# BAF BASE ZAHURUL HAQUE (TRG WG)

**Syllabus : Automobile and Diesel Technology**

**Course : Trade Training Basic, MTOF**

**Subject : Basic Engineering**

**Aim : To Study Metal**

**Ref. : AP 3159 Section 1 Chapter 8**

## METALS

### Introduction

1. The variety of materials now in use in modern engineering is so great that in a single chapter it is not possible to cover the whole field. Therefore, an attempt will be made to deal with broad groups of materials and metal alloys, their main characteristics, recognition and uses. These materials and metal alloys can be divided into three main groups: those which contain a basis of iron and are called ferrous metals; those containing little or no iron are called non-ferrous metals; and a third group of non –metallic materials called Fiber Reinforced Plastics (FRP).

### Properties

2. To ensure quality standards the properties of metals are assessed by accurate tests which are carried out on sample test pieces taken from batches of material. These test prove whether or not a metal matches up to its required specification. The following terms are used to describe the properties of metals; many of these properties can be varied by heat treatment processes.

a. **Elasticity.** This describes the ability of a metal to return to its original size and shape when the distorting load or force is removed.

b. **Ductility.** This property enables a metal to be permanently extended or stretched, by a tensile force, without breaking.

c. **Malleability.** A malleable metal is one which can be forged, rolled or extended into shape without fracture.

d. **Conductivity.** A good conductor has the ability to allow the passage of heat and electricity.

e. **Hardness**. This is the property, which enables a metal to resist wear and impacted penetration.

f. **Brittleness.** A brittle material cannot resist breaking by bending, twisting or sudden blows.

g. **Toughness**. A tough metal has the ability to withstand the sudden application of loads.

# BAF BASE ZAHURUL HAQUE (TRG WG)

## (Aero Engg Trg Sqn)

**Syllabus : Automobile and Diesel Technology**

**Course : Trade Training Basic, MTOF**

**Subject : Basic Engineering**

**Aim : To Study Ferrous Metals**

**Ref. : AP 3159 Section 1 Chapter 8**

---

## FERROUS METALS

### Introduction

1. Ferrous metals are those, which consist mainly of iron ore which is transformed into metallic iron in a blast furnace. This material is called 'pig' iron and it is the base metal from which all other ferrous metals are made.

### Cast Iron+

2. This material is produced by re-melting pig iron in a furnace when it becomes a hard brittle alloy of iron and carbon. When in the molten state it is suitable for making intricate casting.

### Carbon Steel

3. This group covers most steels; it is an alloy of iron and carbon. Produced from pig iron, it offers considerable strength and physical properties, which are modified by the amount of carbon present in the mixture. Normally carbon steels fall into one of the following categories:

a. **Low Carbon Steel.** This is usually called 'mild steel' and it is the softest and most ductile class of steel.

b. **Medium Carbon Steel.** As the carbon content in the mixture is increased it produces stronger, harder steel, which is more difficult to work.

c. **High Carbon Steel**. This is the best grade of steel and it contains sufficient carbon to make it suitable, after heat treatment, for use as a tool steel.

# BAF BASE ZAHURUL HAQUE (TRG WG)

## (Aero Engg Trg Sqn)

**Syllabus : Automobile and Diesel Technology**

**Course : Trade Training Basic, MTOF**

**Subject : Basic Engineering**

**Aim : To Study Non-ferrous Metal**

**Ref. : AP 3159 Section 1 Chapter 8**

---

## NON-FERROUS METAL

### Introduction

1. In their commercially pure state, non-ferrous metals are used for certain specialized engineering purposes. Metals such as copper, lead and aluminium are made up into sheets, tubes, pipes and wires; they can also be used to provide a thin coating upon other metals. The more expensive precious metals, such as platinum and silver, are used more sparingly, usually in the manufacture of high grade electrical instruments, although platinum may be used o tip sparking plugs and contact breaker points in piston engine ignition systems. Nickel, chromium, cadmium, zinc and tin are also used to provide an anti-corrosion coating for other metals. In addition to their pure state uses, these metals are often used as alloying elements to provide desired properties in other metals. Non-ferrous metals and alloys can be divided into two groups:

### Light Alloys

2. The brief description of a selection of light alloys which follows is consolidated under:

a. **Aluminium**. This is a light-weight comparatively weak metal which, in its pure state, is not much used in structures. However, when it is alloyed with others elements it become use full in almost all engineering fields. It can be cut and shaped by normal workshop process and it can be joined by welding or riveting; it does not solder in a satisfactory manner and therefore, solder joint should not be attempted. Aluminium is a good electrical conductor and is resistant to corrosion in most normal atmospheric conditions.

b. **Aluminium Alloy.** The material is aluminium which has been improved by alloying with copper, tin, manganese, magnesium, zinc or silicon. Many such alloys,

using one or more of these alloying elements, are used in engineering; they are light metals comparable in strength with steel.

c. **Duralumin**. This metal is an example of aluminium - based alloy which contains copper, magnesium, manganese and silicon. It has a marked resistance to corrosion which can be improved by a process known as anodizing. Duralumin is a metal almost as strong as steel and is widely used in sheet form.

d. **<u>Y' Alloy.</u>** This is another example of an aluminium-based metal, where the aluminium is mixed with copper, nickel and magnesium. This material is suitable for casting or forging and is frequently used in the manufacture of reciprocating engine pistons.

# BAF BASE ZAHURUL HAQUE (TRG WG)

## (Aero Engg Trg Sqn)

**Syllabus** : **Automobile and Diesel Technology**

**Course** : **Trade Training Basic, MTOF**

**Subject** : **Basic Engineering.**

**Aim** : **To Study Heat Treatment of Steel.**

**Ref** : **A.P 3358.**

---

## HEAT TREATMENT OF STEEL

**Annealing**

1. a. **Purpose.** To reduce stresses, induce softness and ductility or to refine the grain structure.

b. **Procedure.** Heating to a point above the upper critical temperature until the grain structure has been refined followed by slow cooling. Must not be heated more then 28$^0$C-40$^o$ C above the upper critical point.

**Normalizing**

2. a. **Purpose**. To establish a metal homogeneous in grain size by removing strains, which may be induced by machining, forging, bending or welding.

b. **Procedure**. Heating to a point approximately 56$^o$C above the upper critical temperature followed by cooling to room temperature in still air.

(c) Cool the parts in the still air.

**Hardening**

3. a. **Purpose.** To produce extreme hardness, maximum tensile strength and minimum ductility. Generally, steel in this condition is too brittle for most of the practical uses, although this treatment is the first step in the production of high strength steel.

b. **Procedure.** Heating the metal slightly in excess of upper critical temperature followed by rapid cooling in water or brine.

**Tempering**

4. a. **Purpose.** To toughen the steel by removing extra brittleness, this induced during the hardening process.

b. **Procedure.** Heating the harden steel to a temperature below the lower critical point, holding at this temperature in water, oil or AIR. The degree of hardness, strength and ductility obtained, depend directly upon the temperature to which the steel is heated. High tempering temperature improve ductility at the sacrificed of hardness and tensile strength.

**BAF BASE ZAHURUL HAQUE(TRG WG)**
**(Aero Engg Trg Sqn)**

**Syllabus : Automobile and Diesel Technology**

**Course : Trade Training Basic, MTOF**

**Subject : Basic Engineering.**

**Aim : To Study Corrosion in Metals.**

**Ref : A.P 3159 Section 1 Chap 9.**

---

# CORROSION IN METALS

**Introduction**

1. Corrosion (rust) is the greatest enemy the owner and user of motor vehicle has to face when trying to preserve and protect his vehicle. Corrosion means the gradual or not-so-gradual, destruction of the construction metals. However, one basic cause of corrosion is known to be an electro-chemical action, which thrives in damp humid conditions. If pockets of corrosion are not found and checked at an early stage, they will continue to eat away the metals until structural failure occurs. Corrosion is a natural process, which never stops unless preventive measures are used against it. It can occur in any unprotected metal, anywhere, at any time. To understand how metals can be protected and how you can help to prolong their life, it is necessary for you to understand why corrosion occurs.

**Types, Appearances and Causes of Corrosion**

2. There are five types of corrosion normally attack the metals and those are briefly discussed below:

a. **Surface Corrosion.** This type of corrosion attacks on the surface of the metal. The most common effect of the surface corrosion on the metal is called “pitting”. On aluminum alloy it is first noticeable as white or gray powdery deposits. On steel, its color is reddish brown while on copper a greenish discoloration appears.

b. **Intergranular Corrosion.** This form of corrosion attacks on the boundaries of the metal. The adjacent grains of various elements of different potential in any alloy and with the presence of an electrolyte (water) react each other as anode and cathode. The potential differences of various elements are mainly caused by improper heat treatment. Such corrosion is much more dangerous since it attacks the minute crack, visible only with the aid of a magnifying glass. The spread of the corrosion, going entirely hearth the surface,. Weakens the strength and causes brittleness of the metal in a very short period.

c. **Galvanic Corrosion.** It occurs when dissimilar metals of different electrical potential are placed in contact with each other, in the presence of an electrolyte. An electrical current flows from one metal to another resulting in the gradual dissolution of one of the metal. The more active metal serves as anode; the moisture becomes the electrolyte while the less active metal acts as a cathode. This type of corrosion can be spotted mostly near the joints.

d. **Dissimilar Metal corrosion.** It occurs when dissimilar metals of different electrical potential are placed in contact with each other, in the presence of an electrolyte. An electrical current flows from one metal to another resulting in the gradual dissolution of one of the metal. The more active metal serves as anode; the moisture becomes the electrolyte while the less active metal acts as a cathode. This type of corrosion can be spotted mostly near the joints (Fig-30).

e. **Fretting Corrosion.** This is a type of corrosion which you are almost certain to meet. It is a form of stress corrosion that is likely to occur when two heavily loaded surfaces rub together. Because of the rubbing contact, the metal's surface protection is torn away, exposing unprotected metal. The metallic dust produced by the metal to metal fretting becomes a hard gritty substance which aggravates the fretting action. The corrosion deposits are again characteristic in colour, producing reddish brown discoloration for steel parts and grey black deposits for aluminium and magnesium alloys. The fretting can be reduced by eliminating the movement or by lubricating the rubbing surfaces. If this kind of corrosion is allowed to continue unchecked it can lead to more serious metal fatigue.

**Causes of Corrosion**.

3. In any metal there are areas, which have a greater electrical potential than others. The more positive areas are called 'anodes' and less positive areas are the 'cathodes'. Like any simple electric cell, each corrosion cell, which forms, has its own anode and cathode; the electrolyte is usually water, either as a liquid or as moisture in the atmosphere. The electro-chemical action eats away the metal at the positive area (anode) where the electric current leaves the metal and enters the electrolyte (Fig. 1). The area of the cathode remains untouched. The electrolyte is clearly a major requirement of any corrosion cell and without it there can be no corrosion. It may be in any form of moisture, ranging from ordinary water to strong acid or alkali. Frequently, it is water condensed from the air which it self may be clean or polluted. Whilst clean water in the form of rain, or damp conditions, may cause a slow, steady rate of corrosion, an atmosphere laden with salt, industrial smog, or engine exhaust fumes, will cause a much more rapid attack.

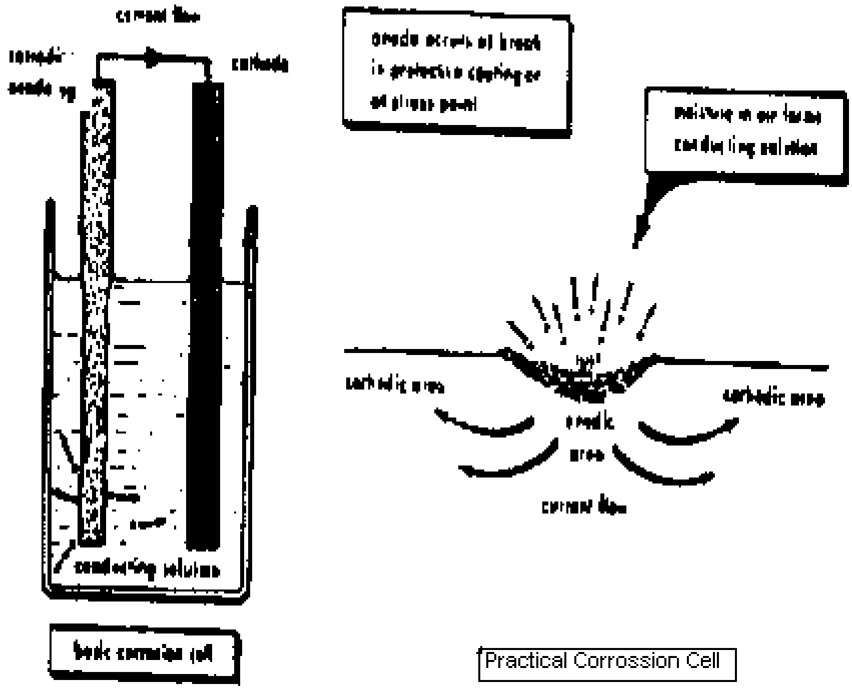



Fig- 1 Corrosion Cells

## BAF BASE ZAHURUL HAQUE (TRG WG)

## (Aero Engg Trg Sqn)

**Syllabus : Automobile and Diesel Technology**

**Course : Trade Training Basic, MTOF**

**Subject : Basic Engineering**

**Aim : To study Hand Tools**

**Ref. : AP 3196A**

---

## VICE

**Introduction**

1. The vice is a holding device.

**Purpose**

2. It able to hold the material (job) firmly in a position suitable to work upon.

**Types**

3. There are two types of vice. These are as follows:

a. **Hand Vice**. A hand vice is used for holding small object that have to be shaped or drilled. The screw is made of mild steel and carries a wing nut for the operation of the vice (Fig-2a).

b. **Bench Vice**. A bench vice is classified by the weight and length of the jaws e.g. 4.5 inches/45 lbs. The working face of each jaw is serrated or cross-hatched. The screw is made of mild steel with a square or buttress thread. Most types of bench vice have a quick release mechanism, which enables the jaws to be opened or closed quickly. To protect materials from damage by the jaws, clamps made of copper, aluminium, or fiber is placed over the working surfaces of the jaws (Fig-2b).

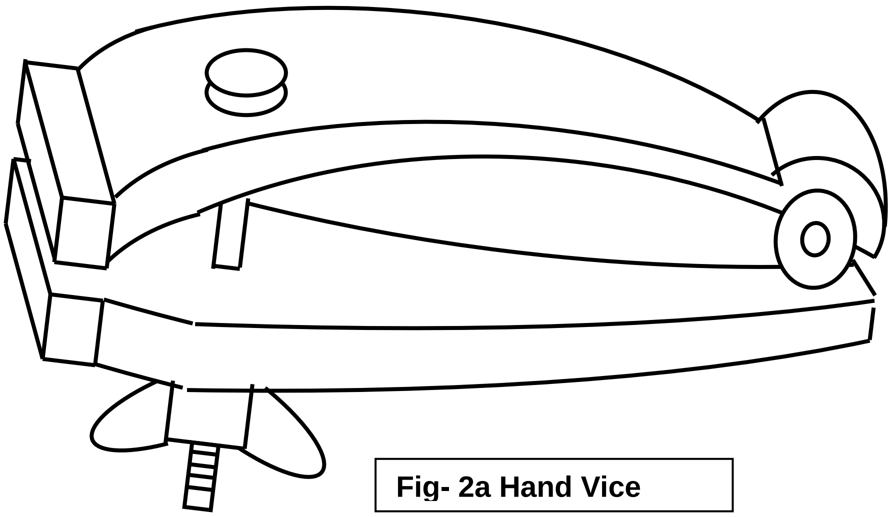


**Fig- 2a Hand Vice**

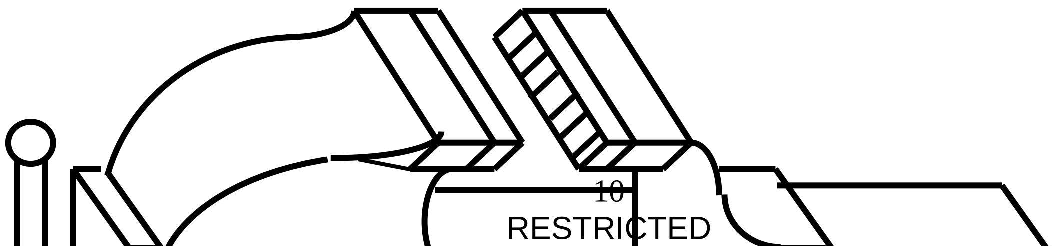


**Fig- 2b Bench Vice**

**Materials**

4. Hand vice is made of body mild steel with jaws are case hardened. The bench vice is made of body malleable cast iron or cast steel and the jaws, which are detachable arte made of harden and tempered steel.

**Classification**

5. Bench vice is classified by weight and length of the jaws. The height of the vice from the ground is important and should be such that the top of the vice is leveled with the user elbow. Hand vice are classified by weight only.

**Care and Maintenance**

6. a. The Vice should be properly secured and the screw is cleaned and well lubricated before use.

b. All metal parts, filling should be removed and unpainted parts should be slightly oiled.

c. Avoid damage to the work by over tightening the vice, protect the surfaces from damage by the jaws using clamp of copper, lead or aluminum.

d. Vice should not be kept strained when not in use.

## BAF BASE ZAHURUL HAQUE (TRG WG)

## (Aero Engg Trg Sqn)

| | | |
|---|---|---|
| **Syllabus** | : | **Automobile and Diesel Technology** |
| **Course** | : | **Trade Training Basic, MTOF** |
| **Subject** | : | **Basic Engineering** |
| **Aim** | : | **To Study Hand Tools** |
| **Ref.** | : | **AP 3159.** |

## HAMMER

**Introduction**

1. The hammer is a striking tool.

**Types**

2. The following types of hammer are used as follows:

a. **Ball Pein**. The flat surface is used for most general-purpose work and the ball pein is used primarily for riveting.

b. **Cross- Pein**. Used for general work, the narrow cross-pein being particularly suitable for use where access to the work is limited.

c. **Straight Pein**. As for cross-pein.

d. **Hide Faced**. The rawhide facing enable heavy blows to be delivered without damaging the surface of the work.

e. **Lead and Copper**. As for hide faced hammers but used for heavier work.

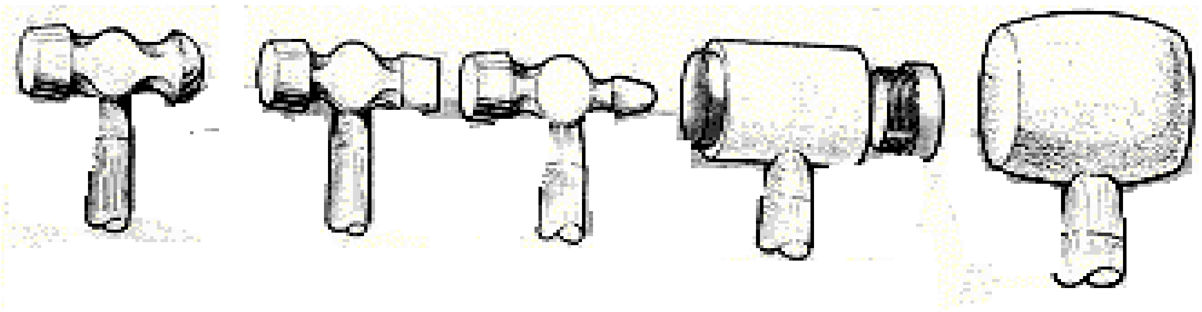



**Fig- 3 Hammers**

## BAF BASE ZAHURUL HAQUE (TRG WG)

## (Aero Engg Trg Sqn)

**Syllabus : Automobile and Diesel Technology**

**Course : Trade Training Basic, MTOF**

**Subject : Basic Engineering**

**Aim : To Study Hand Tools**

**Ref. : AP 3159 & 3196**

---

## PUNCHES

**Purpose**

1. Punches are used to:

a. Locate center for drawing circle.

b. Start a hole for drilling.

c. Make a pop mark.

d. Remove damage rivets pins and beats.

e. Driving out tight fitting parts.

**<u>Types</u>**

2. Following types are used:

a. **<u>Center Punch.</u>** Centre punches are made of high carbon steel; the point is hardened and tampered. A centre punch is used to make a pop mark for locating the point of drill. $90^0$point punch is used for general work & $60^0$point punch is used for light job (Fig-4a).

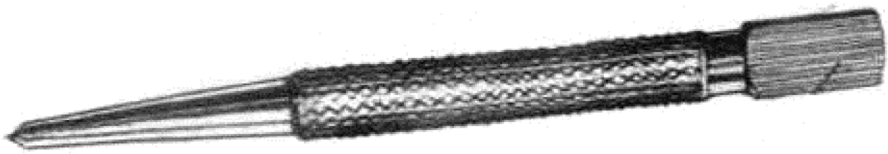


**Fig-4a Center Punch**

b. **<u>Pin punch.</u>** These are used to drive out tight bolts, rivets and taper pins. Pin punches are made of high carbon steel, harden and tampered at the working end to prevent bending and spreading. There are two types of pin punches (Fig-4b). They are classified by the diameter of the working end.

(1) Parallel Pin Punch.

(2) Tapered Pin Punch.

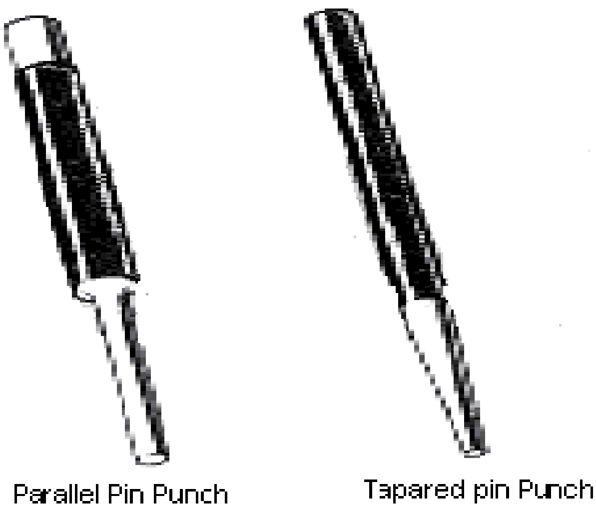



**Fig-4b Pin Punch**

b. **<u>Hollow Punch</u>.** These are made of high carbon steel hardened and tempered at the cutting edge. They are used when holes are required at the soft materials. Such as wood, rubber, leather etc (Fig-4c).

**Fig-4c Hollow Punch**

# BAF BASE ZAHURUL HAQUE (TRG WG)

## (Aero Engg Trg Sqn)

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **Basic Engineering** |
| **Aim** | **:** | **To Study Hand Tools** |
| **Ref.** | **:** | **AP 3159** |

## SCREW DRIVER

### Introduction

1. The screwdriver is a fitting and removal tools. Screwdrivers are used for screwing in and screwing out (loosen or tighten screws).

### Types

2. The screwdrivers are following types:

a. **Common**. It has a single flat blade for driving screws with slotted head (fig-5).

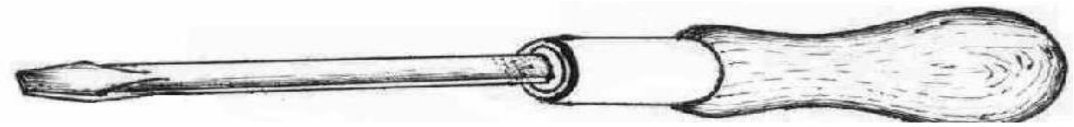


**Fig-5 Common**

a. **Philips or Cross Point.** Made with specially shaped blade. These are used on Philips or crossed slot screws (Fig-6).

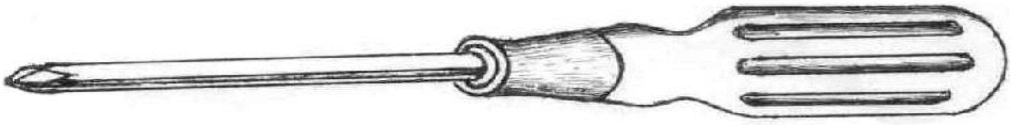


**Fig-6 Philips or Cross Point**

### Care and Use of Screwdrivers

3. The fit of the screwdriver blade in the slotted head of the screw is most important. The end of the blade should never be ground to a chisel edge and a screwdriver of the correct size to fit snugly into the slot should always be used. Screwdrivers of the wrong size cause damage to screw heads and eventual difficulty in the removal or tightening of screws.

## BAF BASE ZAHURUL HAQUE (TRG WG)

### (Aero Engg Trg Sqn)

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **Basic Engineering** |
| **Aim** | **:** | **To Study Hand Tools** |
| R**ef** | **:** | **AP 3159 and General Engg Workshop Technology** |

## SPANNERS

**Introduction**

1. In English term it is called spanner but in American term it is known as wrench.

**Purpose**

2. Spanners are used for tightening or slackening nuts or bolts on screw threads.

**Types**

3. There are various types of spanner. The most common types of spanners are as follows:

a. **Open Jaws or Set Spanner**. This very common type of standard spanner is usually made in double ended from to give two available sizes in the one tool. It is not altogether a satisfactory device because the jaws of the spanner bear against only two of the six flats of the hexagon head or nut and there is a definite tendency for jaws to open when pressure is applied on the other end. The use of the open ended spanners is not recommended if one of the enclosed types can be used (Fig-7).

**Fig**-7 **Open Jaws or Set Spanner**

b. **Ring Spanner**. These spanners give full enclosure of the hexagon head or nut each corner of which engages snugly with an angle in the aperture of the spanner. The aperture is usually bi-hexagonal to facilitate the use of the spanner when angular movement is restricted. This type of spanner like the open jaw type is usually supplied in double ended from to fit nuts of consecutive sizes. The ends of generally of set, but straight shank versions are also available (Fig-8).

**Fig-8 Ring Spanner**

c. **Socket Spanner**. This form of standard spanner is used in conjunction with variety of ratchet handles, Tommy bars, extension pieces and universal joints. These fitments greatly facilitated the used of the sockets and extent their range of application. The socket aperture is bi-hexagonal at one end to take the nut or bolt head and square at the other end to accommodate the wrench fitting by means of which the socket is turned. Socket spanners are usually supplied in complete sets to cover a range of consecutive sizes, each set being complete with the requisite ancillary components (Fig-9).

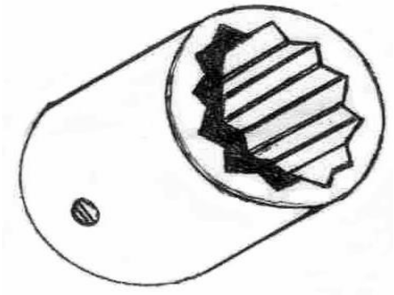


**Fig-9 Socket Spanner**

c. **Box Spanner**. This type also gives full enclosure of nut or bolt head. They are particularly useful where access to the nut or bolt head is restricted to the line of the screw axis (Fig-10).

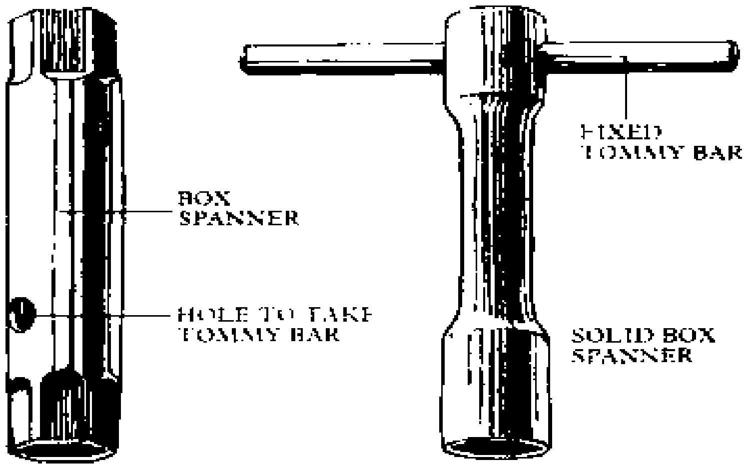



**Fig-10 Box Spanner**

e. **Adjustable Spanner**. They are used when a fixed spanner of the correct size is not available. Although tools of this type are very convenient because of the ease with which they can be adapted for use on various sizes of nuts and bolt heads, their limitations must be recognized. There is a tendency for the jaws to spring open if considerable force is applied during use and this can lead to damage to the nut or bolt head by rounding off the corners. In extreme cases the spanner may slip off the nut completely and cause personal injury. It is recommended that the adjustable spanner be regarded as a stopgap tool only. Do not use it if suitable fixed size spanner is available. (Fig-11).

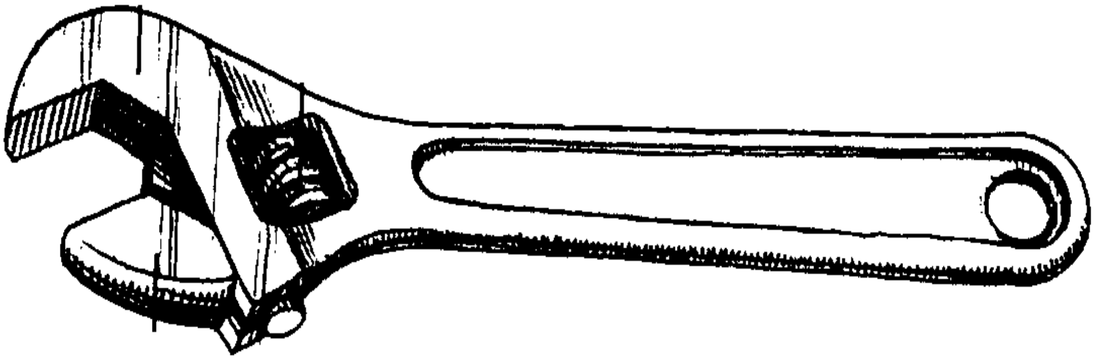


**Fig-11 Adjustable Spanner**

f. **Torque Wrench**

(1) **Definition**. Tortuous described as a twisting or turning force that tends to produce rotation. It is calculated as the load applied (in lbs) multiplied by the shortest distance from the line of action of force. That unit of measurement is inch-lbs or ft-lbs.

(2) **Purpose** Torque wrenches enable the mechanic to tighten a nut or bolt to the proper amount of tightness. A torque wrenches indicates the turning force that is being applied to the nut or bolt.

(3) **Types** There are four different types of torque wrenches.

(a) **Dial Indicator**. This type of torque handle has a gauge mounted on the handle which registers the amount of torque applied and is graduated normally inch pounds.

(b) **Bending Deflection Bar.** It has got a metal bar inside which bends as the mechanic applies the torque to a nut or bolt by pulling the handle. A scale that indicates the amount of torque is mounted on the bar, which moves as the bar bends and gives reading under a stationary pointer.

(c) **Micrometer Setting**. This type has a micrometer type scale, which can be adjusted to any amount within the range. It release or bread away automatically when the pre-set amount of torque reached and gives a “Click”. The handle also gets free travels of about $15^0$ - $20^0$ as that moment.

(d) **“T” Handle**. This type is shaped like “T” as the ram applies. This has pre-set torque value and cannot be adjusted like other types. When the pre-set torque is reached, the handle will ratchet and further turning of the handle will not tighten the nut any more.

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **Basic Engineering** |
| **Aim** | **:** | **To Study Cutting Tools** |
| **Ref** | **:** | **AP 3159 Section 1 & Chap 4** |

# FILES

**Purpose**

1. Files are used for removing metal from a surface.

**Construction**

2. The main parts of files are:

 a. Tang
 b. Heel
 c. Length
 d. Face
 e. Edge
 f. Tip
 g. Handle

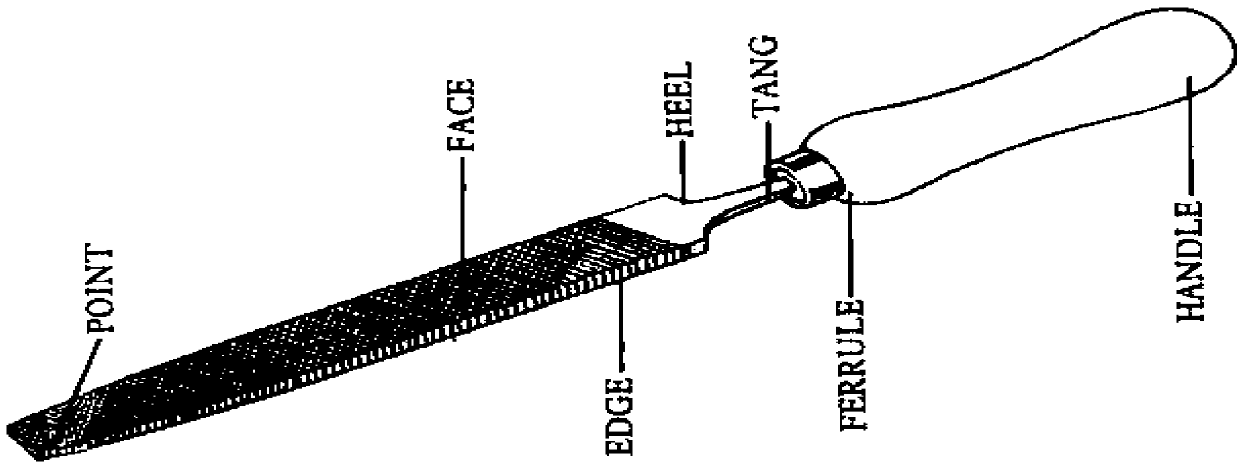



**Fig-12 File**

**Materials**

3. Files are made of high carbon steel hardened only.

**Classification**

4. Files are classified by their length, section, cut and grade.

a. **Cut**. Various arrangements of cutting teeth are provided to give the most satisfactory. It's when working on different materials. These arrangements are known" cuts", details of the more widely used cuts are as follows:

:

(1) **Single Cut**. This type of cut is relatively open and the teeth do not clog easily, it is therefore preferably for filling soft metals. Round files and the curved surface of half round files are usually single cut (Fig-13).

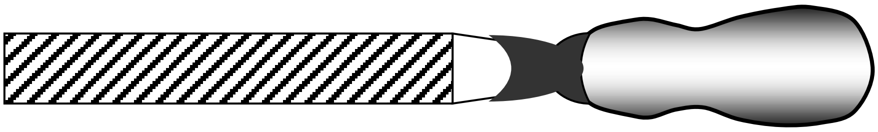


**Fig-13**

(2) **Double Cut.** This is the most widely used type of cut for general purposes (Fig-14).

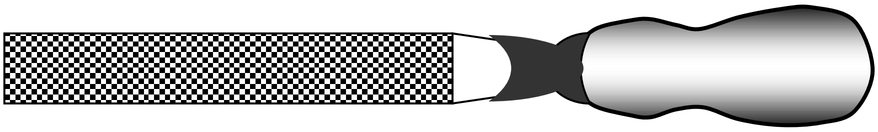


**Fig**-14

(3) **Dreadnought.** The shape of the teeth makes this file especially suitable for heavy cutting on board soft metal surface. Its use in generally restricted to the larger size of the flat files (Fig-15).

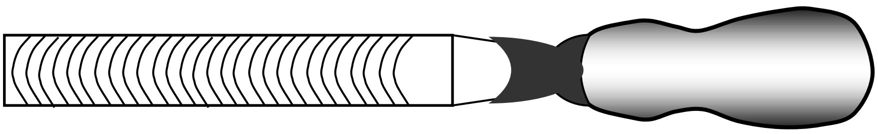


**Fig-15**

(4) **Rasp**. This type of cut is used for filling very soft materials such as wood or leather (Fig-16).

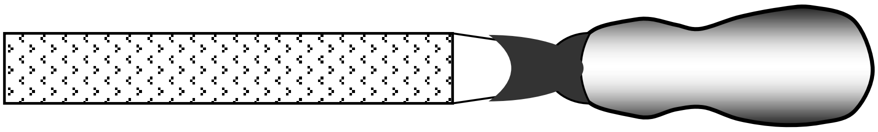


**Fig-16**

b. **Grade**. It is a depth a spacing of the teeth on the face of fie. Teeth may be file, coarse depending on their finish of the job. The following are the commonly used grade:

(1) Bastard
(2) Second cut
(3) Smooth

c. **Section or Shape.** The section of the file to be used depends on job for which it is required. The following section is commonly used:

(1) **Hand (Flat)** commonly called flat file and is used for filling flat surfaces (Fig-17).

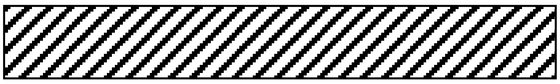


**Fig-17**

(2) **Round** It is used for filling round holes and curved surfaces of small radii. This type of file is generally called rat-tail file(Fig-18).

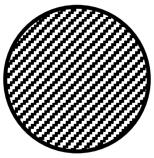


**Fig-18**

(3) **Half round** One side of the file is flat and another is convex. It is used for finishing large internal curved surfaces (Fig-19).

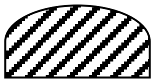


**Fig-19**

(4) **Three square (Triangular)** The file of this section is generally used for filing awkward corners and angles less than $90^0$ (Fig-20).

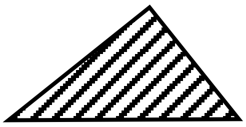


**Fig-20**

(5) **Square.** It is used for filling square and rectangular holes, key ways and narrow surfaces.

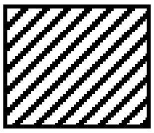


**Fig-21**

**Care & Uses**

5. a. The work, which is to be fitted, should be held firmly on the Bench vice. It should be above the level of the works man elbow.

b. Stand with the left foot pointing to wards the Bench and apart at right foot 8'' to 12" from the left foot.

c. Body should be slightly bent forward at the hips.

d. Right arm should be bending about $90^0$ and left arm nearer strength.

e. Keep the handle against weight hand palm with the thumb on tap.

f. Hold the end of the file with left hand.

**Precautions**

6. a. Never use a file without handle and ensure that the handle is tight on the tang.

b. Apply pressure on the forward stroke and release it an return strokes.

c. Always use the appropriate length and grade of file to the so work at hand.

d. Use full length of file an each stroke

e. Keep the teeth of the file clean by using "Search Card".

f. Oil or grease should not be allowed to come in contact with the file blade as this will cause clogging of the teeth.

## BAF BASE ZAHURUL HAQUE (TRG WG)

## (Aero Engg Trg Sqn)

| | | |
|---|---|---|
| **Syllabus** | : | **Automobile and Diesel Technology** |
| **Course** | : | **Trade Training Basic, MTOF** |
| **Subject** | : | **Basic Engineering** |
| **Aim** | : | **To study Cutting Tools** |
| **Ref** | : | **AP 3159** |

---

## CHISELS

**Purpose**

1. Chisels are used in connection with a steel headed hammer for cutting steel and sheet metal.

**Description**

2. They are made of high carbon steel with cutting edge hardened and tempered and the rest is left softer and tougher. They are also made of nickel alloy steel. Chisels are ground to correct

cutting angles depending on the type of material on which is to be used i.e. $60^0$ for mild steel $70^0$ to $75^0$ for hard steel and $40^0$ to $45^0$ for brass or other soft metals.

**Classification**

3. They are classified by their shape, overall length, section of the shank and width of cut.

**Types**

4. a. **Flat.** It is used for general chipping work on flat surface i.e. parting off sheet metals. The edge of this chisel is made slight convex to prevent digging in the corners.

**Fig-22**

b. **Cross Cut.** It is forged to produce a cape of flare, causing the cutting edge to be narrow. It is used for cutting narrow slots, rectangular grooves and key ways.

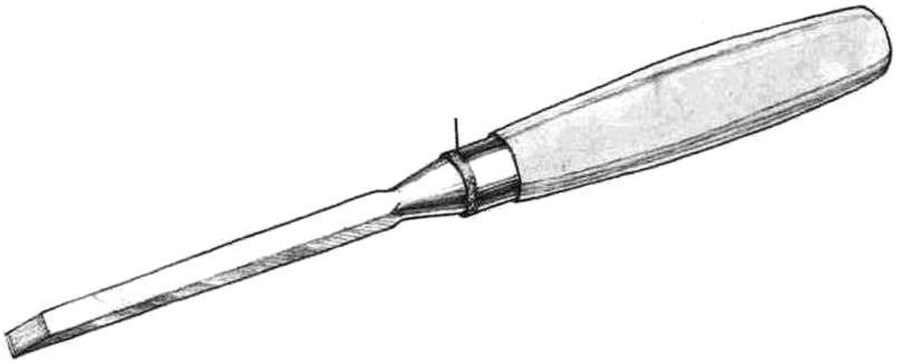


**Fig-23**

c. **Diamond Point.** It is used for clearing out corners cutting small oil grooves and for rectifying incorrect start of drilling.

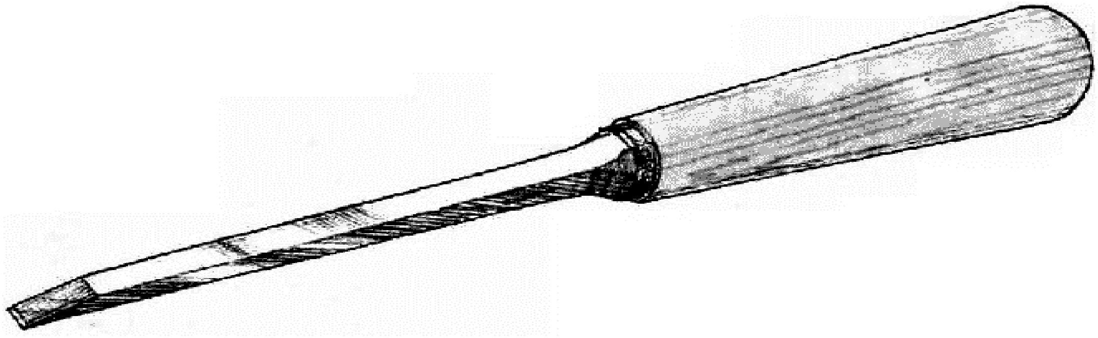


**Fig-24**

d. **Round Nose Chisel.** It is used for producing a concave surface and for cutting round or semi circular grooves.

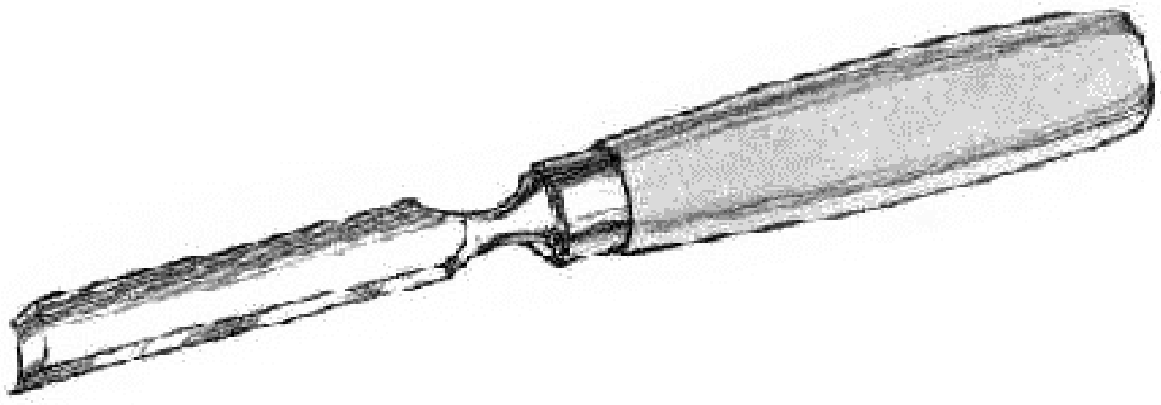


**Fig-25**

e. **Half Round**. They are suitable for cutting half round bottom grooves. They are also used for rectifying an incorrect start when drilling.

**Care & Uses**

5. a. Chisel should be sharpened by grinding or emery.

b. The cutting edge should be kept cool.

c. The striking and for hammer blow should be kept flat and free from ragged metal by grinding. The chisel head and hammer should be kept free from oil, grease etc.

d. Chisel should be chosen according to the nature of work and the material to be cut.

e. Strike the chisel with a light blow of hammer to get a start.

f. Always use goggles while chipping.

## BAF BASE ZAHURUL HAQUE (TRG WG)

### (Aero Engg Trg Sqn)

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **Basic Engineering** |
| **Aim** | **:** | **To Study gripping Tools** |
| **Ref.** | **:** | **AP 3196A** |

## P L I E R S

**Introduction**

1. Pliers are most frequently used by the mechanics for holding small object, bending thin material and for cutting wires. This tool is made of high carbon steel hardened and tempered jaws. Some are provided with insulating grip. Pliers are obtainable in various shapes and sizes to suit special jobs. It is classified by type and overall length.

**Types**

2.

a. **Side Cutting Pliers.** It is used for cutting wires.

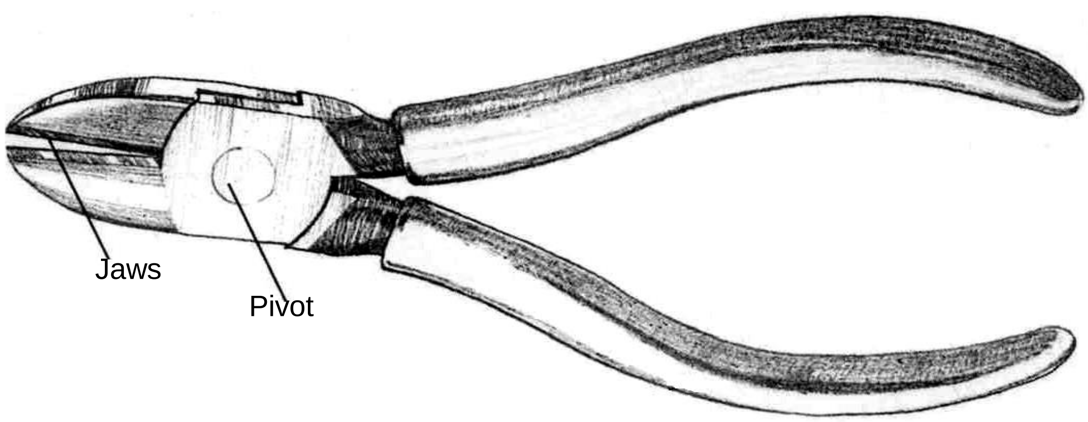



**Fig-26**

b. **Round Nose Pliers.** It has got two round jaws. It is used for bending wires.

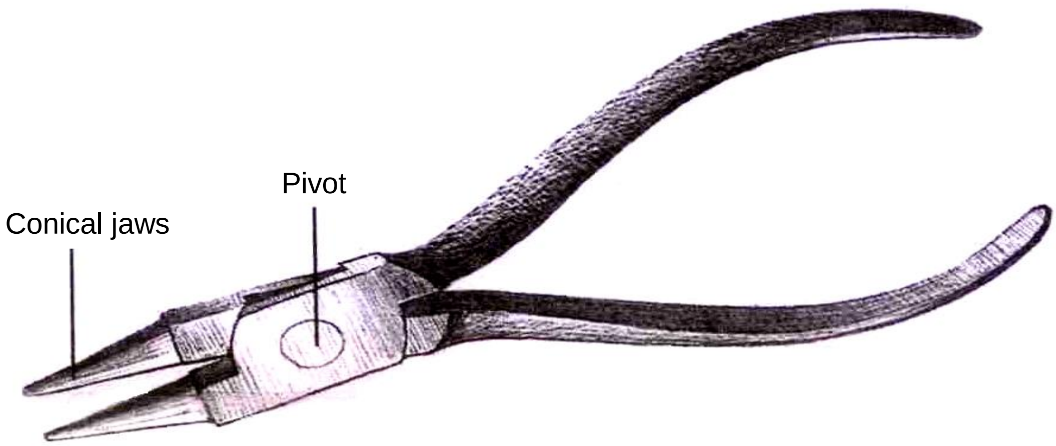



**Fig-27**

c. **Slip joint pliers.** It is constructed such a way that can hold the job of various thicknesses, because of its slip joint mechanism.

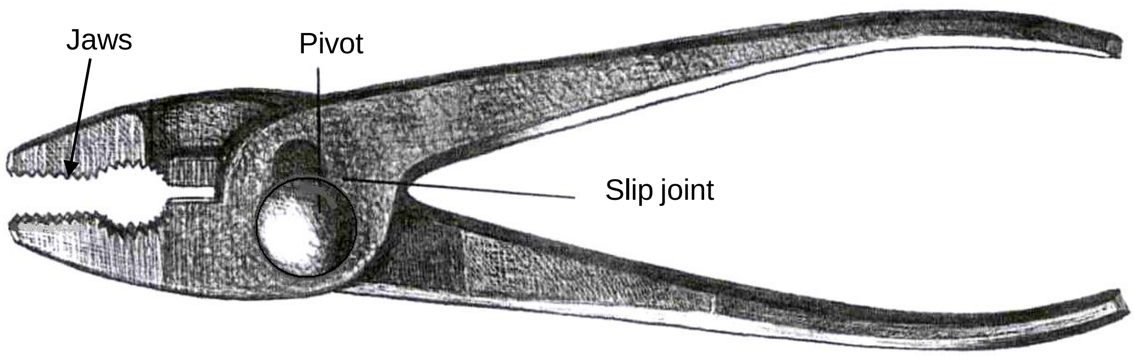



**Fig-28**

d. **Flat Nose Pliers.** It is the most common pliers used to grip small flat jobs. Some times it is provided with a cutting edge to cut wires.

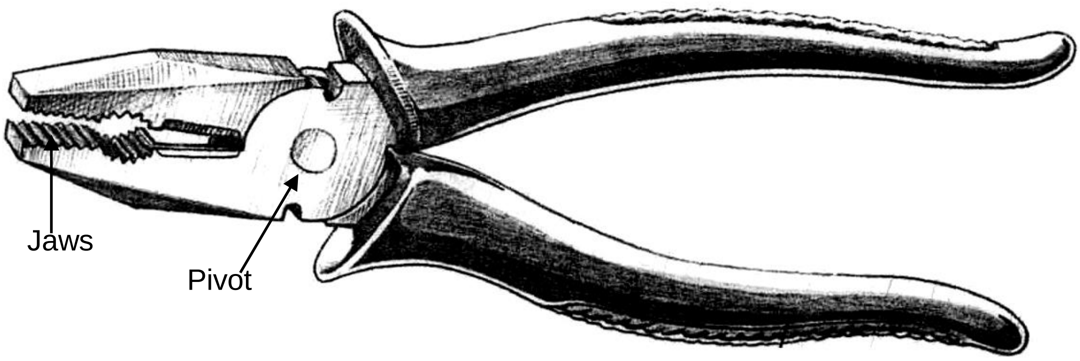



**Fig-29**

e. **Long Nose Pliers :** It is also common pliers used to grip small jobs, to bend and cut wires etc. It has long nose and it can work where place is inaccessible. It is also provided with a cutting edge.

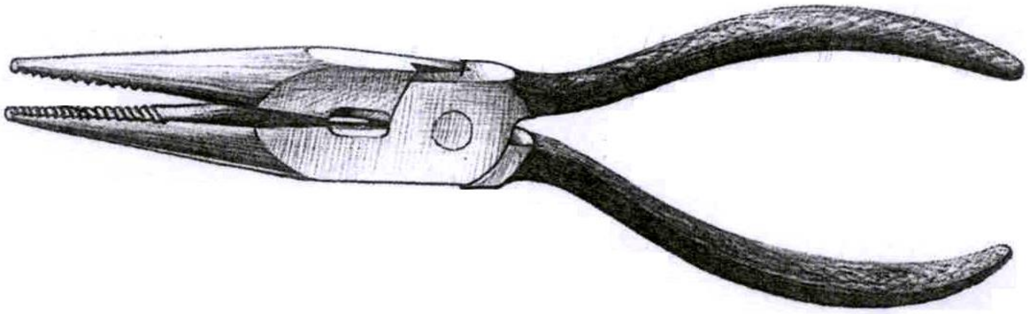


**Fig-30**

## Care and Uses

3. Pliers are a very useful tool. It is to be used properly. For job proper pliers is to be selected. Never use pliers for work for which they are not intended. Too much pressure on the handle may cause the breakage of pliers. Do not use pliers as a wrench. All dirt like oil, grease should be cleaned before use from the job as well as from the pliers. For electrical work insulated pliers are to be used.

# BAF BASE ZAHURUL HAQUE (TRG WG)

## (Aero Engg Trg Sqn)

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **Basic Engineering** |
| **Aim** | **:** | **To Study Drill** |
| **Ref** | **:** | **AP 3159 Section1 Chap 4** |

## DRILL

**Introduction**

1. These are used to drill holes in metals. The common hand tools for holding and turning the twist drill are hand breast drills or braces. Holes up to ¼" diameter can be drilled in metal by hand efficiently.

**Twist Drill**

2. Twist drill is made from a cylindrical rod which has two helical grooves (flutes) cut along its length (Fig-31). The flutes serve a triple purpose in that they:

* Allow the formation of an efficient angle, or rake, at the tip.
* Automatically expel swarf from the hole.
* Permit a coolant to reach the cutting edges.

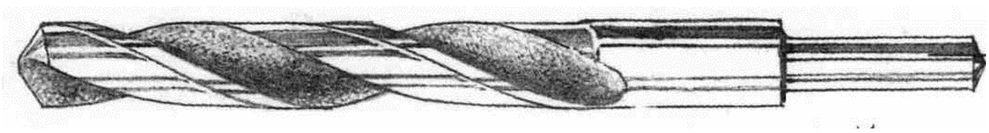


**Fig-31 Twist Drill**

a. **Sizes.** Drills sizes are expressed in terms of numbers, letters and inches or fractions of inches. The size is stamped on the shank:

(1) **Numbered**. They decrease in size from 1to 80.

(2) **Letters.** Decrease in size from A to Z.

b. **Drilling Procedure/ Uses.** While operating a twist drill by hand the following procedure will give satisfactory results:

(1) Locate the exact position of the hole by drawing two lines on the work at right angle so that they cross each other at the point to be the center of the hole.

(2) Make a light mark with a pin punch where the lines intersect.

(3) Since the mark deep enough with a center punch to receive the chisel point of the drill.

(4) Select a sharp drill of desired size. Insert it into the jaws of the hand drill and fasten it tightly.

(5) Grip the job firmly in the vice.

(6) Put a drop of oil into the pop, made by the pin punch.

(7) Be certain to keep the drill at right angle to surface of the work, through the operation.

(8) Place the point of the drill in the pop and begin drilling.

(9) Keep the steady pressure on the head of the drill.

(10) While drilling if the start is incorrect, lift the drill and make a nick in the impression with a round nose chisel.

(11) Put another drop of oil into the impression and continue drilling until the point of t drill just breaks through the metal.

(12) If the drill catches while finishing the hole, work the drill back and forth carefully until it cuts through the work.

c. **Care & Uses**. When drilling most common materials a lubricant is desirable. This improves the finish of the work and by reducing the temperature of the drill; it retains the temper of the cutting edges, thus lengthening the life of the drill. Soluble cutting oil will be satisfactory when drilling mild steel, whereas kerosene or turpentine is used for very hard steel; kerosene alone is used for aluminium alloy. Cast iron and brass are considered self-lubricating and are usually drilled without a lubricant.

# BAF BASE ZAHURUL HAQUE (TRG WG)

## (Aero Engg Trg Sqn)

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **Basic Engineering** |
| **Aim** | **:** | **To Study Gauges** |
| **Ref** | **:** | **AP 3159** |

## G A U G E

### Introduction

1. In service various types of gauges are used for measuring thickness of sheet metal, gaps between two parts, thread pitch etc. These are manufactured with standard unite of measurement.

### Types

2. The types of gauges are as follows:

a. **Feeler Gauge.** This gauge consists of a series of thin flexible steel blades in graduated thickness varying from xx to 15 thousand of an inch. Feeler gauge are classified by the length of the blades and it is used to measure small clearance or gaps. Feeler gauges are available in metric system also.

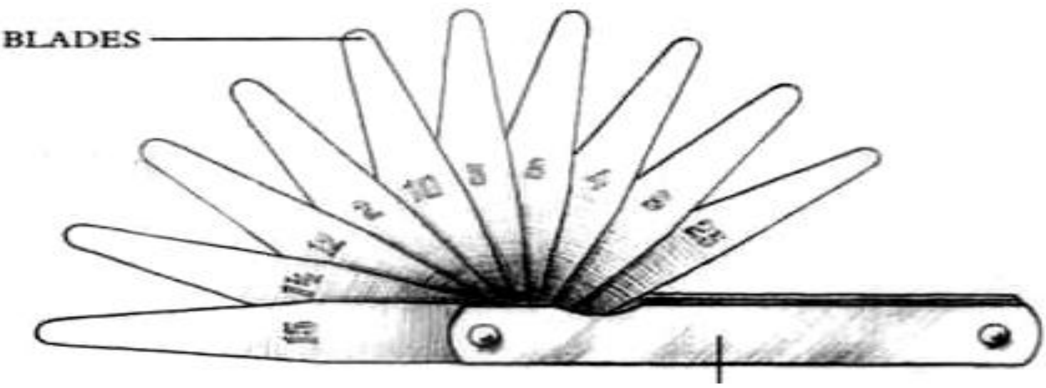



**Fig-32 Feeler Gauge**

b. **Thread Gauge.** This gauge is used to determine the number of thread per inch of an object. In metric system it is used to determine the pitch distance of a thread. The gauge consists of a number of steel blades each of which is cut with a given number of teeth per inch the blade is marked with the number of threads per inch.

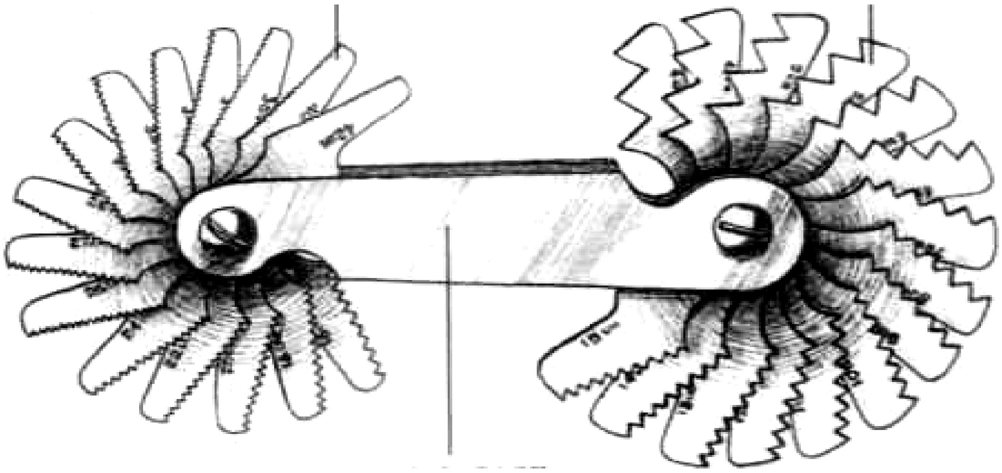


**Fig-33 Thread Gauge**

c. **Sheet Metal Wire Gauge.** It is used to find out the thickness of sheet metal and the diameters of wires. It is a round steel sheet having slots on its circumference exactly the same thickness of a particular gauge. The number of slots that fit the thickness of the sheet or wires is the gauge number. Gauge run from allow to high number i.e. 10 gauges is thicker than 200 gauges.

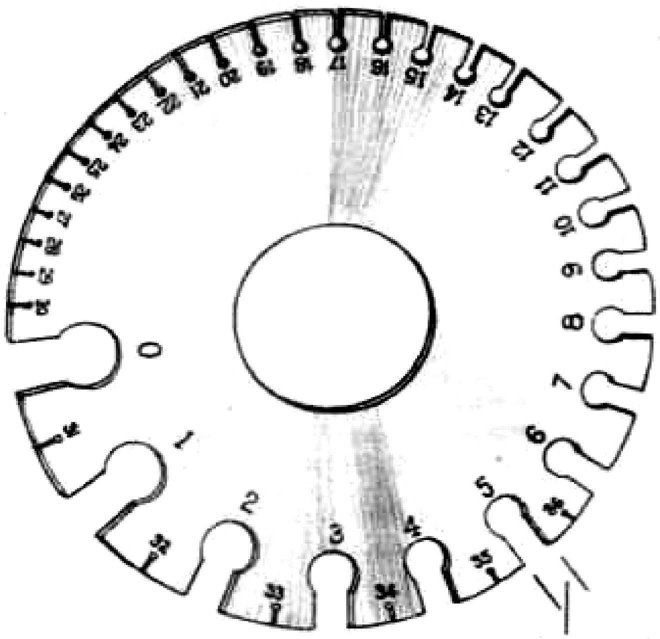


**Fig-34 Sheet Metal Wire Gauge**

d. **Twist Drill Gauges.** It is used to find the size of any drill. It is a flat steel plate containing holes of various sizes, each marked with its particular size in code number, fractional or decimal equivalent.

# BAF BASE ZAHURUL HAQUE (TRG WG)

## (Aero Engg Trg Sqn)

**Syllabus : Automobile and Diesel Technology**

**Course : Trade Training Basic, MTOF**

**Subject : Basic Engineering.**

**Aim : To Study Screw Threads.**

**Ref : A.P 3159 Section 1 & Chap 6**

---

## SCREW THREADS

### Introduction

1. A screw thread is the raised product by forming, on a cylindrical or conical surface, a continuous helical; groove of uniform section. For simplicity, the term “crew thread” is often abbreviated to thread. .

### Types of Thread

2. There are different types of threads which are as follows:

a. **Internal or Female Thread.** it is a thread on the internal surface of a hollow cylinder or a cone e.g. nuts and hollow tubes.

b. **External or Male Thread.** It is a thread on the external surface of a cylinder or a cone e.g. bolts screws and studs.

c. **Left Hand Thread.** This thread when viewed axially winds in a counter clock wise and receding direction. It engages when rotate counter clockwise. All left hand threads are designed LH.

d. **Right Hand Thread.** This thread when viewed axially winds in a clock wise and receding direction. This type of thread engages when rotate clock wise.

# BAF BASE ZAHURUL HAQUE (TRG WG)

## (Aero Engg Trg Sqn)

**Syllabus** : **Automobile and Diesel Technology**
**Course** : **Trade Training Basic, MTOF**

**Subject** : **Basic Engineering.**
**Aim** : **To Study Locking Device**

**Ref** : **A.P 3159 Section 1 & Chap 7**

---

## B O L T S

### Introduction

1. A bolt is a rod or cylindrical bar with male thread cut on one end and a head machined at the other end. The bolt is used to fasten various members together on assembly and disassembly the matching parts when necessary thus providing detachable joints. The bolt is externally threaded and is used in conjunction with a nut. The bolt head is larger in size than bolt diameter provides a shoulder for gripping the parts together. The shape of the head fits the standard spanner sizes. The bolt may be made of various types of material to various types of requirements.

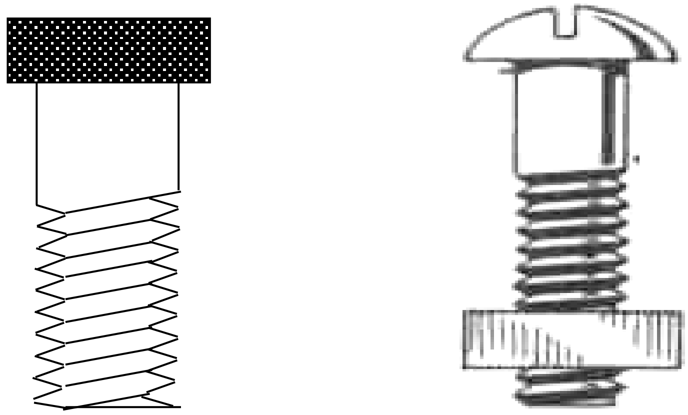


**Fig-35 Bolts**

### Identification

2. The bolts are classified by its types and sizes. In addition individual bolt may have special markings on the head. There markings indicate their identifications.

a. A dash (-) on the bolt head denotes corrosion resistance steel.

b. A cross (X) denotes alloy steel.

c. A recessed triangle (∆), Triangle with dimple (∆) or triangle with cross (∆x) denotes close tolerance bolts.

d. A double dash (- -) denotes aluminium alloy.

e. Two parallel dash (=) denotes bronze.

f. Hexagonal steel bolts, high tensile steel bolts are identified by grooves cut in the head at right angle to the bolt axis.

g. Letter ‘L’ on the bolt head indicates that the bolt with a left hand thread.

h. Letter ‘E’ on the bolt head indicates that the bolt is made of stainless steel.

**Types**

3. a. **Standard Bolt.** It is all-purpose structural bolts used for general applications involving tension and shear load. It is not machined accurately.

b. **Close Tolerance Bolt.** It is machined more accurately and is hexagonal headed or 100 countersunk headed. It is used in application where light drive fit is desired and bolted joint is subjected to severe load and vibration.

c. **Cleaves Bolt.** These are round headed bolts either slotted to receive a common screw driver or recessed to receive a cross point screw driver. These are used only where shear loads occurs.

d. **Internal Wrenching Bolts.** These bolts are fabricated from high strength steel and are used where severe tension occurs.

e. **External Wrenching Bolts.** These are high strength steel bolts used primarily in high tensile and fatigue strength applications.

f. **Eye Bolt.** These are used to carry external tension load for the attachment of devices suck as the hook of turnbuckle, eye rod end or hanging point of a motor or small generator etc.

## N U T S

**Introduction**

1. The term nut is applied to any shaped block that has a male thread and is readily detached from the bolt or stud by using standard hand tools. It is used to fasten various member together on de-assembly the matching parts. Thus providing detachable joints. All standard nuts are hexagonal in shape and are made of similar material to that used in bolts.

**Identification**

2. All nuts of ¼” in diameter and over are marked with their part number on one of the hexagonal faces. This part number comprises: -

a. Letter ‘E’ preceding size code letter indicates that the material is stainless steel.

b. Letter ‘L’ following the size code letter indicates left hand thread.

c. ‘V’ groove machined in corner indicate high tensile steel.

d. Aluminium nuts are identified by washer faced machined on bolt faces of the nuts.

e. Brass nuts are identified by code letter ‘B’.

**Types**

3. a. **Self Locking Nuts.** These nuts provide the tight connection, which will not be loosening under vibration. All metal nuts with non-metallic inserts are to provide the locking action. New self-sealing nuts will be used each time in the components are installed in the critical areas through out aircraft including all flight control, engines and fuel control linkage.

b. **Non-Self Locking Nuts.**

(1) **Shear Nuts.** These are designed for using with devices such as drill Clevis bolts land threaded taper pin, which are normally subjected to shearing stress only. They are locked with a cotter pin.

(2) **Castle Nut.** These nuts are used with drilled shank bolts, hexagonal head bolts, Clevis bolts and drilled head studs. These are designed to be secured with cotter pins or safety wire.

(3) **Plain Nut.** The plain nuts are available as self-locking or non-self licking nuts. When the non-self locking plain nuts are used then check nut or lock washer should be used.

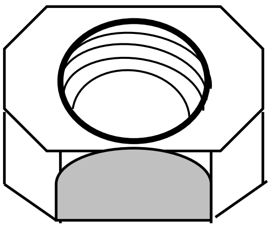


**Fig-36 Plain Nut**

c. **Lock Nuts.** It is a thin nut, which is tightened down firmly on the top of the main nut. Thus action prevents the main nut from slackening.

d. **Wing Nuts.** Wing nuts are made of either steel or brass etc. They are used on studs like threaded parts where torque value is of no importance. They are tightened with hand and locks by the safety wire. Parts needed frequent removing and installing where the wing nut is used.


**Fig-37**

e. **Nylon-lock Nut.** The nut has an unthreaded nylon insert permanently housed at the outer end. As the bolt threaded engage their insert, because it has an internal diameter less than the effective diameter of the bolt. On assembly the bolt displaces the nylon in forming a thread thus high friction is set up which prevents the nut from unscrewing.

f. **Nylon-lock Cap Nut.** Similar to nylon-lock stiff nuts but incorporates a nylon inserts in the cap form to seat the end of the bolt or screw to which the nut is fitted. This nut is used for especial application such as pressurized cabin, fuel and oil tanks etc.

g. **Locking Plate.** This is a thin metal plate fitted over the given size and shape of nut after tightening. After fitting the locking plate over the nut, the plate is secured in position by setscrew. A locking plate may be used repeatedly provided its fits properly on the nut. Locking plates are used to prevent loosening of parts due to vibration.

## S C R E W S

### Introduction

1. It is a cylindrical bar having external thread on its body. It may be made of various types of steels, preferably high tensile steel. It is not equipped with a body of a particular item where screw fits. It is available in length and diameters. The shape of the head of a screw may be round, countersunk it is used. The head of the screw have either a single cut mark or star shaped cut mark to allow for the common screw driver or star head screw drivers to drive the screws in or out.

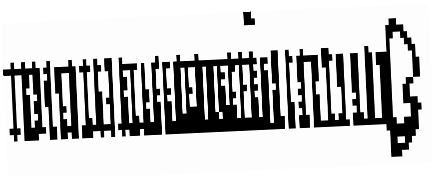


**Fig-38 Screw**

**Types**

2. There are many types of screws available, such as :

a. Structural Screw.

b. Machine Screw.

c. Self taping Screw.

Where certain parts are to be opened time-to-time they are usually screwed together instead of riveting which forms a permanent joint.

## WASHERS

**Introduction**

1. Generally washer is used under the nut and the head of the bolt. It is used to prevent damage to the surface in between nut and the head of a bolt. Some times it acts as a locking device of the nut. It may be made of various types of materials.

**Types**

2. a. **Tab Washer.** This is a metal washer with two or more tabs (legs) and is suitable for using with standard nuts. One tab is bent against one of the flats of the nut and the other is over an edge or into a hole in the component. It is used once only.

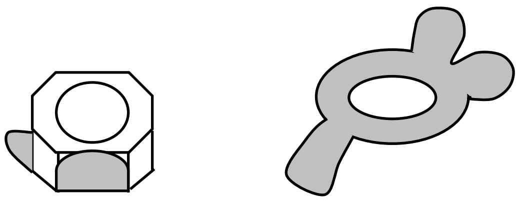
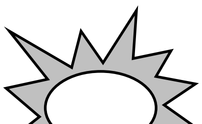


**Fig-39 Tab Washer**

b. **Spring Washer.** It is a angle or double coil spring which is fitted underneath the nut. When the nut or bolt is tightened and spring compressed, considerable friction is set up between the faces of the screw threads, which is sufficient to prevent the nut or bolt from turning. This washer can be re-used provided that it retains its spring action.

c. **Shake Proof Washer.** It is a spring steel washer, which is slotted on its internal or external edges. The angle of the serrations is such that the nut is able to slide over them, when being tightened, but any tendency to unscrew will be resisted by the sharp edges of the serrations.



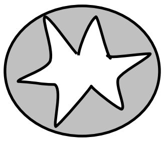


**Fig-40 Shake Proof Washer**

## RIVETS

### Introduction

1. Rivets are used considerably in sheet metal work. In aircraft skin and structural parts it is used frequently. Rivets are nothing but metal pins used to hold two or more metal sheets, plates and pieces of material together. A head is formed on shank of rivet is placed through matched holes in two pieces of material, and the tip is then mushroomed over to form a second head to clam the pieces together. The second head is formed by hand hammering or by pneumatic hammer and is called shop head. The shop head functions in the same manner as a nut on a bolt.

### Types

2. a. **Brazier Head Rivet.** It is used on the exterior surfaces of the aircraft where more strength is required than a counter sunk head rivet. Like countersunk head rivet it is also used in the interior of aircraft where head clearance is required.

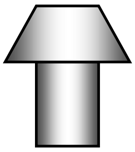


**Fig-41 Brazier Head Rivet**

b. **Round Head Rivet.** It is used generally in the entire of aircraft except where the clearance is required for the adjacent member.

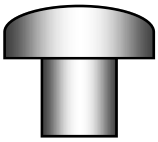


**Fig-42 Round Head Rivet**

c. **Counter Sunk Rivet.** It is used on the exterior surfaces of the aircraft to minimize turbulent airflow. It is also used in the interior of aircraft where head clearance is required.

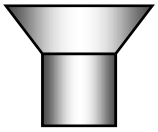


**Fig-43 Counter Sunk Rivet**

d. **Universal Head Rivet.** It is the combination of brazier countersunk and flat head. It can be used in place o f those braziers, counter sunk and flat head rivets.

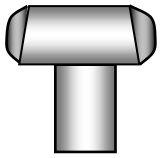


**Fig-44 Universal Head Rivet**

e. **Flat Plate Rivet.** It is used generally in the interior surfaces of the aircraft where head clearance is required for the adjacent member.

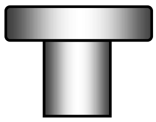


**Fig-45 Flat Plate Rivet**

## SAFETY DEVICE

**Introduction**

1. Many engineering products consist of number of individual parts assembled together to become one working unit. Therefore a tradesman should be very much concerned with the technique of securing parts together and with the use of variety safety devices.

**Types**

2. a. **Cotter Pin.** These are steel and nickel alloy steel pins of different diameter and length. These are used in slotted nuts and pass through a hole in bolt or stud to lock them. Pins are secured by bending the legs. A cotter pin must be used once only.

b. **Safety Wire.** Safety wire (Locking wire) is used to ensure positive means of locking to various components. The nut and the bolt are provided with drilled hole to accept the wire. The wire must always be so positioned that it prevents the nut unscrewing. Wire must be twisted carefully.

c. **<u>Tab Washer.</u>** This is a metal washer with two or more tabs (legs) and is suitable for using with standard nuts. One tab is bent against one of the flats of the nut and the other over an edge or into sole in the components. It is used once only.

d. **<u>Locking Plats.</u>** This is a thin metal plate fitted over the given size and shape of the nut after tightening. After fitting the locking plate snugly over the nut, the plate is then secured in position by a setscrew. A locking plate may be used repeatedly provided it is a good fit on the nut. Locking plates are used to prevent loosening of parts due to vibrations.

e. **<u>Spring Washer.</u>** It is a single or double coil spring, which is fitted beneath the nut. When the nut or bolt is tightened and spring compressed, considerable friction is set up pattern the faces of the screw threads which is sufficient to prevent the nut or bolt from turning, provided that spring washer retains its spring action and may be reused. To prevent damage to the finish surface of the components it is common practice to fit a plain washer and the spring washer.

# BAF BASE ZAHURUL HAQUE (TRG WG)

## (Aero Engg Trg Sqn)

**Syllabus : Automobile and Diesel Technology**

**Course : Trade Training Basic, MTOF**

**Subject : Engine**

**Aim : To Study Introduction of Automobile**

**Ref : The Automobile by Harbans Singh Reyat**

---

## INTRODUCTION OF AUTOMOBILE

**Automobile**

1. An automobile is a self-propelled vehicle, which is used for the transportation of passengers and cargo over the ground.

### Vehicle

2. Vehicle is a machine, which is used, for the transportation for the passengers and cargo. A vehicle consists of two parts, i.e. Carriage portion and Machine portion.

### Self-propelled Vehicle

3. A self-propelled vehicle is that in which power required for propulsion purpose is produced from within. Aeroplane, ship, motorboat, locomotive, car, bus, motorcycle, scooter etc. are example of self-propelled vehicles.

**Motor Vehicle**

4. It is a vehicle, which contains motor (DC motor or engine) to drive it. Motor vehicle is another popular name of the automobile. Motor + Vehicle = Motor vehicle.

### Parts of the Automobile

5. Every automobile consists of the two main parts:

a. **Machine portion, i.e. Chassis.** It is the machine portion of the automobile, which carries the carriage portion. The chassis contains almost all those parts of an automobile, which are necessary to drive the vehicle. It consists of the following main parts (Fig-1):

(1) **Frame**. It is the main structure around which all the other parts are connected or suspended to form chassis.

(2) **Springs, Shock absorbers Axles and Wheels**. These are the main parts on the suspension system of an automobile with the help of which chassis frame is put on legs and is able to roll on smoothly on the ground.

(3) **Power Unit or Engine**. Power plant is to develop the requisite power for the propulsion of an automobile.

(4) **Clutch, Gear box (Transmission), Propeller Shaft, Differential and Self-shafts or Axle shafts.** These are the main constituents of the transmission line through which power developed by the engine is transmitted t the wheels of an automobile.

(5) **Steering, Brakes and Accelerator**. These are the main controls by means of which the vehicle is turned to right or left, stopped and engine speed, which ultimately affects the speed of the vehicle, is controlled respectively.

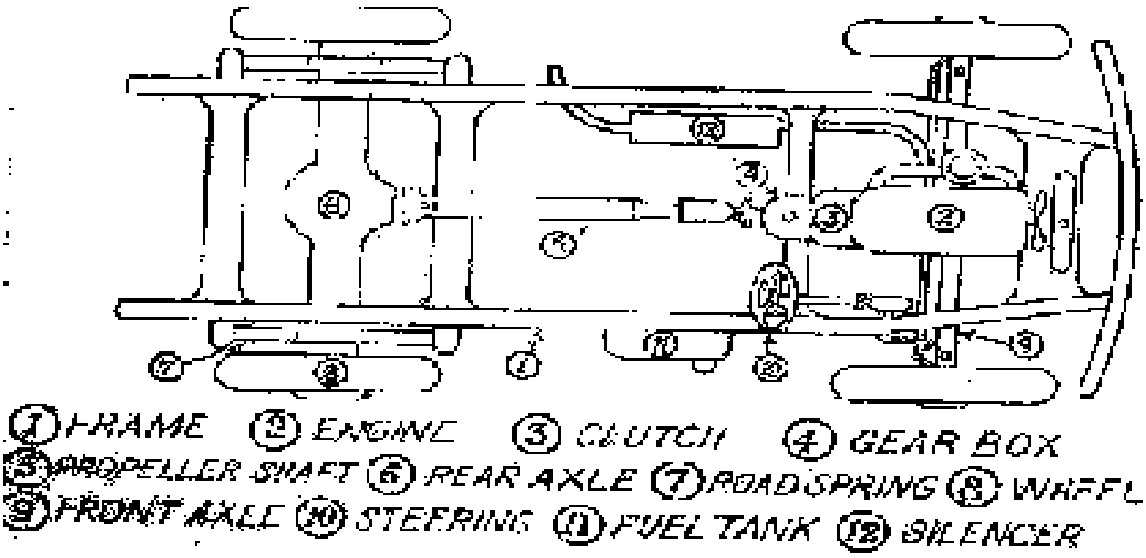



**Fig-1 Automobile Chassis**

b. **Body or Carries Portion.** It is that portion of an automobile where the passengers have their seats or where the cargo to be carried is placed (Fig-2).

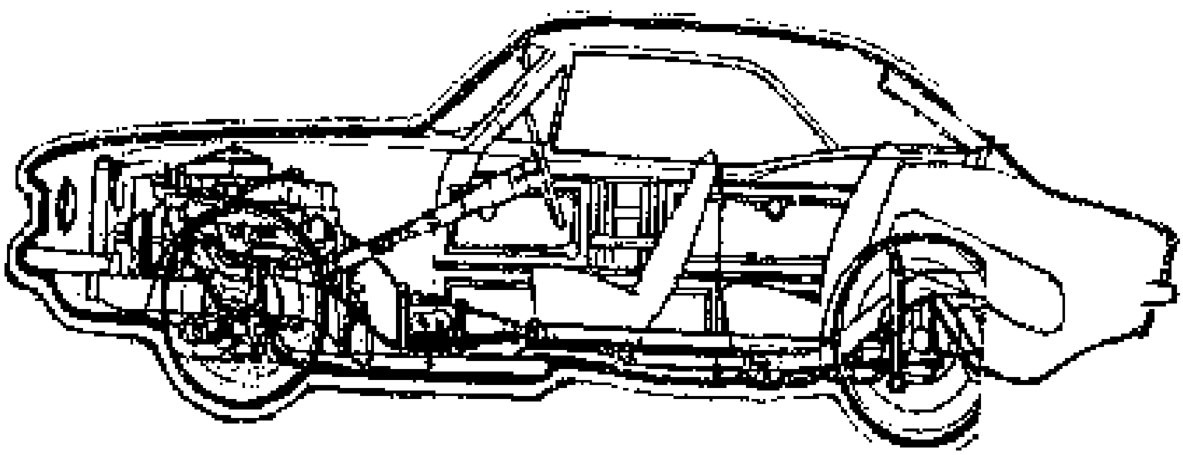


**Fig-2 Body**

**BAF BASE ZAHURUL HAQUE (TRG WG)**
**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **Engine** |
| **Aim** | **:** | **To Study Glossary of Terms** |
| **Ref** | **:** | **The Automobile by Harbans Singh Reyat** |

# GLOSSARY OF TERMS

**Cylinder**

1. The bore in the engine in which piston operates. The cylinder is a long, round air pocket, somewhat like a tin can with bottom cut out.

**Piston**

2. A cylindrical part closed at one end, which moves inside a cylinder.

**Bore.**

3. The bore is the diameter of the cylinder. The size of an engine cylinder is given by its bore.

**Stroke**

4. The distance from BDC to TDC or TDC TO BDC in an engine cylinder as traveled by the piston is known as stroke.

**Top Dead Center (TDC)**

5. The high limits traveling of piston inside the cylinder is known as TDC.

**Bottom Dead Center (BDC)**

6. The low limits traveling of piston inside the cylinder is known as BDC.

**Combustion Chamber**

7. It is the place left at the top of the piston crown when the piston is at TDC. It is the space where combustion takes place.

**Reciprocating Movement**

8. Up and down movement of the piston inside the cylinder is known as reciprocating movement.

**Cycle**

9. A serious of event or operations taking place according to established sequence is known as cycle.

Dead Center

10. The extreme upper or lower position of the crankshaft through at which the piston is not moving in either direction.

**Firing Order**

11. The order in which firing takes place in the various cylinder of an engine.

# BAF BASE ZAHURUL HAQUE (TRG WG)

## (Aero Engg Trg Sqn)

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **Engine** |
| **Aim** | **:** | **To Study Modified Cycle** |
| **Ref** | **:** | **AP-3159 Section 3 Chap 3** |

## MODIFIED OTTO CYCLE

### Purpose

1. To ensure that an engine gives much more power and runs more efficiently if the valve operations occur when the crank is at slightly different positions.

### Description

2. In the modified four-stroke cycle to indicate the modified valve operation in the engine, the following terms are used (Shown in Fig-3):

a. **Valve Lead**. When a valve is open before TDC or BDC. It is said to be valve lead.

b. **Valve Lag**. When a valve is closed after the dead center position it is said to be valve lag.

c. **Valve Over Lap**. When inlet valve is opened before the exhaust valve is closed, there is a short period during both the valves are remain open, this is referred to be as valve over lap.

d. **Ineffective Crank angle.** This is the angular position around TDC and BDC where for a large movement of the crankshaft there is a relatively small movement of the piston.

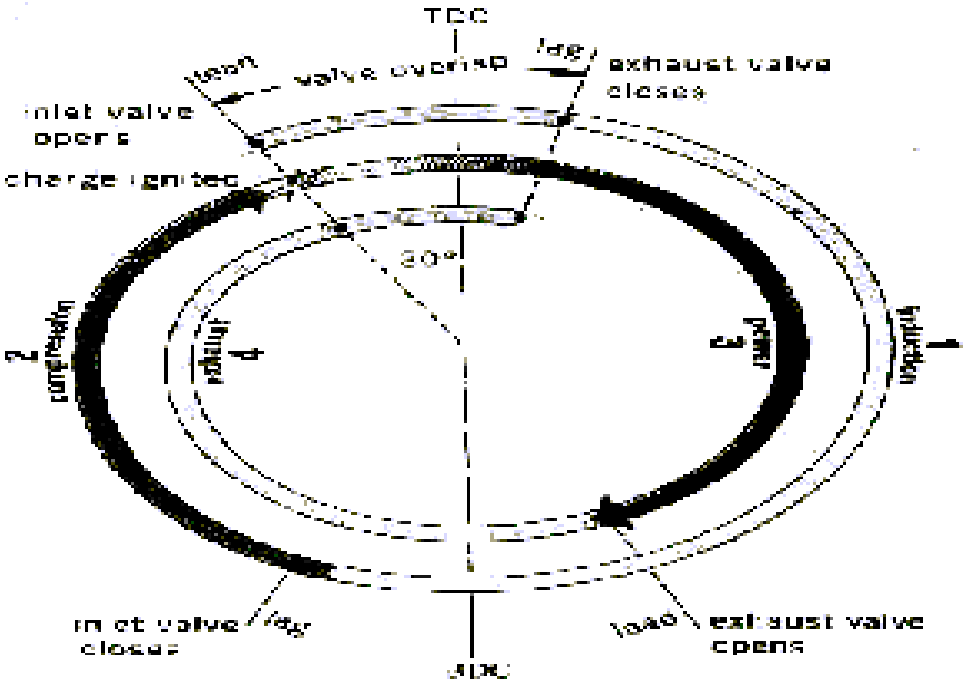



**Fig-3 Terms of Modified Otto Cycle**

# BAF BASE ZAHURUL HAQUE (TRG WG)

## (Aero Engg Trg Sqn)

**Syllabus : Automobile and Diesel Technology**

**Course : Trade Training Basic, MTOF**

**Subject : Engine**

**Aim : To Study Cycle Operation of Engine**

**Ref : Automobile by Harban Sing Reyat & Automotive Mechanics by Joseph Heintner.**

---

## CYCLE OPERATION OF ENGINE

**Principle**

1. Internal combustion engine works on two basic principles of physics:

a. Combustion or burning is always accompanied by the production of heat.

b. When a gas is heated, it expands. If the volume remains constant, the pressure rises. This, in general, is known as “Charles’ Law”. What actually happens in the production of power by this internal combustion engine may be described as follows: Gasoline, a liquid fuel, is mixed with air, broken up into a mist and partly vaporized in a carburetor. The mixture is then sucked into a cylinder. There it is compressed by the upward movement of a piston within the cylinder and is ignited by an electric spark. When the mixture in the cylinder is burned, the resulting heat causes the gases to expand. Since the natural expansion is prevented because the gases are confined within the cylinder, pressure is exerted on the cylinder walls and on the piston. The piston, being movable, is pushed downward by the force of these expanding gases to the full length of its stroke.

**Types of Reciprocating Engine**

2. Reciprocating engine can be classified as under:

a. **Petrol Engine (Spark Ignition Engine).** Petrol or gasoline is used in this engine. Ignition takes place by means of an electric spark.

-

b. **Diesel Engine (Compression Ignition Engine).** Diesel is used as fuel in this engine. Injected fuel is ignited due to the temperature of compressed air in the cylinder.

c. **Two stroke engine.** In which all the events of the cycle are completed in two strokes of the piston.

d. **Four Stroke Engine.** In which all the events of the cycle are competed in four strokes of the piston.

## Cycle of Operation

3. There are mainly two types of cycle of operation (a) Four stroke cycle (b) Two stroke cycle. Both petrol and diesel engines are using four/two stroke cycle. In this chapter we will discuss only four-stroke cycle. In the four-stroke cycle engine the four strokes are named intake (suction), compression, power and exhaust.

a. **Induction Stroke**. During this stroke, piston is moved downward by the crankshaft, which is revolved either by the momentum of the flywheel or by the power generated by the electric starting motor. This movement crankshaft will move 180 o, piston will move from TDC to BDC and inlet valve will open. Suction will create inside the cylinder. Then the higher pressure of the outside atmosphere forces fresh mixture into the combustion chamber (space) through the open inlet valve (Fig-4 a).

b. **Compression Stroke**. At the end of the intake stroke piston reaches at the bottom of the cylinder, called BDC.The next stroke commences when the piston moves from BDC to TDC.Crankshaft turns 180 o Both the inlet and exhaust valves are closed to prevent escape of the charge (mixture). This seals the upper end of the cylinder. As the crankshaft continues to rotate it pushes up the piston through the connecting rod. As the piston is pushed upward it compressed the combustible mixture in the combustion chamber. The mixture is compressed to about a sixth or seventh of its original volume. Temperature will rises up due to compression. The energy in the fuel is concentrated into a smaller space as both the valves are closed (Fig-4b).

c. **Power Stroke**. At the end of the compression stroke as soon as the piston reaches at TDC, the compressed fuel air mixture is ignited by an electric spark, which is caused by ignition system. The mixture burns quickly. Very high temperature produces. Due to increase of temperature pressure also increase. The gases expand due to rapid rises of temperature and exert force on the piston crown. Piston moves downward and crankshaft is forced to turn. This is called power stroke. Both the valves remain closed (Fig-4c).

d. **Exhaust Stroke**. Just after the power stroke is finished, the piston starts to move TDC. Exhaust valve opens. The piston forces the burned gases to go out of the cylinder through the opened exhaust valve. The inlet valve remains closed (Fig-4d). Now, as the piston passes through TDC and starts down again, the exhaust valve closes. Another cycle of operation will continue.

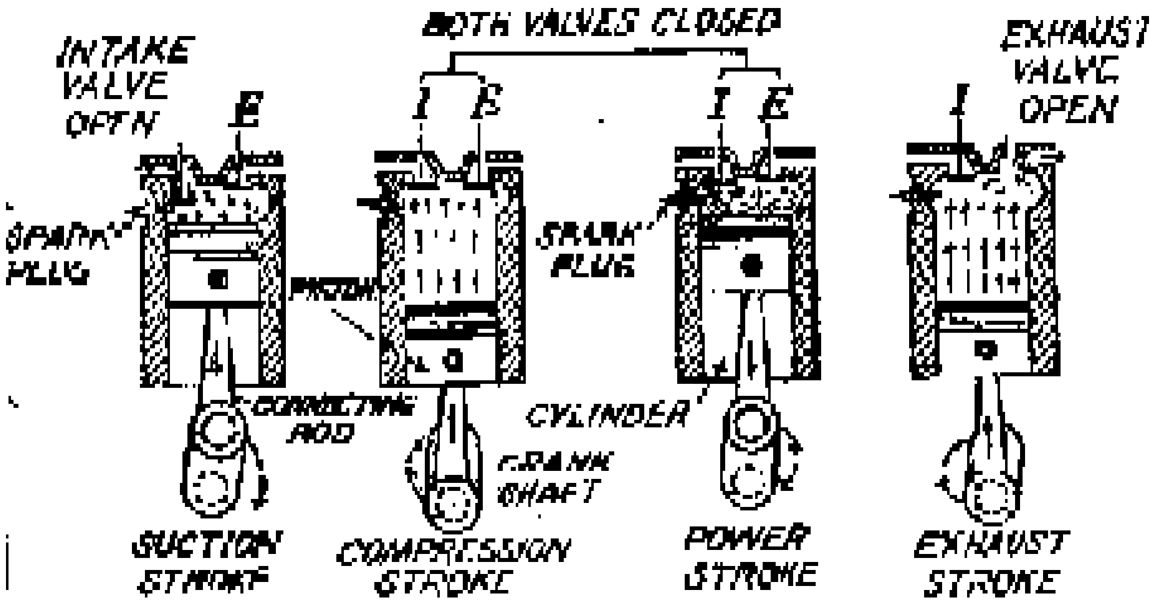


**Fig-4 Four-Stroke Cycle**

## Diesel Cycle or Constant Pressure Cycle Engines

4. Which works on diesel cycle or constant pressure cycle. In diesel cycle, the combustion takes place at constant pressure because burning takes place gradually without an explosion as the fuel enters. Hence this cycle is known as constant pressure cycle. In diesel cycle, the following events takes place one after the other:

a. Suction of only air.

b. Compression of air.

c. Injection of fuel.

d. Action of power impulse (working).

e. Exhaust of burnt gases.

## Cycle of Operation for Four Stroke Diesel Engine

5. Diesel cycle; (4 stroke, 5 event cycle): -

a. **First Event (Suction Stroke):**

(1) Air from the atmosphere is sucked into the cylinder through the air cleaner, by the downward movement of the piston from TDC to BDC.

(2) Inlet valve is closed and exhaust valve is closed.

b. **Second Event (Compression Stroke):**

(1) Piston moves upwards from BDC to TDC.

(2) Both inlet and exhaust valves are closed.

(3) The drawn in air is compressed into the combustion chamber.

c. **Third Event (Injection):** When the piston reaches near compression TDC, fuel is injected into the combustion chamber by means of Fuel Injection System.

d. **Fourth Event (Working or Power Stroke):** As soon as the injection fuel comes in contact with compressed hot air, it catches fire. The gases expand rapidly and provide power impulse to the piston.

(1) Piston moves downwards from TDC to BDC carrying the power produced due to the combustion of fuel.

(2) Both inlet and exhaust valves are closed.

e. **<u>Fifth Event (Exhaust Stroke):</u>**

(1) Piston travels upward from BDC to TDC.

(2) Exhaust valve is open and intake valve closed

(3) Used gases are expelled out of the cylinder.

| **STROKE** | **DIRECTION** | **INTAKE VALVE** | **EXHAUST VALVE** | **GAS** |
|---|---|---|---|---|
| Intake | Down | Open | Closed | Enters |
| Compression | Up | Closed | Closed | Compressed |
| Power | Down | Closed | Closed | Burnt |
| Exhaust | Up | Closed | Open | Expelled |

# BAF BASE ZAHURUL HAQUE (TRG WG)

## (Aero Engg Trg Sqn)

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **Engine** |
| **Aim** | **:** | **To Study Engine Firing Order** |
| **Ref** | **:** | **Automotive Mechanics by Josep Heitner** |

## ENGINE FIRING ORDER

### Introduction

1. The sequence in which the power impulses occur in an engine is called the firing order. When the cylinders are in line, the cylinder farthest in front or nearest the radiator is designated as No-1 and the one directly behind is No-2 as so on.

### One cylinder Engine

2. In one cylinder engine (Fig-5) there is but one-power impulses in two revolutions of the crankshaft-resulting in uneven distribution of power. There is one piston and connecting rod, which reciprocate with no working parts to counterbalance their weight; a one-cylinder engine does not have mechanical balance. The engine however, can be balanced to some extent by the use of counterweights attached to crankshaft and also by the use of a flywheel so heavy that its momentum produces a comparatively steady movement. Fluctuations in the speed of the engine will cause vibration, even in the best design of one-cylinder engines, making this type undesirable for use in motor vehicles.

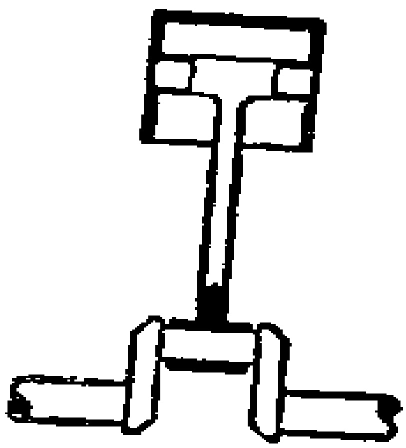


**Fig-5 One Cylinder Engine**

### Two Cylinder Engine

3. Two cylinders engines have firing order 1 and 2. In two-cylinder engine following three arrangements (Fig-6 a b c); (a) In line with crankshaft, i.e. side by side in single row and parallel to one another. They can be either horizontal or vertical. (b) Horizontally opposed. The cylinders are at $180^0$ to each other. (c) The Vee twin, here the cylinders are arranged in two rows at some predetermined angle to one another, i.e. usually $90^0$.

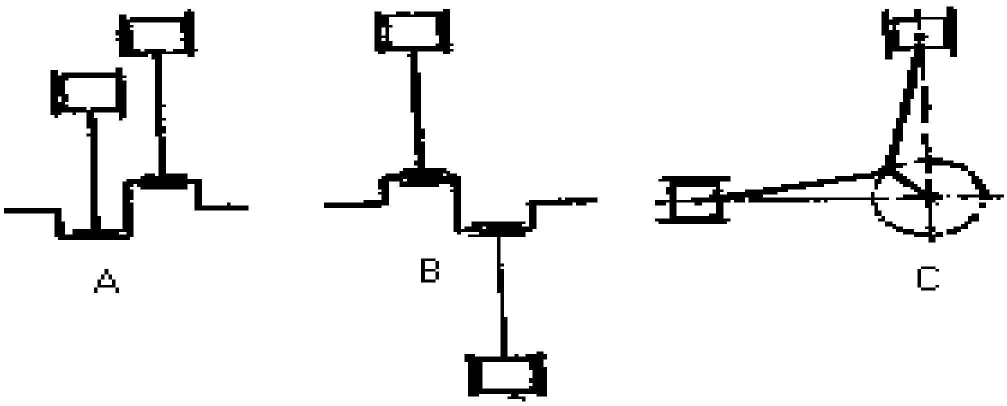



**Fig-6 A, B & C Twin Cylinder**

## Four Cylinder Engine

4. In four cylinder engine firing order has been arranged 1,3,4,2 and 1,2,4,3 with a 180 degrees crankshaft. The crank arms for No- 1 and 4 cylinders project in the same direction and crank arms for No 2 and 3 cylinders project from the opposite side of the crankshaft. Hence, the angle between the pairs of throw is 180 degrees (Fig-7).

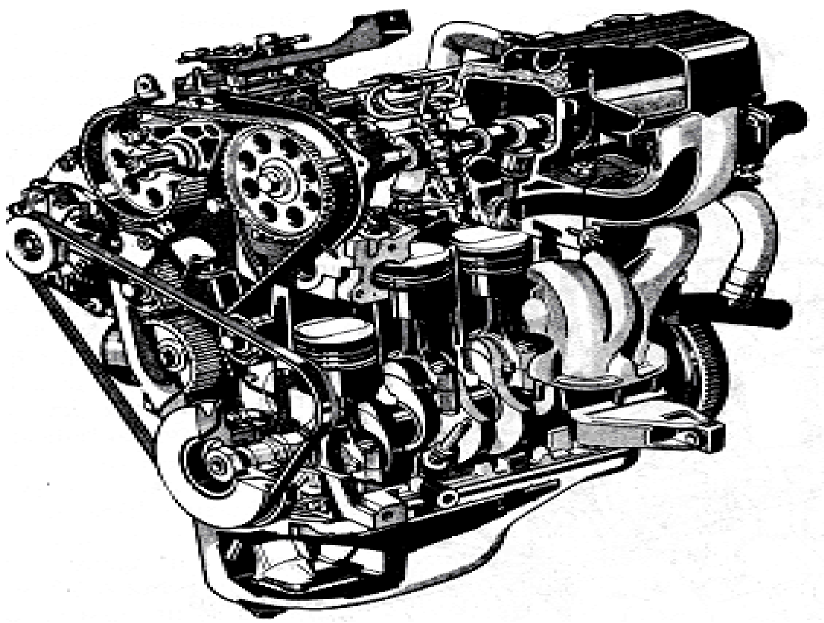


**Fig-7 Four Cylinder Engine**

## Six Cylinder Engine

5. Six cylinders engine firing order 1,5,3,6,2& 4 and alternative 1,4,2,6,3 & 5. The crankshaft banks are arranged 120 degrees. The crankshaft is arranged so that the crank throws of No 1 & 6, 2 & 5 and 3 & 4 are in the same radial plane. The angle between the planes is 120 degrees. With this construction there will be six power impulses during two revelations of the crankshaft or one power stroke every 120 degrees of crankshafts rotation (Fig-8)

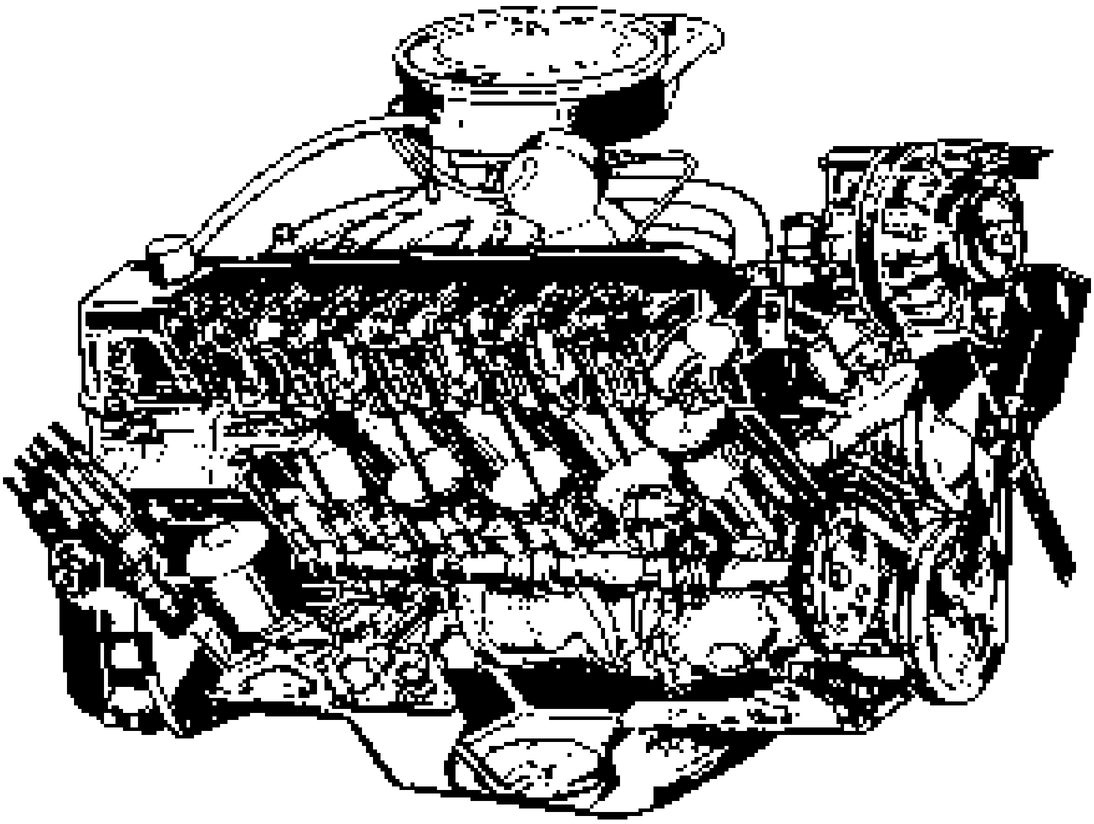


**Fig-8 Six-Cylinder Engine**

**Eight Cylinder Engine**

6. a. Inline eight cylinder engines which have their cylinders in line use a crankshaft with the throws set $90^0$ from each other. The crank throws for cylinder No 1&8 are in the same radial plane, as are the throws for cylinders 2&7, 3&6, and 4&5 Firing order of eight cylinders inline engine is 1, 6, 2, 5, 8, 3, 7 & 4(Fig-9).

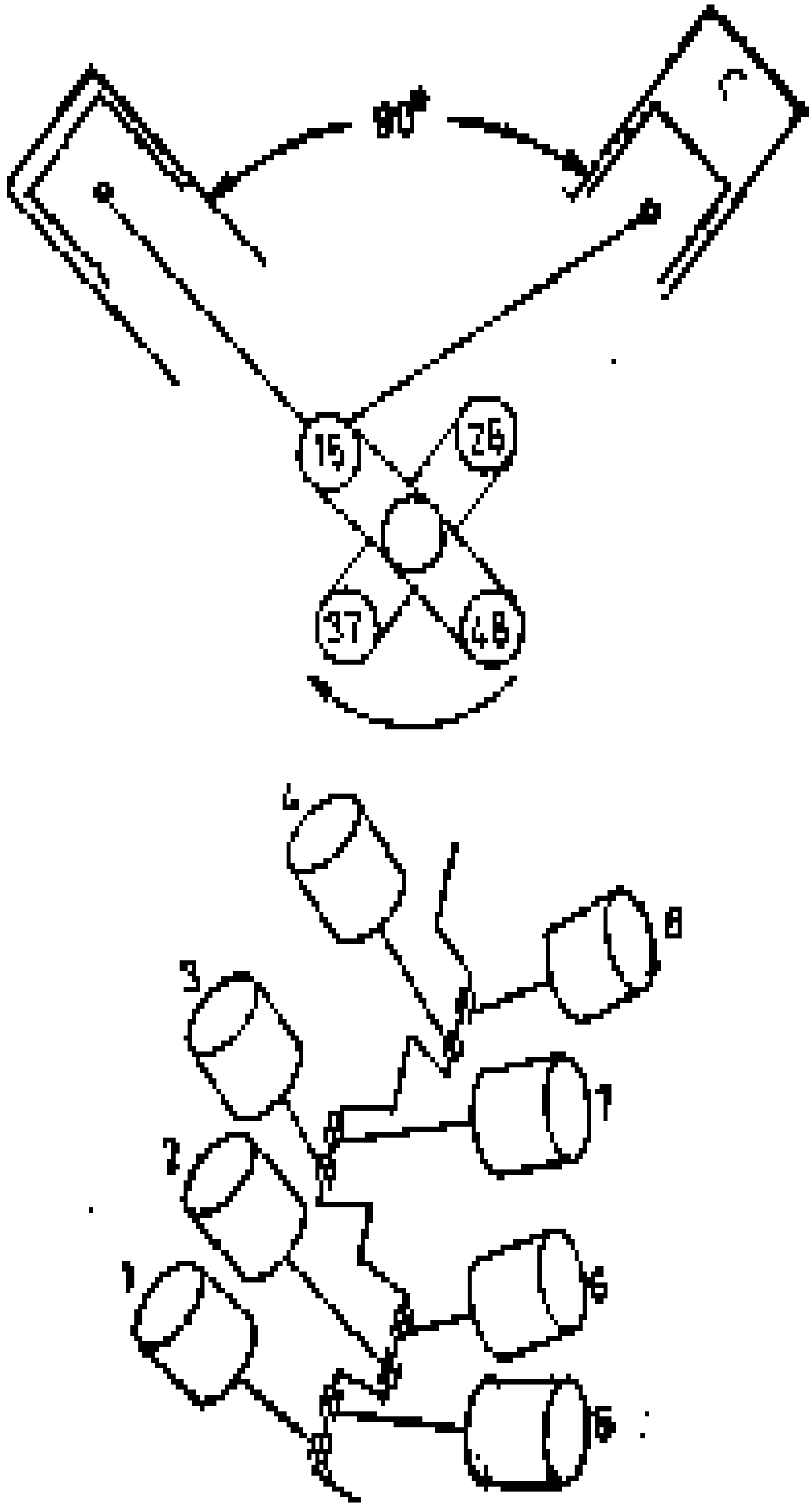



**Fig-9 Eight-Cylinder engine**

# BAF BASE ZAHURUL HAQUE (TRG WG)

## (Aero Engg Trg Sqn)

**Syllabus : Automobile and Diesel Technology**

**Course : Trade Training Basic, MTOF**

**Subject : Engine**

**Aim : To Study Engine**

**Ref : The Automobile by Harban Sing Reyat and Automotive Fundamentals by Frederick C. Nash**

---

## ENGINE

**Introduction**

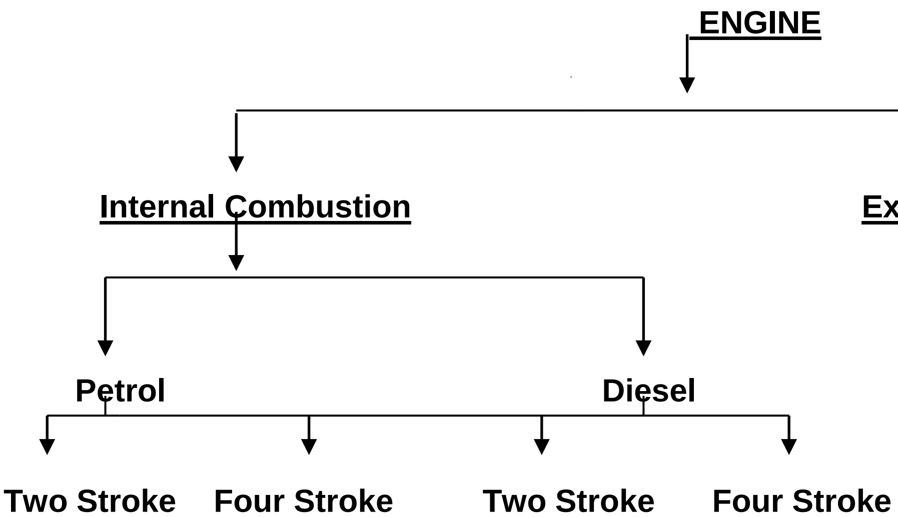
1. Power is required to propel a vehicle. There are two popular methods of producing power for land transportation. The internal combustion engine, which uses gasoline or diesel fuel and the external combustion engine, which burns fuel such as coal or wood to produce steam.

**Definition of Engine**

2. An engine is a device that converts chemical energy into heat energy and heat energy into mechanical energy. Engine is the heart of the automobile. If it fails to work, the vehicle is dead. It is placed mostly in the front of the vehicle. It is also located in the rear as well as in the middle of the chassis frame. A covered known as bonnet is provided to keep the engine under safe condition. The engine is fitted over the chassis frame by means of rubber mountings in order to insulate in from shocks.

**Types of Engines**

3.




a. **External Combustion Engine.** It is that types of engine in which combustion takes place out side the engine. Steam engine is external combustion engine (E.C.E.).

b. **Internal Combustion Engine.** It is that engine in which combustion takes place inside the engine. Petrol and diesel engines are internal combustion engine (I.C.E.). Generally, this type of engine is used in automobile today.

# BAF BASE ZAHURUL HAQUE (TRG WG)

## (Aero Engg Trg Sqn)

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **Engine** |
| **Aim** | **:** | **To Study Engine Construction** |
| **Ref** | **:** | **AP-3159 and Automobile by Harban Sing Reyat.** |

### ENGINE CONSTRUCTION

**Cylinder Block**

1. It is the main block of the engine, which contains cylinders. It provides housing for the crank and camshafts and other engine parts. It forms the basic framework of the engine. The other parts of the engine are attached to it or fitted in it. It thus forms the main body for the engine. The cylinder block is cast in one piece from gray iron alloyed with other metals such as nickel or chromium. Some blocks are made of aluminium in which cast iron or steel cylinder sleeves are employed. In some engines, the cylinder walls are plated with chromium, which is very hard metal to reduce wall wear and lengthen their life of service. Side valve engine blocks contain openings for the valves and valve ports. Water-cooled engine blocks are provided with water jackets around the cylinders whereas air-cooled engines contain fins. At the bottom part of the block, crankshaft is held in bearings, which are surrounded by the oil sump. At the top of the block, cylinder head is held with it through gasket. The manifolds are further jointed to side valve engines (Fig-10).

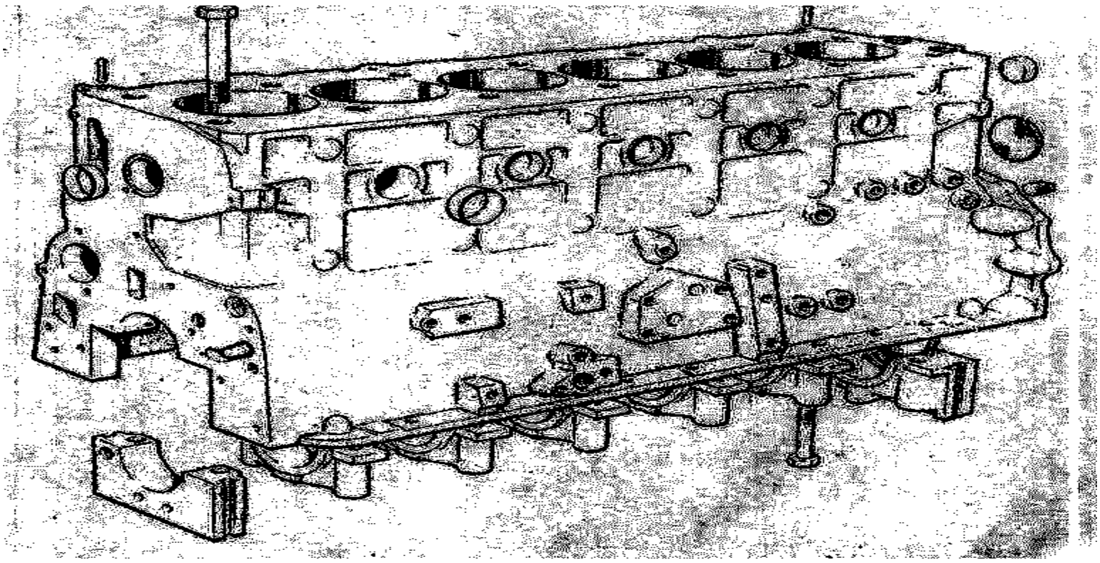


**Fig-10. Cylinder Block**

**Cylinder Head**

2. It is the upper most part of the engine, which covers the cylinders and provides cavity for the ignition of fuel. It is held with the cylinder block by means of gasket mostly of soft copper and asbestos sheets, to make the joint tight so that it may with stand the pressure and heat developed in the combustion chambers. The cylinder head is usually cast in one piece from iron, iron alloyed with other metals or aluminium. The modern trend is towards aluminium cylinder heads. This is due to the fact that aluminium has the advantage of combining lightness with high heat conductivity due to which it runs cooler. Cylinder head for side valve and overhead valves differ much in construction.

Cylinder head for side valve engine is comparatively simple, as it contains no valves, valve ports and valve operating mechanism. Side valve engine head contains water jackets for cooling, spark plug holes to which plugs are screwed, combustion chamber cavity, bolt holes through which holding down bolts or studs pass and certain other holes. Cylinder head for over head valve engine is more complex as it carries valves and valves operating mechanism. It contains water jackets, valves ports and cavities for combustion chamber, boltholes and certain other holes. Manifolds are also attached to it. Cylinder head for air-cooled engines is surrounded by fins and contains no water jackets (Fig-11).

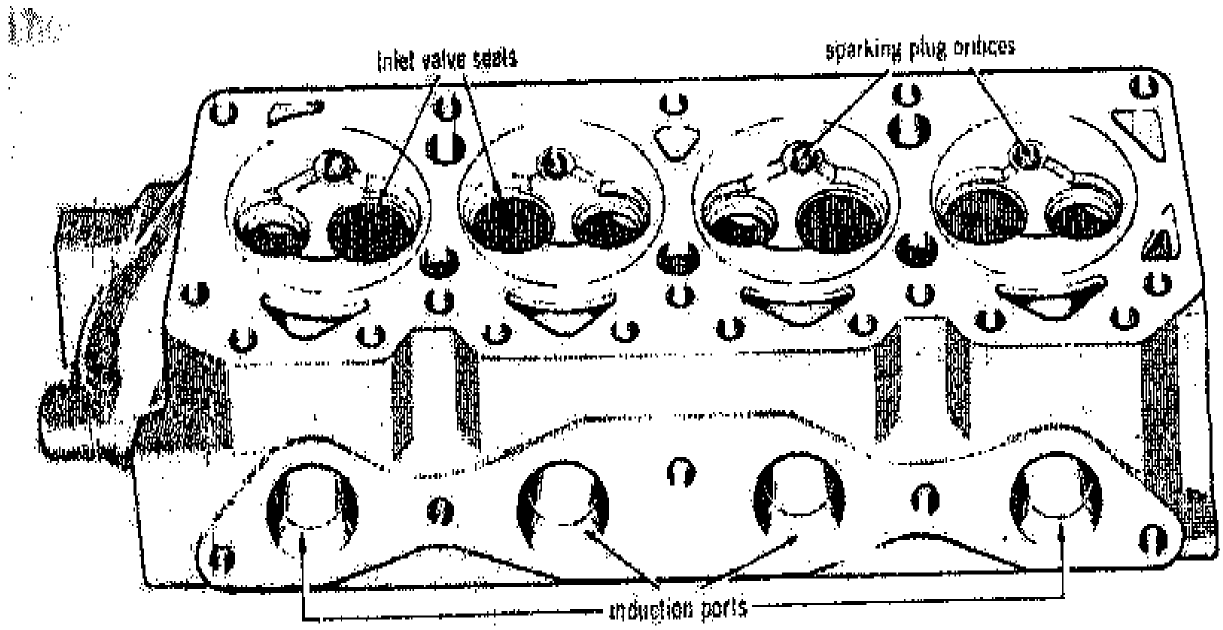



**Fig-11 Cylinder Head**

**<u>Cylinder Liner</u>**

3. a. **<u>Purpose</u>**: A liner is a kind of sleeves which is fitted in the cylinder bore either as original component or as an overhaul feature to obtain standard size bore after using over size pistons. The liner provide a suitable war resistant surface for the cylinder bores of aluminium alloy cylinder blocks or simplify the production of cast iron cylinder block through open-deck form.

b. **<u>Types:</u>** Cylinder liners are of the following two types (Fig-12):

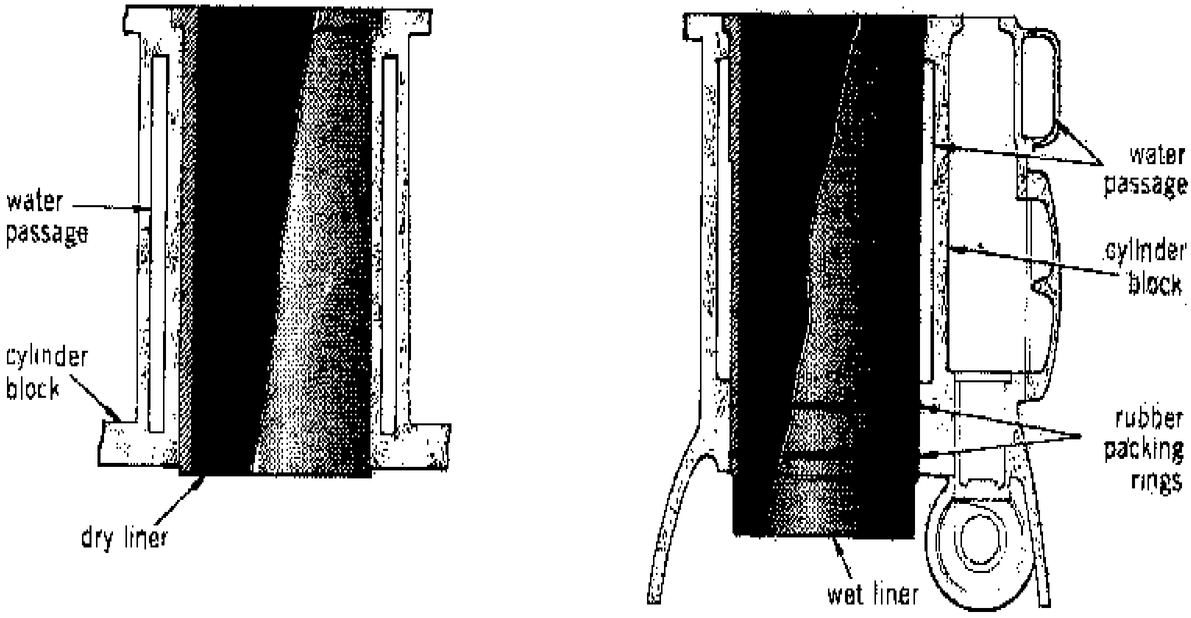



**Fig-12 Cylinder Liners**

(1) **Dry Liners.** The dry liner is in close metal- to metal conduct with the cylinder block and does not touch cooling water. It is detachable or cast into gray with aluminium alloy cylinder blocks. The dry liner is press fit and can be removed under pressure.

(2) **Wet Liners.** These are those liners whose outer walls is largely surrounded or wetted by cooling water. A wet liner is a flanged sleeve and acts as a seal for the water jacket in addition to providing wear resistant surface for the piston to move inside. It is either suspended through thee water jacket and clamped between the cylinder head and upper deck of the cylinder block or held in compression within in the water jacket between cylinder head and lower deck of cylinder block. Synthetic rubber sealing rings are provided at the lower end of wet liner to seal the leakage of water from the jacket in closed deck cylinder blocks. A compression sealing gasket is generally used between the flange towards the bottom of liner and its seat in the lower deck of the block incase of open- deck cylinder blocks. The cylinder head gasket seals the liners at the top in both closed and open deck cylinder blocks.

**Oil Sump**

4. It is the lower bottom parts of the engine which caries oil for the lubrication of the engine. It encloses the crankshaft. It is usually made of pressed steel; cast iron or aluminium sumps are also employed in the engines. They contain fins around them, which help in cooling oil contained in the sump. See fig-13.

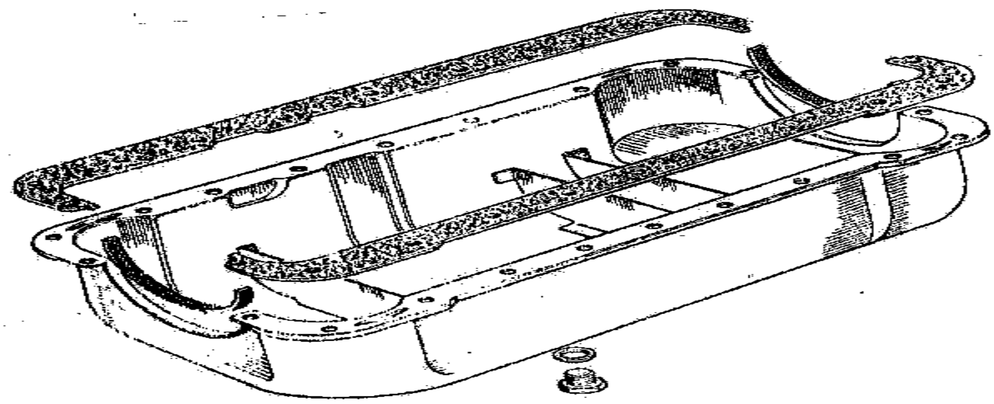


**Fig-13 Oil Sump**

**Engine Manifolds.**

5. a. **<u>Purpose</u>** Manifolds are just complex tubes through which the gases are in and out of the engine. There are two types of manifolds induction and exhaust. These are used as combined units as well as separate. These are attached over the inlet and exhaust ports in the cylinder head in case of overhead valve engines and cylinder block in case of side valve engines.

b. **<u>Types</u>**

(1) **<u>The Induction Manifold.</u>** Provide passage for the flow of fuel air mixture from carburetor to the inlet ports of the engine. The carburetor is installed at the induction manifold (Fig-14).

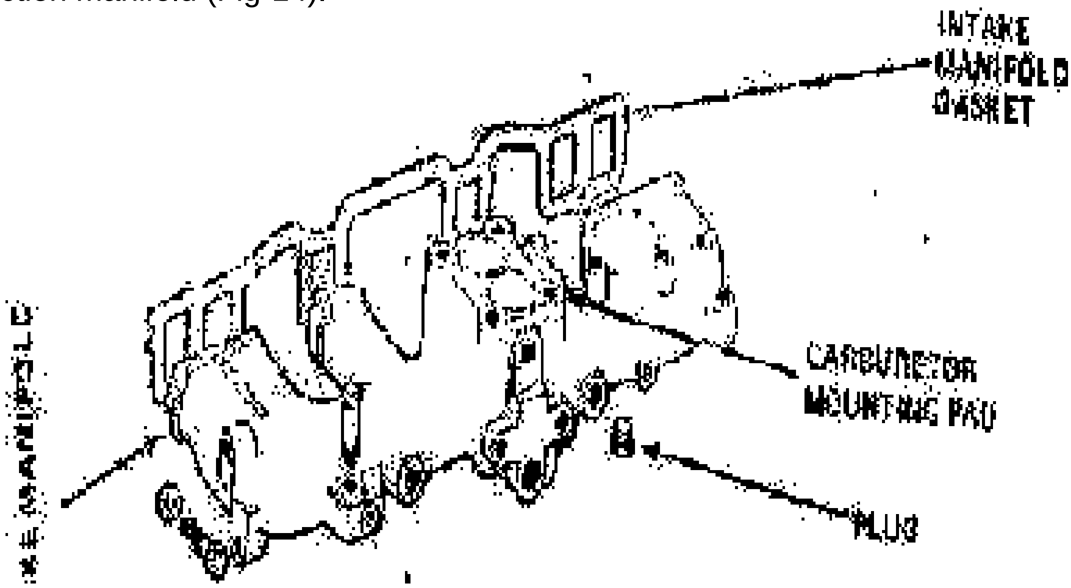



**Fig-14 Induction Manifold**

(2) **<u>The Exhaust Manifold.</u>** Provides passage for the out flow of burnt gases from engine exhaust ports to the exhaust pipe of silencer. In V-8 engines, there are two exhaust manifolds one for each bank of cylinders. In some V-8 engines, the exhaust manifolds are connected by a crossover exhaust pipe connected to a common muffler and tail pipe as in the case of V-8 ford engine. In other V- 8 engines, each manifold is connected to a separate exhaust pipe and muffler and tail pipe. In combination unit of induction and exhaust manifold. A heat control valve is provided which opens and closes due to heat effect. In such units, the inlet pipe carrying fuel from the carburetor passes through the exhaust manifold so that inlet pipe may be kept warm (Fig-15).

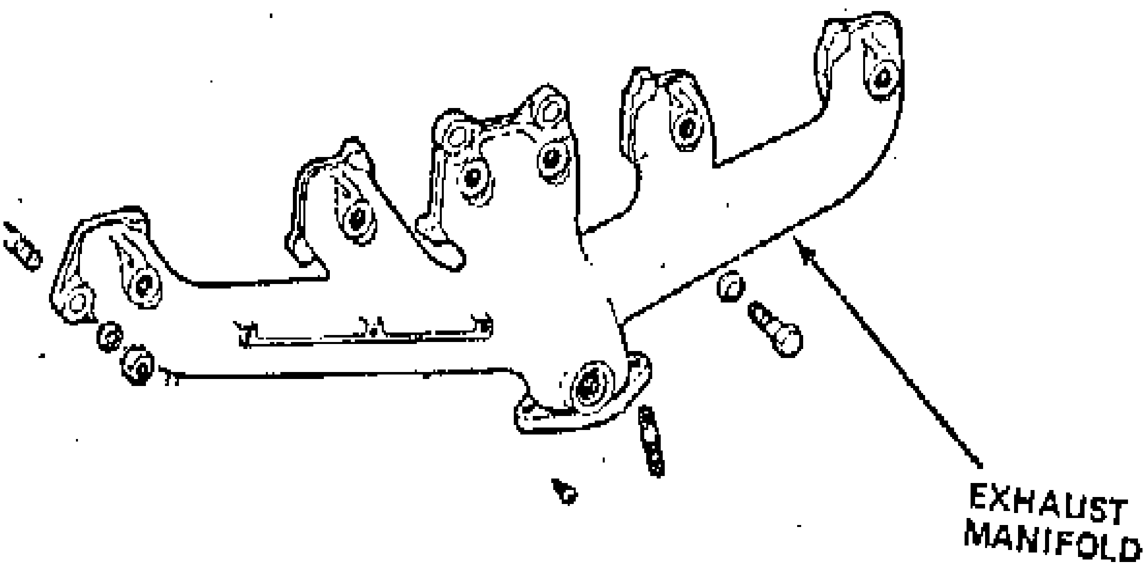



**Fig-15 Exhaust Manifold**

C. **The Heat Control Valve.** The heat control valve is a flap type valve, which is installed in the junction. The low temperatures it keeps the direct passage in the exhaust manifold closed and the exhaust gases pass out through the by pass which surrounds the inlet pipe. As the temperature rises, the heat control valve is begins to open they're by opening the direct passage and closing the bypass (Fig-16).

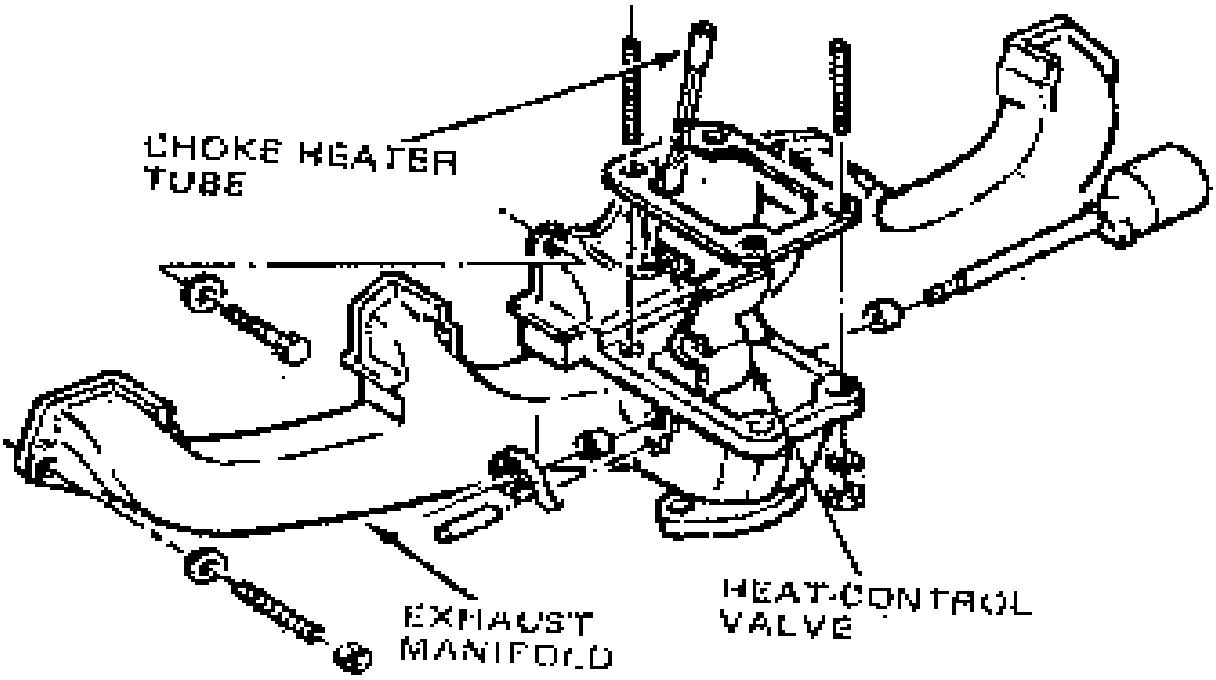



**Fig-16 Heat Control Valve**

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **Engine** |
| **Aim** | **:** | **To Study Crankshaft** |
| **Ref** | **:** | **AP-3159 and Automobile by Harban Sing Reyat** |

## CRANKSHAFT

### Introduction

1. It is the main shaft in the engine to which all the other working parts are directly or indirectly related. It is known as backbone of the engine due to this importance. Through the connecting rod, it converts reciprocating motion of the piston into rotary motion.

### Qualities

2. The crankshaft is a one piece casting or forging of heat treated alloy steel having considerable strength. It should possess the following qualities:

a. It must be strong enough to take the downward thrusts of the pistons during the power strokes without excessive distortion.

b. It must be well balanced to eliminate undue vibration resulting from the weight of the offset cranks.

**Construction**

3. The crankshafts are provided with counter weights opposite to the cranks for keeping them in balance. These contain drilled passages through which oil flows from the main bearings to the connecting rod bearings for lubrication purposes (Fig-17). A flywheel is attached to the rear end of the crankshaft in order to keep it in the regular motion as the flow of power from the engine cylinders is not smooth. The flow of more or less power to the crankshaft at different times tends it to speed up and then slow down. The flywheel absorbs power as the crankshaft tries to speed up and gives back power as the crankshaft tries to slow down. Thus the inertia of flywheel tends to keep the crankshaft turning at the constant speed. At the front end of the crankshaft, the following parts are carried: (a) The gears or sprocket which drives camshaft. (b) The vibration damper. (c) The pulley which drives dynamo, water pump and fan. The crankshaft is held with the engine block through split type plain bearings. The bearing back is usually of steel to which is attached the lining. The lining is a combination of several metals such as copper, lead, tin, mercury, antimony, cadmium, silver etc.

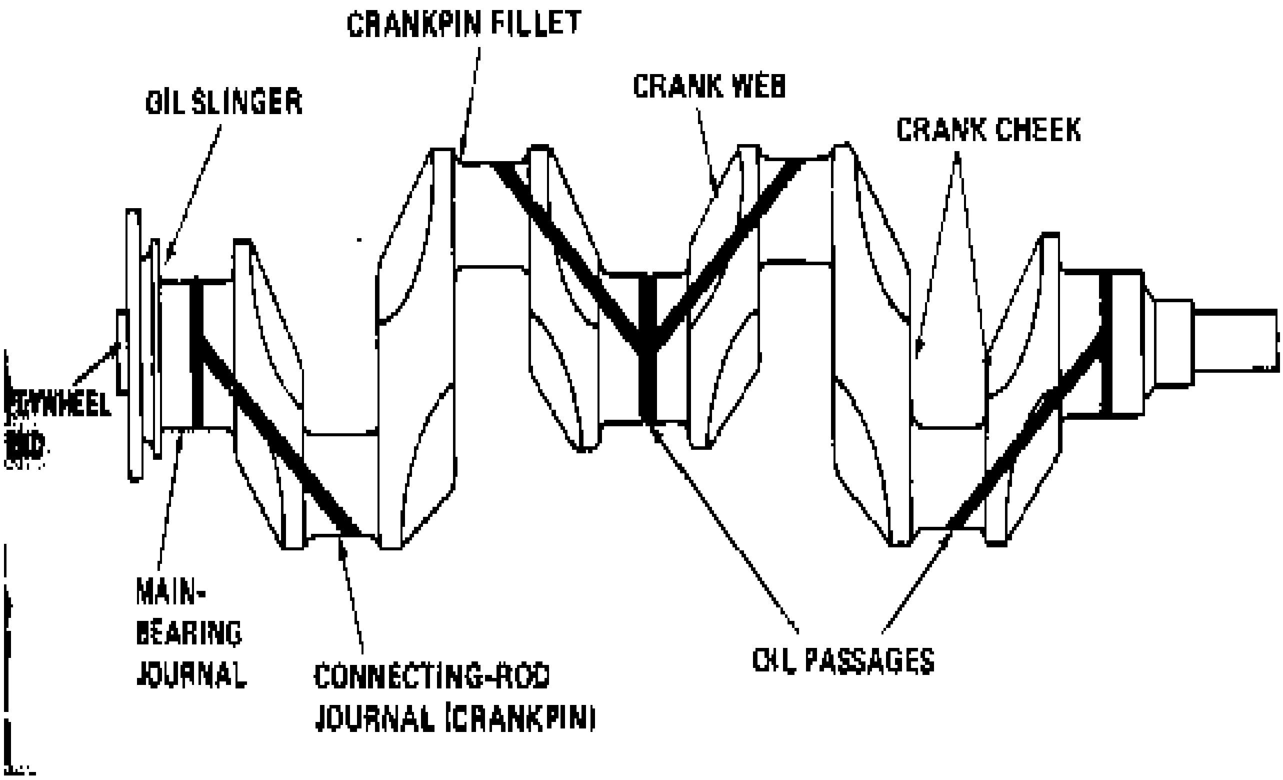



**Fig- 17 Crankshaft**

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

**Syllabus : Automobile and Diesel Technology**

**Course : Trade Training Basic, MTOF**

**Subject : Engine**

**Aim : To Study Flywheel**

**Ref : Automobile by Harban Sing Reyat**

---

# FLYWHEEL

**Introduction**

1. The flywheel stores energy during power stroke and delivers it out during the other strokes to keep the crankshaft moving at the uniform speed. A ring gear is mounted over the flywheel which meshes with the self-starter drive pinion for cranking the engine. The rear face of the flywheel also serves as driving member of the clutch.

**Purpose**

2. Purposes of flywheel are:-

(a) It tends to keep the crankshaft to move at uniform speed.

(b) It acts as a carrier for the ring gear meant for starting motor drive.

(c) It acts as a driving member of the clutch.

**Vibration Damper**

3. The power impulses tend to set up a twisting vibration in the crankshaft. When a piston moves down on its power stroke, it thrusts, through the connecting rod, against a crankpin with a force that may exceed 2 tons. This force tends to twist the crankpin ahead of the rest of the crankshaft. Then, as the force against the crankpin recedes, it tends to untwist or move back into its original relationship with the rest of the crankshaft. This twist-untwist action, repeated with every power impulses, tends to set up an oscillating motion in the crankshaft. This is called ***torsional vibration***. If it were not controlled, it could cause the crankshaft to break at certain speeds. To control torsional vibration, devices which are used, called vibration dampers or harmonic balancers. These dampers are usually mounted on the front end of the crankshaft and the drive-belt pulleys are incorporated into them. A typical damper is made in two parts, a small inertia ring or damper flywheel and the pulley. They are bonded to each other by a rubber insert about ¼-inch thick (fig-18). The damper is mounted to the front end of the crankshaft. As the crankshaft speeds up or slows down, the damper flywheel has a dragging effect, This effect, whish slightly flexes the rubber insert, tends to hold the pulley and crankshaft to a constant speed. This tends to check the twist-untwist action or torsional vibration of the crankshaft.

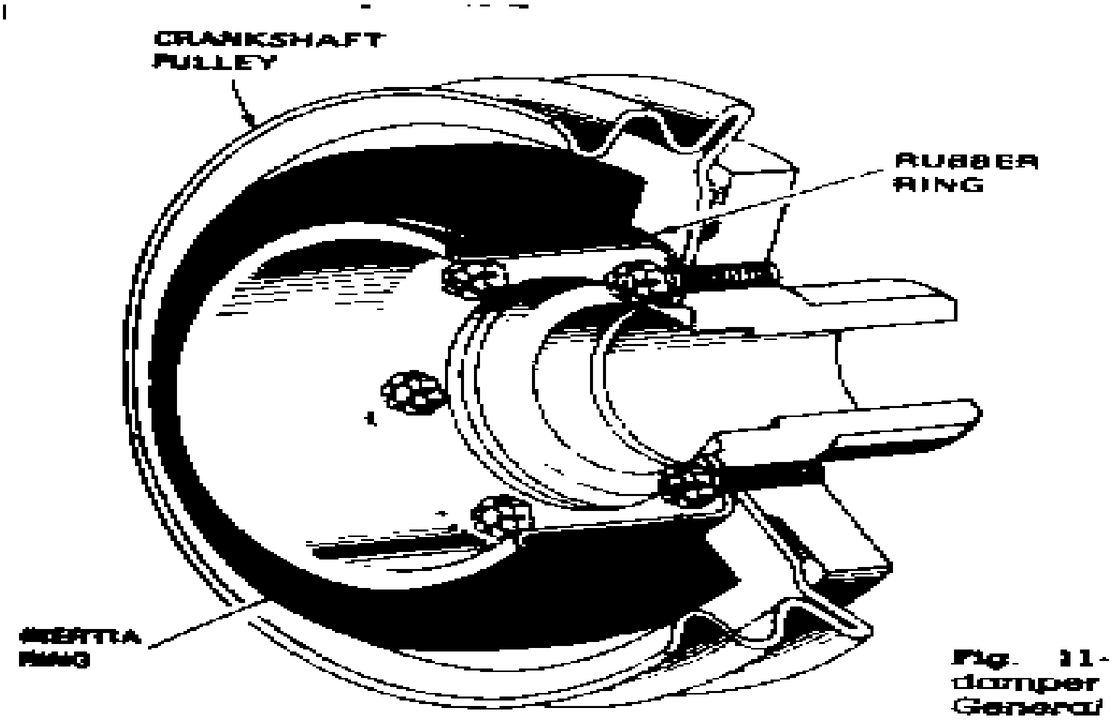



**Fig-18 Vibration Damper**

# BAF BASE ZAHURUL HAQUE (TRG WG)

## (Aero Engg Trg Sqn)

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **Engine** |
| **Aim** | **:** | **To Study Connecting Rod** |
| **Ref** | **:** | **AP-3159 and Automobile by Harban Sing Reyat** |

## CONNECTING ROD

### Purpose

1. It connects piston with the crankshaft. Power impulses produced during combustion are transmitted to crankshaft by this rod. As this rod is to carry power thrusts from the piston to crank pin so it should possess the following qualities:

a. It should be strong and rigid enough to carry the power impulses.
b. It should be light in weight to minimize vibration and bearing loads.

### Construction

2. The connecting rod contains bearings in its big and small end. The small end usually contains a bush through which gudgeon pin passes for making connecting with the piston. It is connected with the crank pin through its big end which is of split type. The cap of the big end is held with the connecting rod by means of bolts and nuts or studs and nuts having locking arrangement. Some connecting rods contain a direct drilled hole from big end to small end for providing passage for lubricating oil. In some designs there is one small hole each at big end of the junction to form jet or nozzle for the oil to the sprayed out at piston bosses, gudgeon pin and cylinder walls. The connecting rods are mostly of **I**-section and are made of forged steel (Fig-19).

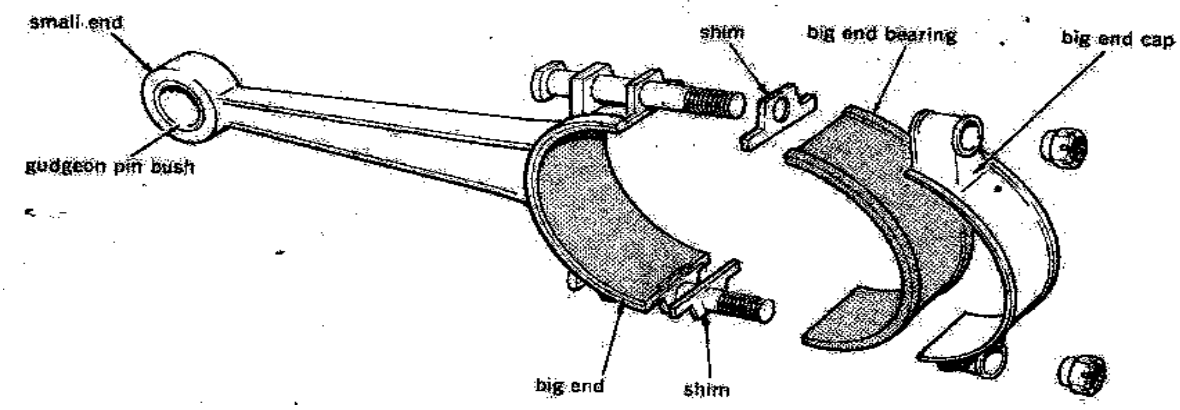



**Fig-19 Connecting Rod**

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **Engine** |
| **Aim** | **:** | **To Study Piston.** |
| **Ref** | **:** | **The Automobile-by Harbans Singh Reyat.** |

# PISTON

## Purpose

1. It is a cylindrical plug or bucket, which moves up and down in the cylinder. It serves the following purposes:

a. It serves as a moveable gas tight plug to keep the gases inside the cylinder.

b. It transmits the force of explosion to the connecting rod.

c. It acts as a guide and bearing to the small end of connecting rod and bears the thrust when the rod is oblique.

d. It acts as a carrier for piston.

## Construction

2. The piston looks like a bucket, which carries rings at the upper part to provide a good seal between the cylinder walls. Inside the open end, connection of the connecting rod is made with it through the gudgeon pin. The lower part of ring grooves is known as skirt which provides a bearing and guiding surface in contact with the cylinder wall. The top of the piston is called piston head or crown. The projections inside the open end, through which gudgeon pin passes are known as bosses as shown in the diagram. Pistons are made of cast iron, semi-steel or aluminum alloy. In early days, cast iron pistons were popularly employed in the engine due to their excellent wearing qualities and general suitability to manufacture. The question of weight reduction has led to the manufacture of aluminum alloy pistons, which are most common now a day. Pistons are of different designs. Some have plain head whereas others are of convex or concave crown. Pistons for two stroke engines contain a deflector at their head whereas pistons for diesel engines contain combustion chamber in their head. In certain cases special steel seats are attached to the piston crown to withstand the high pressures of fuel spray. Some pistons of over head valve engines contain depressions in their crown to allow the free movement valves downward (Fig-20).

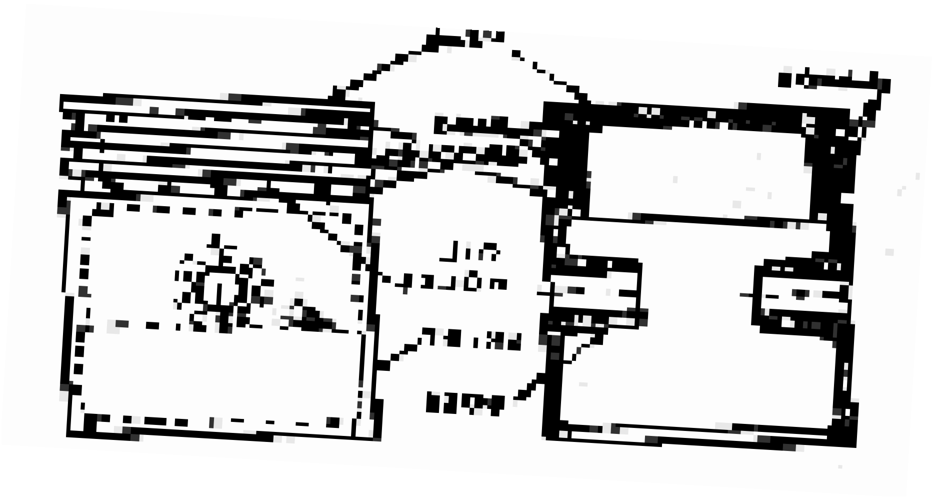


**Fig-20 Piston**

**<u>Types of Piston</u>**

3. According to the skirt constructions, the pistons can be divided into the following type or classes:

a. Solid skirt piston.
b. Split skirt piston

Solid skirt pistons, as the name indicates, have their skirt without any break where as the split skirt pistons contain **"T", "I" or "C"** type slots in their skirts to allow for expansion (Fig-21). In some heavy-duty pistons an oil ring is provided below the gudgeon pin holes.

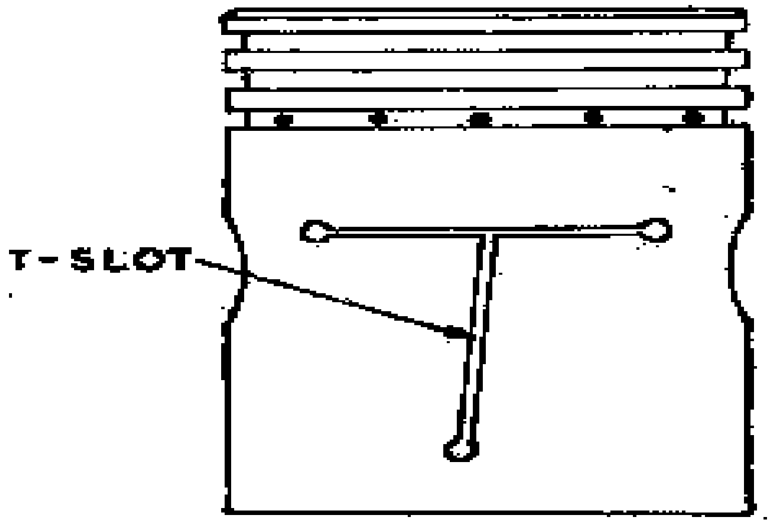



**Fig-21 Split Skirt Piston**

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **Engine** |
| **Aim** | **:** | **To Study Piston Rings.** |
| **Ref** | **:** | **The Automobile-by Harbans Singh Reyat.** |

# PISTON RINGS

## Purpose

1. Rings are fitted in the piston ring grooves to provide a seal between the piston and cylinder wall to avoid the escape of gases from the combustion chamber to crank chamber.

## Construction and Types

2. Ring is a type of bangle, which is cut at one point it provide two ends (Fig-22). The piston rings are of the following types:

(a) Compression rings
(b) Oil rings

The compression rings seal the gases in the combustion chamber whereas the oil rings scrape off excessive oil from the cylinder wall which is returned to the oil sump. The oil rings control rings as well as the grooves in the pistons, contain holes or slots through which the scraped off oil goes back to the crank chamber. The rings are usually made of cast iron. Compression rings of some engines are chromium plated to increases their life.

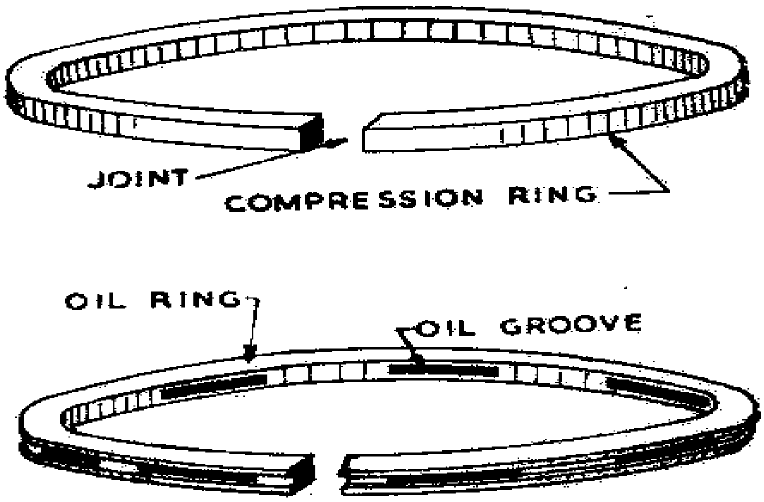



**Fig-22 Piston Rings**

**<u>Gaps</u>**

3. There are different designs of ring joints such as butt, angled, lapped or a sealed type. Some compression rings contain vertical lines at shorter distances at the inside wall. These depressions are known as hammerings which makes the rings are some times used below the main rings to keep them expanded so that they could provide better seal (Fig-23).

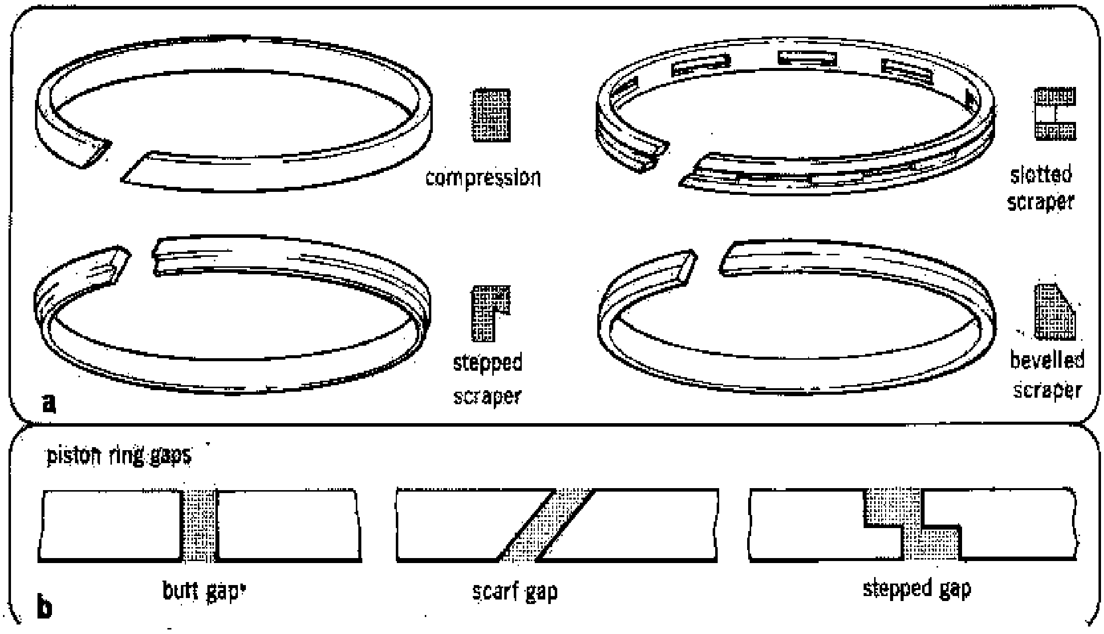



**Fig-23 Ring Gaps**

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **Engine** |
| **Aim** | **:** | **To Study Gudgeon Pin/Piston Pin.** |
| **Ref** | **:** | **The Automobile-by Harbans Singh Reyat.** |

# GUDGEON PIN/PISTON PIN

## Purpose

1. It holds the piston with the small end of the connecting rod.

## Construction

2. It is a hollow pin made of steel, the upper surface of which a very hard. There are different ways of holding connecting rod with the piston through the gudgeon pin.

## Classification

3. Owing to this holding down arrangement the piston pins are classified as below:

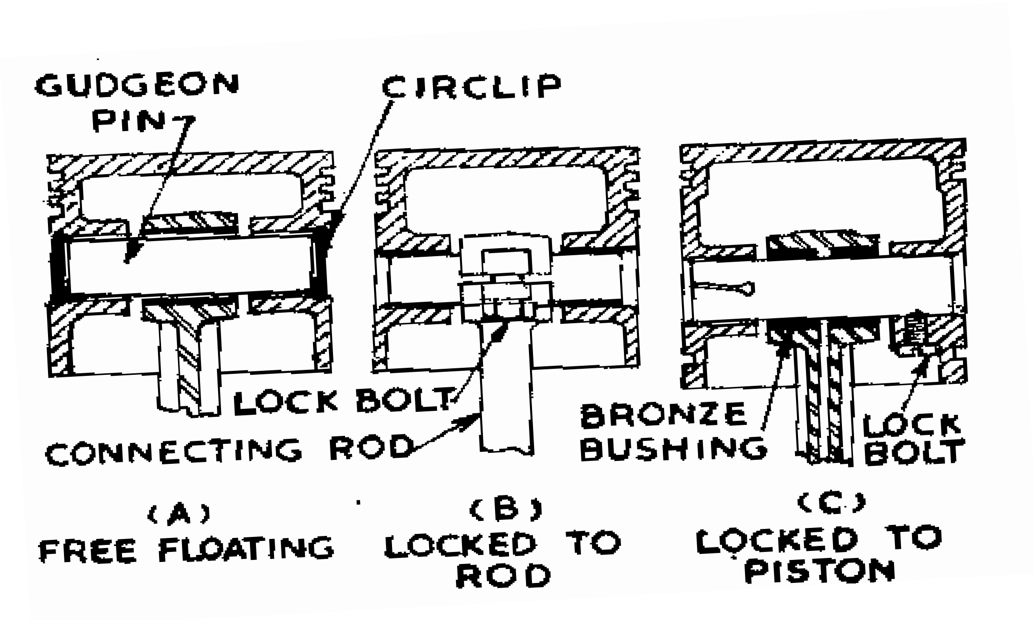



**Fig-24 a, b & c Gudgeon Pin**

a. **Fully Floating**. It is that types of gudgeon pin which is free to rotate inside the small end of connecting rod as well as in the piston bosses. It is held in the piston by means of circlips which keeps the pin inside the bosses (Fig-24 a).

b. **Semi-floating**. It is that types of pin which is fixed in the small end of connecting rod and is held tight by means of a cotter bolt. It is free to rotate in the piston bosses (Fig24b).

c. **Stationary**. These types of gudgeon pin are bolted to the piston and can not rotate. The connecting rod moves around it (Fig-24 c).

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

**Syllabus : Automobile and Diesel Technology**

**Course : Trade Training Basic, MTOF**

**Subject : Engine**

**Aim : To Study Camshaft**

**Ref : The Automobile-by Harbans Singh Reyat**

# CAMSHAFT

## Purpose

1. Purpose of camshaft is to open valves in relation to the piston position and operate the oil pump by screw gears also to operate the distributor (for petrol engine)

## Construction

2. It is that type of shaft which contains cams to change rotary motion into straight line or leaner motion. The camshaft contains so many cams as the number of valves in the engine. An additional eccentric is provided to drive the fuel pump. The camshaft causes the intake and exhaust valves to open. A gear is also providing at the camshaft to give drive to the distributor or oil pump as the case may be. The shaft rotates inside the plain bearings and driven by the crankshaft through gears, sprockets, chain or toothed belt. In four stroke engine the camshaft gear or sprocket contains double the teeth then the gears or sprockets on the crankshaft as the camshaft is required to rotate the half the crankshaft speed. Since each valve opens every camshaft revolution, the camshaft must rotate only once while the crankshaft rotates twice. This 1:2 gear ratio is achieved by making the camshaft gear or sprocket twice as large as the crankshaft gear or sprocket. The gears are called *timing gears.* The chain is called the *timing chain*. The toothed belt is called *timing belt*. The reason for this is that the gears, chain and sprocket or belt and sprockets "time" the opening of the valves. The camshaft is usually located in the crank chamber. In case of 'V' shape engine, it is installed between the two banks of the cylinders. In case of over head camshaft engines, it is located at the cylinder head (Fig-25).

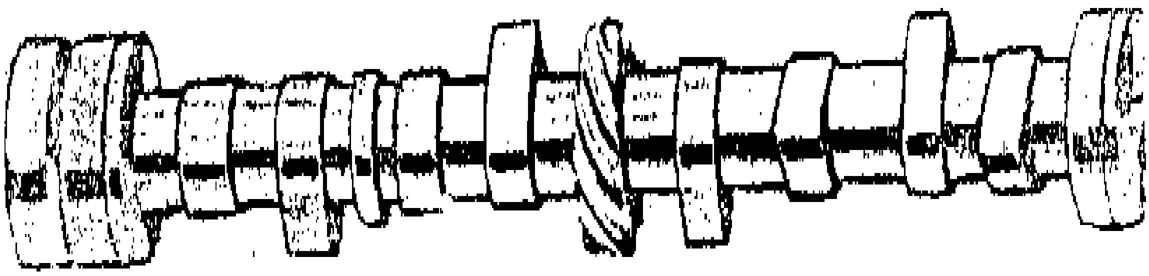


**Fig-25 Camshaft**

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

**Syllabus : Automobile and Diesel Technology**

**Course : Trade Training Basic, MTOF**

**Subject : Engine**

**Aim : To Study Tappet**

**Ref : The Automobile-by Harbans Singh Reyat**

# TAPPET

## Introduction

1. It is a circular steel barrel closed at both ends which acts as a lifter for the valve. It is located between the cam and valve or push rod. It rises up due to cam pressure and lifts the valve off its seat.

## Types & Construction

2. The tappets can be divided into their following classes:

a. **Non-adjustable**. Tappets whose lengths are fixed and can not be adjusted to reduce or increase clearance between valve stem and the tappet are known as non-adjustable tappets. Such tappets are applicable in Ford engine.

b. **Adjustable.** The tappets which could be adjusted to increase or decrease tappet clearance are called adjustable tappets. A screw having lock nut is provided at the head of the adjustable tappet, which could be screwed up or down to adjust clearance between the tappet and the valve stem or rocker arm and valve stem as the case may be. After the required adjustment, the screw is locked with the tappet by means of the lock nut. These types of tappets are most commonly used in the engine.

c. **Self-adjustable.** These type of tappets are adjusted automatically to the suit the desired needs. Cadillac engine employed these types of tappets. Self-adjustable tappets are adjusted automatically by the oil pressure from the pressure feed lubrication system of the engine. Following are the main parts of this type of tappet:

(1) Body.
(2) Plunger.
(3) Spring.
(4) One-way check valve.

The upper part of the tappet acts as a cylinder, which contains valve and plunger. There is a spring inside the plunger head and tappet body, which keeps the plunger raised up, making its contact with the valve stem end. Below the plunger is housed the one-way check valve. There is a hole at the lower part of the cylinder through which oil enters into the cylinder from the reservoir. The oil reservoir is located on one side of the tappet, which keeps oil under pressure at all times. The check valve opens due to oil pressure and the oil pressure enters into the upper part of the cylinder. This oil keeps the plunger raised up and acts as a cushion to absorb any noise. When pressure of cam is released from the tappet, it falls down due to which the oil hole in the tappet coincides with the oil reservoir. During this period the deficiency of oil between the plunger and the cylinder is made up (Fig-26).

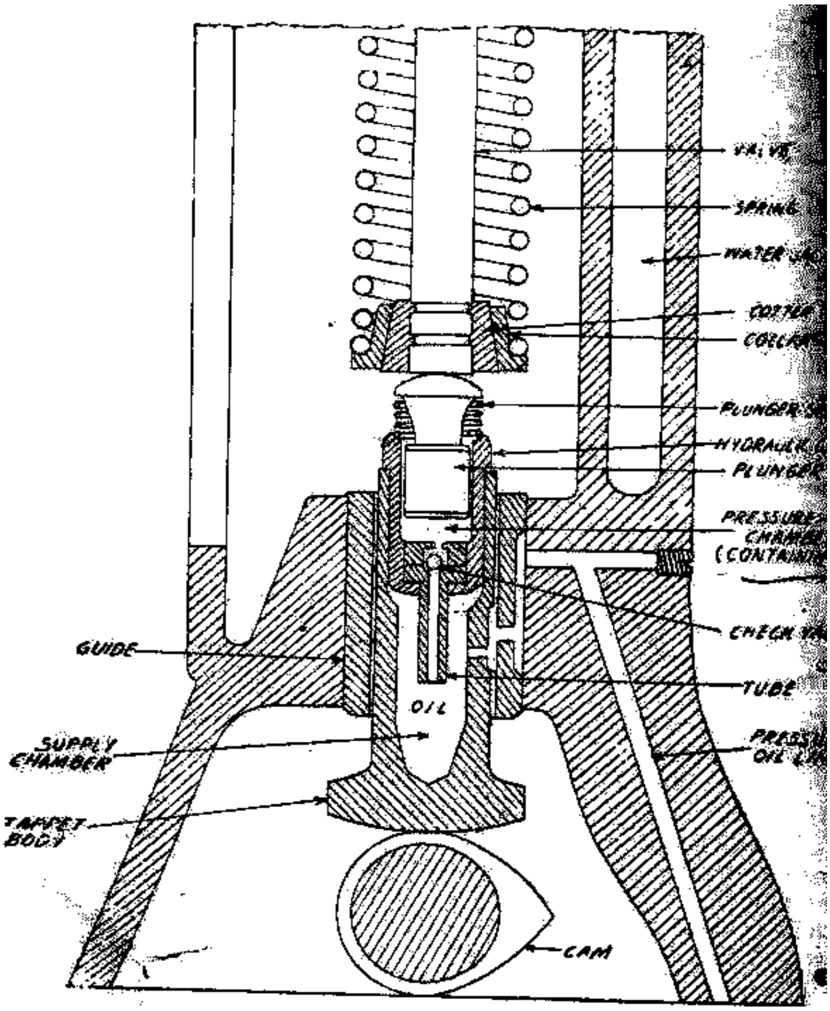



**Fig-26 Self-Adjustable Tappet**

d. **Roller type.** If a roller is employed in the foot of non-adjustable tappet, it shall become roller type tappet. This type of tappet is prevented from the retailing by the engagement of roller in cross slot in the guide (Fig-26).

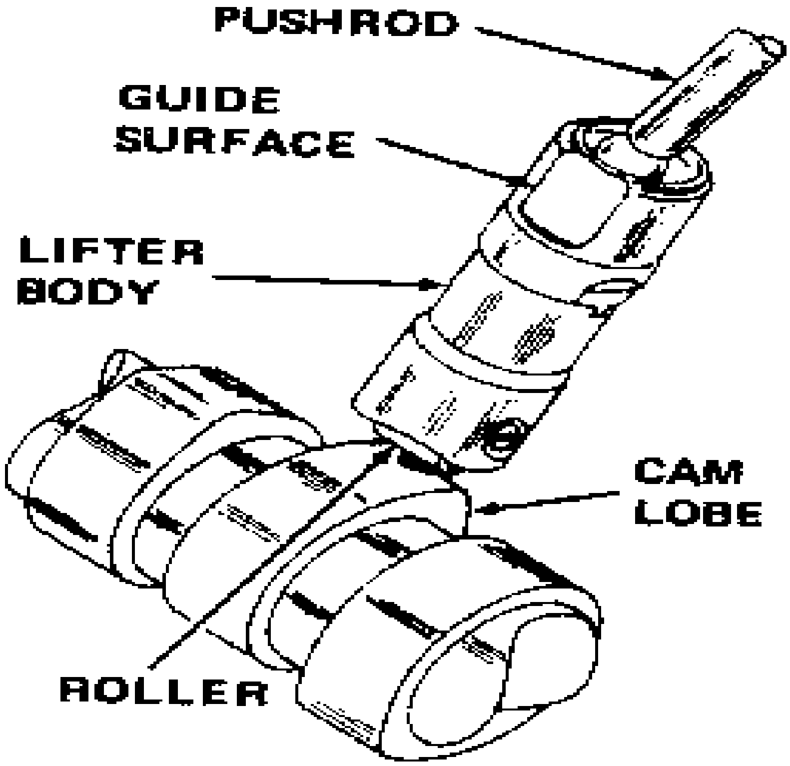



**Fig-27 Roller Tappet**

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **Engine** |
| **Aim** | **:** | **To Study Valve** |
| **Ref** | **:** | **The Automobile-by Harbans Singh Reyat** |

# VALVE

## Introduction

1. The valves act as gates in the engine through which gasses go in and out. There is one-way traffic for the gasses. The fresh gasses enter in to the combustion chamber through the inlet valves and used gasses go out from the combustion chamber through the exhaust valves. Inlet and exhaust valves differ in size and even in material. The exhaust valves are subjected to more heat and it should be capable to withstand high temperatures. Usually, the intake valve is larger than the exhaust valve. The reason is that when the intake valve is opened, the only force moving air-fuel mixture into the cylinder is atmospheric pressure. When the exhaust valve is opened, the piston is moving up and there is a high-pressure driving the exhaust gases out. Therefore, the intake port must be larger to allow enough air-fuel mixture to enter. Each cylinder has two valves, an intake valve and an exhaust valve (Fig-28).Some high-performance engines have three or four valves per cylinder-in case of three, two intake and one exhaust for four valves, two intake and two exhaust valves.

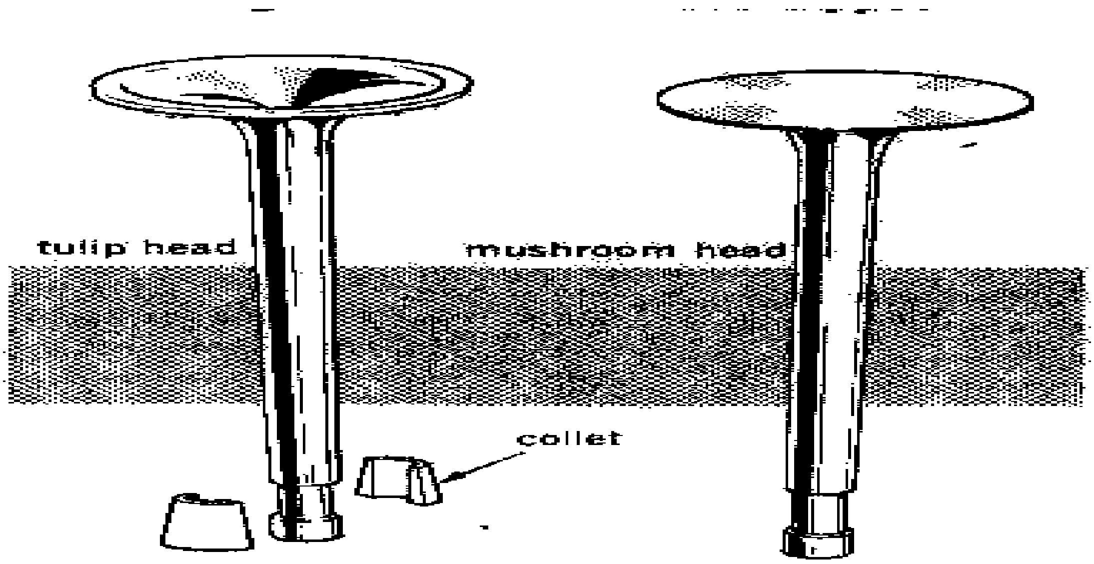



**Fig-28 Engine Valves**

## Types

2. Several types of valves have been used in the past; among them are the sliding-sleeve and rotary types. But the valve in general use today is the mushroom or poppet valve. According to their construction, the following are the various types of valves:

a. **Sleeve Valves.** Sleeve valve is a long barrel, which contains holes. This valve is located in the engine in such a way that its holes may face towards combustion chamber on one side and exhaust and induction manifold holes on the other side. When the holes of the valve coincide with the induction manifold holes and combustion chamber, fresh charge of fuel enters into the combustion chamber. During this occasion, exhaust manifold holes are not coinciding with the combustion chamber on the other side. When the sleeve is moved up and down, its holes coincide either induction manifold or with exhaust manifold holes and on the other side with the combustion chamber. When the exhaust manifold holes come into coincidence, the used gasses go out of the engine. Sleeve valves open and closed by sliding as explained above.

b. **Rotary Valves.** Rotary valves open and closed due to their rotation. These are of the following types:

(1) **The Cylindrical Rotary Valve.** This type of valve resembles with that of a sleeve valve. Sleeve valve opens and closes by sliding it up and down whereas the cylindrical rotary valve opens and closes down when it is rotated. This valve rotates in a cylindrical housing, the gasses entering and leaving the valve in axial direction.

(2) **Disc type rotary valves.** These valves are mostly used in two stroke engines. This type of valve contains disc having holes. In some cases, a part of the disc is removed. The disc is rotated by the operating mechanism to open and close the valve. When the hole in the disc or its cut way part coincides with the hole in the manifold, the gasses come in or go out of the engine. This type of valve is applicable in two stroke pearl Yamaha scooter engine.

c. **Pop pet or Mushroom valves.** This type of valve is most commonly used in the conventional engines. When this valve opens and closes down, it creates a popping noise. That is why this mushroom type valve is known as pop pet valve. The various parts of this valve are shown in this figure. The valve stem is moves up and down in the valve guide, which is fixed in the engine. The valve seats at the valve port. It opens when it rises up the seat. For closing down it falls over the seat (Fig-29).

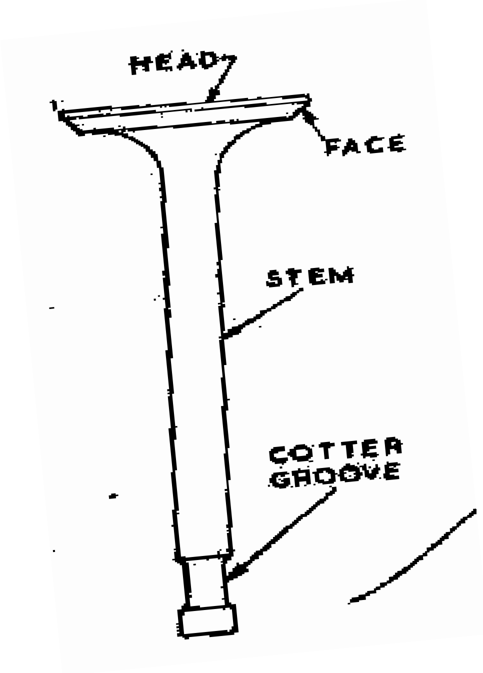



**Fig-29 Poppet Valve**

# BAF BASE ZAHURUL HAQUE (TRG WG)

## (Aero Engg Trg Sqn)

**Syllabus : Automobile and Diesel Technology**

**Course : Trade Training Basic, MTOF**

**Subject : Engine**

**Aim : To study Valve Seat, Guide & Spring**

**Ref : AP 3159 & Automotive Mechanics By William H Crouse**

---

## VALVE SEAT, GUIDE & SPRING

### Valve Seats

1. The exhaust- valve seat is heated to extremely high temperatures by the exhaust gases. The cylinder-head material is adequate to take these temperatures under normal operating conditions. But where the engine is put to severe service, as for example in trucking, special provisions must be made. One is to harden the valve seats by the electric induction hardening process. The other is to install seat inserts. These are special heat resistant steel-alloy insert rings. These rings can withstand the higher temperatures without undue wear. If they do wear, they can be replaced. Many engines use an interference angle between the valves and valve seats. The interference angle is usually attained by grinding the valve at an angle $1^0$ flatter than the seat angle. This produces greater seating force at the outer edge of the valve seat. Therefore, the valve seat edge tends to cut through any deposits that have formed. This produces a good seal. An interference angle is not always recommended where the valve is faced with satellite and seat is induction hardened. The difference in angles between the valve face and the valve seat gradually disappears as the valve face and seat wear. The contact between the two changes from line contact (interference angle) to area contact. (Fig-30).The valve seat and face are accurately machined to an angle of either $30^0$ or $45^0$

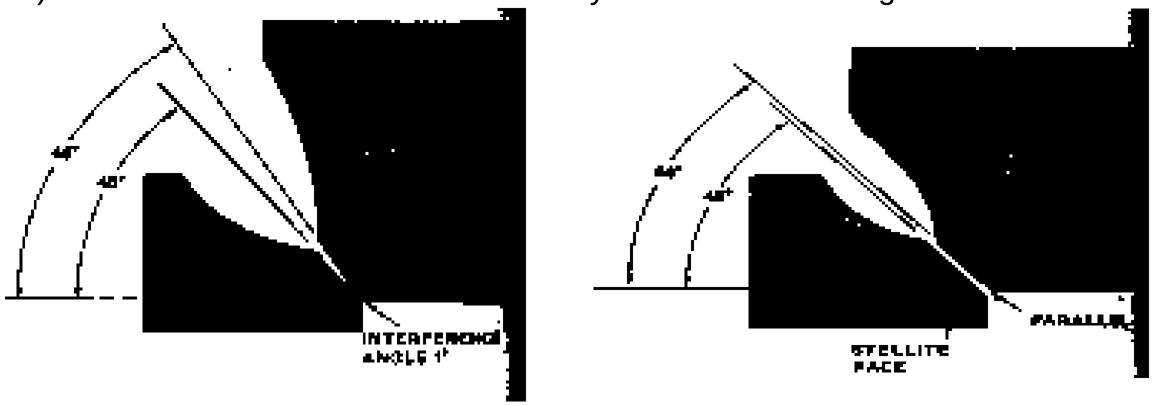



**Fig-30 Valve Seat and Angles**

## Valve Guides

2. Although the valve stems of some engines work directly in bores machined in the head or block, the majority are fitted with bronze or cast iron guides that are normally a press fit in the casting. Valves guides are prone to wear because lubrication presents something of a problem, and as wear would allow leakage, they are therefore made to be easily renewable. The inlet valve guides of overhead valve engines are often fitted with oil seals (Fig-31).

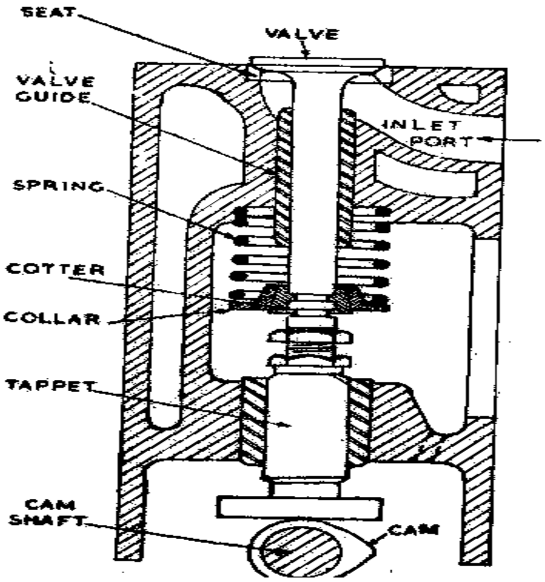



**Fig-31 Valve Guide**

## Valve Springs

3. Valve springs are used to close the valves and to keep them closed except when opened by the action of the cams. They are often duplicated to reduce valve bounce, and wound in opposite directions. They are fitted with at least one end washer or retaining plate, this being used in conjunction with the provision made on the valve to retain the springs. It will be found in practice that many valve springs are of the "progressive rate" type, ei the springs have one end that is close-coiled; these closed coil ends should be fitted nearest to the valve head (Fig- 32).

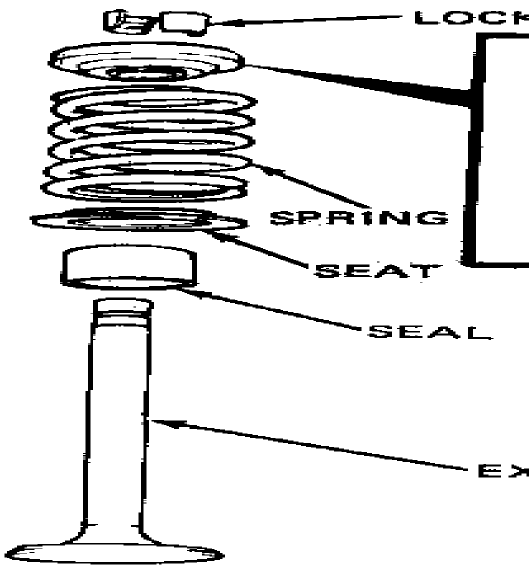



**Fig-32 Valve Spring**

# BAF BASE ZAHURUL HAQUE (TRG WG)

## (Aero Engg Trg Sqn)

**Syllabus : Automobile and Diesel Technology**

**Course : Trade Training Basic, MTOF**

**Subject : Engine**

**Aim : To Study Push rod and Rocker arms.**

**Ref : Automotive fundamentals-by Frederick C. Nash.**

---

## VALVE PUSH ROD AND ROCKER ARMS

### Description

1. Valves push rods and rocker arms are required on over head valve engines. The push rod is used to transferred the up and down motion of the valve lifter to the rocker arm. The rocker arm reverses the upward motion of the valve lifter to push the valve down ward to open. A push rod and rocker arm is required for each valve of the engine. The rocker arm may be pivoted on a common rocker arm shaft or individually on rocker arm studs. The rocker arm shaft is attached to the cylinder head by mounting brackets. The individual rocker arm studs are pressed into the cylinder head (Fig-33 &34)

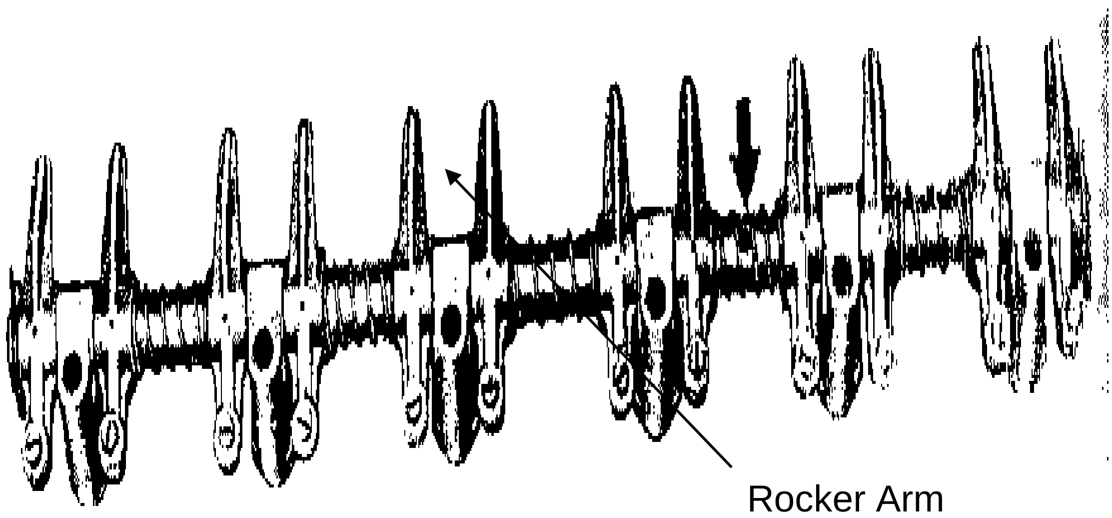



**Fig-33 Rocker Shaft**

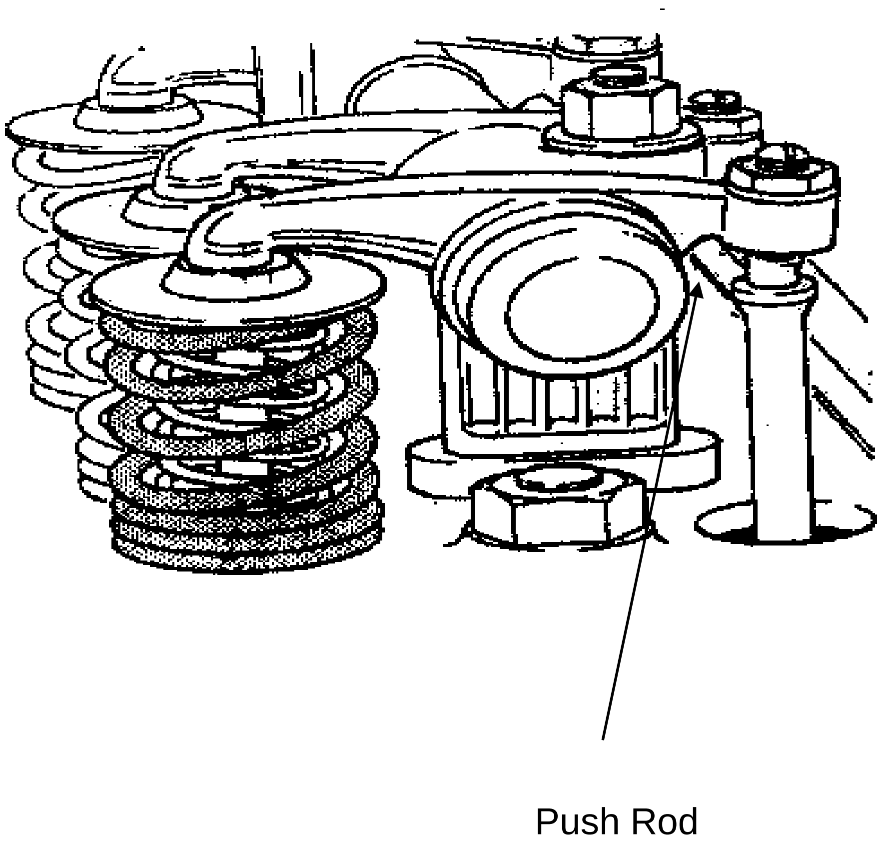



**Fig-34 Push Rod**

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

**Syllabus : Automobile and Diesel Technology**

**Course : Trade Training Basic, MTOF**

**Subject : Engine**

**Aim : To Study Valve Location**

**Ref : AP 3159 Section 2 Chapter 1**

# VALVE LOCATION

## Introduction

1. The location of the valves in a four stroke engine is decided by the designer having full regard to many requirements and the over riding factors imposed by the particular performance required of the engine. Much could be written about the subject but it would be far beyond the scope of these notes, which are, therefore, confined to brief information on the three layouts which the tradesman is likely to have to service; these are side valves, over head valves and the combination of the two types. Whatever the design, it is essential that heat variation will not result in the valves not seating when the engine is hot; this can be ensured by maintaining a small gap "valve clearance" between the tappet or rocker and valve stem.

## Side Valves

2. These are fitted in the cylinder block, the inlet and exhaust ports being formed in the block itself with the valves opening upwards. Thus, the layout is simple and requires a minimum number of parts, so keeping the cost of production as low as possible. The shape of the combustion chamber is far from being the most efficient; the size of the valves and port cooling present a problem and the induced charge is further limited by the changes in direction of the gas flow. Nevertheless, for all ordinary purposes, a side valve engine is satisfactorily efficient. As stated previously, provision is usually made for adjustment of the valve clearance. This consists of flats on the follower enabling it to be held by a spanner; the tappet bolt screws into a fine thread in the follower and is locked by a lock nut. The actual clearance and procedure to be used when setting the valve clearance can be found in the relevant AP, but it is important that the setting must be done only when the tappet is resting on the back of the cam (Fig-35).

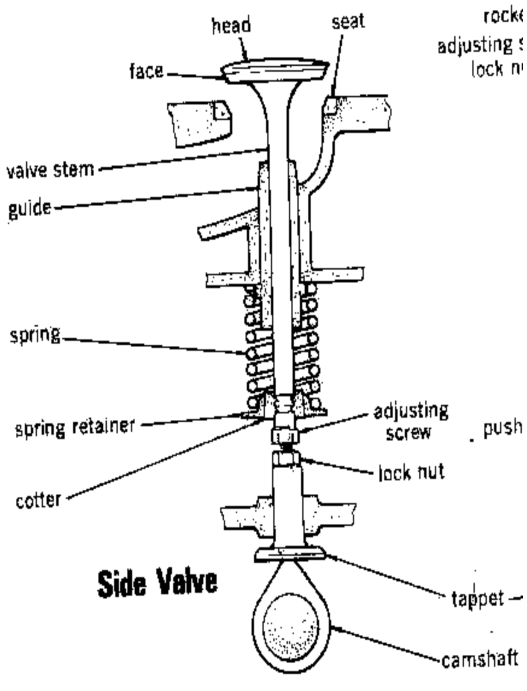



**Fig-35 Side Valve**

## Over Head Valves

3. These valves allow a more efficient shape of combustion chamber space than is possible with side valves, i.e. the shape can be nearer to the ideal hemispherical head. Also, the flow of the induced charge is better, Scavenging is more complete and therefore, size for size, an over head valve engine will be more efficient and will develop power than a side engine valve. Overhead valves are fitted in the cylinder head; the inlet and exhaust ports being formed in the head with the valves opening downwards into the combustion chamber. The most widely used layout is in fig-36, where valves

being operated by means of rockers and pushrods and means of adjusting the valve clearance are provided on the rocker arms. There are applications also where the valves are operated either by single or double overhead camshafts.

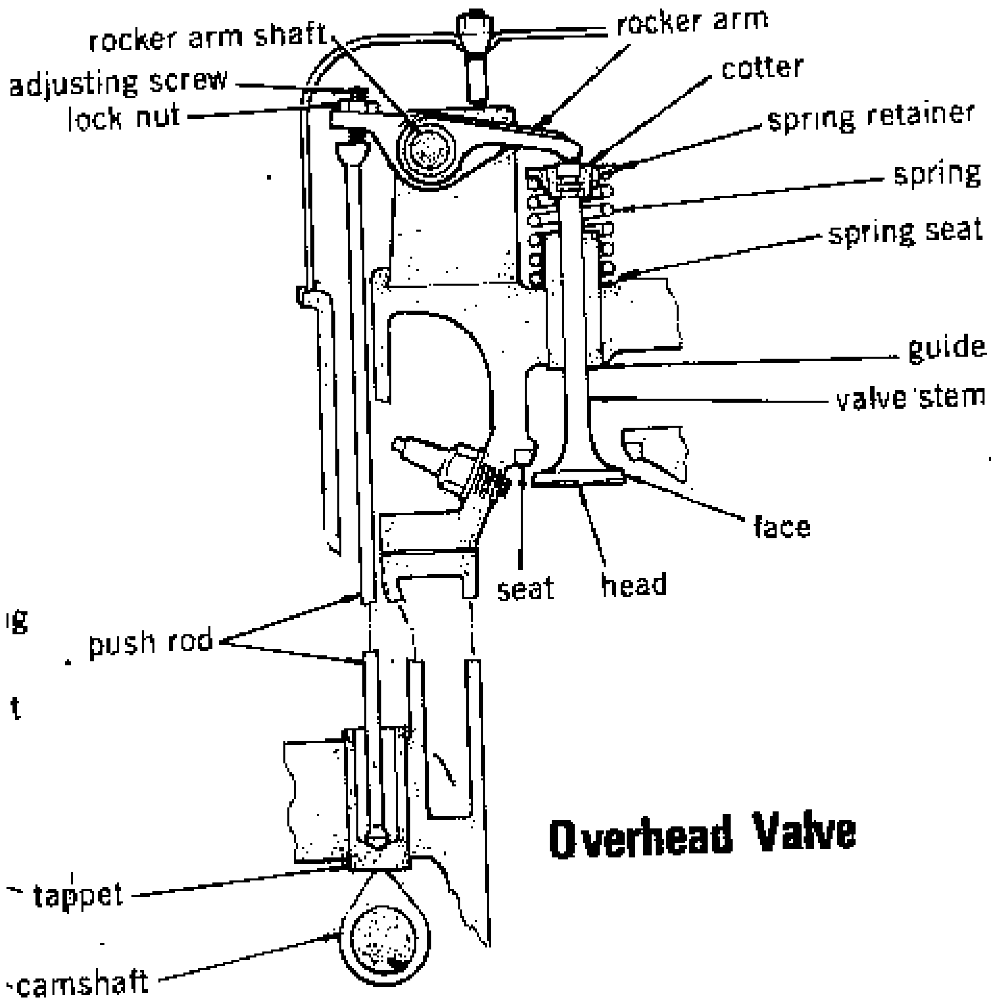



Fig-36 Over Head Valve

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

**Syllabus : Automobile and Diesel Technology**

**Course : Trade Training Basic, MTOF**

**Subject : Engine**

**Aim : To study Valve Tappet Clearance**

**Ref : Automotive Mechanics Principles and Practices By Joseph Heithner**

# VALVE TAPPET CLERANCE

## Introduction

1. Valve-tappet clearance, some times called as valve lash. The valve tappet clearance allows for expansion of the valve stem and other parts as the engine become heated. If sufficient clearance is not given the valve will not seat properly when the engine gets hot and this will cause loss of power and pitting the valves with detrimental result of the engine. It is better to have more clearance than necessary rather than have too little, in spite of the slight increase in noise of the valve mechanism. There is usually more clearance at the exhaust than on the inlet valves, because the former, exposed to the exhaust gases, are subjected to greater heat, while the inlet valve is cooled by the incoming fuel mixture/air. Valve clearance differs on each engine design because it must be varied in relation to length of the valve stem, the material used in the valve and the temperature at which the engine is operated.

## Over head Valve/Tappet clearance

2. In over head valve engine, this clearance is maintained in between rocker arm and valve stem. In this engine valve operating mechanism for valve located in engine cylinder head which requires two additional moving parts push rod and rocker arm, when the camshaft lifts the valve lifter which actuates the push rod. This action pushes the rocker arm and cause one end to push down on the valve stem to open the valve. So the tappet/ valve clearance is kept between the rocker arm and the bottom of the valve stem and it is adjusted by means of adjusting screw (with or without a lock nut) on the rocker arm end that contacts the push rod (Fig-37).

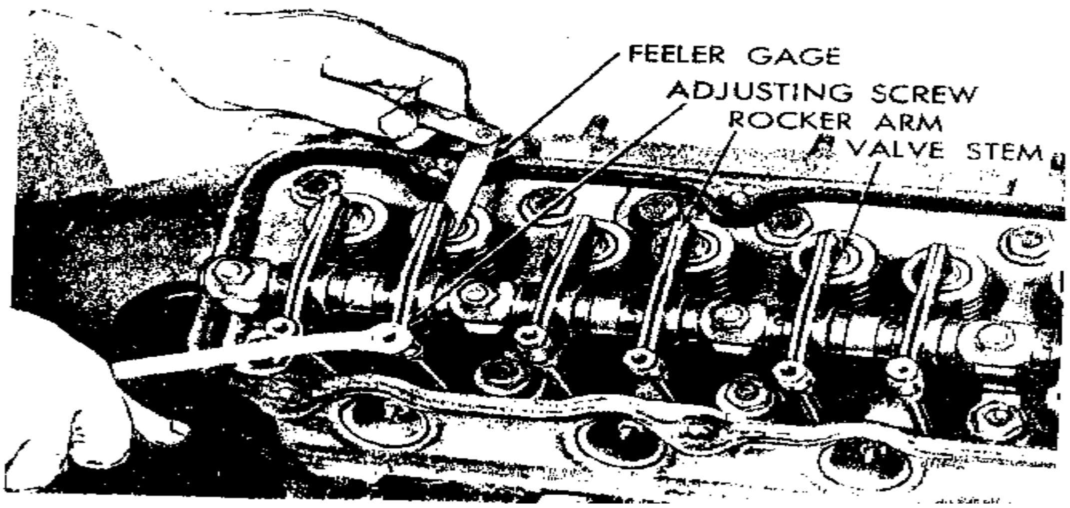



**Fig-37 Over head valve/Tappet Clearance**

**<u>Side Valve clearance</u>**

3. In side valve engine valve/tappet clearance is maintained in between the valve lifter or tappet and valve stem. The clearance is adjusted by turning the tappet adjusting screw to increase or decrease the length of the tappet (Fig-38). In some designs the adjusting screw is self locking, in others a lock-nut is used to lock the adjusting screw at the correct setting. In non-adjustable valve tappet, the clearance is adjusted by grinding the bottom valve stem to increase clearance or by using a longer valve to decrease the clearance (In repair work the clearance can also be decrease by grinding the valve face and valve seat).

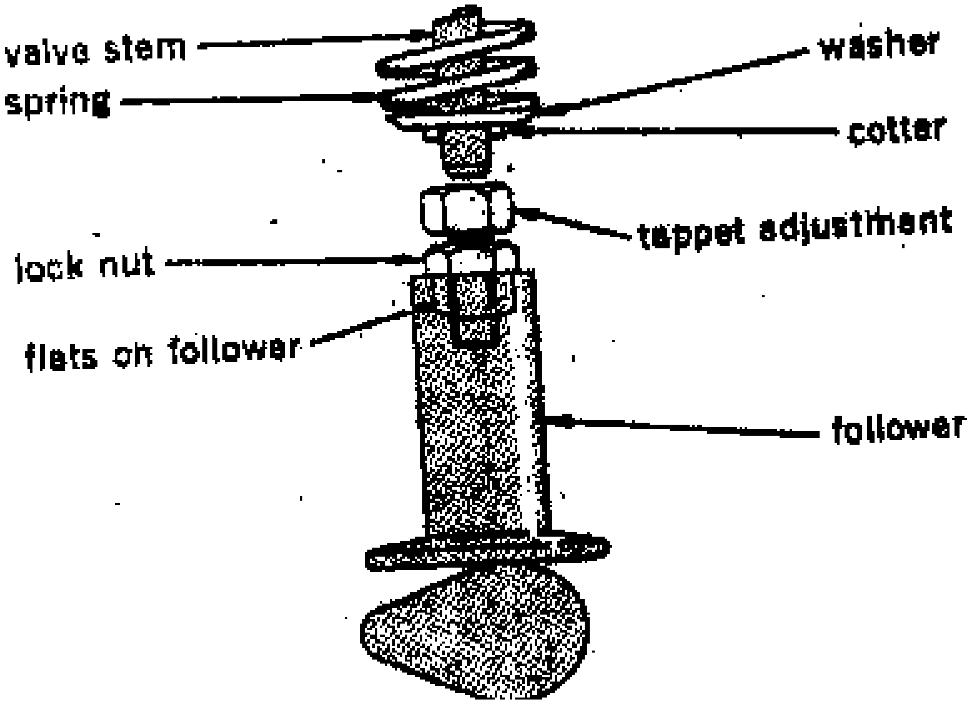



**Fig-38 Side Valve/Tappet Clearance**

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

**Syllabus : Automobile and Diesel Technology**

**Course : Trade Training Basic, MTOF**

**Subject : Engine**

**Aim : To Study Valve Periods**

**Ref : Automotive Mechanics By**

# VALVE PERIODS

## Introduction

1. In four stroke cycle operation it is assumed that the inlet valve opens during the suction stroke and the exhaust valve opens during the exhaust stroke. Now let us discuss the exact time at which each of the valves opens and closes in relation to the piston position.

## Inlet Valve Period

2. During the suction/inlet stroke, the inlet valve must be open to admit the charge. The charge is drawn into the cylinder. Due to the pressure being reduced inside the cylinder as the piston moves down ward. Actually, the inlet valve opens slightly before the piston starts downward on the suction stroke and closes after the piston has starts upward following completion of the suction stroke. The reason is that the inlet valve is opened before the start of the suction stroke. As both inlet and exhaust valves are made to open and close very slowly and this timing of the opening of the inlet is necessary to permit this valve to be open sufficiently during the suction stroke. The valves are made to open & close very slowly to provide quit operation The timing of the opening & closing of both inlet and exhaust valves are, of course, controlled by the design of the cams on the engine camshaft. The rapid decrease in pressure in the cylinder due to the downward motion of the piston causes the gases to rush into fill up the space above the piston. If the piston moves slowly, the mixture will be able to enter fast enough to keep the pressure in the combustion chamber space equal to that out side. The inlet valve is permitted to remain open, therefore, until the piston reaches a point in its next upward stroke (compression stroke) at which the pressure in the cylinder equals that outside. This period varies in different designs. It has been observed that the valve starts to open 5 degrees before TDC (exhaust stroke) as measured in degrees of crankshaft rotation. It remains open during the 180 degrees of the normal suction stroke and in addition during 44 degrees of the beginning of the compression stroke. This gives total inlet of 229 degrees of crankshaft rotation.

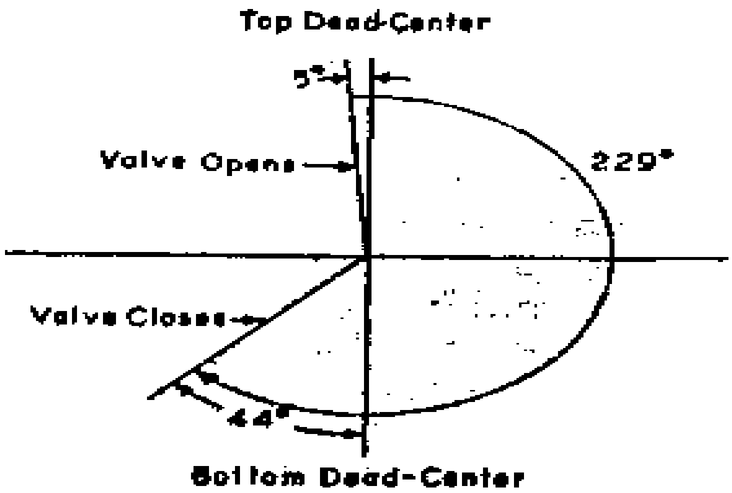



**Fig-39 Inlet Valve Period**

## Exhaust Valve Period

3. Exhaust valve opens 47 degrees before BDC (power stroke). It closes 12 degrees after TDC (suction stroke) which added to the 180 degrees of the normal exhaust stroke and the 47 degrees of the pre-release, produces a total valve opening of 239 degrees. As the piston is forced downward by the expanding gases, it is necessary to open the exhaust valve before the piston reaches the end of the stroke. By opening the exhaust valve before the piston reaches the end of its power stroke, the gases have an outlet for expansion and begin to rush out of their own accord. If the exhaust valve opens too early, there is a waste of power. The best result is obtained, not by closing the exhaust valve at the end of the exhaust stroke, but a short time after the piston has begun to move downward on the next suction stroke (Fig-40).

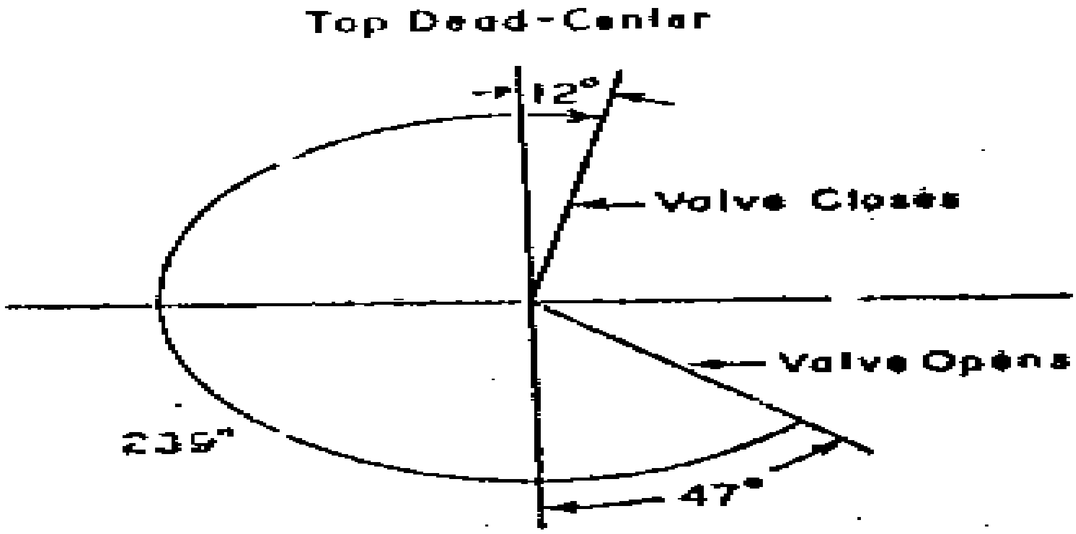



**Fig-40 Exhaust Valve Period**

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **Engine** |
| **Aim** | **:** | **To Study Two stroke Operation** |
| **Ref** | **:** | **The Automobile by Harbans Singh** |

---

# TWO STROKE ENGINE OPERATION

**First Phase (Induction and Compression**

1. a. Piston travels upwards from BDC to TDC, closing exhaust port and opening the inlet port.

b. Fresh charge of fuel and air mixture enters into the crank chamber from the carburetor through the inlet port.

c. Transferred in air/fuel mixture is compressed into the combustion chamber.

d. Ignition takes place by means of spark supplied by the spark plug when the piston reaches near TDC (Fig-41).

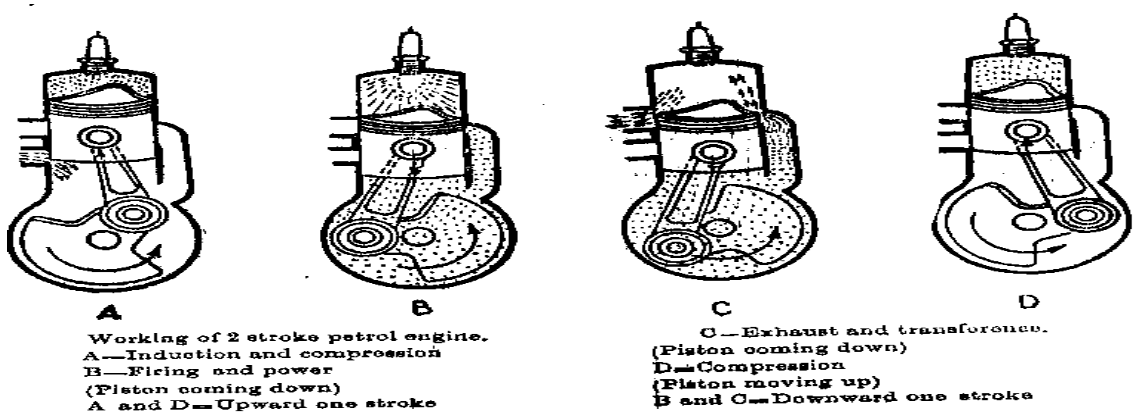



**Fig-41 First Phase & Second Phase of Two-Stroke Petrol Engine**

**Second Phase (Working or Power, Transference and Exhaust)**

2. a. Piston receives power impulses from the rapidly expanding gases and moves downwards from TDC to BDC.

b. Fresh charge of fuel and air mixture which has been entered into the crank chamber during first stroke is pumped into the cylinder though the transferred port, by the downward movement of the piston.

c. Exhaust port is cleared up and burnt gases go out of the engine.

**BAF BASE ZAHURUL HAQUE (TRG WG)**
**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **Engine** |
| **Aim** | **:** | **To study Exhaust System** |
| **Ref** | **:** | **Automotive Mechanics by Joseph Heitner** |

# EXHAUST SYSTEM

## Purpose

1. To expel out the burnt gases from the engine through this system with out any harm to the engine or its systems.

## Construction

2. The main component of the exhaust system and their purposes are given bellow:

a. **Exhaust Valve**. During the exhaust stroke through the exhaust valve port burnt gases go out.

b. **Exhaust Manifold**. It is a component of the system whose structure is many folded. The number of cylinder in the engine has the same number of exhaust valves and passage lines are linked with the exhaust manifold.

c. **Exhaust Pipe**. It is a pipe which is connected one end of the exhaust manifold and other end to silencer box. It is that pipe by which burnt gases from the exhaust manifold entered into the silencer box.

d. **Silencer Box**. It is a component of the exhaust system where the noises of the engine control by some mechanism. The burnt gases come to this box through exhaust pipe. Its shape is like a cylinder and both ends are closed except two pipe holes in the both ends.

e. **Silencer Pipe**. It is a pope whose one end is connected with the silencer box and other end to the atmosphere. The controlled burnt gases of the silencer come out to air atmosphere by this pipe.

## Operation

3. When there is an exhaust stroke inside the engine, the burnt gases from the engines combustion chamber come through exhaust valve and enter into the exhaust manifold and then through exhaust pipe

burnt gases enter into the silencer box there the gases coming out are noise controlled and reduced to minimum. After the burnt gases are controlled, come out to the atmosphere through the silencer pipe (Fig-42).

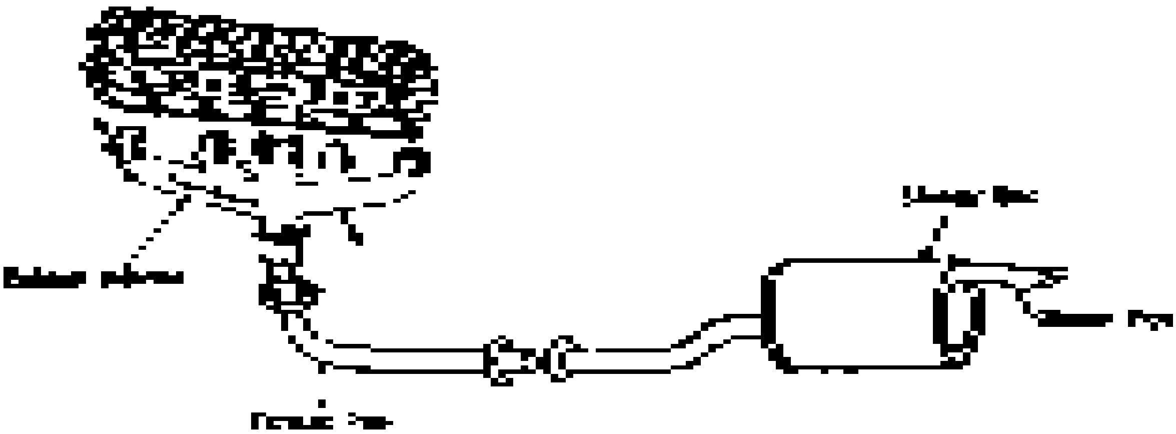


**Fig-42 Exhaust System**

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **Engine** |
| **Aim** | **:** | **To Study Engine Valve Timing** |
| **Ref** | **:** | **AP 3159 Section 3 Chapter 4** |

# ENGINE VALVE TIMIMG

## Purpose

1. To ensure that the valves open and close at correct time in relation to the piston position.

## Methods

2. There are three general methods:

a. **Marks on Timing Gears or Sprockets**.

(1) Assemble the camshaft and crankshaft in the block.

(2) Turn the crankshaft till No. 1 & 4 pistons at TDC-the fan pulley and crankshaft sprocket keyways will be pointing vertically downwards.

(3) Turn the camshaft till the mark on the gear or sprocket is inline with the mark on the crankshaft gear or sprocket and connects the chain.

(4) Fit the chain on to the crankshaft sprocket, remove the camshaft sprocket, taking care not to alter the camshaft position and fit it to the chain.

(5) Fit the camshaft sprocket to the camshaft so that the scribed lines on the two sprockets are in line and the driving side of the chain is tight (Fig-43)

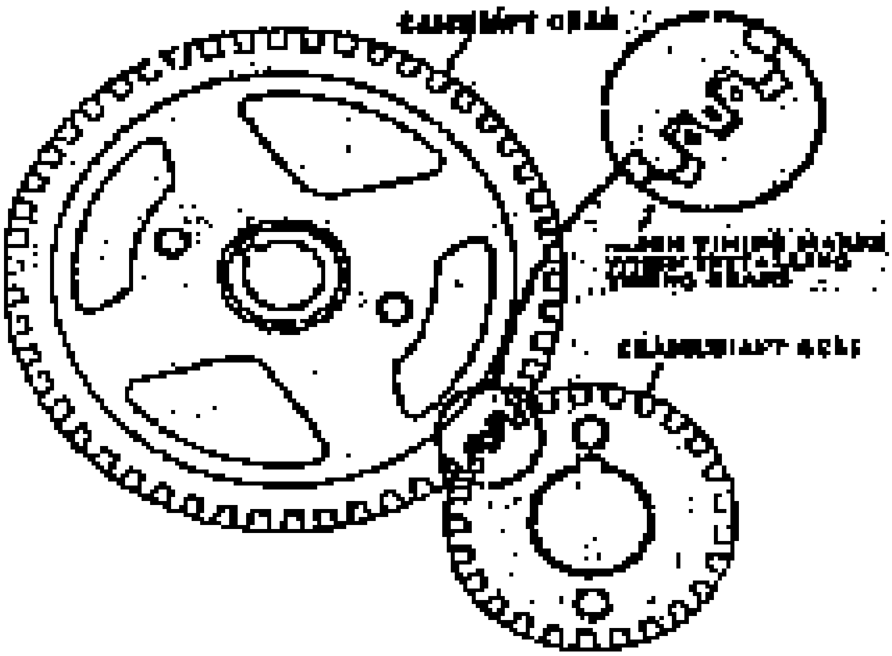


**Fig-43 Valve Timing Marks**

b. **Mark on Fly Wheel I.V.O).**

(1) Assemble the camshaft, crankshaft, pistons and valves.

(2) Adjust the tappet clearance as per MS.

(3) Increase 0.005” or as per MS clearance on No.1 inlet valve.

(4) Insert 0.oo5” feeler between the stem and tappet on No. 1 valve.

(5) Turn the camshaft till the feeler is nipped.

(6) Carefully remove the camshaft gear and turn the crankshaft till No. 1 piston is on TDC and IVO mark on the flywheel is inline with the pointer.

(7) Check that the feeler is still nipped between no 1 cylinder inlet stem and the rocker. Assemble the thrust button and spring to the bore of the camshaft gear hub. Now connect the chain or gears and read just the clearance of No. 1 valve as per MS.

(8) Checks the operation of all valves.

c. **Valve Over Lap Method**. This method can be used when the timing marks have been omitted.

(1) Connect the crankshaft and camshaft provisionally.

(2) Adjust the tappet clearance of No 1 cylinder valve as per MS.

(3) Turn the engine in D O R until the valves on NO. 1 cylinder is on over lap.

(4) Disconnect crankshaft from camshaft and turn the crankshaft only till No. 1 piston is at TDC.

(5) Reconnect the crankshaft and camshaft and check the timing. If satisfactory mark the sprocket.

# BAF BASE ZAHURUL HAQUE (TRG WG)

## (Aero Egg Trg Sqn)

**Syllabus : Automobile and Diesel Technology**

**Course : MTOF Basic Trade Training**

**Subject : Basic Engineering**

**Aim : To Study Basic Engineering**

**Ref. : AP 3159 Section 1 Chapter 1 & Automotive Mechanics Chap 2**

---

## WORKSHOP SAFETY PRECAUTIONS

### Introduction

1. Certain compulsory rules are displayed in every workshop. Theses are concerned with workshop safety precautions and based upon the Factories. Act,(revised 1961), they are designed to safeguard those employed in the workshop. These rules are concerned with the levels of cleanliness, ventilation, heating, lighting, and the use of electric and pneumatic power, fire protection, accident prevention and first aid. In some jobs there are special risks for which additional local instructions are needed; in these instances a poster or notice is displayed near the danger to draw attention to the particular risk involved.

### Personal Safety

2. Safety means protecting yourself and others from possible danger and injury. You do not want to get hurt and you do not want to hurt others. But you could hurt yourself or others if you become careless and thoughtless. Every reasonable safeguard is incorporated in the design of modern workshop equipment (such as guards and fences at danger points) but no safety device or set of rules can be fully effective against a person's incorrect behavior. A careless act, a moment of over confidence, can be very costly in terms of working hours lost because of injury to personnel or damage to equipment. The lesson is simple; THINK before acting.

### First Aid

3. First aid is the immediate help given to a person who is injured or who has become suddenly ill. In this respect your task is to be able to:

a. Treat a minor injury.

b Comfort a seriously injured person and so far as circumstances permit, prevent the worsening of the condition until skilled medical help arrives.

c. Obtained skilled medical help as soon as possible.

Fortunately, first aid in the workshop is largely concerned with minor injuries and ailments. With more severe injuries the first aider has only to know what to do until skilled medical help arrives.

**Prevention of dermatitis**

4. Dermatitis is a skin irritation caused by contact with material such as kerosene, gasoline or oil. There before starting any practical work apply barrier cream to those hands. After completions of the work scrub and wash the hands, using brush, soap and hot water.

**Treatment of Electric Shock**

5. Electrical accidents in workshops are often due to faulty electrical apparatus and hand tools. An electrical shock may vary from a mild tingle to a more sever shock which causes unconsciousness. Your first move is to switch off the master switch so that the person receiving electrical shock is disconnected from the source of electrical supply. You must on no account touch the person while he remains in contact with the electric supply or you will risk electrocuting yourself. Your actions are:

a. Switch off the supply

b. If for some reason this is not possible, stand on a dry surface and push or pull the person away from the electrical contact. Do not handle the person but use a con-conductor for example, a dry broom handle.

c. One the person is cleared from the electrical contact it is safe to approach for a closer examination. If his breathing has stopped it is vital that artificial respiration is started at once. It cannot be over- emphasized that in this emergency no time must be lost. A delay of seconds may prove disastrous.

d. When artificial respiration has continued for two or three minutes with air passing freely in and out of the person's lungs, then and only then, may attention be paid to other details. Whilst continuing with artificial respiration, send somebody else for medical help and get a bystander to cover the person and make him comfortable.

e. Once the person begins to breathe for himself he should be laid on his side until expert medical help arrives. Stay with him in case breathing stops and further help is needed.

**Artificial Respiration**

6. The mouth- to mouth or mouth-to- nose method, commonly called "kiss of life", is the recommended way of giving artificial respiration. It is easy to apply and since no movement of the patient's limbs is required, it avoids increasing the severity of any injuries the person may have. Followings are the methods of artificial respiration:

a. Lay patient on his back. Clear mouth and throat of obstructions. Tilt head well back and push jaw upwards to keep air passages open.
b. Pinch nostrils. Take a deep breathe, open your mouth wide and seal your lips around the patient's open mouth. Blow into his lungs and watch for his chest to rise and then fall as you remove your mouth.
c. Repeat the process five or six times as quickly as possible. Continue at steady rate-about ten inflations per minute watching for a consistent rise and fall of the patient's chest until he recovers.
d. If mouth to mouth is impracticable, seal off the patient's mouth and blow through his nose using same procedure as above.

**Prevention of Acid and Alkaline Burns**

7. A chemical burn is the result of contact with corrosive chemicals such as the acid or alkaline, electrolyte of electric batteries. Burns are always painful and are often accompanied by shock. To prevent those, you are to :

a. **Protective Clothing**. Rubber, Aprons and Gloves are to be worn at all times when handling batteries or electrolyte. Apron, gloves and goggles are to be worn when mixing either acids or alkaline electrolyte.

b. **Electrolyte spill on Benches or floors**. The spill electrolyte should be soaks up with saw dust, which is then to be removed and burned. The affected surface should then be washed with a saturated solution of bicarbonate of soda or with a saturated solution of boric acid, followed by washing with water.

c. **Electrolyte spill on Clothes**. The affected part of the clothing should be washed with a solution of ammonia, if acid electrolyte or with a solution of boric acid, if alkaline electrolyte, then washed with water.

d. **Electrolyte Spill on Skin**. Washed with saturated solution of bicarbonate of soda (for acid) or boric acid (for alkaline) should be applied on skin without delay, followed by washing with worm water. If the skin burnt apply olive oil and report to sick quarters at once.

e. **Electrolyte in the Eyes**. If acid get into eyes, bath immediately with a 5% solution of bicarbonate of soda (this supplied ready for use by sick quarters and forms part of the first aid kit). Follow this by washing with warm water and report at once to sick quarters. In no case should ammonia be put into the eyes. The treatment for alkaline electrolyte is similar substituting solution boric acid for bicarbonate of soda.

**BAF BASE ZAHURUL HAQUE(TRG WG)**

**(Aero Engg Trg Sqn)**

**Syllabus : Automobile and Diesel Technology**

**Course : MTOF Basic Trade Training**

**Subject : Petrol and Diesel Engine**

**Aim : To study Automobile Engine**

**Ref : Automobile Engineering G.B.S.Narang**

---

# AUTOMOBILE ENGINE

## Introduction

1. Numerous types of power plants of engine units have been in use for propulsion of commercial and passenger vehicle since time immemorial. It was Huygens in 1680, who invented the first automobile engine using gun power for providing motion to the piston; He was followed by Cecil in 1820; Lenoir in 1860 and Otto in 1876. They used gas (Hydrogen or coal gas for producing motion. The piston provides motion to crankshaft and various other moving parts of the engine. These parts of the engine (i.e. connecting rod, piston, camshaft etc) are connected directly or indirectly or indirectly. It is rotated mechanically by means of a self –starter or starting motor. The moving parts of the engine are set in motion by the rotation of the crankshaft. This helps to complete the cycle of operation. The power house of an automobile is the engine. The heat energy produced by burning of the fuel is converted by the engine into mechanical power or energy of rotation (motion) or rotary motion through its various parts. An assembly of a large number of parts used to do work and make the transfer of energy is called a power plant. This motion is stored in the flywheel connected to the crankshaft. After completing various cycles of operation in the engine the flywheel transmits this motion to the wheels through the transmission system. In this way the engine as well as the vehicle is set in motion.

## Types of Automobile Engines

2. The rapid increase in the number of commercial and passenger vehicle has created a demand for a convenient source of power to propel the different designs of automobiles. For this purpose numerous types of automobile engines ranging from the small motor cycles light weight engine of about 1` B.H. P to heavy weight or larger high power car or truck from 150 to 400 B. H. P. out put pr more are in use. There are two main types engines used in automobiles piston engine (most common), rotary engine (Wankel engine car-Japan). The various types of automobile engine with respect to different classifications are grouped as under:

a. **With Respect to the Number of cylinders**

(1) **Single Cylinder Engine.** This engine is now generally employed in auto cycles, mopeds, scooters, and motor cycles and on certain small three wheeled cars. In this engine there is only one power stroke in two revolutions of the crankshaft. It may be two or four stroke cycle engine. 600 to 700c.c. is maximum size above this. Due to lack of balance of the reciprocating parts, the vibratory effects are very much marked. The crankshaft consists of one crankpin and two main journals made either as a one piece forging of alloy steel or as bolted together assembly. It does not provide a mechanical balance due to the presence of one piston, one

gudgeon pin and one connecting rod which have a reciprocating motion with no working parts to counter-balance their weight. Another reciprocating mass moving oppositively can only balanced to some extent by the use of counter-weights attached to the crank-shaft. The heavy flywheel attached to it also produces a steady movement of the vehicle. Due to vibrations caused by fluctuations in engine speeds it can not be used in motor vehicle-cars etc. but the vibration reduction level is acceptable for stationary engines as well as for motor cycles, scooters, mopeds, lawn movers, concrete mixers portable water pumps, electric power generators etc (Fig- 1).

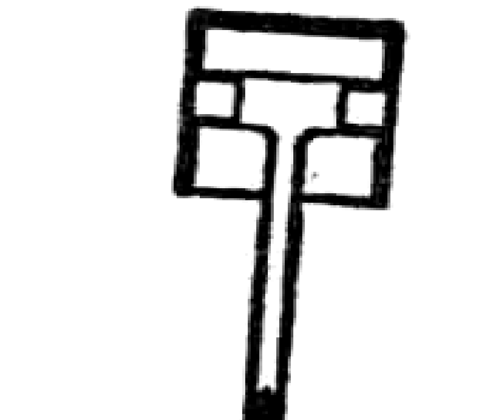


**Fig- 1Single cylinder engine**

(2) **Two Cylinder Engine**. In order to provide power, better balance, smaller size, reduced overall height and even torque. The cylinders of motor cycles and light car engines are duplicated. The capacity of the twin cylinder engines ranges from 500 to 800 c.c. the identity of an engine is dictated by the layout of the cylinders. In two cylinder engine following three arrangements shown in fig-2 (a) in line with crank-shaft, i.e. side by side in single row and parallel to one another. They can be either horizontal or vertical. The pistons move up and down together. (b) Horizontally opposed: the cylinders are at $180^0$ to each other. (c) The Vee twin> here the cylinders are arranged in two rows at some predetermined angle to one another, i.e. usually $90^0$. The firing order cannot be arranged in to provide the required power impulse every $360^0$ in case of a two cylinder engine operating on four stroke cycles. Although $90^0$ Vee twins is generally in better balance yet perfect balance is difficult to obtain in each of the above arrangements. A twin cylinder has two power strokes in two revolution of the crank shaft with firing interval of $180^0$ AND $540^0$. In case of two cylinder two stroke engines, two power strokes are produced in one revolution of the crankshaft with firing interval of $180^0$.

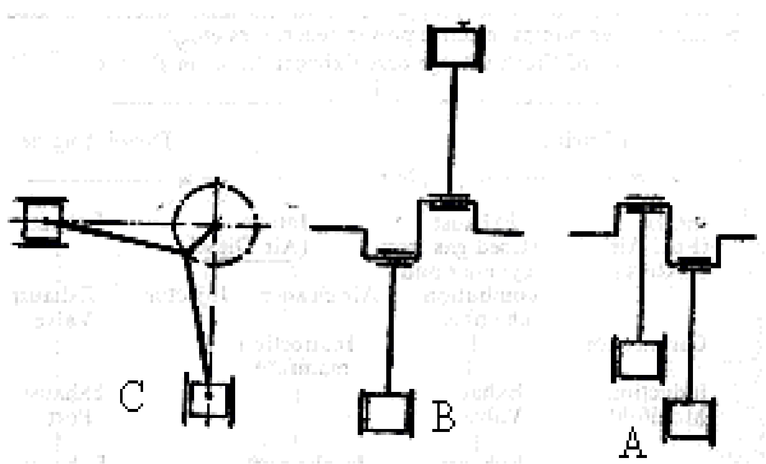



**Fig-2. Two cylinder engine**

(3) **Three Cylinder Engine**. These engines are confined to only two strokes. They produce a power impulse every $120^0$ indicating that the torque produced is comparatively smooth. Since no two pistons can oppose each other exactly at any moment, the overall balance ids only moderate. The cylinders are arranged vertically in line with the crankpins arranged at $120^0$ intervals around the shaft. The crankcase serves as intake and pre-compression chamber. The crankcase is divided into three separate compartments. Each sealed off section of the crankcase is provided to one of the cylinders. Its differential ids located between the engine and the transmission. It is mainly used on a front drive car. In case of three cylinder two stroke engine, three power strokes in one revolution of the crankshaft with firing interval of $120^0$ take place. A three cylinder units used in compression ignition engines or four stroke petrol engines is shown in fig-3. It has equal firing intervals of $240^{0.}$

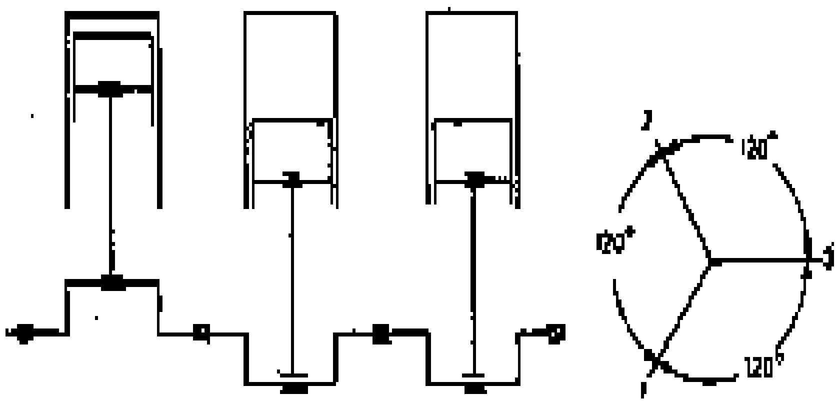



**Fig- 3. Three cylinder engine**

(4) **Four Cylinder Engine**. It is the most popular arrangement for use kin the small, light and medium sizes of present day car. These engines are operating on a four stroke principle. An $180^0$ crankshaft arrangement is always used. The cylinders are arranged in a line above a flat, four-throw crankshaft. The balance of the four cylinder engines is knot as good as the balance of the opposed two-cylinder engines providing excellent balance and torque. But the overall lengths and cylinder dimensions of two cylinder engine limit to smaller power units for car. More-over, for the slow running and low speed torque, these also provide discouraging results. Here the torque is much more uniform than a single cylinder engine with good balance of the four cylinder engine. In these engines two pairs of the four cylinders are moving in the opposite direction. Pistons 1 and 4 will be at top dead centre with the pistons 2 and 3 being together at the bottom dead centre. The pairs move up and down together with each cylinder being on a different stroke. In case of four cylinder four stroke engines, four power strokes in two revolutions of the crankshaft with firing interval of $180^o$ are produced The main components of a four cylinder internal combustion engines are shown in figure- 4The four cylinders in this engines may be arranged inline, opposed, square four and Vee four resulting the engines to be called as such, i.e., inline, opposed, square four and Vee four cylinder engines. In line four cylinder engines pistons 1and 4 are always moving in pair opposite to the direction of piston pair 2 and 3. In this arrangement, firing interval in regular. Every $180^0$ rotation of the crankshaft provide one power impulse. This engine has a continuous torque which fluctuates in value with the dying away of one power stroke and building up of the next in unison.

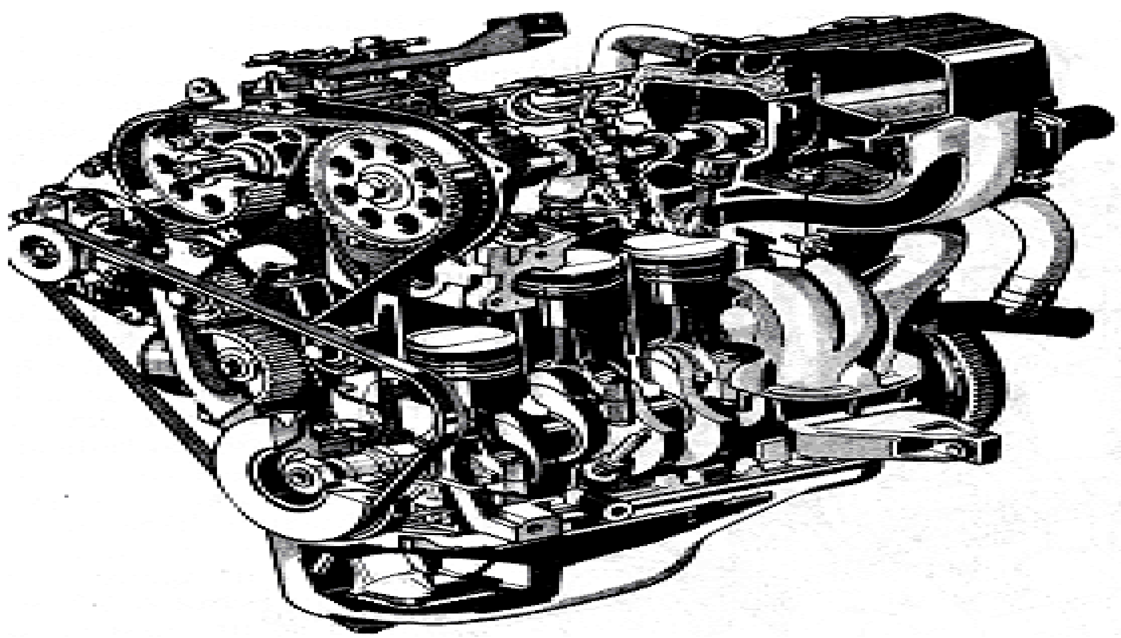


**Fig- 4.Four cylinder engine**

(5) **Five Cylinder Engine.** Some five cylinder automotive engines are being built. Mercedes produces a five- cylinder diesel engine. Volkswagen has a five-cylinder in line spark-ignition engine (fig-5) for a front-drive car. Note the axle coming out the side of the transmission. The engine is mounted ahead of the from wheel drive axles.

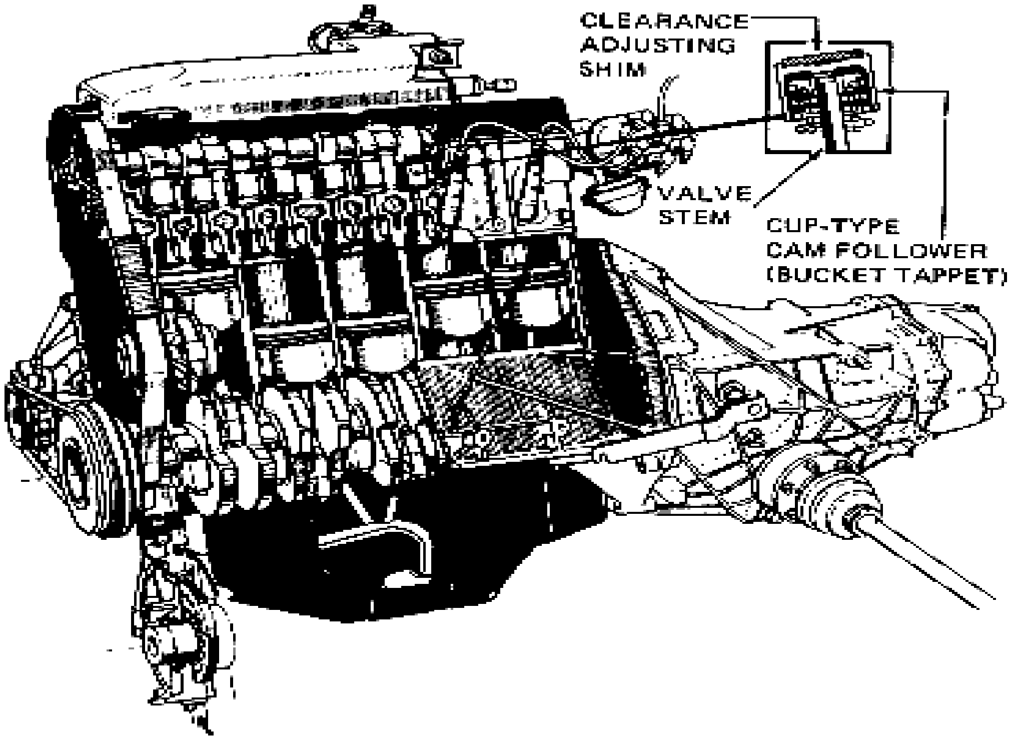



**Fig- 5 Five Cylinder Engine**

(6) **Six-Cylinder Engine.** As compared to a four cylinder engines, a better dynamic balance and a more uniform torque or turning moment can be obtained by six-cylinder engines. Most of the high powered as well as the modern cars of moderate powers are employing the six-cylinder engines. Though expensive and complicated these engines have much smoother, more flexible and quitter running. It requires only a light flywheel due to the lower ratio of maximum to mean torque. Six cylinder engines are generally in-line engines built with $120^0$ crankshafts. The arrangement of the crankshaft is as shown in fig- 6 so that the crank throws of cylinders 1and 6, 2and 5, 3 and 4 are in the same radial plane. In other words, two outer cranks are parallel and at $240^0$ to the middle pair, two centre cranks are parallel and the second and fifth are also parallel and at $120^0$ to the central ones. With this arrangement every $120^0$ (or of a revolution) a pair of pistons will be at TDC. (1 and 6) one at compression (2 and 5) and the other at the exhaust stroke (3 and 4) therefore, there are six power impulses during two rotations of the crankshaft or three firing strokes per one revolution of the crankshaft or one power stroke every $120^0$ of crankshaft rotation. For good distribution of fuel to all cylinders, the possible firing order is 153624 and 142635. There are no unbalanced

secondary forces in case of six cylinder engine resulting in almost perfect balance. But a very small unbalanced force called the sixth harmonic causing a slight vibration at six times engine-speed frequency is present sometimes. The six cylinder engines according to the position of the cylinder are in lineV-6 engines, Flat six-cylinder engine. In-line engines have overhead valves. This is an I- head engine with crankshaft supported by seven main bearings provided to every crank for additional support and rigidity, a bearing on each of its sides. Another engine similar to in- line engine is a slant six overhead-valve engine with cylinders slanted to one side. It is provided with either a cast iron or die-cast aluminum cylinder block. Still another similar engine is six cylinder in-line overhead crank-shaft engines. The crankshaft is driven by a neoprene belt reinforced with fiber-glass cords. V-engines are important engines which are built to have a bank of three cylinders set at an angle or at V to each other. Same crank pin is used to attach connecting rods from opposing cylinders in two banks. Flat six-cylinder engine used in Chevrolet corvoir is air-cooled and is mounted at the rear of the vehicle.

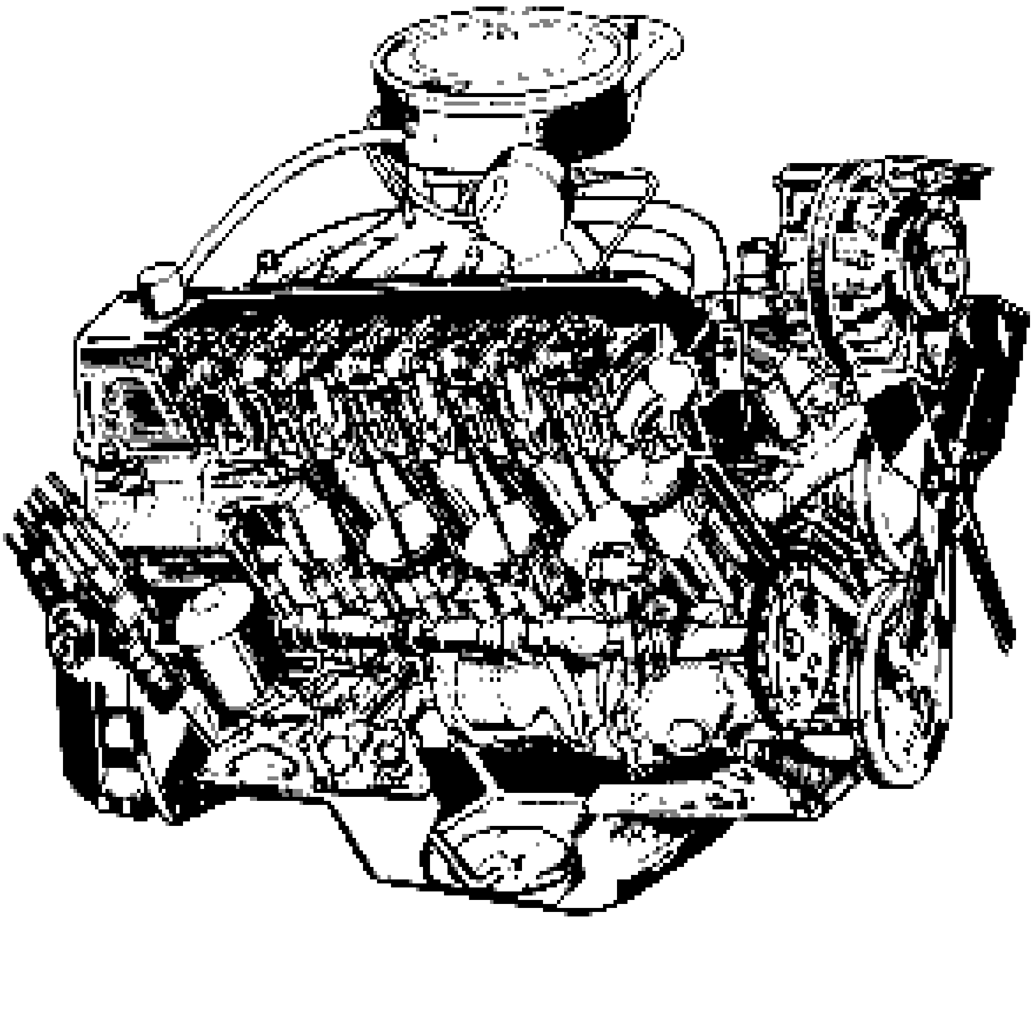


**Fig- 6 Six-Cylinder Engine**

(7) **Eight-Cylinder Engines**. The eight-cylinder engines have many advantages over six-cylinder engines. They provide more uniform torque and better acceleration while the balance is not very good. These engines can be arranged in one long line (straight eight engines) or in two rows of four cylinders each inclined to one another (v-eight engines). The straight eight engines provide a long engine with long and expensive crank and camshafts. The v-8 engines although more compact than straight eight engines are not good in balance. The interval of explosions in straight eight engines is $90^0$ because they use a crankshaft with throws set $90^0$ from each other. The crank throws for different pairs of cylinders are in the same radial plane like cylinder 1 and 8, cylinders 2and 7, 3 and 6, and 4, 5. as compared to v-8 engines, these engines are more compact in width. Due to the angularity of these cylinders, the pistons do not bear on one side of the cylinder walls. Moreover, these engines are perfectly balanced due to both the primary and secondary inertia being in balance except a small rocking action caused by these forces not acting in the same line (Fig-7).

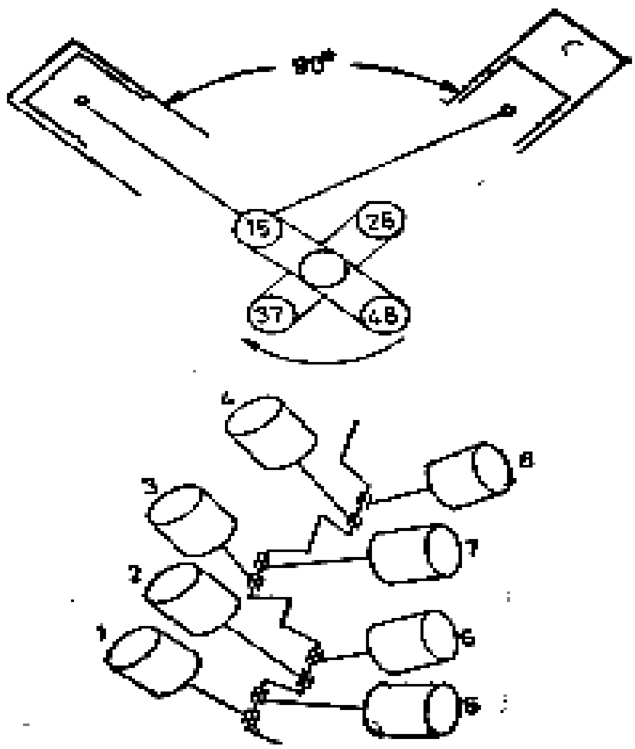



**Fig- 7 Eight-Cylinder Engines**

(8) **Twelve Cylinder Engines**. These engines were originally designed for aero planes. But certain cars like Roll Royce, packed,

Lincoln Zephter and Daimler "Double" six are also employing these engines. These providing a much superior torque and perfect balance have extra complication and expense of manufacture. Essentially the twelve cylinders engines consist of two sets of sex cylinder in line engines with each forming a bank V- inclined at $60^0$ or $75^0$. They have a common crankshaft and camshaft with six sets of forked and plain connecting rods. The engine employs a pair of magnets of coil ignition units, two circulating pumps, and two carburetors for best results. These engines have a firing order of 1 4 9 8 5 2 1 10 3 6 7 1 2.the Italian Ferrari is the only car which is being manufactured with a twelve-cylinder engine.

(9) **Sixteen-Cylinder Engine**. These engines having two sets of straight eight cylinders inclined at an angle or Vee have been used in Cadillac car. These engines have been perfectly balanced with top gear performance. This engine provides a continuous flow of power and very smooth operation with eight power impulses equally spaced for ever revolution of the crankshaft. The firing order to the engine is 1,4,9,12,3,16,11,8,15,14,7,6,13,2,5,10.the other specifications of this engine are: bore and stroke 88.9 mm each, cylinder capacity 7060cc and B.H. P. 185 at 3600 r.p.m. the cylinders arranged in two banks of eight cylinder each are inclined at $135^0$ a single casting includes both cylinder type of valve tappets are used for automatic maintenance of correct clearance.

b. **With Respect to the Type of Motion**

(1) **Reciprocating Piston Engine**. It is the most popular engine which is commonly used in the modern vehicles. These engines contain pistons which reciprocate inside the cylinders for completing the cycle of operation resulting kin the development of power. The pistons are connected with crank-shaft by means of connecting rods. Owing to this attachment, reciprocating movement of the pistons is converted into rotary motion which is required to drive the vehicle.

(2) **Rotary Engine**. Until now, we have been describing reciprocating engines. These engines have pistons that move up and down, or reciprocate, in cylinders. Another type of engine has no pistons. Instead, it has a rotor that is spun by the burning of the fuel in the engine. Two general types of rotary engines are the gas turbine and the wankel (Fig-8).

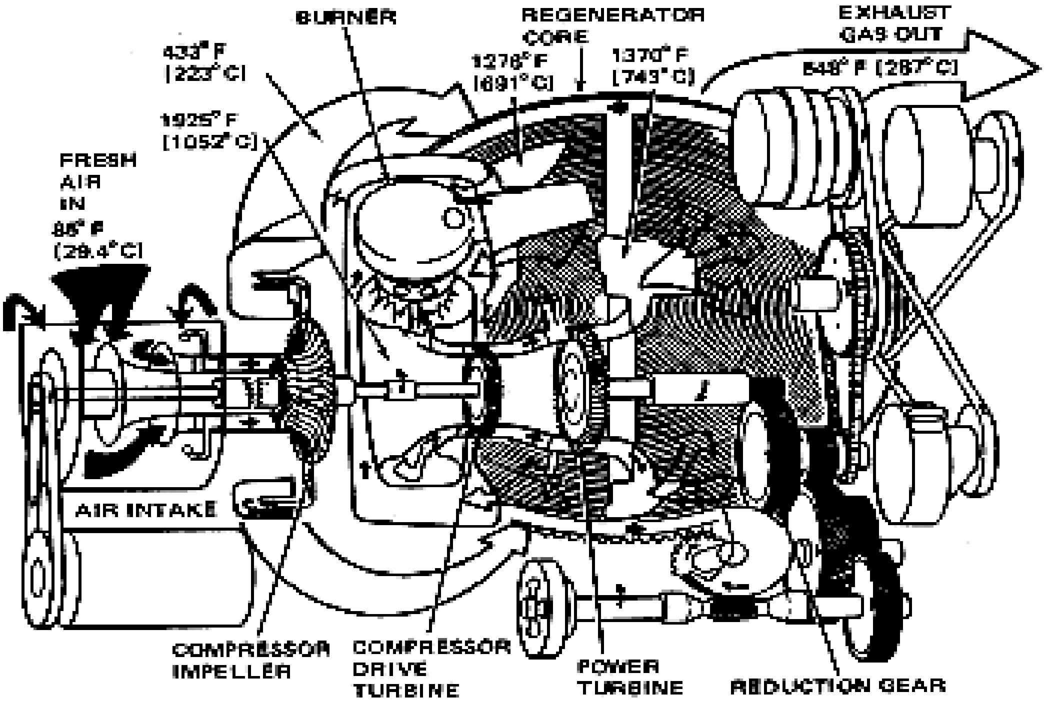



**Fig- 8 Rotary engine**

c. **With Respect to Arrangement or Placement of the Cylinder:**

(1) **Straight or Inline Engine**. In-line engines in which the cylinders are in one line or row.

(2) **Vee Engine**. V-shaped engines in which the cylinders are placed in two rows if centre lines are drawn in both rows of the cylinders these will meet at the bottom forming the shape of 'V' and hence the 'V' shaped engine.

(3) **Radial Engine**. Radial engines in which the cylinder radiate from a common centre like the spokes of a wheel these are not used in automobiles,

(4) **Opposed Cylinder Engine.** Opposed cylinder engines in which the cylinders are opposite it each other and the crankshaft is placed between them. These are multi cylinder engines and contain

even number of cylinders, half the number on opposite direction to the other.

d. **With Respect to Fuel Used**:

(1) **Petrol Engine or Gasoline Engine or oil Engine**. Petrol or gasoline engines in which petrol or petrol gas is used.

(2) **Diesel Engine**. Diesel engines in which diesel is used as fuel.

e. **With Respect to Arrangement of Valves Type of Engine Head:**

(1) **"I" Head or over Head Valve Engine**. This type of engines in which the valves are located over the head of the engine, i.e. at the cylinder head. In these engines the fresh charge of gases goes down from the valves in the cylinder in a straight path ad similarly the used gases go out of the cylinder to the valve mouth in a straight line. The path of gases in the engine being of 'I' shape. Combustion chamber and cylinder forming 'I' and hence 'I' head engine (Fig-9).

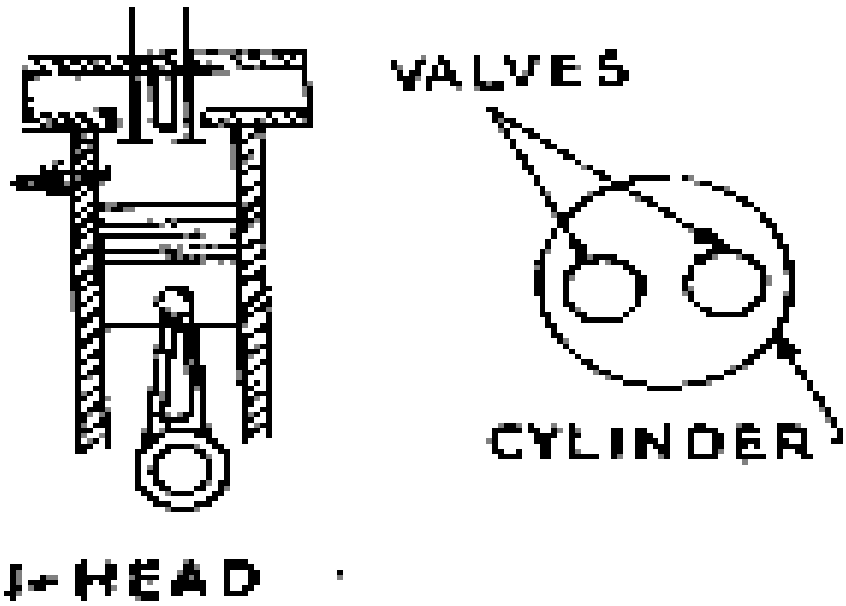



**Fig-9 "I" head or over head valve engine**

(2) **"T" Head or both Side Valve Engines**. "T" head engines in which intake and exhaust valves are placed in separate rows by the opposite sides of the cylinders, the path of flow of gases of and from the engine is like letter 'T'. The combustion chamber and cylinder form 'T' and hence 'T' head engine (Fig-10)

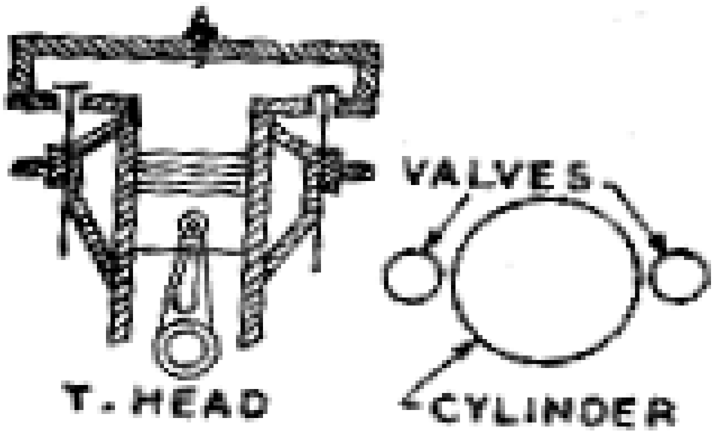



**Fig- 10"T" head or both side valve engines.**

(3) **<u>"L" Head or flat Head or Side Valve Engine</u>.** 'L' head or side valve engines in which the inlet and exhaust valves are in one row and located by the side of cylinders. In these engines, the path of gases travel to and from the engine is of inverted 'L' shape as shown in the diagram. The combustion chamber and cylinder form an inverted 'L' and hence 'L' head engines (Fig- 10).

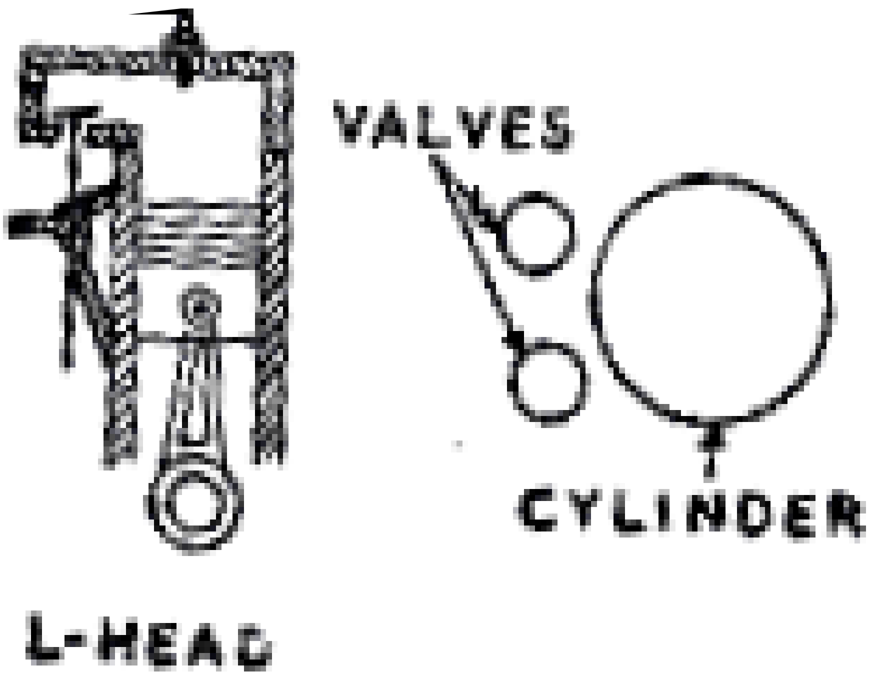



**Fig- 11 "L" head or flat head or side valve engine**

(4) **<u>"F" Head or Head and Side Valve Engine</u>.** 'F' head engine in which inlet valves are located in the cylinder head and exhaust valves by the sides of the cylinders. These engines being combinations of L-head and I- head engines are known as F-head engines.

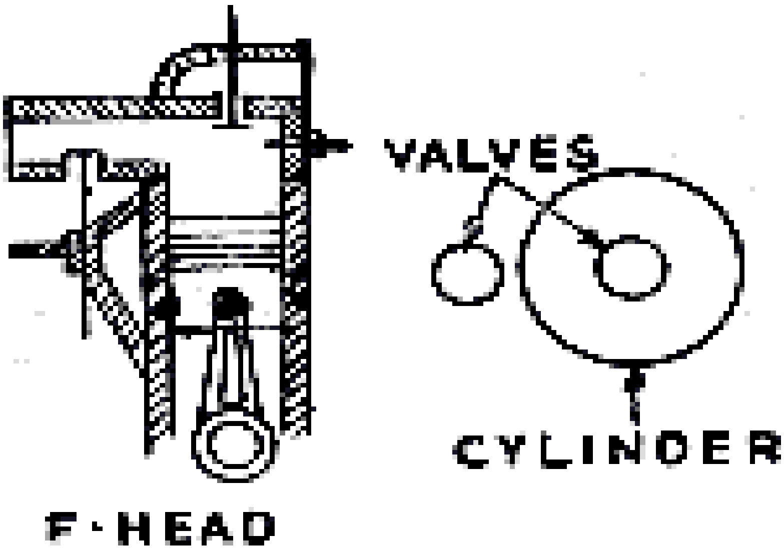



**Fig-12 F" head or head and side valve engine**

f. **With Respect to the Type of the Valve**

(1) **Poppet Valve Engine**. Poppet valve engines containing poppet valves.

(2) **Sleeve Valve Engine**. Sleeve valves engines containing sleeve valves.

(3) **Rotary Valve Engines**. Rotary valve engines having rotary valves.

g. **With Respect to Type of the Cycle Operation**

(1) **Otto Cycle or Constant Volume Cycle (Petrol Engine)**. The Otto cycle comprises of the following events taking place one after the other.

(a) Suction of fuel air mixture inside the cylinder.

(b) Compression of fuel air mixture.

(c) Ignition.

(d) Power impulse action (working).

(e) Exhaust of burnt gases.

The engines which work on this cycle are known as Otto Cycle engines. In Otto Cycle, combustion takes place at constant volume as whole of the fuel is burned instantaneously as an explosion. Hence engines which work on Otto cycle are known as constant volume cycle engines. Petrol engines are Otto cycle engines.

(2) **Diesel cycle or Constant Pressure Cycle (Diesel Engine)**. Diesel cycle engines or constant pressure cycle engines which work on diesel cycle or constant pressure cycle. In diesel cycle, the combustion takes place at constant pressure because burning takes place gradually without an explosion as the fuel enters. Hence this cycle is known as constant pressure cycle. In diesel cycle, the following events take place one after the other.

(a) Suction of only air.

(b) Compression of air.

(c) Injection of fuel.

(d) Action of power impulse (working).

(e) Exhaust of burnt gases.

h. **With Respect to Number of Cycles:**

(1) **Two Stroke Cycle Engine.** Two stroke engines in which all the events of the cycle are completed in two strokes of the piston.

(2) **Four Stroke or Four Cycle Engine**. Four stroke engines in which all the events of the cycle are completed in four strokes of the piston.

k. **With Respect to Cooling Method**

(1) Air cooled engine

(2) Water cooled engine or indirect air cooled engine

(3) Evaporation cooling engine

l. **With Respect to Degree of Comparison**:

(1) Low compression engine

(2) High compression engine

m. **With Respect to Ignition of the Engine**

(1) Compression ignition of engine

(2) Spark ignition engine

r. **With Respect to the Application of Engine**

(1) Stationary Engine

(2) Portable engine

(3) Automotive engine

(4) Locomotive engine

(5) Marine engine

**Diesel Engines or Compression Ignition Engines**

3. a. **Introduction & Description of Compression ignition Engines**. These are the engines in which the charge is neither pre-mixed at a carburetor, nor it is ignited by a spark but the air entering through the inlet valve or ports in the cylinder wall is highly compressed raising its temperature beyond the self-ignition temperature of fuel (700°C absolute). By injecting the fuel in a fine spray, it gets ignited by the turbulent hot air to get burnt with the oxygen present in the air. A spark ignition engine is a volume controlled while the compression ignition engine is quality controlled with the mixture strength varying from 10: I to 16: 1 and 20: 1 to 120: 1 respectively. Due to this higher compression ratio, the thermal efficiency is higher in case of compression ignition engine as compared to spark ignition engines. The higher compression ratio requires the temperature of the air to be raised to high value resulting in large thermal forces exerted on the cylinder head, cylinder piston, gudgeon pin, connecting rod, crankshaft, and bearings. This necessitates a more robust construction in compression to a spark ignition engine. These engines are generally used in certain commercial vehicles (like trucks, buses, Ashok Leyland buses, and Tata Mercedes Benz trucks), Tampos (Bajaj) taxicabs and delivery vehicles. They may be valves or ported engines (Fig-13 a & b).

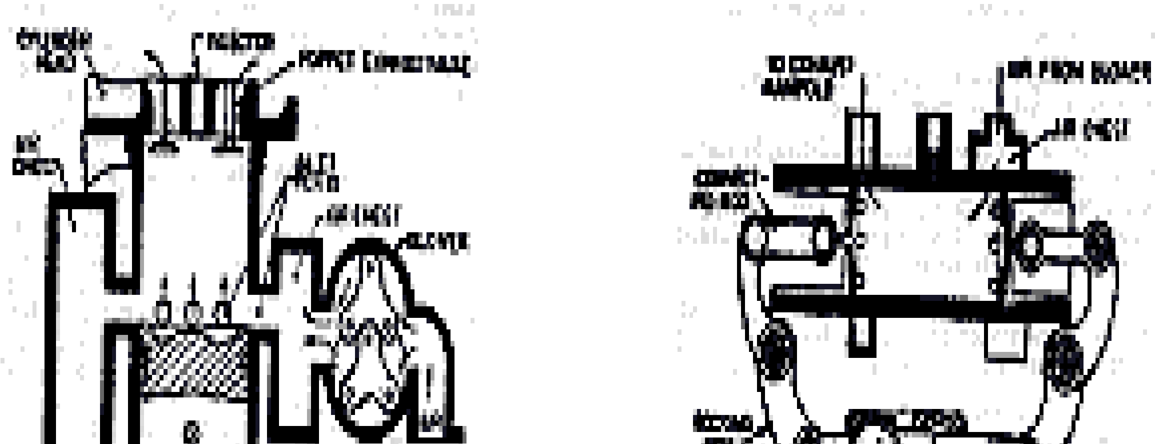


**Fig-13a & b Diesel Engines**

4. **Petrol Engine or Spark Ignition Engine**. The unit which furnishes the power to propel the modern American automobile is a gasoline burning, spark-ignition, four-stroke cycle, internal-combustion engine, like all other types of internal combustion engines, its ability to furnish these power rests on two basic principles of physics:

a. Combustion or burning is always accompanied by the production of heat.
b. When a gas is heated, it expands. if the volume remains constant, the pressure rises, this in general, is known as "Charles law".

What actually happens in the production of power by this internal combustion engine may be described as follow:

❖ Gasoline a liquid fuel, is mixed with air, broken up into a mist and partially vaporized in a carburetor. The mixture is then sucked in a cylinder. There it is compressed by the upward movement of a piston within the cylinder and is ignited by an electric spark. When the mixture in the cylinder is burned, the resulting heat causes the gases to expand. Since the natural expansion is prevented because the gases are confined within the cylinder, pressure is exerted on the cylinder walls and on the piston. The piston, being movable, is pushed downward by the force of these expanding gases to the full length of its stroke, to transfer the energy resulting from this expansion into useful work,

❖ The force exerted on the piston is transmitted through the connecting rod to the crankshaft that is made to revolve, turning through one-half of a revolution as the piston moves downward. Attached to the crankshaft is a flywheel, which stores up energy. The momentum of the flywheel carries the piston through the balance of its motion until kit receives another power impulse. In this way the reciprocating motion of the piston is transformed in a rotary motion at the crankshaft. (From that point on the power is transmitted back to the rear wheels, as will be explained in unit seven on the power train). For the continuous operation of the engine this series of events must be repeated over and over again in regular order. These events that are repeated make up the "cycle" of the engine. The number of strokes of the piston required to complete the cycle varies with the type of engine. In the type universally used in modern American passenger cars the cycle is extended through four strokes of the piston or two revolutions of the crankshaft. This is called four-stroke cycle or a four-cycle engine. (if the cycle were completed in two strokes of the piston or one revolutions of the , as is the case in some engines knot currently used in American passenger cars, but employed in some diesel- powered trucks and busses, the engine would be called two-stroke-cycle). In the four stroke cycle engine the four strokes are named suction or intake, compression, power and exhaust in accordance with the operations of the cycle which occur during each particular strokes.

c. **Cycle Operation of Four Stroke Petrol Engine (Otto Cycle) FIG-**

(1) **First Event (suction stroke)**

(a) Piston moves downwards from T.D.C.
(b) Intake valve is open and the exhaust valve is closed.
(c) Fuel air mixture is sucked into the cylinder.

(2) **Second Event (Compression Stroke)**

(a) Piston moves upwards from B.D.C.
(b) Both intake and exhaust valves are closed.
(c) Drawn in fuel air mixture is compressed into the combustion chamber.

(3) **Third Event (Ignition)**

(a) When the piston reaches near compression top dead centre, a spark is provided by the spark plug, which ignites the compressed fuel air mixture.

(4) **Fourth Event (Working or Power Stroke)**

(a) Rapidly expanding burning gases thrust the piston downward from T.D.C. to B.D.C.
(b) Both intake and exhaust valves are closed.
(c) Power impulse is provided to the piston which is transmitted to the crankshaft through connecting rod.

(5) **Fifth Event (Exhaust Stroke)**

(a) Piston moves upwards from B.D.C.
(b) Exhaust valve is open while the intake valve is closed.
(c) Burnt gases are expelled out of the cylinder.

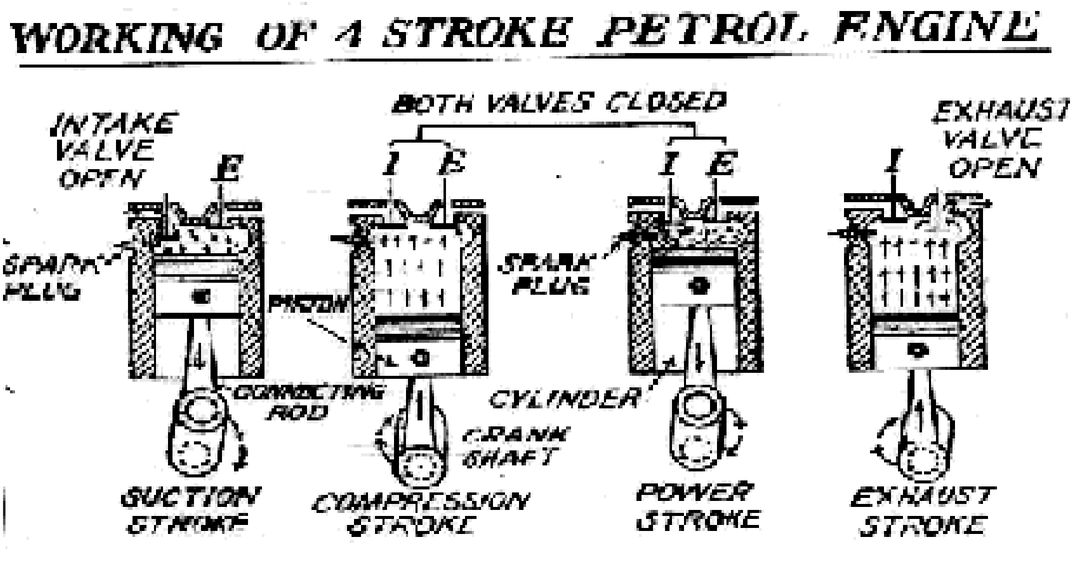



**FIG- 13 Working of Four Stroke Petrol Engine**

**Comparison between Petrol and Diesel Engine**

5. Although the gasoline (spark ignition) engine and the C I engine are similar in construction in many ways, still a lot many differences are there. These differences are furnished below:

| **Petrol Engine** | **Diesel Engine** |
|---|---|
| a. Mixture of petrol and air is drawn during intake stroke. | a. Only air is drawn during intake stroke. |
| b. Mixture is ignited by means of a spark supplied by the sparking plug at the end of compression stroke. | b. A t the end of the compression to stroke, injector supplies the atomized fuel in the combustion chamber which comes in contact with the compressed hot air and it is ignited. |
| c. Comparatively lower compression ratio usually between 5 to 9: 1 | c. Comparatively higher compression ratio usually between 14-20:1. |
| d. Comparatively lower compression pressure (Average compression pressure is 100 psi) | d. Comparatively higher compression pressure (Average compression pressure is 500 psi) |
| e. Comparatively lower temperature of the compressed fuel and air mixture usually between $60^0$C to $80^0$C. | e. Comparative higher temperature of the compressed air usually between $500^0$ to $800^0$C |
| f. It has carburetor for supply of fuel and air mixture; spark plug, distributor for magneto for the supply of spark. | f. No carburetor, spark plug, distributor or magneto is required but in lieu of that injector and fuel injection p ump is fitted. |
| g. High speed engine | g. Comparatively low speed engine. |
| h. Light in construction | h. Heavy in construction |
| j. Initial cost is less. | j. Initial cost is higher. |
| k. Produces less torque | k. Produces better torque. |

and motor cars than in heavy good vehicles. Both rpm and power output of the gasoline engine are controlled by varying the throttle valve setting which, in turn, alters the amount of both air and gasoline that is fed to the cylinders. The compression ignition engine does not throttle the air supply and, therefore, the amount xxx entering the cylinders per revolution is almost constant for normally aspirated engines, and the power output and rpm are altered by varying the amount of fuel oil that is injected into the cylinders, with the pumping action of the pistons taking care of the air supply within the capabilities of the engine. Because the compression ignition engine runs at higher pressures and is less smooth in operation, it is of heavier construction and physically larger than a gasoline engine of similar power output and thus is more suited or use in heavy commercial vehicles than in motor cars. It is also less inclined to rev freely generally has a maximum rpm of a lower value than a gasoline engine. The compression ignition engine is completely free from pre-ignition problems because air alone is compressed with gas pre-ignition detonation limits the compression ratio of the gasoline engine. Within xx the higher compression ratio the more efficient is the engine.

# BAF BASE ZAHURUL HAQUE(TRG WG)

## (Aero Engg Trg Sqn)

**Syllabus : Automobile and Diesel Technology**

**Course : MTOF Basic Trade Training**

**Subject : Fuel and Carburetion Systems**

**Aim : To Study Fuel System**

**Ref : The automobile – by Harbans Singh Reyat**

---

# FUEL SYSTEM

## General

1. The type of fuel system to be used in a particular application will be decided after consideration of such factors as the positioning of the fuel tank, the positioning of the carburetor and the run of the feed pipes. Various methods have been used for the supply of fuel. This is the system by means of which fuel applied to the engine according to its requirements.

## Types of fuel systems

2. Different ways have been adopted to supply fuel to the engine from time to time. The fuel is carried in a tank located at a suitable place in the vehicle. From the tank, it is fed to the carburetor or injection pump by different ways. The following are the different ways by means of which fuel is fed to the engine:

a. **Gravity feed system**. In this type, the fuel tank is placed at a higher level than the engine. Fuel from the tank flows through the fuel line towards the carburetor or injection pump by its own weight (gravity) and hence the system is known as gravity feed system.

b. **Autovac feed system**. This system uses engine manifold vacuum to draw fuel from tank to autovac tank from where it is fed to the carburetor by gravity. The fuel tank is placed away from the engine at some suitable place in the vehicle.

c. **Pressure feed system**. In pressure feed system, fuel is feed to the carburetor under pressure. In early automobiles, fuel in the tank was kept under a constant air pressure of about 3 lbs psi above atmospheric pressure. The air pressure was supplied by an engine driven pump. Now-a day, fuel is fed to the carburetor by means of a mechanically or electrically operated fuel pump. Fuel s drawn from the tank and feed to the carburetor under suction and pressure of the pump. Since this pressure system uses pump for the fuel feed so this system is known as pump pressure feed or pump feed system.

This system consists of the following main components (Fig-1):

(1) Fuel tank.
(2) Fuel filter.
(3) Carburetor/F I Pump.
(4) Air cleaner.
(5) Fuel gauge.
(6) Fuel pump.

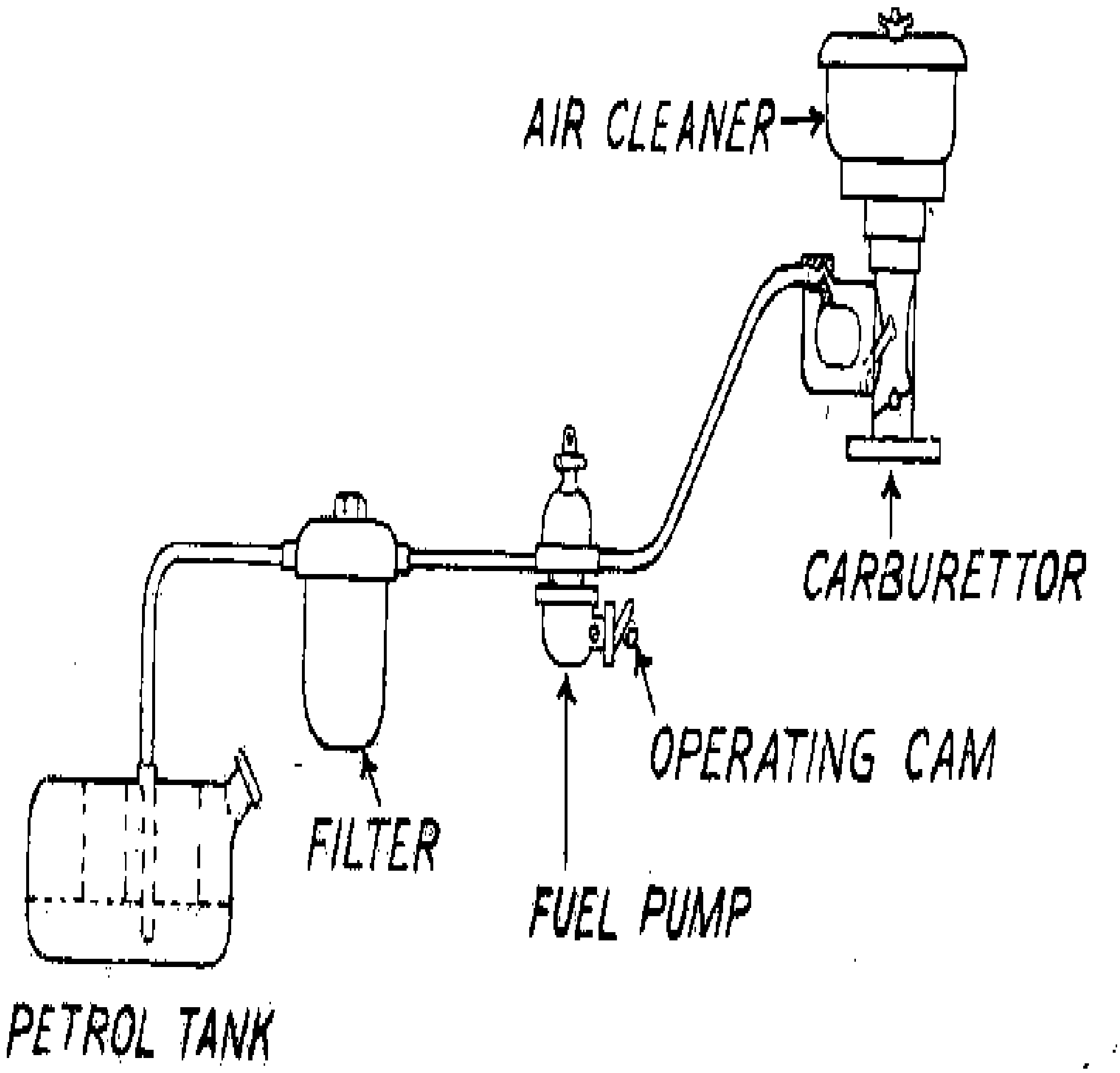



**Fig-1 Fuel system**

# BAF BASE ZAHURUL HAQUE(TRG WG)

## (Aero Engg Trg Sqn)

| | | |
|---|---|---|
| **Syllabus** | : | **Automobile and Diesel Technology** |
| **Course** | : | **MTOF Basic Trade Training** |
| **Subject** | : | **Fuel and Carburetion Systems** |
| **Aim** | : | **To Study AC Mechanical Fuel Pump** |
| **Ref** | : | **A P 3159 Section 3 Chap 7** |

## AC MECHANICAL FUEL PUMP

### General

1. The purpose of mechanical fuel pump is to draw the fuel from low level tank and to supply the fuel to the carburetor at a pressure of $2^{1/2}$ lbs psi. It works on the principle of suction and pressure.

### Construction

2. The body of the pump consists of two casings; the diaphragm fits in between them and is secured by the clamping action provided by the setscrews securing the upper to the lower casing. A return spring fits under the diaphragm and the diaphragm is connected to the rocker arm link, the rocker arm being kept in contact with the eccentric cam or (push rod) by a light spring. In the upper casing are fitted inlet and outlet no return valves, a fine mesh gauze filter, and the top is enclosed by a cover having a cork gasket between it and the upper casing; the securing set screw has a fiber washer fitted under its head. A screw fits into the lower part of the upper casing and this can be removed when it is required to drain away any sediment. A drain hole is provided at the base of the pump to allow gasoline, should the diaphragm become punctured, to drain away instead of entering the crankcase. On some pumps, provision is also made to enable the diaphragm to be operated by hand for priming (Fig-2).

### Operation

2. Rotation of eccentric lifts the rocker arm, thus causing the link to pull the diaphragm downwards and compressed the diaphragm spring. This action causes a drop in pressure in the pump chamber; therefore, the inlet valve opens and fuel flows from the tank, through the filter and past the valve into the pump chamber. As the high part of the cam passes the rocker arm, the light spring causes the rocker arm to follow the cam, and the diaphragm return spring pushes the diaphragm upwards. This action closes the inlet valve and opens the outlet valve, and the fuel in the pump chamber is forced out via a pipeline to the carburetor float chamber. Thus, there is one inlet and one delivery stroke of the pump for each complete revolution of the eccentric*.* Idling Because the pump is always capable of supplying more fuel than

the carburetor requires and as requirements vary considerably with the engine speed and load, the flow of fuel from the pump to the carburetor must be controlled, otherwise, wastage would result: this is the reason for the diaphragm operating lever being made in two parts, i.e. the rocker arm and the link. When the fuel in the carburetor reaches the required level, a needle valve closes and prevents the entry of any more fuel. Continued delivery of fuel by the pump causes a back pressure which pushes the diaphragm down against its spring, thus holding the link away from the rocker arm and allowing the rocker arm to "idle" without working the pump diaphragm. This continues until, when the carburetor requires more fuel, the valve is opened, thus allowing the diaphragm spring to force the diaphragm upwards again and normal pumping action is resumed.

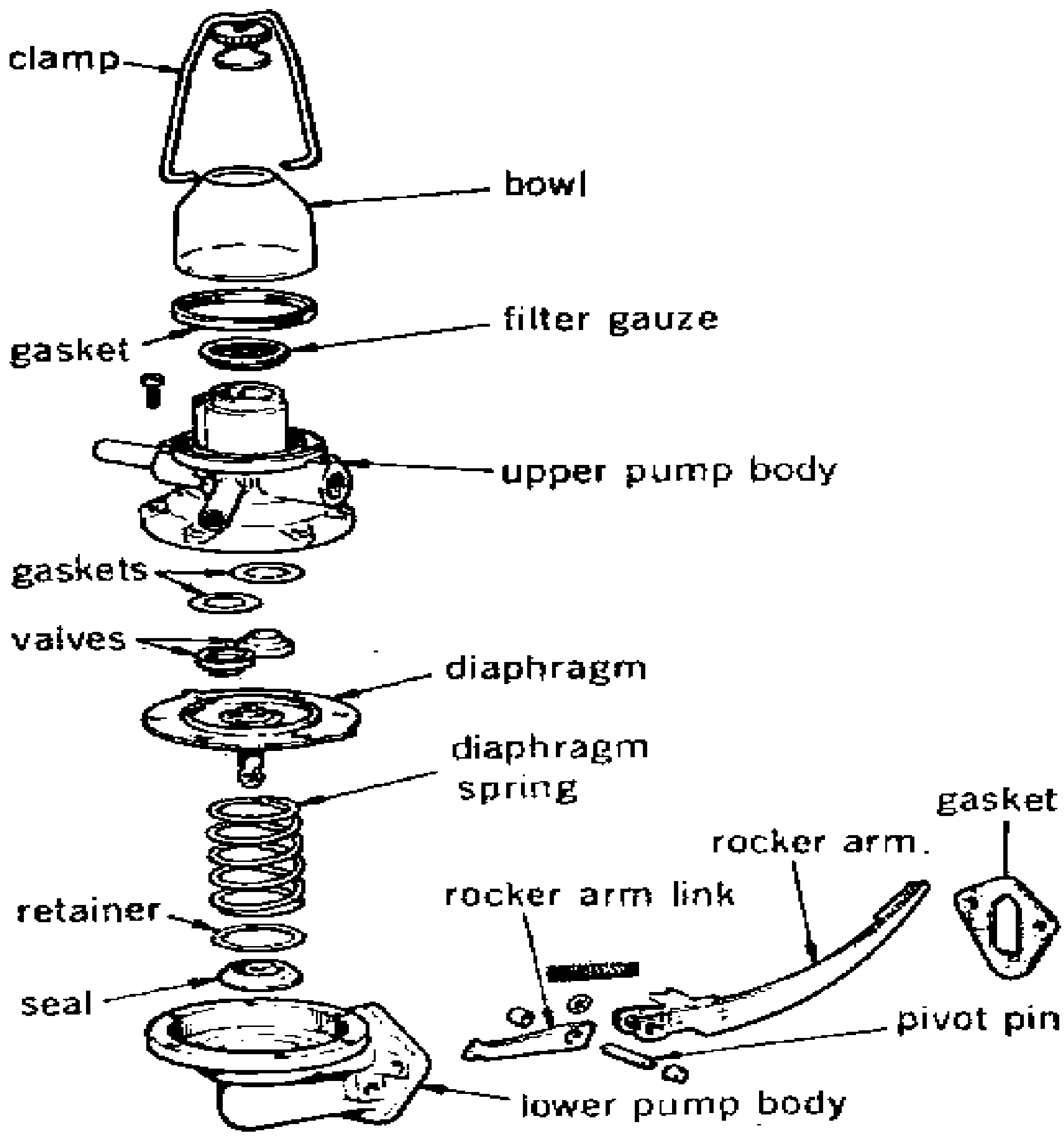



**Fig- 2 AC Mechanical Pump**

# BAF BASE ZAHURUL HAQUE (TRG WG)

## (Aero Engg Trg Sqn)

**Syllabus : Automobile and Diesel Technology**

**Course : MTOF Basic Trade Training**

**Subject : Fuel and Carburetion Systems**

**Aim : To Study Piston Engine Fuel and Fuel system**

**Ref : The Automobile – By Harbans Singh Reyat & A P 3159**

**Section 3 Chap 7**

---

## PISTON ENGINE FUEL AND FUEL SYSTEM

### Introduction

1. Gasoline and oil engines, the power units with witch we are concerned, convert the potential heat energy contained in the fuel into mechanical work.

### Fuels

2. The most common fuels used in automobile engines are diesel and petrol or gasoline. Other fuels used in I.C. engines are alcohol, alcohol-gasoline blends, benzyl, liquid petroleum gas and methanol.

### Petrol

3. Petrol or gasoline is a colorless liquid obtained from crude petroleum by means of distillation and cracking process. It has two main properties, volatility and anti-knock value. The volatility of any liquid is its vaporizing ability. It is usually determined by its boiling point. Petrol or gasoline is a mixture of hydrocarbon compounds, each having its own boiling point. Petrol for automobile engines has boiling point range from about $100^0$F to $400^0$F.

### Anti-knock value

4. Anti-knock value denotes the ability of fuel to burn without causing detonation or knocking. The tendency towards detonation is overcome by adding certain compounds such as tetraethyl lead in petrol. The ability of a fuel to resist detonation is measured by octane rating. The octane rating of a fuel is determined by matching it with the mixtures of normal heptane and iso-Octane in a test engine.

## Requirements

5. The fuel used by the engine is in liquid form; therefore, there must be a storage tank and means of delivering the fuel of the engine, the whole lay out being known as the fuel system. Having delivered the fuel to the engine, the fuel must be measured and mixed with AIR in the correct proportions to form a combustible mixture for the various engine-running conditions. This is done by a carburetor; there is an alternative method of measuring the gasoline known as fuel injection but, although it is more accurate than a carburetor, it has only specialized uses at present.

## Fuel Pipes

6. The fuel is conveyed from the tank to the engine by means of pipes that are usually made of copper, although flexible piping is often used particularly where movement is likely to occur, such as when the engine is flexibly mounted. When copper tubing is used it should always be annealed before being fitted, as this will reduce the risk of fracture; it should also be adequately secured so as to minimize the effect of the vibration and where movement is likely to occur, the pipe should be coiled for one or two turns.

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

**Syllabus : Automobile and Diesel Technology**

**Course : MTOF Basic Trade Training**

**Subject : Fuel and Carburetion Systems**

**Aim : To Study Routine Maintenance of Mechanical Fuel Pumps**

**[Ref : A P 3159 Section 3 Chap 7**

# ROUTINE MAINTENANCE

## General

1. The filter screen, sediment bowl, and the sediment chamber require periodic cleaning. The frequency of the cleaning operation will be given in the vehicle servicing schedule but normally they should be cleaned:

a. After the first 600 miles

b. After the first 3000 miles

c. At 6000 mile intervals

## Removing Sediment

2. Unscrew the retaining clamp and remove the sediment bowl(Fig-3). Remove the filter screen and wash in clean gasoline. Remove all traces of sediment from the chamber and bowl before refitting the filter screen and sediment bowl to the pump body. Before finally tightening the sediment bowl clamp ensures that the gasket is in good condition because an airtight joint is essential.

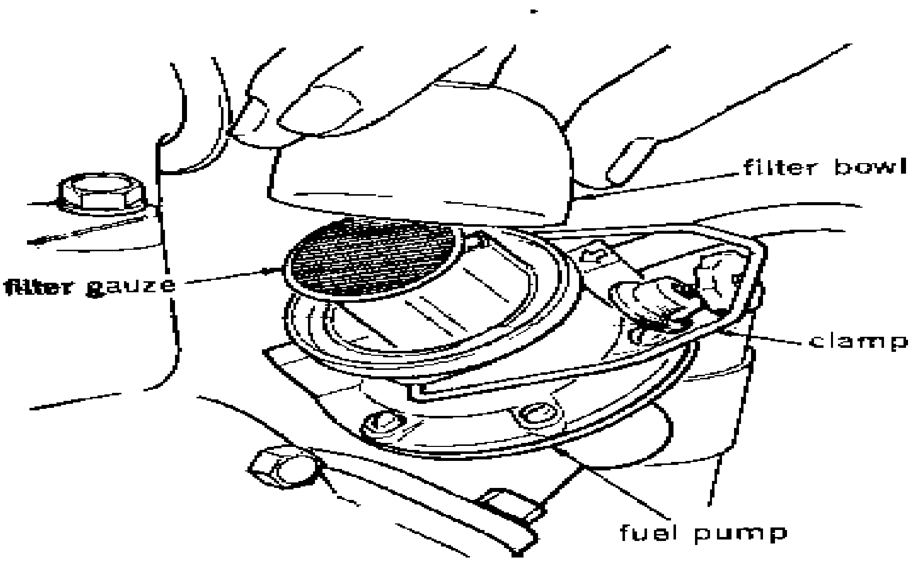



**Fig-3 Removing Sediment**

**<u>Removing a Diaphragm</u>**

3. In time a diaphragm may crack or punctures and the fuel pump will cease to supply fuel to the engine. Before the pump will function again a satisfactory manner the diaphragm will need to be renewed. This simple task is easier to perform if the fuel pump is removed from the engine. To remove the pump from the engine:

a. Disconnect and blank the fuel lines.
b. Remove the two nuts, and washers, which secure the pump to the engine crankcase.
c. Remove the pump from the engine.
d. When the pump has been removed from the engine continue with the following works:
(1) Remove the sediment bowl and filter screen.
(2) Mark the position of the diaphragm tab on each side of the pump body.
(3) Remove the body retaining screws and separates the body halves.

e. Detach the diaphragm from the bottom half of the pump body by unhooking the pullrod from the rocker arm link and remove both diaphragm and return spring; discard the diaphragm and pullrod but keep the return spring.

**Fitting**

4. To fit a new diaphragm:

a. Place the return spring under the new diaphragm and carefully insert the pull rod into the rod oil seal.

b. Engage the rocker arm hook with the slot in the pull rod so that the smaller tab on the diaphragm aligns with its mating mark on the lower body flange.

c. Re-assemble the pump.

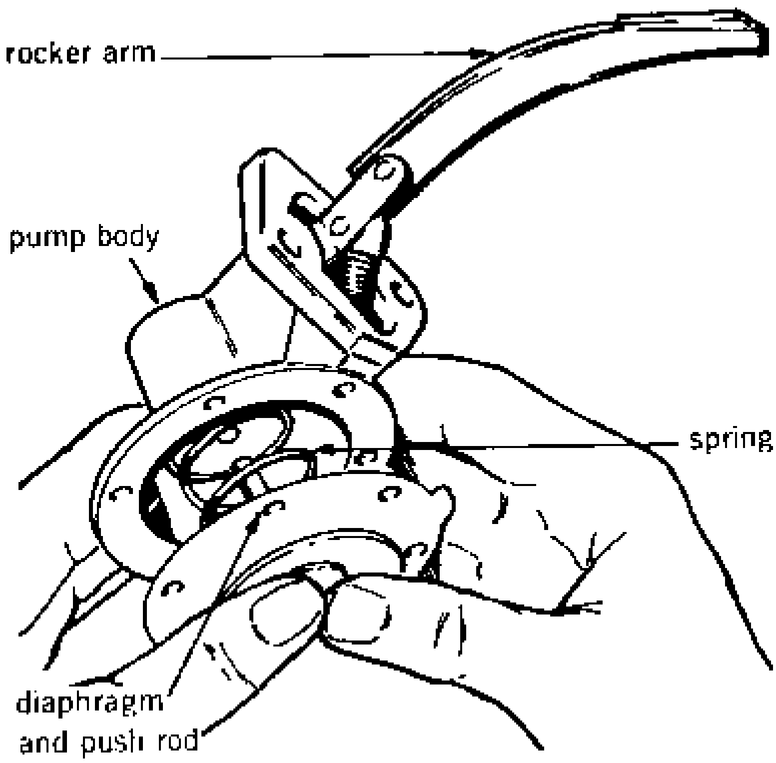



**Figure-4 Fitting a Diaphragm**

**Testing the Pump**

5. The pumping action of the unit needs before it is refitted on the engine, and if vacuum pressure testing equipment is not available; a simple but satisfactory test is to:

a. Connect the fuel supply line to the pump.

b. Operate the rocker arm: A well-defined spurt of fuel should leave the pump outlet each time the rocker is depressed and released.

c. Refit the pump to the engine.

d. Connect the fuel lines.

e. Run the engine to check for fuel leaks and satisfactory operation.

# BAF BASE ZAHURUL HAQUE (TRG WG)

## (Aero Engg Trg Sqn)

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **MTOF Basic Trade Training** |
| **Subject** | **:** | **Fuel and Carburetion Systems** |
| **Aim** | **:** | **To Study Requirements of Carburetion** |
| **Ref** | **:** | **The automobile – By Harbans Singh Reyat** |

---

## REQUIREMENTS OF CARBURETION

### Airflow

1. The airflow into the simple carburetor is in an upward direction but in actual practice it will be found that carburetors are designated as up draught, downdraught or horizontal draught, according to the direction of the airflow, the most widely used flow is the downdraught type, the reason for this being that power obtained is dependent upon the weight of mixture got into the cylinder and it is much easier for the air to flow downwards, aided by gravity, then it is to flow upwards or horizontally. The second requirement of a carburetor is to atomizer break up the gasoline and mixes it uniformly with the air flow. The spraying action of a carburetor helps to achieve this object and the design of the spray devices in particular carburetors is such as to further this aim. Also, when particular carburetors are being considered later, it will be noted that, for a definite reason, air is held into the gasoline system before it even reaches the discharge point, and these are also atomize the gasoline to a high degree.

### Vaporization

2. Vaporization is a change of state of the fuel from a liquid to a vapor. The last function of the carburetion process is to vaporize the liquid gasoline.

## Normal Aspiration

3. The basis of obtaining a mixture of gasoline and air in the cylinder, is by means of difference in pressures, or as it is commonly known, by normal aspiration. Atomization also is required for carburetion which is a mechanical breaking-up of the liquid fuel into small particles so that every minute particle of the fuel is surrounded by air. The ideal carburetor would pass a mixture of completely vaporized fuel and air in the proper proportion to the intake manifold and cylinders. Heated intake manifold and hotspots in the manifold vaporized part of the finely divided mixed or atomized fuel passed to the manifold by the carburetor.

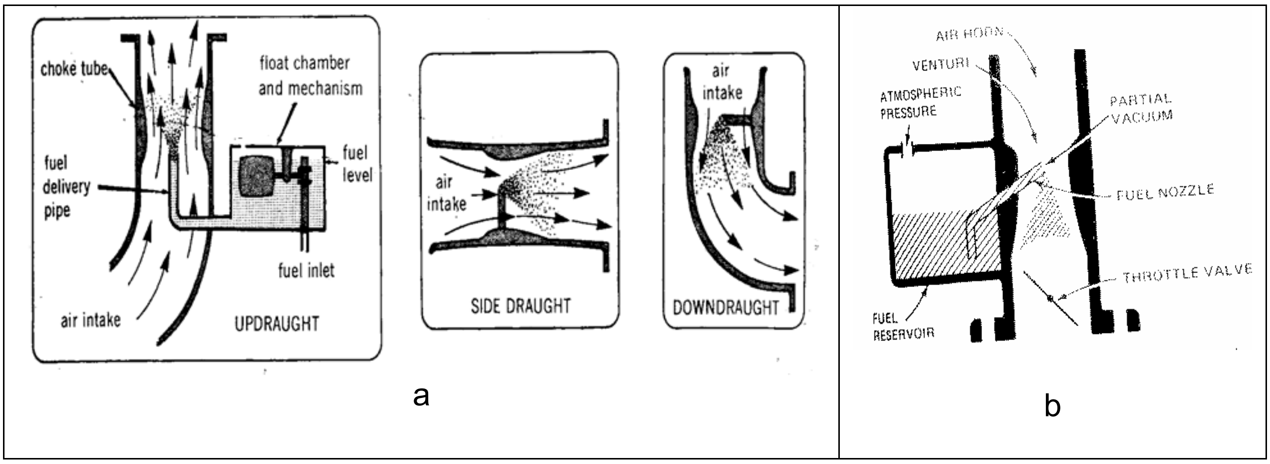



**Fig-5 a&b A Simple Carburetor**

# BAF BASE ZAHURUL HAQUE(TRG WG)

## (Aero Engg Trg Sqn)

**Syllabus : Automobile and Diesel Technology**

**Course : MTOF Basic Trade Training**

**Subject : Fuel and Carburetion Systems**

**Aim : To Study A Simple Carburetor**

**Ref : The Automobile – By Harbans Singh Reyat**

---

## A SIMPLE CARBURETOR

**Purpose**

1. The purpose of a simple carburetor is to supply a combustible mixture of air and fuel in correct proportions during all conditions of engine working.

**Construction**

2. A simple carburetor consists of the following two main parts:

a. **Float Chamber**. It is containing float, needle valve, metering jet and metering rod. The float chamber is a small tank or bowl incorporated in the carburetor in which the flow of fuel from the line is regulated by means of float controlled needle valve. The metering rod, if installed, measures the amount of fuel going out from the float chamber to the main nozzle. It works in the metering jet placed at the junction of main nozzle in the float chamber.

b. **Mixing Chamber**. It is long barrel attached to the float chamber, which contains venturi. The outlet of main nozzle opens at an angle in the venturui it contains two butterfly type valves, one fitted in the air horn or upper part of the barrel, known as choke valve and the other installed in the carburetor outlet known as throttle valve. The choke valve controls the flow of air into the mixing chamber and the throttle valve controls the flow of air fuel mixture from the carburetor to the engine.

**Operation**

3. The main nozzle keeps the same level of fuel as contained in the float chamber since one end of the nozzle is connected with the float chamber. This is upon the principle that the liquids keep equal levels. When engine intake valve is open during the suction stroke, the carburetor barrel is in line with the cylinder. Downward movement of the piston creates suction or vacuum in the cylinder. Suction leads to pressure difference between the cylinder and out side the carburetor. Air from the atmosphere rushes into the carburetor through the air cleaner. The passing in air sweeps over the mouth of fuel nozzle placed in the venturi due to which fuel is split up into fine particles and mixed with air resulting in air fuel mixture. The flow of air fuel mixture from the carburetor to the engine is controlled by the throttle valve that is operated by the accelerator. During cold starting, choke valve is closed through a choke cable. Closing of the choke valve causes greater pressure difference due to which more fuel flows out of the nozzle resulting in rich mixture.

# BAF BASE ZAHURUL HAQUE(TRG WG)

## (Aero Engg Trg Sqn)

**Syllabus : Automobile and Diesel Technology**

**Course : MTOF Basic Trade Training**

**Subject : Fuel and Carburetion Systems**

**Aim : To Study Circuits and Controls in the Carburetor**

**Ref : The Automobile – By Harbans Singh Reyat**

## CIRCUITS AND CONTROLS IN THE CARBURETOR

### General

1. The carburetor is subjected to supply suitable mixture of air and fuel during all condition of engine operation. To accomplish this, the carburetor must be provided with additional circuits and controls. The following are the main circuits and controls are required by the carburetor for its proper operation.

### Float Circuit

2. For regular atomization of fuel, it is necessary that the level of the fuel in the jet is always maintained at the same level. This is accomplished by means of float circuit. This circuit regulates the flow of fuel into the float chamber automatically through a float-operated needle valve. The needle valve is located in the entrance of float chamber. It is opened and closed through the float when it moves down and up due to fall and rise of fuel level in the float chamber. Fig-6shows the basic float system. The float level should be set accurately because if the fuel level is too low, engine efficiency shall be affected due to insufficient fuel supply to the jets. If the fuel is too high, too much fuel shall reach the jets resulting in overflow. The overflowing of fuel continues even when the engine is not running. Overflow leads to excessive fuel consumption, starting and operating troubles, carbon formation in the combustion chamber, crankcase oil dilution due to flow of liquid fuel past the pistons into the crank chamber and above all, wastage of useful fuel and fall in engine efficiency.

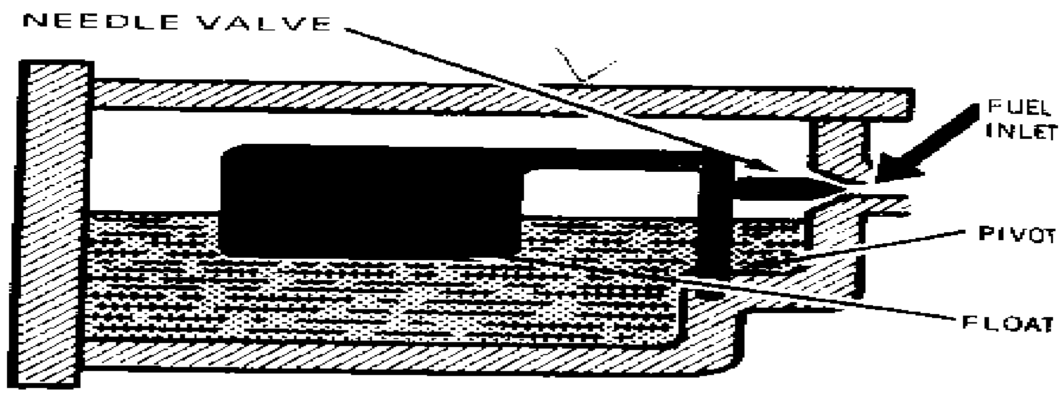



**Fig – 6 A Basic Carburetor Float Systems**

The float chamber contains a vent to admit outside atmospheric pressure. In some carburetors, the vent opens into the air horn on which air cleaner is installed. The air has to pass through the air cleaner before it enters the float chamber. This results in equized pressure on the fuel in the float chamber and on the flow of air through carburetor air horn. This is known as balancing. Carburetors provided with this type of arrangement are called balanced carburetors. In the balanced carburetors, restrictions due to accumulation of dirt in the air cleaner do not affect the fuel air ratio. During extremely hot weather, the fuel in float chamber vaporizes and leads to vapor lock. In the balanced carburetor, the vapors formed in the float chamber pass through the vent tube into the air stream in the air horn where they mix up with the air. This helps in eliminating vapor lock but enriches the fuel air mixture unnecessarily.

**Idle Circuit**

3. Fuel flows from the float chamber towards the mixing chamber through the idle circuit when the throttle valve is fully closed. During closed throttle, the engine suction acts at the tiny hole known as idle port, provided in the mixing chamber wall below the throttle disc. Discharge of fuel air mixture is at this hole. This idle passage is shown in the diagram. Air from the air horn enters into the idle passage through a hole and bypass provided in the upper part of the mixing chamber. The air sweeps over the slow running jet, contained in the passage connected with float chamber. This passage contains the same level of fuel as in the float chamber. The fuel particles are swept into the idle passage by the ingoing air. The air entering through the bypass helps in pushing down the heavier fuel particles. The discharge of fuel air particles is at idle port from where they travel into the engine. The idle port-hole contains a conical seat for the spring loaded idle mixture –adjusting screw. By turning the screw clockwise, the amount of fuel discharge from the idle port is decreased while turning the screw anti-clockwise, the discharge rate is increased. The idle circuit supplies fuel air mixture to the engine during its idle speed when throttle valve is closed. In the absence of idle circuit, the engine would stop with the closing of throttle valve. Fig-7 shows the idle system in a carburetor.

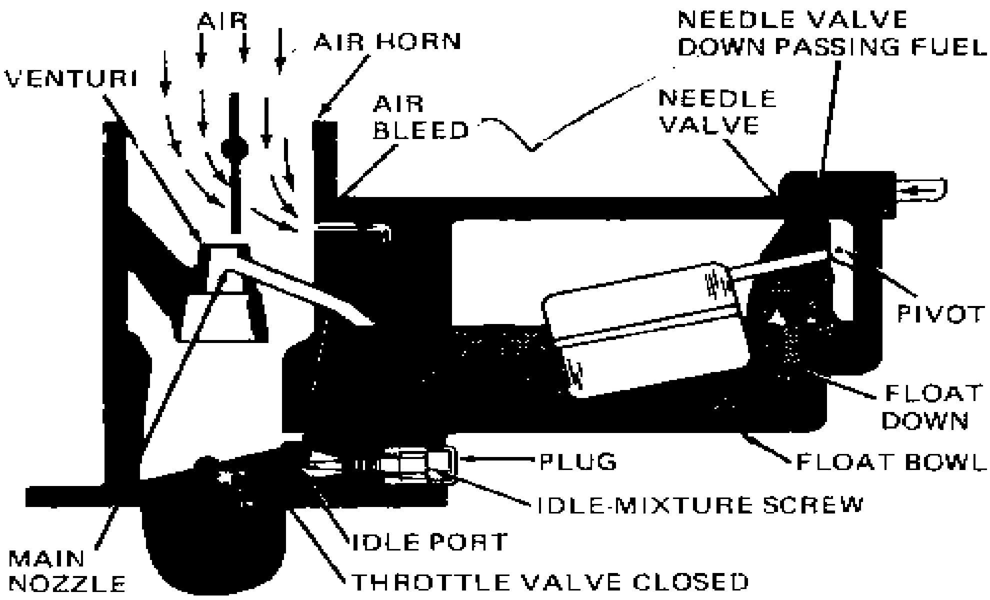



**Fig-7 Idle system in a carburetor.**

**Low Speed Circuit**

4. During low engine speed or slow running of the engine, the throttle valve is partly opened and the air from the air horn passes down by the sides of throttle disc. The throttle is operated by means of accelerator pedal. When the accelerator pedal is pressed down, throttle valve is opened, metering rod rises up and the pump plunger moves down in a carter like carburetor. When the metering rod rises up along with the opening of throttle valve, fuel flows into the main nozzle through the metering jet. The sweeping in air takes along with fuel particles from the main nozzle, the mixing of which results in fuel air mixture. Fig-8 shows the low speed operation.

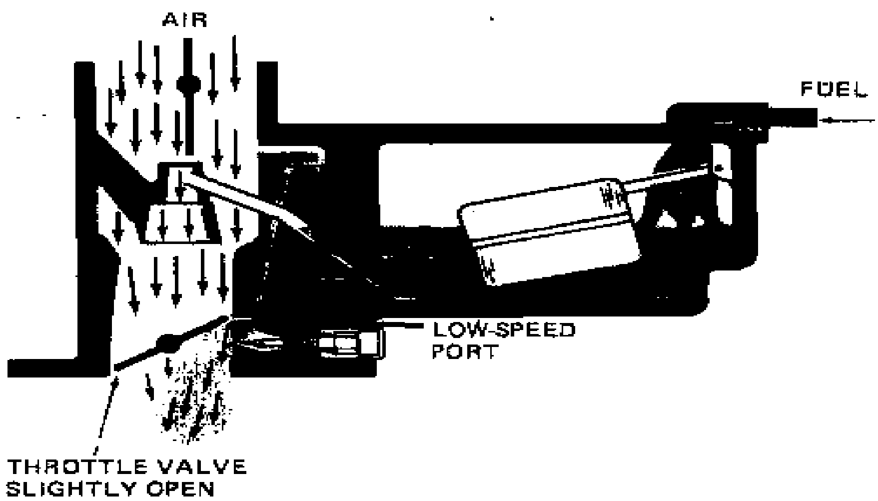



**Fig-8 Low speed operation.**

**High Speed Circuit**

5. The fuel flows through the same passage as in the low speed circuit and the operation is similar with the exception that the metering rod is raised high and throttle valve is wide open. So, proportionately, more fuel air mixture is supplied by the carburetor through this circuit. Fig-11 shows the high speed operation. In order that the correct mixture of fuel air may be supplied through this circuit during all speeds and throttle openings, compensating or air bleed arrangements are provided in the carburetors. In the compensating arrangement, an additional nozzle is provided which discharges fuel at the constant rate. In combination, the two nozzles supply a constant mixture. The main nozzle gets fuel directly from the float chamber whereas the compensating nozzle is fed through a standpipe. The upper end of standpipe is open to the atmosphere. The fuel enters the standpipe through a metered passage from the float chamber. The discharge rate of fuel from the compensating nozzle is constant as the flow of fuel into the standpipe is constant due to the constant level in the float chamber. At high engine speed, the compensating nozzle delivers less fuel than at low speed. This way, it compensates the tendency of main nozzle to supply a rich mixture at high speed or wide throttle. In air-bleed arrangement, air bleed holes are provided in the upper section of main nozzle at a point below the level of fuel in the nozzle. Introduction of air into the air bleed holes reduce the surface tension of

fuel and assists it to flow at low pressures. Air bleed also restricts the flow of the fuel through the main nozzle during high vacuum.
Flow of fuel at low pressure and a low rate, controls the fuel air ratio and offset the tendency of increasing the richness of mixture due to increasing air velocity. Thus by means of air-bleed arrangement, the increased richness of mixture is compensate and the fuel –air ratio is maintained at a constant rate. For maximum engine speed and power, additional fuel must be supplied. The economizer valve or power jet and the metering help in providing additional fuel for maximum power. The power jet is provided in ford carburetors. It is operated by the engine manifold vacuum. It is a diaphragm or plunger types no return valve. It opens to permit the required amount of fuel to passes through the main nozzle when engine vacuum is less. During idle speed or low speed, when throttle valve is fully or partly opened, the engine vacuum keeps the diaphragm or plunger pulled down resulting in closed position.

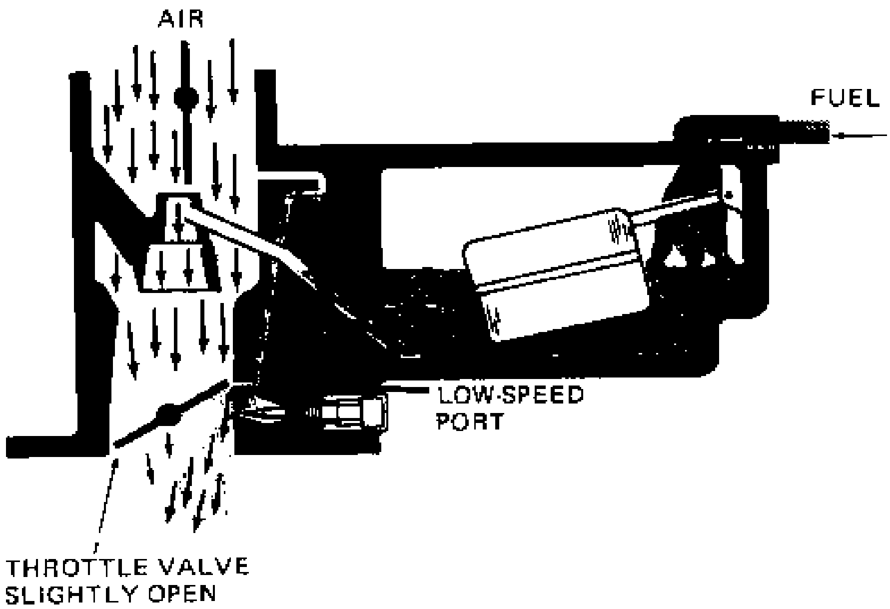



**Fig-9 High Speed Operation.**

The metering rod also assisting in supplying additional fuel for more power during high-speed circuit. The metering rod contains several steps pr tapers on its lower end and operates on a calibrated metering jet, which supplies fuel to the main nozzle. When in the high speed, throttle valve is wide opened, the metering rod is raising high and more fuel is permitted to flow through the circuit. Metering rod is also operated by means of a vacuum control piston as discussed above and shows in the diagram.

**Pump Circuit**

6. When the throttle valve is opened quickly for rapid acceleration, the fuel mixture tends to become lean due to the fact that fuel is heavier than air. The fuel lags behind the flow of air, resulting in lean mixture. In order to keep the fuel mixture of proper strength for more speed, additional fuel is injected directly in the air stream by means of a pump. Fig-10a&10b shows the operation of the pump circuit.

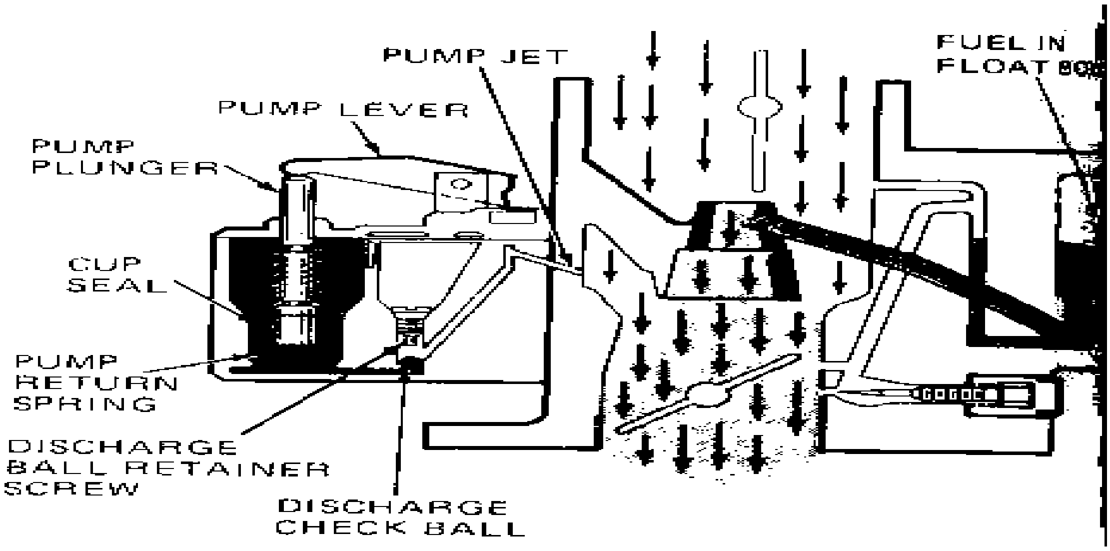



**Fig-10a Operation of Pump Circuit.**

The pump is operated by the accelerator and is related with throttle valve. The pump is of plunger or piston or diaphragm type. The stroke of the pump is adjustable through its operating link. The longer stroke provides the maximum amount of fuel and is usually used during cold weather. The plunger or piston or diaphragm works inside the pump well located in the float chamber.

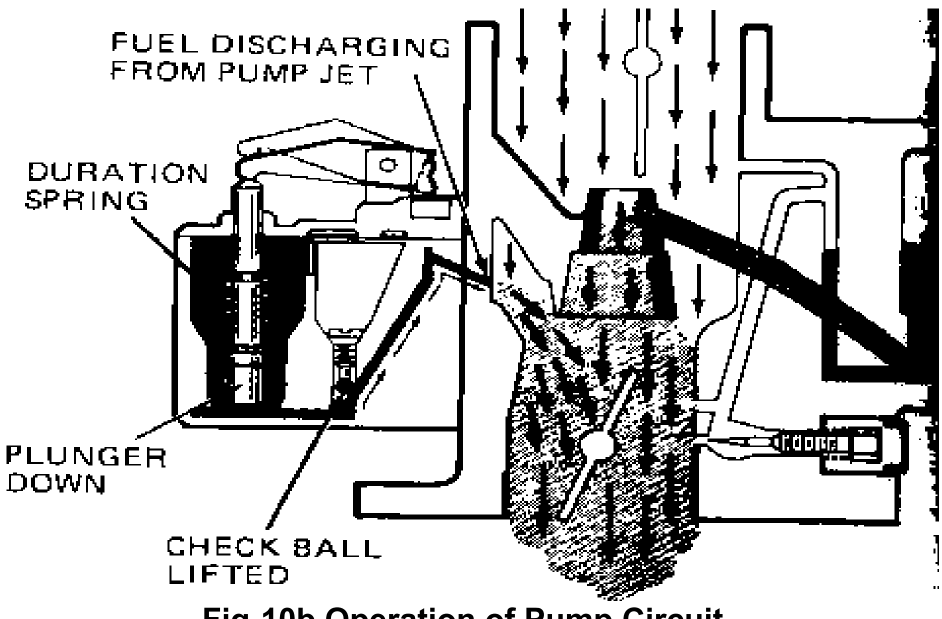



**Fig-10b Operation of Pump Circuit.**

**Choke Circuit**

7. Rich mixture is required for cold starting. The rich mixture is obtained by the application of choke. When choke valve is closed, the air enters in to the mixing chamber through a tiny hole, or a light spring loaded poppet valve in the butter fly disc or by the sides of the choke disc in case it is elliptical. The closing of choke valve caucuses greater pressure difference between the pressure affecting inside the mixing chamber and the pressure outside the carburetor. Pressure above the choke disc is much more than the pressure acting on the other side as the air passage decreases due to the closing of disc. The decreased air passage increases the air velocity and decreases the pressure inside the mixing chamber. The varying difference between the atmospheric pressures affecting the float chamber and the decreased pressure inside the mixing chamber causes the fuel to flow rapidly towards the mixing chamber which results in rich air fuel mixture. Some carburetors are provided with special passages which carry hot exhaust gases or hot engine water around the carburetor to keep it warm during cold weather to avoid icing in the carburetor (Fig-11).

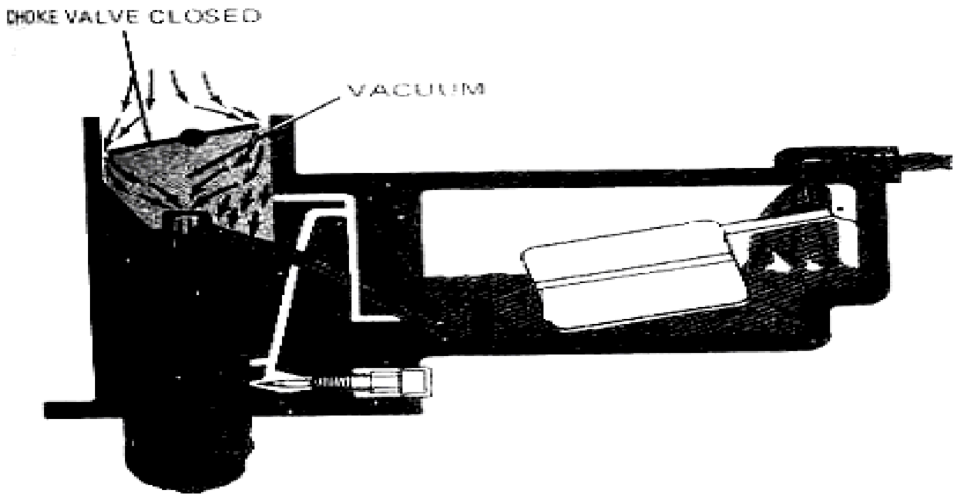



**Fig-11 Choke Circuit**

**Throttle Control**

8. As mentioned already, supply of air fuel mixture into the engine is controlled by means of throttle. The throttle is a butterfly or sleeve or disc type valve which opens or closes the passage for the flow of air fuel mixture into the engine. Butterfly valve is quite common. Sleeve valve is used in “Amal” carburetors applicable to motor cycles and disc valve is used in small carburetors just as one fitted with vespa scooter. The throttle valve is located in the throat of carburetor and is operated by the accelerator. It is connected with the accelerator pedal or twist grip by means of linkages or cables. More the throttle opening, more the engine speed and less the throttle opening, less the speed of the engine. Opening of the throttle valve is adjusted by means of a stopper screw known as slow running adjustment screw.

**Choke Control**

9. Choke in the carburetor helps in providing rich mixture for starting a cold engine. During cranking, vacuum affecting in the mixing chamber is sufficient to draw adequate fuel flow for starting. To produce sufficient fuel flow during cranking, the choke is installed in the carburetor. The choke is a butterfly type valve which is placed in the air horn. It is operated mechanically or automatically. In mechanically

operated choke, the butterfly valve is opened and closed by means of a cable and lever which is operated through a knob placed at the dash board. When the knob connected to the choke cable is pulled up, choke valve is closed which restricts the air passage and greater pressure difference is caused between the inside and outside the carburetor. Greater pressure difference causes greater vacuum inside the mixing chamber due to which more fuel flows out of the main nozzle resulting in rich mixture. When choke knob is pushed down, the choke valve is opened. If the driver forgets to push back choke knob, the carburetor will continue to supply a very rich mixture to the engine. The excessive rich mixture will cause poor engine performance and lead to carbon deposit inside the combustion chamber. In order to prevent this trouble, the cars are provided with automatic chokes. Most of the automatic chokes are operated thermostatically through the exhaust manifold temperature and induction manifold vacuum. The thermostatically controlled choke consists of a thermostatic spring and a vacuum piston or diaphragm which is linked with the choke valve. The thermostatic spring is made up of two different metal strips which are welded together and formed into a spiral. Due to difference in expansion rates of the two metals, the spring tends to wind or unwind with the changing temperature. During low temperature, spring is moved up and keeps the choke valve in the closed position. When the engine is cranked, a rich mixture is supplied to the engine. As the engine starts, movement of air through the air horn causes the choke valve to open slightly. Also the induction manifold vacuum acts upon the piston which is pulled outwards to open the choke valve further. When manifold vacuum falls down during high engine speed, the piston is pushed back due to which choke valve is closed, when the engine temperature is low. The thermostatic spring is enclosed in a housing which is connected to the exhaust manifold through a small tube. The exhaust gas circulates over the thermostat spring and warms it. Warming of the spring unwinds it which results in the choke valve to start opening. When operating temperature is reached, the thermostatic spring unwinds enough to keep open the choke valve up to full extent. When the engine is switched off and cools down, the thermostatic spring again winds up to close the choke valve. In some carburetors, hot water from the engine cooling system is used in place of exhaust hot gas from the exhaust manifold, to operate the thermostat spring. The operation of vacuum operated diaphragm in lieu of piston is quite similar.

**Throttle Cracker**

10. When the engine is cranked for starting, the throttle valve must be opened or cracked slightly so that enough air may pass it. A special linkage between the self-starter and the throttle linkage fulfills this necessity. When self-starter is operated, the throttle valve is opened slightly.

**Unloader**

11. When an engine does not start immediately, prolonged cranking will result in carburetor overflow. The mixture no longer remains vapor and goes to the engine in the liquid state, which is difficult to explode. In order to overcome this problem, special linkage is provided between the throttle and choke levers, which holds the choke valve, open when the accelerator is pushed to the floorboard. Then, when the engine is cranked again, the excessive petrol is cleared off as air enters the manifold and cylinders.

**BAF BASE ZAHARUL HAQUE ( TRG WG)**

**(AERO ENGG TRG SQN)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **MTOF Basic Trade Training** |
| **Subject** | **:** | **Fuel and Carburetion Systems** |
| **Aim** | **:** | **To Study Carter Carburetor** |
| **Ref** | **:** | **Practical Automobile Engineering** |

# CARTER CARBURETOR

**Purpose**

1. To keep the mixture strength constant through out the cruising speed (range).

**Principle**

2. It works on the principle of triple venturi.

**Construction**

3. Carter carburetor has five conventional circuits: float, low/idle circuit, high-speed circuit, pump and choke circuit.

a. **Float Circuit.** The float circuit is similar to that of other carburetors pump circuit. Using an inside vent the tube of which is connected into the air horn on the air-cleaner side of the choke valve.

b. **Low/Idle Speed Circuit.** The idle circuit passes fuel through the calibrated idle jets, where it mixes with air drawn in through the top air bleeds. The mixture then passes through a calibrate orifice where it is broken up into a finer mixture. Additional air, through the lower bleeds, mixes with this mixture and passes down the passage through the throttle body, where it is metered by the idle adjusting screw.

c. **High Speed Circuit.** The high-speed circuit incorporates a vacuum system of operating the metering rods. The main discharge nozzles are pressed into place and are not removable. The anti-percolator well vents the well to atmosphere during idle operation, but affects a balance between the high-speed passages during high-speed operation, practically eliminating any back bleeding of air into the carburetor’s high-speed circuit.

d. **Pump Circuit.** The pump contains a double-spring type plunger, delayed action being controlled by the compression of the upper spring and by the ratio of compression of the lower one. The pump discharge is then fed into a small pocket at the pump jet-cluster and feeds from there into the discharge jets. This small pocket is vented to atmosphere to prevent pump pull-over at constant throttle operation. Repeated pressing of the accelerator with the engine switch off will force fuel out of the vent to the outside of the carburetor.

e. **Choke Circuit.** The choke is a round valve, shaped like the throttle valve located in the top of air horn. It is controlled mechanically or by an automatic device. When choke is closed, it is almost horizontal. Only a small amount of air can get pass it. The valve has “choked off” the airflow.

**Operation**

3. When the engine is cranked, a fairly high vacuum develops in the air horn. This vacuum causes the main nozzle to discharge a heavy stream of fuel. The quantity delivered is sufficient to produce the air-fuel mixture needed for starting the engine. The engine is starting condition .Now, throttle valve is opened slightly, the edge of the throttle valve moves past the low-speed circuit in the side of the air horn. Therefore, additional fuel is fed into the intake manifold through the low-speed circuit. This fuel mixes with the additional air moving past the slightly opened throttle valve. When the throttle is widely opened, the metering rod is lifted enough to cause the smaller diameter of the rod to move up into the metering-rod jet. Now, the jet is less restricted and more fuel can flow. The main nozzle is therefore supplied with more fuel and the resulting air-fuel mixture is richer. For acceleration, the carburetor must deliver additional fuel. Rapid opening of the throttle allows a sudden inrush of air. This causes a sudden demand for additional fuel. When the throttle is opened, the pump lever pushes the pump plunger down against the return spring. This downward movement of the plunger causes pressure over the fuel and fuel is flown through pump jet. Then fuel enters into the air horn and pump will discharge fuel for several seconds or until the power system can take over. The result is smooth acceleration.

## FAULTS AND RECTIFICATION OF CARBURETOR

| | Fault | Possible Cause | Remedy |
|---|---|---|---|
| 1. | Fuel extravagance | (a) Enlarge main jet | a. Fit a new main jet of correct size |
| | | (b) Flooding | b. Check the needle valve for cleanliness and wear |
| | | (c) Cold starter not closing | c. Adjust cold starter or strangler as applicable |
| | | (d) Choked air cleaner | d. Remove, clean and refit the air cleaner |

| | | |
|---|---|---|
| 2. Knocking with overheating | (a) Mixture to lean | a. Fit a new main jet, one size larger than the original |
| 3. Bad slow running | (a) Incorrect adjustment of carburetor | (a) Adjust carburetor to suit the engine with which it is being used |
| | (b) Main jet to large enough | (b) Fit a large main jet than is normally necessary for the vehicle |
| 4. Lack of maximum speed | (a) Choke tube and main jet too small | (a) Fit a larger choke tube and main jet |
| | (b) Over corrected | (b) Adjust |
| | (c) Main jet too small | (c) Fit a larger main jet |
| | (d) Fuel supply restricted | (d) Check the fuel pump for faults, and the supply and delivery pipes for obstruction, adjust as necessary |

| **Fault** | **Possible Cause** | **Remedy** |
|---|---|---|
| 5. Bad acceleration and flat spots | (a) Insufficient correction | (a) Adjust the correction |
| | (b) Choke tube too big | (b) Fit a smaller choke tube |
| | (c) Main jet too small | (c) Fit a larger main jet |
| | (d) Carburetor pump failure | (d) Clean the two non-return valve |
| 6. Complete impossibility of acceleration | (a) With starting and idling possible, an obstruction of the main jet | (a) Remove, examine, clean and refit the main jet |
| 7. Hard starting with a hot engine | (a) Over richness with a downdraught type carburetor | (a) Examine and clean the downdraught carburetor induction manifold draining orifice |
| | (b) Over richness with a horizontal and vertical carburetors | (b) Open the throttle fully and turn the engine a number of times |

| | | |
|---|---|---|
| 8. Hard starting with a separate starter and a cold engine | (a) Gasoline jet too small | (a) Fit a larger starter gasoline jet |
| | (b) If the engine fires a few times and then stops (often repeated), the air and gasoline jets of the starter too small | (b) Fit larger air and gasoline jets |
| 8. Flooding | (a) Loose joints | (a) Check and adjust all exterior joints |
| | (b) Dirt on the needle seating. | (b) Remove needle and clean it and the seating |
| | (c) Puncture float | (c) Renew the float or solder the point of leakage |
| | (d) Fuel pressure excessive | (d) Remove, check, adjust and refit the fuel pump. For a quick temporary adjustment fit a new needle valve one size smaller than the original |
| 9. Knocking without over heating | (1) Over advancement of ignition | (1) Adjust the ignition |

## BAF BASE ZAHURUL HAQUE
**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **MTOF Basic Trade Training** |
| **Subject** | **:** | **Fuel System of Diesel Engine** |
| **A i m** | **:** | **To Study Fuel** |
| **Ref** | **:** | **A.P. 3159 Section 5, Chapter 1** |

# FUEL

**Description**

1. The word "Diesel" is still widely used when referring to compression ignition engine fuels, which are the heavier distillates of petroleum crude's after the kerosine fractions have been removed, or with heavier diesel fuels, blends of the distillates and residual fuel oil. Low speed engines can use the heavier blends of fuels but high speed compression ignition engines require the lighter blends, being no less sensitive to the quality of the fuel than high efficiency gasoline engines. The fuel used in compression ignition engines is unlike gasoline in many ways:

  a. It does not vaporize at low temperature.

  b. Its flash point is much higher than that of gasoline, thus reducing the fire risk.

  c. It has lubricating qualities, which are utilized in the pump mechanism.

  d. Its specific gravity is higher than that of gasoline i.e. a greater weight of fuel for the same volume.

  e. It has greater penetrative power, so that joints etc. must be joined oil tight fit.

Ignition Qualities

2. The most important quality of a fuel for a high-speed compression ignition engine is its ignition quality or its willingness for self-ignition with the least delay after the beginning of injection. All most all-modern compression ignition engines are of the "solid injection" type, in which fuel only is sprayed into the combustion chamber, without the helps of the compressed air, which was used in many of the older engines. Injection commences before the end of the compression stroke, but the fuel does not ignite immediately it is injected; the reason for the delay or "Ignition Lag" leads to combustion knock, because a comparatively large amount of fuel accumulates in the combustion chamber and once ignition starts all of this fuel burns very rapidly, causing a rapid rise of temperature and pressure which results in combustion knock the delay time increases with reduction in temperature, therefore, if the temperature is very low, the delay time may be such that ignition cannot commence in the time available thus fuels with high quality make starting easier. Engine operating conditions such as compression ratio, degree of air turbulence and intake air temperature, coolant temperature injection timing and engine speed, also have considerable bearing on the delay time fuel properties are equally important. The higher the speed of the engine, the higher in the ignition quality of the fuel required.

**Cetane Number**

3. The service designation of a diesel fuel appears as a number and the words "Dieso" which indicates that the fuel has a Cetane number, which is similar to the octane number for fuel used by spark ignition engine. The reference fuel of good self-ignition quality for comparative testing purposes is hexadecane of Cetane as it is more usual called. The complimentary fuel of very low ignition quality with which Cetane is blended is alphmethlnathalene. The cetane number of a fuel is the percentage by volume of Cetane in a blend with alphmethlnathalene, which has the same ignition quality as the sample fuel when tested in the same engine under the same conditions; this number ranges from 30 to 70.

## BAF BASE ZAHURUL HAQUE

**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **MTOF Basic Trade Training** |
| **Subject** | **:** | **Fuel System of Diesel Engine** |
| **A i m** | **:** | **To Study Comparison of C.I Engine** |
| **Ref** | **:** | **A.P. 3159 Section 4, Chapter 1.** |

]

## COMPARISON OF C.I ENGINE

**Comparison**

1. Although the gasoline (spark ignition) engine and the C I engine are similar in construction in many ways, still a lot many differences are there. These differences are furnished below:

| **Petrol Engine** | **Diesel Engine** |
|---|---|
| a. Mixture of petrol and air is drawn during intake stroke. | a. Only air is drawn during intake stroke. |
| b. Mixture is ignited by means of a spark supplied by the sparking plug at the end of compression stroke. | b. A t the end of the compression to stroke, injector supplies the atomized fuel in the combustion chamber which comes in contact with the compressed hot air and it is ignited. |
| c. Comparatively lower compression ratio usually between 5 to 9: 1 | c. Comparatively higher compression ratio usually between 14-20:1. |
| d. Comparatively lower compression pressure (Average compression pressure is 100 psi) | d. Comparatively higher compression pressure (Average compression pressure is 500 psi) |
| e. Comparatively lower temperature of the compressed fuel and air mixture usually between $60^0$C to $80^0$C. | e. Comparative higher temperature of the compressed air usually between $500^0$ to $800^0$C |
| f. It has carburetor for supply of fuel and air mixture; spark plug, distributor for magneto for the supply of spark. | f. No carburetor, spark plug, distributor or magneto are required but in lieu of that injector and fuel injection p ump is fitted. |
| g. High speed engine | g. Comparatively low speed engine. |

| | |
|---|---|
| h. Light in construction | h. Heavy in construction |
| j. Initial cost is less. | j. Initial cost is higher. |
| k. Produces less torque | k. Produces better torque. |

and motor cars than in heavy good vehicles. Both rpm and power output of the gasoline engine are controlled by varying the throttle valve setting which, in turn, alters the amount of both air and gasoline that is fed to the cylinders. The compression ignition engine does not throttle the air supply and, therefore, the amount xxx entering the cylinders per revolution is almost constant for normally aspirated engines, and the power output and rpm are altered by varying the amount of fuel oil that is injected into the cylinders, with the pumping action of the pistons taking care of the air supply within the capabilities of the engine. Because the compression ignition engine runs at higher pressures and is less smooth in operation, it is of heavier construction and physically larger than a gasoline engine of similar power output and thus is more suited or use in heavy commercial vehicles than in motor cars. It is also less inclined to rev freely generally has a maximum rpm of a lower value than a gasoline engine. The compression ignition engine is completely free from pre-ignition problems because air alone is compressed with gas pre-ignition detonation limits the compression ratio of the gasoline engine. Within xx the higher compression ratio the more efficient is the engine.

**Advantages**

2. The C.I. engine offers certain advantages for long distance commercial use, these are:

a. More economical fuel consumption.

b. Less risk of fire (diesel oil has at higher flash point than gasoline).

c. A more reliable power unit.

d. Longer life between overhauls.

e. Better low speed torque.

f. Less harmful pollution from the exhaust of correctly adjusted engines.

**BAF BASE ZAHURUL HAQUE**
**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **MTOF Basic Trade Training** |
| **Subject** | **:** | **Fuel System of Diesel Engine** |
| **A i m** | **:** | **To Study Starting Device** |
| **Ref** | **:** | **A.P. 3159** |

# STARTING DEVICE

**Purpose**

1. To overcome the difficulty of starting C.I Engine, in cold weather, especially it is applicable for the engine of pre-combustion chambers or indirect injection type.

**Types**

2. a. **Heater Plug.** Heater plug. The heater plug is screwed into the pre-combustion chamber of each cylinder in the manner of a sparking plug. A wire element glows red-hot when current from the battery is passed through it by closing a switch. The switch is kept closed for 30 seconds, during which time the combustion chamber walls are heated, and then the starter is operated. A warning light indicates when the heater plugs are switched on (Fig-1).

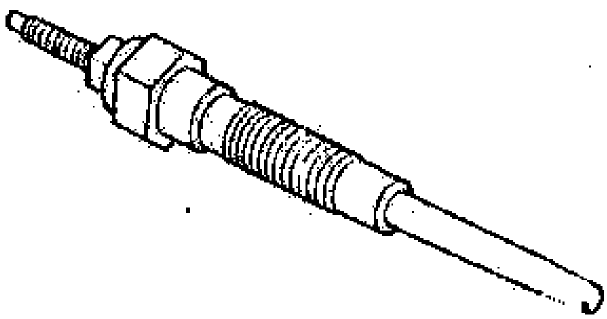


*Fig-1 Heater Plug*

b. **Compression ratio change over Valve.** It has been stated previously that indirect injection type engines require some aid to starting; this is achieved on some engines by using a device, which raises the compression ratio during starting to a higher degree than that used during normal running. This device is known as the compression ratio change over valve and a typical is shown in Fig. 5.1.6. It will be seen that the cylinder head incorporates double combustion chambers for each cylinder, each secondary chamber being connected to its main chamber by a throat or passage, which can be opened or closed by operation of the hand operated change over valve. Under ordinary running conditions the valve is held in the retracted position by a spring, so that the connecting throat between the two combustion chambers is open and both chambers are used.

To provide the higher compression required when starting the valve lever is lifted until the end of the plunger seals the passage between the two chambers thus confining combustion to the main chamber (Fig-2).

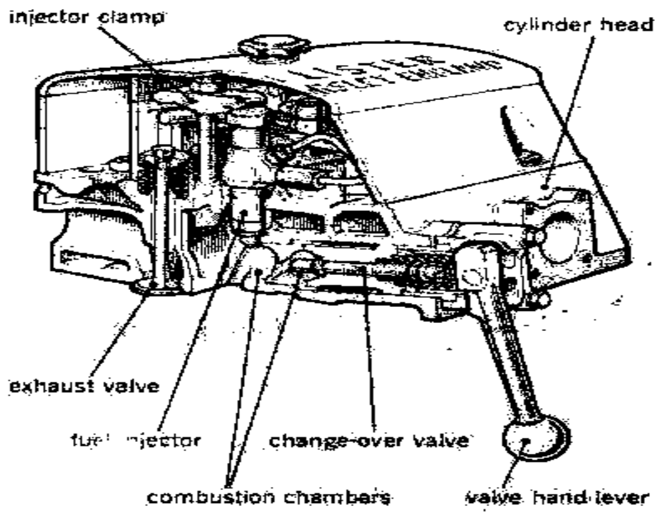



**Fig-2 Compression ratio change over Valve**

# BAF BASE ZAHURUL HAQUE

**(Aero Engg Trg Sqn)**

**Syllabus : Automobile and Diesel Technology**

**Course : MTOF Basic Trade Training**

**Subject : Fuel System of Diesel Engine**

**Aim : To study CAV Fuel Feed Pump**

**Ref : A.P. 1464, Vol-1, Book-1, Part-1, Sec-2, Chap-9.**

---

## CAV FUEL FEED PUMP

### General

1. This chapter describes the two plunger type feed pumps BFP/K22/N2 and the diaphragm-type pumps DFP1, DFP2, DFP3, and DFP6.The two plunger-type pumps are identical except for an additional connection on the inlet side of the N62 pump which drains excess fuel from the relief valve of the main filter. The diaphragm pumps are intended for use with BPE, N and NN and the AA range of fuel injection pumps respectively. Although a priming device is fitted to the plunger-type pumps the primer is supplied under its own Ref. No. 16K/8310.The feed pump is flange-fitted to the injection pump and operated by an eccentric on the injection pump camshaft. Diaphragm pumps are capable of delivering a pressure of 41/2 ib/in2 but higher pressure up to 28 ib/in2 may be obtained when a plunger is fitted to the diaphragm spindle. The diaphragm-type pumps may be fitted with a second diaphragm to act ass a seal and prevent leakage of fuel into the injection pump cam box and may deliver the fuel through an internal passage instead of via an external filter. When due to a hydraulic governor or internal gravity vent valve being fitted, it is found necessary too remove excess fuel from the cam box, a scavenge pump is fitted to the feed pump is fitted to the feed pump and return excess fuel to the tank.

Construction of Plunger Type Pump

2. Fig.3-shows sectional view of the pump with the priming device fitted above the inlet valve. The feed pump comprises a cast one-piece body (17) with machine chambers to accommodate the fuel inlet (11) and outlet (1) connections, inlet (9) and outlet (3) valves, and the pump plunger (15)

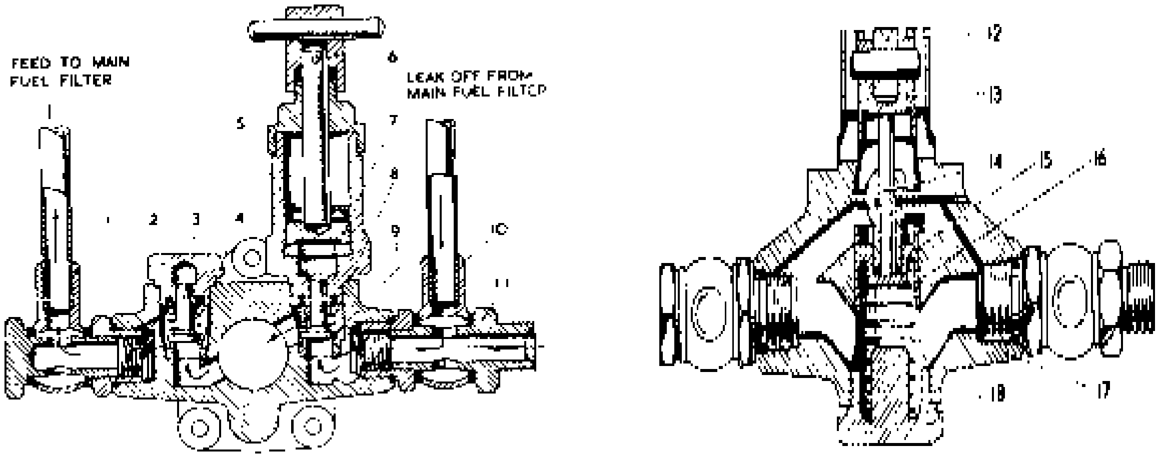



**Fig 3 Plunger type pump-sectional views**

Passages, interrupted by the spring -loaded inlet and outlet valves, connect the inlet and outlet chambers to the plunger chamber. Normally, the two valve chamber are sealed by plugs, which also serve as guides for the valve steams, but when the priming device is fitted, this replaces the plugs over the inlet valve. The plunger pump is sealed at one end by a plug (18) which also houses one end of the plunger spring (16) , whilst the casing at the opposite end oft he plunger chamber is drilled concentrically with the chamber to house a spindle (14) which transmits the movement of the cam roller (12) to the plunger. A circumferential groove in the spindle is connected by a passage to the inlet chamber. This arrangement ensures that the fuel, which would otherwise leak past the spindle into the injection pump casing, is drawn back in to the feed pump on the suction stroke.

## Operation

3. The functioning of the pump can be more easily followed from the diagrammatic sketches in fig 4. For the purposes of description, that part of the plunger chamber occupied by the plunger spring will be called inner chamber and that on the other side of the plunger, the outer chamber.

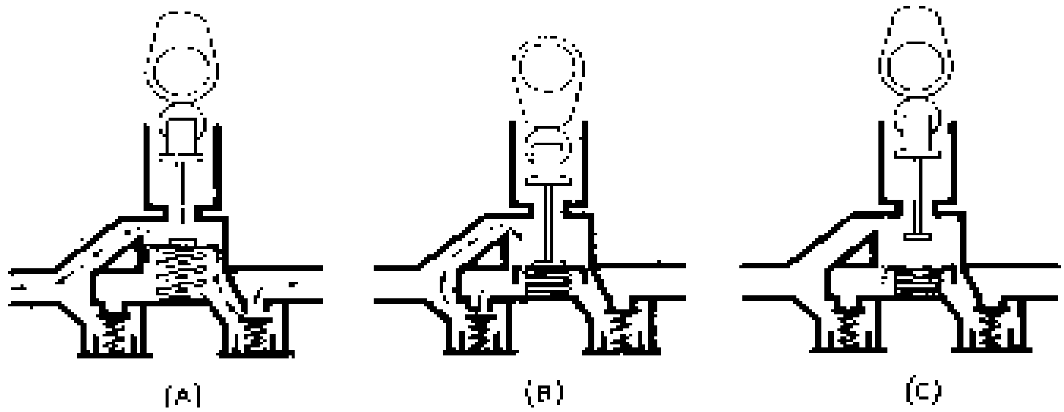



**Fig 4 Functional diagram**

If, it is assumed that the pump is primed, then as the cam moves from the position of maximum lift to that of minimum lift (fig.4A), the plunger spring, which has been compressed in the previous stroke, reasserts itself and forces the plunger down the chamber. This plunger movement lifts the inlet valve off its seat, by suction, and fuel is drawn into the inner chamber. During the same movement, fuel is forced from the outer chamber, along the connecting passage to the fuel outlet. As the cam moves from minimum to maximum lift (fig 4B) the plunger movement lift the outlet valve, by fluid pressure, which also augments the spring pressure to close the inlet valve, the fuel in the inner chamber is forced out, through the connecting passage, to the outlet connection and the outer chamber. When the pressure of the fuel in the fuel delivery pipe, which is connected to the outer chamber, balances that of the plunger spring, the plunger will remain stationary , or visually so, as shown in (fig,4C) and will remain thus until the consumption of fuel reduces the pressure in the delivery outlet, excess fuel supply is thus obviated.

# BAF BASE ZAHURUL HAQUE

**(Aero Engg Trg Sqn)**

**Syllabus : Automobile and Diesel Technology**

**Course : MTOF Basic Trade Training**

**Subject : Fuel System of Diesel Engine**

**Aim : To Study Fuel Injection Pump**

**Ref : A.P. 3159 Section 5.**

---

## FUEL INJECTION PUMP

### Introduction

1. This chapter describes the CAV. Type BPE fuel injection pump and also applies to the Type BPE. The Type BPE is an enclosed camshaft type, that is, a camshaft is incorporated in the pump casing. Type BPF pumps do not incorporate a camshaft and are flange mounted on the engine over the engine designer's own operating gear. Type BPE is the type in most general use and incorporates all the fundamental features of the Type BPF, hence this chapter applies equally to both types.

Identification plate

2. Type BPF fuel injection pumps are fitted with an identification plate inscribed with type formula for the pump and it is essential that this formula is correctly understood. Before considering the formula in detail it should be understood, that when facing the inspection plate of the pump, the left-hand end of the housing is No. 1 end, and the right-hand end is No.2. Also a notch or sawent will be found marked on the extreme end of one of the threaded ends of the camshaft fitted to 4.6 and 8 cylinder, Type BPE fuel injection pumps. This is an assembly mark as explained in the formula.

A typical identification plate might read BPE680Q320S626 and is explained as:

a. **BP** – stands for British made pump. AP would mean American made and **P** German.

b. **E** - Indicates that the pump camshaft is enclosed in the pump easing F would indicate flange fixing without camshaft.

c. **6** - Indicates the number of elements m the pump according to the number of cylinders in the engine it is designed to serve.

d. **B** - Indicates the plunger stroke size. B size pumps have a stroke of 10 mm and are suitable for all medium and heavy vehicles and similar size engines.

e**.** **80** – Is the diameter of the pump plunger expressed in tenths of a millimeter?

f. **Q** – Design Change letter. Each change of design takes a new letter.

g. **320** – Assembly numbers.

h. **<u>Hundreds Figure</u>**

**1**-Camshaft notch at no 1 end, no fuel feed pump flange on the pump housing.

**2**- Camshaft notch at no –2 end, no fuel feed pump flange on the pump housing.

**3**- Camshaft notch at No 1 end, fuel feed pump can be fitted.

**4**- Camshaft notch at No 2 end, fuel feed pump can be fitted.

j. **<u>Ten Figure</u>**

**0**- Without governor.

**1**- With governor at No 1 end.

**2**- With governor at no 2 end

k. **<u>Unit Figure</u>**

**0**- Without injection advance device.

**1**- With injection advance device at No 1 end.

**2**- With injection advance device at No 2 end.

**/3**- After **320** in the assembly no indicates that a blanking plate is fitted instead of a fuel feed pump.

l. **S626** Indicates special feature to engine manufactures.

# BAF BASE ZAHURUL HAQUE

**(Aero Engg Trg Sqn)**

**Syllabus : Automobile and Diesel Technology**

**Course : MTOF Basic Trade Training**

**Subject : Fuel System of Diesel Engine**

**A i m : To Study C A V Fuel Injection Pump**

**Ref : A.P. 3159 Section 5.**

---

## CAV FUEL INJECTION PUMP

### Purpose

1. The purpose of fuel injection pump is to deliver correct quantity of fuel in right time to the engine cylinder in equiangular interval of time in relation with the piston position.

### Construction

**2. a.** Pump Casing. **The pump casing is an aluminum alloy casting formed with three longitudinal chambers. The base chamber houses the camshaft, which is supposed in bearing housings secured to each end of the casing. Above this is a larger chamber which houses the control mechanism of the plunger pumps, it is fitted with an inspection plate over a full length opening on the front of the casing, thus providing access to the units for assembly and adjustment. A gallery which runs the full length of the upper part of the casing is the fuel suction chamber. This gallery terminates at each end of the casing with a screwed plug hole, to one of which the delivery pipe is fitted; either end may be used for fuel delivery, the other end being plugged. The pump casing is suitably bored for the fitting of plunger p ump assemblies, camshaft and control rod. A heavy section web above the camshaft chamber incorporates the taper guides, these being bored and slotted in the web. Communicating with the sump of the camshaft, the casing is fitted with a dipstick and oil filler, as well as a drain plug. Mounting for a fuel feed pump is provided near the base at the front of the casing and, if a pump is not fitted, the opening is closed by a cover plate. Four lugs, one near each corner of the casing are for mounting the injection pump on the engine.**

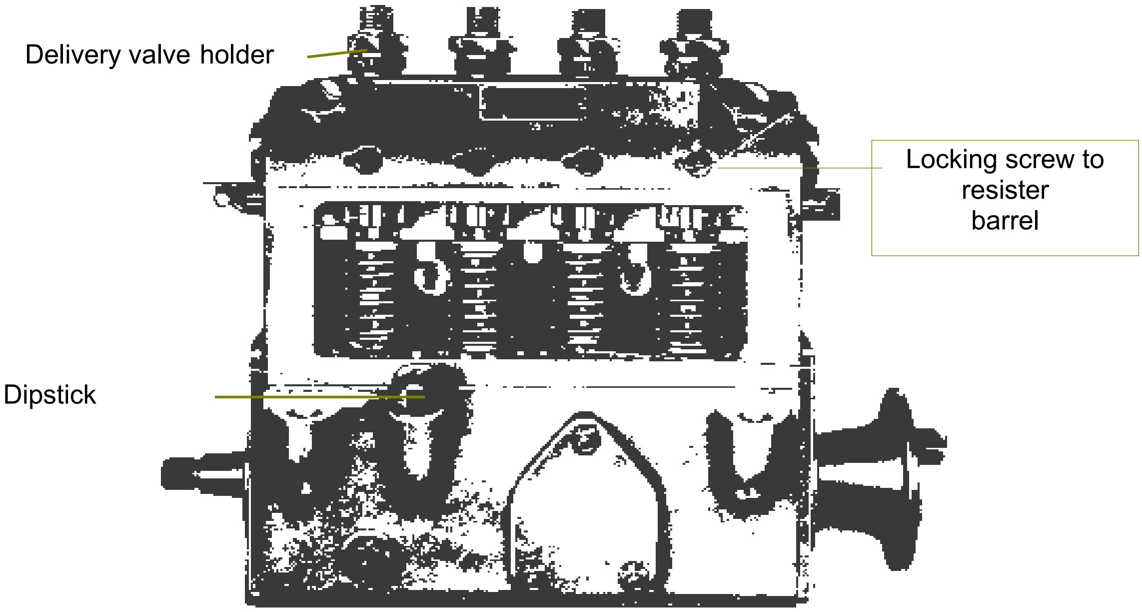
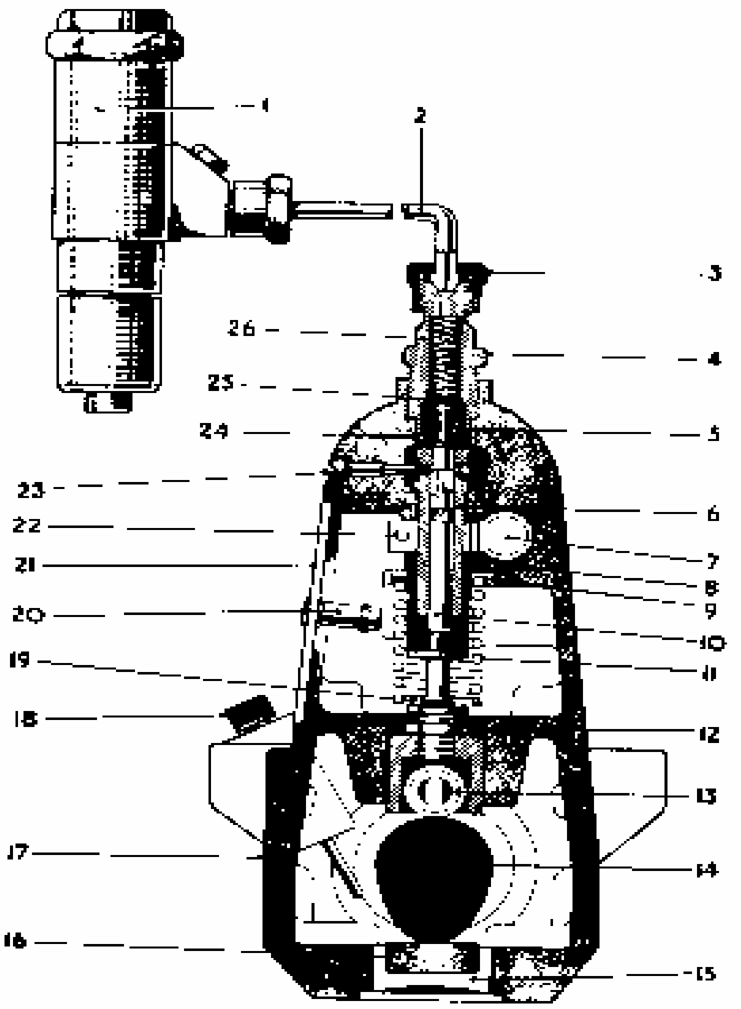



**Fig.5 Pump Casing**

**b.** Plunger Pump Assemblies**.** **Figure 6 shows a cross section of an injection pump through one of the plunger pump through one of the plunger pump assemblies. Each plunger pump assembly consists of a pump element and a delivery valve. The pump element comprises a plunger, barrel, regulating sleeve, regulating quadrant and return spring the delivery valve has a valve, valve seating, spring and valve holder.**




Fig, 6 Section of plunger pump assembly

## Key way to fig, 6

| | | | |
|---|---|---|---|
| 1. | Injector | 14. | Cam |
| 2. | Delivery pipe | 15. | Closing plug |
| 3. | Union nut | 16. | Felt pad |
| 4. | Valve housing | 17. | Pump |
| 5. | Valve seat | 18. | Dipstick |
| 6. | Barrel | 19. | Lower spring plate |
| 7. | Control rod | 20. | Inspection plate screw |
| 8. | Regulating sleeve | 21. | Inspection plate |
| 9. | Upper spring plate | 22. | Regulating quadrant |
| 10. | Plunger | 23. | Barrel locking screw |
| 11. | Return spring | 24. | Seating washer |
| 12. | Tappet | 25. | Valve |
| 13. | Tappet roller | 26. | Valve spring |

**(1)** Pump Element. **The pump elements are the following parts:**

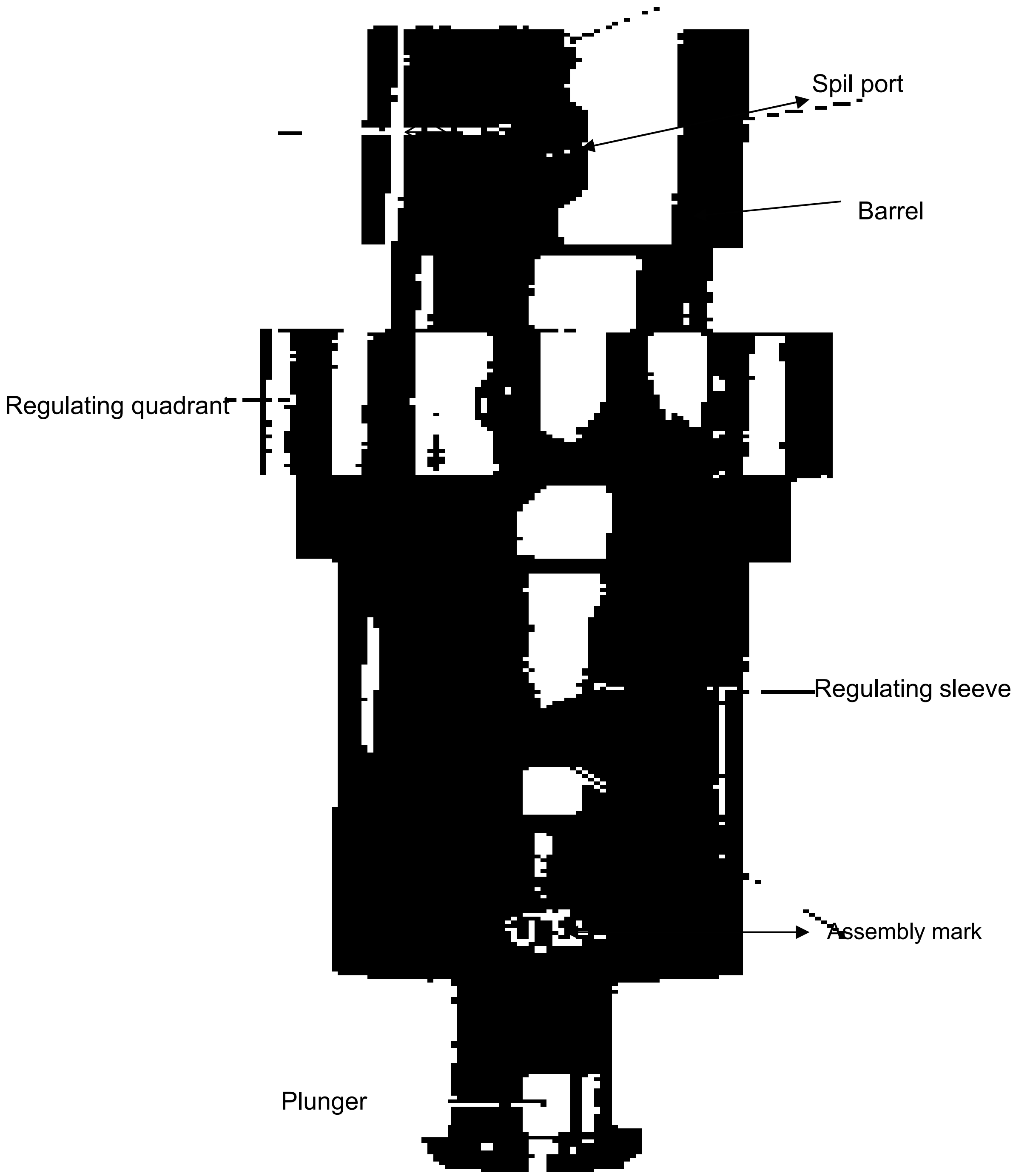



**Fig 7 Assembly of Pump Elements**

(a) **Plunger.** The plunger operates in the barrel, both parts being made of hardened steel, ground and finished to precision limits; each pair must be regarded as inseparable and must not be interchanged. The pumping end of the plunger is wasted, the top edge being in the shape of a helix; this provides an angular space of increasing depth on its circumference, starting from a minimum and at its maximum depth terminates with a vertical slot in the side of the plunger. Two lugs on the lower portion of the plunger engage in slots cut in the regulating sleeve, thus enabling the plunger to be rotated in the sleeve whilst working. Below the lugs is a shoulder for sealing the plunger spring retaining plate and a hardened contact for the tappet.

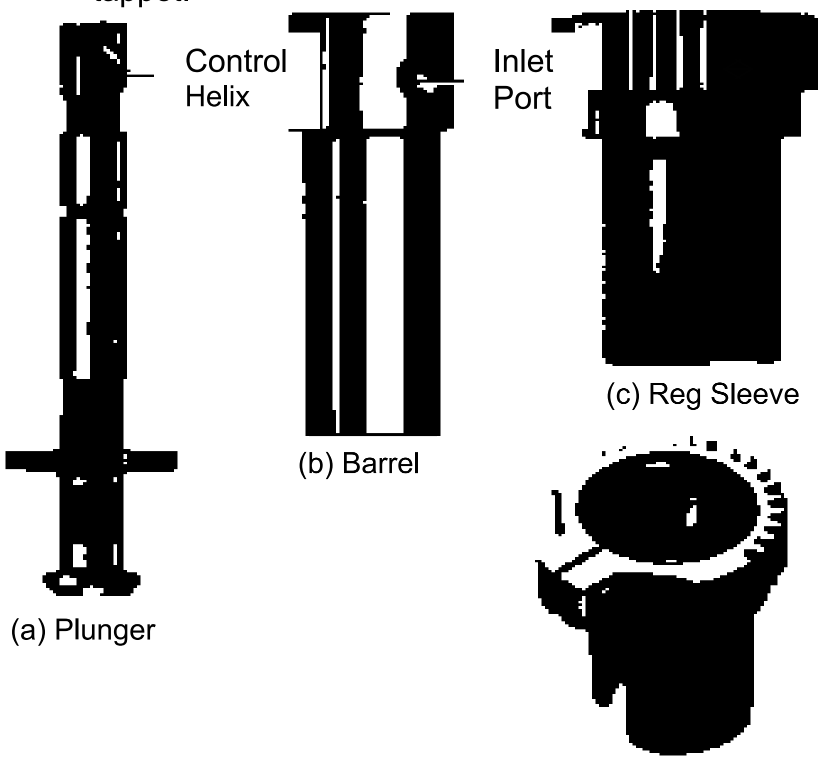



Fig 8, Components of the pump element

(b) **Barrel.** The barrel in which the plunger operates is secured in the casing by the delivery valve holder and butts on a shoulder against the top of the web forming the fuel suction chamber. The barrel has two ports which communicate with the fuel suction chamber and which are uncovered by the plunger when it is at the bottom of its stroke. A slotted recess in one of the ports is engaged by a locking screw in the front of the casing and serves to register the barrel axially.

(c) **Regulating sleeve.** The regulating sleeve fits over the lower end of the barrel about which it is free to oscillate. Two slots at the lower end of the sleeve engage the plunger lugs to impart axis movement to the plunger, such movement being applied by a gear segment, namely the regulating quadrant, clamped to the top end of the sleeve.

(d) **Regulating quadrant .** The regulating quadrant is formed as part of a spur gear, concentric with the centre of the regulating sleeve. It incorporates two clamping straps, which fit round. the top of the regulating sleeve, each strap having a lug drilled for a clamping screw. Adjustment of the clamped position of the regulating quadrant on the regulating sleeve, in relation to the axial position of the slots in the lower end of the sleeve, provides timing or phasing of the injection cut-off. A vertical line scribed across the strap of the regulating quadrant and the top of the sleeve indicates their normal assembled position.

(e) **Spring.** A spiral spring, fitted between a spring plate which butts on a shoulder on the upper end of the regulating sleeve, and a slotted spring plate which butts on a shoulder at the base of the pump plunger, provide impetus for the return or suction stroke of the plunger.

(2) **Delivery Valve Assembly**

(a) **Valve.** The valve is miter-faced, with a cruciform guide, and is topped by a spigot for the valve return spring. Separated from the valve face by an annular groove, the top of the valve guide is formed as a shallow piston which fits accurately in the bore of the valve seating. This device provides a sharp cut-off of fuel injection at the termination of the pump delivery and is termed the anti-dribble device.

(b) **Valve seat and valve holder.** The valve seat is clamped on to the top of the pump barrel by the delivery valve holder, which screws into the top of the pump casing. Thus the valve holder houses the valve and its components and secures the pump barrel in the pump casing.

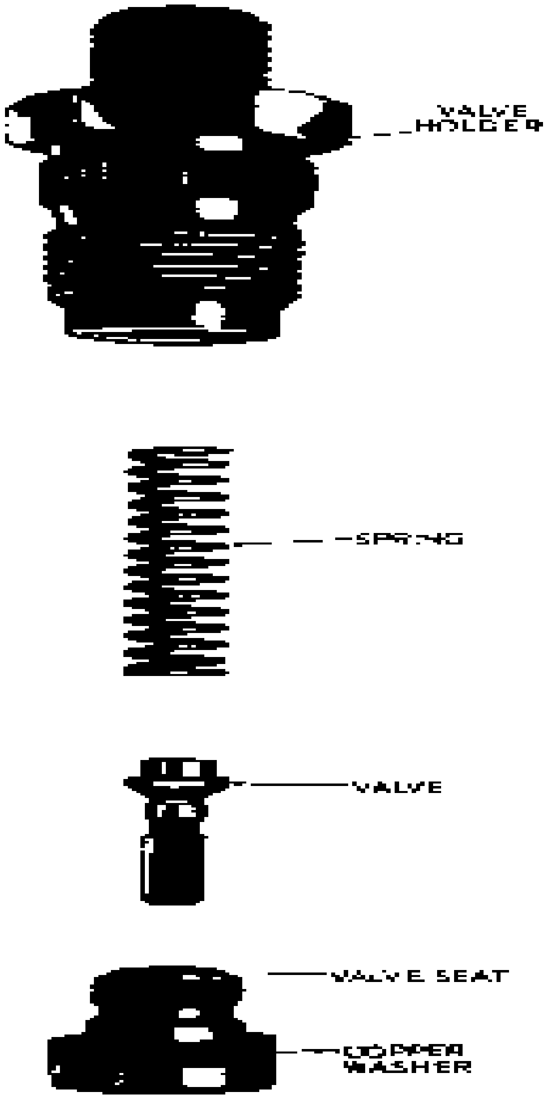



**Fig 9 Delivery valve components**

c. **Tappet.** The tappet operates in a guide formed in a heavy web in the casing over the camshaft chamber and comprises a cylindrical body fitted with a roller to engage the operating cam and an adjustable tappet face which engages with the base of the pump plunger. The tappet is positioned axially in the guide by an extended roller pin which operates in slots in the guides

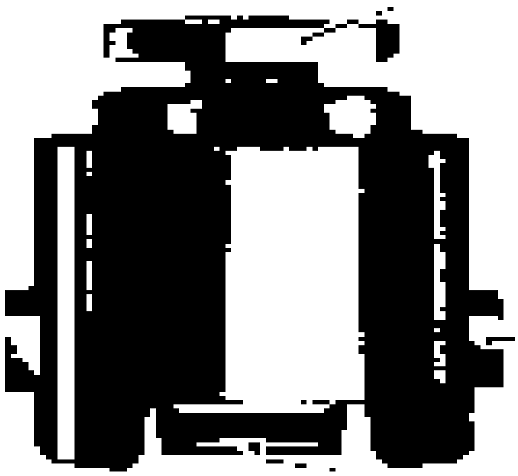


*Fig 10 Tappet*

d **Control rod.** A control rod, passing through and extending outside each end of the casing, is machined in the form of a rack which engages the toothed quadrant of each pump element and permits uniform control of all pump elements simultaneously. Each end of the control rod is similarly formed for fork and pin attachment of controls. One end is inscribed with an arrow and stop, and both ends are marked with a centre-dot to indicate the centralized position of the control rod travel. The rack is located radially, on assembly, by a slot in the middle of its length and diametrically opposite the rack; a pin screwed into the back of the casing engages this slot.

**Fig, 11-Control rod**

e. **Camshaft.** The camshaft is supported by ball bearings mounted in detachable housings, which fit into each end of the casing. It is extended outside these housings and formed with keyed taper shanks and screwed spigots so that either end may be coupled to them engine. The end opposite to that coupled to the engine may be fitted with a centrifugal governor. One end of the camshaft varying with the series, has a diametrical mark scribed on the end face of the spigot to indicate its correct assembled position; a reversed camshaft would not operate in the correct firing order of the engine. The camshaft operates in an oil bath in the base of the casing and felt pads are fitted in closing plugs beneath each cam to assist cam lubrication.

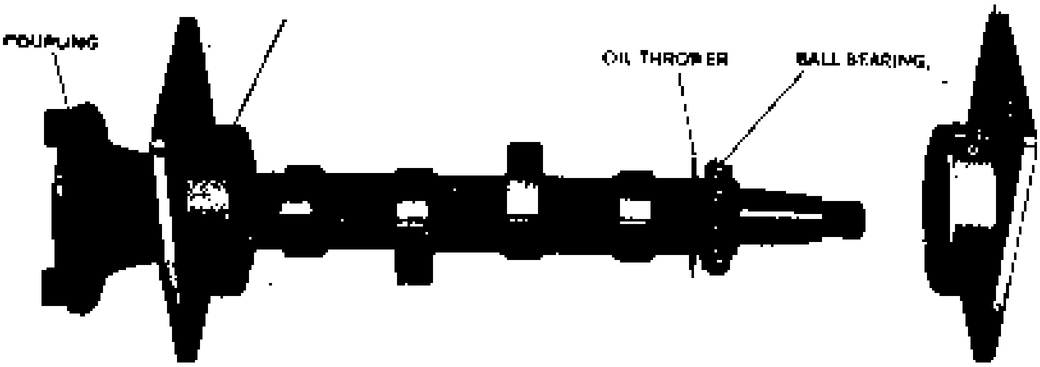



*Fig-12 Camshaft*

3. **Operation of Fuel Pump Unit are as follows.**

a. **Pump Unit Movements.** The operation of a pump element comprises two movements, reciprocation of the plunger within the barrel for the suction and deliver of fuel, and axial movement of the plunger within the barrel to control the amount of fuel delivered to the injector. The reciprocating movement, or stroke, of the plunger is constant and is operated by the camshaft and return spring. The time of commencement of injection is also constant, but axial movement of the plunger, by adjusting the plunger helix so that pressure relief of fuel occurs earlier or later in the plunger stroke, effects the time of "cut-off" of delivery of fuel. This consequently effects the amount of fuel injected for a particular stroke of the plunger. Axial movement of the plunger is obtained by the regulating quadrant being operated by the rack on the control rod. All pump elements in an injection pump unit, Irrespective of number, are operated by the same rack and uniform control of pump elements is obtained.

b. **Fuel delivery.** In a primed system, when the plunger is at the bottom of its stroke (fig. 13-A), fuel enters the barrel from the suction chamber through the barrel ports, assisted by the vacuum created by the down-stroke of the plunger. The suction chamber is fed either by gravity from an overhead tank, or by force feed from a fuel feed pump.

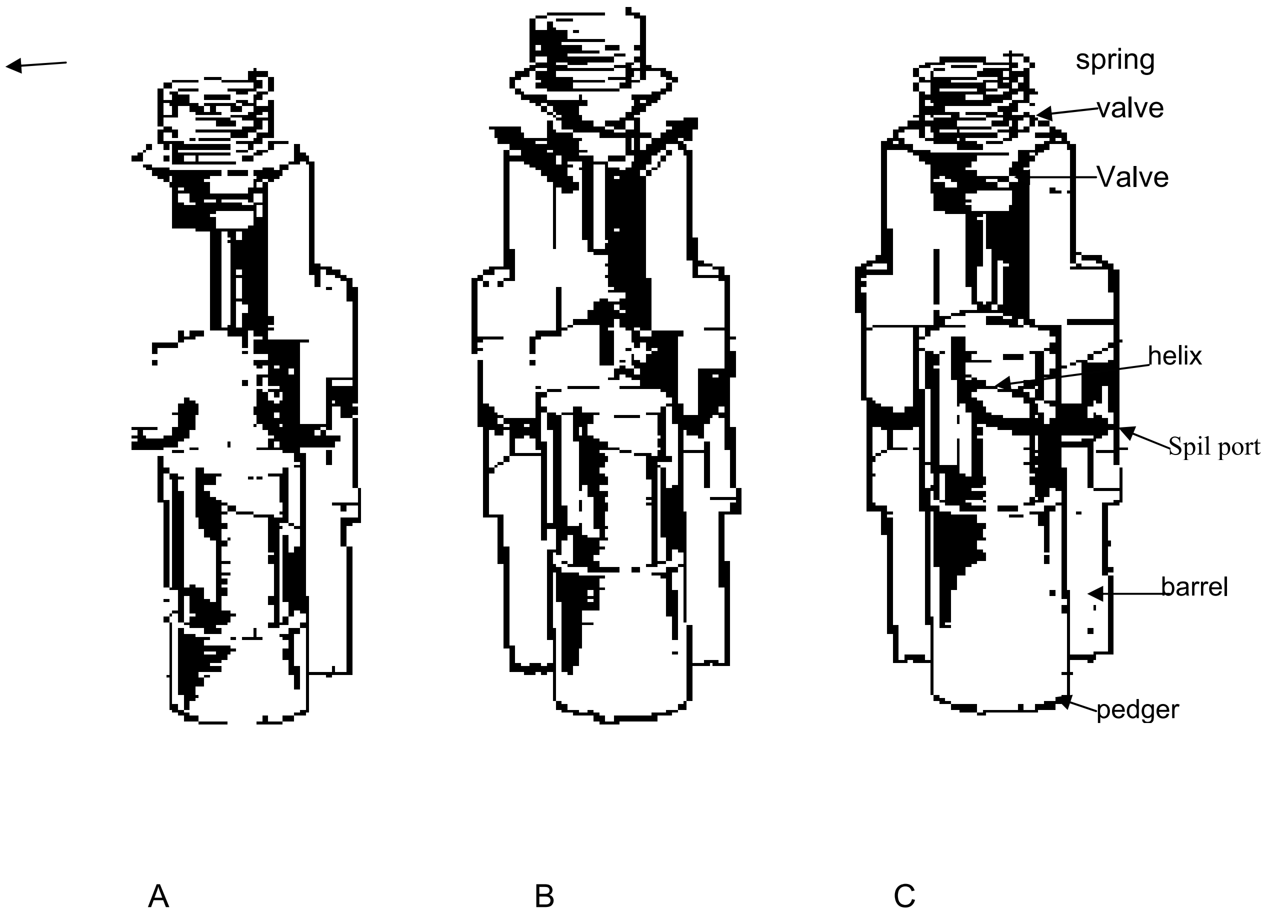
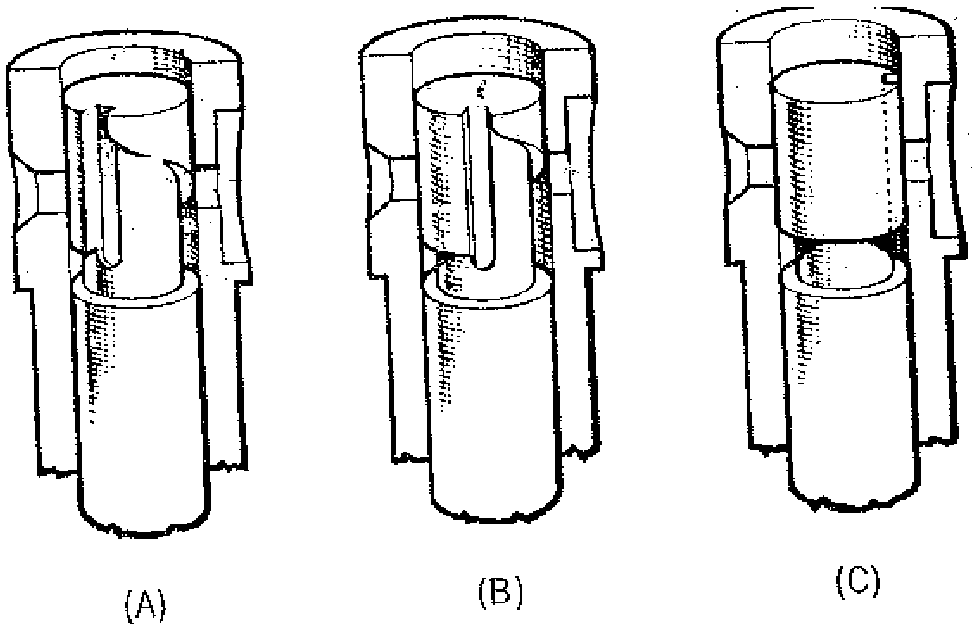



**Fig -13 Functional Diagram of Plunger pump**

As the plunger is urged by its cam on the upstroke, some oil is forced back through the ports, until the plunger reaches the position (fig.13- B), where the top edge of the plunger has closed both ports. Further upward movement of the plunger exerts pressure on the fuel trapped into he barrel and causes it to lift the delivery valve, which is mounted on the top of the barrel, and the fuel passes into the pipe connecting the pump to the injector. When this occurs, as the system is already full of fuel, the extra fuel which is being pushed in by the pump causes the is being pushed in by the pump causes the pressure to rise and lift the injector valve (nozzle needle) and fuel to be sprayed into the combustion chamber. At this movement, fuel is being pumped into the delivery line at the pump end and an equal quantity is being sprayed out at the nozzle end. This continues until the plunger reaches the position in (fig13-C). There the edge of the control helix has uncovered one of the barrel ports (spill port) which release the pressure created by the plunger by allowing fuel to pass back, through the vertical slot and the plunger waist, into the suction chamber. When the pressure is thus released, it causes the delivery valve to shut under the action of its spring, and with consequent collapse of pressure in the delivery line, the injector valve also closes, under the action of its spring, and injection of fuel cease. The delivery valve not only functions as a non-return valve upon closing but also as an anti-dribble device. When the valve closes, the small piston-shaped portion at the top of the guide sweeps down the bore of the valve seating with a plunger action, causing a reduction of pressure in the delivery line, so that the injector nozzle valve snaps back on to its seat, thus terminating the spray of fuel into the engine cylinder without dribble.

c. **<u>Control of Amount of Fuel Pumped</u>.** The amount of fuel injected can be varied from that required for idling, to full load, or to stop when no fuel is pumped. To achieve this, the plunger is rotated axially within the barrel so that the helix at the top edge of the plunger waist uncovers the spill port and causes cut-off of fuel delivery earlier or later in the stroke, thus varying the volume of fuel pumped. Compare the positions of the plunger shown in fig, 14-A and B which show its axial positions for full load and idling of the engine respectively and observe the earlier cut-off in fig.14-B. The stop position is shown in fig.14-C, where the plunger is turned so that the vertical slot in the plunger coincides with the spill port during any position of the plunger stroke. In this position no fuel can be pumped. Hence, axial movement of the plunger controls engine speed by varying the amount of fuel pumped and consequently injected by the spray nozzles.




Cut off at full load    Cut off at slow running    stop position

**Fig - 14 Functional diagram of variation of fuel delivery**

d. **Stopping the Engine :** To stop the engine, some form of control is necessary whereby the control rod is retarded beyond the idling position and turns the pump plungers to the stop position. This may vary in design according to engine makers. In the C.A.V. spring loaded idling stop (fig.15) a pawl in the control cross-shaft bears, at idling speeds, against a spring-loaded plunger which is adjusted to balance against the accelerator pedal return spring. With this device, the engine is stopped by increasing the pressure against the spring-loaded plunger until the control rod is moved to the stop position. This is affected by lifting the accelerator pedal, upon release of which, when the engine has stopped, the stop returns to the normal idling position.

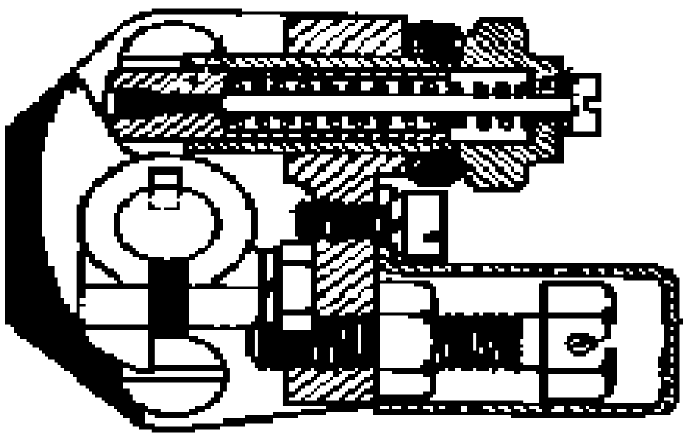


**Fig -15 Idling stop**

# BAF BASE ZAHURUL HAQUE

**(Aero Engg Trg Sqn)**

**Syllabus : Automobile and Diesel Technology**

**Course : MTOF Basic Trade Training**

**Subject : Fuel System of Diesel Engine**

**Aim : To study CAV Fuel Injectors**

**Ref : A.P. 1464, Vol-1, Book-1, Part-1, Sec-2,Chap13.**

---

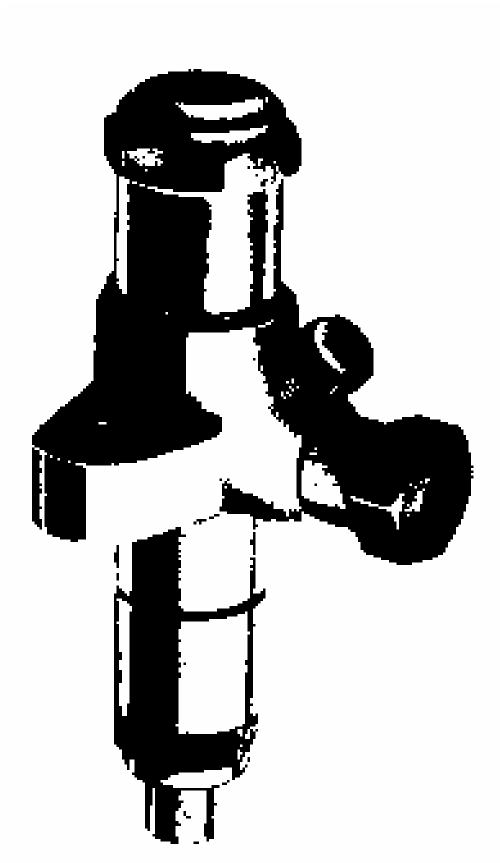
## C.A.V. FUEL INJECTORS

### Introduction:

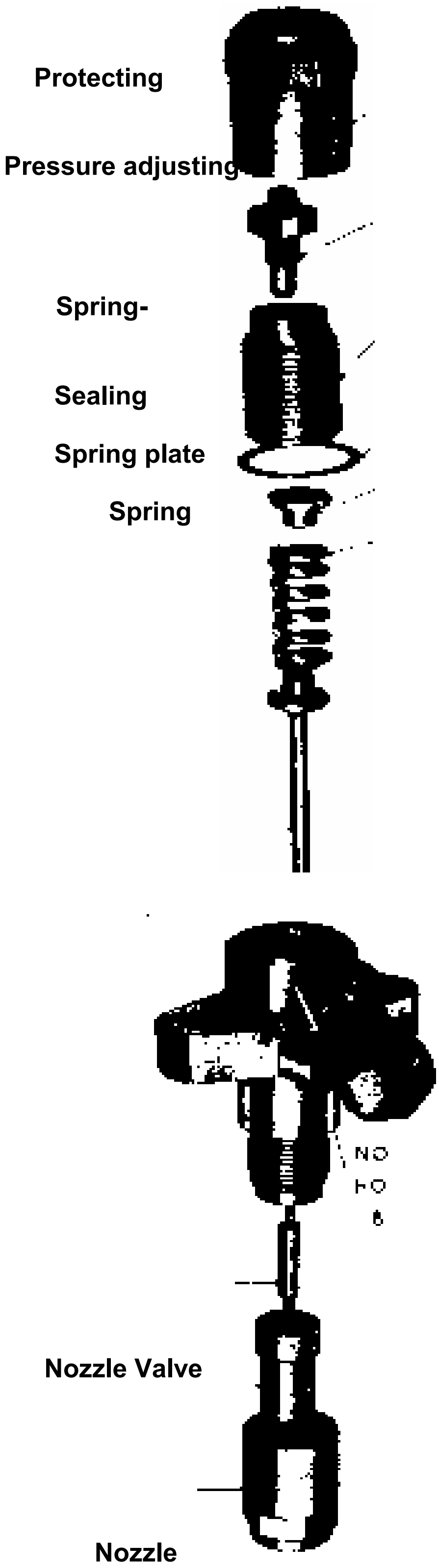
1. There are three essentials, apart from mechanical efficiency and the use of the correct fuel, to the satisfactory functioning of a compression-ignition engine. They are the delivery of the fuel to the cylinders at the right time and in the right quantity, and the delivery of the fuel in the right condition for instantaneous combustion. The first two requirements are met by the correct adjustment of the fuel injection pump. The third requires a separate mechanism fitted to each cylinder and connected to the relevant delivery valve of the pump in a manner analogous to that in which the sparking plugs of a gasoline engine are connected to the H.T. distributor. The mechanism known generally as in injector comprises two assemblies' viz., a nozzle and nozzle holder. The nozzle atomizes the fuel for instantaneous combustion and the nozzle holder provides the means of securing the nozzle to the engine cylinder and connecting the fuel supply from the pump; which is necessary for the loading of the nozzle valve.

### Construction

2. A nozzle consists of the two parts, the nozzle valve and the nozzle body. These two parts are mated in manufacture and must kept as such throughout their service life. The valve is of plunger form, as shown in fig.16 the main portion being lapped to very fine limits into a central boring in the nozzle body. Each end of the valve is reduced in diameter, one end, known as the stem, being machined to a valve face, and the other, the stalk, being a plain portion on which a spring loaded spindle is located. The nozzle body house the valve in a central boring, as mentioned in the preceding Para, and incorporates the valve seating on which the valve seats to seat off an injection aperture in the lower part of the nozzle body. Additionally, the body has a series of small diameter passages leading from a concentric groove in its top face to a gallery or reservoir immediately above the valve seat. The top face of the body is ground to a mirror like finish, to mate with a similar face on the lower part of the nozzle holder.



C.A.V. Fuel Injector




**Fig,16 -C.A.V. Fuel Injector--Exploded View**

a. **Nozzle Holder.** Nozzle holders are made and classified to correspond with the nozzle they will hold. Therefore, an S-size holder will accommodate only S-size nozzles. There are variations in the design of holders, in all size groups, to suit the requirements of engine designs, but the functioning of all is the same. They are coded for identification purposes and the decoding a of a typical marking, BDB50S24 is as follows:

B …. British made

KB Nozzle holder

50 .. Barrel length in mm

S .. Size i.e. barrel diameter of 25 mm.(The T-size holders have a barrel diameter of 32 mm.)

24 Individual features number

**Note:-**If a letter D follows the size letter e.g., BKB 50 SD 24, it indicates that a special spring, for use with delay nozzles, is fitted. If a letter b follows the individual features number, e.g. BKB 50 S 24b, it indicates that an edge-type filter is fitted to the inlet connection.

**Injector Operation**

3. At each upward stroke of the pump plunger, fuel is forced via the pump delivery valve and connecting pipe to the inlet connection of the injector. From here it passes down the offset passage in the nozzle holder, around the groove in the top face of the nozzle body, and through the series of passages in the body to the gallery above the valve seating. The pressure builds up at each delivery stroke of the plunger until it balances the spring loading on the nozzle valve. At each subsequent stroke the fuel pressure exceeds that of the spring, lifts the valve off its seat and ejects, through the nozzle in a fine spray, an amount of fuel equal to the volume displaced by the pump plunger; the spring then reasserts itself and closes the valve.

**Types of nozzles**

4. a. **General.** To ensure the efficiency of engines which, because of their design, require different kinds of spray, both the nozzle valve an nozzle body vary for different types of engine. For this reason, it is imperative that un-serviceable nozzle are replaced by identical nozzle. There are five classes or types of nozzle and each of these may embrace differences in detail. A general description of these types is given under appropriate headings in the following paragraphs and typical examples are shown in (fig-17)

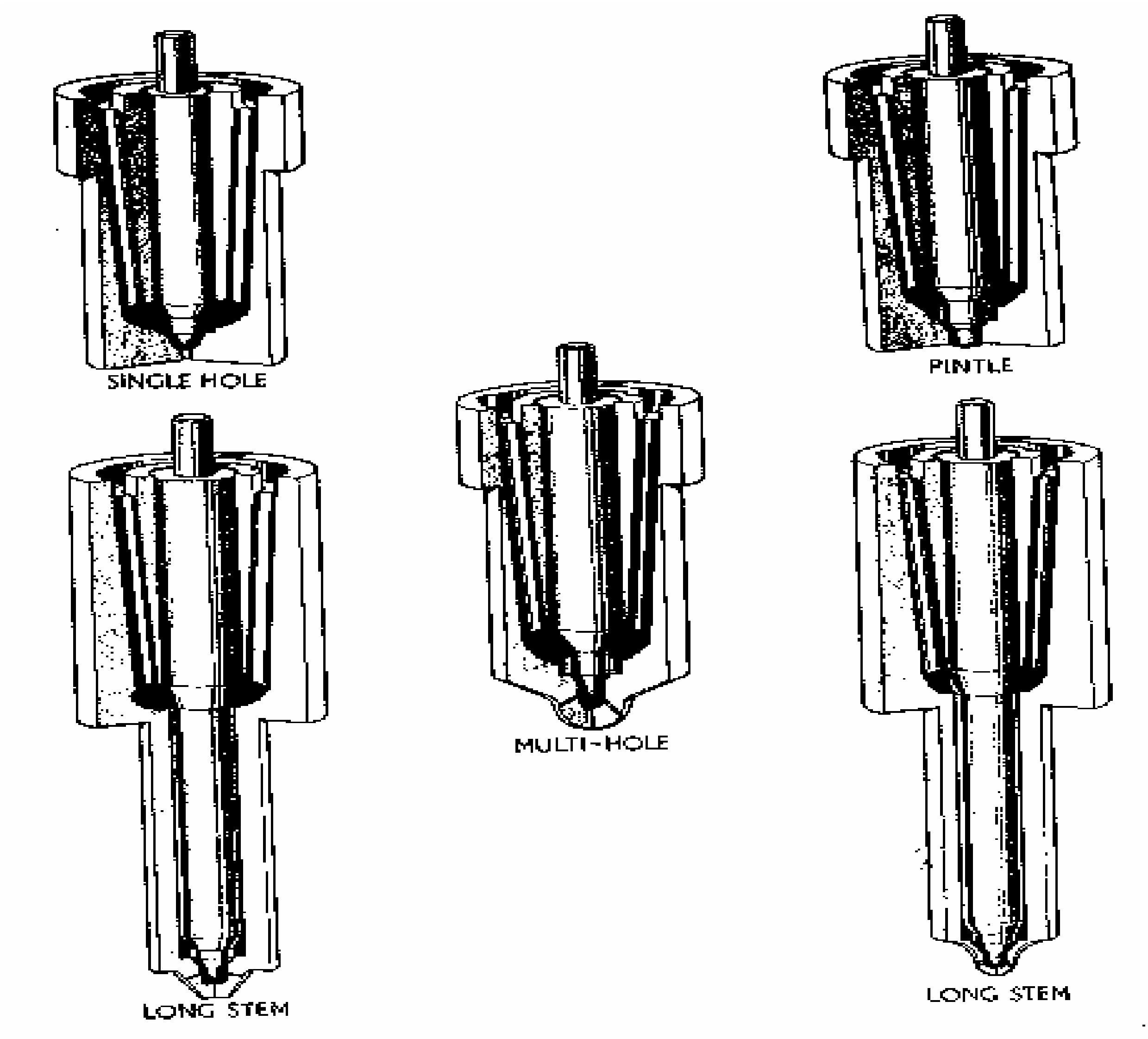
b. **Pintle nozzles.** This type of nozzle is used on engines which incorporate a pre-combustion chamber or "air-cell" in each cylinder. The stem of the valve is extended to form a pin or pintle which protrudes through an injection orifice in the base of the nozzle body. By varying the size and shape of the pintle, a variation in the spray is obtained; the form of the spray may vary from one of pencil-form to one of cone form with an included angle of 60. or more.

c. **Delay nozzles:** Delay nozzles are, in general, a variation of the pintle type; they improve the idling performances of some engines, usually of the pre-combustion chamber type. In this type of nozzle the pintle is designed to increase the rate of injection towards the end of each delivery and this has the effect of lengthening the period of injection at idling speeds without interfering with combustion at higher speeds.

d. **Single-hole nozzle:** These may be of two types; one has the spray hole drilled centrally through the base of the nozzle body, and the other has the hole drilled at an angle to the centre line of the body.

e. **Multi-hole nozzles.** As the name implies, this type of nozzle has more than one spray hole, and generally, these holes are drilled radially from the centre on an even pitch. The number of holes, their size, and the angle at which they are drilled, depend upon the particular engine requirements. A variation of this type of nozzle is one in which the spray holes are drilled at various angles and often on an uneven pitch. This is required on engines for which the spray must be in a particular direction. This type of nozzle must, therefore, be fitted to the engine at all times with the spray holes located in the same position relative to the combustion chamber, and to ensure this two short dowels are fitted in the joint face of the nozzle holder, and mating holes are drilled in the joint face of the nozzle body.

f. **Long-stem nozzle.** One of the main considerations in the design of all nozzles are the necessity to maintain the working parts in as cool a condition as possible. For direct injection engines where, because of the limited space between the valves in the cylinder head, adequate cooling is not possible for the normal nozzle, a longer nozzle is used. The extra length a longer nozzle is used. The extra length allows the critical portion of the nozzle to be more remote form the source of heat, and by a reduction in diameter of the extended portion a more efficient dissipation of heat is obtained.




**Fig, 17 Types of Nozzle**

# BAF BASE ZAHURUL HAQUE

**(Aero Engg Trg Sqn)**

**Syllabus : Automobile and Diesel Technology**

**Course : MTOF Basic Trade Training**

**Subject : Fuel System of Diesel Engine**

**A i m : To Study Servicing of Fuel Injectors**

**Ref : A.P. 3159 Section 5, Chapter 4.**

---

## SERVICING OF FUEL INJECTORS

### Servicing

1. Nozzle should be removed from the engine for routine servicing at periods specified in the relevant servicing schedules. They may be removed, if thought to be defective, when one or more of the following symptoms develop:

   a. One or more cylinder knocks.

   b. Engine over heats.

   c. Engine losses power.

   d. Exhaust contains black smoke.

   e. Fuel consumption increases.

A fault nozzle can often be located by slackening each nozzle feed pipe union but in turn, cutting out that particular nozzle. When a fault nozzle is cut-out there will be not noticeable difference in the running of the engine. To check a suspected nozzle on the engine, removed the injector and reconnect it to the fuel supply so that the nozzle points outwards, slacken the unions of all the other injector feed pipes, turn the engine and observe the spray from the suspected nozzle. If the spray is unduly 'wet' (i.e. not finally atomized), or if it is streaky, emerges to one side, or the nozzle dribbles, then the injector should be replaced by a serviceable one and the unserviceable injector returned for workshop attention. All servicing work on injectors must be done in conditions of scrupulous cleanliness and under no circumstances must cotton waste or rags be used. A special nozzle cleaning kit is provided and when these tools are not in use they must be placed in the hold-all and kept in a dust proof drawer or cupboard. A slotted plate fixed to the injector during servicing operations. Before a nozzle is removed from the holder the spring pressure on the nozzle valve must be released by slackening the pressure adjusting screw. To remove a nozzle, position the injector in the slotted plate and remove the nozzle cap nut with the special spanner. The nozzle cap nut must never be gripped in a vice.

**Warning**: Personnel must keep their hands off from contact with the spray.

The procedure for cleaning nozzles is as follows:-

Remove the valve from the nozzle body and place it in a bath of kerosene or fuel oil. Brush off all the carbon from the outside of the nozzle body and place the body in the kerosene or fuel oil. When the parts have soaked sufficiently to soften the carbon, clean out the fuel feed passages in the body with a drill or a piece of wire of 1.70 mm dia.

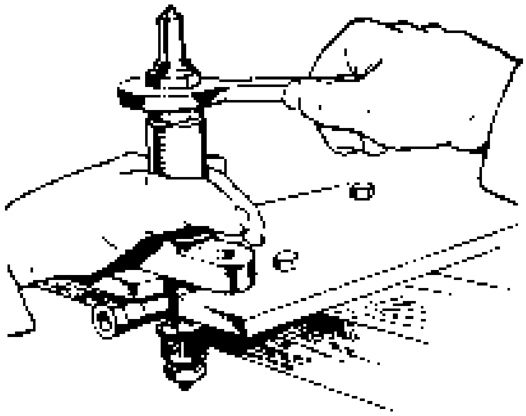


**Fig 18, Removing A Nozzle**

Insert the tool in the nozzle body until the nose locates in the gallery, and, with considerable pressure against the gallery wall, rotate the tool to dislodge all deposit. Using a dome cavity cleaner, appropriate to the type of nozzle remove the carbon deposit from the dome cavity. Clean any carbon deposit from the valve scraper on to the seat and rotating it. Use the probing tool with the appropriate sized wire to clear the spray holes of carbon. The wire should protrude for about ½ mm at first being progressively lengthened as the carbon is cleared. Rotate the probe gently with light pressure to prevent breaking the wire. Tap the nozzle body gently on a soft pad to dislodge the loosened carbon. Fit the nozzle to the flushing adaptor on the testing outfit, if available, and then blow out with compressed air. Always blow out or flush in the opposite direction to normal fuel flow. Care fully cleans the nozzle valve using the brass wire brush. The nozzle must be rejected if there are any scores or other defects on the working surface of the valve. Fit the nozzle body and the valve together whilst immersed in clean fuel oil. Thoroughly wash the nozzle holder, spring and cap nut in clean kerosene or fuel oil, and after inspecting these components for damage or corrosion, reassemble them. Great care must be taken to avoid damaging the lapped pressure face of the holder. Ensure that the lapped joint faces of the holders and nozzle body are perfectly clean, and that there is no tension on the spring. Place the holder, joint face uppermost, in the slotted plate, and place the nozzle in position, taking care to locate the holder dowels (if fitted)in the holes in the nozzle . Fit the nozzle cap-nut and tighten it with the correct spanner. This nut must be reasonably tight, but distortion, causing a seized valve, may result if it is over-tightened. The injector is now ready for testing.

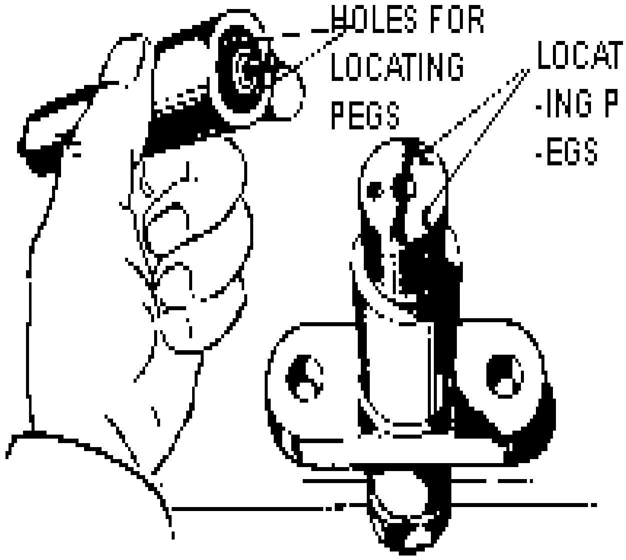



**Fig 19 Fitting a Nozzle**

Power-operated equipment which can simulate actual working conditions is necessary for the complete testing of an injector, but the general performance and estimation of the leakage rate can be made on equipment which is hand-operated.

**BAF BASE ZAHURUL HAQUE**

**(Aero Engg Trg Sqn)**

**Syllabus : Automobile and Diesel Technology**

**Course : MTOF Basic Trade Training**

**Subject : Fuel System of Diesel Engine**

**Aim : To Study CAV Nozzle Setting Outfit**

**Ref : A.P. 3159 Section 5**

---

# NOZZLE SETTING OUTFIT

## Installation

1. When it is necessary to test the operation of nozzles, the work is carried out on an apparatus known as a Nozzle Setting Outfit. The model described and illustrated is made by CAV and it is suitable for '"'size adapter is available for use when it is necessary to test units installed in stationary or marine engines. A nozzle setting outfit is made of components of the same quality, accuracy and finish which characterize all fuel injection equipment The outfit should be bolted firmly down on a zinc or linoleum covered workbench should may be kept apart from the others. As mentioned earlier these components are mated in production and must not be interchanged. When assembling the handle to the outfit, the adjusting screw on the base casting, which limits the handle's downward travel, should be screwed in until the screw head is level with the red line marked on the casting. The adjusting screw should then be secured by tightening the horizontal locking screw. A fuel tank supplied with the outfit has a capacity of 1½ pint, and contains a filter element to ensure cleanliness of fuel delivered through the pumping element to the nozzle under test. An unfiltered fuel supply must never be connected direct to the pump inlet as this would permit dirt and foreign matter to be pumped through the nozzle under test, and so cause damage to the valve faces in addition to dirtying the nozzle and outfit.

## BAF BASE ZAHURUL HAQUE

**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and diesel Technology** |
| **Course** | **:** | **MTOF Basic Trade Training** |
| **Subject** | **:** | **Fuel System of Diesel Engine** |
| **A i m** | **:** | **To Study Faults and Remedies of Fuel Injectors** |
| **Ref** | **:** | **A.P. 3159 Section 5.** |

## FAULTS AND REMEDIES

| Ser No | Faults | Possible Cause | Remedy |
|---|---|---|---|
| 1. | Nozzle does not buzz during injection. | a. Nozzle valve too tight, binding or valve leaking. | Clean nozzle |
| | | b. Nozzle cap nut distorted. | Examine nut; if necessary fit serviceable nozzle. |
| 2. | Excessive Leak-off. | a. Nozzle valve slack. | Replace nozzle |
| | | b. Nozzle cap nut not tight. | Tighten nut |
| | | c. Foreign matter between contact faces of the nozzle and nozzle holder. | Remove nozzle and clean nozzle. |
| 3. | Nozzle Bluing. | Fault fitting or faulting engine cooling. | Fit new nozzle and check engine-cooling system. |
| 4. | Nozzle Opening Pressure Incorrect. | a. Adjusting screw improperly set. | Adjust for prescribed pressure |
| | | b. Valve corroded and seized up. | Fit new nozzle |
| | | c. Valve dirty and sluggish in movement. | Clean nozzle |
| | | d. Spray holes clogged with dirt and carbon. | Clean nozzle |
| | | e. Pressure spring broken. | Fit new spring and set to prescribed pressure. |

| | | | |
|---|---|---|---|
| 5. | Nozzle Drips. | a. Nozzle leak owing to carbon deposits. | Clean nozzle. If fault is not remedied, fit a new nozzle. |
| | | b. Valve sticking. | Fit new nozzle. |
| 6. | Distorted Spray. | a. Excessive carbon deposits on the nozzle tip. | Clean nozzle. |
| | | b. Spray holes partially chocked. | Clean nozzle. |
| | | c. Valve Damaged. | Fit new nozzle. |

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

**Syllabus : Automobile and Diesel Technology**

**Course : MTOF Basic Trade Training**

**Subject : Engine Cooling System**

**Aim : To Study Engine Cooling System**

**Ref : The Automobile – By Harbans Singh Reyat**

---

# COOLING SYSTEM

**Purpose**

1. The purpose of the cooling system is to keep the engine at its most efficient operating temperature at all speeds under all operating conditions.

**Types**

2. There are two types of cooling system applicable in automobile engines. These are as:

a. **Air Cooling System**. This type of cooling system is mostly employed in light engines used in motorcycles and scooters. Air-cooled engine contain fins or ribs on the outer surfaces of the cylinders and cylinder heads. These fins provide more area for air contact resulting in better radiation of heat. The heat produced by the combustion of fuel passes through the cylinder walls and cylinder head to the fins, from where it is dissipated into the surrounding atmosphere. The air-cooled engines require the circulation of large volumes of air over and past the fins. In motorcycle, flow of air is achieved by their forward motion. In case of cars, the air is thrown over the engine by a fan or blower built into the engine flywheel. A shroud or cowling often encloses the engine to control the flow of air over the engine. Baffles are provided near the cylinders to deflect air through the fins area (Fig- 1)

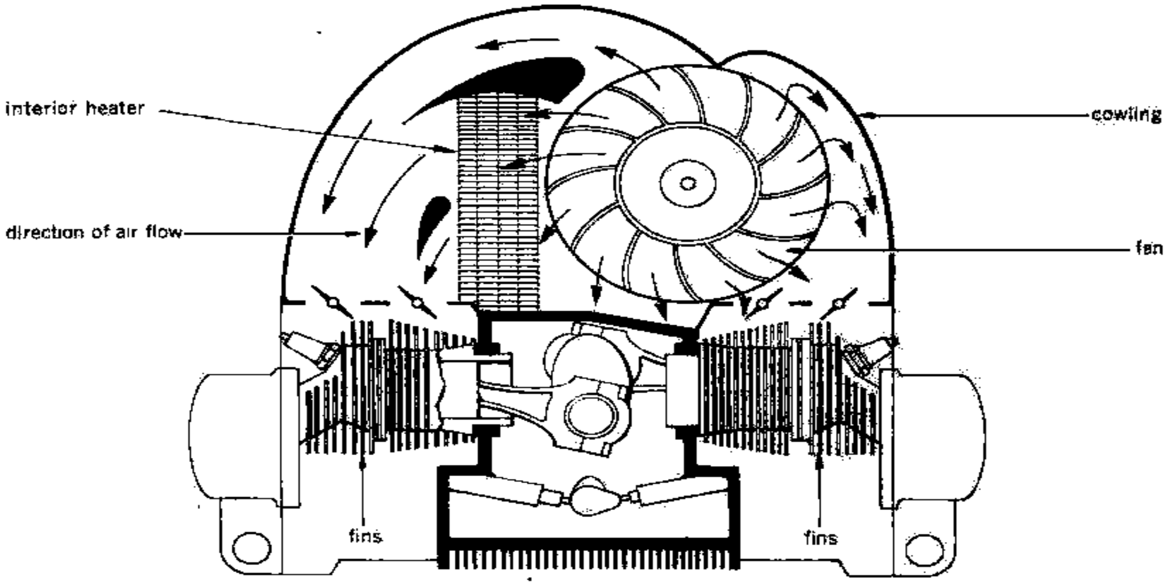



**Fig- 1 Air Cooling System**

b. **<u>Liquid or Water Cooling System.</u>** In liquid or water-cooling engines, heat from the cylinders is transferred to the water or liquid contained in jackets surrounding the cylinders, combustion chambers and valve ports etc. Through the water or liquid, heat is carried into the radiator where it is conducted to its fins for radiation to the passing air. Forward motion of the vehicle and an engine driven fan accelerate to the circulation of air over the radiating surface (Fig- 2).

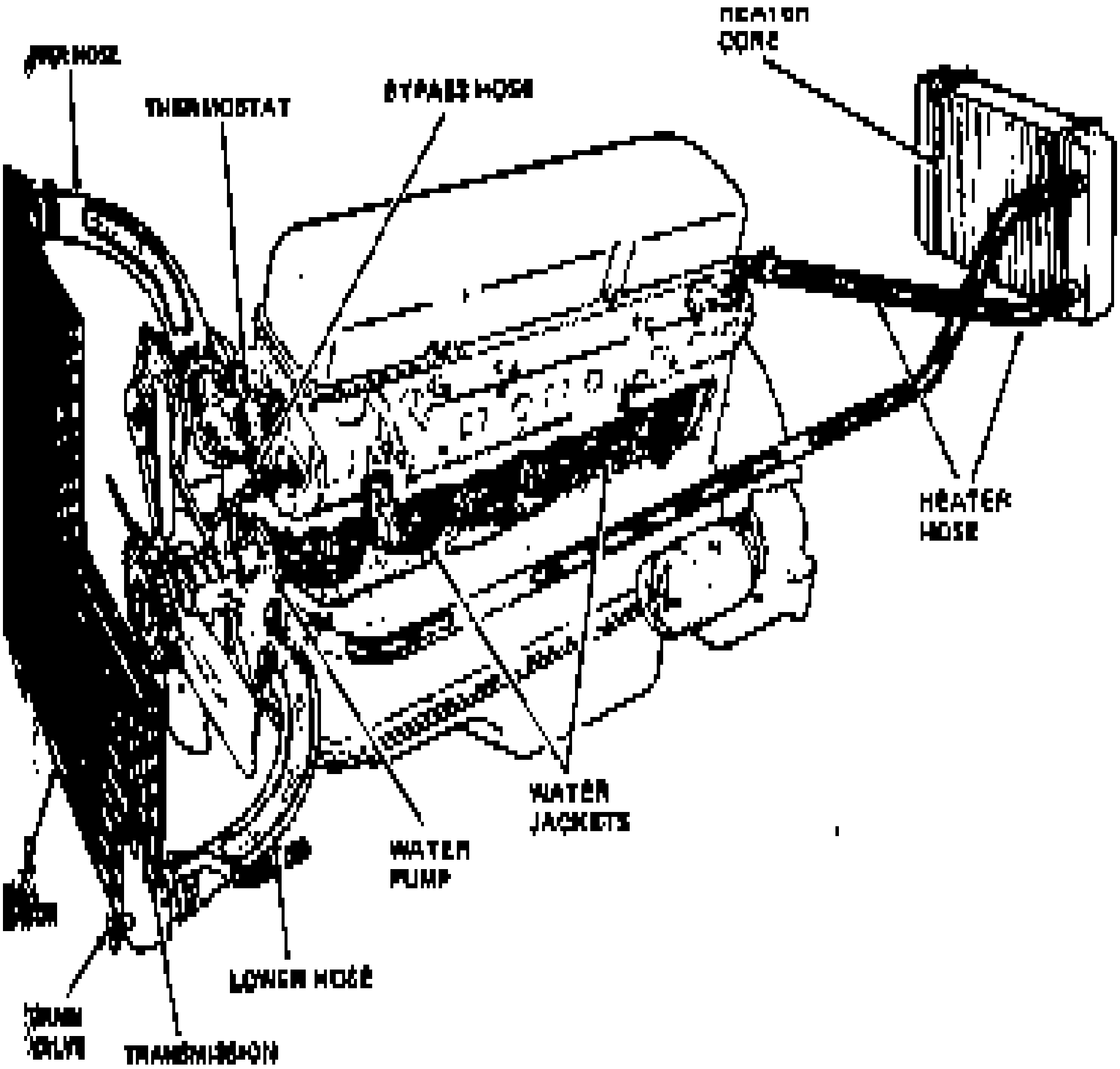



**Fig- 2 Liquid or Water Cooling System**

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **MTOF Basic Trade Training** |
| **Subject** | **:** | **Engine Cooling System** |
| **Aim** | **:** | **To Study Engine Cooling System** |
| **Ref** | **:** | **The Automobile – By Harbans Singh Reyat** |

## TYPES OF WATER COOLING SYSTEM

### General

1. These system serves to Cools the engine and saves it from over heating also Warms the engine to bring it to the working temperature for efficient and economical working.Cooling is done by the circulating water or liquid in the jackets around the hot spots of the engine, i.e. cylinders, combustion chambers exhaust valve ports. In winter season, the temperature of the engine is raised to the working temperature through a thermostatically controlled cooling system. In this system, hot water is kept in circulation inside the water jackets. The water in the jackets obtains heat from the cylinders due to conduction. The hot water keeps the cylinders warm. The water is not allowed to flow into the radiator till it attains $140^0$ F temperatures at which the thermostat valve starts to open and provides passage for the flow of water towards the radiator for cooling down. Hence water cooling system warms the engine too, to bring it to the working temperature. Water cooling system is of the following two types:

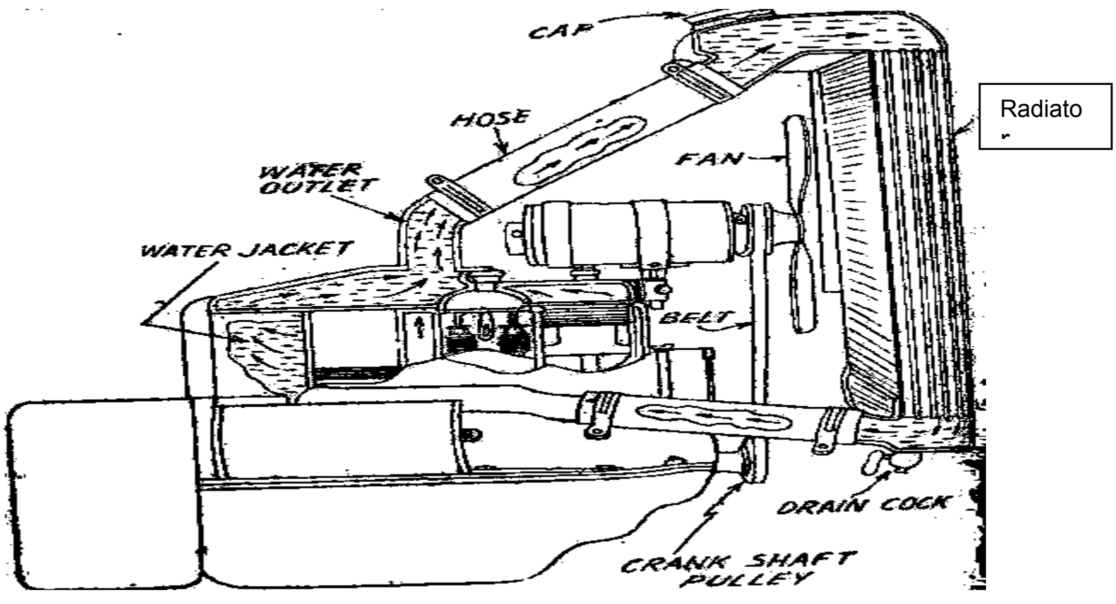



**Fig- 3 Thermo-syphon System**

a. **Thermo-syphon System.** This system works on the principle that, hot water being lighter, rises up and cold water being heavier falls down. It depends upon gravity to circulate water or liquid in the system. In this system radiator is kept above the bottom level of water jacket. This system contains no pump to keep the circulation of water regular. When water in the jacket becomes hot as a result of engine combustion, it expands and therefore becomes lighter. The hot water rises up and the cold water comes to take its place. The hot water flows to the radiator through the upper connection where it is cooled down by the air passing through the core. The cold water being heavier moves

Downwards to take the place of displaced hot water. This way a circulation is set up due to which heat is carried away from the engine. Radiator and an engine driven fan are two main parts in this system, which play an important part in keeping the engine, cool (Fig-3).

b. **Pump Circulation System.** The pump or forced circulation system very much resemble in construction with the thermo-syphon system. This system makes use a centrifugal pump to circulate water. In certain engines, Water distributing tubes or nozzles are inserted in the cylinder block or head to direct the coolest water towards the exhaust valve ports (Fig-4).

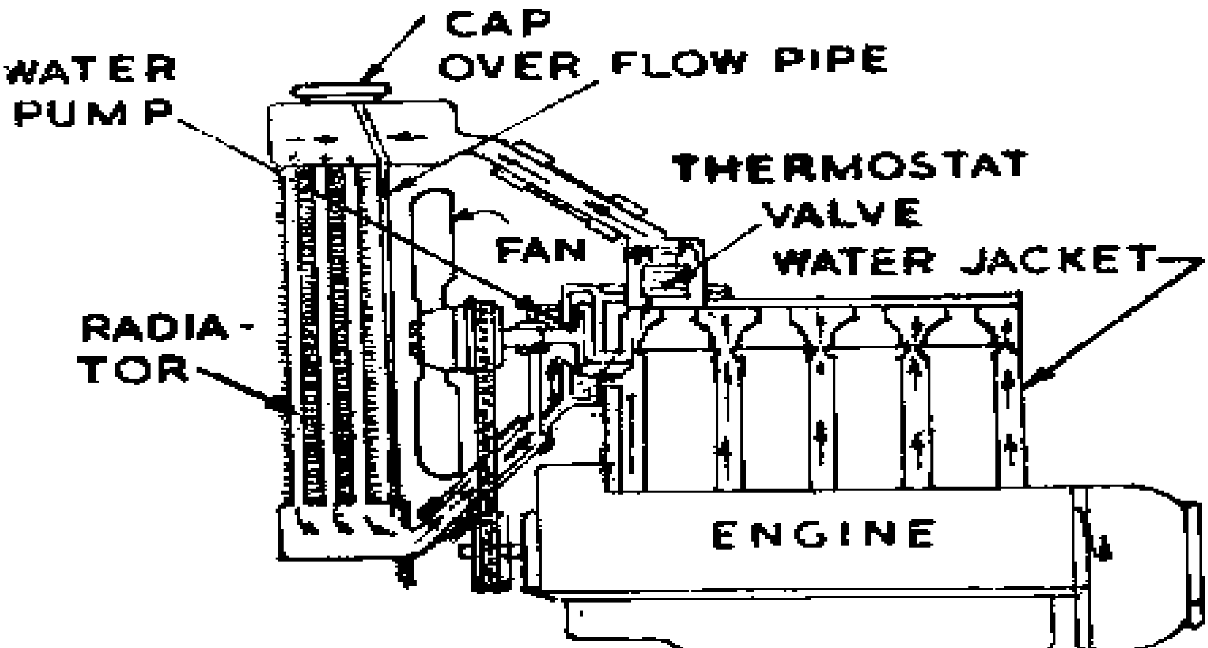



**Fig-4 Pump Circulation System**

**Main Parts**

2. The following are the main parts of this system:- (a) Radiator, (b) Radiator cap, (c) Overflow Tank, (d) Fan, (e) water pump, (f) Thermostat valve and (g) Temperature gauge or indicator.

# BAF BASE ZAHURUL HAQUE(TRG WG)
## (Aero Engg Trg Sqn)

**Syllabus : Automobile and Diesel Technology**

**Course : MTOF Basic Trade Training**

**Subject : Engine Cooling System**

**Aim : To Study The Radiator.**

**Ref : The Automobile – By Harbans Singh Reyat**

## RADIATOR

**Purpose**

1. The purpose of radiator is to cool the hot water received from the engine.

**Construction**

2. The radiator consists of three parts- upper tank, lower tank and core. Upper tank and lower tanks are joined by the core. The upper tank contains a neck through which water is filled into it and to the side of which an over flow pipe is connected. A connection is also provided for the inflow of hot water from the engine into it. The lower tank again contains connection for the out flow of water. A drain cock is provided at the bottom of lower tank to remove water from the radiator. The core is in between upper and lower tanks. Hot water flows down to the lower tank through the core during which process heat from the water is transferred to the passing air by the core.

**Types**

3. The radiator is usually made of copper or brass in order to provide rapid dissipation of heat. The radiator can be divided into following classes with regard to the construction of their core:

a. **Tubular.** It is a tube and fin type radiator, which contains of a series of long tubes extending from upper to lower tank. The fins are copper or brass strips of fine thickness through which pass the tubes at right angles. Air passes around the out side of the tubes, between the fins, absorbing heat from the water when it passes through them (Fig-5).

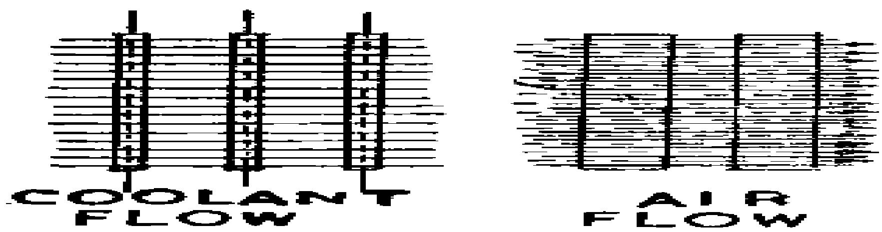



**Fig-5 Tubular**

b. **Gilled**. In gilled tube radiator, each tube contains individual's fins surrounding it. Rest of its construction is like the tubular radiator as it is also tube and fin type radiator.

c. **Honeycomb or cellular**. A cellular radiator contains a large number of individual air cells which are surrounded by water. It is made up of a large number of narrow water passages formed by pairs of thin metal ribbons soldered together along their edges, running from upper to lower tank. The water passages are separated by air fins of metal ribbon, which provide air passages between the water passages. Air passes through these passages from front to back, absorbing heat from the fins, which in turn absorb heat from the water flowing downward through the water passages. The construction of this type of radiator is like the beehive that is why it is known as honeycomb. In tubular radiator, if one tube is clogged, the cooling effect of the entire tube is lost. In the cellular radiator, the clogging of any passages results in loss of small part of the total cooling surface (Fig-6).

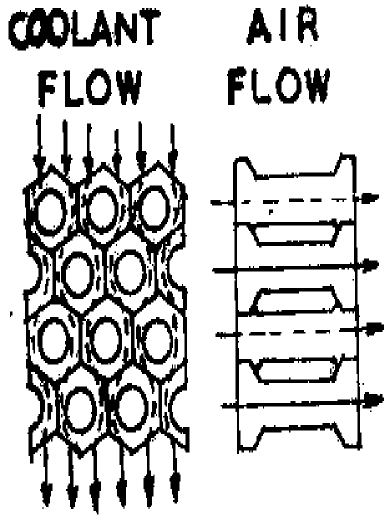


**Fig-6 Honeycomb**

## Radiator Cap

4. It provides a cover for the filler hole through which water is filled into the radiator. There are two types of caps in common use. One is the simple cap, which acts only as a cover so that water may not flow out through the filler hole. The other type of cap contains a double check valve through which cooling contents go in or out to the over flow tank. This type of cap is known as pressure cap (F-g-7). By the use of this cap, cooling efficiency is increased; evaporation is prevented and water losses due to surging when the vehicle is suddenly stopped are avoided. At see level where atmospheric pressure is higher (about 15 lb /sq"), water boils at higher temperature (about $212^0$ F). At higher altitudes, where atmospheric pressure is lees, water will boil at lower temperature. Higher pressures increase the temperature required to boil water whereas lower pressure lower down boiling temperature. The use of a pressure cap on the radiator in creases air pressure within the cooling system and the water is circulated at higher temperatures without boiling. The water enters the radiator at a higher temperature and the difference between the water and air temperature is greater. Heat is thus transferred from water to air more quickly which results in improvement in cooling efficiency. The double check valve in the pressure cap consists of a blow off valve and a vacuum valve. The blow off valve is held against the seat by means of a calibrated spring. The spring keeps the valve held close so that pressure is produced in the cooling system .If the pressure reaches the predetermined value for which the system is designed, the blow off

valve is raised off its seats and the excessive pressure is released through the over flow pipe. The vacuum valve prevents the formation of a vacuum in the cooling system when the engine is put off and begins to cool down. When vacuum is formed inside the cooling system, atmospheric pressure from the outside causes vacuum valve to open, admitting air into radiator. Incase over flow tank is connected with the radiator over flow pipe; coolant collected therein runs back into the radiator along with air.

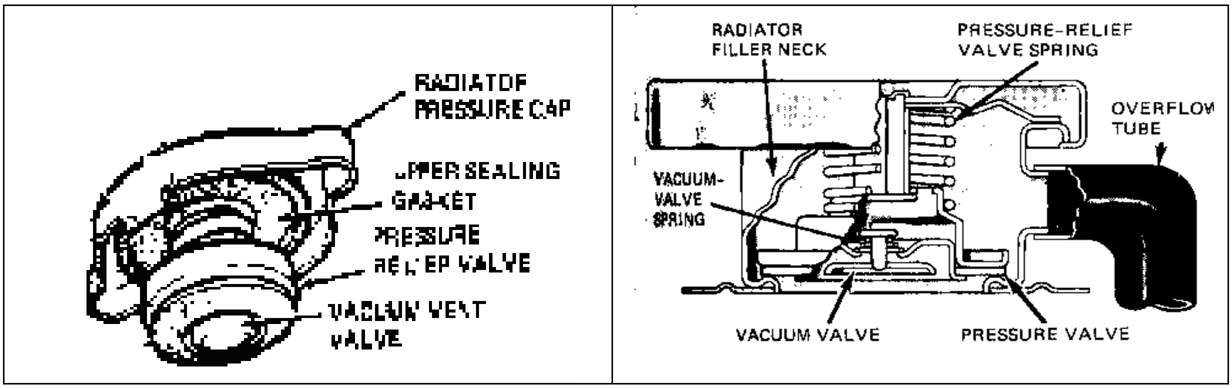



**Fig- 7 Pressure Cap**

## BAF BASE ZAHURUL HAQUE (TRG WG)

## (Aero Engg Trg Sqn)

**Syllabus : Automobile and Diesel Technology**

**Course : MTOF Basic Trade Training**

**Subject : Engine Cooling System**

**Aim : To Study Temperature control.**

**Ref : The Automobile – By Harbans Singh Reyat**

---

# TEMPERATURE CONTROL

**Purpose**

1. The purpose of temperature control is that the temperature of the cooling system is raised to the normal working temperature as quickly as possible, and is then maintained at that temperature for continuous operation of the engine.

**Description**

2. **Thermostat Valve.** It is one kind of check valve opens and closes by the temperature effect. It is fitted in the engine outlet (Fig-8). It helps in raising the temperature of coolant during cold season, which warm the engine to bring it to the operating temperature. The thermostat valves are designed to open at certain fixed temperature and do not provide passage for the engine water to flow into the radiator until the temperature of the coolant reaches that degree. Usually thermostat valve is open at near about $170^0$ F.

a. **Types of Thermostat Valve.** Thermostat valves are of the following three different types:

(1) **The Bellows Type**. The bellows type valve contains a poppet valve attached to metallic bellows held in a cage. The bellows are filled with liquid such as acetone or alcohol. The liquid evaporates due to increase in temperature and the internal pressure tends the bellows to expand resulting in the rising of valve off its seat. When the temperature falls below the specified at which the valve is designed to open, the valve closes down due to squeezing of bellows (Fig-8).

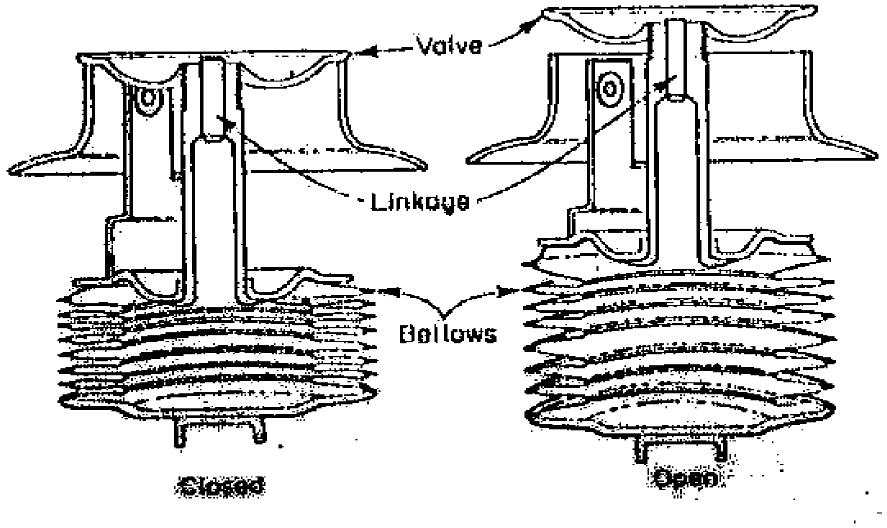



Fig-8 Bellows Type Thermostat

(2) **<u>Sleeve and Butterfly Type.</u>** Sleeve and butterfly type thermostat valves differ in construction from bellows type. Instead of liquid, they are powered by a wax pellet, which expands with increasing temperature to open sleeve or butterfly valve. A bypass is provided for the engine outlet and water jacket when thermostat valve is closed. A small valve is located in the bypass, which is forced open by the water pressure during thermostat valve shut off (Fig-9).

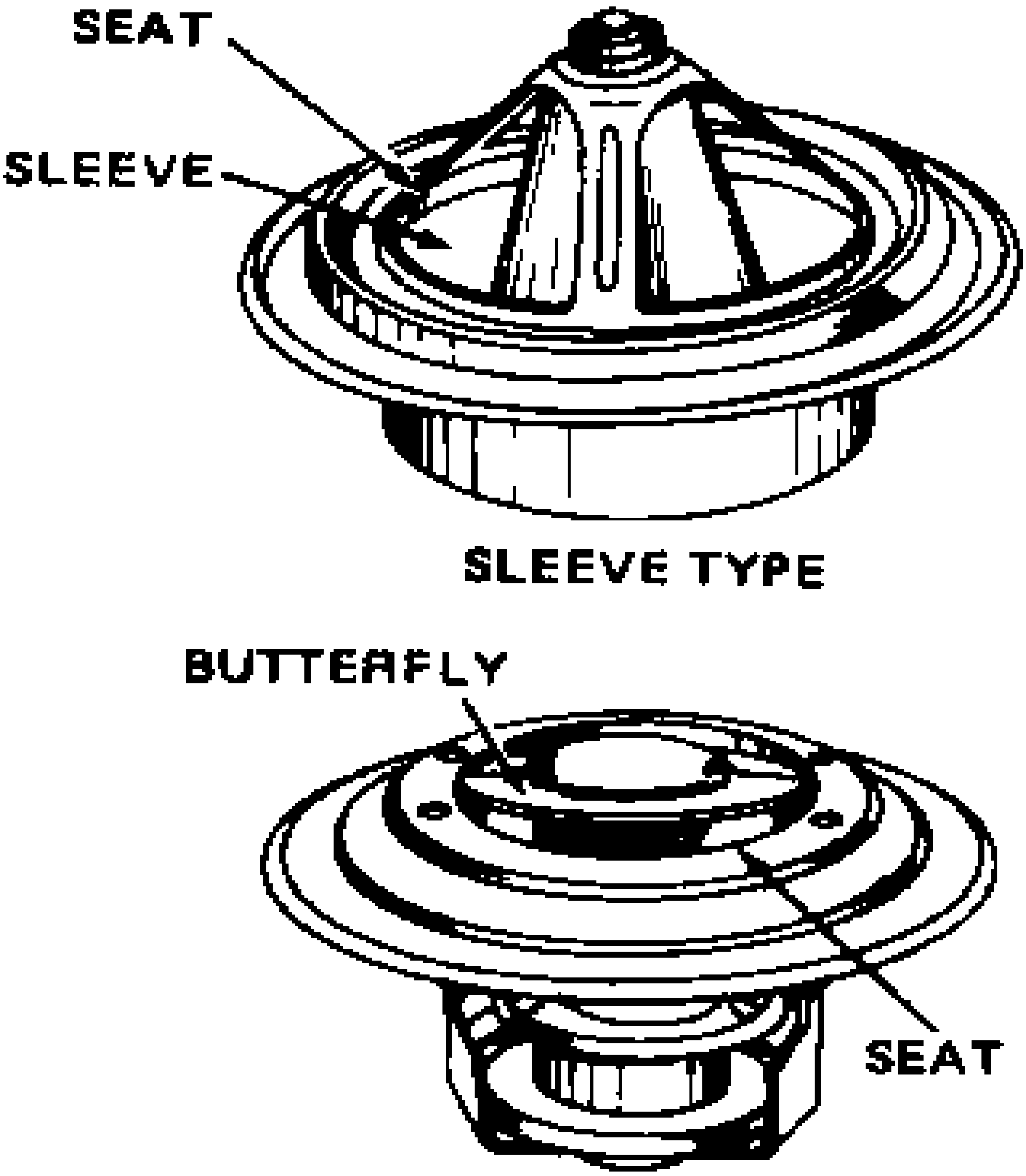



**Fig-9 Sleeve & Butterfly Type Thermostat**

**BAF BASE ZAHURUL HAQUE(TRG WG)**

**(Aero Engg Trg Sqn)**

**Syllabus : Automobile and Diesel Technology**

**Course : MTOF Basic Trade Training**

**Subject : Engine Cooling System**

**Aim : To Study Over Flow Tank.**

**Ref : The Automobile – By Harbans Singh Reyat**

---

# OVER FLOW TANK

## Purpose

1. The purpose of overflow tank is to collect the coolant after it flows out from the radiator during higher pressure.

## Description

2. It is a small tank, which collects the coolant after it flows out from the radiator during higher pressure. It is connected with over flow pipe of the radiator. It contains a small curved tube at the top through which atmospheric pressure acts in the tank. During higher pressure, when blow off valve in the pressure cap opens, the contents of the radiator run out and are collected by the overflow tank. There the coolant vapors condense down. When the vacuum valve in the pressure cap opens due to vacuum created in the cooling system during cooling down of the contents at engine shut off, the content runs back into the radiator from the overflow tank, there by making up the deficiency of coolant and maintaining proper level in the cooling system. Overflow tank is necessary when anti-freeze solution is used as it saves the costly solution to run waste. The sealed engine cooling system is factory filled with a permanent anti freeze mixture, formulated for very low temperatures ($35^0$c) and sealed. It offers the advantage that emptying and flushing of the system at the beginning and end of winter is no longer necessary and no top-ups are required (fig-10).

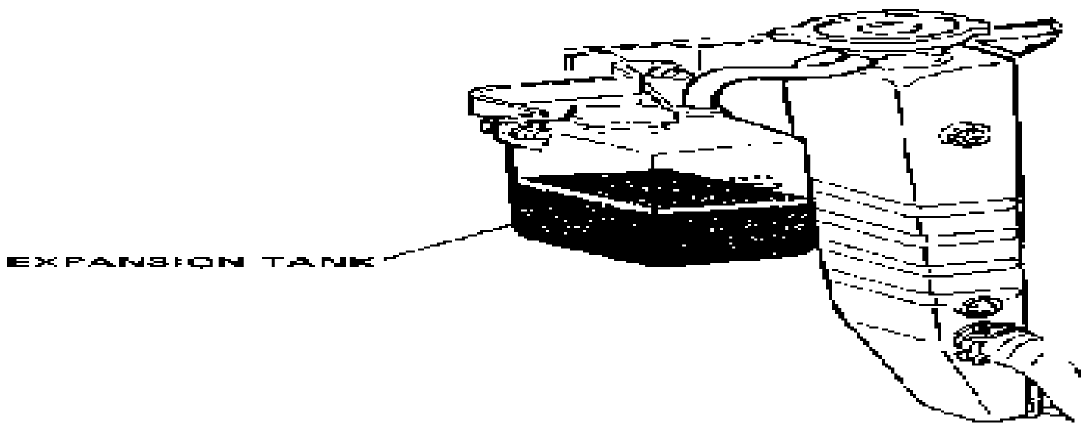


**Fig-10 Overflow Tank**

# BAF BASE ZAHURUL HAQUE (TRG WG)
## (Aero Engg Trg Sqn)

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **MTOF Basic Trade Training** |
| **Subject** | **:** | **Engine Cooling System** |
| **Aim** | **:** | **To Study Fan** |
| **Ref** | **:** | **The Automobile – By Harbans Singh Reyat** |

## FAN

**Purpose**

1. It serves the following purposes in the engine cooling system:

   a. It ensures regular flow of air through the radiator fins and thus increases its heat radiating ability.

   b. It throws fresh air over the outer surface of the engine due to which heat conducted is taken away and thus it increases efficiency of the cooling system.

**Construction**

2. The fan is fitted between the engine and the radiator. It is driven by belt and pulleys, drive taken from the crankshaft (Fig-11).

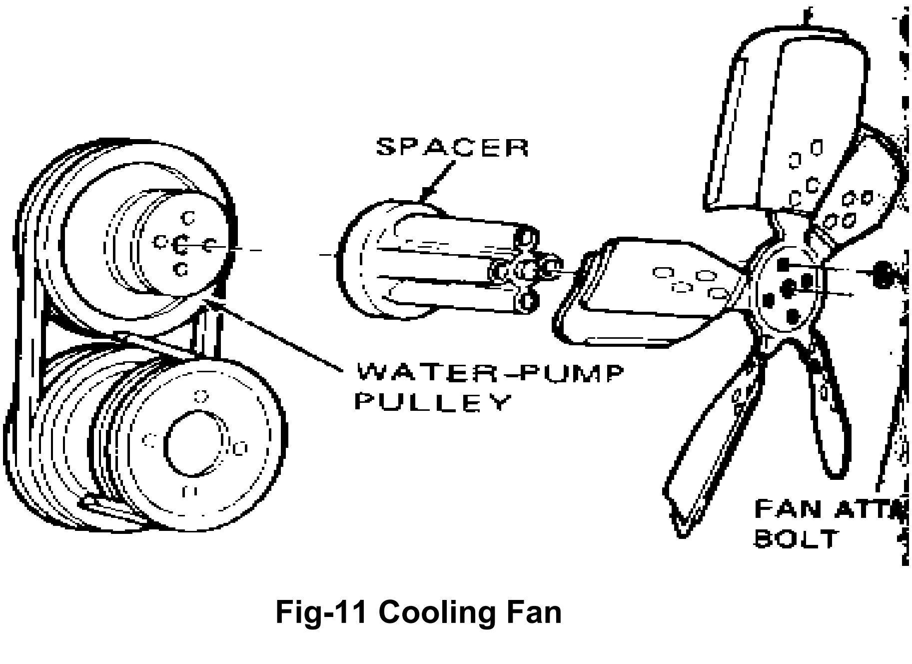



**Fig-11 Cooling Fan**

**Use**

3. The fans vary in number of blades, which range from two to eight. In cold countries or during winter season, there is more problem of keeping the engine warm than to cool down. Fan is usually removed during extreme cold. Even a canvas is spread over the radiator core or radiator shutters are employed to keep it warm. Removal and replacement of the fan leads to unnecessary headache. In order to over come this difficulty, automatic fans have been developed and employed in cars. Automatic fans are operated by different ways, electro magnetically or thermostatically. When engine temperature is low or falls down, the drive to the fan is cut off and when it temperature rises up, the fan begins to rotate. Many engine are variable speed fan drive which reduces fan speed to conserve power at high engine speed as well as when cooling requirements are low during cold season. The variable speed fan drive uses a fluid coupling. When cooling requirements of the engine are more during high speed and high temperature, more oil is injected into the fluid coupling causing the fan to run fast. When cooling requirement is low during cold season or low engine speed, oil is withdrawn from the fluid coupling due to which the fan speed drops off. The oil flow to the fluid coupling is controlled thermostatically.

## BAF BASE ZAHURUL HAQUE (TRG WG)

### (Aero Engg Trg Sqn)

**Syllabus : Automobile and Diesel Technology**

**Course : MTOF Basic Trade Training**

**Subject : Engine Cooling System**

**Aim : To Study Water Pump.**

**Ref : The Automobile – By Harbans Singh Reyat**

---

## WATER PUMP

**Purpose**

1. The purpose of water pump is to draw the water from the radiator lower tank and supplied it to the engine water jacket.

**Construction**

2. Usually the water pumps are impeller types and are fitted at the front end of the cylinder block, between the block and the radiator. The impeller pump consists of housing with an inlet and outlet and an impeller. The impeller is a sort of flat disc or rotor having a series of flat or curved blades or vans and is fixed over the pump shaft. When the impeller rotates, the water between the blades is thrown outwards by centrifugal force and is forced through the pump outlet into the engine water jackets. The pump inlet is connected to connection at the lower tank of the radiator through a hose. The water from the radiator is drawn into the pump to replace water forced out through the outlet. A plain bearing supports the impeller drive shaft and a seal prevents water leakage out of the pump. The pump is driven by a pulley and V-belt, the drive being provided by a pulley at the crankshaft (Fig-12).

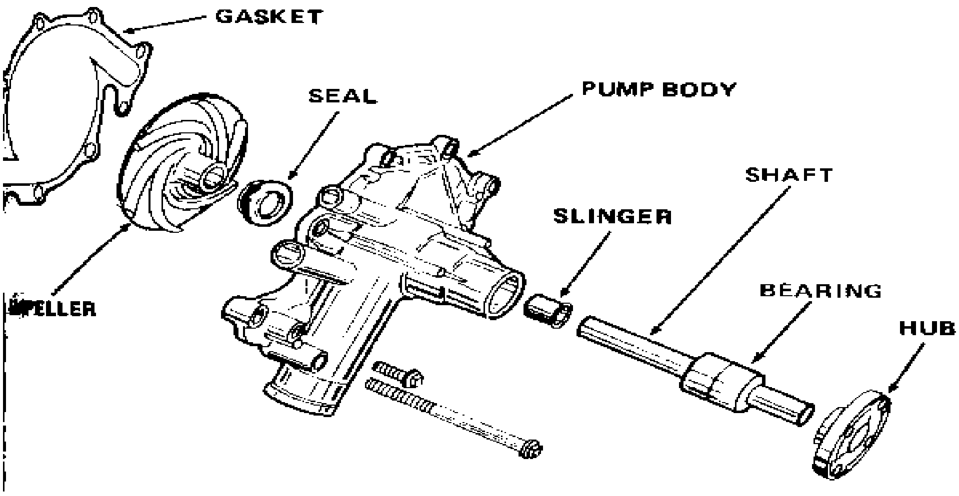



**Fig-12 a Disassembled Water Pump**

# BAF BASE ZAHURUL HAQUE (TRG WG)

## (Aero Engg Trg Sqn)

**Syllabus : Automobile and Diesel Technology**

**Course : MTOF Basic Trade Training**

**Subject : Superchargers and Turbochargers**

**Aim : To study Superchargers and Turbochargers**

**Ref : Automotive Mechanics by William H. Crouse (Seventh and ninth Edition)**

---

## SUPERCHARGERS AND TURBOCHARGERS

### Introduction

1. The word "supercharger" tell you what the device is. It is a mechanism for supplying the engine with a supercharge of air-fuel mixture. The idea is simple. A centrifugal pump, somewhat similar to the engine water pump, is located between the

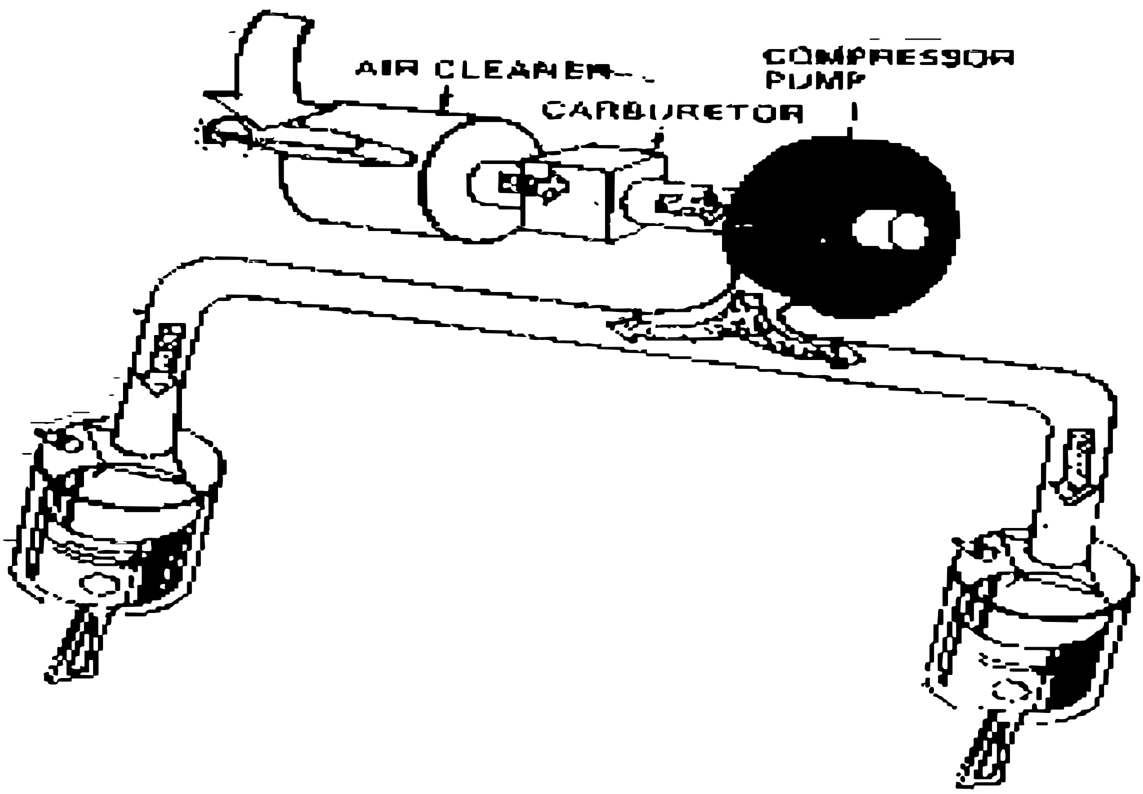



***Fig*-1, *Schematic Diagram Showing Principle of the Supercharger***

Carburetor and the engine cylinders (Fig -1). It is driven at high speed. It compresses the air-fuel mixture from the carburetor and delivers it to the cylinders. A greater amount of air-fuel mixture therefore enters in the cylinder, and the power strokes are stronger. That is, the engine can deliver more horsepower. The supercharger can increase the pressure on the mixture as much as 16 psi (pounds per square inch) [1.25 kg/cm2] above normal air pressure. An increase in engine horsepower of up to 50 percent is possible with supercharging. The problem with the early supercharger was in the drive arrangement. It was driven by a belt, by 'gears or by a chain and sprockets. These mechanical drives were put through great stress and sometimes caused trouble. Today, the supercharger is driven by the exhaust gas and carries the name turbo super charger, or simply turbocharger. Figure-2 shows the arrangement. The exhaust gas, still under some pressure as it leaves the engine cylinders, is directed into a turbine. The turbine wheel is spun by the exhaust gas. In to the turbine wheel is on the same shaft as the compressor-pump rotor; so the pump rotor is driven to produce the high pressure on the in going air-fuel mixture.

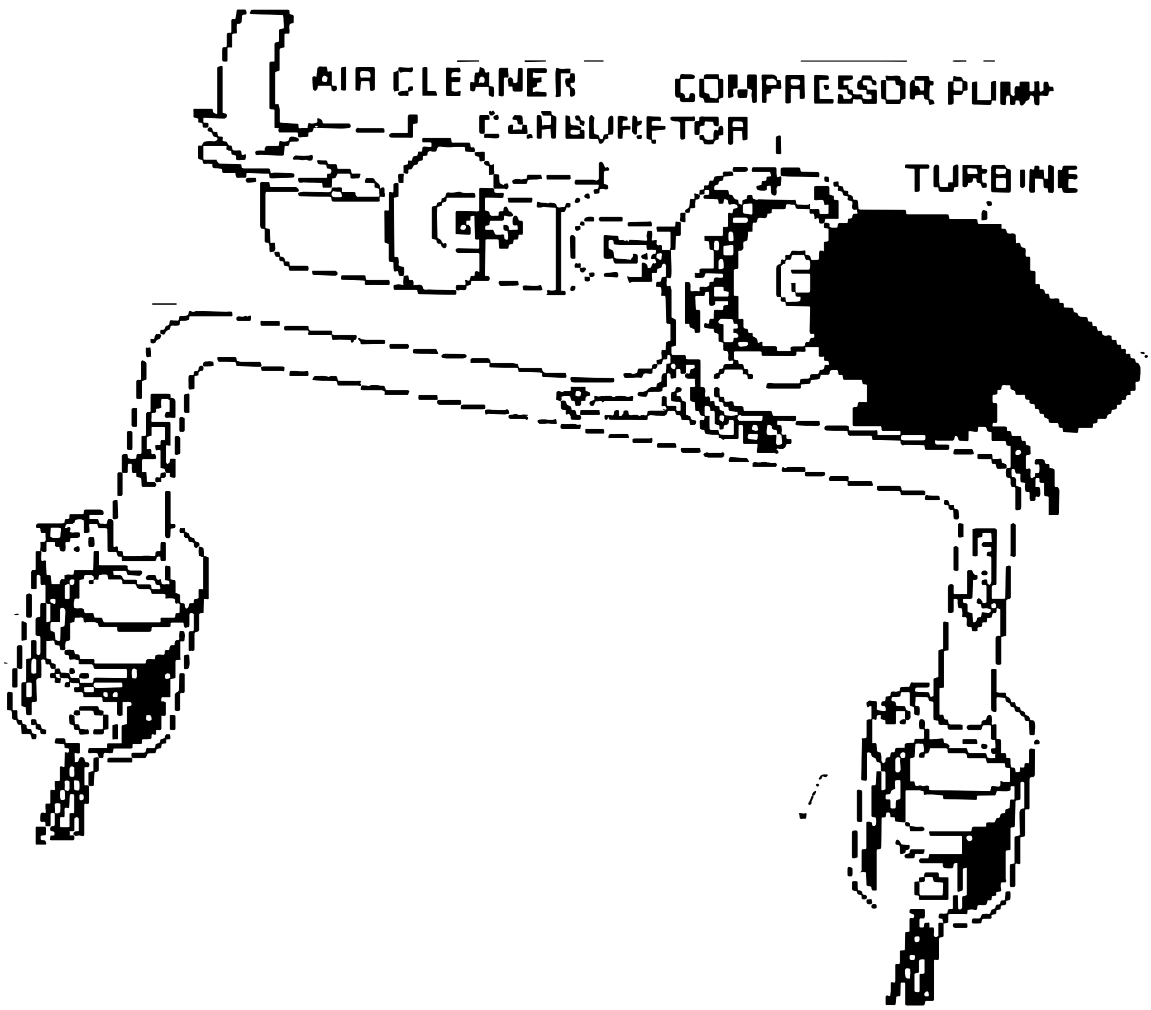



***Fig-2, Schematic Diagram Showing Principle of the Turbocharger***

**Description**

2. Many engines use a special air pump to deliver a "super charge" of air or air fuel mixture to the engine. This increases the power output of the engine. In the spark ignition engine, more air fuel mixture enters the cylinders during the intake stroke. This means higher pressures. During the power stroke and higher engine power out put. In the diesel engine, more air in the cylinders allows more fuel to be injected in to the cylinders, .Greater engine power results. There are two types of engine supercharging devices. Both use a rotary air pump, or compressor. Major difference is in the way the compressor is driven. One type~ usually called a super charger has the compressor driven by a belt from the engine crankshaft. The other type, called a turbo charger, has the compressor driven by the exhaust gas from the engine. This is the type most commonly installed on car engines. The turbo charger has two basic parts, an air pump and a turbine. Exhaust gas flows through the turbine and spins the turbine rotor. The other end of the shaft on which the turbine is mounted supports the compressor rotor.

**Operation**

3. When the turbine spins, the compressor rotor spins, producing pressurized air or pressurized air fuel mixture. In some systems, the compressor produces pressurized air, which is sent to the carburetor. In other system the compressor is placed between the carburetor and the intake manifold and delivers compressed air fuel mixture to the intake manifold. With either arrangement, additional air-fuel mixture enters the engine cylinders when the turbo charger is operating in *boast.* This means extra power is produced. Engine power may be increased 30 percent or more. However, the turbo charger provides boost only part of the time. This is when the engine is called upon to deliver maximum power, such as when passing on the high way or going up a hill.

**BAF BASE ZAHURUL HAQUE(TRG WG)**
**(Aero Engg Trg Sqn)**

**Syllabus** : **Automobile and Diesel Technology**

**Course** : **MTOF Basic Trade Training**

**Subject** : **Maintenance and Operation of Aerospace Ground Equipment**

**Aim** : **To Study APA Generator**

**Ref** : **T . O,s.**

---

# APU GENERATOR

## Purpose

1. It is an external source of power supply to start the aircraft.

## Construction

2. It is a generator placed on the vehicle chassis, driven by the vehicle engine. The generator is capable of producing DC/AC voltage and maximum output is 28.5 DC voltage and 115AC voltage. The generator is made from USSR.

## Operation

3.

a. Start the vehicle engine.

b. Disengage the power take off.

c. Raise the R. P. M. up to 450

d. Engage the generator.

e. Put the unite switch on.

f. Now raise the r.p.m. up to 1500 at the same time voltage will raise up to 28v. In this position lock the accelerator. Now put the load switch on and the supply will be available through the out put lead up to the aircraft.

**BAF BASE ZAHURUL HAQUE (TRG WG)**
**(Aero Engg Trg Sqn)**

**Syllabus : Automobile and Diesel Technology**

**Course : MTOF Basic Trade Training**

**Subject : Maintenance and Operation of Aerospace Ground Equipment**

**Aim : To Study Air Truck**

**Ref : T . O,s.**

---

# AIR TRUCK

## Introduction

1. It is a truck which is having 20 air cylinder (bottle) . It has five (5) group and each group having 4 cylinder (bottle) i.e. 4x5=20 cylinder. These cylinders are charged from H.P.compressor.

## Purpose

2. The purpose of air truck is to supply the air to the aircraft system for various and to the aircraft road wheel.

## Operation

3. At the time of requirement air truck is to be parked near to the aircraft. Air delivery hosepipe is to be connected to the aircraft system and the system to be charged from the air cylinder of the air truck.

## Safety Precautions

4. a. Fire extinguisher of the air truck is to be checked for serviceability.

   b. Vehicle is to be placed in safe distance.

   C. Air delivery hosepipe should be checked for its serviceability.

# BAF BASE ZAHURUL HAQUE(TRG WG)
# (Aero Engg Trg Sqn)

**Syllabus : Automobile and Diesel Technology**

**Course : MTOF Basic Trade Training**

**Subject : Maintenance and Operation of Aerospace Ground Equipment**

**Aim : To Study Oxygen Truck**

**Ref : T. O, s.**

---

## OXYGEN TRUCK

### Introduction

1. It is a vehicle consists of oxygen cylinder and may other instruments in the truck. There are 20 cylinders (bottle) in this truck. These cylinders are charged from Bangladesh Oxygen Limited (B.O.L).

### Purpose

2. The purpose of oxygen truck is to be supplying the oxygen to the aircraft for pilots breathing and other purpose also.

### Operation

3. This truck can be taken to the required places for aircraft pre- flight and post flight. The oxygen is to operate from the driver's cabin. The operators of this truck are following some sequence of operation. The sequences are follows:

a. Parked the vehicle properly.

b. Put the hand brake 'on'.

c. Disconnect the drive from gear by 4x4 gear lever.

d. Engage the second gear.

e. Connect the hose.

f. Put the oxygen lever 'on' and engine will continue to run in idle speed.

***Note*** Oxygen supply to the aircraft is done by the instrument fitter. The rear compartment of this truck is having many instruments to control the oxygen supply.

## Safety Precautions

4. A fire extinguisher is to be kept to the operator's cabin and an automatic fire extinguisher is kept to the rear compartment of this truck and is operated automatically if fire occurs.

# BAF BASE ZAHURUL HAQUE(TRG WG)
## (Aero Engg Trg Sqn)

**Syllabus : Automobile and Diesel Technology**

**Course : MTOF Basic Trade Training**

**Subject : Maintenance and Operation of Aerospace Ground Equipment**

**Aim : To Study Hydraulic Test Stand**

**Ref : T. O, s.**

---

## HYDRAULIC TEST STAND

### Introduction

1. Hydraulic test stand is a vehicle or stand, which is having system to supply of hydraulic fluid now days. Hydraulic test stand, which is used in BAF mainly, Russian made and that is known as “UPEGA”.

### Purpose

2. The purpose of hydraulic stand is to supply the hydraulic fluid to the aircraft for the functional check and rectification of the hydraulically operated system of an aircraft.

### Operation

3. This vehicle can be taken nearer to the aircraft and is to be parked. There are many hoses in the vehicle and that will be connected to the respective aircraft system. This test stand is having rear engine to operate all the system.

### Safety Precaution

4. a. It is to be parked in safe distance from the aircraft.

   b. Fire extinguisher to be kept nearer to the operator.

   c. All the hoses must be checked before using in the aircraft.

**MODED BY JAHID (BD/474652)**

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

**Syllabus : Automobile and Diesel Technology**

**Course : Trade Training Basic, MTOF**

**Phase : The Engine Fundamentals**

**Aim : To study Engine Fundamentals**

**Ref : Automotive Mechanics by William H. Crouse Chapter 9, Page no 56-62.**

---

## ENGINE FUNDAMENTALS

### Atoms

1. You might think it strange to start this chapter on engines by talking about atoms. But an engine will not run until atoms start getting together inside the engine. So let's see what atoms are. Take a look at all the different things around you-this book, your chair, the window, trees, buildings, and so on. You're looking at atoms. All these things are made of metals, wood, paper, plastics, clay, water, air, and thousands of other materials. But all these different materials are made up of only a few basic "building blocks" we call atoms. There are only about 100 different kinds of atoms. But they can be put together in millions of ways to form millions of different substances. You can compare this with the 26 letters of our alphabet. These letters can be put together in many different ways to make the several hundred thousand words in our language. Now, about those 100 or so kinds of atoms. We have a special name for each kind: copper, iron, carbon, oxygen, silver, gold, uranium, aluminium, and so on. The silver in dime is made up of trillions of one kind of atom. The oxygen in the air you breathe is made up of a great number of another kind of atom. Any substance made up only one kind of atom is called an element. Silver is an element.

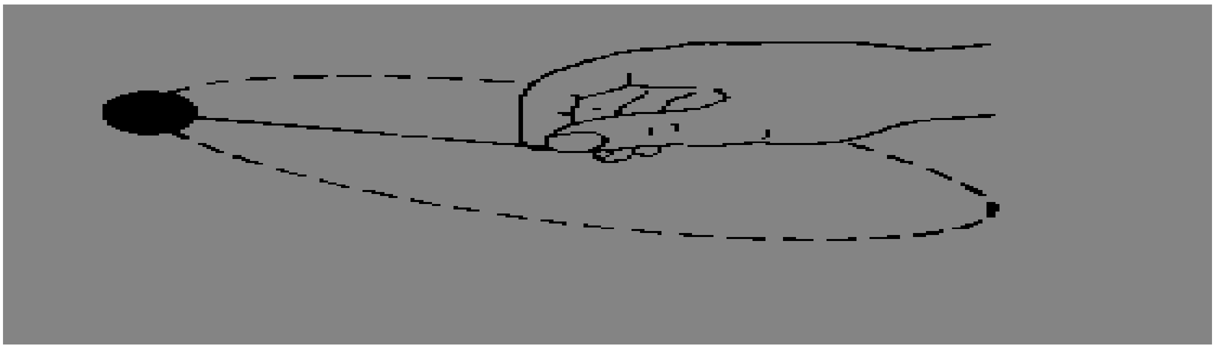


Fig -1, The electron in a hydrogen atom circles the proton. This like a ball on a rubber band swung in a circle around your hand.

**Size of Atoms**

2. Atoms are very small. There are more than 100 billion billion atoms in a single drop of water. That's about 30 billion atoms for every person on earth. Suppose you tried to count your share - you're 30 billion. It would take you 1,000 years if you counted one atom every second day and night. You must admit that atoms are very small.

**Inside the Atom**

3. If you were able to look inside an atom, you would find that it is mostly empty space. Take the hydrogen atom, the simplest atom of all, as an example. In the center, or "nucleus," you would find a single particle. Whirling around this particle, in an almost circular path, or "orbit," you would find a second particle. And that's all. The center particle in hydrogen is called a proton. The outer particle is called an electron. Electrons in motion make up an electric current. Now back to our atom of hydrogen. How close are the two particles? Well, suppose the proton were the size of a marble. If you laid this marble less than one basket of a basketball court (84 feet long) [25.603m], the electron would be at the other basket. And in between –nothing. Nothing but empty space.

**The Proton and Electron**

4. The proton has a tiny charge of positive electricity. Positive electricity is indicated by a plus (+) sign. The electron has a tiny charge of negative electricity. Negative electricity is indicated by a negative (-) sign. Opposites attract. Positive attracts negative. Negative attracts positive. Thus, the negative electron is attracted toward the positive proton. But this inward pulling force is balanced by the outward pull of centrifugal force. This is somewhat like the balancing of forces you get when you whirl a ball on a rubber band around your hand shown on (Fig. -1). The rubber band pulls the ball toward your hand But centrifugal force pushes the ball away. As a result, the ball moves in an orbit, a circle, around your hand

## Helium

5. The simplest atom is hydrogen, a gas. It has one proton and one electron. Next, as we go from the simplest to the more complex atoms, is helium, another gas. The helium atom has two protons (two + charges) in its nucleus, or center. It has two electrons (two - charges) circling the nucleus shown on (Fig.-2) The nucleus also contains two particles called neutrons. They have no electric charge. The neutrons seem to serve as a nuclear "glue" to hold the protons together. For, just as unlike charged particles attracts, so do like charged particles repel each other. Without neutrons, the protons in the nucleus would fly apart, and we would not have any atoms except hydrogen atoms.

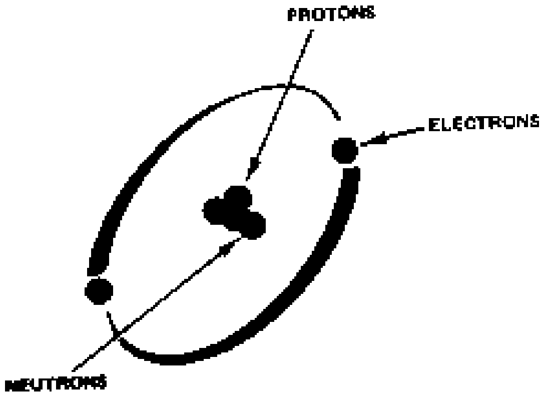



Fig -2, The helium atom has two electrons circling the nucleus. The nucleus contains two protons and two neutrons.

## More Complex Atoms

6. The next more complex element after helium is lithium, a very light metal. The lithium atom has three protons and four neutrons in its nucleus. Three electrons, one to balance each proton, orbit the nucleus. Next comes beryllium, another metal, with four protons, five neutrons, and five electrons. Then carbon with six, six, and six; then nitrogen with seven, seven, and seven; then oxygen with eight, eight, and eight; and so on. Note that each atom normally has the same number of electrons as protons. This makes the atom electrically neutral, since negative charge balance positive charges. However, many kinds of atoms do not hold their electrons very well. Electrons are forever wandering off, leaving electrically unbalanced atoms behind (with + charges). These wandering electrons give us electricity, as we shall see later.

## Chemical Reactions

7. Atoms of different elements can get together, and actually link up. The process is called a chemical reaction. Chemical reactions go on around us all the time. The burning of gasoline in the automobile engine is a chemical reaction. Whenever atoms react, or link up, they form molecules. For example, atoms of hydrogen and oxygen can act to form a molecule of water shown on (Fig, -3).

Water has the chemical formula $H_20$. This means that each water molecule has two atoms of hydrogen and one atom of oxygen. Another chemical reaction occurs when one atom of carbon unites with two atoms of oxygen, as shown in Fig.-4. The result is a molecule of carbon dioxide, or $CO_2$ . During a chemical reaction, electrons move from an atom of one element to an atom of another element. This exchange of electrons produces an unbalance of electric charge. That is, the atoms that gain electrons take on negative electric charges. The atoms that lose electrons take on positive electric charges. This difference in electric charges hold the atoms together in a molecule.

## Combustion

8. Combustion or fire, is a common chemical reaction. in combustion, oxygen in the air combines with other elements, such as hydrogen or carbon. This is what happens in the automotive engine. A mixture of air and gasoline vapor is compressed and then ignited, or set on fire. The air is about 20 percent oxygen. Gasoline is mostly hydrogen and carbon (and is thus called a hydrocarbon). In the engine, oxygen atoms unite with hydrogen atoms in the gasoline to form $H_2$ 0 as water shown on (Fig.-3.) Oxygen atoms also unite with carbon atoms to form $C0^2$ or carbon dioxide (Fig.-4). During combustion, the temperature may go as high as $6000^0$ F [$3316^0$ C]. This high temperature produces the pressure, which makes the engine run.


Fig-3

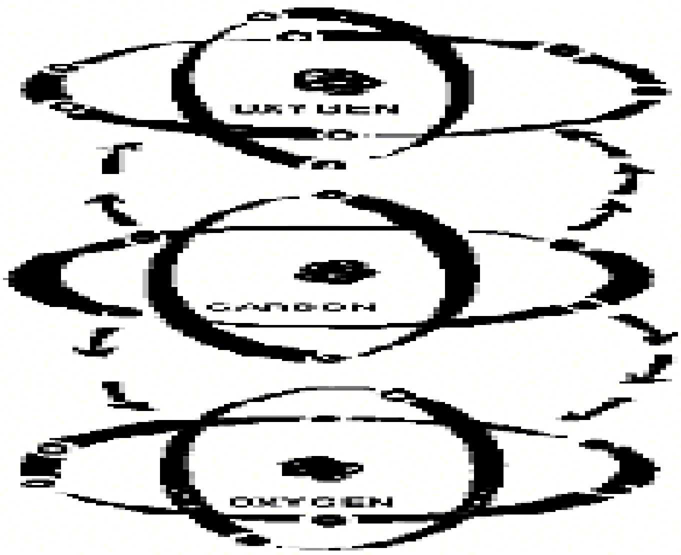


Fig -4, Two atoms of oxygen uniting with one atom of carbon to form a molecule of carbon dioxide ( $co_2$ ).

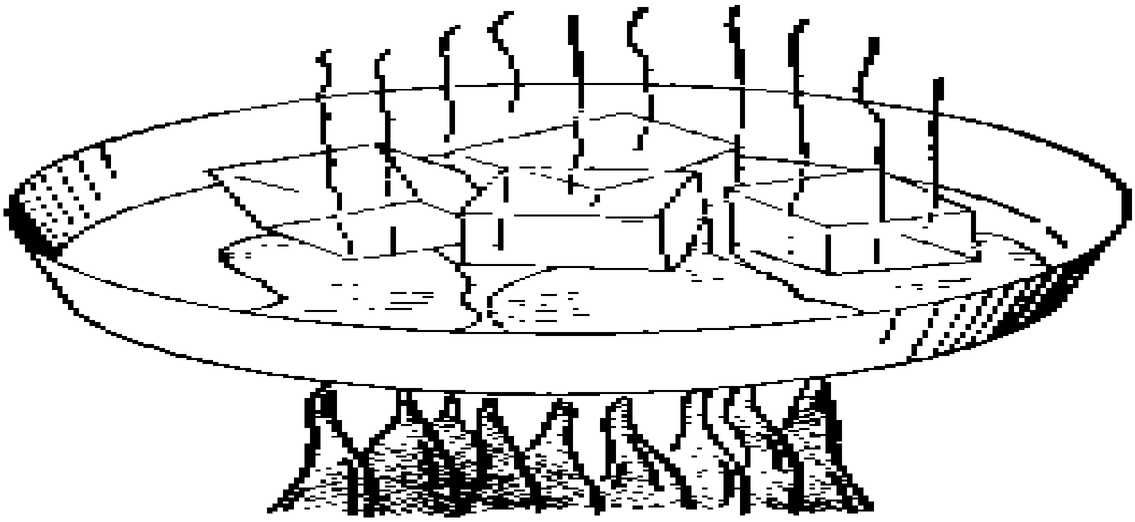
***Note:*** *With ideal (perfect) combustion, all the hydrogen and carbon in the gasoline would be made into harmless $H^20$ (water) and $C0_2$ (carbon dioxide). However, in the engine, we do not get ideal combustion. Some hydrocarbons are left over. Also, some carbon monoxide (CO) is produced instead of some $C0_2$. These products contribute to the pollution problem. They are the reason for the emission controls on modern cars. These controls and how they work are described in later chapters.*

**<u>Heat</u>**

9. We mentioned that combustion produces high temperatures. But what do we mean by "high temperatures" and heat”? Actually, heat is the rapid motion of atoms of molecules in a substance. That may be a little hard to understand. First, you must realize that the atoms and molecules of any substance are in rapid motion. Even though a piece of iron appears solid and motionless, its atoms and molecules are moving rapidly. The atoms in a piece of hot iron move faster than the atoms in a piece of cold iron. It’s that simple.

**<u>Change of State</u>**

10. Atoms and molecules in motion may be a little hard to understand, as we said. But let’s look at "change of state" to see if we can’t make it a little clearer. suppose we put a pan of ice cubes over a fire (Fig. -5). First, the ice cubes melt, or turn to water. Then the water boils, or vaporizes. Each of these changes is a change of state. There are three states: solid, liquid, and gas or vapor. A change of state is caused by changes in the speed of the atoms and molecules in a substance. In the ice, for example, the molecules of water move slowly and in restricted paths. That is, they don’t wander very far. But as the temperature increases, the molecules move faster. Soon, the molecules are moving so fast that they break out of their restricted paths. That is when the ice turns to water (at $32^0$F) [$0^0$C]. As the temperature increases still more, the molecules reach speeds that allow them to fly clear out of the water. This is, the water boils, or turns to vapor. This happens when the water reaches $212^0$ F [$100^0$ C] (at sea-level pressure).



Fig, -5: The ice cubes in a pan over a fire will first melt, or turn to water. Then the water will evaporate, or vaporize each of these changes, from a solid to a liquid to a vapor, is called a change of state.

**Expansion of Solids with Heat**

11. When a piece of iron is heated, it expands. Suppose a steel rod measures 10feet [3.048m] in length at $100^0$ F [37.8 $^0$C]. It will measure 10.07 feet [3.069m] in length at 1000 $F^0$ (537.$8^0$ C] (Fig.-7). Here is the reason: As the rod is heated, the molecules in it move faster and faster. They need more room for this, and so they push neighboring molecules away. The rod gets longer and wider. Expansion of solids with heat is important in the engine. As the engine goes from cold to hot, the engine parts expand. This expansion must be taken into account when the engine is designed. It is also important in engine servicing.

**Expansion of Liquids and Gases**

12. Liquids and gases also expand when heated. One cubic foot [0.0283$m^3$] of water at $39^0$F [3.$89^0$ C] becomes 1.01 cubic feet [0.0286 $m^3$] when heated to 100 F [37.$8^0$ C]. One cubic foot of air at $32^0$ F [$0^0$ C] becomes 1.14 cubic feet [0.0323$m^3$] when heated to $100^0$F[37.$8^o$ C] without a change of pressure. These expansions are also the result of molecules moving faster. The faster-moving molecules spread out more and take up more room.

**Increase of Pressure**

13. Suppose we don't let the molecules spread out when we heat them up. We can do this by holding the volume constant and heating a cubic foot of air from $32^0$ to $100^0$ F [$0^0$ to 37.8 $^0$C]. If we start with a pressure of 15 psi (pounds per square inch) [1.05 kg/$cm^2$ ], we find that the pressure increases to about 17 psi [1.195 kg/$cm^2$ ]. The higher pressure is also due to the higher speed of the moving molecules. The molecules keep hitting the inside surfaces of the container (Fig.-6). As they move about. With higher temperatures, the molecules move faster.
They hit the surfaces harder and more often. The result is an increase in pressure. Another way to

increase the pressure in a container of gas is to compress it into a smaller space. This is what happens in the engine cylinders. The mixture of air and gasoline vapor is squeezed into one-eighth or one-ninth of its original volume. This puts the molecules closer together. They hit the piston head far more often. That is, the pressure goes up . The pressure gets even higher when the compressed air –fuel mixture is ignited. As we have explained, this makes the molecules move much faster. They bombard the piston head still harder. These billions upon billions of molecules, moving at great speeds, hit the piston head so hard and so often that they add up to a total push of a ton or more .This push, or pressure, is due only to the pounding of the fast-moving molecules.

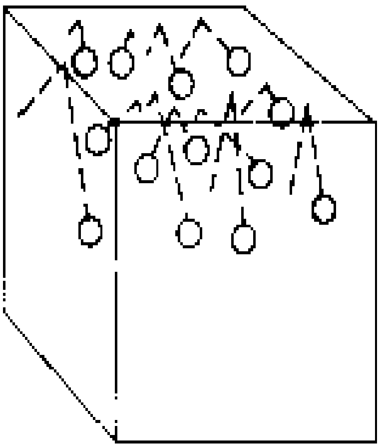


Fig -6, The molecules keep hitting the inside surfaces of the container as they move about.

**Increase of Temperature**

14. When a gas compressed, its temperature also increases. Having the molecules closer together causes them to bump into one another more often. That makes them moves faster. In other words, the temperature of the gas goes up. In the diesel engine, air is compressed to one-sixteenth of its original volume. This sends the temperature of the air as high as $1000^0$ F[$537.8^0$C]. Of course, the heat produced by compressing a gas does not stay in the gas. It soon escapes from the compressed gas to the container and then to the outside air. Any hot object loses heat until its temperature is the same as the temperature around it.

**The Thermometer**

15. The thermometer (Fig. -7), is a familiar example of expansion with heat. It is just a hollow glass tube partly filled with a liquid such as mercury. As the temperature increases, the mercury expands. Part of it is forced up the tube. The higher the temperature, the more the mercury expands, and the farther up the tube the mercury rises. The tube is marked off in degrees to indicate the temperature.

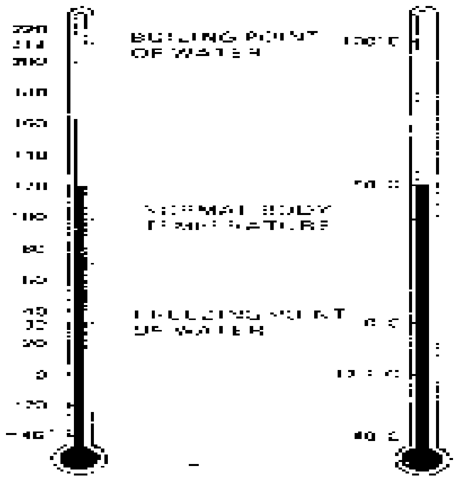


Fig -7, Fahrenheit and Celsius thermometers

**The Thermostat**

16. Different metals expand different amounts when they are heated. For example aluminium expands about twice as much as iron. Such differences in expansion are used in many thermostats. One type is shown in (Fig.-8). It is a coil made of two strips of different metals, such as brass and steel, welded together. When the coil is heated, one metal expands more than the other. This causes the coil to wind up or unwind. The motion of the coil can be used to control liquids or electricity. It is used in this manner in several places in the automobile. A different sort of thermostat depends on the expansion of a gas inside a bellows.

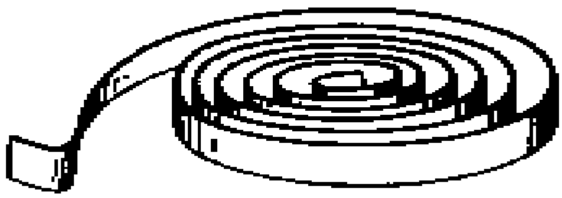


**Fig -8, Coil –type thermostat**

For example, one type of engine cooling system thermostat includes a bellows (Fig.-9). The bellows is a sealed metal container with flexible sides. When the pressure in the bellows goes up, the bellows gets longer. This action can be used as a control actually, the thermostat shown in Fig. -11 Contains a liquid. The liquid boils when the temperature goes up, and this produces the higher pressure. The idea is the same, however. Higher temperature and more rapid molecular motion produce the higher pressure, which elongates the bellows.

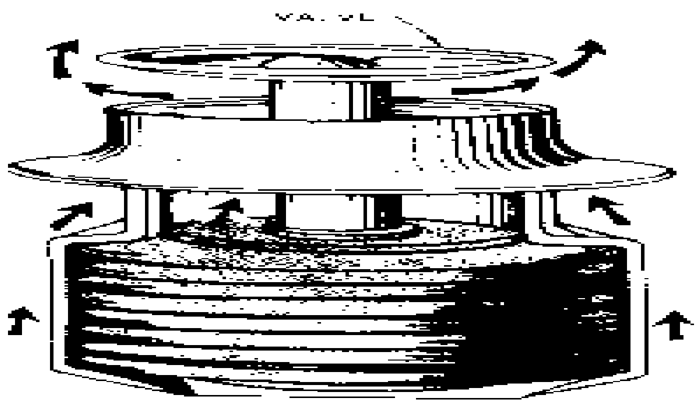


Fig -9, Bellows type thermostat

## Gravity

17. Gravity is the attractive force between the earth and all other objects. When we release a stone from our hand, it falls to earth. When a car is driven up a hill, part of the engine power is used to raise the car against gravity. Likewise, car coasts down a hill with the engine turned off, because gravity pulls downward on the car. Gravitation attraction is usually measured in terms of weight. We put an object on a scale and note that it weighs 10 pounds [4.536 kg]. What we mean is that the earth registers that much pull on it. Gravitational attraction gives any object its weight. Astronauts out in space, where the earth's gravitational attraction is almost zero, are weightless. They float freely around in the interior of their spaceships.

## Atmospheric Pressure

18. The air is also pulled toward the earth by gravity. At sea level and average temperature, a cubic foot of air weighs about 0.08 pound, or about 1.25 ounces (0.035 kilogram). This seems like very little. But the blanket of air surrounding the earth-our atmosphere -is many miles thick, . It is like thousands of cubic feet of air piled one on top of another, all adding their weight. The total weight, or downward push, is about 15 pounds for every square inch. Since the human body has a total surface area of several square feet, the weight of the air pressing on your skin amounts to several tons. Why doesn't all that pressure crush you? It can't because pressures inside your body balance this atmospheric pressure. Atmospheric pressure also affects the amount of power that an engine can produce. At sea level, an engine gets more air and produces more power. In Denver, Colorado, which is a mile above sea level, an engine gets less air and produces less power.

## Vacuum

19. A vacuum is the absence of air or any other matter. Astronauts on their way to the moon soon pass through our atmosphere and into a vast region of empty space. This is a vacuum.

## Producing a Vacuum

20. There is a process to produce a vacuum here on earth, in a small volume. The automobile engine, as it operates, produces a partial vacuum in the engine cylinder. Atmospheric pressure then pushes the air-fuel mixture into the cylinders. This is how the engine gets the air-fuel mixture it needs to run. Such as Vacuum Gauge, vacuum gauge is used in automotive service. It is really a pressure gauge. It measures the pressure in a closed space and compares it with atmospheric pressure. If the pressure in the closed space is lower, the vacuum gauge records so many "inches of mercury. When the vacuum gauge is connected, it measures the amount of vacuum in the engine. If the measurement is low or unsteady, then there is engine trouble. The vacuum gauge contains a bellows, or diaphragm, linked to a needle on the dial face. When vacuum is applied, the bellows or diaphragm moves. This causes the needle to move, to show the amount of vacuum.

## Humidity

21. Almost all air has some water vapor (evaporated water) in it. When the air is carrying a good deal of water vapor, the air is said to be humid. That is, it has high humidity. You find humid air around bodies of water. Air over deserts has low humidity. It has very little water vapor. Humidity is measured in terms of percentages. Zero percent humidity means the air has no water vapor. Hundred percent humidity means the air is holding all the water vapor it can hold. A reading of 50 percent humidity means that the air is holding half as much water vapor as it could. Humidity affects engines. An engine puts out less power in hot, dry conditions than in cool most conditions. The cool air is denser (molecules are closer together) so that more air enters the engine and this means more power. Also, moisture has a quieting effect on combustion so the engine runs more smoothly.

## Atmospheric Factors Affecting Combustion

23. Changes in temperature, atmospheric pressure, and humidity affect combustion in the engine. They affect the way the fuel burns and the power output of the engine. Accurate testing of engines requires that all readings be corrected to account for temperature, atmospheric pressure and humidity.

# BAF BASE ZAHURUL HAQUE (TRG WG)
## (Aero Engg Trg Sqn)

**Syllabus : Automobile and Diesel Technology**

**Course : Trade Training Basic, MTOF**

**Subject : Transmission System**

**Ref : The automobile – By Harbans Singh Reyat**

---

## TRANSMISSION SYSTEM

### Purpose

1. It is the system by means of which power developed by the engine is transmitted to the road wheels to propel the vehicle.

### Main Unit of the Transmission System

2. a. **Clutch**. It provides a smooth means of disengagement and engagement between the engine and the remainder of the transmission system.

   b. **Gear box**. It provides varied leverage to the drive wheels.

   c. **Transfer case**. It helps in diverting power flow in the opposite direction.

   d. **Propeller Shaft and Universal Joints**. Propeller shaft enables the drive wheels to move back and forth due to flexing of road springs. It enables the power to be transmitted to the road wheels at varied lengths and varied angles owing to slip joint and universal joints contained in it.

   e. **Final Drive**. It diverts the power at right angles towards the driving wheels and provides a final gear reduction between the engine and the driving wheels.

   f. **Differential**. It allows the outer wheel to run at greater speed than the inner one while negotiating a turn or moving over upheaval road.

   g. **Torque Tube**. In torque tube drive, all the driving thrust, braking effort and torque reactions are taken by the torque tube.

   h. **Road Wheel**. The road wheels provide last leverage to the engine power to act as tractive effort at them. More the diameter of a road wheel, more the leverage it would provide.

### Types of Transmission System

3. a. Mechanical transmission system.

   b. Hydraulic transmission system.

# BAF BASE ZAHURUL HAQUE (TRG WG)

## Aero Engg Trg Sqn)

**Syllabus :** **Automobile and Diesel Technology**

**Course :** **Trade Training Basic, MTOF**

**Subject :** **Transmission System**

**Aim :** **To study Clutch**

**Ref :** **The automobile – By Harbans Singh Reyat & A P 3159**
**Section 6, Chapter 1.**

---

## CLUTCH

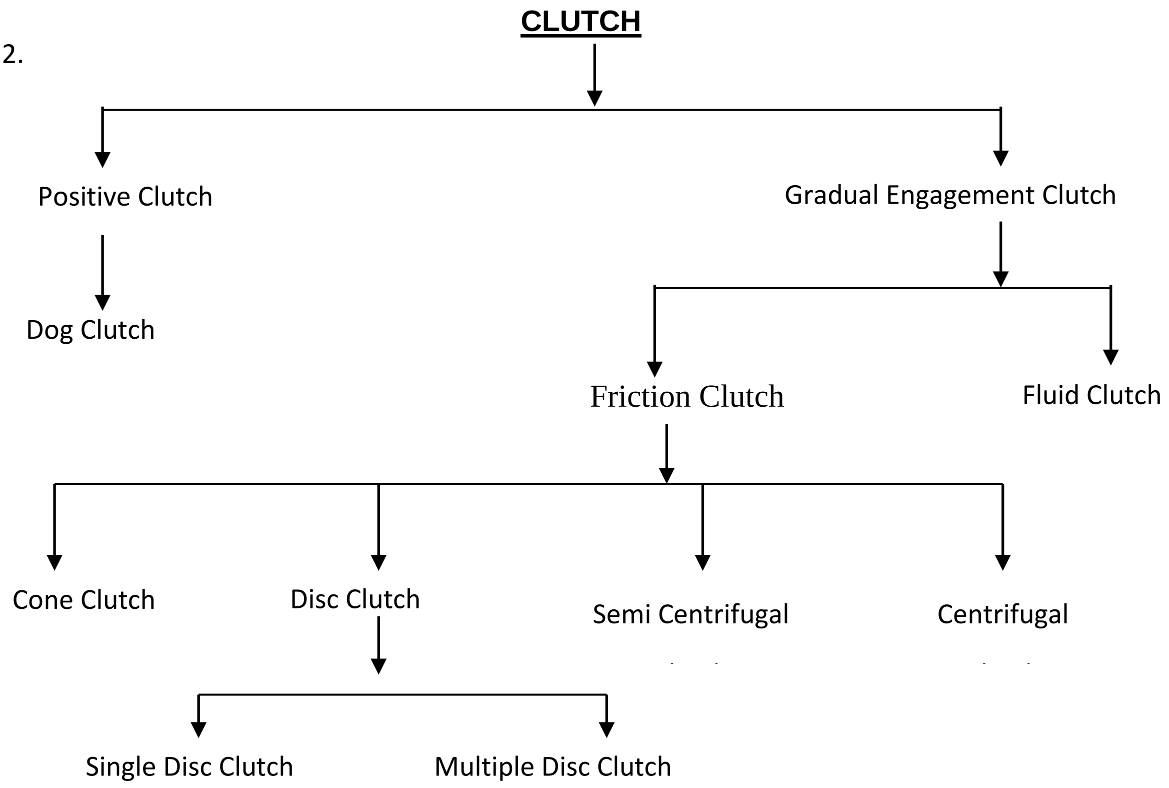
.

**Purpose**

1. It is a mechanism by means of which engine is connected or disconnected from the rest of transmission. Clutches enable the rotary motion of one shaft to be transmitted to a second shaft having the same axis, when required.

**Types of Clutch**

2.



**BAF BASE ZAHURUL HAQUE(TRG WG)**
**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **Transmission System** |
| **Aim** | **:** | **Friction Clutch** |
| **Ref** | **:** | **The automobile – By Harbans Singh Reyat** |

# FRICTION CLUTCH

**Purpose**

1. These types of clutches depend for their action upon the frictional force, which acts between two members when they are pressed together (In friction clutches, the pressure is exerted by means of coil springs. The spring tends to keep the clutch always engaged and when it is desired to disengage the clutch, the spring pressure is released).

**Types of Friction Clutches**

2. **Friction clutches are of the following main types:**

**a. Cone Clutch.** It consists of two cones having leather facings. The cones are known as male and female cones. The female cone is fixed with the driving shaft whereas the male member is splinted on the driven shaft. The driven shaft is supported in the driving shaft having the same axis. The spring pressure keeps the driven member in contact with the driving member and the clutch is consider to be engaged when there is no slip between the male and female cone. In order to disengage clutch, the driven member is moved back through leverage, against the tension of the spring.(Fig-1)

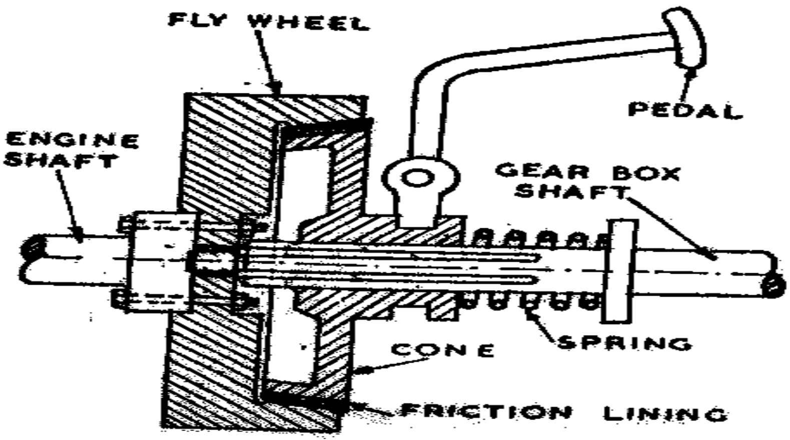



**Fig-1 Cone Clutch**

b. **Disc Clutch.** This type of clutch employs a disc having linings on its both facings. This disc is known as clutch plate and is held between the two members, which are attached to the driving shaft. The clutch disc acts as a driven member and is splined over the driven shaft. The clutch is disengaged when spring pressure acting on the clutch plate is released through clutch operating mechanism by pulling back pressure plate. Disc clutches are of the following types:

(1) Single disc clutch and

(2) Multiple disc clutches.

c. **Semi-Centrifugal Clutch**. The only difference between single dry disc clutch and semi-centrifugal clutch being that the construction of operating fingers or levers is different. In semi-centrifugal clutch, extra weight is provided at the weight arm of the levers, which acts on the pressure plate. When pressure plate moves, centrifugal forces through the weight arms of the operating levers, exerts an extra pressure in addition to the pressure of the springs on the clutch plate through the pressure plate. It is owing to this fact, that this clutch is known as semi-centrifugal clutch. (Fig-2).

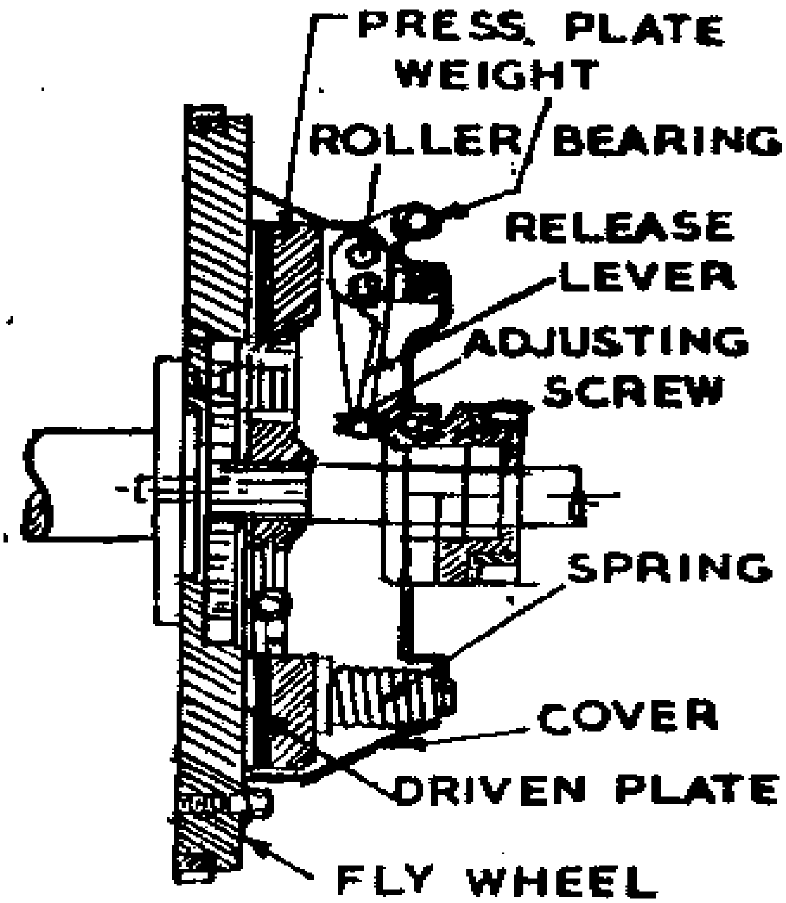



**Fig-2 Semi-Centrifugal Clutch**

d. **Centrifugal Clutch**. It is an automatic clutch, which is controlled by the engine speed through the accelerator. When the engine speed falls down, the clutch is automatically disengaged and when the engine speed rises above the predetermined value, the clutch engaged (Fig-3).

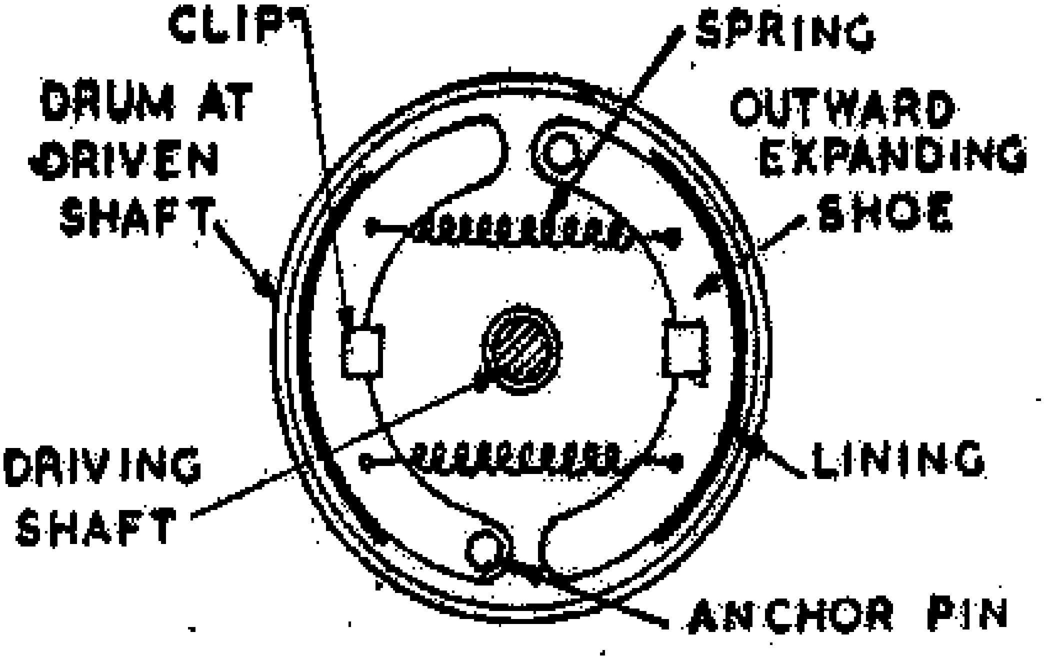



**Fig-3 Centrifugal Clutch.**

**BAF BASE ZAHURUL HAQUE (TRG WG)**
**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **Transmission System** |
| **Aim** | **:** | **To Study Single Disc Clutch** |
| **Ref** | **:** | **The Automobile – By Harbans Singh Reyat** |

---

# SINGLE DISC CLUTCH

## Introduction

1. It is the most common type of clutch used with majority of the vehicles. It contains only one clutch plate, which runs dry. It consists of the following parts:

a. Driving plate.

b. Driven plate.

c. Pressure plate.

## Driving Plate

2. Engine flywheel which is attached at the tail of crankshaft, acts as a driving plate for the operation of disc plate clutch in cars, buses, trucks, etc.

## Driven Plate

3. It is the clutch plate which is held by the pressure plate with the driving member, I .e, flywheel. It is a steel disc, which is connected to the splined hub through springs. At its outer facings, the disc contains lining of heat resisting material having a high coefficient of friction. The linings are riveted to the clutch plate and can be replaced after they wear out. The springs are mounted so that when torque is applied to the clutch plate, the springs compress, absorbing any shock before the hub turns. These springs are known as torsion damper springs because they cushion the vibrations in the clutch plate produced during engagement and dis-engagement. (Fig-4).

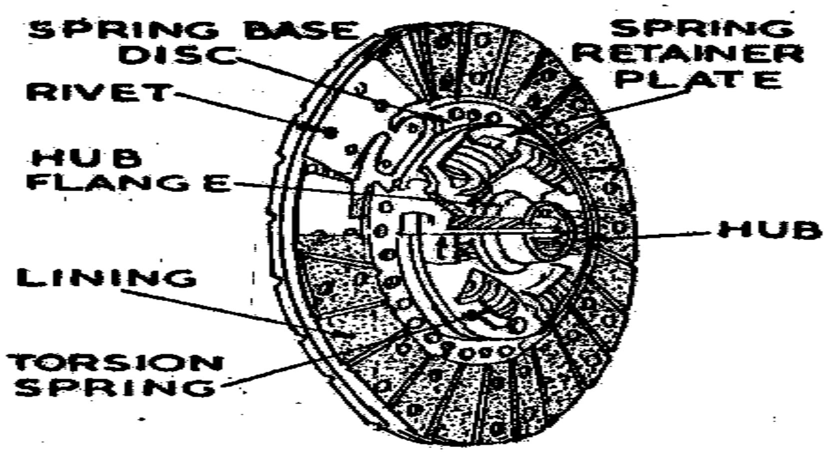



**Fig-4 Driven Plate**

**Pressure Plate**

4. The pressure plate assembly is connected with the flywheel and holds the clutch plate with the flywheel due to its pressure. It consists of pressure disc, springs, operating fingers and holding down cover. The pressure plate is held with the cover through the bolts. The coil springs are held between the cover and the plate. The fingers act as levers and when pressed down, help in lifting off pressure plate as the springs are pressed and pressure is released (Fig- 5). In some cases, crown or diaphragm type conical spring is employed in the pressure plate in place of coil springs. The diaphragm spring is either of flat cone type or corrugated cone type, the center section of flat cone type diaphragm spring is clutch, which uses diaphragm spring, is known as Diaphragm Clutch (Fig-6).

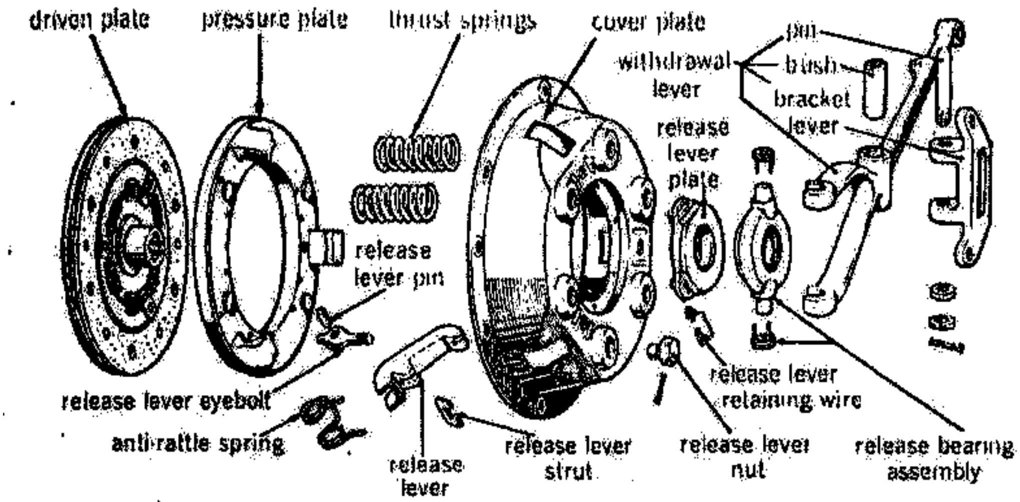



**Fig-5 Pressure Plate Assembly.**

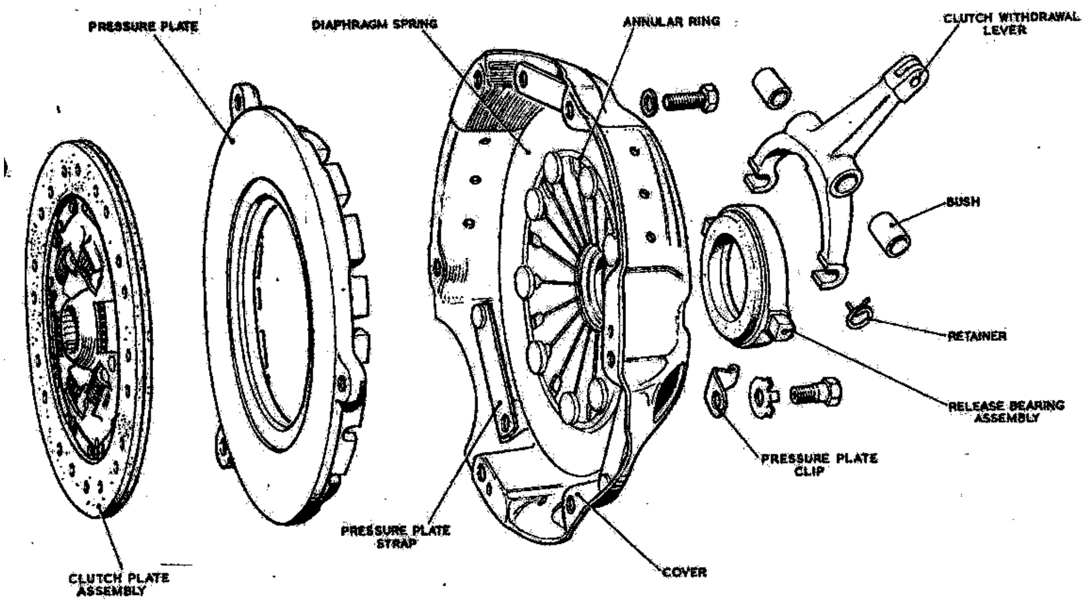



**Fig-6 Diaphragm Clutch**

**Operating Mechanism**

5. It consists of the foot pedal, linkage and release or withdrawal bearing. The release bearing is held in a fork and is free to move over the clutch shaft. The fork in turn is connected with the foot pedal through the linkage. The release bearing operates the clutch release fingers or levers provided in the pressure plate. . See fig-5.

**Working**

6. When pressure is applied at the foot pedal, it is transmitted to the release fingers or levers through linkage, fork and release bearing. As a result, the springs are compressed and pressure disc moves back thereby releasing pressure from the clutch plate. The clutch is disengaged as the clutch is suspended. During disengaged condition, the pressure plate and flywheel rotate with the engine while the clutch plate inside them become stationary. When pressure at the release levers is released, the full pressure of the pressure plate springs is exerted through the pressure disc at the clutch plate. The clutch plate is thus held between the flywheel and the pressure plate, rotating as one unit. This is the engaged position.

**BAF BASE ZAHURUL HAQUE(TRG WG)**
**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **Transmission System** |
| **Phase** | **:** | **Multiple Disc Clutches** |
| **Ref** | **:** | **The automobile – By Harbans Singh Reyet** |

# MULTIPLE DISC CLUTCHES

**Purpose**

1. It is used for connecting and disconnecting two independently mounted revolving members, such as crankshaft and the gearbox shaft.

**Construction**

2. As is apparent from its name, multiple disc clutches contains more than one disc to act as clutch plate or driven member. This clutch is either of wet type or dry type. *Wet clutch* is that which runs in oil whereas *dry clutch* is that which does not run in oil. Multiple disc clutches are used at several places in an automobile. These are used between engine and gearbox, in planetary transmission, in steering or differential clutches etc. In this type of clutch, all the driven plates are splined to the shaft. There is one driving plate between each two driven plates. The plates are made of steel; bronze and brass etc. In certain cases the driven plates are fitted with linings or cork segments. The driving plates are carried in a cylindrical shell and are attached to the shell by means of splines around the outer edges of the discs. This way all the discs are free to move lengthwise along the shaft; one set turning with the shaft and alternately positioned set turning with the outside shell. A pressure plate is attached inside the cylindrical shell behind all the discs ( Fig-7).

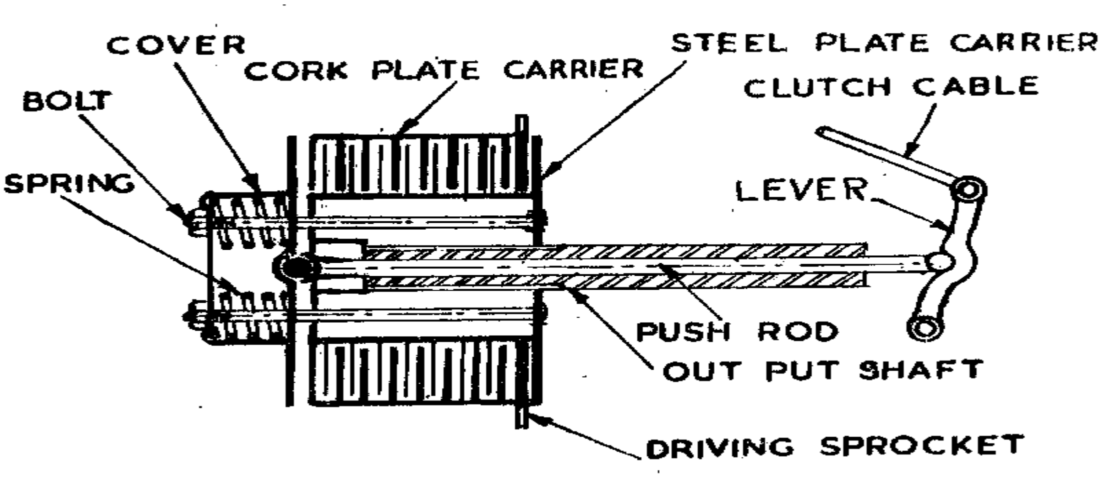



**Fig-7 Multiple Disc Clutches**

**Operation**

3. The pressure of the springs with the pressure plate is released through the operating mechanism**.** When full pressure is acting on the clutch plates, all the discs are pressed together and both sides of each driven plate rub against driving plates causing the two sets to run together at the same speed**.** When the pressure is released, the squeezed plates move off causing slip and thereby disengagement .See fig 7.

**BAF BASE ZAHURUL HAQUE(TRG WG)**
**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **Transmission System** |
| **Aim** | **:** | **To study Centrifugal Clutch** |
| **Ref** | **:** | **The automobile – By Harbans Singh Reyat** |

# CENTRIFUGAL CLUTCH

## Introduction

1. It is an automatic clutch which is controlled by the engine speed through the accelerator.

## Description

2. When the engine speed falls down, the clutch is automatically disengaged and when the speed rises above the pre-determined value, the clutch is engaged. Greater the centrifugal force due to higher engine speed, more powerful the contact between the driving and driven members and better the engagement. The simplest form of centrifugal clutch consists of two members, one fitted on the driving shaft and the other attached to driven shaft. The driven member is just a drum, which encloses the driving member. The driving member contains two curved shoes having frictional linings at their backs. The shoes are anchored at one end to the back plate and are kept in position by means of coil springs, which hold the free end. When the clutch is disengaged due to low engine speed, the back plate is held back by the outer springs. When the engine speed increases, the balance weights, usually three in number, tend to fly outwards until they contact the flywheel rim, while the other ends of the levers press against the back plate. The pressure in turn is transmitted through the inner springs to the pressure plate, thus overcoming the strength of the outer springs. This results in the gripping of clutch plate between the flywheel and pressure plate and thereby engagement. Thus this type of clutch acts entirely as an automatic self-contained unit (Fig-8).

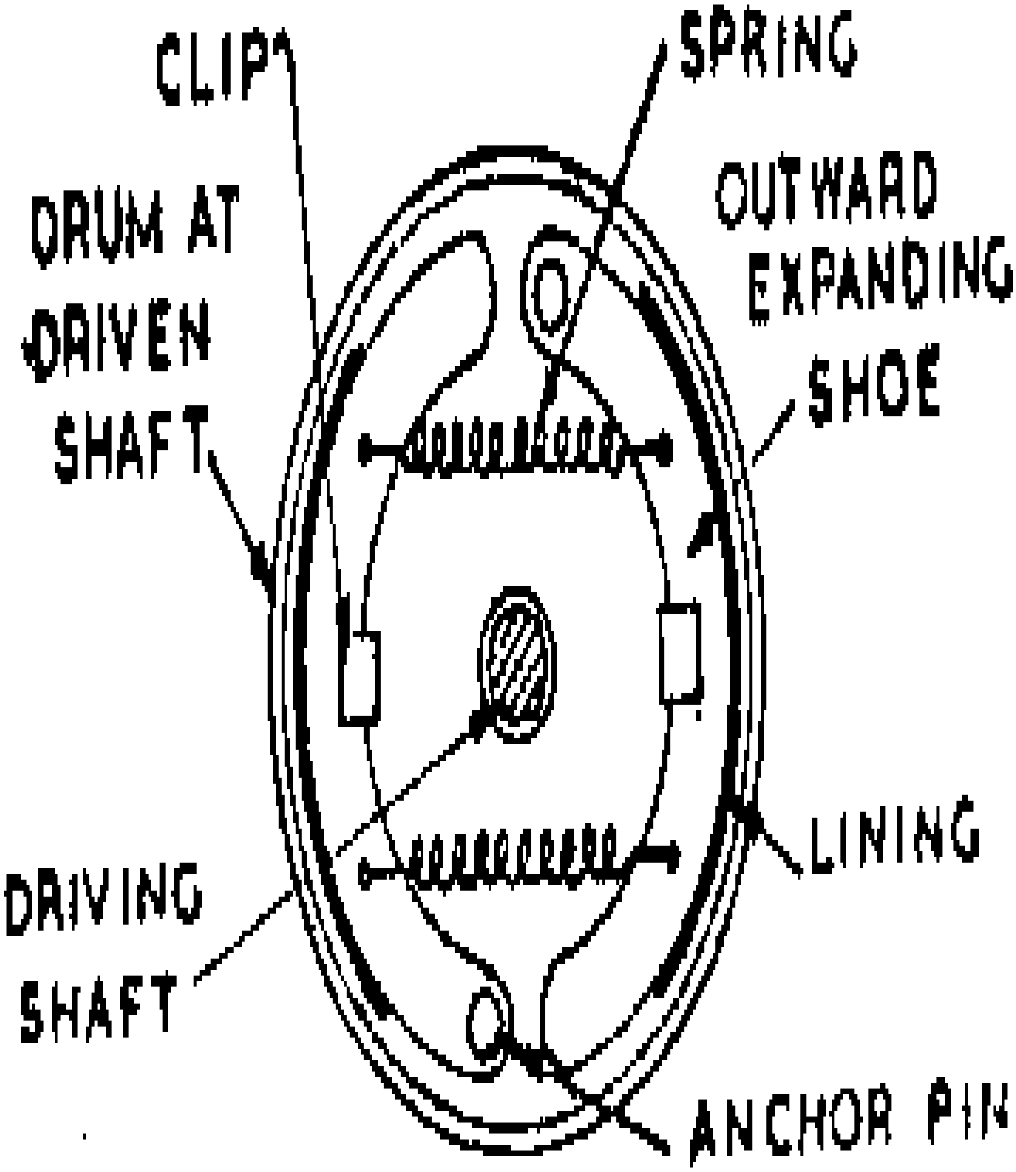



**Fig- 8 Centrifugal Clutch**

**BAF BASE ZAHURUL HAQUE(TRG WG)**
**(Aero Engg Trg Sqn)**

**Syllabus : Automobile and Diesel Technology**
**Course : Trade Training Basic, MTOF**
**Subject : Transmission System**
**Aim : To study Clutch pedal adjustment**
.
**Ref : AUTOMOBILE ENGINEERING-By G B S NARANG.**

---

# CLUTCH PEDAL ADJUSTMENT

## Purpose

1. The clutch pedal adjustment is carried out to compensate for wear of the friction surface**.**

## Description

2. The clutch is fitted and correctly set on initial assembly of the vehicle but , after a considerable time, some adjustment is necessary to compensate for wear of the friction surfaces. As the clutch linings wear, the pressure plate will move closer to the flywheel face, and this will cause the release leavers to move away from the flywheel and bear against the release bearing. This loss of clearance between release bearing and release levers will cause the clutch to slip, overheating the linings and scoring the flywheel and pressure plate surfaces. It will also cause excessive wear of the release bearing and release levers. The clutch release mechanism should be adjusted to restore this clearance between release bearing and release levers until it is apparent as free paddle movement (F P M ) of approximately 1 inch at the pedal pad . Two typical methods of adjustment are shown in fig-9, but reference should always be made to the vehicles maintenance/operation manual for information on clearances and method of adjustment.

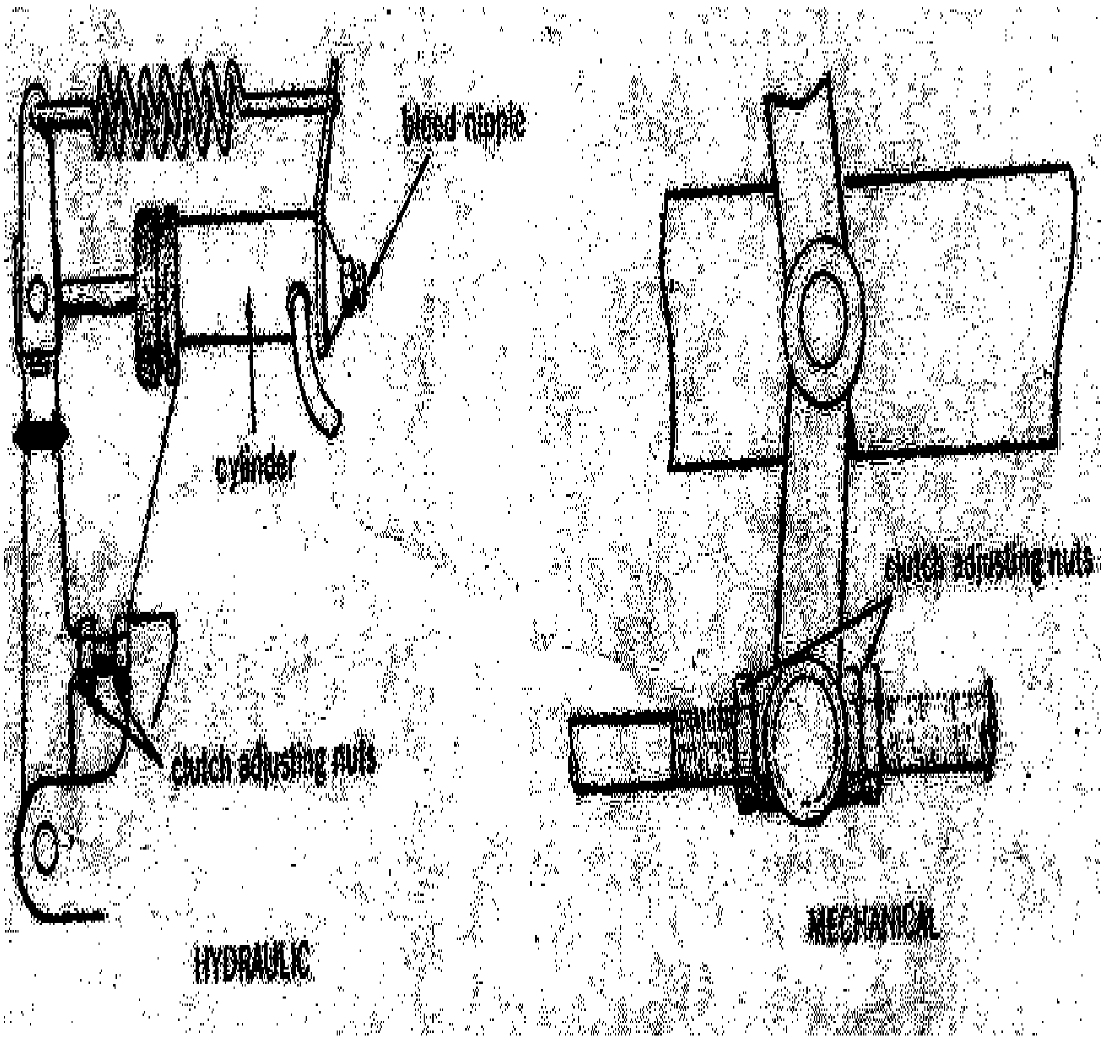



**Fig -9 Method of Adjustment**

**BAF BASE ZAHURUL HAQUE (TRG WG)**
**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **Transmission System** |
| **Aim** | **:** | **To study servicing and faults of the clutch** |
| **Ref** | **:** | **A. P. 3159, section 6, chapter 1.** |

# SERVICING AND FAULTS OF CLUTCH

## Servicing

1. The modern clutch plate requires very little servicing, consisting chiefly of lubricating the clutch pedal on the shaft and the adjustment of the pedal for free movement.

## Faults

2. a. **Clutch Slip.** This occurs when the two friction surfaces do not 'grip' each other sufficiently to convey the full power from the engine. The symptoms are that the engine accelerates without a proportionate increase to the road speed of the vehicle. *Clutch slip* may be caused by one of the following faults:

(1) Oil or grease on the linings.

(2) Insufficient free pedal movement or pedal fouling the floor board.

(3) Worn friction linings.

(4) Weak or broken pressure springs.

b. **Clutch spin.** When the clutch pedal is depressed and the friction plate and the gearbox driving shaft continue to rotate difficultly is experienced when engaging gears. One of the following faults may cause the trouble:

(1) Too much free pedal movement.

(2) Release levers unevenly adjusted.

(3) Clutch stops incorrectly adjusted or worn.

(4) Defective driven plate.

(5) Lack of lubrication on driving shaft splines.

(6) Bushes or roller races on driving shaft spigot seized.

(7) Badly worn graphite thrust ring on Borg and Beck release bearing assembly.

(8) Engine & gear box out of alignment.

c. **Fierce Clutch.** This is a rough engagement of the clutch when it is taking up the drive from stationary or during gear changes. However, carefully the clutch pedal is released, the vehicle lurches violently. The probable cause may be one of the following: -

(1) Uneven wear or loose linings on the clutch plate.

(2) Ridges worn on sliding portions of the clutch.

(3) Worn spigot bearing.

d. **Clutch Judder.** This is noticeable when the clutch is being engaged, as it causes the vehicle to shudder and vibrate violently. It may be caused by one of the following defects: -

(1) Cracked or distorted pressure plate

(2) Loose or protruding rivets

(3) Linings badly worn

(4) Bearing badly worn

**BAF BASE ZAHURUL HAQUE (TRG WG)**
**(Aero Engg Trg Sqn)**

**Syllabus : Automobile and Diesel Technology**

**Course : Trade Training Basic, MTOF**

**Subject : Transmission System**

**Aim : To study gear box**

**Ref : The Automobile By Harbans Shing Reyat & A. P. 3159.**

# GEAR BOX

## Purpose

1. It is a speed and torque-changing device between the engine and the driving wheels. It serves the following purposes in the transmission system of an automobile:

a. It exchanges engine power for greater torque and thus provides a mechanical advantage to drive the vehicle under different conditions.

b. It exchanges forward motion or reverse motion.

c. It provides a neutral position to disallow power flow to the rest of power train.

## Types of Transmission (Gear Box)

2. a. Selective type.

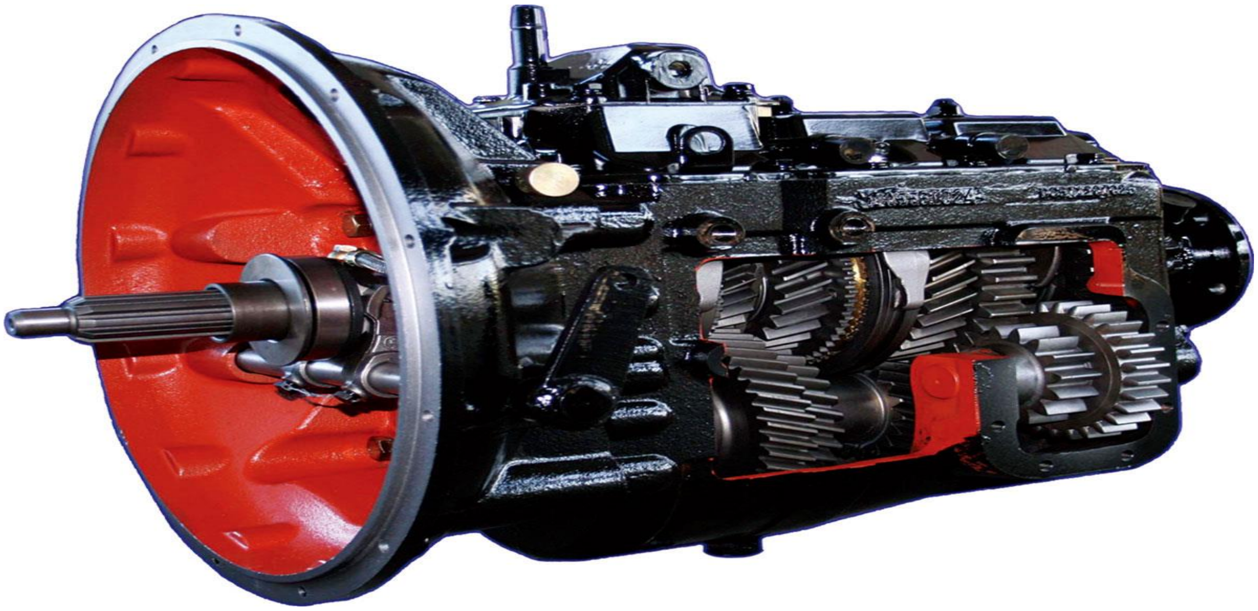
(1) Sliding mesh.

(2) Constant mesh.

(3) Synchromesh.

b. Progressive type.

c. Epicyclic or planetary



. **Fig-1, Cut view section of Gear Box**

**<u>Components of Gear Box</u>**

3. Disregarding the specialist types of gearboxes, the main components of other gearboxes are as follows:

a. **<u>The Box</u>**. This is the casing, which houses the gears and is usually made of aluminium alloy or cast iron. The gearbox is filled with oil to a point approximately half way up the lay shaft, the level being determined by an oil level plug or dipstick. Rotation of the lay shaft splash lubricates all gears and bearings.

b. **<u>Primary or Clutch shaft.</u>** The front end of this shaft is supported in a spigot bearing in the engine flywheel or crankshaft and the rear end in a bearing in the gearbox casing (Fig-10).

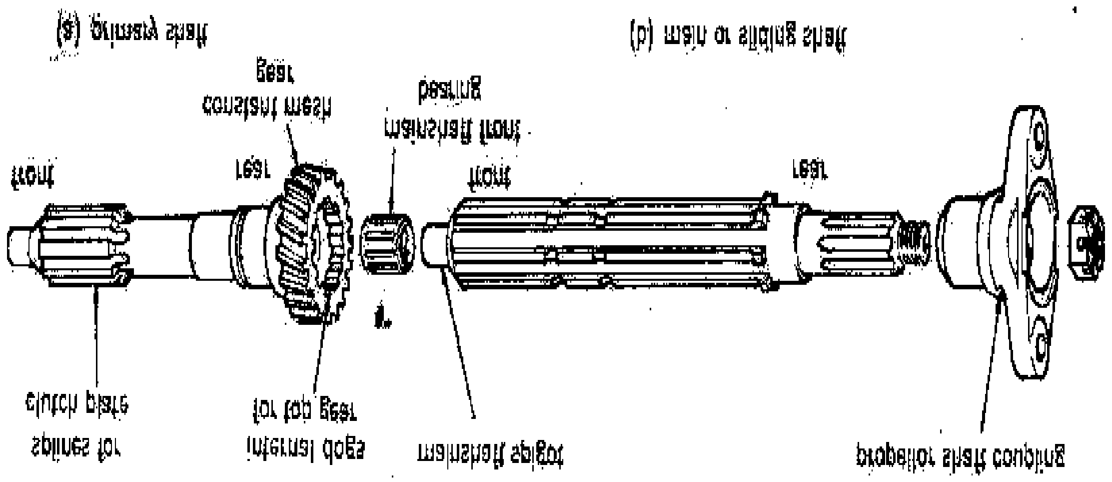



**Fig-10 Primary & Main shaft**

c. **<u>Lay shaft</u>.** This shaft is driven by and in constant mesh with the primary shaft; it carries different sized gears for meshing with the main shaft gears. It is supported in bushes or bearings in the gearbox casing (Fig-11).

d. **Main shaft.** This shaft carries different sizes of gear for meshing as required with the lay shaft gears. It is supported at front end in a spigot bearing in the primary shaft and at the rear in a bearing in the gearbox casing (Fig-11).

e. **Reverse shaft.** This is a short fixed shaft carrying a spur gear, which may be meshed with main shaft and lay shaft to reverse the direction of rotation of the main shaft when reverse gear is engaged (Fig-11).

f. **Selector mechanism.** This may be operated by a direct floor- change lever or by a lever mounted on the steering column. It enables the driver to select the particular gear ratio required (Fig-11).

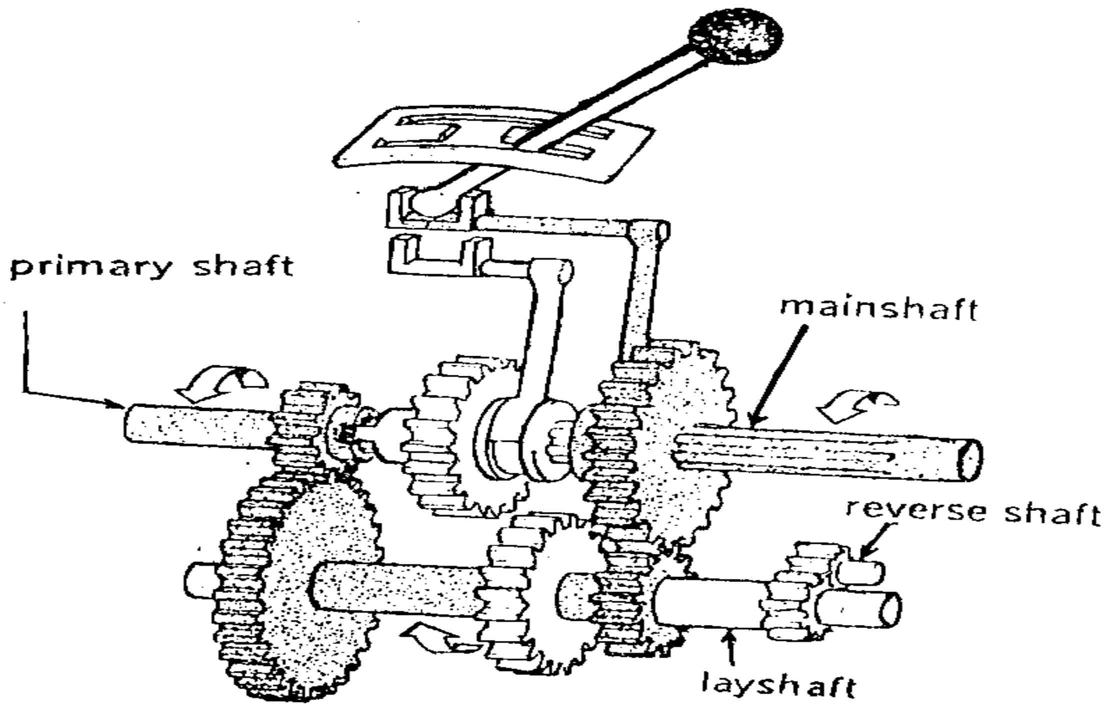



**Fig-11 Lay, Reverse Shaft & Selector Mechanism**

# BAF BASE ZAHURUL HAQUE (TRG WG)
## (Aero Engg Trg Sqn)

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **Transmission System** |
| **Aim** | **:** | **To study constant mesh gear box** |
| **Ref** | **:** | **A. P. 1464 E Vol 1, Book 1 Section 4 & chapter 5** |

## CONSTANT MESH GEAR BOX

### Purpose

1. With the constant mesh gear box, the gears are always in mesh and cannot be chipped or broken by bad gear changing.

### Description

2. In the gear boxes fitted to certain medium and heavy load carrying vehicles, some or all of the intermediate gears are of constant mesh type, and are brought into engagement by dog clutches instead of by sliding gears. This arrangement allows gears with teeth of helical form to be used for all the constant mesh pairs, and such gears tend to be quieter in operation than straight cut gears. In such a box, the primary shaft conveying the drive from the engine, and the lay shaft and main shaft, remain as in the gear box previously described, and the lay shaft gears and the primary shaft gear rotate solidly with their shafts. The 1st and 2nd speed gear wheel on the main shaft also remains as before, and slides into engagement with the mating lay shaft gears when actuated by the appropriate selector fork of the gear change mechanism. The main shaft 3rd speed gear, however, is arranged differently. The gear wheel, instead of being splined to the main shaft, is mounted on a phosphor- bronze bush, and is therefore; free to rotate at a speed different from that of the shaft. Referring to the figure it will be seen that, mounted on the main shaft between the primary shaft gear and the 3rd speed gear, is the top- 3rd speed driving dog. This is in effect a sleeve carrying dog teeth at either end, which enable it to engage with similar sets of teeth in the primary shaft gear and the 3rd speed gear. The sleeve is fitted to splines in the main shaft, and there fore revolves with it, while it can be moved along the shaft by the top-3rd speed selector fork.

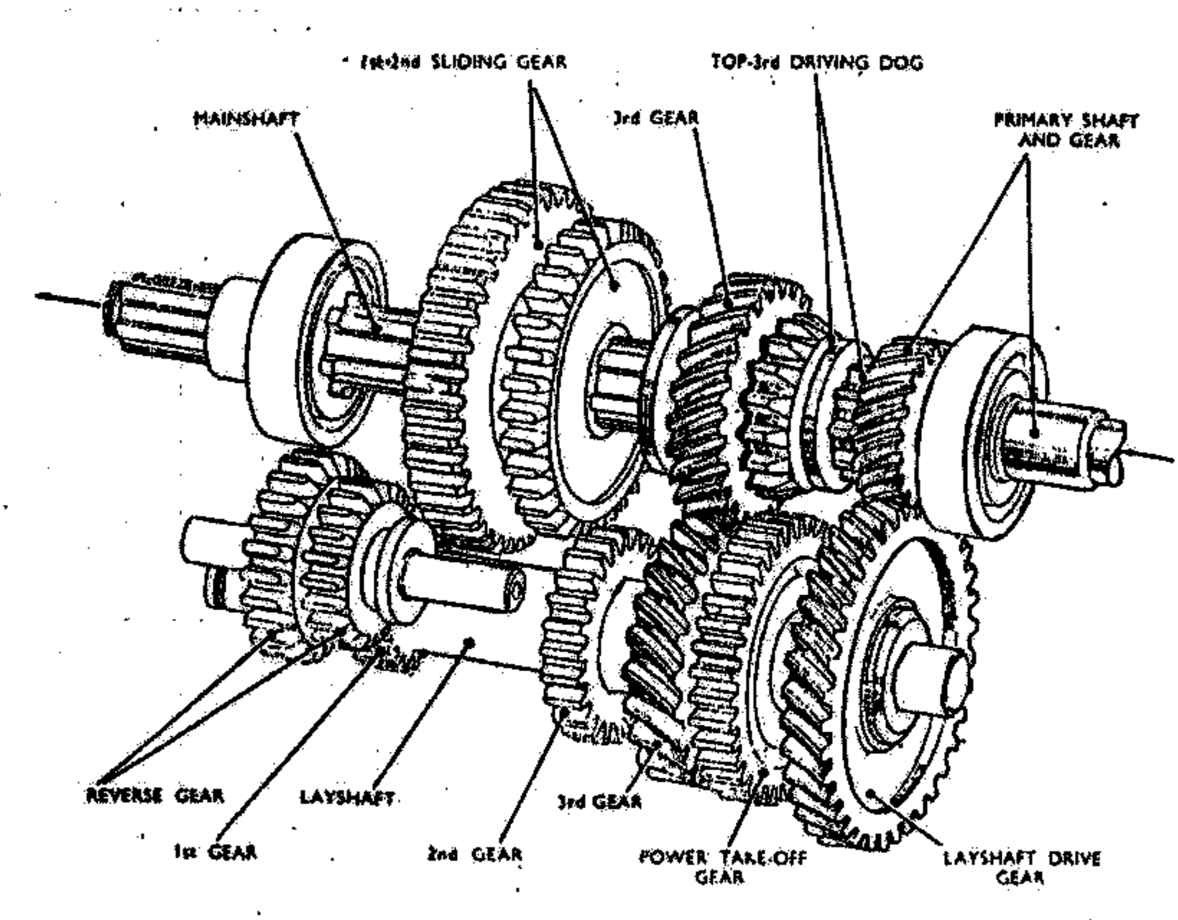



**Fig-12 Constant Mesh Gear**

## Operation

3. Engagement of top or 3rd speed in a gearbox of type described is effected by movement of the top 3rd speed-driving dog. When the gear lever is placed into 3rd speed position, the dog clutch is moved backwards until the teeth engage with the dogteeth on the boss of the main shaft 3rd speed gear, thus locking this gear to the main shaft. The drive is then transmitted from the primary shaft to the main shaft by way of primary shaft and lay shaft constant mesh gears, the lay shaft and main shaft 3rd speed constant mesh gears, and the driving dog. Movement of the gear lever to top speed position slides the driving dog out of mesh with the 3rdspeed gear on the main shaft, and engages it with the opposite set of dogs in the primary shaft gear. The primary shaft is thus locked to the main shaft and direct drive is obtained. The lay shaft, lay shaft gear cluster, and main shaft 3rdspeedgear, continue to rotate, because the lay shaft drive gear is in constant mesh with the primary shaft gear, but they revolve idly, since the main shaft 3rd speed gear is not now coupled to its shaft (Fig-12).

**BAF BASE ZAHURUL HAQUE (TRG WG**
**(Aero Engg Trg Sqn)**

**Syllabus : Automobile and Diesel Technology**
**Course : Trade Training Basic, MTOF**
**Subject : Transmission System**
**Aim : To study Synchro mesh gear box**
**Ref : A. P. 3159, section 6, chapter 2**

---

## SYNCHRO MESH GEAR BOX

### Purpose

1. The purpose of synchromesh gearbox is to reduce operational noise to a minimum.

### Construction

2 Gear wheels with helical teeth are used for all gears except 1st and reverse. The gearbox has a driving shaft, lay shaft and main shaft with gear wheels rotating solidly on primary and lay shaft, in the same way as a crash type or constant mesh gearbox. The low speed pinions on the main shaft and the reverse pinion are the only gear wheels which can be moved in and out of mesh, while the intermediate gears are in constant mesh.

### Operation

3 When the gears are in the neutral position, the primary and the lay shaft are turned by the engine and the intermediate gears of the main shaft, because they are in constant mesh with the lay shaft gears, also turn. However, as the intermediate gears are not splined to the main shaft but floats freely on plain bushes, the main shaft remains stationary and no drive is transmitted to the road wheels. When the 1st speed is selected, a selector fork slides the low speed gear along the splines of a sleeve which in turn is splined to the main shaft and meshes it with the low speed gear wheel on the lay shaft. The other forward speed gear changes involve synchromesh action.

**BAF BASE ZAHURUL HAQUE(TRG WG)**
**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | : | **Automobile and Diesel Technology** |
| **Course** | : | **Trade Training Basic, MTOF** |
| **Subject** | : | **Transmission System** |
| **Aim** | : | **To study Synchro mesh Hub or Unit** |
| **Ref** | : | **A. P. 3159, section 6, chapter 2** |

# SYNCHROMESH HUB OR UNIT

## Introduction

1. Originally one synchromesh unit was mounted on the main shaft of a 3-speed gearbox and two units on that of the 4-speed gearbox. On a 3-speed gearbox it is between second and top speeds and on a 4-speedgearbox, one is used between first and second speeds and one between third and top speeds. A synchromesh unit between third and top speeds in a 4-speeds gearbox is constructionally the same as one used between second and top speeds on a 3-speeds gearbox (Fig-13) but the unit between first and second speed is rather different. Latter gearboxes are 'all synchromesh' and all gear changes enjoy the benefit of synchromesh.

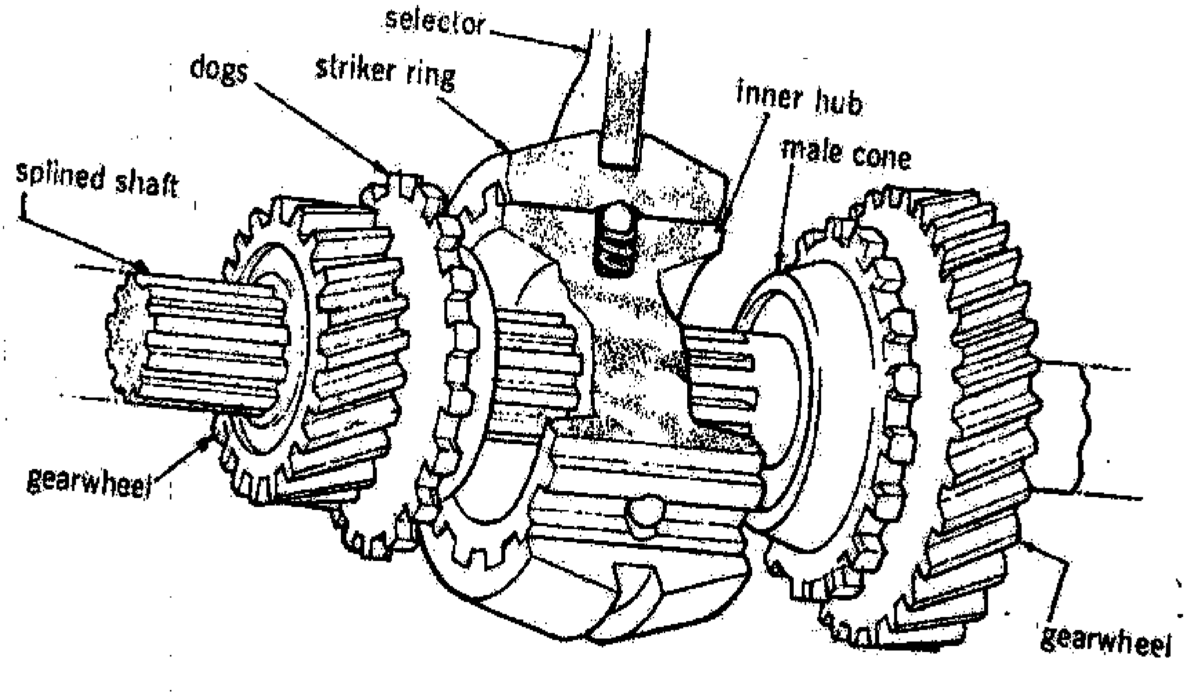



**Fig-13 Synchromesh Unit**

## Construction

2. An outer ring (striker ring) is controlled in movement by the change speed lever mechanism, and has internal dogs meshing with similar dogs on the hub or sleeve(see fig-19). The hub is splined and free to slide on the main shaft and, therefore, rotates with it. Positioned radially in the hub are a number of balls and springs, which locate the striker ring by registering in a central groove. Consequently, when the striker ring is moved in either direction by the selector, the hub is carried

with it. On both the inside edges of the hub are fitted phosphor-bronze cones, which act as female cones to the male cones formed on the gear wheel. Internal dogs or teeth are machined on the striker ring so that this can be locked in engagement with the dogs or teeth, which are also an integral part of the gears.

**Operation**

3. When the driver operates the gear lever, the selector moves the striker ring towards the gear to be selected, and the female cone of the hub will contact the male cone of the gear to be engaged. This has the effect of speeding up or slowing down the gear until it is revolving at the same speed as the hub. Further movement of the gear lever will overcome the pressure of the spring-loaded balls and the striker ring is slid noiselessly into mesh with the teeth of the respective gear. Thus, the main shaft Is positively locked to the gear and the drive is completed.

**BAF BASE ZAHURUL HAQUE(TRG WG**
**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **Transmission System** |
| **Aim** | **:** | **To study Transfer gear box** |
| **Ref** | **:** | **A. P. 3159, section 6, chapter 2.** |

# TRANSFER GEAR BOX

## General

1. On vehicles where four-wheel drive is employed, the driving power can be applied to the front axle as well as the rear. It is then necessary to transfer the drive from main gearbox to another gearbox known as the transfer gearbox (Fig-14).Three propeller shafts are fitted, one from the main to the transfer gearbox, one from the transfer box to the rear axle and other from the transfer box to the front axle.

## Description

2. The transfer gearbox has four shafts:

a. **Main Shaft.** The main shaft is driven by the propeller shaft from the main gearbox is splined and carries a toothed gear wheel which has dogs machined on its rear face. The gear wheel can be moved along the splined shaft by the selector mechanism to engage similar dogs machined on the front face of another gear wheel also mounted on the main shaft, but not keyed to it. The sliding gear wheel can also be moved in the opposite direction, so that the teeth engage those of a large gear wheel on the lay shaft.

b. **Lay Shaft.** The lay shaft carries two fixed gear wheels. A large one, which, engaged by the sliding gear wheel of the main shaft, transmits the drive and gives the gear reduction; and a smaller gear wheel at the rear end of the lay shaft which is in constant mesh with a wheel on the main shaft and with one on the output shaft connected to the rear axle propeller shaft. The wheel on the main shaft is freely mounted, but the wheel on the output shaft is fixed to that shaft.

c. **Two Output Shafts.** There are two output shafts, the front one being connected to the front axle propeller shaft and the rear one to the rear axle propeller shaft. The front output shaft is splined and carries a sliding dog which can be moved along the splines by the selector mechanism to engage dogs cut on the front face of the gear wheel fixed to the rear axle output shaft. The rear end of the front output shaft is supported in a spigot formed in the rear output shaft.

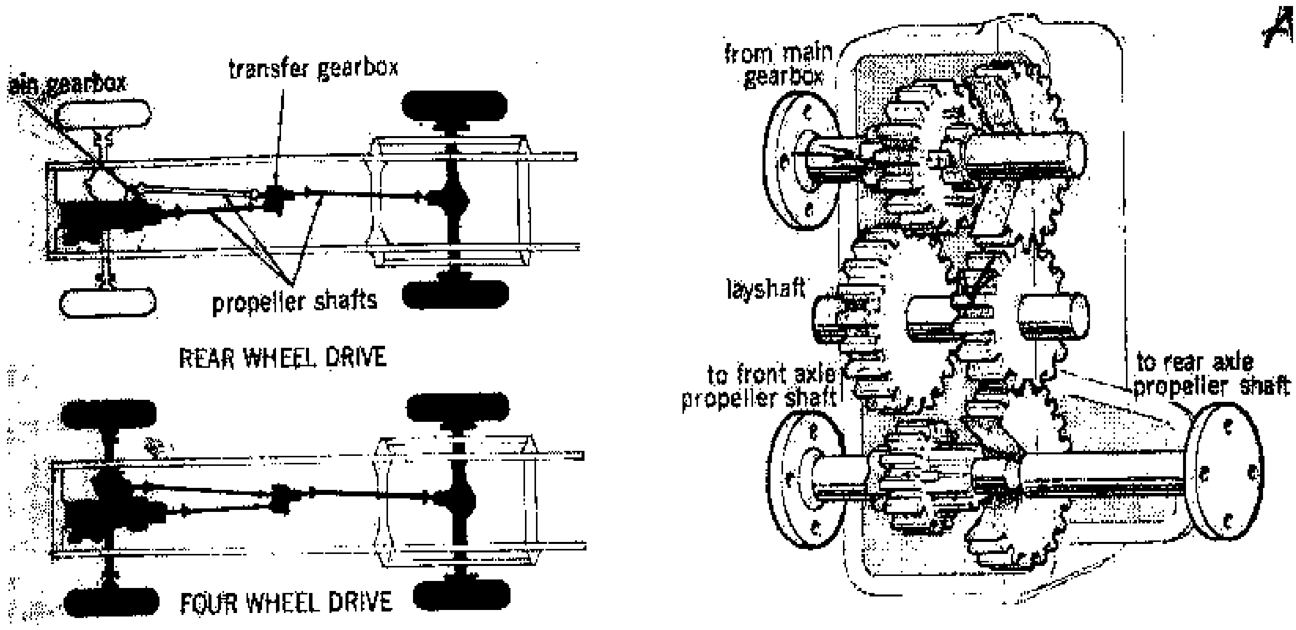



**Fig- 14 Transfer Gear box.**

**<u>Operation</u>**

2. When high gear and rear axle drive only is selected, the sliding gear wheel on the main shaft is moved along the splines and its dogs engage those of the constant mesh gear that is freely mounted on the main shaft (Fig- 15). The drive is then transmitted through the main shaft and constant mesh gears to the rear output shaft connected to the rear axle propeller shaft. No power is transmitted to the front output shaft and there is no gear reduction. Where low gear and four-wheel drive is selected,, the positions of the gears alter as shown in the drawings. The sliding gear on the main shaft moves along the splines in a forward direction and its teeth engage those of the large gear wheel to the lay shaft. At the same time, the sliding dog on the output shaft connected to the front axle propeller shaft is moved rearwards to engage the dogs cut on the front face of the constant mesh wheel fixed to the output shaft which is, in turn, connected to the rear axle propeller shaft. Therefore, the drive line is from the main shaft to the lay shaft (with gear reduction), through the constant mesh gears to *both* output shafts, so that the drive is conveyed to the front and rear axles. Transfer gearboxes are sometimes known as auxiliary gearboxes, but although a transfer gearbox is always an auxiliary gearbox, an auxiliary gearbox is not necessarily a transfer gearbox. Gear changes in transfer gear boxes are affected by on or two gear levers and normal selector mechanism. Change of gear should be carried out when vehicle is stationary.

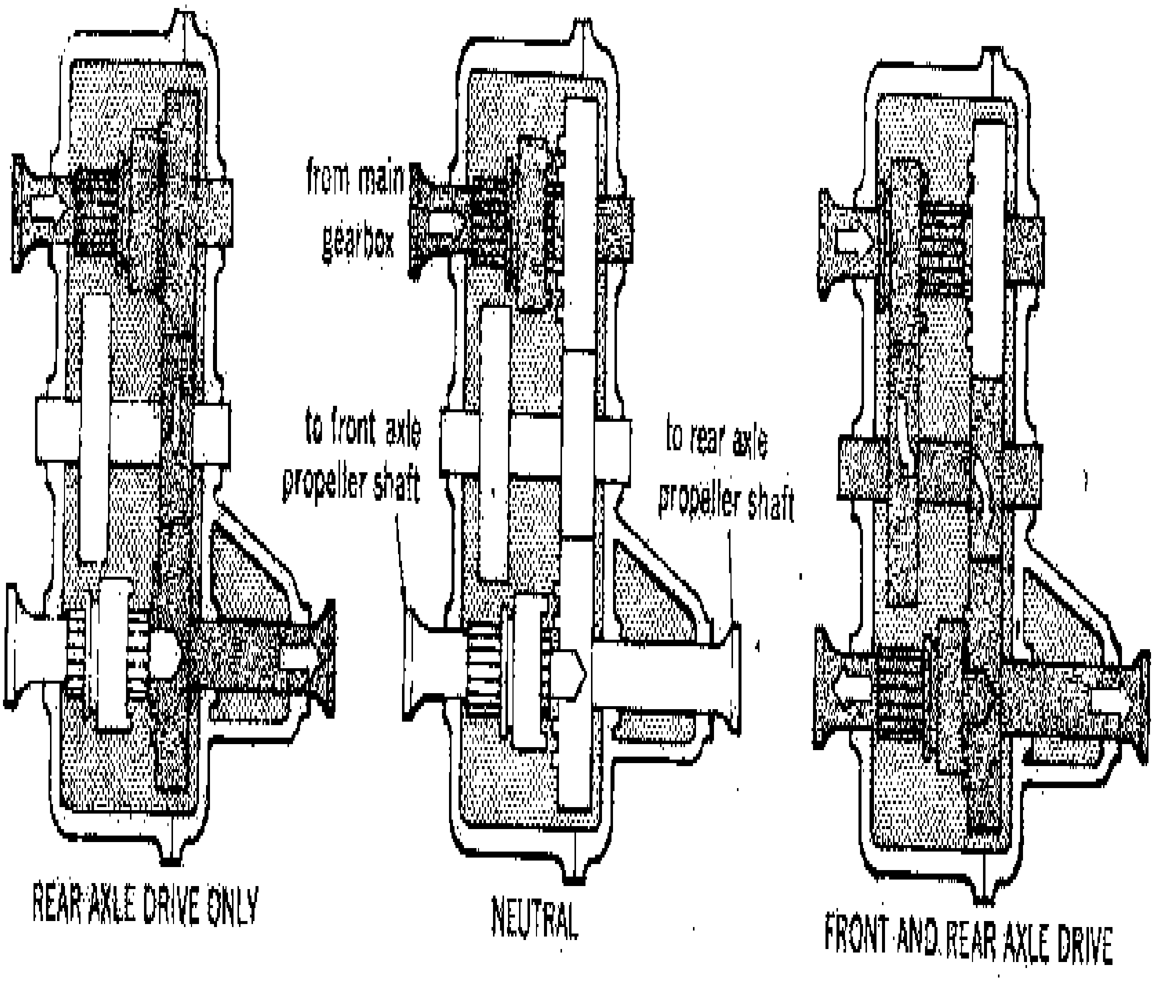



**Fig. 15 Transfer Gear Box Operation**

**BAF BASE ZAHURUL HAQUE(TRG WG)**
**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **Transmission System** |
| **Aim** | **:** | **To study constant mesh gear box** |
| **Ref** | **:** | **A. P. 1464 E Vol 1, Book 1 Section 4 & chapter 5.** |

# SLIDING MESH GEAR BOX

## Introduction

1. The gears of sliding mesh gearbox are straight or spur type. The spur gears have high efficiency also operation of these gears needs considerable skill of the driver. Skill is termed as "double declutching "during changing up or down the gear ratios (vehicle speed).

## Construction

2. This gearbox has four shafts.

a. **Primary Shaft.** The primary shaft gear or pinion is either out integrally with the shaft or keyed to it, so that shaft and gear rotate solidly as a unit. The forward end of the shaft is splined into the clutch disc and aligned with the engine crankshaft by a spigot bearing and the rear end of the shaft is supported by a bearing in the gearbox casing.

b. **Lay Shaft.** The lay shaft and Its gears rotate as a unit, the gears being either cut integrally with the shaft or keyed to it.

c. **Main Shaft.** The main shaft is permitted to rotate independently of the primary shaft, being aligned and supported at its forward end by a spigot bearing located in the primary shaft gear. Splines on the main shaft permit the 3rd gear and 1st-2nd gear to slide along the shaft and also cause them to revolve with it. The 1st –2nd gear consists of two pinions in one unit. The 3rd gear has internal teeth or dogs, which are designed to slide over and mesh with external teeth on a boss of the primary shaft gear.

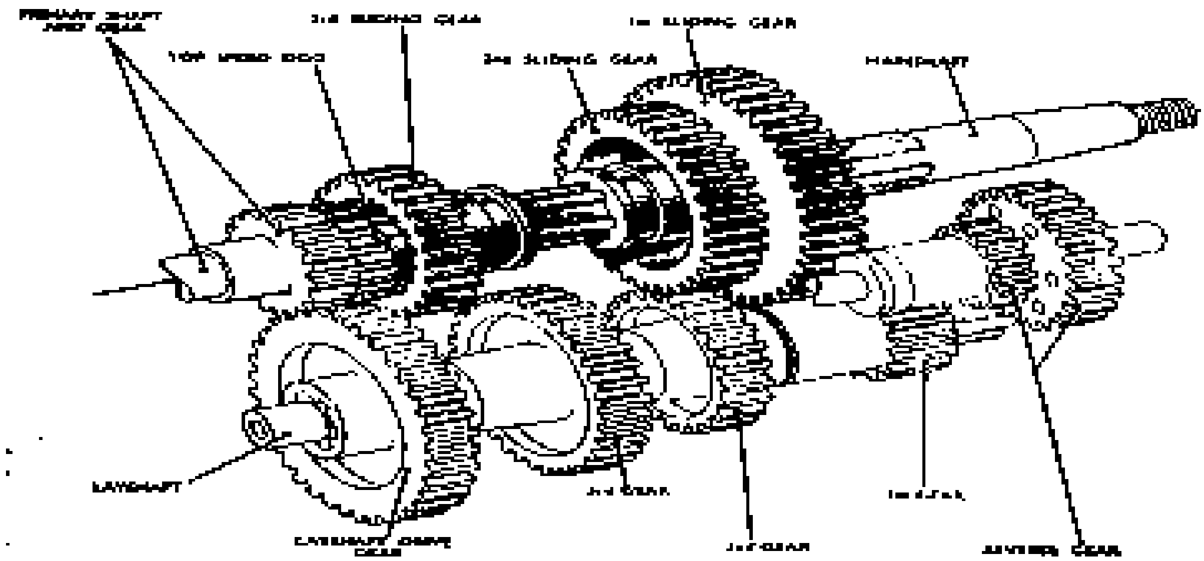


**Fig -16 Sliding Mesh Gear Box**

d. **<u>Reverse Idler Shaft</u>.** The reverse idler shaft lies to one side of the gear box and carries two gear wheels, which rotate as a unit with the lay shaft and are out of mash with any of the lay shaft and main shaft gears except when reverse gear is actually engaged.

**<u>Operation</u>**

3. Sliding mesh gear functions in the following manner:

a**.** **<u>Neutral Position</u>.** When the gear lever is placed in the neutral position, all the sliding gears on the main shaft are moved into a position in which they are out of mesh with mating lay shaft gears. With the engine running and the clutch engaged, the primary shaft will rotate, and the lay shaft will be driven through the primary shaft and lay shaft constant mesh gears, but as there is no connection between the lay shaft and the main shaft, no drive will be transmitted to the propeller shaft .

b. **<u>To Engage 1st Gear</u>.** When the clutch is disengaged and the gear lever moved into 1st speed position, the appropriate selector fork moves the 1st-2nd speed sliding gear backwards along the main shaft. This brings the 1st speed sliding gear into mesh with 1st speed gear on the lay shaft. When the clutch is engaged, drive is transmitted from the primary shaft through constant mesh gears to the lay shaft, through the lay shaft gear and 1st speed sliding gear, and out through the main shaft to the final drives (Fig- 17).

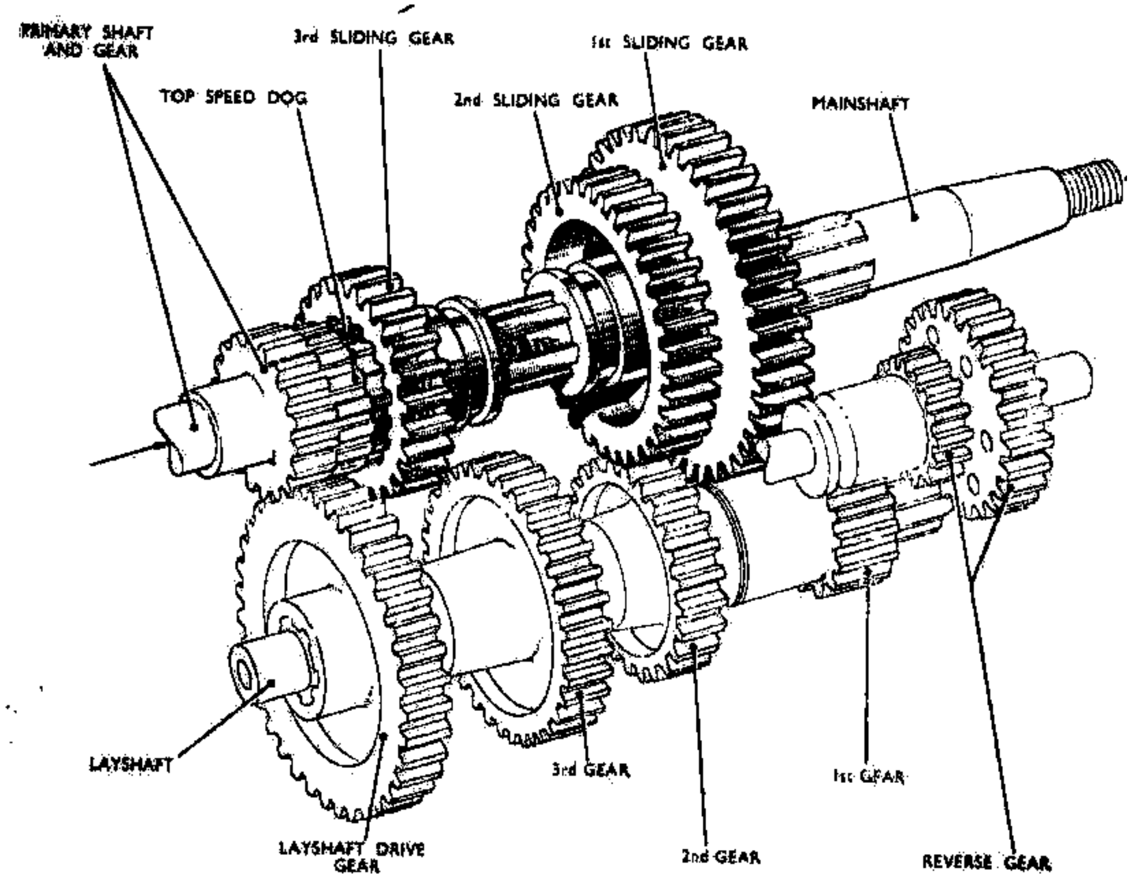



**Fig-17 Low Gear**

c. **<u>To Engage 2nd Gear</u>**. When the gear lever moved into 2ndspeed position causes the 1st-2nd-speed selector fork to be pushed forward, taking with it the 1st-2nd speed sliding gear. This brings the 1st speed sliding gear out of mesh with the lay shaft 1st speed gear, and causes the 2nd speed sliding gear to mesh with the lay shaft 2nd speed gear. In this position, the drive is transmitted from the primary shaft, through the constant mesh gears and lay shaft 2nd speed gear to the 2nd speed sliding gear, and so out through the main shaft (Fig- 18).

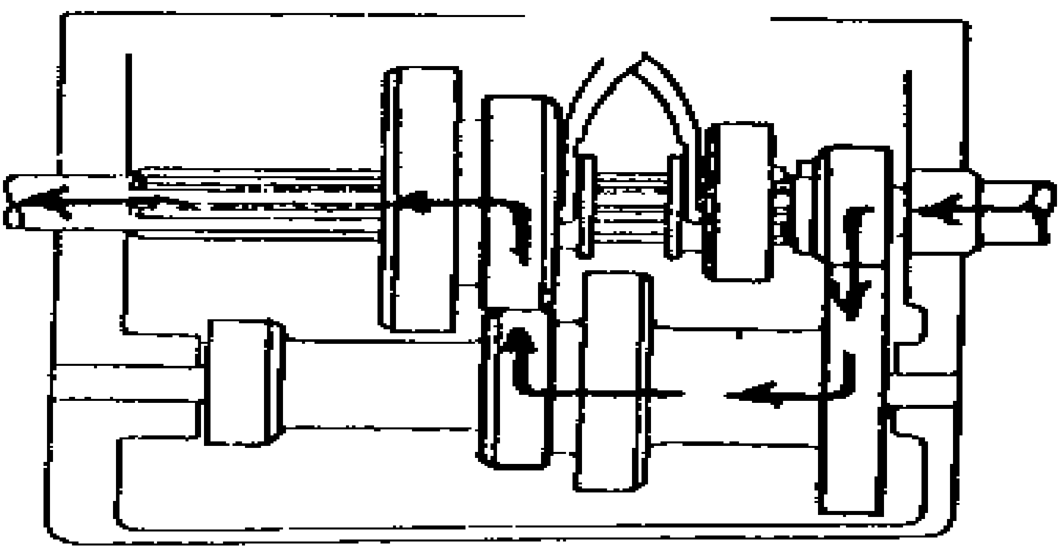


**Fig-18 2ND GEAR**

d. **To Engage 3rd Gear**. When the gear lever is moved into neutral, preparatory to engaging3rd gear, the 1st-2nd speed sliding gear is returned to a position where neither pinion is in mesh with its lay shaft gear. If the lever is then moved sideways and forwards, the 3rd-top selector shafts and fork are engaged, causing the 3rd speed sliding gear to move backwards into mesh with the lay shaft 3rd speed gear. The drive will now be transmitted through the primary shaft and lay shaft constant mesh gears, the lay shaft 3rd speed gear, and the 3rd speed sliding gear, to the main shaft (Fig- 19).

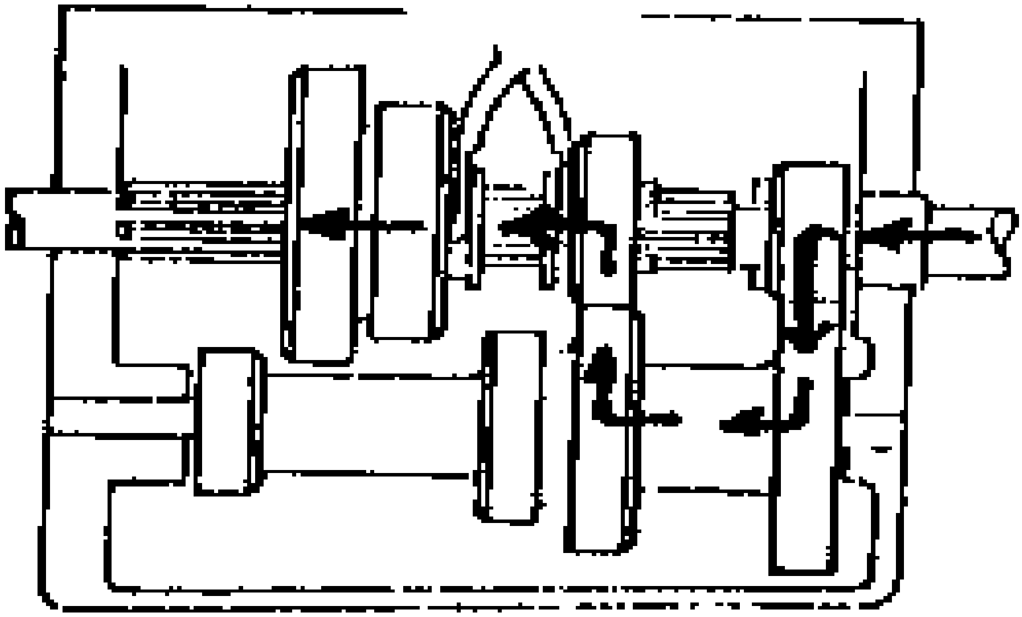


**Fig-19 3RD GEAR**

e. **To Engage Top Gear**. When the gear lever is placed into 4th or top gear position, the selector fork causes the 3rd speed sliding gear to move forward out of mesh with the mating lay shaft gear and the internal teeth or dogs cut in this sliding gear engage with teeth on the extended boss of the primary shaft gear. In top speed, therefore, the drive is taken direct from the primary shaft to the main shaft, the two shafts rotating as one assembly. The lay shaft continues to be driven through the primary shaft and lay shaft constant mesh gears, but as none of the lay shaft gears is engaged with a gear on the main shaft the lay shaft revolves idly and does not transmit drive (Fig 20).

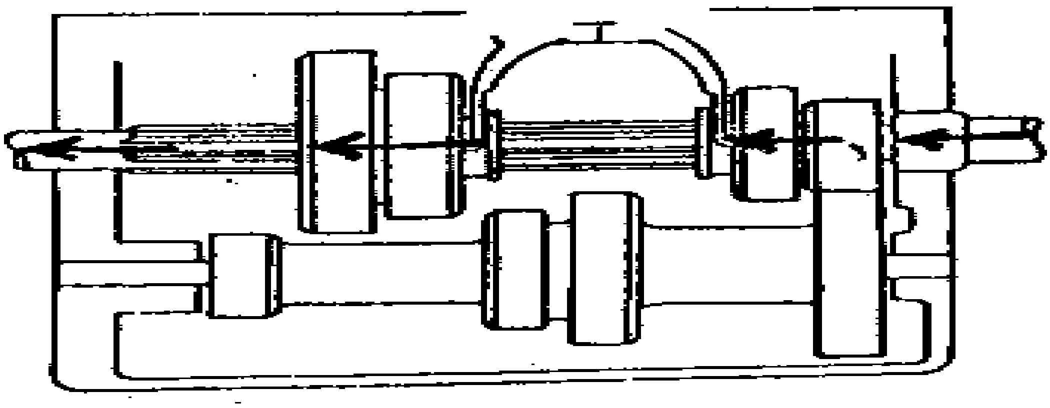


**Fig-20 TOP GEAR**

f. **To engage reverse gear**. Movement of the gear lever into the neutral position brings all the main shaft and lay shaft gears out of mesh. A third selector shaft and fork are then engaged, which slide the reverse idler gear into mesh simultaneously with the 1st speed sliding gear on the main shaft and lay shaft 1st speed gear. Drive will now be transmitted from the primary shaft through the constant mesh gears to the lay shaft 1st speed gear, and then up to the reverse idler pinion and to the 1st speed sliding gear. The interposition of the additional gear reverses the direction of rotation of the main shaft and therefore of the propeller shaft, final drive and road wheels (Fig21).

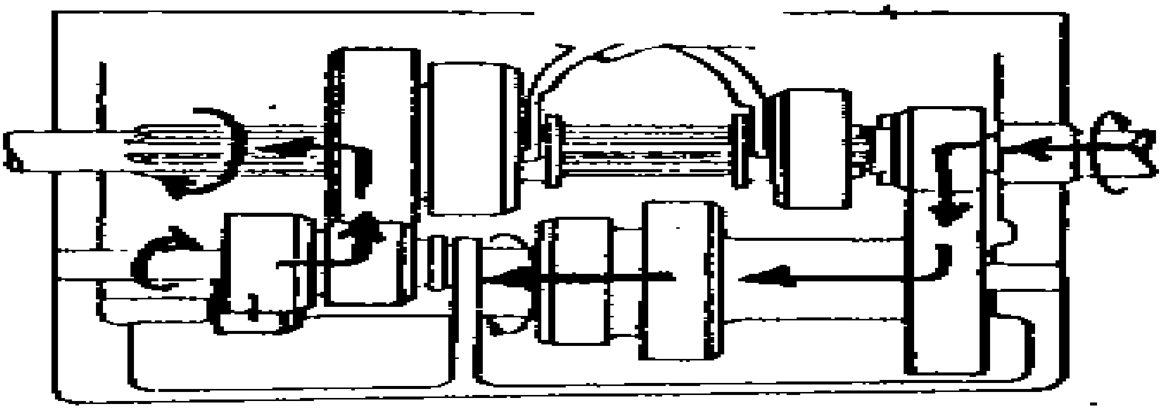


**Fig-21REVERSE**

**BAF BASE ZAHURUL HAQUE(TRG WG**
**(Aero Engg Trg Sqn)**

**Syllabus : Automobile and Diesel Technology**

**Course : Trade Training Basic, MTOF**

**Subject : Transmission System**

**Aim : To study Auxiliary gear box**

**Ref : A. P. 3159, section 6, chapter 2.**

# AUXILIARY GEAR BOX

## General

1. The auxiliary gearbox is used to lower the whole range of gear ratios

## Description

2. On some vehicle it is fitted immediately behind the main gearbox (See fig -22). The auxiliary gear box is operated by means of a separate gear change lever having three positions: one for high, giving no reduction after the main gear box, one for low gear which gives a further reduction after the main gearbox, and a neutral position. The change speed lever is normally left in the high-speed position, but when the load necessitates the use of the reduction, the gear change must be made when the vehicle is stationary. Similarly, when changing from low to high gear the vehicle must be stationary. An auxiliary gearbox has three shafts:

a. **Main Shaft.** The main shaft or driving shaft is driven from the main gearbox; but with its rear end is supported in a spigot formed in the tail shaft. The main shaft is splined and carries a single gear wheel, which, in addition to straight cut teeth, has dogs machined on one face.

b. **Subsidiary Shaft.** A subsidiary shaft having two gear wheels, one is large and another one is small, both the gear wheels are solid with the shaft, small gear wheel is in constant mesh with the tail shaft gear wheel.

c. **Tail Shaft.** Tail shaft having a gear wheel, which is constant mesh with the small gear of the subsidiary shaft and having dogs on its front face and this shaft is connected with propeller shaft by universal joint.

## Operation

3. A selector mechanism similar to that of a main gearbox can be manipulated to move the sliding gear on the splined main shaft to obtain either high or low gear (Fig – 22). It is affected in the following manner:

a. **High Gear.** The sliding gear wheel is moved along the splines of the main shaft so that the gear wheel dogs engage those of the gear wheel on the tail shaft. The drive is, therefore, straight through with no reduced ratio.

b. **low Gear.** The sliding gear wheel is moved in the opposite direction along the splines of the main shaft so that it meshes with the larger gear wheel mounted on the subsidiary shaft. The drive is through the main shaft to the subsidiary shaft and then to the tail shaft through the constant meshes gears. The reduction is effected by the ratio between the number of teeth on the sliding gear wheel and the number of teeth on the subsidiary shaft gear wheel.

**Note:** Neutral is obtained when the gear lever is in a central position, so that the sliding gear wheel is mid-way between the gear wheel on the subsidiary shaft and that of the tail shaft.

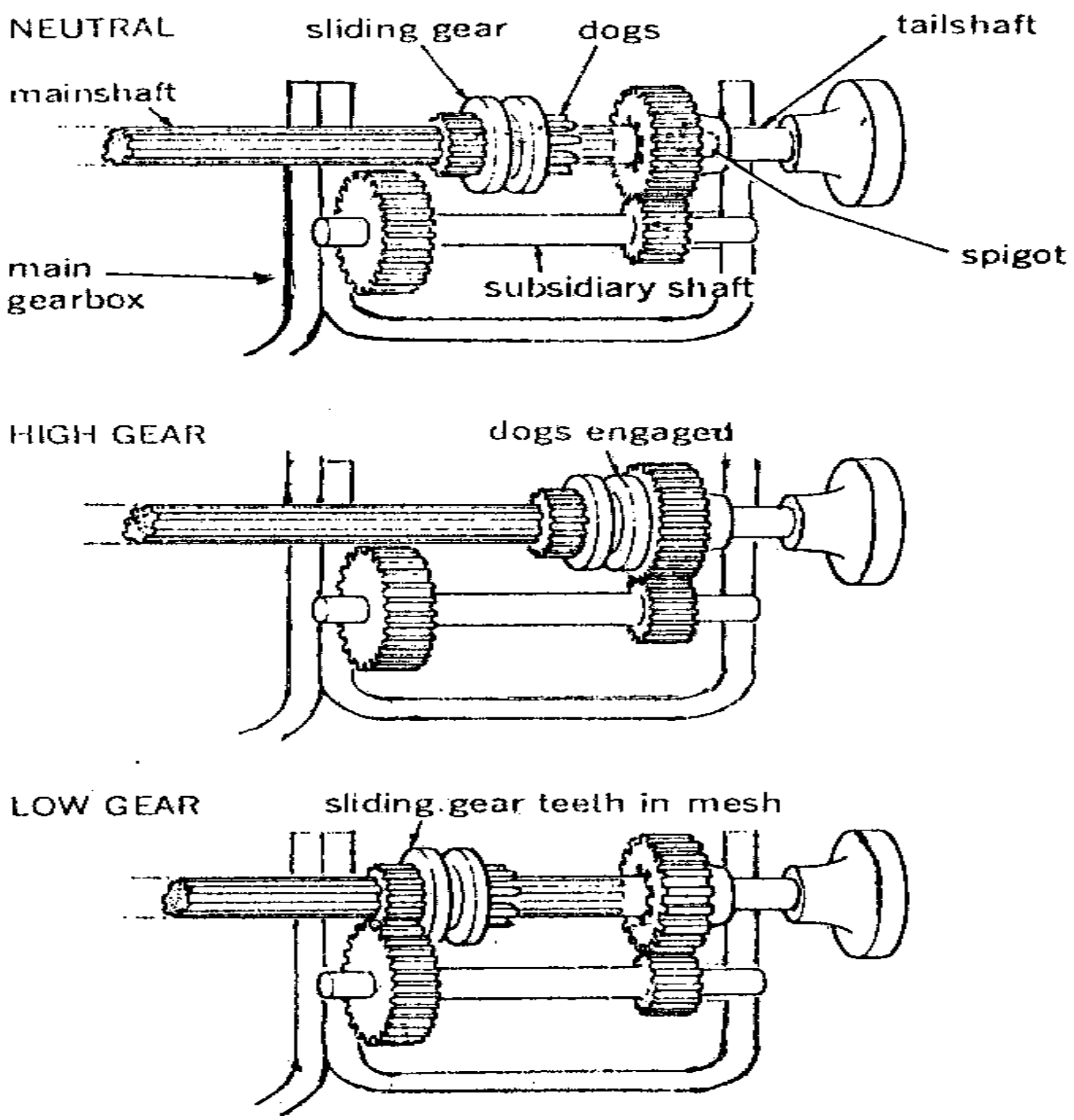



**Fig-22 Auxiliary Gear Box**

**BAF BASE ZAHURUL HAQUE(TRG WG**
**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **Transmission System** |
| **Aim** | **:** | **To study Servicing & Faults of Gearbox.** |
| **Ref** | **:** | **A. P. 3159, section 6, chapter 2.** |

# SERVICING & FAULTS OF GEARBOX

## Servicing

1. There is not a great deal of normal servicing to carry out on a gearbox, the main items being:

a. Maintain oil level in accordance with relevant AP or servicing schedule.

b. Keep all joints, housings, cover plates and drain cocks, oil tight.

c. Keep the gearbox clean.

d. Keep all mounting and assembly nuts tight.

e Lubricate gate or ball change mechanism, including reverse trigger if fitted.

## Faults and Probable Causes

2. a. **Knocking Noises.** Probably due to chipped teeth or worn balls in bearings.

b. **Whining or Hammering Noises.** Gear wheels meshing badly due to worn bearings.

c. **gears Jump Out of Mesh.** End float on lay shaft excessive or stops on lay shaft badly adjusted; worn plungers or V grooves in selector mechanism: plungers seized in guides; broken plunger springs; excessive wear on the gear wheel teeth making them tapered towards the edges.

d. **Difficulty in Engaging Gears.** Burrs on splines. Bent or twisted striking finger, selector rod or selector rod forks.

# BAF BASE ZAHURUL HAQUE(TRG WG
## (Aero Engg Trg Sqn)

**Syllabus : Automobile and Diesel Technology**

**Course : Trade Training Basic, MTOF**

**Subject : Transmission System**

**Aim : To study Universal joints.**

**Ref : A. P. 3159, section 6, chapter 3.**

---

## UNIVERSAL JOINTS

**Purpose**

1. It is the joint, which transmits the engine power through an angle at varying velocity to the final drive and onward to the road wheels.

**Types and Construction**

2. The various type of universal is described in the flowing paragraphs:

a. **The Flexible Hardy Coupling.** This consists of a specially constructed fabric disc made up in layers of fabric; some times the hole is rubber impregnated. Six equally spaced holes are formed in the disc and each hole has a stiffening steel plate on each side (Fitg-23). A three- are spider each fastened to each side of the disc wit the arms bolted to alternate hole. I.e. with the arms of each spider bolted to the holes not used by the arms of the other spider. The bolt s securing the spider arms to the fabric disc must not be tightened excessively as this damages the fabric, resulting in fraying and rapid collapse of the disc nominal tightness only is necessary and split pins inserted. Couplings constructed in this manner are usually fitted between a clutch and gear box and on some vehicles, between gear box and propeller shaft and between propeller shaft and rear axle. The advantages of the fabric coupling are that it is flexible in all direction and it has a small amount of lateral movement; a sliding joint may not be required. It is silent in operation; it is very hard wearing and requires no lubrication; in fact, oil and grease on the fabric merely accelerate the deterioration.

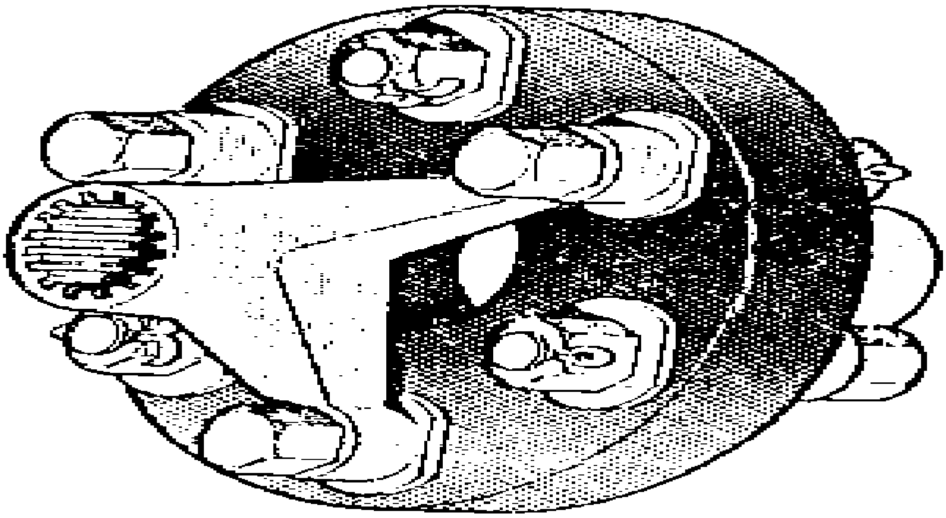


**Fig.23 Flexible Hardy Coupling**

b. **<u>The Hardy Spicer Needle Bearing type.</u>** This is the most commonly used universal joint. It has working in faces of needle roller bearings which are either packed in grease or work in an oil reservoir. Each needle bearing assembly consists of a hardened cage caring the needle rollers. When fitted to the trunnion and yokes, a circlip or locking ring snapped into a groove in each of the yoke ends retains the whole assembly in position. (Fig.24).

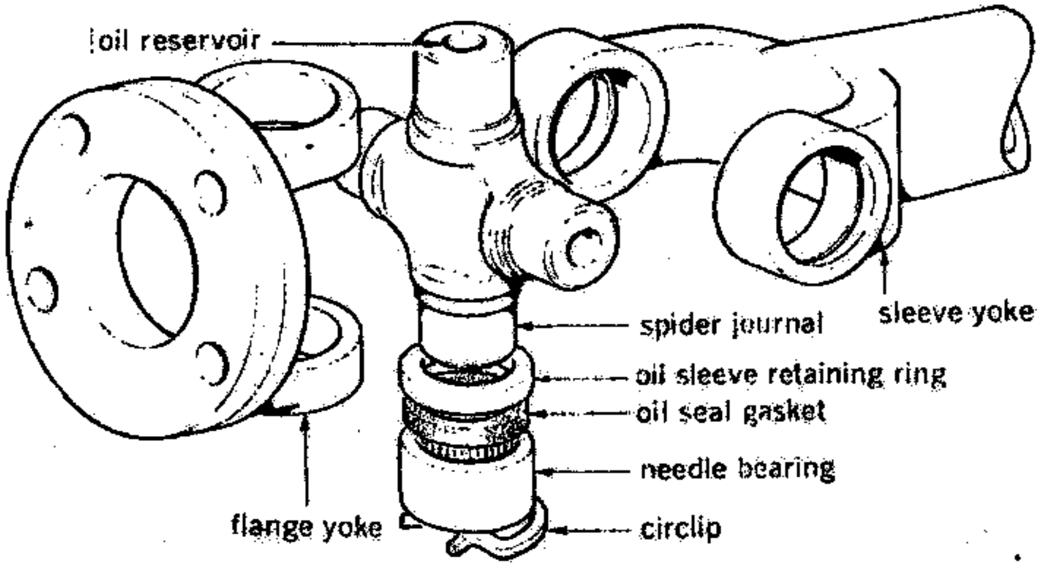



**Fig.24 Hardy Spicer Coupling (Circlip type)**

c. **The Layrub Coupling.** This type (Fig 25) is used on short tubular propeller shafts, where the inclination between the gearboxes and rear axles is very small. It consists of two pressed steel dished pressings welded or riveted together. The four pressed-out bosses on the plate form housings for special rubber blocks. Each rubber block is fitted with a steel sleeve to carry a bolt to secure the coupling to the forked ends of the shafts to be coupled. These bolts are frightened up hard and split pin inserted. No provision is made for telescopic movement. It has the advantage of requiring no servicing and when worn, the complete coupling is changed.

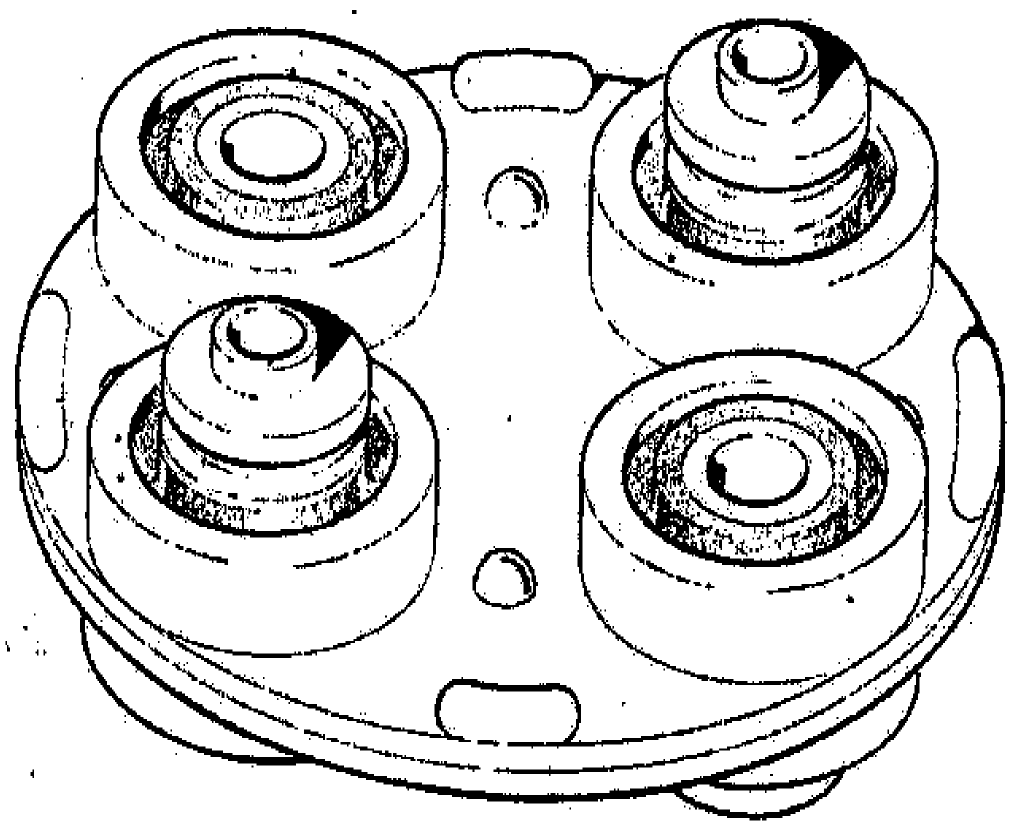


**Fig. 25 the Layrub Coupling**

**B A F BASE ZAHURUL HAQUE(TRG WG**
**(Aero Engg Trg Sqn)**

**Syllabus : Automobile and Diesel Technology**
**Course : Trade Training Basic, MTOF**
**Subject : Transmission System**
**Aim : To study Methods of transmission.**
**Ref : A. P. 3159, section 6, chapter 4.**

---

# METHODS OF TRANSMISSION

## Introduction

1. Whenever driving or braking efforts are applied through the rear axle of a vehicle, the axle structure as a whole tends to turn over or rotate about the axis of the wheels. When the brakes are applied, the tendency to rotate is in the forward direction whilst, when the vehicle is driven forwards, the axle structure tends to rotate backwards.

## Method

2. The two most commonly used methods of transmission of the torque and driving thrust from the rear axle to the frame are the 'Hotchkiss' drive and the 'Torque Tube' drive:

a. **The Hotchkiss Drive.** The chassis springs are pivoted on fixed pins at their front ends and are shackled at the rear end, the centers being rigidly fixed to the spring mountings on the axle casing (Fig. 26). The springs locate the rear axle on the chassis, resist the driving and braking torque and transmit the thrust to the vehicle. An open propeller shaft is used with a universal joint at each end.

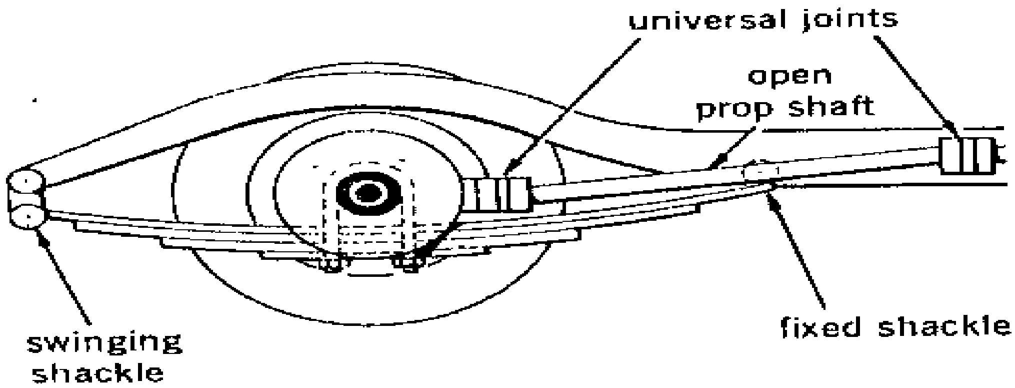


**Fig. 26 Hotchkiss drove**

b. **Torque Drive.** When torque tubes or torque rods is used, the springs do not need to be rigidly fixed to the axle casing because they no longer take the torque loading. When the springs are freed from the need to transmit torque, none of the springing qualities is lost; thus the ride is usually improved when torque rods are combined with the 'Hotchkiss drive'.

**B A F BASE ZAHURUL HAQUE(TRG WG**
**(Aero Engg Trg Sqn)**

**Syllabus : Automobile and Diesel Technology**
**Course : Trade Training Basic, MTOF**
**Subject : Transmission System**
**Aim : To study Axle casing.**
**Ref : A. P. 3159, section 6, chapter 4.**

# AXLE CASING

## Purpose

1. The purpose of the axle casing is to carry the final drive, differential assembly and the axle shafts.

## Construction

2. The axle also includes the road wheel hubs and brake assemblies. The casings are made of steel castings (machined where necessary), provided with inspection covers, oil level plugs or dipstick and are made oil tight with oil retaining washers. Differential gear assemblies are mounted in a casing in a variety of ways but always with adjustment facilities between crown wheel and driving pinion, or worn and wheel. Differential gear assemblies can be removed complete from casings but the method of removal is depends on the casing construction.

## Types

3. Three casings are described but there are variants of these.

a. **The Split Casing.** An axle with a split casing must be dismantled from a chassis before the differential gear assembly can be removed from the casing. The casing is in two halves, bolted in the center to form the complete casing (Fig.27).

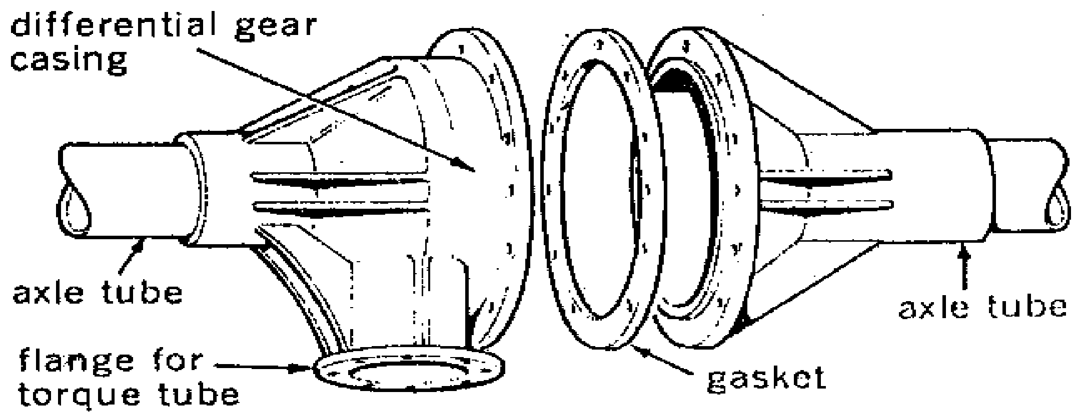



**Fig- 27 Split axle Casing**

b. **The Banjo Casing.** This is a one piece casting with flanged faces on the enlarged center portion (Fig-28). The rear flange carries an inspection cover and the front flange carries housing, complete with differential gear and bevel pinion assemblies. The differential gear assembly can be dismantled from the casing after the inspection cover and axle shafts have been removed.

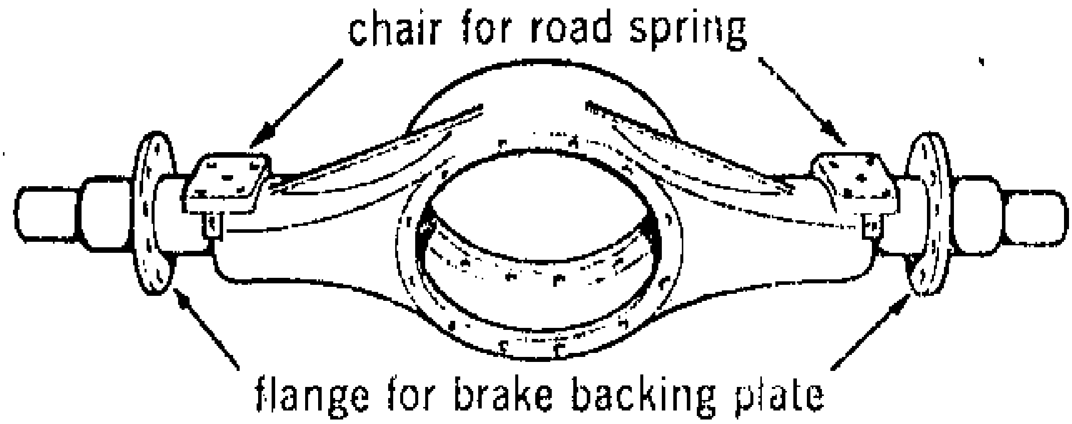



**Fig-28 Banjo Casing for Rear Axle**

c. **Built-up Casing.** The two axle tubes of pressed steel are bolted to the differential housing, which is steel or aluminum alloy casting (Fig-29). Before the differential assembly can be removed from a built up axle, the whole axle must be removed from the vehicle. Worm drive axles are made with built-up housings, because the pressed steel banjo housing is not sufficiently stiff for a worm drive, which requires very rigid support for the differential bearings.

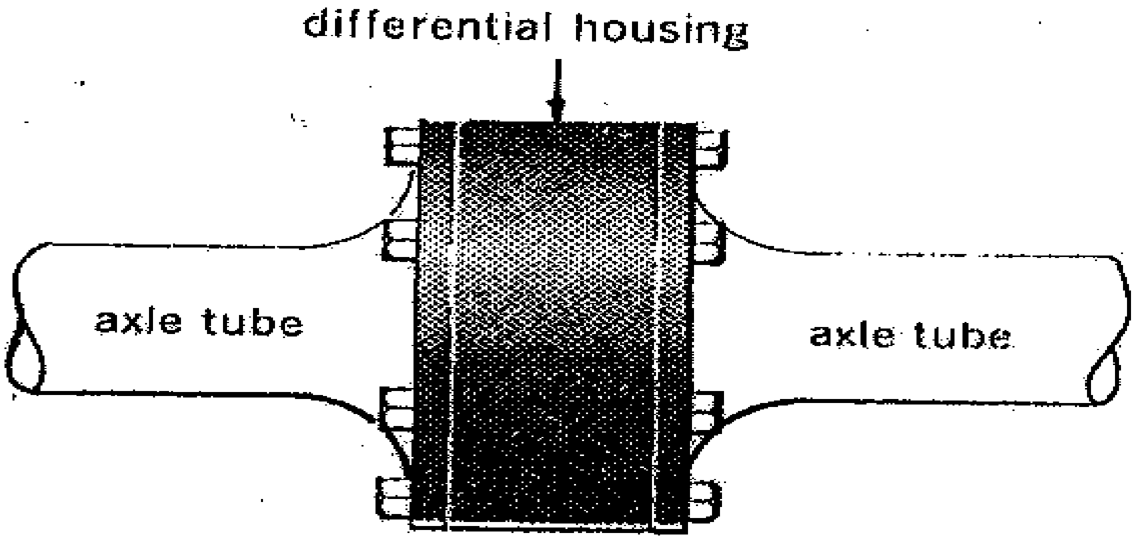



**Fig-29 Built-up Rear Axle Casing**

**B A F BASE ZAHURUL HAQUE(TRG WG**
**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **Transmission System** |
| **Aim** | **:** | **To study Final Drive.** |
| **Ref** | **:** | **A. P. 3159, section 6, chapter 4.** |

# FINAL DRIVE

## Purpose.

1. The purpose of the final drive is to convert the drive from the propeller shaft to the rear axle shaft.

## Construction

2. The final drive consists of a mechanical arrangement for converting the drive from the propeller shaft (with a gear reduction) to the axle shafts. The gear reduction varies according to the type of vehicle but it is rarely below 4:1 or above 7:1. When an axle transmits power to the road wheels it is known as “live axle”, but when an axle is not capable of transmitting the engine power, it is known as “dead axle”. A dead axle is, therefore, one that does not transmit power to road wheels and it is usually fitted to increase load capacity of a chassis. The driving shaft worn gear (or bevel pinion), crown wheel, differential gears and axle shafts, all rotate in a heavy steel casing. The rear axle casing supports some of the weight of the vehicle and is adapted to carry the rear road wheels and the rear wheel braking mechanism.

## Types

3. There are two types in common use today and these are:

a. **Bevel Wheel and Pinion or “Bevel Drive”.** The bevel pinion and crown wheel were made with straight cut teeth. Now a day’s, spiral bevel gearing is used because it is operates less noisy. The pinion is carried on a short shaft mounted on ball or roller bearings in the rear axle casing. When the propeller shaft is an open one, it drives the bevel pinion shaft through a universal joint but where a torque tube is fitted, a universal joint is not used. The pinion is meshed into and drives the crown wheel, as (Fig-29) and the number of teeth on the pinion relative to those on the crown wheel determines the reduction. To obtain correct mesh with the crown wheel, some provision for adjustment is usually incorporated on the bevel pinion shaft and differential assembly.

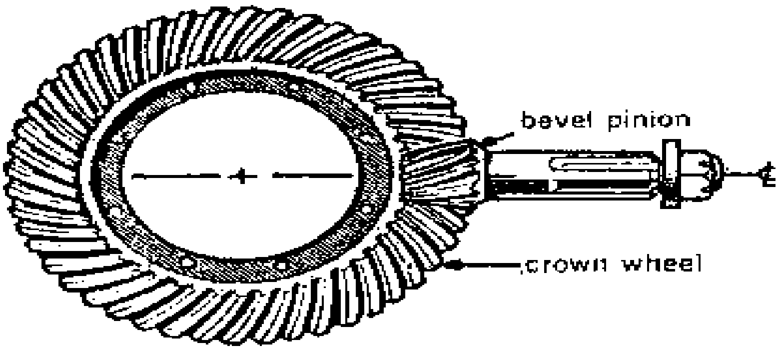



**Fig-30 Spiral Bevel Drive**

b. **Worm and Wheel.** In this type, worm shaft or shaft with a screw thread cut on it, is mounted in bearings and although free to rotate, is prevented from moving backward or forward (Fig-30). This shaft is mounted along the top or the bottom of the rear axle casing, so that the worm meshes into the teeth of the worm wheel. The screw thread is usually something between a square thread and a V-thread and any desired gear ratio may be obtained by varying the pitch of the worm and the number of starts. The worm may be cut with one thread running from end to end or it may have three, four or more threads. One revolution will then move the worm wheel through a distance considerably in excess of the space between two adjacent teeth. Since the teeth are continually in engagement, worm gearing is absolutely silent. The worm wheel is made of phosphor bronze, which makes the worm gearing more expensive than the bevel drive. This type of final drive is often used on heavy vehicles because of its strength and large gear reduction ratio. Lubrication is of the greatest importance and the oil level must be maintained at the correct level; any oil shortage would have much more serious results then on the bevel gearing because of the greater friction between the teeth of the worm and worm wheel. For the same reason it is important that only the specified oil should be used.

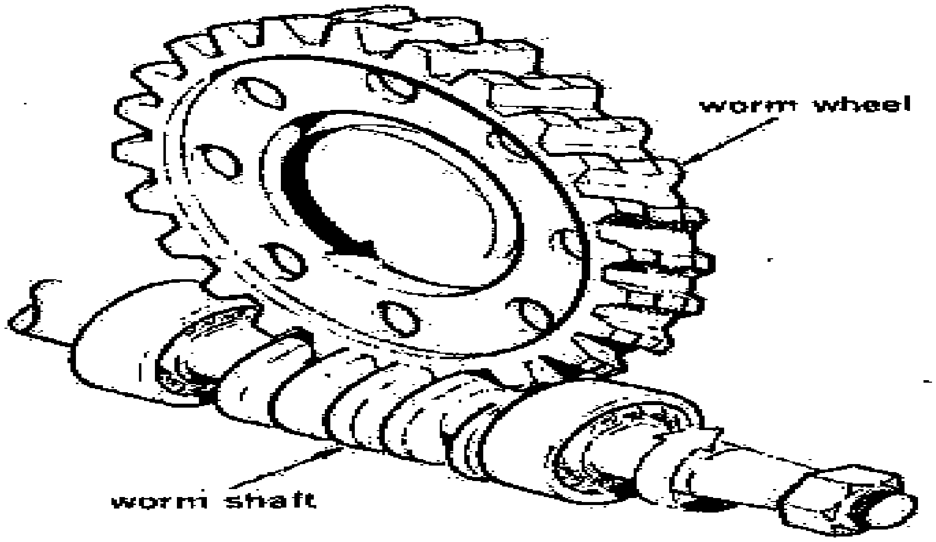



**Fig-31 Worm and Worm Wheel Drive**

c. **Hypoid Drive.** This is a modified version of the bevel wheel and pinion. The principle difference is that the axis of the bevel pinion is below that of the crown wheel. This arrangement enables the chassis cross members and the floor of the body to be lowered several inches without touching the propeller shaft. Hypoid gear axles run in a special grad of oil which must always be used.

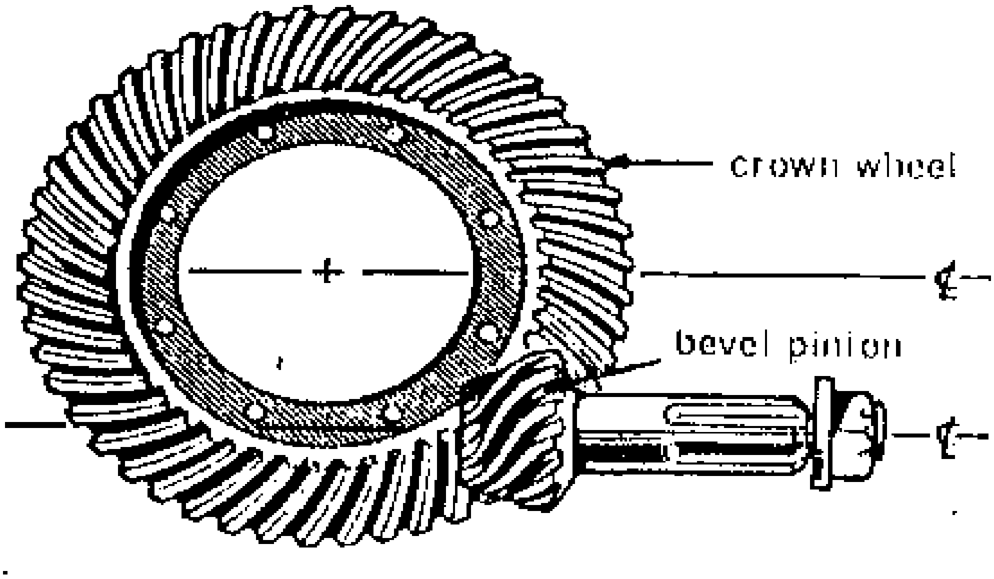



**Fig-32 Hypoid Drive**

**B A F BASE ZAHURUL HAQUE(TRG WG**
**(Aero Engg Trg Sqn)**

**Syllabus : Automobile and Diesel Technology**
**Course : Trade Training Basic, MTOF**
**Subject : Transmission System**
**Aim : To study Differential Unit.**
**Ref : A. P. 3159, section 5, chapter 4.**

---

# DIFFERENTIAL UNIT

## Purpose

1. A differential is required to compensate for the difference in distance that the drive wheels travels when the vehicle rounds a curved.

## Construction

2. The differential gear is a box or cage which is bolted to the crown or worm wheel so that the cage rotates with the crown or worm wheel (Fig32). Two pins are mounted diametrically opposite each other within the cage and they carry small differential (planet) pinions on their outer ends. The planet pinions are free to rotate about the pins but they are also in mesh with two large bevel wheels ( sun wheels ) secured by splines on the inner ends of the axle shafts .The differential cage rotates on the same axis as the axle shaft but quite independently of them.

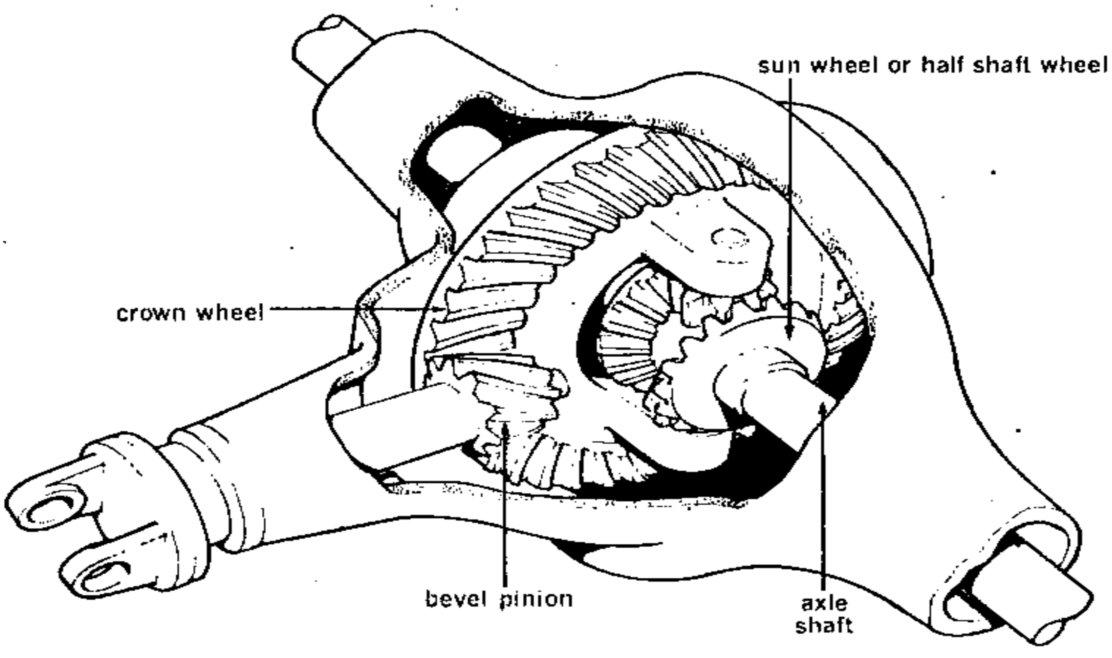



**Fig-33 Differential Unit**

**Operation**

3. The axle shafts rotate at the same speed when the vehicle is traveling in a straight line and there is no rotation of the differential pinions on their pins, the whole assembly of the crown wheel, cage, differential pins, pinions and axle shafts, rotating as one component. The drive is, however, transmitted though the differential pinions to the sun wheels on the axle shafts all the time (Fig-33). The wheels are balanced by their engagement with opposite sides of the differential pinions. However, when one road driving wheel has to turn faster than the other, the differential pinions will rotate round the pins and allow the sun wheels and axle shafts to revolve at different speeds as required by the road conditions. Thus, assuming the power transmitted to the driving axle to be constant, one of the axle shafts would rotate faster than the crown wheel and cage, and the other would rotate slower. The differential pinions, therefore, transmit the drive from crown wheel and cage, to the sun wheels and axle shafts but at the same time they provide an infinitely variable ratio between the road wheels as required.

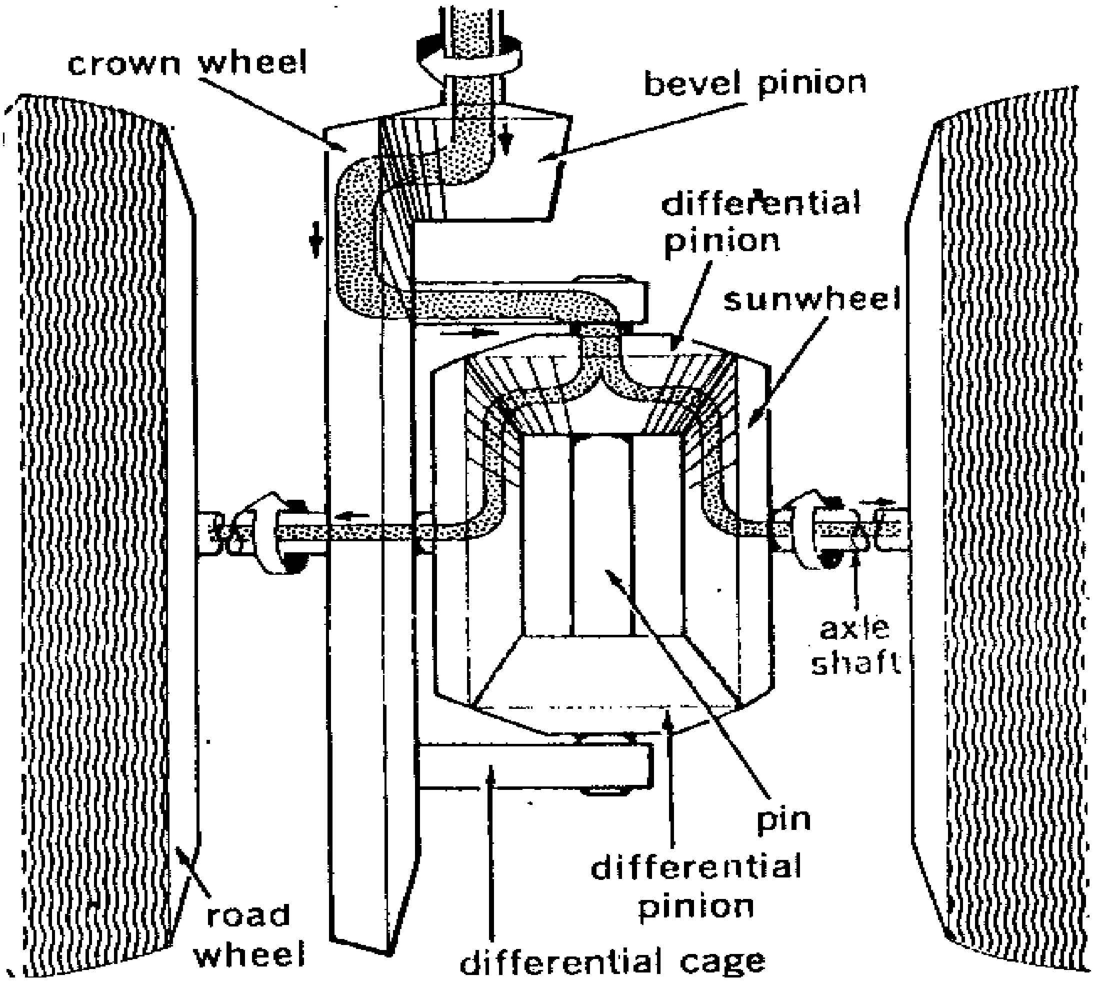



**Fig-34 Path and Direction of Final Drive**

**BASE ZAHURUL HAQUE(TRG WG**
**(Aero Engg Trg Sqn)**

**Syllabus : Automobile and Diesel Technology**
**Course : Trade Training Basic, MTOF**
**Subject : Transmission System**
**Aim : To study Propeller shaft**
**Ref : The automotive fundamental chap-9.**

---

# THE PROPELLER SHAFT

## Purpose

1. The purpose of the propeller shaft is to transmit the drive from the gear box to the driving axle.

## Types

2. There are two types of propeller shaft in general use.

a. **The Torque Tube Type Drive Shaft.** In this type the propeller shaft is enclosed in a hallow steel tube and there is only one universal joint on the transmission side. It is so named because it resists the torque and twisting motion of the rear axle casing due to the application of brakes and reaction of the drive.

b. **The Hotchkiss Type Drive Shaft.** This drive shaft is not enclosed in any cover, so it's another name is open type drive shaft. It is having the universal joint at each end. Both universal joints are used to compensate for the changes in the drive shaft angle as the wheel counters irregularities in the road. It is not designed to absorb any rear end action.

## Servicing and faults

3. Little servicing is required for the propeller shafts but it is very necessary and must not be neglected. Periodical inspection must be carried out to ensure security of nuts and bolts and adequate lubrication where necessary.

**BAF BASE ZAHURUL HAQUE (TRG WG)**
**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile Diesel and Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **Steering System** |
| **Aim** | **:** | **To Study Steering System** |
| **Ref.** | **:** | **The Automotive by Harbans Singh Reyat & AP 3159** |

# STEERING SYSTEM

## Purpose

1. The steering system allows the operator to guide the automobile along the road and turn left or right as desired.

## Construction

2. Steering system consists of the following main parts (Fig-1):

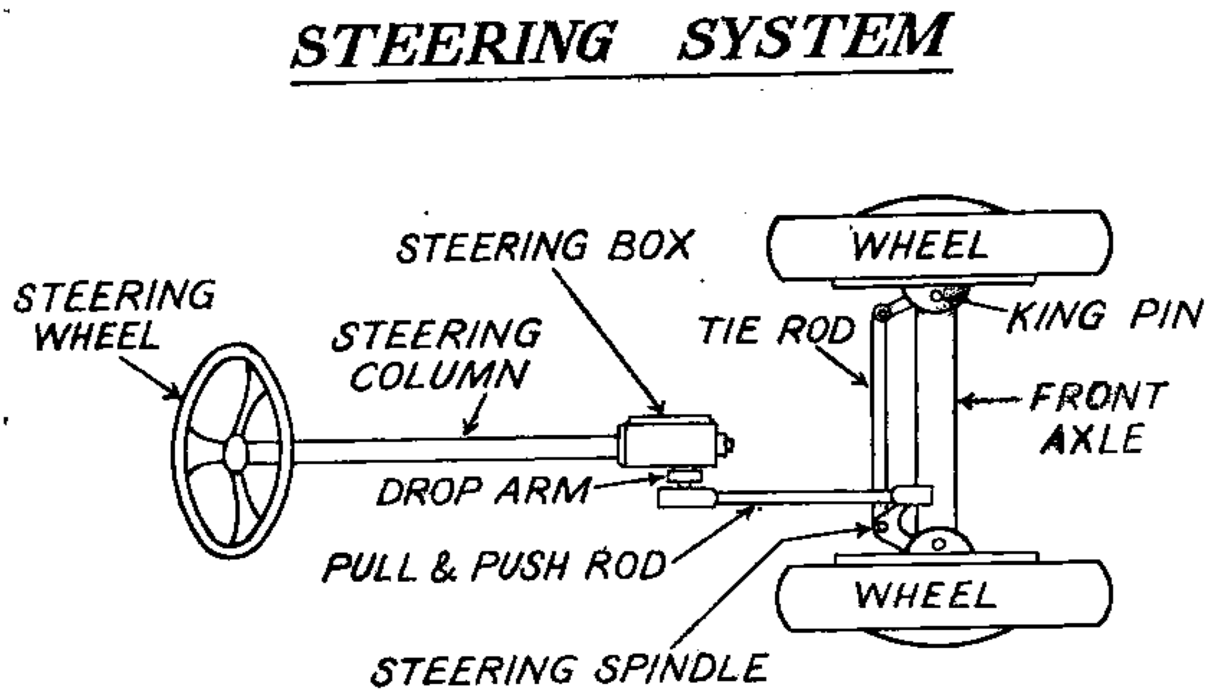



**Fig 1 Steering System**

a. **Steering Wheel**. This consists of a wheel of fairly large diameter, connected by spokes to a central hub. The rim is often notched on the under side to provide a good grip for the operator's fingers.
The hub is bored and either splined or fitted with a key way so that it may be secured to the top end of the steering shaft, more often called the inner column. The size of the wheel depends on

the weight of the vehicle and the type of gearing used. A horn push button/push ring is fitted at its hub. The steering hub sometimes contains Trafficator switch, lighting switch or selector lever for controlling automatic transmition.

b. **Outer Steering Column**. This is a tube in which the inner column rotates. It has an internal bearing or bush at, or near, the top end; its lower end fits on the steering box or it is made integral with the steering box.

c. **Inner Steering Column**. The inner steering column is housed in bushes or some type of bearing, which are carried in the outer column. The top end, which protrudes from the outer column, is either serrated, splined, or fitted with a key or keyway to receive the steering wheel. Its lower end is fitted with a worm thread and the worm is often brazed to the column.

d. **The Steering Gearbox**. The housing, which contains the steering gears, is known as the steering gearbox. It also provides the housing for the steering cross-shaft and forms the reservoir for the oil used to lubricate its mechanism.

e. **Cross or Rocker Shaft.** The rotary movement of the inner column and worm is converted by one of the various forms of gearing to give a turning movement to the steering cross shaft or rocker shaft. The rocker or cross-shaft is mounted in phosphor-bronze bushes at right angles to the steering column. The shaft extends beyond the steering box and carries the steering drop arm.

f. **Drop Arm.** This is tough steel forging which is bored at either end. The bore of the larger end is internally serrated, splined, or keyed to fit on the rocker shaft. The smaller end is fitted with a ball joint which connects the drop arm to the drag link or pull-and-push rod.

g. **The Pull and Push Rod or Drag Link**. The connection between the steering arm of the front axle and the drag arm of the steering assembly is made by a pull-and-push rod, sometimes called a drag link. It is usually made of steel tubular construction, with a spring-loaded ball socket at each end. One end fits on the steering arm of the stub axle and the other on the rod of the steering drop arm. On the majority of vehicles, the pull-and-push rod lies parallel to the chassis, with the steering arm carried on the right-hand side stub axle. On other vehicles the pull-and-push rod lies across the chassis and connects with the steering arm mounted on the left-hand side stub axle.

h. **Stub Axle arm or Steering Spindle or Steering knuckle.** It is the arm, sometimes known as steering spindle, which is integrated with the stub axle of its movements around the pivot which known as king pin. The steering effort is conveyed to the steering knuckle by means of steering linkages for turning the road wheels to the right or left direction. Each stub axle has its own steering knuckle arm which is connected with each other through tie rods.

j. **The Stub Axles.** There are two stub axles fitted to a front axle; they are steel forgings and are mounted on a front axle beam by swivel pins so that the stub axles can swivel as required for steering. Each stub axle is made complete with an arm, the stub axle arms being connected to each other by track rod. In addition, one of them has a steering arm for connection to the pull-and-push rod. Thus any movement of the pull and push rod to swivel the stub axle carrying the steering arm with also swivel the other stub axle. A road wheel mounted on bearings is carried by each stub axle.

k. **The Track Rod**. The track rod connect the two stub axles are to each other through knuckle joints, or more commonly ball joints; the joints are known as track rod ends. The ends are invariable screwed on to the rack rod and permit track rod adjustment. The track rod is therefore, threaded at both ends, one end being threaded with a left-hand thread and the other having a right-hand thread. To adjust a track rod, it is only necessary to slacken off the locking devices on the track rod ends so that the track rod can be turned in the end sockets. Turning the track rod in one direction would lengthen the track rod; the reverse direction shorter the rod. The amount of toe-in is decreased.

# BAF BASE ZAHURUL HAQUE (TRG WG)
## (Aero Engg Trg Sqn)

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile Diesel and Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **Steering System** |
| **Aim** | **:** | **To Study Types of Steering System** |
| **Ref.** | **:** | **The Automotive by Harbans Singh Reyat** |

---

## TYPES OF STEERING BOXES

**Worm and Wheel.**

1. This is one of the earlier types, but in still in used some vehicles to day. It consists of worm and a wheel permanently in mesh. The movement of the worm by the steering wheel causes the worm wheel to rotate according to the way the steering wheel is turned. Attached to the center-shaft of the worm wheel is a drop arm, which may be keyed, splined, or serrated to the worm wheel shaft. One advantage of the worm and wheel type of steering is that the wear of the wheel can be rectified by removing the wheel from the box so that it can be mashed to the warm in a different sector. The drop arm is then reset on the rocker shaft. Filling effects lubrication of the gear or partially filling the steering gear box with specified lubrication oil; an oil-filling plug is provided for this purpose.

**Worm and Sector**

2. The principles of worm and sector steering are the same as those of the worm and wheel, but instead of having a complete wheel in mesh with the worm, a sector is only used. The sector has a working radius, which is sufficient to deflect the front wheels through the required angle of turn. The sector movement is limited by adjustable stop fitted on the steering box, or by steering stops embodied in the front axle assembly, which limit the swing of the stub axles. In some steering gear is thrust race is fitted between the worm and casing to resist any tendency of up and down movement of the inner column which carries the worm (Fig-2).

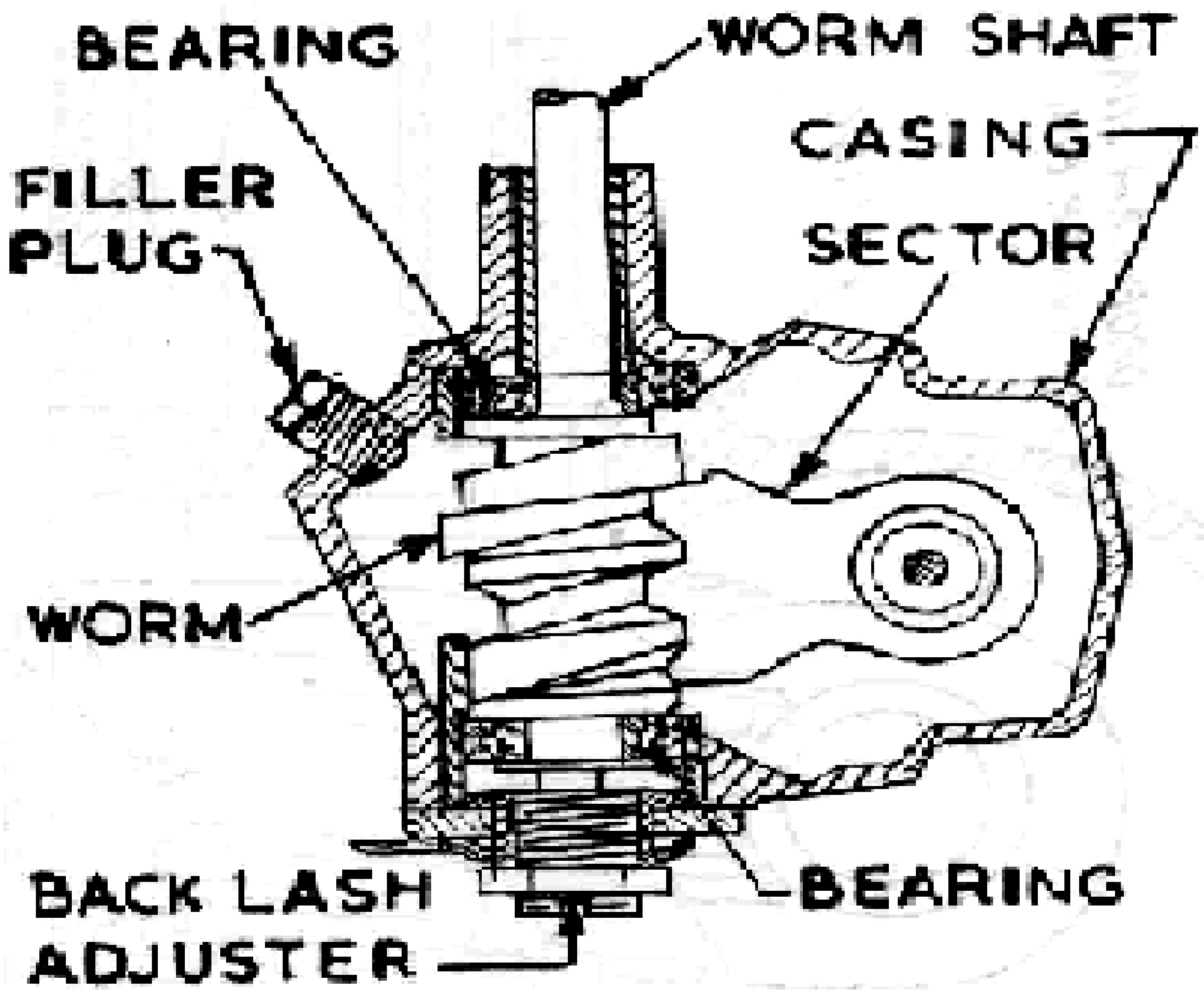



**Fig-2 Worm and Sector**

**Worm and Nut**

3. Basically, this steering is similar to those already mentioned, but a nut, which moves up and down the thread of the worm when the steering column is rotated, replaces the wheel or sector. The steering nut is connected by a ball and socket arrangement to one or two levers which are integral with, but at right angles to the cross shaft, the up and down movement of the steering nut oscillated the cross-shaft, on the outer end of which the drop arm is mounted in the usual manner.(fig-3)

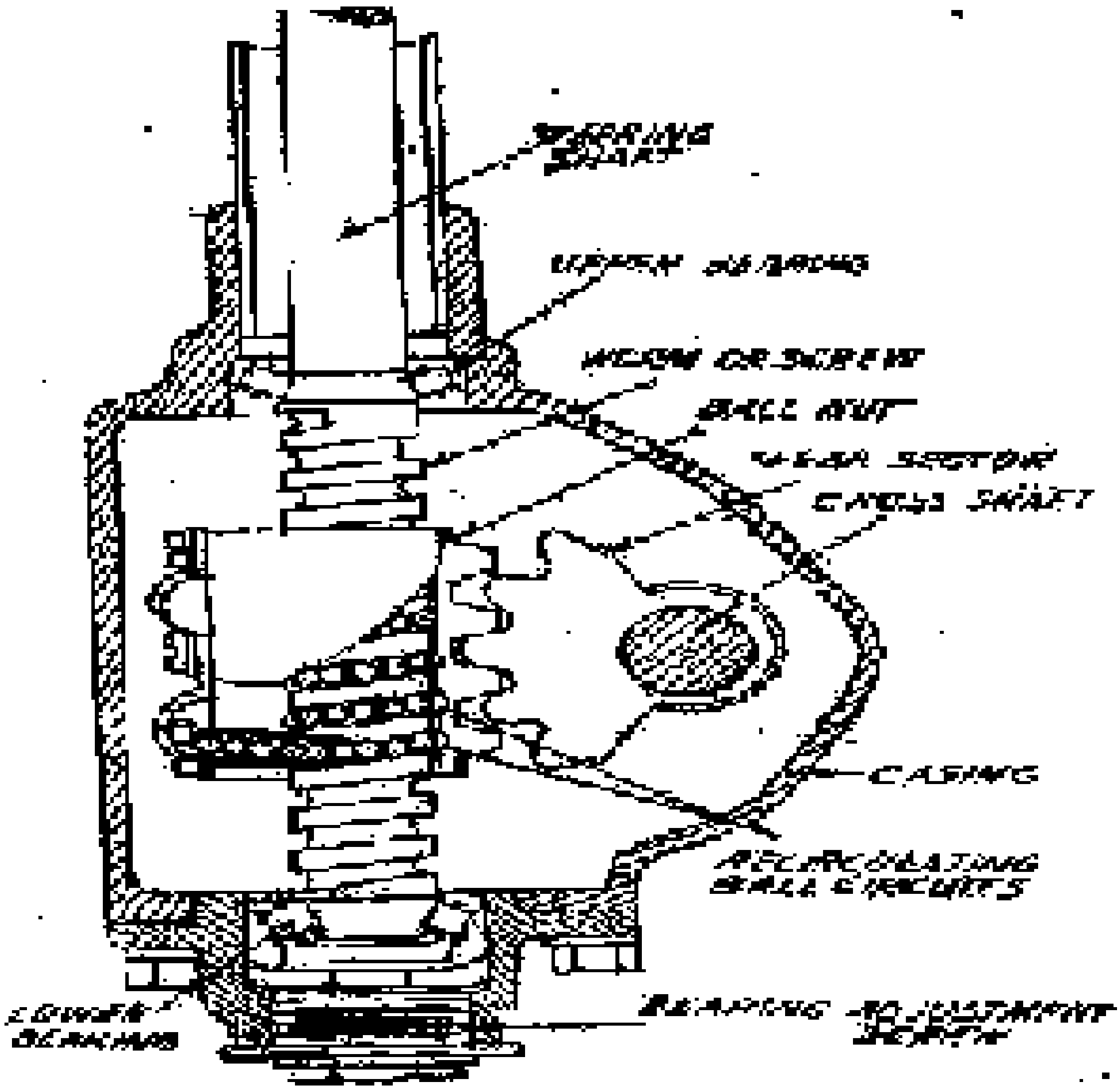



**Fig-3 Worm and nut**

**<u>Bishop Steering</u>**

4. The bishop steering dispenses of a mechanism in which there is no sliding contact and therefore little wear. The moving parts roll on one another. The steering column carries a specially shaped worm on its lower end, which is engaged by a roller mounted in ball bearings on the end of an arm secured to the cross shaft. The space between the forks of the arm accommodates the roller and ball bearings, which are located by a pin passing through the fork. As the cam or worm rotates it swing the roller and arm about the axis of the cross-shaft and thus operates the drop arm. The diameter of the cam or worm increases towards the end so that the roller is always in proper engagement through out its movement. The pin locating the roller to the arm of cross shaft is eccentric so that the engagement of roller to cam is adjusted. The merles steering is very easy to operate and the road wheels cannot radially turn the steering wheel. (Fig-4)

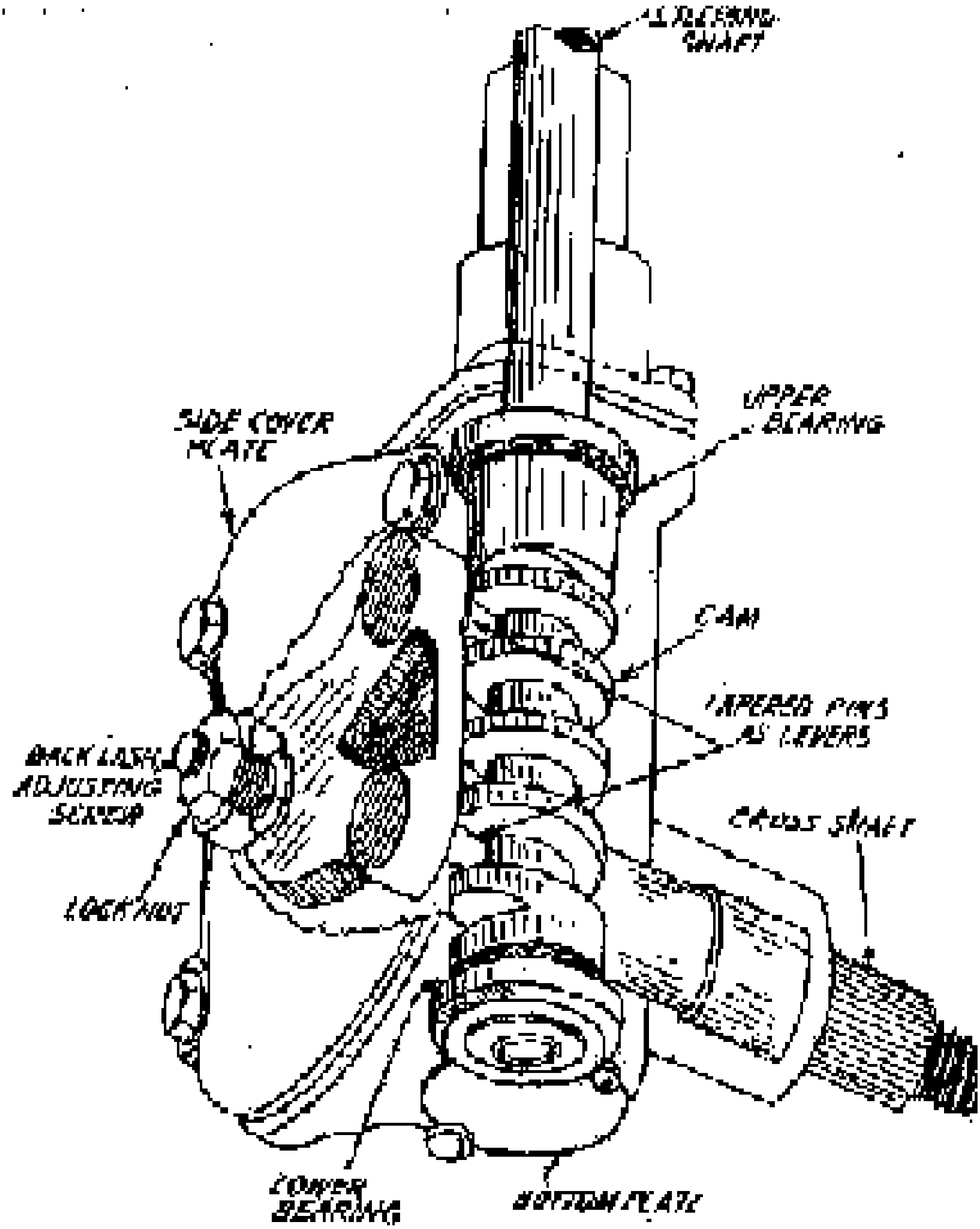



**Fig-4 Bishop Steering**

**The Merles Cam and Roller**

5. Here a roller is fitted at the drop arm shaft. When the worm moves along with the movement of steering wheel, the roller rides up and down in the worm giving a twist to the drop arm shaft which in turn moves the drop arm.(fig-5)

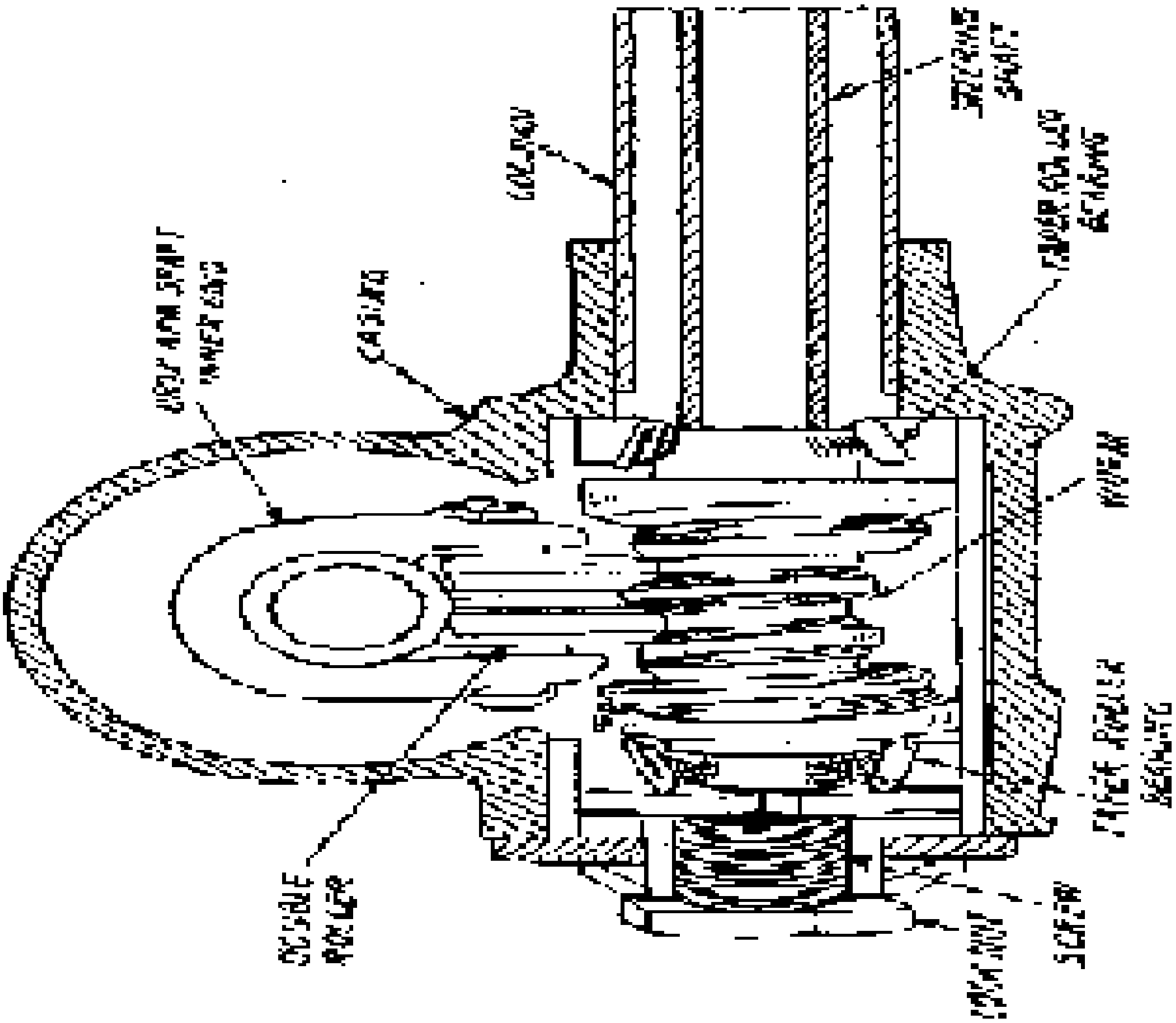


**Fig-5 Merles Cam and Roller**

**Note**: Reversible and irreversible are terms applied to the motions of a steering gear. If it is possible to reverse the normal procedure and by moving the road wheels, turn the steering wheel easily, the steering is known as reversible. Where this is not possible is known as irreversible. Modern steering is a compromise, and is so designed that the steering wheel can deflect the front wheels with the least amount of effort, but the transmission of shocks back from the front wheels to the steering wheel is resisted but not entirely eliminated.

# BAF BASE ZAHURUL HAQUE (TRG WG)

## (Aero Engg Trg Sqn)

**Syllabus : Automobile Diesel and Technology**

**Course : Trade Training Basic, MTOF**

**Subject : Steering System**

**Aim : To Study Front Axles**

**Ref. : AP 3159 Section 7chap 1**

---

## FRONT AXLES

### Purpose

1. Front axles are designed for two purposes. To transmit the weight of the vehicle from the springs to the front wheels. To permit the front wheels to turn right or left as required.

### Construction

2. A front axle assembly is a complete major component of a vehicle. It includes the axle beam, stub axles with brake assemblies and the track rod. It does not include the pull-and-push rod but for continuity this item is included in this chapter (fig-6).

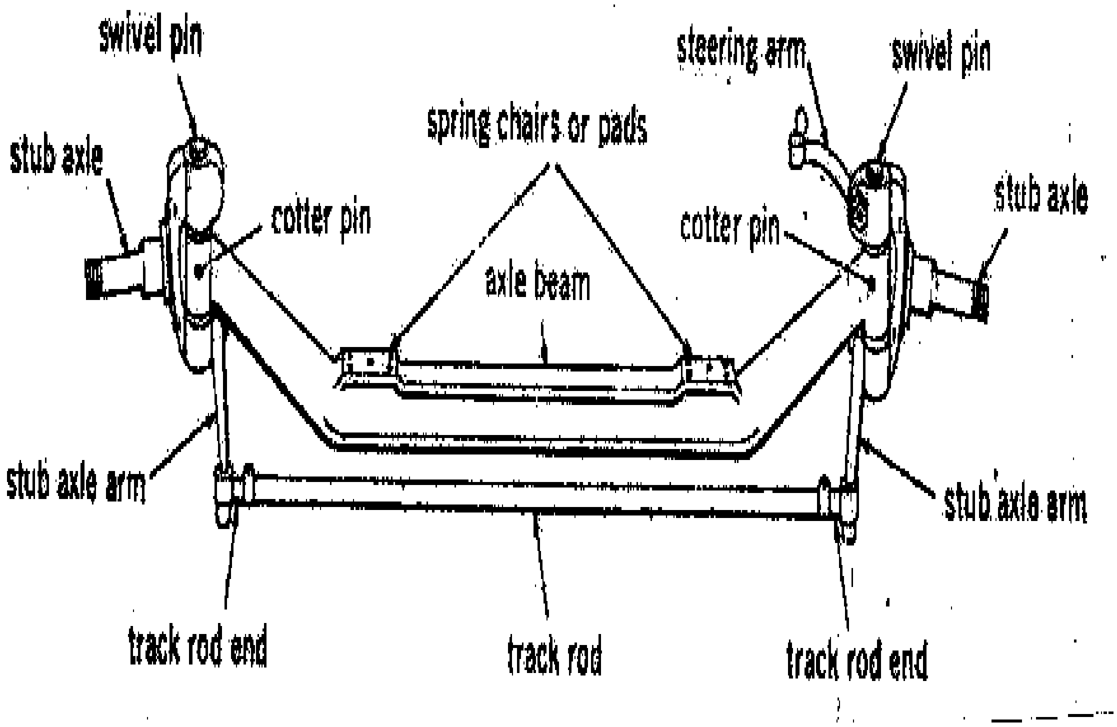



**Fig-6 Front Axle Assembly**

a. **The Axle Beam**. This is made of steel forging, usually of "I" or "H" section and serves the dual purpose of transmitting the weight of the vehicle from the springs to the front wheels and an anchorage on which the stub axles pivot. The stub axles are attached to the end of the axle by swivel pins, so that they can swivel about their pins in the horizontal plane. Two machined surfaces on the axle beam, equidistance from its center, and known as spring-pads (or chairs), carry the road springs. Each pad is drilled with four holes so that the springs can be rigidly bolted to the axle. The spring center bolt mating with a dowel hole on the spring pad ensures positive location of a road spring. The axle beam can have either a yoke or a plain end is illustrated in (fig.6), depending on the method on mounting the stub axles.

b. **The Stub Axles.** There are two stub axles fitted to a front axle; they are steel forgings and are mounted on a front axle beam by swivel pins so that the stub axles can swivel as required for steering (see fig-6). Each stub axle is made
complete with an arm, the stub axle arms being connected to each other by track rod. In addition, one of them has a steering arm for connection to the pull-and-push rod. Thus any movement of the pull and pushrod to swivel the stub axle carrying the steering arm with also swivel the other stub axle. A road wheel mounted on bearings is carried by each stub axle. There are two types of stub axles are follows:

(1) **The Elliot Stub Axle.** In this design, the swivel pin is fixed in the stub axle forging and the ends of the swivel in can turn freely in bushes fixed in the axle beam fork (fig-7&8).

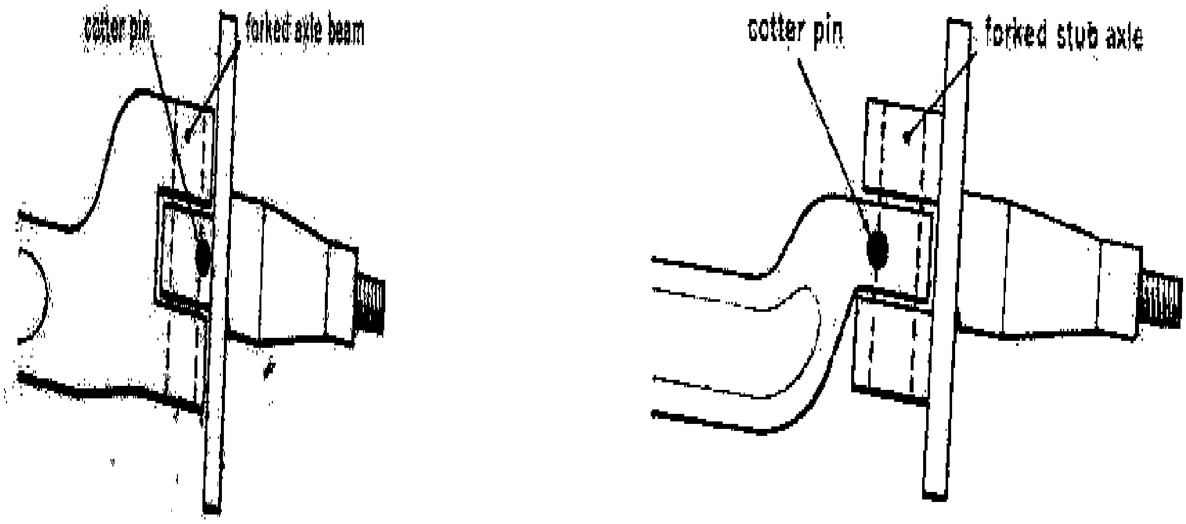



**Fig-7 & 8 The Elliot Stub Axle & Reversed Elliot Stub Axle**

(2) **The Reversed Elliot Stub Axle.** This design is the one most commonly used and has the swivel pin fixed in the end of the axle beam and locked by a cotter pin , so that the forked stub axle can turn on the swivel pin ends.(fig-7 b).

c. **Swivel Pins**. These are the pins securing the stub axles to the axle beam. They are also variously known as stub axle pins, pivot pins and king pins. They are made of good quality steel and usually casehardened. A cotter pin is generally used to locate and lock each pin in position (see fig-6).

d. **The Track Rod**. The track rod connect the two stub axle are to each other through knuckle joints, or more commonly ball joints; the joints are known as track rod ends. The ends are invariable screwed on to the rack rod and permit track rod adjustment. The track rod is therefore, threaded at both ends, one end being threaded with a left-hand thread and the other having a right-hand thread. To adjust a track rod, it is only necessary to slacken off the locking devices on the track rod ends so that the track rod can be turned in the end sockets. Turning the track rod in one direction would lengthen the track rod; the reverse direction shorter the rod. The amount of toe-in is decreased (see fig-6).

e. **The Pull-and Push Rod or Drag Link**. The connection between the steering same of the front axle and the drag arm of the steering assembly is made by a pull-and-push rod, sometimes called a drag link. It is usually made of steel tubular construction, with a spring-loaded ball socket at each end. One end fits on the steering arm of the stub axle and the other on the rod of the steering drop arm. On the majority of vehicles, the pull-and-push rod lies parallel to the chassis, with the steering arm carried on the right-hand side stub axle. On other vehicles the pull-and-push rod lies across the chassis and connects with the steering arm mounted on the left-hand side stub axle (see fig-1).

# BAF BASE ZAHURUL HAQUE (TRG WG)
## (Aero Engg Trg Sqn)

**Syllabus : Automobile Diesel and Technology**

**Course : Trade Training Basic, MTOF**

**Subject : Steering System**

**Aim : To Study Center Point Steering**

**Ref. : AP 3159 Section 7 Chap 1**

---

## CENTER POINT STEERING

### Purpose

1. The purpose of center point steering is for easy and light steering operation.

### Description

2. If the pivot of the stub axle is vertical or parallel to the center line of the wheel, then the forward thrust of the vehicle will tend to push the wheel backward about its pivot. In order to reduce this tendency, the pivot pin and the road wheels are "hung" so that their center lines at a point where the wheel touches the ground. This is accomplished by one of the following methods (Fig-9).

### Method

3. a. Outward inclination of the king pins.

b. Inward inclination of the stub axles and wheels (known as wheel camber).

c. Inclination of bolt king pins and wheels towards each other. This method is the one most commonly used.

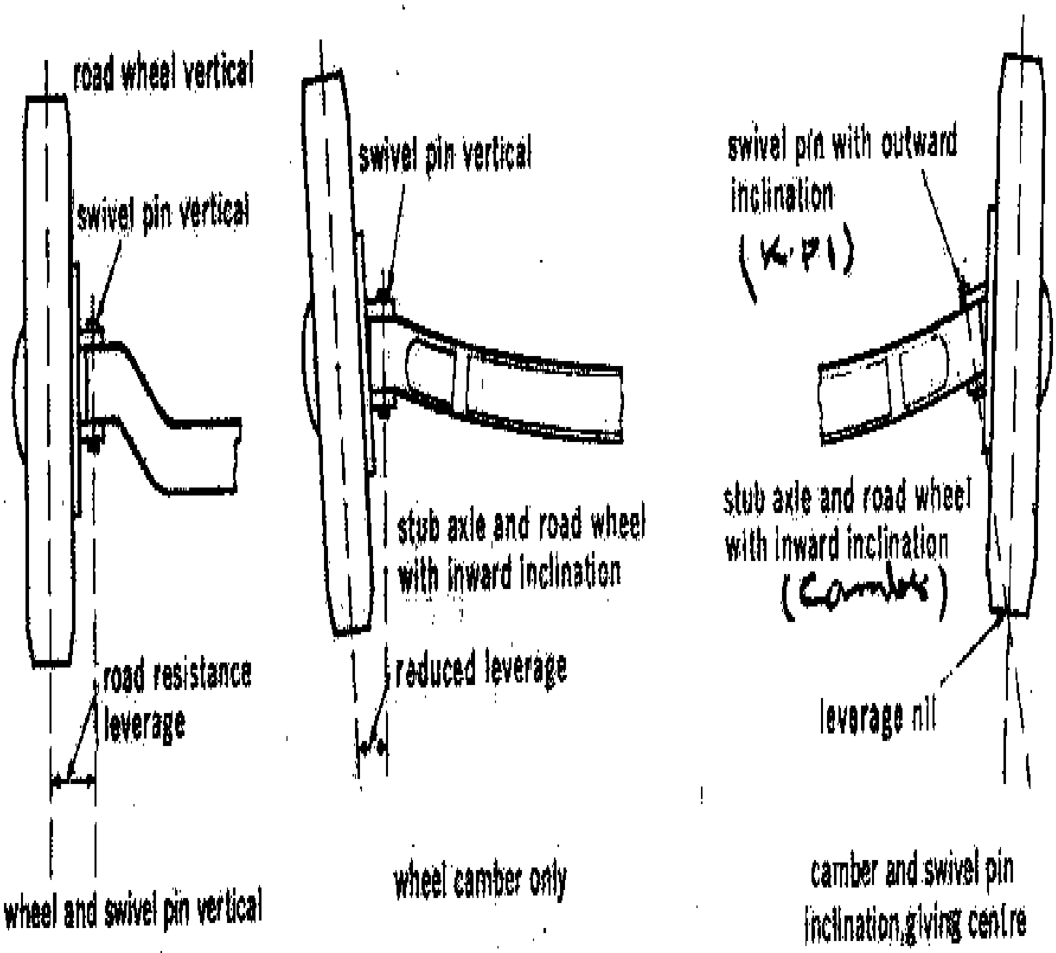



**Fig-9 Center Point Steering**

## BAF BASE ZAHURUL HAQUE (TRG WG)
## (Aero Engg Trg Sqn)

**Syllabus : Automobile Diesel and Technology**

**Course : Trade Training Basic, MTOF**

**Subject : Steering System**

**Aim : To Study the Caster Action**

**Ref. : AP 3159, Section 7, Chapter 1.**

---

# CASTER ACTION

**Purpose**

1. Caster action on the front wheels is incorporated to give a trailing and self straightening action to the wheels.

**Description**

2. The front wheels of a vehicle in motion always tend to return to a straight ahead position. The self centering action is particularly noticeable when a turn has been completed for it is much easier to return the steering to “straight ahead”. This steering attribute is brought about by providing the front wheels with a castoring or trailing action. The illustration of furniture castor wheel is a good example of castor the bearing point of the wheel on the ground, thus giving a trailing on self straightening action on the wheels. To obtain this action on the steering wheels of a vehicle, see the following methods are employed (Fig-10):

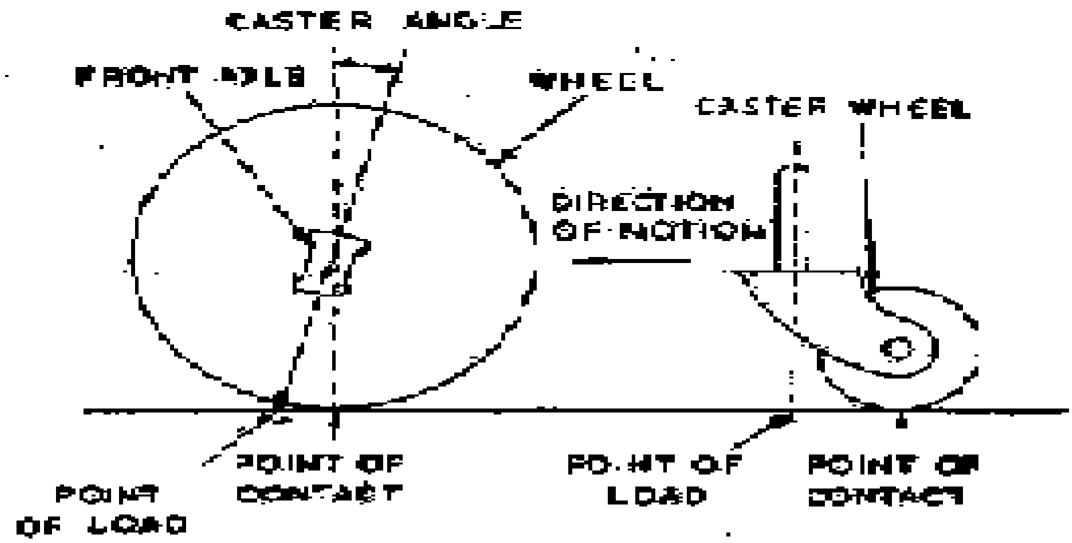



**Fig-10 Castor Action**

**Method of Obtaining Caster Action**

3. a. By fitting wedges between the front axle and road spring as the spring pads so that the axle is tilted from the perpendicular.

b. By locating the axle to off-self center bolts of the road spring and hanging the springs to the chassis in such a manner that the combination of the axle location and set to the spring gives the axle the required tilt.

c. When transverse road springs are used, the “set” of the front axle is determined by the radius rod.

**BAF BASE ZAHURUL HAQUE (TRG WG)**
**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile Diesel and Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **AIM** | **:** | **To Steering Geometry (Camber Angle)** |
| **Subject** | **:** | **Steering System** |
| **Ref.** | **:** | **AP 3159, Section 7, Chapter 1.** |

# STEERING GEOMETRY (CAMBER ANGLE)

## Purpose

1. The purpose of camber angle is to reduce the effect of road shocks on the steering gear and to have easier control.

## Effects

2. It brings center of the tyre nearly under the center of the king pin. Front wheels of the car are usually not mounted parallel to each other, but are tilting slightly outward at the top and inward at the bottom. This tilting of the front wheels from the vertical whether inward or outward or the angle between the center line of the tyre and the vertical is called camber. The amount of tilt measured in degrees is known as camber angle. This makes the wheel easier to survival as well as causes higher steering and compensates for small suspension defects upon the steering.

a. Outward inclination of the pivot pins.

b. Inward inclination of the stub axles and wheels known as wheel camber.

c. Inclination of both pins and wheels towards each other.

## Checking the Camber Using a Gauge.

3. Put the road wheels in a straight a head position.

a. Make sure that the axle is in a straight plane by using a split-level and deflating the tyre on the high side until the babuls in the level is in the center. The straight degree is then held against the wheel in a vertical position touching the top extremity of the rim and the angle can then be measured by an assistant using a protractor. If the angle is the same within $^{1/2}$ "on both wheels, it can be assessed that the camber angle is correct.

**BAF BASE ZAHURUL HAQUE (TRG WG)**
**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile Diesel and Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **Steering System** |
| **Aim** | **:** | **To Study Steering Geometry (King Pin Inclination)** |
| **Ref.** | **:** | **AP 3159, Section 7, Chapter 1.** |

# STEERING GEOMETRY (KING PIN INCLINATION)

## Purpose

1. To swing the front wheels or steering knuckles around the center line or keeping the front wheels pointed forward automatically after the turn is made.

## Methods

2. a. Outward inclination of the pivot pins.

a. Inward inclination of the stub axles and wheels known as wheel camber.

b. Inclination of both pins and wheels towards each other.

## Checking

3. a. Remove the axle from the vehicle and strip the beam and of its components.

b. The beam can then be checked by inserting a pair of sighting bars into the axle beam ends and setting the beam in the axle stand with the bars in a vertical plane and the beam horizontal. By using an engineer's protector, ascertain the inclination of the pivot pin. Cold setting in a press can make small corrections to a damaged beam. The beam should not however, be heated to correct excessive damage as the effect of the original heat treatment given to the beam will all multiplied, with the result that the beam would fail in service.

# BAF BASE ZAHURUL HAQUE (TRG WG)
## (Aero Engg Trg Sqn)

**Syllabus : Automobile Diesel and Technology**

**Course : Trade Training Basic, MTOF**

**Subject : Steering System**

**Aim : To Study Toe-in**

**Ref. : AP 3159, Section 7 Chapter 1.**

## TOE-IN

**Purpose**

1. Toe-in is given to avoid the front wheels to splay outwards when traveling straight ahead thus given good steering qualities and less tyre wear.

**Description**

2. The front wheel of a vehicle when traveling straight ahead will splay outwards to the limit of any play, which is present in track rod and stub axle linkages. If no provision is made to counteract this characteristic, the front wheels would splay outwards beyond parallel stage and this would give steering qualities and excessive tyre wear. Therefore, it is usual to give to front wheels a certain amount of "toe-in", i.e. the front wheels are turned slightly inwards towards the front. The length of the track rod controls "Toe-in", which is adjustable as explained previously. Some makers specify the measurement to the taken from the inner side of the wheel rims others; other maker's state that the measurement should be taken from the center of the tyre treads. The makers always state the amount of "toe-in" and give the location where the measurement must be made. This information is embodied in the servicing schedule, for each vehicle and must be adhered to.

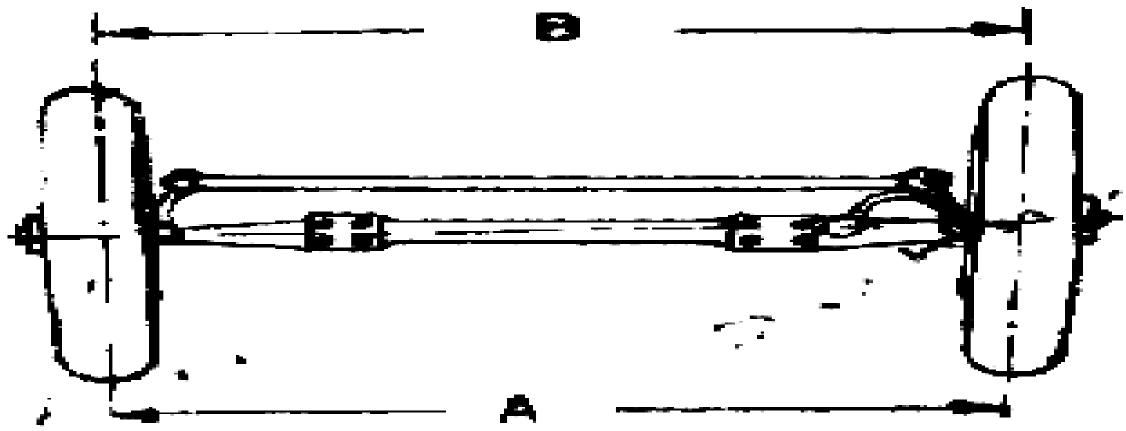



**Fig.-11 Toe in**

**Checking Toe-in**

3. Assuming that the makers of a vehicle specify that the toe-in should be measured from the center of the tyre treads, the sequence should be as follows:

a. Check wheels for truth.

b. Check and equalize tyre pressure.

c. Set wheels in straight ahead position.

d. Set arms of the trammels to the height of hub center.

e. Place trammels to rear of wheels with chalk and then push vehicle forward for one-half revolution of wheels.

[

f. The front reading should be smaller then the rear by the makers specified amount of “toe-in”. If incorrect, adjust by means of the track rod.

# BAF BASE ZAHURUL HAQUE (TRG WG)

## (Aero Engg Trg Sqn)

**Syllabus : Automobile Diesel and Technology**

**Course : Trade Training Basic, MTOF**

**Subject : Steering System**

**Aim : To Study Servicing and Faults of Steering.**

**Ref. : AP 3159, Section 7, Chapter 2.**

---

## SERVICING AND FAULTS

**Servicing**

1. A steering gear can be adequately service by periodical inspection as laid down in the servicing schedules. The inspection should ensure the working parts are clean and well lubricated. The working parts are:

a. Steering gear in the steering box

b. Pivot pins and bushes

c. Track rod ends

d. Pull and push rod joint to drop arm and steering arm

All nuts and bolts are clamping the steering assembly to chassis and dashboard, drop arm to cross shaft and road spring to front axle must be examined and tighten where necessary. When play is found in any ball joint, which cannot be eliminated by *adjustment, the ball joint must be renewed.*

***Faults***

2. a. **Stiff and Difficult Steering.** It may be caused by:

(1) Tyre pressure too low

(2) Lack of lubrication

(3) Bushes in steering box too tight

(4) Pivot pin bushes dry or too tight

(5) Ball and socket joints too tight

(6) Road wheels out of track

(7) Broken road spring

(8) Steering gear box too deeply in mesh.

b. **Uncertain Steering**. It may be caused by:

(1) Tyres inflated with too much air pressure

(2) Track of wheels out of alignment

(3) Excessive play in ball and socket joint steering box

(4) Excessive play between gear components in steering box

(5) Swivel pin bushes worm

(6) Front axle out of alignment

(7) Worm steering shackle pins and bushes

(8) Shock absorbers unevenly adjusted

c. **Wheel Wobble**. It may be caused by:

(1) Loose wheels

(2) Worn or loose bearings

(3) Broken spring center bolt or U bolt broken

(4) Front spring flattened giving insufficient caster

(5) Loose steering arm

(6) Loose steering box on chassis

**Note**: Correct tyre pressures are essential to good steering and should always be checked prior to testing for faults. A steering or wheel wobble can be a difficult problem and when no faults can be found in a front axle and steering assembly to account for this phenomena, the only remedy is not fit a steering damper.

## BAF BASE ZAHURUL HAQUE (TRG WG)
## (Aero Engg Trg Sqn)

**Syllabus : Automobile Diesel and Technology**

**Course : Trade Training Basic, MTOF**

**Subject : Brake System**

**Ref. : The Automotive by Harbans Singh Reyat**

---

# BRAKES

**Purpose**

1. Brakes are used in automobile to slow down or to stop the automobile quickly and smoothly whenever required by the operator with the minimum effort.

**Types**

2. **Mainly, there are two types of brakes**

a. Foot brake or service brake

b. Hand brake or parking brake

a. **Foot brake or Service brake.** Service brake is operated by the foot pedal that is why it is known as foot brake. This brake is used to slow down or to stop the automobile when it is in motion.

b. **Hand brake or Parking brake.** This brake is operated by a hand lever and is used to hold the automobile while it is stationary. It is used during parking so that the automobile may not roll off due to road gradient or fast blowing wind. It is also used in emergency when the service brake fails or proves ineffective. Owing to its use during emergency, it is also known as emergency brake.

**Classification**

3. According to the method of braking, automobile brakes can be classified as follows:

a. External contracting brakes.

b. Internal expanding brakes.

c. Caliper or disc brakes.

**Brakes**

Drum breaks

Disc brakes

External Contracting breaks

Internal Expanding brakes

a. **<u>External Contracting Brake</u>** This type of brake consists of a drum, an external contracting brake band, linkage and operating lever. It is usually the hand brake of the automobile. The drum is fitted with the transmission out put shaft and rotates with it. The brake band having lining of frictional material encircles the brake drum. In order to hold the rotating brake drum, the brake band is contracted about the drum by means of a lever and linkage.

b. **<u>Internal Expanding Brake.</u>** This type of brake consists of a brake drum inside which there are two brake shoes anchored at the lower ends to the back plate and connected with each other at the top through a spring. The upper ends of the shoes rest at an operating cam or wheel cylinder. The shoes are expanded outward to hold the rotating brake drum through the cam or wheel cylinder.

c. **<u>Disc Brake.</u>** It consists of a disc held between two pads. The disc is attached to the axle in lieu of brake drum. The rotating disc is held up through the frictional force exerted by the brake pads. The action of brake pads is similar to the action of caliper brakes in an ordinary bicycle. It is due to this fact that this brake is known as caliper brake.

**<u>Categorization</u>**

4 According to method of operation, the automobile brakes can be divided into the following categories:

a. **<u>Mechanical brakes.</u>** The brakes which are operated mechanically by means of levers, linkages, pedals, cams, bell cranks, etc, are known as mechanical brakes. The external contracting brake which is usually hand brake in automobiles is mechanical brake. Automobiles contain service brakes operated mechanically.

b. **Hydraulic brakes.** Brakes which are operated by means of hydraulic pressure are known as hydraulic brake.

c. **Electric brakes.** These brakes are operated electrically. The electric current is supplied by the battery and controlled by a rheostat in the brake pedal. Each brake drum encloses an armature which is operated by an electromagnet. The amount of electric current passing through the electromagnetic circuit is subjected to the armature. The armature operates the cam to expand the brake shoes in the same way as in mechanical brakes.

d. **Vacuum brakes**. The brakes are operated with the vacuum of engine manifold. The brakes include a vacuum booster to operate the cam inside the brake drum.

e. **Hydrovac brakes.** It is a combination of hydraulic and vacuum brakes. In this type, vacuum system assists in to operation of hydraulic brakes.

f. **Air brakes.** In these brakes, the brake shoe operating cam is operated by means of air pressure, which is developed by an air compressor driven by the engine.

**BAF BASE AURAL HAGUE (TRG WG)**
**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile Diesel and Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **Brake System** |
| **Aim** | **:** | **To Study Cam Operated Brakes** |
| **Ref.** | **:** | **The Automotive by Harbans Singh Reyat** |

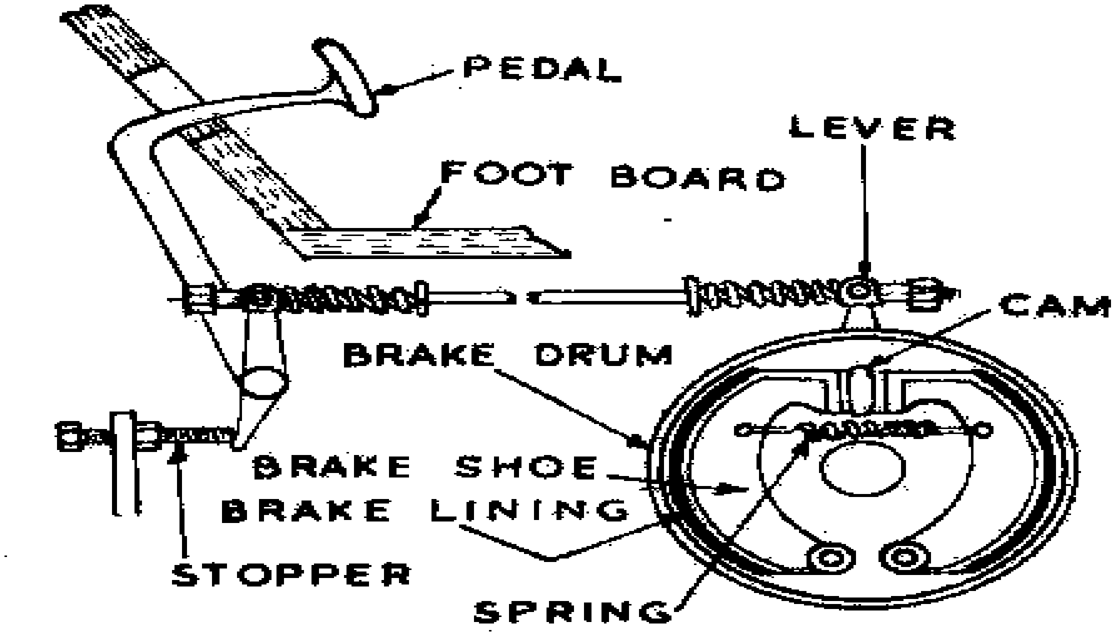
# CAM OPERATED BRAKES

## Purpose

1. Brakes are used in automobile, to slow down or to stop the automobile quickly and smoothly whenever required by the operator with the minimum effort.

## Construction

2. Two brake shoes are mounted on fulcrum pins or pivots and their other ends, which have flat faces, bear against the sides of a double cam (Fig -1) the complete assembly is carried on a back-plate rigidly mounted to the axle casing or stub axle. The shoes are retained in position, out of engagement with the drum, by strong tension springs and they are surrounded by a brake drum, which is fastened to and rotates with, the hub of the road wheel. The brake shoes are made to bear against the drum by partial rotation of the double cam on one end of the operating shaft. The operating shaft is carried in phosphor-bronze bearings and extends either side of the back-plate. Rods or cables to the foot and hand controls connect a lever on its external end. A minimum clearance between shoes and drum in the “off” position allows the drum and hub to rotate freely. A compensating arrangement may be incorporated in the cable or rod layout to ensure an even distribution of braking effort.




**F ig-1 Cam Operated Brake**

## Operation

3. When the brake pedal is pressed down, the cam inside the brake drum, over which the free ends of brake shoes are resting, is operated through linkage and levers. The operating cam expands the brake shoes outwards against the inner circumferential surface of the brake drum causing to hold its rotation. When the brake pedal is released, it comes up through the assistance of return spring and the brake shoe operating cam is operated in the opposite direction. This results in the contacting of brake shoes and release of brakes.

# BAF BASE ZAHURUL HAQUE (TRG WG)
## (Aero Engg Trg Sqn)

**Syllabus : Automobile Diesel and Technology**

**Course : Trade Training Basic, MTOF**

Subject: Brake System

**Aim : To Study Hydraulic Brakes**

**Ref. : The Automotive by Harbans Singh Reyat**

## HYDRAULIC BRAKES

### Purpose

1 Purpose of hydraulic brake is to slow down or to stop the automobile quickly and smoothly whenever required by the operator with the minimum effort. Brakes are operated by means of hydraulic pressure is known as hydraulic brake.

### Principle

2. It works on the principle of Pascal's law which reads as below:

"Pressure applied to a liquid is transmitted equally in all directions".

### Construction

3. The hydraulic brake system contains two important components upon which the system is mostly dependent. The components are wheel cylinder and master cylinder. Besides this it also having brake mechanism and pipe line (Fig-2)

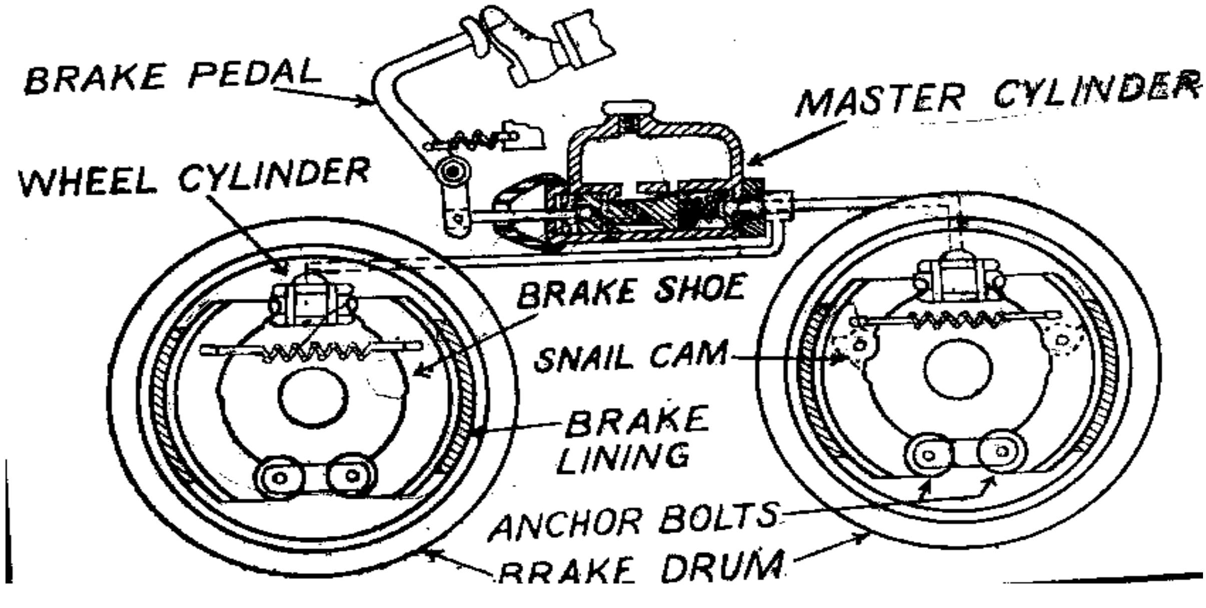



**Fig-2 Hydraulic Brake System**

a. **Wheel Cylinder**. Wheel cylinder is fitted in back plate. It consists of cylinder body, pistons, rubber cups, coil spring and bleeder valve. The cylinder body contains two holes which provide connections for the pipe line and the bleeder valve. The coil spring inside the cylinder, keeps the rubber cups in position with the pistons. The rubber cups avoid the leakage of fluid out of the wheel cylinder. The piston transmits fluid pressure to the brake shoes for the application of brakes (Fig-3).

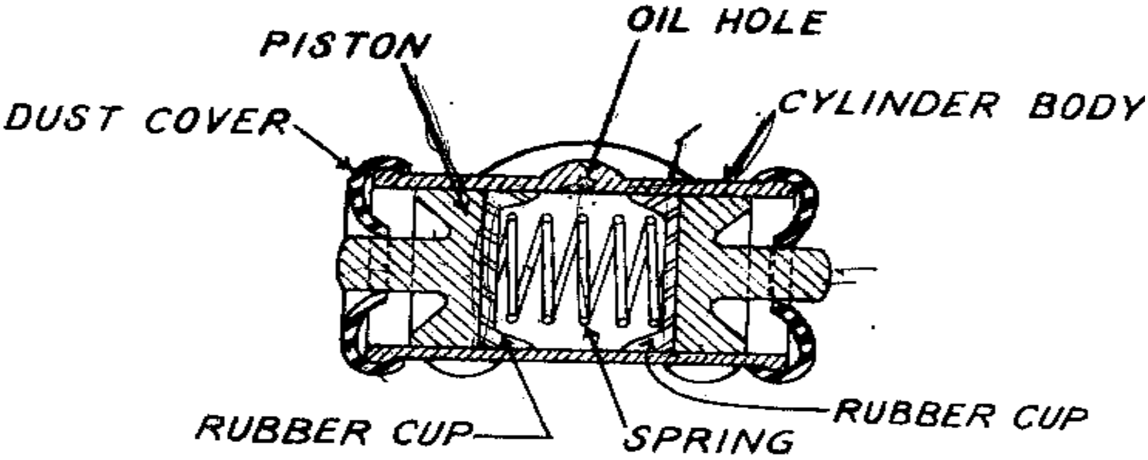



**Fig-3 Wheel Cylinder**

c. **Master Cylinder**

(1) It is the main cylinder in the hydraulic brake system. There are two types of master cylinder;

(i) Single master cylinder.

(ii) Tandem master cylinder.

d. **Single Master Cylinder:** In this chapter we will discuss only single master cylinder. It consists of two portions, reservoir and main cylinder. The reservoir is above the main cylinder. There is a hole at the reservoir through which fluid is filled into it. The filler hole is covered with a plug which contains an air vent. The main cylinder contains a piston, primary and secondary rubber cups, coil spring, out let check valve and a rubber seat. The cylinder is connected with reservoir through two holes known as main port and compensating port (Fig-4).

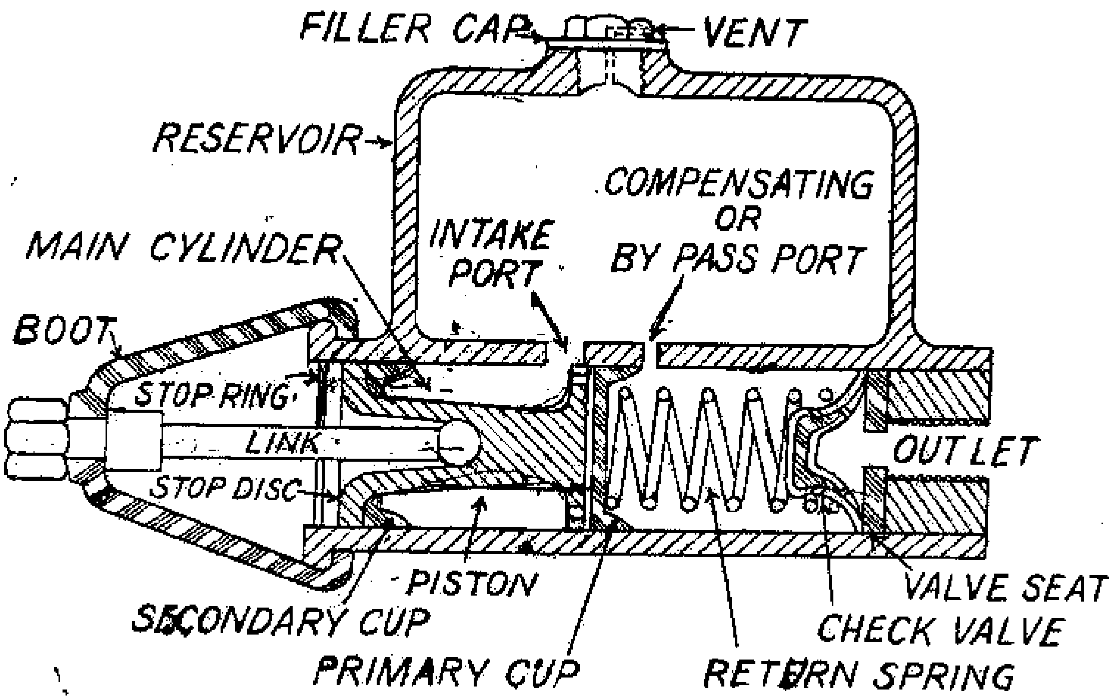


**Fig-4 Master Cylinder**

c. **Brake Mechanism**. The drum brake has a steel or iron drum to which the wheel is bolted. The drum and wheel rotates together. Inside the drum, attached to the steering knuckle or rear axle, is the brake mechanism. The brake mechanism at the front wheels is attached to the steering knuckle (see steering chapter) and at the rear wheel brake is attached to the axle housing (Fig-5). There are two brake shoes at each wheel. The bottoms of the shoes are held apart by an adjusting screw, or star wheel. The tops of the shoes are held apart by actuating pins from the wheel cylinder. The shoes are made of metal. A facing of friction material, called brake lining, is riveted or cemented (bonded) to each shoe.

The linings are made of asbestos or similar friction material which can withstand the heat-producing braking action. Both the shoes in the drum brake are not the same. The shoe towards the front of the automobile is the primary/leading shoe and the shoe towards the rear is secondary/trailing shoe.

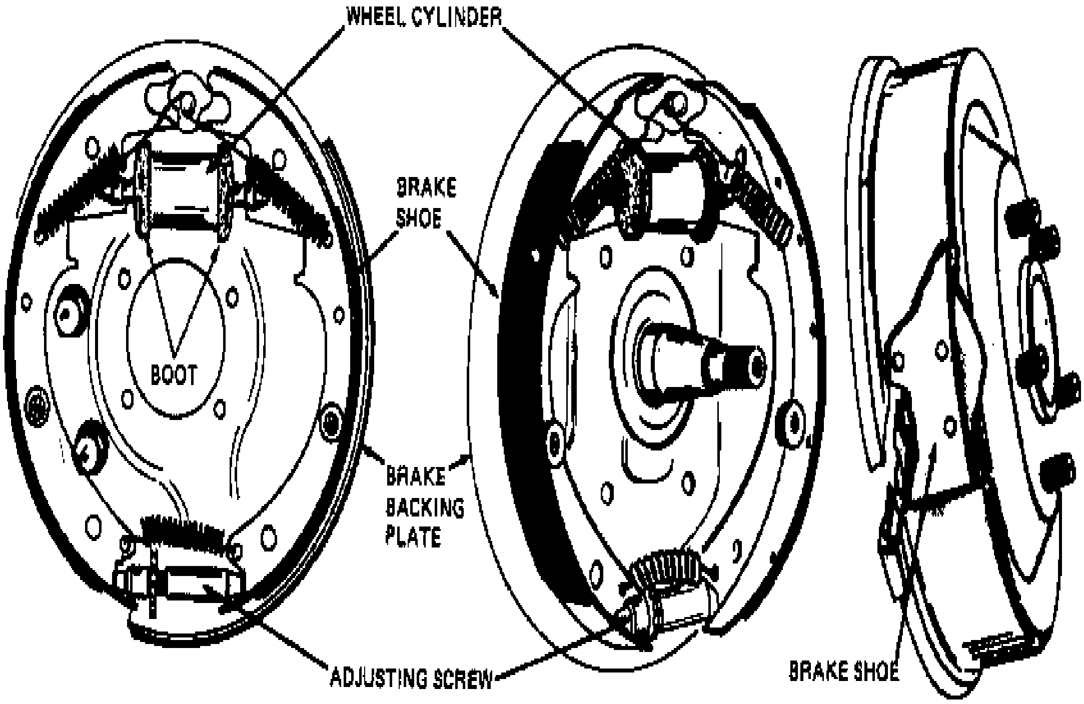



**Fig-5 Brake mechanism**

**Operation**

4. Before operation of hydraulic brake ensure that the master cylinder reservoir is filling up by the hydraulic fluid. The complete system, from master cylinder to wheel cylinder is fully charged by the hydraulic fluid. When operator press the brake pedal at that time brake pedal link rod apply the pressure to the master cylinder piston and primary cup. When this piston and primary cup covers the bypass port, at that time pressure will be created on the hydraulic brake fluid in side the master cylinder. When produces the maximum pressure, check valve will be opened and pressurized fluid will flow through out let port to the wheel cylinder via pipe line. At the same time, wheel cylinder pistons move outward and push the brake shoes. So that the brake shoes will expand outwards and contact with the rotating brake drum. When rotating brake drum and road wheel will be stopped and vehicle will also stop, that means brake is applied. After that when operator release the brake pedal at the same time, there will be two actions. The brake shoes return spring will pull the brake shoes inward direction and pistons also move inward direction inside the wheel cylinder. Due to inward

movement of the pistons, back pressure will be created on the fluid, due to that back pressure check valve will lift off from its seat and fluid will enter into the master cylinder. When the operator release the brake pedal quickly, the master cylinder piston back quickly due to pressure of master cylinder return spring. The backward movement of the piston vacuum will be create in front of the master cylinder piston, which assist lifting the check valve from its seat and fluid entered into the master cylinder and the excess fluid will go to the reservoir through by-pass port. The complete system is ready for further operation. See fig-2.

**BAF BASE ZAHURUL HAQUE (TRG WG)**
**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile Diesel and Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **Brake System** |
| **Aim** | **:** | **To Study Air Assisted Hydraulic Brake** |
| **Ref.** | **:** | **Maintenance Manual Bedford Trucks** |

# AIR PRESSURE ASSISTED HYDRAULIC BRAKE SYSTEM

## Introduction

1. This system ensures a positive braking to stop a moving automobile. The system is operated by the foot brake pedal, which controls the air supplies by means of brake valve and in turn it operates the master cylinder actuator and hydraulic tandem master cylinder.

## Construction

2. This brake system comprises with the following components:

a. **Air Compressor**. The compressor is mounted on the engine timing case and is being driven by the crankshaft through an idler gear. It supplies air to charge the air reservoir mounted with chassis side or cross member incorporated in the brake system.

b. **Compressor Cylinder Head**. The compressor cylinder head comprises a manifold and base plate, which are secured together by bolts. A loader valve consisting of a spring-loaded plunger is incorporated in the manifold above the intake valve. The intake and exhaust valves are consists of steel discs spring loaded against seats in the manifold and base plate.

c. **Condensing Reservoir**. A condensing reservoir, fed by air from the compressor via a non-return valve, is mounted on the chassis side member. The reservoir is fitted with an automatic water drain valve and non-adjustable ball type safety valve. It ensures maximum air-cooling and condensation of water vapor.

d. **Dual Air Reservoir**. A duel reservoir compressing a service air reservoir and a secondary air reservoir combined in one assembly, is mounted on the chassis cross member. The reservoirs, which are fed with, dry air from the condensing reservoir via non-return valve, supply air to the foot brake valve. If parking brake is incorporated with air pressure system, then the secondary reservoir also supplies air to the parking brake control valve.

e. **Governor Valve**. It is incorporated between the condensing diaphragm of the governor valve over come the spring pressure diaphragm, which lifts the diaphragm and pull the inlet/exhaust valve, this movement closes the exhaust valve and opens the inlet valve, the air pressure through the hollow plunger and delivery port and its operate the unloaded valve of the compressor head. The unloaded valve plunger is pushed down and it opens the inlet valve of the compressor, thus allowing the compressor to run light. Again when the air pressure of the condensing reservoir goes down the specified pressure, the governor valve diaphragm is returned to its original position by the spring pressure and normal operation of the compressor is continued. Cut out pressure of the governor valve is usually between 118-122 lb psi.

f. **Safety Valve** A safety valve, located in the condensing reservoir, protects the air system against excessive air pressure in the event of the governor valve failure. The valve is non-adjustable and consists of a body containing a spring loaded ball check valve retained by a washer and circlip. A dust cover is fitted over the valve body. The safety valve is operates when the air pressure of the governor reaches within 142-150 lb psi.

g. **Unloaded Valve**. It is located on the compressor cylinder head and operates when governor valve allows air pressure to pass through the unloaded valve is operated it in turned operate the inlet valve of the compressor cylinder head and keep it opened till the governor valve closes.

h. **Foot Brake Valve**. The dual foot brake valve, which is operated by the brake pedal, is mounted on the chassis side member at the front of the vehicle on the driver's side. When the brake pedal is depressed, forced is applied via the plunger and buffer spring to the front piston, causing the exhaust valve seat on the piston to close on the inlet/exhaust valve. The force is also transmitted via the valve carrier to the rear position, causing the exhaust valve seat on the piston to close on the inlet /exhaust valve. Further pressure on the brake pedal cause the piston to lift the inlet valves from the seat in the body and seat in the carrier, allowing compressed air from the dual reservoir to pass through the valve to the master cylinder actuator. The air pressure delivered by both halves of the valve is proportional to the effort applied to the brake pedal and the valve inwards a reaction relative to the movement of the brake pedal so that the driver can sense the degree of the brake application. When the brake pedal is released, the pistons and valve carrier returned under the action of spring and air pressure. This movement closes the inlet valves and unseats the exhaust valves to release the pressure in he brake line through the exhaust diaphragm.

(1) **Master Cylinder Actuator**. When the footbrake is applied, compressed air passes to the master cylinder actuator, which is mounted, together with the hydraulic vandem master cylinder, on chassis side member. The actuator consists of a circular body clamed between two cylinders, each containing a piston. A push rod, is held towards the rear of the actuator, by a return spring. Passes through the center of one piston and about the center of the other. Movement of either piston is transmitted by the push rod to the master cylinder primary piston. Both cylinders are vented to atmosphere.

(2) **Hydraulic Tandem Master Cylinder.** It is operated by the actuator. When the air pressure operates the actuator, as the actuator piston is connected with the master cylinder push rod, it operates the master cylinder. If the master cylinder piston is pushed forward which create pressure on the hydraulic fluid. This force is transmitted through pipelines to the wheel cylinder and thus wheel cylinder is operated.

**Operation**

3 As the compressor is running by the engine, it applies air, which is passed through the condensing reservoir and stored in the dual reservoir (service and secondary reservoir). The compressed air of the dual reservoirs is available up to the foot brake valve and vehicle air presser gauge. When the brake pedal operates the foot brake valve, it allows the compressed air to pass through the service and secondary lines to the master cylinder actuator pistons are operated (there are two pistons by the service and secondary air pressure respectively). It is turn operates hydraulic master cylinder. The hydraulic master cylinder pistons are pushed forward which creates force on the hydraulic fluid in front. This force is transmitted via the hydraulic pipelines to the wheel cylinder and wheel cylinder pistons are operated. As the tips of the brake shoes are supported with the wheel cylinder piston, so the brake shoes are expanded outward which comes in contact with the brake drum and it stops the movement of the drum. When the brake pedal is released, brake valves to return to its original position which stop the air supply passing through service and secondary lines. Actuator pistons returned to the original position by the tension of the spring, so pressure on the hydraulic is released and brake shoes are returned to off position by the brake shoe return spring.

# BAF BASE ZAHURUL HAQUE (TRG WG)
## (Aero Engg Trg Sqn)

**Syllabus : Automobile Diesel and Technology**

**Course : Trade Training Basic, MTOF**

Subject: Brake System

**Aim : To Study Bleeding of Hydraulic Brake**

**Ref. : The Automotive by Harbans Singh Reyat & AP 3159.**

---

## BLEEDING OF HYDRAULIC BRAKE

### Purpose

1. The purpose of bleeding system is to expel out air from the hydraulic braking system when they are spongy.

### Description

2. When any part of hydraulic line is replaced, air traps into the system and If the fluid reservoir is allowed to run dry or if leaks develop at the various pips connections. The presence of air in the system detected by the spongy feeling, which resist the brake pedal and of course, by the poor braking action Air being compressible, the effort of brake pedal goes waste in applying brakes. Until and unless air from the system is removed, the brakes would not function properly. The process of removing air from the brake system is known as bleeding system.

### Operation

3. When bleeding the system, it is most important that only the correct braking fluid is used to replenish the master cylinder throughout the operation. Before bleeding the system, the reservoir of the master cylinder assembly should be topped up in correct level with the makers' specified hydraulic fluid. Throughout the bleeding operation, the reservoir should be inspected and topped up after every six stroke of the brake pedal. A glass jar, containing brake fluid to about a third from the top of the jar and a flexible rubber tube is required (Fig-6). The wheel cylinder furthest away from the master cylinder should be bleeding first, the remainder being taken in order so that the wheel cylinder nearest the master cylinder is the last one to be bled. The bleeding tube is attached to the nozzle of the bleeding screw of the selected wheel cylinder and the other end is submerged in the brake fluid contained in the glass jar. The bleeding screw is than slackened back one turn and the brake pedal firmly and smoothly depressed to the limits of its movement and then allowed to return idly to the off position. This operation carried out by an assistant, pumps the fluid from the master cylinder through the pipelines to the wheel cylinders. As a consequence, any air that is present between the mater cylinder and the wheel cylinder being bled is expelled with the fluid.
The air is detected by the presence of bubbles in the fluid as it is pumped into the glass jar. Each wheel cylinder is to be bled until no air bubbles can be seen in the expelled fluid and the bleeding screw is then re-tightened.

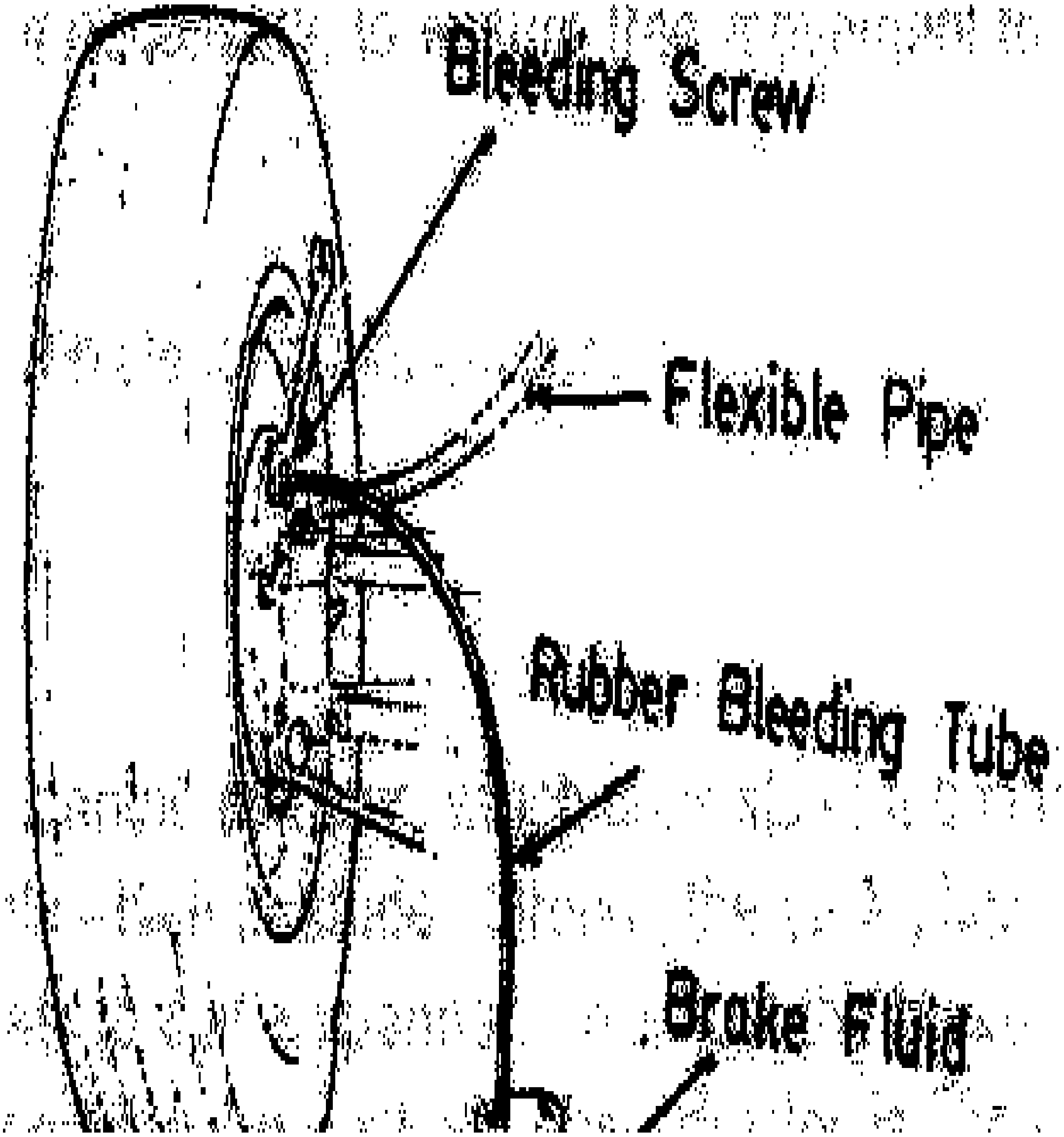



**Fig-6 Bleeding of Hydraulic Brakes**

**BAF BASE ZAHURUL HAQUE (TRG WG)**
**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile Diesel and Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **Brake System** |
| **Aim** | **;** | **To Study Hand Brake Mechanism** |
| **Ref.** | **:** | **AP 3159, Section 7, Chapter 4** |

# THE HAND BRAKE MECHANISM

## Purpose

1. Thins is use as a parking brake only but it could be used in emergency if foot brake fails.

## Construction

2. On most hydraulic braking systems the hand brake operates only on the rear wheels by mechanical linkages. The hydraulic action of the rear brakes is in no way effected by additional of the hand brake mechanism. The hand brake cable is connected to the shoes by an arm and link (Fig-7). When the hand brake lever is pulled on, the cable pulls the arm, which is so connected to the link, that the brake shoes are forced apart to press against the drums. The pull on each brake cable is balanced by some form of equalizer embodied in the operating mechanism.

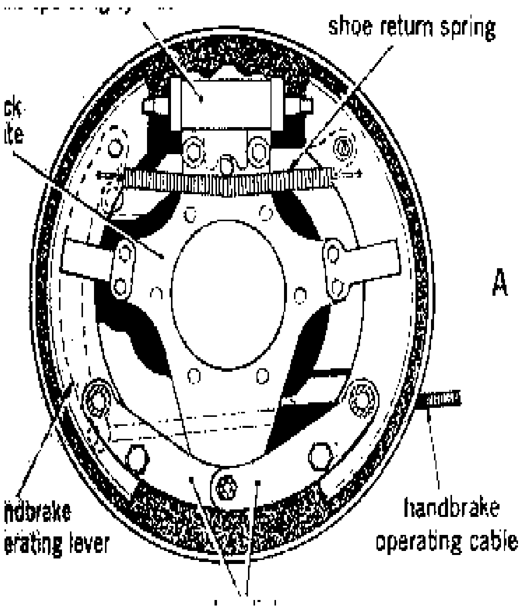
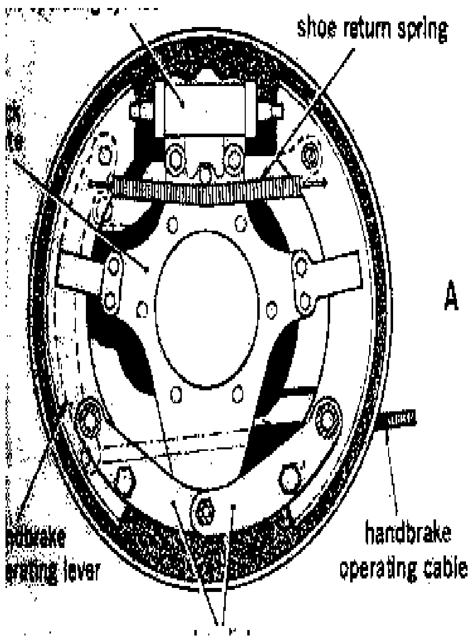



**Fig-7 Hand Brake**

**Lockheed Rear Wheel Cylinder- Hand Brake Operation**

| | |
|---|---|
| 3. The rear wheel cylinder is fitted in an elongated slot in the rear back plate and it is free to slide in the slot between the tips of the brake shoes. The piston acts on the tip of leading shoe at one end, the opposite tip butting against a fixed anchor block on the back plate. Normally a micram adjuster is fitted to the cylinder. The inner part of the piston is operated hydraulically while the outer part is manually actuated by the hand brake lever (Fig-14). When the foot brake pedal is actuated, the inner part of the piston is forced against the outer part leaving the hand brake lever undisturbed and applies a thrust to the tip of the shoe. When the hand brake is applied; the hand brake lever thrusts the outer part of the piston outwards against the tip of the shoe without disturbing the inner part of the piston | <br>**Fig-8 Lockheed Hand Brake** |

**Bisector Unit**

4 The bisector unit allows mechanical hand operation of the hydraulic rear brakes on heavy vehicles. When the hand brake is applied, the pull rod pulls the rod box and draw bar outwards; the rollers are pulled between the inclined face of the tappets, which move out and apply the brake shoes to the drum. Operation of the footbrake forces fluid between the rubber cups. The rubber cups move apart, the rod box and draw-bar moves upwards and the brake is applied in the same way as before. The pull rod is fitted in the end of the rod box such that, during foot brake operation, the rod box can slide over the pull rod. The draw bar passes through a tubular distance piece fitted through the center of the rubber cups, thus preventing fluid leakage to the hand brake mechanism (Fig-9).

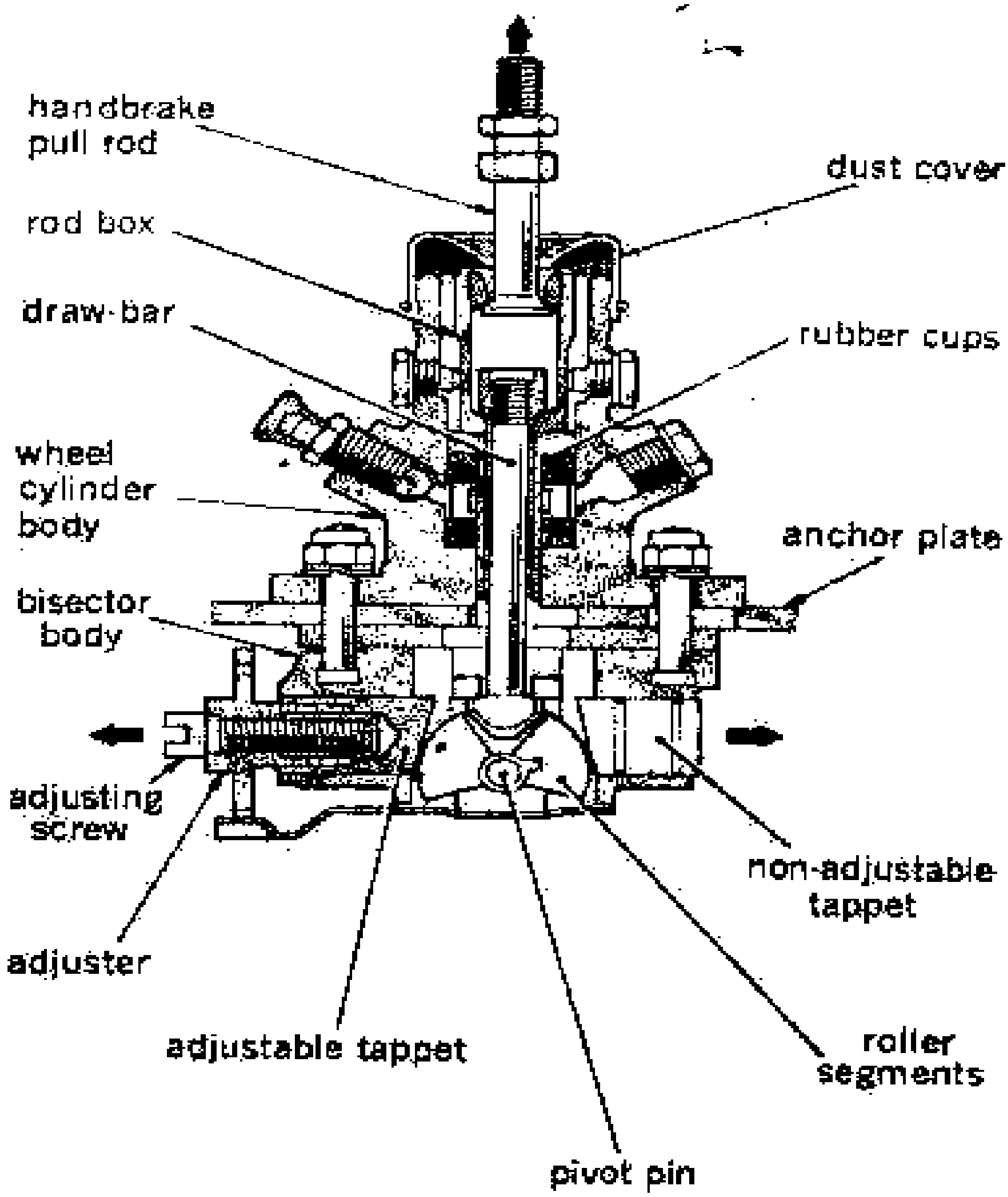



**Fig-9 Bisector Unit**

**BAF BASE ZAHURUL HAQUE (TRG WG)**
**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile Diesel and Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **Brake System** |
| **Aim** | **:** | **To Study Adjustment of Hand Brake** |
| **Ref.** | **:** | **AP 3159, Section 7, Chapter 4** |

# ADJUSTMENT OF HAND BRAKES

## Purpose

1. The hand brake is adjuster to take any wear on the brake or after repairs.

## Adjustment

2. Hand brake may be mounted on the transmission as external contracting brake or combined with the rear wheel brakes, working on the same brake shoes. When the hand brake is employed on the rear wheels, a bisector unit is incorporated in the same system to allow for independent function of foot brake on the same shoes. In this case, hand brake has no separate adjustment, all adjustments being carried out at the wheel drums. This brings both the hand brake and the pedal to the correct positions. The length of the connecting rods should not be altered except when necessary after replacing damaged lever or rods. When fitting new lever or rods, the rod adjustment should be thus that with the hand brake in the “off” position, both wheel cylinder levers are in the pull “off” position with no tension on the rods. When the hand brake is mounted on the transmission at the rear of the transfer case, the adjustment is made as fallows:

a. Release hand brake lever.

b. Adjust rod from hand brake cam until flat side of cam is in full contact with brake shoe ear.

c. Remove locking wire from lower adjustment screw; adjust until clearance between brake drum and lining is 010’’ to 015” or MS. Replace lock wire.

d. Loosen upper locking nuts and adjust until clearance at the top and the center is 020” or MS. Retighten lock nuts.

e. Now check the parking brake by applied hand brake three notches. If the brake drum if gripped firmly, the brake is then correctly adjusted. If it does not, the adjustment is to be carried out again as above.

**Note**: For checking of correct hand brake adjustment, the vehicle should be on a slope or steep and the hand brake applied for parking. The vehicle should not move at all three notches and brake should not drag when the hand lever is fully released.

**BAF BASE ZAHURUL HAQUE (TRG WG)**
**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile Diesel and Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **Brake System** |
| **Aim** | **:** | **To Study General Brake Faults** |
| **Ref.** | **:** | **AP 3159, Section 7, Chapter 4** |

# GENERAL BRAKE FAULTS

## Binding Brakes

1. a. Return spring broken or weak.

b. Partial seizure of any of the various connections due to lack of lubrication or the presence of dirt.

c. Dirt or grit inside the drum.

d. Foot pedal fouling the footboards and not returning to the fully “off” position.

e. Control valve in the servo sticking, so that a depression remains in the servo cylinder.

f. Piston in servo sticking through dirt or lack of oil.

g. Rods or cables too tightly adjusted.

h. Friction linings worn.

j. Road wheel hub bearings worn, allowing the drums to run out of truth.

k. Components so badly set or worn that the operating cams may go over the limit of travel and prevent a return to the “off” position.

## Fierce Brakes

2. One or more brakes acting violently and possibly causing the vehicle to skid:

a. Seizure or partial seizure of connections and bearings.

b. Axles loose at spring seats.

c. Center bolts or road springs broken.

a. Linings torn.

e. Oil and dirt on friction surfaces.

f. The operating rod for the control valves incorrectly adjusted.

## Inefficient Brake Action

3. a. Linings worn.

b. Air in hydraulic system.

c. Servo cylinders not working, leaky unions or pipe. Control valve not functioning.

d. Oil or water in the friction surfaces.

e. Tyre treads worn.

f. Brakes incorrectly adjusted.

g. Hand brake pawl and ratchet worn.

**MODED BY JAHID (BD/474652)**

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **MT Electrical System** |
| **Aim** | **:** | **To Study Name of all Electrical Parts & Symbol** |
| **Ref** | **:** | **AP 3159 Section 4 Chapter 5** |

# NAME OF ALL ELECTRICAL PARTS

**Name of all electrical parts used in vehicles**

1.

| | | | |
|---|---|---|---|
| 1. | Battery | 21. | Switch wiper motor |
| 2. | Self starter | 22. | Switch Dimmer |
| 3. | Alternator | 23. | Switch cabin lamp |
| 4. | Voltage regulator | 24. | Switch ignition |
| 5. | Horn | 25. | Switch oil pressure |
| 6. | Wiper motor | 26. | Switch temperature |
| 7. | Head lamp | 27. | Switch water temperature |
| 8. | Side lamp | 28. | Fuel indicating float |
| 9. | Tail lamp | 29. | Flasher unit |
| 10. | Brake lamp | 30. | Buzzer unit |
| 11. | Door lamp | 31. | Pressure meter |
| 12. | Cabin lamp | 32. | Mile meter (speedometer) |
| 13. | Meter lamp | 33. | Temperature (water) meter |
| 14. | Mark lamp | 34. | Fuel indicating meter |
| 15. | Navigation lamp | 35. | Ammeter |
| 16. | Search lamp | 36. | Voltmeter |

| | | | |
|---|---|---|---|
| 17 | Black out lamp | 37. | Battery positive and negative lead |
| 18. | Switch head lamp | 38. | Starter Neg. lead |
| 19. | Switch indicating lamp | 39. | Turn signal lamp |
| 20. | Switch horn | | |

**BAF BASE ZAHURUL HAQUE (TRG WG)**
**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **MT Electrical System** |
| **Aim** | **:** | **To Study Effects of Electricity** |
| **Ref** | **:** | **A.P. 3159 Sec 4, Chap 1** |

# ELECTRICAL EFFECTS

## Heating Effects

1. When a current flows in a wire, the wire becomes heated (Fig-1a). The amount of heat produced depends upon the size and material of the conducting wire and the quantity of current passing through it. This explains why the current for electric light flows safely through the connecting wire and yet causes the fine wire filament of the lamp to become white hot. Another example of the use of the heating effect of a current is the circuit fuse. This is a thin wire designed to fail at a known load value; if the current exceeds this value the fuse wire melts and disconnects the circuit. Another well-known example of the heating effect of an electric current is the common electric heater (Fig-1 b).

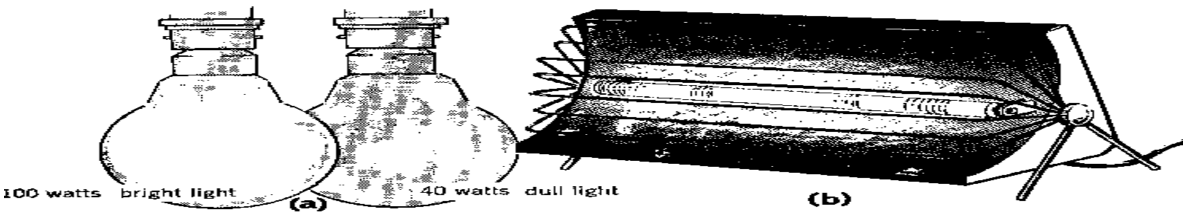



**Fig-1a & b Heating Effect**

b. **Magnetic Effects**: Any current flowing along a wire develops a magnetic field around the wire. If the wire is wound into a coil it becomes a 'solenoid' which, when current is passed through it, behaves like a normal bar magnet. This temporary 'electromagnetism' is lost when the current is switched off. Great use is made of this important effect; electric motors, transformers, relays and similar parts, all rely upon it for their operation (Fig-2).

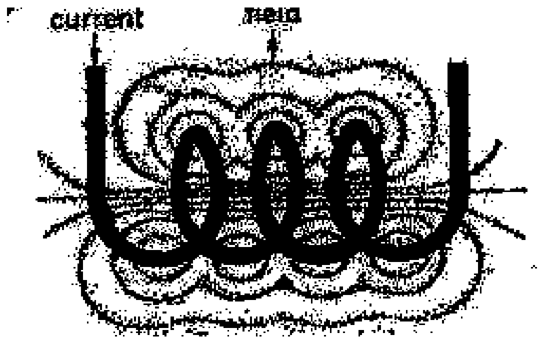



**Fig-2 Magnetic Effect**

c. **Chemical Effects**: When a current flows through certain chemical solutions, known as electrolytes, chemical changes occur in the solutions and in the metals immersed in them and connected to the circuit. The effect is used in charging electrical batteries and in electroplating processes.

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **MT Electrical System** |
| **Aim** | **:** | **To Study Electrical Terms** |
| **Ref** | **:** | **A.P. 3159 Section 4, Chapter 1** |

# ELECTRIC TERMS

## General

1. To make an electric circuit all the terms and conditions are to fulfill; these are source of supply, fuse, conductor, switch and load. Without any one of these will not be an electric circuit

## Description

2. a. **Conductor.** All the materials are divided into two categories; conductor and insulator. A good conductor is a material that has a large number of free electrons. All metals are conductors of electricity to some extent but some are better conductor than others. Examples of these conductors are silver, copper and aluminum. Silver is the better conductor than copper but copper is more widely used because it is less expensive than silver. Aluminium is used where weight is a major consideration.

b. **Resistance**. It is the opposition offered to the flow of current. Alll materials more or less offer opposition to the flow of current. This property of materials is called resistance.

c. **Ohms**. The unit of resistance is called Ohms.

d. **Amps**. It is the unit of electric current. The rate at which electrons flow in a circuit is called amps.

e. **Watts**. Watt is the unit of electric power.

$W = V \times I = I^2 R$

Watt = Voltage X Current

f. **Volts.** The unit of electric pressure is volt. It may be defined that when a pressure of one volt exists between two points in an electric circuits if one joule expended in moving one column of electricity.

# BAF BASE ZAHURUL HAQUE (TRG WG)

## (Aero Engg Trg Sqn)

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **MT Electrical System** |
| **Aim** | **:** | **To Study Magneto Ignition** |
| **Ref** | **:** | **A.F. 3159 Section 4, Chapter 1** |

---

## MAGNETO IGNITION

### Purpose

1. The purpose of the magneto ignition is to generate a high voltage for ignition on gasoline engines.

### Theory

2. A horse- shoe shaped permanent magnet is used to provide a field. A force or magnetic field, which is concentrated between the ends of the magnet, i.e. its north and south poles. An armature consisting of a soft iron core and wound with primary and secondary windings. When armature revolves in the magnetic field cuts the lines of force and induces a law voltage into the primary winding. The flow of electricity in the primary winding produces a magnetic field around the secondary winding. When the contact breaker points open, the flow of the current in the primary winding is interrupted, the field collapses, and a very high voltage is induced in the secondary winding. It is this high voltage, which gives spark in the sparking plug points. The voltage strength depends on the number of turns forming the secondary coil and the rotational speed of the armature. Soft iron cores are used because they are easily magnetized and can be instantaneously demagnetized.

### Construction

3. An armature core is built up of thin soft iron plates insulated one another and tightly compressed between two solid iron plates. It is shaped so that a cancel is left around its circumference to receive of winding and it is fitted with brass and pieces formed with spindle end to run in ball bearings. One end of primary winding is connected to the fixed arm of the contact breaker and also to a condenser and earthling switch, the other end is earthed. A secondary winding is wound over the primary and has one end connected to the end of the primary circuit, to other end is in circuit with slip ring and carbon brush to the distributor rotor and electrodes, H.T. leads and sparking plugs. The contact breaker is a complete unit, positioned by a small key and secured to the armature by a center bolt so that it rotates with the armature, it consists of two contact breaker points, one being fixed but with means of adjustment, and the other on one end of a rocker and. A leaf spring normally holds the contact points closed, but a separation affected by the cam of a cam box so that the primary circuit is broken twice in every revolution. Contact breaker

points are made of tungsten or platinum alloy. A safety spark gap is provided in the high-tension circuit, so that should there be any fault preventing the normal passage of the high voltage it would earth across the gap and obviate damage to the windings. Gearing drives the distributor rotor arm from the armature, and it always set to coincide with corresponding marks on the distributor wheel. The distributor electrodes are fixed in a detachable ever. Advance and retard action is made by part rotation of the cam box to alter its relative position with the armature and contact breaker. An earthing switch is connected in the primary circuit to make the magneto in operative and give complete control of the engine. In off position the switch is closed to make the magneto in operative and give complete control of the engine. In the off position the switch is closed to short circuit the contact breaker points and earth the primary circuit. In the on position the switch is open and the primary circuit is controlled by the action of contact breaker
(Fig-3).

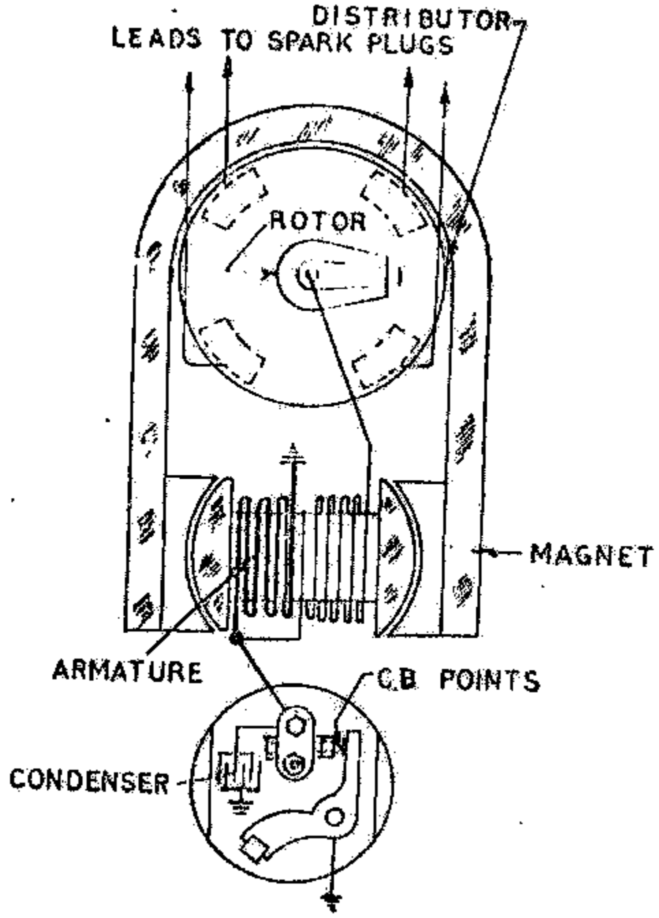



**Fig-3 Magneto Ignition**

## BAF BASE ZAHURUL HAQUE (TRG WG)

### (Aero Engg Trg Sqn)

**Syllabus : Automobile and Diesel Technology**

**Course : Trade Training Basic, MTOF**

**Subject : MT Electrical System**

**Aim : To Study Coil Ignition System**

**Ref : AP. 3159 Section 4, Chapter 2**

---

## COIL IGNITION SYSTEM

### Description

1. Ignition of fuel air mixture in MT engine cylinders may be accomplished by either of the two methods. By heat of the compression as in diesel engine or by electrical spark as in gasoline engines. Spark ignition is of two types i.e.:

a. Battery ignition system (coil ignition)

b. Magneto ignition system

Coil ignition system works more efficiently at lower speed as compared with magneto ignition system.

### Parts of Coil Ignition System

2. The coil ignition system (Battery ignition system) consists of the following (Fig-4):

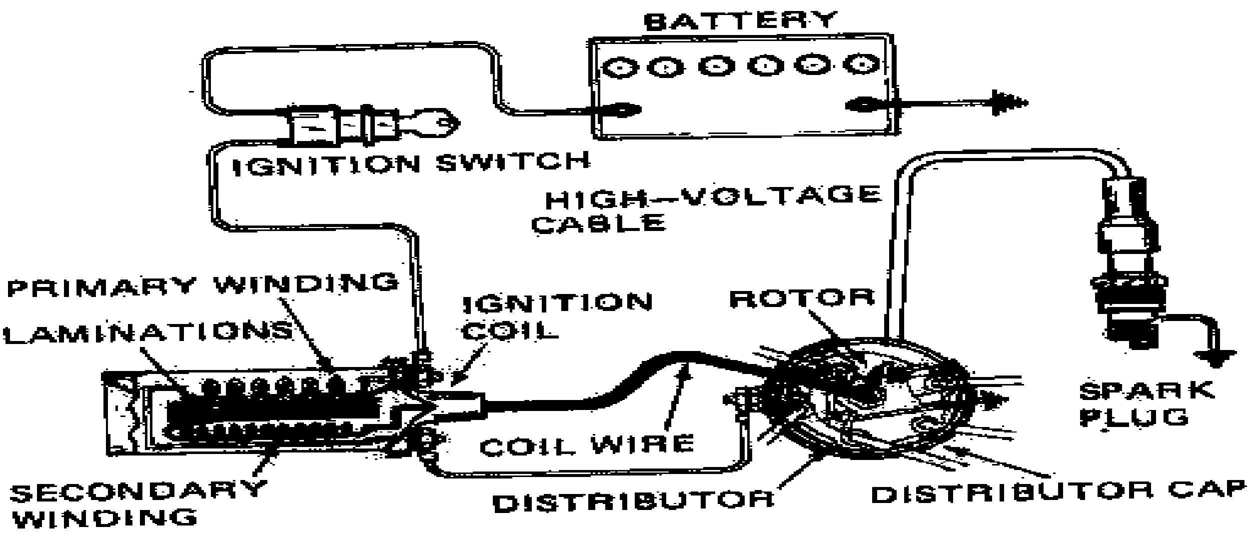



**Fig.4 Coil Ignition System**

a. **Battery** It is the source of electrical energy in the ignition system and supplies electric current for the primary circuit.

b. **Switch Ignition.** It is usually a locking switch by means of which ignition system and ultimately in is kept under lock and key. Ignition circuit is closed when the key is put in and turned in the lock. The lock is opened and circuit is closed resulting in the flow of current from battery to primary circuit of the ignition system. When ignition lock is closed, the electrical circuit opens and the engine stop working as the ignition is put off.

c. **Ignition Coil.** The purpose of this coil is to convert a low voltage to a high voltage. It consists of a soft iron core with primary and secondary windings of copper wire, the whole being housed in a metal cylinder, which can be secured in any convenient position in the vicinity of the engine.

d. **CB Point.** It is the mechanism by means of which make and break is affected in the primary circuit of the ignition system for obtaining high tension current.

e. **The Condenser.** It is a device, which avoids arcing at the contact breaker; points at the time of break in the primary circuit and thus save them from pitting or burning away.

f. **Distributor Unit.** A distributor unit performs a double function. A part of the assembly distributes the high- tension current to the cylinder sparking plugs in the correct firing order and the other part (the contact breaker) makes and breaks the primary circuit. The distributor shaft is driven from the engine camshaft at half engine speed. A rotor - arm is fitted on top of the distributor shaft, and it rotates inside a Bakelite cap fitted with electrodes. Each electrode is connected to a particular spark plug by a HT lead. Thus, on a distributor for a four-cylinder engine there are four electrodes. An HT lead from the secondary winding in the ignition end is secured to a terminal mounted centrally on the distributor unit cap and makes electrical contact with the rotor arm by a spring loaded carbon brush .The body of the distributor houses a capacitor (Condenser) and a contact breaker operated by cams formed on the distributor shaft. There are four cams on a distributor shaft for a 4-cylinder engine. The fixed arm of the contact breaker is connected to the primary winding in the ignition coil via a terminal and low-tension wire.

g **Sparking Plug.** A spark plug consists of the metal base, ceramic insulator and central electrode. The central electrode is surrounded by the ceramic insulator, which is sealed in the metals base. A small tip is welled with the screwed end of the metal base and provides a gap between the central electrode and the tip.

**Operation of coil ignition system**

3. Put the ignition switch on. Current flow from the battery through the primary winding and CB point to earth. A low- tension primary circuit is made. When engine starts cranking CB point begins to open and close. When CB point opens, primary circuit breaks and magnetic field collapse in the primary winding and it cuts the secondary winding. A high voltage induced in the secondary winding. This high voltage is transmitted from the ignition coil via rotor arm and distributor cap electrode to the sparking plug. The gap between the fully opened points of a contact breaker should be .012 inch to .015 inch or as marker instructions.

# BAF BASE ZAHURUL HAQUE (TRG WG)

## (Aero Engg Trg Sqn)

**Syllabus : Automobile and Diesel Technology**

**Course : Trade Training Basic, MTOF**

**Subject : MT Electrical System**

**Aim : To Study Coil Ignition Timing**

**Ref : AP. 3159 Section 4, Chapter 2**

---

## COIL IGNITION TIMING

**Purpose**

1. To ensure that spark occurs in the engine combustion chamber to ignite compressed fuel air mixture in relation to the piston position at right time.

**Methods**

2. a. **Engine setting.**

(1) Remove valve cover; turn engine until the inlet valve of No. 1 cylinder closes; continue turning until firing mark or TDC is in line with pointer.

(2) Recheck; that piston is now at TDC on the compression stroke and about to start power stroke.

b. **Distributor Unit Setting**

(1) Remove the distributor cap and ascertain direction of shat rotation.

(2) Check CB point gap and adjust, when fully open, to .012" or as makers' specification.

(3) Turn distributor shaft until rotor is pointing towards front of engine; assemble to engine, ensuring that dog or gear is properly meshed. In some engines it is important to note that the distributor drive also meshes with oil pump properly.

(4) With distributor clamping bolt loose, the body can now be turned wither way.

(5) Turn the distributor body against DOR until the contact breaker is just opening; tighten clamping bolt.

(6) Temporarily fit the distributor cap; remove and note which segment the rotor arm is pointing to; connect this segment to No. 1 spark plug. Connect the remainder of the leads in the firing order in DOR of rotor.

(7) Turn engine and recheck; Start engine. Slight adjustment may be necessary; this can be obtained by loosening the clamping bolt and moving distributor body in DOR of rotor to retard and vice versa.

# BAF BASE ZAHURUL HAQUE (TRG WG)

## (Aero Engg Trg Sqn)

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **MT Electrical System** |
| **Aim** | **:** | **To Study Ignition Faults** |
| **Ref** | **:** | **AP- 3159, Section 4, and Chapter 2.** |

---

## IGNITION FAULTS

**Engine will not start**

1.

| | **Faults** | **Rectification's** |
|---|---|---|
| a. | Flat battery or incorrect ignition timing. | Fit serviceable battery; check ignition timing. |
| b. | A broken or detached LT lead anywhere between switch and distributor. | Visually check coil and distributor LT leads. |
| c. | Poor LT connections at Battery, coil or distributor. | Remove all LT connections; clean, replace and tighten. |
| d. | HT leads between coil and distributor detached or earthing. | Check –fit new lead if insulation is cracked. |
| e. | CB Points dirty and pitted. | Remove, stone flat, clean, replace, re-gap. |
| f. | CB points stuck open. | Remove, clean, lightly oil, re-place, re-gap. |
| g. | CB spring broken. | Fit new set of points and re-gap. |
| h. | No washer under the insulated CB point- no insulated bush for the spring. | Fit insulated washer or bush. |
| j. | HT brush or rotor missing. | Replace. |
| k. | Coil brunt out. | Replace. |
| l. | Capacitor earthing. | Replace. |

**Engine Misfiring**

2.

| | | |
|---|---|---|
| a. | One or more HT leads loose or earthing. | Check leads and then in-solution, especially where leads are near metal surfaces. |
| b. | One or more faulty sparking plugs. | Remove, clean, test, replace. |
| c. | CB points dirty and pitted. | Remove, stone down, replace, re-gap. |
| d. | Tracking in distributor. | Fit new distributor cap. |
| e. | Faulty capacitor. | Replace. |
| f. | Rotor insulation faulty. | Replace. |

**Engine Over heating**

3.

| | | |
|---|---|---|
| a. | Retarded ignition. | Check and re-time if necessary. |
| b. | Wrong type sparking plugs. | Fit correct type. |

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **MT Electrical System** |
| **Aim** | **:** | **To Study Magneto Timing** |
| **Ref** | **:** | **AP 3159, Section 4, and Chapter 2.** |

# MAGNETO TIMING

## Purpose

1. To ensure that the spark occurs in the sparking plug at the correct instant in relation to the piston position.

2. **Method**

a. **Internal**. To obtain the maximum HT voltage at the right time the internal mechanism of the magneto must be assembled so that the marks on both the distributor and armature gears are aligned. This will ensure that when the CB points open the armature is in the position in which maximum current is flowing through the primary winding and the rotor arm is opposite to distributor segment.

b. **External.** For this timing the magneto spindle must be engaged with the engine magneto drive in such a manner that the following conditions are fulfilled:

(1) The piston in the selected cylinder (usually No.1) is in the correct firing position specified for the engine.

(2) The distributor rotor brush or rotor arm overlaps, the distributor segment connected to the selected cylinder sparking plug.

(3) The contact breaker points are just opening, (The timing lever being in the advanced or retard position as specified).

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **MT Electrical System** |
| **Aim** | **:** | **To Study CB Points Adjustment** |
| **Ref** | **:** | **AP 3159 Section 4 & Chap 2** |

## CB POINTS ADJUSTMENT

**Object**

1. As the points are subjected to a very severe hammering and if un-evenly worn should the refaced or cleaned and adjusted again to give further useful service.

**Cleaning of CB Points**

2. When the points are dirty or pitted, these should be refaced in the following manner:-

a. Remove the points from the distributor.

b. Hold one point lightly in a small hand vice or in a special holding jig and rub it flat and evenly on a carburendum or oil stone till the pitting is removed.

c. The same way the other is cleaned.

**Setting or Adjusting of CB Points**

3. After the points have been cleaned, they are to be adjusted as follows.

a. Ensure the electrical power is ***off.***

b. Fit the CB points on CB plate of the distributor, leaving the locking screw of the fixed point loose.

c. Turn the distributor body or shaft till the heel of the moveable point is on the peak of one of the cam lobe. (Points fully opened).

d. Adjust the gap by means of the adjusting screw to maker's specified gap, and then lock the locking screw.

e. Check the gap on the cam lobes.

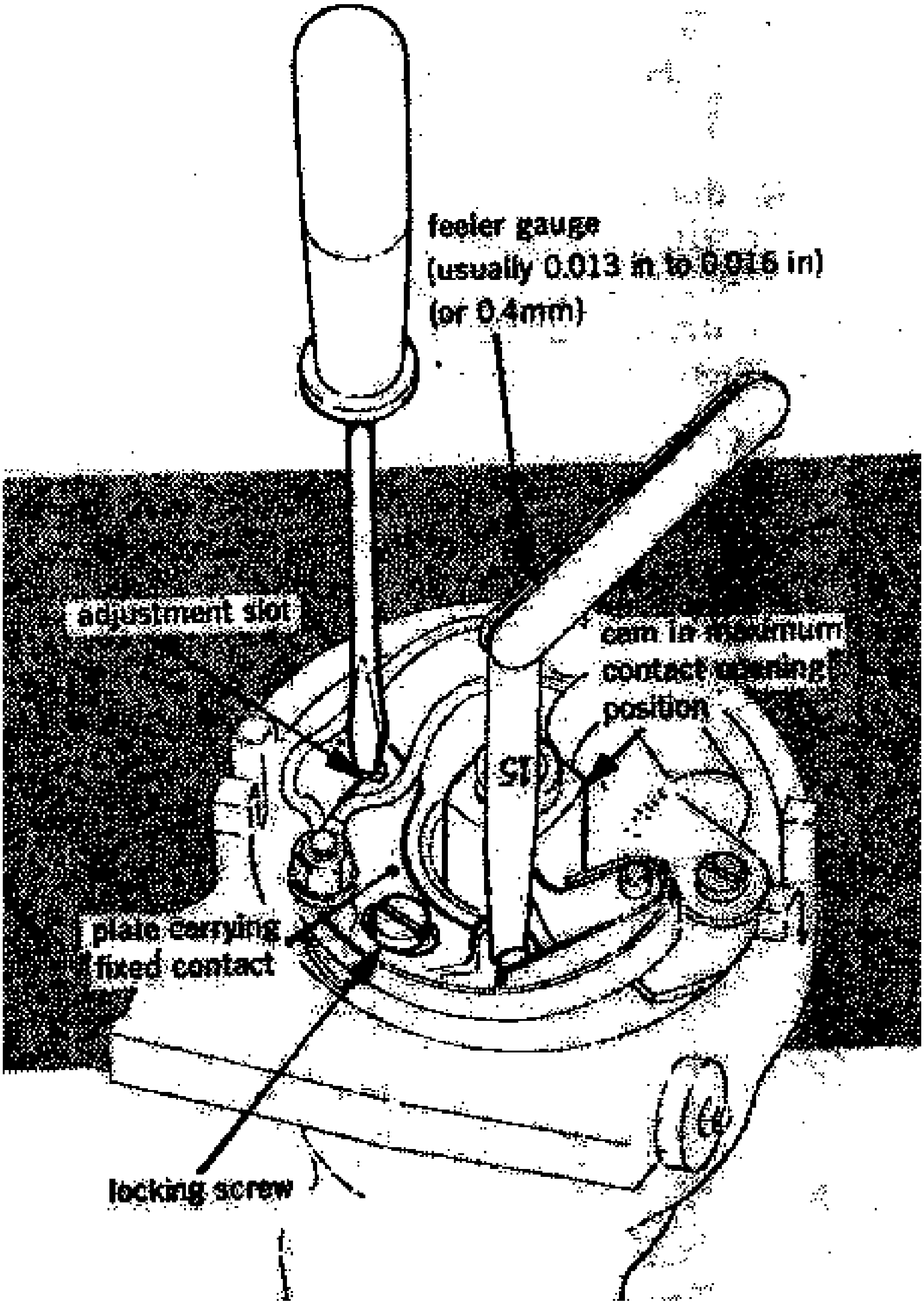



**Fig:5 Adjustment of CB point.**

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **MT Electrical System** |
| **Aim** | **:** | **To Study Sparking Plug** |
| **Ref** | **:** | **Harbens Singh Reyat, Chapter 11, Page-311 & AP 3159** |

# SPARKING PLUG

## Purpose

1. Purpose of sparking plug is to provide spark for the ignitions of compressed fuel air mixture in side the cylinder.

## Construction

2. A spark plug consists of the following parts:

   a. Metal base (body).

   b. Ceramic insulator.

   c. Central electrode.

   d. Ground electrode (earth electrode).

   e. Terminal cap.

The central electrode is surrounded by the ceramic insulator, which is sealed in the metal base. A small tip (ground electrode) is welded with the screwed end of the metal base and provides a gap between the central electrode and the tip. The complete assembly known as spark plug and it is screwed into the cylinder head of the engine and the lower end thus reaches the dome of combustion chamber. High-tension lead from the distributor is connected at the outer end of central electrode through a screwed cap. The body is made of steel with a hexagon out side to fit the spanner and a thread at the lower end to screw into the cylinder head. Its lower end is having earth electrode, the central electrode is made of special alloy steel, to withstand great heat,

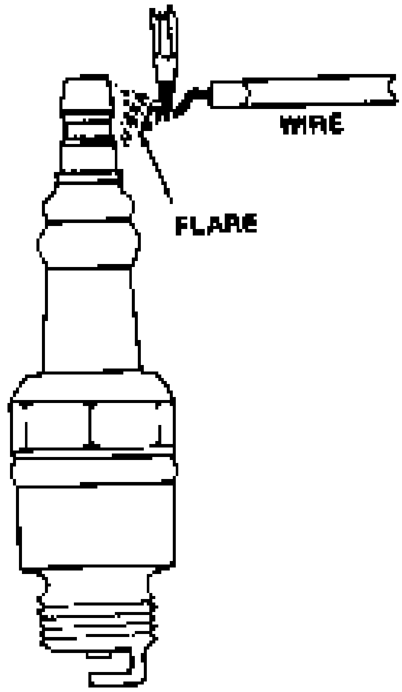


**Fig-6 Sparking Plug**

and has a threaded extension for the attachment of the terminal nut. Separating the earth electrode on the body and the central electrode is the insulator, which is made of porcelain. A copper washer is fitted between sparking plug and cylinder head to ensure gas tightness.

**<u>Classification</u>**

3. A sparking plug is classified by the diameter and length of its threaded portion. The diameter is stated in millimeter e.g. 10mm, 14mm, 18mm and the length in inches (. e.g. 3/8”, 9/16” and 13/16”). The length is termed the reach (e.g. short, medium, or long). The majority of vehicle engines use 14mm plugs, while the 18mm plugs are used mainly on ground equipment engines. “Reach” of the plug differs according to the design of the engine and correct “reach” of plug should be fitted. If a shorter reach plug is fitted the spark will occur in a socket. If a too long reach plug is fitted it will damage to the piston and valves.

**<u>Heat Range</u>**

4. A spark plug must dissipate heat so that the electrodes do not overheat and glow, there-by causing pre-ignition and yet retain enough heat so that oil adhering to the electrodes is burnt off before it can bridge the air gap. As some engines have very low operating temperature, the plug manufactures have made a heat range of plugs to cope with these conditions (Fig-12):

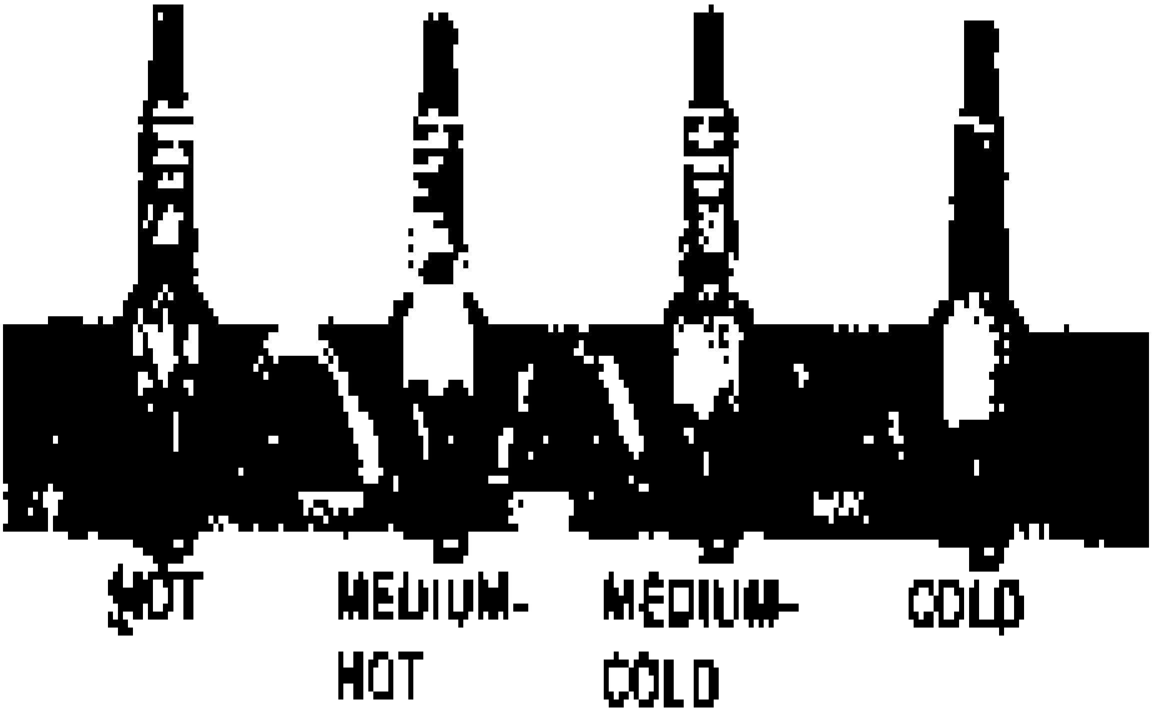
a. **<u>Hot or Soft Plug.</u>** If heat-absorbing surface of the insulator nose of a spark plug is large due to long nose, the spark plug is known as hot plug. Hot spark plugs have low heat value. Lower speed, intermittent loading and colder operating conditions of the engine require a hotter plug.

b. **<u>Medium.</u>** These are used on medium temperature engines.

c. **<u>Cold of Hard Plug.</u>** Spark plugs having short insulator nose are known as cold spark plugs because their heat value is high. These plugs remain high in the combustion chamber and their insulator noses are not heated up sufficiently by the combustion gases as heat is transferred quickly from insulator nose to cylinder head through the metallic base of the plug. Cold spark plugs are generally used in heavy loading and high-speed operation where high temperatures are encountered.

**Pre-ignition (Due to Sparking Plug)**

5. Pre-ignition can be caused by the electrodes becoming hot enough to fire the charge before the timed ignition spark occurs and it is usually due to the use of an incorrect type of sparking plug-one which does not dissipate the heat of combustion rapidly enough. Pre-ignition may also be caused when a plug of the correct type has become defective under unusually severe working conditions. Persistent pre-ignition causes the electrodes to burn away very rapidly; The engine symptoms are poor performance at high speeds or when pulling hard, usually accompanied by an audible knock, because so often pre-ignition results in detonation.




**Fif-7 Heat Range**

**Plug Testing**

6. A faulty plug can usually be located by shorting each plug in turn, when the engine is running slowly, by using the steel blade of a wooden handled screw driver to make a connection between the terminal head and the cylinder (i.e. to earth). The plug that does not alter the engine note when shorted is faulty. Sometimes, however, a plug may break down at higher speeds only and it is difficult to detect. When this happens, the plugs should be removed from the engine, thoroughly cleaned, and tested under air pressure on a plug-testing machine. When removing or fitting sparking plugs always use the correct size spanners, as a badly fitting spanner may slip and break the porcelain insulator and thus render the plug unserviceable.

**Radio Interference Suppression**

7. a. **General:** Where intermittent and surging voltages are present in a circuit, some form of suppression is necessary to prevent interference to radio and radar installations either on the vehicle itself or in the vicinity. Electrical components, such as the generator and windscreen wiper motor, cause interference to some degree, but the ignition system is the main cause.

b. **Methods of Suppression**. Interference from the generator and windscreen wiper motor can be eliminated by fitting capacitors (condensers) to the electrical terminals. Two methods are in use for the suppression of radio interference from the ignition system: by screening the leads and by the use of resistors:

(1) **Screening:** This method is employed on radio and radar vehicles and consists of enclosing the ignition components in earthed metal cases and of covering the leads with a flexible metallic sheath which is also earthed. In this way any oscillation generated by the high-tension current can be by- passed to earth).

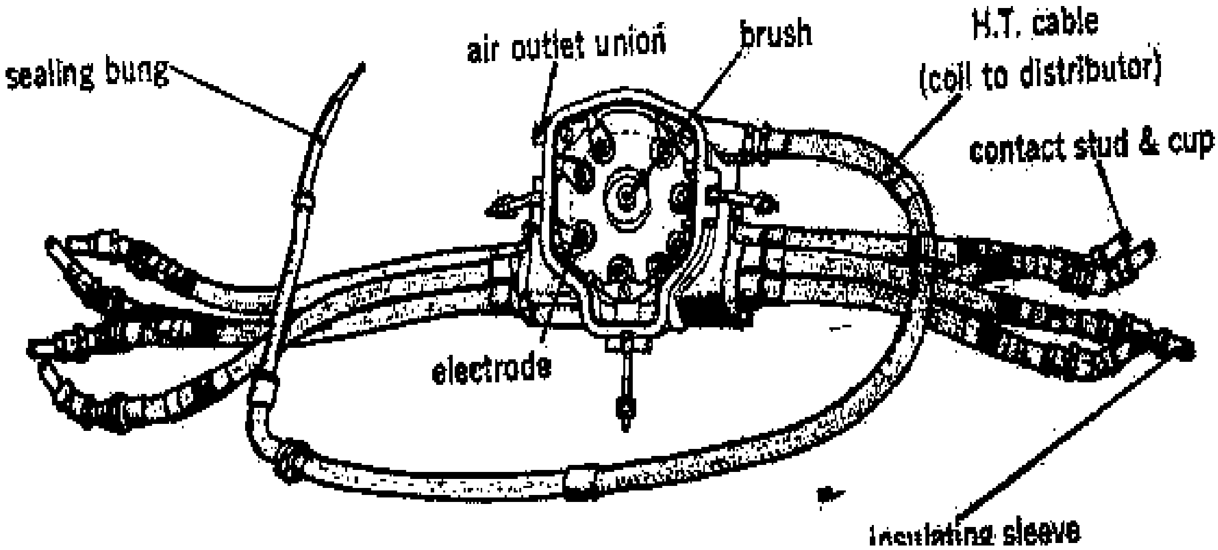



**Fig-8 Screening**

(2) **Resistor or Suppressors**. Fitting resistors to the high-tension lead is the most commonly used method of suppressing radio interference. The resistors damp down the high frequency component of the current and reduce the radiation to a level, which is too low to be picked up by radio aerials.

c. **Types of Resistors.** Several types of resistors are available, some being connected into the HT lead and others screwing on to the plug tops or coil connection. In all cases, some high resistance material is incorporated which damps down the oscillations given out by the current.

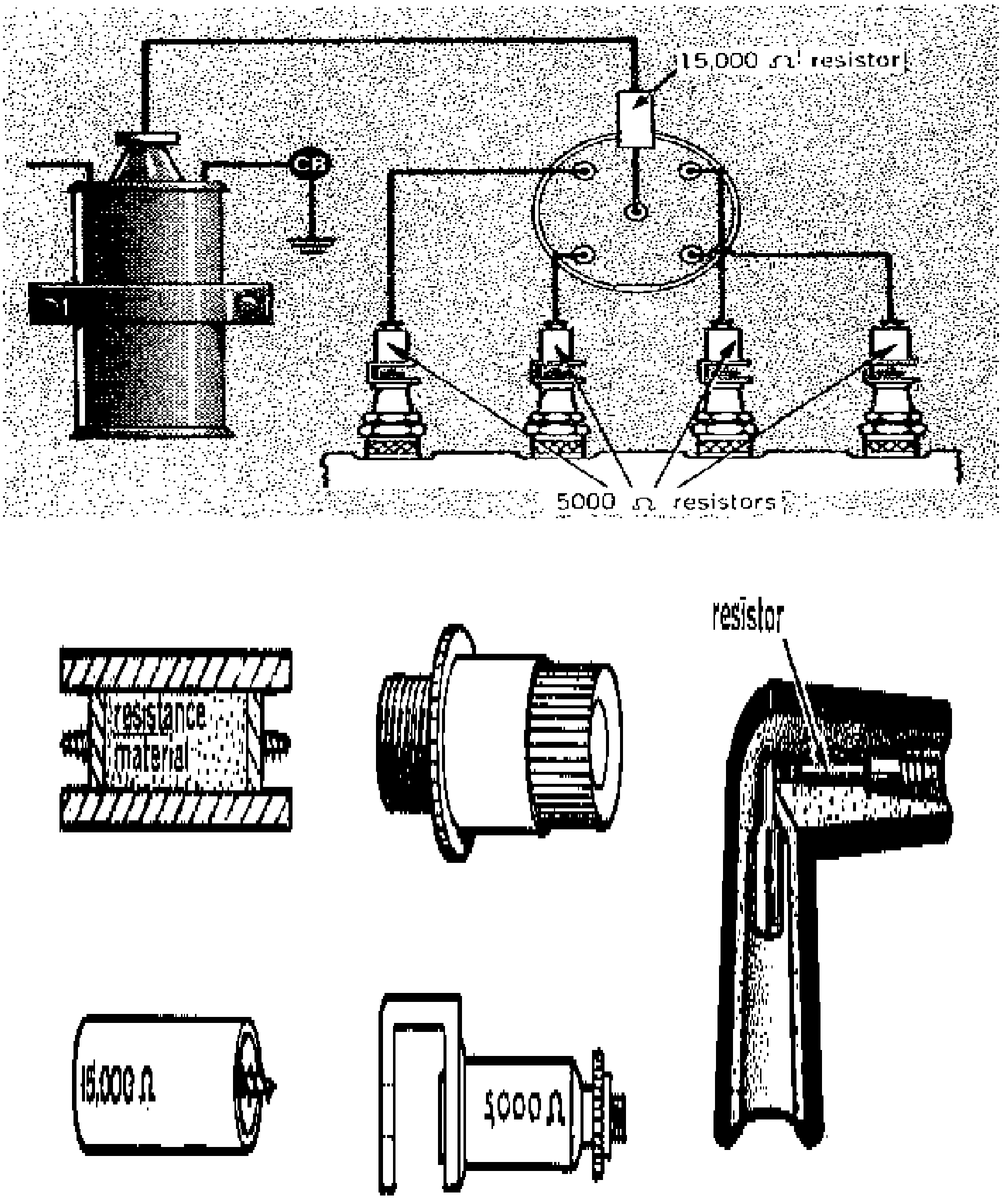



**Fig-9 Resistors**

d. **<u>Location of Resistors</u>.** The two sizes of resistors used in the service are 5000 ohm and 15000 ohm. As the total resistance between the coil and any plug should be at least 20,000 ohms, a 5000 ohm resistor is fitted to each sparking plug and a 15000 ohm resistor in the coil lead, as close to the distributor as possible. Some distributors are now being fitted with a resistor forming part of the carbon brush in the centre of the distributor cap so that some measure of suppression is built into the ignition system.

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **MT Electrical System** |
| **Aim** | **:** | **To Study Electrical Circuits** |
| **Ref** | **:** | **A P 3159 Section 3, Chapter 2.** |

# BATTERIES

## Definition

1. The source of electricity by which, Electrical energy is converted into chemical energy during charging and chemical energy is converted into electrical energy during discharging is called battery.

## Principle

2. Electrical energy is converted into chemical energy during charging and chemical energy is converted into electrical energy during discharging.

## Purpose

3. The purpose of battery is to stores electrical energy in the form of chemical energy.

## Construction

4. The cells are connected in series to form a battery. The cells are made of positive and negative plate. There is always a negative plate more than the number of positive plate to avoid bucking the positive plate. There is always a separator is used in between the negative and positive plate to avoid short circuit between two plates. $H2SO4 + H20$ is used as an electrolyte for lead acid battery (Fig-10).

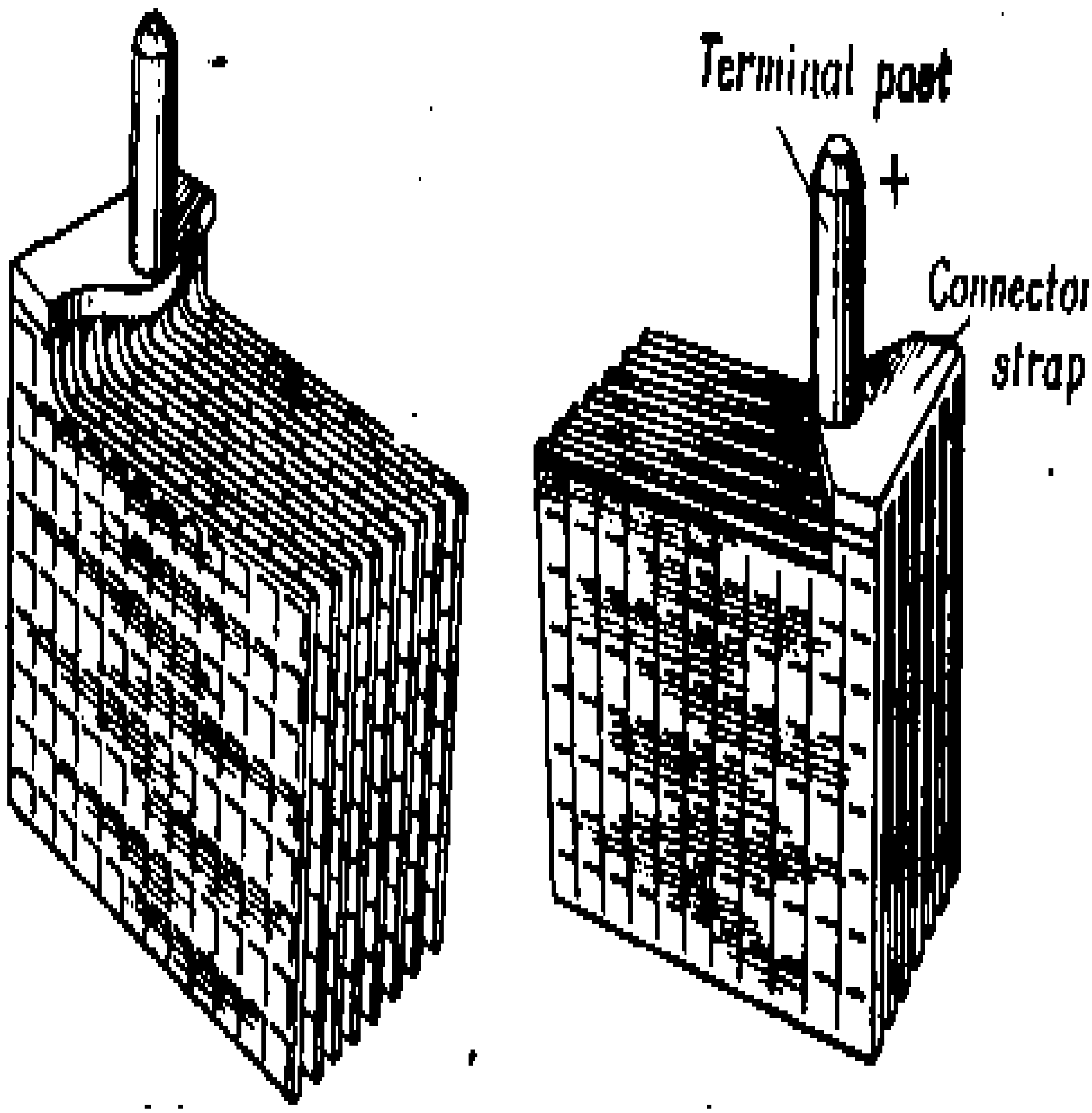



**Fig –10 Plate Assemblies of Battery**

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **MT Electrical System** |
| **Aim** | **:** | **To Study Generator.** |
| **Ref** | **:** | **A P 3159 Section 4 Chapter 4** |

## GENERATOR

### Definition

1. Generator is a machine, which converts mechanical energy into electrical energy. The purpose of the generator in MT vehicle is to provide electricity for electrical system and to charge the battery.

### Principle

2. Generator works on the principle of Faraday's law. It states that when there is a relative motion between a conductor and magnetic field, the conductor is cut by the magnetic field and an e. m. f. is induced in the conductor. When external circuit is made current starts flowing.

### Construction

3. To construct a generator the following parts are required (Fig-11).

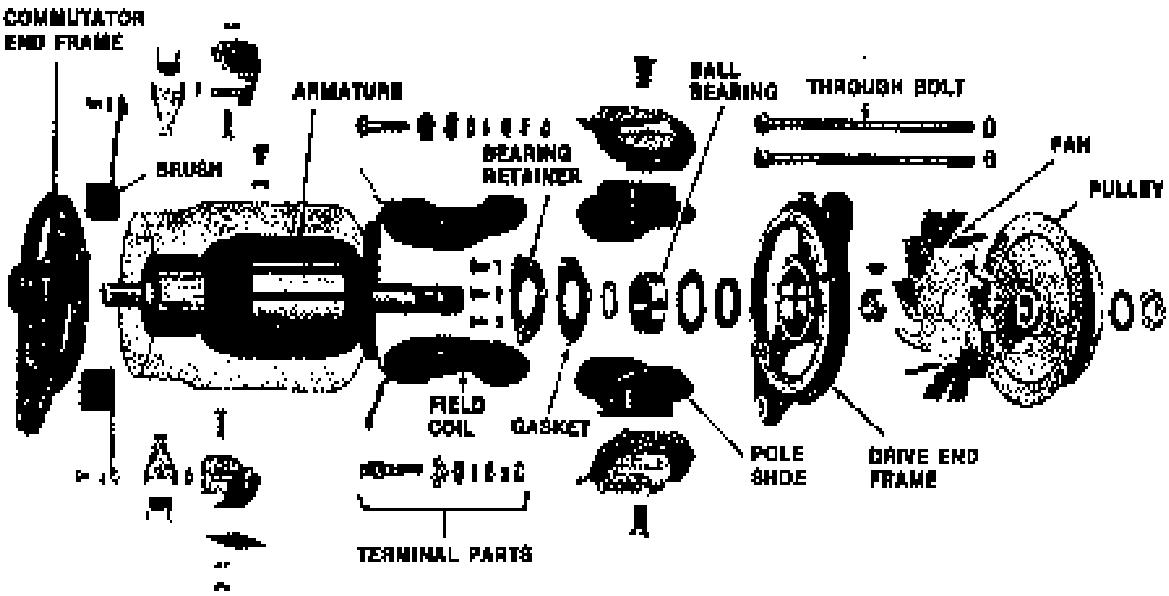



**Fig-11 Generator**

a. **The field assembly**. The field assembly has the following parts.

(1) **The yoke**. A cylindrical frame made of rolled steel cast. Cast steel and cast iron may also be used.

(2) **Pole pieces**. These component from the cores of the magnetic coil and bolted to the inside of the yoke.

(3) **Field Winding.** Copper wire wound around the pole piece and when current flows through the coil it becomes magnetic field. The field windings are bound in such a way they make alternate field.

b. **Armature Assembly.** The armature assembly consists of the following parts:

(1) **Armature Core.** It is a cylindrical drum made of soft iron core. It houses the armature conductor. The laminations are approximately 0.5mm thick.

(2) **Armature Winding.** These are the main winding of generator. These are made of copper wire.

(3) **Commutator.** The Commutator is used to convert AC into DC. Voltage induced in the armature conductor is AC. It comes out to the external circuit as DC through commutator. The commutator is made up number of individual segment insulated from each other and from the armature shaft. There are two segments for each armature conductor.

c. **The Brush and Gear Assembly**. The brush and gear assembly consist of following parts:

(1) **Brush**. Made of carbon, copper, alloy of carbon and copper.

(2) **Brush Holder**. The brushes are carried in small open-end boxes whose inside surfaces are machined to the size of the brush and slight clearance is kept so that brush may slide freely.

(3) **Brush Rockers**. The brush holder is bolted through insulating sleeves to a steel ring mounted on the end of the frame of machine. In many cases this ring is adjustable for position and can be rotated through a few degrees to alter the position of the brush. A moveable ring of this type is known as brush rocker.

## Operation of DC Generator

4. Normally, the generator is driven by means of the engine fan belt at the front of the engine. As the armature rotates, the coils cut the lines of force of the weak magnetic field set up by the residual magnetism of the field magnets. This generates a small current in the armature coils, which is picked up by brushes and fed through the field windings. The field strength is increased, which gives more lines of force, and so more current is generated in the armature. As the windings are in parallel the current can flow either through the field windings or to the battery and what ever forms the external circuit. The amount, which flows through the field circuit, will depend upon the resistance of that circuit and the voltage generated in the armature.

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **MT Electrical System** |
| **Aim** | **:** | **To Study Alternator** |
| **Ref** | **:** | **A P 3275 Part-3 & W H C Chapter 30-7** |

# ALTERNATOR

## Introduction

1. It is considered that a vehicle power supply system is obtained from a DC shunt wound generators. As the traffic density has increased, especially in the big town and cities, the average speed of vehicle has fallen. This has resulted in the battery having to take more of the electrical load for a longer period of time and falling to reach a fully charged state as a consequence. To over come the problem of battery, the rotating field type of alternator is capable of rotating at much higher speed, is used. Despite the inherent advantage of the alternator over the DC generator. Vehicles could make little use of this until fairly recently. The reason was that it is necessary to rectify the output to provide the DC charge current for the battery and until recently no suitable rectifier was available. However, with the advent of semi-conductor devices, with their advantage of lightness, cheapness and robustness over previous devices and the development of the silicon power rectifier diode in particular the rectification problems have been solved. Thus, alternators with their associated rectifiers are now widely used in modern vehicles.

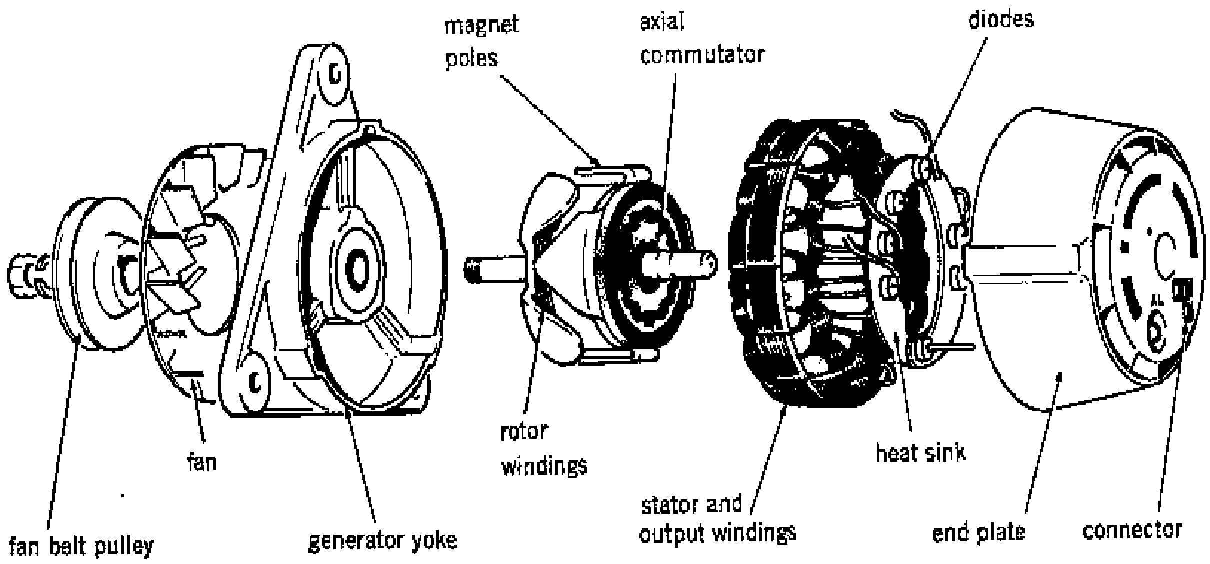



**Fig-12 Alternator**

## Description

2. The dc generator rotates the conductors in a stationary magnetic field. The alternator rotates a magnetic field so that stationary conductors cut the moving magnetic lines of force. In a simple alternator the rotating bar supplies the moving field. At the top, the North Pole of the bar magnet passes the upper leg of the loop, and the South Pole passes the lower leg of the loop. Current (electron flow) is induced in the loop in the direction shown by the arrows. At the bottom, the magnet

has rotated half a turn. Its South Pole is now passing the upper leg of the loop, and its North Pole is passing the lower leg. Now, magnetic lines of force are being cut by the two legs in the opposite direction. So current (electron flow) is induced in the loop in the opposite direction. Thus, as the magnet spines and the two poles alternately pass the two legs of the loop, electrons in the loop are pushed first in one direction, then in the other. In

other words, the electrons alternate in direction; alternating current flows. Three thing will increase the current (number of electrons) moving in the loop. They are increasing the strength of the magnetic field, and increasing the speed with which the magnetic field rotates. The current can also be increased by increasing the number of loops. In the actual alternator; both the magnetic field and the number of loops are increased. Instead of a simple bar magnet, the rotating part of the alternator is made up of two or more pole pieces. They are assembled on a shaft over an electromagnetic winding. The electromagnet is made up of many turns of wire. When current flows in the electromagnetic winding, a strong magnetic field is created. The pointed ends of the two pole pieces become, alternately, north and south poles the winding is connected to the battery through a pair of insulated rings that rotate with the shaft. A pair of stationary brushes rides on the rings. The two ends of the winding are attached to the rings, and the brushes make continuous sliding (or slipping) contact with the slip rings.

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **MT Electrical System** |
| **Aim** | **:** | **To Study Cut out.** |
| **Ref** | **:** | **A P 3159 Section 4& Chapter 4.** |

# CUT OUT

## Purpose.

1. The purpose of the cutout is to disconnect the battery from the generator and so prevent the battery from discharging through the generator winding.

## Construction

2. A soft iron core carries two windings. One the voltage coil, is of fine wire with its ends connected across the generator terminals, whilst the other, of thicker wire, and known as the current coil, has one end connected to the battery terminal. The other end is led out to a hinged soft iron armature, which passes across the top of the core and carries a contact on its free end. The opposite or fixed contact is connected to a battery terminal. A tension spring holds the contacts apart when no current is flowing in the coils (Fig-13).

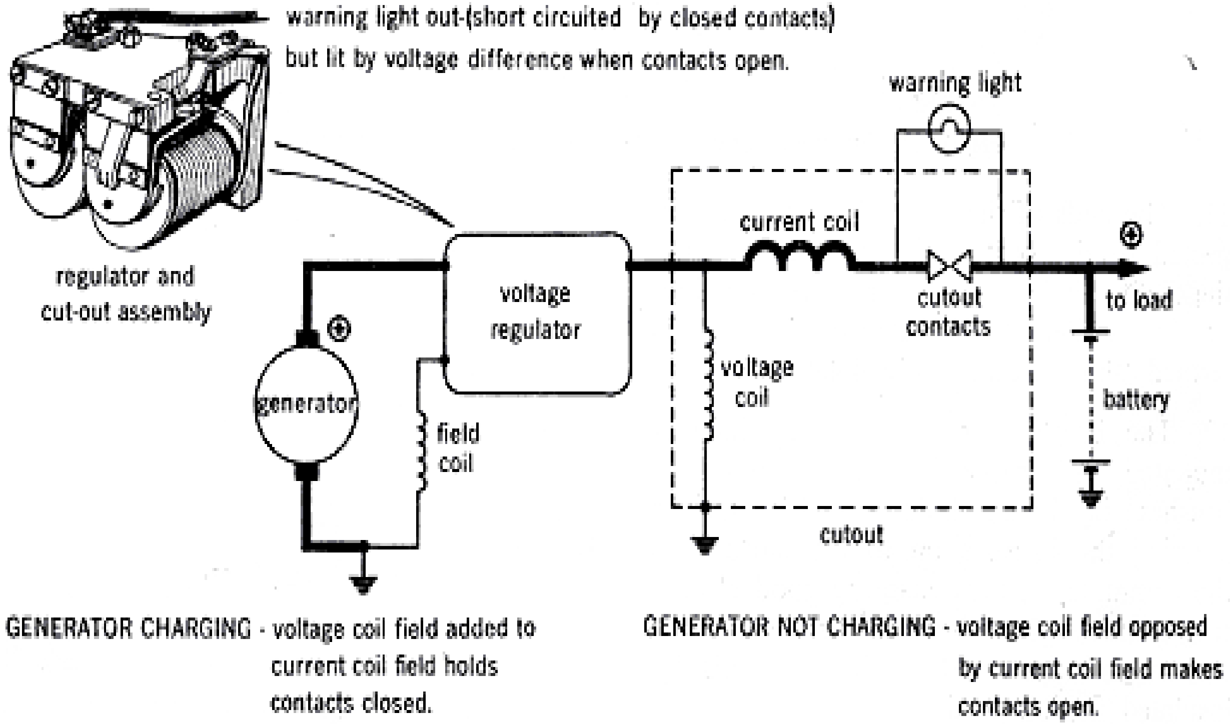



**Fig-13 Cut Out**

## Operation

3. When the engine started and the “revs” increase, the generator voltage rises until the voltage coil associated with the cutout has sufficient magnetic pull to close the contacts against spring tension. The spring tension is adjusted to allow the contacts to close ONLY when the generator voltage is greater than the battery. A series or current coil is included in the cutout to prevent the contacts from “chattering” about the “pull-in” voltage. Whilst the generator is charging the battery,

all the current passes through the current coil, and the field associated with this coil acts in such a way as to assist the voltage coil field. Also, when the generator stops (or when the generator voltage falls below that of the battery) reverse current from the battery flows through the series coil. This creates a magnetic field, which opposes the shunt field, thus "speeding up" the opening of the cutout contacts. Thus prevent the battery from discharging through the generator winding.

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **MT Electrical System** |
| **Aim** | **:** | **To Study Voltage Regulator.** |
| **Ref** | **:** | **A P 3159 Section 4& Chapter 4.** |

# VOLTAGE REGULATOR

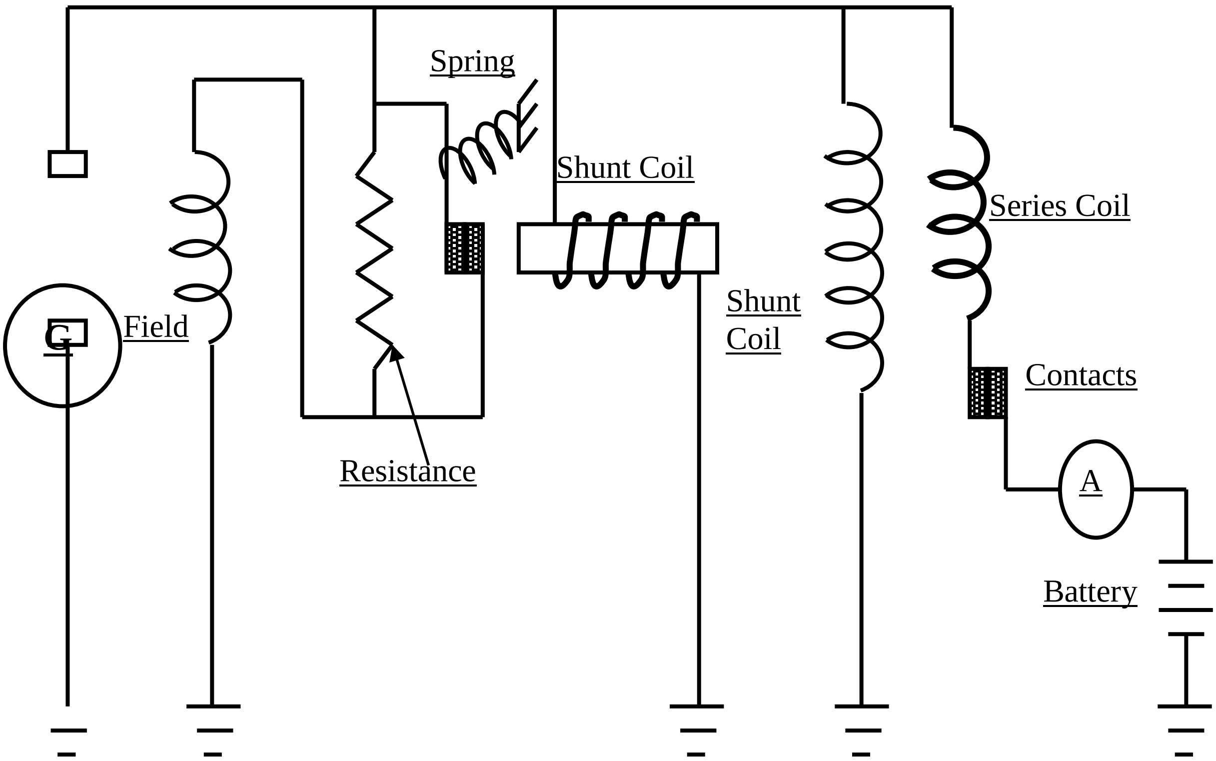



**Fig-14 Voltage Regulator**

## Purpose

1. The purpose of voltage regulator is to prevent excessive voltage supplied by the generator.

## Construction

2. It consists of following parts (Fig-14).

a. Electromagnet. It is having a soft iron core and a voltage coil of fine gauge of wire. The coil is connected across the output of the generator.

b. Contact points. A set of contact point normally held closed by the control spring.

c. Resistance unit. A resistance unites connected across the contact points and in series with the generator shunt field current. It is of higher value than similar resistance used in current regulator.

d. Armature. An armature, which carries the moving contact point.

**Operation**

3. When the generator is not operating, the regulator contact points are held closed by the control spring which short circuit the resistance unit and remain out from the generator field. The regulator fine winding is connected across the generator out put. When the generator starts operating, a current proportional to the voltage of the generator starts flowing through winding of the regulator which magnetized the soft iron core, which in turn, exerts pull on the regulator armature and tends to separate the contacts. When the generator voltage coil exceeds the predetermined value, the voltage coil of the regulator will sufficiently magnetize the soft iron core to attract the armature and open the contact points against the spring tension. This in turn inserts the resistance unit in the shunt field of the generator, weakening the field strength. Due to weak field, the out put of the generator falls the control spring overcomes the magnetic pull of the soft iron core and closes the contact points. This short-circuits the resistance unit and once again the output of the generator increases. The regulator will continue to repeat this cycle, thus maintaining the output of the generator constant on varying speed and loads. The charging rate dose not remains constant but depends on the state of the batteries. The regulator on most late type military vehicles will prevent the generator from building up an excessive voltage if a break occurs in the charging circuit. But this is not true on standard passenger’s car and light duty equipment. In these, if a break dose occur in the voltage regulator, regulation of the generator may be lost and excessive charging current will flow at high speed.

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **MT Electrical System** |
| **Aim** | **:** | **To Study Starter Motor.** |
| **Ref** | **:** | **W H CROUSE & A P 3159 Section 4& Chapter 4.** |

# STARTER MOTOR

## Principle

1. When current flows through the conductor loop, the current produces a magnetic field, which opposes the magnetic field of the magnet. This causes the loop spin.

## Purpose

2. Starter motor is used to spin the crankshaft of an engine for starting purpose.

## Types

3. There are two types of starter drives:

a. **Inertia drive coupling.** The starter motor has an extended armature shaft and the motor is mounted in such a way that the protruding end of shaft is positioned alongside and just *beyond* the teeth on the starter ring of the engine flywheel. The shaft is machined with a coarse spiral thread, known as a lead screw. Also mounted on the shaft is a loose-fitting, weighted pinion gear whose teeth are so shaped that can mesh with the teeth on flywheel starter ring.

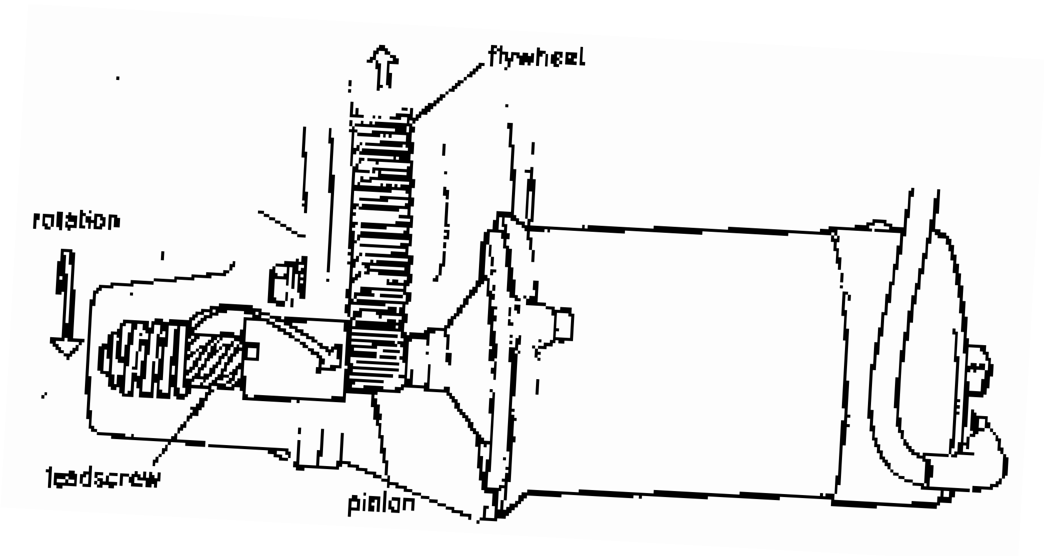


**Fig-15 Inertia Drive Coupling**

b. **<u>Pre-engaged Starter Drive.</u>** This is name given to starter motors in which an electrical solenoid is employed to move the pinion into engagement with the fly wheel starter ring before the motor is switched on, so avoiding the ‘crash’ engagement of the inertia type drive. This system causes less wear to the teeth but has the disadvantage that a free- wheel is needed to ensure that the motor will not be over speeded by the engine when the engine fires. The pre- engaged starter drive is used extensively in starting diesel engines. These normally require starter assistance for a longer period than to gasoline engines. During its efforts to become self-supporting the diesel engine tends to fire spasmodically giving several ‘false’ starts. Under these conditions, the inertia type drive would be ejected from engagement before the engine has truly started. With the pre-engaged drive this does not happen (Fig-16).

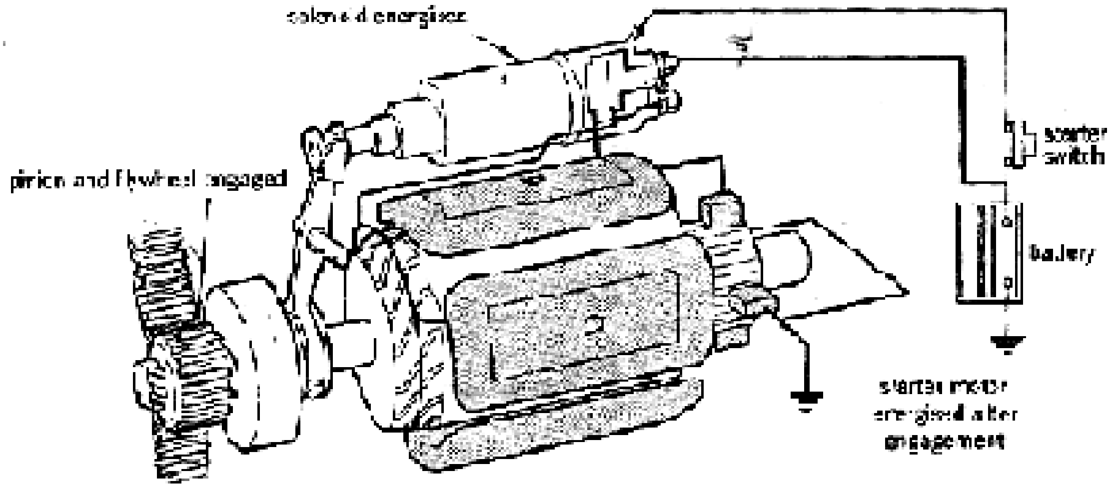



Fig-16 Pre-engaged Starter Drive

**<u>Construction</u>**

4. To construct a starter motor mainly the following parts are used (Fig-16):-

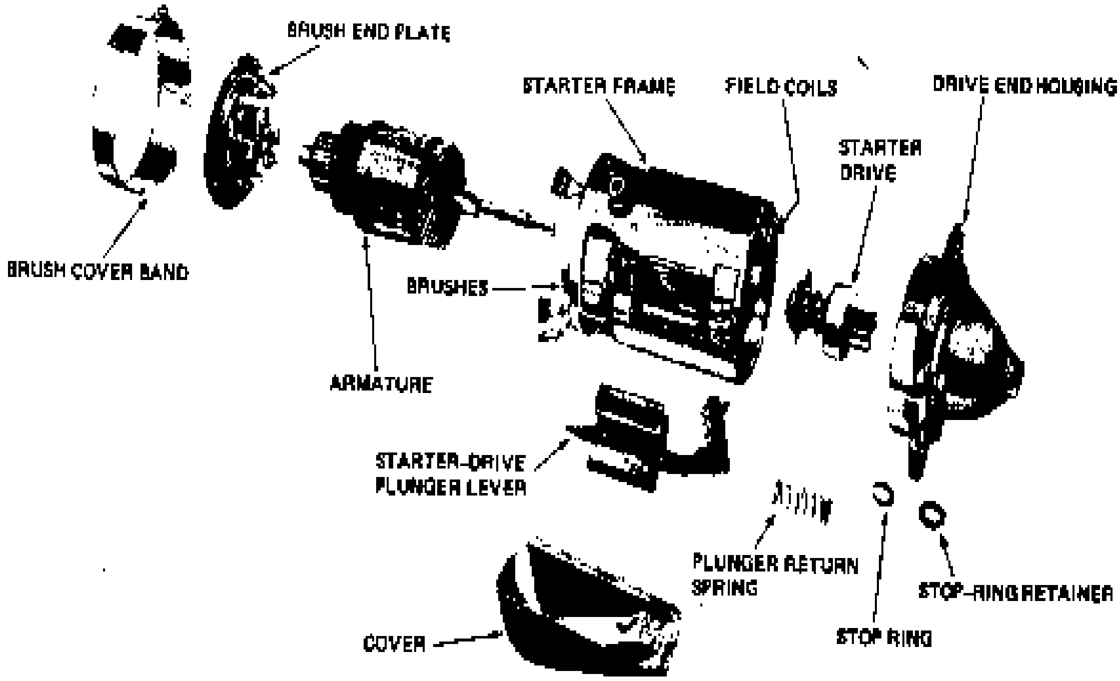



**Fig-17 Starter Motor**

a. **<u>Field assy</u>.** Field assembly consists of the following parts.

(1) Field core.

(2) Field coil.

(3) Body or field housing.

b. **<u>Armature assembly</u>**. Armature assembly consists of the following parts:

(1) Armature core.

(2) Armature coil.

(3) Commutator.

(4) Brush with brush holders.

(5) Commutator end frame assembly.

(6) Drive end frame assembly.

(7) Clutch hub assembly.

(8) Center bearing hub assembly.

(9) Solenoid switch assembly.

**<u>Operation</u>**

5. When the starter button is pressed/switch is on, the first stage contacts on the solenoid switch close, completing the circuit for the auxiliary field windings. This allows a small current

to flow, causing the armature to rotate slowly. At the same time the magnetic field set up, draws the armature towards the driving end of the machine until the pinion engages the starter ring. As the armature nears the end of its travel a trip plate operates trigger on the solenoid switch, allowing the second stage contacts to close. The full battery current now flows through the main series windings and armature, thus developing full torque, and turns the engine up to 'self-sustaining' revs. The pinion disengages automatically when the engine 'fires'. When the armature is at rest (starter off) it is held in the disengaged position by a spring.

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

| | | |
|---|---|---|
| **Syllabus** | **:** | **Automobile and Diesel Technology** |
| **Course** | **:** | **Trade Training Basic, MTOF** |
| **Subject** | **:** | **MT Electrical System** |
| **Aim** | **:** | **To Study Solenoid Switch** |
| **Ref** | **:** | **A P 3159 Section 4, Chapter 5.** |

# SOLENOID SWITCH

## Purpose

1. The purpose of the solenoid switches to contact the battery to starter field and armature and drive the pinion forward to engage with flywheel.

## Operation

2. When the starter button is operated a current flows round the coil of the wire energizing the magnet, attracting the plunger and bridge the contacts of the main starter motor circuit. When button is released, the current ceases to flow and the coil spring returns the plunger to its original position, breaking the main starter circuit. On some starter switches a small rubber button is provided over the end of the plunger to allow for manual operation of the switch. When turning over the engine during starting. The switch is located either on the starter motor itself or in the engine compartment.

# BAF BASE ZAHURUL HAQUE (TRG WING)

## (Aero Engg Trg Sqn)

**Syllabus : Automobile Diesel and Technology**

**Course : Trade Training Basic, MTOF**

**Subject : Engine Lubrication System**

**Aim : To Study Engine Lubrication System**

**Ref : The Automobile – By Harbans Singh Reyat, Automotive Mechanics By W H Crouse &A P 3159.**

---

## LUBRICATION SYSTEM

### Introduction

1. The engine lubrication system supplies lubricating oil to all engine moving parts. Fig-1 shows the system for a four cylinder OHC (over head camshaft) spark-ignition engine. The oil pump picks up oil from the oil pan. Then the oil is sent up through the oil lines to the main bearings that support the crankshaft. This lubricates the main bearings. Oil from the main bearings feeds through oil holes drilled in the crankshaft to the rod bearings. Oil feeds through an oil line up to the cylinder head. There, the oil flows through an oil gallery to lubricate the camshaft bearings and the valve-train parts. The pistons, piston rings and piston pins are lubricated by the oil thrown off the connecting-rod bearings. This oil lands on the cylinder walls to lubricate the pistons, rings and pins. The oil circulates to all the parts shown by the arrow in fig-1. Then oil drops back down into the oil pan. It is the systems by means of which various engine parts are lubricated to reduce friction and thus ensure their free movement. It provides a film of oil between the moving parts and their bearing surfaces. It avoids direct friction by keeping the parts floating upon the oil film. This enables the parts to work for longer time resulting in longer engine life. Due to decrease in friction, the engine runs free which results in less power consumption in driving the engine, leading to increase in power output.

### Lubricating oil

2. **It serves the flowing purposes in an engine**:

a. Lubricates the moving parts to minimize the wear.

b. Provides an oil film for the floating of parts for free movement so that power losses in friction could be reduced.

c. Helps in keeping the parts cool.

d. Absorb shocks between the bearing surfaces and other engine parts and thus reduces noise and extends engine life.

e. Forms a good seal between piston rings and cylinder walls and thus avoids the leakage of gases down to the crank chamber.

f. Washes off and carries away dirt, carbon particles and other foreign matter from the passage of moving parts so that these may not create obstruction in the movement of engine parts.

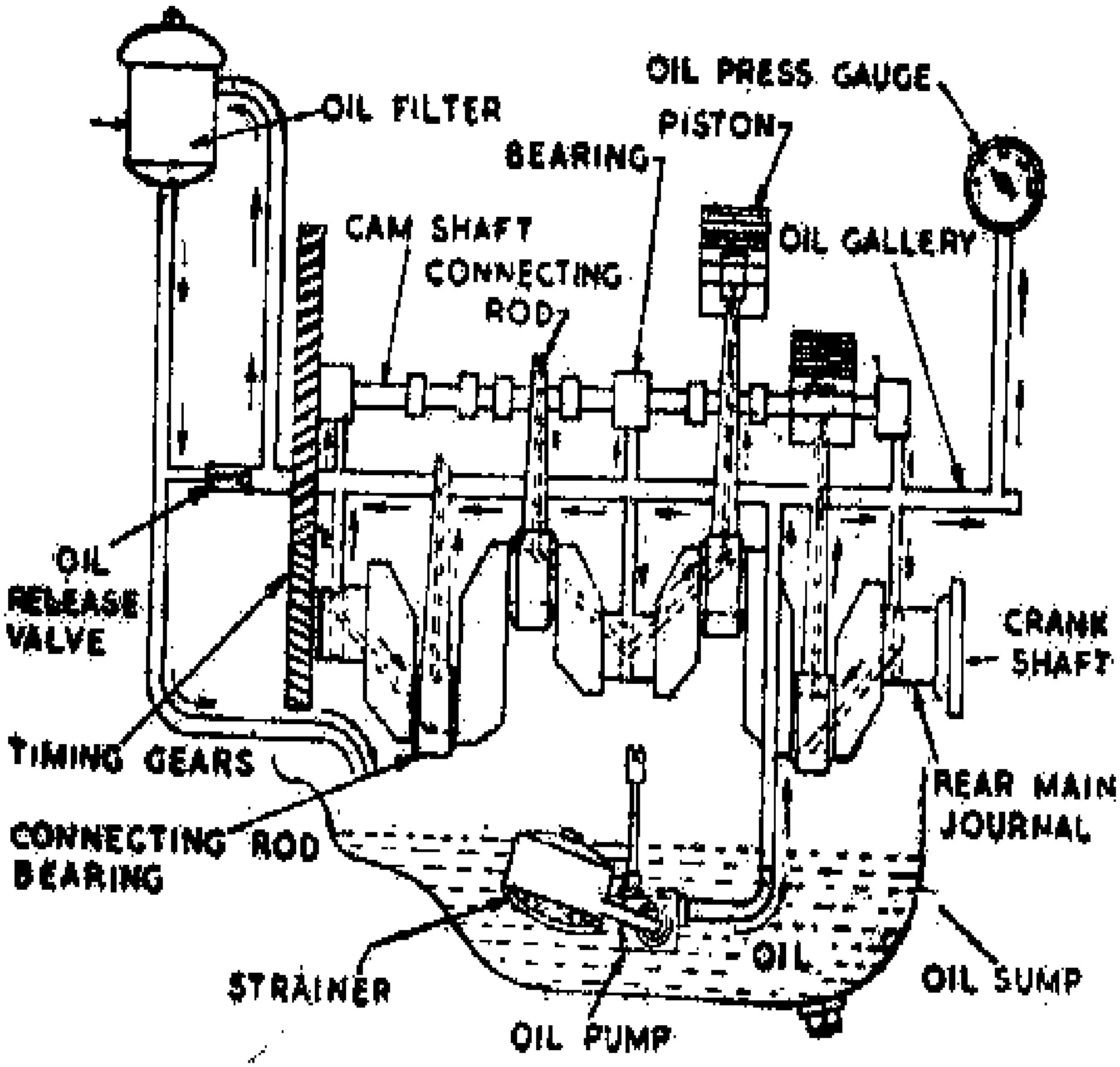



**Fig-1 Lubrication System**

**Viscosity**

3. It is a most important property of lubricating oil. It refers to the tendency of oil resist flowing. Layers of oil must move or slip with respect to each other. Viscosity of oil determines the case with which this slipping can take place. Viscosity may be divided into two parts---body and fluidity. *Body* relates to the resistance to oil film puncture or penetration due to the application of heavy loads. The body of oil prevents the load from squeezing out the film between the working parts and the bearing surfaces. This property cushions shock loads, helps in maintaining a good seal between the piston rings and cylinder walls and maintains an adequate oil film on all bearing surfaces under load. Fluidity relates to the ease with which the oil flows through oil lines and spreads over bearing surfaces. In some respects, the body and fluidity are opposing properties because if oil is more fluid, it shall have less body. The temperature affects viscosity. Increasing temperature reduces viscosity. It causes to lose body and gain fluidity. Decreasing temperature increases oil viscosity. The oil gains body and loses fluidity.

## Viscosity Rating

4. Viscosity of oil is determined by means of a device known as viscosimeter, which determines the length of time required to flow a definite amount of oil through an opening of a definite diameter with relation to temperature. SAE (Society of Automotive Engineers) ratings define oil viscosity in two different ways. Winter grade oils are suffixed with 'W' whereas for other than winter, all grades are without the suffix 'W'. Such as SAE 5 W and SAE 30 respectively.

**Viscosity Index**

5. Some oils change viscosity to a great extent with the change in temperature. The viscosity index (VI) was adopted to maintain an accurate measure of change in viscosity of particular oil with temperature change. Originally it runs from 0 to 100. The higher the number, the less the oil viscosity changes with temperature change.

## Types of Lubrication System

6. Engine parts are lubricated in different ways in different engines. Following are different types of lubrication system:

a. **Petro-oil System.** This is the simplest form of lubrication system and is generally adopted in two stroke petrol engines. There is no separate part exclusively meant for lubrication such as oil pump. The lubricating oil is mixed with petrol according to prescribed ratio, which is usually 1 to 30, during fuel filling in the tank. When fuel is induced into the crank chamber during engine operation, lubrication particles go deep into the bearing surfaces and lubricate them. The main drawback of this system being that lubricating oil separates off from petrol if allowed to remain unused for a considerable period. It leads to clogging of passages in the carburetor resulting engine starting trouble.

b. **Splash System.** In this system, lubricating oil is contained in the oil sump. When the engine operates, oil is splashed in the crank chamber by means of flywheel, crank webs or dippers attached to big ends of connecting rods. The splashed oil spread over likes the mist and runs into minute clearances resulting in their lubrication. The engines, which are provided with dippers to splash oil, contain turfs below the dippers in the sump. These turfs remain filled with oil to which the dippers dip into and splash oil. Splash system mostly works in collaboration with pressure feed lubrication system in an engine, some parts being lubricated by splash system whereas some by pressure system. In four-stroke engine, splash system lubricates cams of the camshaft, tappets, cylinders, pistons, piston pins and rings and valve guides, valve stems and springs, inside valve-engine(Fig-2).

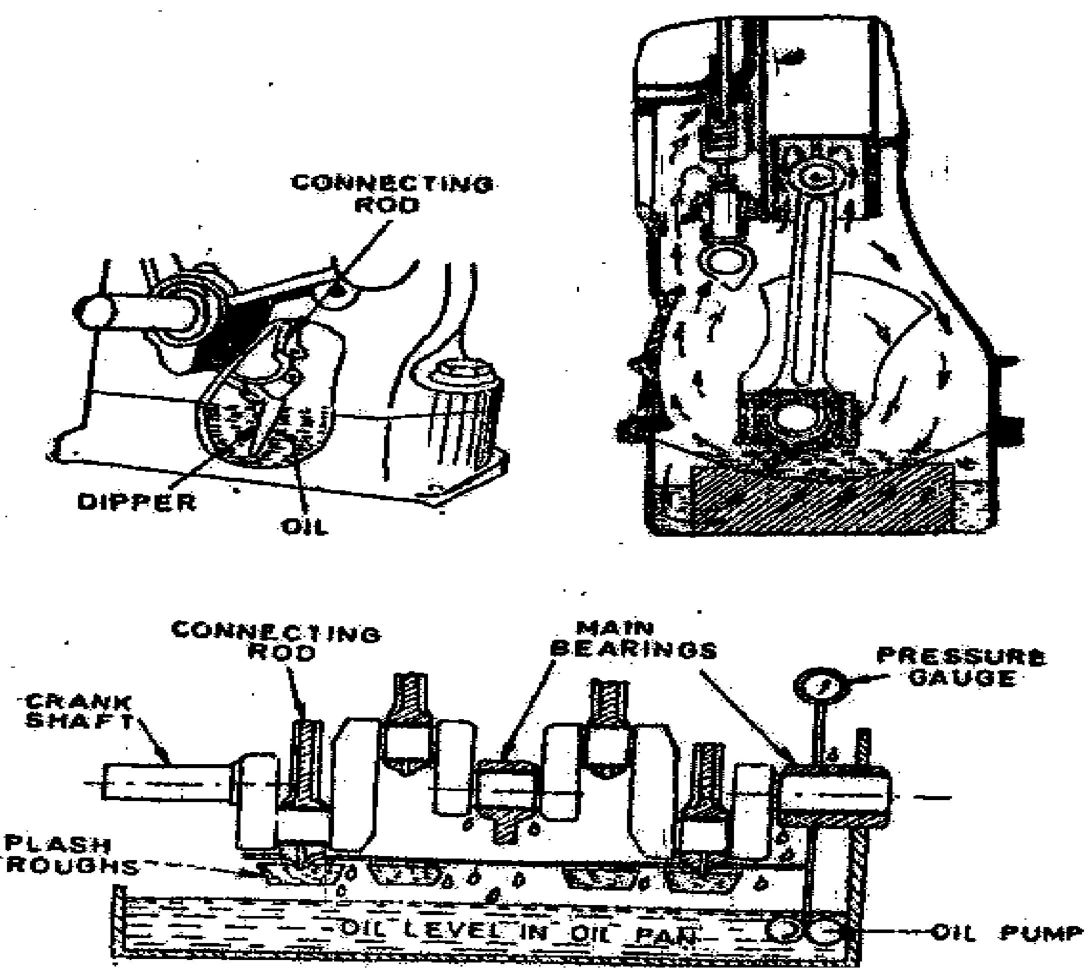



**Fig-2 Splash Lubrication System**

c. **Semi-pressure System**. Engine, in which some parts are lubricated by splash system and some by pressure system, is said to be having semi-pressure lubrication system. Almost al the four stroke engines are lubricated by this method now a days.

d. **Pressure System**. Engine parts are lubricated under pressure feed in this system. The lubricating oil is contained in the oil sump or in a separate tank from where oil is pumped to the engine gallery. The oil then flows under pressure to main bearings of crankshaft and crankshafts, big end bearing of connecting rods and in certain cases small end bearings of connecting rods and timing gears or sprockets and chains. In overhead valve engines, rockers, rocker shafts, valve stems, guides and springs etc, are also lubricated by pressure feed system. The lubricating oil flows to various parts of the engine through the specially built in passages. In order to control the pressure of oil in the system, an oil relief valve is provided which releases the built in high pressure. The pressure of oil in the system is indicated by the oil pressure gauge provided in the instrument panel of the vehicle. Oil filters and strainers clear off the oil from dust, metal and other harmful particles. In certain engine nozzles are provided in the sump, through which oil under pressure is sprayed on the cylinder walls. This arrangement is provided in Chevrolet engine (Fig-3).

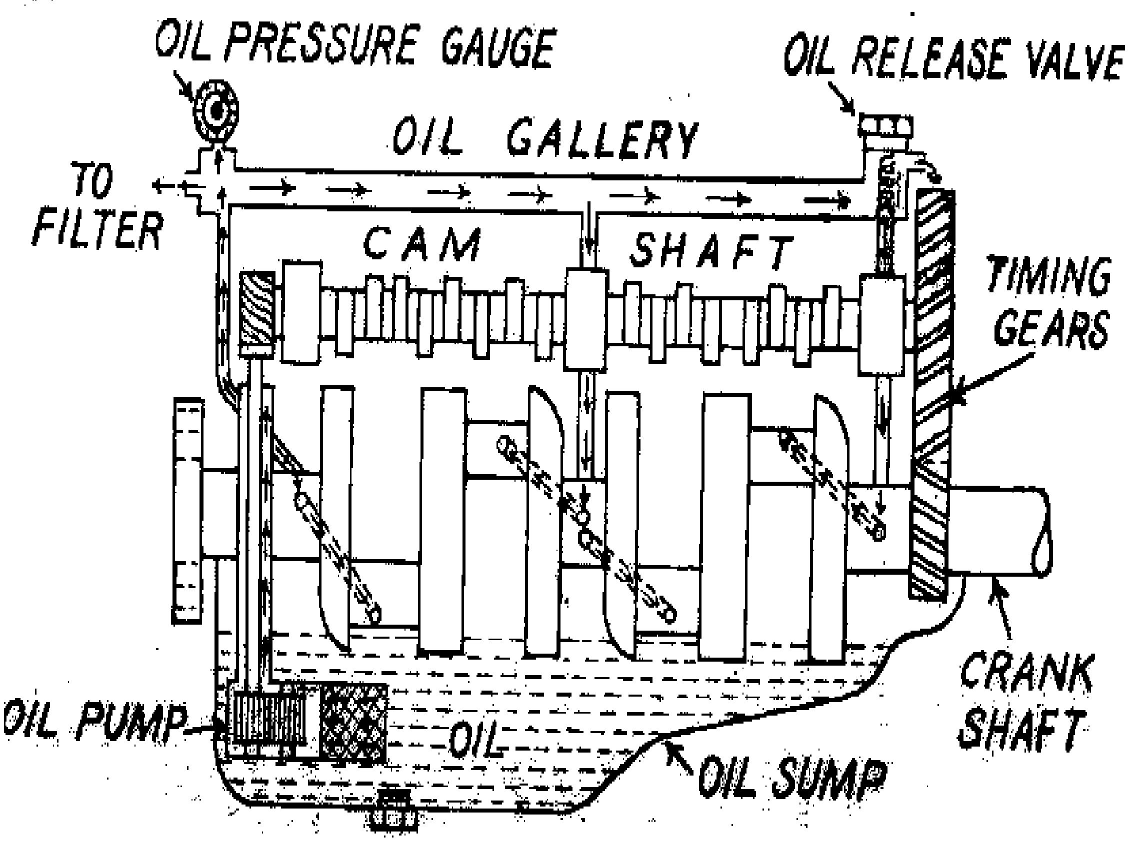



**Fig-3 Pressure Lubrication System**

e. **Wet Sump System**. As mention in the description under pressure system, oil for lubrication is contained in the oil sump in most cases. The systems, in which lubricating oil is contained in the oil sump, are known as wet sump lubrication systems (Fig-4).

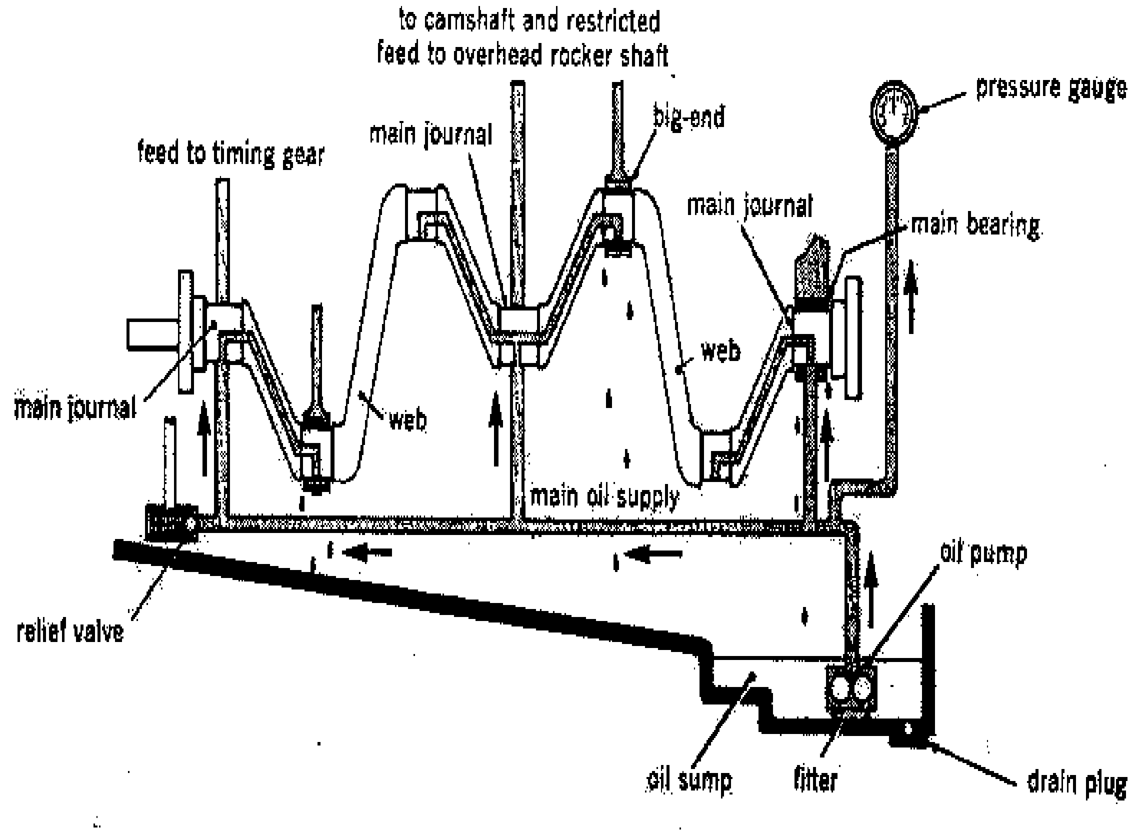



**Fig-4 Wet Sump Lubrication System**

f. **<u>Dry Sump System</u>.** In some engine, lubricating oil is contained in the separate tanks from where it is fed to the engine. The oil, which falls into the oil sump after lubrication, is send back to the oil tank by a separate delivery pump. The lubrication system, in which lubricating oil is not kept in the oil sump, is known as dry sump system. In this system, two pumps are provided, one to fed oil and another to deliver oil back to the oil tank. Usually motorcycles and aircraft engines employed this type of lubrication system. The main advantage of this system being that during up and down movement of the vehicle, there is no apprehension of breakdown in oil supply. In engines employing wet sump system, the oil collects in the rear or front part of the sump when the vehicle rises up or down the high hills (Fig-5).

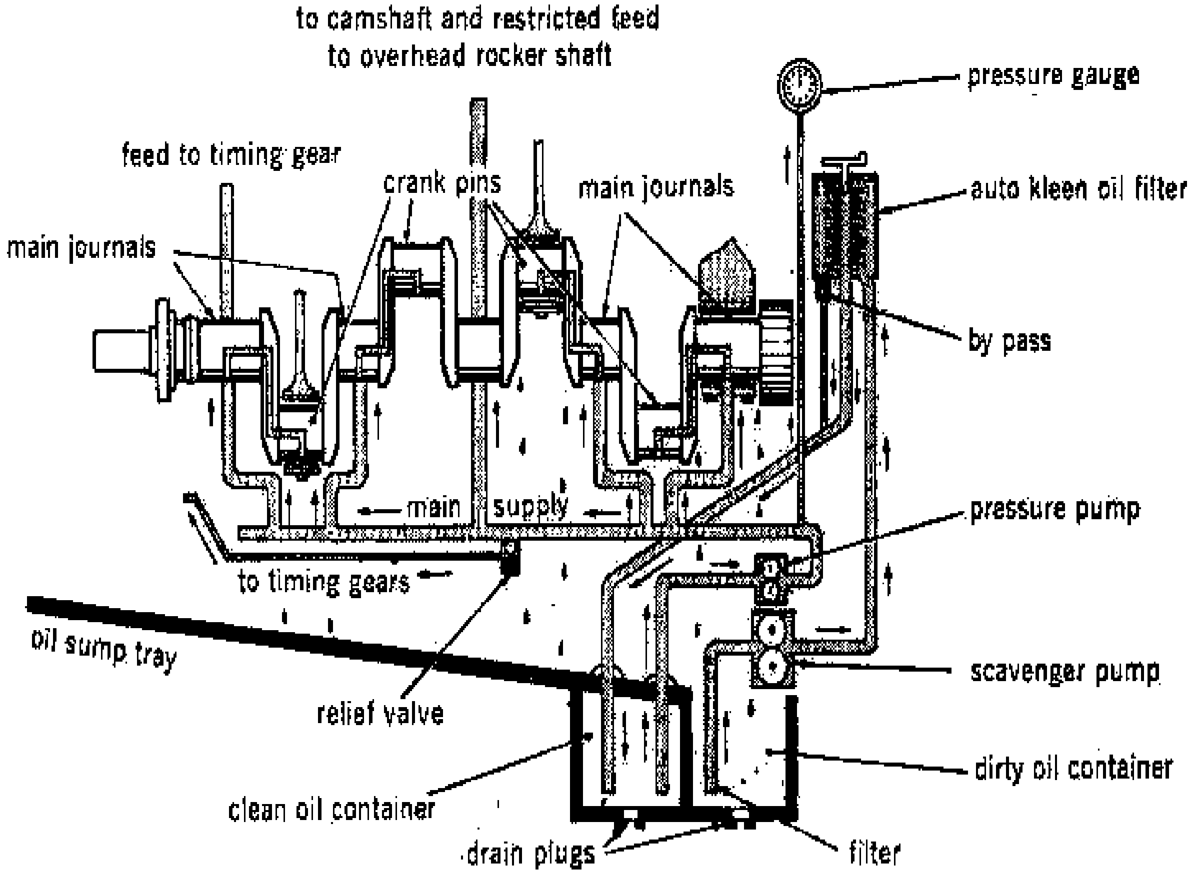



**Fig-5 Dry Sump Lubrication System**

**Parts of the Lubrication System**

7. The lubrication system in the four-stroke engine consists of the following parts:

a. **Oil Sump**. It is the lower bottom part of the engine, which provides covering for the crankshaft, and other parts contained in the crank chamber. In wet sump lubrication system, oil is contained ion it that is why it is known as oil sump or oil pan. It is usually made of steel pressings. In some cases, it is made of aluminum or cast iron. It contains a drain plug at its bottom to drain out oil. A Barrel for dipstick is screwed into in it in some cases. A connection for oil line is also made in some engines. Baffle plates are provided in the sump to avoid surging of oil. In some cases, it contains an oil well to house oil strainer. In case of dry sump lubrication system, lubricating oil is contained in a separate tank. This tank contains one filler hole through which oil is filled into it. There are two other holes at which connection is made for the inlet and outlet of oil. The tank contains an oil strainer. Oil coming back to the tank is strained through the strainer before it is fed to the engine.

b. **<u>Oil Pump.</u>** The following types of oil pumps are used in the engine lubrication system:

(1) **<u>Gear Type Pump</u>**. This type of pump contains two spur gears, which rotate in the body. One gear is fixed with the drive shaft where as the other gear is mounted on a pin. The second gear is free to rotate around its axis i.e. pin. In same cases the driveshaft contains a gear through which connection is made with the camshaft from where it gets drive. In some cases, the drive shaft contains a slot at its end, which fits the distributor shaft end notch. In this case, the drive from the camshaft is through the distributor. The pump contains two holes, one serving as inlet and the other acting as out let. The inlet hole is connected to the strainer where as the out let is connected to the oil gallery. There is a bypass in the body of the pump, which contains an oil relief valve to release oil when high pressures are built up. During fitment with the engine, the pump is filled with oil. When the engine works, the drive gear of the pump drives the idler gear. Since the gears work in oil field housing so, the movement pushes oil out of the chamber. Oil from the inlet travels forward to take the place of thrown out oil. This way a circulation is setup due to which oil is are drawn from the oil sump and pumped out to the oil gallery. Gear chamber is kept well tight so that oil may not leak away. Usually the chamber portion of the pump is kept submerged in the oil sump (Fig-6).

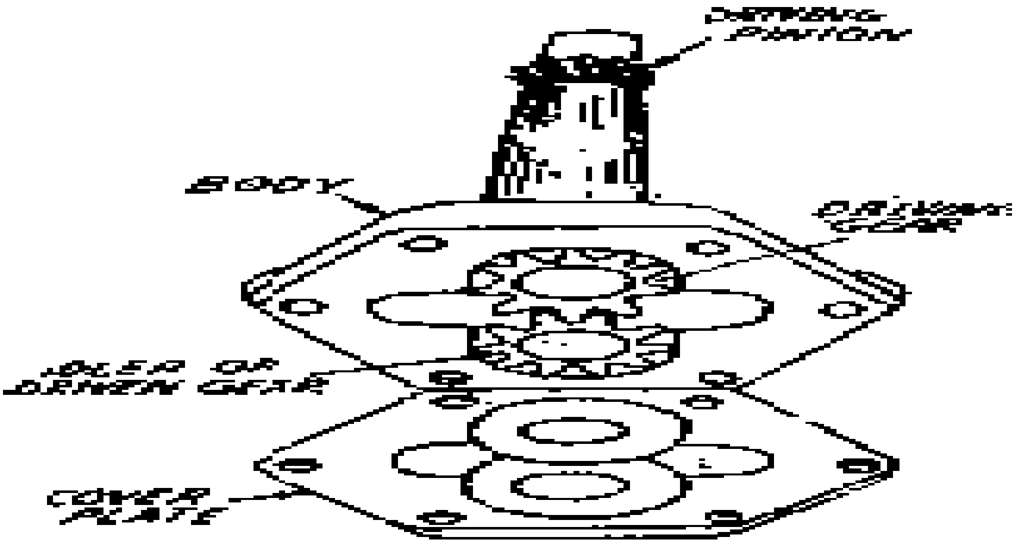


**Fig-6 Gear type Oil Pump.**

(2) **<u>Rotor Type Pump</u>**. The construction of this type pump very much resembles with gear type pump. In rotor type pump, there are two rotors, one inner and other outer in lieu of gears. The inner rotor is fixed with the drive shaft and gives drive to the outer shaft. When the pump shaft rotates, oil is filled in to the segments of outer rotor. Oil is squeezed in the outer rotor due to the movement of inner rotor. Oil under pressure is then pushed out through out let hole

(Fig-7).

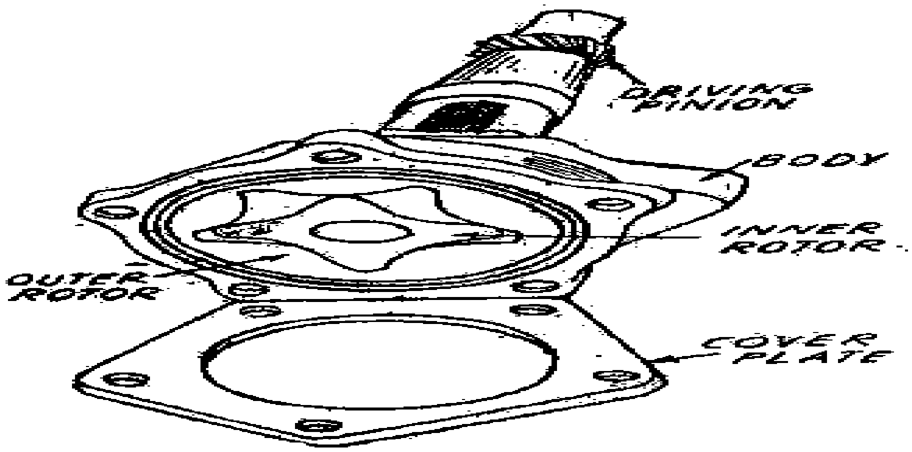



**Fig-7 Rotor type Oil Pump.**

(3) **Plunger Type Pump.** In this type of pump, a plunger works up and down in a barrel. Up and down movement is affected by a cam on the engine camshaft or by an eccentric provided at the crankshaft. Up ward movement of the plunger creates suction in the barrel and oil is sucked in from the oil sum or tank, through a non-return valve housed in the pump. When the plunger moves down, oil trapped in to the barrel during up ward movement, is pumped out through out let check valve.

c. **Oil Relief Valve.** At higher engine speed, greater pressures are developed in the pressure feed lubrication system. If the high pressures are not released, oil lines may burst or backpressure may develop which will hold the movement of pump and other engine parts. In order to release high pressure built in the system, oil relief valve is employed. It opens the oil pressure riches the pre determined limit. This limit is adjusted by Increasing or decreasing the tension of spring in the valve. Oil relief valve contains ball, plunger or flap, which is kept against the hole of oil passage. A spring keeps the ball, plunger or flap pushed against the hole. Due to high pressure, the ball, plunger or flap is lifted off the seat and oil goes out through it. Oil relief valve is located in the oil pump bypass or in the oil gallery (Fig-8).

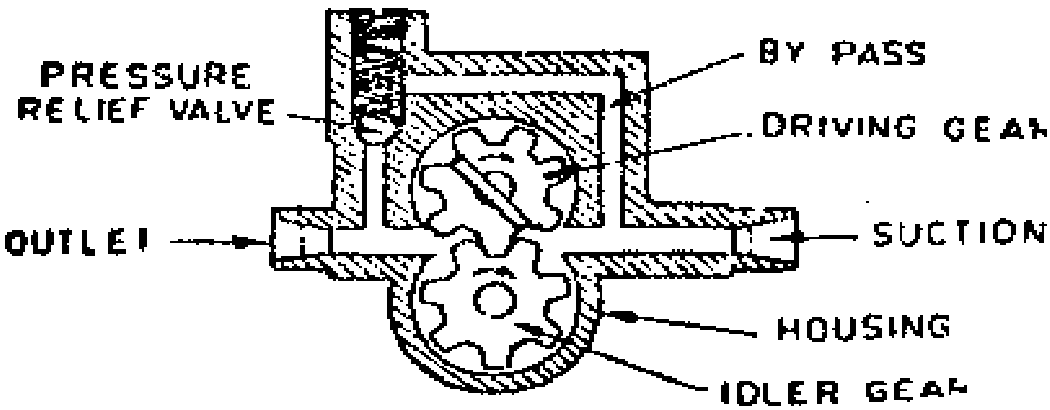



**Fig-8 Oil Relief Valve**

d. **Oil Filter.**

(1) **Introduction.** As the name indicates, lubricating oil is filtered through it. Lubricating oil serves several purposes in the engine. During engine operation, metal particles removed due to wear and tear, dirt and other harmful particles are washed away into the oil sump. If oil is not freed from these harmful particles, engine life will decrease as these particles will come in the way of moving parts, there by restricting their free movement and leading to more friction. Oil filter catches these particles and makes the oil free from them. Oil filter consists of a round container, which is closed at one end, a central tube filtering element, a cap, spring and holding down bolt. The filtering element contains a through hole in the center into which passes the tube which is fixed in the center of container. After putting in filtering element, the cap is held over the open end of container by means of holding down bolt. The spring is held between the cap and strainer at the center. This keeps the strainer held down. When all parts are held in position, the upper end of the tube is closed by the holding down bolt as it is screwed into it. The lower end of the tube acts as outlet for the filter. A tiny hole is provided at the upper part of the tube through which oil from, the filtering element enters into the tube for outlet. An inlet connection is made at the upper of the container through which oil enters into the filter. This type of filter is placed in the bypass so that regular flow of oil may not be restricted due to clogging of filtering element. This type of filter is known as bypass filter. There are two types of oil filters, which are given below:

(2) **Types of Oil Filter.**

(a) **Bypass Filter**. Its construction has been explained above. Since it not placed in the direct passage of pressure feed lubrication system so only a part of the oil fed to oil gallery by the oil pump, is filtered. The inlet connection for this oil filter is taken from oil gallery and outlet connection is made at the pump (Fig-9).

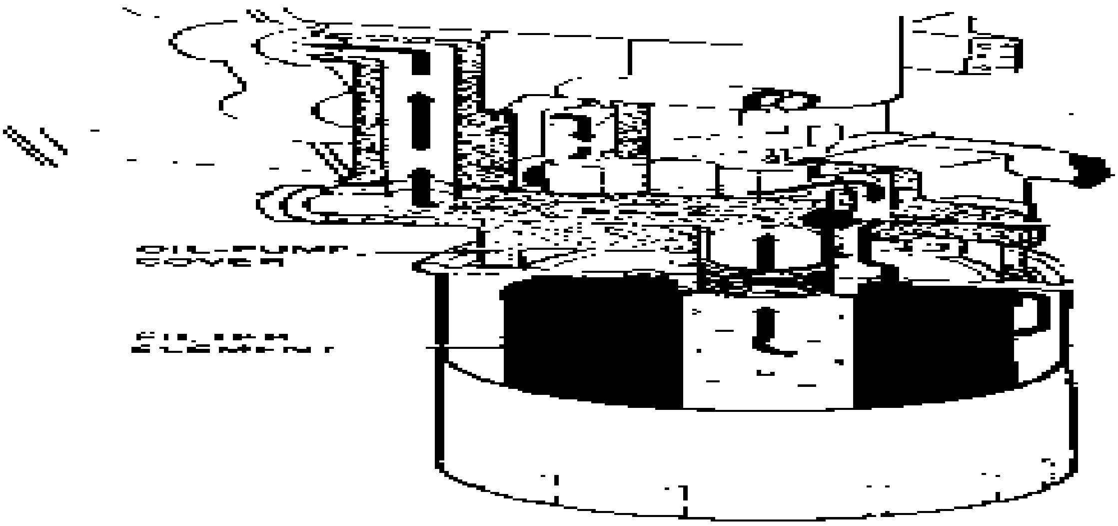


**Fig-9 Bypass oil Filter.**

(b) **Full Flows Filter**. The filter is placed in the direct passage of pressure lubrication system and whole of the pumped oil is filtered before it is fed to lubricate engine parts. A bypass is provided in this type of filter. A pressure spring type non-return valve is placed in this by pass, which opens when high pressure is developed due to clogging of filtering element. This valve saves the engine from the destructive consequences of oil supply failure due to blockade of filtering element. It is therefore quite necessary that the filtering elements are cleaned or replaced as per manufacture's instructions within due period.

e. **<u>Oil Dip Stick</u>.** It is a steel stick graduated at the front end for measuring the amount of oil in the sump. The graduations are in different forms. In one form marks of "Full", "Half", "Empty" and their parts are provided. In another form, the marks are indicated by the words "Full" "Half" or "Danger". The danger or empty region contains cross-hatchings. These marks show whether the oil is up to the required full or half level or the level is so low, which may cause danger to engine life. For measuring oil level, the stick is removed from the engine, cleaned, dipped into the oil sump and again taken out to see up to which graduation oil has sticked. This will show the amount of oil in the sump. Since this stick is dipped into oil to find out the level, so this stick is known as oil dipstick (Fig-10).

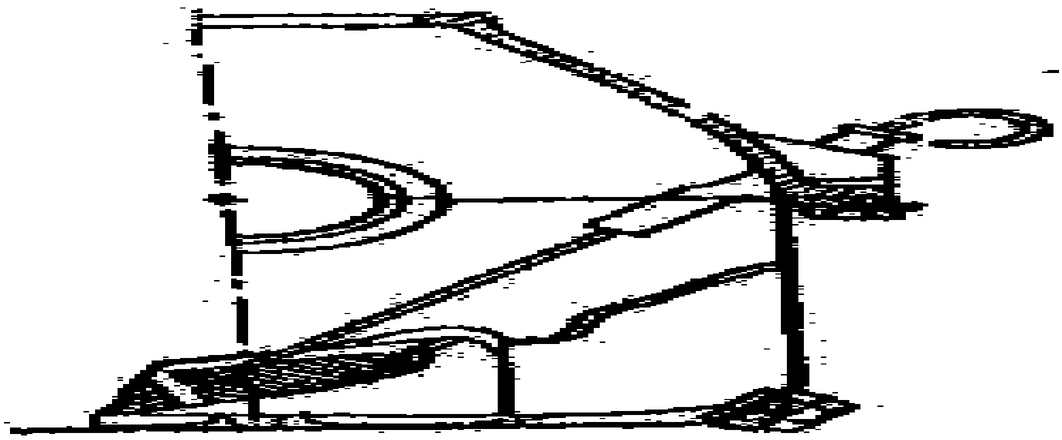


**Fig-10 oil Dip Stick**

f. **<u>Oil Pressure-indicating Light.</u>** It is a warning light provided at the instrument panel and indicates the presence and absence of oil pressure in the pressure system. It is a small red light, which is separated by means of oil pressure operated switch. The switch is located somewhere at the oil gallery. Its connection with the warning light is through the ignition switch. When engine is working and there is sufficient oil pressure in the pressure system, the indicating light switch is open due to oil pressure effect on it and no current flows to the light. During this occasion, the warning light is off. As soon as oil pressure in the pressure system falls down due to any breakdown in the system or engine stoppage, the warning light switch is closed and the light starts to glow. If the engine is not running and the ignition switch is put on, this warning light should glow. If it does not glow, it may be due to some defect in circuit (Fig-11).

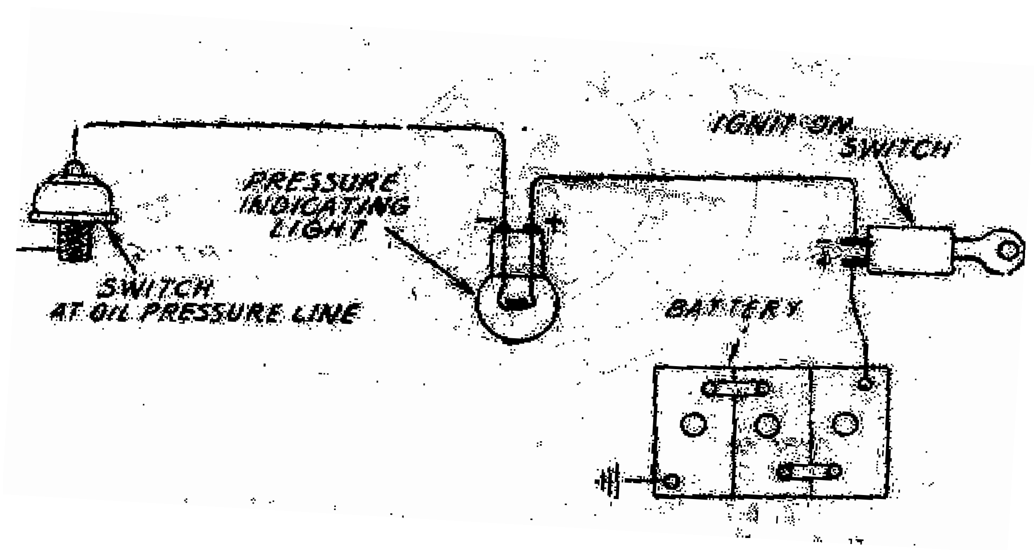


**Fig-11 Oil Pressure-indicating Light**

g. **Oil pressure Gauge.** As its name indicates, it is a gauge or indicator which records oil pressure prevalent in the pressure system. Oil pressure gauges are of two types as mentioned below.

(1) Pressure expansion type.

(2) Electric type.

h. **Breather.** This prevents crankcase pressure rising above atmospheric pressure (14lb/sq in).

J. **Oil retainers.** Oil retainers, in various forms, are usually used between rotating shafts and casings to prevent the leakage of oil; e.g. adjacent to the crankshaft rear main journal, some oil retaining devices are usually incorporated. It may take the form of an oil thrower ring, shaped so as to deflect the oil into oil ways or ducts communicating with the pump. The device may be an oil return thread, cut into or raised, so that it traps the oil and runs along the thread, thus being screwed back and so returned to the sump. When leakage is found from a system using this method of retention, it is usually due to foreign matter blocking the thread, thus preventing the normal oil return action. Other causes could be excessive wear on the shaft and its bush or housing.

## Flushing of Lubrication System

8. a. **Purpose**. To clean the lubrication system's foreign matters.

b. **Checking**

(1). Check up the colour of oil.

(2) Check the external leakage of the system.

(3) Check up the functioning of the gauge.

(4) If pump does not function properly, check and overhaul the pump

(5) If pump is removed, fit new gasket.

**Operation**

c. The operation should be performed in the following manner:

(1) Place the vehicle in a position favorable to the effective draining of gearbox engine sump and rear axle.

(2) Securely chock the front wheels of the vehicle in both directions, and jack up rear wheels clear of the ground.

(3) Run the engine to bring it at the normal working temperature.

(4) Removed the drain plug and leave it opened till the oil is fully drained.

(5) Tighten the plug and refill half the level of the system with flushing oil (store Ref No. 34D/68 OM 21).

(6) Run the engine for about 10 minutes in normal way and drains the oil.

(7) Top up with correct grade of oil and test the engine.

(8) If flushing oil is not available recommended engine oil may be used for flushing purpose.

(9) If the engine is new / recondition oil must be replaced after 700miles (Ref. AFO.37 / 57).

***Note:*** Draining is best carried out when the vehicle has just completed a run, as oil being then warm, will flow readily.

**Routine Servicing Of Lubrication System**

9. a. **Purpose.** To maintain an accurate and constant clean oil level in the sump.

b. **Description.** The oil level is to check daily by the driver with the help of the dipstick and poured more if required. The specification of oil must be the same as directed by the makers. On every three monthly inspection the oil in the sump is drained off and replaced by new engine oil of the same specific gravity as laid down or mentioned in the maker's specification.

**BAF BASE ZAHURUL HAQUE (TRG WG)**
**(Aero Engg Trg Sqn)**

Syllabus : Automobile Diesel and Technology

**Course : Trade Training Basic, MTOF**

**Subject : Chassis, Frame and Suspension**

**Aim : To Study Chassis Frame**

Ref. : AP 3159, Section 8, Chapter 1

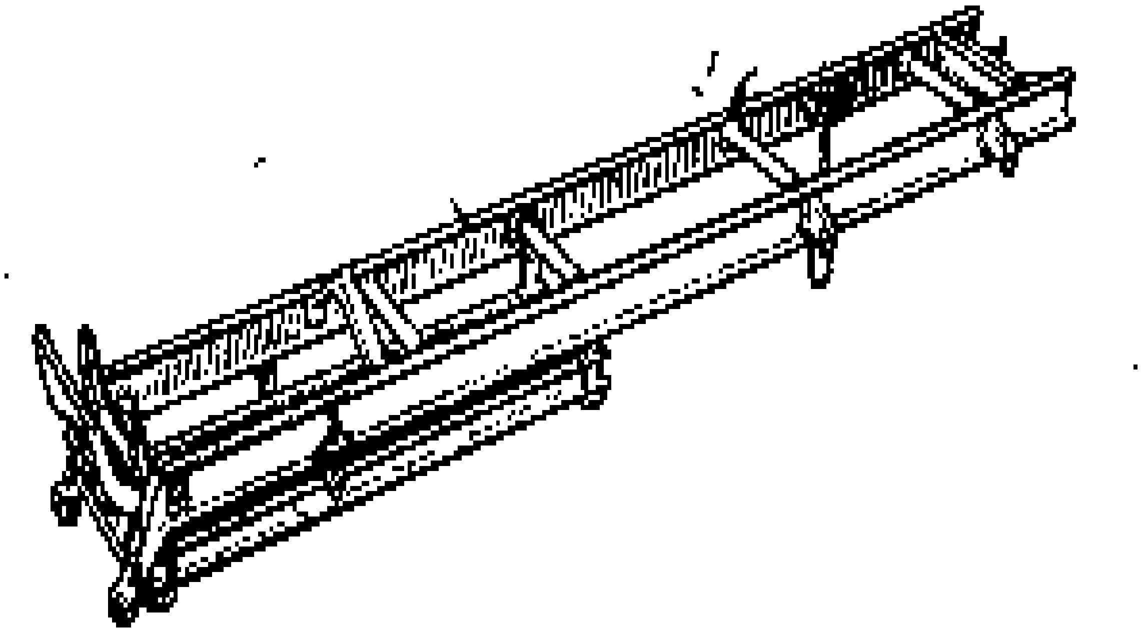
# CHASSIS FRAME

## Purpose

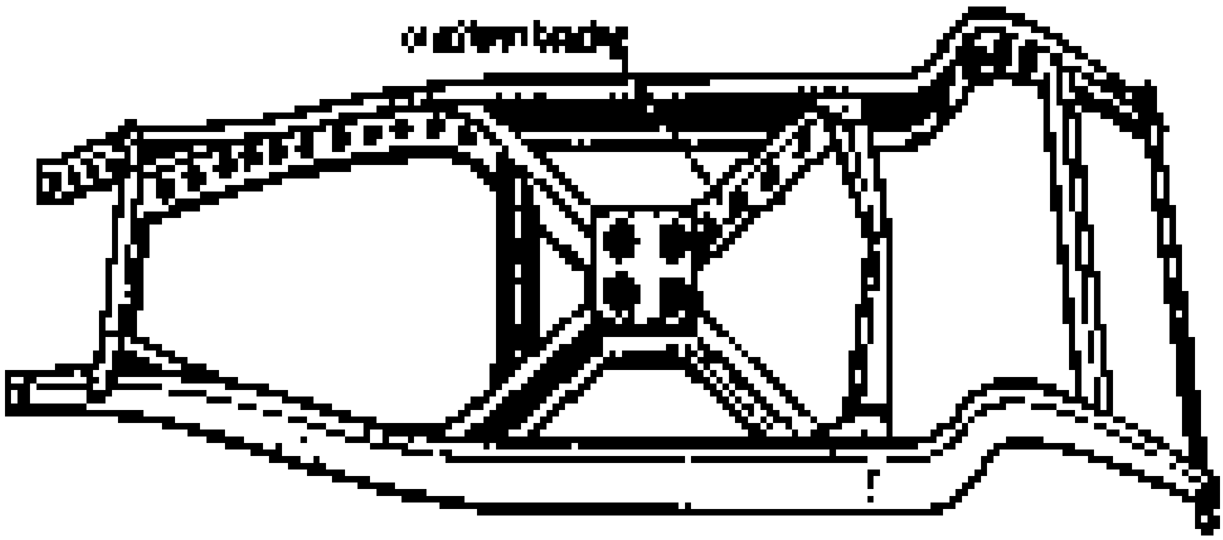
1. The chassis frame of an automobile is the basic structure to hold the engine, transmission, steering, body and suspension.

## Description

2. Early types of chassis frames were rectangular in shape and consisted of two side-members of channel or “U” section steel, interconnected by cross-members of similar or tubular section (Fig-1). The form of construction is now mainly used for heavy vehicle chassis frame as it has certain disadvantages when used for light vehicle chassis. The higher road speeds of light vehicles made it necessary to lower the center of gravity by lower mounting of the chassis. So enable the front wheels to be turned on an adequate lock the front chassis members are in swept and clearance for the raise and fall of the rear axle on its springs is obtained by arching the rear chassis members. The rear chassis members are also swept out and the rear springs mounted as near as possible to the rear wheels to achieve maximum stability. This light chassis with plain cross members were also found to be insufficiently strong in resisting the forces, tending to distort the frame along the diagonals from corner to corner, thus cruciform bracing of the chassis was introduced to overcome this weakness. Two channel section members shaped in to wide “Vees” and joined at the apexes with vended or riveted plates are attached to the side members by welding or riveting with gusset plates. The increased use of wilding has facilitated the forming of box sections; formerly the open side of the channel section side member was necessary to give access for bolting or riveting. A further type of chassis fabricated from pressed steel is now in general use. This is known as chassis body, integral or mono construction. The basic structure is an under ground or floor structure consisting of side members, cross members, floor and others components welded together to form one assembly. For added strength and rigidly the surfaces are ribbed and dished. Attached to this by welding or bolting is the pressed steel body shell. A stub-frame is often attached to the front of the body shell to carry the engine and suspension.



Heavy vehicle frame



**Light vehicle frame**

**Fig-1 Heavy and Light Vehicle Frame**

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

Syllabus : Automobile Diesel and Technology

**Course : Trade Training Basic, MTOF**
**Subject : Chassis, Frame And Suspension**
**Am : To Study Chassis Frame**

Ref. : AP 1464E Voll. 1 Part 1 Section 7, Chapter 1

## FRAME ALINGMENT CHECK

### Purpose

1. Purpose of frame alignment check is to reduce abnormal and un-even tyre wear, unbalanced and possibly poor braking and transmission misalignment.

### Procedure

2. To check the alignment of a vehicle with the road wheels in position, the vehicle should be run on to a hard level floor. If the wheels have been removed, the chassis should be supported over such a floor on suitable jacks or trestles. The main features of the frame should then be projected from the frame to the floor using a plumb bob and line. If the floor is not suitable size should be fastened in position on the floor with the center of each sheet approximately under each point to be projected, the projected point can then be marked on the paper. For a small frame it is normally sufficient to project the suspension brackets, but for a larger frame, the point projected should include the ends of the side members are joint between side and cross members. When all the necessary points have been marked, the vehicle or chassis frame should be withdrawn to facilitate further work on the plot. The frame widths, front and rear, should be checked and points marked midway between the frame width marks. The intersections between the diagonal line joining the various points should then be marked, either on the floor, or further sheets of paper, if straight edge of suitable length is not available, the intersections may be obtained by stretching thread between the points connected. The center line of the frame can now established by drawing a line through the center point of one end of the frame and the inter sections of any two, or more than two, sets of diagonals. Any distention of the frame will be indicated by the intersections of diagonals in the region of the distortion being offset to the true centerline. Checking the lengths of each diagonal of an interesting pair will assist location of the distorted section; these lengths should be equal and in-equality is a further indication of distortion. The amount of distortion can be finally determined be checking the location of the point concerned with regarded to the centerline. This is most easily done by striking arcs, with the points concerned as center, to cut the centerline and comparing these with arcs struck from points known to the correct. Individual members or portions of the frame that should be straight can often be checked for alignment by stretching a length of thread along the edge of the member concerned; they can be chucked also for twist by the use of squares and straight edges laid across the top of the frame.

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

Syllabus : Automobile Diesel and Technology

**Course : Trade Training Basic, MTOF**

**Subject : Chassis, Frame and Suspension**

**Aim : To study Road Springs**

Ref. : AP 3159, Section 8, Chapter 2

# ROAD SPRINGS

## Purpose

1. The purposes of road springs are as follows:

a. Transmit the weight of the vehicle and its load to the axles and road wheels with flexibility.

b. Absorb the road shocks.

c. The springs are usually acted as the means where by the axle are secured by the frame and they prevent any relative sideways or lengthwise movement between axles and frame.

d. Furthermore the front springs have to resist the braking torque of the front wheels and when the Hotchkiss type of drive is used, the road springs takes both the braking and driving torque.

## Construction

2. The road springs use on almost all types of vehicles ion the BAF are of "laminated leaf" construction and they are composed of a n umber of tempered spring steel plates which are graduated in length and degree of camber and held together by a center bolt and cut. The number, length and thickness of the leaves is determined by the load, the spring will have to support the longest leaf is usually known as the master leaf with end turned over the house a phosphor-bronze bush or silent-bloc through which the springs can be bolted to the chassis. Some springs are enclosed in flexible leaf leather gaiters, which retained lubricating grease and exclude dirt, other spring assemblies have thin inter leaves of zinc or other nonferrous metal which prevent the steel leaves corroding on one another. When the spring's eyes are fitted with phosphor bronze bushes, the shackles pins or bolts are fitted with a lubrication nipple, but when "silent bloc " is used, lubrication is not necessary.

## Types

3. The types of road springs are follows:

a. **The Semi-Elliptic Springs**. Road springs of semi-elliptic shaped are fitted on all kinds of vehicles, varying from the lightest to the heaviest. The method on mounting these springs to the axles and frame of the majority of vehicles as follows. The forward end of the road spring is bolted to the dumb-iron or other suitable mounting. So that the spring ha no lateral movement, but only a limited pivotal movement about the shackle pin. The rear end of the spring is secured to the frame by means of a shackle, which pivots about a frame anchorage and provides for the variable relation between the front-end rear bushes throughout the continuous flexing of the spring. There are some vehicles on which the springs are mounted differently and the swinging shackle is carried on the front end of the spring, the rear end is mounted on a bracket which does not permit any lateral movement, but only pivotal movement about the shackles pin. This latter arrangement is adopted to prevent the up and down movement of the front axle interfering with the steering mechanism. Thus when the rear of the front spring is pivoted to the frame, the axle moves about the pivotal connection to the spring which coincides approximately with the ball joint connecting with rear end of the drag link to the drop arm. The front thus moves approximately on the same radius as the drag link. When used a rear axle fitted with a torque tube, semi-elliptic spring is attached to the frame at each end by means of a shackle in the same way as front spring. One of the disadvantages of the semi-elliptic spring is that the greater part of its weight is a un-spring weight. The shackle pins or bolts, made of casehardened steel, are very heavily loaded therefore their lubrication is of the utmost importance (fig-2).

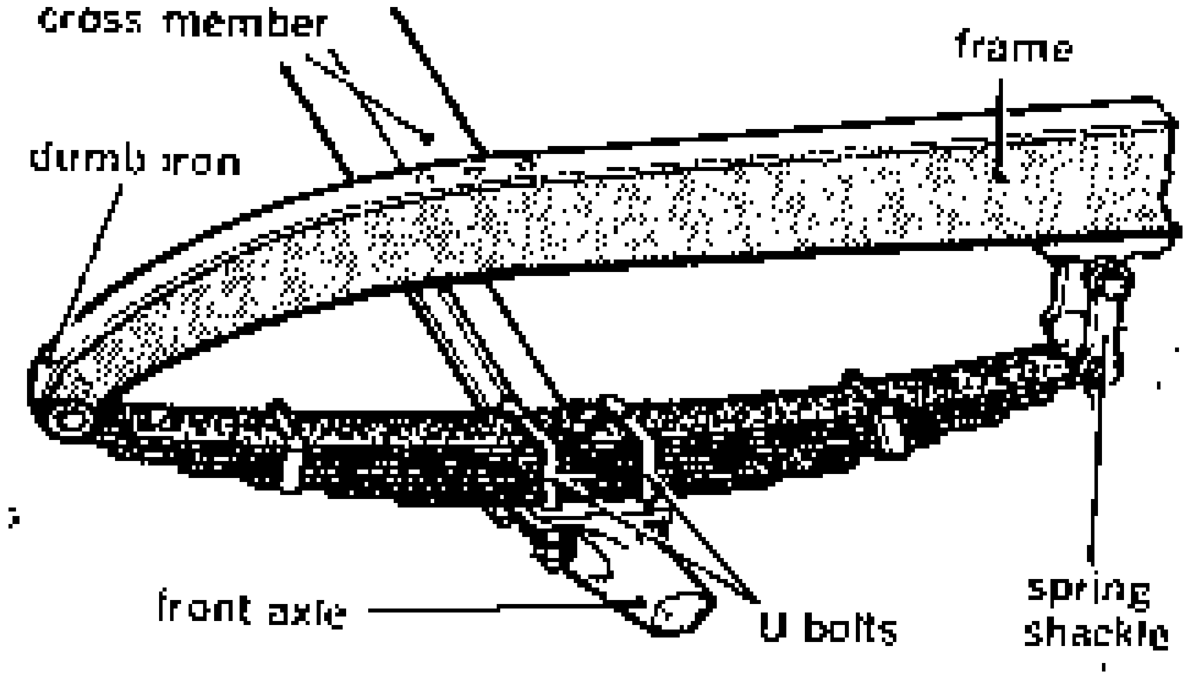



**Fig-2 Semi-elliptic Springs**

b. **The Cantilever Spring.** Strictly this type is a double cantilever spring. It is a laminated spring with very little or no camber on the leaves. This type of spring is used for rear axle suspension only and is secured to a pivoting turning, usually situated at its center, the turning being riveted to the frame. The front end of the spring is secured to a shackle on the frame and the rear end is secured to the rear axle. Thus, the two portions of the spring, one on either side of the turning, can act or flew independently, having the effect of a double spring. Radius rods and torques tubes are necessary to absorb the driving and braking torque. One advantage is that most of the weight can be considered as spring weight, on the other hand the turning become an additional bearing needing lubrication and is subject to wear (Fig-3).

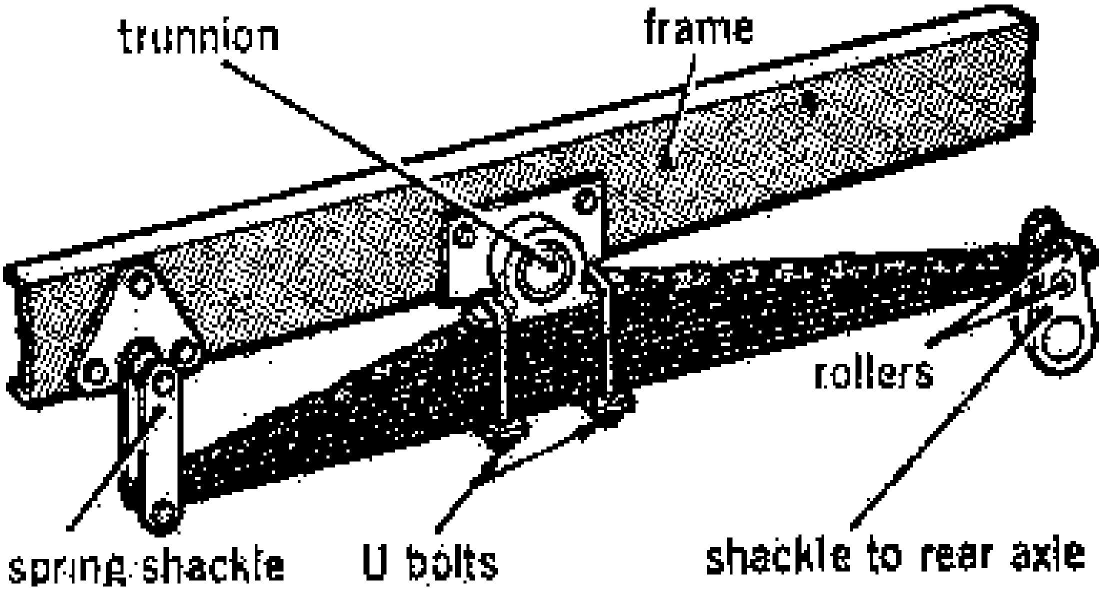



**Fig-3 Cantilever Spring**

c. **The Quarter Elliptic.** This is a true cantilever and is mostly used on rear axle suspension for light and medium vehicles. It has also been used for front axle suspension on sports and racing cars. Thick end is secured rigidly to the frame and other end mounted to the axle. Radius rods or torque tubes are fitted with this type of spring because it does not absorb the driving and braking reactions. The frame is subjected to extra stress where the spring are attached and it is therefore, reinforced. The upspring weight is very small (Fig-4).

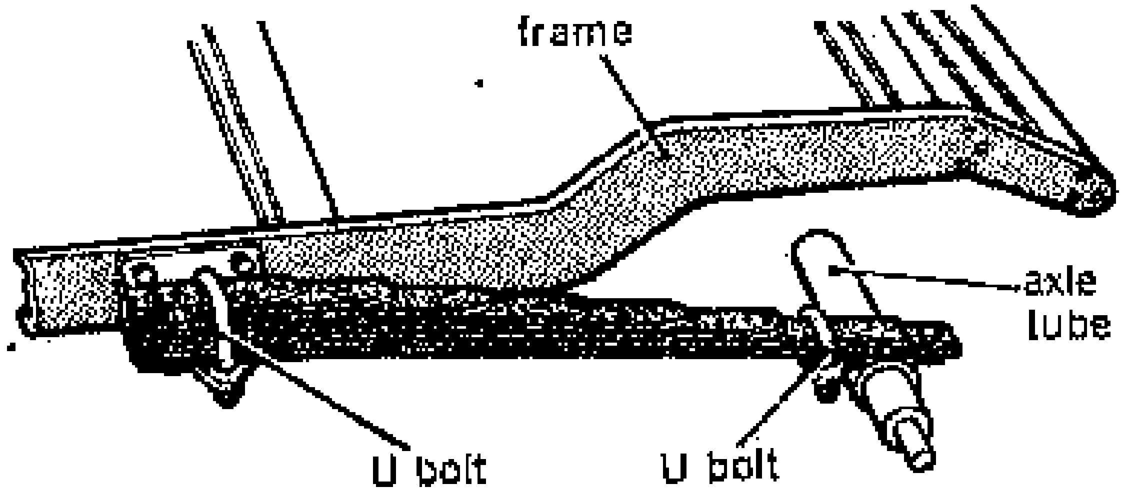



**Fig-4 Quarter Elliptic**

d. **The Transverse Spring**. With the three types of spring are described above, four per vehicle are required the two front springs and two rear springs. With the transverse spring only one spring for axle is required. The transverse spring is semi-elliptic spring attached rigidly to the front or rear cross member at its center by heavy "U" bolts, the ends of the spring is mounted to each end of the front or rear axle by shackles and bolts. Both front and rear transverse road springs having additional braking from the axle to the frame in the torque or radius rods which are fitted to stop any forward or rearward movement relative to the frame. The rods are absorbing the braking and driving torque (Fig-5).

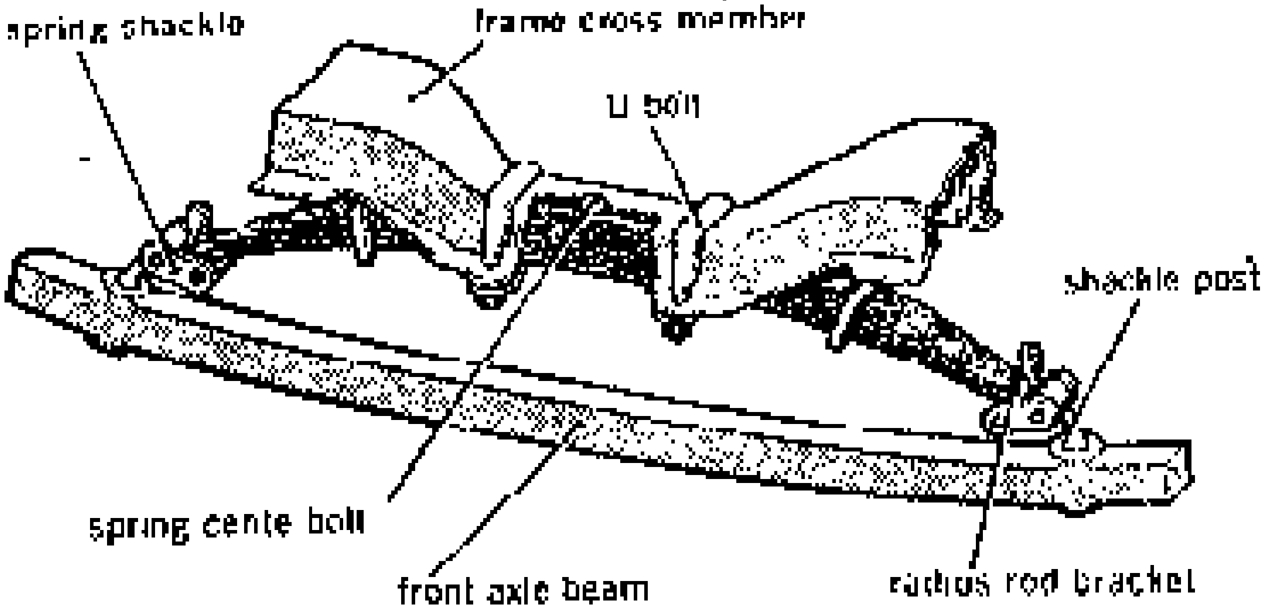



**Fig- 5 Transverse Spring**

## Servicing

4. The maximum periods between servicing operations on the suspension system are given in AP 3260. Lubricating points are usually provided on shackles pins, fulcrum pins and turning bearings where normal pressure lubrication is required. If no such provision is made, it is an indication that the component does not require lubrication e.g. an bonded rubber bush or that is requires special lubrication and in this case the required information could be obtained from AP 3260 or from relevant vehicle AP.

## Lubrication

5. Lubrication nipple should be kept clean. Soaking in kerosene can rectify a blocked nipple. When pressure lubrication is applied, it should be ensured that the lubrication penetrates to the bearing surfaces. If clean lubrication is seen to from the ends of the bush or bearing, this is a good indication that sufficient lubricant has been applied. Some leaf springs are not lubricated, but where the lubrication is specifies oil OM 21 for the spraying of road springs. If this type of oil is not available a substitute is prepared by thinning engine oil with kerosene, which is suitable for spraying. Before lubricating a road spring the weight of the vehicle relived by using a jack under the chassis frame and in some causes the removal of the spring clips, will enable the leaves to be separated, so that the lubricant can reach all required surfaces. In desert area lubrication of road springs is harmful due adherence of sand and grit to oil on the spring which can lead to the formation of an abrasive paste. In such localities instructions will be issued to prevent damage to the springs, e.g. by fitting of suitable gaiters.

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

Syllabus : Automobile Diesel and Technology

**Course : Trade Training Basic, MTOF**

**Subject : Chassis, Frame and Suspension**

**Aim : To Study Shock Absorbers**

Ref. : AP 3159, Section 8, Chapter 3.

---

# SHOCK ABSOBERS

## Purpose

1. Shock absorber is used in addition to road springs for the comfort of the driver and the passengers with the minimum stresses on the frame and springs.

## Description

2. When deflected all the road springs has a tendency to oscillate about the normal static position, so spring dampers or shock absorbers must be included in the suspension system. The energy, given the spring by the wheel hitting a dump, is absorbed by the shock absorbers; the two methods used are friction damping and hydraulic damping. The shock absorbers are in use on service vehicles are of hydraulic type. The two main types. The hydraulic type is the radial lever position type and the direct acting telescopic type. In both cases they operate on the principle of hydraulic displacement through a restricted orifice from one chamber to another, brought about by the relative movement between the axle and the chassis of the vehicle (Fig-6).

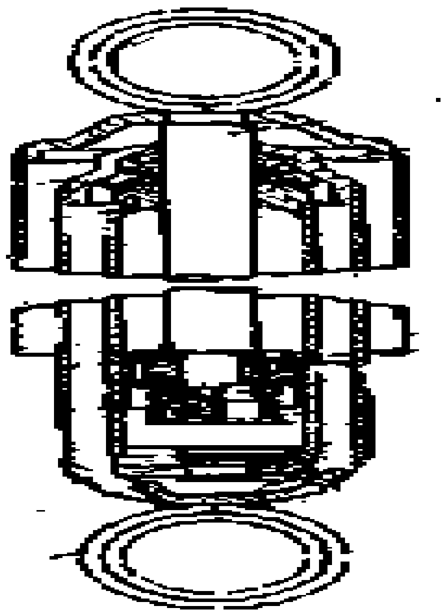


**Fig-6 Shock Absorber**

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

Syllabus : Automobile Diesel and Technology

**Course : Trade Training Basic, MTOF**

**Subject : Chassis, Frame and Suspension**

**Aim : To study Servicing of Shock Absorbers**

Ref. : AP 3259, Section 8, Chapter 3

# SERVICING OF SHOCK ABSORBERS

## Servicing

1. The servicing of hydraulic absorbers is confined to the following points. Minor servicing involves the periodical examination of the anchorage to the chassis, the fixing bolts being tightened as required. Major servicing involves a periodical check of the bearing for wear and “topping-up” with fluid as laid down in the servicing schedule. This operation requires the removal of the shock absorbers from the chassis. When shock absorber has been remover from the chassis for “topping-up” each one must be thoroughly cleaned before the filler cap is removed. Only the specified fluid may be used and the shock absorbers should be held in a vice by flexing lugs. While adding the fluid, the lever arm must be worked through out its full stroke to expel any air that might be present in the working chamber. The fluid should be added until it over flows at he filler plug. There is no adjustment required or provided, for and no attempt must be made to dismantle the hydraulic shock absorber. If the addition of fluid does not produce a moderate resistance throughout the full stroke of the lever arm, a serviceable unit should replace the shock absorber. 2. Apart from replacement of rubber mounting bushes; no servicing van is carried out o telescopic shock absorbers. Resistance can be checked against a new one of the same type and if found to have deteriorated, the shock absorber must be renewed.

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

Syllabus : Automobile Diesel and Technology

**Course** : **Trade Training Basic, MTOF**

**Subject** : **Chassis, Frame and Suspension**

**Aim** : **To study Independent Front Wheel**

Ref. : AP 3159, Section 7 , Chapter 2

---

# INDEPENDENT FRONT WHEEL SUSPENSION

## Introduction

1. Independent front wheel suspension means that each front wheel is mounted to chassis independently; they are not mounted at either end of a solid front axle. Each wheel can, therefore rise and fall more or less vertically to follow the uneven road surface without influencing the other wheel suspension is used on passenger cars and light truck, as it increase the ability of the vehicle.

## Purpose

2. When a vehicle has a rigid front axle contacts irregularities on the road surface, the rising and falling of the front wheel causes the axle to till and transmit this motion to other wheel. The vehicle as a whole is tilled at the front, which stresses the chassis and body by twisting. Independent suspension of the front wheel eliminates this twisting of the chassis and body by allowing each front wheel to be deflected upwards or downwards without affecting the other, at the same time retaining the correct steering geometry. There are various designs of independent front suspension, the following description being of the parallel link type, which is very widely used.

## Types

3. **Parallel Link Type**. This type is very widely used. When a front wheel strikes an irregularity on the road surface it is deflected upwards and the “knee action” of the upper and lower links prevents the motion being transmitted to the other wheel. If the links (wishbones) are of equal length there is a variation in track as the wheel is deflected. This gives a sideways movement to the wheel with consequent scrubbing of the tyre on the road. In practice, the lower wishbone is made longer than the upper and gives a variation in camber angle as the wheel is deflected. This practically eliminates the sideways movement of the wheel, reducing it to a degree, which can be absorber by the flexibility of the tyre, and preventing tyre scrub.

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

Syllabus : Automobile and Diesel Technology

Course : Trade Training Basic, MTOF

**Subject : Compressed Natural Gas.**

**Aim. : To Study C N G.**

# COMPRESSED NATURAL GAS

**Introduction**

1. There was a pilot hypothesize in our country with the assistance of World Bank to convert petrol and diesel engine into C N G In the year of 1982. In between 1985-86 with the financial assistance of World Bank the hypothesize begins to start. In the year 1987 under petro-bangla it bears the name "Natural Gas Converting Company Limited."

**Purpose of C N G**

2. C N G means Compressed Natural Gas. This gas is made from mineral mithen by compressing more then 3,000 lb psi. It is purely from our natural resources. Different countries of the world are using this gas as fuel of their automobile engine. Such as; Italy, Newziland, Holland etc.

**Use of C N G in Automobile Engine**

3. To convert into C N G it requires adding eight more additional parts. They are as follows:

a. Cylinder.

b. Three way shut off valve.

c. C N G solenoid valve.

d. Three stage C N G regulator.

e. Mixture.

f. Petrol solenoid valve.

g. Selector switch.

h. C N G meter.

a. **Cylinder.** It is made of steel. According to the quality and quantity of the vehicle cylinders will be different in shape. The cylinders contain gases 3,000lb psi. The weight of the cylinder in between 36to 55 kg in a car and it contains average 15 cubic meter gas (18.5 ltr petrol, 1 cubic meter CNG= 1.23 ltr petrol). Weight of the cylinder will be increased for other heavy vehicles. It is situated by the side of the petrol tank. The cylinder having a three way shut off valve.

b. **Three way shut off valve**. This valve has three-way traffic. By this valve three cylinders can be used as fuel tank, but always one cylinder will be in operation and other two will remain closed.

c. **CNG solenoid valve.** This valve is used for only refueling of CNG in the cylinder.

d. **Three stage CNG regulator**. This CNG regulator has three stages. In first stage it reduces the pressure of gas from 3,000lb psi to 1,800 lb psi, in second stage it reduces the pressure from 1,800 lb psi to 1,200 lb psi and in third/final stage it reduces the pressure from 1,200 lb psi to normal atmospheric pressure (14.7lb psi).

e. **Mixture.** It mixes the gas and air in a ratio of 1:9, ie; one part of gas and 9 part of air. Then it supplies the mixture to the carburetor.

f. **Petrol solenoid valve.** It closes the petrol line when vehicle is running in CNG.

g. **Selector switch.** This switch is used to select the fuel system of an engine. Weather the system will run in CNG or petrol.

h. **CNG Meter**. A meter is provided to show the level of CNG contains in the tank. It is as like as fuel meter.

j. **Operation:** Before driving the car with CNG some works are to be done, they are as fellows:

(1) Petrol line should be closed by the *Petrol solenoid valve* before starting the engine.

(2) Ensure that CNG *selector switch* is on.

(3) Ensure that cylinder is charged with CNG by help of *CNG level meter*.

(4) Turn ignition switch on, CNG from cylinder will flow towards the carburetor.

## Advantages of C N G

4. a. Economically benefited. 01cubic meter CNG= 1.23 Liters petrol= 1.6 Liters diesel.

b. It does not pollute the air. In CNG sulfur and leads are not available. For that in exhaust gas percentage of carbon monoxide is very less.

c. Maintenance cost is less.

d. Engine vibration is less. Engine runs smoothly.

e. It is 100% safety and established fuel.

f. It is completely local source of our own.

g. Better performance of engine.

h. Engine longevity more.

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

**Syllabus : Automobile and Diesel Technology**

**Course : Trade Training Basic, MTOF**

**Subject : MT Organization**

**Aim : To Study MT Organization**

**Ref : AFO –77-12, 17, 24, 26, 29, 38 &42.**

---

# MT ORGANIZATION

## Control at Air Headquarters

1. a. Directorate of Engineering is responsible for the organization, administration and servicing policy relating on all MT.

b. Directorate of supply is responsible_provisioning of MT its associated equipment and spare parts. Allotments of vehicles are also responsibility of Directorate of supply.

c. Directorate of Establishment is responsible for establishments of transport at a station/unit are determined by its role and commitments.

## Control at Station/Units

2. The responsibility for the control of all M.T. at a station is vested in the officer commanding. Officer commanding Admin wing is in turn responsible to the officer commanding for the administration, operation, maintenance and economical running of all M.T. on the strength of his station. The M.T. squadron at station comprises off repair and inspection flight and M.T. operations flight. An officer of the M.T. Engg. Branch is established at all major BAF stations as officer in charge M.T. Squadron. Where a warrant o9fficer M.T.D. trade is established, he is to take charge of the M.T. Section/M.T. operations flight as M.T. officer. On a station/Unit where a warrant officer MTD is mot established the officer commanding is to detail a officer in station/ Unit routine order to take charge of the M.T. section. The person so detail M.T. officer will be authorized to approve Forms 658E on behalf of officer commanding.. Where separate M.T. is established for different lodger units on a station, the lodger unit commander is to co-ordinate fully with the parent station and ensure that general service type vehicle held at the strength of the unit are made available if f required for the administrative services of the station as a whole. It is to be clearly understood that all M.T. held with lodger unit is also under the complete control of station commander.

**Necessity for Economy**

3. Station/Unit commanders are to ensure that utmost economy, consistent with the actual requirements of the service, is observed in the use of M.T. they are to take steps as considered necessary. The most economical and suitable vehicles which will serve the purpose of the duty are to be invariably used. The use of service bicycles should be encouraged, if appropriate, this particularly applies to runs within the confines of station. If on examination of M.T. documents it is revealed that the transport has been used irregularly or any person, who has acted without proper authority, will be held responsible for the expenditure involved.

**Responsibilities of M.T. Officer**

4. Duties and responsibilities of M.T. officer are given below:

a. Authorizing the use of M.T.for duty journeys on behalf of station commander.

b. Co- ordination, economical routine, maintenance and efficient running of all M.T. on the strength of station/unit.

c. Safe custody of all M.T. vehicles, tools and equipment held on charge of the M.T. section.

d. Co- ordination with nearly stations /units with a view to co-ordinate journeys common to any two or more stations.

e. Correct complication of M.T. records and submission of all M.T. returns.

f. The application of instructions laid down in Air Force regulations, relevant Air Force letters, Air Force orders Air Force Instructions relation to the operation and use of mechanical transport.

g. Efficient administration of the M.T. section.

h. Organization of M.T. in such a way that the duties are equally divided among all and that each person knows his duties are to be issued as a M.T. Section order and placed in the M.T. Order book. One copy is to be handed over to the respective NCO or airman concerned.

j. Supervision of the work done by his various NCO.

k. O.J.T. of drivers.

l. Maintenance and safe custody of M. T. O's report register.

m. Safe custody of Form 658E.

n. Progress on M.T. audit objections.

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

**Syllabus : Automobile and Diesel Technology**

**Course : Trade Training Basic, MTOF**

**Subject : MT Organization**

**Aim : To Study MT Servicing**

**Ref : AP 3260**

---

## MECHANICAL TRANSPORT SERVICING

**Object**

1. In order to improve the first and second line servicing and to permit the extension of periods between overhaul of MT vehicles, the following system of MT servicing is being introduced.

**Servicing Cycle**. It is divided into four phases, thus:

2. a. Daily servicing.

b. Intermediate servicing (1,000 miles) or monthly, whichever occurs earlier.

c. Minor servicing (3,000 miles) or 3 monthly, whichever occurs earlier.

d. Major servicing (12,000 miles) or annually, whichever occurs earlier.

**Specified Servicing Period**

3. a. Specified periods are not laid down for such operation as de-carbonizing and valve grinding; the need for them is to be determined as a result of running experience and the functional test which form part of the minor and major servicing.

b. Daily servicing is to be done in the MT section by the operators. The programme of NCOs monthly check is to be detailed by the officer in charge of the MT section who is responsible that these are done efficiently. Intermediate inspections are to be done in mechanical transport repairing and inspection section by the operators, supervised by a competent MT fitter. Minor and major servicing is to be done in the mechanical transport repairing and inspection section. Officer or NCO in charge of mechanical transport repairing and inspection section will be responsible for the quality of servicing and repair work done in his section. Whenever necessary the operator is to accompany his vehicle and assist fitter / mechanic during defect rectification or routine servicing.

c. After major servicing repairs or whenever a major assembly is replaced, the vehicle is to be road tested by warrant officer/NCO in charge mechanical transport repairing and inspection section. The fuel consumed in workshop during servicing/repairs or road test should not exceed quantities authorized for various types of vehicles vide AFI 52/51, as amended by AFI 109/55.

d. When it is necessary to convert stationary engine running time to vehicle mileage, one hour running is to be regarded as the equivalent of ten miles.

e. The various documents to be used in servicing MT are listed at Annex "A" to this order. These, which are used as posters, are for wall displayed in mechanical transport repairing and inspection and MT section.

**f. All major defect rectifications, minor and major inspections and replacement of new component, entries are to be recorded into the repair log book of F-813 and singed by warrant officer/NCOIC mechanical transport repairing and inspection section.**

**g. Base/Unit mechanical transport repairing and inspections are equipped and manned to under take first and second line servicing and repairs by replacement of an engine, the base/unit holding the vehicle on charge is to approach Air Headquarters (Dte of Engineering), given details of defect a mileages done by the original engine for prior approval.**

**Responsibility of MT R& SU**

4. a. **Third Line Servicing**. This consists of storage servicing and preparation of vehicles for issue.

b. **Fourth Line Servicing**. This consists of repairs, overhauls beyond user units' capacity and complete reconditioning of specialist vehicles.

c. In order to prevent deterioration of vehicles and specialist equipment mounted on BAF MT when stored in MT storage units or when specialist vehicles are employed in static or semi-static roles, adequate protective servicing appropriate to each case is to be applied. The comprehensive instruction for the protective treatment of specialist vehicles, given bellow are designed to over the long term case, i.e. where it is anticipated that vehicle once positioned will remain on the site over a long period and where mobility at short notice is not a requirement. It is appreciated that in certain cases the requirement for mobility at shirt notice may preclude and include the implementation of such items as the draining of fuel tanks, removal of batteries, rising of vehicle on blocks etc.

d. Officer responsible for the maintenance of MT vehicles at base/ units are under take a survey of all specialist vehicles/trailers employed in the static and semi static roles, in consultation with the specialist officer concerned and to detail such protective measures as to be applied in each case. Where concessions, to omit elements of the comprehensive schedule are agreed in the interests of ready mobility, the appropriate vehicle log books are to be annotated accordingly. Where protective measures, as scheduled, cannot be implemented in full, suitable alternative measures to prevent deterioration are to be instituted.

**MT Storages Procedure**

5. a. **Initial Servicing**.

(1) Road test the vehicle and rectify defects, if any. Drain and flush out coolant system.

(2) Drain the engine sump, clean the oil filter and refill with fresh oil.

(3) Inhibit the engine.

(4) Drain the fuel tanks completely, clean the filters and spray the inside of the tanks with sufficient protective to ensure that the surfaces are completely covered.

(5) Check and fill the correct level with oil, as applicable, gear boxes, steering box, axles and master cylinders.

(6) Remove batteries, level and return to electrical section for storage.

(7) Vehicles are to be retreated as for initial servicing and prepared for storage. Re-treatment of the parts unaffected by the test run may be omitted at the discretion of officer in charge.

b. **Monthly Servicing**.

(1) Check tire pressures and correct as necessary. If vehicle is not checked clear of ground, jack up and partially rotate each wheel.

(2) The engine of the prime mover and auxiliary engine if fitted is to be turned 20 / 30 times. Engine to be reinitiated as for initial servicing. External treatment may be omitted, if un warranted.

c. **Twelve Monthly Servicing**.

(1) Vehicle may be taken out of storage and road tested through all ranges of gears, main an auxiliary. Carry out rectification or repairs, reveal as a result of the test.

(2) All times listed under monthly and six-monthly servicing.

(3) Vehicles are to be retreated as for initial servicing and prepared for storage. Re-treatment of the parts unaffected by the test run may be omitted at the discretion of the officer in charge.

d. **Road Test**. A vehicle is to be road tested at the time of *initial servicing, twelve monthly servicing and pre- allotted inspection*. A road test and inspection record sheet is to be completed and field with the history sheet of the vehicle.

e. **Documentation**

(1) Storages servicing records are to be maintained and kept in a folder (history sheet) for each vehicle. The history sheet is to indicate, name of unit/section. BA number and type of vehicle, chassis no. Date of receipt, allotment No and signature officer in charge.

(2) After a vehicle leaves unit on allotment-out, history sheet is to be closed, the allotment-out authority and date of dispatch is to be endorsed. The history sheet is to be held for period of 12 month after the closing date.

(3) Initial, six monthly and pre-allotment servicing inspections are also to be recorded on F-813.

BAF BASE ZAHURUL HAQUE (TRG WG)

**(Aero Engg Trg Sqn)**

**Syllabus : Automobile and Diesel Technology**

**Course : Trade Training Basic, MTOF**

**Subject : MT Organization**

**Aim : To Study Grease and Their Uses**

**Ref : Automotive Mechanic by William H Crouse Ninth Edition**

---

## GREASE AND THEIR USES

### General

1. This is a fluid lubricant such as mineral oil mixed with a thickening agent to make it a semisolid or plastic. The thickening agent may be a metallic soap or a no soap substance such as clay. The soaps commonly used are lithium, calcium, oxidation and barium. Each of these, alone or in combination, gives the grease special characteristics. Aluminum gives the grease good adhesion. Sodium gives the grease a thick, fibrous appearance. A number of additives are also mixed into improve the performance of the grease. Among the characteristics good grease must have are consistency, stability, and oxidation resistance ability to protect against friction, wear and corrosion and feed ability (ability to flow through dispensing equipment).

### Purpose

2. The purpose of grease is to reduce friction and prevent seizure of the bearing surfaces also to act as a coolant for bearing surfaces.

### Uses

3. Greases are commonly classified according to their use, as follows:

a. **Wheel-bearing Greases.** Theses grease are resistant to high temperatures and the separating effect of centrifugal force.

b. **Universal-Joint Greases.** These greases are compounded to stay in place as the universal-joints spin and flex.

c. **Chassis Greases**. These are greases that can be applied with grease guns through fittings. They have the characteristic needed to keep them in place on the moving chassis surfaces without separating or losing lubricating effect.

d. **Extended-Lubrication-Interval (ELI) Chassis Greases.** These are greases with the composition, structure, consistency, life, and, anti wear and anticorrosion characteristics for use in "lifetime" applications. These include suspension, drive-line, and steering systems having sealed joints, prepacked during manufacture or assembly. They normally do not need re-lubrication for long intervals.

e. **Multipurpose Greases**. These greases are compounded to meet the performance requirements for chassis grease, wheel-bearing grease, universal –joint grease, and other automotive uses such as fifth-wheel service. Some ELI greases are good for multipurpose uses.

f. **Extreme-Pressure (EP) Greases.** These greases are suitable for high-load-carrying applications. Some have a surface-active additive that gives anti wear or antiseize properties beyond those of other greases. "Surface-active" means the agent bonds to metal surfaces to form a barrier that protects the surface if the normal lubricant film is pierced.

g. **Other Greases**. There are other special greases. Brake grease is specified for the moving parts in the drum-brake mechanisms. Distributor breaker-cam grease is specified for the cam in ignition distributors. Speedometer-cable lubricant is another special lubricant.

# BAF BASE ZAHURUL HAQUE (TRG WG)

## (Aero Engg Trg Sqn)

**Syllabus : Automobile and Diesel Technology**

**Course : Trade Training Basic, MTOF**

**Subject : MT Organization**

**Aim : To Study BAF Forms**

**Ref : AP-3159 sec 8**

---

## BAF FORMS

**Forms- 793**

1. When transport is required on payment for sport, recreation or other reason that that must be authorized by the station or unit commander on F-793. It is raised in triplicate by the adjustment and is signed by the station or unit commander. One copy is sent to the MT Section, One is passed to the Account Officer and the third copy is retained by the adjustment.

a. The conditions are the same as those of F-658.

b. When the work has been completed, the Form-793 is handed over to the MT Officer and the entries completed in F-814 and F-814a in red ink.

c. F-793 is then passed to the Accounting Officer for retention and the signature contained in the MT Section Receipt Book.

**Forms- 658**

2. Application for M.T. for duty journey.

**Form- 813**

3. Log Book for MT Vehicles.

**Form-814**

4. Record of Journey of Mechanical Transport and Marine craft.

**Form-347**

5.

**Form- 1022**

6. Defects Report

**Form- 363**

7. Certificate of Competence to drive a vehicle.

**Form- 637**

8. Emergency permits to drive

**Form- 925**

9. Maintenance unit journey permit

**Form- 1629**

10. Identification card for MT Operators.

**Form- 1839**

11. Identification card for officers authorizes to drive service vehicle.

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

**Syllabus : Automobile and Diesel Technology**

**Course : Trade Training Basic, MTOF**

**Subject : MT Organization**

**Aim : To Study Monthly Servicing Schedule or Intermediate Servicing**

**Ref : AP-3260**

---

# MONTHLY SERVICING SCHEDULE OR INTERMEDIATE SERVICING

## Introduction

1. Intermediate inspections are to be done in mechanical transport repairing and inspection section by the drivers, supervised by a competent MT fitter.

.

## Procedure

2. a. Check all wheel nuts for tightness.

b. Examine the brake systems generally for wear, damage, leaks fraying cable and security. Lubricate all bearings, all joints, clevis pins, guide and pulleys with oil, lubricate brake cables with grease.

c. Examine the brake connection for damage and security and flexible hose for deterioration.

d. Adjust the brake as necessary.

e. Examine the spring, spring clips, center bolts and “U” bolts for tightness and spray spring with oil 34/161 or 1623.

f. Examine shock absorbers for leaks and damage.

g. Examine spring shackles for wear.

h. Examine rear hook towing for wear and damage.

j. Examine spare wheel carrier or frame for damage.

k. Examine all bolts and nuts for tightness.

l. Examine the tyre for cuts and damage.

m. Engine examines and replenishes the air cleaner.

# BAF BASE ZAHURUL HAQUE (TRG WG)

## (Aero Engg Trg Sqn)

**Syllabus : Automobile and Diesel Technology**

**Course : Trade Training Basic, MTOF**

**Subject : MT Organization**

**Aim : To Study Use of Form 41125, 656 &813 in Respect of Servicing**

**Ref : AP-3159**

---

## FORMS- 4115, 656 & 813

**Routine Servicing Work sheet (F-4115)**

1. This form is used for 3000/12000 miles servicing. These are to be serially numbered are retained for record purpose for a period of one year.

a. **Instructions for Use NCOIC Servicing**. The part I of this sheet is filled by NCOIC in that he is to write down the particulars of a vehicle to be serviced, the type of servicing and name of the trade's man detailed to carry out the servicing. He is carry out the functional test of the vehicle in according with part II of the work sheet. On completion of the test he is to complete column 3, 4 & 5 of part II. A tick mark in column 3 is indicated a complete functional servicing. A cross mark in column 4 is to indicate the adjustment is required and cross in column 5 indicated as item is referred is U/S and is to be repaired or replaced. He is to allocate items to the tradesman according to their trades and knowledge. If during the servicing defect is found which will necessitate repair, in this case he is to enter the particulars of the defect and of the subsequent repair action (2 para 5 on the reverse side of the sheet). On completion of the repair the NCOIC is to ensure that the tradesman detailed to carry out the repair, who need not necessarily be the man detailed to carry out the servicing signs in part "5" of the work sheet a heavy carried out the repair and also initials in column '6' of part II to indicate that the servicing of particular item has been completed. On completion, the NCOIC servicing g is to be check:

b. That the each item in para 2,3, 4 of the work sheet has been indicated by the tradesman to indicate he has serviced.

c. Check that all defects recorded in part V has been rectified.

d. Complete part VI of the work sheet and transfer al, applicable details to the MT servicing F. 656 of vehicle concerned.

e. Make appropriate entries in vehicles log book F. 813.

**Mechanical Transport Servicing (F-656)**

2. A MT servicing form is raised monthly for each MT vehicle and each trailer on charge of an MT section. The form is retained in the section office and is readily accessible to drivers. When a vehicle is detailed for detached duty a copy of the current F. 656 is given to the driver. The driver will keep the Form on the vehicle throughout the duration of the detachment, or until the end of the current month whichever is the shorter period, the form is then returned to the section office. If the detachment does infect extend from one month to another a replacement F -656 is forwarded to the driver before the end of the current month. The driver must ensure that the Speedo meter readings shown on the F. 656 for the last day of the expired month is correctly

3. transferred to the form indicates daily servicing task and the dates on which each task is be done. The tasks are accordance with poster No. 33. The back of the form is a record of repairs servicing modifications; special technical instructions etc. for use of the MTR&SU personnel, and a daily servicing certificate for the vehicle and appropriate the specialist equipment.

**Mechanical Transport Vehicle Log Book (F-813)**

3. The revised mechanical transport vehicle logbook is deigned to last the life of a vehicle. It is opened by the MT Storage unit responsible for the acceptance of a new vehicle into the BAF from the manufacturers or contractors. It is transferred with the vehicle and remains with it throughout its service life. The M.T. storage unit is responsible for the initial inspection the test of the vehicle or the specialist equipment and for completing the entries in section-1, 2 & 3 of the logbook. There after the relevant, details of monthly mileage and fuel consumption, reconditioning, replacements of major components, routines servicing, minor replacements and repairs, modifications and special technical instructions are entered in the log book. When a vehicle is struck off charge, written of charge, or handed over to the Directory of supply for disposal, the BAF Form-813 is closed by the completion of section-3 and is sent by the holding unit to the Air Ministry (M.T.2)

# BAF BASE ZAHURUL HAQUE (TRG WG)
## (Aero Engg Trg Sqn)

**Syllabus : Automobile and Diesel Technology**

**Course : Trade Training Basic, MTOF**

**Subject : MT Organization**

**Aim : To Study Three Monthly Servicing**

**Ref : AP 3260**

## THREE MONTHLY SERVICING

**Points are to be checked and procedure of servicing as follows:**

**Hand Brake**

1. If lever travel exceeds 2/3 of range, adjust it.

**Starting System**

2. Check the starting handle and crank shaft dog for case operation.

**Engine**

3. Check for case of starting.

**Engine Slow Running**

4. a. Check the idling speed.

   b. Check for excessive smoke from the exhaust.

**Oil Pressure**

5. Check oil pressure on different speeds.

**Charging Rate**

6. a. Check that ammeter is reading "Zero" both the engine and all switches off.

b. With engine running at normal speed check the reading. The ammeter should register a change of 1 of 2 amps under load of all light.

**Clutch Operation**

7. a. Check the free pedal movement.

b. Check the engagement and disengagement of the clutch.

c. Check the action of return spring.

**Gear Change Control and Operation**

8. a. Move the main gear lever, auxiliary gear lever to all positions and check freedom of movement for engagement of gears.

b. Check the "Front wheel drive" control for operation and freedom movement.

c. Check the power takes off for case engagement and satisfactory operation

**Foot Brake**

9. a. Check the amount of the pedal travel when brake is applied.

b. Check the uneven braking.

c. **Air Pressure Brake**

(1) Check the gauge reading.

(2) Apply and release brake pedal enlisted for air release indicating correct functioning of the system.

(3) Brake pedal with the engine running. Check the operation of each brake cylinder in turn noting any excessive movement.

(4) With engine at rest check air pressure gauge for indication of leakage from pipe lines, plugs or faulty control.

d. **Vacuum-servo Assisted Brake**

(1) Check the gauge reading.

(2) Obtain the assistance of second men to operate with the engine running. Check that the serve motor functions correctly.

(3) With engine at rest check the vacuum gauge for indication of leakage or incorrect adjustment of linkage.

**Meters Gauges-Warning Lights.**

10. Check that all meters, gauges and warning lights are functioning correctly.

**Windscreen Wiper and Trafficators**

11. Check windscreen wipers and traffictors for security and correct operation.

**General Inspection- Engines**

12. a. Examine all hoses (air, oil and coolant) for serviceability.

b. Examine engine controls for their actions.

**Belts**

13. Examine all driving belts for wear and correct tension.

**Sparking Plugs**

14. Remove examines and if necessary clean adjust before refitting.

**Contract Breaker Assembly**

15. a. Examine all cable connections for security.

b. Examine the automatic advance and retard mechanism for freedom of action.

c. Examine contact breaker points for signs of pitting or burning clean and adjust as necessary.

**Ignition-General**

16. a. Examine HT& LT leads for cleanliness, signs of deterioration and security.

b. Examine distributor cap rotor for signs of cracks or tracking.

**Cooling System**

17. a. Examine radiator locating bolts for security.

b. Examine water pump for leaks.

**Fuel System**

18. a. Examine fuel lines for leakage.

b. Examine fuel taps for easy operation.

c. Examine fuel pump for leaks.

d. Examine fuel tank cap for security of attachment.

e. Fuel Injection System (C.I. Engine)

(1) Examine injector pipes and union for leakage.

(2) Vent the fuel system.

(3) Change the oil in fuel injection casing.

**Air Cleaner**

19. a. **Oil Bath Type**

(1) Drain oil and clean the base.

(2) Wash the element in paraffin.

(3) Top up the base to correct level with oil.

b. **Wire Gauge Type**

(1) Remove filter and wash in a bath of clean paraffin.

(2) Replace filter.

**Steering Gear and Linkage**

20. a. Examine steering connection and ball joints

b. Examine drop arm security on own shaft.

c. Examine track rod and push rod for security and damage.

d. Examine steering gear box for oil leak.

**Gear Boxes**

21. Clean gear box and examine for leaks.

**Front Axle**

22. Jack up the front axle, clean and test for play in swivel and hub bearing. If driving axle, examine for leaks.

**Rear Axle**

23. Clean examine for leaks.

**Battery and Connection**

24. a. Check specific gravity of electrolyte.

b. Examine earth and starter motor connections.

**Lights Horn, Wiring, Starter and Dynamo**

25. a. Examine horn for security and attachment.

b. Examine all fuse for serviceability.

c. Examine all wiring for signs of deterioration

d. Lubricate starter motor and dynamo bearing.

**Wheel and Tyres**

26. a. Examine spare wheel for service ability. Check tyre pressure.

b. Examine all wheel for wear, creaks and other damage.

**Spring and Shock Absorbers**

27. a. Examine road spring for fractures.

b. Examine road spring clips.

c. Examine road spring center bolts.

d. Examine shackle pins and brackets.

e. Examine shock absorber linkage and arm security of attachment.

f. Check level of fluid in hydraulic shock absorbers and top up as necessary.

g. **Independent Front Suspension**

(1) Examine linkage pins and unit mounting.

(2) Examine hydraulic system for leaks and damage.

**Propeller Shafts**

28. a. Examine propeller shafts and universal joints for wear.

b. Examine coupling bolts for security.

**Brakes**

29. a. Check that any defects noted on item No. 1and 9 have been rectified.

b. **Hydraulic Brakes**

(1) Top up master cylinder.

(2) Examine hoses and pipelines for signs of leakage.

(3) Examine hand brake rod and cables for damage.

(4) Examine servo motor for security or attachment.

c. **Air Pressure Brakes**

(1) Drain condensate from air storage tank.

(2) Change the Oil of Compressor oil sump (if fitted).

(3) Check the air leakage in the system.

(4) Dismantle, clean and reassemble the following filters and strainers:

(a) Air compressor, crank case, breather and strainer, Governor Strainer. Driver control valve. Primary air strainer for compressor.

**Exhaust System**

30. Examine for security, damage and joints for gas leakage.

**Body Mounting**

31. Tight all body locating bolts where body is located by U/bolts. Examine for signs of creeping on chassis. Examine all passenger seating, doors, windows and mounting step.

**Fire Extinguisher**

32. Ensure that the extinguisher is full and bracker for serviceable.

**Lubrication**

33. **Change Engine Oil**

a. Drain engine oil whilst engine is hot.

b. Check oil level in sump governing casing of (CI Engine)

c. Ensure that oil filler cap is secured.

d. Check level of fluid kin turbo-transmitter supply tank.

**Gear Boxes**

34. Check the oil level in the main gear box, auxiliary gear box, and change speed box.

**Axles**

35. a. Check the level of oil in front, middle and rear axle casings.

b. Check level of oil in steering knuckles (tracts joints).

**Steering Box**

36. Check the level of oil in the steering gear box.

**Power Take off Winch Worm Gear**

37. Check the level of oil in the power take off and winch gear casing.

**Wheel Hubs**

38. Where nipples are fitted inject correct lubricant Refer to the lubrication chart in the relevant AP VO. 1 consisting that the following items are included as appropriate:

a. Water pump spring.

b. Front axle swivel pins.

c. Track rod ends.

d. Drag link and steering rocker shaft.

e. Road spring pins and shackles.

f. Clutch withdraw surface.

g. Brake and clutch pedal shaft.

h. Accelerator pedal shaft.

j. Hand Brake lever pivot.

k. Brake cross shaft.

l. Brake servo motor.

m. Brake control valve.

n. Brake cylinders (Air pressure brakes)

o. Propeller shaft and universal joints.

p. Towing hooks.

q. Winch clutch shaft.

r. Winch cable rollers.

s. Winch cable guide pins.

t. Brake cables.

u. Articulated carrier attachment.

**Clean and Using Oil Cane Lubricate**

39. a. Engine and hand throttle control joint and pivot pins.

b. Brake rod or cable joints and fulcrum pins.

c. Gear box control joints.

d. Towing hook latches springs.

e. Body and cub locks, latches and hinges.

**Clean and Spray with Oil Ref. 346/161**

40. a. Road springs.

b. Towing gear locating springs.

**BAF BASE ZAHURUL HAQUE (TRG WG)**

**(Aero Engg Trg Sqn)**

**Syllabus : Automobile and Diesel Technology**

**Course : Trade Training Basic, MTOF**

**Subject : MT Organization**

**Aim : To Study Twelve Monthly or 12000 Miles Servicing**

**Ref : AP 3260**

# TWELVE MONTHLY OR 12000 MILES SERVICING

**Servicing of all Major Components of MT Vehicle as Follows:**

**Hand Brake**

1. a. Check hand brake mechanism for operation.

b. Check amount of travel, if exceeds 2/3 of maximum range, adjust it.

c. Check security of ratchet and Powel when in “ON” position.

d. Check the efficiency of hand brake.

**Starting**

2. a. Examine starting handle and pin and dog for wear.

b. Start engine by hand.

c. Check for overheating.

**Engine Slow Running**

3. a. Engine should not idle too fast.

b. **Check Exhaust Smoke for**

(1) Excessive oil consumption.

(2) Too rich a mixture

(3) Defective injectors, faulty injector pump calibration or incorrect timing.(CI Engine)

**Oil Pressure**

4. Check oil pressure when engine is warm at idle speed and high speed.

**Charging Rate**

5. a. check that ammeter should show zero when all switches and engine is off.

   b. With the engine running and all right switches are on position. The ammeter must show its amp charging.

**Clutch Operation**

6. Check that clutch engages and disengages freely.

**Gear Change Controls and operation**

7. a. check main gear lever for freeness.

   b. Check auxiliary gear lever for freeness.

   c. Engage front wheel drive and check operation.

   d. Engage power takes off and checks operation.

**Foot Brake**

8. a. Check the brake control rods, cables and levers for operations.

   b. Check the amount of the pedal travel.

   c. Test efficiency of brakes in all speeds.

   d. When engine at rest check air pressure or vacuum gauge for identification of air leaks.

**Meters-Gauge-Warning Lights**

9. a. Check the operation of wiper motor and wiper blades.

b. Check the traficators for their action.

**General Inspection-Engine**

10. a. Check engine all control

b. Check tappet clearance and adjust.

c. Check water hoses.

d. Check engine mounting.

e. Check the dynamo belts for correct tension and wear.

f. Remove sparking plugs and contact breaker point for cleaning and adjust for their gaps.

**Ignition General**

11. a. clean and examine dust cap and rotor for crack damage.

b. Examine carbon brush.

c. Ensure that all; HT lead are clean and secure.

**Cooling System**

12. a. Examine hoses for leaks.

b. Flush out radiator.

c. Examine fan and radiator.

d. Examine the water pump for leaks

**Fuel system**

13. a. Clean all fuel filter and sediment bowel.

b. Examine all unions, fuel line, pump and tap for leaks or damage.

c. Examine tank cap for security.

d. Remove service and refit injectors.

e. Examine fuel feed and injector, pipes union for leakage,

e. Check the oil in pump casings.

**Air Cleaner**

14. a. **OIL Bath Type:** Remove air cleaner assembly, dismantle drain oil clean it with paraffin, refill with correct oil level.

b. **Wire Gauge Type:** Remove filter clean with paraffin and refit.

**Steering Gear and Linkage**

15. a. Examine steering wheel, ball joint, linkages and steering box for play, wear , security and oil leaks.

b. Check and adjust toe-in.

**Clutch Pedal Clearance**

16. Check clutch pedal free movement and adjust (approximate 1”).

**Gear Boxes**

17. Check the mounting for tightness and oil leaks.

**Front and Rear Axle**

18. a, Examine for oil leaks.

b. Remove brake drum and examine brake shoes linings and mechanism for wear, damage and corrosion.

c. Clean bearing and hub and repack with grease.

d. Refit brake drum.

**Battery and Connection**

19. a. Check the specific gravity of the electrolyte.

b. Clean the battery lugs and smear the terminal with grease.

c. Examine the connection for damage and cleanliness.

**Light, Horn, Wining, Starter and Dynamo**

20. a. Check all lamp rims and glass for damage and corrosion.

b. Operation of all lights and dipper.

c. Check the connection of the wiring.

d. Check the starter motor and dynamo brushes for wear and spring for pressure.

**Wheel and Tyre**

21. a. Examine wheels for cracks, damage and securing nuts of two halves of split-rim for tightness and all those should be painted red.

b. Check the tyre pressure.

c. Examine all tyres excessive wear, cuts, bruises wells.

**Spring and Stock Absorbers**

22. a. Examine road springs for fractures and indicate broken or loose centre bolts.

b. Examine 'U' bolts for tightness and shackle pins or wear.

c. Examine shocks absorbers for leakage.

d. Check the level of fluid and top up.

d. Check the linkage for security of attachment and damage.

**Lubrication**

23. Drain all oil i.e. Engine oil, gear boxes axles and flush it with flushing oil and refill with correct grade of oil.

# BAF BASE ZAHURUL HAQUE (TRG WG)

## (Aero Engg Trg Sqn)

**Syllabus : Automobile and Diesel Technology**

**Course : Trade Training Basic, MTOF**

**Subject : MT Organization**

**Aim : To Study Maintenance of Storage Vehicles**

**Ref : AP 3260**

~~MAINTENANCE OF STORAGE VEHICLES AND STORAGE PROCEDU~~RE

**General**

1. The maintenance of storage vehicle and the procedure of storing are to be adopted through out the Air Force. In no way it is to be regarded as relieving personnel from their responsibility for taking any action to ensure the safety and reliability of the vehicle on their charge. Generally, storage procedure will become necessary for any vehicle for equipment there on which is out of use for period of more than one month.

**Acceptance of Vehicles for Storage**

2. Before preparation for storage all vehicles are to be thoroughly washed and cleaned. After washing the vehicle is to be inspected by the AIS or other competent authority, which is to take any repair or rectification necessary before the vehicle is placed in the storage. When the vehicle has been passed as in a serviceable condition it is to be prepared for storage as detailed in appropriate appendix. It is essential that the vehicle is thoroughly dry before storage preparation servicing carried out.

**Composition of Schedule**

3. Storage preparation schedules are lists of operation which are to be carried out by the appropriate tradesman before the vehicle is placed into covered storage or open storage as applicable.

**Instructions for Use**

4. a. **Tradesman.** Before the vehicle is placed in either cover or open storage, the tradesman is to refer to the appropriate schedule and perform the operations listed there in. They are to report dry defects to the NCOIC storage preparation, and on completion of the servicing are to sing into he appropriate column of F.656 or F.565fA as applicable.

b. **NCOIC Storage preparation.** Should any defects be reported the NCOIC storage preparation is to arrange for necessary remedial action to be taken. The NCO is to ensure that details of the defect and of subsequent repair are entered in the repair record of F.6567A applicable.

**Preparation of Covered Storage**

6. **To be performed by the Tradesmen Detailed.** The operation of covered storage is to be carried out as per appendix “A” to chap-18, Sec-3 AP 3260A.

**Preparation For Open Storage**

7. **To be carried out by the Tradesmen Detailed.** The preparation for open storage is to be carried out as per appendix “P” to chap-18, Sec-3 of AP 3260A.

**Intermediate storage servicing**

8. Intermediate storage servicing mainly concerns anti-deterioration checks on the vehicles in storage. This servicing is to be performed by the tradesman detailed and should normally be done monthly for vehicles in open storage and every three monthly for vehicles in covered storage. In special circumstances the periodicity may be extended by command headquarters.

9. **Instructions for Use**

a. **Tradesmen.** When the intermediate servicing becomes due tradesmen are to be detailed to perform the servicing items detailed in the appendix. On completion of servicing, they are to endorse F.656 or f.656 as applicable.

b. **NCOIC Servicing.** The NCOIC servicing is to ensure that details of servicing are entered on f.656 or F.656A, which is available in card size for use.

**Minor and Major Servicing Schedule**

10. **To be performed by the tradesmen detailed.** The servicing schedules for Minor and Major servicing of the stored vehicles are available in card size, as per appendix “A” and appendix “B” to chapter 20, Sec-3, of AP 3260A.