

6th Sem

AUTOMOBILE

ENGINEERING

CHAPTER-1.

INTRODUCTION

(*) Automobile :- (Imp)

- Automobile is the combination of two words
- (a) Auto (a) mobile
- Auto means automatic and mobile means movable
- An automobile is a self propelled vehicle which is used for the transportation of passengers and goods upon the ground
- A self propelled vehicle is that in which the power required for propulsion is produced inside it (inside the engine cylinder)
- Example :- scooter, car, bus, truck etc.

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(*) Types or classification of Automobile :-

→ The automobiles are classified on the following basis.

(1) According to the purpose :-

- (i) Passenger vehicle (car, jeep, bus)
- (ii) Goods vehicle (Truck, Pick up van)

(2) According to the capacity :-

- (i) Light motor vehicle (car, jeep)
- (ii) Heavy motor vehicle (bus, truck)

(3) According to the fuel used :-

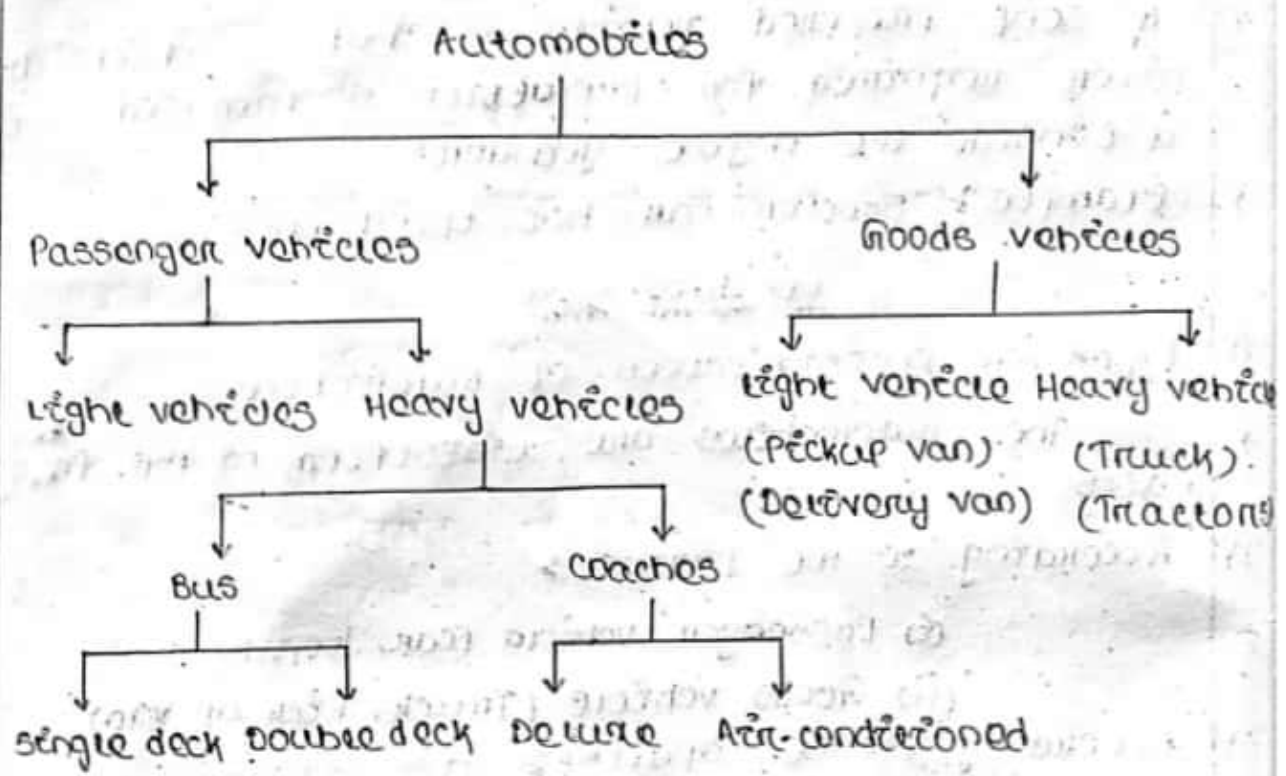
- (i) Petrol vehicle (Bike, car, jeep)
- (ii) Diesel vehicle (bus, truck)
- (iii) Electric vehicle (Bike, Battery car)

(4) According to the wheels :-

- (i) Two-wheeler (Bike, scooter)
- (ii) Three-wheeler (Auto rickshaw)
- (iii) Four-wheeler (car)
- (iv) Six-wheeler (bus)
- (v) Ten-wheeler (Truck)
- (vi) Eighteen-wheeler (Tractor)

(b) According to the drive of vehicle :-

- (i) single-wheel drive (car)
- (ii) Two-wheel drive (motor cycle)
- (iii) Four-wheel drive (jeep or tractor)
- (iv) six-wheel drive (Truck or Bus)
- (v) left-hand drive (Foreign cars)
- (vi) Right-hand drive (Indian cars)



(*) Specification of Automobile :-

→ The following specifications are mentioned while purchasing an automobile

(a) According to type :-

→ Car, Bus, Truck, motor cycle, scooter etc

(b) According to capacity :-

→ 2-seater, 4-seater, 6-seater, 22-seater, 32-seater

(c) 1-ton, 2-ton, 5-ton, 10-ton, 15-ton, 20-ton

(d) According to make :-

→ Hero, Honda, Ashok Leylands, Tata, Vespa, Mahindra

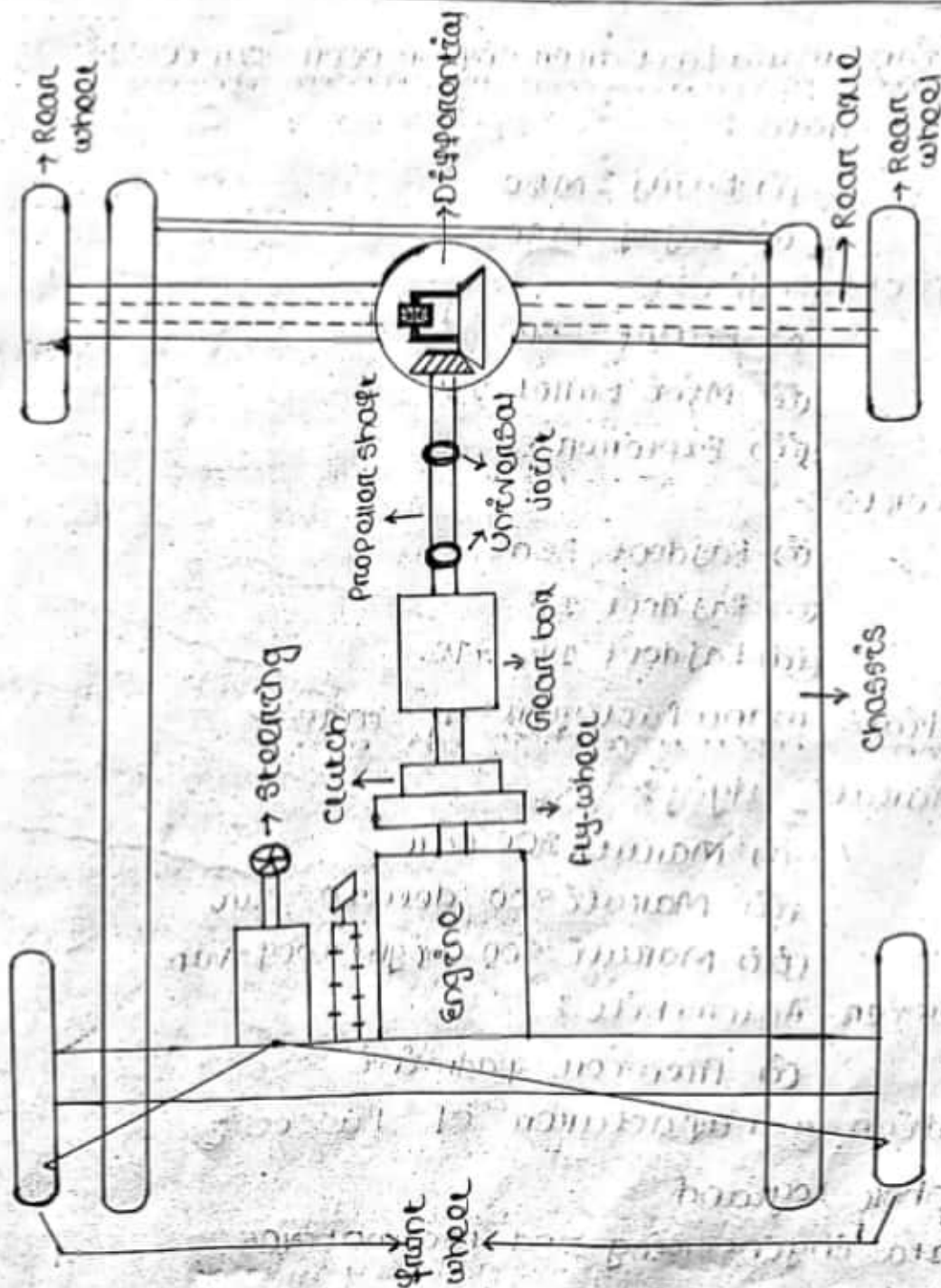
(e) According to drive :-

→ 2-wheel drive, 4-wheel drive, six-wheel drive
→ left-hand drive, right hand drive

- (e) According to the model:-
 → Year of manufacturing and code no.

(*) Note:

- In 1769, a French engineer Captain Nicholas Cugnot built the 1st road vehicle propelled by its own power
 → It was a 3-wheeler, 4-seater vehicle fitted with a steam engine
 → It attained a speed of 2.5 mile per hour for 15 mins



(Layout of the Automobile chassis)

(*) Indian manufacturer of scooters :-

(1) Andhra Pradesh scooters :-

- (i) Vespa PL 140
- (ii) Allwyn Puspak 150

(2) Bajaj Auto :-

- (i) Bajaj 150 CBU
- (ii) Bajaj 150 CKD

(3) Lohia machines :-

- (i) Vespa XE 100
- (ii) Vespa XE 150

* Indian manufacturer of motor cycles :-

(1) Bajaj Auto :-

- (i) Bajaj M50
- (ii) Bajaj M80

(2) Enfield, India :-

- (i) Bullet 350
- (ii) Mini Bullet 198
- (iii) Explorer-50

(3) Escorts :-

- (i) Rajdoot 350
- (ii) Rajdoot 175
- (iii) Rajdoot 175 ATB

* Indian manufacturer of cars :-

(1) Maruti Udyog :-

- (i) Maruti 800 car
- (ii) Maruti 800 deluxe car
- (iii) Maruti 800 high roof van

(2) Premier Automobile :-

- (i) Premier padmanti

(*) Indian manufacturer of Busses :-

(1) Ashok Leyland

(2) Tata Engineering and Locomotives

(3) Hindustan Motors

(*) Classification of Automobile engine :-

→ Automobile engines are classified according to the following basis.

(1) Type of fuel used :-

- (a) Petrol engine
- (b) Diesel engine
- (c) Gas engine

(2) Cycle of operation :-

- (a) Otto cycle
- (b) Diesel cycle
- (c) Dual cycle or semi-diesel cycle

(3) Number of strokes per cycle :-

- (a) 2-stroke engine
- (b) 4-stroke engine

(4) Types of ignition :-

- (a) Spark ignition engine
- (b) Compression ignition engine

(5) Number of cylinder :-

- (a) Single cylinder engine
- (b) Two cylinder engine
- (c) Three cylinder engine
- (d) Four cylinder engine
- (e) Six cylinder engine
- (f) Eight cylinder engine
- (g) Twelve cylinder engine
- (h) Sixteen cylinder engine

(6) Arrangement of cylinder :-

- (a) Vertical engine
- (b) Horizontal engine
- (c) Radial engine
- (d) V-shape engine
- (e) Opposed cylinder engine

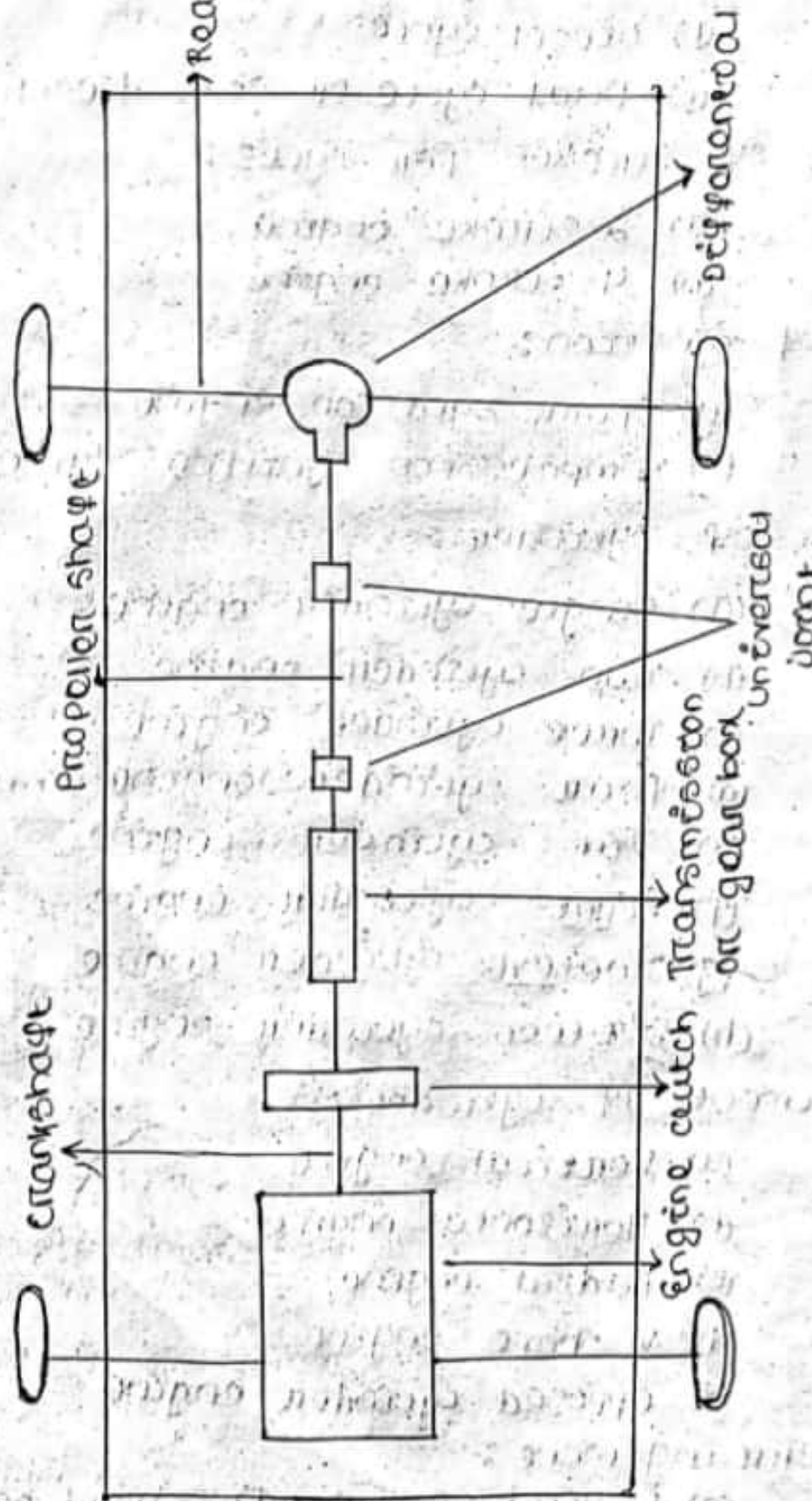
(7) Valve arrangement :-

- (a) L-Head engine
- (b) F-Head engine
- (c) I-Head engine
- (d) T-Head engine

CHAPTER-2.

TRANSMISSION SYSTEM.

Handwritten title: Transmission System of Automobile



Automobile power transmission system

- The power developed inside the engine cylinder is aimed to turn the wheels so that the motor vehicle can move on the road.
 - The reciprocating motion of the piston is converted into rotary motion of the crankshaft by the connecting rod and also the flywheel rotates.
 - The clockwise motion of the crankshaft is transmitted to the rear wheels through clutch, gear box, universal joints, propeller shaft and differential to the wheels.
 - The transmission of engine power to the rear wheels is called power transmission.
 - The figure shows the power transmission system of an automobile in which the motion of the crankshaft is transmitted through the clutch to the gear box.
 - The gear box consists of a set of gears to change the speed, from the gear box the motion is transmitted to the propeller shaft through the universal joint and then to the differential through another universal joint.
 - Universal joint is used between two shafts which are connected at an angle for the transmission of power.
 - From the differential the power is transmitted to the rear wheel through rear axle.
 - The differential provided on the rear axle is used to provide relative motion between the rear wheels while taking turn.
 - In this way, the engine power is transmitted to the rear wheels.
- ⊙ Clutch :- (Imp)
- Clutch is a device, used in the transmission system of a motor vehicle to engage and dis-engage the engine to the transmission system.

- The clutch is placed between engine and the transmission system.
- When the clutch is engaged the ~~Power~~ ^{Power} flows from the engine to the rear wheels through the transmission system and the vehicle moves.
- When the clutch is disengaged the power is not transmitted to rear wheels and the vehicle stops while the engine is running.
- The clutch is disengaged when at the time of starting, shifting gears and breaking of an engine of the vehicle.

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(*) Principle of operation :-

- The clutch works on the principle of friction when two friction surfaces are brought in contact with each other and then pressed there united due to the friction between them.
- When one member revolve, the other one also revolve, the friction between two surfaces depends upon area of the surfaces, pressure applied and coefficient of friction.

(*) Main parts of a clutch :-

- The main parts of a clutch are divided into 3 groups.
 - (1) Driving member
 - (2) Driven member
 - (3) Operating member

(*) Driving member :-

- The driving member consist of a flywheel connected to engine crankshaft and the flywheel is bolted to a cover which carries a pressure plate and driving disc, releasing lever and pressure spring.

- The entire assembly of the flywheel and the

cover rotates all the time.

(*) Driven member:-

→ The driven member consist of a disc known as clutch plate. It is free to slide lengthwise on the spring clutch shaft.

→ When it is gripped between the flywheel and pressure plate it rotates the clutch shaft.

(*) Operating member:-

→ The operating member consist of clutch pedal, linkage, pressure spring and releasing lever for proper operation of the clutch.

(*) Types of clutch:-

→ The clutch's are classified into following categories.

(1) Friction clutch

(i) Single plate clutch

(ii) Multi plate clutch

(a) wet (b) dry

(iii) Cone clutch

(a) External (b) Internal

(2) Centrifugal clutch

(3) Semi-centrifugal clutch

(4) Hydraulic clutch

(5) Vacuum clutch

(6) Electro-magnetic clutch

(7) Positive clutch - dog and spline

(8) Over-running clutch.

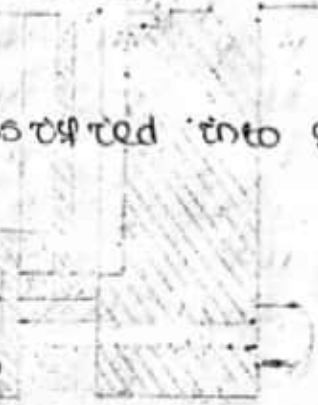
(*) Single plate clutch:- (imp)

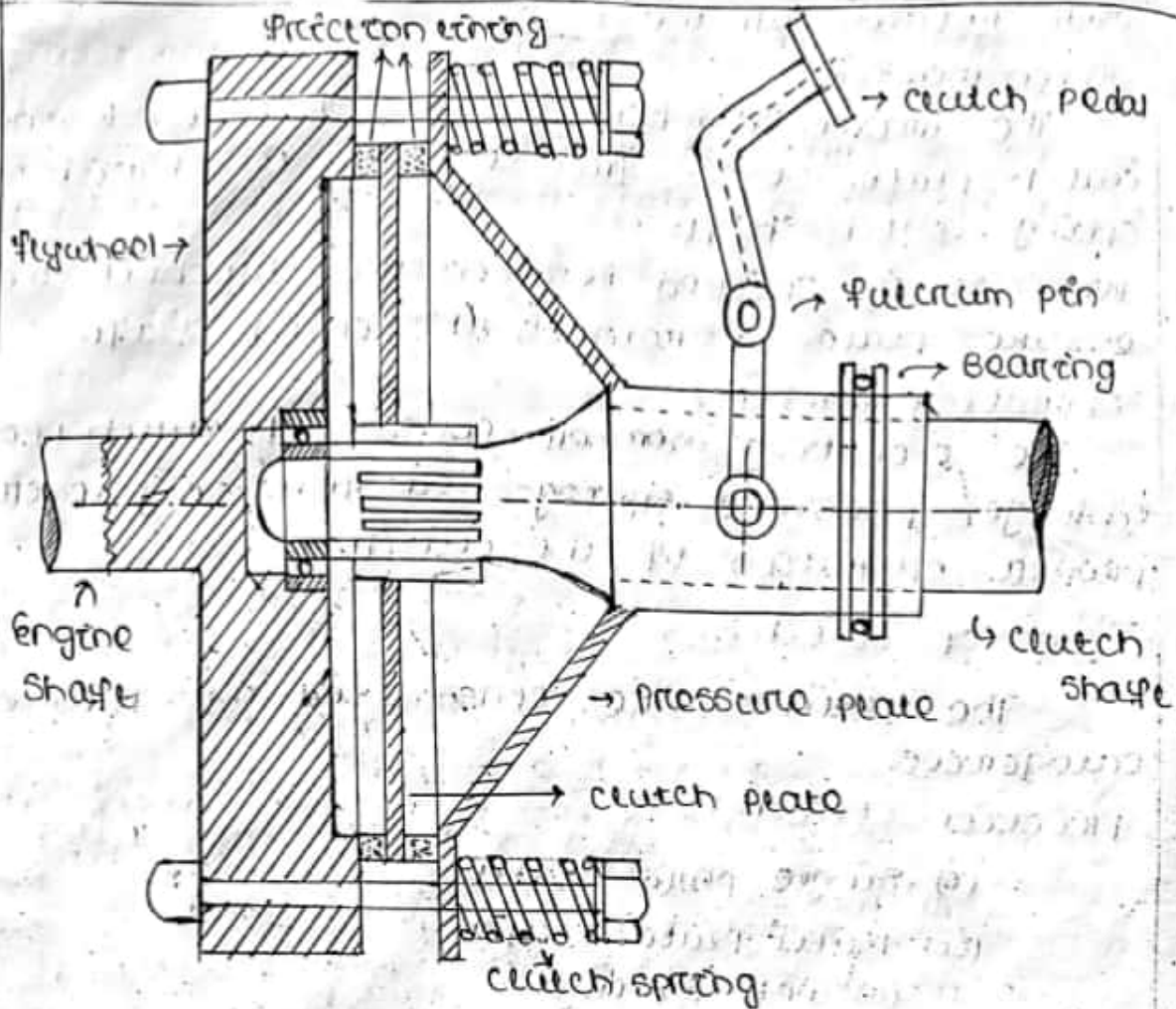
→ It is the most common type of clutch used in motor vehicle.

→ It consist of only one clutch plate mounted on the splined clutch shaft as shown in the figure.

→ The flywheel is mounted on the engine crankshaft and rotates with it.

→ The pressure plate is bolted to the flywheel.





through clutch spring 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 and the friction linings on both side of the clutch plate

→ Due to friction between the flywheel, clutch plate and pressure plate, the clutch plate revolves with the flywheel

→ When the clutch plate is rotated the clutch shaft is also rotated and the clutch shaft is connected to the gear box so the engine power is transmitted to the clutch shaft from the crank shaft

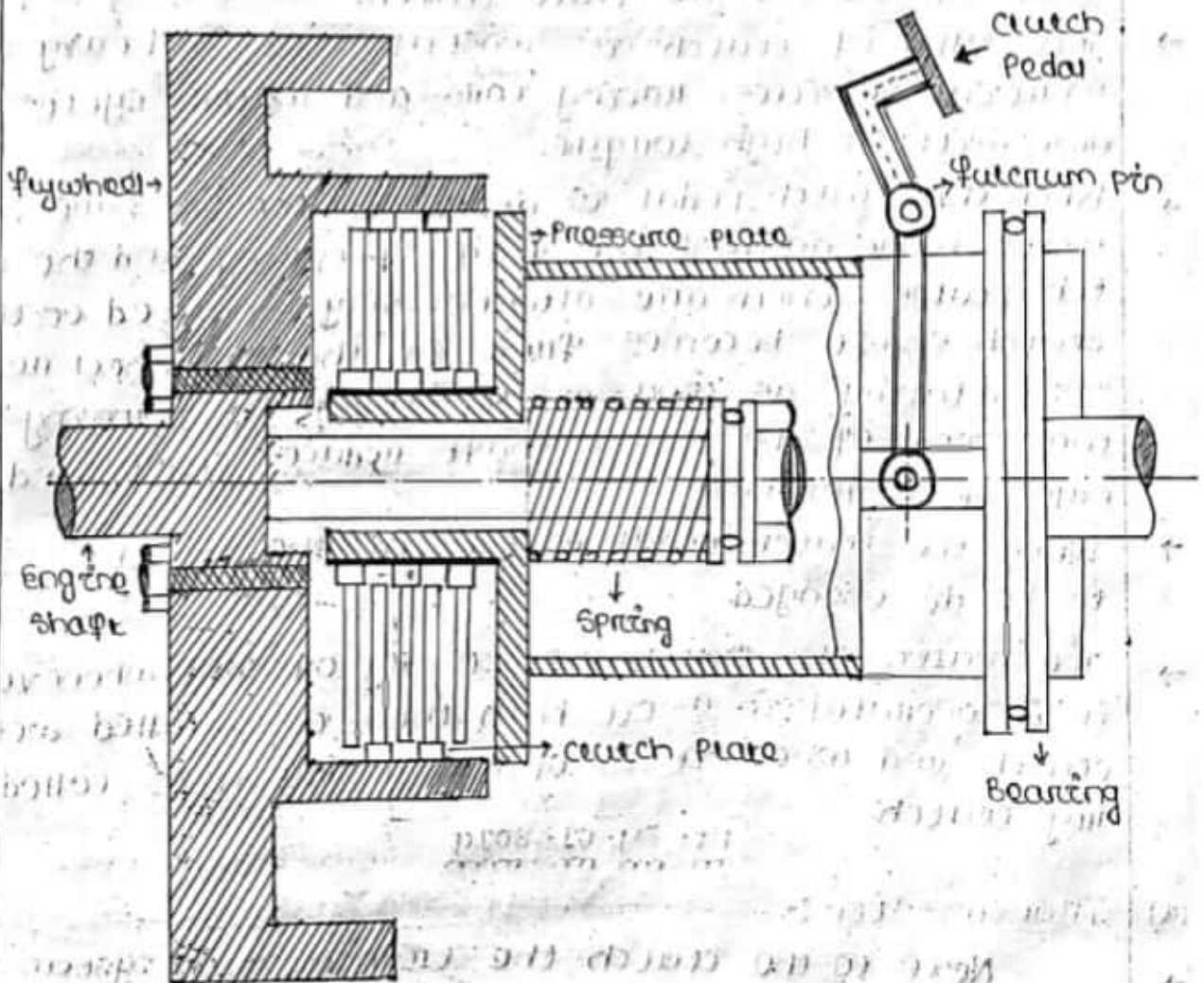
→ When the clutch pedal is pressed, the pressure plate moves back against the force of spring and the clutch plate becomes free between flywheel and the pressure plate

→ In this way, the flywheel remains rotating as long as the engine is running and the clutch shaft speed reduces slowly and finally stops rotating.

→ When the clutch pedal is pressed the clutch is said to be disengaged otherwise it always remains engaged due to spring force.

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(c) Multiplate clutch :-



→ Multiplate clutch consists of a number of clutch plates instead of one clutch plate as in the case of single plate clutch.

→ As the number of clutch plates are increased the friction surface also increases. The increase in friction surface also increases the capacity of the clutch to transmit torque.

→ The plates are alternatively fitted to the engine shaft and clutch shaft.

- They are firmly pressed by strong coil spring as shown in the figure.
- Each of the alternative plate slides in grooves on the flywheel, and other plates on the spines of the clutch shaft.
- The alternate plates have internal and external splines.
- The multiple plate clutch works on the same way as that of the single plate clutch.
- This type of clutch is mostly used in heavy commercial vehicles, racing cars and motor cycles for transmitting high torque.
- When the clutch pedal is depressed the pressure plate moves back against the force of spring and the clutch plates which are alternatively mounted on the clutch shaft becomes free so the flywheel remains rotating as long as the engine is running but the speed of the clutch shaft reduces slowly and finally stops rotating.
- When the clutch pedal is pressed the clutch is said to be disengaged.
- The multiple plate clutch may be dry or wet, whenever it is operated in a oil bath then it is called wet clutch and when it is operated dry it is called as dry clutch.

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(*) Transmission:-

- Next to the clutch the transmission system is used in the motor vehicle, the word transmission is used for a device that is located between the clutch and propeller shaft. It may be a gear box, torque converter, fluid drive, over drive, hydraulic drive etc.

(*) Gear box:- (imp)

- The purpose of gear box is to provide high torque at the time of starting, hill climbing, accelerating and pulling a load.
- When a vehicle is starting from rest, hill climbing

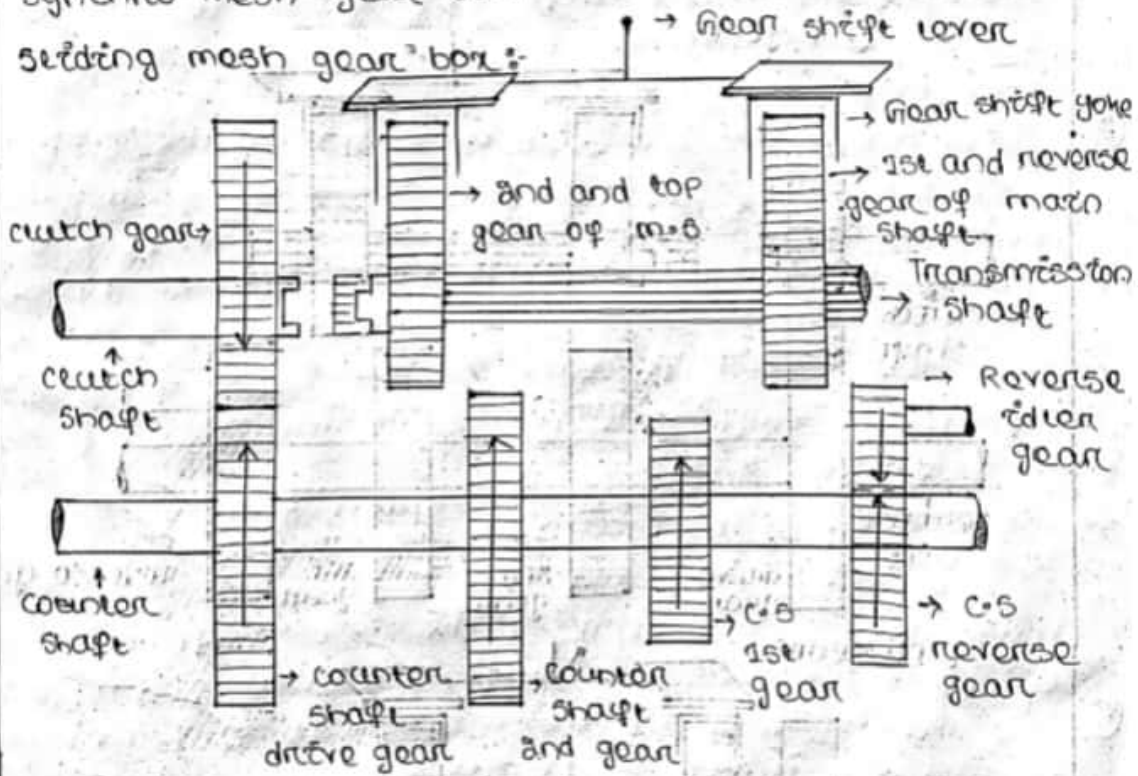
high torque or tractive effort is required at the driving wheels. Hence a device must be provided to permit the engine crankshaft to revolve a relatively high speed while the wheels turn at slower speed.

- This can be obtained by a set of gears called gear set enclosed in a metal box called gear box
- Due to variation of torque the speed of the vehicle is also varied.

(*) Types of Gear box:-

- (i) Sliding mesh gear box
- (ii) Constant mesh gear box
- (iii) Synchro mesh gear box

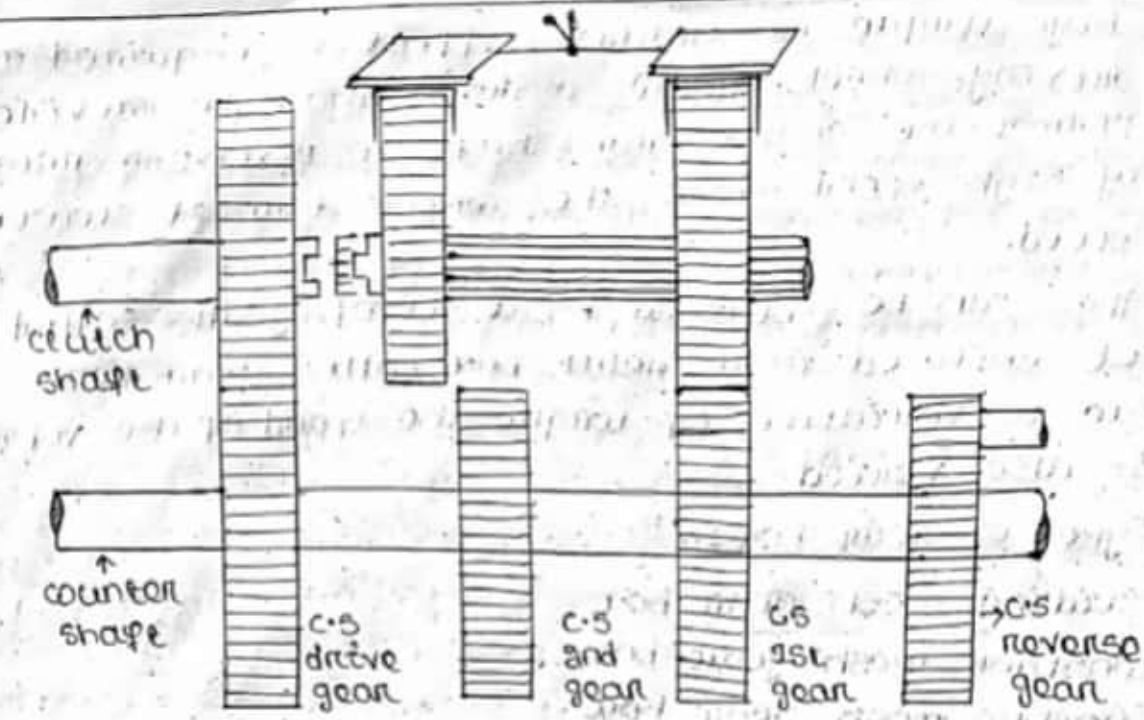
(i) Sliding mesh gear box:-



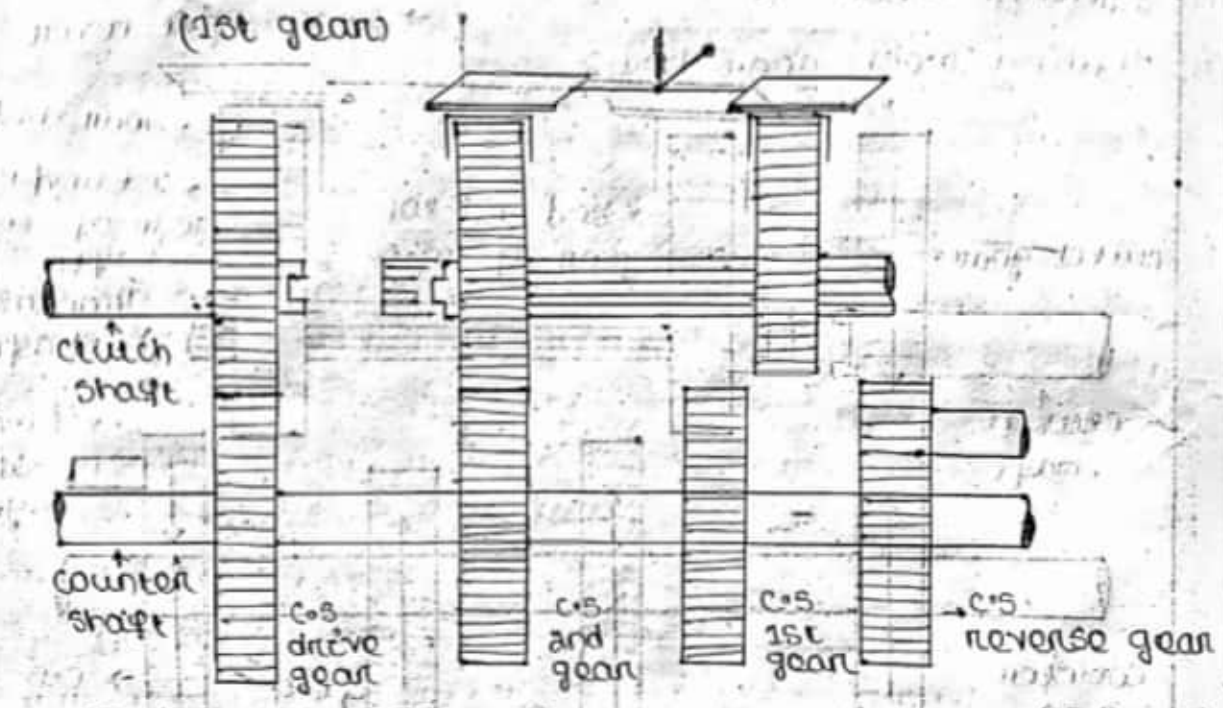
(3-speed sliding mesh gear box)



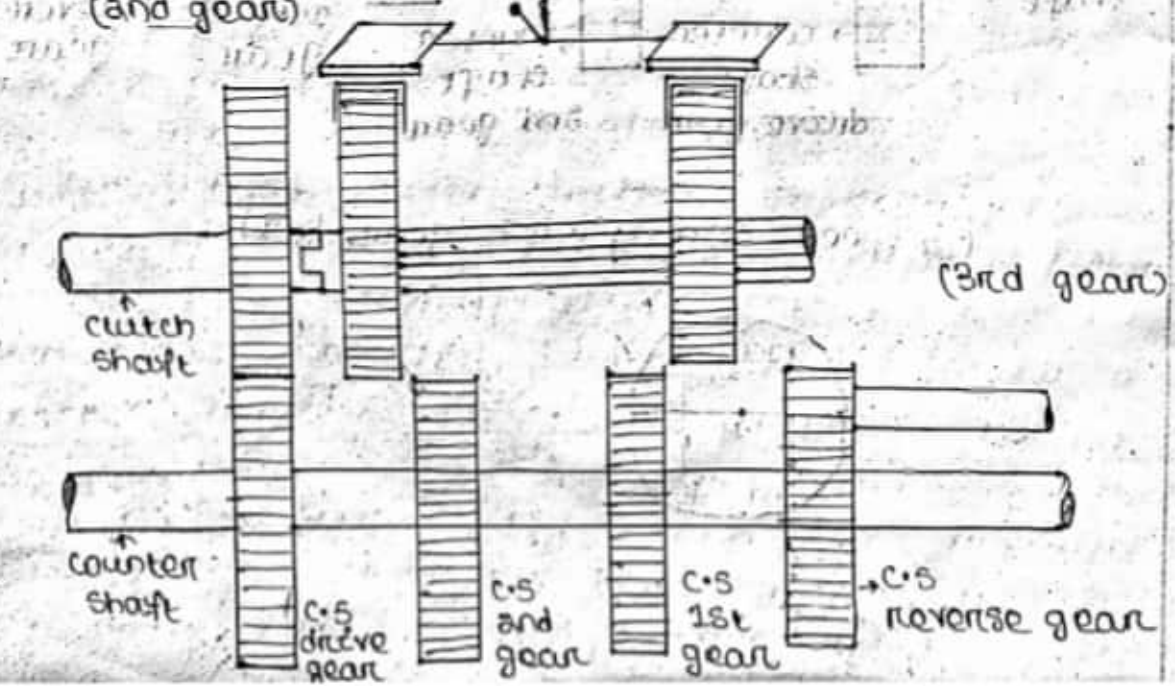
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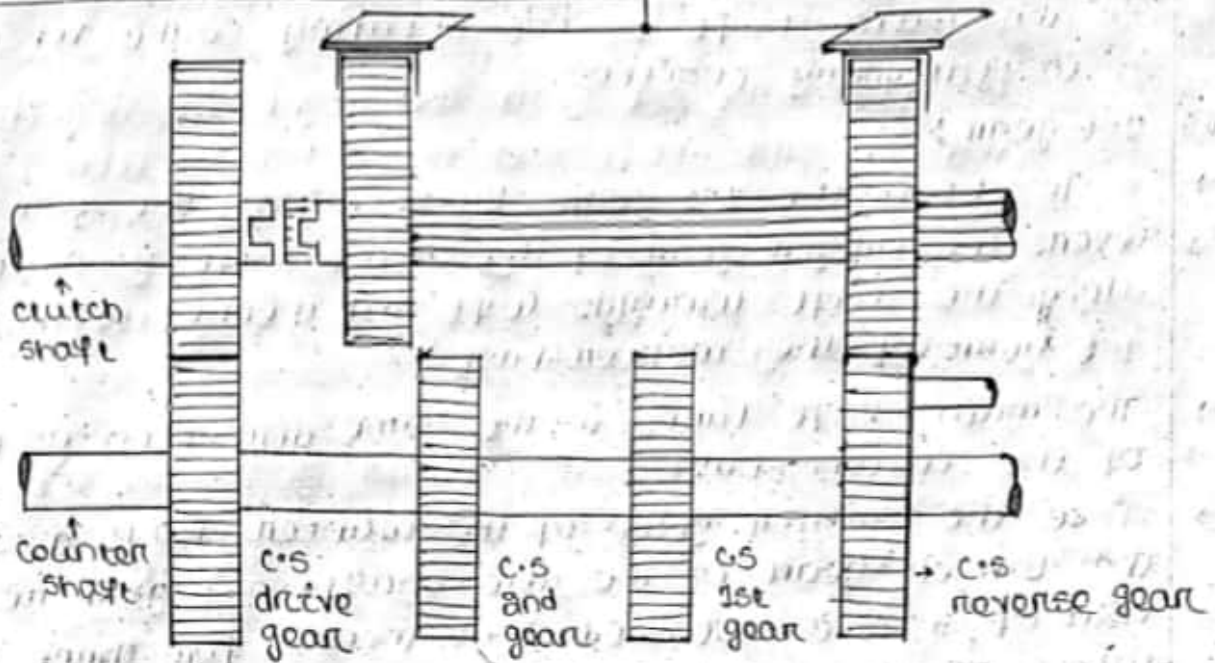
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(Reverse gear)

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(*) 3-speed sliding mesh gear box:-

- It is the simplest type of gear box as shown in the figure.
- The figure shows the neutral position of the gear box in which the clutch gear is rigidly fixed to the clutch shaft and remains always connected to the drive gear of the counter shaft.
- Three other gears named as and gear, 1st gear and reverse gear are connected to the counter shaft and 3 gears are mounted on the splined main shaft named as and and top gear, and another is 1st and reverse gear.
- A reverse idler gear is mounted on an auxiliary shaft and always meshes with the reverse gear of the counter shaft.
- (a) Neutral Position:-
 - When the engine is running and clutch is engaged the clutch shaft drives the counter shaft and all the gears rotate with the counter shaft in opposite direction as that of the clutch shaft.
 - In this position the gears of the main shaft are free

so the main shaft is not rotating so the vehicle is in stationary position.

(b) 1st gear:-

→ To obtain the 1st gear by operating the gear shift lever the larger gear of the main shaft is moved along the shaft towards left and meshes with the 1st gear of the countershaft.

→ The main shaft turns in the same direction as that of the clutch shaft.

→ Since the smaller gear of the counter shaft drives the larger gear of the main shaft so a gear reduction of 3:1 is obtained, that means for three revolution of the clutch shaft the main shaft rotates only in one revolution.

(c) 2nd gear:-

→ To obtain the 2nd gear by operating the gear shift lever the larger gear of the main shaft is de-meshed from the smaller gear of the counter shaft and smaller gear of the main shaft moves towards right and meshes with the 2nd gear of the counter shaft.

→ Here the main shaft turns in the same direction

of clutch shaft. Here is a gear reduction of 2:1 is obtained.

(d) 3rd and top gear:-

→ To obtain the 3rd gear by operating gear shift lever the smaller gear of the main shaft is de-meshed from the counter shaft and gear and then the 2nd and top gear of the main shaft is forced axially against the clutch shaft gear.

→ External teeth of the clutch shaft gear meshes with the internal teeth on the 2nd and top gear and the vehicle moves in forward direction.

→ Here a gear reduction of 1:1 is obtained.

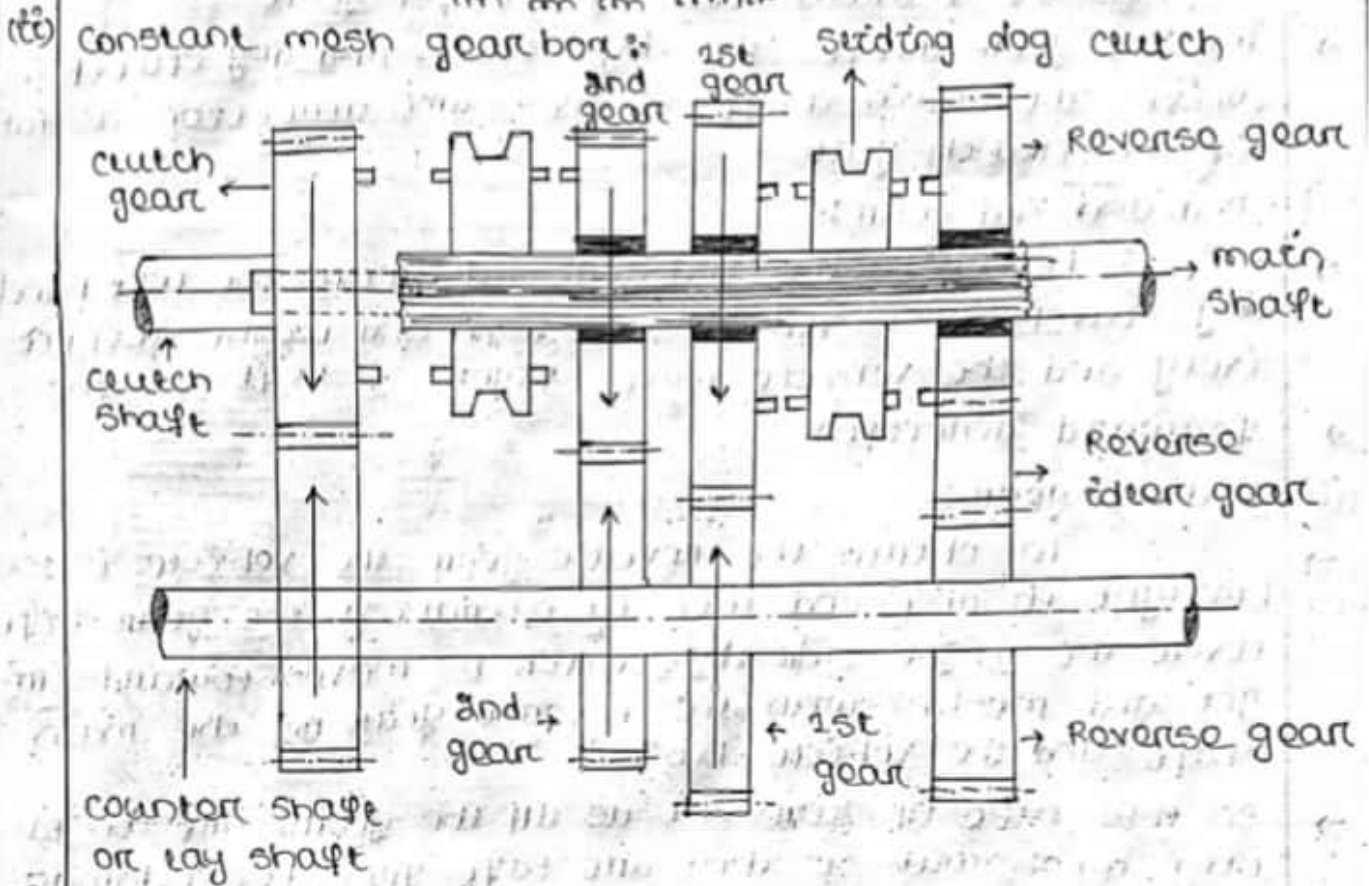
(e) Reverse gear:-

→ To obtain this gear by operating the gear shift lever the vehicle is first brought to rest and by operating the lever the first and reverse gear of the main shaft is moved towards right and meshes

with the reverse idler gear

→ The main shaft rotates in the opposite direction of the clutch shaft and the vehicle backs.

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→ In this type of gear box all gears of the main shaft are in constant mesh with the corresponding gears of the countershaft and a dog clutches are provided on the main shaft one between clutch gear and 2nd gear and the other between 1st gear and reverse gear.

→ All the gears of main shaft are free on it. The main shaft is splined and the dog clutches can slide on the shaft and rotates with it.

→ All the gears of the counter shaft are rigidly fixed to the shaft.

→ In neutral position the clutch gear drives the counter shaft drive gear and the countershaft rotates and all the gears of the countershaft also rotate. All the gears of the main shaft are constantly meshed with the gears of the counter shaft so rotate on its axis without affecting the main shaft.

(i) 1st gear:

- To obtain the 1st gear the right side dog clutch is moved towards left and its external teeth mesh with the internal teeth of the 1st gear
- The 1st gear drives the dog clutch and dog clutch drives the main shaft in the same direction as that of the clutch gear

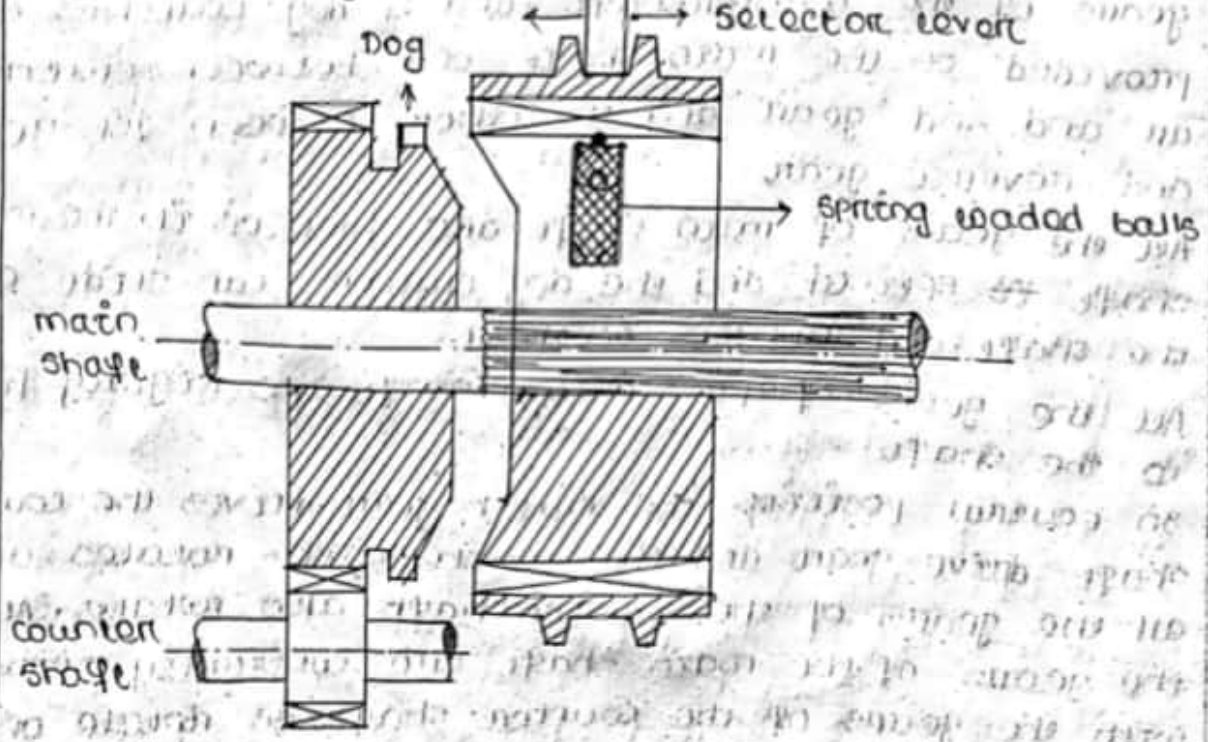
(ii) 2nd and 3rd gear:

- To obtain the 2nd and 3rd gear the left hand dog clutch is moved toward left and right respectively and the vehicle moves right = left in the forward direction.

(iii) Reverse gear:

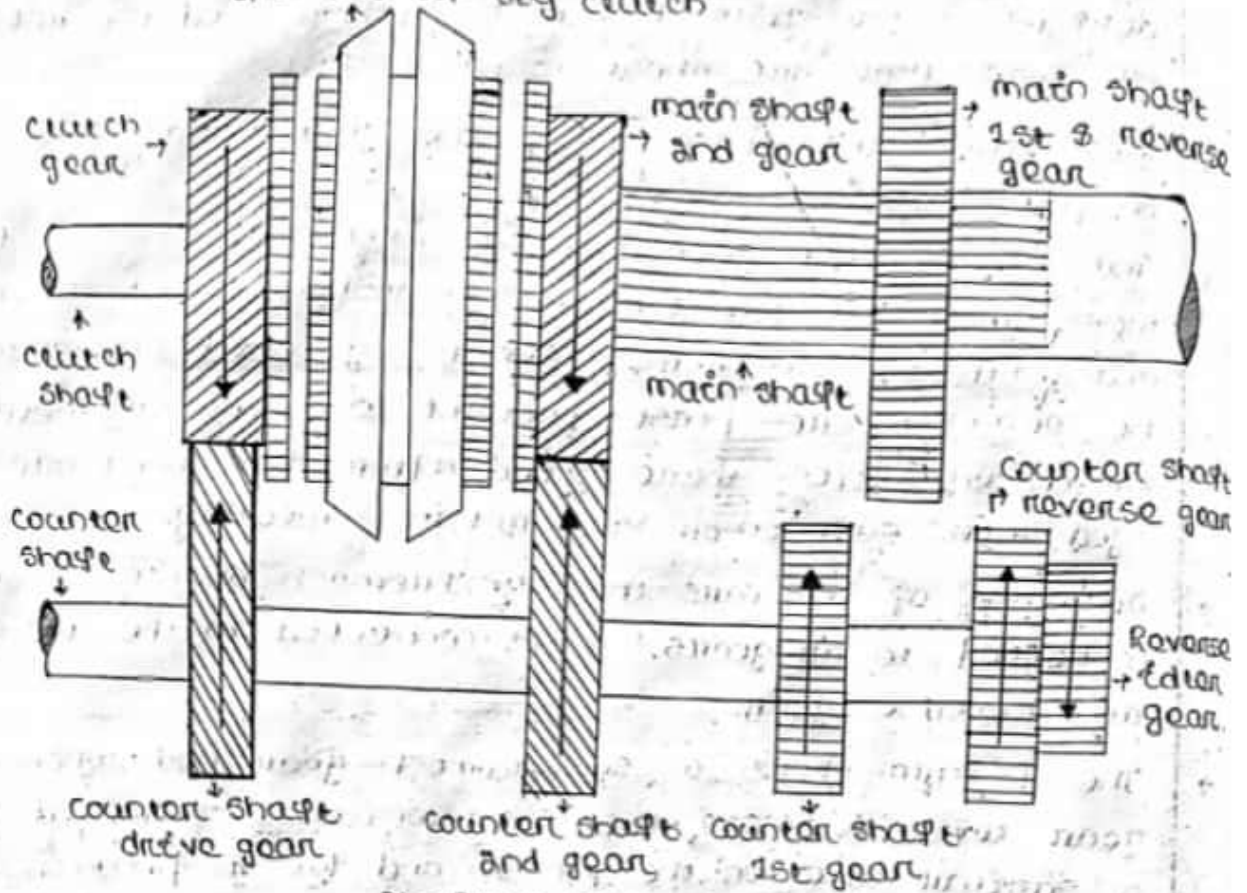
- To obtain the reverse gear the vehicle is brought to rest and then by operating the gear shift lever the right side dog clutch is moved towards right and meshes with the reverse gear of the main shaft and the vehicle backs.
- In this type of gear box as all the gears are constantly mesh with so they are safe from being damaged and unpleasant sound at the time of engagement and dis-engagement.

(iv) Synchromesh gear box:-



- The modern cars use helical gears and synchromesh devices in the gear box that synchronized the rotation of gears that are about to be meshed.
- This eliminates clashing of the gears and make gear shifting easier.
- The synchromesh gear box is similar to the constant mesh gear box but the synchromesh gear box is provided with the synchromesh device by which two gears to be engaged are first brought to frictional contact which equalizes their speed after that, they are engaged with each other and rotate smoothly.
- In most of the cars the synchromesh device is not connected to all gears, it is connected to the top gear and reverse gear.
- The figure shows a synchromesh gear box when the gear lever is move the synchroniser cone meshed with a similar cone on the pinion and due to friction the rotating pinion is made to rotate at the same speed as the synchromesh cone.
- To give positive drive for further movement of the gear lever enables the coupling to override several spring loaded balls.
- In this case the engagement is done without noise or damage to the dogs.

(*) 3-Speed synchronomesh gear box:-
and and top dog clutch



Dt- 31-01-2019

- * The figure shows layout of 3-speed gear box with a synchronomesh system connected between and and the top gear
- The total assembly is contained in a box named as gear box
- The dog clutch, synchroniser unit constitute the rotating part

(*) Neutral Position:-

- The figure shows the gear box in the neutral position. In this position the gears inside the gear box simply rotate without affecting the main shaft of the gear box
- The power transmitted by the clutch rotates the clutch gear and the clutch gear drives the counter shaft drive gear and the counter shaft rotates and all the gears of the countershaft rotate as they are rigidly fixed to the shaft.
- The 2nd gear of the main shaft rotate as it is constantly mesh with the 2nd gear of the counter shaft

(*) 1st gear:-

→ To obtain the 1st gear the 1st and reverse gear of the main shaft is moved towards left and meshes with the 1st gear of the countershaft. In this position the 1st gear of the countershaft drives the 1st gear of the main shaft and the vehicle moves forward.

(*) 2nd gear:-

→ To obtain the 2nd gear by operating the gear shift lever the 1st gear is slid out of mesh and bringing the gear box to neutral position and after that the dog clutch is moved to the right making its internal teeth to mesh with the external teeth of the 2nd gear of the main shaft.

→ Here the dog clutch is splined on the main shaft.

(*) 3rd gear:-

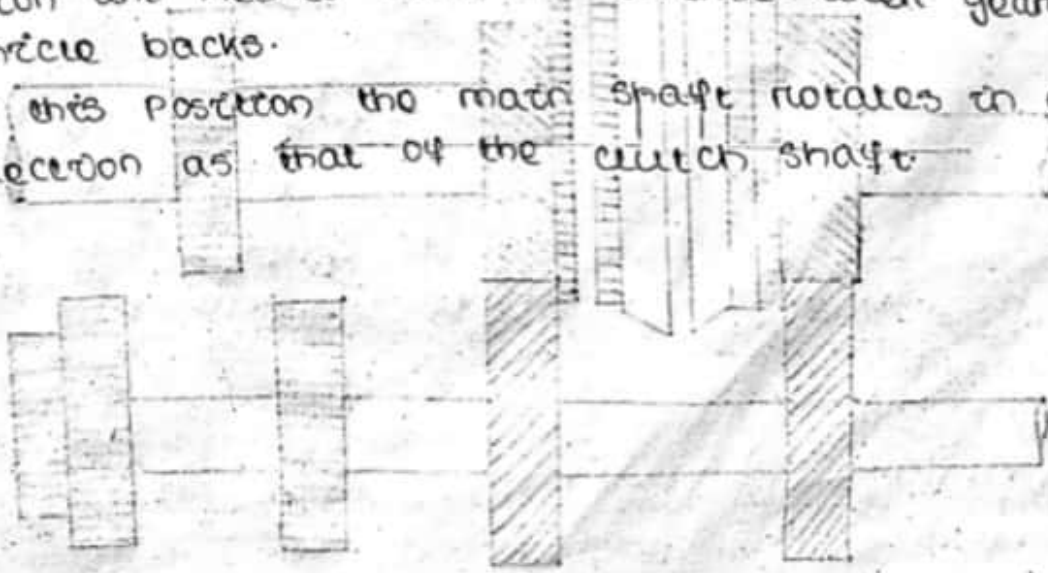
→ To obtain the 3rd gear by operating the gear shift lever 1st the dog clutch is moved towards the neutral position i.e. right side and again moved towards left till its internal teeth meshes with the external teeth of the clutch gear.

→ In this position the main shaft is locked with the clutch shaft and gives a direct drive.

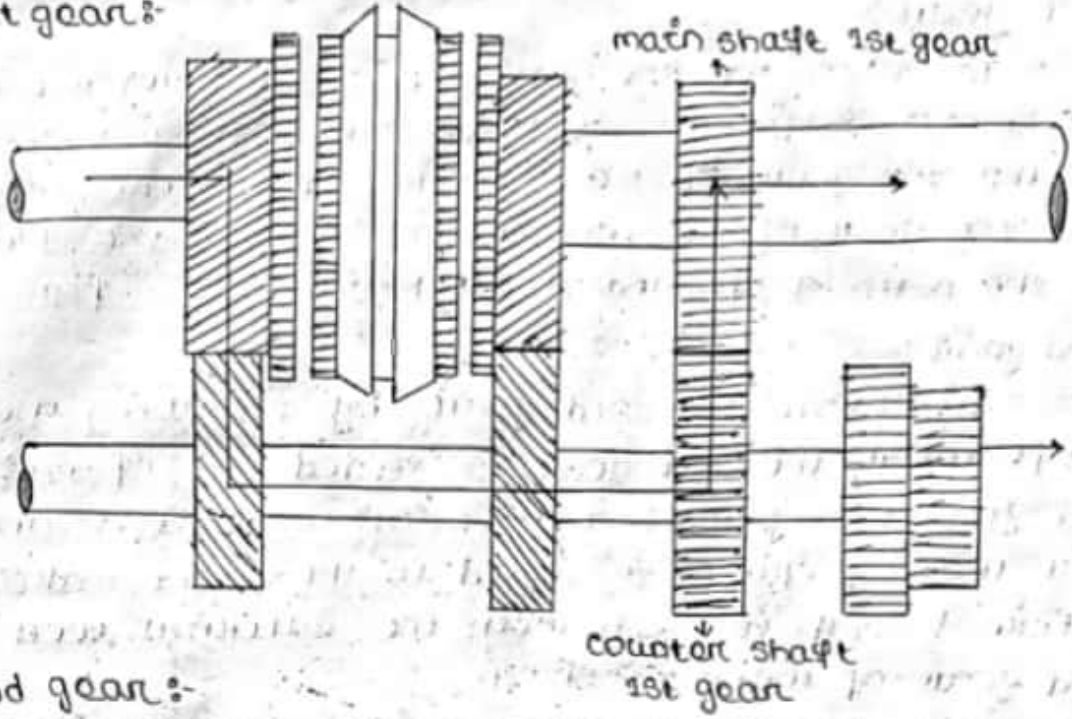
(*) Reverse gear:-

→ To obtain the reverse gear 1st the vehicle is brought to rest and by operating the gear shift lever the gear box is brought to neutral position and after that by operating the lever the 1st and reverse gear of the main shaft is moved towards right from its position and meshes with the reverse idler gear so the vehicle backs.

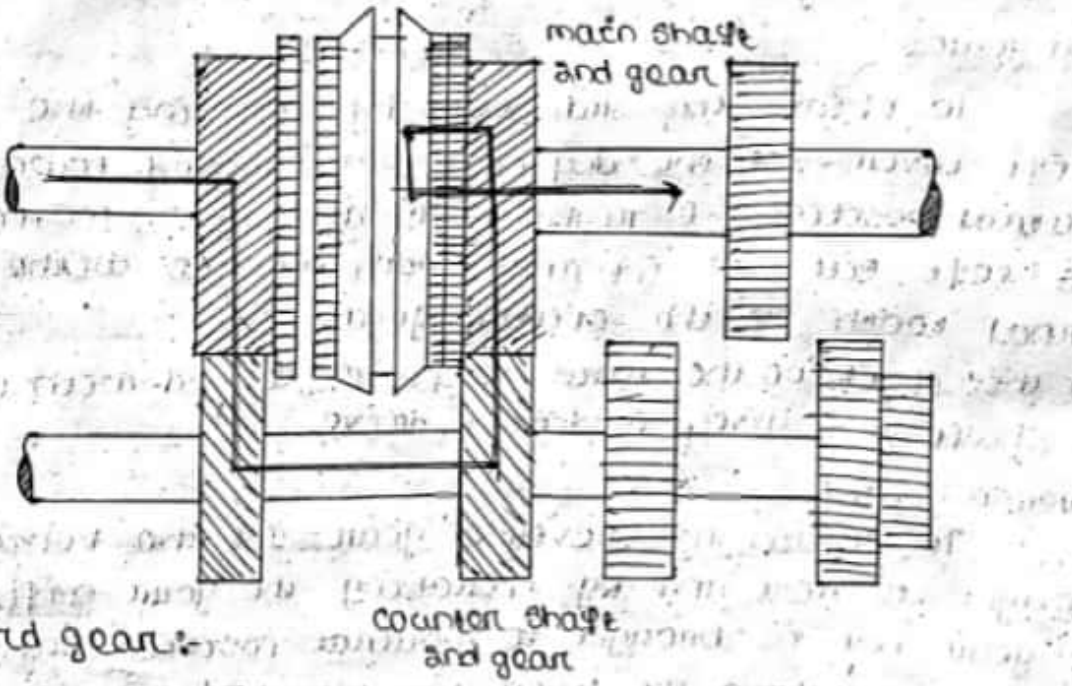
→ In this position the main shaft rotates in opposite direction as that of the clutch shaft.



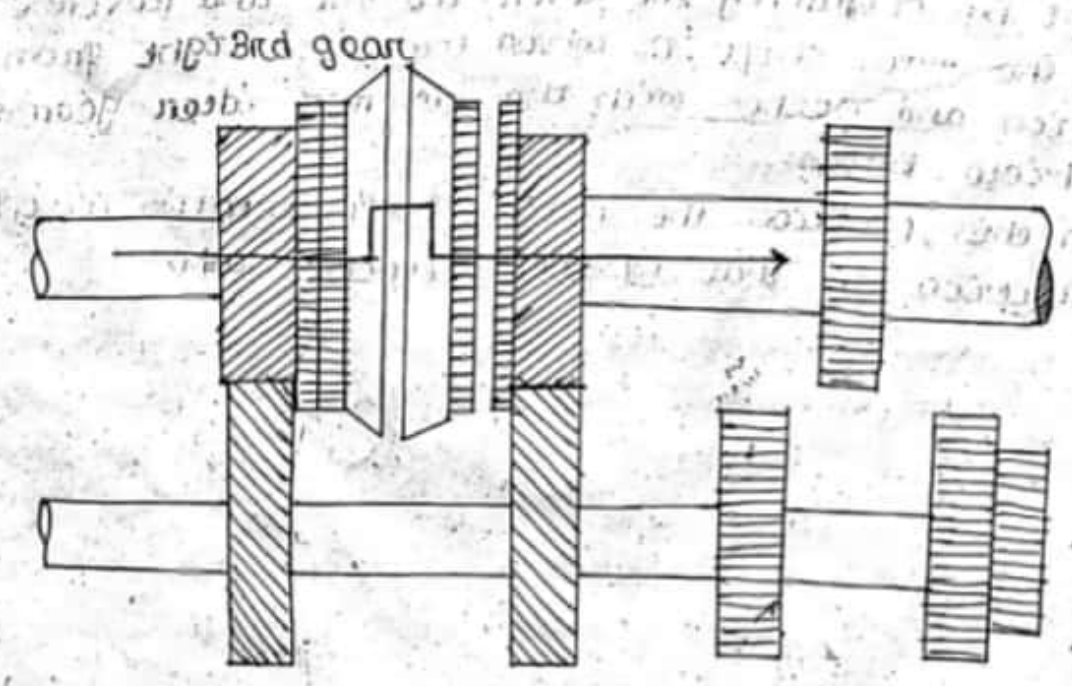
① 1st gear:-



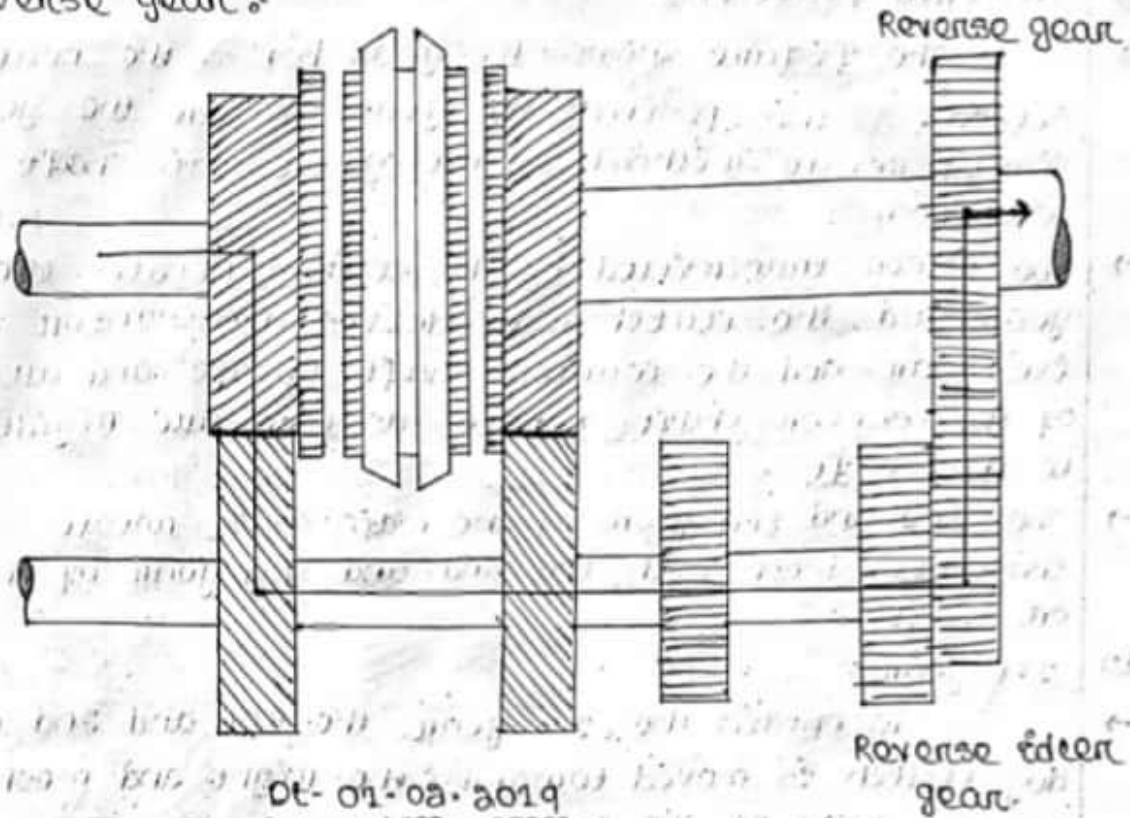
② 2nd gear:-



③ 3rd gear:-



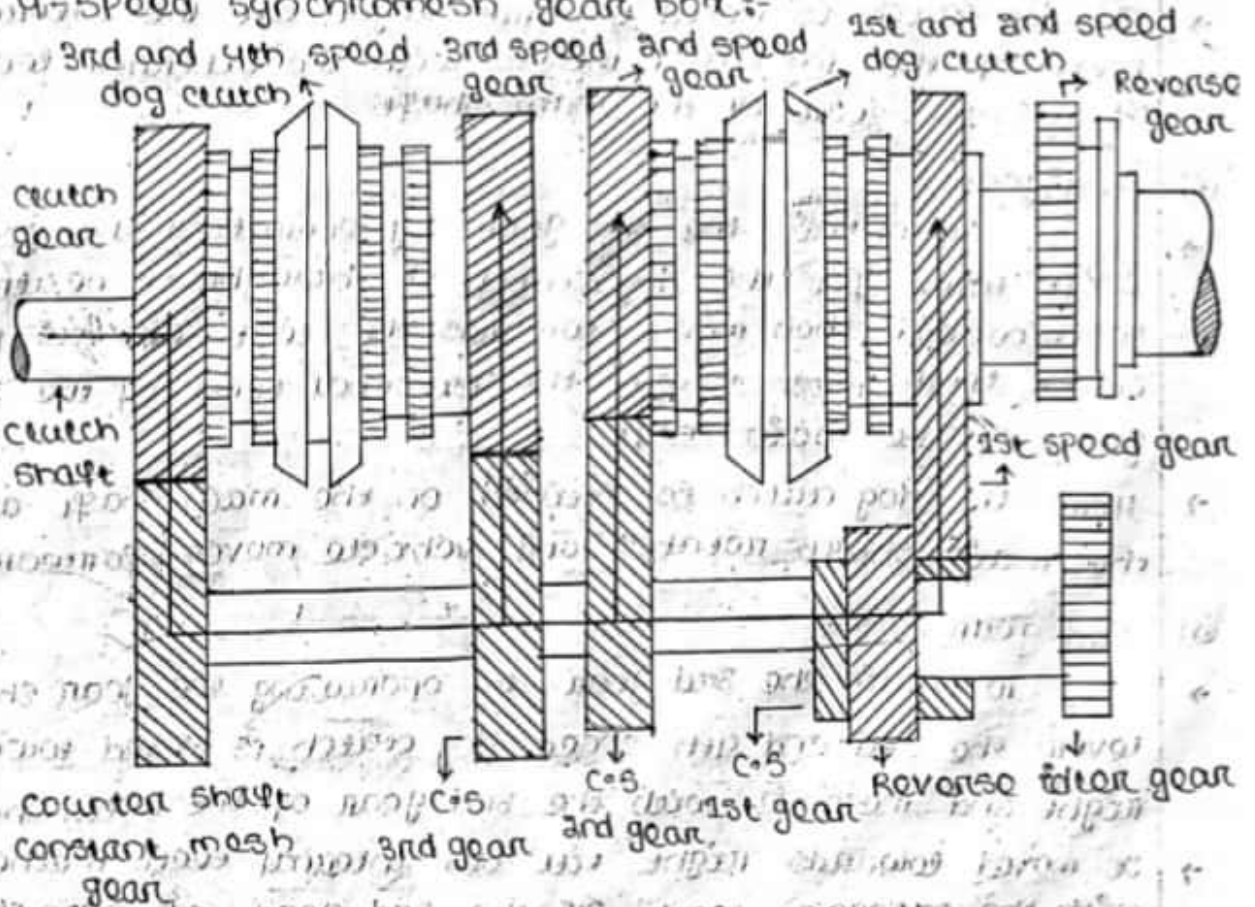
④ Reverse gear :-



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⑤ 4-speed synchronesh gear box :-



counter shaft
constant mesh
gear

3rd gear

C.S.
1st gear

Reverse idler gear

→ The figure shows layout of 4-speed gear box with a synchronesh system connected between 3rd and 4th gear and another between 1st and 2nd gear
 → The total assembly is contained inside a box known as gear box

(a) Neutral position:-

- The figure shows the gear box in the neutral position. In this position the gears inside the gear box simply rotate without affecting the main shaft of the gear box.
- The power transmitted by the clutch rotates the clutch gear and the clutch gear drives the counter shaft drive gear and the counter shaft rotates and all the gear of the counter shaft rotates as they are rigidly fixed to the shaft.
- The 2nd and 3rd gear of the main shaft rotate as it is constantly mesh with the 2nd and 3rd gear of the counter shaft.

(b) 1st gear:-

- To obtain the 1st gear, the 1st and 2nd speed dog clutch is moved towards the right and meshes with the 1st gear of the counter shaft.
- The dog clutch is moved towards right till the internal teeth of the dog clutch meshes with the external teeth of the 1st gear of the main shaft.

(c) 2nd gear:-

- To obtain the 2nd gear by operating the gear shift lever 1st the dog clutch is brought to neutral position and then moves towards the left till its internal teeth meshes with the external teeth of the 2nd gear of the main shaft.
- Here the dog clutch is splined on the main shaft and the main shaft rotates and vehicle moves forward.

(d) 3rd gear:-

- To obtain the 3rd gear by operating the gear shift lever the 3rd and 4th speed dog clutch is moved towards right and meshes with the 3rd gear of the main shaft.
- It moved towards right till its internal teeth meshes with the external teeth of the 3rd gear of main shaft.

(e) 4th gear:-

- To obtain the 4th gear by operating the gear shift lever the 3rd and 4th speed dog clutch is first brought to neutral position and meshes out from 3rd gear.

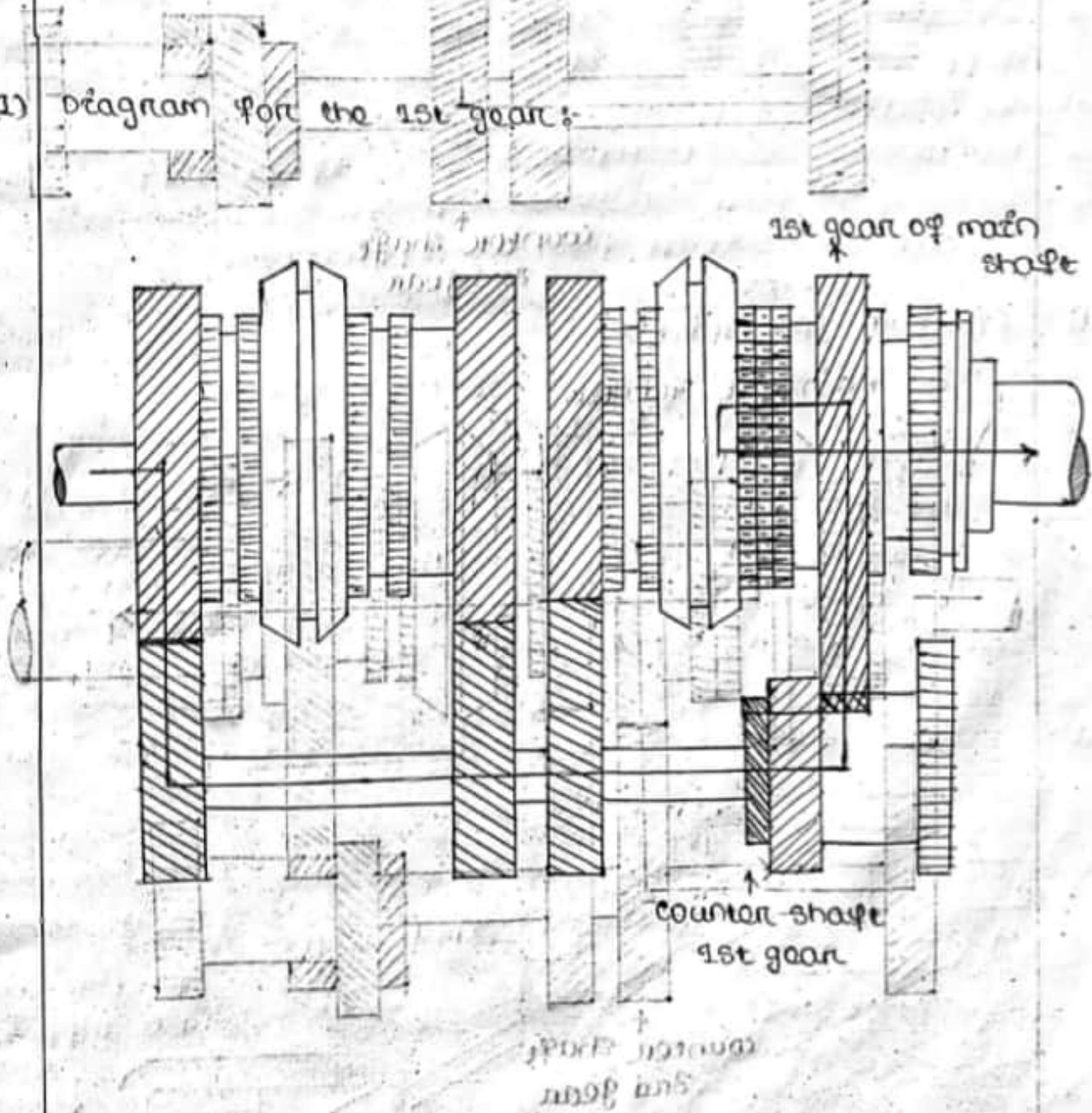
→ After that, the dog clutch is moved towards left and all its internal teeth meshes with the external teeth of the clutch gear.

→ In this position the main shaft is locked with the clutch shaft and gives a direct and fast speed drive.

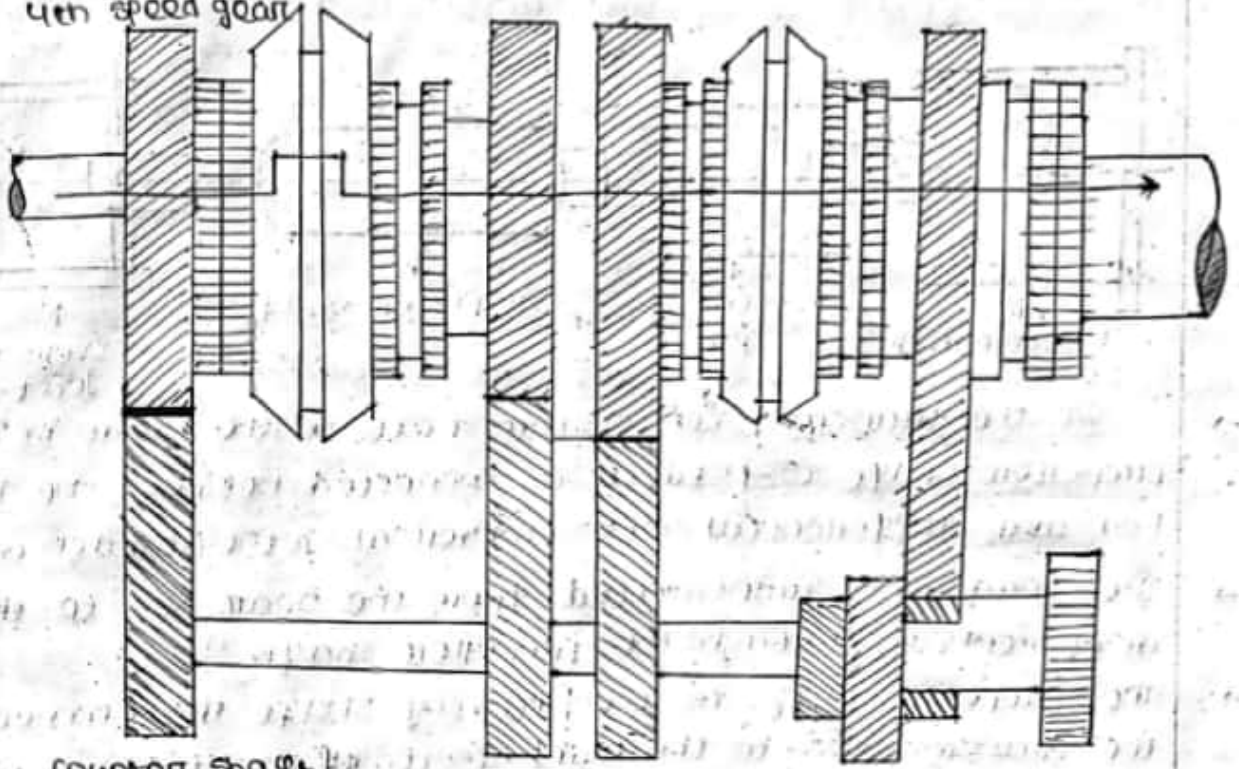
(P) Reverse gear:

→ To obtain the reverse gear by operating the gear shift lever 1st the vehicle is brought to rest by operating the lever vehicle is brought to neutral position and then the reverse gear of the main shaft moves towards left and meshes with the reverse idler gear of the counter shaft so that the vehicle backs.

(1) Diagram for the 1st gear:

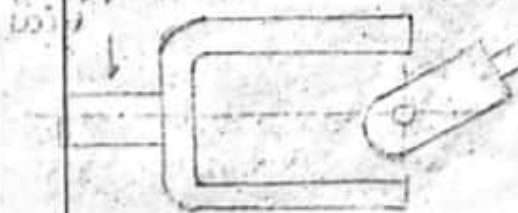
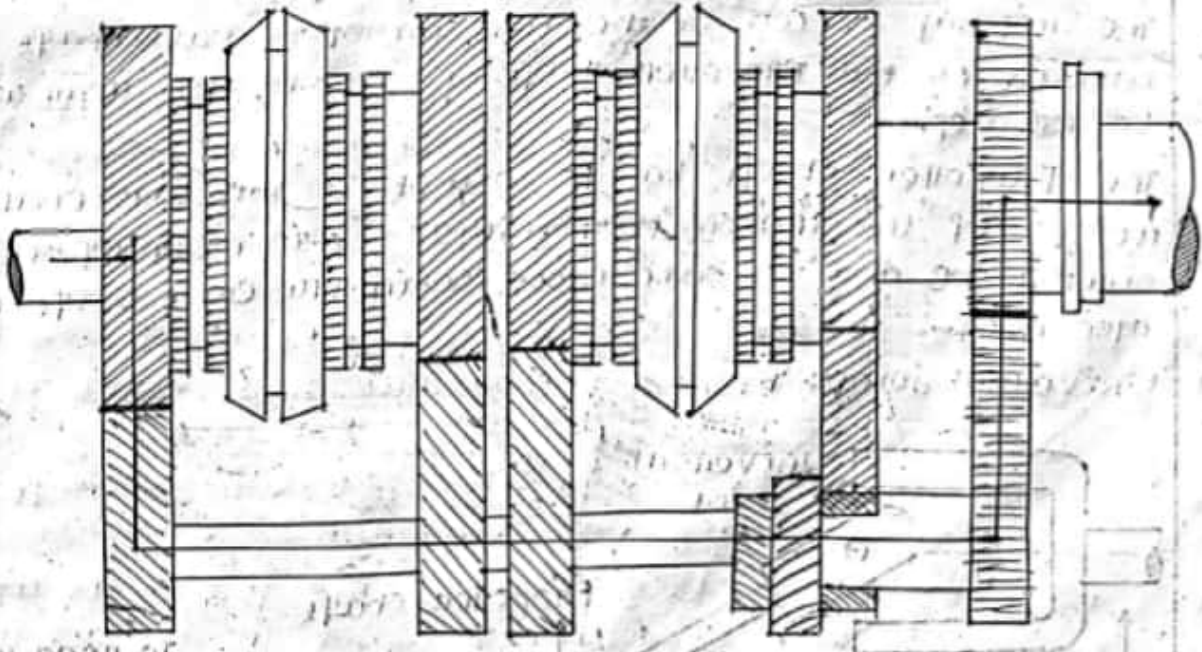


(4) Diagram for 4th gear:-
4th speed gear

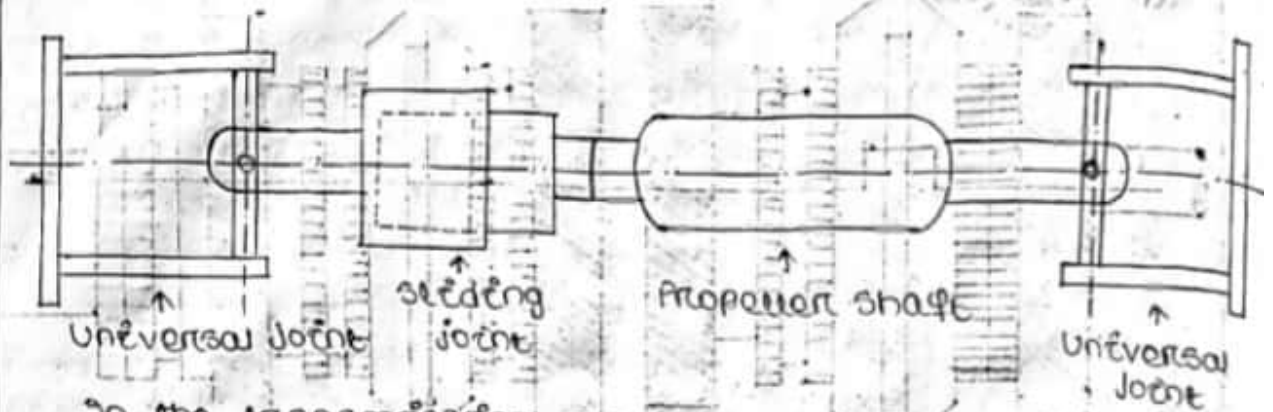


counter shaft
4th gear

(5) Diagram for reverse gear:-

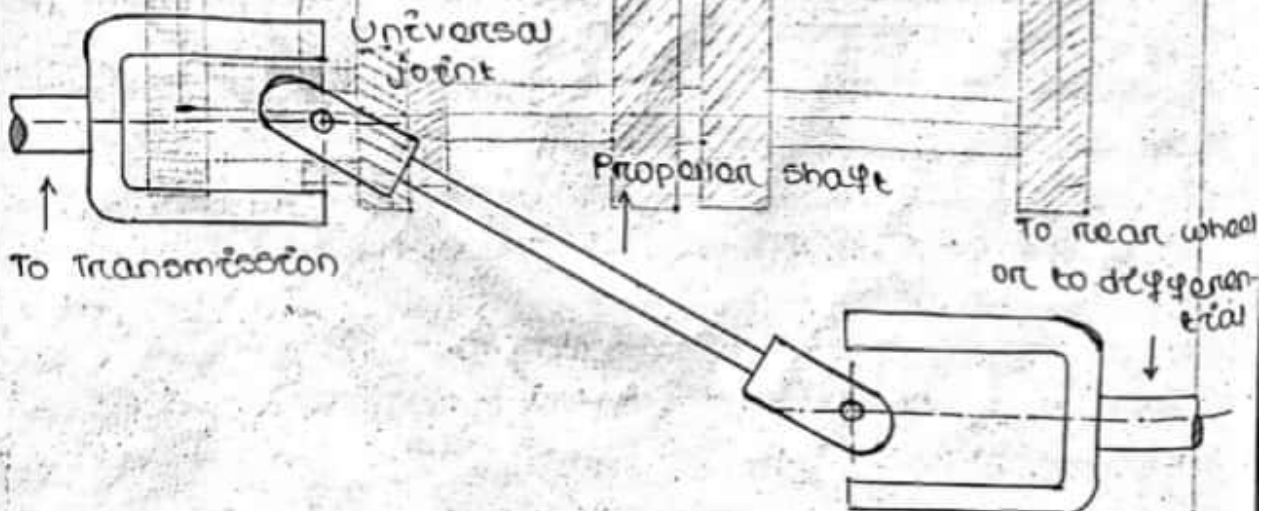


(*) Propeller shaft :- (Imp)



- In the transmission system next to the gear box a propeller shaft is used, it is connected between the gear box and differential with universal joint at each end.
- The torque is transmitted from the gear box to the differential through the propeller shaft.
- The propeller shaft is the driving shaft that connects the transmission to the transmission of the differential.
- The output shaft or main shaft from the transmission and the pinion shaft from the differential are connected to the propeller shaft and universal joint.
- A sliding or stop joint is used between the propeller shaft and universal joint near the gear box.
- The rotary motion of the transmission main shaft is carried by the propeller shaft and causes the rear wheel to rotate.
- The propeller shaft has to withstand the torsional stresses of the transmitting torque. It is made of strong steel tube and in some cases solid propeller shaft is also used.

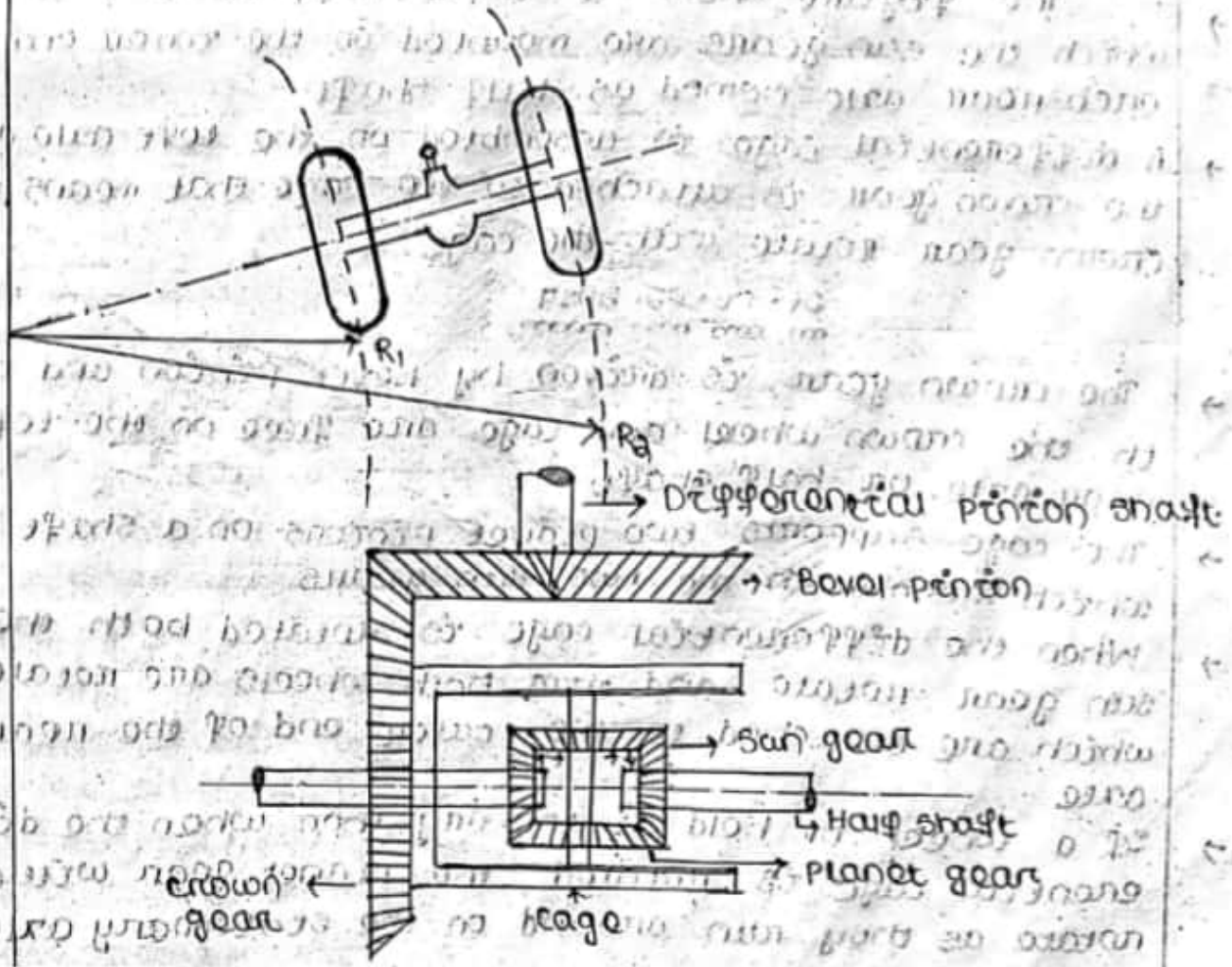
(*) Universal joint :-



- An universal joint is used where two shafts are connected at an angle to transmit power.
- In the transmission system of a motor vehicle, the transmission main shaft, propeller shaft and differential pinion shaft are not in one line and hence the connection between them are made by universal joint.
- One universal joint is used to connect the main shaft of the gear box and the propeller shaft and the other one is use to connect the propeller shaft and differential pinion shaft.
- In this case the connection between three shafts are flexible and at an angle with each other.
- Universal joint permits the torque transmission not only an angle but also when the angle is changing.
- A simple universal joint consist of two Y-shaped yokes one on the driving shaft and other one on the driven shaft. The cross pieces are known as spiders and the four arms are known as trunnions.

Dt-06.02.2019

⊙ Differential :- (imp)



→ When a vehicle moves in a straight line the two rear wheels turn on the road exactly at the same speed there is no relative motion between the two rear wheels but when the vehicle taking a turn the outer wheel travels a larger radius than the inner wheel. The outer wheel turns faster than the inner wheel and if the wheels are rigidly mounted to the rear axle, the inner wheel will slip which cause rapid tyre wear, steering difficulty and poor road holding.

→ So there must be some device is needed to provide the relative motion between the wheels and the differential serve the purpose.

→ Differential is a part of inner axle housing assembly which includes differential, rear axle, wheels and bearings.

→ The differential consist of a system of gears arranged in such a way that connects the propeller shaft with the rear axle.

(*) Construction of Differential:-

→ The figure shows a simple differential in which the sun gears are mounted on the inner end of each rear axle named as half shaft.

→ A differential cage is assembled on the left axle and the crown gear is attached to the cage that means the crown gear rotate with the cage.

Dt. 06.02.2019

→ The crown gear is driven by bevel pinion and both the crown wheel and cage are free on the left rear axle or half shaft.

→ The cage supports two planet pinions on a shaft which mesh with the two sun gears.

→ When the differential cage is rotated both the sun gear rotate and thus both wheels are rotate which are attached to the outer end of the rear axle.

→ If a wheel is held stationary then when the differential cage is rotated the planet gear will also rotate as they run around on the stationary axle sun gear.

- While rotating in this manner the planet pinions carry rotary motion to the other axle sun gear causing it and the wheel to rotate. Therefore while turning one wheel rotates rapidly than the other.
- When the vehicle takes a turn the planet gears spin on its shaft transmitting more rotary motion to one rear wheel than the other.
- When a vehicle moving in a straight path and the two wheels rotate at same speed then the planet pinions do not rotate on the shaft. In this case the crown wheel, differential cage planet pinion with the sun gear turn as an unit without any relative motion between them.
- When the car takes a turn the planet pinions rotate on their shaft to permit the "outer" rear wheel to turn more rapidly than the "inner" wheel.

CHAPTER - 3

BRAKING SYSTEM.

(*) Brake:-

→ As the vehicle is started, accelerated and running on the road it is needed to stop the vehicle at any point of time so brakes are applied on the wheels to stop the vehicle.

→ Before applying the brakes the accelerator pedal is released to stop the fuel supply and thus the engine develops no power to run the vehicle.

→ In this case when the brake is applied it stops the rolling of the wheels on the road and hence the vehicle is stop.

(*) Function of Brakes:-

→ There are a main functions of brake and are:

→ To stop or slowdown the vehicle in the shortest possible distance in emergency.

→ To control the vehicle to be retained while moving downward in the inclined path or hills.

(*) Classification of brakes:-

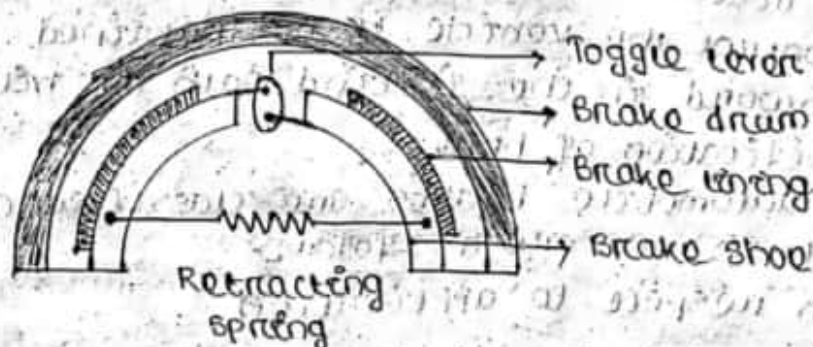
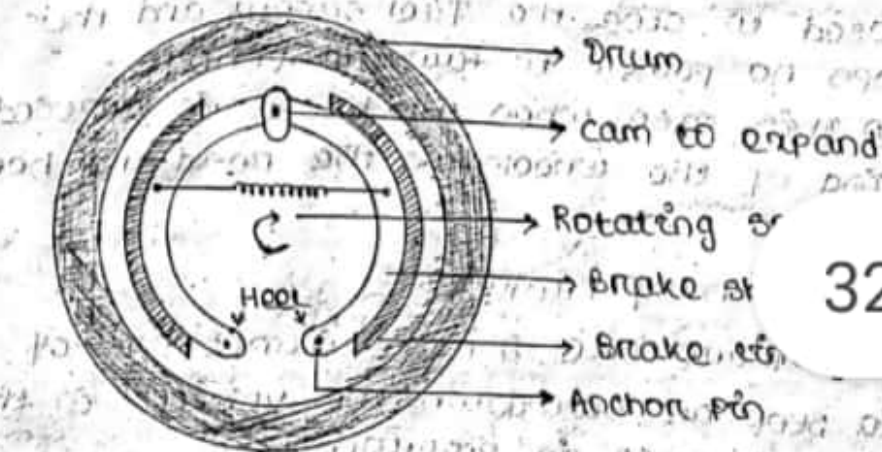
→ The automobile brakes are classified according to the basis, and are as follows.

(2) with respect to application

- (a) Hand brake (b) Foot brake

- (2) With respect to no. of wheels
 - (a) Two wheel brake
 - (b) Four wheel brake
- (3) With respect to the method of braking contact
 - (a) internal expanding brake
 - (b) external compressive brake
- (4) With respect to method of applying braking force
 - (a) single acting brake
 - (b) double acting brake
- (5) With respect to the brake gear
 - (a) mechanical brake
 - (b) power brake
- (6) With respect to the nature of power employed
 - (a) Air brake
 - (b) Hydraulic brake
 - (c) vacuum brake
 - (d) Electric brake
 - (e) Hydrostatic brake
- (7) With respect to the power transmission
 - (a) Direct acting brake
 - (b) Diaphragm brake

(*) Mechanical Brake :-



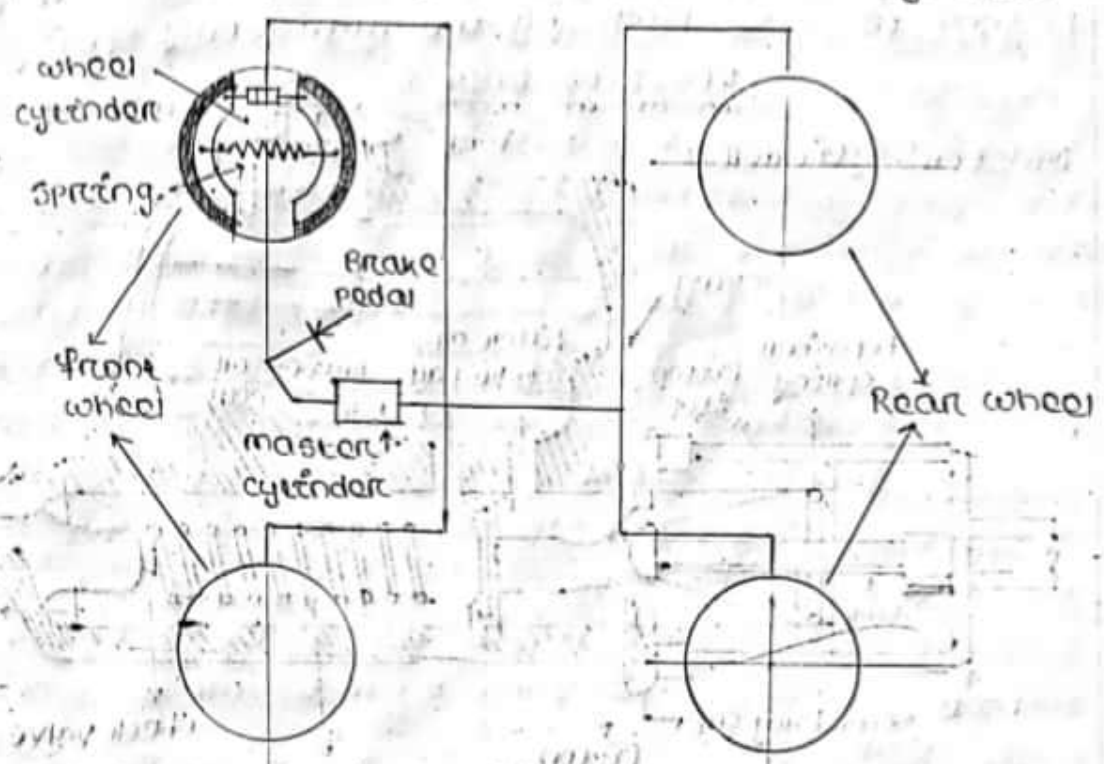
- In motor vehicle the wheel is attached to an auxiliary wheel known as drum the brake shoes are made to contact with this drum.
- In most of the cases two brake shoes are used with each brake drums to form a complete brake mechanism.
- The brake shoes have brake linings on their outer surface and each brake shoe is hinged at one end by an anchor pin and the other end is operated by some means so that brake shoes expands outward and the brake lining come into contact with the drum.
- A retracting spring is used to keep the brake shoes into position when the brakes are not applied.
- The drum encloses the entire mechanism to keep out from dust and moisture.
- In mechanical brake the wheel attaching bolt and drum are used to contact the wheel and the drum the shoes are generally mounted to ~~rest~~ rub against the inside surface of the brake drum.
- The figure shows an internal expanding brake, when the brake pedal is pressed the cam turns by means of brake linkage and when cam turns the shoes expands outward against the drum.
- The toggle lever are shown in the figure is also used for the same purpose as that of the cam. The brake linings rub against the drum and thus stops its motion.
- The entire mechanical linkage between the brake pedal and brake shoes operates to transmit force of pedal to the brake shoes.
- This pedal force through linkage produced effective braking force to stop the vehicle.
- A retracting spring is used to keep the brake shoes in its position after the removal of the force from the brake pedal.

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(*) Hydraulic brake:-

- The hydraulic brakes are operated by the liquid pressure. The pedal force is transmitted to the brake shoe by means of a compressed liquid to a system of force transmission.
- The force applied to the brake pedal is multiplied and transmitted to all the brake shoes by force transmission system.
- It is based on Pascal's principle that means the confined liquid transmits pressure without loss equally in all directions.

The figure shows a hydraulic braking system consist of two main components master and wheel cylinder



The master cylinder is connected by tubes to each of the wheel cylinder of the four wheels. The system is filled with the liquid under light pressure when the brakes are not in operation.

The liquid is known as brake fluid usually a mixture of Glycerine, Alcohol and castrol oil with some additives.

Each wheel brake consist of a cylindrical brake drum which is mounted on inner side of the wheel and revolves with it and 2 brake shoes which are mounted inside the brake drum and do not rotate. The shoes are fitted with heat and wear resistance brake lining.

When the brake pedal is depressed the piston inside the master cylinder moves forward and increases pressure of the fluid in the master cylinder and in the entire hydraulic system.

This pressure is conducted to all the wheel cylinder of the four wheels.

The wheel cylinder has a double acting piston which forces outward and in turn the brake shoes rub against the brake drum and the brake is applied. When the brake pedal is released the master cylinder piston return to its original position due to spring.

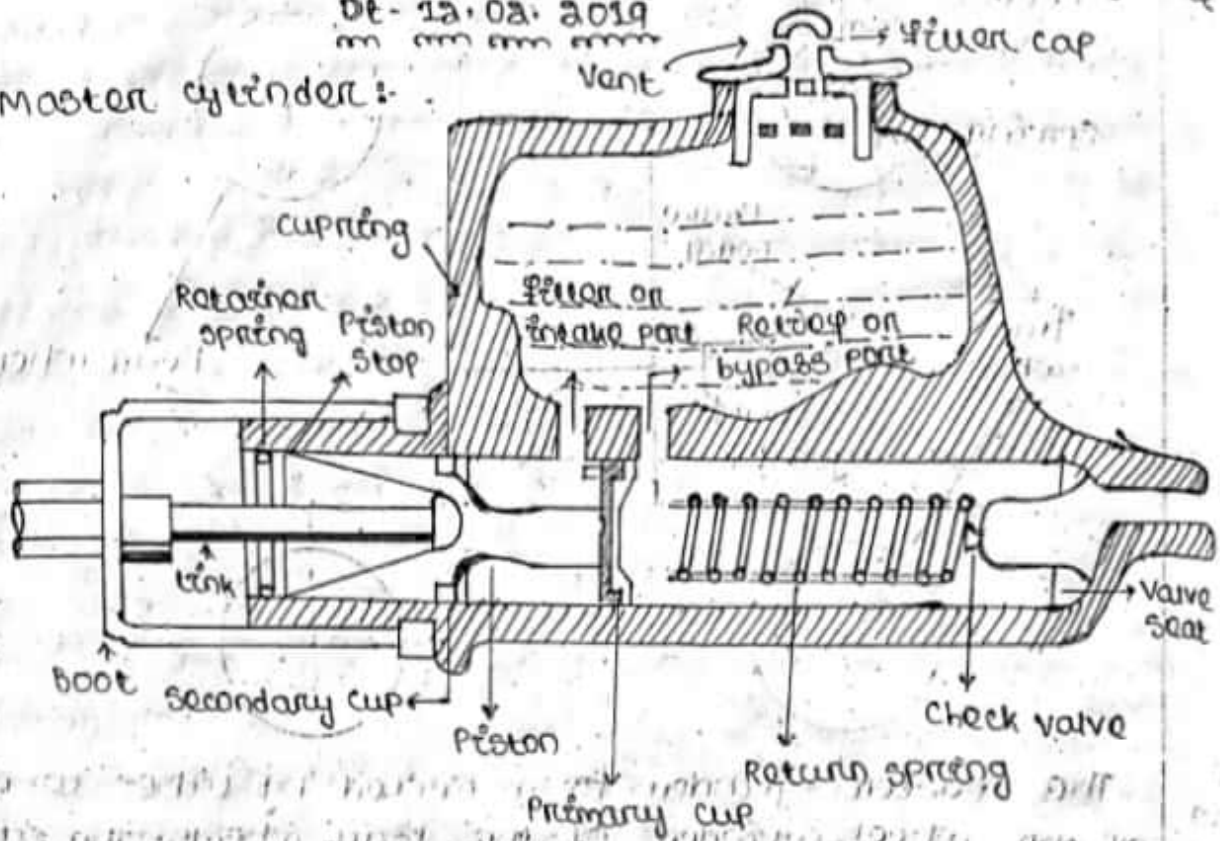
Pressure and the pressure inside the entire hydraulic system drops. This allows the wheel cylinder pistons to move back by the retracting spring force

(*)

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(*)

Master cylinder:



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The master cylinder is the heart of hydraulic braking system and it consists of two main chambers the fluid reservoir which contains the brake fluid to supply the braking system and a compression chamber in which the piston operates

The reservoir supplies fluid to the braking system by two ports. The larger port is known as filler port or intake port, and the smaller port is known as bypass port or relief port

The filler port is connected to the hollow portion of the piston between primary cup and secondary cup and the relief port is connected to the reservoir directly with the cylinder and the brake lines.

The reservoir is vented to the atmosphere so that the atmospheric pressure causes flow through filler port

A boot cover is provided at the end of the cylinder to keep it free from foreign material.

The figure shows a master cylinder and the brake

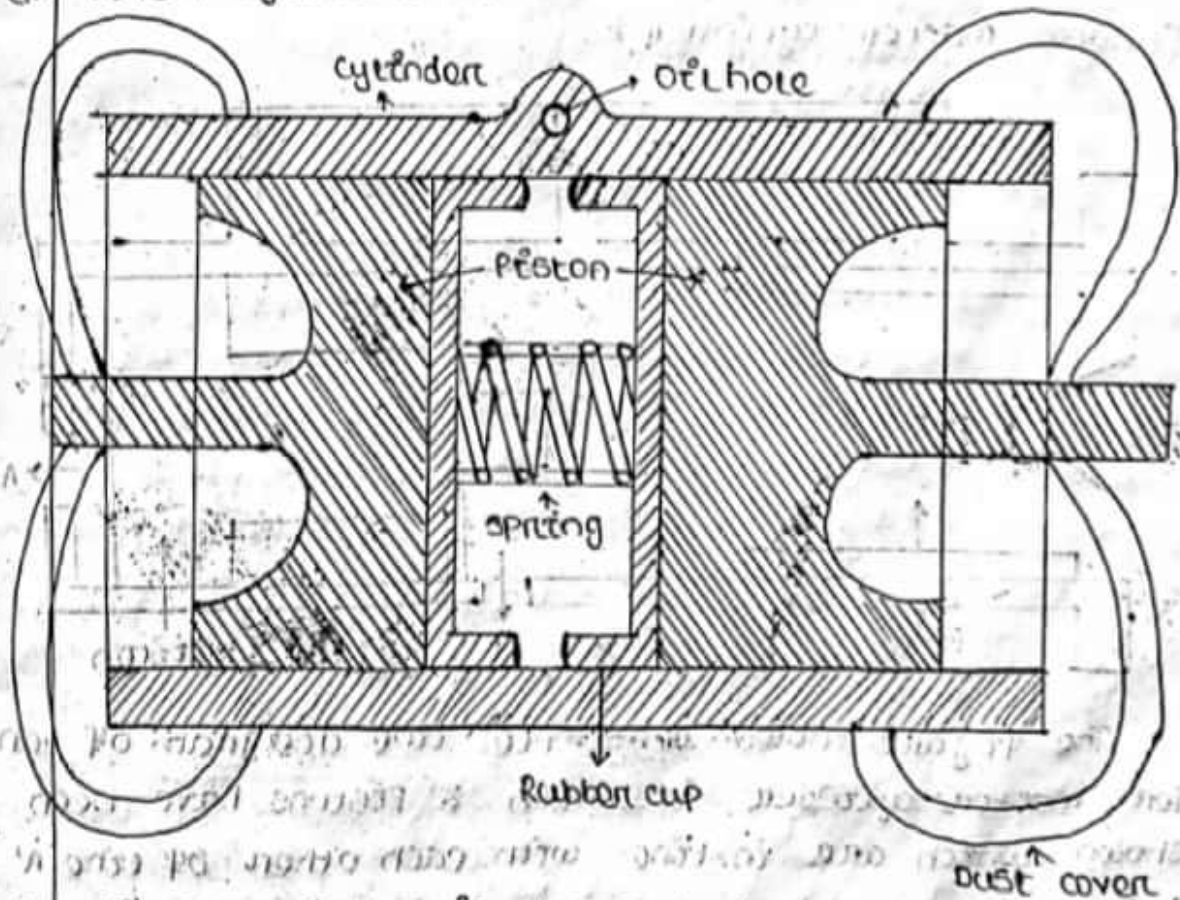
pedal is in off position. In this position the brake oil flows through the filler port and acts as a piston seal between the primary and secondary cup.

→ When the brake pedal is depressed the master cylinder piston moves forward to force the liquid under pressure into the system. The relief port is sealed out of the system, the liquid pressure is conducted to the wheel cylinders where it forces the wheel cylinder piston outward.

→ The piston forces the brake shoes outward to rub against the brake drum for applying brakes.

→ When the brake pedal is released the return spring quickly forces the piston back against the piston stop. In this case the fluid in the brake lines returns slowly and a vacuum tends to form in the front of the cylinder piston which causes the primary cup to collapse and the liquid from the reservoir flows through the filler port past the piston to fill the vacuum. In this way the master cylinder works.

(*) Wheel cylinder:-

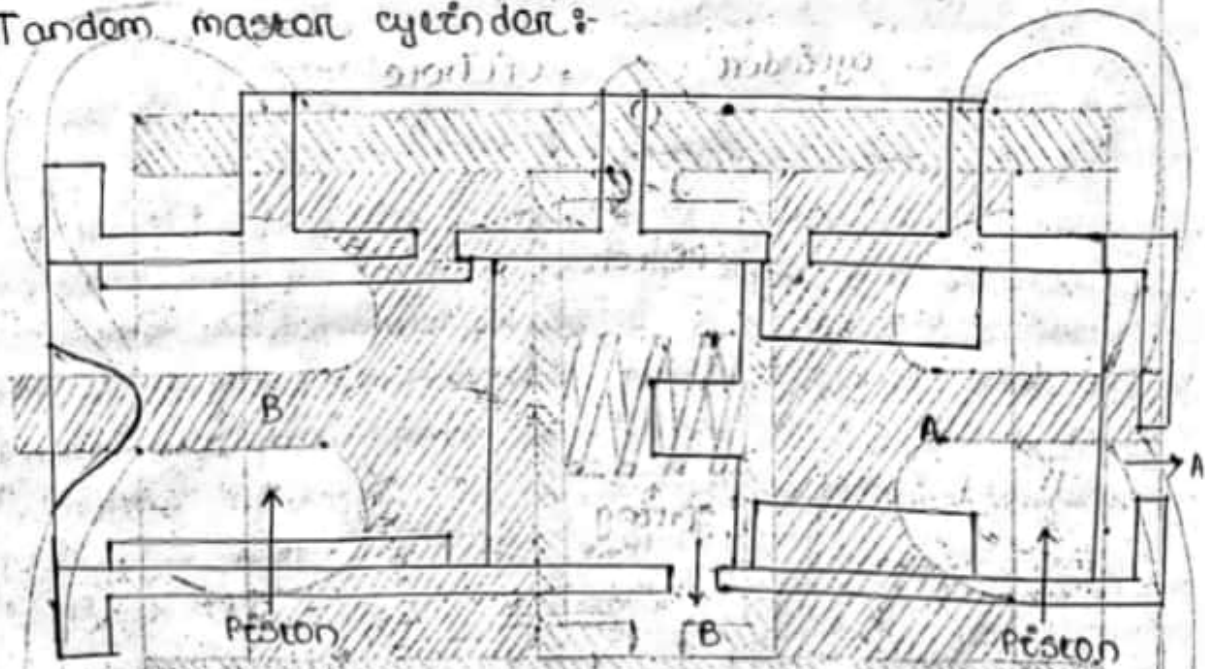


→ wheel cylinder is the and important component of a hydraulic braking system. consists of a double acting

Piston/wheel cylinder as shown in the figure.

- It consists of two pistons which can move in opposite direction by the fluid pressure. It is rigidly mounted on the backing plate.
- The boots are provided to protect the cylinder from the foreign substance. A bleeder valve is provided on the cylinder to permit the air and liquid to be pumped out of the system during bleeding operation.
- A spring is used to keep the pistons in its position. When the brake is applied the brake fluid enters the cylinder from the brake line between the two pistons. It causes to force out the two pistons in opposite direction.
- The motion is transmitted to the brake shoes directly through the links and force them to rub against the brake drum.
- The copper coated, teen plated annealed steel tubes & flexible hoses are used to connect the master cylinder to the wheel cylinder.

(*) Tandem master cylinder:-



- The figure shows a simple line diagram of tandem master cylinder in which two pistons have been shown which are in-line with each other. In this case, the piston-A bottoms against the cylinder while piston-B continues to develop

→ The air braking system consist of an air compressor, brake valve, series of brake chambers, unloader valve, pressure gauge and a safety valve. These are all connected by lines of tubing.

→ The braking system has some additional components like stop light switch, low pressure indicator, air supply valve and quick release valve in its circuit.

→ The figure shows an air braking system in which the air compressor, governor, pressure gauge, safety valve, and the reservoir constitute the compressive and control unit and the rest of the system are known as application unit.

→ The compressed air is used for operate horn and windshield wiper in addition to brake.

→ The compressor sends compressed air to the reservoir which is connected to brake valve.

→ The brake valve is connected to front and rear brake chamber with the tubes.

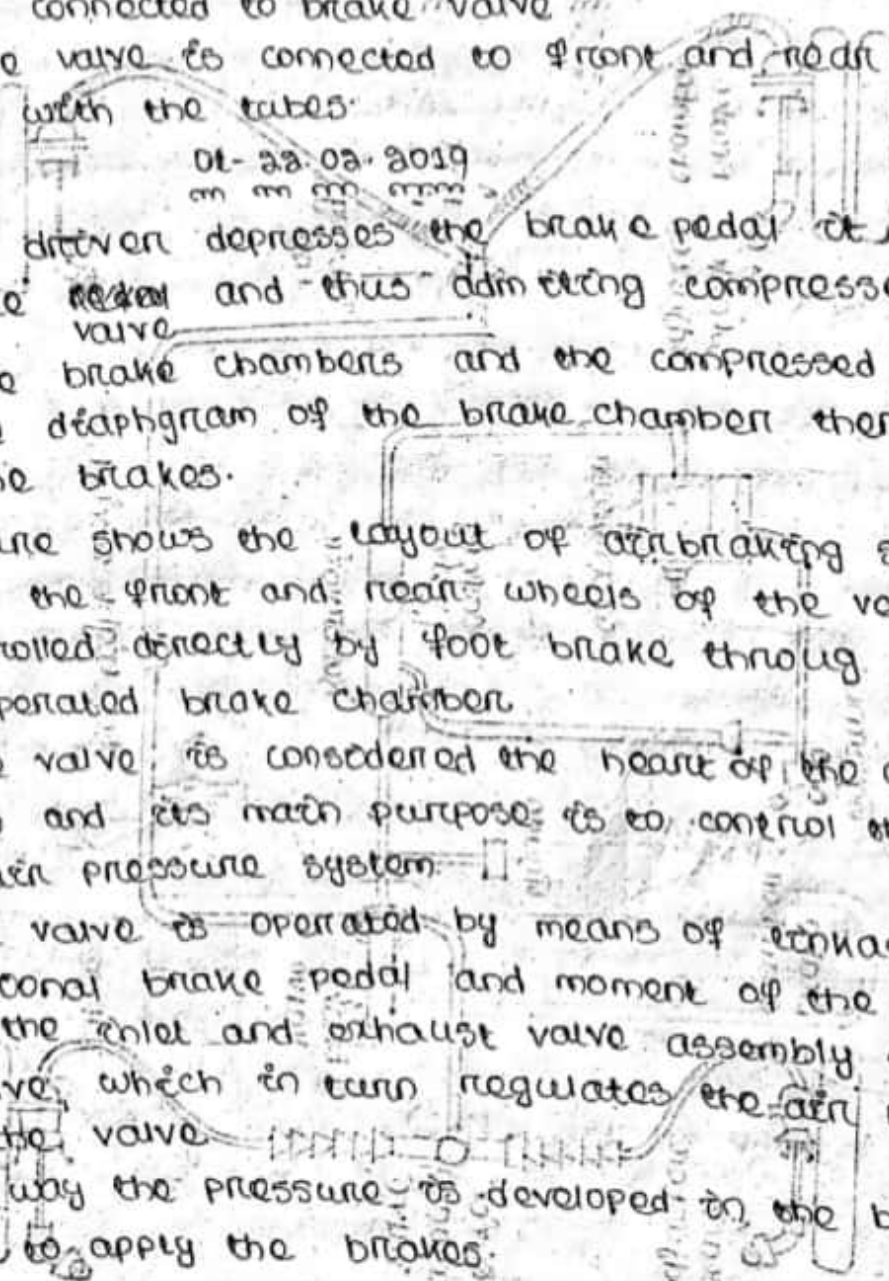
→ When the driver depresses the brake pedal it operate the brake valve and thus admitting compressed air to all the brake chambers and the compressed air operate the diaphragm of the brake chamber thereby applying the brakes.

→ The figure shows the layout of air braking system in which the front and rear wheels of the vehicle are controlled directly by foot brake through the diaphragm operated brake chamber.

→ The brake valve is considered the heart of the air brake system and its main purpose is to control the vehicle by the air pressure system.

→ The brake valve is operated by means of linkage from a conventional brake pedal and moment of the pedal controls the inlet and exhaust valve assembly of the brake valve which in turn regulates the air pressure through the valve.

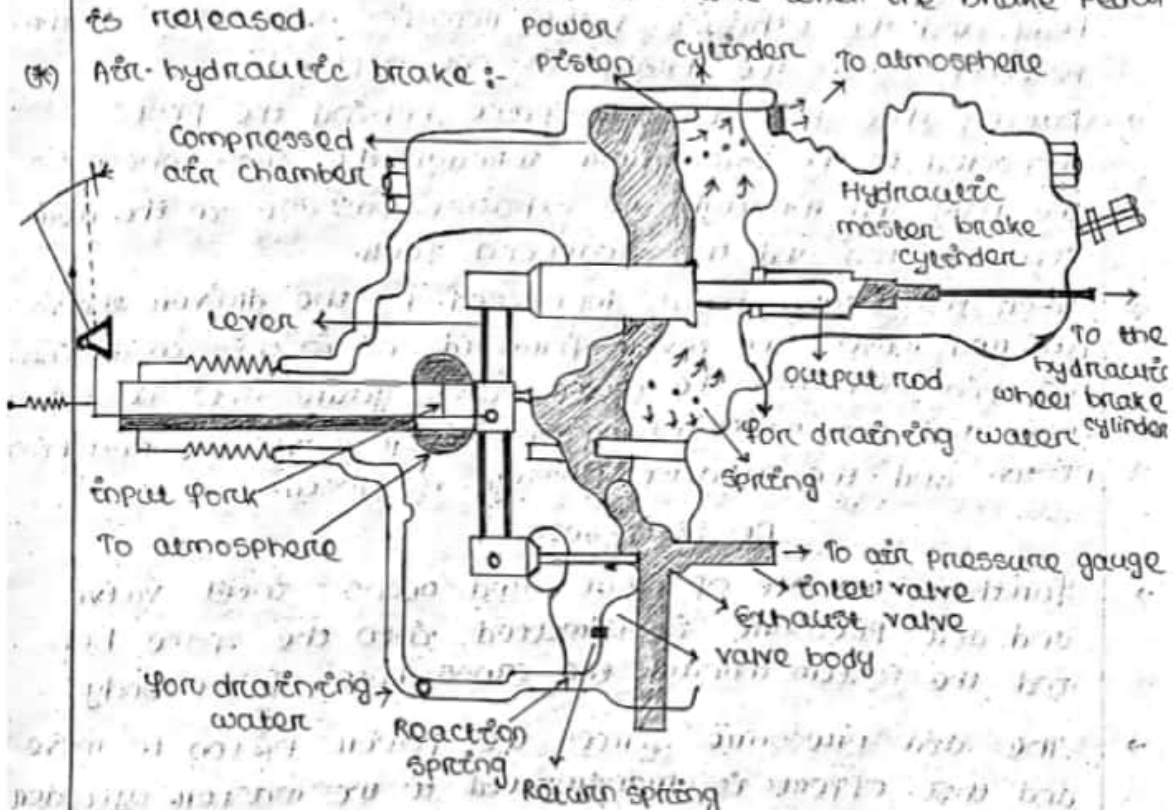
→ In this way the pressure is developed in the brake chambers to apply the brakes.



→ The valve automatically adjust the amount of air passed by the degree of pedal movement

→ A quick release valve is used to release the compressed air after the application of brake when the brake pedal is released.

(*) Air-hydraulic brake :-



→ In this type of braking system the air pressure is converted into hydraulic pressure and here the air power cylinder is combined with hydraulic master cylinder and

→ In this case the ratio between hydraulic pressure to air pressure is generally maintain 15:01

→ The air-hydraulic braking system consist of the following component :-

- (a) air compressor
- (b) air pressure regulator
- (c) Reservoir
- (d) lever type servo

→ Compressed air is delivered by air compressor connected to the engine to assist hydraulic brake. In increasing the brake efficiency.

→ The above figure shows the position of a servo and

master cylinder in which the piston of the brake valve held against the piston stop on the body of the return spring.

→ The inlet valve is kept closed on its seat on the valve body and the exhaust valve remains open. This is the position when the brake is not applied.

→ During this position the space behind the piston is connected to the atmosphere through the cross-hole in the body and through the exhaust passage in the reaction piston and the reaction fork.

→ When the brake pedal depressed by the driver the input rod moves the lever forward and in this condition the pin joint and the power piston guide acts as a fulcrum and the movement of the lever moves the reaction piston and the exhaust passage is closed.

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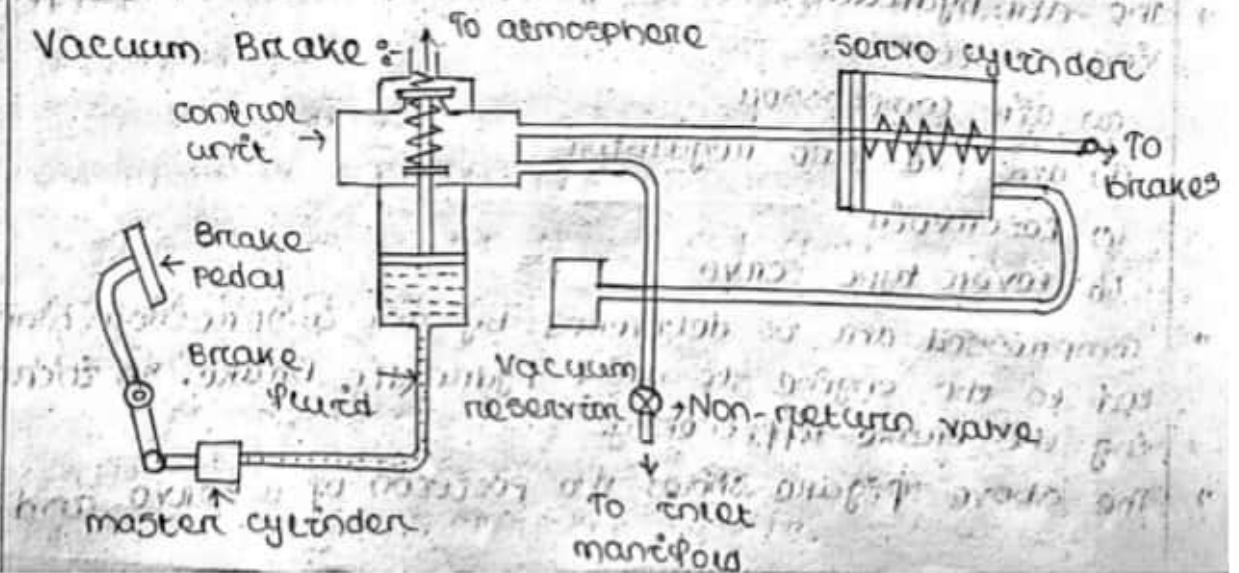
→ Further moment of input rod opens inlet valve and air pressure is admitted into the space behind the system through the cross hole of the body.

→ The air pressure forces the power piston to move and this effort is transmitted to the master cylinder through the output rod.

→ The force acting on the master cylinder creates the hydraulic pressure require for the application of brakes.

→ The above figure shows the position of servo and master cylinder when the brake is applied.

* Vacuum Brake :-



- The above figure shows a vacuum braking system in which the force required to operate the brake is the difference between pressure on opposite side of the piston diaphragm.
- Here if one side is exposed to atmospheric pressure while the other side is exposed to pressure below atmospheric.
- The pressure below atmospheric is obtained by removing the air from that side and vacuum is created.
- This is the basic principle of vacuum brake it may be atmospheric suspended or vacuum suspended.
- If both side of the power cylinder are with atmosphere and at the time of applying brake one side is connected to inlet manifold and the system is said to be atmospheric suspended.
- If both the ends of the power cylinder are in communication with inlet manifold and at the time of applying brake one of them is connected to atmosphere the system is said to be vacuum suspended.
- The figure shows a atmospheric suspended system and the brakes are in released position. For applying brakes engine vacuum is applied to one side of the piston subjecting to the differential pressure and thus operates the brakes through the linkage.
- In vacuum suspended servo system the vacuum reservoir is connected through a non-return valve to the inlet manifold between the carburettor and the engine vacuum reservoir and is further connected to servo cylinder on both side of the piston.
- On left side the connection is through the control unit while on the right side it is directly connected. The control unit also contains a piston to which two valves are attached. The upper valve controls the connection between the atmosphere and left side of the piston in the servo cylinder.
- The lower valve controls the connection between vacuum reservoir and left side of the servo cylinder.

- The piston is the control unit which is actuated by the brake pedal through the master cylinder as shown in the figure.
- When the brake pedal is free the upper valve in the control unit is closed and lower is opened thus both side of the piston in the servo cylinder are exposed to engine vacuum.
- When the brake pedal is depressed the pressure of the brake fluid pushes the piston in the control unit up thereby closing the lower valve and opening the upper valve thus the left side of the piston is exposed to atmospheric pressure where the vacuum is in the right side.
- This causes the servo piston to move to the right and the movement is used to apply the brakes through some mechanical linkage.

CHAPTER - 4

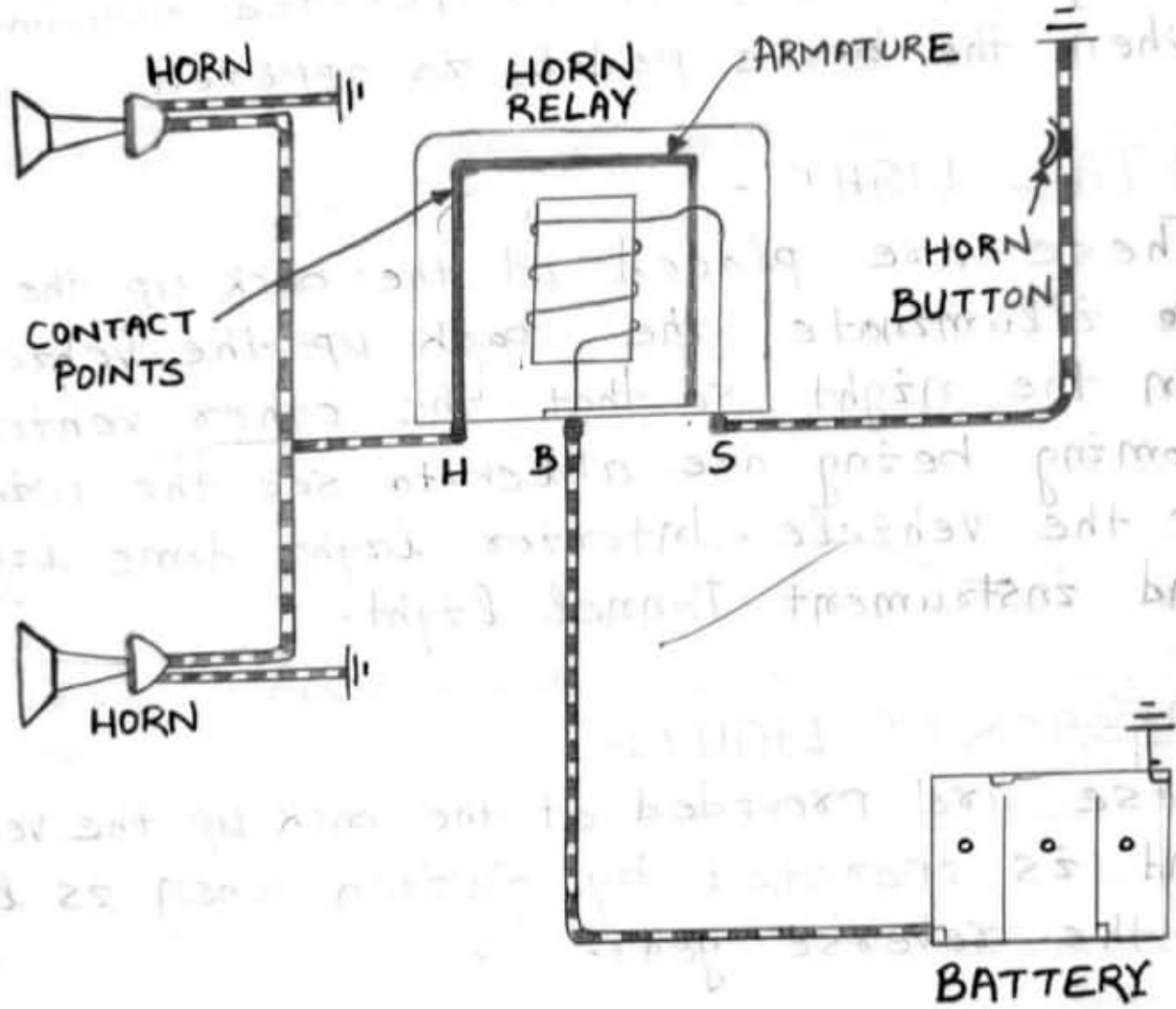
AUTO ELECTRIC SYSTEM.

Ch-4

Auto electric system.

Wiring diagram of Horn circuit. —

- (i) Horn is sound creating device. Electrical horns are used in all the automobile vehicles.
- (ii) When horn is operated it create loud vibrating sound indicating that vehicle is coming so that they may clear path.
- (iii) Horn is also used as casting well to call the person when vehicle is ready to start.
- (iv) Light brake horn are the devices that present of accident light flashes the red horn, makes the road clear and break stop the vehicles. All the 3 devices makes the driving safe from accident.



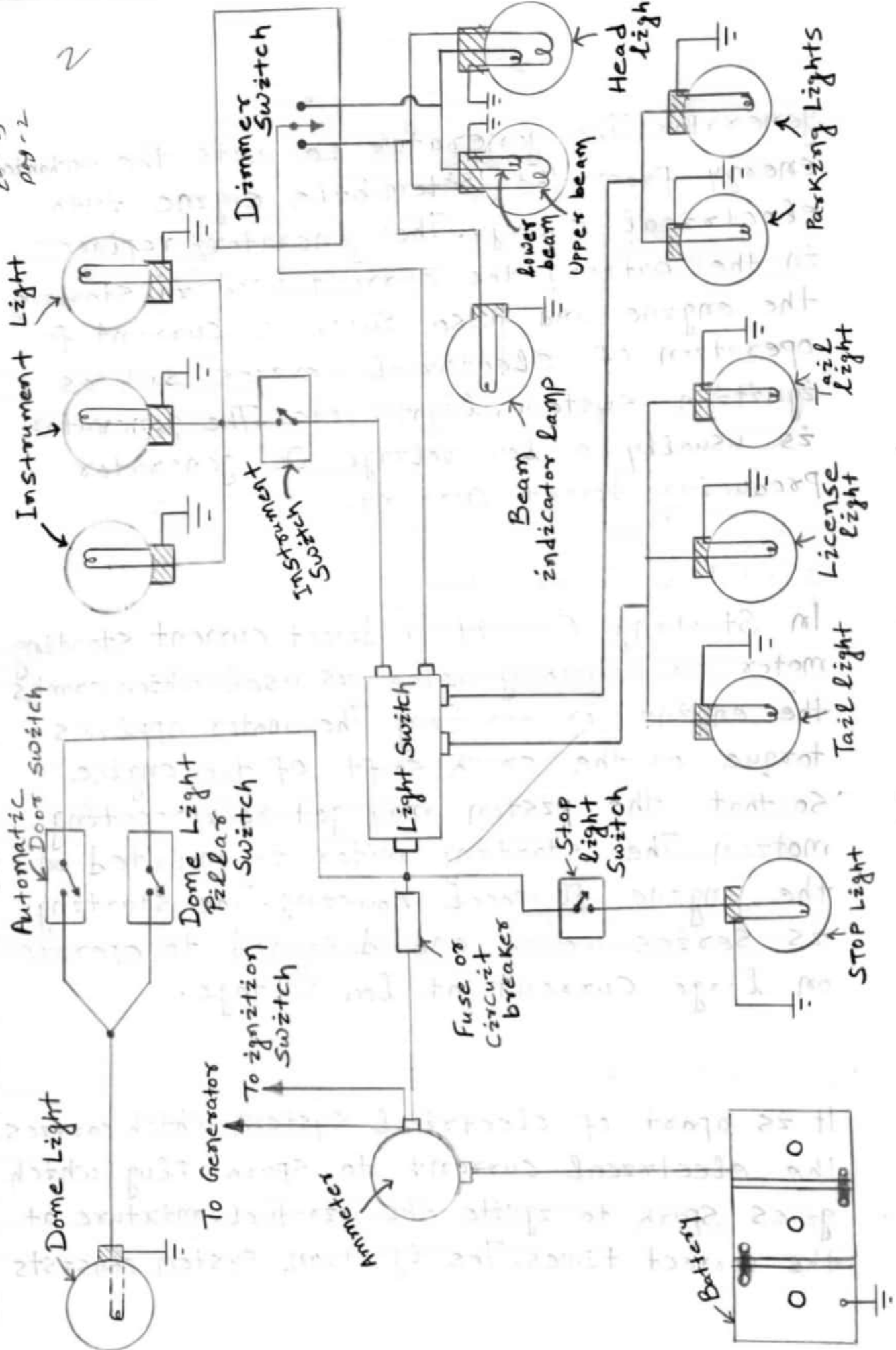
HORN CIRCUIT

Lighting circuit

The lighting circuit is a simple circuit using one wire and ground. The current is supplied to the system from the battery, suitable switches, fuses, circuit breaker are also included in the system to protect it from over loading. The hand lamp circuit generally consists of a foot operation, dimmer switch which determines whether the current is flowing to upper or lower. The dome light is controlled either by a hand operated pillar switch in the brake system so that when the brake apply switch is on. All other lights are controlled by a light switch on the instrument panel. This switch generally has three positions for operate different lights like parking light, tail light, license light and instrument light.

Ex-3
pg-2

2



LIGHTING CIRCUIT

(i) Head light! -

These are required to illuminate the high way sufficiently to permit safe night driving. These are usually provided with two beams, one is upper beam and other is lower beam. Upper beam gives maximum illumination for night driving.

and lower beam gives deflected to the ground and side of the road to minimize to glare when passing other vehicles on the road.

(ii) parking light -

The parking lights are provided in front and back of a vehicle to signal for other moving vehicles and thus avoid accident.

(iii) Blinker light - (Direction, signal light)

These are used to indicate the direction in which the vehicle is to turn. These are provided in front and rear of the vehicle. The blinker lenses are placed in front and rear of the vehicle for signalling which the vehicle is standing or is brake down on the road.

(iv) Stop light -

These are generally provided on the back of the vehicle to indicate that the vehicle is going into stop. It is operated automatically when the brake pedal is applied.

(v) Tail light -

These are placed at the back of the vehicle to illuminate the back of the vehicle in the night so that the other vehicles coming behind are able to see the width of the vehicle. Interior light, dome light and instrument panel light.

(vi) Back up light -

These are provided at the back of the vehicle and is operated by switch when is linked to the reverse gear.

Interior light, dome light & instrument panel light

(i) The interior light includes the panel light various wiring induction light, compartment light, key hole light, radial die light, & door light provided in signal light.

(ii) The dome light illuminates the inside of the vehicle by manual switch or automatic door switch.

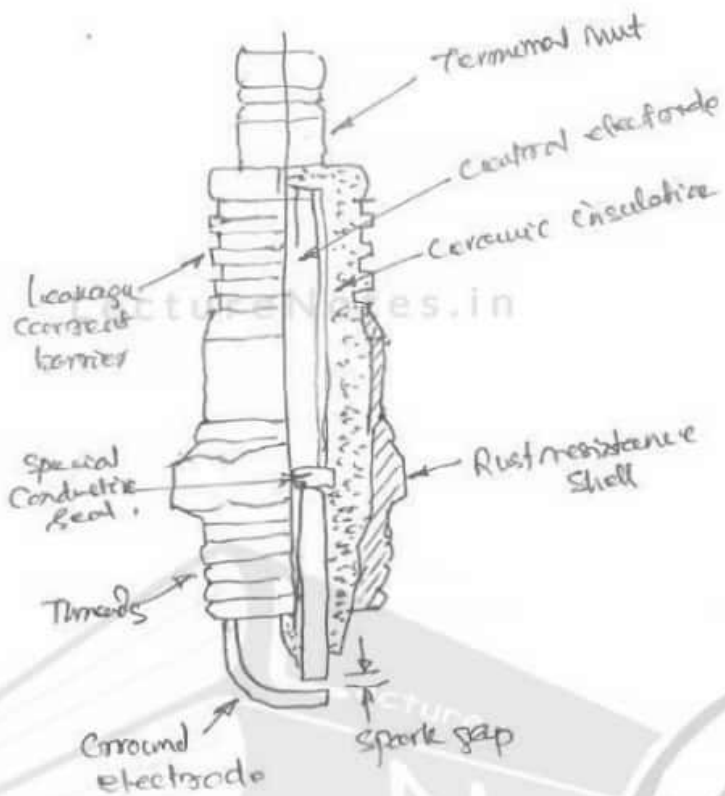
(iii) The wiring diagram of lighting circuit is given in the figure.

SPARK PLUG

The spark plug receives high voltage ignition current from secondary coil of the engine ignition system and supplies spark which jumps across its electrodes.

The major requirements of a spark plug are:

- (i) allow a spark to form within the combustion chamber and initiate spark
- (ii) withstand severe operating conditions in terms of temperature and pressure
- (iii) Continued maintenance of proper gap under all conditions
- (iv) provide suitable insulation between two electrodes to prevent short circuiting.
- (v) resistance to corrosion
- (vi) High heat resistance to prevent the electrode from too hot
- (vii) Gas tightness
- (viii) proper reach into combustion chamber.



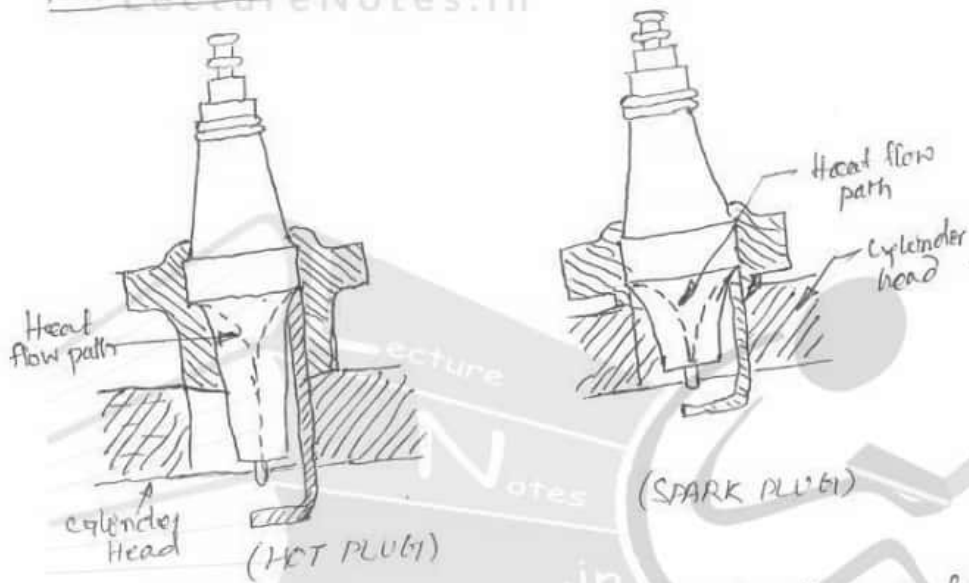
The coil essentially consists of a central electrode, a threaded metallic body with a ground electrode, and an insulator that separates the two electrodes.

The central electrode passes through the porcelain insulator. The electrode extends for a short length through the bottom of insulator and it has external contact at the top of wire from ignition coil. There is a metal screw that surrounds the bottom part of the insulator and fastened onto the cylinder head. The lower part of the metal screw has a ground electrode welded to it. The ground electrode is bent towards the central electrode.

The small gap between the central electrode and the ground electrode is called spark gap. When high tension current is given to the terminal of central electrode, it jumps across the gap and spark is produced.

- NOTE: (1) The spark gap is generally kept 0.6 mm to 1 mm. Too large or too small gap has an adverse effect on the efficiency of ignition system.
- (2) The sparking voltage at the spark plug is 10,000 to 15,000 volt and it last for about 0.001 second.

HOT AND COLD SPARK PLUGS



When the spark plug is short and has thick central electrode and insulator, it remains cooler and is called cold plug. The plug would run better when it has long and thin exposed electrode and is then known as hot plug.

Cold spark plugs are used in heavy duty or continuous running high speed engines. The low speed medium duty engines operating in cold climatic conditions are fitted with a hot spark plug.

CHAPTER - 5

SUSPENSION SYSTEM.

Suspension system.

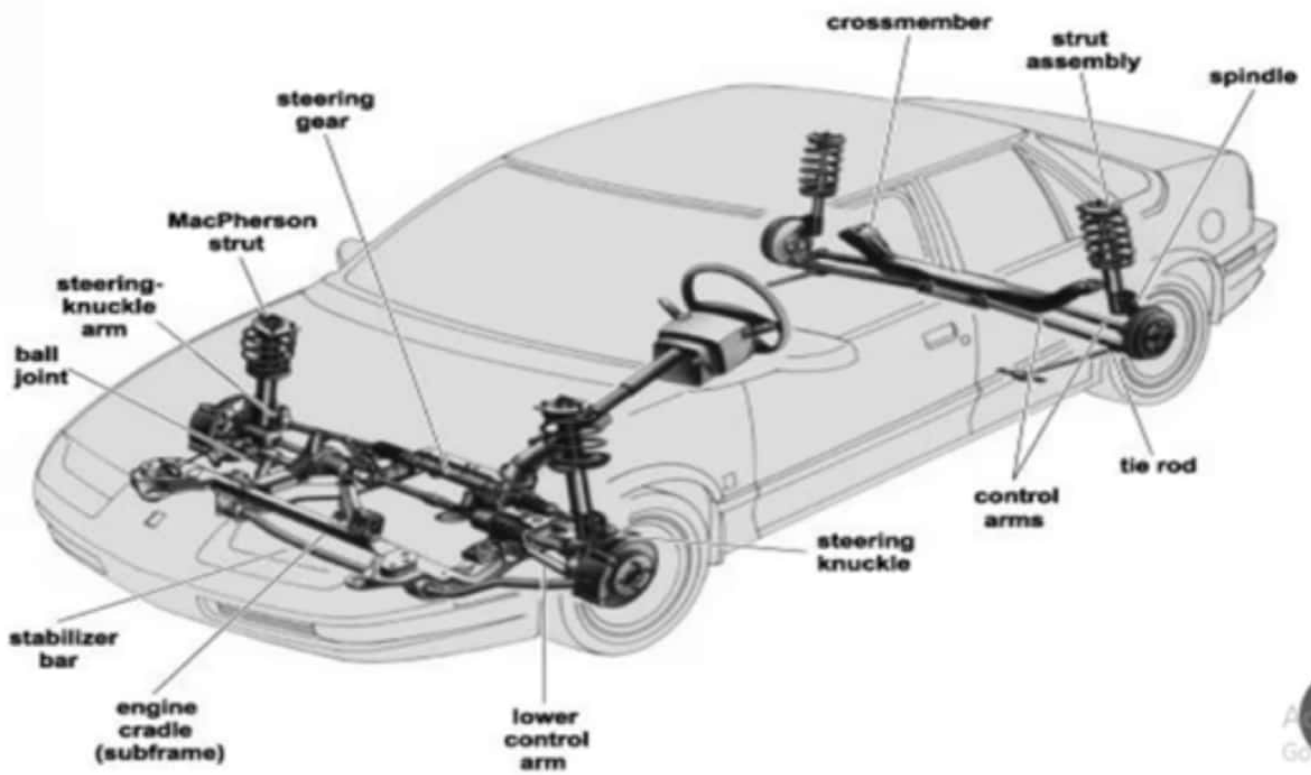
introduction.

- (i) Suspension is the term given to the system of springs, shock absorbers and linkages that connects a vehicle to its wheels.
- (ii) It serves a dual purpose i.e. contributing to the car's handling and braking.
- (iii) It also protects the vehicle itself and any cargo or luggage from damage and wear.

conventional suspension system.

- (i) In conventional suspension system the 2 wheels are mounted on either side of the rigid axle.
- (ii) When one wheel encounters the bump, both the wheel do not execute parallel up and down motion.
- (iii) So it gives rise to gyroscopic effect and wheel wobble.
- (iv) Rear driving wheels mounted on the live axle suspended by laminated leaf springs and shock absorbers.

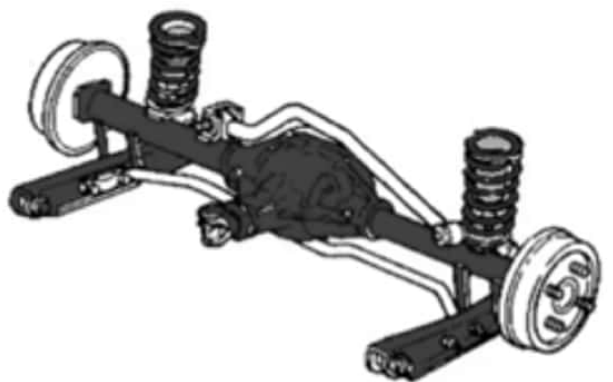
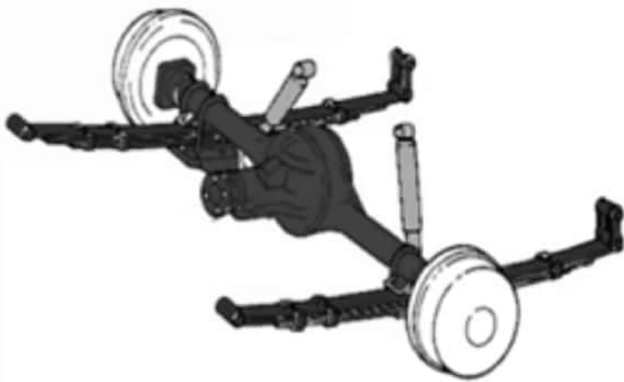
SUSPENSION SYSTEM – LAY OUT



Activate
Go to Settings



DEF 10001



Activate
Go to Settings

Independent suspension system.

- (i) In this suspension system both the front and rear wheels are utilised.
- (ii) Design incorporated in the front axle.
- (iii) If one wheel goes down, the other wheel does not have much more effect.

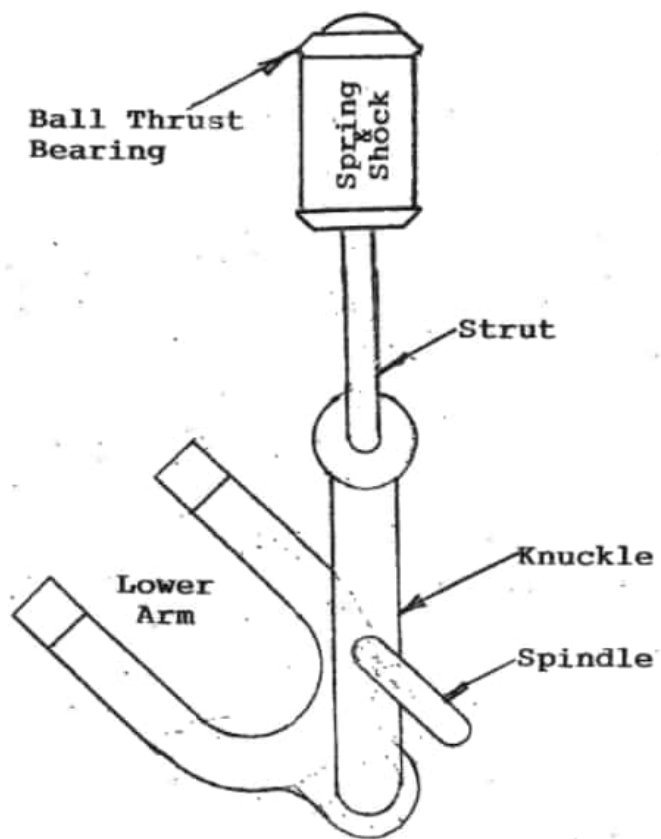
(iv) The basic classification of the design is of 3 types.

- (a) Macpherson strut.
- (b) Double wishbone.
- (c) Multi-link.

(a) Macpherson strut. —

- (i) It is the most widely used front suspension system in cars.
- (ii) It comprises of a strut-type spring and shock absorber combo, which pivots on a ball joint on the single, lower arm.
- (iii) The steering gear is either connected directly to the lower shock absorber housing, or to an arm from the front or back of the spindle.
- (iv) When we steer, it physically twists the strut and shock absorber housing to turn the wheel.

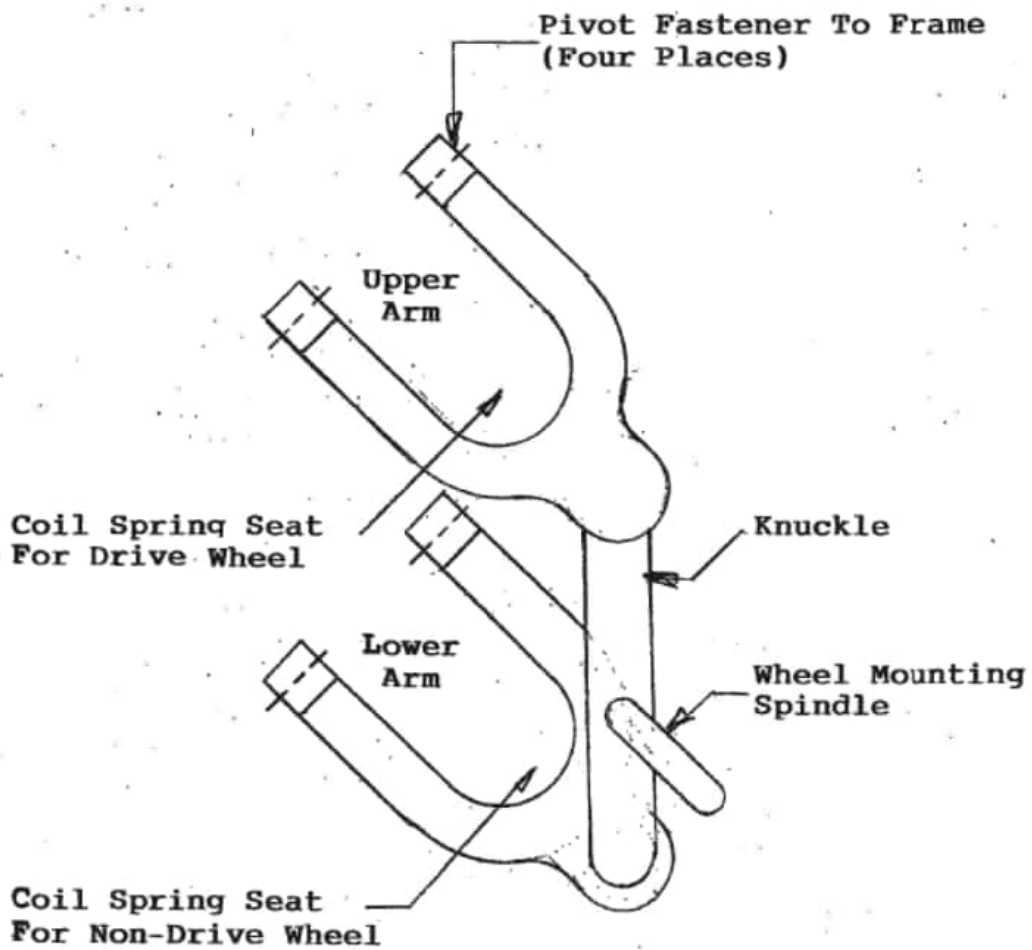
**MacPherson Strut
Suspension Schematic**



b. double wish bone suspension —

- (i) It is also known as double-A suspension.
- (ii) In this type of suspension, the wheel spindles are supported by an upper and lower 'A' shaped arm.
- (iii) The lower arm carries most of the load.
- (iv) If you look head-on at this type of system, parallelogram systems that allow ~~for~~ the spindles to travel vertically up and down.
- (v) This side to side motion is known as scrub.
- (vi) In double-A arm suspension although the lower arm in these systems can sometimes be replaced with a single solid arm.
- (vii) The spring/shock combo is moved from between the arms to above upper arm.
- (viii) This transfers the load-bearing capability of the suspension almost entirely to the upper arm and the spring mounts.

**Double Wishbone
Suspension Schematic**



c. Multi-link suspension system. —

- (i) It is currently being used in the Audi A8 and A4 among other cars.
- (ii) The basic principle of it is same, but instead of solid upper and lower wish bones, each arm of the wishbone is a separate item.
- (iii) These are joined at the top and bottom of the spindle thus forming the wishbone shape.
- (iv) The super weird thing about this is that as the spindle turns for steering it alters the geometry of the suspension by torquing all four suspension arms.
- (v) Spring is separate from the shock absorber.

Tyre specification.

Tyre specification is given as follows.

Ex - P - 205 - 60 - R - 16 - 92 - V

1. Tyre type \rightarrow

It is represented by a letter.

(a) for passenger \rightarrow [P]

(b) Temporary \rightarrow [T]

(c) Light truck \rightarrow [LT].

2. Section width \rightarrow
(mm)

(i) It is represented by a number.

for example (235, 245, 275)

(ii) It is the width of entire tyre.

3.

Aspect ratio -

(i) It is also represented by a number and comes after the section width.

(ii) It is the ratio between the section height and section width.

$$A.R. = \frac{\text{Section height}}{\text{Section width}}$$

for ex - 55, 50, 40.

4. construction type -

(i) It is represented by a letter.

(ii) for example -

R - Radial type tyre.

B - Bias type tyre.

D - Diagonal type tyre.

5.

Rim dia -

(i) It is represented by a number.

(ii) It is given in inches.

ex - 16, 17.

6.

load index -

(i) It is represented by a number.

(ii) It shows how much load a tyre can withstand.

ex - 92 → 600 kg approx.

95 → 630 kg approx.

7.

Speed symbol -

(i) It is represented by a letter.

(ii) It shows the speed limit.

ex - V - 240 km/hr.

Q - 160 km/hr

T - 190 km/hr

S - 180 km/hr

H - 210 km/hr

W - 270 km/hr

Causes of tyre wear

Due to the irregular tyre wear, the performance of the tyre decreases. The following are the important causes of tyre wear.

1. Air pressure.

Improper air pressure will cause tyres to wear in specific patterns, whether the tyre is over pressured or under pressure.

2. Balance Issue.

Improper balance will cause the tyre to spin with a wobble due to unbalanced centrifugal forces. This wobble will cause the tyre to wear improperly and also it causes vibration.

3. Bent wheels.

A bent wheel causes vibration in the car, which also affects the wear on its tyre and can even affect the wear on the other tyres as well.

As the lead of the tyre follows the contour of the wheel, the lead in the wheel will be mirrored by the tyre's shoulder tread as the whole side wall dips to follow the bend.

This can cause the wear.

4. Alignment

A 4-point alignment (as opposed to a front-end alignment) essentially ensures that the tyres are all parallel to each other and flat to the pavement, giving the tyres their optimal wear profile.

If the alignment is incorrect, any number of wear patterns can develop.

Additionally the kind of impact that will bend a wheel will generally also knock the alignment out, creating tyre wear.

Remedies for tyre wear.

As always with tyre and wheels a prevention can be a worth of cure. The best preventive for tyre wear is.

- (i) monitor the air pressure regularly.
- (ii) align the car whenever new tyres go on and rotate the tyres regularly.
- (iii) deflate the tyre to the recommended PSI specified in the manual.
- (iv) avoid over inflation or under inflation of the tyre.

CHAPTER - 6

COOLING AND LUBRICATION

Cooling and Lubrication System (CA-06)

COOLING SYSTEM

INTRODUCTION :-

- We know that fuel is burnt inside the cylinder of an I.C. Engine to produce power. The temperature at the end of expansion stroke reaches as high as 1600°C inside the cylinder, and this temperature is greater than melting point of engine parts.
- It is estimated that about 40% of total heat produced is passed to atmosphere, 30% is removed by cooling and about 30% is used to produce power.
- The engine operating temperature range for most automobiles is between 195°F to 220°F (90°C to 105°C).
- To maintain the engine temperature within operating temperature range cooling system is essential because temperature higher than operating temperature will be able to burn the lubricating film and will melt the engine parts and temperature below operating temperature will cause partial partial combustion of fuels.

Purpose of cooling system

- To maintain optimum temperature of engine for efficient operation under all conditions.
- To reject heat from the engine cylinder for protection of engine components like cylinder heads, piston, piston rings and valves.
- To maintain lubricating property of oil inside engine.

→ There are two types of cooling system is generally used in automobiles. They are

① Air cooling system

② Water cooling system.

→ In some high speed engines liquid cooling is also used.

① AIR COOLING SYSTEM

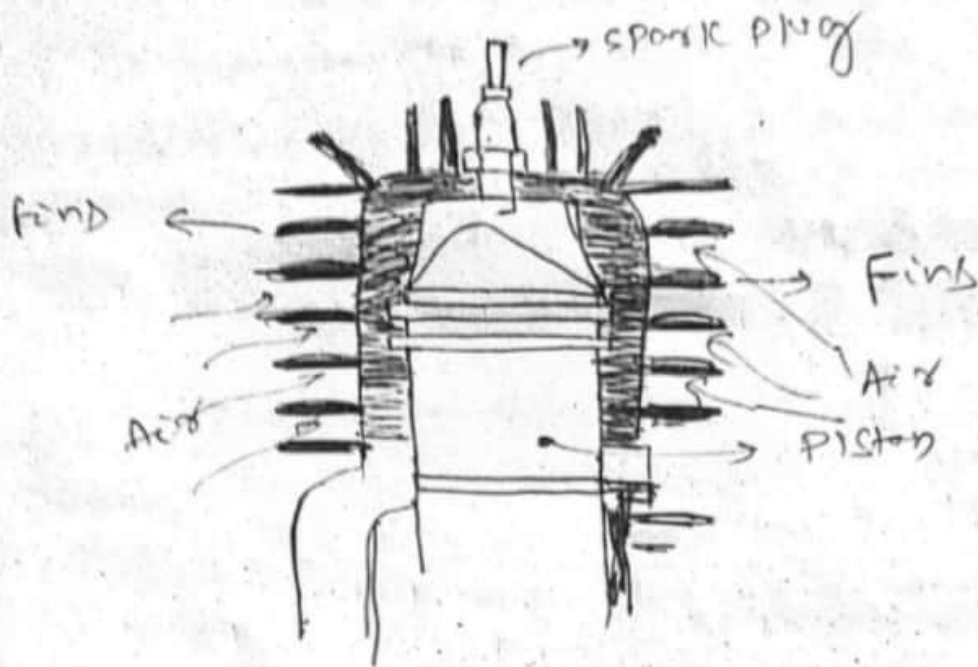
→ In this method of cooling the heat is conducted from the engine to the atmosphere directly.

→ To obtain cooling system the engine cylinders should be kept in such a way that more air should be in contact with the outer region of the cylinder block.

→ For effective air cooling, cooling fins are provided on the outer wall of the cylinder so that the contact surface areas for heat transfer to be more.

→ These type of cooling system arrangements are mostly used in all motor cycles, scooters and in small engines.

→ When the vehicle moves, the air passes over the fins and removes the heat on the engine components and hence the engine gets cooled.



3 / 8

(Air cooling system)

Advantages of Air cooling

- Engine weight is low as there is no radiator, fan fan and pumping unit
- Rust and deposits formations are avoided
- Engine occupies less space
- Design of engine is simple.
- Engine can be operated at all operating conditions.

Disadvantages of Air cooling

- Efficiency of engine decreases
- More noise is produced.
- Heat transfer rate is lower.
- Uneven cooling of engine parts.

② WATER COOLING SYSTEM

- In this method cooling water jackets are provided around the cylinder, cylinder head, valve seats etc.
- The water when circulated through the jackets it absorbs heat of combustion.
- This hot water will then be cooled in the radiator.
- The cooled water is again recirculated through the water jackets.

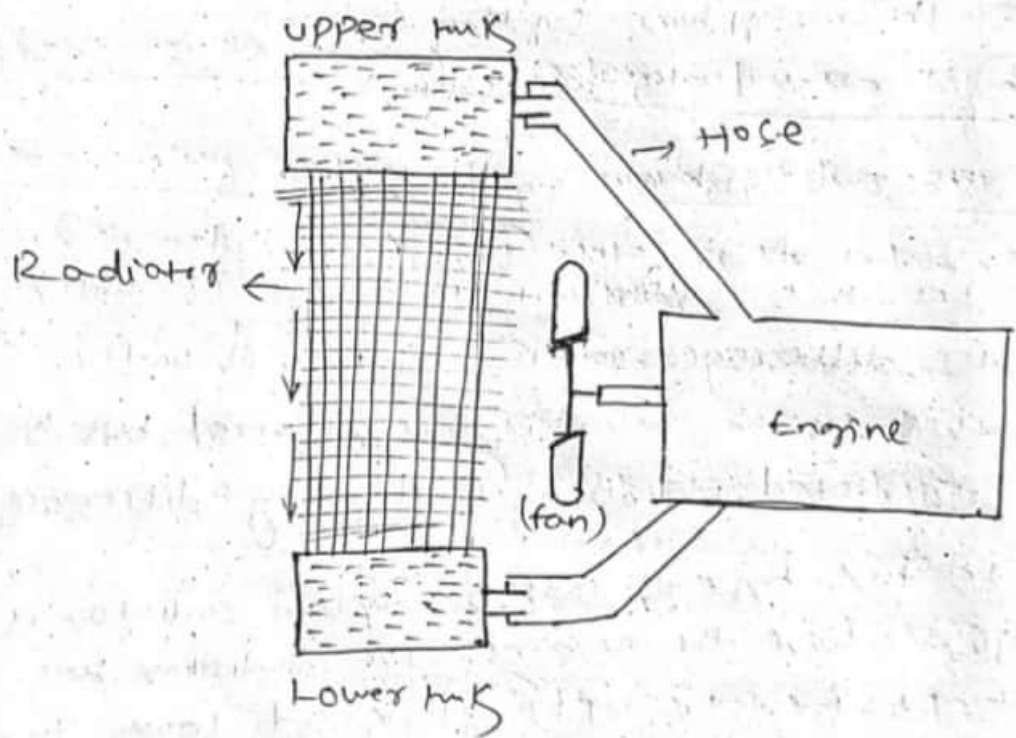
→ There are two types of water cooling system.

- ① Thermosyphon system
- ② Pump circulation system.

① Thermosyphon system :-

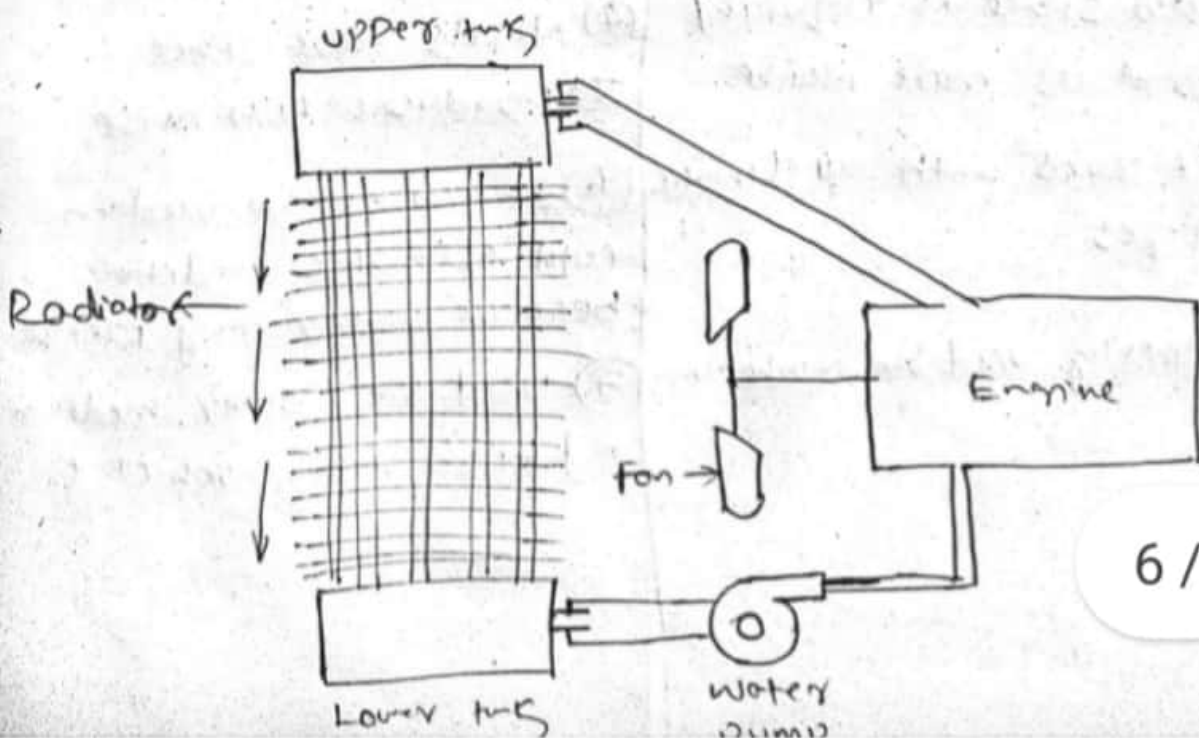
- In this system the circulation of water is due to difference in temperature of water. So in this system pump is not required but water is circulated because of density difference only.
- In this type of cooling system radiator is placed just above the engine. The radiator has two tanks i.e. the upper tank and lower tank. Both the tanks are connected by radiator tubes.
- When the engine runs the hot water in the engine water jacket moves upwards due to low density.
- The hot water moves further towards the radiator upper tank through the hoses provided.

- The hot water from the radiator upper tank falls through the tubes to the ^{Lower} bottom tank. Atmospheric air passes through the spaces between the tubes and rejects heat from the water. A fan is placed behind the radiator for effective cooling of hot water.
- The cooled water at the ^{Lower} bottom tank of the radiator enters into the engine and ~~pushes~~ pushes the hot water upwards and occupies the place of the hot water.



⑥ Pump circulation system :-

- In this system a water pump is used to circulate the water through the system.
- The pump provided in this system, pumps the water into the water jacket of the engine.
- The pumped water takes away the heat from the engine cylinder and goes to the radiator upper tank.
- The hot water from the radiator upper tank falls through the radiator tubes to the lower tank. Atmospheric air passes through the spaces between the tubes and rejects heat from the water. A fan is placed behind the radiator for effective cooling of hot water.
- The cooled water at the lower tank of the radiator is again pumped to the engine by the water pump.



Advantages of water cooling system

- Uniform cooling of cylinder, cylinder head and valves.
- Engine is less noisy.
- Improves engine's thermal efficiency.
- Heat transfer rate is higher.

Disadvantages of water cooling system

- It depends upon the supply of water.
- Engine is costlier.
- Severe damage of engine if cooling system fails.
- Water pump absorbs considerable power.

Difference between Air cooling and water cooling

Air cooling system

- ① Air is the medium of cooling.
- ② Fans are used.
- ③ Construction is easy.
- ④ Less space is required.
- ⑤ Produces more noise.
- ⑥ It runs with all climatic changes.
- ⑦ Mostly used for 2-wheelers.

Water cooling system

- ① Water is the medium of cooling.
- ② Water jacket, water pump and radiator are used.
- ③ Construction is difficult.
- ④ Needs more space.
- ⑤ Produces less noise.
- ⑥ It can not be used in cold climatic conditions because water may freeze.
- ⑦ Used for lower, medium and high duty vehicles.

* ANTI-FREEZING SOLUTIONS

→ During cold climatic condition and at hill stations water generally gets frozen in the water cooling system. Due to this radiator tubes, water jackets and rubber hoses in the cooling system may get damaged.

→ To overcome these difficulties chemical agents are added to ~~the~~ water to prevent it from freezing.

→ These agents are called anti-freezing solutions.

→ Some of the antifreeze solutions used in automobiles are.

- (i) Methanol
- (ii) Methyl Alcohol
- (iii) ~~Glycerin~~ Glycerin
- (iv) Alcohol
- (v) Ethylene glycol.

Lubrication System

INTRODUCTION:-

- As an engine consists of various rotating and moving parts, so it needs to be lubricated well otherwise they wear and tear out and engine may face breakdown.
- The metallic contacts between two moving parts lead to friction, heat, wear, noise and seizure of the engine. To overcome this problem, lubricating system is needed in all automobiles.

Definition:-

- The lubricating system of an engine is an arrangement of mechanisms which maintains the supply of lubricating oil to the rubbing surfaces of an engine at correct pressure and temperature.
- The engine parts which require lubrication are
 - (i) cylinder walls and piston
 - (ii) piston pin
 - (iii) crankshaft and connecting rod bearings
 - (iv) camshaft bearings
 - (v) valve operating mechanism
 - (vi) cooling fan
 - (vii) water pump and
 - (viii) Ignition mechanism

Purpose of Lubrication System:-

- The main function is to reduce the rate of wear and tear on the vehicles and makes the easy running of the engine.
- Lubrication system reduces power loss due to friction.
- It absorbs the heat from the engine part, thereby

- acts as a cooling agent in the engine of the vehicle.
- It also provides the sealing action between moving parts.
 - It also cleans the tiny metal particles and dust that are present between two moving parts.
 - It reduces the vibrations and makes the parts of the engine to function silently.

TYPES OF Lubrication system :-

→ The Lubrication system can be classified into the following types.

- (i) Petrol system
- (ii) Splash system
- (iii) Pressure system
- (iv) Semi pressure system
- (v) Dry sump system
- (vi) Wet sump system

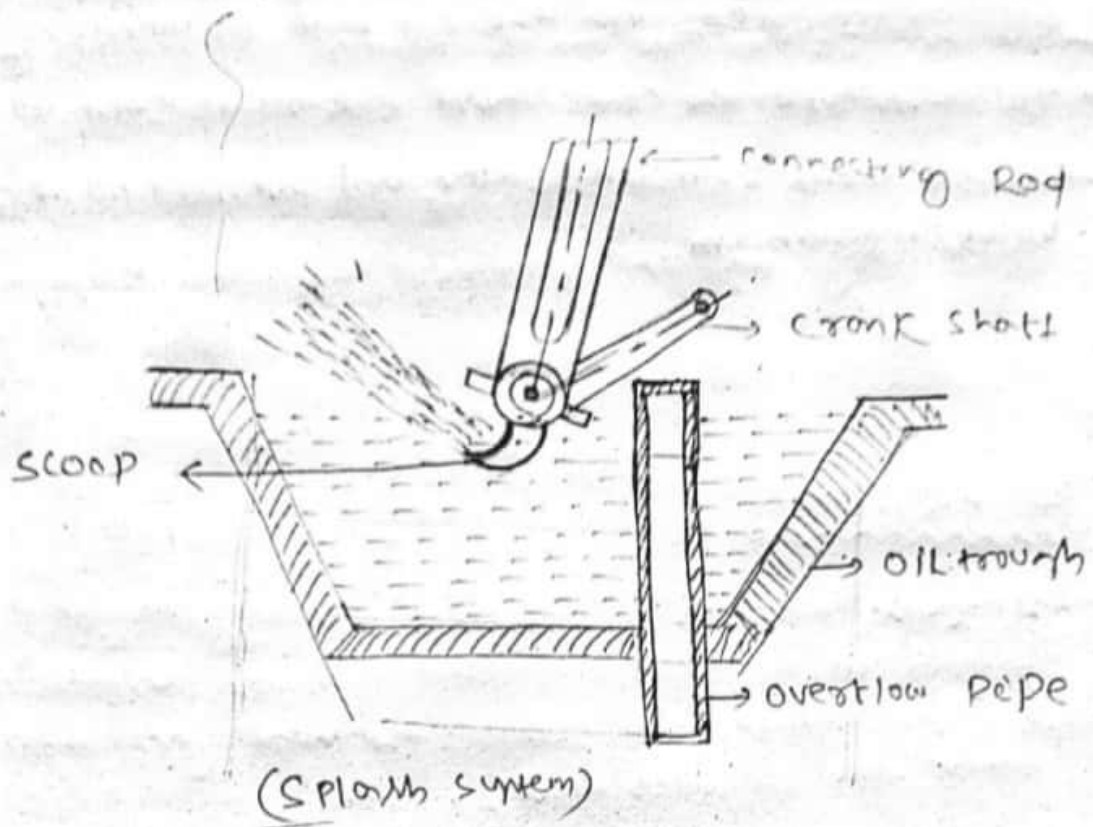
(i) Petrol system :-

- This system is generally used in two-stroke engines like scooters, motorcycles etc.
- In this type of system, a certain amount of lubricating oil is mixed with petrol itself. Generally 8% to 10% of oil is mixed with petrol.
- In this type of system the lubricating oil is mixed into petrol itself while filling in the petrol tank of the vehicle in a specified ratio.
- The amount of lubricating oil to be added is usually about one part of oil to ten part of gasoline by volume.

- When the fuel goes into the crank chamber during the engine operation, the oil particles go deep into the bearing surfaces and lubricate them.
- The piston rings, cylinder walls, piston pin are lubricated in the same way.

(ii) Splash system :-

- This is the most popular type of lubrication system duly used in ~~engs.~~ 4-stroke engines.
- In this system of lubrication, the lubricating oil is stored in an oil trough and or sump.
- A scoop or dipper is made in the lowest part of connecting rod.
- When the engine runs, the dipper dips in the oil once in every revolution of the crankshaft and causes the oil to splash on the cylinder walls.
- This action effects the lubrication of the engine cylinder walls, piston pin, piston rings, crankshaft bearings and big end bearings.
- A hole is drilled through the connecting rod cap through which the oil passes through the bearing surface.
- Oil pockets are provided to catch the splashed oil over all the main bearings and also the crankshaft bearings. From these pockets, oil passes to the bearings through a drilled hole.
- The surplus oil dripping from the cylinder flows back to the oil sump in the crankcase.



(iii) Pressure Lubrication system :-

- Sending the lubricating oil at high pressure using a pump to all the parts of engine is called pressure lubrication system.
- In this system oil is kept at the base of the ~~the~~ crank case.
- During operation of the engine, oil pump sucks the oil from sump through the strainer.
- This lubricating oil is subjected to high pressure of about 200 kPa to 400 kPa and then sent to the oil filter.
- It is then filtered in the oil filter and sent to main gallery.
- From the main gallery, the oil is sent to main journal bearings and sub journal bearings of the crank shaft for lubrication.

- The lubricating oil is then sent to the piston pin and piston rings via the oil hole of connecting rod.
- To lubricate the cam shaft the oil is sent to the rocker arm from oil holder and overhead valve by valve mechanism.



(figure)

④ Semi-Pressure Lubrication System

- It is the combination of splash and pressure lubrication system. This system is used in 4-stroke engines.
- In this system some parts are lubricated by the splash system and some parts are by a pressure system.
- The parts such as cylinder wall, piston, piston pin, connecting rod are lubricated by splash system and remaining parts are by a pressure system.

⑤ Dry Sump System

- In this system the lubricating oil is stored in a separate tank instead of the bottom of the crank case. As soon as the oil sump does not store the oil it is known as dry sump system.
- This system consists of two pumps. One scavenging pump placed below the sump and other pressure pump placed at the tank.
- Scavenging pump supplies lubricating oil to the main tank through the filter and pressure pump supplies oil to the different parts of an engine through the oil cooler.
- This type of system is used in the sports car and certain military vehicles.

(VI) Wet sump system :-

- In this system the oil is always present in the sump, so it is called a wet sump lubrication system.
- Lubrication of the engine parts are done in the same way as in pressure lubrication system.

LUBRICANTS

- A lubricant is a substance, usually organic, introduced to reduce friction between surfaces in mutual contact, and reduces the heat generated when the surfaces move.
- The lubricating oil used for reducing friction is known as lubricant.

Properties of Lubricants

- (i) viscosity
- (ii) oiliness or Adhesiveness
- (iii) fluidity
- (iv) volatility
- (v) flash point and fire point
- (vi) stability
- (vii) corrosion
- (viii) cleanliness
- (ix) foaming

TYPES OF LUBRICANTS

→ The different types of lubricants used in automobiles are

(a) SOLID LUBRICANTS:- Powder of fibre, graphite, carbon, mica etc.

* These are used in high temperature places

(b) SEMICOLID LUBRICANT:- Calcium based grease, sodium based grease, Lithium based grease

* These are used at places of high stress or in all the bearings other than engine bearings

(c) LIQUID LUBRICANTS:- Animal oils, vegetable oils, mineral oils etc.

Ex:- Linseed oil, Castor oil, Palm oil, Crude oil etc.

CHAPTER-7

FUEL AND IGNITION SYSTEM.

(*) Petrol Engine:-

(*) Carburettor:-

→ It is a device a fuel feed system of S.I engine and used for mixing of air and fuel in varying proportion to suit the changing condition of spark ignition engines.

→ The air fuel mixture so obtained from the carburettor is called combustible mixture.

→ The process of mixing the gasoline fuel with air to obtain combustible mixture is called carburation.

(*) Vaporisation:-

→ Carburation is consist of 2 stages known as vaporisation and Atomization.

→ Vaporisation is the change of state of fuel from liquid to vapour.

(*) Atomization:-

→ Atomization is the mechanical breaking of the liquid fuel into small particles so that every particle of the fuel is surrounded by air.

(*) Air-Fuel ratio :-

→ The carburettor must supply the air-fuel mixture in varying proportion to suit to different operating conditions. The mixture must be rich at the time of starting must be lean at the time of idling and intermediate speed.

→ For starting the air-fuel ratio is $9:1$ or is a rich mixture for idling speed the air-fuel ratio is $12:1$ and it is a lean mixture

→ In some case where speed varies from 35 km/hr to 105 km/hr the mixture is used $15:01$

→ At higher speed i.e. $120-130 \text{ km/hr}$ the throttle valve opens widely and the mixture is again enriched to $13:01$ or $12:01$.

(*) Ignition system in petrol engine :-

→ The spark ignition system requires some device to ignite the compressed air-fuel mixture inside the engine cylinder at the end of the compression stroke. The ignition system serves this purpose.

→ The requirement of ignition system is used to supply high voltage i.e. $20000-30000$ volt to the spark plug.

→ This high voltage surge produces electric spark at the spark plug gap to ignite the compressed air-fuel mixture.

(*) Types of ignition system :-

→ There are 2 types of ignition system used in petrol engine
(i) Battery ignition system
(ii) Magneto ignition system.

→ Both the ignition systems are used on the principle of mutual electro magnetic induction.

(i) Battery ignition system.

An ignition system in which we use the battery for the generation of electricity and further that electricity is used in cars, commercial vehicles.

Battery ignition system parts -

↳ ignition switch

(i) This is used to turn on and off the ignition system.

(ii) The battery is connected to the primary winding of the ignition coil by the ignition switch and balast resistor.

↳ Battery.

(i) It is a device that provides electrical energy for the ignition.

(ii) It is charged by a dynamo driven by the engine.

(iii) Generally 2 types of batteries are used in a spark-ignition engine, lead-acid battery and alkaline battery.

(iv) The lead acid battery is used in light duty commercial vehicle while an alkaline battery is used in heavy duty commercial vehicle.

L ignition coil

- (i) It is the main body of battery ignition system.
- (ii) The purpose of the ignition coil to step up the battery voltage (6V or 12V) to a high voltage, which is sufficient to produce a spark at the spark plug.

L Ballast resistor.

This is connected series with primary winding to regulate the current in the primary winding. It is made of iron.

L Contact breaker.

The contact breaker is regulated by the cam and when the breaker is open, current flows through the condenser and charges it.

L Distributor.

It is used in a multi-cylinder engine to regulate spark in each spark plug at the correct sequence.

There are 2 types of distributor used.

1. carbon brush type.
2. gap type

↳ capacitor.

This is a simple electrical capacitor in which 2 metal plates are separated by an insulating material with a distance.

↳ spark plug.

(i) It generates sparks to ignite the air-fuel mixture in the combustion chamber.

(ii) Each spark plug is connected to the distributor of the ignition system.

Battery ignition system working diagram—

(i) In the battery ignition system when the ignition switch is on, the current from the battery starts flowing through the primary circuit and through ballast resistor, primary winding and contact breaker.

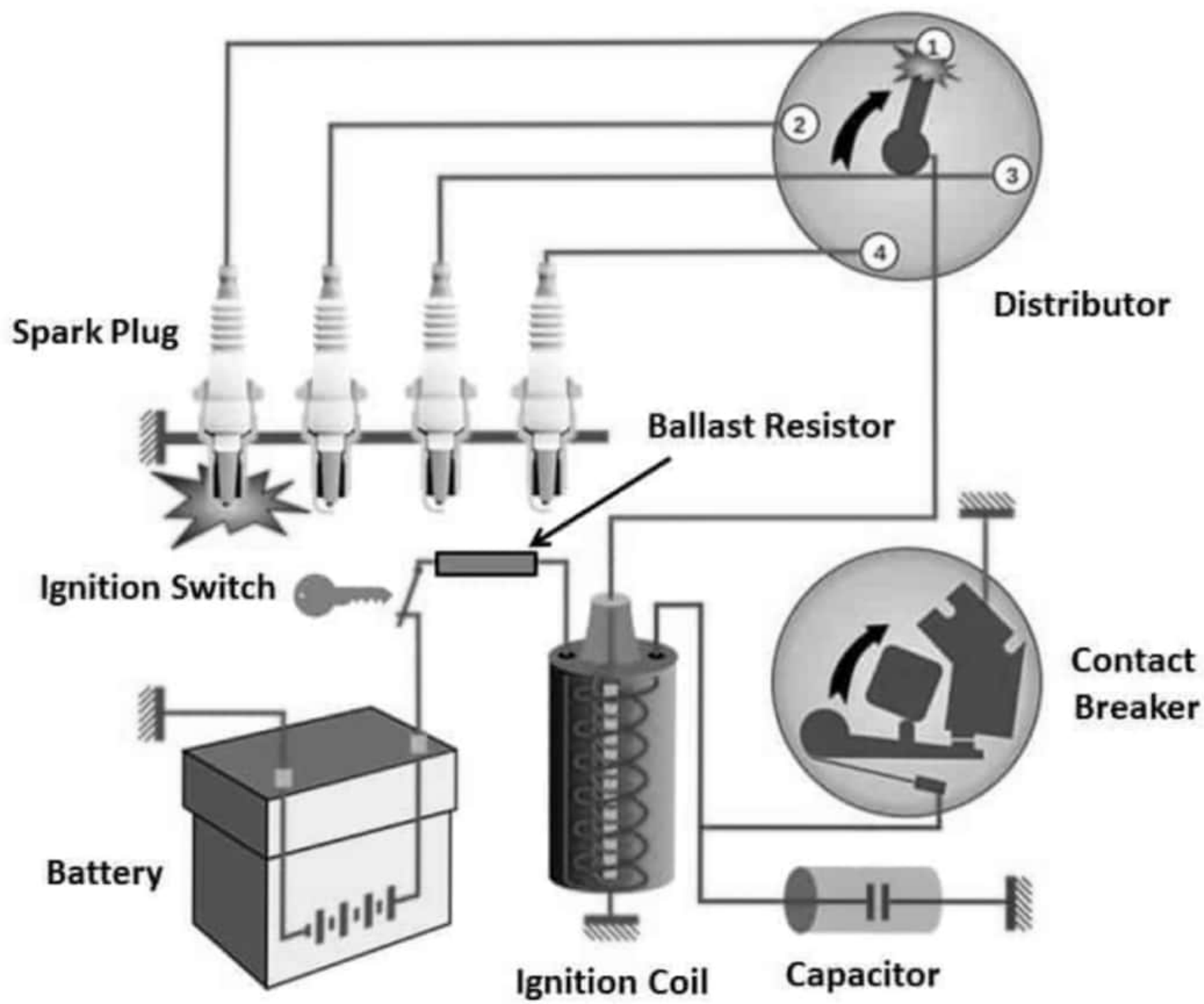
(ii) and then the current which is flowing through the primary winding induces a magnetic field around it

(iii) The more will be the current, the stronger will be its magnetic field.

(iv) Now the contact breaker opens, the current through the primary winding collapses and this immediately

collapse in the current induces a voltage about 300 V in the primary winding.

- (v) This voltage induced in the winding charges the capacitor to the much greater voltage than the battery.
- (vi) As the capacitor charges, the current through the primary winding stops and the current starts to flow to the battery from the capacitor.
- (vii) This reverses the direction of the current and magnetic field in the primary winding.
- (viii) Due to the collapsing and reversing of the current and magnetic field, a very high voltage of about 15000 to 30,000 V induced in the secondary winding.
- (ix) A high voltage current induced in the secondary winding is transferred to the distributor through a high tension cable.
- (x) The distributor has a rotor that rotates inside the distributor cap.
- (xi) The distributor cap has metallic segments embedded into it.



Battery Ignition System

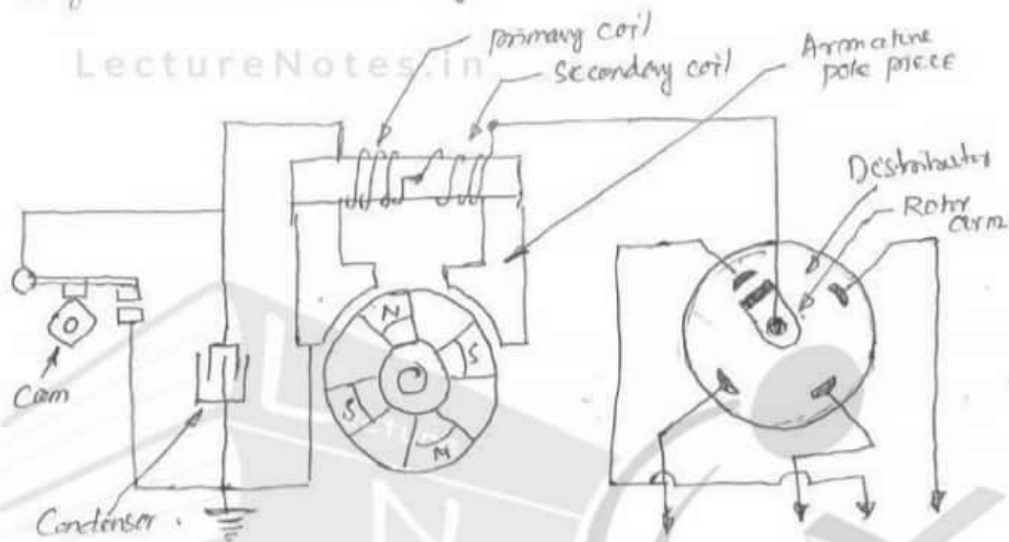
- (xii) As the rotor rotates, it presses and opens the contact breaker point.
- (xiii) This allows the high tension current to transfer to the spark plug through the metallic segments.
- (xiv) As the high tension current reaches the spark plug, it produces the spark in the engine cylinder for the combustion of air fuel ~~mix~~ mixture.

Application

Commonly used in cars and light commercial vehicle.

MAGNETO IGNITION SYSTEM

The magneto ignition system generates the ignition current on its own and does not depend on any battery or generator for its supply.



(1) Permanent magnet which is attached to the engine flywheel and rotates at the engine crank shaft.

(2) Stationary armature fitted with the primary and secondary coils. Since the ignition coil, the primary winding consists of a few hundred turns of thick wire whereas secondary winding comprises some thousands turns of thin wire.

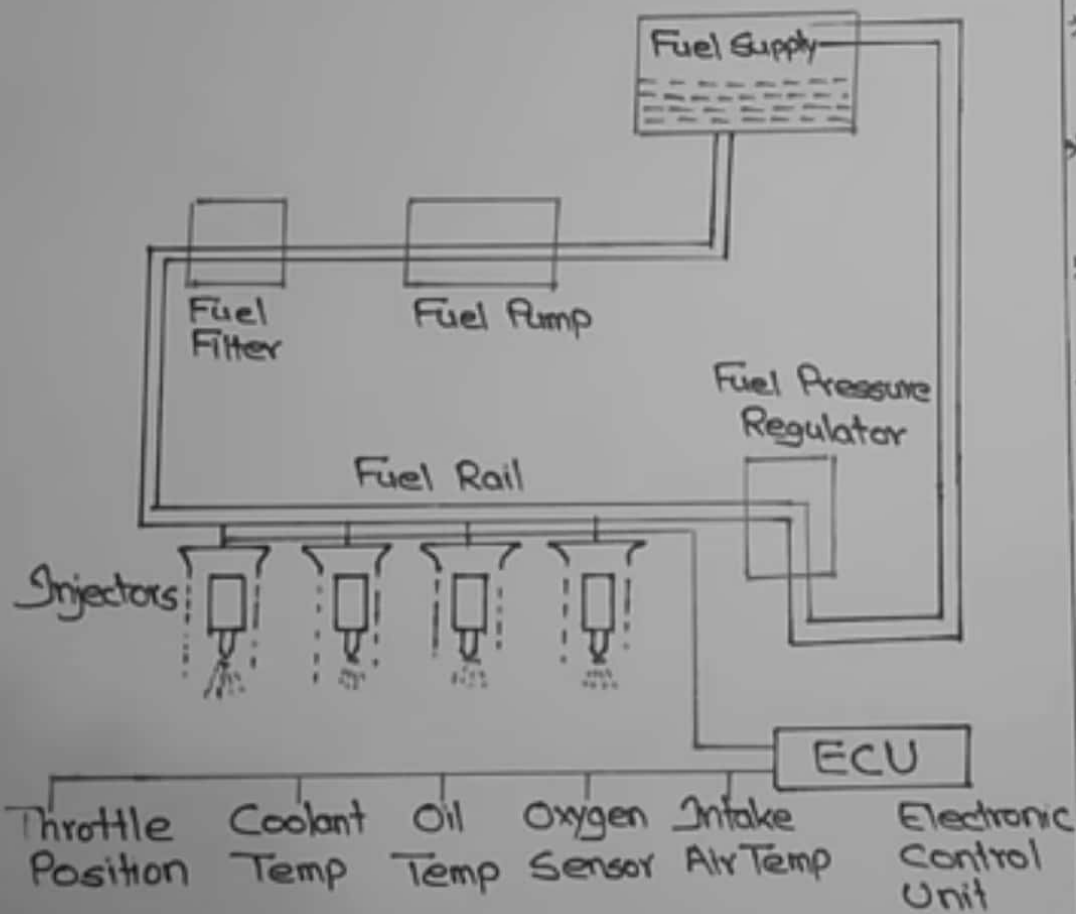
(3) Cam, contact breaker and condenser: The label of the cam correspond to the member of cylinder and in a four stroke cycle engine, the cam is rotated at half the engine speed. The contact breaker clearing one complete cycle of the engine. The condenser is connected in parallel to

to the contact breaker coil, and it absorbs the induced current produced in the primary circuit.

(4) Distributor and spark plug: when the flywheel is rotated, the magnet also rotates. That generates the current flows through the primary coil. The contact points get separated by the rotating cam. Due to sudden discontinuity in the flow of current, high tension current is induced in the secondary coil. The high voltage current induced in the secondary winding is passed on the distributor which distributes it to the respective spark plug.

BATTERY IGNITION SYSTEM	MAGNETO IGNITION SYSTEM
1. Battery supplies the current	1. Magneto generates the current
2. Good sparkers even at low speed	2. Poor sparkers at low speed.
3. Complicated wiring circuit	3. Simple wiring circuit
4. Less costly system,	4. More costly system.
5. Requires more space for installation	5. Needs less space.
6. Less reliable	6. More reliable.
7. Fall in spark intensity with rise in engine speed.	7. Improvement in spark intensity with rise in engine speed
8. Considerable maintenance	8. Less maintenance
9. Used in cars, buses and trucks.	9. Used in scooters, motor cycle, and racing cars

Multi Point Fuel Injection System - MPFI



Advantages

- * Improve fuel efficiency
- * Low carbon emission
- * Improve engine response
- * Effective fuel utilization

The multi point fuel injection system (MPFI) is a system or method of injecting fuel into internal combustion engine through multiple ports situated on intake valve of each cylinder. In the simultaneous system, fuel is injected to all cylinders at the same time, while the sequential system injection is timed to overlap with intake stroke of each cylinder.

- (i) Multi point fuel injection injects fuel into the intake ports just upstream of each cylinder's intake valve.
- (ii) In this system each cylinder has a number of injectors to supply fuel.
- (iii) MPFI system injects fuel into individual cylinders, based on commands from the on board engine management system computer - known as engine control unit (ECU).
- (iv) These techniques results not only in better power balance amongst the cylinder but also gives higher output.

Components of MPFI system

1. Air intake system.
2. Fuel delivery system.
3. Electronic control system.

Air intake system

The air (corresponding to the throttle valve opening) is filtered by the air cleaner, passes through the throttle body and is distributed by the intake manifold and finally drawn into each combustion chamber opening and closing of throttle valve is controlled by ECU according to the demand.

1. Throttle body

Throttle valve which is interposed with the accelerator pedal and controls the amount of intake air.

2. Idle Air control valve

This valve controls the opening of the bypass air passage. The air bypasses the throttle valve through bypass passage and is finally drawn into the intake manifold.

Fuel delivery system.

The fuel in the fuel tank is pumped up by the fuel pump filtered by fuel filter and fed under pressure to each injector through the delivery pipe. The fuel is injected into the intake port of the cylinder head when injector opens according to the injection signal from ECU.

1. Fuel pump.

It is an electric fuel pump & its operation is controlled by ECU. The fuel is drawn through the inlet port with high pressure, it is discharged through the outlet port, the fuel pump also has a check valve to keep some pressure in the fuel feed line even when the fuel pump is stopped.

2. pressure regulator system —

The fuel pressure regulator is diaphragm operated relief valve consisting of diaphragm, spring and valve. It keeps the fuel pressure applied to the injector higher than the intake manifold all the time.

3. Injector.

Each cylinder has one injector which is installed between the intake manifold delivery pipes. It is electromagnetic type injection nozzle, which injects fuel into the intake port of the cylinder head according to the signal from ECU.

Electronic control system.

The Electronic control system consists of various sensors which detect the states of engine and driving conditions.

It controls various devices acc. to the signals from the sensors and various controlled devices.

The systems are as follows.

- (i) fuel injection control system,
- (ii) idler speed control system,
- (iii) fuel pump control system,
- (iv) ignition control system,
- (v) Radiator fan control system.