AUTOMOBILE ENGINEERING

UNIT -1

- INTRODUCTION

INTRODUCTION

- History
- Basic Structure
- General Layout and types of automotive vehicles
- Frameless and unitary Construction
- Position of Power unit

History Of The Automobile

History

- The first car was built by Joseph Cugnot in 1769. It was powered by a steam engine and was very slow.
- Jean Joseph Étienne Lenoir was the first to build the one cylinder engine, internal-combustion engine, was later patent.
- Nikolaus August Otto built the first four cylinder engine.
- In 1886 Gottlieb Daimler designed the first four wheeled automobile. They also created the first v-slanted engine.
- Karl Benz, know as one of the founders of Mercedes-Benz, is the first to build an automobile powered by an internal combustion engine.
- Gottlieb Daimler and Wilhelm Maybach with Benz’s manufacturing firm in 1926 to create Daimler-Benz. The joint company makes cars today under the Mercedes-Benz nameplate, and Daimler Chrysler

History

- Henry Ford, a famous car company founder, manufactured over 15 million Model Ts by 1927
- Hybrid cars have also been around since the 1900’s.
- In the 1900’s Ford made more steam and electric cars than it did gasoline.
- The first hybrid commercial truck was built in 1910, and as the gasoline engine was refined interest in hybrids died down.
- As problems with environment and gas process continue, Hybrids are now a hot commodity in the market place and are now the new wave of future cars

SYSTEMS IN AN AUTOMOBILE

A. POWER TRAIN SYSTEM

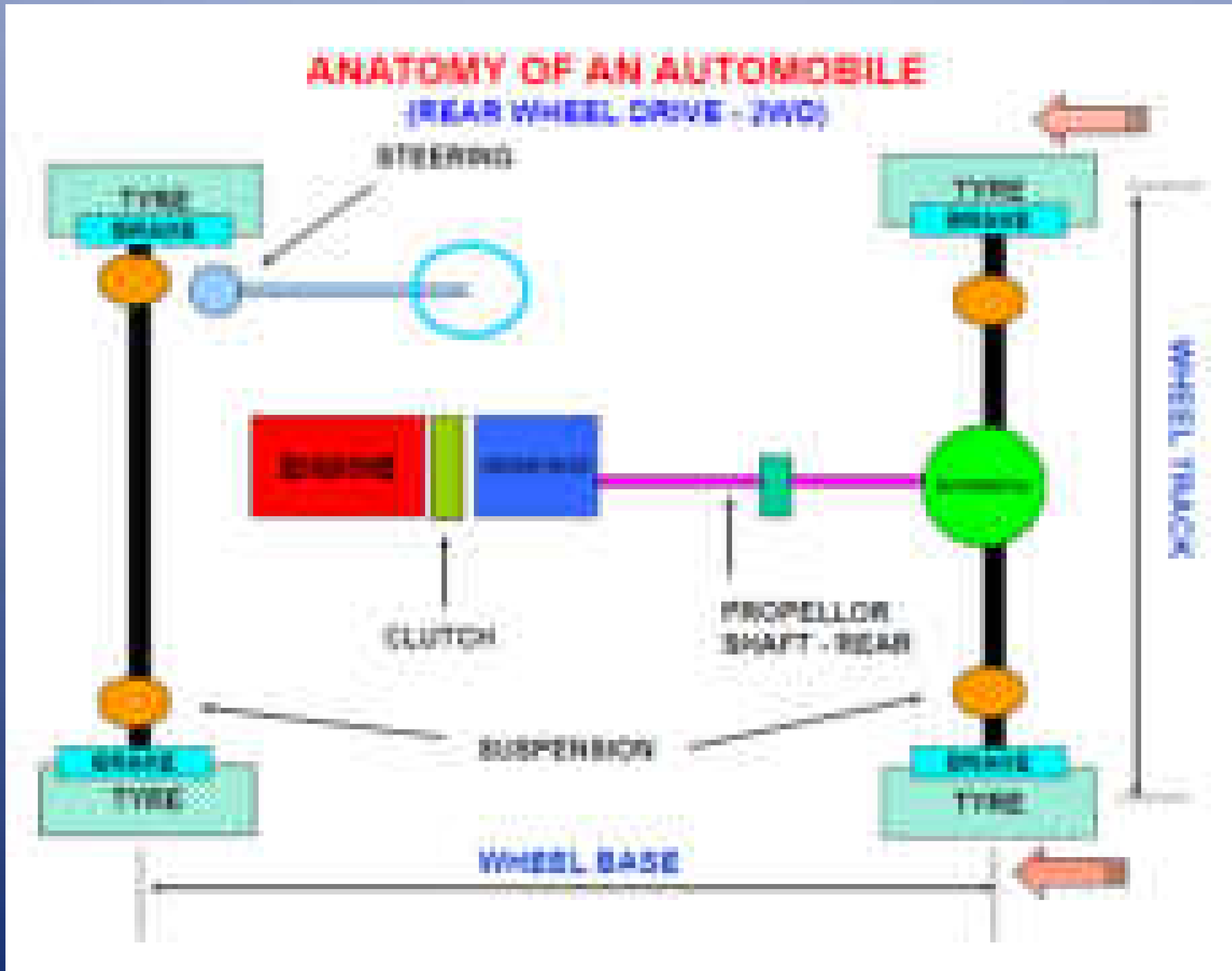
- POWER PLANT (POWER GENERATION - ENGINE)
  - ENGINE
  - FUEL SYSTEM
  - INTAKE SYSTEM
  - EXHAUST SYSTEM
  - COOLING SYSTEM
- DRIVE LINE (POWER TRANSMISSION)
  - CLUTCH
  - GEAR BOX/TRANSMISSION
  - TRANSFER CASE
  - DIFFERENTIAL
  - WHEELS/TYRES

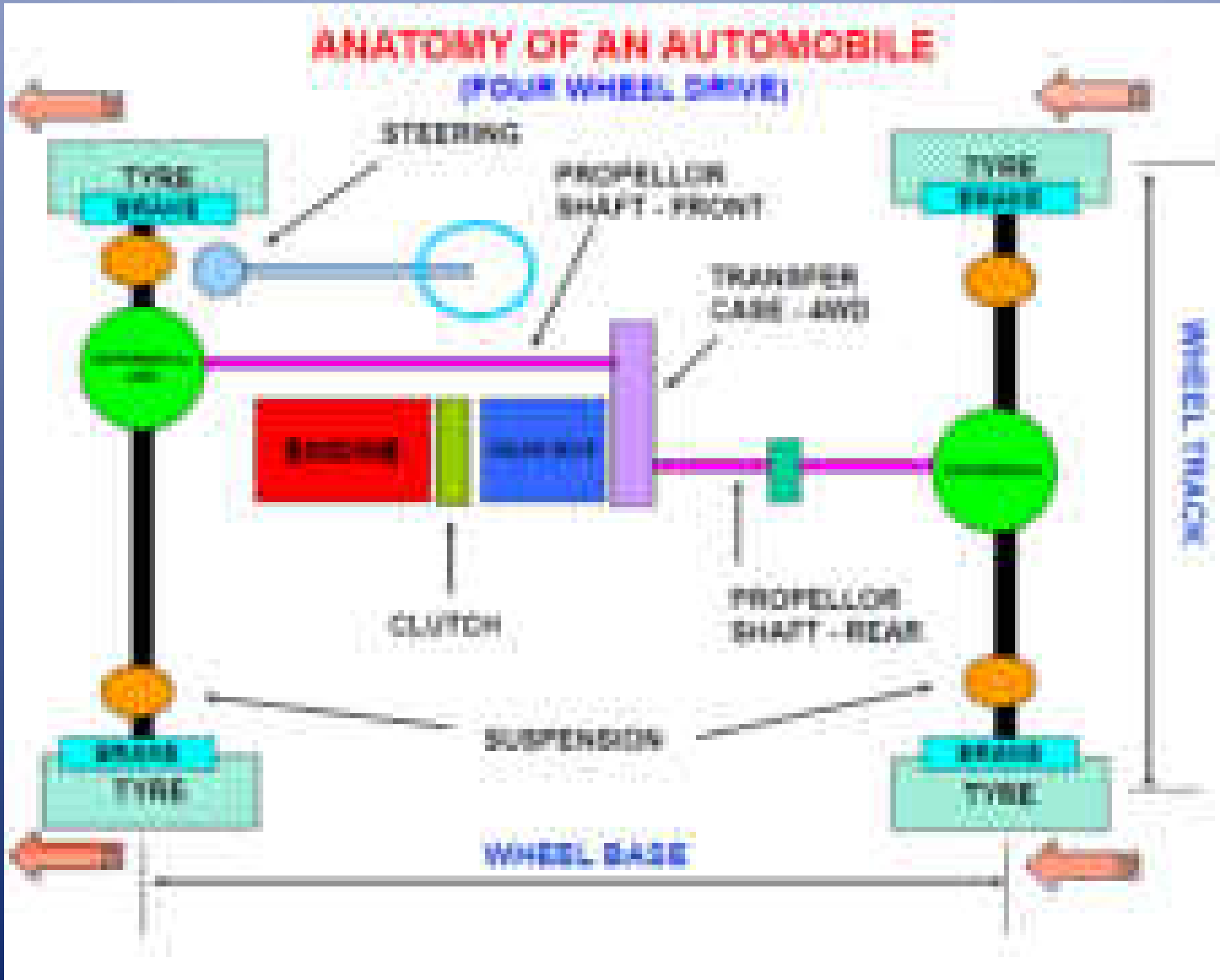
B. RUNNING SYSTEM

- SUSPENSION
- STEERING
- BRAKING

C. COMFORT SYSTEM

- HVAC/AC/HEATER SYSTEM
- SEATING/UPHOLSTRY/FACIA/INSTRUMENTS
- AUDIO/VIDEO/GPS

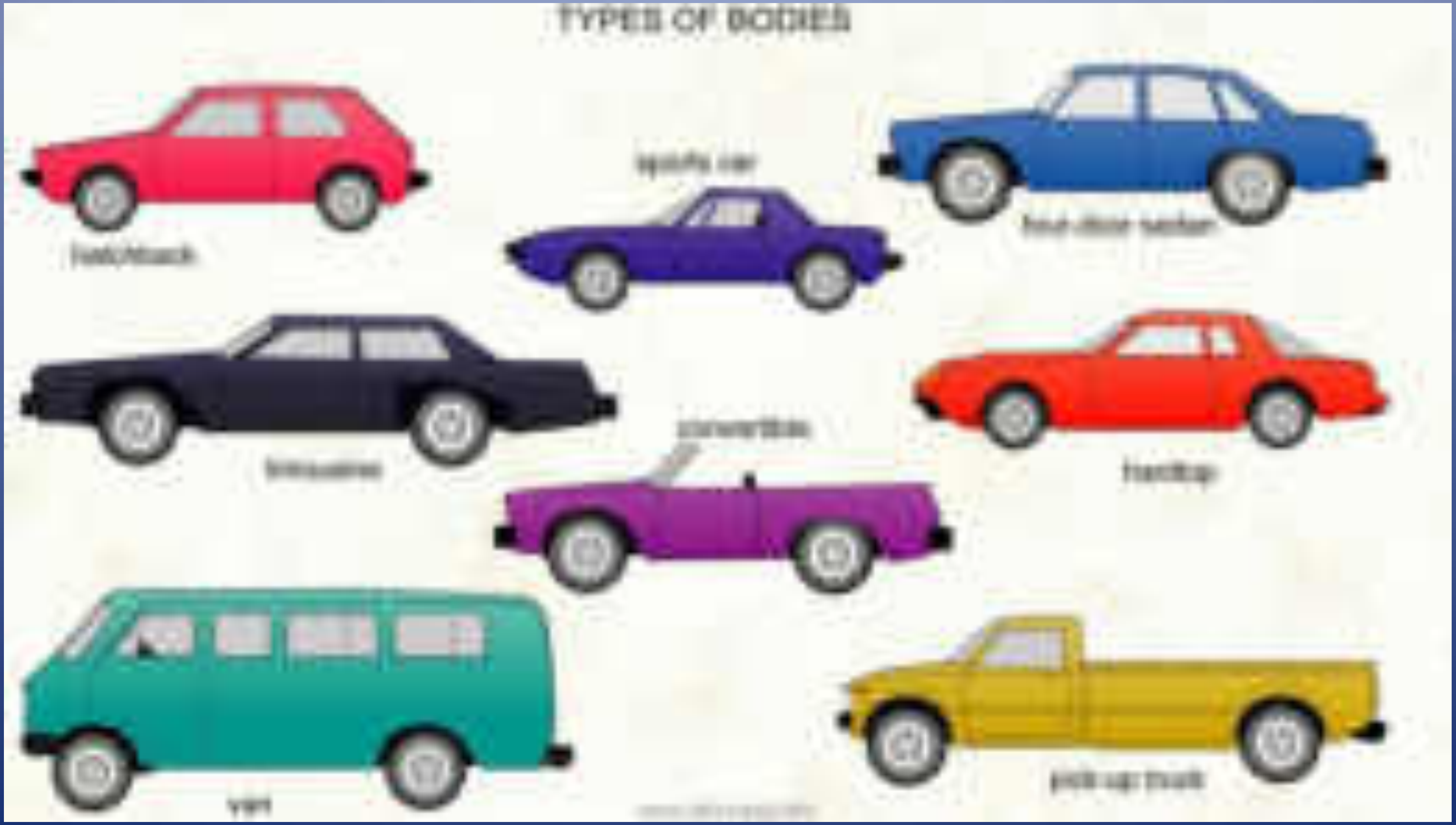

ANATOMY OF AN AUTOMOBILE
(REAR WHEEL DRIVE - 2WD)
STEERING
TYRE
BRAKE
TYRE
BRAKE
CLUTCH
PROPELLOR SHAFT - REAR
SUSPENSION
BRAKE
TYRE
BRAKE
TYRE
WHEEL BASE
WHEEL TRACK


ANATOMY OF AN AUTOMOBILE
(FOUR WHEEL DRIVE)
STEERING
PROPELLOR
SHAFT - FRONT
TRANSFER
CASE - 4WD
TYRE
BRAKE
ENGINE
CLUTCH
PROPELLOR
SHAFT - REAR
SUSPENSION
WHEEL TRACK
WHEEL BASE

Classification of Automobiles

1. Purpose
2. On the basis of load
3. Wheels
4. Fuel used
5. Body
6. Transmission
7. Based on the side of drive

Automobile Body Types



Chassis

- Chassis is a French term and was initially used to denote the frame parts or Basic Structure of the vehicle.
- A vehicle with out body is called Chassis.
- The components of the vehicle like Power plant, Transmission System, Axles, Wheels and Tyres, Suspension, Controlling Systems like Braking, Steering etc., and also electrical system parts are mounted on the Chassis frame.

Function of Chassis frame:

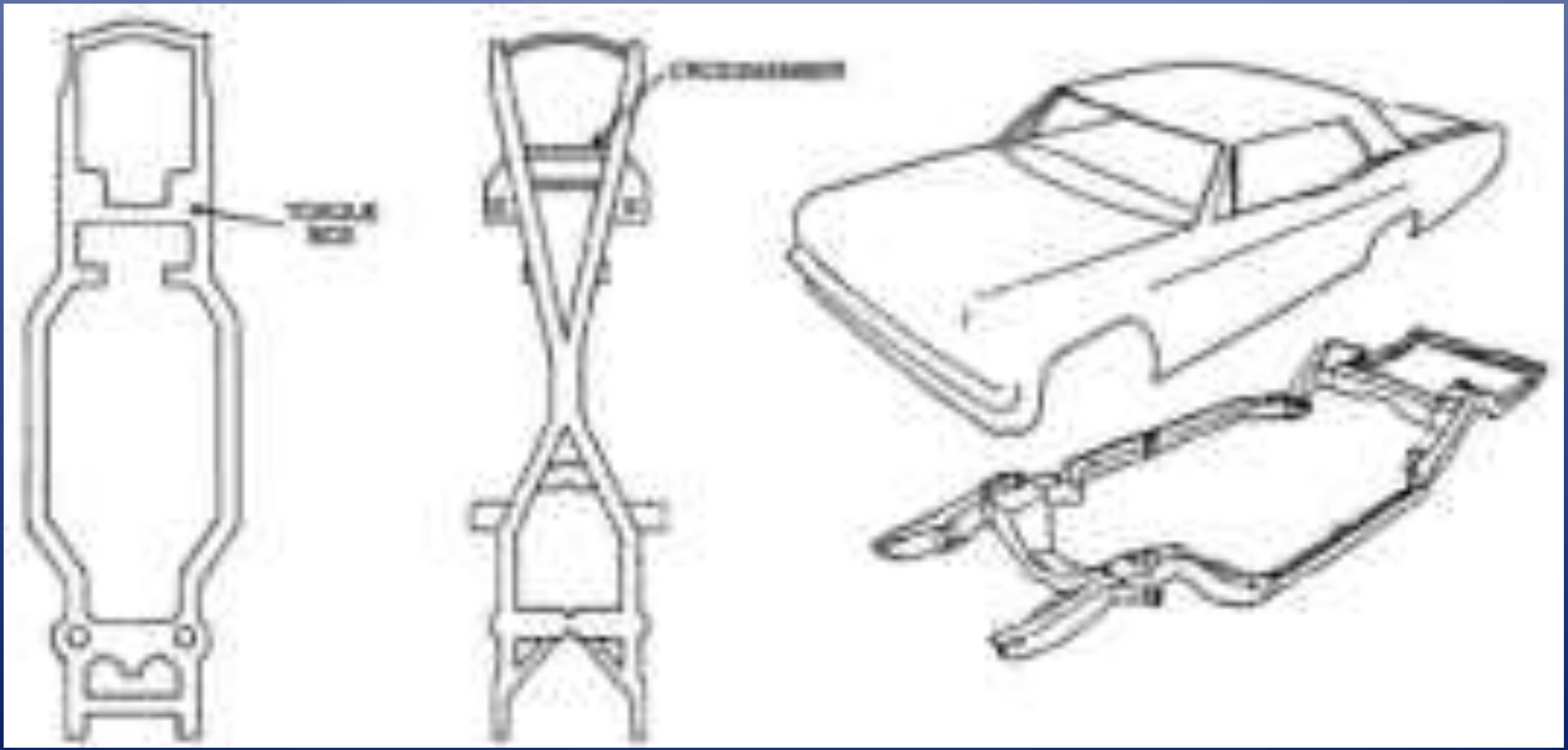
1.To carry load of the passengers or goods carried in the body.
2.To support the load of the body, engine, gear box etc.
3.To withstand the forces caused due to the sudden braking or acceleration
4.To withstand the stresses caused due to the bad road condition.
5. To withstand centrifugal force while cornering

Types of Chassis frame:

- Conventional Frame
- Frameless/Integral Frame
- Semi Integral frame

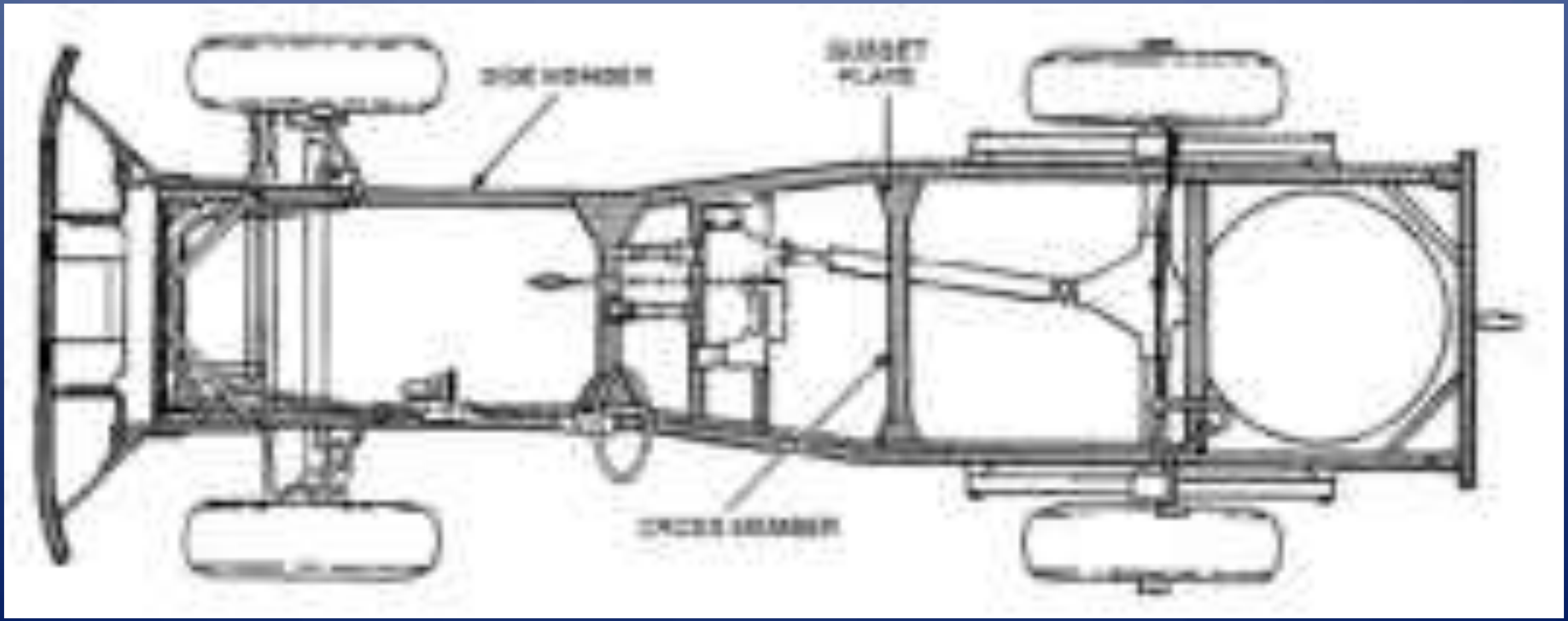
Conventional Frame:

- It is also known as non load carrying frame. Here loads on the vehicles are transferred to the suspensions by frame.
- This type of frame is not suited to resist torsion.



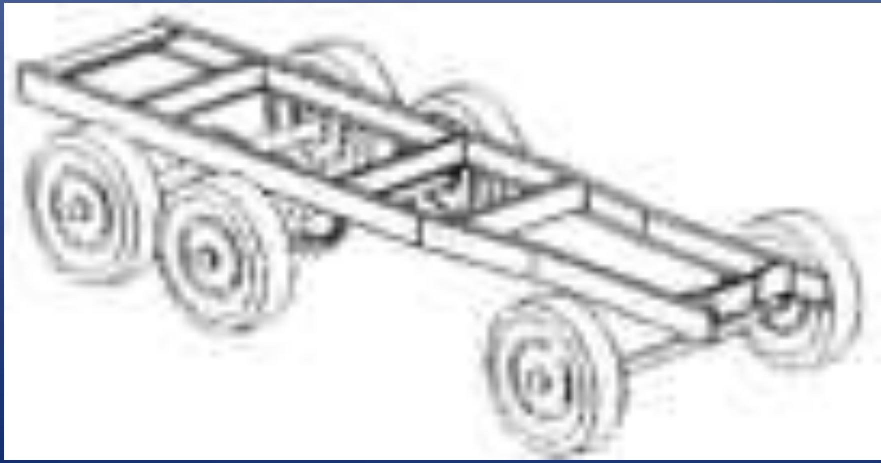
The SIDE MEMBERS or rails are the heaviest part of the frame. The side members are shaped to accomodate the body and support the weight. They are narrow toward the front of the vehicle to permit a shorter turning radius.

The CROSS MEMBERS are fixed to the side members to prevent weaving and twisting of the frame. The number, size and arrangement of the cross members depend on the type of vehicle for which the frame was designed.



Ladder frame:

- The ladder frame is the simplest and oldest of all designs.
- It consists merely of two symmetrical rails
- This design offers good beam resistance because of its continuous rails from front to rear
- Poor resistance to torsion



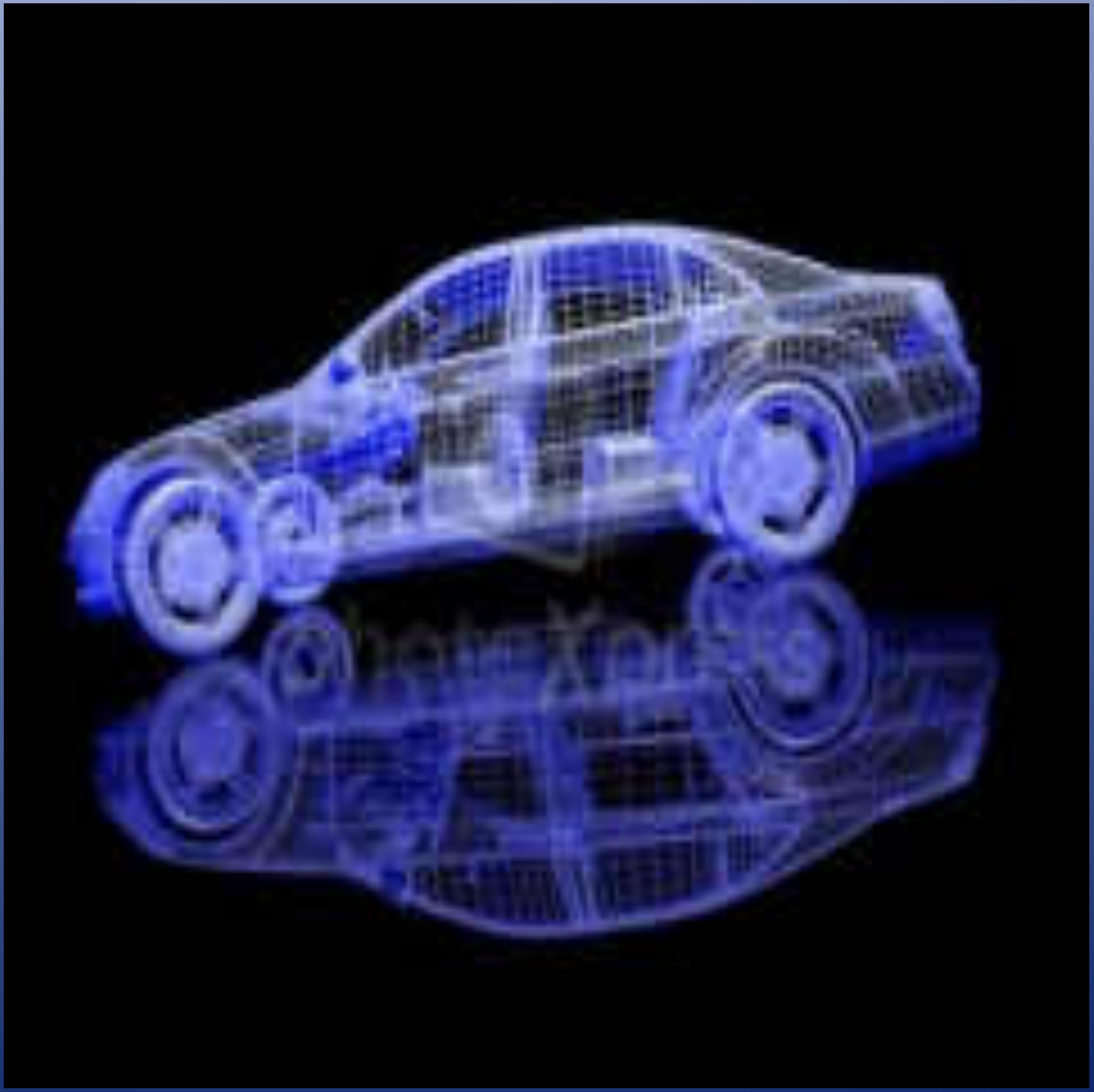
Semi Integral Frame:

- In some vehicles half frame is fixed in the front end on which engine gear box and front suspension is mounted.
- It has the advantage when the vehicle is met with accident the front frame can be taken easily to replace the damaged chassis frame.
- This type of frame is used in some of the European and American cars.

Integral Frame:

- In this type of construction there is no frame and all assembly units are attached to the body.
- The chassis , floor and body are assembled by from a large number of mild steel pressings.
- This is the modern form of construction for almost all cars and lighter commercial vehicles.

Integral Frame



Pros and cons of frameless construction:

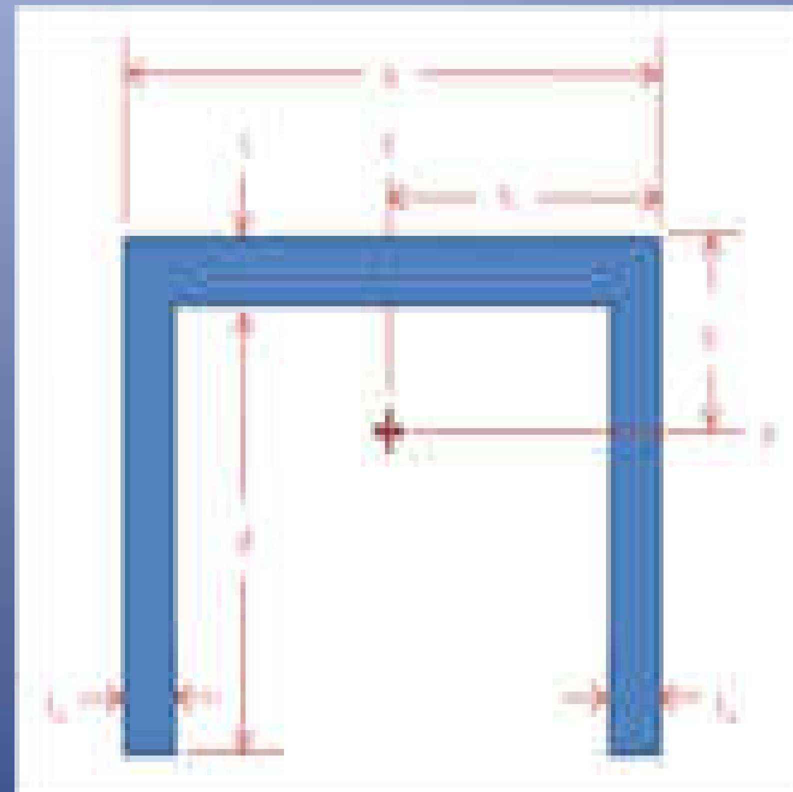
- Drastic decrease in weight, leads to more fuel efficiency
- Manufacturing costs are much lower than those of the traditional ways of frames.
- Better collision properties due to which the entire frame crumbles and absorbs the body shocks in an event of a collision, providing better safety to the passengers.
- Better stability and handling characteristics for the vehicle.

- Disadvantages · Owing to newer and lighter materials being used, there is a minor reduction in strength and durability for the vehicles.
- The economy would be possible only if the frameless construction production can be carried out in mass.
- During accidents, the damages are usually severe and hence there is a marked increase in the costs incurred.
- The frameless construction isn't a feasible option for a lot of vehicle types -- like Roadsters, jeeps and commercial vehicles.

Frame are made of following sections :

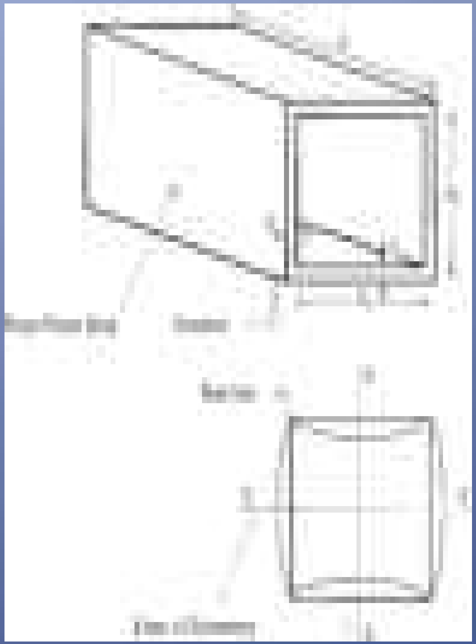
- Channel Section – Good resistance to bending
- Tubular Section – Good resistance to Torsion
- Box Section – Good resistance to both bending and Torsion

• ***Channel sections***



Used in long section of the frame

- ***Box sections***



- *Used in short members of frames*

• ***Tubular sections***

Tubular section is used these days in three wheelers , scooters pick-ups.

Some of important Chassis are:

- *Ladder Frame*
- *Tabular Space Frame*
- *Monocoque Frame*
- *ULSAB Monocoque*
- *Backbone Frame*
- *Aluminum Space Frame*
- *Carbon Fibre*

UNIT -2

• POWER UNIT

This unit deals with :

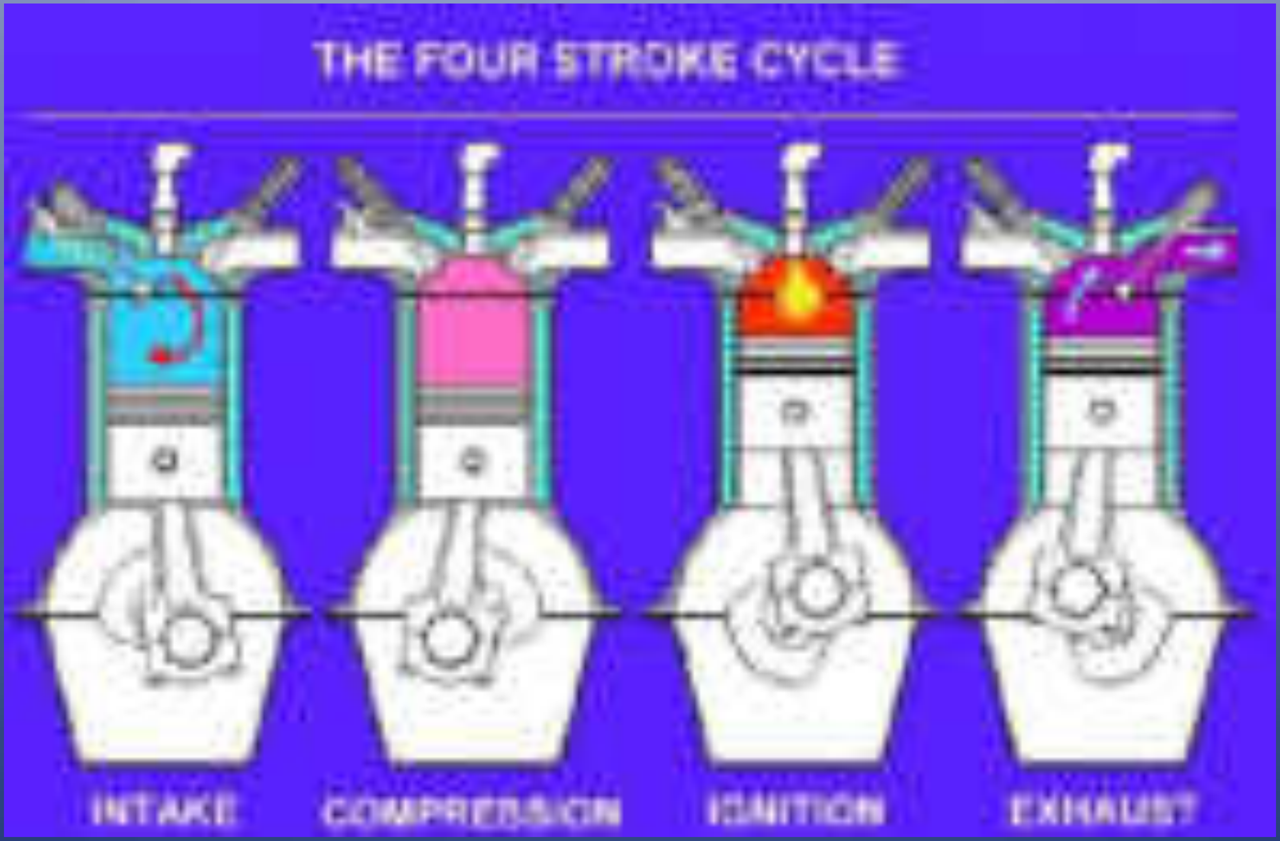
- **Engine Power requirements :**
  - **Operation**
  - **Classification**
  - **Tractive effort and Engine performance curves**
  - **Motion resistance and power loss**
- **Pollution due to vehicle emission**
- **Exhaust emission control system**

ENGINE

ENGINE IS THE HEART OF THE AUTOMOBILE

- IT GENERATES MOTIVE POWER FOR LOCOMOTION
- IT CONVERTS CHEMICAL ENERGY OF THE FUEL TO MECHANICAL ENERGY
- ENGINE DEVELOPS POWER & TORQUE
  - TORQUE : - Is the capacity to do work. Measured in Kg-m , N-m , Lb-ft
  - POWER : - How fast the work can be done. Measured in - Horse Power, Kilo watt

ENGINE OPERATION - 4 STROKE



CLASSIFICATION OF ENGINES

ENGINES CAN BE CLASSIFIED IN MANY WAYS :

1. By Mechanical construction - 4 Stroke/2-Stroke
2. By type of Ignition - Compression Ignition/Spark Ignition

COMPRESSION IGNITION ENGINES

- Basically Diesel engines
- Use diesel fuel
- Combustion is initiated by heat, on its own

SPARK IGNITION ENGINES

- Basically Petrol engines, LPG engines, CNG engines
- Use leaded or unleaded petrol, Alcohol, LPG or CNG
- Combustion is initiated by a spark from a spark plug

PERFORMANCE OF ENGINE

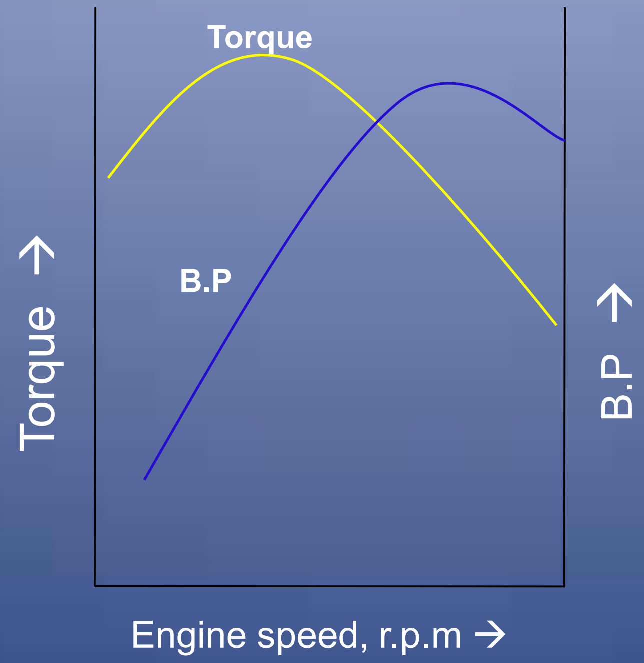
- When the fuel burns in the cylinder, pressure developed. These pressures are transmitted to the crankshaft by the piston and connected rod and **torque is produced**.

- Torque transmitted through the drive line to the road wheel to propel the vehicle.

- Actual power developed by engine is **Brake Horse Power (B.P.)**

$$\text{B.P.} = \frac{2\pi NT}{60 \times 1000} \text{ kW}$$

- Torque increases with the increase in engine speed upto a certain point after which it starts to fall down even though the engine speed continue to increase.



Reason :

– At higher speeds , engine vacuum falls down and less fuel enters the cylinders resulting in lesser force available at the piston and hence the fall in torque.

- **TRACTIVE EFFORT** : The torque available at the contact between driving wheels and road .

  Gear Box and final drive at differential act as leverage to multiply torque which is inversely proportional to speed.

$$F = \frac{T_W}{R_W}$$

where ,

$$T_W = G \times \eta_t \times T_E$$

T_E = Engine torque , Nm

T_W = Torque at driving wheels,

G = Gear box ratio,

η_t = Overall transmission efficiency

R_W = Radius of the driving wheel

Pollution due to Vehicle Emission

- **Air pollution** *can be defined as an addition to our atmosphere of any material which will have a deleterious effect on life upon our planet.*
- Besides I.C. engines other sources such as electric power stations, industrial and domestic fuel consumers also add pollution.
- There has been a great concern, in recent years, that the *internal combustion engines* is responsible for too much atmospheric pollution, which is detrimental to human health and the environment. Thus concerted efforts are being made to *reduce the responsible pollutants emitted from the exhaust system without sacrificing power and fuel consumption.*

- Pollutants are produced by the *incomplete burning* of the air-fuel mixture in the combustion chamber. The *major pollutants* emitted from the exhaust due to *incomplete combustion* are :
  - Carbon monoxide (CO)
  - Hydrocarbons (HC)
  - Oxides of nitrogen *(NO_x)'*
- Other products produced are *acetylene, aldehydes* etc. If, however, combustion is complete the only products being expelled from the exhaust would be *water vapour* which is harmless, and *carbon dioxide,* which is an inert gas and, as such it is not directly harmful to humans.

SPARK IGNITION (S.I.) ENGINE EMISSIONS

- The following are the three main sources from which pollutants are emitted from the S.I. engine :
  - **The crankcase.** *Where piston blow-by fumes and oil mist are vented to the atmosphere.*
  - **The fuel system.** *Where evaporative emissions from the carburettor or petrol injection air intake and fuel tank are vented to the atmosphere.*
  - **The exhaust system.** *Where the products of incomplete combustion are expelled from the tail pipe into the atmosphere.*

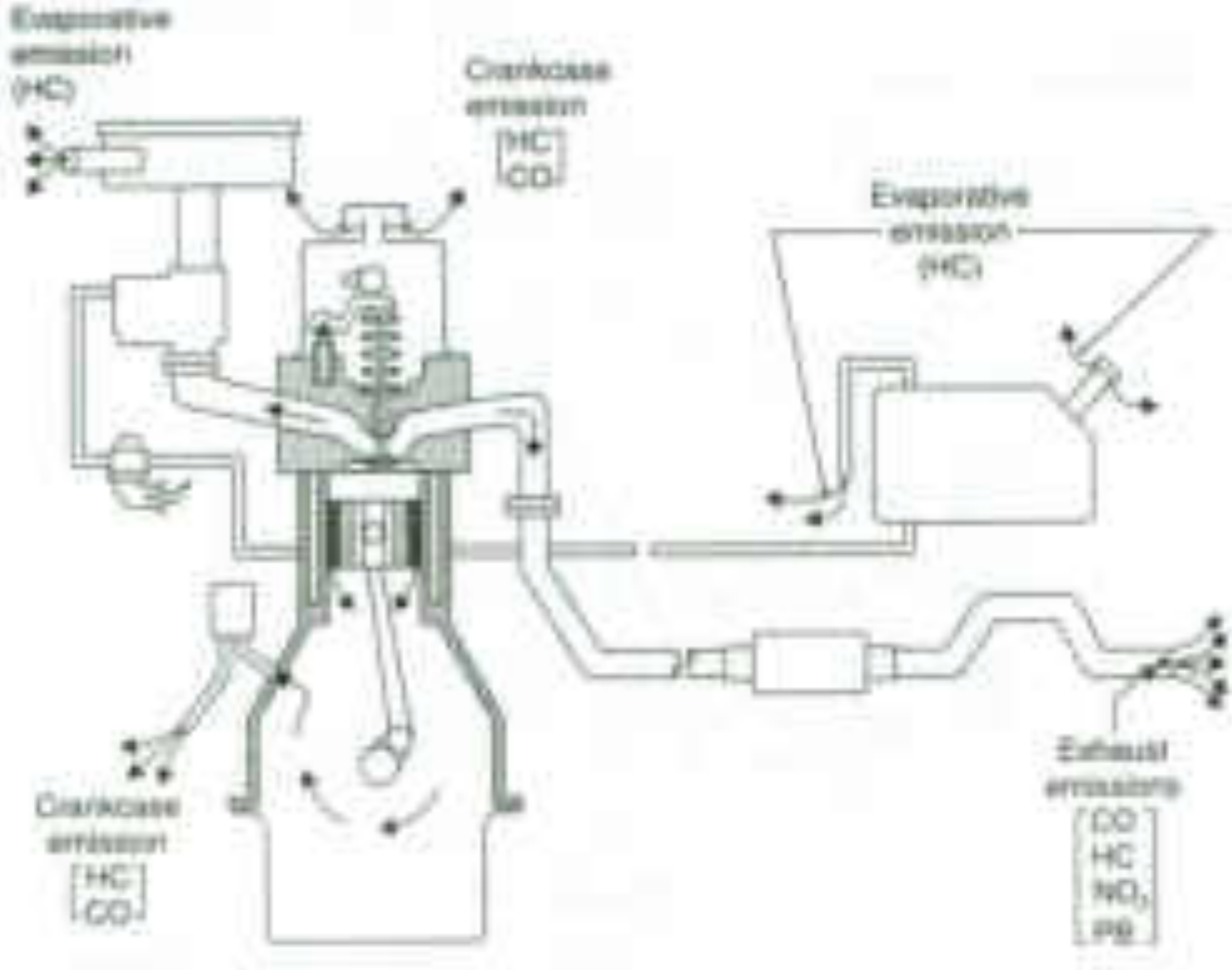


Fig. 2.163. Spark ignition engine emissions.

S.I. ENGINE EMISSION CONTROL

- The main methods, among various methods, for S.I engine emission control are :
  - Modification in the engine design and operating parameters.
  - Treatment of exhaust products of combustion.
  - Modification of the fuels.

Modification in the Engine Design and Operating Parameters

1. **Combustion chamber configuration** :

   It involves avoiding flame quenching zones where combustion might otherwise be incomplete and resulting in high HC emission. This includes:

- Reduced surface to volume *(S/V)* ratio;
- Reduced space around piston ring;
- Reduced distance of the top piston ring from the top of the piston.

2. **Lower compression ratio:**

- Lower compression ratio reduces the quenching effect by reducing the quenching area, thus *reducing HC.*
- Lower compression ratio also *reduces* NO_x emissions due to lower maximum temperature.
- Lower compression, however, *reduces thermal efficiency and increases fuel consumption.*

3. **Modified induction system :**

In a multi-cylinder engine it is always difficult to supply designed *A/F* ratio under all conditions of load and power. This can be achieved by proper design of induction system or using high velocity or multi-choke carburetors.

4. **Ignition timing:**

The ignition timing control is so adjusted as to provide normal required spark advance during cruising and retard the same for idle running. *NO_x emissions are reduced due to lowering of maximum combustion temperatures. Also HC emission gets reduced due to high exhaust temperatures. However, cooling requirements increase. The fuel economy also suffers to some extent accompanied by some power loss.* Thus a judicious balance needs to be struck between fuel economy, power loss and pollutants.

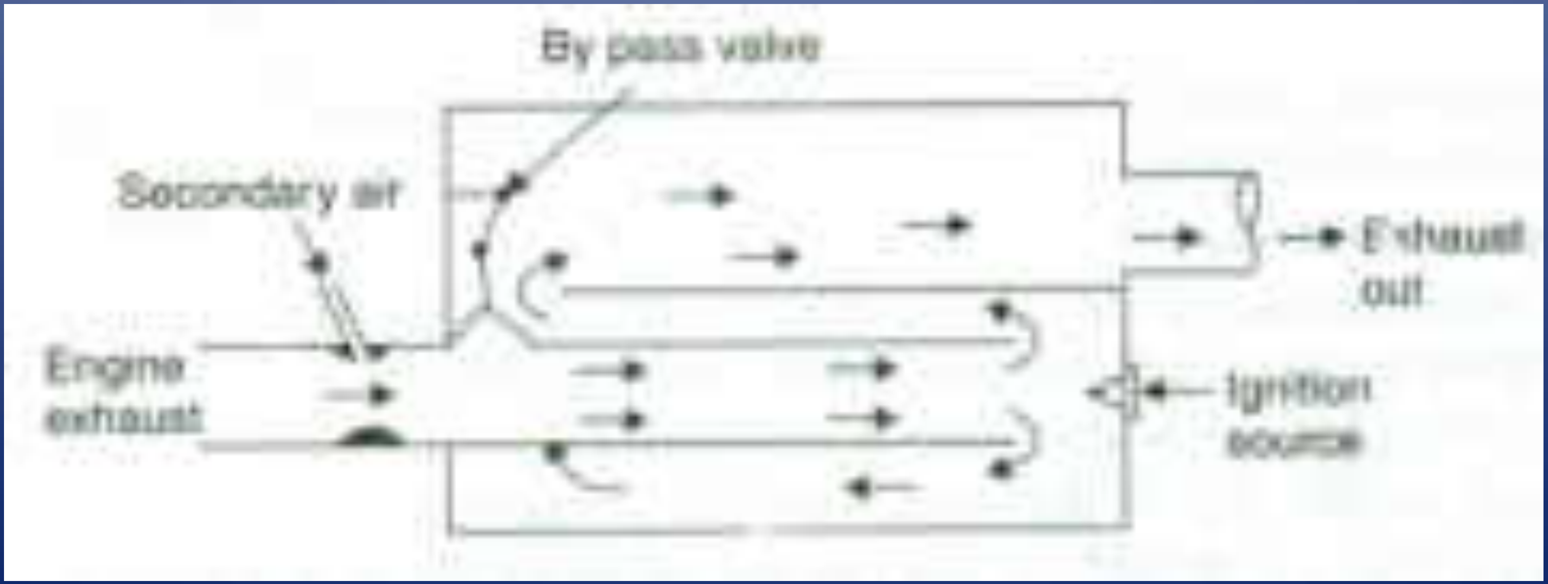
5. **Reduced valve overlap** :

- Increased overlap allows some fresh charge to escape directly and increase emission level. This can be controlled by *reducing valve overlap.*
- A new variable valve timing (VVT) allows for controlled scheduling of valve timing events; improves engine performance. It is also claimed VVT system will work best with petrol injection. This system is also applicable to petrol as well as to diesel engines.

Exhaust Gas Oxidation

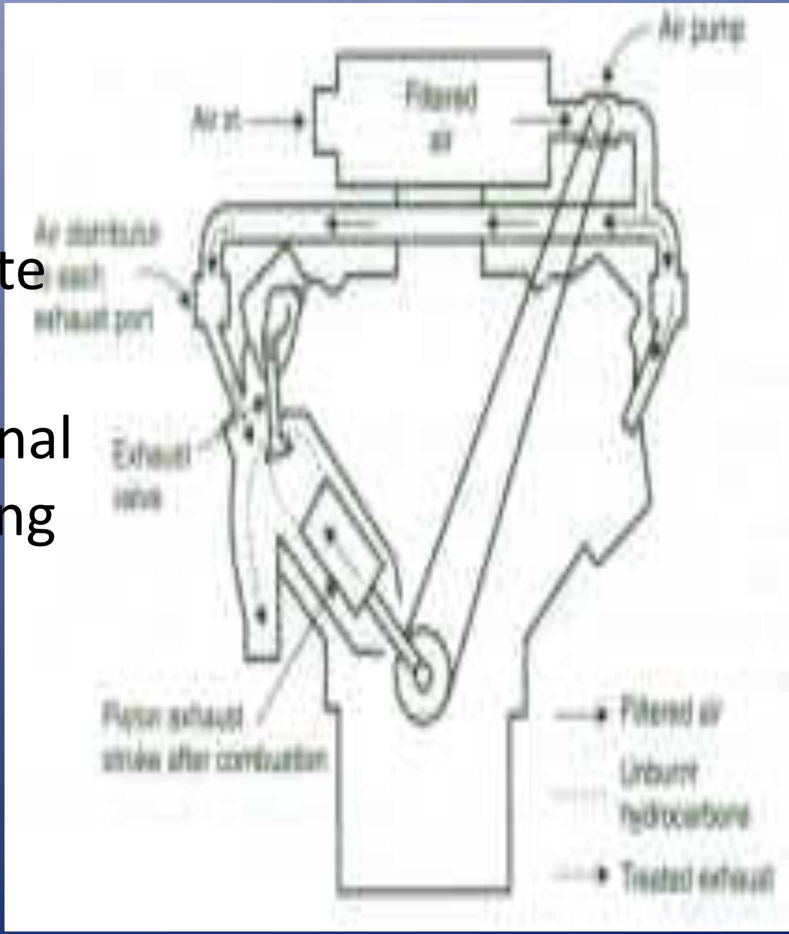
The *exhaust gas coming out of exhaust manifold is treated to reduce HC and CO emissions.* The devices used to accomplish it are discussed below:

1. **After-burner** : An *"after-burner"* is *a burner where air is supplied to the exhaust gases and mixture is burnt with the help of ignition system.*



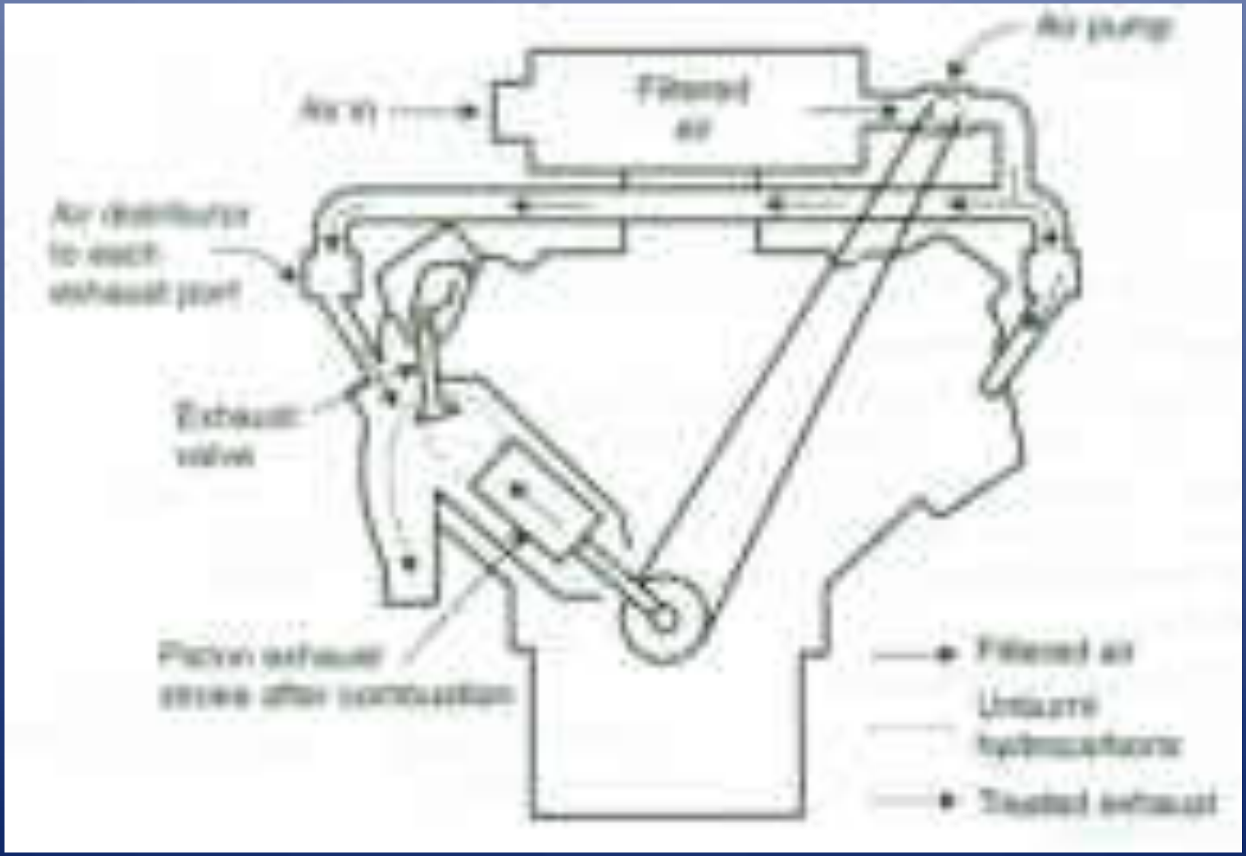
2. Exhaust manifold reactor:

- The exhaust manifold reactor is a further development of after-burner where the design is changed so as to minimize the heat loss and to provide sufficient time for mixing of exhaust and secondary air.
- Here a positive displacement vane pump driven by the engine, inducts air from the air cleaner or from separate air filter.
- The air passes into an internal or external distributing manifold, with tubes feeding a metered amount into the exhaust port of each cylinder and close to the exhaust valve.



Since the exhaust gases are at high temperature, the injected air reacts with HC, CO and aldehydes to reduce greatly the concentration of such emissions.

The injected air is closely metered otherwise it can decrease the temperature of the exhaust



3. **Catalytic converter:**

A *catalytic converter is a device which is placed in the vehicle exhaust system to reduce HC and* CO *by oxidising catalyst and NO by reducing catalyst.*

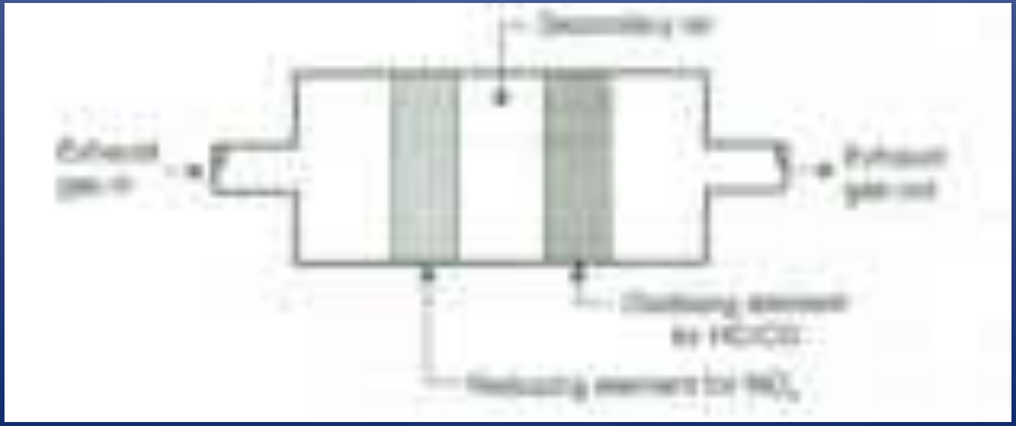
- The *basic requirements of a catalytic converter are:*

(i) High surface area of the catalyst for better reactions.

(ii) Good chemical stability to prevent any deterioration in performance.

(iii) Low volume heat capacity to reach the operating temperatures.

(iv) Physical durability with attrition resistance.



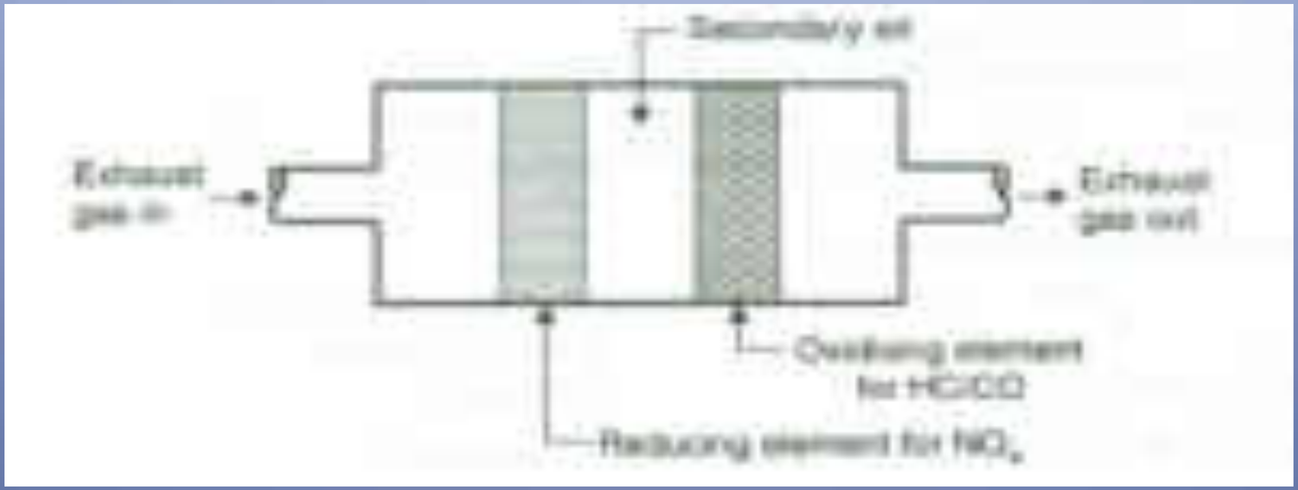


Figure shows a catalytic converter, developed by the Ford Company. It consists of two separate elements, one for NO_x and the other for HC/CO emissions. The secondary air is injected ahead of the first element. The flow in the converter is axial.

Oxidation catalytic reactions. CO, HC and 02 from air are catalytically converted to CO_2 and H_20 and number of catalysts are known to be effective noble metals like platinum and plutonium, copper, vanadium, iron, cobalt, nickel, chromium etc.

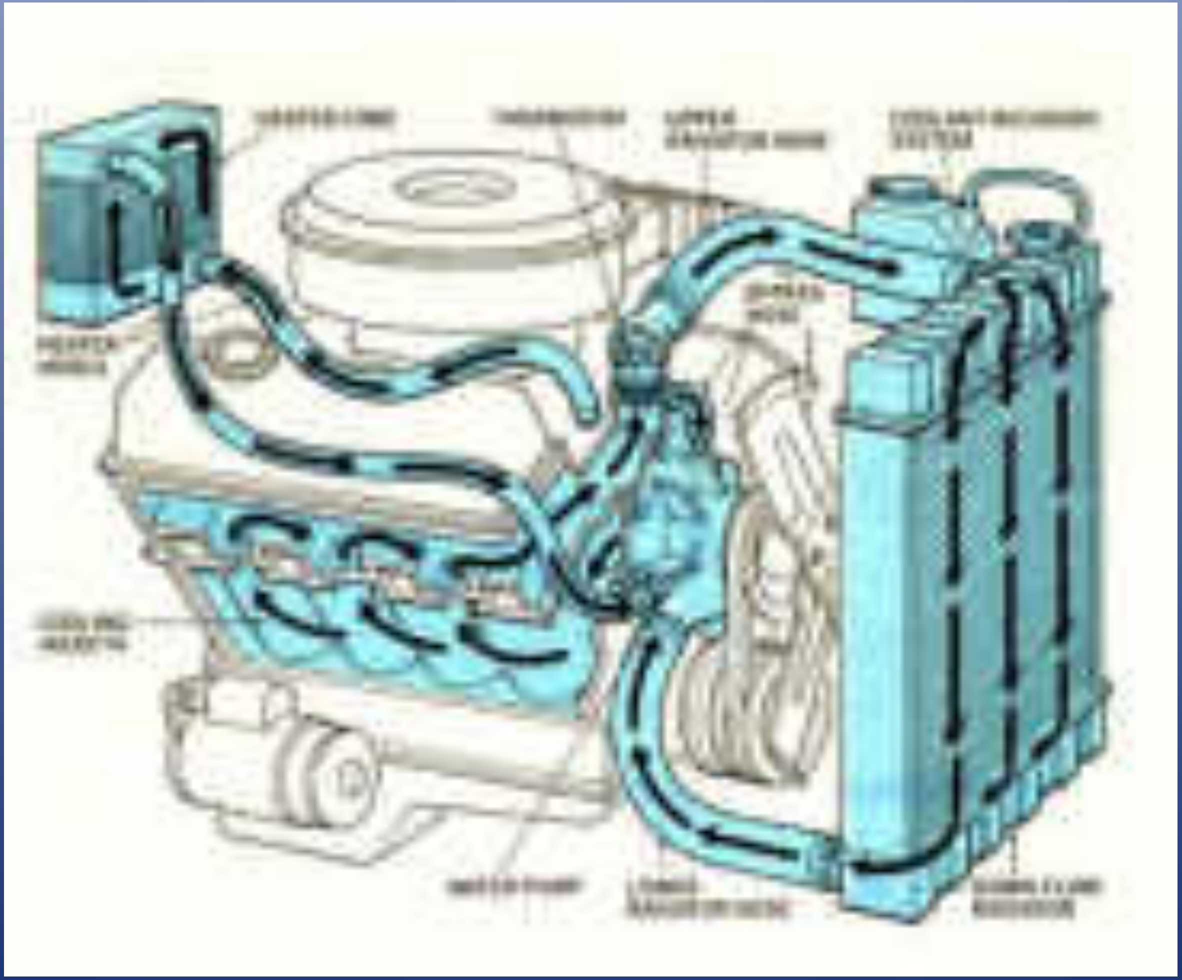
- ***Reduction catalytic reactions.*** The primary concept is to offer the NO molecule an activation site, say nickel or copper grids in the presence of CO but not 02 which will cause oxidation, to form N2 and CO_2, The NO may react with a metal molecule to form an oxide which then in turn, may react with CO to restore the metal molecule.

- *Rhodium is best catalyst to control NO_x but A/F ratio must be within a narrow range of*
  14.6 : 1 *to* 14.7 : 1.

Major drawbacks of catalytic converter

- Owing to the exothermic reactions in the catalyst bed the exhaust systems are *hotter than normal.*
- Cars equipped with such converter *should not use leaded fuel as lead destroys complete catalytic activity.*
- If the fuel contains sulphur (as diesel oil) emission of $S0_3$ is increased.

Cooling System



Engine Efficiency

- In an automobile the heat produced by combustion of fuel in the engine cylinder is not converted into useful power at crankshaft.
- Typical distribution of fuel energy is given below

USEFULL WORK AT CRANK SHAFT	=25 Percent
LOSS TO THE CYLINDER WALLS	=30 Percent
LOSS IN EXHAUST GASES	=35 Percent
LOSS IN FRICTION	=10 Percent

Piston Temperature distribution

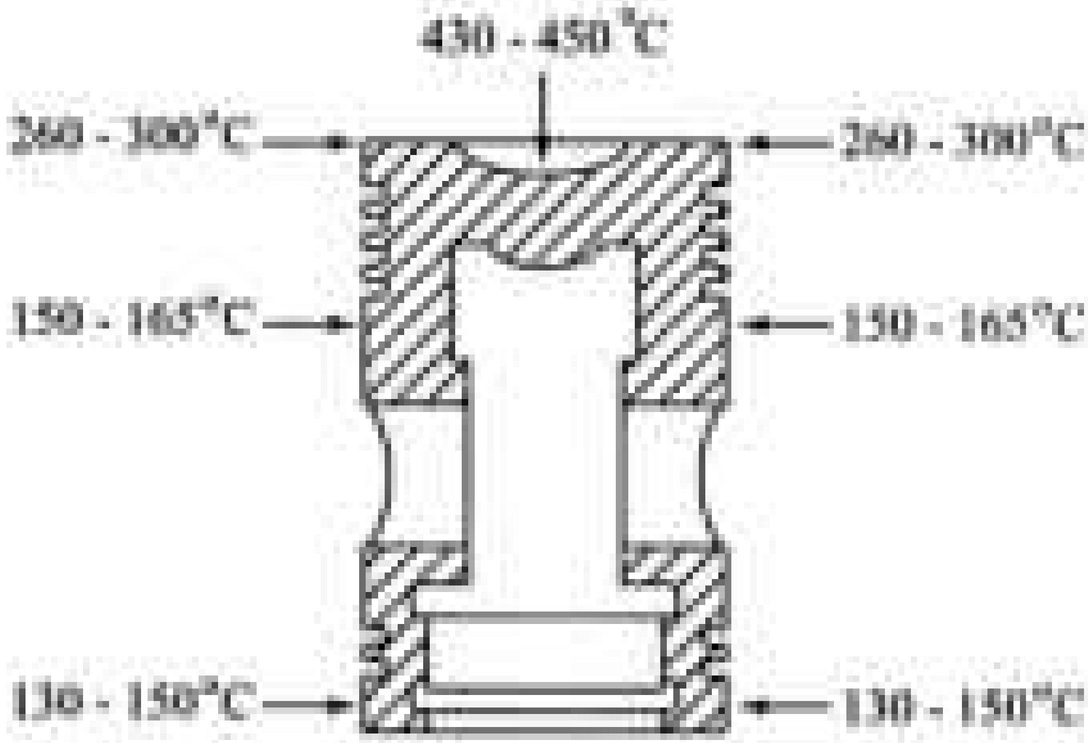


Fig. 14.2 Piston Temperature Distribution

Cylinder Temperature distribution

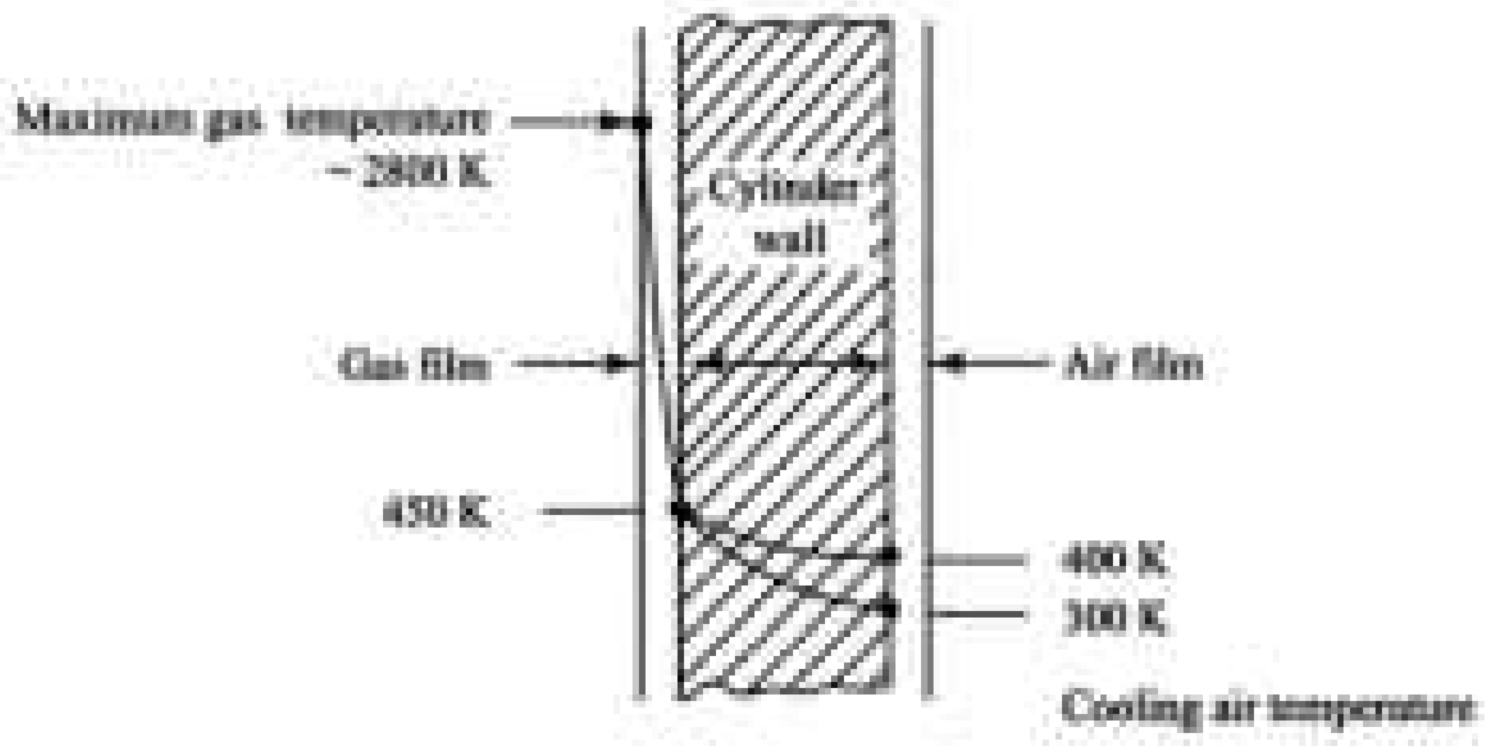


Fig. 14.3 Cylinder Wall Temperature Distribution of a Properly Cooled Cylinder

Necessity of Cooling System

Engine exposed to high temperatures in the absence of cooling system leads to:-

- Pre-ignition of the charge
- Seizure of piston due to even expansion of piston
- Reduced strength of piston and cylinder liner
- Lubricant would also burnt away, leads to the seizing of piston.
- Volumetric efficiency will decrease

Function of Cooling System

- An automotive cooling system must perform several functions
  - Remove excess from the engine
  - Maintain a constant engine temperature
  - Help a cold engine warm-up quickly
  - Provide a means of warming the passenger compartment

Demerits of overcooling

- Difficulty in starting
- Thermal efficiency is decreased due to more heat loss to cylinder walls
- Combustion efficiency is decreased due to less vaporization of fuel
- Mechanical efficiency is decreased due to increase in viscosity of lubricants tends to have more friction at low temp
- Overall efficiency decreases

Cooling System

- Automotive cooling systems operate around
  82° C -100° C
- Engine coolant is used to remove heat from the cylinder to the radiator where it is then dissipated.
- Engine coolant mixture should be approximately a 50/50 mixture of coolant and water.

Coolant Properties

- Water soluble oil is used as a lubricant in all coolants systems components
- Coolant uses lubricant in coolant to lubricate the water pump.
- Coolant is a mixture of water and antifreeze. (Normally 50/50 mixture)
- Antifreeze like ethylene glycol has low freezing point and high boiling point
- Antifreeze has anti corrosion additives also

Methods of Cooling

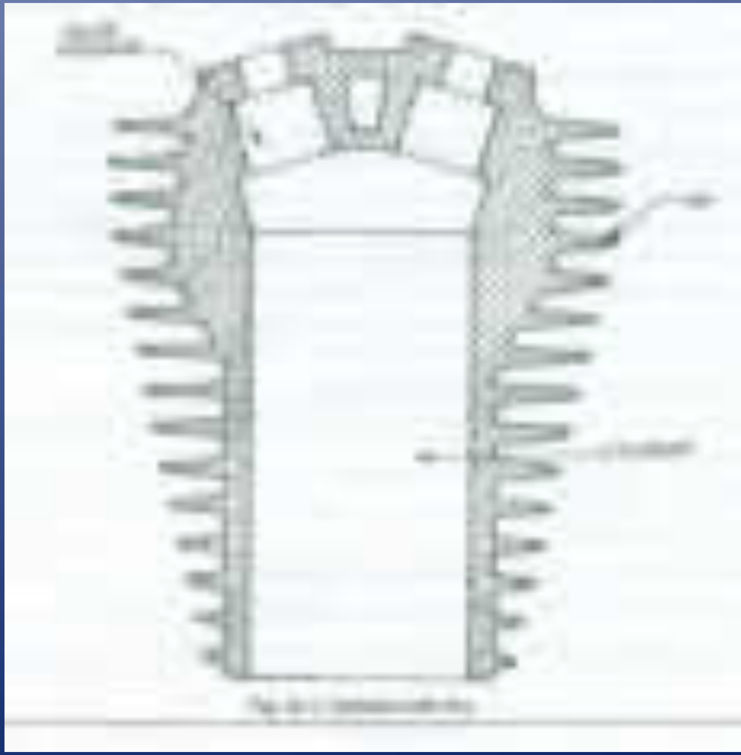
- **Air Cooling**
- **Water Cooling**

AIR COOLING SYSTEM

- The heat is dissipated directly to the air by convection after being conducted through the cylinder walls

TYPES OF AIR COOLING

- Fan cooling.
- Cooling Fins



Air Cooling

The heat dissipated in air cooling system depends upon following factors

- Surface area of metal into contact with air
- Mass flow rate of air
- Temperature difference between heated surface and air
- Conductivity of metal

Some times baffles are used to to increase contact area further

Air Cooling V/S Water Cooling

Sr. No.	AIR COOLED	WATER COOLED
1	Lighter in weight due to absence of radiator, cooling jackets and coolant	Heavier in weight.
2	No leaks to guard against	Leakage may be possible
3	Anti freeze not required	Anti freeze required
4	Less efficient cooling , because co-efficient of heat transfer is less	More efficient due to high co-efficient of heat transfer rate.
5	More noisy operation	Less noisy operation
6	Limited use in motorcycles and scooters	Used in cars and heavy vehicles

Types of Water Cooled system

- Thermo-syphon system
- Pump circulation system

Thermosyphon system

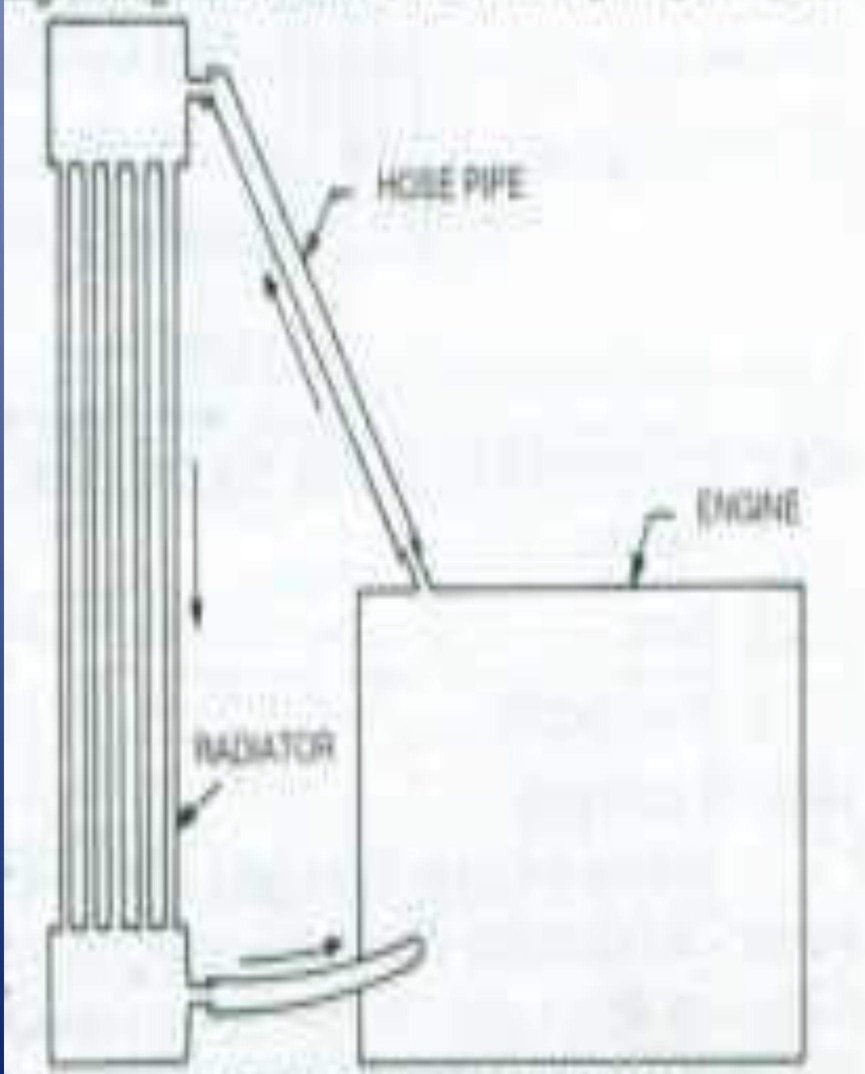
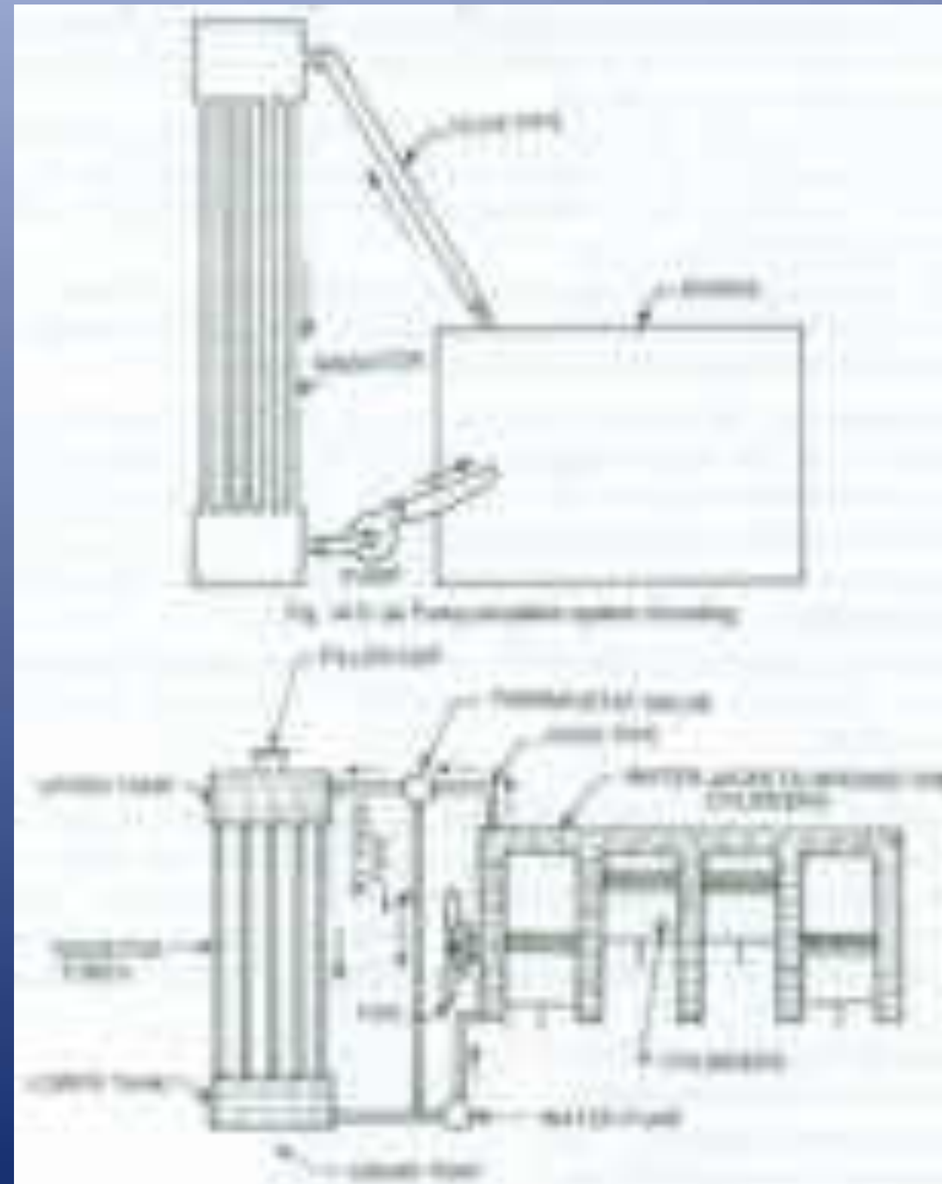


Fig 14.2 Thermosiphon system of cooling

Pump circulation system



Component of water cooling system

- Radiator
- Thermostat
- Pump
- Fan
- Water jackets

Radiator

- An automotive radiator is used as a heat exchanger.
- Hot coolant from the engine is transferred to the radiator and cooler coolant is transfer to the engine by heavy duty hoses.

Types of radiators

Cross flow

– Cross flow radiators have the coolant moving sideways through the radiator. The cross-flow radiator is normally shorter than a down flow allowing for shorter hood lines

Down Flow

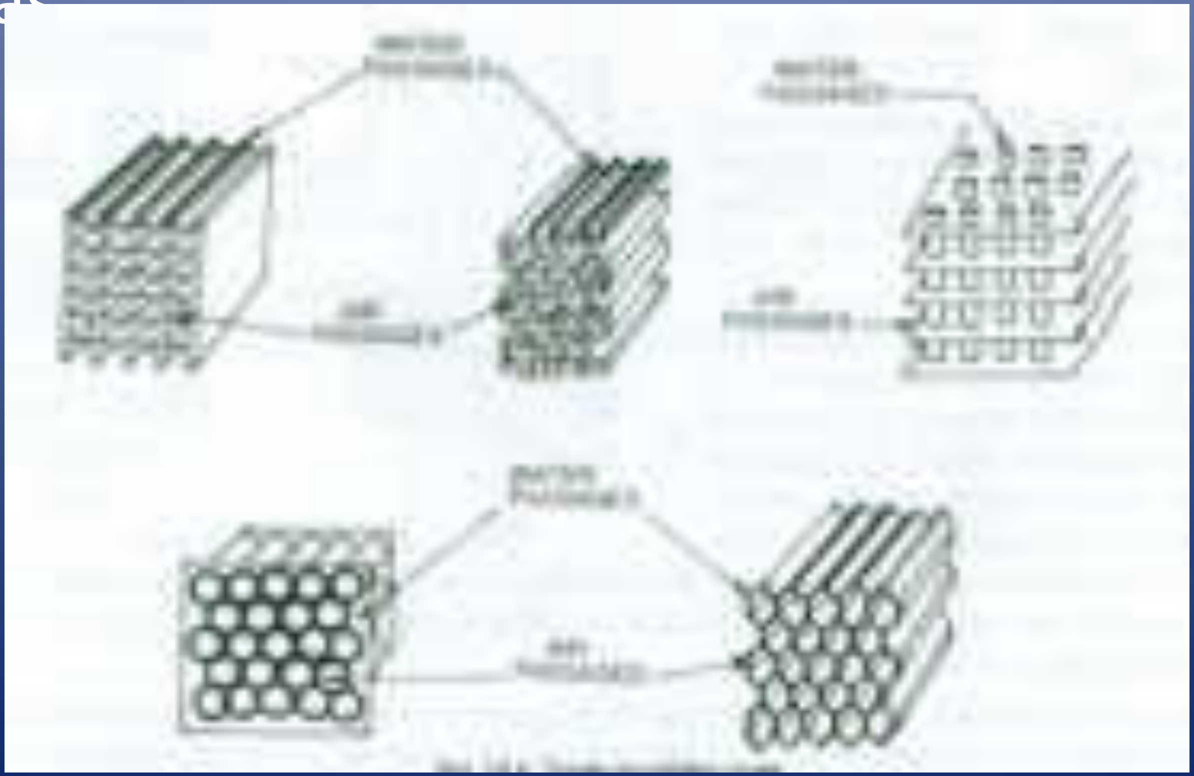
– A down-flow radiator is used on larger vehicles that requires more cooling capacity.

On the basis of radiator cores

– Tubular type or cellular type

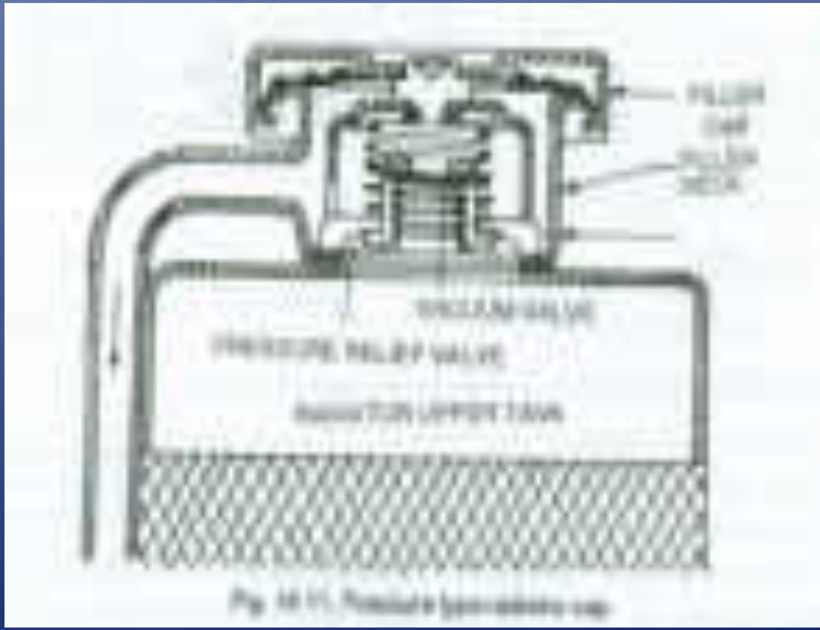
- The components that make-up the radiator is
  - 1. Radiator core: center section of the radiator

    Material for core:- yellow brass or copper
  - 2. Radiator Tank: Metal or plastic end that cover the ends of the core and provide a coolant storage areas



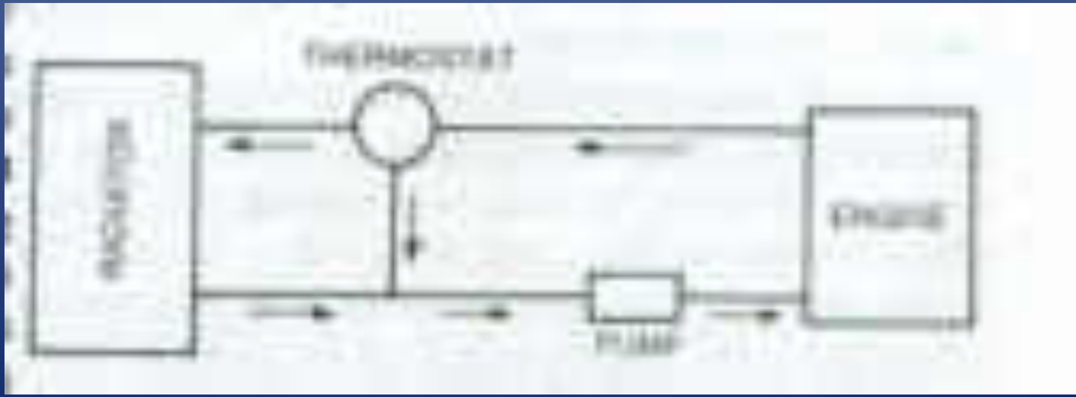
RADIATOR CAP

- Radiator caps are design to hold pressure on modern closed cooling system.
- The higher pressure maintained by the radiator cap will increases coolant boiling point.
- Defective radiator pressure cap should be replaced.
- Vacuum Valve prevents radiator collapse in case of sudden cooling



THERMOSTAT

- The thermostat is used to regulate the flow of coolant thought-out the cooling system.
- It is used to keep rigid control over the cooling
- It helps engine to reach operating temperature as soon as possible
- Installing a thermostat in the wrong direction can cause sever engine damage due to overheating.

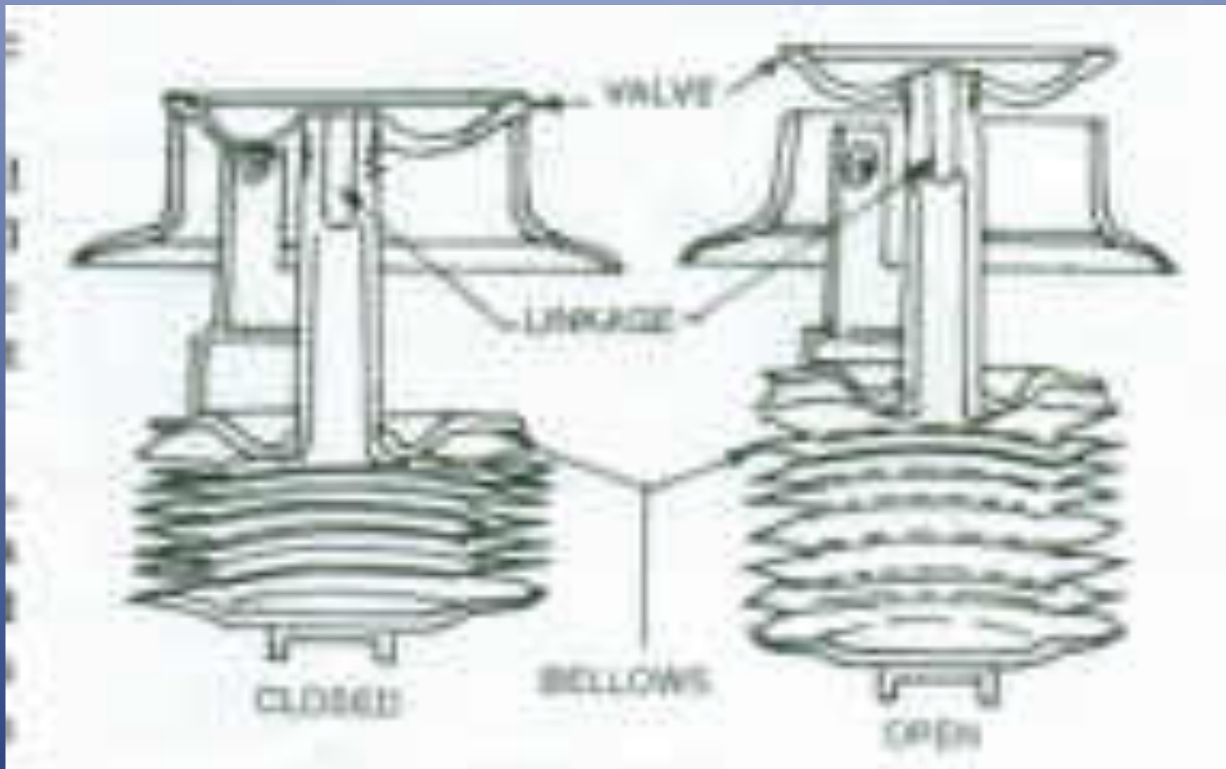


- To maintain proper engine temperature 80° C to 100° C a thermostat is used.
- Modern thermostat open around 80° C
- You should never operate a vehicle without a thermostat.

TYPES OF THERMOSTAT

1. **B**ELLOWS TYPE
2. PELLET TYPE

BELLOWS TYPE



Metallic Bellows filled with volatile liquid such as acetone alcohol having boiling point 70° C – 80 ° C

PELLET TYPE

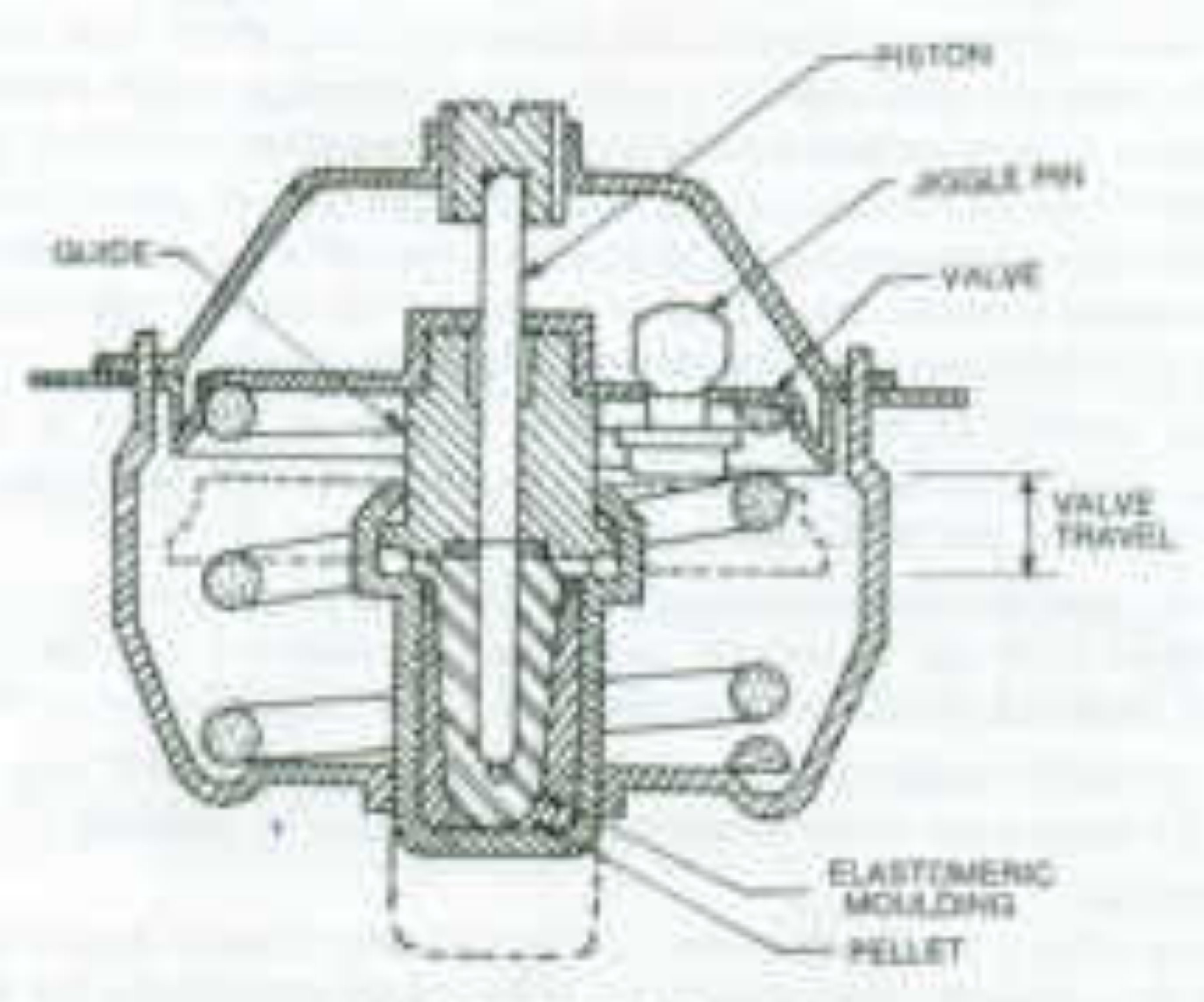


Fig. 14.7 Pellet type thermostat

FAN

- Most cooling system use some type cooling fan there are 3 types of fans
  - A. Electric fan
  - B. Clutch type fan
  - C. Flex fan
- When checking a cooling system its important to ensure that the fan is not broken, this will result in;

  A. Engine could vibrate excessively

  B. Cause premature water pump bearing failure

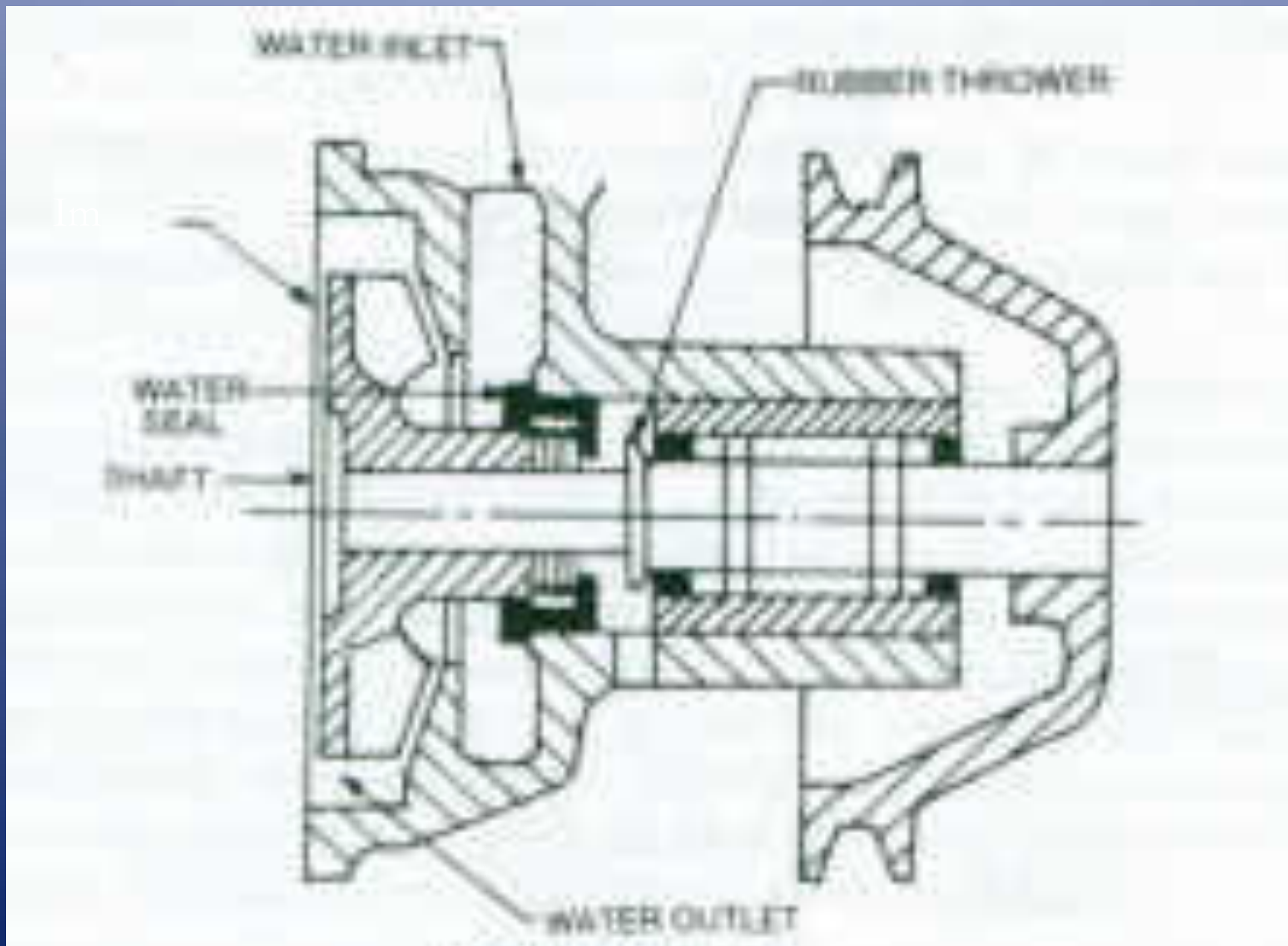
  C. Overheating because not enough air will be pulled through the radiator.

- A **flex fan** is mounted to the front of the engine and operates continually when ever the engine is running.
- A **Clutch fan** is also mounted to the front of the engine but will only pull air through the radiator when the engine is hot
- An **electric fan** is used on front wheel drive vehicles and will only operate when commanded by the PCM.

WATER PUMP

- A water pump is used to circulate coolant thought out the cooling system.
- Water pumps consist of
  - Water pump impeller
  - Water pump shaft
  - Water pump seal
  - Water pump bearing
  - Water pump housing

WATER PUMP FIGURE



WATER JACKETS

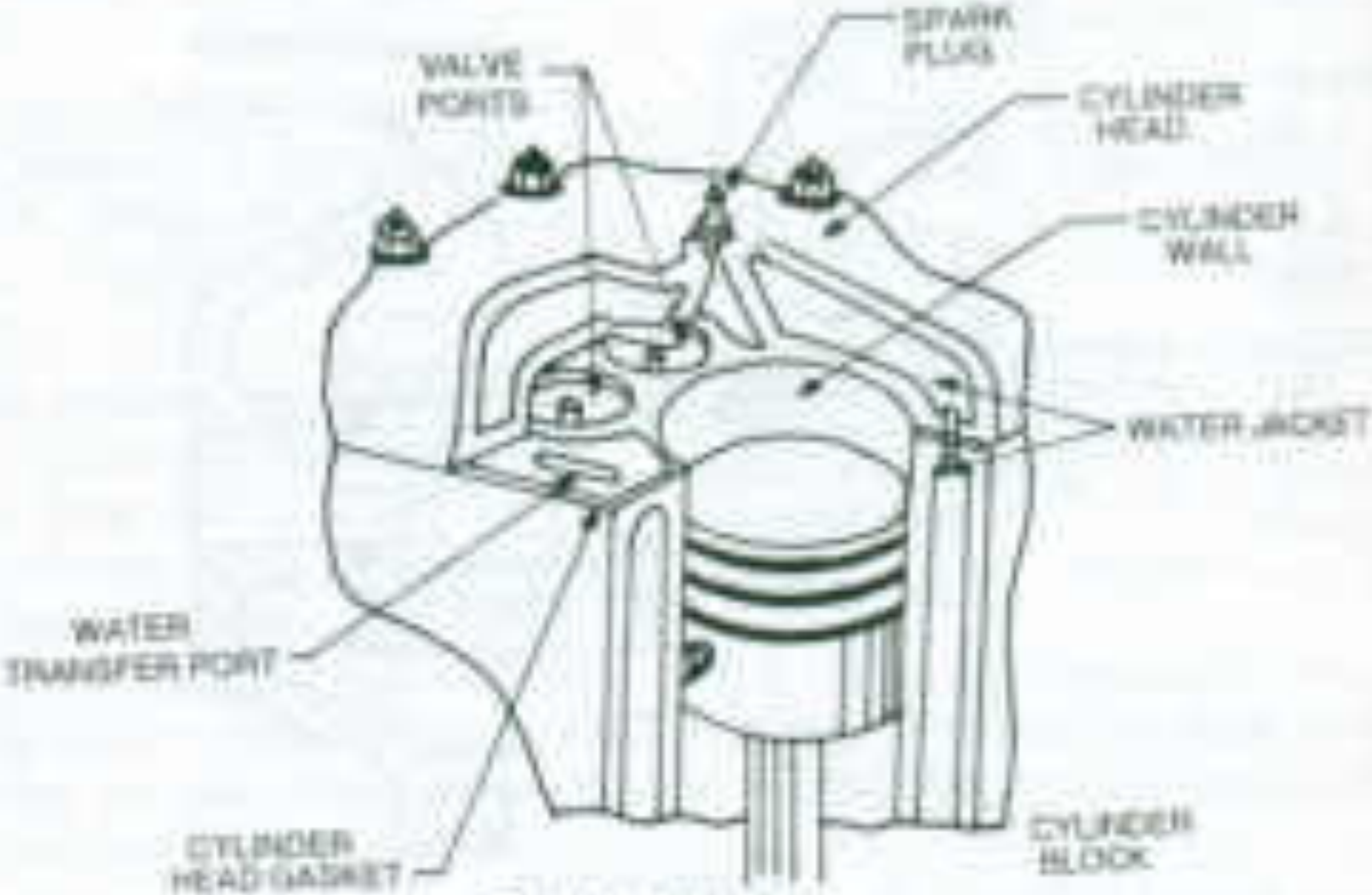


Fig. 14.9 Water jackets

Coolant Quiz

- What is the recommended coolant mixture?
  - A. 80/20
  - B. 70/30
  - C. 60/40
  - D. 50/50

Coolant Quiz

- What part of the cooling system serves as the heat exchanger
  - A. Heater hoses
  - B. Water pump
  - C. Fan belt
  - D. Radiator

Coolant Quiz

- What type lubricate is used inside the cooling system?
  - A. Water soluble oil
  - B. Non water soluble oil
  - C. Engine oil
  - D. Graphite

Coolant Quiz

- A radiator cap is used to:
  - A. Increase cooling system pressure
  - B. Raise coolant boiling temperature
  - C. Control expansion tank flow
  - D. All the above

Coolant Quiz

- Most modern thermostat open at around what temperature in ° C
  - A. 80
  - B. 65
  - C.100
  - D.55

Coolant Quiz

- What coolant system component circulates coolant?
  - A. Radiator
  - B. Heater hoses
  - C. Water pump
  - D. Overflow tank

Coolant Quiz

- What component allows for transfer of coolant from the radiator to the engine block?
  - A. Heater hoses
  - B. Radiator hoses
  - C. Radiator Cap
  - D. All the above

Coolant Quiz

- A broke fan blade can cause:
  - A. Excesses vibration
  - B. Overheating
  - C. Water pump failure
  - D. All the above

Coolant Quiz

- What are two type of cooling systems?
  - A. Water and antifreeze
  - B. Air and coolant
  - C. liquid and coolant
  - D. All the above

Coolant Quiz

- Automotive radiator cap should be removed when:
  - A. The engine is hot
  - B. The engine is cold
  - C. The engine is idling
  - D. There is pressure in the system

FUEL SUPPLY SYSTEM

UNIT -3

• FUEL SUPPLY SYSTEM

This unit deals with :

- **Introduction**
- **Air cleaner and fuel pumps**
- **Carburettor**
- **Fuel injection system**
- **Diesel fuel system**

INTRODUCTION- FUEL SYPPLY SYSTEM

•An important element of an engine.

• Core function : To ensure the smooth and uninterrupted supply of fuel to other peripherals of an engine.

• It comprises of various components and devices like carburetor, fuel pump, fuel tank, fuel coolers, automobile filters.

•Today, almost every automobile has a pressurized fuel supply system equipped with a pump that is used for pushing fuel from the fuel tank to engine of the vehicle.

The fuel can be supplied to the engine under :

1. Gravity System

2. Pressure System

In **Gravity System**, the fuel ***flows*** to the engine under gravitational force as the fuel storage tank is placed at a higher level than ***cylinder*** head. In this system fuel pump is not required.

In **Pressure System**, the fuel from the fuel tank is forced by the fuel pump through the filter to the carburetor. In this case, the fuel tank is placed at lower level than the engine head and some times away from the ***engine***. For example, ***motor cars, trucks*** etc.

By keeping the fuel tank away from the hot engine, we can avoid the chances of catching fire in the event of an accident.

This system mainly consists of below parts,

01) Fuel Storage Tank

02) Fuel Pump

03) Fuel Filter

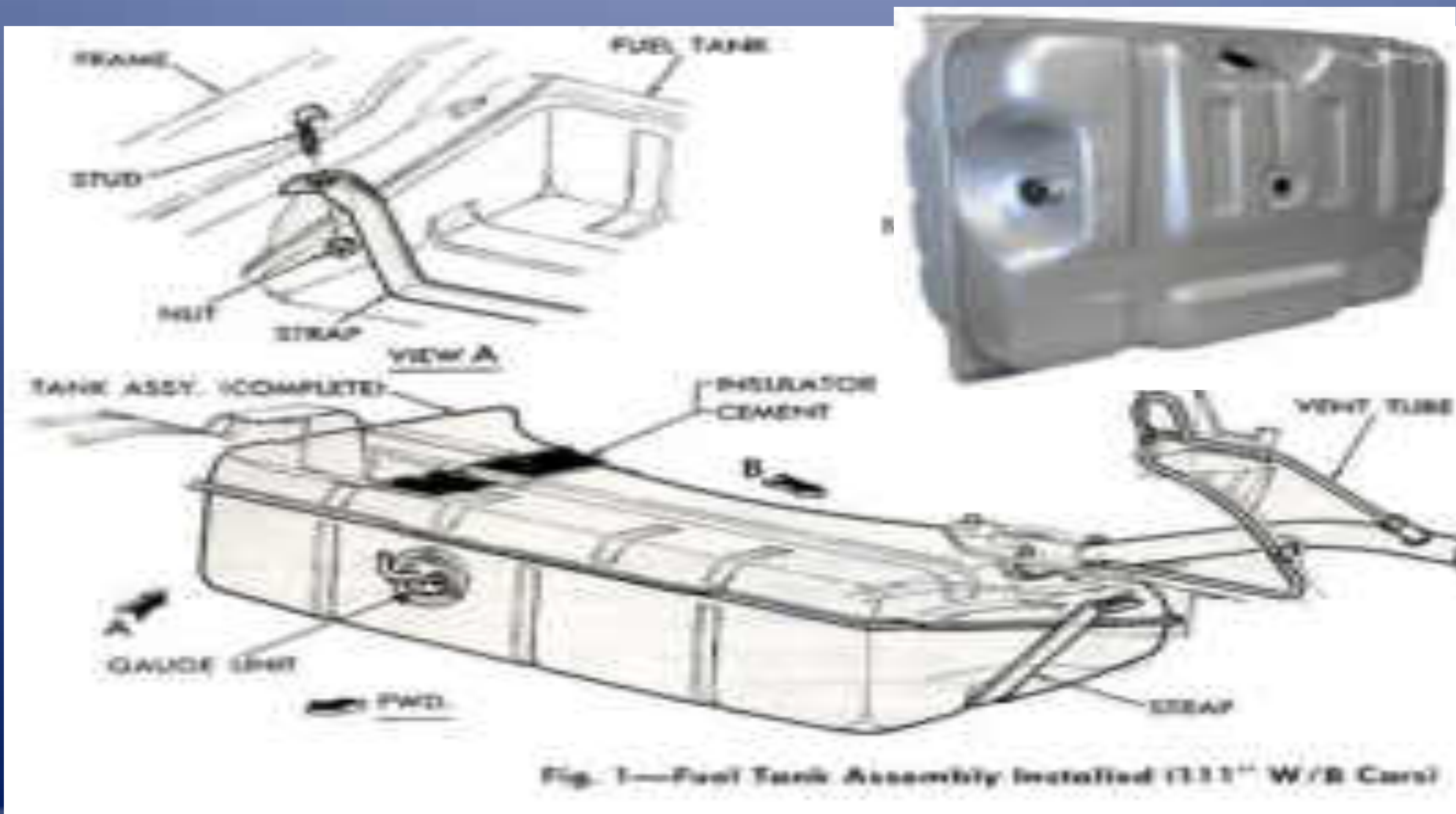
04) Carburetor

05) Inlet manifold

06) Inlet ***Valve***

Fuel Storage Tank

In a fuel system for a ***petrol engine***, the fuel storage tank is located well below the carburetor.



Fuel Pump

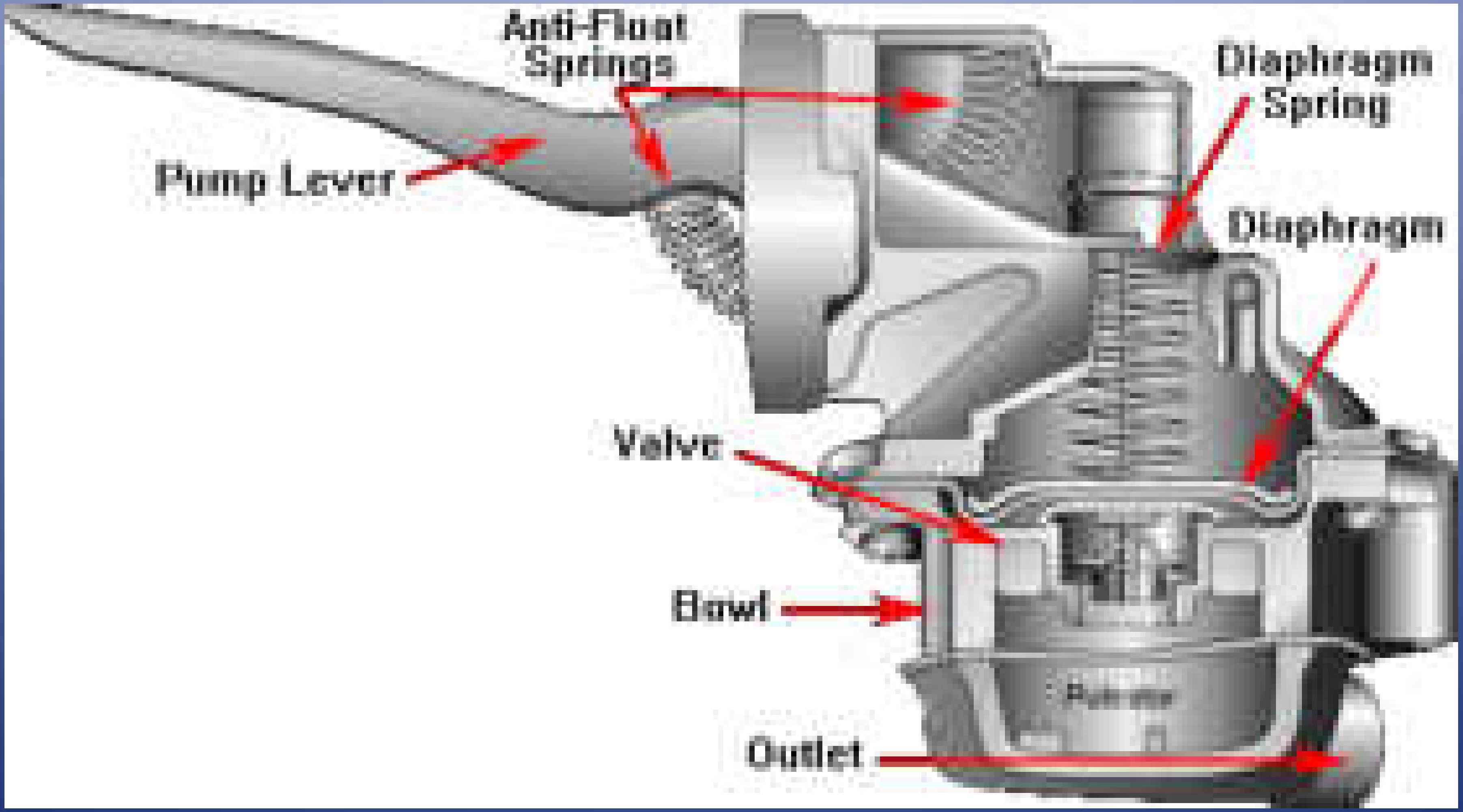
There are two types of fuel pumps :

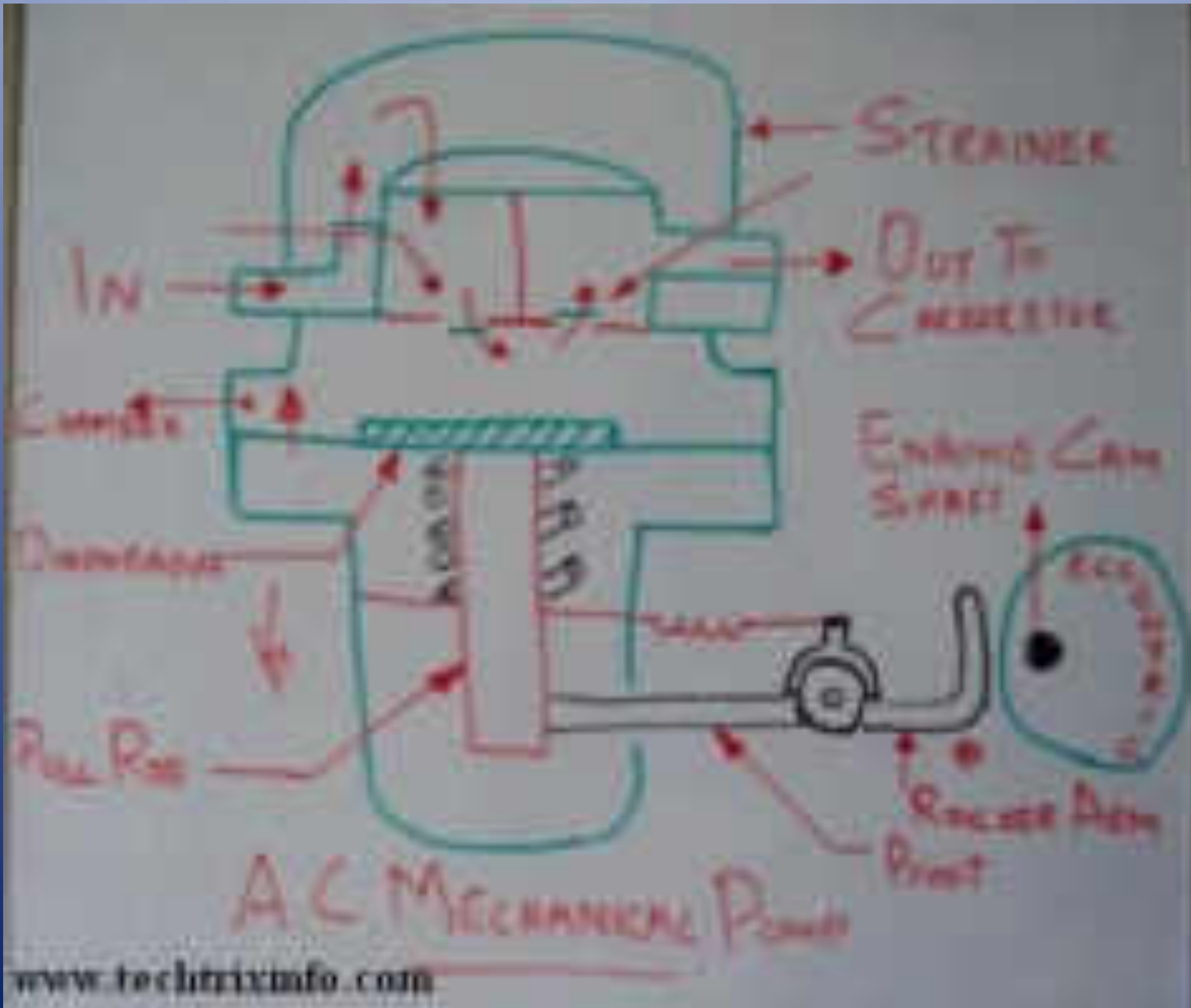
- Mechanical Fuel Pumps
- Electric Fuel Pumps

Mechanical fuel pumps are used on older engines that have carburetors (though some may have a low pressure electric fuel pump mounted in or near the gas tank). The pump siphons fuel from the gas tank and pushes it to the carburetor when the engine is cranking or running.

Mechanical fuel pumps use a lever that rides on the camshaft to pump a rubber diaphragm inside the pump up and down. This creates suction that pulls fuel into the pump, and then pushes it along. A pair of one-way valves inside the pump only allow the gas to move in one direction (toward the engine).

The output pressure of a mechanical fuel pump is typically quite low: only 4 to 10 psi. But little pressure is needed to keep a carburetor supplied with fuel.


Anti-Float Springs
Diaphragm Spring
Pump Lever
Diaphragm
Valve
Bowl
Outlet



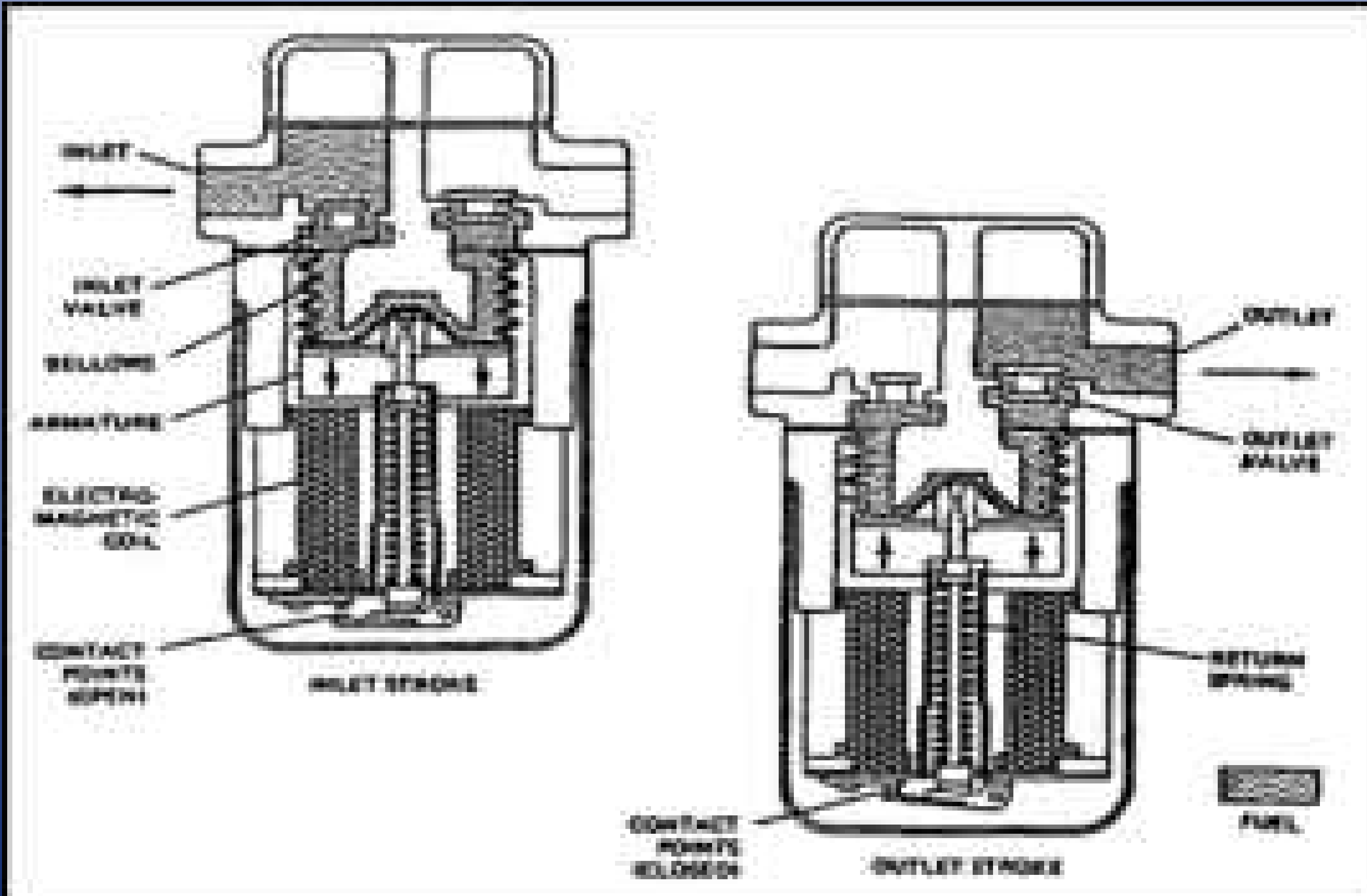
STRAINER
IN
OUT TO
ENGINE CAM SHAFT
PULL ROD
ROCKER ARM
PIVOT
A C MECHANICAL
www.techtrixinfo.com

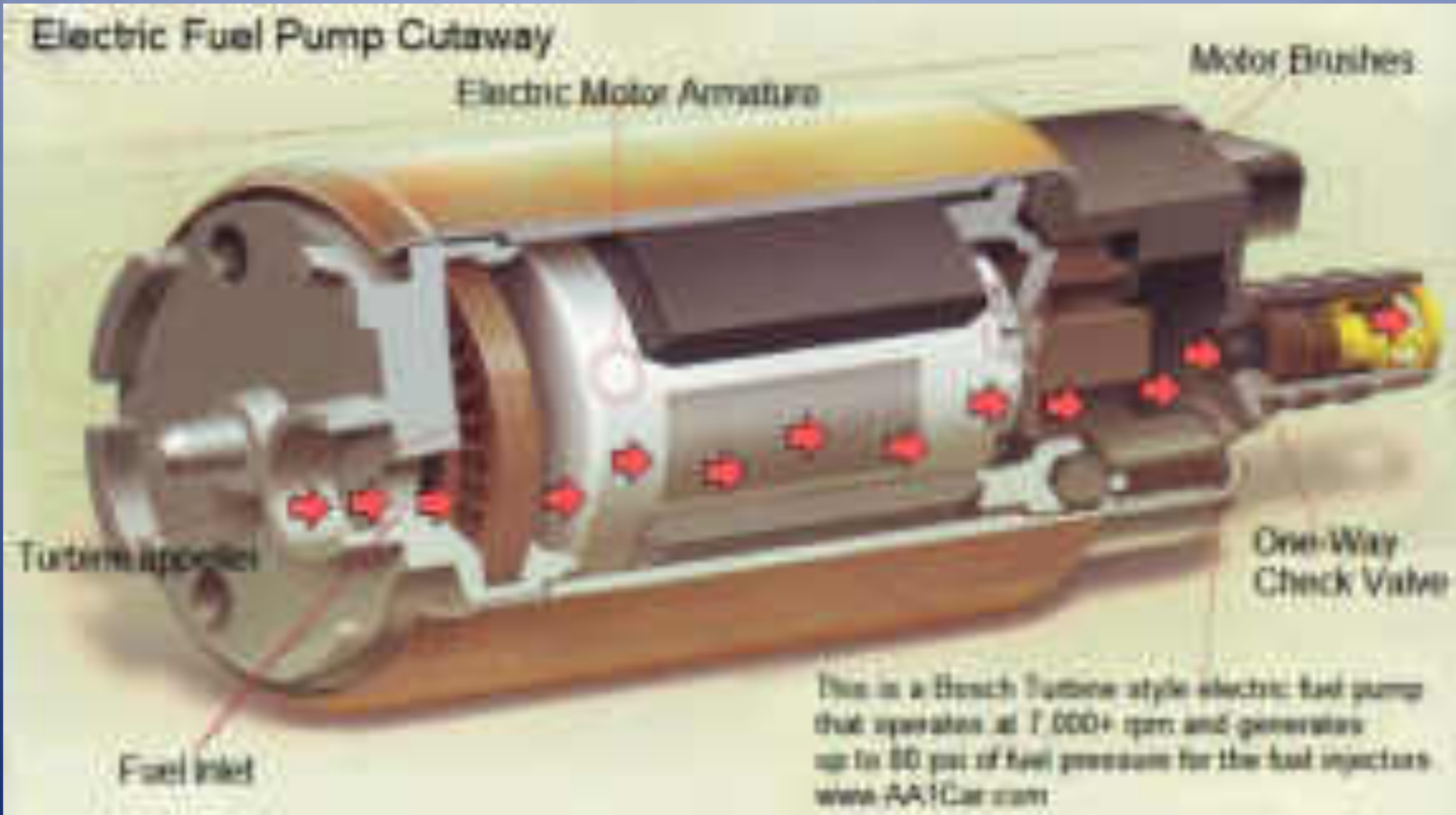
N

ELECTRICAL FUEL PUMP

An electric fuel pump is used on engines with fuel injection to pump fuel from the gas tank to the injectors. The pump must deliver the fuel under high pressure (typically 30 to 85 psi depending on the application) so the injectors can spray the fuel into the engine.

Electric fuel pumps are usually mounted inside the fuel tank, though some may be mounted outside the tank. Some vehicles may even have two fuel pumps (a transfer pump inside the tank, and a main fuel pump outside).


INLET
INLET VALVE
BELLOWS
ARMATURE
ELECTRO-MAGNETIC COIL
CONTACT POINTS (OPEN)
INLET STROKE
OUTLET
OUTLET VALVE
RETURN SPRING
CONTACT POINTS (CLOSED)
OUTLET STROKE
FUEL


Electric Fuel Pump Cutaway
Motor Brushes
Electric Motor Armature
One-Way
Check Valve
Fuel Inlet

When the driver turns the ignition key on, the powertrain control module (PCM) energizes a relay that supplies voltage to the fuel pump. The motor inside the pump starts to spin and runs for a few seconds to build pressure in the fuel system. A timer in the PCM limits how long the pump will run until the engine starts.

Fuel is drawn into the pump through an inlet tube and mesh filter sock (which helps keep rust and dirt out of the pump). The fuel then exits the pump through a one-way check valve (which maintains residual pressure in the system when the pump is not running), and is pushed toward the engine through the fuel line and filter.

The fuel filter traps any rust, dirt or other solid contaminants that may have passed through the pump to prevent such particles from clogging the fuel injectors.

The fuel then flows to the fuel supply rail on the engine and is routed to the individual fuel injectors. A fuel pressure regulator on the fuel rail maintains fuel pressure, and re-circulates excess fuel back to the tank

The fuel pump runs continuously once the engine starts, and continues to run as long as the engine is running and the ignition key is on. If the engine stalls, the PCM will detect the loss of the RPM signal and turn the pump off.

Automobile Filters:

Automobile Filters are the devices or strainers generally tank or tubes used in automobiles for separating impurities from gases or fluids. An automobile filter ensure that the fuel, which is circulated in the engine, is filtered, clean and does not contain any waste material. Filters used in automobile engine come in variety of sizes, shapes and dimensions. These filters are used for filtering air, oil, water, gas and chemicals distributed in the engine of the vehicle. Filters used in automobile are made of high quality material like rubber, carbon, stainless steel, polyurethane, polyester, fiberglass etc.

Filters are of many types such as:

- Fuel Filters
- Air Cleaner
- Inline Filter
- Oil Filters
- Air Filter Assemblies
- Fuel Filter Seal

AIR CLEANER

Function of air cleaner:

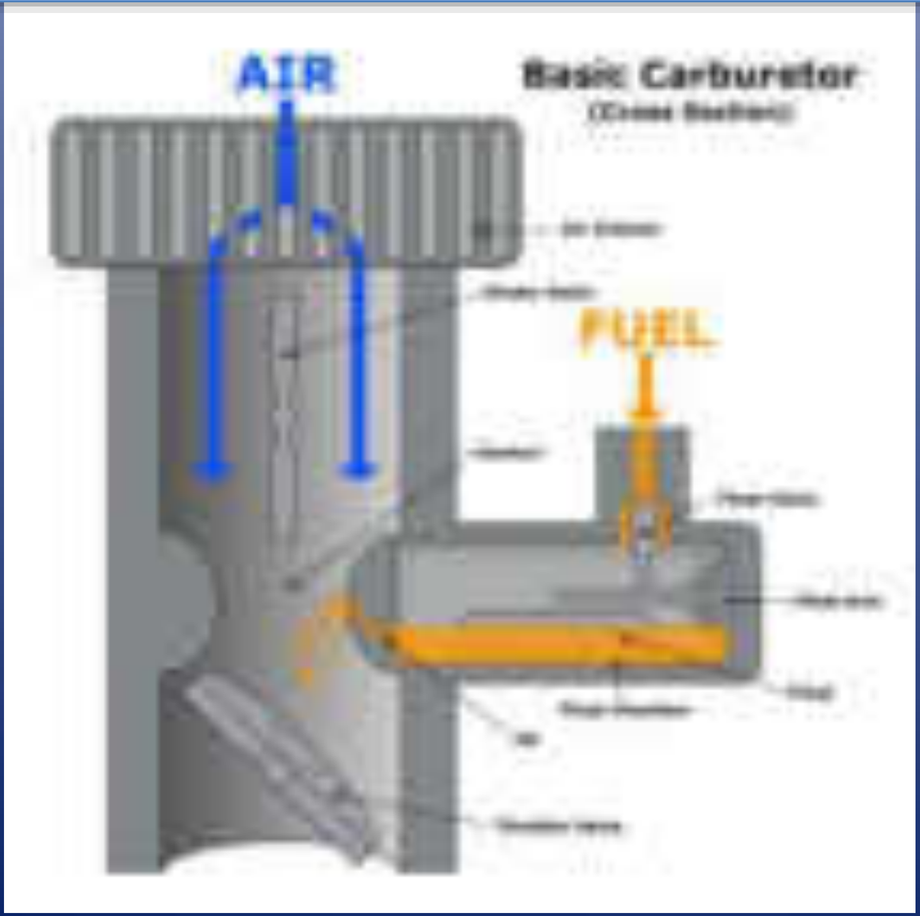
•Filters dirt or dust particles
•Act as silencer for carburetion system
•Acts as a flame arrester in case of engine back fires.

Type of air cleaner :

1. Heave duty or Oil bath Type air cleaner
2. Light duty .
3. Thermostatic air cleaner

CARBURETOR **Mixing the gas vapor with air to make combustion**

The carburetor is a device that vaporizes gasoline and mixes it with air in the proper ratio for combustion in an internal combustion engine. Normally the ratio of fuel to air is about 1:15 by volume. That is one part fuel to fifteen parts air. A higher ratio is called a rich mixture and a lower ratio is called a leaner mixture.



The components of the carburetor consist of:

- Float chamber
- Float valve
- Jet nozzle
- Venturi
- Throttle valve
- Accelerator pedal
- Choke
- Fuel tank
- Fuel pump
- Fuel Filter

The carburetor has a **FLOAT CHAMBER** that is supplied with fuel from the **FUEL TANK**. The fuel is forced through a **FUEL FILTER** under pressure from the **FUEL PUMP**. The float chamber contains a **FLOAT VALVE** that regulates the flow of fuel into the chamber. When the float chamber is full of fuel, the float valve stops the flow of fuel until needed again.

The **JET NOZZLE** is situated within an air chamber that is narrow at one point. The narrowing in the chamber is called a **VENTURI**.

When the engine is running, the motion of the pistons creates a vacuum, drawing air into the air chamber, where it is accelerated by the venturi. This high velocity air creates a low pressure region that the jet nozzle (which extends into the air chamber) draws a fine spray of fuel drawn from the float chamber into the venturi. Here it mixes with the air. The mixture of fuel and air is then fed into the cylinders where it is ignited.

The **THROTTLE VALVE**, which is activated by the **ACCELERATOR PEDAL**, regulates engine speed by regulating the amount of fuel/air mixture that enters the engine.

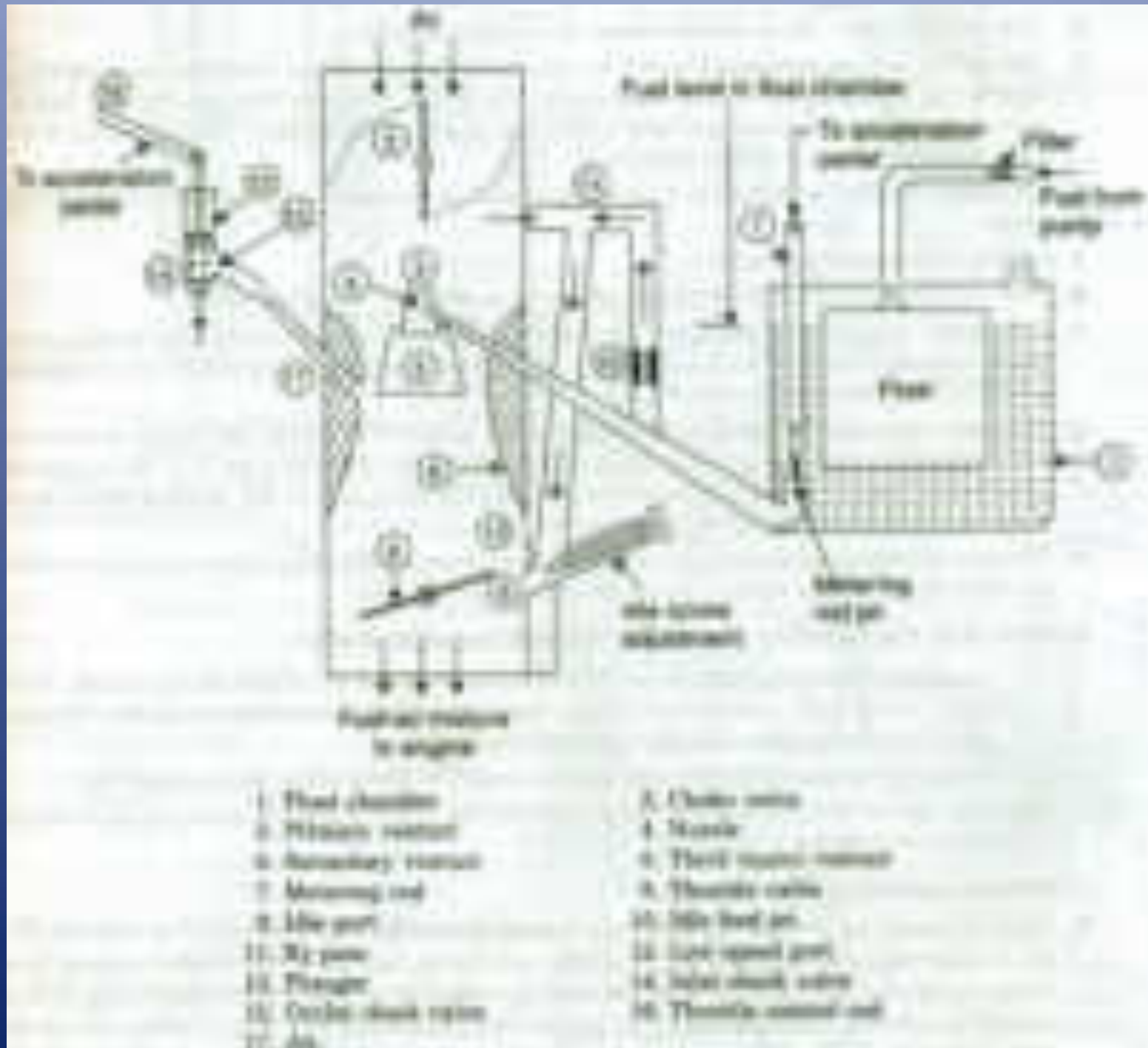
The **CHOKE** is at the entrance to the carburetor and restricts the amount of air entering the carburetor, thereby creating a richer mixture for the spark plugs for starting the engine when cold. The choke valve gradually opens as the engine warms up, reducing the richness of the mixture. Carburetors use various means to ensure an optimum mixture for differing conditions, including idling and rapid acceleration, as well as varied altitudes.

Whenever you have a problem such as a vacuum leak, the engine will die when cold and run badly when warm. The carburetor must be sealed from outside air leaks for it to work properly.

Additives added to the fuel system are not necessary. The use of high quality gasoline is beneficial because they contain detergents that clean the fuel system as you drive.

…and that’s the way the carburetor works!!

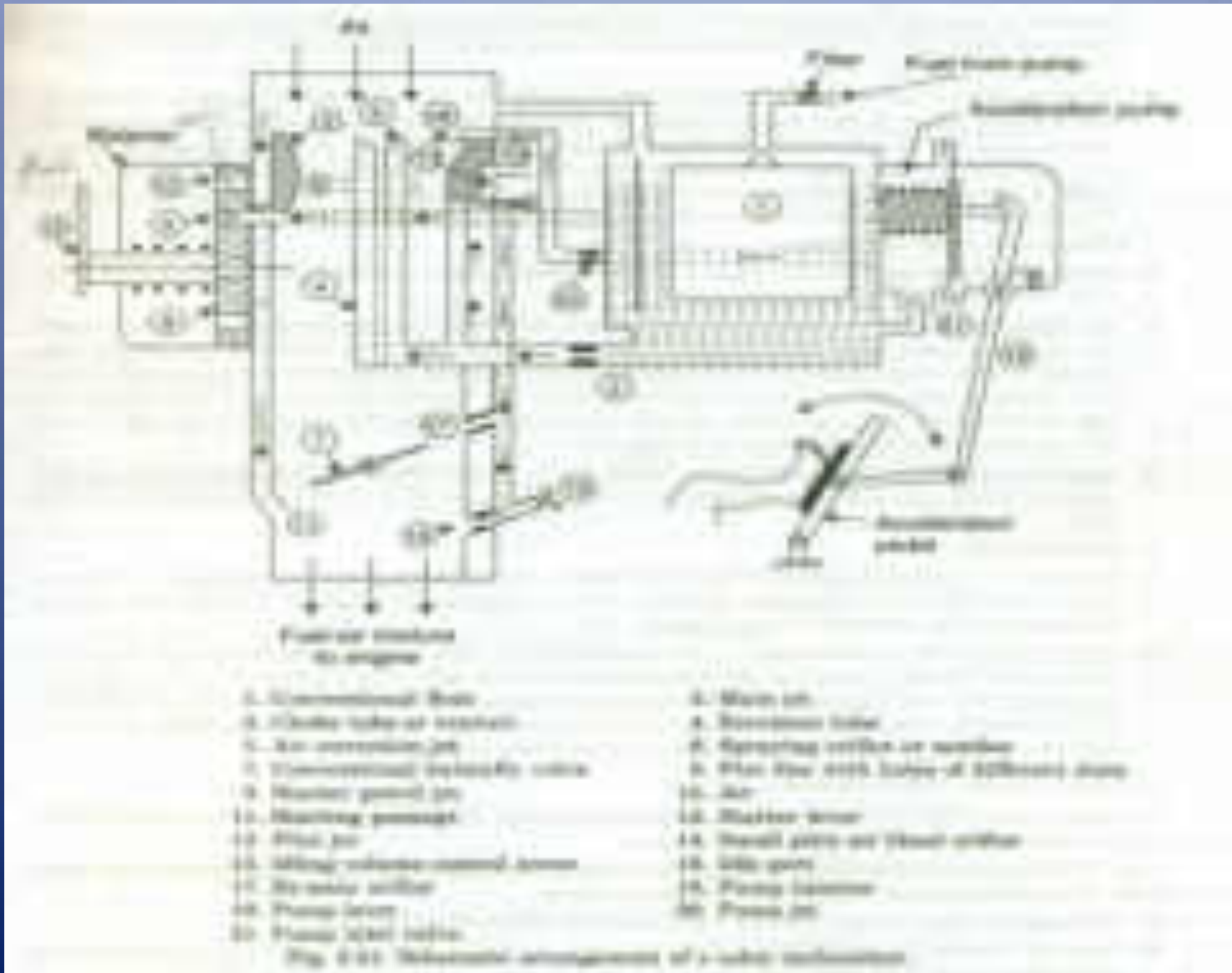
CARTER CARBURETTOR



MULTI VENTURI : It gives more homogenous and better mixture at very low speeds resulting in steady and smooth operation at low speed.

Mechanical Metering Rod: The amount of petrol drawn into the engine is governed by the area of opening between the metering rod jet and metering rod.

SOLEX CARBURETTOR

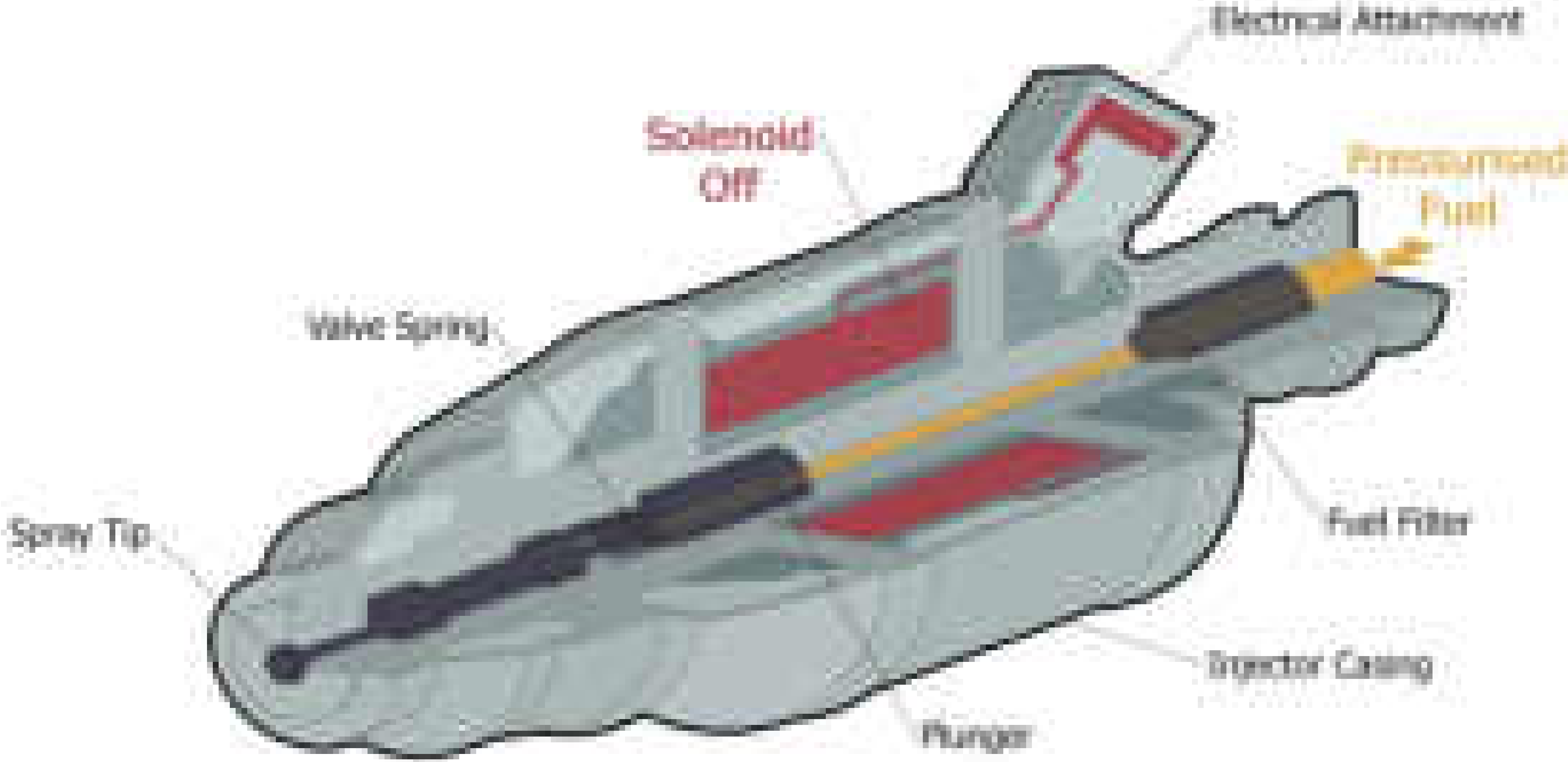


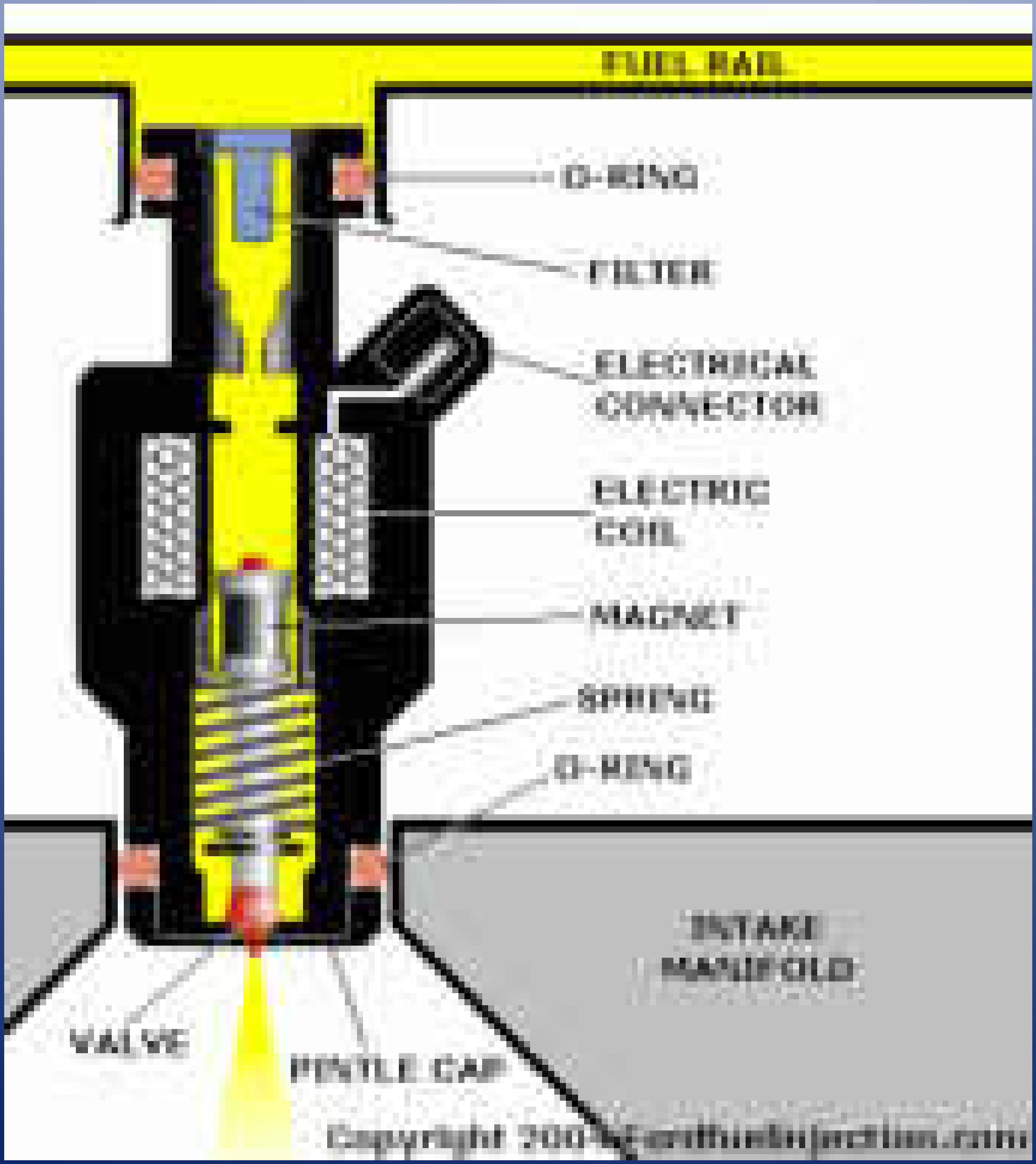
Fuel injection

Fuel injection is a system for mixing fuel with air in an internal combustion engine. It has become the primary fuel delivery system used in automotive petrol engines, having almost completely replaced carburetors in the late 1980s.

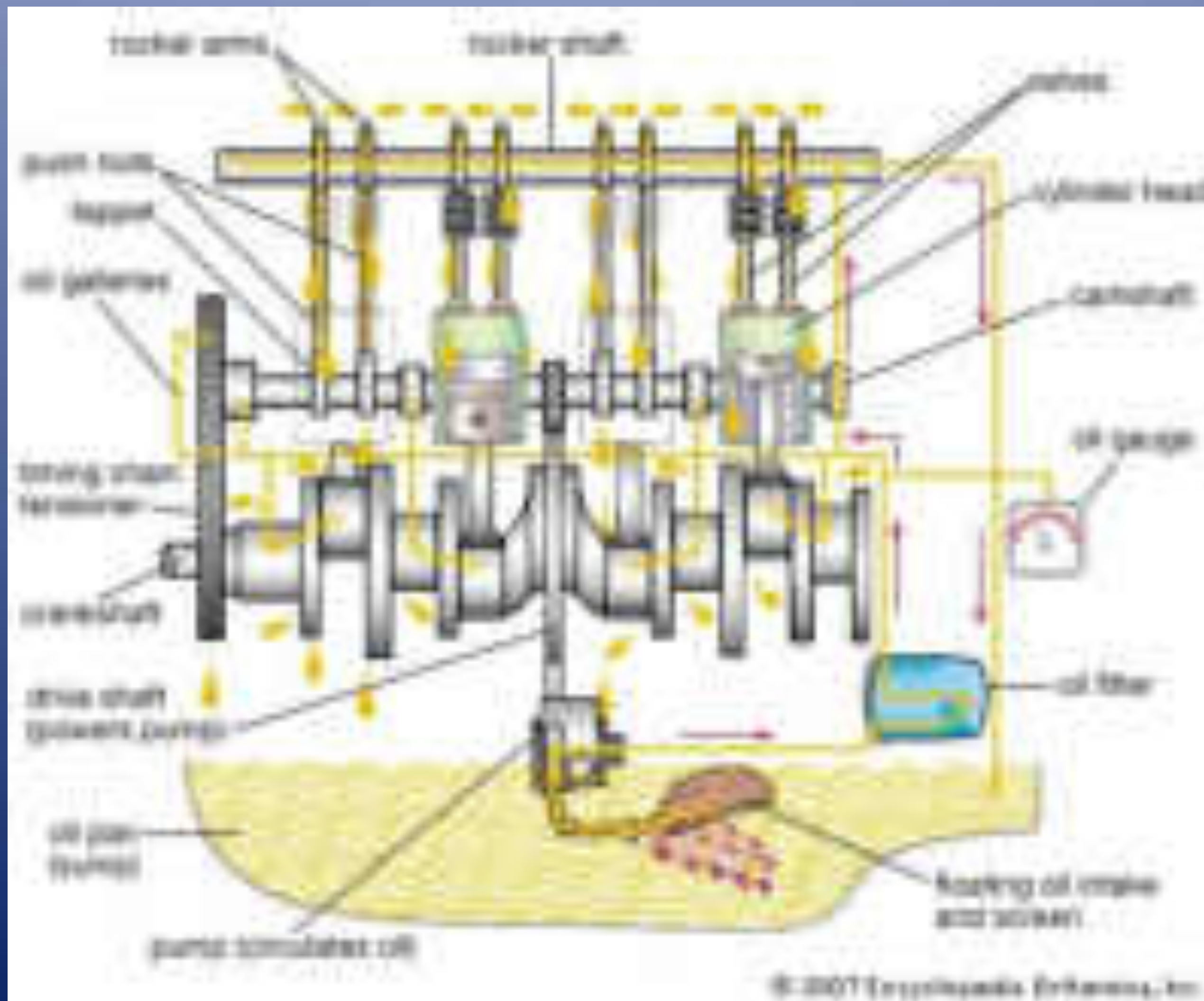
A fuel injection system is designed and calibrated specifically for the type(s) of fuel it will handle. Most fuel injection systems are for gasoline or diesel applications. With the advent of electronic fuel injection (EFI), the diesel and gasoline hardware has become similar. EFI's programmable firmware has permitted common hardware to be used with different fuels.

The primary difference between carburetors and fuel injection is that fuel injection atomizes the fuel by forcibly pumping it through a small nozzle under high pressure, while a carburetor relies on low pressure created by intake air rushing through it to add the fuel to the airstream.


Electrical Attachment
Solenoid
Off
Pressurized
Fuel
Valve Spring
Spray Tip
Fuel Filter
Injector Casing
Plunger


FUEL RAIL
O-RING
FILTER
ELECTRICAL
CONNECTOR
ELECTRIC
COIL
MAGNET
SPRING
O-RING
INTAKE
MANIFOLD
VALVE
PINTLE CAP

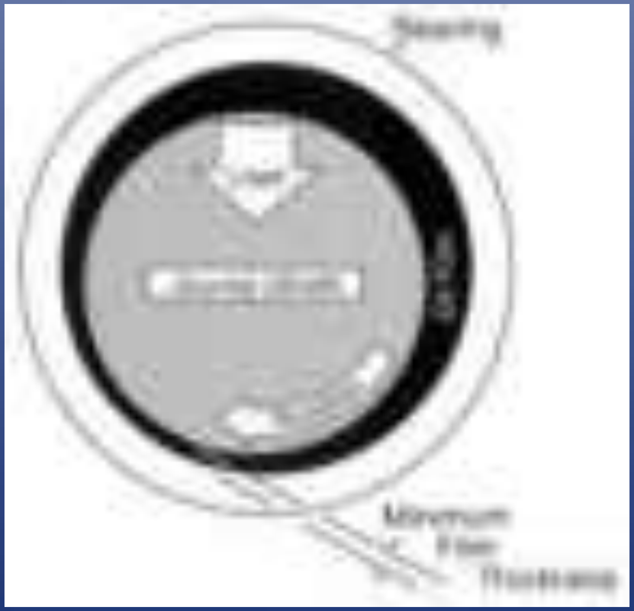

LUBRICATION SYSTEM



Purpose of Lubrication System

- **Lubricate**

Reduces *Friction* between moving by creating a thin **film** *(Clearance)* between moving parts (*Bearings and journals)*

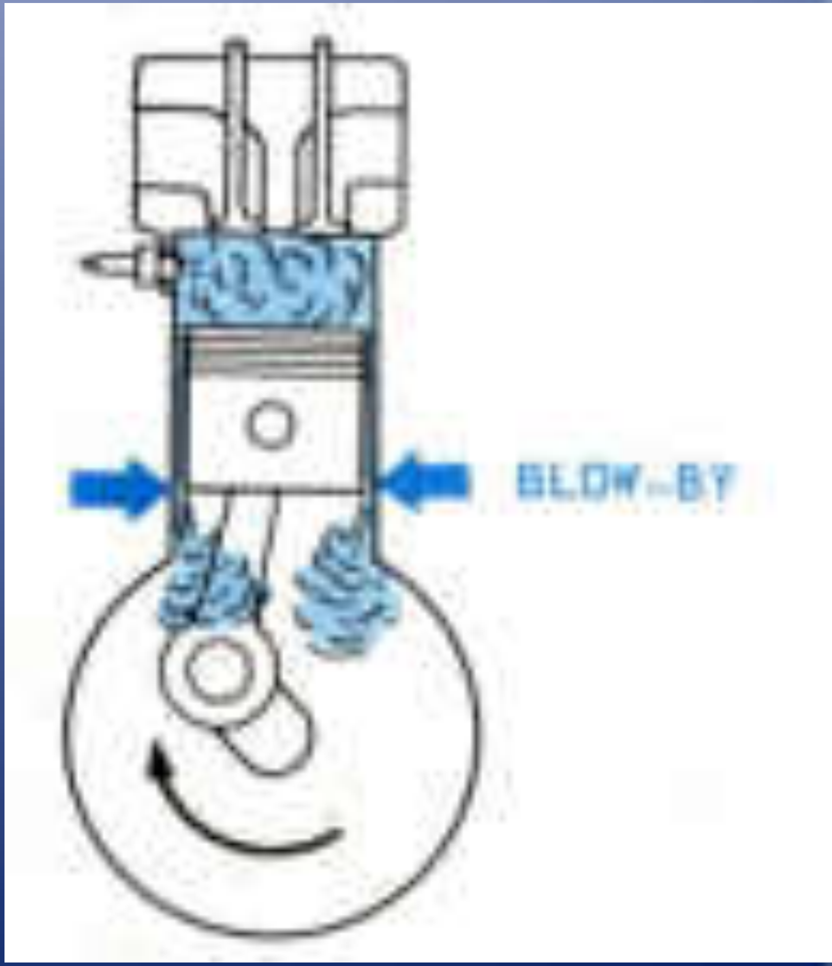


Purpose of Lubrication System

- **Seals**

The oil helps form a gastight seal between piston rings and cylinder walls (*Reduces Blow-By)*

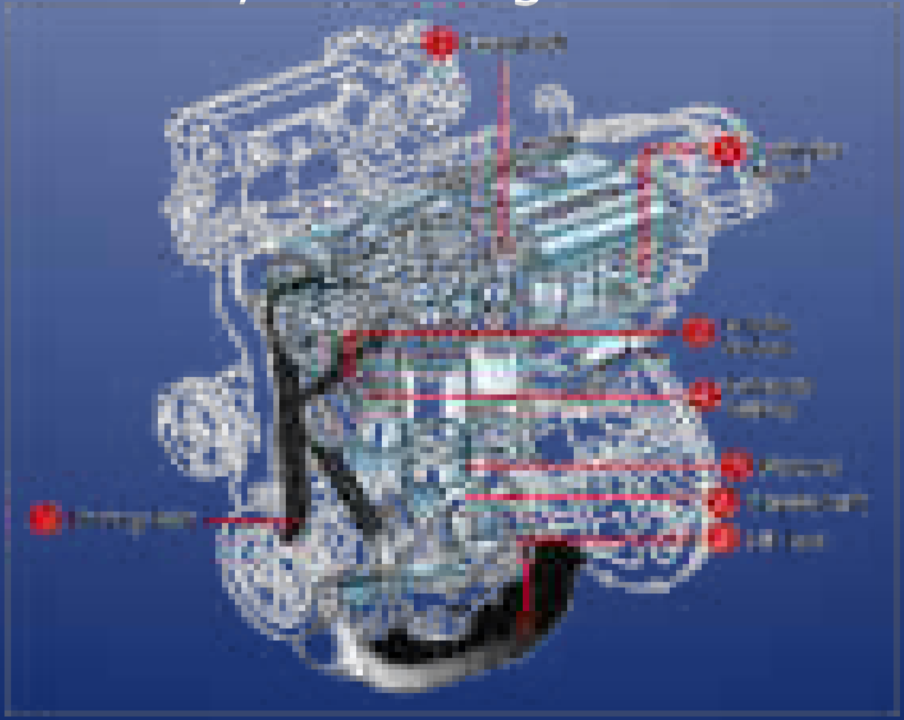
Internal oil leak (blow-by) will result in *BLUE SMOKE* at the tale pipe.



Purpose of Lubrication System

- **Cleans**

As it circulates through the engine, the oil picks up metal particles and carbon, and brings them back down to the pan.



Purpose of Lubrication System

- **Cools**

Picks up heat when moving through the engine and then drops into the cooler oil pan, giving up some of this heat.

Purpose of Lubrication System

- **Absorbs shock**

When heavy loads are imposed on the bearings, the oil helps to cushion the load.

- **Absorbs Contaminants**

The additives in oil helps in absorbing the contaminants that enter the lubrication system.

TYPES OF LUBRICANTS

1. Animal oils
2. Vegetable oils
3. Mineral oils
4. Synthetic Lubricants
5. Grease
6. Solid Lubricants

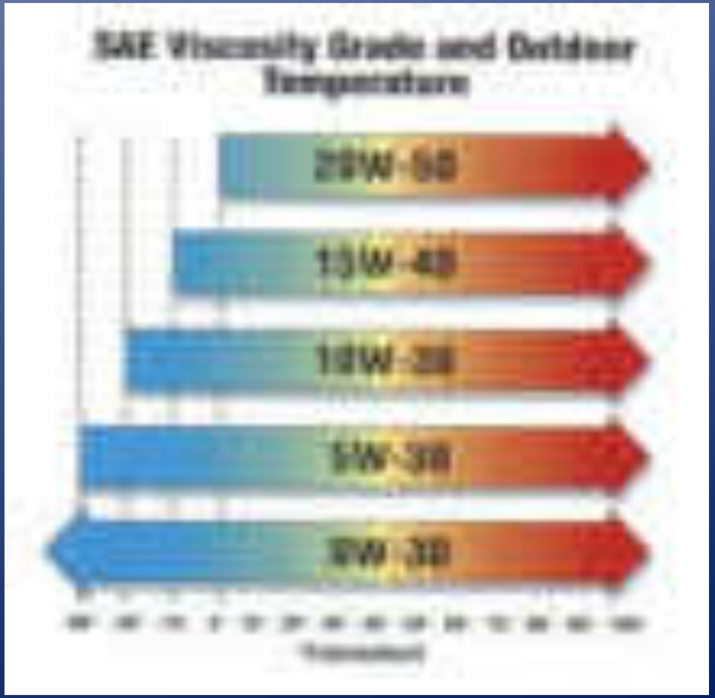
VISCOSITY

Viscosity is a measure of oil’s resistance to flow.

•A low viscosity oil is thin and flows easily

•A high viscosity oil is thick and flows slowly.

•As oil heats up it becomes more viscous (*Becomes thin)*



VISCOSITY

- If the oil is too thin (*has very low viscosity)* it will be forced out from between the moving parts, resulting in rapid wear.

- If the oil is too thick (*has very high viscosity)* it will flow very slowly to engine parts, especially when the engine and the oil are cold, resulting in rapid wear.

Viscosity Index is the measure of how much the viscosity of an oil changes with temperature. (20 W)

- High Viscosity index means less change of oil viscosity with temperature change
- Oil with minimum viscosity variation is preferred

VISCOSITY

Viscosity number is set by **SAE** *(Society of Automotive Engineers)*

- **Single viscosity oils** SAE 5W, SAE 10W (Winter) and
  SAE 20, SAE30 ... (Summer)

- **Multiple viscosity oils** SAE 10W-30.
  This means that the oil is same as SAE 10W when cold and SAE30 when hot.

The higher the number the higher the viscosity(*thickness)* of oil.

Properties of Lubricants

- **PHYSICAL STABILITY : Lubricant must be stable between its lowest and highest temperatures between which the oil is to be used**
- **CHEMICAL STABILITY : Should not be any tendency for oxide formation**
- **FILM STRENGTH : Property of an lubricating oil due to which the oil retail a thin film between the two surfaces even at high speed and load**

Properties of Lubricants

- **Corrosion and Rust Inhibitor:** Displaces water from metal surfaces, to prevent corrosion.

- **Foaming Resistance:** Rotating crankshaft tends to cause bubbles (*Foam)* in the oil and bubbles in oil will reduce the effectiveness of oil to lubricate.

FLASH POINT

It is defined as the lowest temperature at which the lubricating oil will *flash* when a small flame is passed across its surface.

- **It happens due to volatilization of the light particles in the oil.**
- **The flash point of lubricant oil should be sufficiently high so as to avoid of flashing of oil vapors at the temperature occurring in common use .**

POUR POINT

It is the lowest temp. at which the lubricating oil will pour.

- It is indication of ability of lubricating oil to move at low temp.
- This property must be considered because of its effect on starting the engine in cold whether and on free circulation of oil through exterior feed pipes when pressure is not applied.

Service Rating of Oil

SA, SB, SC, SD,…..SG- ratings by American petroleum Institute, in the order of severity of service conditions

- **SA** and **SB** oils are not recommended for use in today's Automobile engines.

- "S" means Service (spark ignition)

- Ratings from SA (straight mineral oil) to SL.

- SL is the highest rated oil starting in 2001.

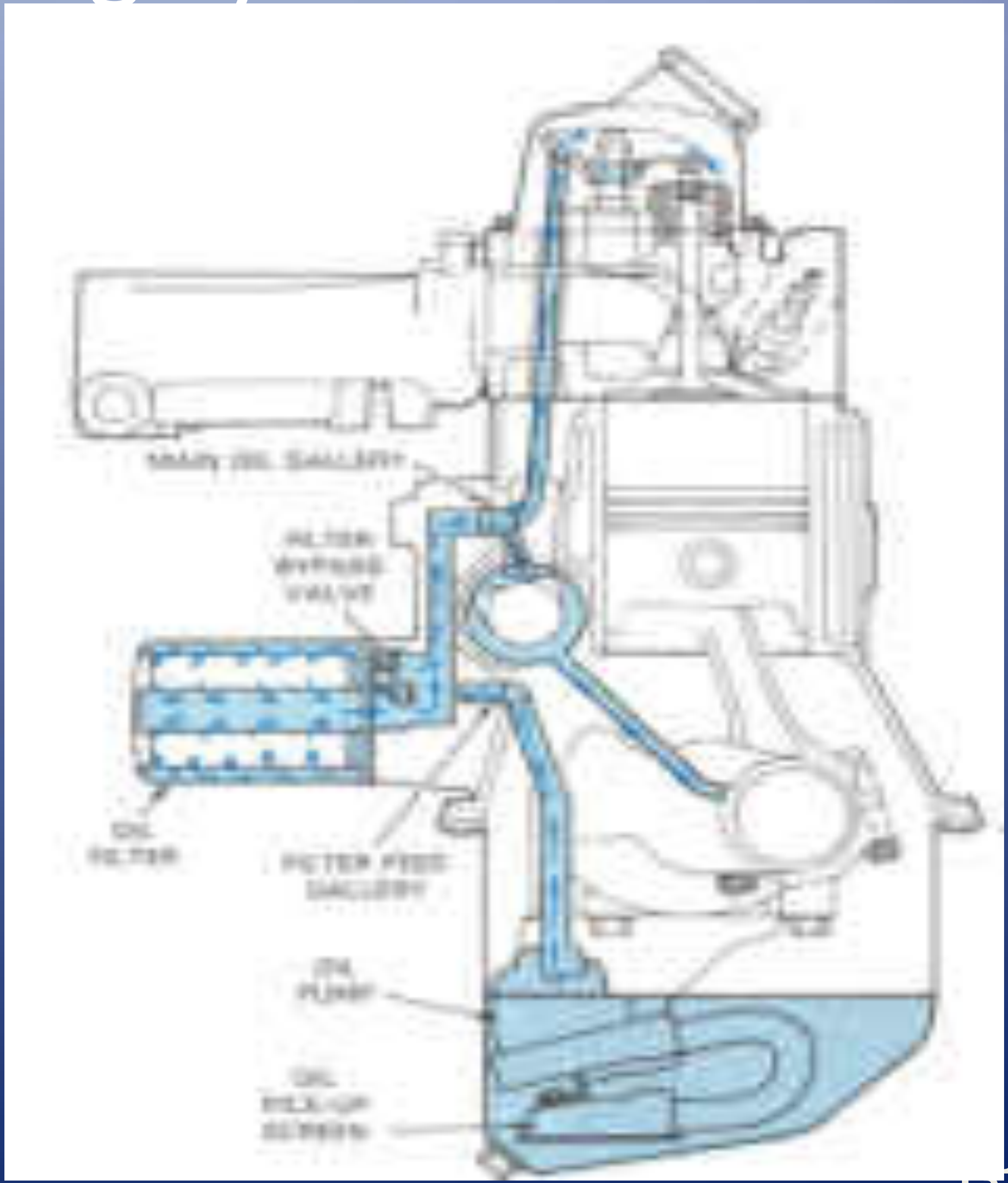
- Use the highest rated oil available (or as specified)

Lubricating Oil Additives

Type	Typical Compounds	Reason for Use
Detergents, dispersants	Succinimides, neutral metallic sulfonates, phenates, phosphonates, polymeric detergents, amine compounds	Keep sludge, carbon and other deposit precursors suspended in the oil
Oxidation inhibitors	Zinc dialkyl dithiophosphates, compounds of nitrogen and sulfur, hindered phenols, Bis-phenols	Prevent or control oxidation of oil, formation of varnish, sludge, and corrosive compounds, limit the viscosity increase over time
Alkaline compounds	Overbased metallic sulfonates and phenates	Neutralize acids, prevent corrosion
Extreme pressure (EP) antiwear, friction modifiers	Zinc dialkyl dithiophosphates, tricresyl phosphates, organic phosphates, chlorine compounds	Form protective film on engine parts. Reduce wear and prevent galling and seizing
Rust inhibitors	High-base additives, sulfonates, phosphates, organic acids or esters, amines	Prevent rust on metal surfaces by forming protective film or neutralizing acids
Metal deactivators	Zinc dialkyl dithiophosphates, metal phenates, organic nitrogen compounds	Form film so that metal surfaces do not catalyze oil oxidation
Viscosity index improvers	Polyisobutylene, methacrylate, acrylate polymers	Increase the viscosity index, allow easier cold starting
Pour point depressants	Methacrylate polymers	Lower "freezing" point of oils, ensure free flow at low temperatures
Antifoamants	Silicone polymers	Reduce foam in crankcase

Lubricating System Parts

- Oil pan
- Oil pump
- Pick-up screen
- Pressure regulator
- Oil filter
- By-pass valve
- Oil galleries
- Dipstick
- Pressure indicator



Oil Pan

- Storage reservoir for motor oil
- Plug on bottom to drain.
- Pick-up screen sucks oil up from oil pump.

Oil Filters

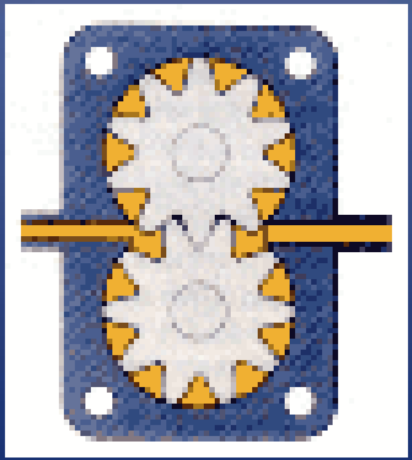
- Micro-porous paper filters used to screen out particles.
- Most filters of the cartridge type.

Oil Pumps

<u>Oil Pumps</u> Driven by camshaft, crankshaft (*Rarely rebuild by an auto technician)*

- Rotor Pump*(Two star shaped rotors pumps the oil)*

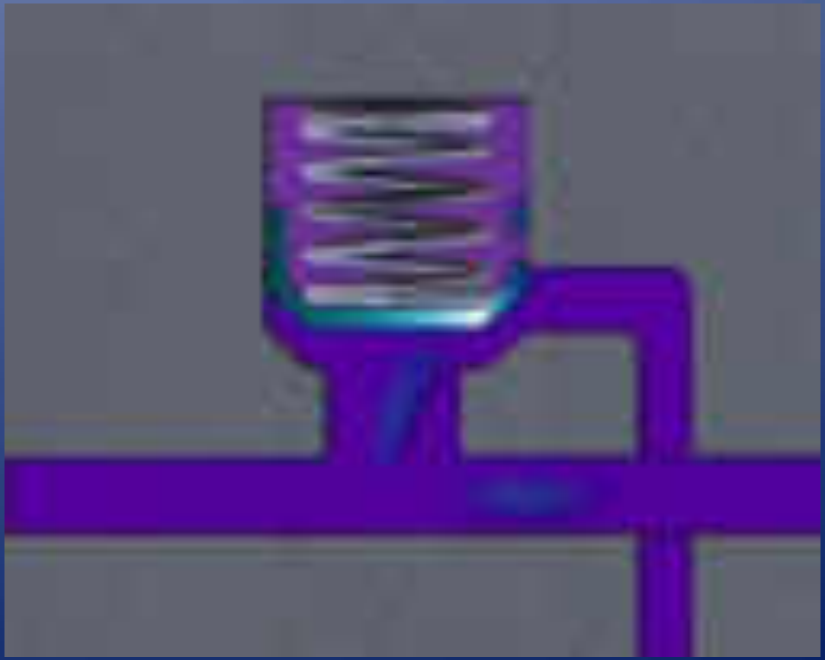
- Gear oil Pump



Pressure Relief Valve

Pressure Relief Valve to prevent the buildup of high Pressure (*Causes the oil filter to bulge, but not a common problem).*

Good oil pressure is 40-60 psi



Oil Pressure Indicator

Oil Pressure Indicator

- Light or a Gauge

The light turns on or gauge reads low when the pressure drops below 10psi.

- **Good oil pressure is 40-60 psi.**

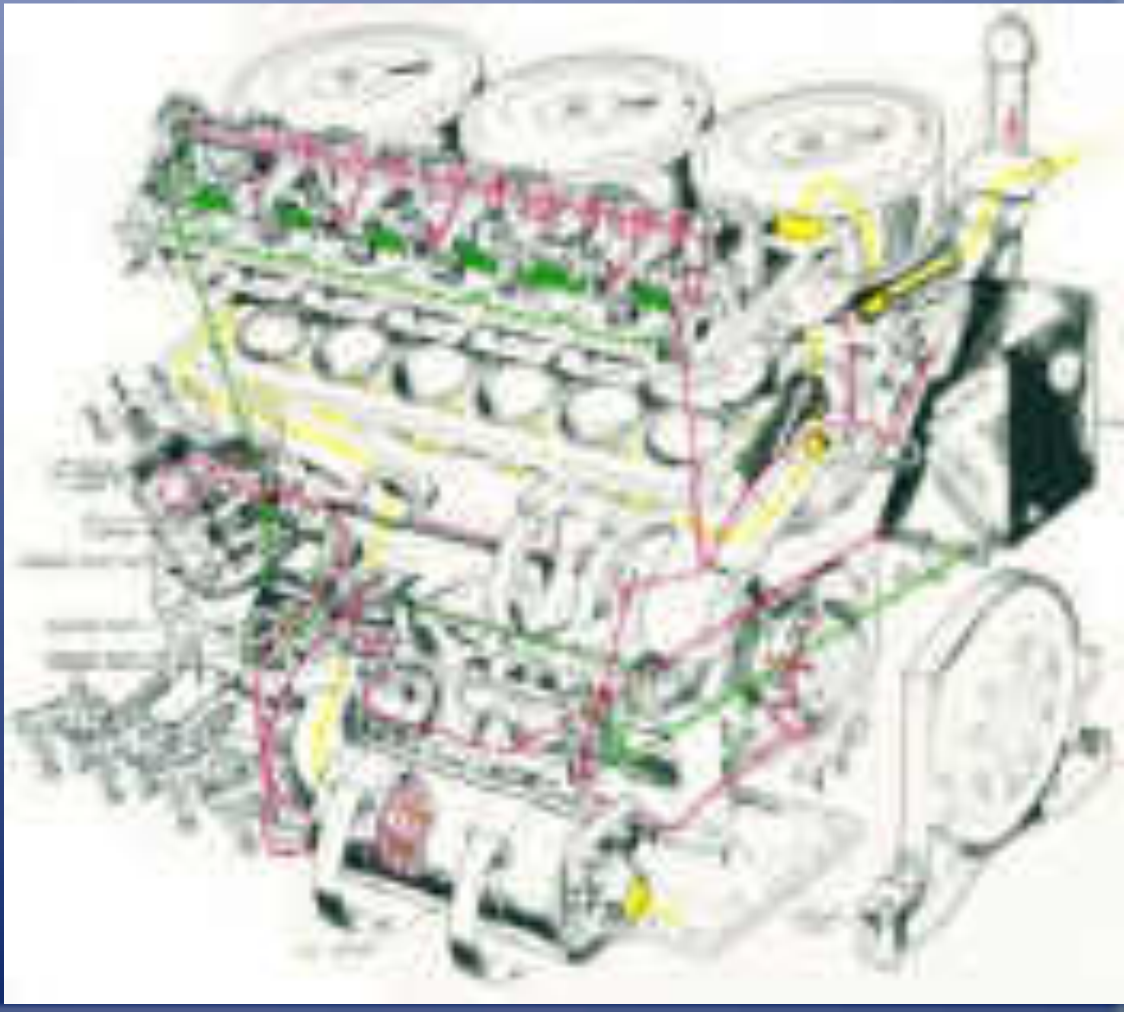
Common causes of low oil pressure are:

- **Low oil level**
- **Worn out pump**

Low oil pressure Safety system will shuts down the car by cutting the ignition System*(Spark).*

Oil Galleries

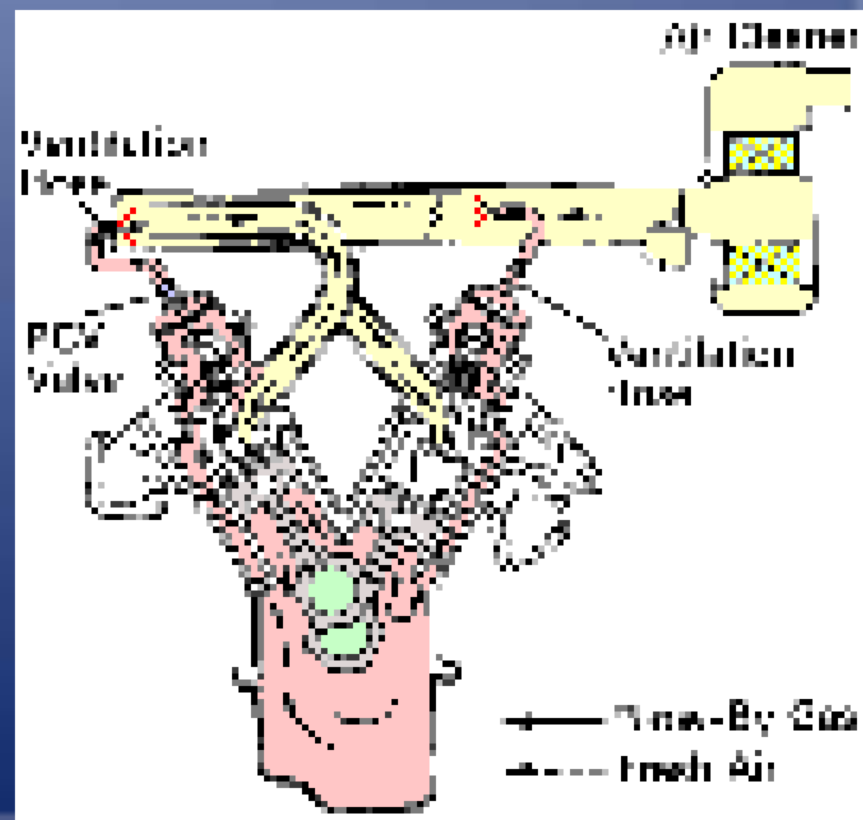
Deliver the oil to top end and returning it To the oil pan.



Crank case ventilation

Positive Crankcase ventilation Valve

- **Pollution prevention**
- **Blow-by back into the intake**
- **Prevent sludge in the engine.**



Parts

<u>Oil Pressure sensing unit</u> electrically sends the signal to the Light or Gauge mounted on the dash.

If the wires get shorted the light will come on or the gauge will read high.

Oil Contamination

- Blow-by gases add raw gasoline and water to the oil causing deterioration.
- Excessive heat can cause thermal breakdown.
- Excessive cranking can dilute oil with gasoline.
- Cooling gasket leaks will ruin oil causing sludge.

Systems of Engine Lubrication

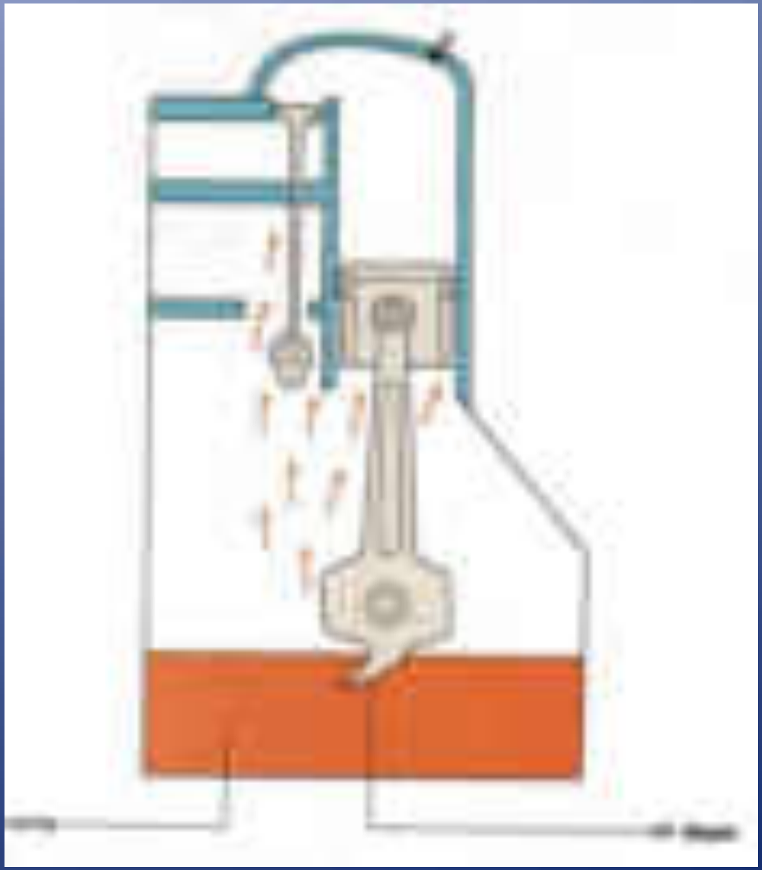
1. **Petroil System**
2. **SPLASH SYSTEM** ***(WET SYSTEM)***
3. **PRESSURE SYSTEM** ***(WET SYSTEM)***
4. **DRY SUMP LUBRICATION SYSTEM** ***(DRY SYSTEM)***

Petroil lubrication system

- **Petroil lubrication method is used in light vehicles such as motor cycles and scooters. In this system, 3% to 6% of lubricating oil is mixed with petrol in the fuel tank. In Petroil lubrication system, there is no separation sump and tank for lubricating oil. The oil is mixed with petrol that acts as a lubricant.**

SPLASH SYSTEM

- The splash system is used only on small four-stroke-cycle engines such as lawn mower engines.
- As the engine is operating, dippers on the ends of the connecting rods enter the oil supply, pick up sufficient oil to lubricate the connecting-rod bearing, and splash oil to the upper parts of the engine.
- The oil is thrown up as droplets, or fine spray, which lubricates the cylinder walls, piston pins and valve mechanism.



PRESSURE SYSTEM

this pump to prevent excessive pressure.

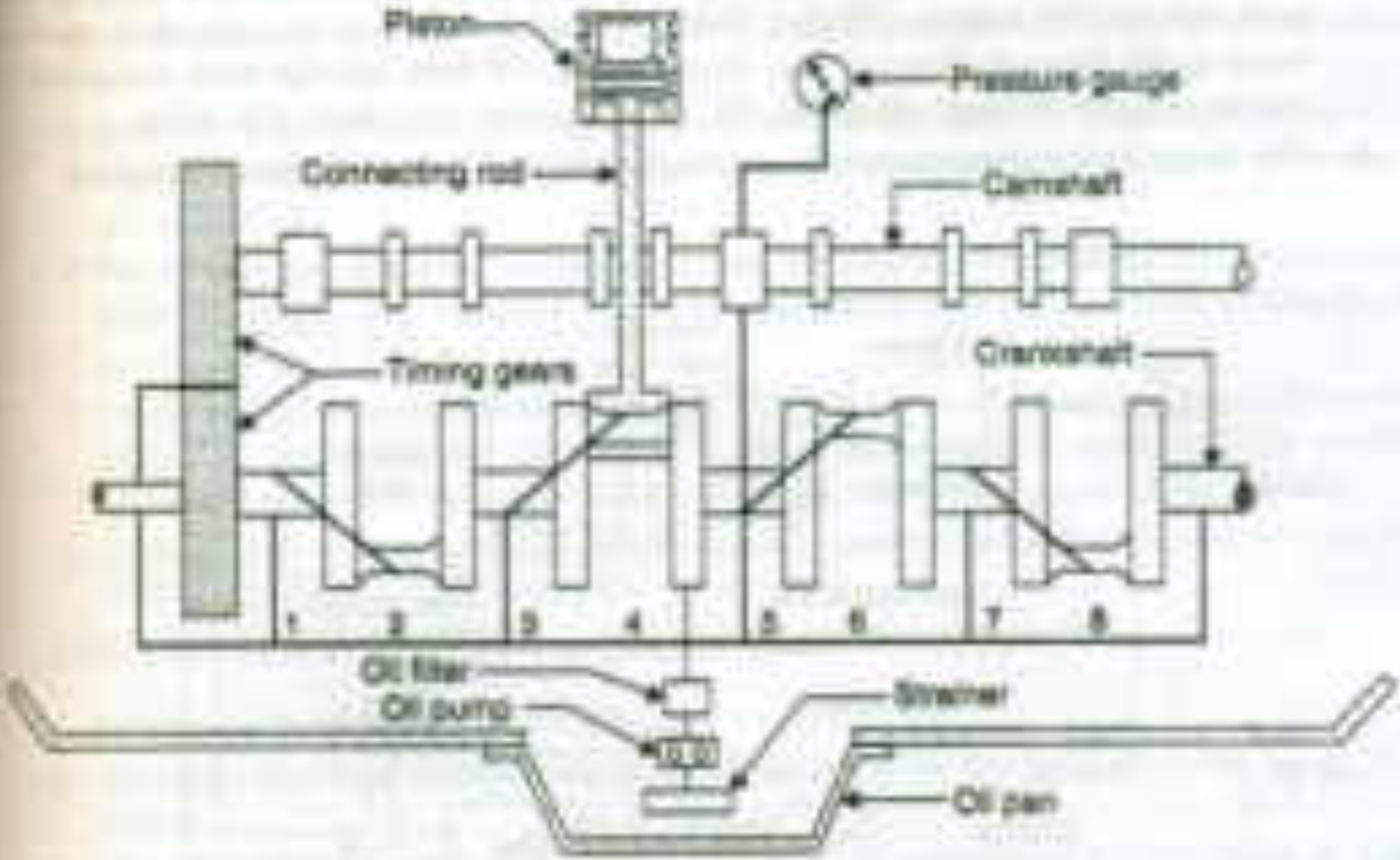


Fig. 4.[illegible]. Full pressure system.

WET SUMP LUBRICATION SYSTEM

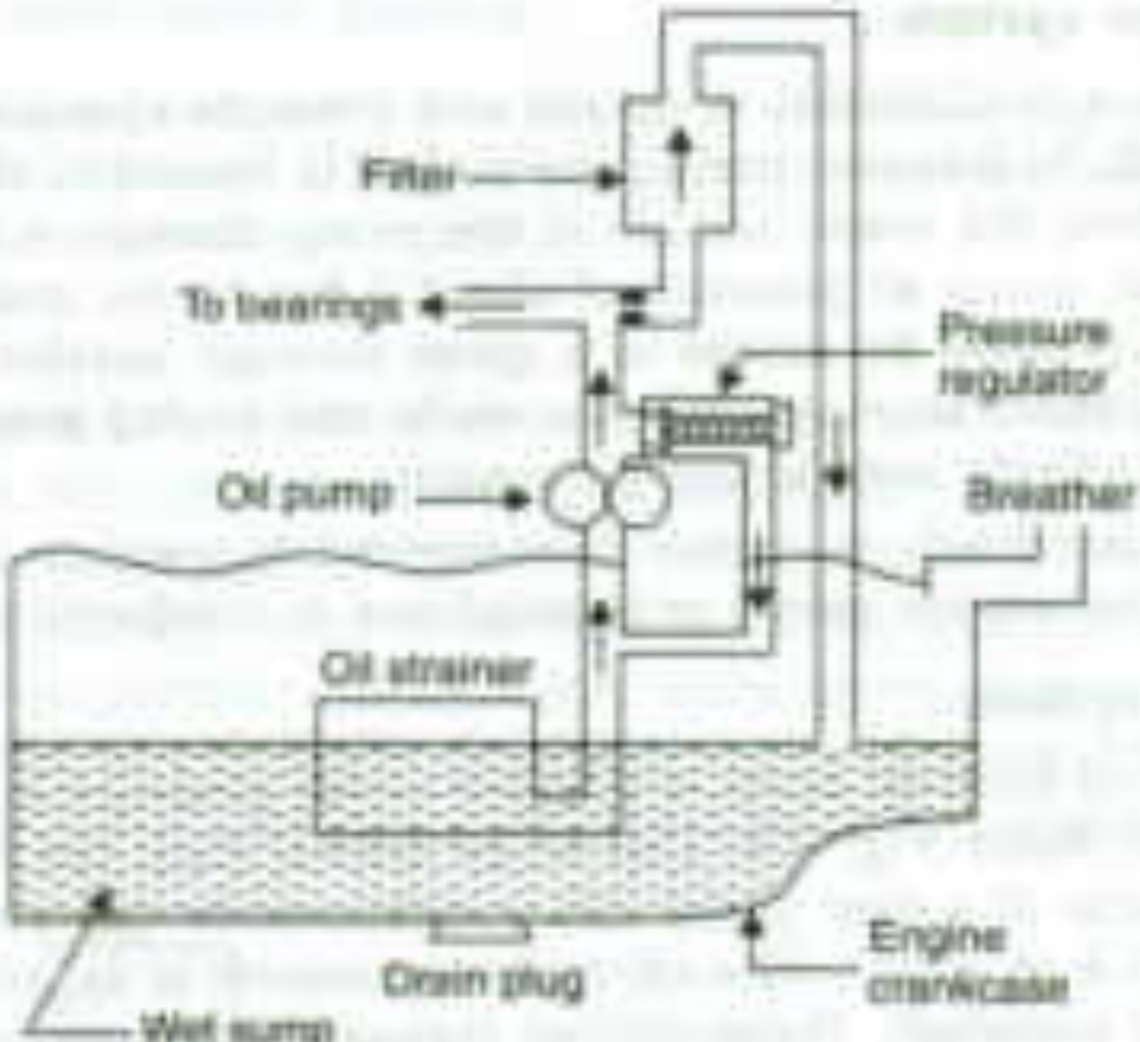
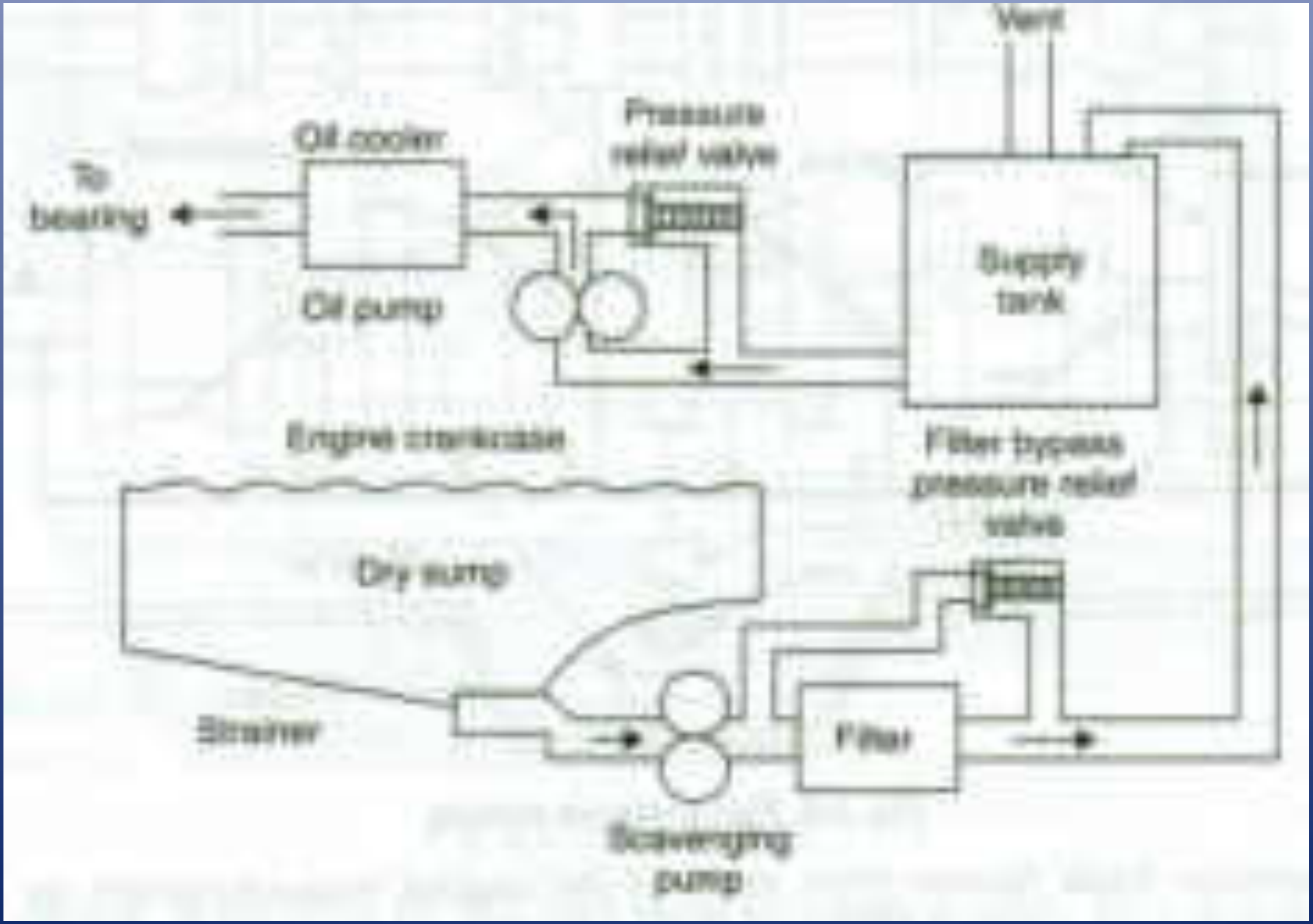


Fig. 4.9. Wet sump lubrication system.

DRY SUMP LUBRICATION SYSTEM



OIL CHANGE

- **Every 5000Km**
- **3 months**

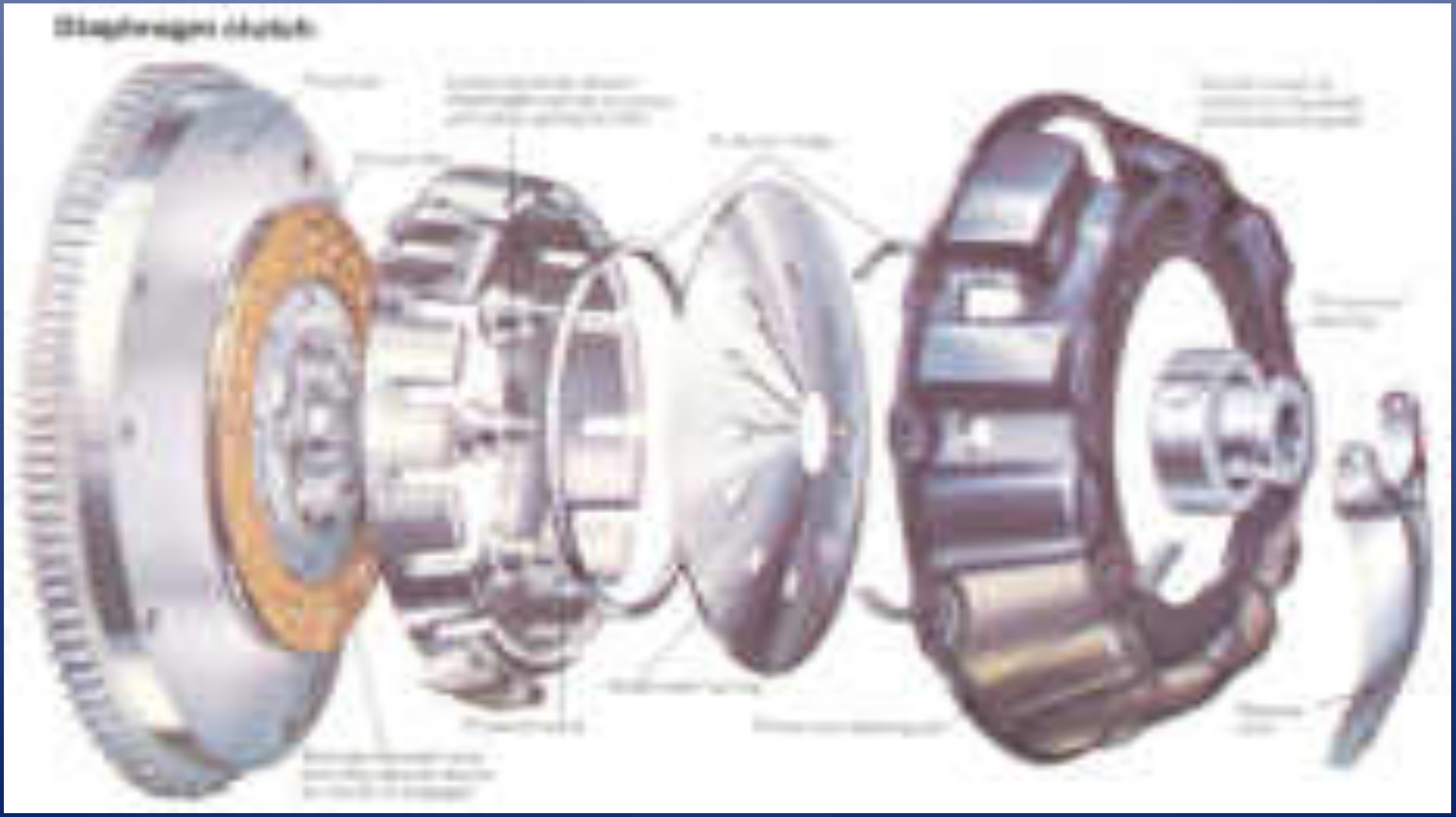
Ignoring regular oil change intervals will shorten engine life and performance.

TRANSMISSION
Part 1
Clutch System

Clutch

- Clutch is a mechanism used in transmission system to engage and disengage the engine to transmission.
- It is used to connect engine to the gear box. It allows to change the gear to supply proper torque to the wheels
- Clutch Disengage when :
  – Starting the engine
  – When shifting the gear
  – When stopping the vehicles
  – When idling the engine

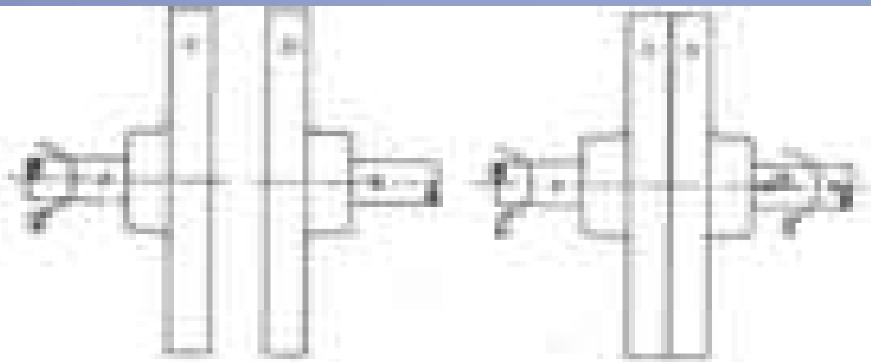
- Engage :
  - When the vehicle is to move.
  - When the vehicle is moving.
- It also permit the gradual locking up the load



REQUIREMENTS OF A GOOD CLUTCH

1. Torque Transmission
2. Gradual Engagement
3. Good Heat Dissipation
4. Dynamic Balancing
5. Compact Size
6. Minimum Inertia
7. Vibration damping
8. Ease of Operation

Principle of Operation: Clutch



1) The shaft A and disc C are revolving at some speed N rpm.
2) Shaft B and disc D are stationary initially when the clutch is not engaged. Now apply some axial force W to the disc D so that it comes in contact with disc C.
3) As soon as the contact is made, the force of friction between C and D will come into play and consequently the disc D will also start revolving.
4) If W is increased gradually, speed of D will increase correspondingly till the stage comes when the speed of D becomes equal to the C.
5) Then the clutch is said to be fully engaged.

Let:

- W=axial load applied
- μ=coefficient of friction
- T=torque transmitted
- R=effective mean radius of the friction surface

$$T = \mu W R$$

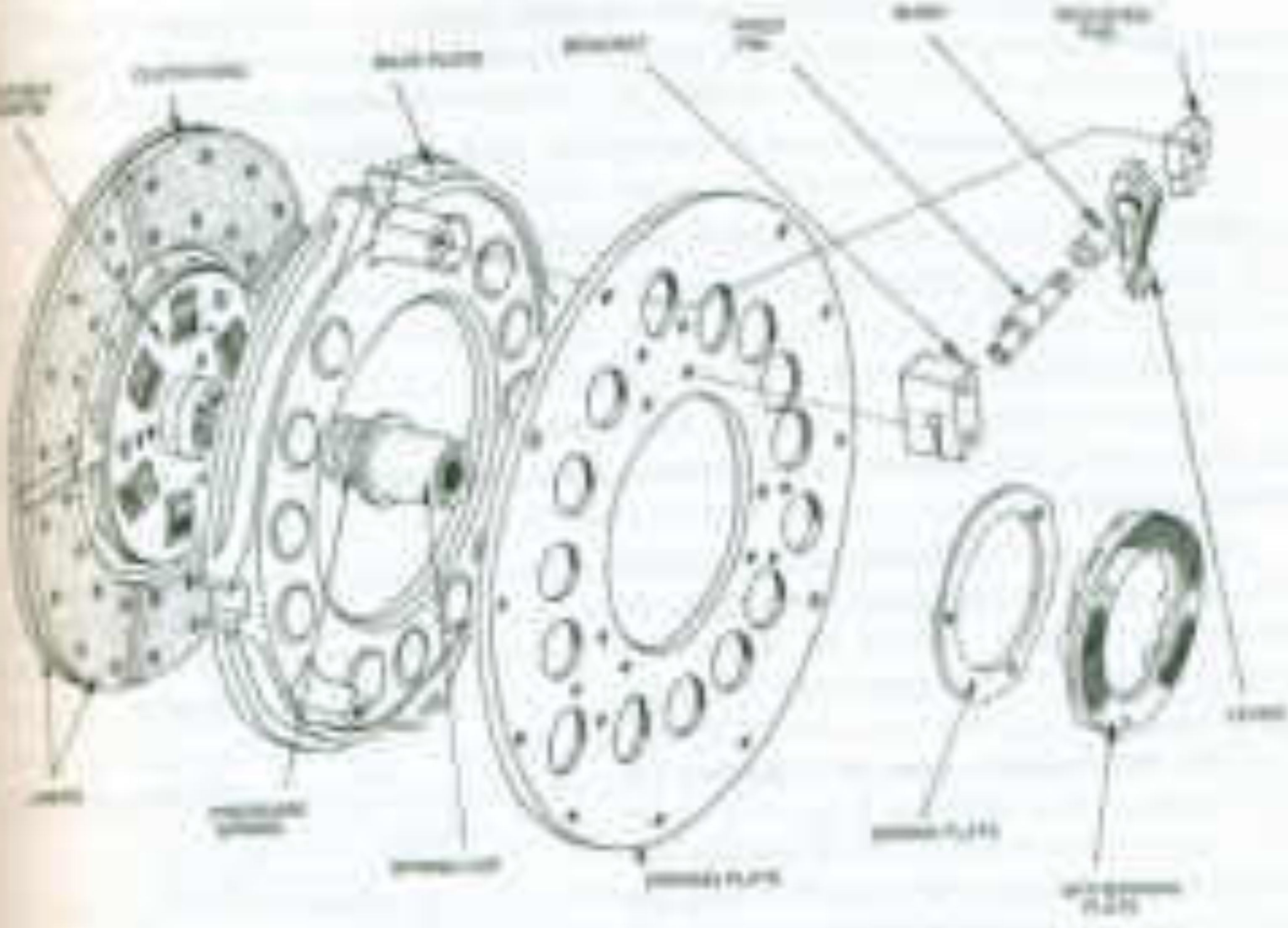


Fig. 27.8 (a). The clutch components (Courtesy : Ashok Leyland)

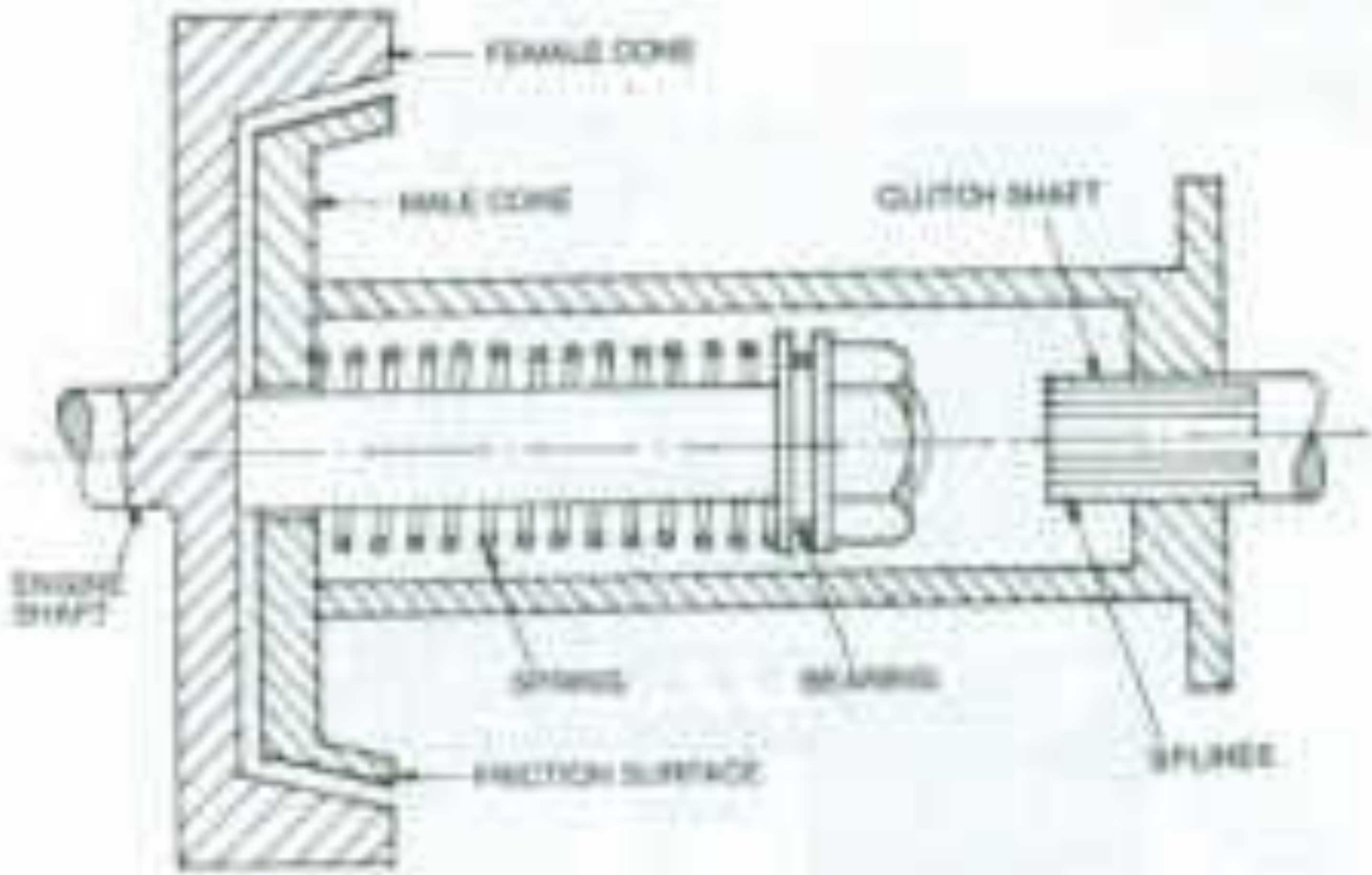
Main Components of Clutch

- Driving Member : Flywheel
  - mounted on engine crankshaft
- Driven member : Clutch Plate
  - Free to slide lengthwise on the splines of the clutch shaft.
  - It carries friction materials on both side of its surface.
  - when gripped between the flywheel & pressure plate, it rotates the clutch shaft through the splines.
- Operating member : Foot pedal, linkages, release or throw out bearing, release lever and spring

TYPES OF CLUTCHES

- Friction clutch
  - Single plate clutch
  - Multiple clutch
    - Wet type
    - Dry type
  - Cone clutch
    - External
    - Internal
- Centrifugal clutch
- Semi- centrifugal clutch
- Diaphragm clutch

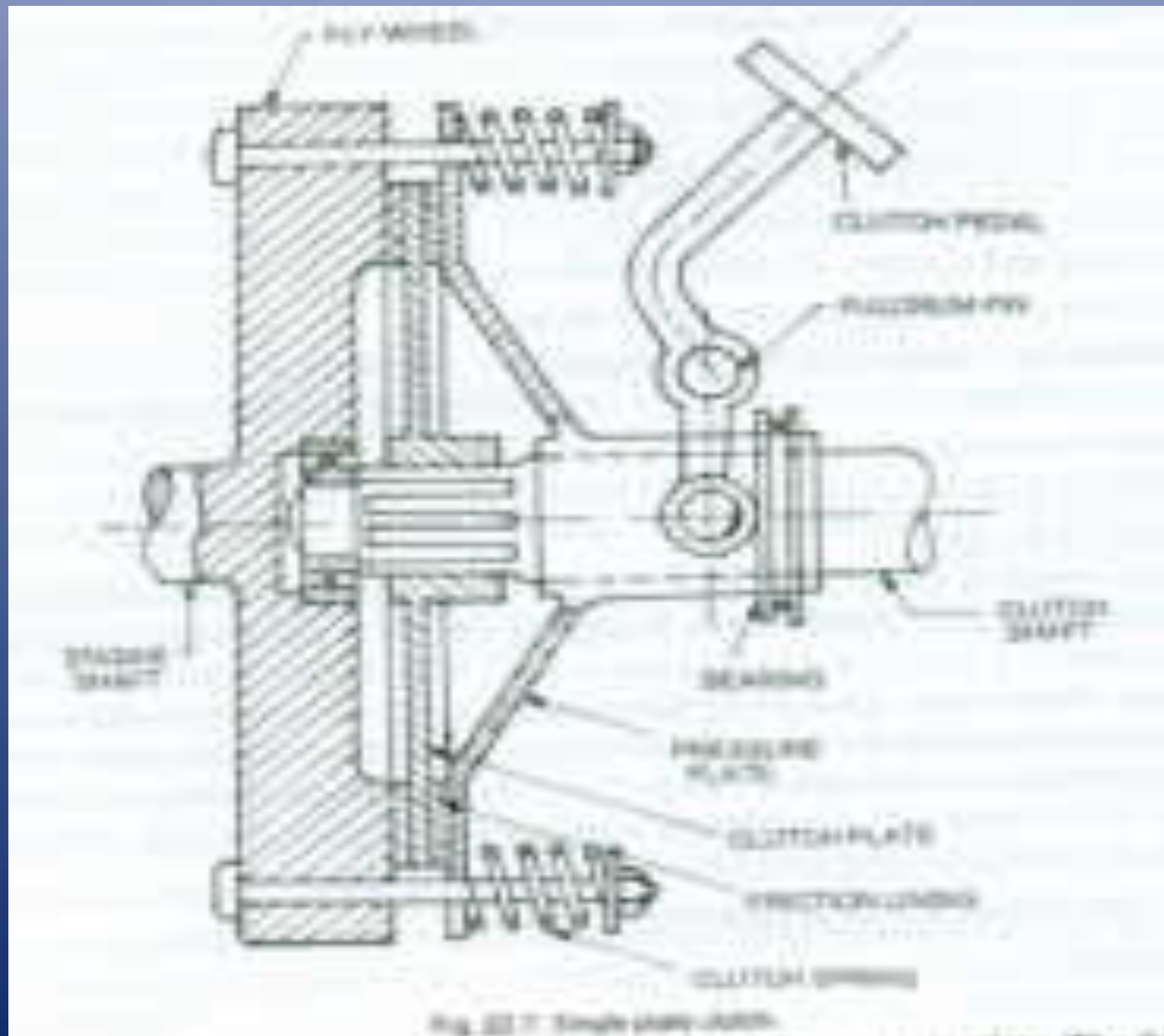
Friction clutch : Cone type



Cone Clutch

- In cone clutch contact surface is in form of cones. The Contact surface is maintained by attaching the cones by means of springs.
- In engaged position torque is transmitted from engine shaft via the fly wheel & and male cones to the gear box shaft .
- During engagement pressure is applied by means of spring. For disengagement male cones are pulled by means of lever .
- In this type of clutch normal force is larger as compared to axial force in single plate clutch, Where axial force is equal to contact surface.

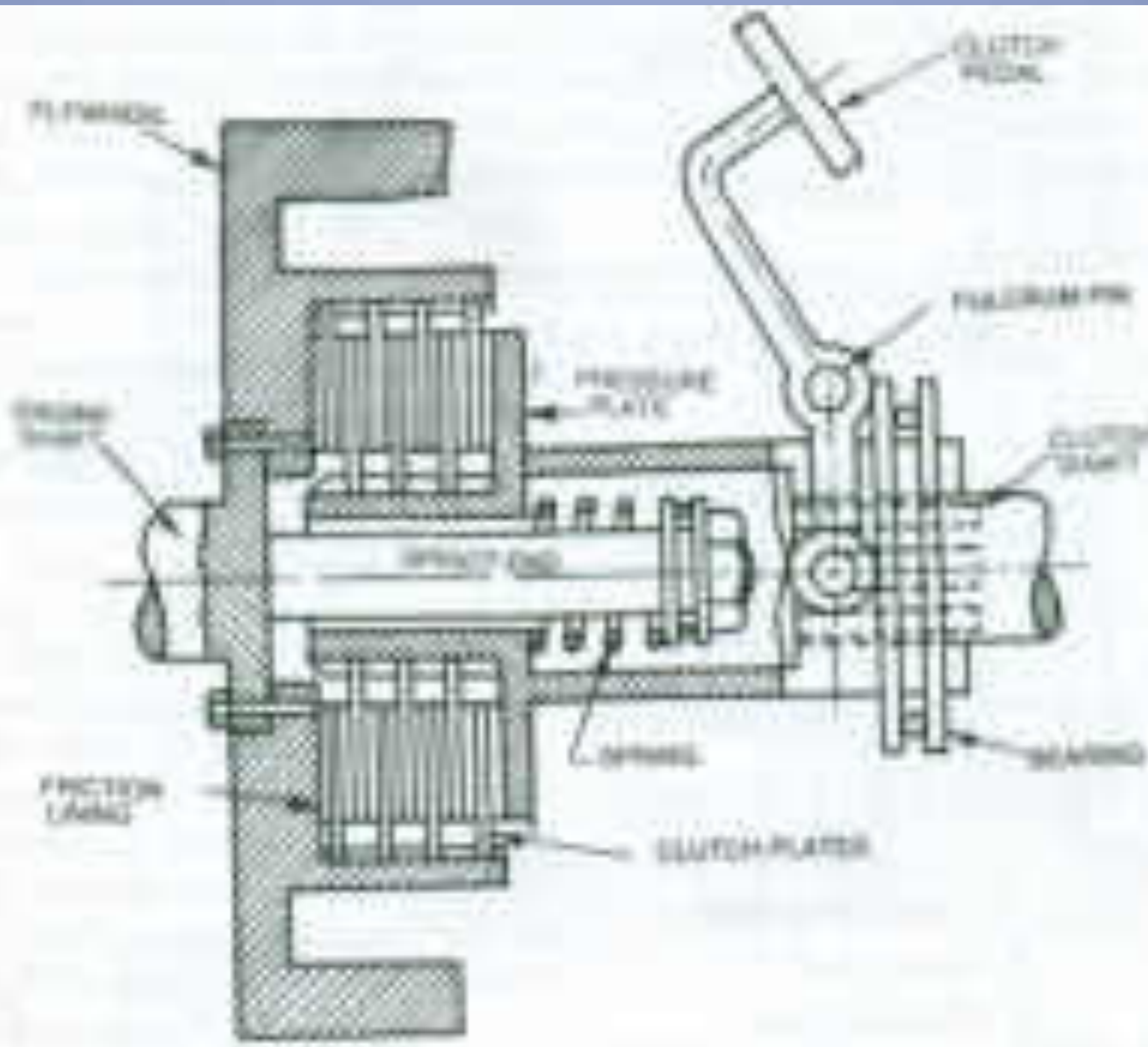
Friction clutch : Single Plate



Single Plate Clutch

- Springs provide axial force and keeps clutch in engaged position.
- Friction plate is mounted on the hub which is splined from inside and is thus free to slide over the gear box.
- Generally friction plate is in engaged position and to disengage this pressure in applied against spring manually by lever mechanism. When pedal is pressed pressure plates are moved to the right against force of spring .
- When pressure plate and friction plate is released then clutch is disengaged.
- Less force is needed to apply on the pedal for disengagement.

Friction clutch : Multiplate



Multiplate Clutch

- This clutch is similar to single plate clutch, Else the number of friction plates are more. This result in increased friction surface and increased torque. Over all diameter of clutch is reduced for some torque transmission.
- Note that friction plates are attached in grooves of flywheel and pressure plate in alternate number series.
- This type of clutch is used in heavy vehicles.

Centrifugal Clutch

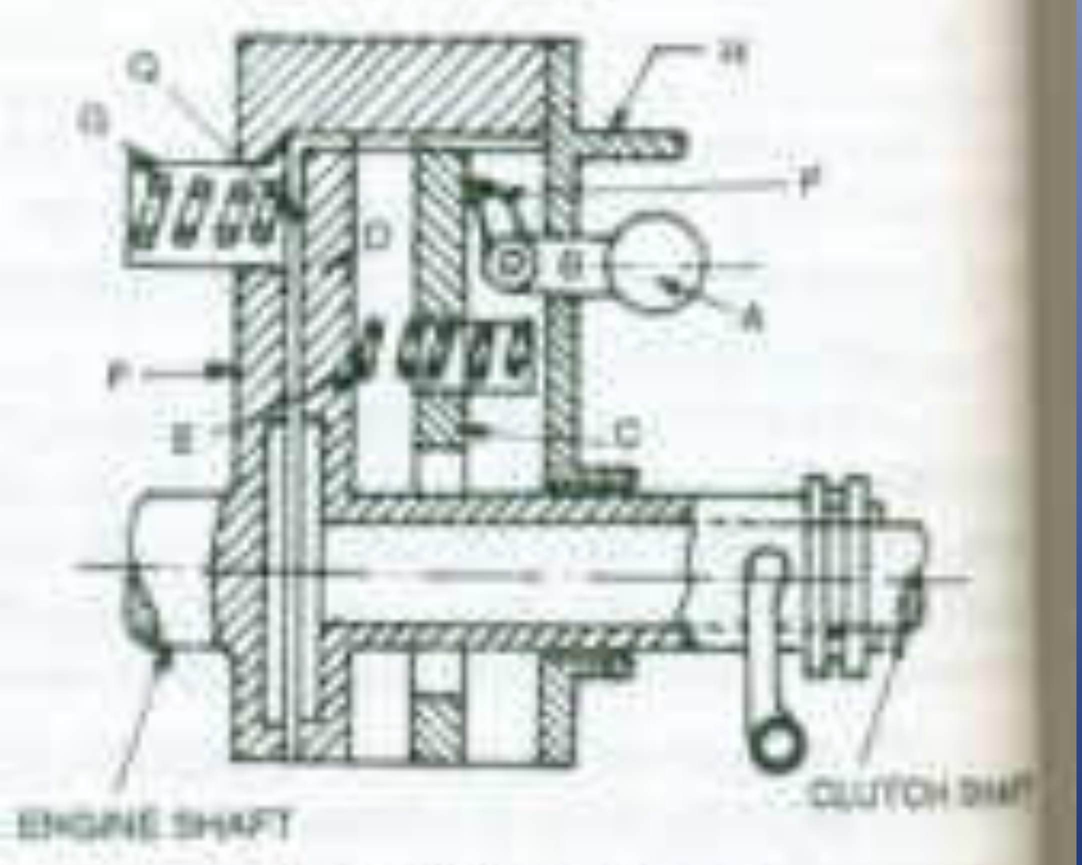
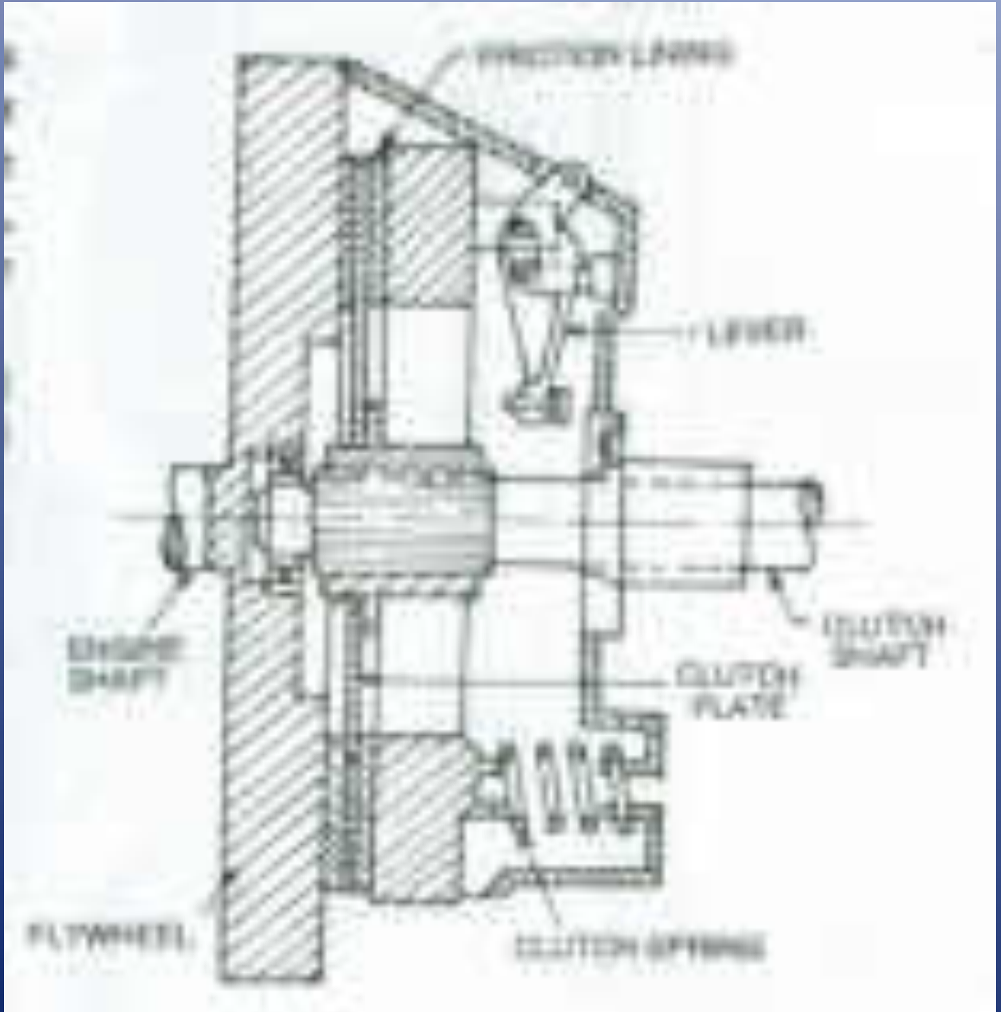
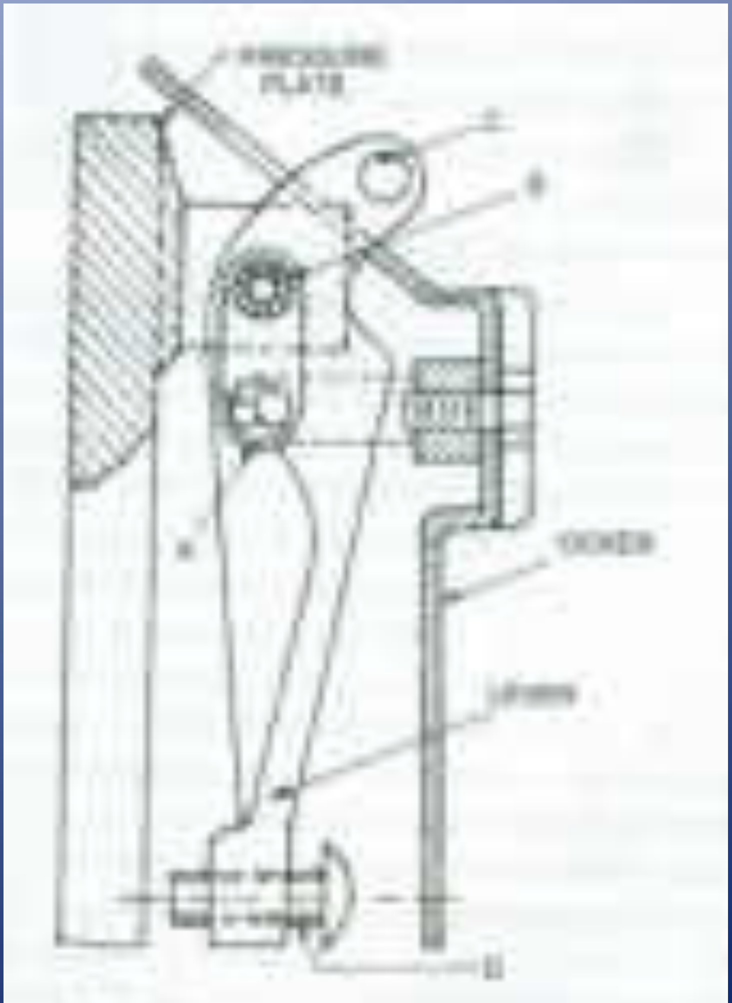


Fig. 23.13. Centrifugal clutch.

Semi-Centrifugal Clutch

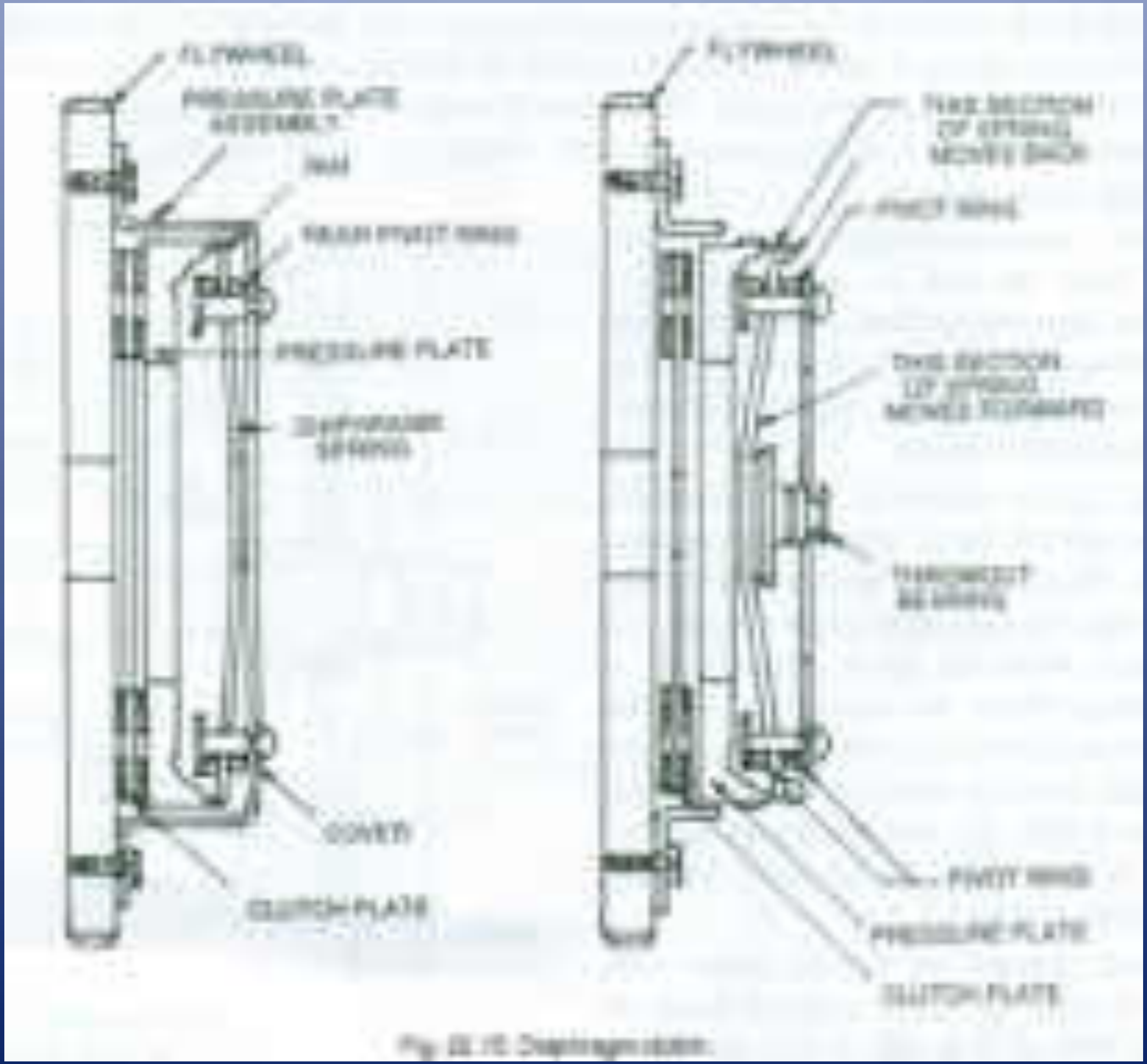




Semi-Centrifugal Clutch

- This type of clutch uses lighter pressure plate springs for a given torque carrying capacity, so that the engagement of the clutch in the lower speed range becomes possible. The centrifugal force supplements the necessary extra clamping thrust at higher speeds

Diaphragm Clutch



HYDRAULIC CLUTCH SYSTEM

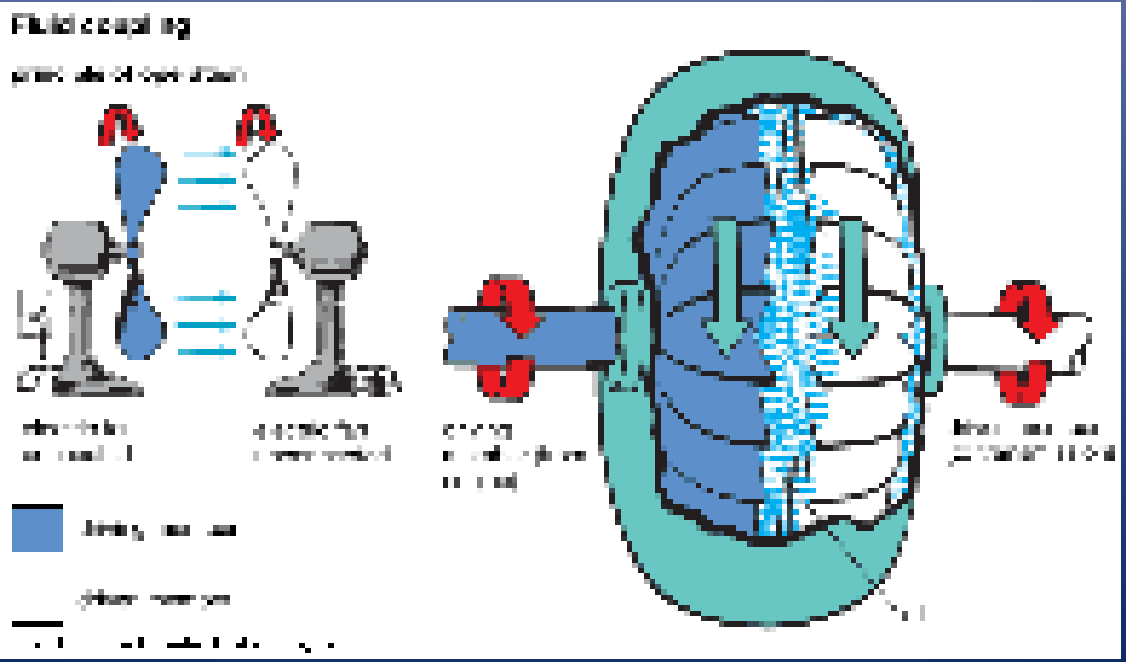
- Hydraulic clutch mechanism is used in heavy vehicles where clutch pedal is located far away from the clutch. This mechanism can be attached to both single plate and multiplate clutch.
- WORKING: When we press the clutch pedal the fluid flows from master cylinder to slave cylinder mounted on the clutch. Fluid from the slave cylinder is released under pressure which further operates the clutch release fork to disengagement of discs.

Clutch facing materials

- Leather $\mu = 0.27$
- Cork $\mu = 0.32$
- Fabric $\mu = 0.40$
- Asbestos $\mu = 0.2$ anti heat characterstics
- Non Asbestos Clutch facing
  - SW3-AF $\mu = 0.28$ at $50^\circ C$ & $\mu = 0.36$ at $250^\circ C$
  - HWK 200 $\mu = 0.40$

Fluid Flywheel / Fluid Coupling

Fluid coupling is a hydraulic unit that replaces a clutch in a semi or fully automatic system, and transmits engine torque to a transmission system. Since the coupling is a major part of the engine flywheel assembly, it is also called a fluid flywheel or fluid-drive acting as an automatic clutch. In this drive the power flows through a fluid instead of through a mechanical device. The fluid drive consists of a driving and a driven member both bowl or half-doughnut shaped, immersed in a fluid contained in a casing. These units are mounted very closely with their open ends facing each other, so that they can be tuned independently without touching.



Operation of Fluid Flywheel

Operation The driving unit (impeller) is linked to the engine crankshaft and sets the oil into motion when the throttle is opened. The force of the rotating, trapped oil impinges on the fins of the driven unit (the runner or turbine) and cause it to move. Thus the fluid transmits the engine power to the clutch-driving plate without any metal to metal contact. Figure 12.12 shows the simplified diagram of a fluid flywheel. It consists of a split housing driven by the engine. The turbine is attached to the gear box clutch shaft and it is inside the housing. It acts as a driven member. Both the driving (pump or impeller) and the driven member have radial vanes. When the driving member rotates with the engine, the fluid is thrown outwards under the action of centrifugal force. It circulates from the flywheel to the turbine vanes. Since the driving member carries around the fluid, it tends to rotate the turbine. As the speed of the driving member increases, the circulating fluid gains energy and the same is imparted to the turbine and causes it to turn. Thus power is transmitted from the impeller or pump to the turbine.

A fluid coupling always slips by about 2 to 4% when transmitting full load. It means that the turbine is always running slightly slower than the impeller and as such complete disconnection of the drive is not possible. Thus the fluid coupling is not suitable for ordinary gear box and is generally used with epicyclic gears to provide a semi or fully automatic gear box.

Advantages & Disadvantages

Advantages

The main advantages of a fluid coupling are:

1. Smooth transmission of power from engine to gears.
2. Elimination of clutch pedal.
3. Damping of the torsional vibrations of the crankshaft.
4. Less maintenance due to absence of friction surface.
5. During braking or coming down a hill, the transmission shocks are absorbed by the fluid.

The main disadvantage of fluid coupling is the presence of idling drag and that overloading of the fluid coupling not only slows down the turbine but also overloads the engine. Also the slip is greater at lower speeds (it is about 2% at max. efficiency).

Thanks

TRANSMISSION
Part 1
Clutch System

Clutch

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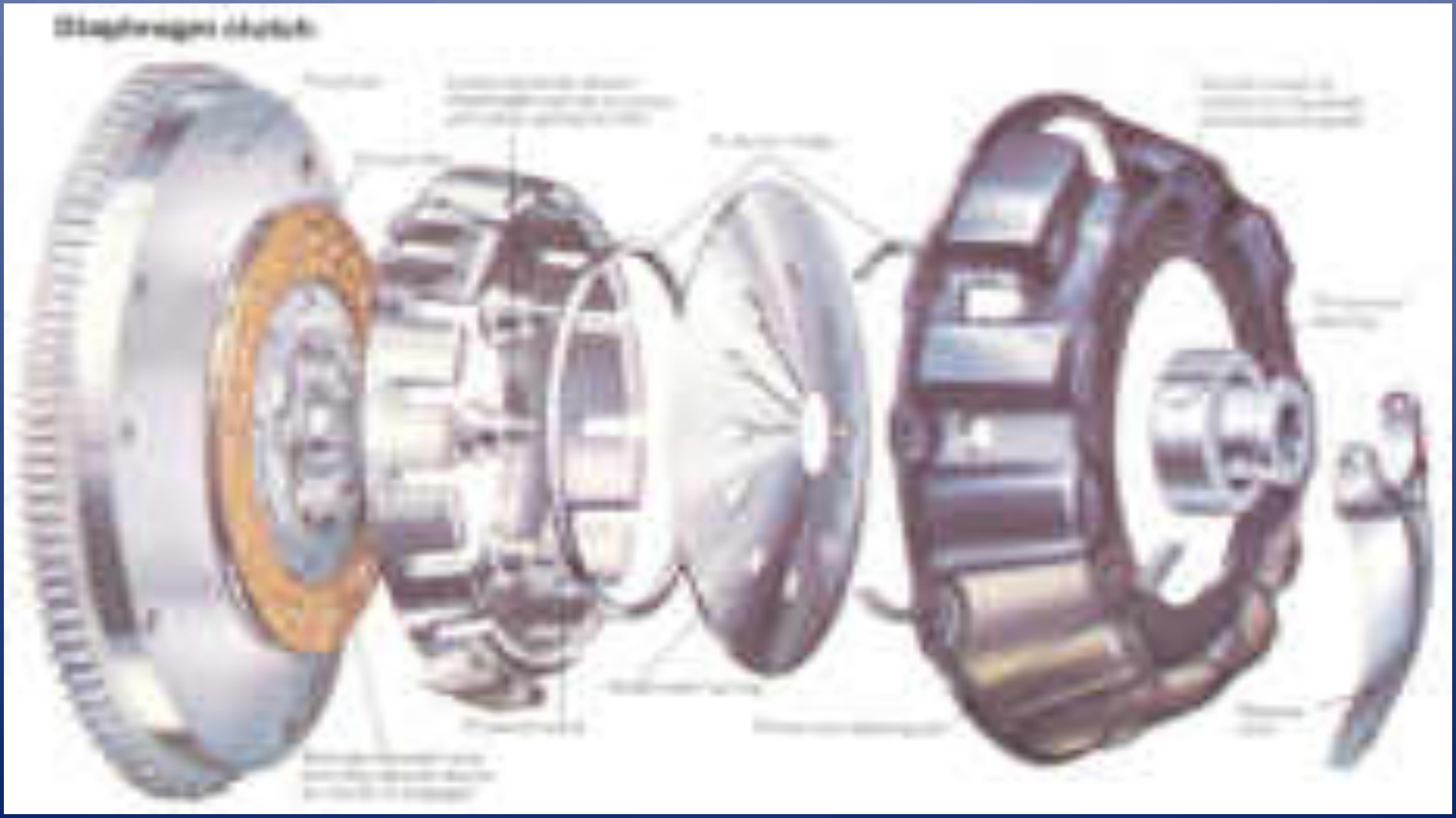
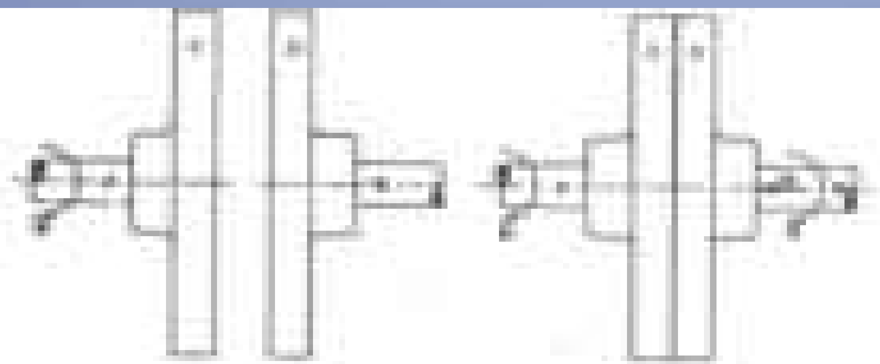


REQUIREMENTS OF A GOOD CLUTCH

1. Torque Transmission
2. Gradual Engagement
3. Good Heat Dissipation
4. Dynamic Balancing
5. Compact Size
6. Minimum Inertia
7. Vibration damping
8. Ease of Operation

Principle of Operation: Clutch



1) The shaft A and disc C are revolving at some speed N rpm.
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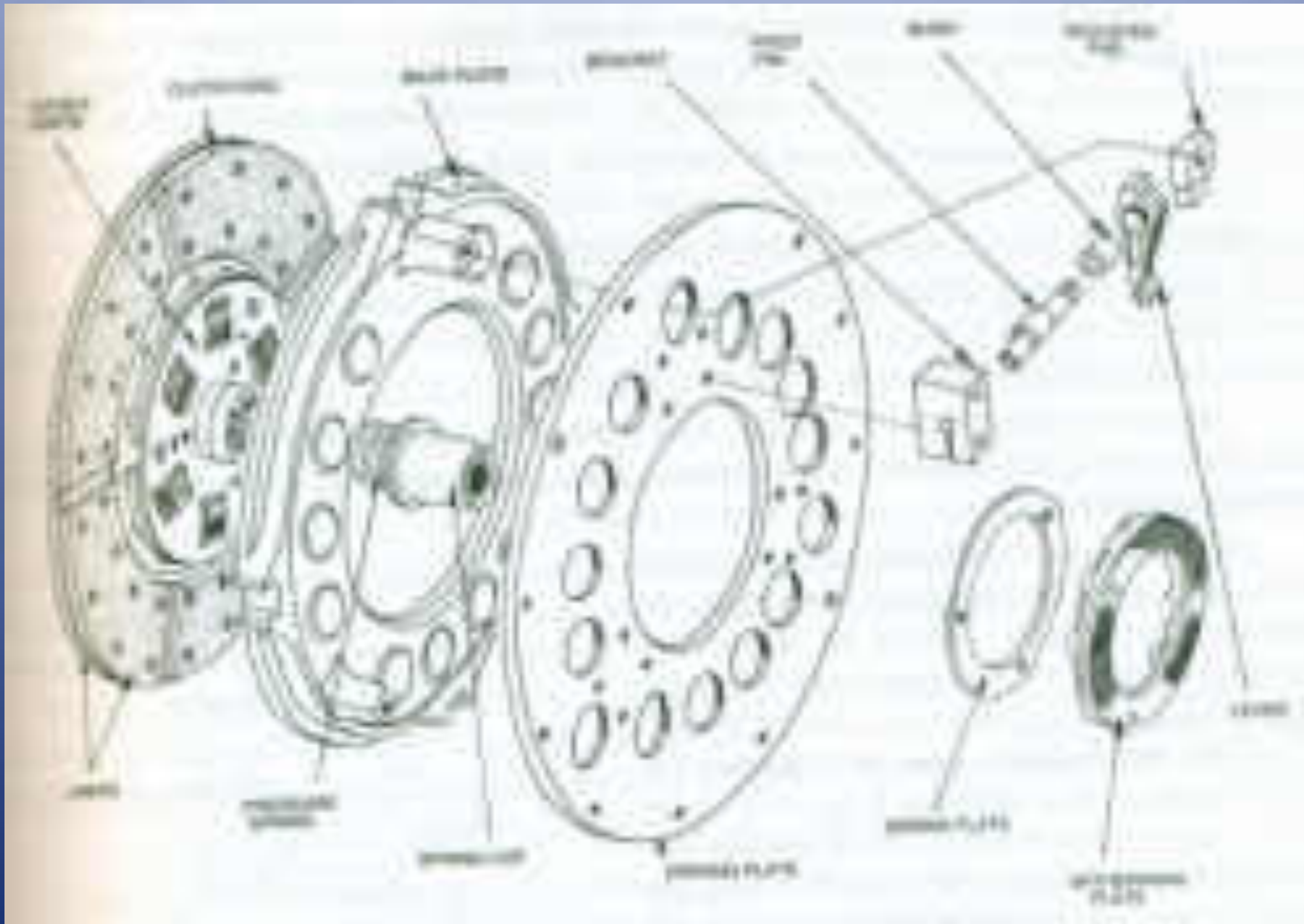

Fig. 27.8 (a). The clutch components (Courtesy : Ashok Leyland)

Main Components of Clutch

- Driving Member : Flywheel
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- Driven member : Clutch Plate
  - Free to slide lengthwise on the splines of the clutch shaft.
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- Operating member : Foot pedal, linkages, release or throw out bearing, release lever and spring

TYPES OF CLUTCHES

- Friction clutch
  - Single plate clutch
  - Multiple clutch
    - Wet type
    - Dry type
  - Cone clutch
    - External
    - Internal
- Centrifugal clutch
- Semi- centrifugal clutch
- Diaphragm clutch

Friction clutch : Cone type

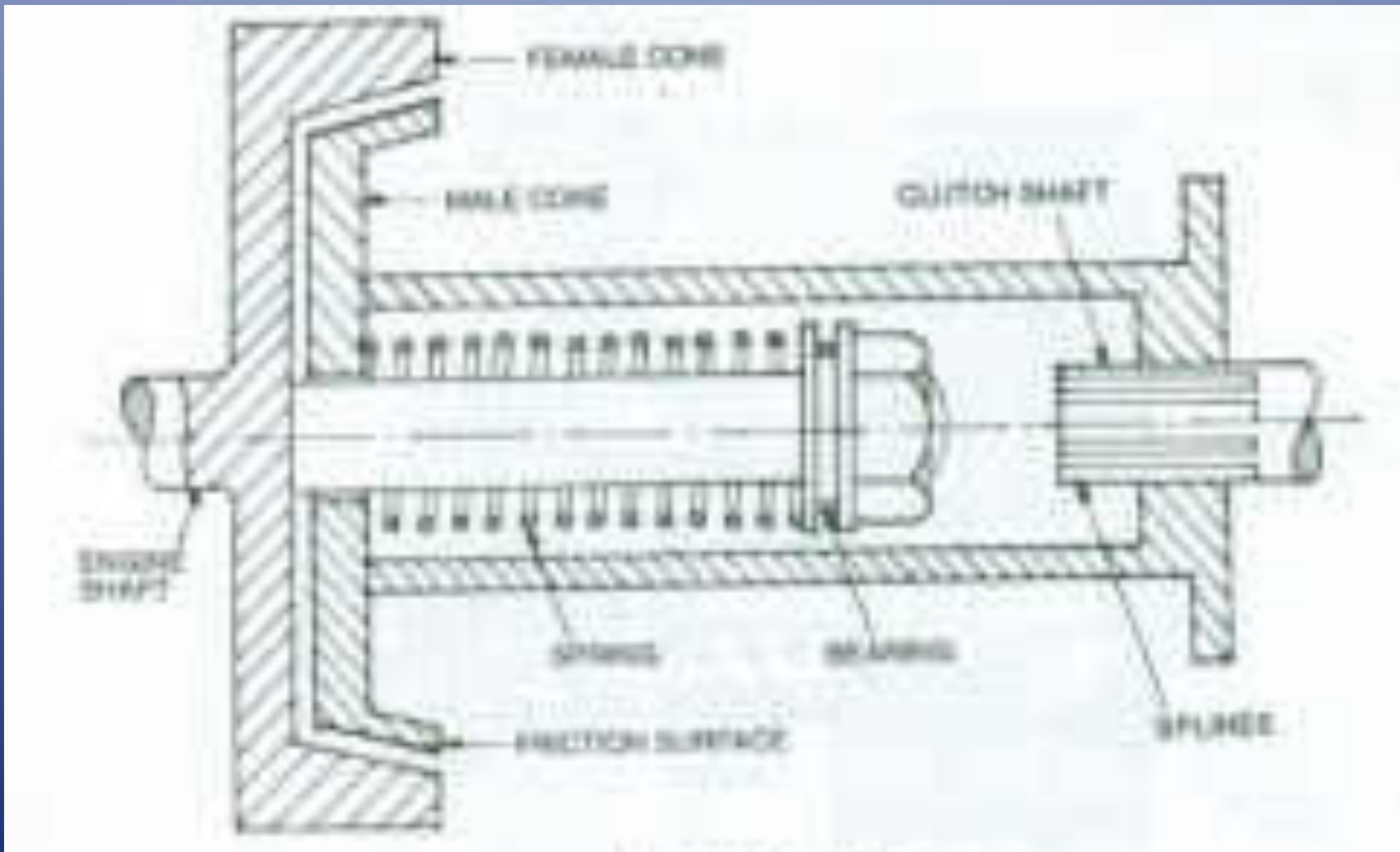

Fig. 22.10: Cone clutch.

Cone Clutch

- In cone clutch contact surface is in form of cones. The Contact surface is maintained by attaching the cones by means of springs.
- In engaged position torque is transmitted from engine shaft via the fly wheel & and male cones to the gear box shaft .
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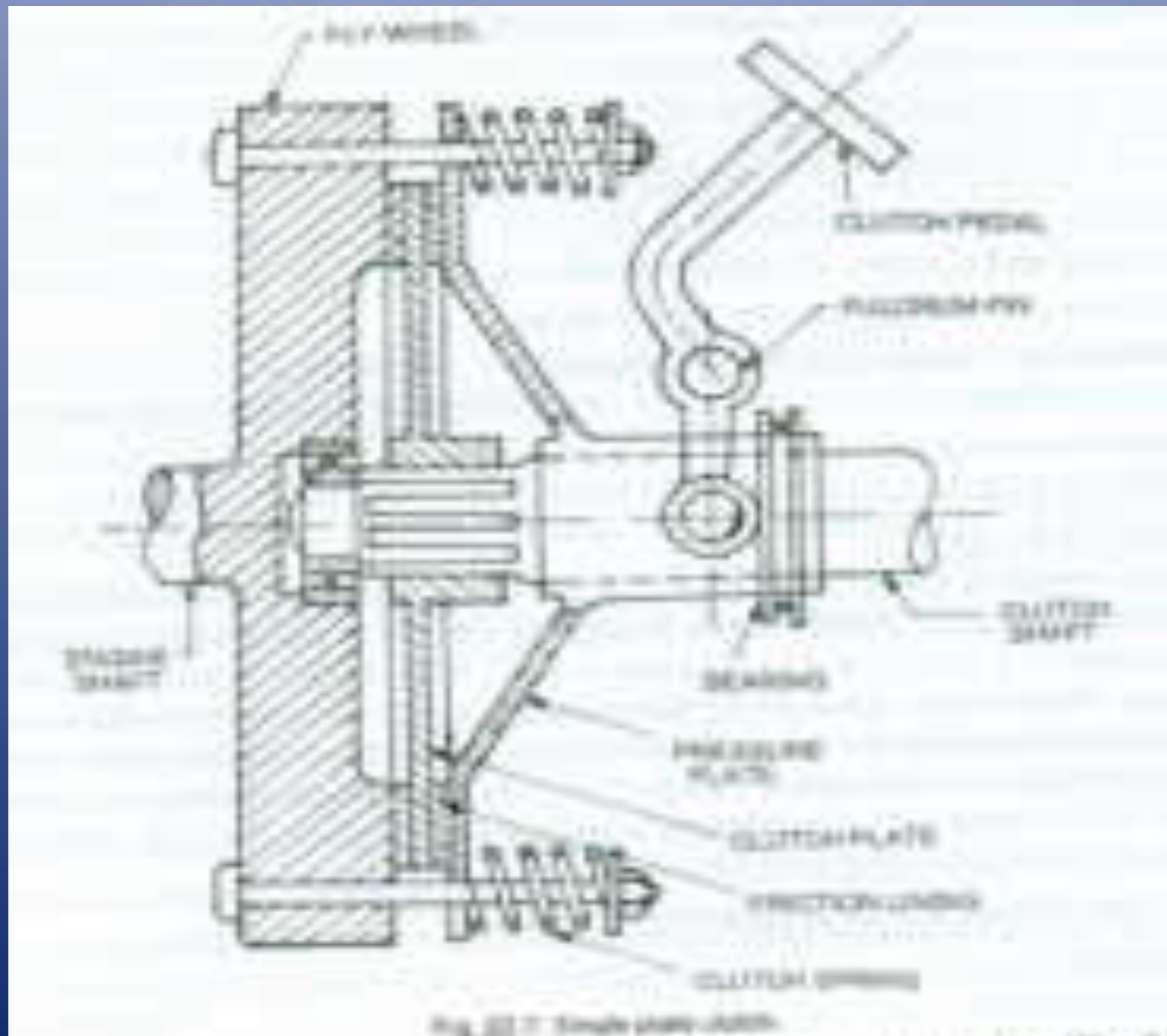
Friction clutch : Single Plate



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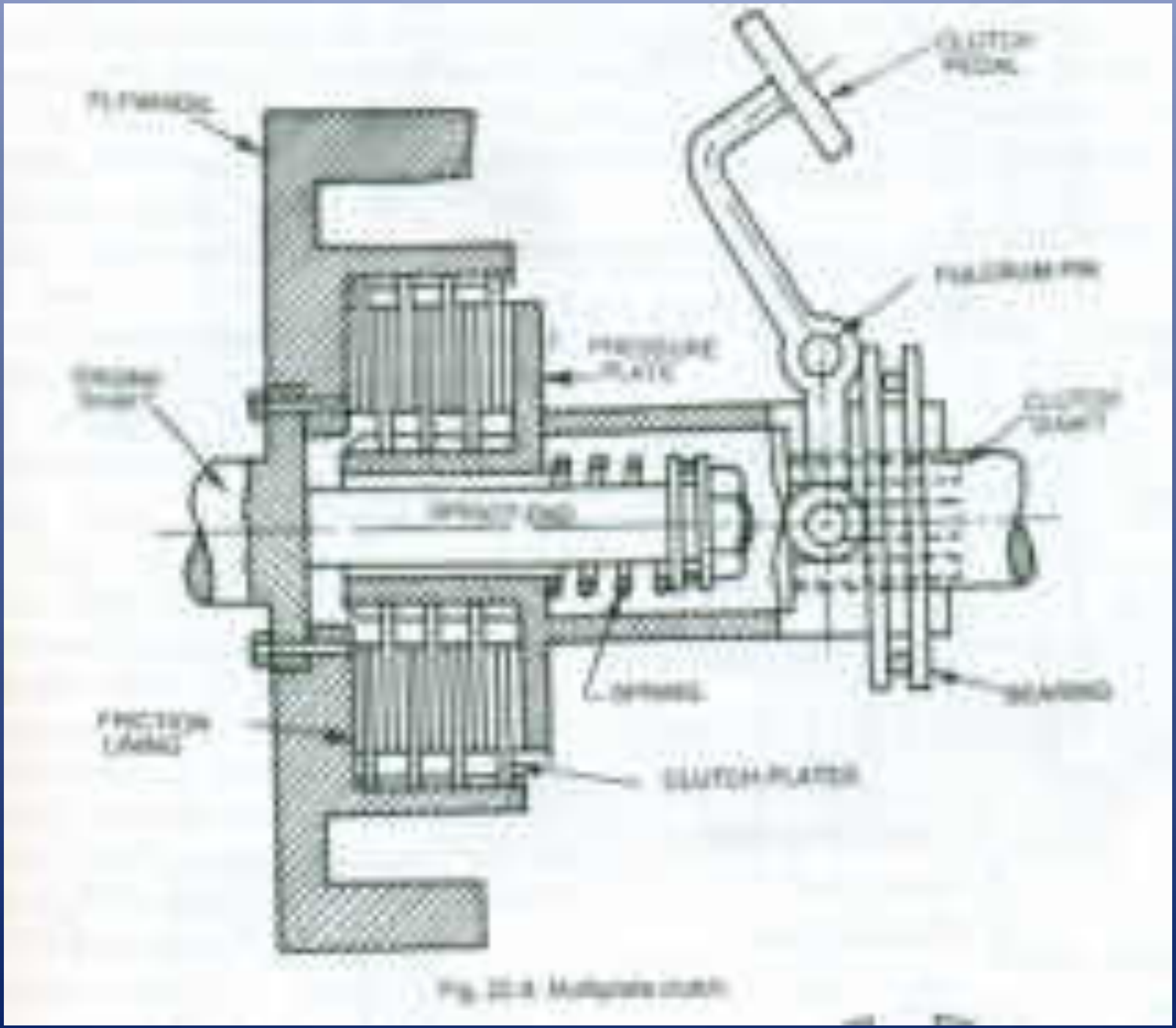
Friction clutch : Multiplate



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Centrifugal Clutch

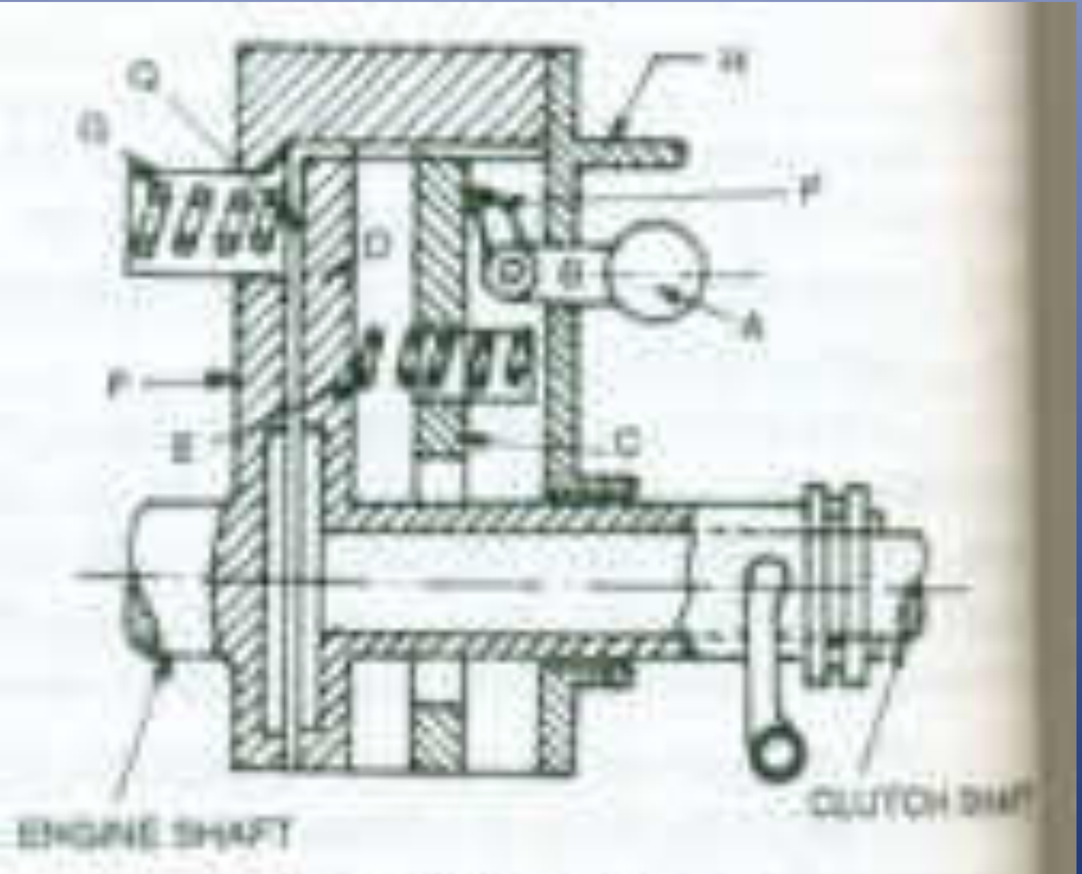
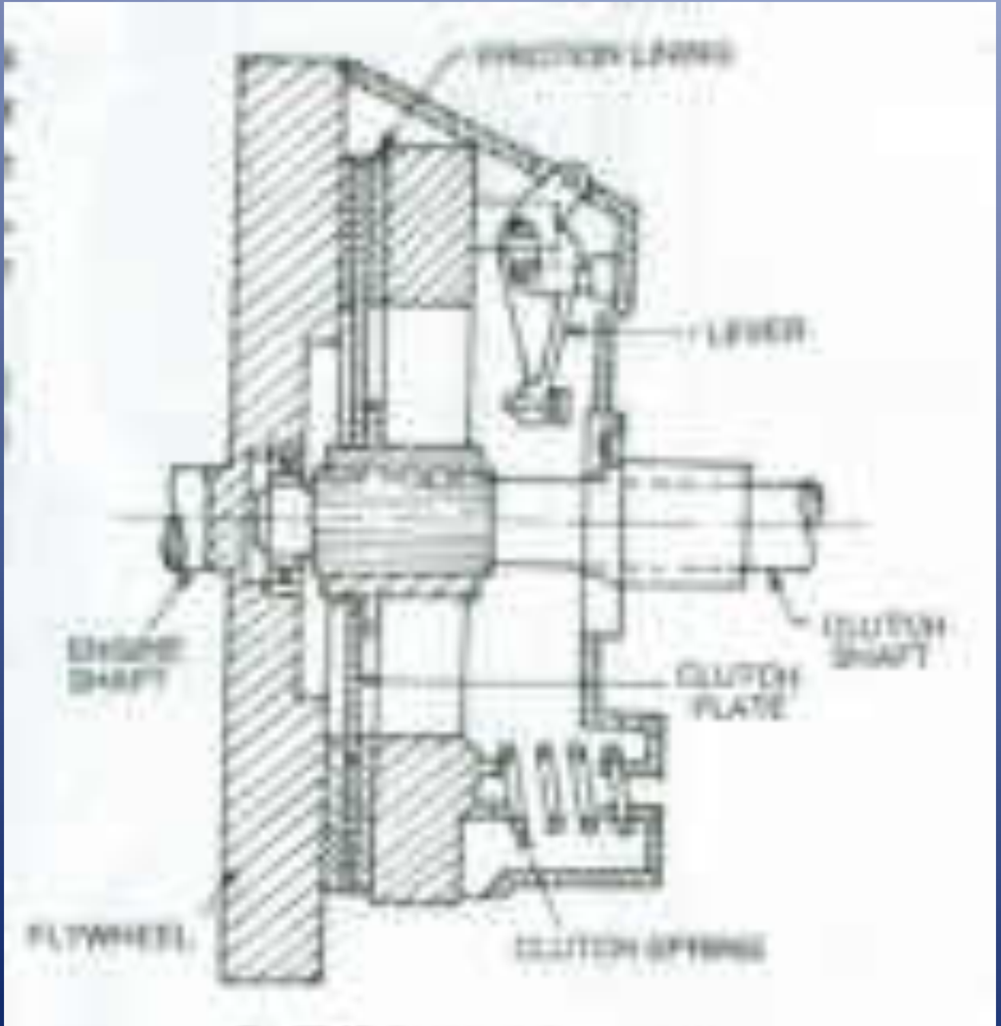
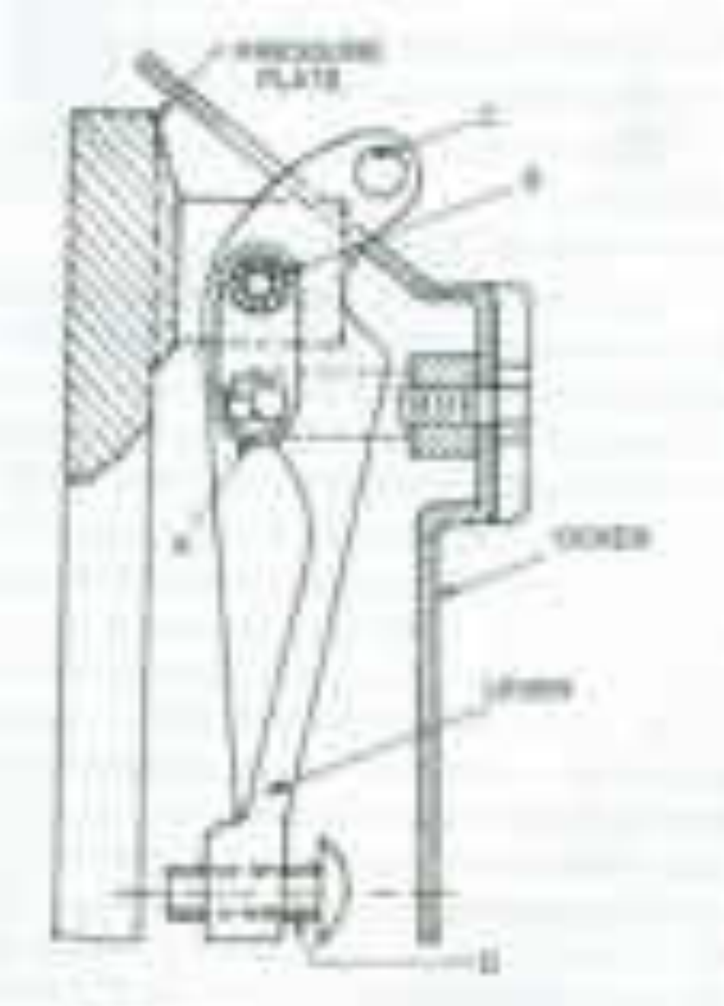


Fig. 22.12. Centrifugal clutch.

Semi-Centrifugal Clutch





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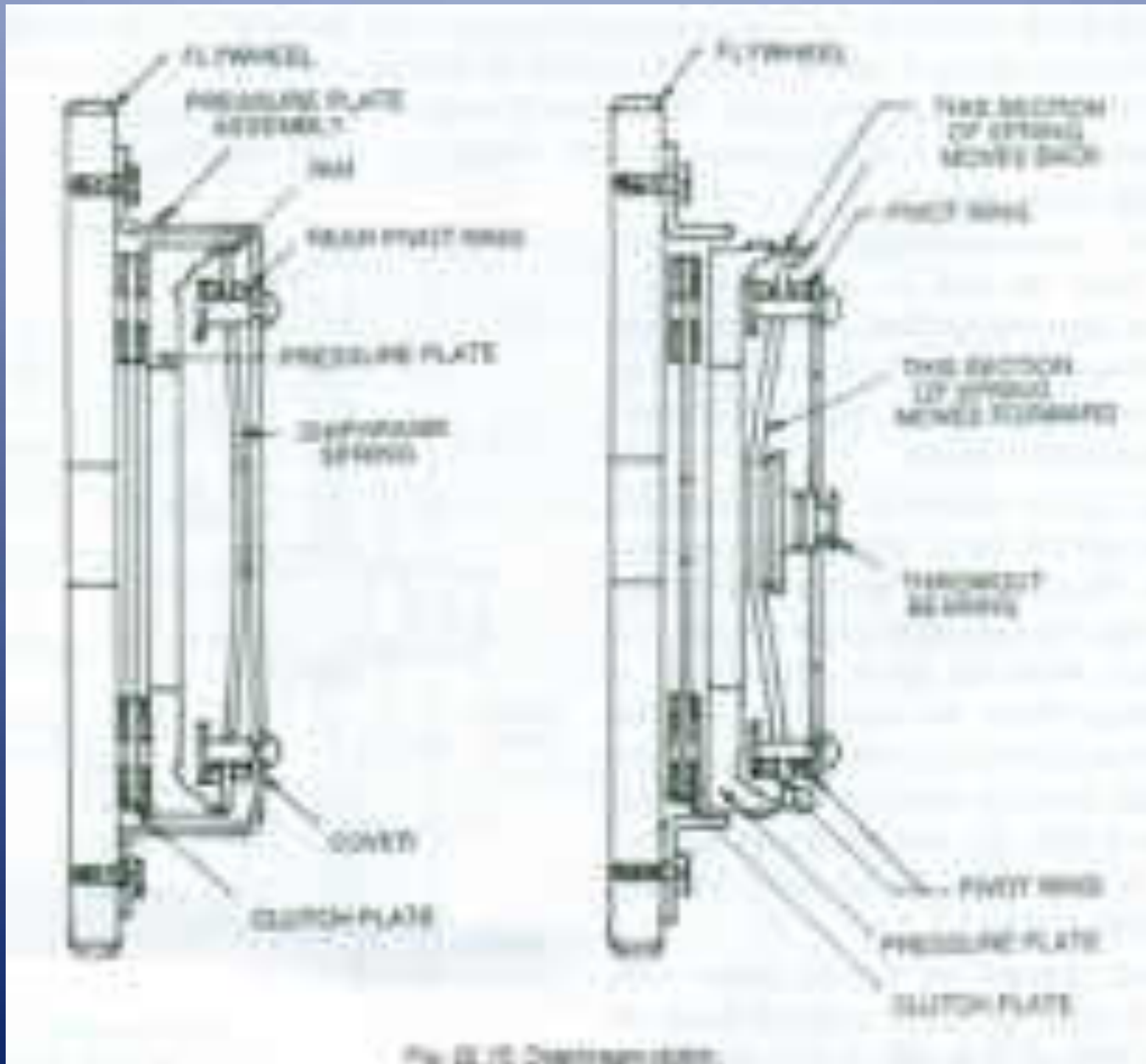
Diaphragm Clutch



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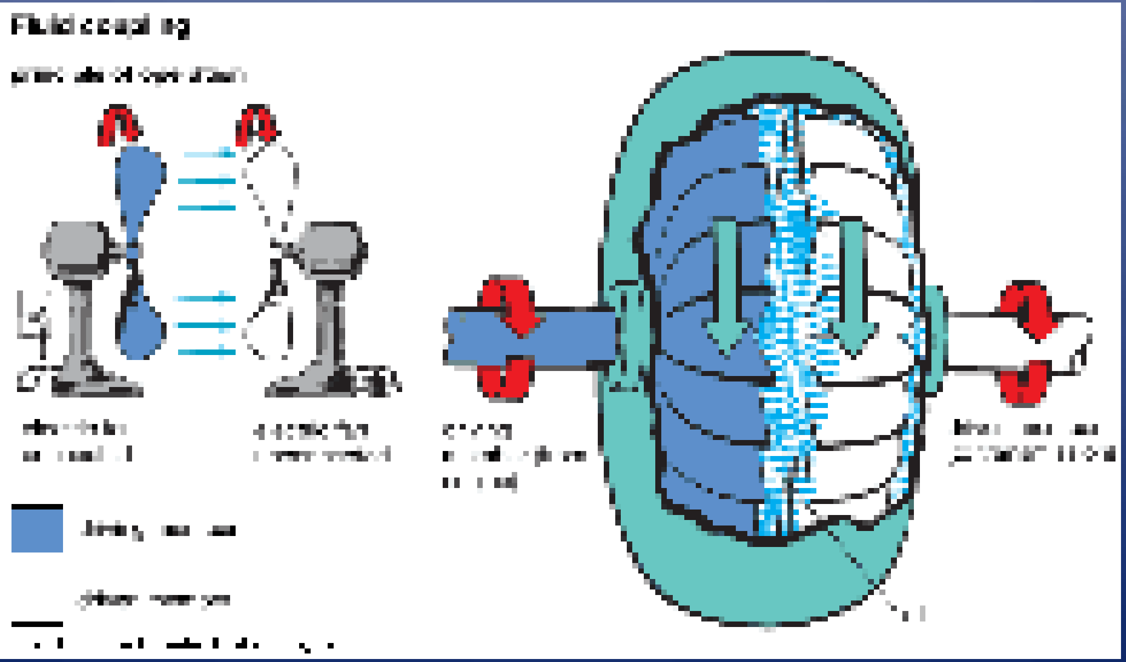

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Thanks