

ARYAN SCHOOL OF ENGINEERING & TECHNOLOGY

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LECTURE NOTE

SUBJECT NAME- AUTOMOBILE ENGINEERING AND HYBRID VEHICLES

BRANCH – MECHANICAL ENGINEERING

SEMESTER – 6TH SEM

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Auto-mobile Engineering

⇒ Automobile engineering is the branch of engg. which deals with the study of characteristics, performance and maintainanc of an automotive vehicle.

!- Automotive vehicle :-

Those vehicle in which motion produce due to generation of power is automatic. i.e without manual effect are called auto-motive vehicle.

-|- Transmission System :

The power produced or developed in the engine eye cylinder is used to turn the wheel of the vehicle in order to run the vehicle on the road.

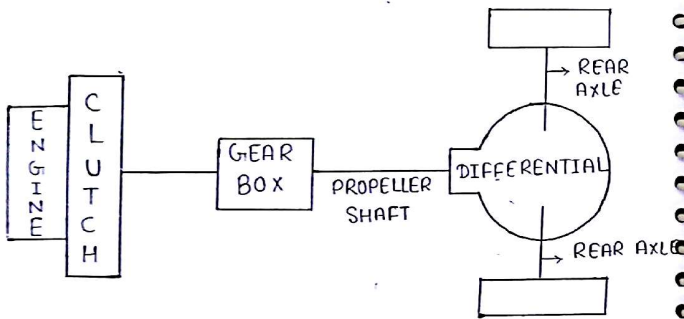
⇒ The power developed in the engine run down the piston in its reciprocating motion and this power is transmitted to the crank-shaft through connecting rod. where the reciprocating motion is converted into rotary motion.

⇒ the circular motion on the crank shaft is transferred through clutch, gear box, propeller shaft, differential, rear axle and to the wheel.

⇒ this both arrangement is known as transmission system and this process ✓

is known as power transmission in automotive vehicle.

BLOCK-diagram of transmission system:



CLUTCH

⇒ Clutch is an integral part of an engine. It is used to engage and dis-engage the engine from transmission system.

⇒ It is placed between the engine and gear box of transmission system.

⇒ It has two working conditions :-

- i) engage condition
- ii) dis-engage condition

i) Engage condition :-

⇒ When the clutch is in engage condition the power from the engine is

transmitted to the rear axle via transmission system.

ii) Dis-engage condition :-

⇒ When the clutch is in dis-engage condition the power from the engine doesn't transmit to the rear axle because the connection between engine and transmission system gets vanished.

Principle of operation of clutch :-

⇒ Clutch works on principle of friction.

⇒ When two members or surfaces are in contact with each other due to friction they are considered as a single unit.

⇒ When one surface or member rotates then another surface or another member also rotates.

⇒ The member which runs is called driving member and other member which is run by driving member is called driven member.

⇒ The driving member is mounted on the flywheel of the engine and driven member is mounted on the pressure plate of transmission system.

⇒ When the clutch is in engage condition the driving member and driven member are in frictional contact and the power is transmitted from engine to transmission system.

• Desirable properties of a clutch :-

i) Torque transmission :-

⇒ the clutch must be capable of transmitting high torque developed in the engine to the transmission system without any loss.

ii) Gradual engagement :-

⇒ the engagement between driving member and driven member should be gradual in nature to reduce the shock.

iii) Heat dissipation :-

⇒ due to friction heat energy is developed therefore there must be provision of small opening in the friction plate (clutch plate) for proper heat dissipation.

iv) Size & weight of clutch :-

⇒ the size of clutch must be small so that it can be accommodated

very easily.

⇒ the clutch must be light in weight so that when the clutch is in dis-engage condition the driven member should stop automatically.

v) Free paddle mechanism :-

⇒ A good clutch should possess free paddle mechanism and by applying a small effort clutch get disengage and when the paddle is released the clutch gets engage automatically.

* Classification of clutch :-

- i) coil spring clutch
- ii) diaphragm clutch
- iii) centrifugal clutch
- iv) semi-centrifugal clutch
- v) dog and spline clutch
- vi) hydraulic clutch
- vii) electro-magnetic clutch
- viii) vacuum clutch
- ix) over-running clutch

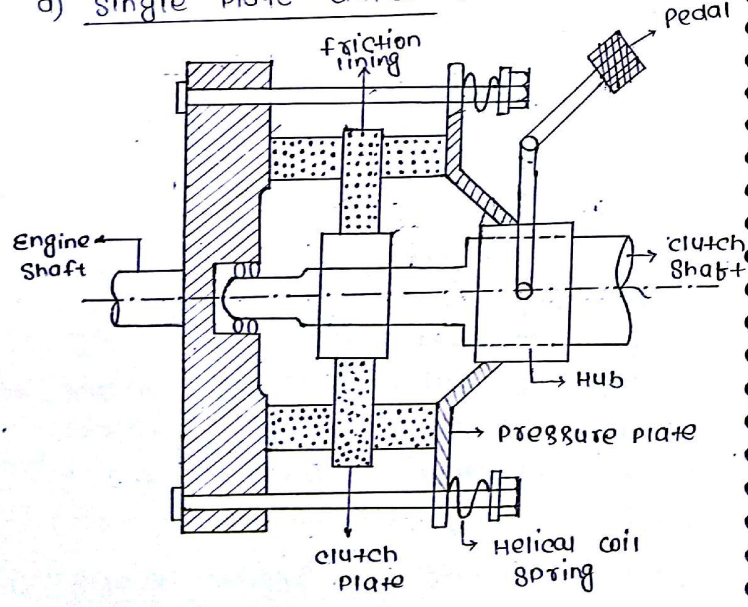
1) coil spring clutch :-

⇒ Those clutch in which the engagement and disengagement are produced with the help of a helical coil spring are called coil spring clutch.

⇒ It is of two types :-

- a) Single plate clutch
- b) Multi plate clutch

a) Single plate clutch :-



* Construction :-

- ⇒ It consists of flywheel, pressure plates, clutch paddle, coil spring and a hub.
- ⇒ It has only one clutch plate mounted over clutch shaft through spline arrangement.
- ⇒ Flywheel is mounted on the engine shaft (crankshaft) and rotate with it.
- ⇒ Pressure plate is bolted to the flywheel through coil spring by means of bolt.
- ⇒ Clutch paddle having fulcrum bar linkage mechanism is mounted on the hub of clutch shaft.

Working :-

- ⇒ Clutch works in two condition.
- a) Dis-engage condition
- b) Engage condition
- i) Dis-engage condition :-
- ⇒ When the paddle is pressed the fulcrum forces the hub of clutch shaft to move away from the engine flywheel. Due to this pressure plate also moves away against the spring which produces potential energy in the spring.

⇒ This movement of pressure plate will vanish the required pressure force on the clutch plate due to which clutch plate also moves away from the engine flywheel. This is our dis-engage condition.

ii) Engage Condition :-

⇒ When the Paddle is released the stored potential energy in the coil spring also releases. This forces the pressure plate to force the clutch plate to get engage with flywheel of engine shaft. This is our required engage condition.

b) Multi-Plate Clutch :-

* Construction :-

⇒ It consists of flywheel, pressure plate, spigot with coil spring clutch pedal having fulcrum mounted on the hub of the clutch shaft.

⇒ Pressure plate is held rigidly with the spigot.

⇒ It consists of two sets of friction

plate. One set of friction plate is mounted on the flywheel and other set of friction plate is mounted on the pressure plate.

⇒ These friction plates are arranged alternately.

Working :-

⇒ The clutch works in two conditions.

i) Dis-engage condition

ii) Engage condition

i) Dis-engage condition :-

⇒ When the Paddle is pressed due to linkage mechanism. It forces the hub mounted on clutch shaft to move away from flywheel.

⇒ This forces the pressure plate attached with the hub to move away from the flywheel.

⇒ This movement of pressure plate has two effects :-

i) The movement of pressure plate is against the coil spring mounted on the spigot. Hence potential energy is stored in the coil spring.

2.) Due to movement of pressure plate the contact between friction plate of pressure plate and friction plate of flywheel gets vanished. this is our required disengage condition.

ii) engage condition :-

⇒ When the pedal released the potential energy stored in the coil spring gets released. due to which the pressure plate moves towards the flywheel. this movement of pressure plate causes the friction plate attached on both the flywheel and pressure plate to get engage. this is our required engage condition.

figure :-

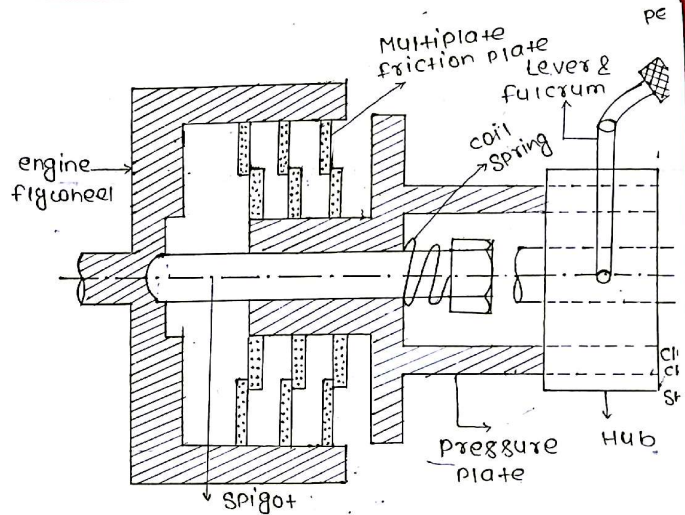


fig :- Multiplate clutch

⊥ Difference between Single plate clutch and Multiplate clutch.

Single plate clutch	Multi plate clutch
1.) It consist of single plate clutch having friction material coated on both side of clutch plate.	1.) It consist of more than one clutch plate friction material coated is only one side of clutch plate.
2.) Torque transmission capacity is low.	2.) Torque transmission capacity is high.
3.) Heat generation is less.	3.) Heat generation is high.

Single plate clutch

Multi plate clutch

- | | |
|---|--|
| 4.) It does not require any cooling medium hence it is called dry clutches. | 4.) cooling medium is required in form of coolant hence it is called wet clutch. |
| 5.) It does not require spigot rod to hold the pressure plate. | 5.) It requires spigot and rod to hold the pressure plate. |
| 6.) Co-efficient of friction must be high in the friction plate. | 6.) Co-efficient of friction is low. |
| 7.) Since the spacing between the friction lining of friction plate and engine flywheel is more which leads to sudden engagement. | 7.) Since the spacing between the friction plate is very less therefore its engagement is gradual. |

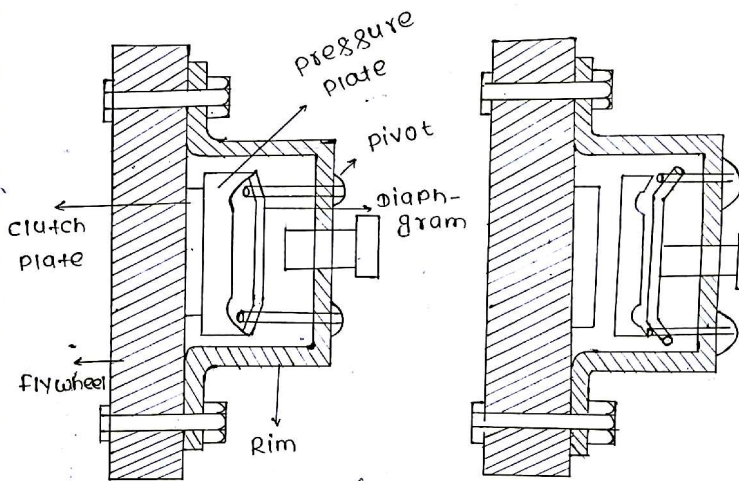
Diaphragm clutch

* Construction :-

⇒ It consists of a flywheel mounted on the crank shaft. A clutch plate attached with the flywheel, a pressure

plate mounted on transmission shaft (clutch shaft).

- ⇒ A diaphragm is used which is pivoted at the rim at its end.
- ⇒ the clutch paddle is attached with a throughout bearing as shown in fig. -



- i) ENGAGE condition ii) DIS-ENGAGE

* Working :-

It works in two conditions

- dis-engage condition
- engage condition

i) Dis-engage condition :-

⇒ When the clutch paddle is pressed it forces the throughout bearing to exert a force at the center of the diaphragm due to which the diaphragm at its center move towards the flywheel. But since the diaphragm is pivoted at its end therefore it gets tilted and moves away from the pressure plate due to this the pressure plate loses its contact with the clutch plate. this is our dis engage condition.

ii) Engage condition :-

⇒ when the paddle is released the throughout bearing moves away from the flywheel due to which diaphragm at its center also moves away from the flywheel. But since the diaphragm is pivoted at the end due to which the diaphragm gets tilted and move towards the pressure plate.

⇒ this forces the pressure plate to get engage with the clutch plate mounted on the flywheel. this is our required engage condition.

v.v.i

* Difference between coil spring clutch and diaphragm clutch.

coil spring clutch	diaphragm clutch
1) It requires helical coil spring.	1) It requires a diaphragm.
2) coil spring is mounted over bolt.	2) diaphragm is pivoted at rim.
3) Released lever with fulcrum is used.	3) No release lever only throughout bearing is used.
4) High torque transmission.	4) less torque transmission.
5) complicated in design.	5) simple in design.
6) due to more number of parts required more maintenance.	6) due to less number of parts required less maintenance.

-|- Gear box -|-

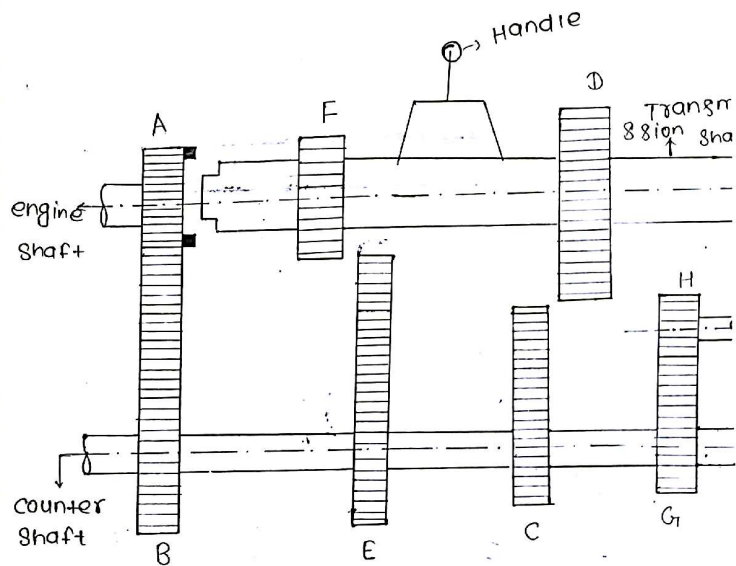
- ⇒ It is a box containing a set of different size of gears to produce different RPM and torque as per requirement.
- ⇒ the arrangement of gears known as gear train is enclosed in a box known as gear box.
- ⇒ It is placed in between clutch and propeller shaft.

-|- Types of gear box :-

- i) Sliding mesh gear box
- ii) constant mesh gear box
- iii) Synchromesh gear box
- iv) ~~ep~~ epicyclic gear box

i) Sliding mesh gear box :-

⇒ In sliding mesh gear box meshing between gear are done by sliding the gear of transmission shaft over counter shaft in neutral position as shown in figure. when engine shaft rotate counter shaft also rotate.



- 1st gear - ABCD
- 2nd gear - ABFE
- 3rd gear - AF
- Reverse gear - ABGH

-|- for first gear :-

⇒ for 1st gear connection between ABCD is done. Since the number of teeth on gear D is more than no. of teeth on gear C. therefore the rpm of D mounted on transmission shaft will be less and hence torque transmission will be more.

$$N_c T_c = N_D T_D$$

$$\therefore N_D = \frac{N_c T_c}{T_D}$$

$$\Rightarrow t_D \leq t_c$$

$$\therefore \boxed{N_D > N_c}$$

† for 2nd gear :-

⇒ the meshing between AB₁E₁F is done. Since number of teeth on gear F will be less than gear E therefore the rpm on gear F mounted on transmission shaft will be more.

$$N_E T_E = N_F T_F$$

$$\Rightarrow N_F = \frac{N_E T_E}{T_F}$$

$$T_F < T_E$$

$$\therefore \boxed{N_F > N_E}$$

† for 3rd gear :-

⇒ the transmission shaft is directly coupled with engine shaft due to which the rpm of engine gets directly transformed to the transmission shaft. This is our high speed gear condition.

† Reverse gear :-

⇒ Meshing between AB₁G₁H₁D is done. Gear

G₁ & D have and intermediate gear H which reverse the direction of rotation. This is our required reverse gear condition.

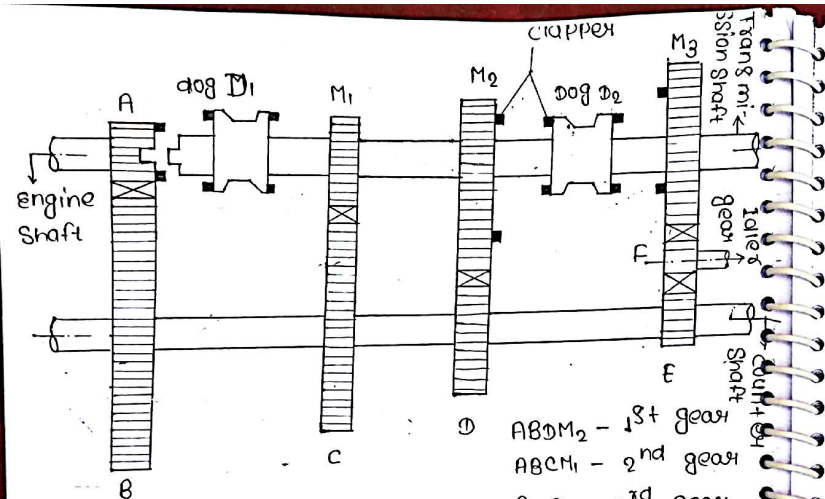
ii) Constant-mesh gear box :-

⇒ In this type of gear box all the gears of transmission shaft is in constantly mesh with the gear of counter shaft or (lay shaft).

⇒ the gear on the transmission shaft is free and the gears of the counter shaft is fixed.

⇒ the dog clutches are mounted on the transmission shaft with the help of spline arrangement.

⇒ the dog clutch Φ_1 lies between gear M_1 and engine shaft while the other dog clutch Φ_2 lies between gear M_2 and gear M_3 .



Working :-

Neutral position :-

⇒ since the dog clutch D_1 and D_2 are separated from gear M_1, M_2, M_3 mounted on transmission shaft. due to which the gear M_1, M_2, M_3 remains free on the transmission shaft. this is our required neutral gear position.

1st gear position :-

⇒ the dog clutch D_2 moves towards gear M_2 due to which M_2 and D_2

gets interlocked and becomes a unit ⇒ the rpm of M_2 will be equal to the rpm of dog D_2 , since D_2 is fixed on transmission shaft. therefore transmission shaft rotate with this rpm i.e equal to rpm of M_2 .

⇒ since no. of teeth on gear M_2 is more than teeth of gear D . therefore rpm obtain on M_2 will be less while torque is more. this is our first gear condition.

2nd gear :-

⇒ dog D_1 moves towards gear M_1 and get interlock with it the rpm of both becomes equal dog D_1 . rpm is directly transferred to the transmission shaft because it is fixed with it.

⇒ since the teeth on gear M_1 is less than gear C . therefore it rotates with increased rpm and reduced torque. this is our required 2nd gear condition.

3rd gear condition :-

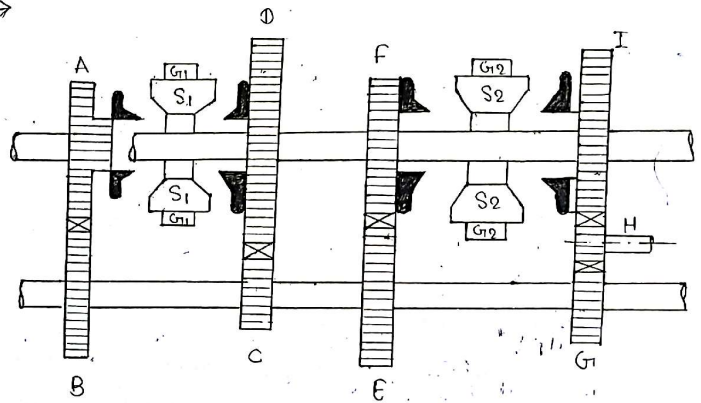
- ⇒ Dog D_1 move towards gear A mounted on engine shaft and gets interlocked with it.
- ⇒ Due to which the dog clutch D_1 rotates with high rpm i.e. equal to rpm of the engine.
- ⇒ Since D_1 is fixed on transmission shaft therefore transmission shaft also rotate with this high rpm. this is our 3rd gear condition.

Reverse gear condition :-

- ⇒ the dog D_2 move towards M_3 and gets interlocked with it.
- ⇒ In this gear F is the idler gear which reverse the direction of motion. therefore M_3 rotates in reverse direction due to which D_2 also rotates in reverse direction.
- ⇒ Since D_2 is fixed on the transmission shaft hence the transmission shaft also rotates in the reverse

direction. this is our reverse gear condition.

iii) Synchromesh gear box :-



⇒ In constant mesh gear box there is a problem that when the gear is on transmission shaft get engage with the dog clutch the teeth of the dog clutch gets damage because the gear on transmission shaft is in motion before the engagement.

⇒ this problem is eliminated by replacing the dog clutch through a synchromesh device in which before engagement synchronisation of speed between synchromesh device and gear on transmission shaft takes place.

⇒ Due to which the gear on transmission shaft comes relatively at rest with synchromesh device before engagement.

* construction : —

⇒ It is a modification of constant mesh gear box. the synchromesh device

has a frictional tapered surface and an internal gear G attached to the transmission shaft.

⇒ the gear of transmission shaft also contains tapered frictional surface with a clapper H.

Working : —

for neutral gear : —

⇒ the synchromesh device S_1 and S_2 are separated from the gear of transmission shaft. the gear of transmission shaft is in mesh with gear of counter shaft but since it is free therefore power cannot be transmitted on transmission shaft.

for first gear : —

⇒ Meshing between ABCD is done. S_1 move towards gear D and gets in frictional contact with it due to which rpm of gear D and S_1 become equal. therefore gear D comes in relatively rest with respect to S_1 .

this phenomena is called synchronisation in speed. after this the internal gear G_1 gets interlocked with the clapper H_1 .

⇒ the rpm of D and gear G_1 will be same due to interlocking and the internal gear G_1 mounted on transmission shaft also moves with this rpm.

⇒ since gear D is larger than gear C therefore less rpm with high torque is transmitted to the transmission shaft.

⊢ for 2nd gear condition :-

⇒ H_2 moves towards the gear E of transmission shaft after synchronisation gear G_2 gets interlocked with the clapper H_2 of gear E. therefore the rpm of G_2 will be equal to rpm of gear E. this rpm is transferred to the

transmission shaft because G_2 is the internal gear of the transmission shaft.

⇒ Gear E is smaller than gear F therefore rpm will be more and torque will be less. this increased rpm with reduced torque is transmitted to the transmission shaft through G_2 .

⊢ for 3rd gear condition :-

⇒ S_1 move towards gear of engine shaft after synchronisation G_1 gets interlocked with H_1 .

⇒ due to which rpm of engine is directly transferred to the gear C and through G_1 it is transferred to the transmission shaft.

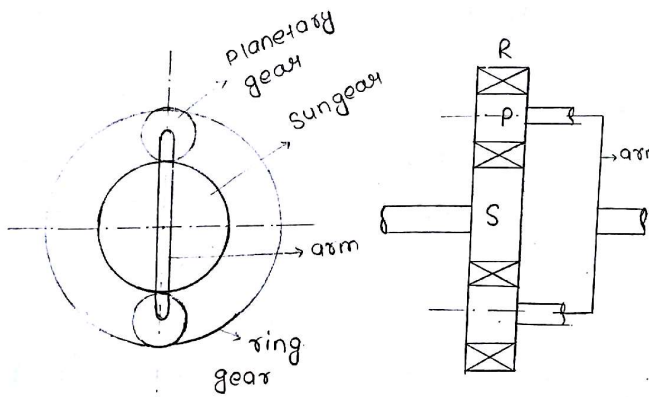
⊢ for reverse gear :-

⇒ S_2 move towards the gear I of transmission shaft after synchronisation G_2 interlocked with H_3

the idler gear H will reverse the direction of rotation of gear I and gear G_2 since interlocked with it also rotates in the reverse direction.

⇒ Since G_2 is connected with transmission shaft therefore transmission shaft also rotates in reverse direction.

iv) epicyclic gear box :-



Construction :-

⇒ It is used in automatic transmission systems. It consists of two planetary gears mounted on the sun gear.

⇒ the whole arrangement is enclosed in a ring gear known as annulus.

Working :-

⇒ It has three conditions.

i) low speed gear condition :-

⇒ Ring gear is fixed, sun gear is connected to the engine shaft i.e. the input shaft while the arm containing planetary gear is connected to the transmission shaft i.e. the output shaft.

⇒ the velocity component exists only at the meshing between the planetary gear and sun gear while the velocity becomes zero at the meshing between the planetary gear and ring gear.

⇒ Since the velocity at a point is zero therefore planetary gear rotates on its own axis while it also revolves

about the axis of the arm. over the sun gear this motion is called epicycloidal motion.

⇒ Since the velocity exist at a point which is at a list velocity ($v=r\omega$) therefore this velocity will be least. hence the rpm will be low and the torque will be high. this is our low speed gear condition.

ii) High Speed gear condition :-

⇒ The sun gear is fixed and the shaft of ring gear is attached with the engine shaft and transmission shaft is attached with planetary gear.

⇒ the velocity component exist only at the meshing of ring gear and planetary gear which has more radial distance therefore velocity ($v=r\omega$) increases due to which rpm increases and torque decreases.

this is our required high speed gear condition.

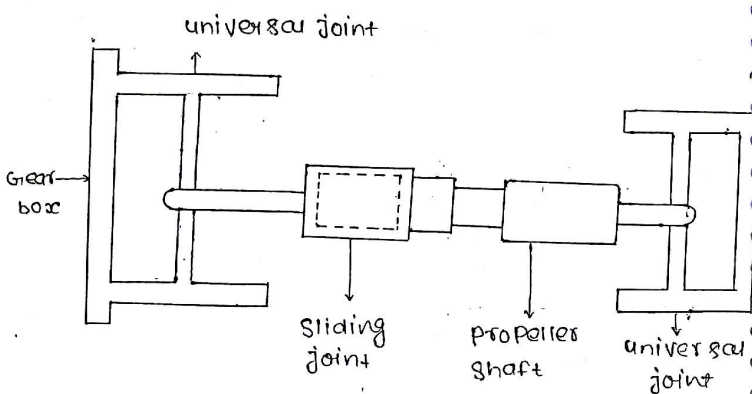
⇒ the motion of the planetary gear about the ring gear is hypo-cycloidal gear profile.

iii) For Reverse gear condition :-

⇒ Arm is fixed while sun gear and ring gear are free the engine shaft is attached to the sun gear. while the ring gear shaft is attached to the transmission shaft.

⇒ Since the direction of rotation of the planetary gear which is in mesh externally to the sun gear is in opposite direction and the ring gear is in mesh internally with the planetary gear therefore the direction of rotation of ring gear will be same as that of planetary but opposite to the direction of rotation of the engine shaft. this is our reverse gear condition.

Propeller shaft :-



Construction Introduction :-

⇒ It connects between the output shaft of gear box at one end and bevel gear shaft of differential at other end.

⇒ Since the power of the engine is transmitted through this shaft to the rear axle to hence it is known as drive shaft.

function of propeller shaft :-

- ⇒ It transmit motion at an angle from gear box to the differential.
- ⇒ It transmit motion at an angle which is varying frequently.
- ⇒ It adjust the change in length between the gear box and differential.

Construction :-

- ⇒ It is made up of steel tube i.e mild steel
- ⇒ It is a hollow shaft containing two type of joint.

- i) universal joint
- ii) sliding joint

⇒ Diameter usually ranges from 50mm-70mm with thickness ranges from 1.5-7.5 mm tubular section makes them lighter and will have strong and high torque transmission capacity than a solid shaft.

function of universal joint :-

- ⇒ when the vehicle has to travel on the elevated road the difference in level between gear box and differential is created.
- ⇒ When the vehicle makes a turn then also inclination between gear box and differential takes place.
- ⇒ But the propeller shaft has to remain straight therefore by providing universal joint transmission of power from gear box to the differential as very inclination is possible and the propeller shaft remains straight.

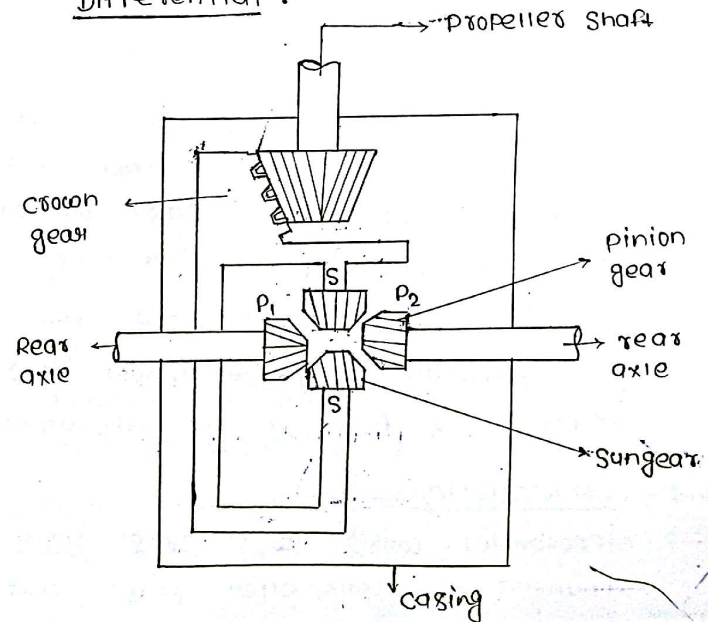
Sliding joint :-

- ⇒ when break is applied the distance between differential and gear box reduces and when the break is released the distance between

the gear box and differential will increase.

- ⇒ Since the propeller shaft is a rigid section therefore there must be a provision for adjusting the change in its length due to variation in speed. this is done by the use of sliding joint.

Differential :-



⇒ Differential is an arrangement of gears between Propeller shaft, crown gear, sun gear and pinion gear of Propeller shaft.

→ It has two basic function.

- i) to transmit the power from the engine to the rear axle through Propeller shaft in two mutual perpendicular direction of Propeller shaft we required differential.
- ii) When we turn the vehicle the outer wheel has to travel much more circumferential distance as compared to the inner wheel therefore outer wheel required more rpm as compared to inner wheel this purpose is fulfilled by differential.

⊥ Construction :-

⇒ differential consist of a bevel gear mounted on propeller shaft and

a crown gear both in mesh.

⇒ crown gear contains two sun gear and has two half axle with pinion gear attached ^{with} this sun gear as shown in figure.

⊥ WORKING :-

⇒ It has two working condition.

i) When to run the vehicle on straight road

⇒ when the propeller shaft rotates the crown gear in mesh with the bevel gear of propeller shaft. therefore it also rotates.

⇒ the sun gear attached with the crown gear also rotates about the axis of the crown gear.

⇒ Since the ^{sun} crown gear is fixed from the pinion gear i.e both are interlocked therefore the pinion gear of the rear axle also rotates.

⇒ Both half axle rotates with same rpm and same torque.

ii) When vehicle makes a turn. :-

⇒ the pinion gear of inner wheel axle loses its contact with the sun gear and the pinion gear of outer wheel axle is constantly in mesh with the sun gear.

⇒ Due to this the sun gear gets loose from one side and starts spinning and transfer its rpm to the pinion gear of outer wheel.

⇒ Whole rpm is transfer to the outer wheel axle and the inner wheel axle adjust its rpm according to outer wheel.

⇒ therefore in this way different rpm are obtained on different rear axle.

⊕ Differential Lock-out :-

⇒ Sometime out of two wheel one is on hard surface and other is on slippery surface.

⇒ when engine deliver power torque transmitted on both wheel will be same.

⇒ the wheel which is on slippery surface get slip while the wheel which is on hard surface is not having sufficient torque and rpm to move the vehicle forward.

⇒ to overcome this problem we use an arrangement known as self-locking differential.

⇒ Self-locking differential transfer all the torque to the wheel on hard surface and lock the axle whose wheel is on slippery surface. therefore no torque is transmitted to that wheel.

⇒ Due to this the wheel on hard surface rotates and pull the wheel which is on slippery surface. this phenomena is known as differential lock-out.

⊕ Rear axle :-

⇒ In between the differential and rear wheel the axle on which the rear wheel is mounted is known as rear axle.

It is clear from the construction of

Differential that the rear wheel is not the single piece axle. It is two half axle. On the outer side of the these half axle wheel is mounted and inner half of these axle pinion gear is mounted.

⇒ Since the power from the engine is transmitted to the rear axle due to which it rotates continuously hence it is known as live center axle.

⊕ Load on rear axle :-

⇒ Generally three types of load act on rear axle.

- i) load due to weight of the body.
- ii) load due to Normal force applied by the ground to the wheel.
- iii) Side thrust force while taking a load.

⇒ these load may damage the rear axle by shearing the axle or bending the axle.

⇒ to resist these load in order to protect the rear axle it is enclosed inside a casing and a wheel hub

is mounted on it over which the wheel is mounted.

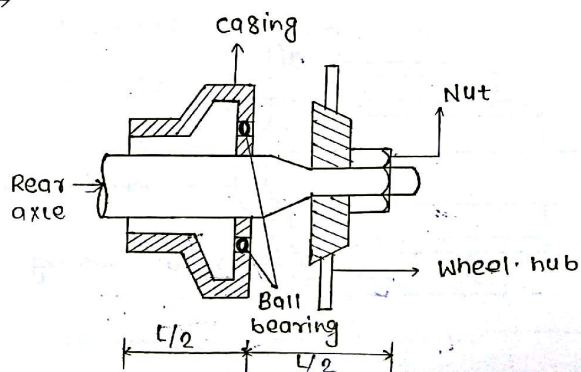
⇒ there is provision of ball bearing in the space between axle and casing and hub & casing.

⇒ these ball-bearing minimize the load which is transmitted on the rear axle
 ⇒ on the basis of arrangement of casing, hub and bearing rear axle is classified in three ways.

- i) Semi-floating rear axle
- ii) full floating rear axle
- iii) Third-quarter floating rear axle.

i) Semi-floating rear axle :-

⇒



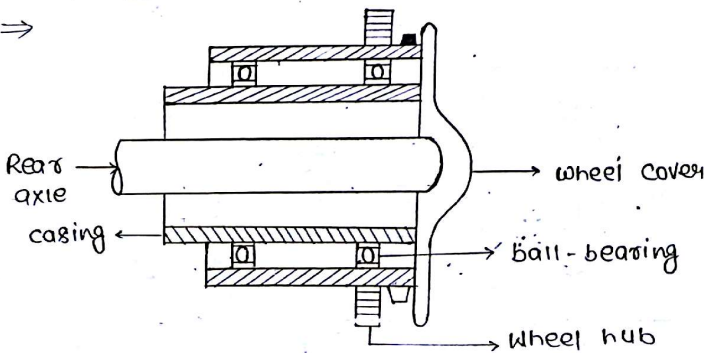
⇒ It is most commonly used rear axle for small vehicle as it is cheap and easily available.

⇒ to absorb different type of load the semi-floating rear axle, half portion is covered with casing and a ball bearing and the axle mounted on casing and axle.

⇒ In this axle a wheel hub is flanged at the outer side of the axle which is bolted to provide locking.

⇒ Since half portion of the rear axle is free from all type of load hence it is known as semi-floating rear axle.

ii) Full-floating rear axle :-



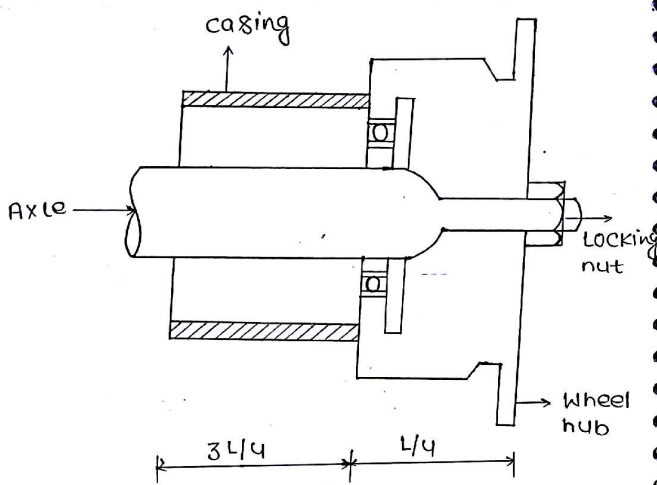
⇒ A full floating axle is such type of axle in which the axle coming out from differential is covered by casing along its entire length.

⇒ therefore axle does not have to resist any type of load as because all the different type of load are absorbed by the casing and the bearing i.e. axle is free from all types of load along its entire length hence it is known as full-floating rear axle.

⇒ It consists of two set of bearing one is between axle and casing and other is in between wheel hub & casing.

⇒ It is used for heavy vehicles.

iii) Three-quarter floating rear axle :-

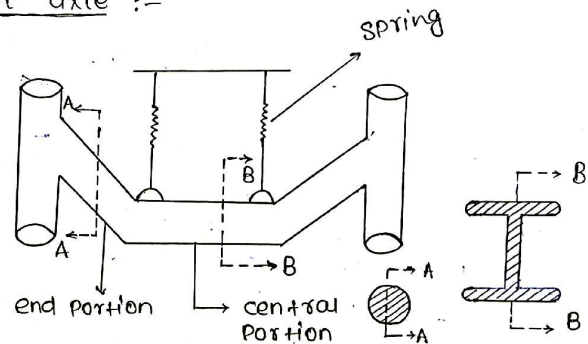


hub and axle.

⇒ It is free from all types of load but since ~~axle~~ casing covers only three quarter length of the axle hence it is called three quarter floating rear axle.

⇒ It is suitable for light weight vehicle. It is simply modification of semi-floating rear axle.

front axle :-



⇒ the above figure shows a front axle it is basically a shaft of varying section. the center portion is I-shape in section and the end portion is

⇒ three quarter floating rear axle is such that three quarter portion of the rear axle is covered by axle casing. and one quarter portion is covered by wheel hub. bearing is provided between wheel

circular or elliptical in section.

the end of front axle has a provision on which the stub axle is mounted through the king pin.

⊖ Main purpose of front axle :-

⇒ to carry the weight of the front position of the vehicle.

⇒ Since it has provision of king pin at its end therefore it helps in turning.

⇒ Since it has suspension system mounted on it which absorb the shock and jerk. (झटका)

⇒ It carries front wheel and brake assembly.

⊖ Automobile electrical system :-

⇒ Electrical system plays very vital role in working of any automobile vehicle.

⇒ electrical system is required to operate the battery or magneto used in ignition system.

⇒ It is required to start the starting motor.

⇒ It is required to supply current to the different bulb used in automobile vehicle.

⊖ Ignition system :-

★ Purpose :- the spark ignition system is a system which is required to ignite the compressed air fuel mixture at the end of compression stroke.

⇒ to produce the spark, spark plug requires a voltage of 30,000 to 40,000 volt but the battery or magneto can supply a maximum of 12 volt.

⇒ In multi cylinder engine the electric current is to be distributed to the

different spark plug of different cylinder.

⇒ To increase the voltage and to distribute the electric current to different cylinders we require a system called ignition system.

→ There are four types of ignition systems used in automobile vehicle.

- i) Battery ignition system
- ii) Magneto ignition system
- iii) electronic ignition system
- iv) capacitor discharge ignition system.

i) Battery ignition system :-

construction :-

⇒ It consists of battery, ignition switch, ballast resistor, primary coil winding, contact breaker, distributor, condenser, secondary coil winding and spark plug.

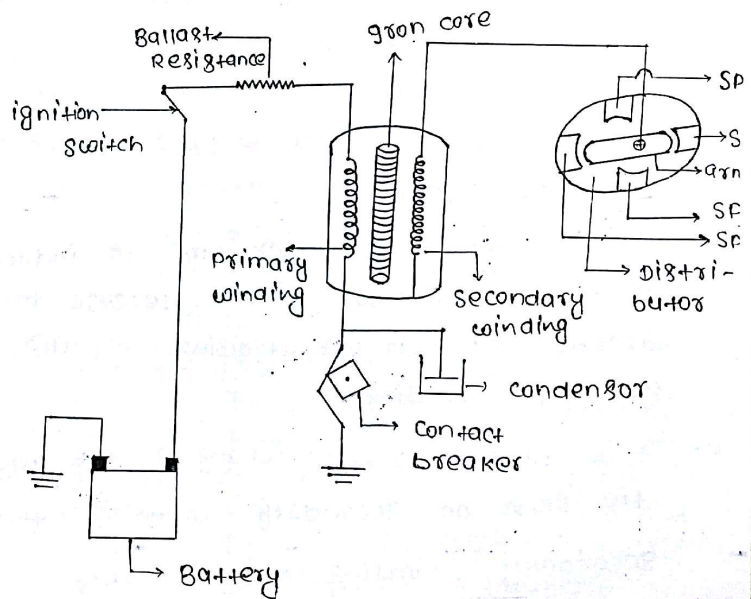
Primary circuit :-

⇒ In primary circuit, current flows from battery to ignition switch, ballast

resistor, primary winding, contact breaker to the ground. ballast resistor protects the primary winding from excessive current.

Secondary circuit :-

⇒ In secondary circuit current flows from the secondary winding to the arm of the distributor to the required spark plug.



Working :-

⇒ When the ignition switch is on current from the battery of 6 to 12 volt starts to flow through the primary winding having 200-300 turns.

⇒ Since contact breaker is adjoining the circuit therefore this current flows through the contact breaker point to the ground.

⇒ When the cam rotates it breaks the circuit and now all the current is flowing to the condenser. due to which its voltage rises to a voltage known as breakdown voltage.

⇒ Due to which a back EMF is induced in the condenser which reverse the direction of current flowing in the primary winding.

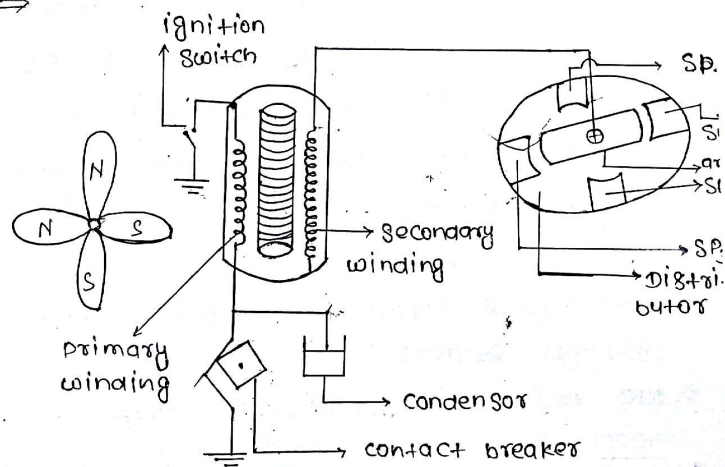
⇒ This reverse current changes the magnetic flux on secondary winding, the secondary winding opposes this

change in flux and induced EMF over itself on the basis of Faraday law of electro-magnetic induction.

⇒ Since secondary winding has 21,000 to 30,000 turns therefore the voltages in the secondary winding step-up upto 30,000 to 40,000 volt.

⇒ this high voltage current is transferred to different spark plug of the distributor.

ii) Magneto ignition system :-



Construction

⇒ the figure shows ignition system in which the battery used in battery ignition is replaced by a rotating magnet assembly which is known as Magneto while the remaining arrangement is same as used in battery ignition system.

Working :-

⇒ Due to rotation of magneto the polarity in front of primary winding of magnetic field changes due to which magnetic flux on primary winding changes to oppose this change in the magnetic flux primary circuit induced an EMF over it which produces electric current.

⇒ this current flows from the contact breaker to the ground.

⇒ when the cam rotates contact breaker breaks the circuit and current flows to the condenser.

⇒ due to which a breakdown voltage is reached in the condenser which reverse

the direction of current.

⇒ this reverse current changes the flux of the secondary winding which also causes an induced EMF on the secondary winding.

⇒ Since secondary winding are having more number of turns therefore the voltage increases. Now this high voltage current from secondary winding is distributed to the spark of different cylinder through distributor.

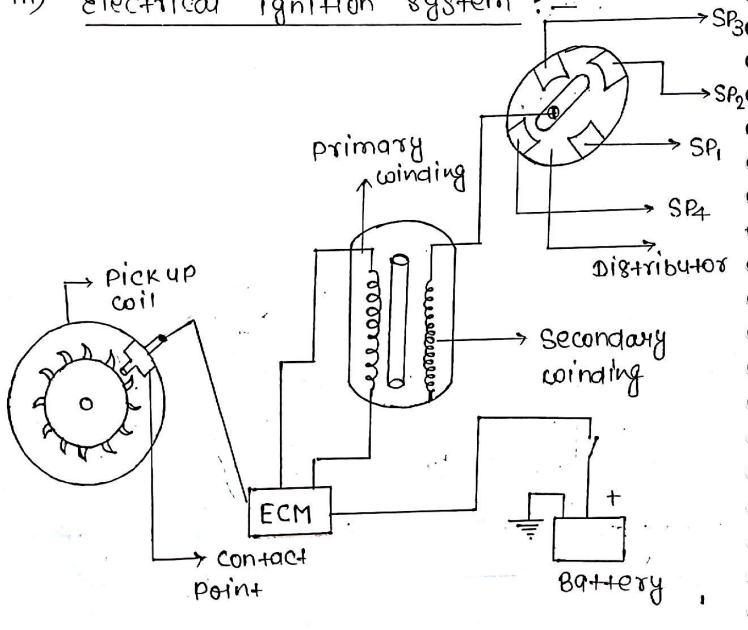
Difference between Battery ignition and Magneto ignition.

Battery ignition	Magneto ignition
i) current is produced from battery	→ current is generated from magnet.
ii) Starting is easier.	→ there is difficulty in starting.
iii) Sparking is good at low engine speed.	→ sparking is poor at low engine speed.

- iv) If battery is discharge engine cannot be started.
- v) complicated in wiring due to presence of battery, ignition switch, ballast resistance.
- vi) It is less costly

- iv) No such difficulty in starting.
- v) wiring is simple No such component is present.
- vi) It is more costly.

iii) Electrical ignition system :-



Construction :-

⇒ It is similar in construction to the battery ignition system but the condenser is replaced by a device known as electronic control module. ECM breaks and connects the primary circuit and the contact breaker is replaced by a pickup coil which gives signal to the ECM when to break and connect the primary circuit.

Working :-

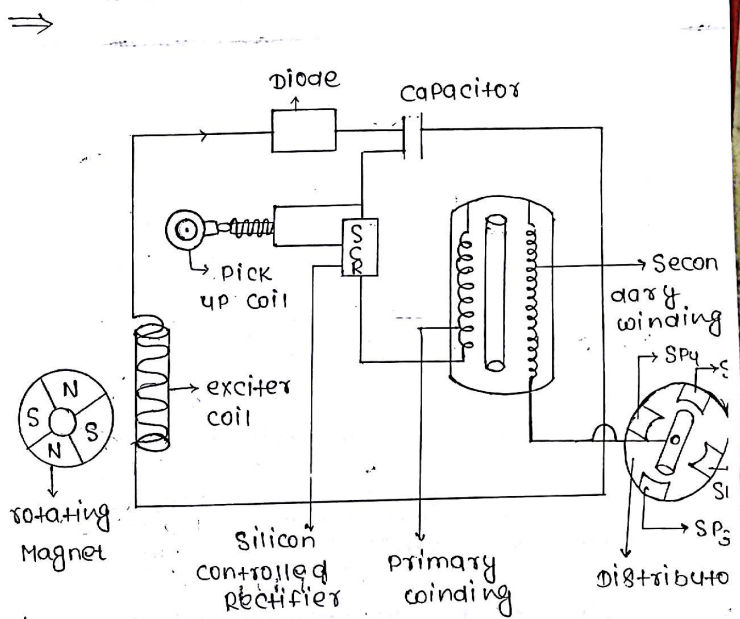
⇒ When the ignition switch is on the battery supplies current to ECM and from ECM current flows to primary circuit.

⇒ When the teeth of the armature of pickup coil touches with the contact point it transfers a signal to the ECM to break this primary circuit and the current from the battery flows to the ground.

- ⇒ when the teeth of pickup coil loses its contact with contact point, then the ECM again connect the primary circuit and current again starts flowing in the primary circuit.
- ⇒ due to closing and opening of primary circuit there is variation in current due to which flux changes.
- ⇒ the secondary winding opposes this change in flux and induce an EMF within itself.
- ⇒ Since the number of turns in secondary winding is upto 30,000. therefore it generates a high voltage current. this
- ⇒ this high voltage current is distributed to the different

spark plug to the distributor.

IV) capacitor discharge ignition system :-



Working :-

- ⇒ when the magnet rotates an EMF is developed in the exciter coil. due to which current flows into the capacitor. the capacitor store this current.
- ⇒ when the polarity of exciter coil changes the capacitor starts discharging

the pickup coil is triggered (भौड़ना) with the SCR contact point and the SCR then transfers the discharge current to the primary winding.

⇒ When the pickup coil loses its contact with the contact point of SCR the current from capacitor stops flowing into the primary winding at the same time rotating magnet changes the polarity of exciter coil and the current from the coil goes to the capacitor and the capacitor gets charged again.

⇒ Again, when the pickup coil touches with the contact point of SCR the current from capacitor starts flowing to the primary winding.

Due to this fluctuation in current in primary winding takes place

which changes the magnetic flux.

⇒ the secondary winding opposes this change in magnetic flux and induces an EMF.

⇒ Since number of turns in secondary winding is more therefore it develops a high voltage current which is distributed to the different spark plug through distributor.

✦ Starting Motor : —

Purpose : —

⇒ All internal combustion engines are not self-starting some motion in the engine is required before ignition such as —

⇒ Motion in piston during suction and compression.

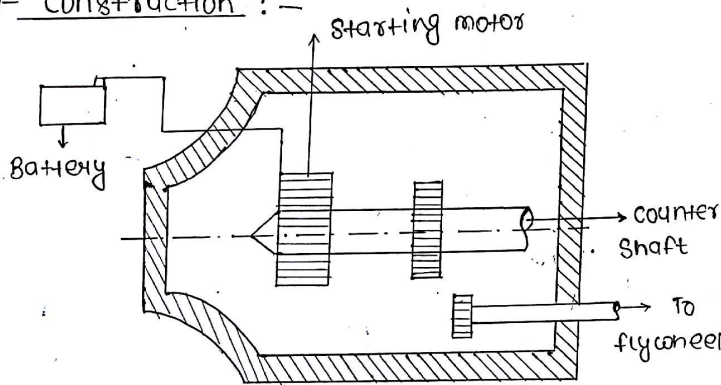
⇒ Motion for opening of valve to maintain fuel supply.

⇒ Motion in the cam of contact breaker

⇒ If magneto system is used motion in magnet.

⇒ All the above function can be fulfilled with the help of a device known as starting motor.

Construction :-



⇒ Starting motor is mounted over engine flywheel. Starting motor is basically a moving armature having coil of wire. This moving armature coil is mounted over a shaft having gear.

⇒ The armature is connected to the battery.

1) Head light :-

⇒ It is required to illuminate the path way to permit safe night driving. They give high intensity light beam which is sufficient for vision of driver.

2) Parking Light :-

⇒ In addition to head light, low intensity parking light are provided in the front portion of the car.

⇒ Parking light are just below the head light.

⇒ Parking light helps the driver in viewing any obstacle such as hole, bump or any moving object in front of car on the ground.

Directional signal indicator light :-

⇒ These light are mounted on the side of the vehicle.

⇒ These light are used to indicate the direction in which the vehicle is to turn.

thus this light gives signal to the vehicle coming from front and rear position.

⊕ STOP light :-

⇒ stop light is mounted on the rear portion of vehicle. when the driver applies the brake the stop light gets on which indicate the vehicle coming from the rear side that it is about to stop.

⇒ It is also known as brake light.

⊕ TAIL light :-

⇒ It is a low intensity light mounted on the rear portion of the vehicle which give signal to the vehicle coming from rear side.

⇒ It is also known as backup light.

⊕ Interior light :-

⇒ It is mounted in the interior position of the vehicle.

⇒ It provides vision to the passenger inside the vehicle.

→ for various lightening purpose.

→ for production of spark in the spark plug.

→ It is a system through which different electrical appliances are connected through wire circuit with the battery.

→ It has four circuit :-

i) Starting motor circuit :-

⇒ Starting motor circuit connects the starting motor with the battery. so that the current required to initiate the motion of starting motor can be reached.

ii) Generator circuit :-

⇒ A dc source generator is connected to the battery through this circuit because when the battery supplies the current it starts to discharge. therefore to charge the battery it is connected with a dc source generator through this circuit.

iii) ignition circuit :-

⇒ this circuit is used to connect the ignition coil with the battery. through this circuit the battery supplies current to the ignition coil in which its voltage increases as required for production of spark in spark plug.

iv) lightening circuit :-

⇒ In this circuit the battery is connected to the different lightening circuit used in automobile vehicle.

→ through this circuit the battery supplies the electric current to the different lightening source.

⚡ lightening system :-

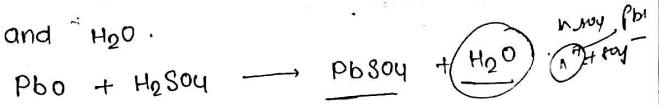
⇒ In automobile vehicle as per requirement and according to purpose different types of light source are used.

⇒ the arrangement of these light source is called lightening system.

⇒ the main light source are :-



⇒ the PbO thus form react with H_2SO_4 at the end of discharging to form PbSO_4 and H_2O .



⇒ the SO_4^{2-} ion moves towards the lead plate where they give their extra electron and becomes radical. $[\text{SO}_4]$

⇒ At the end of discharging the SO_4 radical react with lead plate to form PbSO_4 .

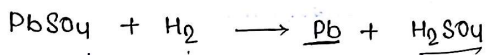
⇒ Due to discharging a layer of PbSO_4 gets deposited at the surface of both plate and the electrolyte becomes weak thus its chemical energy decrea

⚡ Charging :-

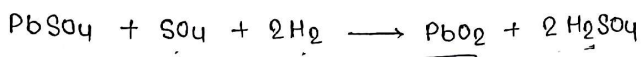
⇒ During charging the load is replaced by a dc source one plate becomes anode and other becomes cathode.

⇒ the H^+ ion move towards cathode and becomes hydrogen gas which reacts

with $PbSO_4$ of anode to form Pb with H_2SO_4 .



⇒ the SO_4^{2-} ion move towards anode and react with $PbSO_4$ in presence of hydrogen to form lead peroxide and H_2SO_4 .



⇒ During charging the solution becomes strong i.e. chemical energy increases.

Wiring circuit :-

⇒ Wiring system is one of the most important system used in automobile vehicle because through this system electricity is supplied through the battery for various purpose :-

⇒ Starting and stopping the starting motor to run the engine or stop the engine.

also rotates over it and move towards the flywheel. this forces the pinion gear to mesh with the gear of flywheel. thus flywheel rotates and require motion is obtained.

Battery :-

⇒ It is the most important component used in electrical system of automobile vehicle. in this electrical energy can be stored in chemical energy and this chemical energy is converted into electrical energy as per requirement.

→ Battery works on two working condition

- i) Discharging
- ii) charging

i) Discharging :-

⇒ During discharging the chemical energy stored in the battery is converted into electrical energy.

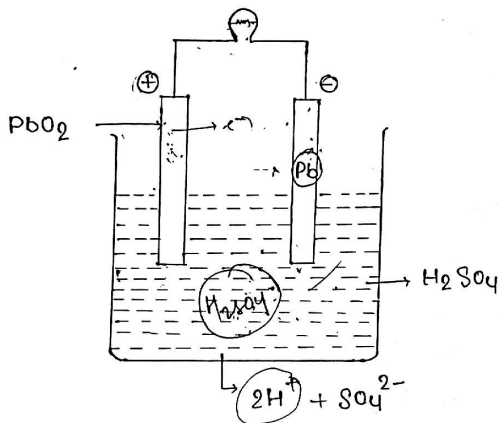
ii) charging :-

⇒ When electrical energy supplied to the battery, it gets converted into chemical energy.

⚡ Lead acid battery :-

⇒ Generally lead acid battery is used in the automobile vehicle.

It has two plate dipped in H_2SO_4 acid one plate is lead peroxide (PbO_2) & other plate is spongy lead (Pb).



⚡ Discharging :-

⇒ During discharging H_2SO_4 contains H^+ and SO_4^{2-} ion.

⇒ the Hydrogen ion (H^+) gains the electron released by PbO_2 and becomes Hydrogen gas. the hydrogen gas attack the PbO_2 plate to form Pb and water (H_2O).

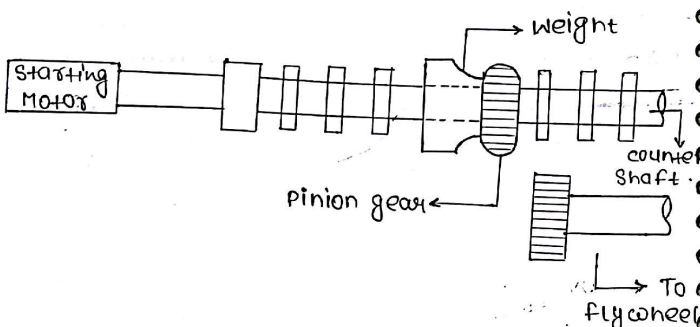
⚡ Working :-

⇒ When the battery supplies current to the coil in presence of magnetic field magnetic force is generate which rotate the armature due to which the counter shaft rotate.

⇒ when the speed of rotation exceed above 25 m/sec. the counter shaft experiences a side thrust force which force the counter shaft to move forward which forces the gear of the counter shaft to get in mesh with the gear of flywheel. Hence the flywheel rotate and desired motion is obtained.

Note : → In this starting motor there is a demerit that counter shaft require a minimum velocity of 25 m/s. for meshing of pinion gear and gear of flywheel. this demerit is overcome by making a slight adjustment and this type of starting motor is known as Bendix drive starting motor.

Belt drive starting motor :-



⇒ In starting motor there is a problem that minimum velocity required in the counter shaft to move forward is 25 m/s but sometimes it is difficult to achieve therefore we make slight adjustment i.e. external thread is made on the counter shaft and internal thread is made on the weight carrying pinion gear.

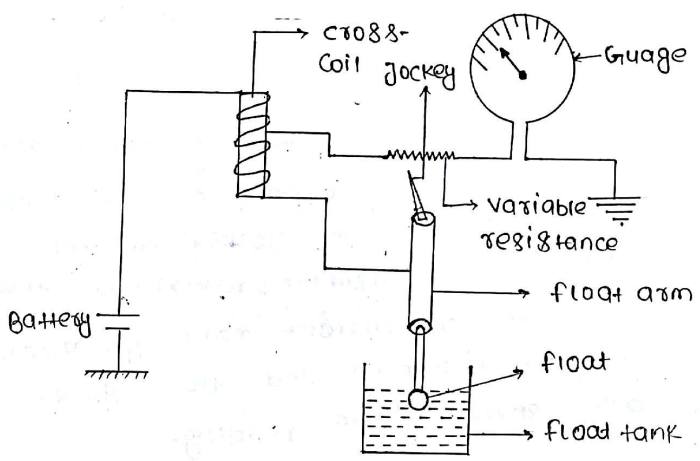
⇒ the arrangement of weight and the counter shaft is just like a nut and bolt arrangement.

⇒ when the switch is on, starting motor rotates which rotates the counter shaft and the weight mounted on it.

Fuel gauge :-

⇒ fuel gauge is a fuel measuring device which is used to indicate the amount of fuel remaining in the tank.
 ⇒ In automobile vehicle the fuel gauge mostly used is cross coil floating type fuel gauge.

Cross-coil floating type :-



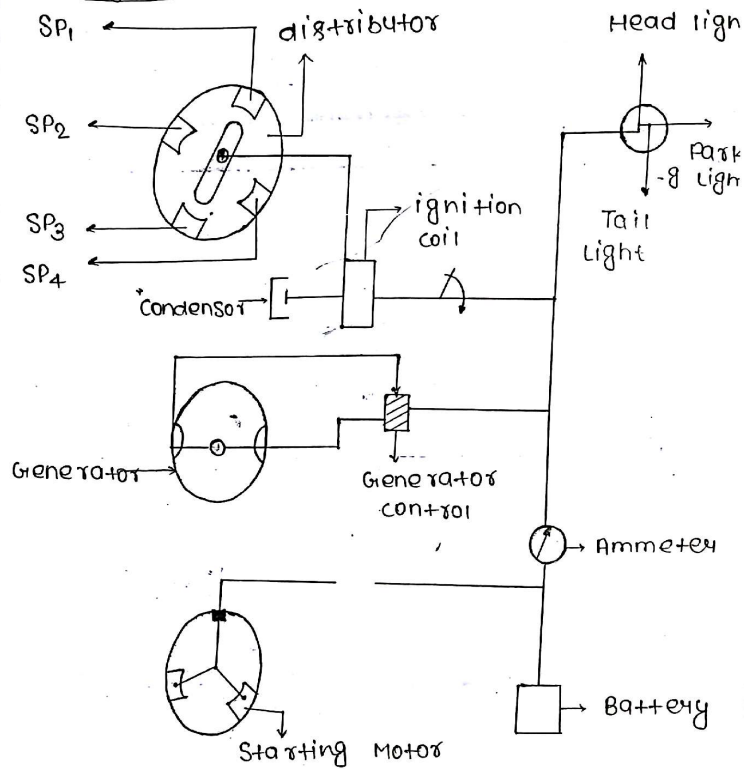
⇒ It consists of two a cross-coil with two set of wire one is connected from the battery to the float arm and one wire carrying variable resistance.

Connects the cross coil with the ammeter which is calibrated with gauge. It consists of a float dipped in the fuel tank.

⇒ When the level of fuel is high the jockey of the float arm shows minimum resistance and max^m current is obtained which is read by ammeter. Since ammeter is in calibration with the gauge therefore the gauge also shows max^m reading.

⇒ When the level of fuel is low float comes at the bottom of the tank due to which the jockey deflects and shows maximum resistance thus the value of current read by ammeter will be minimum and the gauge also shows min^m reading.

Figure: - Wiring Circuit



Control System :-

⇒ Control system is most essential system of automobile vehicle because without it the directional stability of the automobile vehicle and its motion control cannot be achieved.

⇒ It has three units :-

- i) Wheel alignment
- ii) steering system
- iii) braking system

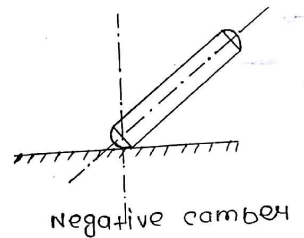
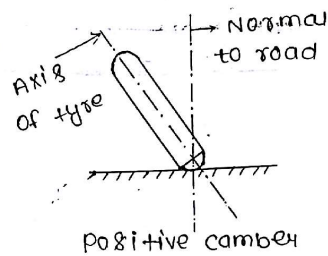
i) wheel alignment :-

⇒ To give better stability with uniform motion while running the automobile vehicle on the straight road or while taking a turn, a slight adjustment in the wheel geometry, has to be made this is known as wheel alignment.

⇒ the various alignment done on the wheels are :-

i) camber angle :-

Camber angle :-



⇒ It is the angle between normal of the road with the axis of the tire it may be positive or negative as per required. The value of camber angle is generally 2° - 3° .

Positive camber :-

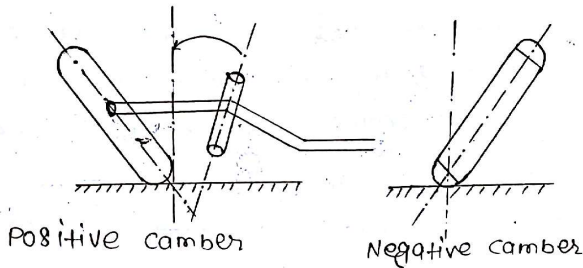
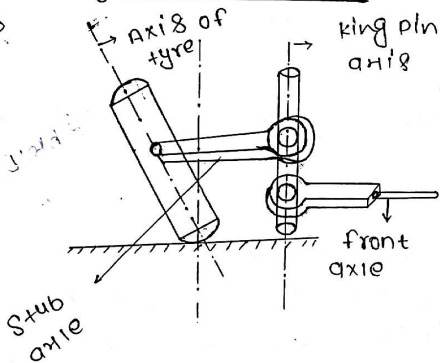
⇒ Positive camber is given to those vehicle which are under heavy load. Due to heavy load the tire tilt inward therefore positive camber is given to compensate this show that the tire will become straight under heavy load.

Negative camber :-

⇒ Negative camber is given to those vehicle

which runs at very high speed.
 when the vehicle runs at very high speed centrifugal force becomes dominant which tends to tilt the tire outward. therefore negative camber is so given that when centrifugal force act it counter balance the outward tiltness and make the wheel straight.

ii) King-pin inclination :-

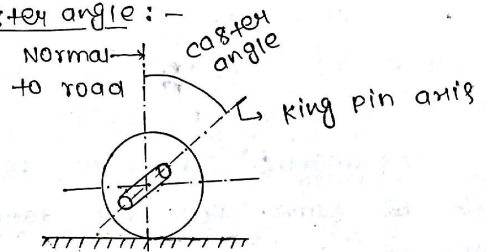


- ⇒ It is the angle between the axis of the King pin and normal to the road surface when viewing from front view.
- It's value lies between 4° - 8°.
- It provides stability while taking a turn because it helps in turning the wheel by giving it more space and thus reduces the restriction.

† Included angle :-

- ⇒ It is the total angle between the axis of the tyre and king pin axis i.e. It is the sum of camber angle and King pin inclination.

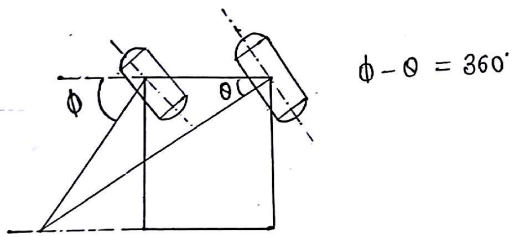
† Caster angle :-



- ⇒ Caster angle is the angle b/w King pin axis with vertical when seen in the side view.

- its value lies between 2° - 8° .
- Caster angle is provided which gives the steering column very less effort to turn the wheel while taking a turn.

Toe out :-

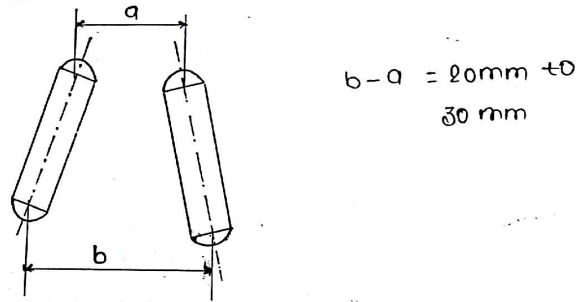


⇒ when the vehicle take a turn the outer wheel has to cover larger distance as compared to inner wheel and the center of rotation that is instantaneous center of rotation must be same. for this reason the angle of inclination of the outer wheel will be less than the angle of inclination of inner wheel.

⇒ this difference between the angle of inclination is achieved by ackerman steering linkage mechanism.

⇒ this difference of angle of inclination of both front wheel while taking a turn is known as toe out.

Toe-In :-



⇒ It is observed that distance between front portion of two front wheel will be less than distance between the rear portion of two front wheel this is known as toe-in.

✦ BRAKE :-

⇒ Brake is the most important component of control system. It helps to control the speed and make the vehicle to change its state from motion to rest.

✦ Classification of Brake :-

⇒ Brake are basically classified in three ways.

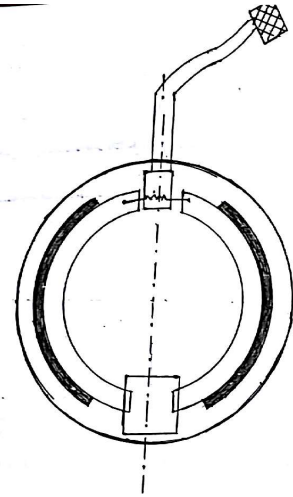
- i) Mechanical brake
- ii) Hydraulic brake
- iii) Pneumatic brake

i) Mechanical brake :-

⇒ Mechanical brake are those brake in which the brake pedal force transferred to the braking system (disc type or drum type) through the help of a cam follower or mechanical linkage.

✦ Drum type mechanical brake :-

Construction :- It consist of a drum which is mounted with rim of the wheel. It encloses two shoe having friction lining along its surface.



⇒ At one end shoe is connected to fixed anchor and at other end the shoe is connected with movable anchor with some mechanical linkage.

⇒ ~~the shoe~~ A spring is also connected between the movable anchor and the shoe.

⇒ the movable anchor is connected to brake pedal through lever fulcrum.

✦ Working :-

⇒ when the brake pedal is pressed the braking effort is transfer to the

movable anchor due to which the anchor moves and the link mechanism forces the shoe to make contact with the drum.

⇒ Due to friction lining attached with the shoe the friction lining also makes contact with the drum which stop the motion of the drum.

⇒ this movement of shoe towards the drum is against the spring. due to which potential energy is stored in the spring.

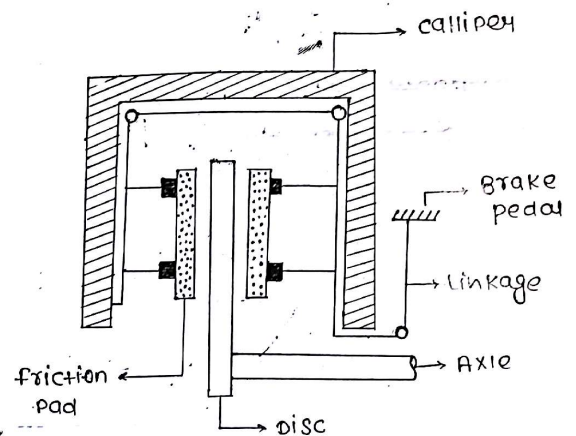
⇒ When the pedal is released the potential energy in the spring also releases and the shoe comes to its original position due to which it loses the frictional contact with the drum and again the drum starts rotating.

✦ Disc type mechanical brake :-

⇒ Construction :-

⇒ It consists of a disc which is attached to axle of the wheel.

It has friction pad attached with link mechanism to the brake pedal.



⇒ these friction pad are present on both side of the disc. whole arrange. is enclosed inside the caliper.

✦ Working :-

⇒ When the brake pedal is pressed the linkage mechanism forces the friction pad to make contact with the disc. due to which the motion of the disc is instantaneously gets stopped and the wheel attached to the disc through the axle also gets stopped.

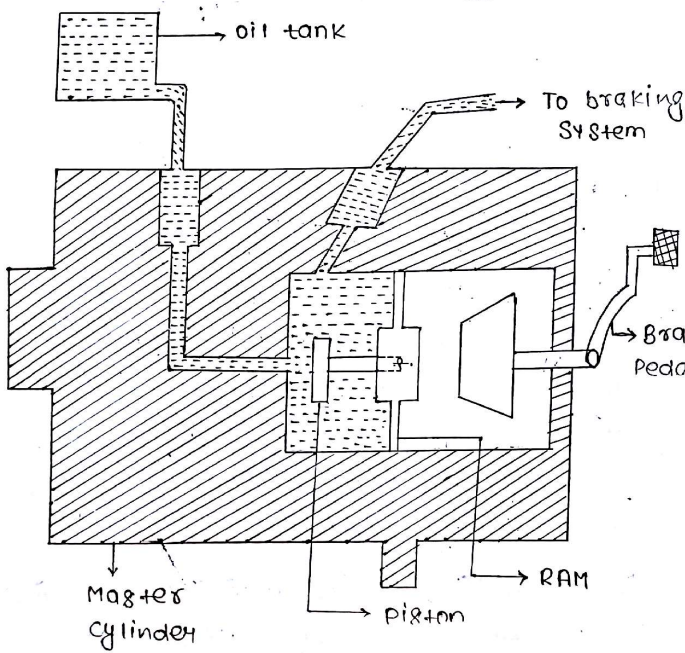
When the pedal is released the linkage mechanism forces the friction pad to

loses its contact with the disc. due to which the disc start rotating again.

2) Hydraulic brake :-

⇒ If the mechanical linkage as used in the mechanical brake replaced by a master cylinder which operates the hydraulic oil to transmit the brake pedal effort to the braking system (disc type, drum type)

Master cylinder :-



⇒ It works on Pascal's law, when the pedal is pressed the brake pedal exert pressure on the ram.

⇒ Since it is attached with the piston through a piston rod due to which the piston moves forward and closes the opening of hydraulic oil chamber in the master cylinder.

⇒ When the brake pedal is continue the effort ram slides on the piston rod and compresses the hydraulic oil in the master cylinder. due to which the pressure energy rises and the high pressurised hydraulic oil is transfer to the shoe or friction pad of the braking system.

3) Pneumatic brake :- (Air brake)

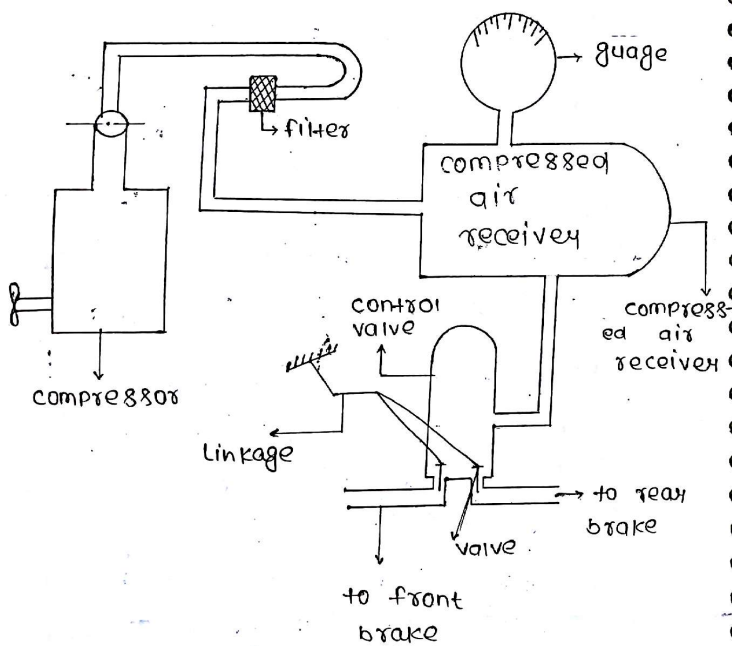
⇒ Pneumatic brake is used in high speed racing car or heavy duty vehicle or various luxurious vehicle.

the pressure of compressed air is used to apply the braking effort instead of the effort made by brake

pedal.

⇒ the compressor compresses the air which is stored in the air receiver at some optimum pressure.

⇒ when the pedal is pressed brake valve open and this compressed air is supplied to the shoe or friction pad used in drum or disc type braking system.



† Difference between hydraulic and pneumatic brake.

Hydraulic brake	pneumatic brake.
i) In case there is any leakage, then the hydraulic oil distorted the friction lining which increases the chance of brake failure.	i) In case of any leakage the air does not have any hazardous effect on the friction lining therefore it has no role in brake failure.
ii) It requires pedal effort to compress the liquid.	ii) It requires pedal effort to open the valve.
iii) for same pedal effort - its brake power is low.	iii) for same pedal effort brake power is high.
iv) It is self lubricating.	iv) It required lubrication.
v) less number of component.	v) More number of component.
vi) less costly.	vi) More costly.
vii) Simple in design.	vii) complicated in design.

† Difference between mechanical and pneumatic brake.

Mechanical brake	pneumatic brake
i) It is less powerful.	i) It is more powerful.
ii) force is transmitted through mechanical linkage.	ii) force is transmitted through compressed air flowing through pipeline.
iii) for same pedal effort brake power is low.	iii) for same pedal effort brake power is high.
iv) construction is simple.	iv) construction is complicated.
v) cost is low.	v) cost is high.
vi) these brakes have no application other than braking.	vi) these brakes have other application as the compressed air is used for tyre inflation, or wiper movement.

therefore more efficient.	therefore less efficient.
iii) Provision of small holes is done for heat dissipation.	iii) No such provision is required.
iv) Better life with less fade characteristics.	iv) less life with fade characteristics.
v) low in weight.	v) heavy in weight.
vi) More costly.	vi) less costly.

† Steering system :-

- ⇒ Steering is the most important system of automobile vehicle.
- It has two main function :-

 - i) to allow the vehicle to run in a straight road by controlling its direction.
 - ii) Minimizes the effort required during making a turn.

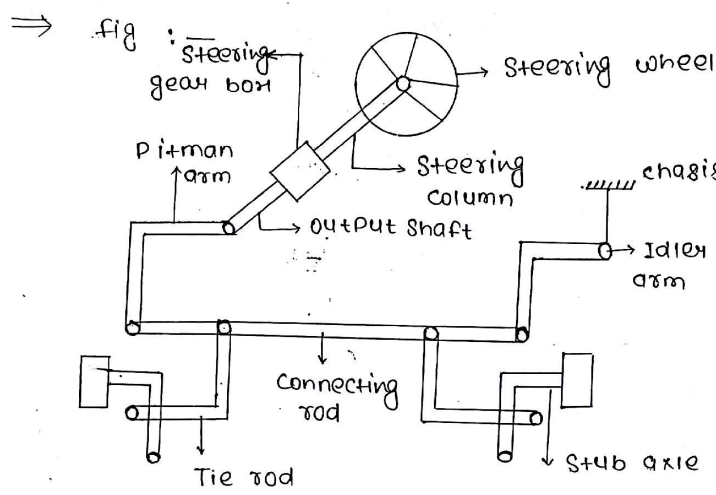
- ⇒ It has three main part.

 - i) steering linkage
 - ii) steering gearbox
 - iii) axle attached to the wheel

† Difference between disc and drum brake

Disc brake	Drum brake
i) friction lining are fixed on plane surface.	ii) friction lining are placed on curved surface.
frictional contact surface area is high	frictional contact surface area is low

Q. Draw and explain the component of a steering system. :-



Component of steering system :-

- i) Steering wheel :-
 - ⇒ Steering wheel rotates to turn the wheel left and right.
 - ⇒ If to turn the wheel in left direction the steering wheel rotates in anti-clockwise direction.
 - ⇒ If to turn the wheel in right direction the steering wheel rotates in clockwise direction.

ii) Steering column :-
 ⇒ Steering column is a hollow circular shaft which transfer the motion from steering wheel to the steering gear box.

iii) Steering linkage :-
 ⇒ It is a linkage mechanism system between the output shaft of the gear box to the axle of the wheel.

→ It has following parts :-

* Pitman arm :-
 ⇒ It connects and transfer the motion from output of steering gear box to the connecting link.

† Idler arm :-
 ⇒ It is generally arranged to the opposite of pitman arm. It is mounted on the chassis and is used to support the steering system.

† Tie-rod :-
 ⇒ Tie-rod connect and transfer the motion from connecting link to the wheel axle. (Stub axle).

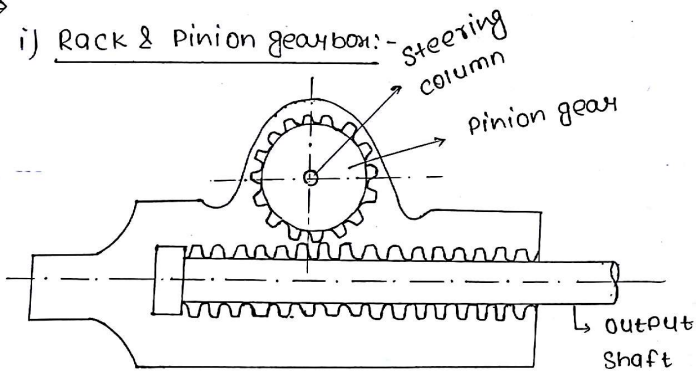
⇒ Since the tie-rod is pivoted on connecting link therefore the tie-rod has swivelling motion.

Stub-axle :-

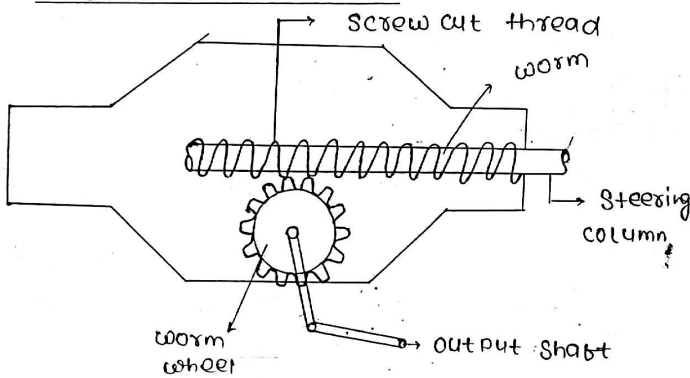
⇒ Stub-axle is connected to the tie-rod through a king pin and the swivelling motion of the tie-rod is transferred to the wheel through the stub axle.

Steering gear box :-

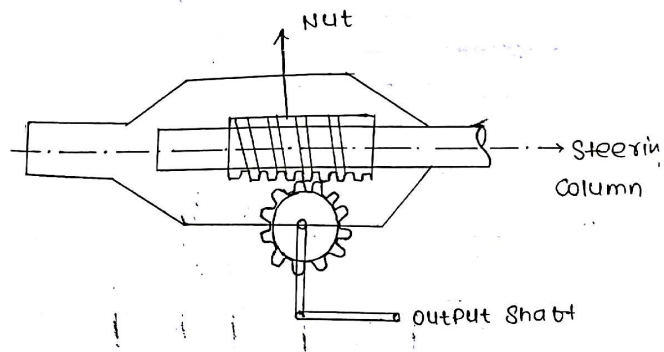
i) Rack & Pinion gear box :-



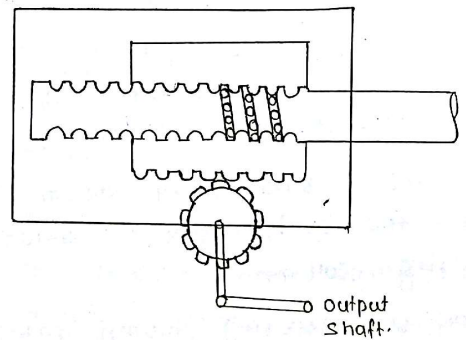
ii) Worm & worm wheel :-



iii) Worm & Nut-type steering gear box.



iv) Re-circulating Ball-type gear box :-



-|- Steering gear box :-

⇒ It is known as speed gear box as it reduces the rpm of output shaft of steering gear box due to which large torque is produced at the output shaft which is transferred to the wheel axle.

⇒ the rpm of the steering wheel will be more as compared to the rpm of the output shaft therefore less effort is required at steering wheel to produce large torque at output shaft.

-|- Types of steering gear box :-

i) Rack & Pinion type gear box :-

⇒ it is a type of gear box in which a rack having more number of teeth is attached to the output shaft.

⇒ It has a small gear known as pinion gear. the pinion gear is attached to the steering column.

⇒ when the steering column rotates the pinion gear also rotates since the rack is in mesh with pinion gear

therefore it reciprocates to and fro this motion is transferred to the output shaft through link mechanism.

⇒ Since the number of teeth on pinion gear is less therefore more rpm is developed and less torque is required.

⇒ Since the output shaft is attached with the rack therefore which have more number of teeth therefore rpm developed will be less and torque generated will be high.

ii) Worm & worm wheel :-

⇒ In this type of gear box the steering column is attached with a worm which has screw cut thread.

⇒ It has a worm wheel which has a teeth on its circumference and is attached to the output shaft.

⇒ when the steering column rotates the worm also rotates which is in mesh with the worm wheel therefore it also rotates.

⇒ Since we know that for one revolution of the worm the worm wheel will travel one teeth circumferential distance
⇒ therefore the rpm on the worm is high and torque required is less while the rpm on the worm wheel will be less. hence torque generated will be high.

iii) Worm & Nut-type steering gear box:-

⇒ we know that bolt and nut are those arrangement in which when bolt rotates nut perform (reciprocate).
⇒ In this the worm has ~~set~~ screw thread is attached to steering column is enclosed by a nut which has teeth on its outer circumference.
⇒ the worm wheel attached to the output shaft is in mesh with the teeth of the worm nut.
⇒ when the column rotates it rotate the worm and nut reciprocate over it. since it is in mesh with the

worm wheel. therefore the worm wheel also rotates.

→ By taking nut & bolt arrangement the life of the thread of worm wheel will increases. since it is not directly in contact with the teeth of worm wheel.
→ rest the working is similar to the worm & worm wheel.

† Recirculating ball-type steering box:-

⇒ It is modified form of worm & nut type gear box. In this the groove of the worm has a series of ball-bearing.
⇒ the ball-bearing reduces the friction b/w the worm & nut and absorb the impact force generated during meshing. hence increases the life of the worm & nut.
→ rest the working is similar to the worm nut type gear box.

† Power Steering :-

⇒

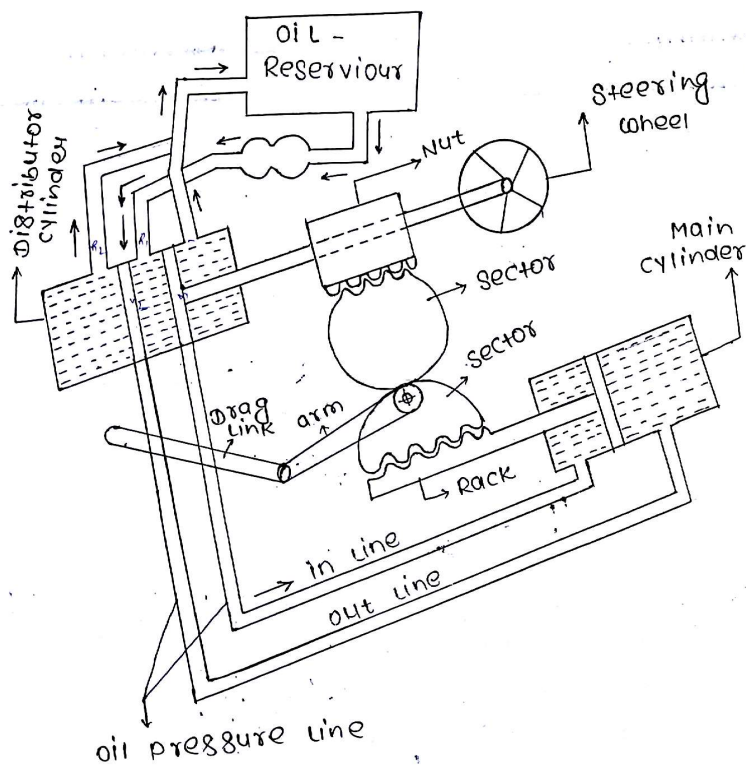


fig :- Power steering

Construction :-

- ⇒ It consist of two cylinder - distributor cylinder and main cylinder.
- ⇒ distributor cylinder contains control valve V_1 & V_2 .
- ⇒ while another cylinder i.e our main cylinder contains piston arrangement with a gear rack attached with the piston.
- ⇒ Both cylinder is connected with the Pipelin Steering column contain recirculating ball-type arrangement having sector with teeth attached with it and the teeth of the sector is in mesh with the rack of the piston of main cylinder. the drag link is coupled with the output shaft.

Working :-

- ⇒ It has two working condition.
 - i) turning
 - ii) returning

turning :-

- ⇒ when the steering wheel rotates valve V_2 closes R_2 and V_1 control

while V_1 opens the outline port and R_1 inline port.

⇒ the high pressurised liquid from the reservoir goes to the rod side of main cylinder through inline pipeline. this pressurised liquid will support the motion of the rack. hence effort ~~apply~~ required minimised to turn the column.

† Returning :-

⇒ when the steering column is released valve V_1 opens outline port and closes R_1 and V_2 opens inline port and port R_2 .

⇒ due to which the pressurised liquid goes to the piston side of main cylinder through outline port. due to which the piston having rack reciprocates in reverse direction and the liquid in the piston rod side return to oil reservoir through inline and port R_2 .

→ thus the liquid helps the rack which helps the column to rotate in reverse direction without applying any effort.

† Suspension System :-

⇒ It is most essential part of an automobile vehicle.

⇒ whenever, the vehicle runs on irregular surface. due to this sudden shock commonly known as jerk is produced.

⇒ If this produced jerk is transmitted inside the vehicle it will create uncomfortable to the passenger.

⇒ therefore to eliminate this jerk we require a system known as suspension system.

† element of suspension system. -

Element of suspension system :-

→ It has two element of suspension system.

i) Spring :-

⇒ Spring is a device or element which absorb the sudden shock or impact and starts oscillating.

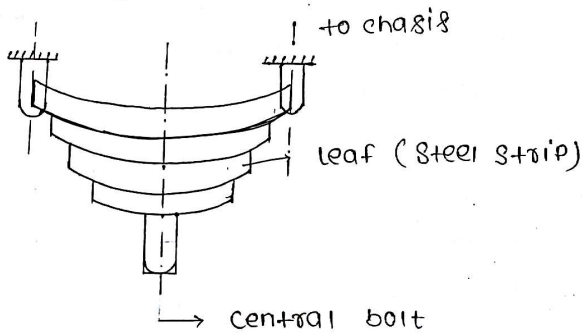
ii) Damper :-

⇒ the oscillation produced by the spring is eliminated by this damper.

⇒ It is also known as shock absorber.

Types of spring used in suspension system

i) Leaf spring :-



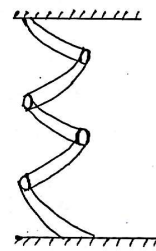
→ they are steel strip made up of mild steel.

→ the steel strip are joint together with the help of a central bolt.

→ the end of the leaf spring is mounted with the chassis.

→ It's major application is found in the rear position of heavy vehicle.

Helical coil spring :-



→ It is a spring generally made up of steel which is rounded in the shape of helix. hence it is known as helical coil spring.

→ It is widely used rear position and front position.

ii) Rubber Spring :-

=> Rubber spring has excellent property to absorb the shock.

=> It is generally made from polymerisation of buta-diene in presence of carbon and sulphur.

iv) gas spring :-

=> In this a cylinder is filled with compressed air which provides cushioning effect.

=> However it is not very successful due to leakage problem the compressibility nature will be lost which reduces its efficiency.

Shock absorber :-

=> If the spring absorb the load or any jerk potential energy gets stored in it.

=> the spring quickly releases this potential energy and starts oscillating.

=> this oscillation is not desirable therefore to eliminate this oscillation some arrangement is taken in addition with the spring known as shock absorber.

Type of shock absorber :-

=> it is of two types :-

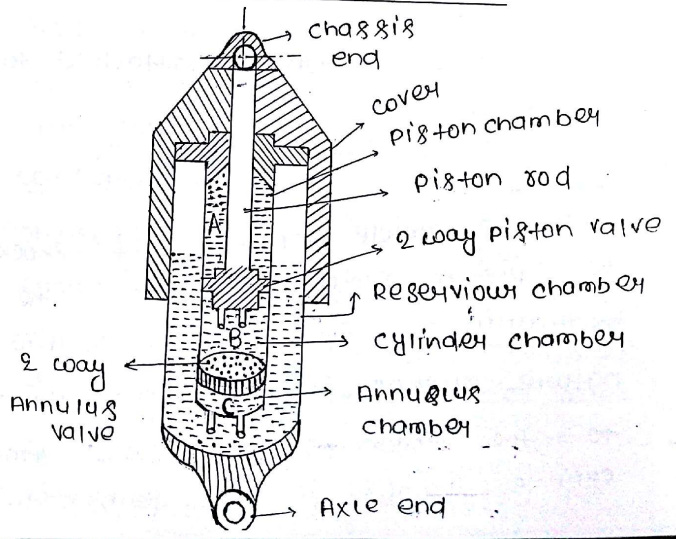
- i) Hydraulic shock absorber
- ii) Mechanical shock absorber

Hydraulic shock absorber :-

=> those shock absorber which uses hydraulic liquid to eliminate the oscillation produced in the spring is called hydraulic shock absorber.

=> Most commonly used shock absorber is telescopic shock absorber.

Telescopic Shock absorber :-



Construction :-

⇒ the upper end of shock absorber is mounted on the chassis. while the lower end is mounted on the axle casing.

⇒ It has four chambers.

- i) Piston chamber
- ii) Cylinder chamber
- iii) Annulus chamber
- iv) Reservoir chamber

⇒ All the chamber is filled with incompressible hydraulic oil.

→ It has two valve.

- i) Piston valve
- ii) Annulus valve

⇒ It has a piston rod attached to the upper end.

Working :-

⇒ When the vehicle encounters any shock the piston reciprocates and the hydraulic oil since incompressible in nature rushes from cylinder chamber to the piston chamber and from cylinder chamber to the reservoir

chamber through annulus. this process is called compression.

⇒ Now, when the oil from cylinder chamber rushes into the piston chamber and reservoir chamber the hydraulic oil already present in the piston chamber and reservoir chamber tends to compress but since it is incompressible. therefore the hydraulic oil from the piston chamber and reservoir rushes into the cylinder chamber which causes the piston to reach its original initial position.

⇒ therefore in this way the oscillation produced in the spring gets damped.

Air - suspension system :-

Component :-

★ Compressor :-

⇒ Compressor is attached to the engine. when engine runs the compressor compresses the atmospheric air present in it.

★ Air - Reservoir :-

→ Air - reservoir is a compressed air

Storage tank.

⇒ the compressed air from compressor is stored in this tank at a pressure of 20 kgf/cm^2 . If the pressure in this tank exceed this value it is released by the relief valve.

Control valve :-

⇒ control valve controls the direction of air flow.

→ It has two function :-

i) Supply the compressed air from air storage tank to the air bag through pressure line.

ii) Reject the excessive pressurised air to the atmosphere through the return line.

Air-bag :-

⇒ Air-bag is made up of rubber whose one end is mounted on the fixed arm which is attached to the chassis and the other end of the bag is attached to the swing arm which is mounted

on the wheel axle.

Working :-

⇒ When the vehicle encounter (सामना करना) any jerk the wheel moves upward due to which the swing arm deflect which compresses the air bag in which pressure exceed beyond 20 kgf/cm^2 .

⇒ Due to this the return line valve opens and the high pressurised air is released from the air bag to the atmosphere through the return line. Till the pressure reaches 12 kgf/cm^2 in the air bag.

⇒ Now, the air from air storage tank rushes into the air bag due to which air bag expand ^{which} ~~with~~ swing the arm and the wheel return to its original position.

figure :-

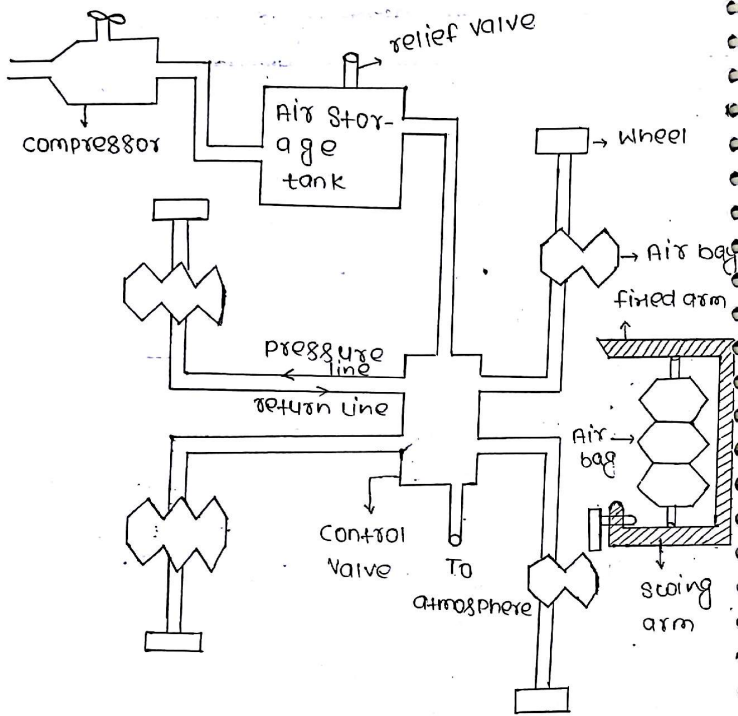
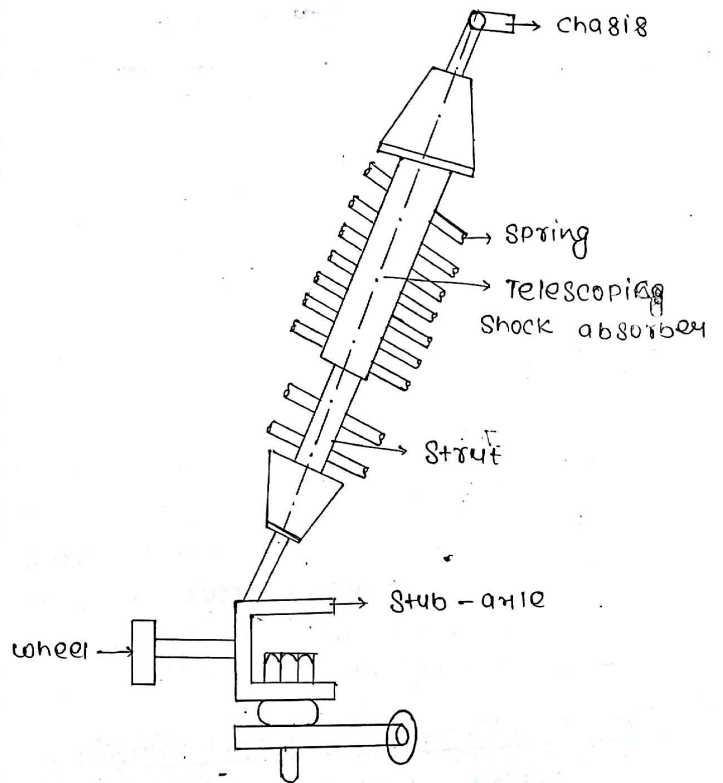


fig:- Air - Suspension System

Mac-pherson Suspension system :-



Mac-pherson is a mechanical engineer developed a telescopic strut type suspension system.

the top most position is mounted on the chassis of the vehicle and

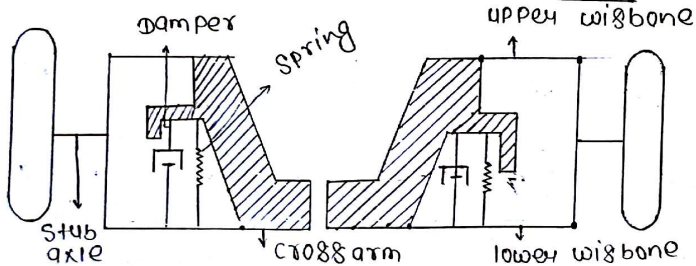
bottom most portion which is a strut is mounted on the stub axle.

⇒ When a vehicle encounters a jerk the spring compresses and absorb the shock which is damped by the telescopic shock absorber.

⇒ But it has a disadvantage that when the wheel encounter the jerk the camber angle of the wheel gets disturb due to which the wear in the tyre increases.

⇒ To eliminate this problem and maintain a constant camber angle some invention is done in it. i.e. instead of using a single strut double strut is used known as double wishbone suspension system.

!- Double wishbone suspension system:-



⇒ It consists of two wishbone are pivoted with stub axle at one end and other end is pivoted with cross arm.

⇒ The upper arm is shorter in length and lower arm is longer in length.

⇒ The spring with damper is attached to the cross arm and lower arm. By using this arrangement constant camber angle is maintained and wheel track also remains constant.

⇒ The vertical force transmitted to the spring through the cross arm which is a rigid structure before transmitting the vertical forces it is damped by the damper.

!- Wheel & Tyre :-

⇒ The power produced by the engine is transmitted through the transmission system to the axle.

⇒ A wheel assembly is mounted on the axle due to which when axle rotates it rotate the wheel, when wheel rotate the vehicle runs on the road.

!- Wheel assembly :-

⇒ It consists of hub mounted on the rear axle, disc or spoke mounted on the hub, rim is

flanged over spoke or disc and tyre is mounted over the circumference of the wheel.

TYPE OF WHEEL :-

→ Generally four types of wheel are used in automobile vehicle.

i) Disc Wheel :-

⇒ It is the simplest type of wheel. It is a circular disc which is cold pressed at its center. due to which its outermost portion gets elongate which provide a seat over which the rim is mounted.

ii) Wire / Spoke wheel :-

⇒ This type of wheel consist of a separate hub with a special rim which has provision of small holes on which wire and/or spoke can be fitted.

⇒ The spoke / wire are placed in uniform order with required tension.

⇒ One end of the wire is fitted on the rim and other end is fitted on the hub.

iii) Split Wheel :-

⇒ It consist of two disc coupled with each other with the help of nut and bolt.

⇒ The topmost portion of the disc must be wide enough so that the rim can be

fitted over it.

⇒ The main advantage of this type of wheel is that in this the rim carrying the tube tyre can be easily removed from the wheel by removing the nut & bolt.

iv) Heavy wheel :-

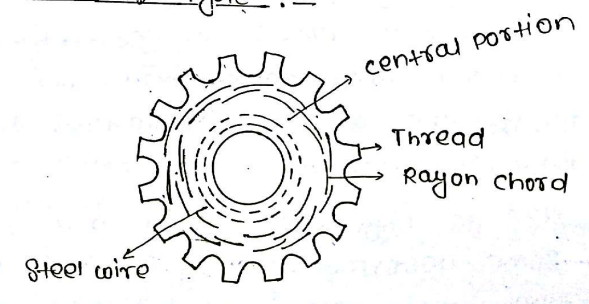
⇒ It is a cylindrical wheel made up of cast iron. It is used in road roller.

TYRE :-

⇒ It is the most essential important and necessary component of the automobile vehicle. as it is responsible for smooth running of the vehicle on the road.

⇒ It is a rubber bag in which compressed air is filled which provides cushioning effect.

Construction of tyre :-



Tread :-

- ⇒ tread are made up of synthetic rubber.
- tread are present at the topmost layer of the tyre.
- ⇒ It is made by vulcanisation of natural rubber in presence of carbon and sulphur which makes the surface very hard and provide the capacity to resist wear at very high temperature.

Central portion :-

- ⇒ central portion made up of natural rubber.
- the central portion of the tyre is natural rubber which is made by polymerisation process.
- ⇒ Natural rubber has an excellent property of toughness.

Rayon chord :-

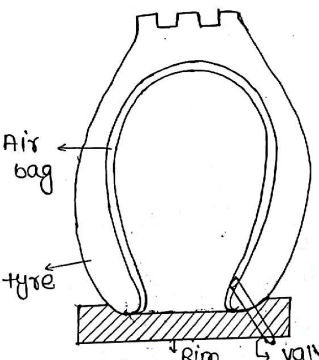
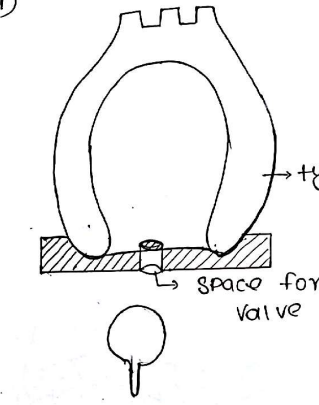
- ⇒ the natural rubber of central portion is inserted with rayon chord this chord binds the atom or molecules of the natural rubber.
- ⇒ due to high temperature and shock some deformation may takes place. Rayon chord provides stiffness which

provide the capacity of elastic recovery in the tyre.

Reinforced steel wire :-

- ⇒ inner circumference of the tyre is fitted with steel wire which provide strength to inner circumference. due to which it resist the wearing and tearing action when the tyre is fitted or removed on the rim.

Difference between tube tyre and tubeless tyre

<u>Tubeless</u>	<u>Tube tyre</u>
	
i) Air bag	i) Tube
ii) Tube is absent.	ii) Tube is present.
iii) It is suitable for all type of wheel except - spoke wheel.	iii) It is suitable for all type of wheel.
iv) valve is present with in tyre.	iv) valve is not present within tyre. It is

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- v) fitting is very easy.
- vi) After pump punching the vehicle may run some distance.
- vii) to repair the spot of puncher is very easy.

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present on the tube.

- v) fitting is difficult.
- vi) After punching of tyre the vehicle stop suddenly.
- vii) to repair the spot of puncher is very difficult.

CROSS-PLY

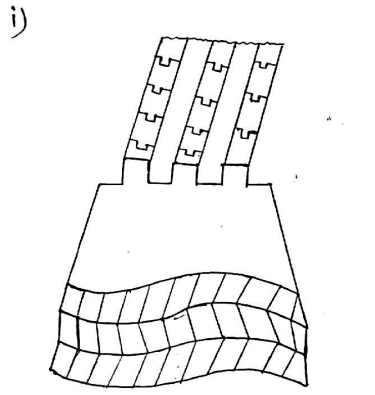
- ii) stiffness and toughness is more.
- iii) less costly.
- iv) less comfortable due to toughness.
- v) steering is hard.
- vi) tyre grip less on road.

RADIAL-PLY

- ii) stiffness and toughness is less.
- iii) More costly.
- iv) More comfortable due to toughness.
- v) steering is easy.
- vi) tyre grip more on road.

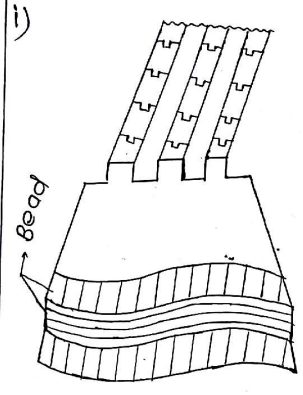
Q: Difference between cross ply and radial ply

CROSS-PLY



i)
 ii) the arrangement of chords are diagonally opposite from one bead to another bead.

radial-PLY



i)
 ii) chords are running radially parallel along its own bead.

Factor affecting tyre life :-

- i) Driving style :-
 → for example aggressive cornering & harsh braking increase wear and decrease the tyre life.
- ii) Position :-
 → front tyre wear faster because of movement through steering.
- iii) speed :-
 → High speed driving increase temperature and increase wear.
- iv) pressure :-
 → Both under inflation and over inflation increase wear.

v) Load :-

↳ Heavy loading increase wear.

vi) Alignment :-

↳ Incorrect wheel alignment results in rapid & uneven wear.