AUTOMOBILE ENGINEERING

Module 2

SYLLABUS

Transmission systems in automobile - working - clutch functions - requirements of clutch - single plate - multi plate - diaphragm -centrifugal clutch, Fluid coupling. - Gear box - functions-working- types- sliding mesh - constant mesh - synchromesh — epicycle gear box -CVT- torque converter- over drive. Propeller shaft - universal joint - final drive - differential.

Stub axle - types of live rear axle - semi floating - three quarter floating and full floating axles

TRANSMISSION SYSTEM

- The transmission system consists of a clutch,gear box,a propeller shaft and a differential gear

Clutch

its purpose is to enable the driver to disconnect the engine drive from the road wheels instantaneously for changing gears and to engage drive from the engine to the road gradually while moving from rest

Gear box

the gear box provides the necessary variation between the engine and road wheels

Bevel pinion and crown wheel

they turn the drive through 90degree and also provide a permanent reduction in speed

Universal joints

they provide a relative movement between the engine and driving wheel due to flexing of road springs

Differential

while taking turns the driving wheel must turn at different speed

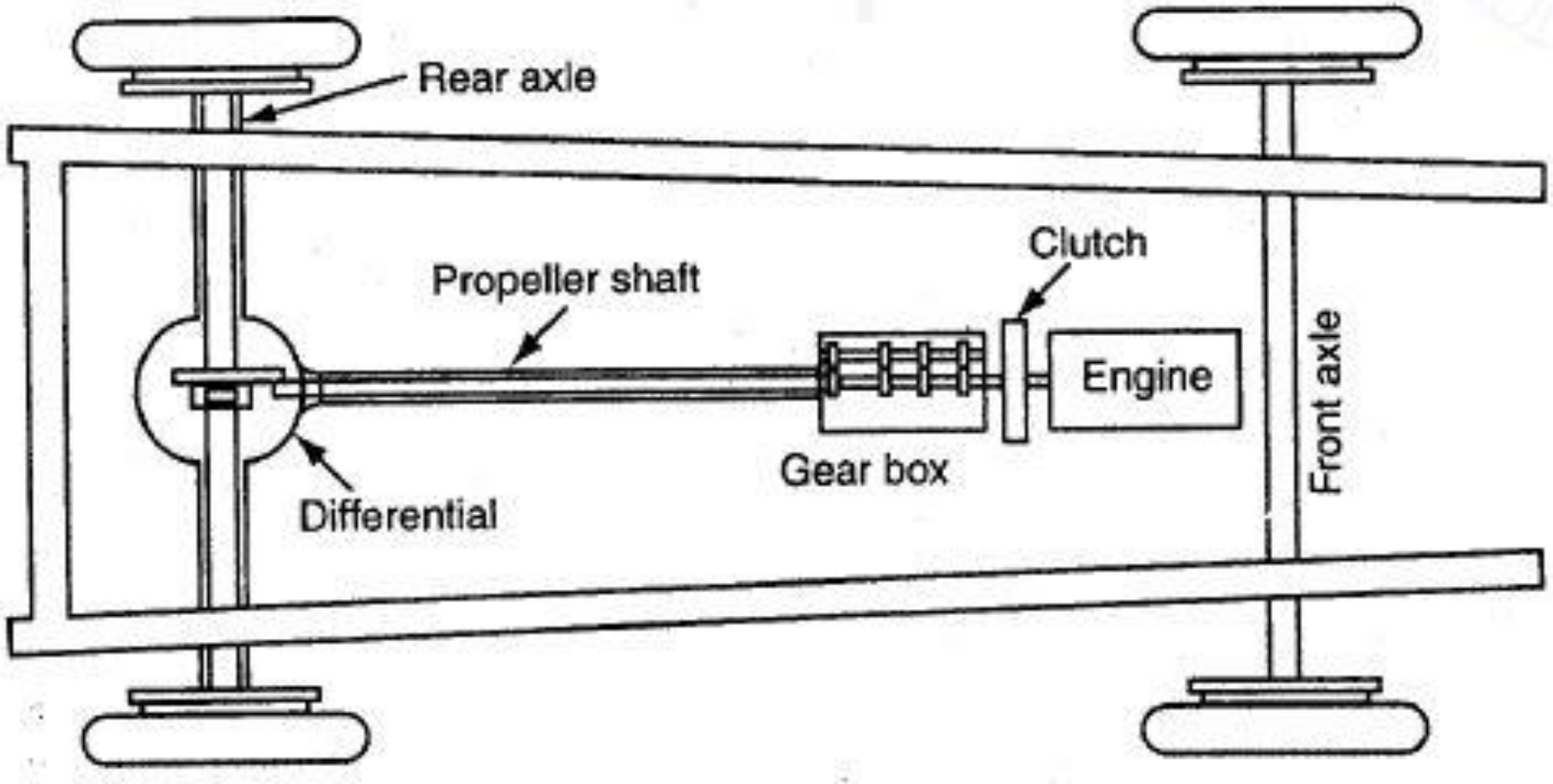


Figure 3.1 General arrangement of power transmission

FUNCTIONS OF TRANSMISSION

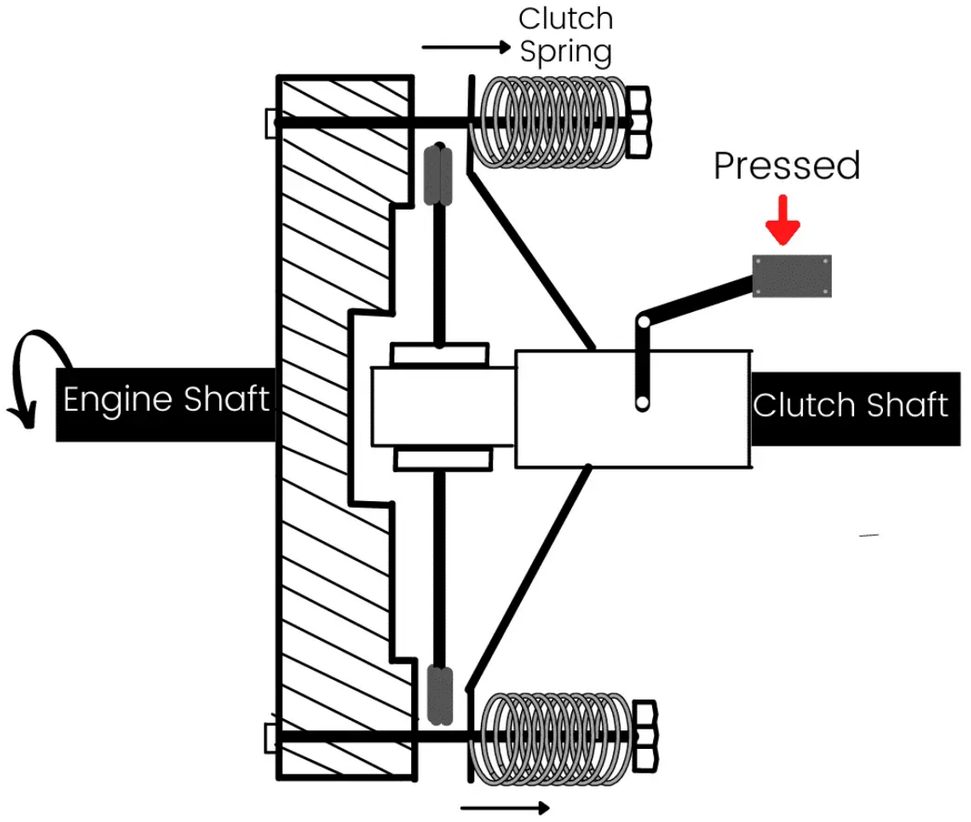
- To connect engine to driving wheel without shock
- To vary the torque ratio between engine and wheel
- To provide a neutral position so that engine and wheel is disconnected .
- To provide reverse direction of motion
- To turn the drive through right angle
- To reduce engine speed permanently in fixed ratio

FUNCTIONS OF CLUTCH

- To transmit power from engine to drivetrain.
- Smooth transmission by gradual engagement.
- Silent operation by reducing vibration due to drive operation.
- Protects drivetrain from engine vibration.
- To remove the speed difference between engine and drivetrain by slip action.
- It delivers the power to wheels via gearbox without stopping during gear change.
- To dissipate heat produced during clutch engagement
- **Different types of clutches:**
- Single-plate clutch
- Multi-plate clutch
- Cone clutch
- Centrifugal clutch

SINGLE PLATE CLUTCH

- **Single plate clutches** are one of the most commonly used types of clutches used in most modern light vehicles. The clutch helps to transmit torque from the engine to the transmission input shaft. As the name states it has only one clutch plate.
- It consists of a clutch plate, friction plate, pressure plate, flywheel, bearings, clutch spring and nut-bolts arrangement.
- The single-plate clutch has only one plate which is attached on splines of the clutch plate. Single plate clutch is one of the main components of the clutch. The clutch plate is simply thin metallic disc which has both side friction surfaces.
- The flywheel is attached on the engine crankshaft and rotates with it. A pressure plate is bolted to flywheel through clutch spring, which provides the axial force to keep the clutch engaged position, and is free to slide on the clutch shaft when the clutch pedal is operated.
- A friction plate which is fixed between the flywheel and pressure plate. The friction lining is provided on both sides of the clutch plate.



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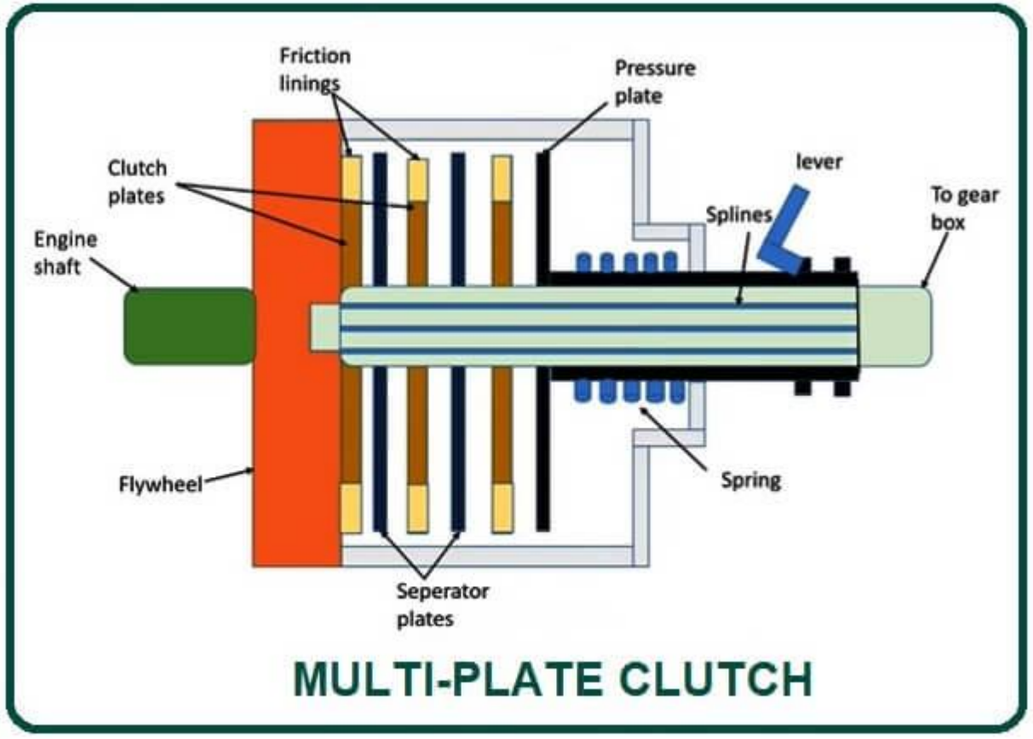
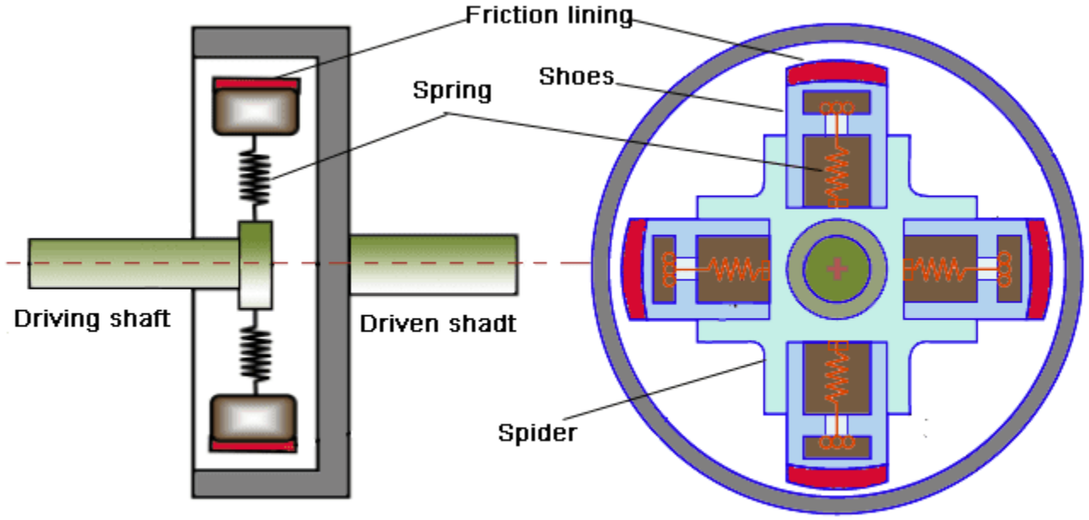
MULTI-PLATE CLUTCH

- **The multi-plate** use multiple plates to make frictional contact with a flywheel of the engine. This makes transmit power between the engine shaft and the transmission shaft of a vehicle. The number of clutches means more friction surface.
- The increased number of friction surfaces also increases the capacity of the clutch to transmit torque. The clutch plates are fitted to the engine shaft and gearbox shaft.
- The working principle of multiple clutches is the same as the working of the single-plate clutch. The clutch is operated by pressing the clutch pedal. The multiple clutches are used in heavy commercial vehicles, racing cars, and motorcycles for transmitting high torque.
- The multiple clutches have two characters dry and wet. If the clutch is operated in an oil bath, it is known as a wet clutch. If the clutch is operated dry without oil, it is known as a dry clutch. The wet clutches are commonly used in connection with, or as a part of the automatic transmission.



CENTRIFUGAL CLUTCH

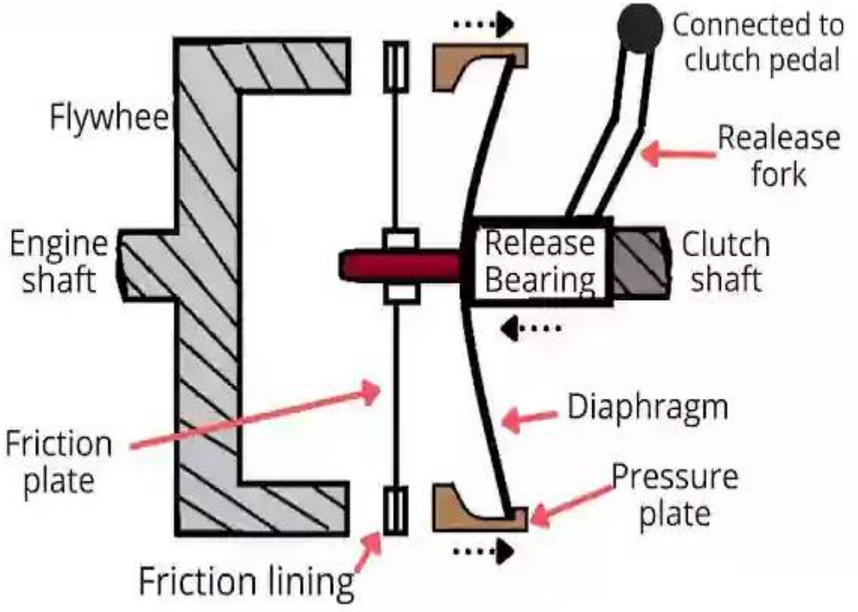
- . To keep the clutches in the engaged position centrifugal clutch uses centrifugal force, instead of spring force. In these types of clutches, the clutch is operated automatically depending upon the engine speed. That's why no clutch pedal is required to operate the clutch.
- This made so easy for the driver to stop the vehicle in any gear without stalling the engine. Similarly, you can start the vehicle in any gear by pressing the accelerator pedal.



Centrifugal Clutch

DIAPHRAGM CLUTCH

- The diaphragm clutch consists of a diaphragm on conical spring which produces pressure on the pressure plate for engaging the clutch.
- In these types of clutches, the engine power is transmitted from crankshaft to flywheel.
- The flywheel has friction lining and it is connected to the clutch.
- The pressure plate is provided behind the clutch plate because the pressure plate applies the pressure on the clutch plate.
- When we press the clutch pedal the outside bearing moves towards the flywheel pressing the diaphragm spring which pushes the pressure plate backwards and the clutch will get disengaged
- This types of clutches have no release levers because the spring acts as a series of levers.
- The driver does not need to apply such heavy pedal pressure to hold the clutch disengaged as with the coil spring type in which the spring pressure increases more when the pedal is depressed to disengage the clutch.



FLUID COUPLING OR FLUID CLUTCH

- Used in cars employing automatic transmissions.
- It consists of two members, the driving and driven .
- Driving member is attached to engine flywheel, driven member to transmission shaft
- Two members do not have any direct contact with each other.
- Driven member is free to slide on splines on the transmission shaft.
- Two rotors are always filled with fluid of suitable viscosity.

Advantages:

1. No wear on moving parts. 2. No adjustment to be made. 3. No maintenance necessary except oil level. 4. Simple design. 5. No jerk on transmission when the gear engages. 6. No skill required for operate it. 7. Car can stop in gear and move also by pressing accelerator pedal only.

Disadvantage:

There is a drag on gear box shaft even when the percentage slip is 100. This makes the gear changing difficult with ordinary gear box. Fluid flywheel is suitable for epicyclic gear box.

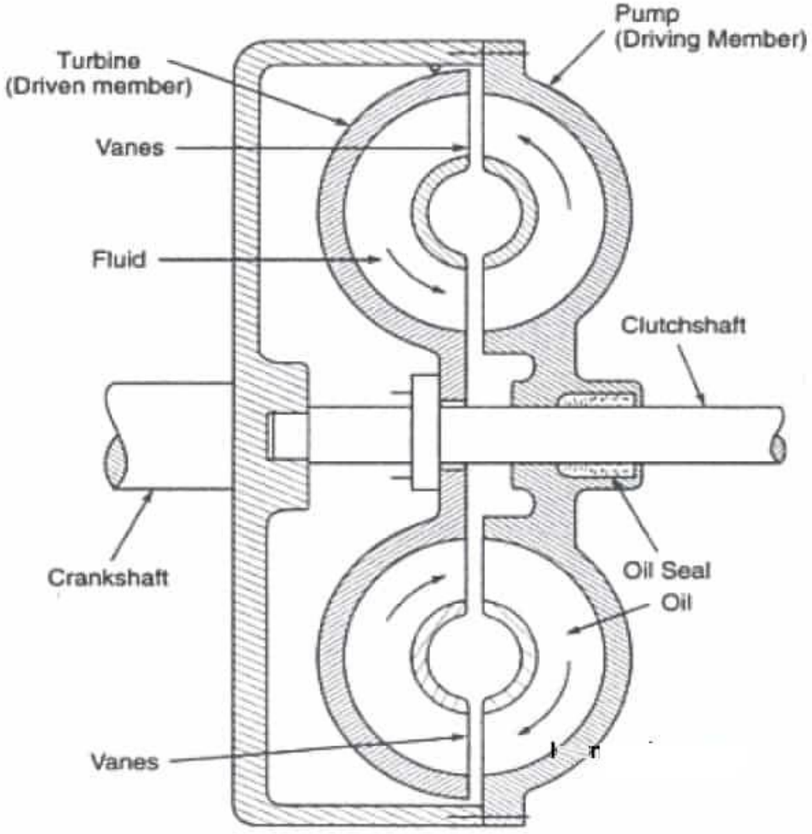


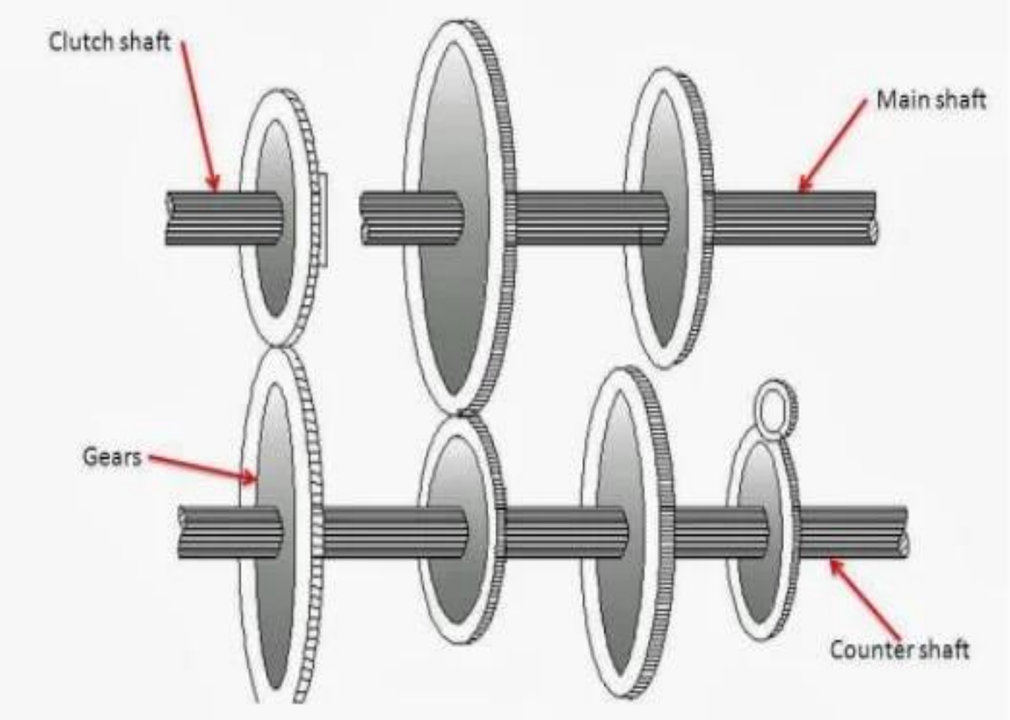
Figure: Fluid Coupling

GEAR BOX

- A device to enable the engine crankshaft to revolve at a relatively higher speed, while the wheels turn at a slower speed. This is surrounded by a metal box called a gearbox. The Gearbox is the process of transmitting energy in a mechanical engine to increase the output torque or to change the speed of a motor.

Parts of Gearbox:

- **Clutch Shaft**
- **Counter Shaft**
- **Main Shaft**
- **Bearings** and
- **Gears**



Main parts of gear box

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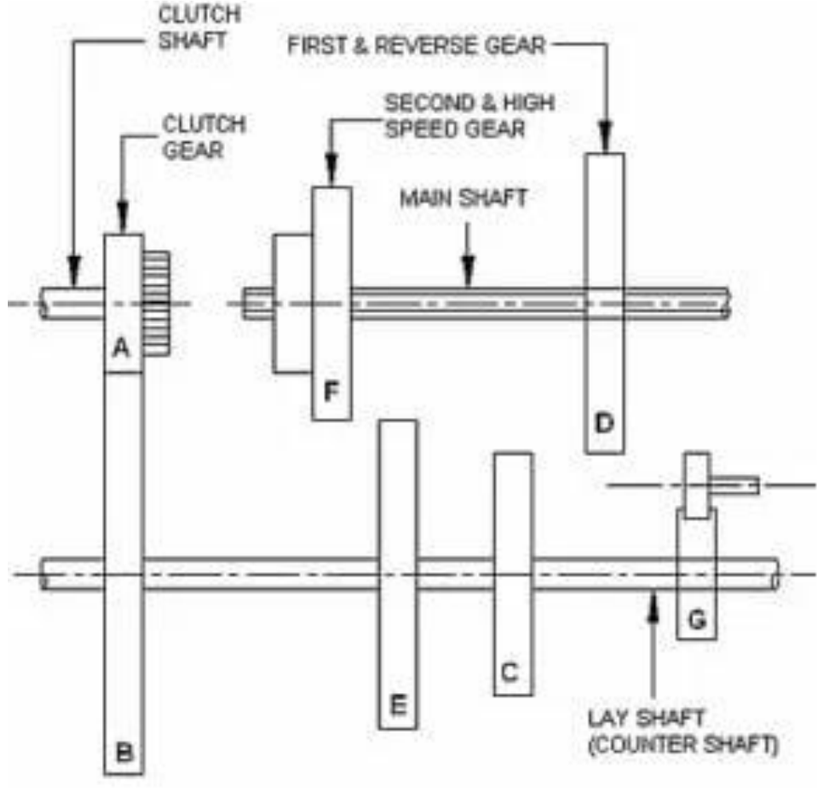
WORKING PRINCIPLE OF GEAR BOX

- A gearbox consists of gears of varying sizes, because of the different demands in times of the torque needed at the wheels depending upon the road, load, for example; climbing vehicles require higher torque than driving on a straight road.
- The first gear is larger compared to the other gears, provides maximum torque outcome while generating minimum speed.
- The gears vary size from first to the last in decreasing ratio, thus it empowers varying combinations in pulling ability and speed.
- A Clutch shaft is also known as a driving shaft, which utilizes the force from the engine and supplies it to the other parts. The driving shaft is attached to them via a clutch, and when the clutch is engaged the driving shaft starts to rotate.
- The clutch gear is provided with a single gear fixed on it and it rotates with the engine speed same as the crankshaft.
- Main Shaft is also known as output shafts. It revolves at a different speed and also gives mandatory torque to the vehicles.
- Gear is used to transport power from one shaft to another. The quantity of torque transported via gears depends on the number of teeth and size of the gear.
- The higher gear ratio produces higher acceleration, and the minor the speed.
- If the ratio of gear is higher than 1, the car will maintain a higher acceleration and will travel at a higher speed.

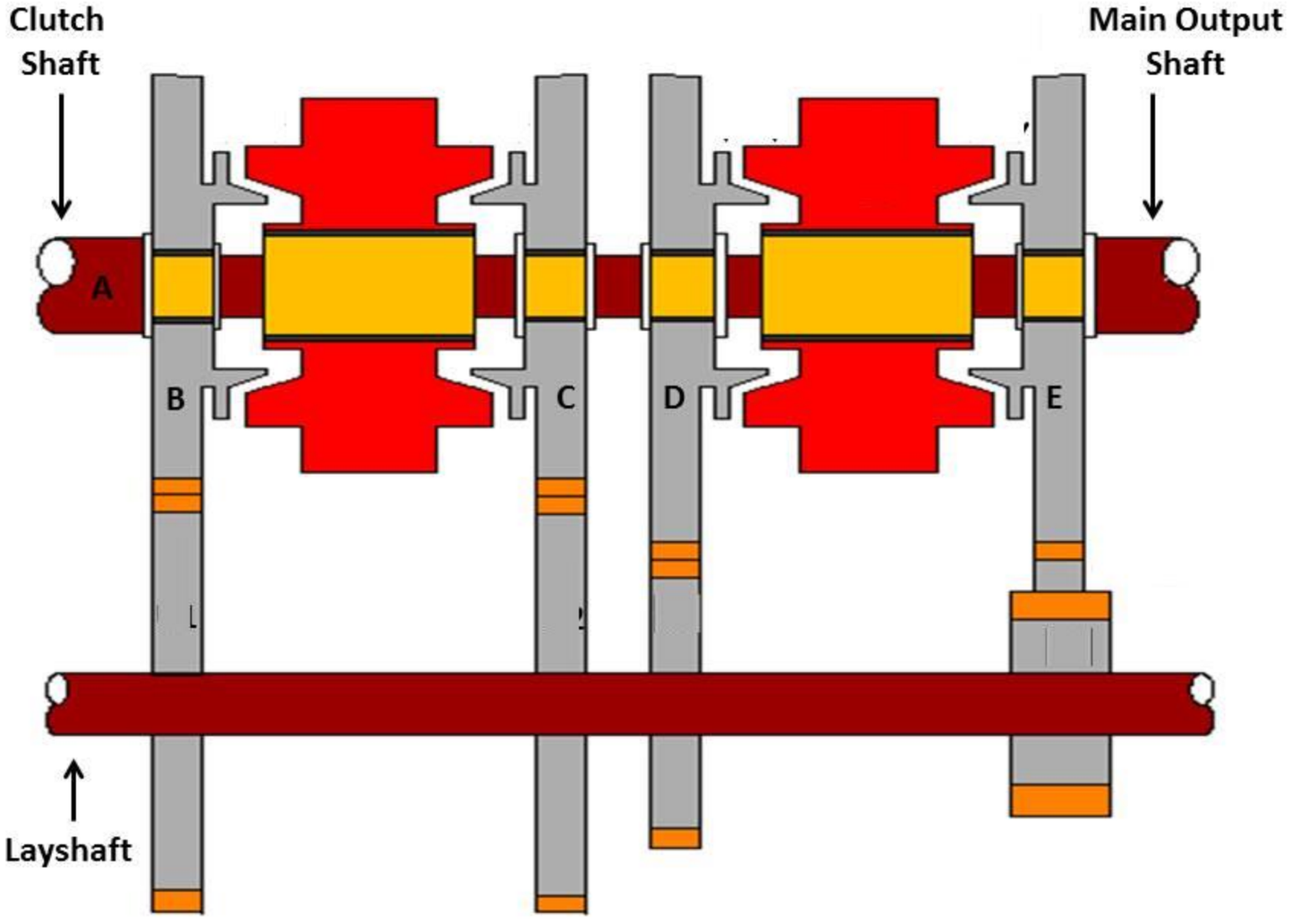
SLIDING GEAR TRANSMISSION

- These gears are found only on older model cars. When the transmission is neutral, the only parts that move within the transmission process are the main gear and the cluster gear. To empower the driving wheels, the clutch pedal should be compressed so that the shifter handle can move
- Moving the shifter handle results in changing the position of the shift linkage slides, and forks a gear along the main shaft quickly above the cluster gear.
- Once these two gear combines, the clutch can be released. To change the gears again, drivers need to unleash both the gears before syncing two new gears.
- This type of transmission fails to have the same diameters and tooth numbers, cause the gear to rotate at different speeds and that can result in a gear clash. This is one of the major reasons this gear is no longer used.



SYNCHROMESH GEARBOX

- Synchromesh gears are mostly used by modern cars in the gearbox, which synchronizes the rotation of gears that are messed. This type of gear eliminates the risk of gear clashing and makes the shifting process easier.
- This gearbox is someway similar to a constant mesh gearbox.
- It is provided with synchromesh equipment by which the two gears which are to be engaged are first taken into frictional contact by adjusting their speed and making the process easy.
- When the lever is shifted, the synchromesh cone comes together to meet with a similar cone on the pinion. Due to the result of friction, the rotating pinion is prepared to rotate at the same speed as the synchromesh unit.
- **Advantages:**
- Smooth and Noise free shifting of gears which is most suitable for cars.
- No loss of torque transmission from the engine to the driving wheels during gear shifts.
- Double clutching is not required.
- Less vibration.
- Quick shifting of gears without the risk of damaging the gears.
- **Disadvantages:**
- high manufacturing cost and high number of moving parts.
- When teeth make contact with the gear, the teeth will fail to engage as they are spinning at different speeds which causes a loud grinding sound as they clatter together.
- Improper handling of gear may easily prone to damage.
- Cannot handle higher loads.

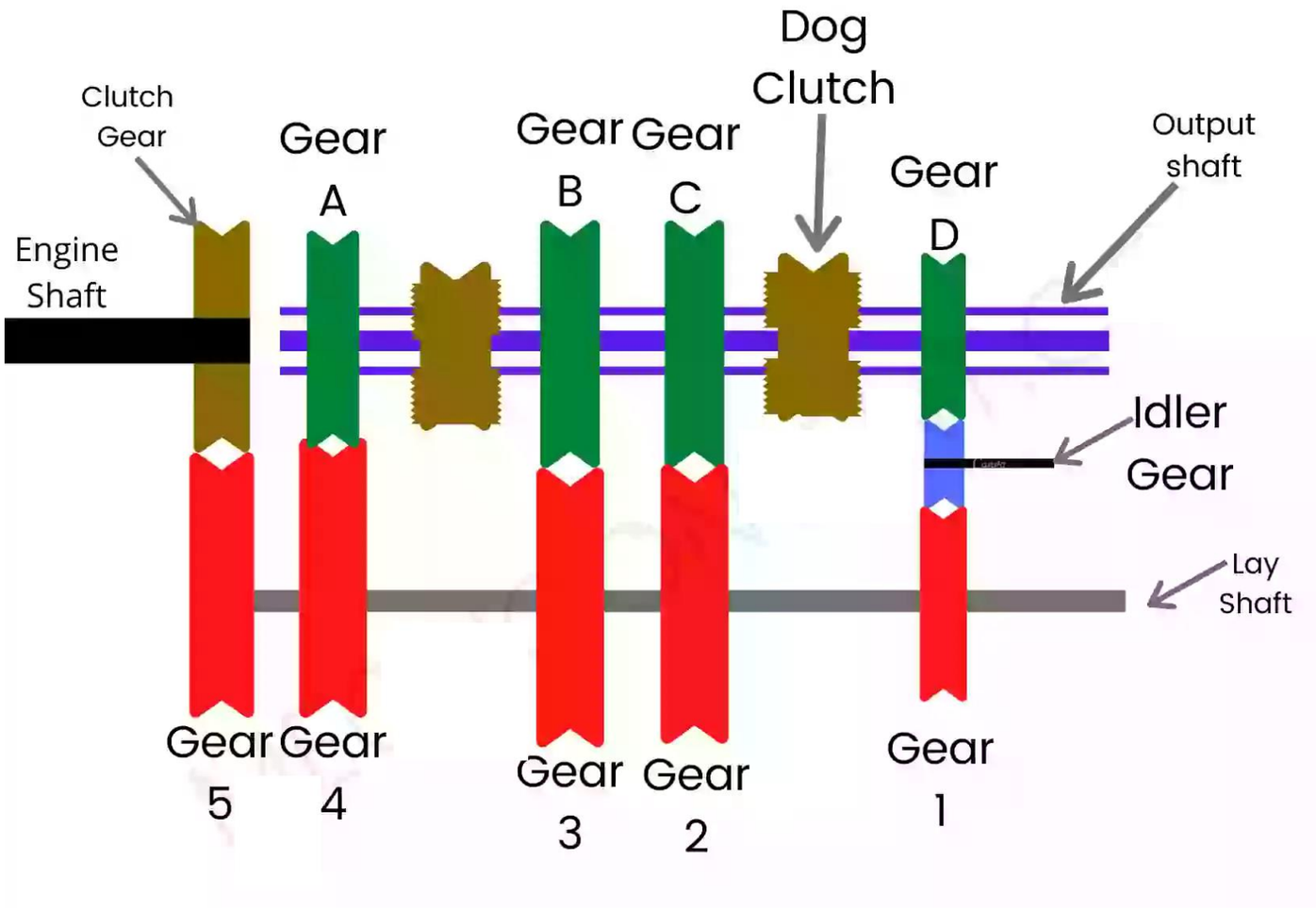


Synchromesh Gearbox

CONSTANT MESH GEARBOX

- In this gearbox, all the gears of the main shaft get in constant mesh with the connected gears of the layshaft.
- The sliding dog clutch is placed in the middle of the clutch gear, and the second gear, the others are positioned in between the first and the reverse gear. All the gears are independent of the splined main shaft.
- Dog clutch skids on the main shaft to rotate with it. All the gear on the layshaft is fixed with it. When the left-hand dog clutch is brought to skid to the left through the gearshift lever, it messes with the clutch gear, and the upper-speed gear is achieved.
- When the left-hand log clutch gets in contact with the second, the second speed gear is achieved. Just like that, by shifting the right-hand dog clutch to the left and right, the first and reverse gear is attained.
- In this process, the gears are in constant mesh. They are safer from damage, prevents gear clashing problems, and also don’t produce any unpleasant sound while engaging and disengaging them.

Constant Mesh Gearbox



CONTINUOUS VARIABLE TRANSMISSION

- The Continuous Variable Transmission doesn’t consist of or offers any gears. Rather, it operates cone-shaped with a band around with an axle. The band shifts up and down to vary its length and the gear ratio.
- It offers infinite and variable ratios between the upper and lower limit, as a result, it be can be faultlessly optimized for fuel efficiency and performance needs at a given time.
- This is more beneficial for hybrid cars, which may use CVT to balance out the work weight between both the petrol engine and electric motor.
- The downfall is the driving experience which sometimes may feel bizarre and unpleasant. When it comes to accelerating, it feels the car is jerking against a rubber band.
- ADVANTAGES
- Constant stepless accelaration from start to high speed giving smooth ride
- Keeps optimum power at all condition,giving better fuel economy
- Less emissions
- DISADVANTAGES
- Torque handling capacity is limited
- More space reqiured
- Much lesser life compared to conventional drives

https://www.youtube.com/watch?v=PEq5_b4LWNY

EPICYCLIC GEAR BOX

- Epicyclic gearing also called as planetary gearing. It is a gear system that consists of one or more outer gear (planet gear) rotating about a central (sun gear). The planet gear are mounted on a moveable arm (carrier) which itself may rotate relative to the sun gear.
- It is used to increase output speed. The planet gear carrier is driven by an input torque. The sun gear provides the output torque, while the ring gear is fixed.
- **Advantages**
- High reduction ratios
- Compact and lightweight with high torque transmission
- High radial loads on the output shaft
- It is quieter in operation
- Uniform distribution of load over all gears having greater tooth contact.
- All gears are constantly in mesh, so a change of one gear to another is possible without any loss.

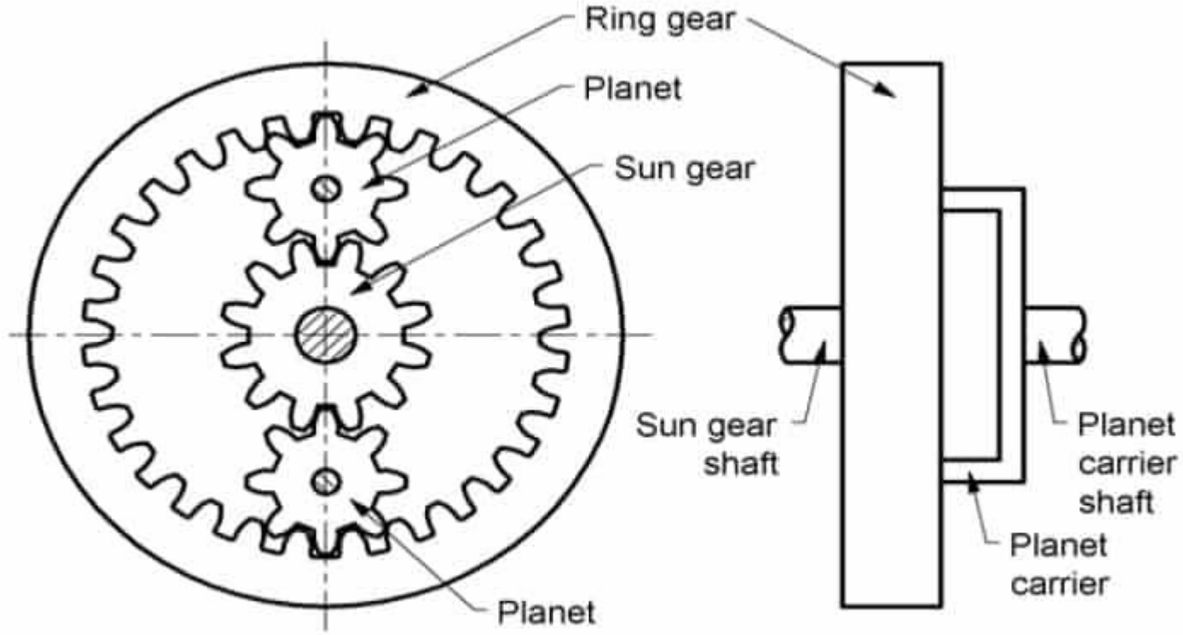


Figure: Simple epicyclic gear box

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Application-automatic transmission of a car, back gear of lathe, differential gears of the automobiles, hoists, pulley blocks, wrist watches, etc.

TORQUE CONVERTER

- Cars with automatic transmissions have no clutch that disconnects the transmission from the engine. Instead, they use a device called a **torque converter.**the torque converter is similar to that of fluid flywheel ,the only difference is that it has additional stationary member called stator.
- The operation of fluid flywheel and torque converter is not similar.fluid flywheel transmits the same torque given by engine shaft,the torque converter increases torque ratio of about 2:1,3:1.
- In gearbox the torque variation is only in finite number of steps,in torque converter output variation is continous .
- However efficiency of a torque converter is high only within narrow limits of speed.

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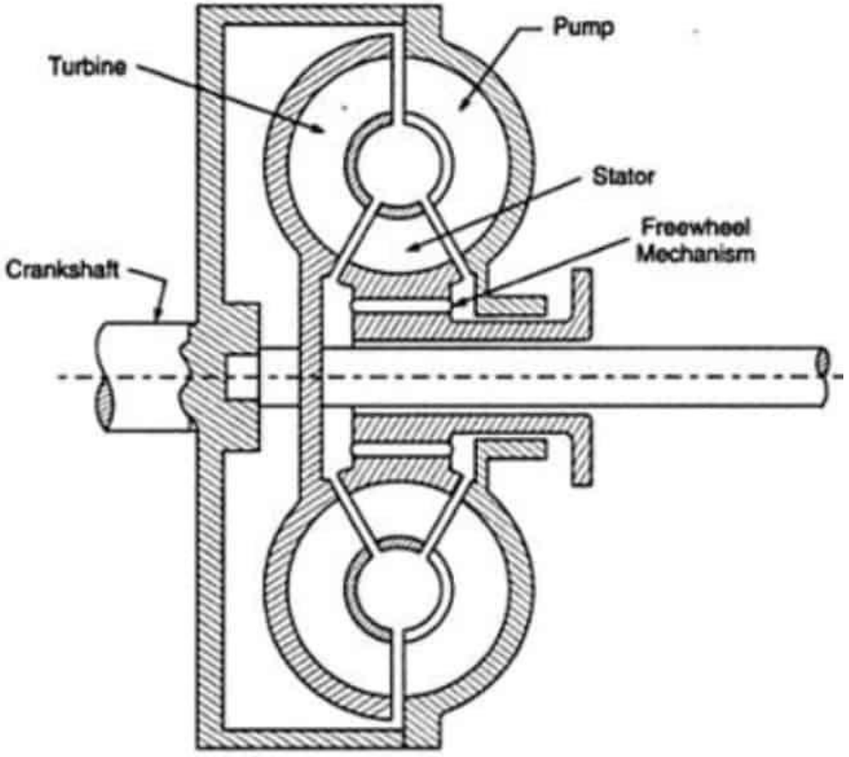
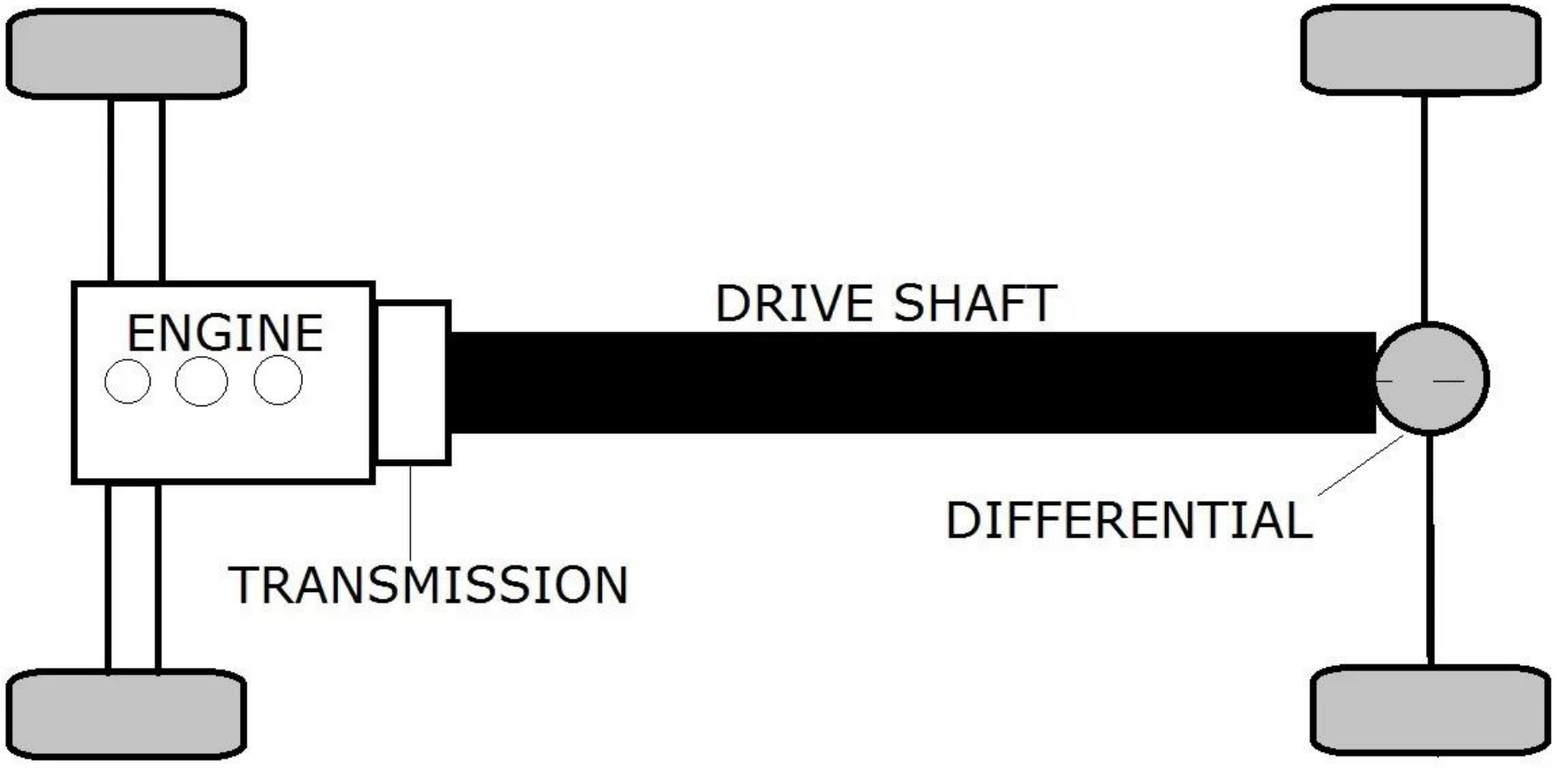


Fig: Torque converter

PROPELLER SHAFT

- The component which is used to transfer torque from the gearbox to the rear axle or differential is called a propeller shaft. It is not only used in cars but is also used in boats and aeroplanes. It is also known as the Cardan shaft or drive shaft.
- The propeller shaft is a hollow tube-like structure with a combination of universal and slip spline joints. In most cars except the modern-day cars, the engine is situated at the front end and it is used to drive the rear wheels.
- Hence, The shaft is used to transmit the power from one end of the automobile to the other end. In automobiles where the front wheel is given power, a short shaft is used.
- <u>Characteristics of the Propeller Shaft:</u>
- The propeller shaft transmits power from the gearbox's output shaft to the differential.
- There are no or very few power losses, this means there is no change in the RPM when the power is transmitted.
- It can transmit power at a different elevation like if the gearbox output shaft is at 1 meter from the ground and differential is at 0.5 meters from the ground.
- The shaft can adjust itself while the vehicle runs through obstacles such as a speed breaker.



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- **Parts of Propeller Shaft:**
- A propeller shaft consists of three main components:
- **Universal joints**,**Split spline joints and Tubular shafts**
- **Universal joint:**
- A universal joint is the most important component of a propeller shaft there are two universal joints in a single-piece propeller shaft. The number of universal joints can be up to three or four depending on the type of propeller shaft.
- A universal joint is that component that allows rotation of the propeller shaft on various axis. It is a flexible joint that compensates for the elevation difference between the gearbox output shaft and the differential.
- **Slip spline joint:**
- A slip spline joint is generally used at the output side of the propeller shaft. It helps in torque transmission at various lengths of the propeller shaft. It comes in action during the obstacles faced by the automobile.
- To transmit power during sudden brake conditions a slip spline joint is used. It also protects the shaft from compressive and tensile stresses.
- **Tubular shaft:**
- The tubular shafts are used to compensate for the distance factor between the gearbox and the rear axle.

UNIVERSAL JOINT

- A universal joint takes care of rising and falling motion of the rear end of the propeller shaft which is connected to differential.
- **Concept of Universal joint :**
- Universal joint is used to connect two shafts at an angle for transmitting torque.
- In the transmission shaft of an automobile, two universal joints are used – one between main transmission shaft and propeller shaft and another between other end of propeller shaft and the differential.
- Therefore, the universal joints make the joints flexible so that power can be transmitted at an angle.
- **Types Of Universal Joint :**
- Three types of universal joints are commonly used. These are listed below:
- **(a) Cross or spider joint** (variable velocity joint).
- **(b) Ball and trunnion joint** (variable velocity joint).
- **(c) Constant velocity joints.**

FINAL DRIVE

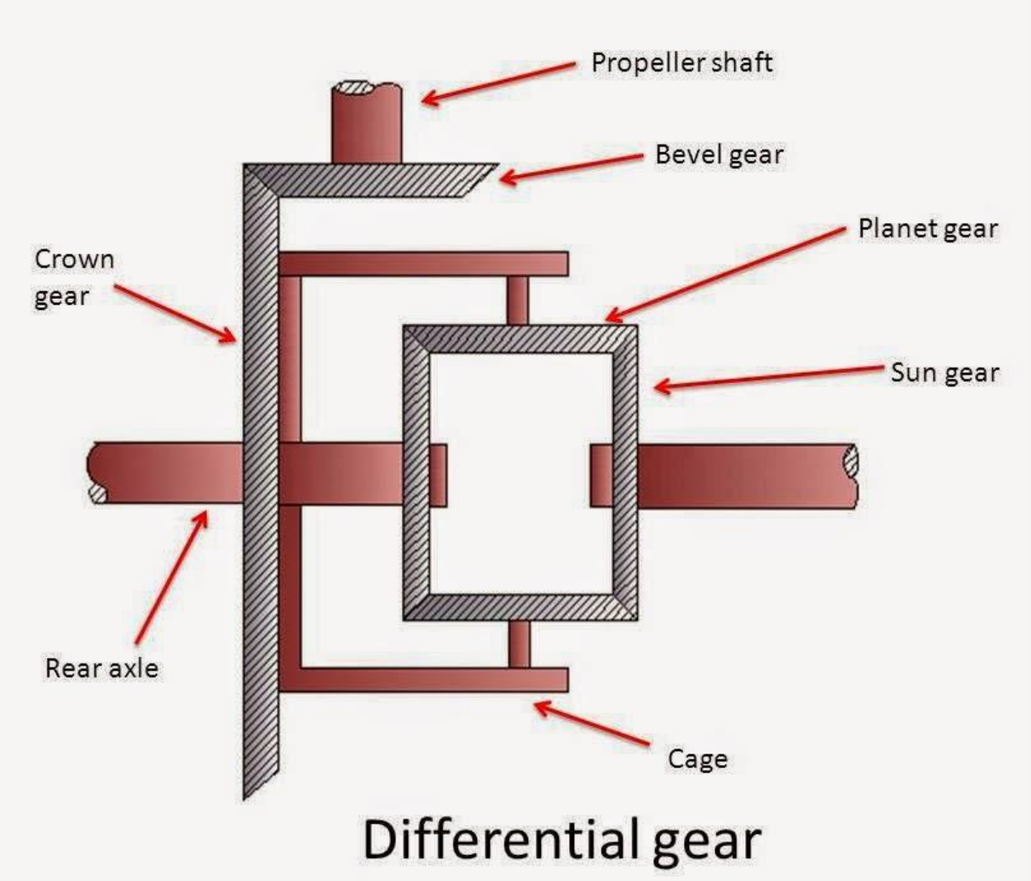
- The Final Drive is the last gearing used while transmitting the engine power to the wheels. It has two purposes. Firstly, it turns the power flow from the propeller shaft to the rear axle at the right angle. Secondly, it also provides a permanent speed reduction from the propeller shaft to the rear axle.
- The Final drive contains a pair of spiral-bevel gears comprising a pinion that connects to the propeller shaft and a ring gear that connects to a flange on the differential case.
- The pinion gets the drive from the engine while the crown wheel is attached to the wheels and rotates them. Usually, there are 3 to 4 times more teeth on the ring gear than the pinion. Thus, it provides the final speed reduction between 3:1 to 4:1 in cars 10:1 in heavy vehicles.

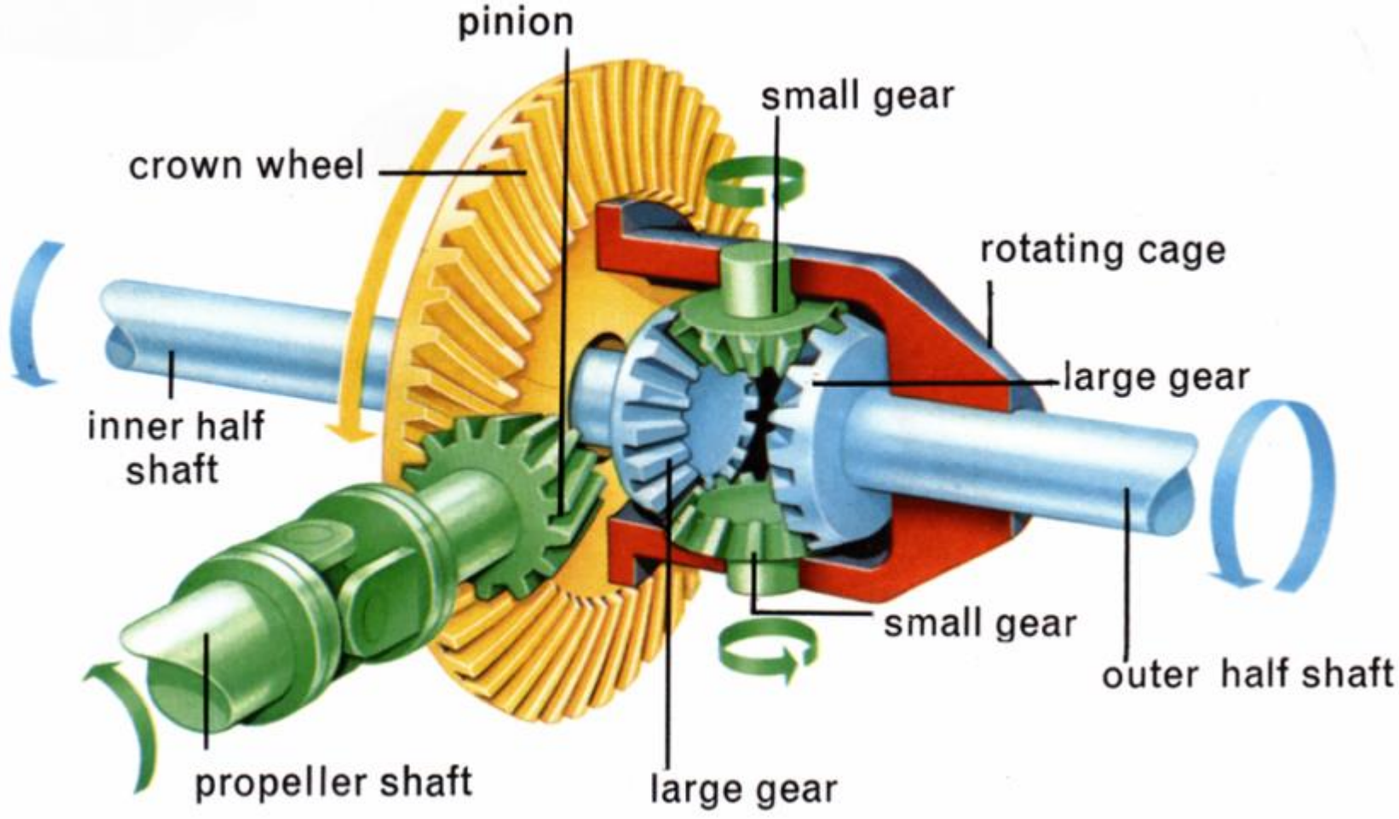
Straight Bevel Gearbox

Spiral Bevel Gearbox

DIFFERENTIAL

- The is a system of gears that allows different drive wheels (the wheels to which power is delivered from the engine) on the same axle to rotate at different speeds, such as when the car is turning.
- The differential mechanism uses multiple gears to transmit power and control RPMs in both wheels connected to each side of an axle. While changing a vehicle's direction, it determines and sends the required rotational power and speed onto each axle shaft.
- The mechanism involves seamless and inter-connected functioning of different gears, including ring gear, drive shaft bevel gear and differential bevel gear.
- A differential is a gear train, which consists of three gears, that transfers engine torque to the wheels. It takes power from the engine and delivers it, allowing each wheel to rotate at a different speed on turns.





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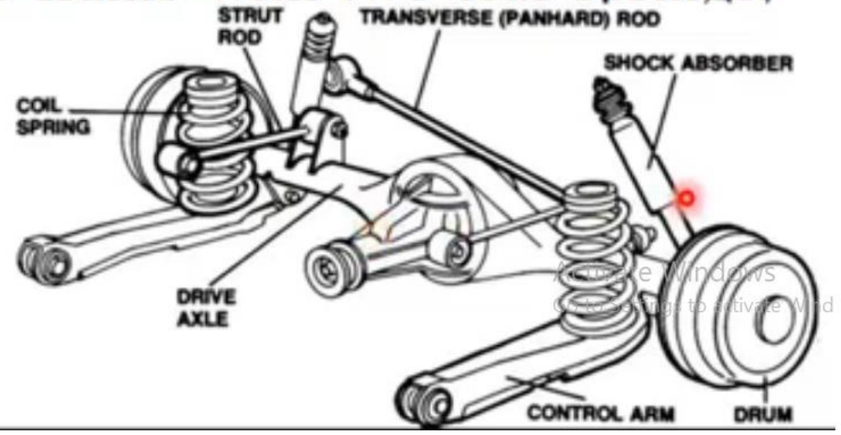
WHAT IS STUB AXLE

- A stub axle is a sub-assembly of a front axle beam upon which the road wheel mount.
- Stub axle is connected to the front axle using kingpin. These stub axles turn about the kingpin, which is light drive fit in the axle beam eye, located and locked by the taper cotter pin.

REAR AXLE

- The rear axle is also termed back axle.
- In a front engine, rear-wheel driven vehicle, the back axle is in two halves each as an output shaft from the differential.
- The differential casing is integral with the back axle which encloses the two axles extending up to the wheels.
- The back axle casing which is thick and hollow supports the weight of the vehicle at the rear end with the help of coil springs and shock absorbers.
- The rear axle casing is connected to the frame with two leaf springs, one at each rear wheel.



FUNCTIONS OF REAR AXLES

1. They supports the weight of the vehicle.
2. They drive the rear wheels via the final drive.
3. They rotate the power flow at the final drive by 90° on either side for driving the wheels.
4. The rear axle casing which is integral with the differential or the final drive casing offers space for filling the lubricant for the final drive components.
5. The rear axle casing serves as a protective guard for the rear axles which extend from the differential to the rear wheels.

Semi-Floating Axle

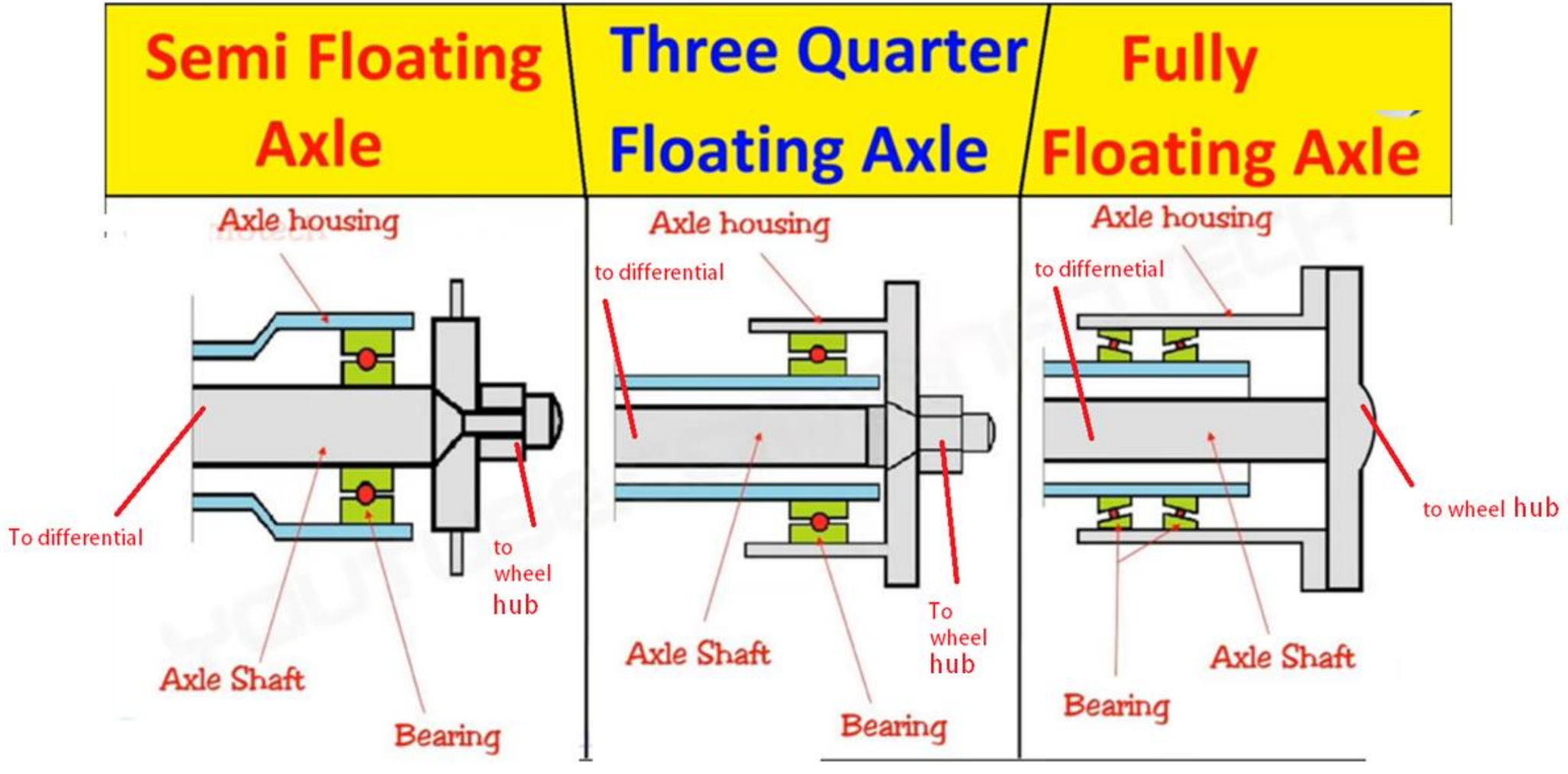
- A semi-floating axle has a bearing located on the axle and inside the axle casing. It has to support all the loads . Therefore, it needs to be of a larger size, for the same torque output, than any other type. The inner end of the axle is supported by the differential side gear.
- The outer end has to support the weight of the car and take end thrust. The inner end of the axle is splined to the differential side gear.
- The outer end is flanged so that the wheel can be bolted directly to it. In some design, the hub of the wheel is keyed to the outer end of the axle. The vehicle load is transmitted to the axle through the casing and the bearing, which causes the bending or shearing of the axle.
- The semi-floating axle is the simplest and cheapest of all other types and widely used on cars.

Three-Quarter Floating Axle

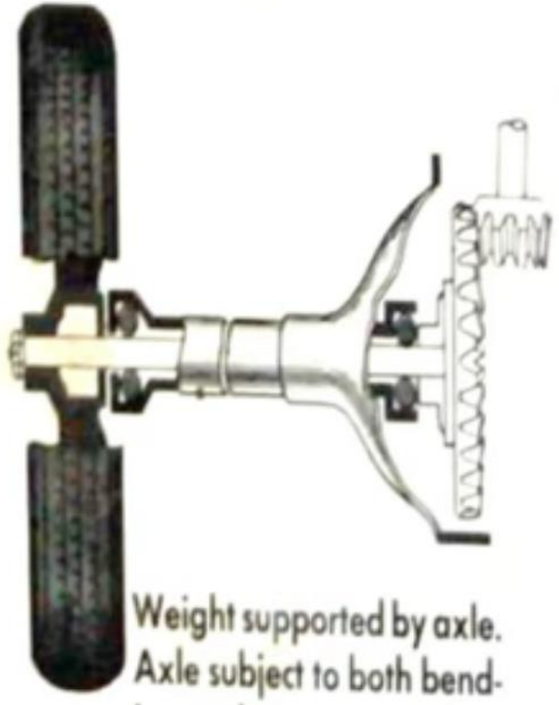
- This type of axle has a bearing placed between the hub and the axle casing. Thus, the weight of the vehicle is transferred to the axle casing, and only the side thrust and driving torque are taken by the axle.
- The axle is keyed rigidly to the hub, thus proving the driving connection and maintaining the alignment of the wheel. The inner end of this axle has the same construction as that of the semi-floating axle. Although the three-quarter floating axle is more reliable it is not as simple as the semi-floating axle.

Full-Floating Axle

- A full floating axle has two deep groove ball or taper roller bearings, located between the axle casing and wheel hub. The outer of an axle is made flanged to which the wheel hub is bolted. The axle is not supported by bearing at either end, and its position is maintained by the way that it is supported at both ends.
- Thus the axle is relieved of all strain caused by the weight of the vehicle on the end thrust. It transmits only the driving torque. For this reason, it is called full floating. The axle may be removed from the housing without distributing the wheel by removing the nuts.
- An additional advantage of this design is the ability to the vehicle even if it has a broken axle. This type of axle is more, expensive and heavier than the other axle. It is usually fitted on commercial vehicles.

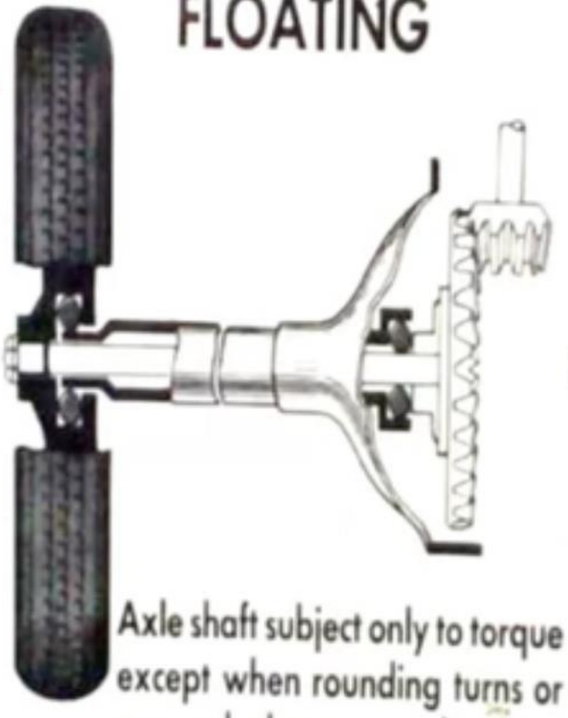

Semi Floating Axle
Three Quarter Floating Axle
Fully Floating Axle
Axle housing
To differential
to wheel hub
Axle Shaft
Bearing
Axle housing
to differential
Axle Shaft
To wheel hub
Bearing
Axle housing
to differnetial
to wheel hub
Bearing
Axle Shaft

SEMIFLOATING



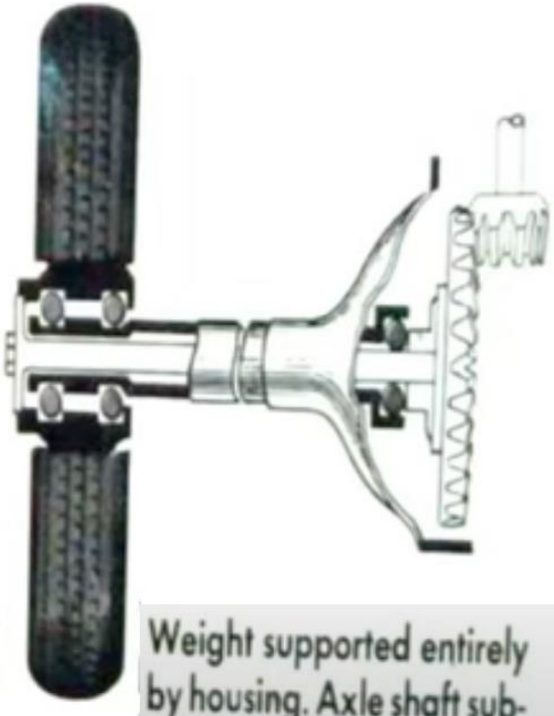
Weight supported by axle. Axle subject to both bending and torque.

THREE QUARTERS FLOATING



Axle shaft subject only to torque except when rounding turns or on roads that are not level.

FULL FLOATING



Weight supported entirely by housing. Axle shaft subject only to torque.