CHAPTER 1

SAFETY IN AUTOMOTIVE WORKSHOP

1.1 INTRODUCTION

We know that number of accidents are happened daily in Industrial field due to the negligence of skilled worker, resulting risk of owner of the industry and other person as it occur only whenever there is lack of knowledge of safety. So safety should be the first consideration when beginning any trade. Machine Maintenance is an Industrial trade and many hazards can cause injury if proper safety guidelines are not followed. Safety working habits cannot be brought or made fractural. He must be learned through practice, a trainee must practice safety working procedures at all times.

WHAT IS SAFETY?

Safety is an attitude, i.e. it is a frame of mind. If the trainee's attitude towards safety is a good one, he will accept the idea that safe safety working habits are the ones to learn and practices for the rest of the working life. (Safety is an action which controls on your all acts in such a way that you do not involve accident or incident).

1.2 TYPES OF SAFETY:

- Self safety or Personal Safety
- Machine and tool Safety
- Workshop safety or General Safety

1.2.1 Self safety or personal safety:

Every worker should take care to protect himself from accident. If you protect yourself then only you can feed your family. So for self safety the following rules should be followed-

1. Do not wear ring, watch, tie, bangle while working on a machine.

2. While working on a machine loose clothes should not be worn.

3. Do not have a fun with other in workshop.

4. Do not run in workshop.

5. Mind should be concentrated while working on machine.

6. Always use thick sole.

7. Use first aid in case of accident.

8. Use safety goggles for eye protection.

1.2.2 Machine and tool safety:

Various types of machines are used for various operations and various tools are used for repairing the machines, so it is very important to protect those tool and machines. Therefore following points should be kept in mind:

1. Do not operate the machine without its proper knowledge.

2. In case of failure of power supply, put all the switches in off position.

3. Do not try to change the gear while it is in running condition.

4. Before start the machine always check the guards, cover, power supply and its cleanliness.

5. Always check that the tools are properly fixed before starting the machine.

6. Do not try to stop the running machine by hand.

7. Ensure that the cutting tools and measuring tools are kept separately.

8. Always used proper size of spanner while assembling or disassembling the bolt.

9. Only recommended lubricants and coolants should be used.

1.2.3 Workshop safety or general safety:

Self safety are followed to protect self, and Machine and tool Safety are followed to protect machines and tools but General safety means self, machine and entire your work area and environment.

1. Display the safety signs or symbols in workshop.

2. Do not touch the support (used as a machine support stand).

3. High voltage electrical connection area should be barricaded.

4. Fixed the guards before starting the machine.

5. Do not try to repair the machine in running condition.

6. There should not be any types of oil, grease and iron waste on the floor.

7. While maintenance, ensure that nobody try to touch or switch on the machine.

8. Heavy body should be lifted carefully.

1.3 SAFETY SIGNS:

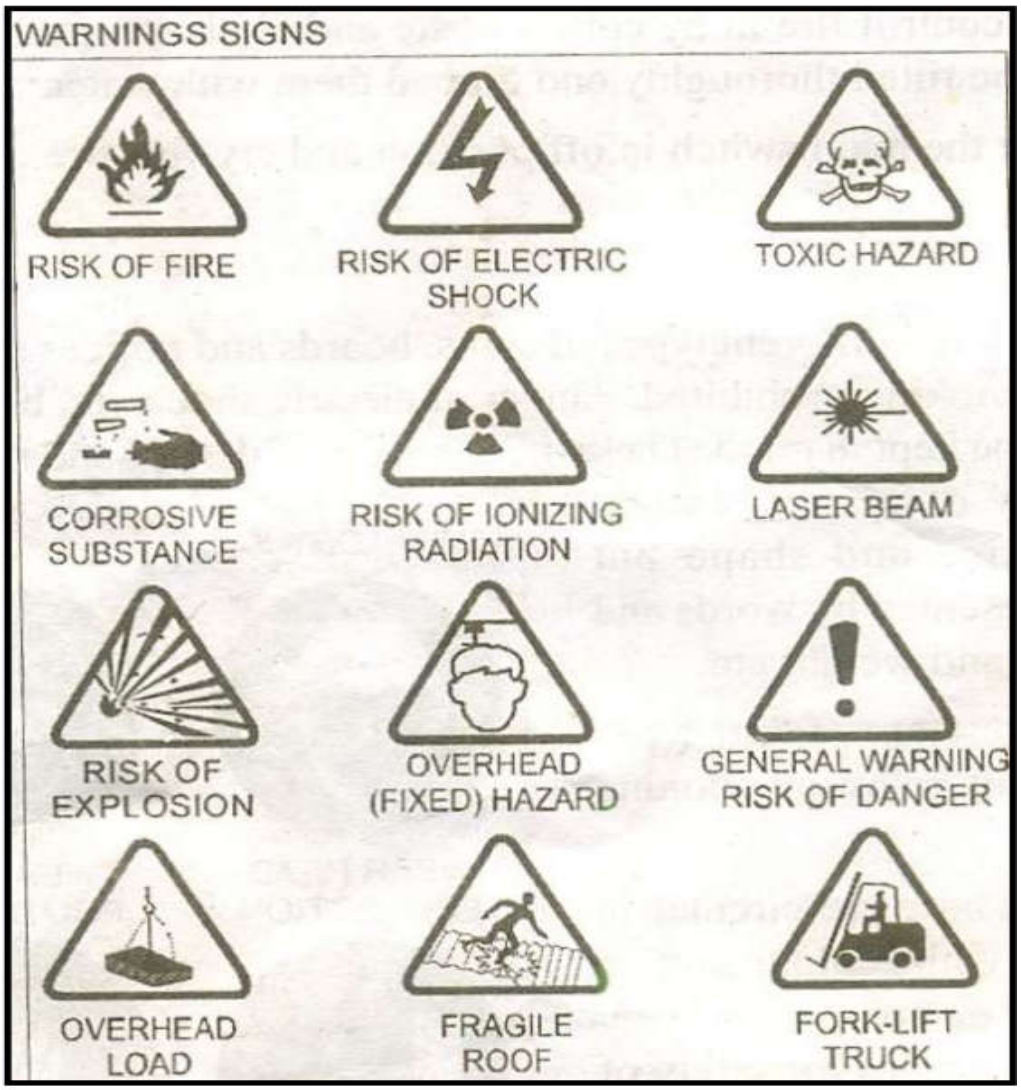
Safety signs give the information through picture about maintaining and following rules in different workplace. These are of four types:

- Mandatory signs
- Prohibition signs
- Warning signs

1.3.1 Mandatory signs

1.3.2 Prohibition signs

1.3.3 Warning signs



1.4 Safety in automotive industry:

1.4.1 Plant

Plant is another word for machinery – it does *not* refer to hand tools or small (hand-held) power tools.

In the automotive industry, **hoists** are used to elevate vehicles so repairs can be made safely by people working beneath the vehicle. The safe operation of hoists is essential, and depends upon competent operators and strict maintenance and inspection routines. Every hoist must be subject to a pre-operation check, and routine inspection and maintenance must be carried out at least every three months.

Other plant commonly used in automotive workshops includes **air compressors** and **overhead cranes** to remove engines from vehicles and move other heavy items around the workshop. Their use can result in serious injury if safe work and maintenance practices are not followed. Air compressors are dangerous items of plant, and should never be used to blow dust or dirt from clothing or work materials. Compressed air accidentally blown into an open wound can prove fatal.

Because **asbestos** has been used in some vehicle components such as brake lining, there is the possibility that asbestos fibre may be found in automotive workshops: compressed air should never be used to blow what may appear to be dust from these items.

Vehicles themselves are mobile machines, and also present significant risks to people: the movement of traffic around an automotive workshop must be managed safely. Members of the public should not be allowed to enter the work area unsuperviced.

Engines have exposed moving parts (fans and belts) which could catch fingers, and exhaust emissions can be fatal if they build up in an enclosed area.

When hazards cannot be eliminated or sufficiently reduced by engineering controls or safe working procedures alone, you may need to wear personal protective equipment (PPE) to improve protection.

PPE may include safety glasses or goggles, earplugs or earmuffs, protective gloves, overalls or other close fitting clothing. Safety shoes or boots with

reinforced toe-caps will protect your feet if any heavy or sharp items are dropped.

When operating any mechanical equipment, employees must follow safe work procedures as instructed by the employer or supervisor. These may include:

- wearing any personal protective equipment provided
- using tools and equipment correctly and safely as they have been trained to do
- switching off machinery and equipment when it is not in use
- concentrating on the job – distractions can contribute to injuries
- keeping the work area around plant and equipment clean, and free from slip and trip hazards.

1.4.2 Mechanical Equipment

A wide range of mechanical equipment is used in the manufacturing industry. Mechanical equipment can be hazardous. The most common injuries are to hands and fingers, which may be cut, sprained, dislocated, broken, crushed or severed by machinery or tools. These injuries can cause lengthy periods of time off work and sometimes they result in permanent disability.

Eye injuries caused by mechanical equipment accidents include being hit by an object (e.g. small particles such as metal shavings as well large objects or pieces of equipment), heat, radiation, hitting an object and falls, trips and slips.

When you are operating any mechanical equipment, you must follow safe work procedures.

- wearing clothing that will not catch in moving parts
- wearing any personal protective equipment
- operating the machinery and equipment correctly and safely according to your training
- keeping all guards in place

- making sure any guards removed during maintenance, repair or cleaning are replaced by an authorised person before you use the machine again
- switching off machinery and equipment when it is not in use
- locking out and isolating machinery before any repair, adjustment, cleaning or maintenance is done
- concentrating on the job, as distractions can contribute to injuries, and keeping the area around the equipment or machinery clean.

1.4.3 Forklifts

Forklifts are often used in the manufacturing industry to load, unload and move materials around work places. They can be dangerous if not driven and operated correctly.

1.4.3 Electricity

The machinery, equipment and tools you will use in the manufacturing industry are usually operated by electricity. You must make sure that all electrical machinery and equipment is kept in good working order, electrical plugs and switches are not damaged, cords are not split or frayed and are regularly checked for damage.

You must follow instructions for using electrical equipment, which may require:

- switching off appliances at the power point before you pull out the plug
- disconnecting broken appliances and not using frayed cords or broken power points
- not using too many appliances from the same power point and always keeping electrical cords off the floor, to reduce the risk of damage from drag or contact with sharp objects.

1.4.4 Powered Tools and Hand Tools

Many of the tools used in the automotive industry are powered by electricity. You must make sure all electrical machinery and equipment is kept in good working order.

Electrical plugs and switches must be checked regularly to make sure they are not damaged. Leads can become split or frayed, and these too must be inspected for wear each time they are used. Electrically powered tools must be tested and tagged regularly.

Instructions for the safe use of powered tools and electrical equipment must be followed closely. These should include:

- switching off powered tools and electrical equipment at the power point before you pull out the plug
- disconnecting broken appliances – *do not use* if cords or power points are damaged
- not overloading power points by "piggy backing" appliances
- keeping electrical leads off the floor – to reduce the risk of contact with fluids or sharp objects, and to prevent wear as a result of dragging across rough surfaces.
- Hand tools – such as spanners, wrenches and screwdrivers – will be used in every job. The most common injuries from use of hand tools are to the hands and fingers. Using the correct tools is an important way to avoid these injuries. If you are asked to carry out work using hand tools, you should be given training in how to use them. Don't hesitate to ask for assistance if you feel you have the wrong tool for the job.

1.4.5 Hazardous Substances and Dangerous Goods

The automotive industry requires the use of dangerous goods (such as petrol and gas) and hazardous substances (such as acids, oils, diesel and solvents). **Petrol containers** and **gas cylinders** must be stored securely, away from heat sources and out of the path of vehicle traffic. These are highly flammable substances and could cause fatality and serious injury if not carefully handled and stored.

Solvents are often used as cleaners or degreasers. They can enter the body when a person breathes in their vapour, through skin contact, or through the mouth from contact with food or fingers. Solvents can impair memory and cause headaches, dizziness, fatigue, mood changes or nausea. Exposure to high levels of solvents can cause liver damage, unconsciousness, death and cancers.

Spray paints contain harmful substances. Inhaling paint fumes may cause occupational asthma. Long term exposure can affect the brain, damage the reproductive system and cause kidney or liver damage. Contact with the skin may cause dermatitis (an inflammation of the skin).

Batteries contain acid and must be treated with caution. If you are asked to handle batteries, you must be given instruction and provided with appropriate PPE – rubber gloves, eye protection (you may need goggles to avoid splashes), overalls and solid work boots. (You should always wear work boots – *not* sneakers or soft shoes – in the automotive industry, no matter what job you are doing.)

Welding operations generate hazardous fumes and should be separated from other workshop activities and from workers who may not be protected by fume extraction systems, ventilation or appropriate PPE. It may be possible to weld out of doors in good weather; at all times, risk controls will be needed to prevent exposing the welder and other workers to risk.

Dust is caused by jobs like sanding, sweeping, grinding and cutting. Small metal pieces can be generated by cutting and sanding operations, and You can reduce dust by using machines that are enclosed or fitted with local exhaust ventilation.

You should:

- always follow safety procedure
- *not* use solvents to clean your hands
- *not* enter confined spaces where exhaust fumes may have collected
- Wear correct personal protective equipment provided, such as a mask, protective overalls, suitable gloves and safety glasses.

1.4.6 Confined Spaces

Some automotive workshops have pits to enable work to be done if a hoist is not available. The vehicle is driven over the pit, and the mechanic works from beneath. This work should never be done by someone working alone: a second person should be on hand (outside the pit) to monitor the work and to provide assistance because carbon monoxide (from the vehicle exhaust) is heavier than air, the fumes may build up in the 'confined space' under the vehicle. These fumes need not be only from the vehicle being worked on: if

other engines are running nearby, there is still a significant risk of exhaust emissions collecting in the pit.

Good ventilation is essential in automotive workshops. Engine bay doors should be fully open at all times. If weather conditions prevent this, the work must be evaluated and tasks such as spray painting, which could result in a build-up of fumes, should be postponed.

Respirators will be necessary for a number of jobs in an automotive workshop. Dust masks do not provide protection against vehicle fumes and gases, or paint drift from spraying operations.

1.4.7 Manual Handling

Lifting and moving equipment and materials, panel beating, and working in awkward postures (such as removing or replacing engine parts under car bonnets) are some examples of manual handling tasks you may have to do in the automotive industry.

At times, your work tasks may involve bending and stretching as well as twisting sideways, or working with materials and equipment above shoulder height. All of these increase the risk of manual handling injury. Risk controls may include:

- organizing the work to reduce the number of manual handling tasks involved
- providing mechanical lifting devices such as trolleys, hoists and overhead cranes where appropriate
- making sure you do not work long shifts involving manual handling activity
- Making sure the workplace layout allows enough space to move and work safely and comfortably.
- Lifting equipment will be necessary for many of the tasks in an automotive workshop. Many engine parts are too heavy to lift safely, and storage of items such as vehicle tyres on racking, while it may be easy at ground level where they can be rolled in, presents manual handling risk if you attempt to lift them. If lifting equipment is not available, the job may require a "two-person lift".

1.4.8 Slips, Trips and Falls

A slip or fall can cause injury to the arms, legs, back, neck or head. Neck and head injuries can cause damage to the spinal cord and nervous system. Many employees have suffered permanent disabling injuries as a result of a fall.

Poor 'housekeeping' in the automotive industry leads to slips, trips and falls. Oil spills, engine parts, air lines and hoses left on the workshop floor can all result in preventable accidents. Metal bins should be provided for waste disposal. These should not be allowed to overflow.

You must follow instructions and safe work procedures which may include:

- sweeping things like metal shavings up regularly
- cleaning all spills immediately – oil spills should be soaked up with a dry absorbent, and then put into a waste container
- making sure there are no trailing electrical cords on the floor
- keeping the workshop floor free of equipment, vehicle parts, tools and rubbish.

1.4.9 Noise

Employees in the automotive industry work with noisy tools and machinery such as wheel removers, compressors, grinders and drills. While in an automotive workshop, you may be exposed to noise levels exceeding 85 decibels or dB (A) that could lead to hearing loss.

Enclosing the source of the noise in a sound absorbing box or erecting sound absorbing barriers will help. And by keeping machinery and equipment in good order so it operates efficiently, noise can be considerably reduced. If the noise cannot be removed at its source or sufficiently reduced by other means, you must be provided personal hearing protection (earmuffs or earplugs) in addition to other risk controls.

CHAPTER 2

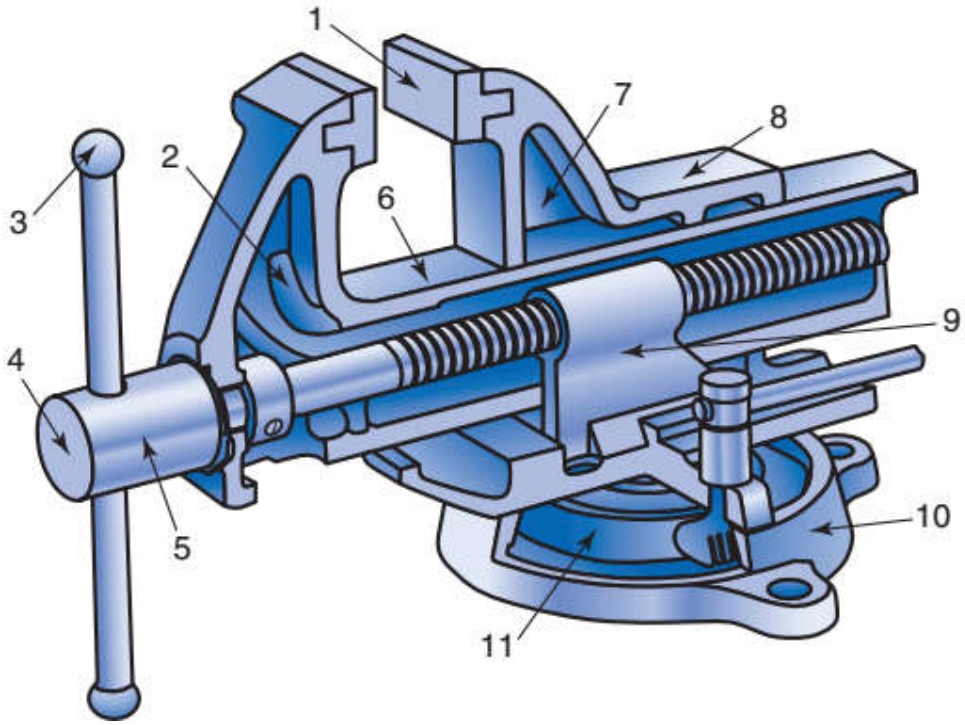
TOOLS & EQUIPMENTS USED IN AUTOMOBILE WORKSHOP

2.1 Bench vice

Vices are used to hold work for filing, hack sawing, chiseling and bending light metal. They are also used for holding work when assembling and disassembling parts.

Most bench vices have hardened insert jaws that are serrated for greater gripping power. These crisscross serrations are sharp and will dig into finished workpieces enough to mar them beyond repair. Soft jaws made of copper, other soft metals, or wood, are used to protect a finished surface on a workpiece. These soft jaws are made to slip over the vice jaws. Some vices used for sheet metal work have smooth, deep jaws.

Vices should be placed on the workbench at the correct working height for the individual. The top of the vice jaws should be at elbow height. Poor work is produced when the vice is mounted too high or too low. A variety of vice heights should be provided in the shop or skids made available to stand on.



(1) replaceable hardened tool steel faces pinned to jaw; (2) malleable iron front jaw; (3) steel handle with ball ends; (4) cold-rolled steel screw; (5) bronze thrust bearing; (6) front jaw beam; (7) malleable iron back jaw body; (8) anvil; (9) nut, mounted in back jaw keyseat for precise alignment; (10) malleable iron swivel base; (11) steel tapered gear and lock bolt.

Care of vices

Like any other tool, vices have limitations. "Cheater" bars or pipes should not be used on the handle to tighten the vice. Heat from a torch should not be applied to work held in the jaws, as the hardened insert jaws will then become softened. There is usually one vice in a shop reserved for heating and bending.

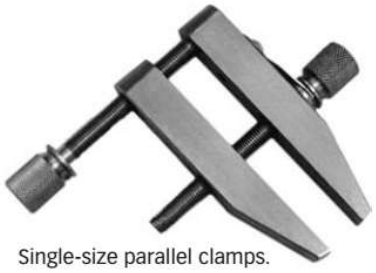
Heavy hammering should not be done on a bench vice. The force of bending should be against the fixed jaw rather than the movable jaw of the vice. Bending light flat stock or small round stock in the jaws is permissible if a light hammer is used.

2.2 C-Clamps

C-clamps are used to hold workpieces on machines such as drill presses, as well as to clamp parts together. The size of the clamp is determined by the largest opening of its jaws. Heavy-duty C-clamps are used by machinists to hold heavy parts such as steel plates together for drilling or other machining operations.

Heavy-duty C-clamp.

Two types of C-clamps



Single-size parallel clamps.

The clamp screw is protected by a sheet metal cover. Thus the screw is protected from dirt and damage. Parallel clamps are used to hold small parts. Since they do not have as much holding power as C-clamps, this

usually limits the use of parallel clamps to delicate work. Precision measuring setups are usually held in place with parallel clamps.

2.3 Pliers

Pliers come in several shapes and with several types of jaw action. Simple combination or slip joint pliers will do most jobs for which you need pliers. The slip joint allows the jaws to expand to grasp a larger size workpiece. They are measured by overall length and are made in 5-, 6-, 8-, and 10-in. sizes.

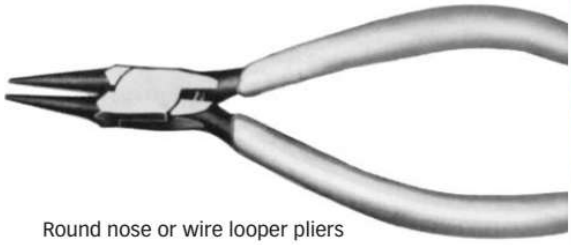
Slip joint or combination pliers.

Needlenose pliers, straight.

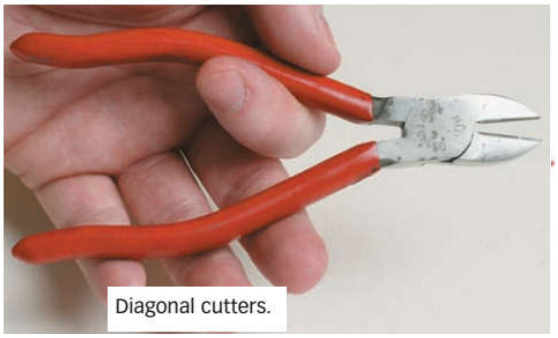
Needlenose pliers, bent.

Interlocking joint or water pump pliers.

Side cutting pliers



Round nose or wire looper pliers



Diagonal cutters.

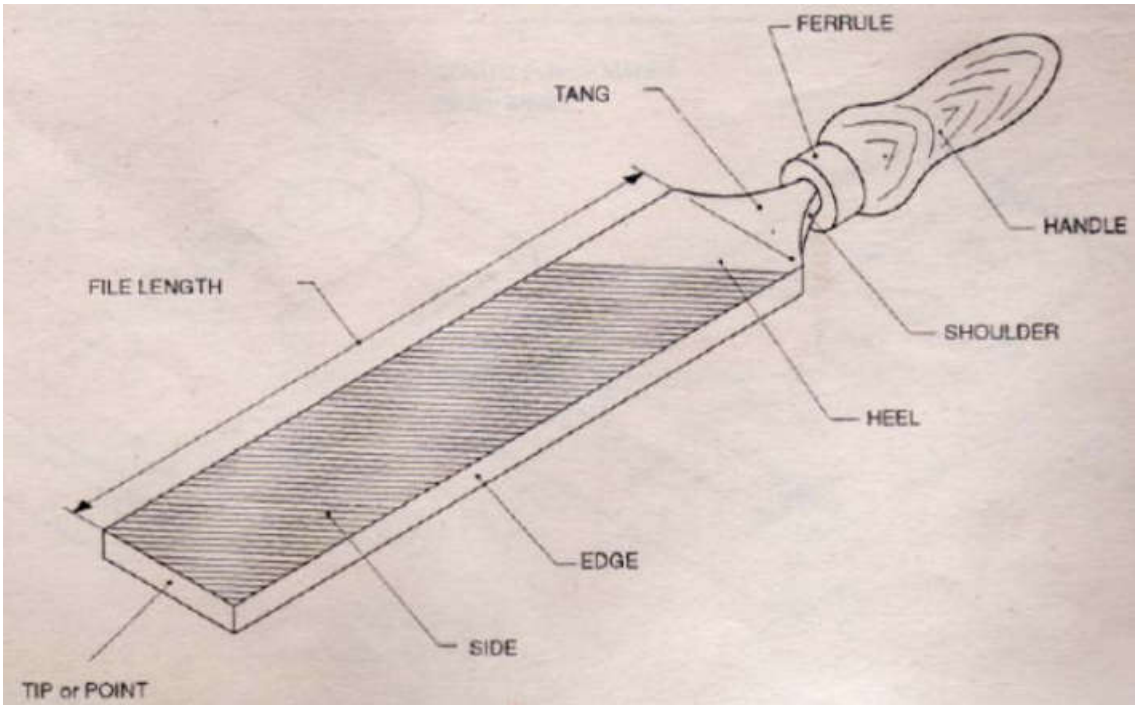
Interlocking joint pliers water pump pliers, were made to tighten packing gland nuts on water pumps on cars and trucks but are useful for a variety of jobs. Pliers should never be used as a substitute for a wrench, as the nut or bolt head will be permanently deformed by the serrations in the plier jaws, and the wrench will no longer fit properly. Round nose pliers are used to make loops in wire and to shape light metal. Needle nose pliers are used for

holding small delicate workpieces in tight spots. They are available in both straight and bent nose types. Linemen's pliers can be used for wire cutting and bending. Some types have wire stripping grooves and insulated handles. Diagonal cutters are used only for wire cutting.

2.4 File:

It is a tool used for removing small quantity of surplus material from a work piece. It is made of HCS or High grade cast steel. Body portion is hardened& tempered.

Parts of file:



Types of cut

- Single cut file
- Double cut file
- Rasp cut file

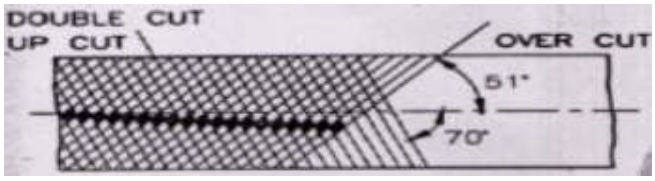
Single cut file

- A single cut file has rows of teeth cut in one direction across its face either straight, inclined or curved so it is called single cut or under cut or float cut files.

- The teeth are at angle is 60° to the centre line.
- Useful for filing soft metals like brass, Al, bronze, Cu.
- Removes less stock.
- Provides good surface finish.

Double cut file

- A double cut file has two rows of teeth cut diagonal to each other.
- The first row of teeth known as over cut with an angle of 50°-60°.
- The other cut made diagonal to this is known as up cut with an angle of 70°-80°
- Metal removal is faster.
- The files are grouped such as rough, bastard, 2rd cut, smooth dead and super smooth according to the cuts



Rasp cut file

- It has coarse and fine triangular shaped teeth projecting over the body.
- It has individual sharp, pointed teeth in a line.
- Useful for filing wood, leather & other soft materials.
- Available in only half round shape

Specification of file

- Length of file – Length is the distance from the tip of the file to the heel. For example 4", 6", 8", 12", 14", 16".
- Grade – File grades are determined by the spacing of the teeth. Different Grades of the file- Rough, bastard, second cut, smooth, dead smooth and Super smooth
- Cut of file - single/double cut.
- Shape of file - The shape of the file is specified by their cross-section. Flat, triangular, square, half round, round, knife edge

Types of file

- Flat file
- Safe edge file
- Square file
- Round file
- Half round file
- Tri-angular file
- Knife edge file

Flat file

- Flat file are of rectangular cross section.
- Edges along the width are parallel up to 2/3 of the length and then taper towards the point.
- Faces are double cut, and the edges are single cut.
- Used for general filing of external & internal surfaces.

Hand file or safe edge file

- Cross section is similar to Hand file is (rectangular).
- Edges along the width are parallel throughout its length.
- Faces are double cut.
- One edge is single cut & other is safe edge.
- Safe edge helps to file surfaces which are at right angles to surfaces already finished.
- Its used to filing steps, shoulder to square work but not touching or spoiling the adjacent surface which already made true

Square file

- Cross section is square.
- The width is parallel up to the middle and then taper towards the tip.
- It has double cuts on the all four faces
- Used for filing square holes, internal Square corners, rectangular, openings, Keyways & splines

Round file

- Cross section is round.
- It have same diameter up to 2/3 of its length and then taper towards the tip.
- It have single cut all over the body
- Used for enlarging circular holes & filing profiles with fillets

Triangular file

- Cross section is triangular (60°).
- It has double cuts on all the three face
- Used for filing, vee - grooves corners & angles, the file is also used by carpenters for sharpening the hack saw which are more than 60°.

Knife edge file

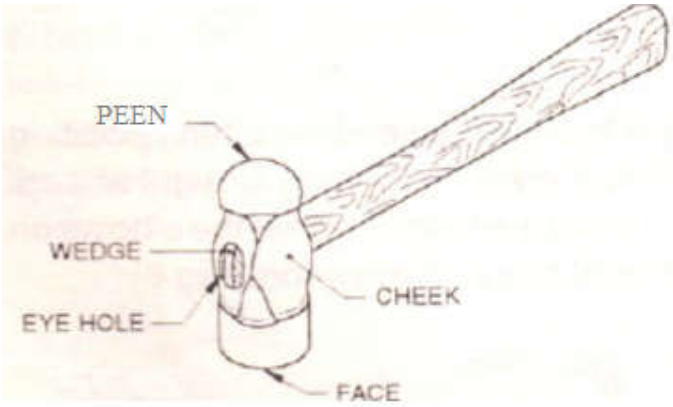
- Cross section is a sharp triangle.
- Used for filing narrow grooves & angles above 10°.

2.5 Hammer

Hammer is a simple striking tool used to make the job to a required shape either in cold or hot conditions beating directly on the top of the tool. It is mainly used for striking purposes while punching, bending, straightening, chipping, forging, riveting, etc.

It is made of forged steel, the both ends are hardened and tempered leaving the eye hole soft and tough

Parts of hammer



The major parts of a hammer are head and handle.

The head is made of drop forged carbon steel while the wooden handle must be capable of absorbing shock.

Wedge is inserted to split the shaft, this prevent the hammer from flying off during the striking work

Face is the striking portion. Slightly convexity is given to it to avoid digging of edge.

Peen is the other end of head used for shaping & forming work like riveting & bending.

Eye hole is oval in shape with a though recess enlarged towards on both ends to accommodate the wooden handle.

Types of peen

Ball peen Hammer

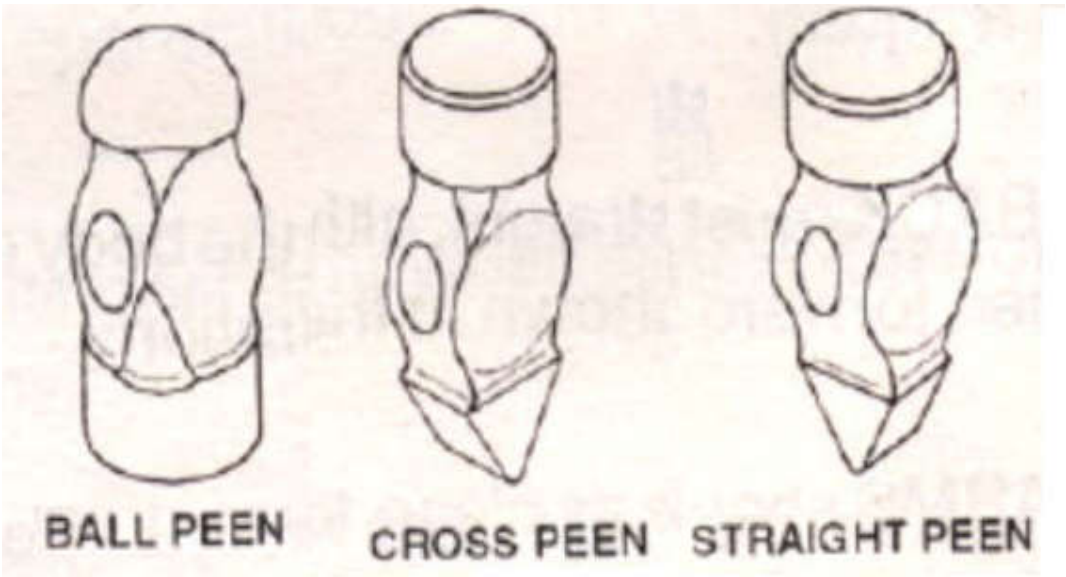
The shape of the peen is like a ball. The rounding on the peen helps to spread the metal and it is used for striking purpose and it is convenient while riveting, the face side is used to give heavy blows, the size is available from 0.11 to 0.91 kg (IS: 847-957), medium work 0.45kg for heavier work 0.91 kg hammer may selected

Straight peen hammer

The peen is straight to the shaft and is tapered flat towards its end, which is curved or rounded; the width is usually equal to the diameter of the space. It is used for stretching the metal. The available size is from 0.11 to 0.91kg (IS: 847-1957).

Cross peen hammer

The peen is similar on shape of straight peen hammer but the hammer peen is across the shaft or eye hole. It's used for hammering into shoulders or to hammer inside curves for bending and for stretching the metal. The available size is from 0.11 to 0.91kg (IS: 847-1957).



Types of hammers and applications

Hand hammer - Black smithy section, riveting work in ship yards (4.5 to 9 kg)
Sledge hammer - Black smithy section for heavy striking on hot condition(10 to 35 kg)

Soft hammer - Used for striking on finished or polished surface to protect the jobs from fracturing
Hide faced hammer – It is used in machine shop for driving close fitting parts together or knocking them apart
Claw hammer – It is more useful for carpenters
Mallet - It is more useful for carpenters and sheet metal workers

Specification of a hammer

A hammer is specified by their: Shape of peen and Weight

The weight of an engineer's hammer is 250 Gms.

Square face hammers come in eight sizes:

50g, 100g, 200g – All the tool room work.
400g, 500g, 600g – For chipping, fitting, bending, riveting etc.
800g,1000g For repair work

Round face hammers come in six sizes:

200g – For tool making, straightening jobs, layout
400g,500g,600g For general Fitting applications
800g,1000g For repair jobs

2.6 Screw driver

Screw driver is used for tightening or loosening screw. A round rod with flat end, having a handle at the other end is called a screw driver.

Main parts :-

1.Handle

Generally handles are made up of wood or plastic are fixed to the screw drivers. In order to save the wooden handle from being broken, an iron ring is fixed to the handle

2.Shank

The middle part between the blade and the handle is called shank. On it's, lower part tip or blade is made. On the Upper part either there is a hole through, which a wire is passed or this end is made flat so that when this part is fixed to the handle it does not allow the shank to move separately. These are generally made of carbon steel.

3.Blade

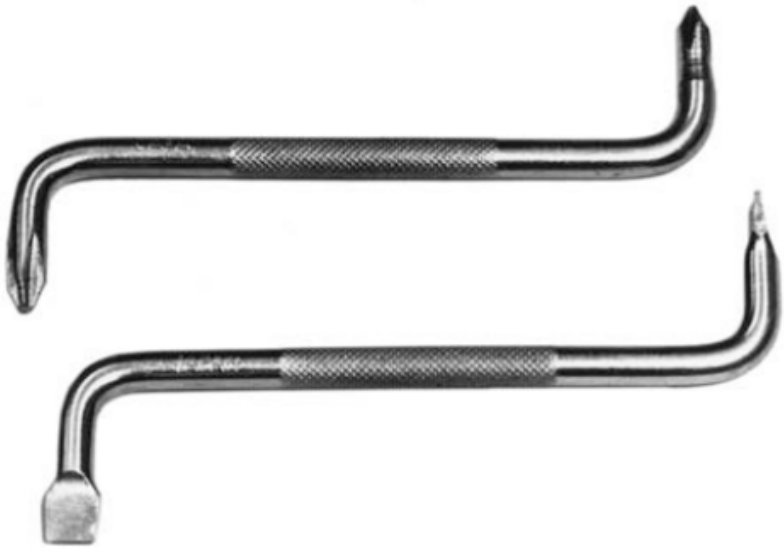
Blade is the lower part of the shank. It is also known as tip. This part is hardened and tempered

Types of screw driver:

1. Ordinary Flat Screw Driver

This type of screw driver is used for tightening or loosening different types of screws. These are available in small as well as larger sizes. These screw drivers have a handle of wood or plastic fixed to them. According to needs, there are light duty screw drivers or heavy duty screw drivers. They have a flat tip.

2. Offset Screw Driver



These screw drivers also have flat blade. But no handle is used in these screw drivers. Their shank is used in these Screw drivers. These shank is turned at 90 degrees angle at both the ends. In cases of narrow or slanting spaces, where ordinary flat screw driver cannot work, this offset screw driver is used. It is shown below.

3. Ratchet Screw Driver

In this type of screw driver a spring or ratchet is fitted in the handle. There is a button at its handle. When this button is pressed, shank of the ratchet screw starts revolving through the spring. When the button is left free, again the shank comes to its original position. With its help screws can be quickly tightened or loosened.

4. Philips Screw Driver

Tip of this type of Screw driver is different from that of others. This tip is pointed and is made after cutting four flutes. Such screw drivers are used where the screws have T cross-shaped groove at their heads. These screws are available in varying number measurements

5. Watch Maker Screw Driver

These screw drivers are available in sets. In a set there are six screw drivers, having number markings from 0 to 5. In place of handle, a cap is fixed to the shank. The cap is fixed to the shank in such a way that both cap and the shank can be moved independently.

For tightening or loosening a screw, tip is placed at the head of the screw and cap is pressed with one finger, while with other fingers shank is rotated. Watch Maker Screw Driver can be used in all kinds of instruments and watches.

6. Carpenter Screw Driver

This is made of a round rod and flat tip. Its handle is made flat from-two sides. This enables the worker to exert full force on the screw driver.

Methods of using screw driver

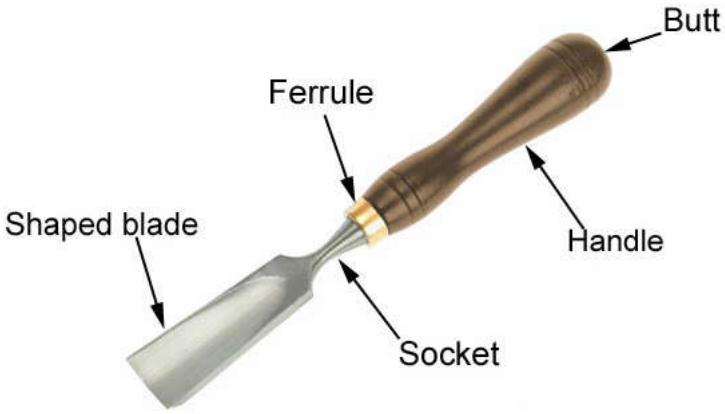
- Always select the correct size screwdriver for the screw being handled. A poor fit damages the screw slot and frequently the tip. Damaged screw heads are dangerous and difficult to remove.
- When driving or removing a screw, hold the screwdriver square with the screw. Guide the tip with the left hand.
- A worn screwdriver tip must be reground. Use a fine grinding wheel and little pressure. The tip should be checked during the grinding operation by fitting it to a screw slot. Do not overheat the tip during the grinding operation as the temper will be destroyed.

2.7 Chisel

Chisel is a cutting tool made of HCS of Hexagonal or Octagonal bars. It is used to remove the unwanted metal from the surface of a job by cutting in small pieces. This act is known us chipping. Chisels are used both on hot and cold metals, to cut flat, round or angle iron

A chisel is essentially a rod made from a carbon tool steel. The cutting edge is hardened through 0.3 to 0.5mm to HRC 53 – 59, The head is made hard to HRC 35 - 45

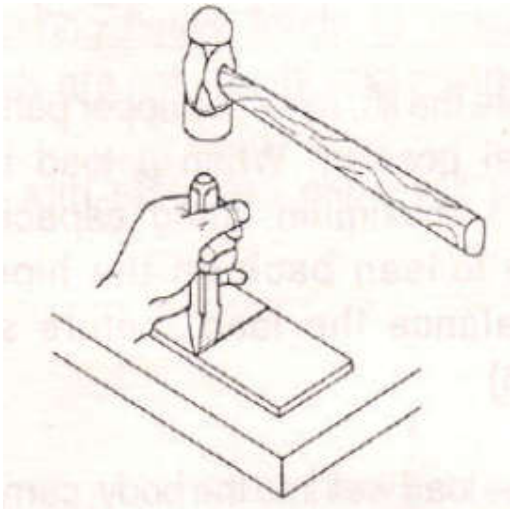
Parts of chisel



Types of chisels

Flat chisel

The shape of point is flat straight. This is one of the most common chisel used for cutting bars, wires, sheets, uprooting the floor, cutting of marbles, tiles etc. The cutting angle of the point can be changed as per the metal to be cut. For normal work the cutting point is ground to 60° angle.



Cow mouth chisel

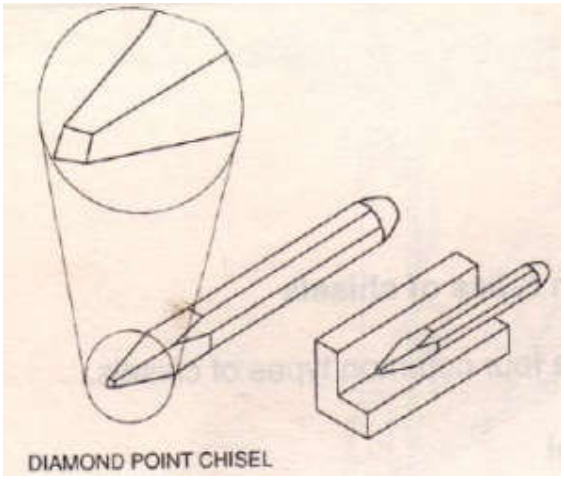
This chisel is named as "gouge chisel" also. This is used for cutting circular blanks from sheet and cutting circular cavities.

Round nose chisel

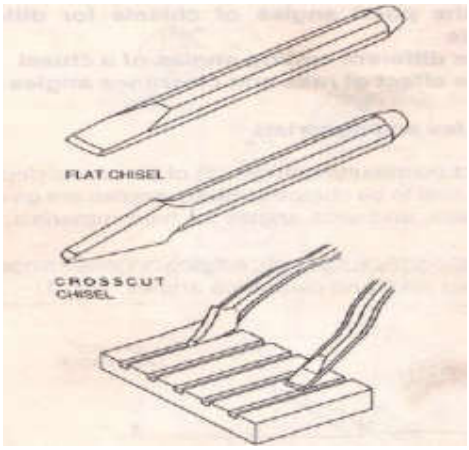
It is used for cutting of oil grooves in the bearings, pulleys ,bringing drill holes in correct position when set of center etc. It is available in the length of 150 to 250mm and the width is 2 to 16mm.

Diamond Point chisel

The diamond point chisel has cutting edge like a square diamond. It is used for producing sharp corners, angular holes oil grooves and V-channels. The available length is from 100 to 400mm and the width off the cutting edge is 6 to 16mm



Cross cut chisel



This chisel is also named as "cape chisel". It is used particularly for cutting keyways, channels narrow grooves and rarely for cutting flat surfaces. The width of the cutting edge is broader than its thickness at the back, which provides clearance in the keyways or channels to move the chisel for further cutting. The width varies from 4 to 12 mm while length varies from 150 to 300 mm.

Side cut chisel

This chisel is used for removing metal from slots and cotter ways, remove excess material from the sides of castings and removing runners and risers from the castings.

Wood working Chisel

Designation of a chisel

Flat chisels are available in the following lengths: 100,125,160,200mm.

The cutting edge of the chisel is differentiated as:5, 10, 16,20mm wide.

The cutting edge is hardened and tempered through 0.3 to 0.5mm to HRC 53-59, the head is made hard to HRC 35-45 HRC

Cross section of Body

Types of Chisel

2.8 Spanner

Spanners are used more than any other tool for tightening or opening different jobs. These are generally made of drop forged steel or carbon steel. These are made in different shapes and sizes, According to the requirements.

Types of spanners

Open end or single end spanner

In this type of spanner only one end is open, in which nut or bolt head is gripped to loose or tight it. It is also known as single end spanner. Their size is taken from the distance between their jaws. Thus selection of a spanner is made according to the distance between the opposite sides of nut or bolt.

Double ended spanner

In this type of spanner open ends are made at both the ends to hold nuts or bolt heads in them. These two ends made at angles of 15degrees from the body. These types of spanners are most widely used.

Combination spanner

Ring spanner

In this type of spanner one or both the ends round rings are made to grip nuts and bolts in order to tight or loose them. These rings are bent down in opposite direction from each other. Inside these rings projected teeth are built with which six sided nut bolts can be easily gripped. As it grips all the sides it does not slip.

Box Spanner

These are made of thick or thin pipes, On one end or both the ends. This spanner six sides are made in which nut bolts with six phrases are easily gripped. Holes are made across the rod on one or both the ends in which a rod can be put and used as a handle, it is used in deeper spaces

Adjustable spanner

This is a special type of spanner. It is also known as screw wrench. Its jaws can be expanded or narrowed down to tight or loose the nut bolts. They are used for those nuts where no other spanner fits well.

Allen key

These are thin steel rods with six faces which are bent at 90 degree angle from one end these are used to open screws, bolts whose heads are made round. They have a hole of six faces on the upper side. Such screws, bolts perform the available in numbers and sets of different sizes.

Hook Spanner

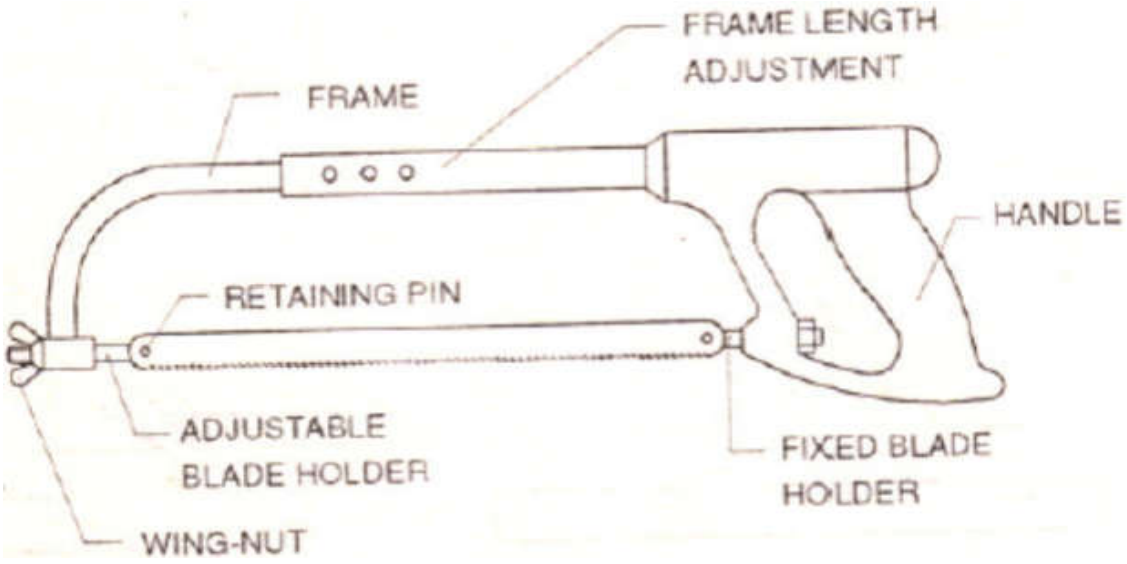
Hints on using Spanners

- Always select a spanner which fits the nut or bolt properly. A spanner that is too large may slip off the nut and possibly cause an accident.
- Whenever possible, it is advisable to pull rather than push on a spanner in order to avoid injury if the wrench should slip.
- Always be sure that the nut is fully seated in the spanner jaw.
- Use a spanner in the same plane as the nut or bolt head.
- When tightening or loosening a nut, a sharp quick jerk is more effective than a steady pull.
- A drop of oil on the threads, when assembling a bolt and nut, will ensure easier removal later.

2.9 Hacksaw

Hacksaw is a tool consisting of a frame and a blade. It is used for cutting the surplus metal on the scribed line. The operation is called hack sawing, it is used along with a blade to cut metals of different sections –rods, pipes, plates or sheet etc.

Parts of hack saw



Hacksaw blades

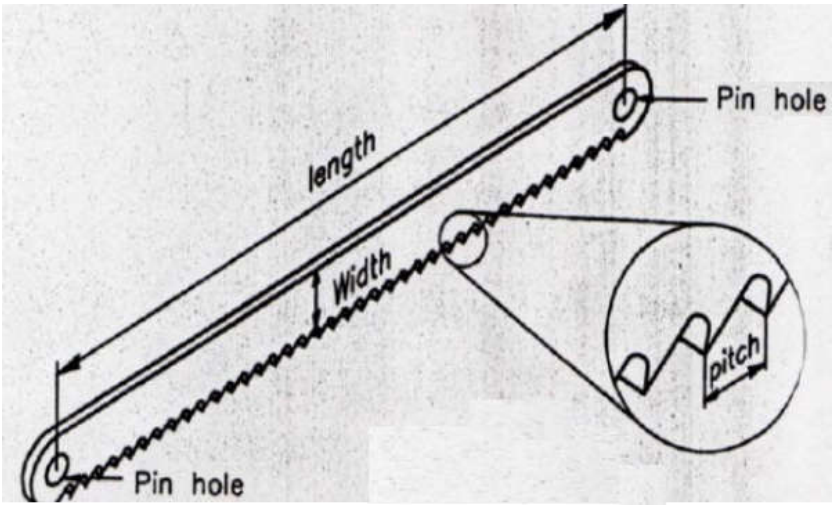
- Hacksaw blade is a cutting tool fitted in a frame to a correct tension and may be tested from sound by giving blows with a finger on it after tightening.
- It is a thin, narrow, steel band with teeth.
- Made of HCS, HSS, alloy steel and low tungsten and Hardened tempered. Most commonly used hacksaw blades are from 250mm to 300mm,12 or 16mm, 0.65 or 0.80mm
- Every tooth of the blade is wedge shaped, It has clearance angle A, wedge angle B, Band Cutting angle C, A+B+C=90 as the hacksaw operates under specific conditions; the values of the angles differ from those in other cutting tools

Types of blades

All hard blades - hardened to full length between pin holes.

Flexible blades - only teeth are hardened. It is useful for cutting curved lines.

Pitch (distance between teeth) of blades

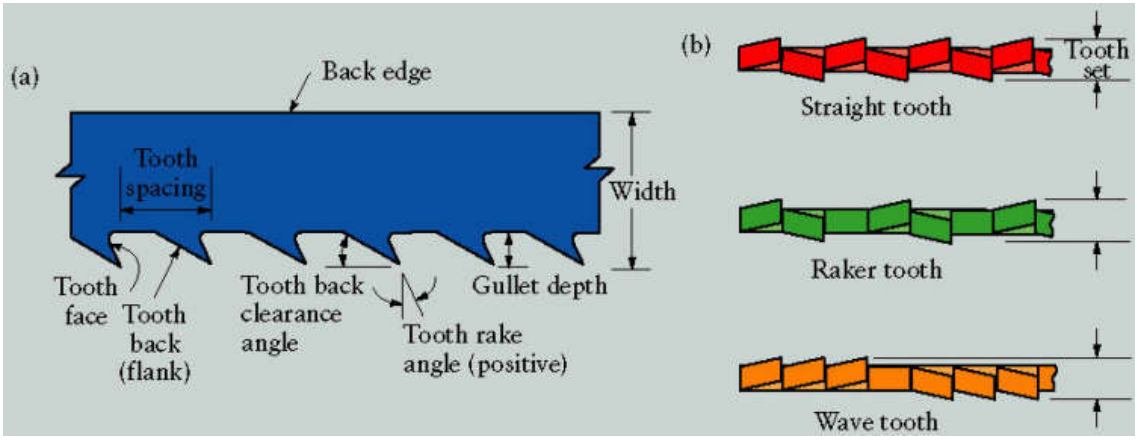


Coarse – 1.8mm.

Medium – 1.4mm & 1.0mm.

Fine – 0.8mm.

Nomenclature of Hack saw blade



Selection of blade

The blades should be selected according to the size and strength of the metals to be cut.

Materials to be cut	T.P.I	Pitch in mm
Aluminium,brass,lead	14	1.8 coarser teeth
cast iron	16 to18	1.8 coarser teeth
Mild steel, bronze	18	1.4 medium teeth
High carbon alloy steel sheet	32	1.0 fine teeth
Medium carbon alloy steel	24	1.0 fine teeth

Specification of blade

- Length of the blade
- Type of blade
- Pitch
- Material of blade.

Precautions while hack saw cutting

- Hacksaw blade should be fitted on the frame very carefully. It should neither be very tight nor very loose

- The job which is to be cut should not be held in a vice much high, otherwise there would be vibrations in it.
- While cutting the thin sheet packing of wood, plastic or any other appropriate material should be used in its front and back.
- Hacksaw blade should not be allowed to become slanting manner we should start a fresh cut. Operating hacksaw in the old cut may break it.
- If the blade gets broken while working, then we should replace it with a blade which has been almost used for the same period rather than using a brand new blade, the new blade can break if it is operated in that old slot.
- If necessary, water should be used as a coolant.
- After using a hacksaw either its blade should be taken out or it must be made lose.

2.10 Drilling

Drilling is a process of making holes on workpieces. The tool used for drilling is a drill and it is rotated with a downward pressure causing the tool to penetrate into the material.

Drill can be defined as a rotary end cutting tool having one or more cutting lips, and having one or more helical or straight flutes for the passage of chips and the admission of a cutting fluid.

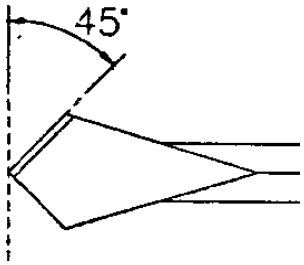
There are two common types of twist drills, **high-speed steel drills, and carbide-tipped drills.**

- The most common type used for normal workshop practice is the high-speed steel twist drill because of its low cost.
- Carbide-tipped metal drills are used in production work where the drill must remain sharp for extended periods, such as in a numerically controlled drilling machine.

- Other types of drills available include solid carbide drills, Tin coated drills, diamond drills etc.
- Twist drills shanks are either straight shank or tapered shank (Morse taper).
- Straight shank twist drills are usually 12mm or smaller and are gripped in the drill chucks.
- Tapered shank drills are usually for the larger drills that need more strength which is provided by the taper socket chucks.
- Common twist drill sizes range from **0.3mm to 90mm in diameter.** Larger holes are cut by special drills that are not considered as twist drills.

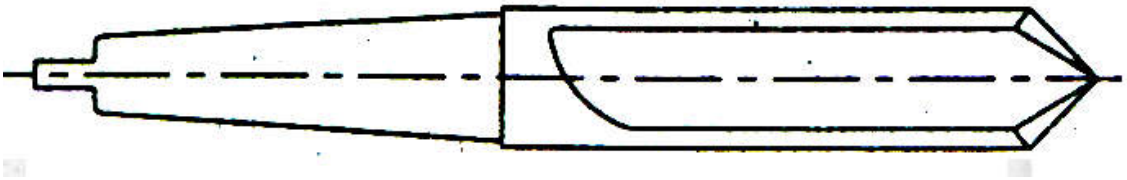
Flat or spade drill

This type of drill is used where the required size of twist drill is not available. It is made from a round tool steel piece which is forged to shape and ground to size, and then hardened and tempered. This type of drill is used for hand drilling (without power) or with a ratchet brace.



Straight fluted drill

It has grooves or flutes running parallel to the drill axis. It is mainly used in drilling brass, copper or soft materials. This type of drill is inconvenient in standard practice, as the chips do not come out from the hole automatically. It is used to drill sheet metals and cores in the castings.



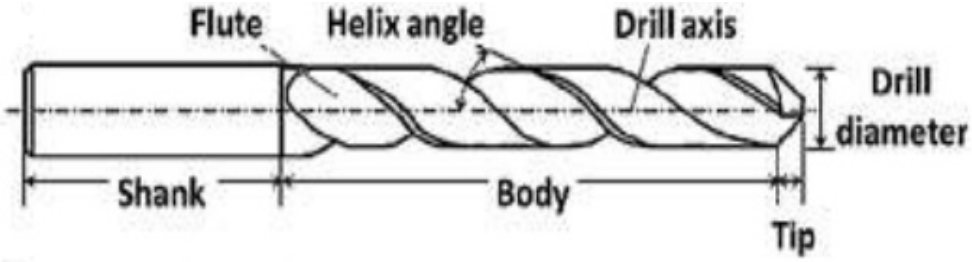
Twist drills

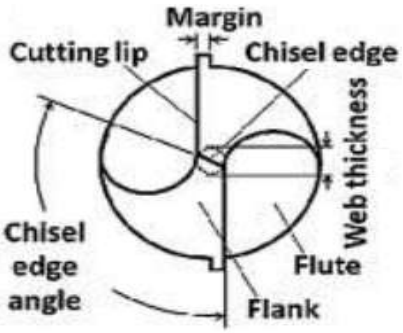
In this type, two spiral flutes or grooves run lengthwise around the body of the drill. It is the most common type of drill used for all purposes, and especially for faster drilling of accurate holes and for harder materials - in comparison with the other drills.

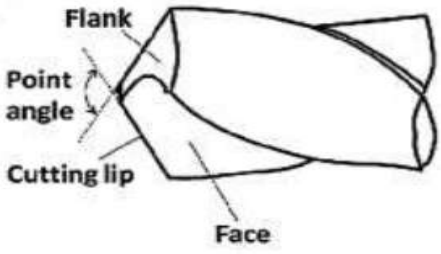
Material for twist drills

Twist drills, used in a machine shop, are usually made out of high-speed steel. For drilling hard materials at higher cutting speeds, there are drills with carbide tips, brazed at the lips of the drill.

Parts of a twist drill







Point

The cone shaped end, which does the cutting, is called the point. It consists of a dead centre, lips or cutting edge and a heel.

Tang

This is provided only on taper shank drills, for driving (giving torque to) the drill, which when overloaded, becomes twisted or gets sheared off.

Flutes

Flutes are the spiral grooves which run to the length of the drill. The flutes help:

- To form the cutting edges
- To cur) the chips and allow these to come out
- The coolant to flow to the cutting edge.

Shank

This is the driving end of the drill which is fitted on to the machine. Shanks are of two types.

Taper shank, with Morse taper provided, is used for larger diameter drills, and the straight shank is used for smaller diameter drills.

Land/margin

The land/margin is the narrow strip which extends to the entire length of the flutes. The diameter of the drill is measured across the land/margin.

Body clearance

Body clearance is that part of the body which is reduced in diameter to cut down the friction between the drill and the hole being drilled.

Web

Web is the metal column, which separates the flutes. It gradually increases in thickness towards the shank.

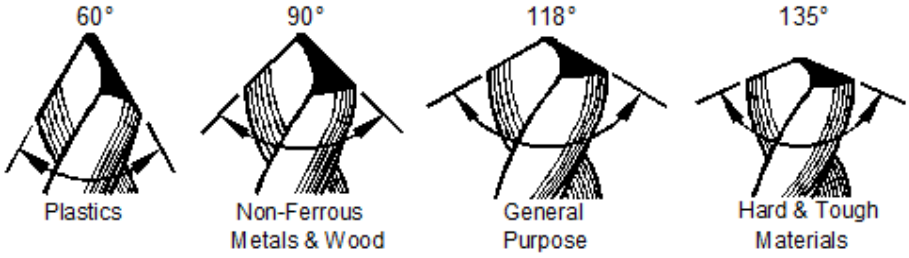
Guide: A cylindrical portion, following the cutting portion of the flutes, acting as a guide to keep the drill in proper alignment; the guide portion may be fluted, grooved, or solid

Heel: The trailing edge of the land

Helical Flutes: Flutes which are formed in a helical path around the axis.

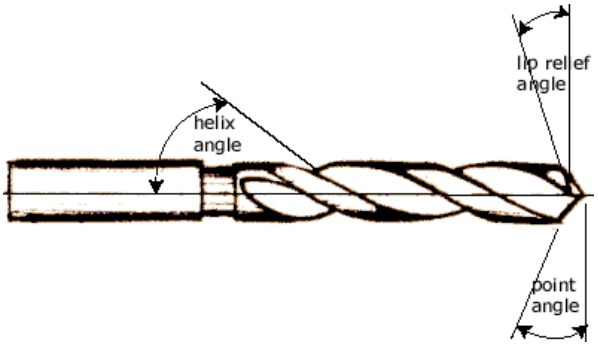
Point angle/cutting angle

The point angle of a general purpose (standard) drill is 118°. This is the angle between the cutting edges (lips). The angle varies according to the hardness of the material to be drilled



Helix angle

Twist drills are made with different helix angles. The helix angle determines the rake angle at the cutting edge of the twist drill.

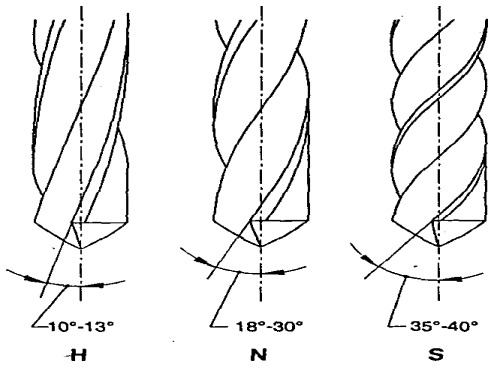


The helix angles vary according to the material being drilled. According to Indian Standards, three types of drills are used for drilling various materials.

Type N - for normal low carbon steel.

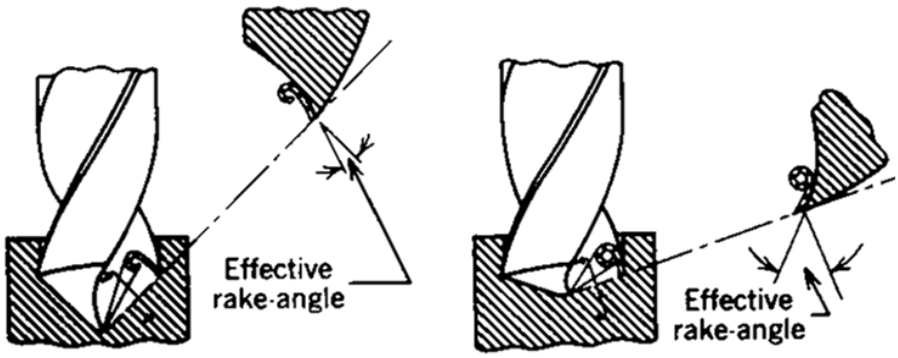
Type H - for hard and tenacious materials.

Type S -for soft and tough materials.



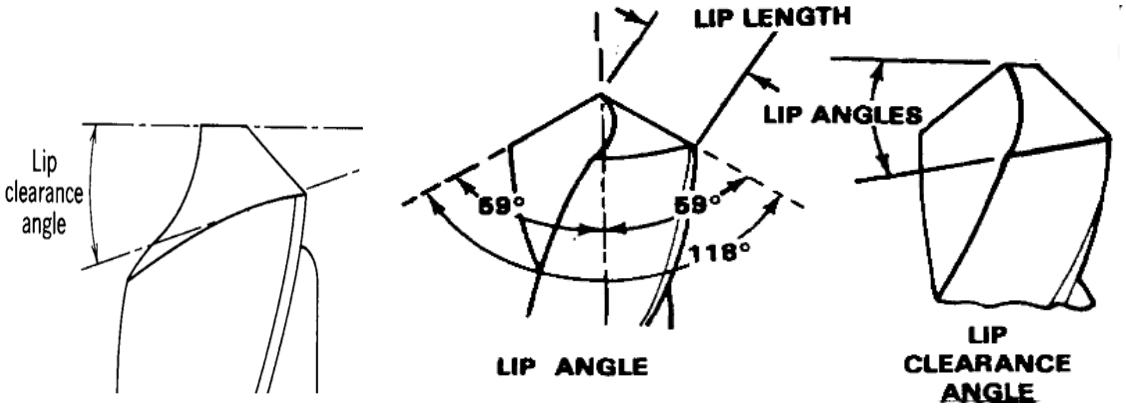
Rake angle

Rake angle is the angle of the flute (helix angle).



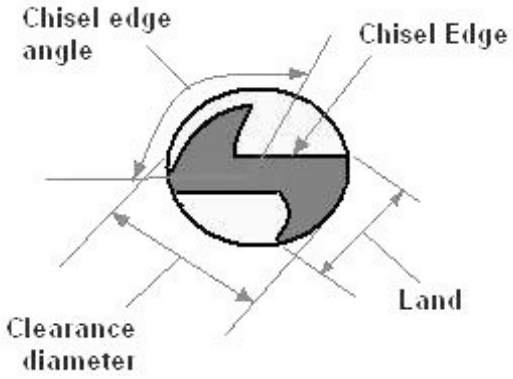
Clearance angle

The clearance angle is to prevent the friction of the tool behind the cutting edge. This will help in the penetration of the cutting edges into the material. If the clearance angle is too much, the cutting edges will be weak find if it is too small, the drill will not cut.



Chisel Edge Angle/Web Angle

This is the angle between the chisel edge and the cutting lip.

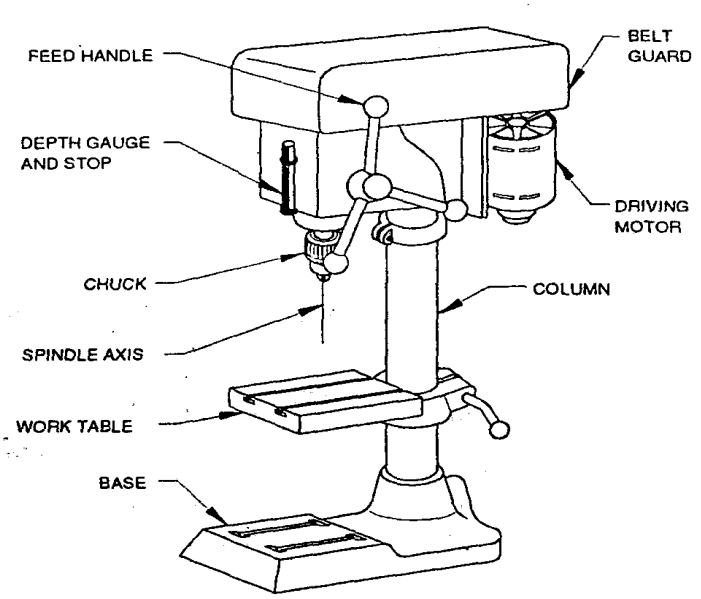


Designation of drills

Twist drills are designated by the

- Diameter
- Tool type
- Material.

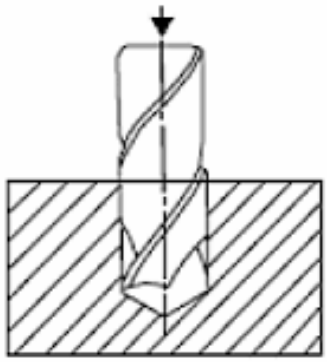
Drilling machine



Drilling Machine Operations

1. Drilling
2. Reaming
3. Boring
4. Counter boring
5. Countersinking
6. Spot Facing
7. Tapping
8. Lapping
9. Grinding
10. Trepanning

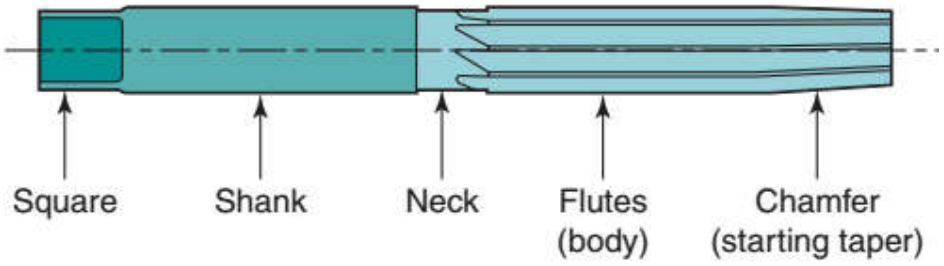
Drilling :

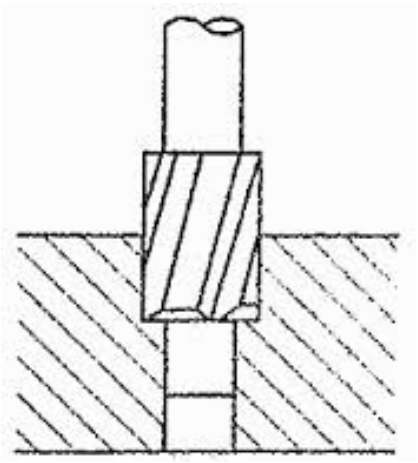


Drilling is the operations, of producing a cylindrical hole by removing metal by the rotating edge of a cutting tool called the drill. The drilling **is** one of the simplest methods of producing a hole. Before drilling the centre of the hole is located on the workpiece by drawing two tines at right angles to each other and then a centre punch is used to produce an in dentation., at the centre. The drill point is pressed at this centre point to produce the required hole. Drilling does not produce an accurate hole in a workpiece and the hole location is not perfect. The internal surface of the hole so generated by drilling becomes rough and the hole is always slightly oversize than the drill used due to the vibration' of the spindle and the drill.

Reamers

Holes produced by drilling are seldom accurate in size and often have rough surfaces. A reamer is used to finish a hole to an exact dimension with a smooth finish. Hand reamers are often used to finish a previously drilled hole to an exact dimension and a smooth surface. When parts of machine tools are aligned and fastened with capscrews or bolts, the final operation is often hand reaming a hole in which a dowel pin is placed to maintain the alignment. Hand reamers are designed to remove only a small amount of material from a hole, usually from .001 to .005 in. These tools are made from high-carbon or high-speed steel.





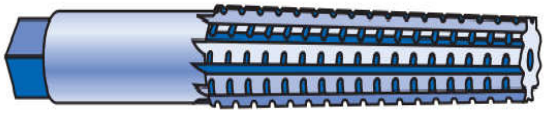
Straight flute hand reamer.

Straight flute taper pin hand reamer.

Helical flute hand reamer.

Spiral flute taper pin hand reamer.

Straight flute expansion hand reamer.



Morse taper socket roughing reamer.

Boring : Boring is performed in a drilling machine for reasons stated below

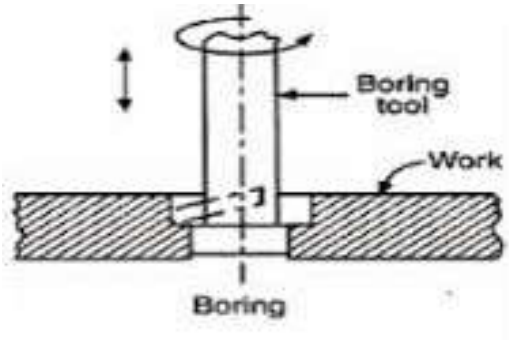
1. To enlarge & hole by means of an adjustable cutting tool with only one cutting edge. This is necessary where suitable sized drill is not available or where hole diameter is so large that it cannot he ordinarily drilled.

2. To finish a hole accurately and to bring it to the required size.

3. To machine the internal surface of a hole already produced in casting.

4. To correct out of roundness of the hole.

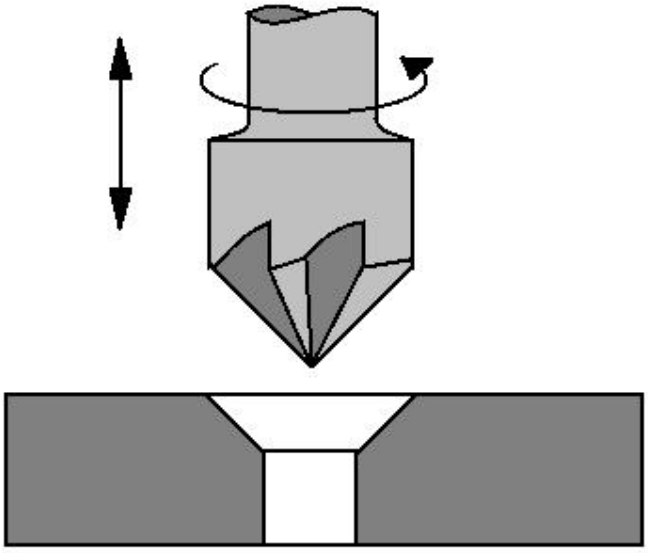
5. To correct the location of the hole as the boring tool follows an independent path with respect to the hole.



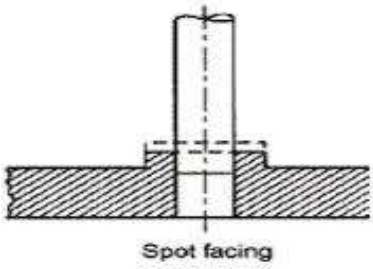
Counter boring : Counter boring is the operation of enlarging the end of a hole cylindrically. The enlarged hole forms a square shoulder with the original hole. This is necessary in some cases to accommodate the heads of bolts, studs and pins. The tool used for Counter boring is called a counter bore. Counter boring can give an accuracy of about +or- 0.050 mm. The cutting speed for counter boring is 25 % less than that of drilling operation.

Countersinking : Countersinking is the operation of making a cone-shaped enlargement of the end of a hole to provide a recess for a flat head screw or

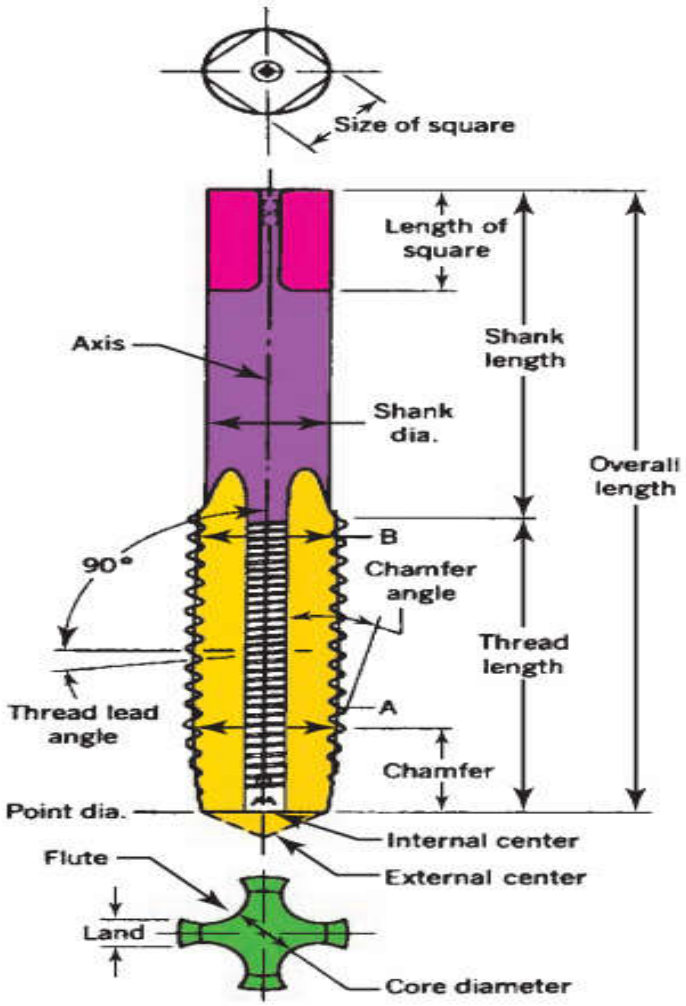
countersunk rivet fitted into the hole. The tool used for countersinking is called a countersink. Standard countersinks have 60 , 82 Or 90 degrees included angle and the cutting edges of the tool are formed at the conical surface. The cutting speed in countersinking is 25 % less than that of drilling.



Spot facing : Spot facing is the operation of smoothing and squaring the surface around a hole for the seat for a nut or the head of a screw. A counter bore or a special spot facing tool may be employed for this purpose.

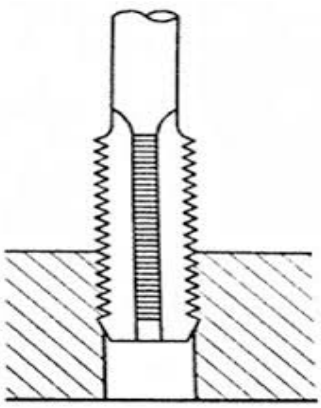


Tapping : Tapping is the operation of cutting internal threads by means of a cutting tool called a tap. Tapping in a drilling machine may be performed by hand or by machine.



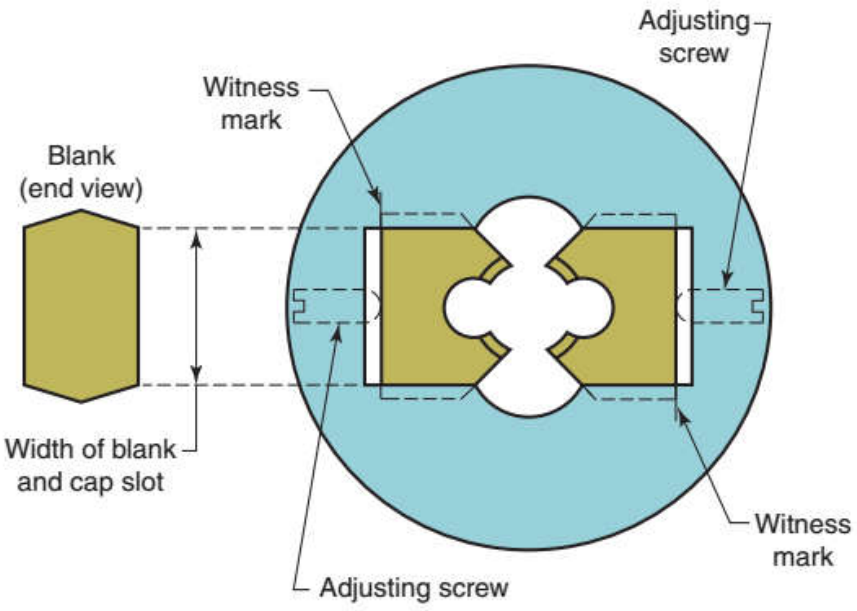
The major diameter is the outside diameter of the tool as measured over the thread crests at the first full thread behind the chamfer. This is the largest diameter of the cutting portion of the tap, as most taps are back tapered or reduced slightly in thread diameter toward the shank. This back taper reduces the amount of tool contact with the thread during the tapping process, hence making the tap easier to turn.

Taps are made from either high-carbon steel or high speed steel and have a hardness of about Rockwell C63. High-speed steel taps are far more common in manufacturing plants than carbon steel taps. High-speed steel taps typically are ground after heat treatment to ensure accurate thread geometry.



Die passing

A die is used to cut external threads on the surface of a bolt or rod. Many machine parts and mechanical assemblies are held together with threaded fasteners, most of which are mass-produced. If necessary, the threaded portion of a bolt may be extended with a die toward the head, but this should be done with unhardened bolts, as cutting heat treated bolts will dull the die.

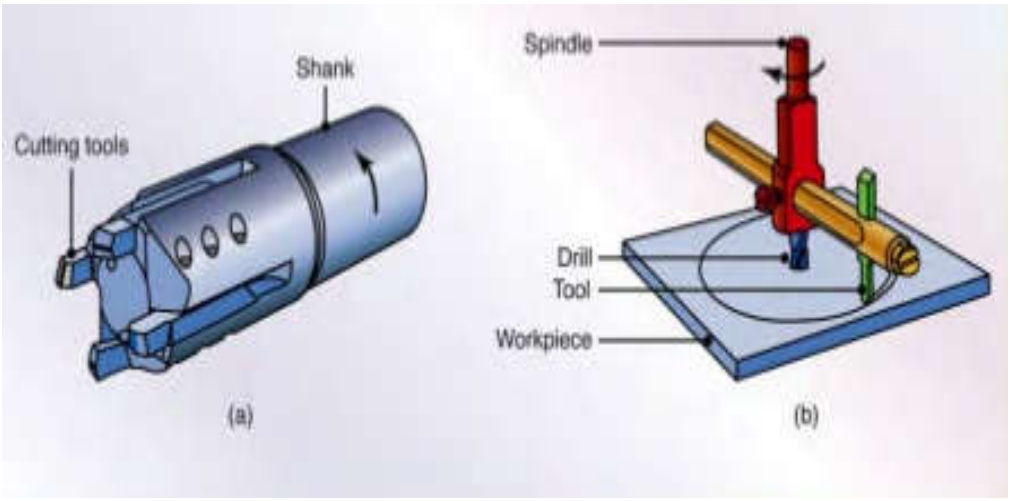


Some dies are made from carbon steel, but most are made from high-speed steel. Dies are identified by the markings on the face as to the size of thread,

number of threads per inch, and form of thread, such as NC, UNF, or other standard designations.

Lapping : Lapping is the operation of sizing and finishing a small diameter hole already hardened by removing' a very small amount of material by using a lap. There are many kinds of lapping tools. The copper head laps are commonly used. The lap fits in the hole and is moved up and down when it revolves.

Trepanning : Trepanning is the operation of producing a hole by removing metal along the circumference of a hollow cutting tool. Trepanning operation is performed for producing large holes. Fewer chips are removed and much of the material is saved while the hole is produced. The tool may be operated at higher speeds as the variation in diameter of the tool is limited by the narrow cutting edge. The tool resembles a hollow tube having cutting edges at one end and a solid shank at the other to fit into the drill spindle. This is one of the efficient methods of producing a hole.



CUTTING SPEED AND R.P.M

For a drill to give a satisfactory performance, it must operate at the correct cutting speed and feed.

Cutting speed is the speed at which the cutting edge passes over the material while cutting, and is expressed in meters per minute.Cutting speed is also sometimes stated as surface speed or peripheral speed. The selection of the recommended cutting speed for drilling depends on the materials to be drilled, and the tool material.

Tool manufacturers usually provide a table of cutting speeds required for different materials. The recommended cutting speeds for different materials are given in the table. Based on the cutting speed recommended, the R.P.M. at which a drill has to be driven, is determined.

Materials being drilled for HSS tool	Cutting speed (m/min)
Aluminum	**70-100**
Brass	**35-50**
Bronze (phosphor)	**20-35**
Cast iron (grey)	**25-40**
Copper	**35-45**
Steel (medium Carbon/mild. Steel)	**20-30**
Steel (alloy, high tensile)	**5-8**
Thermosetting . plastic (low speed due to abrasive properties)	**20-30**

Calculating R.P.M.

$$v = \frac{n \times d \times \pi}{1000} \quad m/min$$

$$n = \frac{v \times 1000}{d \times \pi}$$

n - r.p.m.
v - cutting speed in m/min.

d - diameter of the drill in mm

π= 3.14.

Examples

Calculate the r.p.m. for a high speed steel drill 024 to cut mild steel.

The cutting speed for MS is taken as 30 m/min. from the table.

$$n = \frac{1000 \times 30}{3.14 \times 24} = 398 \text{ r.p.m.}$$

It is always preferable to set the spindle speed to the nearest available lower range. The selected spindle speed is 300 r.p.m.

The r.p.m. will differ according to the diameter of the drills. The cutting speed being the same, larger diameter drills will have lesser r.p.m. and smaller diameter drills will have higher r.p.m.

The recommended cutting speeds are achieved only by actual experiments.

Feed in drilling

Feed is the distance (X) a drill advances into the work in one complete rotation. Feed is expressed in hundredths of a millimeter.

The rate of feed is dependent upon a number of factors.

- Finish required
- Type of drill (drill material)
- Material to be drilled

Factors like rigidity of the machine, holding of the work-piece and the drill, will also have to be considered while determining the feed rate. If these are not to the required standard, the feed rate will have to be decreased.

It is not possible to suggest a particular feed rate taking all the factors into account.

The table for the feed rate given here is based on the average feed values suggested by the different manufacturers of drills.

Drill diameter (mm) H.S.S.	Rate of feed (mm/rev)
1.0-2.5	0.040-0.060
2.6-4.5	0.050-0.100
4.6-6.0	0.075 -0.150
6.1 -9.0	0.100-0.200
9.1 -12.0	0.150-0.250
12.1 -15.1	0.200 - 0.300
15.1 - 18.0	0.230 - 0.330
18.1 -21.0	0.260 -0.360
21.1 -25.0	0.280 - 0.380

Too coarse a feed may result in damage to the cutting edges or breakage of the drill.

Too slow a rate of feed will not bring improvement in surface finish but may cause excessive wear of the tool point, and lead to chattering of the drill.

2.11 OFF-HAND GRINDING ON PEDESTAL GRINDERS

The pedestal grinder is really a machine tool. However, since the workpiece is handheld, it is more logical to discuss this machine in conjunction with hand tools. Furthermore, you must be familiar with the pedestal grinder, as you will be using it early in your study of machine tool practices.

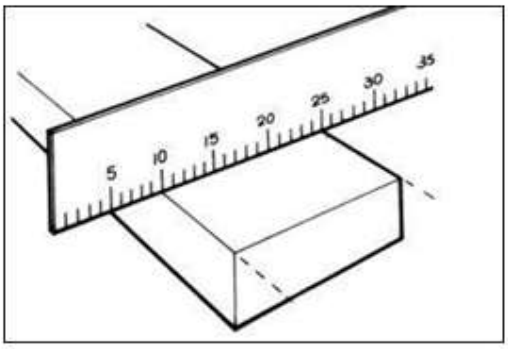
The pedestal grinder gets its name from the floor stand or pedestal that supports the motor and abrasive wheels. The pedestal grinder is a common machine tool that you will use almost daily in the machine shop. This grinding machine is used for general-purpose, off-hand grinding in which the workpiece is handheld and applied to the rapidly rotating abrasive wheel.

One of the primary functions of the pedestal grinder is shaping and sharpening tool bits and drills in machine shop work. Pedestal grinders are often modified for use with rotary wire brushes or buffing wheels.

Large, heavy-duty pedestal grinders are sometimes found in machine shops. These grinders are used for rough grinding (snagging) welds, castings, and general rough work. These machines are generally set up in a separate location from the tool grinders. Rough grinding of metal parts should never be done on tool grinders because it causes the wheels to become rounded, grooved, uneven, and out-of-round. In that condition they are useless for tool grinding.

2.12 Measuring tools

2.12.1 Steel rule



- Most useful tool in shop used for taking linear measurements of blanks & articles to an accuracy of 0.5 to 1mm
- Consists of a strip of hardened steel having line graduations etched or engraved at interval of standard unit of length, marked both in inch & centimeter
- Steel rules are made 150, 300, 500 & 1000mm long

2.12.2 Steel tape

- Made from non rusting spring steel

- Graduations are imprinted or engraved on it
- These are made to 1 to 50 m in length

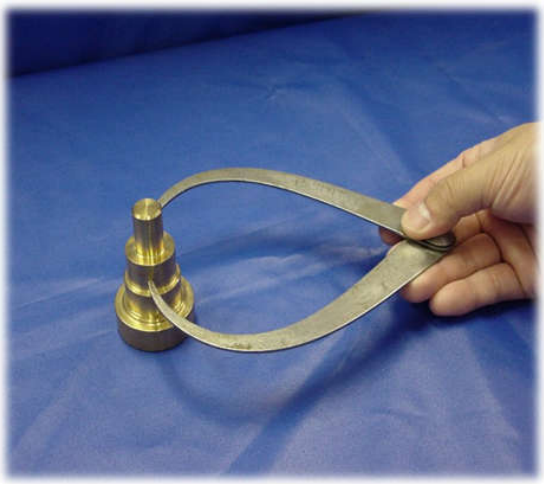
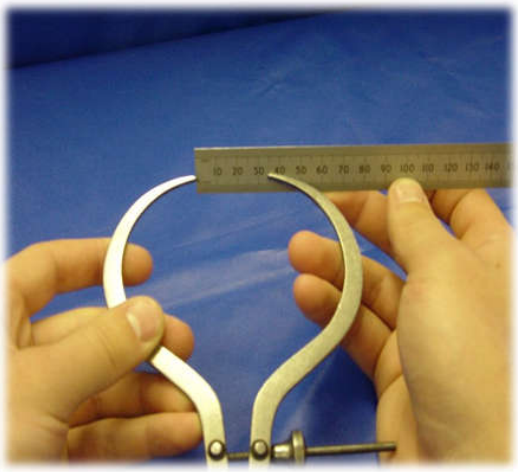
2.12.3 CALIPERS

- Non-graduated tools used for measuring the distance between two points of contact on the work piece
- Consists of two movable metal legs hinged at top, & ends of the legs span the part to be inspected
- Distance must be transferred to an actual dimension by use of a graduated direct measuring instrument

TYPES OF CALIPERS

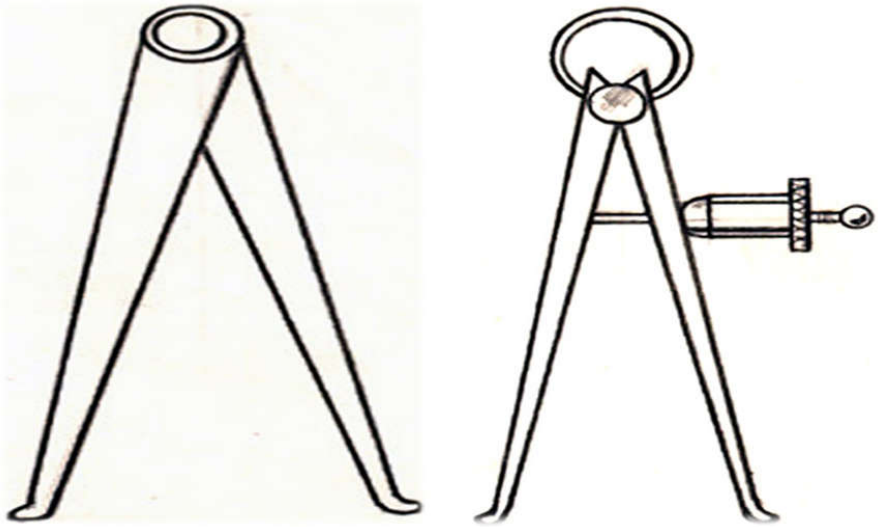
1. Outside caliper
2. Inside caliper
3 .Hermaphrodite caliper
4.Transfer caliper

Outside caliper

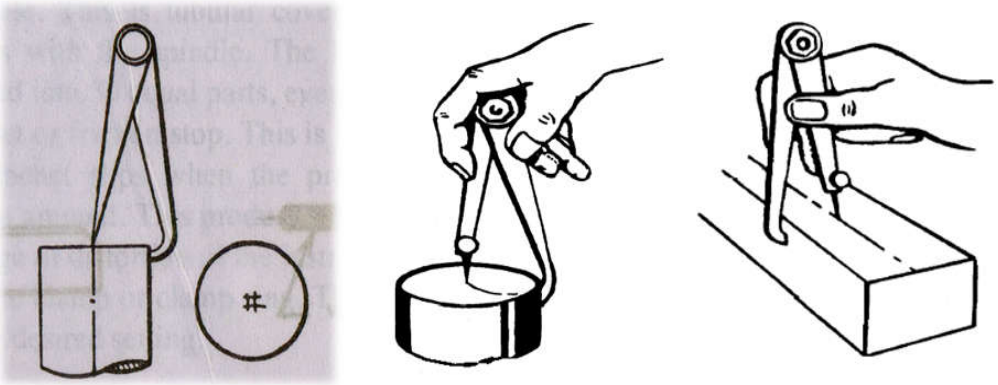
- Two-legged instrument with its leg bent inwards
- Used for measuring or comparing thickness, diameters and other outside dimensions
- Steel rule is needed for direct reading

Inside caliper



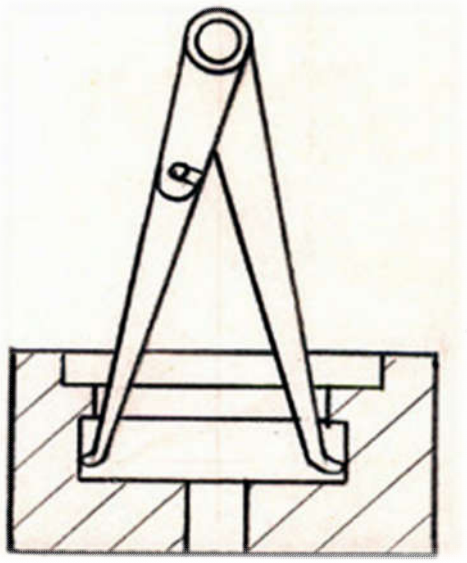
- Two-legged tool with its legs bent outwards
- Used for measuring or comparing hole diameter, distance between shoulders or other parallel surface of any inside dimension
- Steel rule is used for direct reading

Hermaphrodite caliper



- Also called odd leg caliper
- Has one pointed leg like a divider & one bent leg
- The caliper is extremely useful for scribing lines parallel to the edge of the work & for finding the center of a cylindrical work

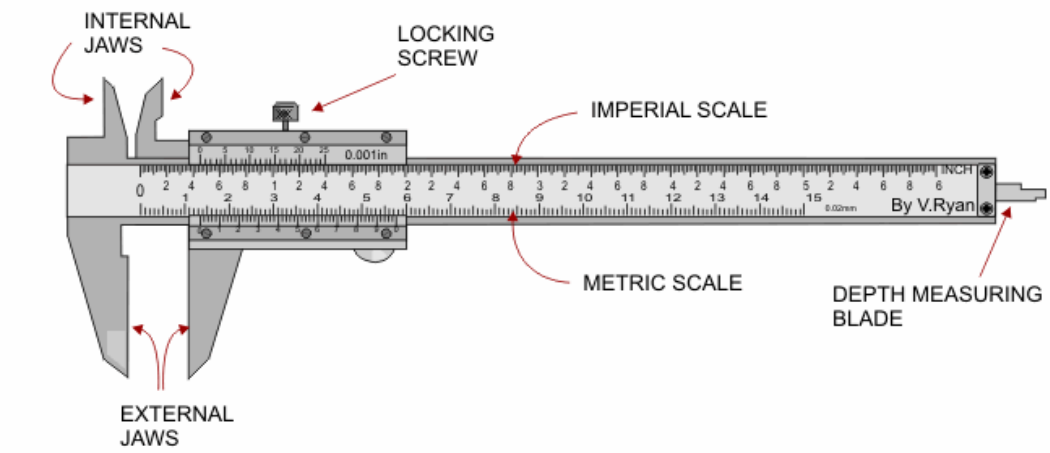
Transfer caliper



- Measuring recessed work

2.12.4 Vernier caliper

Pierre Vernier of France found it out in 1631. A Vernier scale is the name given to any scale making use of the differences between two scales which are nearly, but not quite alike, for obtaining small differences. It is made of stainless steel and hardened throughout. Its range varies from 150mm to 1m in step of 150mm. It is used for measuring internal and external measurements and also depth.



Comprises of a beam, or main scale, measuring jaws, & a vernier head with vernier scale engraved on it

Jaws are attached to the main scale & vernier scale in such away that when the two jaws are brought into contact, the zero of the vernier coincides with the zero of the vernier scale

Usually a vernier caliper is constructed to read both mm & inches

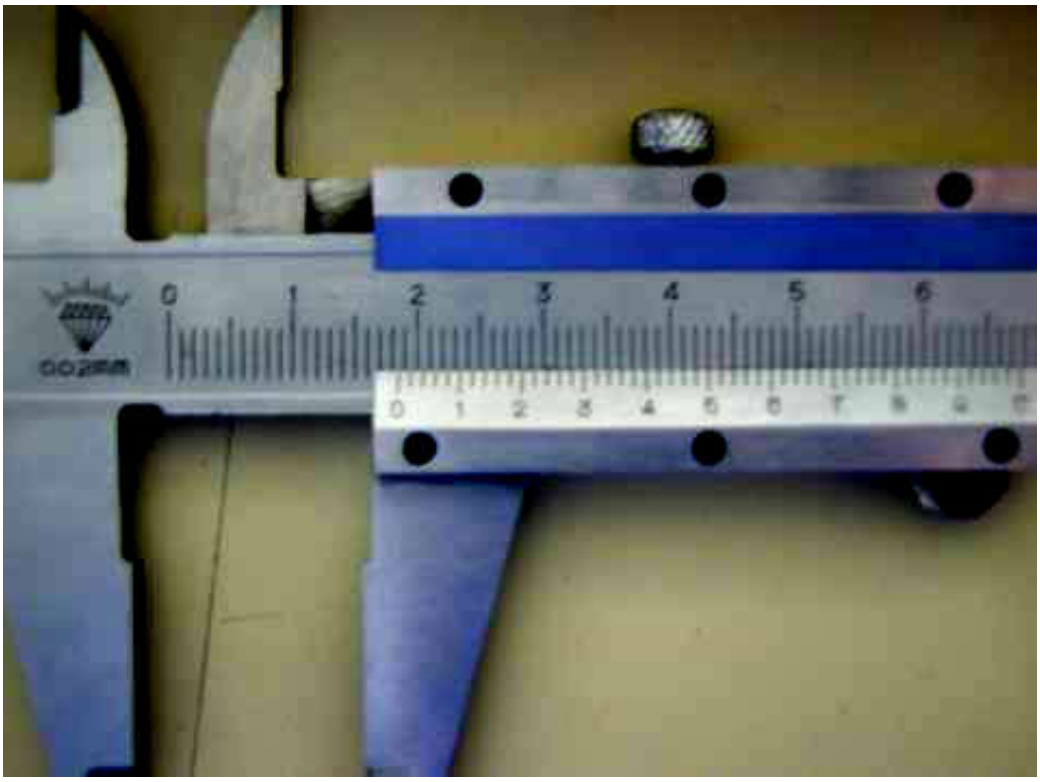
A fine adjustment mechanism is provided on some vernier calipers for the accurate setting of the sliding jaw

The least count of Vernier caliper varies from 0.02mm to 0.05mm. The least count is defined as the least possible measurement that can made by the instrument. The formula for finding out least count is given by

LC=1MSD-1VSD

Commonly used metric verniers are - 0.1, 0.05, & 0.02mm

Reading the Vernier Scale

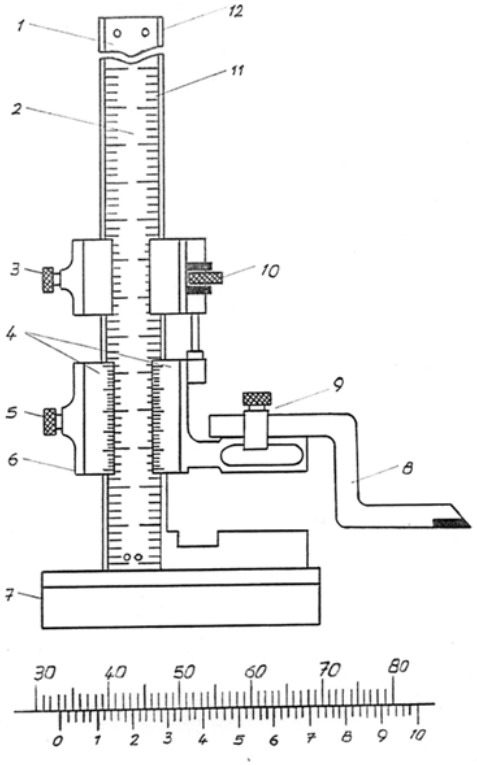


- Read the "0" position of the vernier scale on the main scale to get a rough reading.
- Rough reading = 18mm

- Look along the vernier scale until one of the vernier division coincides with the main scale
- Accurate reading = 18.46mm±0.01 mm

2.12.5 Vernier height gauge

- Used for checking the height of work pieces or scribing lines accurately in relation to a given surface
- Has a base the lower face of which is accurately ground & a beam-mounted square to the base.



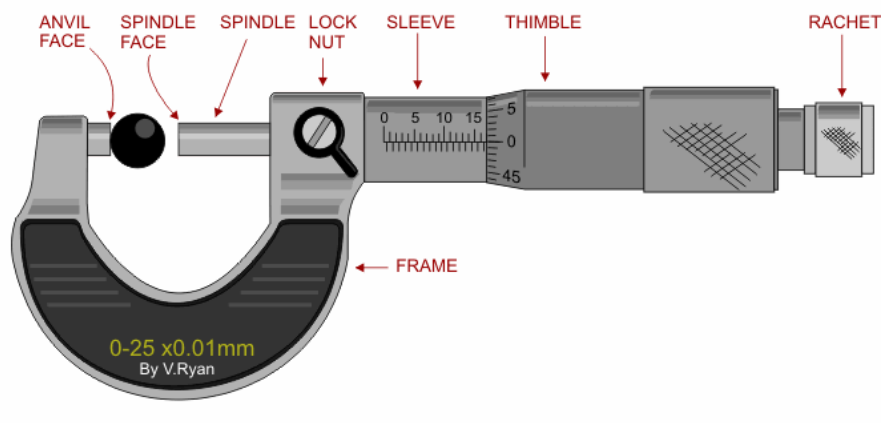
1. Beam
2. Beam face
3. Clamping screw
4. Vernier scale
5. Slider clamping screw
6. Slider
7. Base
8. Scriber
9. Clamp
10. Fine adjustment clamp
11. Main scale
12. Guiding edge

- Both the height gauge & work piece are used in conjunction with precision ground surface such as a surface plate or the worktable of a machine tool.
- Vernier scale is marked on a slider, which can be moved along the beam.
- Slider assembly carries a removable clamp by means of which a scribing attachment or a dial indicator can be held.

- Scribing attachment can be used to scribe line parallel to a reference side & the dial indicator can be used to take height measurement accurately

2.12.6 Micrometer

- One of the most useful close-tolerance measuring devices
- It works on the principle of screw & nut



The measuring face of micrometer is made up of carbide. The measurement ranges from 0-25mm up to 600mm. The diameter of the spindle (measuring face) is 7.5mm. The least count is usually 0.01mm or 0.001mm

Frame : It is made up of steel, cast steel, malleable cast iron or light alloy.

Hardened Anvil : The anvil shall protrude from the frame for a distance of at least 3mm in order to permit the attachment of a measuring wire support.

Screwed spindle: This spindle does the actual measuring and has thread of 0.5mm pitch

Graduated sleeve or Barrel : It is a datum of fixed line and fixed graduations.

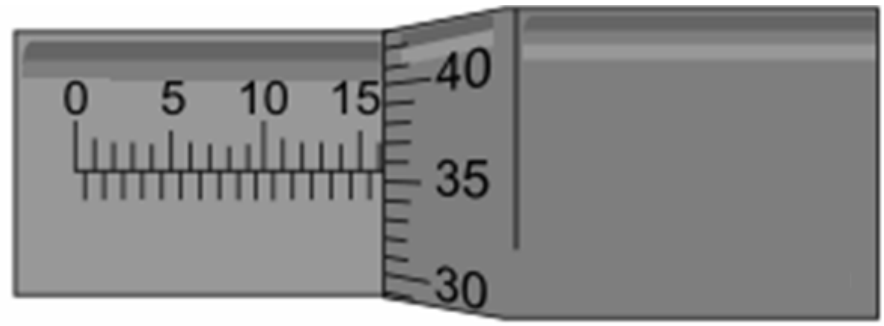
Thimble : This is a tubular cover fastened with the spindle and moves with the spindle. The beveled edge of the thimble is divided into 50 equal parts, every fifth being numbered.

Ratchet or friction stop : This is a small extension to the thimble. The ratchet slips when the pressure on the screw exceeds certain amount. This produces uniform reading and prevents any damage or distortion of the instrument.

Spindle clamp or clamp ring or Lock nut : This is used to lock the instrument at any desired setting.

$$L.C = \frac{\text{Pitch of the spindle screw}}{\text{No of divisions on the spindle}}$$

Reading



Sleeve reads full mm = 16.00

Sleeve reads 0.5 mm = 0.00

Thimble reads = 0.36

Total measurement = 16.36mm

2.13 Materials used in Automobile:

1. Steel

Properties:

Steels used for engineering applications are essentially wrought steels designed for mechanical and allied engineering applications. These require critical and often stringent levels of mechanical properties like elasticity, strength, ductility, toughness and fatigue resistance. Some of the special purpose steel for automotive application should also have high temperature resistance and non-corrosive properties.

Applications of engineering steels include automotive, aerospace, railway, oil and gas extraction, mining, power generation, defence, agriculture, chemical, construction and general engineering and manufacturing sectors. Cars, buses, trucks and off -highway vehicles account for over half the market for engineering steels.

Benefits:

Steel, currently the highest used raw material in the automotive application, some of the benefits of using steel in automotive application are,

- Easy for mass production
- Low Cost
- Good Mechanical Properties
- Environmentally friendly
- Recyclability
- Easy for Repairs
- Easy to join

2. Aluminium

Properties:

Aluminium has some outstanding properties, which explains why it is used so widely. In terms of application in various industries, it is second only to iron. Aluminium is forgeable and malleable. Its oxide film makes it resistant to corrosion and this means that the life of aluminium goods is very long. In addition, it has a high electrical conductivity, is non-toxic and is easily reprocessed.

Applications:

Aluminium is required to produce automobiles, high-speed railway cars and ships. Various types of aluminium products are used in modern construction. Aluminium has almost replaced Cuprum as a material for high-voltage power lines. Nearly half of cooking utensils sold throughout the world each year are made of this metal.

Benefits:

A world where aluminium exists opens a wide range of opportunities, with the following benefits.

- Light Weight
- Excellent corrosion resistance
- Easy to work
- Good heat conductor
- High reflectivity
- Non Magnetic
- Non Toxic

3. Sheet metal

Generally the metal sheets of less than 6 mm in thickness are called as sheet metal;the thin sheets are obtained by reducing the thickness of the materials by applying uniform compressive forces by using huge rolls. Commonly sheet

metals are made out of the metals like Stainless steel, aluminium, copper, brass, zinc etc...

Properties of Sheet Metal

Many types of metals are suitable for sheet metal working depending on their flammability, some of the mechanical properties of sheet metals are,

- Good Malleability
- Good Ductility
- Light weight
- High thermal resistance
- Easy machinability

Sheet Metal Applications

Sheet metal is widely used for numerous industrial and non-industrial applications including:

- **Aircraft:** Fuselages, wings, body panels, trim parts, etc.
- **Automotive**: body panels, bumpers, doors, chassis, trim parts, brackets etc.
- **Construction:** roofing, home building and structural applications.
- **Other applications:** appliances, food and beverage containers, boilers, kitchen equipment, office equipment etc.

Benefits of Sheet metal

Following are some of the benefits of Sheet metal

- Easy to produce complicated shapes and geometries
- Light weight
- Easy to work
- Easy to repair

- Easy to join
- Non corrosive
- Can support good paint finish

4. Fibre reinforced polymers (FRPs)

Properties:

Fibre reinforced polymers (FRPs) are composite materials consisting of fibres dispersed in a continuous matrix phase. The two physical phases of fibre reinforced polymers are the fibres themselves and the resin matrix. A wide range of materials can be used for fibre reinforced materials. The most common fibre materials are: carbon, glass and aramid. Carbon and aramid give better stiffness properties of the composite material than glass fibre. Resins used for matrices include polyester, epoxy, vinyl ester and phenolic types. Selecting the appropriate resin type determines the service temperature capabilities, chemical resistance properties, electrical and adhesive characteristics of the composite

FRPs possess superior mechanical properties like,

- Impact resistance
- Strength
- Stiffness
- Flexibility
- Ability to carry loads

Application: Fibre-reinforced polymers are an attractive substitute for steel (or other metals) in a wide range of applications in aerospace, automotive and construction industries.

Benefits:

The important benefits of Using FRPs are,

- High specific strength
- The ability to fabricate directional mechanical properties
- Good corrosion resistant
- Good fatigue resistance
- Good fracture resistance
- Low thermal expansion

CHAPTER 3

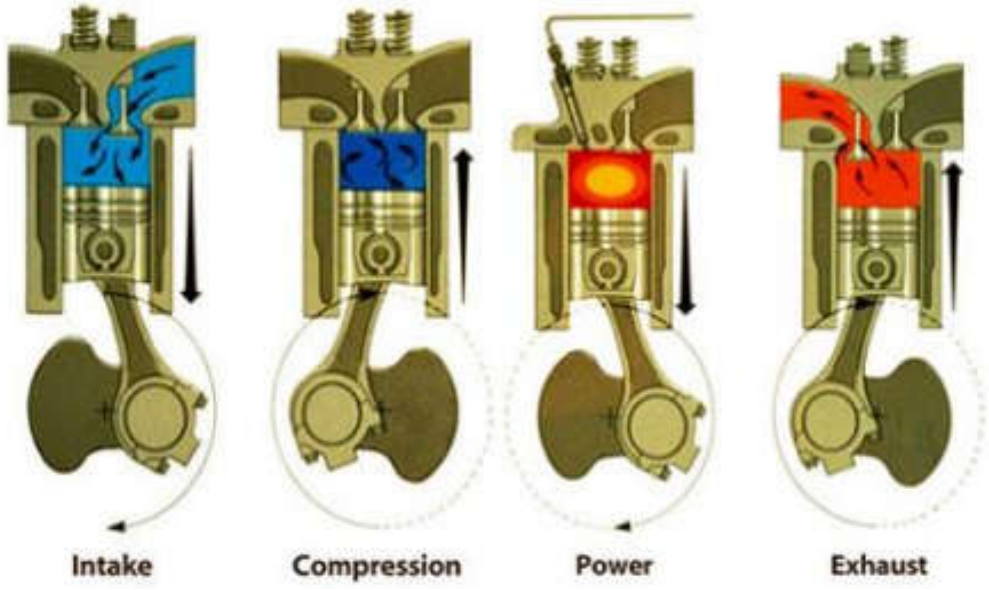
ENGINE ASSEMBLY

3.1 Introduction to engine assembly

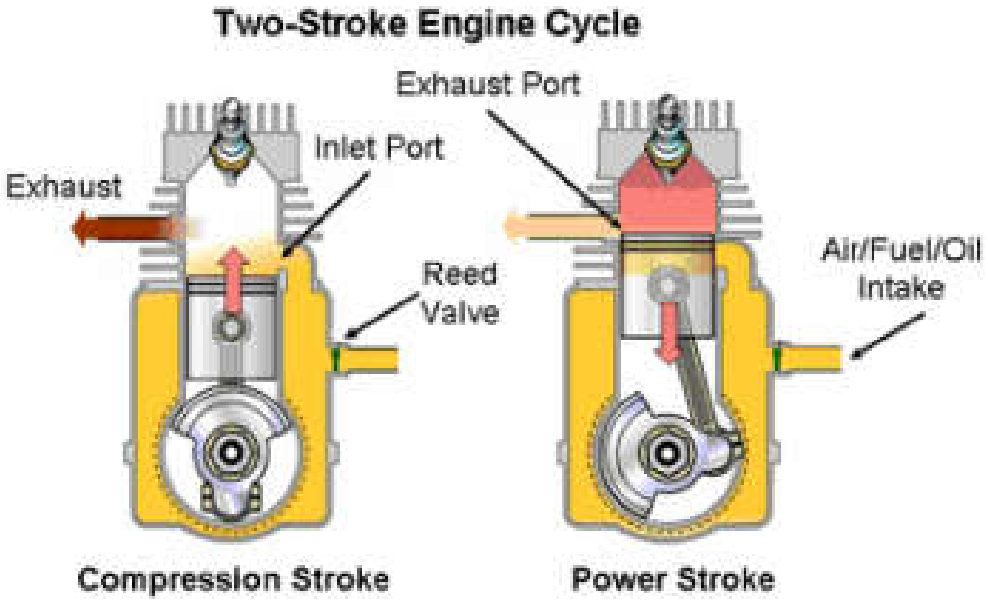
Already we have studied about the different types of engine and its operation in the last semester. In this semester, let us learn about the different engine components and its assembly.

Let us remember the operation of four stroke and two stroke engines.

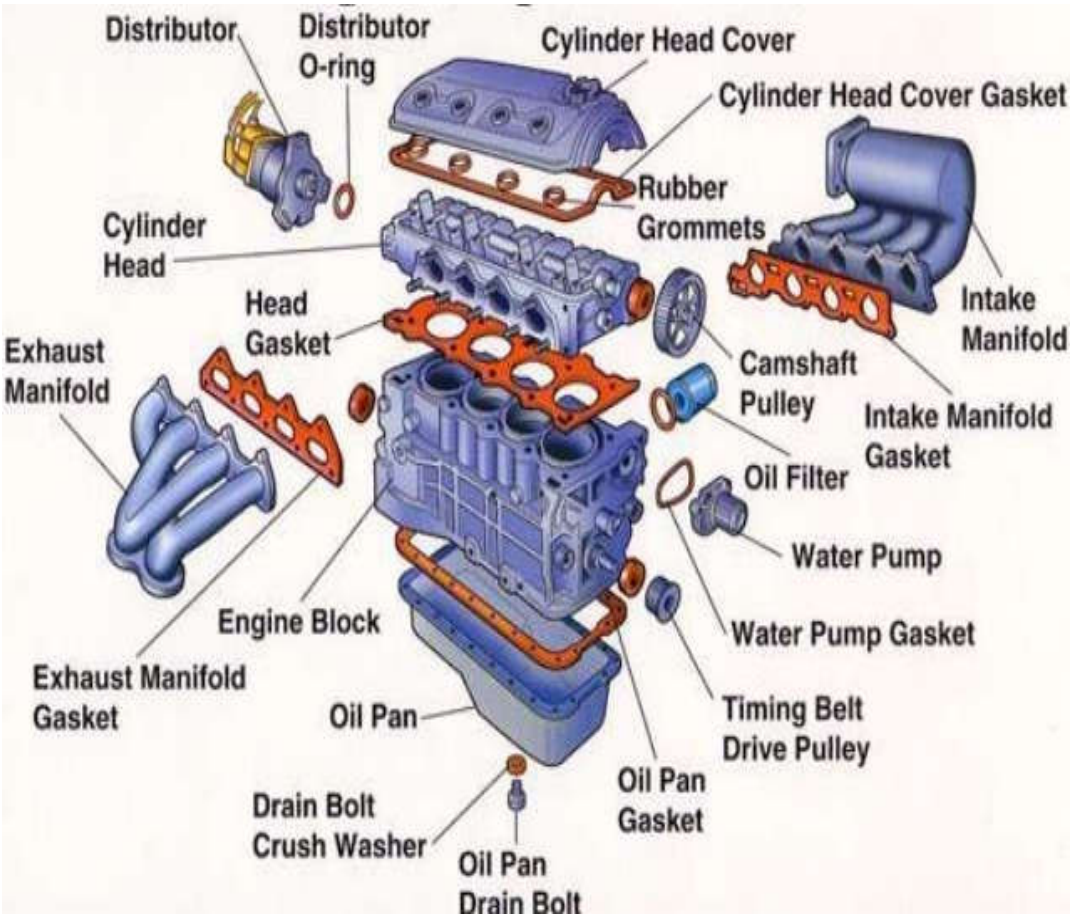
Four stroke engine

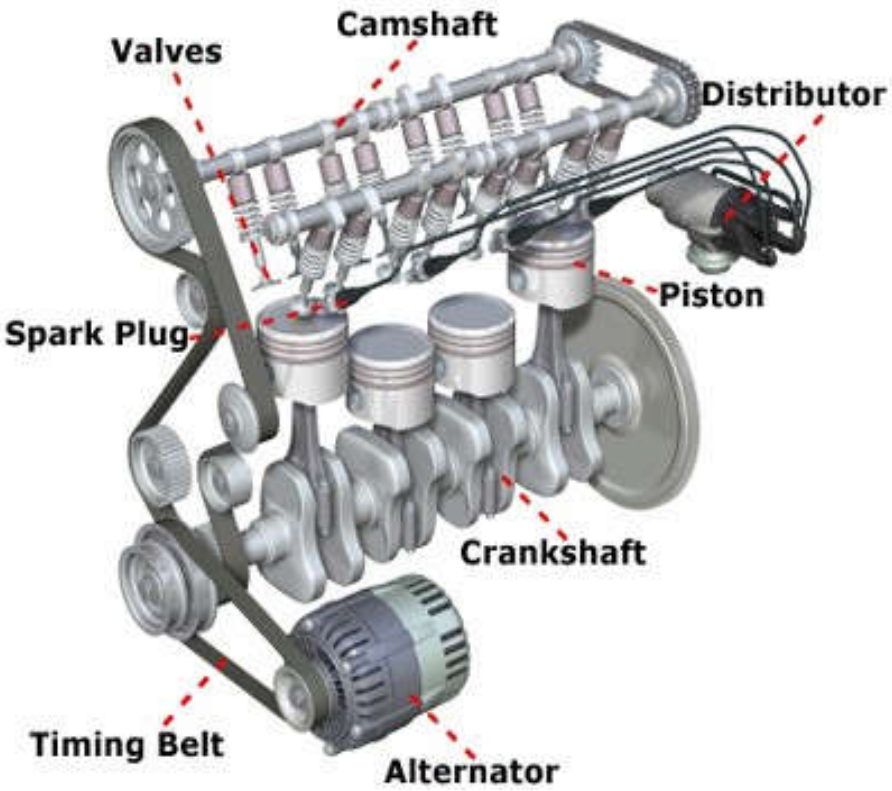


Two stroke engine



3.2 Assembly view





3.3 Engine components

CYLINDER BLOCK:

Cylinder block, cylinder head and crankcase – these three parts form the foundation and main stationary body of the automobile engine. They serve as support and enclosure for moving parts. In modern engines, crankcase to give it extra strength and to support the main and, in some cases, the camshaft bearings. The cylinder block may also have a separate crankcase for the crankshaft, which is mainly confined to large engines, marine and stationary engines. A separate aluminium crankcase would result in saving the weight as well as enable cheaper and quicker replacement. A cylinder block consists of three parts:

1. The cylinder in which the pistons slide up and down.

2. The ports or openings for the valves.

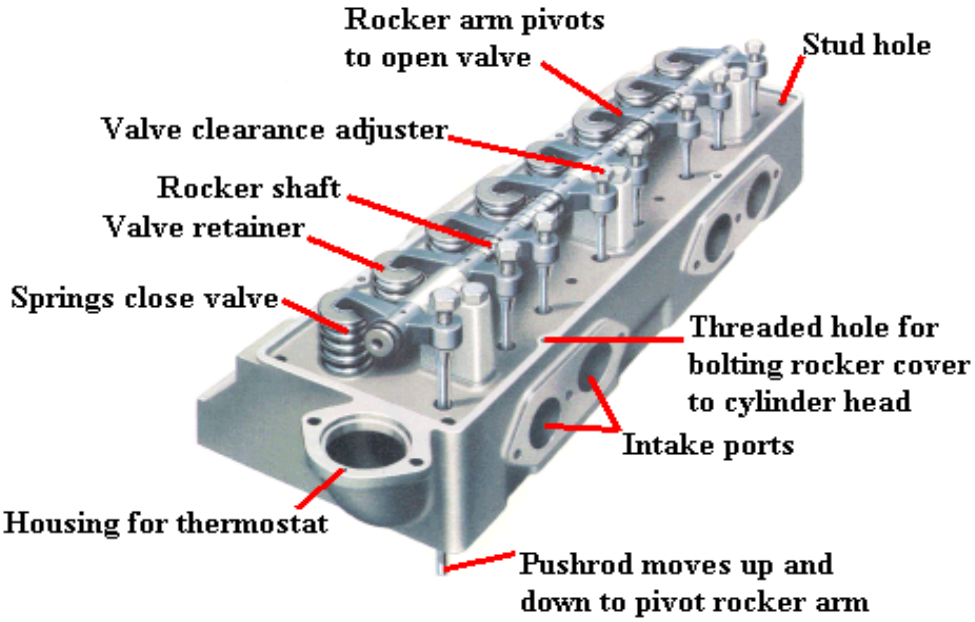
3. The passages for the flow of cooling water.

The round cylinder surfaces are given precision mirror firnish by accurate grinding and honing processes. The cylinder block is usually made from gray cast iron, and sometimes, with addition of nickel and chromium. Some blocks

are cast from aluminium, in which cast-iron or steel sleeves are used. For most engines, cast iron has been found to be a satisfactory cylinder wall material, as it has better wearing qualities. In some small engines, the cylinder walls are plated with chromium, a very hard metal, to reduce wall wear and to increase their service life. Tests are being carried out on high silicon-aluminium alloys to determine their possibilities as a material for cylinder blocks and crankcases. These alloys have a low coefficient of thermal expansion and high wear resistance.

CYLINDER HEAD:

The top of the cylinder is covered by a separate case piece known as the cylinder head. The cylinder head is bolted to the top of the cylinder block. It contains combustion chamber. Spark plug and sometimes valves (in I-and F-head) are mounted in it. It incorporates passages for the flow of cooling water. The cylinder head is usually made of gray iron or aluminium alloy. Aluminium has the advantages of lightness in weight and high heat conductivity. It is cast separately from the cylinder block so that it may be removed for cleaning carbon and grinding valves. To retain compression in the cylinder, a flat piece of gasket is places between the cylinder head and the cylinder block. In certain cases, such as a racing car engine, a separate head is not used. But a single piece of cylinder block and head is difficult and costlier to make; and the internal parts of the engine are not as accessible. Depending upon the valve layout, the cylinder head may carry the camshaft, rockers and valves. Water passage are provided adjacent to the valve and plug seatings.



CYLINDER HEAD GASKETS:

A gasket is placed between the cylinder head and cylinder block to retain compression in the cylinder, to prevent leakage and to ensure metallic tight fit joint. The gasket should be able to withstand not only high pressure but also extreme temperature.

Following important gaskets are used in automobile engines:

1. Copper-asbestos gasket.

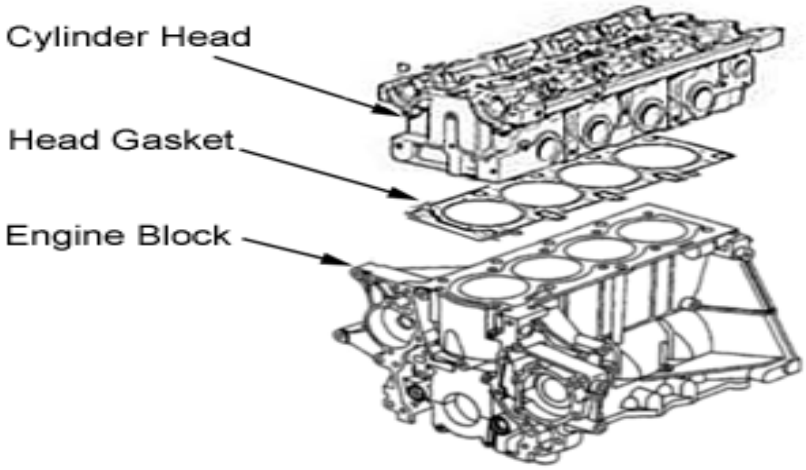
2. Steel-asbestos gasket.

3. Steel-asbestos-copper gasket.

4. Single steel ridged or corrugated gasket.

5. Stainless steel gasket.

Often the gaskets are coated with a special varnish which melts and seals all the small intersticks of the block and head when the engine warms up. Suitable holes are made in the gasket to pass the studs and for cylinder bore. Gaskets are also used to seal joints between other parts, such as between oil pan, manifolds, or water pump and the block.



CRANKCASE:

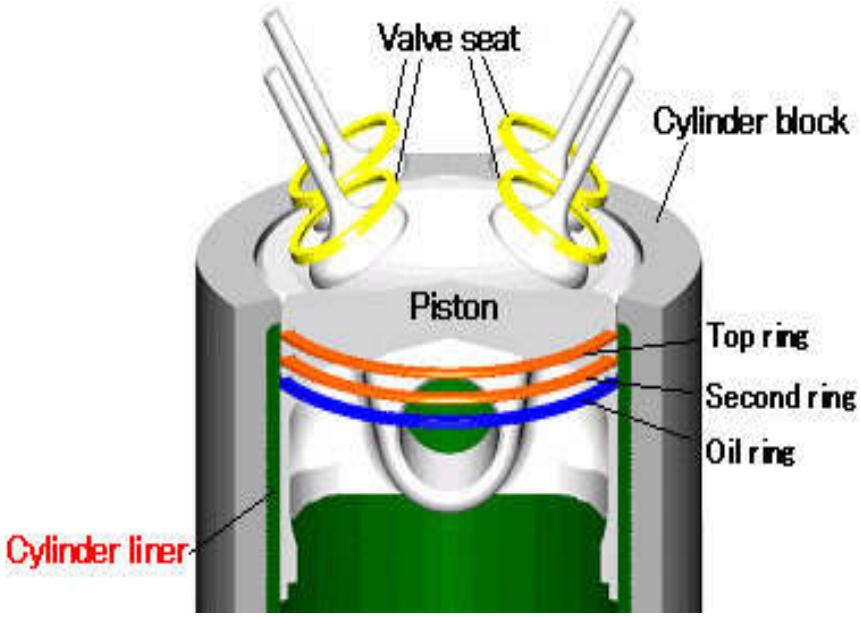
Crankcase is attached to the bottom face of the cylinder block. It acts as the base of the engine. It supports the crankshaft and camshaft in suitable bearings and provides the arms for supporting the engine on the frame. The oil pan and the lower part of the cylinder block together are called the crankcase.

OIL PAN OR SUMP:

The bottom half of the crankcase is called the oil pan or sump. It is bolted or screwed to the lower flange of the main casting and usually is made of pressed steel or aluminium. The oil pan serves as a reservoir for the storage, cooling and ventilation of engine lubricating oil. The oil pump in the lubrication system draws oil from the oil pan and sends it to all working parts in the engine. The oil drains off and runs down into the pan. Thus, there is a constant circulation of oil between the pan and the working parts of the engine.

CYLINDER LINERS:

The problem of cylinder wear is considerable and this has been solved by the use of cylinder liners. The cylinder liners are in the form of barrels made of special alloy iron containing silicon, manganese, nickel and chromium. They are cast centrifugally. It is now customary to fit cylinder liners on engines of cars and commercial vehicles. These liners are of the oil hardening type and offer considerably longer life for the engine. The cylinder liners are of the two types-dry liners and wet liners.



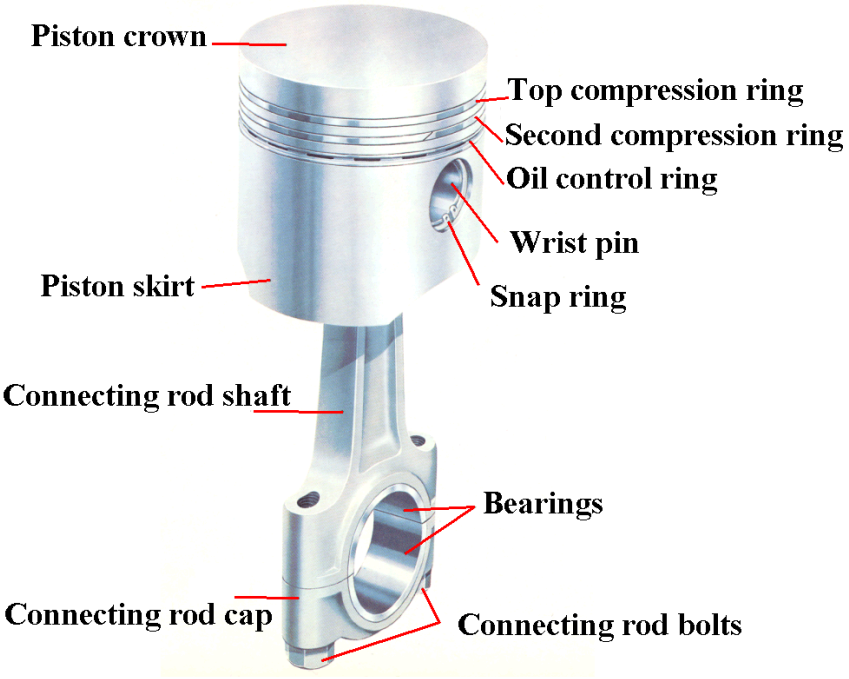
PISTON:

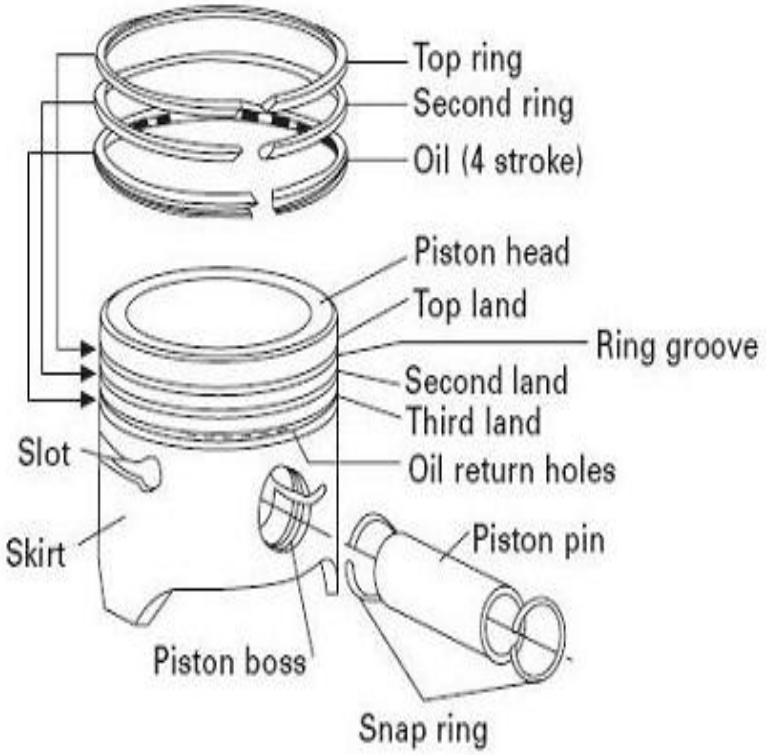
Piston is considered to be one of the most important parts in a reciprocating engine in which it helps to convert the chemical energy obtained by the combustion of fuel into useful mechanical power. The purpose of the piston is to provide a means of conveying the expansion of the gases to the crankshaft, via the connecting rod, without loss of gas from above or oil from below. Piston is essentially a cylindrical plug that moves up and down in the cylinder. It is equipped with piston rings to provide a good seal between the cylinder wall and piston. Although the piston appears to be a simple part, it is actually comples from the design stand point.

The piston performs the following functions:

- To receive the thrust generated by the expansion of the gas cylinder and transmit it to the connecting rod.
- To reciprocate in the cylinder as a gas-tight plug causing suction, compression, expansion and exhaust stokes.
- To form a guide and bearing to the small end of the connecting rod and to take side thrust due to the obliquity of the rod. The top of the piston is called head. Ring grooves are cut on the circumference of the upper portion of the piston. The part below the ring grooved is called skirt. The portions of the piston that separate the grooves are called the lands. Some pistons have a groove in the top land called a heat dam

which reduces heat transfer to the rings. The piston bosses are the reinforced of the piston designed to hold the piston pin or wrinst pin.





COMBUSTION CHAMBER:

Combustion chamber is the space enclosed between the piston head and cylinder head when the piston is at the top dead centre position. It extends upto the upper compression ring of the piston. Exhaust and inlet valves open and close in the combustion chamber and the spark plug projects in it. The design of the combustion chamber is of great importance for the engine performance because the air-fuel missing and combustion take place in it.

Depending upon the location of the spark plug, valve and type of cylinder head, the combustion chambers are of the following shapes:

1. Spherical shape

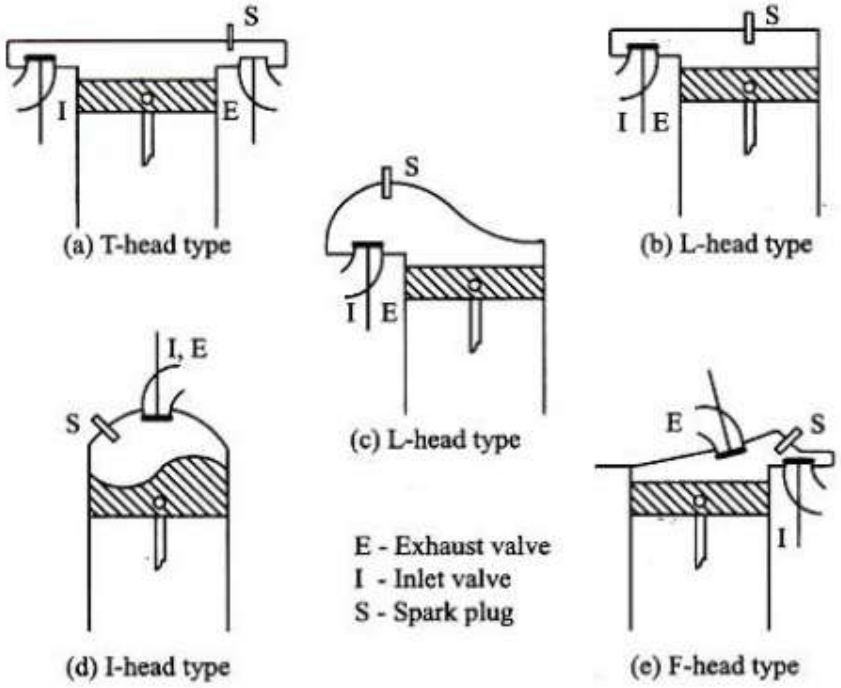
2. I-shape

3. T-shape

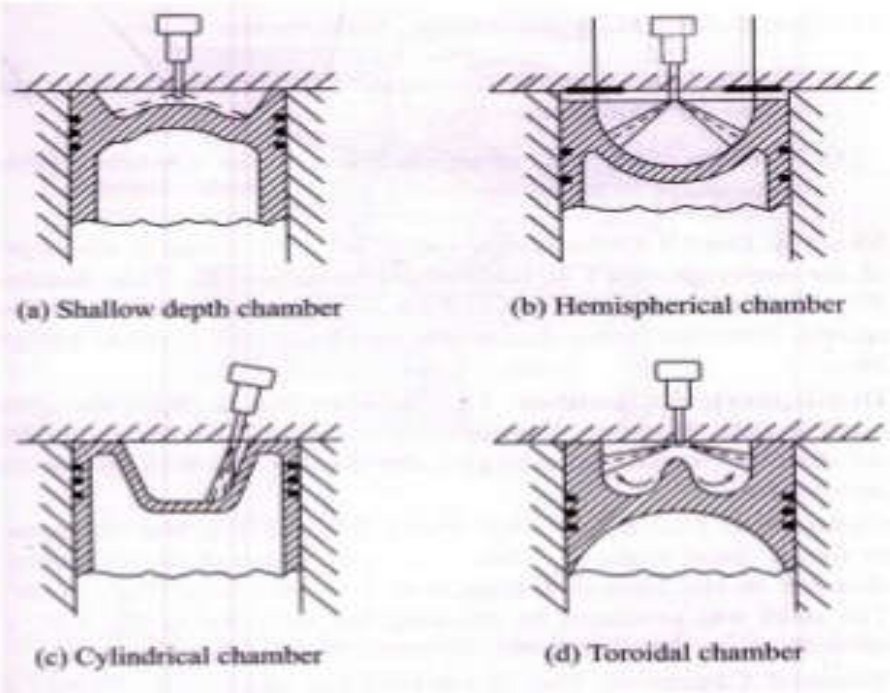
4. F-shape

5. L-shape

In the spherical shape combustion chambers, the inlet and exhaust valves are fitted in the cylinder head. Spark plug may be at a side or at the top of the cylinder head.



The following are combustion chamber shapes for CI engines (direct injection type).



PISTON RINGS:

Piston rings are fitted into the grooves of the piston to maintain good seal between the piston and the cylinder wall.

Piston rings are usually made of fine-grained alloy cast iron. This material possesses excellent heat and wears resisting quantities inherent in its graphic structure. The elasticity of this material is also sufficient to important radial expansion and compression which is necessary for assembly and removal of the ring; and particularly to enable it to exercise flexible pressure on the cylinder walls.

There are three functions of the piston rings as follows:

1. To provide a pressure seal to prevent blow-by of burnt gases. Blow-by is the name that describes the escape of burnt gases from the combustion chamber, past the piston, and into the crankcase.

2. To form the main path for conduction of heat from the piston crown to the cylinder walls.

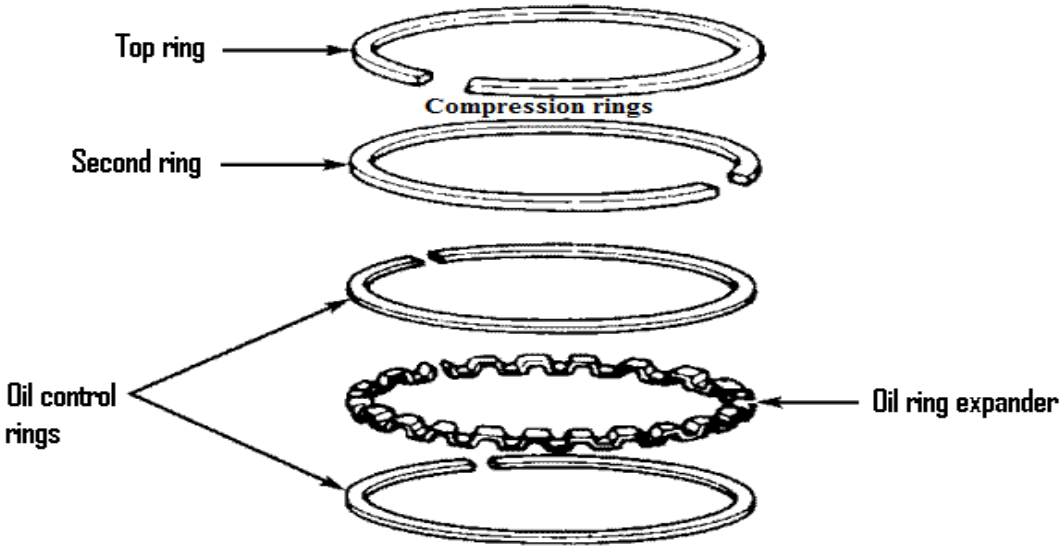
3. To control the flow of oil to the skirt and rings themselves in adequate quantity while preventing and excessive amount reaching the combustion chamber with consequent waste and carbonization.

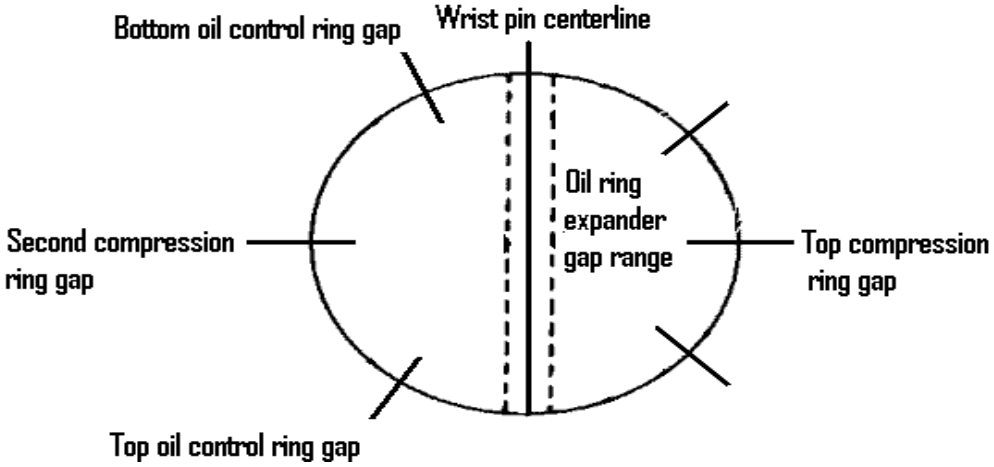
TYPES OF RINGS:

There are two types of piston rings:

1. Compression rings

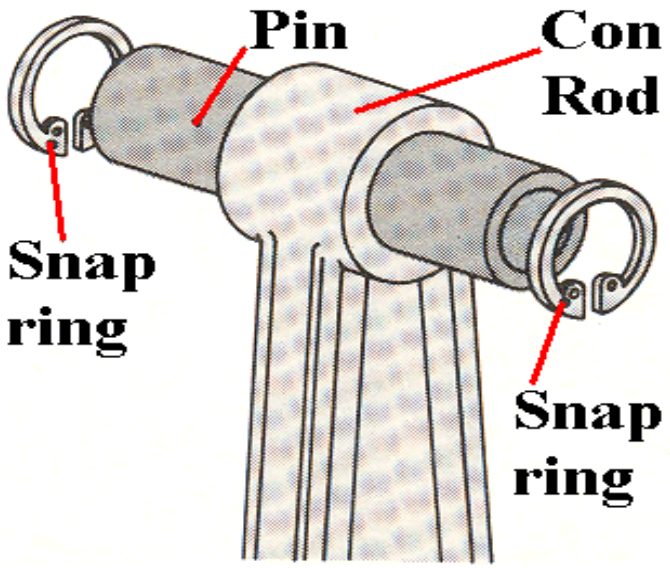
2. Oil control rings





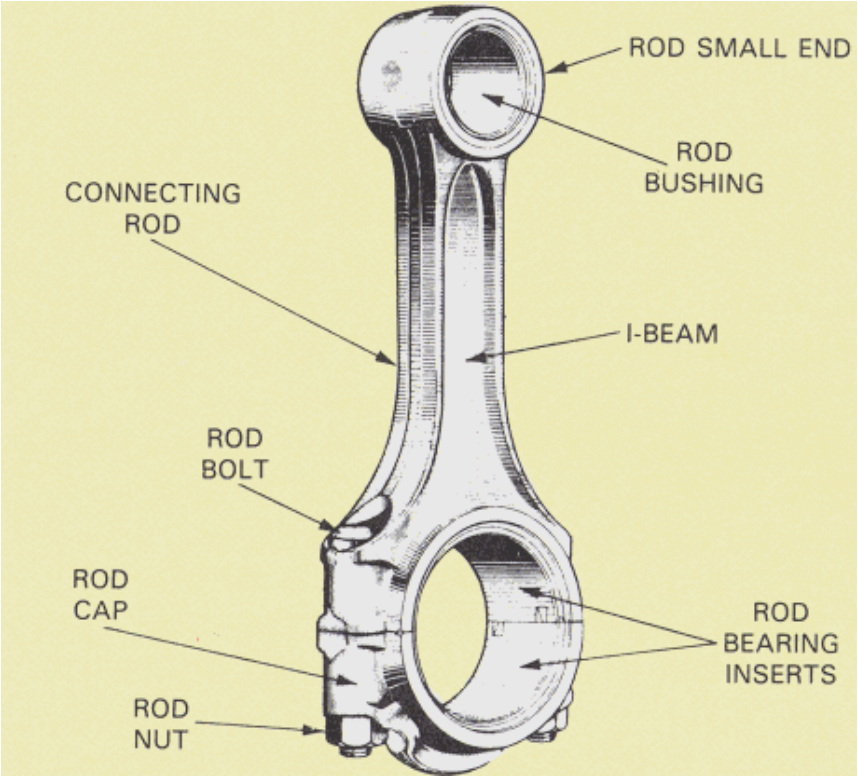
PISTON PIN:

Piston pin or wrinst pin or gudgeon pin connects the piston and the small end of the connecting rod. Piston pin is generally hollow and made from case hardened steel heat treated to produce a hard, wear resisting surface.



CONNECTING ROD:

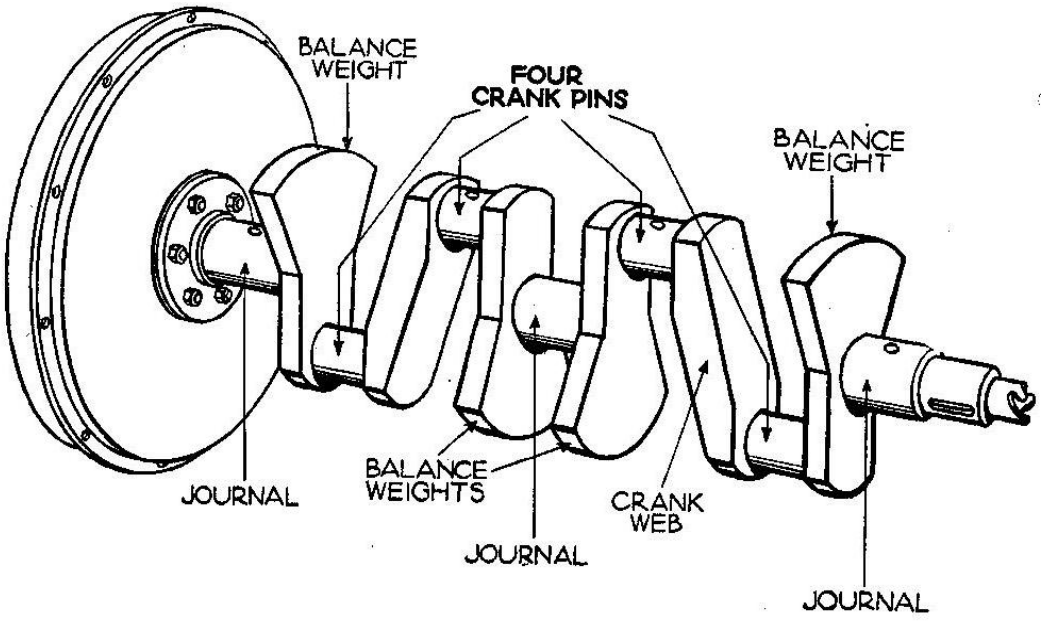
The connecting rod is the connection between the piston and the crankshaft. It joints the piston with the crankpin. Small end of the connecting rod is connected to the piston pin and big end to the crank pin. The function of the connecting rod is to convert linear motion of the piston into rotary motion of the crankshaft. The connecting rod usually has I-beam cross-section; and is made of forged steel. Aluminium alloy is also used for connecting rod. They are carefully matched in sets of uniform weight in order to maintain engine balance. The lighter the connecting rod and the piston, the greater the resulting power and the lesser the vibration because the reciprocating weight is less. The connecting rod carries the power thrust from piston to the crank pin and hence it must be very strong, rigid and also as light as possible.



CRANKSHAFT:

Crankshaft is the first part in the power transmission system on to which the reciprocating motion of the piston is converted into the rotating motion with the help of connecting rod. A crankshaft consists of crankpins, webs (crankarms or cheeks) balancing weights and main journals. Big end of the connecting rod is connected to the crankpin of the crankshaft. Centre of centre distance between the crankpin and crankshaft is half of the piston displacement during a stroke. Thus, one complete revolution of the crankshaft makes two strokes of the piston. The parts of the crankshaft inside the main bearings are called the main journals. The crankshaft is supported by the main bearings on the main journals. Balancing weights are provided on the opposite side of the crankarms for balancing.

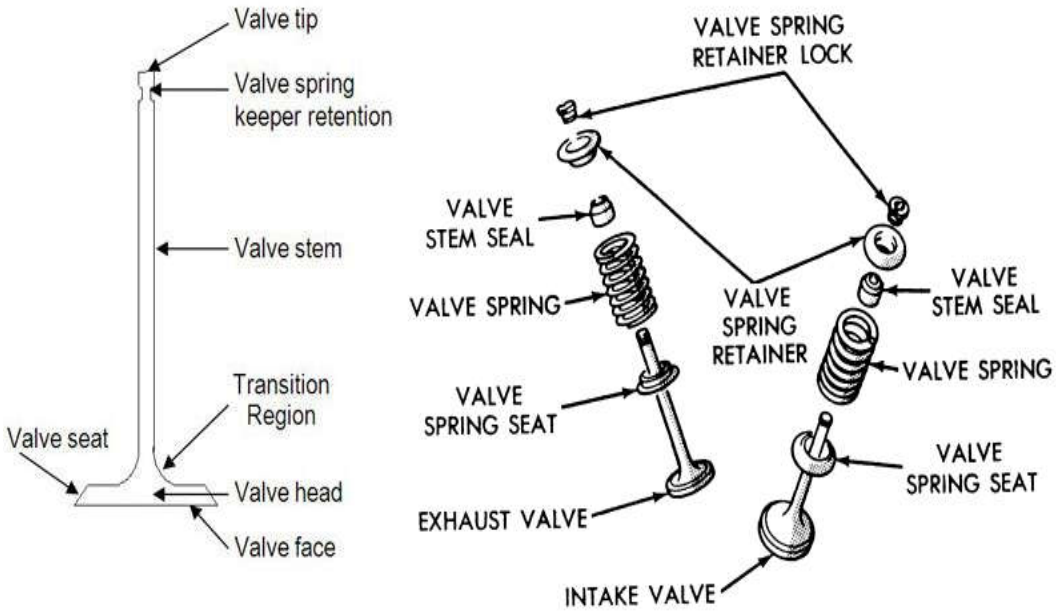
The crankshaft is made of casting or forging of heat treated alloy steel and is machined and ground to provide suitable journals for the connecting rod and main bearings. It must be strong enough to take the thrust of the pistons during the power strokes without excessive distortion. Also, it must be carefully balanced to eliminate undue vibration resulting from the weight of the offset cranks. Crankshafts have drilled oil passages through which oil can flow from the main bearing to the connecting rod bearing.



VALVES:

Valve is a device to close and open a passage. In motor vehicle engines, two valves are used for each cylinder – an inlet or intake valve and an outlet or exhaust valve. Fuel is admitted to the cylinder by the inlet valve, and the burned gases escape by the exhaust valve. When closed, the valve must seal the combustion space tightly. The valves are usually made of austenitic stainless steel which is corrosion and heat resisting material. Exhaust valve is usually made of silchrome steel which is an alloy of silicon and chromium with unusual resistance to heat. Inlet valve being subjected to less heat is usually made of nickel chromium steel.

The valve used in modern passenger car engines are termed as poppet or mushroom valve. The head of the valve has an accurately ground face with enough margin left to avoid a thin edge. The angular face is ground on the valve head to make and angle of 450 or 300 to match the angle of valve seat in the cylinder head. Spring retainer lock grooves are provided at the end of the valve stem.

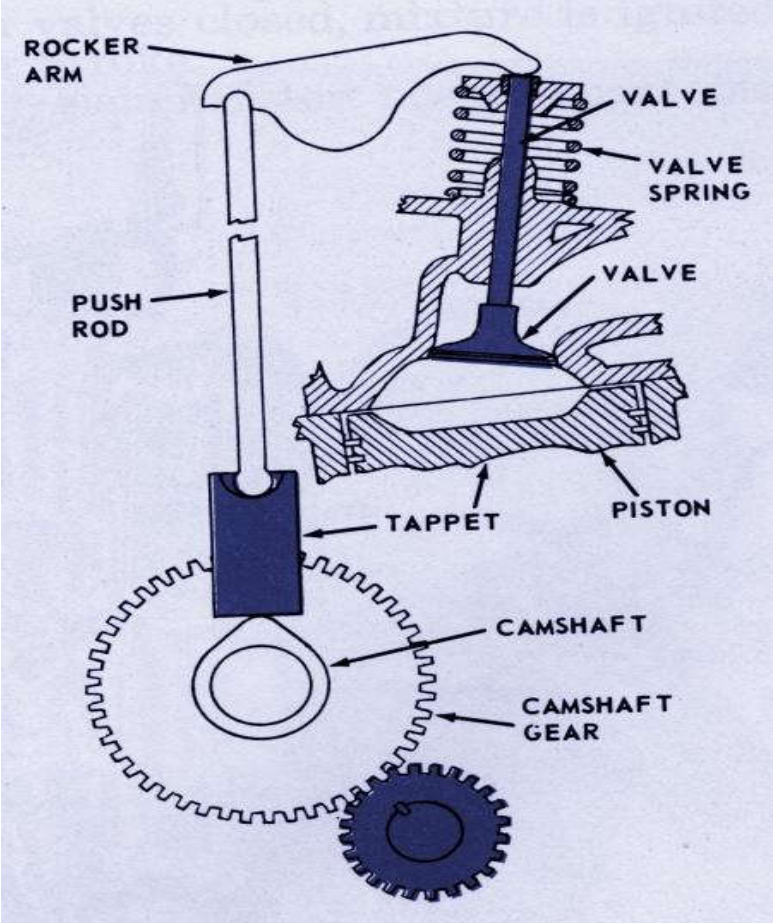


Valve Mechanism

The valve mechanism is an overhead valve type.

- Both the inlet and exhaust valves are made of surface-treated heat-resistant steel. The valve seat angle is 300 in inlet valve and 450 in exhaust valve. The valve stem seal is mounted on the valve stem, which controls the amount of the sliding surfaces between the valve and valve guide. A valve guide with carbon cutter is used for the exhaust side.
- Two unevenly pitched valve springs are used, the inner and outer with coil directions opposite to each other.
- The rocker has an induction-hardened surface in contact with the valve cap. A bushing is used in the hole, into which the rocker shaft is fitted. Wear resistance is significantly improved because of this.
- The rocker shaft is a hollow round with sealing caps at both ends. Its inside serves as an engine oil passage.
- The push rod has a steel ball welded to its bottom end and a spherical or depressed piece welded to its top end. Both ends are carburized case-hardened.

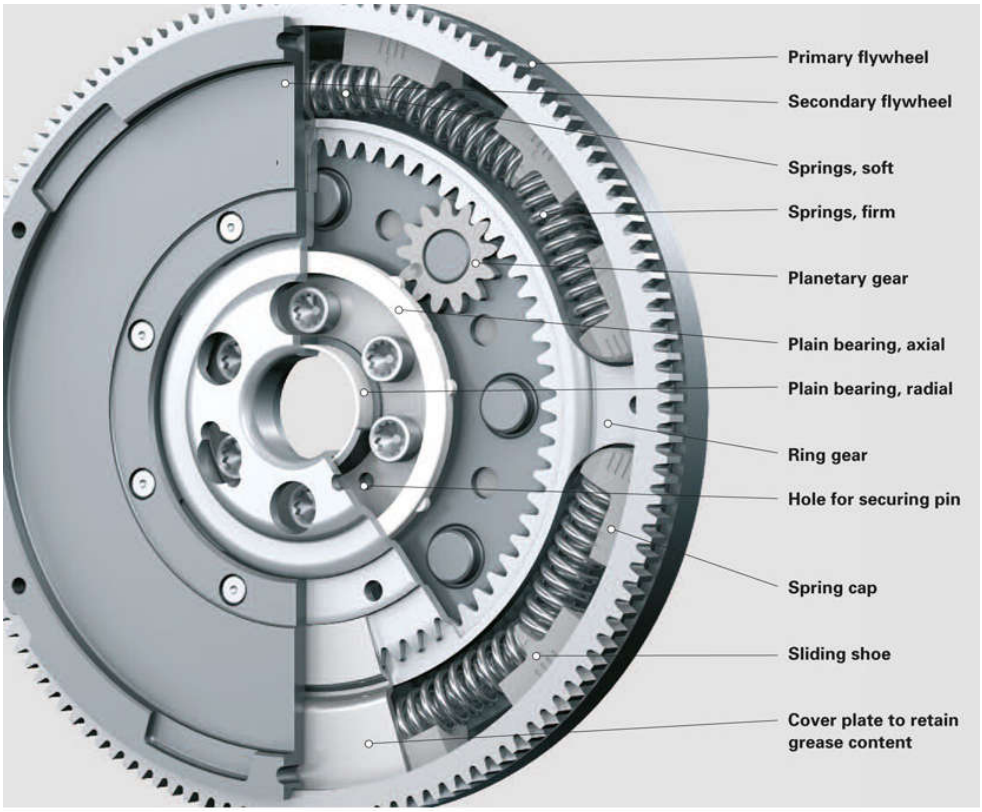
- The tappet is of cylindrical shape and has a larger diameter, spherical surface in contact with the camshaft. This helps in preventing localised wear.
- The camshaft is provided with an oil pump drive gear, with its journal, cams and gears induction-hardened. A tapper cam is used.
- The camshaft is provided with an additional eccentric cam for operating the feed pump plunger.

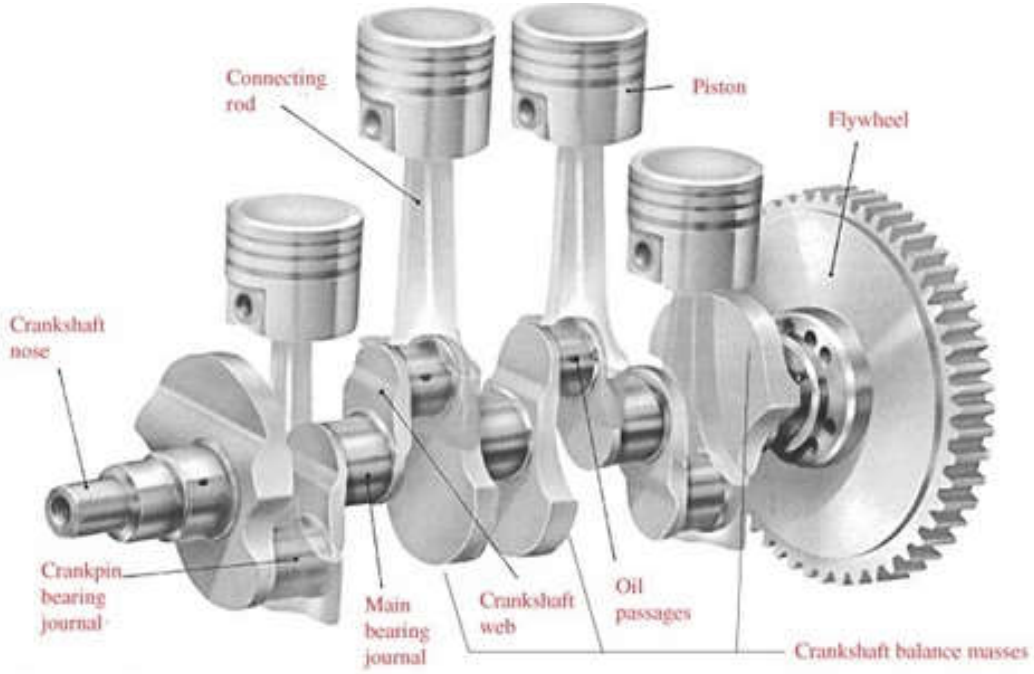


FLYWHEEL:

The flywheel is mounted on the rear of the crankshaft. An oil seal is installed at the front and rear of the crankshaft. Flywheel is the energy reservoir. The flywheel is made of cast iron. The pilot bearing of the transmission drive pinion is installed at its center. On its periphery, the ring gear is shrink-fitted and it meshes with the starter pinion. The ring gear tooth crests are induction-hardened for greater durability. At the same time, one side of the crests is chamfered to ensure that the starter pinion meshes easily when the starter is

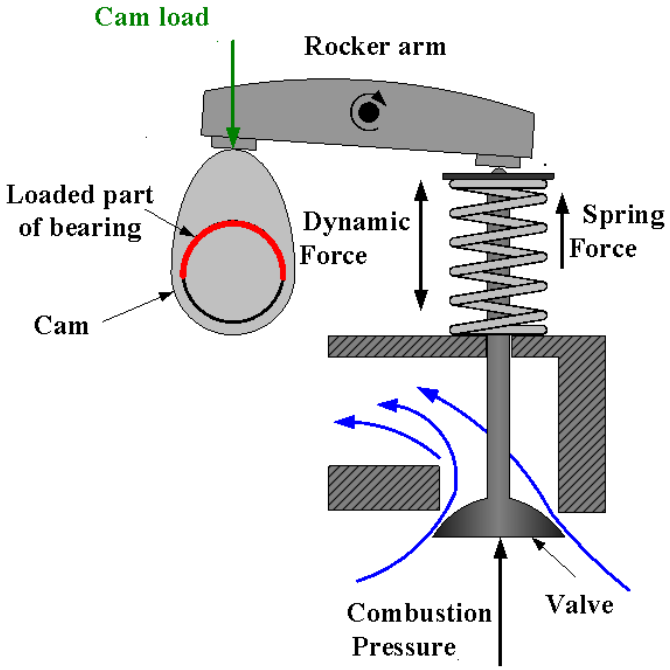
operated. Slots are provided on flywheel for speed sensing through engine speed sensor mounted on clutch housing.





ECCENTRIC ROCKER ARM:

Eccentric rocker arm automatically compensates for the difference in valve-tappet clearance. It consists of a conventional rocker arm modified to hold and eccentric by means of a slot and pin. A plunger and spring control the piston of the eccentric. The plunger is activated by the spring and by oil pressure from an orifice in the rocker arm. When the engine valve is closed (cam on the low side), the eccentric under the action of spring and plunger moves to take up any clearance, in the valve operating train. As the cam rotates to open the valve, the plunger and spring absorb any shock produced by this movement. When the cam is on the upside, the valve is completely open.



3.4 ENGINE MOUNTING:

Automatic engines are mounted on the frame. According to the type of mounting used, it is attached to the frame at two, three or four points. At each mounting point, a flexible or elastic medium, like rubber or spring is usually placed to insulate the automobile frame and body from vibration and noise.

A method of engine mounting is called "floating power" in which only two rubber supports are used one at the front and another at the rear of the engine. The front support is located above the rear support so that a line drawn through the centres of the front and the rear supports passes through the centre of gravity of the engine.

IMPORTANCE

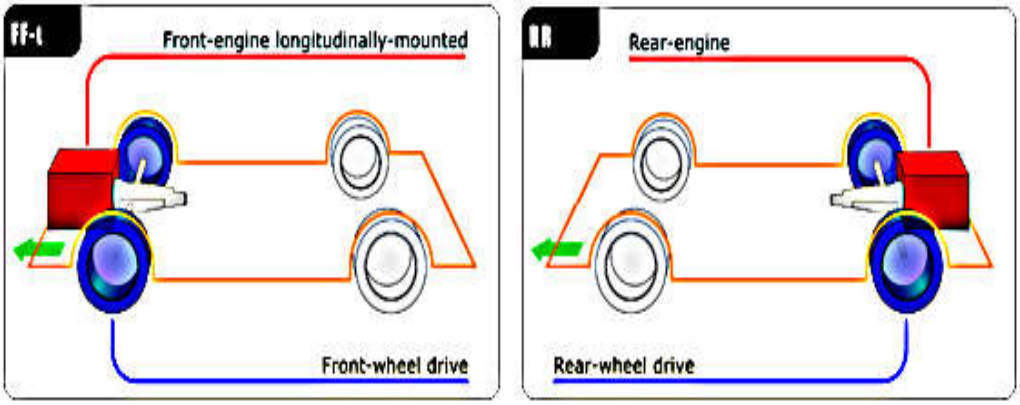
The main tasks which must be performed by the mounting system include the following :

- Positioning of the engine/gearbox assembly
- Support function (absorption of the weight forces)
- Structure-borne noise insulation
- Support of the forces and moments which occur when driving (e.g. drive momentum, mass forces due to acceleration, deceleration or cornering)
- Limiting movements of the assembly (with the aim of guaranteed avoidance of contact with the body)
- Damping of shocks and vibrations caused by the road surface (e.g.shaking)
- Holding the engine in the event of a crash

Mounting layout

The automobile layout describes where on the vehicle the engine and drive wheels are found. Many different combinations of engine location and driven wheels are found in practice, and the location of each is dependent on the application the vehicle will be used for. Factors influencing the design choice include cost, complexity, reliability, packaging (location and size of the passenger compartment and boot), weight distribution and the vehicle's intended handling characteristics.

Layouts can roughly be divided into two categories: front- or rear-wheel drive.



Types of engine mountings:
Rigid mounts

In a rigid mount, the motor mount is attached to the frame of the device with fasteners or bolts. Rigid mountsmay even be built into the vehicle or equipment, or permanently welded in place.

The rigid mounting are most often used with smaller motors rather than large ones. Rigid mounting provide the most accurate alignment between the motor and the surrounding mechanisms, but may be damaged by vibration under heavy-duty operation.

Rubber mounts

Resilient motor mounts feature a layer of rubber or insulation between the mount and the motor. This material helps to reduce noise and vibration, which may extend the life of the motor and related parts.

Resilient motor mounts also allow for some flexibility and movement without compromising the performance of the motor and related parts.These mounts are often found in larger motors or in applications where excess noise or vibration could be problematic. These mounts also help to reduce the impact as the starts and stops, which minimizes shock to the surrounding system

Hydraulictype

Hydraulic, or hydro motor, mounts contain some form of gel or liquid to help absorb impact and vibration during operation. This may include glycol or hydraulic fluid, or any other types of fluid substance. This type of mount is often used in four-cylinder motors, which produce large amounts of vibration or noise. They may also be used with other types of motors when noise levels must be kept to a minimum.

In a motor designed for face mounting, or National Electric Manufacturers Association (NEMA) "C" mounting, the motor attaches directly to the surrounding components without the use of a standard mount. Often, installers will use a NEMA "C" face mount adapter in order to adapt a face-mounted motor for a vehicle designed for another type of motor mount. In this type of mount, the bolts on the motor pass right through pre-drilled holes in the motor casing and into the surrounding components or devices

CHAPTER 4

LUBRICATION SYSTEM:

4.1 INTRODUCTION:

Lubrication is essentially required in motor vehicle maintenance. To supply lubricating oil between the moving parts is simply termed as lubrication. Lubrication of all moving parts (other than nylon, rubber bushed or pre-lubricated components) is essential to reduce friction, wear and to prevent seizure. Lubrication must be done properly; and right type of lubricant should be used. Improper or inadequate lubrication of the engine will cause serious trouble such as scored cylinder, worn or burned-out bearings, misfiring cylinders, dirty spark plugs, stuck piston rings, engine deposits, sludge and excessive fuel consumption.

OBJECTS OF LUBRICATION:

The primary objects of lubrication are as follows:

- To reduce friction between the moving parts.
- To reduce wear of the moving parts.
- To act as a cooling medium for removing heat.
- To keep the engine parts clean, especially piston rings, ring grooves, oilways and filters.
- To absorb shocks between bearings and other engine parts, thus reducing engine noises and extending engine life.
- To form a good seal between piston rings and cylinder walls.
- To prevent deposition of carbon, soot and lacquer.
- To absorb and carry away harmful substances resulting from incomplete
  combustion.
- To prevent metallic components from corrosive attack by the acid formed during the combustion process.
- To resist oxidation this causes sludge and lacquers.

LUBRICATING SYSTEMS:

In motor vehicles, there are two separate systems of lubrication:

1. Engine lubrication system

2. Chassis lubrication system

The engine lubrication system may be either pressure type or splash type, although various combinations of these two systems are used. A single system lubricates the entire of all present day motor vehicles. Only equipments outside the engine, such as starter, generators, water pump and distributors, are separately lubricated. This system circulates the oil from a common reservoir or pump to the main bearings, connecting rod bearings, wrist pins, camshaft bearings, cams, cylinder walls, valves and timing drive. The pump is located at the bottom of the crank case. All modern American passenger cars and trucks use the pressure system in which oil is forced under pressure by a geared pump to the various rotating and reciprocating parts. In splash system, the connecting rod end has a dipper which splashes the oil on the various parts as it travels through the oil while moving the connecting rod.

In chassis lubrication system, each lubricating point is lubricated separately. About 34 points are to be lubricated in the chassis of a modern passenger car. These points may vary from 21 to 45 depending upon the design and construction of vehicle. No single universal lubricant has yet been deviced for all these points. Some of the points require more often than others.

FUNCTIONS OF LUBRICATING OIL:

There are five important functions of the lubricating oil in an automotive engine:

1. To minimize friction and wear.

2. To cool by carrying away heat.

3. To seal the pistons and thus preventing escape of gases in the cylinders with consequent loss of power.

4. To cushion the parts against vibration and impact.

5. To clean the parts as it lubricates them, carrying away impurities.

4.2 TYPES OF LUBRICANTS:

The lubricants are of three types:

1. Solid-graphite, mica, soap stone or sateatite.

2. Semisolid-grease.

3. Liquid-mineral oil, vegetable oil, animal oil, etc.

Graphite and mica are the examples of solid lubricants. Graphite is often mixed with oil to lubricate automobile springs. Graphite is also used as a cylinder lubricant, both in powder and colloidal form. It has low co-efficient of friction and is stable at high temperatures. The graphite fills the pores of the metal and makes it friction free. Mica also has the same lubricating properties as the graphite. The use of solid lubricants depends upon the work required and the surfaces to be lubricated. Soapstone or steatite is a type of soft stone, greasy to touch. It is sometimes used to lubricate bearings of heavy and slow moving machines.

Semisolid lubricants, such as grease, are used in chassis lubrication. Grease is widely used in automobiles at places where retention of liquid liquid lubricants is difficult and where high temperatures encountered, like in axles. Grease is a suspension of metallic soap (calcium or sodium soap of fatty acids) dispersed in a lubricating oil. Other ingredients (chemicals) are also added in it to provide the required structural ability and resistance to deterioration in service. Grease must be corrosive and should preferably be unaffected by water. When used in ball and roller bearings, it must not stiffen unduly. If it becomes too soft, it drains away. If it stiffens, it may be thrown from the moving parts. When used in wheel hubs, it must withstand high temperatures resulting from the braking action; and it is the melting point of the soap in the grease which decides this ability. Thus, the purpose of a grease is to provide a lubricant and yet to stay but without causing drag, as well as being soft enough to pass through the lubrication nipple. Greases are defined according to their purpose, like water pump grease, chassis grease, multipurpose grease, or by the type of soap base, as follows:

1. Calcium-based greases are able to withstand moderably high temperatures and tend to absorb water, which reduces rusting problem.

2. Sodium-based greases are able to withstand moderably high temperatue and tend to absorb water, which reduces rusting problem.

3. Aluminium-based greases have good staying-put properties when combined with a chemical, but are not suitable for high temperatures. They are used on exposed chains, transmissions, chassis and frame fittings.

4. Lithium-based greases. One type of lithium based greases can do all the jobs and sometimes called multipurpose grease. It is grease at temperature of 250C. Two values are adopted:

(a) The worked penetration number.

(b) The unworked penetration number.

Liquid lubricants are used in automobile engine lubricating systems such as transmission and rear-axle systems. Lubricating oils are classified according to their source - as animal, vegetable, mineral.

Animal oils are obtained from the animal fat such as lard and fish, whale, tallow, etc. They are not suitable for automotive engine lubrication because they are oxidized easily and become gummy after some use.

Vegetable oils are obtained from linseed, rope seed, hazel-nut, palm olive, caster, etc. These oils also are not widely used in automobile industries, because they are oxidized easily and become gummy. However, caster oil finds some application because it has high viscosity and high film strength.

Mineral oils are almost entirely used for lubricating automotive engines, because they have good lubricating properties. They are cheap and more plentiful than the other types. Also, they are free from acid and do not attack metal from chemical reaction. Mineral oils are obtained from petroleum and chiefly contain hydrocarbons. When the residue, remaining after distillation of petroleum, is largely paraffin, the oil is termed as paraffin-base oil. Most of the crude oils, from which paraffin base oils are distilled, contain pennsylvania oil. Naphthene base oils have a residue containing quantities of asphaltum. Paraffin base oils weight less than naphthene base oils and have less tendency to thin out at high temperature. Naphthene base oil are more volatile.

Light machine oil is a type of mineral oil and is used for small high speed bearings. Generators, staters and distributors are often provided with oil cups for the use of this oil.

Blended oil is a mixture of animal oil, vegetable oil and mineral oil. This practice of mixing oil is called compounding. Blended oil is obtained to have certain desired properties which are not provided by pure oil for lubrication.

4.3 LUBRICATING SYSTEMS:

The different systems for lubricating the automobile engine are as follows:

1. Splash system

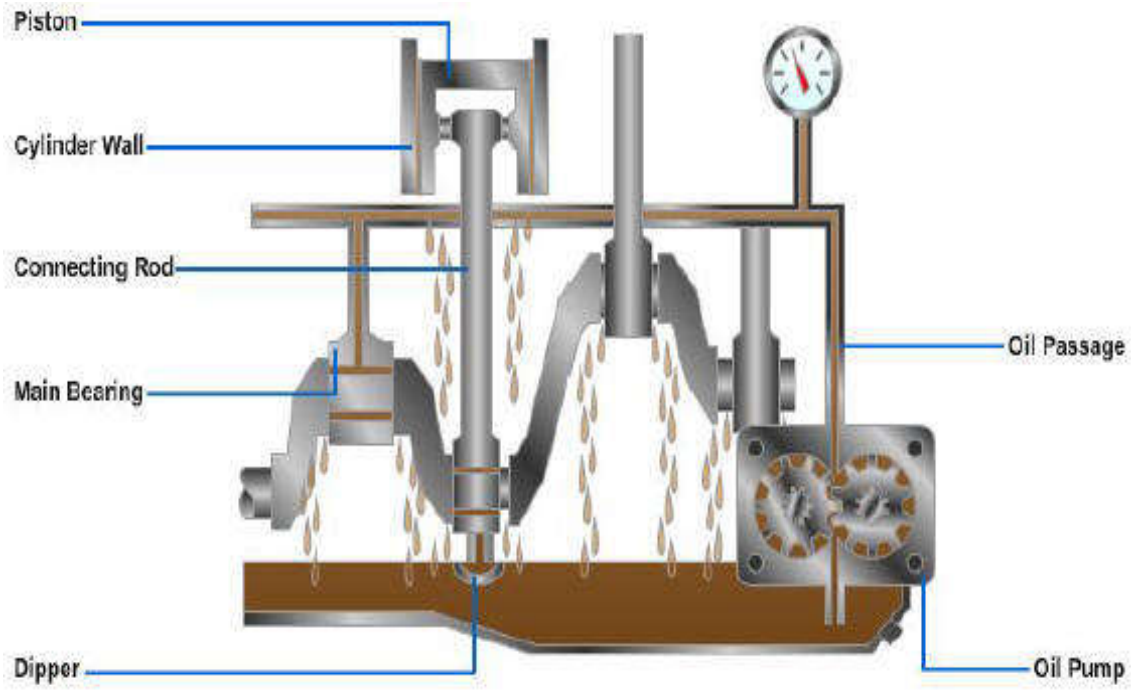
2. Pressure system

3. Semi-pressure system

4. Dry sump system

Splash system:

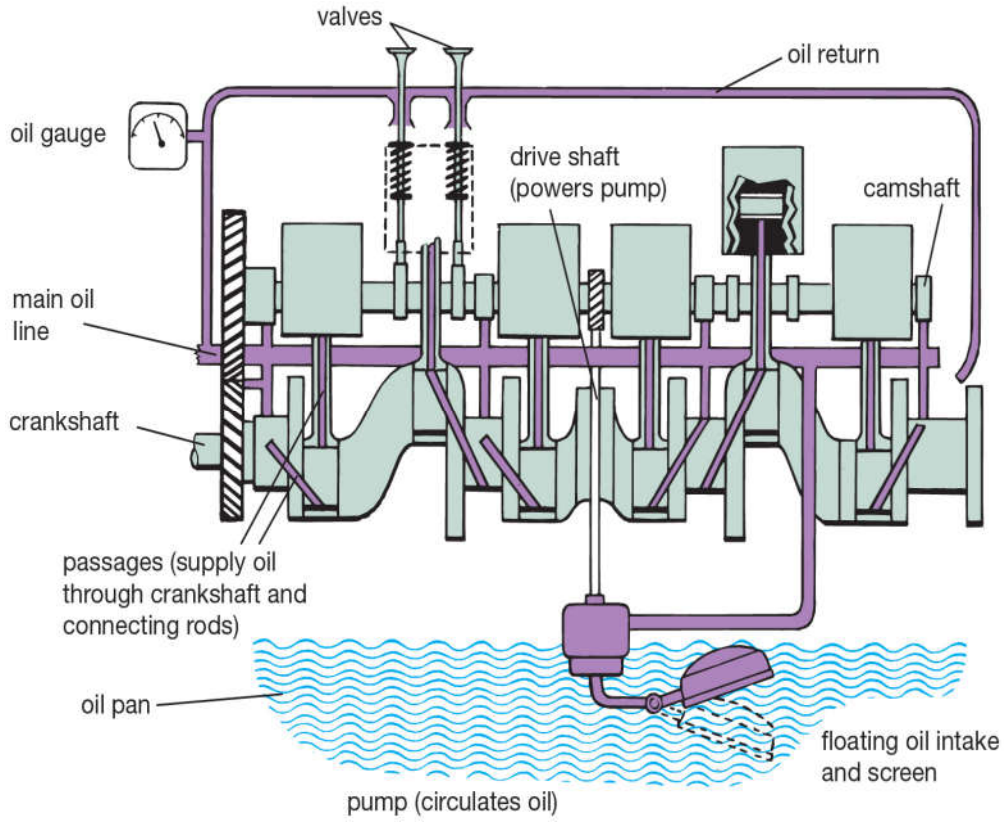
In this system of lubrication, the lubricating oil is stored in an oil trough or sump. A scoop or dipper is made in the lowest part of the connecting rod. When the engine runs, the dipper dips in the oil once in every revolution of the crankshaft and causes the oil to splash on the cylinder walls. This action affects the lubrication of the engine walls, piston ring, crankshaft bearings and big end bearings. Splash system mostly works in connection with pressure system in an engine, some parts being lubricated by splash system and the other by pressure system.



Pressure system:

In this system of lubrication, the engine parts are lubricated under pressure feed. The lubricating oil is stored in a separate tank or the sump, from where an oil pump takes the oil through a strainer and delivers it through a filter to the main oil gallery at a pressure of 4 – 8 N/cm2. The oil from the main gallery goes to the main bearings, from where some of it after lubricating the main bearing, falls back to the sump, some is splashed to lubricate the cylinder walls and the remaining goes through a hole to the crank pin. From the crank pin, it goes to the piston pin through a hole in the connecting rod web, where it lubricates the piston rings.

For lubricating crankshaft and timings gears, the oil is led through a separate oil line from the oil gallery. The valve tappets are lubricated by connecting the main oil gallery to the tappet guide surfaces through drilled holes. An oil pressure gauge at the instrument pannel indicates the oil pressure in the system. Oil filters and strainers in the system clear off the oil from dust, metal particles and other harmful particles.



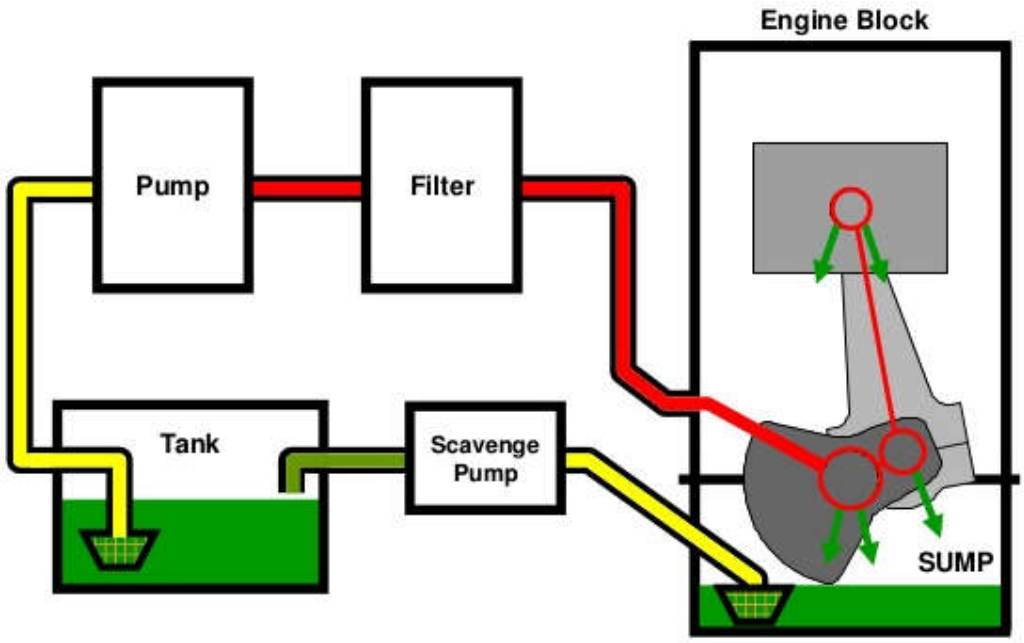
Semi-pressure system:

It is the combination of splash system and pressure system. Some parts are lubricated by splash system and some parts by pressure system. Almost all the four stroke engines are lubricated by this system.

Dry sump system:

The system in which the lubricating oil is stored in the oil sump is called wet sump system, like the pressure system. But the system in which the lubricating oil is not kept in the oil sump is known as dry sump system. In this system, the oil is carried in a separate tank from where it is fed to the engine. The oil which falls into the oil sump after lubrication is sent back to the oil tank by a separate delivery pump. Thus, the system consists of two pumps, one to feed the oil and the other to deliver it back to the oil tank. This system

is used in situations where the vehicle has to change its position continuously, like in aircrafts. The main advantage of this system is that there is no chance of breakdown the oil supply during up and down movement of the vehicle.

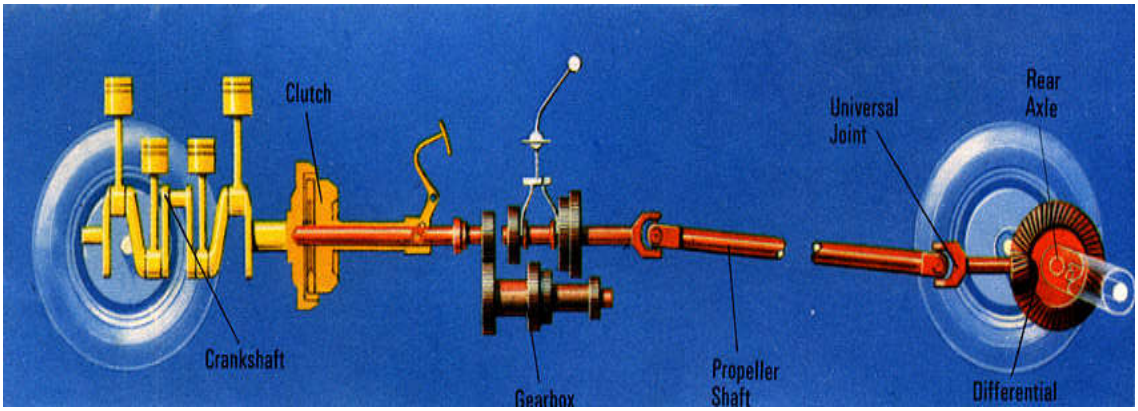


CHAPTER 5

POWER TRANSMISSION SYSTEM

5.1 INTRODUCTION:

The word '*Transmission*' means the whole of the mechanism that transmits the power from the engine crankshaft to the rear wheels, providing the suitable variations of the engine torque at the road wheels, whenever required.



Requirements of transmission system

1. To provide for disconnecting the engine from the driving wheels.

2. When the engine is running, to enable the connection to the driving wheels to be made smoothly and without shock.

3. To enable the leverage between the engine and driving wheels to be varied.

4. It must reduce the drive-line speed from that of the engine to that of the driving wheels in a ratio of somewhere between about 3:1 and 10:1 or more, according to the relative size of engine and weight of vehicle.

5. Turn the drive, if necessary, through 90° or perhaps otherwise re-align it.

6. Enable the driving wheels to rotate at different speeds.

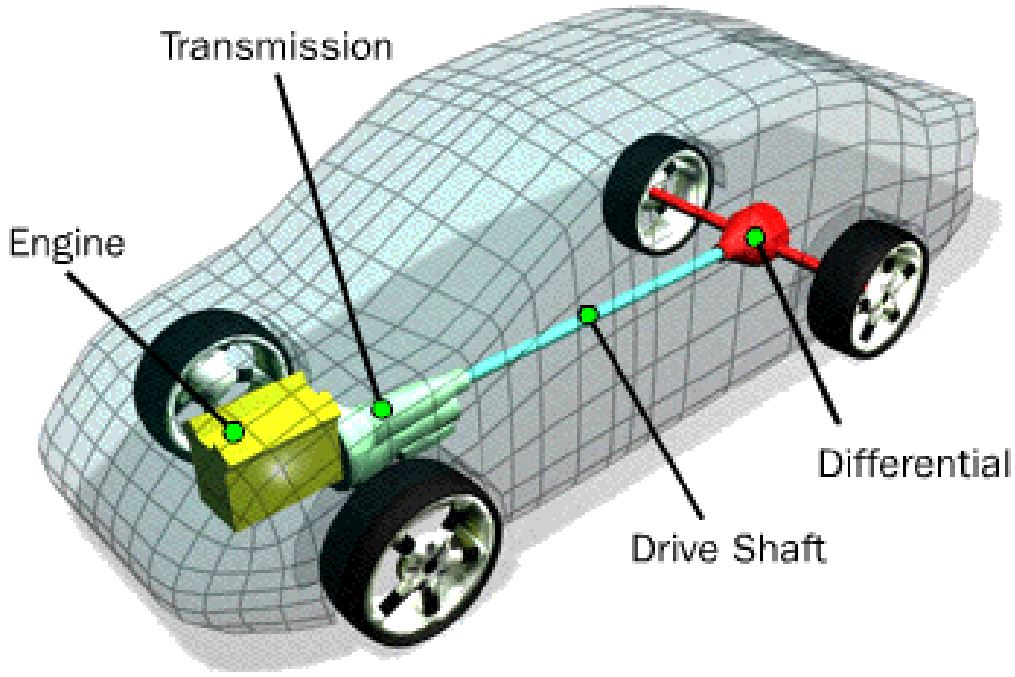
7. Provide for relative movement between the engine and driving wheels.

5.2 Types of power transmission drives

1. Rear wheel drive

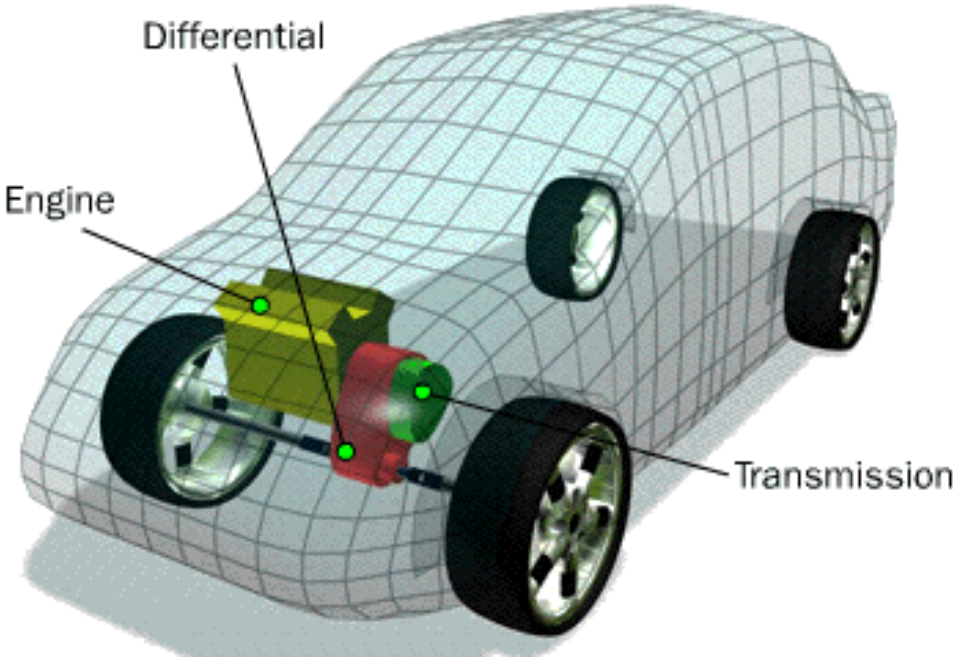
- The transmission is usually mounted to the back of the engine.
- Power flow on this system is simple and straight forward going from the engine, through the torque converter, then through the transmission

and drive shaft until it reaches the final drive where it is split and sent to the two rear wheels.



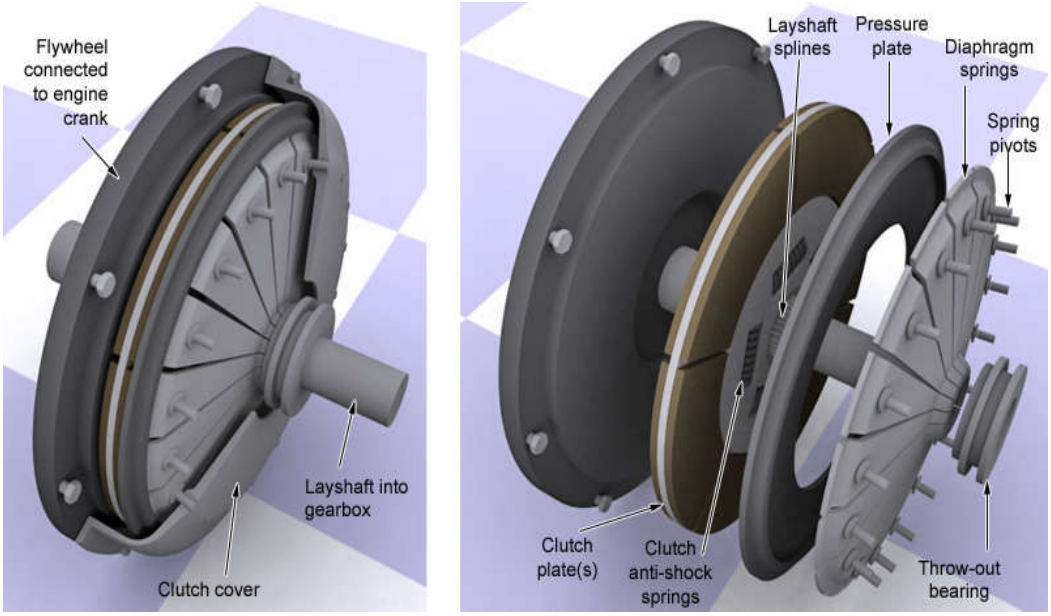
2. Front wheel drive

- On a front wheel drive car, the transmission is usually combined with the final drive to form what is called a transaxle.
- Transaxle is a device set up in the transmission gear box, clutch and final drive, combined into a single unit.
- Front-wheel-drive layouts are those in which the front wheels of the vehicle are driven. The most popular layout used in cars today is the front-engine, front-wheel drive, with the engine in front of the front axle, driving the front wheels.
- This layout is typically chosen for its compact packaging.
- Front axles are connected directly to the transaxle and provide power to the front wheels.



5.3 Power transmission elements:

5.3.1 Clutch



The clutch is housed between the engine and transmission where it provides a mechanical coupling between the engine's flywheel and the transmission input shaft. The clutch is operated by a linkage that extends from the passenger compartment to the clutch housing. The purpose of the clutch is

to disconnect the engine from the driven wheels when a vehicle is changing gears or being started from rest.

Disengaging the clutch separates the flywheel, the clutch plate and the pressure plate from each other. The flywheel is bolted to the end of the crankshaft and rotates with it. The clutch plate is splined to the gearbox in order for both to rotate together and the pressure plate clamps the clutch plate to the flywheel. When the pressure is released by depressing the clutch pedal, the crankshaft and gearbox input shaft rotate independently. When the foot is taken off they rotate as one.

Clutch components materials

Cover plate - Mild steel, Damper spring - Spring steel, Diaphragm spring - Spring steel, Clutch hub - Mild steel, Coil spring - Spring steel, Bolts to fasten flywheel and cover plate – Steel, Pressure plate - Cast iron, Rivets on cushion spring – Brass, Clutch disc - Mild steel, Retainer spring - Spring steel, Friction facing - Asbestos base, Damper spring retainer plate - Mild steel, Rivets on facing - Aluminum brass, Cushion spring - Mild steel

REQUIREMENT OF CLUTCH:

Torque transmission: The clutch should be able to transmit the maximum torque of the engine under all conditions. It is usually designed to transmit 125 to 150 per cent of the maximum engine torque.

Gradual engagement: The clutch should positively take the drive gradually without the occurrence of sudden jerks.

Heat dissipation: During clutch application, large amounts of heat are generated. The rubbing surfaces should have sufficient area and mass to absorb the heat generated. The proper design of the clutch should ensure proper ventilation or cooling for adequate dissipation of the heat.

Dynamic balancing: This is necessary particularly in the high speed clutches.

Vibration damping: Suitable mechanism should be incorporated within the clutch, to eliminate noise produced in the transmission.

Size: The size of the clutch must be smallest possible so that it should occupy minimum amount of space.

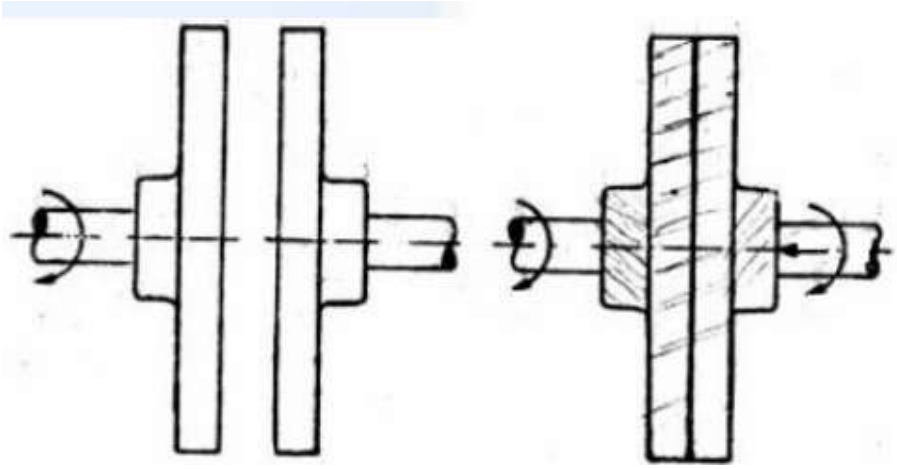
Inertia: The clutch rotating parts should have minimum inertia.

Clutch free pedal play: To reduce effective clamping load on the carbon thrust bearing and wear thereof, sufficient clutch free pedal play must be provided in the clutch.

Ease of operation: For higher torque transmission the operation of disengaging the clutch must not be tiresome to the drive

BASIC PRINCIPLE OF THE FRICTION TYPE CLUTCH

To understand the working principle of clutch, let's take two sanding discs, first one driven by a power drill corresponds to the flywheel of a car, driven by the engine. If a second sanding disc is brought into contact with the first, friction makes it revolve too but more slowly. But when the second disc pressed against the first disc which is connect to the power drill, as the pressure increases the two discs revolve as one. This is how a friction clutch works.



Types of clutch

MULTI COIL SPRING SINGLE PLATE CLUTCH

CONSTRUCTION

A typical clutch actuated by a number of coil springs on a pitch circle nears the periphery is shown. The driven shaft which normally is a forward extension of gearbox primary shaft is supported at its front end in ball bearing in a hole in the centre of flywheel web, which is spigot and bolted on to a flange at the rear end of the crankshaft.

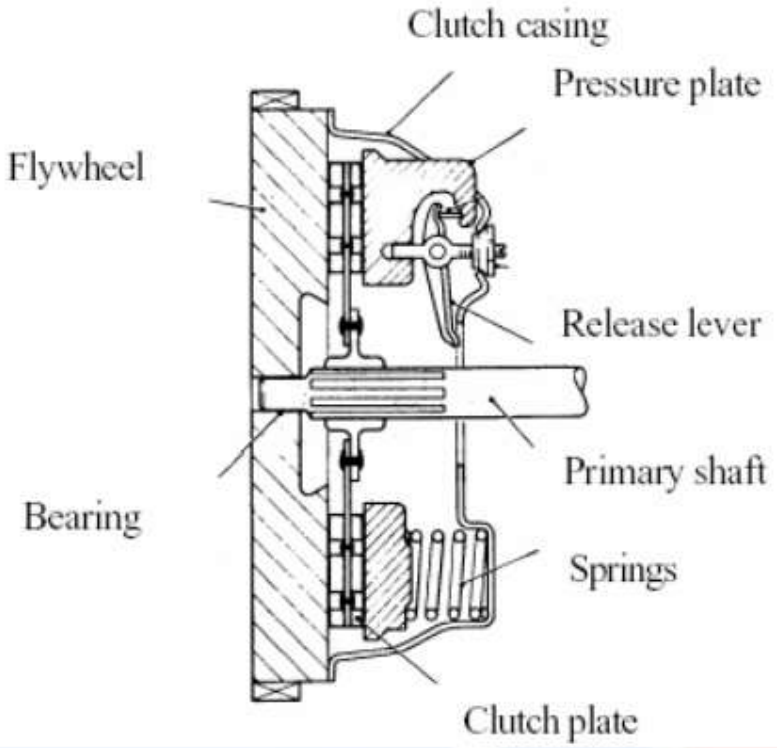
In this clutch, the coil springs force the pressure plate forwards to clamp the driven plate between it and the rear face of the flywheel. Three lugs extend rearwards from periphery of pressure plate both to rotate the

pressure plate and to cause it to rotate with the rest of the assembly. The driven plate of course is splined onto the shaft.

There are three release levers pressing the coil springs at the outer end. The inner ends of the levers can be forced forward by means of thrust bearing made of graphite and slide along the clutch shaft when clutch pedal is depressed. The driven plate mounted between flywheel and pressure plate makes the clutch shaft to rotate to transmit power. It has the clutch facing made of friction materials around the periphery of disc.

WORKING

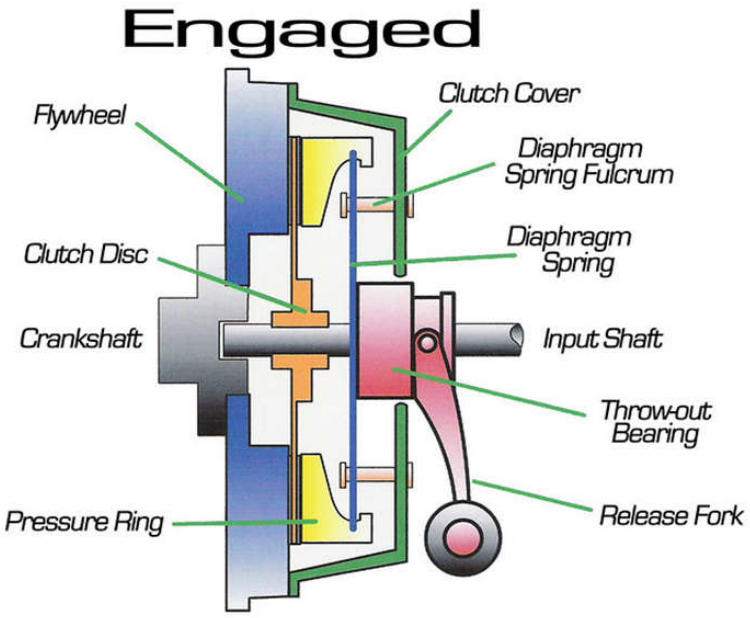
When the clutch is engaged, the clutch plate is gripped between the flywheel and pressure plate. The friction linings are on both sides of clutch plate. Due to friction between flywheel, clutch plate and pressure plate, the clutch plate revolves with the flywheel. As clutch plate revolves the clutch shaft also revolves. Thus, engine power is transmitted to the clutch shaft.



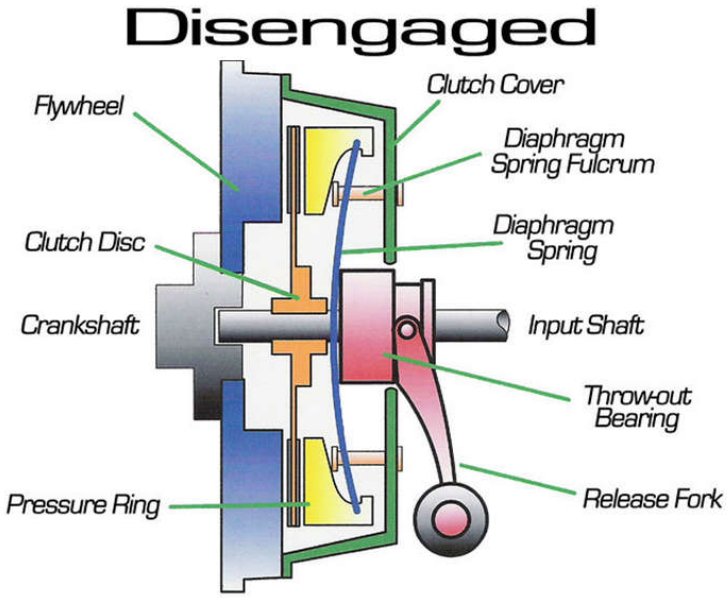
When the clutch pedal is pressed the pressure plate moves back against the spring force and clutch plate becomes free between flywheel and pressure plate. Thus flywheel remains rotating as long as the clutch pedal is pressed, the clutch is said to be disengaged and clutch shaft speed reduces slowly and finally it stops rotating.

DIAPHRAGM SPRING SINGLE PLATE CLUTCH

Diaphragm spring pressure plate assemblies are widely used in most modern cars. The diaphragm spring is a single thin sheet of metal which yields when pressure is applied to it. When pressure is removed the metal springs back to its original shape. The centre portion of the diaphragm spring is slit into numerous fingers that act as release levers. During disengagement of the clutch the fingers are moved forward by the release bearing.



The spring pivots over the fulcrum ring and its outer rim moves away from the flywheel. The retracting spring pulls the pressure plate away from the clutch plate thus disengaging the clutch. When engaged the release bearing and the fingers of the diaphragm spring move towards the transmission. As the diaphragm pivots over the pivot ring its outer rim forces the pressure plate against the clutch disc so that the clutch plate is engaged to the flywheel.



ADVANTAGES OF DIAPHRAGM SPRING CLUTCH

- It is more compact than other designs.
- It is easier to balance rotationally and is less subjected to unwanted effects due to centrifugal force at high rotational speeds.
- It gives uniformly distributed pressure on pressure plate.
- It needs no release levers.
- Minimum effort is sufficient to disengage the clutch.
- It provides minimum number of moving components and hence minimum internal friction is experienced.
- This is very commonly used in cars, light Lorries and mini trucks but is not much used in heavy vehicle

MULTIPLATE CLUTCH

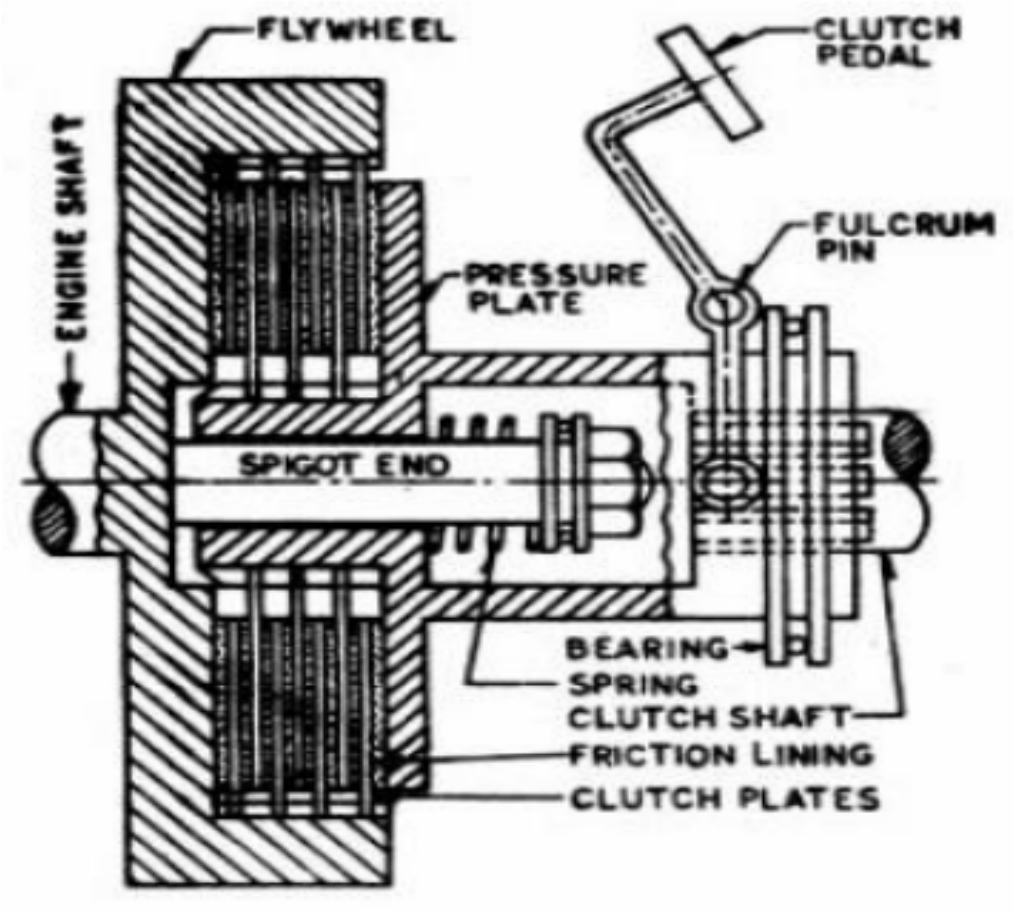
The multi-plate clutch is an extension of single plate type where the number of frictional and the metal plates are increased. The increase in the number of friction surfaces obviously increase capacity of the clutch to transmit torque, the size remaining fixed. Alternatively, the overall diameter of the clutch is reduced for the same torque transmission as a single plate clutch. This type of clutch is, used in some heavy transport vehicles, in epicyclic gearboxes and racing cars where high torque is to be transmitted.

Besides, this finds applications in case of scooters and motorcycles, where space available is limited.

Extension of flywheel is a drum; which on its inner circumference is splined to carry a number of thin metal plates. These must consequently revolve with drum but are able to slide axially. Interleaved with these outer plates are a number of inner plates that are splined to an inner drum which is coupled rotationally to the gearbox shaft.

This drum is supported on a spigot extension of crankshaft. Between the web of inner drum and sleeve in inner drum is a strong coil spring. The inner drum is thus pressed to left being provided with a flange it squeezes the inner and outer plates together so that friction between them transmits driving torque from outer to inner drum.

The clutch is disengaged by pulling inner drum right against spring force. The plates of multi-plate clutch were at one time made alternately of steel and phosphor bronze but now are all of steel or one set may be lined with a friction material. With metal contact lubrication is essential and so clutch is made oil-tight and partly filled with oil. The oil tends to make the plates drag when clutch is disengaged and so some mean should be provided to avoid this drag.



CEN TRIFUGAL CLUTCH

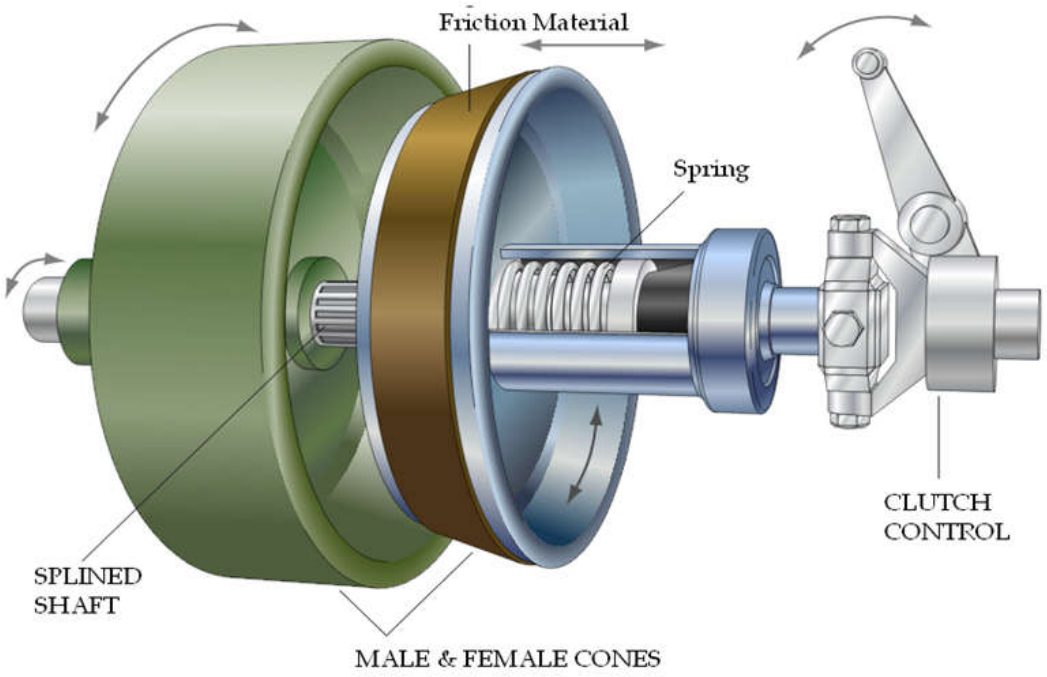
In this type of clutches the springs are eliminated altogether and only the centrifugal force is used to apply the required pressure for keeping the clutch in engagement position.

The advantage of the centrifugal clutch is that no separate clutch pedal is required. The clutch is operated automatically depending upon the engine speed. This means that car can be stopped in gear without stalling the engine. Similarly while starting, the driver can first select the gear, put the car into the gear and simply press the accelerator pedal. This makes the driving operation very easy.

Cone Clutch:

In this type the contact surface are in the form of cones as shown in the figure. In the engaged position, the male cone is fully inside the female cone so that the friction surfaces are in complete contact. This is done by means of springs which keep the male cone pressed all the time.

When the clutch is engaged, the torque is transmitted from the engine via the fly wheel and the male cone to the splined gear box shaft. For disengaging the clutch the male cone is pulled out by means of the lever system operated through the clutch pedal thereby separating the contact surfaces.



Advantages:

The only advantage of the cone clutch is that the normal force acting on the contact surfaces in this case is larger than the axial force, as compared to the simple single plate clutch in which the normal force acting on the contact surfaces is equal to the axial force.

Disadvantages:

1. If the angle of cone is made smaller than about 200 the male cone tends to bind or join the female cone and it becomes difficult to disengage the clutch.

2. A small amount of wear on the cone surface results in a considerable amount of the axial movement of the male cone for which it will be difficult to allow.

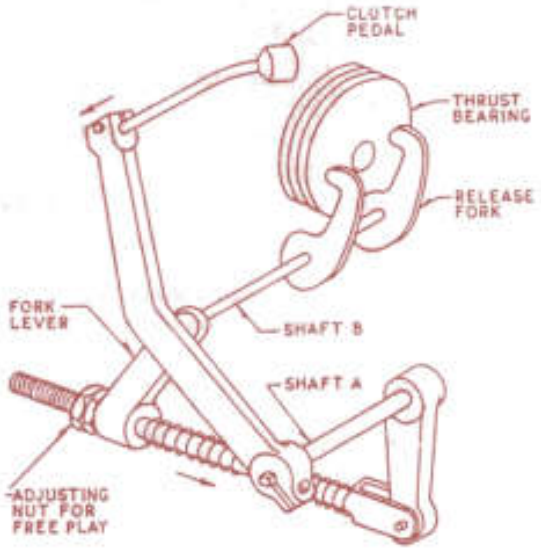
5.3.2 Clutch operation:

Generally, the clutches are operated mechanically through a linkage. However, other means of operation viz., electrical, hydraulic or even vacuum, have also been used. All these will be described in the following briefly.

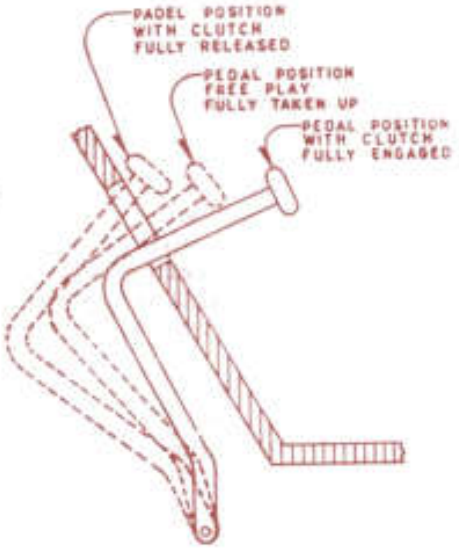
Mechanical operation:

The clutch linkage for this purpose is shown in Fig. On pressing the clutch pedal, the shaft A turns. This movement is further conveyed to clutch levers to disengage the clutch. Generally, mechanical leverage from 10:1 to 12:1 is employed that would require a pedal force of about 100-120 N when using travel to 75 mm.

When the clutch pedal is pressed, the thrust bearing is not pressed immediately. Rather a part of the pedal movement is purposely kept idle. This is done to avoid a rapid wear of the thrust bearing and the clutch plates and is called clutch pedal play. Usually this is kept about 25 mm at the pedal.



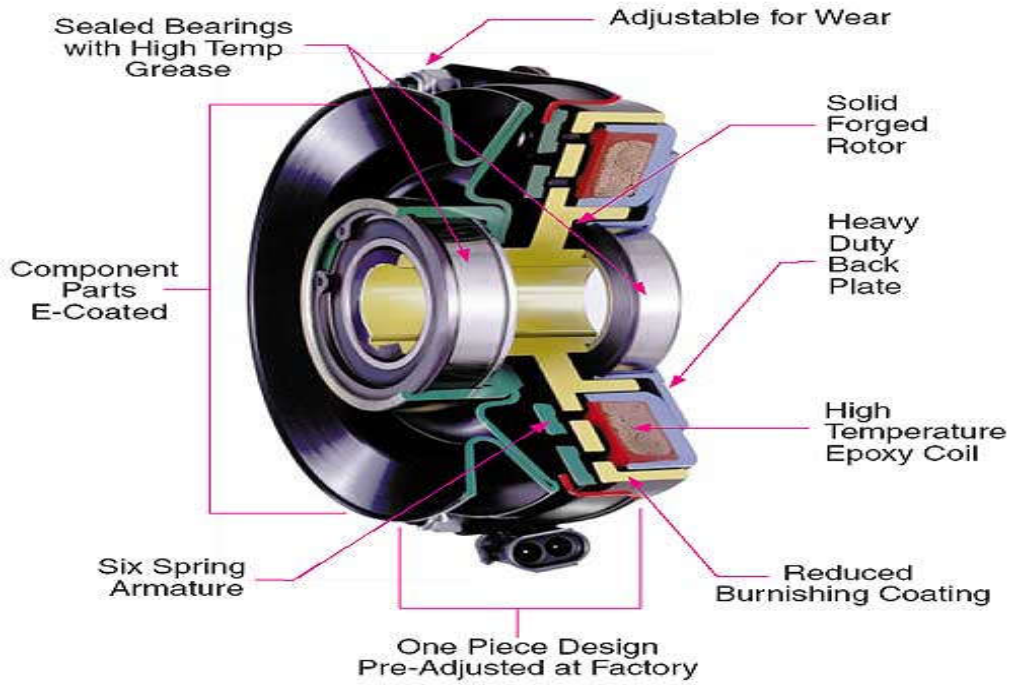
Clutch linkage.



Clutch free pedal play.

Electromagnetic operation:

Clutch plate is lined with friction surfaces and is free to slide on splines on the clutch shaft. The winding is supplied with current from battery dynamo. When the winding is energized, it attracts the pressure plate, thereby engaging the clutch.



When supply to winding is cut off, the clutch is disengaged. Ordinarily the winding is connected to engine dynamo. At lower engine speeds, dynamo output is also low which makes the force in winding very small. Three springs are also provided in the clutch to balance this reduced electromagnetic force at low speeds, thus disengaging the clutch.

During normal operation, the electromagnetic force of the winding is regulated by means of an electrical resistance, which itself is controlled by means of accelerator pedal. As the accelerator pedal is pressed the resistance is gradually cut, thus increasing the electromagnetic force. The electromagnetic type of clutch is best suited where remote operation is desired since no linkages are required to control its engagement. A major limitation of this type is heat capacity since the clutch-operating temperature is limited by the temperature rating of the insulation of the magnetic coil. Another disadvantage is its higher initial cost.

Hydraulic operation:

In heavy-duty mechanically operated clutches with high clutch-spring pressure, the force required by the driver to release the clutch becomes excessive. This can be remedied by the use of hydraulic operation. This type of operation is also suitable for vehicle in which the clutch pedal and the clutch have to be located too far away each other. Hydraulically operated clutch may be either single plate type of the more modern multiplate type.

5.3.3 GEAR BOX

- A gearbox is a mechanical device utilized to increase the output torque or change the speed (RPM) of engine.
- The engine's shaft is attached to one end of the gearbox and through the internal configuration of gears of a gearbox, provides a given output torque and speed determined by the gear ratio.

FUNCTION OF A GEAR BOX

- Provides speed and torque conversions because of the limitations of internal combustion engines.
- Also facilitates change of direction of output shaft for reversing
- Automotive gearboxes are used to reduce load on the engine by manipulating torque and speed. They have the option to select one of several different gear ratios.

- Once the engine has reached a number of revolutions per minute, it is advisable to increase the gear to reduce the engine rpm to reduce wear on the engine, allow more control, and greater speeds, better acceleration, and better fuel economy.
- Most gearboxes are used to increase torque & reduce the speed of a output shaft. This produces a mechanical advantage
- Automotive gearbox also have the provision to do the opposite ie provide an increase in output shaft speed with a reduction of torque (overdrive).

Gears used in power transmission:

The most basic type of gear is a spur gear, and it has straight-cut teeth, where the teeth are cut parallel to the axis of the gear.

Wider gears and those that are cut for smoother meshing are cut with the teeth at an angle. These are called helical gears.

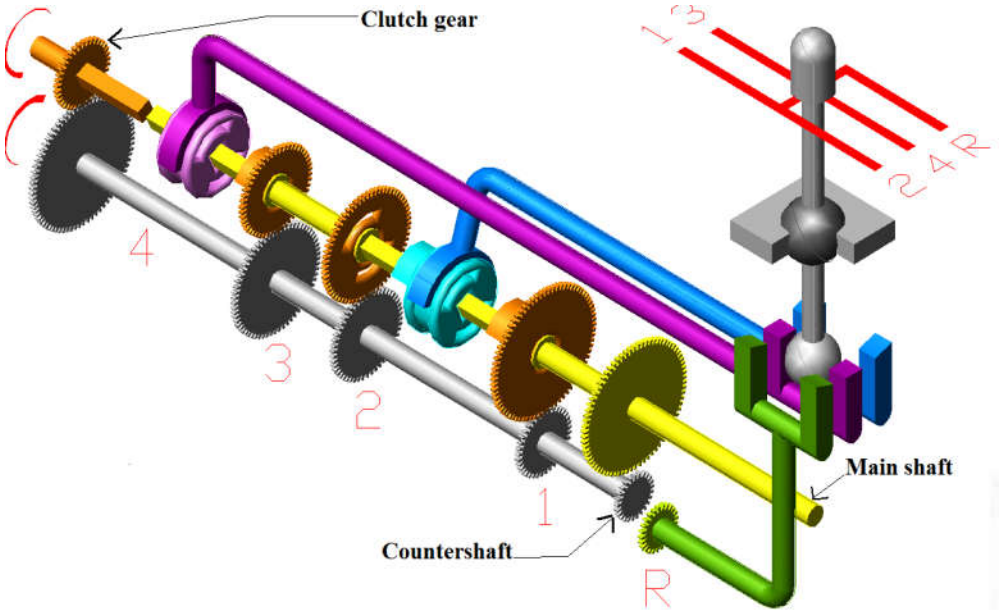
- Because of the angle of cut, helical gear teeth have a much more gradual engagement with each other, and they operate more smoothly and quietly than spur gears.
- Helical gears can transmit more torque because at any time, more number of teeth are in mesh

- Gearboxes for cars and motorbikes almost always use helical gears.
- However, helical gears also exert undesirable axial thrust To prevent axial thrust, double helical gears are used which cancel out the thrust. Double Helical gears are called Herringbone gears.
- Collection of helical gears in a gearbox gives the gearing down of the speed of the engine crank to the final speed of the output shaft from the gearbox.

Types of Gearboxes

SLIDING MESH GEAR BOX

- It is the simplest and oldest type of gear box.
- The clutch gear is rigidly fixed to the clutch shaft.
- The clutch gear always remains connected to the drive gear of countershaft.
- The other lay shaft gears are also rigidly fixed with it.
- Two gears are mounted on the main shaft and can be sliding by shifter yoke when shifter is operated.
- One gear is second speed gear and the other is the first and reverse speed gears. All gears used are spur gears.
- A reverse idler gear is mounted on another shaft and always remains connected to reverse gear of counter shaft.

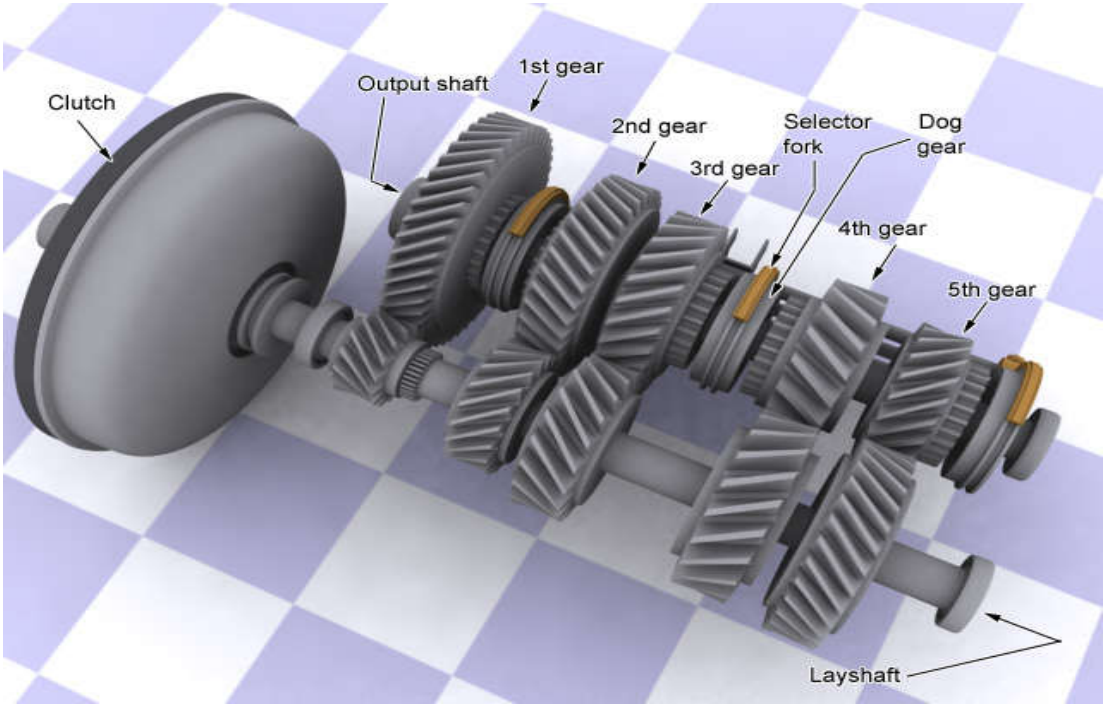


Constant Mesh Gearbox

- All the gears are always in mesh
- Gears on counter shaft are fixed to it
- Gears on main shaft are free to rotate
- Dog clutches can slide on the main shaft and rotate with it
- Dog clutches engage with gears on the main shaft to obtain desired speed

Advantages over sliding mesh Gearbox:

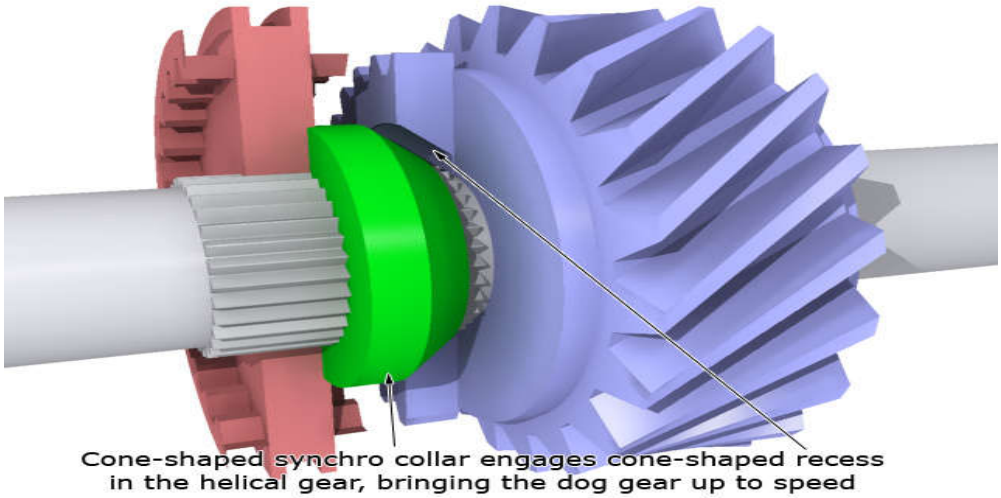
- Helical and herringbone gear can be used in these gearboxes and therefore, constant mesh gearboxes are quieter.
- Since the gears are engaged by dog clutches, if any damage occurs while engaging the gears, the dog unit members get damaged and not the gear wheels.



Synchromesh Gearbox

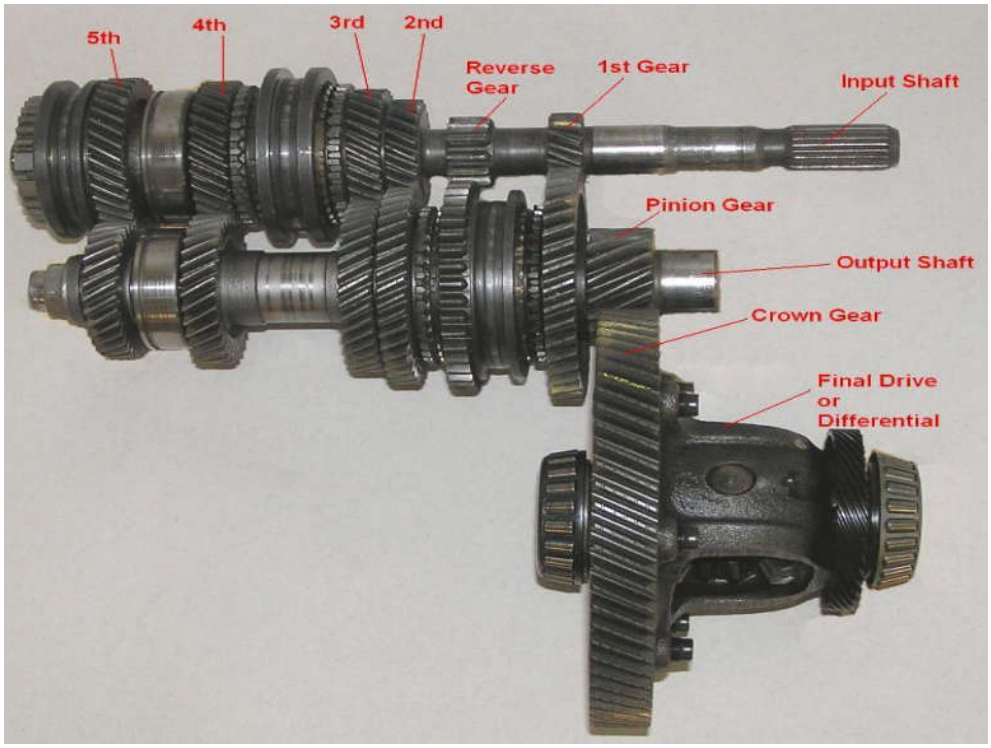
- Sliding synchronizing units are provided to equalize the speeds of gear and dog before meshing
- The device works like a friction clutch
- Equal speeds ensure smooth meshing
- Normally not used in 1st and reverse gear.

Working



- Output shaft is always rotating (because it is positively connected to the wheels)
- Layshaft is connected to the engine, but it rotates freely when the clutch is disengaged
- Because the gears are meshed all the time, the synchro brings the layshaft to the right speed for the dog gear to mesh.
- The layshaft is now rotating at a different speed to the engine. Now, the clutch gradually equalizes the speed of the engine and layshaft, either bringing the engine to the same speed as the layshaft or vice versa depending on engine torque and vehicle speed.

Transaxle Gear Box



- Has only 2 shafts
- Used in vehicles with engine and drive on same side
- Most commonly used
- Gear Box and Differential in same housing

- Combination of transmission and differential in one unit is called transaxle.
- Transaxles are both automatic and manual.

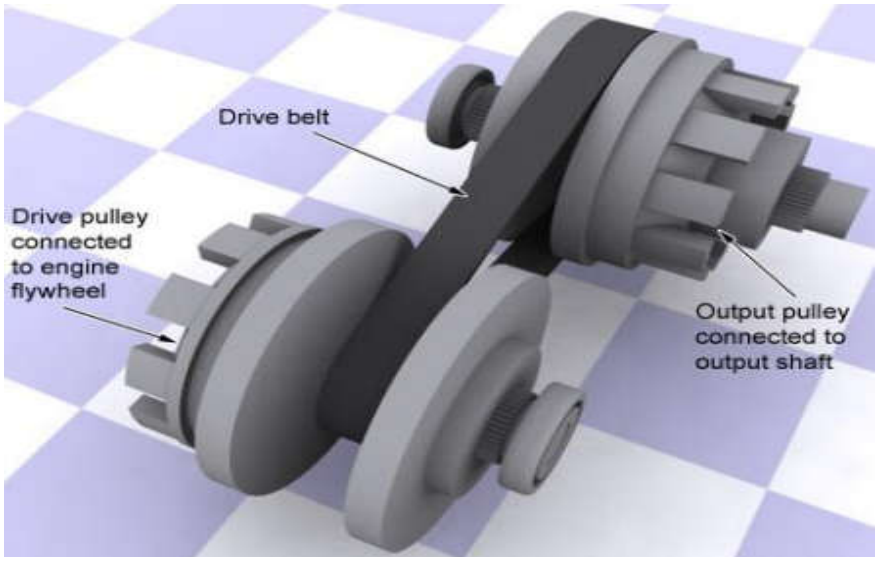
Advantages include:

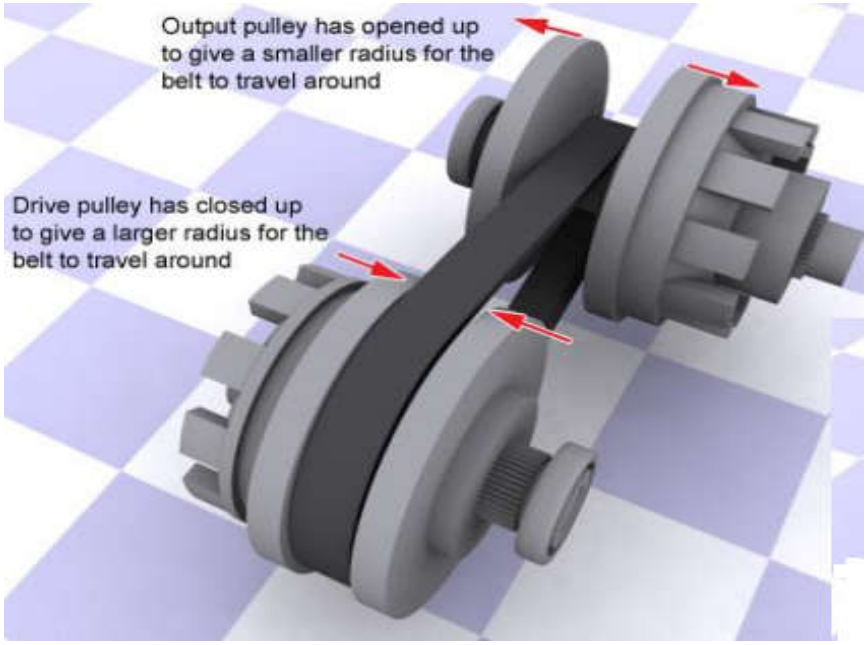
- Reduced drive train weight.
- Improved traction.
- Smoother ride.
- Quieter operation.
- Increased passenger compartment space.

Continuously Variable Transmission

The Continuously Variable Transmission (CVT) is a transmission in which the ratio of the rotational speeds of two shafts, as the input shaft and output shaft of a vehicle or other machine, can be varied continuously within a given range, providing an infinite number of possible ratios.

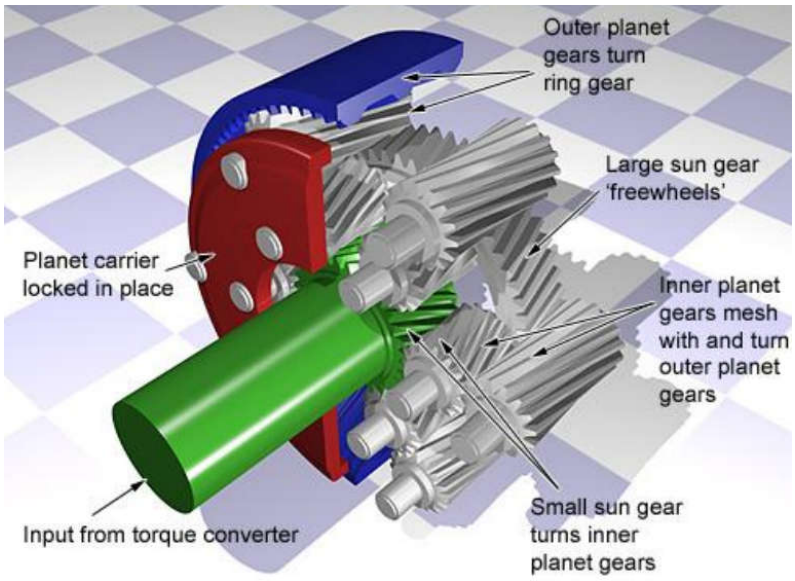
Continuously variable transmission allows the relationship between the speed of the engine and the speed of the wheels to be selected within a continuous range rather than in steps. This provides even better fuel economy if the engine is constantly running at a single speed. The transmission provides better user experience without much rise and fall in speed of an engine, and eliminates the jerk felt when changing gears.





Epicyclic Gearbox

- Epicyclic gear trains are used to get the various gear ratios.
- At least one wheel not only rotates about its own axis but also rotates about some other axis
- Automatic gearboxes typically use one or more compound planetary gear sets having two sun gears and two sets of intermeshing planet gears.
- There is still only one ring gear.

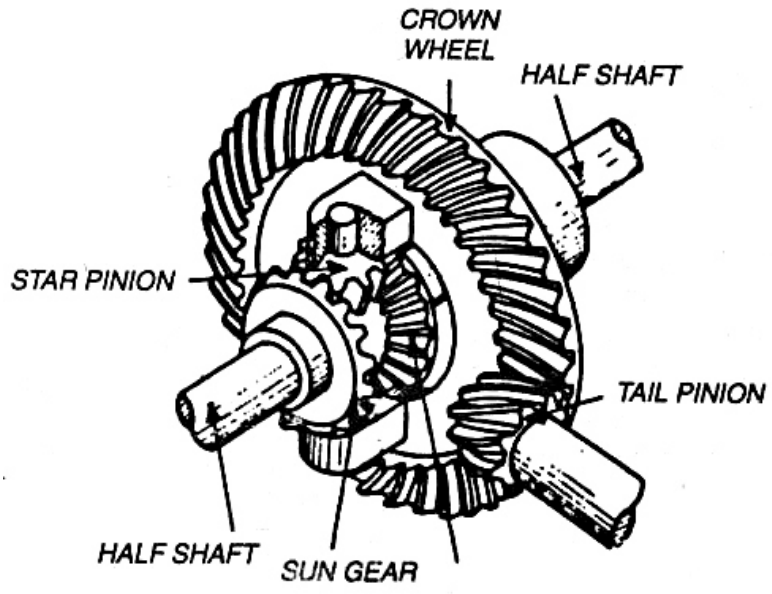


5.3.4 Differential

- Device that splits engine torque two ways, allowing each output to spin at a different speed
- Differential is a mechanism which provide different speed to tyres at cornering.
- It provides equal torque on both tyre not power.
- From the differential, power is transmitted to the rear axles and from there to the wheels of the Automobile.
- The differential is designed to drive a pair of wheels while allowing them to rotate at different speeds.
- When cornering, the inner wheel needs to travel a shorter distance than the outer wheel, so with no differential, the result is the inner wheel spinning and/or the outer wheel dragging, and this results in difficult and unpredictable handling, damage to tires and roads, and strain on (or possible failure of) the entire drive train.

Construction of Differential and its working principle

The crown wheel is kept closed into housing with the differential cage. The pinion side of the tail pinion attached to the propeller shaft is joined with the help of bearing along with the crown wheel in the housing.



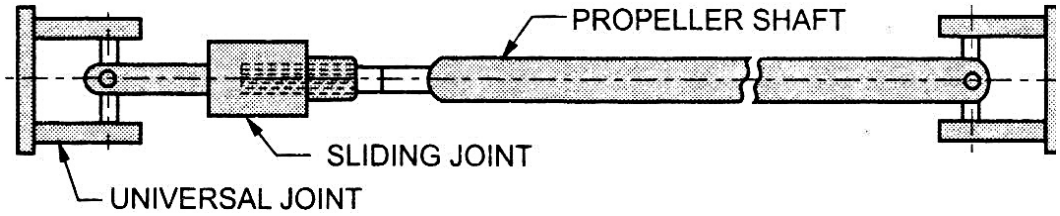
It is usually tightened by chuck nut and along with a flange is fitted where to the propeller shaft is joined with the help of universal joint. For fitting the tail pinion, mostly two bearings are used. These are tightened or loosened to help adjust the black lace. Inside the cage, along with the crown wheel the sun pinion and star pinion are attached by both. Inside the cage, both the sun pinions entrap the axle shaft within themselves. Both these sun pinions are linked with each other by the star pinions and the spider. In this way when the motor vehicle is operated, the propeller shaft activates the tail pinion by the gearbox. The crown wheel rotates by the tail pinion. So the complete cage attached with it rotates like a unit and the axle shaft entrapped into the sun pinion rotates to rotate the wheels. At this moment, by the differential both the wheels receive an equal amount of power and speed as both the sun pinions aremovingat an equal speedas per the entirecage.

When the motor vehicle drives on a shattered space or are taking a turn of direction, then thereis difference of speed in its both rear wheels. At turns, when due to load, the inner wheel speed is lessened then it also lays effect on the sun pinion attached to it. As a result that sun pinion also decreases its speed. At this moment the star pinion attached to it, which till then would have been moving like a unit, starts moving freely in the spider itself at its own place. In this way, the connection of this wheel and the sun pinion with another sun pinion ceases and both the wheels freely move as required. At this moment, the additional power being transmitted to the wheels with lesser plays, is also transferred to the wheel having extra movement whereby turning is immediate in a narrow space.

Propeller shaft

The propeller shaft is a driving shaft that connects the transmission to the differential. The output shaft or main shaft from the transmission and pinion shaft extending from the differential unit are connected to the propeller shaft and the universal joints. A sliding joint is also used between the propeller shaft and the universal joint near the gear box. The rotary motion of the transmission main shaft is carried out through the propeller shaft to the differential, causing the rear wheels to rotate. The propeller shaft has to withstand the torsional stresses of the transmitting torque and yet it must be light and well balanced so that vibrations and whip will not occur at high speeds. For these reasons, it is made of a strong steel tube. Solid propeller shafts are also used. The propeller shaft may be exposed to the atmosphere or protected by an outer tube. Some applications include bearings at or near the propeller shaft centre to support the shaft. On some applications, the

propeller shaft is in two sections, supported by a centre bearing and coupled together by universal joint.



It is to be noted that the transmission main shaft and the differential pinion shaft are not in one horizontal level. The rear axle housing with differential is attached to the frame by springs, therefore, the distance between the gear box and the differential changes due to road irregularities. This also changes the angle of drive. In order that the propeller shaft must take curve of these two changes, it is provided with one or more universal joints to permit variations in the angle of drive. Also, it must be provided with a sliding joint that permits the effective length of the propeller shaft to change.

UNIVERSAL JOINT/COUPLING

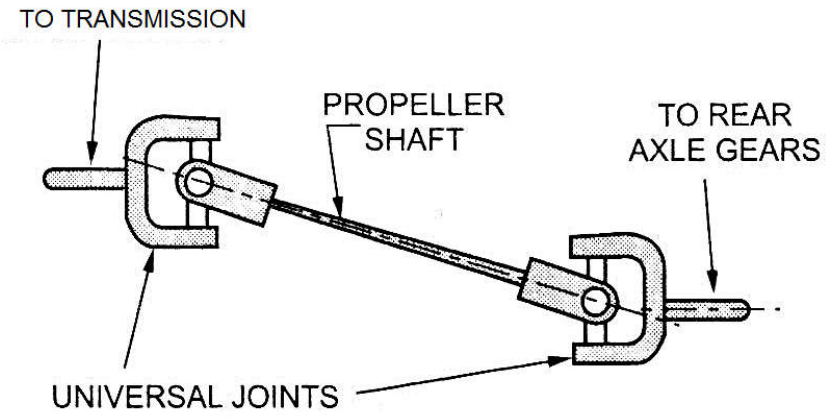
An universal joint is used where two shafts are connected at an angle to transmit torque. In the transmission system of a motor vehicle, the transmission main shaft, propeller shaft and the differential pinion shaft are not in one line and hence the connection between them are made by universal joint.

One universal joint is used to connect the transmission main shaft and the propeller shaft, other universal joint is used to connect the other end of the propeller shaft and the differential pinion shaft. Thus, the connections

between the three shafts are flexible and at an angle with each other. The universal joint permits the torque transmission not only at angle, but also while this angle is changing constantly.

A simple universal joint consists of two Y-shaped yokes, one on the driving shaft and other on the drive shaft and a cross-piece called the spider. The four arms of spider, known as trunnions, are assembled into bearing in the ends of the two shaft yokes. The driving shaft and the driven shaft are at an angle to each other, the bearings in the yokes permits the yokes to swing around on the trunnions with each revolution.

It is to be noted that simple universal joint does not transmit the motion uniformly when the shafts are operating at an angle, except in constant velocity type universal joint. Because the pivot pins do not revolve in the same plane, the driven shaft will increase to a maximum and decrease to a minimum twice in each revolution. Although the degree of variation is small, however, it may be minimized by the use of two universal joints. The two joints are arranged so that the non-uniform rotation of each joint tends to neutralize that of the other as shown in figure below.



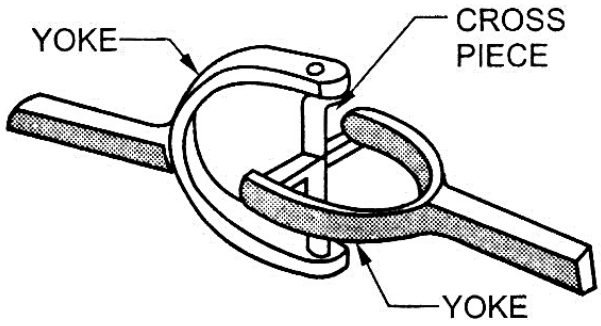
TYPES OF UNIVERSAL JOINTS

The universal joints may be of three types as follows :

1. Cross type or spider and two-yoke type.
2. Ball and trunnion type.
3. Constant velocity type.

Cross type or spider and two-yoke type.

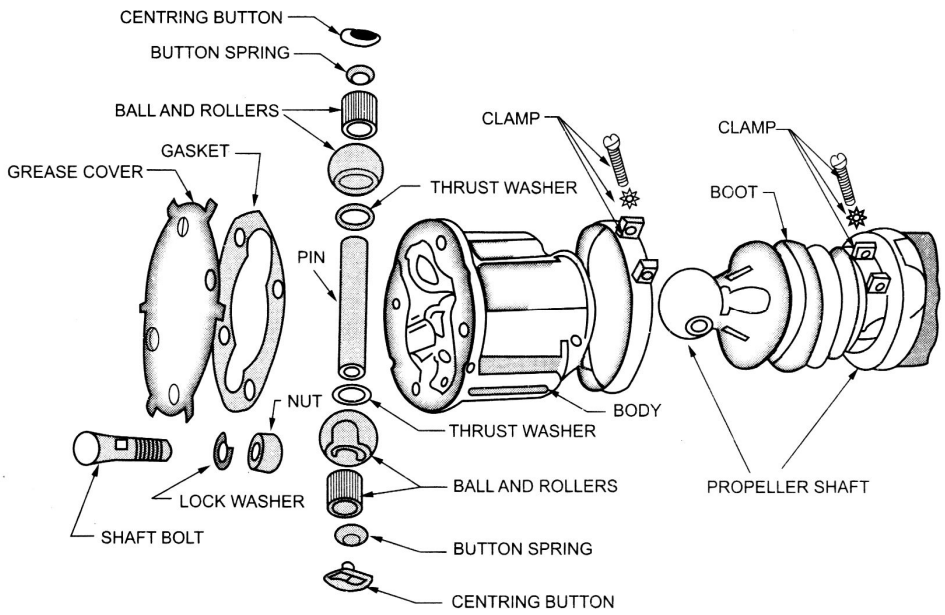
The cross type universal joint is shown in Figure. it consists of a cross piece or spider and two yokes, therefore, it is known as cross type or spider and two-yoke type universal joint. There are four needle bearings, one for each trunnion of the spider.



The bearings are held in place by rings heat drop into undercuts in the yoke-bearing holes. One commercial design of the cross type universal joint incorporates a slip joint. One yoke is integral with the hub that holds the female end of the slip joint. When the joint is used between the propeller shaft and rear axle gear shaft, the slip joint is omitted so that a direct connection is made between the two units. Other designs of cross type universal joint are ring and trunnion type used in torque tube drive; and cross ball type used in Hotch-kiss drive.

Ball and trunnion type

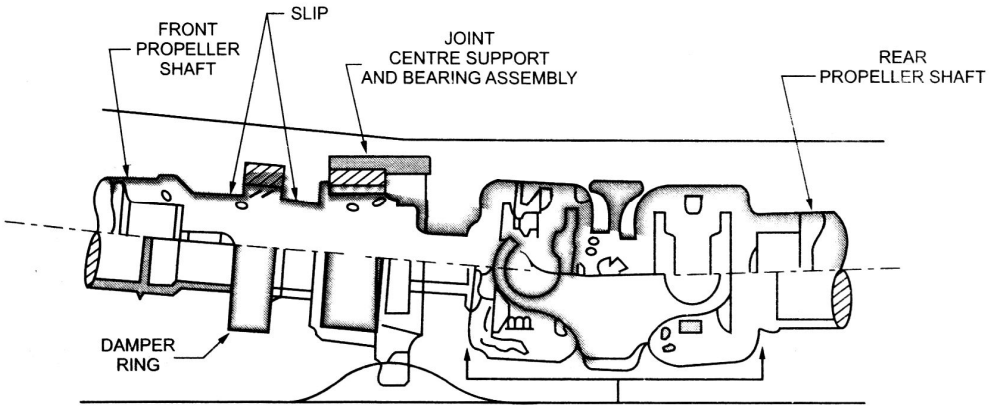
The ball and trunnion type universal joint consists of a ball head fastened to the end of the propeller shaft through which a pin is pressed.



Two steel balls fit over the ends of the, pin. The ball retains the roller bearing between them and U-shaped channel in the body. The centring bottoms and the button spring help to keep the pin properly centred. The universal joints and propeller shaft assembly is bolted to a companion flange with the gasket and grease cover between them. The companion flange (not shown) is splined to the other shaft. The rotary motion is carried out through the pin and balls. The balls can move back andforth in the channels of the body to compensate for varying angle of drive at the same time, they act as a slip joints by slipping into or out of the channels.

Constant Velocity (CV) type

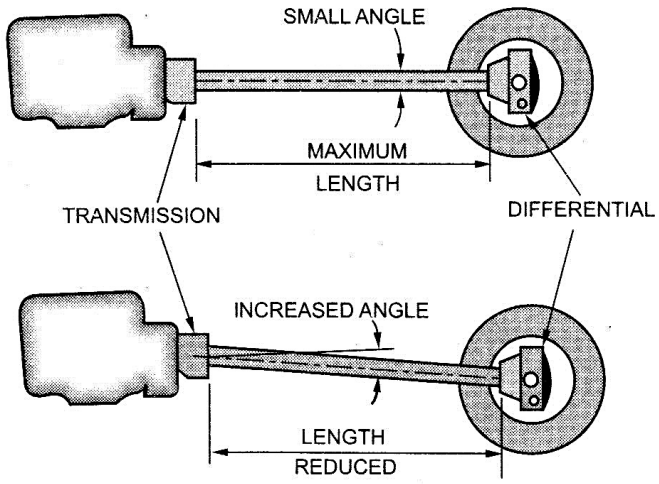
The constant velocity universal joint consists of two individual universal joints linked by a ball and socket. The ball and socket splits the end of the two propeller shafts between the two universal joints.



This type of joint permits uniform motion. Because the two joints are operating at the same angle, the acceleration resulting at any instant from the action of one universal joint is cancelled out by the deceleration of the other and vice versa.

SLIP JOINT OR SLIDING JOINT

The propeller shaft is connected between the transmission main shaft and the differential pinion shaft. It is to be noted here that the engine and the transmission are more or less rigidly attached to the car frame. The rear axle housing, with wheels and differential, is attached to the frame by springs. As the rear wheels encounter irregularities in the road, the springs compress or expand. The differential, with rear axle housing and wheel, moves up and down. This not only changes the angle of drive but also changes the length of the propeller shaft. The universal joint permits variation in the angle of drive. The slip joint permits the effective length of the propeller shaft to change. If there is no slip joint, the propeller shaft would buckle or break.



As the differential moves up and down in an arc, it not only changes the angle of drive but also the effective length of the propeller shaft.

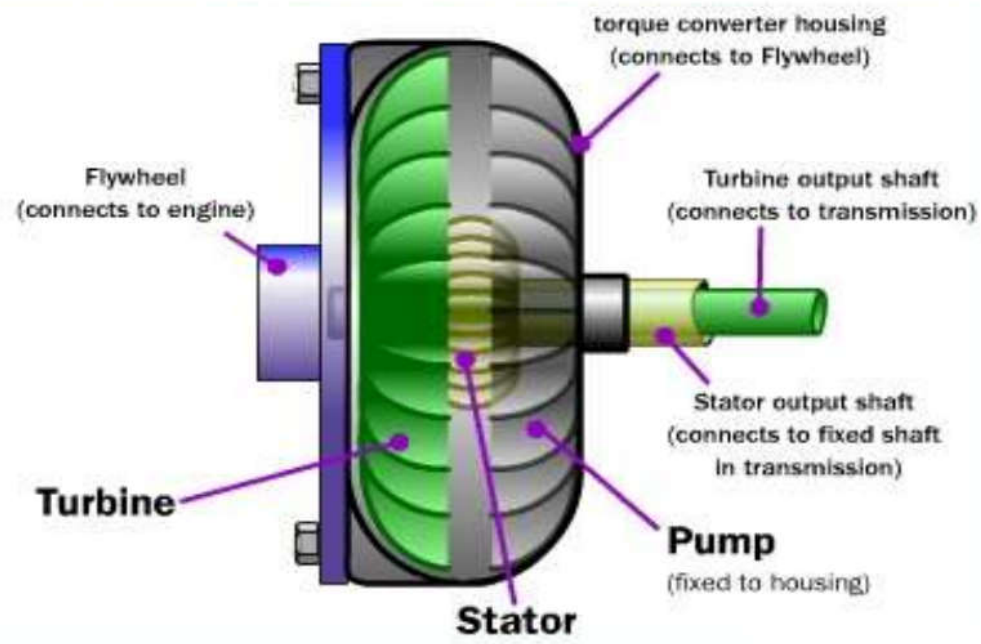
When the rear springs compress, the differential rise up and the propeller shaft is shortened. When the springs again expand, the differential returns to its original position and propeller shaft gets its original length. Therefore, a slip joint is used in the transmission system to compensate for the change in length of the propeller shaft. In some vehicles using Hotchkiss drive, the slip joint lies between the propeller shaft and the universal joint connecting the propeller shaft with the transmission main shaft. In some vehicles, the slip joint lies between the transmission main shaft and the universal joint. In cars provided with a torque tube drive, a slip joint is not always necessary.

Automatic transmission :-

Automatic transmission system is the most advanced system in which drives mechanical efforts are reduced very much and different speeds are obtained automatically. This system is generally also called hydramatic transmission. It contains epicyclic gear arrangement, fluid coupling and torque converter. In these planetary gears sets are placed in series to provide transmission.

Torque converter

Torque converter is a hydraulic transmission which increases the torque of the vehicle reducing its speed. It provides a continuous variation of ratio from low to high. The key characteristic of a torque converter is its ability to multiply torque when there is a substantial difference between input and output rotational speed, thus providing the equivalent of a reduction gear. Cars with an automatic transmission have no clutch that disconnects the transmission from the engine. So, they use an amazing device called a torque converter.



There are four components inside the housing of the torque converter:

- Pump
- Turbine
- Stator
- Transmission fluid

The housing of the torque converter is bolted to the flywheel of the engine, so it turns at whatever speed the engine is running at. The pump inside a torque converter is a type of centrifugal pump. As it spins, fluid is flung to the outside. As fluid is flung to the outside, a vacuum is created that draws more fluid in at the center. The fluid then enters the blades of the turbine, which is connected to the transmission. The turbine causes the transmission to spin, which basically moves your car. The blades of the turbine are curved. This means that the fluid, which enters the turbine from the outside, has to change direction before it exits the center of the turbine. It is this directional change that causes the turbine to spin.

In order to change the direction of a moving object, you must apply a force to that object -- it doesn't matter if the object is a car or a drop of fluid. And whatever applies the force that causes the object to turn must also feel that force, but in the opposite direction. So as the turbine causes the fluid to change direction, the fluid causes the turbine to spin.

The fluid exits the turbine at the center, moving in a different direction than when it entered. The fluid exits the turbine moving opposite the direction that the pump (and engine) is turning. If the fluid were allowed to hit the pump, it would slow the engine down, wasting power. This is why a torque converter has a stator. The stator resides in the very center of the torque converter. Its job is to redirect the fluid returning from the turbine before it hits the pump again. This dramatically increases the efficiency of the torque converter. The stator has a very aggressive blade design that almost completely reverses the direction of the fluid. A one-way clutch (inside the stator) connects the stator to a fixed shaft in the transmission (the direction that the clutch allows the stator to spin is noted in the figure above). Because of this arrangement, the stator cannot spin with the fluid - it can spin only in the opposite direction, forcing the fluid to change direction as it hits the stator blades. The figure (top to bottom) shows the pump, turbine and the stator, sending the fluid in their respective direction.

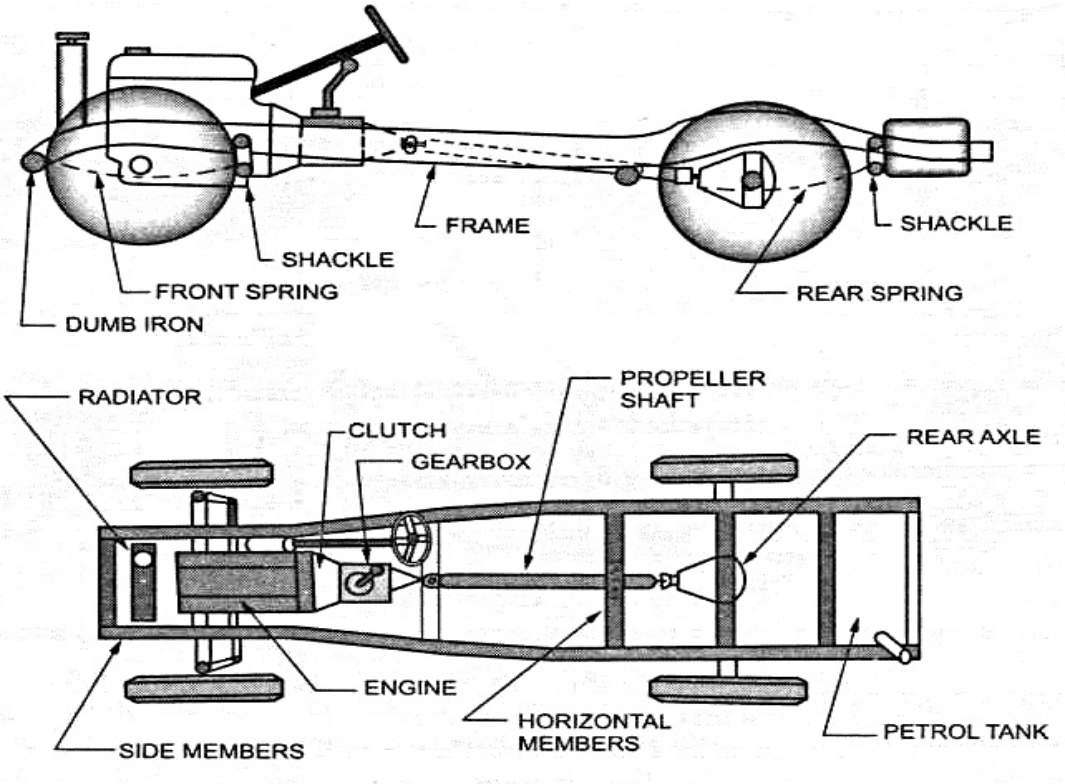
CHAPTER 6

CHASSIS FRAME AND BODY

6.1 Introduction:

Chassis is a French term and was initially used to denote the frame parts or Basic Structure of the vehicle. It is the back bone of the vehicle. A vehicle without body is called Chassis. The components of the vehicle like Power plant, Transmission System, Axles, Wheels and Tyres, Suspension, Controlling Systems like Braking, Steering etc., and also electrical system parts are mounted on the Chassis frame. It is the main mounting for all the components including the body. So it is also called as Carrying Unit.

Layout of Chassis and its main Components:



The following main components of the Chassis are

1. Frame: it is made up of long two members called side members riveted together with the help of number of cross members.

2. Engine or Power plant: It provides the source of power

3. Clutch: It connects and disconnects the power from the engine fly wheel to the transmission system.

4. Gear Box

5. U Joint

6. Propeller Shaft

7. Differential

FUNCTIONS OF THE CHASSIS FRAME:

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

6.2 TYPES OF CHASSIS FRAMES:

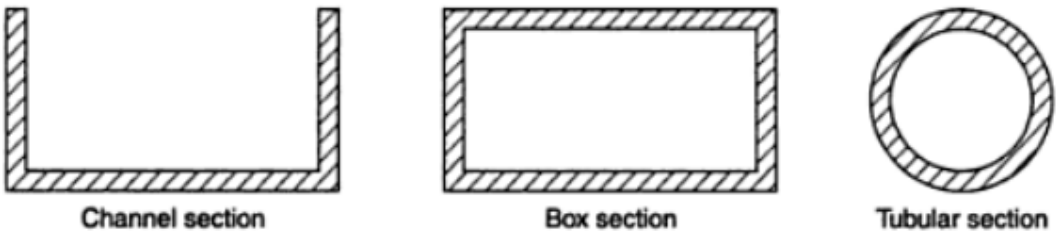
1. Conventional frame:

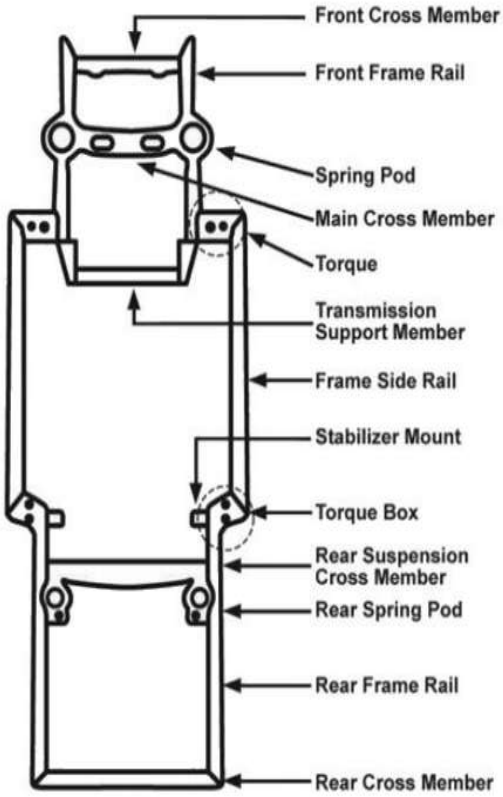
It has two long side members and 5 to 6 cross members joined together with the help of rivets and bolts. The frame sections are used generally.

a. Channel Section - Good resistance to bending

b. Tabular Section - Good resistance to Torsion

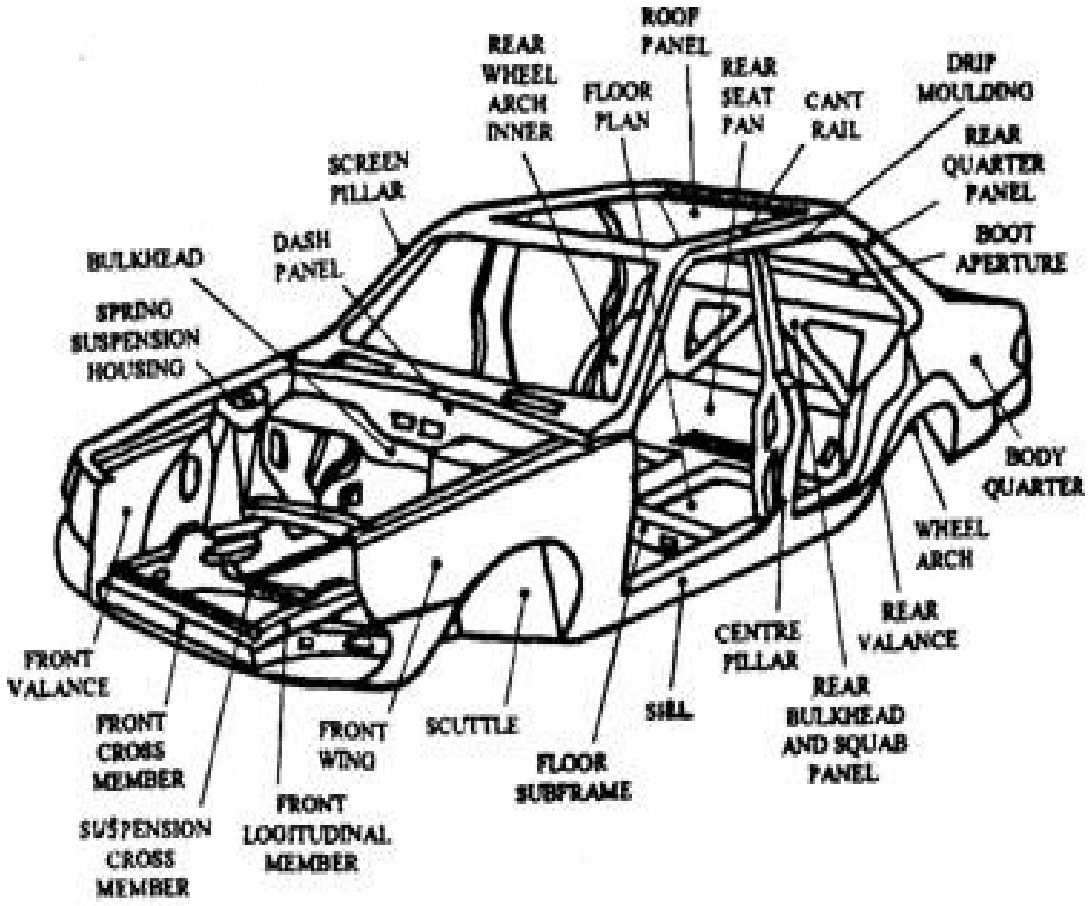
c. Box Section - Good resistance to both bending and Torsion





2. Integral Frame:

This frame is used now a days in most of the cars. There is no frame and all the assembly units are attached to the body. All the functions of the frame carried out by the body itself. Due to elimination of long frame it is cheaper and due to less weight most economical also. Only disadvantage is repairing is difficult.



3. Semi - Integral Frame:

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

VARIOUS LOADS ACTING ON THE FRAME:

- Weight of the vehicle and the passengers, which causes vertical bending of the side members.
- Vertical loads when the vehicle comes across a bump or hollow, which results in longitudinal torsion due to one wheel lifted (or lowered) with other wheels at the usual road level.
- Loads due to road camber, side wind, cornering force while taking a turn, which result in lateral bending of side members.

- Load due to wheel impact with road obstacles may cause that particular wheel to remain obstructed while the other wheel tends to move forward, distorting the frame to parallelogram shape.
- Engine torque and braking torque tending to bend the side members in the vertical plane.
- Sudden impact loads during a collision, which may result in a general collapse.

SUB FRAMES:

Normally, the various components are bolted directly to the main frame. But many a time, these components are mounted on a separate frame called sub-frame. This sub-frame is further divided by the main frame at three points. In this way the components are isolated from the effects of the overhang and flexing of the main frame. The advantage of sub-frames is:

- The mass of the sub-frame alone helps to damp vibrations.
- The provisions of sub-frame simplify production on the assembly line and facilities subsequent overhaul or repair.

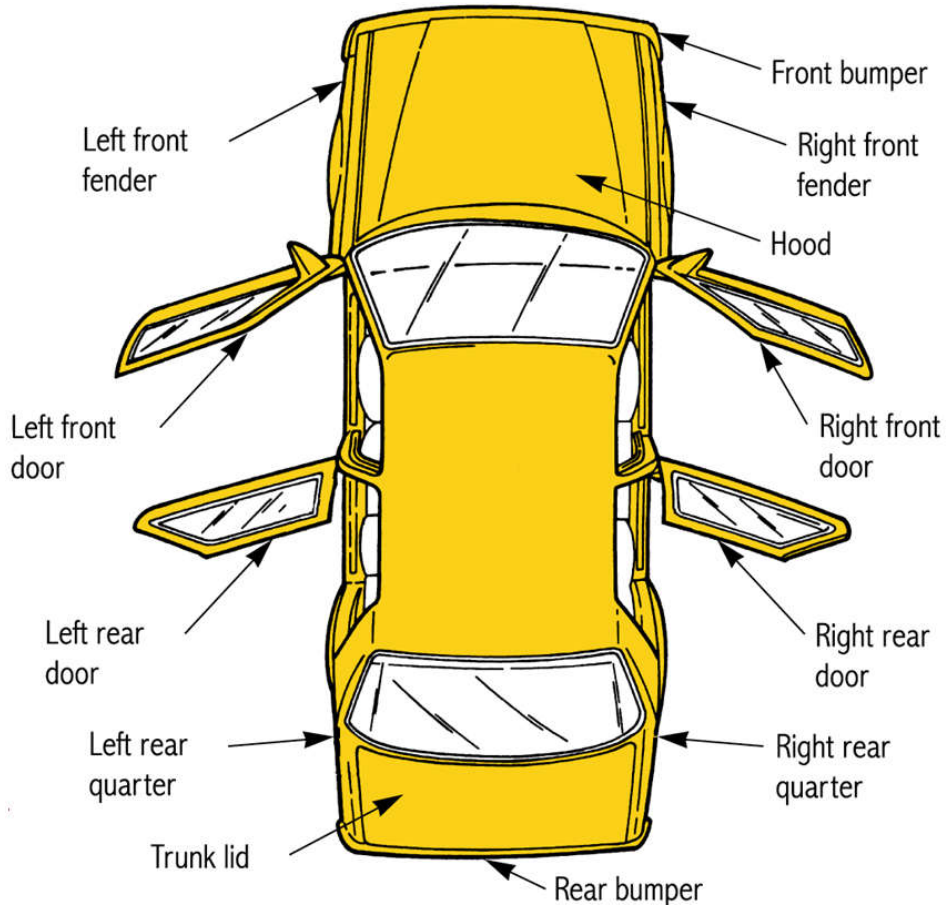
DEFECTS IN FRAMES:

The only prominent defect that usually occurs in the frames due to accidents is the alignment fault. This may be checked by means of a plumb line. The vehicle is placed on a level surface and by suspending plumb line from four different points on each side of the frame; their position on the ground is marked. The vehicle is then taken away and the diagonals are measured between corresponding points. These should not differ by more than 7 or 8 mm. If any of the corresponding diagonals do differ by more than this amount the frame is out of alignment. The possible cause, then, may be any one of the following:

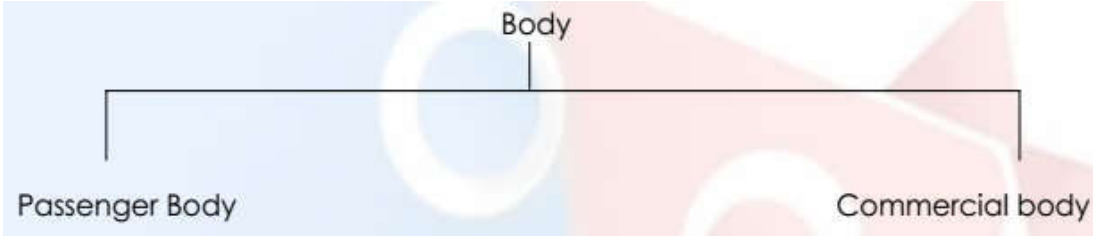
- The dumb irons or side members may be bent.
- Cross members may be buckled.
- Some rivets may be loose or broken.

If the damage to the frame members is small, they can be repaired by means of hydraulic wringing irons. If the damage is more, the bent frame member may be heated to straighten it. Another alternative may be to cut the damaged part and weld a new one instead.

6.3 DIFFERENT BODIES USED IN AUTOMOBILES:



The Automobile bodies are divided in two groups

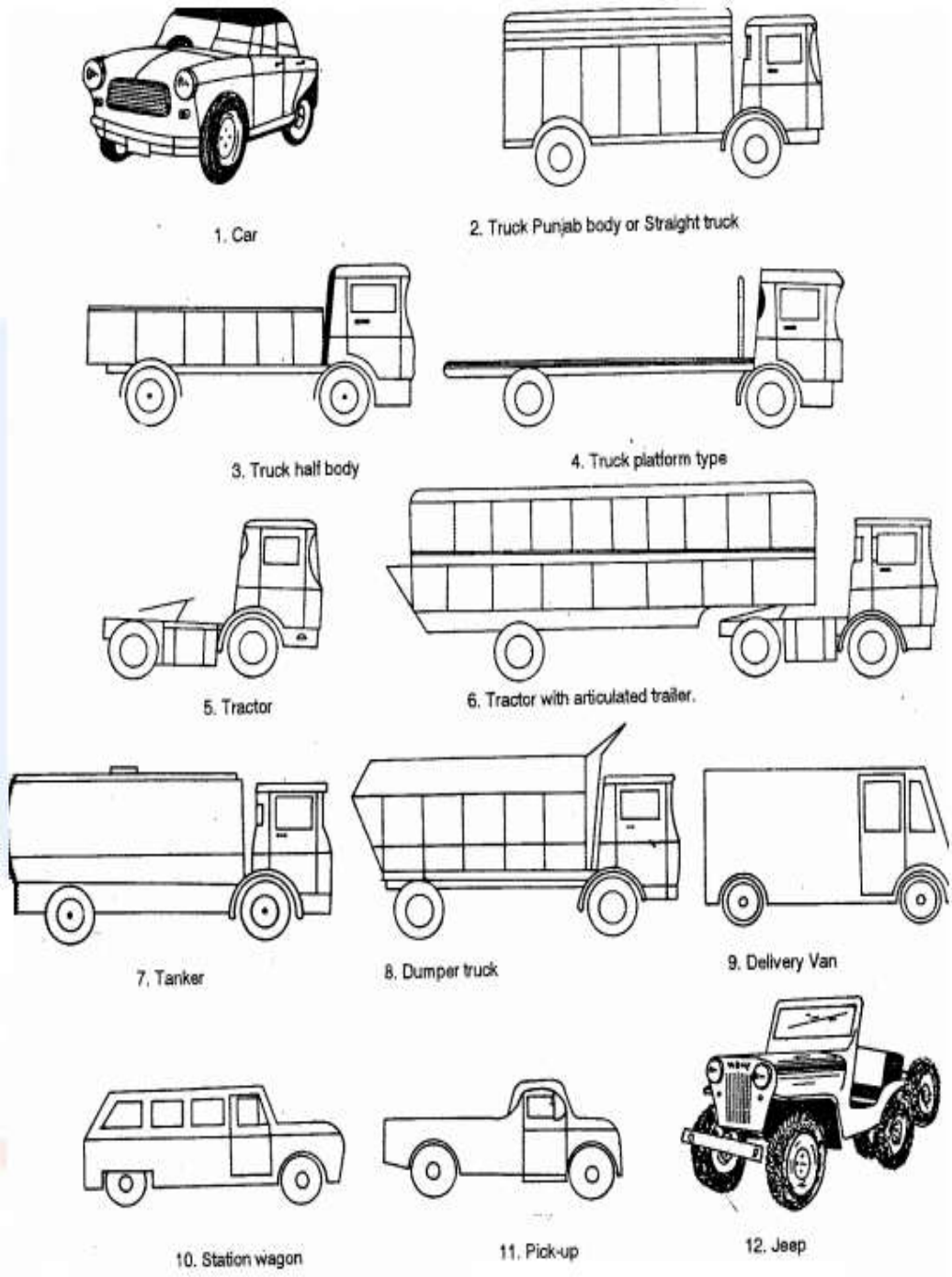


According to Chassis design the body can divided into three types.

- Conventional Type
- Integral type
- Semi- Integral

Type According to other usage:

- Light vehicle Bodies - cars, jeeps
- Heavy vehicle Bodies – Busses, Lorries
- Medium vehicle Bodies - Vans, Metadoors



REQUIREMENTS OF BODIES FOR VARIOUS TYPES OF VECHILE:

The body of the most vehicles should fulfill the following requirements:

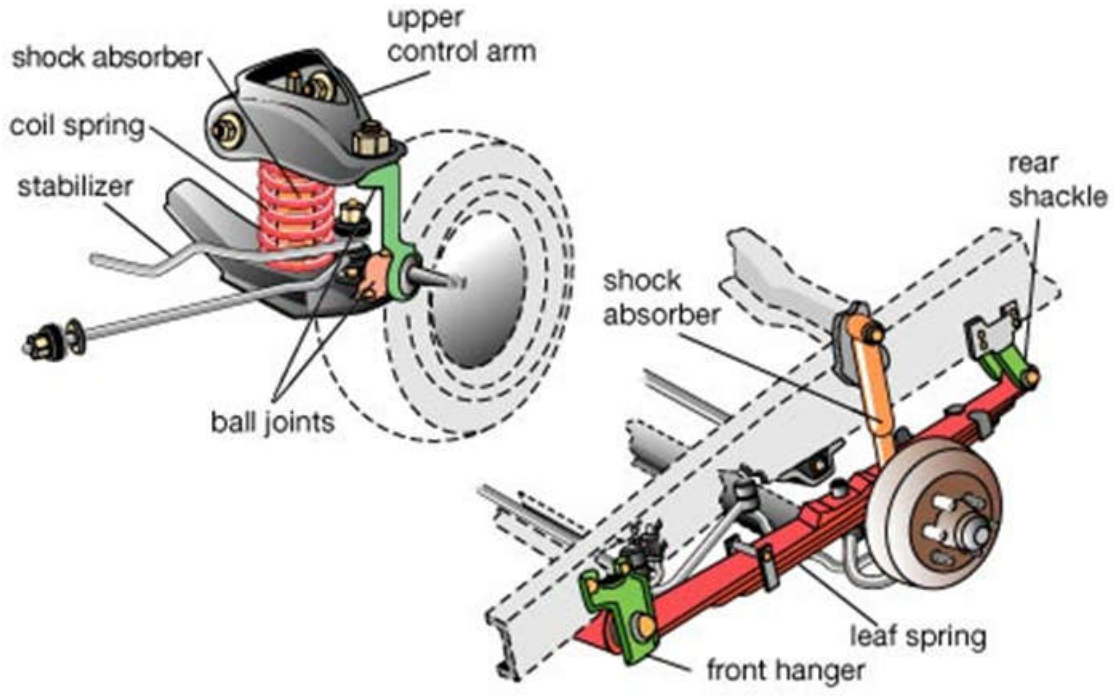
- The body should be light.
- It should have minimum number of components.
- It should provide sufficient space for passengers and luggage.
- It should withstand vibrations while in motion.
- It should offer minimum resistance to air.
- It should be cheap and easy in manufacturing.
- It should be attractive in shape and colour.
- It should have uniformly distributed load.
- It should have long fatigue life
- It should provide good vision and ventilation.

CHAPTER 7

SUSPENSION SYSTEM

7.1 INTRODUCTION:

The automobile chassis is mounted on the axles, not direct but through some form of springs. This is done to isolate the vehicle body from the road shocks which may be in the form of bounce, pitch, roll or sway. These tendencies give to an uncomfortable ride and also cause additional stress in the automobile from the road shocks are collectively called a suspension system. It includes the springing device used and various mountings for the same.



Broadly speaking, suspension system consists of a spring and a damper. The energy of road shock causes the spring to oscillate. These oscillations are restricted to a reasonable level by the damper, which is more commonly a shock absorber.

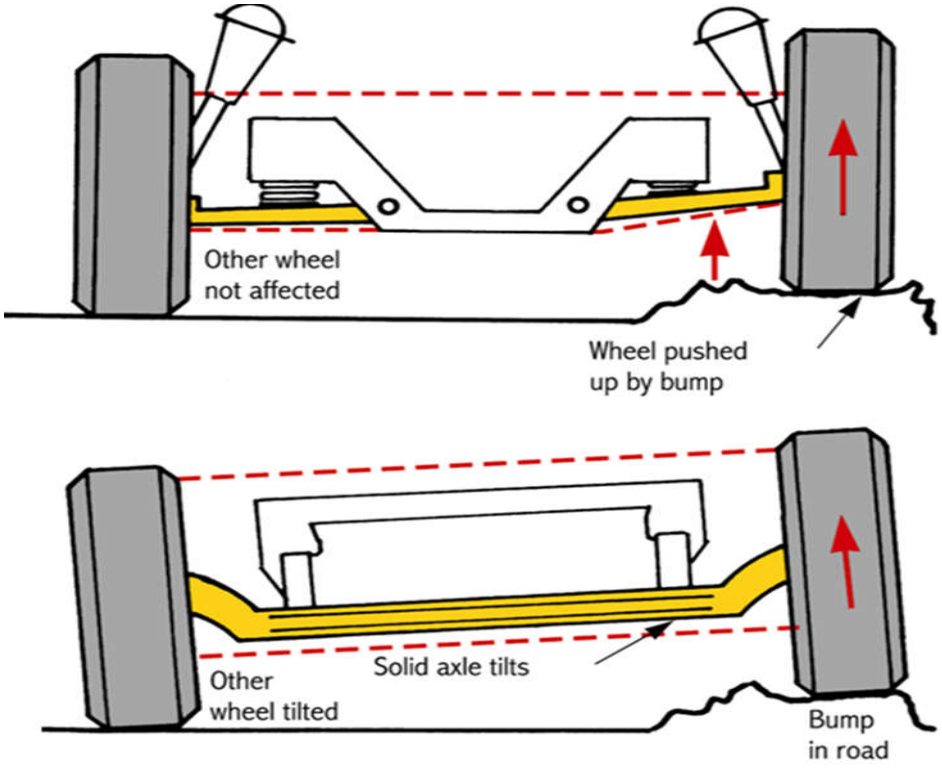
OBJECTS OF SUSPENSION SYSTEM:

- To prevent the road shocks from being transmitted to the vehicle components.
- To safeguard the occupants from road shocks.
- To preserve the stability of the vehicle in pitching or rolling, while in motion.

Types of suspension system:

1.Non-independent/Rigid suspension has both right and left wheel attached to the same solid axle. When one wheel hits a bump in the road, its upward movement causes a slight tilt of the other wheel

2.Independent suspension allows one wheel to move up and down with minimal effect to the other.



FUNCTION OF SUSPENSION SPRINGS:

Springs are placed between the road wheels and the body. When the wheel comes across a bump on the road, it rises and deflects the spring, thereby storing energy therein. On releasing, due to the elasticity of the spring material, it rebounds thereby expending the stored energy. In this way the spring starts vibration, of course, with amplitude decreasing gradually on account of internal friction of the spring material and friction of the suspension joints, till vibrations die down.

7.2 Types of Suspension:

The various suspension may be classified as follows:

1. Steel Springs

    (a) Leaf spring (b) Tapered leaf spring (c) Coil spring (d) Torsion bar

2. Rubber springs

    (a) Compression spring (b) Compression-shear spring

    (c) Face-shear spring (d) Progressive spring

    (e) Face-shear spring (f) Torsional shear spring

3. Air suspension

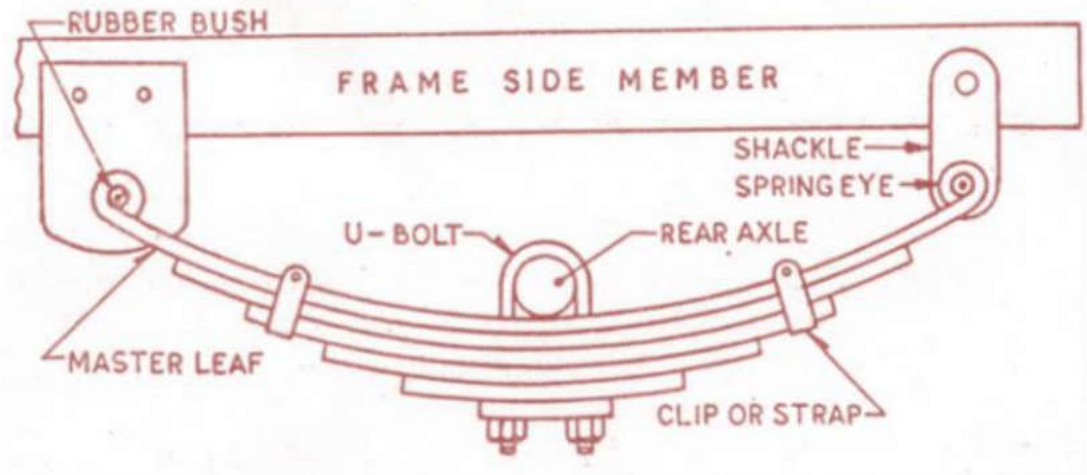
4. Hydraulic Suspension

7.2.1 LEAF SPRINGS:

Semi-elliptic leaf springs are almost universally used for suspension in light and heavy commercial vehicles. For cars also, these are widely used for rear suspension.

Construction:

The spring consists of a number of leaves called blades. The blades vary in length as shown. The composite spring is based upon the theory of a beam of uniform strength. The lengthiest blade has eyes on its ends. This blade is called master leaf. All the blades are bound together by means of steel straps as shown.



The spring is supported on the axle, front or rear by means of a U-bolt. One end of the spring is mounted on the frame with a simple pin, while on the other end; connection is made with a shackle. When the vehicle comes across a projection on the road surface, the wheel moves up, deflecting the spring. This changes the length between the spring eyes. If both the ends are fixed, the spring will not be able to accommodate this change of length. This is provided for by means of a shackle at one end which gives a flexible connection.

Material:

The suitable steels that have been used for the leaf springs are given below:

1. Chrome-Vanadium Steel

Constituents & Percentage C 0.46 Mn 0.57 Si 0.17 Ni 0.15 Cr 1.40 Va 0.18

2. Silico-Manganese Steel

Constituents & Percentage C 0.52 Mn 1.05 Si 1.95 Cr 0.05

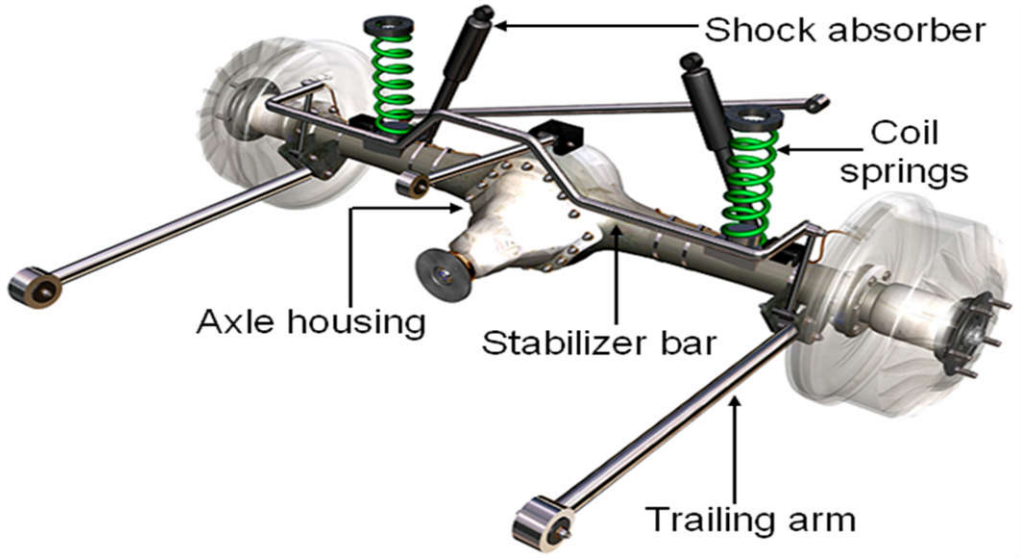
3. Carbon Steel

Constituents & Percentage C 0.55 Mn 0.60 Si 0.20

7.2.2 COIL SPRINGS:

The coil springs are used mainly with independent suspension, through they have also been used in the conventional rigid axle suspension as they can be well accommodated in restricted spaces. The energy stored per unit volume is almost double in the case of coil springs than the leaf springs.

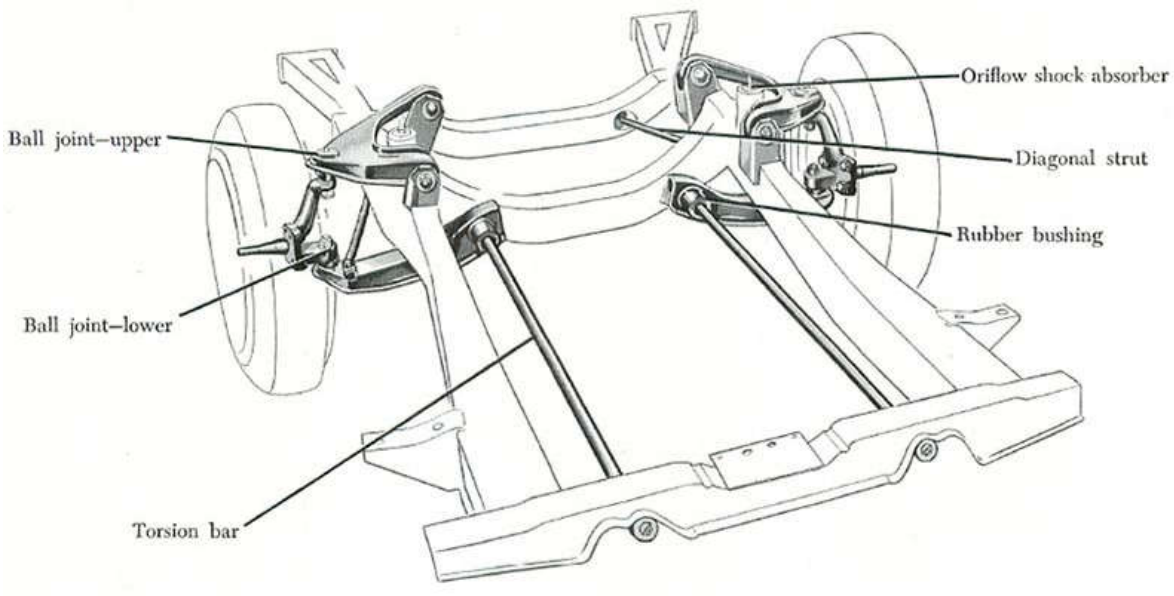
Coil spring does not have noise problems, nor do they have static friction causing harshness of ride as in case of leaf springs.



The spring takes the shear as well as bending stresses. The coil springs, however, cannot take torque reaction and side thrust, for which alternative arrangements have to be provided. A helper coil spring is also sometimes used to provide progressive stiffness against increasing load.

7.2.3 Torsion bar:

Torsion bar is simply a rod acting in torsion and taking shear stresses only. These are made of heat-treated alloy spring steel



The amount of energy stored per unit weight of material is nearly the same as for coil springs. Torsion bar is often used with the independent suspension. A diagrammatic sketch of torsion bar suspension is given in Fig.

The bar is fixed at one end to the frame, while the other end is fixed to the end of the wheel arm and supported in the bearing. The other end of the wheel arm is connected to the wheel hub. When the wheel strikes a bump, it starts vibrating up and down, thus exerting torque on the torsion bar, which acts as a spring.

Torsion bar spring is lighter as compared to leaf springs and also it occupies less space.

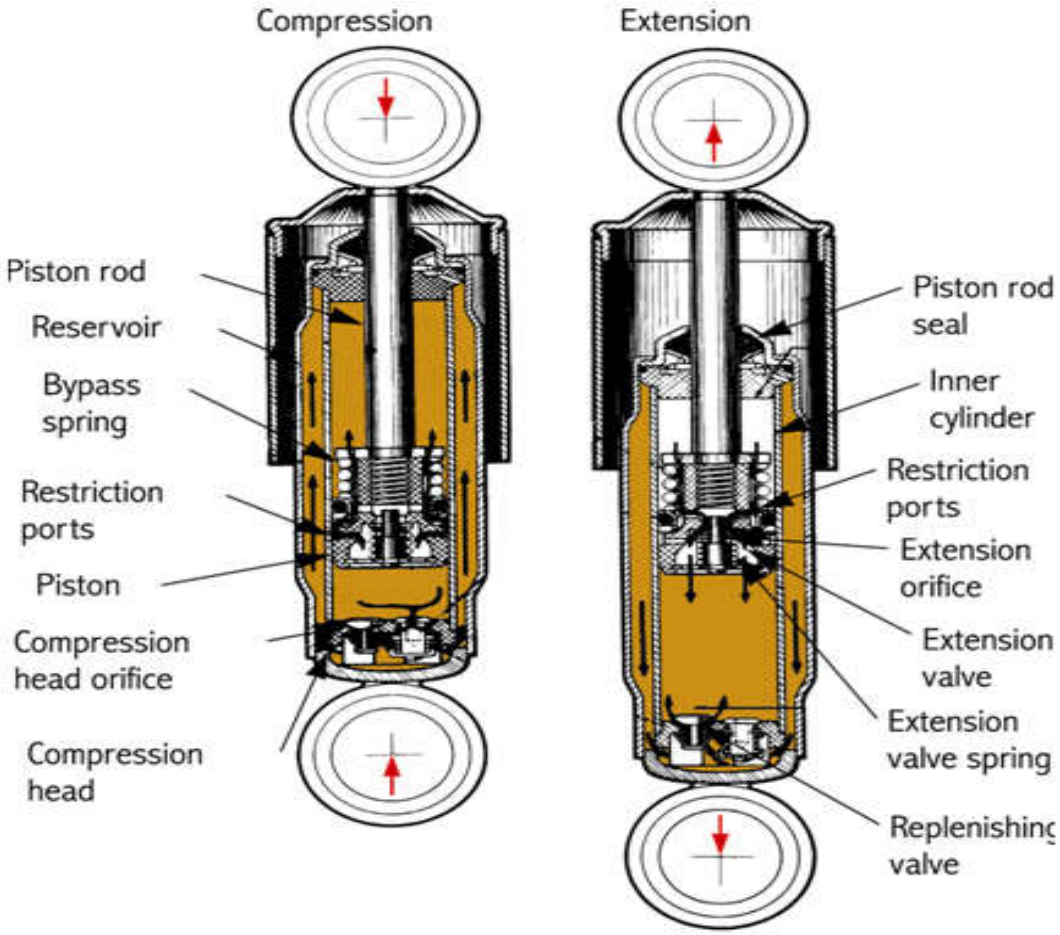
Rubber Springs:

The advantages of using rubber as a means of suspension are:

- It can store greater energy per unit weight than the steel. For this reason rubber springing system can be made more compact.
- The rubber has excellent vibration damping properties.
- The absence of squeaking which is always present in steel springs.
- The number of bearings is reduced considerably for the rubber suspension system. This means longer life.
- Rubber is more reliable. A rubber suspension cannot suddenly fail like the metal springs.

7.2.4 SHOCK ABSORBERS:

A springing device must be a compromise between flexibility and stiffness. If it is more rigid, it will not absorb road shocks efficiently and if it is more flexible it will continue to vibrate even after the bump has passed. So we must have sufficient damping of the spring to prevent excessive flexing. The friction between the leaves of a leaf-spring provides this damping, but because of the uncertainly of the lubrication conditions, the amount of friction also varies and hence the damping characteristics do not remain constant. For this reason, the friction between the springs is reduced to minimum and additional damping is provided by means of devices called dampers or shock-absorbers. In the case of coil springs, the whole of damping is provided by the shock absorbers. The shock absorbers thus control the excessive spring vibrations.



The 'shock absorber' absorbs the energy of shock converted into vertical movement of the axle by providing damping and dissipating the same into heat. Thus, it merely serves to control the amplitude and frequency of spring vibration. It cannot support weight and has zero resilience. The shock absorbers are basically of two types: the friction type and the hydraulic type.

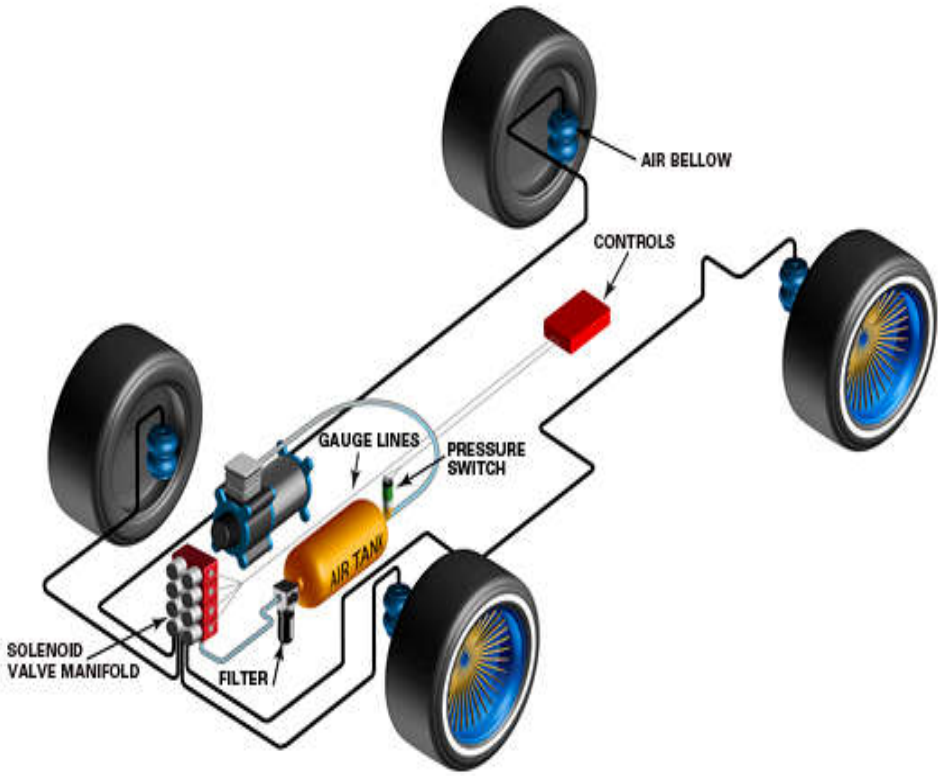
The friction type has almost become obsolete due to its non-predictable damping characteristics. The principle of operation of a hydraulic shock absorber is that when a piston forces the fluid in a cylinder to pass through some hole, a high resistance to the movement of piston is developed, which provides the damping effect.

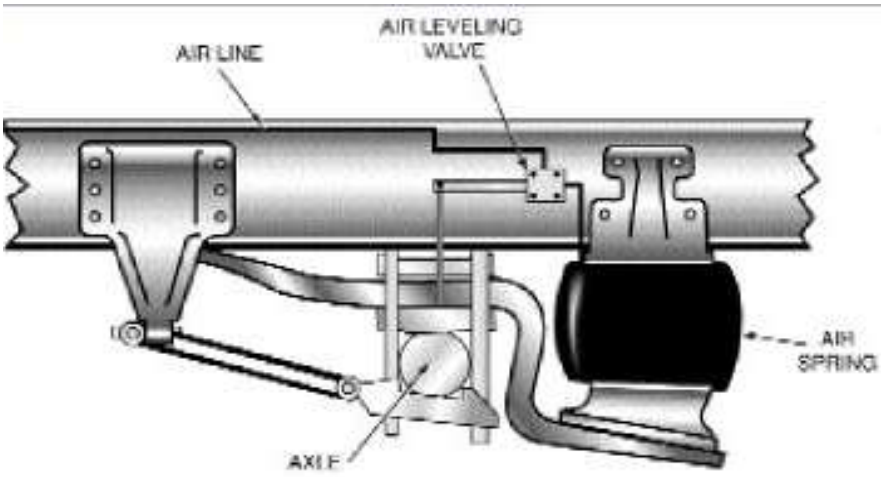
The hydraulic type has the additional advantage that the damping is proportional to the square of the speed. So for small vibrations the damping is also small, while for larger ones the damping becomes automatically more.

7.2.5 AIR SUSPENSION:

Air suspension systems are coming into prominence because of certain advantages they possess over the conventional metal springs. These advantages are:

- A variable space for wheel deflection is put to optimum use by virtue of the automatic control devices.
- Because the vehicle attitude is also constant, changes in head lamp alignment due to varying loads are avoided.
- The spring rate varies much less between the laden and unladen conditions, as compared with that of conventional steel springs. This reduces the dynamic loading.
- The improved standard of ride comfort and noise reduction attained with air springs reduces both driver and passenger fatigue.



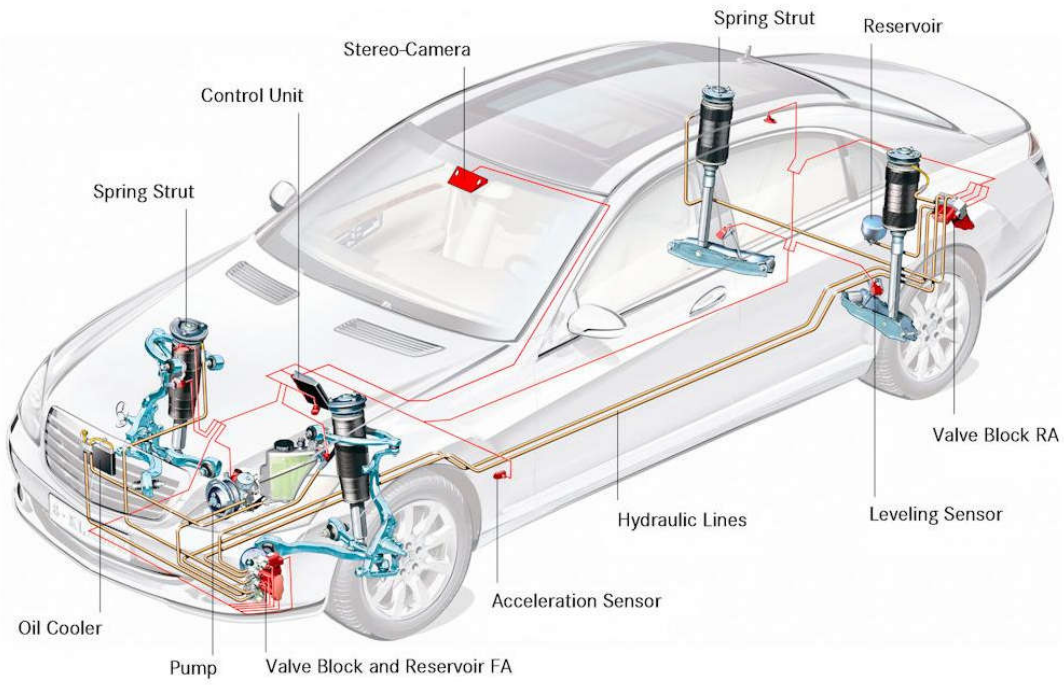


A vehicle with electronic air suspension can provide about three times softer ride as provided by conventional coil springs, simultaneously absorbing bumps and protecting against bottoming, due to variable spring rate.

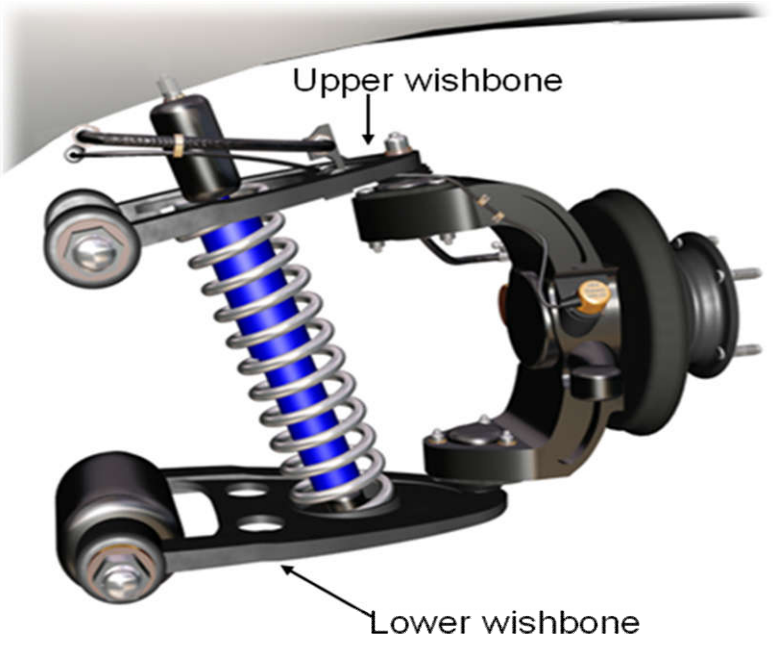
An air compressor takes the atmospheric air through a filter and compresses it to a pressure of about 240 Mpa, at which pressure the air in the accumulator tank is maintained, which is also provided with a safety relief valve. This high pressure air goes through the lift control valve and the leveling valve, to the air springs as shown. The lift control valve is operated manually by means of a handle on the control panel, through a cable running from the valve to the handle.

7.2.6 Hydrolastic Suspension:

In this system a displacer unit is fitted at each of the four wheels. The displacer units are all interconnected by means of fluid. In the displacer unit, rubber (under compression and shear) is used as a spring whereas fluid under pressure acts as damping medium. The stem is connected to the wheel through suitable linkage so that its movement is proportional to the up and down movement of the wheel. A two-way valve assembly controls the up and down flow of the fluid. The upper valve opens up when the fluid pressure below rises sufficiently. Similarly the lower valve allows the fluid to pass in the downward direction under pressure. The two valves are assembled at right angles to each other. When the piston moves up due to the movement of the wheel, the diaphragm pushes the fluid up through the opening, by pushing the damper valve. The fluid under pressure above the valve, then compresses the rubber which acts as a spring.



Wishbone Suspension

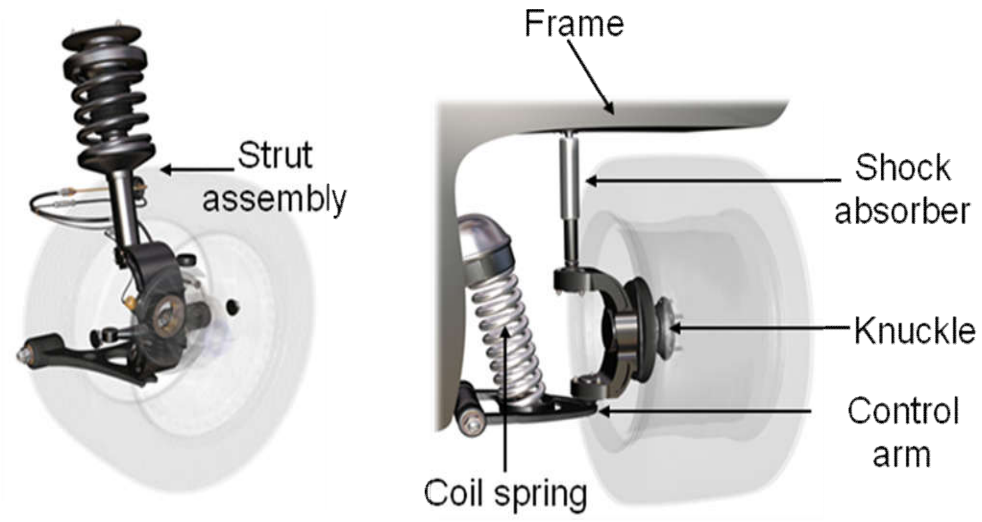


The suspension must be designed in such a way as to keep the wheel upright for maximum tyre contact (vehicle control) and to minimize tyre wear.

The upper wishbone is short and the lower wishbone is longer.

Both wishbones pivot points and lengths are calculated to provide the best operating angle for a given suspension movement.

MacPherson Strut



This is a very popular and efficient form of suspension. It has one control arm and a strut assembly. A coil spring and shock absorber will normally form parts of the strut assembly.

Coil springs may be mounted on the control arm instead of being around the strut. On this type, the shock absorber connects the knuckle to the frame.

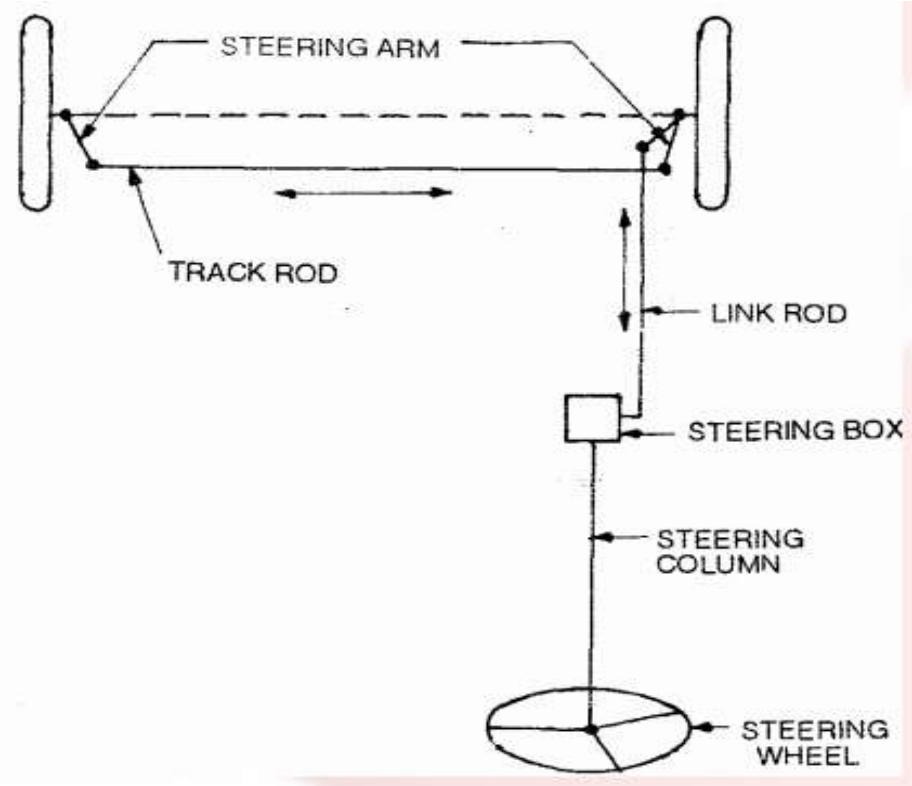
This type of suspension strut is often also used on rear suspension systems.

CHAPTER 8

STEERING SYSTEM

8.1 Introduction:

This system provides the directional change in the movement of an Automobile and maintain in a position as per the driver's decision without much strain on him.



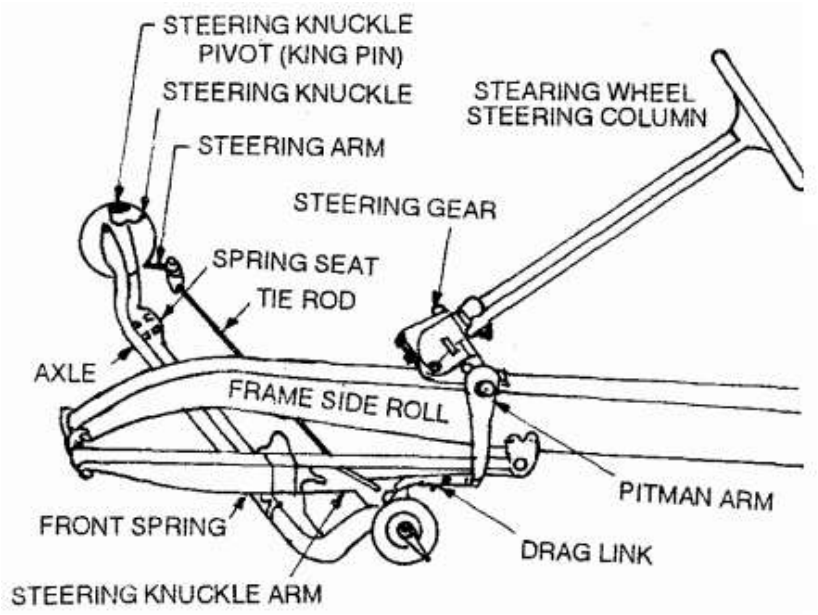
REQUIREMENTS OF STEERING SYSTEM:

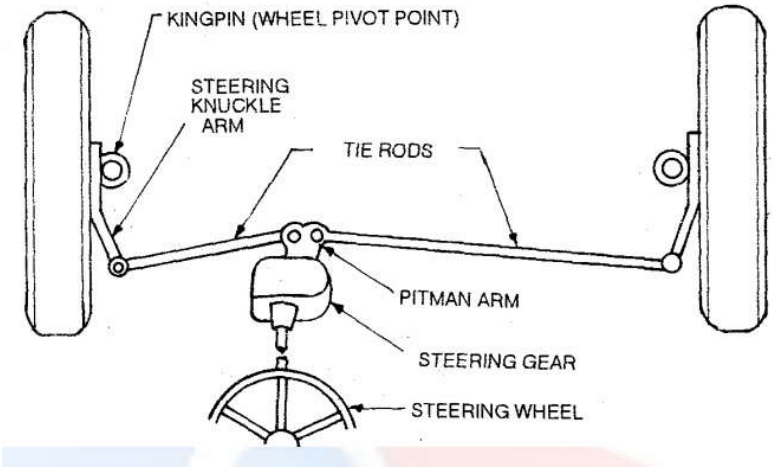
- It must keep the wheel at all times in to rolling motion without rubbing on the road.
- This system should associate to control the speed.
- It must light and stable.
- It should also absorb the road shocks.
- It must easily be operated with less maintenance.
- It should have self-centering action to some extent.

Functions of Steering System:

- It helps in swinging the wheels to the left or right.
- It helps in turning the vehicle at the will of the driver.
- It provides directional stability.
- It is used to minimize the tyre wear and tear.
- It helps in achieving self-centering efforts.
- It absorbs major part of the road shocks.

8.2 Main Components of Steering System:





Functions of Steering Gear Box:

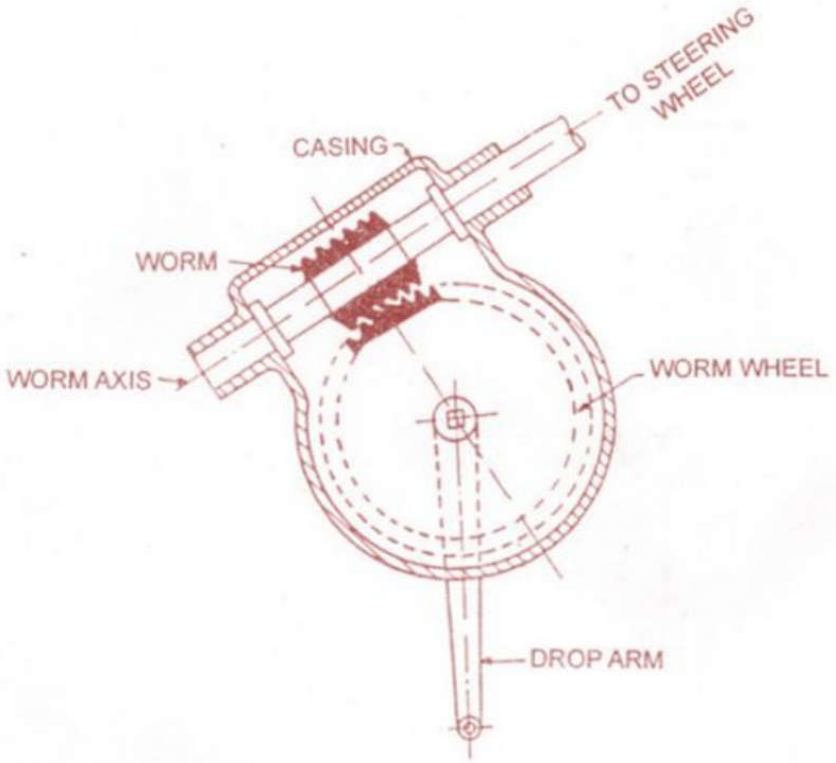
1. It converts the Rotary movement of the steering wheel in to the angular turning of the front wheels.

2. It also multiplies drivers efforts and give mechanical advantage.

Types of Steering Gear Box:

1. Worm and Wheel Type:

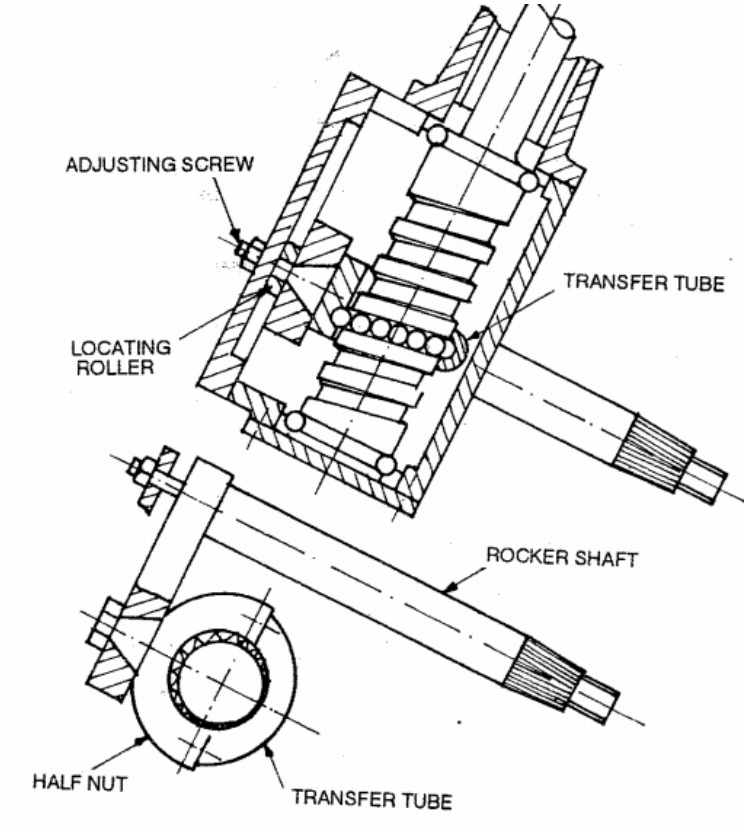
This type of steering gear has a square cut screw threads at the end of the steering column; which forms a worm, at the end of it a worm wheel is fitted and works rigidly with it. Generally covered shaft is used for the worm wheel. The worm wheel can be turned to a new position the drop arm can be readjusted to the correct working position.



2. Re-circulating Ball Type:

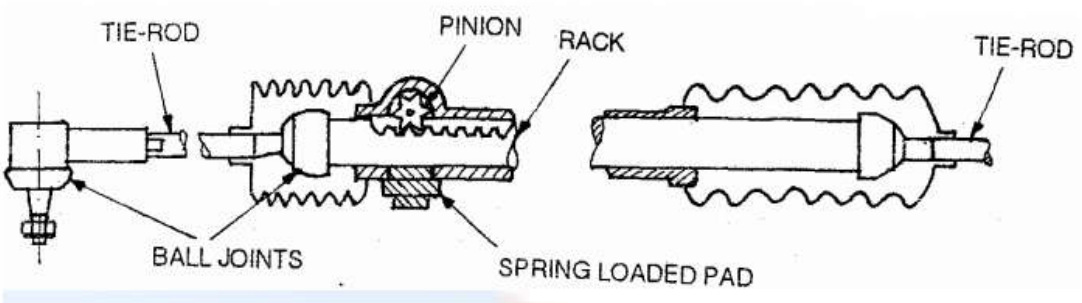
In this type of gear box the endless chain of balls are provided between the worm and nut members. The nut forms a ring of rack having an axial movement. So that the sector on the rocker shaft racks, the balls roll continuously between the worm and nut. This method reduces friction

between worm and nut members. This type of steering gear is used for heavy vehicles.



3. Rack and Pinion Type:

This is common manual type of steering gear box is used in most of the vehicles. In this type of steering a pinion is provided the bottom end of the steering column. The teeth of the pinion wheel in mesh with corresponding teeth provided on the rack, the end of which is connected to the stub axle through the rod. The rotating motion of the pinion operates the rack in FORE and AFT direction which in turn operates the stub axle.

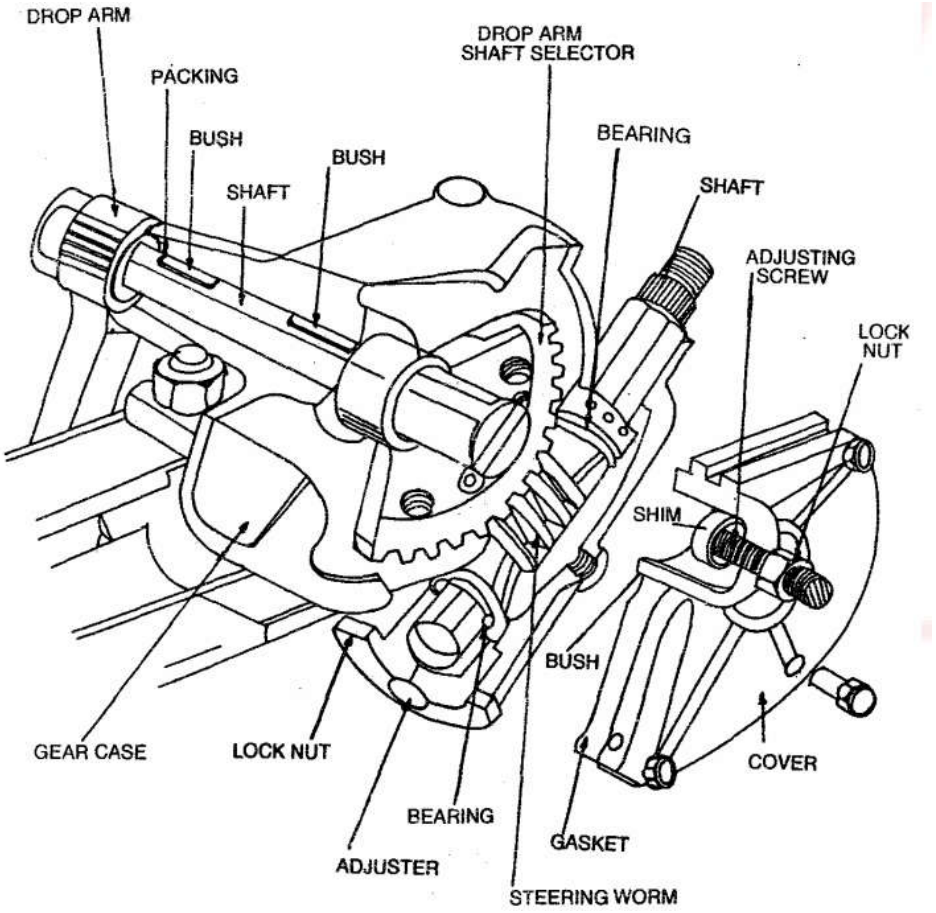


4. Cam and Lever Type:

The cam and lever steering uses one or two lever studs fitted in taper roller bearing. When the worm in the form of helical groove rotates the stub axle and it also rotates along with it. This imports a turning motion to the drop arm shaft.

5. Worm and Sector Type:

In this type the worm on the end of the steering shaft meshes with a sector mounted on a sector shaft. When the worm is rotated by rotation of the steering wheel, the sector also turns rotating the sector shaft. Its motion is transmitted to the wheel through the linkage. The sector shaft is attached to the drop arm or pitmen arm.



Steering Linkages:

Steering Linkage is a connection of various links between the steering gear box and the front wheels. The motion of the pitman arm and steering gear box is transferred so the steering knuckles of the front wheels through the

steering linkages. The swinging movement of the pitman arm from one side to the other side gives angular movement to the front wheel through the steering linkages.

Types of steering Linkages:

1. Conventional steering Linkage.

2. Direct cross type steering linkage

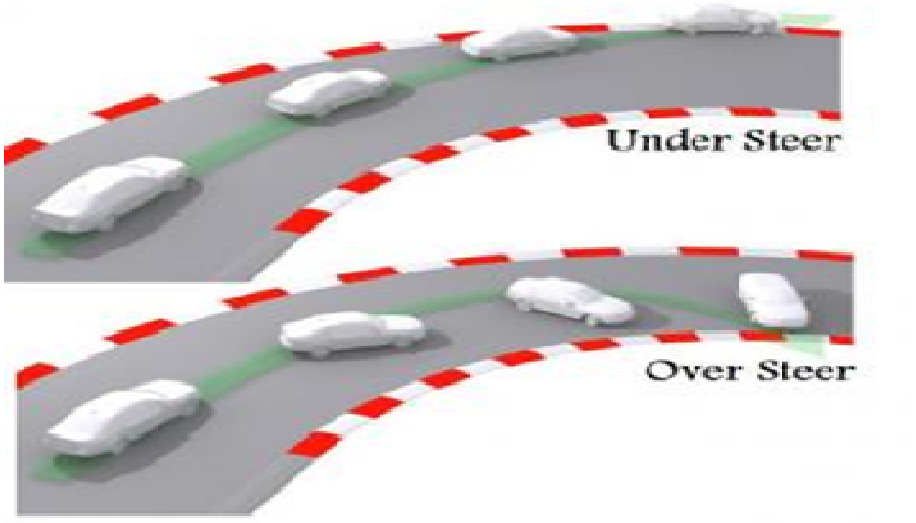
3. Three piece steering linkage

4. center arm steering linkage

5. Relay type steering linkage.

Slip Angle: The angle between direction of the motion of the vehicle and the center plane of the tyre is known as Slip Angle. It ranges from 8° to 10°.

Under steer: When the front slip angle is greater than that of rear, the vehicle tends to steer in the direction of side force. Then it is known as under steer. This provides greater driving stability, especially when there is a side wind.



Over Steer: When the rear slip angle is greater than that of front slip angle, the vehicle tends to move away from the direction of center path. This is known as over steer. This is advantageous when the vehicle moving on the road having many bends curves.

Steering Gear Ratio or Reduction Ratio: It has been defined as the " number of turns on the steering wheel required to produce on turn of steering gear

cross shaft to which the pitman arm is attached. Generally it varies between 14'.1 and 24'.1.

Turning Radius: It is the radius of the circle on which the outside front wheels moves when the front wheels are turned to their extreme outer position. This radius is 5 to 7.5 m for buses and trucks.

Wheel Alignment: It returns to the positioning of the front wheels and steering mechanism that gives the vehicle directional stability; reduce the tyre wear to a minimum.

Factors affect the wheel alignment:

1. Factors pertaining to wheel:-

a. Balance of wheels (Static and Dynamic) b. Inflation of tyre. c. Brake adjustments.

2. Steering Linkages.

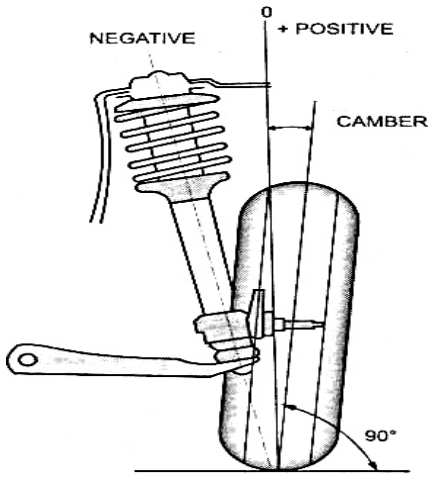
3. Suspension System

4. Steering Geometry –a. caster b. camber c. king pin inclination d. toe-in and toe-out etc.,

Steering Geometry: It refers to the angular relationship between the front wheels and parts attached to it and car frame.

CAMBER

The angle between the centre line of the tyre and the vertical line when viewed from the front of the vehicle is known as camber.



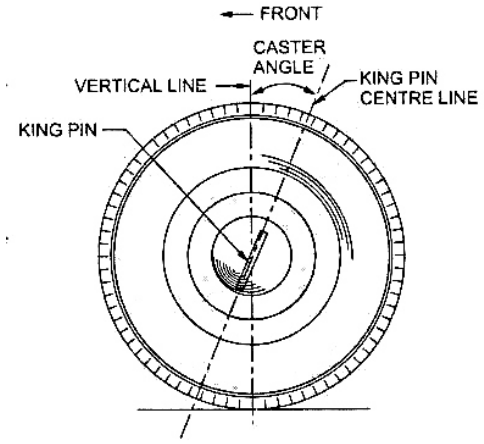
When the angle is outward, so that the wheels are further apart at the top than at the bottom, the camber is positive. When the angle is inward, so that the wheels are closer together at the top than at the bottom, the camber is negative. Any amount of camber, positive or negative, tends to cause uneven or more tyre wear on one side than on the other side. Camber should not exceed 2°.

The front wheels are not usually mounted parallel to each other, but are fitted outward slightly at the top and inward at the bottom to have positive camber. The purpose of the camber is to prevent the top of the wheels from tilting inward too much because of excessive loads or play in the king pins and wheel bearing. When the vehicle is loaded and rolling along on the road, the load will just about bring the wheels to a vertical position. On vehicles having negative chamber the opposite is true.

The chamber on modem vehicles is adjusted by means of shims or an eccentric cam in the control arm shaft. Excessive chamber prevents the tyre from having correct contact with the road which causes it to wear only on the side directly beneath the load. Unequal camber causes vehicle to roll in the direction of the wheel having greater camber which upsets directional stability and tends to scuff the tread on the opposite tyre.

CASTER

In addition to being tilted inward toward the centre of the vehicle, the king pin axis may also be tilted forward or backward from the vertical line. This tilt is known as caster.

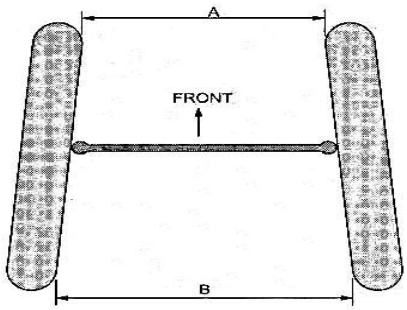


Thus, the angle between the vertical line and the king pin centre line in the plane of the wheel (when viewed from the side) is called the caster angle. When the top of the king pin is backward, the caster angle is positive, and when it is forward, the caster angle is negative. The caster angle in modern vehicles ranges from 2 to 8 degrees.

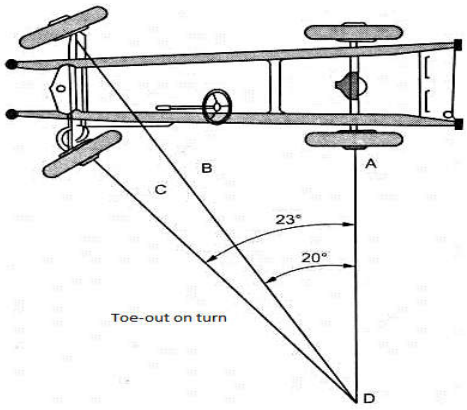
The caster produces directional stability by causing the wheels to lead or follow in the same direction as the vehicle travels. When both the front wheels have positive caster, the vehicle tends to roll out or lean out on turns. But if the front wheels have negative caster, then the vehicle tends to back or lean in on turns. There is another important effect of the caster angle. Positive caster tries to make the front wheels toe-in. With positive caster, the vehicle is lowered as the wheel pivots inward. Thus, the weight of the vehicle is always trying to make the wheel toe-in with negative caster; the wheels would try to toe-out. The positive caster increases the effort required to steer and tries to keep the wheels straight ahead. In the heavy duty trucks negative caster is provided. This makes steering easier.

TOE-IN AND TOE-OUT

The front wheels usually turn in slightly in front so that the distance between the front ends A is slightly less than the distance between the back ends B, when viewed from the top. The difference between these distances is called toe-in/On a car with toe-in, the distance between the front wheels is less at the front (A) than at the rear (B), when viewed from the top. The amount of toe-in is usually 3 to 5 mm.



Toe-in
Distance A is 3 to 5mm less than distance B



Toe-out on turn

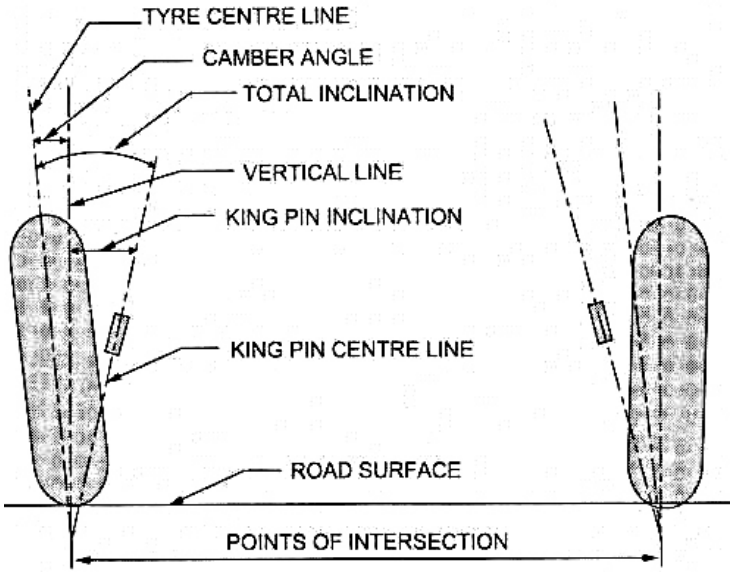
The toe-in is provided to ensure parallel rolling of the front wheels, to stabilize steering and prevent side slipping and excessive tyre wear. It also serves to

offset the small deflections in the wheel-support system which comes out when the car is moving forward. Although the wheels are set to toe-in slightly when the car is standing still, they tend to roll parallel on the road when the car is moving forward. Some alignment specialists set the front wheels in "straightaway alignment" in preference to "toe-in adjustment".

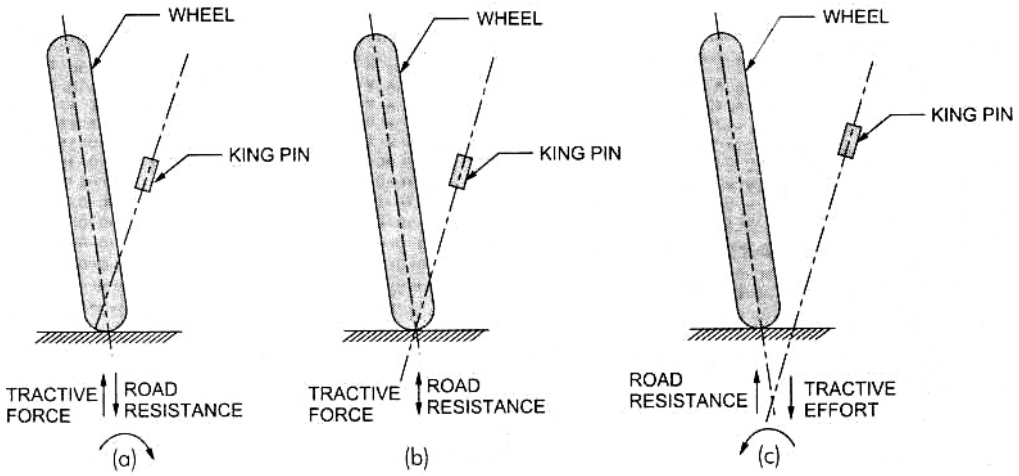
Toe-out is the difference in angles between the two front wheels and the car frame during turns. The steering system is designed to turn the inside wheel through a larger angle than the outside wheel when making a turn. This condition causes the wheels to toe-out on turns, due to the difference in their turning angles. When the car is taking a turn, the outer wheels rolls on a larger radius than the inner wheel,; and the circles on which the two front wheels must roll are concentric. Therefore, the inner wheel must make a larger angle with the car frame than that the outer wheel makes. As shown in Figure above, when the front wheels are steered to make a turn, the inner wheel turns to an angle of 23° with the car frame, while the outer wheel turns only 20° with the car frame. The toe-out is secured by providing the proper relationship between the steering knuckle arms, tie rods and pitman arm.

KING PIN INCLINATION OR STEERING AXLE INCLINATION

The angle between the vertical line and centre of the king pin or steering axle, when viewed from the front of the vehicle is known as king pin inclination or steering axle inclination. The king pin inclination, in combination with caster, is used to provide directional stability in modem cars, by tending to return the wheels to the straight-ahead position after any turn. It also reduces steering effort particularly when the vehicle is stationary. It reduces tyre wear also. The king pin inclination in modem vehicles ranges from 4 to 8 degrees. It must be equal on both the sides. If it is greater on one side than the other, the vehicle will tend to pull to the side having the greater angle. Also, if the angle is too large, the steering will become exceedingly difficult. The kingpin inclination is made adjustable only by bending.



Included angle.



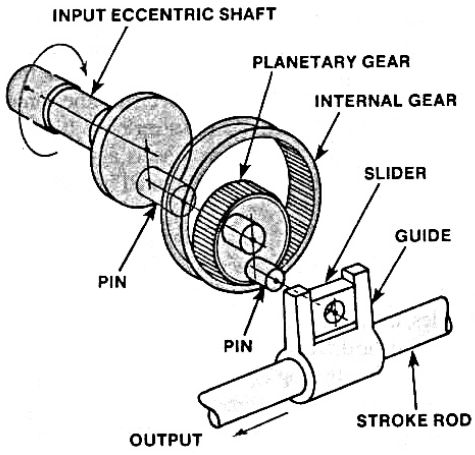
The combined chamber and kingpin inclination is called the included angle. This angle is important because it determines the point of intersection of the wheel and the king pin centre lines. This in turn determines whether the wheel will tend to toe-out or toe-in. If the point of intersection is above the ground, the wheel tends to toe-in. If it is below the ground, the wheel tends to toe-out. If it is at the ground, the wheel keeps its straight position without any tendency to toe-in or toe-out. In this position, the steering is called centre point steering.

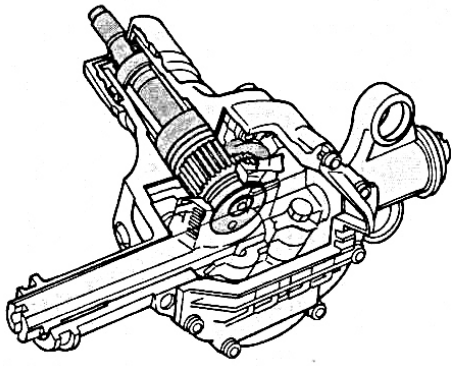
Four-wheel Steering systems

There are three types of production of four-wheel- steering systems: mechanical, hydraulic, and electro/ hydraulic designs. Since each system is unique in its construction and repair needs, the vehicle's service manual must be followed for proper diagnosis, repair, and alignment of a four-wheel system.

Mechanical 4WS

In a straight-mechanical type of 4WS, two steering gears are used one for the front and the other for the rear wheels. A steel shaft connects the two steering gear boxes and terminates at an eccentric shaft that is fitted with an offset pin. This pin engages a second offset pin that fits into a planetary gear.





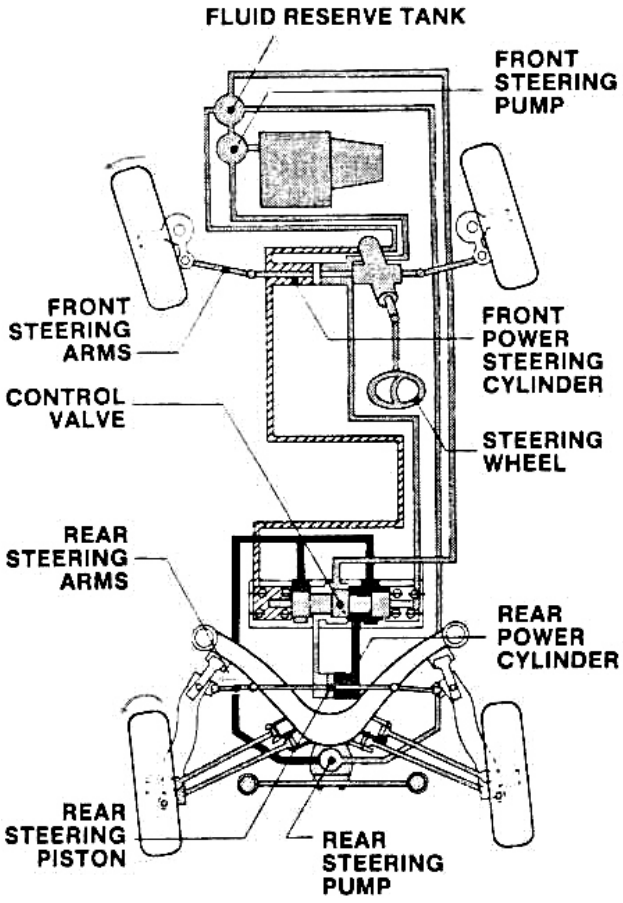
The planetary gear meshes with the matching teeth of an internal gear that is secured in a fixed position to the gearbox housing. This means that the planetary gear can rotate but the internal gear cannot. The eccentric pin of the planetary gear fits into a hole in a slider for the steering gear.

A 120-degree turn of the steering wheel rotates the planetary gear to move the slider in the same direction that the front wheels are headed. Proportionately, the rear wheels turn the steering wheel about 1.5 to 10 degrees. Further rotation of the steering wheel, past the 120- degree point, causes the rear wheels to start straightening out due to the double-crank action (two eccentric pins) and rotation of the planetary gear. Turning the steering wheel to a greater angle, about 230 degrees, finds the rear wheels in a neutral position regarding the front wheels. Further rotation of the steering

wheel results in the rear wheels going counter phase with regard to the front wheels. About 5.3 degrees maximum counter phase rear steering is possible.

Hydraulic 4WS

The hydraulically operated four-wheel-steering system shown in figure is a simple design, both in components and operation.



The rear wheels turn only in the same direction as the front wheels. They also turn no more than $1^{1/2}$ degrees. The system only activates at speed about 30 mph (50 km/h) and does not operate when the vehicle moves in reverse.

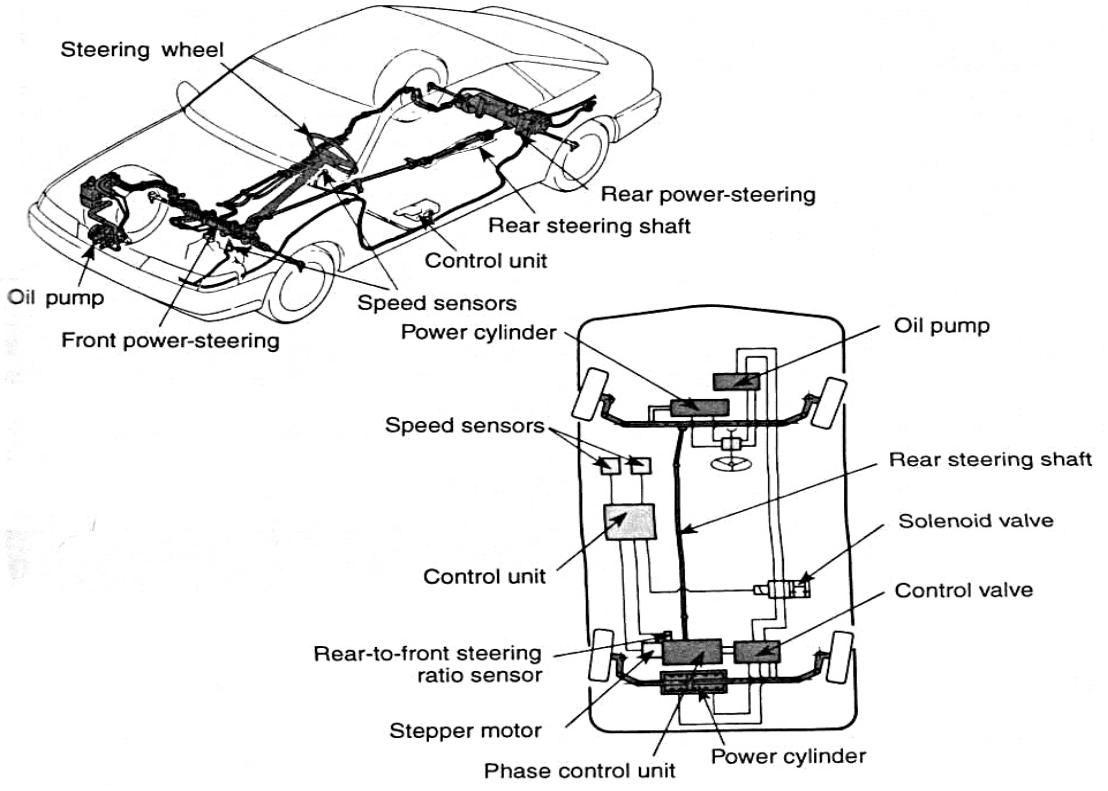
A two-way hydraulic cylinder mounted on the rear stub frame turns the wheels. Fluid for this cylinder is supplied by a rear steering pump that is driven by the differential. The pump only operates when the front wheels are turning. A tank in the engine compartment supplies the rear steering pump with fluid.

When the steering wheel is turned, the front steering pump sends fluid under pressure to the rotary valve in the front rack and pinion unit. This forces fluid into the front power cylinder, and the front wheels turn in the direction steered. The fluid pressure varies with the turning of the steering wheel. The faster and farther the steering wheel is turned, the greater the fluid pressure.

The fluid is also fed under the same pressure to the control valve where it opens a spool valve in the control valve housing. As the spool valve moves, it allows fluid from the rear steering pump to move through and operate the rear power cylinder. The higher the pressure on the spool, the farther it moves. The farther it moves, the more fluid it allows through to move the rear wheels. As mentioned earlier, this system limits rear wheel movement to $1^{1/2}$ degrees in either the left or right direction.

Electro/Hydraulic 4WS

Electro/hydraulic 4WS system is shown in Figure



The basic working elements of the design ire the control unit, a stepper motor, a swing arm, a set of bevelled gears, a control rod, and a control valve within output rod. Two electronic sensors tell the Electronically Controlled Unit (ECU)

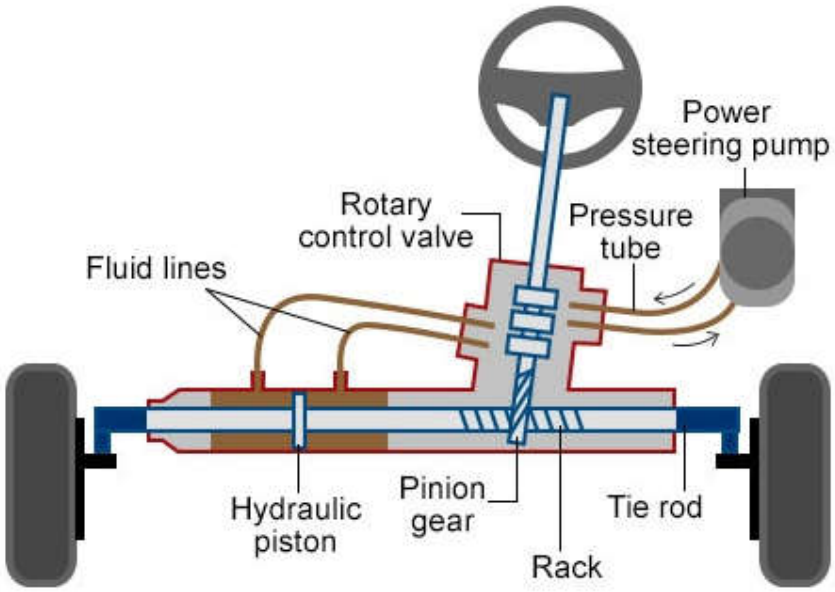
how fast the car is going. The yoke is a major mechanical component of this electro/hydraulic design. The position of the control yoke varies with vehicle road speed. For example, at speeds below 33 mph (53 km/h), the yoke is in its downward position, which results in the rear wheels steering in the counter phase (opposite front wheels) direction. As road speeds approach and exceed 22 mph (35 km/h), the control yoke swings up through a neutral (horizontal) position to an up position. In the neutral position, the rear wheels steer in phase with the front wheels.

The stepper motor moves the control yoke. A swing arm is attached to the control yoke. The position of the yoke determines the arc of the swing rod. The arc of the swing arm is transmitted through a control arm that passes through a large bevel gear. The stepper motor action eventually causes a push-or-pull movement of its output shaft to steer the rear wheels up to a maximum of 5 degrees in either direction.

The electronically controlled, 4WS system regulates the angle and direction of the rear wheels in response to speed and driver's steering. This speed –sensing system optimises the vehicle's dynamic characteristics at any speed, thereby producing enhanced stability and within certain parameters.

POWER-STEERING GEAR BOX

A power-steering gearbox is basically the same as a manual recirculating ball gearbox with the addition of a hydraulic assist. A power-steering gearbox is filled with hydraulic fluid and uses a control valve.



In a power rack and pinion gear, the movement of the rack is assisted by hydraulic pressure. When the wheel is turned, the rotary valve changes hydraulic flow to create a pressure difference on either side of the rack. The unequal pressure causes the rack to move toward the lower pressure, reducing the effort required to turn the wheels.

The integral power steering has the spool valve and a power piston integrated with the gearbox. The spool valve directs the oil pressure to the left or the right power chamber to steer the vehicle. The spool valve is actuated by a lever or a small torsion bar

In linkage systems, the control valve is connected directly to the steering centre link and the pitman arm on the steering gear. Any movement of the steering wheel and the pitman arm compresses the centring spring and moves the valve spool. This opens and closes a series of ports directing fluid under pressure from the pump to one side or the other, of the power cylinder piston.

The power cylinder in the linkage system is attached to the steering centre link and the piston shaft is attached to the frame. As fluid under pressure is directed to one side of the piston by the control valve, power assist is provided to aid the driver in moving the steering linkage and road wheels. Two lines connect the cylinder to control valve. Each one functions as both the return line and the supply line, depending on the direction of the turn.