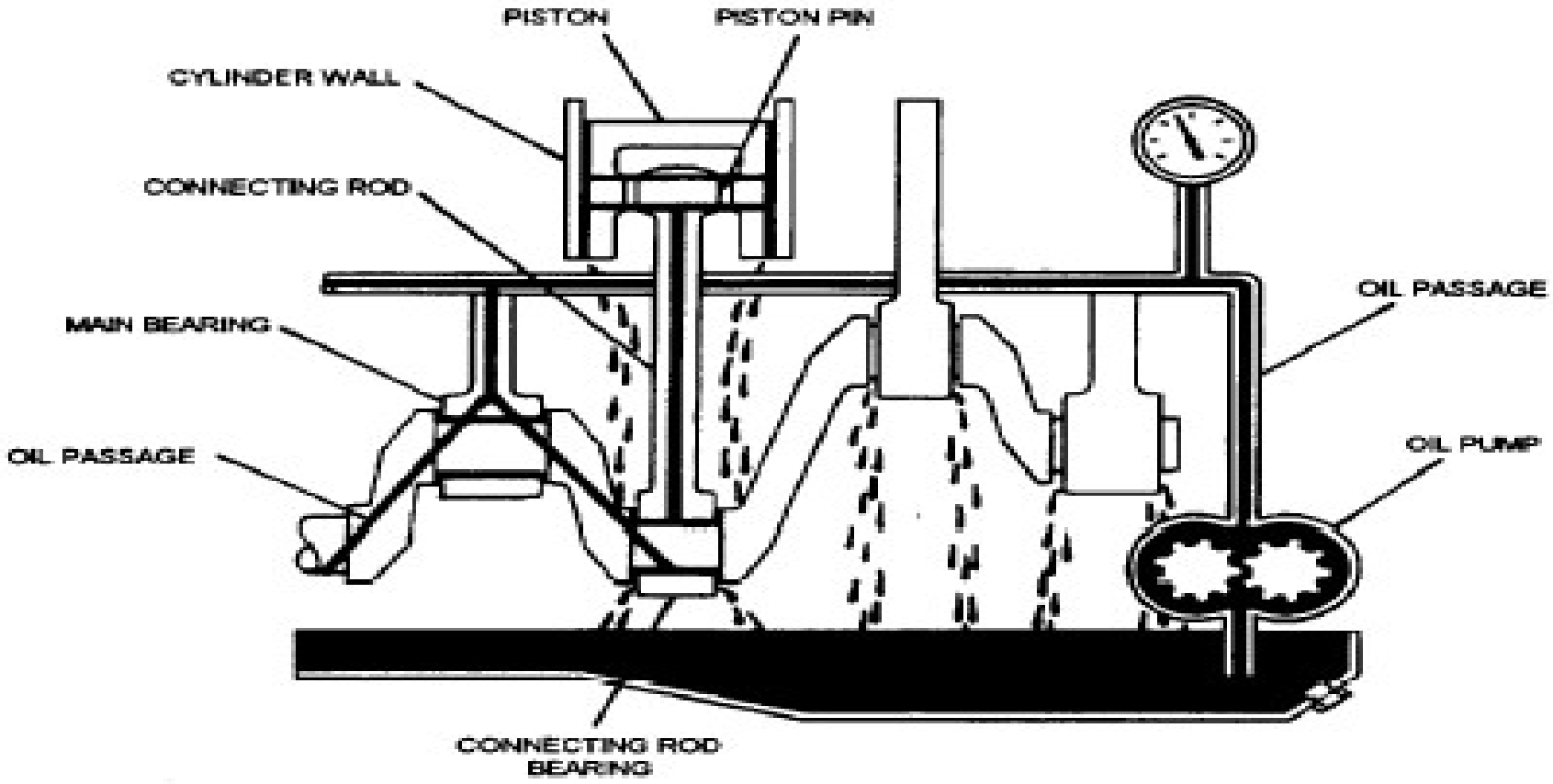
Purpose of Lubrication System

- Reduces friction between moving parts
- Cushions(Oil film between moving parts)
- Absorbs heat(piston and cylinder)
- Cooling
- Forms a seal(Between piston and cylinder walls)
- Reduces abrasive wear by filtering the oil to the oil filter
- Cleans

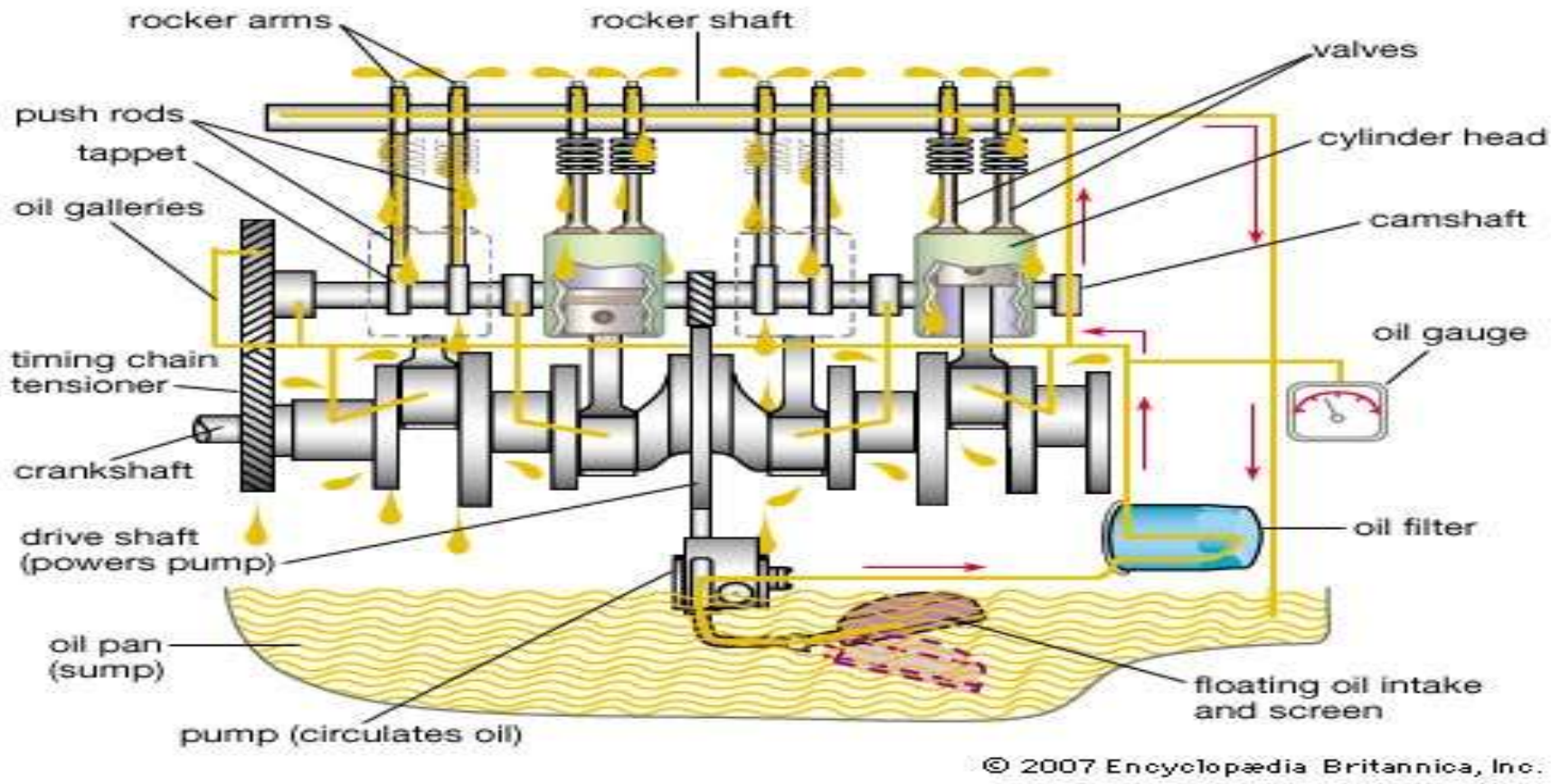
Lubrication system



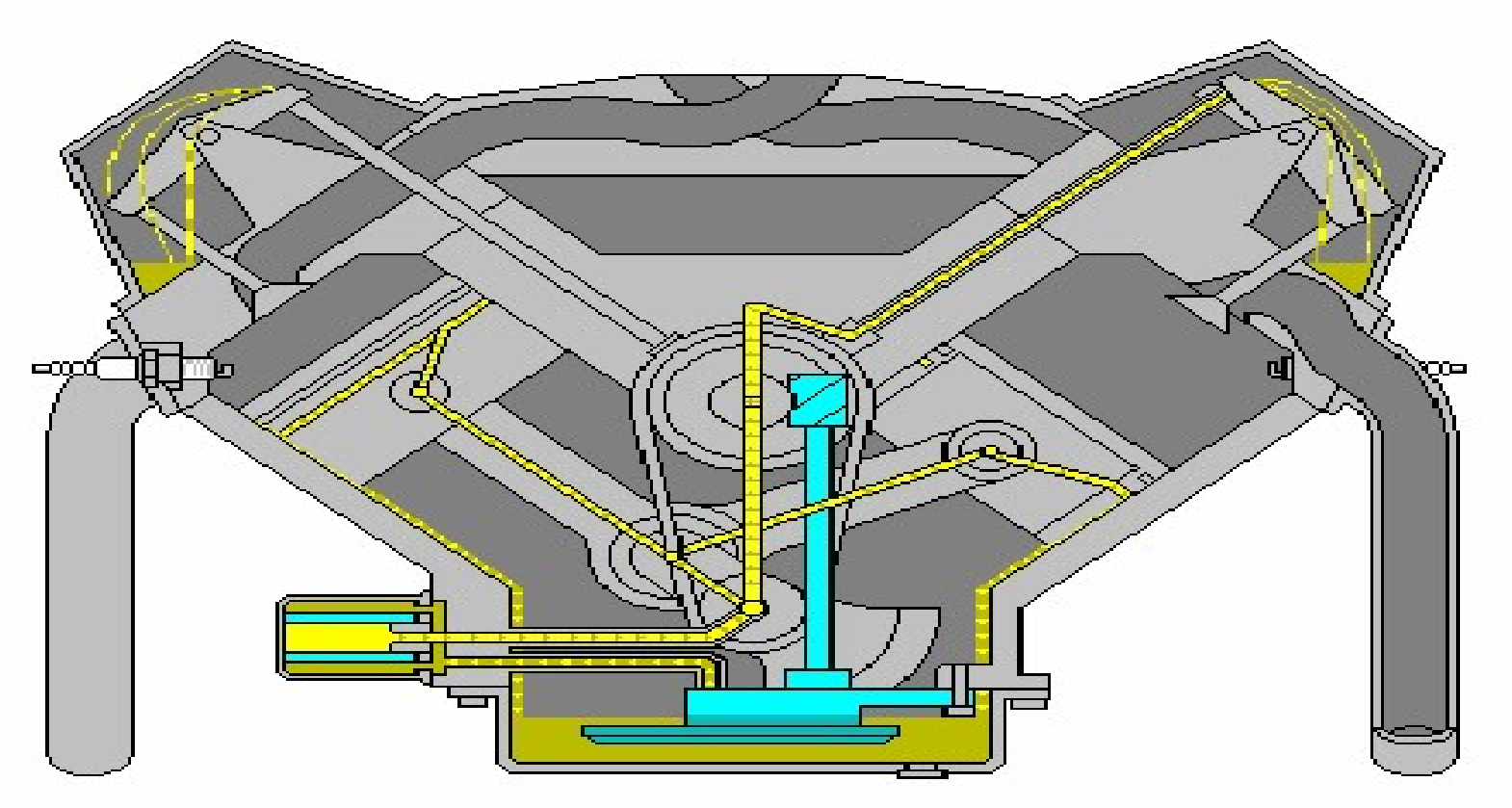
Lubrication system



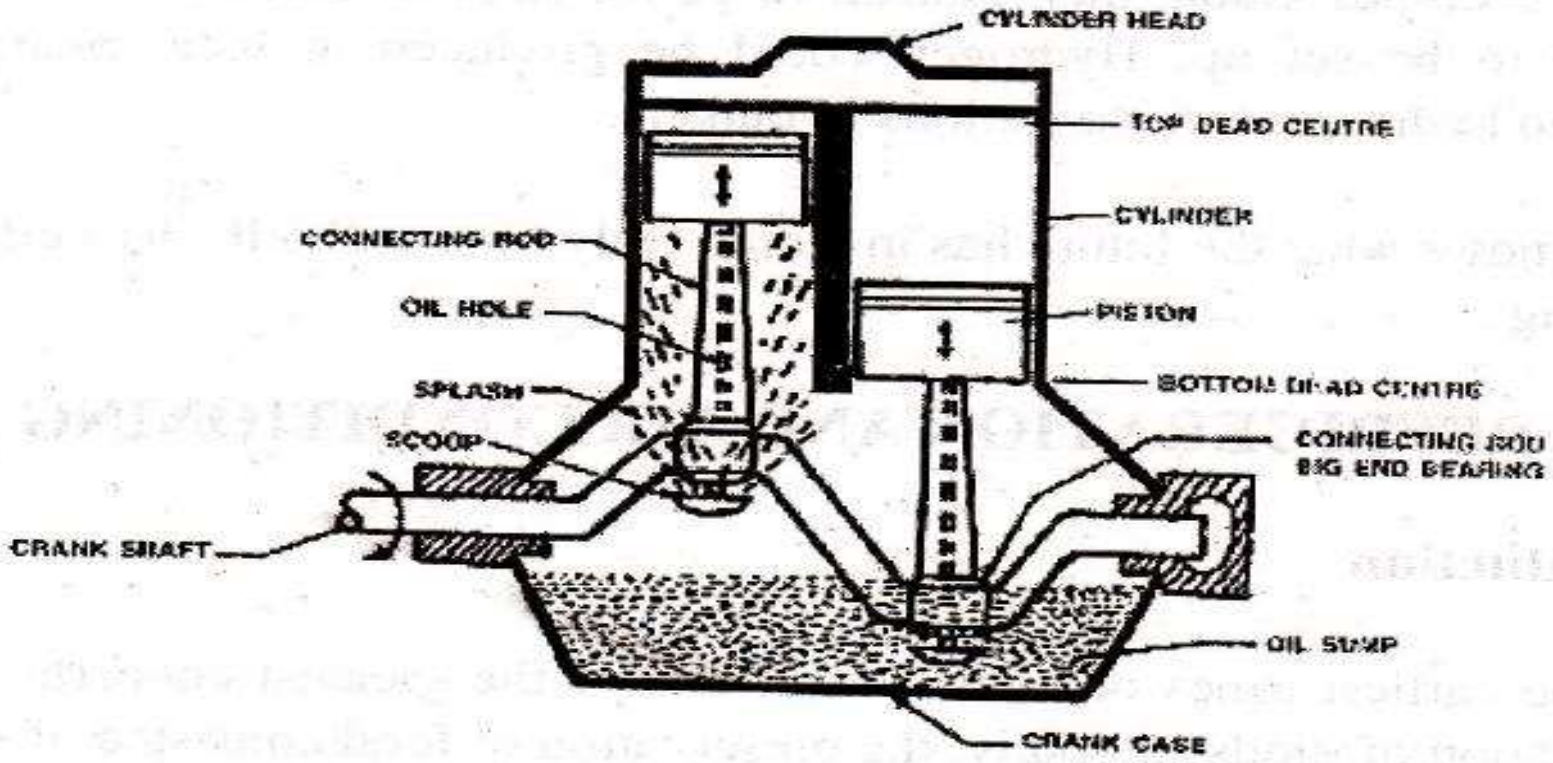
Lubrication system



Lubrication system



Splash Lubrication system



SPLASH LUBRICATION

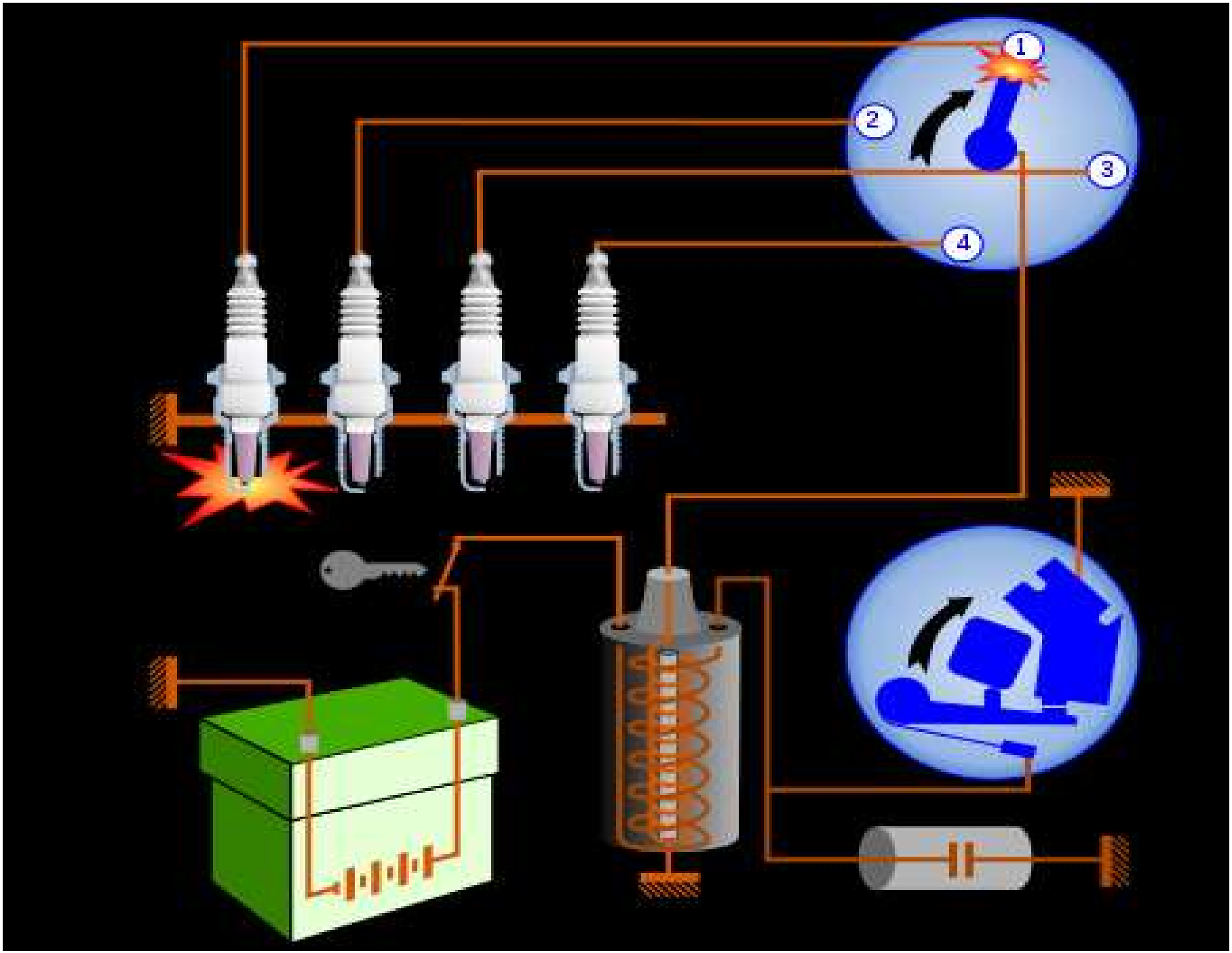
Ignition System

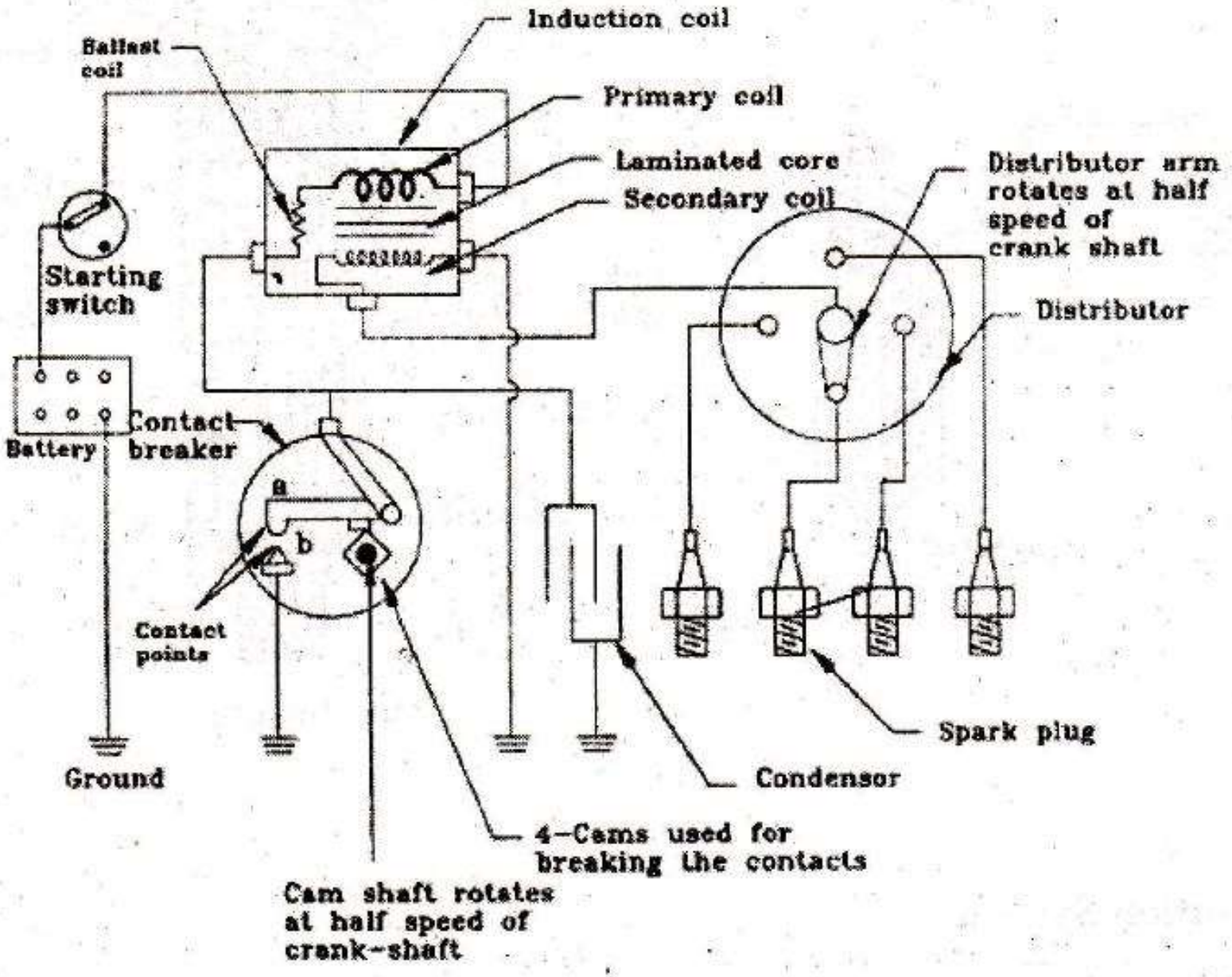
IGNITION FUNCTION

- **Produces 30,000 volt spark across spark plug**
- **Distributes high voltage spark to each spark plug in correct sequence**
- **Times the spark so it occurs as piston is nearing top dead center**
- **Varies spark timing with load, speed, and other conditions**

BASIC IGNITION SYSTEM COMPONENTS

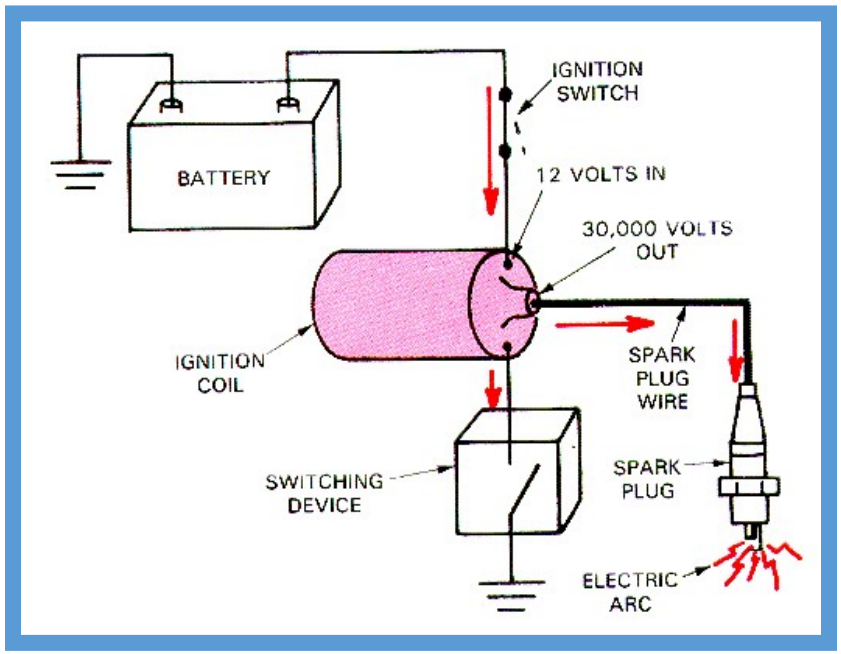
- **BATTERY**
- **IGNITION SWITCH**
- **IGNITION COIL**
- **SWITCHING DEVICE**
- **SPARK PLUG**
- **IGNITION SYSTEM WIRES**


1
2
3
4


Induction coil
Ballast coil
Primary coil
Laminated core
Secondary coil
Distributor arm rotates at half speed of crank shaft
Starting switch
Distributor
Battery
Contact breaker
a
b
Contact points
Spark plug
Ground
Condensor
4-Cams used for breaking the contacts
Cam shaft rotates at half speed of crank-shaft

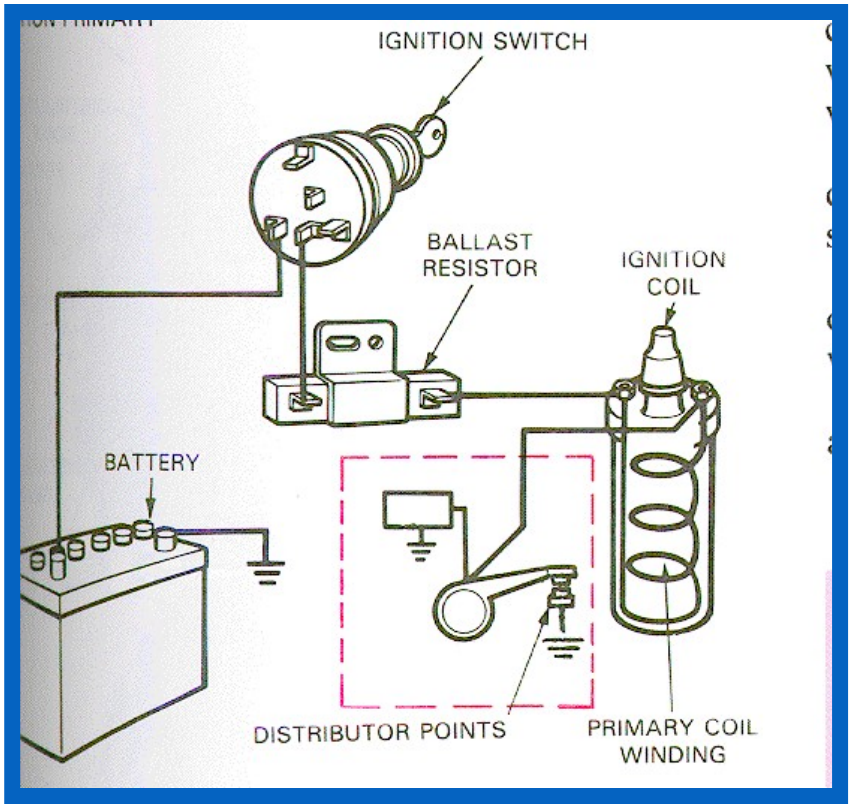
BASIC IGNITION SYSTEM

- **Battery supplies power to entire system**
- **Ignition Switch turns engine on or off**
- **Coil transforms volts**
- **Switching device triggers ignition coil**
- **Spark Plug and wires distribute spark**



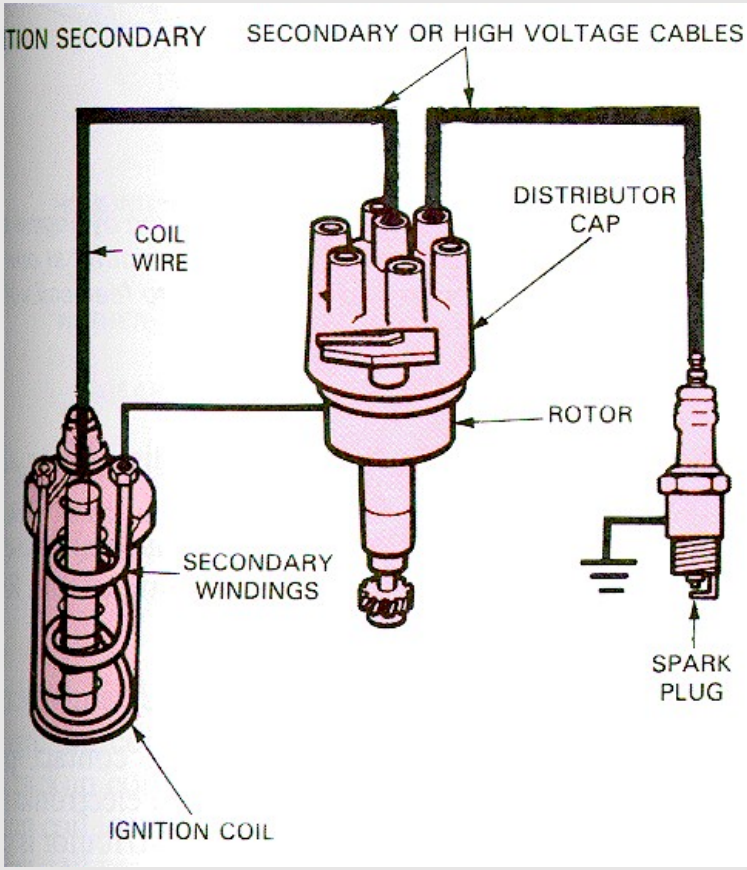
PRIMARY CIRCUIT

- **Consists of low voltage wiring and components**
- **Uses conventional type automotive primary wires**
- **Controls when ignition will take place. (When coil fires)**



SECONDARY CIRCUIT

- **Distributes current to individual cylinders to jump spark plug gap**
- **Must have thicker, heavier insulation on wires**
- **Typical voltage to jump gap - 10K Volts**



Ignition Components

- Primary Winding
  - Thick wire that is wrapped around the core between 150 and 200 times.
  - The primary winding is the low voltage wire that carries 6-12 volts

Ignition Components

- Secondary Windings
  - Thin wire that is wrapped around the primary winding about 20,000 times
  - The secondary winding is the high voltage wire that carries 20,000 – 40,000 volts

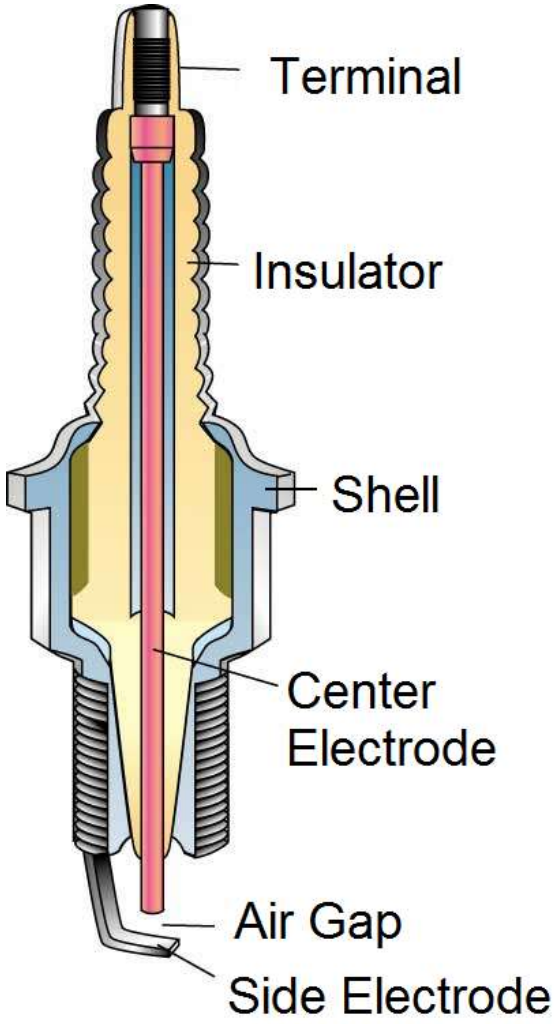
Ignition Components

- Low Voltage Lead – carries low voltage from the battery or armature to primary side of coil

- High Voltage Lead – carries high voltage from the secondary side of the coil to the spark plug

Ignition Components

- Spark Plug
  - provides a gap for electricity to jump across, producing a spark that will ignite the engine's fuel



Basic Ignition System Operation

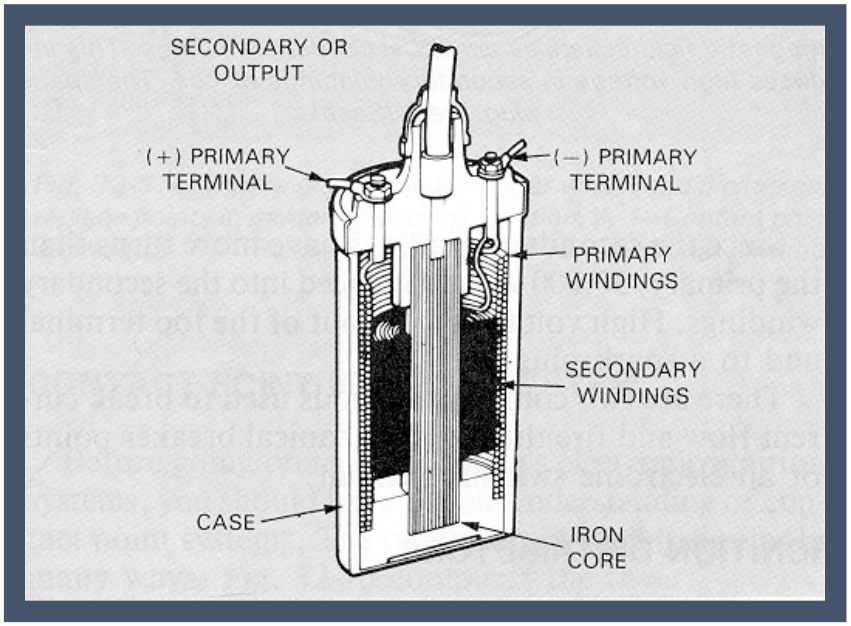
- As starting switch is on.. The current flow from the battery to primary coil

Basic Ignition System Operation

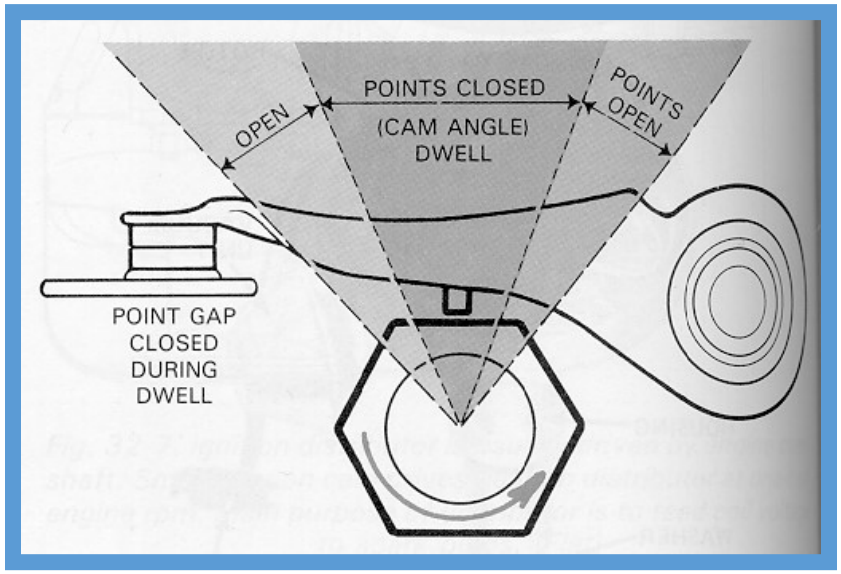
- When the current flow through the primary winding is stopped the magnetic field collapses rapidly and will induce a high voltage current in the secondary winding.
- The current then runs directly to the spark plug and causes a spark to jump across the spark plug gap.

IGNITION COIL

- **TRANSFORMER**
- **2 SETS OF WINDINGS**
  - **Primary windings**
  - **Secondary windings**
- **IRON CORE**
- **PRODUCES MAGNETIC FIELD**



DWELL (CAM ANGLE)



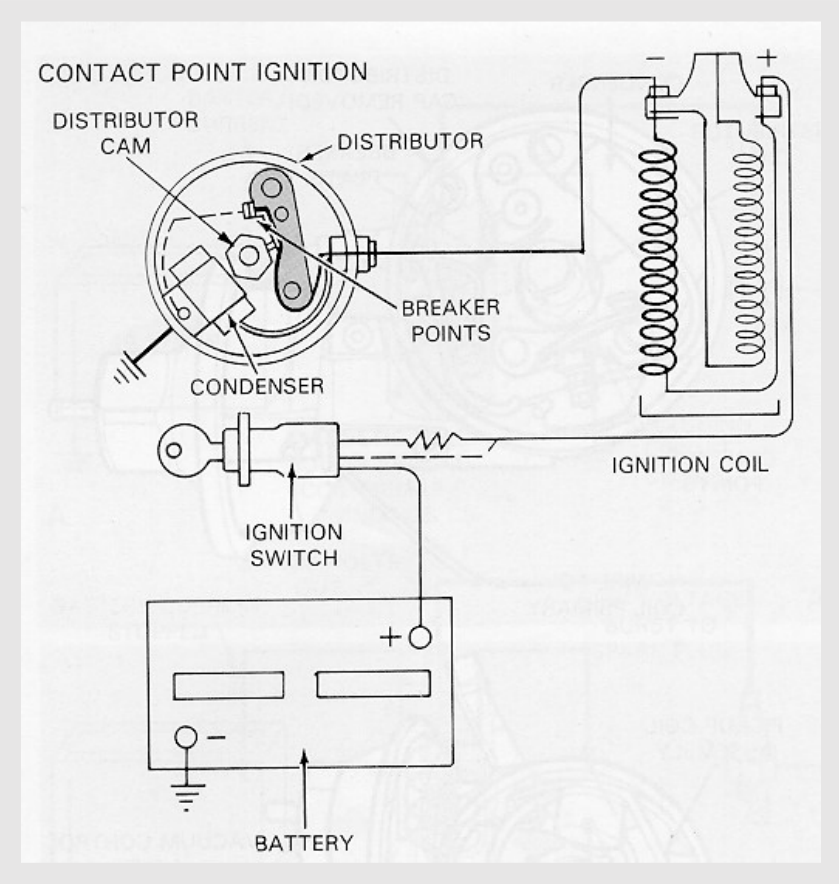
- **Amount of time in distributor degrees that points remain closed between each opening**
- **Coil saturation time is controlled by amount of dwell**

IGNITION SYSTEM TYPES

- **CONTACT POINT IGNITION SYSTEM**
- **ELECTRONIC IGNITION SYSTEM**
- **DISTRIBUTORLESS IGNITION SYSTEM**

CONTACT POINT SYSTEM

- **Distributor turns 1/2 engine rpm**
- **Distributor Cam**
- **Contact Points**
- **Condenser**
- **Point Dwell (Cam angle)**
- **Basis for all Systems**



Ignition system

Purpose of ignition system:

• To ignite the compressed air fuel mixture in the engine combustion chambers.

• This should occur at proper time for combustion to begin.

Ignition system may be either

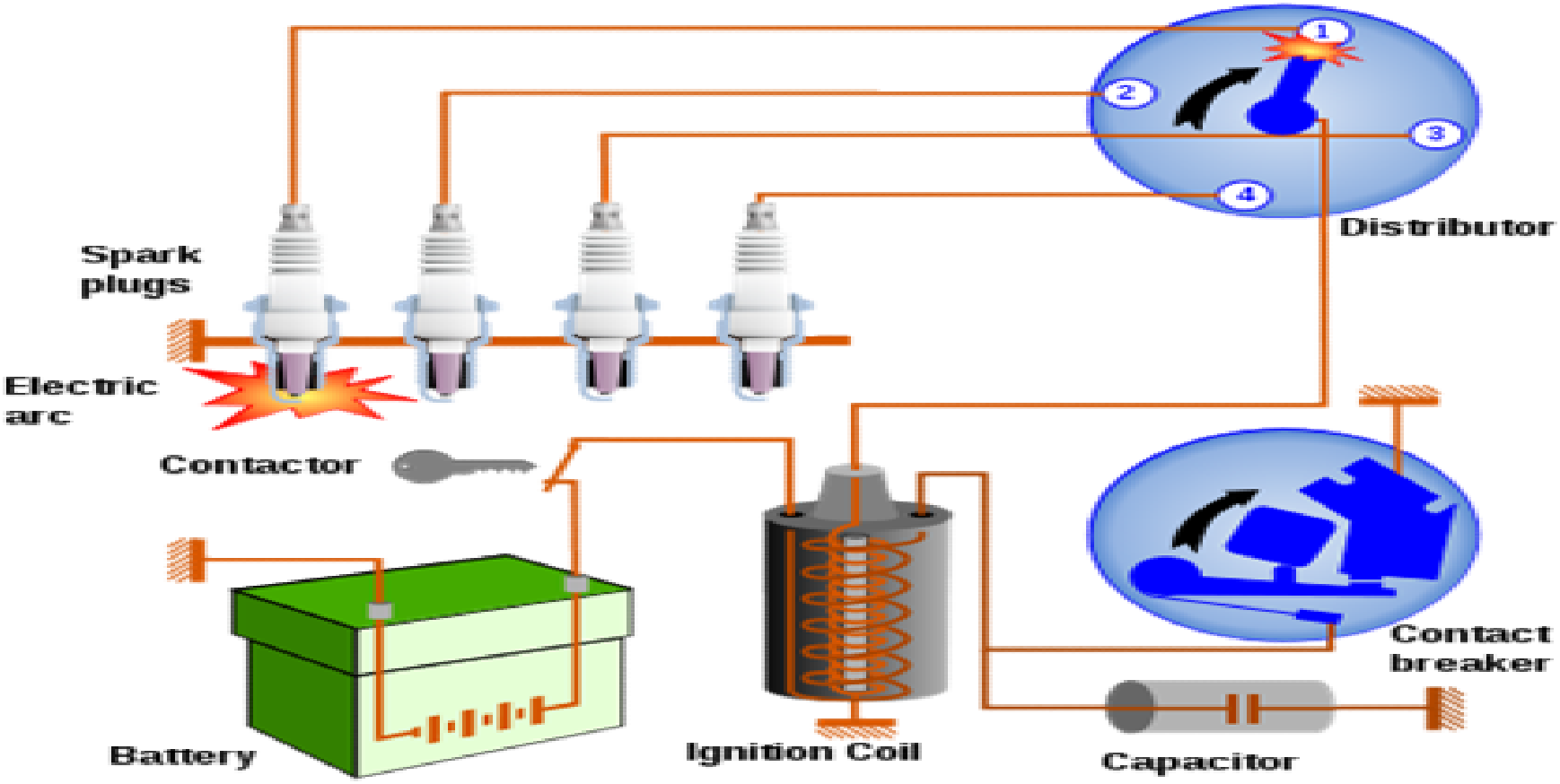
- Contact type ignition system
- Electronic ignition system

Contact point ignition system

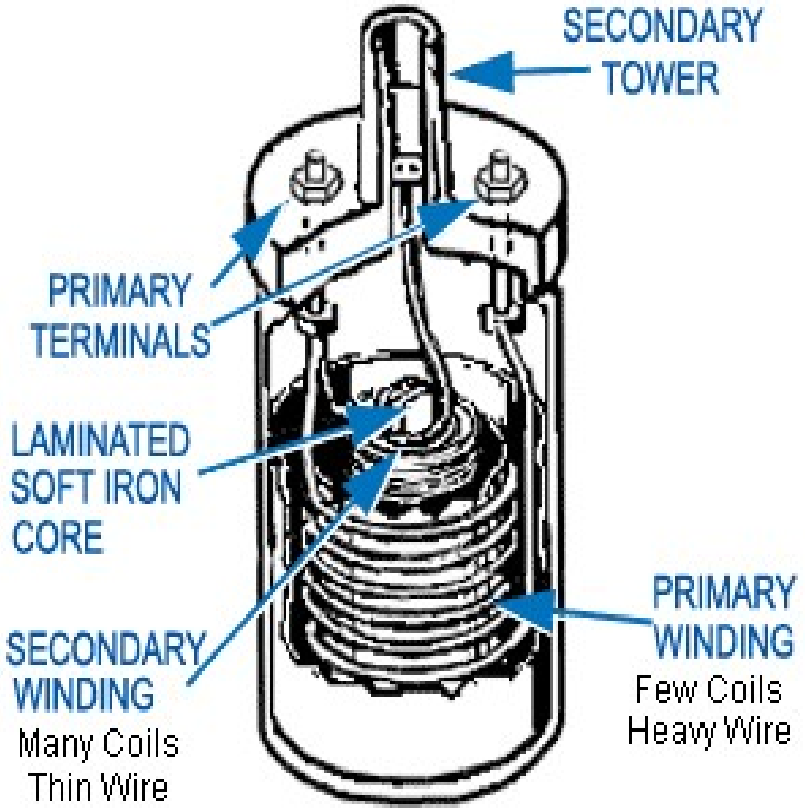
Components:

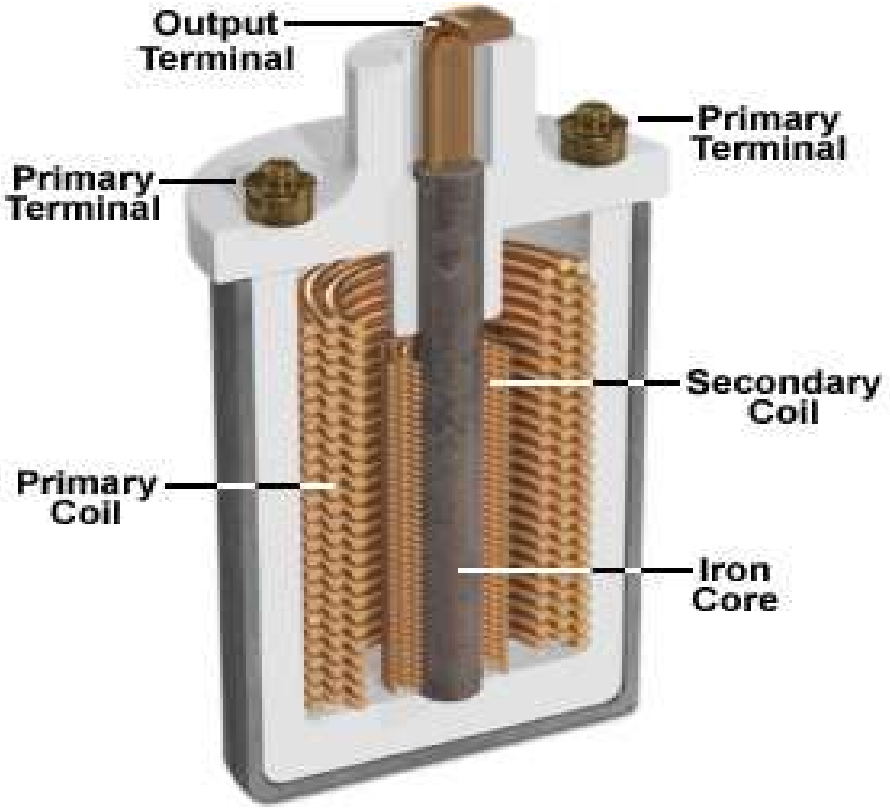
- Ignition switch
- Ignition coil
- Ignition distributor
- Secondary ignition cables
- Spark plugs

Contact point ignition system

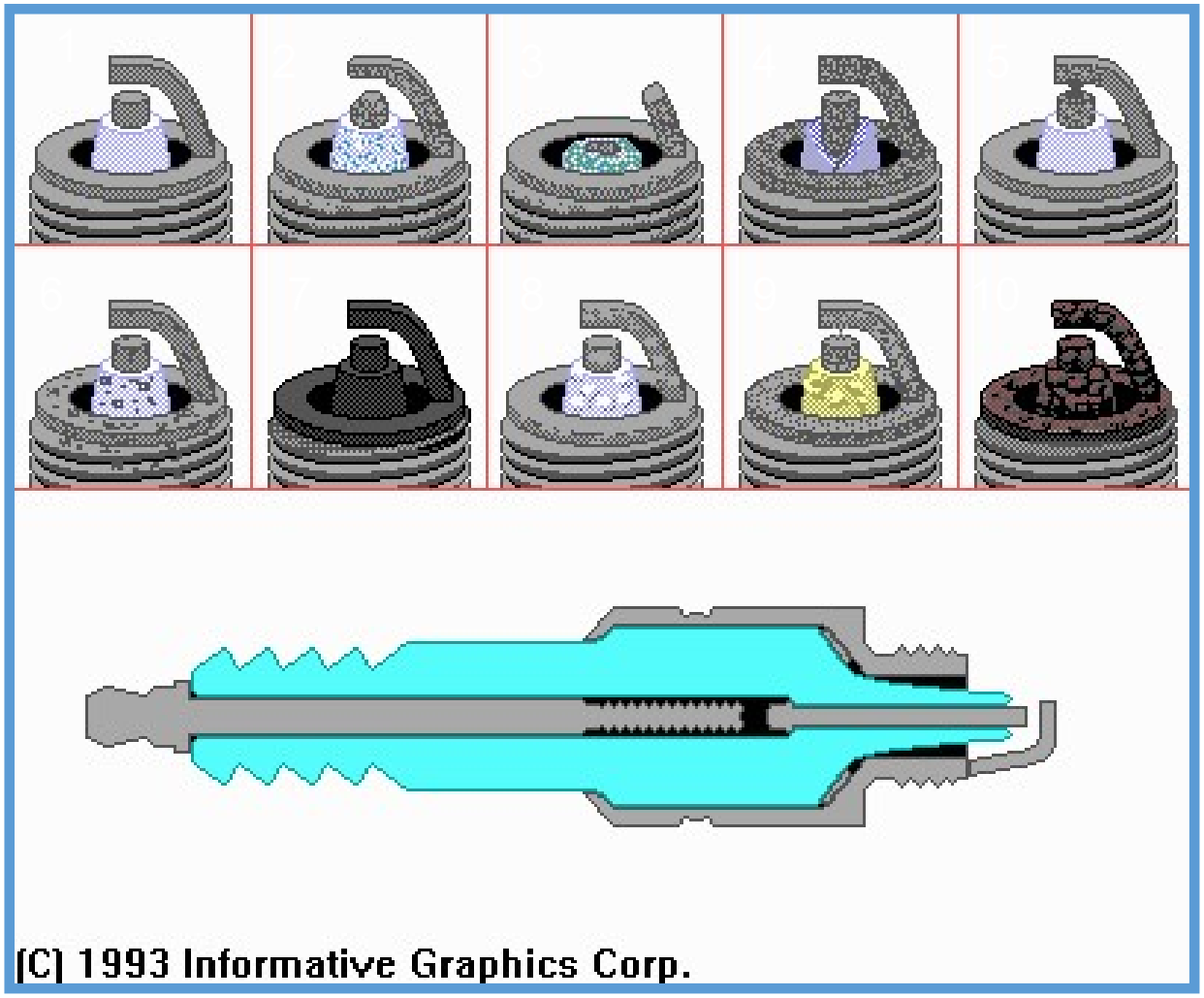


Contact point ignition system





1. Normal
2. Overheated
3. Pre-ignition
4. Cracked insulator
5. Bridged gap
6. Deposit fouled
7. Carbon glazed
8. Splashed
9. Glazed
10. Oil fouled



FAQ

1. What are the various parts of engine?
2. CRDI stands for?
3. How carburetor work in petrol engine?
4. What type of fuel system used in diesel engine?

Refrences

- *"Motor". Dictionary.reference.com. Retrieved 2011-05-09. a person or thing that imparts motion, esp. a contrivance, as a steam engine, that receives and modifies energy from some source in order to utilize it in driving machinery.*
- **Jump up^** Dictionary.com: (World heritage) "3. any device that converts another form of energy into mechanical energy so as to produce motion“
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