CHASSIS, FRAMES AND DRIVES

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FRAME , CHASSIS & BODY

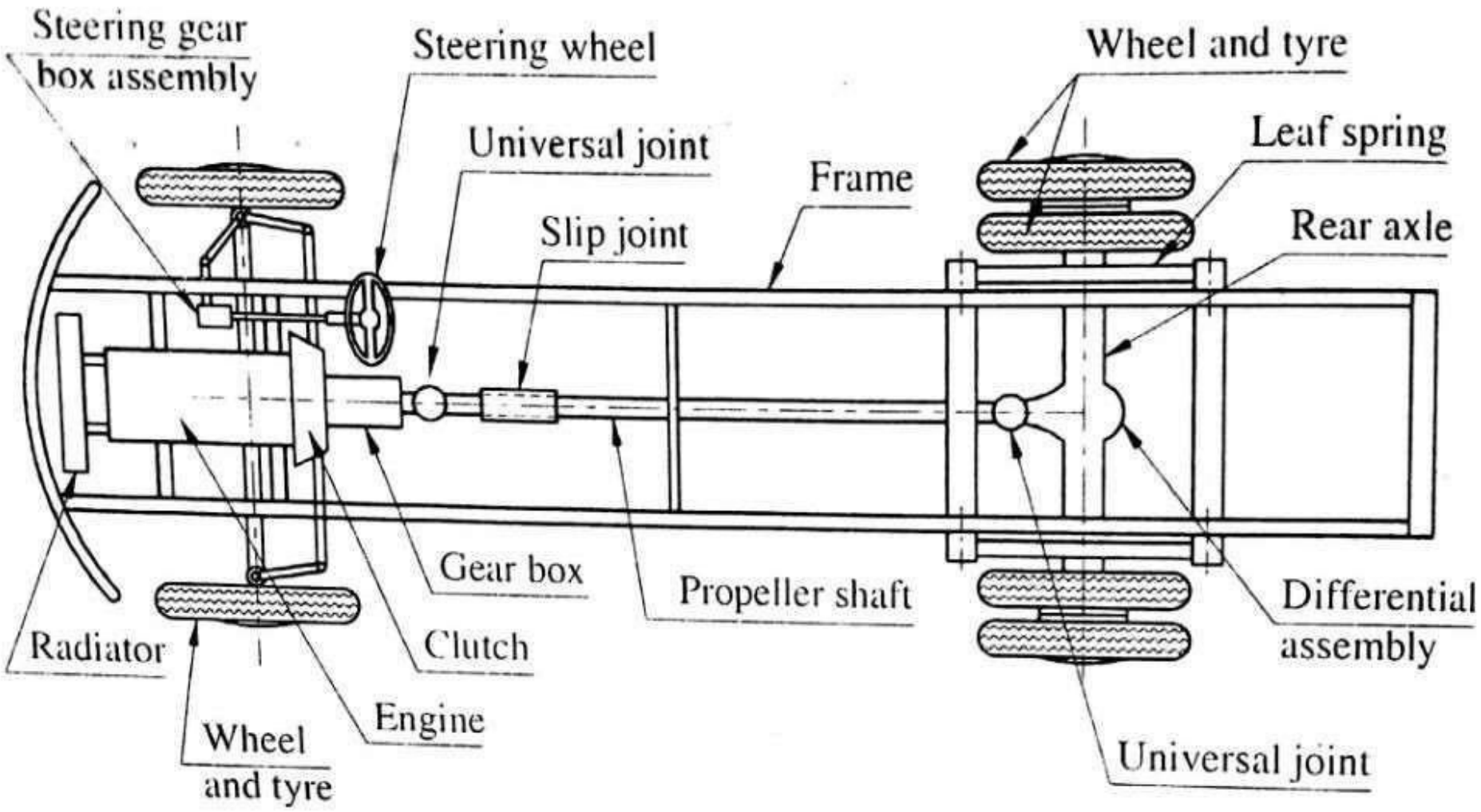
FRAME

- It is the supporting component of automobile vehicle.
- It is the foundation for carrying the engine, transmission system & steering system by means of spring , axle , rubber pads etc.
- The frame are made of box , tubular channels or U-shaped section , welded or riveted together.

CHASSIS

- When engine , transmission system , steering & wheels are fitted on the frame , the assembly known as the "chassis".
- It is the backbone of the vehicle.
- It is the vehicle without body.
- It contains all the major units necessary to propel the vehicle.
- Vehicle can be driven after placing the driver seat on the chassis.

SIMPLE CONSTRUCTION OF TRUCK CHASSIS



- Chassis consist of following components:

1. Engine
2. Wheels
3. Radiator
4. Brakes
5. Fuel tank
6. Steering system
7. Suspension system
8. Transmission system (clutch , propeller shaft , differential , rear axle)

BODY

- It is a super structure of the vehicle.
- Chassis & body makes the complete vehicle.
- For small & light car body & chassis are made as a single unit but in large vehicles both are made as a single unit.
- Generally it is made from metal or fibre.
- Main purpose of car body is to provide comfort & protection to the passenger & also the good look.

TYPES OF BODIES FOR CAR

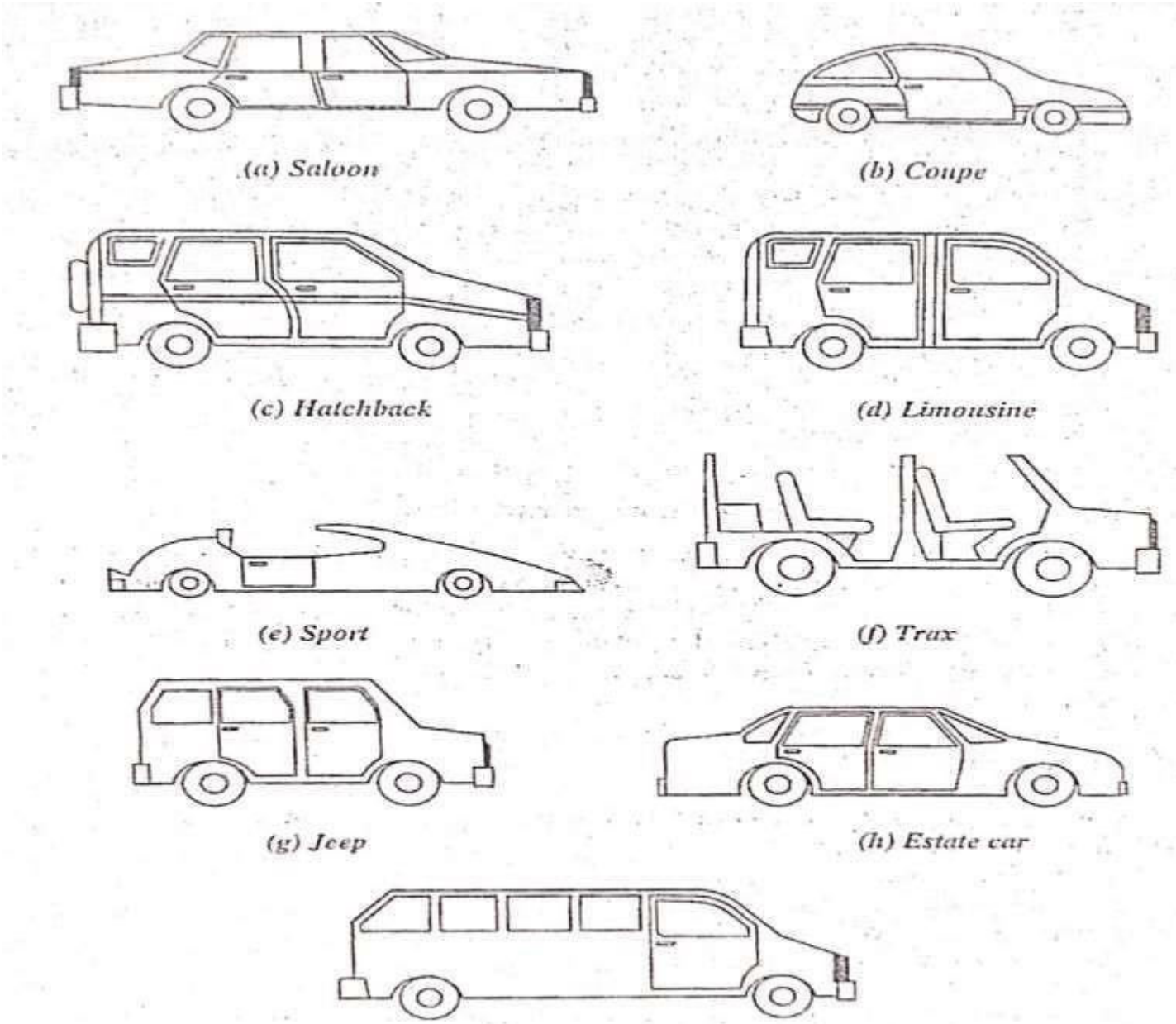


Fig. 2.11 Different types of bodies for car

FUNCTION OF FRAME

1. To support chassis components & the body.
2. To withstand the static & dynamic load of different components of chassis.
3. To withstand load of the body.
4. To carry load of passengers/goods carried in body.
5. To withstand stresses caused due to uneven road conditions.
6. To withstand force caused due to turning of vehicle & sudden braking or acceleration.

TYPES OF FRAME

1. Conventional frame
2. Integral or Unit construction or Frameless chassis
3. Half integral & half frame chassis

(i)CONVENTIONAL FRAME

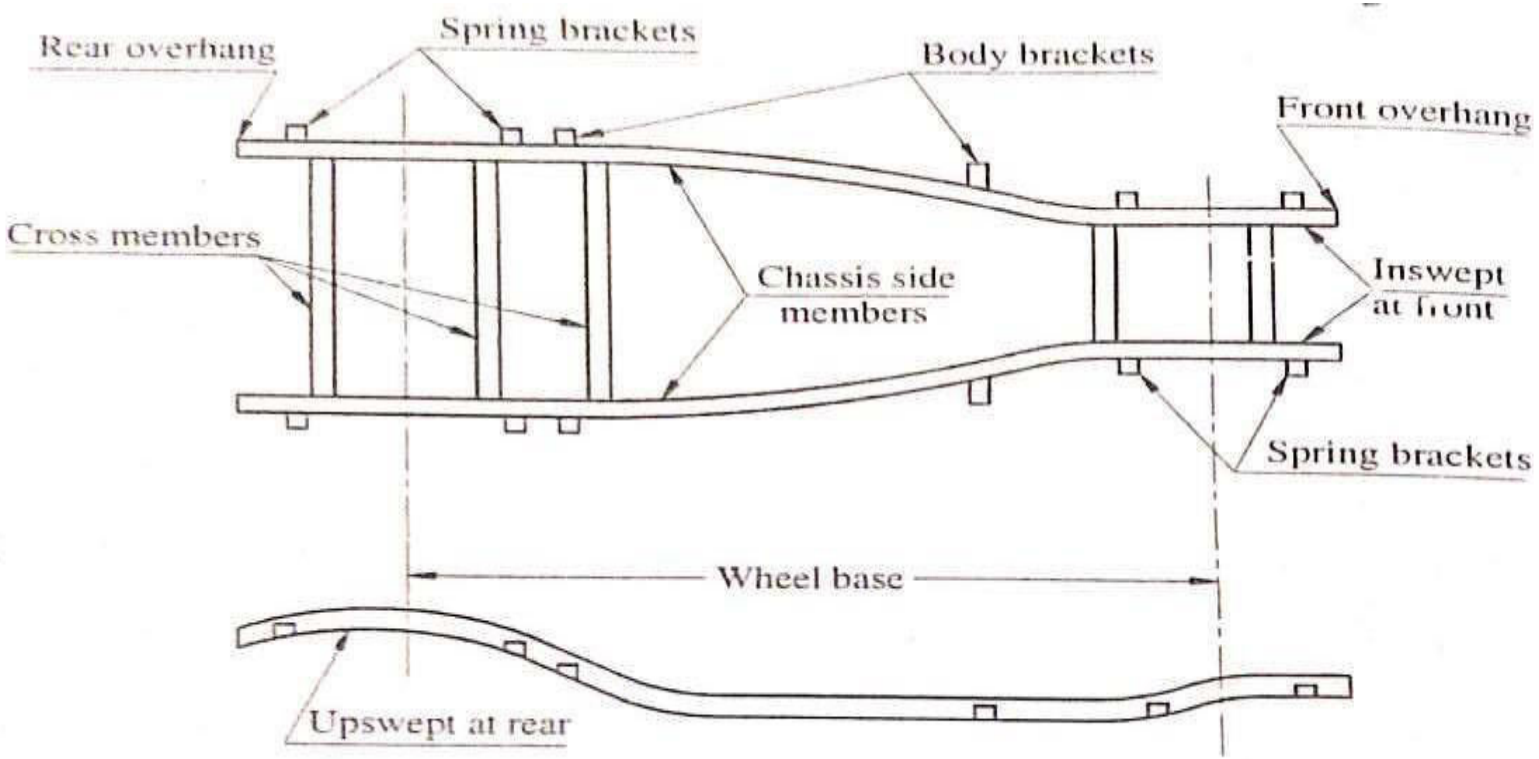


Fig. 2.3 Conventional frame construction

- It is used in most of the heavy vehicles.
- Construction of frame varies according to the type of vehicle.
- Generally made from the steel sections.
- This type of frame has "2 long side members" & "5 to 6 cross members" joined together with the help of rivets or bolts.
- Cross members are used to increase the strength of the frame.
- They are inswept (Narrow) at the front & are upswept (Broad) at the rear.

- The frame is narrowed down at the front (inswept) to have a better steering lock which provides space for pivoting & swinging of the front wheels.

- Upswept at the rear provided to give room for the vertical movement of the rear axle as it travels over road bumps & other road inequalities.
- Body brackets are provided to support the body of the vehicle.
- Spring brackets are provided for mounting the body of the vehicle.
- Extension of chassis frame ahead of the front axle known as front overhung.
- Extension of chassis beyond the rear axle known as rear overhung.
- Different sections are used for long & cross members. Generally channel section & box section are used for long side members & other sections like I section , hat section , tubular section are used for cross members.

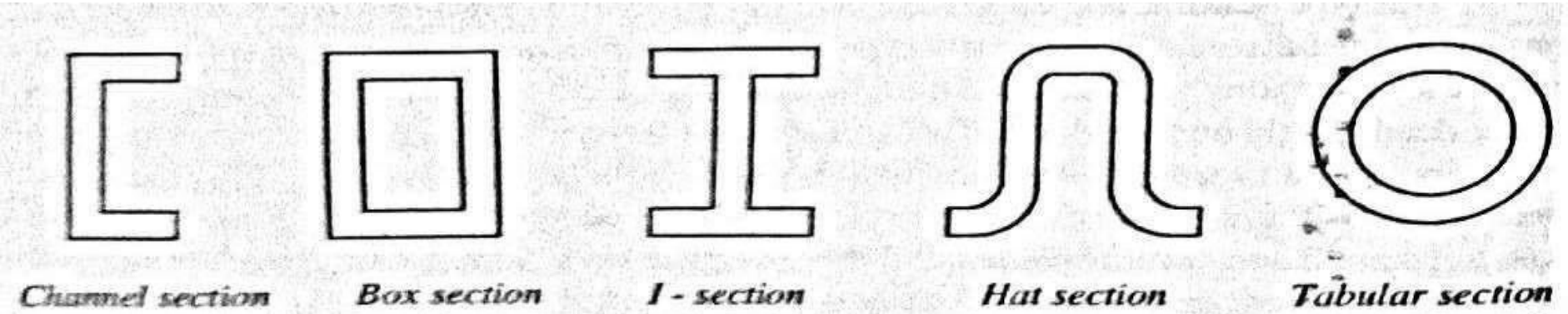


Fig. 2.4 Frame sections

(II) INTEGRATED FRAME CHASSIS or FRAMELESS CHASSIS

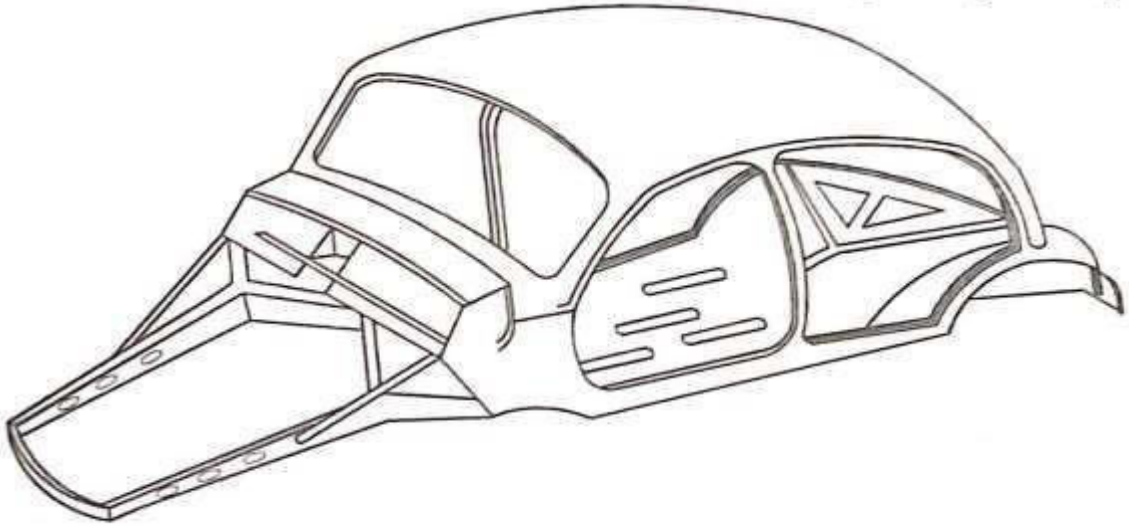
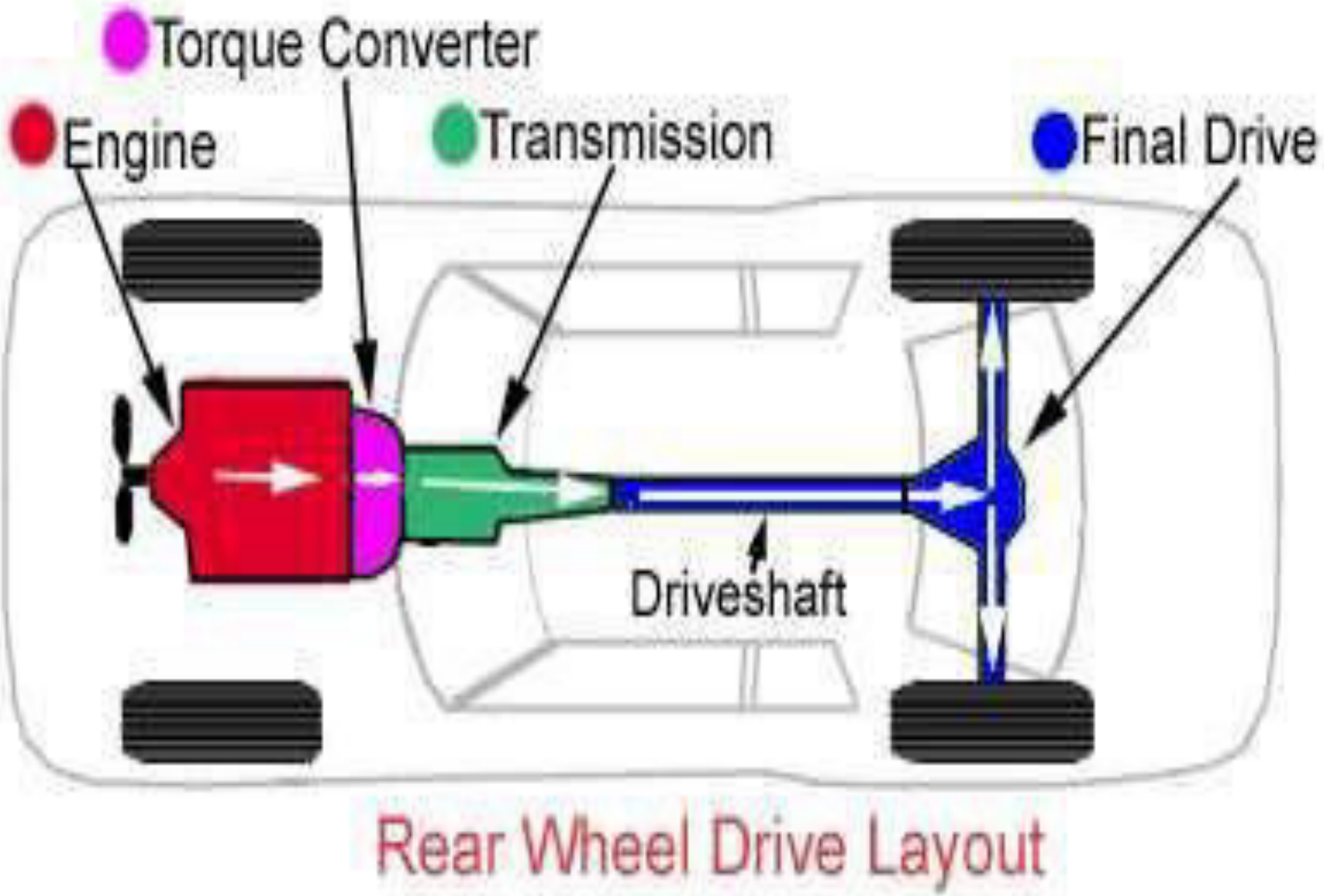


Fig. 2.5 Integrated body and frame construction

- This frame construction, now-a-days used in most of the motor cars called as a frameless or chassisless or mono or unit construction in which the floor assembly & frame form one integral unit.
- Need of the heavy side members are eliminated ,which is used in conventional frame & the floor is strengthened by cross members & body , all welded together.
- In some cases sub-frames are also used on which various chassis components are mounted. This sub-frames are supported by main frame.
- The main purpose of sub-frame are to provide isolation , flexibility & simplified production.
- So, in this type of construction all components like cross member , floor , body are welder or bolted together as one assembly.
- This type of construction gives more strength & rigidity.

FRONT ENGINE – REAR WHEEL DRIVE

- In this chassis layout ,the engine is fitted at the front.
- The engine ,clutch and gear box are fitted at front while drive to the rear axle is given with the help of propeller shaft
- This chassis layout is one of the oldest and still remain popular for heavy commercial vehicle.



Rear Wheel Drive Layout

ADVANTAGE OF FRONT ENGINE – REAR WHELL DRIVE

- The weight distribution is reasonably balanced between the front and rear wheels, which gives good handling characteristics.
- Due to engine and radiator are at front , the forward facing radiator takes full benefit of the Ŷatural air streaŵ , Đreated ďy vehiĐle’s movement .hence reduce the power losses for a large fan.

- The weight of vehicle is shifted to rear driving wheels during acceleration and on steeps resulting in better road grip ,hence ,there are less chances of wheel slipping .
- Since the front wheel are used only to steer the vehicle , hence steering mechanism become simple in design and easy to operate.
- Accessibility to various components like engine , gear box and rear axle is better in comparison to outer layout

- The control linkages –accelerator ,clutch ,choke ,and gear box are shot and simple.
- Large luggage space is available at back of vehicle which providing increased carrying capacity as well as space for easy body extension .

DISADVANTAGE

- During the breaking ,weight of vehicle is fitted to front wheels and weight on rear wheels decreased , results in decreased breaking effort developed
- It required long propeller shaft and diffrential at rear

,therefore height of floor area is increased .Also,due to long propeller shaft transmission problems and weight are increased.

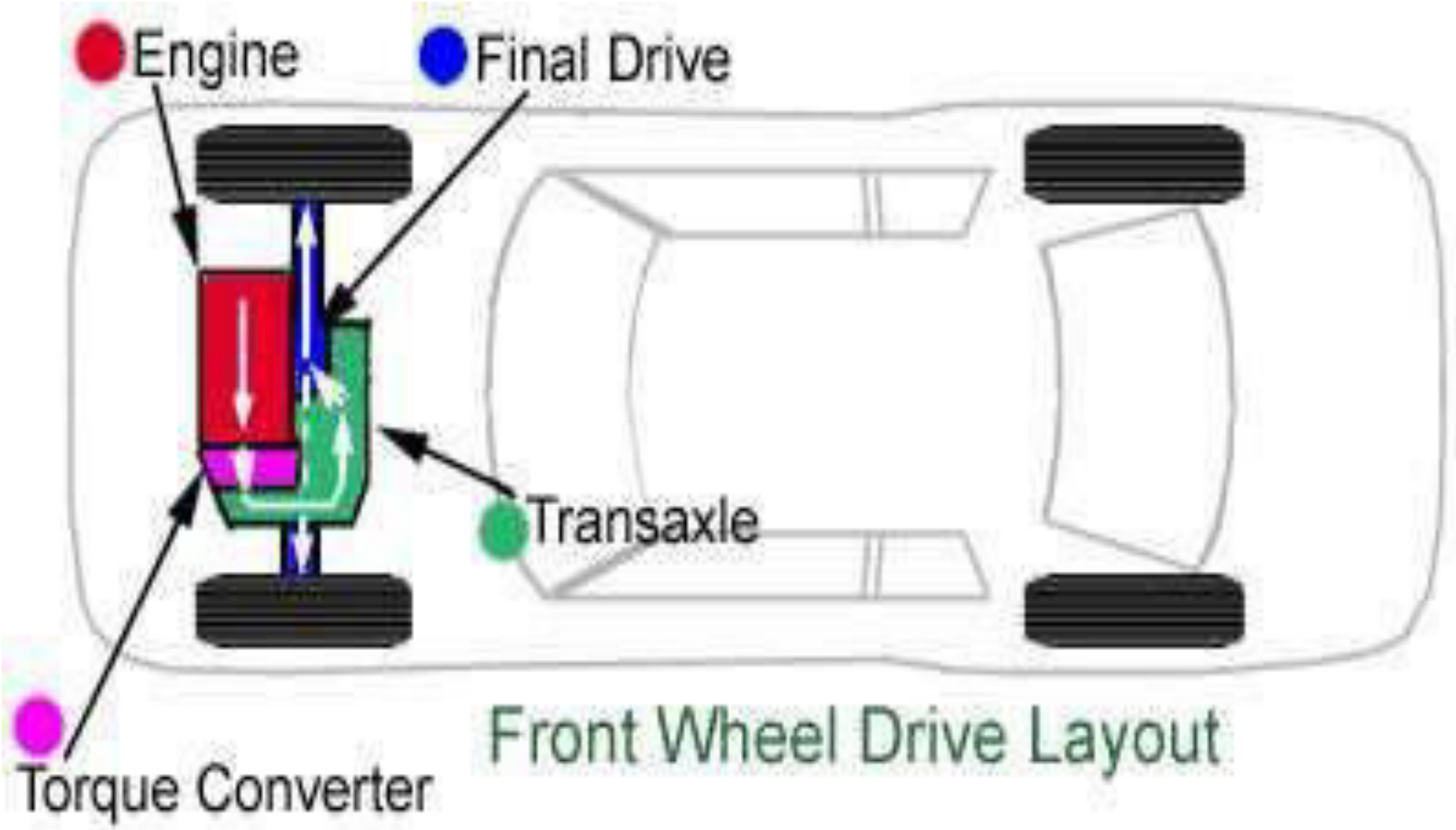
- Due to less weight on driving rear wheels , there is less

adhesion on road and result in less holding capacity

.therefore there is less chance of suidding on slippery surface.

FRONT ENGINE –FRONT WHEEL DRIVE

- In this type of chassis layout the engine is fitted at front and drive is also given to the front wheel .No propeller shaft is used in this layout and diffrential are included in the same assembly.
- This layout provides optimum body luggage space and flat floor line .However , due to all assemblies at front ,it make very difficult to accommodate the steering mechanism.


Engine
Final Drive
Transaxle
Torque Converter
Front Wheel Drive Layout

ADVANTAGE OF FRONT- WHEEL DRIVE

- Due to more weight placed on driving front wheel

, the vehicle has more adhesion on road.Hence good road holding capacity evn on the curves and slippery roads .

- This layout provides low floor , sinces no propeller shaft and the diffrential placed at front instead of rear.
- The clutch ,gearbox, and final drive usually made as one unit thereby coast of vehicle is reduce.

- The wheel do not take to sharply turn into the curve due to tendency of understeering .the understeer condition generally preferred by many drivers are promoted by this type of chassis.
- Either a transverse or longitudinal engine position can be used .In case of transverse mounted engine , as the engine crankshaft and wheels already rotate in the parallel planes ,therefore, they do not require their drive to be turned through 90degree as in case of conventional longitudinally mounted engines.

DISADVANTAGE

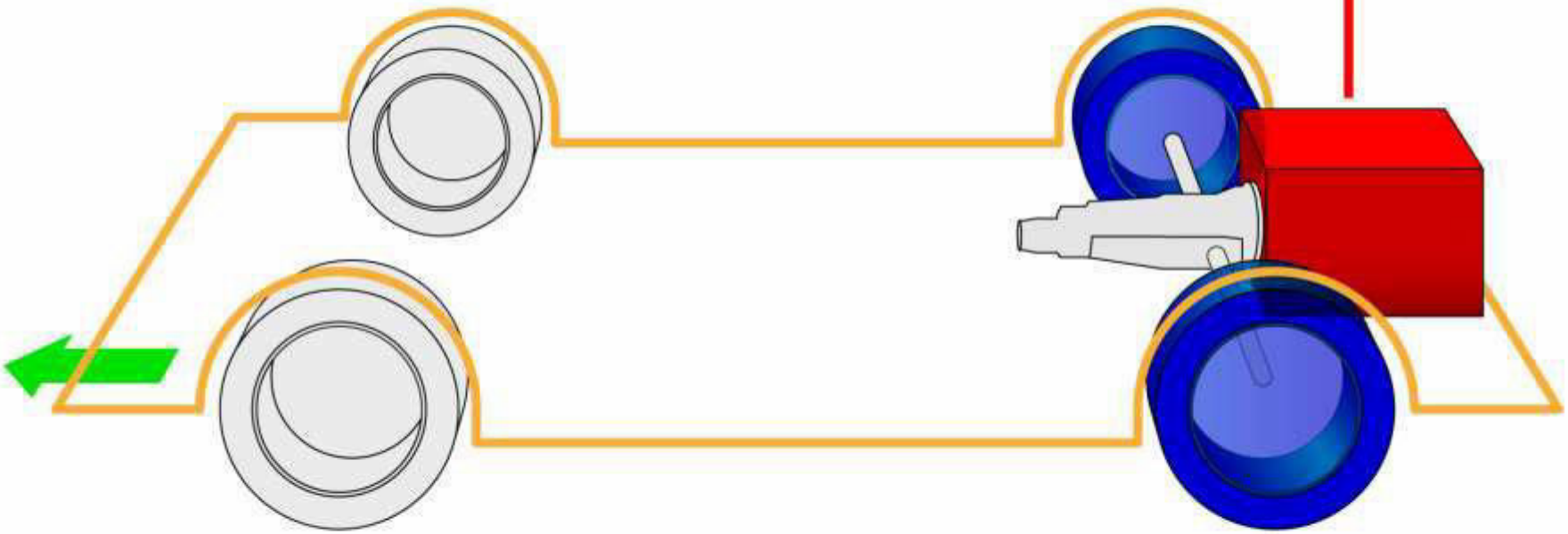
- The weight on the driving front wheels is reduced during acceleration and climbing of steep gradient due to weight of the vehicle shifting to the rear wheels . Hence ,result in decreased tractive effort.
- This dis advantage become more serious on slippery gradient.
- The steering mechanism become more complicated due to accommodation of engine ,clutch ,gearbox & final drive all at front of vehicle.

REAR ENGINE-REAR WHEEL DRIVE

- In this chassis layout engine is fitted at the back and drive is also given to rear wheel
- This arrangement eliminate the necessity for a propeller shaft because engine is mounted near the driven wheel.
- The passenger are kept away from inconveniences like noise, heat and fumes because engine at back of vehicle

RR

Rear-engine



Rear-wheel drive

DISADVANTAGES

- Efficient cooling becomes very difficult to obtain due to air passes through side part of the body
- Long linkages are required to connect the control panel and engine , gear box ,accelerator and clutch.
- The wheel get turned too sharply into the curve due to tendency of oversteering

4 WHEEL DRIVE

4 WHEEL DRIVE

4 WHEEL DRIVE

- 4X2 = 4 Wheel vehicle and 2 Wheels can receive torque.
- 4X4 = 4 Wheel vehicle and all 4 Wheels can receive torque.
- E.g. are Jeeps, SUVs(Sports Utility Vehicle), etc.
- Games derived it’s name from 4WD only.
- Used mostly in defense services or where graveled or slick roads are present.

WHY 4WD ARE USED?

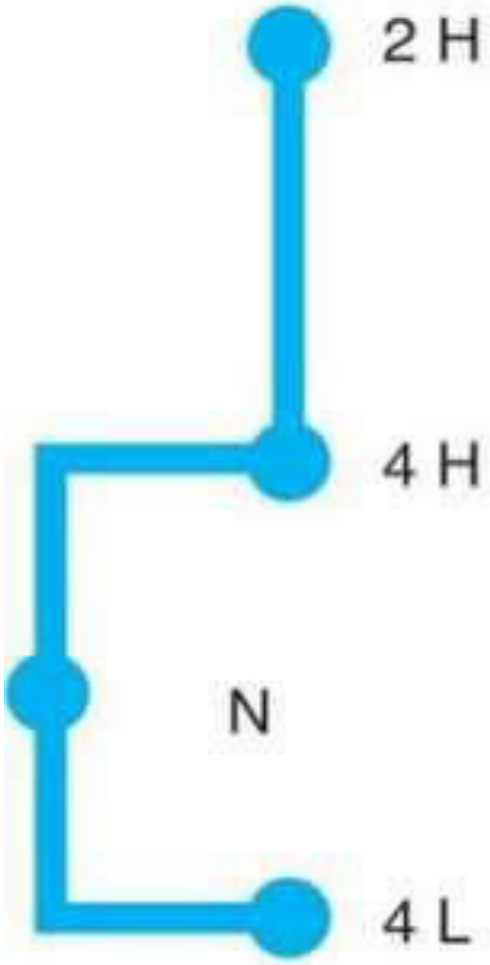
- To get enough “TRACTION” between wheels and road surfaces.
- To move vehicle on slick surfaces, dirt, slippery roads, sand roads and snowy, muddy roads etc.

PART TIME 4WD

–Manual Shift.

–Equipped with Switching mechanism.

–Select 2WD under normal condition and 4WD on off-road situation.



ADVANTAGES

- Increased Traction is obtained in slippery surfaces.
- More balanced axle load distribution.
- Even tire wear.

DISADVANTAGES

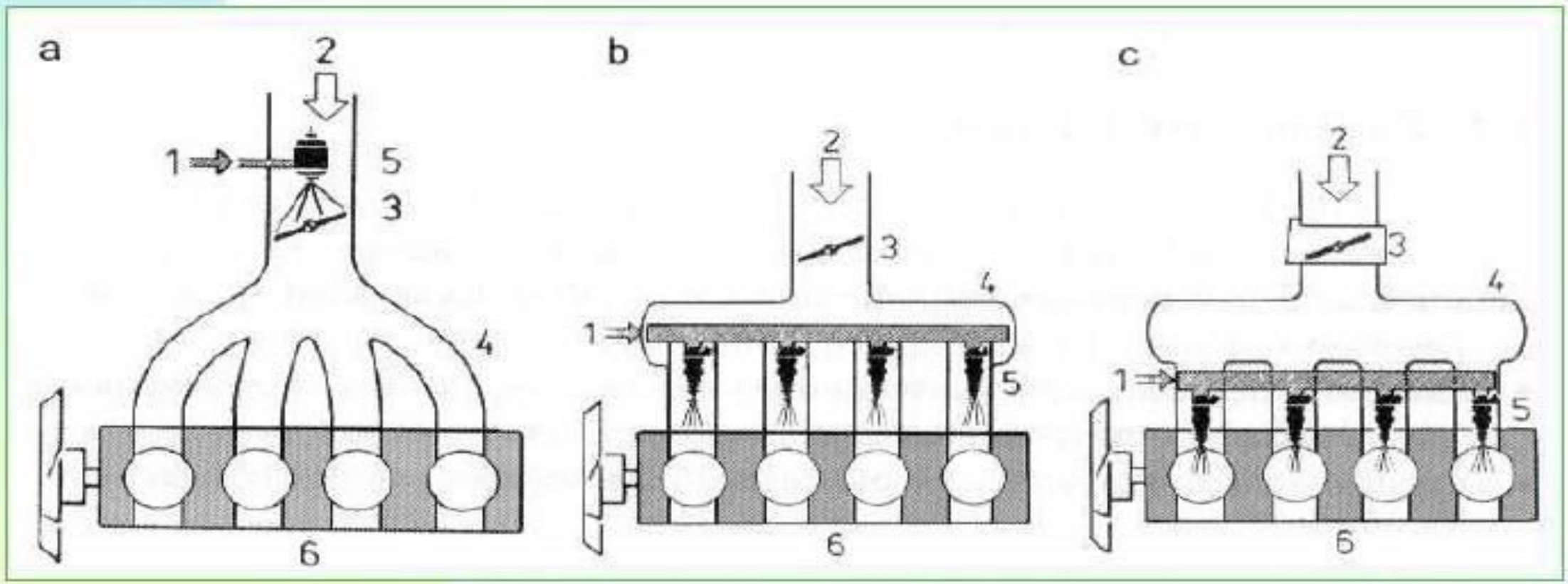
- Weight of vehicle is increased.
- Cost vehicle is increased.
- Maximum speed of vehicle is reduced.
- Less fuel economy than 2WD.

Fuel Injection System

Why fuel system is required?????

- To Supply a proper Ratio of Gasoline and Air to Cylinder.
- To supply power on demand.
- For low fuel pollutant emission.
- To increase the efficiency of petrol engine compare to carburetor engine.

Type Of Injection System on the basis of Injector Position



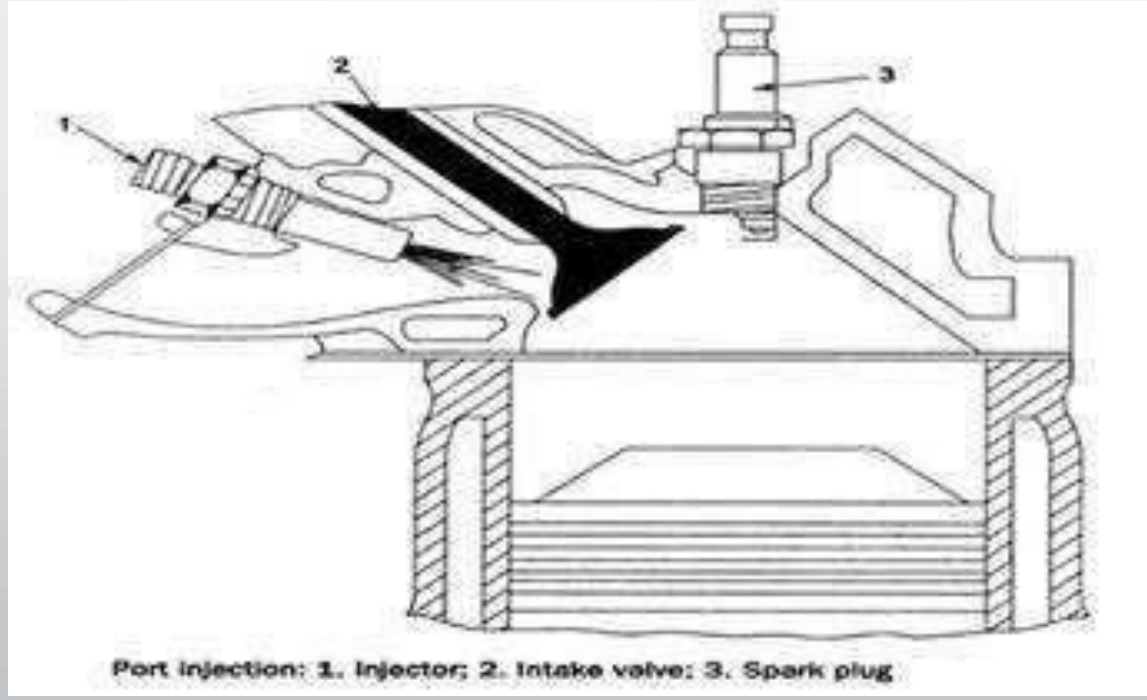
a) single-point, b) multi-point, c) direct injection

MPFI

- Multiport fuel injection injects fuel into the intake ports just upstream of each cylinder's intake valve.
- In this system each cylinder has number of injectors to supply or spray fuel in the cylinders intake manifold space
- MPFI system injects fuel into individual cylinders, based on commands from the "onboard engine management system computer" popularly known as the **Engine Control Unit/ECU**.
- These techniques result not only in better "power balance" amongst the cylinders but also in higher output from each one of them, along with faster throttle response.

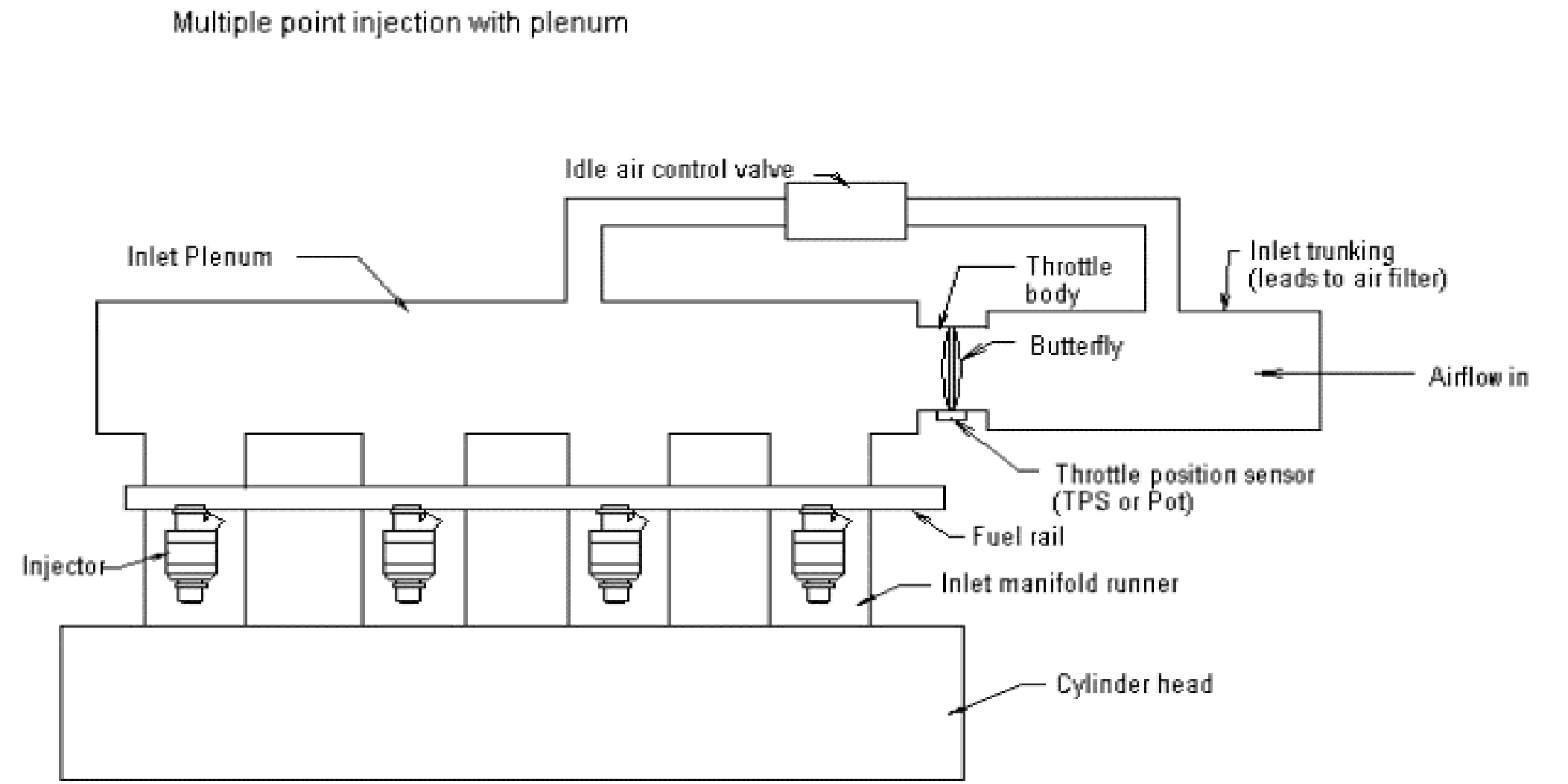
Port Type system

- The Injector is Placed in the Intake Manifold near the intake Port .
- The Injector Sprays Gasoline into the Air inside the manifold .
- Fuel & Air mix in Uniform manner And this mixture Entered into Cylinder .



Port injection: 1. Injector; 2. Intake valve; 3. Spark plug

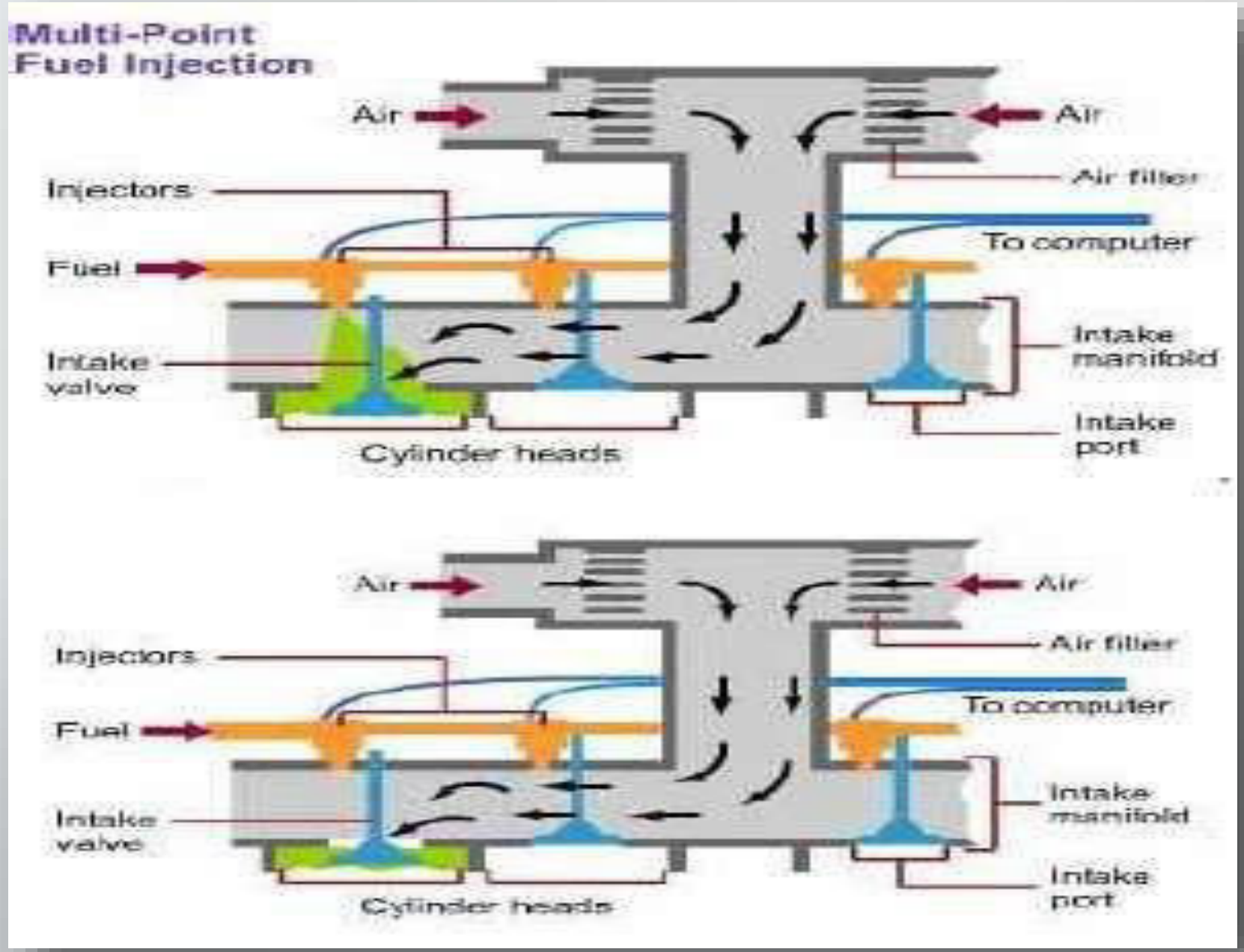
Another design of Port Type system



Components of MPFI

The system has four major components they are

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


Multi-Point
Fuel Injection
Air
Air
Air filter
Injectors
To computer
Fuel
Intake
manifold
Intake
valve
Intake
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Air
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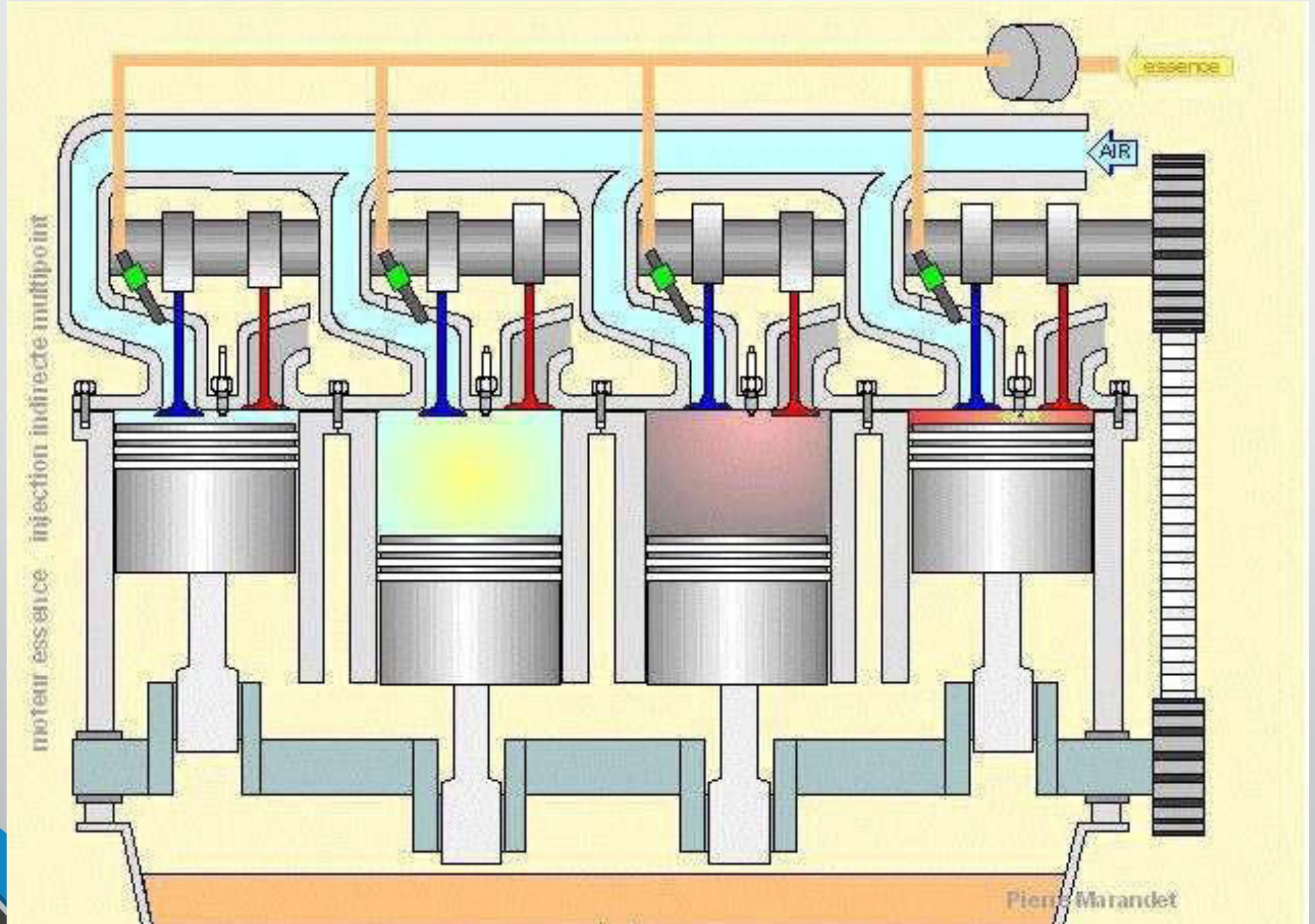
Cylinder heads


moteur essence injection indirecte multipoint
essence
AIR
Pierre Marandet

AIR INTAKE SYSTEM

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

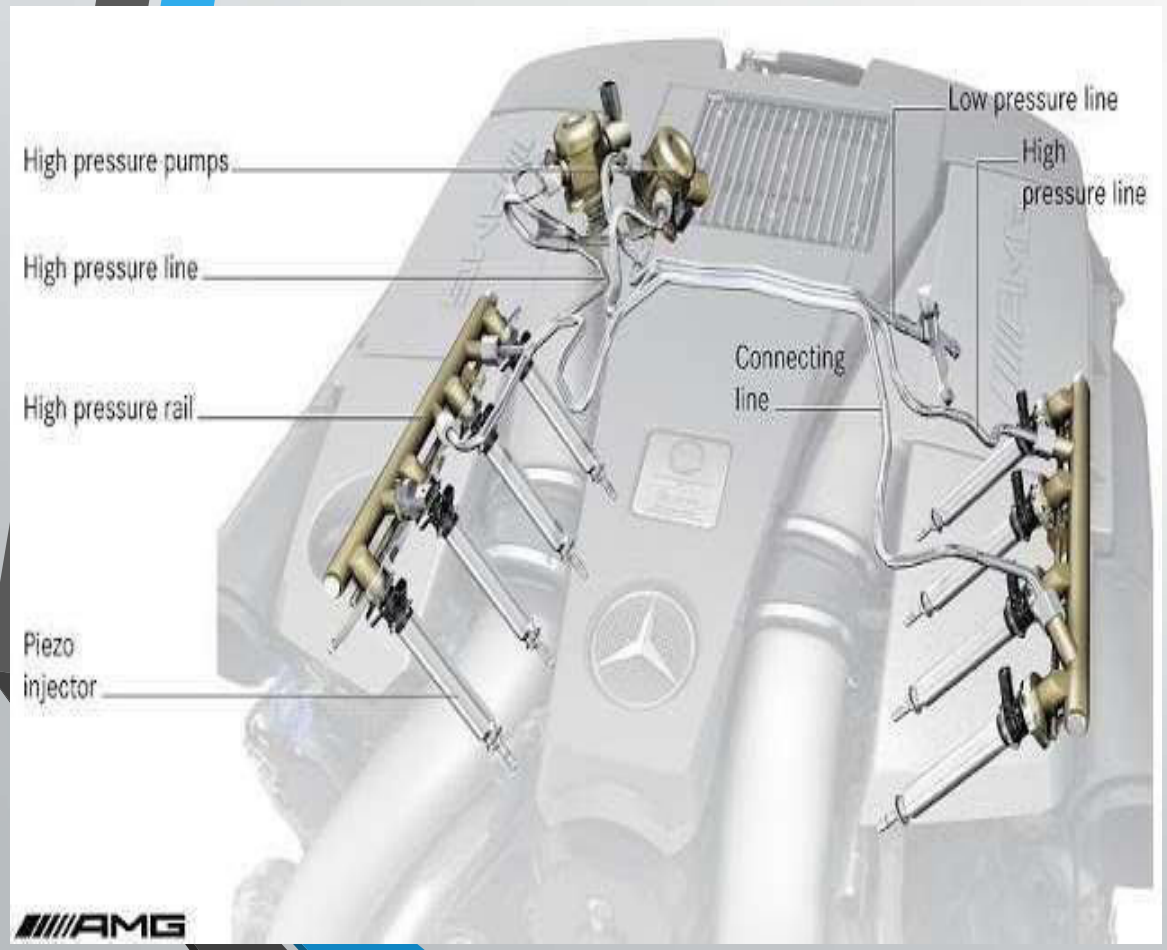
1. **Throttle Body** -Throttle valve, which is interlocked with the accelerator pedal and controls the amount of the intake air . TP sensor which detects the throttle valve opening and sends a signal to ECM
2. **Idle Air Control Valve** -The IAC valve controls opening of the bypass air passage. The air bypasses the throttle valve through bypass passage and is finally drawn into the intake manifold.

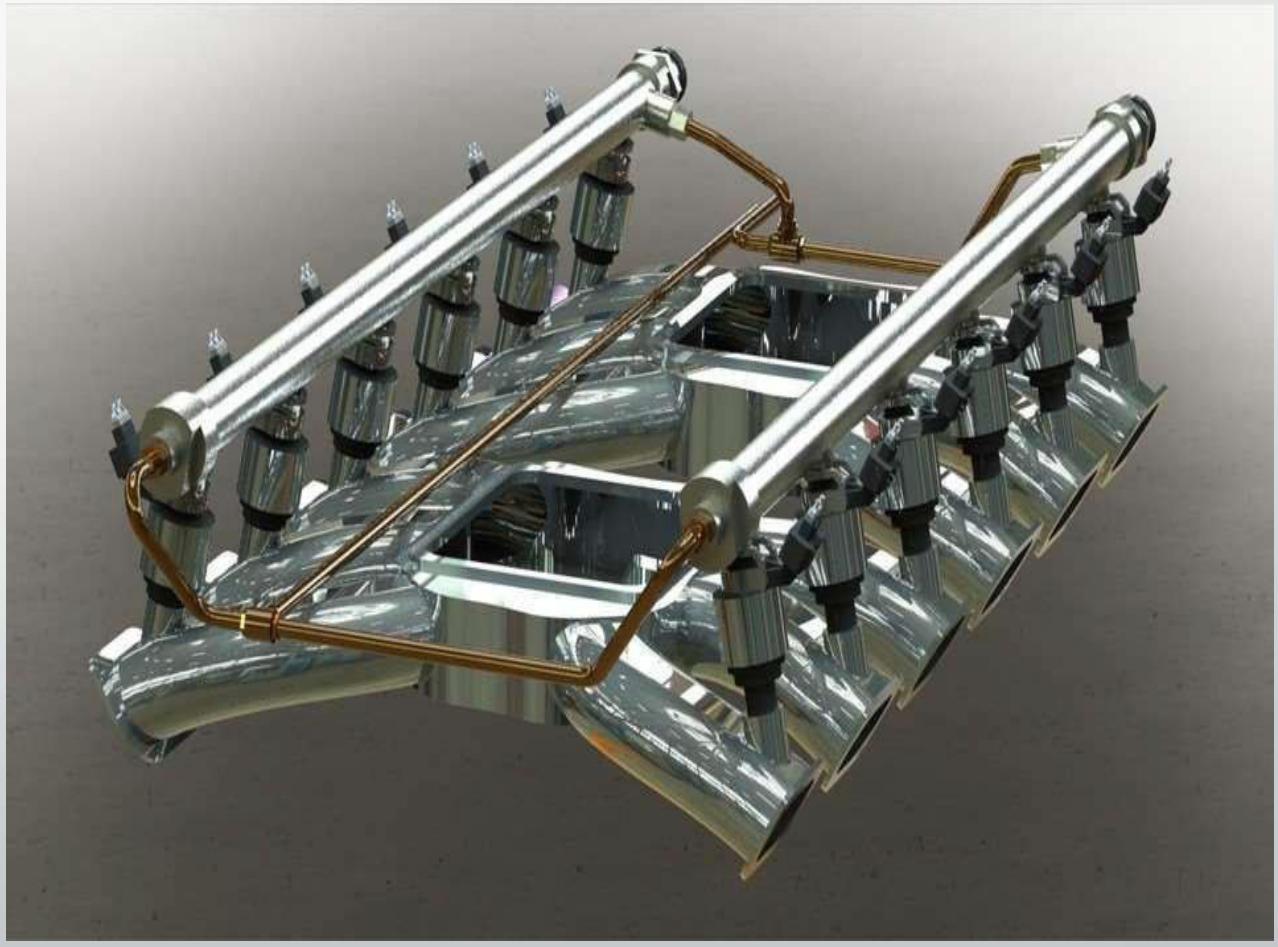
FUEL DELIVERY SYSTEM

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

1. **Fuel Pump-** It is an electric fuel pump and its operation is controlled by ECM**.** The fuel is drawn through the inlet port with high pressure, It is discharged through the outlet port, the fuel pump also has a check valve to keep some pressure in the fuel feed line even when the fuel pump is stopped.
2. **Pressure Regulator System-**The fuel pressure regulator is diaphragm operated relief valve consisting of diaphragm, spring and valve. It keeps the fuel pressure applied to the injector *2.9Kglcm higher* than intake manifold at all times
3. **Injector-**Each cylinder has one injector, which is installed between the intake manifold delivery pipes. It is an electromagnetic type injection nozzle, which injects fuel into the intake port of the cylinder head according to the signal *from* ECM.

8 &12 Cylinder MPFI





ELECTRONIC CONTROL SYSTEM

The electronic control system consist of various sensors which detect the state *of* engine and driving conditions, ECM which controls various devices according to *the* signals from the sensors and Various controlled devices.

The systems are -

- **Fuel Injection Control System**
- **Idle Speed Control System**
- **Fuel Pump Control System**
- **Ignition Control System**
- **Radiator Fan Control System**

Fail- Safe Function

When a trouble has occurred in such area of electronic fuel injection system that includes the following parts and a *failure* signal is sent to ECM. Control over the injector, idle air control valve and others are maintained on the basis of the standard signals and/or CPU. This function is called **failsafe function**. Thus with this function a certain level of engine performance is available even when some failure occurs .

Type Of MPFI Systems

- The various types of MPFI systems are:

1. **Simuntaneous**: Together in all the cylinders.
2. **Sequential**: Direct injection into the individual cylinders against their power strokes.
3. **Group**: In cylinder pairs [in V engines]

Choosing the correct technique according to the engine configuration results in:

- better power balance between cylinders

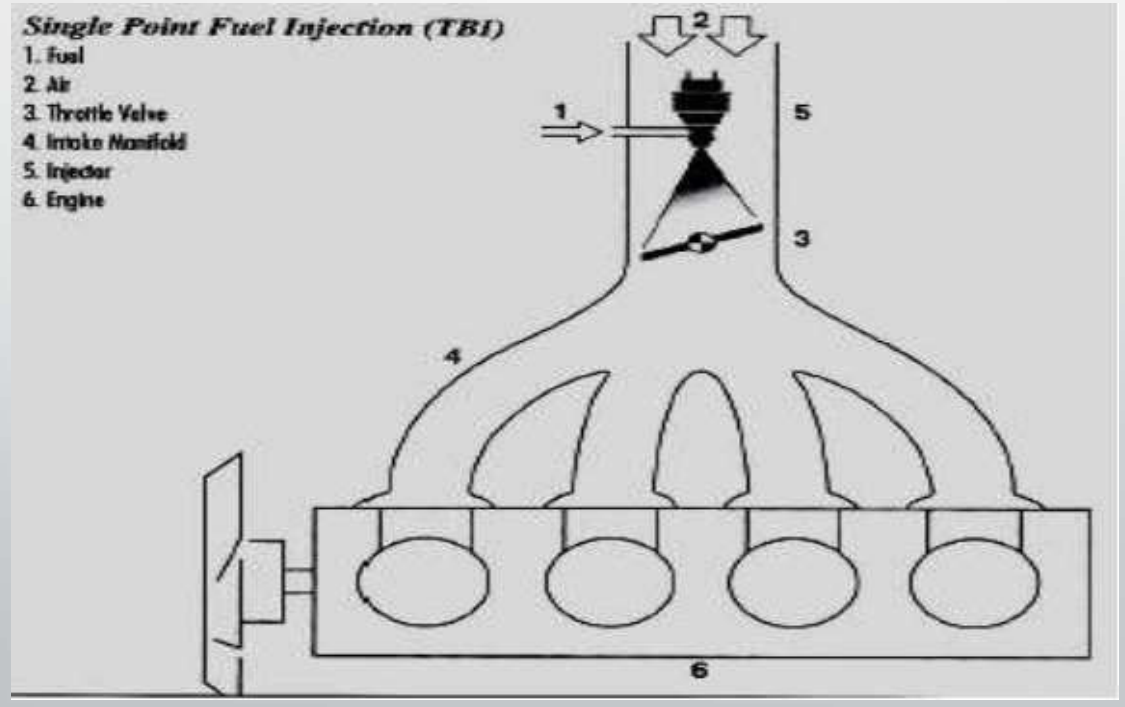
- higher output from each cylinder

- faster throttle response

- Of these technologies, sequential gives the best combination of power balance and output in inline 4 cylinder engines.

Throttle Injection system

- ✓ This is similar to carburetor Body with throttle valve controlling the amount of Air entering intake manifold .
- ✓ The sensor is used to control the fuel mixing level.



Advantages of MPFI

I. Without using of carburetor the product cost is Low.
II. Engine Efficiency is High.
III. Low Maintenance.
IV. High Power to Engine.
V. No extra Heating While Warm up. Etc,.

Disadvantage Of MPFI

1. Hood Height of the Car is High.
2. Manifold Heat control System OR Valve is Required.
3. Intake Manifold control only air not Fuel .

Throttle fuel injection system

What is the difference between quality control and quantity control

Quantity control

- Quantity of supllied air
- Quantity of supplied fuel

Quantity is controlled over here generally the Composition of mixture formed is

1kg of petrol & 14.7 kg of air

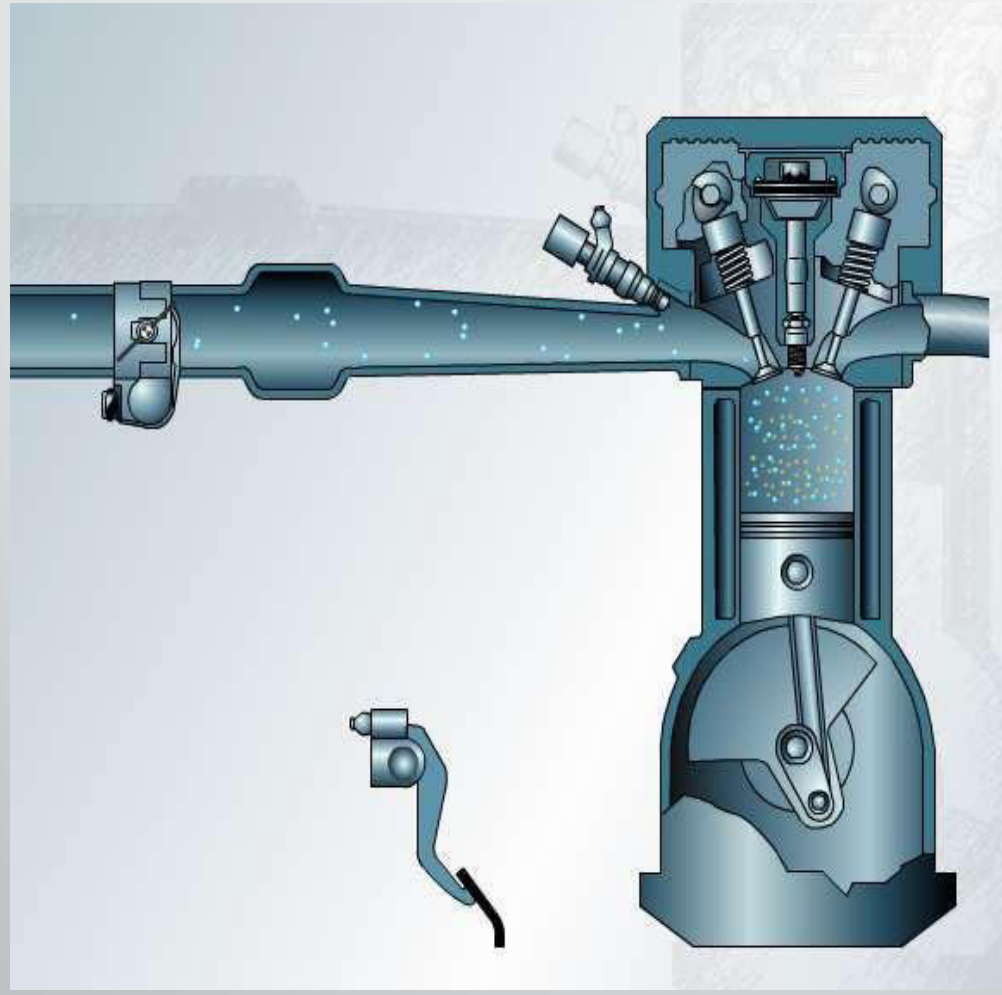
1 litre of petrol & 10000 l of air

Quality control

- Always sufficient quantity of supplied air
- Quantity of supplied fuel determine the engine output

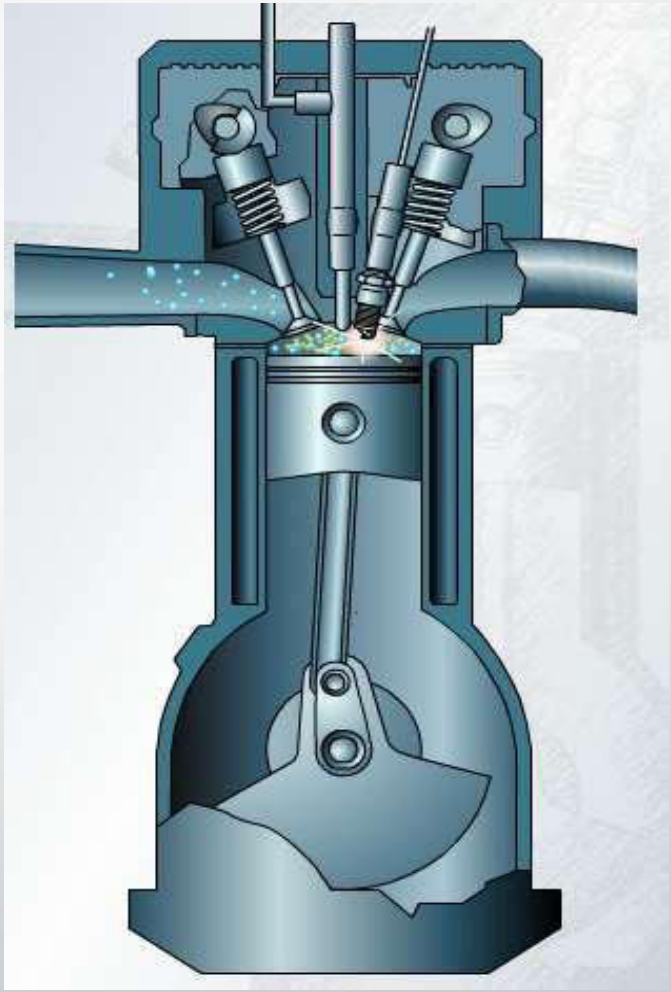
Thus variable composition of fuel mixture is referred as quality control

Quantity control



MPFI System

Quality control

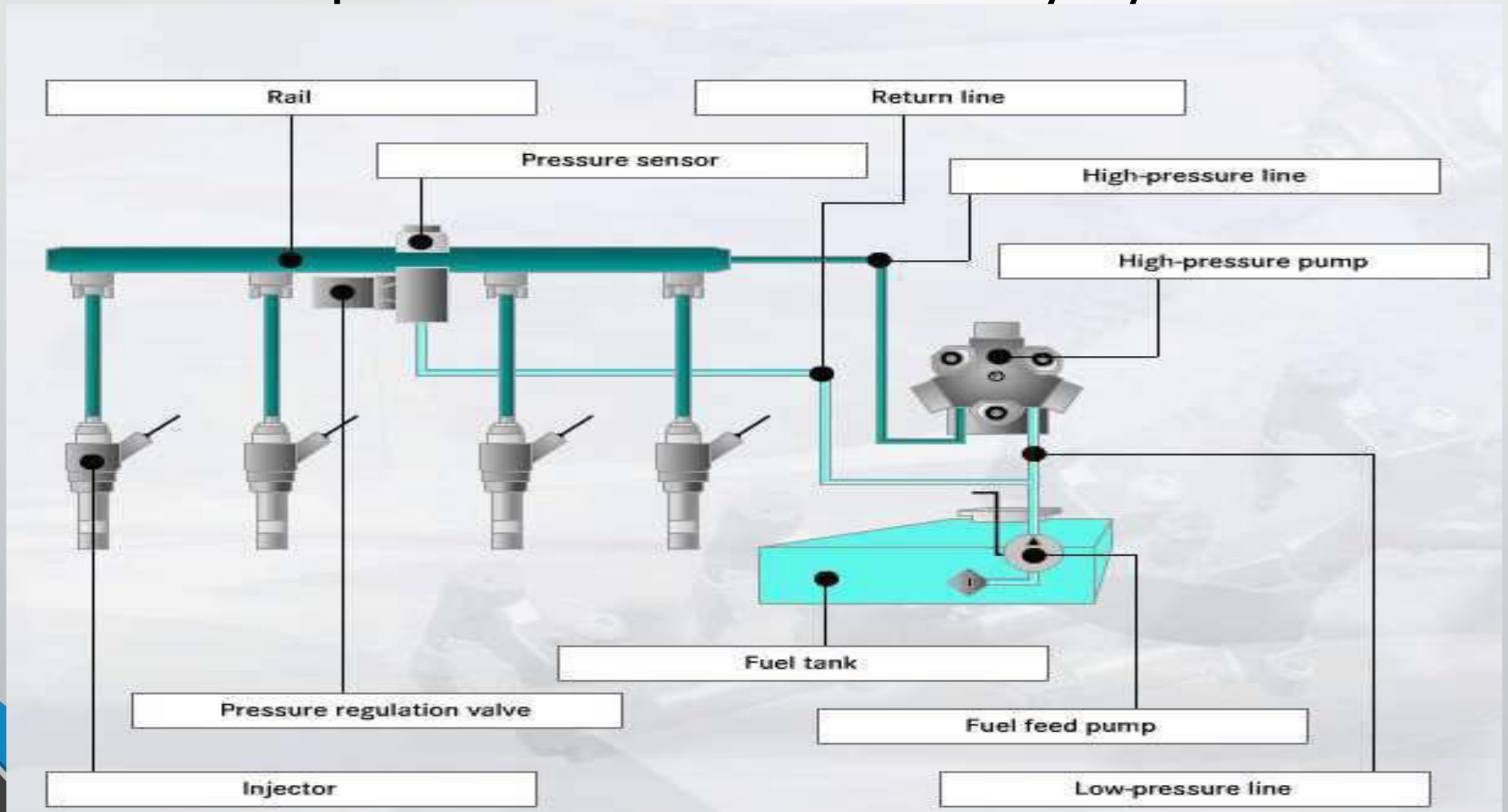


Direct Fuel injection System

Component of Direct Fuel Injection

- **FUEL DELIVERY SYSTEM**
- **AIR INTAKE SYSTEM**
- **ELECTRONIC CONTROL SYSTEM**

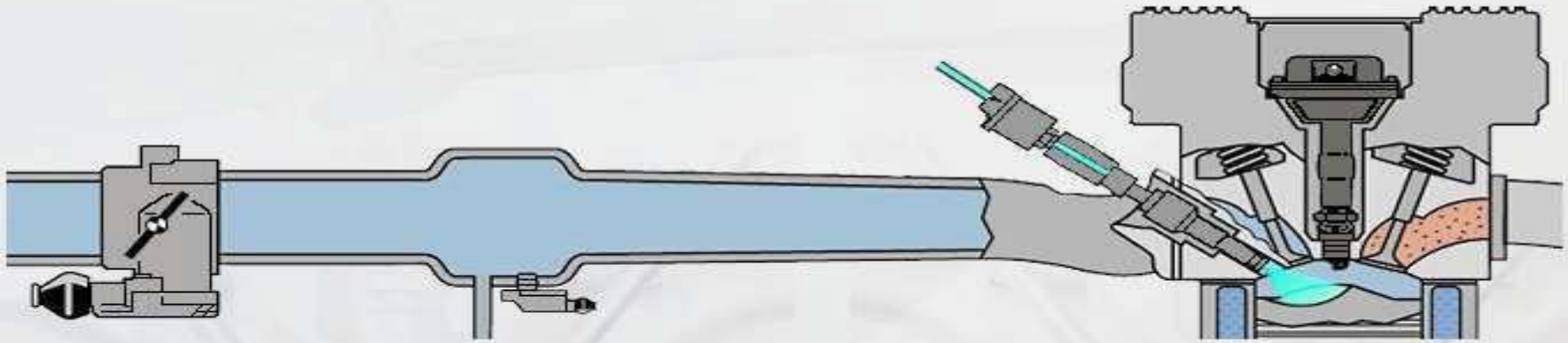
Components of Fuel Delivery system



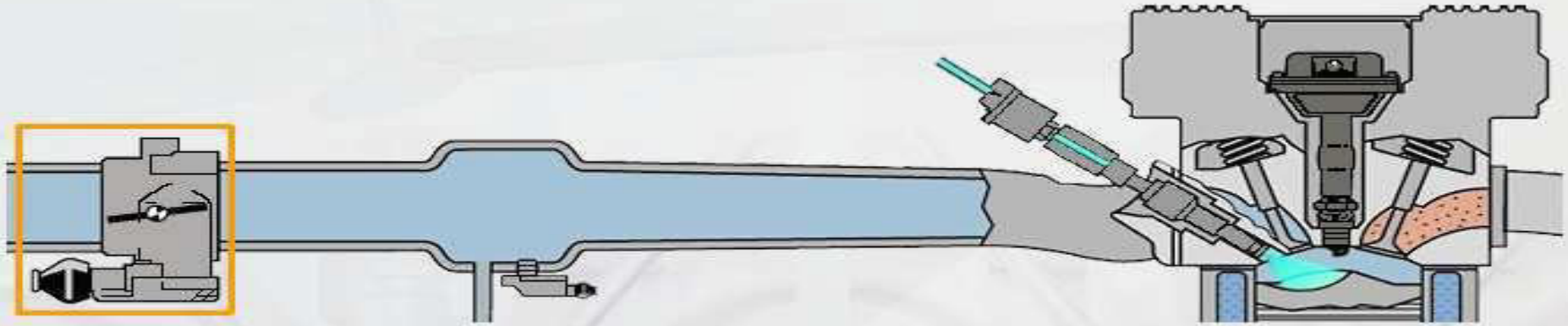
Fuel system

- Fuel from fuel tank is supplied via fuel feed line
- Fuel is then feed into rail with high pressure by high pressure pump or triple plunger radial piston pump
- Pressure of rail is maintain between 50-120 bars depending on idle situation or full load by ECU with help of pressure sensor in fuel rail for receiving signal of pressure and rail pressure is regulated with help of pressure releasing valve .
- Injector is located on cylinder of engine and rate of fuel volume on cylinder for combustion is dependent on the fuel pressure and duration of injection. Fuel is injected at precise moment with help of ECU controlled solenoid valve.

Difference in air supply of MPFI & DFI



In mpfi power delivery depend upon air supplied and petrol is added accordingly. Quantity of air depend on opening of throttle valve.



In direct fuel injection throttle valve is always opened leading always sufficient supply of air and output power depend on amount of fuel injected and time of injection

Air Supply

- In cylinder the air supplied via swirl duct low cross section area lead to high air pressure at intake air and provide necessary swirl motion for the mixture of air and fuel.
- Swirl Duct is only in operation while stratified charged mode or homogeneous low power mode
- During High Power mode large volume of air is required and swirl flap open for supply of air along with swirl duct.

Difference Between stratified charged mode and homogeneous mode

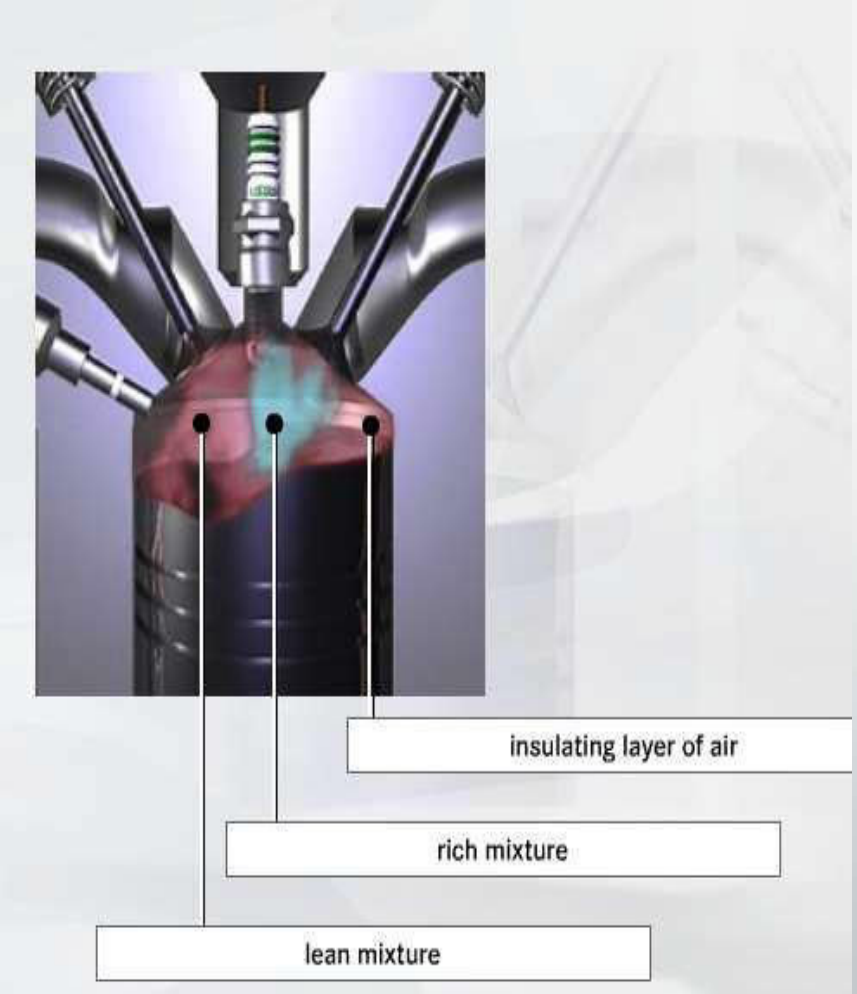
Stratified Charged Mode

- In stratified charged mode fuel supplied to cylinder during compression stroke
- This mode is load dependent and run when engine revolution is under 3000 rpm.
- This mode is generally called eco mode

Homogeneous Mode

- In homogeneous mode fuel is supplied to cylinder during intake stroke.
- This mode is generally used during high load and high engine revolution
- This mode is called power mode

Why stratified charged is more efficient .



- Virtual complete combustion of fuel with high proportion of air
- More favourable temperature pattern lead to sepration of burnt fuel area and unburnt air this help in separation of burnt area and cylinder area .
- Which help in low losses of temperature during work stroke.

Benefits of direct fuel injection

- Virtual complete combustion of fuel with high proportion of surplus air
- More favourable temperature pattern during combustion.
- Reduction of flow losses in intact duct.

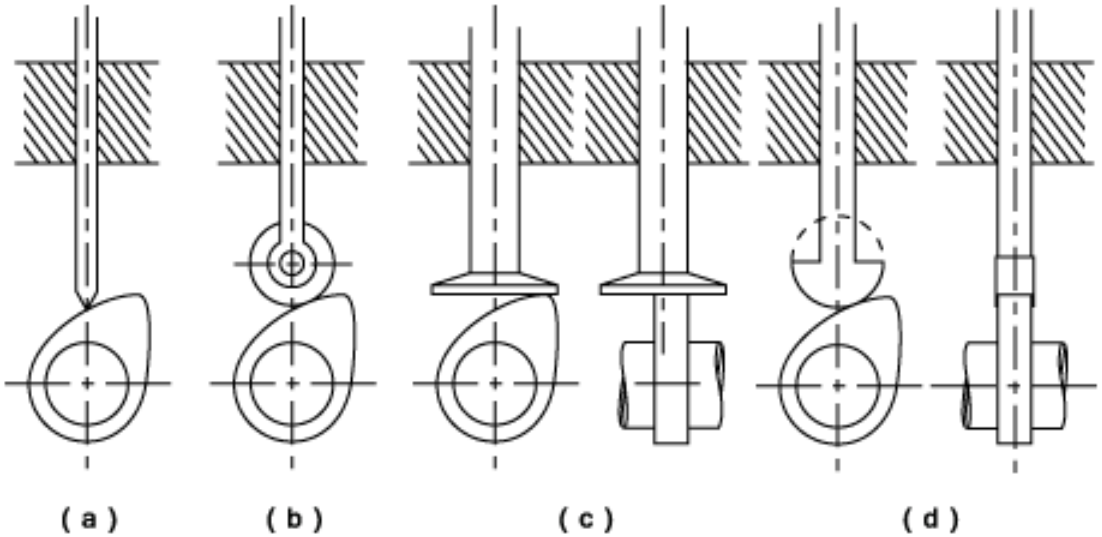
Dual Over Head Cam

CAM

- A **cam** is a rotating or sliding piece in

a mechanical linkage used especially in transforming rotary motion into linear motion or vice versa

Types Of cam



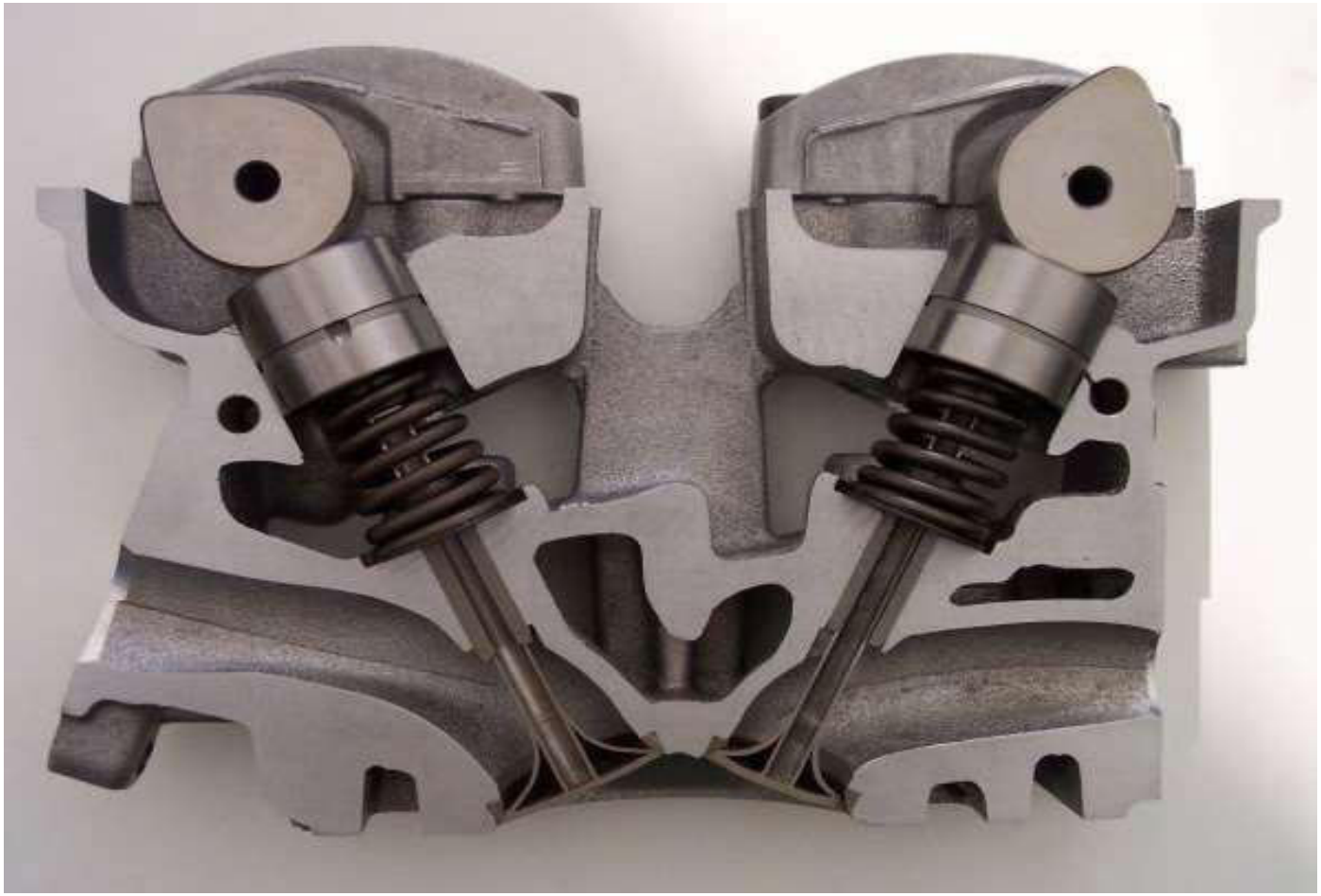
Over Head Cam

- **Overhead camshaft,** commonly abbreviated to **OHC,** is a valve train configuration which places the camshaft of an internal combustion engine of the reciprocating type within

the cylinder heads ('above'

the pistons and combustion chambers) and drives the valves or lifters in a more direct manner compared to overhead valves (OHV) and pushrods

DOHC



DOHC

- First off, DOHC stands for Dual-OverHead Camshaft, meaning that each bank of cylinders has two camshafts controlling the valves. For an inline engine (virtually all 4-cylinders), which has one bank of cylinders lined up, this means 2 camshafts total. For a V-style engine (V6, V8, V10) this means 4 total camshafts, as each head gets their own double camshafts. By having two camshafts per head, each camshaft is dedicated only to the intake valves or the exhaust valves, not both, and because of this, they can be located directly above the valve.

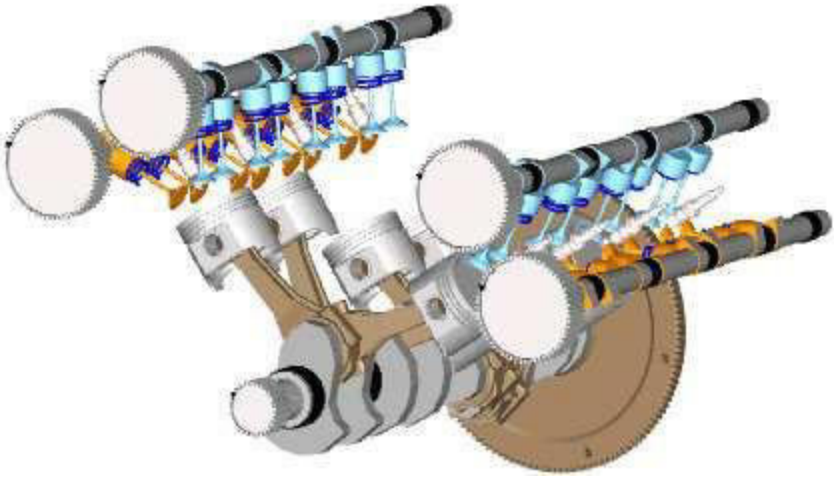
Advantages

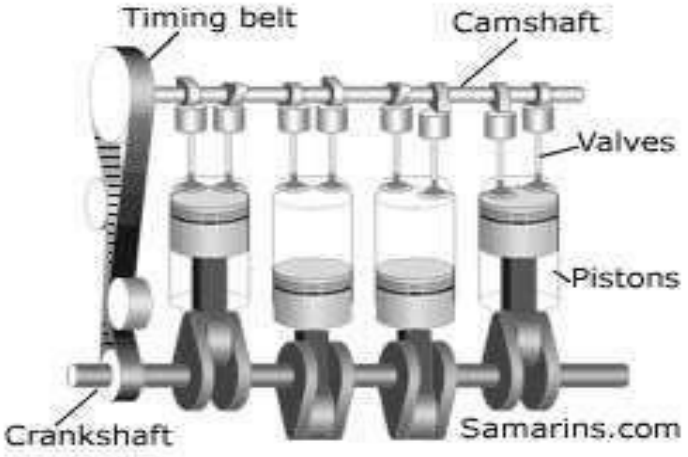
- NO rockerarm, so few moving parts
- Less valve train inertia
- It supports more breathing of engine

Disadvantages

- Engine is large in size
- Having 4 camshafts adds a lot of space in the heads and makes the engine take up much more room than other engines.

DOHC,SOHC,OHV

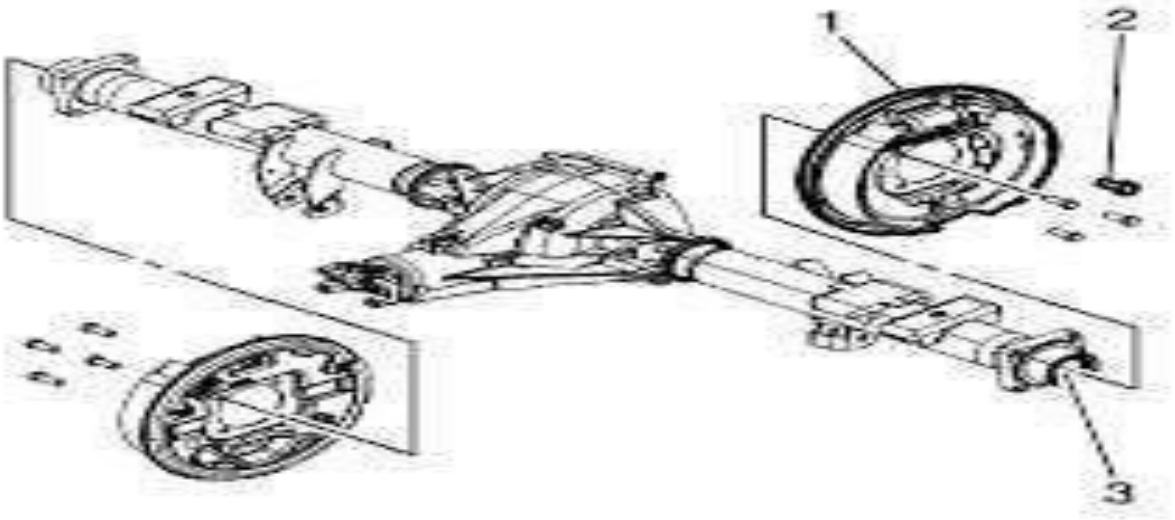




REAR AXLE & REAR AXLE DRIVES

HOTCHKISS DRIVE

REAR AXLE



A GROUP OF SUBASSEMBLIES OR A SEPARATE UNIT OF A MOTOR-VEHICLE CHASSIS (SUCH AS AN AUTOMOBILE AND TRACTOR) THAT TRANSMITS TORQUE FROM THE PROPELLOR SHAFT OR DIRECTLY FROM THE GEAR BOX TO THE PROPELLING MECHANISM.

FORCES ON REAR AXLE

- Weight of the body
- Driving Thrust
- Torque reaction
- Side

TYPES OF REAR AXLE

SEMI FLOATING AXLE

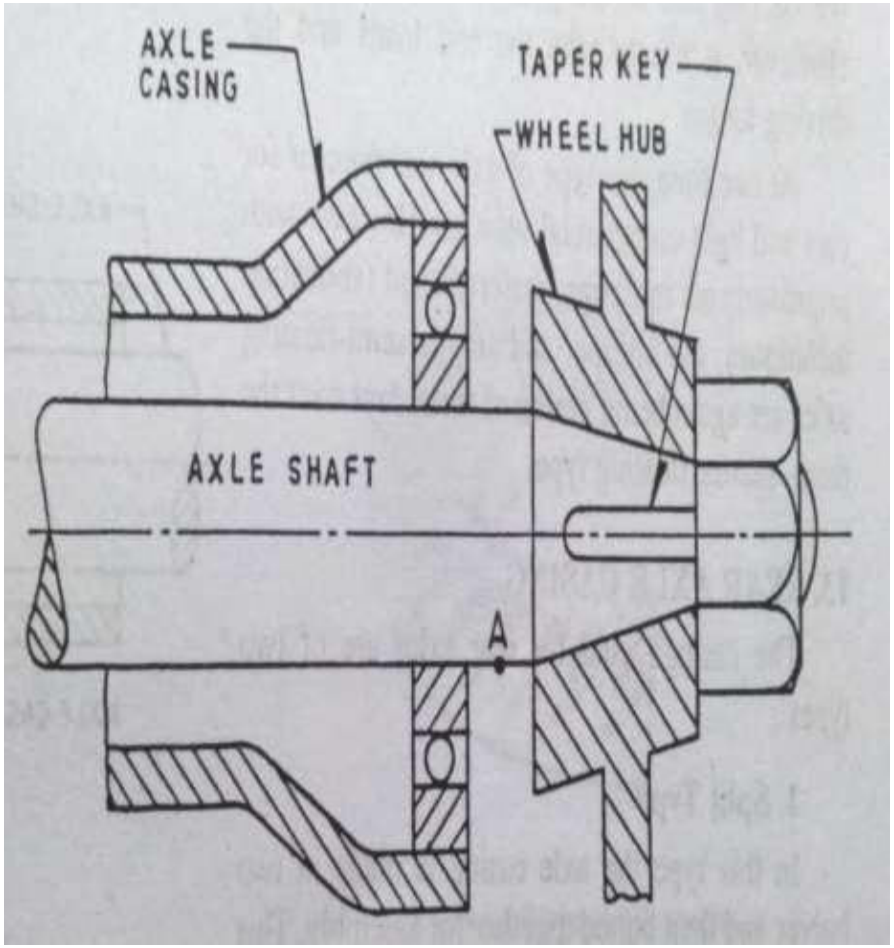
FULL FLOATING AXLE

THREE QUARTER FLOATING

SEMI FLOATING AXLE

- With a semi floating axle, the axle shaft both carries the weight and transmits torque
- The wheel is often bolted directly to the flange on the axle
- Semi float axles are seen on cars and light duty trucks
- Semi floats are more limited in capacity, but lighter and cheaper to manufacture

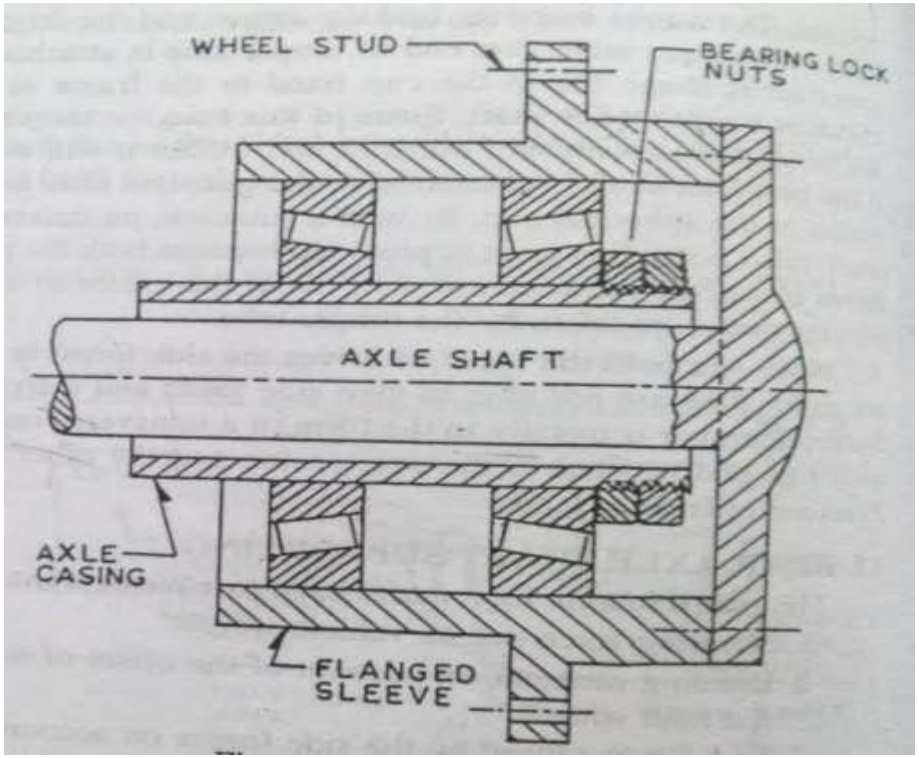
SEMI FLOATING AXLE



FULL FLOATING AXLE

- The weight of the axle is supported by the axle housing-more specifically, a bearing spindle
- attached to the axle housing, and a set of bearings in a separate wheel hub.
- Torque is transmitted by a separate axle shaft that carries no weight.
- As commonly built, full-floaters are considerably heavier, but also much stronger.

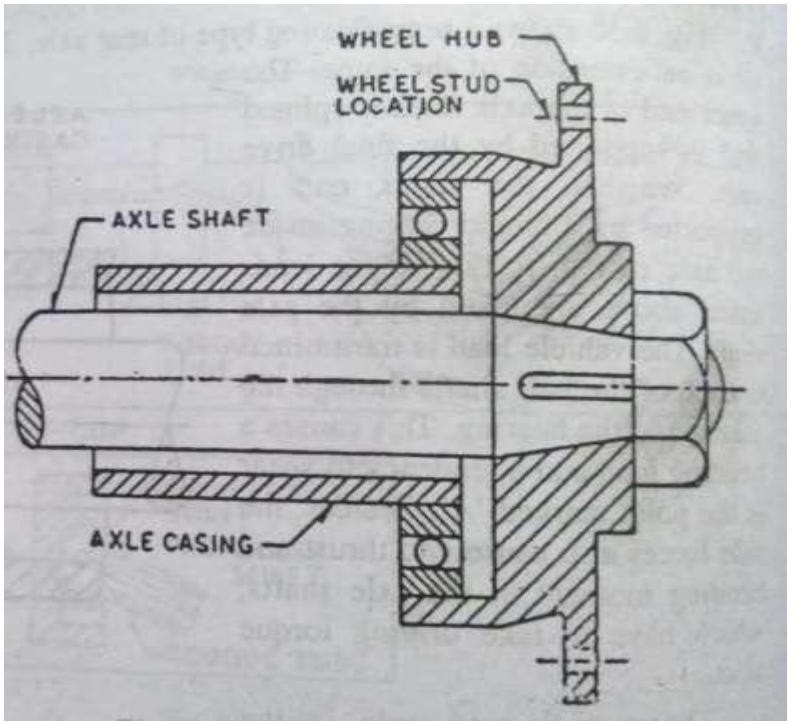
FULL FLOATING AXLE



THREE QUARTER FLOATING

- This type of axle is a combination of full and semi floating bearing.
- In this bearing is locating between the axle casing and hub axle shaft do not have to withstand any shearing or bending action due to the weight of the vehicle, which are taken up by the axle casing through hub and bearing.
- However it has to take the end loads and driving torque.
- A three quarter floating axle is same as semi floating with one difference. The outer bearing is moved to the outside of the outer end of the axle tube, supporting hub assembly via the bearing's outer circumference edge.

THREE QUARTER FLOATING



TYPES OF DRIVES

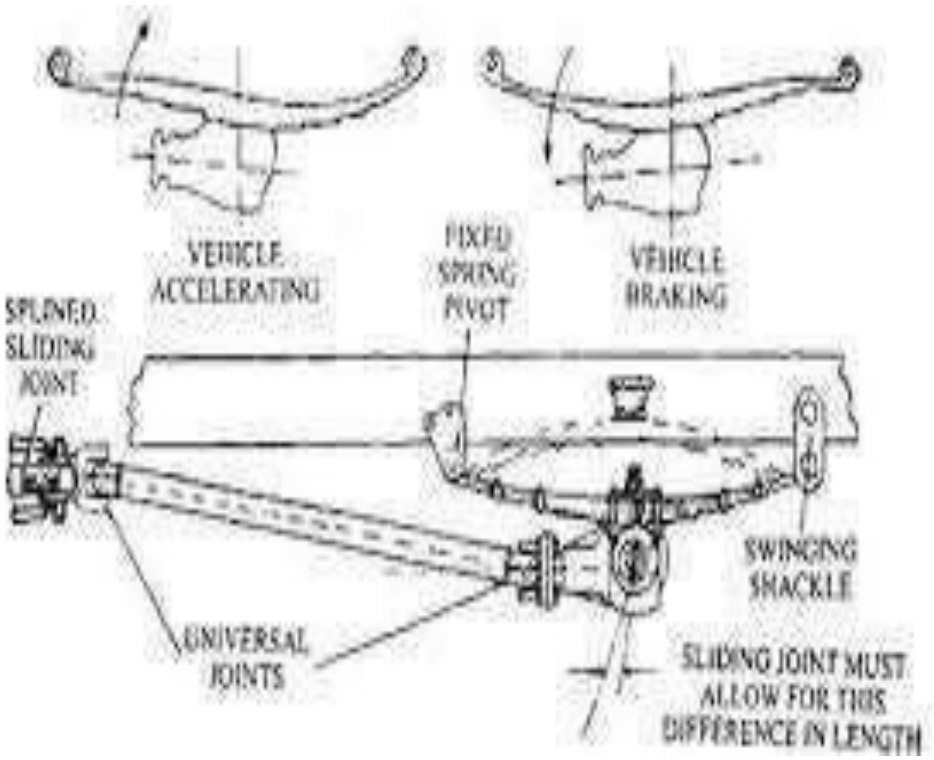
HOTCH KISS DRIVE

TORQUE TUBE DRIVE

HOTCH KISS DRIVE

- The **Hotchkiss drive** is a shaft drive form of power transmission. It was the dominant means for front-engine, rear-wheel drive layout cars in the 20th century. The name comes from the French automobile firm of Hotchkiss, although it is clear that other makers (such as Peerless) used similar systems before Hotchkiss.

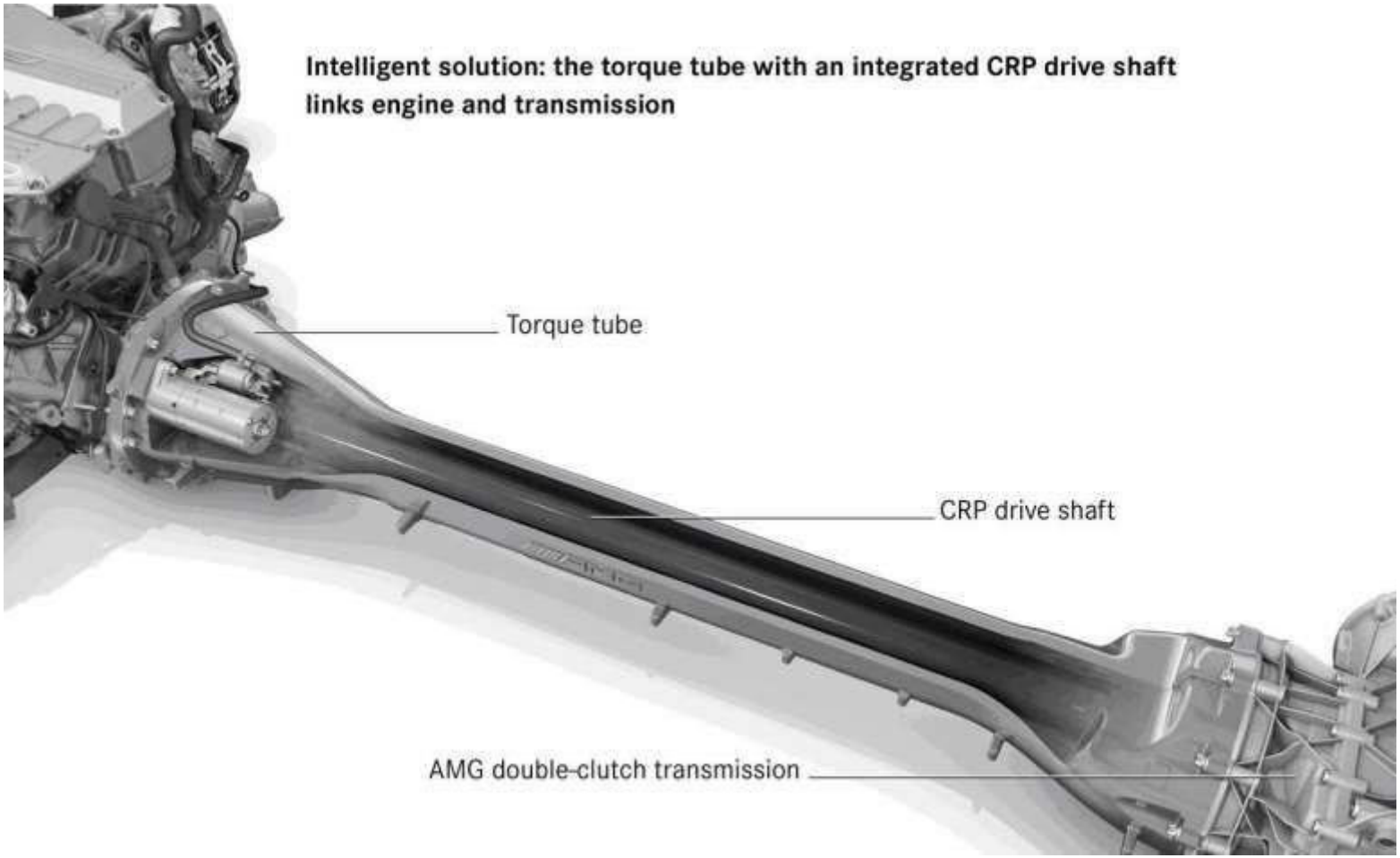
HOTCH KISS DRIVE



TORQUE TUBE DRIVE

- A ball and socket type of joint called a "torque ball" is used at one end of the torque tube to allow relative motion between the axle and transmission due to suspension travel. Later American Motors Rambler models (1962 through 1966) used a flange and cushion mount in place of the ball and socket.[3] Since the torque tube does not constrain the axle in the lateral (side-to-side) direction a panhard rod is often used for this purpose. The combination of the panhard rod and the torque tube allows the easy implementation of soft coil springs in the rear to give good ride quality

TORQUE TUBE DRIVE



Propeller Shaft & Universal Joint

Introduction of Propeller Shaft

- Propeller shaft is connecting the drive from gear box to final drive. Hence it is also called Drive Shaft.

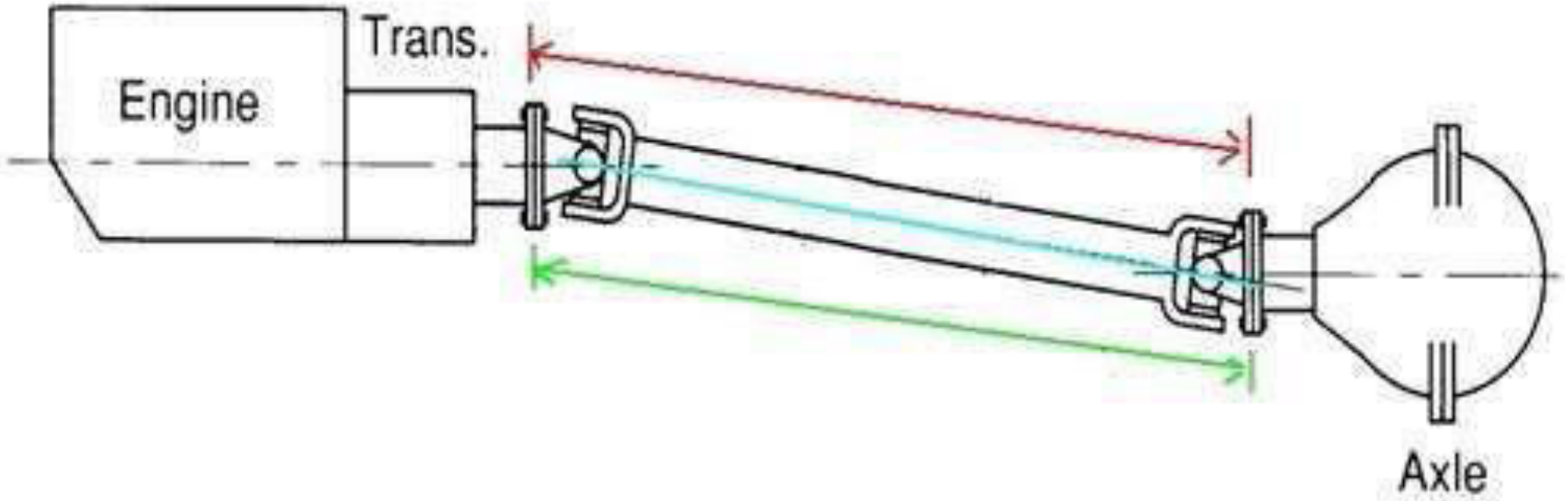
OR

- It is the group of parts connecting the transmission with the drive wheels. It consists of propeller shaft (also called Drive Shaft), Universal Joints/Constant Velocity Joints and Slip Joints.

Introduction of Propeller Shaft

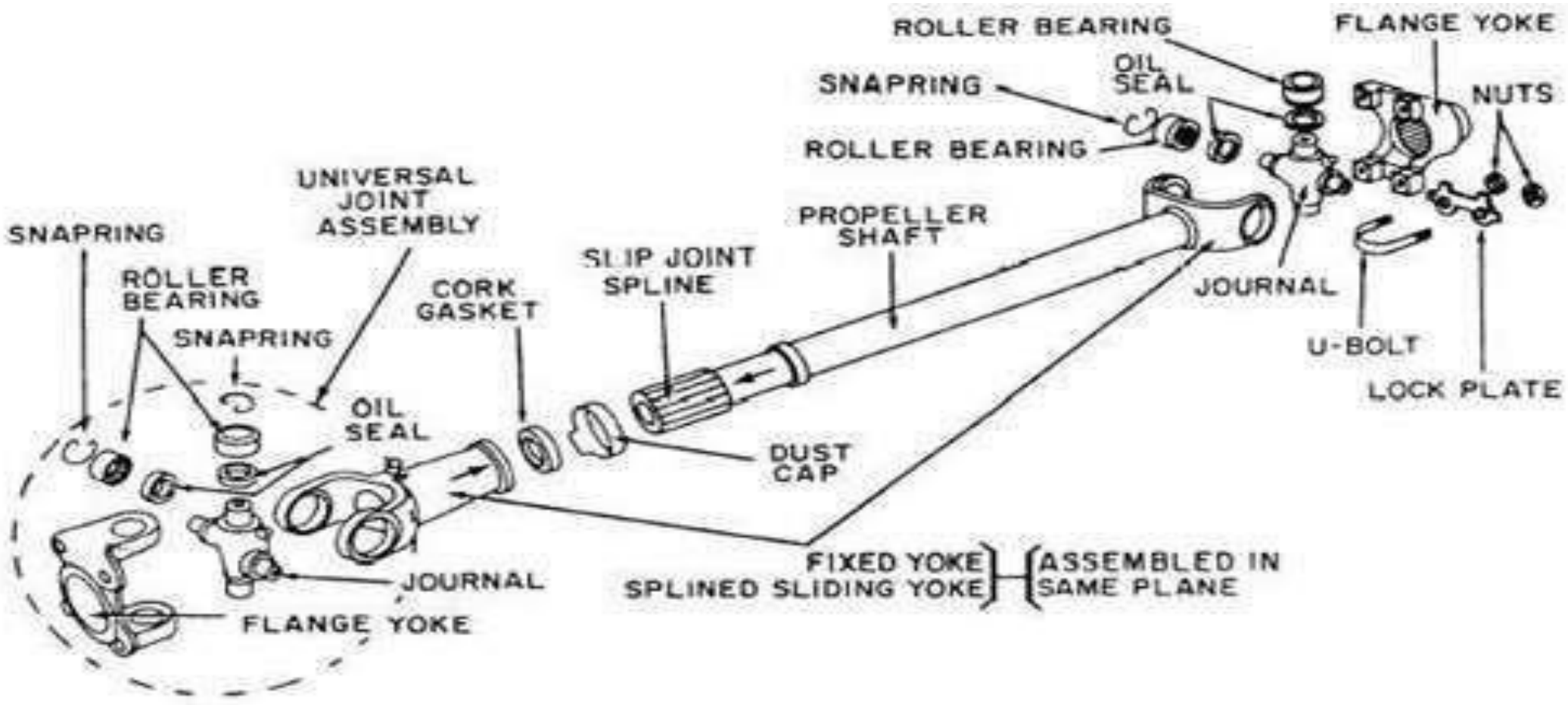
- **Shaft:** As this has to withstand torsional loads, it is usually made of tubular cross-section. It also has to be well balanced to avoid whirling at high speeds. Shafts are made of steel, aluminum or composite materials.
- **Universal Joint:** One or two universal joints, depending upon the type of rear axle drive used. The universal joints account for the up and down movements of the rear axle when the vehicle is running.
- **Slip Joint:** Depending upon the type of drive, one slip joint may be there in shaft. This serves to adjust the length of the propeller shaft when demanded by rear axle movements.

Introduction of Propeller Shaft



PROPELLER SYSTEM

Introduction of Propeller Shaft



COMPONENTS OF PROPELLER SHAFT

More about Propeller Shaft

- The propeller shaft is used as a driving shaft to joint the output shaft of the gear box with the differential unit in the rear axle.
- The rotational motion of the gear box main shaft is transferred to the differential unit for rotating the drive wheels mainly torsional load acts on the propeller shaft, hence it is made of tubular cross-section.
- To prevent the turbulence generation at high speed, it is perfectly balance.
- Universal joint is provide to transmit the power at changing angles of the propeller shaft, while vehicle is running.
- Slip joint is provided with the propeller shaft, to take care of increase in length of propeller shaft, while vehicle is running.

Function of Propeller Shaft

- Propeller shaft take power from the gear box output shaft without making any change in power, it transmits the same to the input pinion of the differential unit, from where power is transmitted to the drive wheels through rear axle.
- To accommodate the change in line and level between gear-box output shaft and differential input pinion shaft.

Constructional details of Propeller Shaft

- The propeller shaft used to transmit the power from gear box output shaft to differential with tubular cross-section & one or two piece construction.
- The two piece propeller shaft is supported at the center by rubber mounted bearing.
- Propeller shaft should be rigid enough to absorb the twisting action due to driving torque and the torsional shock.
- It should also be capable of resisting the vibration.

Constructional details of Propeller Shaft

- Tubular propeller shaft is generally used because...
  - It weight less
  - It can resist misalignment
  - It has good torsional strength
  - It provide less resistance to change of angular speed caused when hook type coupling is used.
- Propeller shaft is running faster when overdrive is used, hence it should be produce as per required design specification and good limit of balances.

Vibration of Propeller Shaft

- The vehicle having bigger wheel base need long propeller shaft. Long propeller shaft generated whirling by bending at its center.
- In such condition resonant vibrations are produced in the body. Hence along with the whirls, vehicle body also vibrates.
- For resonant frequency of propeller shaft there are two groups of main factors producing vibration.
  - Factors related to Propeller Shaft
  - Factors related to Vehicle Body

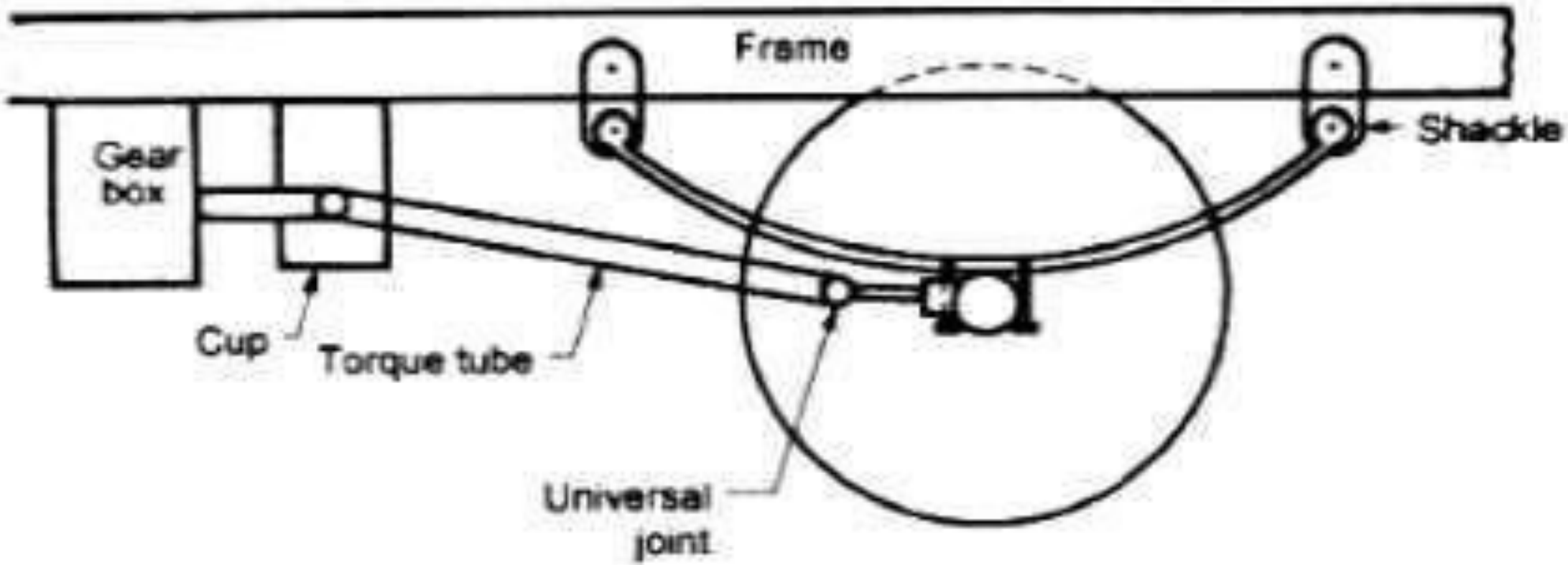
Vibration of Propeller Shaft

- Factors related to Propeller Shaft
  - Shaft Diameter and Length
  - Balancing of assembled shaft and Joints
  - Bending resistance of the Shaft
- Factors related to Vehicle Body
  - Shape and type of body structure
  - Location of body structure parts
  - Engine transmission mountings, springs, bushing and penal insulation by clamping quality for drive shaft vibration

Vibration of Propeller Shaft

- Shifting of center of gravity is also responsible for vibration.
  - Bending of shaft at center
  - Irregular thickness of wall of shaft tube
  - By rolling from flat sheet the shaft is produced finally by welding. The welded portion may not have weight same as that of opposite metal
  - The joints of yoke and trunnions are at one side of axis
  - The clearance of splines shaft is allowing shaft to shift towards one side

Torque Tube Drive



Torque tube drive

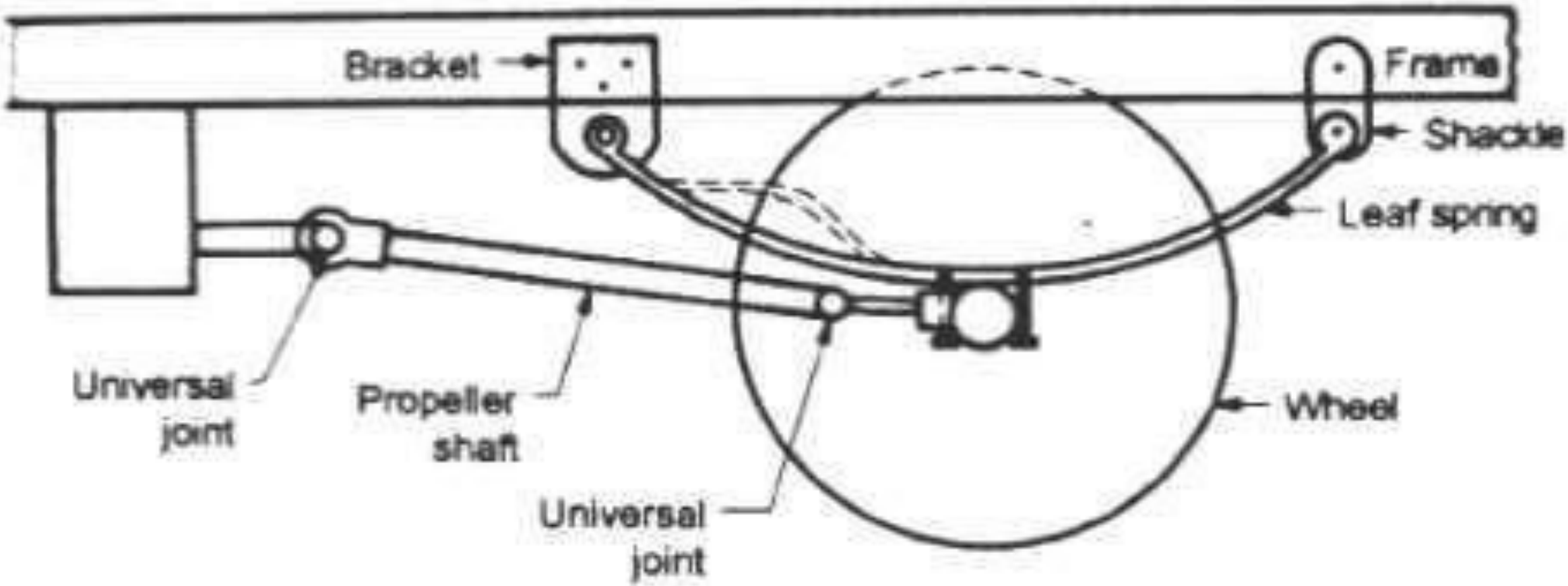
Torque Tube Drive

- In torque drive, the propeller shaft is enclosed in a hollow tube.
- The tube is rigidly bolted to the differential housing at one end and is fastened at the other end to the transmission through a somewhat flexible joint (universal joint) situated in spherical cup fixed to the frame.
- The torque reaction and driving thrust are taken up by torque tube.
- When the vehicle comes across a bump or shocks, the centre line of the bevel pinion shaft will not be shift and always passes through the centre of spherical cup.

Torque Tube Drive

- Hence, only one universal joint is required at front end and no universal joint at the rear end.
- The tube incorporates bearing, which support the propeller shaft.
- It is usually located between the (transmission) gear box and the propeller shaft.
- No sliding joint is required in the propeller shaft.
- In this drive, the leaf springs takes only the side thrust besides supporting weight of the body.

Hotchkiss Drive



Hotchkiss Drive

Hotchkiss Drive

- The Hotchkiss drive is simplest and most popular form of rear axle suspension.
- Hotchkiss drive combines the springing and positioning or locating of the rear axle. It uses a rigid axle with leaf spring mounted at its extremities as far apart as possible on the rear axle.
- The Hotchkiss drive consists of a leaf spring and a propeller shaft with two universal joints and one sliding joint.
- The front end of the leaf spring is pivoted in pin of bracket which is bolted to the vehicle frame.
- While rear end of the leaf spring is supported in swinging shackle with antifriction bush material.
- The leaf springs are bolted rigidly to the rear axle casing at middle.
- The spring takes weight of body, torque reaction and driving thrust.

Hotchkiss Drive

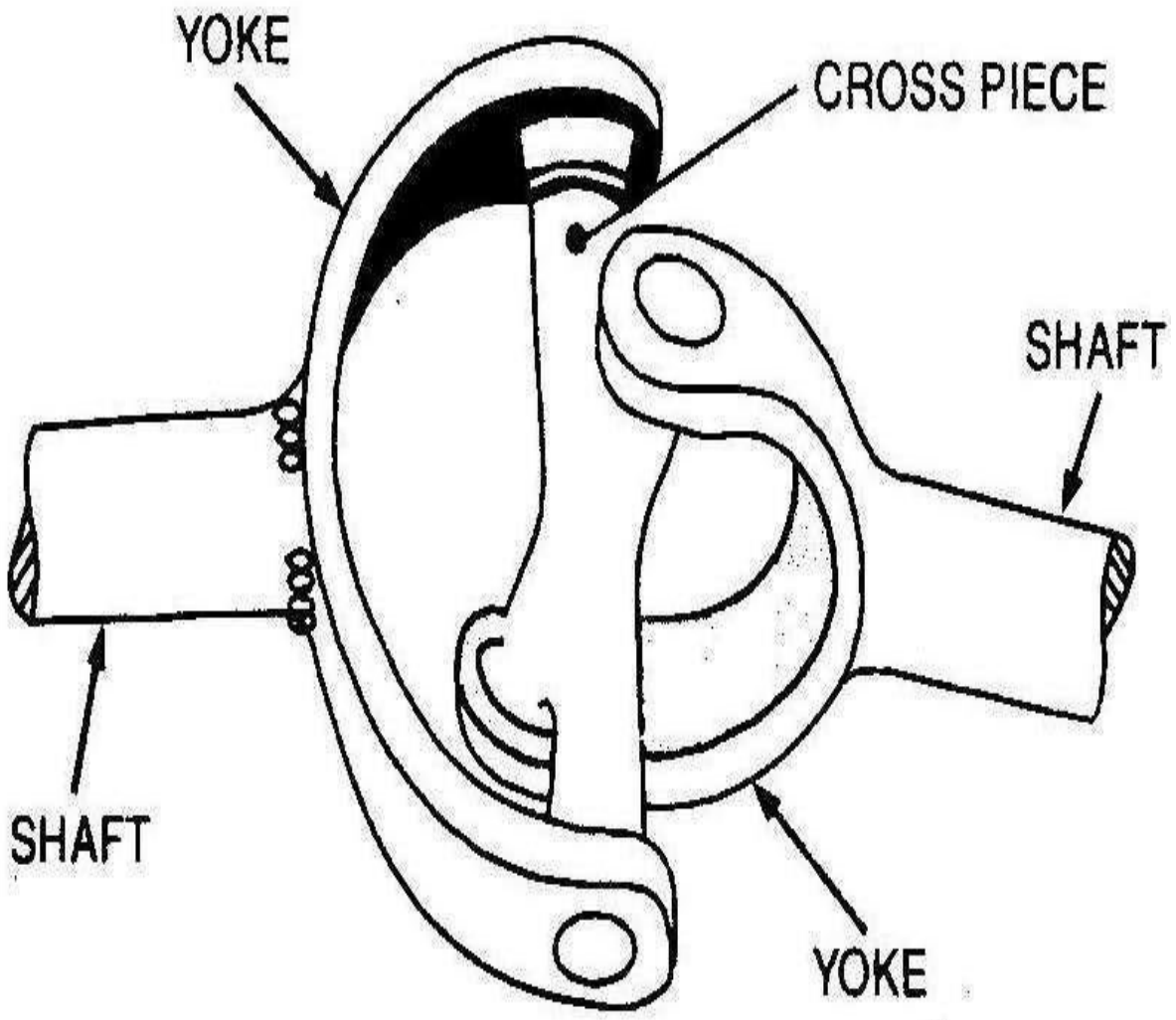
- The driving and braking torques are absorbed through the front half of the rear leaf spring shown by dotted line.
- During driving and braking, the bevel pinion changes the position so the length and angle of propeller shaft changes which will be adjusted by universal joint and sliding joint. Therefore if only one universal joint is at the front end, then the propeller shaft may bend or damage.
- To avoid this, another universal joint is provided at rear end.
- When the vehicle comes across a bump or shocks, the rear axle moves up and down and it has to move in a circle with front spring supported at the frame as centre.
- During this movement of rear axle, the length of the propeller shaft changes which will be adjusted by sliding joint.

Universal Joint

- A universal joint allows driving torque to be carried through two shafts that are at an angle with each other.
- A simple universal joint consist two Y- shaped yoke, one on the driving shaft and other on the driven shaft.
- The four arms of spider are assembled in needle bearings in the two yokes. The driving shaft and yoke force the spider to rotate.
- The other two trunnions of the spider then cause the driven yoke to rotate.
- When the two shafts are at an angle with each other, the needle bearings permit the yokes to swing around on the trunnions with each revolution.

Universal Joint

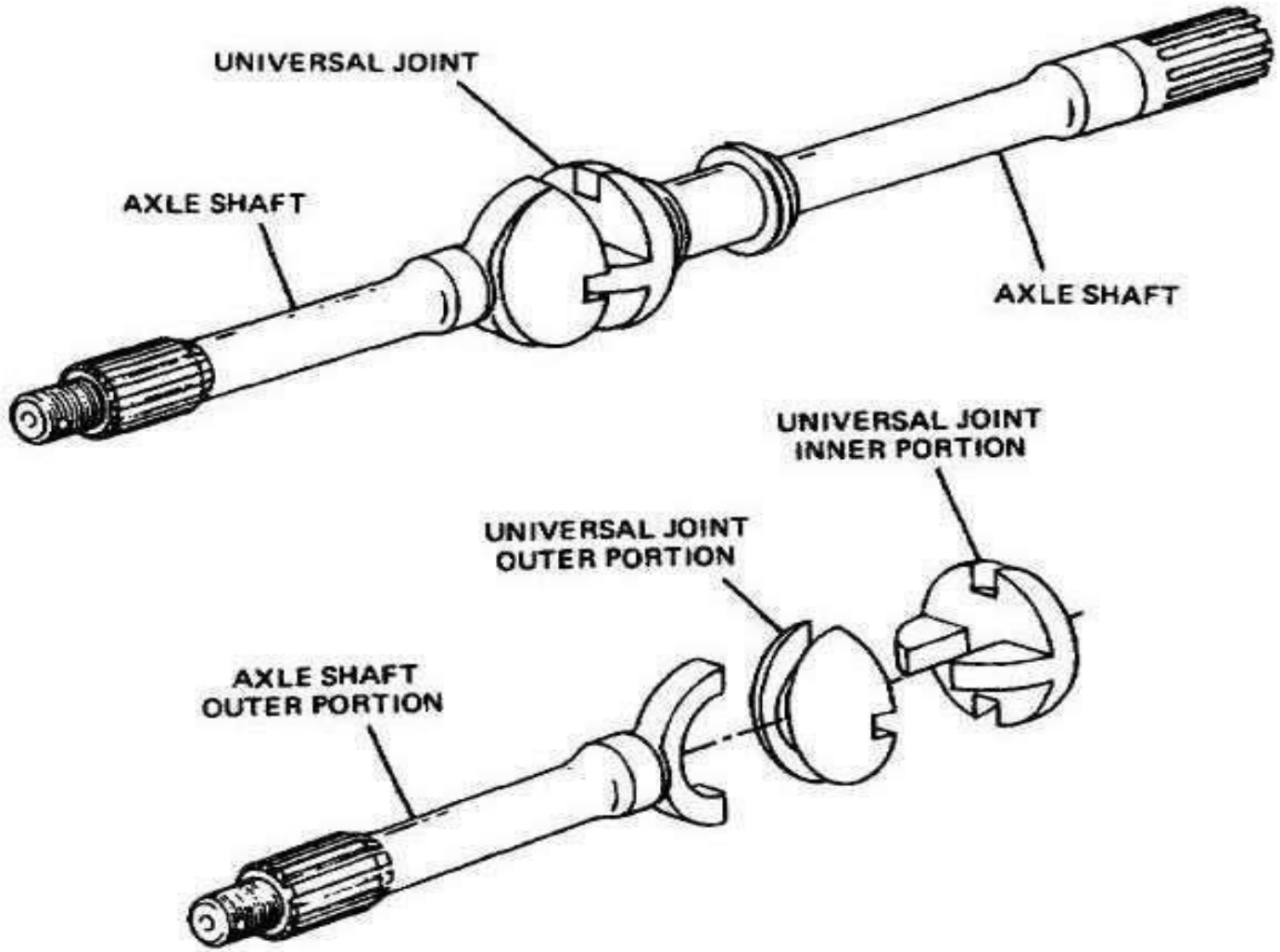
- A simple universal joint does not transmit the motion uniformly when the shafts are operating an angle. Because of this, two universal joints are used in a vehicle, one between the gear box and the propeller shaft and other between the propeller shaft and the differential pinion shaft.



Constant Velocity Joint

- Constant-velocity joints (aka homo kinetic or CV joints) allow a drive shaft to transmit power through a variable angle, at constant rotational speed, without an appreciable increase in friction or play.
- They are mainly used in front wheel drive and many modern Rear wheel drive cars with independent rear suspension typically use CV joints at the ends of the rear axle half shafts, and increasingly use them on the prop shafts.
- Constant-velocity joints are protected by a rubber boot, a CV gaiter. Cracks and splits in the boot will allow contaminants in, which would cause the joint to wear quickly.

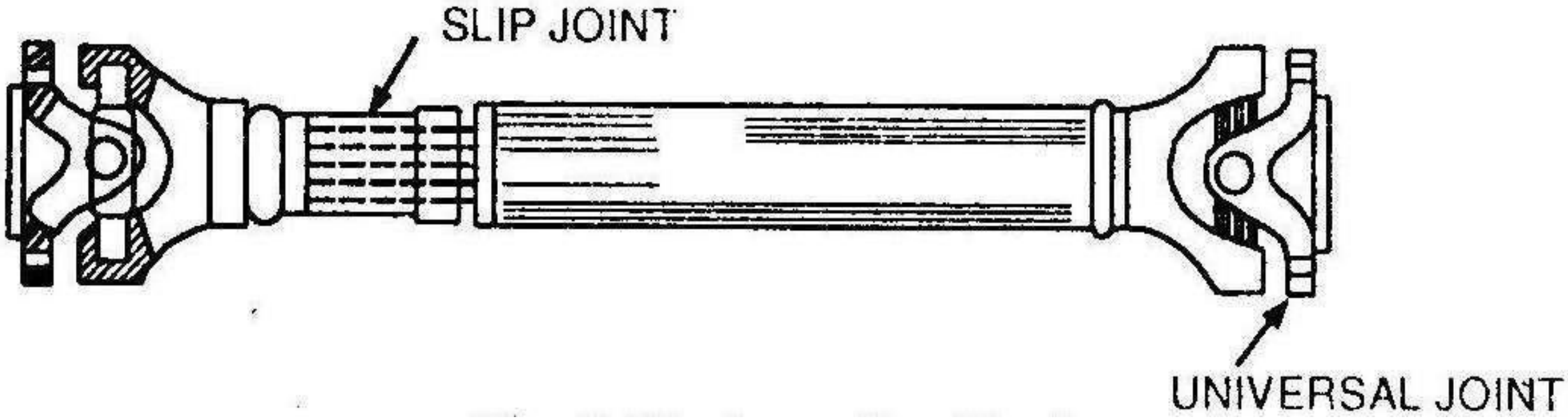
Constant Velocity Joint



Slip Joint

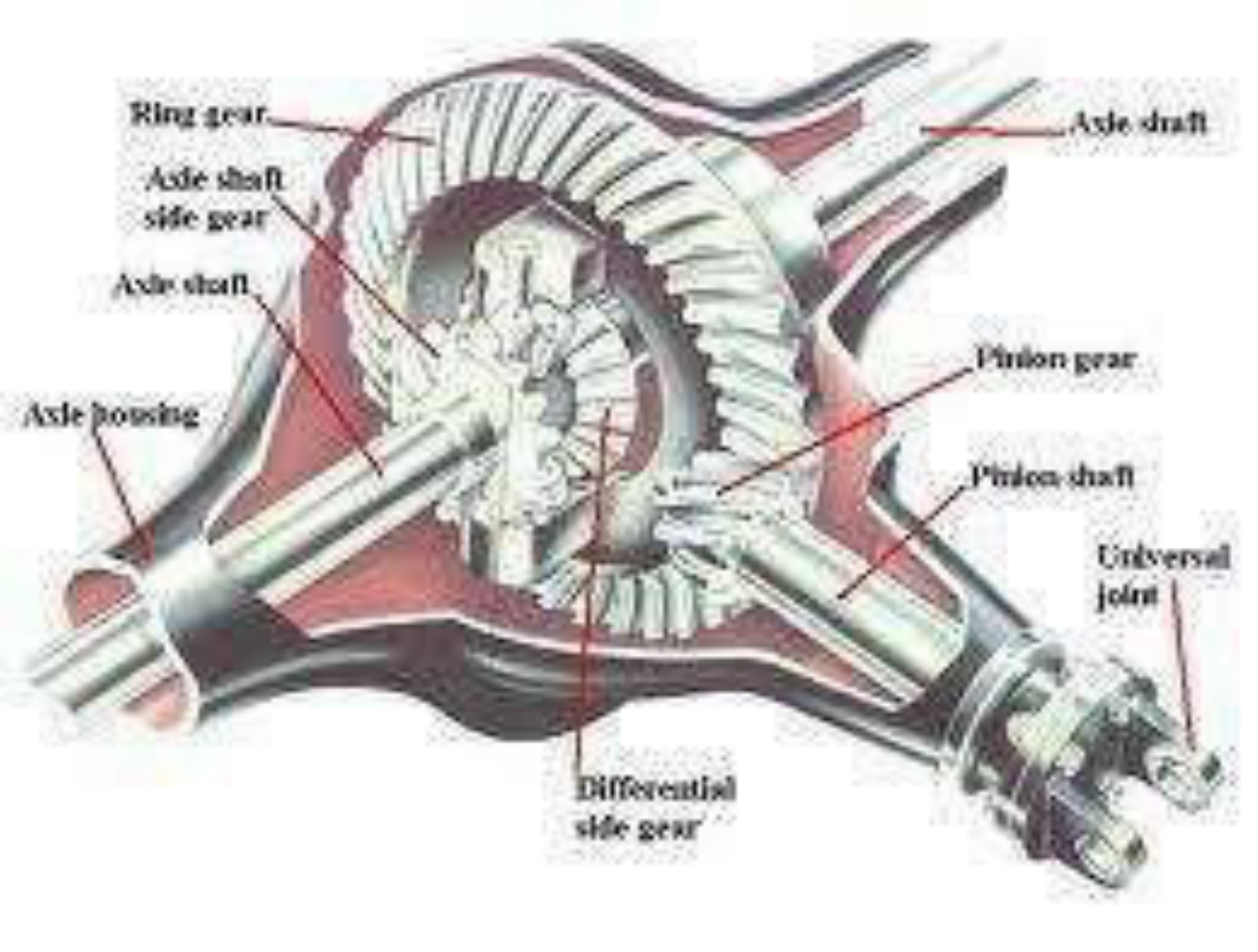
- Slip joint is attached to the driven yoke in order the increase or decrease the length of propeller shaft.
- It has outside splines on the shaft and matching internal splines in a mating hollow shaft or yoke.
- When assembled the splines cause the shafts to rotate together while they can move back and forth. This changes the length of propeller shaft.

Slip Joint



DIFFERENTIAL

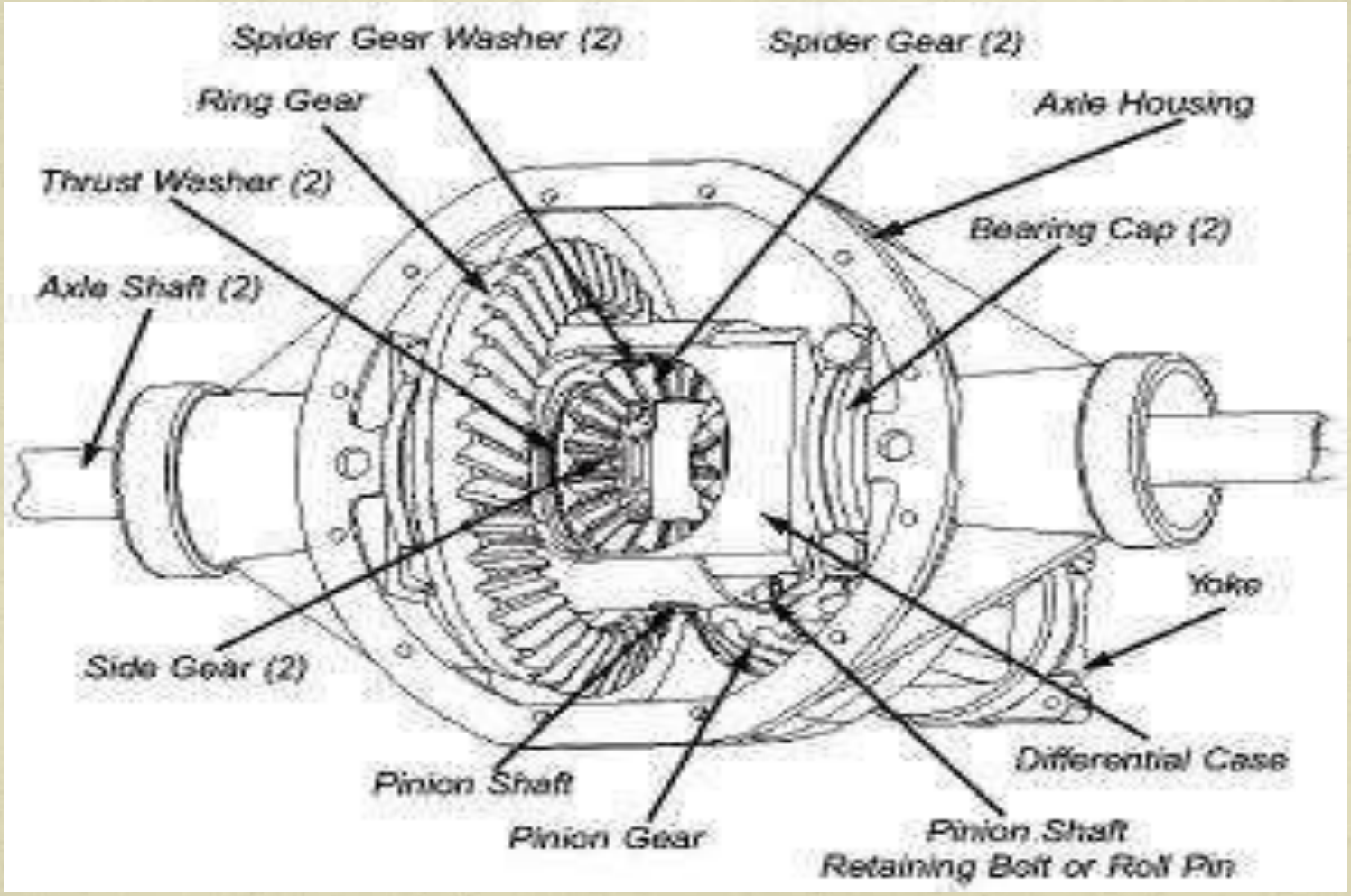
DIFFERENTIAL



Differential

- Differential is a very important part in a vehicle, as a component transfer the engine power is transmitted to the wheels. Engine power is transferred by a rear propeller shaft to wheel first changed direction by differential rotation are then referred to rear axle shafts after that to the rear wheels.

How It Works differential

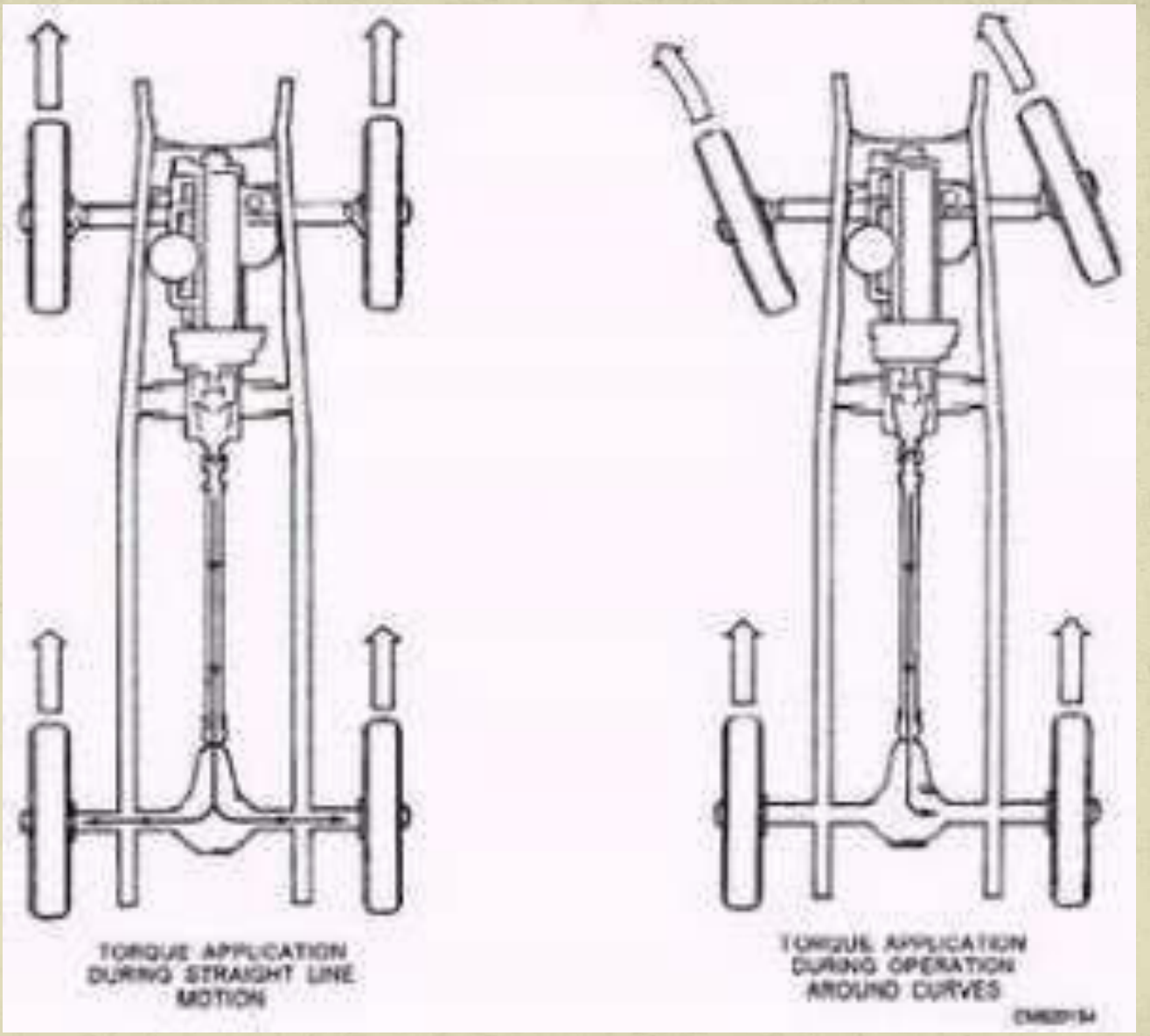


Main Parts of Differential

1. Bevel Pinion
2. Crown Wheel / Ring Gear
3. Half Axle
4. Sun Gear
5. Star Gear
6. Cage
7. Bearing

How It Works differential

- At the time of straight road.
  During the vehicle runs straight, the wheels of the rear axle will be screened by the drive pinion through the ring gear differential case, wheel-wheel differential gear pinion shaft, wheel-pinion differential gears, side gear teeth is not spinning, remain to be drawn into the ring gear rotation. Thus the spin on the wheel left and right alike.



TORQUE APPLICATION DURING STRAIGHT LINE MOTION

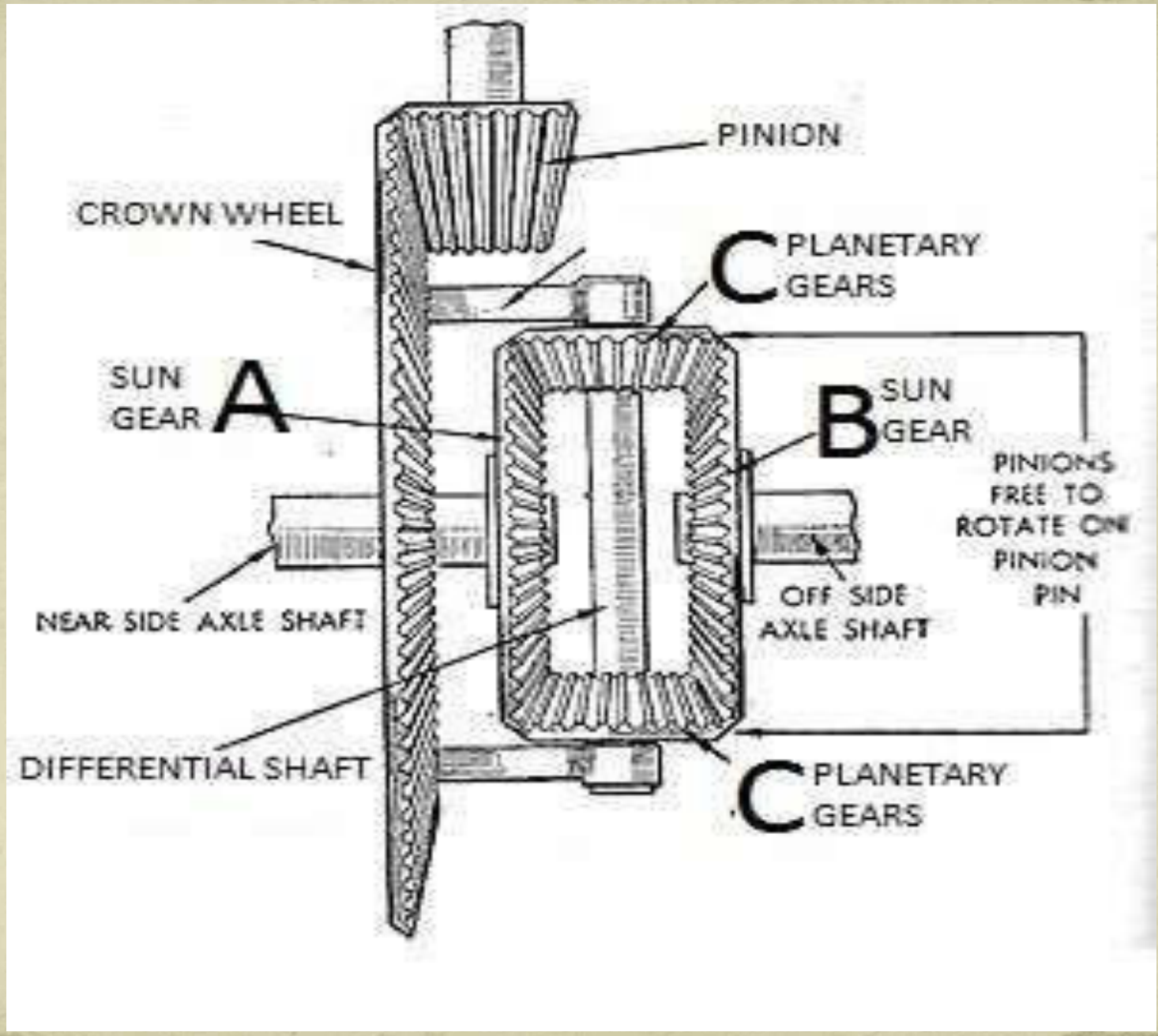
TORQUE APPLICATION DURING OPERATION AROUND CURVES

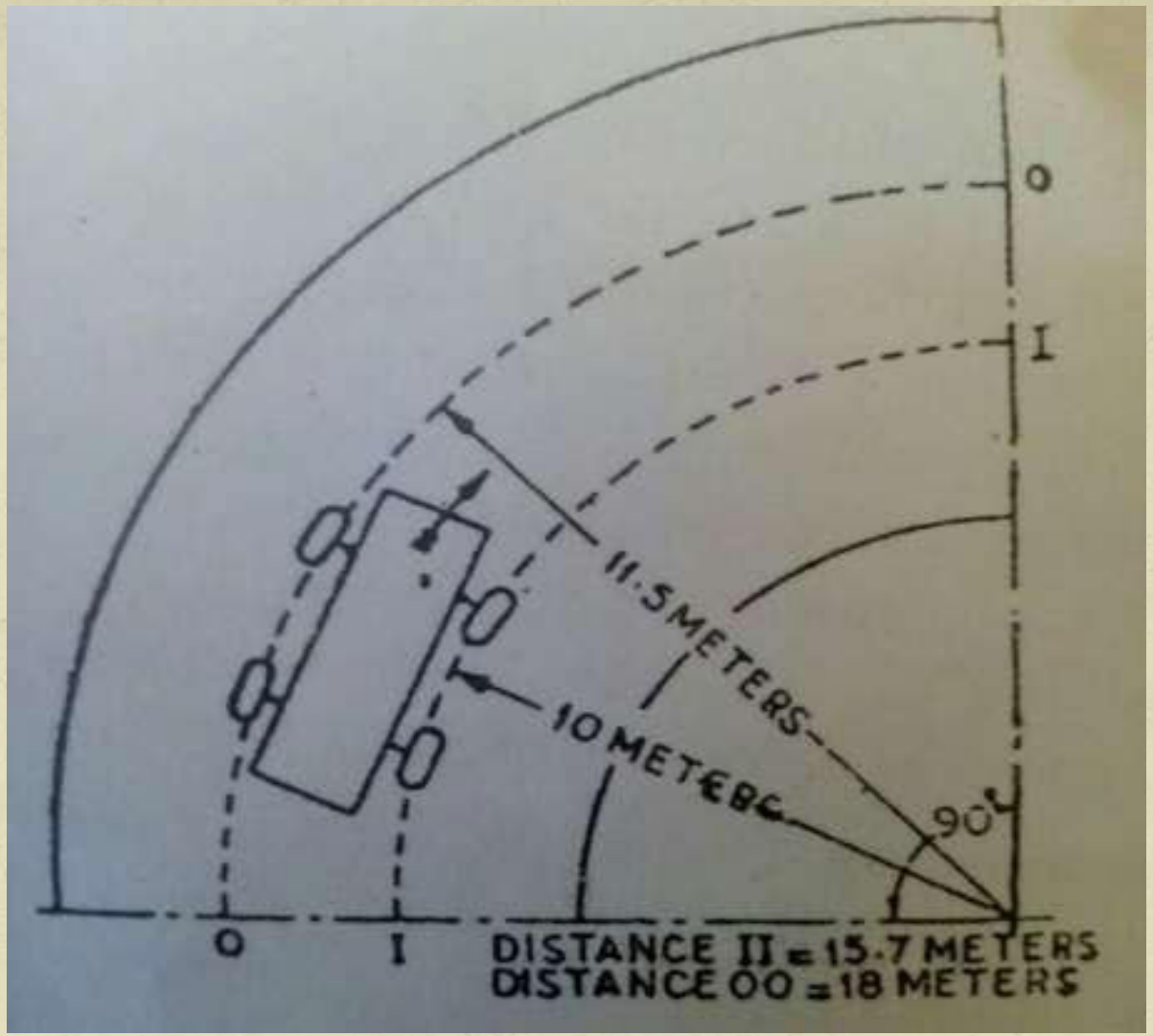
Continue

- At the time of turning.
  At the time of vehicle turning left prisoners left wheel is bigger than the right wheel. If the differential case with the ring gear rotates the pinion will rotate on its axis and also the movement around the left side gear, so round the right hand side gear increases, the side where the number of revolutions of the gear which is 2 times round the ring gear. It can be said that the average second round gear is comparable with the rotary ring gear. as it should.

Working principle of differential

1. The basic principle of the differential gear unit can be understood by using equipment that consists of two gears pinion and rack.
2. Both rack can be moved in the vertical direction as far as the weight rack and slip resistance will be lifted simultaneously. Placed between the tooth pinion rack and pinion gear connected to the braces and can be moved by these braces.


PINION
CROWN WHEEL
C PLANETARY GEARS
SUN GEAR A
B SUN GEAR
PINIONS FREE TO ROTATE ON PINION PIN
NEAR SIDE AXLE SHAFT
OFF SIDE AXLE SHAFT
DIFFERENTIAL SHAFT
C PLANETARY GEARS


0
1
11.5 METERS
10 METERS
90°
0
1
DISTANCE 11 = 15.7 METERS
DISTANCE 00 = 18 METERS

Continue.....

1. When the same load DW_2 placed on each rack then braces (Shackle) is pulled up the second rack would be lifted at the same distance, this will prevent the pinion gear does not rotate.

2. But if a greater burden placed on the left rack and pinion buffer will then be drawn up along the gear rack rotates the load gets heavier, which is attributed to differences in prisoners who are given the pinion gear, so the smaller the burden will be lifted.

1. The raised rack spacing is proportional to the number of turns pinion gear. In other words that rack gets custody larger still and while prisoners who received a smaller load will move. This principle is used in the planning of differential gears.

Automobile Gearbox

The word “Transmission”

- The word transmission means the mechanism that transmits the power from the engine crank shaft to the rear wheels.

Function of Transmission

- Provide a means to vary torque ration between the engine and the road wheels as required.
- Provides a neutral position.
- A means to back the car by reversing the direction of rotation of the drive is also provided by the transmission.

Gear Ratio

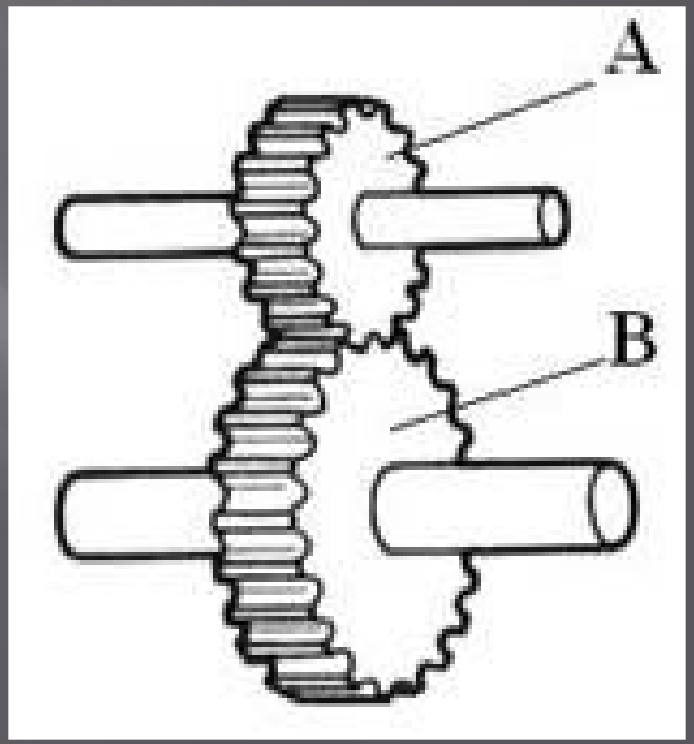
The gear ratio, or velocity ratio, between a pair of gear wheels is in inverse ratio to the number of teeth on each.

Gear Ratio

Thus,

$$N_B/N_A = D_A/D_B = n_A/n_B$$

$$N_B = N_A\,(n_A/n_B)$$



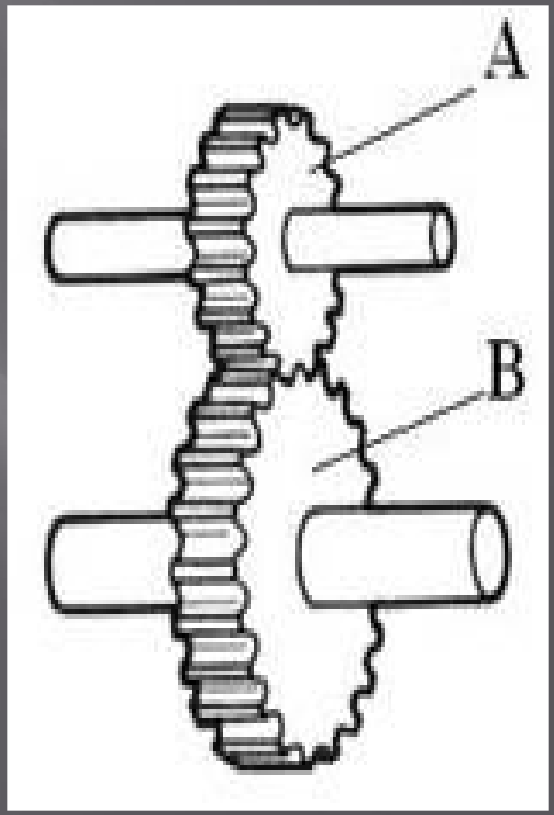
Gear Ratio

Where:

N_A = rev per min of gear A,
n_A = number of teeth on A

N_B = rev per min of gear B,
n_B = number of teeth on B

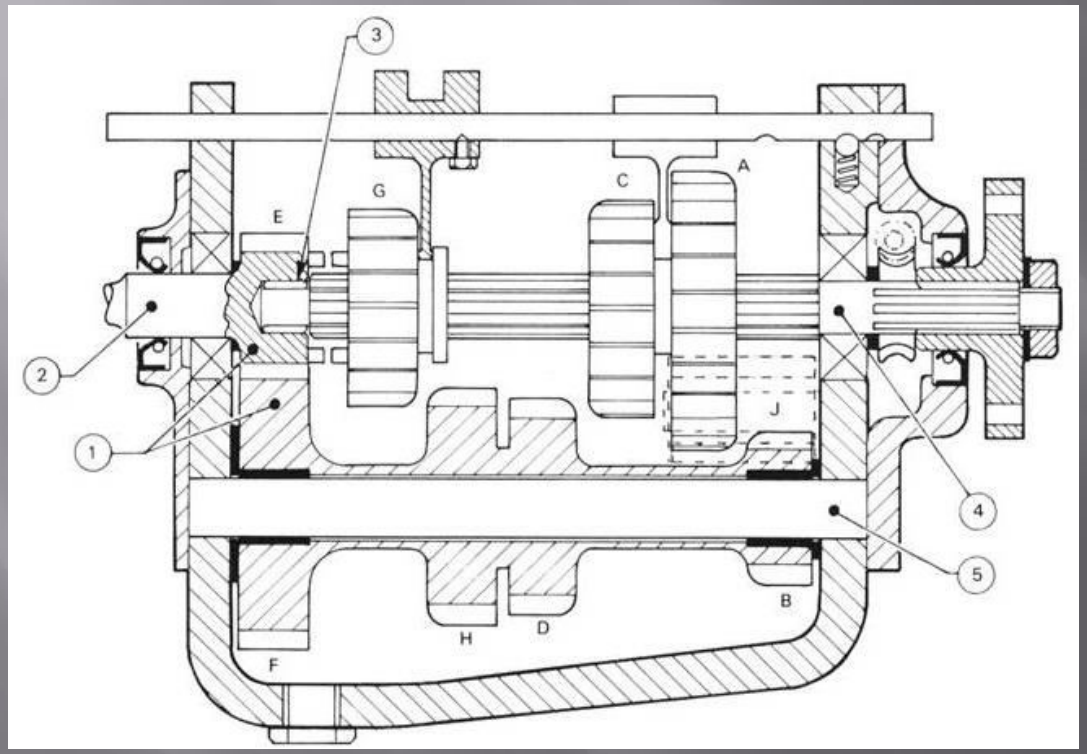
D_A = Diameter of gear A
D_B = Diameter of gear B



Types of Gearbox

- Sliding mesh gearbox
- Constant mesh gearbox
- Synchromesh gearbox
- Epicyclic Gearbox

Sliding mesh type gearbox



1. Constant mesh gears.
2. Primary shaft (Clutch shaft)
3. Spigot bearing.
4. Main shaft.
5. Lay shaft (counter shaft)

Sliding mesh type gearbox

Primary shaft

- This shaft transmits the drive from the clutch to the gearbox .
- At the end, the shaft is supported by a spigot bearing positioned close to the splines on to which the clutch driven plate is connected.

Sliding mesh type gearbox

Primary shaft

- The main load on this shaft is taken by a bearing; normally a sealed radial ball type, positioned close to an input gear called a constant mesh pinion.

Sliding mesh type gearbox

Primary shaft

- **The gear is so named because it is always in mesh with a larger gear**
- **Small driving gear is called a *pinion* and a large gear a *wheel*.**

Sliding mesh type gearbox

Layshaft

- This shaft, which is normally fixed to the gearbox casing, supports the various-sized driving pinions of the layshaft gear cluster

Sliding mesh type gearbox

Main Shaft

- This splined output shaft carries spur gearwheels that slide along the shaft to engage with the appropriate lay shaft gears.
- At the ‘front’ end, the main shaft is supported by a spigot bearing situated in the centre of the constant mesh pinion.

Sliding mesh type gearbox

Main Shaft

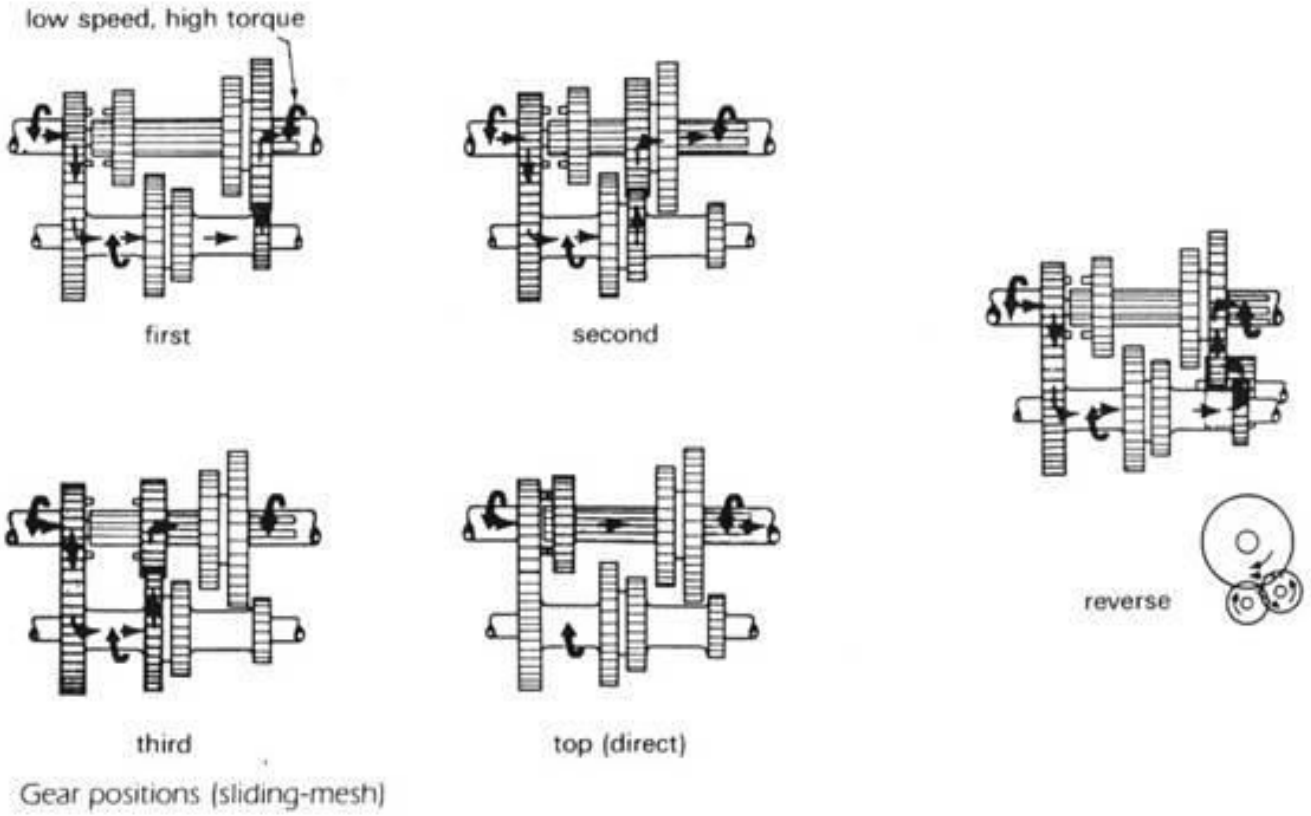
- **A heavy duty radial ball bearing is fitted at the other end to take the force of the gears as the attempt to move apart.**

Sliding mesh type gearbox

- The power comes from the engine to the clutch shaft and thence to the clutch gear which is always in mesh with a gear on the lay shaft.
- All the gears on the lay shaft are fixed to it and as such they are all the time rotating when the engine is running and clutch is engaged.

Sliding mesh type gearbox

Gear position



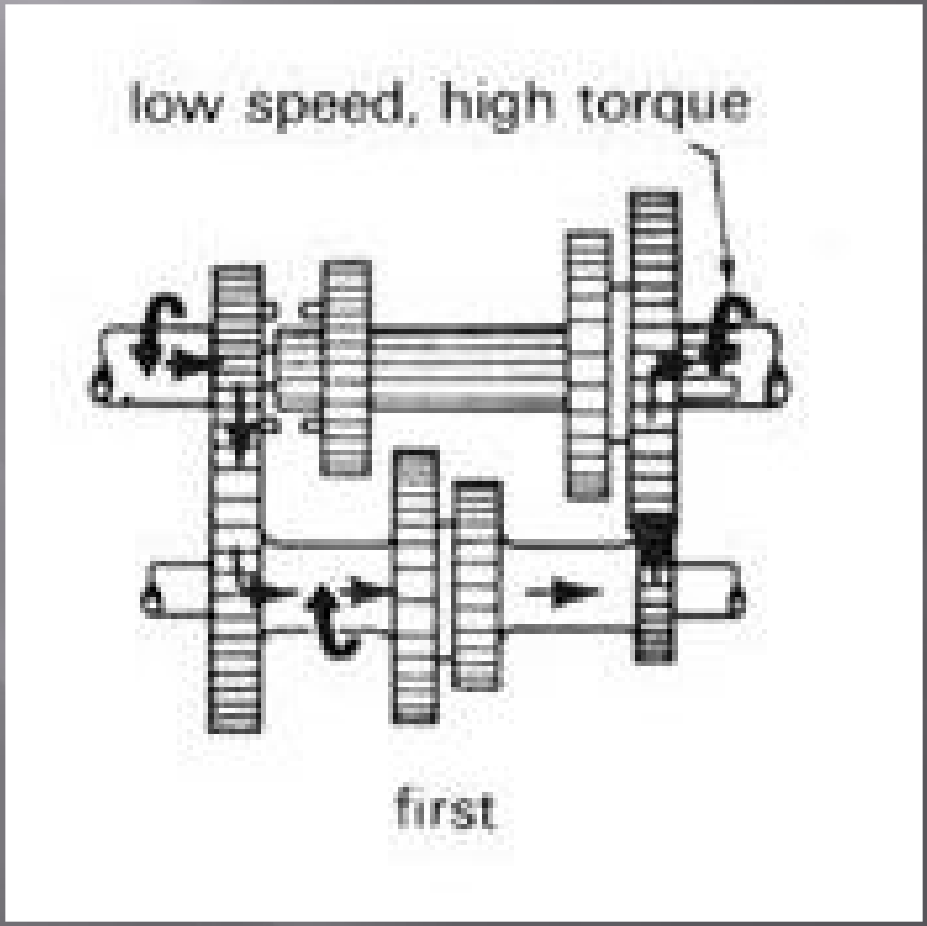
Gear positions (sliding-mesh)

Sliding mesh type gearbox

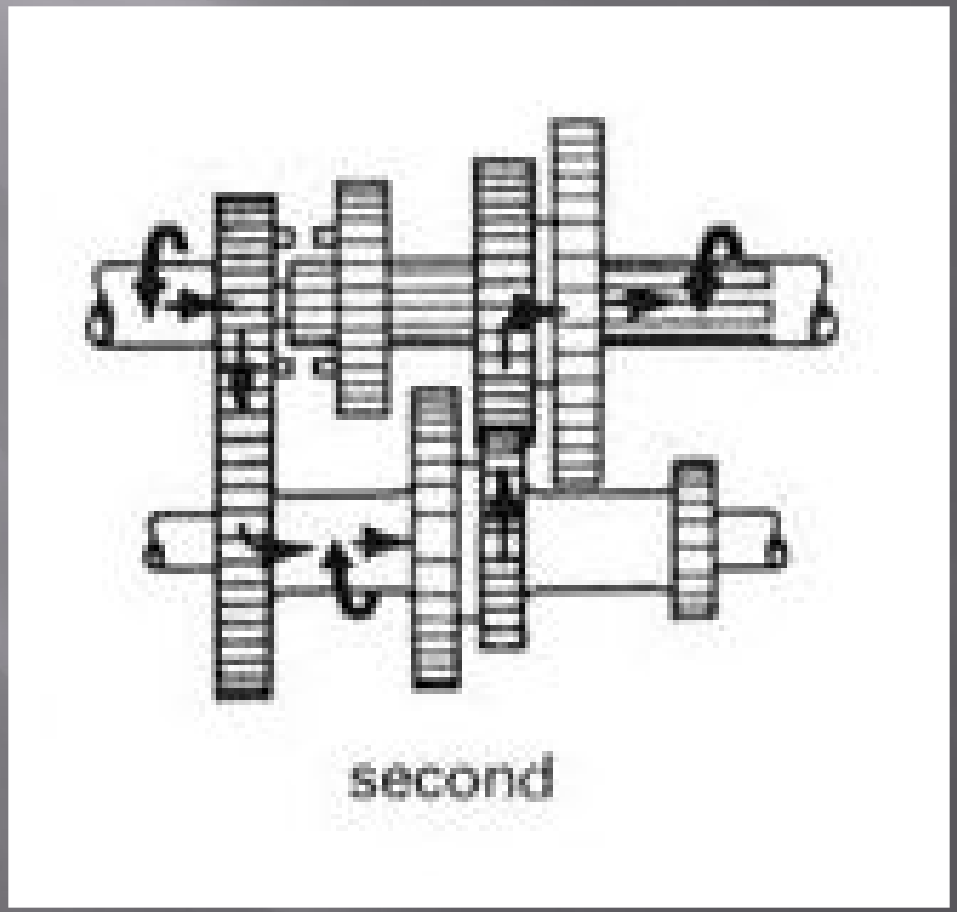
Neutral

- All main shaft gearwheels are positioned so that they do not touch the layshaft gears.
- A drive is taken to the layshaft, but the mainshaft will not be turned in neutral position

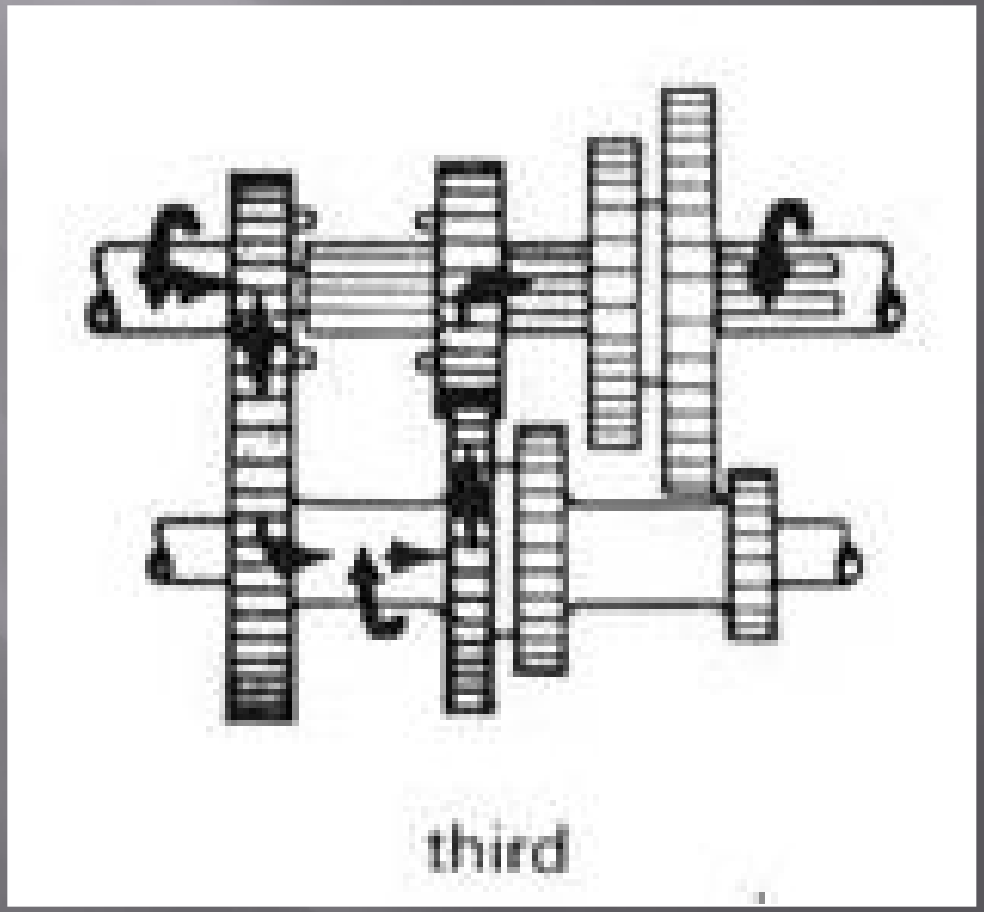
First gear



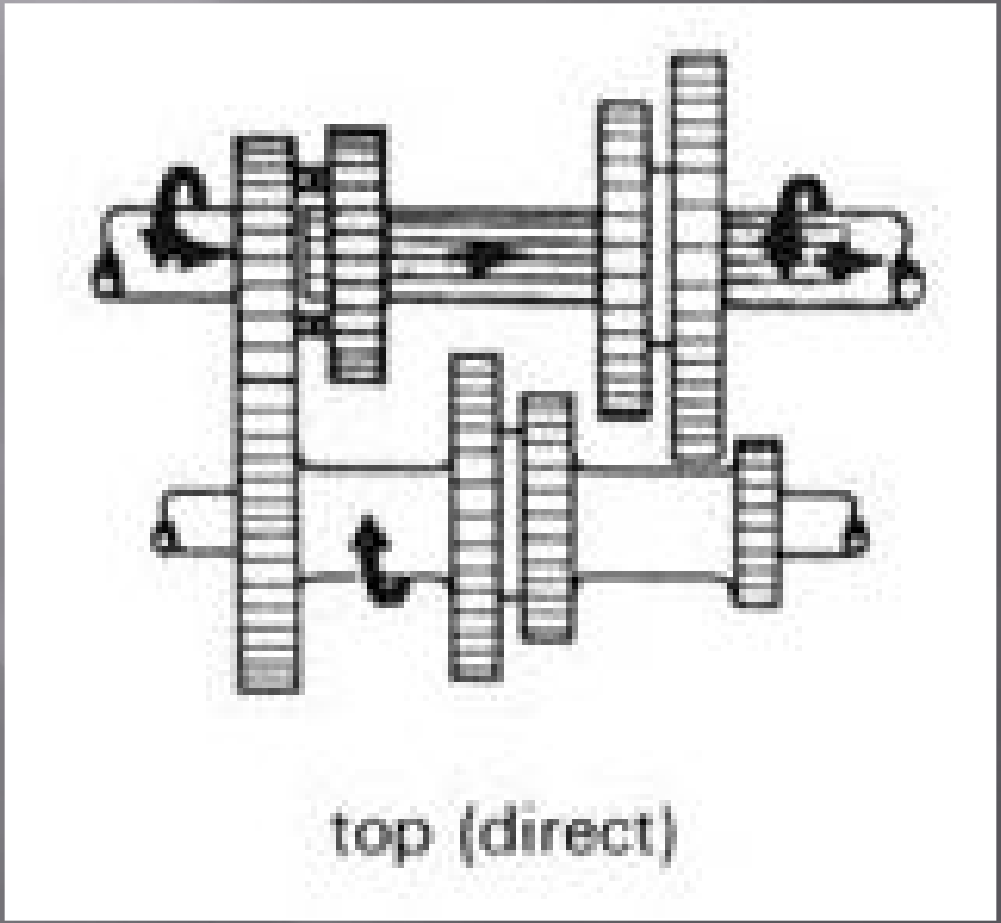
Second



Third

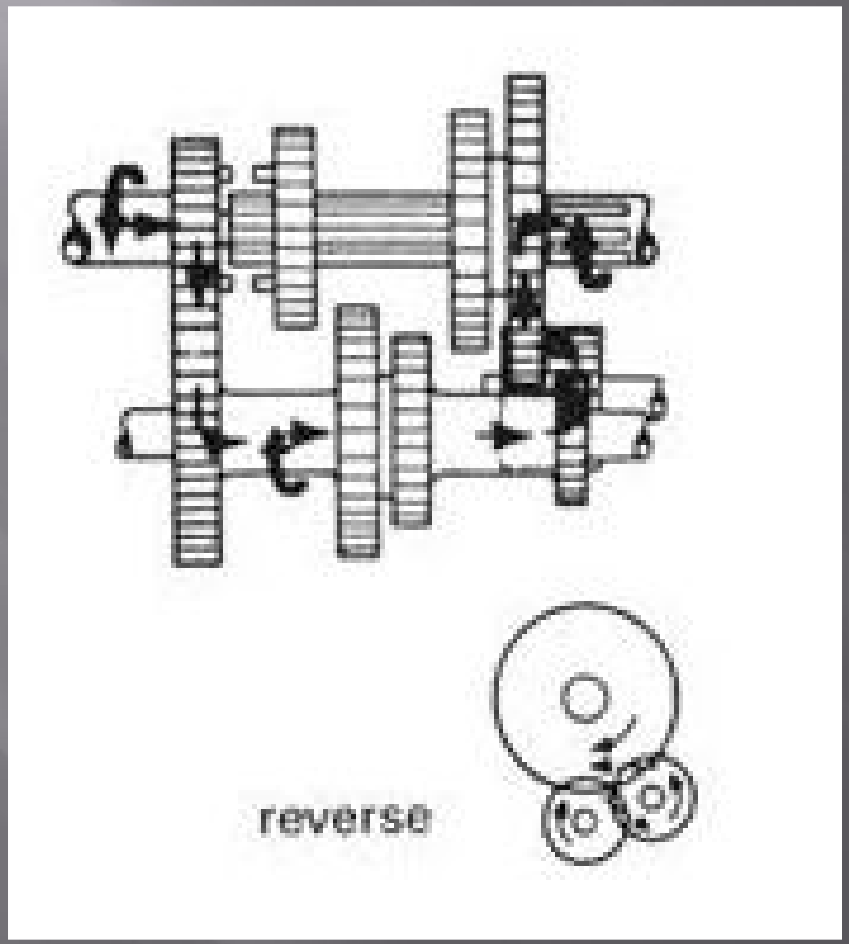


Top



top (direct)

Reverse



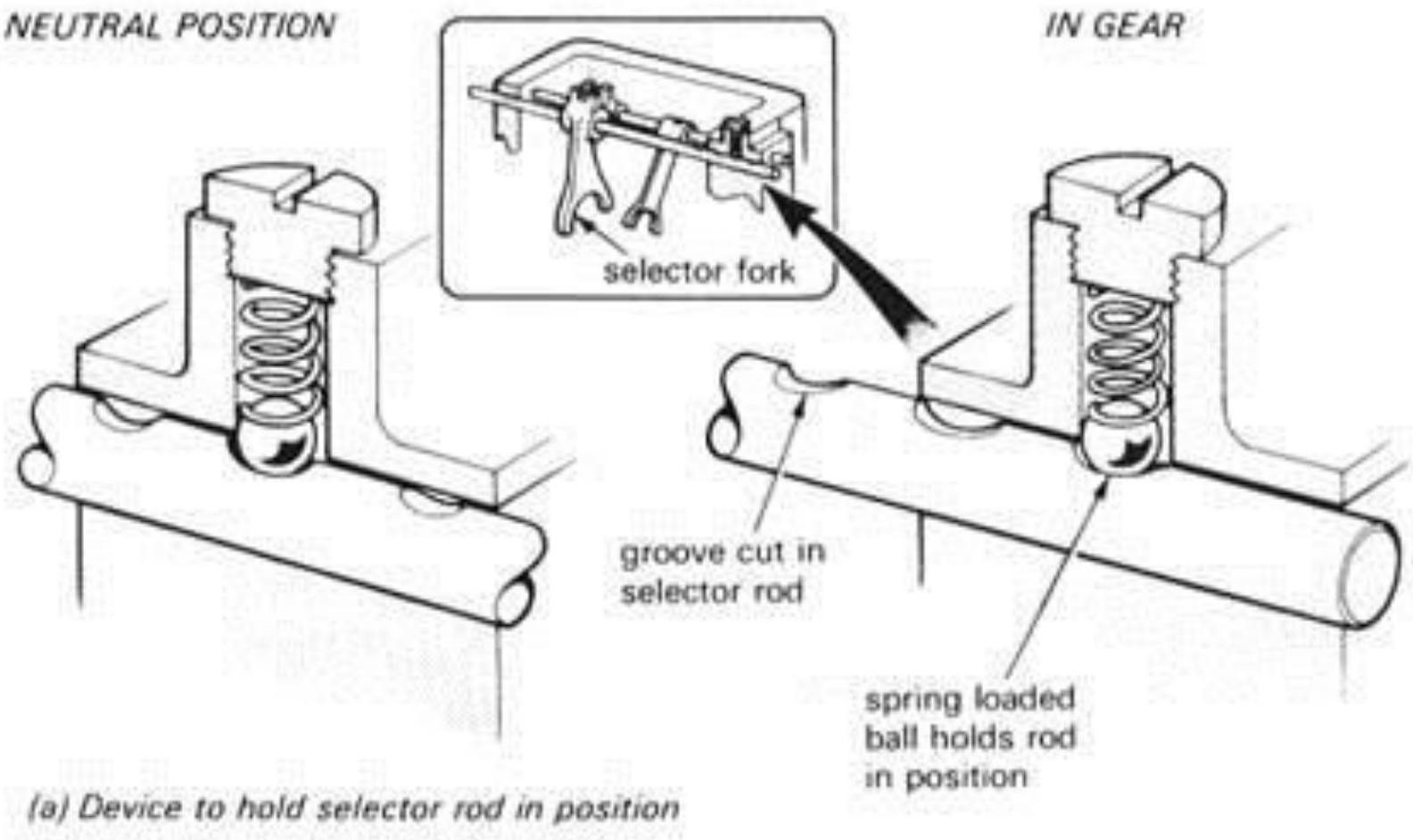
Disadvantage of Sliding mesh Gearbox

- Gear noise due to the type of gear.
- The difficulty of obtaining a smooth, quit and quick change of gear without the great skill and judgment.

Selector Mechanism

- A fork is used to slide a gearwheel along the main shaft in order to select the appropriate gear.
- It is mounted on its own rod and links the driver's gear stick to the sliding gearbox.

Selector Mechanism

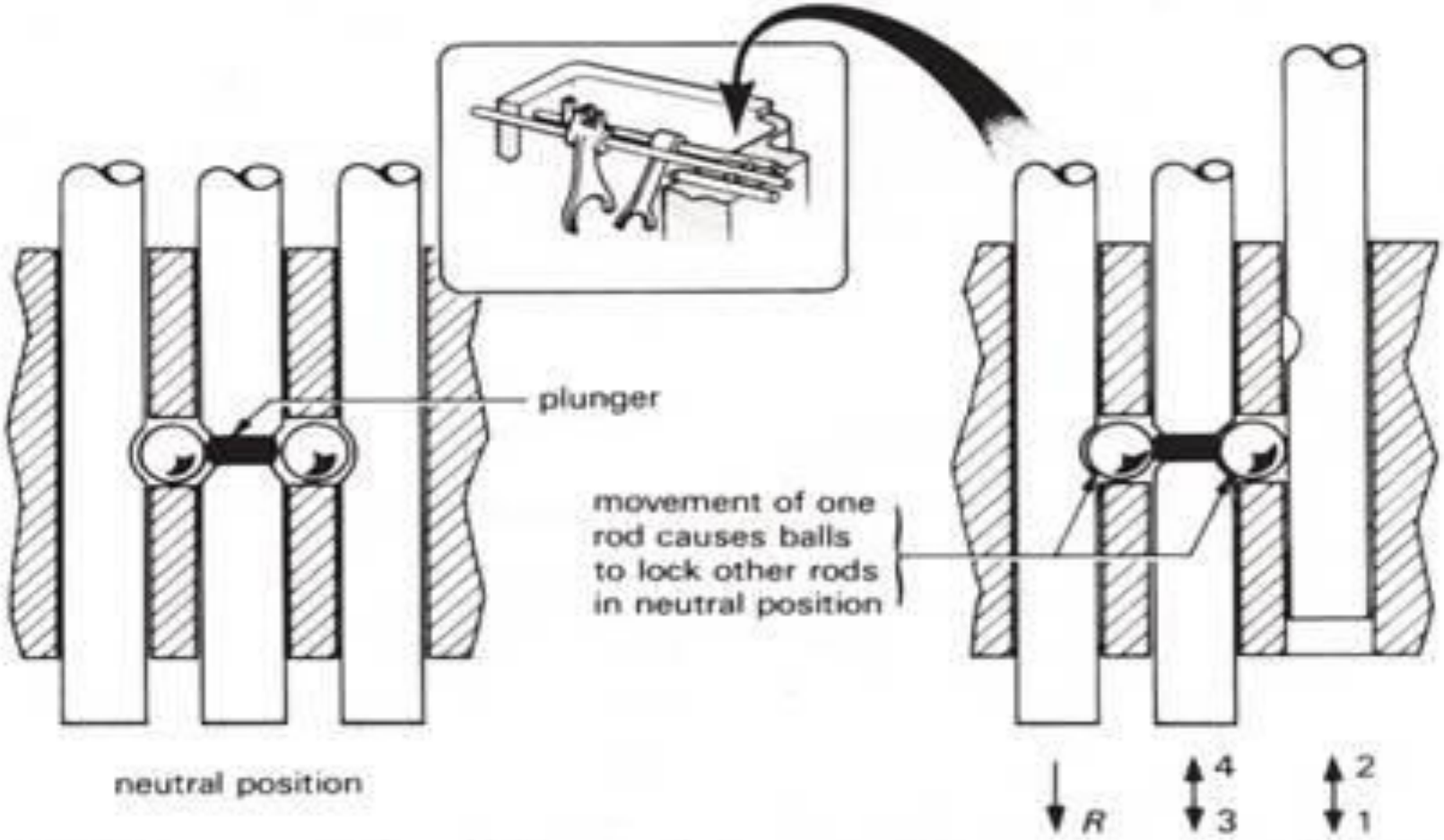


(a) Device to hold selector rod in position

Selector Detent

- It holds the gears and selectors in position and so prevent gear engagement or disengagement due to vibration.
- The figure shows a typical arrangement suitable for a layout having the selector fork locked to the rod

Interlock Mechanism



(b) Ball and plunger type of interlocking mechanism prevents two gears engaging at the same time

Interlock Mechanism

- Prevents two gears engaging simultaneously
- If this occurs the gearbox will lock up and shaft rotation will be impossible.

Power take-off arrangement

- In addition to the mechanism use for driving a vehicle along a road, a power supply is often required for operating external items of auxiliary equipment.
- A light truck having a tipping mechanism is one example, but the most varied application of power take-off units is associated with specialized off-road vehicles

Power take-off arrangement

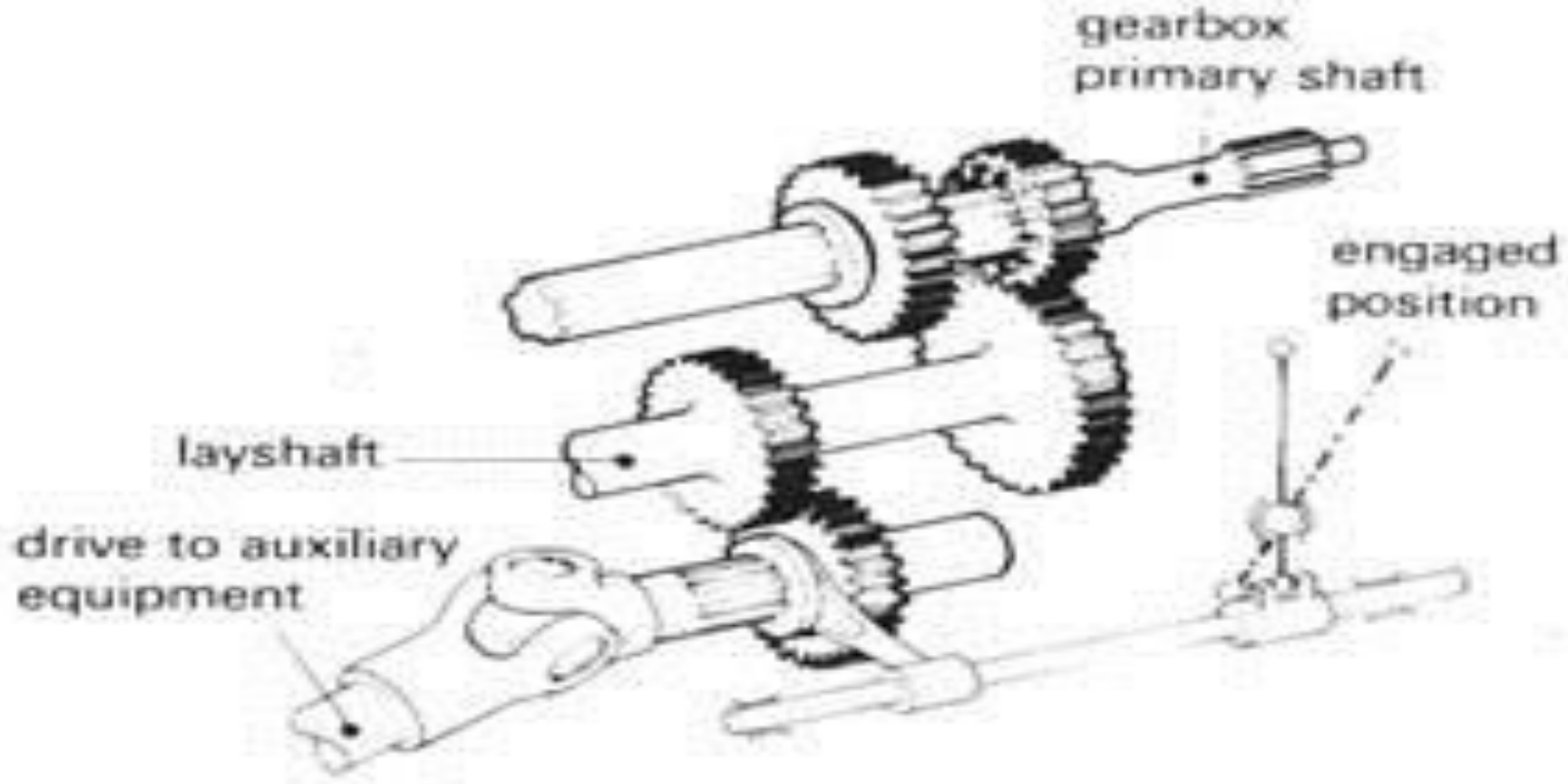
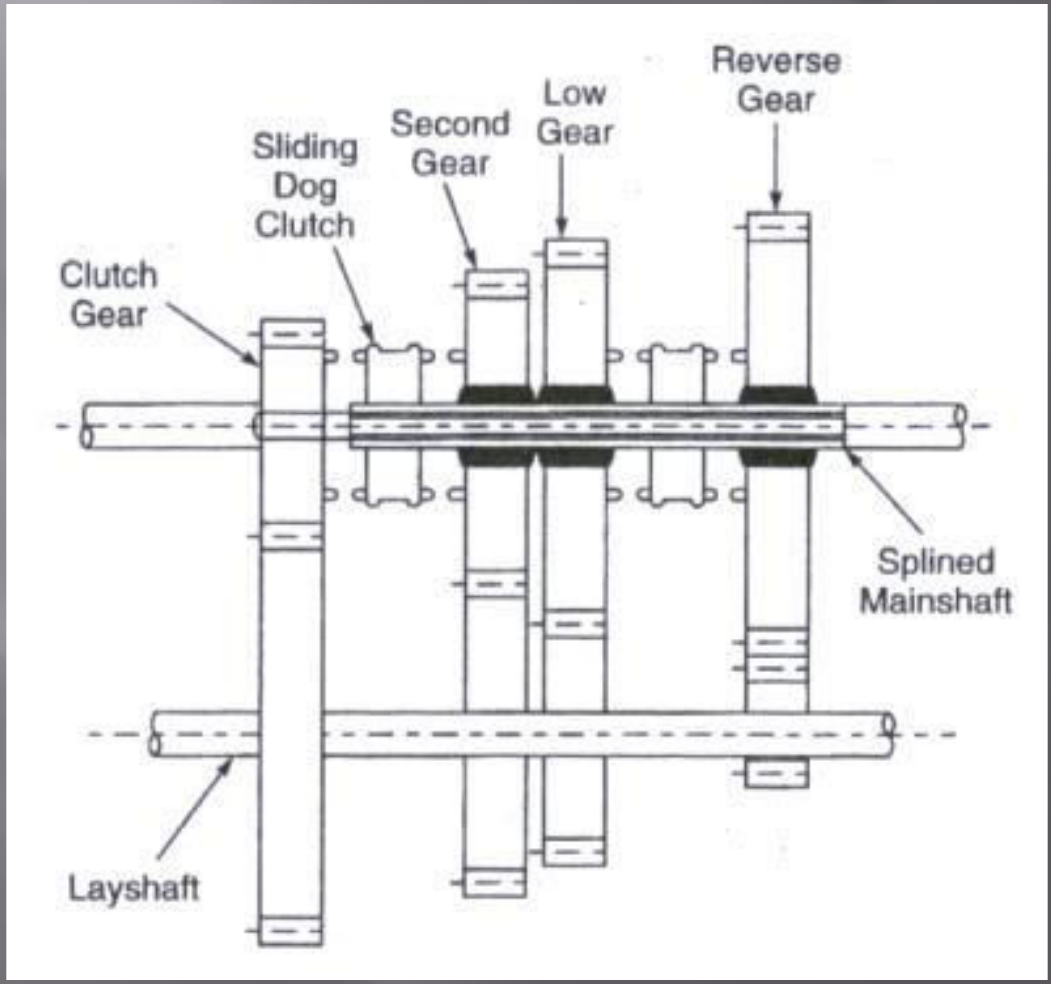


Fig. Power take-off arrangement

Constant mesh gearbox

- All the gear are in constant mesh with the corresponding gears on the layshaft. The gears on the splined main shaft are free
- The dog clutch are provided which are free to slide on the main shaft.
- The gears on the lay shaft are fixed.

Constant mesh gearbox



Constant mesh gearbox

- When the left dog clutch is slid to left by means of the selector mechanism, it's teeth are engaged with those on the clutch gear we get the *direct gear*.

Constant mesh gearbox

- The same dog clutch when slid to right makes contact with the second gear and second gear and second gear is obtained.
- Similarly movement of the right dog clutch to the left result in low gear and towards right in reverse gear.

Double Declutching with Constant mesh Gearbox

- For the smooth engagement of the dog clutches it is necessary that the speed of the clutch shaft, layshaft and main shaft gear must be equal.
- Therefore to obtain lower gear, the speed of clutch shaft, layshaft and the main shaft gear must be increased.
- By Double declutching this can be done.

Double Declutching with Constant mesh Gearbox

- The clutch is disengaged and the gear is brought to neutral.
- Then the clutch is engaged and accelerator pedal pressed to increased the speed of the main shaft gears.

Double Declutching with Constant mesh Gearbox

- After this the clutch is again disengaged and the gear moved to required lower gear and the clutch is again engaged.
- As the clutch is disengaged twice in this process, it is called double declutching

Advantage of Constant mesh Gearbox compared to Sliding mesh Gearbox

- As the gear remain always in mesh, it is no longer necessary to use straight spur gear. Instead helical gear is used which are quieter running.

Advantage of Constant mesh Gearbox compared to Sliding mesh Gearbox

- Wear of dog teeth on engaging and disengaging is reduced because here all the teeth of the dog clutches are involved compared to only two or three teeth in the case of sliding gears.

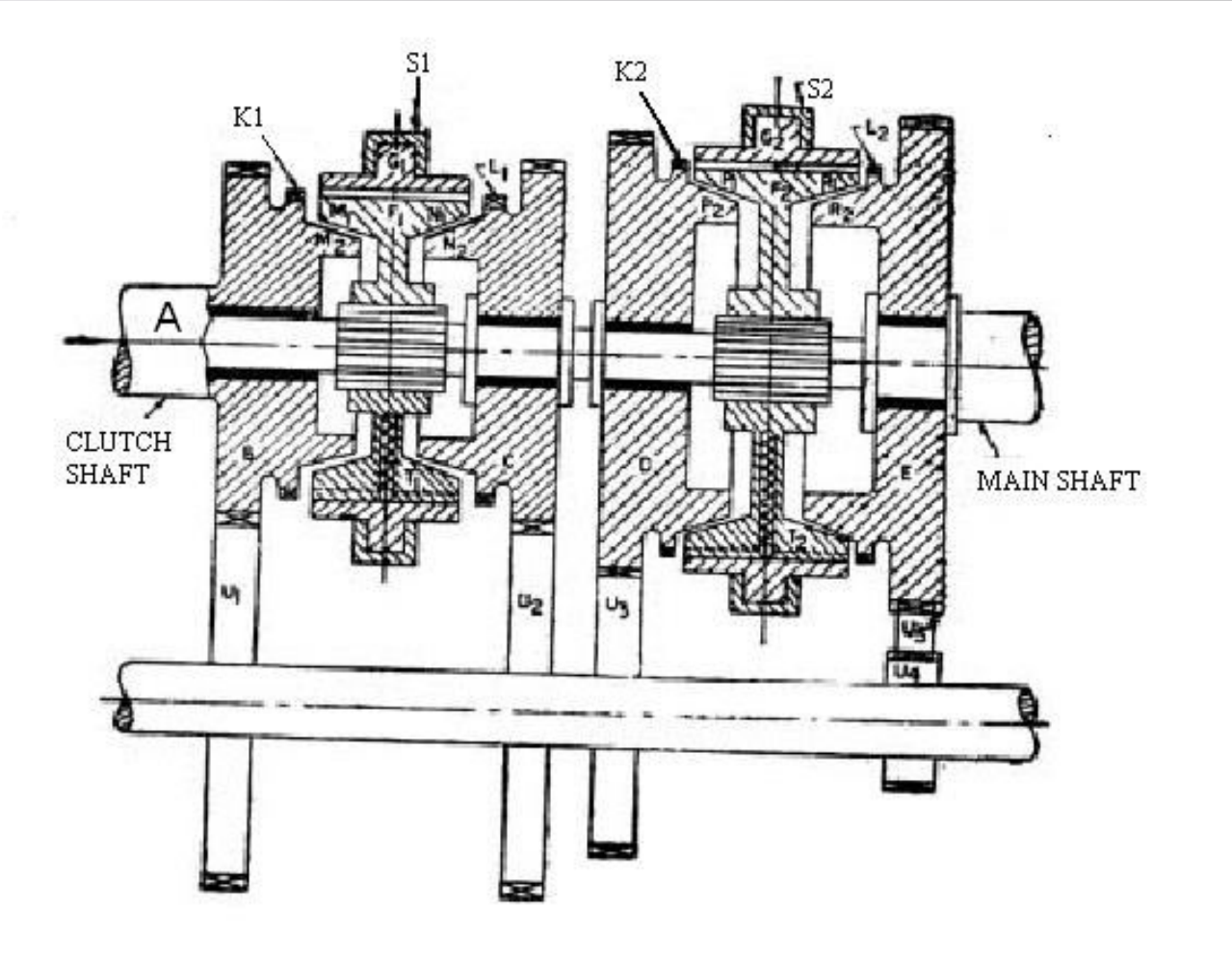
Synchromesh Gearbox

- Similar to constant mesh type, because all the gears on the main shaft are in constant mesh with corresponding gears on the layshaft.
- The gears on the main shaft are free to rotate on it and that on the layshaft are fixed to it.

Synchromesh Gearbox

- Avoids the necessity of double declutching.
- The parts which ultimately are to be engaged are first brought into frictional contact which equalizes their speed, after which these may be engaged smoothly.

Synchromesh Gearbox



Synchromesh Gearbox

- A :engine shaft.
- Gears B,C,D,E are free on the main shaft and always mesh with corresponding gears on lay shaft.
- Members F_1 and F_2 are free to slide on splines on the mainshaft.
- G_1 and G_2 are ring shaped members having internal teeth fit onto the external teeth on members F_1 and F_2 respectively.

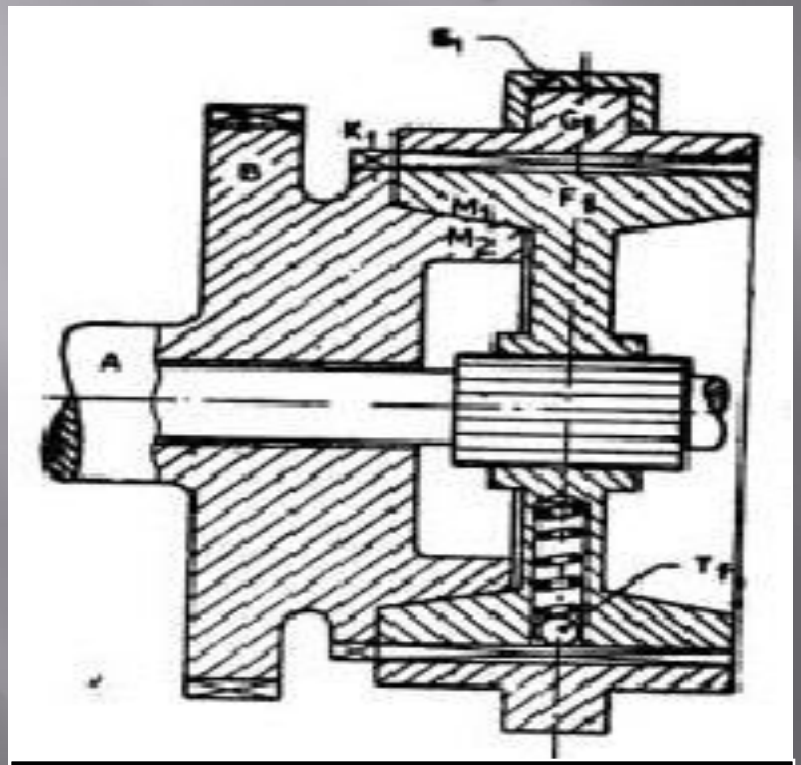
Synchromesh Gearbox

- K_1 and K_2 are dog teeth on B and D respectively fit onto the teeth of G_1 and G_2.
- S_1 and S_2 are the forks.
- T_1 and T_2 are the ball supported by springs.
- M_1,M_2,N_1,N_2,P_1,P_2,R_1,R_2 are the frictional surfaces.

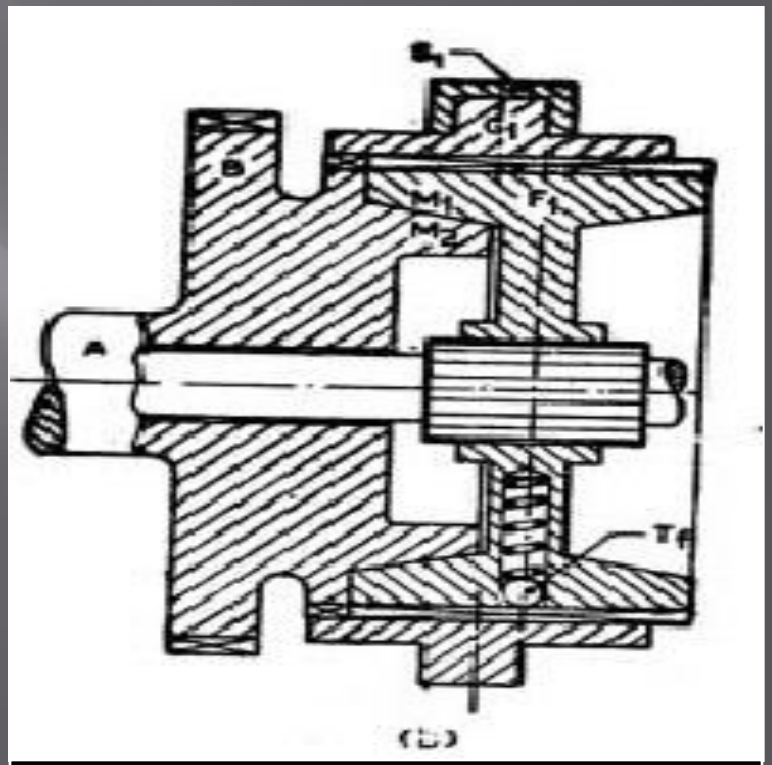
Synchromesh Gearbox

- T_1 and T_2 tend to prevent sliding of members G1(G2) on F1(F2).
- When force applied on G1(G2) through forks $S_1(S_2)$ exceeds a certain value, the balls are overcome and member G1(G2) slides over F1(F2).
- There are usually six of these balls symmetrically paced circumferentially in one synchromesh device.

Engagement of direct gear in Synchromesh Gearbox



Cones M_1 and M_2 mate to equalize speeds.



Member G_1 pushed further to engage with dog k_1

Engagement of direct gear in Synchromesh Gearbox

- For direct gear, member G_1 and hence member F_1 is slid towards left till cones M_1 and M_2 rub and friction makes their speed equal.
- Further pushing the member G_1 to left cause it to override the balls and get engaged with dogs k_1.
- So the drive to the mainshaft is direct from B via F_1 and the splines.

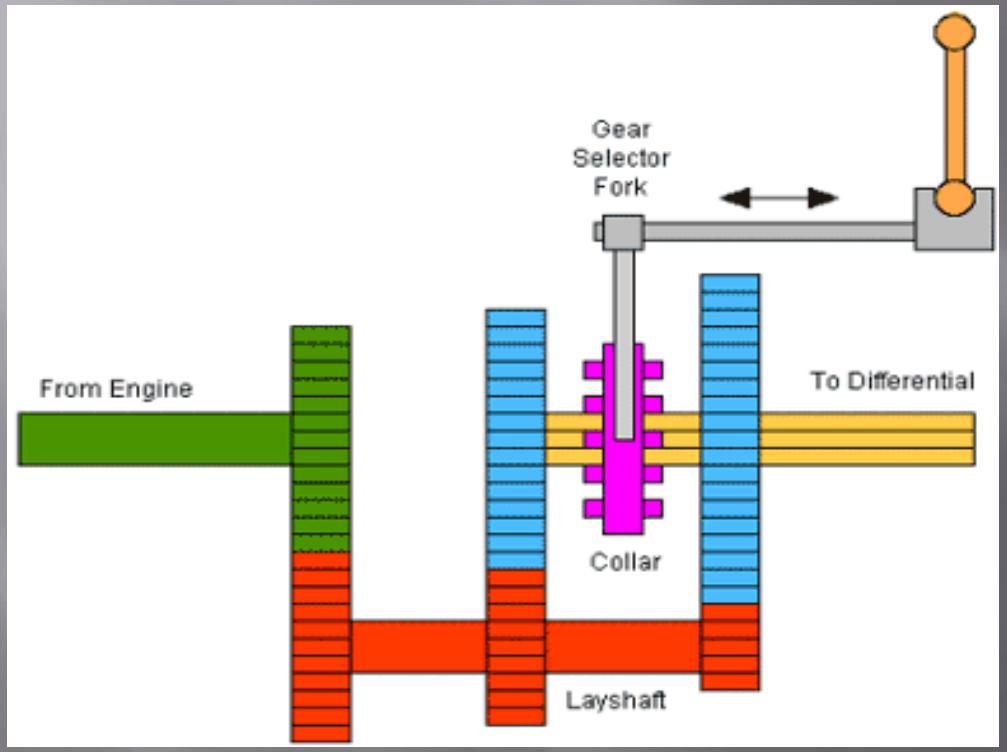
Engagement of direct gear in Synchromesh Gearbox

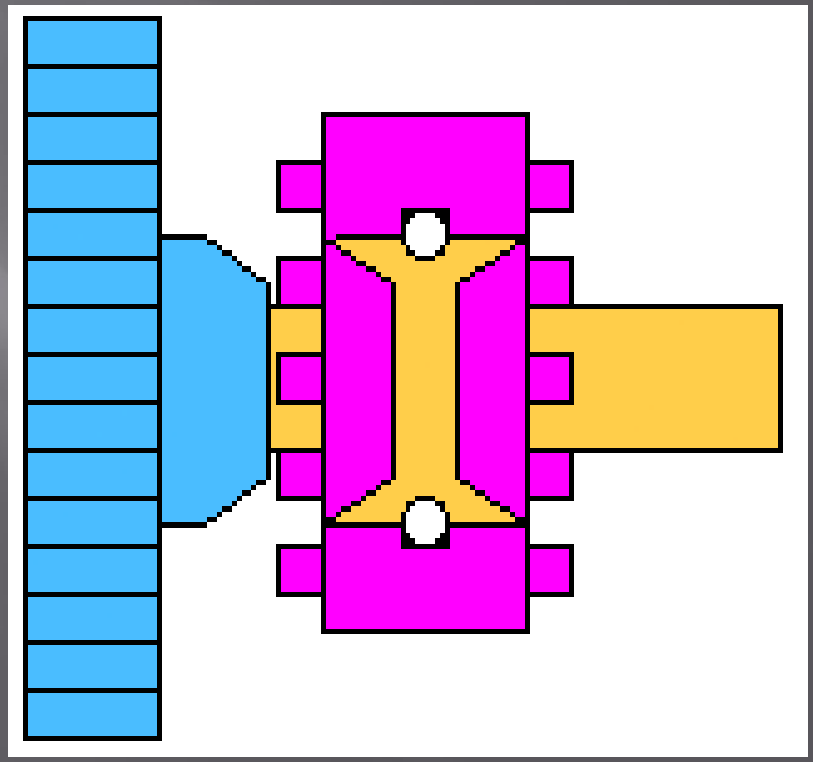
- Similarly for the second gear the members F_1 and G_1 are slid to the right so that finally the internal teeth on G_1 are engaged with L_1.
- Then the drive to mainshaft will be from B via U_1, U_2, C, F_1 and splines.
- For first gear, G_2 and F_2 are moved towards left
- The drive will be from B via U_1, U_3, D, F_2 and splines to the main shaft.

Engagement of direct gear in Synchromesh Gearbox

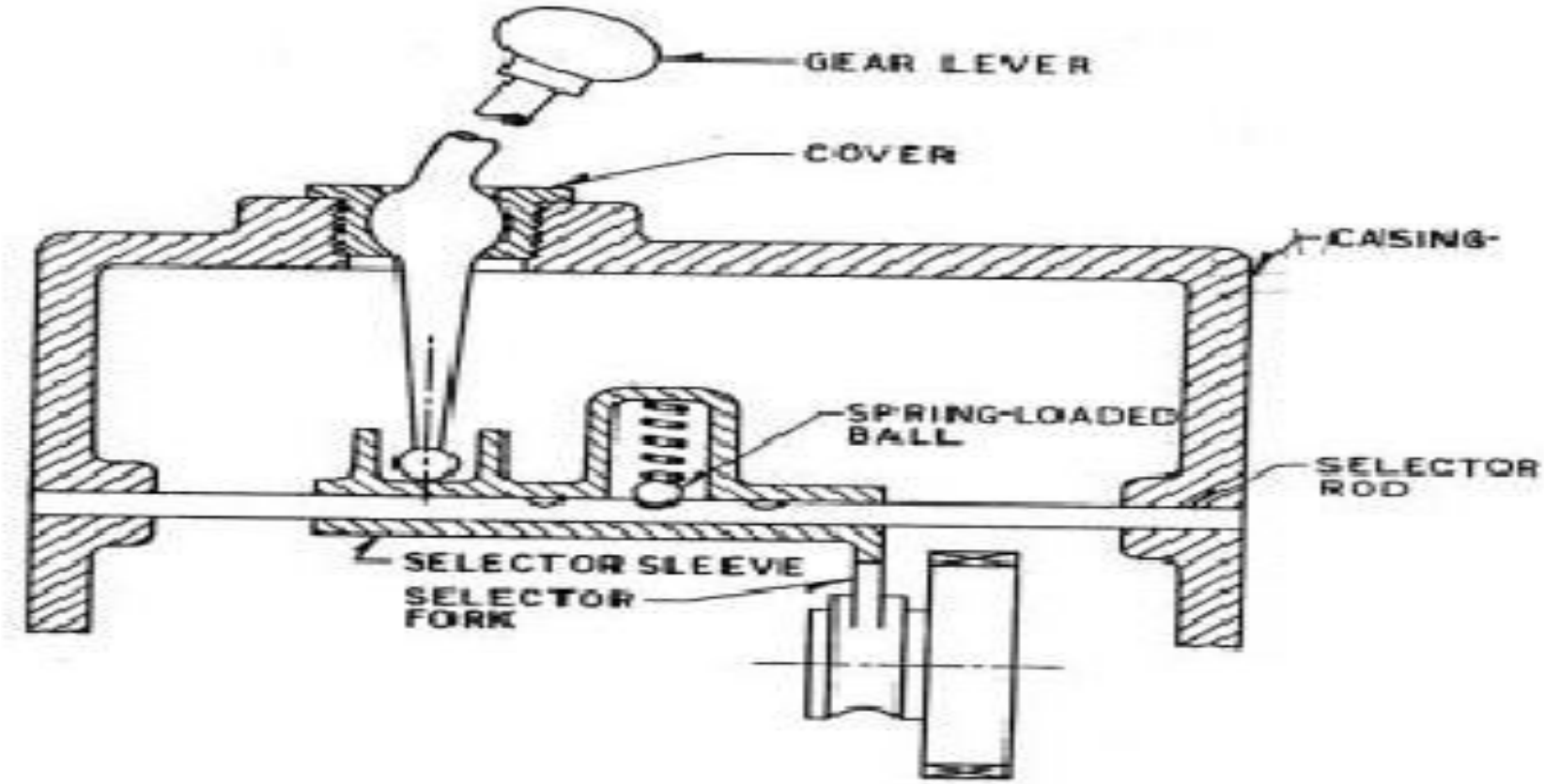
- For reverse, G_2 and F_2 are slid towards right.
- In this case the drive will be from B via U_1, U_4, U_5, E, F_2 and splines to the main shaft.

It's too simple to Understand





Selector Mechanism with gear lever on top of the transmision



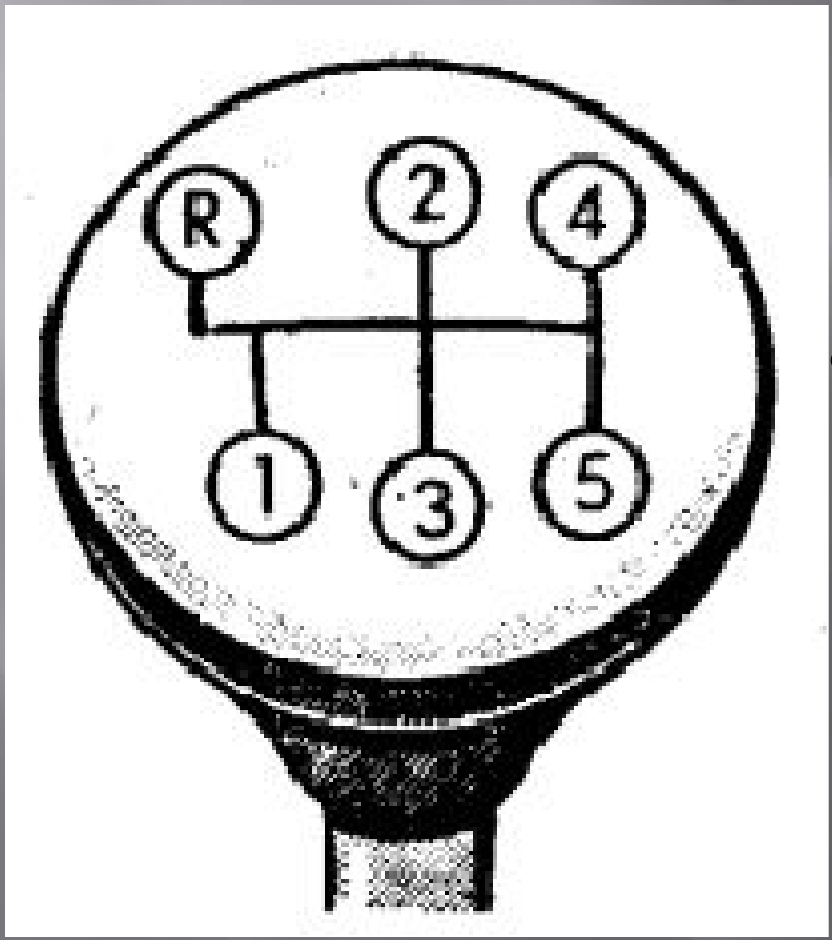
Selector Mechanism with gear lever on top of the transmision

- There are forks mounted on the sleeves on three separate selector rods which are supported in the gearbox casing.
- Each selector sleeve can slide on its rod.
- There are slots on the selector rods and the sleeves are provided with spring loaded balls to avoid unwanted engagement of the gears.

Selector Mechanism with gear lever on top of the transmision

- These balls resist the movement of the forks until some force is applied to the gear lever to overcome their resistance.
- Grooves are provided on the gear bosses where the selector forks can fit in.
- Transverse motion of the gear lever selects the forks which is to be engaged and the longitudinal movement then slides the forks and its gear to engage the selected gear.

Selector Mechanism with gear lever on top of the transmision



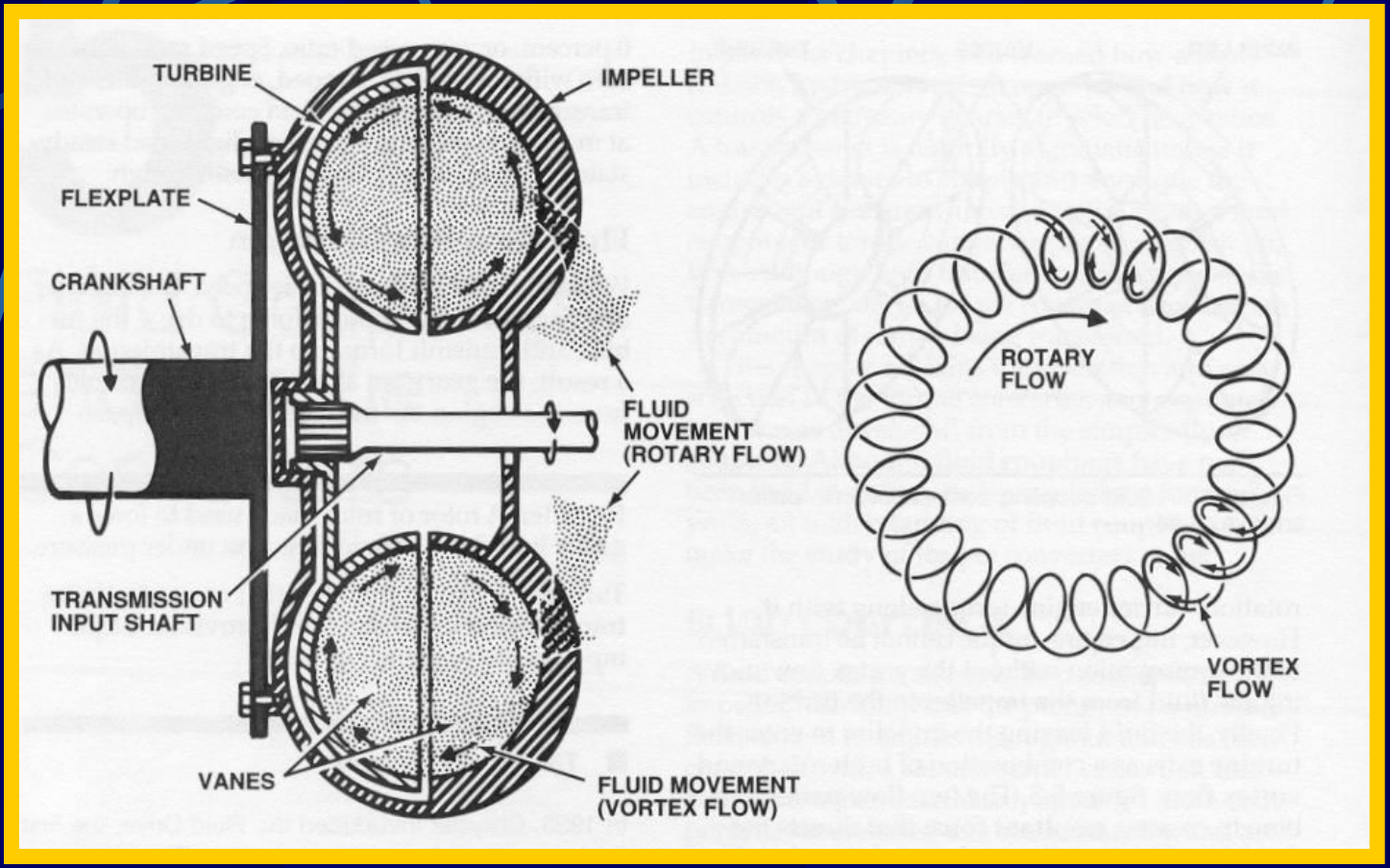
- **Various gear position are marked on the gear lever knob itself.**

Fluid Couplings and Torque Converters

Introduction

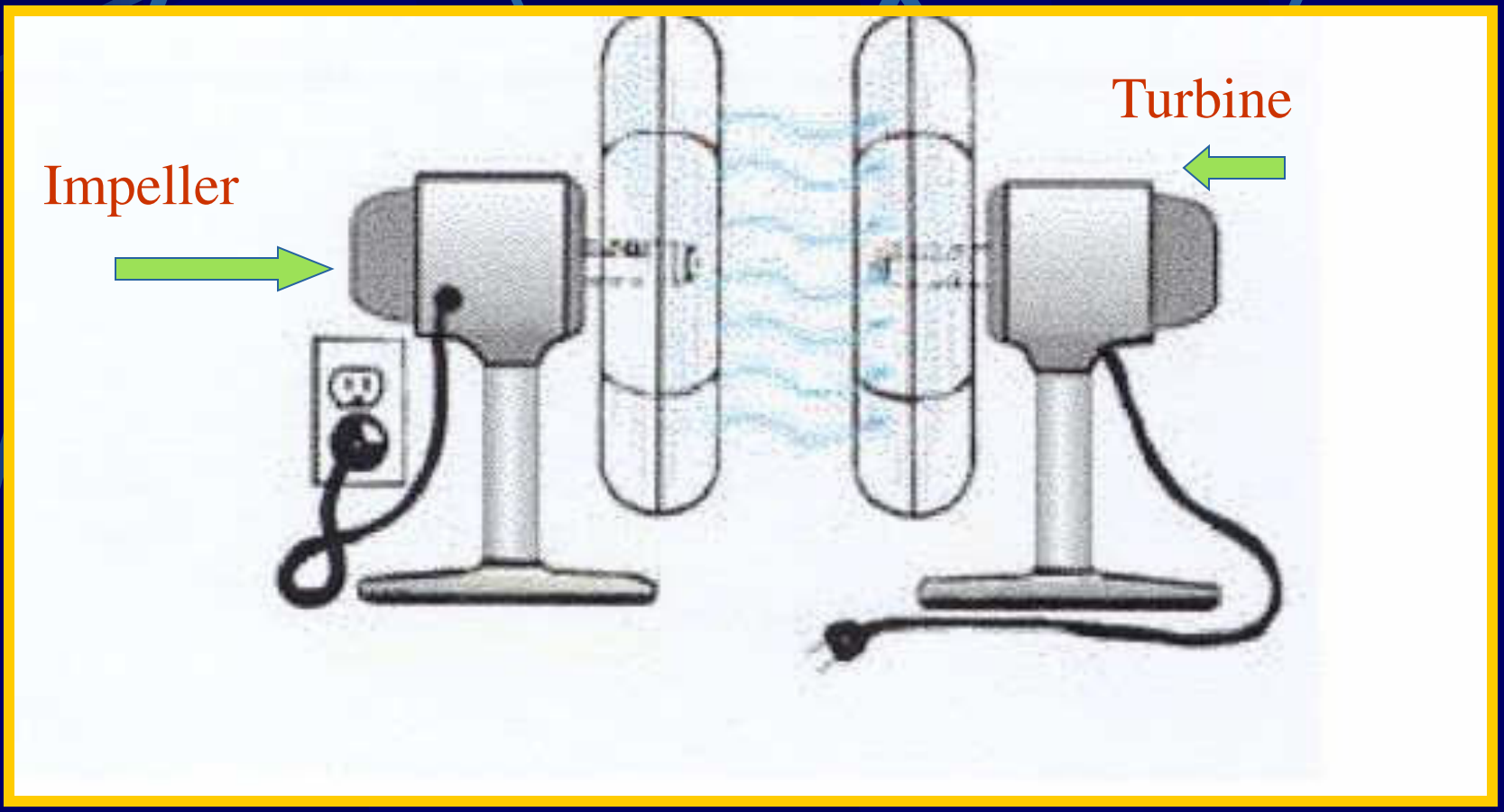
- Engine and Transmission needs to be automatically coupled and uncoupled
- Uses Torque Converter to multiply torque and transmit power
- Components
  - Impeller
  - Turbine
  - Stator

Fluid Coupling



Fluid travels either in a rotary or vortex motion

Impeller turns Tubine



Fluid drives turbine at an angle

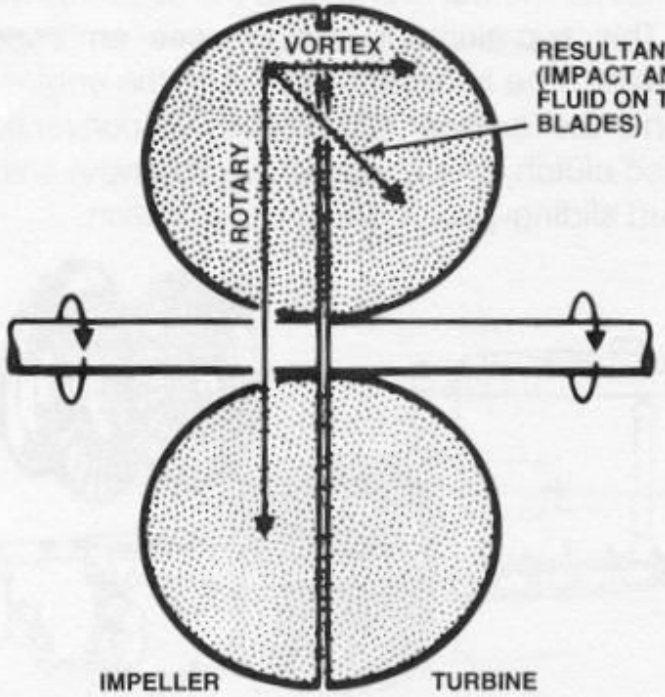
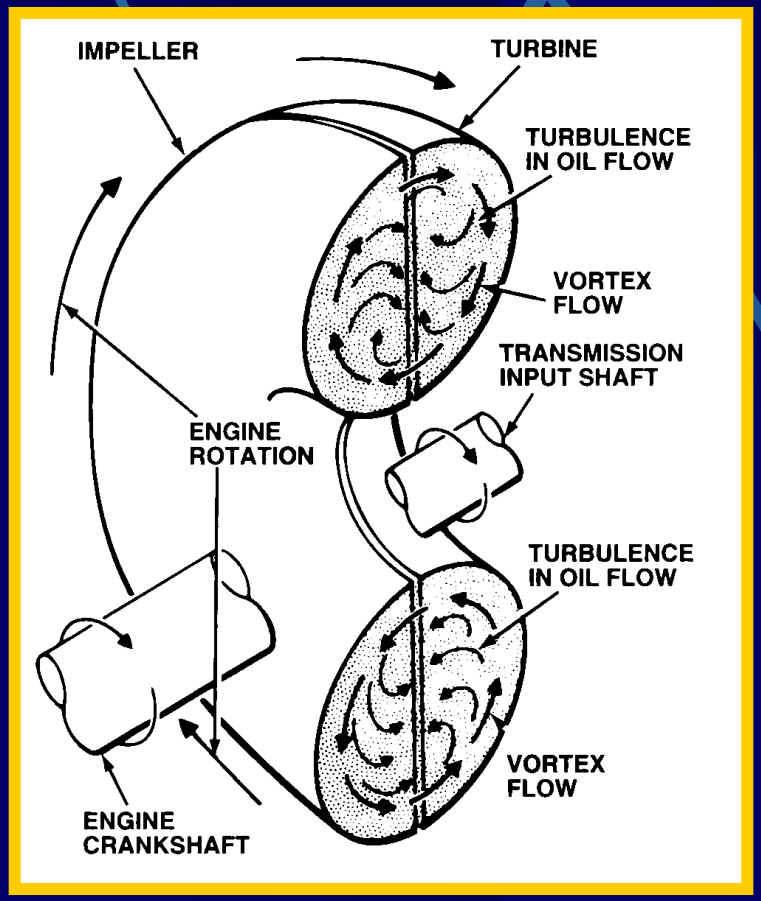
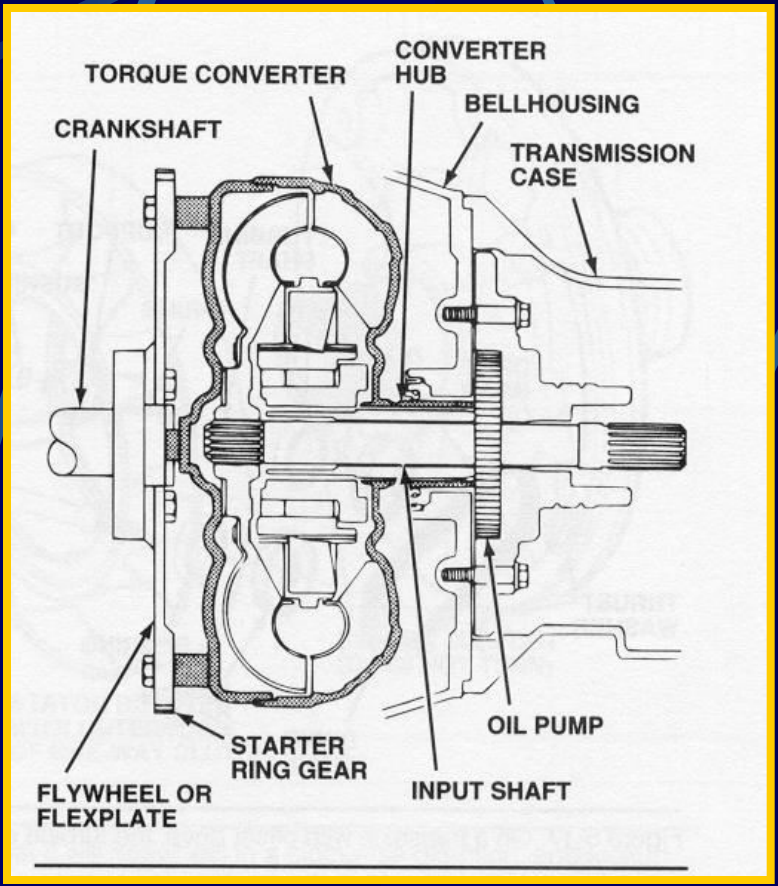


Figure 5-3. Fluid leaves the impeller at an angle that is a combination of the rotary and vortex flow.

Difference in speed creates a turbulence

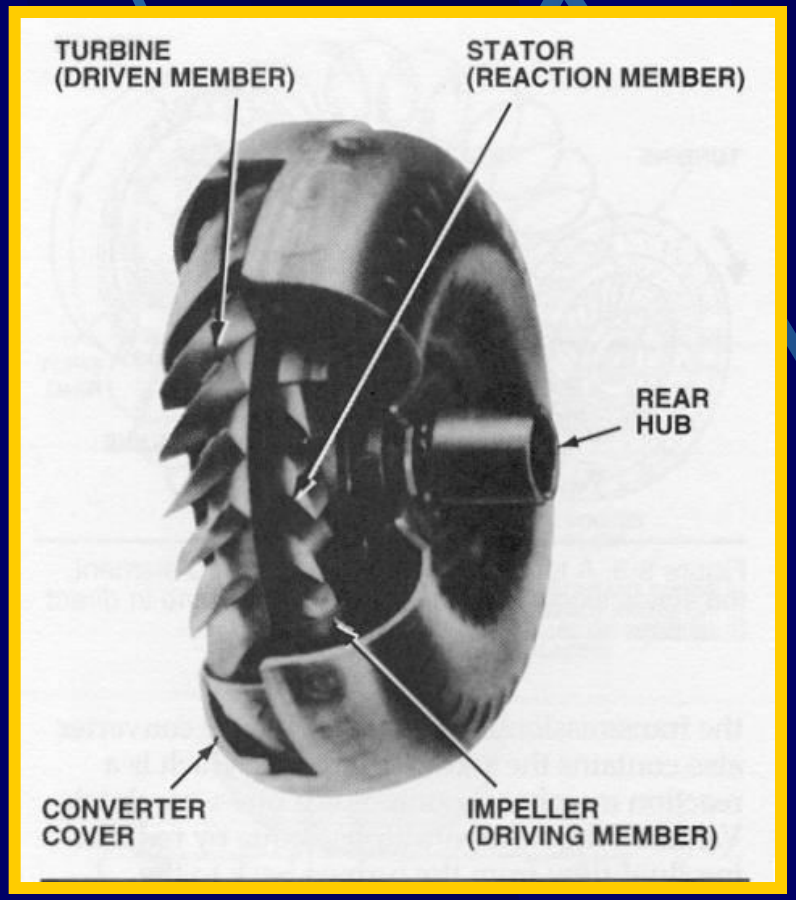


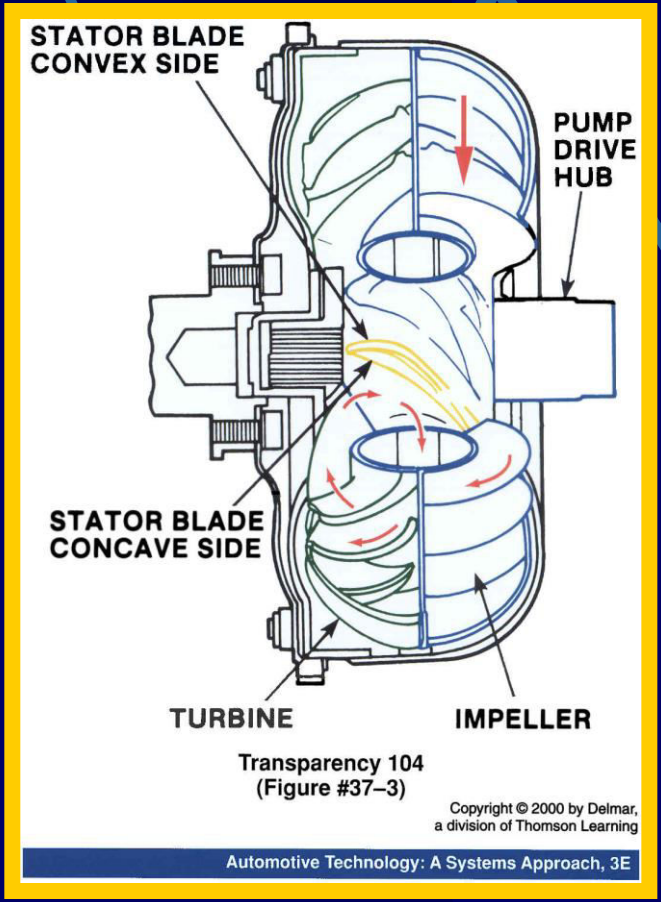
Components



- Flexplate drives T.C.
- Torque Converter Hub drives oil pump
- Impeller drives Turbine
- Turbine drives input shaft
- Input shaft drives Clutch Hub

Vanes are curved to accelerate fluid flow




STATOR BLADE
CONVEX SIDE
PUMP
DRIVE
HUB
STATOR BLADE
CONCAVE SIDE
TURBINE
IMPELLER
Transparency 104
(Figure #37–3)
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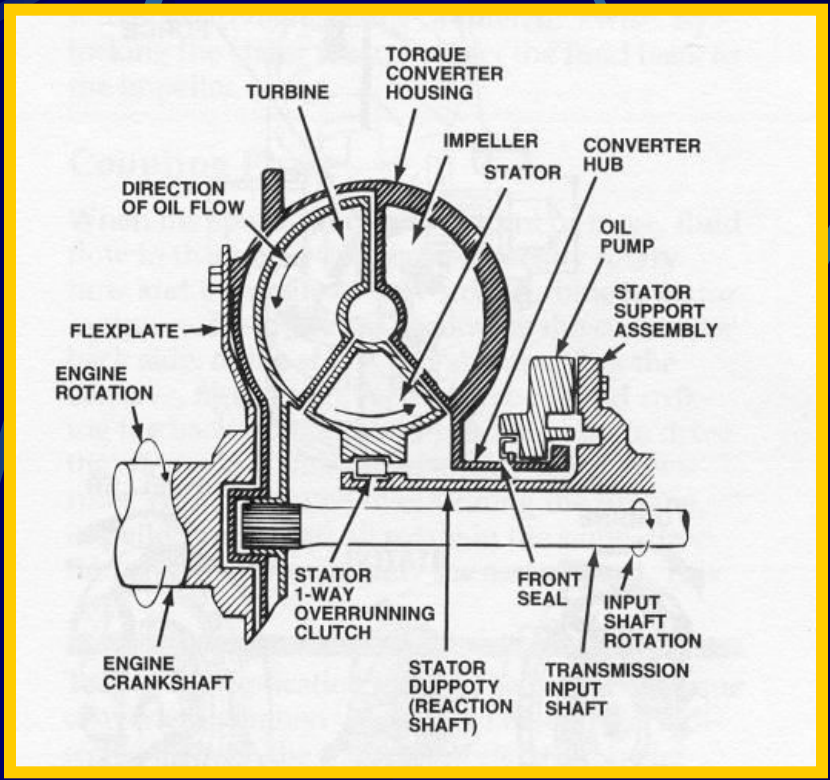
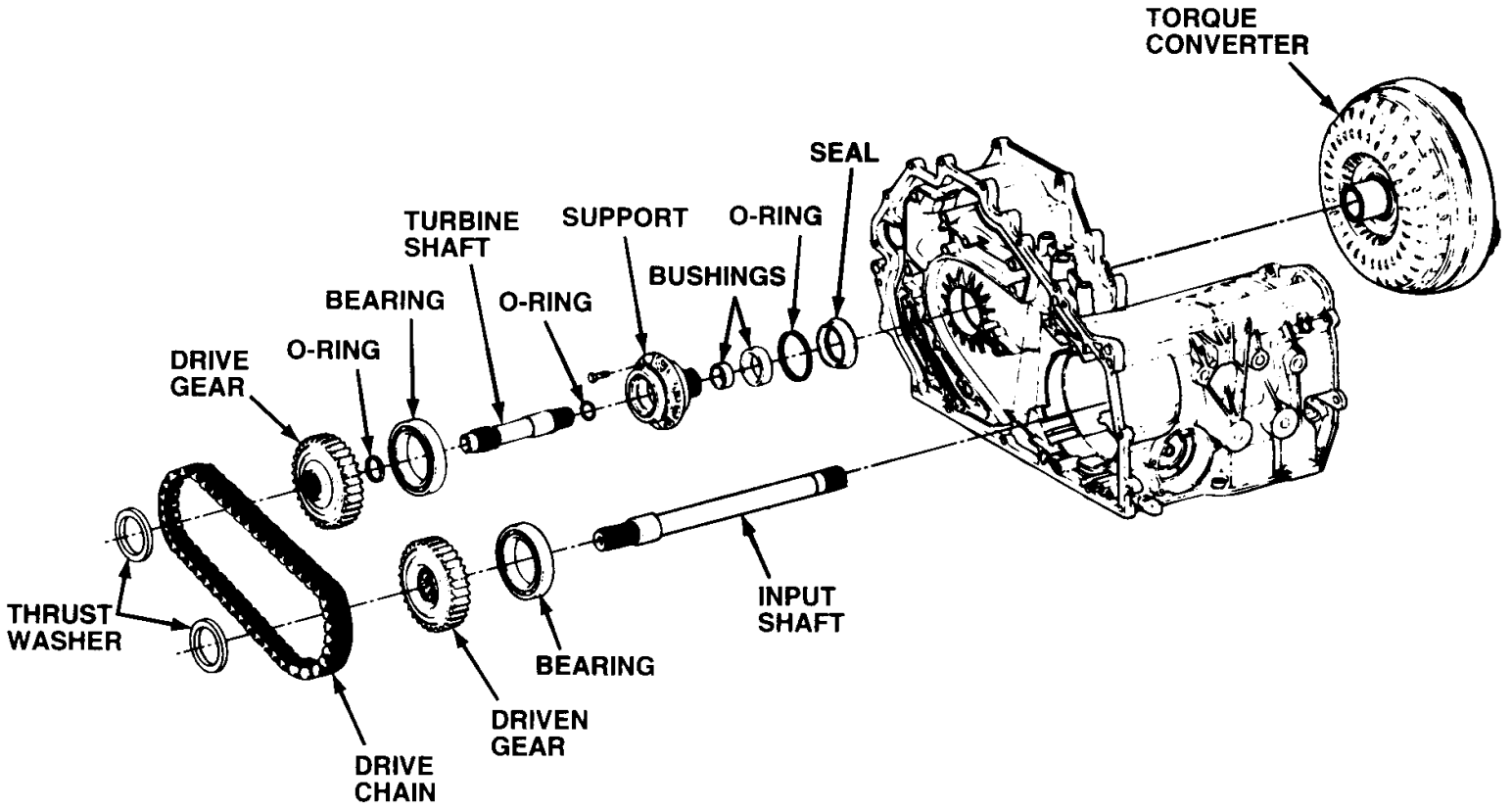
Automotive Technology: A Systems Approach, 3E

Rear Wheel Drive



- Input shaft directly connects to turbine with splines
- Input shaft is usually hollow for lock up operation

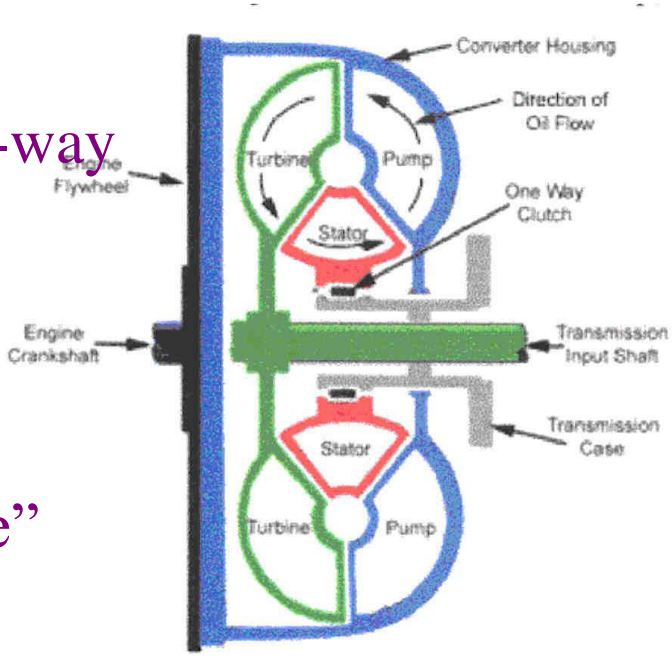
Front Wheel Drive

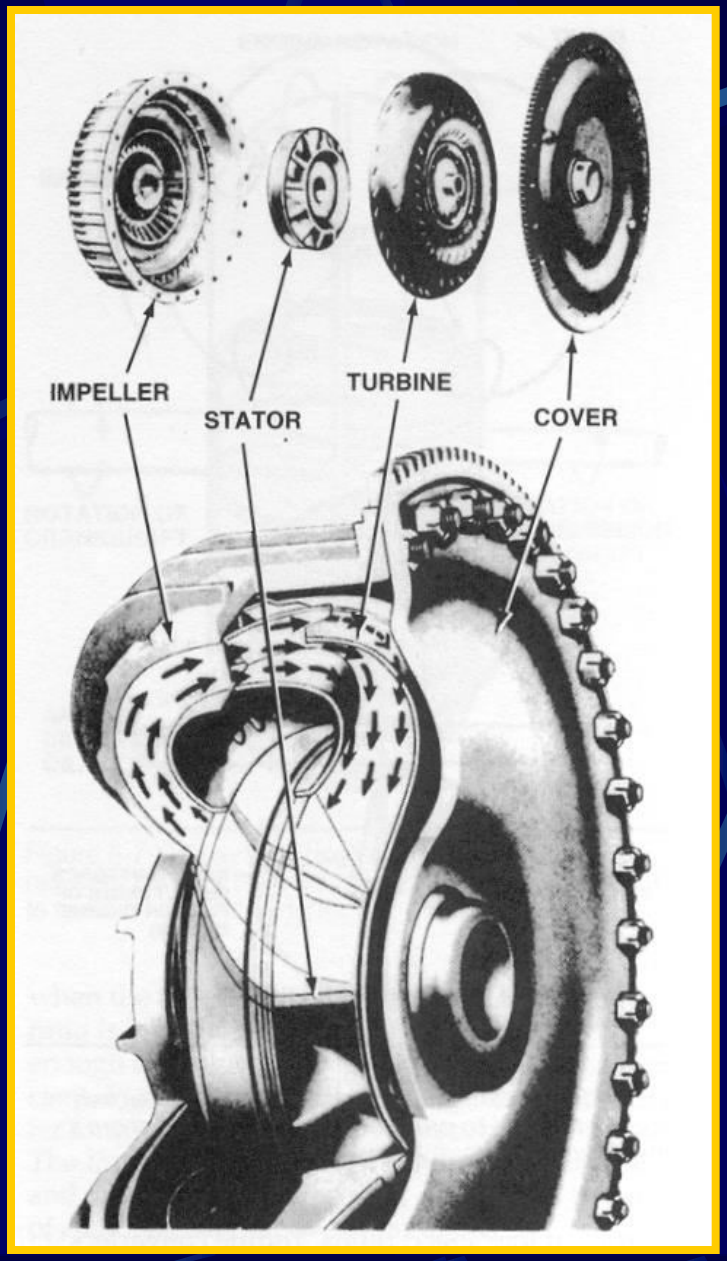


Turbine Shaft drives Input Shaft

Stator Operation

- Stator assembly mounts on One-way clutch.
- Stator multiplies torque
- At 90% speed ratio, the stator rotates same speed as turbine and impeller and “coupling phase” occurs.





- Early Converter were repairable
- Older converters had drains

One Way Clutch

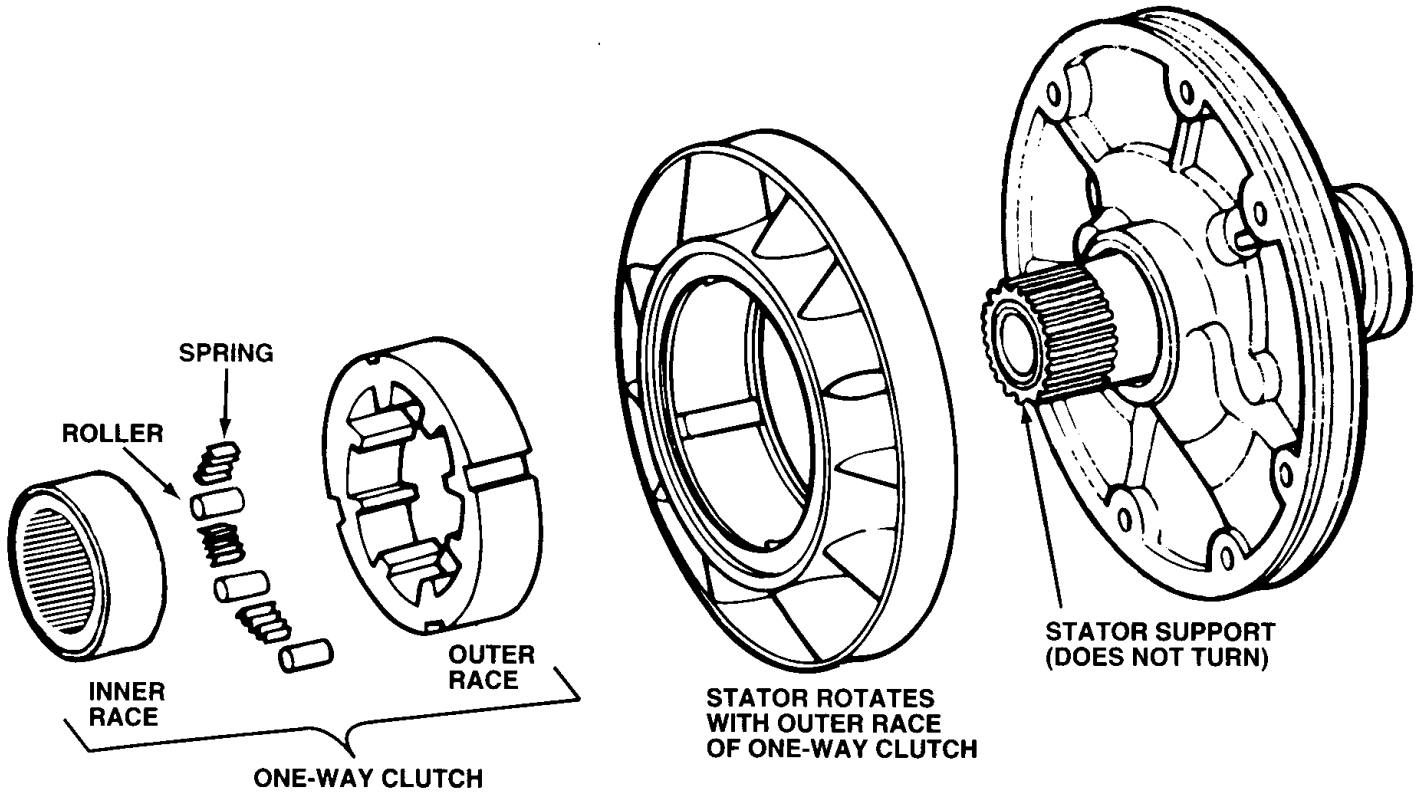
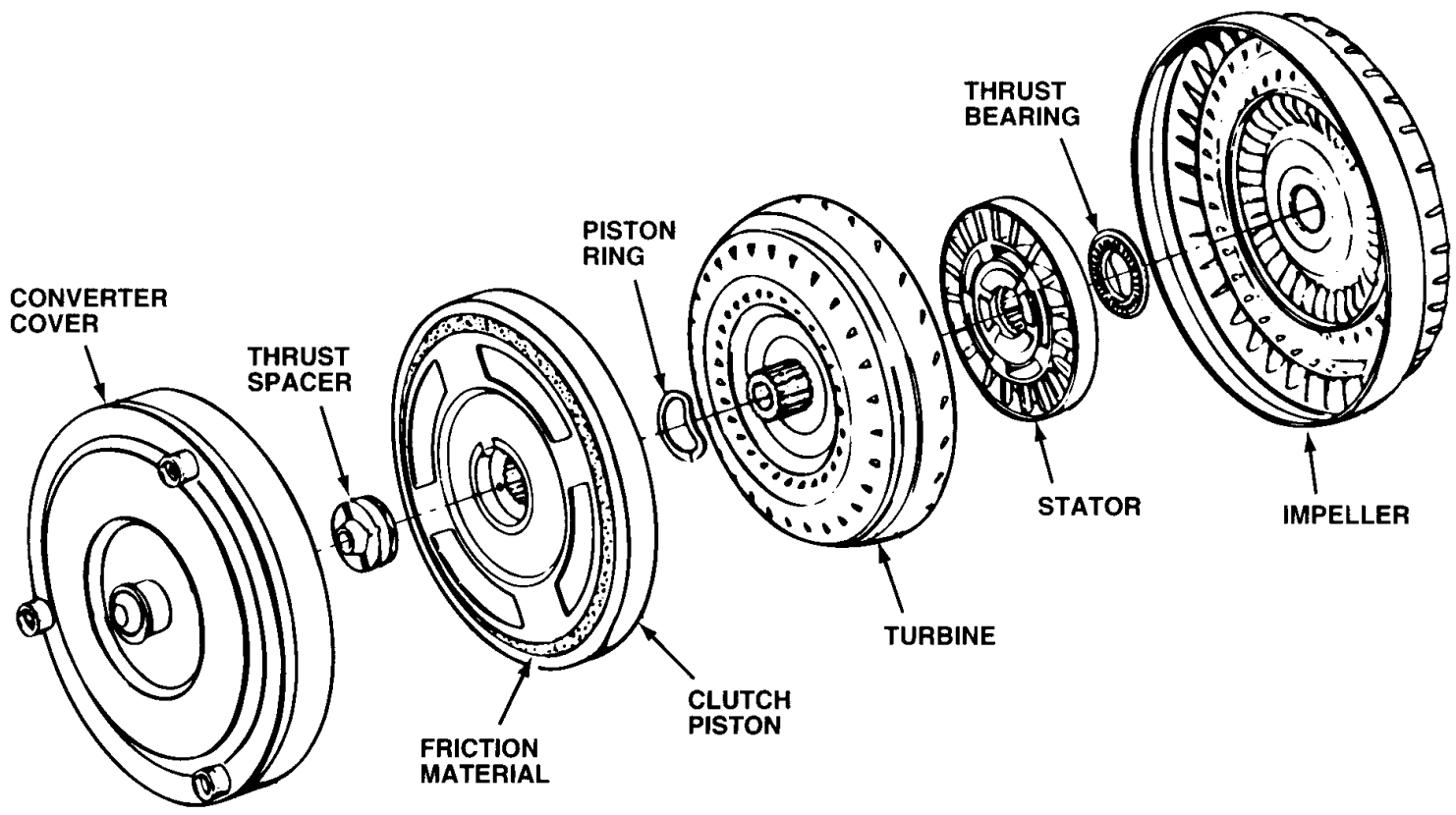


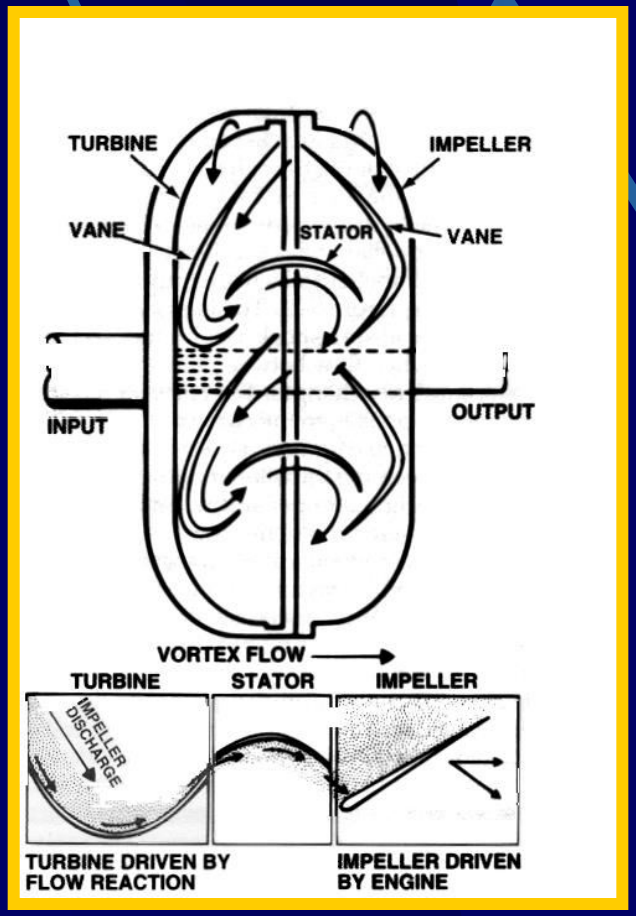
Figure 5-19. The stator mounts on a one-way clutch so that it will freewheel in a clockwise direction, and lockup

GM TCC

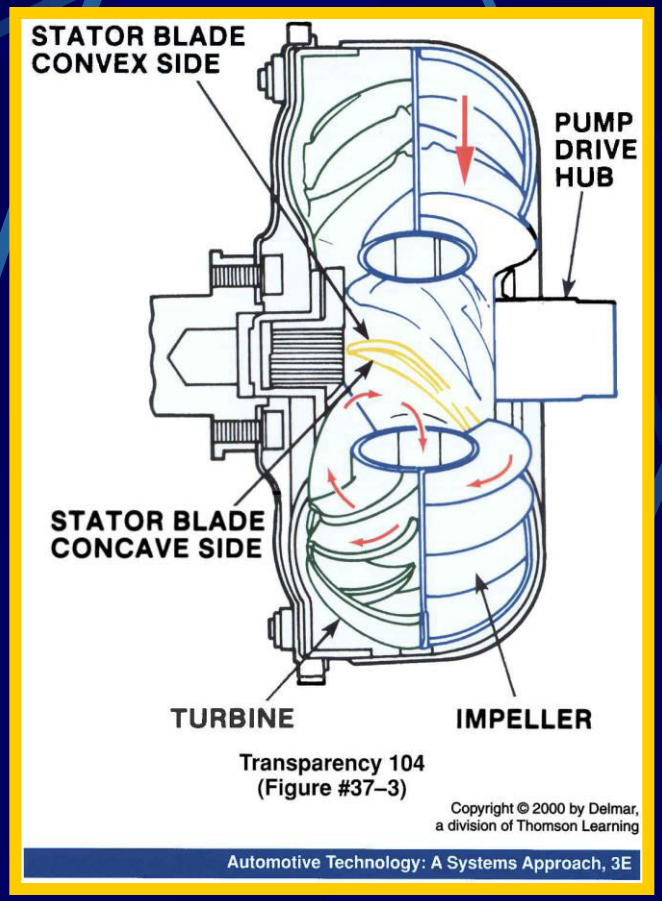


First used in 1980, Applied by TCC Solenoid

Vane curvature controls amount of multiplication



Converter Operation



- Stator redirects fluid back into impeller to multiply force
- More torque happens at lower rpms.
- At higher rpm, components equalize

STEERING SYSTEMS

TOPICS TO BE DISCUSSED

- **Steering system**
  - **Steering geometry**
  - **Types of steering gear box**
  - **Power Steering**
- **Types of Front Axle**
- **Types of Suspension Systems**

STEERING SYSTEM

- **Steering is the term applied to the collection of components, linkages, etc. which allow a vehicle to move in the desired direction**

- **An automobile is steered with the help of steering gears and linkages, which transfer the motion of the hand operated steering wheel to the front wheels**

FUNCTIONS OF STEERING SYSTEMS

- It helps in turning the wheels to left or right
- It converts the rotary movement of the steering wheel into an angular turn of the front wheels.
- It multiplies the effort of the driver by leverage in order to reduce the effort to turn the wheels.
- It absorbs a major part of the road shocks thereby preventing them to get transmitted to the hands of the driver

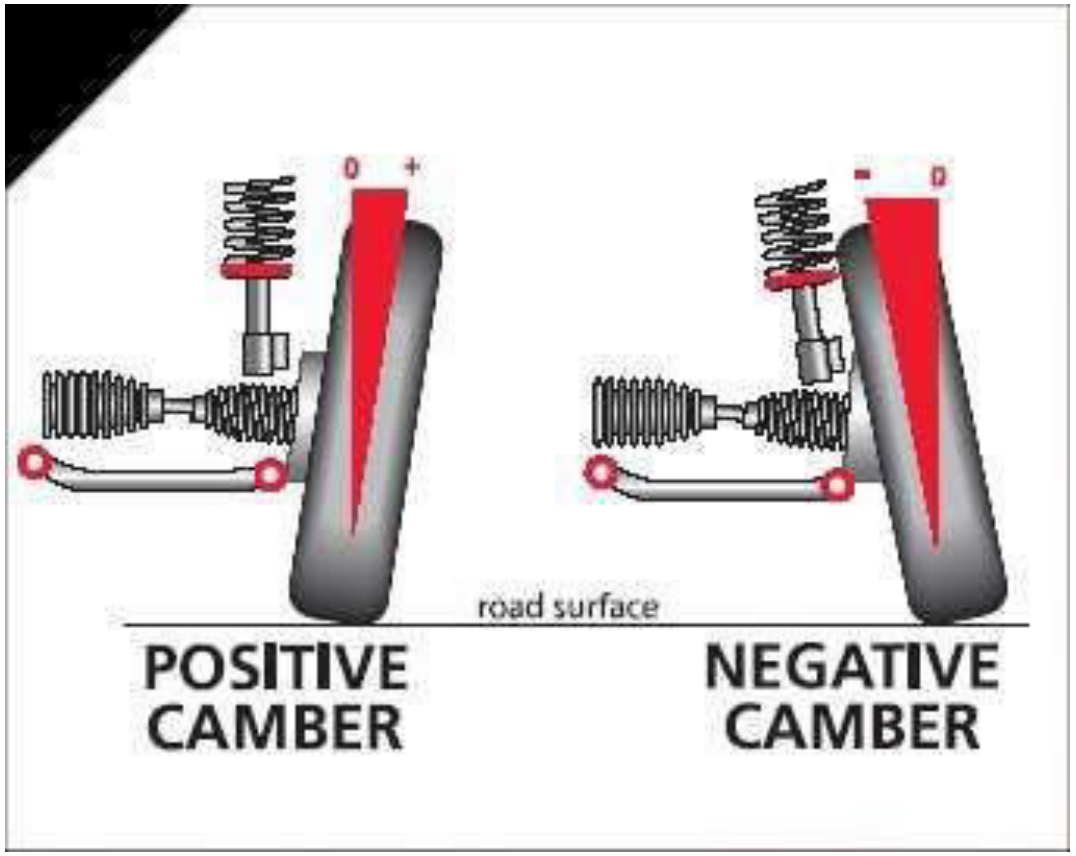
STEERING GEOMETRY

- Camber
- Castor
- King pin inclination (SAI)
- Combined angle and Scrub radius
- Toe in or Toe out

CAMBER

- Camber is the inward or outward tilt of the wheel when compared with a true vertical line.
- Camber is positive when the top of the wheel is tilted out.
- Camber is negative when the top of the wheel is tilted in.
- It is at zero when the wheel is vertical . Front wheels usually have small positive camber.
- Negative camber gives better cornering and positive camber increases straight ahead stability
- Camber should not exceed 2 degrees

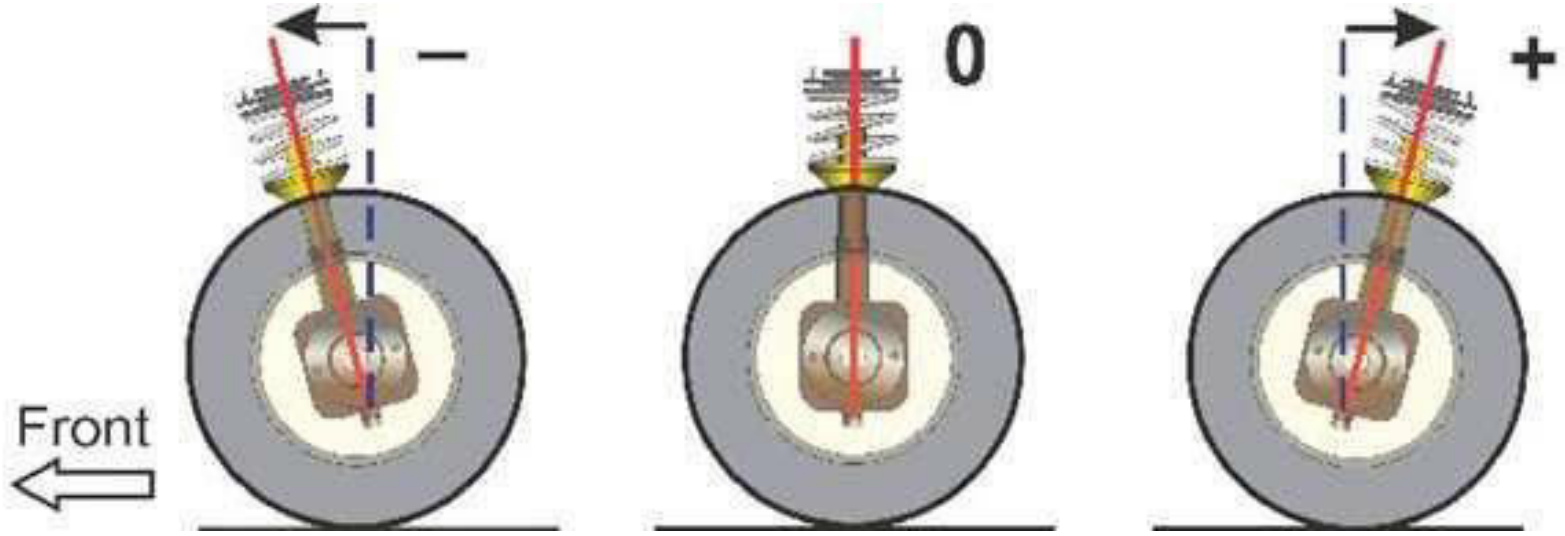

0

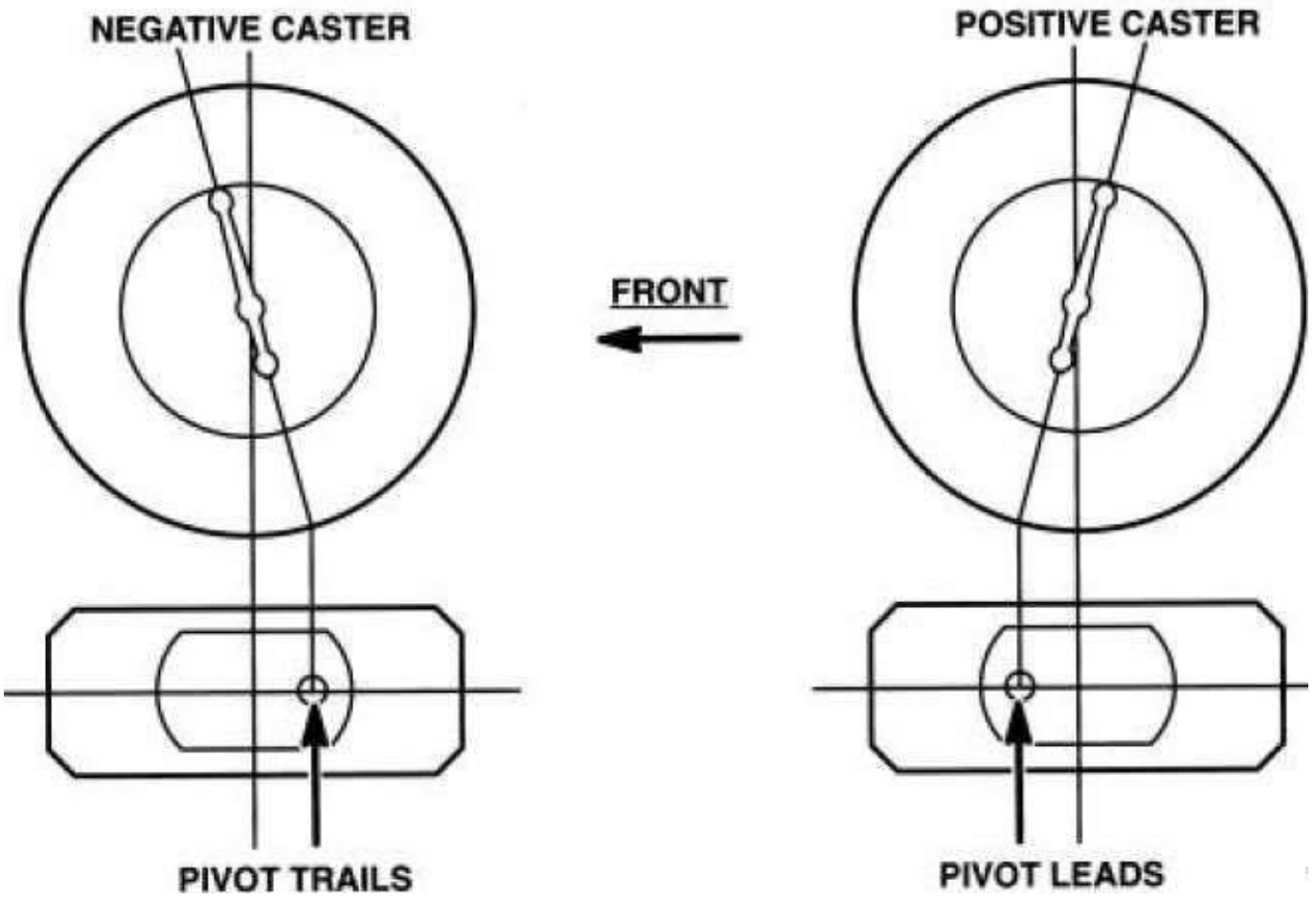

0
+
-
0
road surface
POSITIVE CAMBER
NEGATIVE CAMBER

CASTER

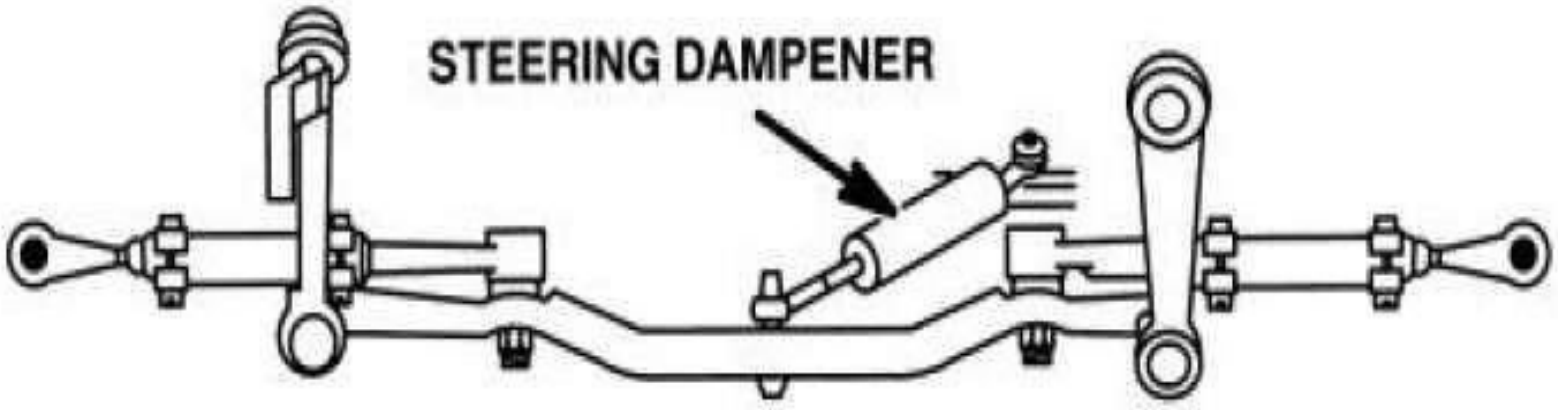
- Caster is the forward or backward tilt of the steering axis when compared with a true vertical line.
- Caster is positive if the axis is leaning rearward.
- Caster is negative if the axis is leaning forward.
- It is zero when the steering axis is straight up or down.
- Caster is measured in degrees (3 degrees gives better result). Most vehicles have a small amount of positive caster.

- Caster gives the front wheels the ability to return to the straight ahead position after a turn. Caster also provides directional stability.
- When a wheel is turned out, the spindle lowers and raises the vehicle. When a wheel is turned in, the spindle raises and lowers the vehicle.
- When the wheels are released from a turn, the weight of the vehicle helps move each spindle back toward the mid-point until the load is equal on both front wheels.



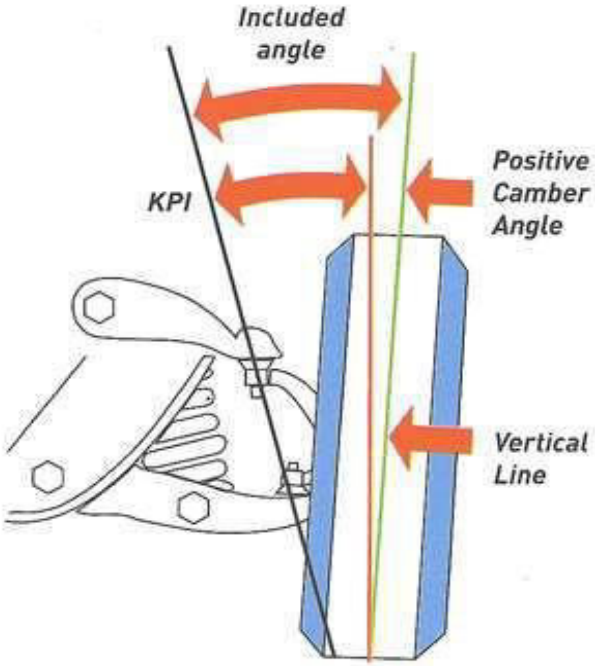

NEGATIVE CASTER
POSITIVE CASTER
FRONT
PIVOT TRAILS
PIVOT LEADS

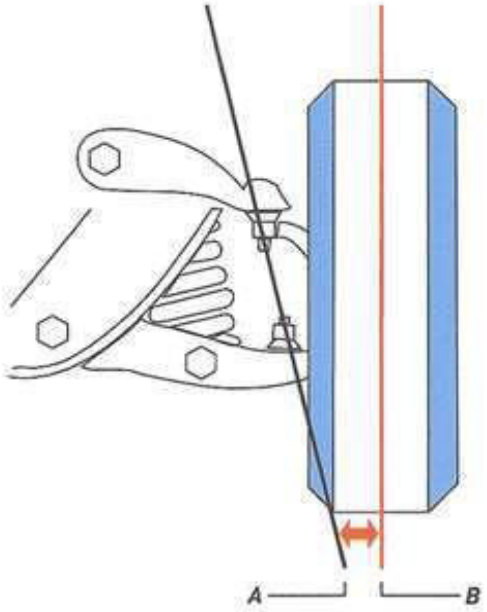
- High positive caster can also cause the wheels to return to center very fast.
- A steering dampener is used in some high caster applications to reduce the speed at which the wheels return to center.
- Some vehicles use a steering dampener to reduce the effects of having a large amount of positive caster.

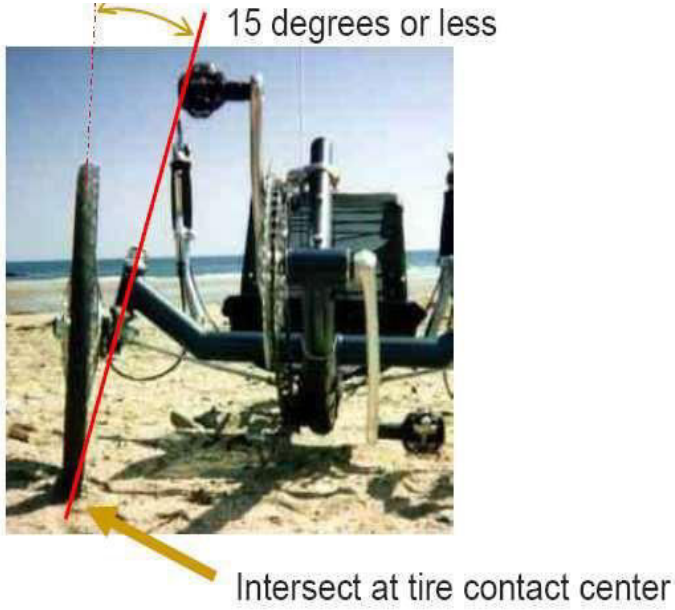


KING PIN INCLINATION OR (SAI)

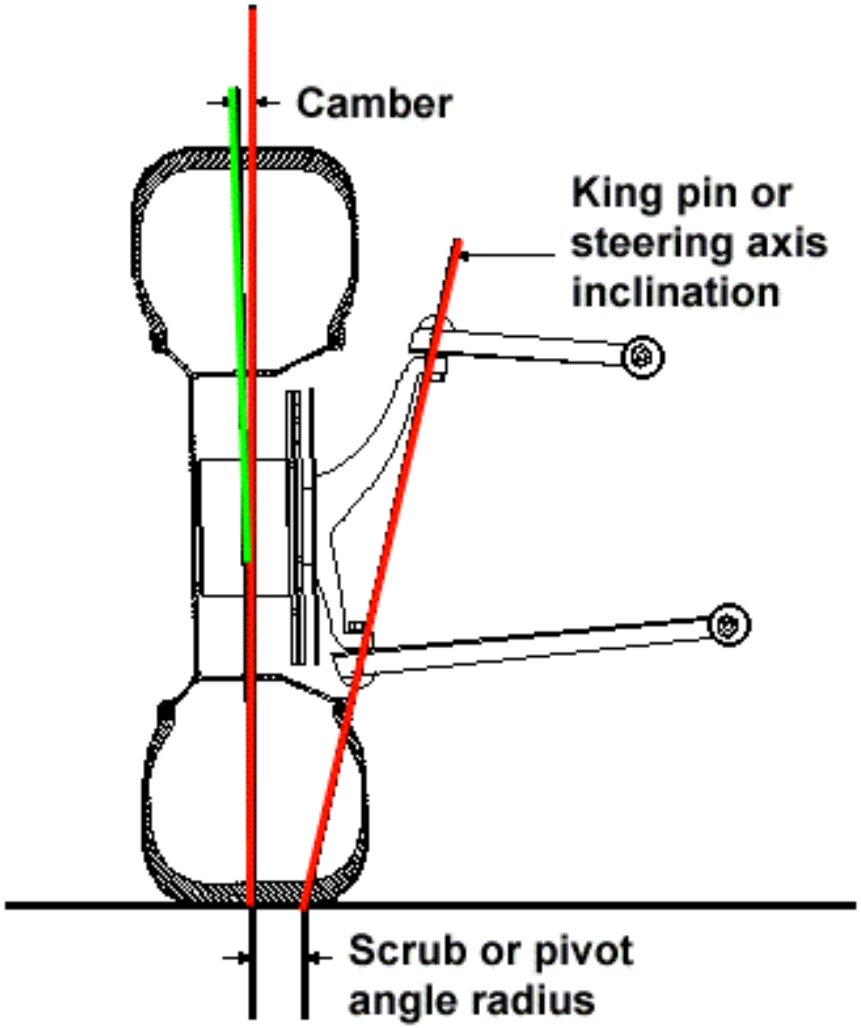
- Inclination of the kingpin from the vertical is called king pin inclination or king pin rake.
- The kingpin are replaced by ball joint in case of modern cars
- SAI is the inclination of ball joint axis with the vertical axis.
- It helps in straight ahead recovery thus providing directional stability.
- Maximum KPI or SAI is 7 to 8 degrees.





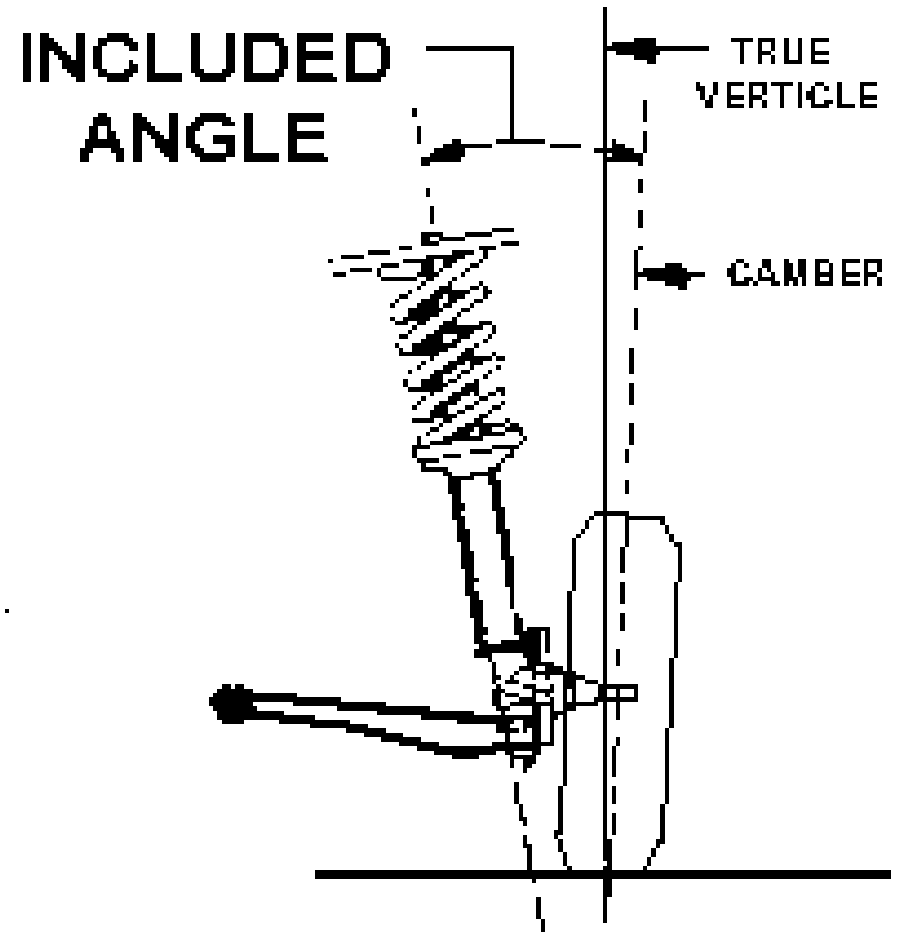


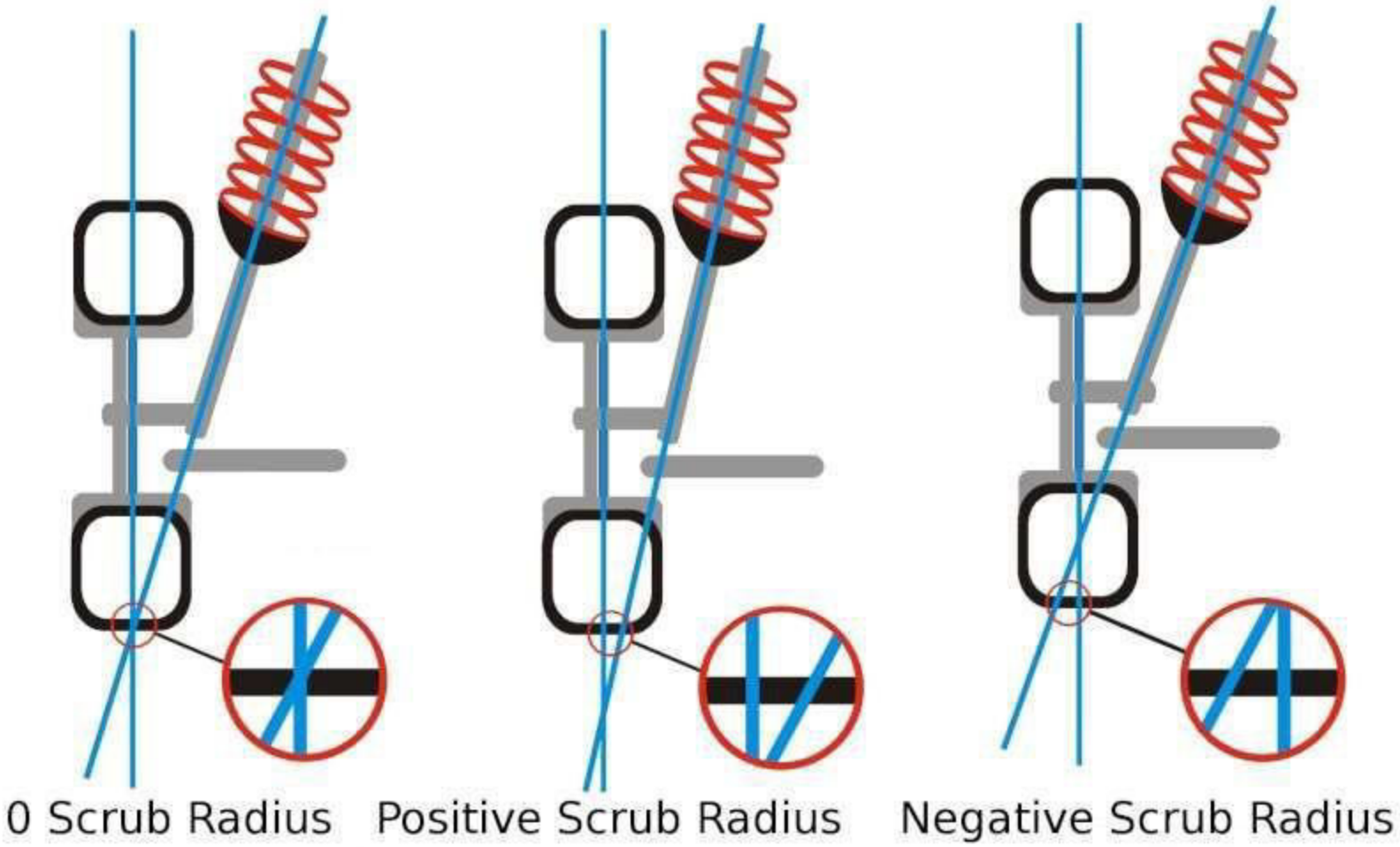
2)Kingpin inclination


Camber
King pin or
steering axis
inclination
Scrub or pivot
angle radius

INCLUDED ANGLE AND SCRUB RADIUS

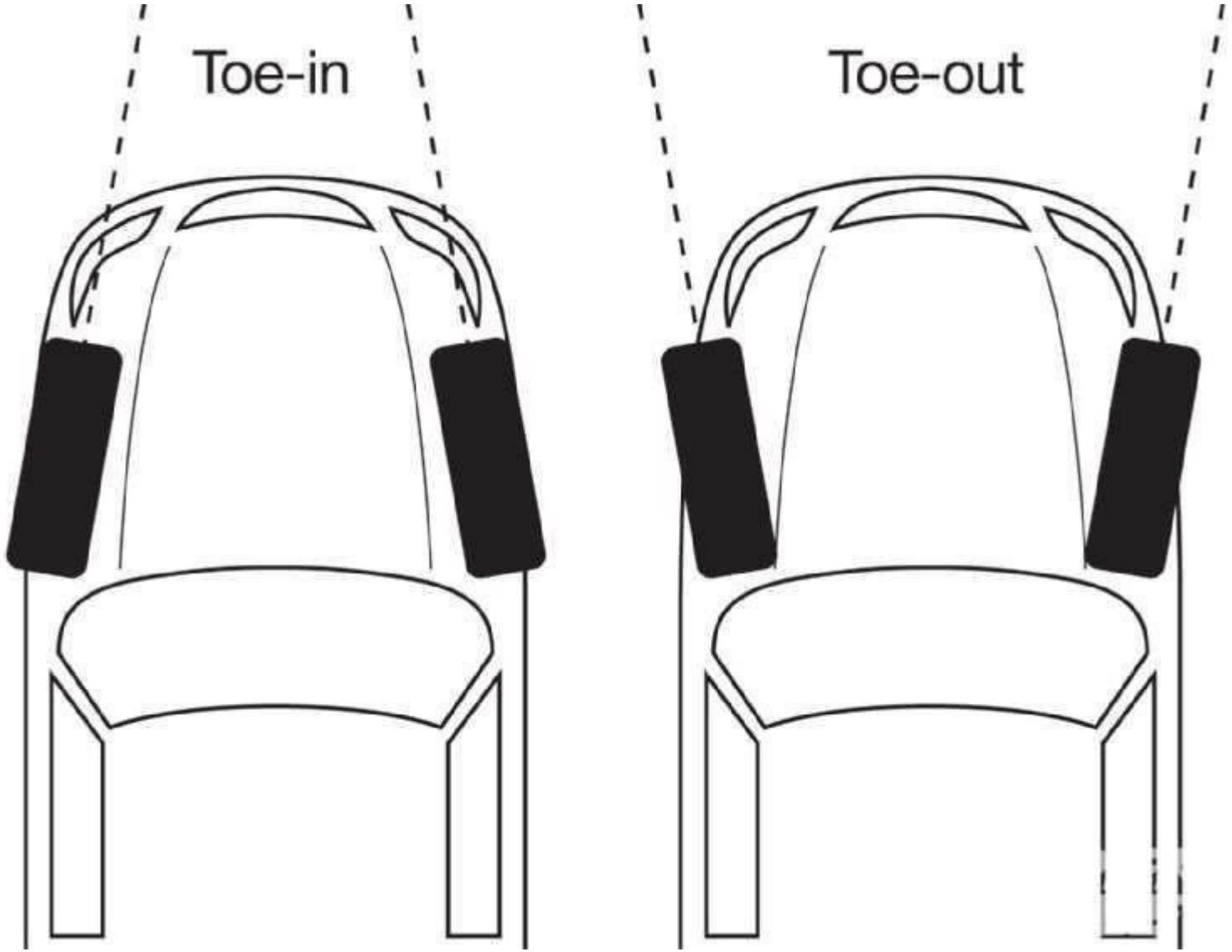
- It is the angle formed in the vertical plane between the wheel centre line and king pin centre line.
- It is also said as the combined angle of camber and king pin inclination.
- Scrub radius is nothing but the point where the wheel centre line and steeringaxis hits the ground.
- If scrub radius is zero the wheel drives straight ahead.
- If it is negative the wheel tends toe-in and it gives better driving condition.
- If positive scrub radius is employed large force is required to turn the wheels and it leads to wear of steering linkage and unequal braking of wheels.


INCLUDED
ANGLE
TRUE
VERTICLE
CAMBER

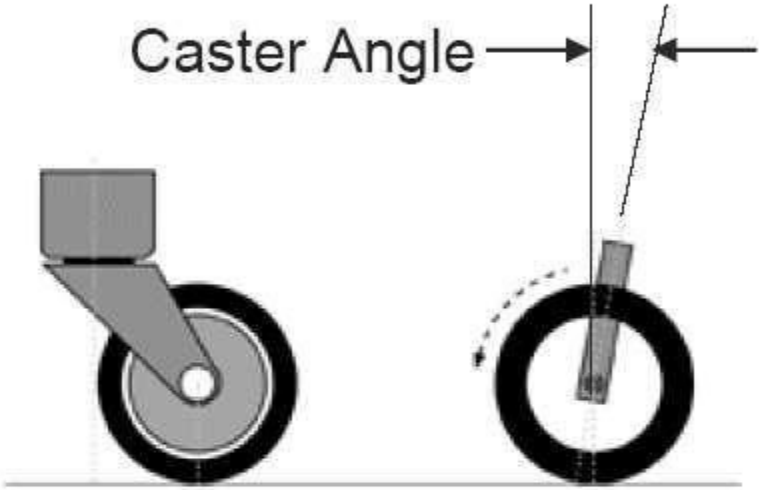

0 Scrub Radius
Positive Scrub Radius
Negative Scrub Radius

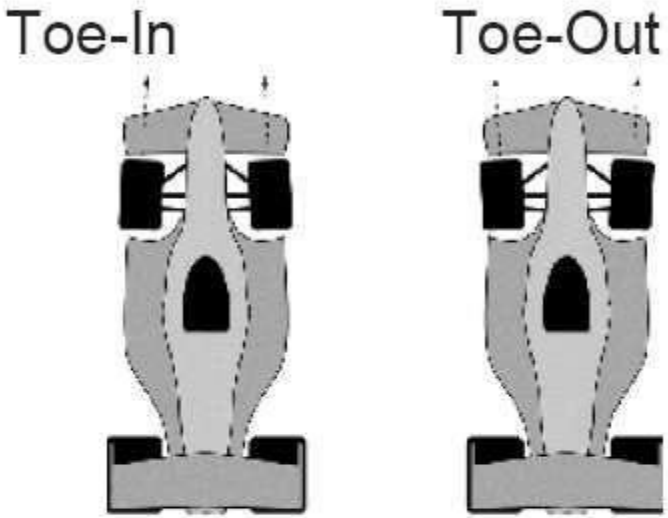
TOE- IN OR TOE- OUT

- Toe is the difference between the front and rear edges of a set of tires. When the wheels are parallel to each other, toe is zero.
- When the front edges of the tires are closer together, the tires are toed-in, and toe is positive.
- When the rear edges are closer, the tires are toed-out, and toe is negative.
- The toe-out are due to deviation in centre point steering and steering angles.
- Toe-in is provided to compensate the toe-out.
- initially provided does not exceed 3 mm.


Toe-in
Toe-out

Caster, Camber and Toe



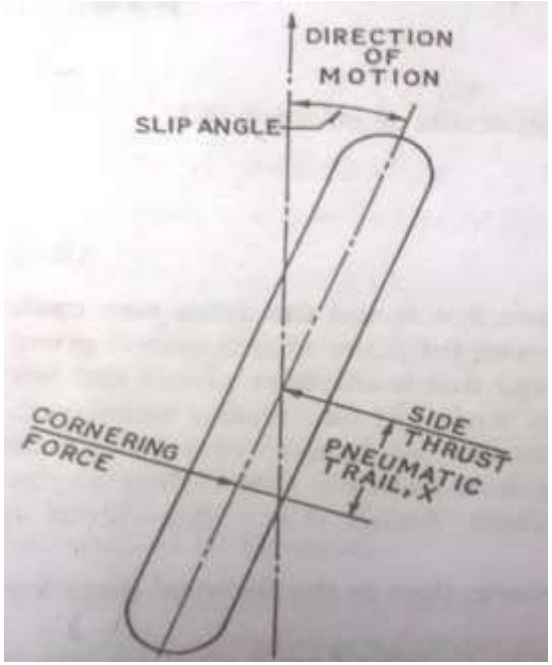


Positive Camber

Negative Camber

SLIP ANGLE

- While taking turn the centrifugal force acts on the vehicle produces a side thrust.
- To sustain that force the plane of the wheel must make some angle with the direction of the motion of the vehicle.
- The angle through which the wheel has to turn sustain the side force is called slip angle.

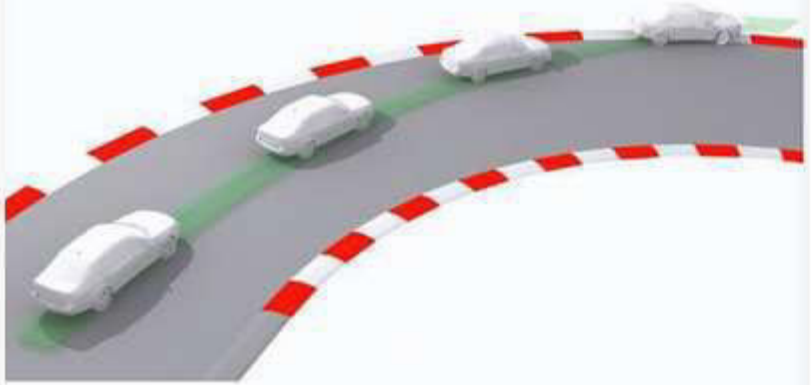


UNDERSTEER

- Slip angle is greater than those of rear wheels, the radius of turn is increased.
- This means the vehicle will turn less sharply than it should for a given rotation of the steering wheel.
- This condition is called understeer.
- May happen due to lower inflation pressure at the front wheels than at rear wheels or when cross ply tyres are used front with radial ply tyres at the rear.

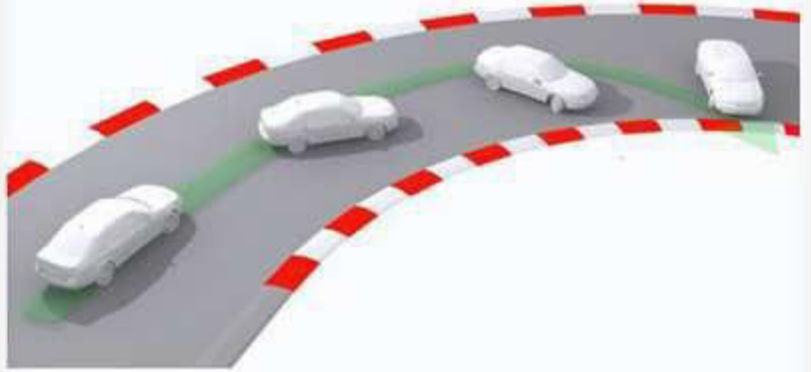
OVERSTEER

- If Slip angle of the front wheels are less than those of rear wheels, the radius of turn is decreased.
- This means the vehicle turn will turn more sharply than it should for a given rotation.
- Therefore to keep it in right path little less steer has to be done. It is called oversteering.



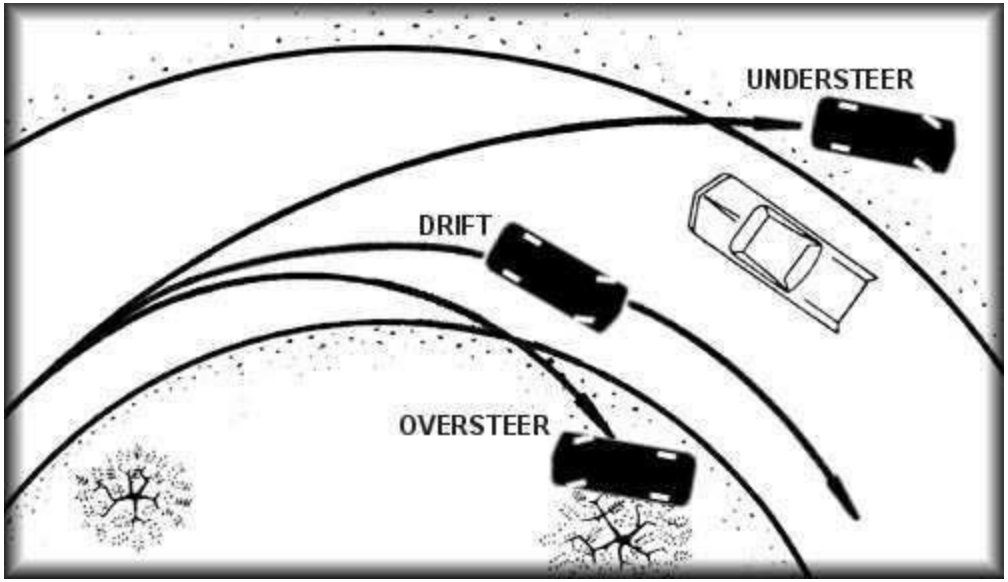
UNDERSTEER :

Front wheels lose their traction and cause the car to go wide. Understeer can be corrected by stiffening the vehicle's rear chassis.



OVERSTEER :

Rear tires lose grip and causing the rear end of the vehicle slides out. Oversteer can be corrected by stiffening the vehicle's front chassis.

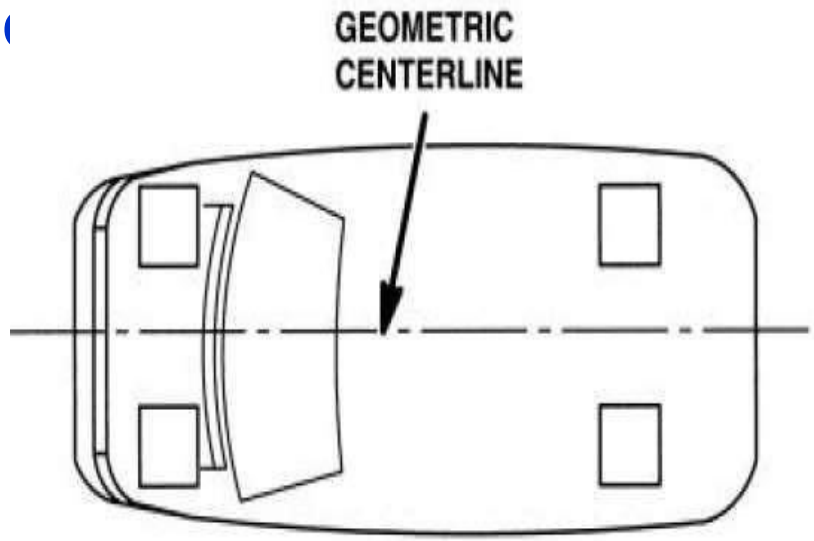


DIRECTIONAL STABILITY

- Directional stability is needed to keep vehicles going in a straight line or in line with the direction of the steering wheel.
- Steering and suspension systems are closely related, and in most cases, are dependent upon each other.
- The steering system allows the driver to direct the movement of the vehicle.
- The most common front steering systems are the parallelogram and rack-and-pinion steering systems.

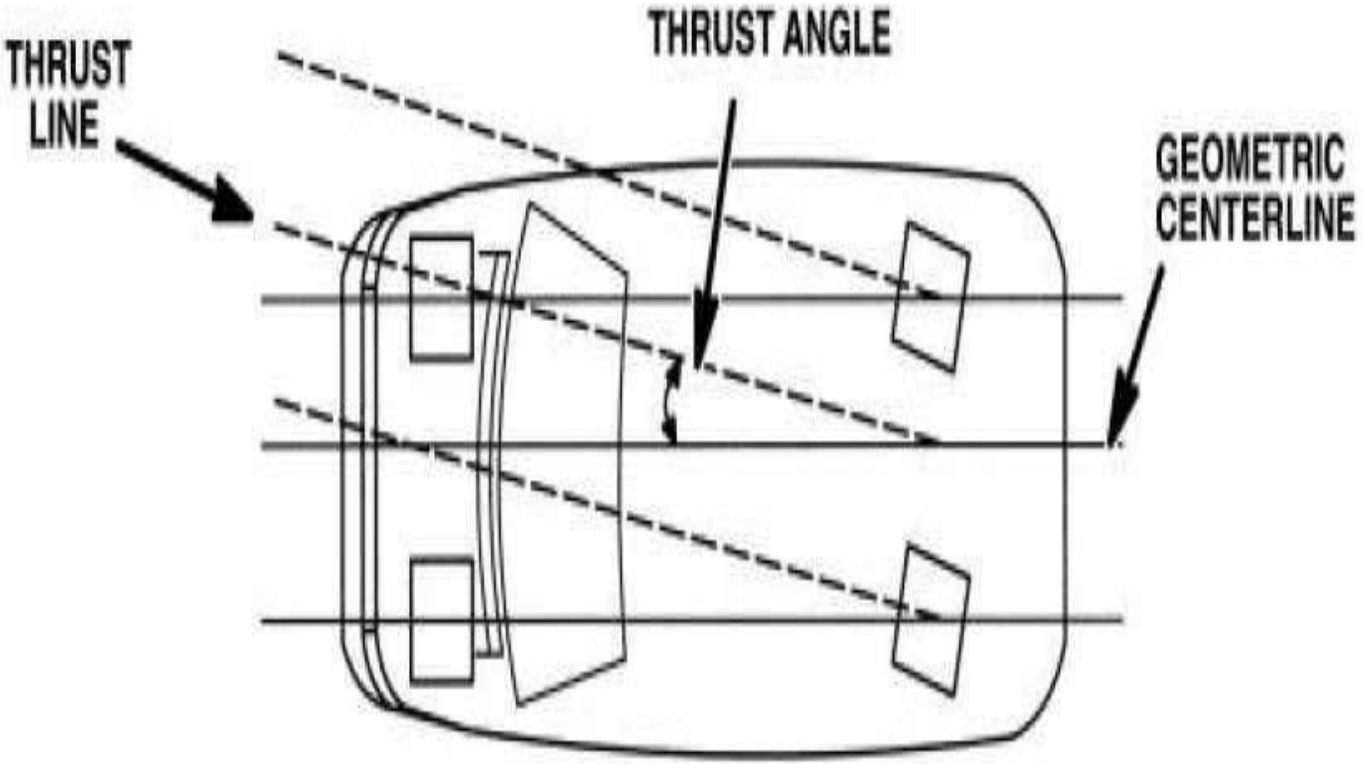
GEOMETRIC CENTERLINE

- The vehicle's geometric centerline is formed between the center of the front wheels and the center of the rear wheels.
- The geometric centerline could also be drawn through the midpoint of the front and rear axles. The geometric
- centerline [illegible] align toe on all four wh[illegible]



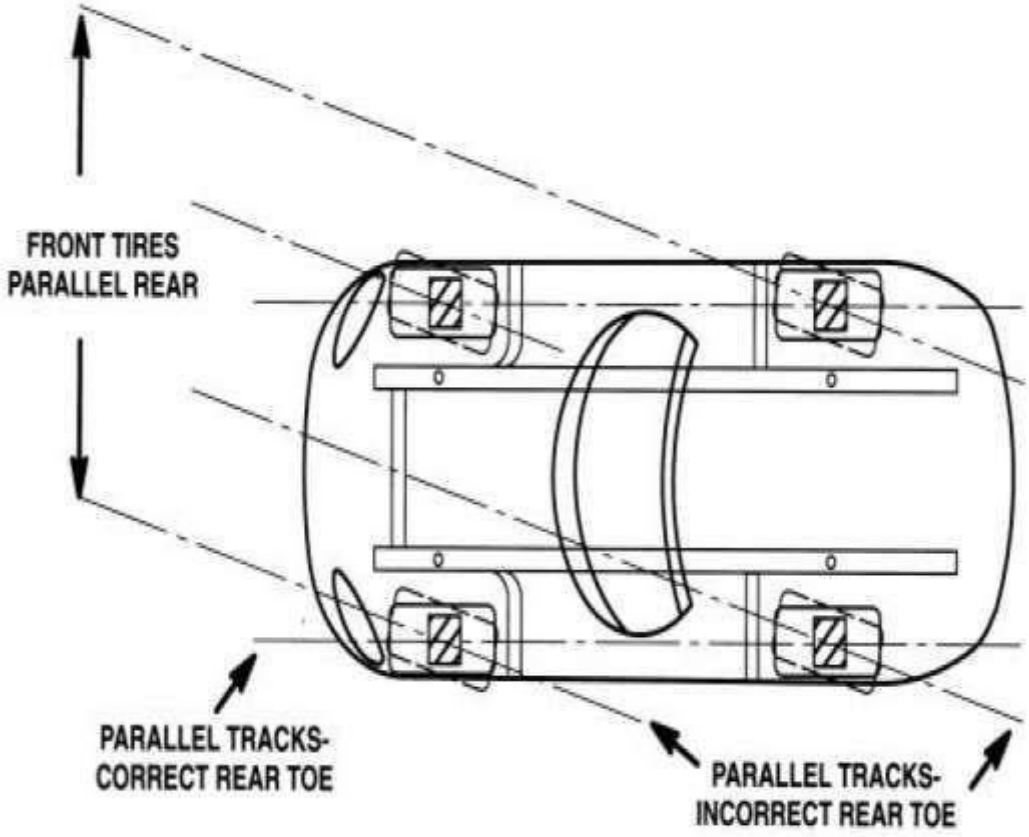
THRUST ANGLE

- The thrust line is the direction the rear wheels are pointing.
- If the rear suspension is not damaged and the rear toe is properly adjusted, the thrust line and the geometric centerline of the vehicle are the same.
- The thrust angle is the difference between the thrust line and the geometric centerline. A thrust angle to the right is positive. A thrust angle to the left is negative. Thrust angle is measured in degrees.
- Thrust Angle = (Left Toe – Right Toe) / 2


THRUST LINE
THRUST ANGLE
GEOMETRIC CENTERLINE

PARALLELISM AND CENTERLINE STEERING

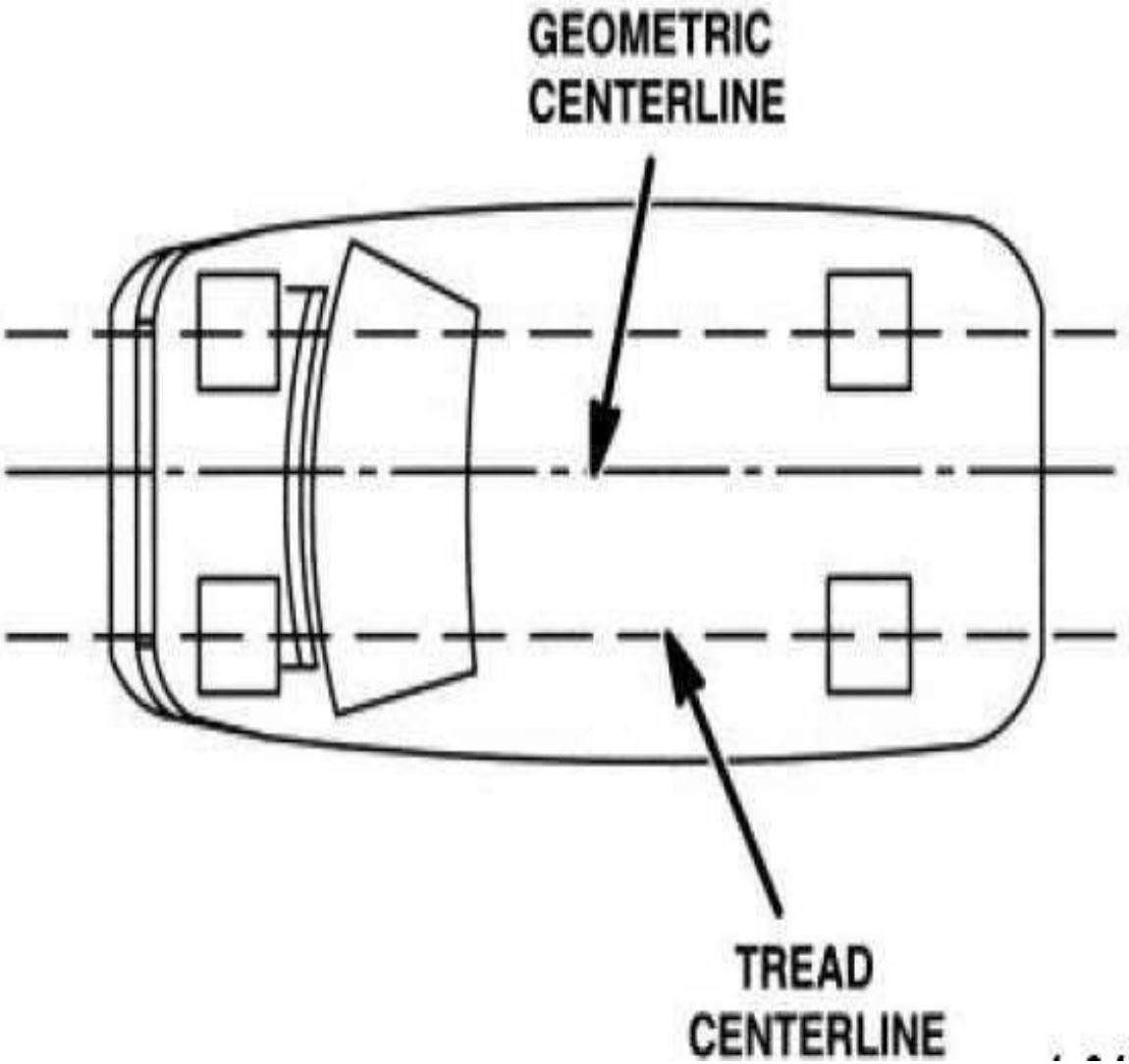
- Parallelism refers to the wheels tread centerlines being parallel to the geometric centerline.
- The steering wheel is set straight and the front toe is adjusted to the thrust line, which is now the centerline.
- If toe is correct on the rear, the front tires will follow a parallel path with the rear, creating centerline steering.


FRONT TIRES
PARALLEL REAR
PARALLEL TRACKS-
CORRECT REAR TOE
PARALLEL TRACKS-
INCORRECT REAR TOE

TREAD CENTERLINE

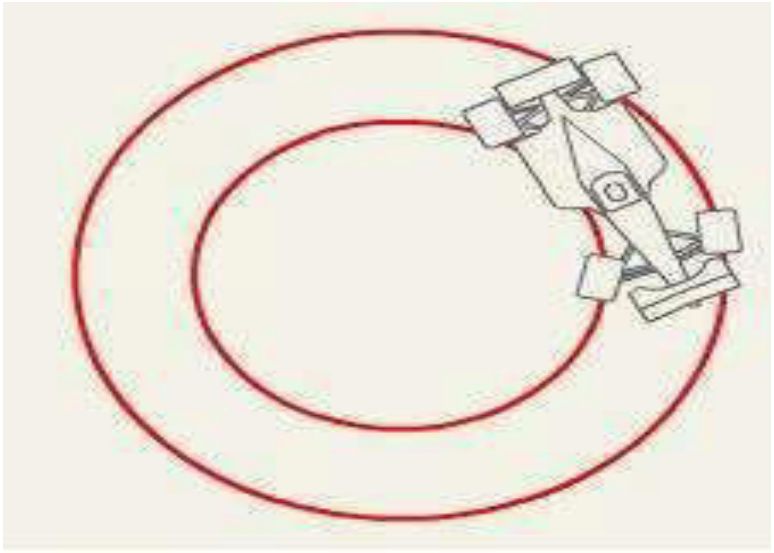
- On a vehicle that has front and rear wheels equally wide apart, the tread centerline is a line from the midpoint of the front tire tread to the midpoint of the rear tire tread on the same side. It should be parallel to the geometric centerline.

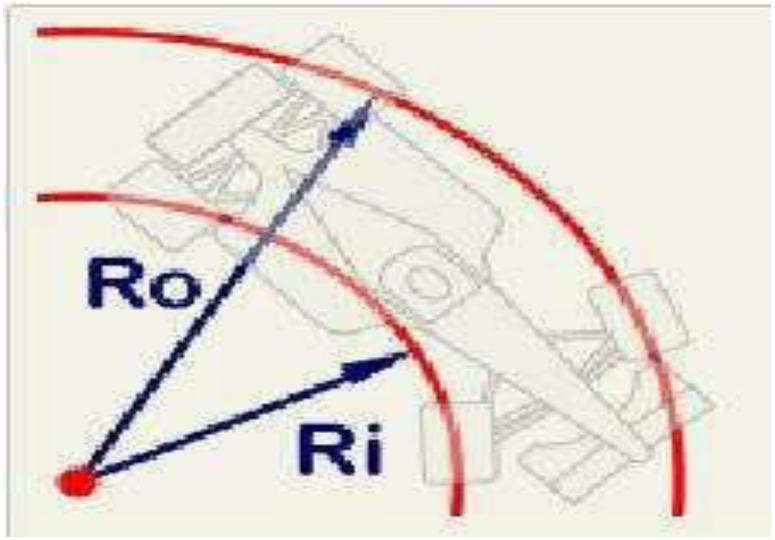
- If the tread centerline is not parallel to the geometric centerline, a cross-member may not be positioned right, or the cradle may be shifted to the side.

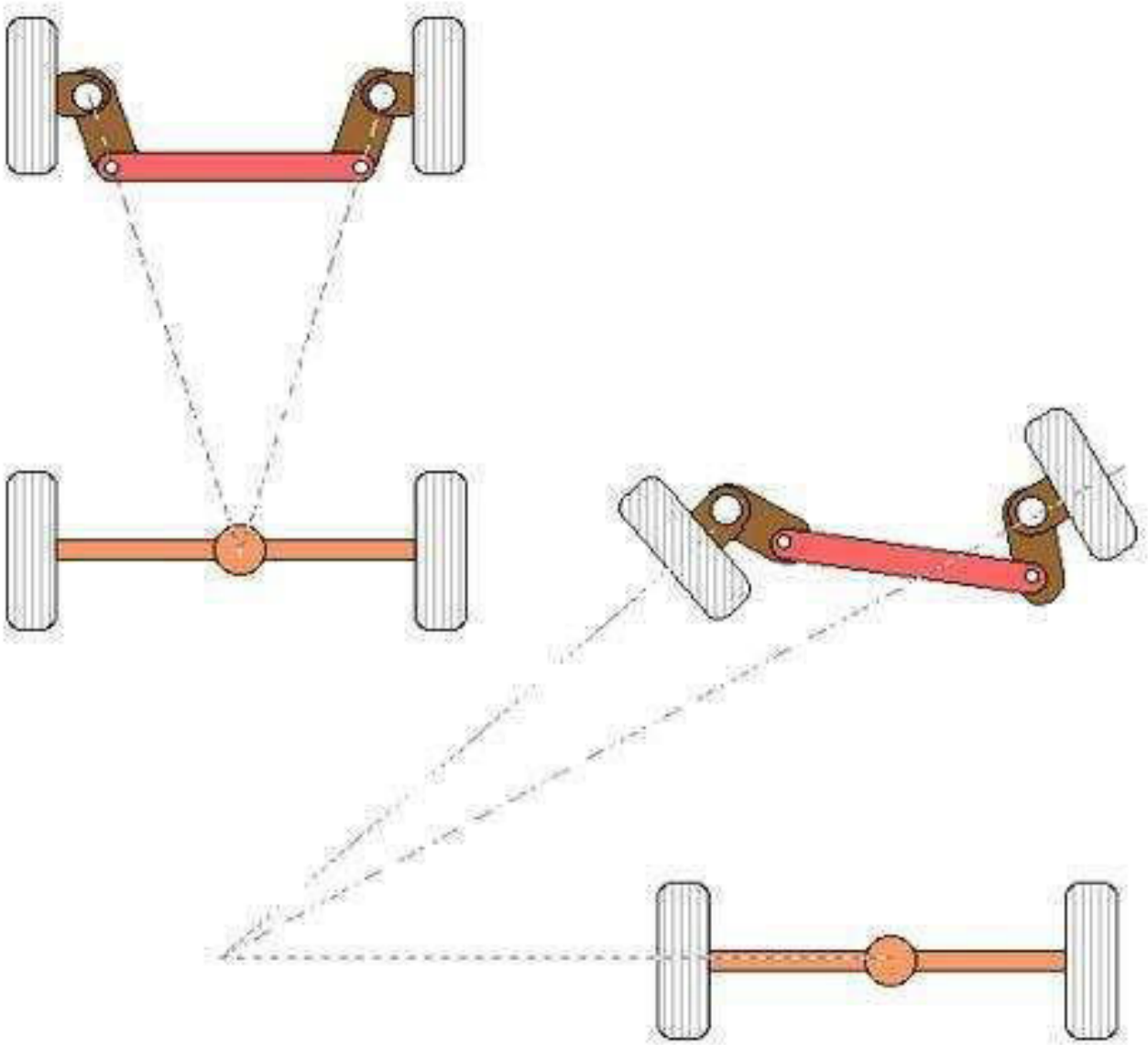

GEOMETRIC
CENTERLINE
TREAD
CENTERLINE

ACKERMAN STEERING

- Steering Ackerman describes the angle difference between the outside and inside tire of a vehicle
- The steering sensitivity of the vehicle is greatly affected by the amount of Ackerman designed into the suspension
- When the vehicle negotiates a turn the two front wheels must carve different arc, the outside wheel travels a further distance than the inner




Ro
Ri



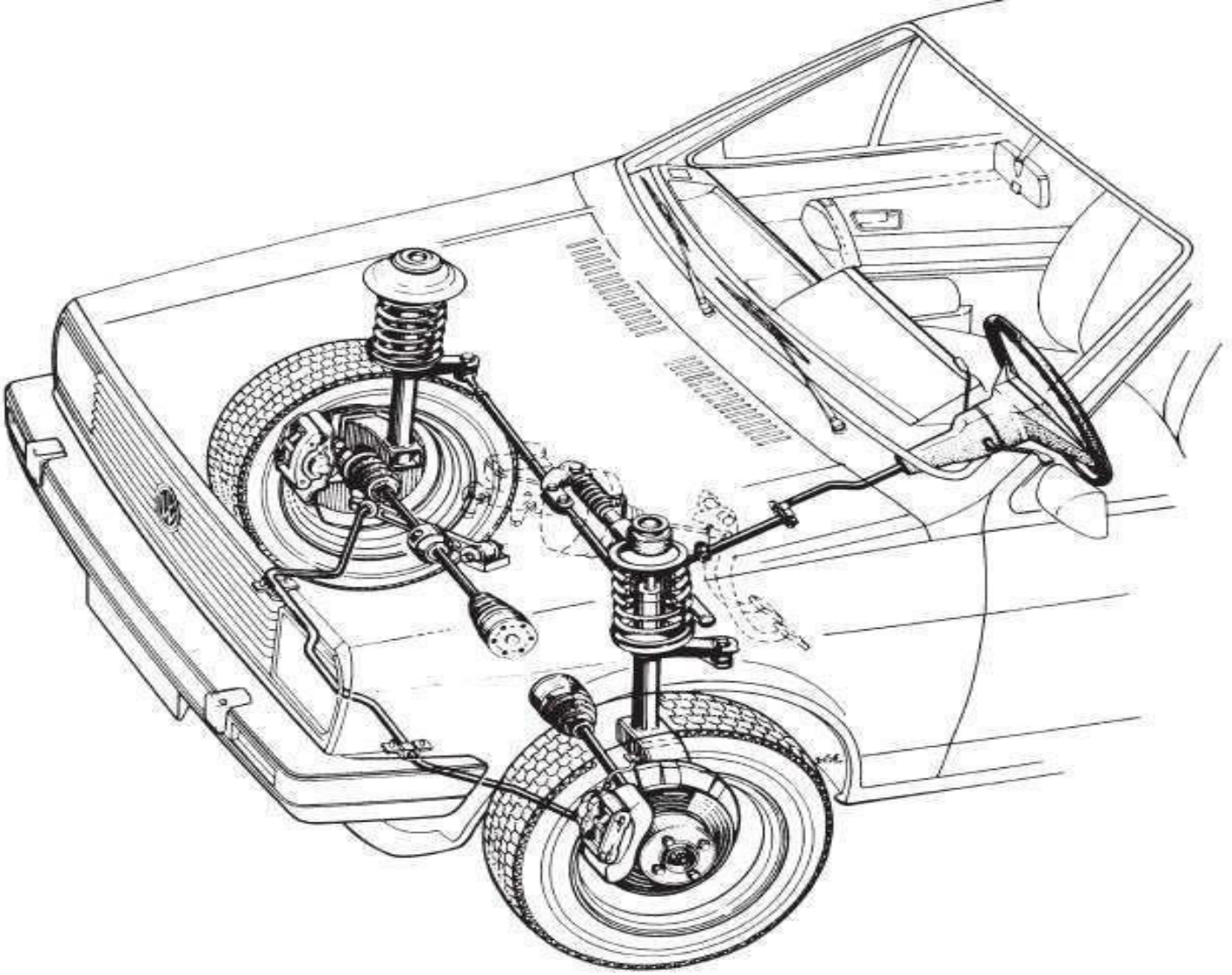
STEERING SYSTEM

Things have to be taken into consideration while steering the vehicle –

- **Effect of road surface irregularities**
- **Tyre behavior under cornering stress**
- **An efficient mechanical system**
- **No (or very little) difference between empty and fully loaded vehicle**
- **Effect of accelerating or braking when the wheels are turned**
- **The front wheels should have a natural tendency to return to the straight ahead position and stay there**

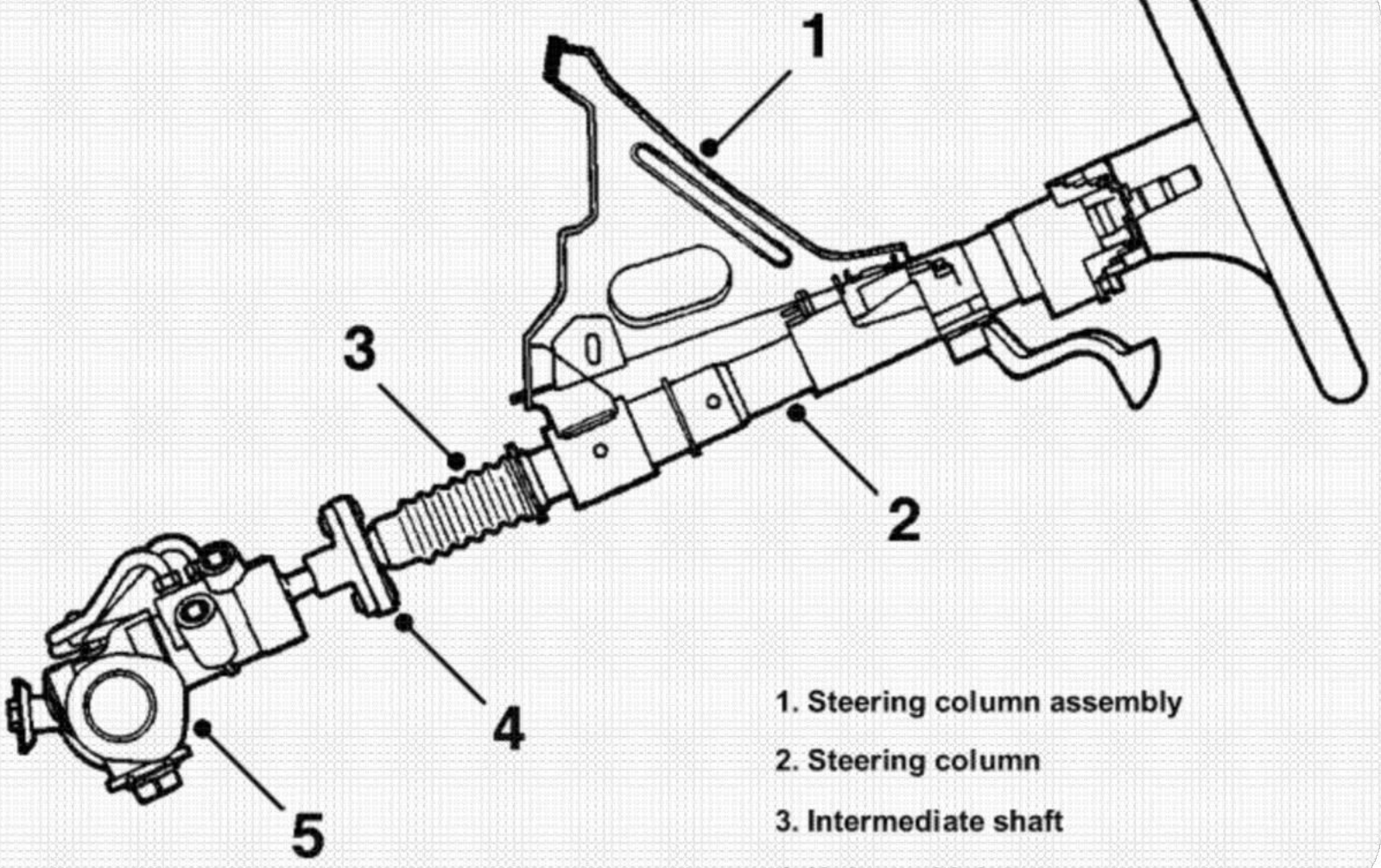
STEERING COLUMN

- the steering column consists of the jacket tube, which is fixed to the body.
- The steering shaft, also called the steering tube. This is only mounted in bearings at the top and transfers the steering-wheel moment to the steering gear.
- If the steering column does not align with the extension of the pinion gear axis, an intermediate shaft with two universal joints is necessary



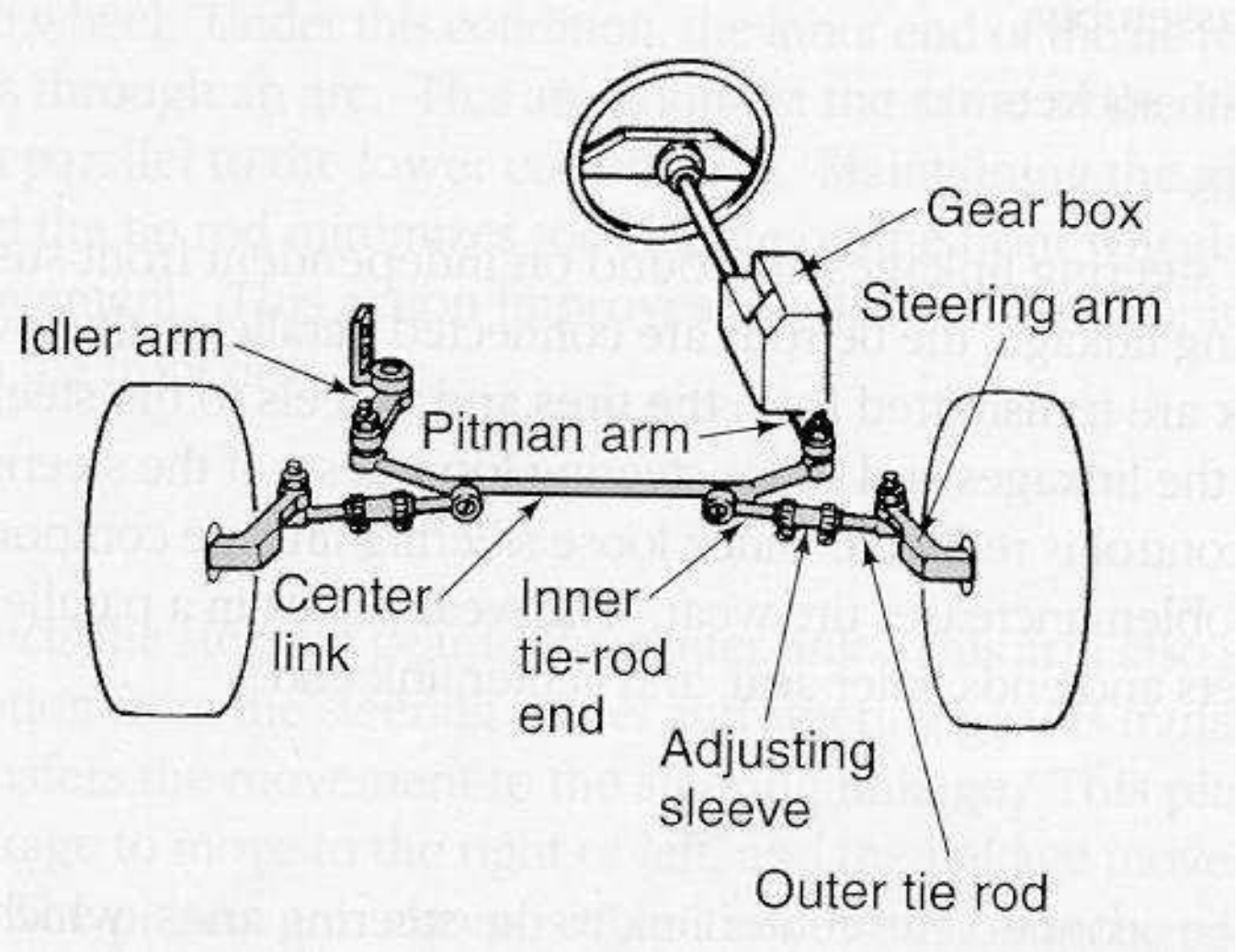
Damper strut front axle of a VW Polo (up to 1994) with ‘steering gear’, long tie rods and a ‘sliding clutch’ on the steering tube

STEERING WHEEL & COLUMN

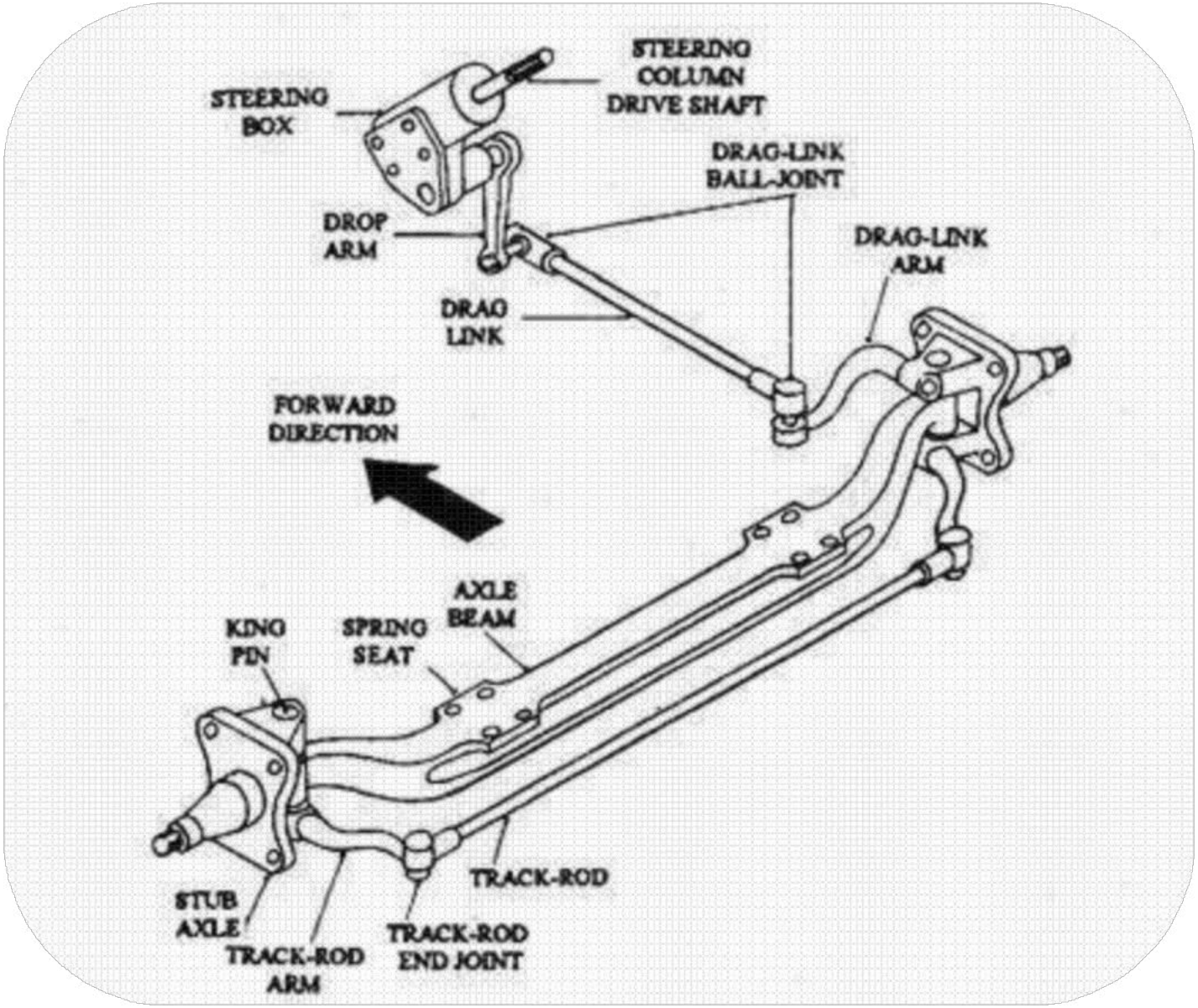


1. Steering column assembly
2. Steering column
3. Intermediate shaft
4. Universal joint
5. Power-assisted steering system

STEERING LINKAGE FOR INDEPENDENT SUSPENSION

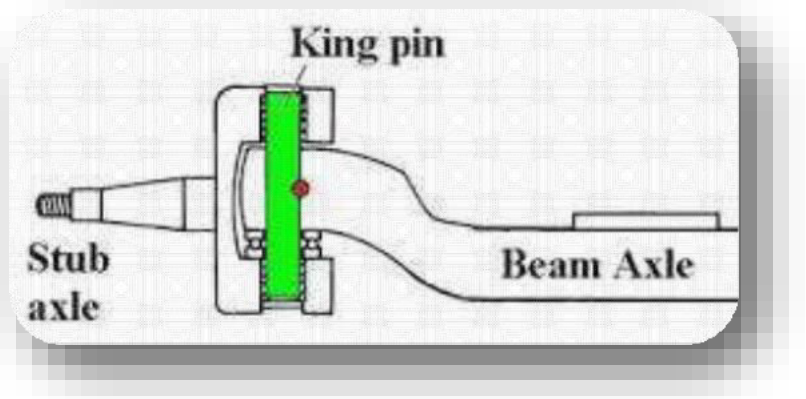


STEERING LINKAGE WITH RIGID AXLE SUSPENSION

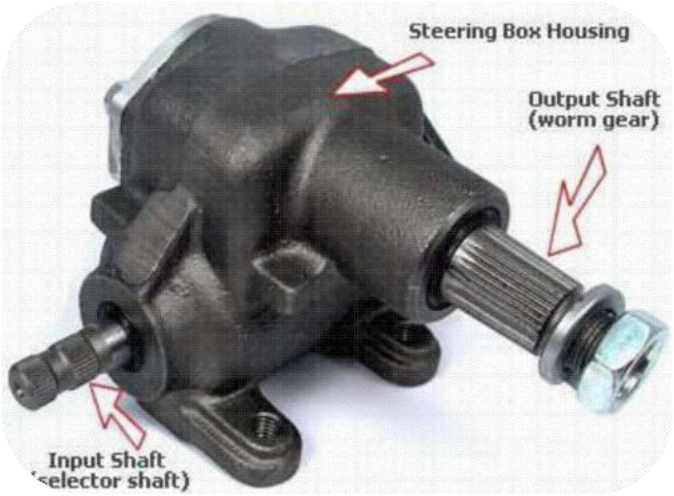


SOME PARTS OF STEERING MECHANISM

Tie Rod End

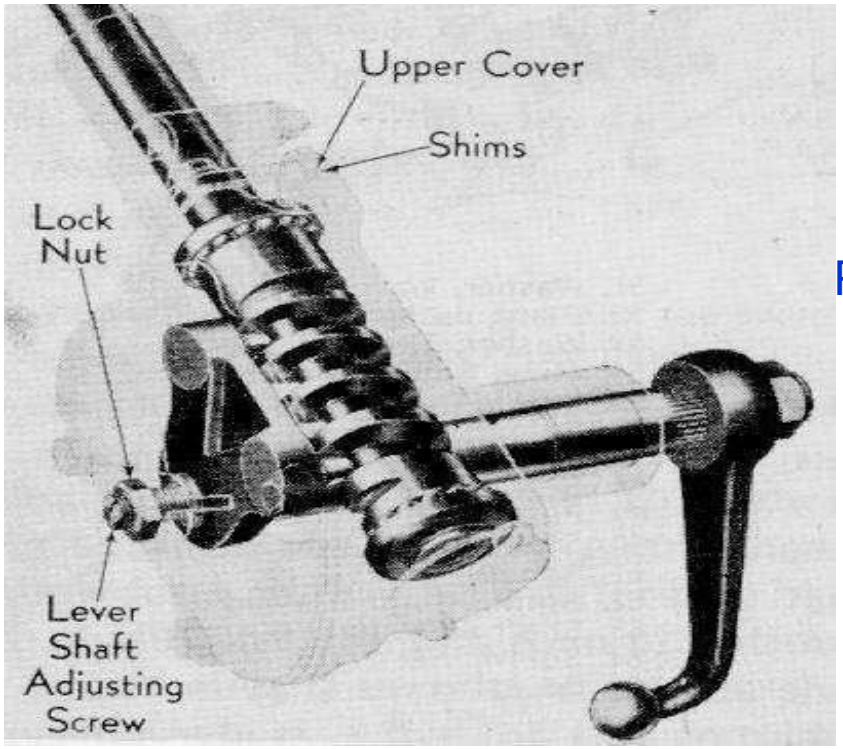


Stub Axle



Steering Box (worm)

Steering arms



Pitman (Drop) Arm

Ball joints

STEERING GEAR BOX

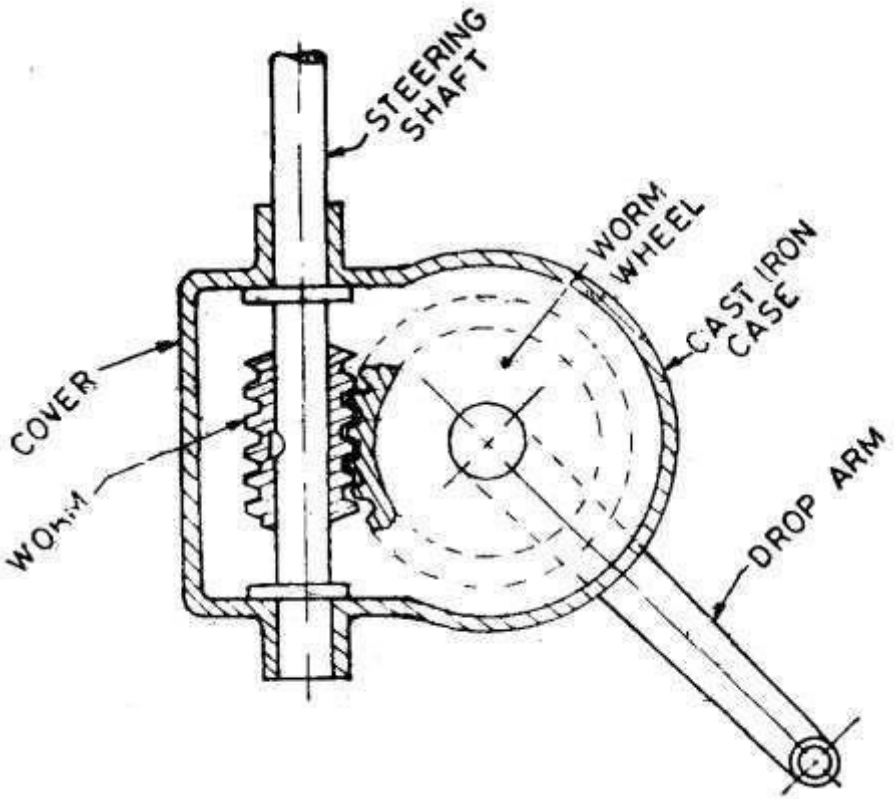
Steering gears are enclosed in a box, called the steering gear box

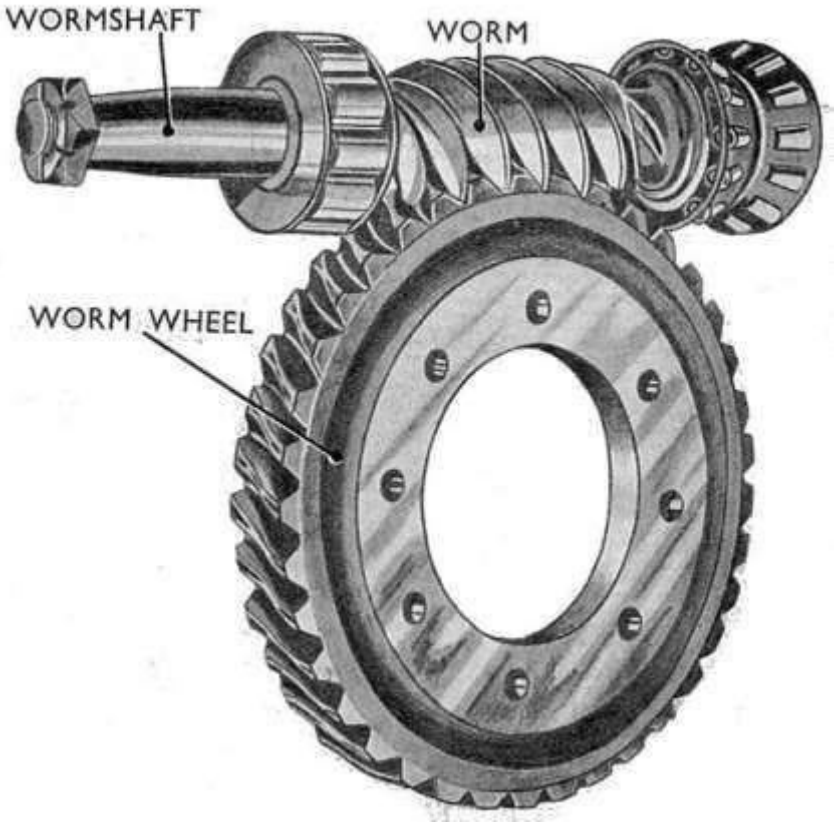
Types of steering gearbox:

- **Worm and wheel steering gear**
- **Worm and sector steering gear**
- **Cam and lever / peg steering gear**
- **Recirculating ball steering gear**
- **Cam and double rollere steering gear**
- **Worm and nut steering gear**
- **Rack and pinion steering gear.**

WORM AND WHEEL STEERING GEAR

- Worm wheel is carried in bearings in a cast iron case.
- Worm wheel is connected to a drop arm.
- The worm which is keyed on to steering shaft meshes with the worm wheel.
- Steering wheel is mounted at the upper end of the steering shaft.
- When driver rotates the steering wheel, drop arm moves in backward or forward direction.
- This results in motion of the stub axles.

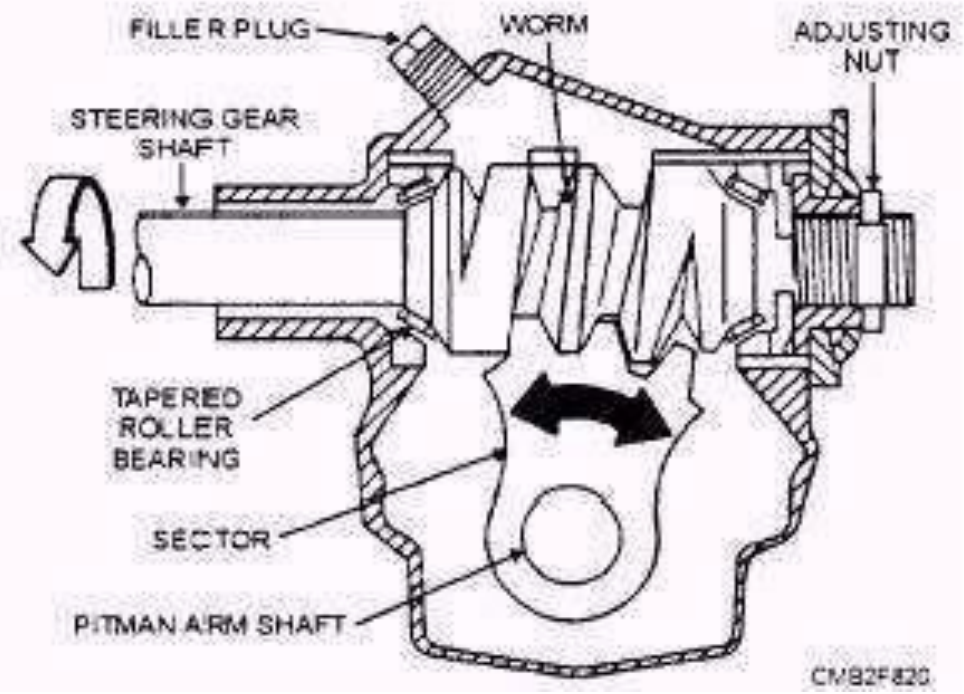


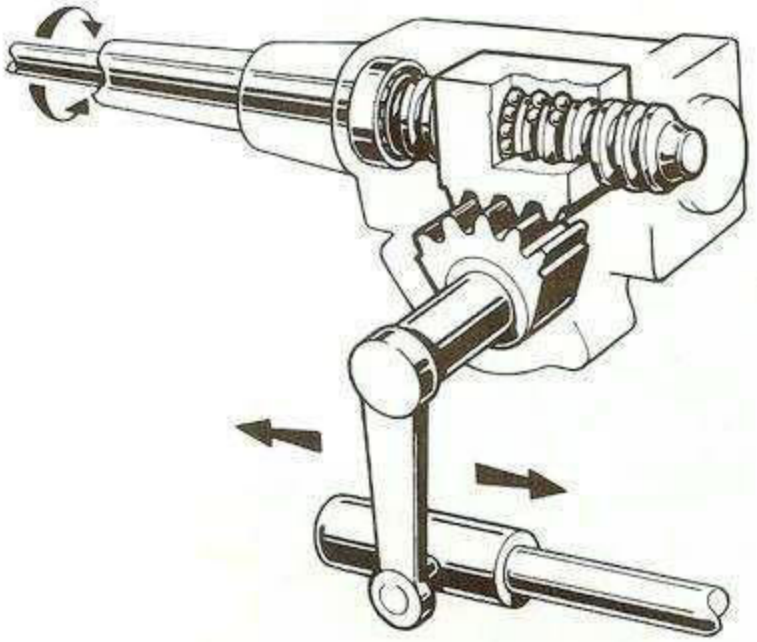


WORM AND WHEEL STEERING GEAR

WORM AND SECTOR STEERING GEA

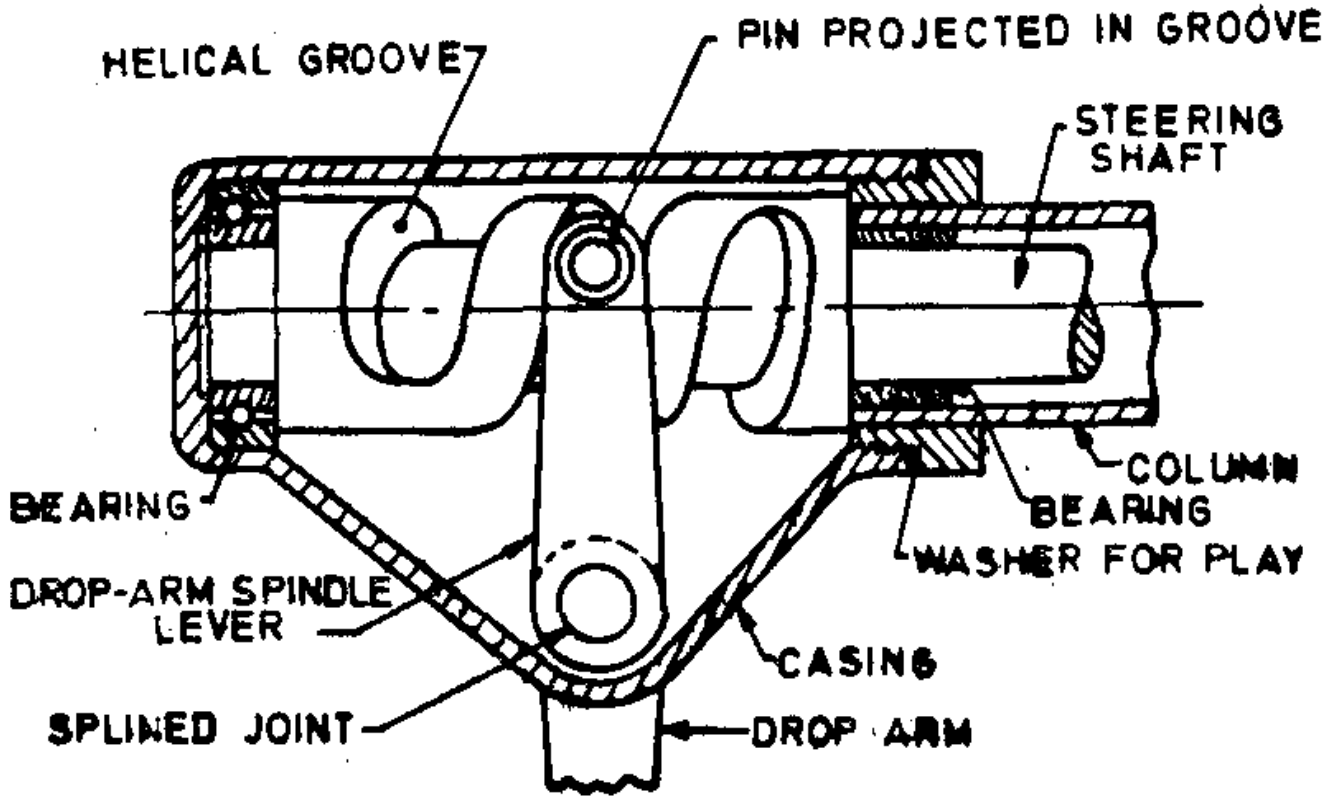
- The end of steering shaft has a worm gear attached to it.
- It meshes directly with a sector gear (section of a full gear wheel).
- When the steering wheel is turned, the shaft turns the worm gear, and the sector gear pivots around its axis as its teeth are moved along the worm gear.
- The box is sealed and filled with grease.
- Worm wheel is not essential as it is having only partial rotation. Hence in this type only a sector of wheel is used instead of worm wheel.


FILLER PLUG
WORM
ADJUSTING NUT
STEERING GEAR SHAFT
TAPERED ROLLER BEARING
SECTOR
PITMAN ARM SHAFT
CMB2F820



CAM AND LEVER STEERING GEAR

- A helical groove is formed at the bottom end of the steering wheel shaft.
- **Helical groove engages the projected pin of the drop arm spindle lever.**
- **Drop-arm is made rigid with the lever by a splined spindle.**
- **The to and fro motion is obtained at the drop-arm when the steering wheel shaft is turned. This motion results the turning of the stub axles.**
- **Projected pin may be in the form of a roller. Pin may be one or two in number.**
- **accordingly they are referred as cam and single lever or double lever steering gear mechanism**

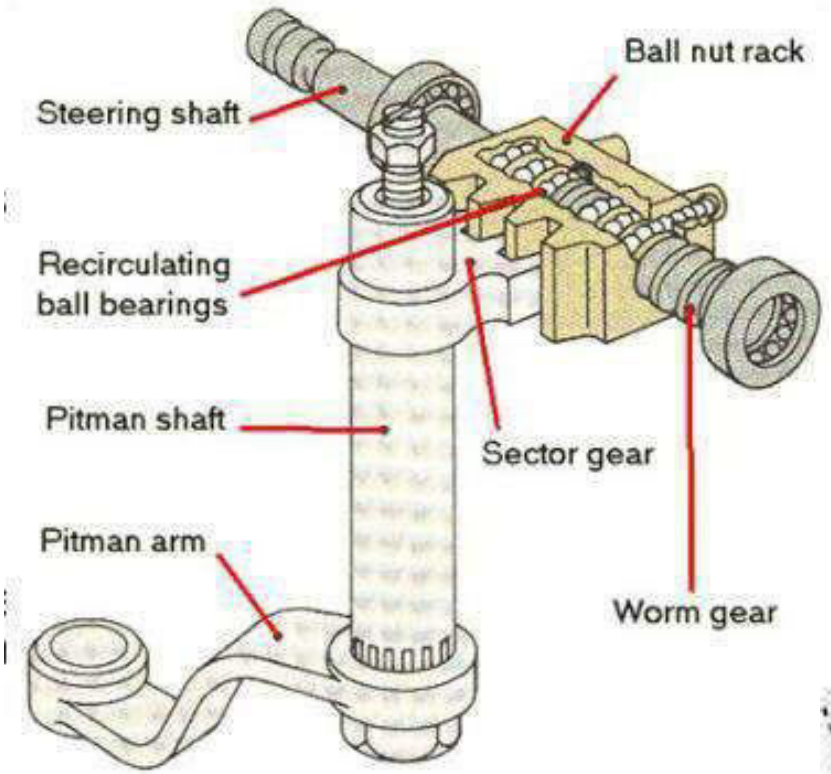

HELICAL GROOVE
PIN PROJECTED IN GROOVE
STEERING SHAFT
COLUMN BEARING
WASHER FOR PLAY
BEARING
DROP-ARM SPINDLE LEVER
CASING
SPLINED JOINT
DROP ARM

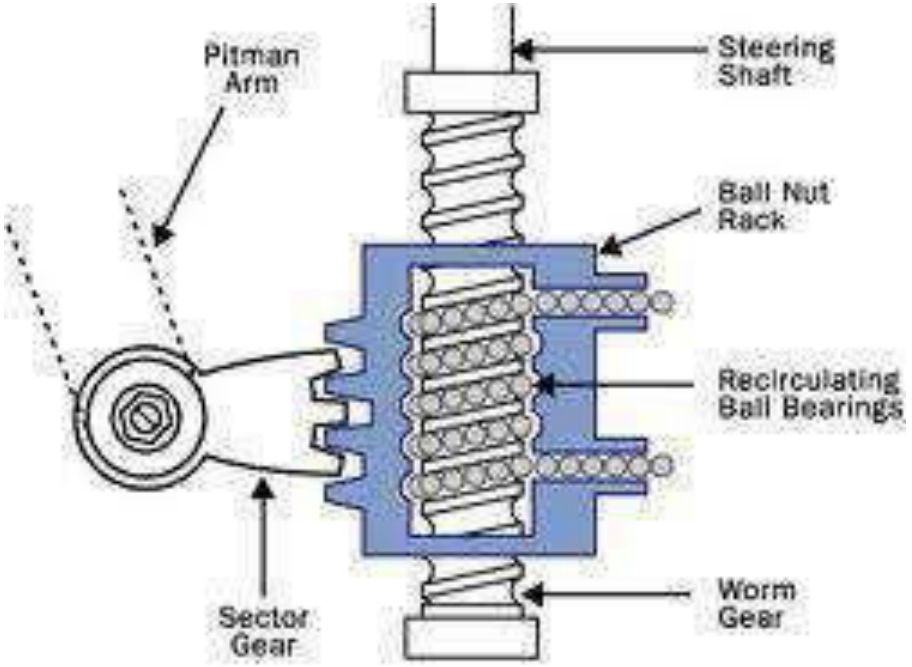
RECIRCULATING BALL TYPE

STEERING GEAR

- It consists of a worm at the end of steering rod.
- When the steering wheel is turned, the balls in the worm roll in the grooves and cause the nut to travel along the length of the worm. The balls are recirculated through the guides.
- Movement of the nut causes the wheel sector to turn and actuate the link rod through the drop arm, resulting in the desired steering of the wheels
- End play of the worm can be adjusted by means of the adjuster nut provided.

- To compensate for the wear of the teeth on the nut and the worm, the two have to be brought closer. To achieve this, the teeth on the nut are made tapered
- Introduction of front-wheel-drive passenger cars led to rack and pinion steering.
- Rack and pinion systems weigh less and use fewer parts.
- Also, the size and cost of rack and pinion systems is less.
- Today, most passenger cars and light trucks are equipped with rack and pinion steering.


Steering shaft
Ball nut rack
Recirculating
ball bearings
Pitman shaft
Sector gear
Pitman arm
Worm gear


Pitman
Arm
Steering
Shaft
Ball Nut
Rack
Recirculating
Ball Bearings
Sector
Gear
Worm
Gear

ADVANTAGE

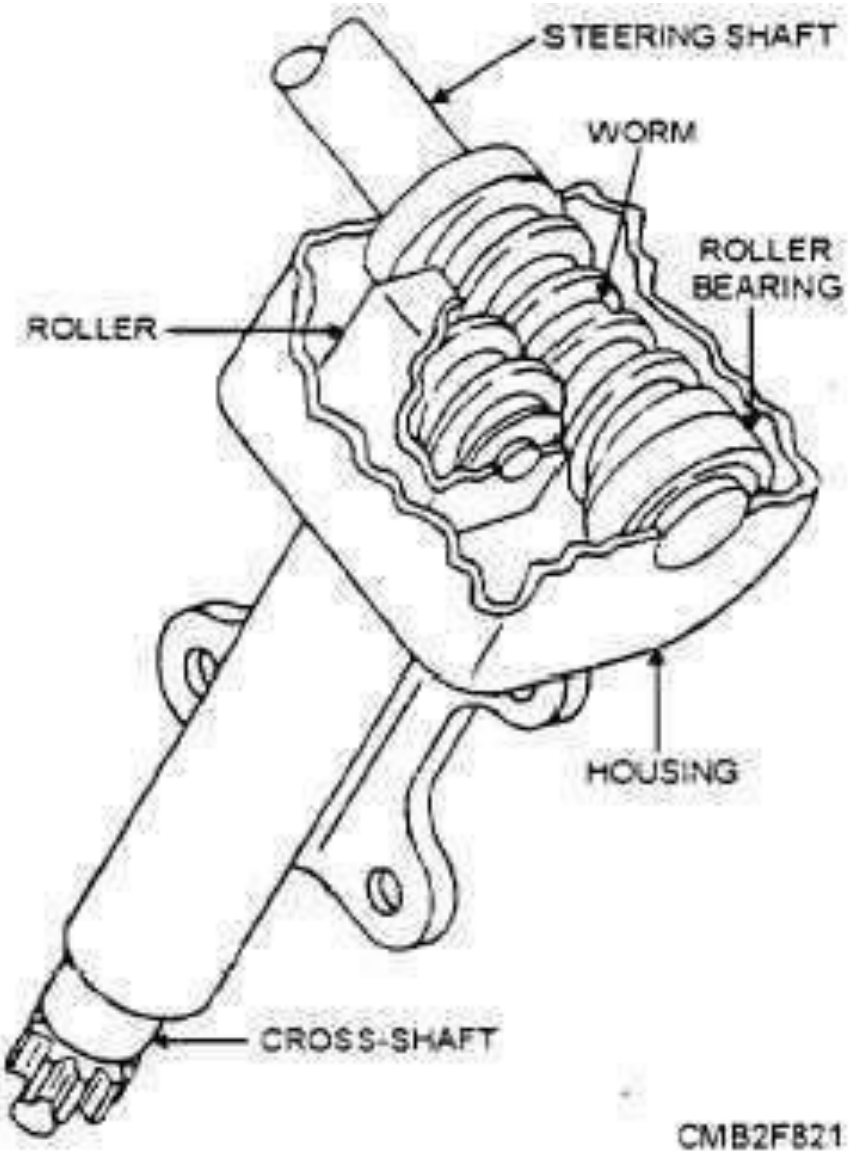
- Can be used on rigid axles.
- Ability to transfer high forces.
- A large wheel input angle possible – the steering gear shaft has a rotation range up to ±45°, which can be further increased by the steering ratio.

DISADVANTAGE

- This type of steering system is more complicated on the whole in passenger cars with independently suspended front wheels.
- More expensive than rack and pinion steering systems.
- It sometimes has greater steering elasticity, which reduces the responsiveness and steering feel in the on-centre range.

WORM AND DOUBLE ROLLER STEERING GEAR

- The worm and sector steering gear is very simple in construction. This makes it cheap to build and easy to maintain.
- A disadvantage is that it has a lot of friction because of the sliding action between the worm and sector gear teeth.
- The worm and roller steering gear is much like the worm and sector, but the sliding friction is changed to rolling friction so that less effort is required to turn the steering wheel.

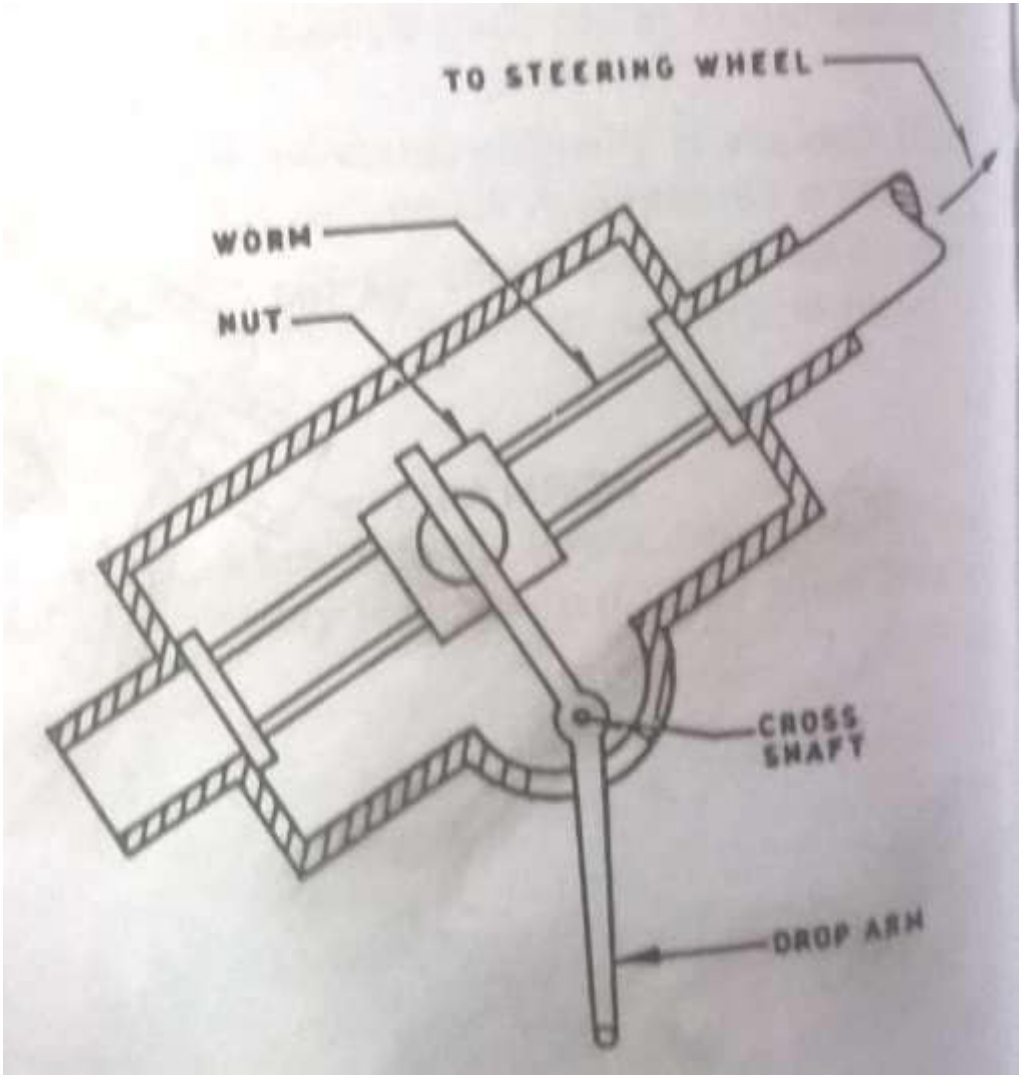

STEERING SHAFT
WORM
ROLLER BEARING
ROLLER
HOUSING
CROSS-SHAFT
CMB2F821

WORM AND NUT STEERING GEAR

- Worm and nut steering gear consists of a worm, which is mounted at the end of steering column. There is a nut which moves along the length of the worm. Inside the nut, there is a cross shaft which is connected to the drop arm. The drop arm in turn is connected to the wheels through the link rod.

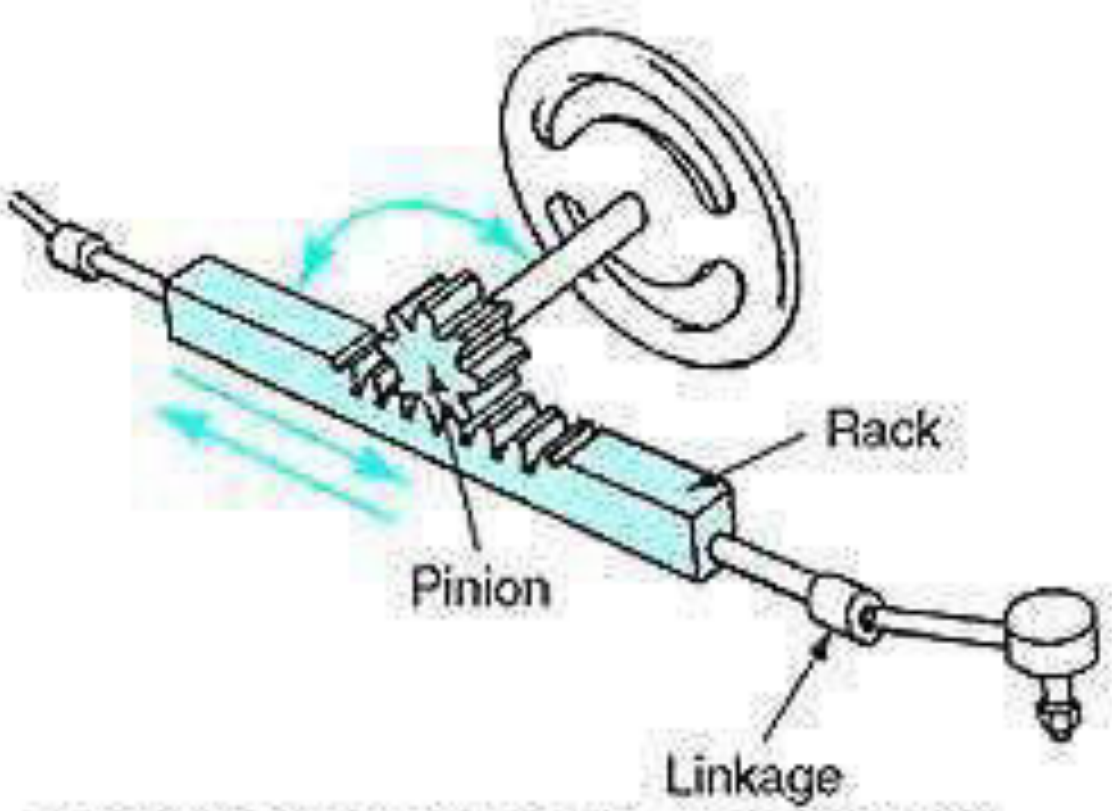
  The rotation of the steering wheel rotates the worm which in turn moves the nut along its length.

  This causes the drop arm end to move linearly, further moving the link rod and thus steering the wheels.


TO STEERING WHEEL
WORM
NUT
CROSS SHAFT
DROP ARM

RACK-AND-PINION STEERING

- On most cars, it takes three to four complete revolutions of the steering wheel to make the wheels turn from lock to lock (from far left to far right).
- The pinion gear is attached to the steering shaft.
- When we turn the steering wheel, the pinion rotates and moves the rack.
- Rack-and-pinion gear set is enclosed in a metal tube, with ends of the rack protruding from the tube.
- A tie rod is connected to each end of the rack.
- The tie rod at each end of the rack is connected to the steering arm

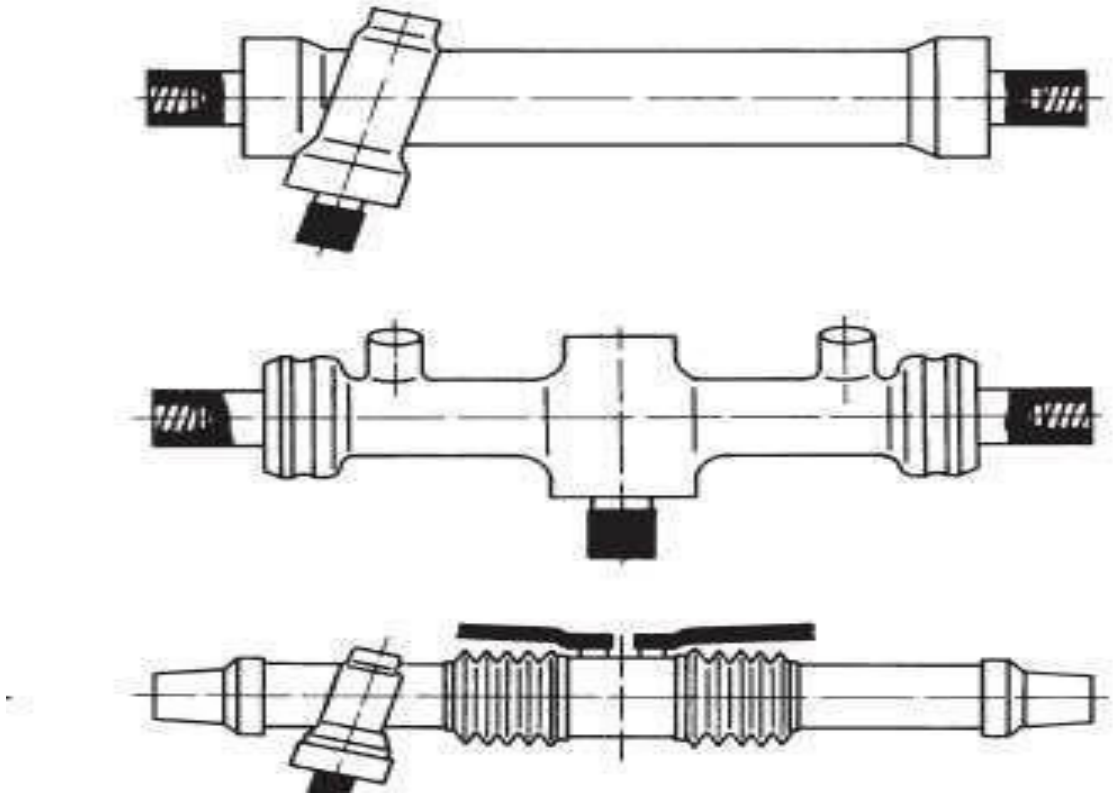


Basic rack and pinion components

RACK AND PINION GEAR CONFIGURATIONS

There are four different configurations of this type of steering gear:

- Type 1 Pinion gear located outside the vehicle centre (on the left on left-hand drive and on the right on right-hand drive) and tie rod joints screwed into the sides of the steering rack (side take-off).
- Type 2 Pinion gear in vehicle centre and tie rods taken off at the sides.
- Type 3 Pinion gear to the side and centre take-off, i.e. the tie rods are fixed in the vehicle centre to the steering rack.
- Type 4 ‘Short steering’ with off-centre pinion gear and both tie rods fixed to side of the steering rack.



The three most common types of rack and pinion steering on left-hand drive passenger cars.

STEERING RATIO

- It is the ratio of the angle turned by the steering wheel to the corresponding turning angles of the stub axle.
- The steering ratio vary from 12:1 for cars to 35:1 for heavy vehicles.
- Average ratio is about one and half complete turns of the steering wheel each side of midpoint to apply full lock of 45 degrees each way on the front wheels.

STEERING COLUMN

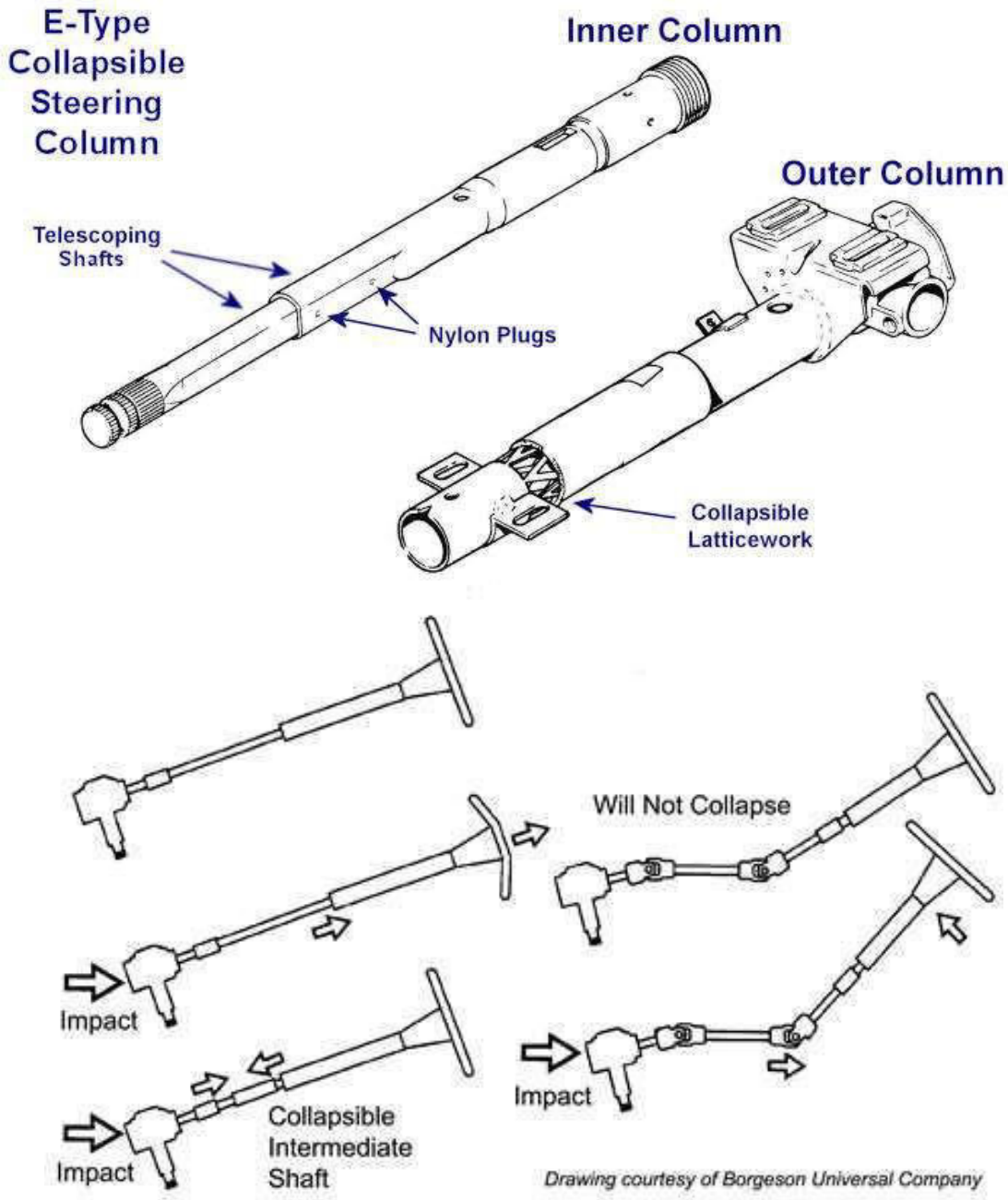
- Contains and supports steering shaft
- Shaft is supported by bearings at top and bottom of column
- Steering wheel is splined to steering shaft located in center of steering column
- May have a tilt mechanism which allows the driver to adjust steering wheel angle
- May be designed to collapse during front impact – has plastic or soft metal rivets that are easily damaged or broken from improper use or removal
- Houses ignition switch

SPECIAL STEERING COLUMNS

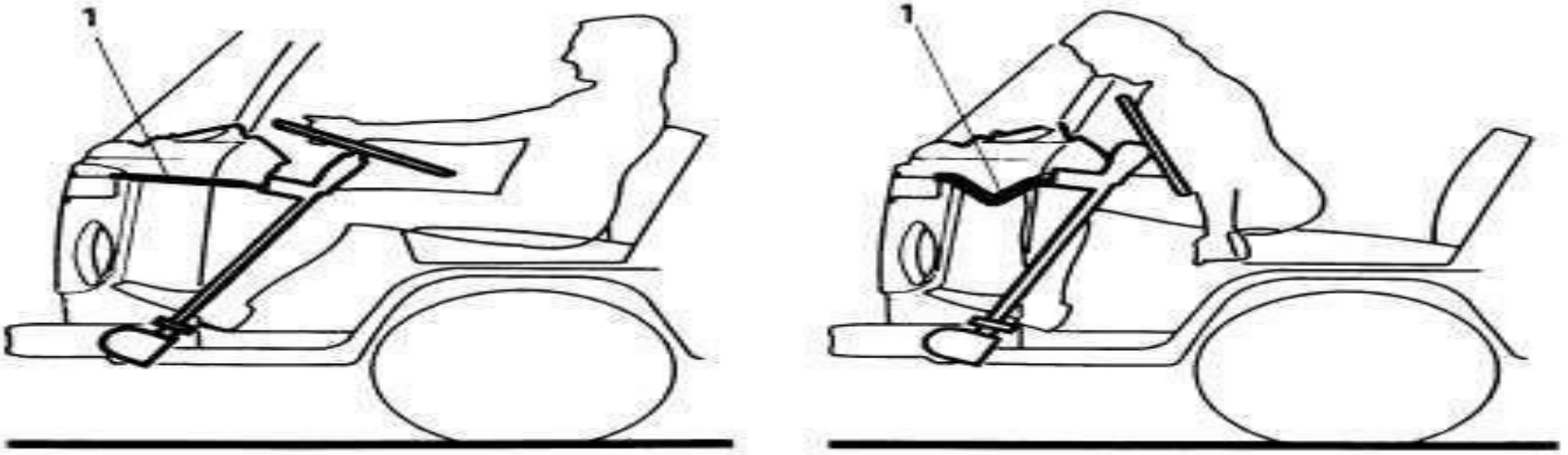
Special type of steering columns are employed in cars for safery and ease of operation to the driver.

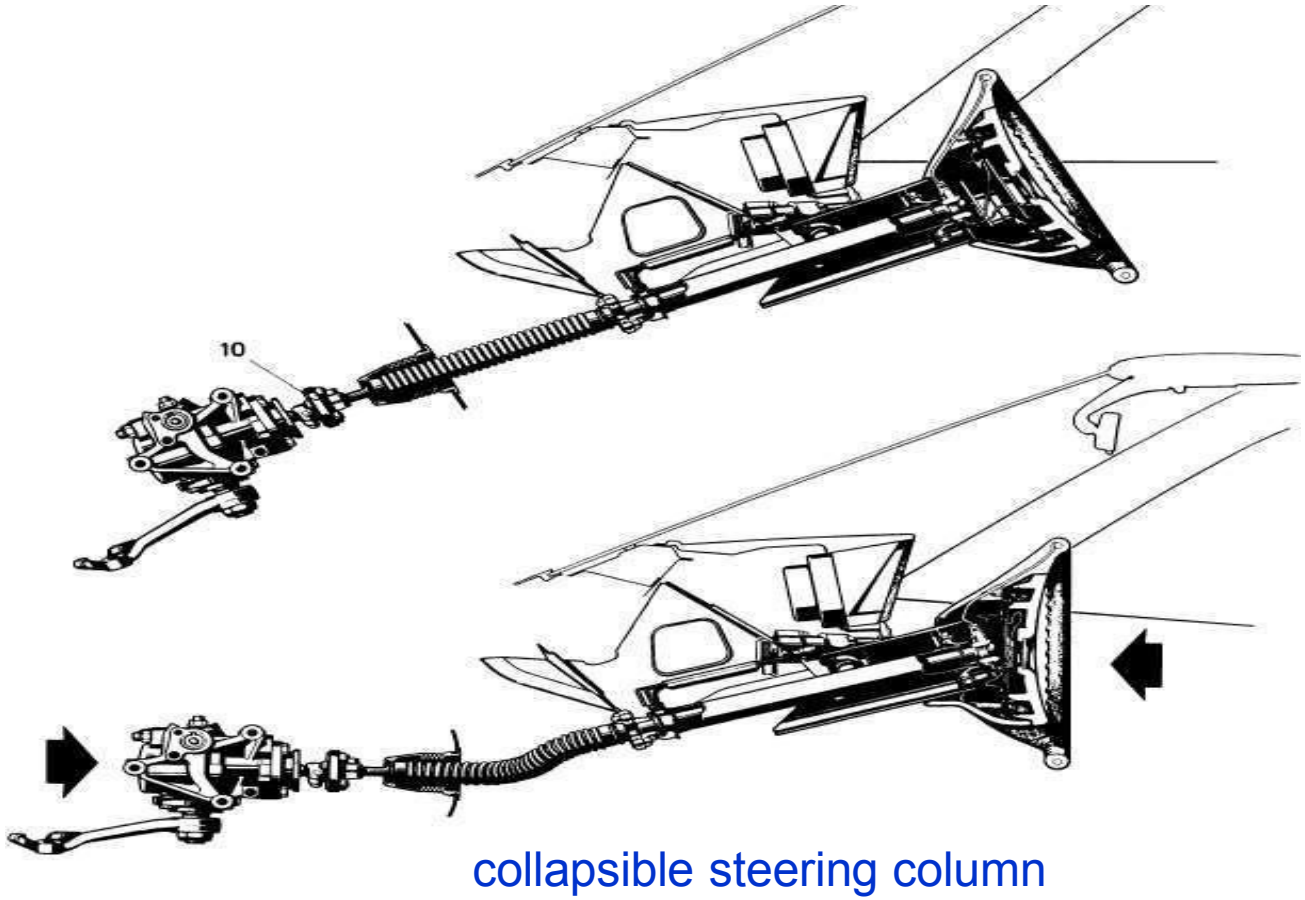
- **Energy absorbing or collapsible steering column**
  - **Mesh type jacket**
  - **Ball type jacket**
  - **flexible corrugated tube.**
- **Tilt wheel steering column**
- **Tilt and telescopic steering column**
- **Steering column with anti-theft lock.**

Mesh type jacket



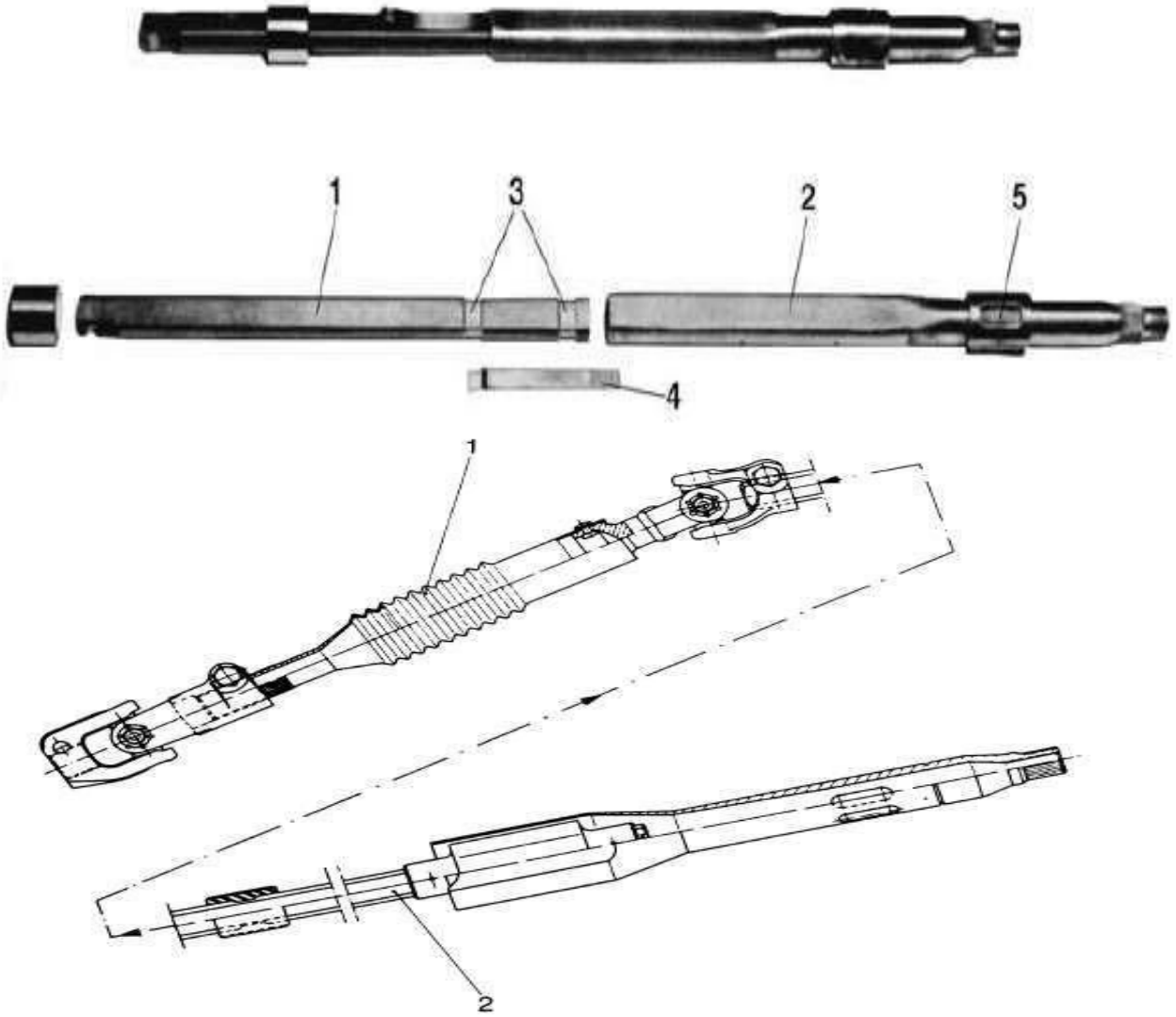
Collapsible Steering Column

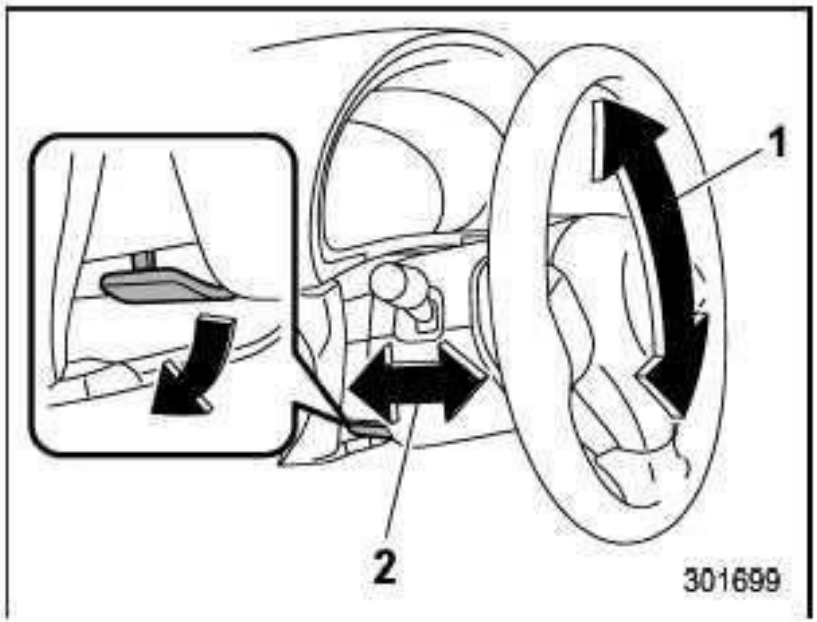




collapsible steering column

collapsible (telescopic) steering tubes




1
2
301699

STEERING WHEEL

- Attaches to steering column and shaft by 1 or more fasteners, mostly single nut in the centre
- Have an interference fit on the shaft. Needs a puller to remove
- Contains horn. May also contain airbag assembly, radio controls etc

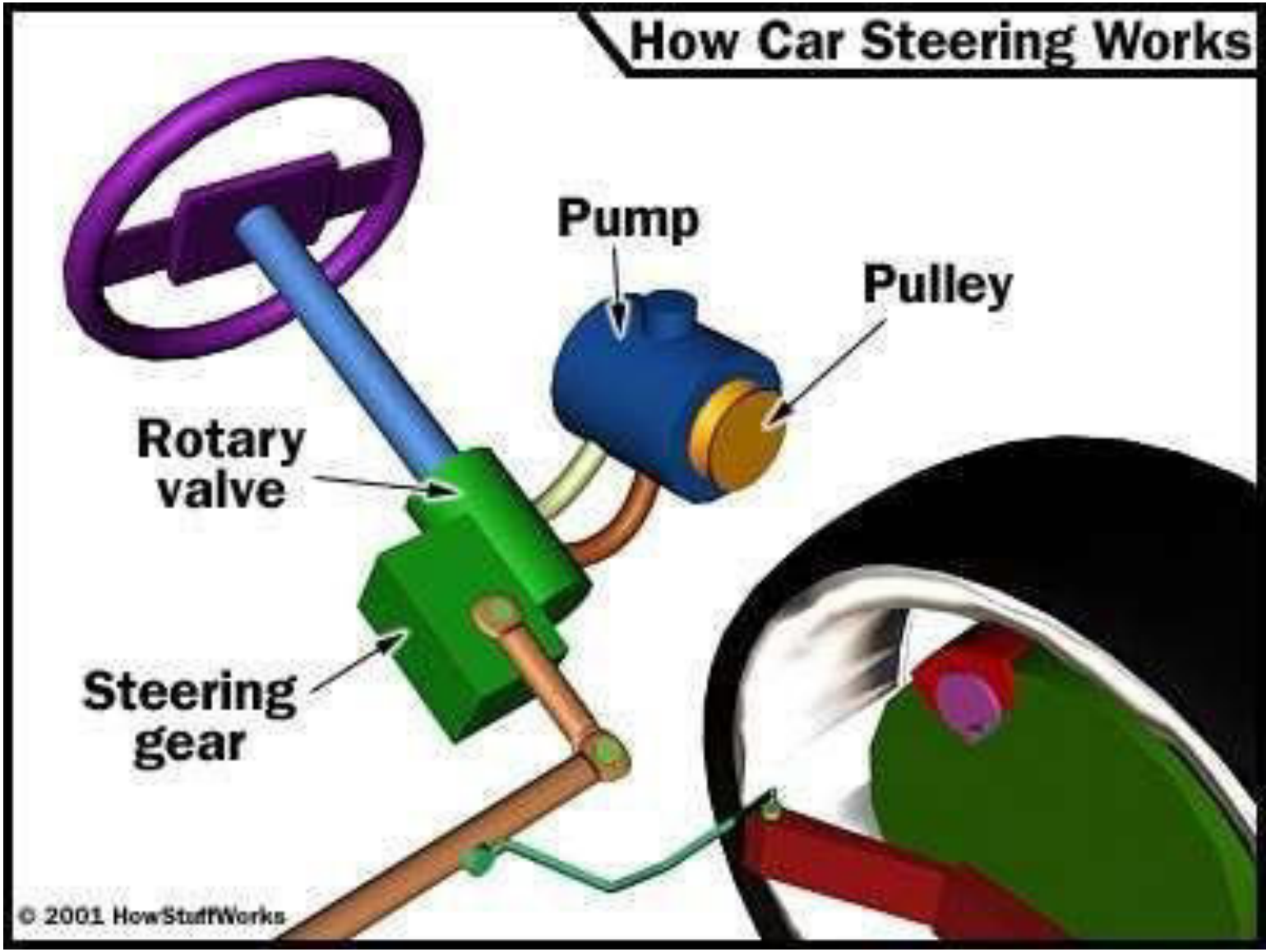
POWER STEERING SYSTEMS

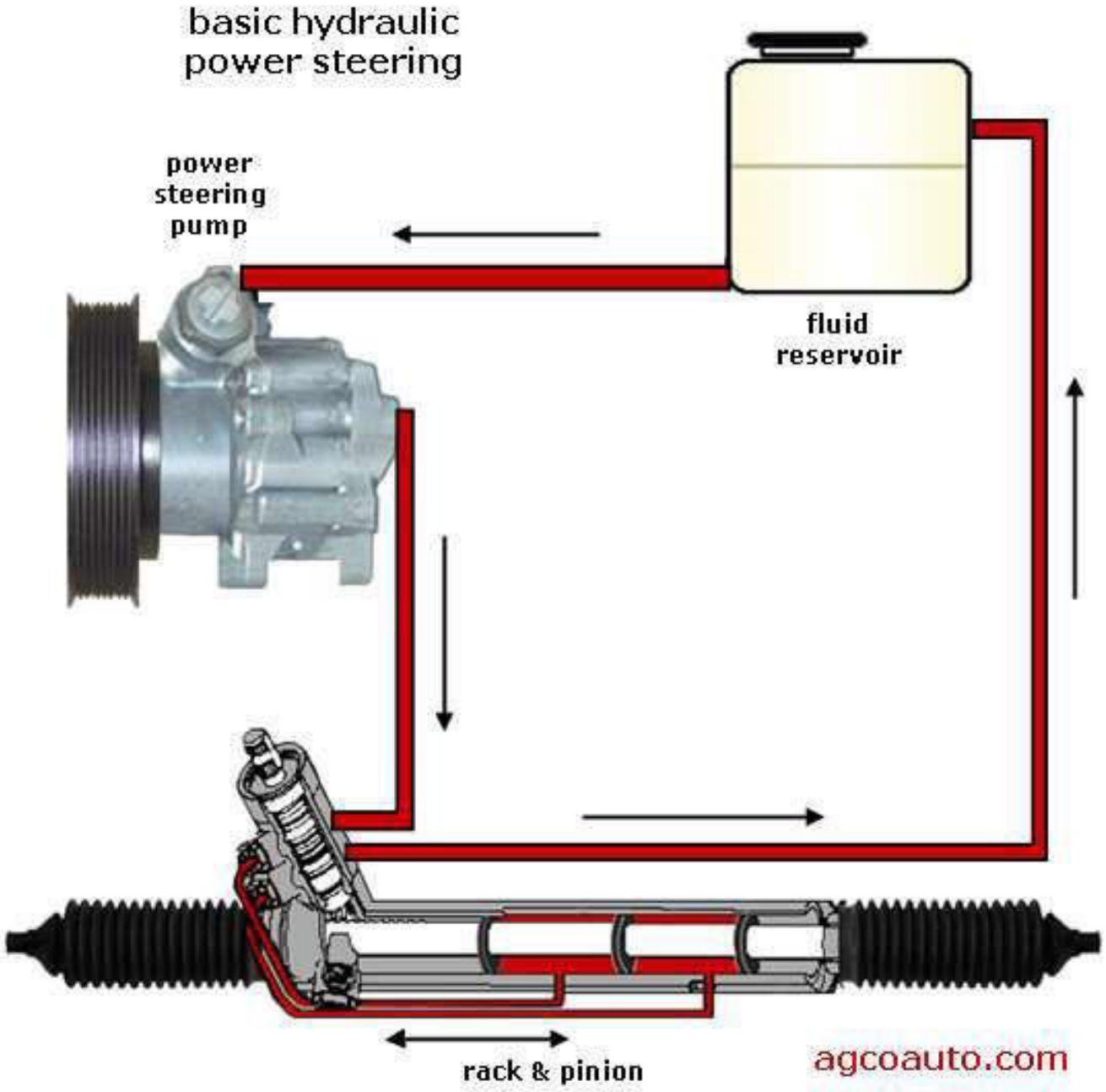
- Power steering systems have become more and more widely used in the last few years.
- Manual steering systems are used as a basis for power steering systems, with the advantage that the mechanical connection between the steering wheel and the wheel and all the components continues to be maintained with or without the help of the auxiliary power.
- The steering boost is thereby reduced, with the aim of achieving better road contact at higher speeds.

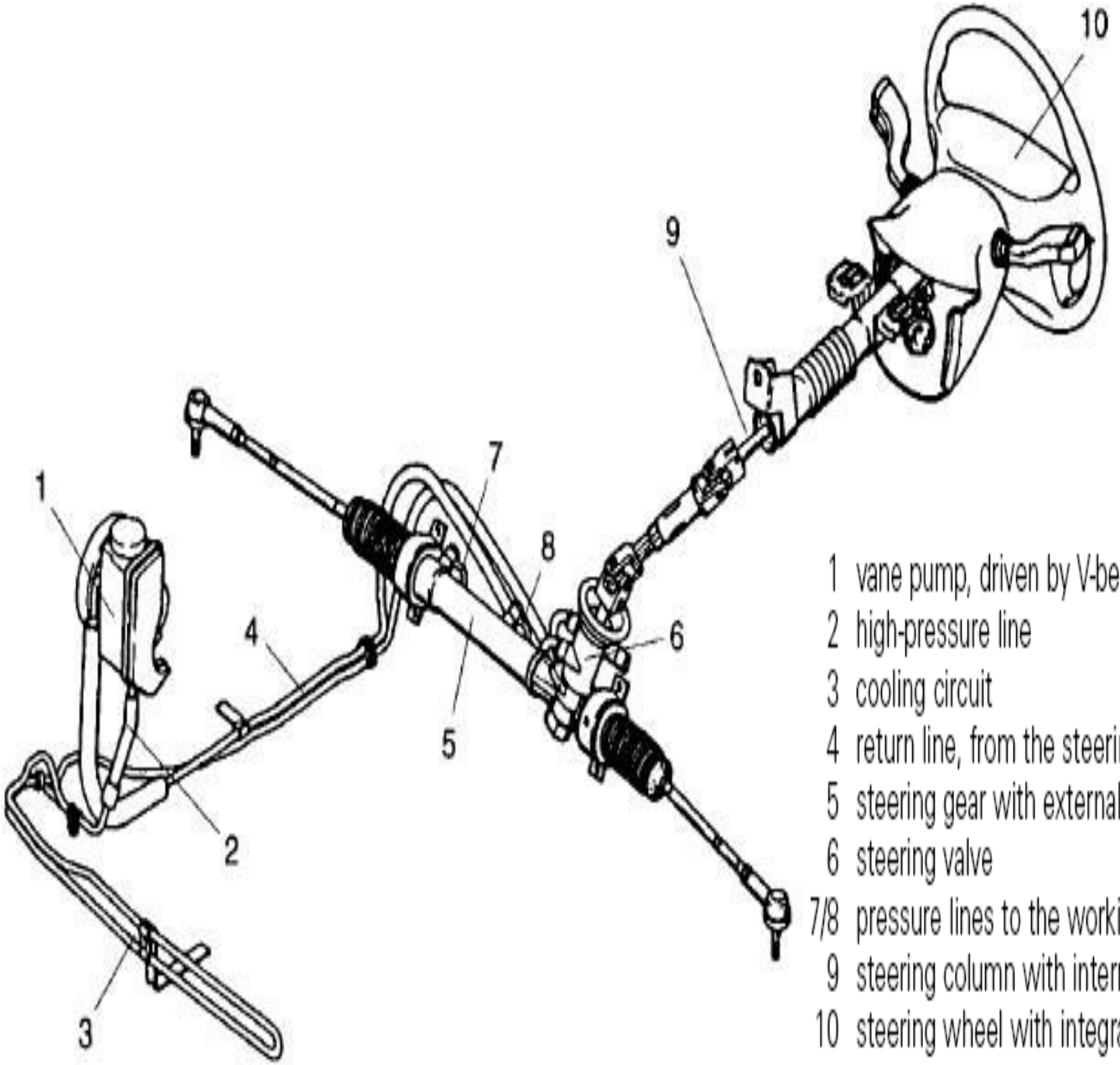
- The method of using oil under pressure to boost the servo is sophisticated and advantageous in terms of cost, space and weight.
- This can be attributed to the hydraulic self-damping.
- The oil pump is directly driven by the engine and constantly generates hydraulic power.
- Depending on the driving assembly and pump design, the additional consumption of fuel can lie between 0.2 and 0.7 l per 100 km.

COMPONENTS IN POWER STEERING

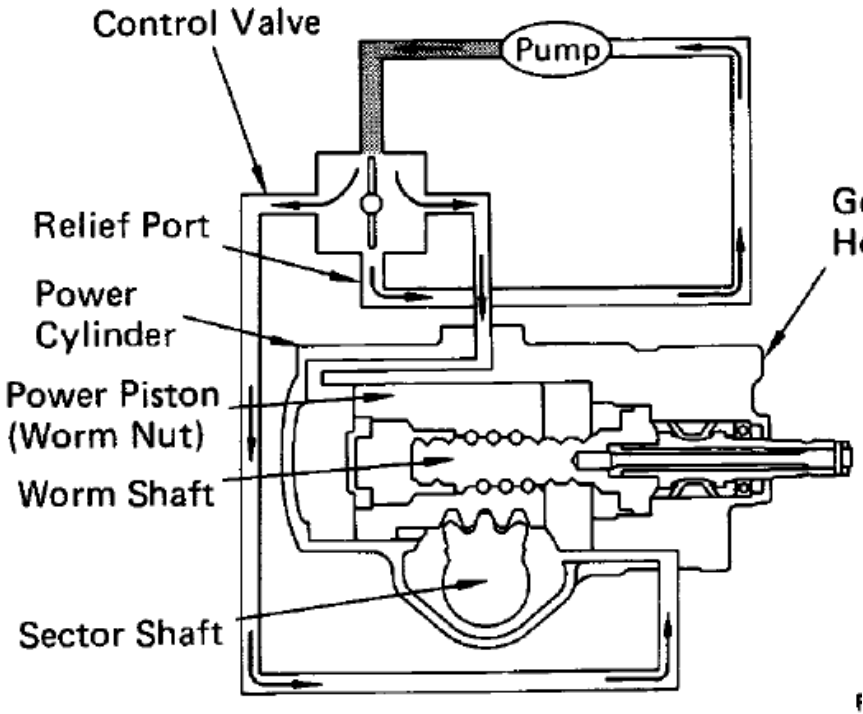
- POWER STEERING PUMP
- **POWER CYLINDER**
- **OIL RESERVOIR**
- **HYDRAULIC LINES OR HOSES**
- **FILTERS**
- **RELIEF VALVE**
- **CONTROL VALVE**


How Car Steering Works
Pump
Pulley
Rotary valve
Steering gear
© 2001 HowStuffWorks


basic hydraulic
power steering
power
steering
pump
fluid
reservoir
rack & pinion
agcoauto.com

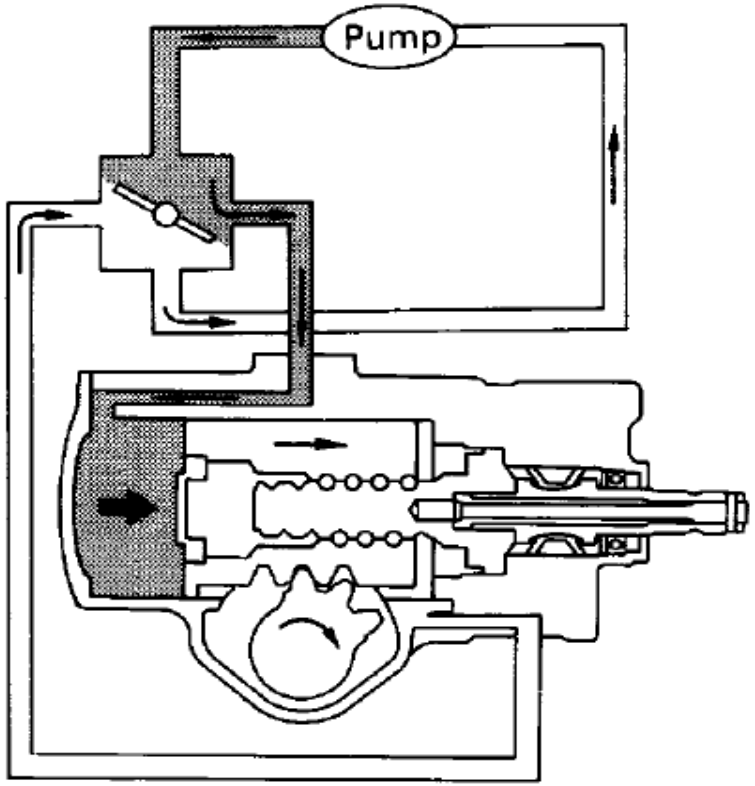


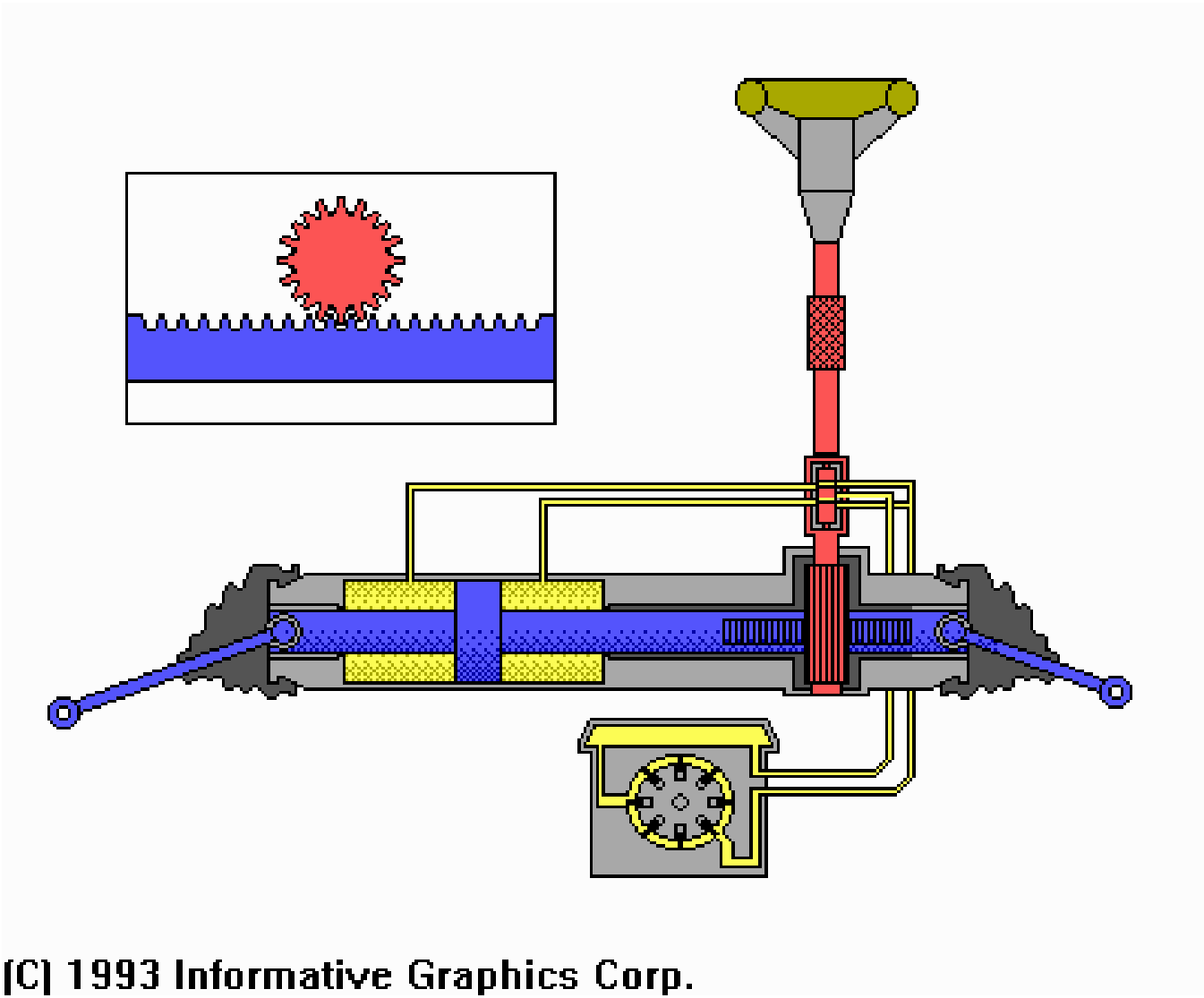
1 vane pump, driven by V-belts
2 high-pressure line
3 cooling circuit
4 return line, from the steering valve to the pump
5 steering gear with external drive, attached to the auxiliary frame
6 steering valve
7/8 pressure lines to the working cylinder
9 steering column with intermediate shaft
10 steering wheel with integrated airbag.



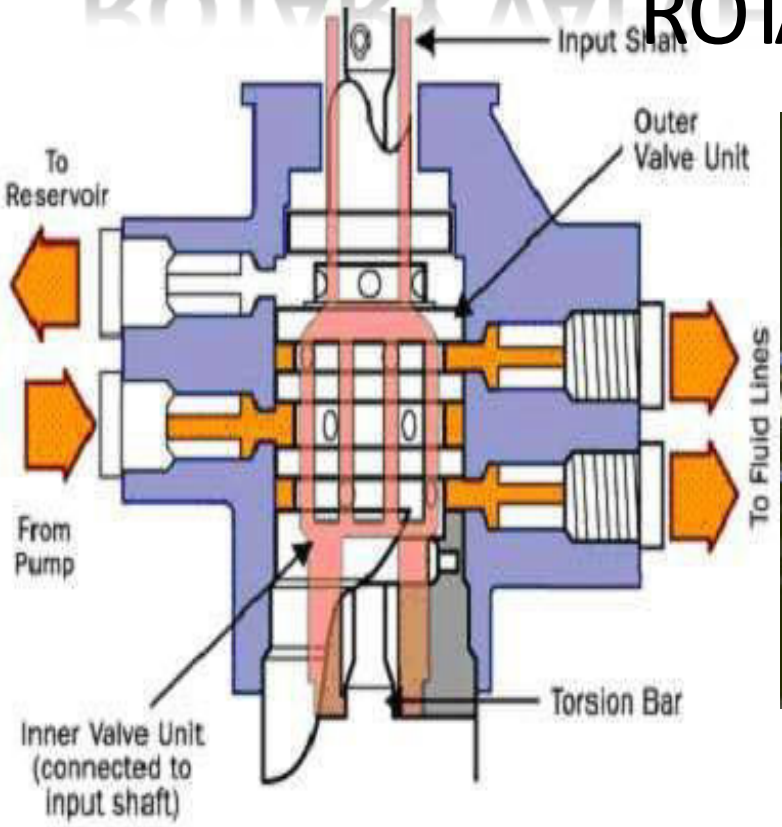
Neutral or straight ahead position

When taking a turn

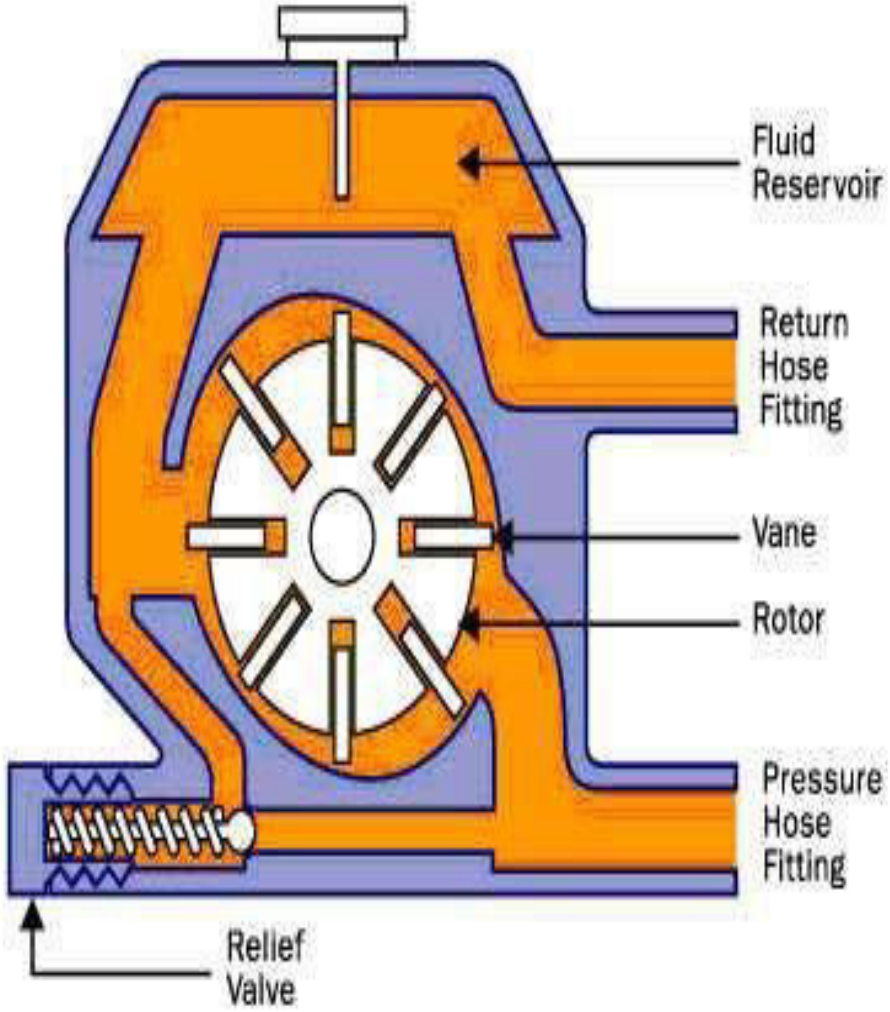




ROTARY VALVE



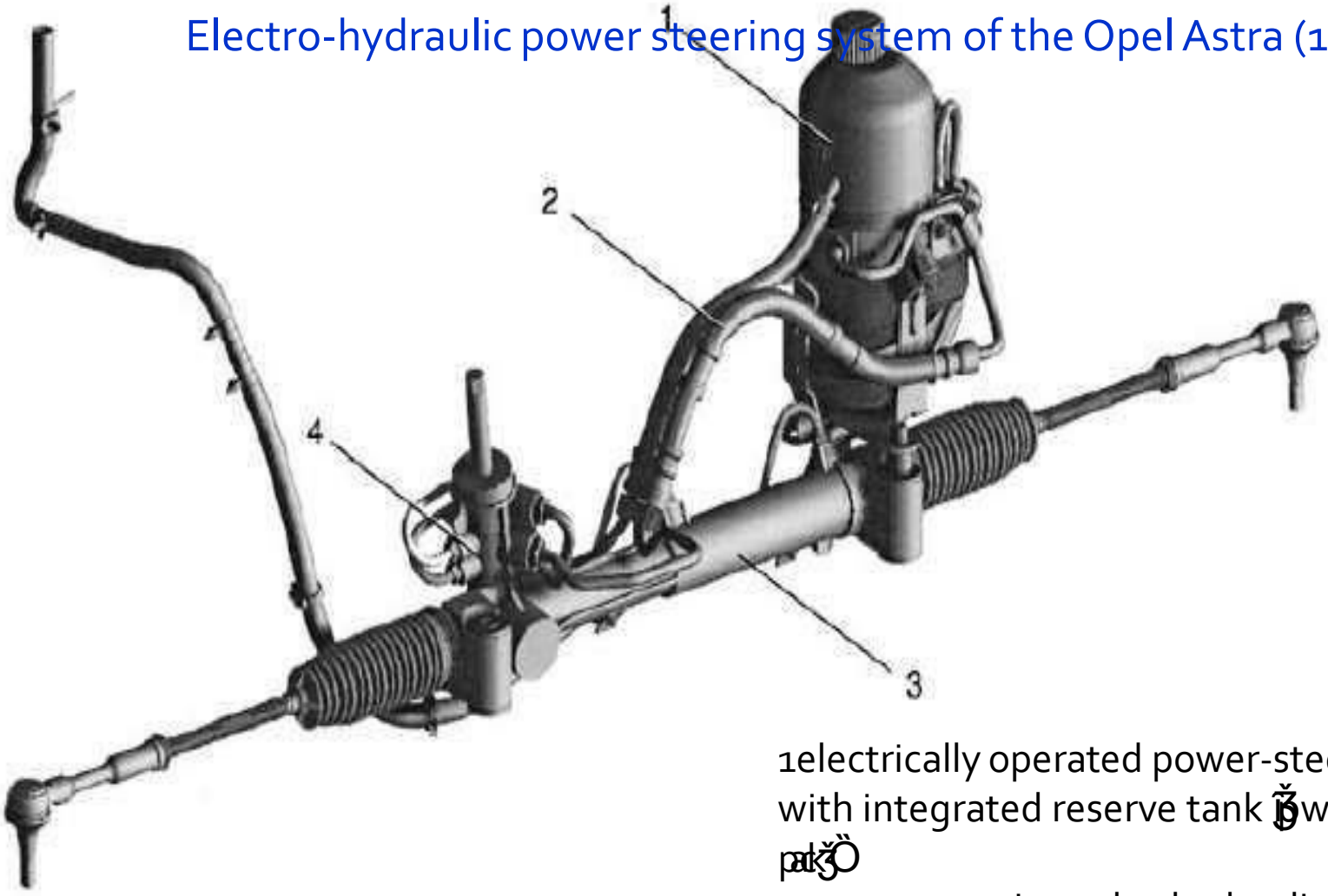
VANE TYPE OF PUMP



ELECTRO-HYDRAULIC POWER STEERING SYSTEMS

- With electro-hydraulic power steering systems, the power-steering pump driven by the engine of the vehicle via V-belts is replaced by an electrically operated pump.
- The pump is electronically controlled – when servo boost is not required, the oil supply is reduced.
- The pressure supply unit can be accommodated in an appropriate location (in relation to space and crash safety considerations).
- Pressure-controlled systems generate only the amount of oil required for a particular driving situation.

Electro-hydraulic power steering system of the Opel Astra (1997).



1electrically operated power-steering pump with integrated reserve tank ĵower pakžÖ

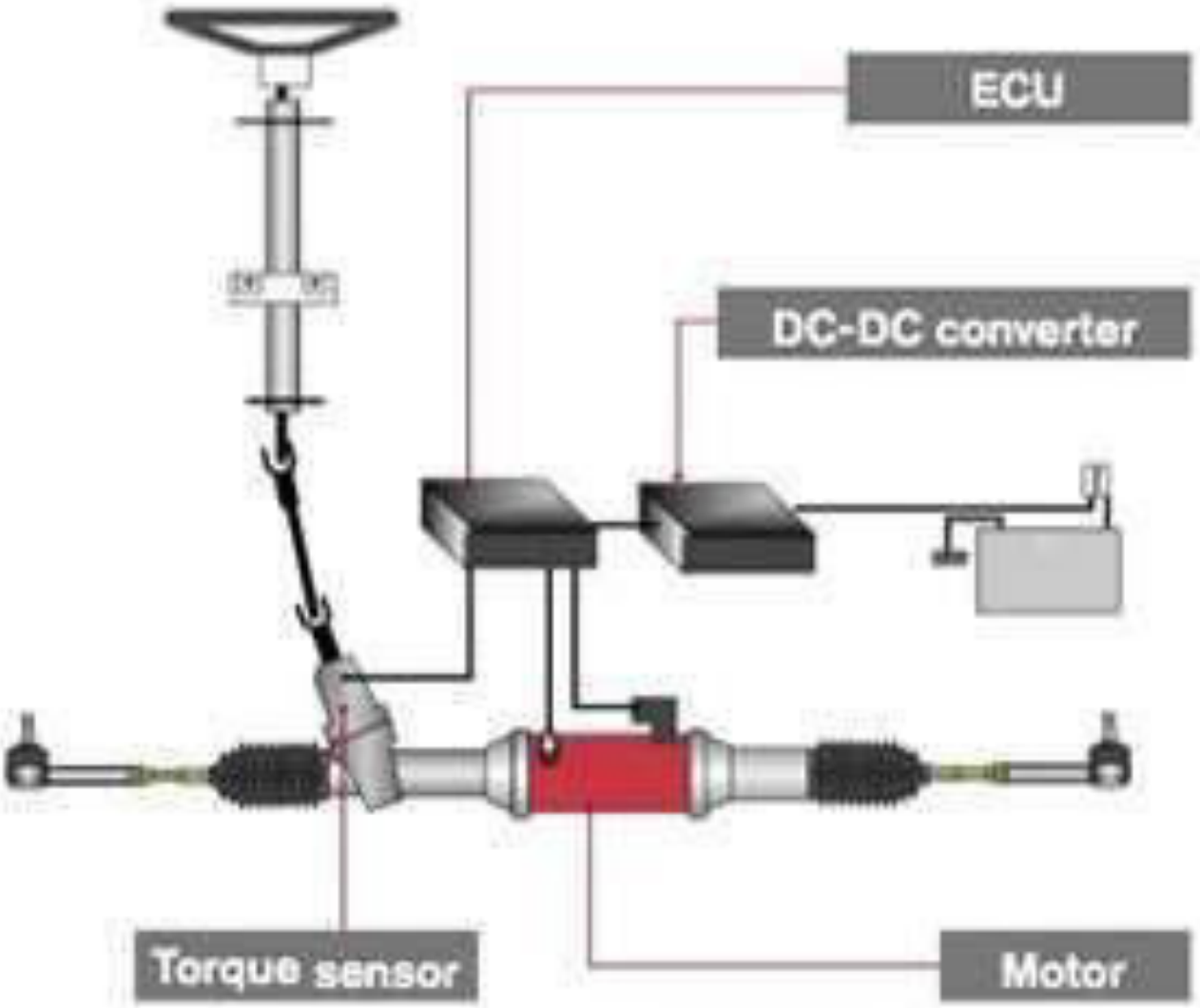
2 pump–steering valve hydraulic lines

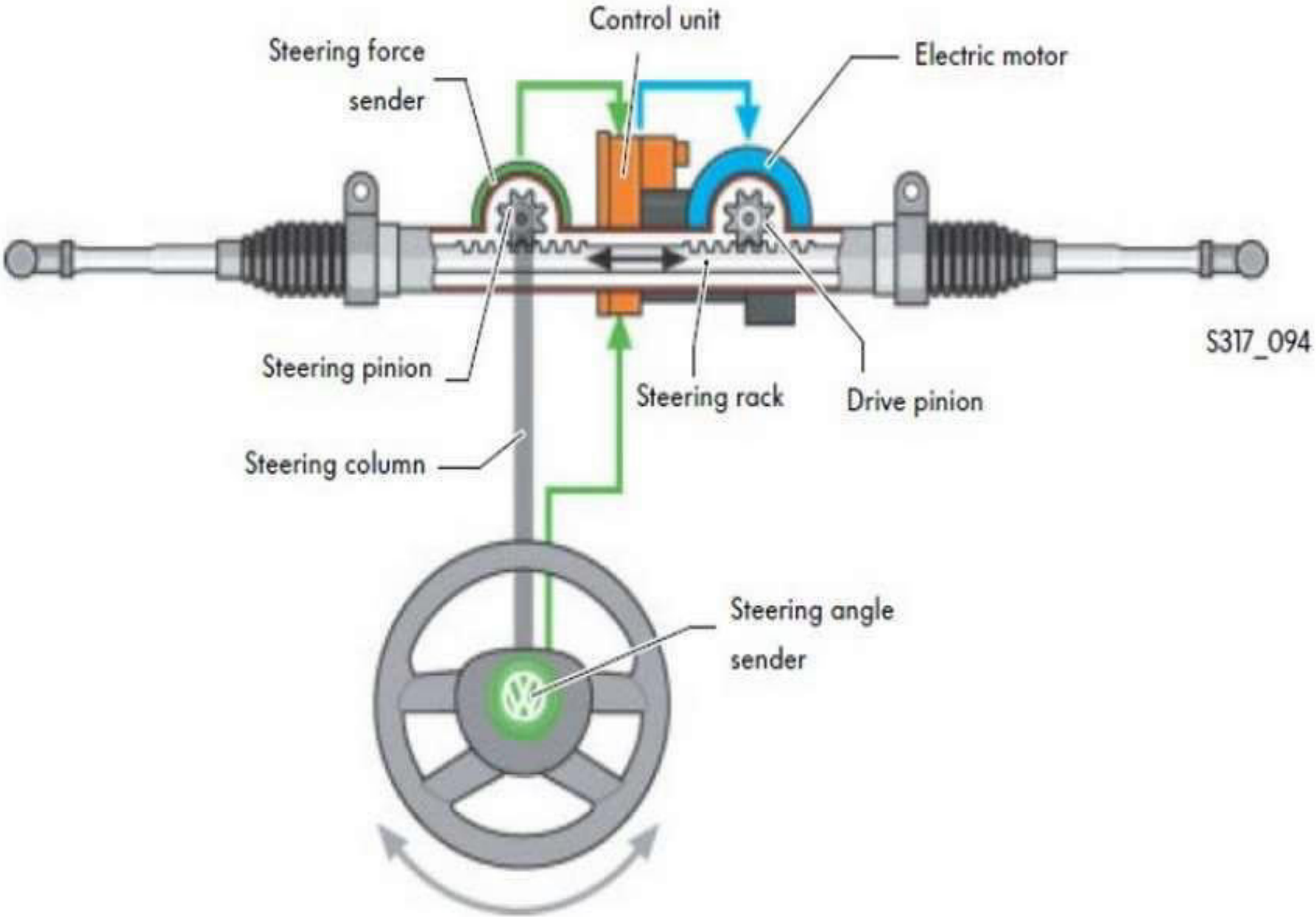
3rack and pinion steering gear with external drive, attached to auxiliary frame

4 steering valve.

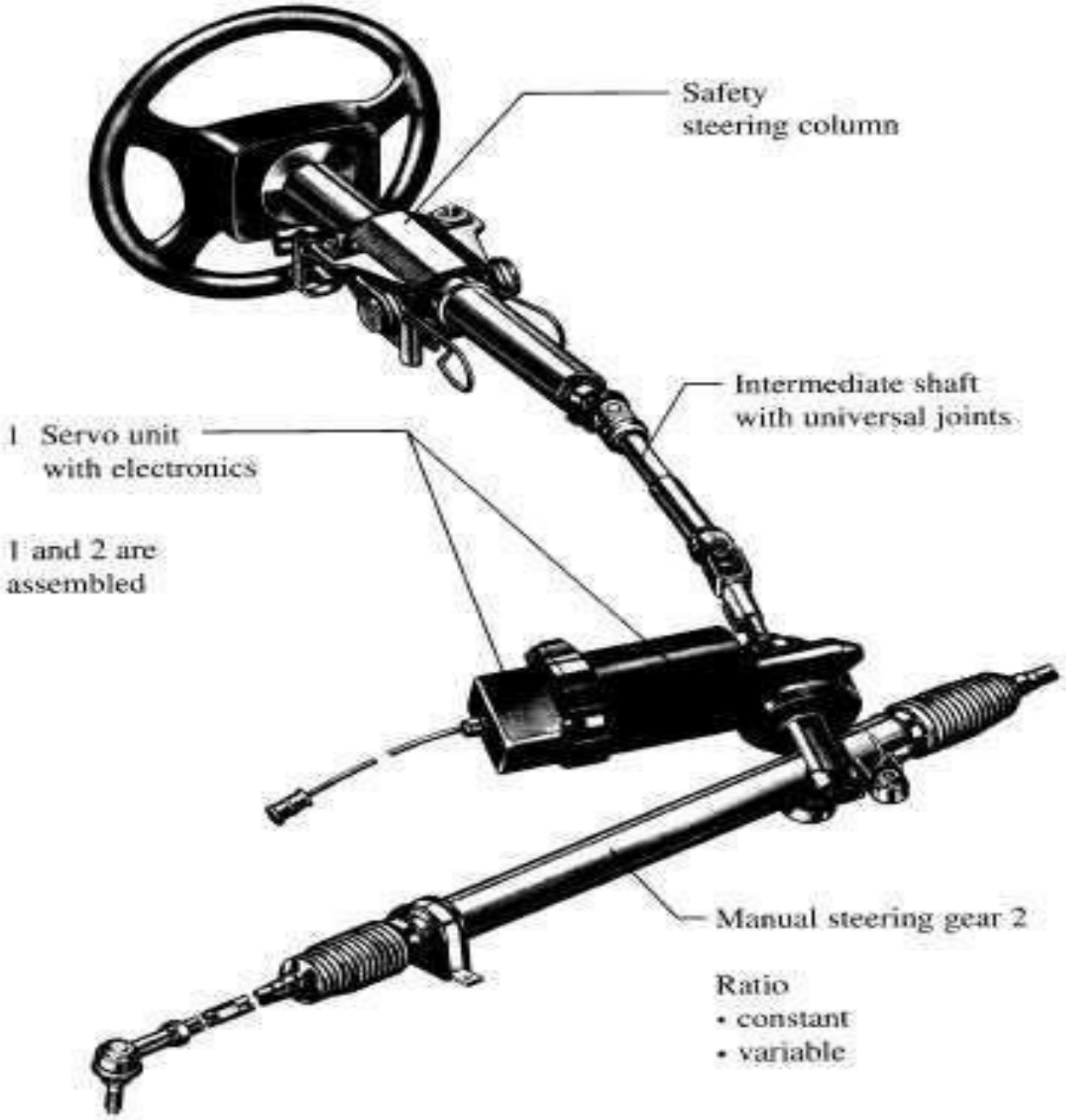
SYSTEMS ELECTRICAL POWER STEERING

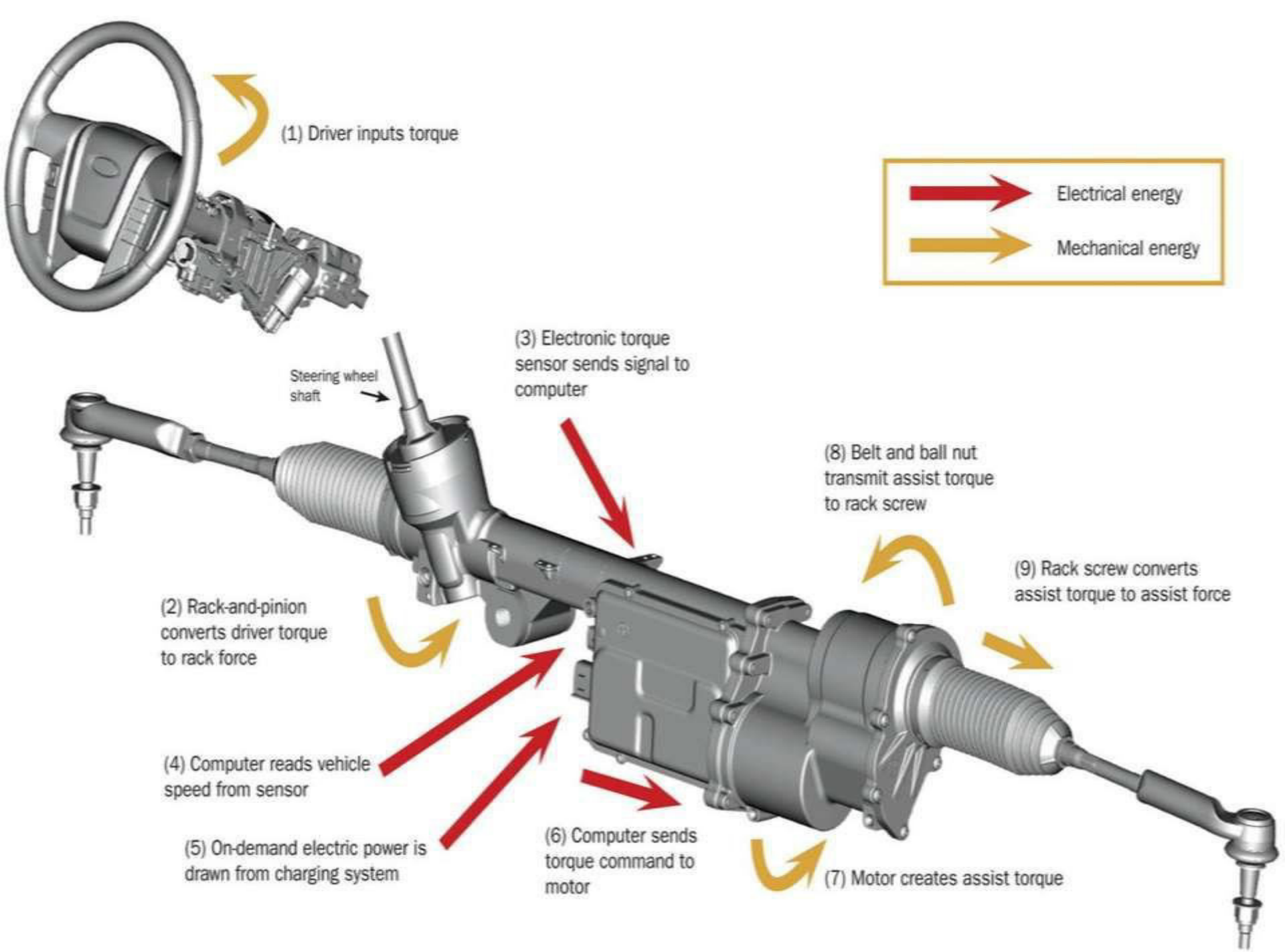
- The bypass of the hydraulic circuit and direct steering boost with the aid of an electric motor has additional advantages in terms of weight.
- Engine bay space compared with electro-hydraulic steering, because of the omission of all the hydraulic components.
- more variations of the steering boost because of the purely electrical signal processing.
- The systems only have limited power because the current is limited by an operating voltage of 12 V.
- They are of interest though for smaller vehicles.


ECU
DC-DC converter
Torque sensor
Motor

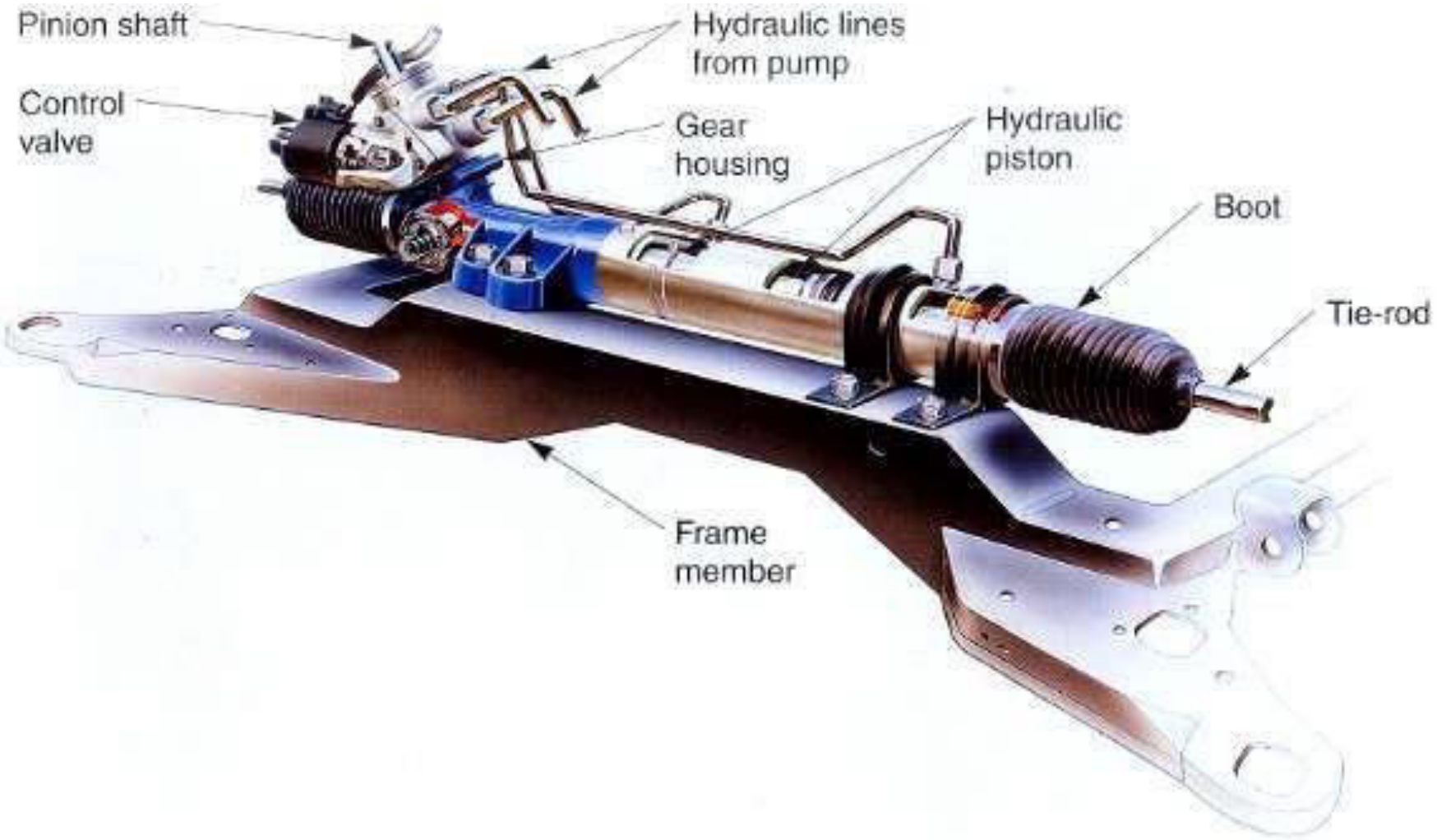

Control unit
Steering force sender
Electric motor
Steering pinion
Steering rack
Drive pinion
S317_094
Steering column
Steering angle sender

Electrical power steering system by ZF.




(1) Driver inputs torque
Electrical energy
Mechanical energy
Steering wheel shaft
(3) Electronic torque sensor sends signal to computer
(8) Belt and ball nut transmit assist torque to rack screw
(9) Rack screw converts assist torque to assist force
(2) Rack-and-pinion converts driver torque to rack force
(4) Computer reads vehicle speed from sensor
(5) On-demand electric power is drawn from charging system
(6) Computer sends torque command to motor
(7) Motor creates assist torque

Electric/Electronic Rack & Pinion System

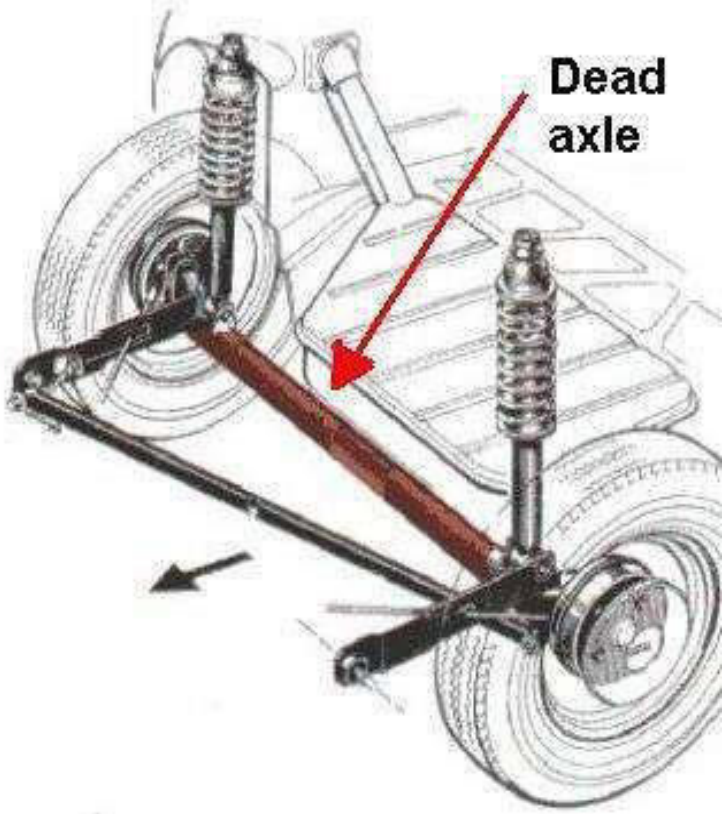


FRONT AXLES

- Front wheels of the vehicle are mounted on front axles .
- It supports the weight of front part of the vehicle.
- It facilitates steering.
- It absorbs shocks which are transmitted due to road surface irregularities.
- It absorbs torque applied on it due to braking of vehicle.

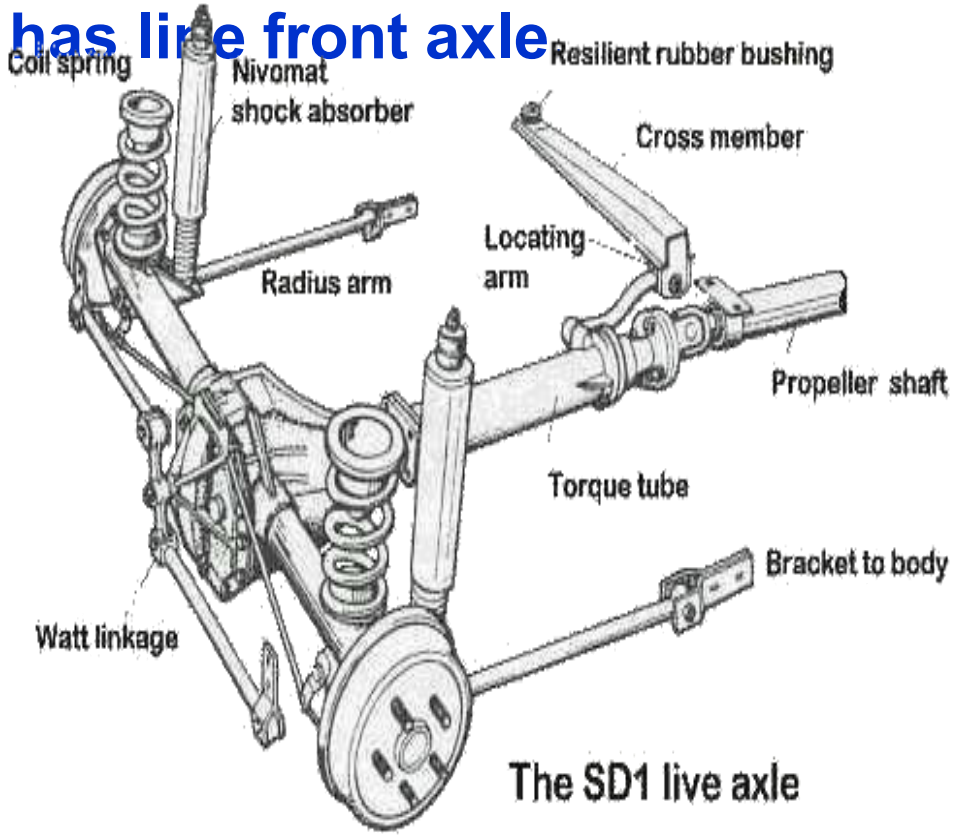
DEAD AXLE

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



LIVE AXLE

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

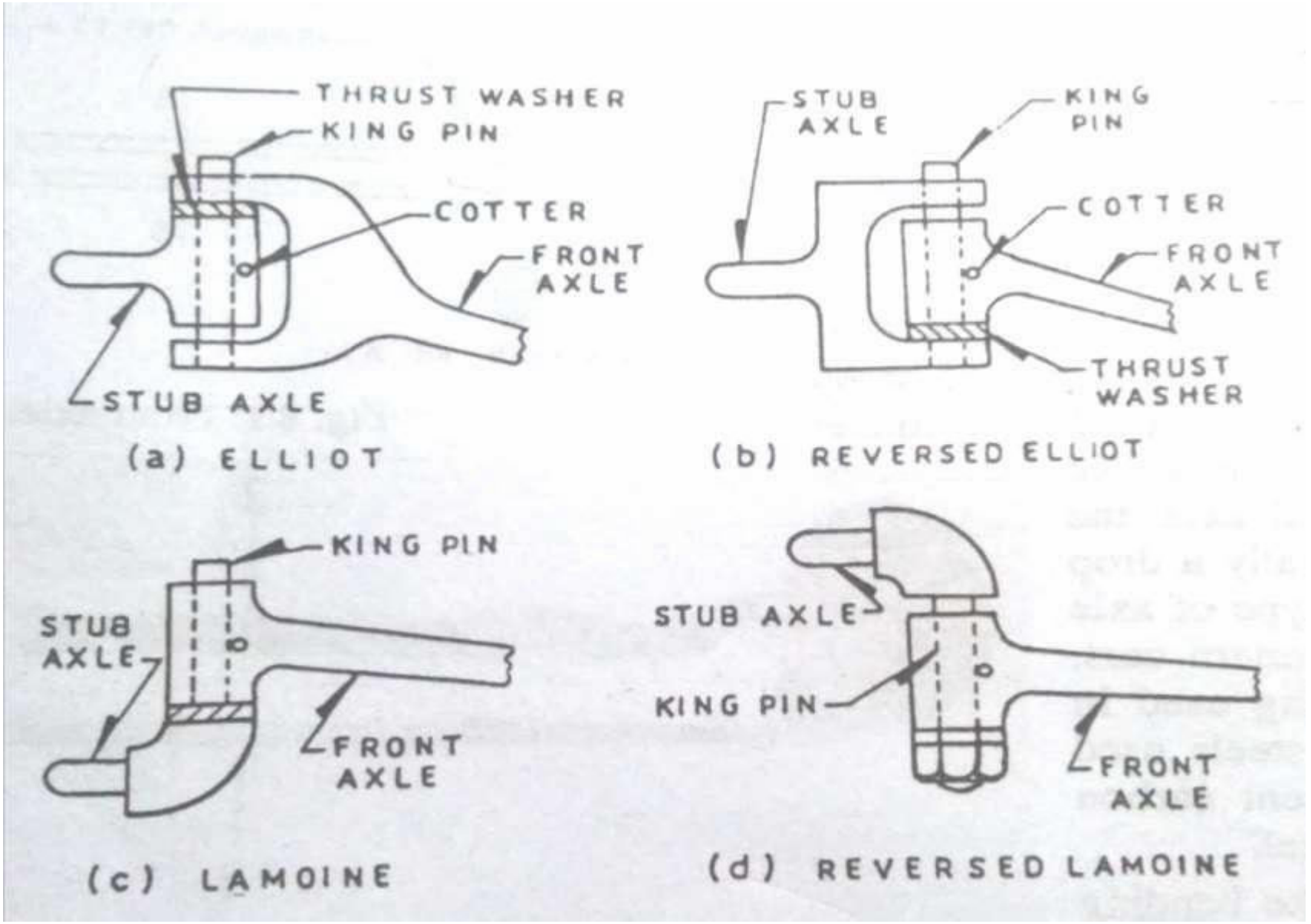


STUB AXLE

- Stub axles are connected to the front axle by king pins.
- Stub axle turns on king pins. King pins is fitted in the front axle beam eye and is located and locked there by a taper cotter pin.
- It is made of 3% nickel steel and alloy steels containing chromium and molybdenum.

STUB AXLES ARE OF FOUR TYPES:

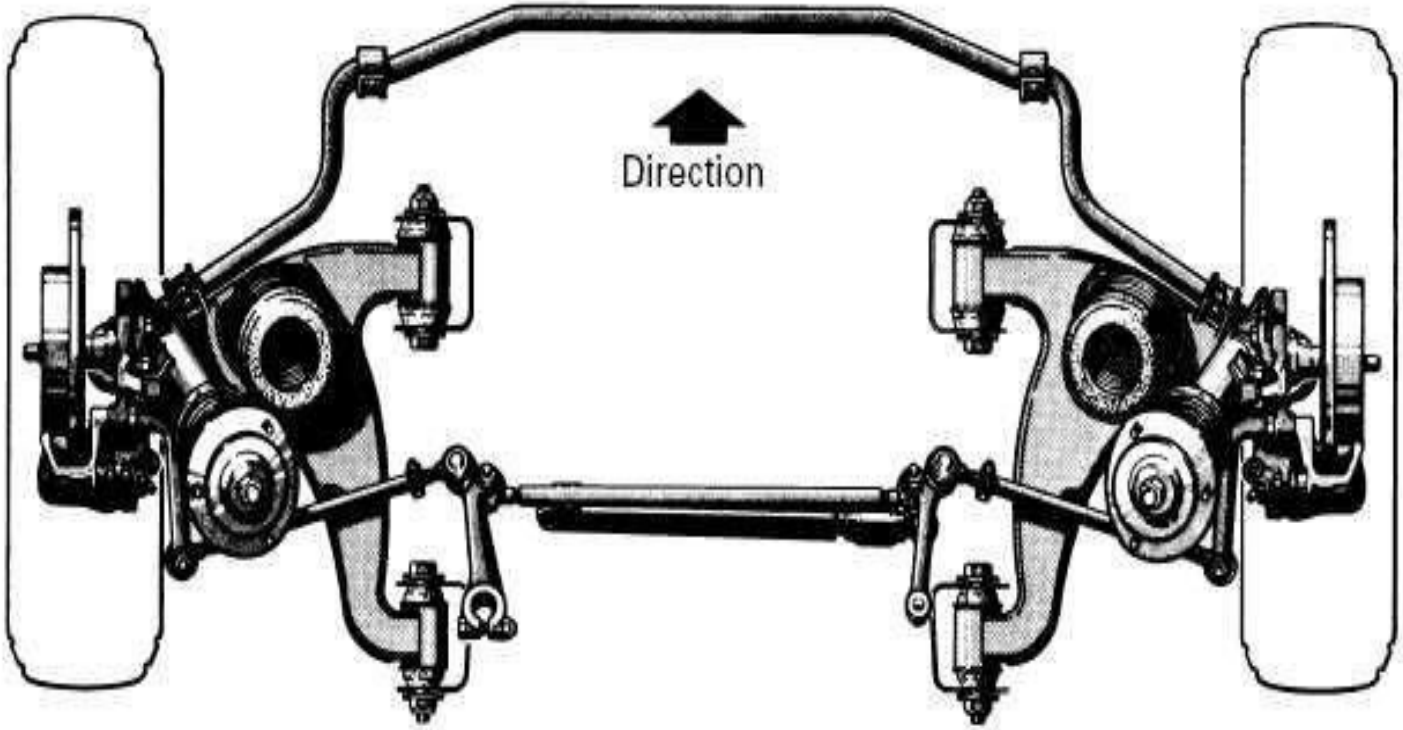
- Elliot
- Reversed Elliot (Most commonly used)
- Lamoine
- Reversed Lamoine


THRUST WASHER
KING PIN
COTTER
FRONT AXLE
STUB AXLE
(a) ELLIOT
STUB AXLE
KING PIN
COTTER
FRONT AXLE
THRUST WASHER
(b) REVERSED ELLIOT
KING PIN
STUB AXLE
FRONT AXLE
(c) LAMOINE
STUB AXLE
KING PIN
FRONT AXLE
(d) REVERSED LAMOINE

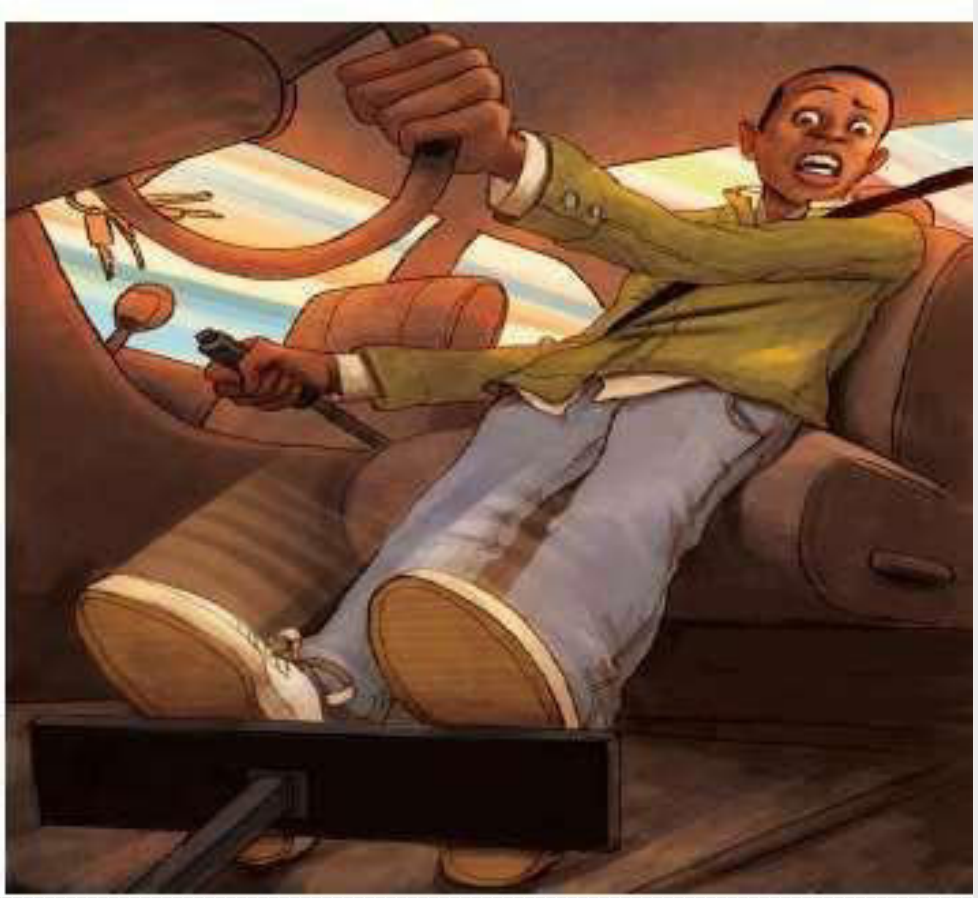
Elliot type

Reversed Elliot type

Top view of the strut damper front axle on a Mercedes vehicle.



Braking system



BRAKE

- A common misconception about brakes is that brakes squeeze against a drum or disc, and the pressure of the squeezing action slows the vehicle down.
- This is in fact a part of the reason for slowing down a vehicle.
- Actually brakes use friction of brake shoes and drums to convert kinetic energy developed by the vehicle into heat energy.
- When we apply brakes, the pads or shoes that press against the brake drums or rotor convert kinetic energy into thermal energy via friction.
- One of most important control componants of vehicle.

BRAKING REQUIREMENTS

- Brakes must be strong enough to stop vehicle with in a minimum distance in an emergency.
- Brakes must have good antifade characterstics (effectiveness doesnot decrease due to prolonged use)

TYPES OF BRAKES

- **PURPOSE**:- From this point of view Brakes are classified as service or primary and parking or secondry brakes.
- **LOCATION**:- From this point of view brakes are located at wheels or at transmission.
- **CONSTRUCTION**:-From this point of brakes are drum brakes and disc brakes.
- **METHOD OF ACTUATION**:- This criterion gives source of power used to apply the brakes

METHOD OF ACTUATION:-

1) Mechanical Brakes
2) Hydraullic Brakes
3) Electric Brakes
4) Vaccum Brakes
5) Air Brakes
6) By-wire Brakes

MECHANICAL BRAKES

- **Mechanical brakes are assemblies consisting of mechanical elements for the slowing or stopping of vehicle.**
- **They use levers or linkages to transmit force from one point to another.**
- **There are several types of mechanical brakes.**

a. Band brake
b. Drum brake
c. Disc brake
d. Cone brake

- BAND BRAKES or EXTERNAL CONTRACTING BRAKES, the simplest brake configuration, have a metal band lined with heat and wear resistant friction material.

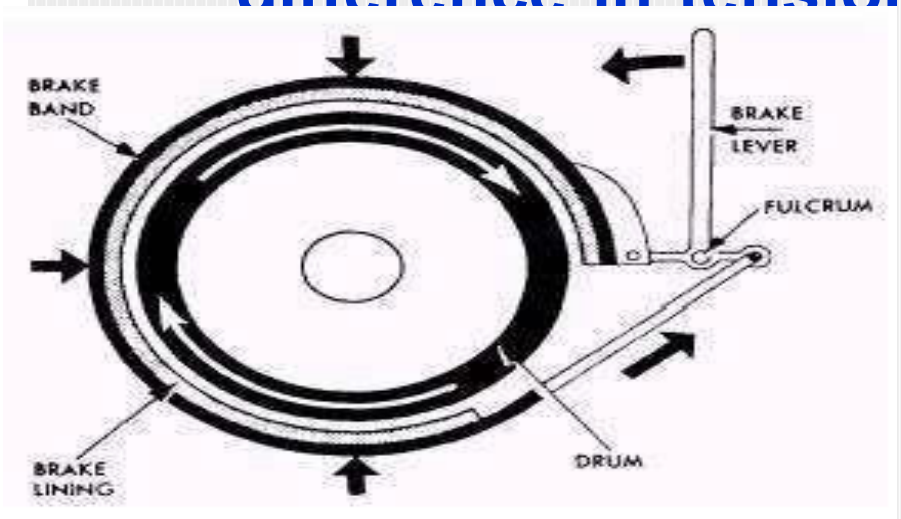
- DRUM BRAKES, which are commonly used on automobile rear wheels work when shoes press against a spinning surface called a drum.

- DISC BREAKS are constructed of brake pads, a caliper, and a rotor. During operation, the brake pads are squeezed against the rotor.

- CONE BRAKES are made with a cup and a cone, which is lined with heat and wear material. During actuation, the cone is pressed

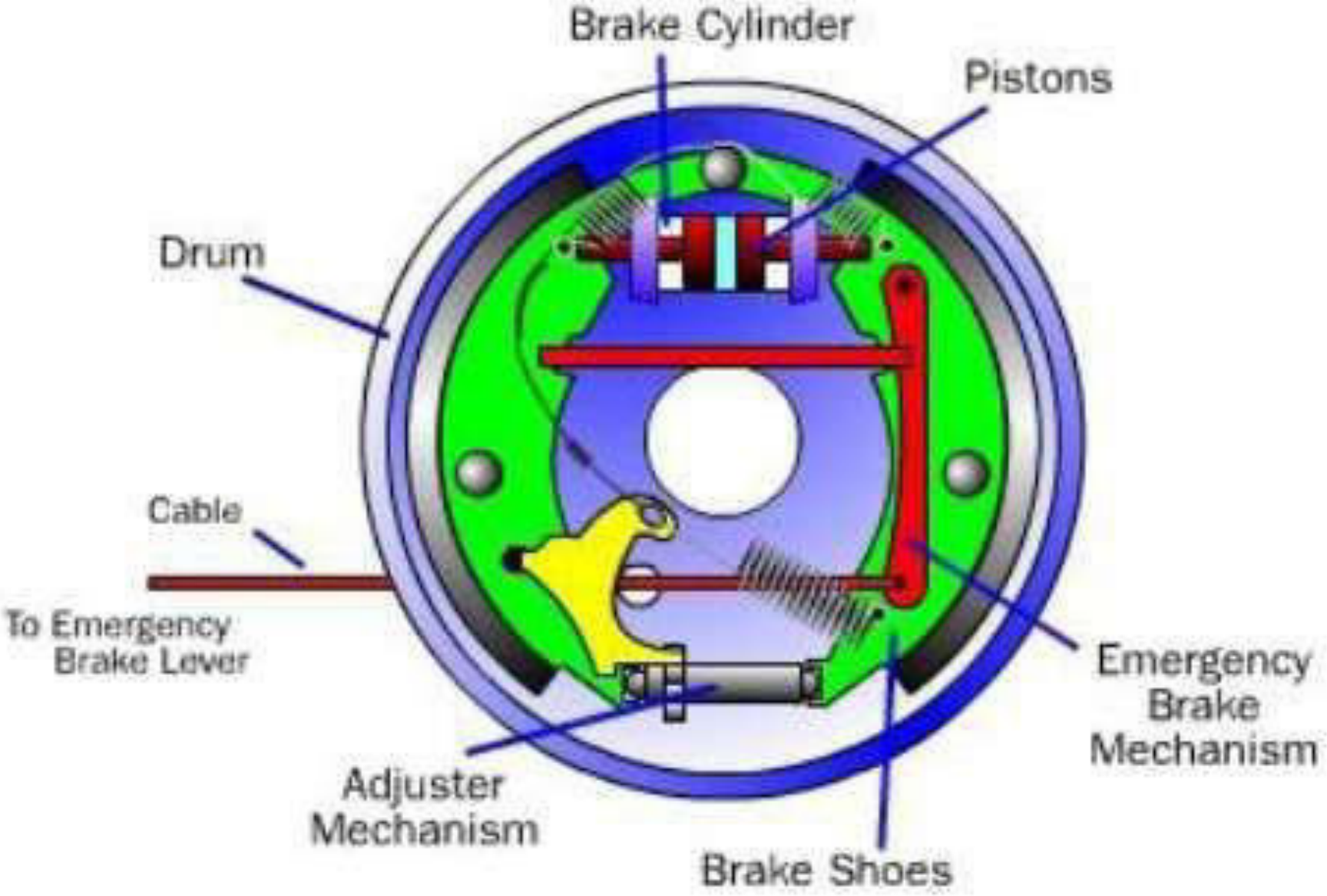
BAND BRAKES

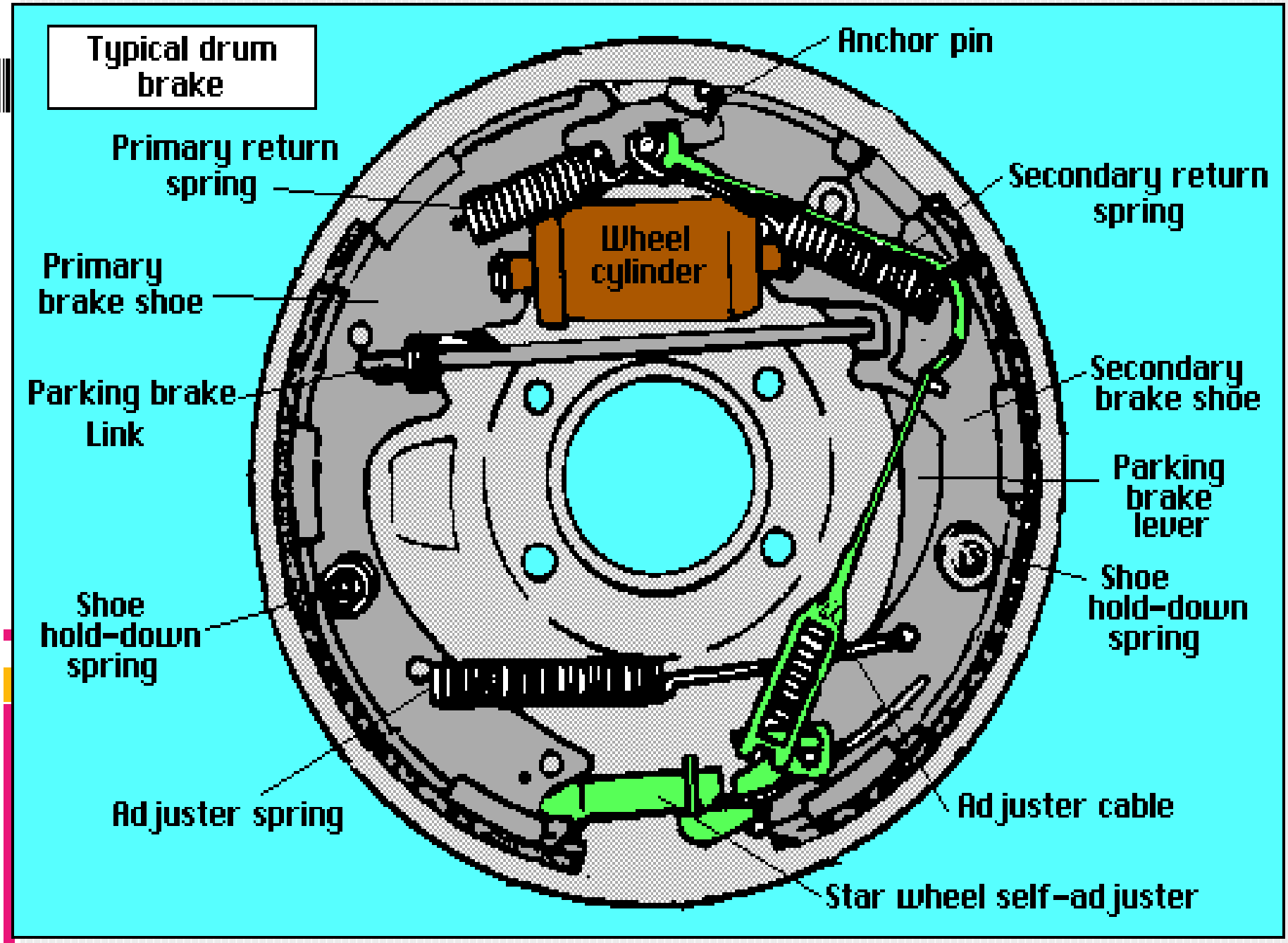
- The principle is that a band is wrapped part round a rotating drum.
- Tension can be applied to the band using a lever.
- The restraining torque results from the difference in tension between the two ends of



DRUM BRAKES

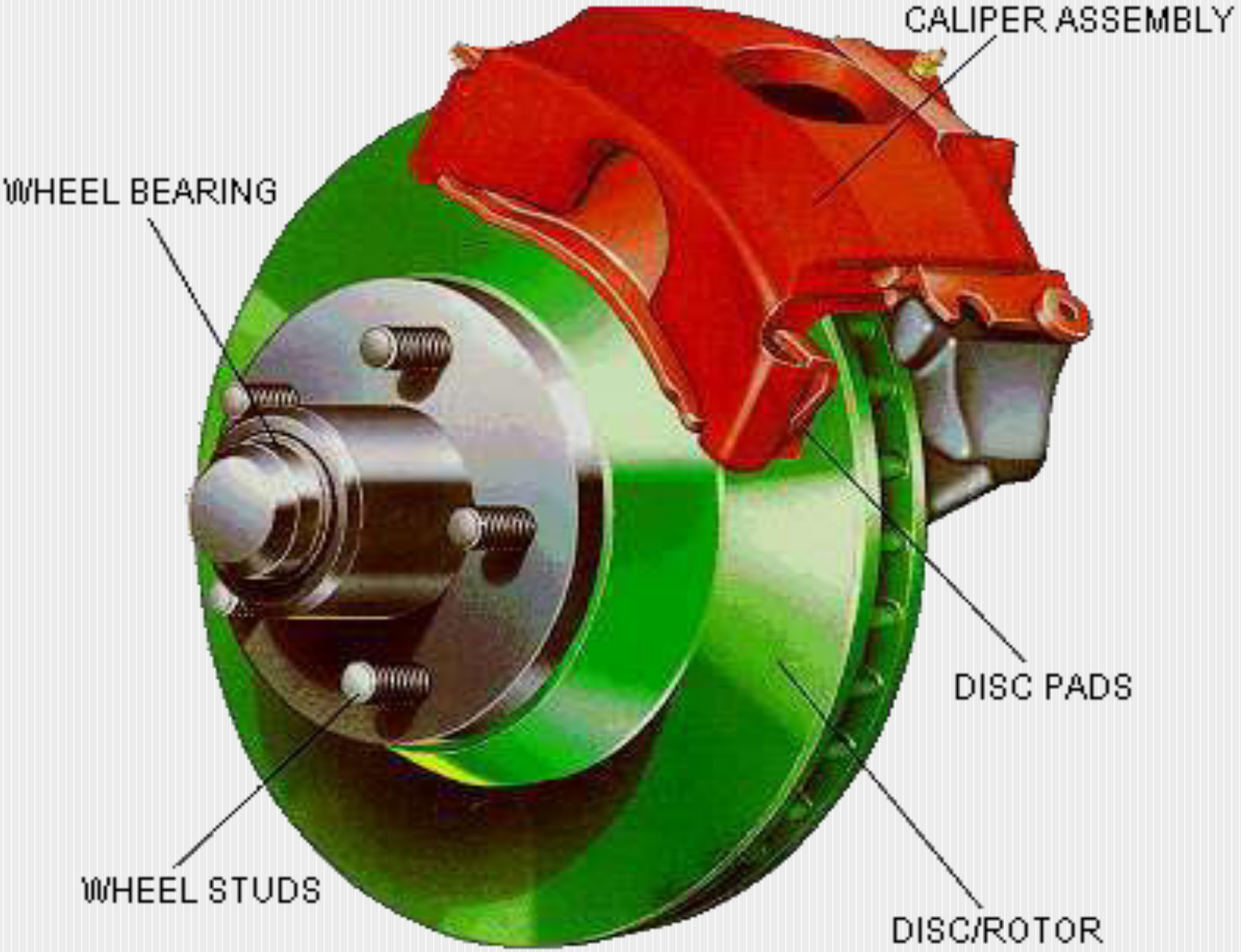
- Shoes press against a spinning surface. In this system, that surface is called a drum.
- Drum brakes have more parts than disc brakes and are harder to service, but they are less expensive to manufacture.
- Drum brake also has an adjuster mechanism, an emergency brake mechanism and lots of springs.
- The shoes are pulled away from the drum by the springs when the brakes are released.

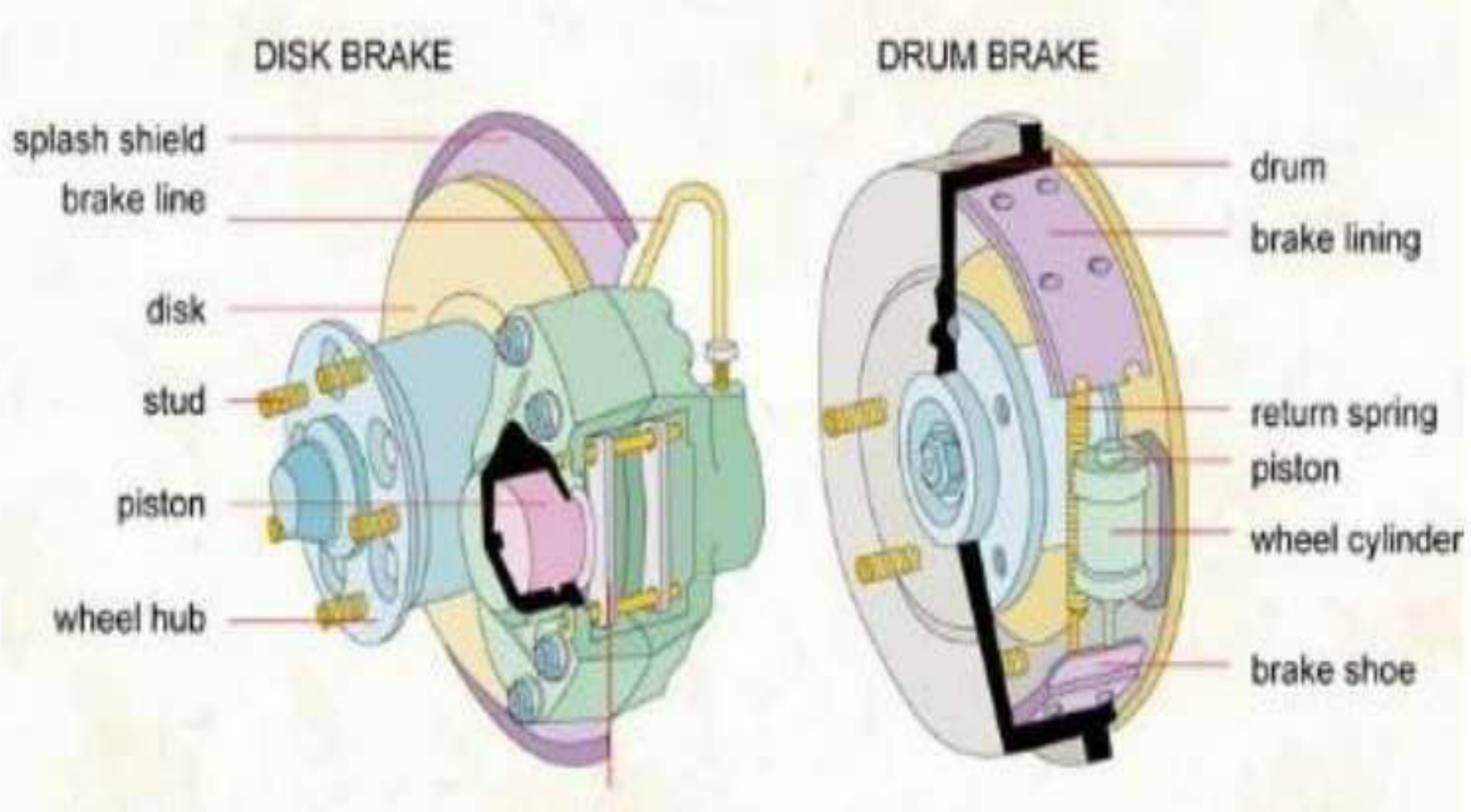

Brake Cylinder
Pistons
Drum
Cable
To Emergency
Brake Lever
Emergency
Brake
Mechanism
Adjuster
Mechanism
Brake Shoes


Typical drum brake
Anchor pin
Primary return spring
Secondary return spring
Wheel cylinder
Primary brake shoe
Secondary brake shoe
Parking brake Link
Parking brake lever
Shoe hold-down spring
Shoe hold-down spring
Adjuster spring
Adjuster cable
Star wheel self-adjuster

DISC BRAKES

- A disc brake consists of a cast iron disc bolted to wheel hub and stationary housing called calliper.
- Calliper is connected to some stationary part of vehical like axle.
- When brakes are applied, piston move friction pads into contact with disc, applying equal and opposite force on disc.
- On releasing brakes, the rubber sealing rings act as return springs and retract piston and friction pads away from disc.


CALIPER ASSEMBLY
WHEEL BEARING
DISC PADS
WHEEL STUDS
DISC/ROTOR

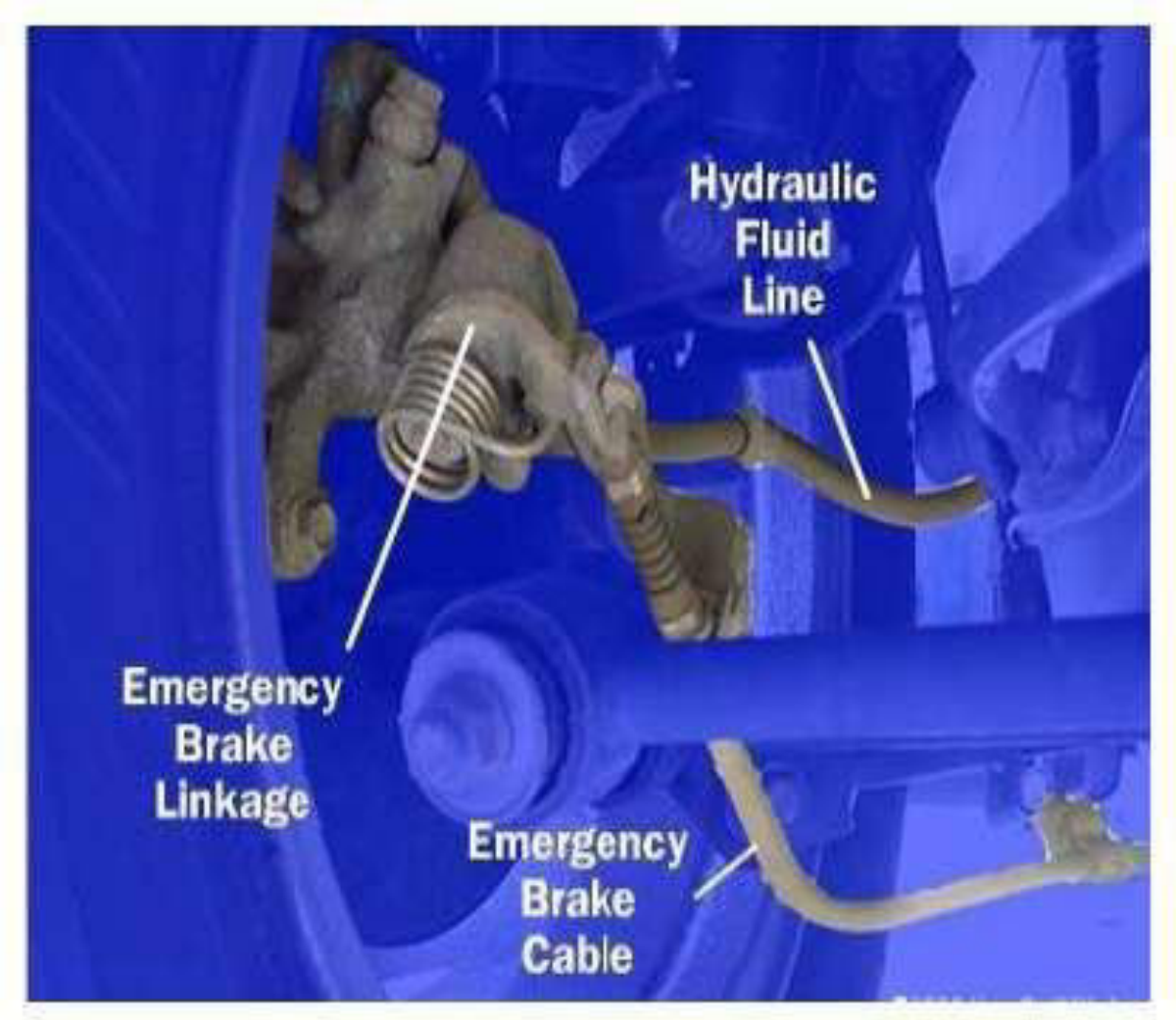

DISK BRAKE
splash shield
brake line
disk
stud
piston
wheel hub
DRUM BRAKE
drum
brake lining
return spring
piston
wheel cylinder
brake shoe

POINTS TO KNOW

- Most modern cars have disc brakes on front wheels and drum brakes on rear wheels and some wheels have disc brakes on all four wheels.
- To increase safety, most modern car brake systems are broken into two circuits, with two wheels on each circuit.
- If a fluid leak occurs in one circuit, only two of the wheels will loose their brakes and the car will still be able to stop when we press the break pedal.

EMERGENCY BRAKES

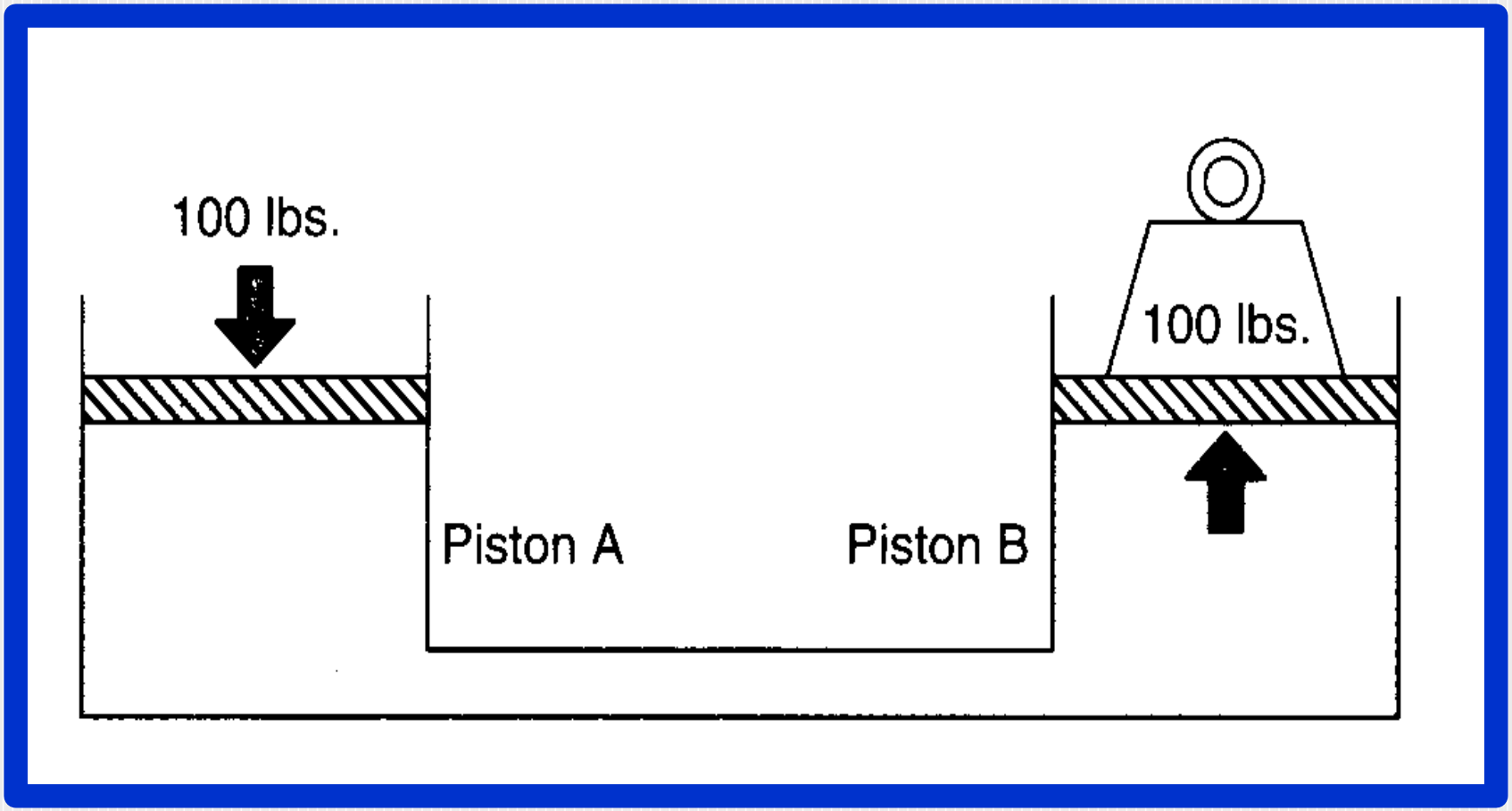
- In cars with disc brakes on all four wheels, an emergency brake has to be actuated by a separate mechanism than the primary brakes in case of a total primary break failure.
- Most cars use a cable to actuate the emergency brake.
- Some cars with four wheel disc breaks have a separate drum brake integrated into the hub of the rear wheels.
- This drum brake is only for emergency break system, an is actuated only by the cable. It has no hydraulics.


Hydraulic
Fluid
Line
Emergency
Brake
Linkage
Emergency
Brake
Cable

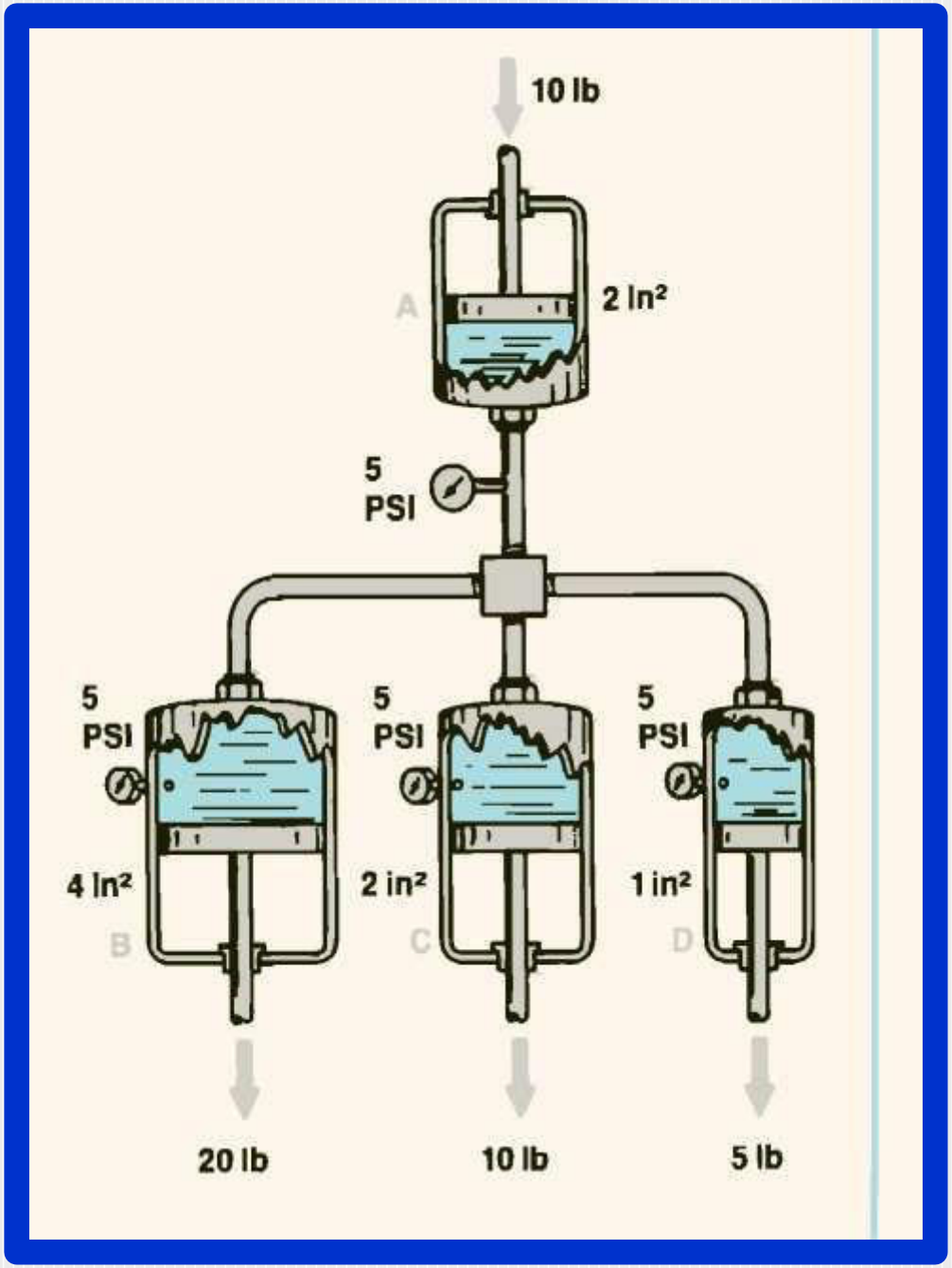
HYDRAULIC BRAKES

- Hydraulics is the use of a liquid under pressure to transfer force or motion, or to increase an applied force.
- The pressure on a liquid is called HYRAULIC PRESSURE.
- And the brakes which are operated by means of hydraulic pressure are called HYDRAULIC BRAKES.
- These brakes are based on the principle of Pascal's law

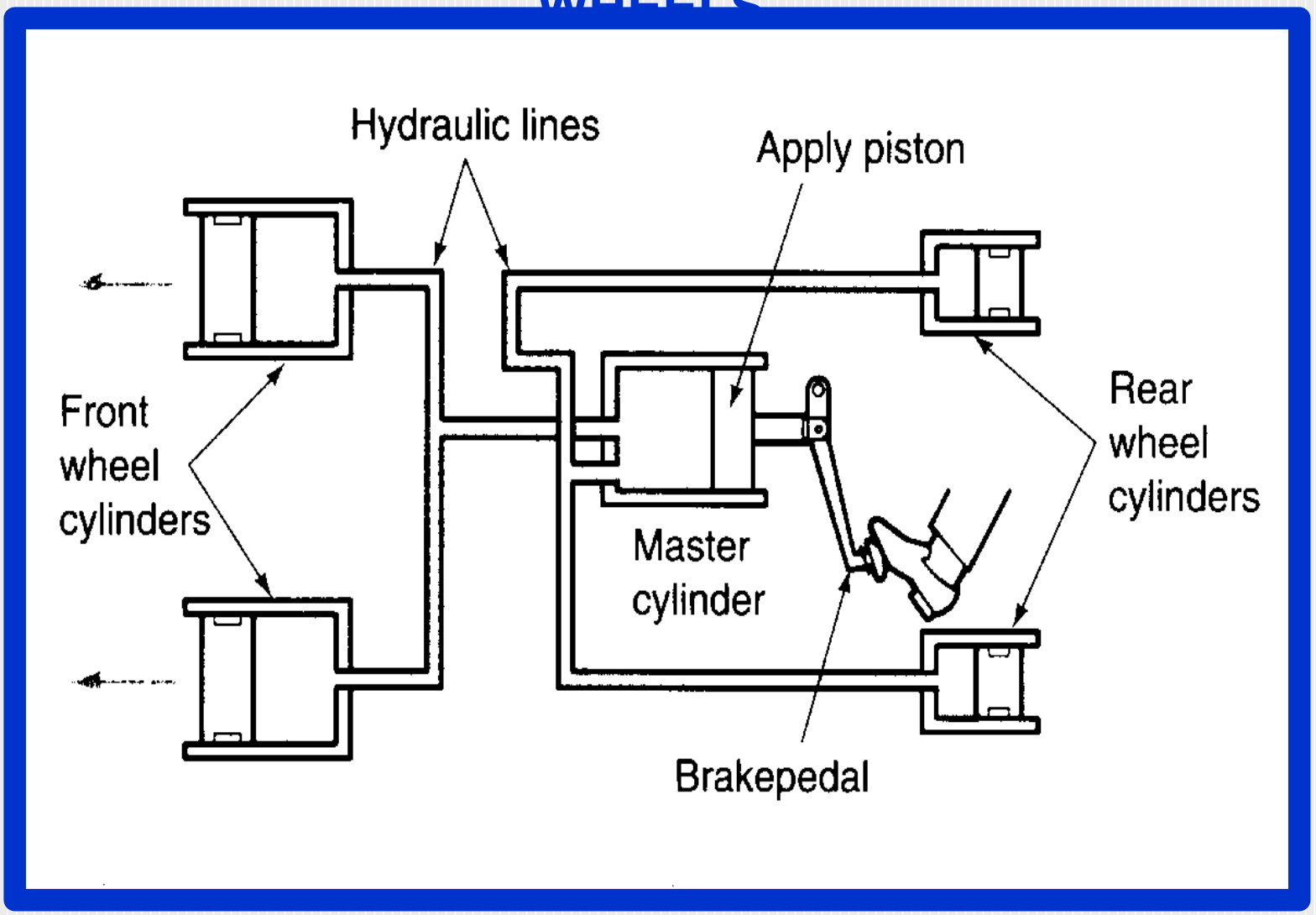
HYDRAULIC PRESSURE IS DISTRIBUTED EQUALLY IN ALL DIRECTIONS



The applied pressure can be raised or lowered by piston size



SAME LINE OF PRESSURE WILL BE EXERTED ON ALL WHEELS



HYRAULIC BRAKING SYSTEM CAN BE OPERATED BY

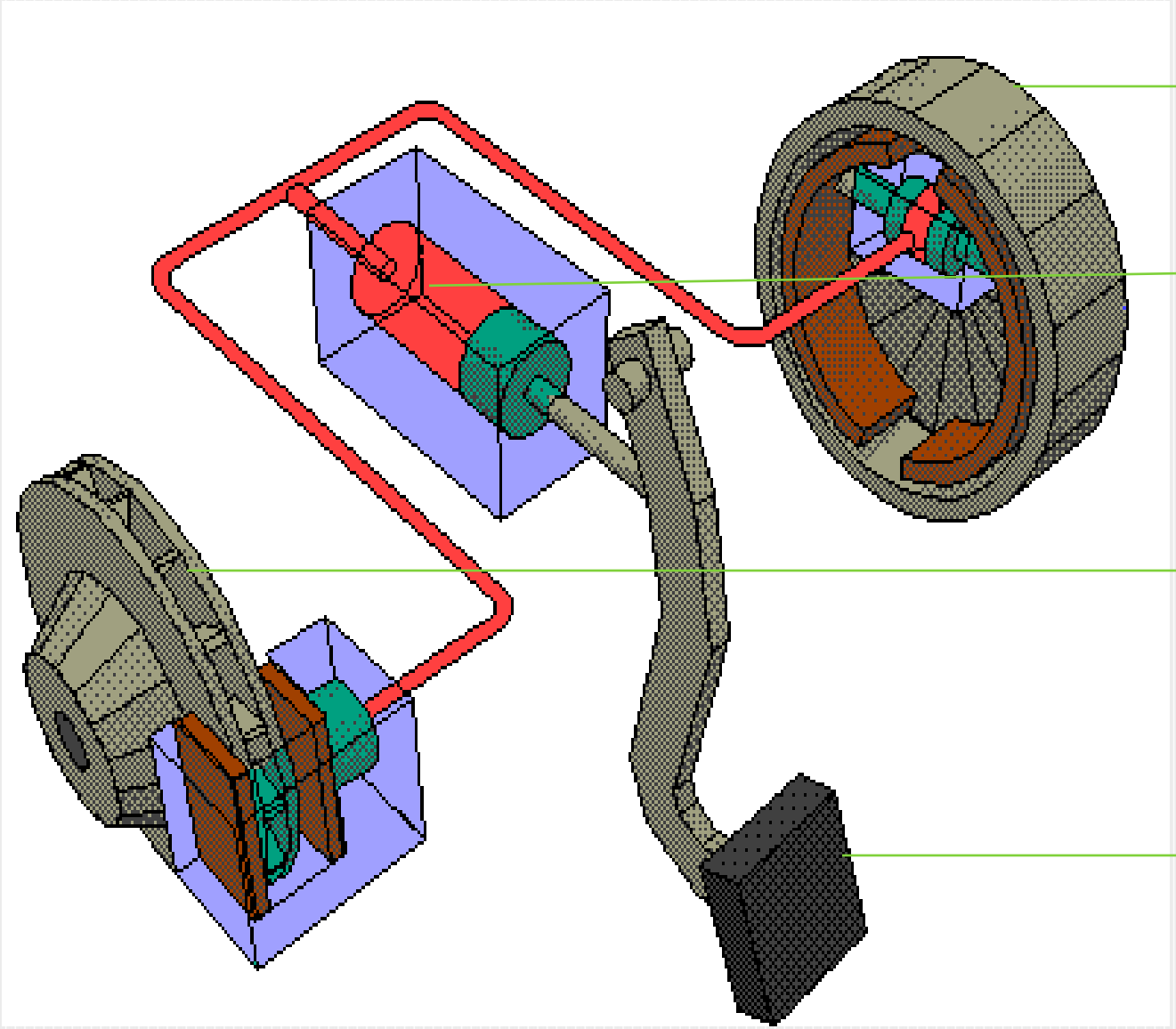
- Vacuum, Hydro or Motor assisted
- Disc System
- Drum System
- Dual System

HYDRAULLIC BRAKES PARTS

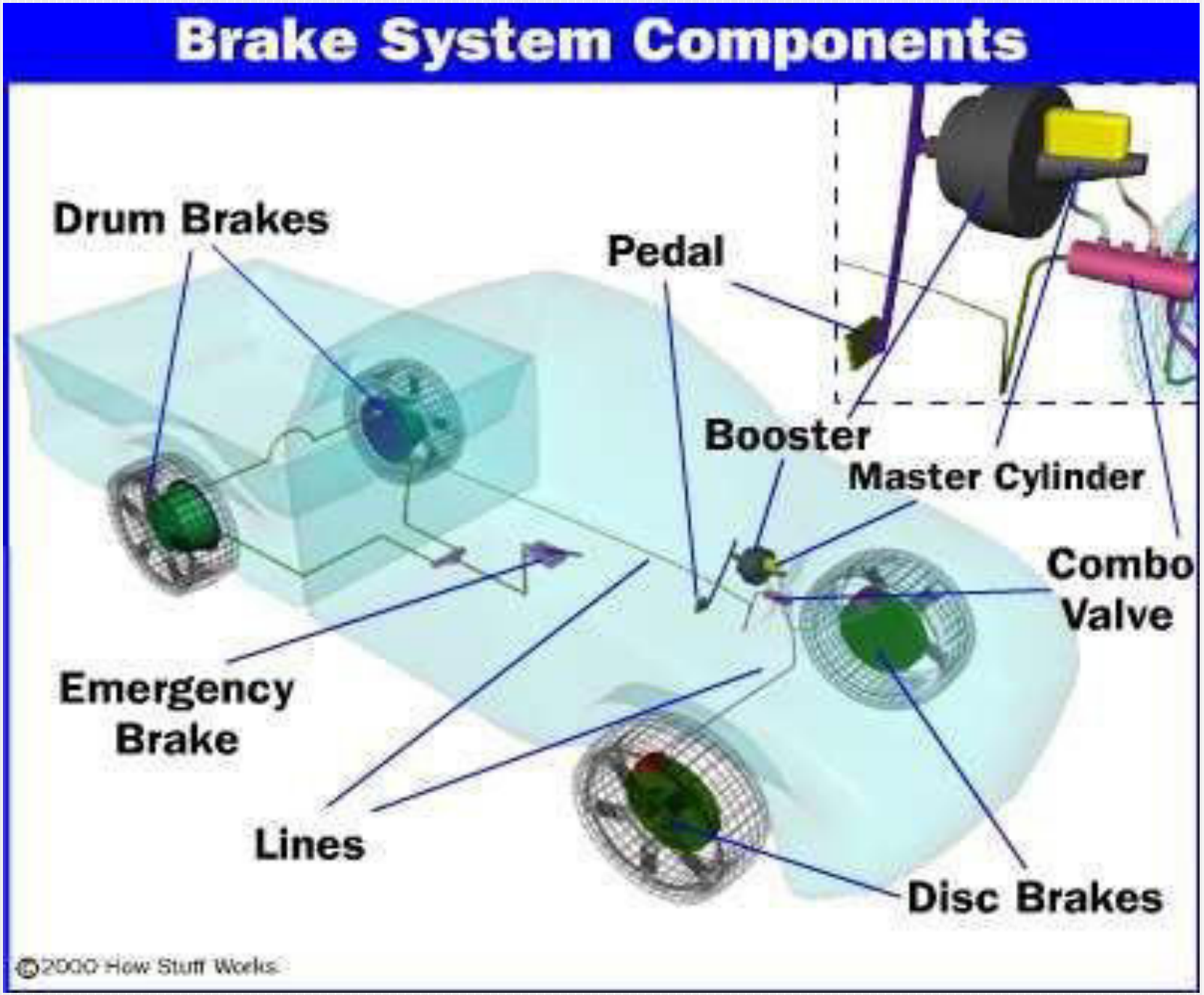
Parts of hydaullic brakes:-

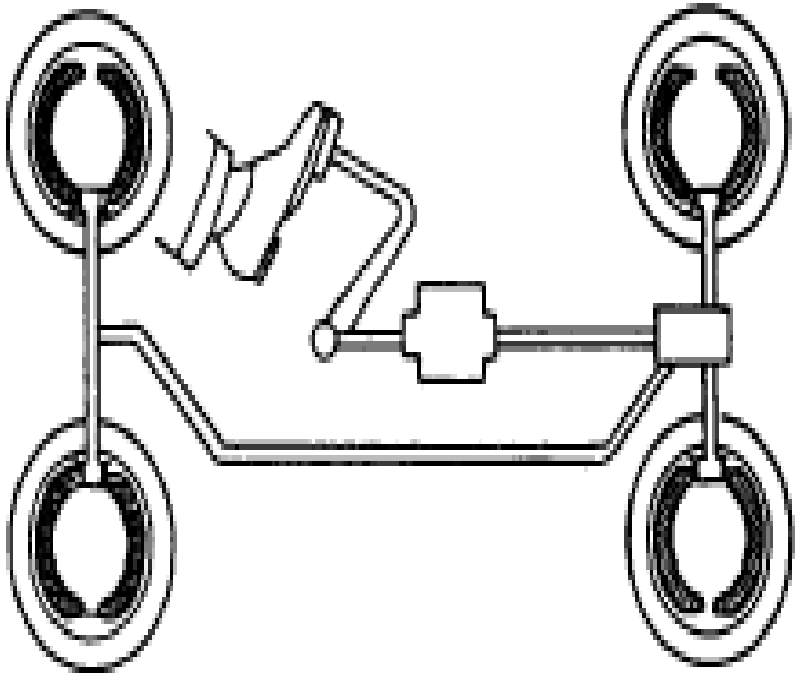
- Brake Pedal
- Push rod
- Master cylinder assembly
- Brake calliper assembly

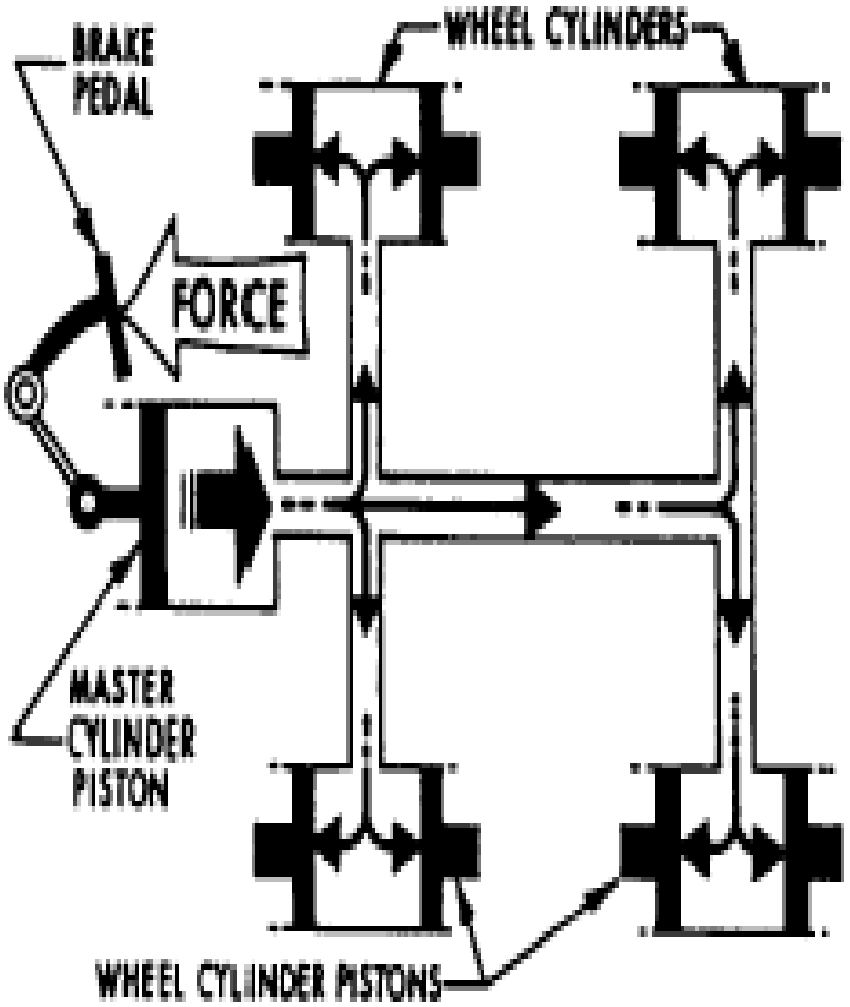
Hydraulic Braking System

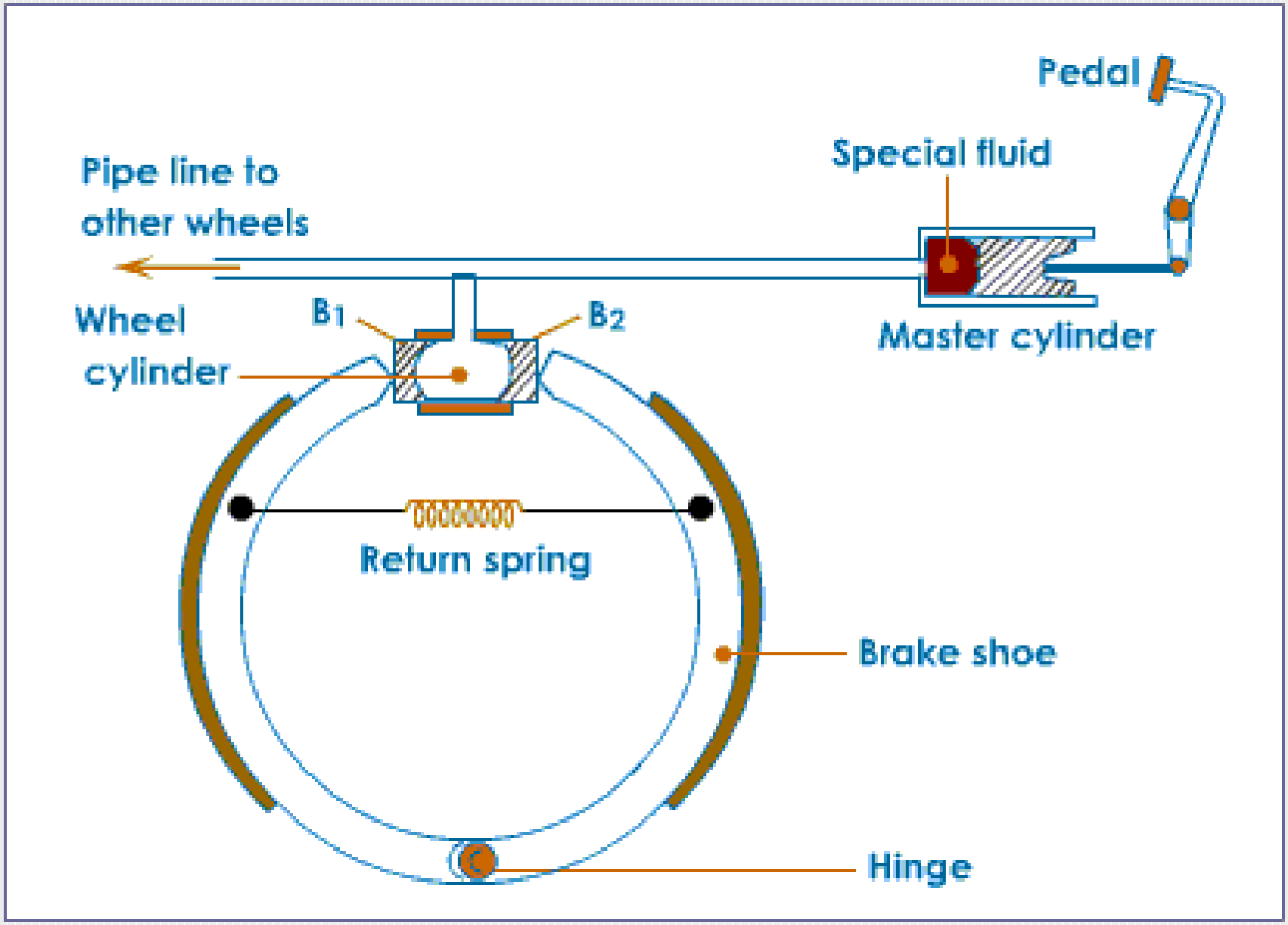


Brake System Components






BRAKE PEDAL
WHEEL CYLINDERS
FORCE
MASTER CYLINDER PISTON
WHEEL CYLINDER PISTONS


Pedal
Special fluid
Pipe line to
other wheels
Wheel
cylinder
B1
B2
Master cylinder
Return spring
Brake shoe
Hinge

MASTER CYLINDER

- Provides a reservoir for brake fluid and contains the driving pistons in the hydraulic circuit. There are two types of master cylinder

- Front - Rear split

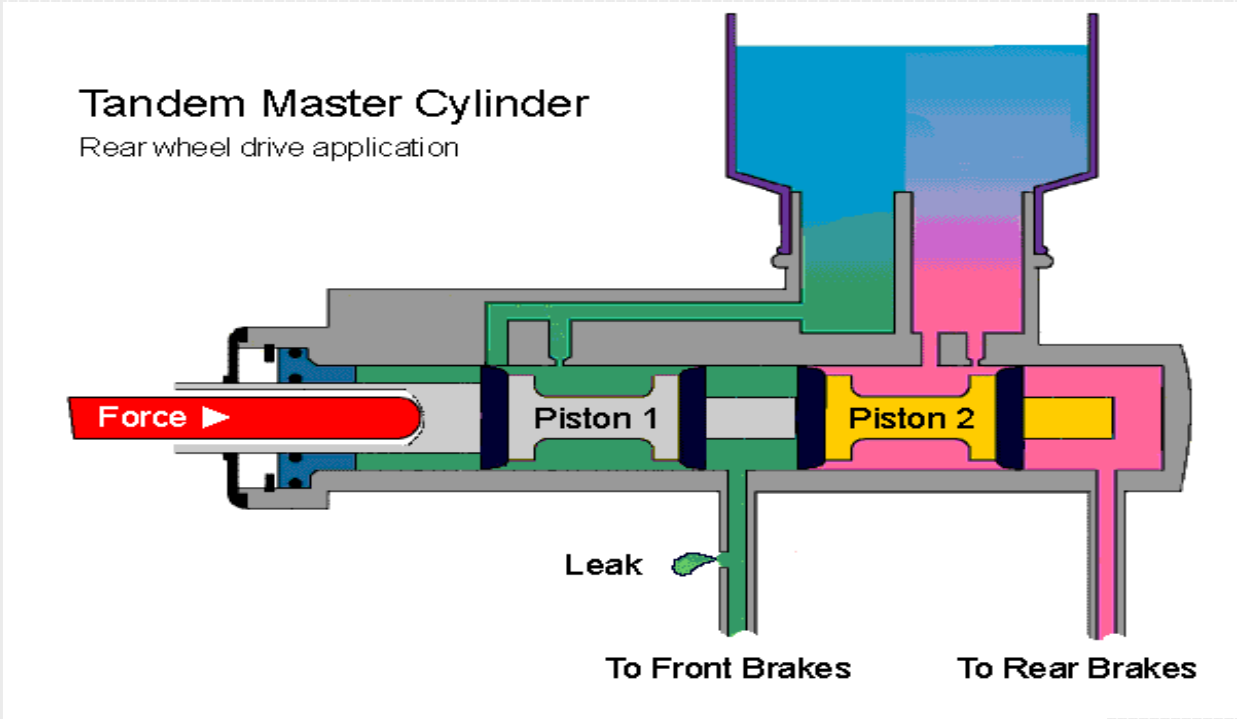
-One piston for front brakes and one for rear

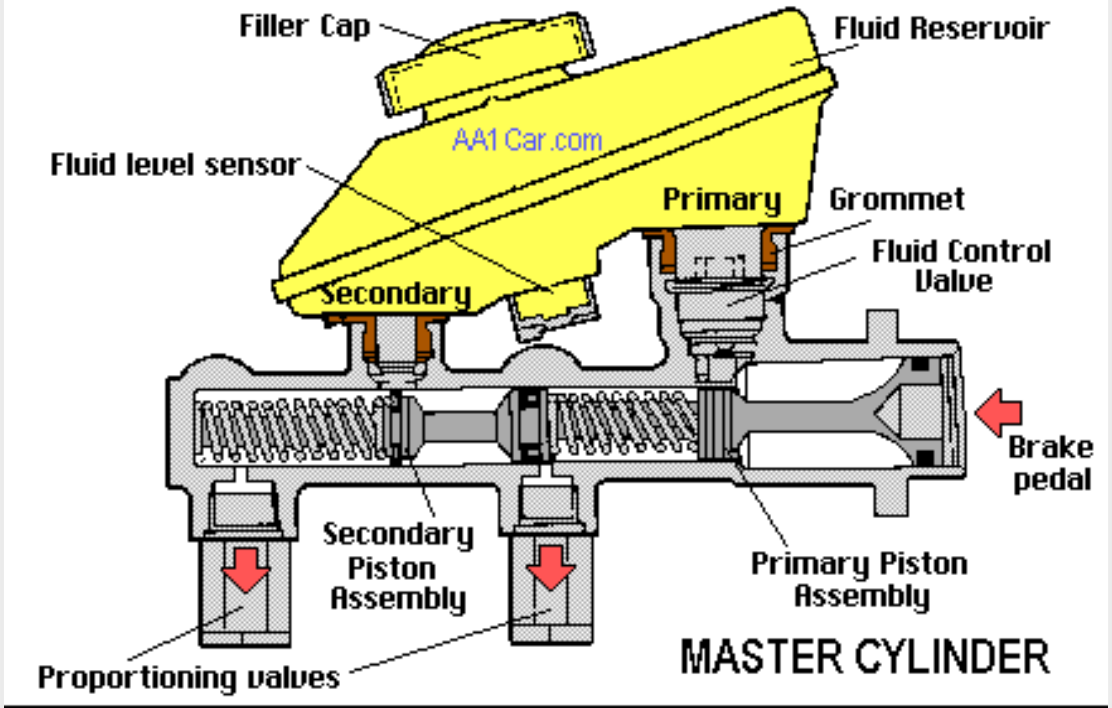
-If a leak occurs you could lose front brakes

- Diagonally split

-One piston drives one front wheel and one rear wheel

-Diagonal layout allows you to maintain directional control if a leak occurs


Tandem Master Cylinder
Rear wheel drive application
Force
Piston 1
Piston 2
Leak
To Front Brakes
To Rear Brakes


Filler Cap
Fluid Reservoir
AA1Car.com
Fluid level sensor
Primary
Grommet
Fluid Control Valve
Secondary
Brake pedal
Secondary Piston Assembly
Primary Piston Assembly
Proportioning valves
MASTER CYLINDER

AIR BRAKE SYSTEM

- Brakes applied with the help of air are called Air Brakes and the system actuated to apply this phenomenon is known as Air Brake System.
- The operation of air brake is similar to hydraulic brakes except that air is used to apply pressure.
- Air brakes are commonly used in heavy vehicles, trucks, buses etc.

COMPONENTS OF AIR BRAKE SYSTEM

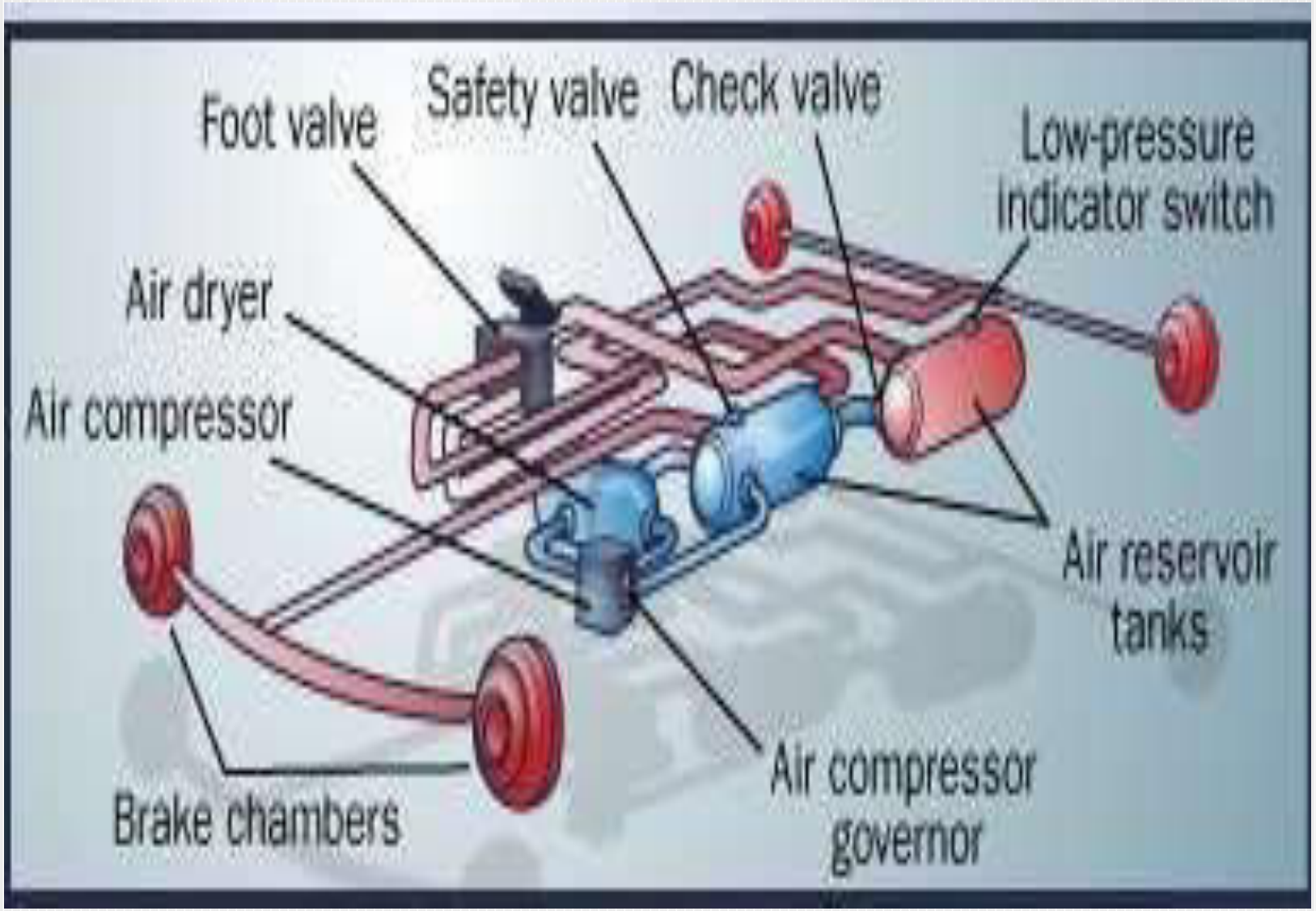
- AIR COMPRESOR - To supply pressurised air which is driven by engine.
- UNLOADER VALVE - It is device maintain constant pressure in reservoir.the excess of pressure is safely removed.
- RESERVOIR - It's a tank in which high pressure air is stored
- RELAY VALVE - It is valve kept in between brake chamber & air chamber for controlling the air chamber

- **BRAKE VALVE - Its is located between air reservoir and brake cylinder. It is used to control the intensity of braking.**

  If the applied force by linkage on piston is less than the air pressure then the valve is closed. Hence no brkaing

  - **HAND CONTROL VALVE - It is used in trucks to control the actuator and the spring brakes simultaneously during secondary brake application and spring brakes only during parking.**

- **SLACK ADJUSTER - It acts as a lever during braking. It is also used to adjust the clearance between the brake shoe and the drum for which it**


Foot valve
Safety valve
Check valve
Low-pressure indicator switch
Air dryer
Air compressor
Air reservoir tanks
Brake chambers
Air compressor governor

ADVANTAGES

- More powerful than mechanical and hydraulic brakes.
- Simple to employ in vehicles since it is doesnot require much change in chassis.
- Apart from braking the compressed air can be used for operating accessories (horn, windscreen wiper, tyre inflation, etc.)

LIMITATION

- The drawback is that it involves more parts and consumes power from engine.

ANTI-LOCK BRAKING SYSTEM (ABS)

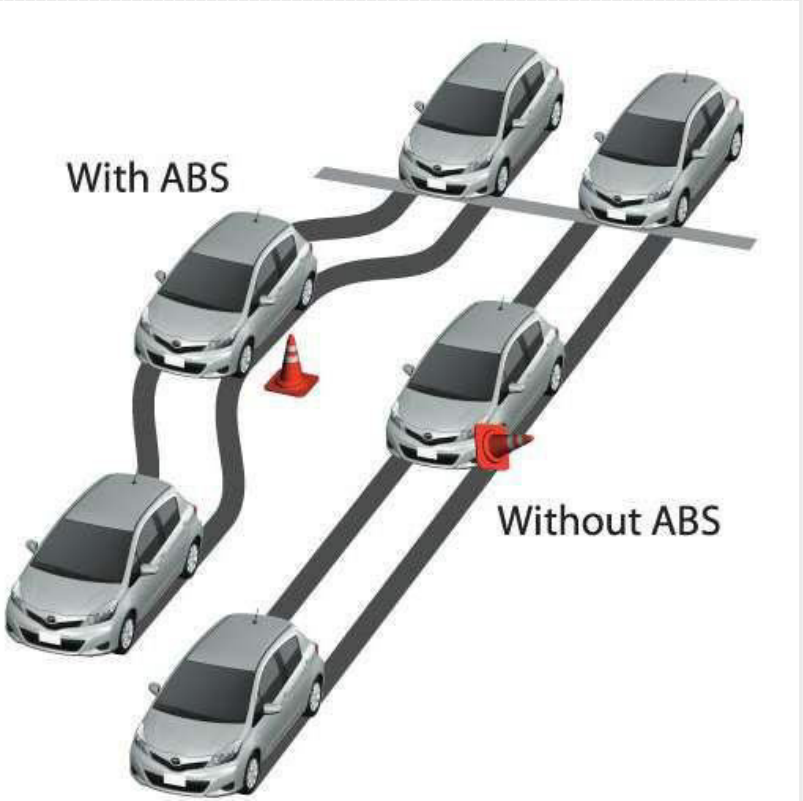
INTRODUCTION

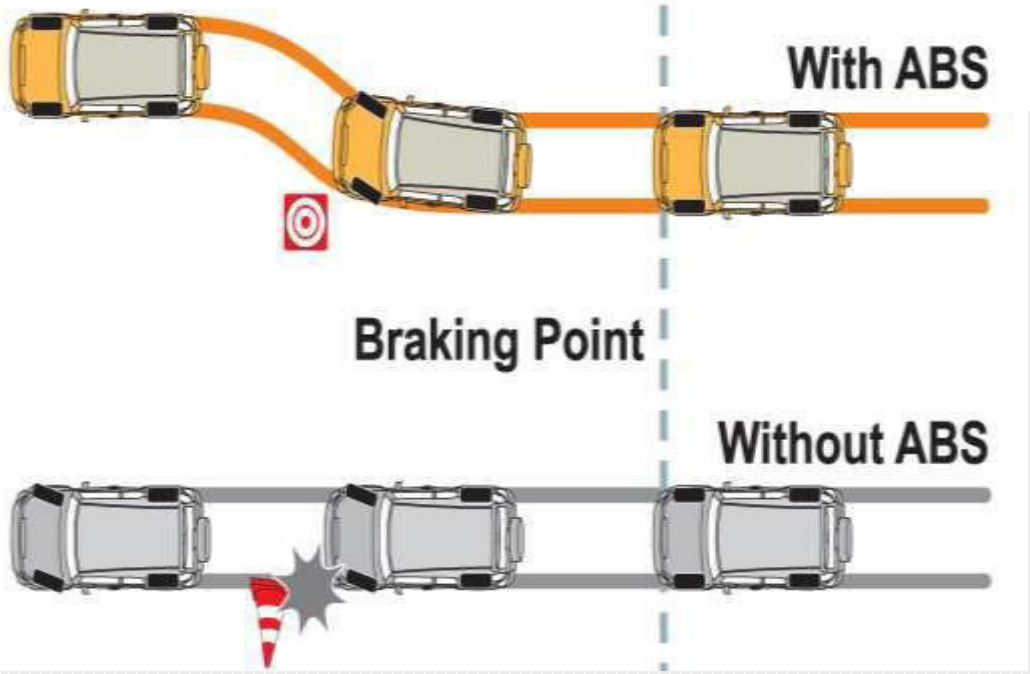
- Antilock braking systems (ABSs) are electronic systems that monitor and control wheel slip during vehicle braking.
- ABSs can improve vehicle control during braking, and reduce stopping distances on slippery road surfaces by limiting wheel slip and minimizing lockup.
- Reducing wheel slip improves vehicle stability and control during braking, since stability increases as wheel slip decreases.

PRNCIPLES OF ABS

- The skidding and loss of control was caused by the locking of wheels.
- The release and reapply of the brake pedal will avoid the locking of the wheels which in turn avoid the skidding.
- This is exactly what an antilock braking system does.

COMPAR





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

PRESSURE MODULATION

- When the brake pedal is pumped or pulsed the pressure is quickly applied and released at the wheels. This is called pressure modulation. Pressure modulation works to prevent the wheel locking.

- ABS can modulate the pressure to the brake as often as 15 times per seconds.

- ABS precisely controls the slip rate of the wheels to ensure maximum grip force from the tire and it there by ensures maneuverability and stability of the vehicle.

ABS COMPONENTS

HYDRAULIC COMPONENTS

1.Accumulator:-

- An accumulator is used to store hydraulic fluid

to maintain high pressure in the brake system.

2.Antilock hydraulic control valve assembly :-

- This assembly controls the release and application of the brake system pressure to the wheel brake assemblies .

3.Booster pump:-

- The booster pump is used to provide pressurized hydraulic fluid to ABS.

4.Booster/Master cylinder assembly:-

- It is needed to modulate hydraulic pressure in the wheel circuit during the ABS operations.

5.Fluid accumulator:-

- accumulator temporarily stored brake fluid that is removed from the wheel brake unit during ABS cycle.

6.Hydraulic control unit:-

- The unit may have one pump and one motor or it have one motor and two pumps.

ELECTRICAL/ELECTRONIC COMPONENTS

1.ABS control module:-

- It monitors system and controls operation antilock function when needed.

2.Brake pedal sensor:-

- Its function is to switch on the brake lights to alert other vehicles that the car is slowing down and/or is going to stop.

3.Wheel speed sensor:-

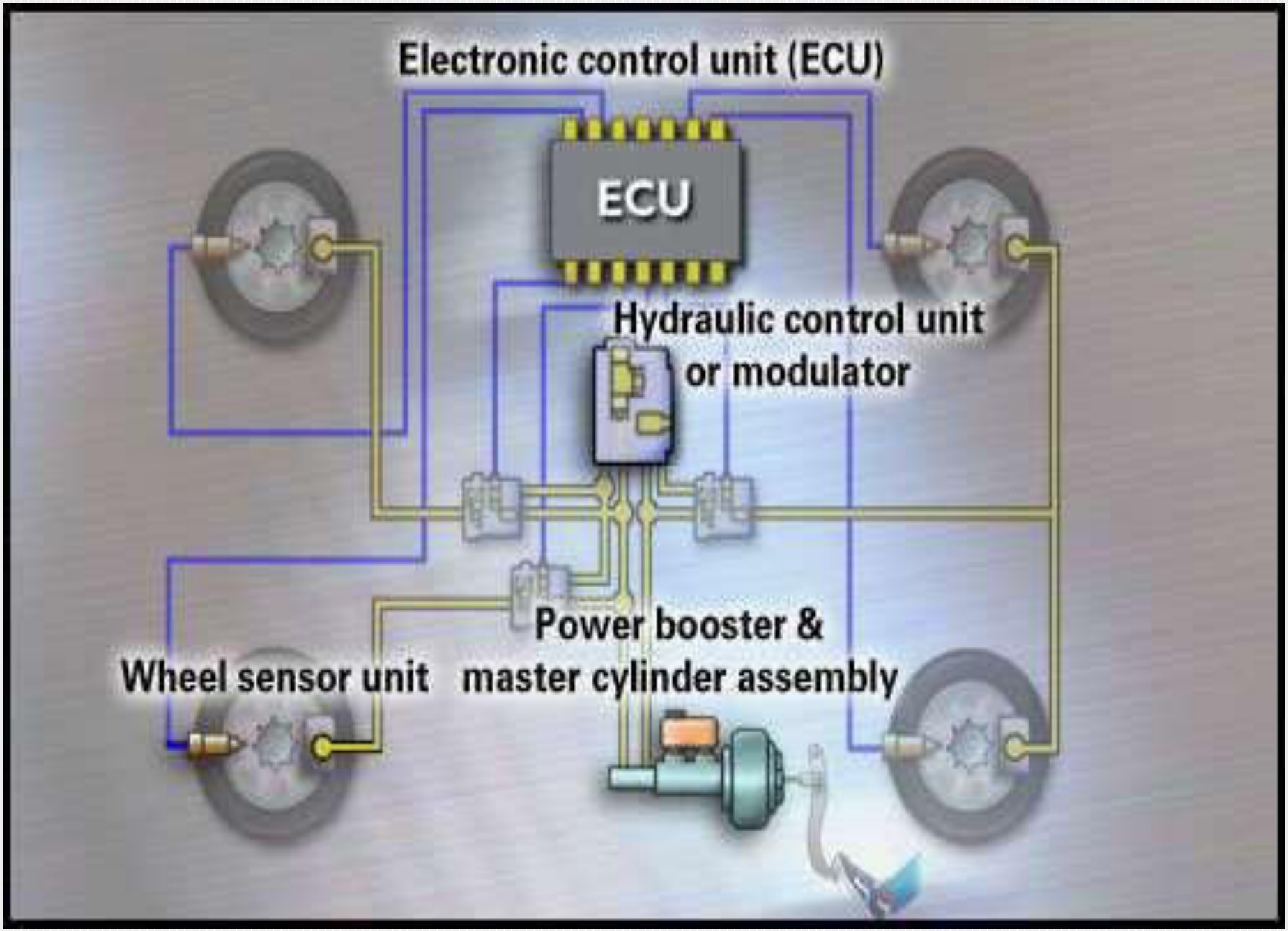
- These are generally used for sensing the wheel speed.

TYPES OF ANTI-LOCK BRAKING SYSTEM

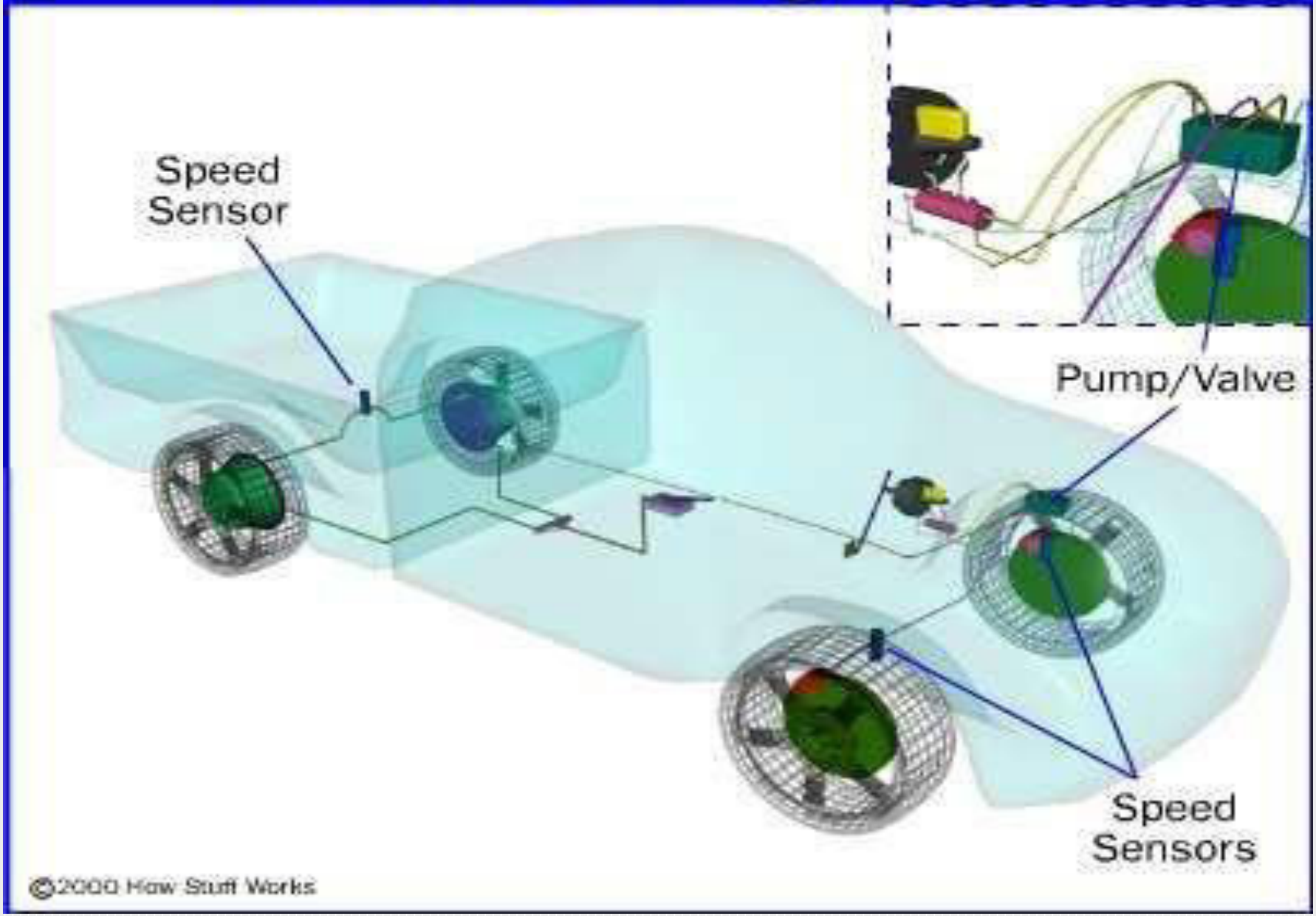
- Four channel, four sensor ABS:- This is the best scheme, there is speed sensor on all four wheels and a separate valve for all the four wheels.

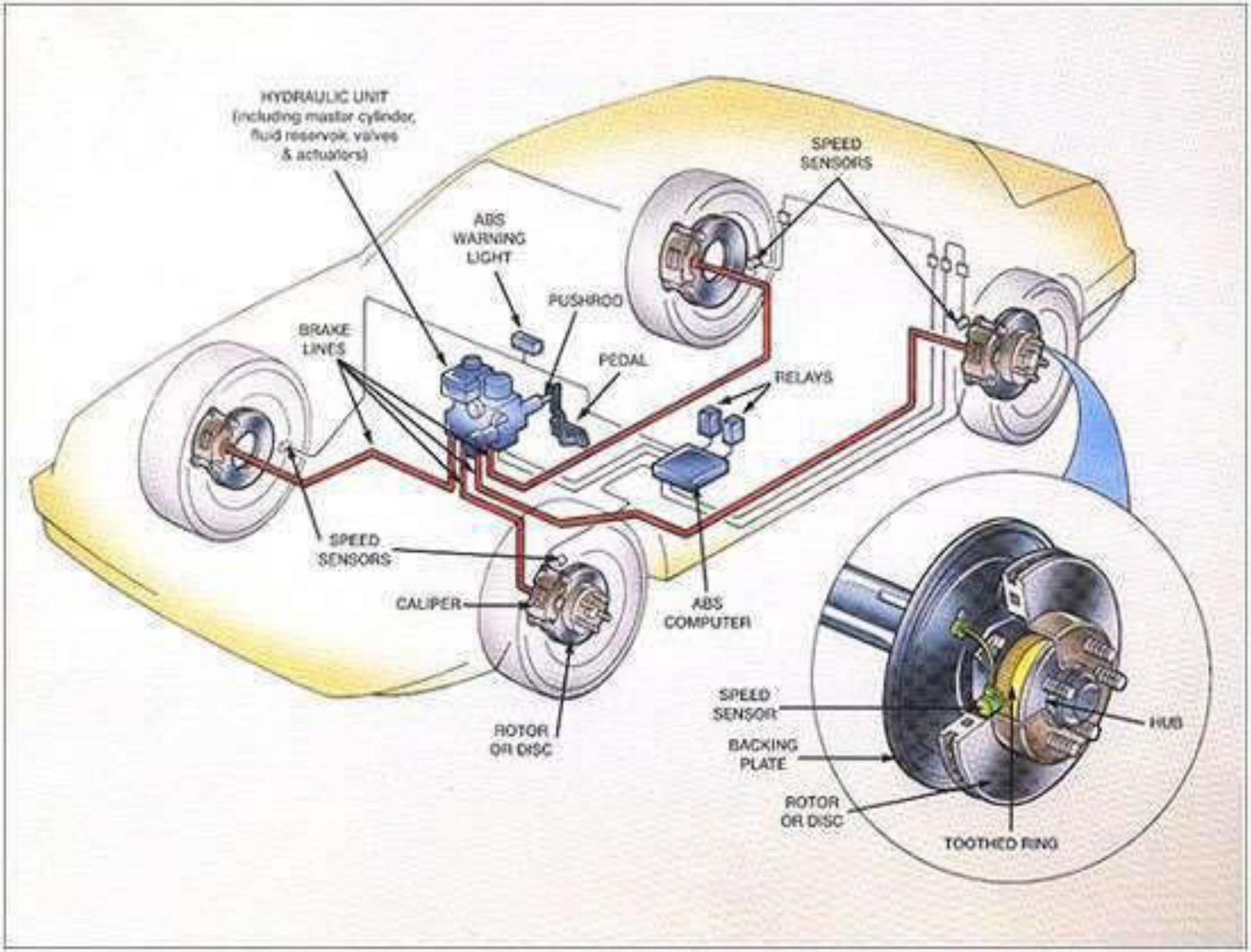
- Three channel , three sensor ABS:- This scheme is commonly found on pick up trucks with four wheels ABS, has a speed sensor and a valve for each of the front wheels, with one valve and one sensor for both rear wheels.

- One channel , one sensor ABS:- it has one valve ,which controls both rear wheels , and one speed sensor, located in the rear axle.


Electronic control unit (ECU)
ECU
Hydraulic control unit
or modulator
Power booster &
master cylinder assembly
Wheel sensor unit

Anti-Lock Braking System




HYDRAULIC UNIT
(including master cylinder,
fluid reservoir, valves
& actuators)
ABS
WARNING
LIGHT
PUSHROD
BRAKE
LINES
PEDAL
SPEED
SENSORS
RELAYS
SPEED
SENSORS
CALIPER
ABS
COMPUTER
ROTOR
OR DISC
SPEED
SENSOR
HUB
BACKING
PLATE
ROTOR
OR DISC
TOOTHED RING

FEATURES AND BENEFITS OF ABS

Features

- Control of steering
- Fail-safe electrical/electronic system
- Traction control
- ABS Malfunction Indicator Lamp

Benefits

- Increases steering ability and vehicle stability during braking
- If the electrical/electronic system fails, the ABS is shut off
- It is an optional feature that controls excessive wheel spin during acceleration
- Informs the driver or technician that an ABS fault has occured

ATOMATIC TRACTION CONTROL

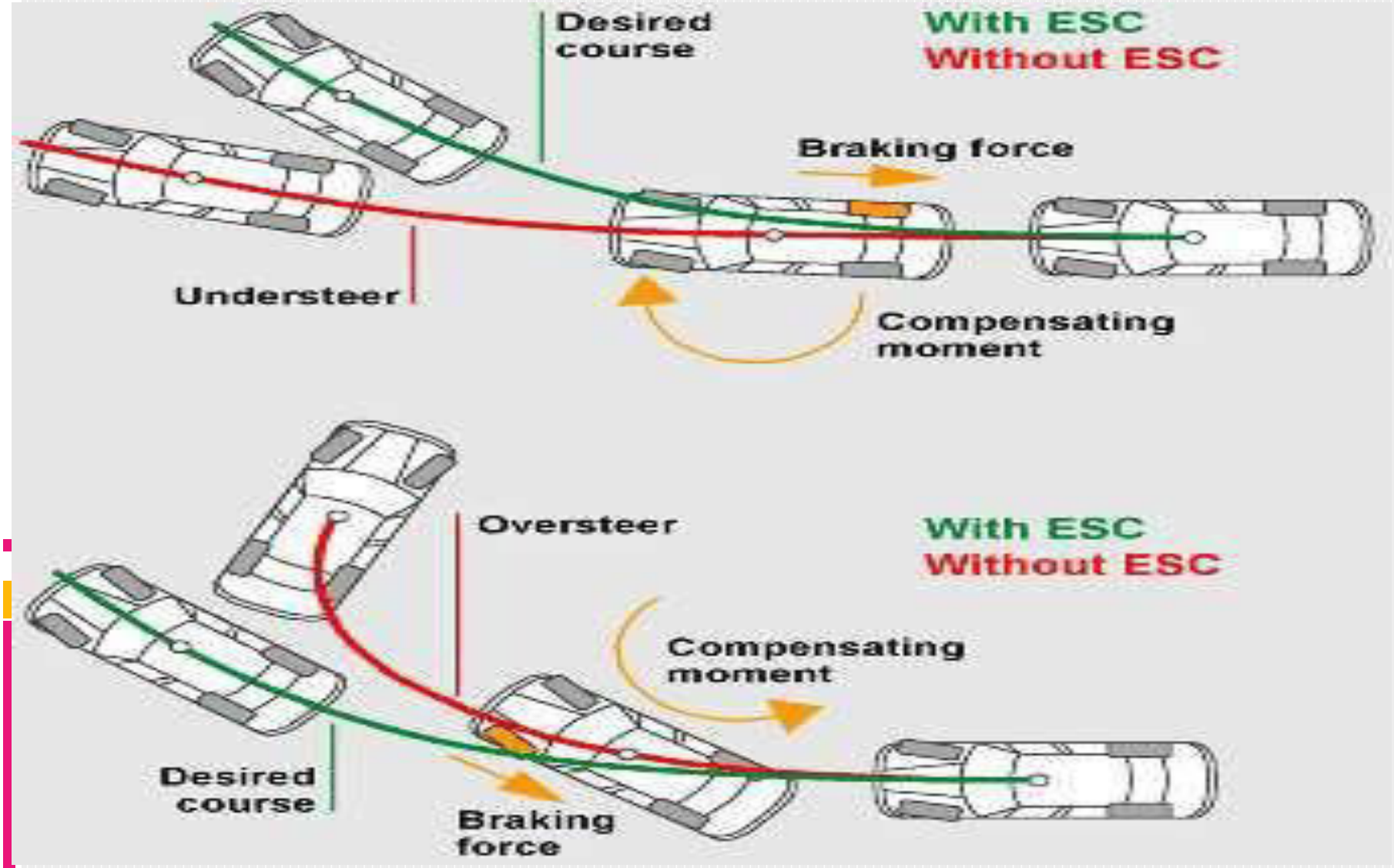
- Automatic traction control systems apply the brakes when a drive wheel attempts to spin and lose traction.
- The system works best when one drive wheel is working on a good traction surface and the other is not.
- The system also works well when the vehicle is accelerating on slippery road surfaces, especially when climbing hills

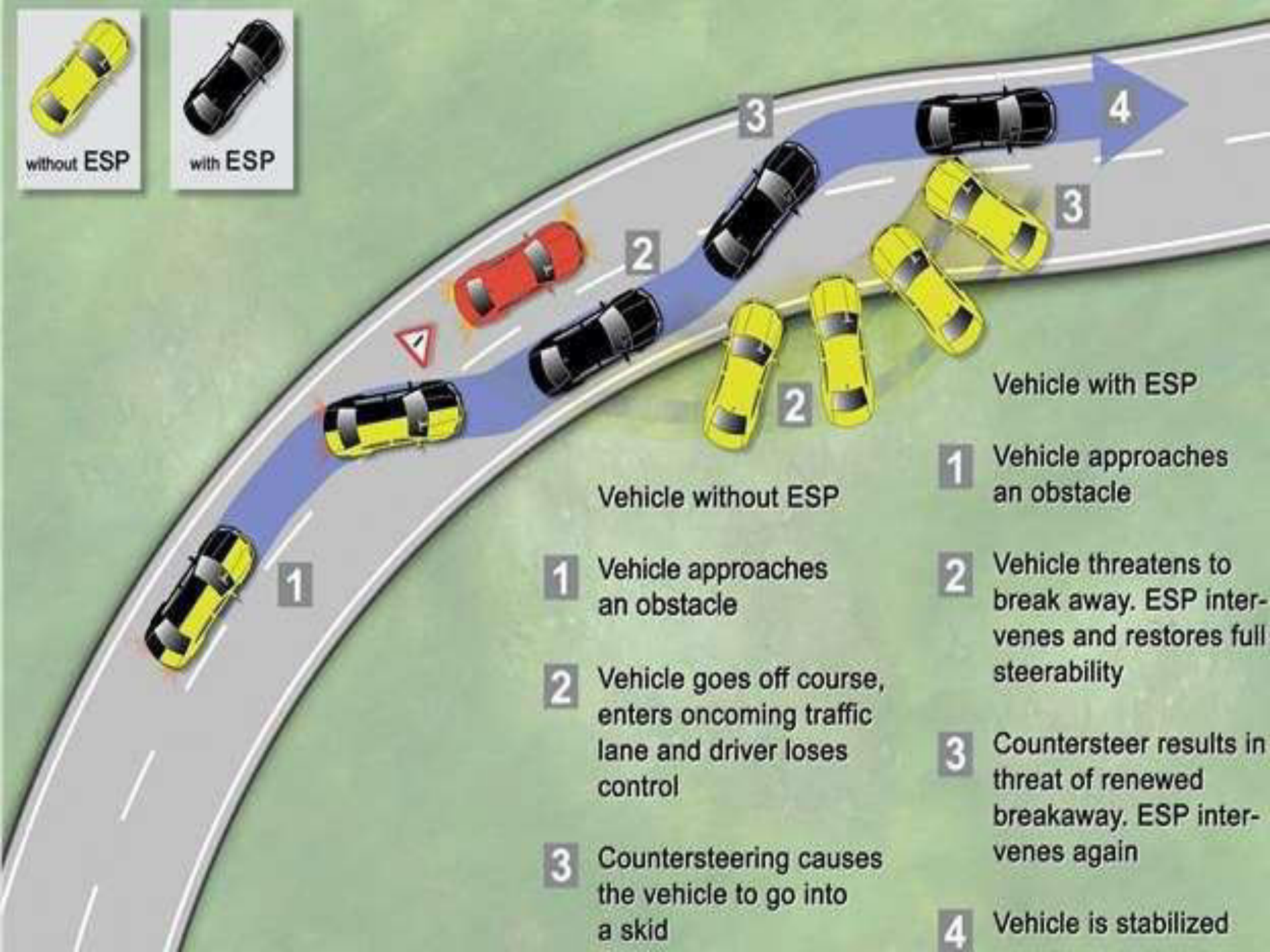
ATOMATIC STABILITY CONTROL

- Stability control systems momentarily apply the brakes at any one wheel to correct over steer or under steer.

- The control unit receives signals from the typical sensors plus a yaw, lateral acceleration (G-force) and a steering angle sensor

ELECTRONIC STABILITY CONTROL (ESC)





Vehicle without ESP

1 Vehicle approaches an obstacle

2 Vehicle goes off course, enters oncoming traffic lane and driver loses control

3 Countersteering causes the vehicle to go into a skid

Vehicle with ESP

1 Vehicle approaches an obstacle

2 Vehicle threatens to break away. ESP intervenes and restores full steerability

3 Countersteer results in threat of renewed breakaway. ESP intervenes again

4 Vehicle is stabilized

ADVANTAGES

- It allows the driver to maintain directional stability and control over steering during braking
- Safe and effective
- Automatically changes the brake fluid pressure at each wheel to maintain optimum brake performance.
- ABS absorbs the unwanted turbulence shock waves and modulates the pulses thus permitting the wheel to continue turning under maximum braking pressure

DISADVANTAGES

- It is very costly.
- Maintenance cost of a car equipped with ABS is more.

TRACTION CONTROL SYSTEM

- Traction control applies the brakes momentarily to one of the drive wheels when the wheel speed sensors indicates a wheel is rotating faster than the other during acceleration

- But in ABS the brake is released when wheel is locked to avoid skidding.

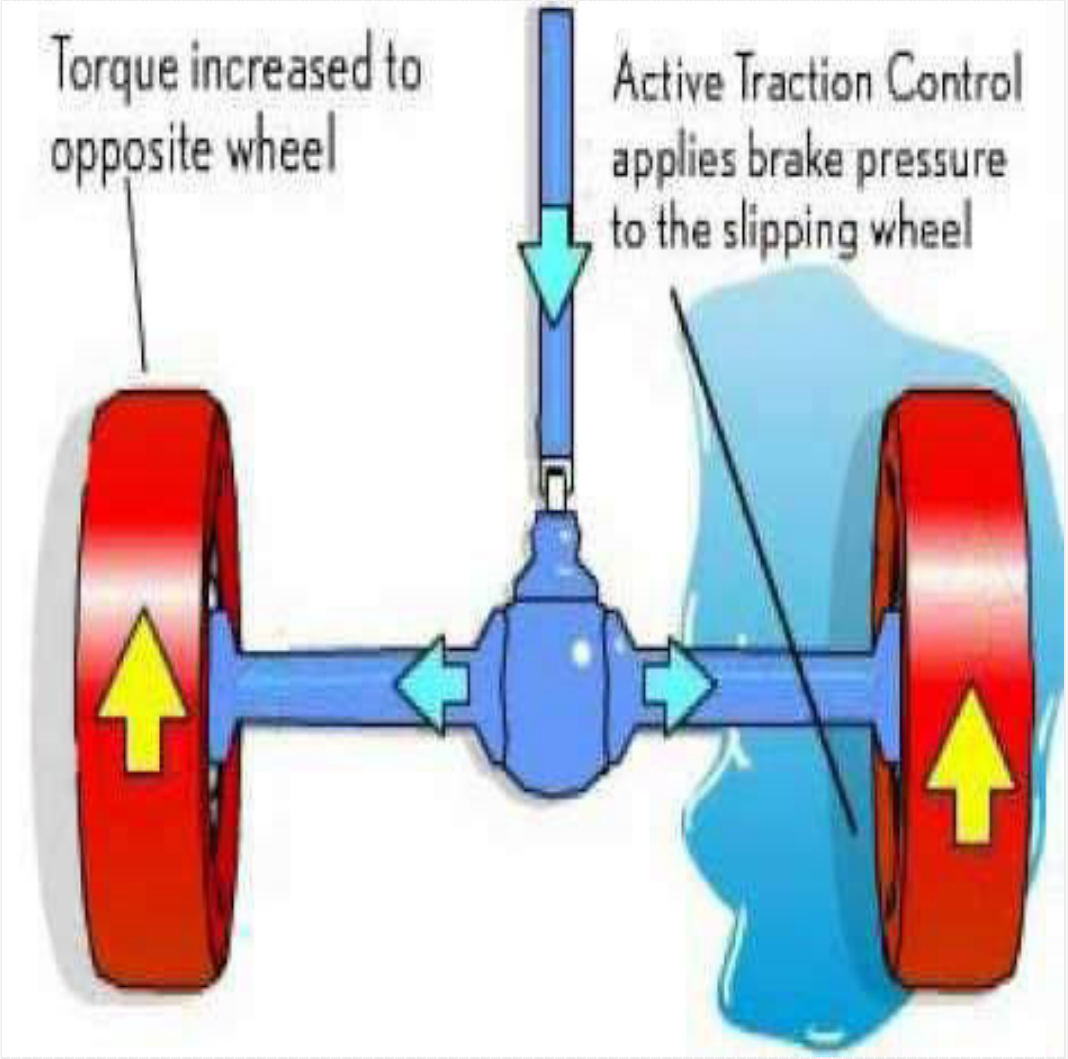
Traction control overview

Traction control basically reduces the slip of the tires on icy surfaces when the car begins to accelerate

It is designed to prevent loos of traction of driven road wheels

It comes into action when throttle input and engine torque are mismatched to road surface conditions

When traction control comes into action



WORKING OF TRACTION CONTROL SYSTEM

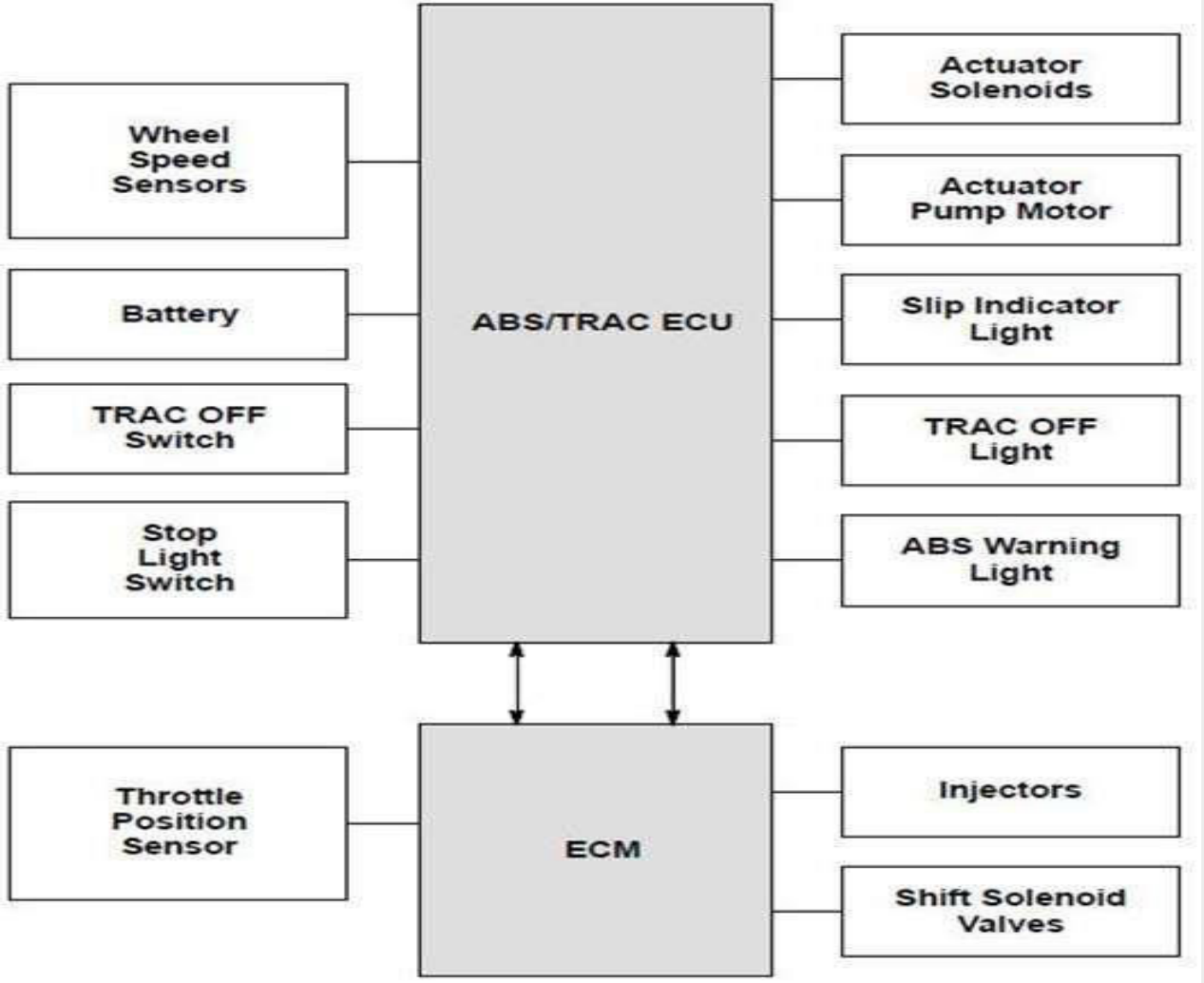
- The sensors picks an indication as the wheel begins to slip, the engine power to the affected wheel is automatically reduced

- This helps the wheel once again have traction with a possibility of initiating the braking system to help the wheel starting to slip

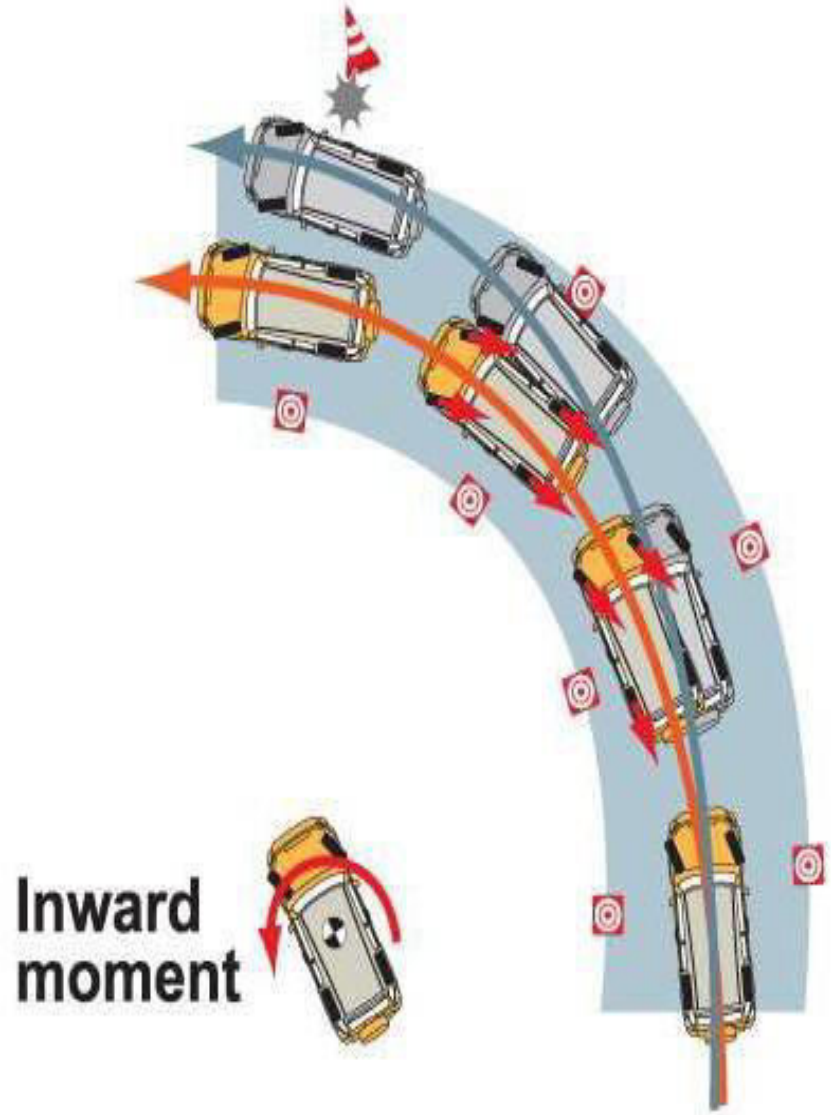
- Power from the engine goes to the other wheel activating transfer of power and brake to prevent wheel spin restricting serious accidents from happening.

BLOCK DIAGRAM OF TRAC:

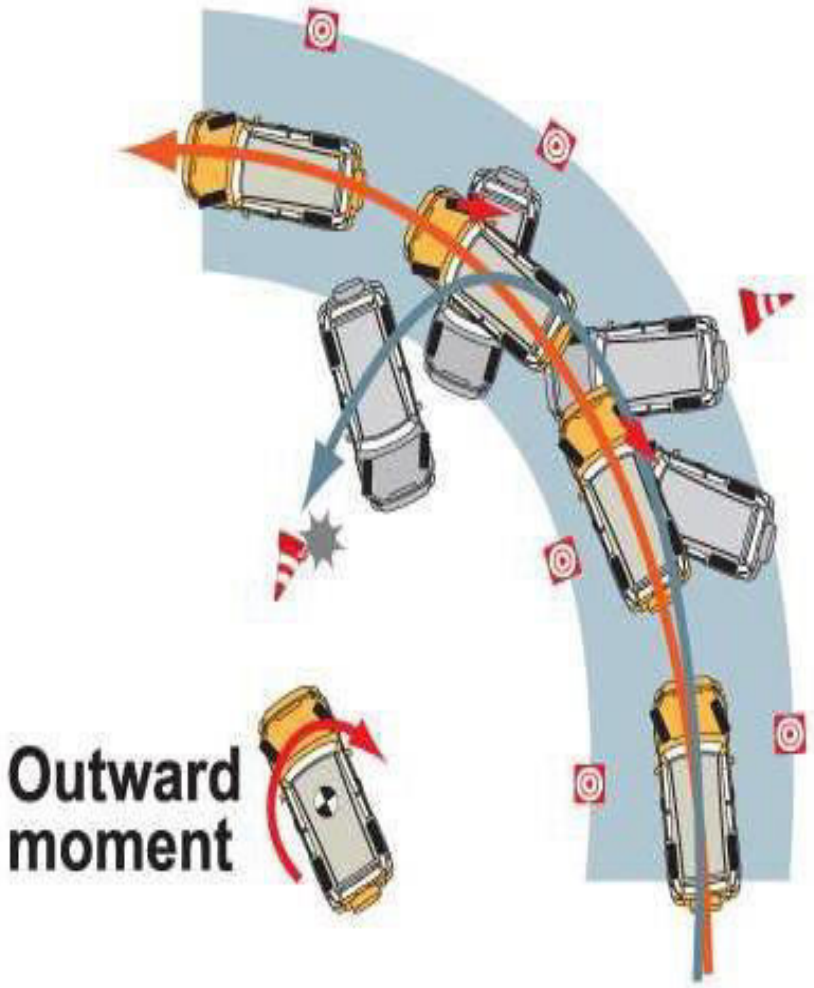
PROCESS



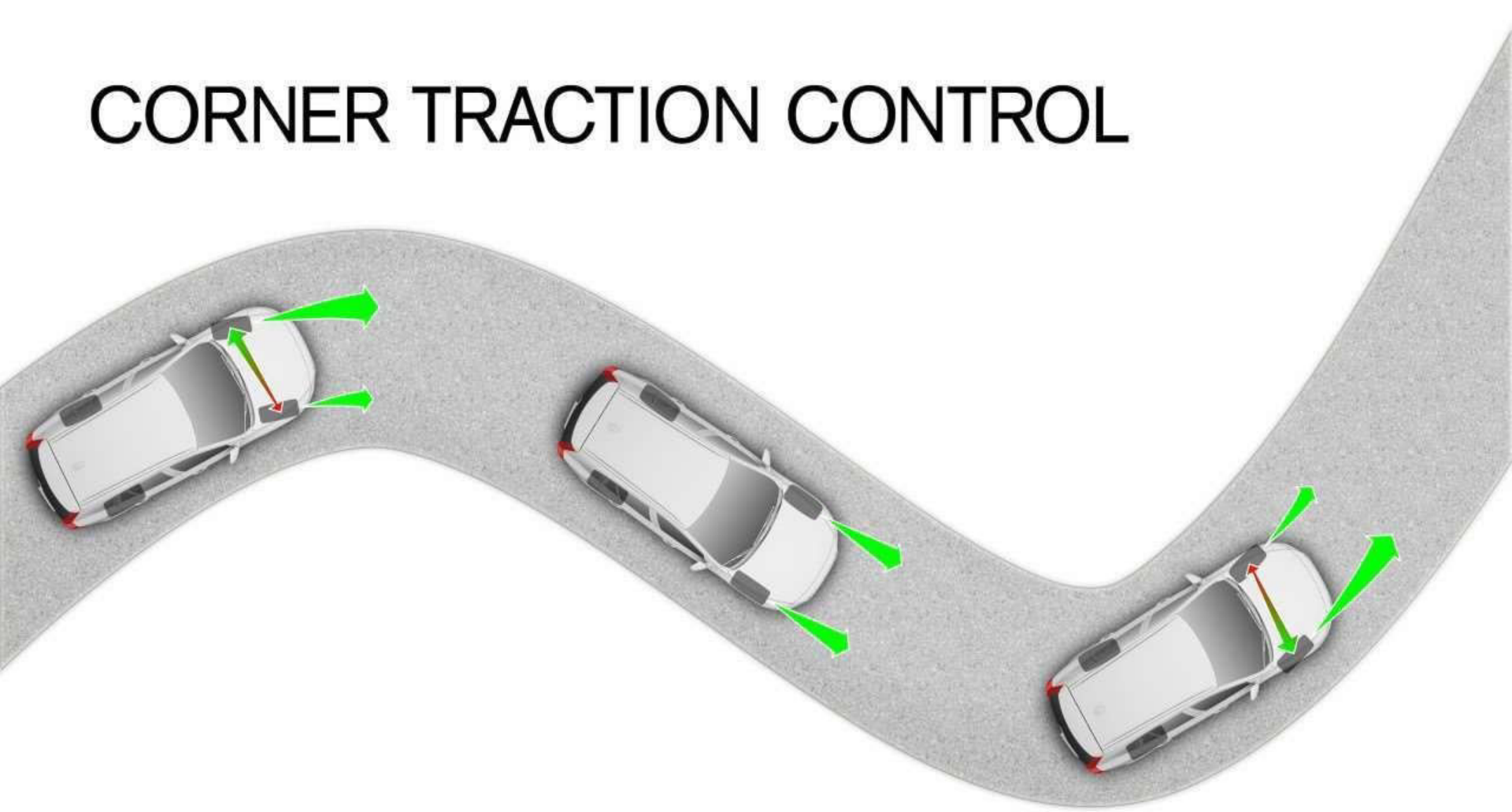
Front wheel skid control



Rear wheel skid control



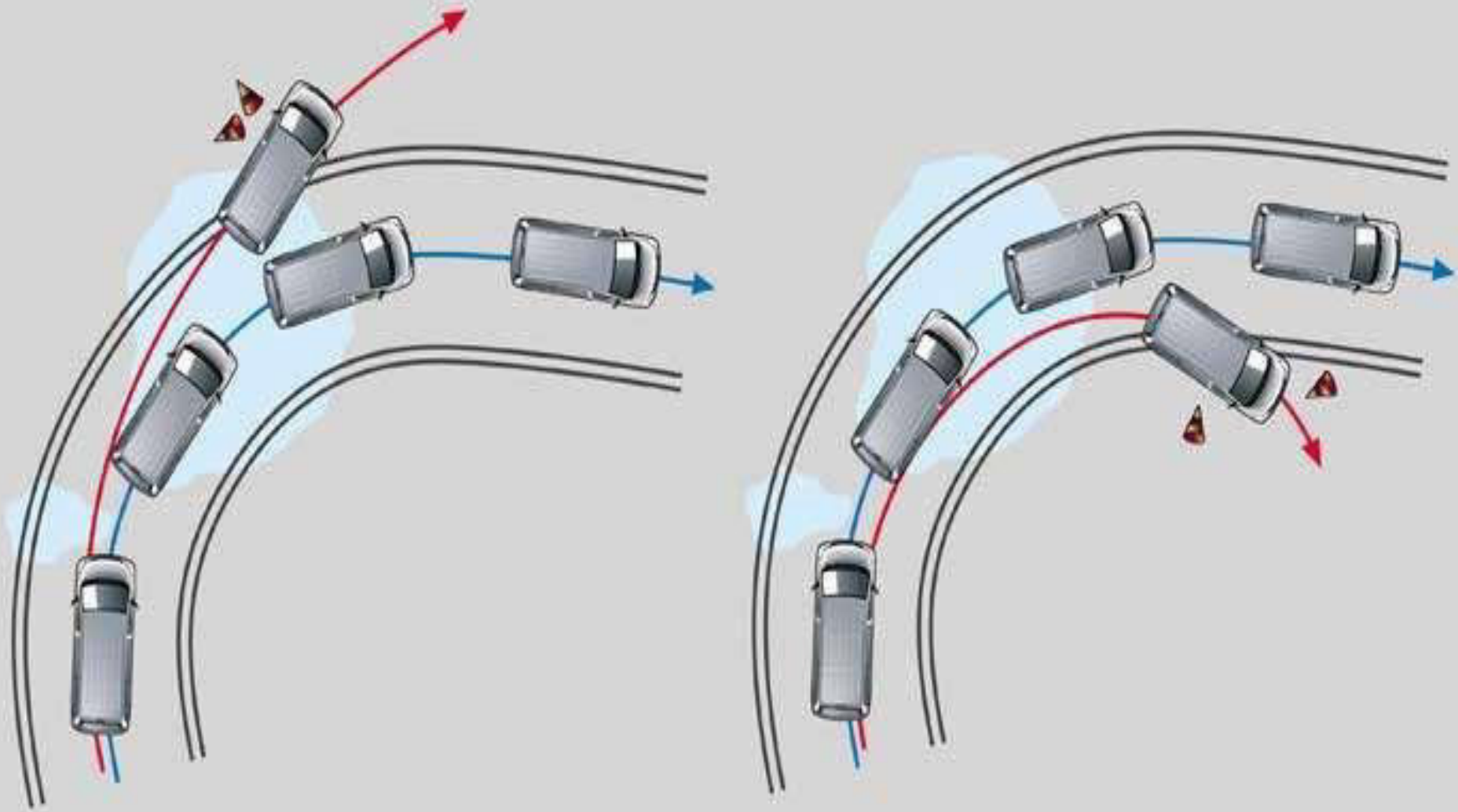
CORNER TRACTION CONTROL



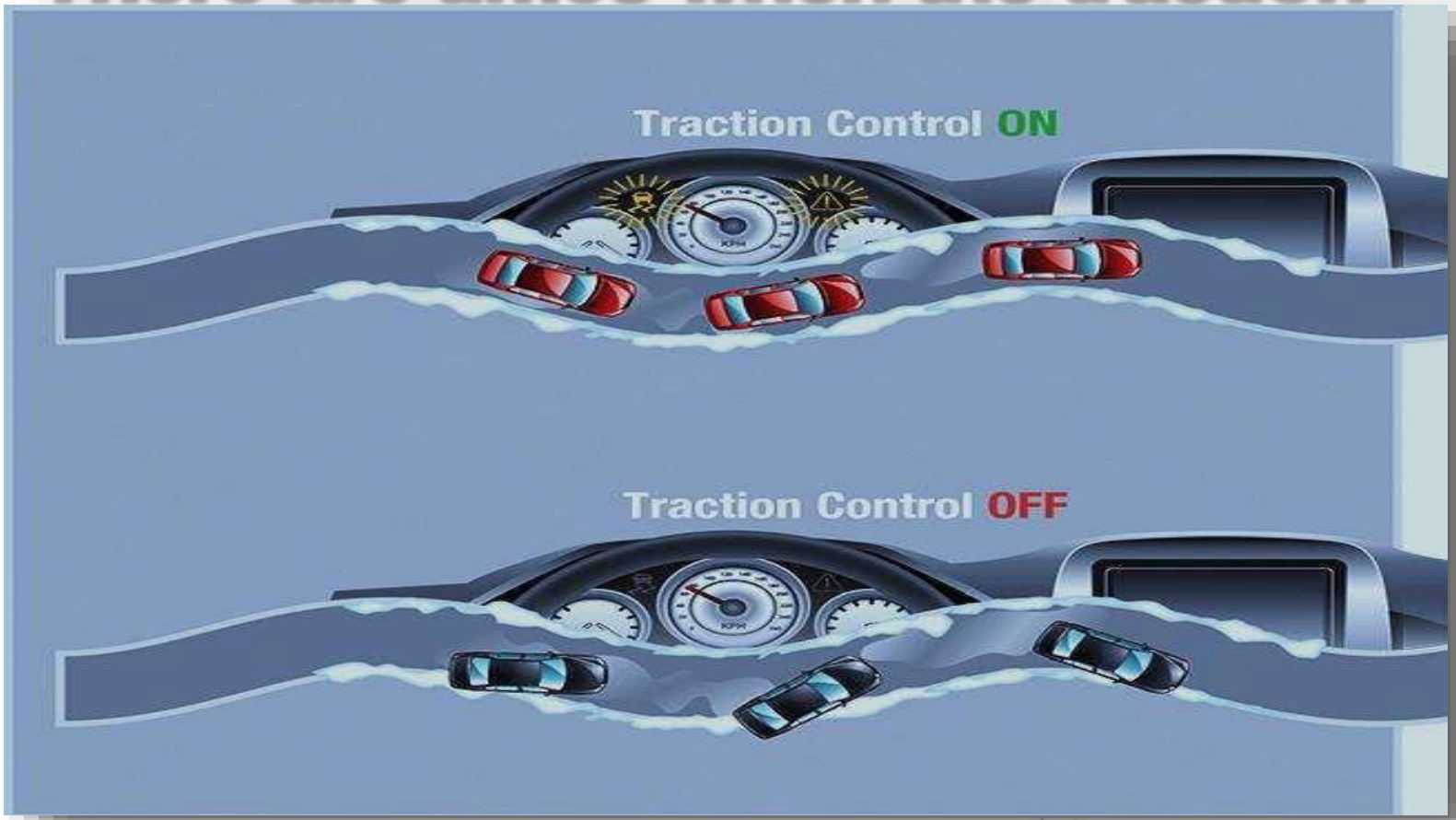
Braking the inner driven wheel and redistributing torque to the outer wheel help to maintain the desired line when turning into a corner.

Corner Traction Control significantly improves traction and performance on winding roads.

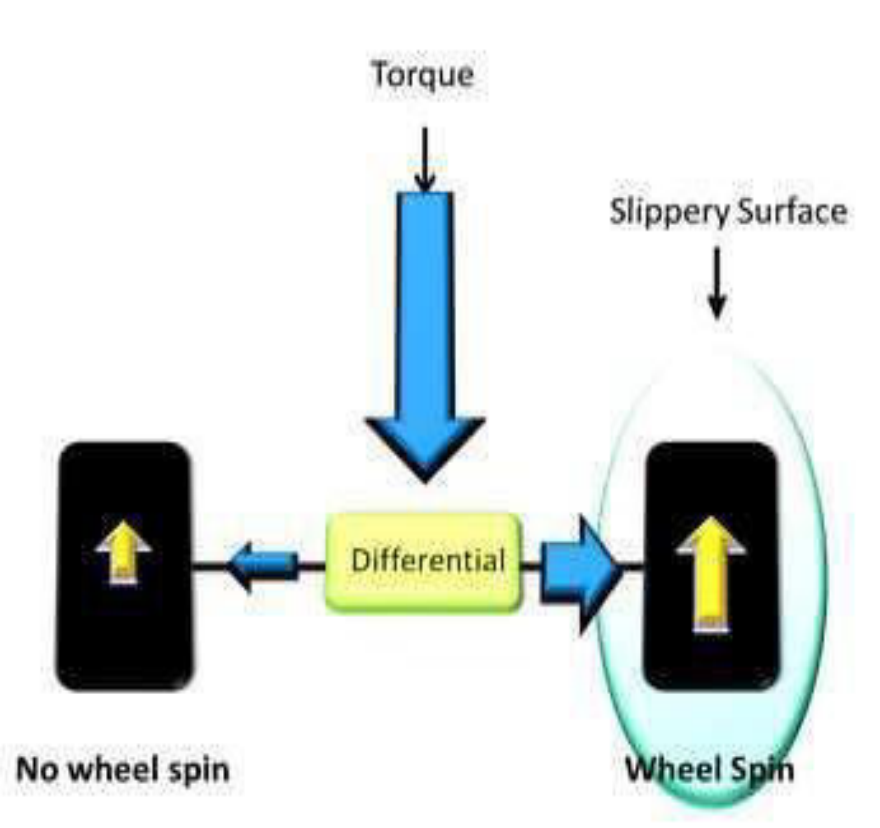
Torque distribution from inner to outer wheel reduces understeer when accelerating out of the corner.



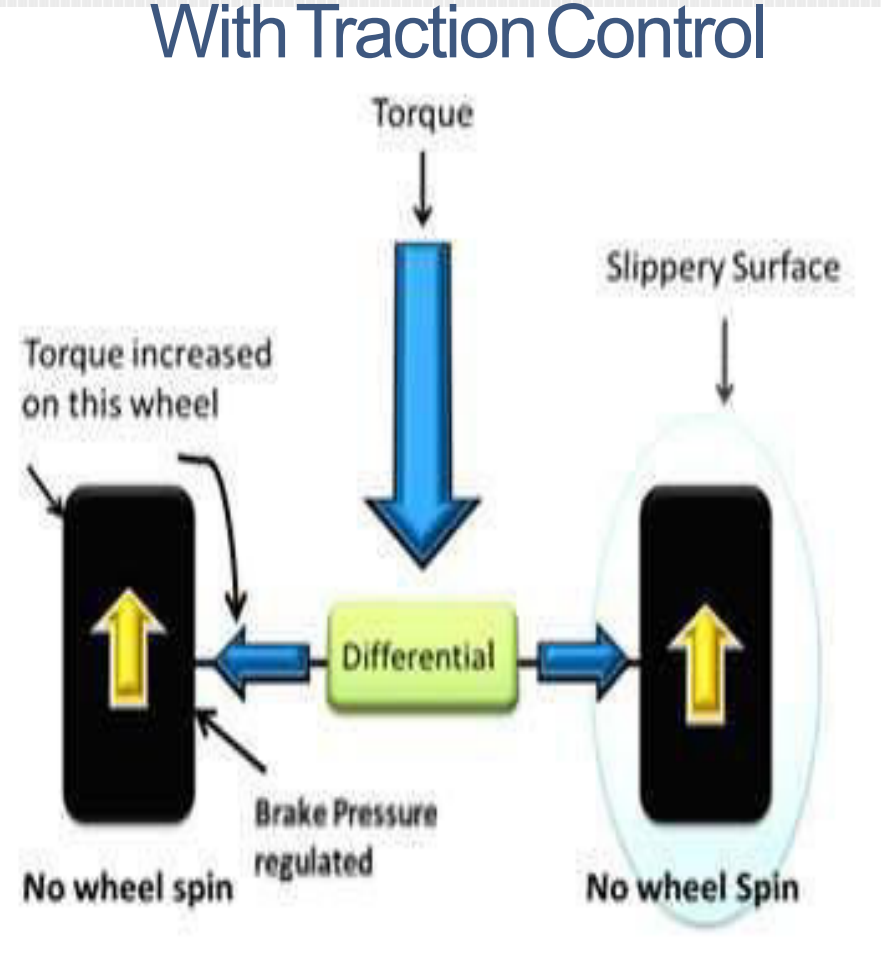
There are times when the traction



WithoutTractio n Control



With Traction Control



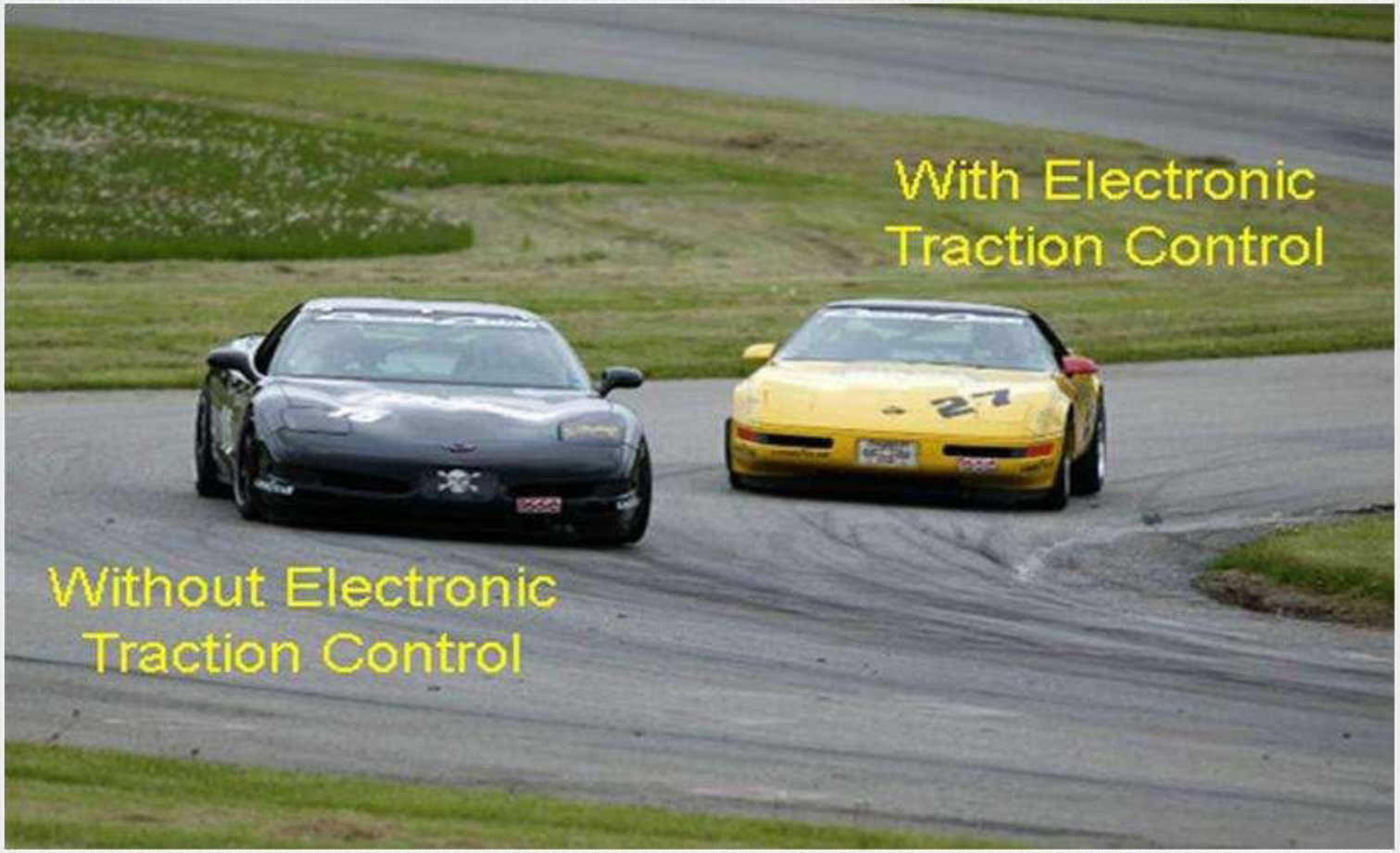
ADVANTAGES

- Avoiding accidents
- Sudden twists and turns
- Slippage of the wheels
- Stopping distances
- Driving a powerful car
- Most gripping.

DISADVANTAGES:

- wear on brake components.
- Holds performance driving.
- Allows 10 % wheel slip.
- Its banned in F1 racing.

IMAGES (APPLICATIONS):



TRAC System difference at cornering

IMAGES (APPLICATIONS):

ICE TRACK RACING (Model subaru STI)

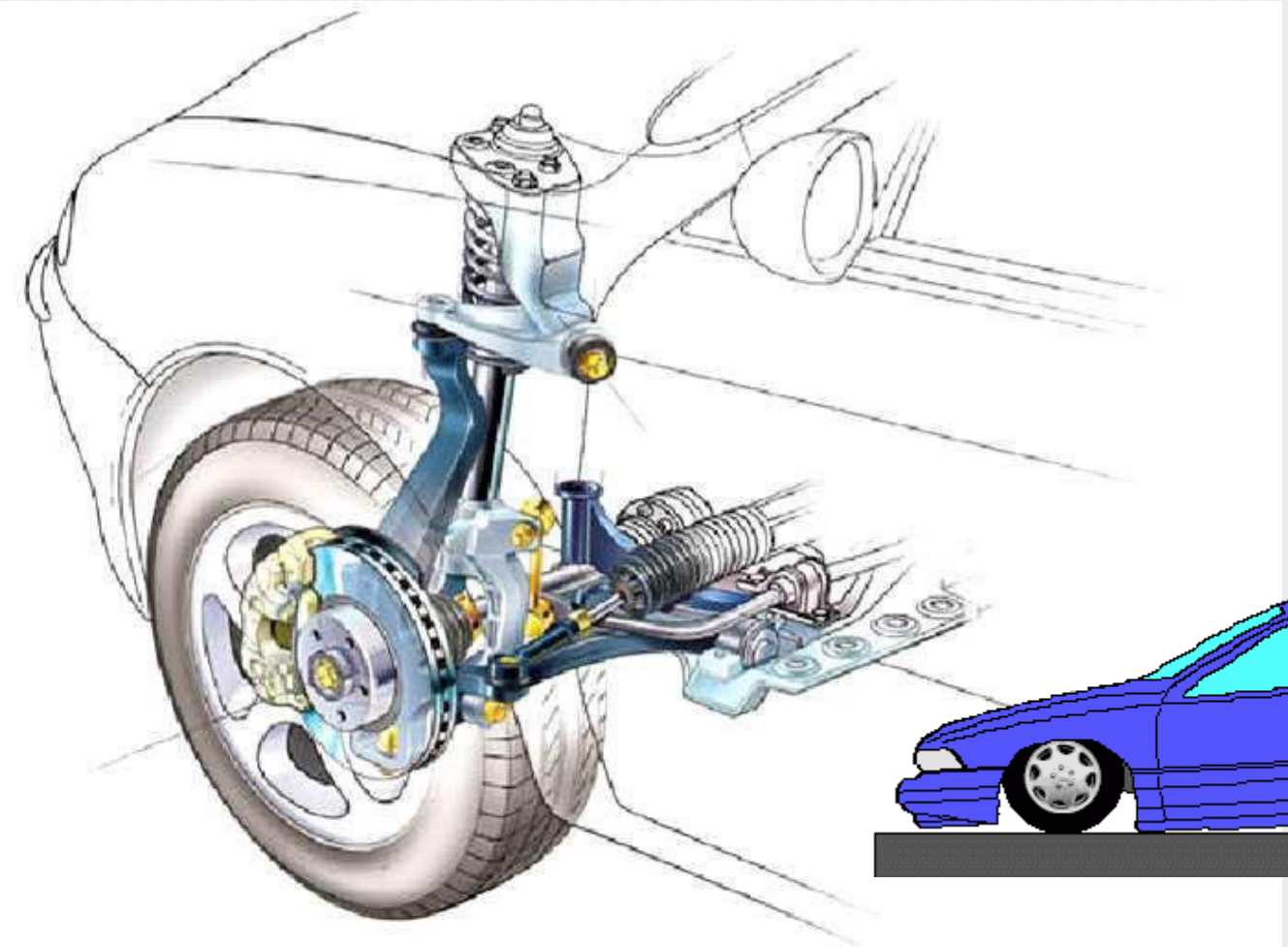
IMAGES (APPLICATIONS):

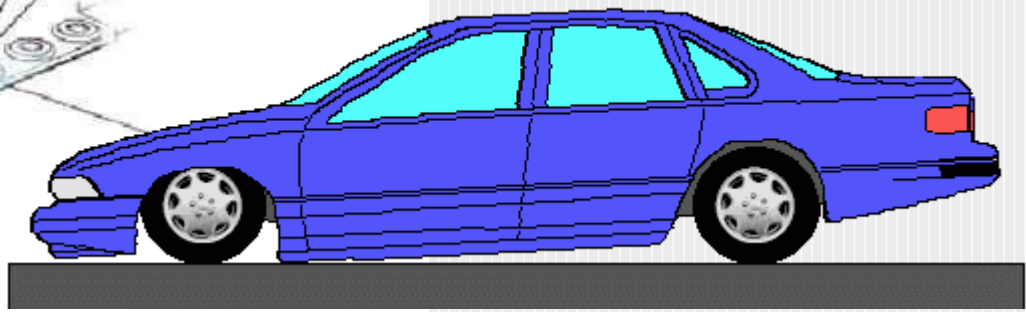
DUCATI bike with TRAC system

IMAGES (APPLICATIONS):

Mitsubishi Eclipse with ASTC

SUSPENSION SYSTEM IN AUTOMOBILES





SUSPENSION SYSTEM

- The automobile chassis is mounted on the axles, not direct but through some form of springs.
- If there is no suspension it give rise to an uncomfortable ride and also cause additional stress in the automobile frame and body.
- All the parts which perform the function of isolating the automobile form the road shocks are collectively called a suspension system.

Objective of suspension system

- To prevent the road shocks
- To safeguard the occupants from road shocks
- To preserve stability of the vehicle

BASIC CONSIDERATIONS

- Vertical loading
- Rolling
- Brake dip and squat
- Side thrust
- Road holding
- Ride and handling
- miscellaneous

Function Suspension System

- Supports the weight.
- Provides a smooth ride
- Allows rapid cornering without extreme body roll.
- Keeps tires in firm contact with the road
- Prevents excessive body squat.
- Prevents excessive body dive.
- Allows front wheels to turn side-to-side for steering
- Works with the steering system to keep the wheels in correct alignment.

TYPES OF SUSPENSION SPRINGS

1. Steel springs

a) Leaf spring

b) Coil spring

c) Tapered leaf spring

d)Torsion bar

2.Rubber spring

a) Compression spring

b) Compression shear spring

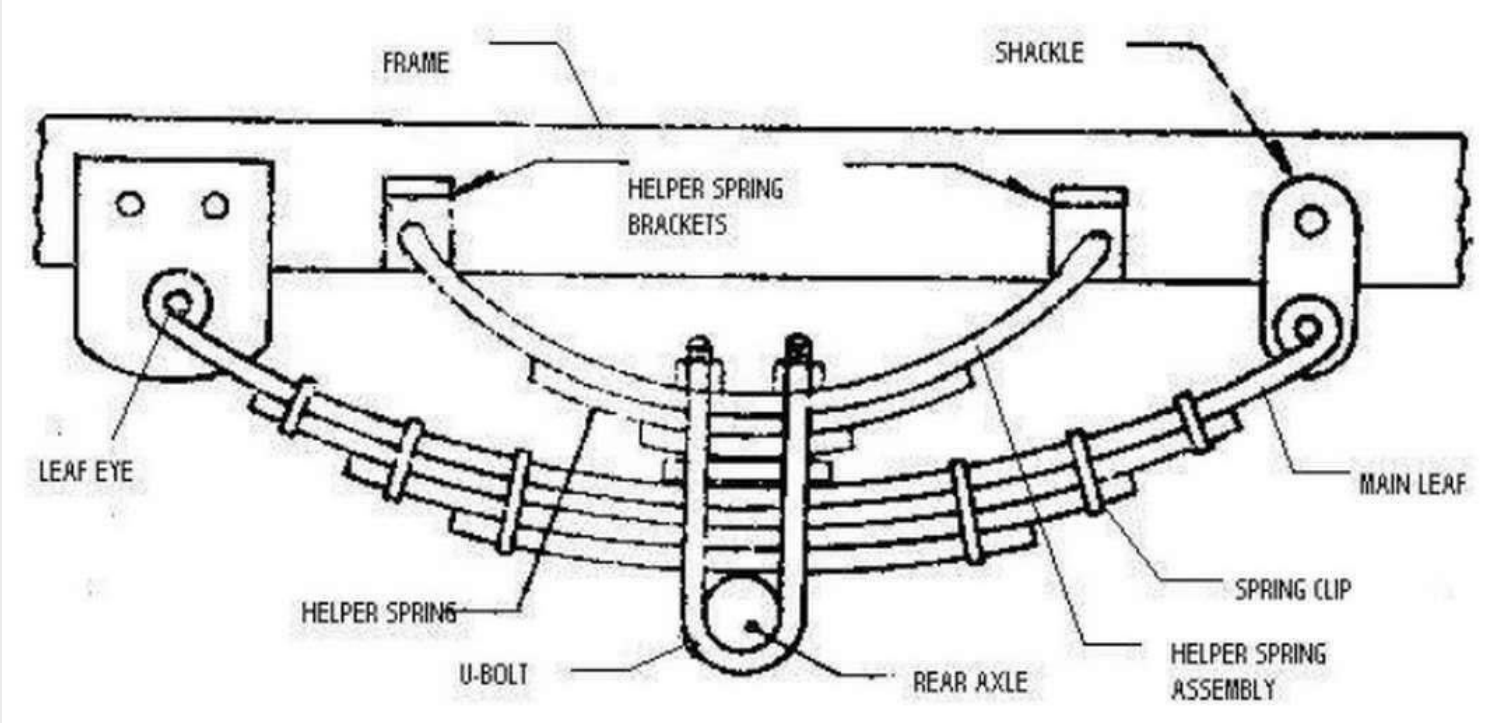
c) Steel reinforced spring

d) Progressive spring

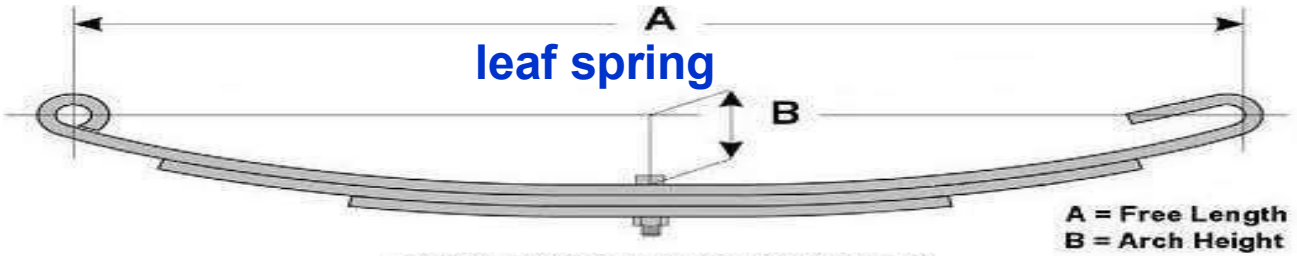
e) Face shear spring

f)Torsional spring

3. Plastic spring 4.Air spring

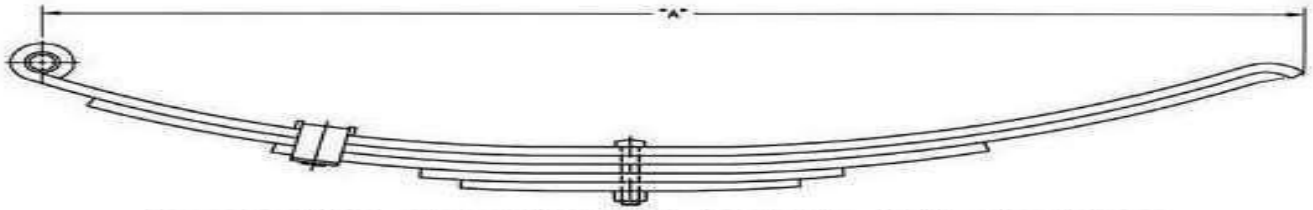


leaf spring



OPEN EYE LEAF SPRINGS

Measure Mounting Point to Furthest Inside Point



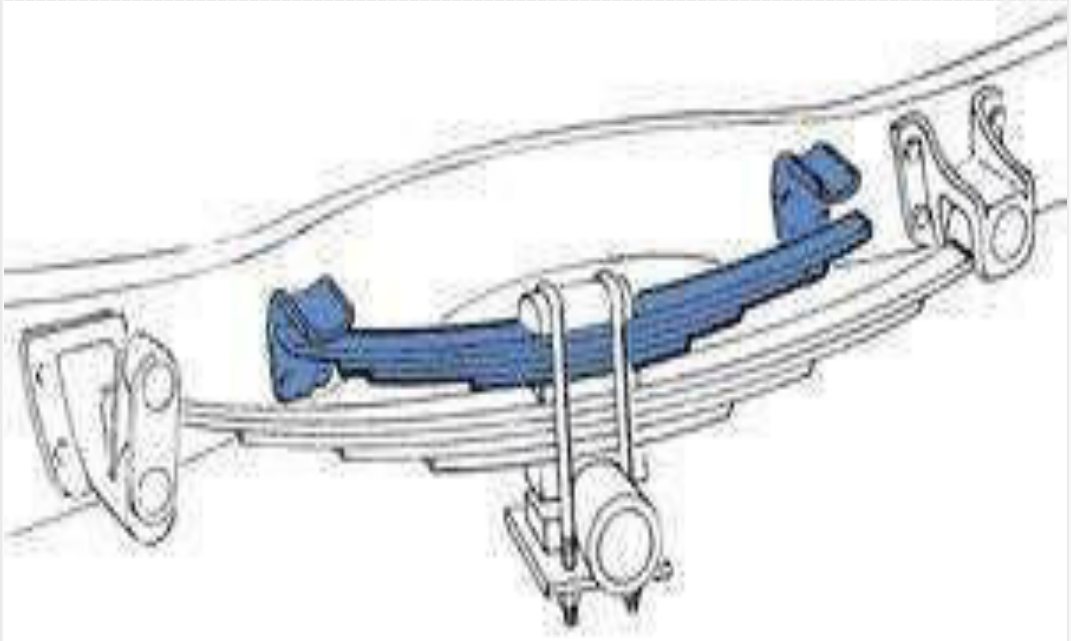
HOOK END, FLAT END & RADIUS END SPRINGS

Measure Front Bolt To End Of Spring

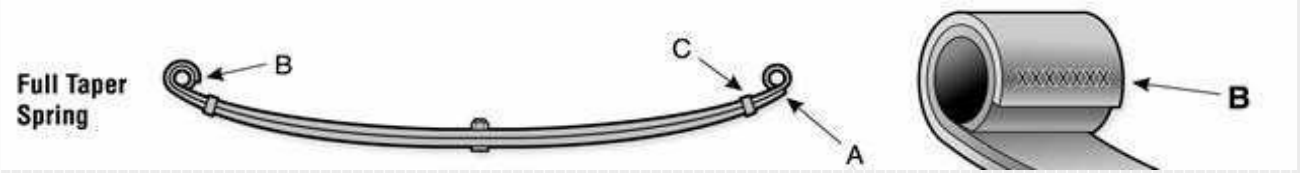
HELPER SPRING

- Directly mounted on main springs
- Take care of large variation in spring load
- During light loads ,only main spirng is active , as load increase to a particular fixed value , both the springs are active

AIR ASSISTED HELPER SPRING



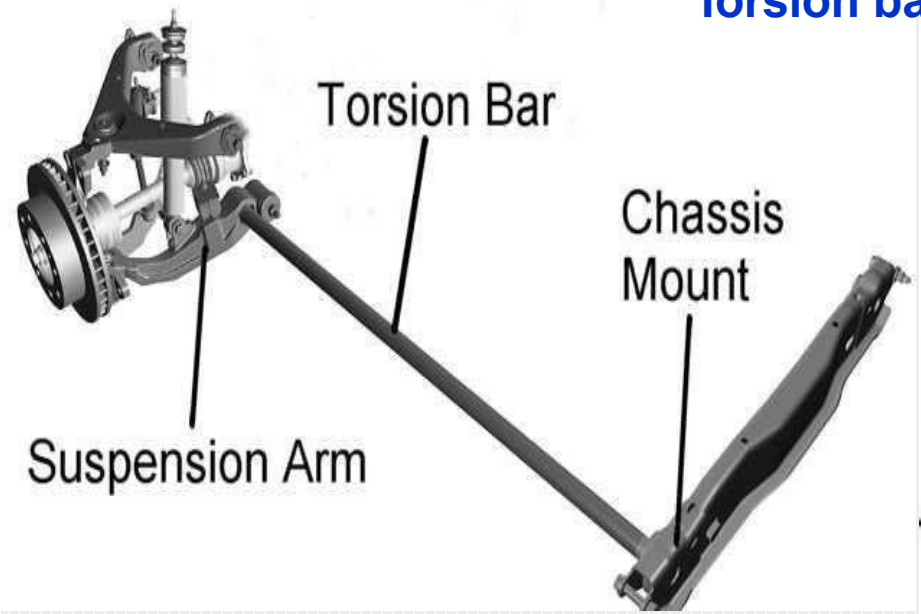
LEAF HELPER SPRING

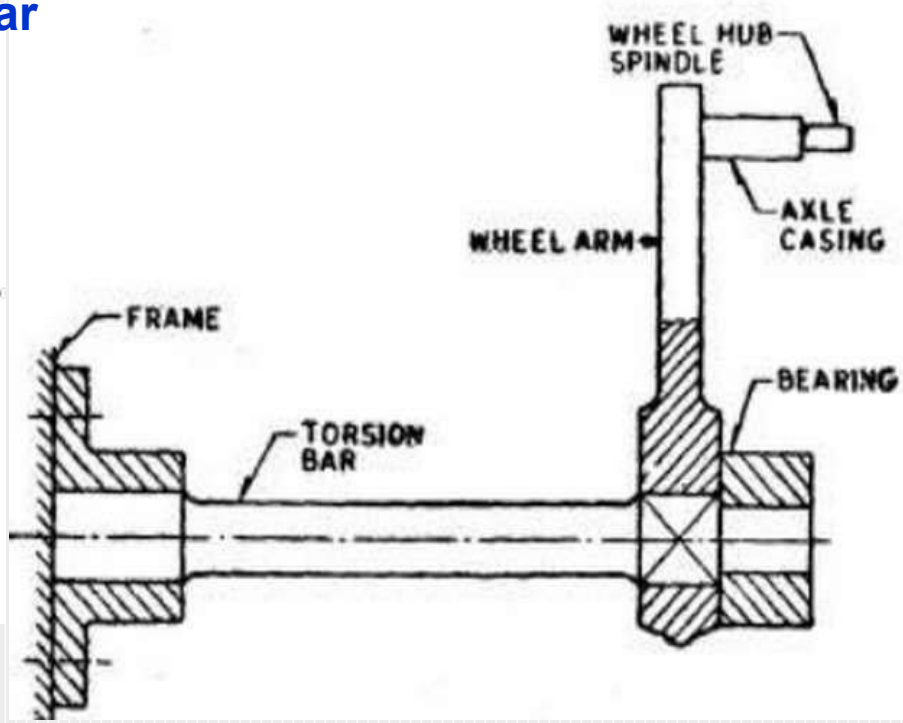


Tapered leaf spring

Coil spring

Torsion bar





RUBBER SPRING

- It can store greater energy per unit weight
- Excellent vibration damping properties
- Absence of squeaking
- Uses less number of bearings and hence longer life
- More reliable (cannot fail suddenly)

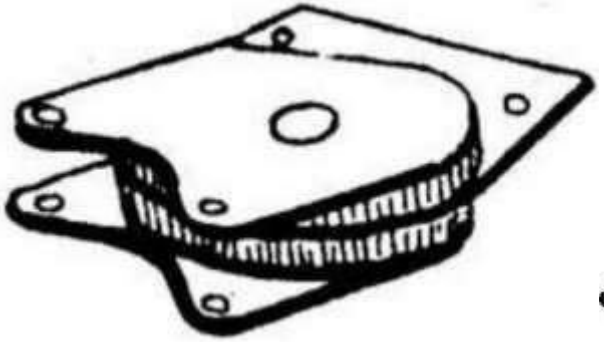
RUBBER SPRING

Compression spring

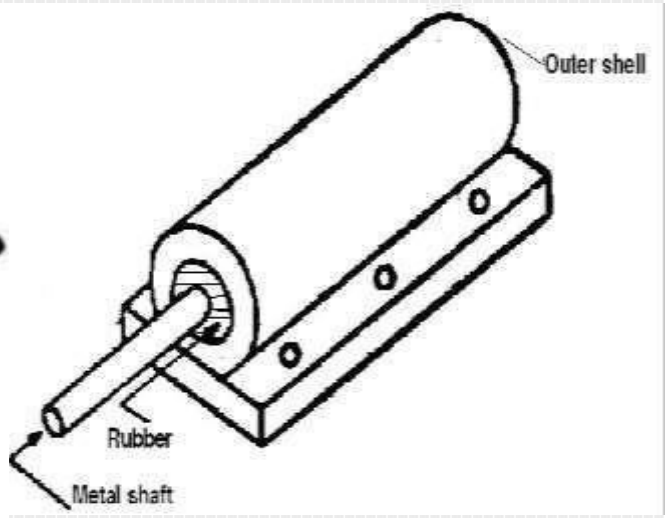
Compression shear spring

Steel reinforced spring

Progressive spring



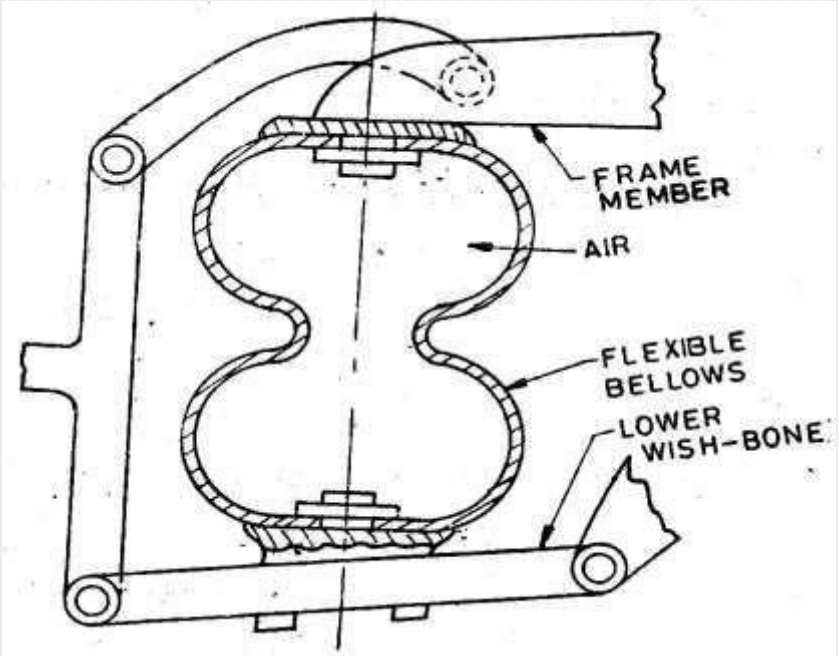
Face shear spring

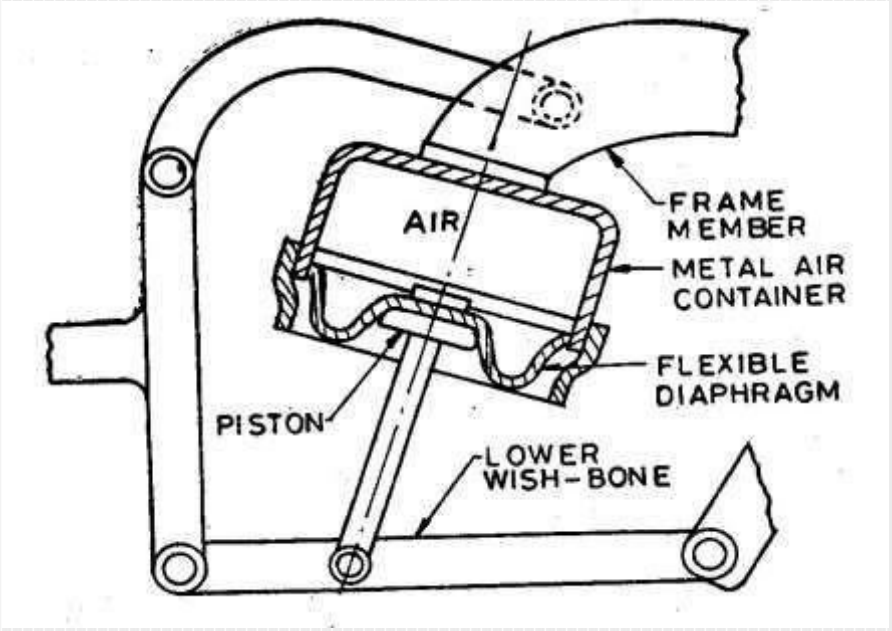


Torsional shear spring

AIR SPRING

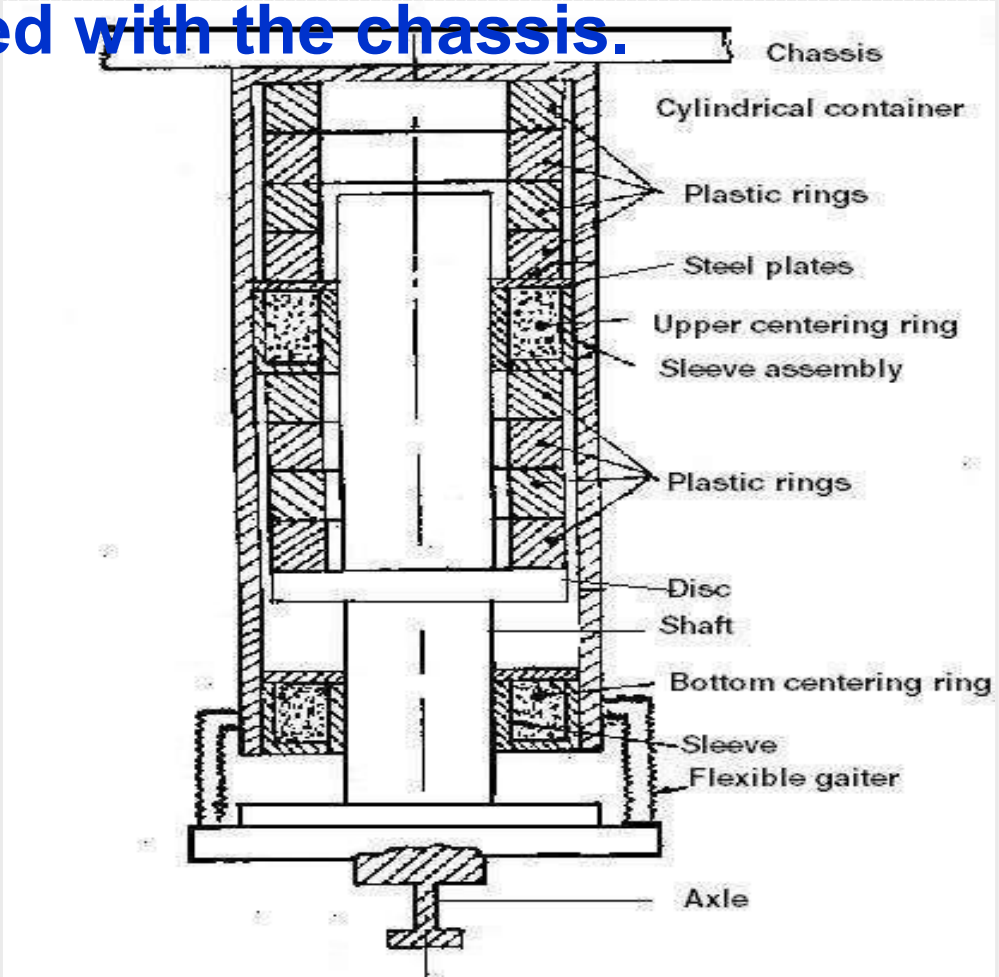
- **BELLOWS TYPE AIR SPRING consists of rubber bellows, which are generally of circular in section.**
- **The bellows has two convolutions for proper functioning. This type of spring is good replacement for the coil springs.**
- **PISTON TYPE AIR SPRING consists of a metal air container in the form of an inverted drum.**
- **The drum is fixed to the frame and the sliding piston is attached to the lower wishbone.**
- **For making the system leak proof a seal is provided by flexible diaphragm.**
- **The diaphragm is secured at its outer**


FRAME MEMBER
AIR
FLEXIBLE BELLOWS
LOWER WISH-BONE


AIR
FRAME MEMBER
METAL AIR CONTAINER
FLEXIBLE DIAPHRAGM
PISTON
LOWER WISH-BONE

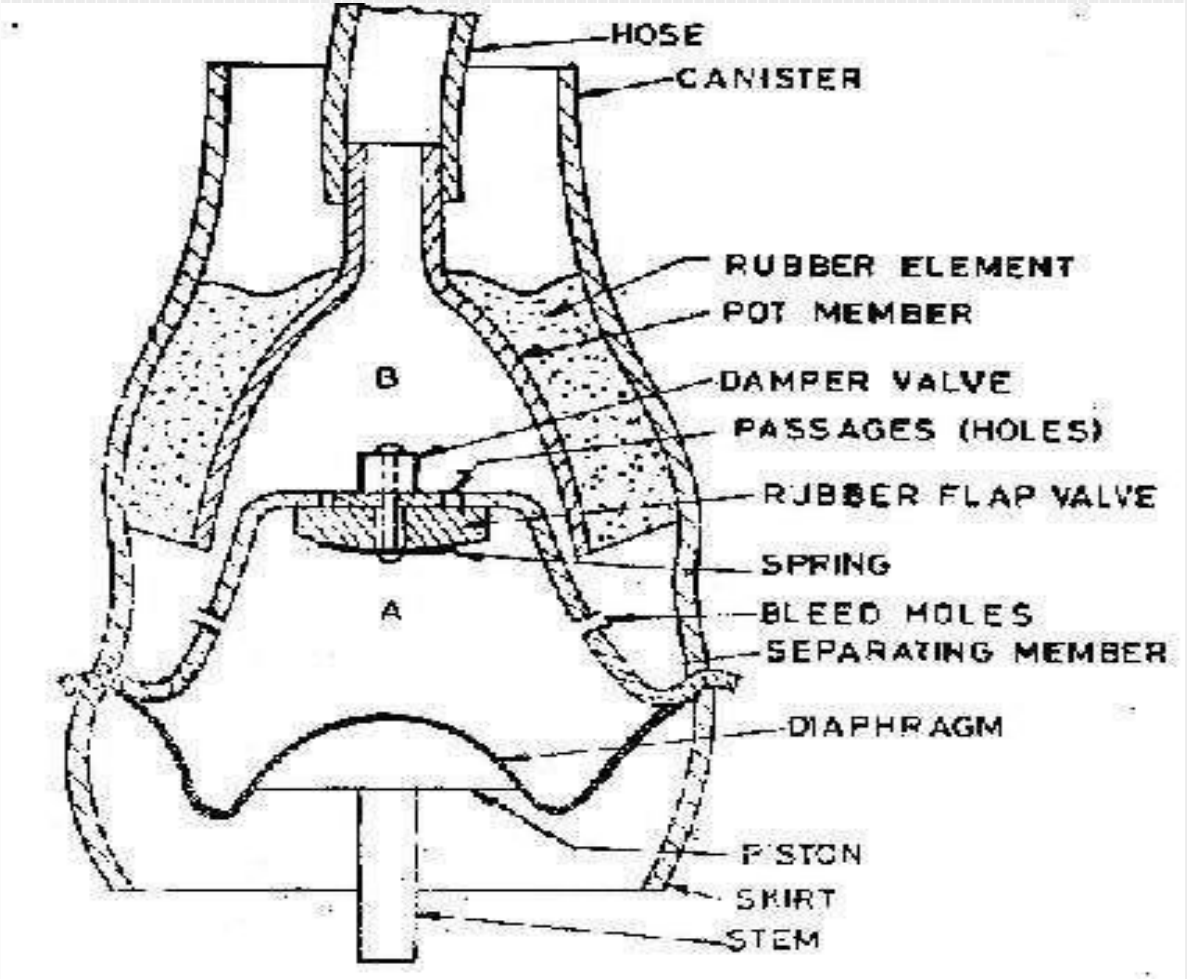
PLASTIC SPRING

- This suspension is similar to the compression type rubber spring but here plastic is used instead of rubber.
- It consists of a metallic cylindrical container which is fixed with the chassis.



HYDRAULIC OR HYDRO-ELASTIC SPRING

- The main component of the hydraulic suspension is the displacer unit, which is attached to the individual wheels of the vehicle.



SHOCK ABSORBER

- A shock absorber is a device used to check or damp out the vibrations of the suspension springs to a comfortable level.
- The resistance to the free oscillation of the springs is obtained in the damper by causing a fluid to pass at high speed through small holes.
- The energy absorbed depends upon the viscosity of the fluid and appears as heat in the fluid.

SHOCK ABSORBER CLASSIFICATION

CLASSIFICATION BY OPERATION:

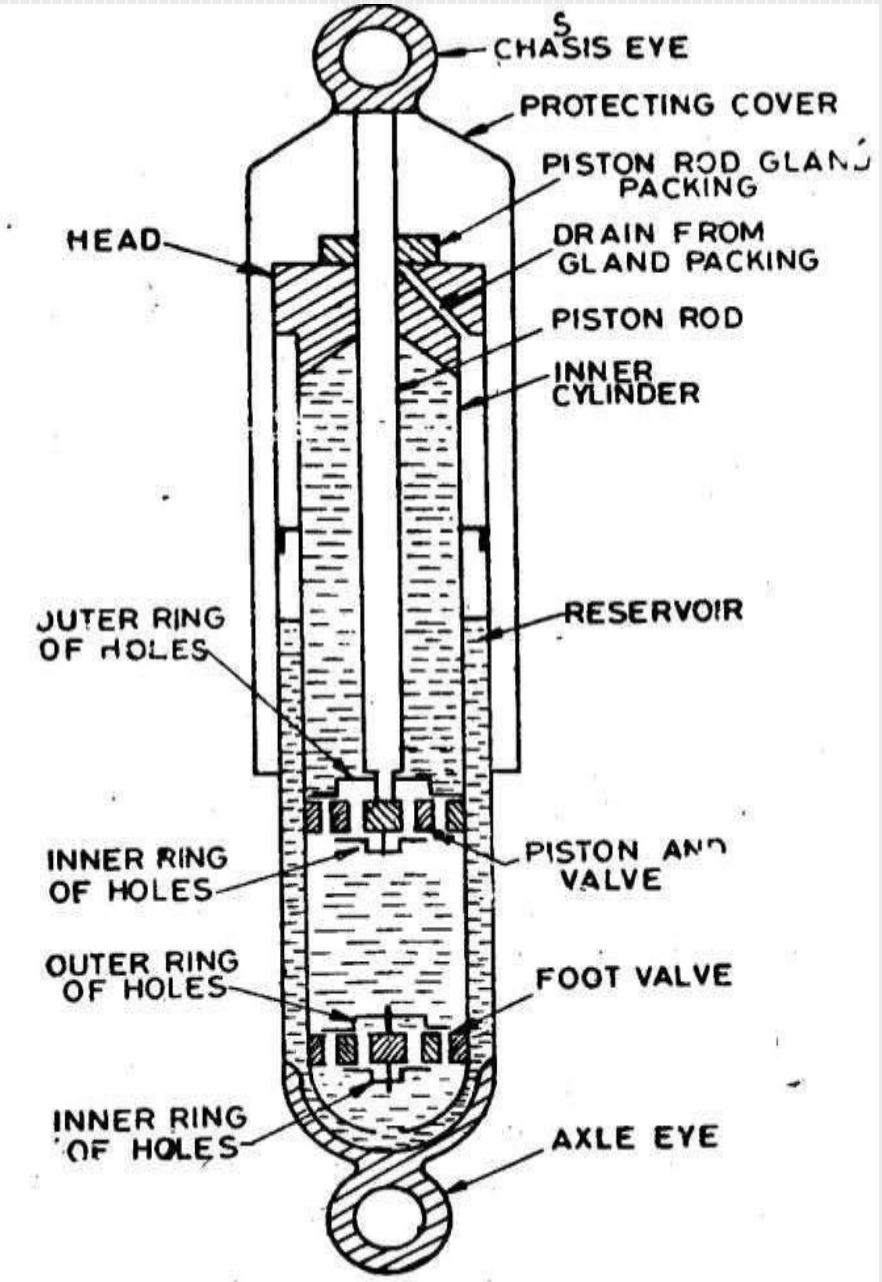
a)Single action b)Multiple action

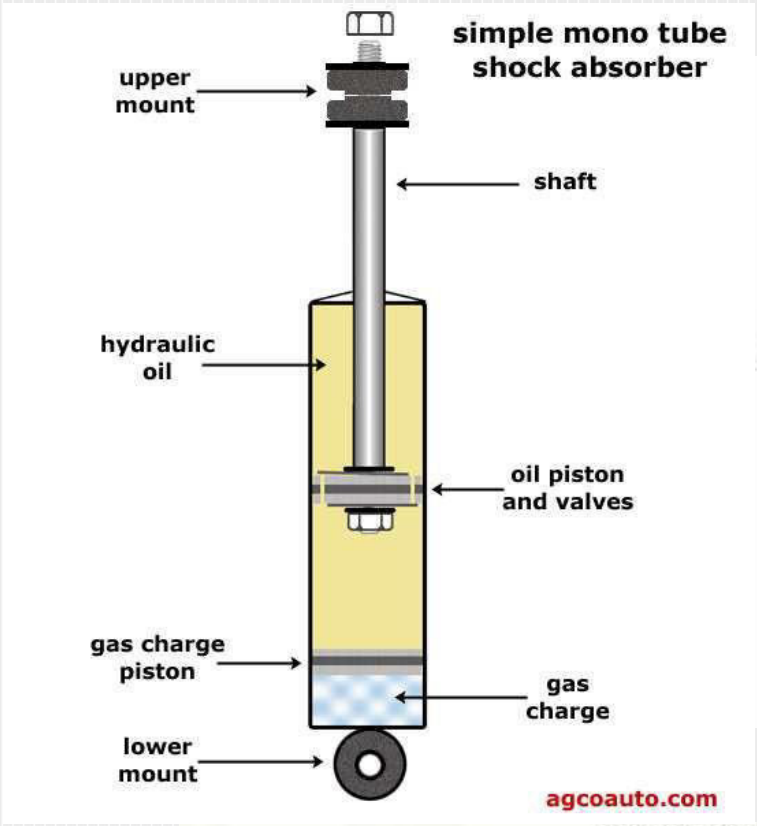
CLASSIFICATION BY CONSTRUCTION:

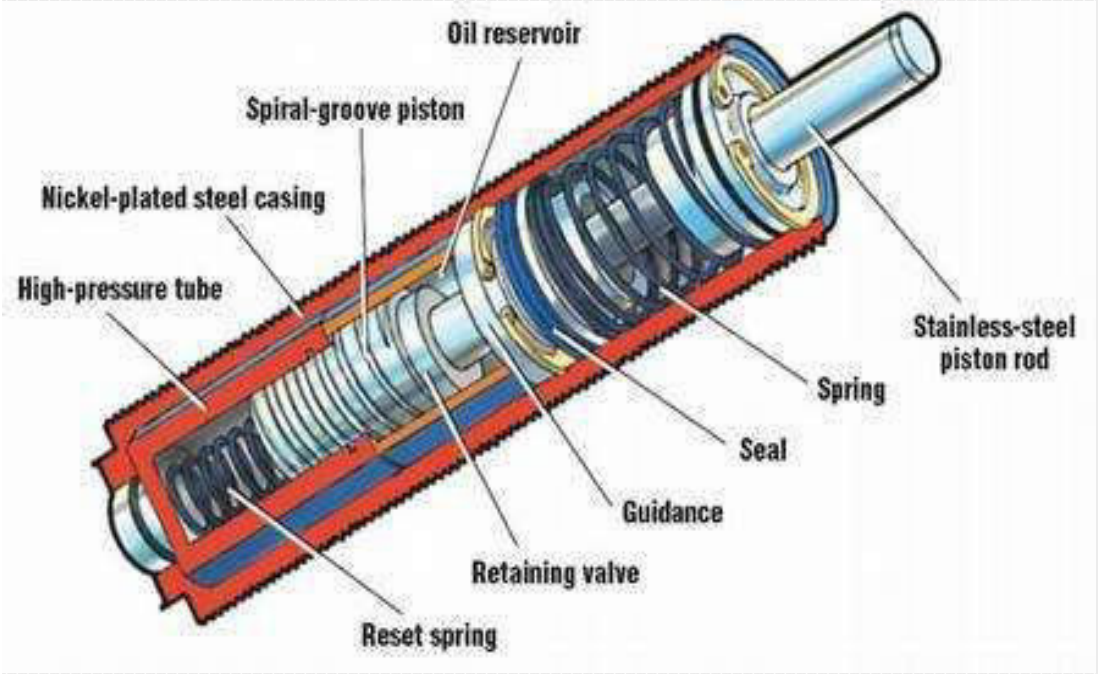
a)Mono tube b) Twin tube

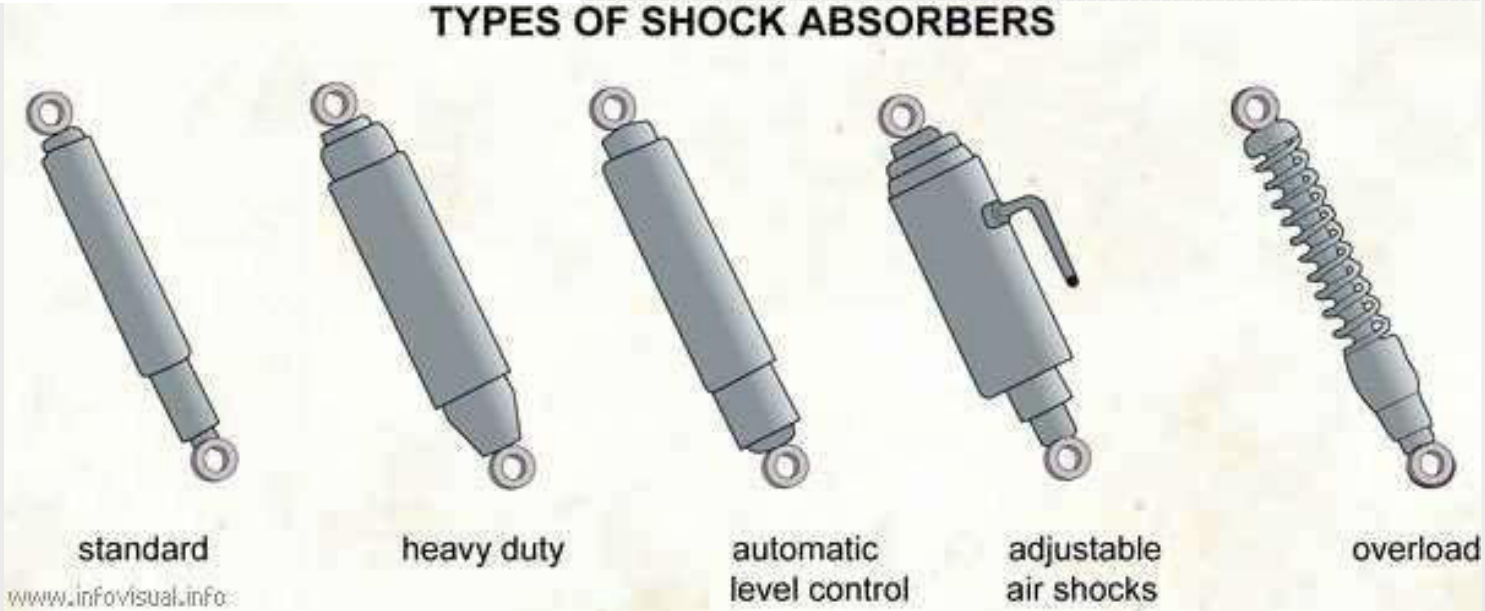
CLASSIFICATION BY WORKING MEDIUM

a)Hydraulic b)Gas filled.


CHASIS EYE
PROTECTING COVER
PISTON ROD GLAND PACKING
HEAD
DRAIN FROM GLAND PACKING
PISTON ROD
INNER CYLINDER
RESERVOIR
OUTER RING OF HOLES
INNER RING OF HOLES
PISTON AND VALVE
OUTER RING OF HOLES
FOOT VALVE
INNER RING OF HOLES
AXLE EYE


simple mono tube
shock absorber
upper mount
shaft
hydraulic oil
oil piston and valves
gas charge piston
gas charge
lower mount
agcoauto.com


Oil reservoir
Spiral-groove piston
Nickel-plated steel casing
High-pressure tube
Stainless-steel piston rod
Spring
Seal
Guidance
Retaining valve
Reset spring


TYPES OF SHOCK ABSORBERS
standard
heavy duty
automatic level control
adjustable air shocks
overload
www.infovisual.info

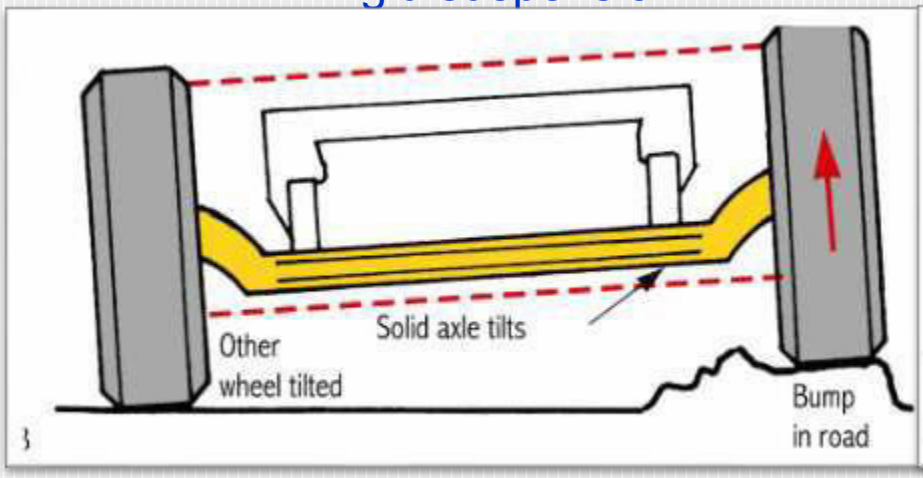
ELECTRONICALLY CONTROLLED SHOCK ABSOR

- These allow the driver to select the amount of shock damping by simply pressing a button on the instrument panel.
- Damping variation is achieved by varying the orifices in the shock absorber valves by means of small electric motor mounted at the top of the shock absorber.

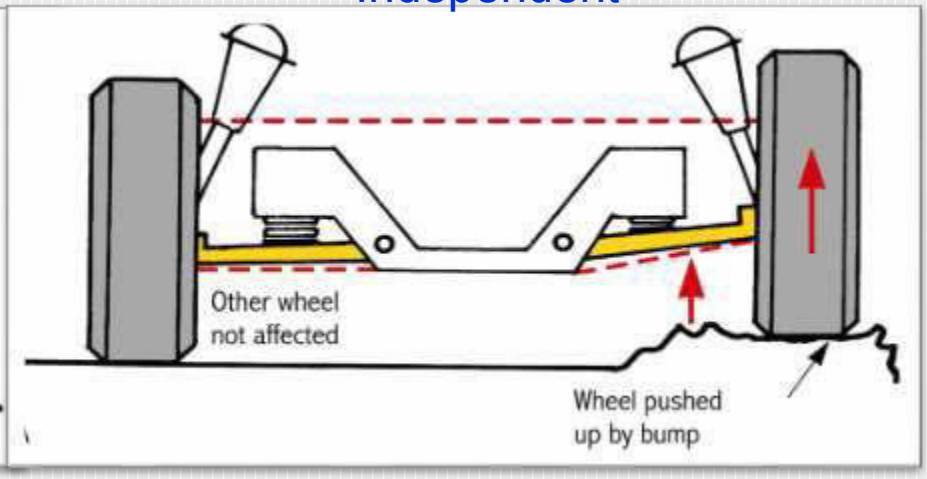
TYPES OF SUSPENSION SYSTEM

1. Independent Suspension System
2. Rigid suspension System

Rigid suspension

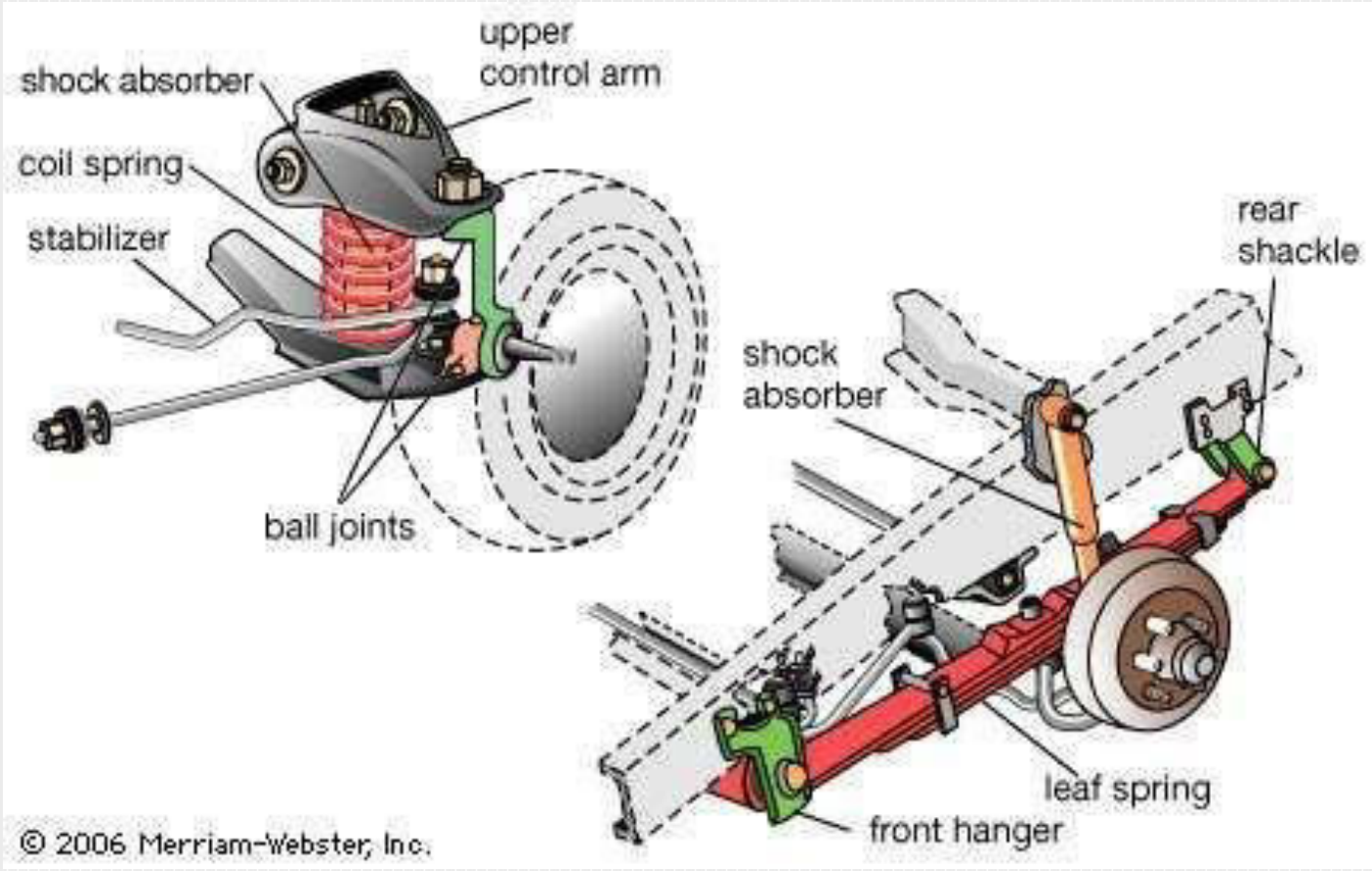


Independent

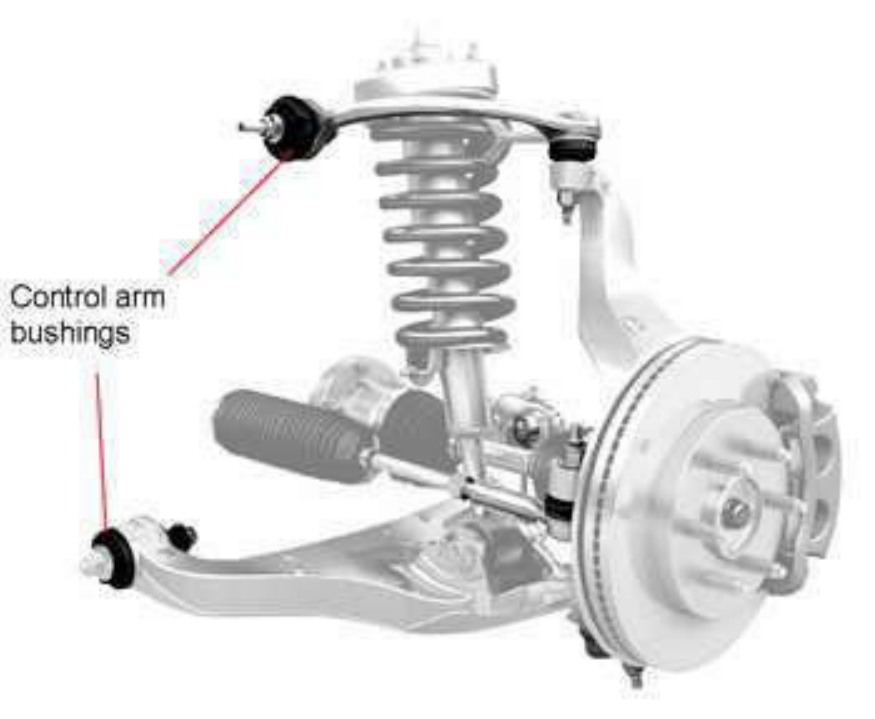


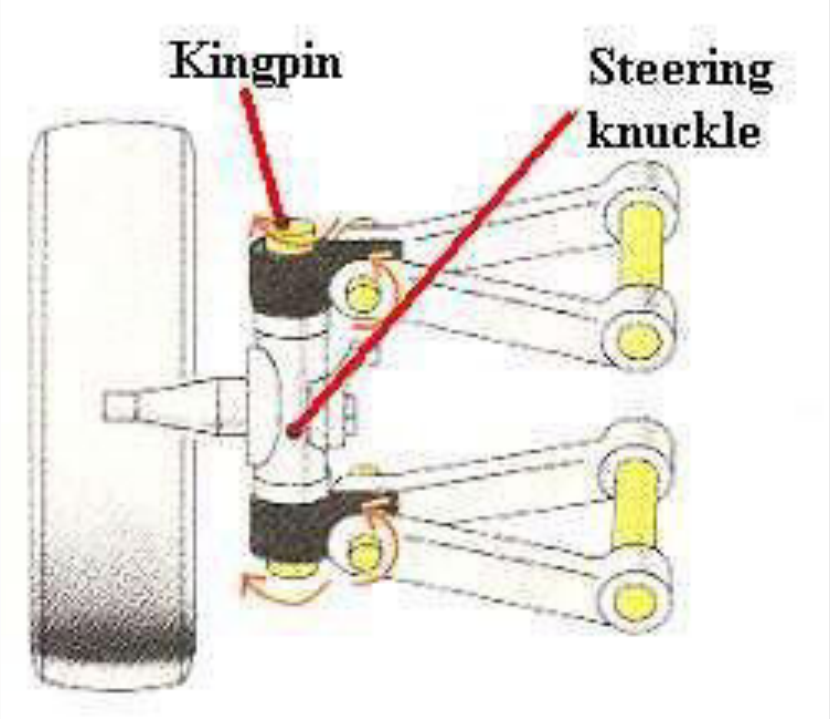
BASIC PARTS SUSPENSION SYSTEM

- Coil spring is the most common type of spring found on modern vehicles.
- Leaf springs are now limited to the rear of some cars.



- **CONTROL ARM** – movable lever that fastens the steering knuckle to the vehicle's body or frame.
- **STEERING KNUCKLE** – provides a spindle or bearing support for the wheel hub, bearings and wheel assembly.

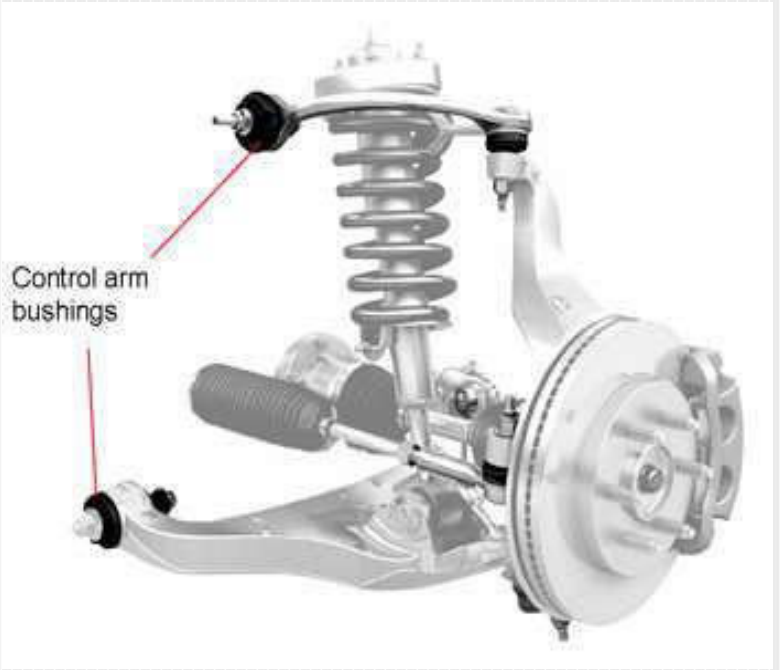




- **BALL JOINTS** – swivel joints that allow control arm and steering knuckle to move up and down and side to side.

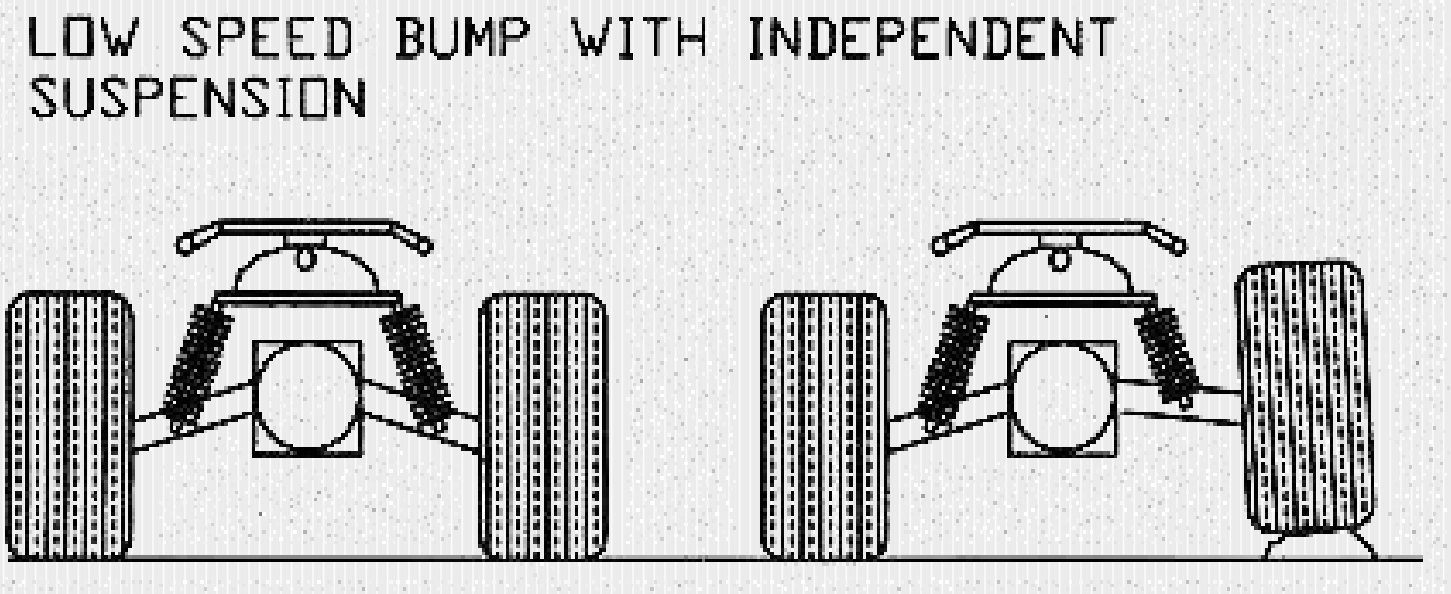
- **SPRINGS** – supports the weight of the vehicle; permits the control arm and Wheel to move up and down.

- **SHOCK ABSORBERS OR DAMPENERS** – keeps the suspension from continuing to bounce after spring compression and extension.
- **CONTROL ARM BUSHING** – sleeves that allows the control arm to swing up and down on the frame.



INDEPENDENT SUSPENSION

SYSTEM allows one wheel to move up and down with minimal effect to the other.



TYPES OF INDEPENDENT SUSPENSION SYSTEM

FRONT WHEEL (DEAD AXLE) INDEPENDENT SUSPENSION

1. Mac Pherson Strut
2. Wish bone Type or parallel link type
3. Vertical guide type
4. Trailing link type
5. Swinging half axle type

REAR WHEEL (LIVE AXLE) INDEPENDENT SUSPENSION

WISHBONE SUSPENSION

- The suspension must be designed in such a way as to keep the wheel upright for maximum tyre contact (vehicle control) and to minimize tyre wear.
- The upper wishbone is short and the lower wishbone is longer.
- Both wishbones pivot points and lengths are calculated to provide the best operating angle for a given suspension movement.
- Mainly used in SUV and CARS

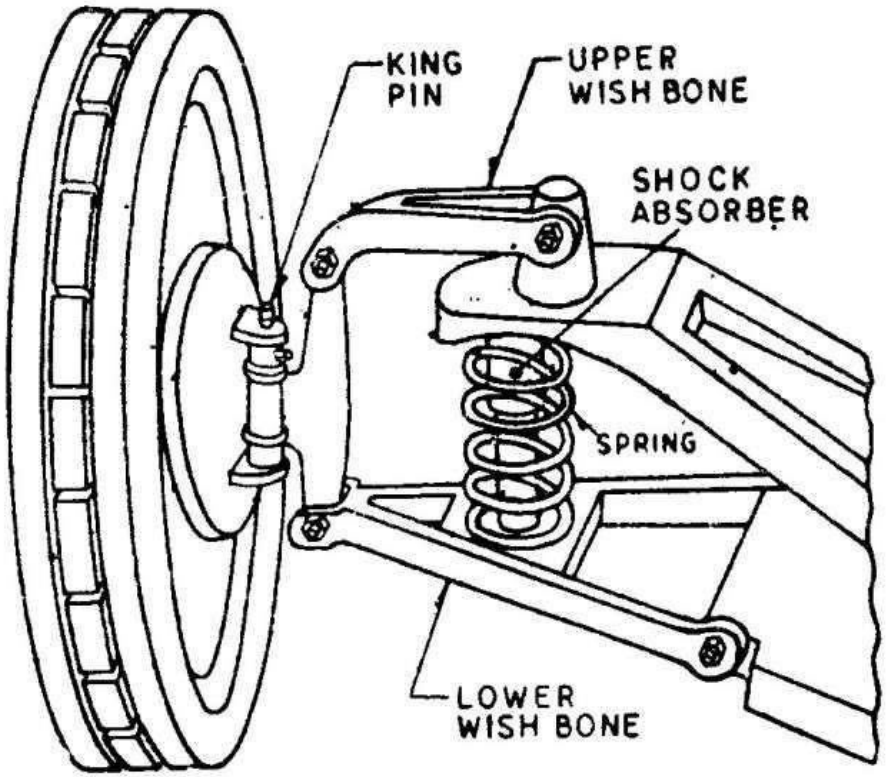
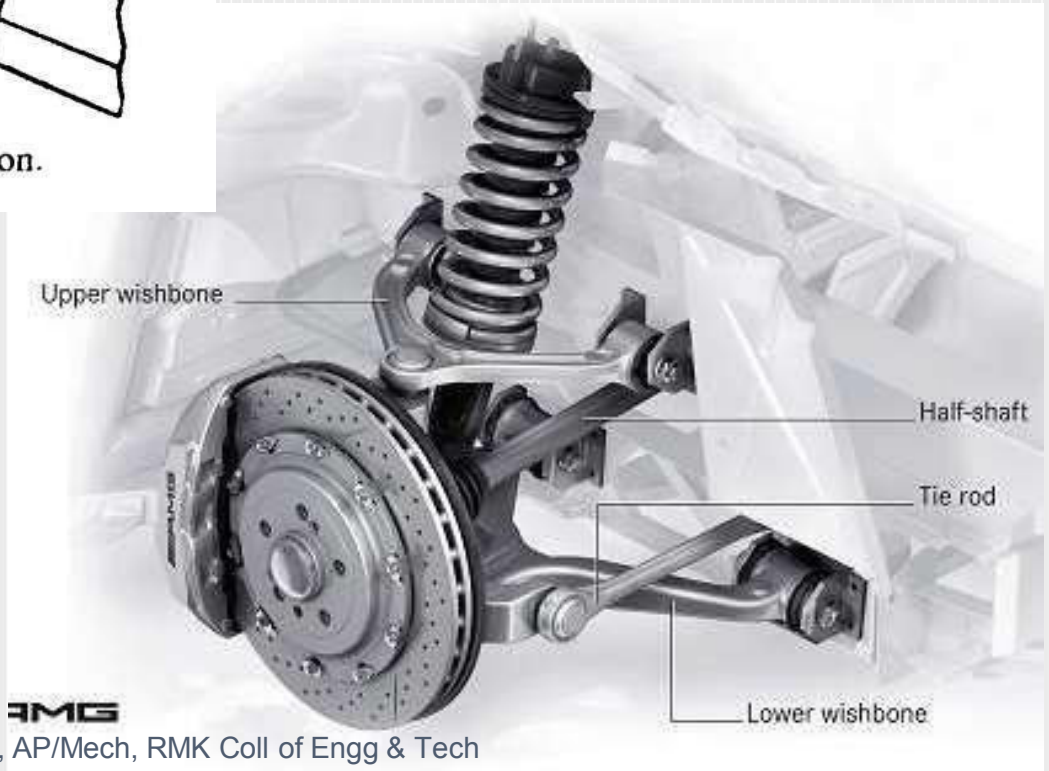


Fig. 6.32. Wishbone type independent suspension.



AUTOMOTIVE BATTERY

Battery :

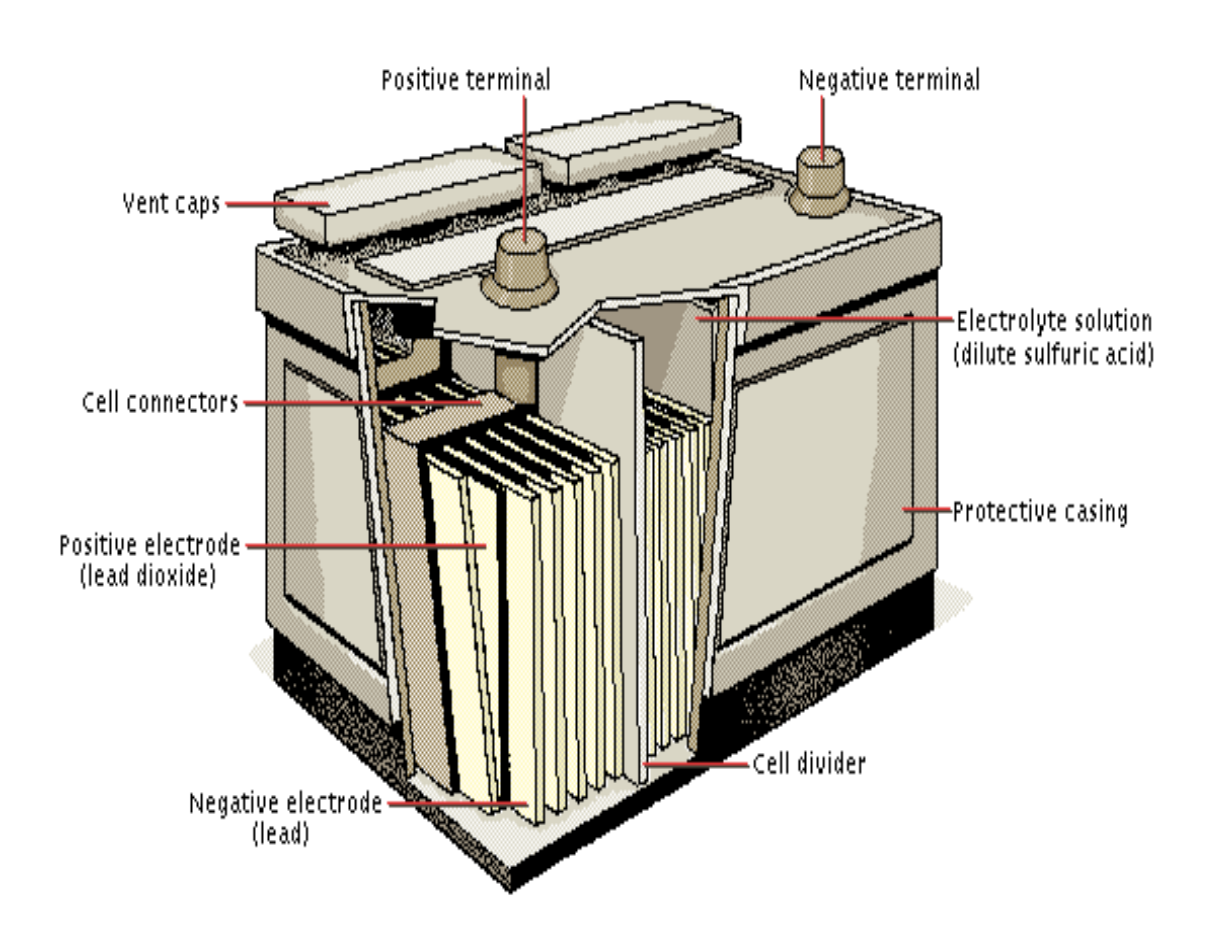
- An electrical battery is one or more electrochemical cells that convert stored chemical energy into electrical energy
- There are two types of batteries: primary batteries (disposable batteries), which are designed to be used once and discarded, and secondary batteries (rechargeable batteries), which are designed to be recharged and used multiple times. Batteries come in many sizes, from miniature cells used to power hearing aids and wristwatches to battery banks the size of rooms that provide standby power for telephone exchanges and computer data centers

AUTOMOTIVE BATTERY

- An automotive battery is a type of rechargeable battery that supplies electric energy to an automobile. Usually this refers to an **SLI** battery (**starting, lighting, ignition**) to power the starter motor, the lights, and the ignition system of a vehicle's engine.
- Automotive SLI batteries are usually lead-acid type, and are made of six galvanic cells in series to provide a 12 volt system. Each cell provides 2.1 volts for a total of 12.6 volt at full charge. Heavy vehicles such as highway trucks or tractors, often equipped with diesel engines, may have two batteries in series for a 24 volt system, or may have parallel strings of batteries.

LEAD ACID BATTERY

LEAD ACID BATTERY



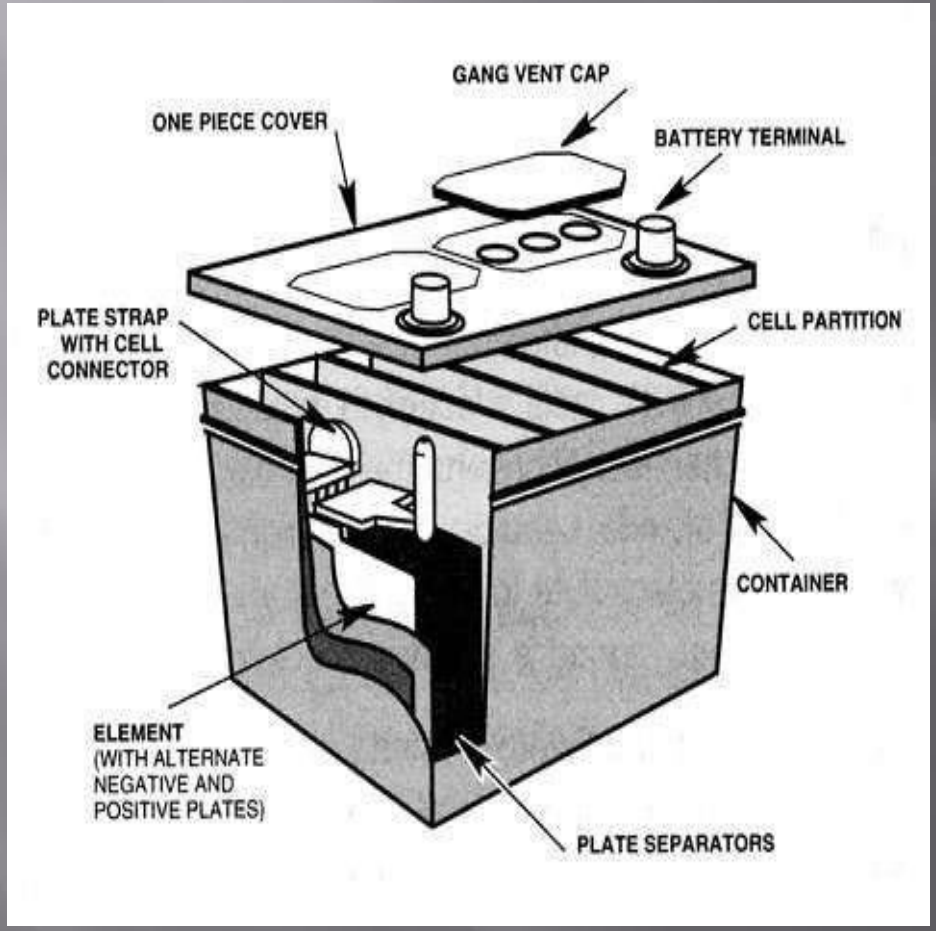
- Lead-acid batteries store energy using a reversible chemical reaction between lead plates and dilute sulphuric acid (electrolyte). There are three basic types of lead acid battery - starter batteries: used to start engines in cars etc, deep-cycle batteries: used in renewable energy applications and camping etc, and marine batteries: used both for starting and for deep cycle applications
- The deep cycle battery has less instant energy but greater long-term energy delivery. Deep cycle batteries have thicker plates and can survive a number of discharge cycles.

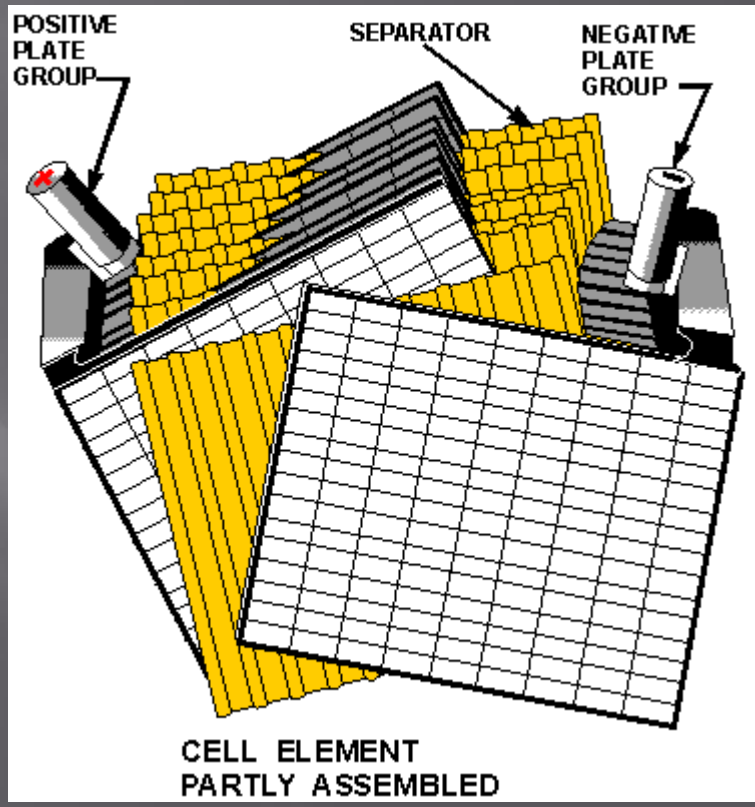
CONSTRUCTION

- In the battery, several similar plates are properly spaced and welded, or lead-burned, to a strap. This forms a plate group.
- Plates of two types are used, one for the positive plate group, the other for the negative plate group. A positive plate group is nested with a negative plate group.
- Separators are placed between the plates to form an element The separators hold the plates apart so that they do not touch. At the same time the separators are porous enough to permit liquid in circulate between the plates. Wooden sheets, spun glass matted into sheets and porous sponge rubber sheets have been used as separators. Late model batteries have separators made of acid-resistant polyvinyl chloride on polyethylene saturated cellulose.

- An effective separator must possess a number of mechanical properties; such as permeability, porosity, pore size distribution, specific surface area, mechanical design and strength, electrical resistance, ionic conductivity, and chemical compatibility with the electrolyte. In service, the separator must have good resistance to acid and oxidation. The area of the separator must be a little larger than the area of the plates to prevent material shorting between the plates. The separators must remain stable over the battery's operating temperature range.
- In many batteries, the cover has openings through which liquid can be added water; the filler plug or vent caps are removed. After the liquid is added and the battery is given an initial charge. It is ready for operation. Maintenance-free batteries have no vent caps

Various components in a battery





ELECTROCHEMISTRY

ELECTROCHEMISTRY

- Postive plate: Lead di oxide (PbO2)
- Negative plate: Spongy lead
- Electrolyte solution :35% sulfuric acid 65% water

Discharge:

Fully Discharged:

Two identical lead sulfate plates

In the discharged state both the positive and negative plates become lead(II) sulfate (PbSO4) and the electrolyte loses much of its dissolved sulfuric acid and becomes primarily water

Negative plate reaction: $Pb(s) + HSO^{-}_{4}(aq) \rightarrow PbSO_4(s) + H^{+}(aq) + 2\text{-}e$

Positive plate reaction: $PbO_2(s) + HSO^{-}_{4}(aq) + 3H^{+}(aq) + 2\text{-}e \rightarrow PbSO_4(s) + 2H_2O(l)$

Charging

Fully Charged: Lead and Lead Oxide plates

In the charged state, each cell contains negative plates of elemental lead (Pb) and positive plates of lead(IV) oxide (PbO_2) in an electrolyte of approximately 33.5% v/v (4.2 Molar) sulfuric acid (H_2SO_4). The charging process is driven by the forcible removal of electrons from the negative plate and the forcible introduction of them to the positive plate.

Negative plate reaction:

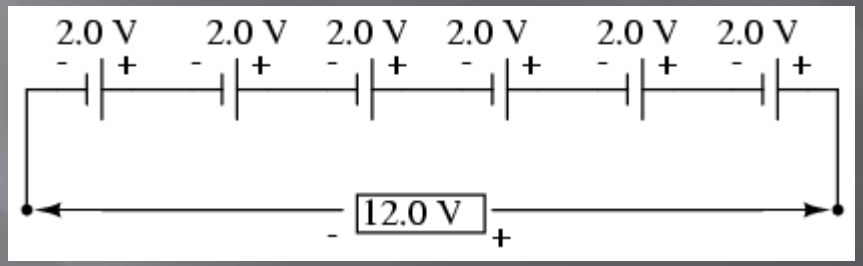
$$PbSO_4(s) + H^+(aq) + 2\text{-}e \rightarrow Pb(s) + HSO^-_4(aq)$$

Positive plate reaction:

$$PbSO_4(s) + 2H_2O(l) \rightarrow PbO_2(s) + HSO^-_4(aq) + 3H^+(aq) + 2\text{-}e$$

Adding up of battery voltages

- A battery is a cluster of cells connected together for greater voltage and/or current capacity. Cells connected together in series (polarities aiding) results in greater total voltage. Physical cell size impacts cell resistance, which in turn impacts the ability for the cell to supply current to a circuit. Generally, the larger the cell, the less its internal resistance. Cells connected together in parallel results in less total resistance, and potentially greater total current.
- The total voltage of a battery is the sum of all cell voltages. A typical automotive lead-acid battery has six cells, for a nominal voltage output of 6 x 2.0 or 12.0 volts:



BATTERY RATINGS

- **Cranking amperes (CA),** also sometimes referred to as marine cranking amperes (MCA), is the amount of current a battery can provide at 32 F (0 C). The rating is defined as the number of amperes a lead-acid battery at that temperature can deliver for 30 seconds and maintain at least 1.2 volts per cell (7.2 volts for a 12 volt battery).
- **Cold cranking amperes (CCA)** is the amount of current a battery can provide at 0 F (−18 C). The rating is defined as the current a lead-acid battery at that temperature can deliver for 30 seconds and maintain at least 1.2 volts per cell (7.2 volts for a 12-volt battery). It is a more demanding test than those at higher temperatures.
- **Hot cranking amperes (HCA)** is the amount of current a battery can provide at 80 F (26.7 C). The rating is defined as the current a lead-acid battery at that temperature can deliver for 30 seconds and maintain at least 1.2 volts per cell (7.2 volts for a 12-volt battery).

- **Reserve capacity minutes (RCM),** also referred to as reserve capacity (RC), is a battery's ability to sustain a minimum stated electrical load; it is defined as the time (in minutes) that a lead-acid battery at 80 F (27 C) will continuously deliver 25 amperes before its voltage drops below 10.5 volts.
- Battery Council International group size (BCI) specifies a battery's physical dimensions, such as length, width, and height. These groups are determined by the Battery Council International organization.
- **Ampere-hours (A·h)** is a measure of electrical charge that a battery can deliver. This quantity is one indicator of the total amount of charge that a battery is able to store and deliver at its rated voltage. Its value is the product of the discharge-current (in amperes), multiplied by the duration (in hours) for which this discharge-current can be sustained by the battery

MAINTENANCE

Fluid level

- Car batteries using lead-antimony plates would require regular watering to replace water lost due to electrolysis on each charging cycle. Modern car batteries have reduced maintenance requirements, and may not provide caps for addition of water to the cells.. Prolonged overcharging or charging at excessively high voltage causes some of the water in the electrolyte to be broken up into hydrogen and oxygen gases, which escape from the cells. If the electrolyte liquid level drops too low, the plates are exposed to air, lose capacity, and are damaged. The sulfuric acid in the battery normally does not require replacement since it is not consumed even on overcharging. Impurities or additives in the water will reduce the life and performance of the battery. Manufacturers usually recommend use of demineralized or distilled water, since even potable tap water can contain high levels of minerals.

CHARGING

- In normal automotive service the vehicle's charging system powers the vehicle's electrical systems and restores charge used from the battery during engine cranking. When installing a new battery or recharging a battery that has been accidentally discharged completely, one of several different methods can be used to charge it. The most gentle of these is called trickle charging. Other methods include slow-charging and quick-charging
- The voltage regulator of the charge system does not measure the relative currents charging the battery and for powering the car's loads. The charge system essentially provides a fixed voltage of typically 13.8 to 14.4 V (Volt), A discharged battery draws a high charge current of typically 20 to 40 A (Ampere). As the battery gets charged the charge current typically decreases to 2—5 A. A high load results when multiple high-power systems such as ignition, radiator fan, heater blowers, lights and entertainment system are running. In this case, the battery voltage will begin to decrease unless the engine is running at a higher rpm and the alternator/generator is delivering at least enough current to power the load.

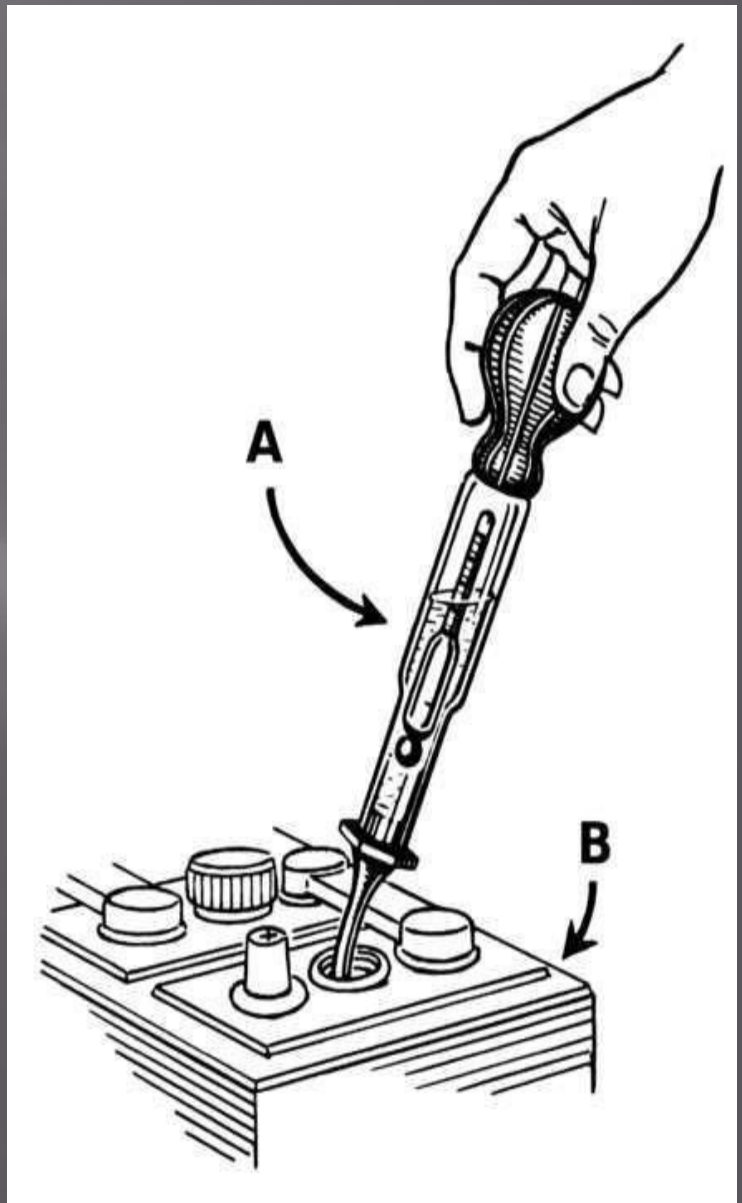
- In emergencies a vehicle can be jump started by the battery of another vehicle or by a portable battery booster.
- Whenever the car's charge system is inadequate to fully charge the battery, a battery charger can be used. Simple chargers do not regulate the charge current, and the user needs to stop the process or lower the charge current to prevent excessive gassing of the battery. More elaborate chargers, in particular those implementing the 3-step charge profile, also referred to as IUoU, charge the battery fully and safely in a short time without requiring user intervention. Desulfating chargers are also commercially available for charging all types of lead-acid batteries.

BATTERY BEING JUMP STARTED

an automotive battery discharged will shorten its life, or make it unusable if left for a long time (usually several years); sulfation eventually becomes irreversible by normal charging. Batteries in storage may be monitored and periodically charged, or attached to a "float" charger to retain their capacity. Batteries are prepared for storage by charging and cleaning deposits from the posts. Batteries are stored in a cool, dry environment for best results since high temperatures increase the self discharge rate and plate corrosion.

MEASUREMENT OF CHARGE

- Because the electrolyte takes part in the charge-discharge reaction, this battery has one major advantage over other chemistries. It is relatively simple to determine the state of charge by merely measuring the specific gravity (S.G.) of the electrolyte**, It is the weight of the sulfuric acid-water mixture compared to an equal volume of water.** the S.G. falling as the battery discharges. Some battery designs include a simple hydrometer using colored floating balls of differing density. When used in diesel-electric submarines, the S.G. was regularly measured and written on a blackboard in the control room to indicate how much longer the boat could remain submerged



CONNECTED. IT CAN BE APPROXIMATELY RELATED TO THE CHARGE OF THE BATTERY

Open circuit voltage for various charges

Open circuit voltage		Approximate charge	Relative acid density
12 V	6 V		
12.60 V	6.32 V	100%	1.265 g/cm^3
12.35 V	6.22 V	75%	1.225 g/cm^3
12.10 V	6.12 V	50%	1.190 g/cm^3
11.95 V	6.03 V	25%	1.155 g/cm^3
11.70 V	6.00 V	0%	1.120 g/cm^3

Reasons for battery failure

Common battery faults include:

- Shorted cell due to failure of the separator between the positive and negative plates
- Shorted cell or cells due to build up of shed plate material below the plates of the cell
- Broken internal connections due to corrosion
- Broken plates due to vibration and corrosion
- Low electrolyte level
- Cracked or broken case
- Broken terminals
- Sulfation after prolonged disuse in a low or zero charged state

Casestudy

delco

Casestudy

IDNS40 BATTERY USED IN MARUTI 800 AND OMNI

Old JIS Battery Type	New ACDelco Part Number	Capacity (AH)		CCA	RC	Max Overall dimensions (mm)			Approx. Weight (Kg)		Application
		5 Hr. Rate	20 Hr. Rate	(Amps)18° C	(Min.)25° C	L	W	H	Dry	Filled	
NS40	IDNS40	26	32	225	45	197	129	227	7.0	10.0	Maruti-800, Maruti Omni, Maruti 800 DX

Plate Details	IDNS40
Positive Plates	24
Negative Plates	30

Delco IDN150 BATTERY USED IN TATA HCVS

Old JIS Battery Type	New ACDelco Part Number	Capacity (AH)		CCA	RC	Max Overall dimensions (mm)			Approx. Weight (Kg)		Application
		5 Hr. Rate	20 Hr. Rate	(Amps)18° C	(Min.)25° C	L	W	H	Dry	Filled	
N150	IDN150	120	150	690	294	508	220	213			TATA HCV, Ashok Leyland Dumpers, Escor JCB Loaders, Fork Lifts, Inverter Application (-— KVA)

Plate Details	IDN150
Positive Plates	72
Negative Plates	78

ELECTRIC VEHICLE BATTERY

- An electric vehicle battery (EVB) or traction battery is a rechargeable battery used for propulsion of battery electric vehicles (BEVs). Traction batteries are used in forklifts, electric Golf carts,, and other electric vehicles.
- They are designed to give power over sustained periods of time
- Batteries for electric vehicles are characterized by their relatively high power-to-weight ratio, energy to weight ratio and energy density; smaller, lighter

Types of batterys used in electric vehicles

- Lead-acid
- Nickel metal hydride
- Zebra
- Lithium ion

Lead-acid batteries are the most available and inexpensive. Such conversions generally have a range of 30 to 80 km Production EVs with lead-acid batteries are capable of up to 130 km (80 mi) per charge.

NiMH batteries have higher energy density than lead-acid; prototype EVs deliver up to 200 km (120 mi) of range.

New lithium-ion battery-equipped EVs provide 320–480 km (200–300 mi) of range per charge. Lithium is also less expensive than nickel.

Nickel-zinc battery are cheaper and lighter than Nickel-cadmium batteries. They are also cheaper but heavier than Lithium-Ion batteries

high power Ni-MH Battery of Toyota NHW20 Prius, Japan

Nissan Leaf's lithium-ion battery pack.

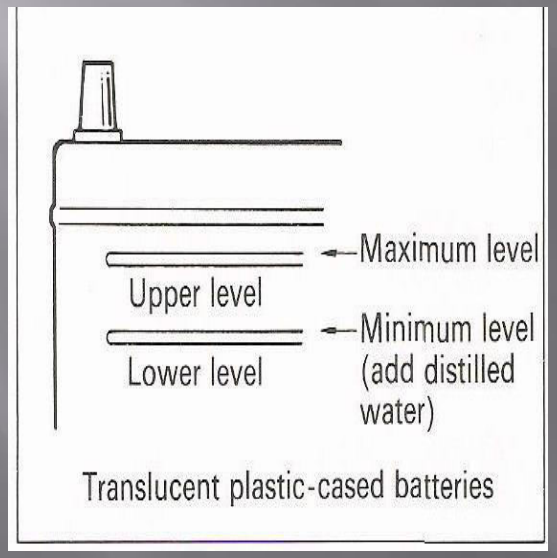
Battery Maintenance

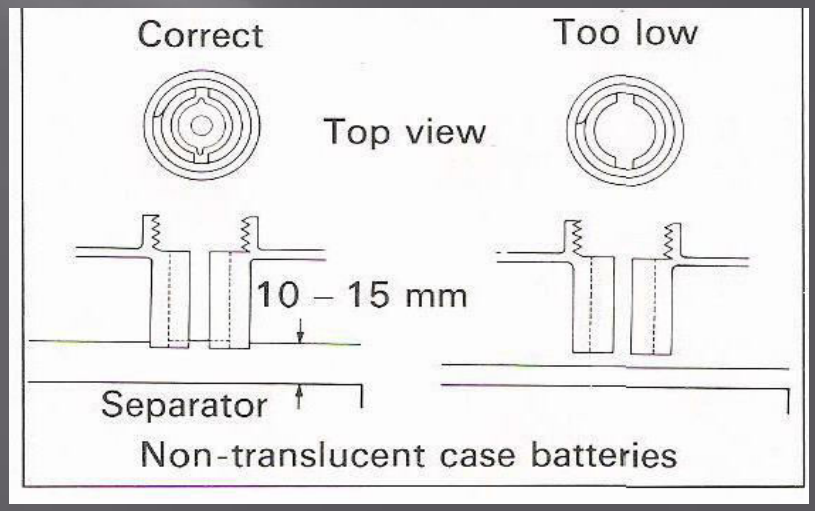
1.Visual inspection

2. Cleaning the battery top, terminals and cable clamps.
3. Testing battery
4. Charging battery

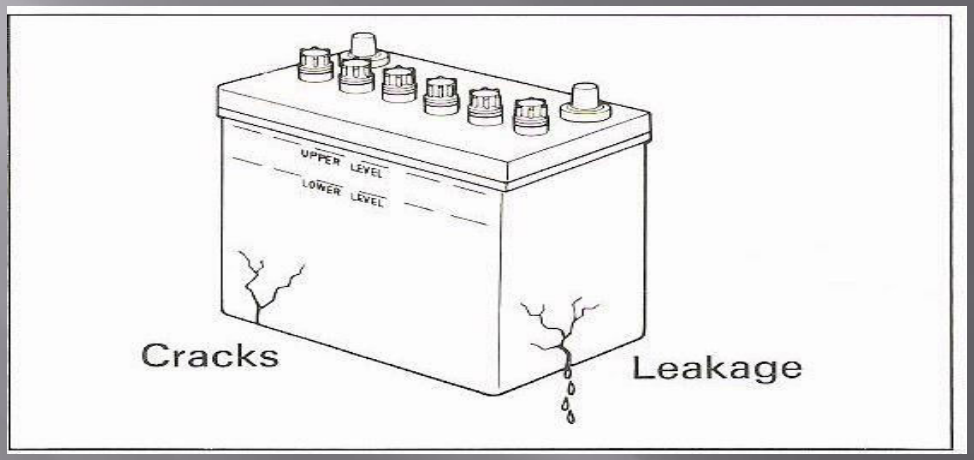
Visual inspection

1. CHECK BATTERY ELECTROLYTE LEVEL

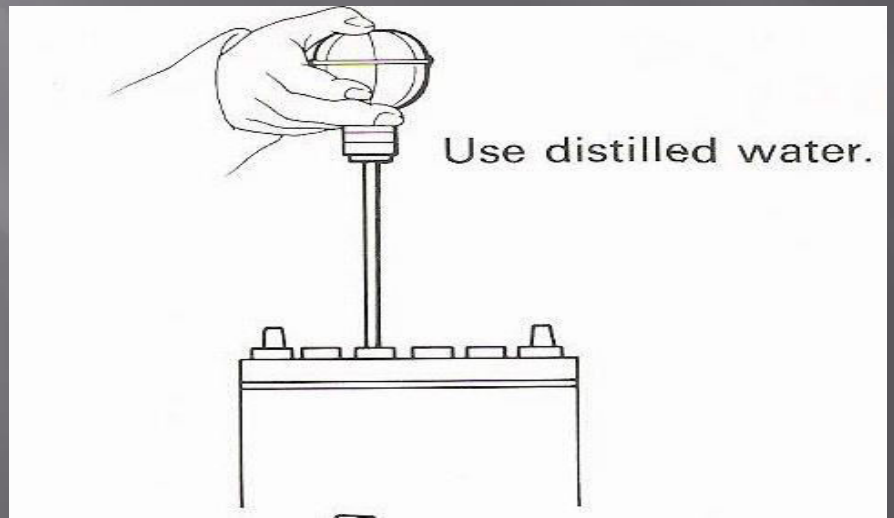




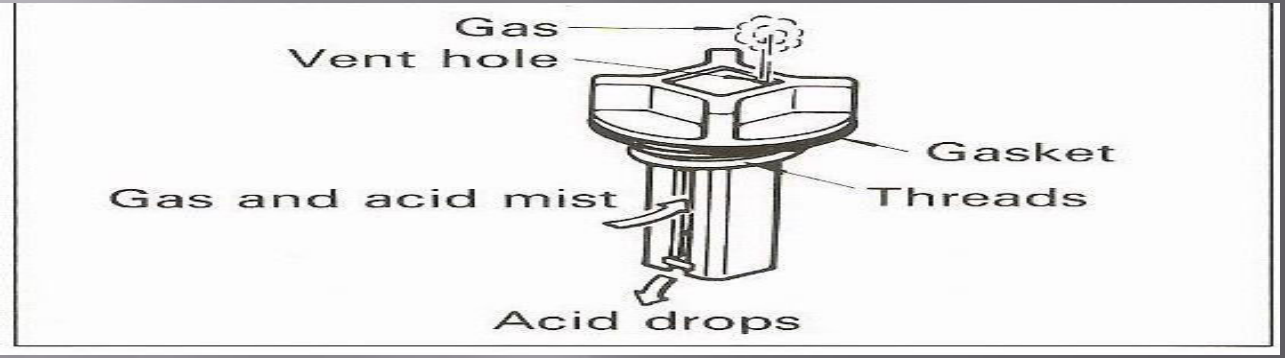
2. CHECK BATTERY CASE FOR CRACKS



IF BATTERY ELECTROLYTE LEVEL IS LOW,ADD DISTILLED WATER TO SPECIFIED LEVEL



4.CHECK BATTERY VENT PLUGS FOR DAMAGE OR CLOGGED BENT HOLES



Cleaning the battery top, terminals and cable clamps

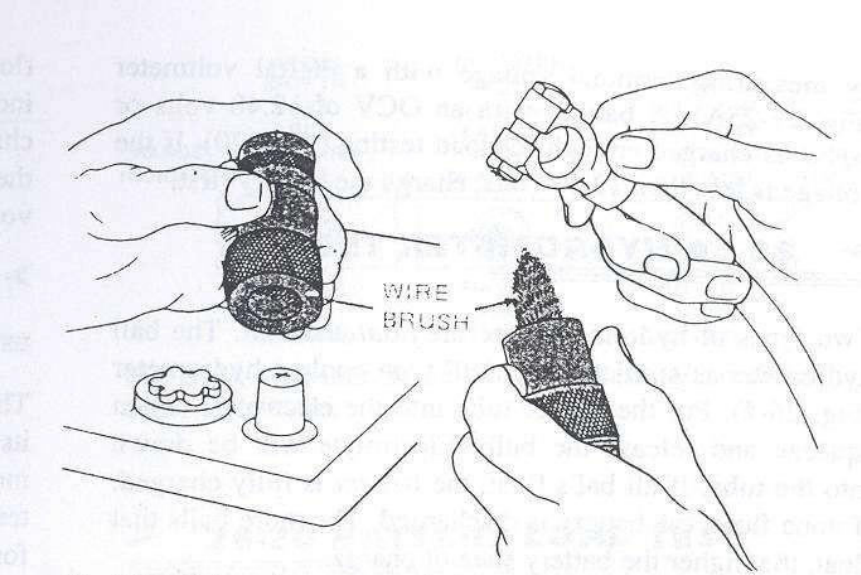


Fig. 28-6 Using a battery-terminal brush to clean the battery terminal posts and cable clamps. (*Buick Division of General Motors Corporation*)

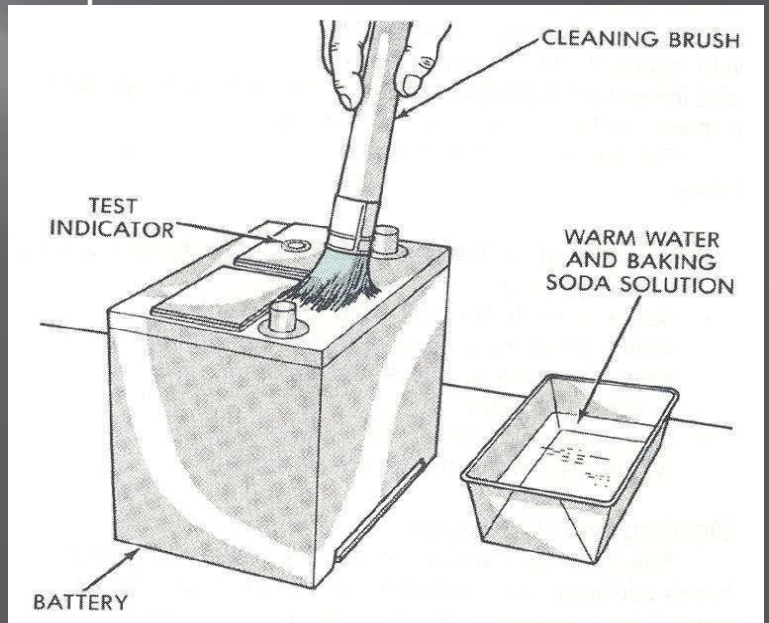


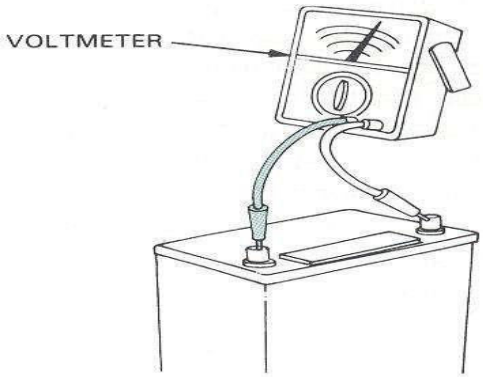
Figure 26-2. A solution of baking soda and water can be used to clean corrosion from a battery. Do not allow the solution to enter the battery cells. (Chrysler)

Battery Testing

Testing determines if the battery:

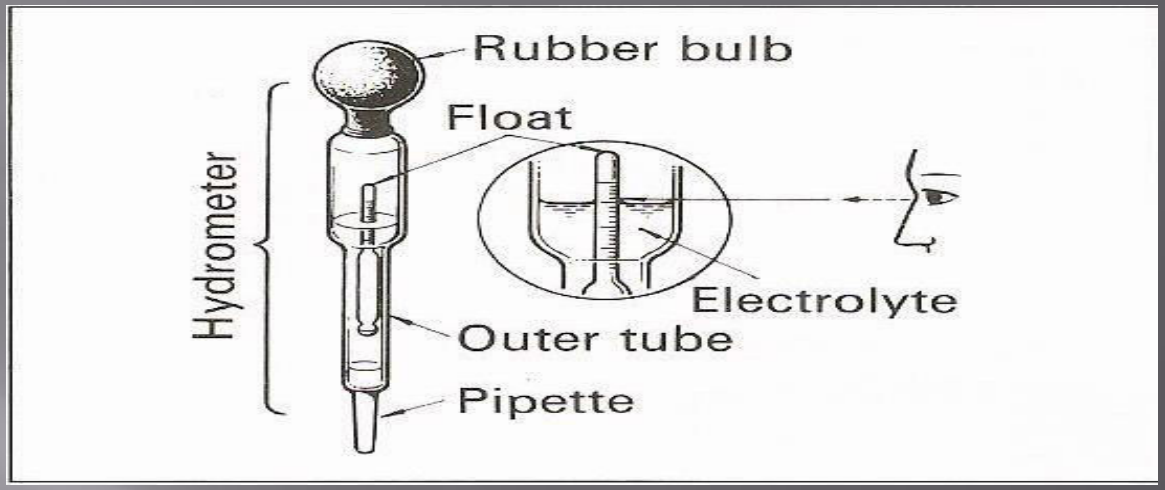
3. Is in good condition
4. Needs recharging
5. Is defective and should be discarded

OPEN CIRCUIT VOLTAGE TEST



BATTERY OPEN CIRCUIT VOLTAGE	
Open Circuit Volts	**Percent Charge**
11.7 volts or less	0%
12.0	25%
12.2	50%
12.4	75%
12.6 or more	100%

HYDROMETER TEST



Measurement Result	Possible Cause
Specific gravity too low in all cells alike.	Undercharged ... Charging system trouble, driving distance or speed too low Overcharged ... Overload, insufficient generator capacity (Leaking ... Lack of cleaning, too much electrolyte)
Specific gravity too low in some cells.	Internal shorts ... lack of electrolyte Impurities in cells ... excessive self-discharge
Specific gravity too high.	Sulfuric acid rather than water has been added

AUTOMOBILE ENGINEERING

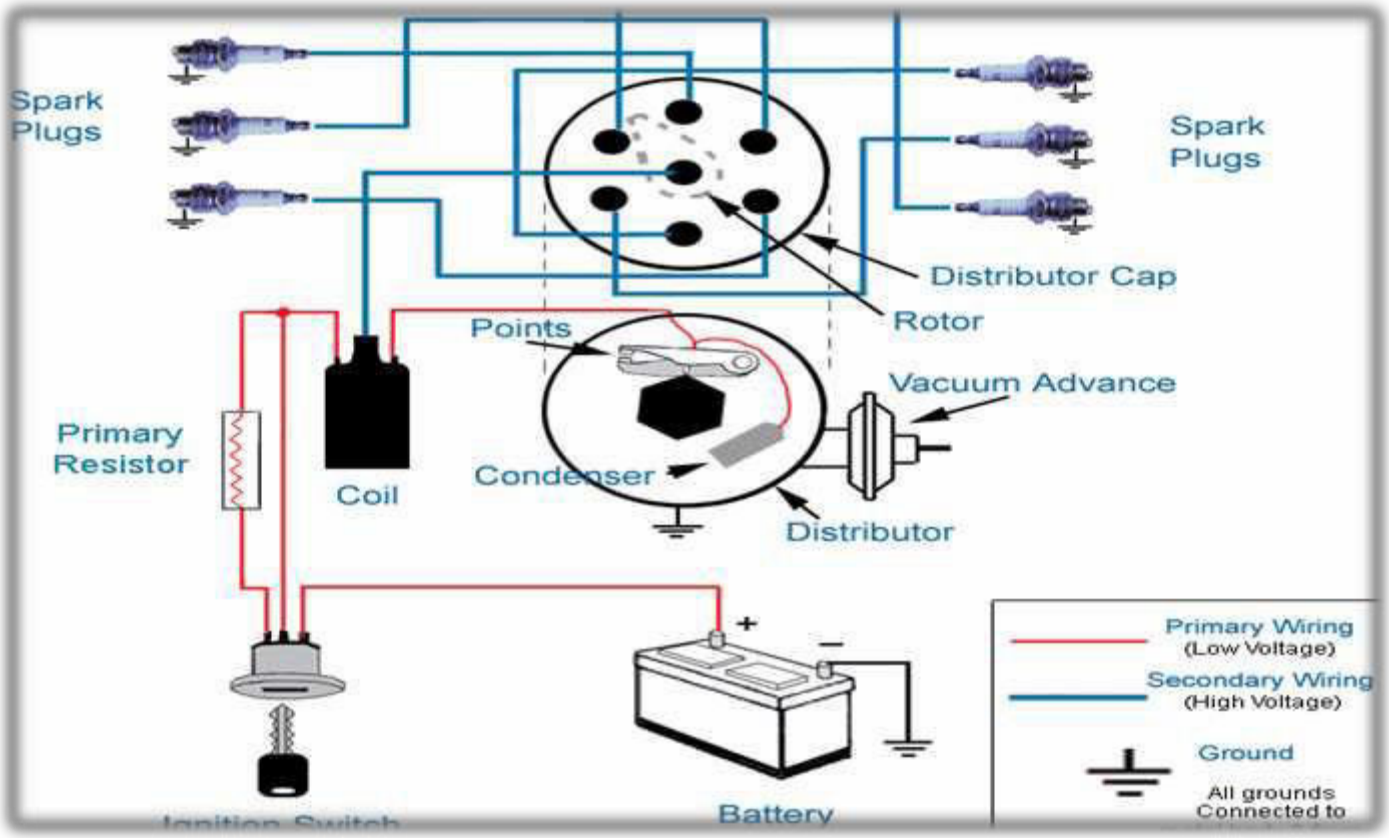
PRESENTATION ON

BATTERY & MAGNETO IGNITION

TYPES OF SPARK IGNITION SYSTEM

- Battery
- Magneto

BATTERY IGNITION SYSTEM



IGNITION SYSTEM PART

BATTERY

IGNITION SWITCH

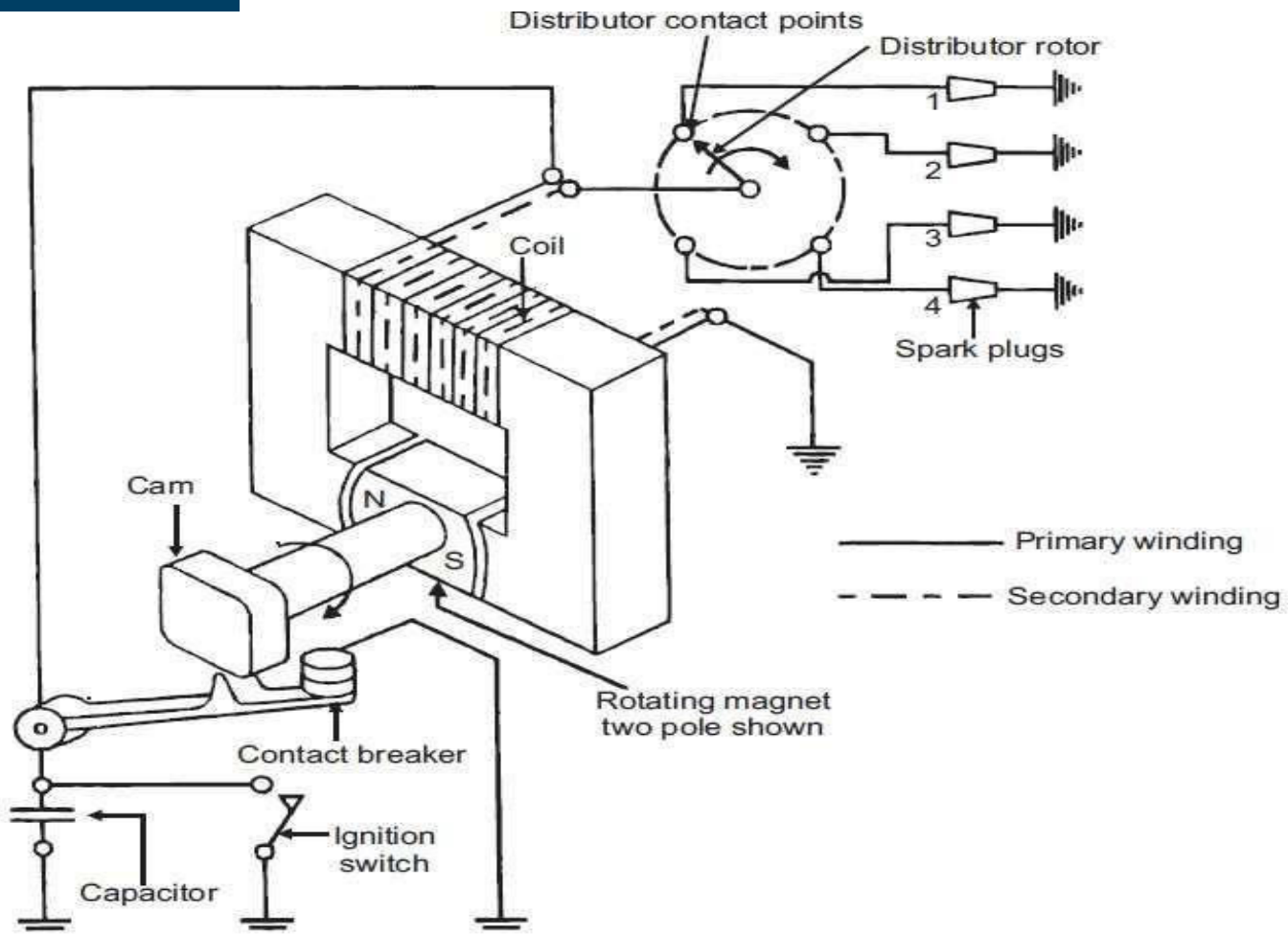
IGNITION COIL

SWITCHING DEVICE

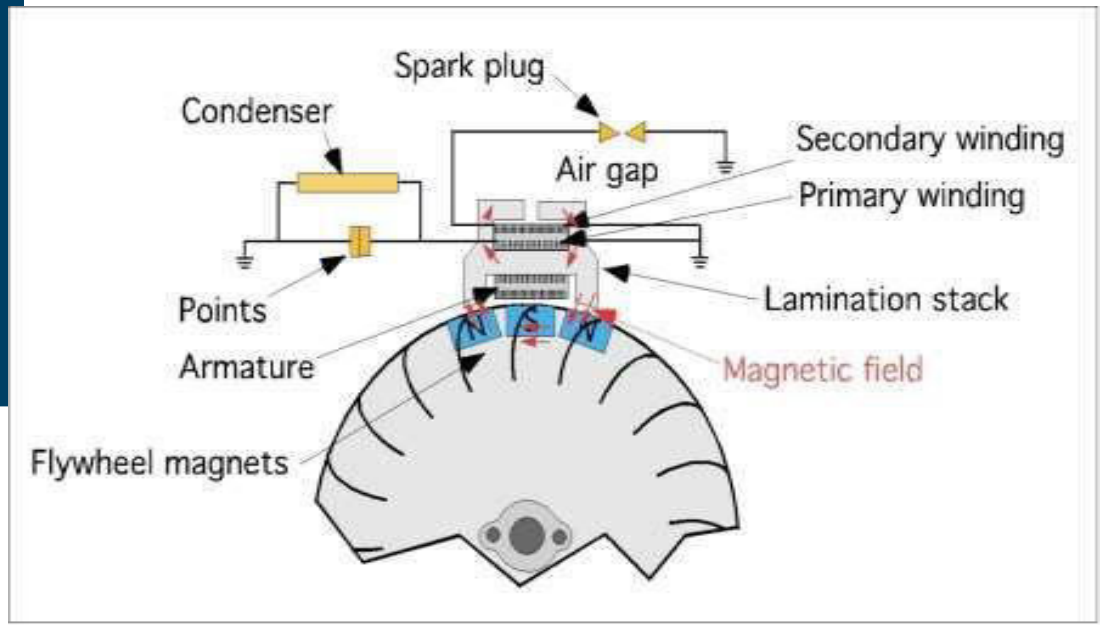
SPARK PLUG

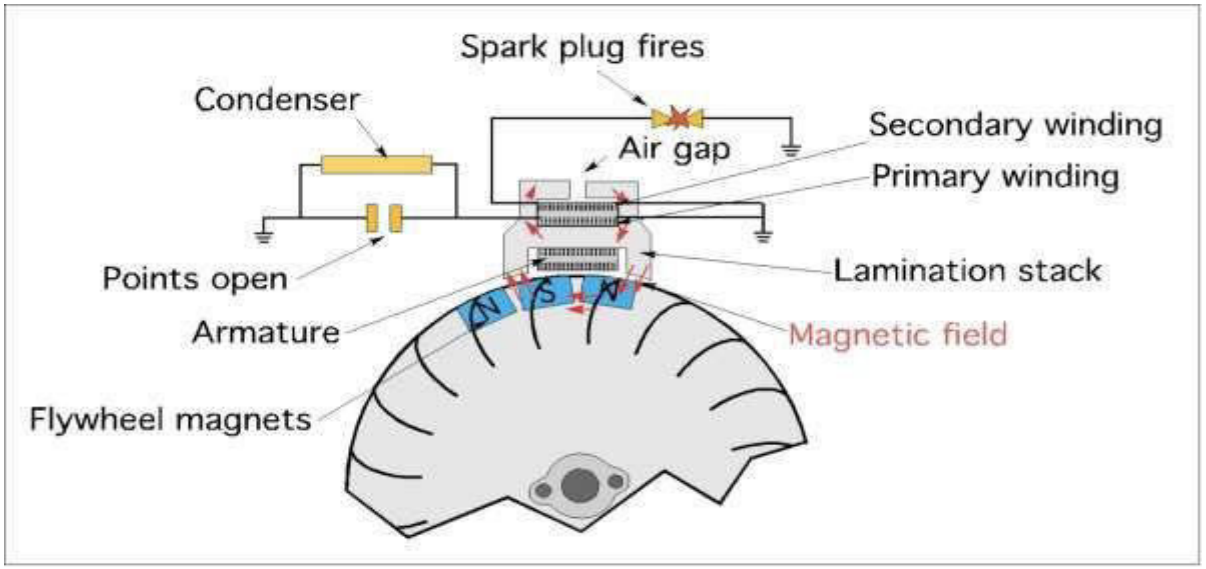
IGNITION SYSTEM WIRES

MAGNETO IGNITION SYSTEM



WORKING


Spark plug
Condenser
Air gap
Secondary winding
Primary winding
Points
Lamination stack
Armature
Magnetic field
Flywheel magnets
N
S
N


Spark plug fires
Condenser
Air gap
Secondary winding
Primary winding
Points open
Lamination stack
Armature
Magnetic field
Flywheel magnets
N
S
N

COMPERISON BETWEEN BATTERY & MAGNETO IGNITION SYSTEM

Battery Ignition System	Magneto Ignition System
Battery is necessary. Difficult to start the engine when battery is discharged.	No battery is needed and therefore there is no problem of battery discharge.
Maintenance problems are more due to battery.	Maintenance problems are less since there is no battery.
Current for primary circuit is obtained from the battery.	The required electric current is generated by the magneto.
A good spark is available at the spark plug even at low speed.	During starting, quality of spark is poor due to low speed.
Efficiency of the system decreases with the reduction in spark intensity as engine speed rises.	Efficiency of the system improves as the engine speed rises due to high intensity spark.
Occupies more space.	Occupies less space.
Commonly employed in cars and light commercial vehicles.	Mainly used in racing cars and two wheelers.

ALTERNATOR

CONTENT

- Definition and Types of Alternator
- Working Principle of Alternator
- Construction of Alternator
- Armature Reaction in Alternator or Synchronous Generator
- Armature Winding of Alternator
- Rating of Alternator
- Application of Induction Generator

DEFINITION AND TYPES OF ALTERNATOR

- An alternator is an electrical generator that converts mechanical energy to electrical energy in the form of alternating current. Most alternators use a rotating magnetic field with stationary armature.
- It is also known as synchronous generator.

According to application

- Automotive type - used in modern automobile.
- Diesel electric locomotive type - used in diesel electric multiple unit.
- Marine type - used in marine.
- Brush less type - used in electrical power generation plant as main source of power.
- Radio alternators - used for low brand radio frequency transmission.

According to their design

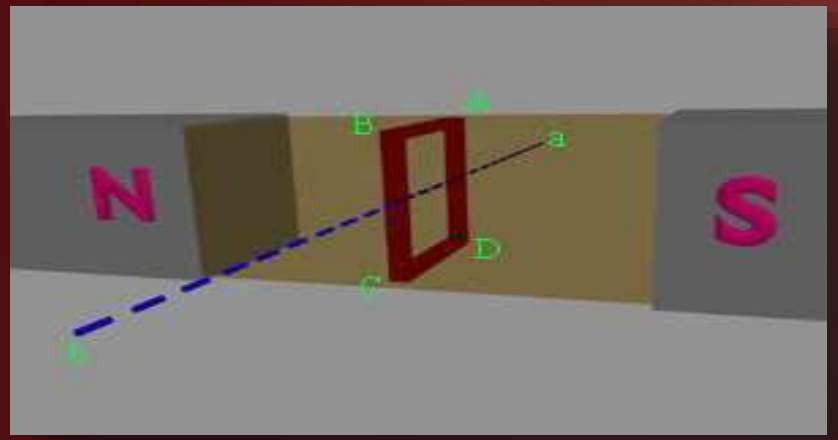
- Salient pole type.
- Cylindrical rotor type.

WORKING PRINCIPLE OF ALTERNATOR

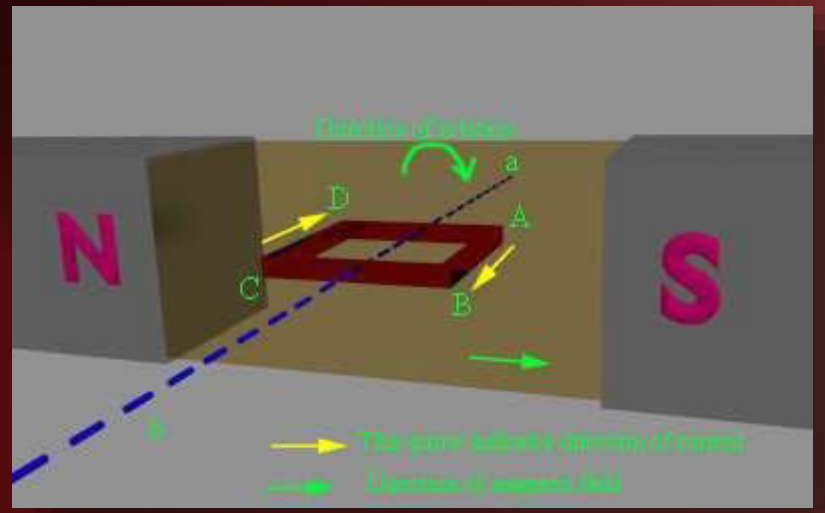
- The working principle of alternator depends upon Faraday's law of electromagnetic induction which says the current is induced in the conductor inside a magnetic field when there is a relative motion between that conductor and the magnetic field.

#Working

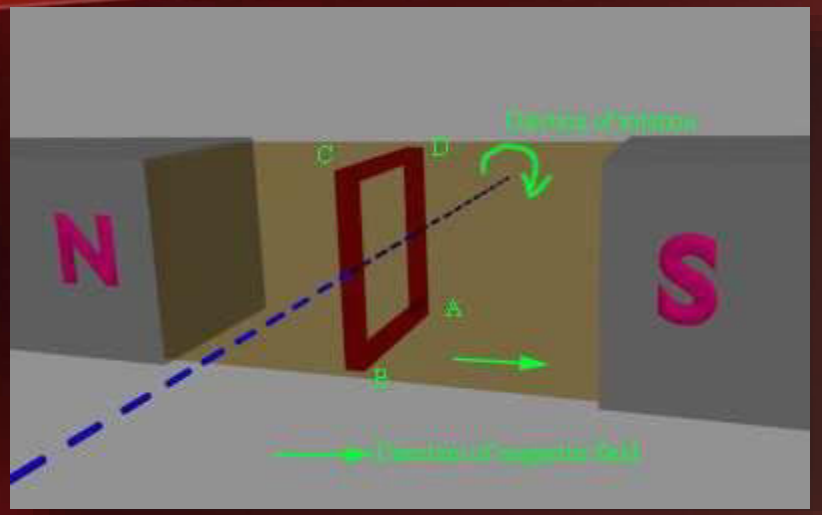
1. For understanding working of alternator let's assume a single rectangular turn placed in between two opposite magnetic pole as shown.



- The single turn loop ABCD starts rotating clockwise against axis a-b

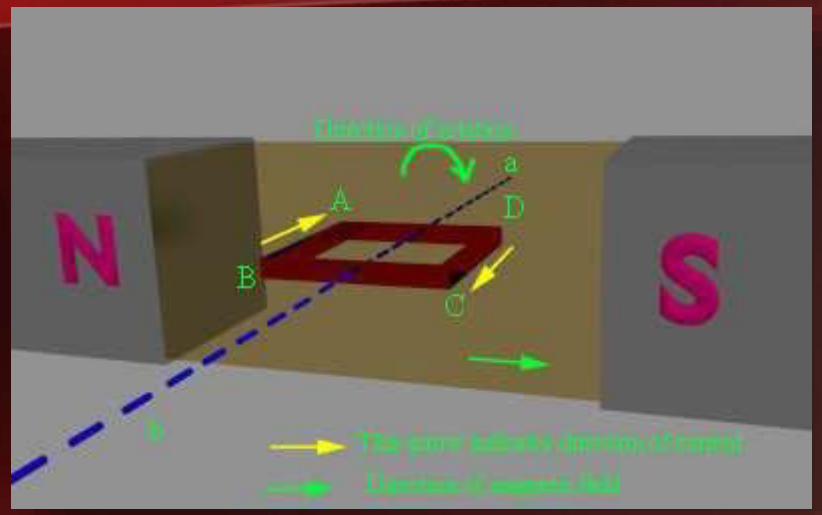


- After 90° rotation the side AB or conductor AB of the loop comes in front of S-pole and conductor CD comes in front of N-pole.
- As per Fleming right hand rule the direction of this current will be from A to B. At the same time conductor CD comes under N pole and here also if we apply Fleming right hand rule we will get the direction of induced current and it will be from C to D.



- Now after clockwise rotation of another 90° the turn ABCD comes at vertical position as shown below. At this position tangential motion of conductor AB and CD is just parallel to the magnetic flux lines, hence there will be no flux cutting that is no current in the conductor.

- While the turn ABCD comes from horizontal position to vertical position, angle between flux lines and direction of motion of conductor, reduces from 90° to 0° and consequently the induced current in the turn is reduced to zero from its maximum value.

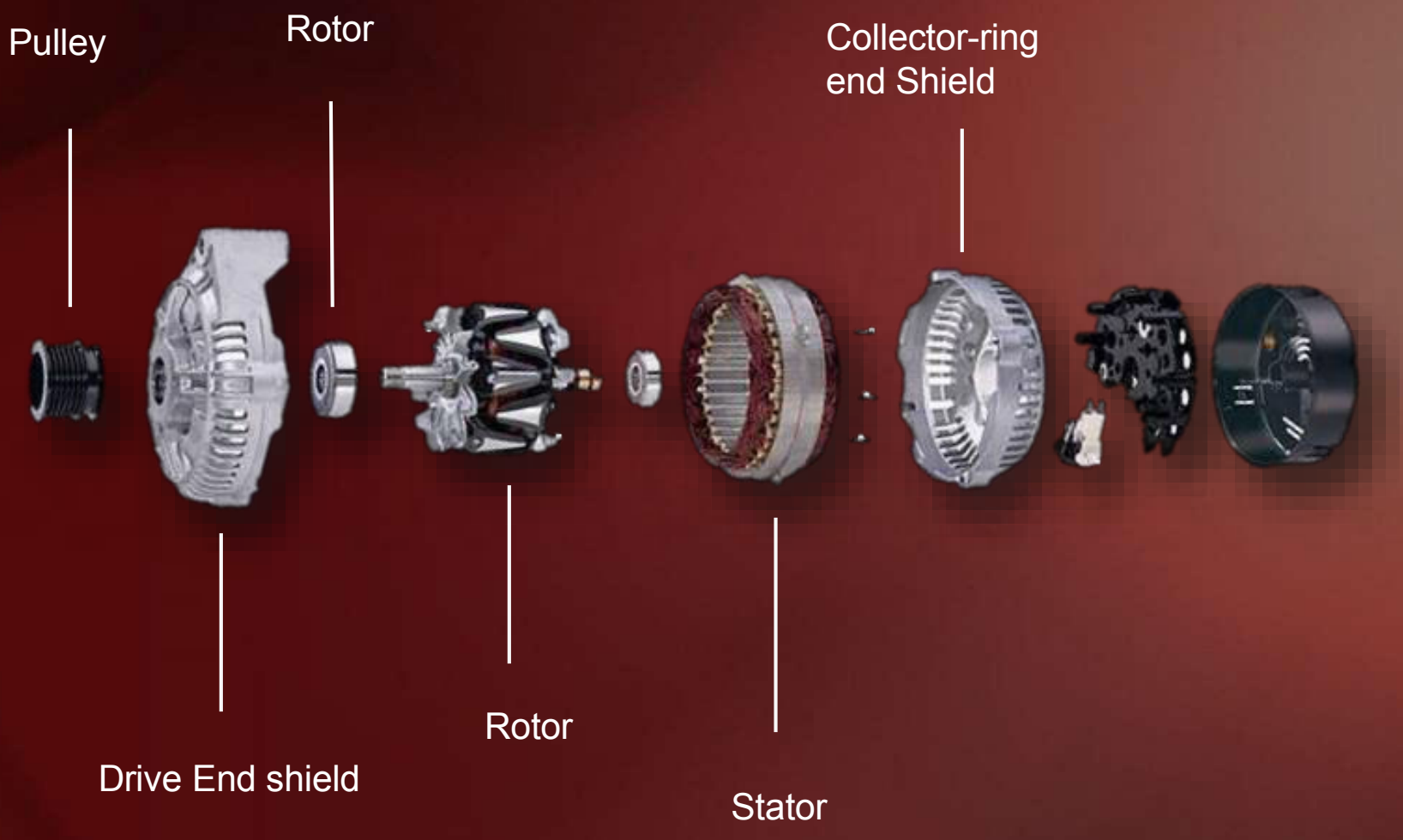


- As at this position the turn comes at horizontal position from its vertical position, the current in the conductors comes to its maximum value from zero. That means current is circulating in the close turn from point B to A, from A to D, from D to C and from C to B

- During every full revolution of the turn, the current in the turn gradually reaches to its maximum value then reduces to zero and then again it comes to its maximum value but in opposite direction and again it comes to zero.

- In this way the current completes one full sine wave form during each 360° revolution of the turn. Thus an alternating current is produced in a turn is rotated inside a magnetic field. From this, we come to the actual working principle of alternator.

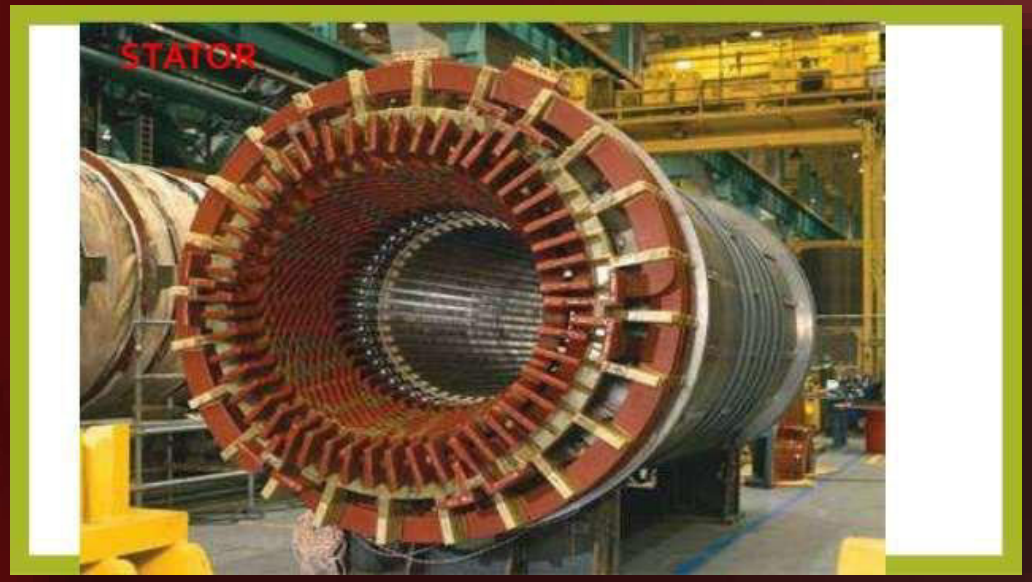
CONSTRUCTION OF ALTERNATOR



I. Stator

:

- Stator is the stationary part of the alternator and contains 3-phase armature windings. Stator core is built up of silicon steel laminations to reduce eddy current losses.
- The laminations are provided with slots on its inner periphery and are packed tightly together by cast iron frame.
- The three phase windings are placed in these slots and serves as the armature windings of the alternator.
- The armature windings are always connected in star and the neutral is connected to ground.



I. Rotor :

- The rotor is rotating part of the alternator. It carries a field winding which is supplied with dc current through two slip rings by a separate dc source.
- This dc source (exciter) is generally a small dc generator mounted on the shaft of the alternator.

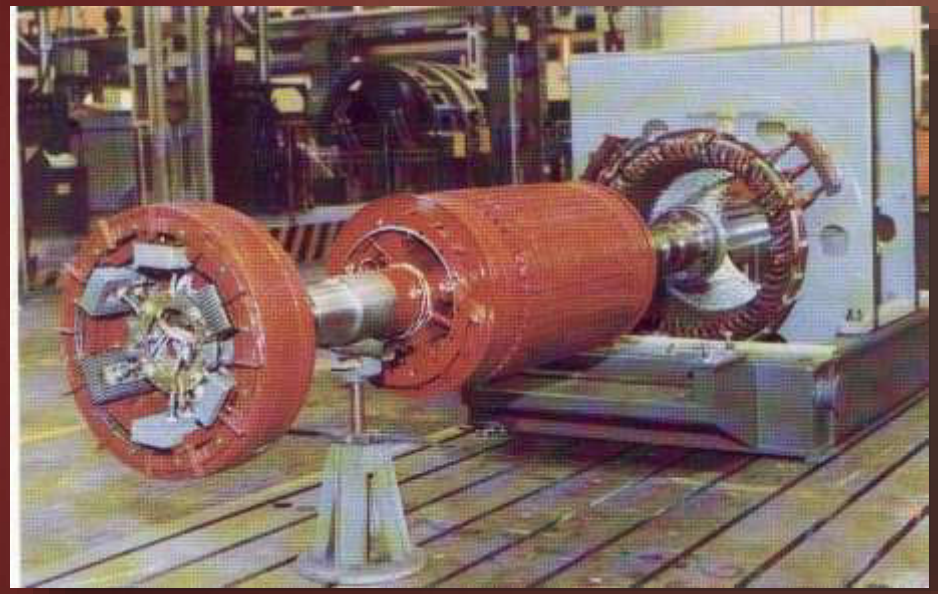
- There are two types of rotors :
  i. Salient pole type
  ii. Cylindrical rotor type

Salient pole type

- Salient means sticking out or projected out. A salient pole is a magnetic pole that is projected out of the rotor surface.
- The salient pole alternators are slow-speed machines, speed varying from 150 to 600 rpm. These alternators are driven by hydraulic turbines. They are also called water-wheel generators or hydro-generators
- Salient type rotor has non-uniform air-gap and two or four poles
- Salient-pole construction can not be made strong enough to withstand the mechanical stress at higher speeds

Cylindrical rotor type

- Cylindrical rotor is non-projecting surface type
- Cylindrical rotor type rotor has small diameter and large length
- Cylindrical rotor type rotor is used for high speed and has uniform air-gap
- Cylindrical rotors have four or more poles
- High speed alternators (1500 – 3000 rpm) are driven by steam turbines and use non-salient type rotors due to following reason :
  - Gives noiseless operation at high speeds
  - Flux is uniformly distributed along the periphery, so proper sine wave is obtained which gives better emf



ARMATURE REACTION IN ALTERNATOR OR SYNCHRONOUS GENERATOR

- Every rotating electrical machine works based on Faraday's law.
- Every electrical machine requires a magnetic field and a coil (Known as armature) with a relative motion between them.
- In case of an alternator, we supply electricity to pole to produce magnetic field and output power is taken from the armature. Due to relative motion between field and armature, the conductor of armatures cut the flux of magnetic field and hence there would be changing flux linkage with these armature conductor.
- According to Faraday's law of electromagnetic induction there would be an emf induced in the armature. Thus, as soon as the load is connected with armature terminals, there is an current flowing in the armature coil.
- As soon as current starts flowing through the armature conductor there is one reverse effect of this current on the main field flux of the alternator (or synchronous generator). This reverse effect is referred as armature reaction in alternator or synchronous generator.
-

- The armature reaction of alternator or synchronous generator, depends upon the phase angle between, stator armature current and induced voltage across the armature winding of alternator.
- The phase difference between these two quantities, i.e. Armature current and voltage may vary from - 90° to + 90° .
- If this angle is θ, then,

- When θ = 0 (Unity Power Factor)
- When θ = 90° (Lagging Zero Power Factor)
- When θ = - 90° (Leading Power Factor)

A. When **θ** = 0 (Unity Power Factor)

- At unity power factor, the angle between armature current I and induced emf E, is zero. That means, armature current and induced emf are in same phase

B. When **θ** = 90° (Lagging Zero Power Factor)

- At lagging zero electrical power factor, the armature current lags by 90° to induced emf in the armature. As the emf induced in the armature coil due to main field flux. The emf leads the main field flux by 90°.

C. When **θ** = - 90° (Leading Power Factor)

- At leading power factor condition, armature current I leads induced emf E by an angle 90°. Again, we have shown just, field flux leads, induced emf E by 90°.

ARMATURE WINDING OF ALTERNATOR

- Armature winding in an alternator may be either closed type open type. Closed winding forms star connection in armature winding of alternator.
- Common properties of armature winding.
  - First and most important property of an armature winding is, two sides of any coil should be under two adjacent poles. That means, coil span = pole pitch.
  - The winding can either be single layer or double layer.
  - Winding is so arranged in different armature slots, that it must produce sinusoidal emf.

- There are different types of armature winding used in alternator. The windings can be classified as
  - Single phase winding.
  - Lap winding
  - wave winding
  - Concentric winding
  - Full pitched coil winding
  - fractional pitched coil winding.

- Single phase and poly phase armature winding

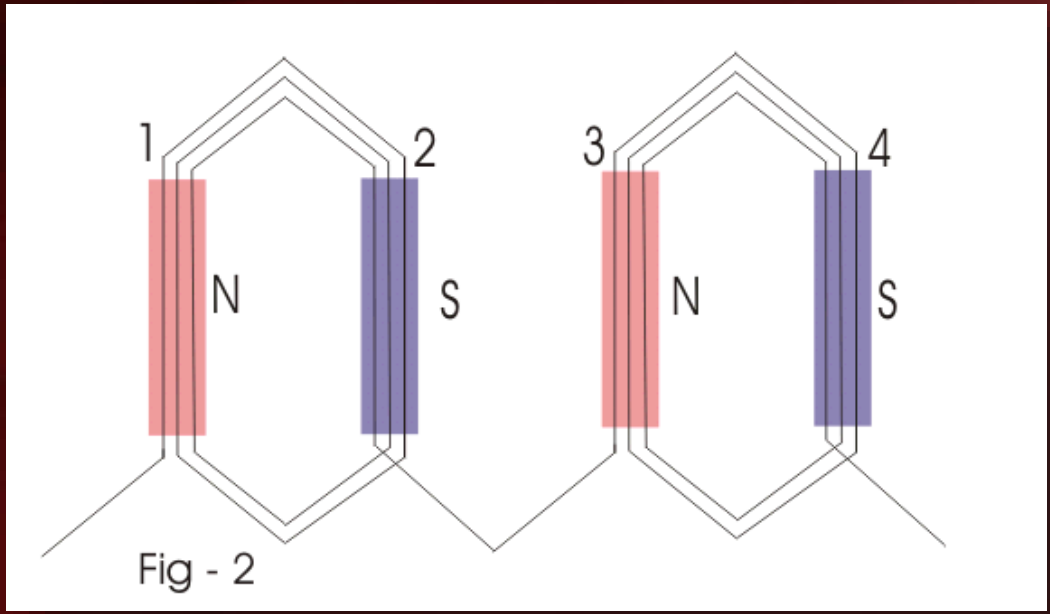


Fig - 2

- Lap winding

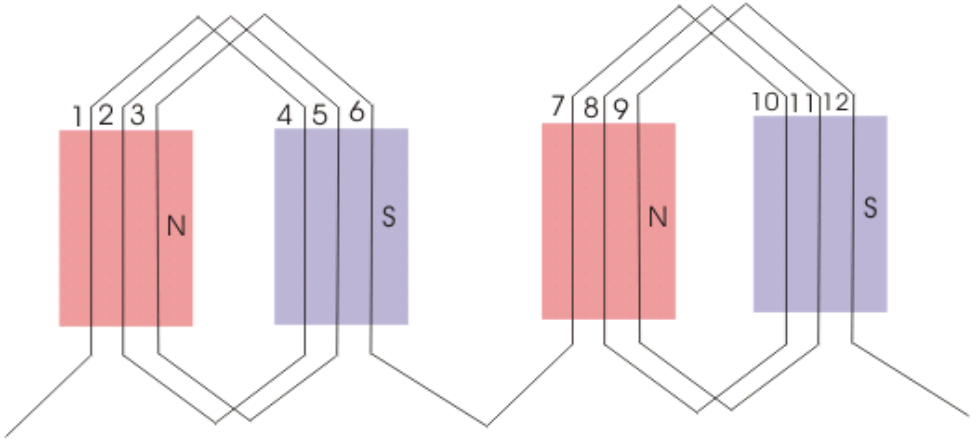


Fig - 4

- wave winding.

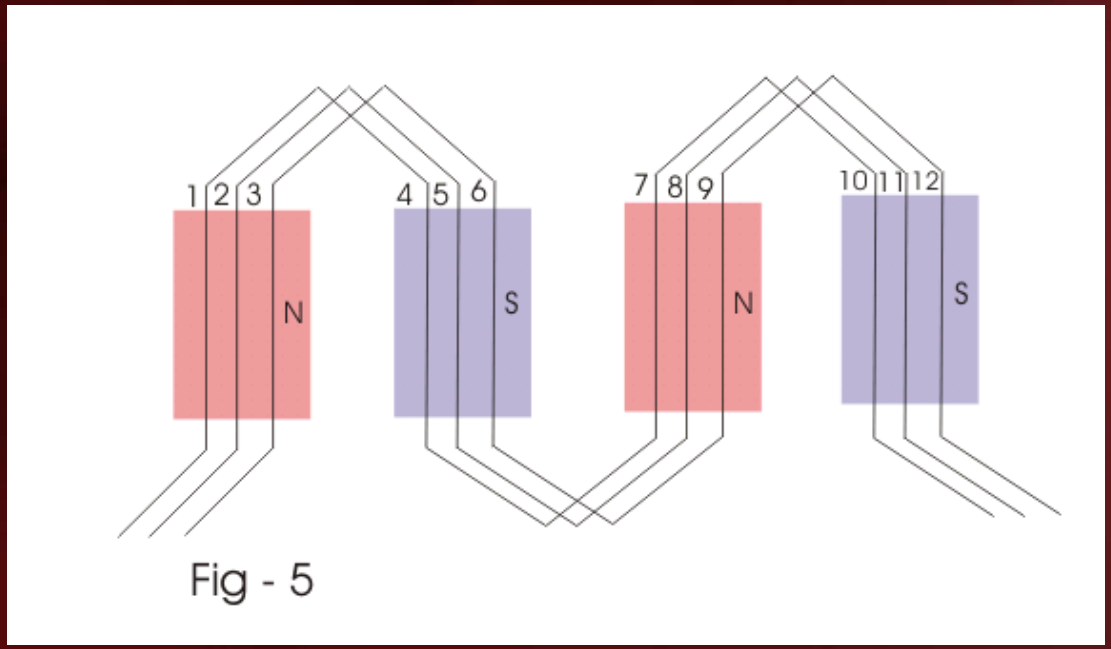


Fig - 5

- Concentric winding

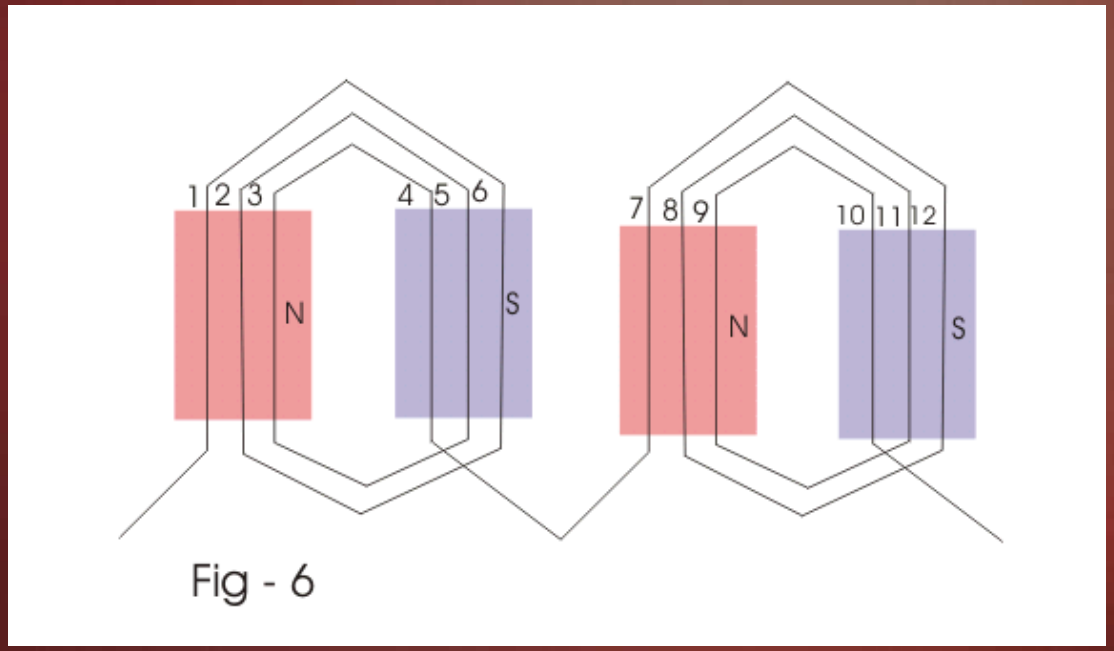


Fig - 6

RATING OF ALTERNATOR

- Power rating of alternator is defined as the power which can be delivered by an alternator safely and efficiently under some specific conditions.
- The power rating of an alternator is so specified, that at that maximum load, the temperature rise of different parts of the machine does not cross their specified safe limit.
- The copper losses i.e. I^2R loss varies with armature current and core losses vary with voltage.
- The temperature rise or heating of alternator depends upon cumulative effect of copper losses and core losses. As there is no role of power factor upon these losses, the rating of alternator generally given in VA or KVA or MVA.
- The electrical output of an alternator is product of power factor and VA and output is expressed in KW. Some times alternators are also rated by its power instead of VA rating.

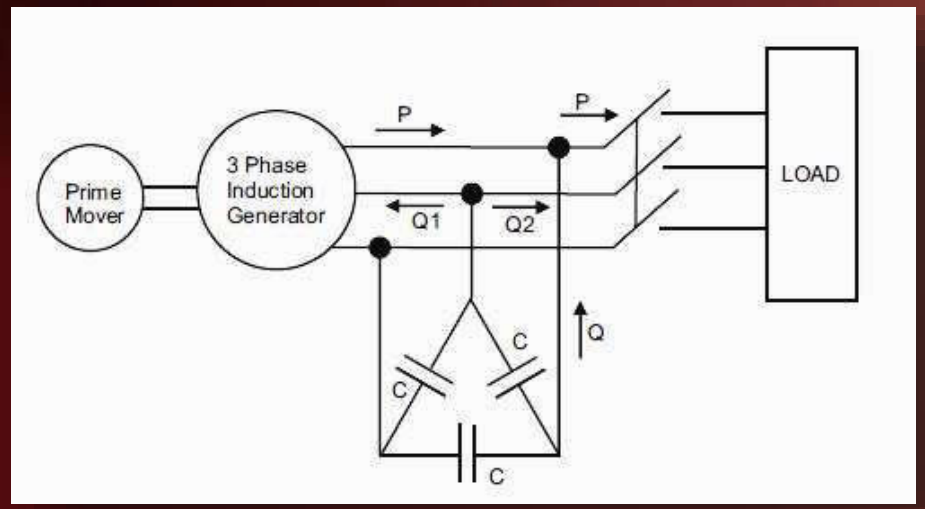
Standered rating Of Alternators

Specification	
Kilo Watt Rating	5000
Power Factor	0.85 lag
KVA Rating	5,88,00
Stator Volt	0
Stator Ampere	21,000
Rotor Volt	16,200
Rotor Ampere	340
R.P.M	4040
Hz	3000
Phas e	50 3
Armature Connection	Double Star
Coolant	Water & Hydrogen (Forced)
Gas Pressure	3.5 bar
Insulation Type	+ F
	IS5422 & IEC34

APPLICATION OF INDUCTION GENERATOR

- The conditions when the induction machine will behave as an induction generator are written below:
  I. Slip becomes negative due to this the rotor current and rotor emf attains negative value.
  II The prime mover torque becomes opposite to electric torque.
- These conditions can be achieve when an induction machine is coupled with the prime mover whose speed can be controlled. If the speed of the prime mover is increased such that the slip becomes negative .
- Due to this, all the conditions that we have mentioned above will become fulfilled and machine will behave like an induction generator.
- Induction generator is not a self excited machine therefore in order to develop the rotating magnetic field, it requires magnetizing current and reactive power.

- we can have a self excited or isolated induction generation in one case if we will use capacitor bank for reactive power supply instead of ac supply system



- The function of the capacitor bank is to provide the lagging reactive power to the induction generator as well as load

- Externally excited generators are widely used for regenerative breaking of hoists driven by the three phase induction motors.
    - The efficiency of the externally excited generator is not so good.
    - We cannot use externally excited generator at lagging power factor which major drawback of this type of generator.
    - The amount of reactive power used to run these types of generator required is quite large.
- Self excited generators are used in the wind mills. Thus this type of generator helps in converting the unconventional sources of energy into electrical energy

Thank You