AUTOMOBILE ENGINEERING

Prepared by
VEERAPANDIAN.K -
AP / MECH

UNIT I: VEHICLE STRUCTURE AND ENGINES

Types of automobiles, vehicle construction and different layouts, chassis, frame and, body, Vehicle aerodynamics (various resistances and moments involved), IC engines –components functions and materials, variable valve timing (VVT).

What Is Automobile ?

- **Automobile – Auto + Mobile = Self + Mobile**
- An automobile is a wheeled vehicle carrying its own power unit.
- This French origin word means all Vehicles that are Self-powered (Semi-Self Powered ie, in most cases, they require a driver)
- They are of many types, based on their shape, size, propulsion system, Engine type, Engine position, drive type, layout and whether they run on the track, air, water, underwater, road

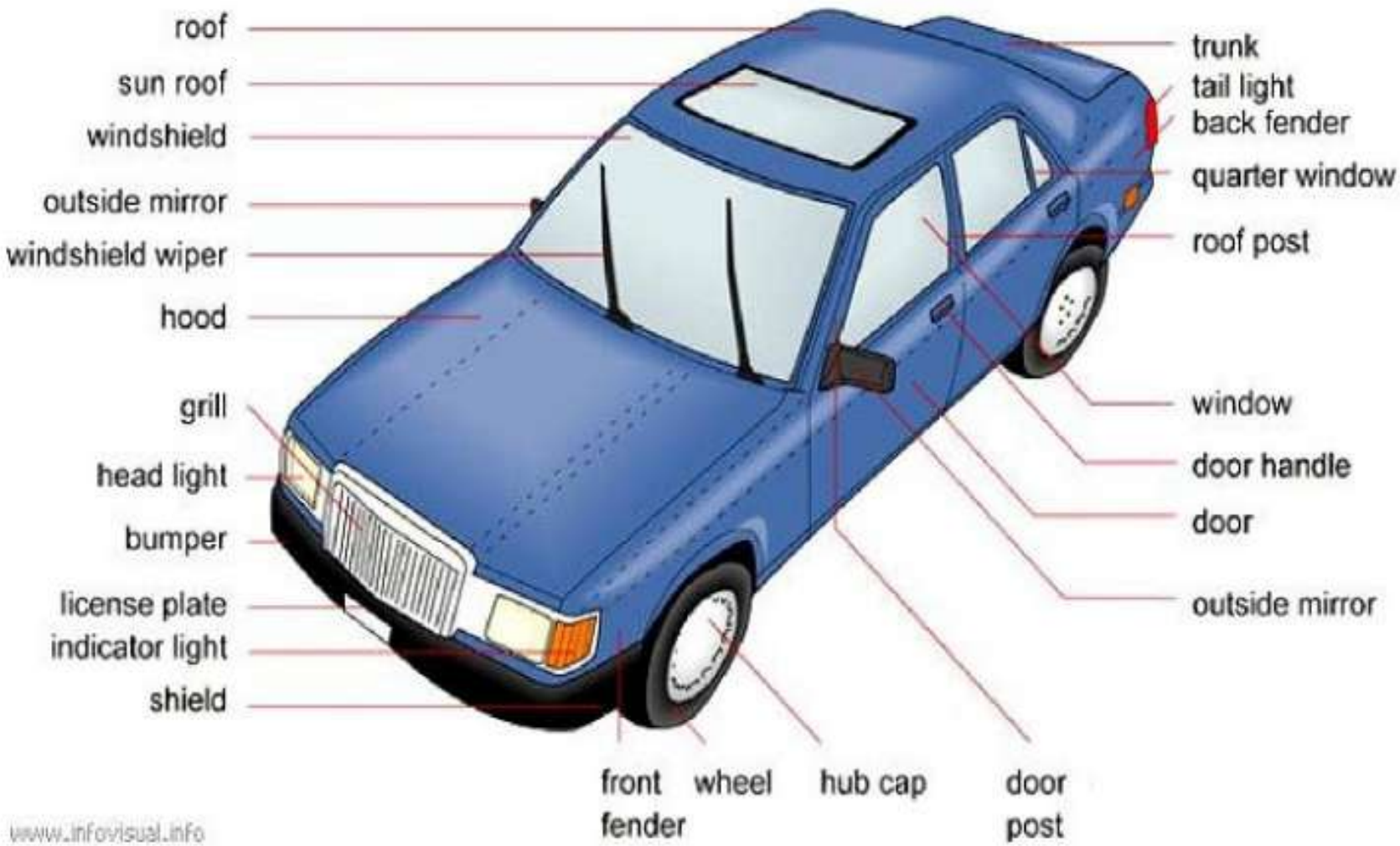
- To put it simply, anything that has its own power source and moves on the road is an automobile. It can be a car/ bike powered by a combustion engine (most of the vehicles we see).

- It can be a vehicle powered by alternative means like an electric battery, fuel cell etc.

Components of an Automobile

- The main units of an Automobile
  - The basic structure
    - Frame
    - Suspension systems
    - Axles
    - Wheels
  - The power unit
    - Engine
  - The transmission system
    - Clutch
    - Gear Box
    - Bevel pinion and crown wheel
    - Universal joints
    - Differential
  - The auxiliaries
    - Supply system-Battery and Generator
    - Starter
    - Ignition system
    - Ancillary devices – driving lights, signaling, other lights.
  - The controls
    - Steering systems
    - Brakes
  - The superstructure

AUTOMOBILE


roof
sun roof
windshield
outside mirror
windshield wiper
hood
grill
head light
bumper
license plate
indicator light
shield
trunk
tail light
back fender
quarter window
roof post
window
door handle
door
outside mirror
front fender
wheel
hub cap
door post
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Types of Automobile;

On the Basis of Load:

- Heavy transport vehicle (HTV) or heavy motor vehicle (HMV),
- Light transport vehicle (LTV), Light motor vehicle (LMV),

On the Basis of Wheels :

- Two wheeler vehicle, for example : Scooter, motorcycle, scooty, etc.
- Three wheeler vehicle, for example : Autorickshaw,
- Three wheeler scooter for handicaps and tempo, etc.
- Four wheeler vehicle, for example : Car, jeep, trucks, buses, etc.
- Six wheeler vehicle, for example : Big trucks with two gear axles.

- **On the basis of Fuel Used:**
- Petrol vehicle, e.g. motorcycle, scooter, cars, etc.
- Diesel vehicle, e.g. trucks, buses, etc.
- Electric vehicle which use battery to drive.
- Steam vehicle, e.g. an engine which uses steam engine.
- Gas vehicle, e.g. LPG and CNG vehicles, where LPG is liquefied

- **On the basis of body style**
- Sedan, Hatchback car.
- Coupe car, Station wagon, Convertible.
- Van Special purpose vehicle, e.g. ambulance, milk van, etc.


CLASSIFICATION OF CARS
tsm
SUV
LUXURY SEDAN
CONVERTIBLE
HATCHBACK
SEDAN
MPV

- **On the basis of Transmission:**

  Conventional vehicles with manual transmission, e.g. car with 5 gears.

  Semi-automatic

  Automatic: In an automatic transmission, gears are not required to be changed manually.

- **On the basis of Drive:**

  Left-hand drive

  Right-hand drive

- **Position of Engine:**

  Engine in Front – Most of the vehicles have engine in the front. Example : most of the cars,

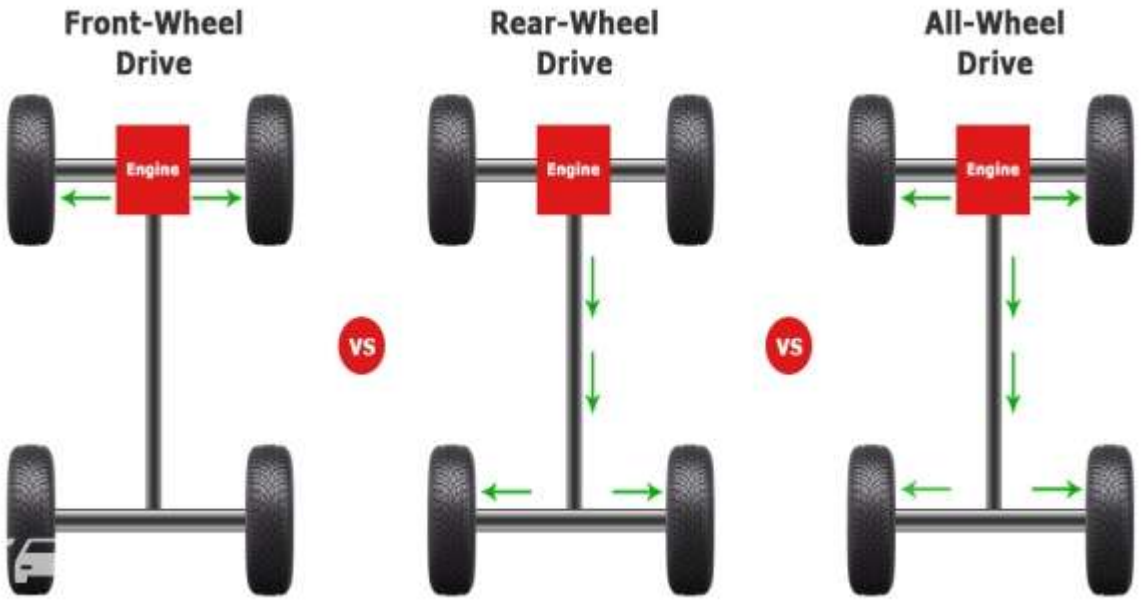
  Engine in the Rear Side Very few vehicles have engine located in the rear. Example : Nano car.

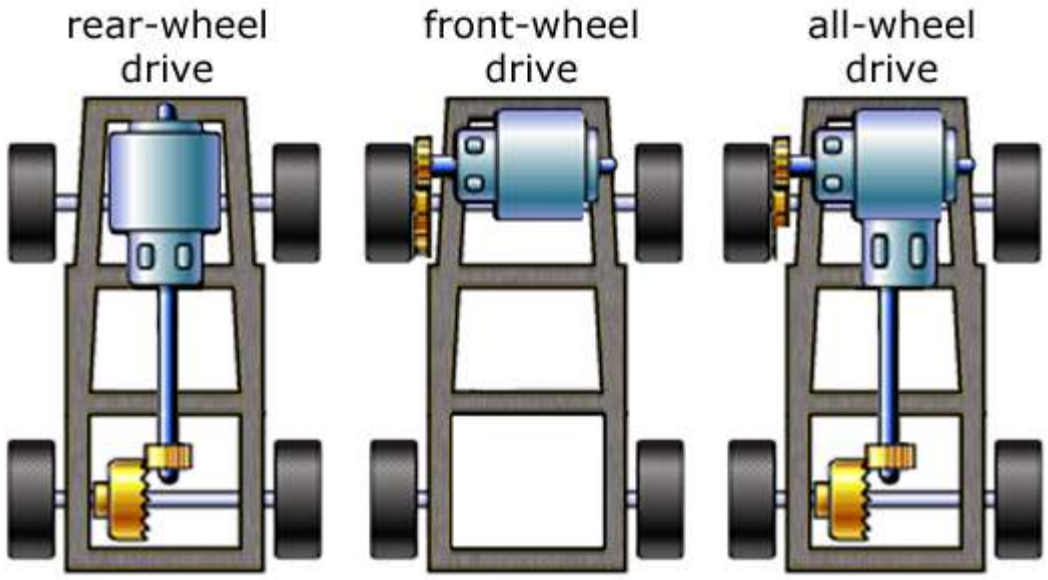
- **On the basis of Driving Axle**

  Front wheel drive

  Rear wheel drive

  All-wheel drive

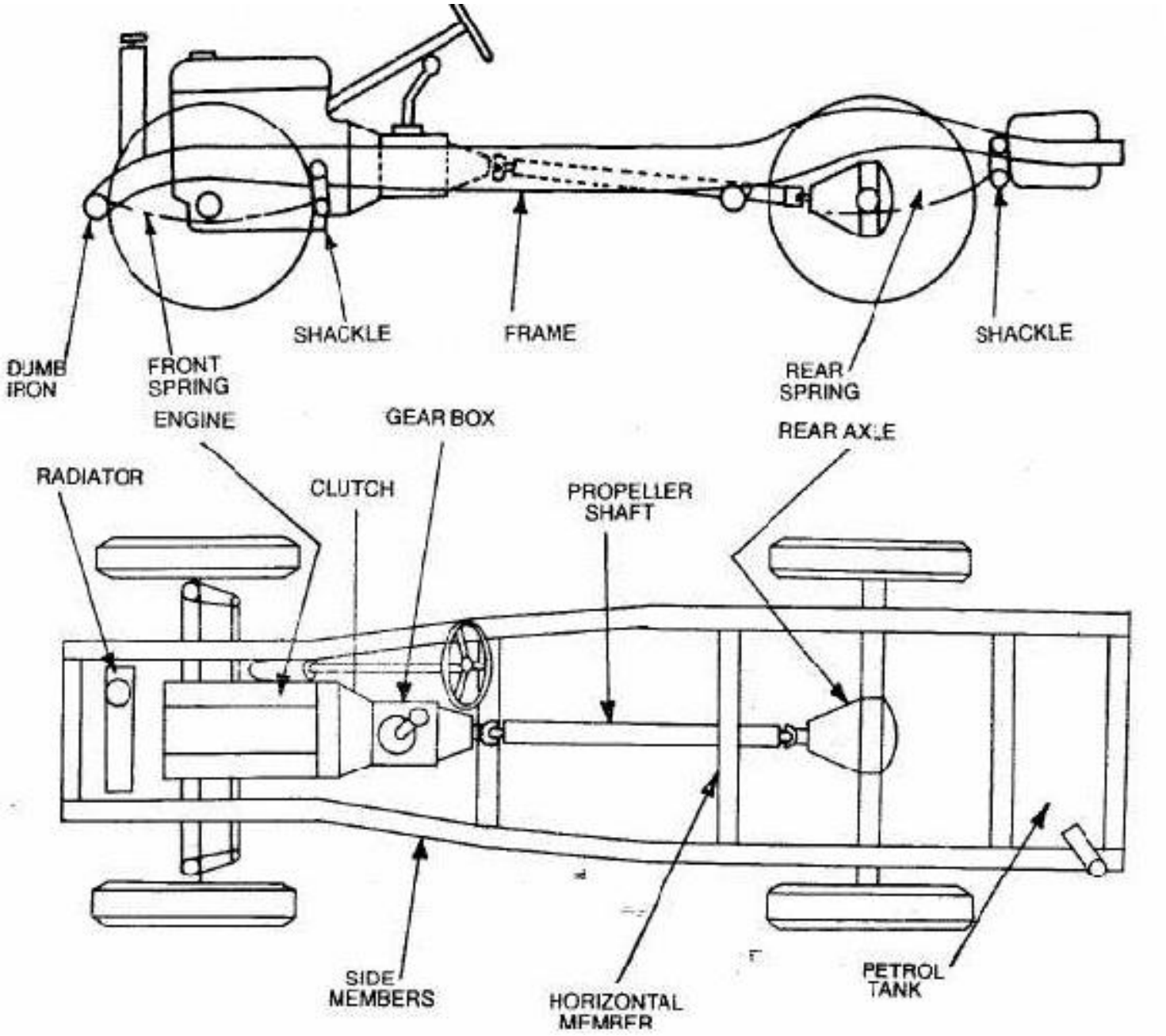

Front-Wheel Drive
Rear-Wheel Drive
All-Wheel Drive
Engine
Engine
Engine
VS
VS


rear-wheel drive
front-wheel drive
all-wheel drive

Vehicle construction and Components

The main components of an automobile refer to the following components;

- Frame,
- Chassis,
- Body,
- Power unit,
- Transmission system.


DUMB IRON
FRONT SPRING
SHACKLE
FRAME
REAR SPRING
SHACKLE
ENGINE
GEAR BOX
REAR AXLE
RADIATOR
CLUTCH
PROPELLER SHAFT
SIDE MEMBERS
HORIZONTAL MEMBER
PETROL TANK

- An automobile is made up of mainly two units, these are Chassis and Body.

- “Frame” + “Base components” = “Chassis”

- “Chassis” + “Body” = “Vehicle”

Frame

The frame is the skeleton of the vehicle. It servers as a main foundation and base for alignment for the chassis.

Types;

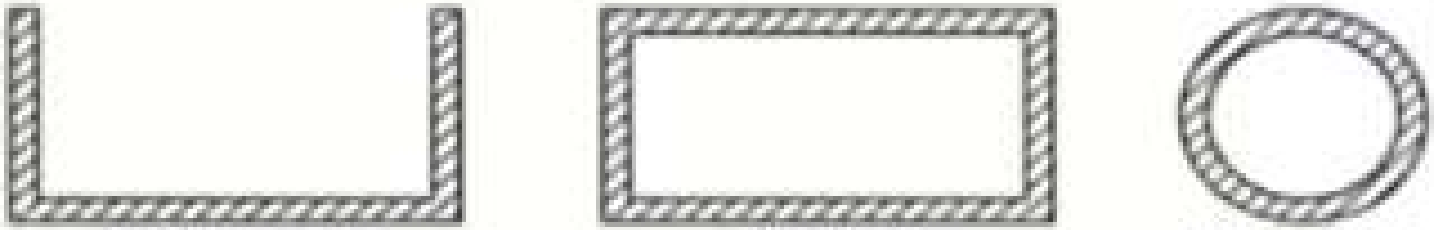
- Conventional frame,
- Semi integral frame;
- Integral or untidiest frame.

CONVENTIONAL FRAME

a.Channel Section - Good resistance to bending

b. Tabular Section - Good resistance to Torsion

c. Box Section - Good resistance to both bending and Torsion



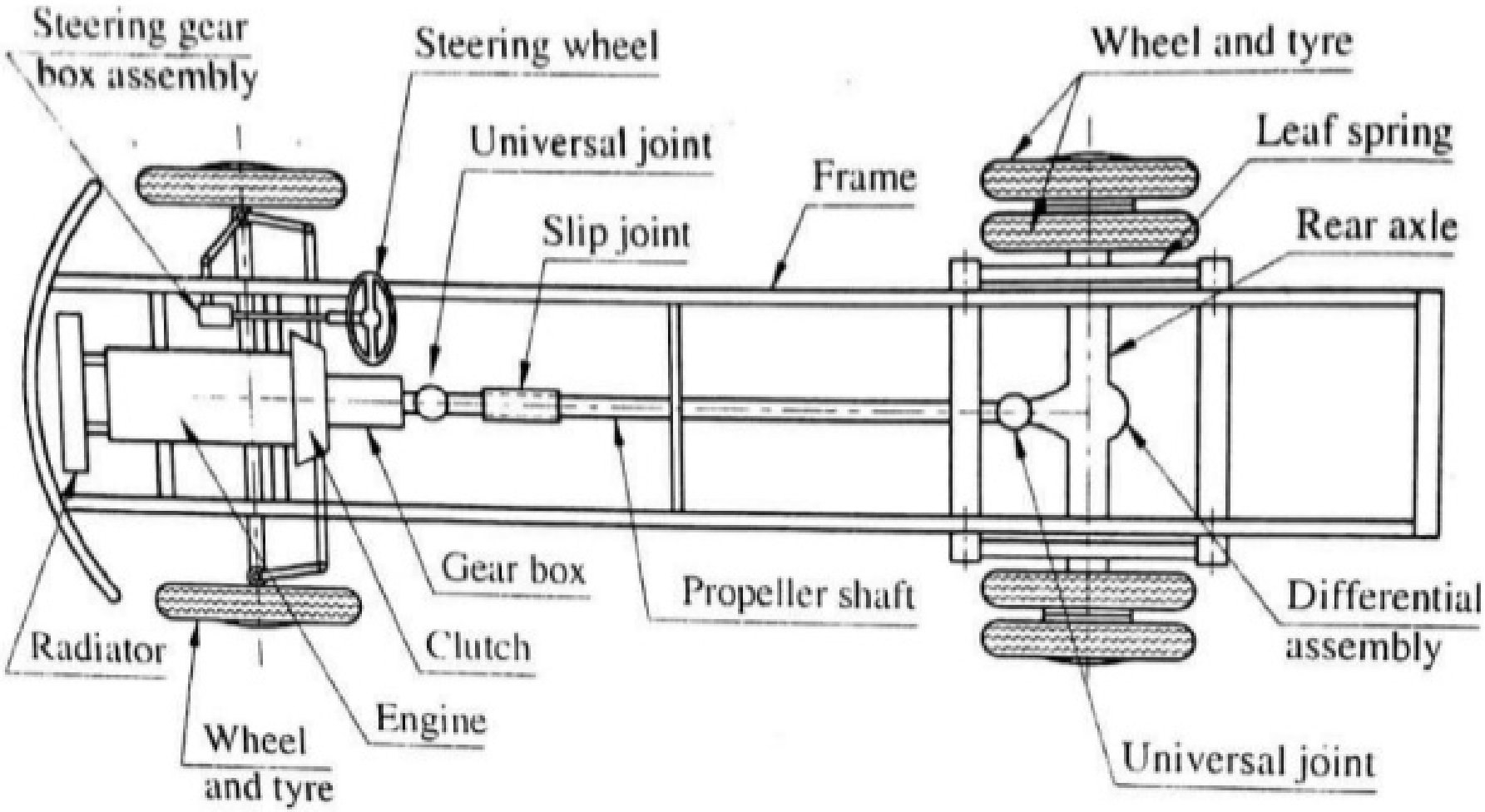
Steel sections used in chassis frame.

Chassis

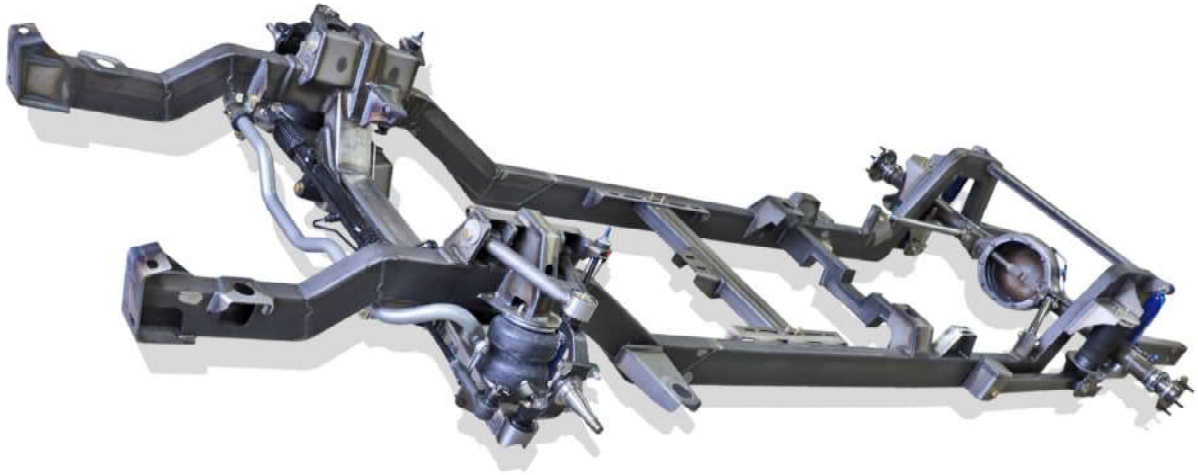
If the frame contains the base components its called as chassis.

The components are like Engine, radiator, clutch, gearbox, silencer, road wheels, fuel tank, wirings, differential units, etc..,

SIMPLE CONSTRUCTION OF TRUCK CHASSIS



'Slammed SPEC' with Airbags
Shown with options.




WARNING
WARNING
CHEETAH
CHEETAHCHASSIS.COM
CHEETAH
CHEETAHCHASSIS.COM

Body:

Body is the superstructure of the vehicle and it is bolted to the chasis.

Types

- Car,
- Truck,
- Tractor,
- Delivery van,
- Jeep,
- Bus, etc..,

Car Types –

Different Body Styles (Explained)

 Sedan	 Coupe	 Hatchback	 Minivan/Van
 Truck	 Station Wagon	 Convertible	 SUV/MUV

TYPES OF BODIES

hatchback

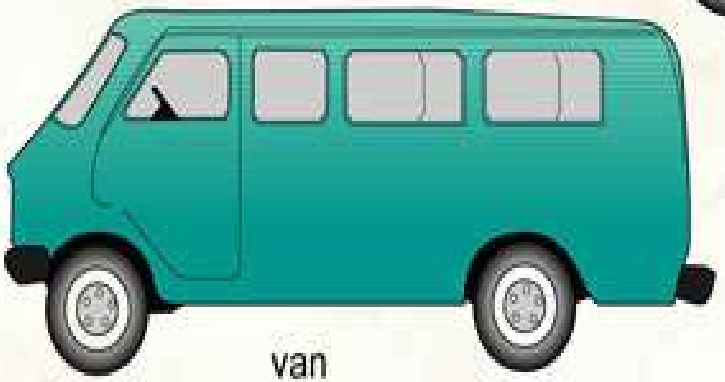
sports car

four-door sedan

limousine

convertible

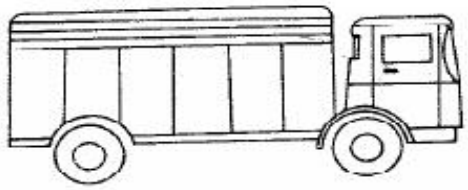
hardtop



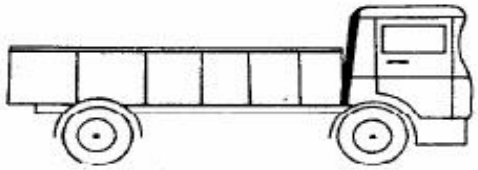
van

pick-up truck

1. Car

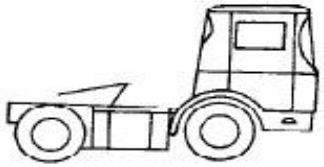


2. Truck Punjab body or Straight truck

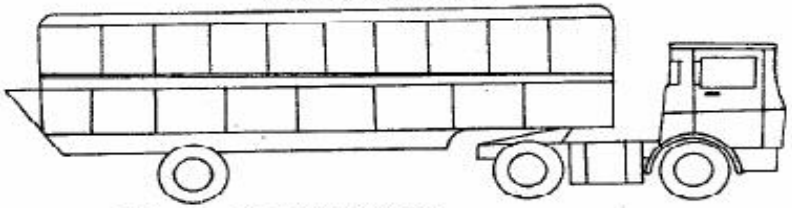


3. Truck half body

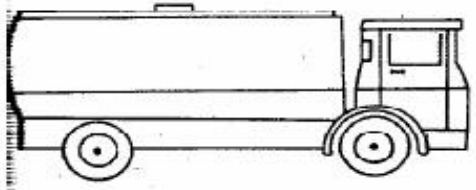
4. Truck platform type



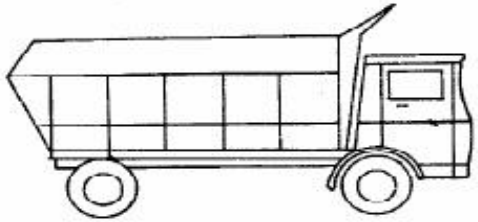
5. Tractor



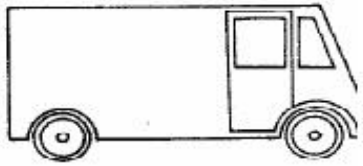
6. Tractor with articulated trailer.



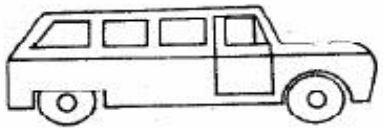
7. Tanker



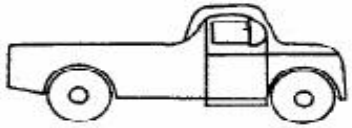
8. Dumper truck



9. Delivery Van



10. Station wagon



11. Pick-up

12. Jeep

Aerodynamics

- Aerodynamics, from Greek ἀήρ aer (air) + δυναμική (dynamics), is a branch of dynamics concerned with studying the motion of air, particularly when it interacts with a solid object, such as an airplane wing.

INTRODUCTION

When objects move through air, forces are generated by the relative motion between air and surfaces of the body, study of these forces generated by the motion of air is called aerodynamics.

CLASSIFICATION:-

on basis of flow environment
1.External Aerodynamics 2. Internal Aerodynamics

on basis of flow behavior
1.Subsonic 2.sonic 3.Supersonic

FIELD OF APPLICATION:-

1.Aerospace Engineering
2.Design Of Automobile
3.Prediction of forces & moments in ships and sails
4.In design of bridges and buildings for calculating wind loads

Aerodynamic Forces on Aerofoil

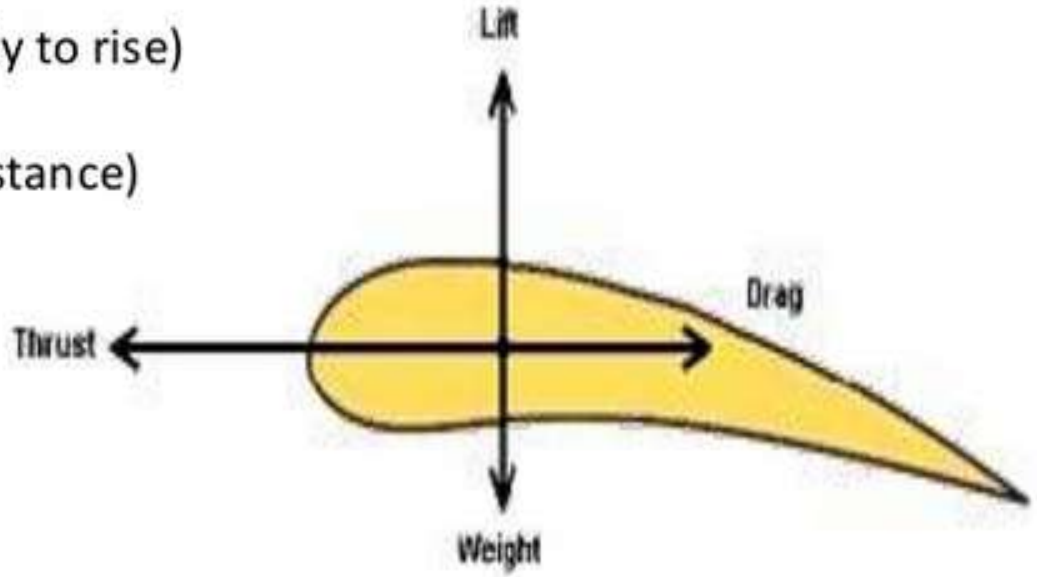
Considered a aerofoil move through air, forces which are considered for aerodynamic analysis over aerofoil are,

1.Lift (causes body to rise)

2.Drag (Fluid resistance)

3.Weight

4.Thrust



Aerofoil

1.Lift :-

Clip slide

It is the sum of all fluid dynamic forces on a body normal to the direction of external flow around the body. it is caused by Bernoulli's effect . It results body to rise by creating pressure difference .

2.Drag:-

It is the sum of all external forces in the direction of fluid flow, so it acts opposite to the direction of the object. it is the force which opposes forward motion of the body through fluid.

3.Weight:-

It is actually just the weight of the object that is in motion. i.e. the mass of the object multiplied by the magnitude of gravitational field.

4.Thrust:-

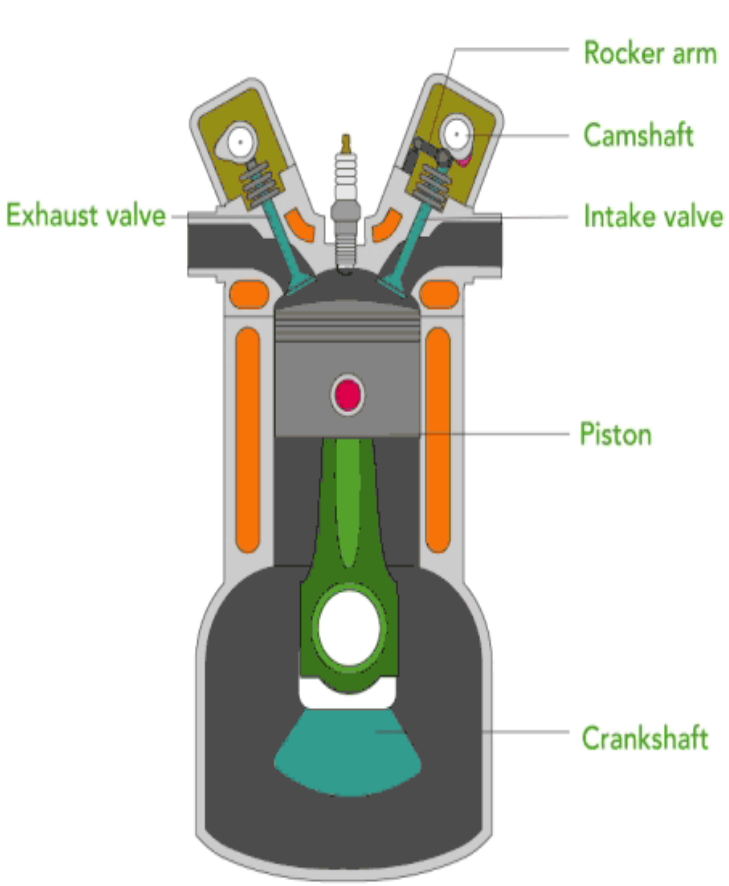
When a body is in motion a drag force is created which opposes the forward motion of the object so thrust can be the force produce in opposite direction to drag. it must be higher than that of drag so that the body can move through the fluid.

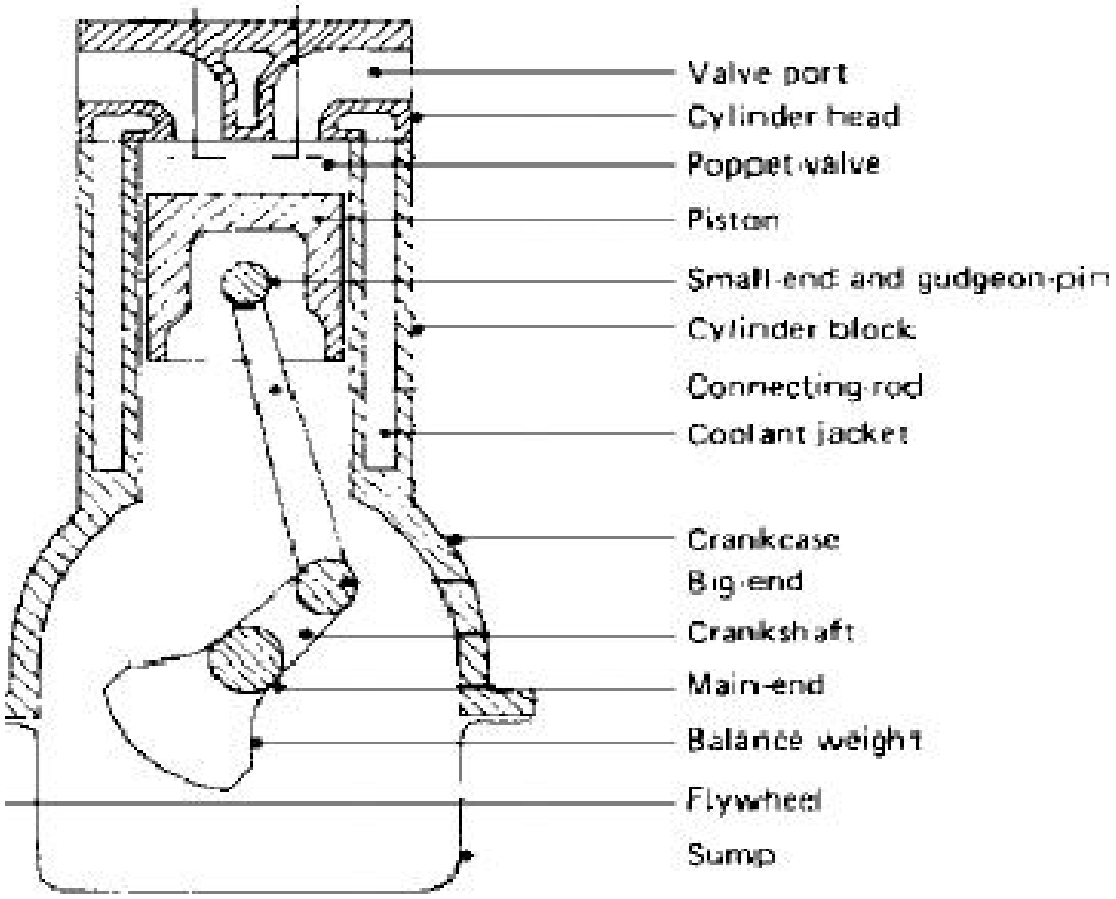
ADVANTAGES OF AERODYNAMICS IN CARS

It is essential that aerodynamics be taken into account during the design of cars as an improved aerodynamics in car would attain

1.More fuel efficiency
2.Higher speeds
3.Good Aesthetic and stylish appearance of car.
4.More stability of car at higher speed
5.Reduces noise level

IC Engines


Rocker arm
Camshaft
Exhaust valve
Intake valve
Piston
Crankshaft


Valve port
Cylinder head
Poppet valve
Piston
Small-end and gudgeon-pin
Cylinder block
Connecting-rod
Coolant jacket
Crankcase
Big-end
Crankshaft
Main-end
Balance weight
Flywheel
Sump

Components

- **Cylinder Block**
- **Cylinder**
- **Piston**
- **Combustion Chamber**
- **Inlet Manifold**
- **Gudgeon Pin**
- **Exhaust Manifold**
- **Inlet and Exhaust Valves**
- **Connecting Rod**
- **Crankshaft**
- **Piston Rings**
- **Camshaft**
- **Cams**
- **Fly Wheel**

Cylinder Block:

- The cylinder block is the main supporting structure for the various components. The cylinder of a multicylinder engine is cast as a single unit, called cylinder block. The cylinder head is mounted on the cylinder block.
- The cylinder head and cylinder block are provided with water jackets in the case of water- cooling with cooling fins in the case of air-cooling.
- Cylinder head gasket is incorporated between the cylinder block and cylinder head. The cylinder head is held tight to the cylinder block by number of bolts or studs.
- The bottom portion of the cylinder block is called crankcase. A cover called crankcase, which becomes a sump for lubricating oil is fastened to the bottom of the crankcase.
- The inner surface of the cylinder block, which is machined and finished accurately to cylindrical shape, is called bore or face.

- **Piston**

It is a cylindrical component fitted into the cylinder forming the moving boundary of the combustion system.

It fits perfectly into the cylinder providing a gas-tight space with the piston rings and the lubricant. It forms the first link in transmitting the gas forces to the output shaft.

- **Combustion Chamber**

  The space enclosed in the upper part of the cylinder, by the cylinder head and the piston top during the combustion process, is called the combustion chamber.

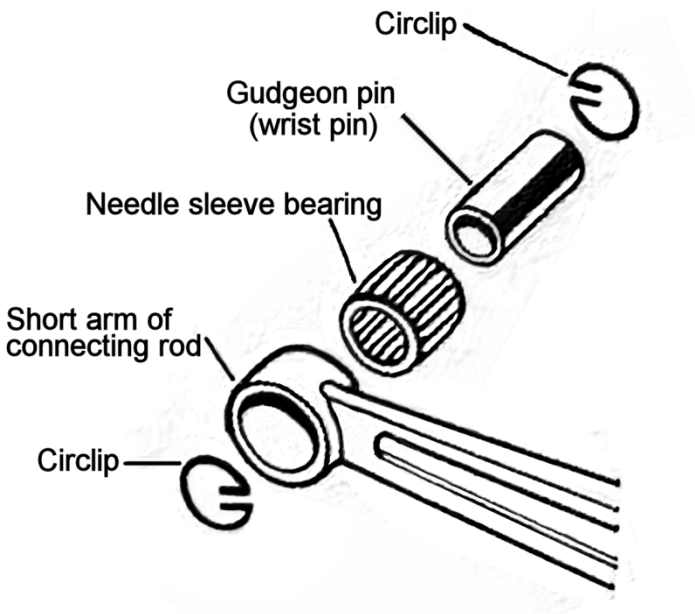
  The combustion of fuel and the consequent release of thermal energy results in the building up of pressure in this part of the cylinder.

- **Inlet Manifold**

The pipe which connects the intake system to the inlet valve of the engine and through which air or air-fuel mixture is drawn into the cylinder is called the inlet manifold.

- **Gudgeon Pin**

  It forms the link between the small end of the connecting rod and the piston.



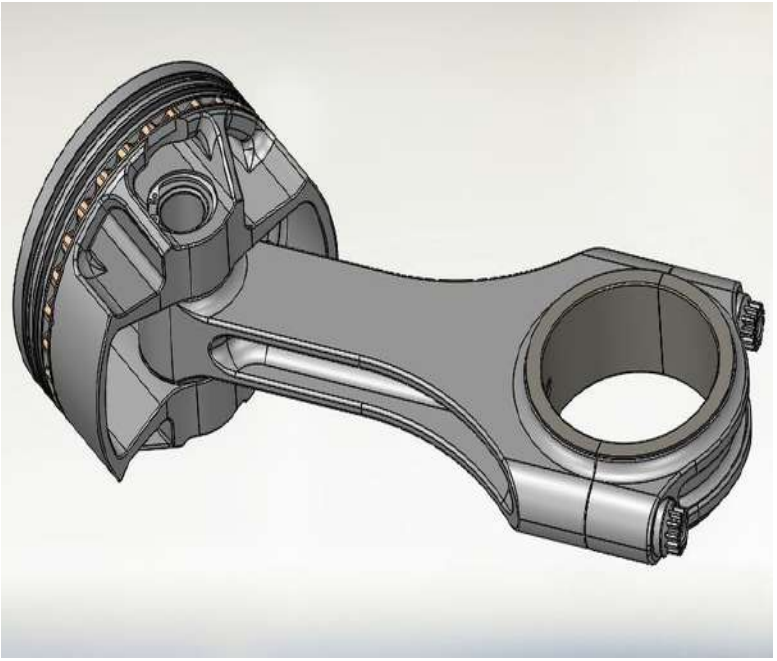
- **Exhaust Manifold**

  The pipe that connects the exhaust system to the exhaust valve of the engine and through which the products of combustion escape into the atmosphere is called the exhaust manifold.

Connecting Rod

It interconnects the piston and the crankshaft and transmits the gas forces from the piston to the crankshaft.

The two ends of the connecting rod are called as small end and the big end. Small end is connected to the piston by gudgeon pin and the big end is connected to the crankshaft by crankpin.



- **Crankshaft**

  It converts the reciprocating motion of the piston into useful rotary motion of the output shaft.

  In the crankshaft of a single cylinder engine there is pair of crank arms and balance weights.

  The balance weights are provided for static and dynamic balancing of the rotating system. The crankshaft is enclosed in a crankcase.

Piston Rings

Piston rings, fitted into the slots around the piston, provide a tight seal between the piston

and the cylinder wall thus preventing leakage of combustion gases

Camshaft

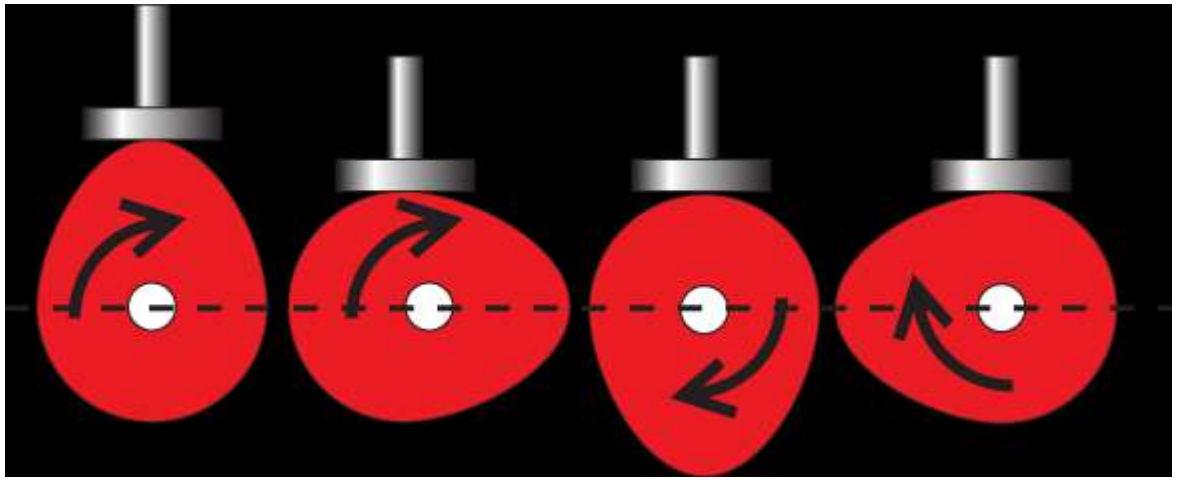
The camshaft and its associated parts control the opening and closing of the two valves.

The associated parts are push rods, rocker arms, valve springs and tappets.

This shaft also provides the drive to the ignition system. The camshaft is driven by the crankshaft through timing gears.

- **Cams**

  These are made *as* integral parts of the camshaft and are designed in such a way to open the valves at the correct timing and to keep them open for the necessary duration.



Inlet and Exhaust Valves

Valves are commonly mushroom shaped poppet type.

They are provided either on the cylinder head or on the side of the cylinder for regulating the charge coming into the cylinder (inlet valve) and for discharging the products of combustion (exhaust valve) from the cylinder.

Variable valve timing

- In internal combustion engines, variable valve timing (VVT) is the process of altering the timing of a valve lift event, and is often used to improve performance, fuel economy or emissions.
- It is increasingly being used in combination with variable valve lift systems

UNIT-II

UNIT II: ENGINE AUXILIARY SYSTEMS 9

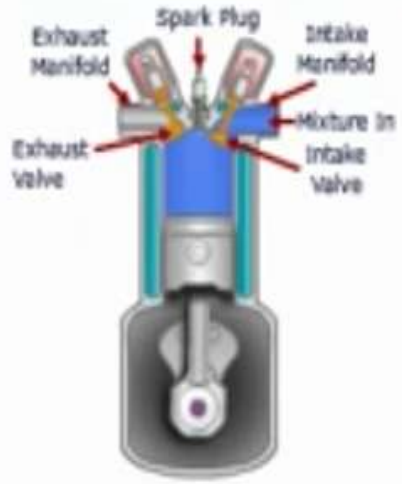
Electronically controlled gasoline injection system for SI engines, electronically controlled diesel injection system (Unit injector system, Rotary distributor type and common rail direct injection system), Electronic ignition system (Transistorized coil ignition system, capacitive discharge ignition system), Turbo chargers (WGT, VGT), Engine emission control by three way catalytic converter system, Emission norms (Euro and BS)

IGNITION SYSTEM

The fuel feed system for the Spark ignition engines and Compression ignition engines are clearly discussed below.

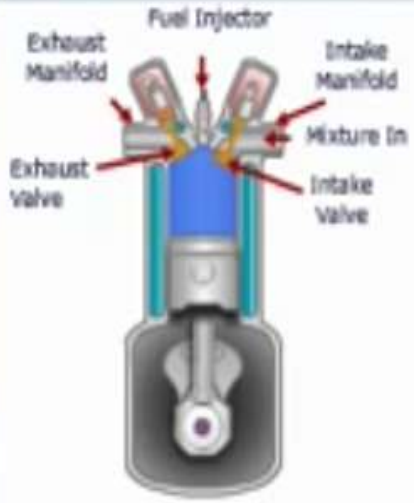
Explain the differences between Spark and Compression Ignition Engines.

Compression Ratio



SI Engine

In SI Engine, Compression Ratio varies from 6 to 10. Here, upper limit of the Compression Ratio is determined by Antiknock Quality of the Fuel.



In CI Engine, Compression Ratio varies from 16 to 20. Here, upper limit of the Compression Ratio is determined by Weight Increase of the Engine.

Fuel Injection system for SI engines

Carburetion

- Spark-ignition engines normally use volatile liquid fuels. Preparation of fuel-air mixture is done outside the engine cylinder and formation of a homogeneous mixture is normally not completed in the inlet manifold.
- Fuel droplets, which remain in suspension, continue to evaporate and mix with air even during suction and compression processes. The process of mixture preparation is extremely important for spark-ignition engines.
- The purpose of carburetion is to provide a combustible mixture of fuel and air in the required quantity and quality for efficient operation of the engine under all conditions.

Definition of Carburetion

The process of formation of a combustible fuel-air mixture by mixing the proper amount of fuel with air before admission to engine cylinder is called carburetion and the device which does this job is called a carburetor.

Definition of Carburetor

The carburetor is a device used for atomizing and vaporizing the fuel and mixing it with the air in varying proportions to suit the changing operating conditions of vehicle engines.

Factors Affecting Carburetion

Of the various factors, the process of carburetion is influenced by

i. The engine speed

ii. The vaporization characteristics of the fuel

iii. The temperature of the incoming air and

iv. The design of the carburetor

Principle of Carburetion

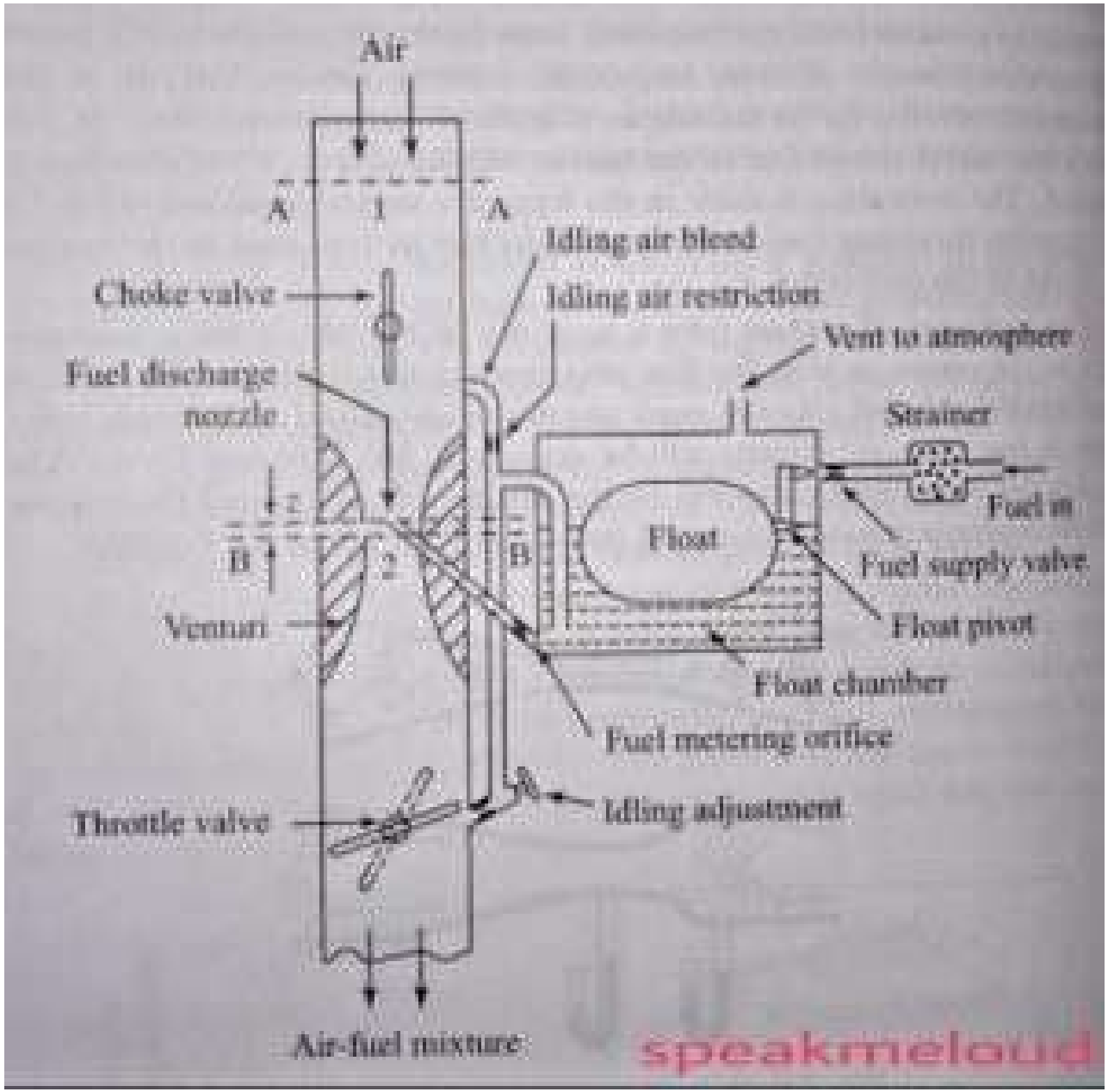
- Both air and gasoline are drawn through the carburetor and into the engine cylinders by the suction created by the downward movement of the piston.
- This suction is due to an increase in the volume of the cylinder and a consequent decrease in the gas pressure in this chamber.
- It is the difference in pressure between the atmosphere and cylinder that causes the air to flow into the chamber.
- In the carburetor, air passing into the combustion chamber picks up discharged from a tube.
- This tube has a fine orifice called carburetor jet that is exposed to the air path.

- The rate at which fuel is discharged into the air depends on the pressure difference or pressure head between the float chamber and the throat of the venturi and on the area of the outlet of the tube.
- In order that the fuel drawn from the nozzle may be thoroughly atomized, the suction effect must be strong and the nozzle outlet comparatively small.
- In order to produce a strong suction, the pipe in the carburetor carrying air to the engine is made to have a restriction.
- At this restriction called throat due to increase in velocity of flow, a suction effect is created. The restriction is made in the form of a venturi to minimize throttle losses.

- The end of the fuel jet is located at the venturi or throat of the carburetor. It has a narrower path at the center so that the flow area through which the air must pass is considerably reduced.
- As the same amount of air must pass through every point in the tube, its velocity will be greatest at the narrowest point.
- The smaller the area, the greater will be the velocity of the air, and thereby the suction is proportionately increased

- As mentioned earlier, the opening of the fuel discharge jet is usually loped where the suction is maximum. Normally, this is just below the narrowest section of the venturi tube.
- The spray of gasoline from the nozzle and the air entering through the venturi tube are mixed together in this region and a combustible mixture is formed which passes through the intake manifold into the cylinders.
- Most of the fuel gets atomized and simultaneously a small part will be vaporized. Increased air velocity at the throat of the venturi helps he rate of evaporation of fuel.

The Simple Carburetor



The Simple Carburetor

- Carburetors are highly complex. Let us first understand the working principle of a simple or elementary carburetor that provides an air fuel mixture for cruising or normal range at a single speed.
- Later, other mechanisms to provide for the various special requirements like starting, idling, variable load and speed operation and acceleration will be included. Figure shows the details of a simple carburetor.

- The simple carburetor mainly consists of a float chamber, fuel discharge nozzle and a metering orifice, a venturi, a throttle valve and a choke. The float and a needle valve system maintain a constant level of gasoline in the float chamber.

- If the amount of fuel in the float chamber falls below the designed level, the float goes down, thereby opening the fuel supply valve and admitting fuel.

- When the designed level has been reached, the float closes the fuel supply valve thus stopping additional fuel flow from the supply system.

- Float chamber is vented either to the atmosphere or to the" upstream side of the venturi. During suction stroke air is drawn through the venturi.

The carburetor is supposed to supply the fuel air mixture in correct proportion under different conditions of temperature, speed and load on engine. Relatively rich mixture of air fuel ratio of 12:1 is required by the engine while accelerating or running at high speeds. A leaner mixture of air-fuel ratio of 16:1 is sufficient while running on levelled roads. For idling, a richer mixture of about 14:1 is needed. Similarly, an extremely rich mixture having a ratio of 9:1 is required during cold starting.

Defects in Simple carburetor

- A simple carburetor is found useful only to a particular load and speed condition.
- But in actual practice the engine has to run at different speeds and load conditions.
- Defects
  - Starting difficulty
  - Idling difficulty
  - Acceleration difficulty
  - Load and speed variation difficulty
  - Influence of weather
  - Icing difficulty

Starting Difficulty

- Ticklers
- Choke
- Adjustable Area Jet
- Separate air passage

Ticklers

(a) Ticklers:

Ticklers are the devices used for flooding of the carburetor while starting an engine. More fuel will be supplied by depressing the tickler which would depress the float.

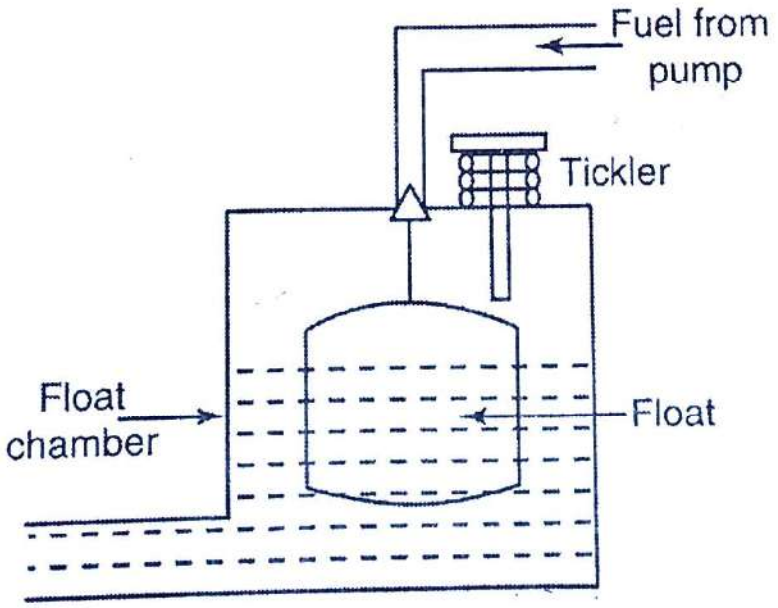


Figure 2.2 Ticklers

Choke

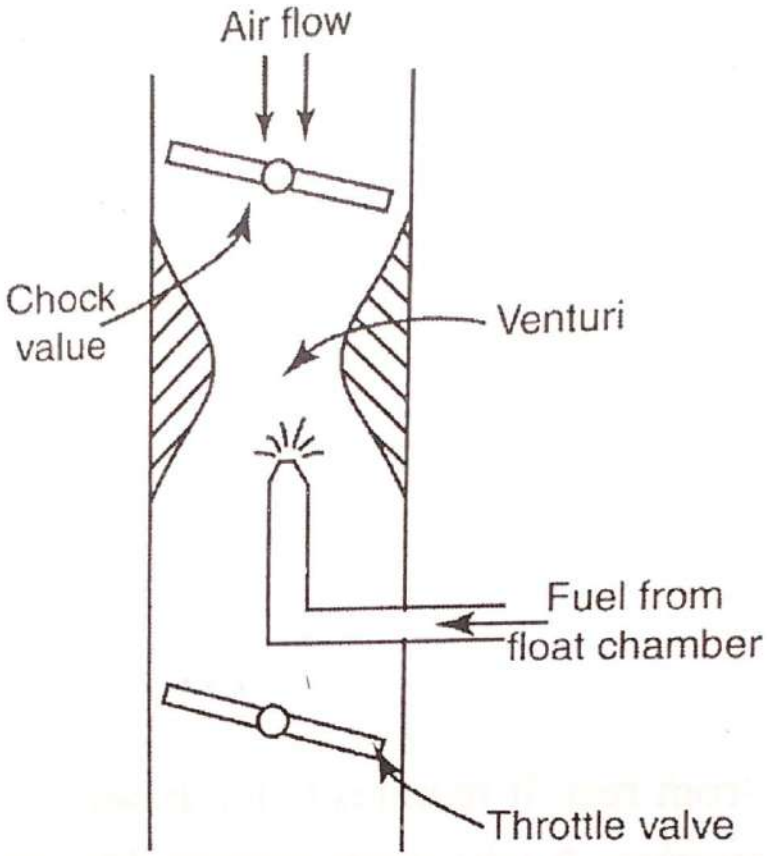


Figure 2.3 Choke

Adjustable Area jet

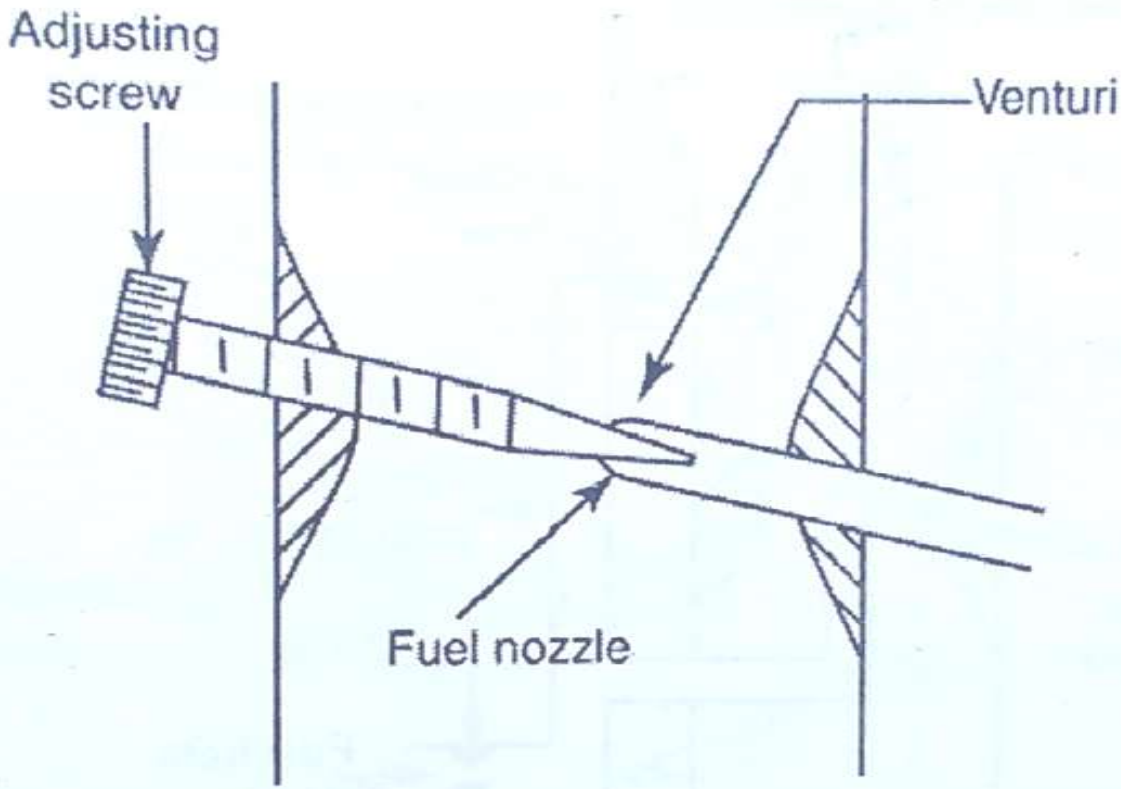


Figure 2.6 Adjustable area jet

Separate Air Passage

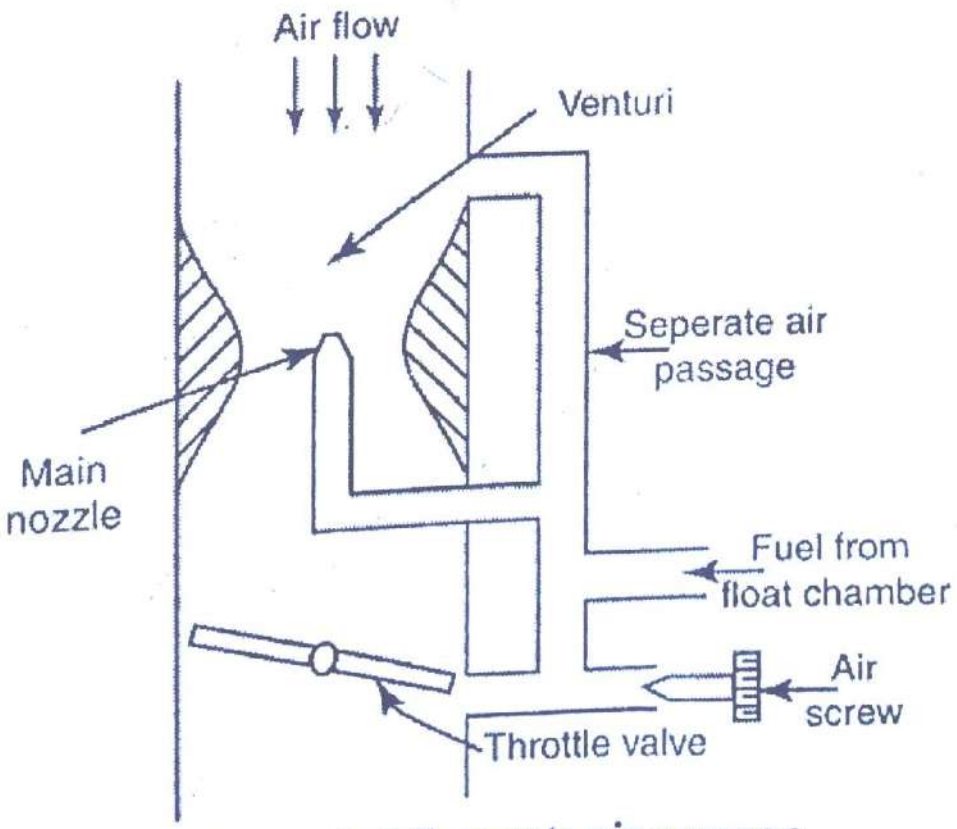


Figure 2.7 Separate air passage

Idling Difficulty

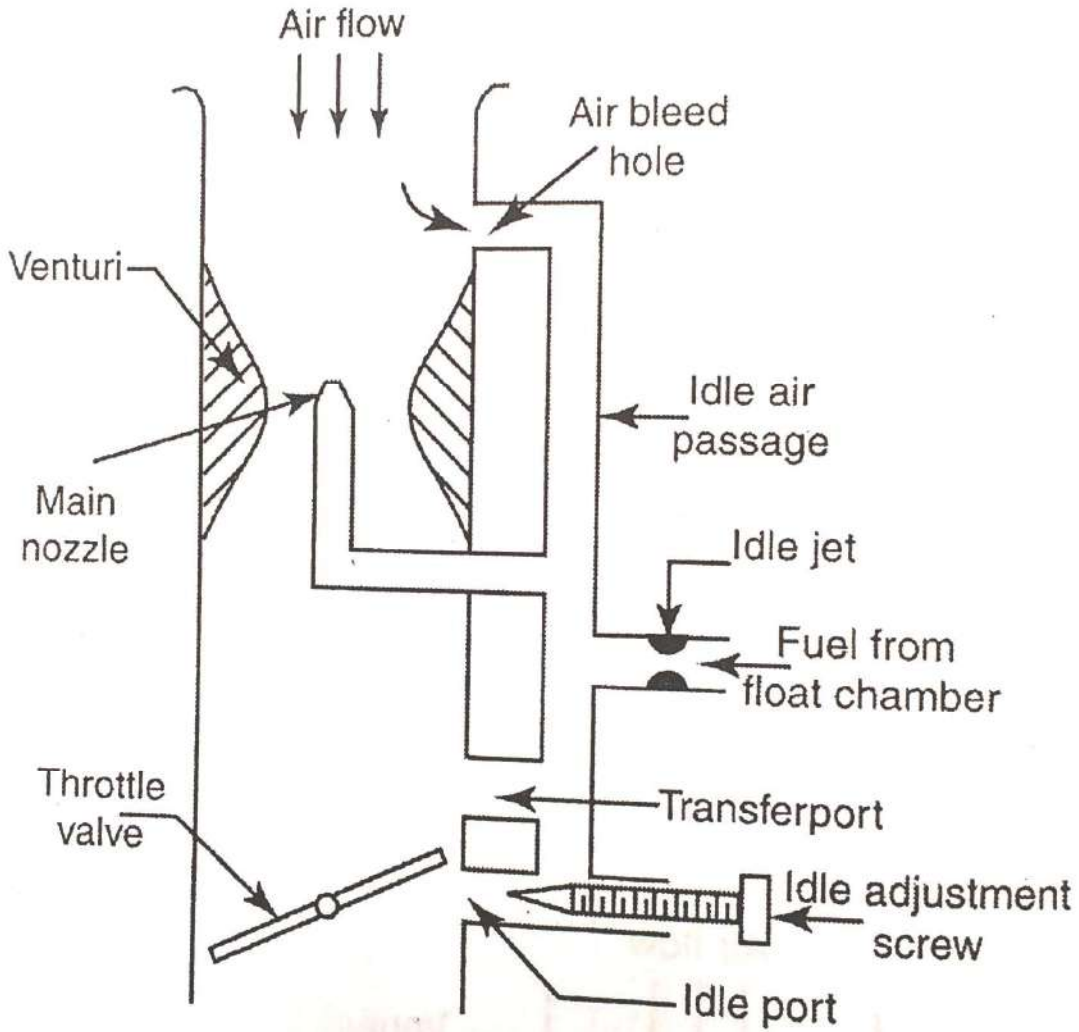


Figure 2.8 Idling circuit

Acceleration Difficulty

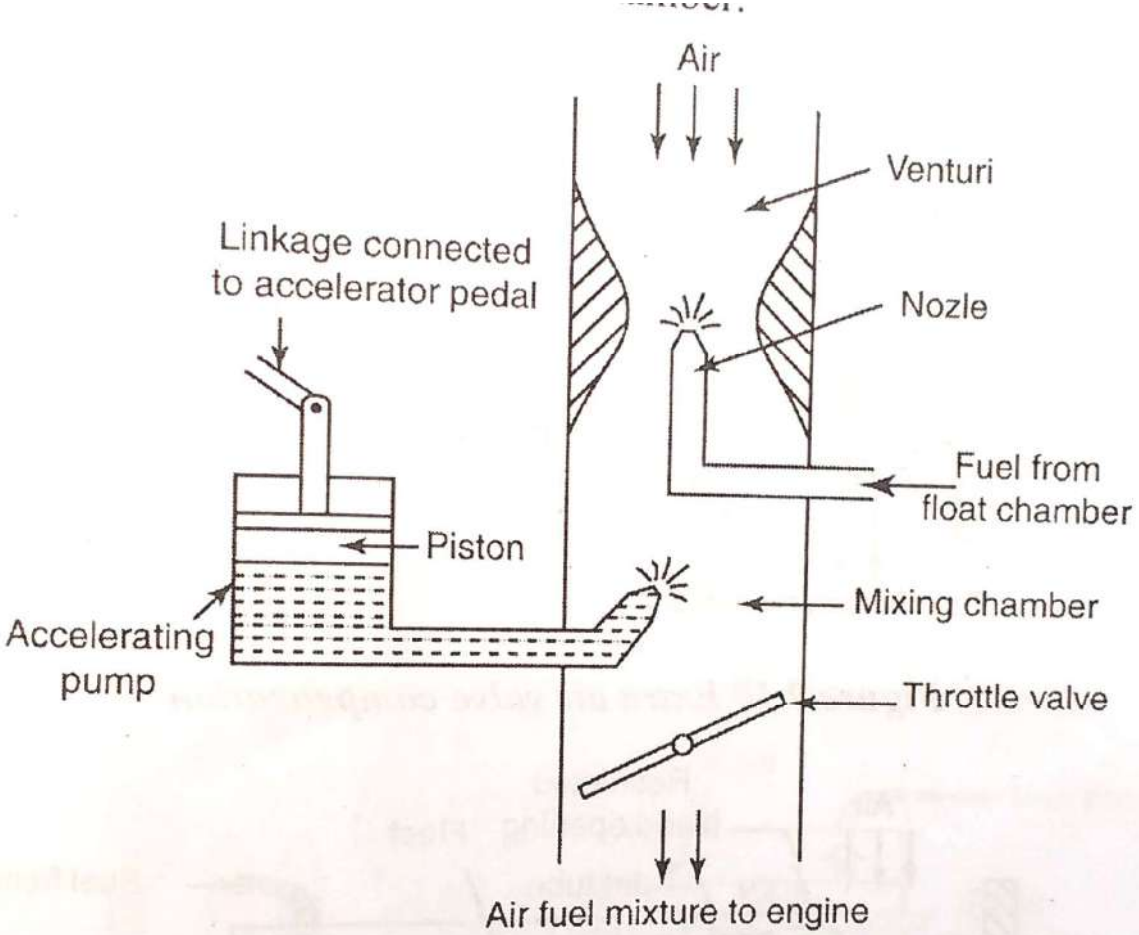


Figure 2.9 Accelerating circuit

Load and Speed Variation Difficulty

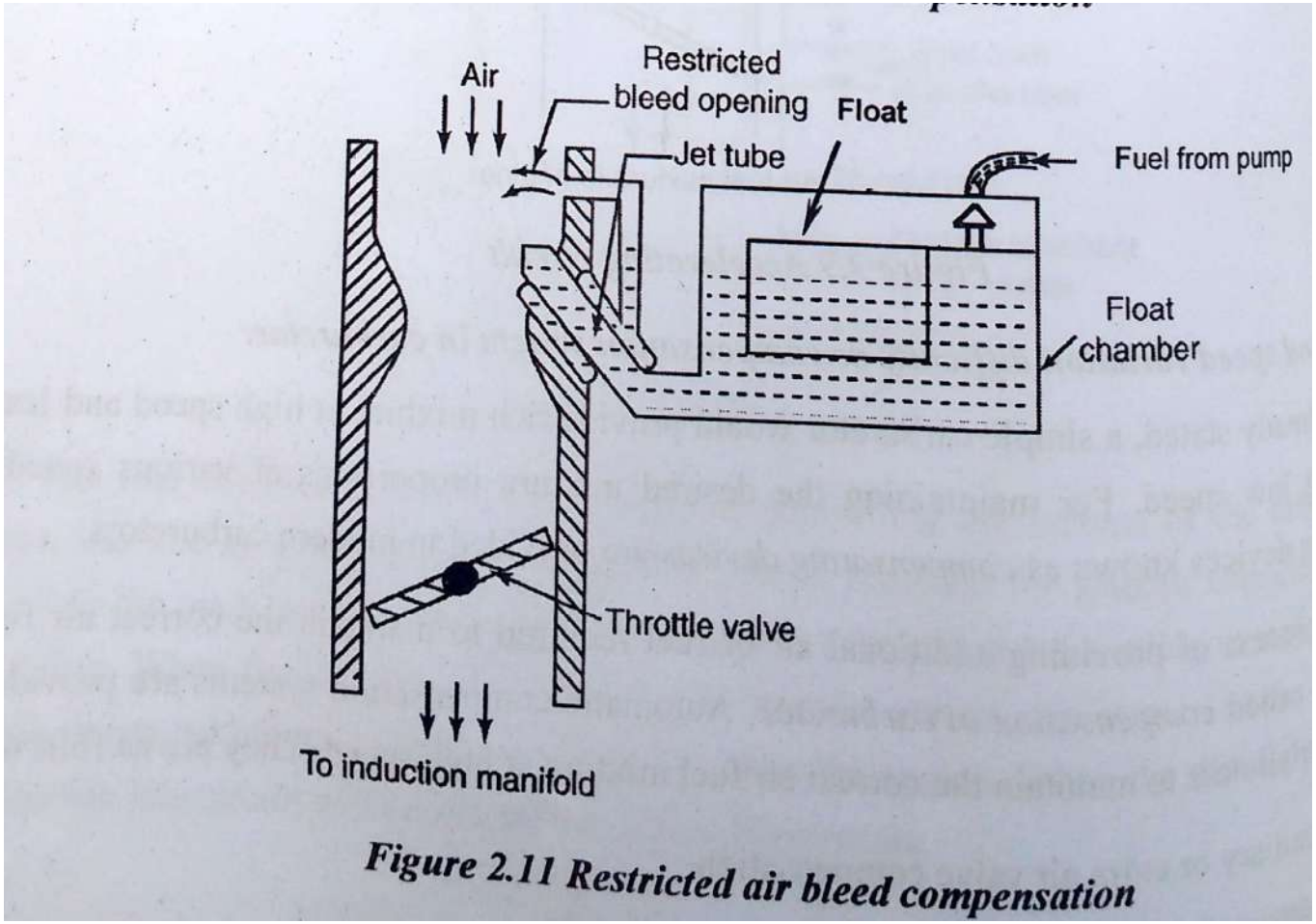


Figure 2.11 Restricted air bleed compensation

Load and Speed Variation Difficulty

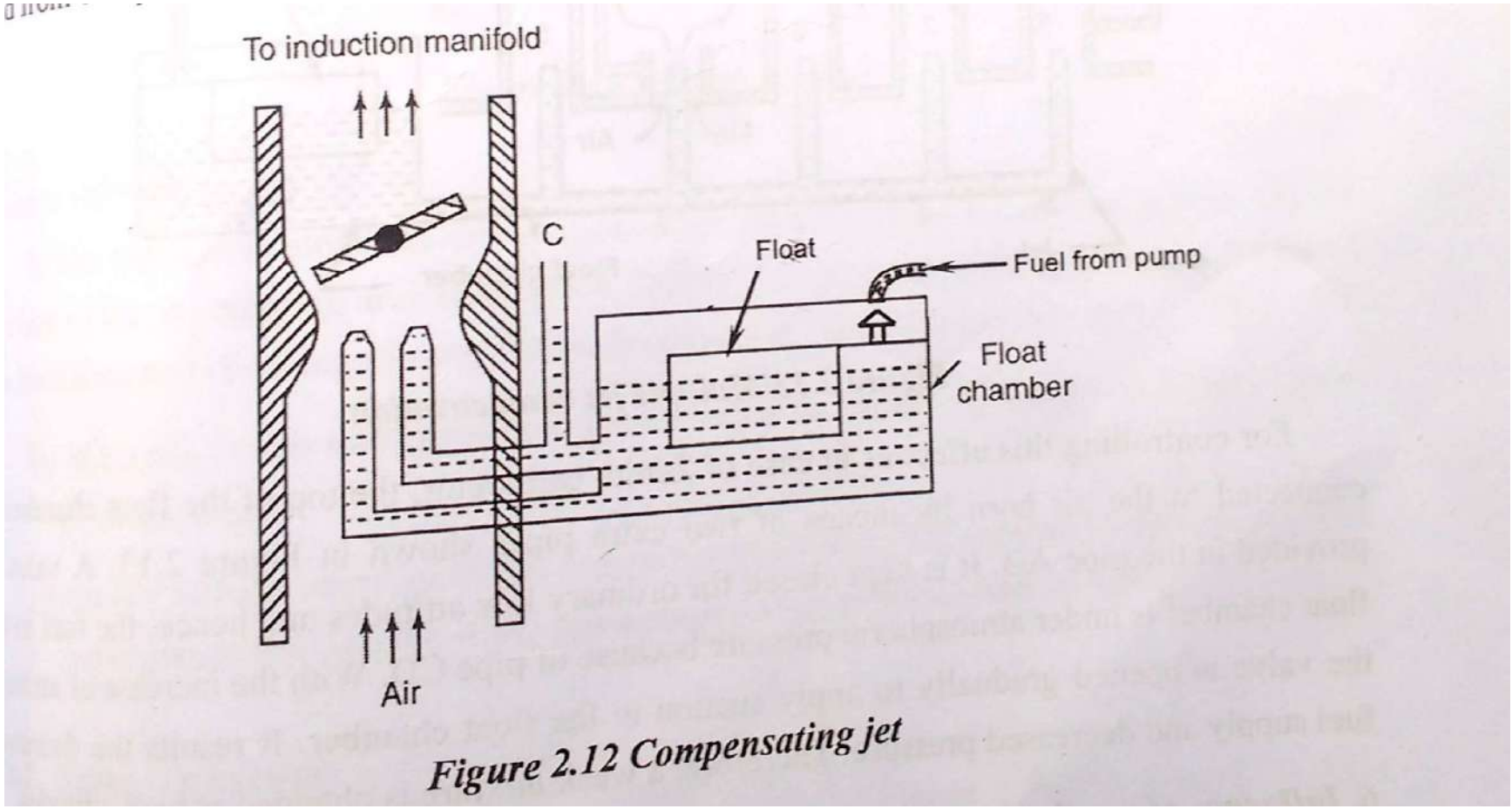


Figure 2.12 Compensating jet

Load and Speed Variation Difficulty

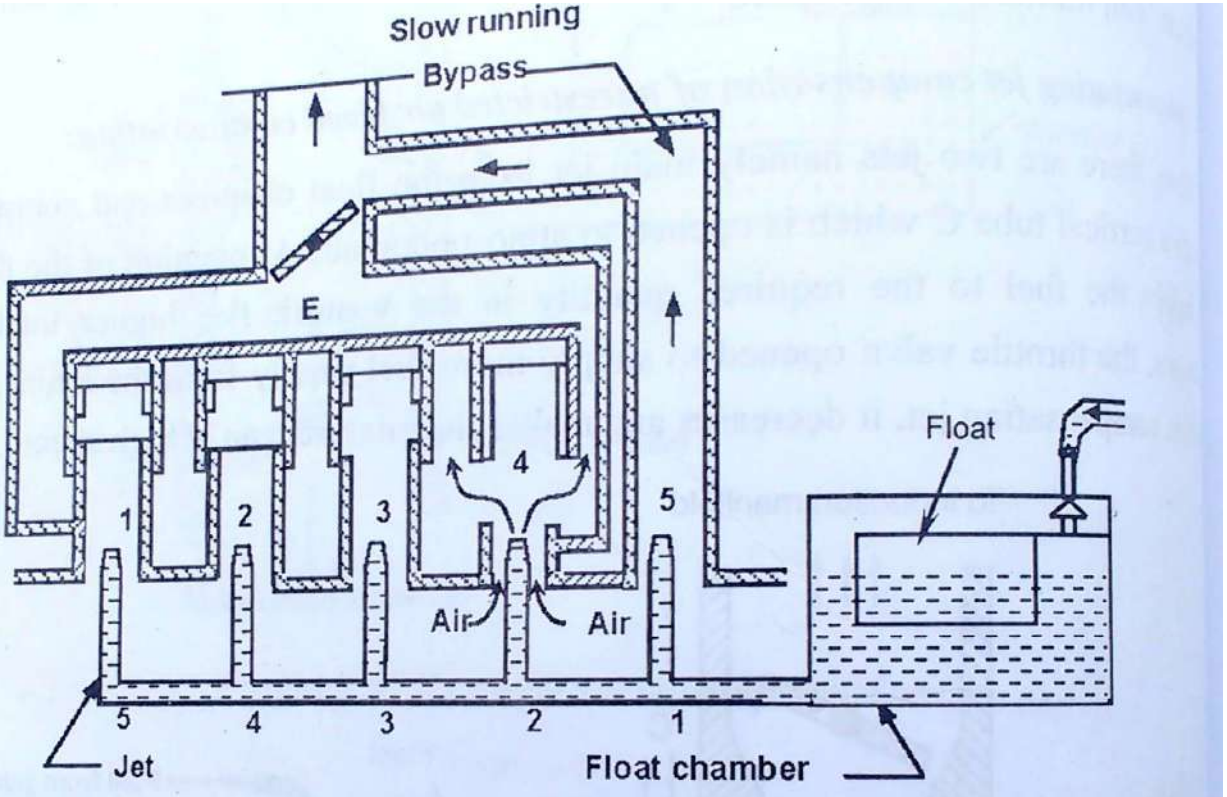
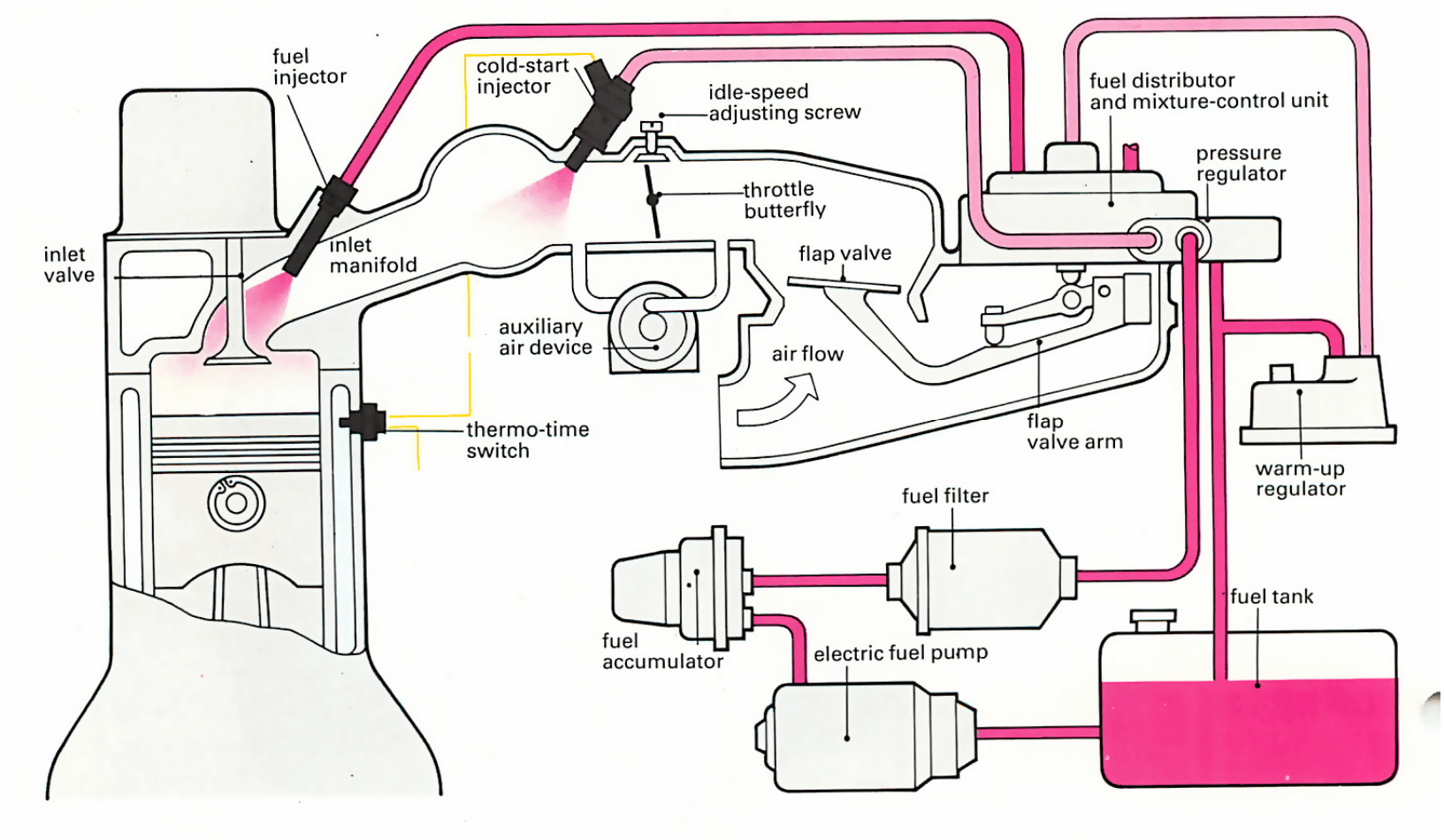


Figure 2.13 Multiple jet compensation

Working of an Electronic Fuel Injection System



Electronically controlled diesel injection system

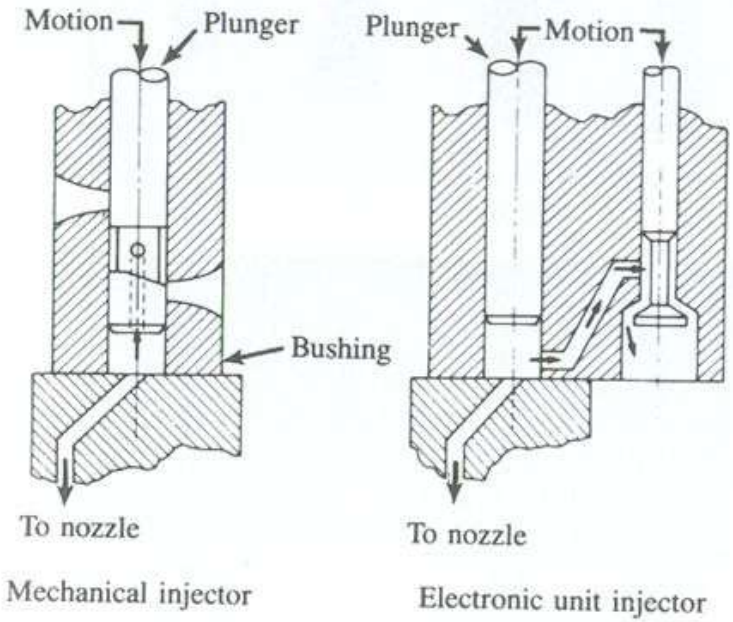
- Unit injector system,
- Rotary distributor type and
- common rail direct injection system

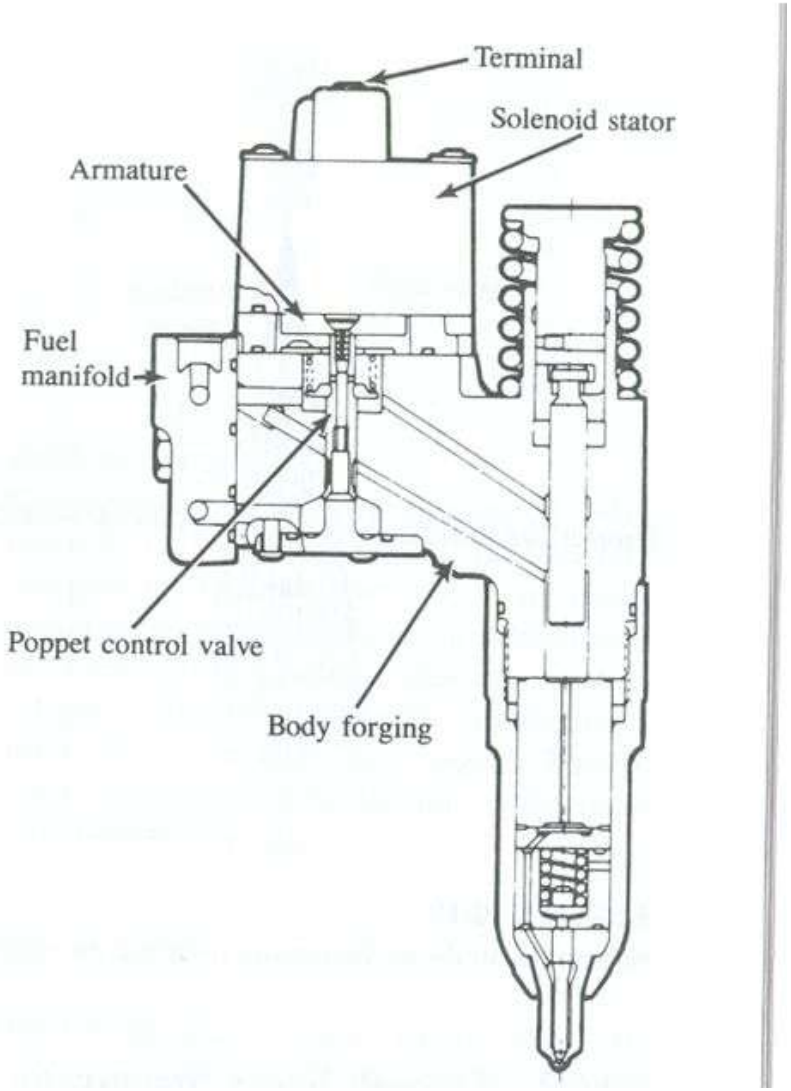
Unit injector system

- Unit injector (UI) is an high pressure integrated direct fuel injection system for diesel engines, combining the injector nozzle and the injection pump in a single component.
- High pressure injection delivers power and fuel consumption benefits over earlier lower pressure fuel injection, by injecting fuel as a larger number of smaller droplets, giving a much higher ratio of surface area to volume.
- This provides improved vaporization from the surface of the fuel droplets, and so more efficient combining of atmospheric oxygen with vaporized fuel delivering more complete and cleaner combustion

It is suitable for cars and light commercial vehicles and 312 hp engine power

Unit Injector System

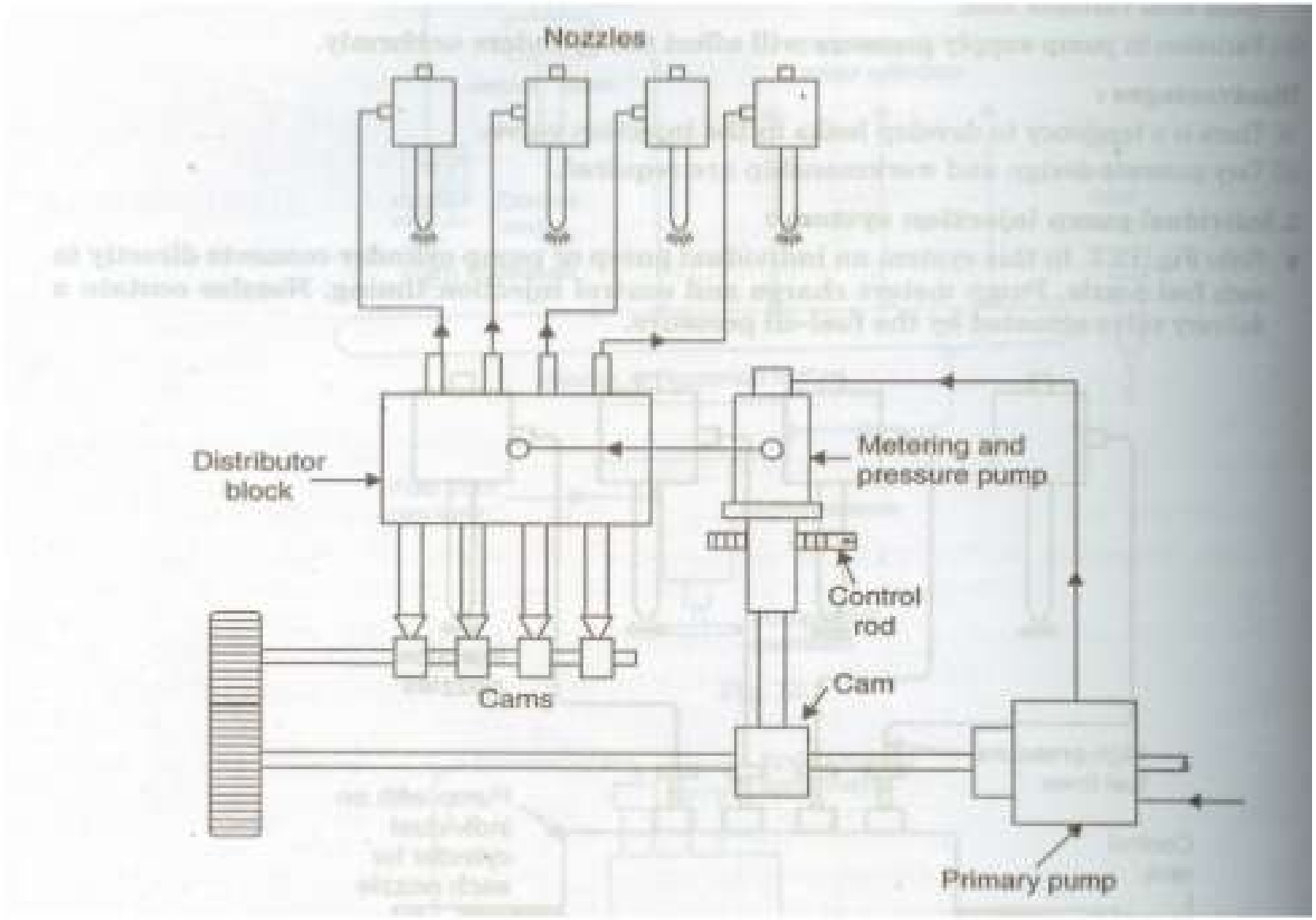


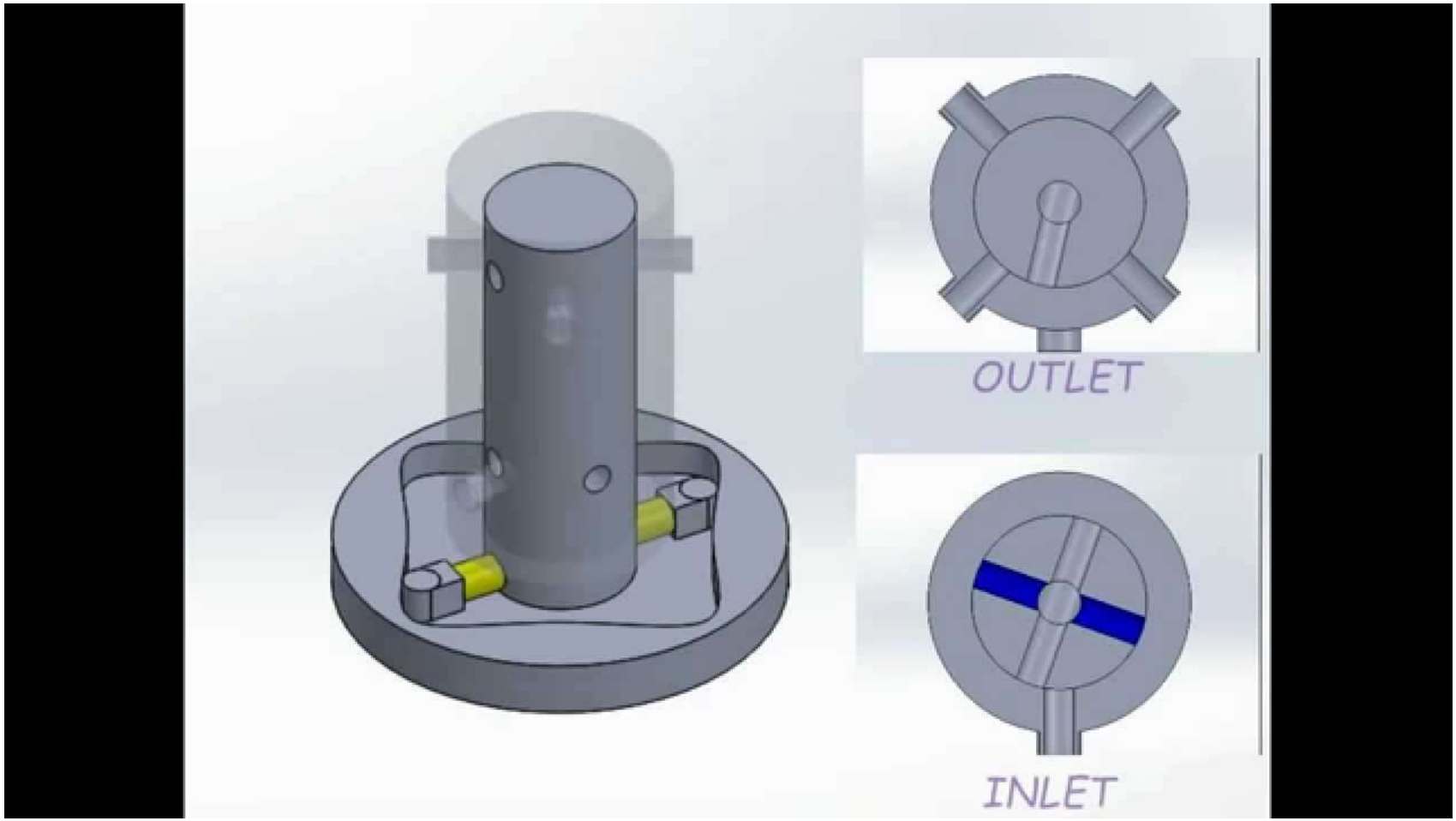


Rotary distributor type

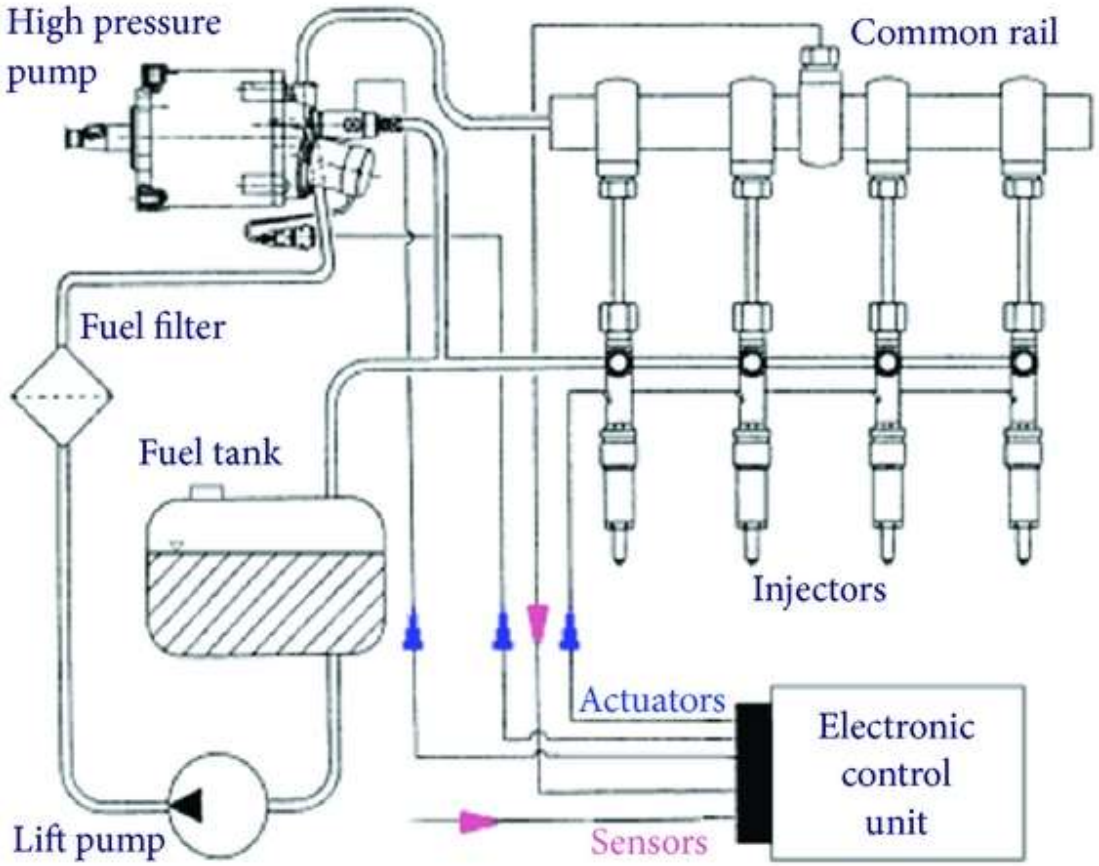
- In distributor-type fuel-injection pumps system two or more plungers serve all the cylinders of the engine, and the fuel is injected to each cylinder in turn by a distributor
- Rotary types distributor pump are those in which the plungers reciprocate in the head of the distributor rotor while revolving around its axis

Working of a Rotary Distributer system



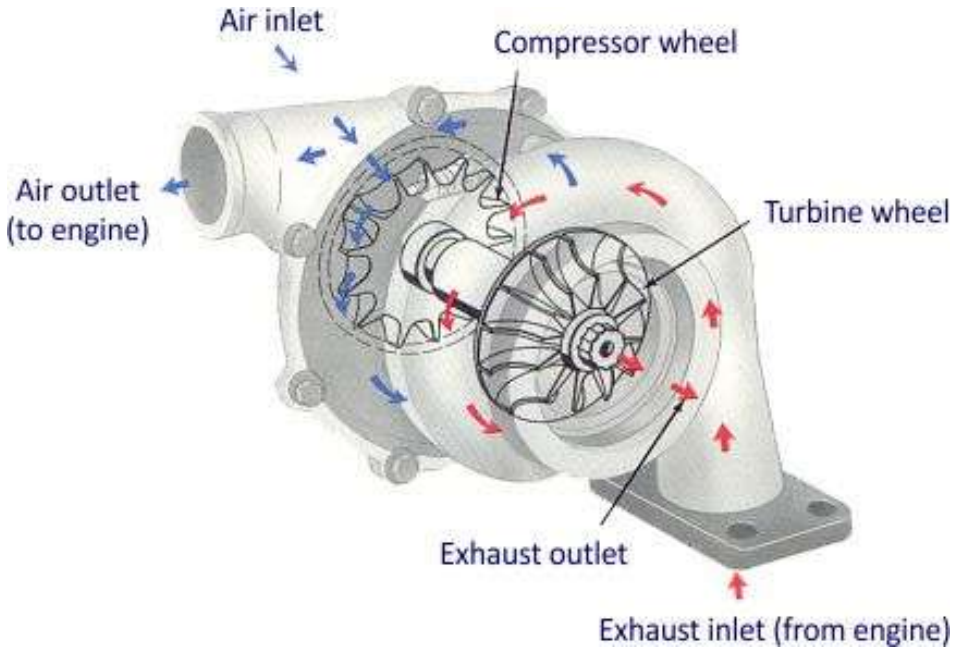

OUTLET
INLET

Common Rail Direct Ignition System



Turbocharger

- A turbocharger is a turbine-driven forced induction device, that increases an internal combustion engine's efficiency and power output by forcing extra compressed air into the combustion chamber.



Turbocharger

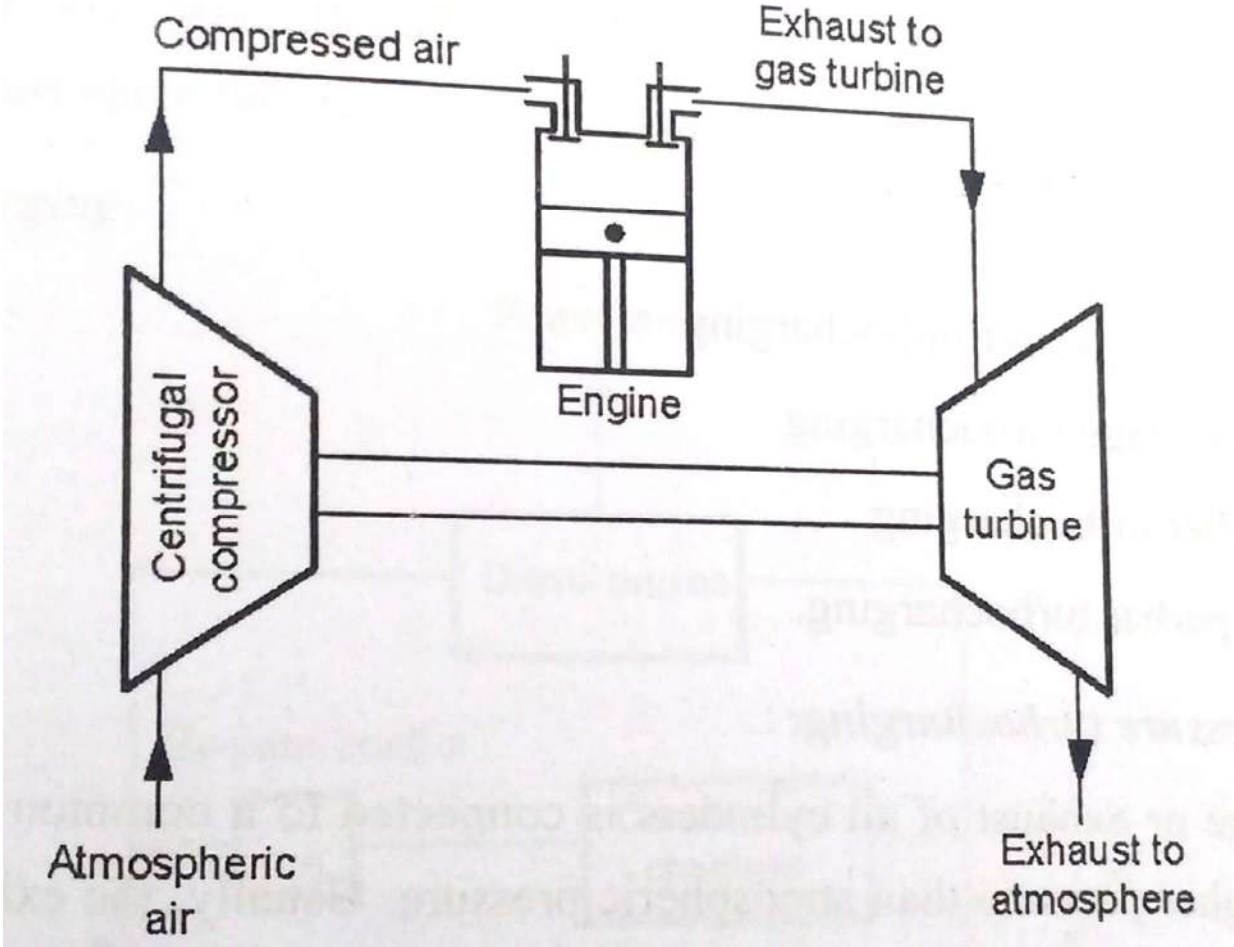


Figure 2.44 Exhaust gas driven turbocharger

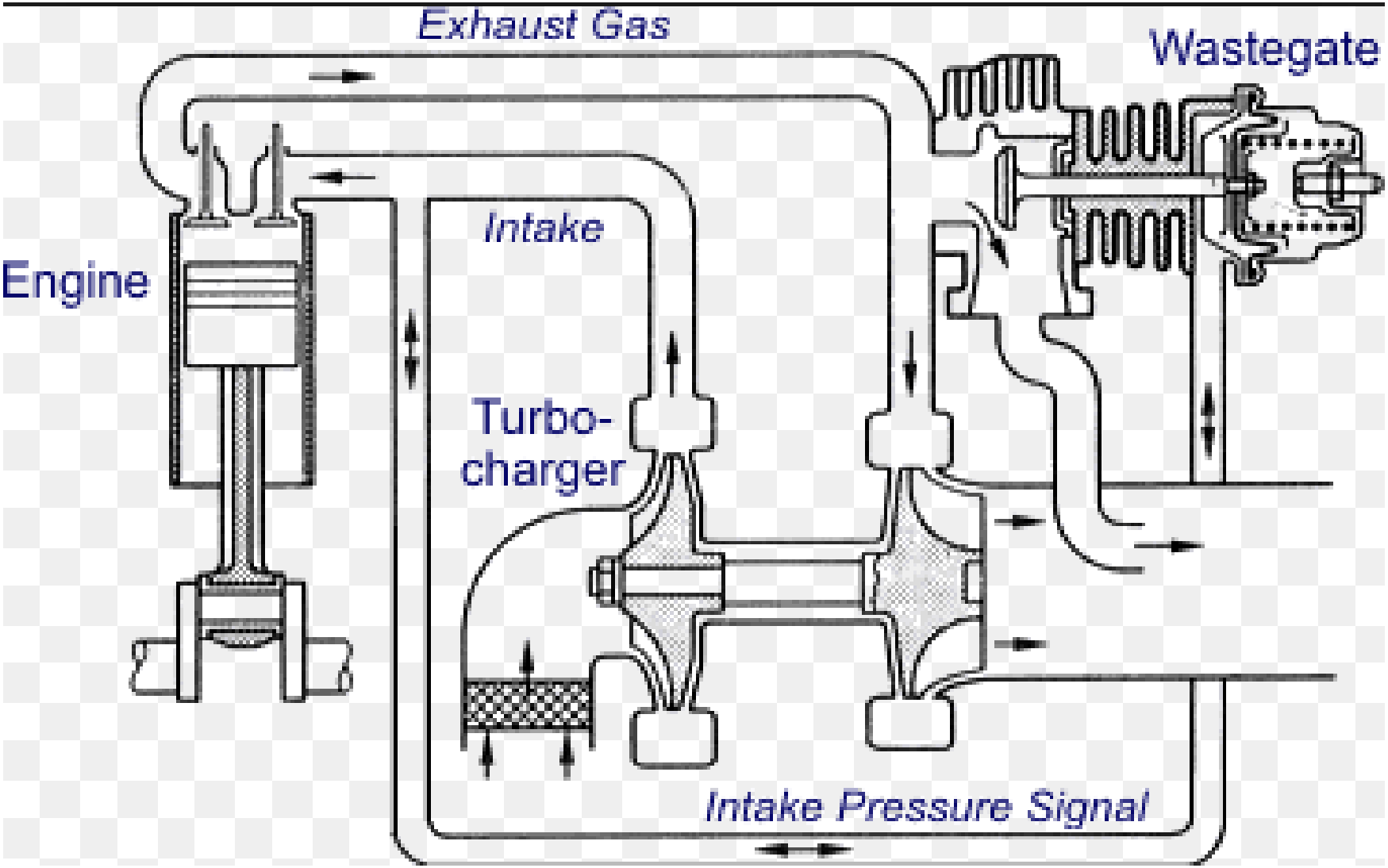
Turbocharger Types

- **Waste gate Turbocharger – WGT**
- **Variable-geometry Turbocharger - VGT**

Waste gate Turbocharger

- A waste gate is a valve that diverts exhaust gases away from the turbine wheel in a turbocharged engine system.
- Diversion of exhaust gases regulates the turbine speed, which in turn regulates the rotating speed of the compressor.
- The primary function of the waste gate is to regulate the maximum boost pressure in turbocharger systems, to protect the engine and the turbocharger

Waste gate Turbocharger

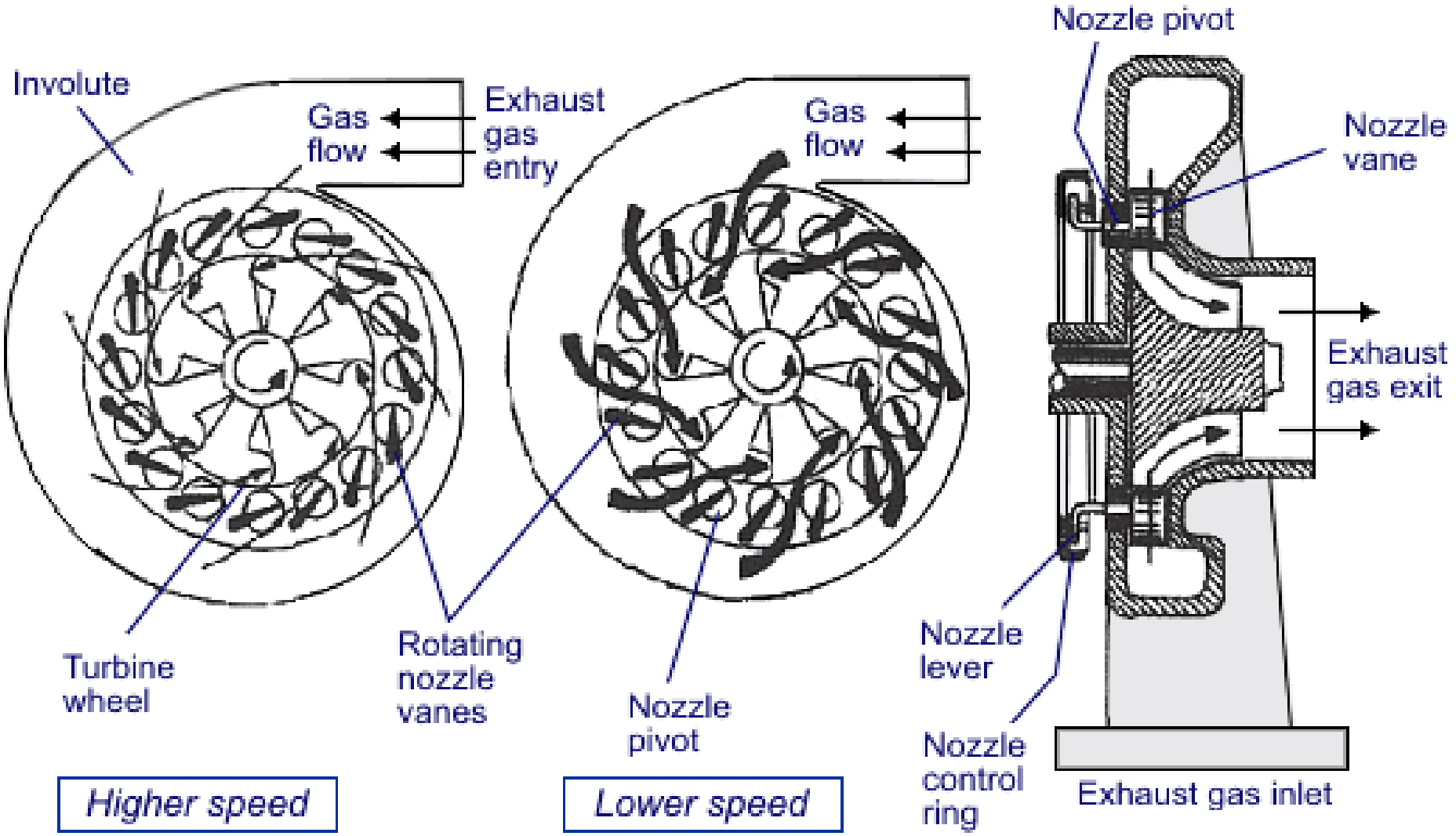


Variable-geometry Turbocharger

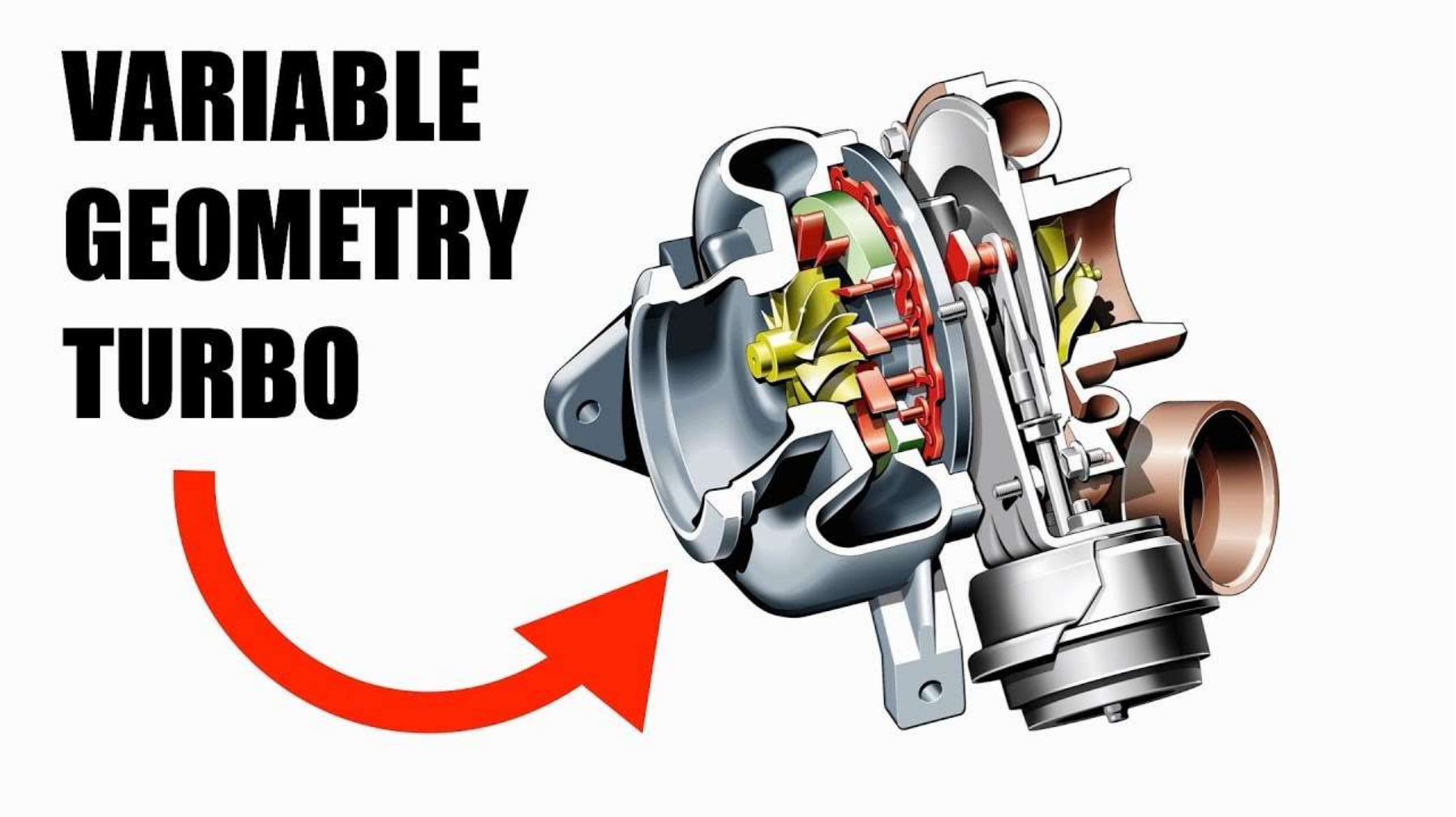
- Variable-geometry turbochargers use moveable vanes to adjust the air-flow to the turbine, imitating a turbocharger of the optimal size throughout the power curve.

- The vanes are placed just in front of the turbine like a set of slightly overlapping walls. Their angle is adjusted by an actuator to block or increase air flow to the turbine.

Variable-geometry Turbocharger



Variable-geometry Turbocharger



IGNITION SYSTEM

- An ignition system generates a spark or heats an electrode to a high temperature to ignite a fuel-air mixture in spark ignition internal combustion engines, oil-fired and gas-fired boilers, rocket engines, etc

IGNITION SYSTEM

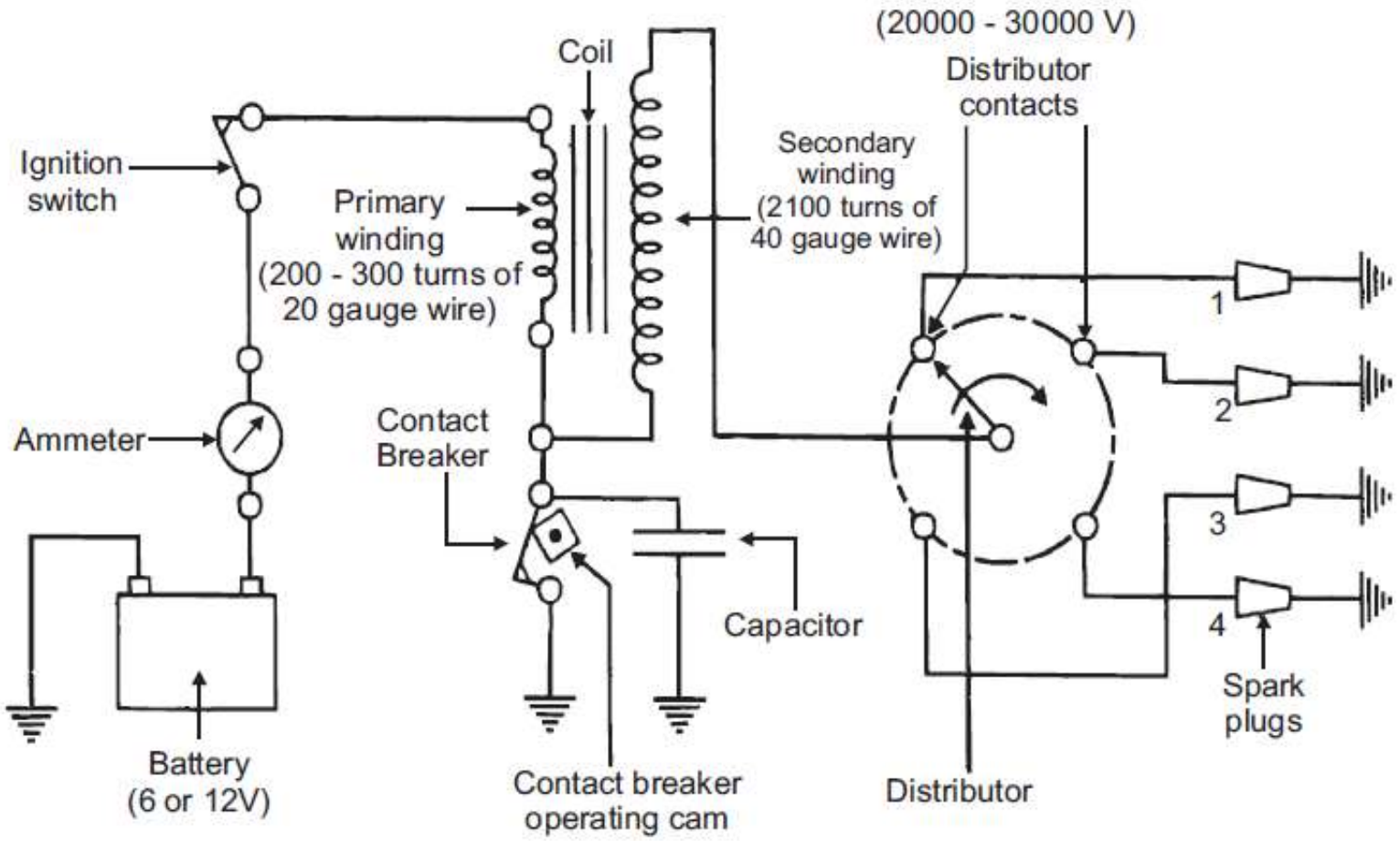
- **Magneto systems**
- **Battery and coil-operated ignition**
- **Mechanically timed ignition**
- **Electronic ignition**
- **Digital electronic ignitions**

Battery Ignition System

- Battery Ignition System is used in automobile to produce spark in the spark plug for the combustion of fuel in the I.C. engine. Here the main source for the spark generation is the battery. It is mostly used in light commercial vehicles.

    1. Battery
    2. Ignition switch
    3. Ballast resistor
    4. Ignition coil
    5. Contact breaker
    6. Capacitor
    7. Distributor
    8. Spark plug

Battery Ignition System



Battery Ignition System

- In the Battery ignition system as the ignition switch is ON, the current from the battery starts to flow through the primary circuit through ballast register, primary winding and contact breaker.
- The current flowing through the primary winding induces magnetic field around it. The more will be the current, the stronger will its magnetic field.
- As the contact breaker opens, the current through the primary winding collapse and this immediate collapse in the current induces a voltage of about 300V in the primary winding. This voltage induced in the winding charges the capacitor to the much greater voltage than the battery. As the capacitor charged, the current through the primary winding stops and the current starts to flow to the battery form the capacitor.
- This reverses the direction of current and magnetic field in the primary winding. Due to the collapsing and reversing of the current and magnetic field, a very high voltage of about 15000 to 30000 V induced in the secondary winding.
- The high voltage current induced in the secondary winding is transferred to the distributor through a high tension cable.
- The distributor has a rotor that rotates inside the distributor cap. The distributor cap has metallic segments embedded into it. As the rotor rotates, it presses and opens the contact breaker point. This allows the high tension current to transfer to the spark plugs through the metallic segments.
- As the high tension current reaches the spark Plug, it produces spark in the engine cylinder for the combustion of the air-fuel mixture.

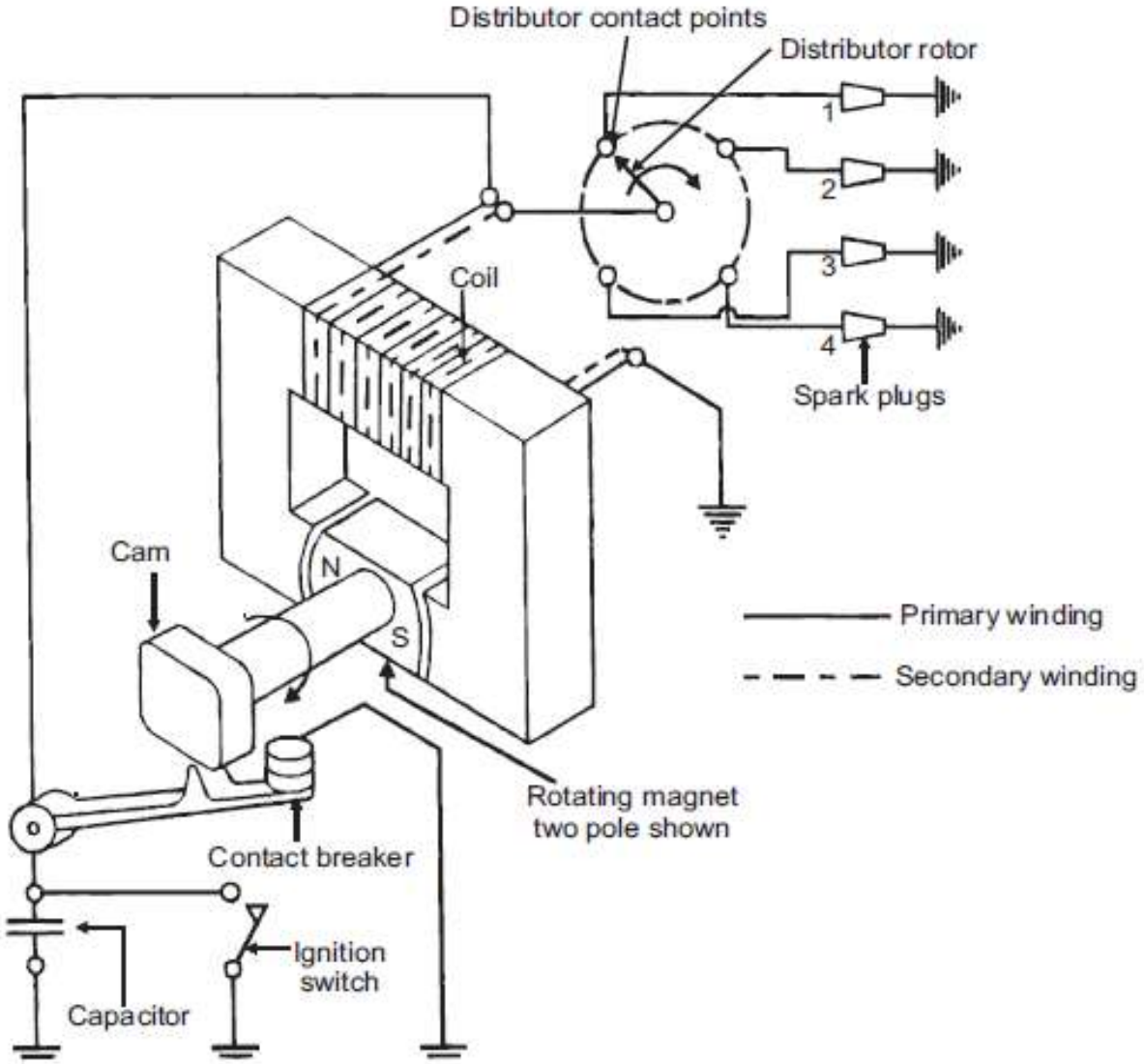
Magneto Ignition System

The **Magneto Ignition System** is a unique kind of Ignition System which has its own source to generate the necessary amount of energy for an automobile or a vehicle to work.

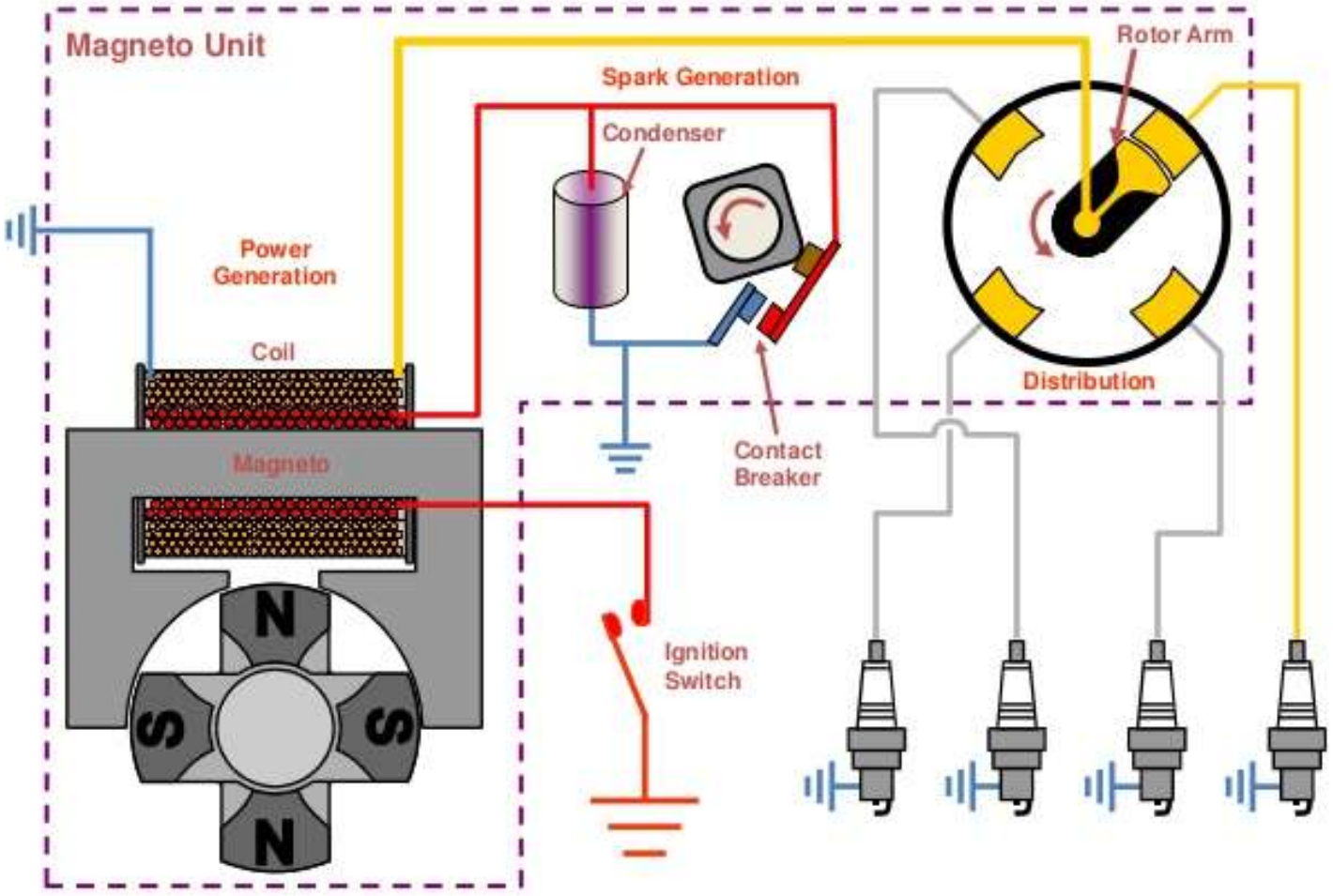
Here is the list of parts that are used in it

- Magneto
- Distributor
- Spark Plug
- Capacitor

Magneto Ignition System



Magneto Ignition System

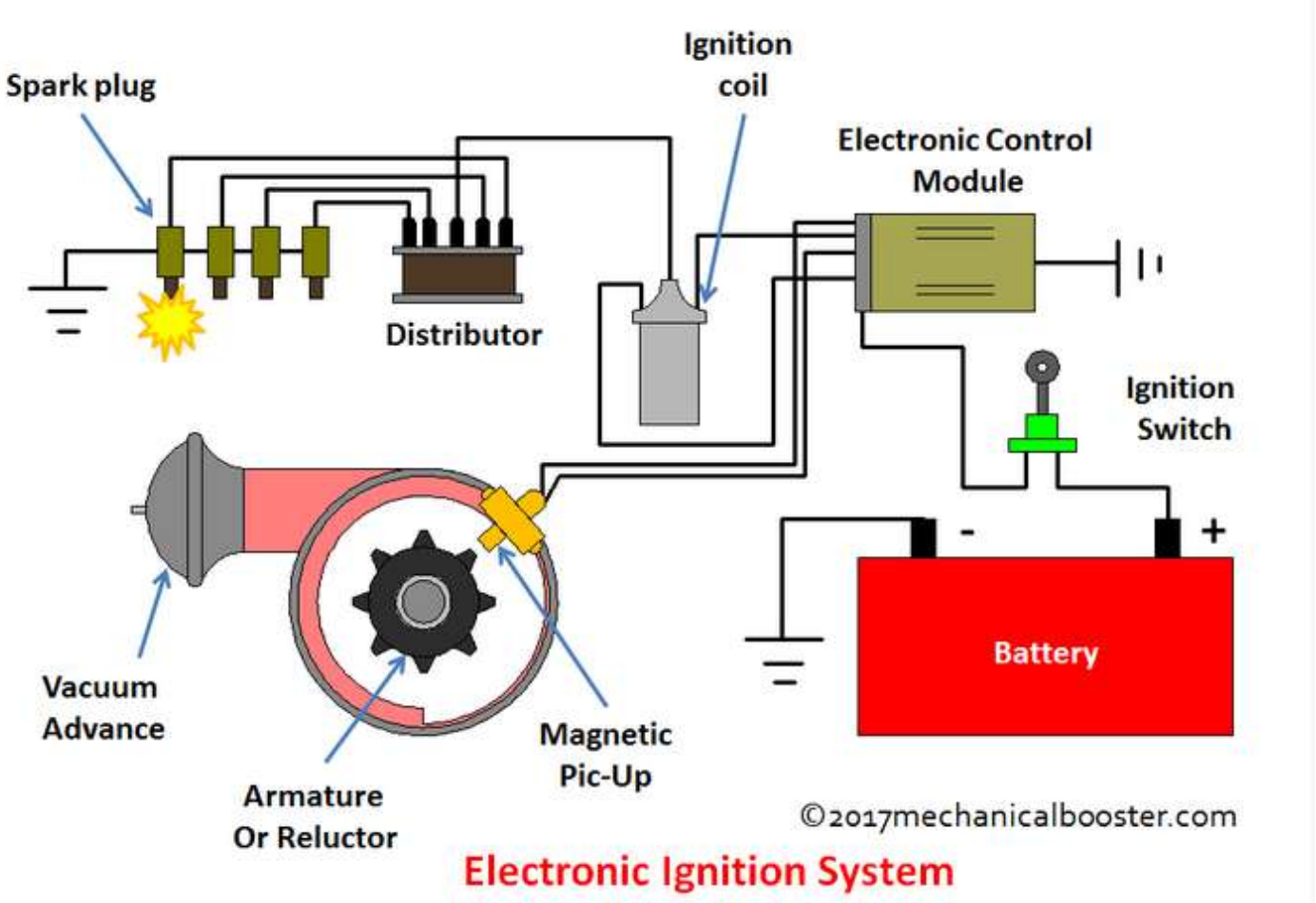


IGNITION SYSTEM – Magneto System

Magneto Ignition System

- When engine in the system starts it help magneto to rotate and thereby producing the energy in the form of high voltage.
- The one end of the magneto is grounded through contact breaker and ignition capacitor is connected to it parallel.
- The contact breaker is regulated by the cam and when the breaker is open, current flows through the condenser and charges it.
- As the condenser is acting like a charger now, the primary current flow is reduced thereby reducing the overall magnetic field generated in the system. This increases the voltage in the condenser.
- This increased high voltage in the condenser will act as an EMF thereby producing the spark at the right spark plug through the distributor.
- At the initial stage, the speed of the engine is low and hence the voltage generated by the magneto is low but as the rotating speed of the engine increases, it also increases the voltage generated by the magneto and flow of the current is also increased. To kick start the engine, we can use an external source such as the battery to avoid the slow start of the engine.

Electronic Ignition



Electronic ignition system

- Electronic ignition system
  - Transistorized coil ignition system,
  - capacitive discharge ignition system

Emission norms (Euro and BS)

- Bharat stage emission standards (BSES) are emission standards instituted by the Government of India to regulate the output of air pollutants from internal combustion engines and Spark-ignition engines equipment, including motor vehicles.
- The standards and the timeline for implementation are set by the Central Pollution Control Board under the Ministry of Environment, Forest and Climate Change.

- The first emission norms were introduced in India in 1991 for petrol and 1992 for diesel vehicles. These were followed by making the Catalytic converter mandatory for petrol vehicles and the introduction of unleaded petrol in the market.
- On 29 April 1999 the Supreme Court of India ruled that all vehicles in India have to meet Euro I or India 2000 norms by 1 June 1999 and Euro II will be mandatory by April 2000.

- In 2002, the Indian government accepted the report submitted by the Mashelkar committee. The committee proposed a road map for the roll out of Euro based emission norms for India.
- It also recommended a phased implementation of future norms with the regulations being implemented in major cities first and extended to the rest of the country after a few years.

- The standards, based on European regulations were first introduced in 2000
- Since October 2010, Bharat Stage (BS) III norms have been enforced across the country
- In 13 major cities, **Bharat Stage IV** emission norms have been in place since April 2010 and it has been enforced for entire country since April 2017.
- In 2016, the Indian government announced that the country would skip the BS-V norms altogether and adopt BS-VI norms by 2020
- In its recent judgment, the Supreme Court has banned the sale and registration of motor vehicles conforming to the emission standard Bharat Stage-IV in the entire country from April 1, 2020.

Table 1: Indian Emission Standards (4-Wheel Vehicles)

Standard	Reference	YEAR	Region
India 2000	Euro 1	2000	Nationwide
Bharat Stage II	Euro 2	2001	NCR*, Mumbai, Kolkata, Chennai
		2003.04	NCR*, 13 Cities†
		2005.04	Nationwide
Bharat Stage III	Euro 3	2005.04	NCR*, 13 Cities†
		2010.04	Nationwide
Bharat Stage IV	Euro 4	2010.04	NCR*, 13 Cities†
		2017.04	Nationwide
Bharat Stage V	Euro 5	(to be skipped)	
Bharat Stage VI	Euro 6	2018.04	Delhi [12]
		2019.04	NCR [13]
		2020.04 [14]	Nationwide

* National Capital Region (Delhi)

† Mumbai, Kolkata, Chennai, Bengaluru, Hyderabad, Ahmedabad, Pune, Surat, Kanpur, Lucknow, Sholapur, Jamshedpur and Agra

Table 2: Indian Emission Standards (2 and 3 wheelers)

Standard	Reference	Date
Bharat Stage II	Euro 2	1 April 2000
Bharat Stage III	Euro 3	1 April 2010
Bharat Stage IV	Euro 4	1 April 2017
Bharat Stage VI	Euro 6	April 2020 with mandate (proposed)

Table 3: Emission Standards for Diesel Truck and Bus Engines, g/kWh

Year	Reference	Test	CO	HC	NO_x	PM
1992	–	ECE R49	17.3–32.6	2.7–3.7	–	–
1996	–	ECE R49	11.20	2.40	14.4	–
2000	Euro I	ECE R49	4.5	1.1	8.0	0.36*
2005†	Euro II	ECE R49	4.0	1.1	7.0	0.15
2010†	Euro III	ESC	2.1	0.66	5.0	0.10
		ETC	5.45	0.78	5.0	0.16
2010‡	Euro IV	ESC	1.5	0.46	3.5	0.02
		ETC	4.0	0.55	3.5	0.03

* 0.612 for engines below 85 kW

† earlier introduction in selected regions, see Table 1 ‡ only in selected regions, see Table 1

Table 4: Emission Standards for Light-Duty Diesel Vehicles, g/km

Year	Reference	CO	HC	HC+NO_x	NO_x	PM
1992	–	17.3–32.6	2.7–3.7	–	–	–
1996	–	5.0–9.0	–	2.0–4.0	–	–
2000	Euro 1	2.72–6.90	–	0.97–1.70	0.14–0.25	–
2005†	Euro 2	1.0–1.5	–	0.7–1.2	0.08–0.17	–
2010†	Euro 3	0.64 0.80 0.95	–	0.56 0.72 0.86	0.50 0.65 0.78	0.05 0.07 0.10
2010‡	Euro 4	0.50 0.63 0.74	–	0.30 0.39 0.46	0.25 0.33 0.39	0.025 0.04 0.06

† earlier introduction in selected regions, see Table 1

‡ only in selected regions, see Table 1

Table 6: Emission Standards for Petrol Vehicles (GVW ≤ 3,500 kg), g/km

Year	Reference	CO	HC	HC+NO_x	NO_x
1991	–	14.3–27.1	2.0–2.9	–	
1996	–	8.68–12.4	–	3.00–4.36	
1998*	–	4.34–6.20	–	1.50–2.18	
2000	Euro 1	2.72–6.90	–	0.97–1.70	
2005†	Euro 2	2.2–5.0	–	0.5–0.7	
2010†	Euro 3	2.3 4.17 5.22	0.20 0.25 0.29	–	0.15 0.18 0.21
2010‡	Euro 4	1.0 1.81 2.27	0.1 0.13 0.16	–	0.08 0.10 0.11

* for catalytic converter fitted vehicles

† earlier introduction in selected regions, see Table 1 ‡ only in selected regions, see Table 1

Table 7: Emission Standards for 3-Wheel Petrol Vehicles, g/km

Year	CO	HC	$HC+NO_x$
1991	12–30	8–12	–
1996	6.75	–	5.40
2000	4.00	–	2.00
2005 (BS II)	2.25	–	2.00
2010.04 (BS III)	1.25	–	1.25

Table 8: Emission Standards for 2-Wheel Petrol Vehicles, g/km

Year	CO	HC	$HC+NO_x$
1991	12–30	8–12	–
1996	5.50	–	3.60
2000	2.00	–	2.00
2005 (BS II)	1.5	–	1.5
2010.04 (BS III)	1.0	–	1.0

UNIT III: TRANSMISSION SYSTEMS

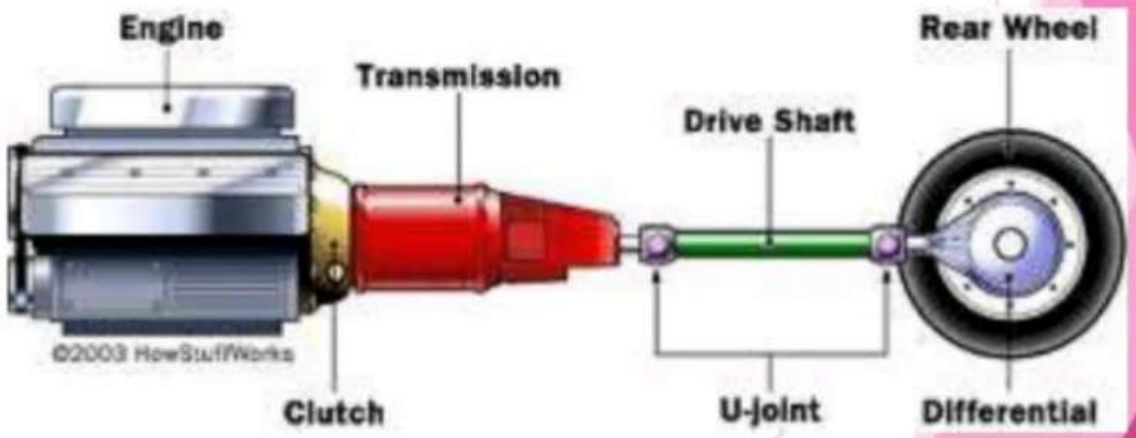
Clutch-types and construction, gear boxes-manual and automatic, gear shift mechanisms, Over drive, transfer box, fluid flywheel, torque converter, propeller shaft, slip joints, universal joints ,Differential and rear axle, Hotchkiss Drive and Torque Tube Drive

TRANSMISSION SYSTEMS

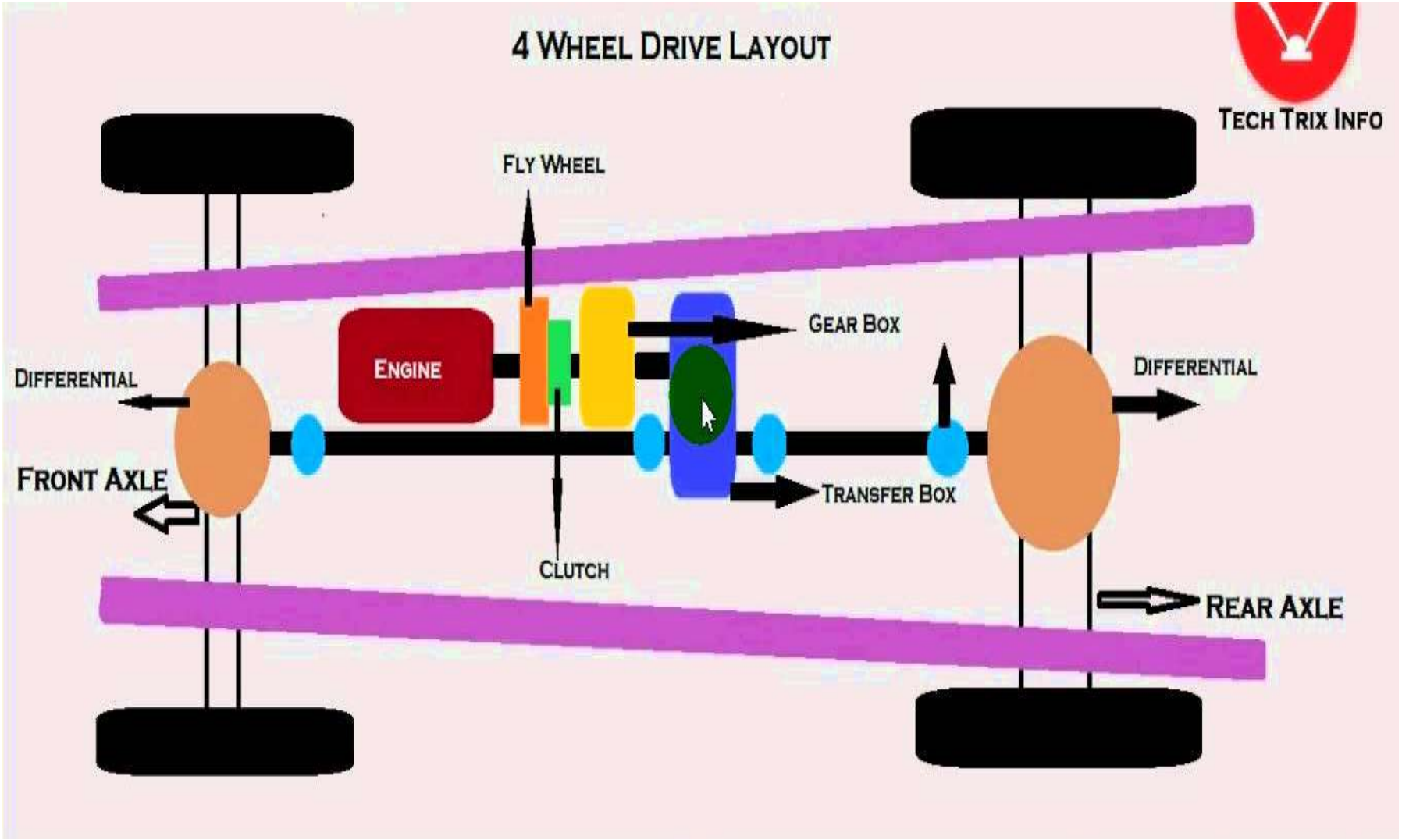
Definition Of Transmission System :-

The mechanism that transmits the power developed by the engine of automobile to the engine to the driving wheels is called the TRANSMISSION SYSTEM (or POWER TRAIN).It is composed of -

- *Clutch*
- *The gear box*
- *Propeller shaft*
- *Universal joints*
- *Rear axle*
- *Wheel*
- *Tyres*



General Arrangement Of Power Transmission



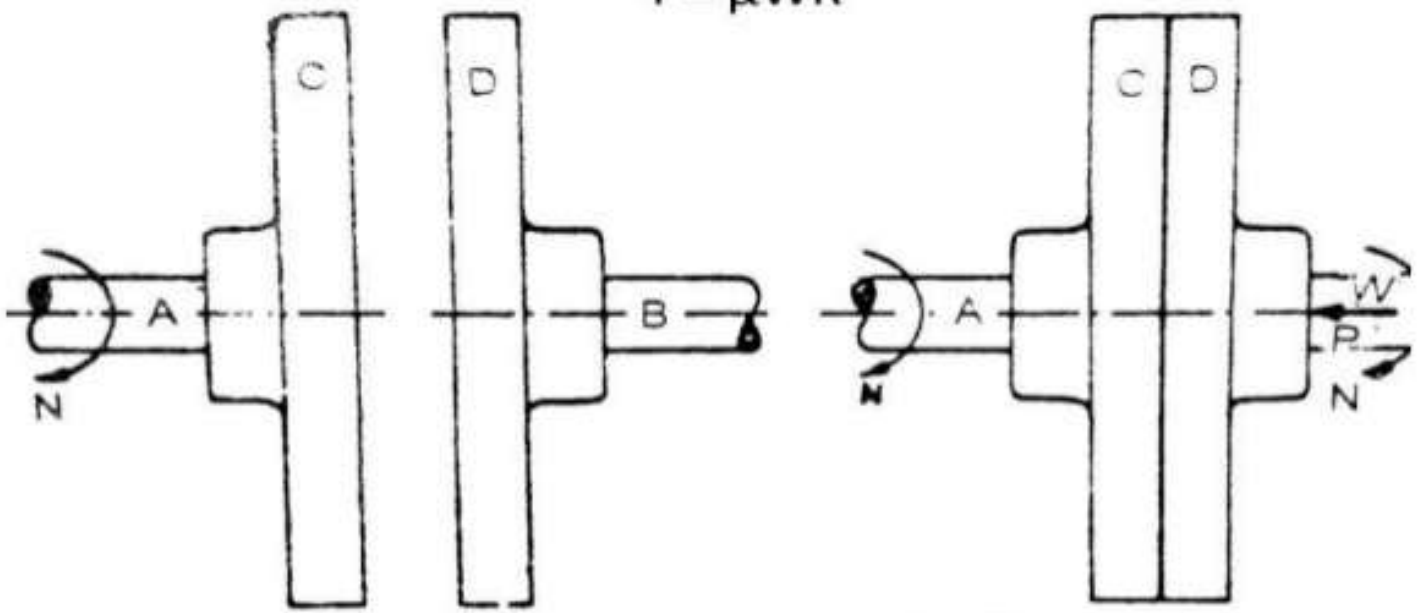
Clutch

- A clutch is a mechanical device which engages and disengages power transmission especially from driving shaft to driven shaft.
- In the simplest application, clutches connect and disconnect two rotating shafts.
- In these devices, one shaft is typically attached to an engine or other power unit (the driving member) while the other shaft (the driven member) provides output power for work.

Friction Clutch

Working Principle of Friction Clutch

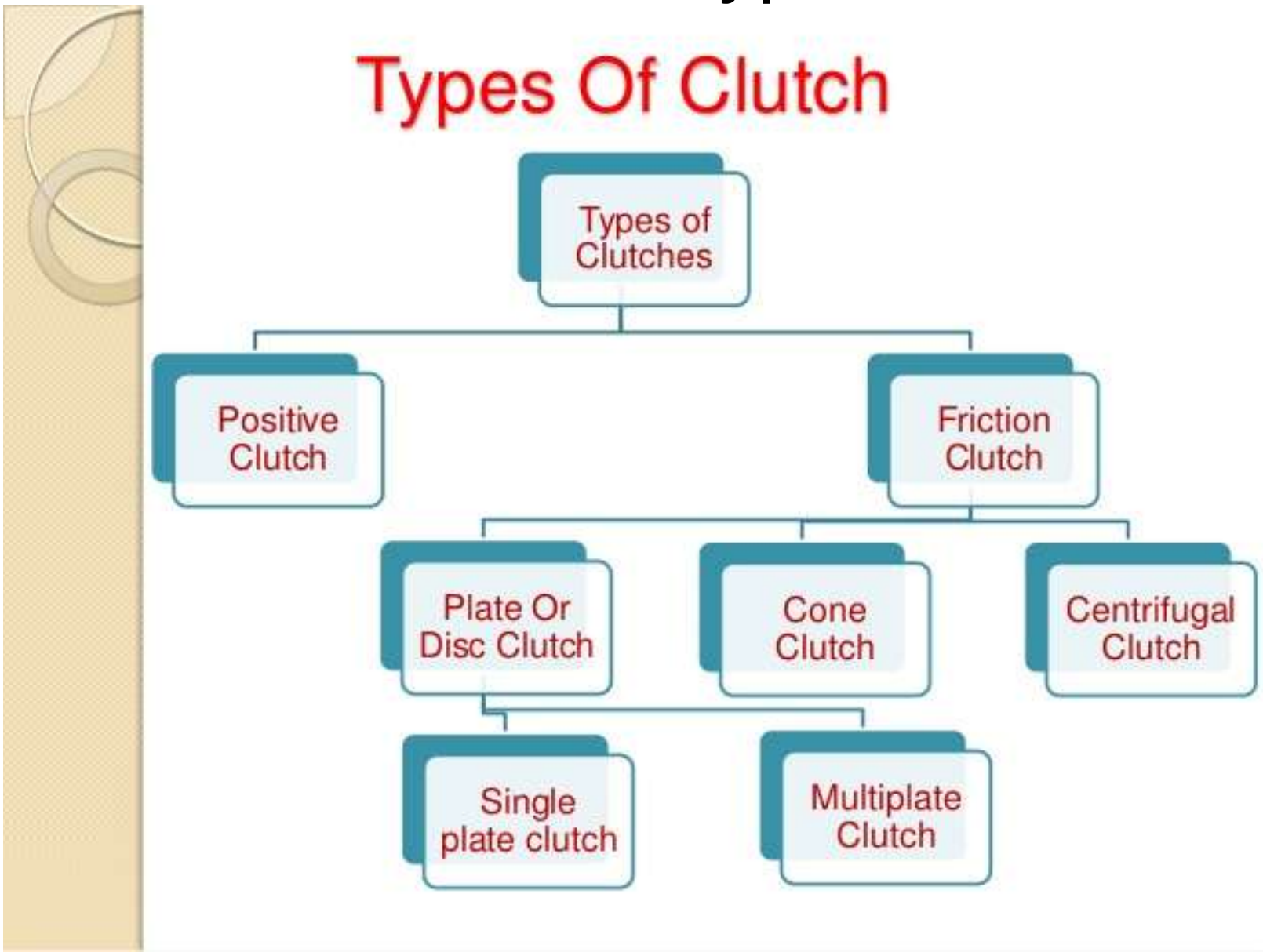
$T = \mu WR$



Clutch Disengaged *Clutch Engaged*

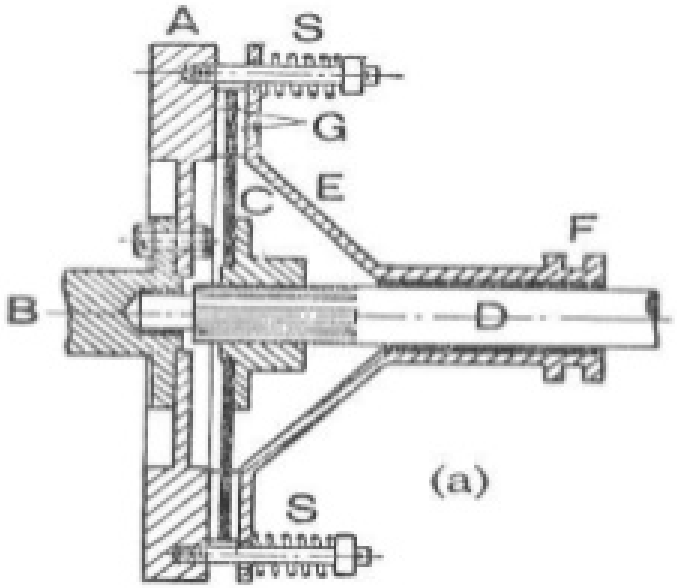
Fig. 2.1 (b) ***Principle of Friction Clutch***

Clutch- Types

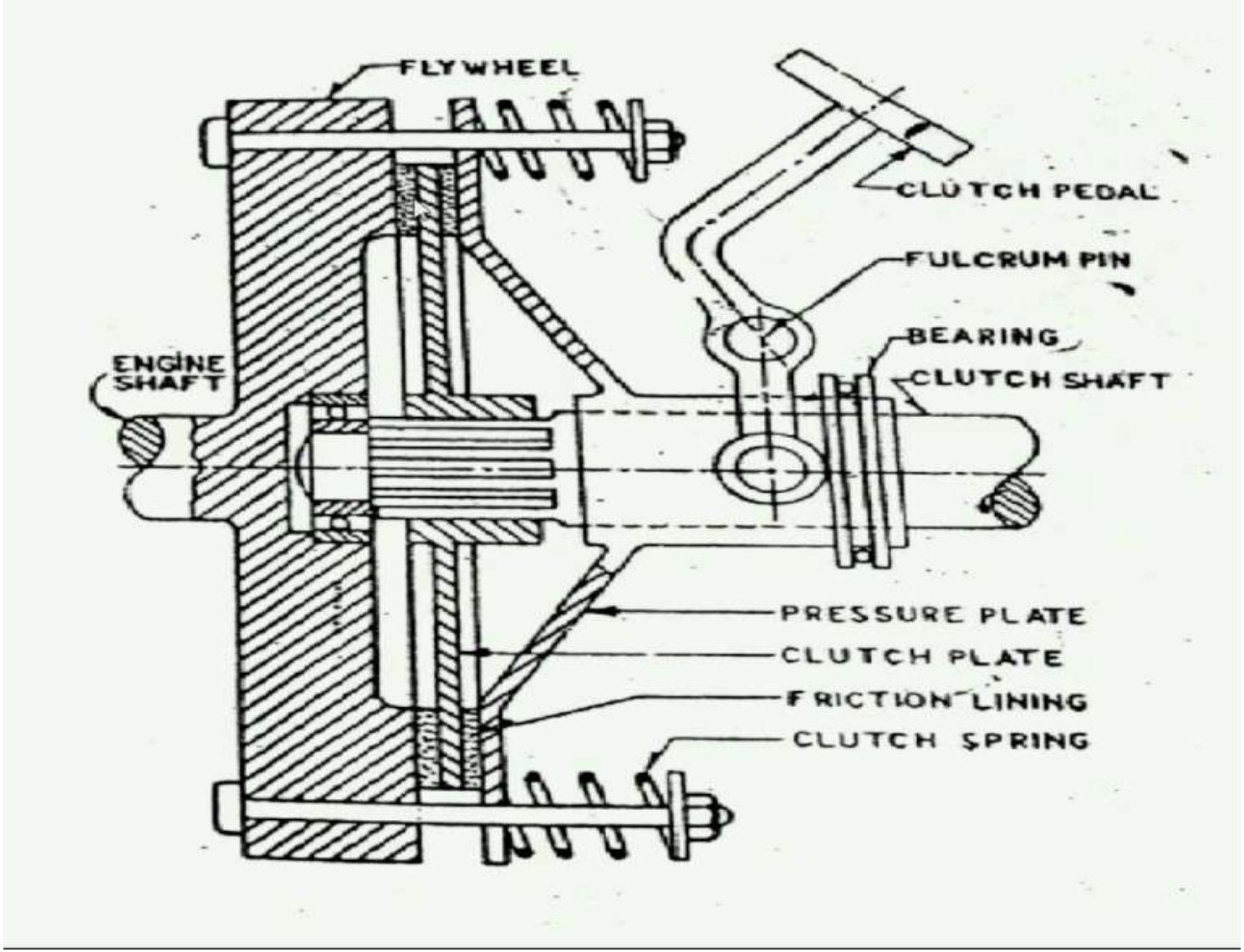


Single plate Clutch

- In the single plate clutch a flywheel is fixed to the engine shaft and a pressure plate is attached to the gear box shaft
- A friction plate is situated between the flywheel and pressure plate



Single plate Clutch



Working of single plate clutch

❖ When the clutch is engage:-

The clutch plate is gripped between the flywheel and the pressure plate. Due to the friction between the flywheel, clutch plate and pressure plate, the clutch plate revolves with the flywheel. As the clutch plate revolves, the clutch shaft also revolves. Clutch shaft is connected to the transmission. Thus, the engine power is transmitted to the crankshaft to the clutch shaft.

❖ When the clutch is disengage:-

When the clutch is pressed, the pressure plate moves back against the force of the springs, and the clutch plate becomes free between the flywheel and the pressure plate. Thus, the flywheel remains rotating as long as engine is running and the clutch shaft speed reduces slowly and finally it stops rotating. As soon as the clutch pedal is pressed, the clutch is said to be disengaged.

Multi plate Clutch

- A multi-plate clutch is a type of clutch in which the multiple clutch plates are used to make frictional contact with the flywheel of the engine in order to transmit power between the engine shaft and the transmission shaft of an automobile vehicle.
- A multi-plate clutch is used in automobiles and in machinery where high torque output is required.

Multi plate Clutch

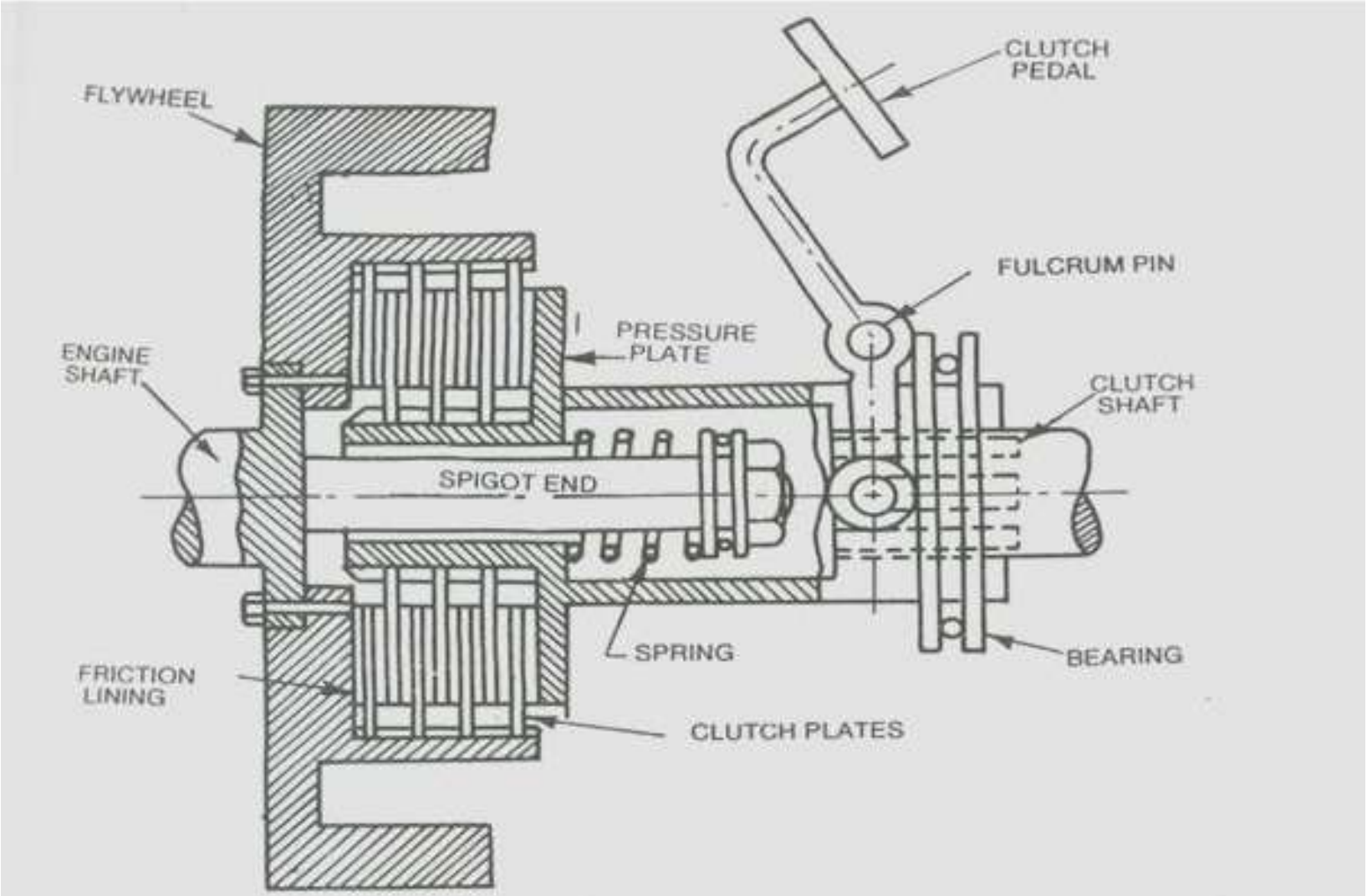
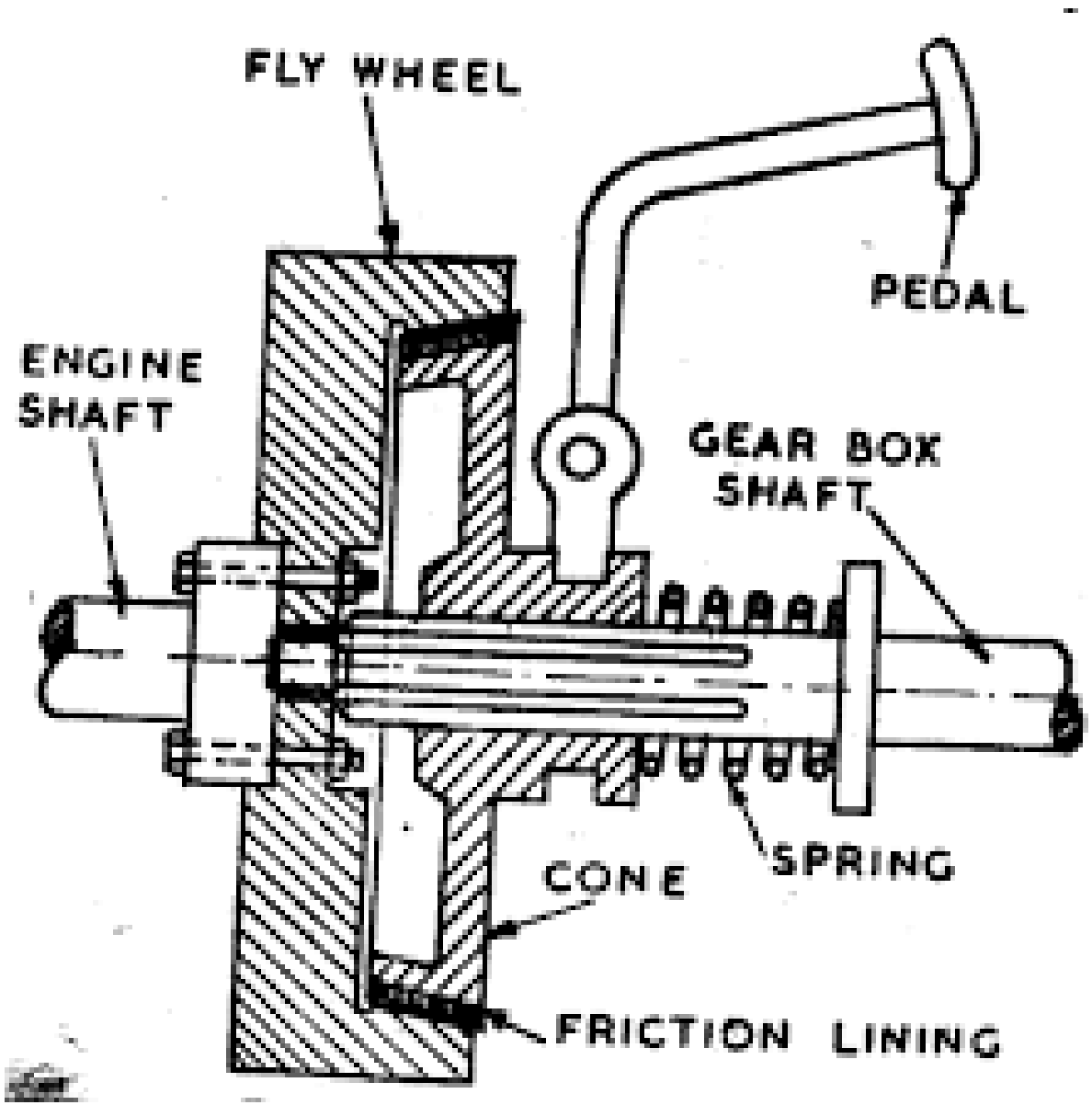


Fig. 22.8. Multiplate clutch.

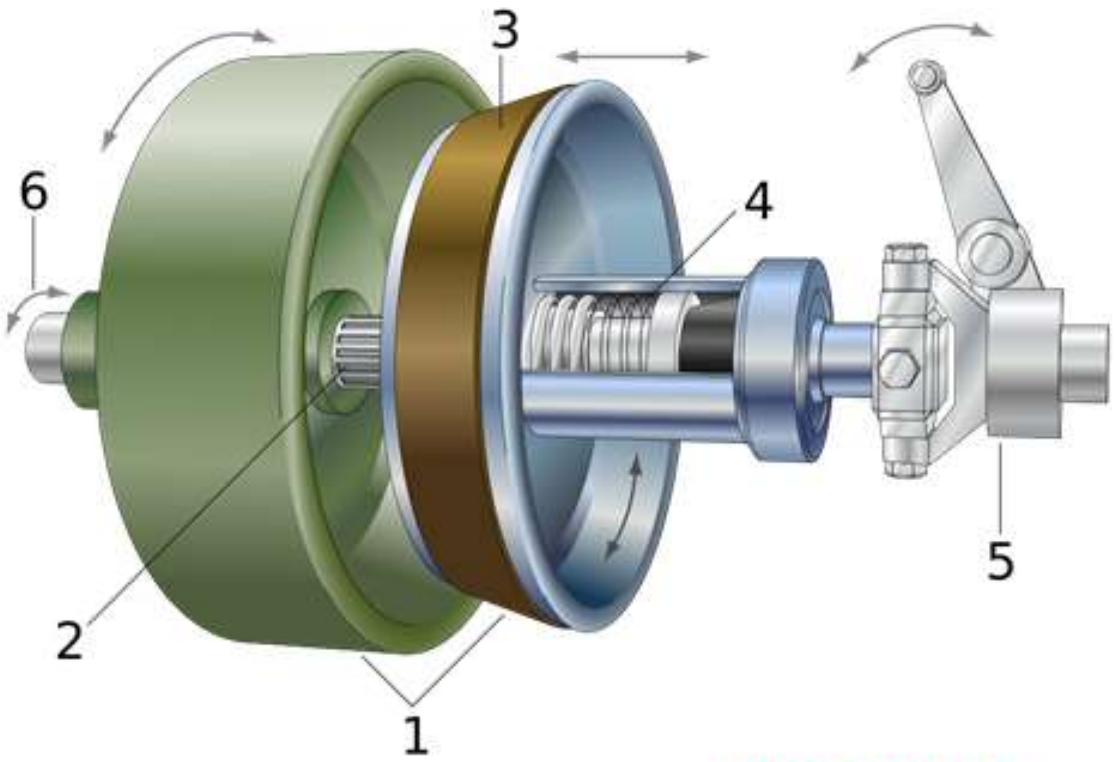
Cone Clutch

- A cone clutch “oldest of all” Is a type of clutch system in which two mating members known as the male member and the female member designed in shape of cones are used, due to the mating of these 2 members frictional force due to the frictional contact between them is generated results in torque or power transmission between them.
- The engagement and disengagement of the male and female member of the cone clutch is controlled by the clutch pedal.
- Due to the large frictional area of contact and also due to the cone like shape of the male and female member of the cone clutch, This clutch system transmit high torque between the engine and the transmission shaft due to which it was widely used in heavy vehicles.

Cone Clutch


FLY WHEEL
PEDAL
ENGINE SHAFT
GEAR BOX SHAFT
SPRING
CONE
FRICTION LINING

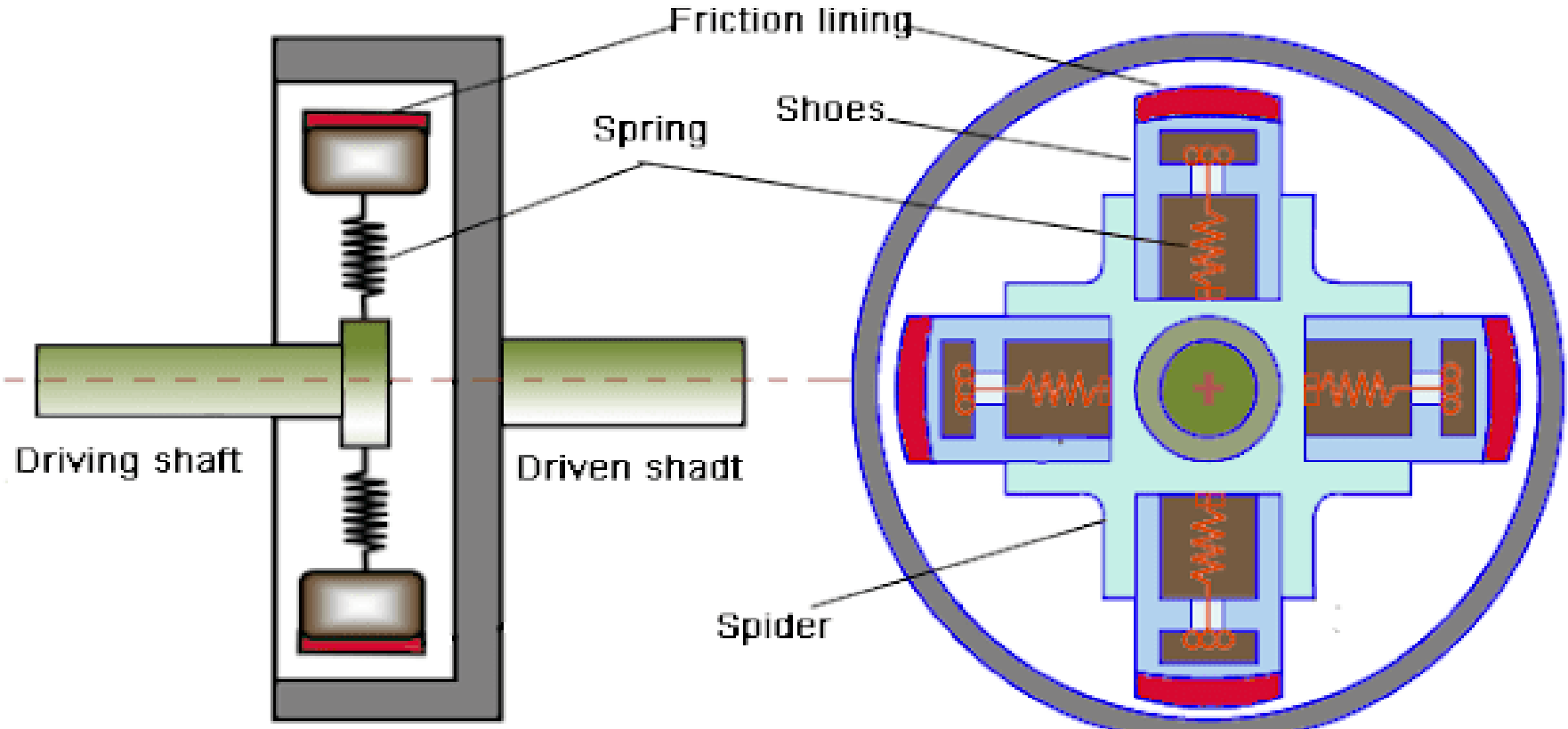
Cone Clutch



Cone Clutch

1: Female cone (green),
: Male cone (blue)
2: Shaft
3: Friction material
4: Spring
5: Clutch control
6: Direction of rotation

Centrifugal Clutch



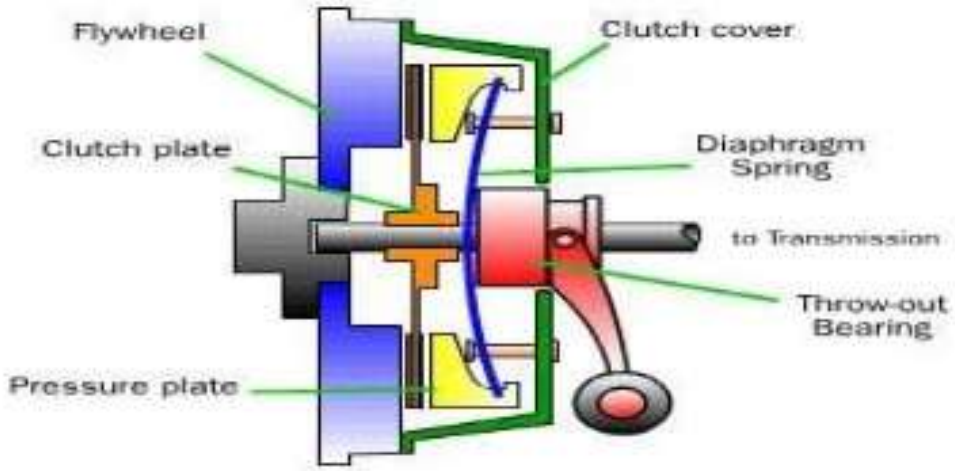
Centrifugal Clutch

Centrifugal Clutch

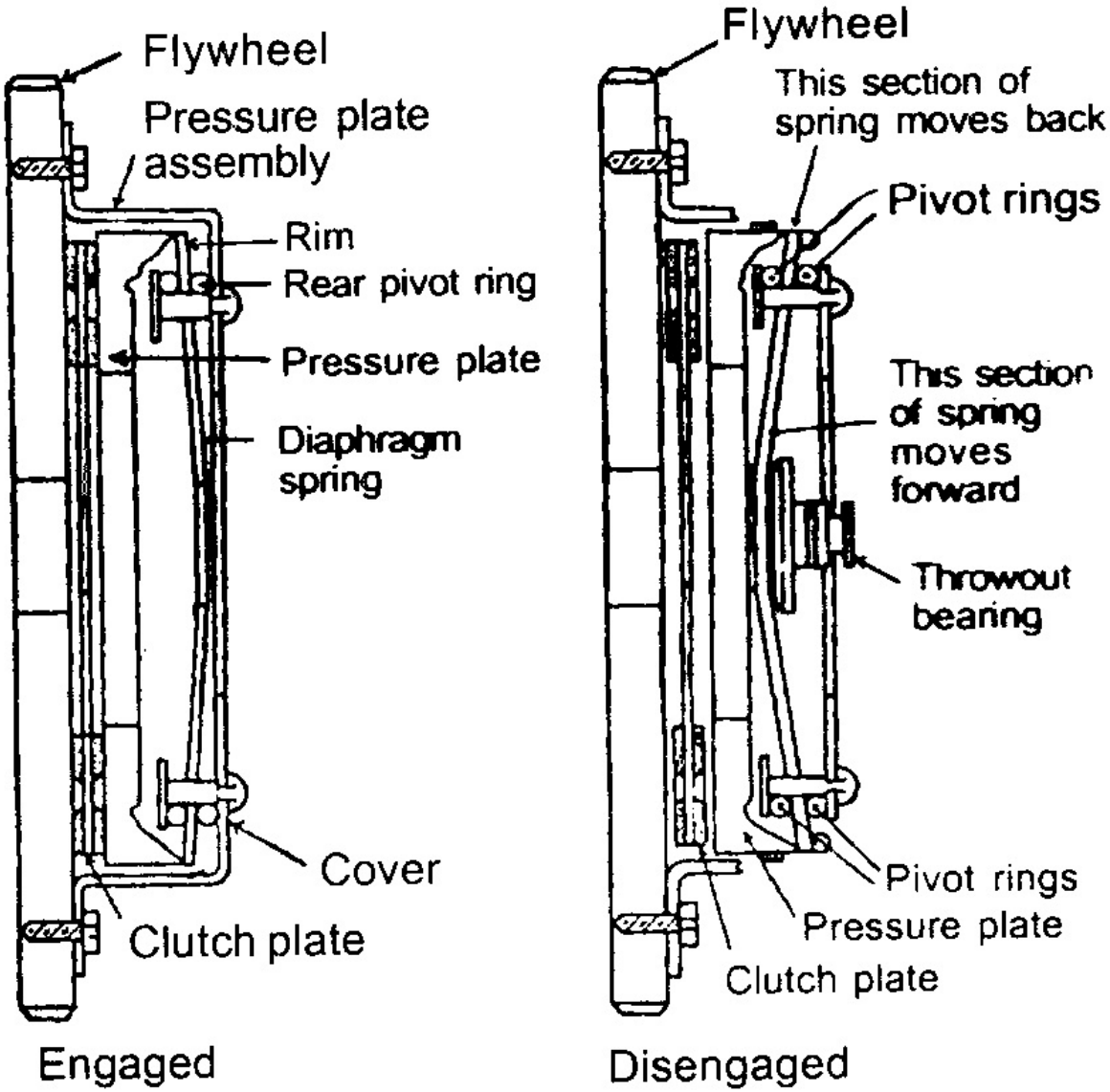
- It consists of a number of shoes on the inside of a drum or rim of the pulley.
- The upper surface of the shoes are covered with a friction material.
- The spider is fitted on the driving shaft.
- When centrifugal force is equal to spring force, the shoe is just floating.
- But, when centrifugal force higher than the spring force, the shoes moves outward and comes into contact with the driven member and pressure against it.
- The increase of speed causes the shoes to press harder and clutch transmit more power.

Diaphragm Clutch

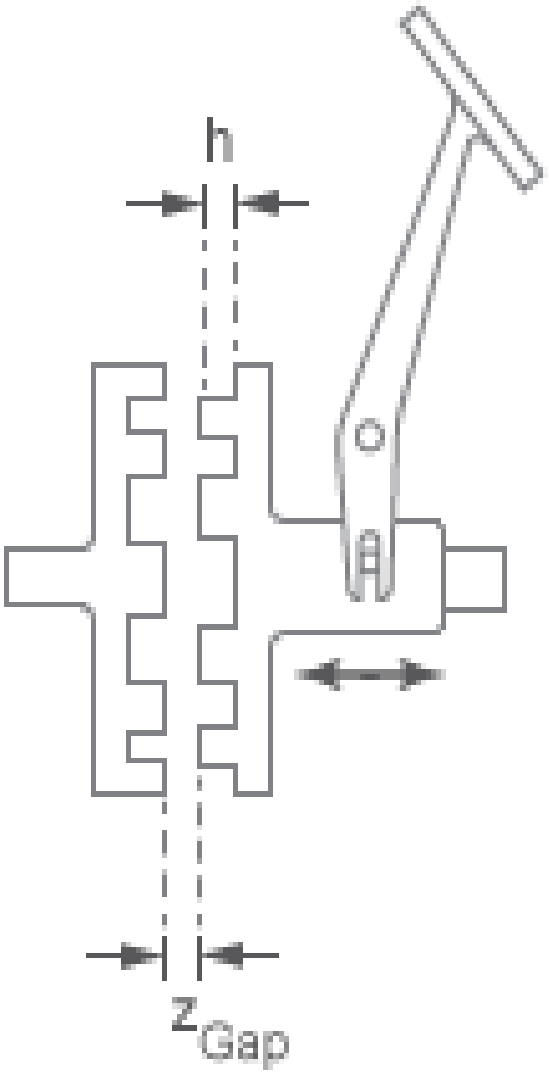
- This clutch is similar to the single plate clutch except diaphragm spring is used instead of coil springs for exert pressure on the pressure plate . In the coil springs, one big problem occur that these springs do not distribute the spring force uniformly. To eliminate this problem, diaphragm springs are used into clutches. This clutch is known as diaphragm clutch.

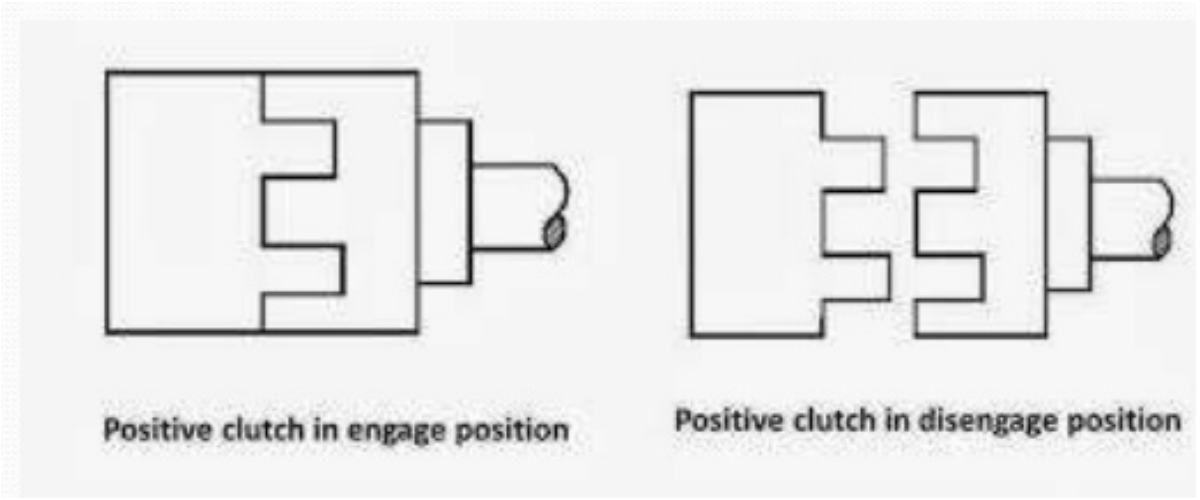


Diaphragm Clutch



Positive Clutch





Positive Clutch

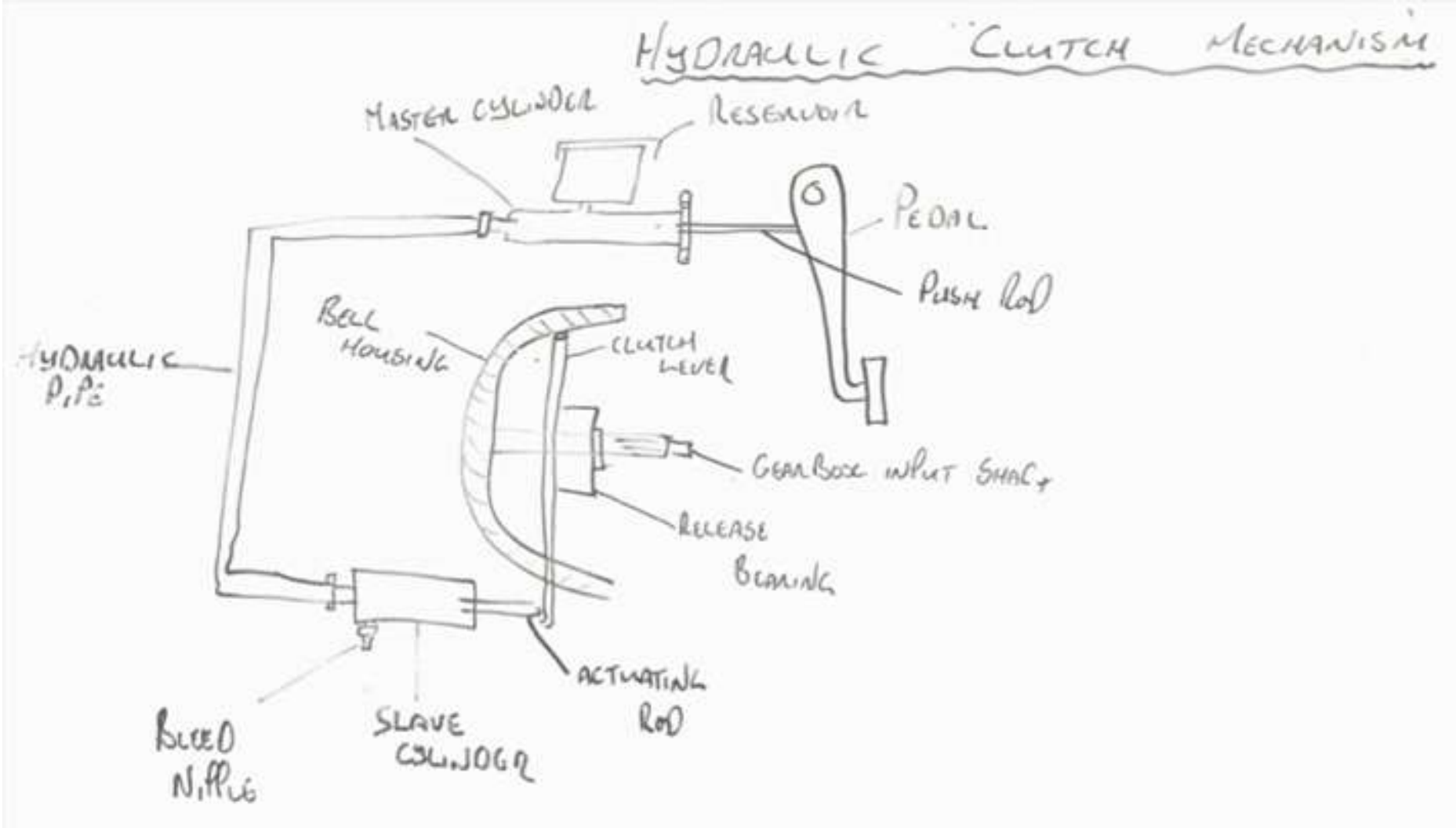
i) Positive Contact clutches

In these clutches, power transmission is achieved by means of interlocking of jaws or teeth. These are classified as:

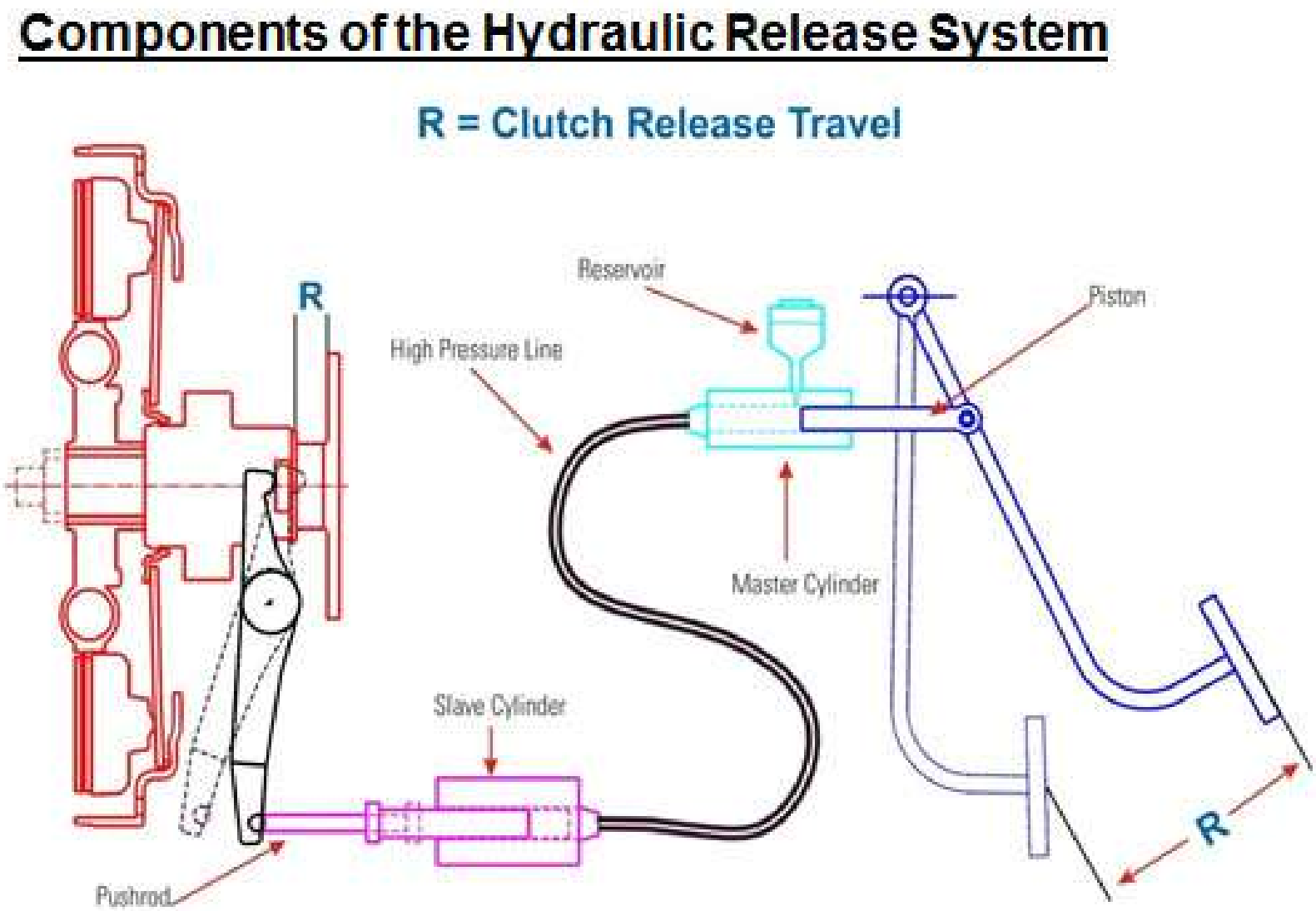
a) Square Jaw Clutches
b) Spiral Jaw Clutches
c) Toothed Clutches.

Their main advantage is positive engagement and once coupled, they can transmit large torque with no slip.

Hydraulic Clutch



Hydraulic Clutch



Gear box

- Gearbox is a speed and torque changing device.
- It changes speed and torque between engine and driving wheels.
- The mechanism through which the driving torque of the engine is transmitted to the driving wheel is the gear box.

Necessity of Gear Box

- To vary the torque as per the requirement for driving the wheels.
- To shift the drive in a neutral position.
- To back the vehicle i.e. Reverse gear.
- Any automobile engine can produce rotation only within a certain range.
- Usually this range is too high for tyres. As tyres have very large diameter as compared to engine shafts, they will have more than required speed, if engaged directly.
- This will lead to accidents and no control of automobile.

Types of Gearbox

- Manual Transmission
  - Sliding mesh gearbox
  - Constant mesh gearbox
  - Synchromesh gearbox
- Epicyclic gearbox
- Automatic Transmission
  - Hydramatic gearbox
  - Torque converter gearbox

Sliding Mesh Gearbox

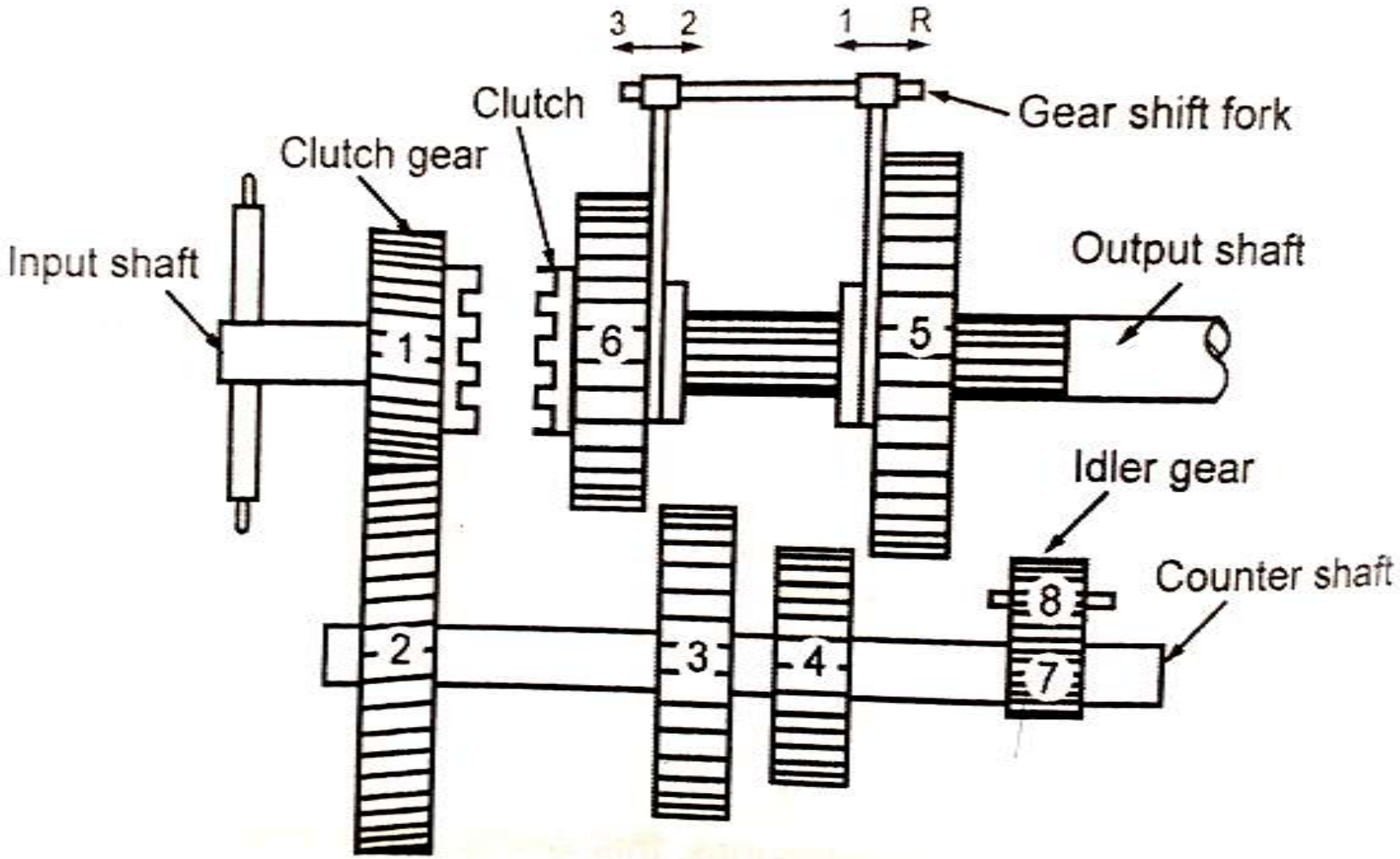


Figure 3.16 Sliding mesh gearbox

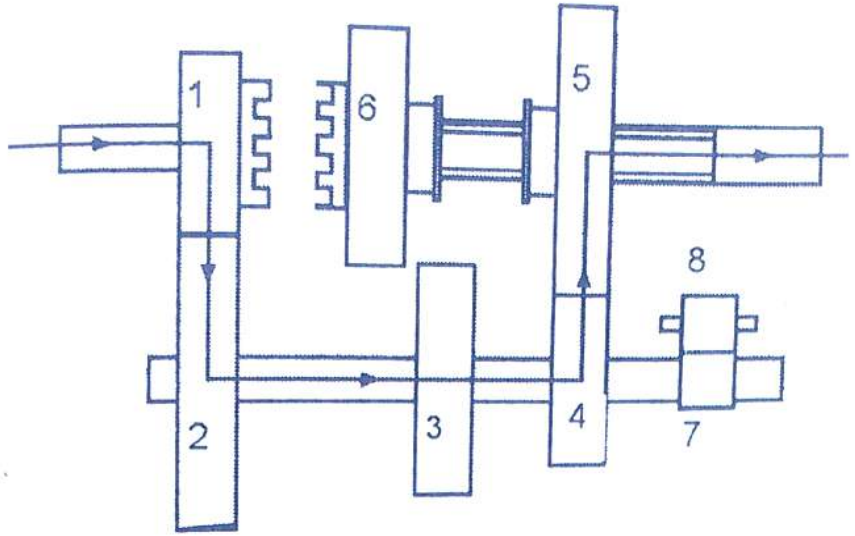


Figure 3.17 First or low speed gear

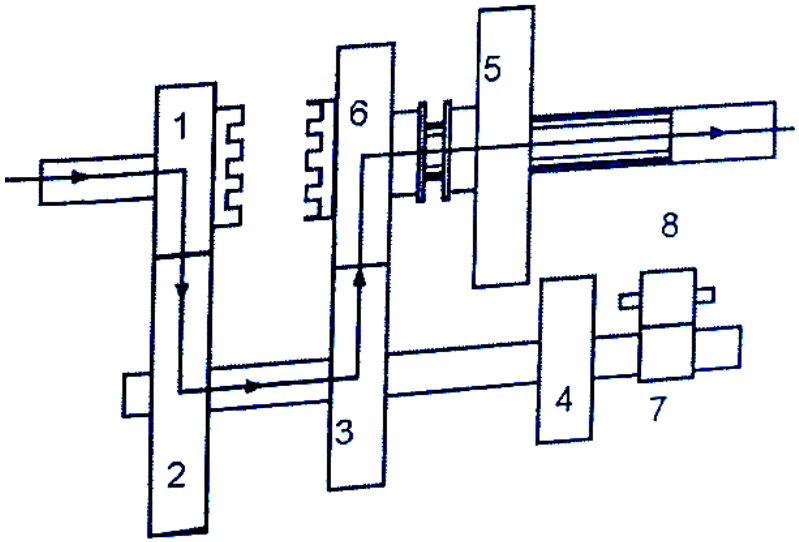


Figure 3.18 Second gear

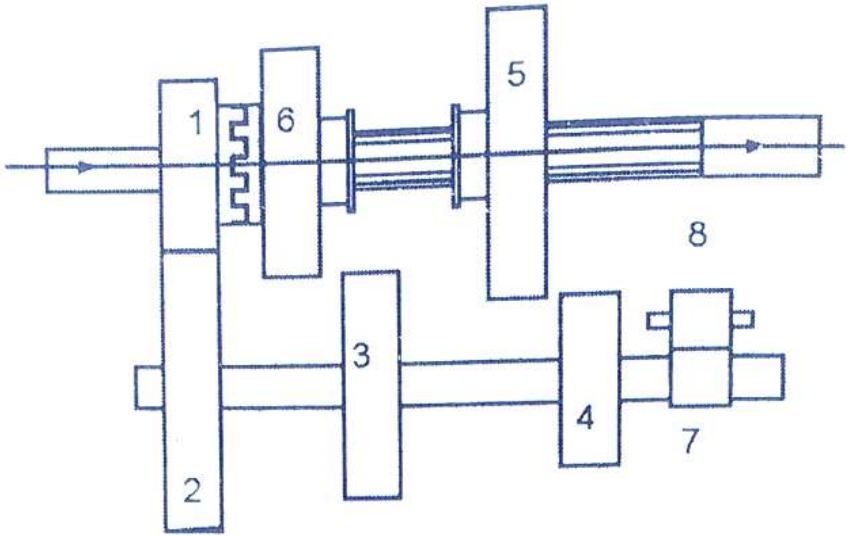


Figure 3.19 Third or top gear

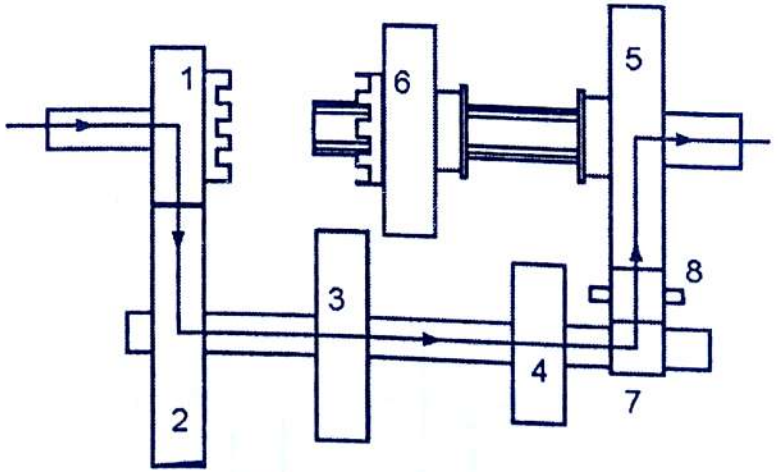


Figure 3.20 Reverse gear

Constant Mesh Gearbox

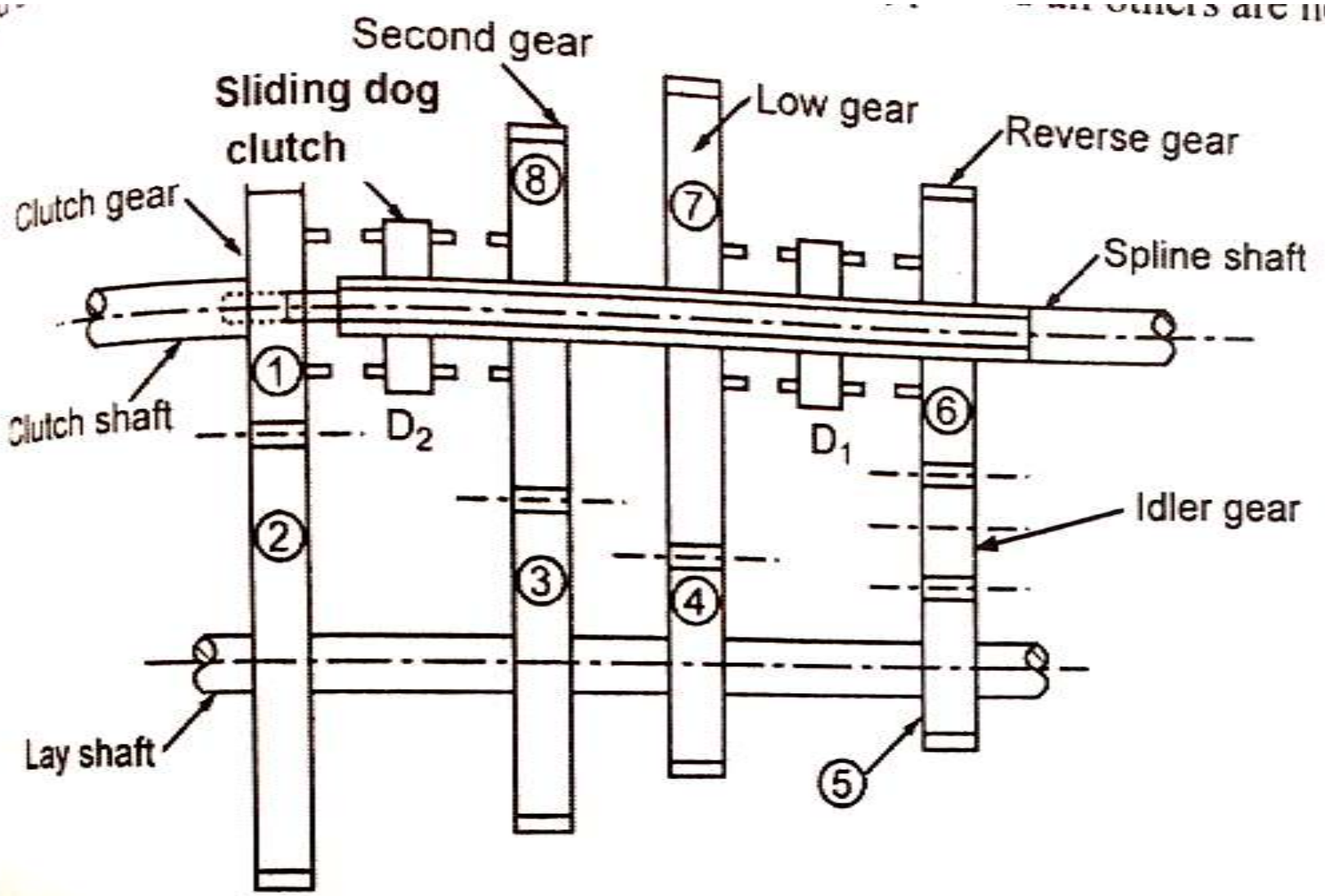


Figure 3.21 Constant mesh gearbox

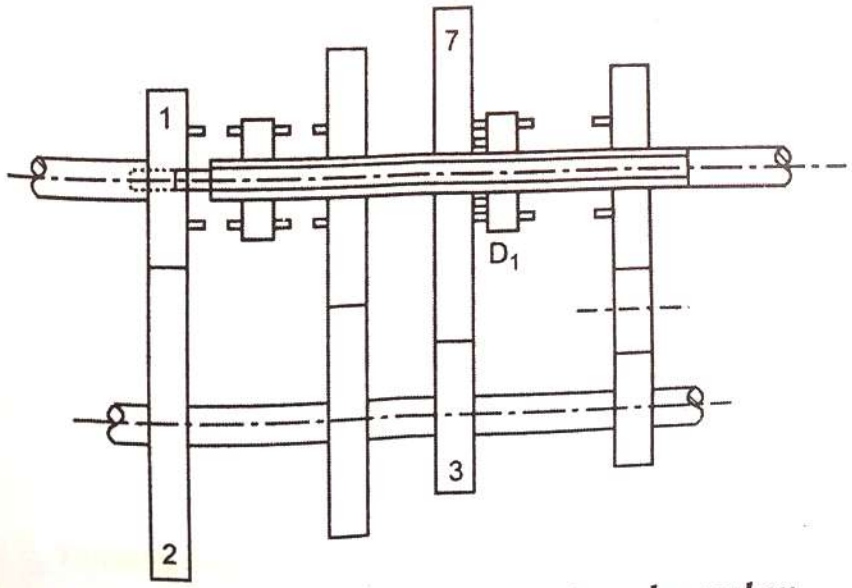


Figure 3.22 First gear of constant mesh gearbox

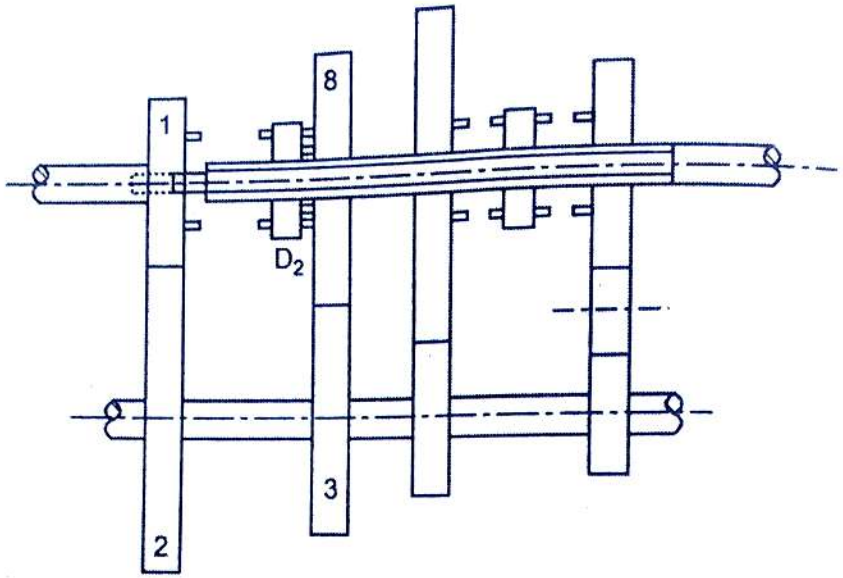


Figure 3.23 Second gear of constant mesh gearbox

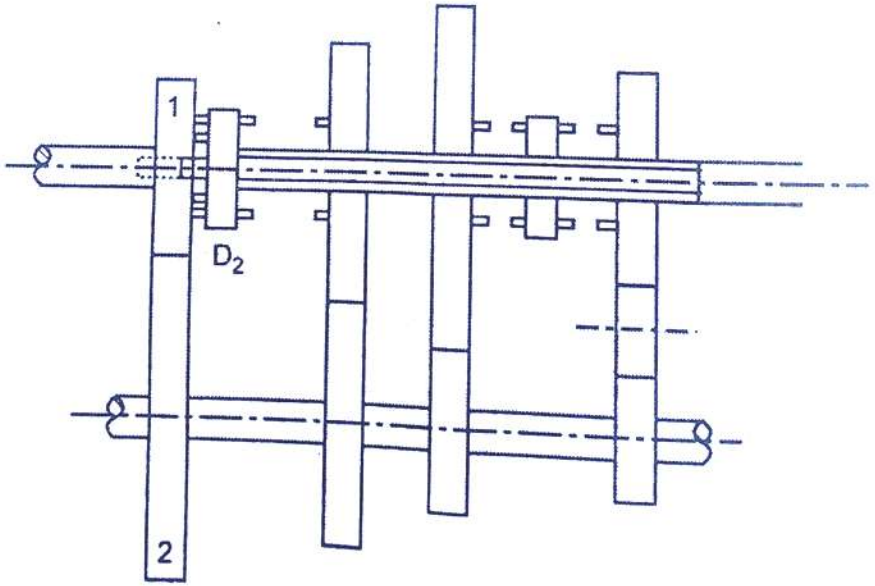


Figure 3.24 Third gear of constant mesh gearbox

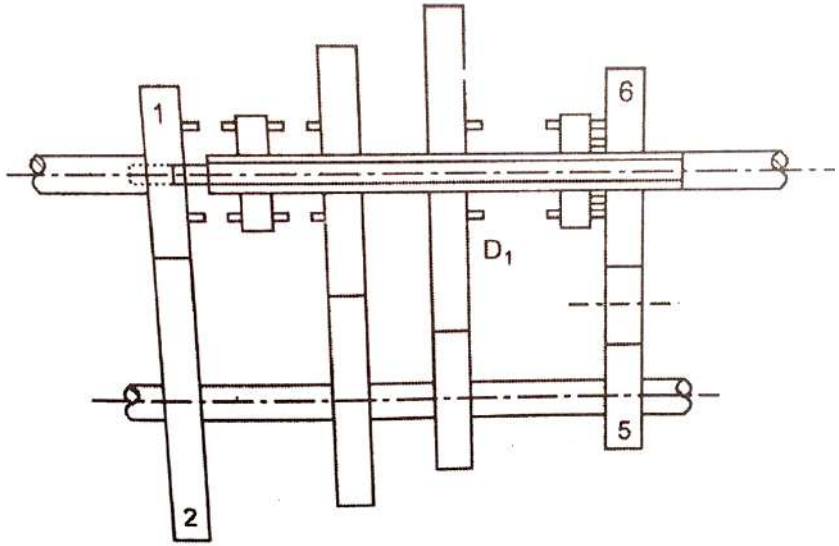


Figure 3.25 Reverse gear of constant mesh gearbox

Synchromesh Gearbox

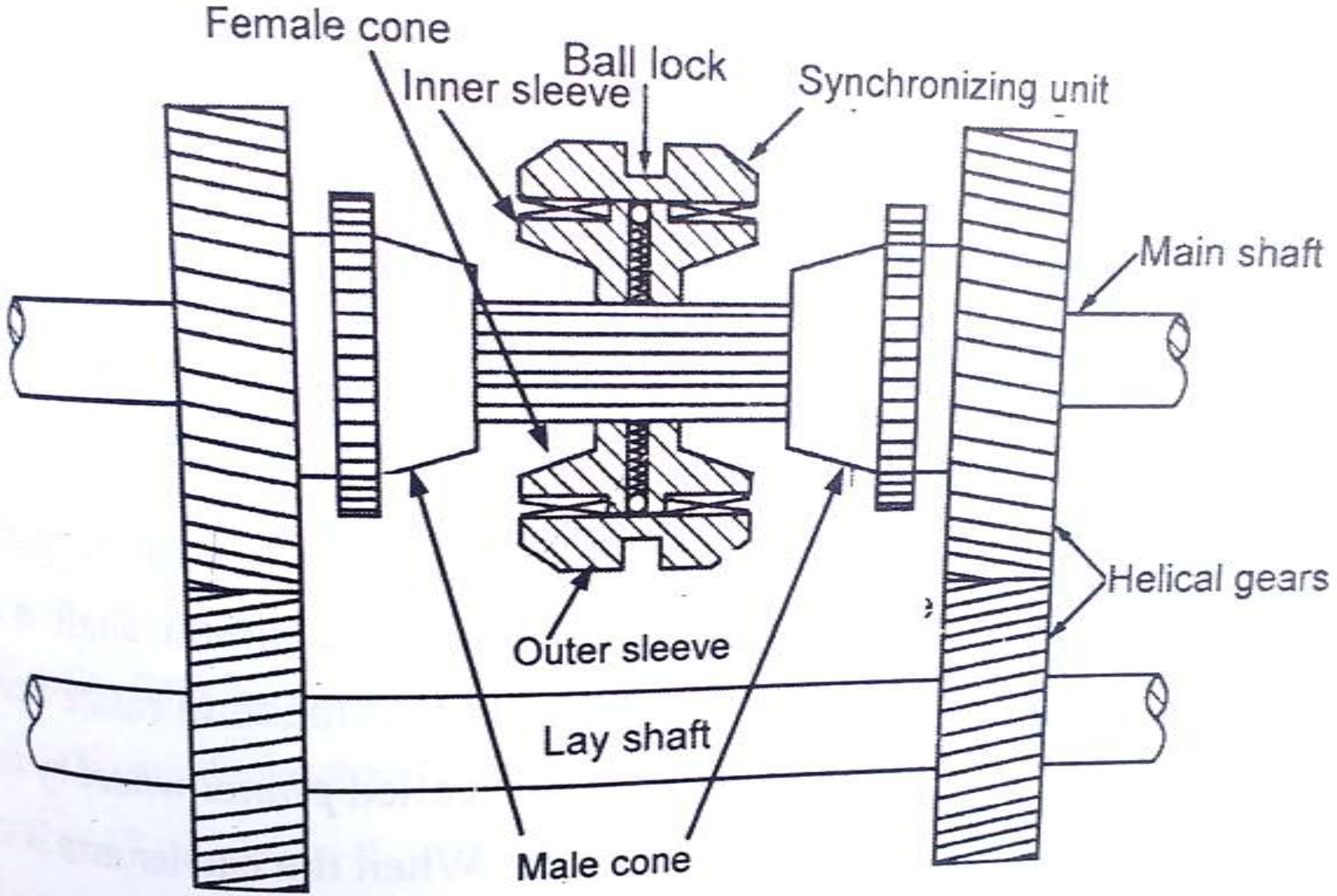
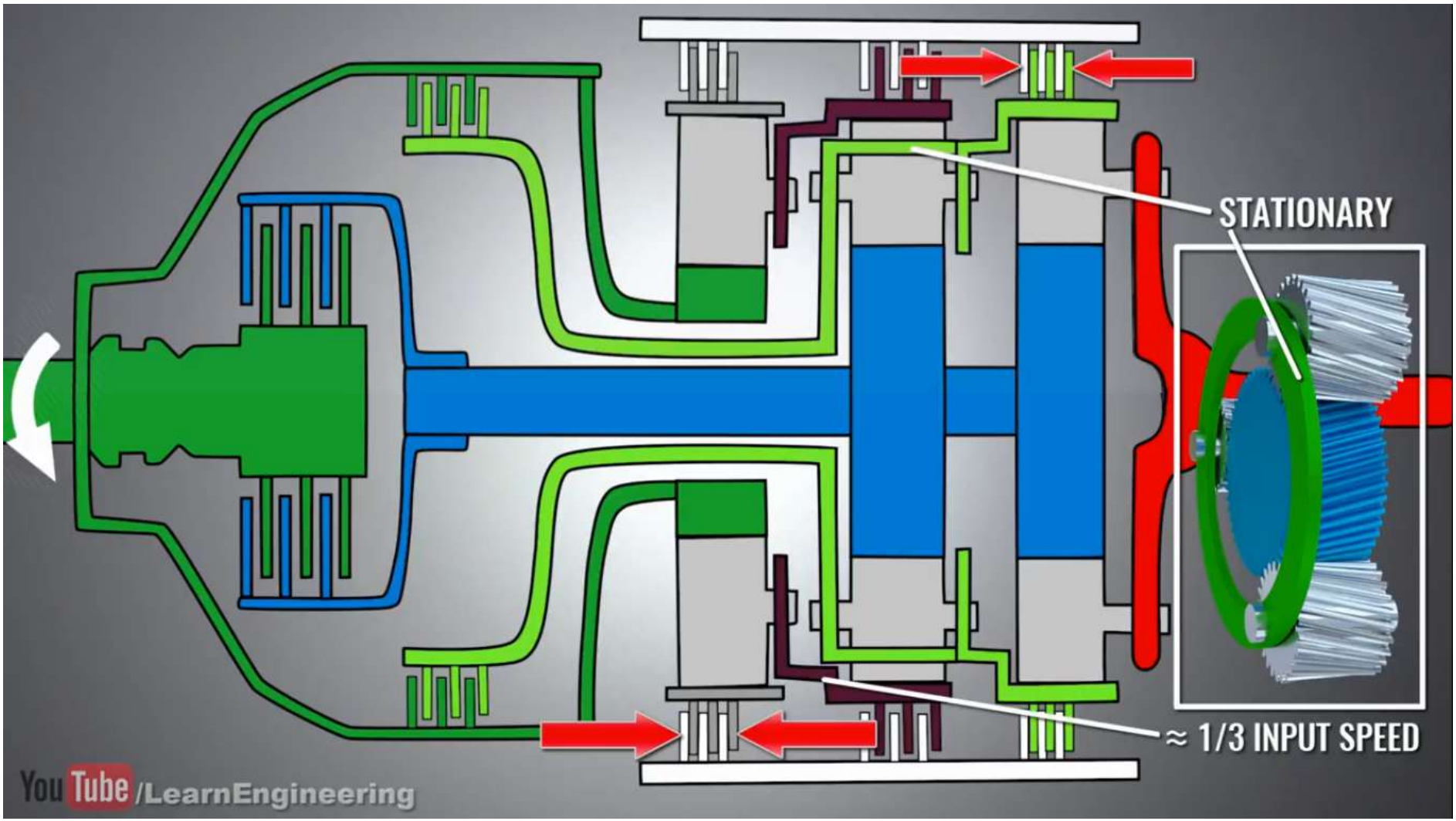


Figure 3.26 Synchromesh unit

Automatic Gearbox



Gear shift Mechanisms

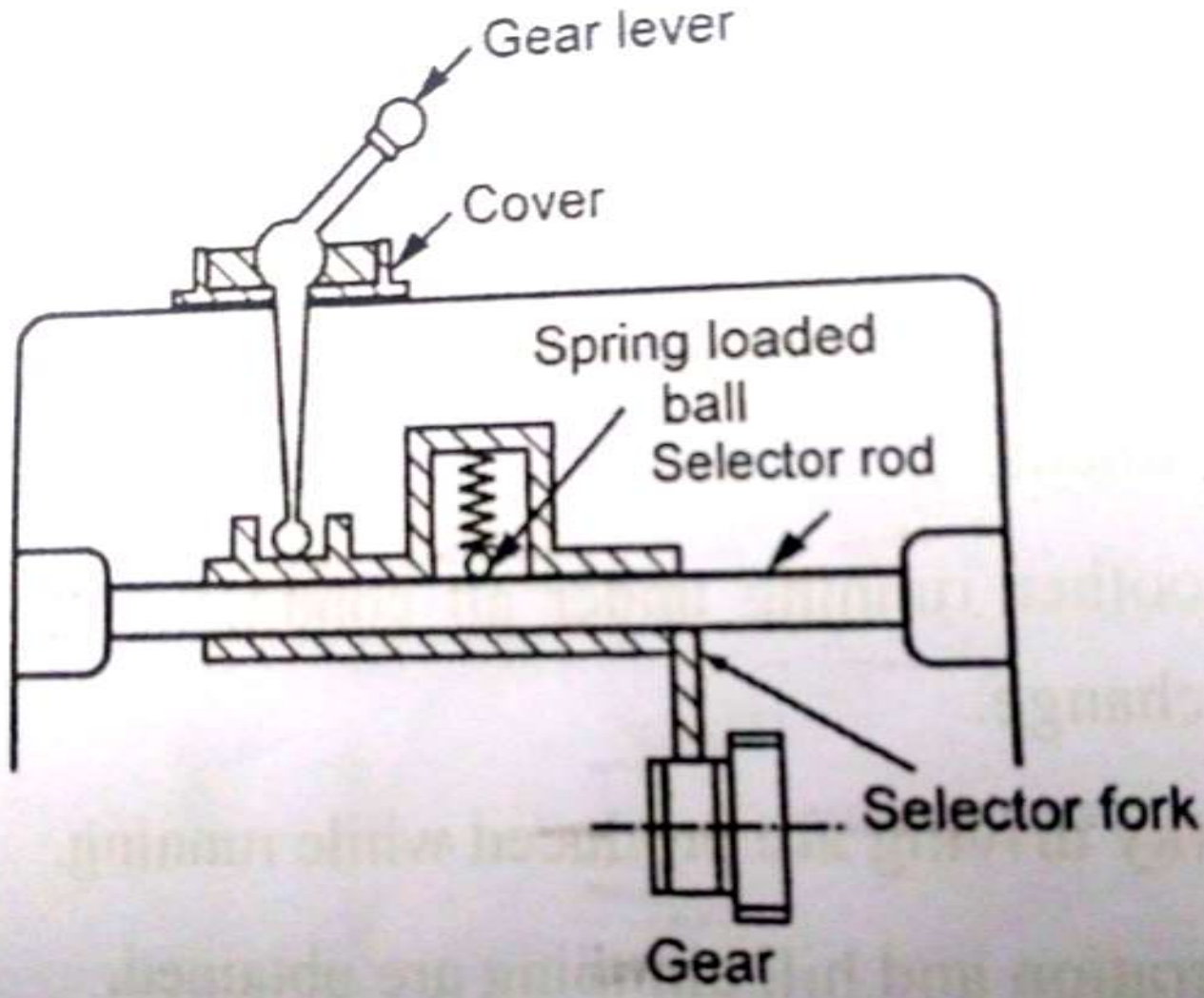


Figure 3.31 Floor board type shift mechanism

Over Drive

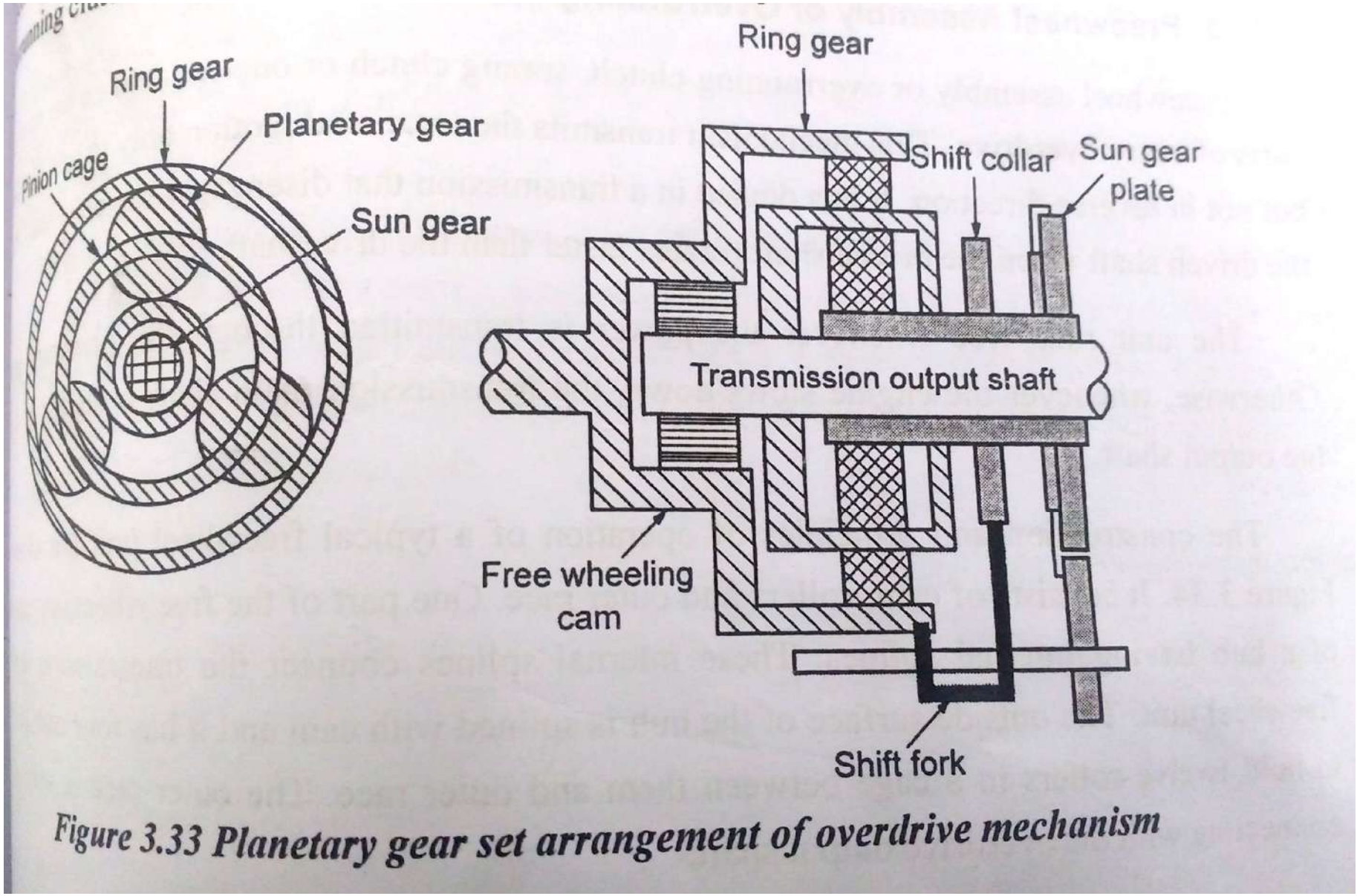


Figure 3.33 Planetary gear set arrangement of overdrive mechanism

Transfer Box

and rear axle[illegible] is controlled [illegible]

The transfer gear box is controlled by a transfer lever or a button in the driver's compartment. It is either in the form of a transfer lever or a button.

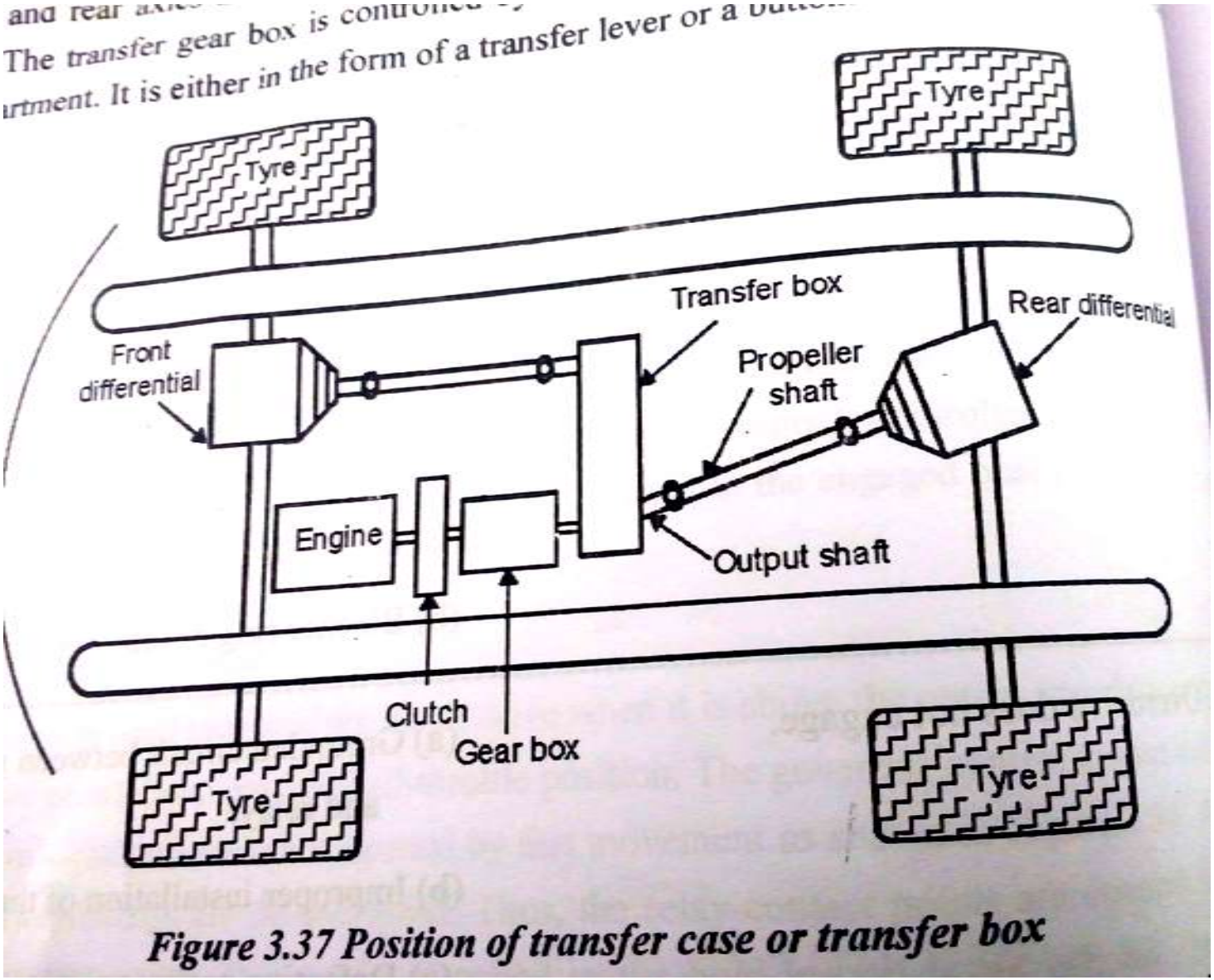


Figure 3.37 Position of transfer case or transfer box

Fluid Flywheel

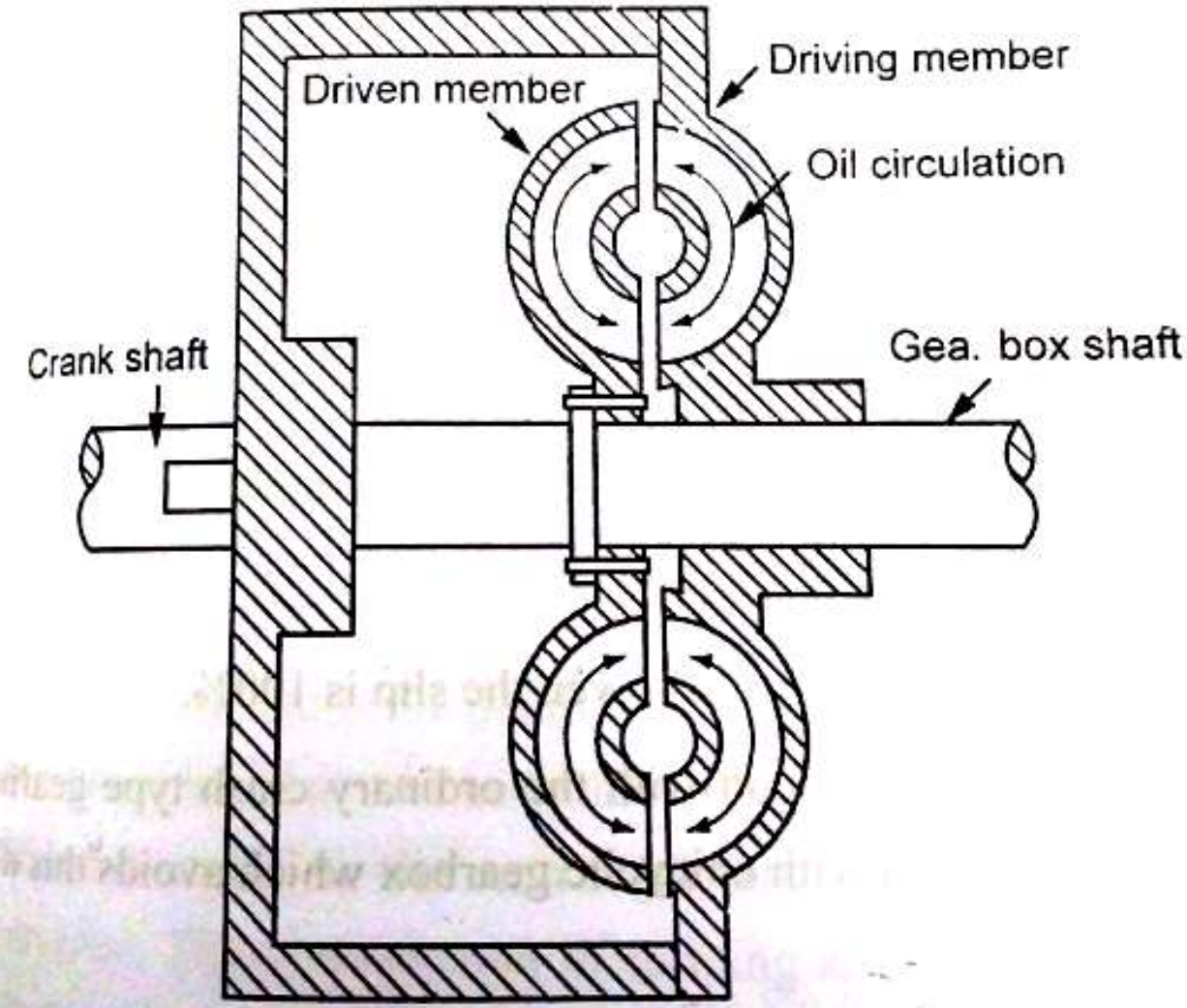


Figure 3.38 Fluid flywheel

Torque Converter

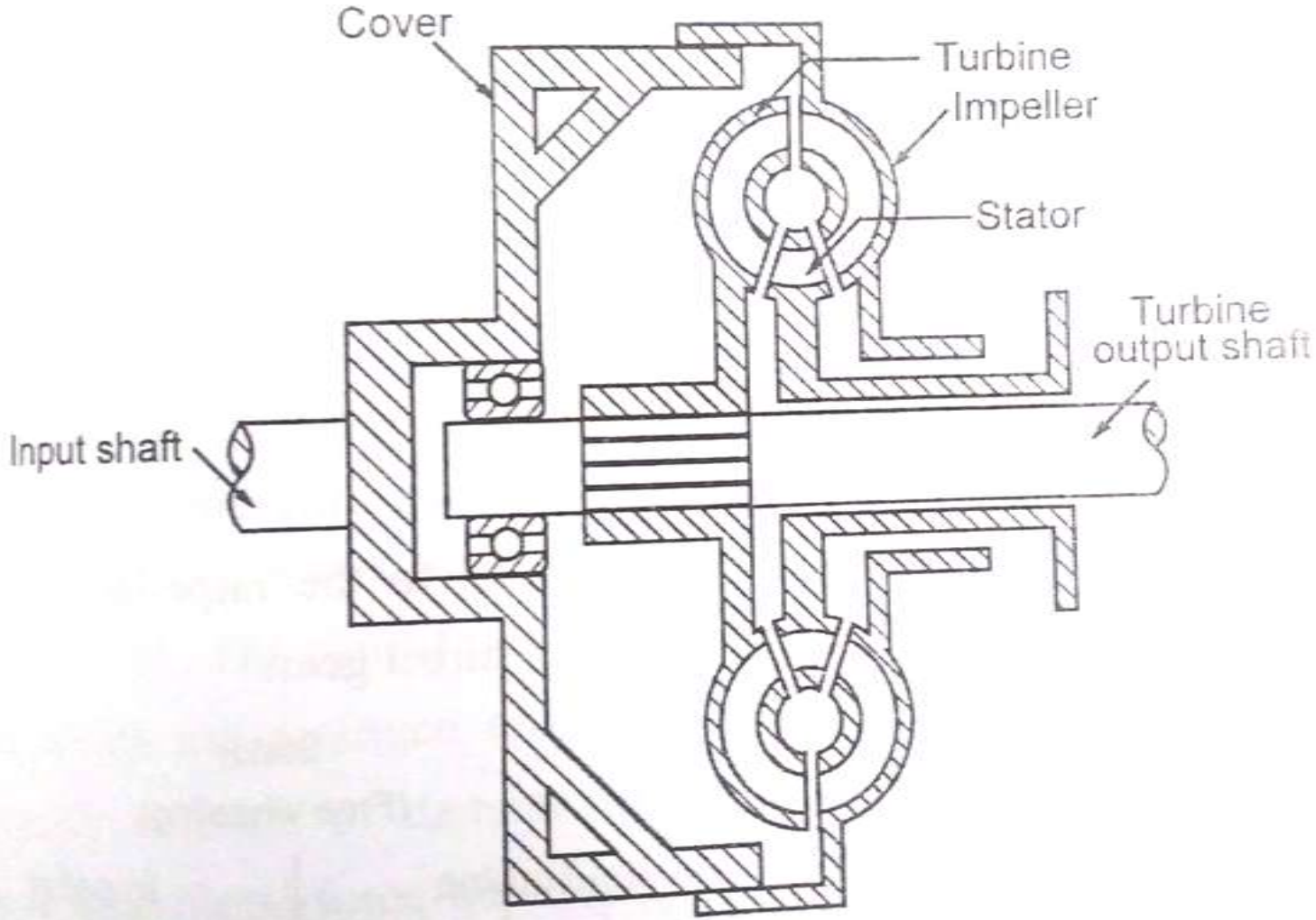


Figure 3.39 Torque converter

Propeller Shaft

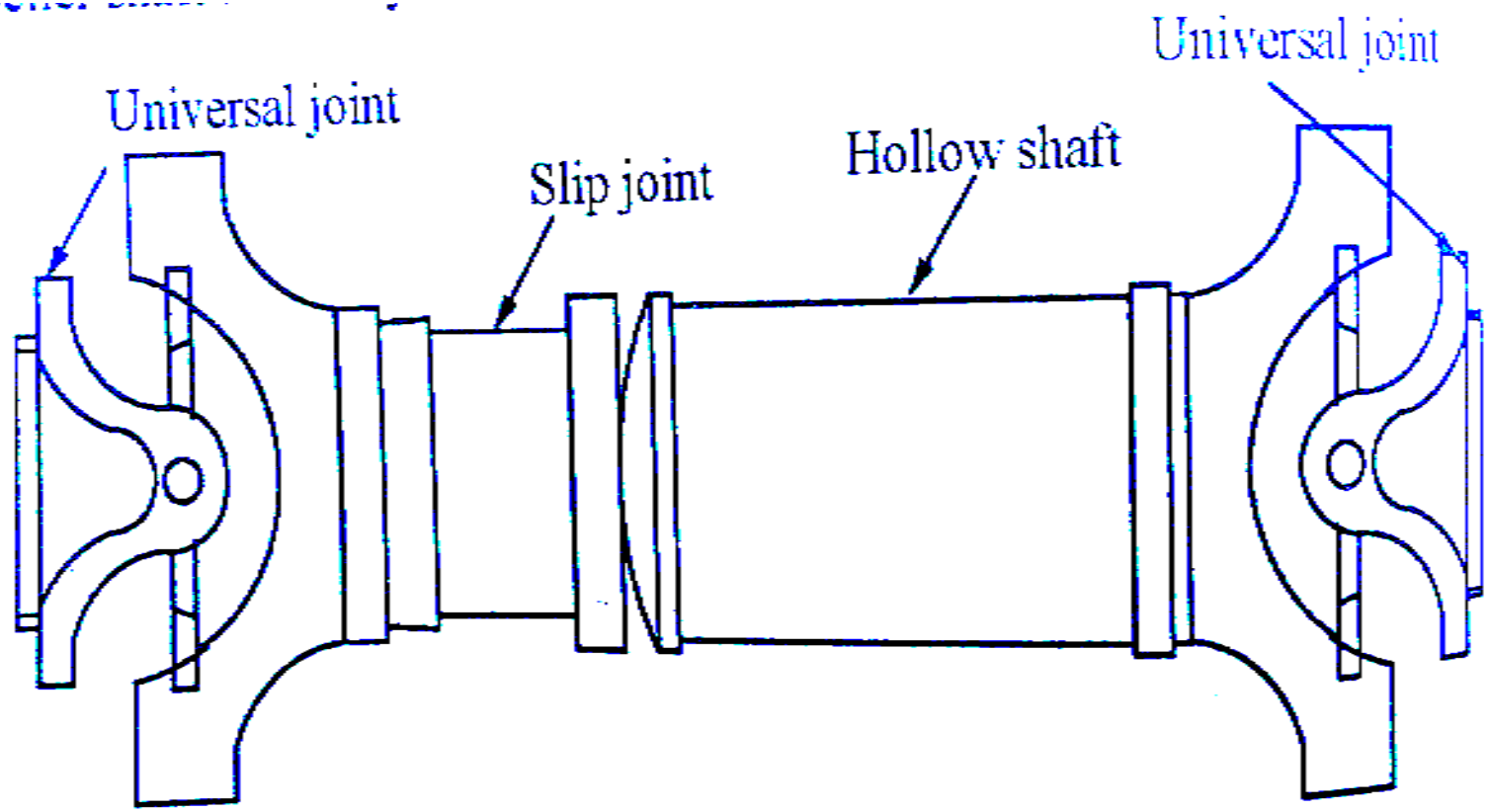


Figure 3.42 Propeller shaft

Slip Joint

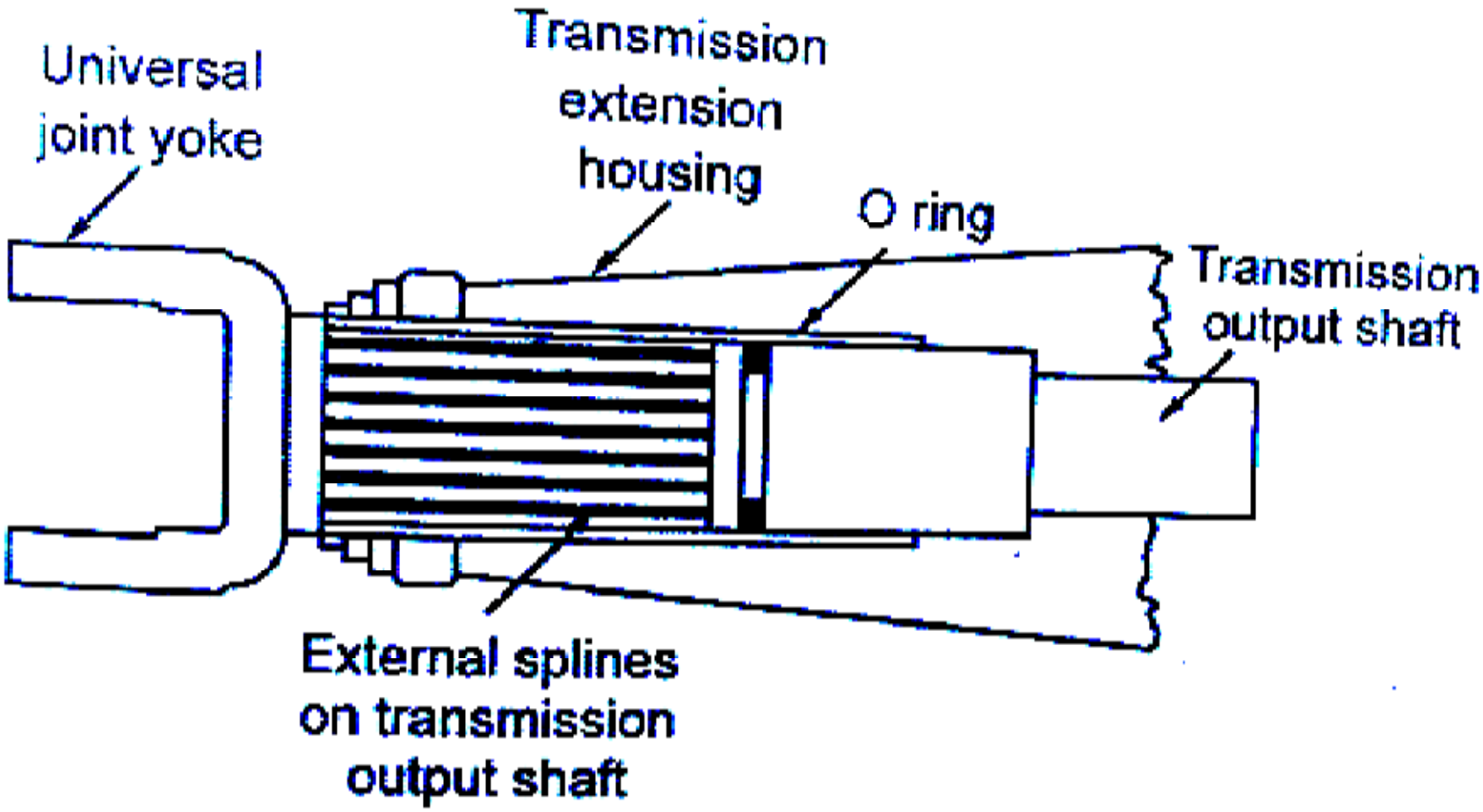


Figure 3.44 Slip joint

Universal Coupling

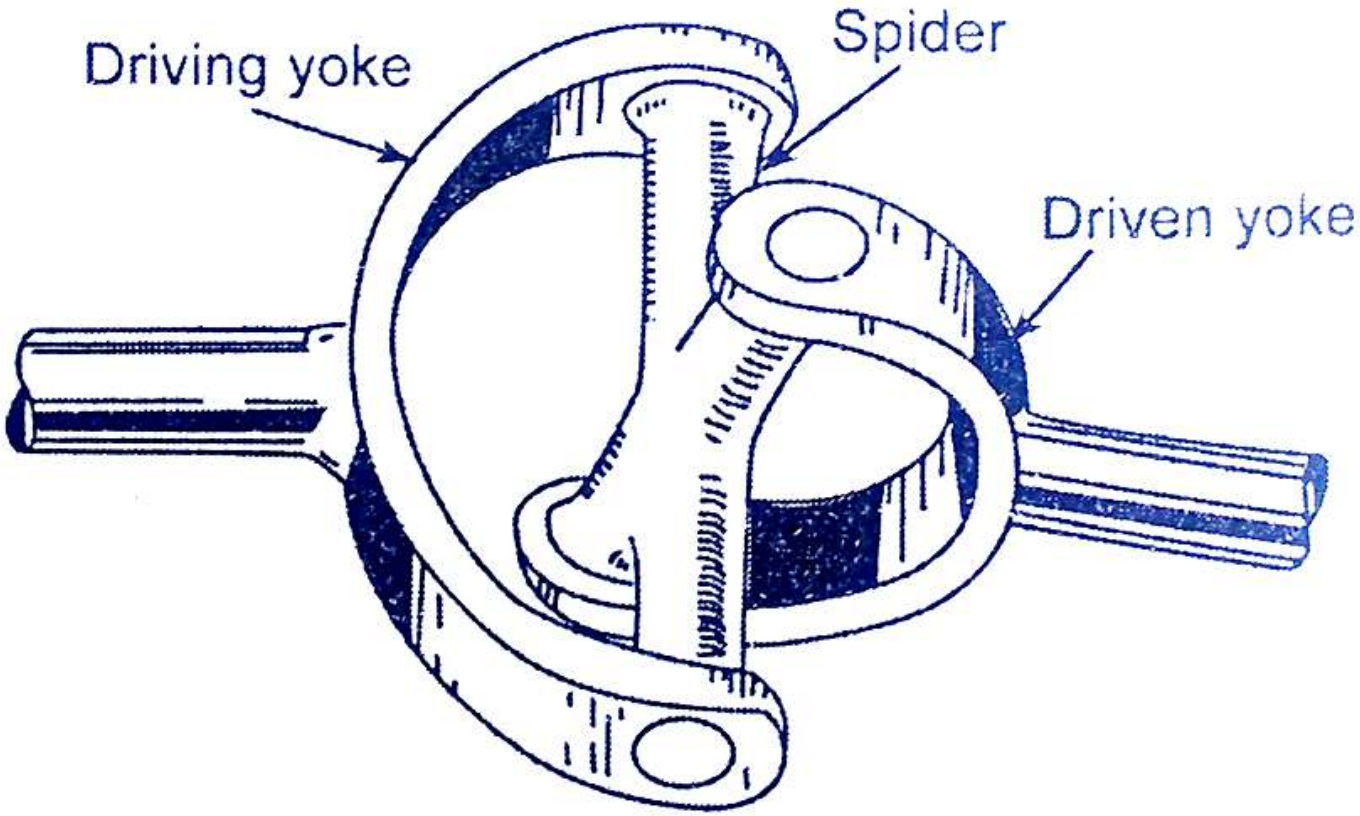


Figure 3.45 Universal joints

Differential

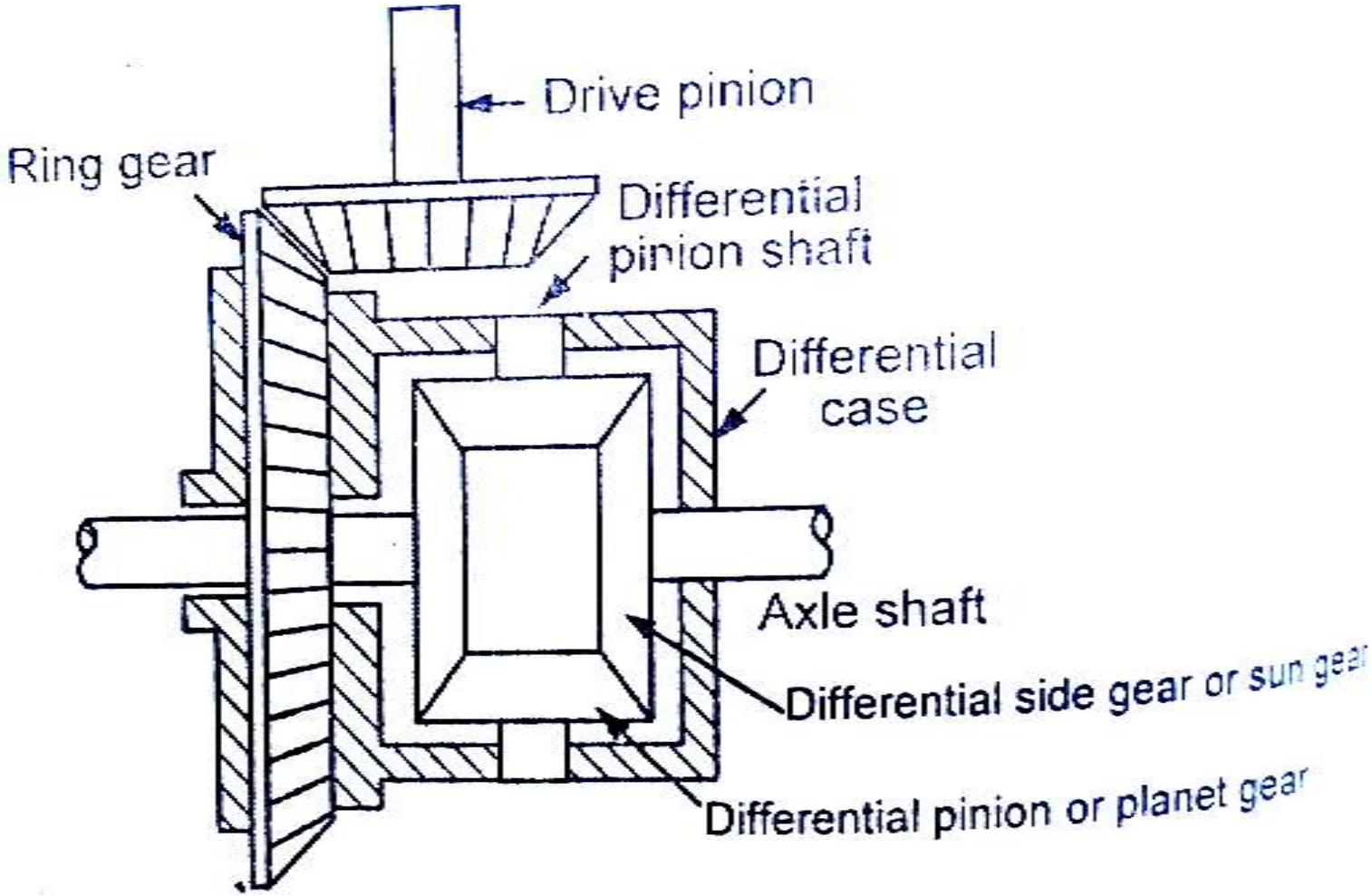


Figure 3.49 Rear wheel drive differential

Differential

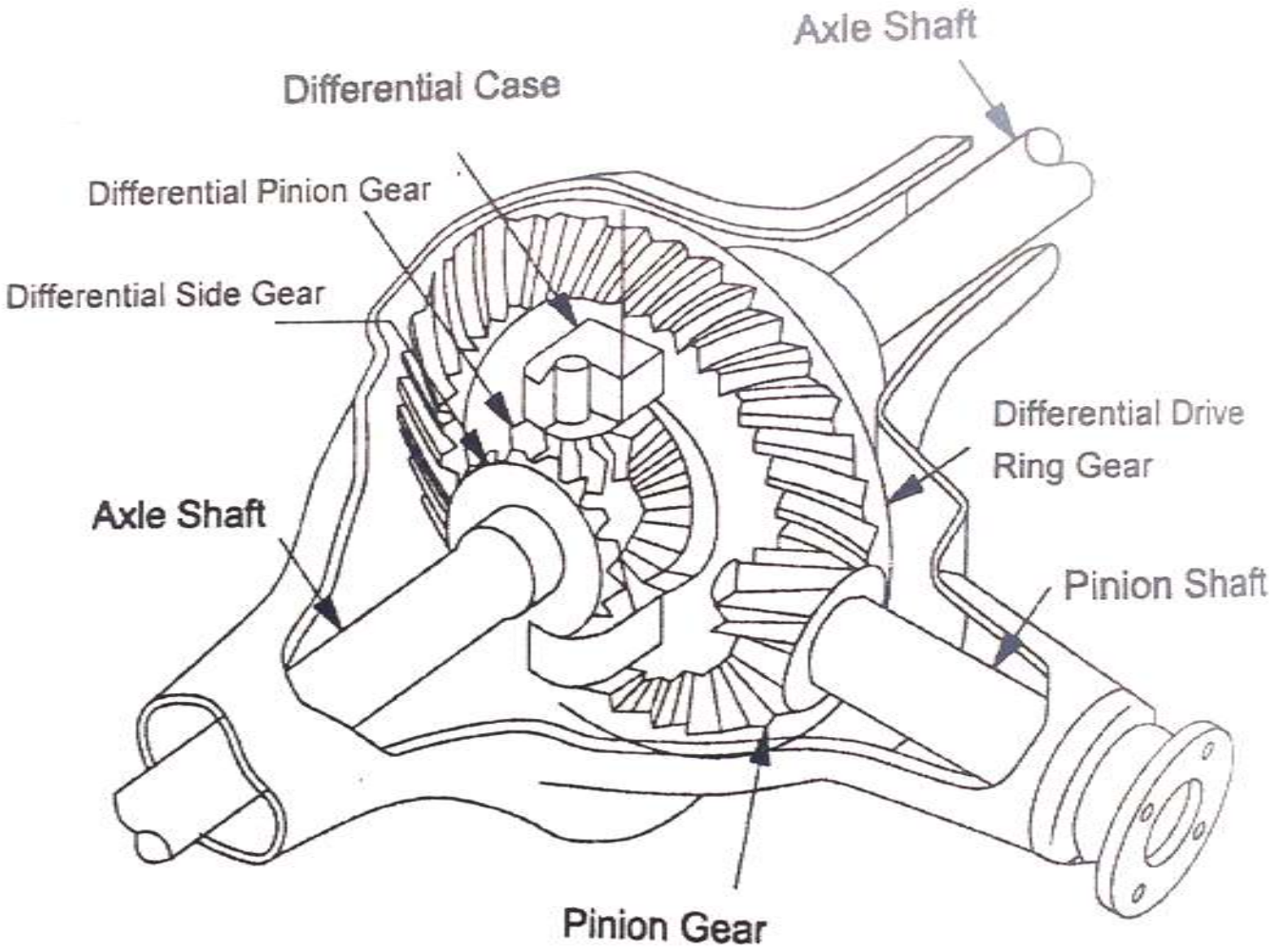


Figure 3.50 Pictorial view of differential

Rear Axle

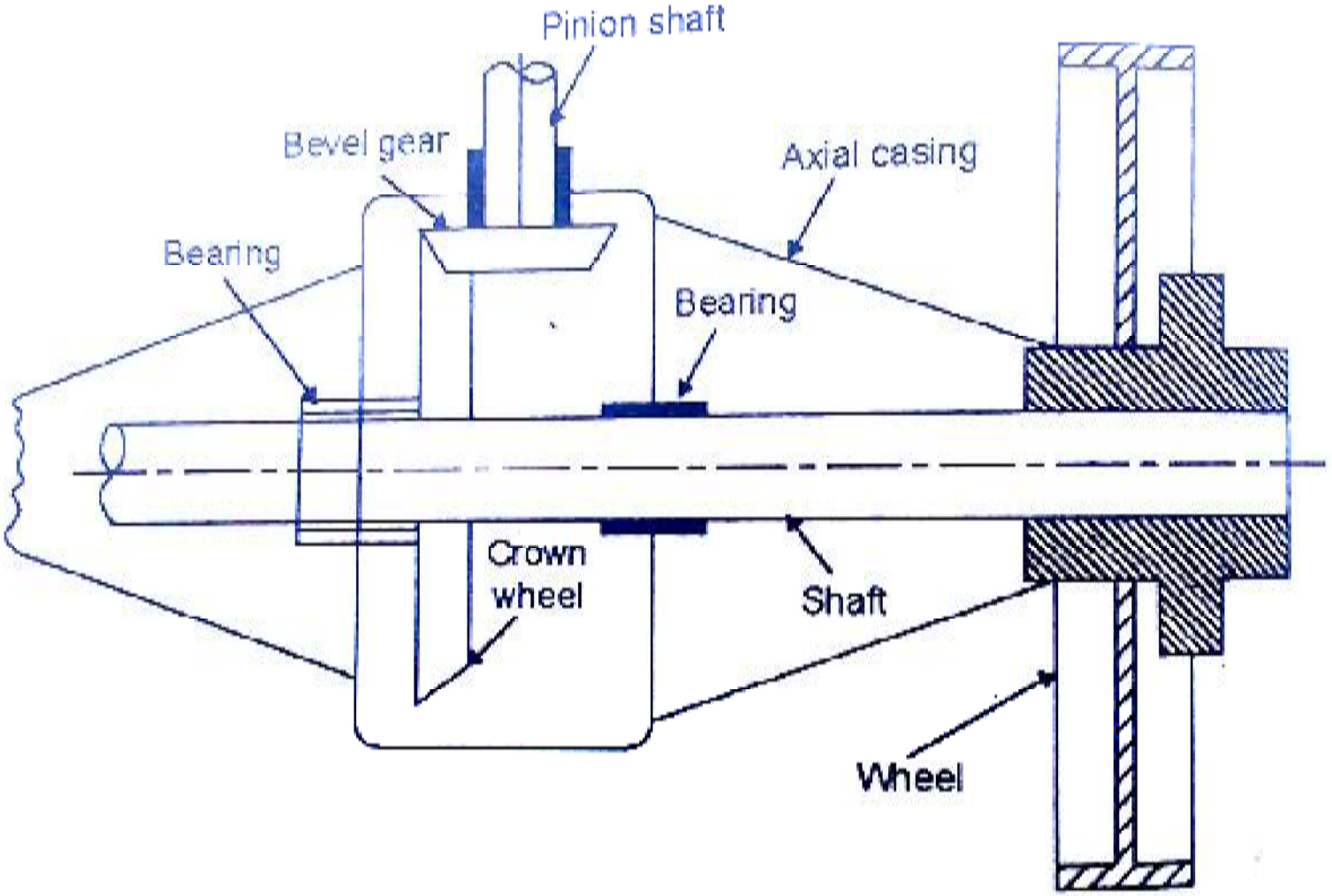


Figure 3.55 Rear axle

Hotch kiss Drive

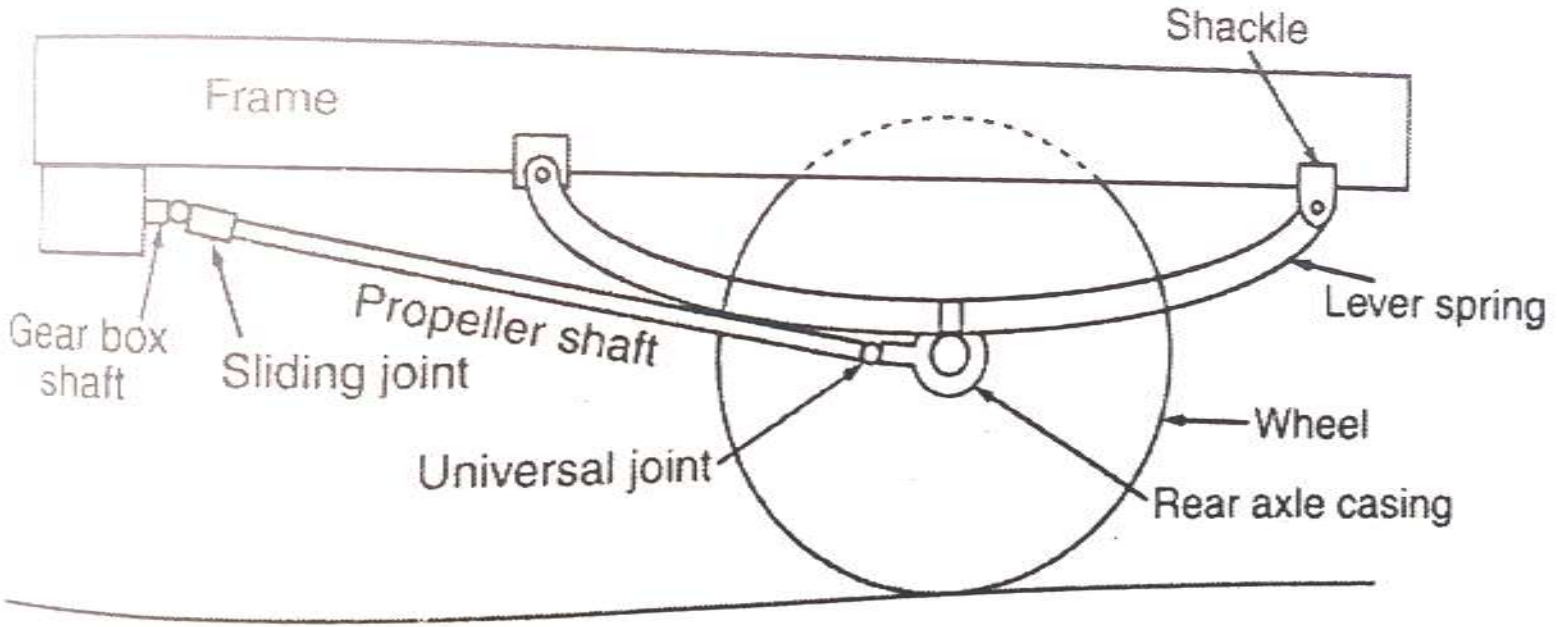


Figure 3.62 Hotchkiss drive

Torque Tube Drive

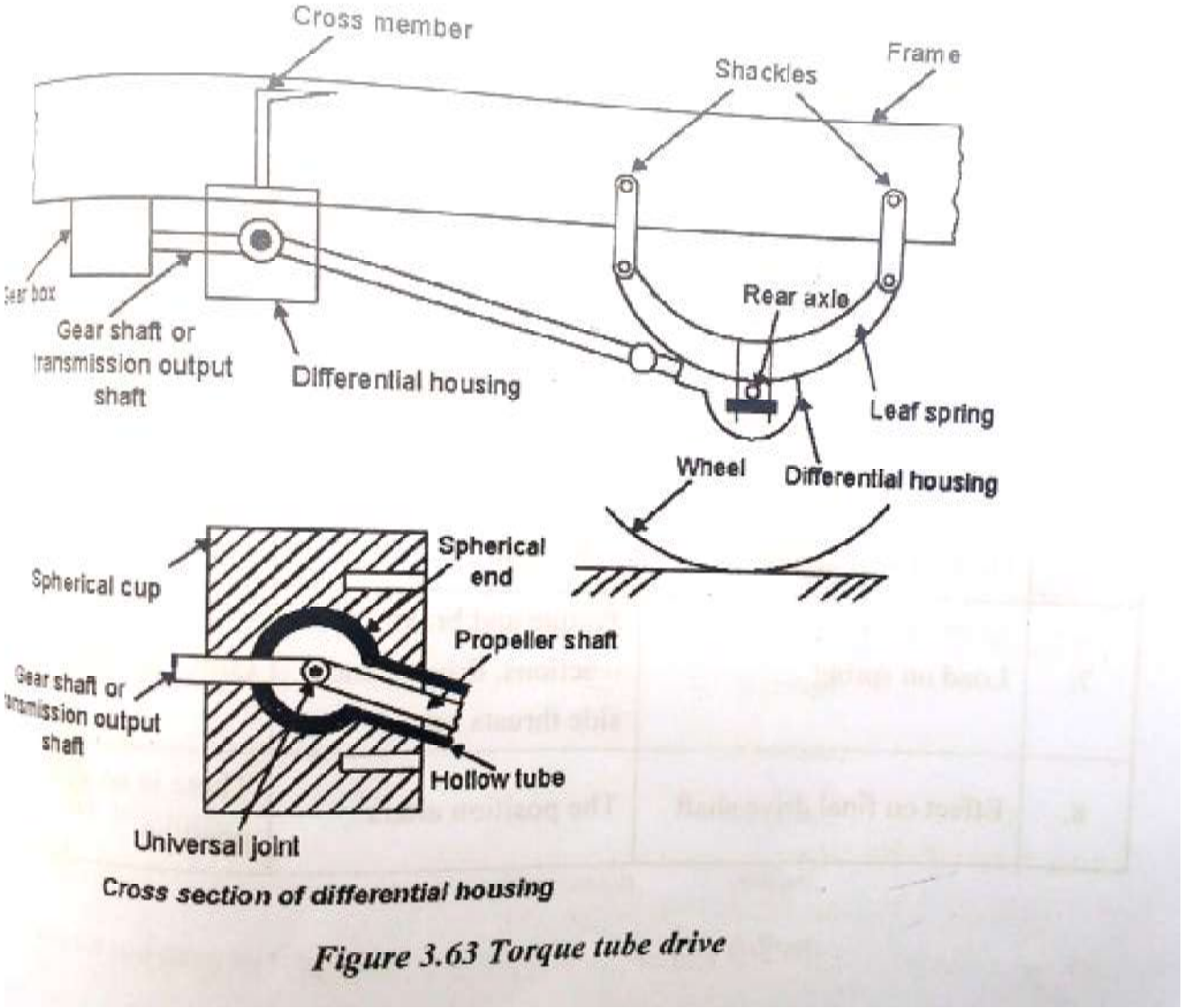


Figure 3.63 Torque tube drive

UNIT IV: STEERING, BRAKES AND SUSPENSION SYSTEMS

Steering geometry and types of steering gear box-Power Steering, Types of Front Axle, Types of Suspension Systems, Pneumatic and Hydraulic Braking Systems, Antilock Braking System (ABS), electronic brake force distribution (EBD) and Traction Control

Steering

- Steering is the collection of components, linkages, etc. which allows any vehicle (car, motorcycle, bicycle) to follow the desired course

Layout of Steering system

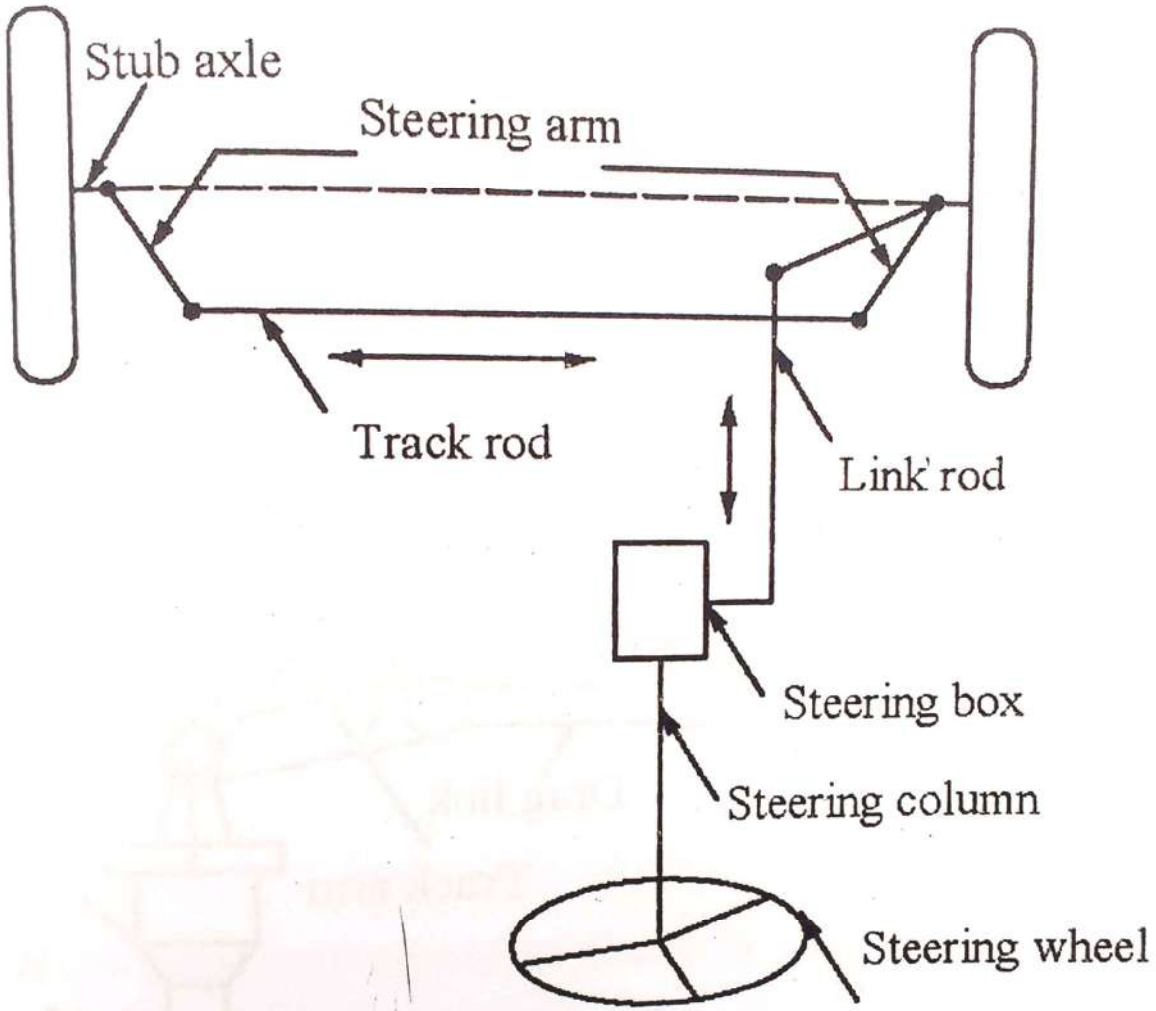


Figure 4.1 Layout of steering system

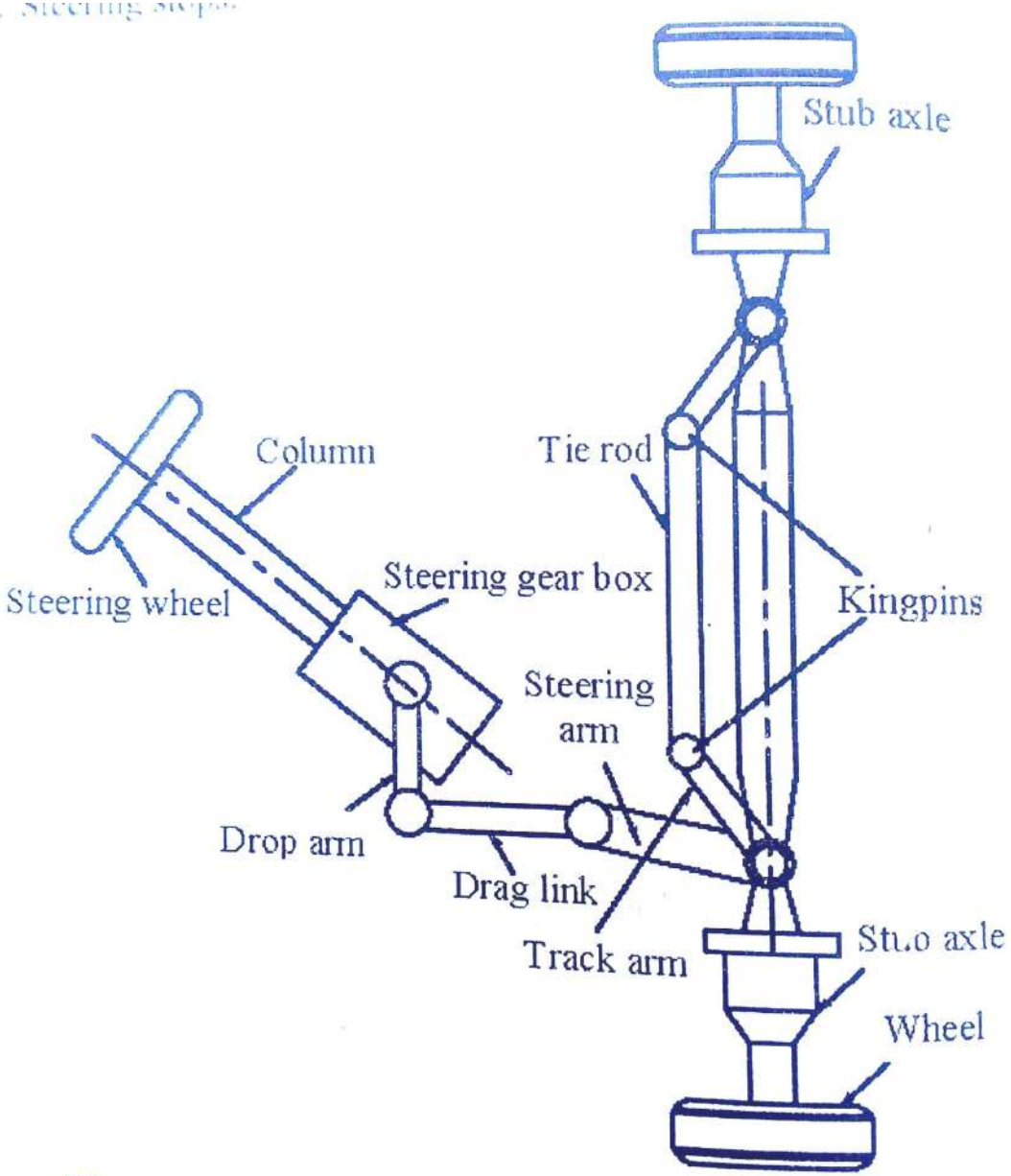


Figure 4.2 Arrangement of steering system components

teel:

A typical rack-and-pinion steering layout

Steering Geometry

STEERING GEOMETRY

- The term "**steering geometry**" (also known as "front-end geometry") refers to the angular Relationship between suspension and steering parts, front wheels, and the road surface. Because alignment deals with angles and affects steering, the method of describing alignment measurements is called steering geometry.

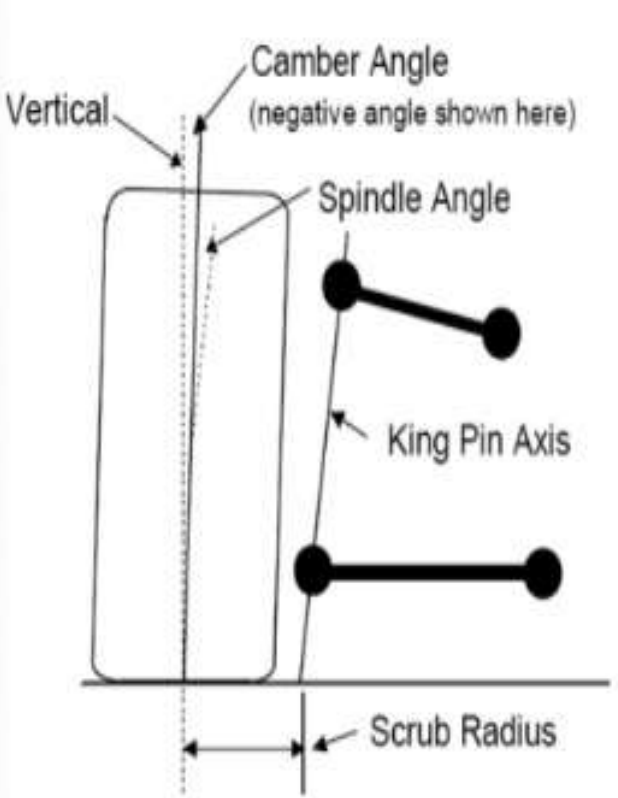
There are five steering geometry angles :

- ✓ Camber
- ✓ Caster
- ✓ king pin inclination
- ✓ Toe in & Toe-out on turns

CAMBER

Camber:-

- ✓ Camber angle is the angle between the vertical line and centre line of the tyre when viewed from the front of the vehicle.
- ✓ Camber angle is positive when this is outward. This happens when wheels are further apart at top than at bottom. On the contrary, camber angle is negative when angle is inward. This happens when wheels are further apart at bottom than at top.
- ✓ The camber, should not be more than 2 degree, because this causes uneven or more tyre wear on one side than on other side.



CAMBER

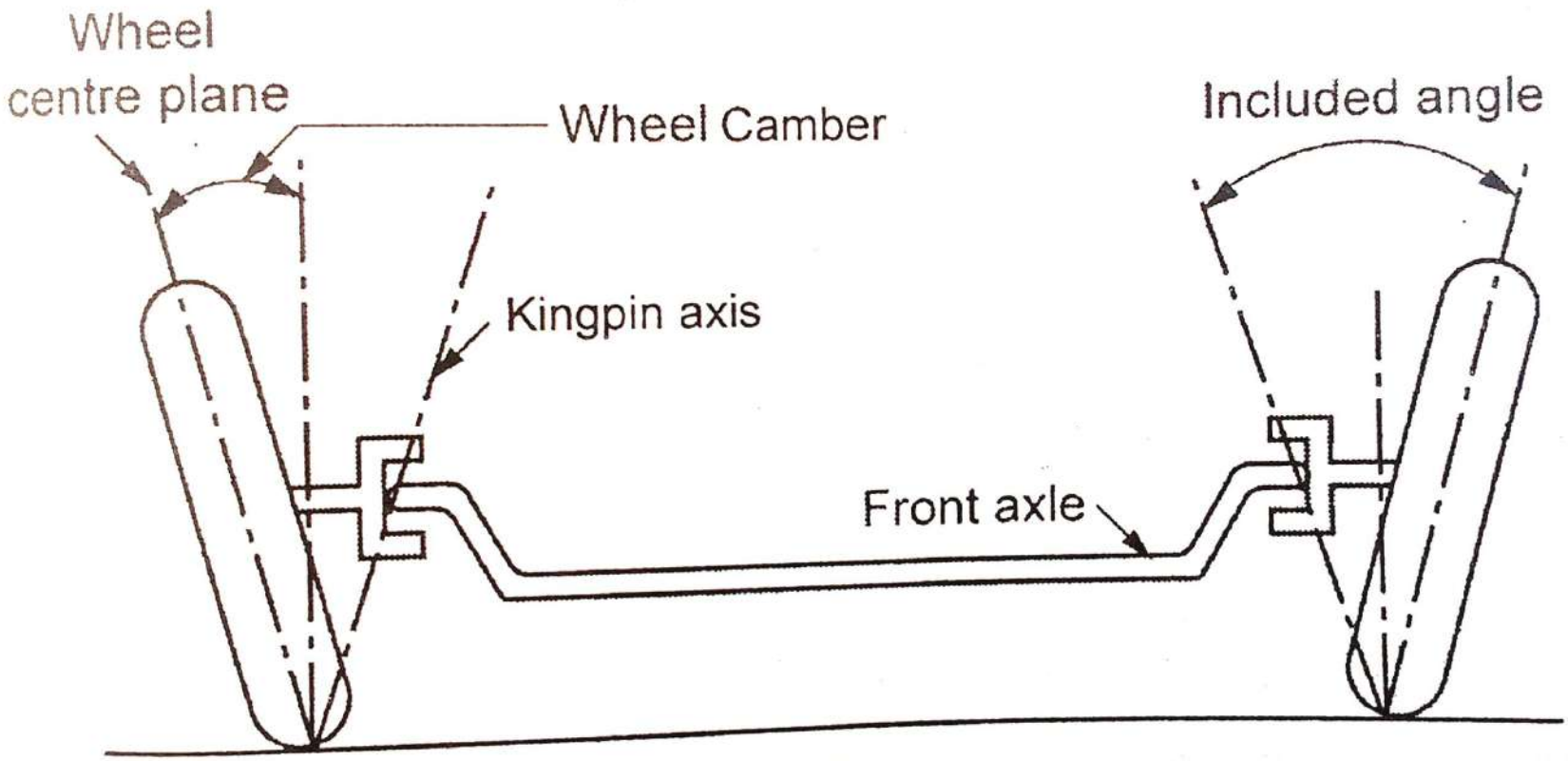


Figure 4.8 Camber

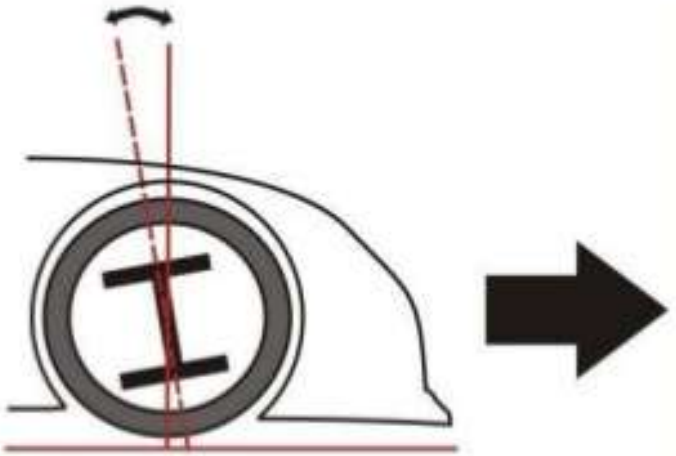
CASTER

Caster

- The angle between the king pin Centre line and the vertical ,in the plane of the wheel is called caster angle.

Effect: Incorrect caster can produce Difficulties like hard steering, Pulling to one side when brakes are Applied.

Amount: It will be about 3°



CASTOR

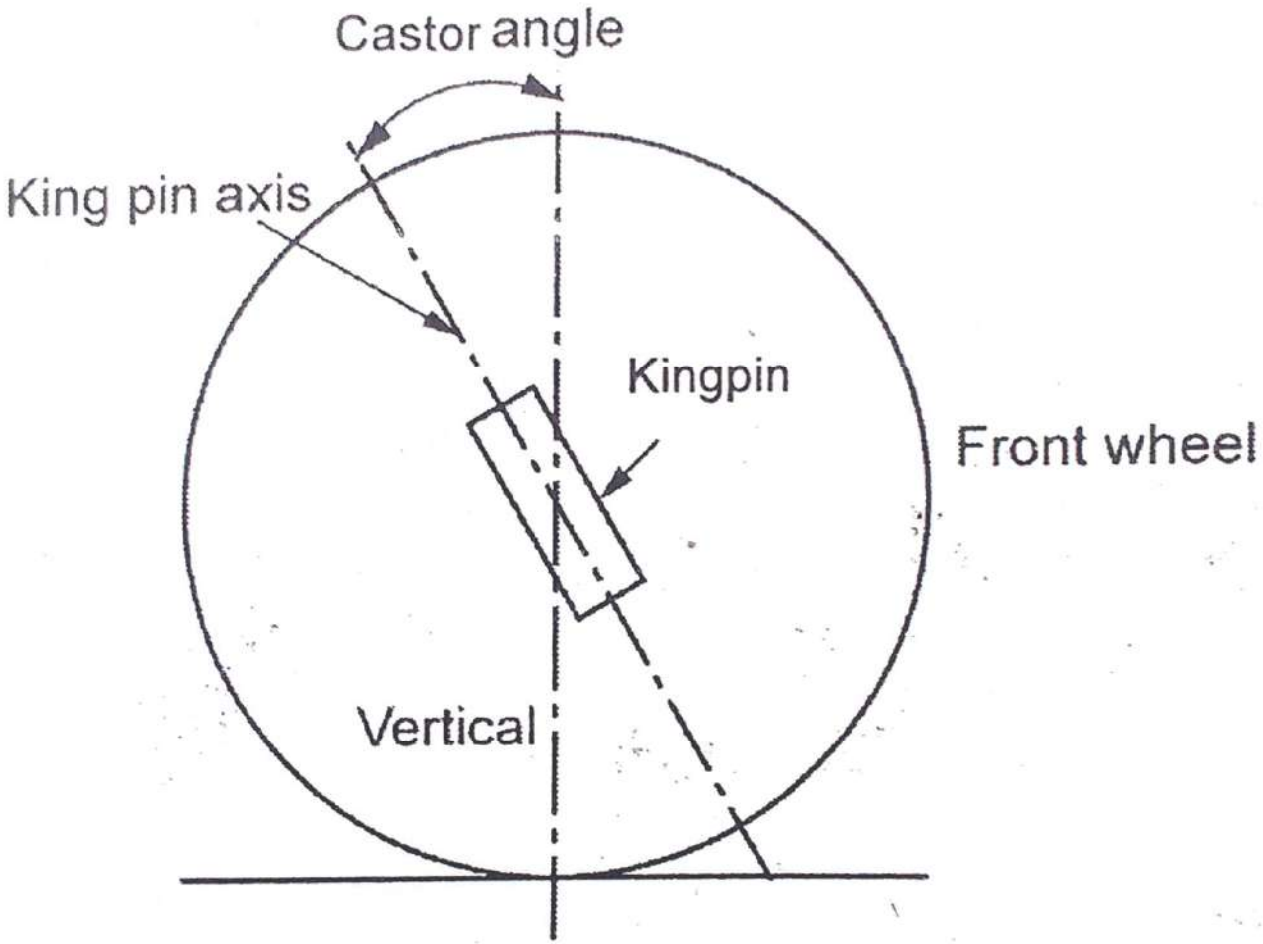
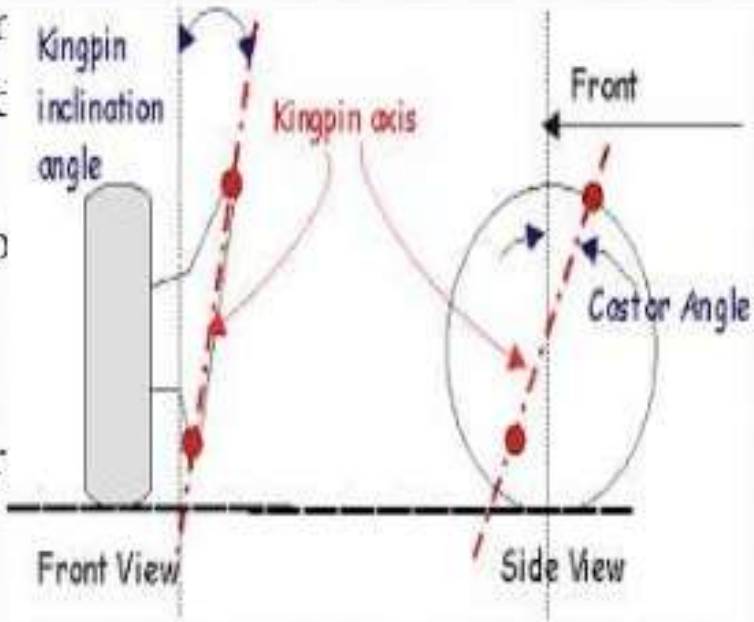


Figure 4.10 Castor

King pin Inclination

King pin inclination

- ✓ It is the angle between king pin centre line and vertical line when seen from the front of the vehicle.
- ✓ It is also called steering axle inclinatior
- ✓ King pin inclination and caster are usec to improve directional stability in cars.
- ✓ This is also used to reduce steering effo when steering a stationary
- ✓ it reduces tyre wear.
- ✓ This inclination varies from 4 to 8 degr in modern cars.



TOE IN & TOE OUT

TOE IN & TOE OUT

- ✓ In automotive engineering, toe also known as tracking.
- ✓ This can be contrasted with steer, which is the anti symmetric angle, i.e. both wheels point to the left or right, in parallel (roughly).
- ✓ Positive toe, or **toe in**, is the front of the wheel pointing in towards the centerline of the vehicle
- ✓ Negative toe, or **toe out**, is the front of the wheel pointing away from the centerline of the vehicle.

TOE IN & TOE OUT

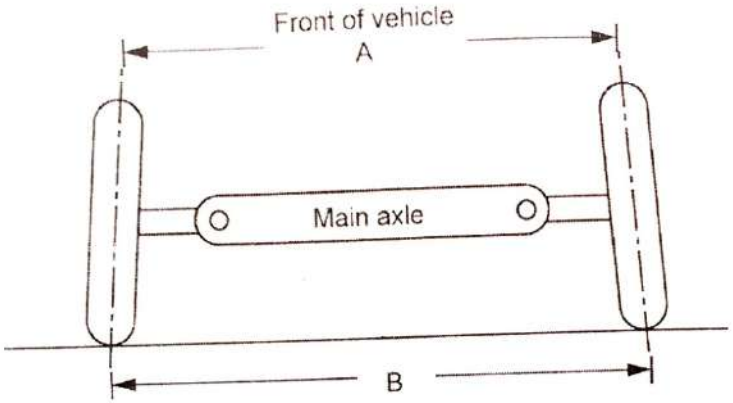


Figure 4.11 Toe-in

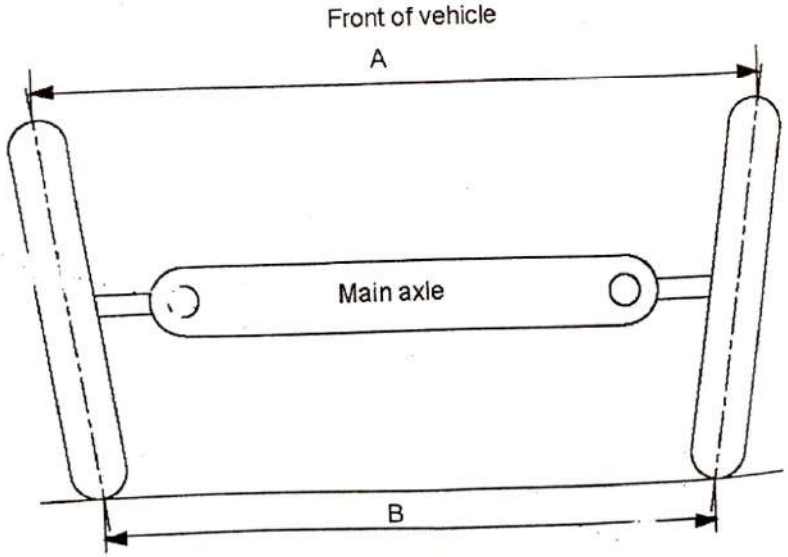


Figure 4.12 Toe-out

Types of Steering Gears

Types of Steering Gears

The types of steering gears are

1. The Pitman-arm type and
2. The Rack-and-Pinion type.

Types of Steering Gearbox

1. Worm and Roller
2. Worm and Sector
3. Cam and Roller
4. Cam and Peg
5. Cam and Turn lever
6. Screw and Nut
7. Recirculationg Ball
8. Worm and Ball
9. Rack and Pinion

Cam and roller steering gear

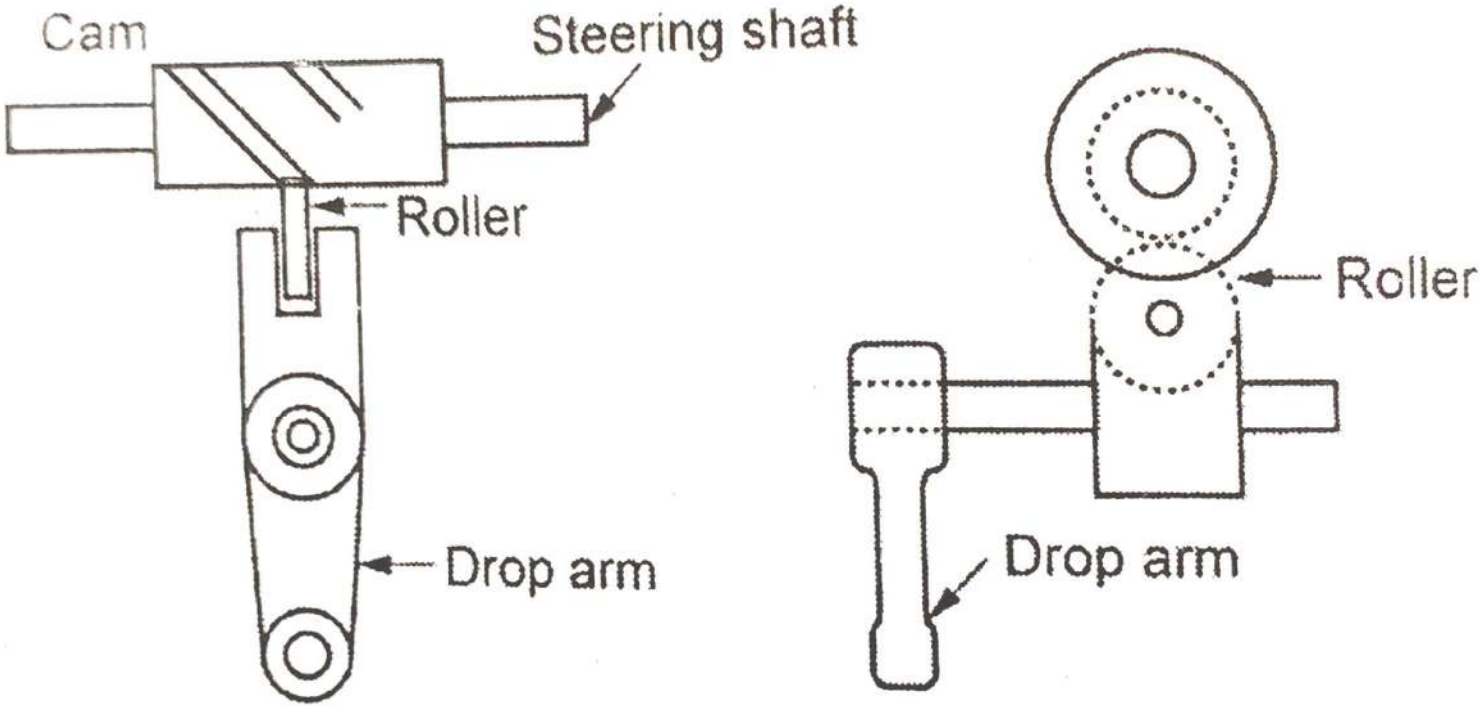


Figure 4.17 Cam and roller steering gear

Recirculating Ball Type Steering Gear

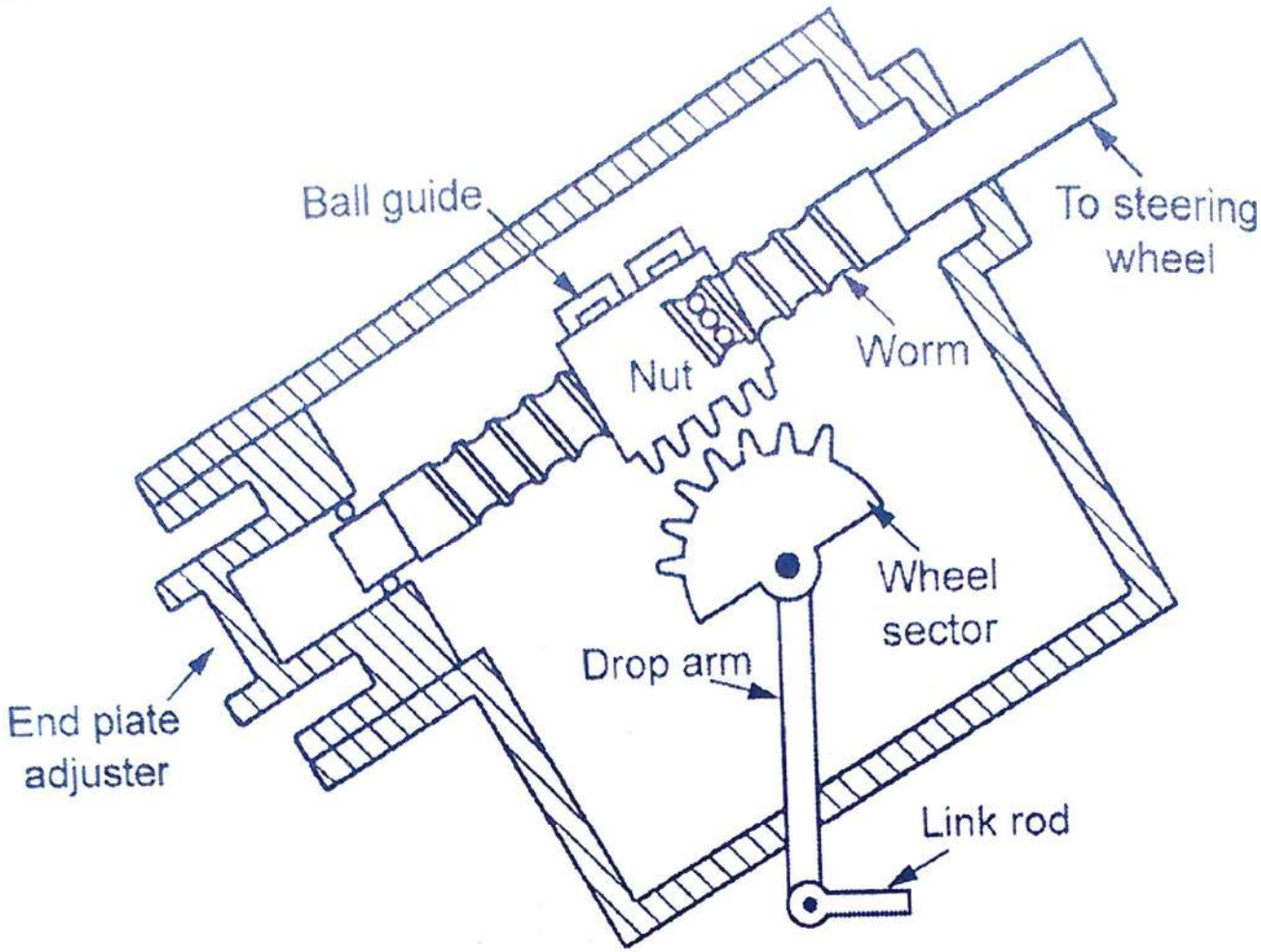


Figure 4.18 Recirculating ball type steering gear

Rack and Pinion Type Steering Gear

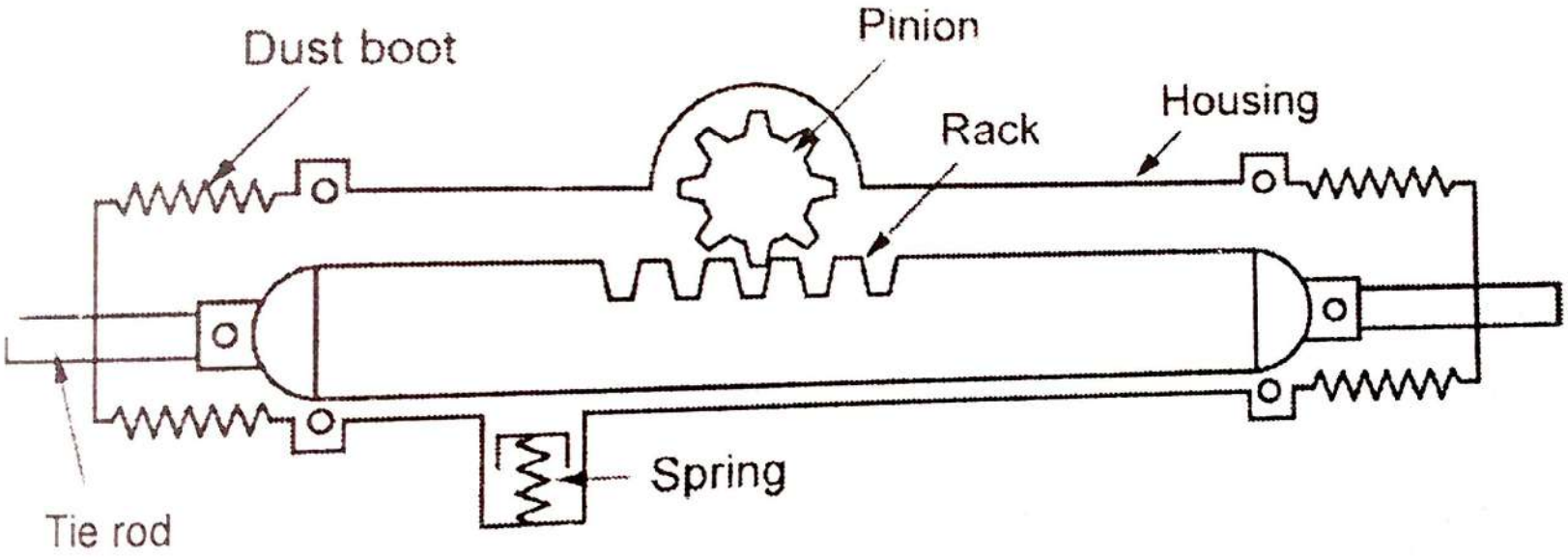


Figure 4.19 Rack and pinion type steering gear

Cam and Lever type Steering Gear

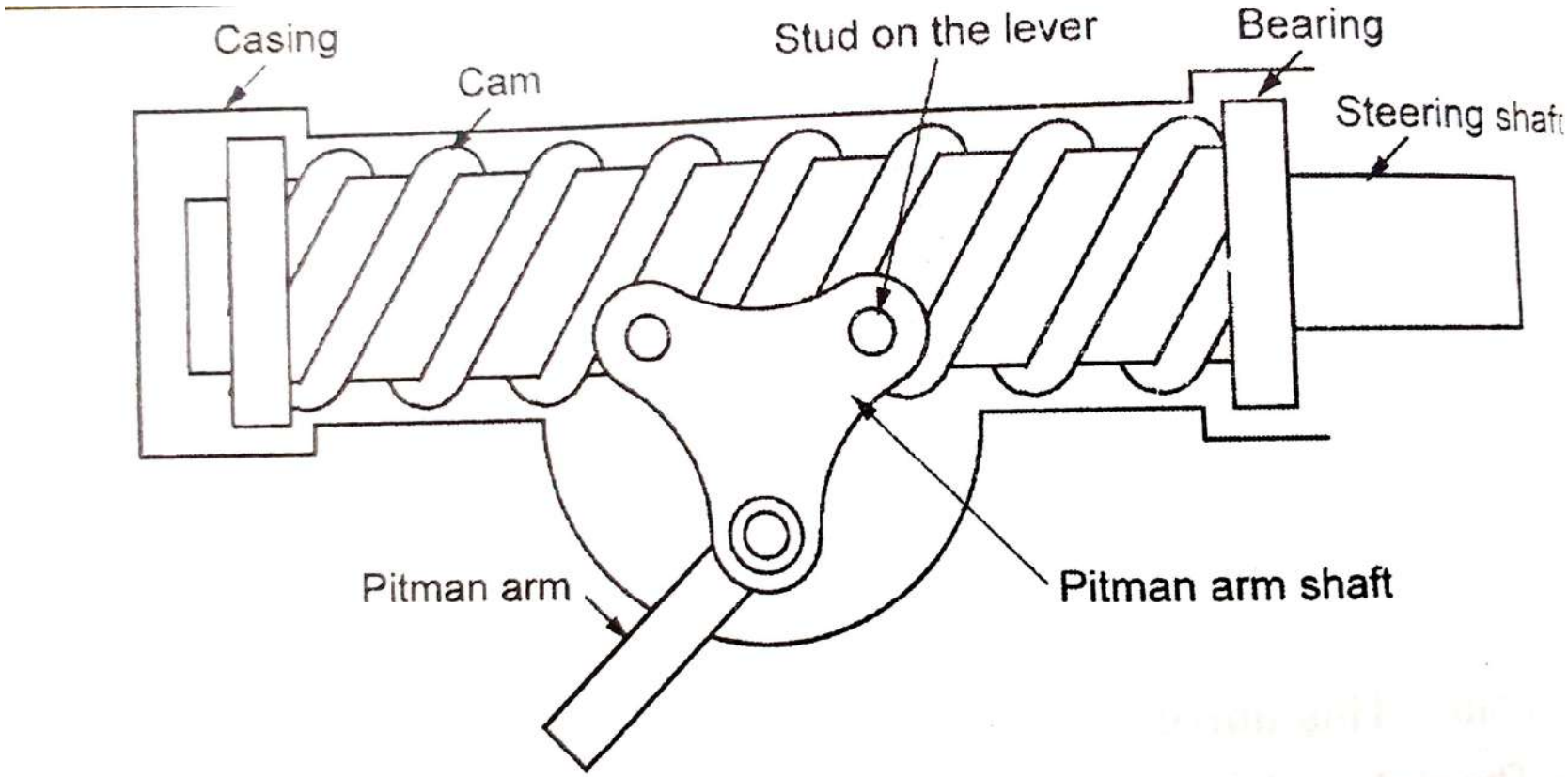


Figure 4.20 Cam and lever type steering gear

Power Steering