E-Learnig Materials

On

AE & HV

Branch –Mechanical

6th Semester

Preapared

By

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1..1. Introduction of Automobile or Vehicle

: An Automobile is a self propelled vehicle which contains the power source for its propulsion and is used for carrying passengers and goods on the ground, such as car, bus, trucks, etc.,,

Types of Automobile;

The automobiles are classified by the following ways,

1. On the Basis of Load:

 Heavy transport vehicle (HTV) or heavy motor vehicle (HMV),

 Light transport vehicle (LTV), Light motor vehicle (LMV),

2. On the Basis of Wheels :

 Two wheeler vehicle, for example : Scooter, motorcycle, scooty, etc.

 Three wheeler vehicle,

for example : Autorickshaw,

 Three wheeler scooter for handicaps and tempo, etc.

 Four wheeler vehicle, for example : Car, jeep, trucks, buses, etc.

 Six wheeler vehicle, for example : Big trucks with two gear axles.

3. On the basis of Fuel Used:

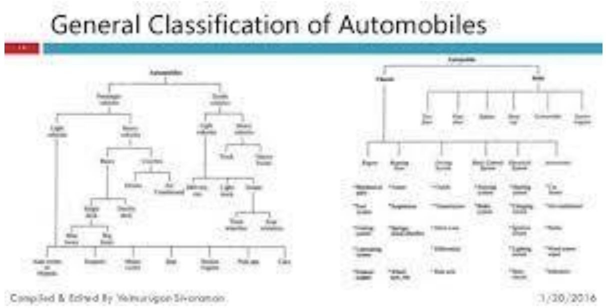
 Petrol vehicle, e.g. motorcycle, scooter, cars, etc.

 Diesel vehicle, e.g. trucks, buses, etc.

 Electric vehicle which use battery to drive.

 Steam vehicle, e.g. an engine which uses steam engine.

 Gas vehicle, e.g. LPG and CNG vehicles, where LPG is liquefied



4. On the basis of body style:

 Sedan Hatchback car

. Coupe car Station wagon Convertible.

 Van Special purpose vehicle, e.g. ambulance, milk van, etc.

5. On the basis of Transmission:

 Conventional vehicles with manual transmission, e.g. car with 5 gears.

 Semi-automatic

 Automatic : In automatic transmission, gears are not required to be changed manually.

6. On the basis of Drive:

 Left hand drive

 Right hand drive

7. On the basis of Driving Axle

 Front wheel drive

 Rear wheel drive

 All wheel drive

8. Position of Engine:

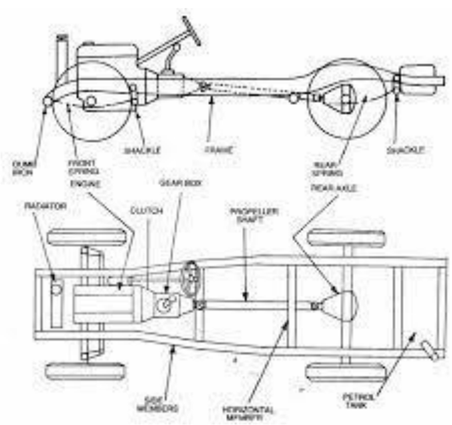
 Engine in Front - Most of the vehicles have engine in the front. Example : most of the cars,

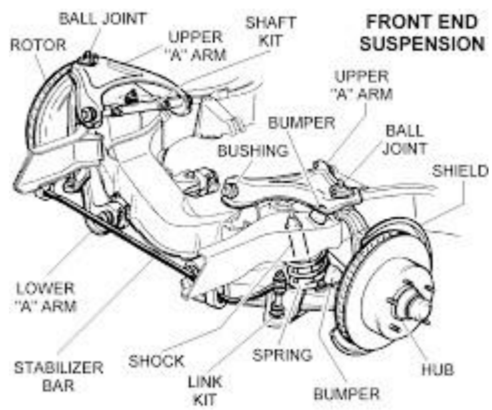
 Engine in the Rear Side Very few vehicles have engine located in the rear. Example : Nano car.

Vehicle construction and Components;

The main components of an automobile refer to the following components;

- Frame,
- Chassis,
- Body,
- Power unit,
- Transmission system.





An automobile is made up of mainly two units, these are Chassis and Body.

"Frame" + "Base components" = "Chassis"

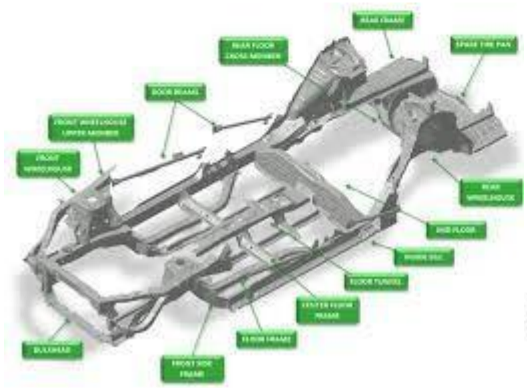
"Chassis" + "Body" = "Vehicle"

Frame :

The frame is the skeleton of the vehicle. It servers as a main foundation and base for alignment for the chassis.

Types;

- Conventional frame,
- Semi integral frame;
- Integral or untidiest frame.



Chassis;

If the frame contains the base components its called as chassis. The components are like Engine, radiator, clutch, gearbox, silencer, road wheels, fuel tank, wirings, differential units, etc..,

Body:

Body is the superstructure of the vehicle and it is bolted to the chasis.

Types;

 Car

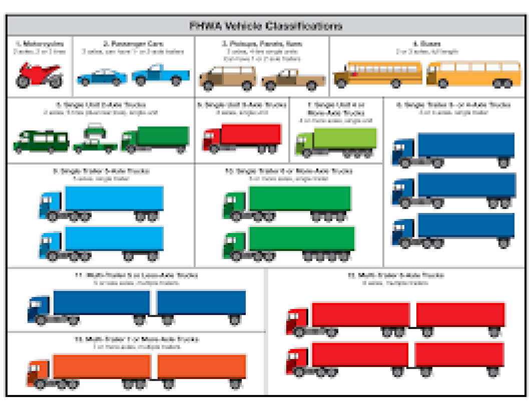
, Truck

, Tractor,

 Delivery van,

 Jeep,

 Bus, etc..,



Resistances to vehicle motion and need for a gearbox

Aerodynamics

Aerodynamics, from Greek ήρ aer (air) + δυναμική (dynamics), is a branch of dynamics concerned with studying the motion of air, particularly when it interacts with a solid object, such as an airplane wing.

Aerodynamics is a sub-field of fluid dynamics and gas dynamics, and many aspects of aerodynamics theory are common to these fields.

The term aerodynamics is often used synonymously with gas dynamics, with the difference being that "gas dynamics" applies to the study of the motion of all gases, not limited to air. Modern aerodynamics only dates back to the seventeenth century, but aerodynamic forces have been harnessed by humans for thousands of years in sailboats and windmills, and images and stories of flight appear throughout recorded history, such as the Ancient Greek legend of Icarus and Daedalus.

Fundamental concepts of continuum, drag, and pressure gradients, appear in the work of Aristotle and Archimedes .

Fundamental Concept

Understanding the motion of air around an object (often called a flow field) enables the calculation of forces and moments acting on the object.

In many aerodynamics problems, the forces of interest are the fundamental forces of flight: lift, drag, thrust, and weight. Of these, lift and drag are aerodynamic forces, i.e. forces due to air flow over a solid body. Calculation of these quantities is often founded upon the assumption that the flow field behaves as a continuum.

Continuum flow fields are characterized by properties such as velocity, pressure, density and temperature, which may be functions of spatial position and time.

These properties may be directly or indirectly measured in aerodynamics experiments, or calculated from equations for the conservation of mass, momentum, and energy in air flows. Density, velocity, and an additional property, viscosity, are used to classify flow fields

Components of an Engine

; Even though reciprocating internal combustion engines look quite simple, they are highly complex machines.

There are hundreds of components that have to perform their functions satisfactorily to produce output power.

There are two types of engines, viz., spark ignition (SI) and compression-ignition (CI) engine.

Let us now go through the important engine components and the nomenclature associated with an engine.

Terms connected with i.c. engines;

- Bore: The inside diameter of the cylinder is called bore
- Stroke: The linear distance along the cylinder axis between two limiting position s is called stroke.

 Top Dead Center (T.D.C.) : the top most position of the piston towards cover end side of the cylinder is called T.D.C.

 Bottom dead Center (B.D.C.) : The lowest position of the piston towards the crank end side of the cylinder is called B.D.C.

 Clearance Volume : The volume contained in the cylinder above the top of the piston , when the piston is at top dead center , is called the clearance volume.

 Swept Volume: The volume swept through by the piston in moving between T.D.C. and B.D.C, is called swept volume or piston displacement.

 Compression Ratio: It is the ratio of Total cylinder volume to clearance volume .

Definition of 'Engine'

An engine is a device, which transforms one form of energy into another form. Normally, most of the engines convert thermal energy into mechanical work and therefore they are called 'heat engines'.

Engine Components

The major components of the engine and their functions are briefly described below.

Cylinder Block:

The cylinder block is the main supporting structure for the various components. The cylinder of a multicylinder engine is cast as a single unit, called cylinder block.

The cylinder head is mounted on the cylinder block. The cylinder head and cylinder block are provided with water jackets in the case of water- cooling with cooling fins in the case of air-cooling.

Cylinder head gasket is incorporated between the cylinder block and cylinder head. The cylinder head is held tight to the cylinder block by number of bolts or studs.

The bottom portion of the cylinder block is called crankcase. A cover called crankcase, which becomes a sump for lubricating oil is fastened to the bottom of the crankcase.

The inner surface of the cylinder block, which is machined and finished accurately to cylindrical shape, is called bore or face.

Cylinder

As the name implies it is a cylindrical vessel or space in which the piston makes a reciprocating motion.

The varying volume created in the cylinder during the operation of the engine is filled with the working fluid and subjected to different thermodynamic processes.

The cylinder is supported in the cylinder block.

Piston

It is a cylindrical component fitted into the cylinder forming the moving boundary of the combustion system. It fits perfectly (snugly) into the cylinder providing a gas-tight space with the piston rings and the lubricant. It forms the first link in transmitting the gas forces to the output shaft.

Combustion Chamber

The space enclosed in the upper part of the cylinder, by the cylinder head and the piston top during the combustion process, is called the combustion chamber. The combustion of fuel and the consequent release of thermal energy results in the building up of pressure in this part of the cylinder.

Inlet Manifold

The pipe which connects the intake system to the inlet valve of the engine and through which air or air-fuel mixture is drawn into the cylinder is called the inlet manifold.

Gudgeon Pin

It forms the link between the small end of the connecting rod and the piston.

Exhaust Manifold

The pipe that connects the exhaust system to the exhaust valve of the engine and through which the products of combustion escape into the atmosphere is called the exhaust manifold.

Inlet and Exhaust Valves

Valves are commonly mushroom shaped poppet type. They are provided either on the cylinder head or on the side of the cylinder for regulating the charge coming into the cylinder (inlet valve) and for discharging the products of combustion (exhaust valve) from the cylinder.

Connecting Rod

It interconnects the piston and the crankshaft and transmits the gas forces from the piston to the crankshaft. The two ends of the connecting rod are called as small end and the big end. Small end is connected to the piston by gudgeon pin and the big end is connected to the crankshaft by crankpin.

Crankshaft

It converts the reciprocating motion of the piston into useful rotary motion of the output shaft. In the crankshaft of a single cylinder engine there is pair of crank arms and balance weights. The balance weights are provided for static and dynamic balancing of the rotating system. The crankshaft is enclosed in a crankcase. Piston Rings Piston rings, fitted into the slots around the piston, provide a tight seal between the piston and the cylinder wall thus preventing leakage of combustion gases .

Camshaft

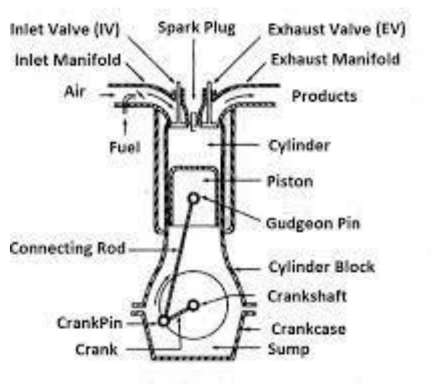
The camshaft and its associated parts control the opening and closing of the two valves. The associated parts are push rods, rocker arms, valve springs and tappets. This shaft also provides the drive to the ignition system. The camshaft is driven by the crankshaft through timing gears.

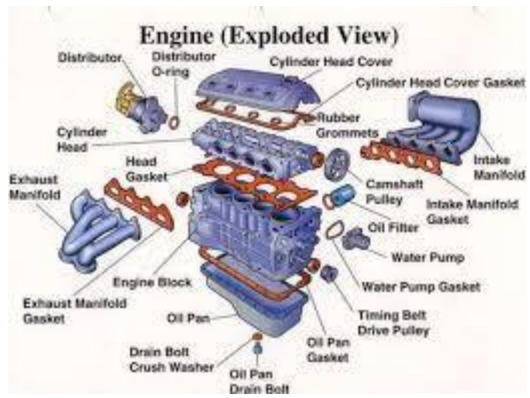
Cams

These are made as integral parts of the camshaft and are designed in such a way to open the valves at the correct timing and to keep them open for the necessary duration.

Fly Wheel

The net torque imparted to the crankshaft during one complete cycle of operation of the engine fluctuates causing a change in the angular velocity of the shaft. In order to achieve a uniform torque an inertia mass in the form of a wheel is attached to the output shaft and this wheel is called the flywheel.





Basic Parts of the Gasoline Engine:

Basic Parts of the Gasoline Engine are listed below;

- Cylinder block
- Piston
- Piston rings
- Piston pin
- Connecting rod
- Crankshaft
- Cylinder head
- Intake valve
- Exhaust valve
- Camshaft
- Timing gears
- Spark plug

Cylinder Block:

Cylinder Block Basic frame of gasoline engine. Contains the cylinder.

Piston:

Piston A sliding plug that harnesses the force of the burning gases in the cylinder.

Piston Rings:

Piston rings seal the compression gases above the piston keep the oil below the piston rings.

Piston Pins:

Piston Pins Also known as the wrist pin, it connects the piston to the small end of the connecting rod. It transfers the force and allows the rod to swing back and forth.

Connecting Rod:

Connecting Rod Connects the piston and piston pin to the crankshaft.

Crankshaft:

Crankshaft Along the the piston pin and connecting rod it converts the up and down motion (reciprocating) of the engine to spinning (rotary) motion.

Flywheel: Flywheel Carries the inertia when there is no power stroke.

Cylinder Head:

Cylinder Head Forms the top of the combustion chamber. Contains the valves, the passageways for the fuel mixture to move in and out of the engine.

Intake and Exhaust Valves:

Intake and Exhaust Valves Doorway that lets the gases in and out of the engine.

Camshaft:

Camshaft Through the use of an eccentric the cam lobes push the valves open. The valve springs close them.

Timing Gears: Timing Gears These gears drive the camshaft from the crankshaft.

Why not diesel engines are not preferred in commercial ?

1. Diesel engines, because they have much higher compression ratios (20:1 for a typical diesel vs. 8:1 for a typical gasoline engine), tend to be heavier than an equivalent gasoline engine.

2. Diesel engines also tend to be more expensive.

3. Diesel engines, because of the weight and compression ratio, tend to have lower maximum RPM ranges than gasoline engines .This makes diesel engines high torque rather than high horsepower, and that tends to make diesel cars slow in terms of acceleration.

4. Diesel engines must be fuel injected, and in the past fuel injection was expensive and less reliable

5. Diesel engines tend to produce more smoke.

6. Diesel engines are harder to start in cold weather, and if they contain glow plugs, diesel engines can require you to wait before starting the engine so the glow plugs can heat up.

7. Diesel engines are much noisier and tend to vibrate.

8. Diesel fuel is less readily available than gasoline Advantages diesel engines: The two things working in favor of diesel engines are better fuel economy and longer engine life. Both of these advantages mean that, over the life of the engine, you will tend to save money with a diesel.

However, you also have to take the initial high cost of the engine into account. You have to own and operate a diesel engine for a fairly long time before the fuel economy overcomes the increased purchase price of the engine. The equation works great in a big diesel tractor-trailer rig that is running 400 miles every day, but it is not nearly so beneficial in a passenger car .

1.6. ENGINE SUPPORT SYSTEMS:

- Cooling system
- Lubrication system
- Fuel and ignition/injection system
- Intake system Exhaust system

TRANSMISSION SYSTEM

Introduction to the Transmission Systems in Automobile:

The most common transmission systems that have been used for the automotive industry are:

- Manual transmission,
- Automatic transmission,
- Semi-automatic transmission,
- Continuously-variable transmission (C.V.T.).

Manual Transmission:

The first transmission invented was the manual transmission system. The driver needs to disengage the clutch to disconnect the power from the engine first, select the target gear, and engage the clutch again to perform the gear change. This will challenge a new driver. It always takes time for a new driver to get used to this skill.

Automatic Transmission:

An automatic transmission uses a fluid-coupling torque converter to replace the clutch to avoid engaging/disengaging clutch during gear change. A completed gear set, called planetary gears, is used to perform gear ratio change instead of selecting gear manually. A driver no longer needs to worry about gear selection during driving. It makes driving a car much easier, especially for a disabled or new driver. However, the indirect gear contact of the torque converter causes power loss during power transmission, and the complicated planetary gear structure makes the transmission heavy and easily broken.

Semi-Automatic Transmission:

A semi-automatic transmission tries to combine the advantages of the manual and automatic transmission systems, but avoid their disadvantages. However, the complicated design of the semi-automatic transmission is still under development, and the price is not cheap. It is only used for some luxury or sports cars currently.

Continuously Variable Transmission (C.V.T.):

- The Continuously Variable Transmission (C.V.T.) 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.

The other mechanical transmissions described above only allow a few different gear ratios to be selected, but this type of transmission essentially has an infinite number of ratios available within a finite range. It provides even better fuel economy if the engine is constantly made run at a single speed. This transmission is capable of a better user experience, without the rise and fall in speed of an engine, and the jerk felt when changing gears

MANUAL TRANSMISSION SYSTEM ;

Manual transmissions also referred as stick shift transmission or just ‘stick', 'straight drive', or standard transmission because you need to use the transmission stick every time you change the gears.

To perform the gear shift, the transmission system must first be disengaged from the engine. After the target gear is selected, the transmission and engine are engaged with each other again to perform the power transmission.

Manual transmissions are characterized by gear ratios that are selectable by locking selected gear pairs to the output shaft inside the transmission.

Components of manual transmission ;

The main components of manual transmission are:

- Clutch
- Gear box
- U- joint
- Shafts
- Differential gear box

CLUTCH

Clutch is a device which is used in the transmission system of automobile to engage and disengage the engine to the transmission or gear box.

It is located between the transmission and the engine. When the clutch is engaged, the power flows from the engine to the rear wheels in a rear- wheel-drive transmission and the vehicle moves.

When the clutch is disengaged, the power is not transmitted from the engine to the rear wheels and vehicle stops even if engine is running.

It works on the principle of friction.

When two friction surfaces are brought in contact with each other and they are united due to the friction between them. If one is revolved the other will also revolve.

The friction depends upon the surface area contact. The friction surfaces are so designed that the driven member initially slips on driving member when initially pressure is applied.

As pressure increases the driven member is brought gradually to speed the driving member.

The three main parts of clutch are:

- Driving member
- Driven member
- Operating member

The driving member consists of a flywheel mounted on the engine crank shaft. The flywheel is bolted to cover which carries a pressure plate or driving disc, pressure springs and releasing levers. Thus the entire assembly of flywheel and cover rotates all the times.

The clutch housing and the cover provided with openings dissipate the heat generated by friction during the clutch operation.

The driving member consists of a disc or plate called clutch plate. It is free to slide length wise on the splines of the clutch shaft. It carries friction materials on both of its surfaces when it is gripped between the flywheel and the pressure plate; it rotates the clutch shaft through splines.

The operating members consists of a foot pedal, linkage, release or throw-out bearing, release levers and springs necessary to ensure the proper operation of the clutch.

Now the driving member in an automobile is flywheel mounted on crank shaft, the driven member is the pressure plate mounted on transmission or gear box input shaft. Friction surfaces or clutch plates is placed between two members.

Types of Friction Materials:

The friction materials of the clutch plate are generally of 3 types:

- Mill Board Type
- Molded type
- Woven type

Mill Board type friction materials mainly include asbestos material with different types of impregnates.

Molded type friction materials are made from a matrix of asbestos fiber and starch or any other suitable binding materials.

They are then heated to a certain temperature for moulding in dies under pressure. They are also made into sheets by rolling, pressing and backs till they are extremely hard and dense. Metallic wires are used sometimes to increase wear properties.

Woven types facing materials are made by impregnating a cloth with certain binders or by weaving threads of copper or brass wires covered with long fiber asbestos and cotton. The woven sheets treated with binding solution are baked and rolled.

Properties Of Good Clutching:

- Good Wearing Properties
- High Resistance to heat
- High coefficient of friction
- Good Binders in it

Operation Of Clutch:

When the clutch pedal is pressed through pedal movement, the clutch release bearing presses on the clutch release lever plate which being connected to clutch release levers, forces these levers forward.

This causes the pressure plate to compress pressure springs, thus allowing it to move away from the clutch driven plate. This action releases the pressure on the driven plate and flywheel, the flywheel is now free to turn independently, without turning the transmission.

When the clutch pedal is released, reverse action takes place i.e. the driven plate is again forced against the flywheel by the pressure plate- because of the force exerted by pressure springs. The pressure plate will keep on pressing the facings of driven plate until friction created becomes equal to the resistance of the vehicle.

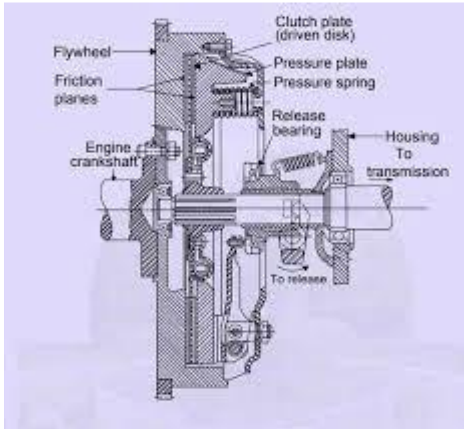
Any further increase in pressure will cause the clutch plate and the transmission shaft to turn along with flywheel, thus achieving vehicle movement.

1. Single Clutch Plate:

It is the most common type of clutch plate used in motor vehicles. Basically it consists of only one clutch plate, mounted on the splines of the clutch plate. The flywheel is mounted on engine crankshaft and rotates with it. The pressure plate is bolted to the flywheel through clutch springs, and is free to slide on the clutch shaft when the clutch pedal is operated.

When the clutch is engaged the clutch plate is gripped between the flywheel and pressure plate. The friction linings are on both the sides of the clutch plate. Due to the friction between the flywheel, clutch plate and the pressure plate the clutch plate revolves the flywheel. As the clutch plate revolves the clutch shaft also revolves. Clutch shaft is connected to the transmission gear box. Thus the engine power is transmitted to the crankshaft and then to the clutch shaft.

When the clutch pedal is pressed, the pressure plate moves back against the force of the springs, and the clutch plate becomes free between the flywheel and the pressure plate. Thus the flywheel remains rotating as long as the engine is running and the clutch shaft speed reduces slowly and finally it stops rotating. As soon as the clutch pedal is pressed, the clutch is said to be engaged, otherwise it remains engaged due to the spring forces.



2. Multi-plate Clutch:

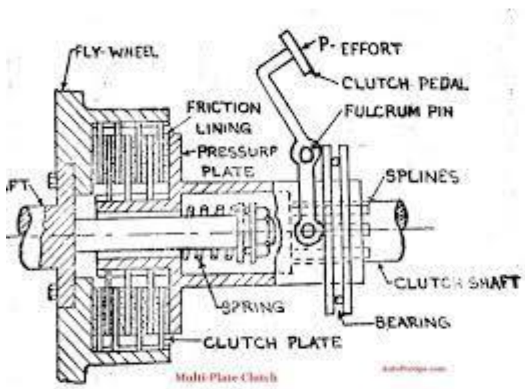
Multi-plate clutch consists of a number of clutch plates instead of only one clutch plate as in case of single plate clutch. As The number of clutch plates are increased, the friction surfaces also increases. The increased number of friction surfaces obliviously increases the capacity of the clutch to transmit torque. The plates are alternately fitted to engine and gear box shaft. They are firmly pressed by strong coil springs and assembled in a drum.

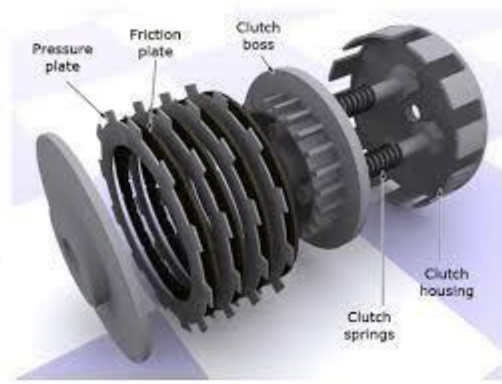
Each of the alternate plate slides on the grooves on the flywheel and the other slides on splines on the pressure plate. Thus, each alternate plate has inner and outer splines.

The multi-plate clutch works in the same way as a single plate clutch by operating the clutch pedal.

The multi-plate clutches are used in heavy commercial vehicles, racing cars and motor cycles for transmitting high torque. The multi-plate clutch may be dry or wet.

When the clutch is operated in an oil bath, it is called a wet clutch. When the clutch is operated dry it is called dry clutch. The wet clutch is used in conjunction with or part of the automatic transmission.





3. Cone Clutch:

Cone clutch consists of friction surfaces in the form of cone. The engine shaft consists of female cone. The male cone is mounted on the splined clutch shaft.

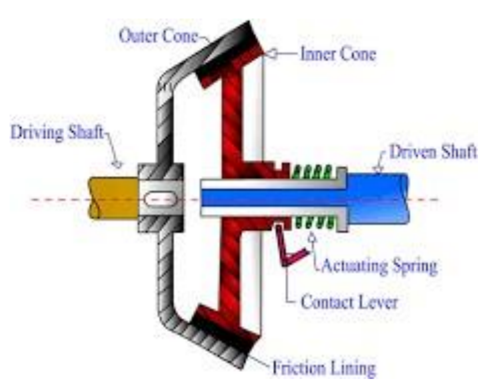
It has friction surfaces on the conical portion. The male cone can slide on the clutch shaft. Hen the clutch is engaged the friction surfaces of the male cone are in contact with that of the female cone due to force of the spring.

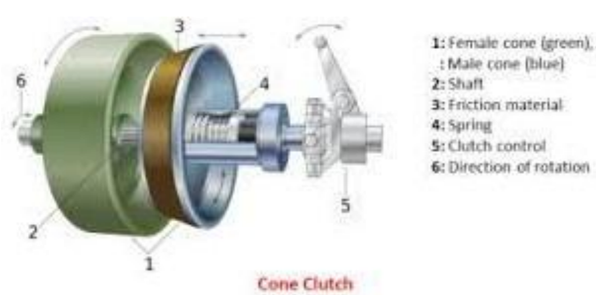
When the clutch pedal is pressed, the male cone slides against the spring force and the clutch is disengaged. The only advantage of the cone clutch is that the normal force acting on the friction surfaces is greater than the axial force, as compare to the single plate clutch in which the normal force acting on the friction surfaces is equal to the axial force.

The disadvantage in cone clutch is that if the angle of the cone is made smaller than 200 the male cone tends to bind in the female cone and it becomes difficult to disengage the clutch.

Cone clutches are generally now only used in low peripheral speed applications although they were once common in automobiles and other combustion engine transmissions.

They are usually now confined to very specialist transmissions in racing, rallying, or in extreme off-road vehicles, although they are common in power boats. Small cone clutches are used in synchronizer mechanisms in manual transmissions.





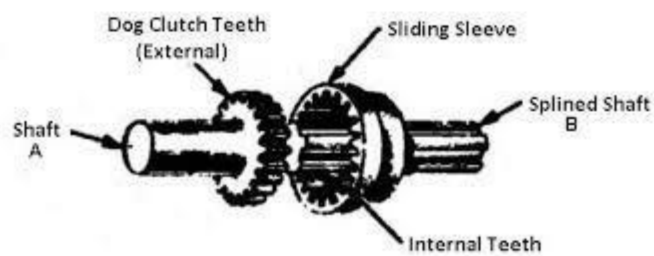
4. Dog & Spline Clutch:

This type of clutch is used to lock two shafts together or to lock a gear to shaft. It consists of a sleeve having two sets of internal splines. It slides on a splined shaft with smallest diameter splines.

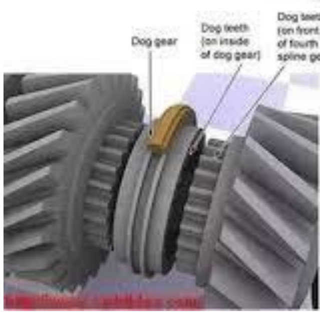
The bigger diameter splines match with the external dog clutch teeth on driving shaft. When the sleeve is made to slide on the splined shaft, its teeth match with the dog clutch teeth of the driving shaft.

Thus the sleeve turns the splined shaft with the driving shaft. The clutch is said to be engaged. To disengage the clutch, the sleeve is moved back on the splined shaft to have no contact with the driving shaft. This type of clutch has no tendency to slip.

The driven shaft revolves exactly at the same speed of the driving shaft, as soon as the clutch is engaged. This is also known as positive clutch.



Dog and Spline Clutch



5. Centrifugal Clutch:

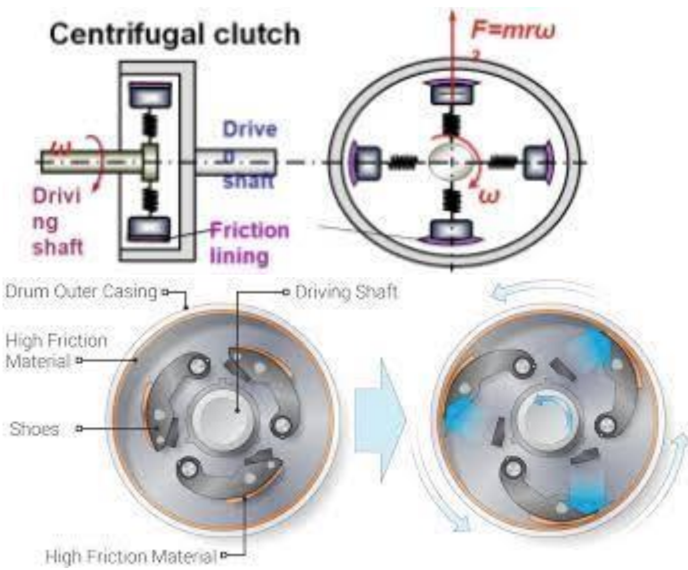
The centrifugal clutch uses centrifugal forces, instead of spring force for keeping it in engaged position. Also, it does not require clutch pedal for operating the clutch. The clutch is operated automatically depending on engine speed.

The vehicle can be stopped in gear without stalling the engine. Similarly the gear can be started in any gear by pressing the accelerator pedal.

A centrifugal clutch works through centrifugal force. The input of the clutch is connected to the engine crankshaft while the output drives gear box shaft, chain, or belt. As engine R.P.M. increases, weighted arms in the clutch swing outward and force the clutch to engage.

The most common types have friction pads or shoes radially mounted that engage the inside of the rim of housing. On the center shaft there are an assorted amount of extension springs, which connect to a clutch shoe.

When the center shaft spins fast enough, the springs extend causing the clutch shoes to engage the friction face. It can be compared to a drum brake in reverse. The weighted arms force these disks together and engage the clutch. When the engine reaches a certain RPM, the clutch activates, working almost like a continuously variable transmission.



As the load increases the R.P.M. drops thereby disengaging the clutch and letting the rpm rise again and reengaging the clutch. If tuned properly, the clutch will tend to keep the engine at or near the torque peak of the engine. These results in a fair bit of waste heat, but over a broad range of speeds it is much more useful then a direct drive in many applications. Weaker spring/heavier shoes will cause the clutch to engage at a lower R.P.M. while a stronger spring/lighter shoes will cause the clutch to engage at a higher R.P.M.

Semi-centrifugal Clutch:-

A semi centrifugal clutch is used to transmit power from high powered engines and racing car engines where clutch disengagements requires appreciable and tiresome drivers effort.

The transmission of power in such clutches is partly by clutch springs and rest by centrifugal action of an extra weight provided in system. The clutch springs serve to transmit the torque up to normal speeds, while the centrifugal force assists at speeds higher than normal.

Besides clutch, pressure plate and splines shaft it mainly consists of: Compression spring (3 numbers) Weighted levers (3 numbers) At normal speeds when the power transmission is low the spring keeps the clutch engaged, the weighted levers do not have any pressure on the pressure plate.

At high speed, when the power transmission is high the weights fly off and levers exert pressure on the plate which keeps the clutch firmly engaged. Thus instead of having more stiff springs for keeping the clutch engaged firmly at high speeds, they are less stiff, so that the driver may not get any strain in operating the clutch.

when the speed decreases, the weights fall and the levers do not exert any pressure on the pressure plate. Only the spring pressure is exerted on the pressure plate which is sufficient to keep the clutch engaged.

GEAR BOX

A gearbox is a mechanical method of transferring energy from one device to another and is used to increase torque while reducing speed.

Torque is the power generated through the bending or twisting of a solid material. This term is often used interchangeably with transmission.Located at the junction point of a power shaft, the gearbox is often used to create a right angle change in direction, as is seen in a rotary mower or a helicopter.

Each unit is made with a specific purpose in mind, and the gear ratio used is designed to provide the level of force required. This ratio is fixed and cannot be changed once the box is constructed. The only possible modification after the fact is an adjustment that allows the shaft speed to increase, along with a corresponding reduction in torque.In a situation where multiple speeds are needed, a transmission with multiple gears can be used to increase torque while slowing down the output speed. This design is commonly found in automobile transmissions. The same principle can be used to create an overdrive gear that increases output speed while decreasing torque.

Principle Of Gearing :

Consider a simple 4-gear train. It consists of a driving gear A on input shaft and a driven gear D on the output shaft. In between the two gears there are two intermediate gears B, C. Each of these gears are mounted on separate shaft.We notice that:

Gear A drives Gear B

DIAGRAM –1

Types of Gear Boxes:

The following types of gear box are used in automobiles:

 Sliding Mesh

 Constant Mesh

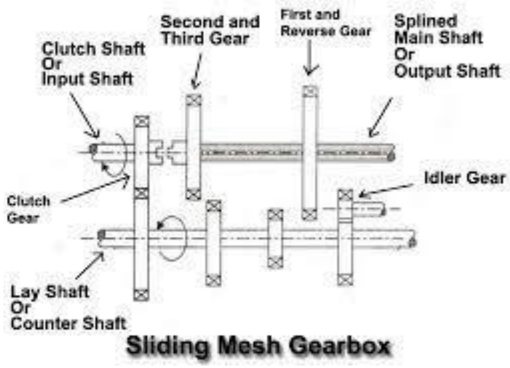
 Synchromesh.

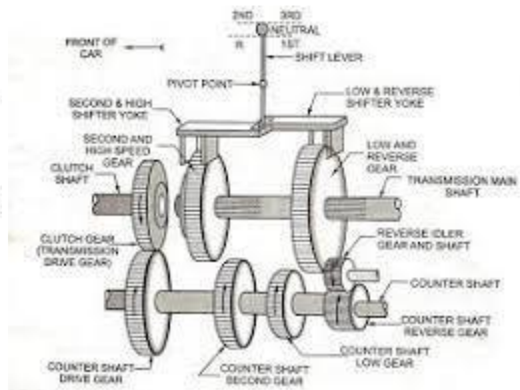
1. Sliding Mesh Gear Box

It is the simplest gear box.

The following figure shows 4-speed gear box in neutral position. 4 gears are connected to the lay shaft/counter shaft. A reverse idler gear is mounted on another shaft and always remains connected to the reverse gear of countershaft.

This “H” shift pattern enables the driver to select four different gear ratios and a reverse gear.





Gears in Neutral:

When the engine is running and clutch is engaged the clutch shaft gear drives the countershaft gear. The countershaft rotates opposite in direction of the clutch shaft. In neutral position only the clutch shaft gear is connected to the countershaft gear.

Other gears are free and hence the transmission main shaft is not turning. The vehicle is stationary.

First or low shaft gear:

By operating the gear shift lever the larger gear on the main shaft is moved along the shaft to mesh with the first gear of the counter shaft.

The main shaft turns in the same direction as that of the clutch shaft. Since the smaller countershaft is engaged with larger shaft gear .

a gear reduction of approximately 4:1 is obtained i.e. the clutch shaft turns 4 times for each revolution of main shaft.

Second speed gear:

By operating the gear shift lever the third gear on the main shaft is moved along the shaft to mesh with the third gear of the counter shaft.

The main shaft turns in same direction as clutch shaft. A gear reduction of approximately 3:1is obtained.

Third speed gear:

By operating the gear shift lever, the second gear of the main shaft and countershaft are demeshed and then the third gear of the main shaft are forced axially against the clutch shaft gear.

External Teeth on the clutch shaft gear mesh with the internal teeth in the third and top gear. The main shaft turns in same direction as clutch shaft.

A gear reduction of approximately 2:1is obtained i.e. the clutch shaft turns 2 times for each revolution of main shaft.

Fourth speed gear/ Top or High-Speed Gear:

By operating the gear shaft lever the third gears of the main and countershaft is demeshed and the gears present on the main shaft along with the shaft is forced axially against the clutch shaft gear.

External teeth present on the main shaft engage with the internal teeth present on the main shaft.

The main shaft turns along with the clutch shaft and a gear ratio of approximately 1:1 is obtained.

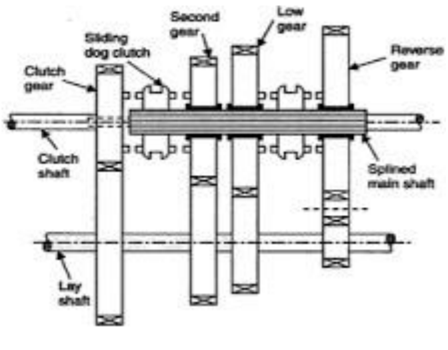
Reverse gear:

By operating the gear shift lever, the last gear present on the main shaft is engaged with the reverse idler gear.

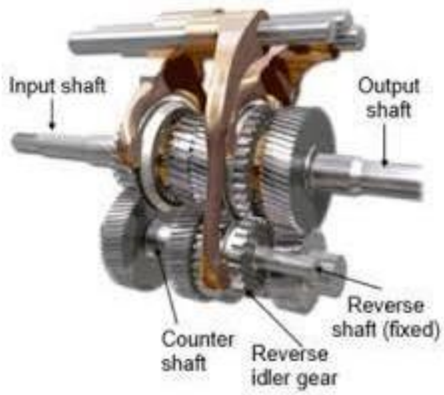
The reverse idler gear is always in mesh with the counters haft gear. Interposing the idler gear between the counter-shaft reverse gear and main shaft gear, the main shaft turns in the direction opposite to the clutch shaft.

This reverses the rotation of the wheels so that the wheel backs.

2.Constant Mesh Gear Box:



Constant Mesh Gear Box



In this type of gear box, all gears of the main shaft are in constant mesh with the corresponding gears of the countershaft (Lay shaft).

Two dog clutches are provided on the main shaft- one between the clutch gear and the second gear, and the other between the first gear and reverse gear.

The main shaft is splined and all the gears are free on it. Dog clutch can slide on the shaft and rotates with it.

All the gears on the countershaft are rigidly fixed with it. When the left hand dog clutch is made to slide to the left by means of the gear shift lever, it meshes with the clutch gear and the top speed gear is obtained.

When the left hand dog clutch meshes with the second gear, the second speed gear is obtained. Similarly by sliding the right hand dog clutch to the left and right, the first speed gear and reverse gear are obtained respectively.

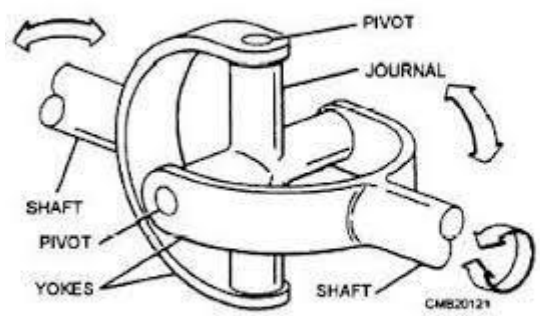
In this gear box because all the gears are in constant mesh they are safe from being damaged and an unpleasant grinding sound does not occur while engaging and disengaging them.

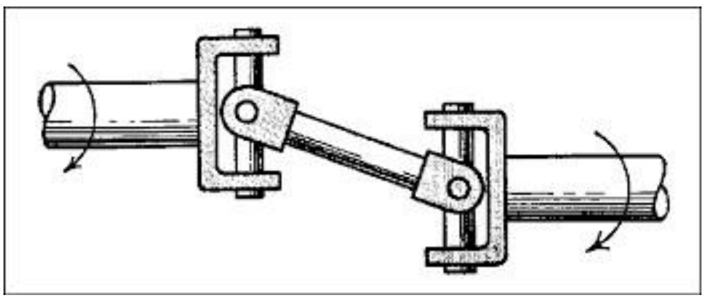
UNIVERSAL JOINTS

A universal joint, U-joint, Cardan joint, Hardy-Spicer joint, or Hooke's joint is a linkage that transmits rotation between two non parallel shafts whose axes are coplanar but not coinciding., and is commonly used in shafts that transmit rotary motion.

It is used in automobiles where it is used to transmit power from the gear box of the engine to the rear axle.

The driving shaft rotates at a uniform angular speed, where as the driven shaft rotates at a continuously varying angular speed.

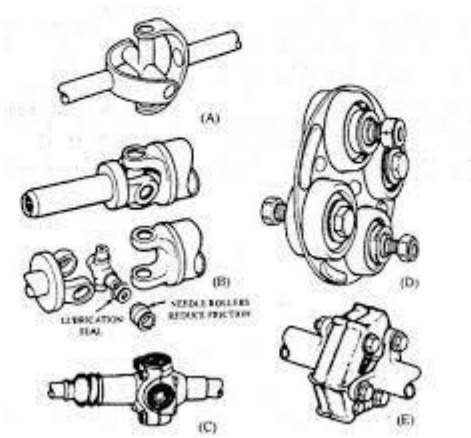




A complete revolution of either shaft will cause the other to rotate through a complete revolution at the same time. Each shaft has fork at its end. The four ends of the two fork are connected by a centre piece, the arms of which rest in bearings, provided in fork ends. The centre piece can be of any shape of a cross, square or sphere having four pins or arms. The four arms are at right angle to each other.

When the two shafts are at an angle other than 180° (straight), the driven shaft does not rotate with constant angular speed in relation to the drive shaft; the more the angle goes toward 90° the jerkier the movement gets (clearly, when the angle $\beta = 90°$ the shafts would even lock).

However, the overall average speed of the driven shaft remains the same as that of driving shaft, and so speed ratio of the driven to the driving shaft on average is 1:1 over multiple rotations.



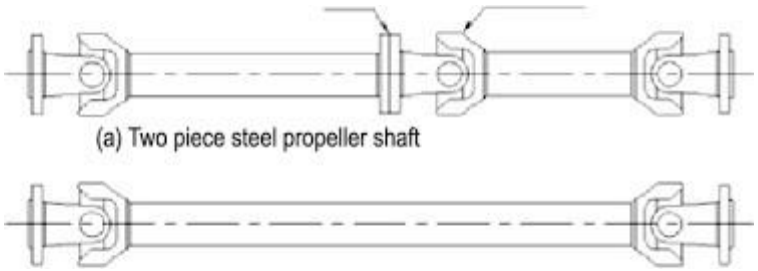
The angular speed $\omega 2$ of the driven shaft, as a function of the angular speed of the driving shaft $\omega 1$ and the angle of the driving shaft $\phi 1$, is found using: $\omega 2 = \omega 1 \cos\alpha / (1-\sin 2\alpha . \cos 2\theta)$ For a given and set angle between the two shafts it can be seen that there is a cyclical variation in the input to output velocity ratio. Maximum values occur when $\sin\theta = 1$, i.e. when $\theta = 900$ and 2700. The denominator is greatest when $\theta = 0$or 1800 and this condition gives the minimum ratio of the velocities.

PROPELER SHAFT/ DRIVER SHAFT

The drive shaft, or propeller shaft, connects the transmission output shaft to the differential pinion shaft.

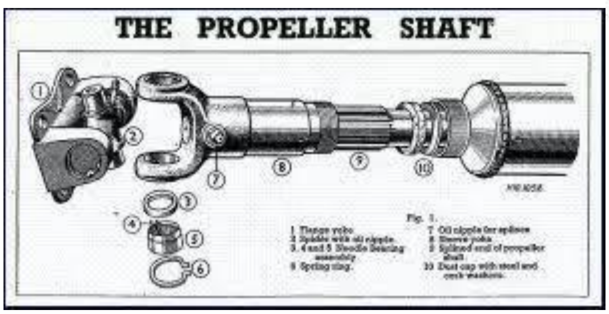
Since all roads are not perfectly smooth, and the transmission is fixed, the drive shaft has to be flexible to absorb the shock of bumps in the road.

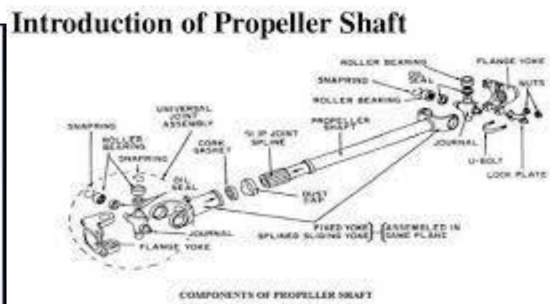
Universal, or "U-joints" allow the drive shaft to flex (and stop it from breaking) when the drive angle changes. Drive shafts are usually hollow in order to weigh less, but of a large diameter so that they are strong.



(a) Two piece steel propeller shaft

High quality steel, and sometimes aluminum are used in the manufacture of the drive shaft. The shaft must be quite straight and balanced to avoid vibrating. Since it usually turns at engine speeds, a lot of damage can be caused if the shaft is unbalanced, or bent. Damage can also be caused if the U-joints are worn out.



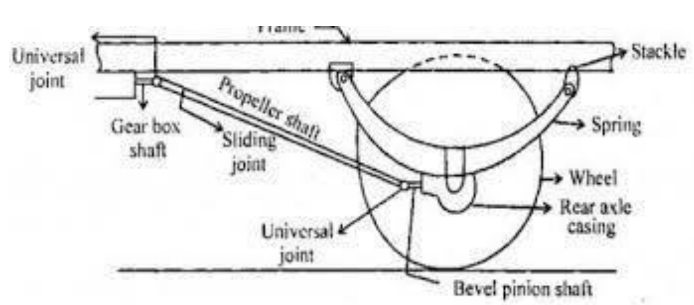


There are two types of drive shafts,

1 > the Hotchkiss drive and

2 > the Torque Tube Drive.

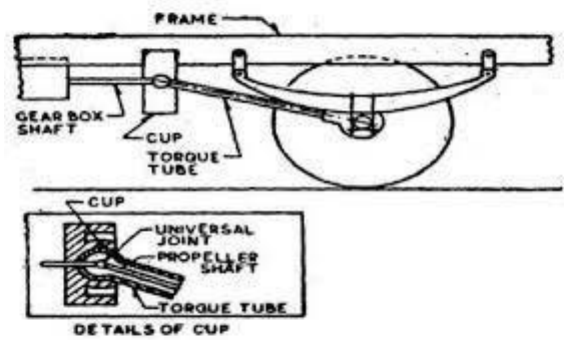
The **Hotchkiss drive** is made up of a drive shaft connected to the transmission output shaft and the differential pinion gear shaft. U-joints are used in the front and rear. The Hotchkiss drive transfers the torque of the output shaft to the differential.



No wheel drive thrust is sent to the drive shaft. Sometimes this drive comes in two pieces to reduce vibration and make it easier to install (in this case, three U-joints are needed).The two-piece types need ball bearings in a dustproof housing as center support for the shafts. Rubber is added into this arrangement for noise and vibration reduction.

The torque tube drive shaft is used if the drive shaft has to carry the wheel drive thrust. It is a hollow steel tube that extends from the transmission to the rear axle housing. One end is fastened to the axle housing by bolts.

The transmission end is fastened with a torque ball. The drive shaft fits into the torque tube. A U-joint is located in the torque ball, and the axle housing end is splined to the pinion gear shaft. Drive thrust is sent through the torque tube to the torque ball, to transmission, to engine and finally, to the frame through the engine mounts. That is, the car is pushed forward by the torque tube pressing on the engine.



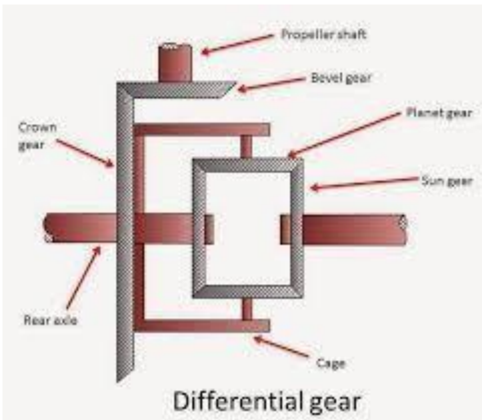
DIFFERENTIAL UNIT

Differentials are a variety of gearbox, almost always used in one of two ways.

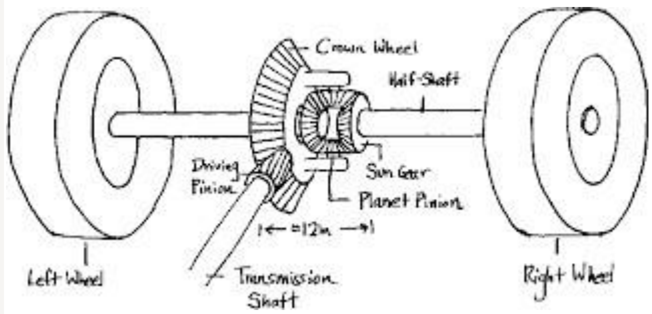
In one of these, it receives one input and provides two outputs; this is found in every automobile. In automobile and other wheeled vehicles, the differential allows each of the driving wheels to rotate at different speeds, while supplying equal torque to each of them.

In the other, less commonly encountered, it combines two inputs to create an output that is the sum (or difference) of the inputs.

In automotive applications, the differential and its housing are sometimes collectively called a "pumpkin" (because the housing resembles a pumpkin).



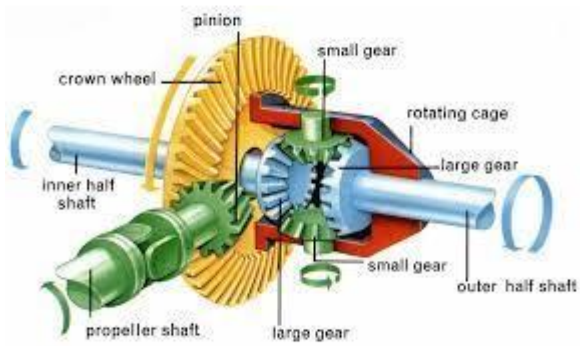
Differential gear

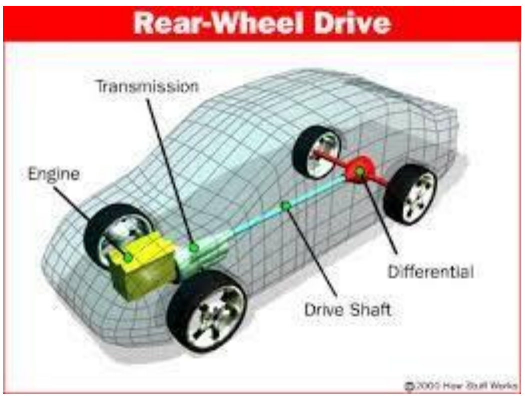


Purpose:-

The differential gear box has following functions:

- Avoid skidding of the rear wheels on a road turning.
- Reduces the speed of inner wheels and increases the speed of outer wheels, while drawing a curve.
- Keeps equal speeds of all the wheels while moving on a straight road.
- Eliminates a single rigid rear axle, and provides a coupling between two rear axles.





The following description of a differential applies to a "traditional" rear- or front-wheel-drive car or truck:

Power is supplied from the engine, via the transmission or gearbox, to a drive shaft termed as propeller shaft, which runs to the differential.

A spiral bevel pinion gear at the end of the propeller shaft is encased within the differential itself, and it meshes with the large spiral bevel ring gear termed as crown wheel. The ring and pinion may mesh in hypoid orientation.

The ring gear is attached to a carrier, which holds what is sometimes called a spider, a cluster of four bevel gears in a rectangle, so each bevel gear meshes with two neighbors and rotates counter to the third that it faces and does not mesh with.

Two of these spider gears are aligned on the same axis as the ring gear and drive the half shafts connected to the vehicle's driven wheels.

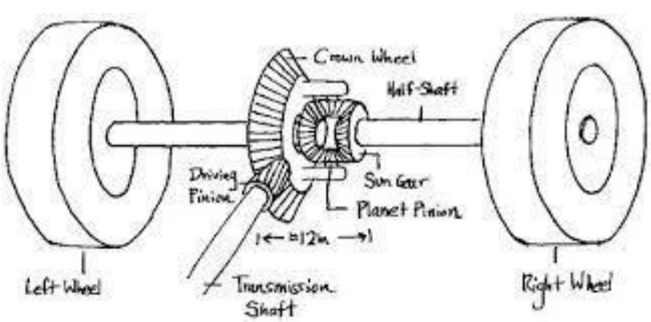
These are called the side gears. The other two spider gears are aligned on a perpendicular axis which changes orientation with the ring gear's rotation. These two gears are just called pinion gears, not to be confused with the main pinion gear. (Other spider designs employ different numbers of pinion gears depending on durability requirements.)

As the carrier rotates, the changing axis orientation of the pinion gears imparts the motion of the ring gear to the motion of the side gears by pushing on them rather than turning against them (that is, the same teeth stay in contact), but because the spider gears are not restricted from turning against each other, within that motion the side gears can counter-rotate relative to the ring gear and to each other under the same force (in which case the same teeth do not stay in contact).

Thus, for example, if the car is making a turn to the right, the main ring gear may make 10 full rotations. During that time, the left wheel will make more rotations because it has further to travel, and the right wheel will make fewer rotations as it has less distance to travel. The side gears will rotate in opposite directions relative to the ring gear by, say, 2 full turns each (4 full turns relative to each other), resulting in the left wheel making 12 rotations, and the right wheel making 8 rotations.

The rotation of the ring gear is always the average of the rotations of the side gears. This is why if the wheels are lifted off the ground with the engine off, and the drive shaft is held (preventing the ring gear from turning inside the differential), manually rotating one wheel causes the other to rotate in the opposite direction by the same amount.

When the vehicle is traveling in a straight line, there will be no differential movement of the planetary system of gears other than the minute movements necessary to compensate for slight differences in wheel diameter, undulations in the road (which make for a longer or shorter wheel path), etc.



. Automatic Transmission:

An automatic transmission (commonly "AT" or "Auto") is an automobile gearbox that can change gear ratios automatically as the vehicle moves, freeing the driver from having to shift gears manually.

Automatic Transmission Modes:

In order to select the mode, the driver would have to move a gear shift lever located on the steering column or on the floor next to him/her. In order to select gears/modes the driver must push a button in (called the shift lock button) or pull the handle (only on column mounted shifters) out. In some vehicles position selector buttons for each mode on the cockpit instead, freeing up space on the central console. Vehicles conforming to U.S. Government standards must have the modes ordered P- R-N-D-L (left to right, top to bottom, or clockwise). Prior to this, quadrant-selected automatic transmissions often utilized a P-N-D-L-R layout, or similar. Such a pattern led to a number of deaths and injuries owing to un-intentional gear miss-selection, as well the danger of having a selector (when worn) jump into Reverse from Low gear during engine braking maneuvers.

Automatic Transmissions have various modes depending on the model and make of the transmission. Some of the common modes are:

Park Mode (P):- This selection mechanically locks the transmission, restricting the car from moving in any direction. A parking pawl prevents the transmission—and therefore the vehicle—from moving, although the vehicle's non-drive wheels may still spin freely. For this reason, it is recommended to use the hand brake (or parking brake) because this actually locks the (in most cases, rear) wheels and prevents them from moving. This also increases the life of the transmission and the park pin mechanism, because parking on an incline with the transmission in park without the parking brake engaged will cause undue stress on the parking pin. An efficiently-adjusted hand brake should also prevent the car from moving if a worn selector accidentally drops into reverse gear during early morning fast-idle engine warm ups.

Reverse (R):- This puts the car into the reverse gear, giving the ability for the car to drive backwards. In order for the driver to select reverse they must come to a complete stop, push the shift lock button in (or pull the shift lever forward in the case of a column shifter) and select reverse. Not coming to a complete stop can cause severe damage to the transmission. Many modern automatic gearboxes have a safety mechanism in place, which does to some extent prevent (but doesn't completely avoid) inadvertently putting the car in reverse when the vehicle is moving. This mechanism usually consists of a solenoid-controlled physical barrier on either side of the Reverse position, which is electronically engaged by a switch on the brake pedal. Therefore, the brake pedal needs to be depressed in order to allow the selection of reverse. Some electronic transmissions prevent or delay engagement of reverse gear altogether while the car is moving.

Neutral/No gear (N):- This disconnects the transmission from the wheels so the car can move freely under its own weight. This is the only other selection in which the car can be started.

Drive (D):- This allows the car to move forward and accelerate through its range of gears. The number of gears a transmission has depends on the model, but they can commonly range from 3, 4 (the most common), 5, 6 (found in VW/Audi Direct Shift Gearbox), 7 (found in Mercedes 7G gearboxes, BMW M5 and VW/Audi Direct Shift Gearbox) and 8 in the newer models of Lexus cars. Some cars when put into D will automatically lock the doors or turn on the Daytime Running Lamps.

Overdrive ([D], Od, Or A Boxed D):-

This mode is used in some transmissions to allow early Computer Controlled Transmissions to engage the Automatic Overdrive.

In these transmissions, Drive (D) locks the Automatic Overdrive off, but is identical otherwise. OD (Overdrive) in these cars is engaged under steady speeds or low acceleration at approximately 35-45 mph (approx. 72 km/h).

Under hard acceleration or below 35-45 mph, the transmission will automatically downshift. Vehicles with this option should be driven in this mode unless circumstances require a lower gear.

Second (2 or S):- This mode limits the transmission to the first two gears, or more commonly locks the transmission in second gear. This can be used to drive in adverse conditions such as snow and ice, as well as climbing or going down hills in the winter time. Some vehicles will automatically up-shift out of second gear in this mode if a certain rpm range is reached, to prevent engine damage.

First (1 or L):- This mode locks the transmission in first gear only. It will not accelerate through any gear range. This, like second, can be used during the winter season, or for towing. As well as the above modes there are also other modes, dependent on the manufacturer and model. Some examples include:

D5:- In Hondas and Acuras equipped with 5-speed automatic transmissions, this mode is used commonly for highway use (as stated in the manual), and uses all five forward gears.

D4:- This mode is also found in Honda and Acura 4 or 5-speed automatics and only uses the first 4 gears. According to the manual, it is used for "stop and go traffic", such as city driving.

D3:- This mode is found in Honda and Acura 4-speed automatics and only uses the first 3 gears. According to the manual, it is used for stop & go traffic, such as city driving. This mode is also found in Honda and Acura 5-speed automatics.

TORQUE CONVERTER :

This is the manual selection of gears for automatics, such as Porsche's Tiptronic. This feature can also be found in Chrysler and General Motors products such as the Dodge Magnum and Pontiac G6. The driver can shift up and down at will, by toggling the shift lever (console mounted) like a semi-automatic transmission.

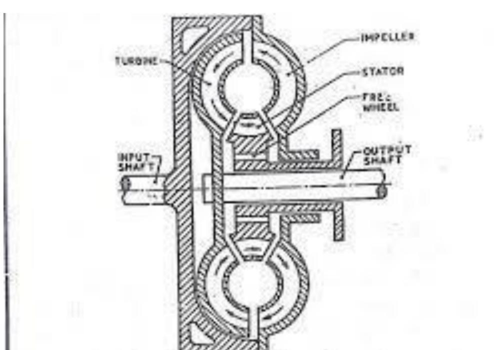
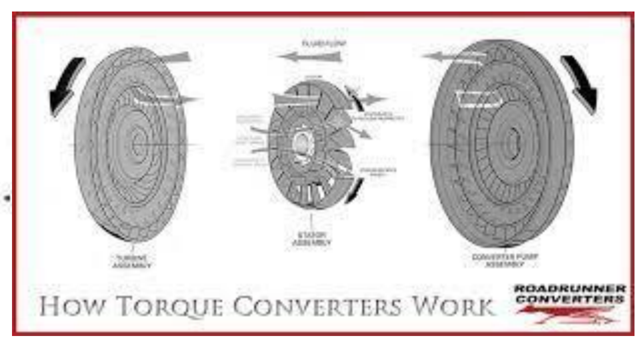


Fig. : Single Stage Torque Converter



This mode may be engaged either through a selector/position or by actually changing gear (e.g. tipping the gear-down paddles mounted near the driver's fingers on the steering wheel). The predominant form of automatic transmission is hydraulically operated, using a fluid coupling/ torque converter and a set of planetary gear-sets to provide a range of torque multiplication.

DIAGRAM OF TORQUE CONVERTER

Parts And Operation:

- A hydraulic automatic transmission consists of the following parts:

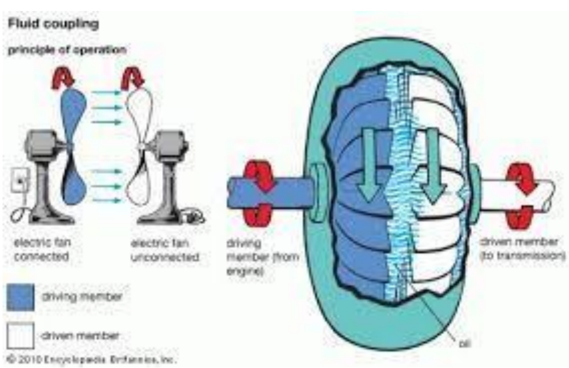
 Torque Converter/Fluid Coupling

 Planetary Gear Set

 Clutch packs & Bands

 Valve Body

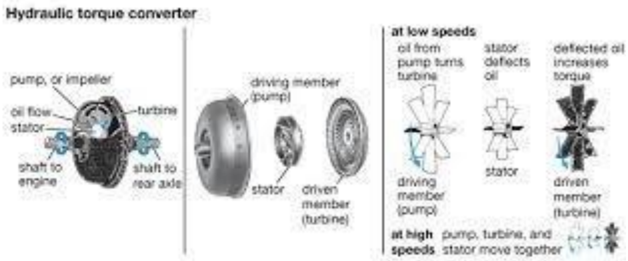
 Hydraulic or Lubricating Oil



Torque Converter/Fluid Coupling:

-Unlike a manual transmission system, automatic transmission does not use a clutch to disconnect power from the engine temporarily when shifting gears.

Instead, a device called a torque converter was invented to prevent power from being temporarily disconnected from the engine and also to pre-vent the vehicle from stalling when the transmission is in gear .



A fluid coupling/torque converter consists of a sealed chamber containing two toroidal-shaped, vaned components, the pump and turbine, immersed in fluid (usually oil). The pump or driving torus (the latter a General Motors automotive term) is rotated by the prime mover, which is typically an internal combustion engine or electric motor.

The pump's motion imparts a relatively complex centripetal motion to the fluid. Simplified, this is a centrifugal force that throws the oil outwards against the coupling's housing, whose shape forces the flow in the direction of the turbine or driven torus (the latter also a General Motors term).

Here, Corolis force reaction transfers the angular fluid momentum outward and across, applying torque to the turbine, thus causing it to rotate in the same direction as the pump. The fluid leaving the center of the turbine returns to the pump, where the cycle endlessly repeats. The pump typically is connected to the flywheel of the engine—in fact, the coupling's enclosure may be part of the flywheel proper, and thus is turned by the engine's crankshaft. The turbine is connected to the input shaft of the transmission. As engine speed increases while the transmission is in gear, torque is transferred from the engine to the input shaft by the motion of the fluid, propelling the vehicle. In this regard, the behavior of the fluid coupling strongly resembles that of a mechanical clutch driving a manual transmission.

A torque converter differs from a fluid coupling in that it provides a variable amount of torque multiplication at low engine speeds, increasing "breakaway" acceleration. This is accomplished with a third member in the "coupling assembly" known as the stator, and by altering the shapes of the vanes inside the coupling in such a way as to curve the fluid's path into the stator. The stator captures the kinetic energy of the transmission fluid in effect using the left-over force of it to enhance torque multiplication.

Tiptronic transmission is a special type of automatic transmission with a computer controlled automatic shift. The driver can switch the transmission to manual mode, which lets her shift the gear at her wish sequentially up (+) or down (-) without disengaging the clutch. This works just like a manual transmission; however, it still uses a torque converter to transfer power from the engine. Unfortunately, this is less efficient than a manual transmission.

Planetary Gear-Set:

- The automatic system for current automobiles uses a planetary gear set instead of the traditional manual transmission gear set. The planetary gear set contains four parts: sun gear, planet gears, planet carrier, and ring gear. Based on this planetary set design, sun gear, planet carrier, and ring gear spin centrifugally. By locking one of them, the planetary set can generate three different gear ratios, including one reverse gear, without engaging and disengaging the gear set. The gear set is actuated by hydraulic servos controlled by the valve body, providing two or more gear ratios.

Clutch Packs And Bands:

- A clutch pack consists of alternating disks that fit inside a clutch drum. Half of the disks are steel and have splines that fit into groves on the inside of the drum.

`The other half have a friction material bonded to their surface and have splines on the inside edge that fit groves on the outer surface of the adjoining hub. There is a piston inside the drum that is activated by oil pressure at the appropriate time to squeeze the clutch pack together so that the two components become locked and turn as one.

A band is a steel strap with friction material bonded to the inside surface. One end of the band is anchored against the transmission case while the other end is connected to a servo.

At the appropriate time hydraulic oil is sent to the servo under pressure to tighten the band around the drum to stop the drum from turning. The bands come into play for manually selected gears, such as low range or reverse, and operate on the planetary drum's circumference.

Bands are not applied when drive/overdrive range is selected, the torque being transmitted by the sprag clutches instead. The sun gear is connected to a drum, which can be locked by a band. The ring gear is directly connected to the input shaft, which transfers power from the engine. The planet carrier is connected to the output shaft, which transfers power into the wheels.

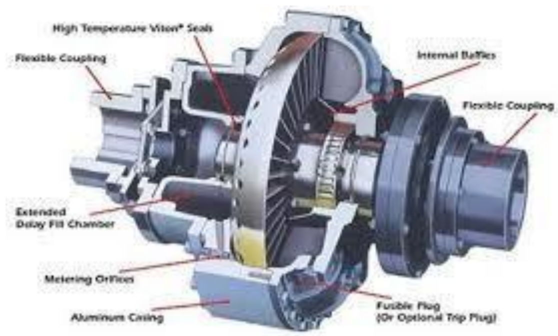
Based on this design, when in neutral, both band and clutch sets are released. Turning the ring gear can only drive planet gears but not the planet carrier, which stays static if the car is not moving. The planet gears drive the sun gear to spin freely. In this situation, the input shaft is not able to transfer power to the output shaft. When shifting to 1st gear, the band locks the sun gear by locking the drum. The ring gear drives the planet carrier to spin. In this situation, the ring gear (input shaft) spins faster than the planet carrier (output shaft).

To shift to higher gear, the band is released and the clutch is engaged to force the sun gear and planet carrier (output shaft) to spin at the same speed. The input shaft will also spin at the same speed as the output shaft, which makes the car run faster than in 1st gear. Using a compound planetary gear set generates more gear ratios with a special gear ratio, over-drive gear whose gear ratio is small than 1.

This will make the gear shift smoother. Both the band and clutch piston are pressurized by the hydraulic system. The part connecting the band or clutches to the hydraulic system is called the shift valve, while the one connecting the hydraulic system to the output shaft is called the governor.

The governor is a centrifugal sensor with a spring loaded valve. The faster the governor spins, the more the valve opens. The more the valve opens, the more the fluid goes through and the higher the pressure applied on the shift valve. Therefore, each band and clutch can be pushed to lock the gear based on a specific spin speed detected by the governor from the output shaft. To make the hydraulic system work efficiently, a complex maze of passages was designed to replace a large number of tubes. For modern cars, an electronic con-trolled (computer controlled) solenoid pack is used to detect throttle position, vehicle speed, engine speed, engine load, brake pedal position, etc., and to automatically choose the best gear for a moving vehicle.

Principally, a type of device known as a sprag or roller clutch is used for routine upshifts/downshifts. Operating much as a ratchet, it transmits torque only in one direction, freewheeling or "overrunning" in the other. The advantage of this type of clutch is that it eliminates the sensitivity of timing a simultaneous clutch release/apply on two planetaries, simply "taking up" the drivetrain load when actuated, and releasing automatically when the next gear's sprag clutch assumes the torque .



. **Semi Automatic Transmission ;**

A semi-automatic transmission (also known as clutch less manual transmission, automated manual transmission, e-gear, shift-tronic, flappy paddle gearbox, or paddle shift gearbox) is a system which uses electronic sensors, processors and actuators to do gear shifts on the command of the driver.

This removes the need for a clutch pedal which the driver otherwise needs to depress before making a gear change, since the clutch itself is actuated by electronic equipment which can synchronize the timing and torque required to make gear shifts quick and smooth.

The system was designed by European automobile manufacturers to provide a better driving experience, especially in cities where congestion frequently causes stop-and-go traffic patterns. Like a tiptronic transmission, a semi-automatic transmission can also be switched to manual mode to perform gear shifting at the drivers wish.

The two most common semi-automatic transmissions ae :

 Direct shift transmission (or dual-clutch transmission)

 Electro-hydraulic manual transmission (or sequential transmission) Direct shift transmission:

In direct shift transmission direct shift gear box is used. The Direct-Shift Gearbox or D.S.G. is an electronically controlled, twin-shaft dual-clutch manual gearbox, without a conventional clutch pedal, with full automatic or semi-manual control.

Unlike the conventional manual transmission system, there are two different gear/collar sets, with each connected to two different input/output shafts. The outer clutch pack drives gears 1, 3, 5 and reverse.

It is just like two conventional manual transmission gear boxes in one. The inner clutch pack drives gears 2, 4, and 6. Instead of a standard large dry single-plate clutch, each clutch pack is a collection of four small wet interleaved clutch plates. Due to space constraints, the two clutch assemblies are concentric.

To automatically shift from 1st gear to 2nd gear, first the computer detects that the spinning speed of the input shaft is too high, and engages the 2nd gear's collar to the 2nd gear. The clutch then disengages from 1st gear's input shaft, and engages the 2nd gear's input shaft. Controlled by computer, the gear shift becomes extremely fast compared with a conventional manual transmission.

Using direct contact of the clutch instead of fluid coupling also improves power transmission efficiency. Another advanced technology used for direct shift trans-mission allows it to perform "double clutching" by shifting the gear to neutral first, adjusting the spinning speed of the input shaft, and then shifting to the next gear. This makes gear shifting very smooth.

Operation Modes Of D.S.G.:- "D" mode:

When the motor vehicle is stationary, in neutral, both clutch packs are fully disengaged. When the driver has selected D for drive (after pressing the foot brake pedal), the transmission's first gear is selected on the first shaft, and the clutch prepares to engage.

At the same time, the second gear is also selected, but the clutch pack for second gear remains fully disengaged. When the driver releases the brake pedal, the clutch pack for the first gear takes up the drive, and the vehicle moves forward. Pressing the accelerator pedal increases forward speed. As the car accelerates, the transmission's computer determines when the second gear (which is connected to the second clutch) should be fully utilized.

Depending on the vehicle speed and amount of power being requested by the driver (full throttle or part-throttle normal driving), the D.S.G. then up-shifts. During this sequence, the DSG disengages the first clutch while engaging the second clutch (all power from the engine is now going through the second shaft), thus completing the shift sequence.

This sequence happens in 8 ms, and there is practically no power loss. Once the vehicle has shifted up to second gear, the first gear is immediately de-selected, and third gear (being on the same shaft as 1st and 5th) is pre-selected, and is pending. Once the time comes to shift, the second clutch disengages and the first clutch re-engages. This method of operation continues in the same manner up to 6th gear.Downshifting is similar to up-shifting but in reverse order. The car's computer senses the car slowing down or more power required, and thus lines up a lower gear on one of the shafts not in use, and then completes the downshift.

The actual shift timings are determined by the D.S.G.'s Electronic Control Unit, or E.C.U., which commands a hydro-mechanical unit, and the two units combined are called a "mechatronics" unit. Because the D.S.G. & E.C.U. uses "fuzzy logic", the operation of the DSG is said to be "adaptive"; i.e. the DSG will "learn" how the user drives the car, and will tailor the shift points accordingly. In the vehicle instrument display, between the speedometer and tachometer, the available shift positions are shown, the current position of the shift lever is highlighted, and the current gear ratio is also displayed as a number.

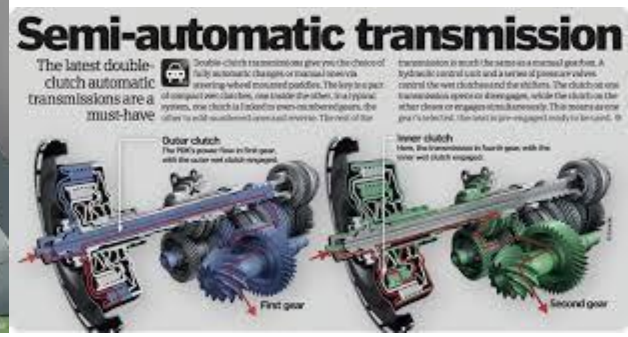
Under "normal", progressive acceleration and deceleration, the DSG shifts in a "sequential" mode, i.e. under acceleration: 1 > 2 > 3 > 4 > 5 > 6, and the same sequence reversed for deceleration.

However, if the car is being driven at sedate speeds, with a light throttle opening, and the accelerator pedal is then pressed fully to the floor, this activates the "kick- down" function. During kick-down, the DSG can skip gears, going from 6th gear straight down to 3rd gear .

"S" mode:

The floor selector lever also has an S position. When S is selected, "sport" mode is activated in the DSG. Sport mode still functions as a fully automatic mode, identical in operation to "D" mode, but up-shifts and down-shifts are made much higher up the engine rev-range. This aids a sportier driving manner, by utilizing considerably more of the available engine power, and also maximizing engine braking. However, this mode does have a worsening effect on the vehicle fuel consumption, when compared to D mode.

S is also highlighted in the instrument display, and like D mode, the currently used gear ratio is displayed as a number.



Manual (Tiptronic) Mode:

Additionally, the floor shift lever also has another plane of operation, for manual or tiptronic mode, with spring-loaded "+" and "−" positions. This plane is selected by moving the stick away from the driver (in vehicles with the drivers seat on the right, the lever is pushed to the left, and in left-hand drive cars, the stick is pushed to the right) when in "D" mode only. When this plane is selected, the D.S.G. can now be controlled like a manual gearbox, even though under a sequential shift pattern.

The readout in the instrument display changes to 6 -5- 4- 3- 2- 1, and just like the automatic modes, the currently used gear ratio is highlighted. To change up a gear, the lever is pushed forwards (against a spring pressure) towards the "+", and to change down, the lever is pulled rearwards towards the "−". The DSG box can now be operated with the gear changes being (primarily) determined by the driver. This method of operation is commonly called "tiptronic". When accelerating in Manual/tiptronic mode, the D.S.G. will still automatically change up just before the red-line and when decelerating, it will change down automatically at very low revs, just before the engine idle speed (tick over).

Furthermore, if the driver calls for a gear when it is not appropriate (i.e., engine speed near the red-line, and a down change is requested) the D.S.G. will delay the change until the engine revs are at an appropriate level to cope with the requested gear.

Paddle Shifters:

On certain "sporty" or high-powered cars paddle shifters are available. The paddle shifters have two distinct advantages: the driver can safely keep both hands on the steering wheel when using the Manual/tiptronic mode; and the driver can immediately manually override either of the automatic programs (D or S) on a temporary basis, and gain instant manual control of the D.S.G. box.

If the manual override of one of the automatic programs (D or S) is utilized intermittently, the gearbox will "default" back to the previously selected automatic mode after a predetermined duration of inactivity of the paddles, or when the car becomes stationary.

Alternatively, should the driver wish to revert immediately to automatic control, this can be done by holding the "+" paddle for at least two seconds.

. Hotchkiss drive;

The Hotchkiss drive is a system of power transmission. It was the dominant form of power transmission for front-engine, rear-wheel drive layout cars in the 20th century.

The name comes from the French automobile firm of Hotchkiss, although it is clear that other makers (such as Peerless) used similar systems before Hotchkiss. During the early part of the 20th century the two major competing systems of power transmission were the shaft-drive and chain-drive configurations.

The Hotchkiss drive is a shaft- drive system (another type of direct-drive transmission system is the torque tube, which was also popular until the 1950s). All shaft-drive systems consist of a driveshaft (also called a "propeller shaft" or Cardan shaft) extending from the transmission in front to the differential in the rear.

The differentiating characteristic of the Hotchkiss drive is the fact that it uses universal joints at both ends of the driveshaft, which is not enclosed. The use of two universal joints, properly phased and with parallel alignment of the drive and driven shafts, allows the use of simple crosstype universals. (In a torque-tube arrangement only a single universal is used at the end of the transmission tail shaft, and this universal should be a constant velocity joint.) In the Hotchkiss drive, slip-splines or a plunge-type (ball and trunnion u-joint) eliminate thrust transmitted back up the driveshaft from the axle, allowing simple rear-axle positioning using parallel leaf springs. (In the torque-tube type this thrust is taken by the torque tube to the transmission and thence to the transmission and motor mounts to the frame.

While the torque-tube type requires additional locating elements, such as a Panhard rod, this allows the use of coil springs.) Some Hotchkiss drive shafts are made in two pieces with another universal joint in the center for greater flexibility, typically in trucks and specialty vehicles built on truck frames.

Some installations use rubber mounts to isolate noise and vibration. The 1984–1987 RWD Toyota Corolla (i.e., Corolla SR5 and GT-S) coupe is another example of a car that uses a 2-part Hotchkiss driveshaft with a rubber-mounted center bearing. This design was the main form of power transmission for most cars from the 1920s through the 1970s. Presently (circa 2012), it remains common in pick-up trucks, and sport utility vehicles.

Torque tube Drive ;

A torque tube system is a driveshaft technology, often used in automobiles with a front engine and rear drive. It is not as widespread as the Hotchkiss drive, but is still occasionally used to this day.

Drive shafts are sometimes also used for other vehicles and machinery. The "torque" that is referred to in the name is not that of the driveshaft, along the axis of the car, but that applied by the wheels.

The design problem that the torque tube solves is how to get the traction forces generated by the wheels to the car frame. The "torque tube" transmits this force by directly coupling the axle differential to the transmission and therefore propels the car forward by pushing on the engine/transmission and then through the engine mounts to the car frame[citation needed]. In contrast, the Hotchkiss drive has the traction forces transmitted to the car frame by using other suspension components such as leaf springs or trailing arms.

A ball and socket type of joint called a "torque ball" is used at one end of the torque tube to allow relative motion between the axle and transmission due to suspension travel. Since the torque tube does not constrain the axle in the lateral (side-to-side) direction a pan hard rod is often used for this purpose. The combination of the pan hard rod and the torque tube allows the easy implementation of soft coil springs in the rear to give good ride quality. In addition to transmitting the traction forces, the torque tube is hollow and contains the rotating driveshaft. Inside the hollow torque ball is the universal joint of the driveshaft that allows relative motion between the two ends of the driveshaft.

In most applications the drive shaft uses a single universal joint which has the disadvantage that it causes speed fluctuations in the driveshaft when the shaft is not straight. The Hotchkiss drive uses two universal joints which has the effect of canceling the speed fluctuations and gives a constant speed even when the shaft is no longer straight .

STEERING SYSTEM

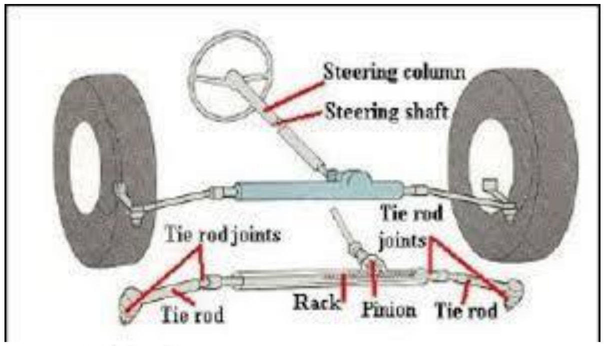
Introduction of Steering system

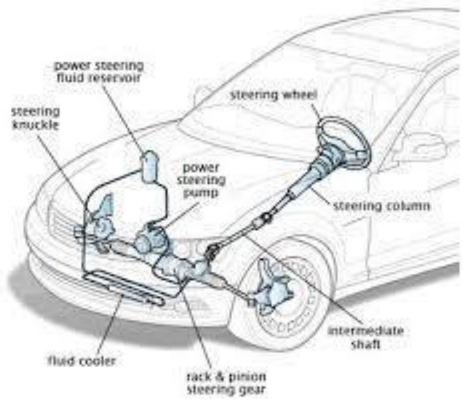
Steering is the collection of components, linkages, etc. which allow a vessel (ship,boat) or vehicle (car, motorcycle, bicycle) to follow the desired course.

An exception is the case of rail transport by which rail tracks combined together with railroad switches (and also known as 'points' in British English) provide the steering function.

The most conventional steering arrangement is to turn the front wheels using a hand– operated steering wheel which is positioned in front of the driver, via the steering column, which may contain universal joints (which may also be part of the collapsible steering column design), to allow it to deviate somewhat from a straight line.

Other arrangements are sometimes found on different types of vehicles, for example, a tiller or rear–wheel steering. Tracked vehicles such as bulldozers andtanks usually employ differential steering — that is, the tracks are made to move at different speeds or even in opposite directions, using clutches and brakes, to bring about a change of course or direction.





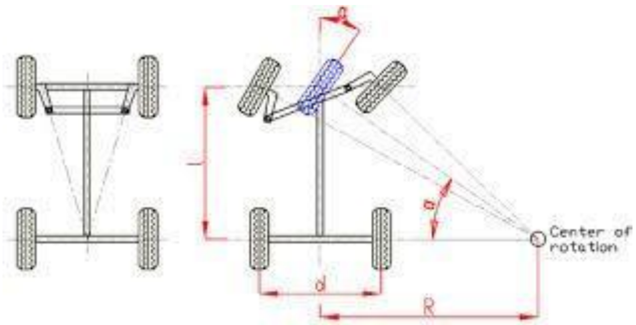
Ackermann steering geometry

Caster angle θ indicates kingpin pivot line and gray area indicates vehicle's tire with the wheel moving from right to left. A positive caster angle aids in directional stability, as the wheel tends to trail, but a large angle makes steering more difficult.

Curves described by the rear wheels of a conventional automobile. While the vehicle moves with a constant speed its inner and outer rear wheels do not. The basic aim of steering is to ensure that the wheels are pointing in the desired directions. This is typically achieved by a series of linkages, rods, pivots and gears.

One of the fundamental concepts is that of caster angle – each wheel is steered with a pivot point ahead of the wheel; this makes the steering tend to be self-centering towards the direction of travel. The steering linkages connecting the steering box and the wheels usually conforms to a variation of Ackermann steering geometry, to account for the fact that in a turn, the inner wheel is actually travelling a path of smaller radius than the outer wheel, so that the degree of toe suitable for driving in a straight path is not suitable for turns.

The angle the wheels make with the vertical plane also influences steering dynamics (see camber angle) as do the tires.



Rack and pinion steering mechanism:

1. Steering wheel;

2. Steering column;

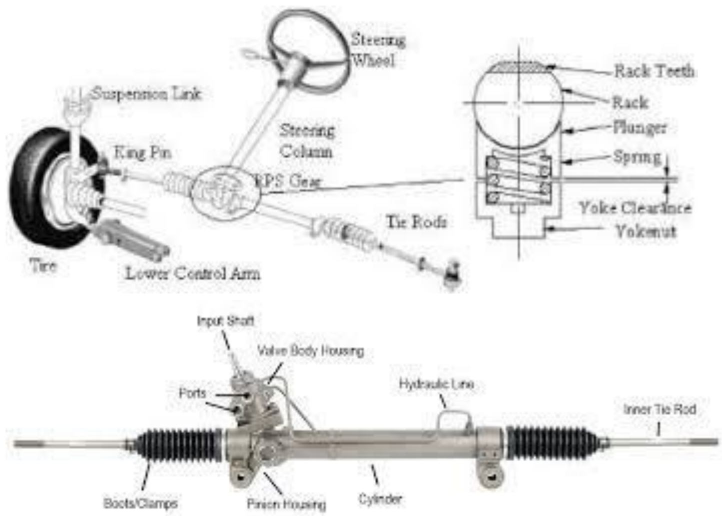
3. Rack and pinion;

4. Tie rod;

5. Kingpin

Rack and pinion unit mounted in the cockpit of an Ariel Atom sports car chassis. For most high volume production, this is usually mounted on the other side of this panel Steering box of a motor vehicle, the traditional (non-assisted), you may notice that the system allows you to adjust the braking and steering systems, you can also see the attachment system to the frame.

Many modern cars use rack and pinion steering mechanisms, where the steering wheel turns the pinion gear; the pinion moves the rack, which is a linear gear that meshes with the pinion, converting circular motion into linear motion along the transverse axis of the car (side to side motion).



Rack and Pinion Diagram

This motion applies steering torque to the swivel pin ball joints that replaced previously used kingpins of the stub axle of the steered wheels via tie rods and a short lever arm called the steering arm. The rack and pinion design has the advantages of a large degree of feedback and direct steering "feel".

A disadvantage is that it is not adjustable, so that when it does wear and develop lash, the only cure is replacement. Older designs often use the recalculating ball mechanism, which is still found on trucks and utility vehicles. This is a variation on the older sector design; the steering column turns a large screw (the "worm gear") which meshes with a sector of a gear, causing it to rotate about its axis as the worm gear is turned; an arm attached to the axis of the sector moves the Pitman arm, which is connected to the steering linkage and thus steers the wheels.

The recalculating ball version of this apparatus reduces the considerable friction by placing large ball bearings between the teeth of the worm and those of the screw; at either end of the apparatus the balls exit from between the two pieces into a channel internal to the box which connects them with the other end of the apparatus, thus they are "recalculated".

The recirculating ball mechanism has the advantage of a much greater mechanical advantage, so that it was found on larger, heavier vehicles while the rack and pinion was originally limited to smaller and lighter ones; due to the almost universal adoption of power steering, however, this is no longer an important advantage, leading to the increasing use of rack and pinion on newer cars.

The recirculating ball design also has a perceptible lash, or "dead spot" on center, where a minute turn of the steering wheel in either direction does not move the steering apparatus; this is easily adjustable via a screw on the end of the steering box to account for wear, but it cannot be entirely eliminated because it will create excessive internal forces at other positions and the mechanism will wear very rapidly.

This design is still in use in trucks and other large vehicles, where rapidity of steering and direct feel are less important than robustness, maintainability, and mechanical advantage. The worm and sector was an older design, used for example in Willys and Chrysler vehicles, and the Ford Falcon (1960s).

Other systems for steering exist, but are uncommon on road vehicles. Children's toys and go-karts often use a very direct linkage in the form of abellcrank (also commonly known as a Pitman arm) attached directly between the steering column and the steering arms, and the use of cable- operated steering linkages (e.g. the Capstan and Bowstring mechanism) is also found on some home-built vehicles such as soapbox cars and recumbent tricycles.

Steering Gear Boxes;

The steering gears converts the rotary motion of the steering wheel into the to-and-fro motion of the link rod of the steering linkages. Moreover it also provides necessary leverage so that the driver is able to steer the vehicle without fatigue.

There are various types of steering gear boxes are available in automobile.

- Worm and Wheel steering gear box,
- Cam and double roller steering gear box,
- Worm and nut steering gear box,
- Recalculating ball type steering gear box,
- Rack and pinion steering gear box,

SUSPENSION SYSTEM

Suspension system is the term given to the system of springs, shock absorbers and linkages that connects a vehicle to its wheels .

It is basically cushion for passengers protects the luggage or any cargo and also itself from damage and wear.

Sir William Brush is the father of suspension system in automobiles.

The main role of suspension system are as follows:

- It supports the weight of vehicle .
- Provides smoother ride for the driver and passengers i.e. acts as cushion.
- Protects your vehicle from damage and wear .
- It also plays a critical role in maintaining self driving conditions.
- It also keeps the wheels pressed firmly to the ground for traction .
- It isolates the body from road shocks and vibrations which would otherwise be transferred to the passengers and load.

Principle : When a tire hits an obstruction, there is a reaction force. The size of this reaction force depends on the unsprung mass at each wheel assembly.

In general, the larger the ratio of sprung weight to unsprung weight, the less the body and vehicle occupants are affected by bumps, dips, and other surface imperfections such as small bridges.

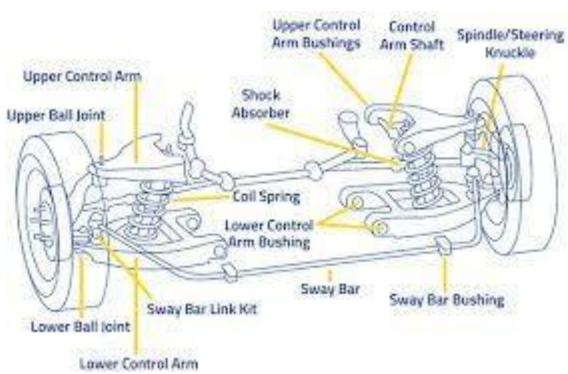
A large sprung weight to unsprung weight ratio can also impact vehicle control. No road is perfectly flat i.e. without irregularities. Even a freshly paved highways have subtle imperfections that can be interact with vehicle's wheels. These are the imperfections that apply forces on wheels. According to Newton 's law of motion all forces have both magnitude and direction.

A bump in the road causes the wheel to move up and down perpendicular to the road surface. The magnitude of course ,depends on whether the wheel is striking a giant bump or a tiny speck. Thus, either the wheel experiences a vertical acceleration as it passes over an imperfection.

The suspension of a car is actually part of the chassis, which comprises all of the important systems located beneath the car's body.

These system include :

- Frame
- Suspension system
- Steering system
- Tires or Wheels



Components of Suspension system;

There are three fundamental components of any suspension system .

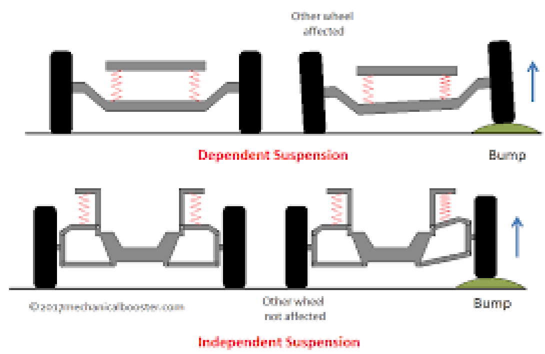
Springs

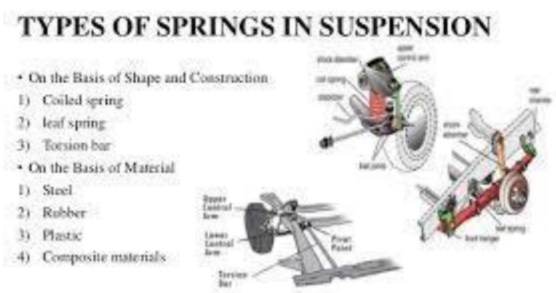
- Coil spring
- Leaf springs
- Air springs

Dampers

- Shock Absorbers
- Struts:- Anti-sway Bars
- Anti sway bars.

Types of Suspension system;





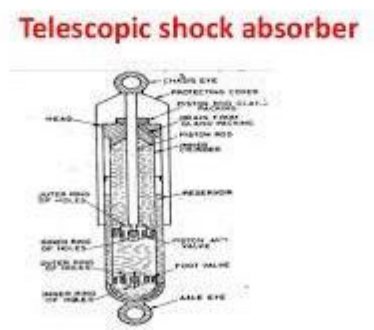
Advantages;

- Comfort to passengers
- Good handling
- Shields the vehicle from damage
- Increases life of vehicle
- Keeps the tires pressed firmly to ground.

TELESCOPIC SHOCK ABSORBER ;

If the suspension springs are rigid enough, they will not absorb shocks efficiently. If they are flexible enough, they will continue to vibrate for a long time even after the bump has passed.

Therefore, the springing device must be a compromise between flexibility and stiffness. Shock absorbers are provided as part of the suspension system of motor vehicles for this purpose.



When the vehicle wheel strikes a bump, the spring is compressed enough and only a little vertical upward motion is transferred to the frame. When the wheel comes down from the bump, the spring expands very rapidly.

If this rebound is not controlled the spring starts to vibrate heavily to control this vibration, at the shock-absorber, is used in the suspension system. Similarly, when the wheel falls over a hole, the spring expands and is unable to take the full vehicle load. The shock absorber takes part in this load.

In the case of a leaf spring suspension system, the friction between the leaves provides the damping effect. But because of the change in lubrication conditions, the amount of friction also changes and hence the damping characteristics do not remain constant.

Therefore, additional damping is provided by means of the dampers or shock-absorbers. Frequently, the shock absorber housing is linked to the frame cross member and the shock absorber arm is connected to the spring, axle or suspension control arm.

Types of Shock Absorbers ;

Mainly the shock absorbers are of two types:

1. Mechanical
2. Hydraulic

Various types of shock absorbers are used in modern vehicles are:

3. Hydraulic type shock absorbers
4. Double acting shock absorbers
5. Single acting shock absorber
6. Friction type shock absorber
7. Lever type shock absorber
8. Telescopic type shock absorber

1. Hydraulic type shock absorbers ;

Hydraulic type shock absorbers are now used on all passenger cars. They increase resistance to the spring action by forcing a fluid through check valves and small holes.

2. Double acting shock absorbers

Double acting shock absorbers offer resistance both during compression and rebound of the springs.

3. Single acting shock absorber

Single acting shock absorber offers resistance only on the rebound.

4. Friction type shock absorber

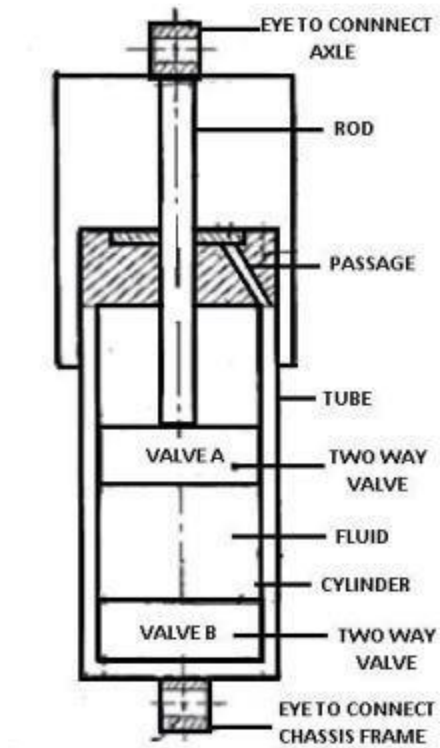
The friction type shock absorbers have almost become obsolete due to their non-predictable damping characteristics.

5. Lever type shock absorber

Lever type shock absorber is of indirect acting type. It is bolted to the chassis through a lever and link. As the axle moves up and down, a double piston arrangement forces the oil through a valve.

6. Telescopic type shock absorber

Telescopic type shock absorber is of direct acting type. It is mounted between the axle and the frame.



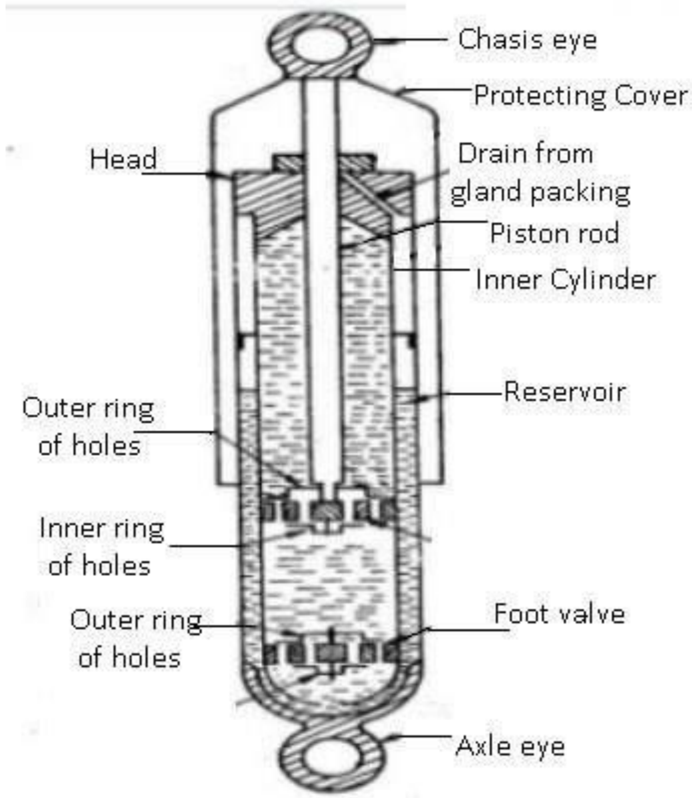
TELESCOPIC SHOCK ABSORBER

A simplified diagram of the telescopic shock absorber is shown in Figure. Its upper eye is attached to the axle and the lower eye to the chassis frame. A two-way valve A is attached to a rod G. Another two-way valve B is connected to the lower end of cylinder C.

The fluid is in the space above and below the valve A, and also in the annular space between the cylinder C and tube D, which is connected to the space below the valve B. The head J has a gland H. Any fluid scrapped off by the rod G is brought down into the annular space through the inclined passage.

Working of Shock Absorbers

The shock absorber works as follows when the vehicle comes across a bump the lower eye moves up. Therefore, the fluid passes from the lower side of valve A to its upper side. But since the volume of the space above valve A is less than the volume of the rod G, the fluid exerts pressure on the valve B.



This pressure of the fluid through the valve openings gives the damping force. Thus, when the lower eye E moves down, the fluid passes from the upper side of the valve A to the lower side, and also from the lower side of the valve B to its upper side.

The shock absorber must be filled with shock absorber fluid at regular intervals as recommended by the manufacturer or when required by its condition. The modern telescopic shock absorbers are no longer serviced. If they leak or do not offer proper resistance to push and pull they should be replaced.

TESTING OF A SHOCK ABSORBER ;

The shock absorbers should be tested by moving the front or rear of the vehicle up and down quickly. If the vehicle does not come to rest almost immediately, the shock absorbers must be removed for further testing. Often noise results from loose shock absorber arm-to-frame connections. These joints should always be kept tight.

In the case of damages to shock absorbers, the operation may become irregular and result in noisiness and vibration in dampening the effect. The noise may originate from other sources. Therefore, before replacing shock absorbers, inspect carefully the entire suspension system and the mountings of shock absorber on body and axle.

Check that shock absorber mounting eyes firmly locked on rubber bushes and that these are not worn. Replace worn or damaged parts. Other possible causes of noisiness are a distortion of pipes or due to bumps against obstacles, to stones thrown up by wheels.

The vibrations in the damping effect may occur either as an increase or reduction in damping ability. Generally, the first case is rare and originates either from thickening of fluid or from the closer matching of valves and setting, with a resultant increase in shock absorber resistance. The second case may be the result of breakage of some inner part, shortage of fluid or stuck valves.

BRAKING SYSTEM

A brake is a mechanical device which inhibits motion, slowing or stopping a moving object or preventing its motion. The rest of this article is dedicated to various types of vehicular brakes. Most commonly brakes use friction between two surfaces pressed together to convert the kinetic energy of the moving object into heat, though other methods of energy conversion may be employed.

For example regenerative braking converts much of the energy to electrical energy, which may be stored for later use. Other methods convert kinetic energy into potential energy in such stored forms as pressurized air or pressurized oil.

Eddy current brakes use magnetic fields to convert kinetic energy into electric current in the brake disc, fin, or rail, which is converted into heat. Still other braking methods even transform kinetic energy into different forms, for example by transferring the energy to a rotating flywheel.

Brakes are generally applied to rotating axles or wheels, but may also take other forms such as the surface of a moving fluid (flaps deployed into water or air). Some vehicles use a combination of braking mechanisms, such as drag racing cars with both wheel brakes and a parachute, or airplanes with both wheel brakes and drag flaps raised into the air during landing. Since kinetic energy increases quadratically with velocity ( ), an object moving at 10 m/s has 100 times as much energy as one of the same mass moving at 1 m/s, and consequently the theoretical braking distance, when braking at the traction limit, is 100 times as long. In practice, fast vehicles usually have significant air drag, and energy lost to air drag rises quickly with speed. Almost all wheeled vehicles have a brake of some sort.

Even baggage carts and shopping carts may have them for use on a moving ramp. Most fixed-wing aircraft are fitted with wheel brakes on the undercarriage. Some aircraft also feature air brakes designed to reduce their speed in flight.

Notable examples include gliders and some World War II-era aircraft, primarily some fighter aircraft and many dive bombers of the era. These allow the aircraft to maintain a safe speed in a steep descent. The Saab B 17 dive bomber and Vought F4U Corsair fighter used the deployed undercarriage as an air brake. Friction brakes on automobiles store braking heat in the drum brake or disc brake while braking then conduct it to the air gradually. When traveling downhill some vehicles can use their engines to brake.

When the brake pedal of a modern vehicle with hydraulic brakes is pushed, ultimately a piston pushes the brake pad against the brake disc which slows the wheel down. On the brake drum it is similar as the cylinder pushes the brake shoes against the drum which also slows the wheel down. Brakes may be broadly described as using friction, pumping, or electromagnetic.

One brake may use several principles: for example, a pump may pass fluid through an orifice to create friction: Frictional brakes are most common and can be divided broadly into "shoe" or "pad" brakes, using an explicit wear surface, and hydrodynamic brakes, such as parachutes, which use friction in a working fluid and do not explicitly wear.

Typically the term "friction brake" is used to mean pad/shoe brakes and excludes hydrodynamic brakes, even though hydrodynamic brakes use friction .

Friction (pad/shoe) brakes are often rotating devices with a stationary pad and a rotating wear surface. Common configurations include shoes that contract to rub on the outside of a rotating drum, such as a band brake; a rotating drum with shoes that expand to rub the inside of a drum, commonly called a "drum brake", although other drum configurations are possible; and pads that pinch a rotating disc, commonly called a "disc brake". Other brake configurations are used, but less often. For example, PCC trolley brakes include a flat shoe which is clamped to the rail with an electromagnet; the Murphy brake pinches a rotating drum, and the Ausco Lambert disc brake uses a hollow disc (two parallel discs with a structural bridge) with shoes that sit between the disc surfaces and expand laterally.

Pumping brakes are often used where a pump is already part of the machinery. For example, an internal-combustion piston motor can have the fuel supply stopped, and then internal pumping losses of the engine create some braking. Some engines use a valve override called a Jake brake to greatly increase pumping losses

. Pumping brakes can dump energy as heat, or can be regenerative brakes that recharge a pressure reservoir called a hydraulic accumulator. Electromagnetic brakes are likewise often used where an electric motor is already part of the machinery.

For example, many hybrid gasoline/electric vehicles use the electric motor as a generator to charge electric batteries and also as a regenerative brake. Some diesel/electric railroad locomotives use the electric motors to generate electricity which is then sent to a resistor bank and dumped as heat.

Types of Braking system in Automobile;

 By applications –

1. Foot Brake,

2. Hand brake.

 By Method of power –

1. Mechanical brake,

2. Hydraulic brake.

3. Vacuum brake,

4. Electrical brake

and 5. Air brake.

 By method of operations –

1. Manual brake,

2. Servo brake.

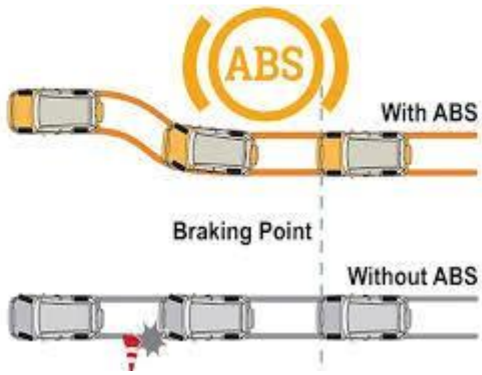
3. Power operation.

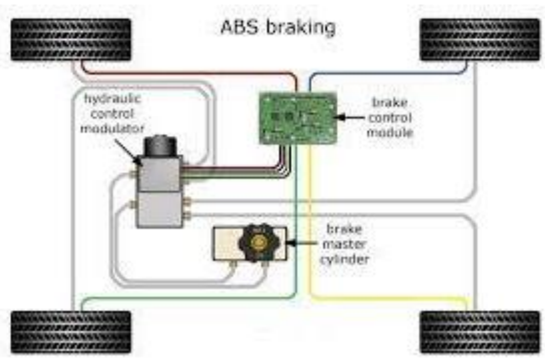
 By construction –

1 .Drum type brake,

2. Disc type brake.

. Anti-lock braking system (ABS) ;





Anti-lock braking system (ABS) is an automobile safety system that allows the wheels on a motor vehicle to maintain tractive contact with the road surface according to driver inputs while braking, preventing the wheels from locking up (ceasing rotation) and avoiding uncontrolled skidding.

It is an automated system that uses the principles of threshold braking and cadence braking which were practiced by skillful drivers with previous generation braking systems. It does this at a much faster rate and with better control than a driver could manage.

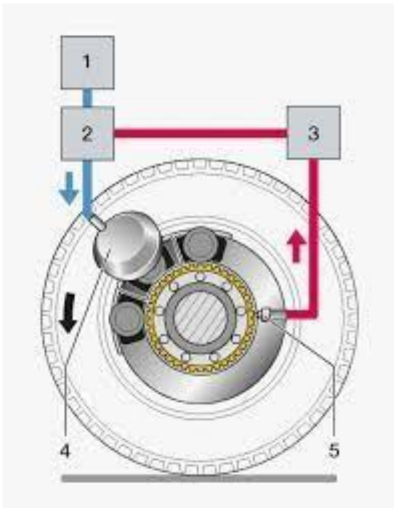
ABS generally offers improved vehicle control and decreases stopping distances on dry and slippery surfaces for many drivers; however, on loose surfaces like gravel or snow-covered pavement, ABS can significantly increase braking distance, although still improving vehicle control. S

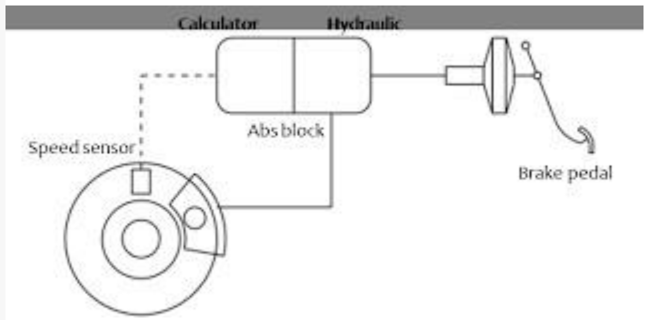
Since initial widespread use in production cars, anti-lock braking systems have evolved considerably. Recent versions not only prevent wheel lock under braking, but also electronically control the front-to-rear brake bias. This function, depending on its specific capabilities and implementation, is known as electronic brake force distribution(EBD), traction control system, emergency brake assist, or electronic stability control(ESC).

Operation ;

The anti-lock brake controller is also known as the CAB (Controller Anti-lock Brake). Typically ABS includes a central electronic control unit (ECU), four wheel speed sensors, and at least two hydraulic valves within the brake hydraulics.

The ECU constantly monitors the rotational speed of each wheel; if it detects a wheel rotating significantly slower than the others, a condition indicative of impending wheel lock, it actuates the valves to reduce hydraulic pressure to the brake at the affected wheel, thus reducing the braking force on that wheel; the wheel then turns faster. Conversely, if the ECU detects a wheel turning significantly faster than the others, brake hydraulic pressure to the wheel is increased so the braking force is reapplied, slowing down the wheel. This process is repeated continuously and can be detected by the driver via brake pedal pulsation.





Some anti-lock systems can apply or release braking pressure 15 times per second.[17] Because of this, the wheels of cars equipped with ABS are practically impossible to lock even during panic braking in extreme conditions.

The ECU is programmed to disregard differences in wheel rotative speed below a critical threshold, because when the car is turning, the two wheels towards the center of the curve turn slower than the outer two. For this same reason, a differential is used in virtually all roadgoing vehicles.

If a fault develops in any part of the ABS, a warning light will usually be illuminated on the vehicle instrument panel, and the ABS will be disabled until the fault is rectified. Modern ABS applies individual brake pressure to all four wheels through a control system of hub-mounted sensors and a dedicated micro-controller.

ABS is offered or comes standard on most road vehicles produced today and is the foundation for electronic stability control systems, which are rapidly increasing in popularity due to the vast reduction in price of vehicle electronics over the years.

Modern electronic stability control systems are an evolution of the ABS concept. Here, a minimum of two additional sensors are added to help the system work: these are a steering wheel angle sensor, and a gyroscopic sensor.

The theory of operation is simple: when the gyroscopic sensor detects that the direction taken by the car does not coincide with what the steering wheel sensor reports, the ESC software will brake the necessary individual wheel(s) (up to three with the most sophisticated systems), so that the vehicle goes the way the driver intends. The steering wheel sensor also helps in the operation of Cornering Brake Control (CBC), since this will tell the ABS that wheels on the inside of the curve should brake more than wheels on the outside, and by how much. ABS equipment may also be used to implement a traction control system (TCS) on acceleration of the vehicle. If, when accelerating, the tire loses traction, the ABS controller can detect the situation and take suitable action so that traction is regained. More sophisticated versions of this can also control throttle levels and brakes simultaneously.

Components of ABS ;

There are four main components of ABS:

 Speed sensors,

 Valves,

 Pump,

and Controller.

Speed sensors ; A speed sensor is used to determine the acceleration or deceleration of the wheel. These sensors use a magnet and a coil of wire to generate a signal. The rotation of the wheel or differential induces a magnetic field around the sensor.

The fluctuations of this magnetic field generate a voltage in the sensor. Since the voltage induced in the sensor is a result of the rotating wheel, this sensor can become inaccurate at slow speeds. The slower rotation of the wheel can cause inaccurate fluctuations in the magnetic field and thus cause inaccurate readings to the controller.

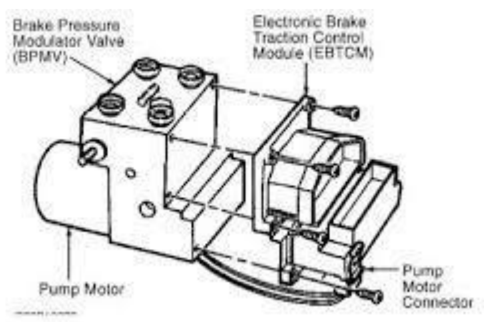
Valves ; There is a valve in the brake line of each brake controlled by the ABS. On some systems, the valve has three positions: In position one, the valve is open; pressure from the master cylinder is passed right through to the brake.

In position two, the valve blocks the line, isolating that brake from the master cylinder. This prevents the pressure from rising further should the driver push the brake pedal harder. In position three, the valve releases some of the pressure from the brake.

The majority of problems with the valve system occur due to clogged valves. When a valve is clogged it is unable to open, close, or change position. An inoperable valve will prevent the system from modulating the valves and controlling pressure supplied to the brakes.

Pump

The pump in the ABS is used to restore the pressure to the hydraulic brakes after the valves have released it. A signal from the controller will release the valve at the detection of wheel slip. After a valve release the pressure supplied from the user, the pump is used to restore a desired amount of pressure to the braking system.



The controller will modulate the pumps status in order to provide the desired amount of pressure and reduce slipping. Controller The controller is an ECU type unit in the car which receives information from each individual wheel speed sensor, in turn if a wheel loses traction the signal is sent to the controller, the controller will then limit the brake force (EBD) and activate the ABS modulator which actuates the braking valves on and off.

Use

There are many different variations and control algorithms for use in ABS. One of the simpler systems works as follows, The controller monitors the speed sensors at all times. It is looking for decelerations in the wheel that are out of the ordinary.

Right before wheel locks up, it will experience a rapid deceleration. If left unchecked, the wheel would stop much more quickly than any car could. It might take a car five seconds to stop from 60 mph (96.6 km/h) under ideal conditions, but a wheel that locks up could stop spinning in less than a second.

The ABS controller knows that such a rapid deceleration is impossible, so it reduces the pressure to that brake until it sees an acceleration, then it increases the pressure until it sees the deceleration again. It can do this very quickly, before the tire can actually significantly change speed. The result is that the tire slows down at the same rate as the car, with the brakes keeping the tires very near the point at which they will start to lock up. This gives the system maximum braking power.

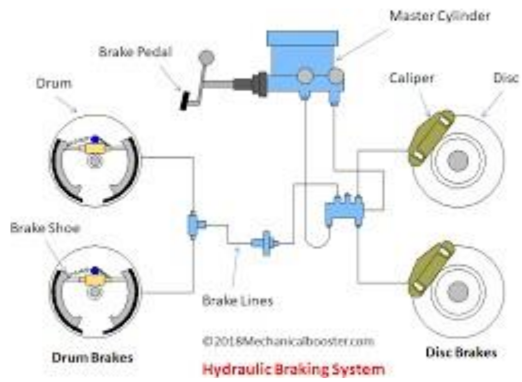
This replaces the need to manually pump the brakes while driving on a slippery or a low traction surface, allowing steering even in the most emergency braking conditions. When the ABS is in operation the driver will feel a pulsing in the brake pedal; this comes from the rapid opening and closing of the valves. This pulsing also tells the driver that the ABS has been triggered. Some ABS systems can cycle up to 16 times per second.

Hydraulic braking system ;

The disc brake or disk brake is a device for slowing or stopping the rotation of a wheel while it is in motion.

A brake disc (or rotor in U.S. English) is usually made of cast iron, but may in some cases be made of composites such as reinforced carbon-carbon or ceramic-matrix composites. This is connected to the wheel and/or the axle. To stop the wheel, friction material in the form of brake pads (mounted on a device called a brake caliper) is forced mechanically, hydraulically, pneumatically or electromagnetically against both sides of the disc.

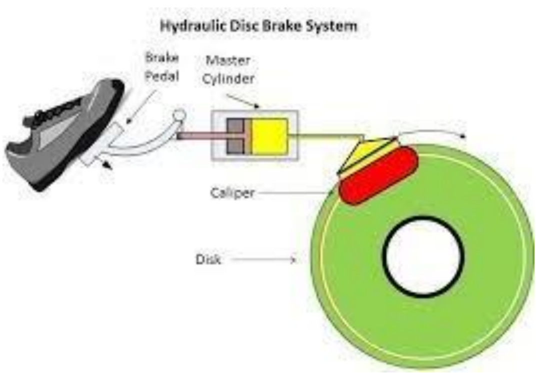
Friction causes the disc and attached wheel to slow or stop. Brakes (both disc and drum) convert motion to heat, but if the brakes get too hot, they will become less effective because they cannot dissipate enough heat. This condition of failure is known as brake fade.

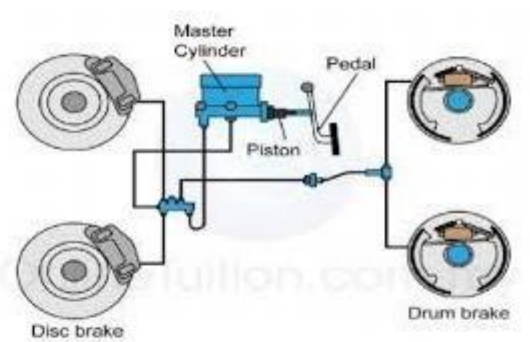


Construction of Braking system;

The most common arrangement of hydraulic brakes for passenger vehicles, motorcycles, scooters, and mopeds, consists of the following:

- Brake pedal or lever
- A pushrod (also called an actuating rod)
- A master cylinder assembly containing a piston assembly
- Reinforced hydraulic lines





Brake caliper assembly usually consisting of one or two hollow aluminum or chrome-plated steel pistons (called caliper pistons), a set of thermally conductive brake pads and a rotor (also called a brake disc) or drum attached to an axle.

The system is usually filled with a glycol-ether based brake fluid (other fluids may also be used). At one time, passenger vehicles commonly employed drum brakes on all four wheels. Later, disc brakes were used for the front and drum brakes for the rear.

However disc brakes have shown better heat dissipation and greater resistance to 'fading' and are therefore generally safer than drum brakes. So four-wheel disc brakes have become increasingly popular, replacing drums on all but the most basic vehicles. Many two-wheel vehicle designs, however, continue to employ a drum brake for the rear wheel.The following description uses the terminology for and configuration of a simple .

In a hydraulic brake system, when the brake pedal is pressed, a pushrod exerts force on the piston(s) in the master cylinder, causing fluid from the brake fluid reservoir to flow into a pressure chamber through a compensating port. This results in an increase in the pressure of the entire hydraulic system, forcing fluid through the hydraulic lines toward one or more calipers where it acts upon one or two caliper pistons sealed by one or more seated O-rings (which prevent leakage of the fluid).

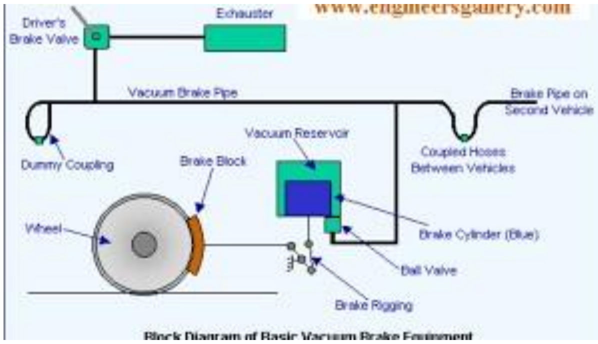
The brake caliper pistons then apply force to the brake pads, pushing them against the spinning rotor, and the friction between the pads and the rotor causes a braking torque to be generated, slowing the vehicle. Heat generated by this friction is either dissipated through vents and channels in the rotor or is conducted through the pads, which are made of specialized heat-tolerant materials such as kevlar or sintered glass.

Subsequent release of the brake pedal/lever allows the spring(s) in my master cylinder assembly to return the master piston(s) back into position. This action first relieves the hydraulic pressure on the caliper, then applies suction to the brake piston in the caliper assembly, moving it back into its housing and allowing the brake pads to release the rotor.

The hydraulic braking system is designed as a closed system: unless there is a leak in the system, none of the brake fluid enters or leaves it, nor does the fluid get consumed through use.

VACUUM BRAKING SYSTEM ;;

A moving train contains kinetic energy, which needs to be removed from the train for stopping the train. The best way of doing this is to convert the energy into heat. The conversion of kinetic energy into heat is usually done by adding a contact material in between the rotating wheels or to discs which is attached to the axles. The material which is added creates friction and converts the kinetic energy into heat. The speed is slow down and the train stops. For the braking the material used is pad or blocks. In the world's many trains are equipped with braking systems which use compressed air as the force for pushing the blocks on wheels. Such type of braking system known as "air brakes" or "pneumatic brakes".

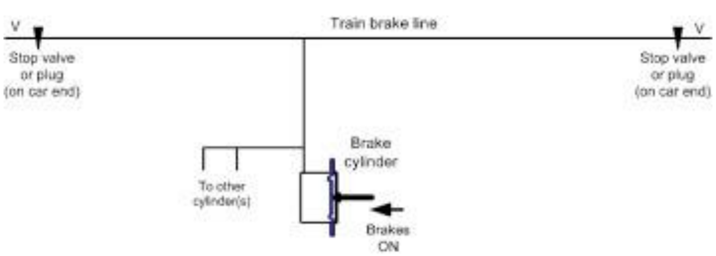


In these braking system the compressed air is transmitted along the train through a device known as a brake pipe. Different level of air pressure in the pipe causes a change in the magnitude of the brake on each vehicle. This can apply the brake, release it or hold it "on" after a partial application. This system is in limited use all over the world. There is alternative braking system to the air brake, known as the vacuum brake[VB], which was introduced around the early 1870s, the same time as the air brake. Similar to the air brake, the vacuum brake system is controlled or operated through a brake pipe. But the brake pipe connecting a brake valve in the driver's cab with braking equipment on every vehicle.

The operation of the brake equipment on each vehicle depends on the condition of a vacuum created in the pipe by an ejector or exhauster. The ejector, using steam on a steam locomotive, or an exhauster, using electric power on other types of train, removes atmospheric pressure from the brake pipe to create the vacuum. When a full vacuum in the brake pipe, the brake is released & when no vacuum, i.e. normal atmospheric pressure in the brake pipe, that time the brake is fully applied.

PARTS OF VACCUME BRAKING SYSTEM:

Driver's Brake Valve The driver brake valve used to control & monitor the brakes. The brake valve will have the following positions: Release, Running,Lap and Brake On. There may also be a Neutral or Shut Down position, which locks the valve out of use. In the release position, the exhauster connects to the brake pipe and switches the exhauster to full speed.



Vacuum Braking System

This causes rise in the vacuum in the brake pipe as fastly as possible to get a release. Brake Cylinder Every vehicles has atleast one cylinder but sometimes two or three cylinders are also there. Inside the cylinder piston is moves which operates the brakes through links called "rigging". The links which is known as rigging applies the blocks to the wheels.

The piston in the brake cylinder moves with respect to the vacuum in the brake pipe. Loss of vacuum applies the brakes,whereas restoration of the vacuum releases the brakes. Vacuum Reservoir The operation of the vacuum brake depends on the difference in pressure between one side of the brake cylinder piston and the other. Vacuum reservoir is provided to ensure that there is always availability of source of vacuum for operates the brakes. Which is connected to upper side of piston. In the simplest type of the brake cylinder is integral with the vacuum reservoir. Some vehicles has the brake have a separate reservoir and a piped connection to the upper side of the piston. Brake Block Brake block is the friction material which is pressed against the piston of brake cylinder.

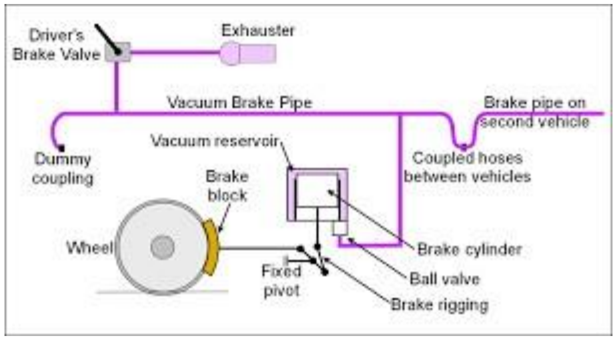
The brake block made of cast iron or some composition material, brake blocks are the main source of wear in the brake system. This brake block require regular inspection to see that they work effectively or not. Brake Rigging Brake rigging is the system in which the movement of the piston in the brake cylinder transmits pressure to the brake blocks on each wheel. Rigging can rarely be complex, generally under a passenger car with two blocks to each wheel, making a total of sixteen. The careful adjustment is needed by rigging to ensure that all blocks should be operated from same cylinder which provides the even rate of application on each wheel. When we change one block, that time we have to check and adjust all the blocks on that same axle. Exhauster A two-speed rotary machine fitted to a train to deplete the atmospheric pressure from the brake pipe, reservoirs and brake cylinders to release the brakes.

This is usually controlled from the driver's brake valve, in which switched in at full speed brake is release or at slow speed to maintain the vacuum at its release level while the train is running. Exhausters can be run directly from a diesel engine. Brake Pipe The vacuum-carrying pipe transmits the pressure difference required to control the brake throughout its length. By flexible hoses the brake pipes connected between the vehicles, which can be uncoupled to allow vehicles to be separated.

The use of the vacuum system makes the brake safe and prevents from failing of brakes, i.e. the loss of vacuum in the brake pipe will cause the brake to apply.

CONSTRUCTION OF VACUUM BRAKING SYSTEM

Vacuum braking system as shown in fig. consists of brake cylinder, compressor, vacuum reservoir, direction control valve, flow control valve, brake hoses, brake linkages, drum brake and foot brake pedal.



ADVANTAGES:

1. Simple in design.

2. Without any additional equipment ability to get partial release.

3. Greater amount of safety because the vacuum loss age results in the braking of the vehicle.

4. In case of rail wagons, highly reliable.

5. It permit the automatic application of brakes down the entire length of the train from the simple control in the driver's hand.

DISADVANTAGES: 1. On none ejector a vacuum pump is required.

2. Low pressure means relatively large brake cyclinder are required which may be awkward to site.

3. Leaks can be difficult to find.

4. High initial cost.

AIR BRAKES ;

Why Air Brakes?

Air brakes are used on heavy vehicles for a number of reasons:

• Air brake systems use a much greater force to apply the brakes than hydraulic braking systems do. This greater force is needed to cope with the heavy loads of commercial vehicles.

• Air brake systems are more tolerant to small leaks. The smallest leak in a hydraulic system could result in brake failure. An air brake system includes a compressor to generate more compressed air as needed.

• Air brakes are used on heavy vehicles because they have proven they are capable of stopping these vehicles safely.

This diagram shows the components that are used to make the simplest possible air brake system:

• A compressor to pump air, with a governor to control the compressor.

• Air lines to allow the pressurized air to flow between the air brake system components.

• A reservoir to store the compressed air.

• A brake pedal (usually called a foot valve) to apply the brakes by directing compressed air from the reservoir to the brakes.

• Foundation brakes, including brake chambers, slack adjusters, brake linings and drums or rotors, to transfer the force generated by the compressed air through a mechanical linkage to apply the brakes.

DIAGRAM

The above diagram shows the most common device used to apply truck air brakes — the air brake chamber.

It converts the force of compressed air into a strong mechanical force through the pushrod and slack adjuster. The air brake chamber consists of a flexible diaphragm clamped between two steel housings. The diaphragm construction is similar to a tire sidewall, consisting of a reinforced fabric core with a rubber coating. Other main parts are the pushrod and plate assembly, and a return spring.

DIAGRAM

This diagram shows how air under pressure is admitted to one side of the di a phragm, causing it to inflate. As it inflates, the diaphragm pushes against the pushrod, plate assembly and the return spring, causing them to move. Note the position of the slack adjuster — it is now at about a 90 degree angle to the pushrod. The amount of pushrod force is governed by the air pres sure (in pounds per square inch) and the effective surface area of the diaphragm (in square inches). The pushrod force is exerted against the brake mechanism, causing the brakes to apply.

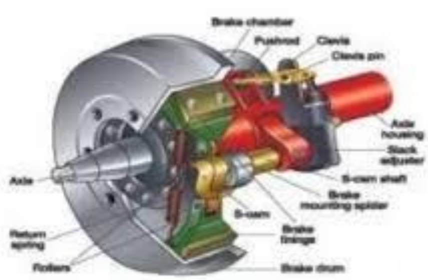
The most common size air chamber used on truck drive axles and trailer axles is a regular Type 30 clamp type chamber with 30 square inches of effective di a phragm area.

Air chambers are very powerful. The common Type 30 reg u lar chamber shown in the diagram above if applied with air pressure of 100 p.s.i. (690 kPa) develops a pushrod force of 3,000 pounds. Air chambers are made in a number of sizes, ranging from Type 9 (with nine square inches of effective di a phragm area) to Type 36 (with 36 square inches of ef fec tive diaphragm area).

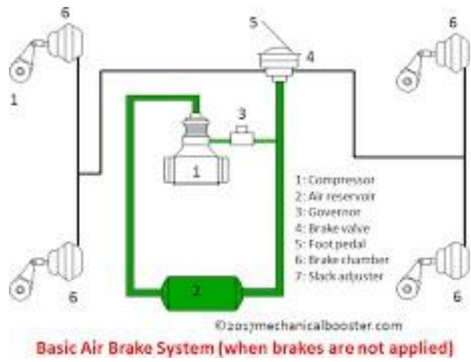
The range of sizes allows the truck engineer to match air chamber force with axle capacity so that no axle is under or over braked. However, even though truck air brake system pressures are 100 p.s.i. (690 kPa) and above, much lower air application pressure, usually less than 20 p.s.i. (138 kPa) is used to make normal stops.

Foundation brakes: S-cam type The brake assembly at each wheel is generally called the foundation brake. The assembly consists of the brake parts around the wheel that are operated by the air brake system, including the brake chamber. The most popular type of foundation brake is the “S” cam drum brake.

The brake drum on the right is mounted on the wheel and rotates with it. This diagram shows the main components used in the S-cam drum foundation brake. The air brake chamber pushrod is connected to a lever arm called a slack adjuster. The slack adjuster is attached to a camshaft with an S-shaped head called an S-cam. Air pressure applied to the chamber causes the pushrod to move for ward, causing the slack adjuster to rotate the S-cam. This causes the brake linings to press against the brake drum, causing friction, which causes the wheel to decelerate, stopping the vehicle.



The slack adjuster is also the means of adjusting the brakes to compensate for brake lining and brake drum wear. Brake adjustment is important and is covered in Chapter 8 — Air Brake Adjustment. Brake shoe return springs are used to keep the brake linings away from the drum when the air pressure is released from the air chamber.

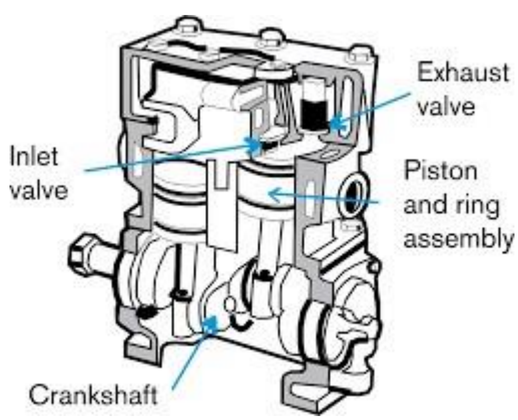


Compressor

The fi rst requirement of an air brake system is a means of compressing air and storing it in reservoirs (tanks) so that it is available for instant use. The source of the compressed air is the compressor, which takes in air from the atmosphere and compresses (pressurizes) it.

The compressed air is then pumped through an air line to a supply reservoir. A gear-driven compressor and governor.

The compressor is mounted on the engine of the bus or truck. On most new en gines, the compressor is mounted on the side of the engine and driven by gears. A belt, like a fan belt, drives some compressors. As long as the engine is run ning, the compressor will be running. All trucks use piston-type air compressors. They may have one, two or four cyl in ders depending on the volume demands of the particular vehicle.



When air is compressed, its temperature rises. With a truck air compressor op er at ing at a pressure of 120 p.s.i. (827 kPa), the air temperature as it leaves the compressor is over 204° C (400° F). To prevent the compressor from overheating, two types of cooling systems are used. The most common method on heavy trucks is to circulate engine coolant through the compressor, while some compressors on lighter units may be air-cooled.

Oil is used for lubricating the moving parts of the com pres sor, just like oil is used to lubricate the mov ing parts of a car's engine. Oil also helps to cool the compressor. The compressor is usually lubricated from the same oil as the engine of the truck or bus, though some compressors have their own separate oil supply. It is important to check that there is suffi cient oil sup ply .

Since the compressor pumps air, it needs a supply of clean air to work properly. Air from the atmosphere supplies both the truck engine and the compressor. An air fi lter is used to keep this supply clean. The air fi lter should be checked regularly to make sure it is not clogged, as this would restrict air fl ow. A piston-type compressor operates on a similar prin ci ple to that of the intake and compression strokes of a typical car engine.

Intake stroke ; As the piston moves down in the cylinder, it creates a lower pressure (vacuum) within the cylinder than the atmospheric pressure outside the compressor. With the inlet valve open, air is then drawn into the cylinder to fi ll the vacuum .

Compression stroke When the piston reaches the bottom of the cylinder it then begins to rise. The inlet valve closes, causing the air in the cylinder to compress. As the piston nears the top of the stroke, the discharge valve opens, and the pressurized air is forced past the valve and into the discharge line leading to the reservoir. Governor The compressor is capable of compressing air to over 500 p.s.i. (3,448 kPa).

This is far higher than is needed to operate an air brake system. Most current air brake systems operate with a maximum pressure of 125 p.s.i. (862 kPa). There needs to be a way to stop compressing air once a certain air pressure has been reached. And, if the air pressure in the tanks drops below a certain level (such as after a series of brake applications), there needs to be a way to start compressing air again. This is the job of the governor. When suffi cient pres sure has been built up, the governor causes the com pres sor to go into an "unloading" stage.

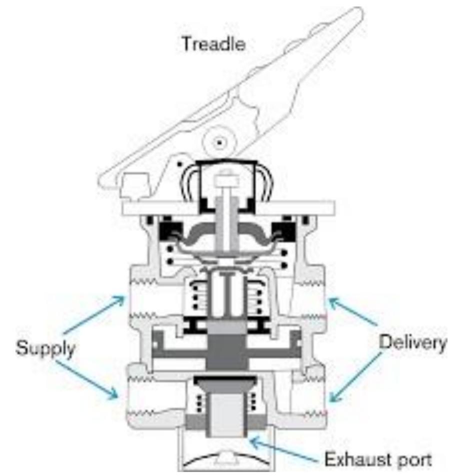
RESERVOIRS : Steel tanks (known as reservoirs) are used to store the compressed air from the compressor.

A safety valve will be installed on the fi rst reservoir to protect the res er voirs from being over-pressurized and bursting if the governor was to fail to unload the compressor. The safety valve consists of a springload ed ball to al low reservoir air to exhaust into the atmosphere. The valve's pressure set ting is determined by the force of the spring. Safety valves are normally set to vent the excess pressure at approximately 150 p.s.i. (1,034 kPa). If the safety valve has to relieve the pressure, this means that the governor or compressor needs service or repair. Only a qualifi ed mechanic should do this.

The air that is delivered from the compressor usually contains some water vapour that condenses into liquid water. This is why the supply reservoir is often called the wet tank. Most compressors also pass a small amount of oil and car bon particles. The oil and any other con tam i nants mix with the water, making a grey sludge. If allowed to accumulate, this sludge would enter other components of the brak ing system. An excess of water in the system causes trouble with valves and oth er parts.

In winter, water in the system may freeze, causing mal func tion of valves or brake chambers. To prevent this sludge from contaminating the air valves in the system, drain valves (also known as drain cocks) are installed in all reservoirs. Draining the reservoirs can prevent this sludge build up. Most manufacturers recommend that reservoirs be drained daily

Foot Valve : Pressing on the brake pedal (called the foot valve treadle) applies the air brakes, just like stepping on the brake pedal applies the brakes in a car.



Releasing the foot valve allows the application air to be exhausted through the assembly's exhaust ports to the atmosphere. In effect, it is a foot-controlled pressure regulator. It is the device that allows you to select any application pressure needed to make a gentle, or a very rapid stop. A unique feature of a foot control valve is the ability to maintain the ap pli ca tion pressure that you have cho sen, even if there are small leaks downstream from the foot valve. You need only to maintain the treadle po si tion and the foot valve will momentarily open, re plen ish any air that has been lost, and then close — all automatically.

WORKING :

In this simplifi ed diagram, air at full system pressure is in di cat ed by the dark shading in the line connecting the supply reservoir to the foot valve. The driver is making a brake application. This can be seen by the light shading in the air lines connecting the foot valve to the air chambers. Arrows show the direction of air fl ow.

The air chambers are pressurized and the brake linings have contacted the brake drums, slowing the vehicle

In this simplifi ed diagram, the driver's foot is off the brake pedal, allowing the brakes to release. This action has caused an exhaust port in the bottom of the foot valve to open, allowing the air that was applied to the brake chambers to es cape. Note the burst of exhaust air below the foot valve.

The return springs in the air chambers have returned the pushrod assembly to the released position, and the slack adjusters and S-cams have rotated to their re leased position. Brake shoe return springs (not shown) have retracted the brake linings away from the brake drums.

COOLING SYSTEM

The cooling system removes excess heat to keep the inside of the engine at an efficient temperature.

 Air Cooling

 Liquid Cooling

 Water cooling Coolant.

Water Jackets:

Water Jackets Surrounds the cylinders with water passage. Absorbs heat from the cylinder wall. Pump move water to radiator where heat is exchanged to the air.

Coolant Flow: Coolant flows through the water jackets where it absorbs heat. It then flows through the radiator where heat is transferred to the air passing through.

The amount of flow is determined by the water pump. The flow direction is controlled by the thermostat.

Warm Engine:

The thermostat opens when the engine warms up. This allows coolant to circulate through the radiator and the water jackets.

Cold Engine: When an engine is cold, the thermostat is cold. Coolant flow is through the bypass hose and the water jackets. This allows the engine to warm up evenly.

Coolant :

 Coolant Water (Boiling Point 100° C)

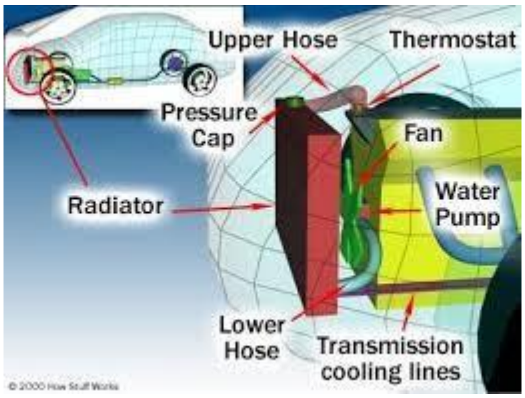
 Glycerin (Boiling Point 290 ° C) Ethylene glycol (Boiling Point 197 ° C)

 Antifreeze (methyl alcohol, ethyl alcohol) Cooling System:

 Water pump is driven by the crankshaft through Timing Belt (Keeps Cam and Crank shafts in time)

 Drive/accessory Belt (Runs alternator, power-steering pump, AC, etc.) Serpentine Belt V- Belt

 Electric fan is mounted on the radiator and is operated by battery power. It is controlled by the thermostat switch.



Need for cooling system:

The cooling system has four primary functions. These functions are as follows:

1. Remove excess heat from the engine.
2. Maintain a constant engine operating temperature.
3. Increase the temperature of a cold engine as quickly as possible.
4. Provide a means for heater operation (warming the passenger compartment).

Types of cooling system:

The different Types of cooling system are

1. Air cooling system
2. Liquid cooling system
3. Forced circulation system
4. Pressure cooling system

Air-Cooled System : The simplest type of cooling is the air-cooled, or direct, method in which the heat is drawn off by moving air in direct contact with the engine Several fundamental principles of cooling are embodied in this type of engine cooling.

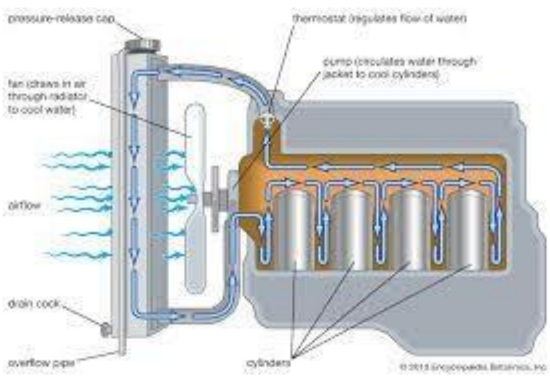
The rate of the cooling is dependent upon the following:

1. The area exposed to the cooling medium.

2. The heat conductivity of the metal used & the volume of the metal or its size in cross section .

3. The amount of air flowing over the heated surfaces.

4. The difference in temperature between the exposed metal surfaces and the cooling air.

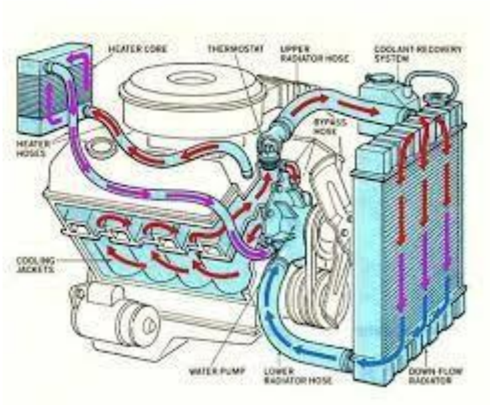


Liquid-cooled system; Nearly all multi cylinder engines used in automotive, construction, and material-handling equipment use a liquid-cooled system. Any liquid used in this type of system is called a COOLANT.

A simple liquid-cooled system consists of a radiator, coolant pump, piping, fan, thermostat, and a system of water jackets and passages in the cylinder head and block through which the coolant circulates. Some vehicles are equipped with a coolant distribution tube inside the cooling passages that directs additional coolant to the points where temperatures are highest.

Cooling of the engine parts is accomplished by keeping the coolant circulating and in contact with the metal surfaces to be cooled. The operation of a liquid- cooled system is as follows: The pump draws the coolant from the bottom of the radiator, forcing the coolant through the water jackets and passages, and ejects it into the upper radiator tank.

The coolant then passes through a set of tubes to the bottom of the radiator from which the cooling cycle begins.



The fan ensures airflow through the radiator at times when there is no vehicle motion. The downward flow of coolant through the radiator creates what is known as a thermosiphon action. This simply means that as the coolant is heated in the jackets of the engine, it expands. As it expands, it becomes less dense and therefore lighter. This causes it to flow out of the top outlet of the engine and into the top tank of the radiator. As the coolant is cooled in the radiator, it again becomes more dense and heavier. This causes the coolant to settle to the bottom tank of the radiator.

The heating in the engine and the cooling in the radiator therefore create a natural circulation that aids the water pump. The amount of engine heat that must be removed by the cooling system is much greater than is generally realized. To handle this heat load, it may be necessary for the cooling system in some engine to circulate 4,000 to 10,000 gallons of coolant per hour. The water passages, the size of the pump and radiator, and other details are so designed as to maintain the working parts of the engine at the most efficient temperature within the limitation imposed by the coolant.

Pressure cooling system

Radiator Pressure Cap :: The radiator pressure cap is used on nearly all of the modern engines. The radiator cap locks onto the radiator tank filler neck Rubber or metal seals make the cap-to-neck joint airtight.

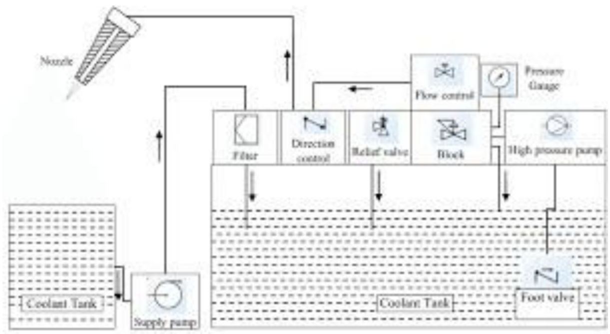
The functions of the pressure cap are as follows:

1. Seals the top of the radiator tiller neck to prevent leakage.

2. Pressurizes system to raise boiling point of coolant.

3. Relieves excess pressure to protect against system damage.

4. In a closed system, it allows coolant flow into and from the coolant reservoir.



The radiator cap pressure valve consists of a spring- loaded disc that contacts the filler neck. The spring pushes the valve into the neck to form a seal. Under pressure, the boiling point of water increases. Normally water boils at 212°F. However, for every pound of pressure increase, the boiling point goes up 3°F. Typical radiator cap pressure is 12 to 16 psi. This raises the boiling point of the engine coolant to about 250°F to 260°F. Many surfaces inside the water jackets can be above 212°F. If the engine overheats and the pressure exceeds the cap rating, the pressure valve opens. Excess pressure forces coolant out of the overflow tube and into the reservoir or onto the ground. This prevents high pressure from rupturing the radiator, gaskets, seals, or hoses. The radiator cap vacuum valve opens to allow reverse flow back into the radiator when the coolant temperature drops after engine operation. It is a smaller valve located in the center, bottom of the cap. The cooling and contraction of the coolant and air in the system could decrease coolant volume and pressure. Outside atmospheric pressure could then crush inward on the hoses and radiator. Without a cap vacuum or vent valve, the radiator hose and radiator could collapse .

LUBRICATION SYSTEM

Parts require lubrications Crankshaft bearing Piston pin Timing gears Valve mechanism Piston ring and cylinder walls Camshaft and bearings.

Purpose of lubrication:

- Reduce friction & wear - by creating a thin film (Clearance) between moving parts
- Seal power - The oil helps form a gastight seal between piston rings and cylinder walls
- Cleaning - Cleans As it circulates through the engine, the oil picks up metal particles and carbon, and brings them back down to the pan.
- Absorb shock - When heavy loads are imposed on the bearings, the oil helps to cushion the load
- Cooling. - Cools Picks up heat when moving through the engine and then drops into the cooler oil pan, giving up some of this heat.

Types Lubrication System:

 Petroil system

 Splash system

 Pressure system

 Dry-sump system

Oil change:

 Every 5000Km for four wheeler , Every 2000 Km in two wheeler Ignoring regular oil change intervals will shorten engine life and performance. All internal combustion engines are equipped with an internal lubricating system. Without lubrication, an engine quickly overheats and its working parts seize due to excessive friction.

All moving parts must be adequately lubricated to assure maximum wear and long engine life.

Purpose of Lubrication; The functions of an engine lubrication system are as follows:

Reduces friction and wear between moving parts.

Helps transfer heat and cool engine parts.

Cleans the inside of the engine by removing contaminants (metal, dirt, plastic, rubber, and other particles).

Absorbs shocks between moving parts to quiet engine operation and increase engine life. The properties of engine oil and the design of modern engines allow the lubrication system to accomplish these functions.

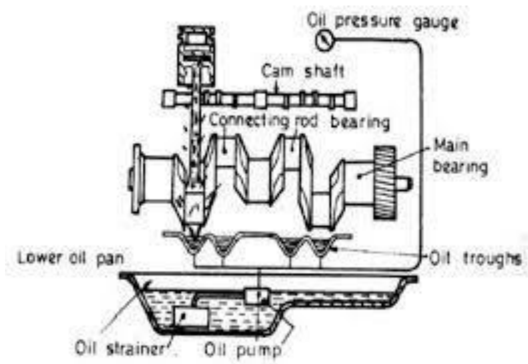
Types of Lubrication Systems;

Now that you are familiar with the lubricating system components, you are ready to study the different systems that circulate oil through the engine. The systems used to circulate oil are known as splash, combination splash force feed, force feed, and full force-feed.

1 .Splash Systems :

The splash system is no longer used in automotive engines. It is widely used in small four- cycle engines for lawn mowers, outboard marine operation, and so on. In the splash lubricating system, oil is splashed up from the oil pan or oil trays in the lower part of the crankcase.

The oil is thrown upward as droplets or fine mist and provides adequate lubrication to valve mechanisms, piston pins, cylinder walls, and piston rings. In the engine, dippers on the connecting-rod bearing caps enter the oil pan with each crankshaft revolution to produce the oil splash. A passage is drilled in each connecting rod from the dipper to the bearing to ensure lubrication.



This system is too uncertain for automotive applications. One reason is that the level of oil in the crankcase will vary greatly the amount of lubrication received by the engine. A high level results in excess lubrication and oil consumption and a slightly low level results in inadequate lubrication and failure of the engine.

2. Combination Splash and Force Feed :

In a combination splash and force feed, oil is delivered to some parts by means of splashing and other parts through oil passages under pressure from the oil pump. The oil from the pump enters the oil galleries.

From the oil galleries, it flows to the main bearings and camshaft bearings. The main bearings have oil-feed holes or grooves that feed oil into drilled passages in the crankshaft. The oil flows through these passages to the connecting rod bearings. From there, on some engines, it flows through holes drilled in the connecting rods to the piston-pin bearings. Cylinder walls are lubricated by splashing oil thrown off from the connecting-rod bearings. Some engines use small troughs under each connecting rod that are kept full by small nozzles which deliver oil under pressure from the oil pump. These oil nozzles deliver an increasingly heavy stream as speed increases.

At very high speeds these oil streams are powerful enough to strike the dippers directly. This causes a much heavier splash so that adequate lubrication of the pistons and the connecting-rod bearings is provided at higher speeds. If a combination system is used on an overhead valve engine, the upper valve train is lubricated by pressure from the pump. Force Feed A somewhat more complete pressurization of lubrication is achieved in the force-feed lubrication system.

Oil is forced by the oil pump from the crankcase to the main bearings and the camshaft bearings. Unlike the combination system the connecting-rod bearings are also fed oil under pressure from the pump. Oil passages are drilled in the crankshaft to lead oil to the connecting-rod bearings.The passages deliver oil from the main bearing journals to the rod bearing journals. In some engines, these opening are holes that line up once for every crankshaft revolution. In other engines, there are annular grooves in the main bearings through which oil can feed constantly into the hole in the crankshaft.

The pressurized oil that lubricates the connecting- rod bearings goes on to lubricate the pistons and walls by squirting out through strategically drilled holes. This lubrication system is used in virtually all engines that are equipped with semi floating piston pins. Full Force Feed In a full force -feed lubrication system, the main bearings, rod bearings, camshaft bearings, and the complete valve mechanism are lubricated by oil under pressure. In addition, the full force-feed lubrication system provides lubrication under pressure to the pistons and the piston pins. This is accomplished by holes drilled the length of the connecting rod, creating an oil passage from the connecting rod bearing to the piston pin bearing. This passage not only feeds the piston pin bearings but also provides lubrication for the pistons and cylinder walls. This system is used in virtually all engines that are equipped with full-floating piston pins.

CARBURETION

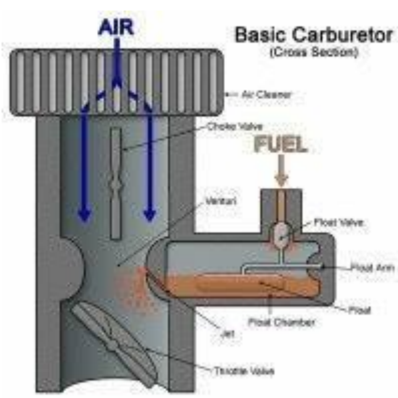
The fuel feed system for the Spark ignition engines and Compression ignition engines are clearly discussed below.

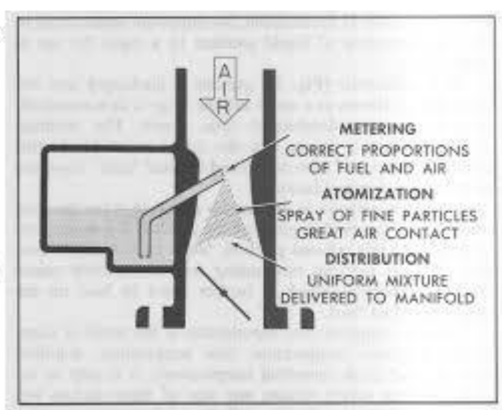
1. Fuel Injection system for SI engines;

Carburetion

Spark-ignition engines normally use volatile liquid fuels. Preparation of fuel-air mixture is done outside the engine cylinder and formation of a homogeneous mixture is normally not completed in the inlet manifold. Fuel droplets, which remain in suspension, continue to evaporate and mix with air even during suction and compression processes.

The process of mixture preparation is extremely important for spark-ignition engines. The purpose of carburetion is to provide a combustible mixture of fuel and air in the required quantity and quality for efficient operation of the engine under all conditions.





Definition of Carburetion;

The process of formation of a combustible fuel-air mixture by mixing the proper amount of fuel with air before admission to engine cylinder is called carburetion and the device which does this job is called a carburetor.

Definition of Carburetor;

The carburetor is a device used for atomizing and vaporizing the fuel and mixing it with the air in varying proportions to suit the changing operating conditions of vehicle engines. Factors Affecting Carburetion Of the various factors,

the process of carburetion is influenced by

i. The engine speed

ii. The vaporization characteristics of the fuel

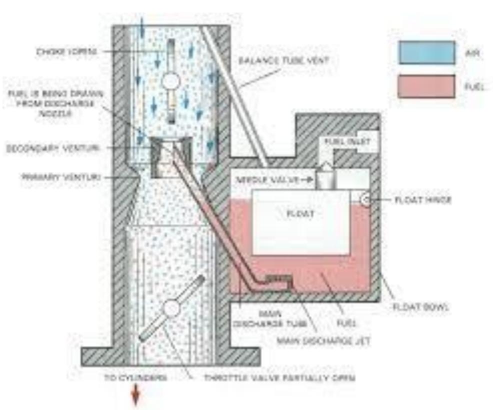
iii. The temperature of the incoming air and

iv. The design of the carburetor

Principle of Carburetion

Both air and gasoline are drawn through the carburetor and into the engine cylinders by the suction created by the downward movement of the piston. This suction is due to an increase in the volume of the cylinder and a consequent decrease in the gas pressure in this chamber.

It is the difference in pressure between the atmosphere and cylinder that causes the air to flow into the chamber. In the carburetor, air passing into the combustion chamber picks up discharged from a tube. This tube has a fine orifice called carburetor jet that is exposed to the air path. The rate at which fuel is discharged into the air depends on the pressure difference or pressure head between the float chamber and the throat of the venturi and on the area of the outlet of the tube. In order that the fuel drawn from the nozzle may be thoroughly atomized, the suction effect must be strong and the nozzle outlet comparatively small.



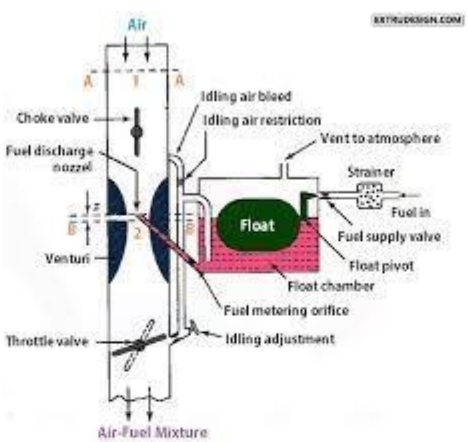
In order to produce a strong suction, the pipe in the carburetor carrying air to the engine is made to have a restriction. At this restriction called throat due to increase in velocity of flow, a suction effect is created. The restriction is made in the form of a venturi to minimize throttling losses. The end of the fuel jet is located at the venturi or throat of the carburetor.

The geometry of venturi tube is as shown in Fig.16.6 . It has a narrower path at the center so that the flow area through which the air must pass is considerably reduced. As the same amount of air must pass through every point in the tube, its velocity will be greatest at the narrowest point. The smaller the area, the greater will be the velocity of the air, and thereby the suction is proportionately increased As mentioned earlier, the opening of the fuel discharge jet is usually loped where the suction is maximum. Normally, this is just below the narrowest section of the venturi tube.

The spray of gasoline from the nozzle and the air entering through the venturi tube are mixed together in this region and a combustible mixture is formed which passes through the intake manifold into the cylinders. Most of the fuel gets atomized and simultaneously a small part will be vaporized. Increased air velocity at the throat of the venturi helps he rate of evaporation of fuel. The difficulty of obtaining a mixture of sufficiently high fuel vapour -air ratio for efficient starting of the engine and for uniform fuel-air ratio indifferent cylinders (in case of multi cylinder engine) cannot be fully met by the increased air velocity alone at the venturi throat.

The Simple Carburetor :

Carburetors are highly complex. Let us first understand the working principle bf a simple or elementary carburetor that provides an air fuel mixture for cruising or normal range at a single speed. Later, other mechanisms to provide for the various special requirements like starting, idling, variable load and speed operation and acceleration will be included.



The simple carburetor mainly consists of a float chamber, fuel discharge nozzle and a metering orifice, a venturi, a throttle valve and a choke. The float and a needle valve system maintain a constant level of gasoline in the float chamber. If the amount of fuel in the float chamber falls below the designed level, the float goes down, thereby opening the fuel supply valve and admitting fuel. When the designed level has been reached, the float closes the fuel supply valve thus stopping additional fuel flow from the supply system. Float chamber is vented either to the atmosphere or to the” upstream side of the venturi.

During suction stroke air is drawn through the venturi. As already described, venturi is a tube of decreasing cross-section with a minimum area at the throat, Venturi tube is also known as the choke tube and is so shaped that it offers minimum resistance to the air flow. As the air passes through the venturi the velocity increases reaching a maximum at the venturi throat. Correspondingly, the pressure decreases reaching a minimum. From the float chamber, the fuel is fed to a discharge jet, the tip of which is located in the throat of the venturi. Because of the differential pressure between the float chamber and the throat of the venturi, known as carburetor depression, fuel is discharged into the air stream.

The fuel discharge is affected by the size of the discharge jet and it is chosen to give the required air -fuel ratio. The pressure at the throat at the fully open throttle condition lies between 4 to 5 cm of Hg, below atmospheric and seldom exceeds8 cm Hg below atmospheric.

To avoid overflow of fuel through the jet, the level of the liquid in the float chamber is maintained at a level slightly below the tip of the discharge jet. This is called the tip of the nozzle. The difference in the height between the top of the nozzle and the float chamber level is marked in figure .

The gasoline engine is quantity governed, which means that when power output is to be varied at a particular speed, the amount of charge delivered to the cylinder is varied. This is achieved by means of a throttle v alve usually of the butterfly type that is situated after the venturi tube. As the throttle is closed less air flows through the venturi tube and less is the quantity of airfuel mixture delivered to the cylinder and hence power output is reduced. As the" throttle is opened, more air flows through the choke tube resulting in increased quantity of mixture being delivered to the engine. This increases the engine power output

. A simple carburetor of the type described above suffers from a fundamental drawback in that it provides the required A/F ratio only at one throttle position. At the other throttle positions the mixture is either leaner or richer depending on whether the throttle is opened less or more.

As the throttle opening is varied, the air flow varies and creates a certain pressure differential between the float chamber and the venturi throat. The same pressure differential regulates the flow of fuel through the nozzle. Therefore, the velocity of flow of air II and fuel vary in a similar manner.

The Choke and the Throttle :

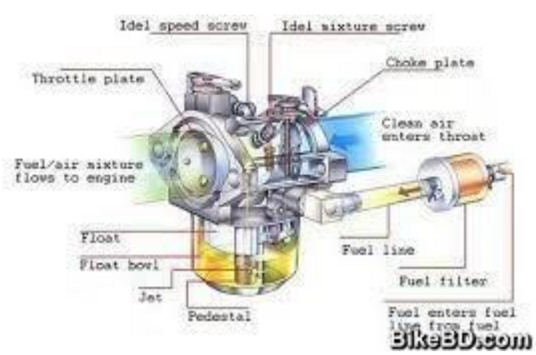
When the vehicle is kept stationary for a long period during cool winter seasons, may be overnight, starting becomes more difficult. As already explained, at low cranking speeds and intake temperatures a very rich mixture is required to initiate combustion.

Some times air-fuel ratio as rich as 9:1 is required. The main reason is that very large fraction of the fuel may remain as liquid suspended in air even in the cylinder. For initiating combustion, fuel-vapour and air in the form of mixture at a ratio that can sustain combustion is required. It may be noted that at very low temperature vapour fraction of the fuel is also very small and this forms combustible mixture to initiate combustion. Hence, a very rich mixture must be supplied.

The most popular method of providing such mixture is by the use of choke valve. This is simple butterfly valve located between the entrance to the carburetor and the venturi throat as shown in fig. When the choke is partly closed, large pressure drop occurs at the venturi throat that would normally result from the quantity of air passing through the venturi throat.

The very large depression at the throat inducts large amount of fuel from the main nozzle and provides a very rich mixture so that the ratio of the evaporated fuel to air in the cylinder is within the combustible limits. Sometimes, the choke valves are spring loaded to ensure that large carburetor depression and excessive choking does not persist after the engine has started, and reached a desired speed.

This choke can be made to operate automatically by means of a thermostat so that the choke is closed when engine is cold and goes out of operation when engine warms up after starting. The speed and the output of an engine is controlled by the use of the throttle valve, which is located on the downstream side of the venturi. The more the throttle is closed the greater is the obstruction to the flow of the mixture placed in the passage and the less is the quantity of mixture delivered to .the cylinders.



The decreased quantity of mixture gives a less powerful impulse to the pistons and the output of the engine is reduced accordingly. As the throttle is opened, the output of the engine increases. Opening the throttle usually increases the speed of the engine. But this is not always the case as the load on the engine is also a factor. For example, opening the throttle when the motor vehicle is starting to climb a hill may or may not increase the vehicle speed, depending upon the steepness of the hill and the extent of throttle opening. In short, the throttle is simply a means to regulate the output of the engine by varying the quantity of charge going into the cylinder.

Compensating Devices :

An automobile on road has to run on different loads and speeds. The road conditions play a vital role. Especially on city roads, one may be able to operate the vehicle between 25 to 60% of the throttle only. During such conditions the carburetor must be able to supply nearly constant air-fuel ratio mixture that is economical (16:1).However, the tendency of a simple carburetor is to progressively richen the mixture as the throttle starts opening.

The main metering system alone will not be sufficient to take care of the needs of the engine. Therefore, certain compensating devices are usually added in the carburetor along with the main metering system so as to supply a mixture with the required air-fuel ratio.

A number of compensating devices are in use.

The important ones are I

. Air-bleed jet

ii. Compensating jet

iii. Emulsion tube

iv. Back suction control mechanism

v. Auxiliary air valve

vi. Auxiliary air port

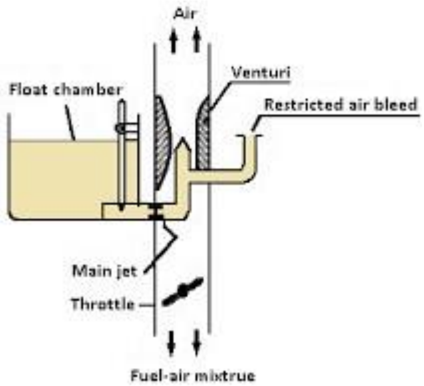
As already mentioned, in modern carburetors automatic compensating devices are provided to maintain the desired mixture proportions at the higher speeds.

The type of compensation mechanism used determines the metering system of the carburetor. The principle of operation of various compensating devices are discussed briefly in the following sections.

Air-bleed jet

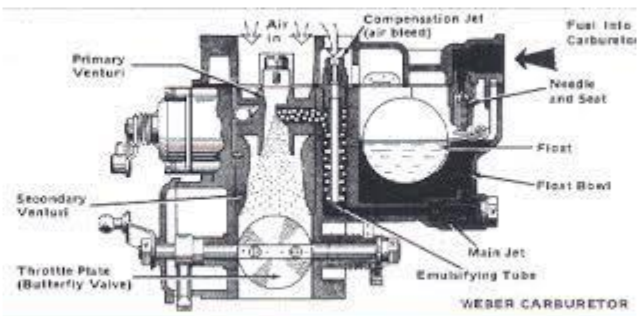
Air bleed principle in a typical carburetor Figure illustrates a principle of an air -bleed system in atypical modern downdraught carburetor. As could be seen it contains an air-bleed into the main nozzle. An orifice restricts the flow of air through this bleed and therefore it is called restricted air-bleed jet that is very popular. When the engine is not operating the main jet and the air bleed jet will be filled with fuel. When the engine starts, initially the fuel starts coming through the main as well as the air bleed jet (A).

As the engine picks up, only air starts coming through the air bleed and mixes with fuel at B making a air fuel emulsion. Thus the fluid stream that has become an emulsion of air and liquid has negligible viscosity and surface tension. Thus the flow rate of fuel is augmented and more fuel is sucked at low suctions. ‘By proper design of hole size at B compatible with the entry hole at A, it is possible to maintain a fairly uniform mixture ratio for the entire power range of the operation of an engine. If the fuel flow nozzle of the air-bleed system is placed in the centre of the venturi, both the air-bleed nozzle and the venturi are subjected to same engine suction resulting approximately same fuel-air mixture for the entire power range of operation.



AIR BLEED PRINCIPLE IN A TYPICAL CARBURETOR

Compensating Jet Compensating Jet device .The principle of compensating jet device is to make the mixture leaner as the throttle opens progressively. In this method, as can be seen from in addition to the main jet, a compensating jet is incorporated. The compensating jet is connected to the compensation well. The compensating well is also vented to atmosphere like the main float chamber



. The compensating well is supplied with fuel from the main float chamber through a restricting orifice. With the increase in airflow rate, there is decrease of fuel level in the compensating well, with the result that fuel supply through the compensating jet decreases. The compensating jet thus progressively makes the mixture leaner as the main jet progressively makes the mixture richer. The main jet curve and the compensating jet curve are more or less reciprocals of each other.

Emulsion Tube:

The mixture correction is attempted by air bleeding in modern carburetor. In one such arrangement as shown in Fig.6, the main metering jet is kept at a level of about 25 mm below the fuel level in the float chamber. Therefore, it is also called submerged jet. The jet is located at the bottom of a well. The sides of the well have holes. As can be seen from the figure these holes are in communication with the atmosphere. In the beginning the level of petrol in the float chamber and the well is the same. Emulsion Tube When the throttle is opened the pressure at the venturi throat decreases and petrol is drawn into the air stream.

This results in progressively uncovering the holes in the central tube leading to increasing air -fuel ratios or decreasing richness of mixture when all holes have been uncovered. Normal flow takes place from the main jet. The air is drawn through these holes in the well, and the fuel is emulsified and the pressure differential across the column of fuel is not as high as that in simple carburetor

Acceleration Pump System:

Acceleration is a transient phenomenon. In order to accelerate the vehicle and consequently its engine, the mixture required is very rich and the richness of the mixture has to be obtained quickly and very rapidly. In automobile engines situations arise when it is necessary to accelerate the vehicle. This requires an increased output from the engine in a very short time. If the throttle is suddenly opened there is a corresponding increase in the air flow.

However, because of the inertia of the liquid fuel, the fuel flow does not increase in proportion to the increase in air flow. This results in a temporary lean mixture ca11singtheengine to misfire and a temporary reduction in power output.

To prevent this condition, all modern carburetors are equipped with an accelerating system. Figure 7. illustrates simplified sketch of one such device. The pump comprises of a spring loaded plunger that takes care of the situation with the rapid opening of the throttle valve. The plunger moves into the cylinder and forc es an additional jet of fuel at the venturi throat.

When the throttle is partly open, the spring sets the plunger back. There is also an arrangement which ensures that fuel in the pump cylinder is not forced through the jet when valve is slowly opened or leaks past the plunger or some holes into the float chamber.

Mechanical linkage system, in some carburetor, is substituted by an arrangement where by the pump plunger is held up by manifold vacuum. When this vacuum is decreased by rapid opening of the thr ottle, a spring forces the plunger down pumping the fuel through the jet.

Types of Carburetors:

There are three general types of carburetors depending on the direction of flow of air.

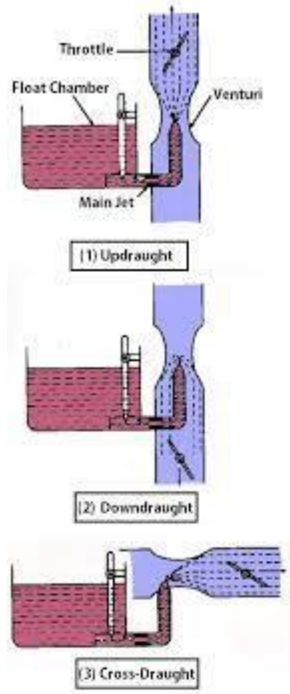
The first is the up draught type shown in fig. in which the air enters at the bottom and leaves at the top so that the direction of its flow is upwards. The disadvantage of the up draught carburetor is that it must lift the sprayed fuel droplet by air friction. Hence, it must be designed for relatively small mixing tube and throat so that even at low engine speeds the air velocity is sufficient to lift and carry the fuel particles along. Otherwise, the fuel droplets tend to separate out providing only a lean mixture to the engine.

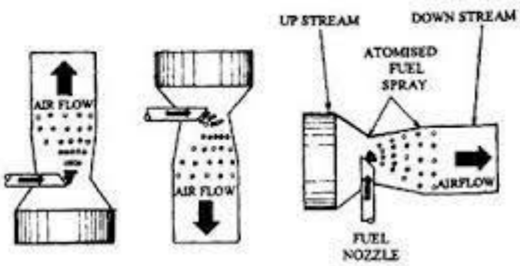
On the other hand, the mixing tube is finite and small then it cannot supply mixture to the engine at a sufficiently rapid rate at high speeds . Types of Carburetors In order to overcome this drawback the downdraught carburetor is adopted. It is placed at a level higher than the inlet manifold and in which the air and mixture generally follow a downward course. Here the fuel does not have to be lifted by air friction as in the up draught carburetors but move into the cylinders by gravity even if the air velocity is low. Hence, the mixing tube and throat can be made large which makes high engine speeds and high specific outputs possible.

Constant Choke Carburetor:

In the constant choke carburetor, the air and fuel flow areas are always maintained to be constant. But the pressure difference or depression, which causes the flow of fuel and air, is being varied as per the demand on the engine. Solex and Zenith carburetors belong to this class.

Constant Vacuum Carburetor: In the constant vacuum carburetor, (sometimes called variable choke carburetor) air and fuel flow areas are being varied as per the demand on the engine, while the vacuum is maintained to be always same. The S.U. and Carter carburetors belong to tills class.





. Fuel Injection system for C I engines;

Fuel system components FUEL INJECTION PUMP - Fuel injection pump sucks fuel from the tank , pressurizes the fuel to approx. 600 - 1000 bar and sends it to the injectors. Inline FIP - Has separate pumping chambers for each cylinder Rotary **FIP** (Distributor pump) - Has one pumping chamber and the pump distributes to each cylinder as per sequence- firing order

INJECTORS - Inject the high pressure fuel in to each cylinder. FUEL FILTER - Filters the fuel from dirt & sediments, since the Fuel injection pump requires clean fuel.

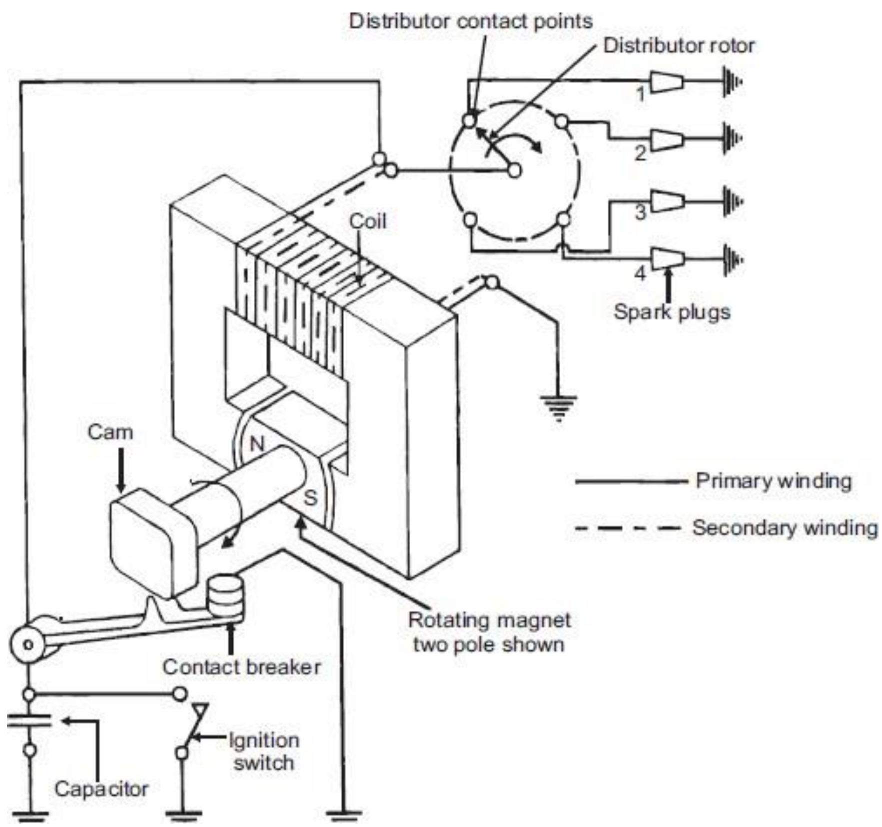
Injection system In the C.I. engine the fuel is injected into the combustion chamber, it the has to mix thoroughly with the air, ignite and burn all at the same time. To insure this happens, two types of combustion chamber have been developed. Direct Injection Indirect Injection 2.2.1.

Electronic Diesel Control :

Electronic Diesel Control is a diesel engine fuel injection control system for the precise metering and delivery of fuel into the combustion chamber of modern diesel engines used in trucks and cars.

The mechanical fly-weight governors of inline and distributor diesel fuel injection pumps used to control fuel delivery under a variety of engine loads and conditions could no longer deal with the ever increasing demands for efficiency, emission control, power and fuel consumption.

These demands are now primarily fulfilled by the Electronic Control, the system which provides greater ability for precise measuring, data processing, operating environment flexibility and analysis to ensure efficient diesel engine operation. The EDC replaces the mechanical control governor with an electro-magnetic control device.



Diagram

Magneto Ignition System

Definition:

The magneto ignition system is an ignition system in which we use magneto for the generation of electricity and further that electricity isused in several things like :To run the vehicles.

This is basically used in two-wheeler vehicles (SI Engine) nowadays.

A rotating magnet produces high voltage, which is used in:

Tractors, Outboard Motors

Washing Machines

Buses

Power Units, Marine Engines, and Natural Gas Engines.

Magneto ignition system is a special type of ignition system with its own electric generator to provide the required necessary energy for the vehicle (automobile) system. It is mounted on the engine and replaces all components of the coil ignition system except the spark plug. A magneto, when rotated by the engine, is capable of producing a very high voltage and doesn't need a battery as source of external energy.

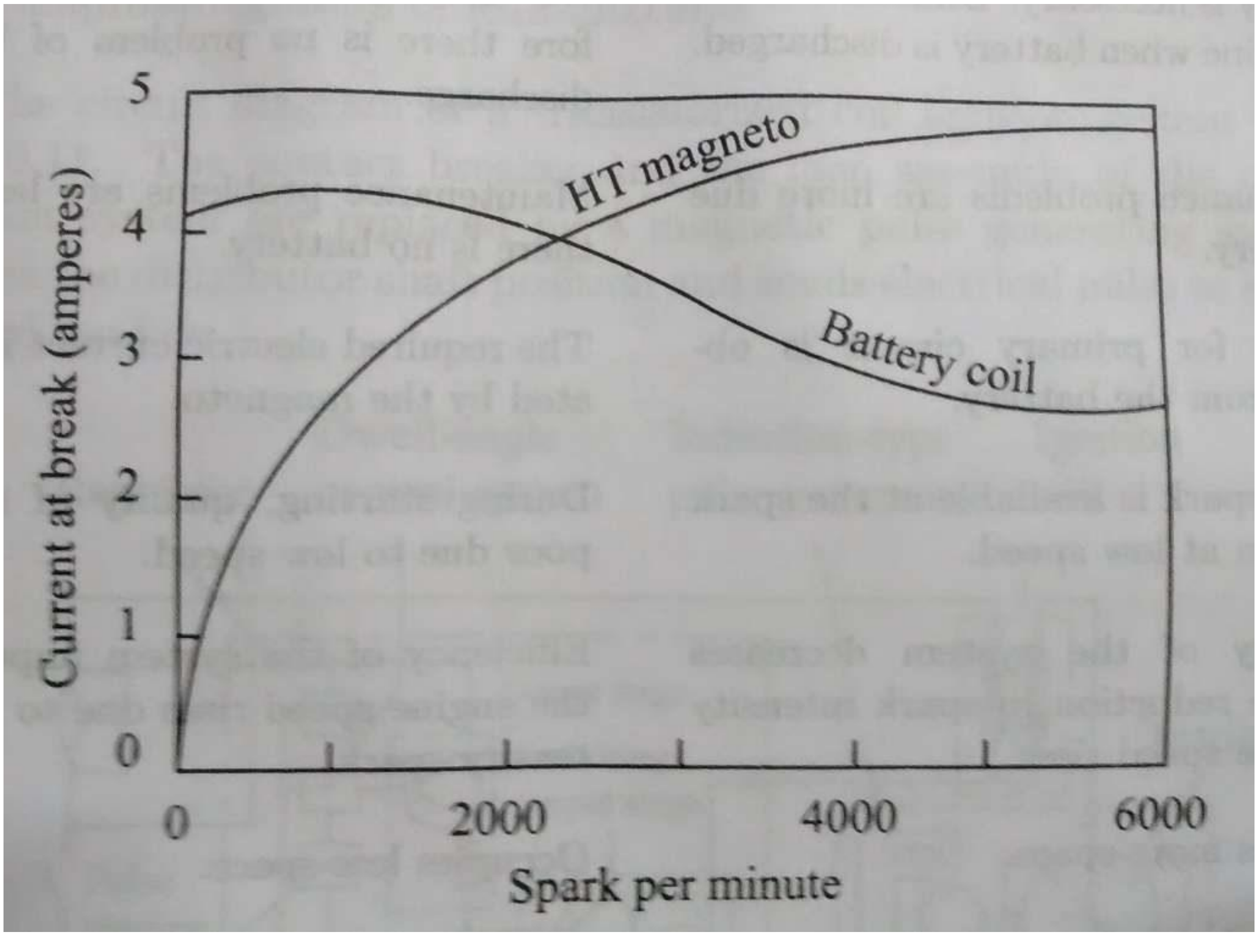
A schematic diagram of a high tension magneto ignition system is shown in the figure 1 under. The high tension magneto ignition system incorporates the windings to generate the primary voltage as well as to set up the voltage and thus does not require to operate the spark plug.

Magneto ignition system can be either rotating armature type or rotating magneto type.

9. In the first type, the armature consisting of the primary and secondary windings all rotate between the poles of a stationary magnet.
10. In the second type, the magnet revolves and windings are kept stationary.
11. The third type of magneto called the polar inductor type in use. In the polar inductor type magneto, both the magnet and the windings remain stationary but the voltage is generated by reversing the flux field with the help of soft iron polar projections, called inductors.

The working principle of the magnetic ignition system is same as that of the coil ignition system. With the help of a cam, the primary circuit flux is changed and a high voltage is produced in the secondary circuit.

The variation of the breaker current with speed for the coil ignition system and the magnetic ignition system is shown in the graph 1. It can be seen that since the cranking speed at stat is low the current generated by the magneto is quite small. As the engine speed increases the current flow also increases. Thus, with magneto, there is always a starting difficulty and sometimes a separate battery is needed for starting. The magneto ignition system is best suitable at high speeds and is widely used in automobiles like sports and racing cars, aircraft's engines etc.



Graph 1: Breaker current vs speed in coil and magneto ignition system

In comparison, the battery ignition system is more expensive but highly reliable. Because of the poor starting characteristics of the magneto system invariably the battery ignition system is preferred to the magneto system in automobile engines. However, in two wheelers magneto ignition system is favored due to light weight and less maintenance.

The main advantage of the high tension magneto ignition system lies in the fact that the wirings carry a very high voltage and thus there is a strong possibility of causing engine misfire due to leakage. To avoid this the high tension wires must be suitably shielded. The development of the low tension magneto system is an experiment to avoid this trouble. In the low tension, magneto ignition system the secondary winding is changed to limit the secondary voltage to a value of about 400 volts and distributor is replaced by a brush contact. The high voltage is obtained with the help of a step-up transformer. All these changes have the effect of limiting the high voltage current in the small part of the ignition system wiring and thus avoid the possibilities of leakage etc.

Battery Ignition System

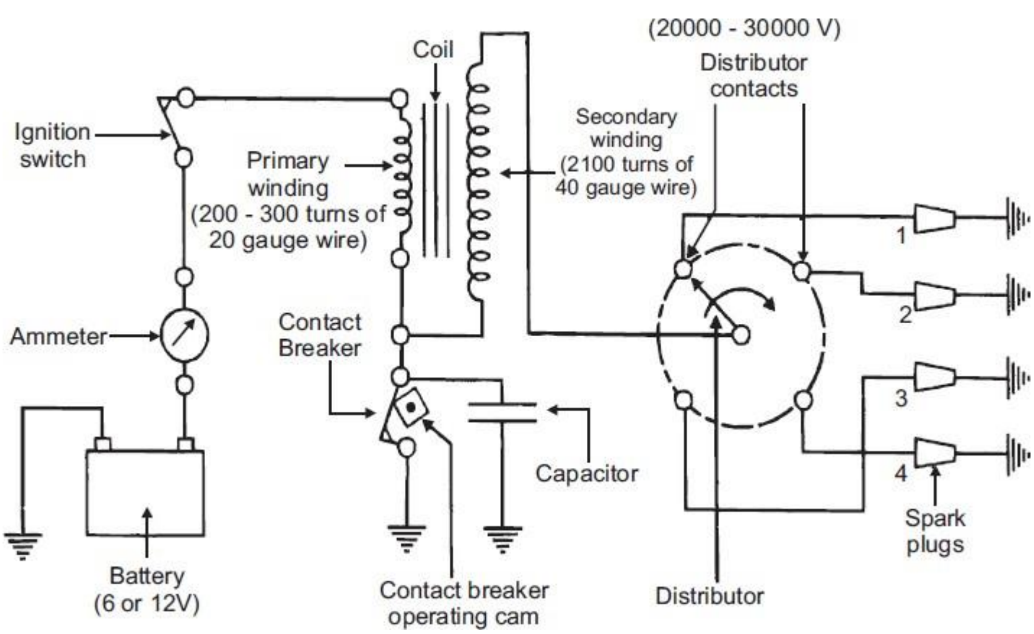
Most of the modern spark-ignition engines use **battery ignition system**. The essential components of battery ignition system are a battery, ignition switch, ballast resistor, ignition coil, breaker points, condenser, capacitor distributor and spark plugs.

The breaker points, condenser, distributor rotor and the spark advance mechanisms are usually housed in the ignition distribution. The breaker points are actuated by a shaft driven at half engine speed for a four stroke cycle engine. The distributor rotor is directly connected to the same shaft.

The system has a primary circuit of low-voltage current and a secondary circuit for the high-voltage circuit.

The primary circuit consists of the battery, ammeter, ignition switch, primary coil winding and breaker points. The primary coil winding usually has approximately 240 turns of relatively heavy copper wire wound around the soft iron core of ignition coil.

The secondary circuit contains the secondary coil windings, distributor, spark plug leads and the spark plug. The secondary windings consists of about 21000 turns of small, well insulate copper wire.



Schematic diagram of Battery Ignition System

When the ignition switch and the breaker points are closed a low-voltage current flows from the battery through the primary circuit and builts up a magnetic field around the soft iron core of the ignition coil.

When the breaker points are opened by the action of the cam on the distributor shaft, the primary circuit is broken and the magnetic field begins to collapse, an induced current from the collapsing magnetic field flows in the same direction in the primary circuit as the battery current and charges the condenser which acts as a reservoir for the flowing current due to a rapidly collapsing magnetic field, high voltage is induced in the primary (it might be as high as 250 volts) and even higher in the secondary (10,000 to 20,000 volts).

The high voltage in the secondary passes through the distributor rotor to one of the spark plug leads and into the spark plug. As soon as sufficient voltage is built up in the secondary to overcome the resistance of a spark plug, the spark arcs across the gap and the ignition of the combustible charge in the cylinder takes place.

The induced current in the primary to overcome the resistance of a spark across the gap and the ignition of the combustible charge in the cylinder takes place. The induced current is the primary, as it was pointed out above flows in the same direction as it did before the breaker points opened up and charges the condenser.

The increasing potential of the condenser retardsand finally stops the flowof current in the primary circuit and the rapidly 'backfires' or discharges again through the primary, but in the direction opposite to the original flow of current. This rapid discharge of condense produces directional oscillation in the current flow in the primary circuit.

This oscillation is weekend with every succeeding reversal in the current flow until the original potentials and the direction of current flow the primary circuit are established. The discharge of condenser by itself does not produce the spark, but only hastens the collapse of the magnetic field around the soft iron core.

The condenser, which has a capacitance range from 0.15 to 0.24 mf in the automotive system, not only assists in the collapse f the magnetic field, but also prevents arcing at the breaker points by providing a place for the induced current to flow in the primary circuit.

If the condenser is too small or too large, the breaker points will lead to excessive pitting will result the breaker points and the distributor must be carefully synchronized with the crankshaft of the engine to give the proper timing of the spark in each of the cylinders. The breaker is often refereed to as the timer, since the time or point in the cycle that the spark occurs depends upon the time of opening of the breaker points.

The spark plug leads are called the ignition harness. Since the lead carry a very high potential, a special insulation is required to prevent a short circuit. Even with the special insulation, these leads are subjected to breakdowns which result in high-tension short circuits and to leakage that lower the voltage available at the work plug. Also, the leads should be shielded to aid in the prevention of radio interference.

FUELS &FUEL INJECTION ;

In IC engines, the chemical energy contained in the fuel is converted into mechanical power by burning (oxidizing) the fuel inside the combustion chamber of the engine.

Fuels suitable for fast chemical reaction have to be used in IC engines, they are following types-

(a) Hydrocarbons fuels derived from the crude petroleum by proper refining processsuch as thermal and catalytic cracking method, polymerisation, alkylation, isomerisation, reforming and blending.

(b) Alternative fuels such as-Alcohols (methanol, ethanol) Natural gas (methane) LPG (propane, butane) Hydrogen *Classification of petroleum fuels used for IC engine: Liquid hydrocarbons- Engine fuels are mainly mixtures of hydrocarbons, with bonds between hydrogen and carbon atoms. During combustion these bonds are broken and new bonds are formed with oxygen atoms, accompanied by the release of chemical energy.

Principal products are carbon dioxide and water vapour. Fuels also contain small amounts of S, O_2, N_2, H_2O. The different constituents of crude petroleum which are available in liquid hydrocarbons are-paraffins, naphthenes, naphthenes, olefins, aromatics.

(i) Paraffin- -Paraffins or alkanes can in general be represented by-C_nH_{2n+2} -All the carbon bonds are single bonds – they are “saturated” high number of H atoms, high heat content and low density (620 – 770 kg/m3) -The carbon atoms can be arranged as a straight chain or as branched chain compounds. -Straight chain group (normal paraffins)

 shorter the chain, stronger the bond

 not suitable for SI engines – high tendancy for autoignition according to the value of “n” in the formula, they are in gaseous (1 to 4), liquid (5 to 15) or solid (>16) state.

-Hexan C_6H_{14} (normal paraffin) H H H H H H H – C – C – C – C – C – C – H H H H H H H - Branched chain compounds (isoparaffins) When four or more C atoms are in a chain molecule it is possible to form isomers, they have the same chemical formula but different structures, which often leadsto very different chemical properties.

Example: Iso-octane- C_8H_{18}

(ii) Naphthenes- -Also called as cycloparaffins and represented as C_nH_{2n} -Saturated hydrocarbons which are arranged in a circle have stable structure and low tendancy to autoignite comparedto alkanes (normal paraffins) -Can be used both in SI-engines and CI-engines -Low heat content and high density (740 – 790 kg / m^3)

(iii) Olefins- -Olefins or alkenes are represented as Mono olefins-C_nH_{2n} or Dio-olefins C_nH_{2n-2} -Olefins have the same C-to-H ratio and the same general formula as naphthenes, their behavior and characteristics are entirely different -They are straight or branch chain compounds with one or more double bond. The position of the double bond is indicated by the number of first C atom to which it is attached, i.e., $CH_2=CH.CH_2.CH_2.CH_3$ called pentene-1 $CH_3.CH=CH_3$ called butene-2 -Olefinic compounds are easily oxidized, have poor oxidation stability -Can be used in SI-engines, obtained by cracking of large molecules low heat content and density in the range 620 – 820 kg / m^3 Alkenes are such as, Hexen (mono-olefin) H H H H H H H – C – C – C – C – C = C - H H H H H Butadien (dio-olefin) H H H H H – C = C – C = C – H

(iv) Aromatics- -These are so called due to aromatics odour and represented as C_nH_{2n-6} -They are based on a six-membered ring having three conjugated double bonds -Aromatic rings can be fused together to give polynuclear aromatics, PAN, also called polycyclic aromatic hydrocarbons, PAH simplest member is benzene (C_6H_6) -Can be used in SI-engines, to increase the resistance to knock not suitable for CI-engines due to low cetene number -Low heat content and high density in the range 800 – 850 kg / m^3

*Refinery processes:

Crude oil is the liquid part of the naturally occurring organic material composed mostly of HCs that is trapped geologically in underground reservoirs – it is not uniform and varies in density, chemical composition, boiling range etc. for different fields. The refinery processes involved in production of different range of fuel is shown in

(i) CNG (Compressed Natural Gas)

-Natural gas consists of elements of compressor, some sort of compressed gas storage and dispensing unit of CNG into vehicles -Two types of CNG refueling system- slow fill and fast fill. In slow fill system, several vehicles are connected to the output of the compressor at one time. These vehicles are then refilled over several hours of compressor operation. In fast fill systems, enough CNG is stored so that several vehicles can be refueled one after the other, just like refueling from a single gasoline dispenser -The storage system of CNG is arranged as several tanks in cascade form. The CNG pressure in cascade is higher than the maximum storage pressure of the cylinder on the vehicle. The cascade attempts to deliver as much of its CNG to vehicles as possible before the pressure difference decreases to where the flow rate slows dramatically. A dryer should include in most CNG refueling systems to remove water vapor, impurities and hydrogen sulphide from natural gas before it is compr essed. If water vapor is present then it can condense in the vehicle fuel system, causing corrosion especially if hydrogen sulphide is present. CNG driven vehicles with catalytic converter have less CO and HC emission but NOx emission is high

(ii) LPG (Liquefied Petroleum Gas) -

LPG is available in the market in two forms- one is propane and the other is butane. Propane is popular alternative fuel because of its infrastructure of pipe lines, processing facilities and storage for its efficient distribution and also it produces fewer emissions. Propane is produced as a byproduct of natural gas processing and crude oil refining - Natural gas contains LPG, water vapor and other impurities and about 55% of the LPG is compressed from natural gas purification. LPG is a simple mixture of hydrocarbon mainly propane/propylene (C3S) and butane/ butylenes (C4S) -Propane is an odorless, nonpoisonous gas which has lowest flammability range. Utilization of LPG LPG is used as a fuel in heating appliances and vehicles. It is increasingly used as an aerosol propellant and a refrigerant, replacing chlorofluorocarbons in an effort to reduce damage to the ozone layer -In Europe, LPG is used as an alternative to electricity and heating oil (kerosene).It can also be used as power source for combined heat and power technologies (CHP). CHP is the process of generating both electrical power and useful heat from a single fuel source. This technology has allowed LPG to be used not just as fuel for heating and cooking, but also for de - centralized generation of electricity -LPG has higher potential as an alternate fuel for IC engine.

Advantages of LPG

-Emission is much reduced by the use of LPG.

-LPG mixes with air at all temperatures.

-Uniform mixture can be supplied to all cylinders of multi-cylinder engine.

-Engine with high compression ratio (10:1) can use propane.

-There is cost saving of about 50% and longer life with LPG running engine.

Disadvantages of LPG

(i) A good cooling system is necessary because LPG vaporizer uses engine coolant to provide the heat to convert the liquid LPG to gas [2].

(ii) The weight of vehicle is increased due to the use of heavy pressure cylinder for storing LPG.

(iii) A special fuel feed system is required for LPG.

(iv) Requirement of safety device to prevent accident due to explosion of gas cylinders or leakage in the gas pipes.

(f) Producer Gas:

-Producer gas is a product of oxidation-reduction reactions of air with biomass. Biomass is chemically composed of elements C, H, O and some N and hence the oxidation results in products of combustion like CO2 and H2O. The molecules of O2 in the air oxidises C and H to produce these products. The gases which are at high temperature due to partial oxidation pass through a bed of charcoal (which is produced because of oxidation reaction itself) and the reduction reaction of these gases with carbon leads to carbon monoxide and hydrogen -Volumetric composition of producer gas is CO (16-20%), H_2 (16-18%), CO_2 (8-10%) and some traces of higher hydrocarbons. Producer gas has a high percentage of N_2, since air is used.

So it has a low heat value. Density of producer gas is 0.9 to 1.2 kg/m3 -Producer gas is used in reciprocating engines and furnace. It needs little air to burn stoichiometrically and raise the temperature to a value of 1500 K at normal temperature and pressure. It is also used to power gas turbines (which are well-suited to fuels of low calorific value), spark ignited engines (where 100% petrol fuel replacement is possible) or diesel internal combustion engines (where 40% - 15% of the original diesel fuel) is still used to ignite the gas.

(g) Blast Furnace Gas:

It is a byproduct of melting iron ore in steel plants. It principally consists of CO and contains low heat value similar to producer gas. It consists of about 60% nitrogen, 18 -20% CO_2 and some amount of oxygen which are not flammable. It may be combined with natural gas or coke oven gas before combustion or a flame support with richer gas or oil is provided to sustain combustion. The auto ignition temperature of blast furnace gas is approximate 630 °C and it has Lower Explosive Limit (LEL) of 27% &Upper Explosive Limit (UEL) of 75% in an air-gas mixture at normal temperature and pressure. The gas is hazardous due to higher concentration of carbon monoxide [50].It should be cleaned properly because it contains lot of dust particles. Blast furnace gas depends upon types of fuel used and method of operating the blast furnace.

(h) Coke Oven Gas:

It is produced during the making of coke. It is also resulting from oxidation-reduction reactions of coal or coke with air and sometimes steams. It depends upon the type of coal used and operation method of oven. The composition of coke oven gas is H_2 (54% vol), CH_4 (24%), CO (8%), CO_2 (6%) and some traces of higher hydrocarbon and nitrogen. With the application of heat the heavier hydrocarbons are cracked and volatile portion of coal is driven off and results in high composition of $H_2$and CH_4. Its heat value per cubic meter is only about one half that of natural gas and density is 0.40 kg/m3 .

*General Fuel Specifications:

Different properties of fuels have,

Relative density (specific gravity) Fuel composition Specific heating value Flash point Viscosity Surface tension Freezing point

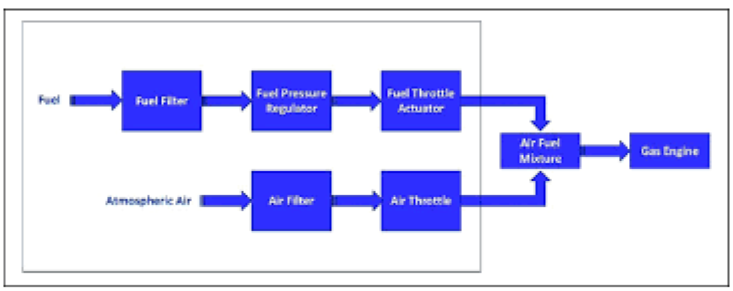
(a) Relative density (specific gravity): It is related to the measurement of the ratio of the weight of a given volume of fuel to the weight of the same volume of water, both at 20 OC and 101.325 kPa For gasoline, the relative density is around 0.72 to 0.78 - which is equivalent to an API (American petroleum institute) range of 65 to 50, $\rho = 700 - 800$ [kg/m3], for unleaded gasoline this value is higher due to the aromatics For diesel fuel, $\rho = 830 - 950$ [kg/m3]

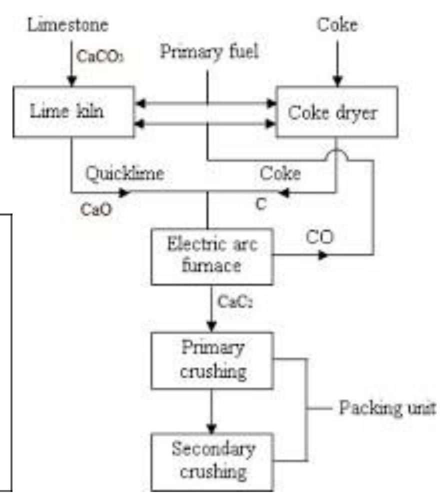
(b) Fuel composition: C and H: carbon content of aromatics is around 89 %, and of paraffins and naphthenes is around 86 % Benzene: max allowable concentration is specified because it is highly toxic material, the level is 5 % Sulphur content: HC fuels contain free sulphur, hydrogen sulphide and other sulphur compounds which are objectionable it is a corrosive element that can corrode fuel lines, carburettor and injection pump. It will unite with oxygen to form sulphur dioxide, which in presence of water at low T, forms sulphurous acid. -It has low ignition T, promote knock in SI engines. limited to approx 250 ppm (50 ppm is aimed for low pollutant emitting vehicles) Gum deposits: gasoline with unsaturated HCs forms gum in the engine, paraffin, naphthene and aromatic HCs also form some gum – it causes operating difficulties, sticking valves and piston rings, deposits in the manifold etc.

Water: both dissolved and free water can be present in gasoline, free water is undesirable because it can freeze and cause problems. Dissolved water is usually unavoidable during manufacture.

Lead: for leaded and unleaded gasoline max lead content is specified, lead causes pollution and destroys catalytic converters in the exhaust system.

Manganese: used for antiknock in gasoline (MMT), max amount is specified, 0.00025 to 0.03 gMn/L Oxygenates: oxygenated compounds such as alcohols are used in gasoline to improve octane rating. In USA gasohol (10% ethanol contains 3.5% oxygen), TBA and methanol up to 3.5% oxygen methanol up to 5% volume, MTBE up to 15% are used. In EC monoalcohols and ethers with atm boiling points lower than the final atm boiling point of gasoline in the standards can be used. Higher concentrations require modifications on the vehicles - carburator or fuel injection system must be modified to compensate for the oxygen content of the fuel. Blends with 15% methanol can be used.





(C) Specific heating value: -Specific heating value, Hu is a measure of the energy content of the fuel per unit mass (kJ/kg or kcal/kg) -Gaseous fuels sp heating value is given in terms of energy content per unit volume (kJ/liter or kJ/m3 , kcal/m3) -In IC engines lower heating value is given as the combustion products contain water in vapour form. For gasoline and diesel fuel Hu=42000-44000 kJ/kg or Hu=10200-10500 kcal/kg -Heating value of the combustible air-fuel mixture is a decisive factor for engine performance.

(d) Flash point: -Flash point is the lowest temperature of a sample at which the fuel vapour starts to ignite when in contact with a flame (ignition source). -Marcusson method – fuel container is slowly heated, while the fuel vapour is in contact with an open flame – T is measured -For gasoline it is 25 oC, diesel fuel 35 oC and heavy diesel 65 oC

(e) Viscosity: -Viscosity is an important parameter for CI engines, also influences fuel metering orifices since Re is an inverse function of fuel viscosity lower the viscosity, smaller the diameter of the droplets in the spray. -Below certain limits, low viscosity increases the leaks in the fuel system. It is a strong function of T – must be given at certain T values at 50 oC, 1.5 – 5.0 Engler or 0.5 to 0.6 centistokes

(f) Surface tension: -Surface tension is a parameter which effects the formation of fuel droplets in sprays - increasing the surface tension will reduce mass flow and air-fuel ratio in gasoline engines -lower the value, smaller the droplet diameter diesel fuel value is in the range of 0.023 – 0.032 N/m and for gasoline it is 0.019 – 0.023 N/m

(g) Freezing point: -the precipitation of paraffin crystals in winter can lead to clogged filters. It can be prevented by either removing paraffins from the fuel or adding flow improvers (additives). -Antifreezing properties are determined by its filterability. -For gasoline freezing point is –65 oC and for diesel fuel –10 oC *Important fuel specifications for gasoline

(a) Gasoline volatility: Benzene for example has vapor pressure of 0.022 MPa at 38 OC in a closed container of 38 OC, benzene evaporates until the partial p has a value of 0.022 MPa, If T is raised to 80.5 OC, then saturation p will be 0.1 MPa and will be constant during the boiling For gasoline it is not possible to indicate a single value of evaporation T or vapor pressure. Gasoline contains large number of compounds - up to about 400 It has a smooth distillation curve - with good fractionation efficiency .

*Diesel injection system:

Requirements of diesel injection system:

-fuel must introduce precisely defined period of cycle -amounts metered very accurately

-rate of injection meet desired heat release pattern

-quantities of fuel meet changing speed and load condition

-good atomisation of fuel

-good spray pattern for rapid mixing of fuel and air

-no dribbling and after injection of fuel i.e. sharp injection

-injection timing suits the speed and load requirements

-distribution of fuel in multi-cylinder should uniform

-weight, size and cost of fuel injection system should be less

Types of diesel injection system:

(a) Air injection system:

-fuel supplied through camshaft driven fuel pump

-fuel valve is also connected with high pressure airline to inject into cylinder

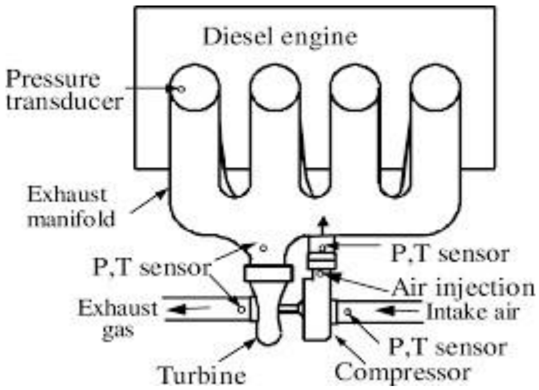
-multi-stage compressor which supply air at a pressure of about 60 to 70 bar Fig. 17. Air injection system -blast air sweeps the fuel along with it -

good atomisation results in good mixture formation and hence high mean effective pressure

-heavy and viscous fuels are used -fuel pump require small pressure -but it is complicated due to compressor arrangement and expensive

-bulky engine and low bhp

-overheating and burning of valve seat



(b) Solid injection system:

-Fuel directly injected to combustion chamber without primary atomisation termed as solid injection.

-Also known as airless mechanical injection

-2 units-pressurise and atomising unit 3 different types which are described below, (i) Individual pump and injector or jerk pump system: -separate metering and compression pump is used for each cylinder -reciprocating fuel pump is used to meter and set the injection pressure of the fuel -heavy gear arrangements which gives jerking noise, hence name is given is jerk pump -jerk pump is used for medium and high speed diesel engines Fig. 18. Individual pump and injector or jerk pump system Fig. 19. Unit injector

(ii) Common rail system:

-high pressure fuel pump delivers fuel to an accumulator whose pressure is constant

-plunger type of pump is used

-driving mechanism is not stressed with high pressure hence noise is reduced -common rail or pipe is connected in between accumulator and distributing elements -separate metering and timing elements connected to automatic injector -self-governing type Fig. 20. Common rail system

(iii) Distributor system: -fuel pump pressurises, meters and times the fuel supply to rotating distributor -number of injection strokes per cycle for the pump equals to the number of cylinder -One metering element which ensure uniform distribution Distributor system

* Fuel Injectors;

3 main types of fuel injectors, Blast injector: -these are superseded by mechanically operated injectors used in air injection system Mechanically operated injector: -consist of a set of camshaft, cams and rocker gear and other cams for controlling the timing of the fuel injection Automatic injector: -consists of spring loaded needle valve and operated hydraulically by the pressure of fuel

-quanity of fuel is metered by the fuel pump Types of nozzles:

(a) Depends on the type of combustion chamber, Open combustion chamber: -fuel seeks air -air swirl is created due to inclined induction port -multi-hole nozzle injects fuel at a pressure of about 200 to 300 bar to slow moving air -provide good cold starting performance and improved thermal efficiency Pre -combustion chamber: -air velocity is very much high -single hole nozzle with 65 to 100 bar injection pressure is used -used in high speed engine due to rapid combustion -external heating device for easy starting of the engine

(b) Open and closed type of nozzle, Open type: -consists of fuel orifices and open to burner -cheap and less efficient ex- opposed piston two-stroke Junkers diesel engine Closed type: pressure drop is minimised compared to open type

(c) Different types of nozzle for different combustion chamber (i) Single hole nozzle: -used in open combustion chamber -size of hole larger than 0.2 mm -very high injection pressure required (ii) Multi-hole nozzle: -no. of hole varies from 4 to 18 and the size from 1.5 to 0.35 mm -injection rate is not uniform (iii) Pintle nozzle: -a projection or pintle is provided in the nozzle to avoid weak injection and dribbling -pintle may be cylindrical or conical shape -cone angle varied from 0 to 60º -provide good atomisation and reduced penetration -fuel pressures are lower than single and multi-hole nozzle (iv) Pintaux nozzle: -injected fuel in upstream of air -development of pintle nozzle with auxiliary hole drilled in the nozzle body -reduced delay period and increased thermal efficiency .

Spark plug ;

The function of a spark plug ;

The demands placed on a modern spark plug The spark ignition engine The ignition system on petrol-driven engines

– in contrast to diesel engines – is external: during the compression cycle the combustion of the compressed fuel-air mixture is triggered by an electrical spark produced by the spark plug.

It is the task of the spark plug to generate this spark. Created by the high voltage produced by the ignition coil, it leaps between the electrodes. A flame front spreads from the spark and fills the combustion chamber until the mixture has been burned. The heat released increases the temperature, there is a rapid buildup of pressure in the cylinder and the piston is forced downwards (Power stroke).

The movement is transferred via the connecting rod to the crankshaft; this drives the vehicle via the clutch, the gears and the axles. In order for the engine to operate smoothly, powerfully and in an environmentally friendly manner, a number of requirements have to be met: the correct amount of perfectly balanced fuel/ air mixture must be present in the cylinder, and the high-energy ignition spark must leap between the electrodes precisely at the predetermined moment.

For this purpose spark plugs have to meet the highest performance requirements : they must deliver a powerful ignition spark between around 500 and 3,500 times a minute (in 4-stroke operation) - even during hours of driving at high revs or in stop-and-go traffic conditions. Even at -20 °C, they have to ensure a completely reliable ignition. High-tech spark plugs provide low-emission combustion and optimum fuel efficiency – without misfiring, which can cause unburnt fuel to get into the catalytic converter, and destroying it.

A modern spark plug must meet the following requirements:

Electrical requirements :

n Reliable high-voltage transmission, even at ignition voltages of up to 40,000 volts n Good insulation capability, even at temperatures of 1,000 °C, prevention of arcing and flashover

Mechanical requirements n Pressure-tight and gas-tight sealing of the combustion chamber, resistance to oscillating pressures up to approx.

100 bar n High mechanical strength for reliable

installation Thermal requirements n Resistance to thermal shock (hot exhaust gases – cold intake mixture) n Good thermal conduction by insulator tip and electrodes .

Electrochemical requirements n Resistance to spark erosion, combustion gases and residues n Prevention of build-up of deposits on the insulator

Spark plug design and types

Materials :

BERU offers a wide range of spark plugs to ensure that the optimum spark plug is always available for the many different engine types and applications. Diverse materials are used for the center electrodes. Special nickel-based alloys and copper-core electrodes offer good thermal conductivity and high corrosion resistance. Silver has even higher thermal conductivity. Platinum and Iridium offer excellent resistance to erosion, so it extends the length of time between replacements. The design of the earthing electrode is just as important. Its geometry influences mixture accessibility, wear, heat dissipation and ignition voltage requirement, among other things. Titanium, platinum and iridium offer particularly long operating lives, for the same electrode gap.

Electrode gap

The shortest distance between the central and earth electrode(s) on the spark plug is called the electrode gap. This is what the ignition spark must jump across. The optimum electrode gap in any particular situation depends partly on the engine, and it is determined in close collaboration with the vehicle manufacturer. Maximum precision in maintaining the electrode gap is important since an incorrect gap can have a considerable detrimental effect on spark plug function and consequently on engine performance.

If the electrode gap is too small this may cause misfiring, noisy idling and poor exhaust gas quality levels.

If the electrode gap is too large, this may lead to misfiring.

The co-ordinated spark positioning on multi-electrode plugs means the electrode gaps does not have to be adjusted (for example Ultra X Titan, air/glide spark technology).

AUTO – ELECTRIC SYSTEM

The electrical systems on equipment used by the Navy are designed to perform a variety of functions. The automotive electrical system contains five electrical circuits:

charging,

starting,

ignition,

lighting,

and accessory.

Electrical power and control signals must be delivered to electrical devices reliably and safely. This goal is accomplished through careful circuit design, prudent component selection, and practical equipment location.

By carefully studying this chapter, you will understand how these circuits work and the adjustments and repairs required to maintain the electrical systems in peak condition.

STARTING CIRCUIT:

The internal combustion engine is not capable of self-starting. Automotive engines (both spark-ignition and diesel) are cranked by a small but powerful electric motor. This motor is called a cranking motor, starting motor, or starter.

The battery sends current to the starter when the operator turns the ignition switch to start. This causes a pinion gear in the starter to mesh with the teeth of the ring gear, thereby rotating the engine crankshaft for starting. The typical starting circuit consists of the battery, the starter motor and drive mechanism, the ignition switch, the starter relay or solenoid, a neutral safety switch (automatic transmissions), and the wiring to connect these components.

Starter Motor :

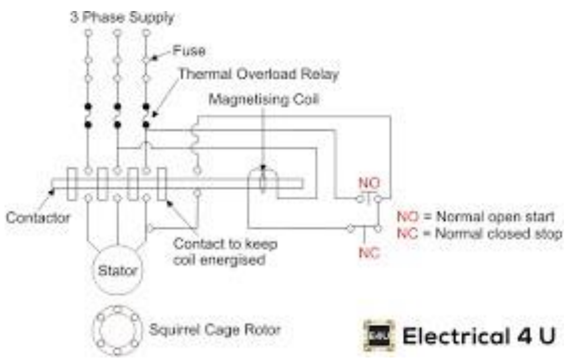
The starting motor converts electrical energy from the battery into mechanical or rotating energy to crank the engine (Figure 8-18). The main difference between an electric starting motor and an electric generator is that in a generator, rotation of the armature in a magnetic field produces voltage.

In a motor, current is sent through the armature and the field; the attraction and repulsion between the magnetic poles of the field and armature coil alternately push and pull the armature around. This rotation (mechanical energy), when properly connected to the flywheel of an engine, causes the engine crankshaft to turn.

STARTER DIAGRAM

1 **Starting Motor :**

Construction The construction of all starting motors is very similar. There are, however, slight design variations. The main parts of a starting motor are as follows:



• The armature assembly consists of an armature shaft, armature core, commutator, and armature windings. The armature shaft supports the armature assembly as it spins inside the starter housing. The armature core is made of iron and holds the armature windings in place. The iron increases the magnetic field strength of the windings. The commutator serves as a sliding electrical connection between the motor windings and the brushes and is mounted on one end of the armature shaft. The commutator has many segments that are insulated from each other. As the windings rotate away from the pole shoe (piece), the commutator segments change the electrical connection between the brushes and the windings. This action reverses the magnetic field around the windings. The constant changing electrical connection at the windings keeps the motor spinning.

• The commutator end frame houses the brushes, the brush springs, and the armature shaft bushing. The brushes ride on top of the commutator. They slide on the commutator to carry battery current to the spinning windings. The springs force the brushes to maintain contact with the commutator as it spins, thereby no power interruptions occurs. The armature shaft bushing supports the commutator end of the armature shaft.

• The pinion drive assembly includes the pinion gear, the pinion drive mechanism, and solenoid. There are two ways that a starting motor can engage the pinion assembly: first with a movable pole shoe that engages the pinion gear, and second with a solenoid and shift fork that engages the pinion gear.

AUTOMOTIVE WIRING:

Electrical power and control signals must be delivered to electrical devices reliably and safely so that the electrical system functions are not impaired or converted to hazards. To fulfill power distribution military vehicles, use one - and two-wire circuits, wiring harnesses, and terminal connections.

Among your many duties will be the job of maintaining and repairing automotive electrical systems. All vehicles are not wired in exactly the same manner; however, once you understand the circuit of one vehic le, you should be able to trace an electrical circuit of any vehicle using wiring diagrams and color codes.

ONE-AND TWO-WIRE CIRCUITS

Tracing wiring circuits, particularly those connecting lights or warning and signal devices, is no simple task.

The branch circuits making up the individual systems have one wire to conduct electricity from the battery to the unit requiring it and ground connections at the battery and the unit to complete the circuit. These are called ONE-WIRE CIRCUITS or branches of a GROUND RETURN SYSTEM.

In automotive electrical systems with branch circuits that lead to all parts of the equipment, the ground return system saves installation time and eliminates the need for an additional wiring to complete the circuit. The all -metal construction of the automotive equipment makes it possible to use this system. The TWO-WIRE CIRCUIT requires two wires to complete the electrical circuit- one wire from the source of electrical energy to the unit it will operate, and another wire to complete the circuit from the unit back to the source of the electrical power. Two-wire circuits provide positive connection for light and electrical brakes on some trailers.

The coupling between the trailer and the equipment, although made of metal and a conductor of electricity, has to be jointed to move freely. The rather loose joint or coupling does not provide the positive and continuous connection required to use a ground return system between two vehicles. The twowire circuit is commonly used on equipment subject to frequent or heavy vibrations. Tracked equipment, off-road vehicles (tactical), and many types of construction equipment are wired in this manner.

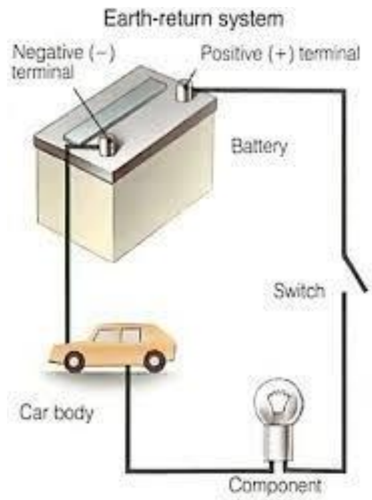
Insulated Return Some vehicle application requires a separate insulated-cable system for both the feed and the return conductors. It is also safer because with separate feed and return cables, it is practically impossible for the cable conductors to short even if chafed and touching any of the metal bodywork, as the body is not live since it is not a part of the electrical circuits. From the safety reasons, an insulated return is essential for vehicles transporting highly flammable liquids and gases, where a spark could very easily set off an explosion or a fire. The vehicles, such as coaches and double-decker buses use large quantity of plastic panelling. For these vehicles an insulated return is more reliable and safer.

The insulated return off course uses extra cable that makes the overall wiring harness heavier, less flexible, and bulky, consequently increases the cost to some extent. Earth Return. All electrical circuits incorporate both a feed and a return conductor between the battery and the component requiring supply of electrical energy. The vehicle with a metal structure can be used as one of the two conducting paths. This is called as the earth return . A live feed wire cable forms the other conductor. To complete the earth-return path, one end of a short thick cable is bolted to the chassis structure while the other end is attached to one of the battery terminal posts. T

he electrical component is also required to be earthed in a similar way. Only one battery-to-chassis conductor is necessary for a complete vehicle's wiring system and similarly any number of separate earth-return circuits can be wired. An earth-return system, therefore, reduces and simplifies the amount of wiring so that it is easy to trace electrical faults.

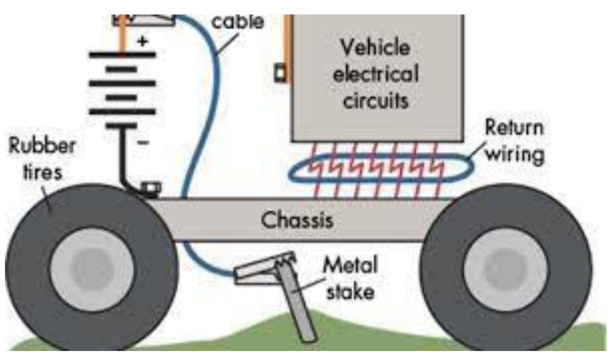
Positive and Negative earthing ;

In the beginning, it was the general practice of earthing the negative terminal of the battery, whereas the positive current was supplied to the electrical units. The negative earthing system is still used in the cars of American make. In some countries, the negative earth system has been replaced by the positive earth system.



This is because the positive earth system possesses certain advantages over the negative earth system. These advantages concern the temperature of the central spark plug electrode and the corrosion of some parts, it is well known fact that the positive terminal of the leadacid battery is attacked by the liberated gases. If this is the live terminal and the negative terminal earthed, the exposed part of the positive will become corroded. Further it is also a well known fact that the positive point of the spark plug wears away more quickly than the negative point. In view of this fact, the central electrode of the plug will wear away quickly if made electrode of the plug will wear away quickly if made positive when compared with the metal electrode of the shell.

Alternatively, the central electrode of the plug will have much longer life if made negative by earthing the positive terminal of the battery. Another factor which plays an important role in the voltage requirements of a spark plug is the temperature of the negative electrode. The hotter this electrode is, the lower will be the voltage required for producing the spark, It has also been observed that more uniform voltages at the sparking points have been obtained with the central electrode being negative. Further, the metal rotor arm of the distributor, if made negative, will wear at a slower rate than if it were made positive. There is an additional advantage of the positive earth method in the ignition coil elements the primary circuit voltage is added to the secondary circuit voltage, making it more economical. Recently, with the adoption of alternators in place of generators, it has been observed that employing negative earth method is advantageous along with an ac current rectifier having transistors and diodes. This has meant shifting back to the negative earth method. However it is worth mentioning that the important advantages of the positive earth for the ignition system still hold good .



LIGHTING:

The lighting circuit includes the battery, vehicle frame, all the lights, and various switches that control their use. The lighting circuit is known as a single-wire system since it uses the vehicle frame for the return. The complete lighting circuit of a vehicle can be broken down into individual circuits, each having one or more lights and switches. In each separate circuit, the lights are connected in parallel, and the controlling switch is in series between the group of lights and the battery.

The marker lights, for example, are connected in parallel and are controlled by a single switch. In some installations, one switch controls the connections to the battery, while a selector switch determines which of two circuits is energized. The headlights, with their high and low beams, are an example of this type of circuit. In some instances, such as the courtesy lights, several switches may be connected in parallel so that any switch may be used to turn on the light. When a wiring diagram is being studied, all light circuits can be traced from the battery through the ammeter to the switch (or switches) to the individual light.

LAMPS

Small gas-filled incandescent lamps with tungsten filaments are used on automotive and construction equipment. The filaments supply the light when sufficient current is flowing through them. They are designed to operate on a low voltage current of 12 or 24 volts, depending upon the voltage of the the vehicle will be of the single -or double-contact small one-half candlepower bulbs to large 50- candlepower bulbs. The greater the candlepower of the lamp, the more current it requires when lighted. Lamps are identified by a number on the base. When you replace a lamp in a vehicle, be sure the new lamp is of the proper rating. The lamps within Lamps are rated as to size by the candlepower (luminous intensity) they produce. They range from types with nibs to fit bayonet sockets, as shown in lamp is also whiter than a conventional lamp, which increases lighting ability.

HEADLIGHTS

The headlights are sealed beam lamps that illuminate the road during nighttime operation. Headlights consist of a lens, one or two elements, and a integral reflector. When current flows through the element, the element gets white hot and glows. The reflector and lens direct the light forward. Many modern passenger vehicles use halogen headlights. A halogen headlight contains a small, inner halogen lamp surrounded by a conventional sealed housing. A halogen headlamp increases light output by 25 percent with no increase in current. The halogen The headlight switch is an ON/ OFF switch and rheostat (variable resistor) in the dash panel) or on the steering column. The headlight switch controls current flow to the lamps of the headlight system. The rheostat is for adjusting the brightness of the instrument panel lights. Military vehicles that are used in tactical situations are equipped with a headlight switch that is integrated with the blackout lighting switch. An important feature of this switch i s that it reduces the possibility of accidentally turning on the lights in a blackout. With no lights on, the main switch can be turned to the left without operating the mechanical switch to get blackout marker lights (including blackout taillights and stoplights) and blackout driving lights. But for stoplights for daylight driving or headlights for ordinary night driving, you must first lift the mechanical switch lever and then turn the main switch to the right. The auxiliary switch gives panel lights when the main switch is in any of its ON positions. But it will give parking lights only when the main switch is in service drive (to the extreme right). When the main switch is off, the auxiliary switch should not be moved from the OFF position.

DIMMER SWITCH The dimmer switch controls the high and low headlamp beam function and is normally mounted on the floorboard or steering column. When the operator activates the dimmer switch, it changes the electrical connection to the headlights. In one position, the high beams are turned on, and, in the other position, the dimmer changes them to low beam. Aiming Headlights The headlights can be aimed using a mechanical aimer or a wall screen. Either method assures that the headlight beams point in the direction specified by the vehicle manufacturer. Headlights that are aimed too high can blind oncoming vehicles. Headlights that are aimed too low or to one side will reduce the operator's visibility.

Automotive Wiring

Electrical power and control signals must be delivered to electrical devices reliably and safely so that the electrical system functions are not impaired or converted to hazards. To fulfill power distribution, military vehicles use one- and two-wire circuits, wiring harnesses, and terminal connections.

Among your many duties will be the job of maintaining and repairing automotive electrical systems. All vehicles are not wired in exactly the same manner; however, once you understand the circuit of one vehicle, you should be able to trace an electrical circuit of any vehicle using wiring diagrams and color codes.

One-Wire Circuit

Tracing wiring circuits, particularly those connecting lights or warning and signal devices, is no simple task. Branch circuits making up the individual systems have one wire to conduct electricity from the battery to the unit requiring it, and ground connections at the battery and the unit to complete the circuit. These are called one- wire circuits or branches of a ground return system. In automotive electrical systems with branch circuits that lead to all parts of the equipment, the ground return system saves installation time and eliminates the need for an additional wiring to complete the circuit. The all-metal construction of the automotive equipment makes it possible to use this system.

Two-Wire Circuits

The two-wire circuit requires two wires to complete the electrical circuit—one wire from the source of electrical energy to the unit it will operate, and another wire to complete the circuit from the unit back to the source of the electrical power.

Two-wire circuits provide positive connection for light and electrical brakes on some trailers. The coupling between the trailer and the equipment, although made of metal and a conductor of electricity, has to be jointed to move freely. The rather loose joint or coupling does not provide the positive and continuous connection required to use a ground return system between two vehicles. The two-wire circuit is commonly used on equipment subject to frequent or heavy vibrations. Tracked equipment, off-road vehicles (tactical), and many types of construction equipment are wired in this manner.

Shielded Wiring

Shielded wire has a center conductor that is surrounded by an outer metal shield. Insulation is used to separate the shield and the conductor. This construction keeps magnetic pulses from being inducted into the center conductor causing unwanted voltage pulses.

This type of wire is mostly used for the automotive antenna. The lead must be protected from the magnetic fields from the engine’s ignition system to prevent static from being heard over the radio.

There is also twisted shield wire. This type of wire uses multiple insulated conductors wrapped around each other. This design still provides the protection from the magnetic fields and is used to connect the computer to various sensors, particularly those near the ignition system. Twisted shield wire helps keep high voltage pulses from interfering with the tiny voltage signals going between the computer and other sensors in the vehicle.

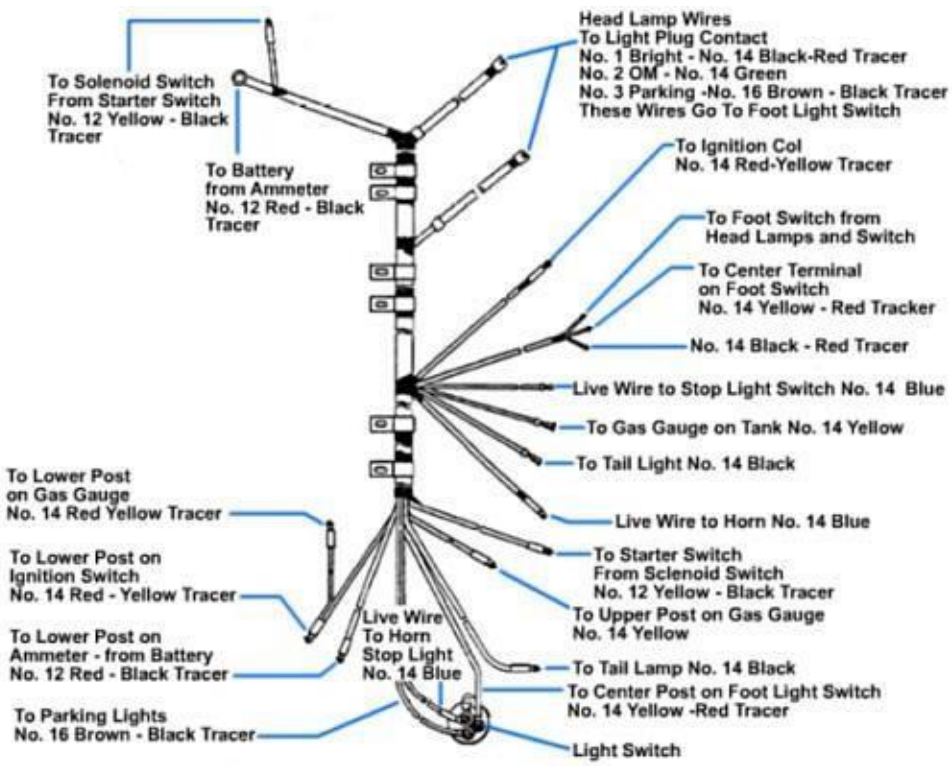
Unshielded Wiring

Unshielded wire is the most common type of wire found in automotive manufacturing. There is no shield on the wire except for the insulation wrapped around the wire to prevent accidental grounding. There is no special shield to protect the wire from electromagnetic force.

Wiring Assemblies

Wiring assemblies consist of wires and cables of definitely prescribed length, assembled together to form a subassembly that interconnect specific electrical components and/or equipment. The two basic types of wiring assemblies are as follows:

The cable assembly consists of a stranded conductor with insulation or a combination of insulated conductors enclosed in a covering or jacket from end to end. Terminating connections seal around the outer jacket so that the inner conductors are isolated completely from the environment. Cable assemblies may have two or more ends.



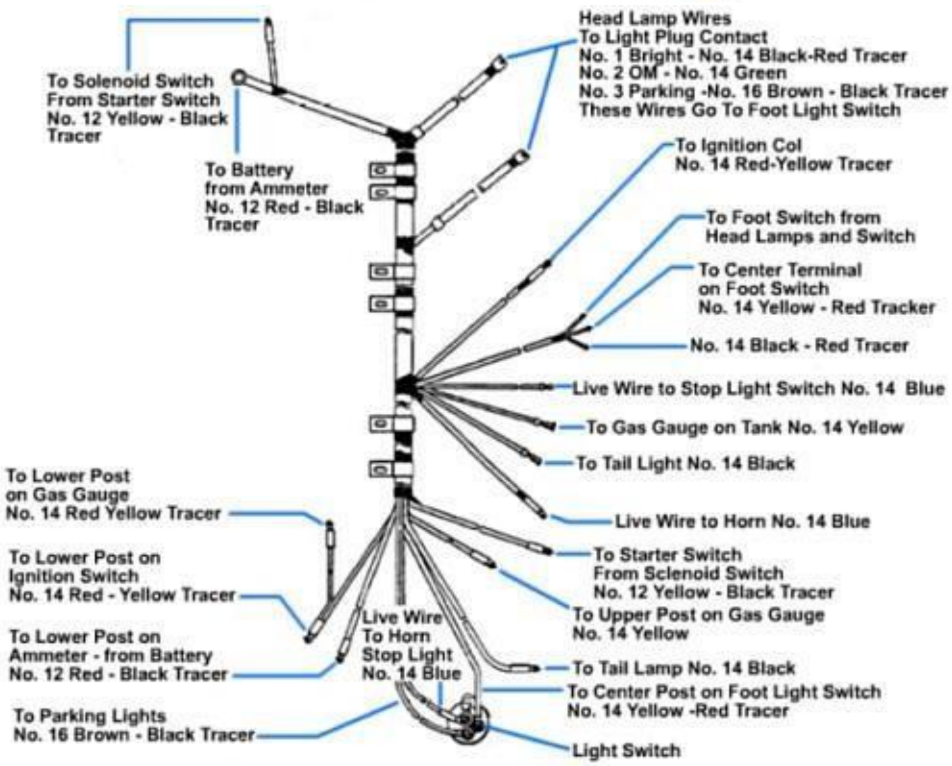


Figure 7-57— Wiring harness.

Wiring harness assemblies serve two purposes (Figure 7-57). They prevent chafing and loosening of terminals and connections caused by vibration and road shock while keeping the wires in a neat condition away from moving parts of the vehicle. Wiring harnesses contain two or more individual conductors laid parallel or twisted together and wrapped with binding material, such as tape, lacing cord, and wire ties. The binding materials do not isolate the conductors from the environment completely, and conductor terminations may or may not be sealed.

Wiring harnesses also may have two or more ends.

Wiring Identification

Wires in the electrical system should be identified by a number, color, or code to facilitate tracing circuits during assembly, troubleshooting, or rewiring operations. This identification should appear on wiring schematics and diagrams and whenever practical on the individual wire. The assigned identification for a continuous electrical connection should be retained on a schematic diagram until the circuit characteristic is altered by a switching point or active component.

Wiring color codes are used by manufacturers to assist the mechanics in identifying the wires used in many circuits and making repairs in a minimum of time. No color code is common to all manufacturers. For this reason, the manufacturer's service manual is a must for speedy troubleshooting and repairs.

Wiring found on tactical equipment (M-series) has no color. All the wires used on these vehicles are black. Small metal tags stamped with numbers or codes are used to identify the wiring illustrated by diagrams in the technical manuals (Figure 7-58). These tags are securely fastened near the end of individual wires.

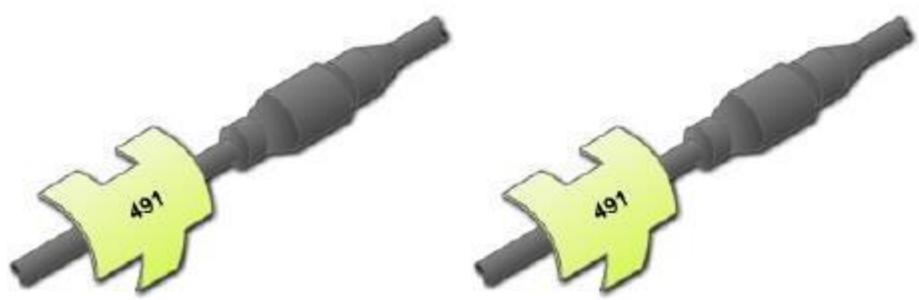
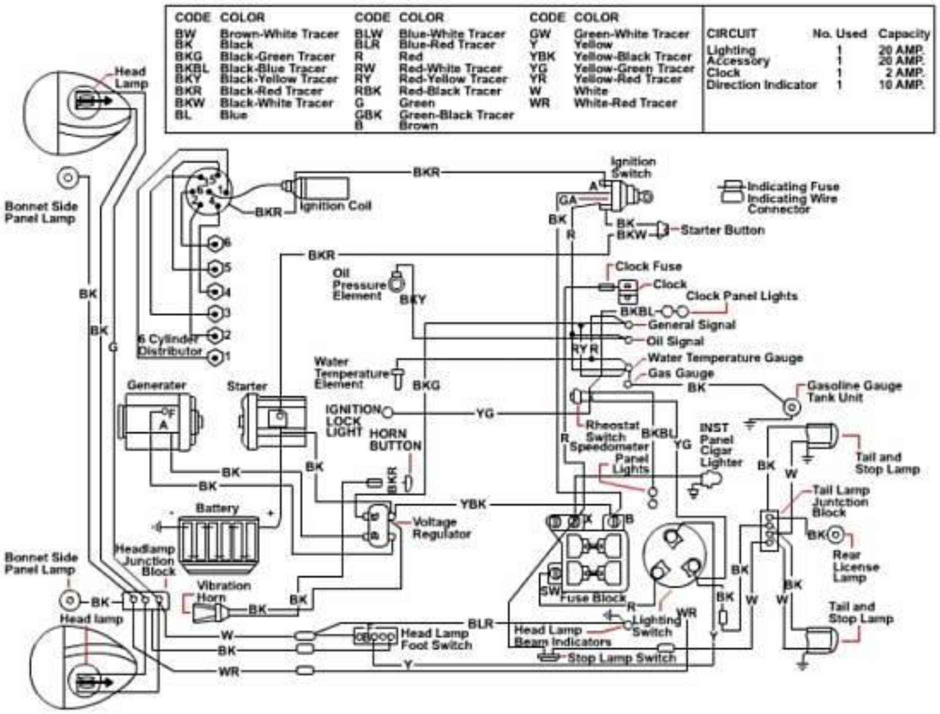


Figure 7-58 — Metal tag wire identification.

Wiring Diagrams

Wiring diagrams are drawings that show the relationship of the electrical components and wires in a circuit (Figure 7-59). They seldom show the routing of the wires within the electrical system of the vehicle.



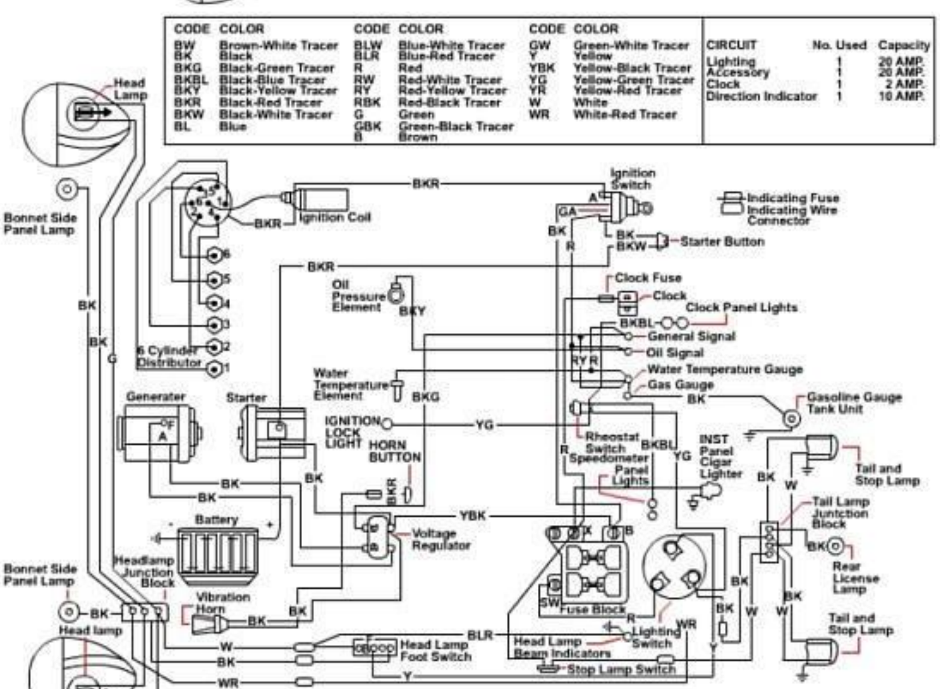
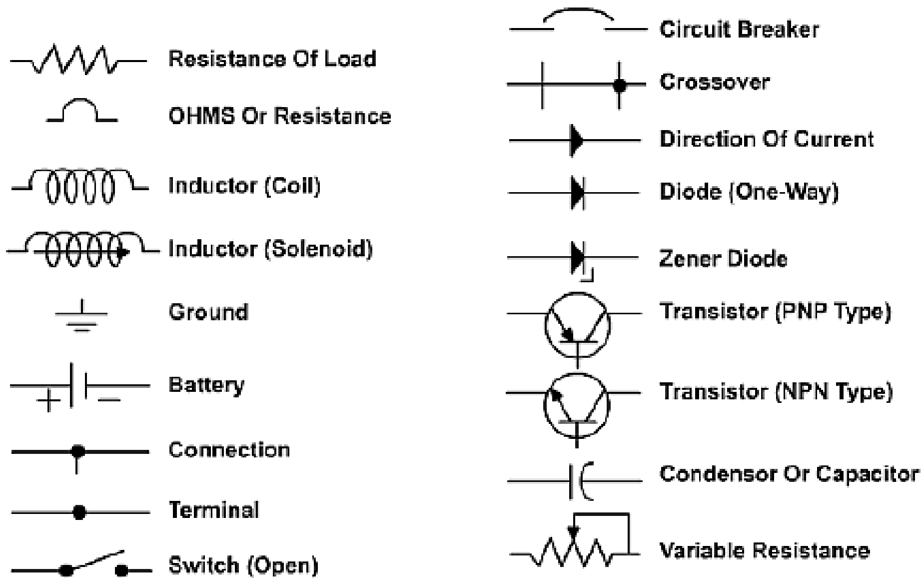
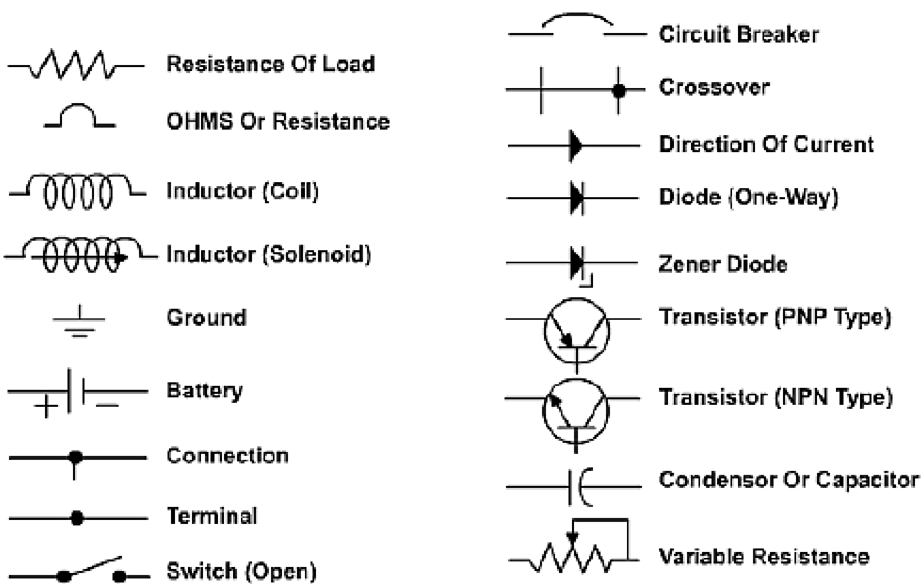


Figure 7-59 — Wiring diagram.

Often you will find electrical symbols used in wiring diagrams to simulate individual components. Figure 7-60 shows some of the symbols you may encounter when tracing individual circuits in a wiring diagram.





— Wiring diagram symbols.

Wire Terminal Ends

Wire terminals are divided into two major classes—the solder type and the solder-less type, which is also known as the pressure or crimp type. The solder type has a cup in which the wire is held by solder permanently. The solder-less type is connected to the wire by special tools that deform the barrel of the terminal and exert pressure on the wire to form a strong mechanical bond and electrical connection. Solder-less type terminals are gradually replacing solder type terminals in military equipment.

Wire Support and Protection

Wire in the electrical system should be supported by clamps or fastened by wire ties at various points about the vehicle. When installing new wiring, be sure to keep it away from any heat-producing component that would scorch or bum the insulation.

Wire passing through holes in the metal members of the frame or body should be protected by rubber grommets. If rubber grommets are not available, use a piece of rubber hose the size of the hole to protect the wiring from chafing or cutting on sharp edges.

Checking For Spark

• If the engine is equipped with a separate ignition coil, remove the coil wire from the center of the distributor cap, install a spark tester, and crank the engine.

• A good coil and ignition system should produce a blue spark at the spark tester. 3 Chec king For Spark (continued) • Typical causes of a no-spark (intermittent spark) condition include the following: 1. Weak ignition coil 2. Low or no voltage to the primary (positive) side of the coil 3. High resistance or open coil wire, or spark plug wire 4 . Negative side of the coil not being pulsed by the ignition module 5. Defective pickup coil 6. Defective module 4 Electronic Ignition Troubleshooting Procedure

• When troubleshooting any electronic ignition system for no spark, follow these steps to help pinpoint the exact cause of the problem:

• Step 1

• Turn the ignition on (engine off) and, using either a voltmeter or a test light, test for battery voltage available at the positive terminal of the ignition coil.

• If the voltage is not available, check for an open circuit at the ignition switch or wiring. 5 Electronic Ignition Troubleshooting Procedure (continued)

• Step 2

• Connect the voltmeter or test light to the negative side of the coil and crank the engine.

• The voltmeter should fluctuate or the test light should blink, indicating that the primary coil current is being turned on and off.

• If there is no pulsing of the negative side of the coil, then the problem is a defective pickup, electronic co ntrol module, or wiring.

6 Ignition Coil Testing Using An Ohmmeter

• To test the primary coil winding resistance, take the following steps: 7 Pickup Coil Testing

• The pickup coil, located under the distributor cap on many electronic ignition engines, c an cause a no-spark condition if defective.

• The pickup coil must generate an AC voltage pulse to the ignition module so that the module can pulse the ignition coil.

• A pickup coil contains a coil of wire, and the resistance of this coil should be within the range specified by the manufacturer. 8 Pickup Coil Testing (continued)

• The pickup coil can also be tested for proper voltage output.

• During cranking, most pickup coils should produce a minimum of 0.25 volt AC.

• This can be tested with the distributor out of the vehicle by rotating the distributor drive gear by hand. Manufacturer Pickup Coil Resistance (Ohms) General Motors 500 – 1500 (white and green leads) Ford 400 – 1000 (orange and purple leads) Chrysler 150 – 900 (orange and black lead) 9 Testing Hall Effect Sensors

• Using a digital voltmeter, check for the presence of charging voltage (pulsed on and off DC) when the engine is being cranked. • The best test is to use an oscilloscope and observe the waveform. 10 Ignition System Diagnosis Using Visual Inspection

• Check all spark plug wires for proper routing. All plug wires should be in the factory wiring separator. • Check that all spark plug wires are securely attached to the spark plugs and to the distributor cap or ignition coil(s).

• Remove the distributor cap and carefully check the cap and distributor rotor for faults.

• Remove the spark plugs and check for excessive wear or other visible faults. Replace if needed.