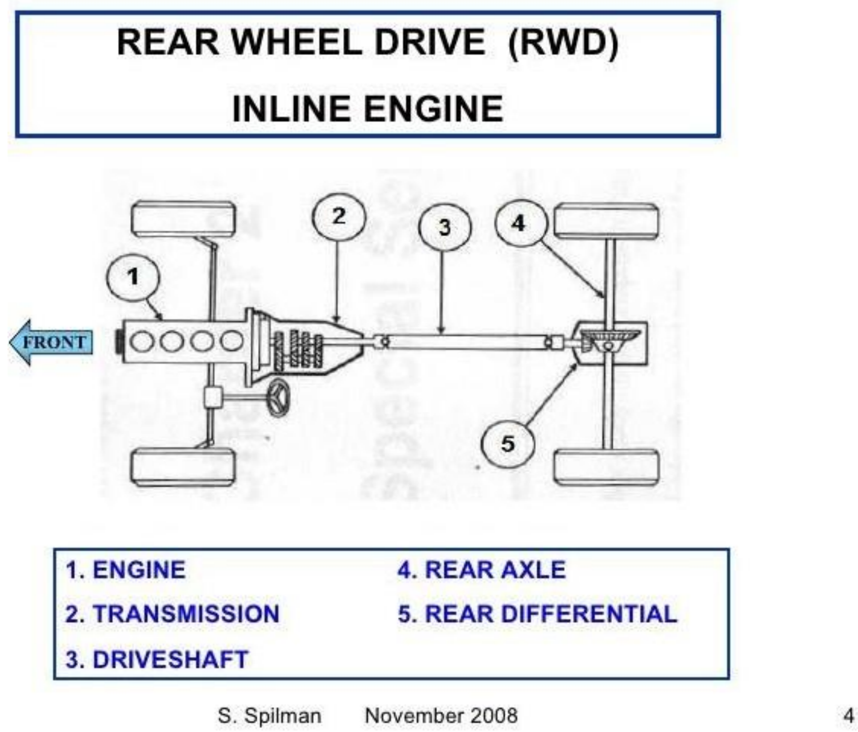
UNIT I - INTRODUCTION

Unit-1

1. Introduction:

- The power developed inside the engine cylinder is ultimately transmitted to the driving wheels so that the motor vehicle can move on the road. This mechanism is called power transmission.
- It consists of clutch, gearbox, universal joint, propeller shaft, final drive, and axle shaft.

General arrangement of power transmission system (or) front engine rear wheel drive:



- Fig (1) shows that layout of the front engine rear wheel drive.

- Power is produced inside the engine cylinder transmitted to flywheel through crankshaft.
- Clutch is conduct with flywheel to engage and disengage drive from the engine to gearbox.
- Gearbox consists of s set of gears to change the speed.
- The power is transmitted from the gearbox to the propeller shaft through the universal joint and then to the differential through another universal joint.
- Finally, the power is transmitted to the rear wheels through the rear axles.

Front engine front wheel drives:

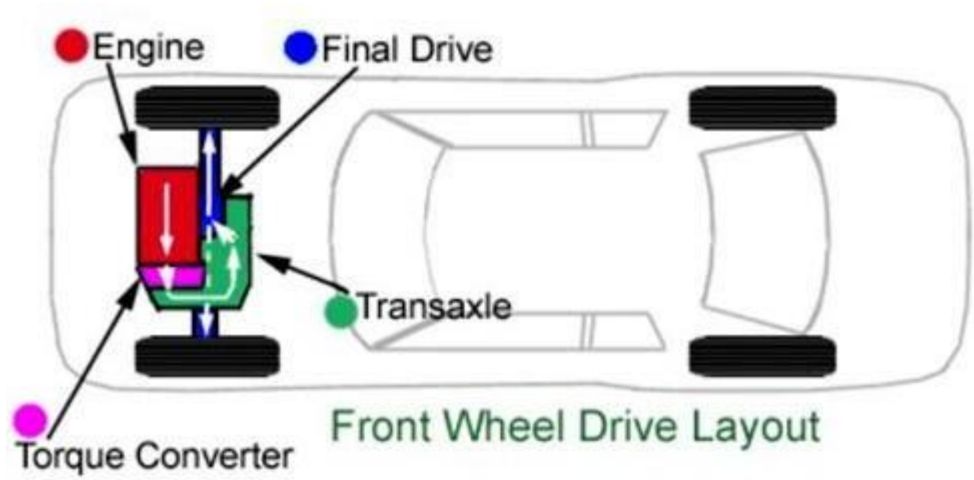


Fig (2): shows that layout of the front engine front wheel drive.

- In this drive the clutch, gear box, differential is arranged in a common housing.
- In this arrangement there is no need of separate long propeller shaft for transmitting power to the rear wheels.
- Because the engine power is transmitted only for front wheels alone.
- Rear axle is dead axles, when front wheels are rolling with power and rear wheels are freely move in the direction of front wheels.

Rear Engine rear wheel drive:

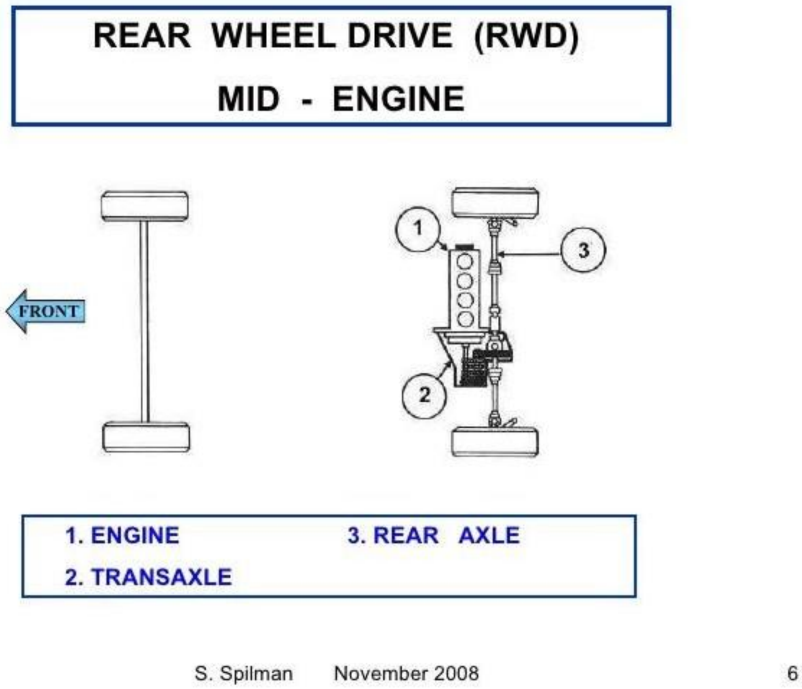


Fig (3): shows that layout of the rear engine front wheel drive.

- In this drive the clutch, gear box, differential and drive shaft are arranged in a common housing that are placed in the rear side of the vehicle as shown in fig(3).
- The main difficulty of this layout is the complicated control of the engine, clutch and gearbox, since they are positioned far away from the driver.
- Besides with this layout the driver and the front passenger sit near the front of the vehicle and in the case of collision (or) striking an obstacle they may be severely injured.
- In this arrangements also eliminate the propeller shaft and all other functions are similar to the front wheel drive.

Four-wheel drive:

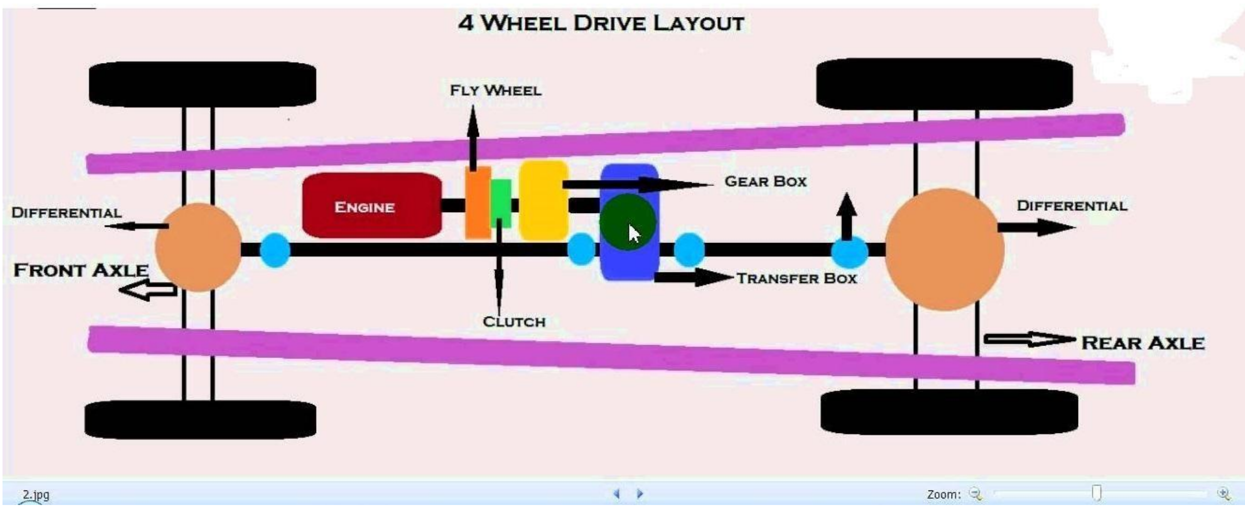


Fig (4): shows that layout of the four-wheel drive.

- In this drive the power is transmitted to both rear and front axle by means of transfer case gearbox.
- So that pulling force is more when compared to other drives.
- The constant velocity type universal joints are used in the front axle. It provides large angular movements during steering.
- It is mostly used in military vehicles, jeeps, heavy duty vehicles.

The basic structure: Frame:

In this type of chassis construction, the frame is the basic unit to which the various components are attached and body is bolted on to the frame later.

Function of the frame:

- To support the chassis components and the body.
- To withstand static and dynamic loads without under deflection and distortion.

Loads on the frame:

- Weight of the vehicle and the passengers, which causes vertical bending of the side members.
- Vertical loads when the vehicle comes across a bump or hollow, which results in

longitudinal torsion due to one wheel lifted.

- Sudden impact loads during a collision which may result in a general collapse.

Classification of Chassis

- Conventional Control chassis: Engine is mounted in front of the driver's cabin.
- Semi-forward control Chassis: Engine is mounted that half of it is in the driver's cabin whereas the other half is in front, outside the driver's cabin.
- Full-Forward control Chassis: Engine is mounted completely inside the driver's cabin.

Ladder Type Frame

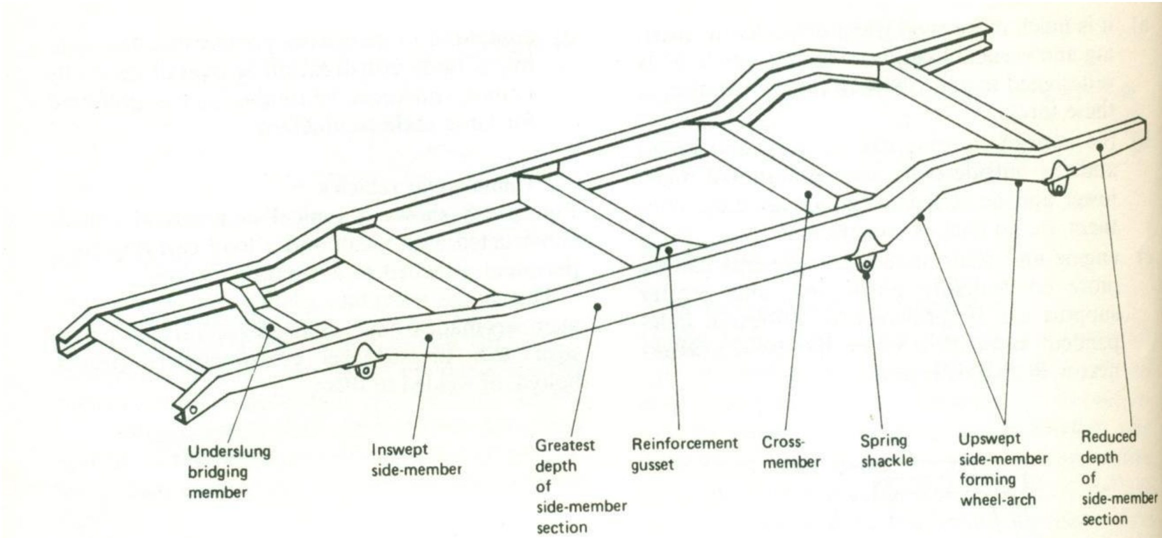


Fig. 1.9 Light-commercial-vehicle chassis

Fig (5): shows that layout Frame

Back bone type Frame

The tubular type has been adopted principally for some Czechoslovakian, German and Austrian designed vehicles- Tata, Daimler-Benz. In some instances the ends of the tubular backbone are bolted directly, at the front, to the gearbox and, at the rear, to the final drive casing, while in others, they have forked extensions, between the arms of which components are accommodated.

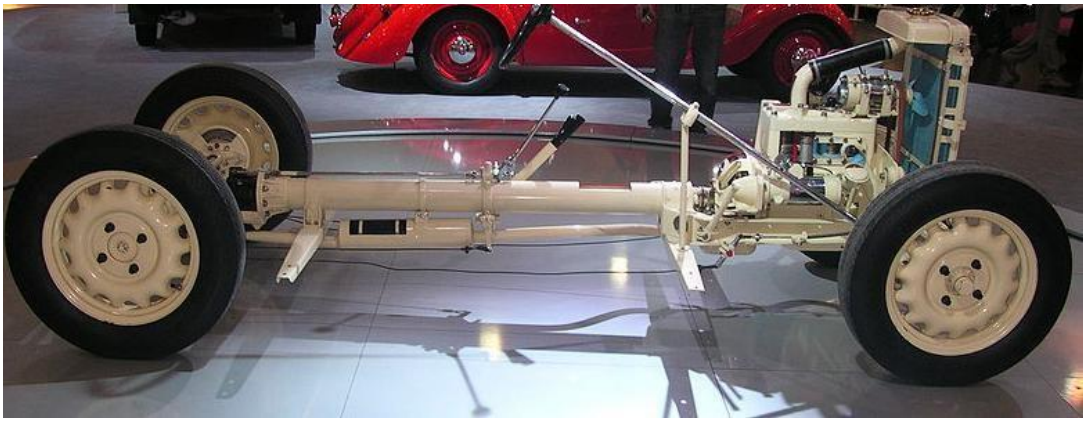


Fig (6): shows that layout Back Bone Frame

Integral Construction:

Integral construction is that in which a chassis frame is welded to, or integrated with, the body. Chassis less construction is that in which no chassis frame is discerned.

Sub- Frames

(i) to isolate high frequency vibrations of, for example , an engine or a suspension assembly, from the remainder of the structure. In this case, rubber or other resilient mountings are interposed between the sub-frame and main structure.

(ii) The sub-frame can isolate an inherently stiff sub-assembly such as the engine or gearbox from the effects of flexing of the chassis frame. This is done generally by interposing a three- point mounting system between the sub-frame and main frame, one of the mountings being on the longitudinal axis about which the main frame twists and the others one on each side.

(iii) It may be used to carry, for instance, the front and rear suspension sub-assemblies, where to utilize the front and rear ends of the body structure for this purpose would increase unacceptable its complexity or cost, or introduce difficulties in either manufacture or servicing or both.

Loads on the frame

(i) Vertical Bending

(ii) Longitudinal Torsion

(iii) Lateral Bending

(iv) Horizontal Lozenging

Vertical Bending:

If a chassis frame is supported at its ends (such as by the wheel axles) and a weight equivalent axles) and a weight equivalent to the vehicle's equipment, passengers and luggage is concentrated across the middle of its wheel base, the side members will be subjected to vertical bending making them sag in the centre region.

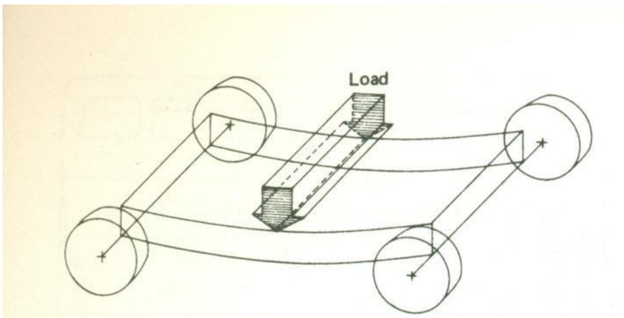


Fig (7): shows that vertical bending

Longitudinal Torsion

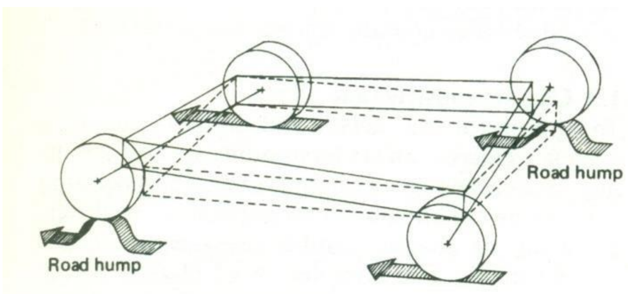


Fig (8): shows that longitudinal torsion

When front and rear diagonally opposite road-wheels roll over bumps simultaneously, the two ends of the chassis will be twisted in opposite directions. Both the side and the cross members with thus be subjected to longitudinal torsion which distorts the chassis.

Lateral Bending

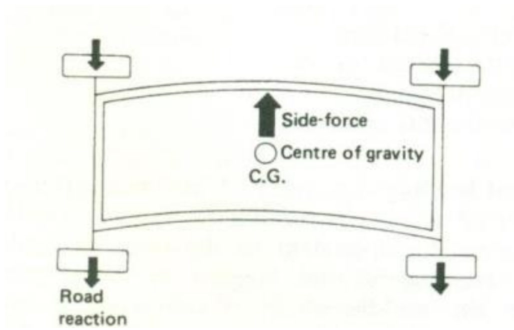


Fig (9): shows that lateral bending

Under certain conditions, the chassis may be exposed to lateral (side) force – possibly due to camber of the road, side wind, centrifugal force as when turning a corner, or collision with some object. The adhesion reaction of the road-wheel tyres will oppose these lateral forces, with the net result that the chassis side-members will be subjected to a bending moment which ends to bow the chassis in the direction of the force.

Horizontal Lozenging:

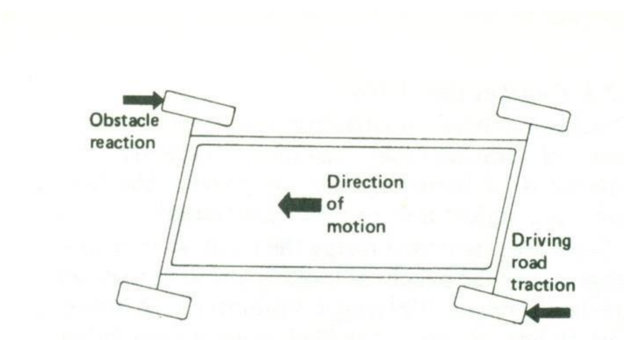


Fig (10): shows that horizontal lozenging

A chassis frame driven forward or backwards will continuously be exposed to wheel impact with road obstacles such as pot-holes, road joint, surface bumps and curbs while other wheels will be providing the propeller thrust. Under such conditions the rectangular chassis will distort to a parallelogram shape. This is known as lozenging.

Materials used for making Frames

Properties

1) Sufficiently high yielded strength and endurance limit.
2) Low sensitivity to stress concentrators.
3) Good stamping quality in the cold state.
4) Weld ability (for riveted frames, this property is of significance when repair jobs are performed).
5) Small content of scarce alloying materials.

- The chassis frame is not designed to be completely rigid, but to combine both strength and flexibility to some degree.
- Motor-car frames must be narrow in front, to permit of sufficient steering lock.
- The frames of passenger cars must be wide at the rear, because the body sills usually are bolted to brackets riveted to the outside of the frame rails, and the body is made as wide as the space between wheel permits.
- Front-end widths of passenger-car frames range between 32 and 36 inch, this dimension being limited by the front tread, the diameter of the front wheels and the maximum wheel deflection required for steering.
- Rear-end widths of passenger car frames vary between 47 and 50 inch. Truck frames are made with parallel side rails and the width of such frames has been standardized at 34 inch by the SAE.
- While there is no standard for frame lengths, what is known as the CA dimension, the distance from the back of the cab to the rear- axle centre, has been standardized at 34, 48, 60, 72, 84, 96, 108, 120, 132, and 156 inch.

Materials

Low Carbon Steel - 0.18 or .20 percent carbon content High

Carbon Steel - 0.25 percent carbon content

Alloy Steel - Nickel-Chromium

- All or practically all passenger car frames are made of low-carbon steel.
- The rigidity of a steel part is practically independent of the grade of steel which it is made.
- The frames are more likely to have insufficient rigidity than insufficient strength since the rigidity of a steel part is practically independent of the grade of steel of which it is made.
- High speed vehicles have trouble from front end shake (and sometimes also rear end shake) than from frame breakage.

FRAME TESTS:

Preliminary designs for passenger car frames usually are based on experiments with cars of similar specifications. After experimental frames have been built, road and laboratory tests are made, and if any weaknesses show up, the design is suitably modified. This is followed by the final proof-testing. Stiffness or rigidity tests may be made on the frame alone, on the body alone, and on the complete car. These tests serve to determine the linear deflection of the frame etc., under the bending loads and the angular deflection under torsion.

FRAME BENDING TEST

(1) The frame is anchored in the vertical plane through the rear wheel axis, its side members being clamped to pedestals with ‘C’ clamps.

(2) Half round files are placed between the side rails and pedestal to permit rotary but not of translatory motion.

(3) The bending test of passenger car frames consists of 3 loads to 600 lb weight.

(4) Two of these, representing passenger weight are supported by adjustable by the adjustable bars clamped to the side rail flanges at the locations of the seats, while the third, representing the weight of the power plant, is placed on a triangular support, with

its center of gravity in the same location as that of power plant.

(5) The front end of the frame is supported on rollers in the vertical plane through the front wheel axis.

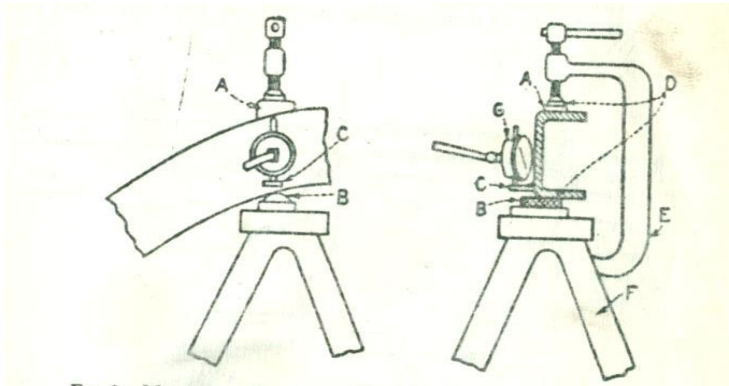


FIG. 6.—METHOD OF ANCHORING REAR END OF FRAME FOR BENDING TEST.

Fig (10): FRAME BENDING

(6) Dial indicators showing the vertical movements of the side rails are installed at substantially equal distances between the supports and there are such indicators also at the support.

(7) In making a bending test, after the setup is completed, the maximum load is applied and removed, and all gauges are then set to zero, to eliminate lost motion in the setup.

(8) Next, the load is applied again, and deflections at all points are recorded.

(9) Readings at corresponding measuring points on opposite sides of the frame are averaged, and from the results a curve may be plotted in which the x-axis is represented by the distance between the measuring points and y-axis represents the deflections.

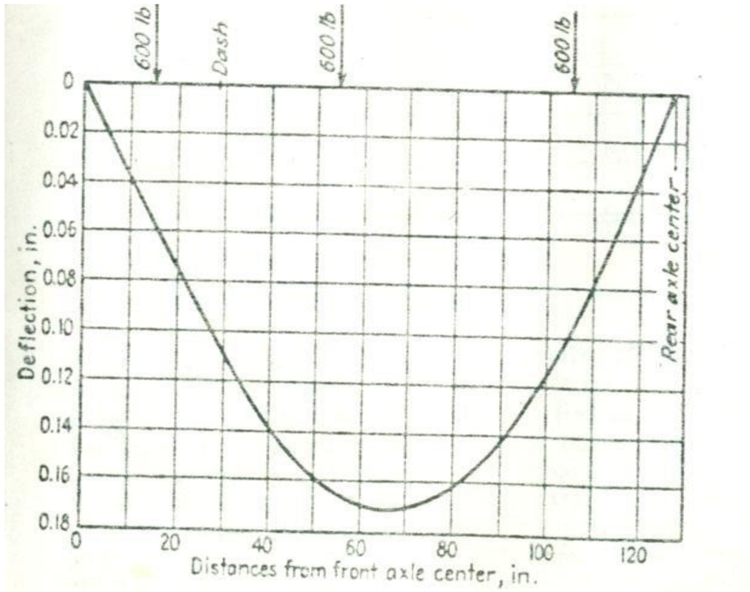


FIG. 8.—CURVE OF DEFLECTIONS IN BENDING TEST.

Fig (11): FRAME BENDING

(10) From the graph it can be seen that the bending moment is zero at both the ends and it increases gradually and the maximum value lies in the center portion.

TORSION TEST

(1) In a test for torsional rigidity the frame is anchored to pedestals in the vertical plane through the rear wheel axis, being clamped to the pedestals with half round files between.

(2) The front end is supported by a roller resting on a level flat surface.

(3) In the case of a frame with a relatively rigid front cross member, the roller may support the frame at the center of that member.

(4) In other cases a rigid cross bar is clamped to the side rails to serve the same purpose.

(5) A load bar is clamped to the frame in vertical plane through the front wheel axis. It is made to project equally on both sides, so as not to create a torsion moment, and it is rigidly clamped to one side rail only, to prevent stiffening of the frame.

(6) Reading bars are placed crosswire on the frame and secured to it. Dial gauges are placed under both ends of each bar 57.29 inch apart and substantially at equal distances from the frame axis.

(7) A couple is applied to the front end of the frame by means of a weight basket on one arm of the load bar and a jack on a platform scale under the other arm.

(8) The weight in the basket is adjusted until the deflection of one side of the frame is between 0.200 and 0.250 inch, and an equal moment is then applied to the other arm by means of the jack.

(9) Applied torques or couples can be varied by moving the weight basket along the load arm, to points 2.25, 2.75, 3.25 and 3.75 ft from the axis. The jack remains in the same position, 3.75 ft from the axis, and is adjusted until its moment is the same as that of the weight.

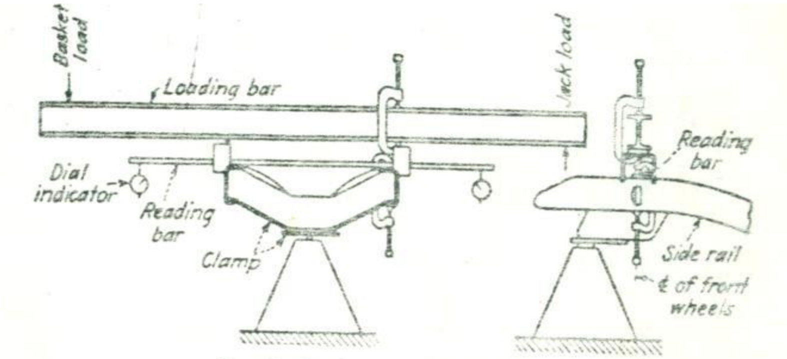


FIG. 9.—SET-UP FOR TORSION TEST.

Fig (12): TORSION TEST

(10) In this test the load is applied in increments. The frame is subjected to torque first in one direction and then in the other, and readings for the same torque load and the same measuring point are averaged.

(11) Deflections for any given torque at any measuring point are converted to equivalent deflections under a torque of 1000 lb-ft, and the results are plotted as ordinates with the wheelbase (distance from front-axle center) as X axis and torsional deflection as Y axis.

(12) From the graph it can be seen that the deflection increases most rapidly at the ends, where the torsional rigidity is smallest, because the side rails are of less depth there and the effect of the X member is missing.

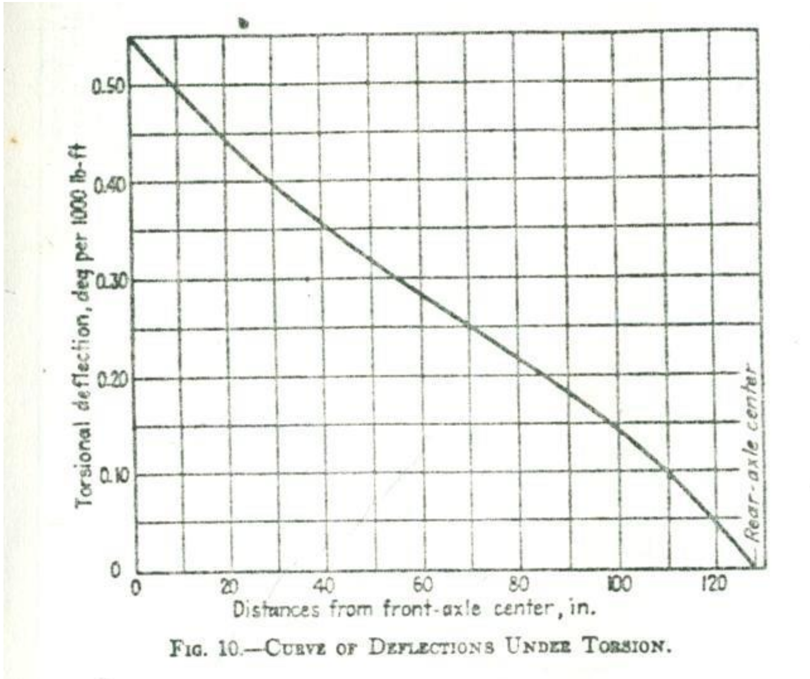


Fig (12): TORSION TEST

TEXT / REFERENCE BOOKS

1. Kirpal Singh, "Automobile Engineering Vol I"12 th edition Standard Publishers, 2011.

2. Banga T.R. & Nathu Singh, "Automobile Engineering"3 rd edition Khanna Publications, 2012.

3. Rajput R.K., "A Text–Book of Automobile Engineering", Laxmi Publications Private Limited

4. Heldt.P.M. "Automotive Chassis", 3 rd edition Chilton Co. Publications, New York, 1990.

5. Heinz heisler "Advanced vehicle technology"2 nd edition Edward Arnold publication 2002.

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UNIT 2 - FRONT AXLE AND STEERING SYSTEM

INTRODUCTION:

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

REQUIREMENTS OF STEERING SYSTEM:

a. It must keep the wheel at all times in to rolling motion without rubbing on the road.

b. This system should associate to control the speed.

c. It must light and stable.

d. It should also absorb the road shocks.

e. It must easily be operated with less maintenance.

f. It should have self-centering action to some extent.

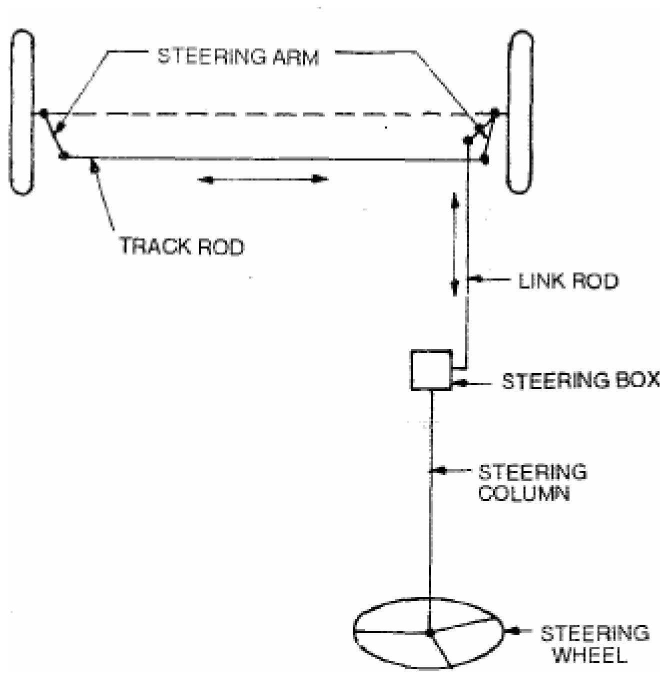


Fig:1 Steering System

Functions of Steering System:

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

Types of Steering Gear Boxes:

1. Worm and Wheel Steering Gear.
2. Worm and Roller Steering Gear.
3. Re-circulating Ball type Steering Gear.
4. Rack and Pinion type Steering Gear.
5. Cam and Roller Gear type Steering Gear.
6. Cam and Peg Steering Gear.
7. Cam and Double lever Steering Gear.
8. Worm and Sector Type Steering Gear.

Functions of Steering Gear Box:

1. It converts the Rotary movement of the steering wheel in to the Angular turning of the front wheels.
2. It also multiplies driver's efforts and gives mehanical advantage.

1. Worm and Wheel Type:

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

2. Re-circulating Ball Type:

In this type of gear box the endless chain of balls are provided between the worm and nut members. The nut forms a ring of rack having an axial movement. So that the sector on the rocker shaft racks, the balls roll continuously between the worm and nut. Being provided with return chambers at the ends of the worm. This method reduces friction between worm and nut members. This type of steering gear is used for heavy vehicles.

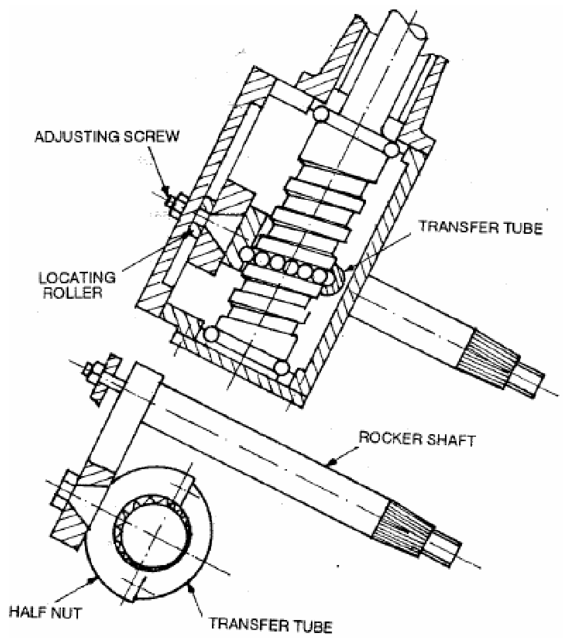


Fig: 2 Re-circulating Ball

3. Rack and Pinion Type:

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

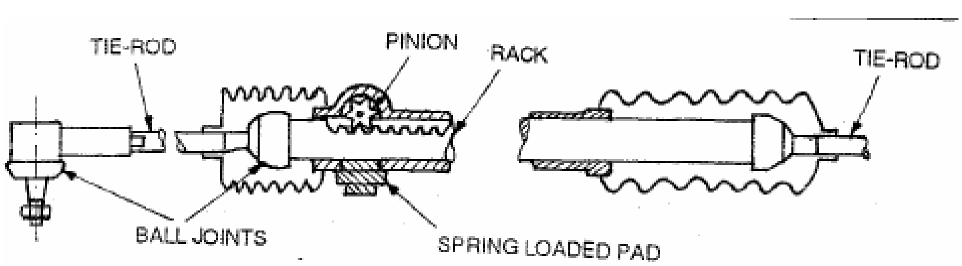


Fig 3: Rack and Pinion

4. Cam and Lever Type: The cam and lever steering uses one or two lever Studs fitted in taper roller bearing. When the worm in the form of helical Groove rotates the stub axle and it also rotates along with it. This imports a Turning motion to the drop arm shaft.

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

Power Steering:

Power steering reduces much strain on the part of the driver while negotiating sharp curves. It makes easy to turn sharp corners. It is usually arranged to be operative when the effort of steering wheel exceeds a predetermined value. It is fitted on heavy commercial vehicles and medium cars.

Steering Linkages: Steering Linkage is a connection of various links between the steering gear box and the front wheels. The motion of the pitman arm and steering gear box is transferred so the steering knuckles of the front wheels through the steering linkages. The swinging movement of the pitman arm from one side to the other side gives angular movement to the front wheel through the steering linkages.

Types of steering Linkages:

1. Conventional steering Linkage.
2. Direct cross type steering linkage
3. Three piece steering linkage
4. Center arm steering linkage
5. Relay type steering linkage.

Slip Angle:

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

Under steer:

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

Over Steer:

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

Steering Gear Ratio or Reduction Ratio:

It has been defined as the “number of turns on the steering wheel required to produce on turn of steering gear cross shaft to which the pitman arm is attached. Generally it varies between 14'.1 and 24'.1.

Turning Radius:

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

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

Factors effect the wheel alignment:

1. Factors pertaining to wheel: - a. Balance of wheels (Static and Dynamic)

b. Inflation of tyre.

c. Brake adjustments.

2. Steering Linkages.

3. Suspension System

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

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

The steering Geometry includes

1. Caster angle
2. Camber angle
3. King-pin inclination
4. toe-in
5. toe-out etc.

Caster Angle:

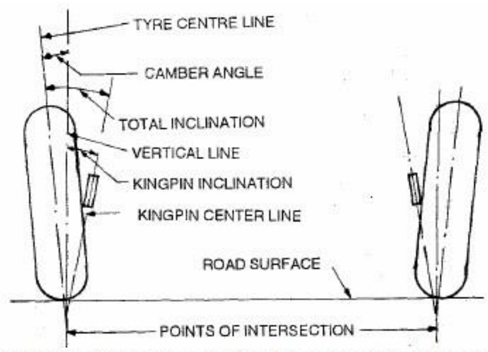
This is the angle between backward or forward tilting of the king pin from the vertical axis at the top. This is about 2º to 4º. The backward tilt is called as positive caster. The forward tilt is called negative caster.

Camber:

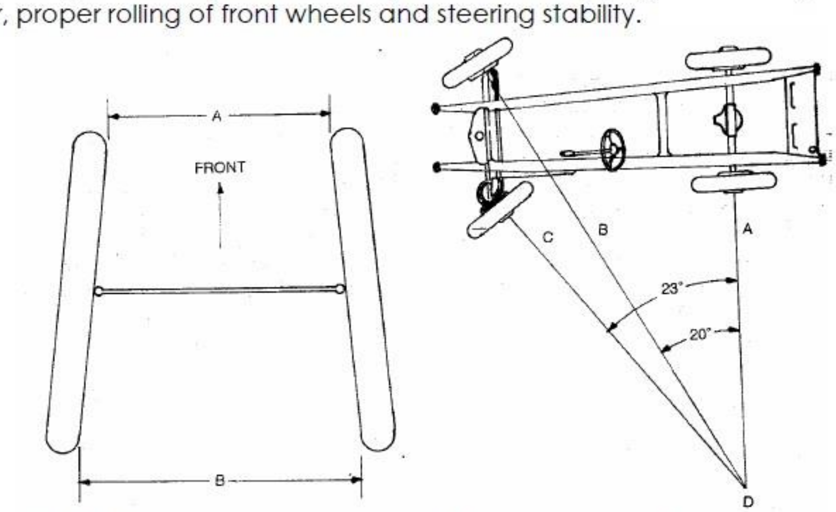
The angle between wheel axis to the vertical line at the top is called camber angle. It is approximately ½º to 2º.

King-pin inclination:

It is the angle between vertical line to the king pin axis. The inclination tends to keep wheels straight ahead and make the wheels to get return to the straight position after completion of a turn. The inclination is normally kept 7º to 8º.



Toe-in: It is the amount in minimum at the front part of the wheel points inwards approximately 3 to 5 mm. It prevents side slipping excessive tyre wear, proper rolling of front wheels and steering stability.



Toe-out: It is the difference in angles between two front wheels and vehicle frame during turning. It is used to prevent dragging of tyre during turn. Reversible steering: When the deflection of road wheels is transmitted through the steering wheel to road surface, the system is called Reversible.

If every imperfection of road surface causes the steering to rotate, it causes much strain on the part of the driver to control the vehicle. It causes much strain on the part of the driver to control the vehicle. There fore such of the reversibility is not desired. But, some degree of reversibility desired, so that the wheel becomes straight after taking a curve.

Fig :4 king pin axis

Steering Mechanism: There are two types of steering gear mechanisms

1. Davis Steering gear 2. Ackermann Steering gear]

1. Davis Steering Gear:

The Davis Steering gear has sliding pair; it has more friction than the turning pair, therefore the Davis Steering Gear wear out earlier and become inaccurate after certain time. This type is mathematically Accurate. The Davis gear mechanism consists of cross link KL sliding parallel to another link AB and is connected to the stub axle of the two front wheel by levers ACK and DBK pivoted at A and B respectively. The cross link KL slides in the bearing and cross pins at its ends K and L. The slide blocks are pivoted on these pins and move with the turning of bell crank levers as the steering wheel is operated. When the vehicle is running straight the gear is said to be in its mid-position. The short arms AK and BL are inclined an angle 90 t α to their stub axles AC and BD respectively. The correct steering depends upon the suitable selection of cross arm angle α, and is given by

Tan α = b/2l Where b= AB = distance between the pivots of front axle. l=wheel base

2. Ackermann Steering System: It has only turning pair. It is not mathematically accurate except in three positions. The track arms are made inclined so that if the axles are extended they will meet on the longitudinal axis of the car near rear axle. This system is called Ackermann steering.

Ackermann steering geometry is a geometric arrangement of linkages in the steering of a car or other vehicle designed to solve the problem of wheels on the inside and outside of a turn needing to trace out circles of different radii. It was invented by the German Carriage Builder "Lankensperger" in 1817, then being patented by his Agent in England Rudolph Ackermann (1764–1834) in 1818 for horse drawn carriages. Erasmus Darwin may have a prior claim as the inventor dating from 1758.

A simple approximation to perfect Ackermann steering geometry may be generated by moving the steering pivot points inward so as to lie on a line drawn between the steering kingpins and the centre of the rear axle. The steering pivot points are joined by a rigid bar called the tie rod which can also be part of the steering mechanism, in the form of a rack and pinion for instance. With perfect Ackermann, at any angle of steering, the centre point of all of the circles traced by all wheels will lie at a common point. Note that this may be difficult to arrange in practice with simple linkages, and designers are advised to draw or analyze their steering systems over the full range of steering angles.

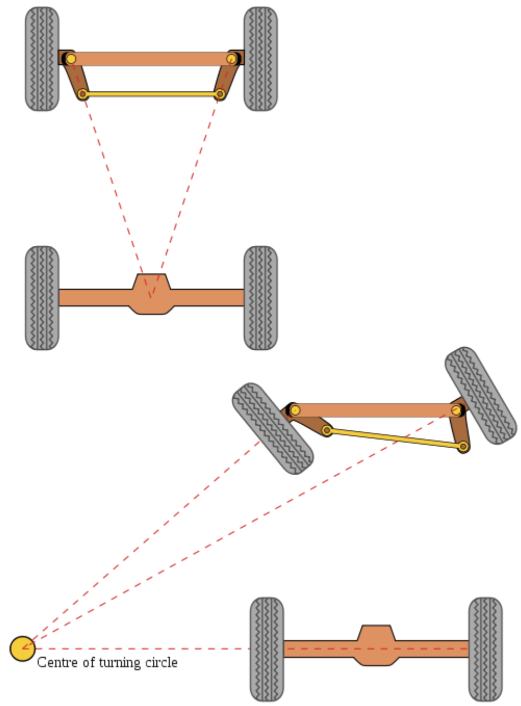


Fig:5 Ackermann steering

Modern cars do not use *pure* Ackermann steering, partly because it ignores important dynamic and compliant effects, but the principle is sound for low speed manoeuvres. Some race cars use *reverse* Ackermann geometry to compensate for the large difference in slip angle between the inner and outer front tires while cornering at high speed. The use of such geometry helps reduce tire temperatures during high-speed cornering but compromises performance in low speed manoeuvres.

FRONT AXLE

- Front wheels of the vehicle are mounted on front axles. Functions of front axle are listed below:
- (a) It supports the weight of front part of the vehicle.

- (b) It facilitates steering.
- (c) It absorbs shocks which are transmitted due to road surface irregularities.
- (d) It absorbs torque applied on it due to braking of vehicle.

CONSTRUCTION AND OPERATION:

Front axle is made of I-section in the middle portion and circular or elliptical section at the ends. The special x-section of the axle makes it able to withstand bending loads due to weight of the vehicle and torque applied due to braking. On kind of front axle is shown in Figure 7.1 which consists of main beam, stub axle, and swivel pin, etc. The wheels are mounted on stub axles.

TYPES OF FRONT AXLES

There are two types of front axles:

(a) Dead front axle, and

(b) Line front axle.

Dead Front Axle

Dead axles are those axles, which don't rotate. These axles have sufficient rigidity and strength to take the weight. The ends of front axle are suitably designed to accommodate stub axles.

Line Front Axle

Line axles are used to transmit power from gear box to front wheels. Line front axles although, front wheels. Line front axles although resemble rear axles but they are different at the ends where wheels are mounted. Maruti-800 has line front axle.

Power Assisted Steering:

Power-assisted steering is designed

- to reduce the effort the driver has to exert on the steering wheel and

- to reduce the steering wheel movement for a give swivel pin (king pin) angular turn, that is, to make the input (steering wheel movement) to output (swivel pin movement) more direct.

A small car may only receive 25% input assistance so that 75% of the effort needed to steer the car is provided by driver.

A large truck fully laden may require up to 90% input assistance so that only about 10% of the input effort is supplied by the driver.

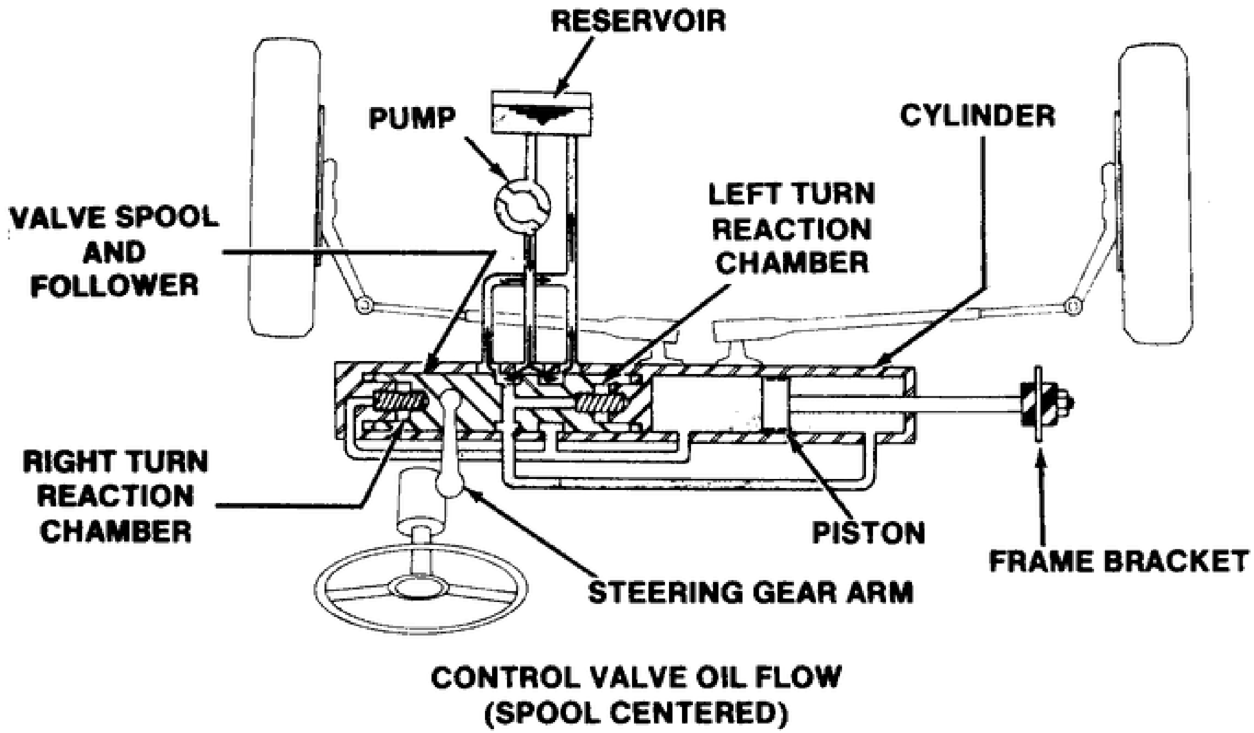


Fig: 6 Integral Power-assisted Steering box and linear reaction control valve

The integral power assisted steering gearbox can be used for rigid front axle suspension commonly used on vans and commercial vehicles.

It can also be used with independent front suspension layouts on large cars and vans.

Operation

Anticlockwise rotating of the steering wheel

- Control land (1) uncovers the fluid exit passage from the left hand power cylinder to the reservoir.

- Control land (2) blocks off the pump fluid supply exit to the reservoir, and
- Control land (3) uncovers the pump to the right hand cylinder.

Clockwise rotation of the steering wheel

- The reaction nut tongue pushes the reaction control valve to the left hand side so that the control land (1) blocks the exit of fluid from the pump to the reservoir
- control land (3) uncovers the fluid exit passage from the right hand power cylinder to the reservoir and
- land (2) uncovers the passage connecting the pump fluid supply to the left hand power cylinder

Rack and pinion power assisted steering with rotary control valve Clockwise

rotation of the steering wheel (Turning Right)

- Valve rotor land(3) to block the fluid supply from the pump going to the right hand power chamber, and at the same time uncovers the passage connecting the right hand power cylinder to the reservoir tank.
- Valve rotor land (2) blocks the passage connecting the left hand power chamber to the reservoir and uncovers the fluid supply passage from the pump going to the left hand power chamber

Anticlockwise rotation of the steering wheel (Turning Left)

- The rotor land (2) now blocks the fluid supply from the pump going to the left hand power chamber and simultaneously uncovers the passage connecting the left hand power chamber to the reservoir.

- The rotor land (3) blocks the passage connecting the right hand power chamber to the reservoir and uncovers the fluid supply passage from the pump going to the right hand power chamber

Reversible Steering

- The steering gear is said to be reversible if the deflection of the steered wheels due to road surface is transmitted through the steering linkage and steering gear box to the steering wheel.

- If every small imperfection of the road surface causes the steering wheel to rotate, the driver would find much tiring and frustrating.

Irreversible Steering

- The steering system is said to be irreversible if the steered wheels do not transfer any deflection to the steering wheel.

- It would not tend to straighten out after negotiating a turn and would not easily follow the course of rutted road without undue stress on the mechanism.

Semi-reversible Steering

- Some degree of irreversibility is desired to stop shocks sustained by the road wheels.

- Some degree of reversibility is desired to feel the road condition very sharply by the driver.
- Therefore, there should be a compromise between the reversible and irreversible steering and that is what known as semi-reversible steering. Semi-reversible steering gears are used.

TEXT / REFERENCE BOOKS

1. Kirpal Singh, “Automobile Engineering Vol I”12 th edition Standard Publishers, 2011.

2. Banga T.R. & Nathu Singh, “Automobile Engineering”3 rd edition Khanna Publications, 2012.

3. Rajput R.K., “A Text–Book of Automobile Engineering”, Laxmi Publications Private Limited

4. Heldt.P.M. “Automotive Chassis”, 3 rd edition Chilton Co. Publications, New York, 1990.

5. Heinz heisler “Advanced vehicle technology”2 nd edition Edward Arnold publication 2002.

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UNIT 3- DRIVE LINE

Hotchkiss drive:

- All shaft-drive systems consist of a driveshaft (also called a "propeller shaft" or Cardan. shaft) extending from the transmission in front to the differential in the rear.
- The differentiating characteristic of the Hotchkiss drive is the fact that it uses universal joints at *both* ends of the driveshaft, which is not enclosed.
- The use of two universal joints properly phased and with parallel alignment of the drive and driven shafts, allows the use of simple cross-type universals. (In a torque-tube arrangement only a single universal is used at the end of the transmission tail shaft, and this universal should be a constant velocity joint.)

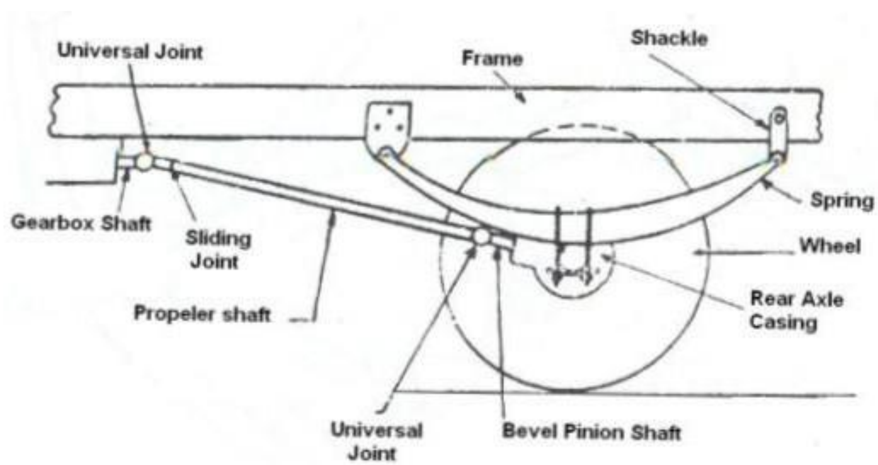


Fig:1 Hotchkiss drive

- In the Hotchkiss drive, slip-splines or a plunge-type (ball and trunnion u- joint) eliminate thrust transmitted back up the driveshaft from the axle, allowing simple rear-axle positioning using parallel leaf springs. (In the torque-tube type this thrust is taken by the torque tube to the transmission and thence to the transmission and motor mounts to the frame. While the torque-tube type requires additional locating elements, such as a Panhard rod, this allows the use of coil springs.)

- Some Hotchkiss driveshafts are made in two pieces with another universal joint in the center for greater flexibility, typically in trucks and specialty vehicles built on truck frames.
- Some installations use rubber mounts to isolate noise and vibration

Torque-tube Drive

- This drive system is generally used in passenger cars and light commercial vehicles. Whereas the Hotchkiss drive uses stiff springs to resist torque reaction and driving thrust, the torque tube drive permits the use of either „softer‟ springs or another form of spring, like helical to perform their only intended duty so that a „softer‟ ride is possible.
- Figure illustrates a layout using laminated springs, which are connected to the frame by a swinging shackle at each end. A tubular member called torque-tube, encloses the propeller shaft and is bolted rigidly to the axle casing.
- The torque-tube is positioned at the front by a ball and socket joint, which is located at the rear of the gearbox or cross-member of the frame. Bracing rods are introduced between the axle casing and the torque tube to strengthen the arrangement.
- A small-diameter propeller shaft is installed inside the torque tube and splined to the final-dr

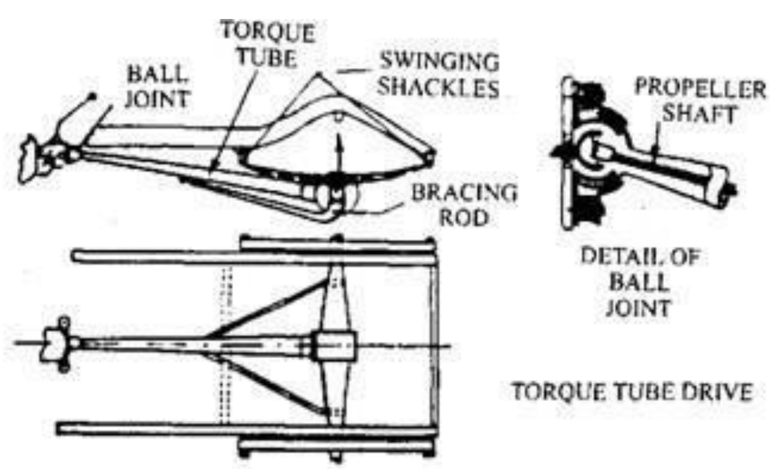


Fig:2 Torque tube drive

Types of rear axle:

- Semi-floating axle
- Full floating axle
- Three quarter floating axle
- In **semi floating type** of rear axle all the load of rear portion of the vehicle is carried by the axle shaft.
- Therefore it needs to be of a large size for the same torque output, than any other type.

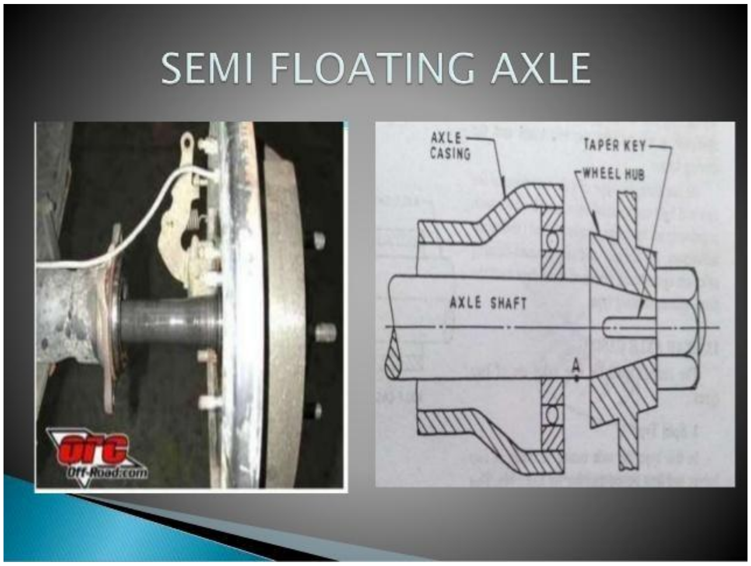


Fig:4 Semi Floating Axle

- The inner end of the axle shaft is splined and is supported by a single bearing inside the axle casing.
- In this type of axle the wheel hub is directly fitted on the axle shaft. Full

floating:

- This type is very robust one and is used for heavy vehicles.
- It has two deep-groove ball or taper roller bearings, located between the axle casing and wheel hub.

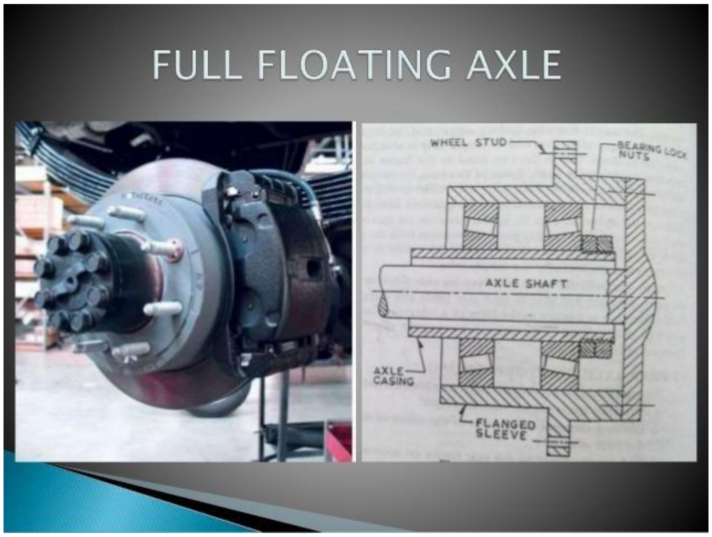


Fig:4 Full Floating

- The outer of the axle is made flanged to which the wheel hub is bolted.
- With this arrangement the axle shaft may be removed from the housing without disturbing the wheel by removing the hub cap and the coupling.
- The vehicle load is taken by the axle casing.
- The axle shaft takes only the driving thrust.

Three quarter floating:

- The three quarter floating axle is shown in fig
- In this axle the single bearing is located between the hub and the axle casing.

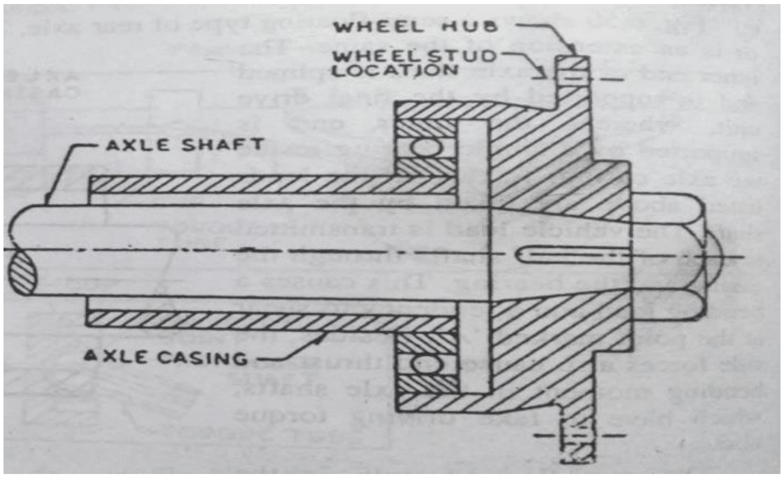


Fig:5 quarter floating

- Thus the weight of the vehicle is transferred to the axle casing and only the side thrust and driving torque are taken by the axle.
- Although the three quarter floating axle is more reliable but it is not as simple as the semi-floating axle.

PROPELLER SHAFT:

- It must transmit torque from the transmission to the axle. This requirement makes it necessary that the driveshaft becapable of transmitting the maximum low gear torque developed by the engine and transmission ratio and any shock loads which may develop. It must also be capable of rotating at the maximum speed required for vehicle operation. This speed is often engine speed increased by an over drive ratio in the transmission.

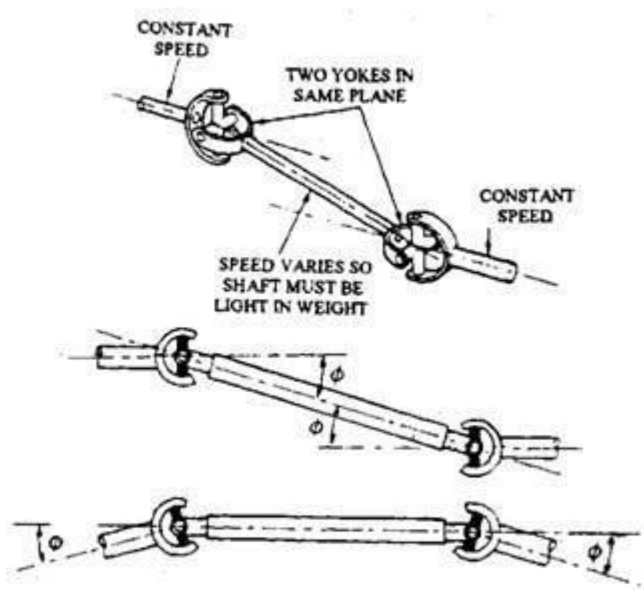


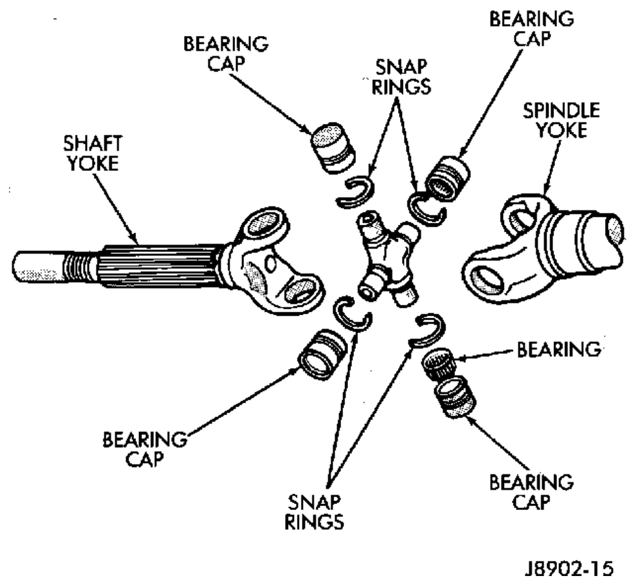
Fig:6 Driveshaft

- The driveshaft must operate through constantly changing relative angles between transmission driveshaft and axle.
- The length of the driveshaft must be capable of changing while transmitting torque. Length changes are caused by necessary axle movement due to torque

reaction, road deflections, braking loads, etc.

Universal Joints

A universal joint, also called a U-joint, is a flexible coupling between two shafts



that

Fig:7 Universal Joint

permits one shaft to drive another at an angle to it (Figure).

The universal joint is flexible in a sense that it will permit power to be transmitted while the angle of the other shaft is continually varied. A simple universal joint is composed of three fundamental units consisting of a journal (cross) and two yokes. The two yokes are set at right angles to each other and their open ends are connected by the journal. This construction permits each yoke to pivot on the axis of the journal and also permits the transmission of rotary motion from one yoke to the other. As a result, the universal joint can transmit power from the engine through the shaft to the rear axle, even though the engine is mounted in the frame at a higher level than the rear axle, which is constantly moving up and down in relation to the engine. A peculiarity of the conventional universal joint is that it causes a driven shaft to rotate at a variable speed in respect to the driving shaft. There is a cyclic variation in the form of an acceleration and deceleration of speed. Two universal joints are placed in a drive shaft to eliminate the speed fluctuations of the shaft while the shaft is at an angle to the power source. The universal joints are placed at a 90-degree angle to each other, and one counteracts the action of the other while in motion. Three common types of automotive drive shaft.

universal joints are used on rear-wheel drive vehicles: cross and roller, ball and trunnion, and double-cardan (constant velocity) universal joints

Differential:

Wheels receive power from the engine via a drive shaft. The wheels that receive power and make the vehicle move forward are called the drive wheels. The main function of the differential gear is to allow the drive wheels to turn at different rpms while both receiving power from the engine.

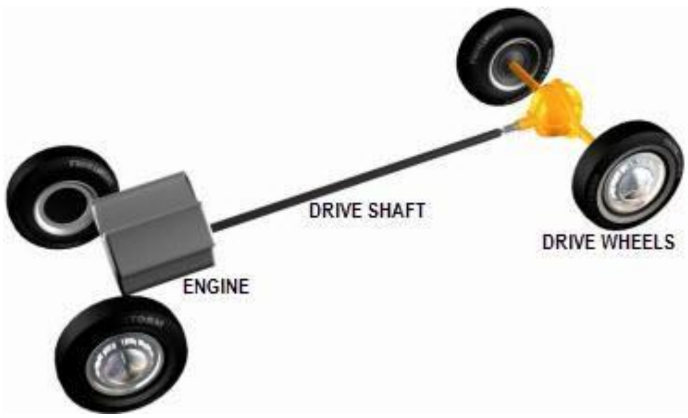


Fig:8 Differential

Fig.1 Power from the engine is flowed to the wheels via a drive shaft

Consider these wheels, which are negotiating a turn. It is clear that the left wheel has to travel a greater distance compared to the right wheel.

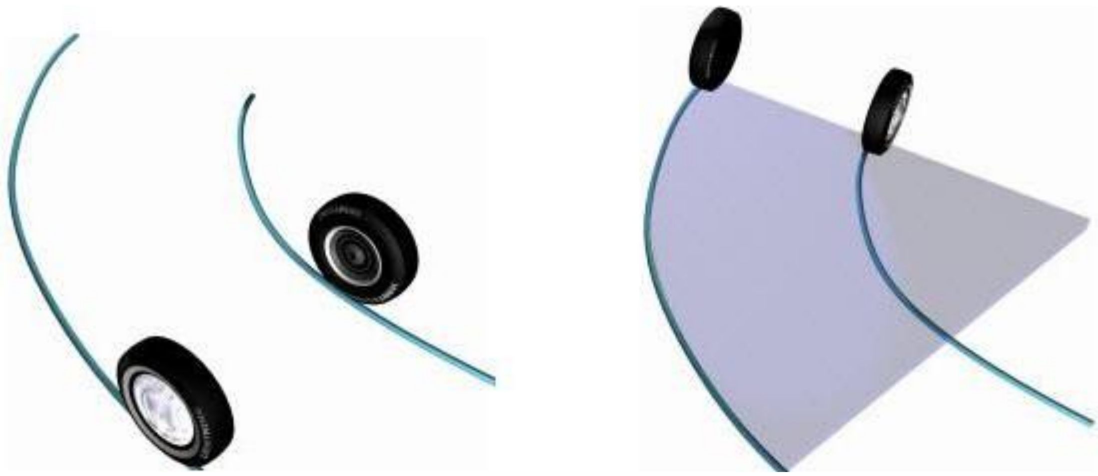


Fig.9 While taking a right turn the left wheel has to travel more distance; this means more speed to left wheel

This means that the left wheel has to rotate at a higher speed compared to the right wheel. If these wheels were connected using a solid shaft, the wheels would have to slip to accomplish the turn. This is exactly where a differential comes in handy. The ingenious mechanism in a differential allows the left and right wheels to turn at different rpms, while transferring power to both wheels.

Parts of a Differential

We will now learn how the differential achieves this in a step-by-step manner using the simplest configuration. Power from the engine is transferred to the ring gear through a pinion gear. The ring gear is connected to a spider gear.

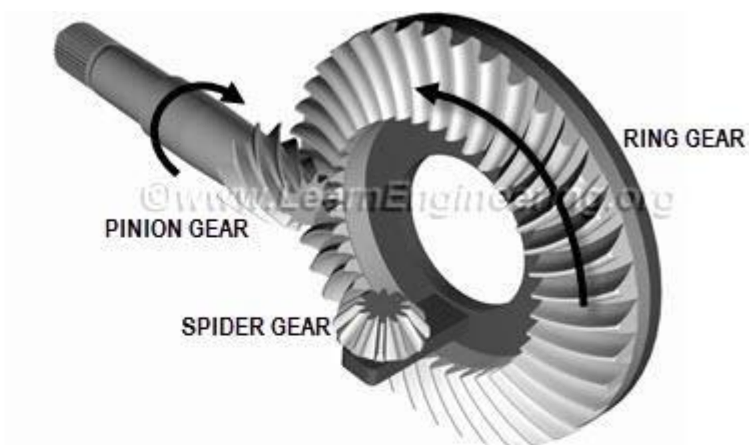


Fig.10 Motion from the pinion gear is transferred to the spider gear

The spider gear lies at the heart of the differential, and special mention should be made about its rotation. The spider gear is free to make 2 kinds of rotations: one along with the ring gear (*rotation*) and the second on its own axis (*spin*).

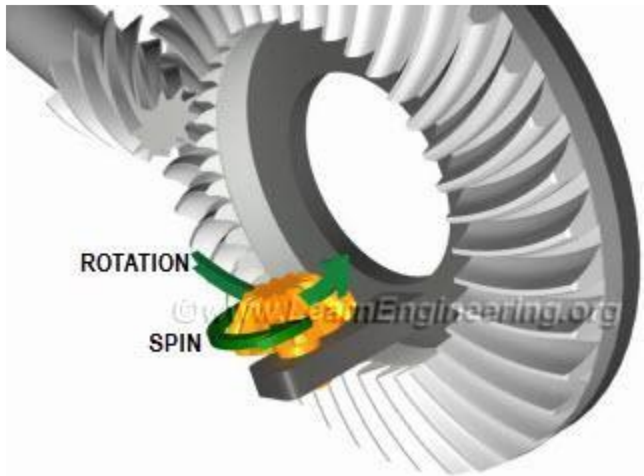


Fig.11 Spider gear is free to make 2 kinds of rotations

The spider gear is meshed with 2 side gears. You can see that both the spider and side gears are bevel gears. Power flow from the drive shaft to the drive wheels follows the following pattern. From the drive shaft power is transferred to the pinion gear first, and since the pinion and ring gear are meshed, power flows to the ring gear. As the spider gear is connected with the ring gear, power flows to it. Finally from the spider gear, power gets transferred to both the side gears.

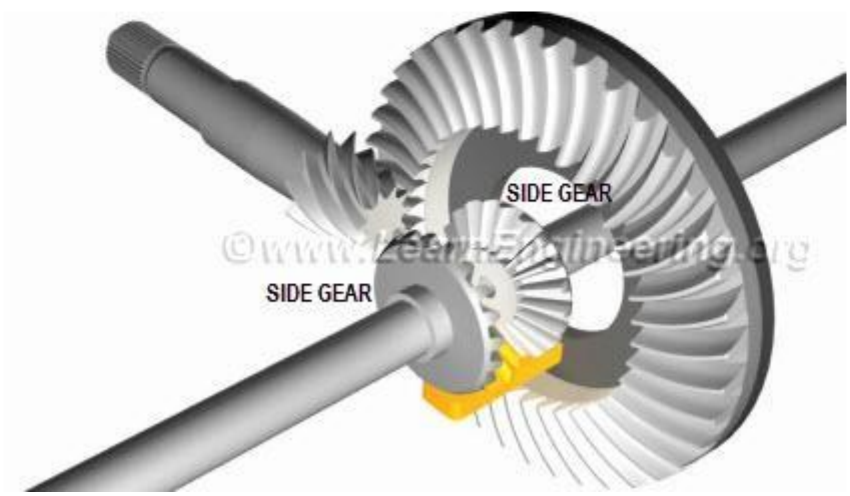


Fig.12 The basic components of a standard differential

TEXT / REFERENCE BOOKS

1. Kirpal Singh, “Automobile Engineering Vol I”12 th edition Standard Publishers, 2011.

2. Banga T.R. & Nathu Singh, “Automobile Engineering”3 rd edition Khanna Publications, 2012.

3. Rajput R.K., “A Text–Book of Automobile Engineering”, Laxmi Publications Private Limited

4. Heldt.P.M. “Automotive Chassis”, 3 rd edition Chilton Co. Publications, New York, 1990.

5. Heinz heisler “Advanced vehicle technology”2 nd edition Edward Arnold publication 2002.

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UNIT 4- SUSPENSION SYSYTEM

Unit-4

Suspension System

Requirement of automobiles suspension system:

The automobile suspension system is having the following requirement

- To have minimum deflection to the vehicles with required stability
- To have minimum wheel hop.
- To safe guard the occupants and cargo against road shocks
- To minimize the effects of stresses due to road shocks on the Mechanism of the vehicle.
- To keep the body perfect in level while travelling over rough anduneven roads.
- To keep the body of the vehicle safe from road shocks.

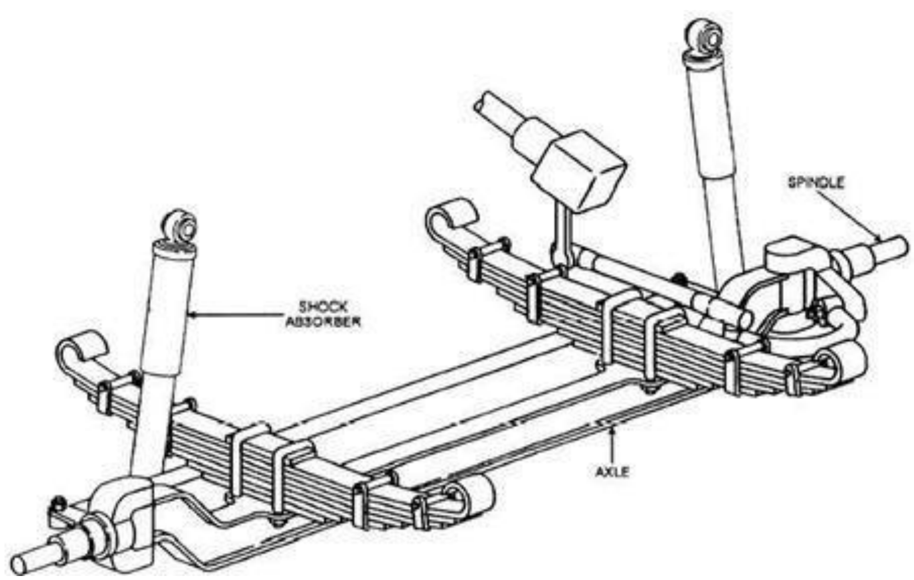
Types of suspension system - conventional and Independent

There are different types of suspension system provided in different vehicles. Those are

(i) Conventional suspension system
(ii) Independent suspension system

Conventional suspension system

In this suspension system. The wheels are fitted on beam type which are attached to the chassis frame through road springs. In this type of suspension, the effect on one wheel is directly



transmitted to the other side wheel through the axle.

Fig 4.1 Conventional Suspension System

Independent suspension system:

In this system the suspension for each wheel in an independent unit and in free from the effect of one another. There will be no effect of road shocks on the vehicle directly.

Types of independent suspension system

(i) Wishbone arm system
(ii) Trailing ling system
(iii) Sliding pillar system

Wishbone arm system

Wishbone arm type independent suspension system is most popular

type of all independent suspension system. In this system transverse springs along with coil, springs are mostly used. In European cars, torsion bars instead of coil springs are used. In this system there are two suspension or control arms are used in each side of the vehicle. There arm are like two legs of chicken wishbone or better „V‟, . These wishbone arms are connected with chassis frame on the open end. The closed end spread out of the chassis frame. One arm is below whereas the other is above the frame. The closed ends of both upper and lower suspension arms are connected with steering knuckle support to which the steering knuckle is attached by means of kingpin. A coil spring is placed between the frame and the lower wishbone arm. Mostly the open end of upper control arm is connected with the sock absorber shaft which is fitted at the frame when there is a bump, the wheel tends to go up, the control since the shock absorber is fitted with the upper control arm, ti damps the vibrations set up in the coil spring due to road irregularities.

Trailing link system

The trailing link independent suspension use parallelogram linkages lying beside the frame side members usually a horizontal coil springs is used in this type of suspension system. During compression and rebound, the spring winds and unwinds . In some vehicles the torsion bar may also be fitted instead of horizontal coil spring.

Sliding pillar system

In this system the pillar or elongated king pin is attached to the wheel and slides up and down in the axle type beam a fixed rigidly to the vehicle frame.

Types of springs - Laminated Spring, coil spring, helical spring

The springs support the chassis frame. The entire weight of the vehicle live engine, power train, body, passengers, cargo etc, falls on the chassis frame. The spring damp the road shocks transmitted to the wheels as they travel over the road thereby protecting the units supported directly by the frame. The springs are placed between the chassis frame and the axle.

Types of springs

(i) Leaf springs

(ii) Coil springs

(iii) Helical Springs

(i) Leaf springs: The leaf springs are of different types namely-full elliptic three quarter elliptic, semi elliptic, quarter elliptic transverse. In almost all automobiles which are having conventional suspension system the semi elliptic leaf springs are most commonly used.

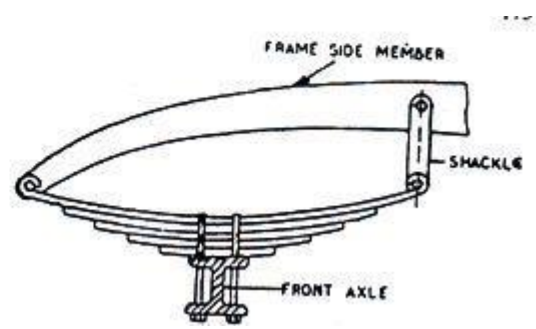


Fig 4.2 Leaf Springs

The leaf springs are made of long flat strip steel. Several strips are placed one on the other and held together by means of centre bolt and champs. Each strip is called is leaf. There is one main leaf which is extended to full length.

Each succeeding leaf is shorter than the proceeding one. The main leaf contains eyes are both ends for making connections with the frame. The entire

set is fitted from the chassis frame by hanging with a shackle at one side and the other side is fixed to frame. During jerks, the leaf spring bounces and each strip flexes and rebounces again and again.

(ii) Coil springs : Coil spring is made of a length of special spring steel, usually round in section which is wound in the shape of coil The ends of coil spring are kept flat so that could seat properly . They can store twice energy per unit volume in comparison to leaf spring. To seat the coil springs pan shaped brackets or spring seats are attached to the axles. This suspension is also used in combination with torque tube or torque rod.

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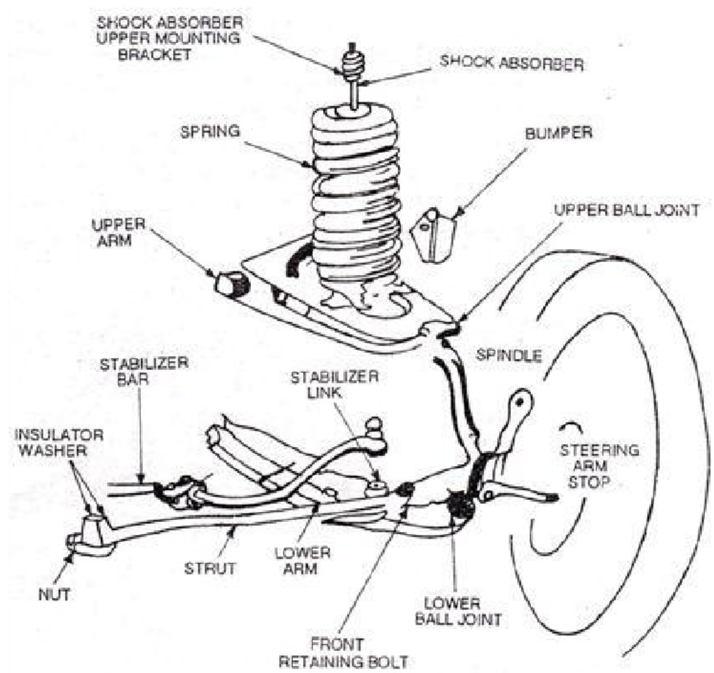

Fig:4 Coil Spring

(iii) Helical Springs: The helical springs are preferably used in combination with independent suspension system. The length and diameter of the spring wire greatly affect the stiffness of the spring. But the length is controlled by the diameter of the coil and the number of active coils.

Need of Shock absorber

Shock absorber compresses with the road shock and rebalances while travelling on uneven roads due to usage of this, the effect of road shock in required by the shock absorber suddenly and releases slowly whole travelling on uneven roads.

There shock absorber are of two types

(i) Mechanical type

(ii) Hydraulic type

Hydraulic Shock Absorber

The shock absorber develop resistance to the spring by forcing a fluid through check valves and small holes. „Double" acting shock absorber offer resistance both during compression and rebound of the spring. The „Double acting Hydraulic telescopic shock absorber „ are the commonly used shock absorber which are described as shown in the figure below

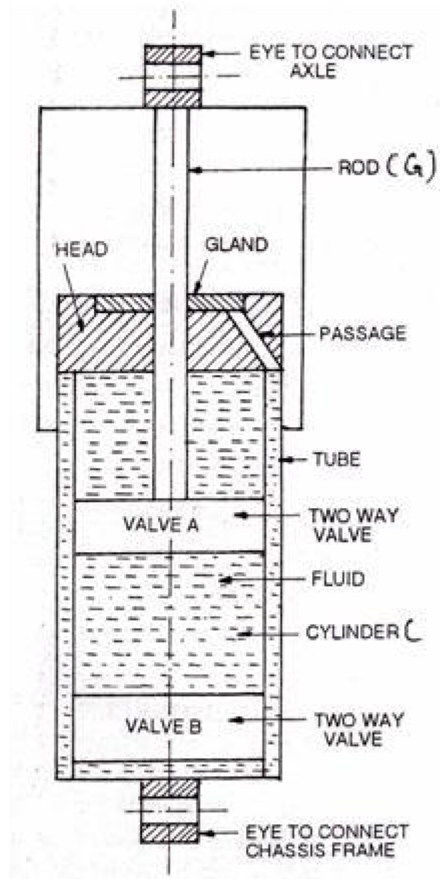

Fig 4.4 Hydraulic shock absorber

Its upper eye is connected to the axle and the lower eye to the chassis frame. A two way valve „A" is attached to as rod „G". Another two way valve Bis attached to the lower and of the cylinder C . The fluid is in the space above and below the cylinder C and tube D, which is connected to the space below the valve B. The J has glad H . Any fluid scrapped off the rod G is brought down into the annuler space through the inclined passage.

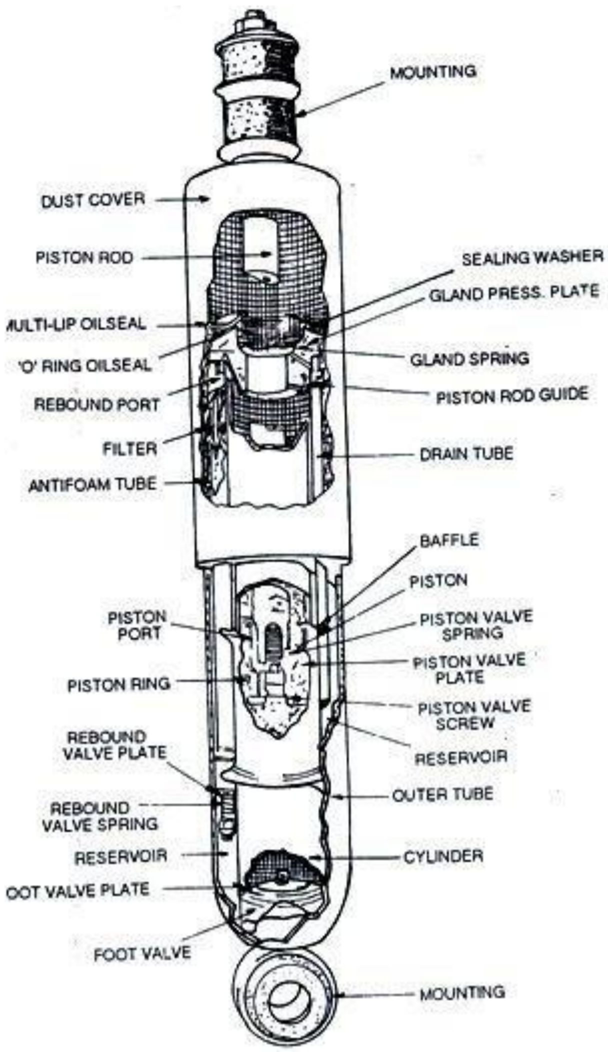

Fig 4.5 Hydraulic shock absorber (detailed construction)

When the vehicle comes across a bump the lower eye E moves up. Therefore the fluid passes from the lower side of the vehicle A to its type's side .But since the volume of the space above valve A is less than the volume B. This pressure of the fluid through the valve opening provides the damping force. Similarly when the lower eye E moves down. the fluid passes from the upper side of the valve A to the lower side and also from the lower of the valve B to the upper side.

Stabilizers bar and torsion bar Stabilizer:

A stabilizer or a sway bar is necessarily used in all independent front suspension units. It reduces the tending the vehicle to roll or tip and either side when taking a turn. This tendency has been increased due to the use of softer springs and independent front end suspension.

A stabilizer is simply a bar of as long steel with arms at each and connected to the lower wishbone arm of independent suspension or to the axle. supported i bush bearing fixed to the frame and is parallel to the cross member. When both the wheels deflect up or down by the same amount the stabilizer bar simply turns in the bearings. When only one wheel deflects then only one end of stabilizers moves, thus twisting the stabilizer has which acts as springs between two sides of independent suspension system. In this way, the stabilizer reduces healing or tipping of the vehicle on curves.

Torsion bar:

In independent suspension system, the torsion bar is attached to the axle with the king pin of the front axle. The torsion bar axles the shock by moving in certain angle with the axle. It is almost being used along with any kind of independent suspension system. It is used along with rubber torsion units.

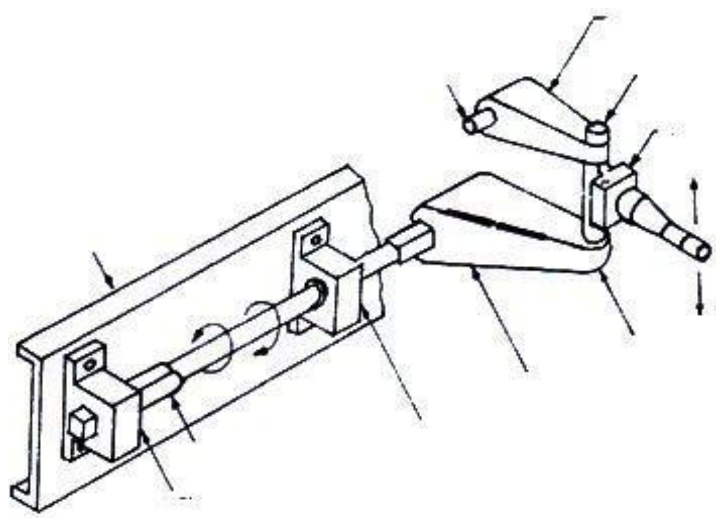

Fig. 4.7 Torsion bar

TEXT / REFERENCE BOOKS

1. Kirpal Singh, “Automobile Engineering Vol I”12 th edition Standard Publishers, 2011.

2. Banga T.R. & Nathu Singh, “Automobile Engineering”3 rd edition Khanna Publications, 2012.

3. Rajput R.K., “A Text–Book of Automobile Engineering”, Laxmi Publications Private Limited

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UNIT 5- BRAKING SYSTEM

Introduction

In Automobiles brakes play important role in slowing down and stopping of the vehicle as and when required by the driver. Fundamentally the brakes are of two types

(i) Internal expanding (ii) External contracting type.

(ii) Different types of brakes are used in different vehicles as per the requirement. According to application, the brakes are of different types-**mechanical, hydraulic air, vacuum, Air assisted Hydraulic**.

Functions of Brakes

(i) To slow down or to stop the vehicle as and when required.

(ii) To control the vehicle when the vehicle is rolling down on a slope road down ward.

(iii) To travel smoothly and safely even in heavy flow of traffic by Controlling the movement of the vehicle.

Requirement of Automobile Brakes

(i) The brakes must stop the vehicle within shortest possible distance.

(ii) These must be released suddenly after releasing them

(iii) Total control of the vehicle should be there

Stopping time and Stopping Distance

The stopping time and stopping distance shows the efficiency of brakes. The maximum retarding force applied by the brake at the wheels, F,

Depends upon the coefficient of friction between the road and tyre surface and the component of the weight of the vehicle on the wheel, w.

In actual practice 100% of brakes efficiency is not used. The stopping time and distance depend upon

(i) Vehicle speed

(ii) Condition of road surface

(iii) Condition of tyre tread.

(iv) Coefficient of friction between the tyre tread and road surface.

(v) Coefficient of friction between brake drum and brake lining (in case of Drum brakes).

(vi) Coefficient of friction between the disc and the friction pad (in case of

Disc brakes).

(vii) Brake force applied by the driver.

Types of Braking system - Disc and Drum Braking system

Disc Brakes

The disc brake consists a cast iron disc bolted to the wheel hub and a stationary housing called calliper. The Calliper is connected to some stationary part of vehicle, like axle casing or the stab axle and is cast in two parts, each part containing a piston. In between each piston and the disc, there is a friction pad held in position by retaining pins, spring plates etc.

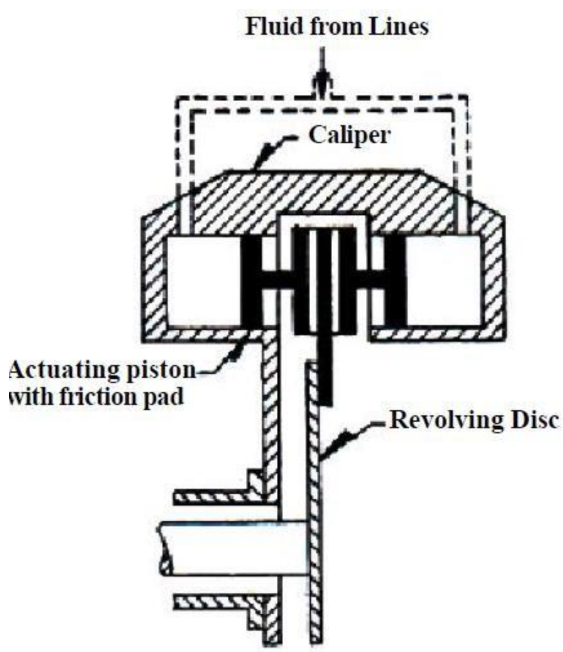

Fig:1 Disc Brakes

When the brakes are applied, hydraulically actuated piston move the friction pads into contact with the disc, applying equal and opposite forces on the later. On releasing brakes, the rubber sealing rings act as return springs and retract the pistons and the friction pads away from the disc.

Drum Brakes

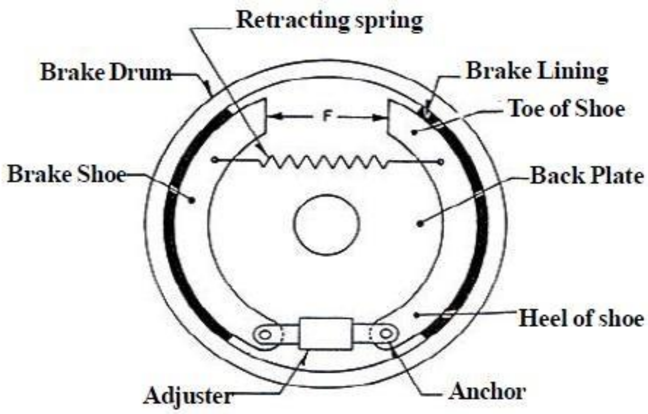

Fig:2 Drum brakes

In this type of brakes, a brake drum is attached concentric to the axle hub whereas on the axle casing is mounted a back plate. In case of front axle, the brake plates are bolted to the steering knuckle. The back plate is made of pressed steel and is ribbed to increase rigidity and to provide support for the expanding brake shoes. These brakes are also known as internal expanding brakes.

Construction and working of Mechanical, Hydraulic and Air brakes.

Construction and working of Mechanical Brakes

These brakes are operated completely through mechanical links and lever. These are applied in two wheelers and these wheeler. These are also applied in four wheeler as parking or Emergency brakes . In the wheel drum there are two brake shoes which are linked closely by a retracting spring. There will be a can between the two shoes. When brake pedal is applied, the can will rotate causing the brake shoes expand against the force of the returning spring. This causes the shoes to rub against rotating wheel drum and thereby stopping it. When brake pedal is released, the can inside wheel drum will come back to its position causing the brake shoes to come back with the presence of returning position and thus releasing brakes.

Construction and working of hydraulic brakes

The hydraulic brakes are being operated in the Pascal"s law which states that "The pressure applied on any liquid is equally transmitted to all the direction at the same time". In the same manner the pressure of brake pedal which is applied on the brake fluid in the master cylinder is transmitted to all the four wheel cylinder with equal pressure and at the same time. In this way the brake shoes which are attached to the wheel cylinder (s) are expanded and thus the brakes are applied. The parts of hydraulic braking system one (i) Brake pedal (ii) Pull and push rod (iii)- Master cylinder (iv) Brake pipe lines (v) wheel cylinder (vi) brake shoes . When the brake pedal is applied the piston inside the master cylinder in pushed forward and it caused the pressurized brake fluid moves forward to all the four wheel cylinder at the same time with same pressure. There at the wheel cylinder the brakes shoes will be expanded with the developed pressure in the wheel cylinder. All the wheel cylinder will be operated at the same time according to Pascal"s law. This is how the brakes are applied. While releasing brakes with contracting of brake shoes with spring force the brake fluid in the wheel cylinder will try to go back to the master cylinder. As there is no pressure on the position of the master cylinder, the brake fluid push the check valve of master cylinder and the enter into the reservoir through barrel and by pass valve of master cylinder.

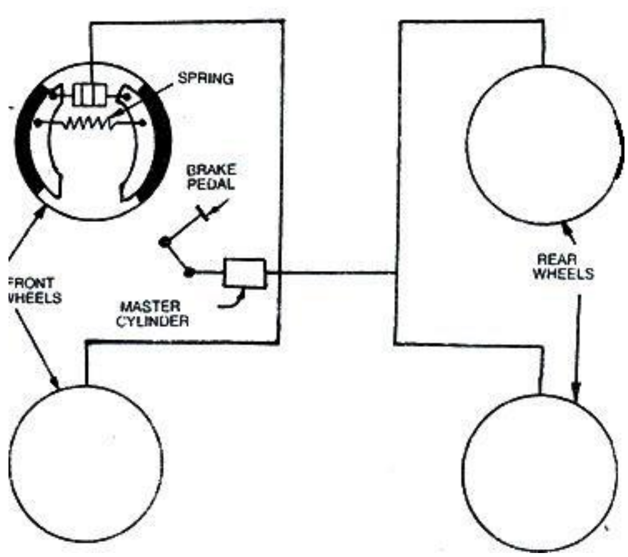

Fig 3.3 Hydraulic Brake System

Master cylinder

It is the most important part of hydraulic braking system. It contains two main chambers.

(i) Fluid reservoir – which stores the brake fluid in it

(ii) Barrel-which is compressor and develops pressure in brake fluid

(i) Reservoir : The reservoir also contains two parts . The larger part is called filler or intake port and the smaller port is called by pas through which the returned fluid from the system will enter into reservoir from barrel.

(ii) Barrel : In the barrel of master cylinder the parts are – (a) Primary cup (b) Position (c) Secondary cup (d) Return spring (d) Return spring (e) Check value .

When the brake pedal is applied the push rod will push the piston of master cylinder and there by the pressure is applied on the Hydraulic Brake fluid. The pressurized brake fluid will enter into system through check valve which does not allow the fluid to return back. This causes the pressure on the system and applying brakes at the wheel cylinder.

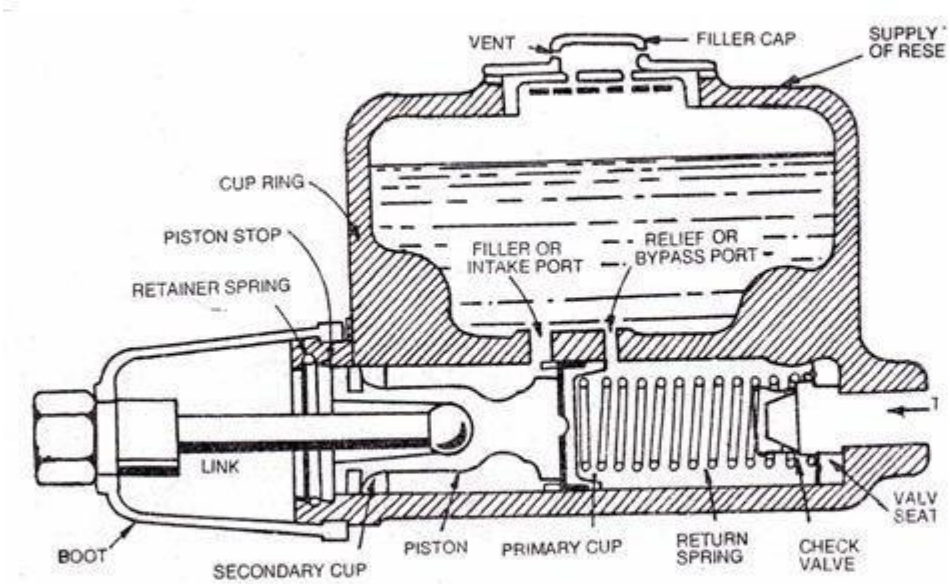

Fig 3.4 Master Cylinder

Wheel cylinder:

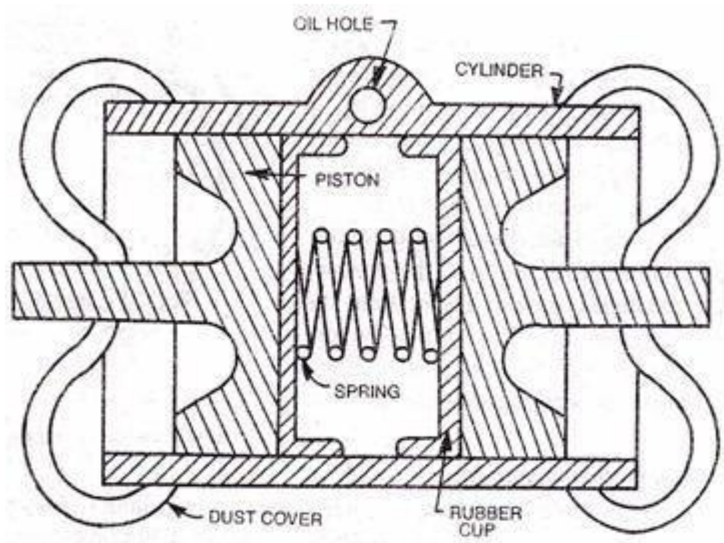

Fig 3.5 Wheel Cylinder

Wheel cylinder or slave cylinder assist the main master cylinder in covering the pressure to the piston inside it and push the brake shoes attached to it . Some of the wheel cylinder having one piston and some having two pistons. The wheel cylinder having one piston will operate only one brake shoe and the two-wheel cylinder are require to operate two brake shoes. In some wheel cylinder, both brake shoes are operated as they are having two pistons in them.

When brakes are applied the brake fluid enter into the cylinder through a brake pipe line. It causes to force out the piston. This motion is transmitted to brake shoes causing them to expand against the running wheel drum to hold it tightly and stop it.

Bleeding of brakes in Hydraulic brakes:

In Hydraulic Brakes, the removal of air from the entire Hydraulic system starting from master cylinder to different wheel cylinders is known as Brake Bleeding

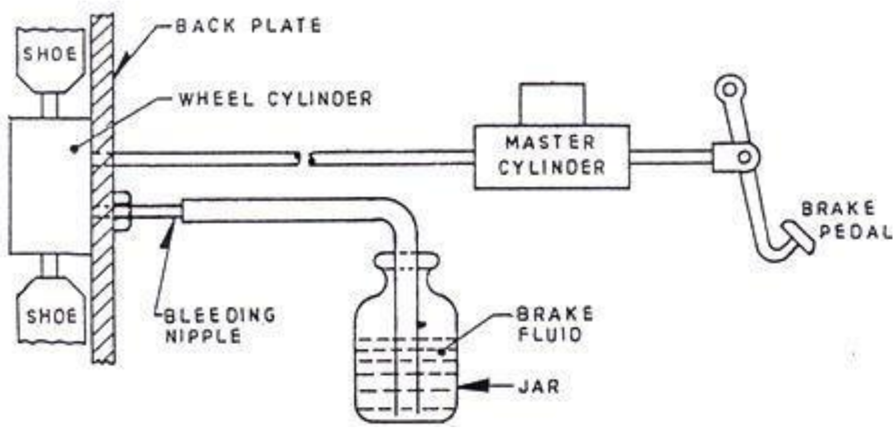

Fig: 3.5 Bleeding of brakes

It includes the following process:

(i) At first check all the pipe lines and junction boxes from master cylinder to wheel cylinder. Whether there is any leak among them.

(ii) Ask one person to pump the brake pedal and keep it in pressing position

(iii) The second person should loosen the bleeding nipple at the back plate of the wheel cylinder position.

(iv) Keep the bleeding nipple in open until the air bubbles disappear and the brake fluid comes out with a force. Collect the brake fluid in a glass tumbler.

(v) Then tighten the bleeding nipple

(vi) Repeat this process in all the wheel cylinders starting from the farthest wheel to the master cylinder and ending with the nearest wheel.

(vii) Make sure that the level of brake fluid in master cylinder is ¼ less than the top covers while filling it.

Air Brakes:

The manufacturers of braking systems offer a variety of air brake equip- ment. However, the simplest system consists of an air compressor, a brake valve, series of brake chambers, unloader valve, a pressure gauge and a safety valve. These are all connected by lines of tubing. The other braking systems may have additional components such as stop-light switch, a low pressure indicator, an air supply valve to supply air for tyre inflation, a quick release valve to release air quickly from the front brake chambers when pedal is released, a limiting valve for limiting the maximum pressure in the front brake chambers and a relay valve to help in quick admission and release of air from rear brake chambers.

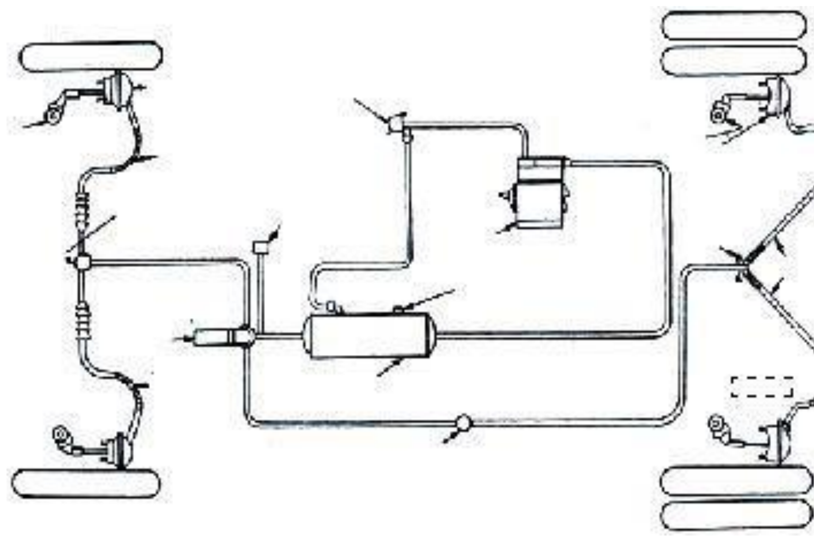

Fig 3.7 Air Brake

- The compressor sends compressed air to the-reservoirs which are connected to the brake valve.
- The lines of tubing from the brake valve extend to the front and rear brake chambers.
- When the drive depresses the pedal, it operates the brake valve thus admitting compressed air to all the brake chambers.
- The compressed air operates the diaphragm of the brake chambers thereby applying the brakes.

TEXT / REFERENCE BOOKS

(i) 1. Kirpal Singh, "Automobile Engineering Vol I"12 th edition Standard Publishers, 2011.

(ii) 2. Banga T.R. & Nathu Singh, "Automobile Engineering"3 rd edition Khanna Publications, 2012.

(iii) 3. Rajput R.K., "A Text–Book of Automobile Engineering", Laxmi Publications Private Limited

(iv) 4. Heldt.P.M. “Automotive Chassis”, 3 rd edition Chilton Co. Publications, New York, 1990.
(v) 5. Heinz heisler “Advanced vehicle technology”2 nd edition Edward Arnold publication 2002.