Knowledge institute of technology, salem.
Department of mechanical engineering

AUTOMOBILE ENGINEERING

BY

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UNIT 1

VEHICLE STRUCTURE AND ENGINES

DEFINITION

- Automobile engineering is a branch of engineering which deals with everything about automobiles and practices to propel them.
- Automobile is a vehicle driven by an internal combustion engine and it is used for transportation of passengers and goods on the ground.
- ***Automobile can also be defined as a vehicle which can move by itself.***

Examples :

- Car, jeep, bus, truck, scooter, etc

UNIT I
VEHICLE STRUCTURE AND ENGINES

Types of Automobiles

- 1. **Based on Purpose :**

According to the purpose the vehicles are classified as passenger vehicles and goods vehicles

1. Passenger vehicles: Car, Bus, Jeep, Auto-rickshaw.
2. Goods vehicles: Truck.

TYPES OF AUTOMOBILES

- **2. Based on Load Capacity:**

  According to the capacity the vehicles are classified as light motor vehicles and heavy motor vehicles.

  The light motor vehicles can able to carry light things and are also less in size and weight.

  But the heavy motor vehicles can carry very heavy materials and possess large mass and are bigger in size.

- 1. Light motor vehicles: Motorcycle, Car, Scooter
- 2. Heavy motor vehicles: Bus, Tractor, Truck.

TYPES OF AUTOMOBILES

- **3. Based on fuel used:**
- **Petrol engine vehicles :**
  - Automobiles powered by petrol engine. e.g: scooters, cars, motorcycles.
- **Diesel engine vehicles :**
  - Automobiles powered by diesel engine. e.g: Trucks, Buses, Tractors.
- **Gas vehicles :**
  - Vehicles that use gas turbine as power source. e.g: CNG vehicles.
- **Electric vehicles :**
  - Automobiles that use electricity as a power source. e.g: Electric cars, electric buses.

TYPES OF AUTOMOBILES

- **4. Based on Drive of the vehicles:**
- **Left Hand drive** : Steering wheel fitted on left hand side.
- **Right Hand drive** : Steering wheel fitted on right hand side.
- **5. Based on number of wheels and axles:**
- **Two wheeler** : motor cycles, scooters
- **Three wheeler** : Tempo, auto-rickshaws
- **Four wheeler** : car, Jeep, Bus, truck
- **Six wheeler** : Buses and trucks have six tires out of which four are carried on the rear wheels for additional reaction.

TYPES OF AUTOMOBILES

- **6. Based on type of transmission:**
- **Automatic transmission vehicles:** Automobiles that are capable of changing gear ratios automatically as they move. e.g: Automatic Transmission Cars.
- **Manual transmission vehicles:** Automobiles whose gear ratios have to be changed manually.
- **7. Based on Suspension system used:**
- **Convectional** – Leaf Spring
- **Independent** – Coil spring

TYPES OF AUTOMOBILES

Position of Engine

Engine in Front

Most of the vehicles have engine in the front. Example : most of the cars, buses, trucks in India.

Engine in the Rear Side

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

Vehicle Construction

- A vehicle consists of engine to drive the vehicle
- In addition to that, an automobile also consists of power transmission systems such as clutch, gear box, propeller shaft, universal joints, differential etc.
- Automobile is also provided with steering for directional control, acceleration for speed control

CHASSIS

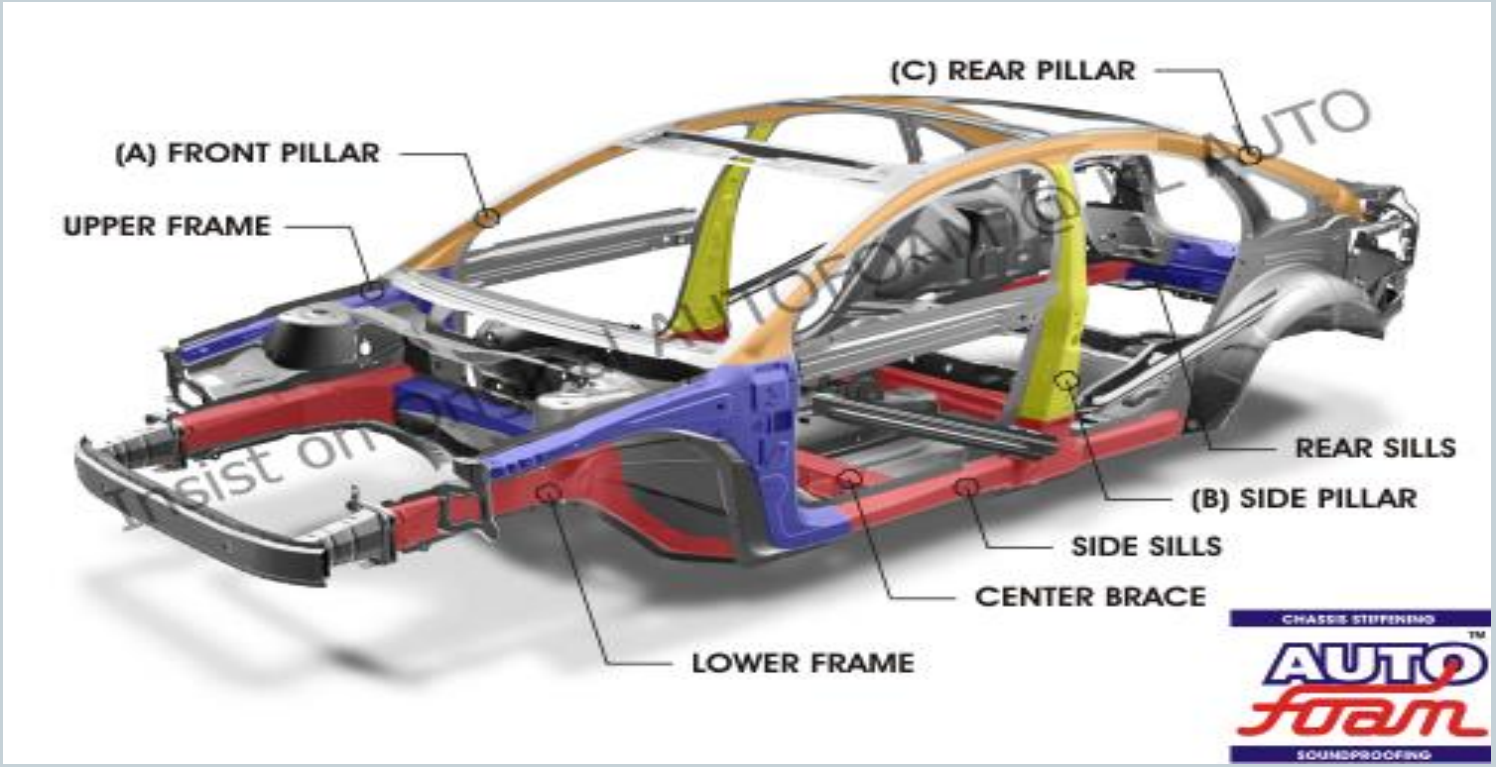
- A vehicle without body is called chassis
- chassis is a skeletal frame on which various mechanical parts like engine, tires, axle assemblies, brakes, steering etc. are bolted
- It is the most crucial element that gives strength and stability to the vehicle under different conditions
- Automobile frames provide strength and flexibility to the automobile
- The backbone of any automobile, it is the supporting frame to which the body of an engine, axle assemblies are affixed.

LAYOUT OF AN AUTOMOBILE CHASSIS

LAYOUT OF AN AUTOMOBILE CHASSIS

- It contains the source of power, i.e. engine, the frame which supports the engine, wheels, body, transmission, the braking system and the steering. It also gives support to suspension system and springs.

Vehicle Frame



Vehicle Body and Aerodynamics

COMPONENTS OF THE AUTOMOBILE

The automobile can be considered to consist of five basic components :

(a) **The Engine or Power Plant :** It is source of power.

(b) **The Frame and Chasis :** It supports the engine, wheels, body, braking system, steering, etc.

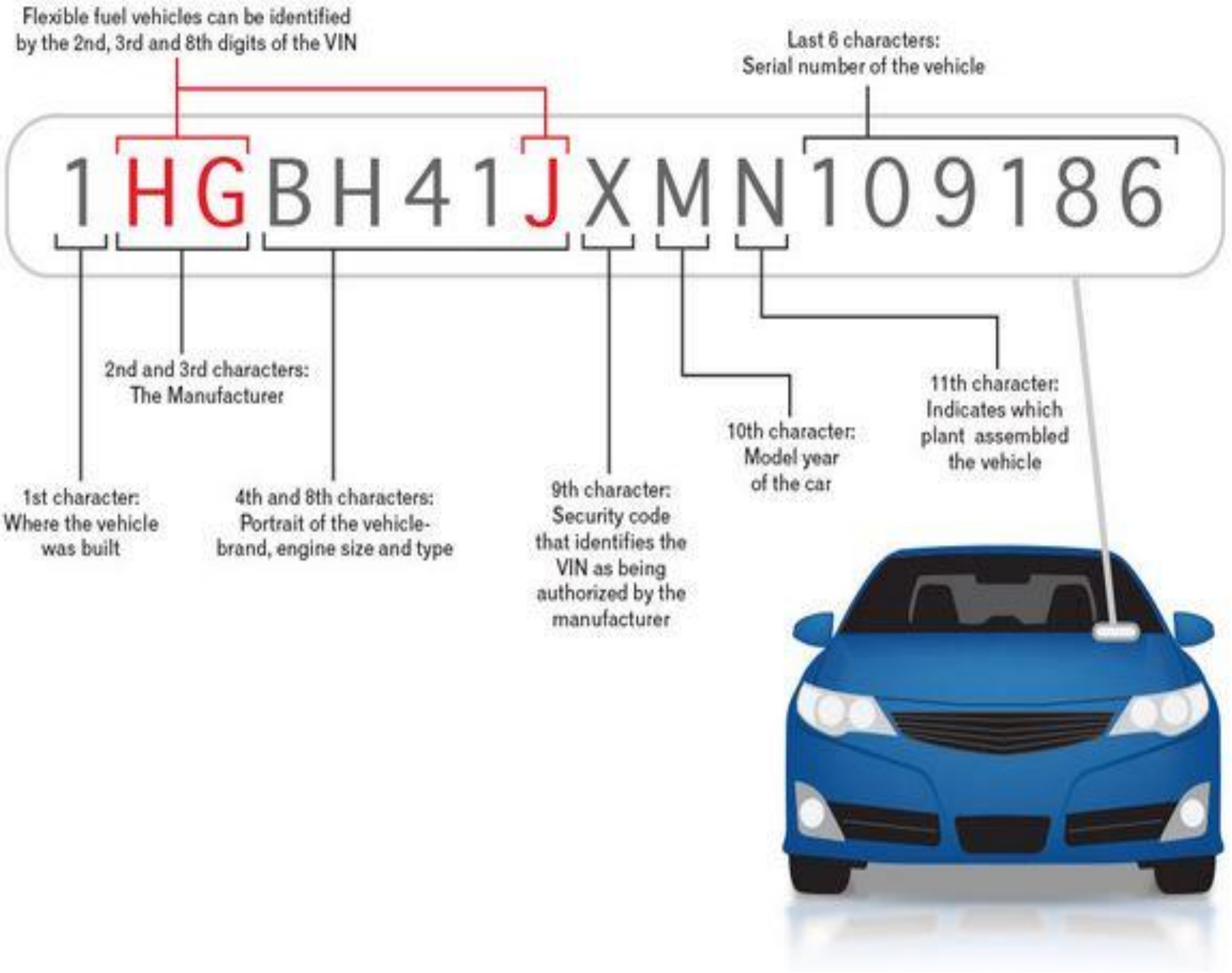
(c) The transmission which transmits power from the engine to the car wheels. It consists of clutch, transmission, shaft, axles and differential.

(d) The body.

(e) Accessories including light, air conditioner/hearer, stereo, wiper, etc.

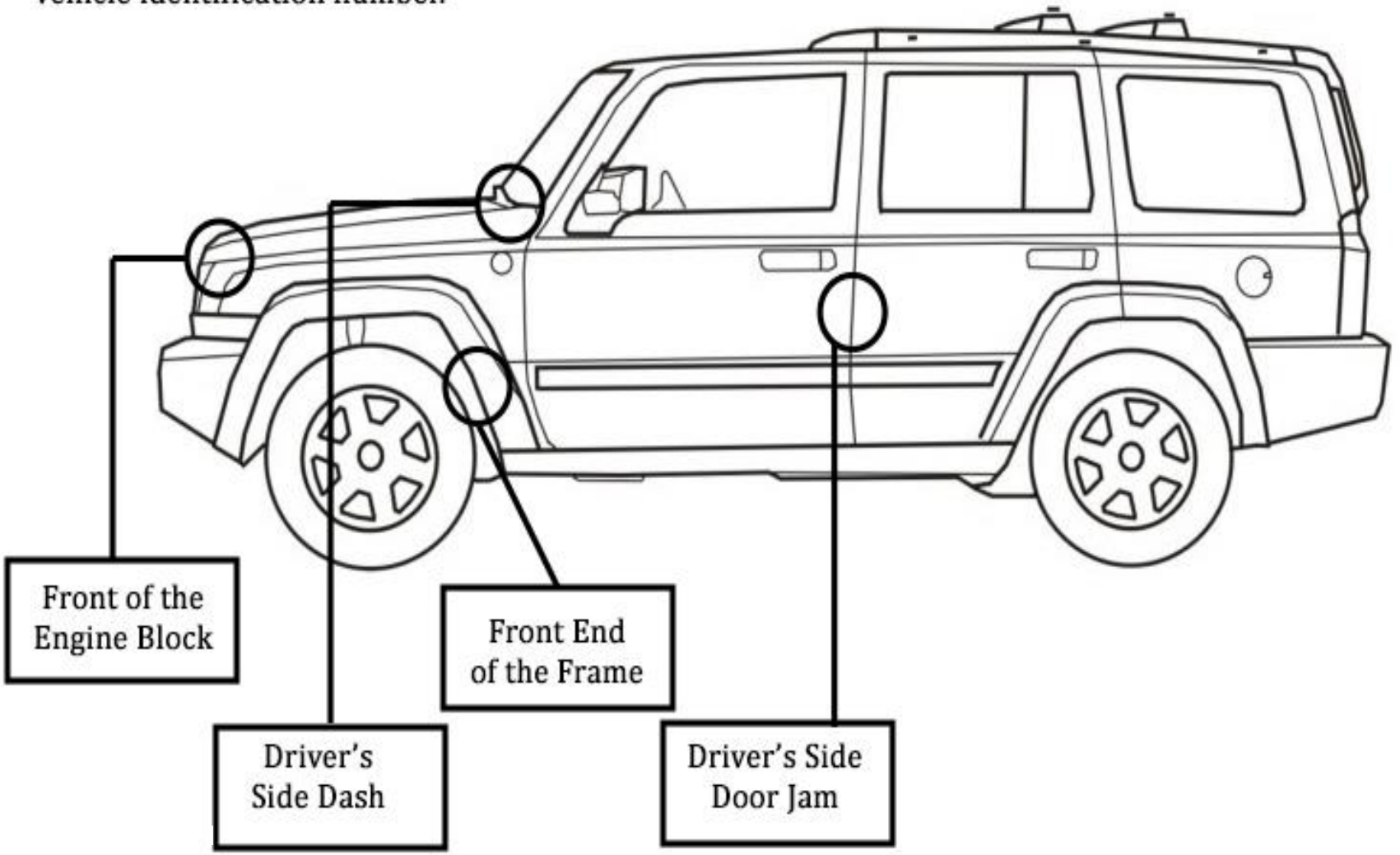

Homework
Read p.16
Do exercise B
NOVELS
Westcoast Reader


Homework
Read p.16
Do exercise A
HISTORY
Eastcoast Reader
DICTIONARY


Flexible fuel vehicles can be identified by the 2nd, 3rd and 8th digits of the VIN
Last 6 characters: Serial number of the vehicle
1HGBH41JXMN109186
2nd and 3rd characters: The Manufacturer
1st character: Where the vehicle was built
4th and 8th characters: Portrait of the vehicle- brand, engine size and type
9th character: Security code that identifies the VIN as being authorized by the manufacturer
10th character: Model year of the car
11th character: Indicates which plant assembled the vehicle

Can't find your VIN?

Four common places to find your vehicle identification number.



FUEL INJECTION SYSTEMS
UNIT INJECTOR AND COMMON RAIL

1. **UNIT INJECTOR: Cylinder and plunger in cylinder head, sprays or squirts fuel into combustion chamber, for ignition. Fuel is INDUCTED from fuel tank to fuel injectors under pressure from a pump.**

2. **COMMON RAIL: Most commonly used. One pump for all cylinders. Fuel under pressure from tank to cylinder.**

DRAWBACKS: System must be purged of all air until only fuel comes out. Time consuming, awkward and messy.

IGNITION SYSTEM COMPONENTS

1. **IGNITION COIL: The generated power source (FOR THE SPARK IN THE SPARK PLUG)**
2. **MECHANICAL BREAKER(POINTS): Break the current at proper time**
3. **CONDENSER: Prevents "arcing" when the points are open.**
4. **DISTRIBUTOR: Serves as a "selector switch" to distribute the current to the individual spark plugs (gas engine only)**
5. **SPARK PLUG(S): (Gasoline engines only)Provided the "fire" to ignite the fuel in the combustion chamber. (Spark comes from the**

Engine Components and Operation

Objectives

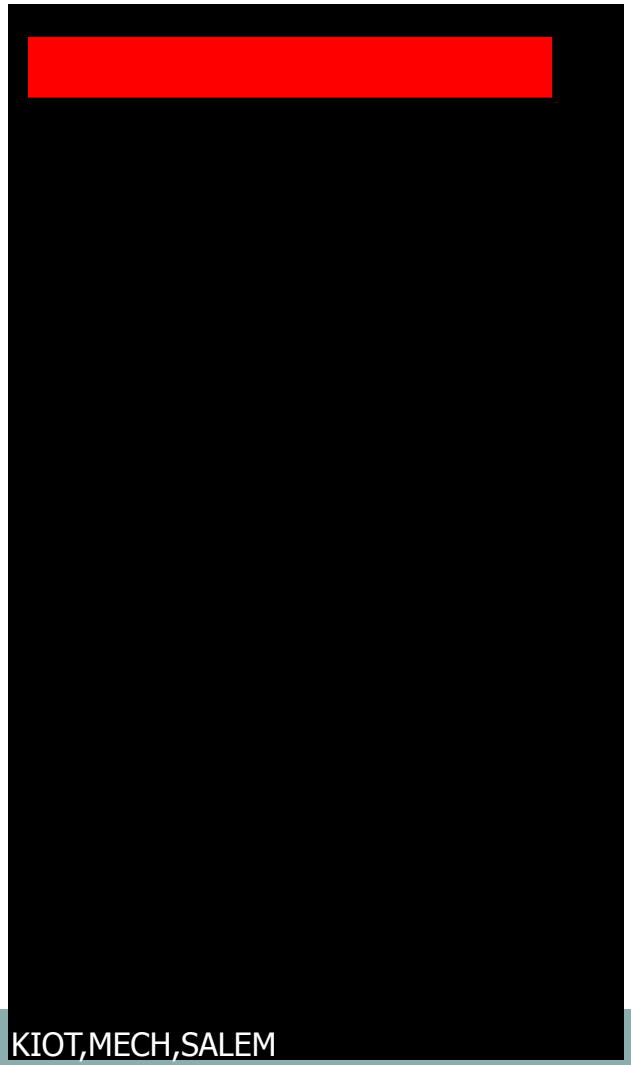
- Explain the basic function of an internal combustion engine.
- Describe the five events required for internal combustion engine operation.
- Describe selected individuals and events in the history of engine development.
- Identify and describe the construction and function(s) of primary engine components.
- Explain principles of 2- and 4-stroke cycle engine operation, both S.I. And C.I.

Internal Combustion Engine

- Function - Converts potential chemical energy in fuel into heat energy then to mechanical energy to perform useful work.

Chemical → Heat → Mechanical

Requirements for I.C. Engine Operation

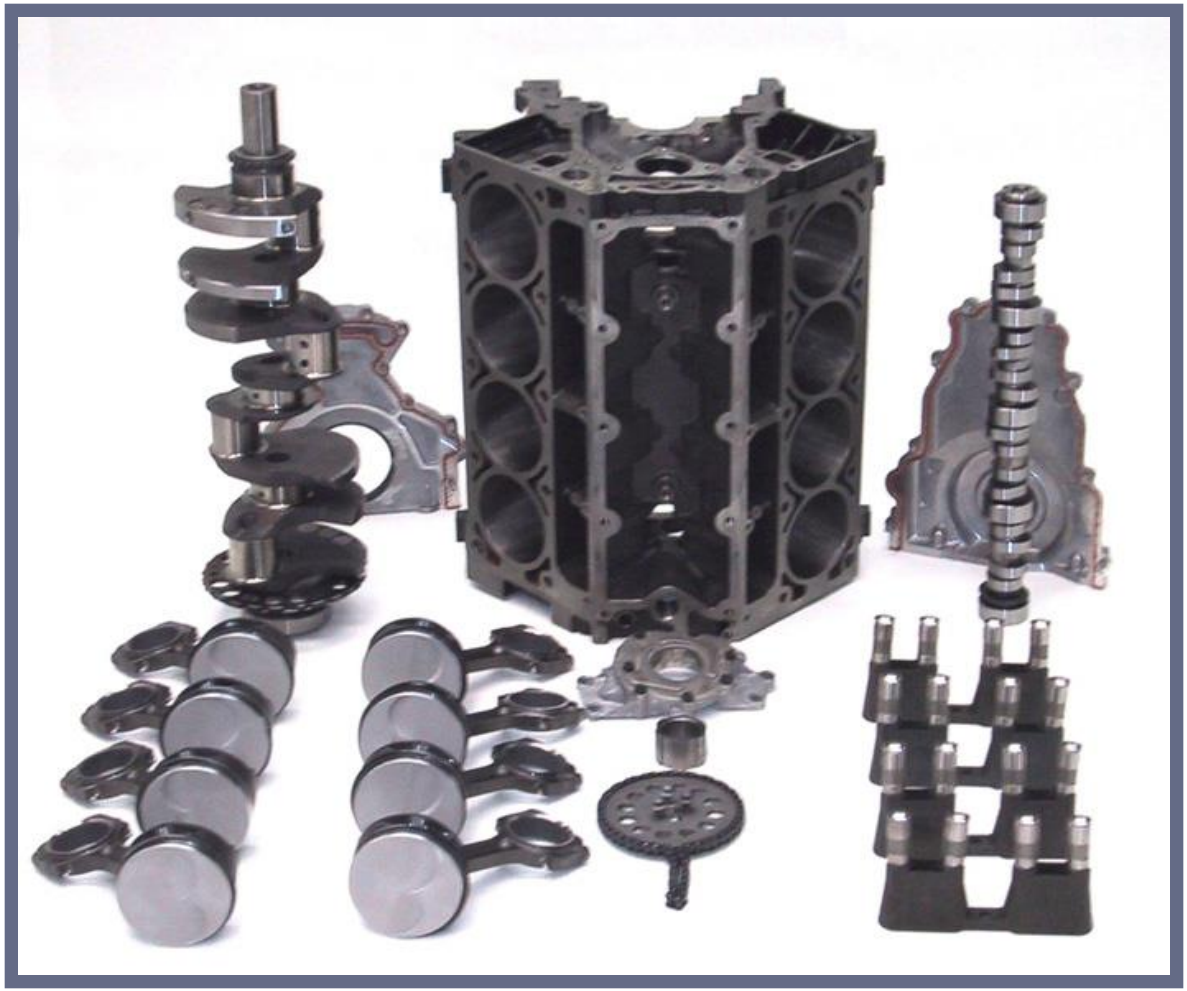


- **All Internal combustion engines must carry out five events:**
  - Air-fuel mixture must be brought into the combustion chamber.
  - Mixture must be compressed.
  - Mixture must be ignited.
  - Burning mixture must expand into increasing combustion chamber volume.
  - Exhaust gasses must be removed.

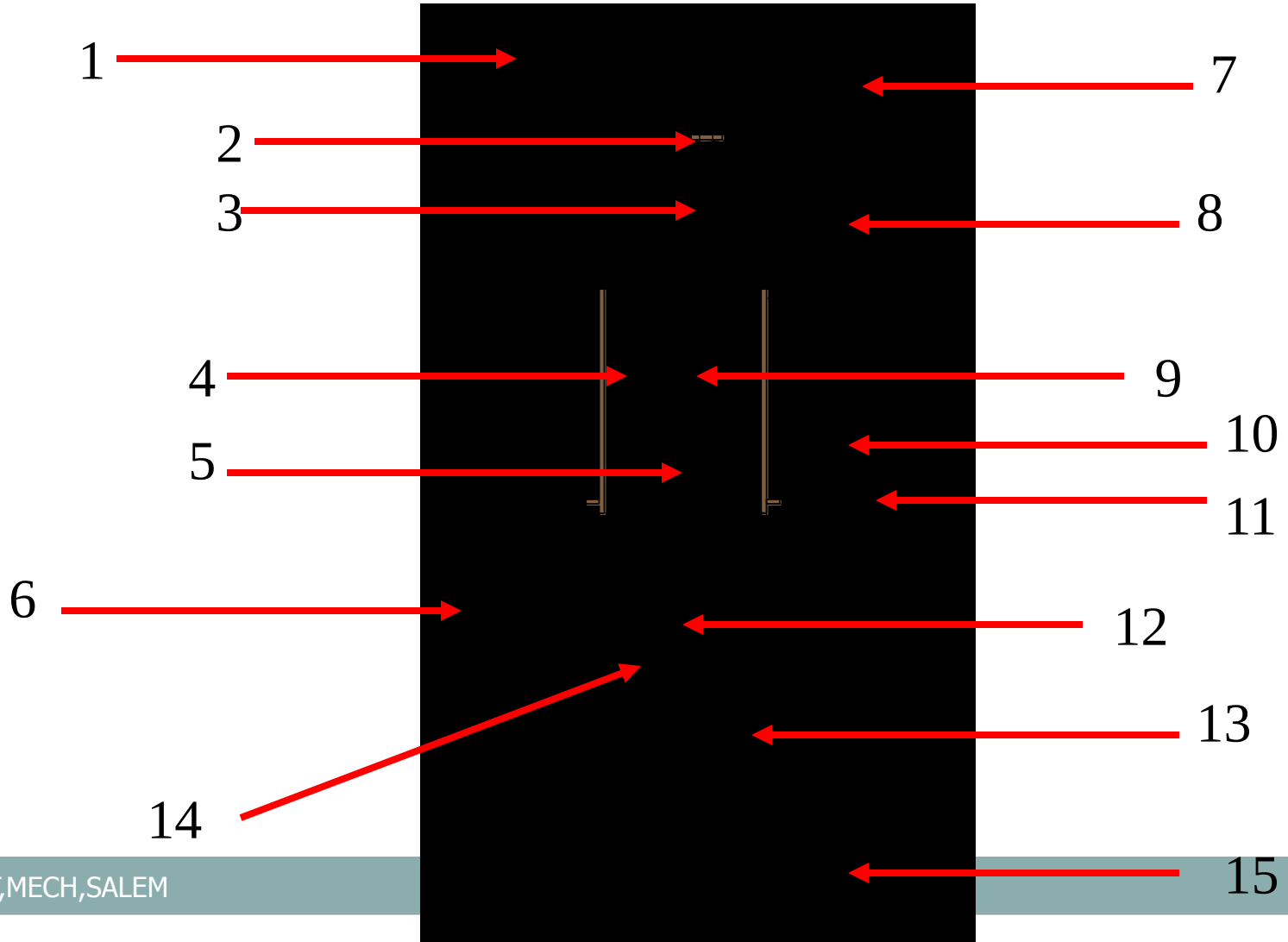
Historical Development of the I.C. Engine

- 1862 -- Rochas described the basic principles essential for efficient engine operation.
- 1878 – Otto built the first successful 4-stroke cycle engine.
- 1891 – Day built an improved 2-stroke cycle engine.
- 1892 – Diesel patented the compression-ignition (diesel) engine.
- To present – emphasis on improved engine efficiency, through refinement.

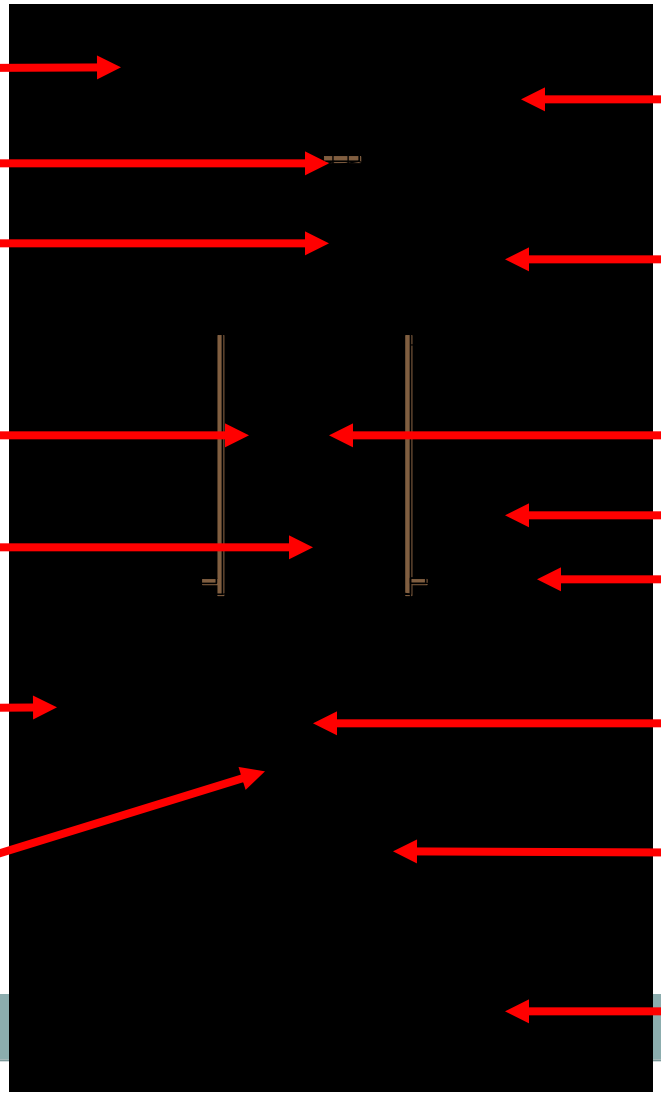
Engine Components and Functions



Name that Engine Part



Name that Engine Part



Valve cover

Valve spring

Valve

Piston

Connecting rod

Engine block

Connecting rod cap

Rocker arm

Push rod

Piston pin

Valve tappet

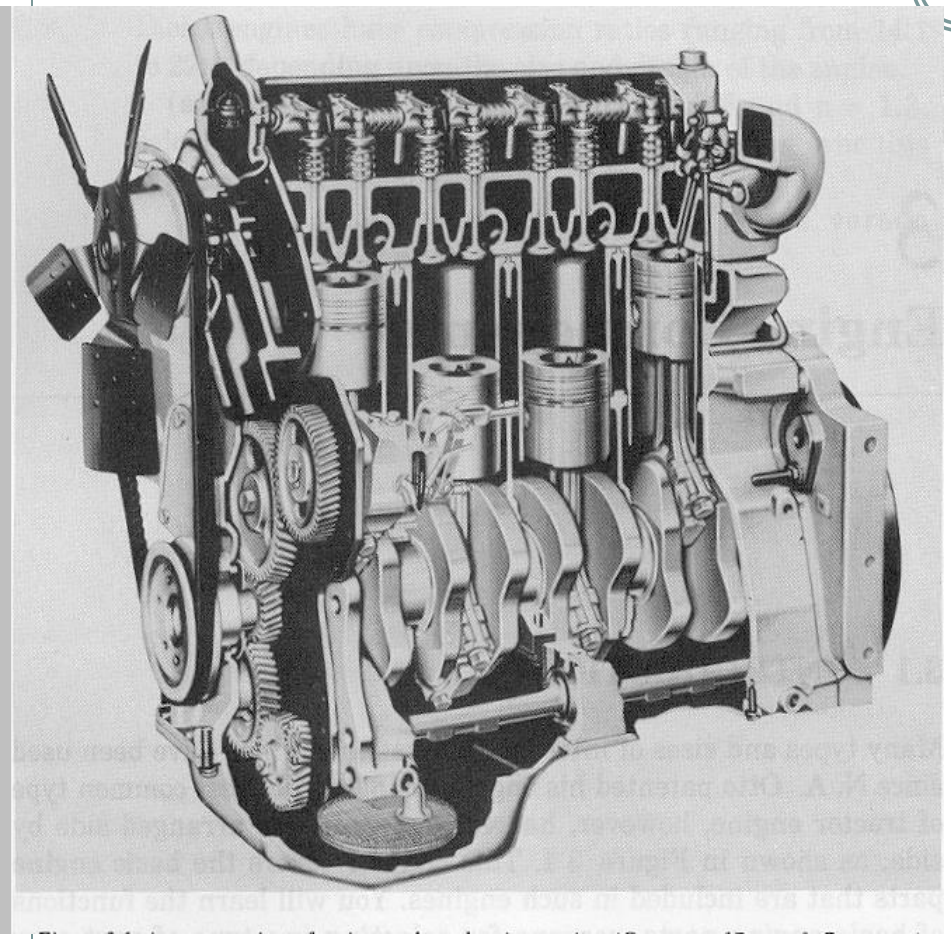
Camshaft

Connecting rod

Main journal

Oil pan

Cylinder Block



"Backbone" of the engine.

Supports / aligns most other components.

Part of basic tractor frame.

Contains:

Cylinders

Coolant passages

Oil passages

Bearings

One-piece, gray cast iron

Cylinders

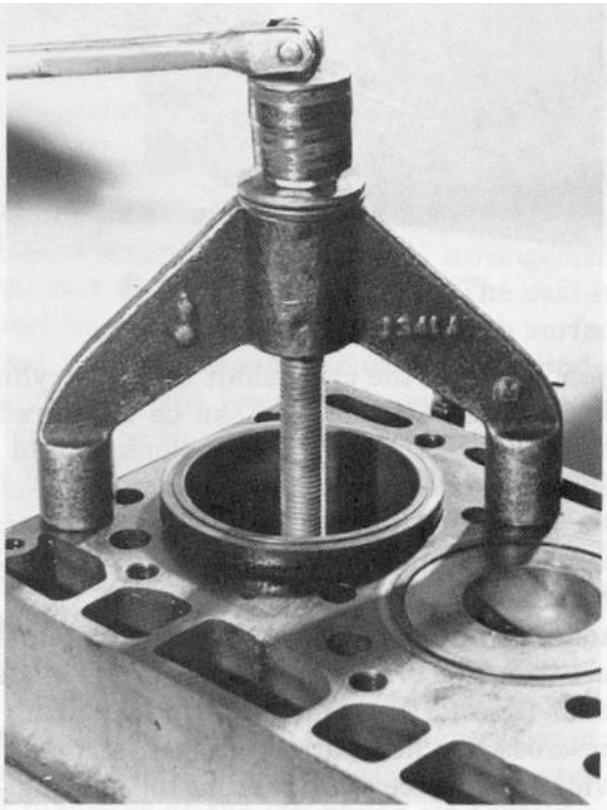
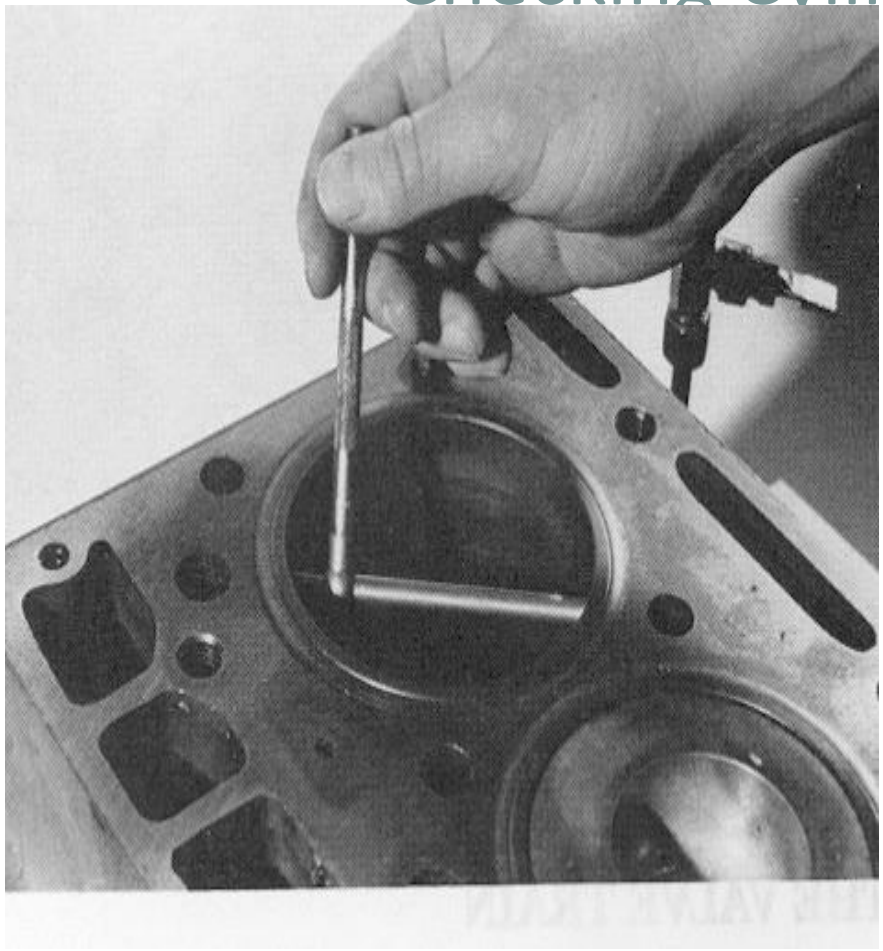


Figure 3.4–Removal of a cylinder liner. (Photo by Laurie Goering.)

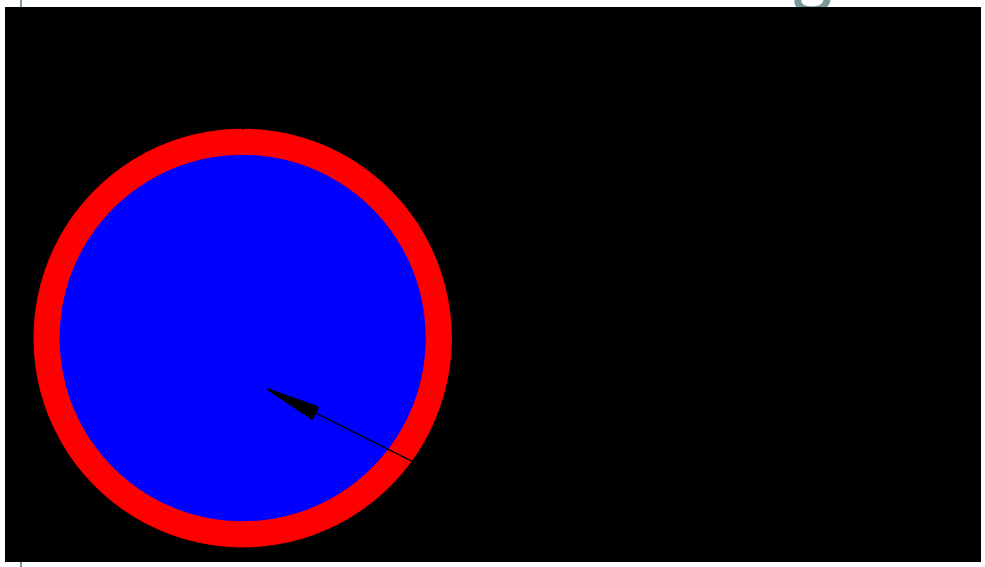
- Cylindrical holes in which the pistons reciprocate.
- May be:
  - Enblock
  - Liners
    - **Wet liners**
    - **Dry liners**
- Cylinder bore – diameter of cylinder

Checking Cylinder Condition



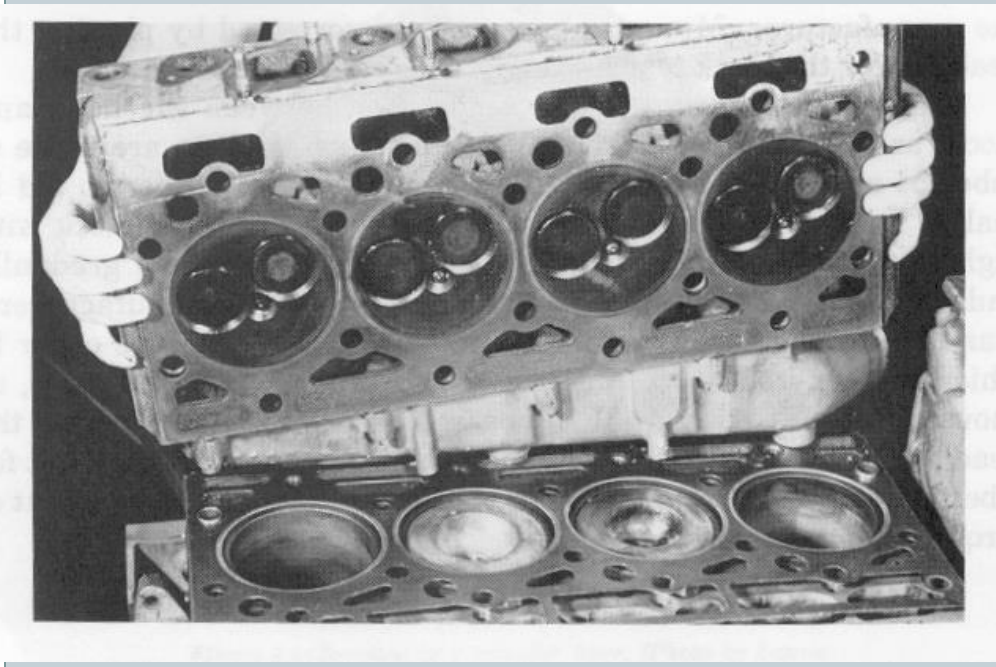
- During engine overhaul, cylinder is checked for:
  - Excessive wear (oversize)
  - Out-of Round
  - Taper

Bearings and Journals



- Bearing – Stationary (non-rotating) surfaces providing support to moving (rotating) component.
  - Main bearings
  - Rod bearings
  - Cam bearings
- Journal – Surface of moving component supported by a bearing.

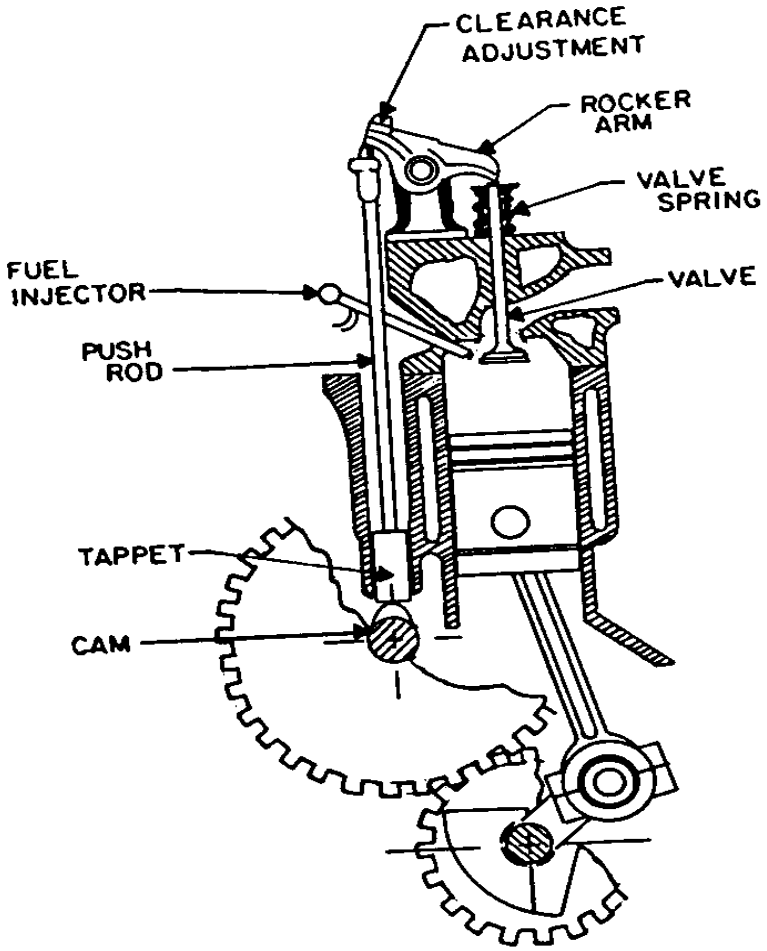
Cylinder Head



Seals the “top-end” of the combustion chamber. Contains the valves and the intake and exhaust “ports”. Head bolts and head gasket ensure air-tight seal of the combustion chamber. Contains oil and coolant passages.

One-piece castings of iron alloy.

Valve Train



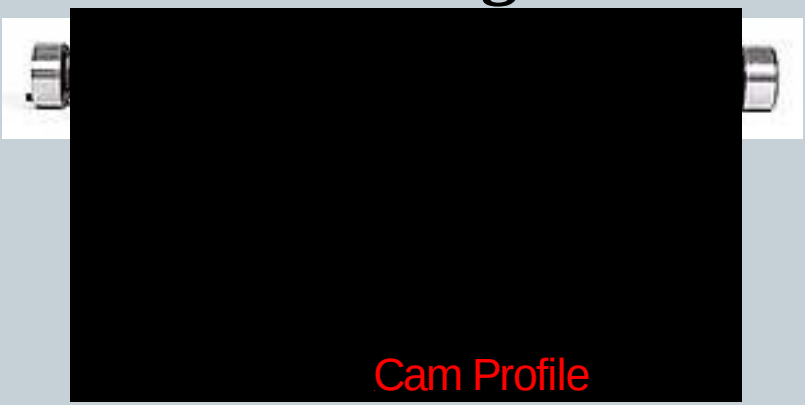
- Controls flow into and out of the combustion chamber.
  - Time and Duration
- Tractor engines use "Overhead Valve (OHV)" configuration.
- Components
  - Camshaft
  - Valve tappets
  - Push rods
  - Rocker arm
  - Valves
  - Valve springs
  - Valve rotators

Camshaft

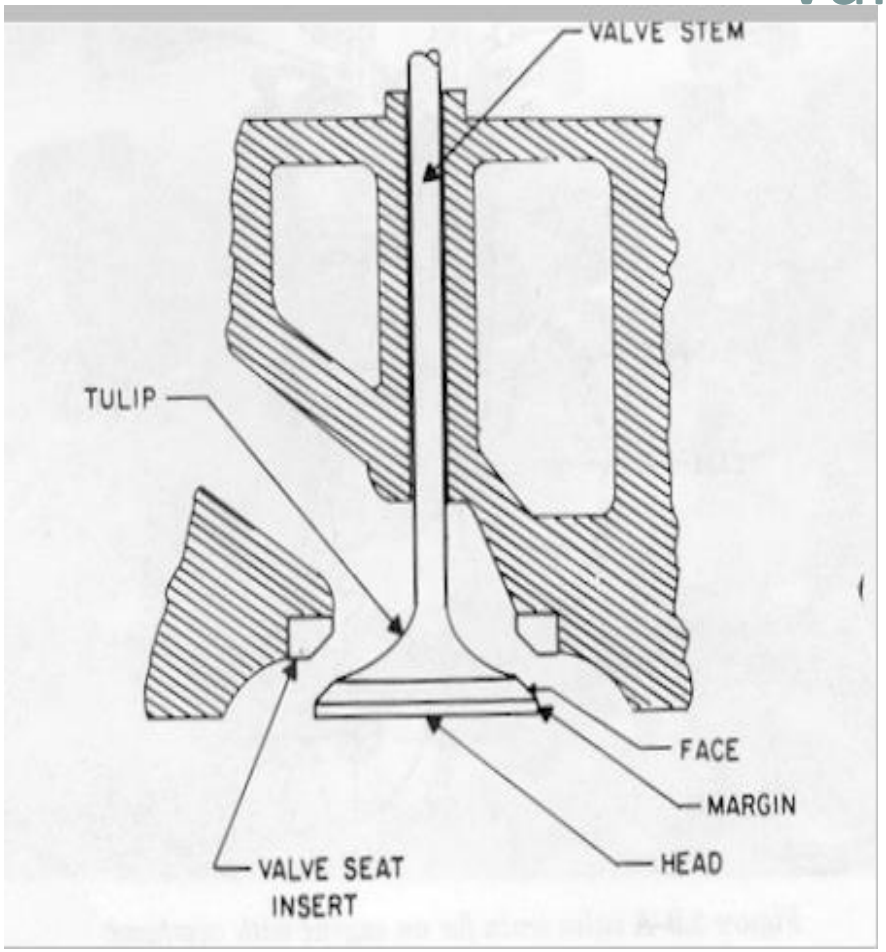
Open the intake and exhaust valves at correct time and for correct duration.

Driven by gear (or chain) from the crankshaft.

2:1 crankshaft to camshaft gear ratio.

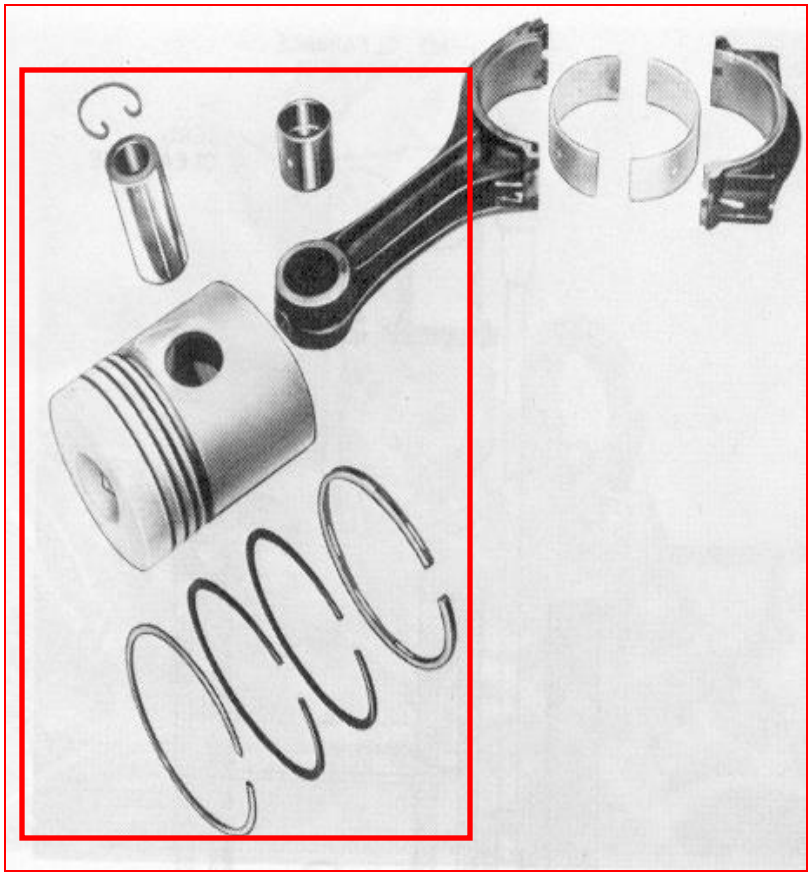


Valves



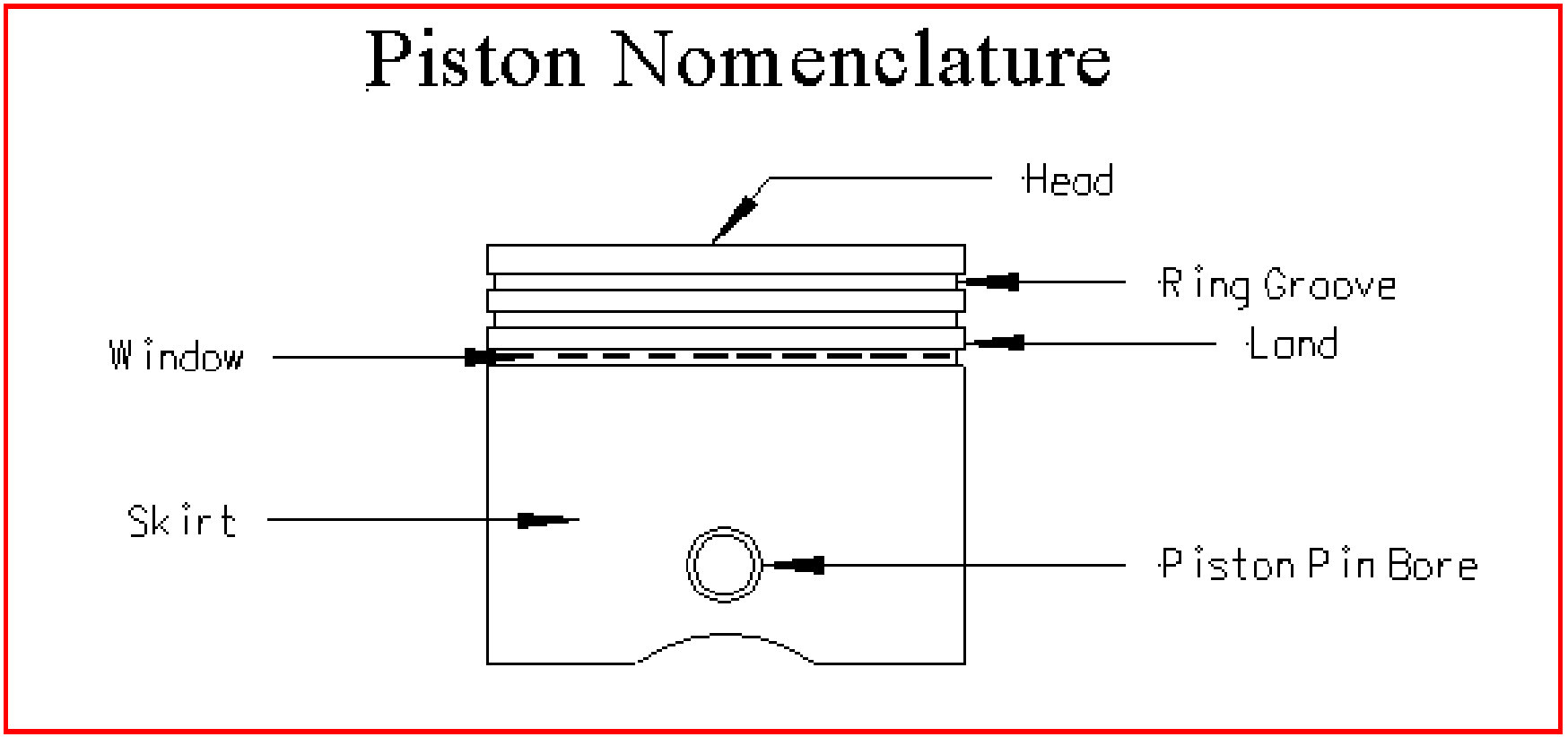
- Each cylinder will have:
  - Intake valve
  - Exhaust valve
- **Valve nomenclature**
  - Head
  - Margin
  - Face
  - Tulip
  - Stem

Piston and Rings

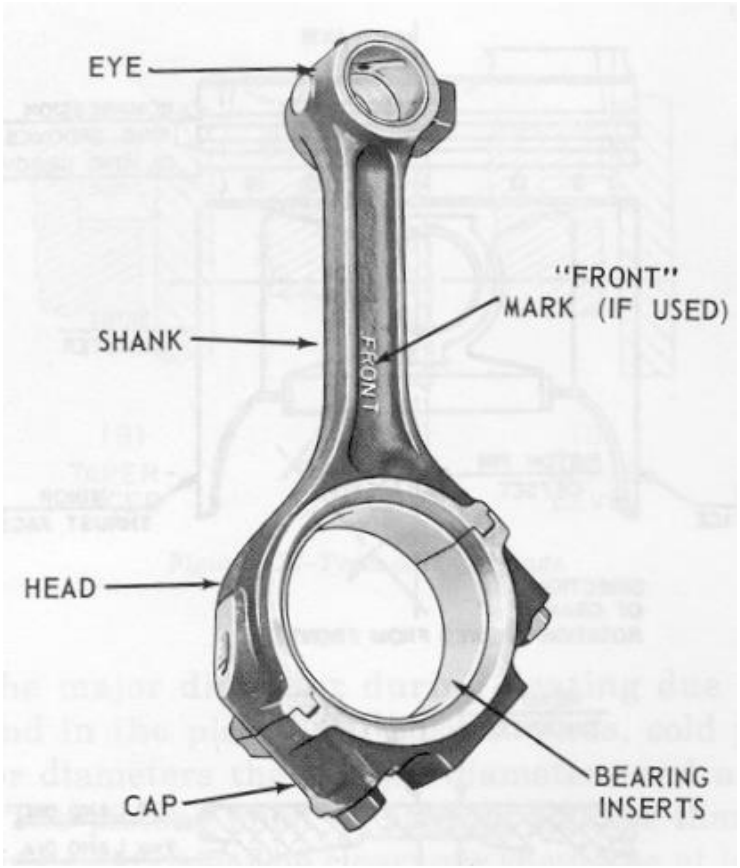


- Piston
  - Forms the “moveable bottom’ of the combustion chamber.
    - Iron alloy or aluminum
- Rings
  - Compression
  - Oil-control
    - Cast iron
- Piston pin

Know Your Piston!

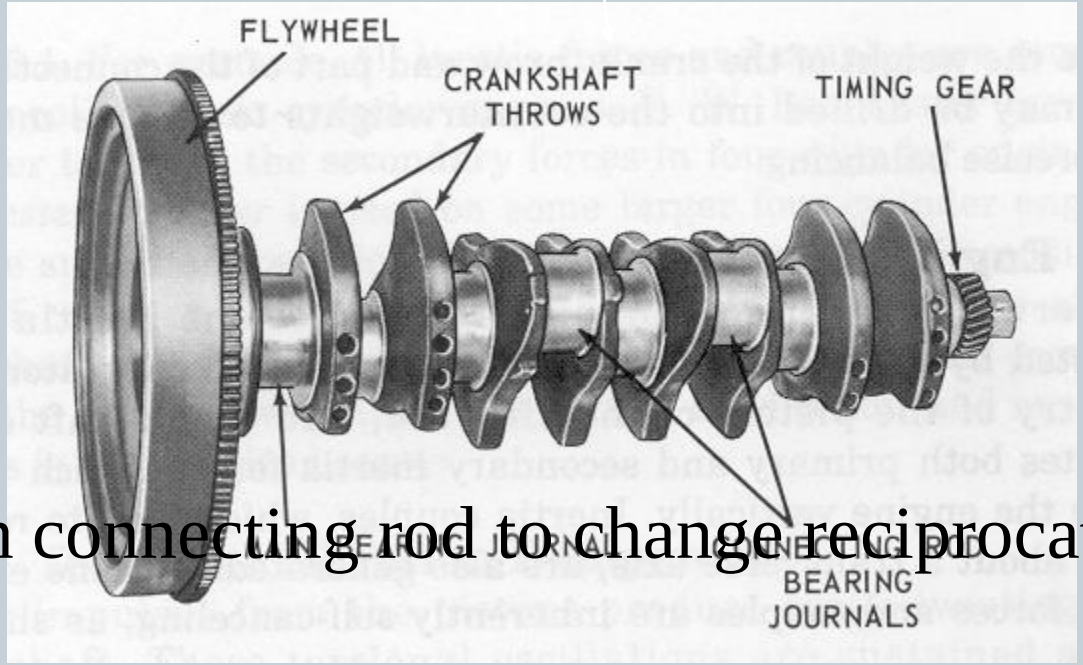


Connecting rod



- Connects the piston to the crankshaft
- Converts reciprocating piston motion to rotary motion at the crankshaft.
- Nomenclature
- Drop-forged steel

Crankshaft

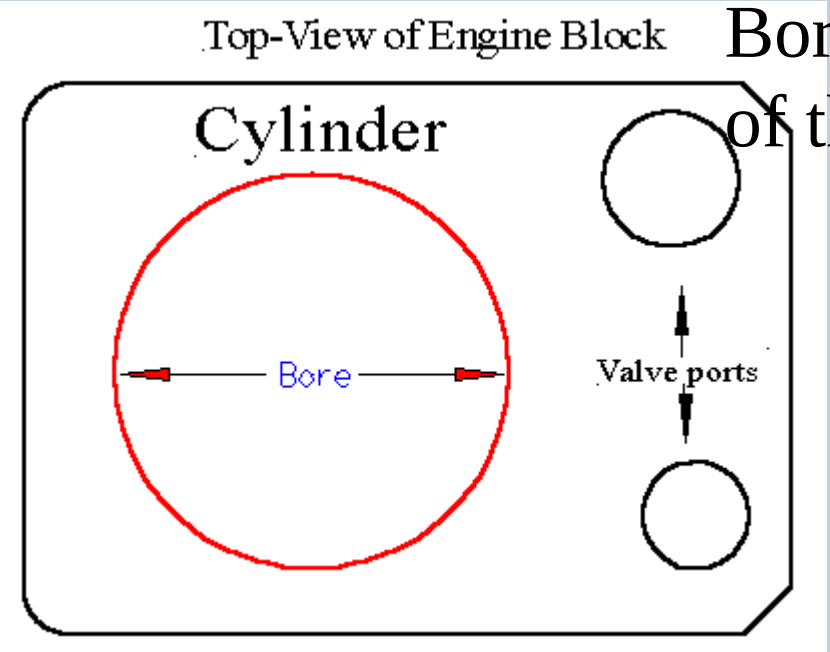


Works with connecting rod to change reciprocating to rotary motion.

Transmits mechanical energy from the engine.

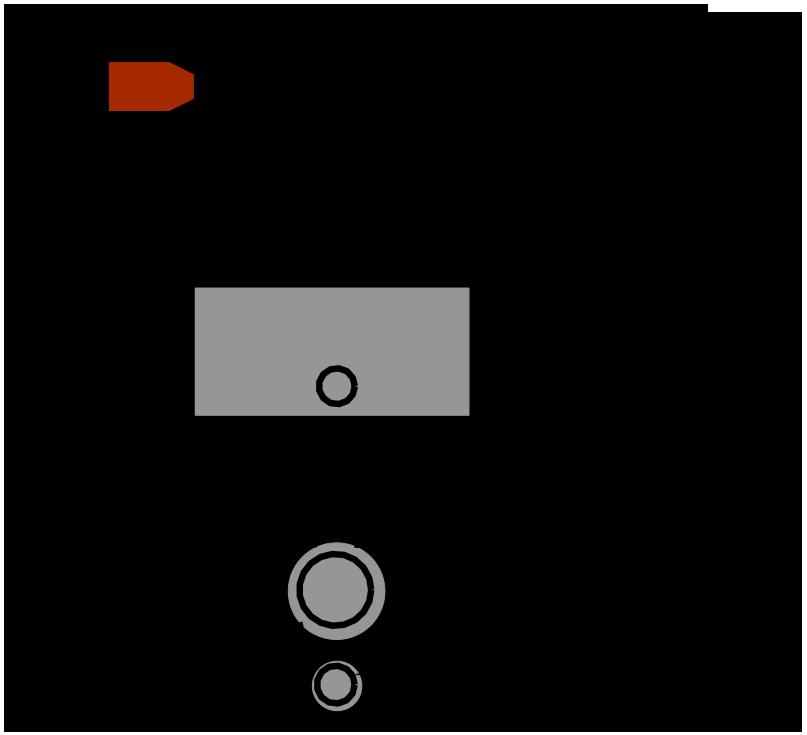
Made of heat-treated steel alloys.

Cylinder Bore



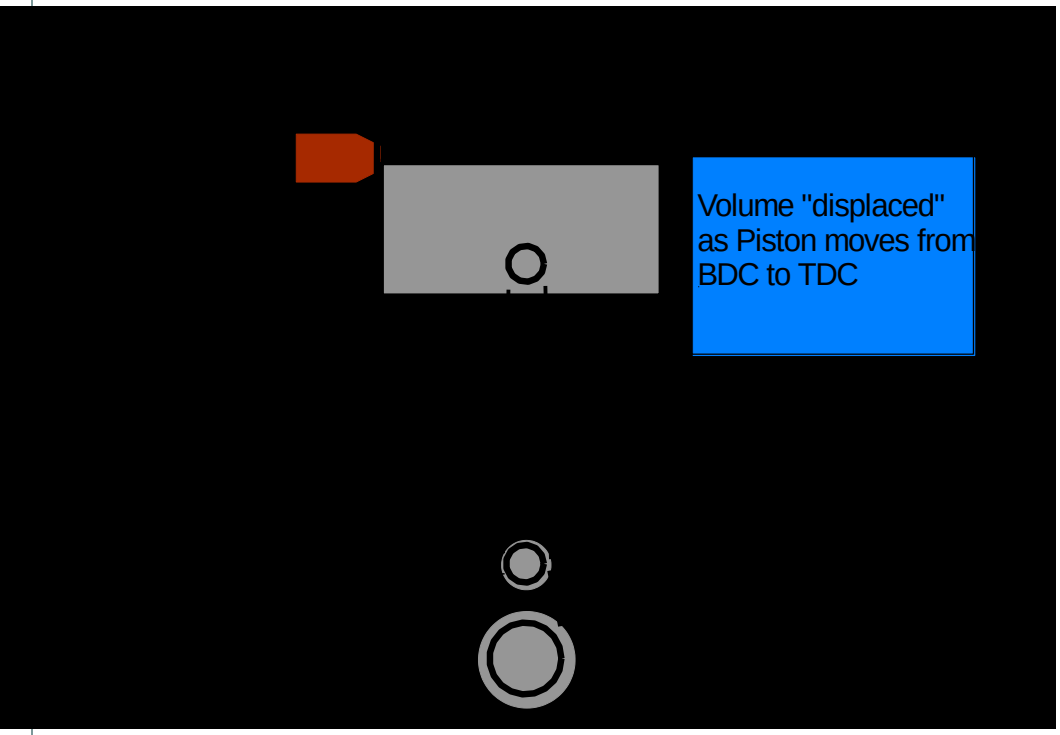
Bore is the diameter of the cylinder

Stroke



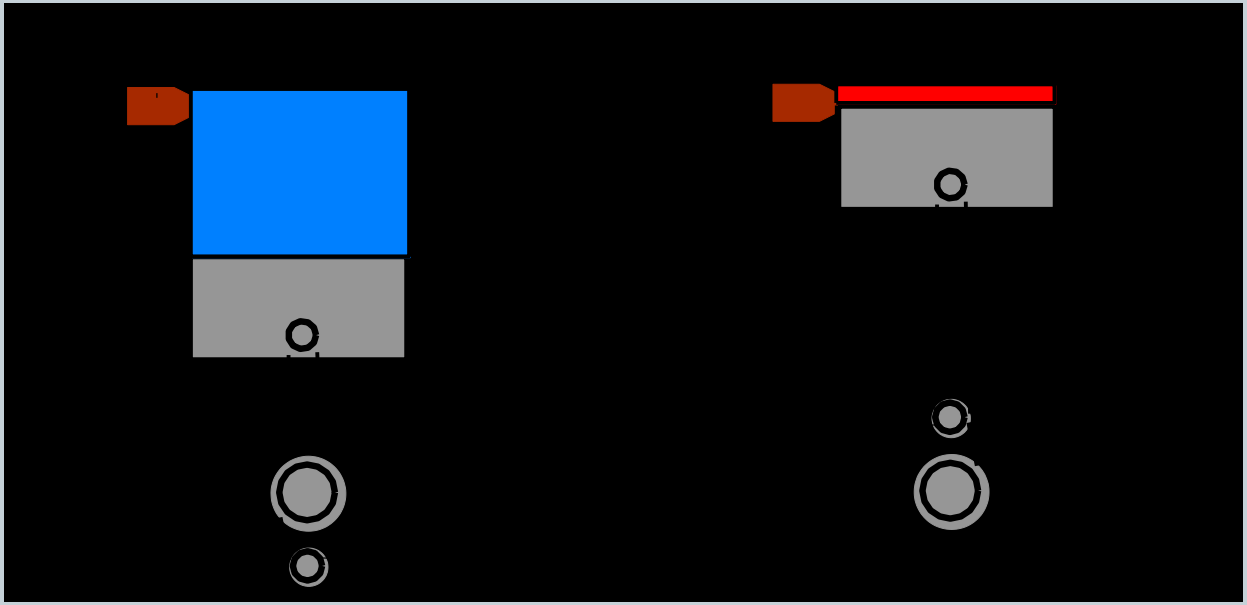
Linear distance piston travels from Top Dead Center (TDC) to Bottom Dead Center (BDC).

Piston and Engine Displacement



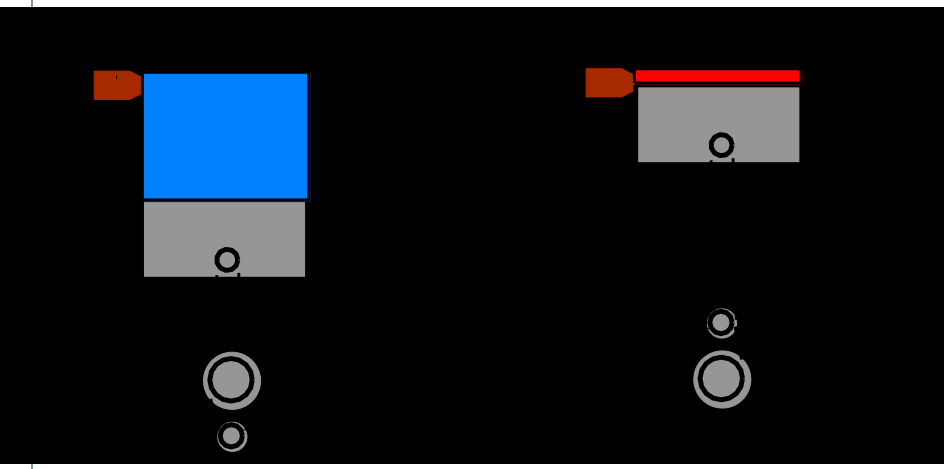
- **$Pd = (B^2 \times pi \times s) / 4$**
- **$Ed = [(B^2 \times pi \times s) / 4] \times n$**

Compression Ratio



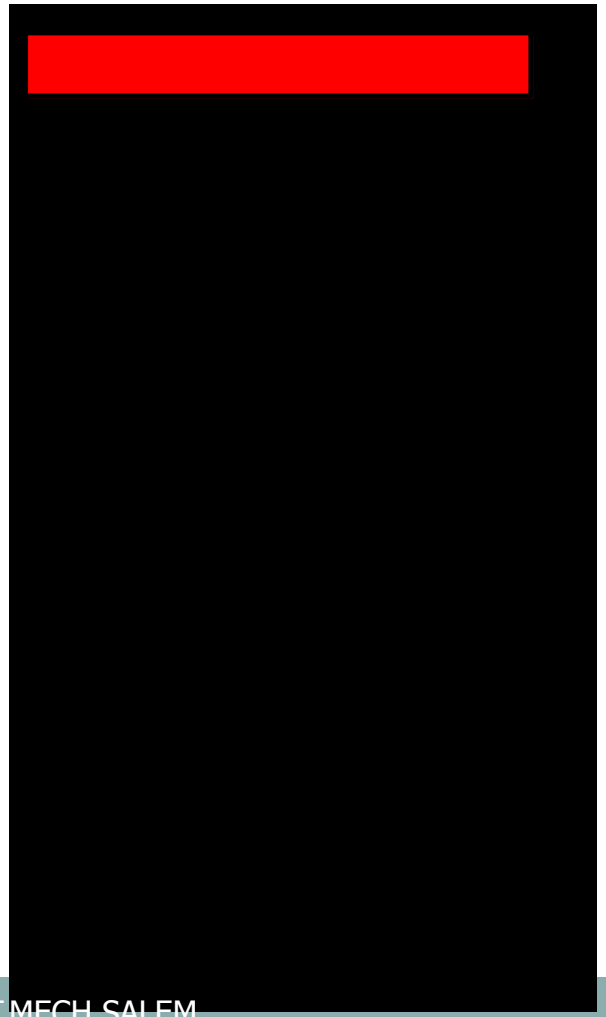
Ratio of “Total Volume” in cylinder at BDC to TDC.

Compression Ratio and Gasoline Octane Rating



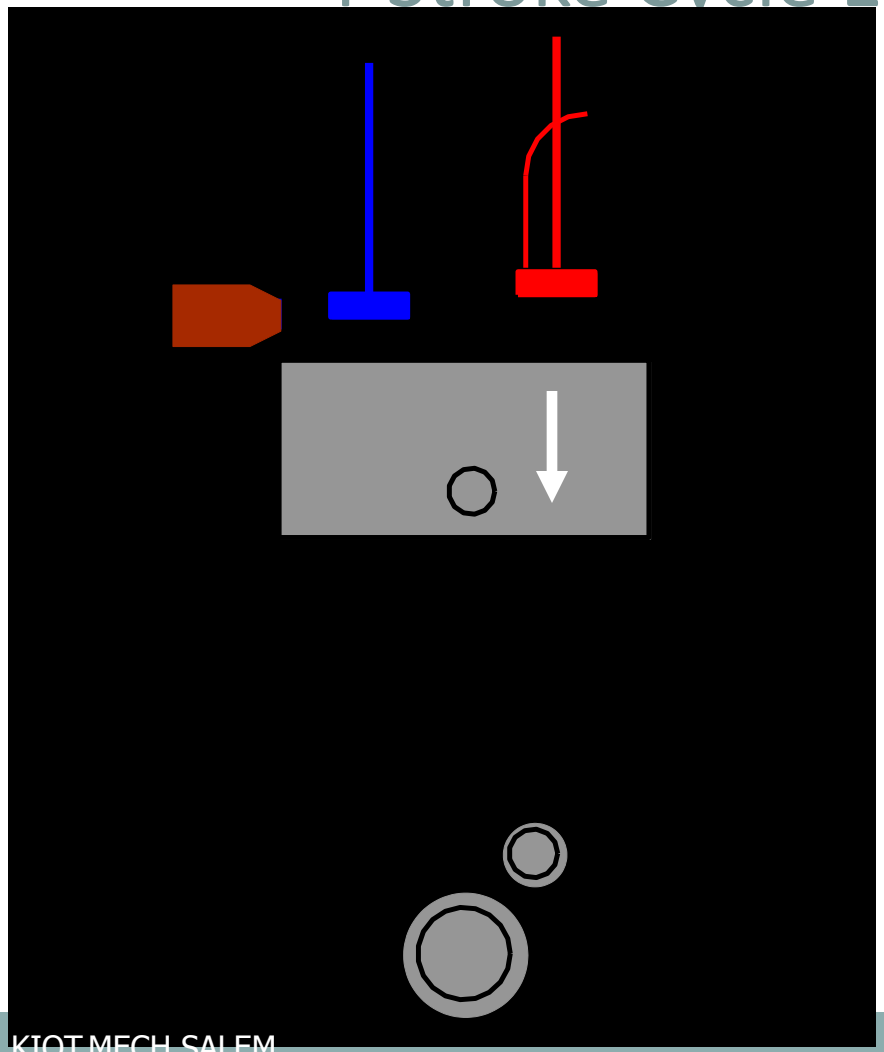
CR	Octane Rating
5:1	73
6:1	81
7:1	87
8:1	91
10:1	98
11:1	100
12:1	102

4-Stroke Cycle Engine Operation



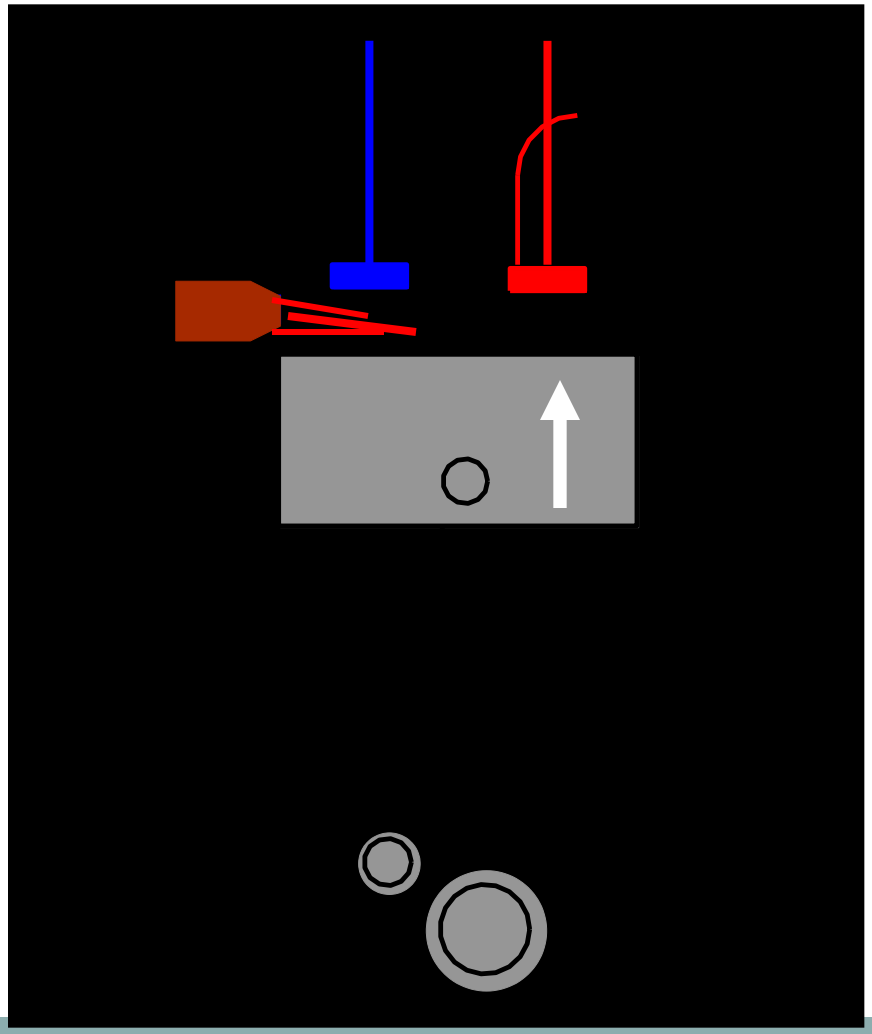
- 4-stroke cycle engines require four strokes of the piston to complete the five events necessary for engine operation.
  - 1 piston stroke = ½ crankshaft revolution.
  - 4 piston strokes = 2 crankshaft revolutions.

4-Stroke Cycle Engine Operation



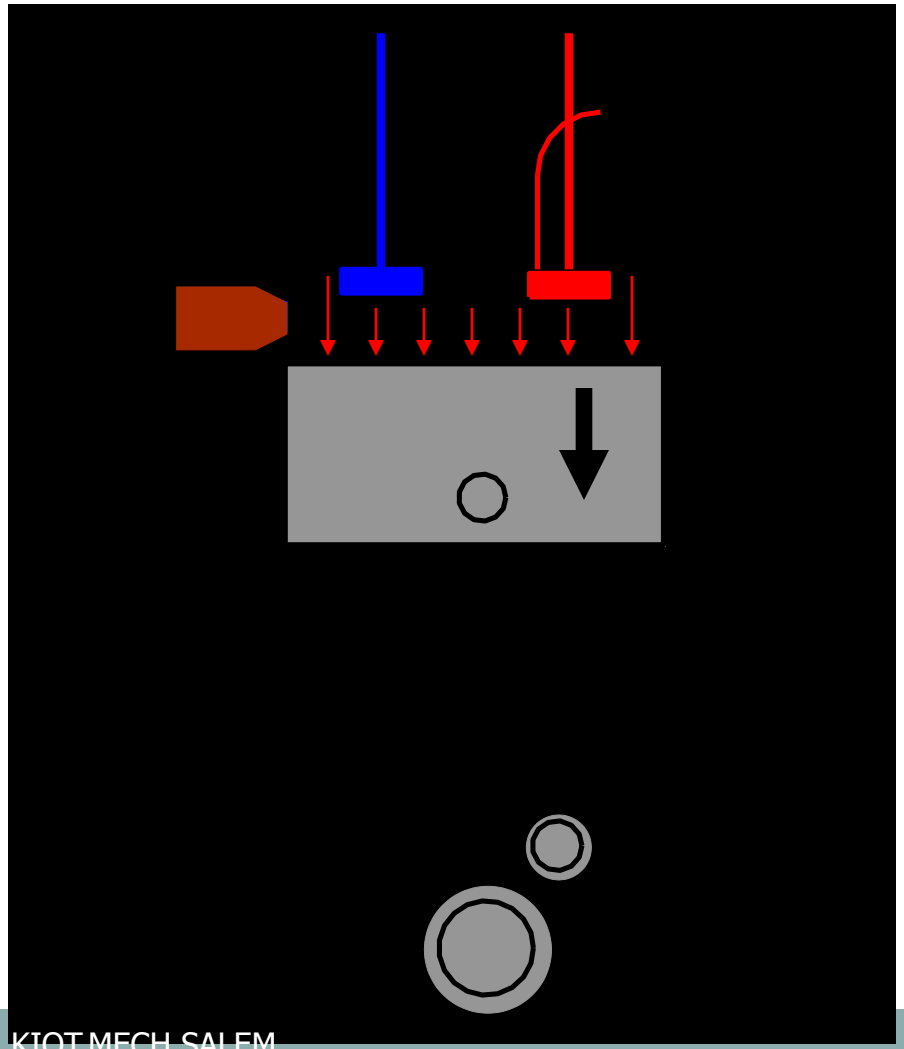
- Intake Stroke
  - Intake valve open.
  - Piston moves down (TDC to BDC) in cylinder.
  - Low pressure is created in cylinder.
  - Air is brought into the combustion chamber due to pressure differences.

4-Stroke Cycle Engine Operation



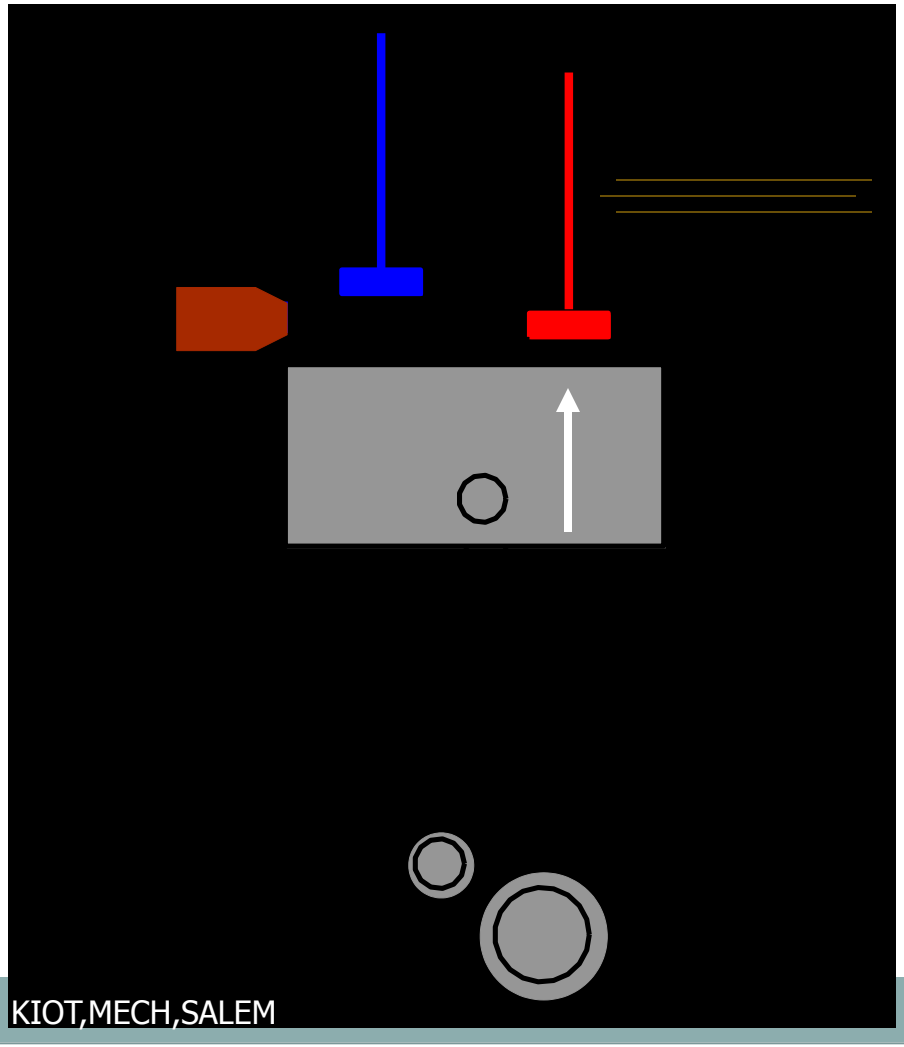
- Compression Stroke
  - Both valves closed.
  - Piston moves from BDC to TDC
  - Air in combustion chamber is compressed, raising its temperature.
  - Near TDC of Compression stroke, diesel fuel is injected into the combustion chamber.

4-Stroke Cycle Engine Operation



- Power Stroke
  - Both valves are closed
  - Air-fuel mixture burns rapidly
  - Expansion of the burning air-fuel mix applies force to the head of the piston
  - Piston is driven down in the cylinder.

4-Stroke Cycle Engine Operation



- Exhaust Stroke
  - Piston moves from BDC to TDC.
  - Exhaust valve is open.
  - Burnt air-fuel mixture is scavenged from combustion chamber.

Comparison of 4-Stroke Cycle for C.I. And S.I. Engines

Stroke	C.I. (Diesel)	S.I. (Gasoline)
Intake	Air only	Air-fuel mix
Compression	C.R. $\geq$ 14:1 Temp > 729 ^{o}F	C.R. 6:1 – 12:1
Power	No difference	
Exhaust	No difference	

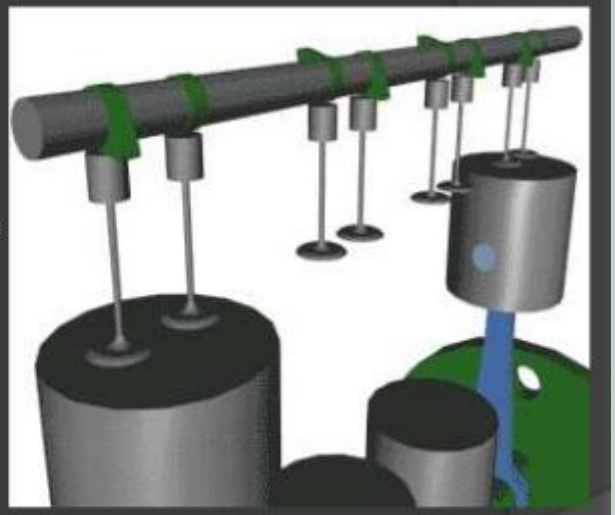
Comparison of Two-Stroke vs. Four-Stroke Cycle Engines

Two-Stroke Cycle Engines	Four-Stroke Cycle Engines
Lighter weight	Heavier weight
Operates in many positions	Operates in limited positions
Higher power to weight ratio	Lower power to weight ratio
Engine oil usually mixed with fuel	Engine oil in a reservoir
Louder operation	Quieter operation
Higher engine speeds	Slower engine speeds
More vibration	Smoother operation
Rough idling operation	Smoother Idling operation

Variable Valve Timing

How the valves are opened and closed?

- Consists of a central cam shaft
- When cam shaft rotates the lobes push against the valves to open them
- The cam is driven by taking input from the crank shaft.
- A single cam shaft can be used to open both the (i.e. intake and exhaust) valves (SOHC) or two cams can be used one for intake and one for exhaust (DOHC).



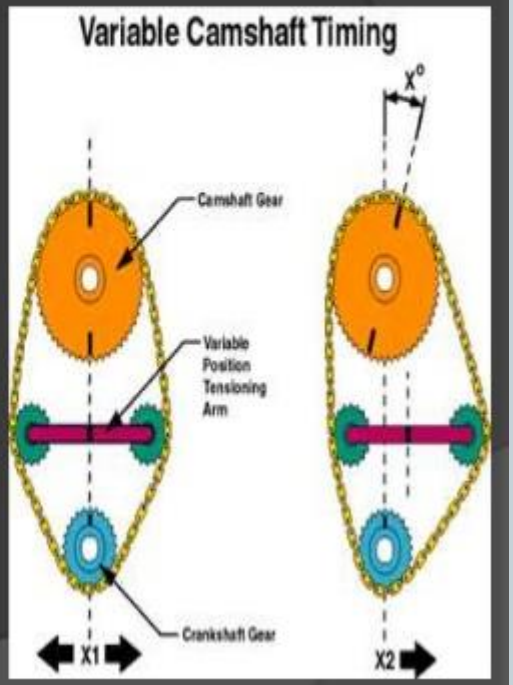
What is variable valve timing?

- As the rpm of the engine changes the “ideal” valve opening and closing points change
- Without variable valve timing , the valve timing must be the same for all engine speeds and conditions which decreases the engine performance and fuel economy
- Variable valve timing (VVT) allows valve opening and/or closing points to be changed at specific engine speeds

➢ How variable valve timing is achived?

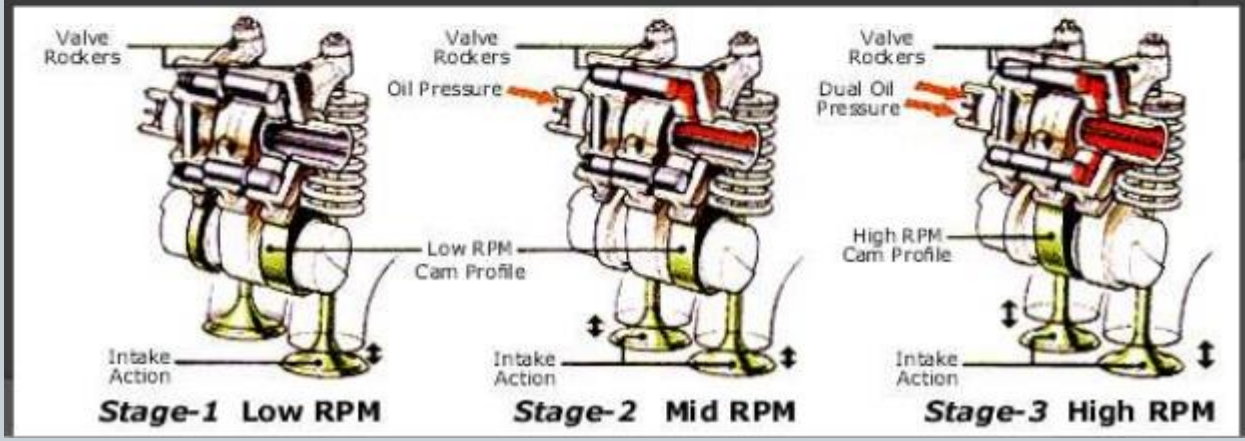
Advance/Retard Systems

- Cam shaft is connected to crankshaft by means of a chain or a timing belt. It is kept in tensioner by a tensioner,
- A movable tensioner moves the chain "slack" from one side to the other thereby advancing or retarding the camshaft
- This movable tensioner is either controlled by a centrifugal governor or by ECM.
- This technology is used by Porche and Lexus



Multiple Cam Profiles

- The most common technology under this is Variable Timing And Lift Electronic Timing System (VTEC)
- Uses three rocker arms per two intake valves
- At low rpm the valves are actuated by a short duration cam lobe
- An oil line passes through the cam shaft,
- At high rpm the ECM opens an oil control valve which hydraulically engages the third rocker arm which runs on a cam lobe with more duration and lift



Solenoid Operated Valves

- Depending on RPM and engine load the ECM would directly control all valve timings.
- There will be no cam (Camless Valves)
- Valve timing would be infinitely controllable
- Valve timing will be controlled electrically by Electronic Control Module (ECM)
- It is a future technology and currently not in production.

Electronically operated valves could replace cams in the future. This cutaway of a BMW prototype engine shows the powerful solenoid above each valve that controls its movement.

Advantages:

- Better fuel efficiency
- High initial torque
- Lover emission
- Better performance

Disadvantages:

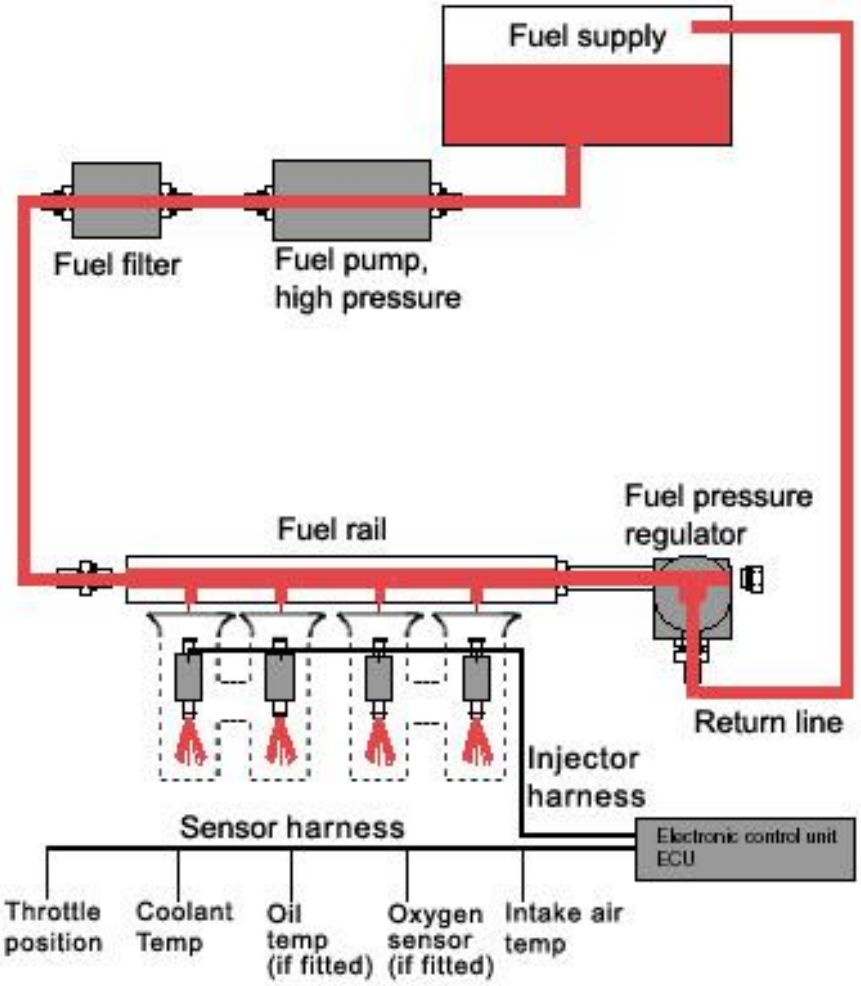
- Higher cost of engine
- More complex mechanisms
- Lower overall engine life because of increased wear.

UNIT – II ENGINE AUXILIARY SYSTEMS

Fuel Injection System

- Uses pressure (not Vacuum) from an electrical pump to spray fuel into the intake manifold.

- Provides the engine with proper air-fuel ratio (14.7 : 1)



Fuel Injection System

Advantages

- Improved Atomization
- Better fuel flow
- Smoother idle
- Improved fuel economy
- Lower emissions
- Better cold weather drivability
- Increased engine power
- Simpler

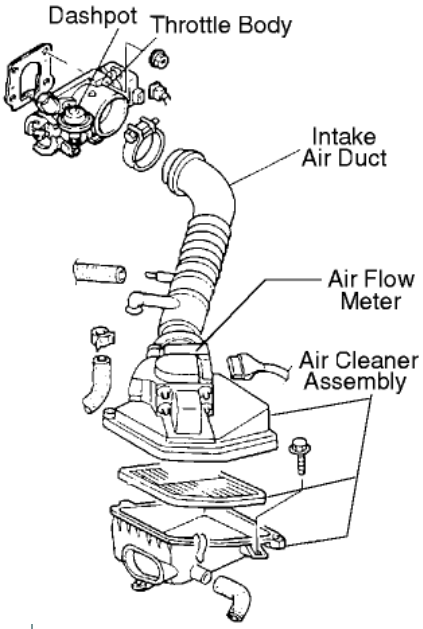
Fuel Injection System

Engine Throttle Valve

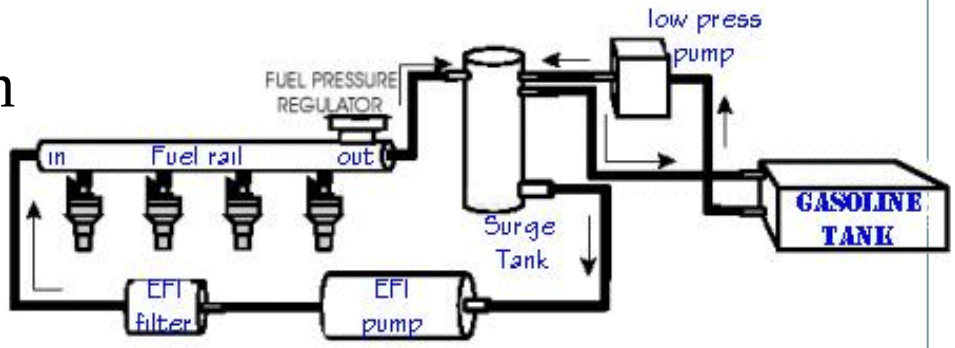
- Controls air flow and gasoline to power engine.
- When butterfly valve is closed it restricts air-flow and the resulting flow of fuel into the engine.
- When accelerator is pressed, the air-flow is increased in the intake manifold.
- Engine sensors detect the resulting changes and increase fuel flow through the injectors.

Fuel Injection System

Electronic Fuel Injection uses various engine sensors and control module to regulate the opening and closing of injector valve.

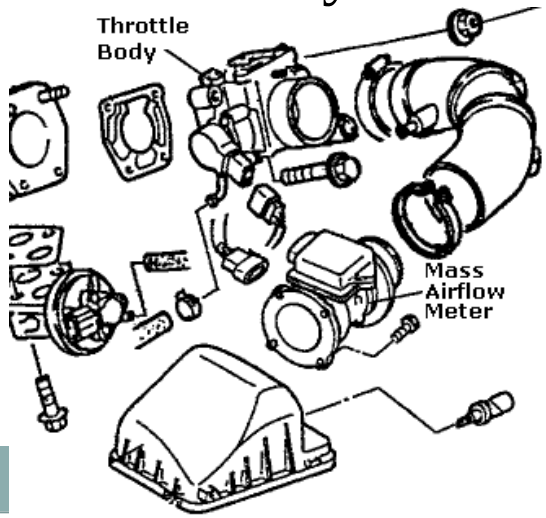


•Fuel delivery system



FUEL SYSTEM USING ANTI-SURGE TANK

•Air induction system



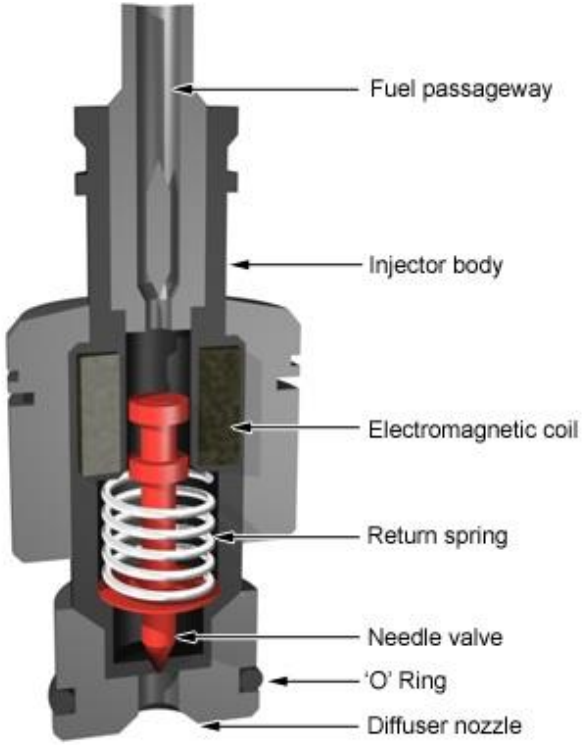
•Sensor system

•Computer control system

Fuel Delivery system

•**Electrical Fuel Pump** draws fuel from tank and forces it into the regulator.

•**Pressure Regulator** controls the amount of pressure that enters the injector and any extra fuel is returned to the fuel tank.



•**Fuel Injector** is simply a coil or solenoid operated valve.

•Spring pressure holds the injector closed.

•When engaged, the injector sprays fuel into the engine.

Injector Pulse Width indicates the time each Injector is energized (*Kept Open*).

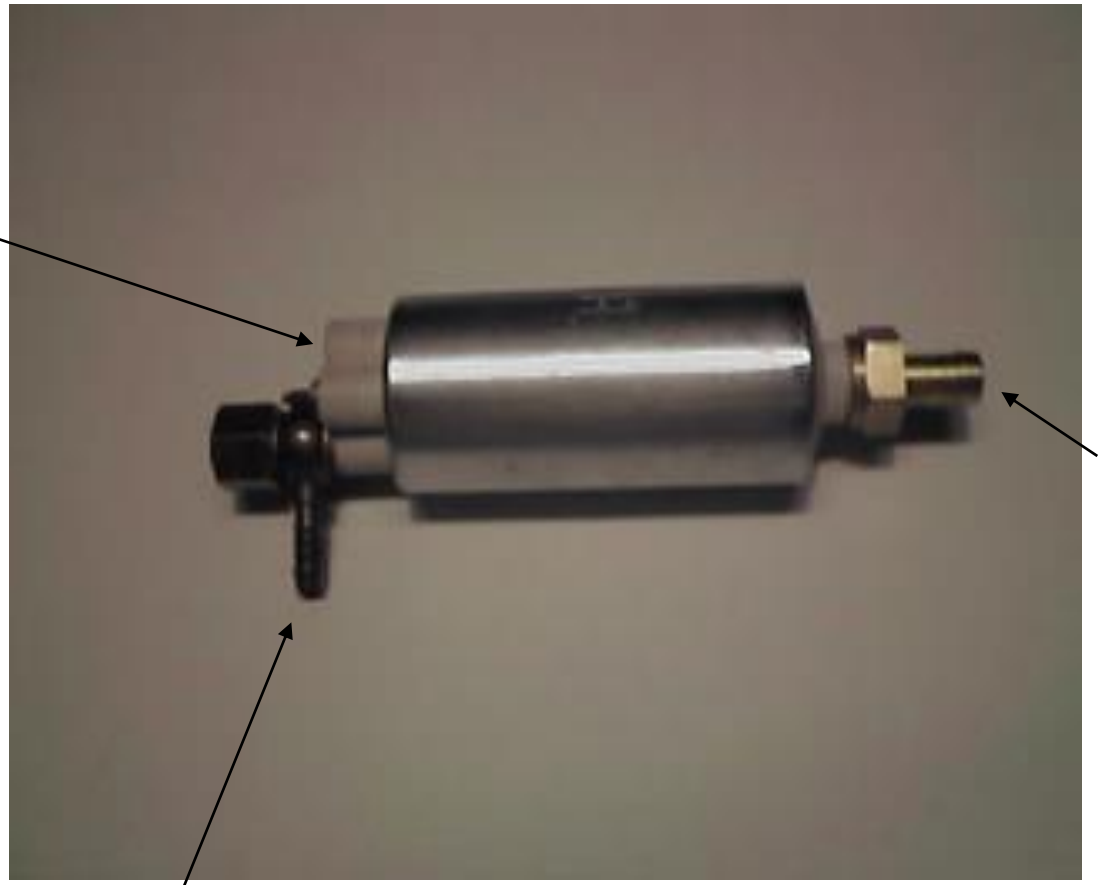
ELECTRONIC FUEL INJECTION COMPONENTS

ELECTRIC FUEL PUMPS

PURPOSE - Pumps fuel under high pressure to fuel pressure regulator.

In tank high pressure electric fuel pump, capable of over 100psi.

Frame mounted high pressure fuel pump capable of over 100 psi.



electrical connector

fuel inlet

fuel outlet

FUEL PRESSURE REGULATOR

PURPOSE - regulates fuel pressure to manufactures specifications, by returning excess fuel pressure to the gas tank..

Fuel pressure regulator And fuel rail

vacuum hose connection

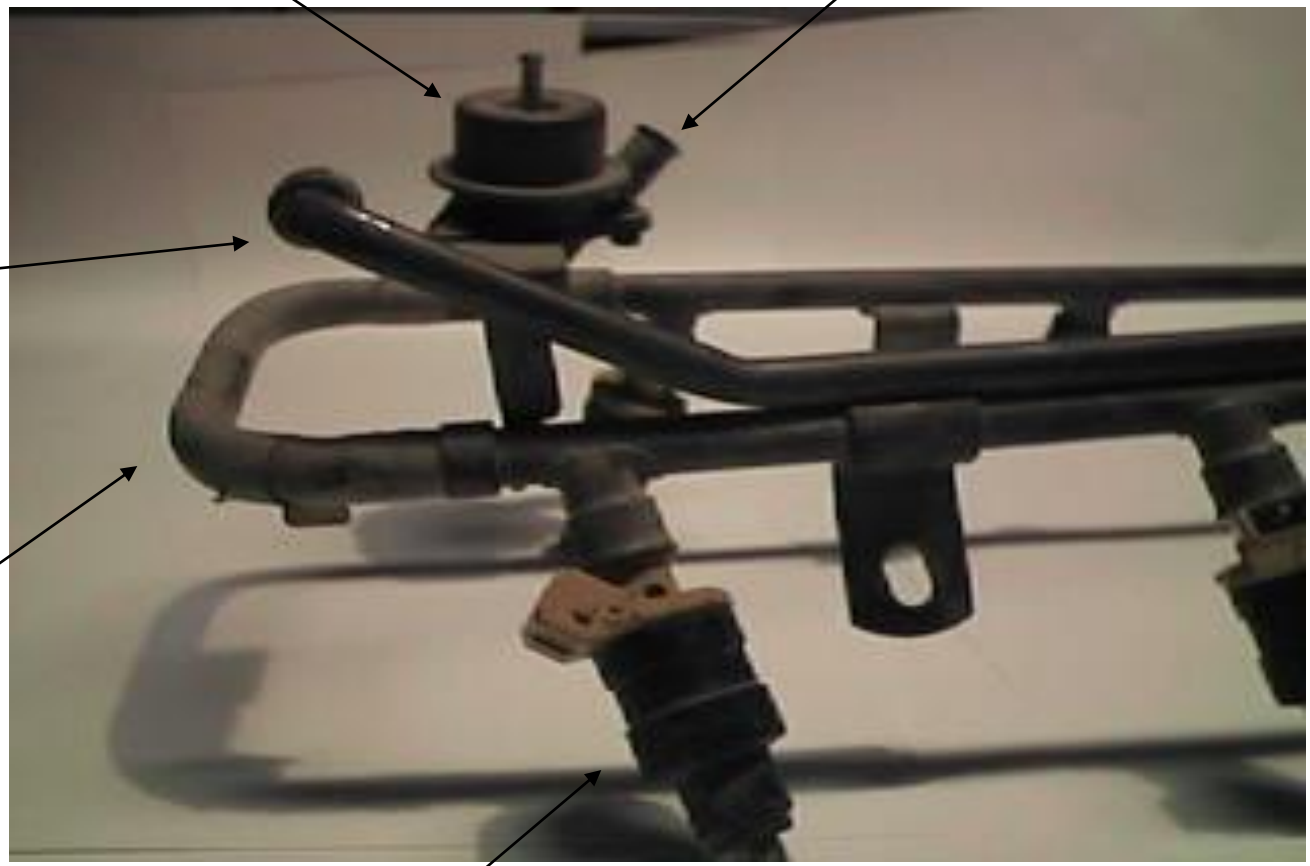
fuel rail

fuel return

INJECTORS AND FUEL RAIL

PURPOSE - SUPPLIES FUEL UNDER REGULATED PRESSURE TO THE COMBUSTION CHAMBER OF EACH CYLINDER.

Fuel rail, Injectors, Fuel inlet and pressure regulator



Typical fuel injector

fuel inlet from fuel rail, uses o-rings for seals

electrical connector

fuel outlet - fuel comes out as a very fine mist

GASOLINE INJECTION

Whv Gasoline iniection instead of Carburetion?

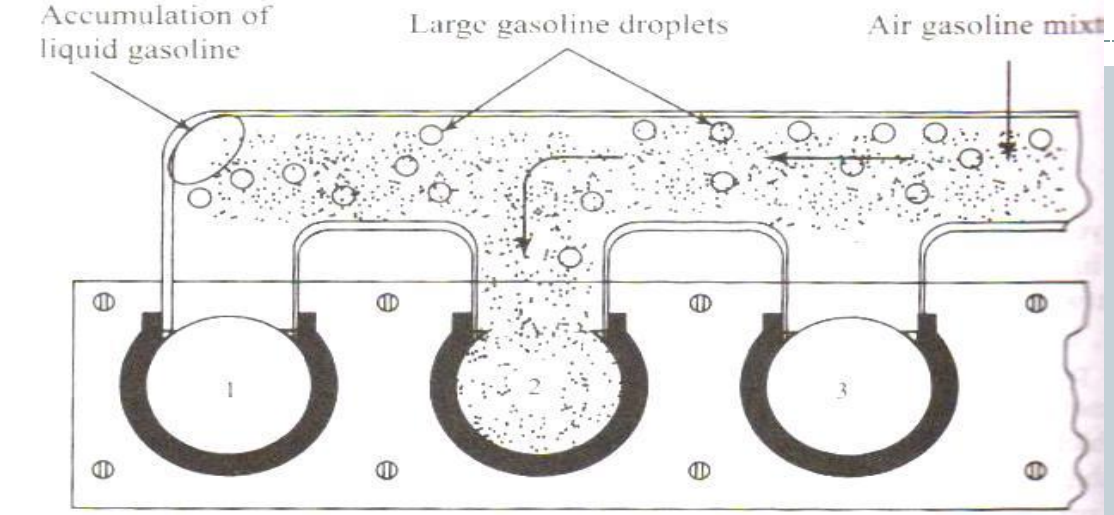
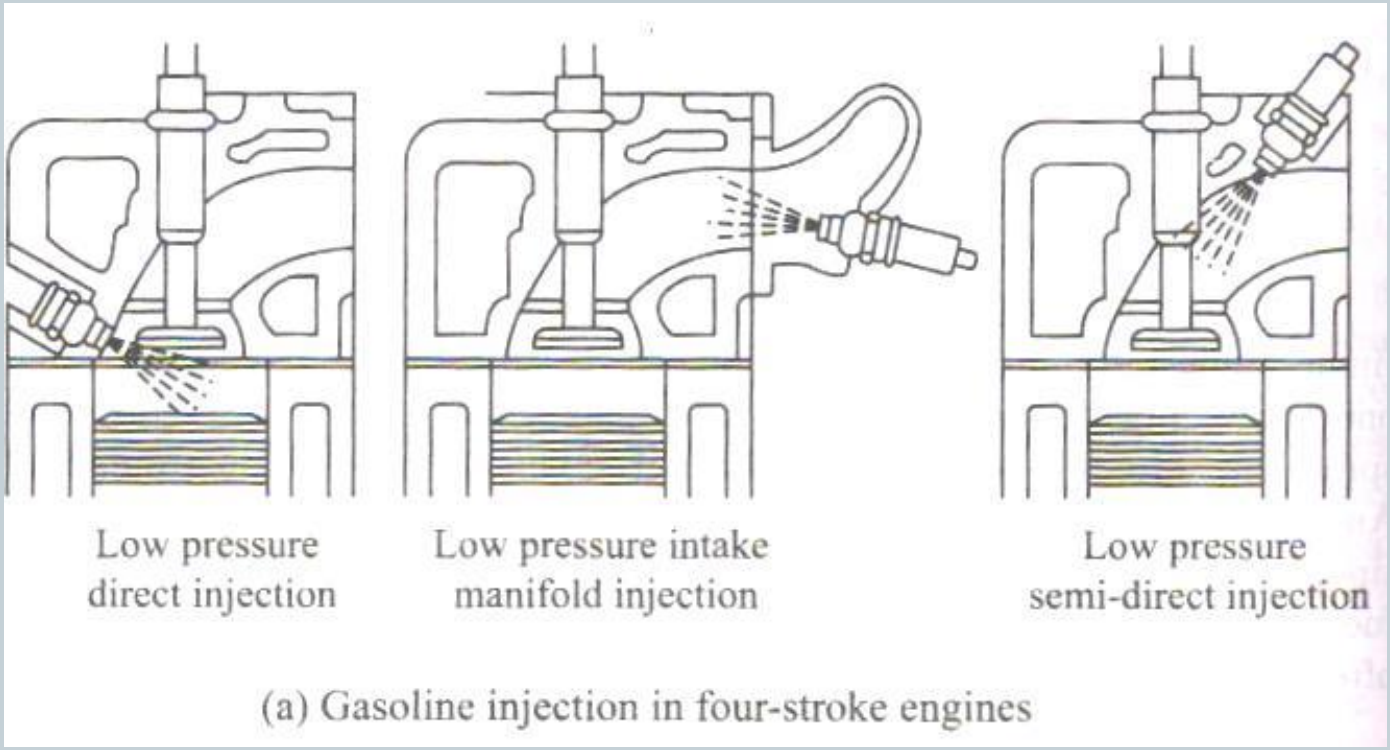


Fig. 10.1 Typical Pattern of Mixture Distribution in a Multi-Cylinder Engine

- To have uniform distribution of fuel in a multi-cylinder engine
- To increase volumetric efficiency
- To reduce detonation
- To prevent fuel loss during scavenging

CLASSIFICATION ACCORDING TO THE LOCATION OF THE INJECTOR



(a) Gasoline injection in four-stroke engines

THROTTLE BODY INJECTION (SINGLE POINT)

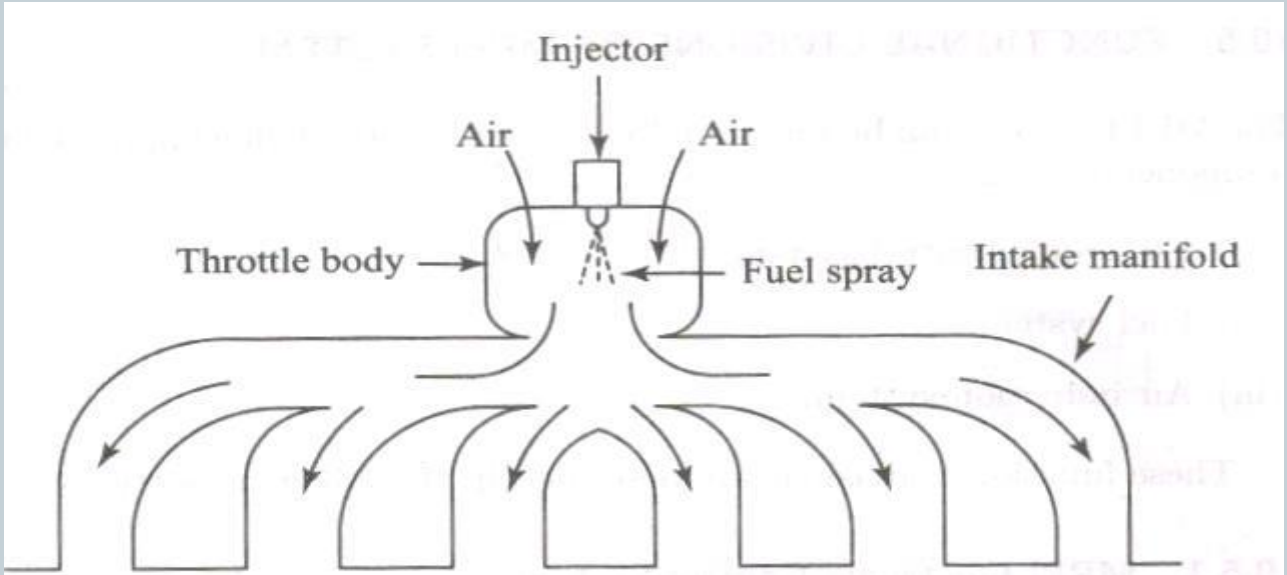


Fig. 10.5 Throttle Body Injection (Single Point)

SENSORS FOR AN EFI SYSTEM

- *Exhaust gas sensor*
- *Engine temperature sensor*
- *Air flow sensor*
- *Air inlet temperature sensor*
- *Throttle position sensor*
- *Manifold pressure sensor*
- *Camshaft position sensor*
- *Knock sensor*

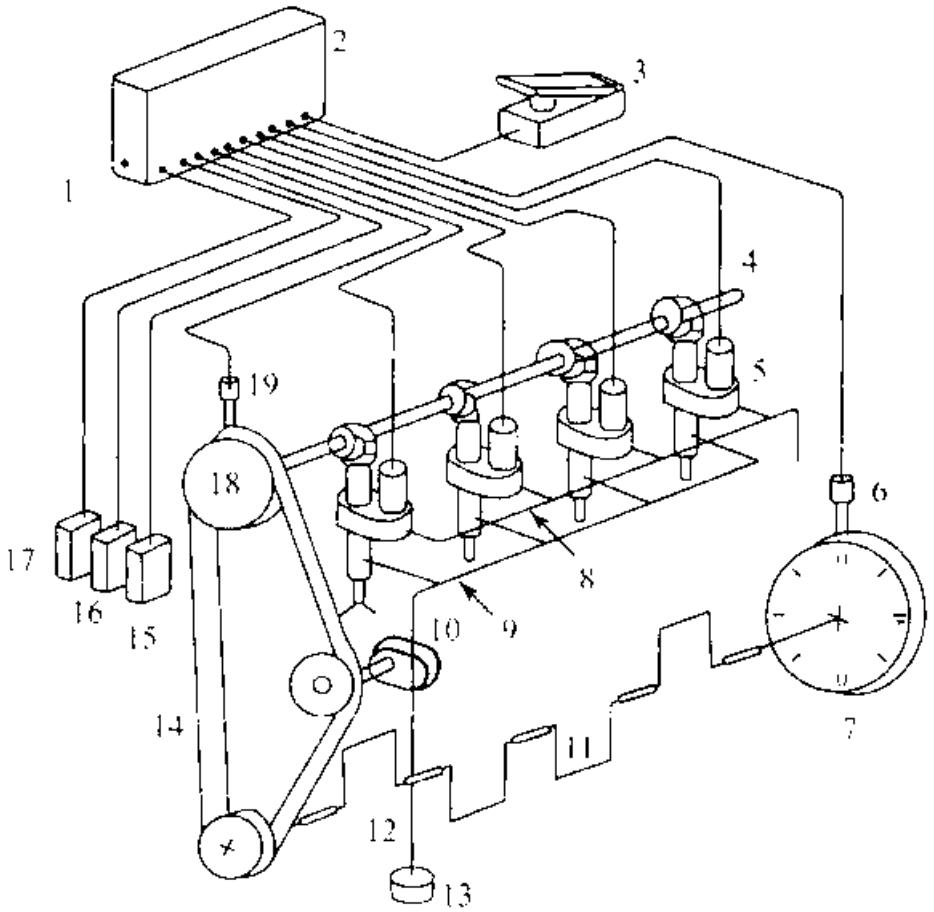
Merits of EFI system

- Volumetric efficiency
- Better atomization and vaporization – starting easier and less knock
- Fuel distribution independent
- Variation of A/F ratio is negligible

Demerits

- High maintenance cost
- Difficulty in servicing
- Possibility of malfunction of some sensors

ELECTRONIC DIESEL INJECTION SYSTEM



1 Battery supply (12 V or 24 V)
2 Electronic control unit (ECU)
3 Driver command (Accelerator pedal)
4 Injector camshaft
5 Injector unit
6 Magnetic transducer monitors engine speed and crankshaft position
7 Sixty tooth flywheel
8 Fuel return gallery
9 Fuel supply gallery
10 Fuel gear pump
11 Crankshaft
12 Fuel pickup
13 Gauze strainer
14 Timing belt
15 Boost sensor connection
16 Coolant temperature connection
17 Other sensor connection
18 Camshaft four-toothed gear wheel
19 Magnetic transducer firing order sens.

AUTOMOBILE ELECTRICAL IGNITION SYSTEMS

INTRODUCTION

- Automobile electrical system includes starting system, charging system, ignition system and lighting system and some accessories. The accessories include cigarette lighter horn and mobile charging system, etc.

Major components of a typical electrical systems are given below :

- **Ignition System**

(a) Spark plugs (for petrol vehicle)

(b) Distributor

(c) Ignition coil

(d) Ignition switch, etc.

- **Charging System**

(a) Alternator

(b) Regulator, etc.

- **Starting System**

(a) Battery

(b) Starting motor

(c) Wiring,

(D) Switches, etc.

Objectives

After studying this unit, you should be able to

- define electrical system,
- understand about major components of the electrical system,
- describe the types of ignition systems,
- know the starting system of an automobile, and
- explain the functions of components used in electrical system circuits.

IGNITION SYSTEM

- In spark ignition engines, a device is required to ignite the compressed air-fuel mixture at the end of compression stroke. Ignition system fulfills this requirement. It is a part of electrical system which carries the electric current at required voltage to the spark plug which generates spark at correct time.

- It consists of a battery, switch, distributor ignition coil, spark plugs and necessary wiring.

- A compression ignition engine, i.e. a diesel engine does not require any ignition system. Because, self ignition of fuel air mixture takes place when diesel is injected in the compressed air at high temperature at the end of compression stroke.

Requirements of an ignition system

(a) The ignition system should be capable of producing high voltage current, as high as 25000 volts, so that spark plug can produce spark across its electrode gap.

(b) It should produce spark for sufficient duration so that mixture can be ignited at all operating speeds of automobile.

(c) Ignition system should function satisfactory at all engine speeds.

(d) Longer life of contact points and spark plug.

(e) Spark must generate at correct time at the end of compression stroke in every cycle of engine operation.

(f) The system must be easy to maintain, light in weight and compact in size.

(g) There should be provision of spark advance with speed and load.

(h) It should be able to function smoothly even when the spark plug electrodes are deposited with carbon lead or oil.

TYPES OF IGNITION SYSTEMS

There are three types of ignition systems which are used in petrol engines.

(a) Battery ignition system or coil ignition system.

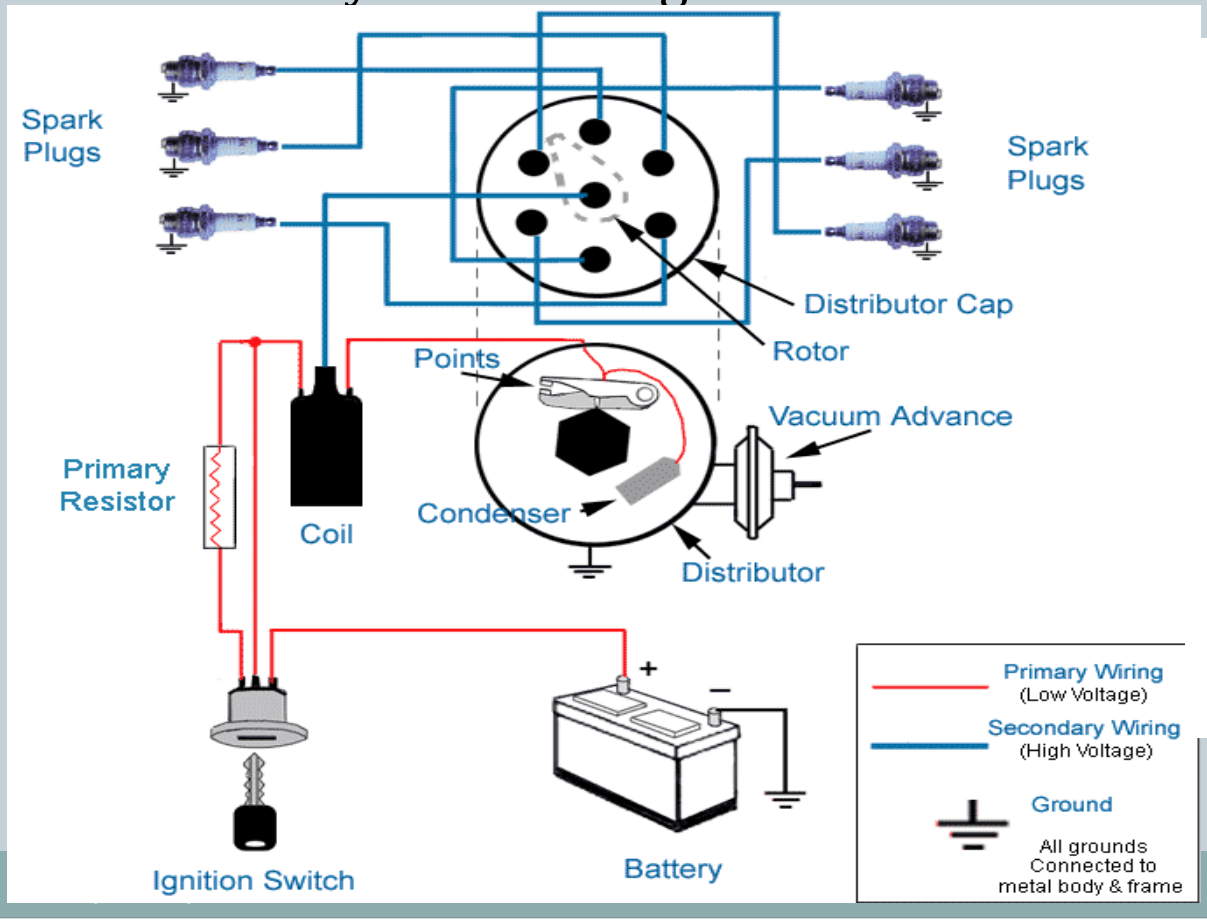
(b) Magneto ignition system.

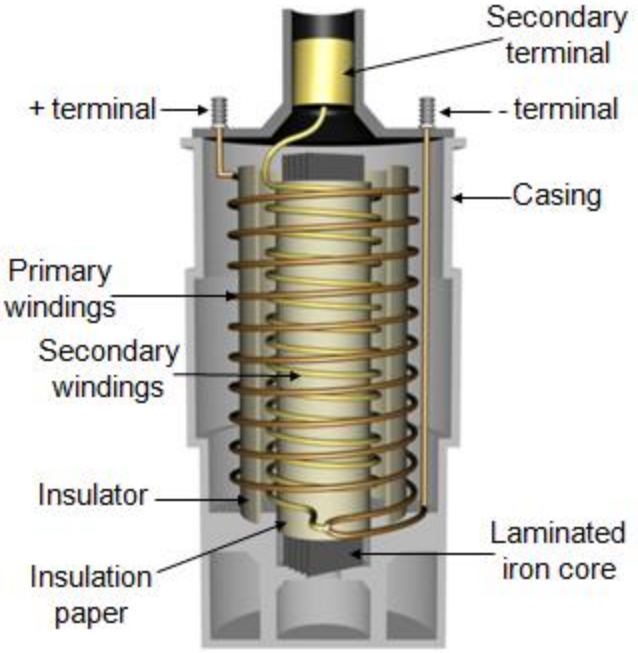
(c) Electronic ignition system.

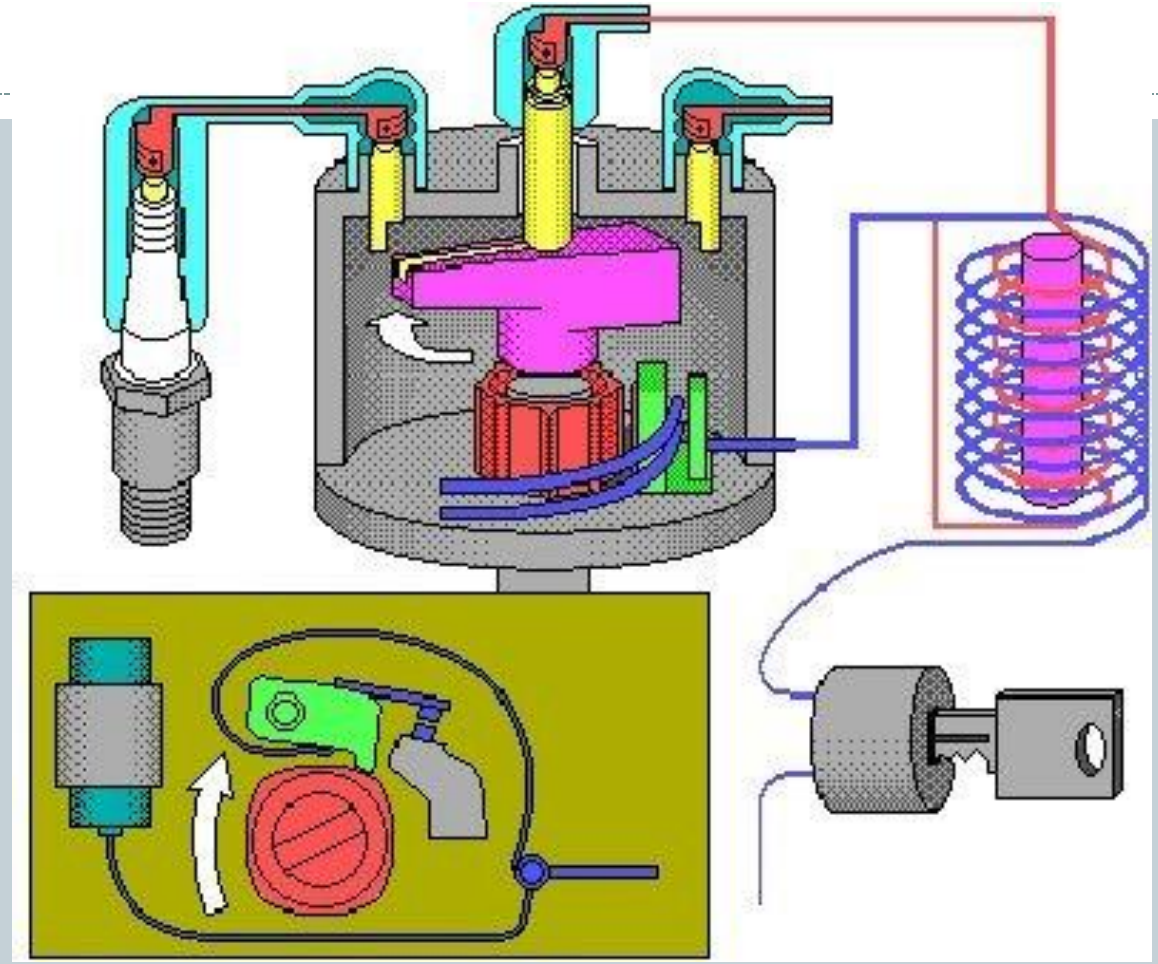
- In battery ignition system, the current in the primary winding is supplied by a battery whereas it is supplied by a magneto in magneto ignition system.
- Battery ignition system is used in cars and light truck. Magneto ignition system is used in some scooters.
- Both the systems work on the principle of mutual electromagnetic induction.
- Electronic ignition systems use solid state devices such as transistors and capacitors.

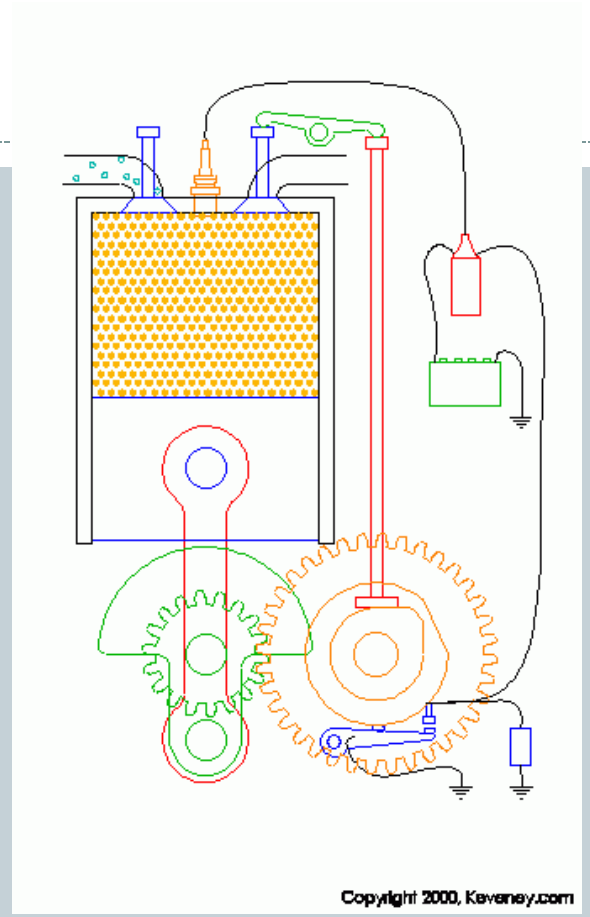
1. Battery or Coil Ignition System

- Battery ignition system consists of a battery of 6 or 12 volts, ignition switch, induction coil, contact breaker, condenser, distributor and spark plugs. A typical battery ignition system for four cylinder SI engine has been shown in Figure.

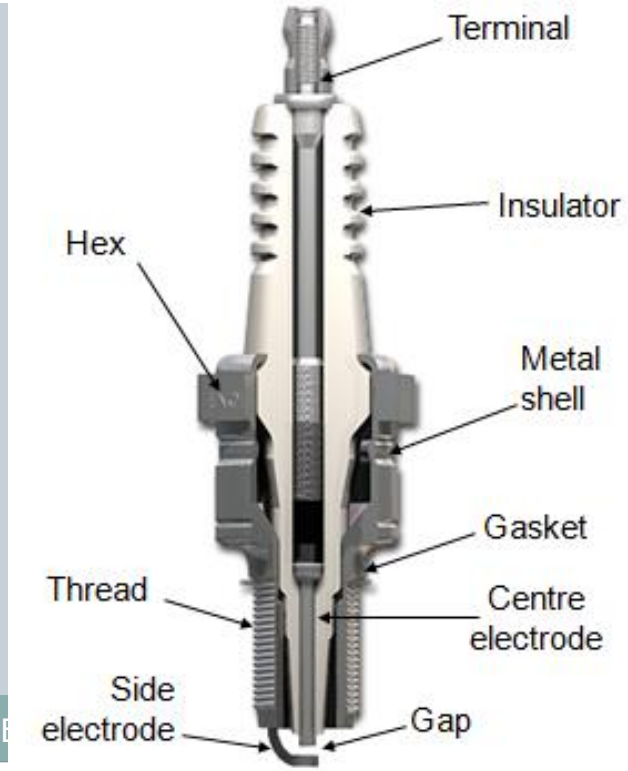


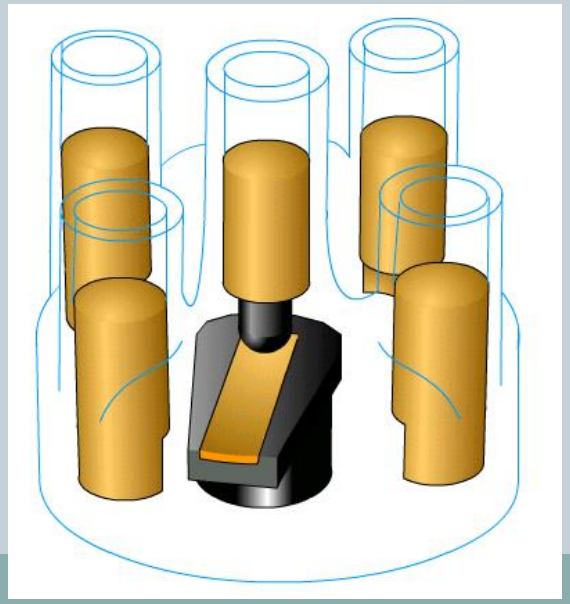





Copyright 2000, Keveney.com


MAGNECOR KV85 COMPETITION


Terminal
Insulator
Hex
Metal shell
Gasket
Thread
Centre electrode
Side electrode
Gap



- The primary circuit consists of battery, switch, primary winding and contact breaker point which is grounded. A condenser is also connected in parallel to the contact breaker points. One end of the condenser is grounded and other connected to the contact breaker arm. It is provided to avoid sparking at contact breaker points so as to increase their life.
- The secondary ignition circuit consists of secondary winding distributors and spark plugs. All spark plugs are grounded.
- The ignition coil steps up 12 volts (or 6 volt) supply to a very high voltage which may range from 20,000 to 30,000 volts. A high voltage is required for the spark to jump across the spark plug gas. This spark ignites the air-fuel mixture as the end of compression stroke.
- The rotor of the distributor revolves and distributes the current to the four segments which send the current to different spark plugs. For a 4-cylinder engine the cam of the contact breaker has four lobes. Therefore, it makes and breaks the contact of the primary circuit four times in every revolution of cam. Because of which current is distributed to all the spark plugs in some definite sequence.

- The primary winding of ignition coil has less number of turns (e.g. 200 turns) of thick wire. The secondary winding has relatively large number of turns (e.g. 20,000 turns) of thin wire.
- When ignition switch in turned on, the current flows from battery to the primary winding. This produces magnetic field in the coil. When the contact point is open, the magnetic field collapses and the movement of the magnetic field induces current in the secondary winding of ignition coil. As the number of turns in secondary winding are more, a very high voltage is produced across the terminals of secondary.
- The distributor sends this high voltage to the proper spark plug which generates spark for ignition of fuel-air mixture. In this way, high voltage current is passed to all spark in a definite order so that combustion of fuel-air mixture takes place in all cylinders of the engine.
- A ballast register is connected in series in primary circuit to regulate the current. At the time of starting this register is bypassed so that more current can flow in this circuit. The breaker points are held by a spring except when they are forced apart by lobes of the cam.

Advantages

(a) Low initial cost.

(b) Better spark at low speeds and better starting than magneto system.

(c) Reliable system.

(d) No problems due to adjustment of spark timings.

(e) Simpler than magneto system.

Disadvantages

(a) Battery requires periodical maintenance.

(b) In case of battery malfunction, engine cannot be started.

2. Magneto-ignition System

- This system consists of a magneto in place of a battery. So, the magneto produces and supplies current in primary winding. Rest of the system is same as that in battery ignition system.

- 1. Rotating Armature type
  2. Rotating Magnet type

- The magneto consists of a fixed armature having primary and secondary windings and a rotating magnetic assembly. This rotating assembly is driven by the engine. Rotation of magneto generates current in primary winding having small number of turns. Secondary winding having large number of turns generates high voltage current which is supplied to distributor. The distributor sends this current to respective spark plugs.
- The magneto may be of rotating armature type or rotating magnet type.
- In rotating armature type magneto, the armature having primary and secondary windings and the condenser rotates between the poles of a stationary horse shoe magnet. In magneto, the magnetic field is produced by permanent magnets.

Advantages

(a) Better reliability due to absence of battery and low maintenance.

(b) Better suited for medium and high speed engines.

(c) Modern magneto systems are more compact, therefore require less space.

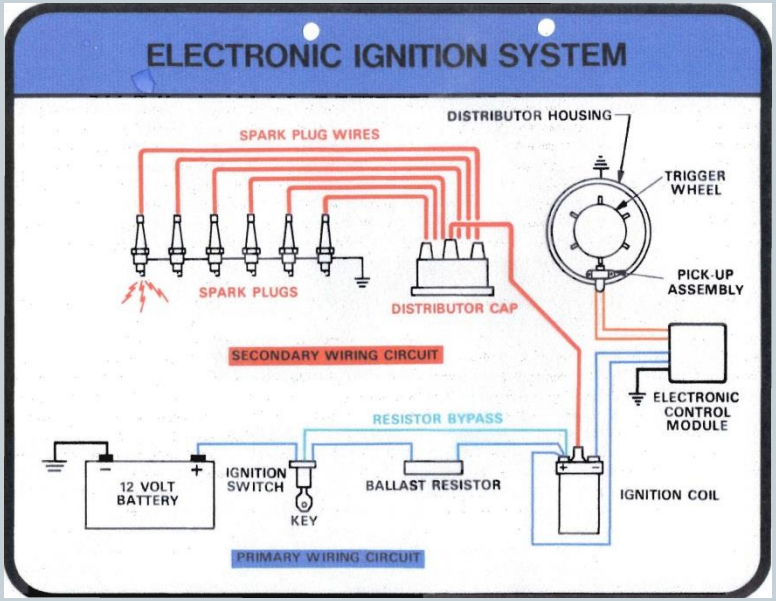
Disadvantages

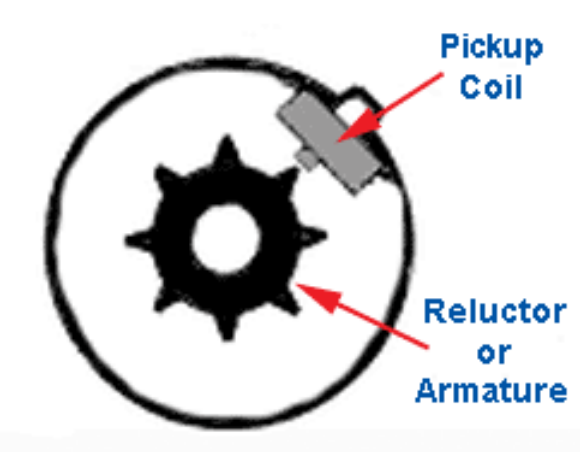
(a) Adjustment of spark timings adversely affects the voltage.

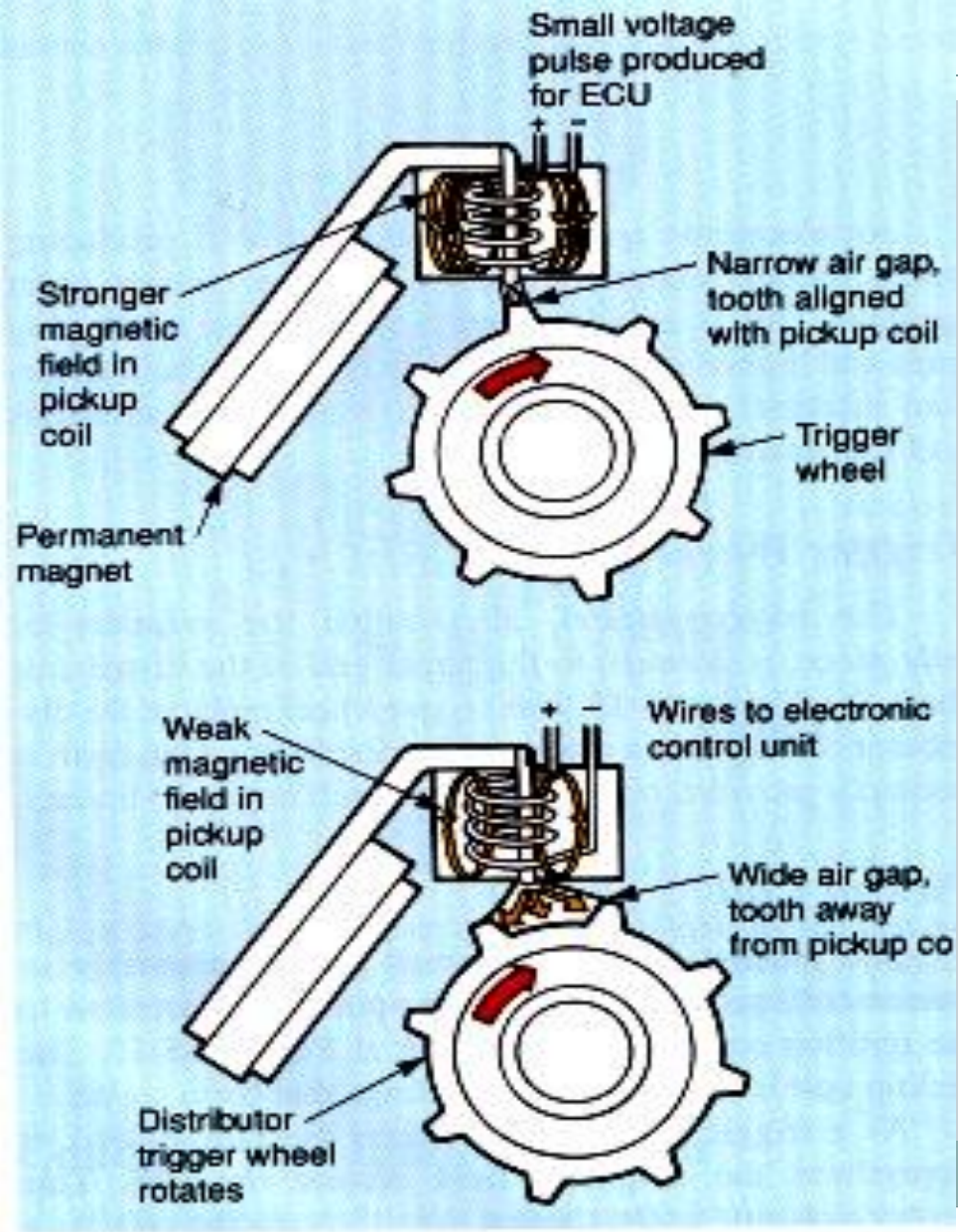
(b) Burning of electrodes is possible at high engine speeds due to high voltage.

(c) Cost is more than that of magneto ignition systems.

3. ELECTRONIC IGNITION SYSTEM




Pickup Coil
Reluctor or Armature


Small voltage pulse produced for ECU
+
–
Stronger magnetic field in pickup coil
Narrow air gap, tooth aligned with pickup coil
Trigger wheel
Permanent magnet
Weak magnetic field in pickup coil
Wires to electronic control unit
Wide air gap, tooth away from pickup co
Distributor trigger wheel rotates

- Electronic ignition systems use some solid state devices like transistor and capacitors, etc. to generate right sparking voltage at right time. These systems have overcome the limitations of conventional (battery ignition and magneto-ignition) ignition systems.
- Modern automobiles make use of these systems. Two systems, common in use, are :

  (a) Capacitive discharge ignition, and

  (b) Transistorized coil ignition.
- These systems are more reliable and require less maintenance. Wear and tear of components is reduced and life of spark plugs is increased with the use of electronic ignition.

SUPERCHARGER, TURBOCHARGER AND THREE WAY CATALYTIC CONVERTER

Unit 1/Class 4

Reference:

Internal Combustion Engines by V. Ganesan

DEFINITION

The most efficient method of increasing the power of an engine is by supercharging, i.e. increasing the flow of air into the engine to enable more fuel to be burnt.

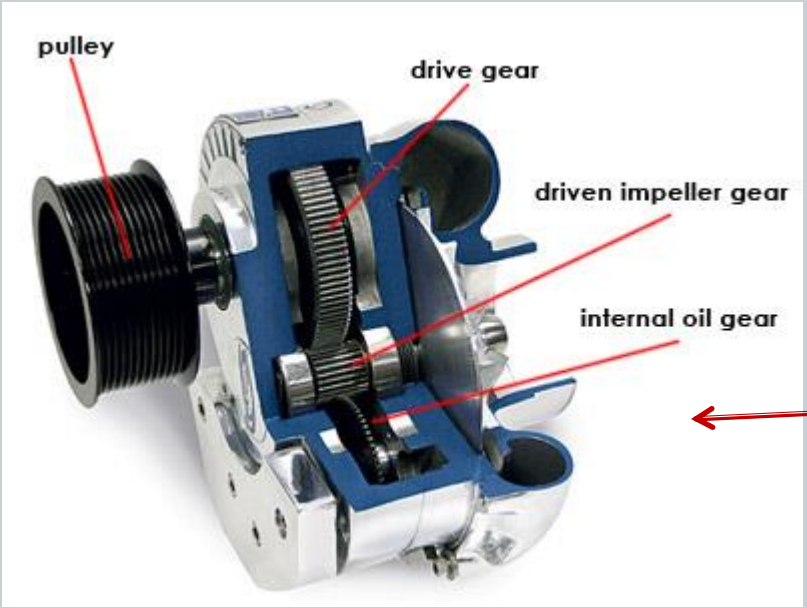
- A **Supercharger** is run by the mechanical drive, powered by engine power .
- A **turbocharger** uses the otherwise unused energy in the exhaust gases to drive a turbine directly connected by a co-axial shaft to a rotary compressor in the air intake system.

NEED OF TURBOCHARGER AND SUPER CHARGER

- **For ground installations, it is used to produce a gain in the power out put of the engine.**

- **For aircraft installations, in addition to produce a gain in the power out put at sea-level, it also enables the engine to maintain a higher power out put as altitude is increased.**

COMPRESSED AIR



Air inlet

Fig.1 Supercharger

Super charging

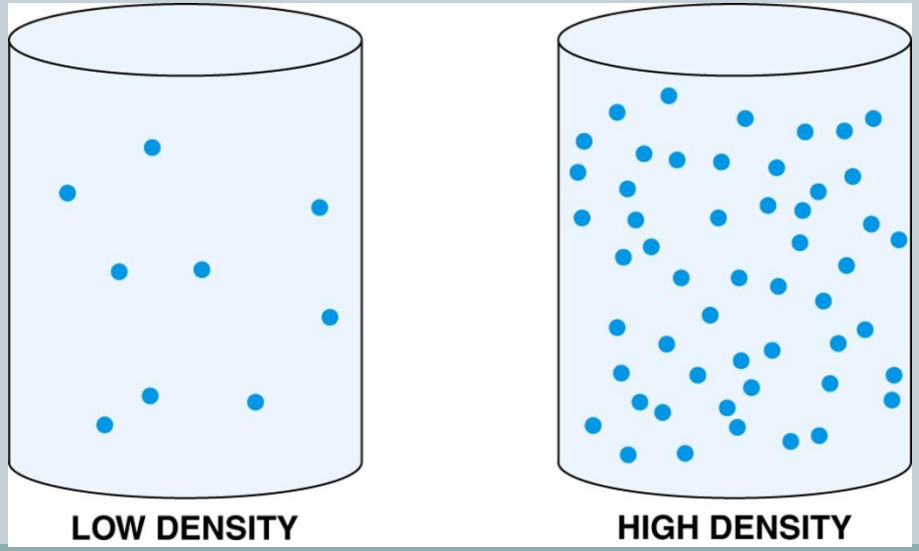
- The power output of an engine depends mainly on
  - Amount of air inducted into the cylinder.
  - Extent of utilization of the inducted air.
  - The speed of the engine.
  - Quantity of fuel & combustion characteristics.
  - Thermal efficiency.

$$BP = \frac{p_{bm} \times V_s \times n \times K}{60000}$$

  - The most preferred method of increasing the BP is by means of increasing the **mean effective pressure**, which is achieved by supplying the air-fuel mixture at a **higher pressure than P_{atm}**
  - Density ↑, and mass of air-fuel mixture ↑ and Power output ↑

SUPERCHARGING PRINCIPLE

- The amount of force an air–fuel charge produces when it is ignited is largely a function of the charge density.
- Density is the mass of a substance in a given amount of space.



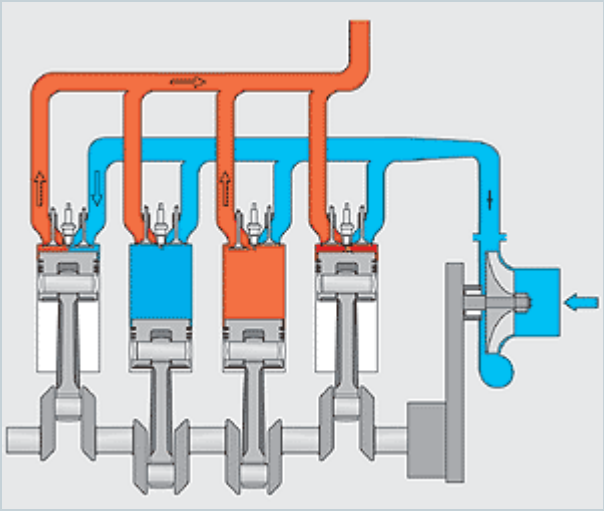
SUPERCHARGERS

- Usually compress the fuel/air mixture after it leaves the carburetor.
- A supercharger is driven directly from the engine.
- Some of the power created is offset by the power required to drive the supercharger.

Types

1. Centrifugal type
2. Root's type
3. Vane type

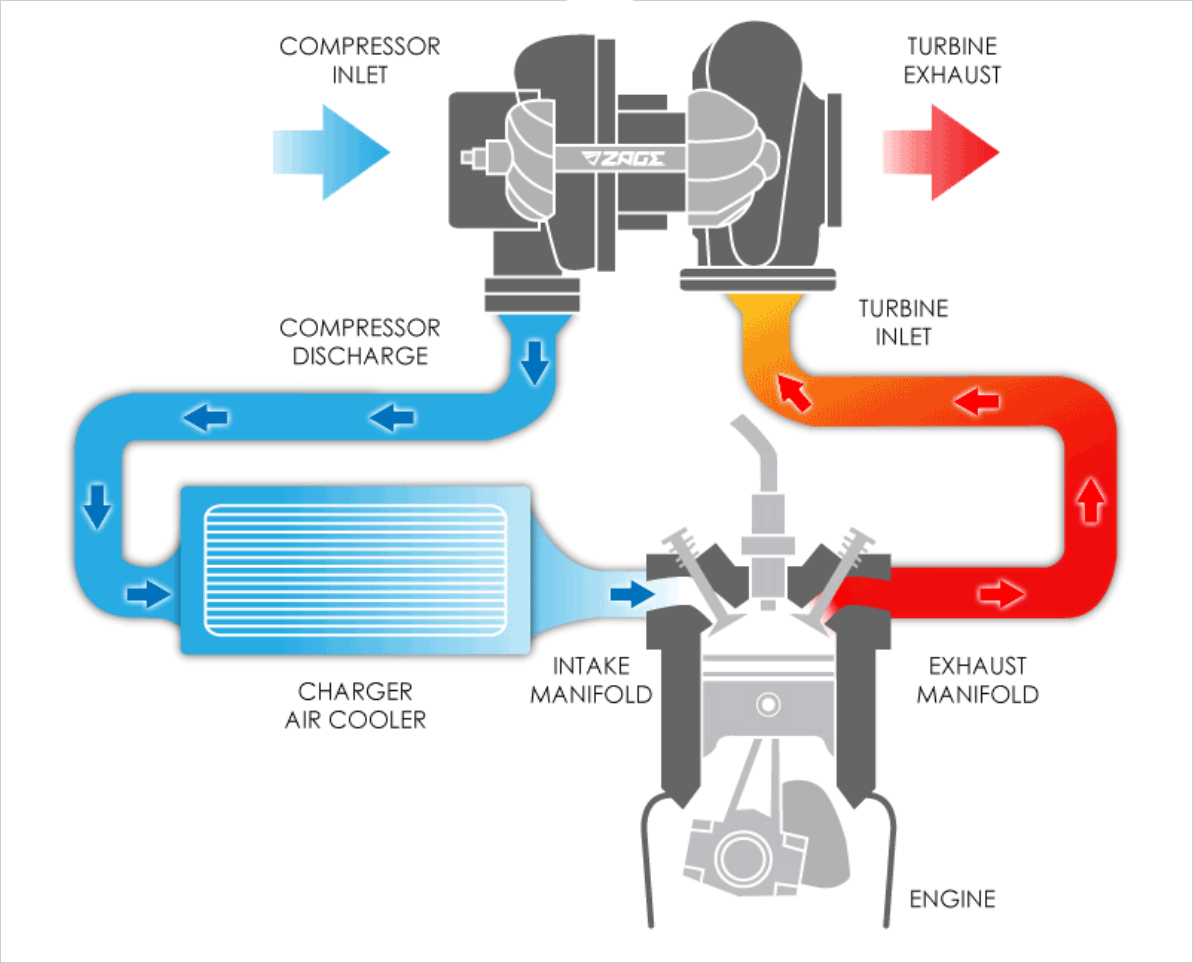
SUPERCHARGERS



TURBOCHARGERS

- In turbo-charging, the supercharger is being driven by a gas turbine which uses the energy in the exhaust gases. There is no mechanical linkages between the engine and the supercharger.
- The major parts of a turbo-charger are
  - Turbine wheel
  - Turbine housing
  - Turbo shaft
  - Compressor wheel
  - Compressor housing and
  - Bearing housing

TURBOCHARGERS



WORKING PRINCIPLE OF A TURBOCHARGER:

- A turbocharger is a small radial fan pump driven by the energy of the exhaust gases of an engine.
- A turbocharger consists of a turbine and a compressor on a shared shaft.
- The turbine converts exhaust to rotational force, which is in turn used to drive the compressor.
- The compressor draws in ambient air and pumps it in to the intake manifold at increased pressure, resulting in a greater mass of air entering the cylinders on each intake stroke.

WHERE THE TURBOCHARGER IS LOCATED IN THE CAR

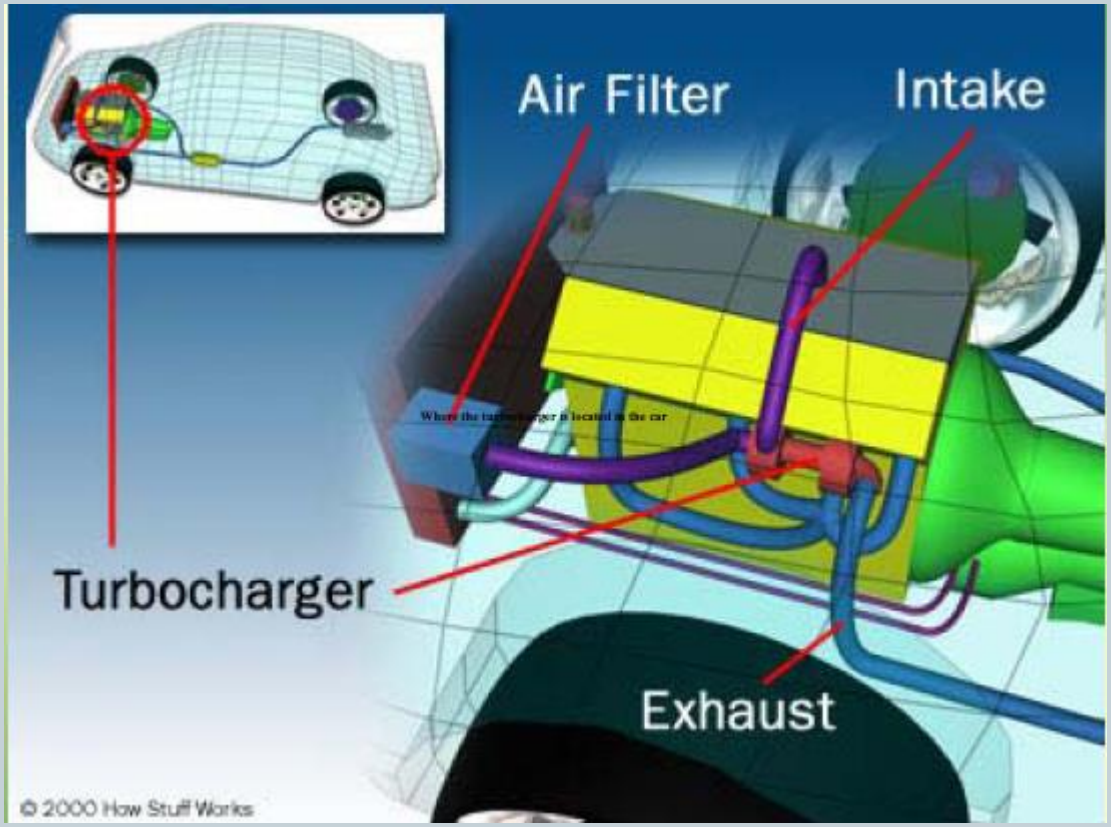


FIG. 5

ADVANTAGES OF SUPERCHARGER AND TURBOCHARGER

- **The more increase the pressure of the intake air above the local atmospheric pressure (*boost*), the more power the engine produces. Automotive superchargers for street use typically produce a maximum boost pressure between 0.33 to 1.0 bar , providing a proportionate increase in power.**

- **Engines burn air and fuel at an ideal (*stoichiometric*) ratio of about 14.7:1, which means that if you burn more air, you must also burn more fuel.**

- **This is particularly useful at high altitudes: thinner air has less oxygen, reducing power by around 3% per 1,000 feet above sea level, but a supercharger can compensate for that loss, pressurizing the intake charge to something close to sea level pressure.**

DISADVANTAGES OF TURBOCHARGER AND SUPERCHARGER

- Cost and complexity
- Detonation
- Space
- Turbo lag

3 WAY CATALYTIC CONVERTER

Engine emissions

1. Exhaust emissions
   - HC
   - CO and CO_2
   - NO and NO_2
   - Oxides of sulphur
   - Particulates
   - Soot and smoke

2. Non-exhaust emissions
   - Fuel tank
   - Carburator
   - Crank case

- In order to reduce emissions, some after treatments are necessary.
- Secondary reactions- occur much more readily and completely if the temperature is high. So some engines are equipped with **thermal converters.** It is a high temperature (above 700 °C) chamber through which exhaust gas flows.
- CO and HC can be oxidized into CO_2 and H_2O if the temperature is held at 600 – 700 °C

$CO + ½ O_2 \rightarrow CO_2$

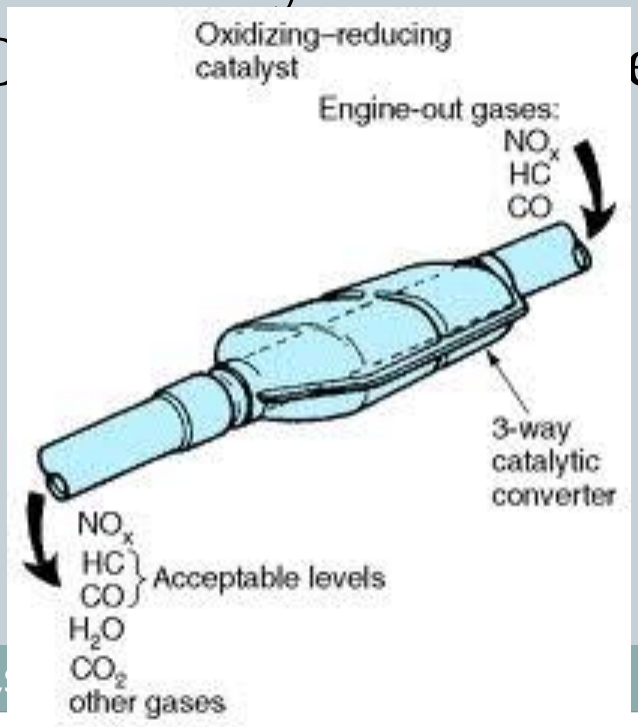
$C_x H_y + z O_2 \rightarrow x CO_2 + y H_2O$

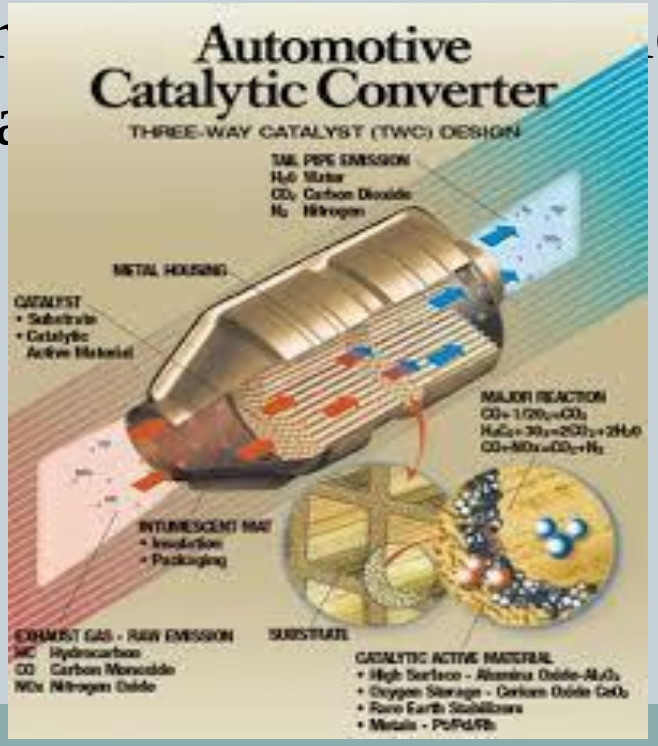
- However the NO_x emissions cannot be reduced.

CATALYTIC CONVERTERS

- The most effective after treatment for reducing engine

- If certain catalysts are present, the temperature needed to sustain these oxidation process is reduced to 250-300 °C. A **catalyst** is a substance that accelerates a chemical reaction by lowering the energy needed for it to proceed.
- Catalytic converters are called **three-way converters** because they are used to r on of CO exha





- It is usually a stainless steel container inside it is a porous ceramic structure (honeycomb with flow passages) with flow passages.
- Surface of the ceramic passages is embedded with catalytic materials that promote oxidation reactions.
  - Ceramic structure – Alumina
  - Catalysts
    - **Palladium** - promotes the oxidation of CO
    - **Platinum** - promotes the oxidation of HC
    - **Rhodium** - promotes the reaction of NO_x

$$NO + CO \rightarrow \frac{1}{2}N_2 + CO_2$$

$$2NO + 5CO + 3H_2O \rightarrow 2NH_3 + 5CO_2$$

$$2NO + CO \rightarrow N_2O + CO_2$$

$$NO + H_2 \rightarrow \frac{1}{2}N_2 + H_2O$$

$$2NO + 5H_2 \rightarrow 2NH_3 + 2H_2O$$

$$2NO + H_2 \rightarrow N_2O + H_2O$$

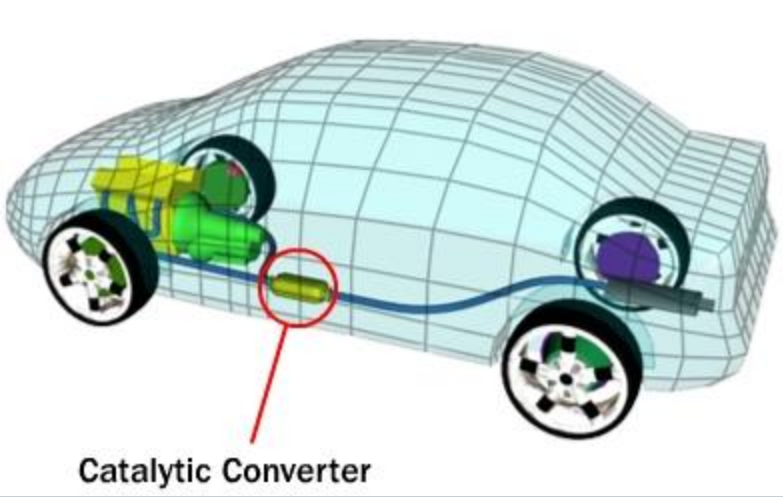
ENGINE EMISSIONS
EMISSION NORMS (EURO AND BS)

POLLUTANTS FORMATION AND CONTROL

- Combustion in Diesel engines is characterised by a high concentration of fuel droplets (poor atomization/vaporization of the fuel).
- Main pollutants:
  - **Particulate Matter (PM)**
  - **Unburned Hydrocarbons, HC**
  - **Carbon Monoxide, CO**
  - **Nitrogen Oxides, NO_x**

POLLUTANTS FORMATION AND CONTROL

- Emissions control:
  - Exhaust Gas Recirculation, EGR
  - Particulate Filters
  - Catalytic Converters



POLLUTANTS FORMATION AND CONTROL

- Emissions control
- **Diesel:**
  - Exhaust Gas Recirculation, EGR (prevents the formation of NO_x)
  - Particulate Filters, active and passive (PM)
  - Oxidation Catalytic Converters (HC and CO)
  - Selective Catalytic Reduction, SCR (NO_x into N_2 and H_2O)
- **Petrol:**
  - 3-way Catalytic Converters
    - Oxidation Catalysts (CO and HC into CO_2 and H_2O)
    - Reduction Catalysts (NO into N_2 and O_2)

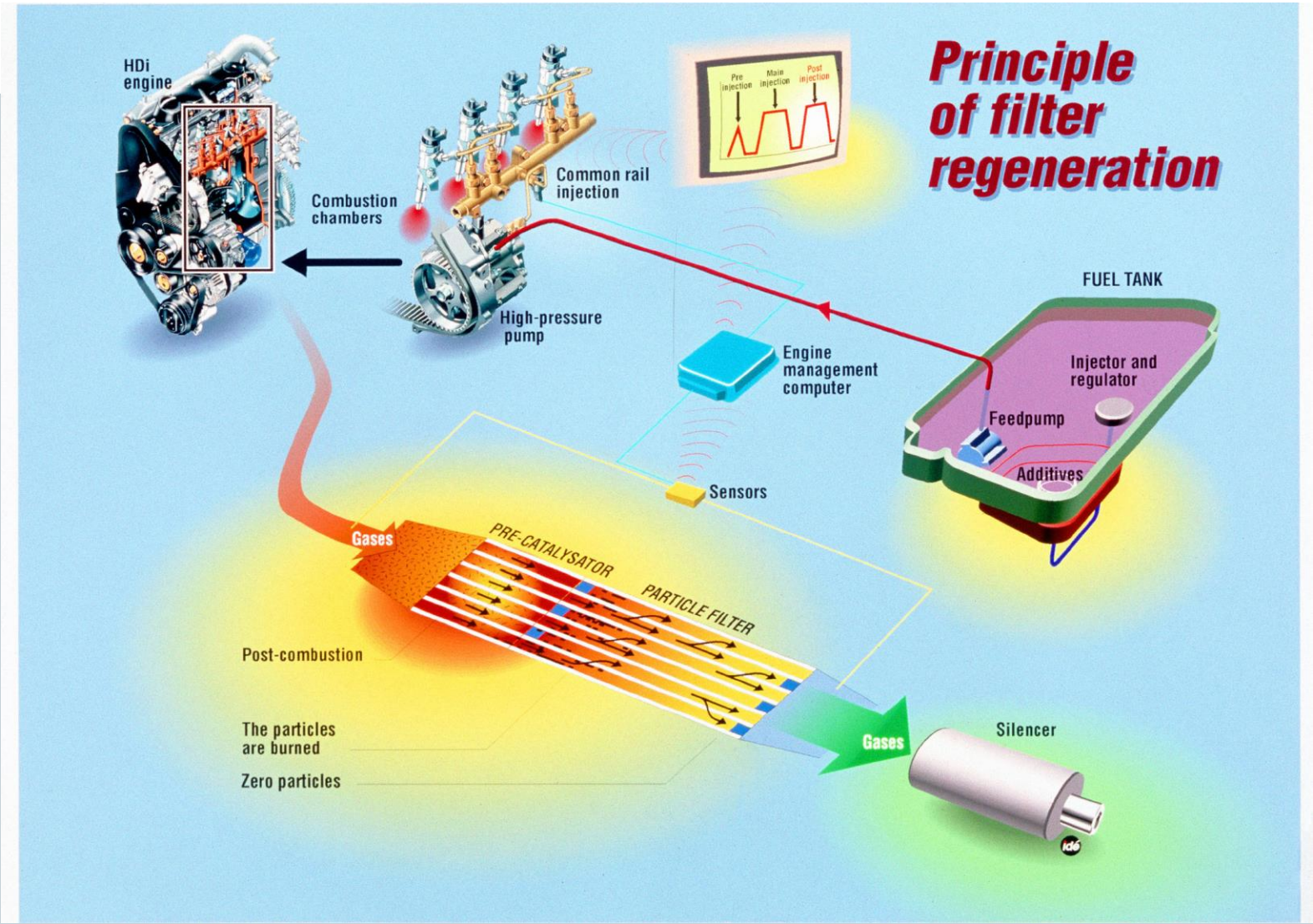
Fuel Quality, Diesel:

Diesel is cetane derived ($C_{10}H_{22}$)

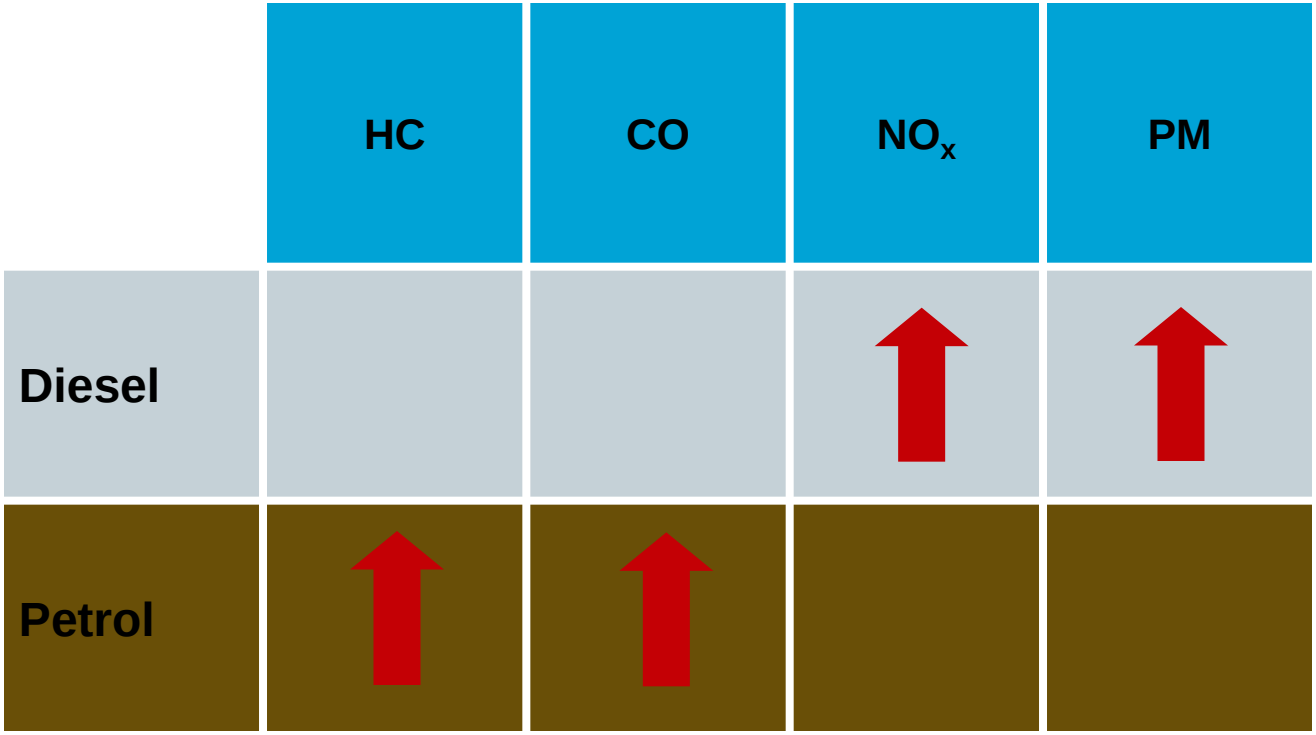
Cetane Number: Indicates the higher or lower capacity of the fuel to auto-ignite
($\Rightarrow$ lower delay to auto ignition)

15: Low capacity to auto-ignite: isocetane
100: High capacity to auto-ignite: cetane
Minimum cetane number demanded: 51

Sulphur content: Less than 50 ppm $\Rightarrow$ Low sulphur fuel
Eliminate emissions of sulphur dioxide (SO_2)
Reduce PM emissions
Less than 10 pmm: Sulphur free fuel (From 2009)


Principle of filter regeneration
HDi engine
Combustion chambers
Common rail injection
Pre injection
Main injection
Post injection
High-pressure pump
FUEL TANK
Engine management computer
Injector and regulator
Feedpump
Additives
Sensors
Gases
PRE-CATALYSATOR
PARTICLE FILTER
Post-combustion
The particles are burned
Zero particles
Gases
Silencer

POLLUTANTS FORMATION AND CONTROL



EUROPEAN EMISSIONS STANDARDS

Diesel Passenger vehicles ≤ 2.5t (values in g/km)

Standard	Year	CO	HC	HC + NO_x	NO_x	PM
Euro 1	1992	2.72	-	0.97	-	0.14
Euro 2 - IDI	1996	1.00	-	0.70	-	0.08
Euro 2 - DI	1999	1.00	-	0.90	-	0.10
Euro 3	2001	0.64	-	0.56	0.50	0.05
Euro 4	2005	0.50	-	0.30	0.25	0.025

UNIT – III TRANSMISSION SYSTEMS

INTRODUCTION

- A Clutch is a machine member used to connect the driving shaft to a driven shaft, so that the driven shaft may be started or stopped at will, without stopping the driving shaft.
- A clutch thus provides an interruptible connection between two rotating shafts
- A popularly known application of clutch is in automotive vehicles where it is used to connect the engine and the gear box. Here the clutch enables to crank and start the engine disengaging the transmission.
- Disengage the transmission and change the gear to alter the torque on the wheels.

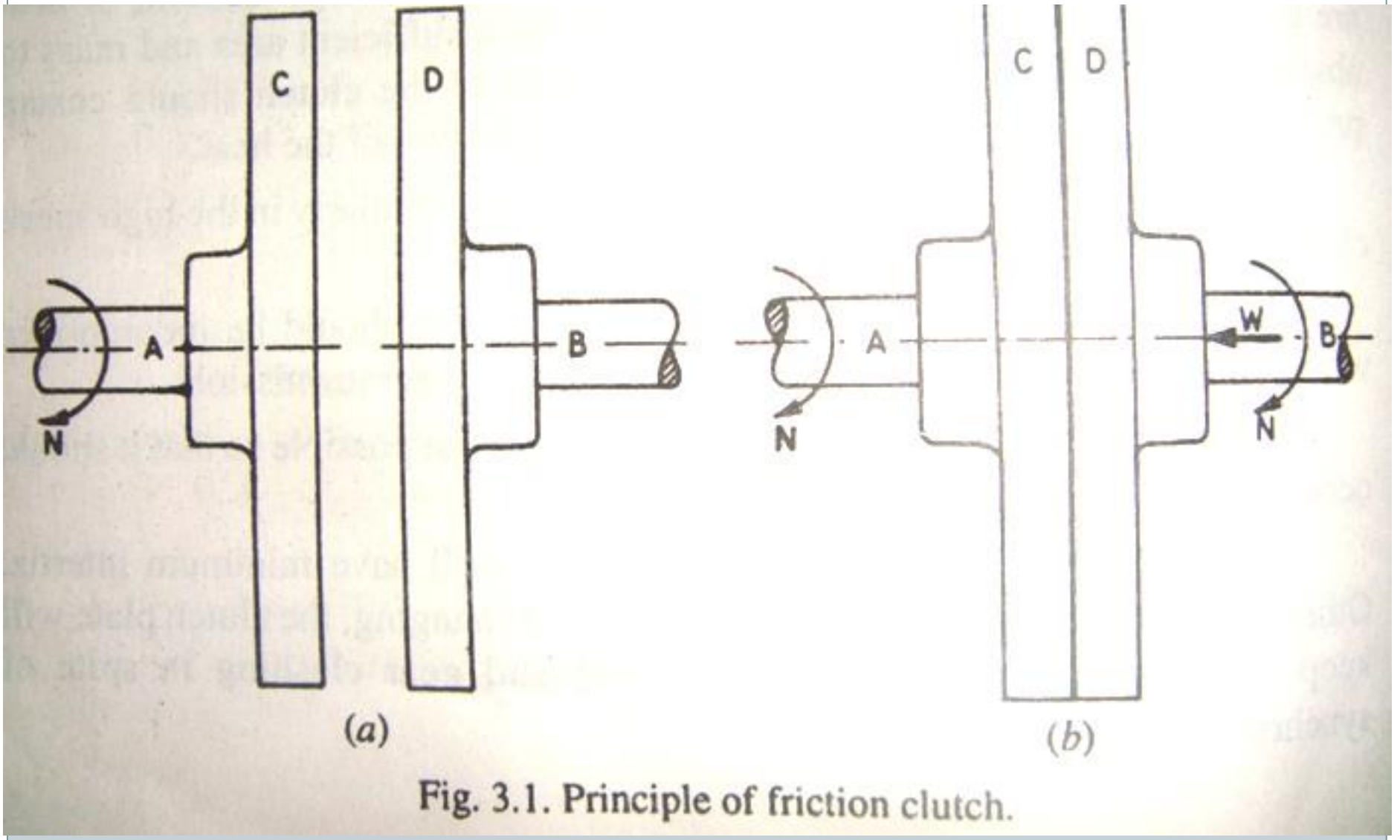
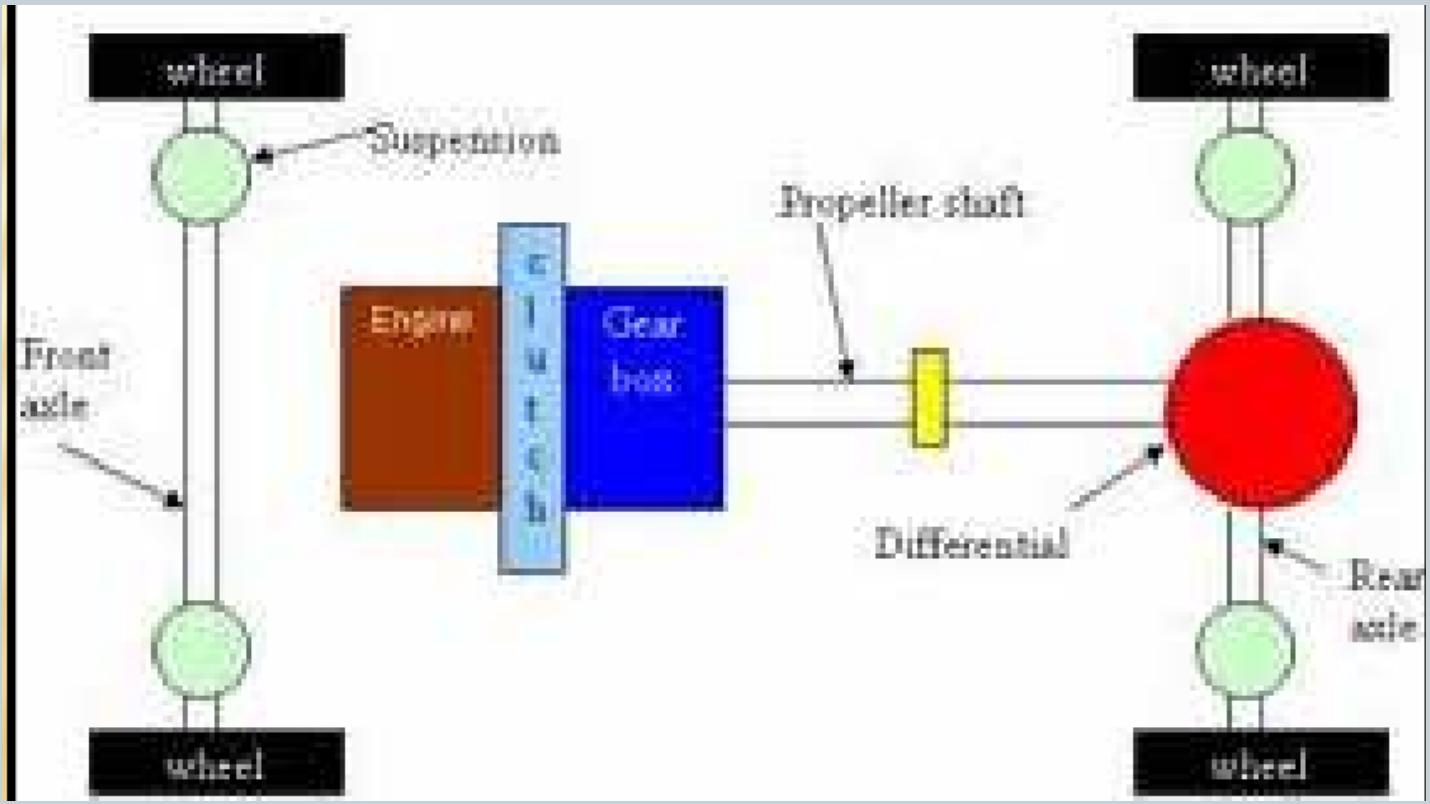


Fig. 3.1. Principle of friction clutch.

REQUIREMENTS

- Torque transmission
- Gradual engagement
- Heat dissipation
- dynamic balancing
- Vibration damping
- Size
- Inertia
- Ease of operation


wheel
wheel
Suspension
Propeller shaft
Front axle
Engine
Clutch
Gear box
Differential
Rear axle
wheel
wheel

TYPES OF CLUTCHES

1. Cone Clutch

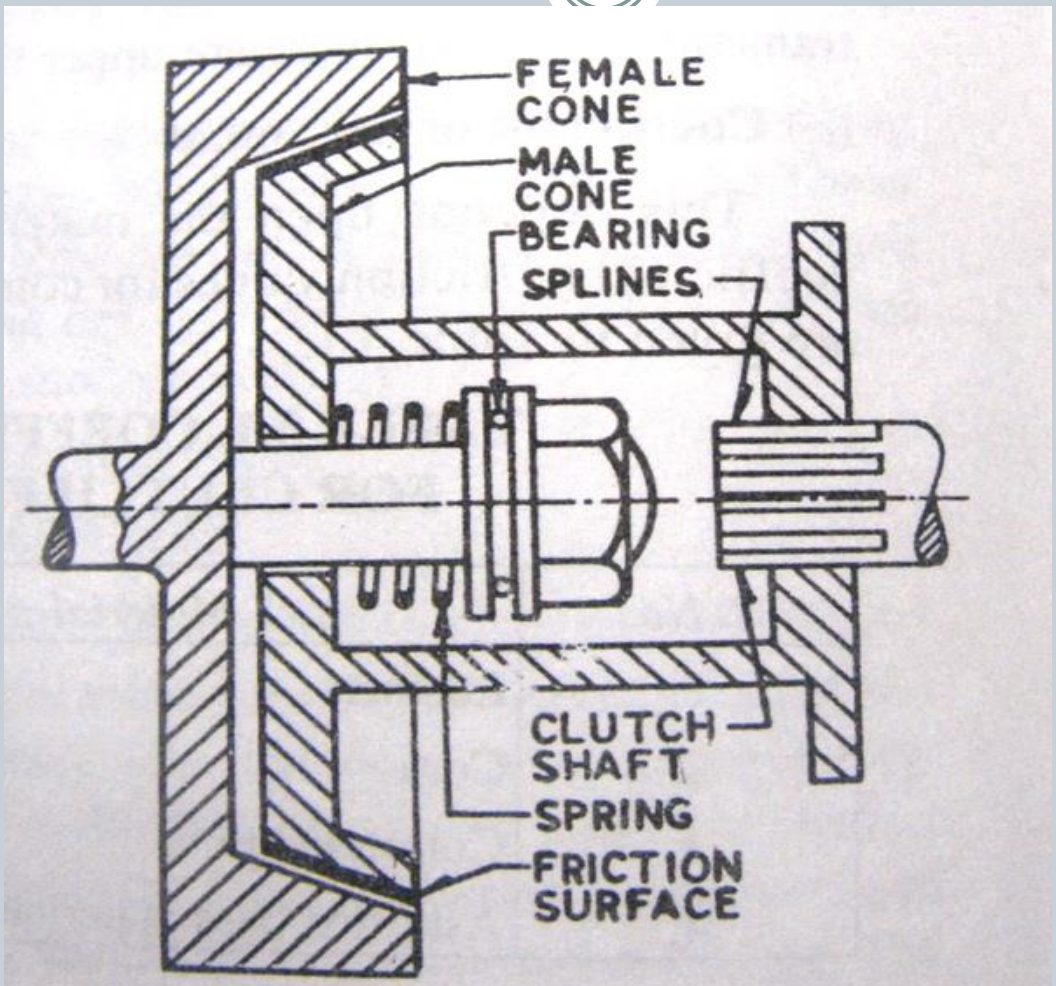


Fig. 3.2. Cone Clutch.

Advantages:

- Normal force acting on the contact surfaces is greater than the axial force compared to plate clutches.

Disadvantages:

- If Angle of cone is made less than 20 deg, then binding of the male and female cone happens and it becomes difficult to disengage the clutch.
- A small amount of wear on the cone surface results in considerable amount of axial movement of the

2. Single Plate Clutch

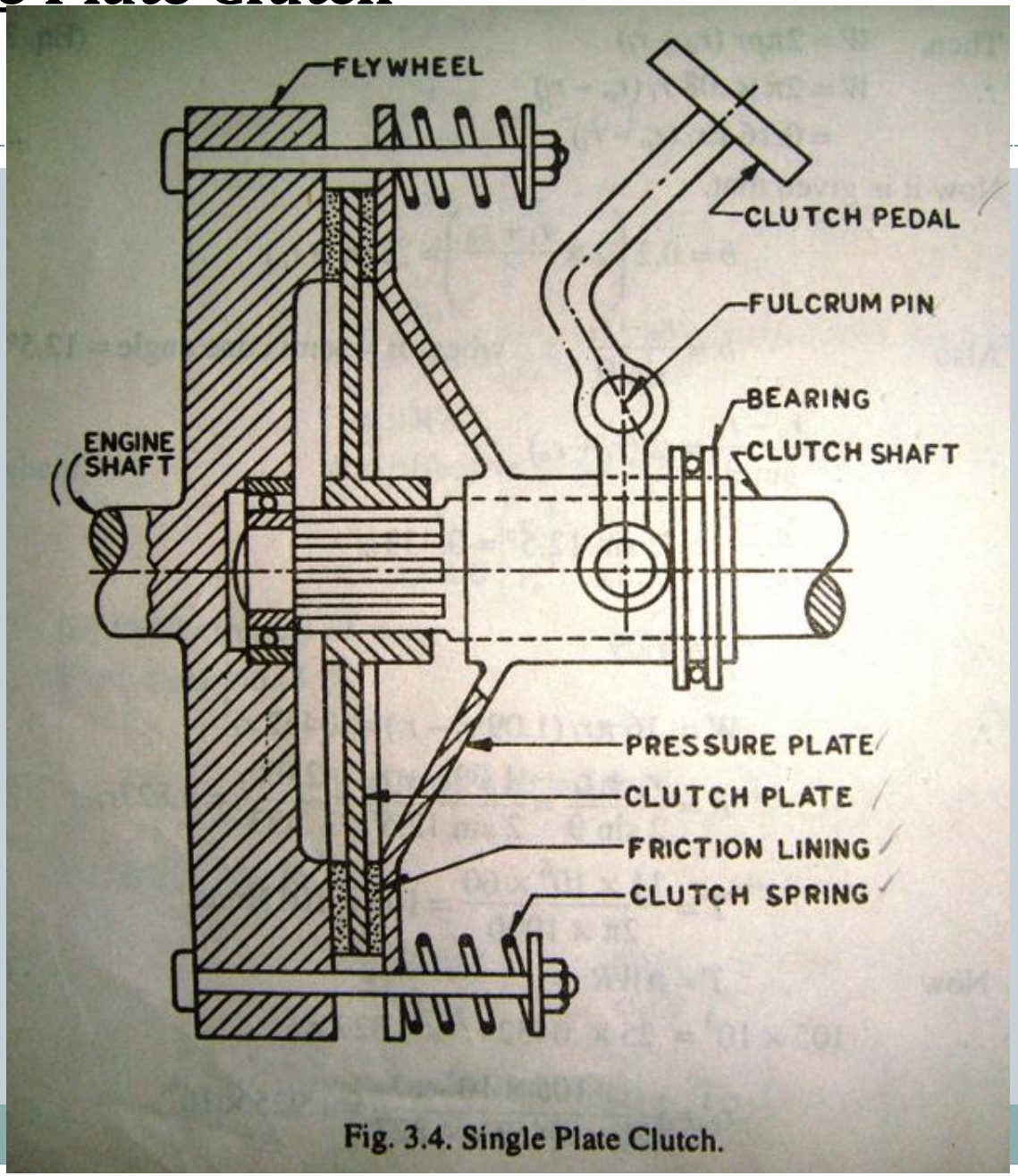


Fig. 3.4. Single Plate Clutch.

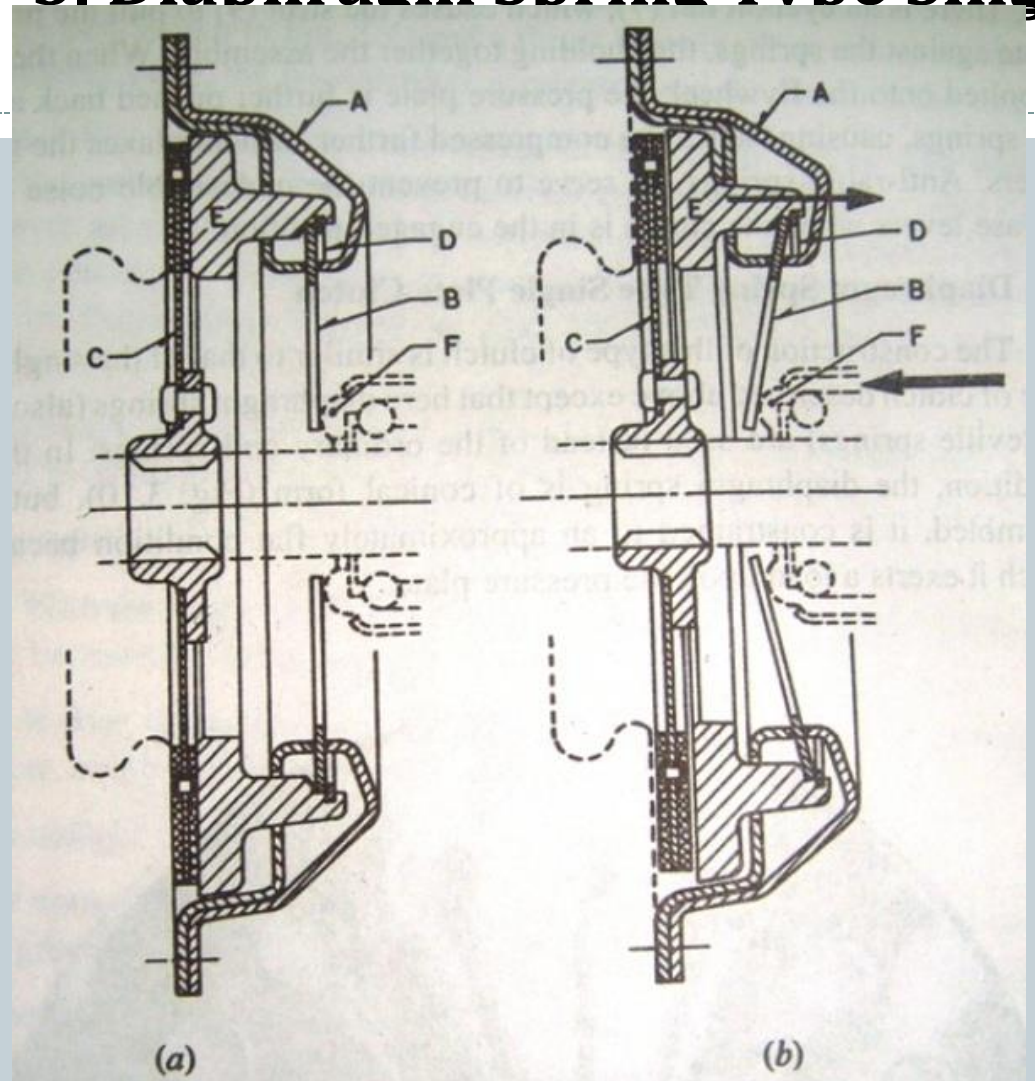
Advantages:

- Gear change is easier than the cone clutch because the pedal movement is less in this case.
- It does not suffer from disadvantages of cone clutch i.e., binding of cones etc. and hence it is more reliable.

Disadvantages:

- As compared to cone clutch, the springs have to be more stiff and this means greater force required to

3. Diaphragm Spring Type Single Plate



(a) (b)

Fig. 3.11. Diaphragm spring type clutch.
(a) engaged (b) disengaged
A—Cover, B—Diaphragm spring, C—Clutch plate, D—retaining ring, E—pressure plate, F—release ring.
(Courtesy—Laycock Engineering Ltd., England)

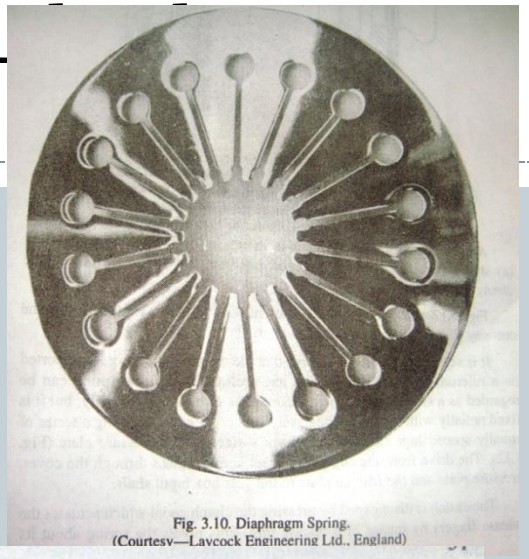


Fig. 3.10. Diaphragm Spring.
(Courtesy—Laycock Engineering Ltd., England)

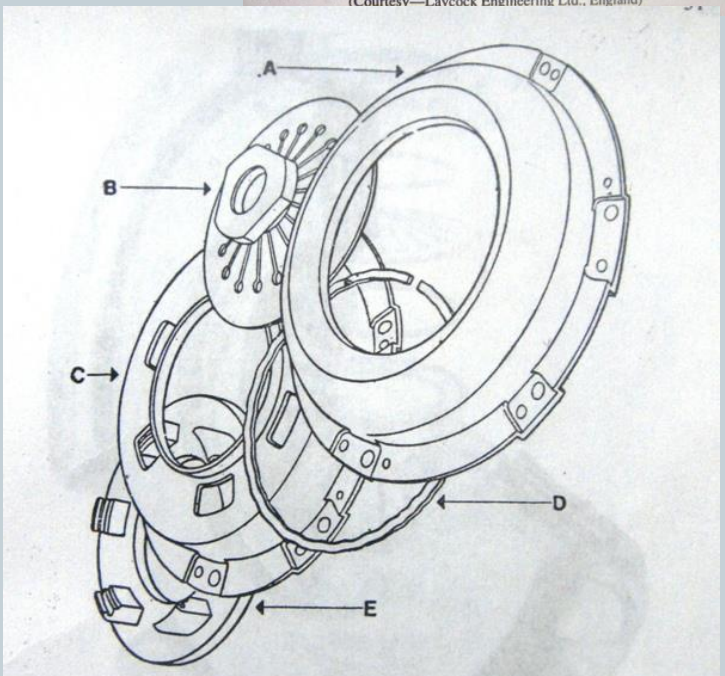


Fig. 3.12. Exploded view of a diaphragm spring type clutch. A—Cover, B—Diaphragm spring, C—clutch plate (friction plate), D—retaining spring, E—pressure plate. (Courtesy—Laycock Engineering Ltd., England)

4. Multi Plate Clutch:

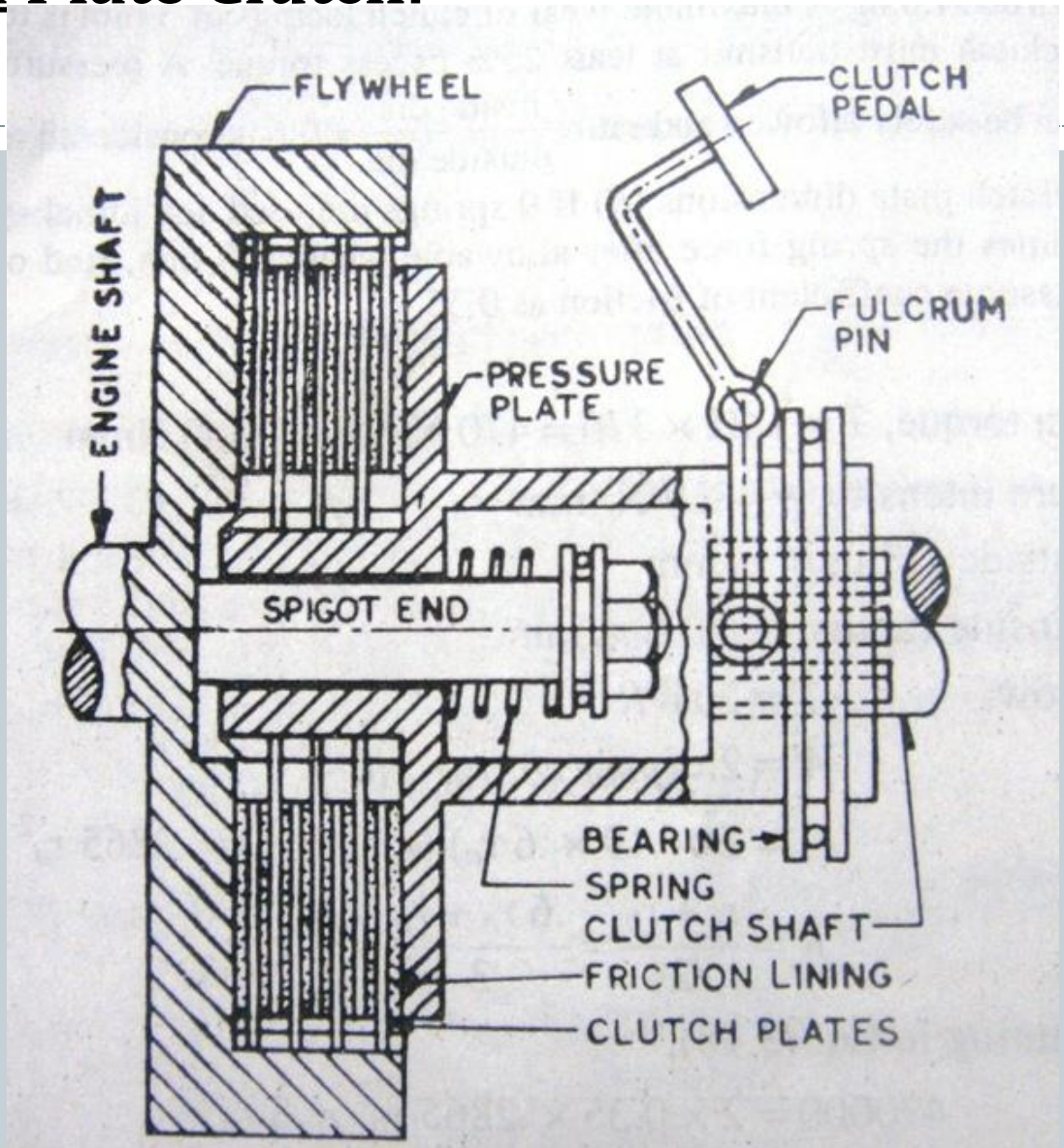


Fig. 3.19. Multiplate Clutch.

5. Semi-Centrifugal Clutch:

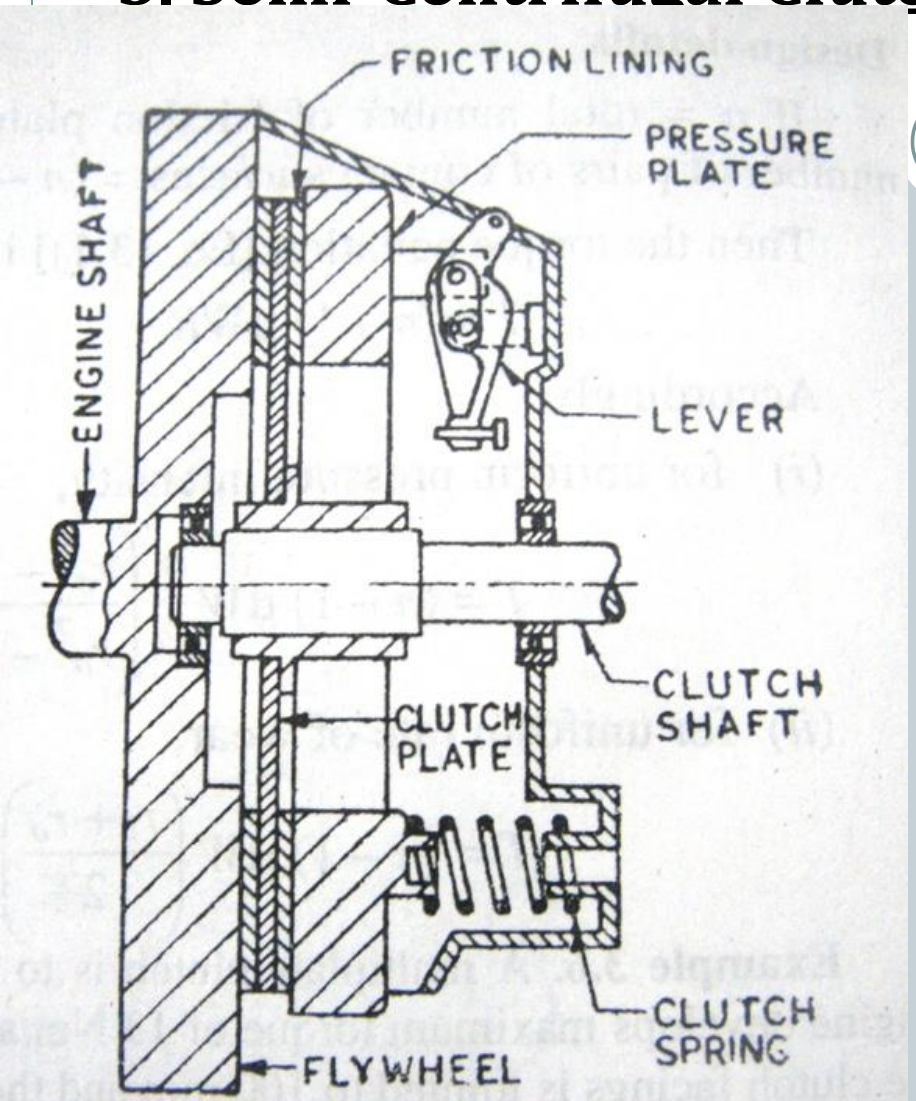


Fig. 3.21. Semi-centrifugal clutch.

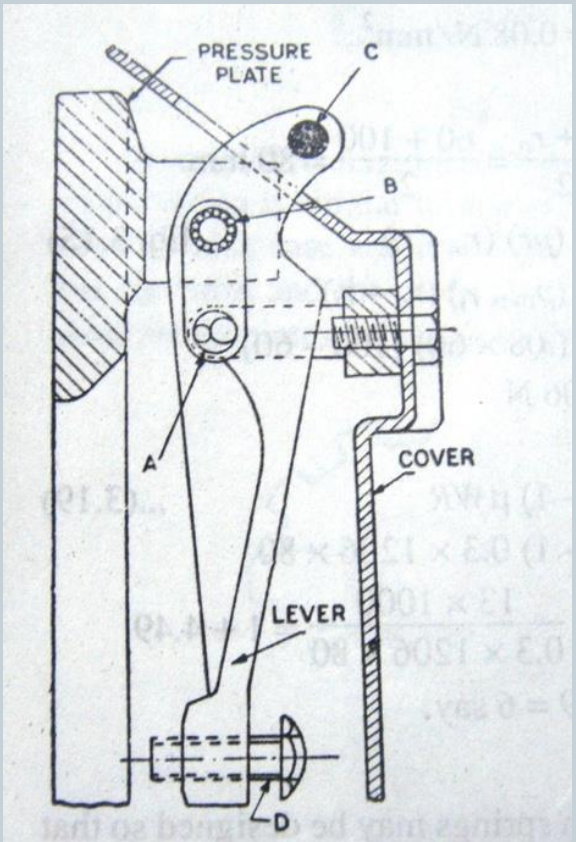


Fig. 3.22. Details of lever in semi-centrifugal clutch.

6. Centrifugal Clutch:

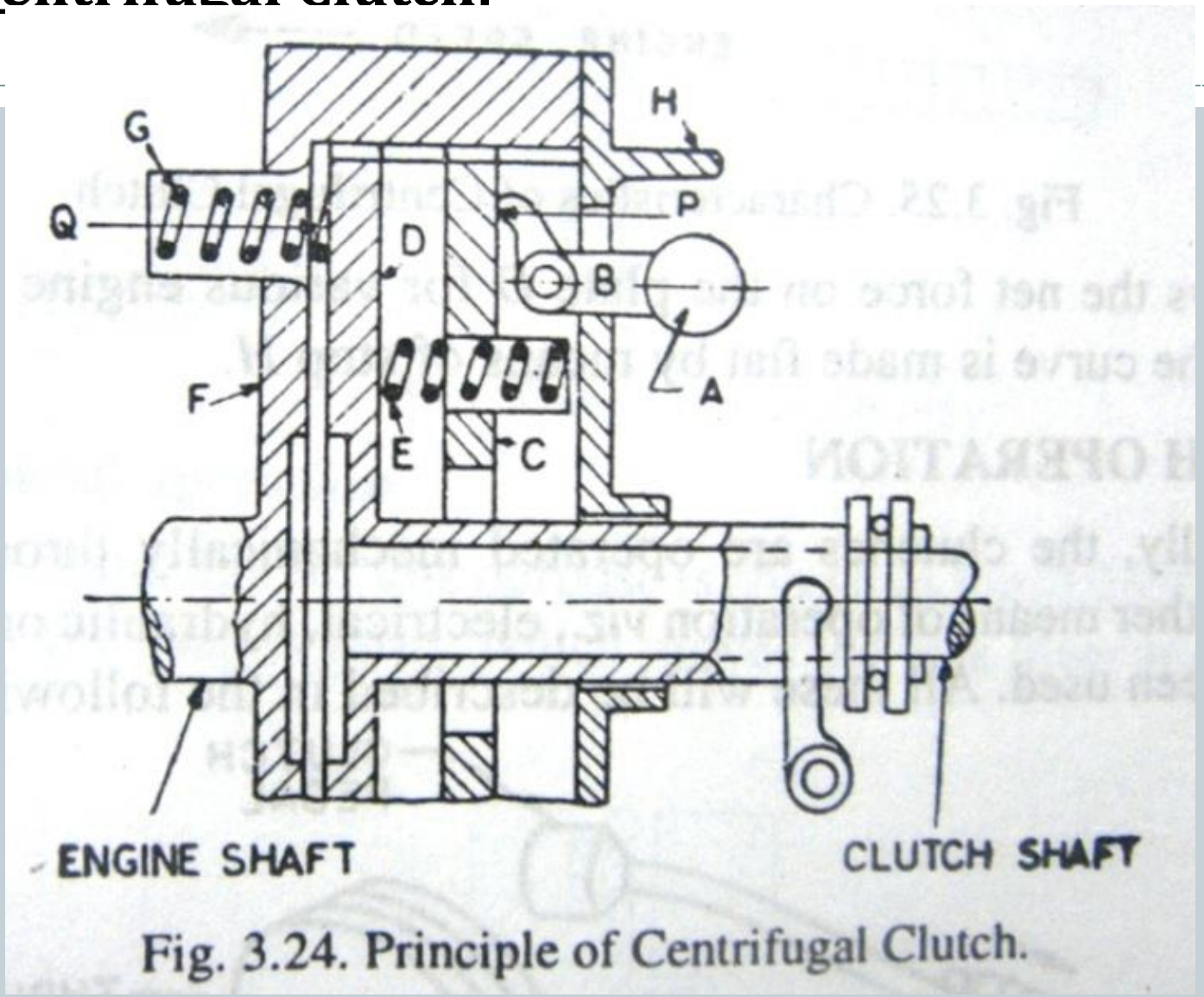


Fig. 3.24. Principle of Centrifugal Clutch.

Wet Clutch

Spray type. Single plate wet clutch:

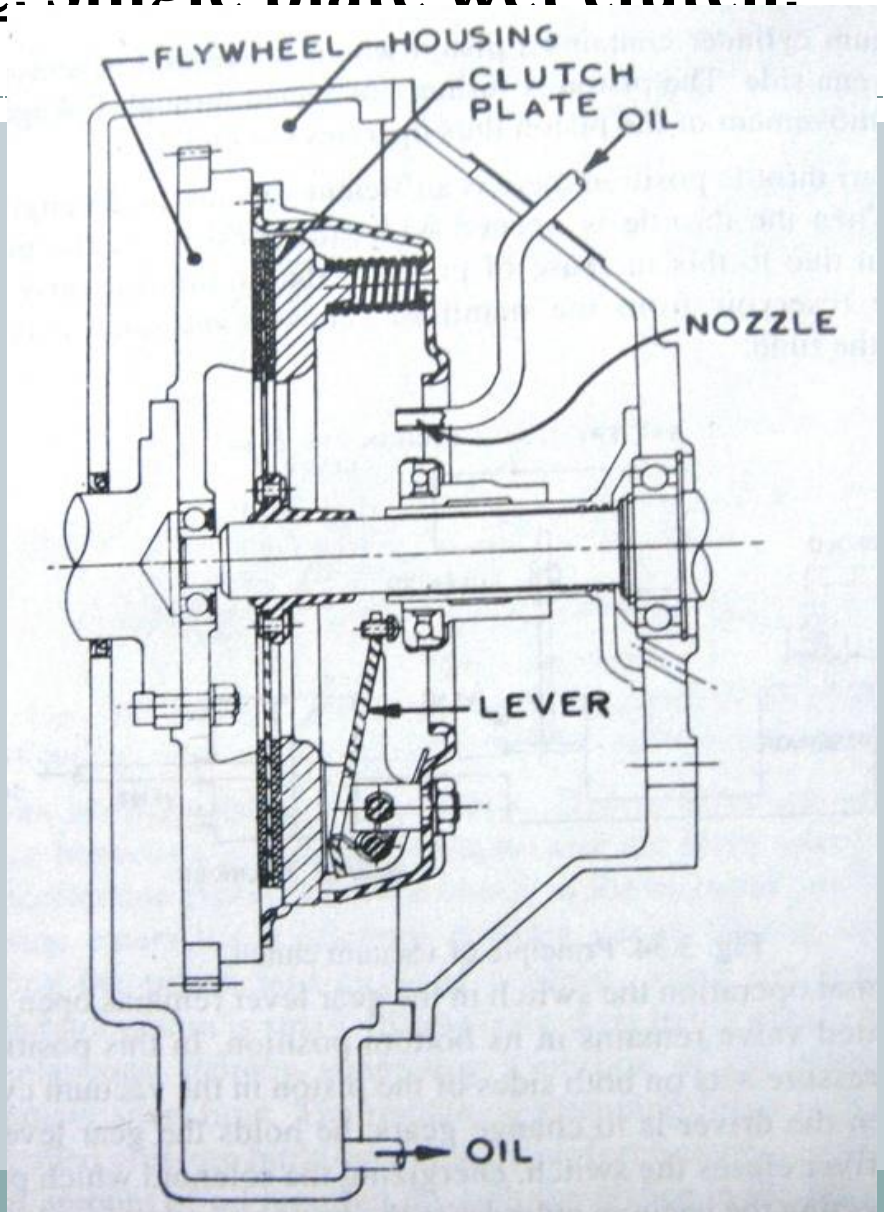


Fig. 3.35. Spray type, single plate wet clutch (Ref 2)

CLUTCH OPERATION

- Mechanical operation
- Electromagnetic operation
- Vacuum operation

MECHANICAL

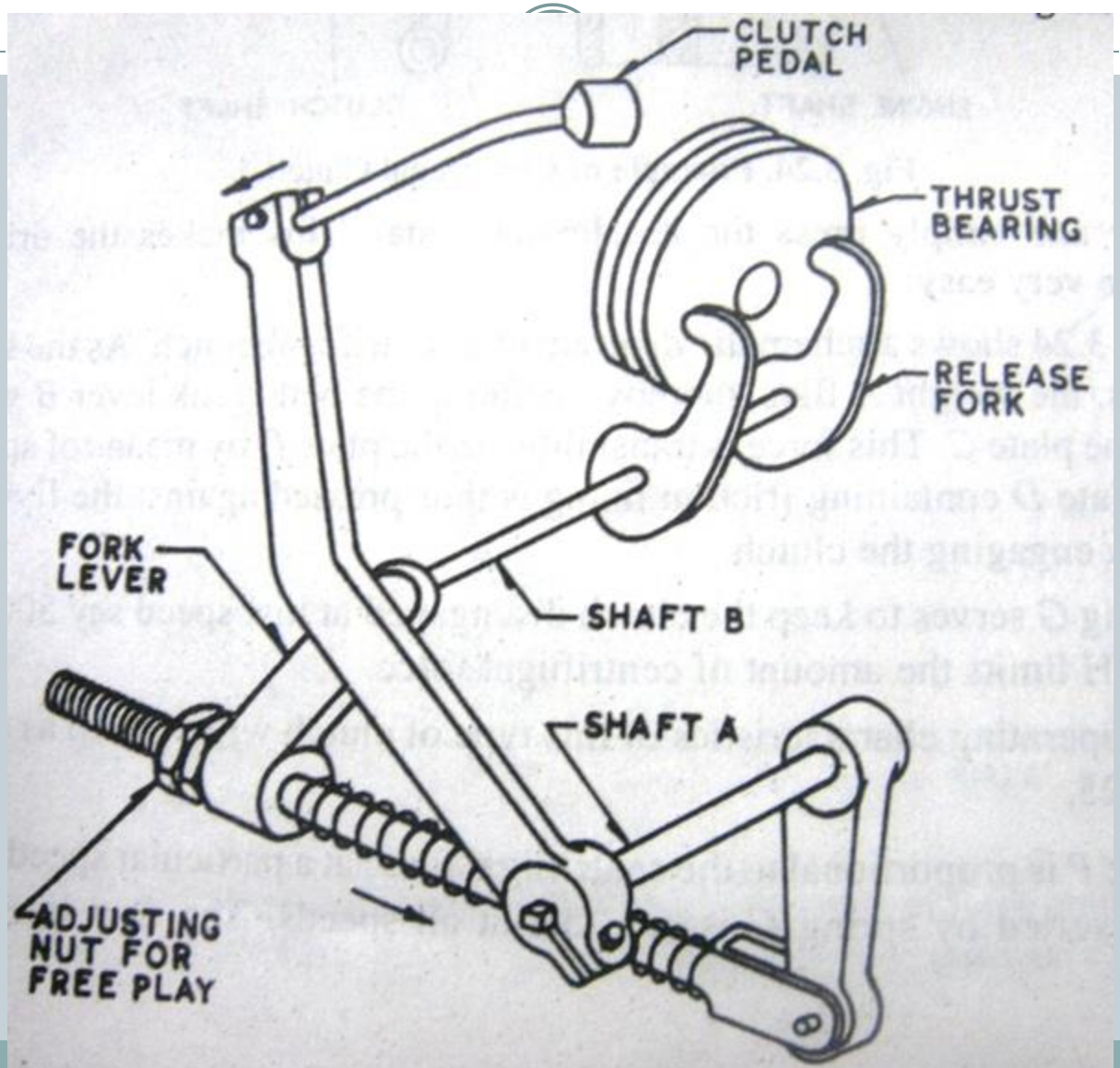


Fig. 3.26. Clutch linkage.

ELECTROMAGNETIC

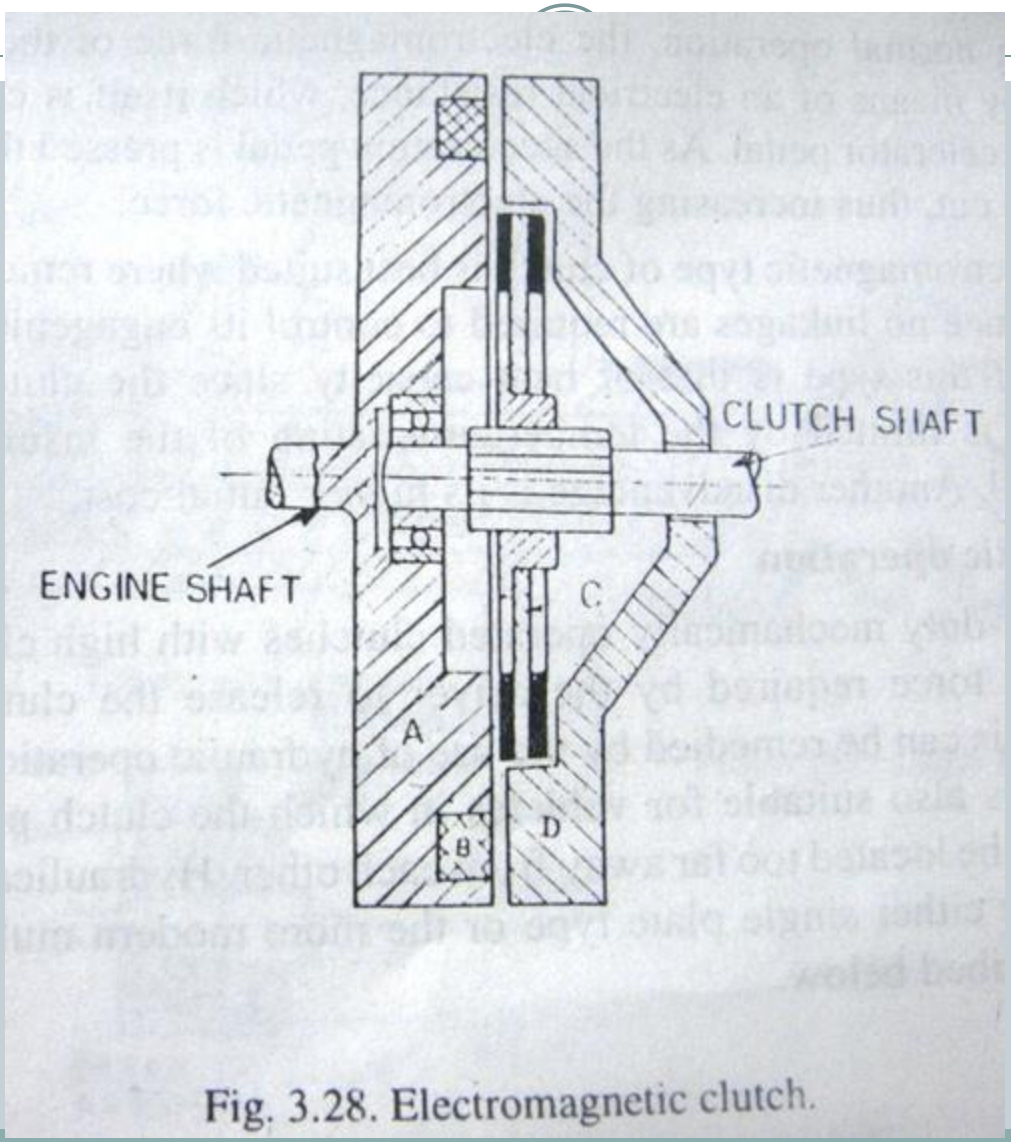


Fig. 3.28. Electromagnetic clutch.

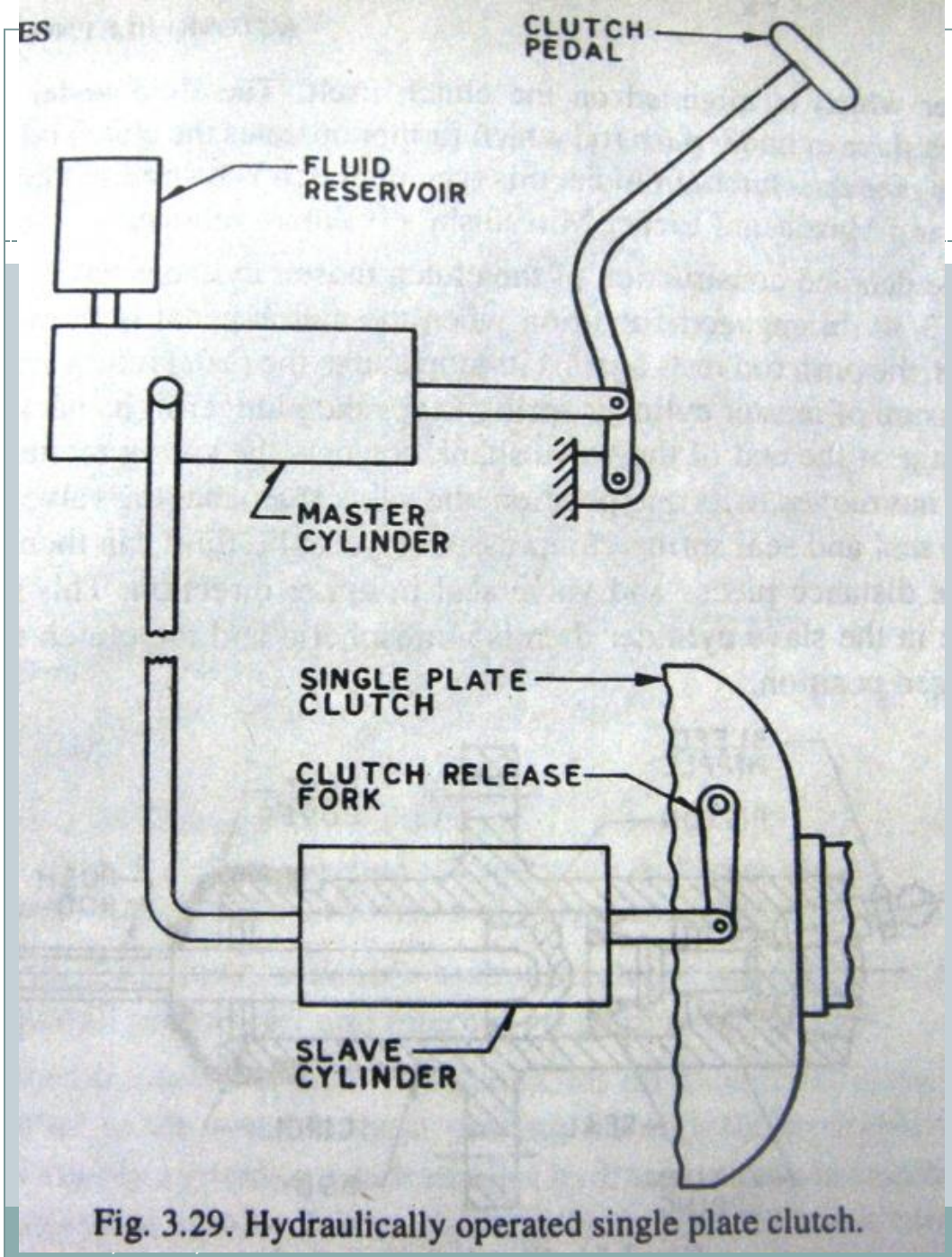


Fig. 3.29. Hydraulically operated single plate clutch.

HYDRAULLIC

Transmission Features

- A manual transmission should:
  - be able to increase torque to the drive wheels for quick acceleration
  - supply different gear ratios to match load conditions
  - provide a reverse gear
  - provide an easy means of shifting gears
  - operate quietly with minimum power loss

Gear Fundamentals

- Gears are round wheels with teeth machined on their perimeters
- They transmit turning effort from one shaft to another
- When gears are different sizes, output speed and torque change

TYPES OF GEARS

1. According to the position of axes of the shafts.

a. Parallel

1.Spur Gear

2.Helical Gear

3.Rack and Pinion

b. Intersecting

Bevel Gear

c. Non-intersecting and Non-parallel

worm and worm gears

SPUR GEAR

HELICAL GEAR

BEVEL GEAR

Gear Reduction

- Occurs when a small gear drives a larger gear
- Increases turning force (torque)
- Used in lower transmission gears

OVERDRIVE RATIO

- Results when a larger gear drives a smaller gear
- Output gear speed increases
- Output torque is reduced

Gear Backlash

- Distance between the meshing gear teeth
- Allows lubricating oil to enter the high-friction area between the gear teeth
- Allows the gears to expand during operation

TRANSMISSION GEAR RATIOS

- First gear 3:1
- Second gear 2:1
- Third (high) gear 1:1
- Reverse gear 3:1

Gearbox Types

- Selective gear box (Manual)

  1) sliding mesh gear box

  2) constant mesh gear box

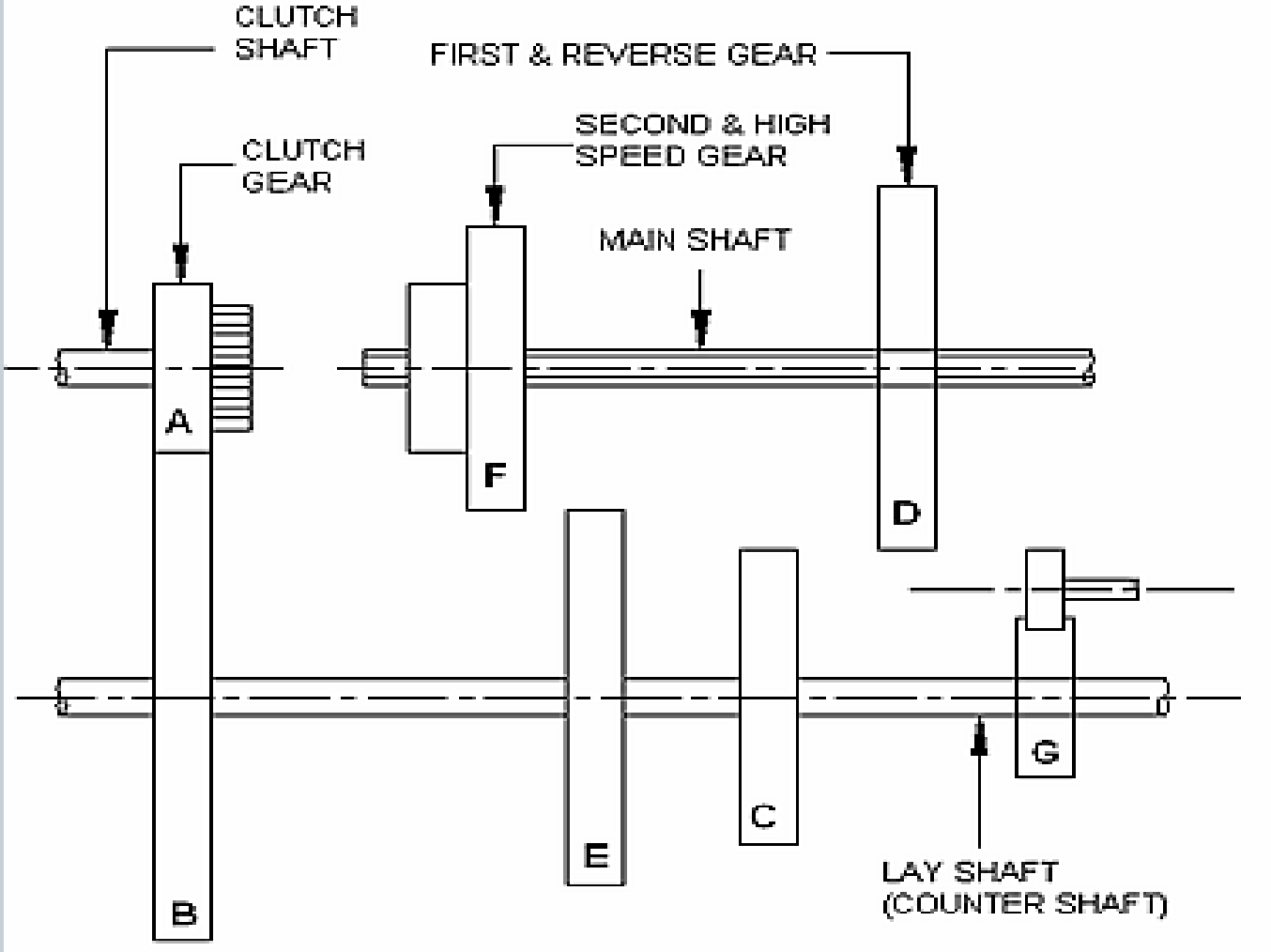
  3) synchromesh gear box

- Epicyclic or Planetery gearbox

  1) semi automatic

2) fully automatic

Sliding mesh gear box:



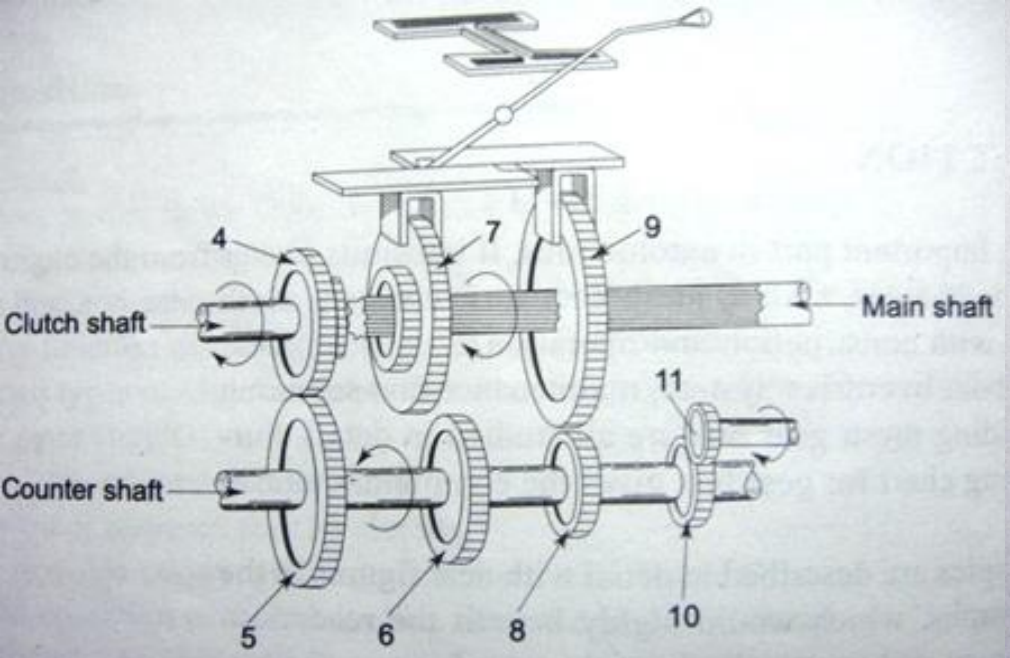


Fig. 2.3 Sliding mesh gear box—first gear position

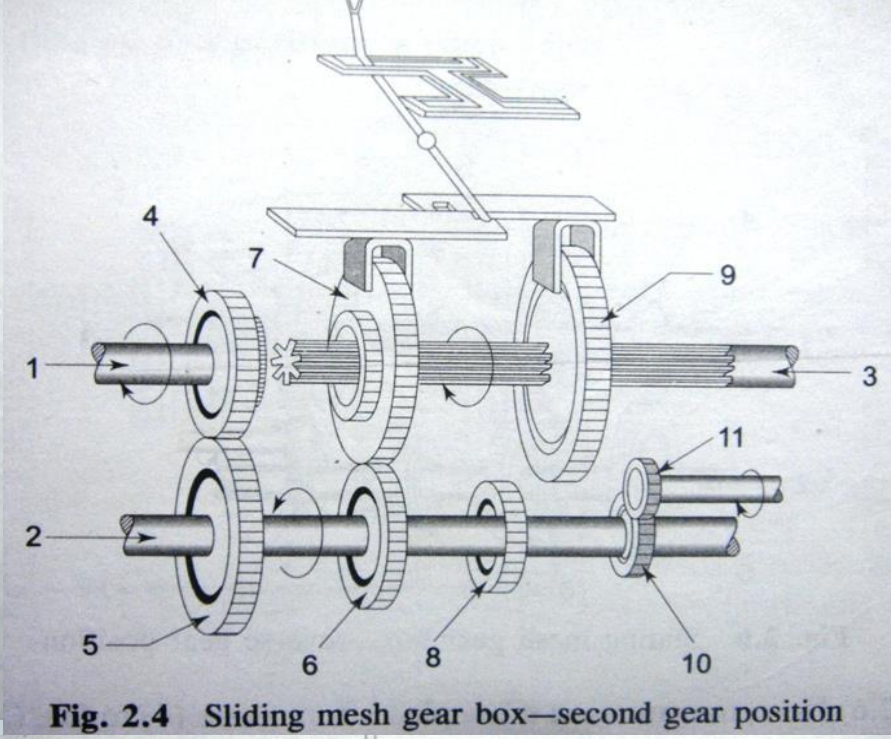


Fig. 2.4 Sliding mesh gear box—second gear position

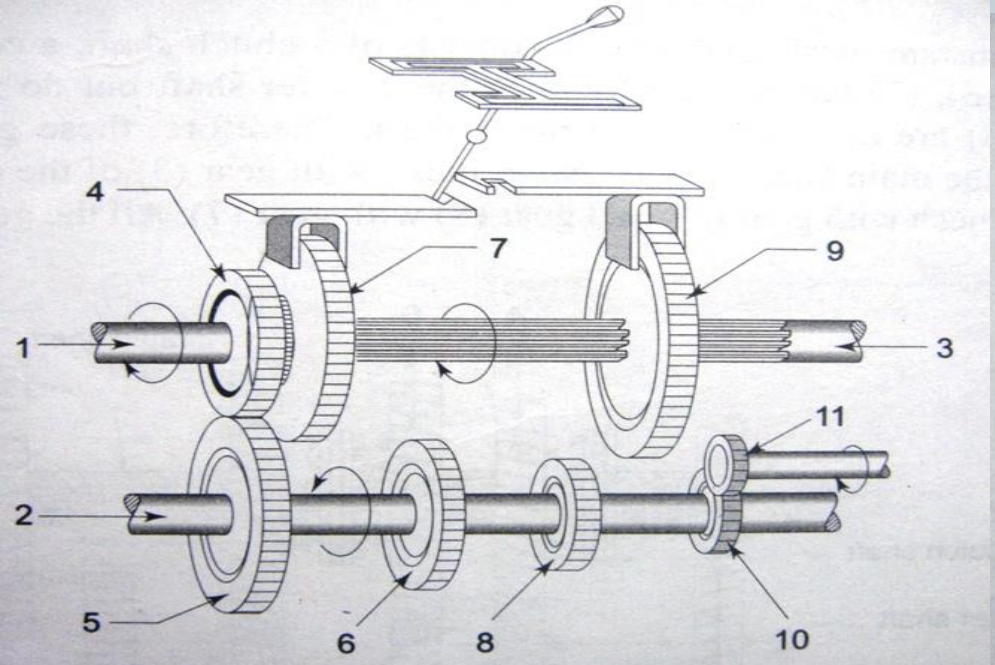


Fig. 2.5 Sliding mesh gear box—third gear position

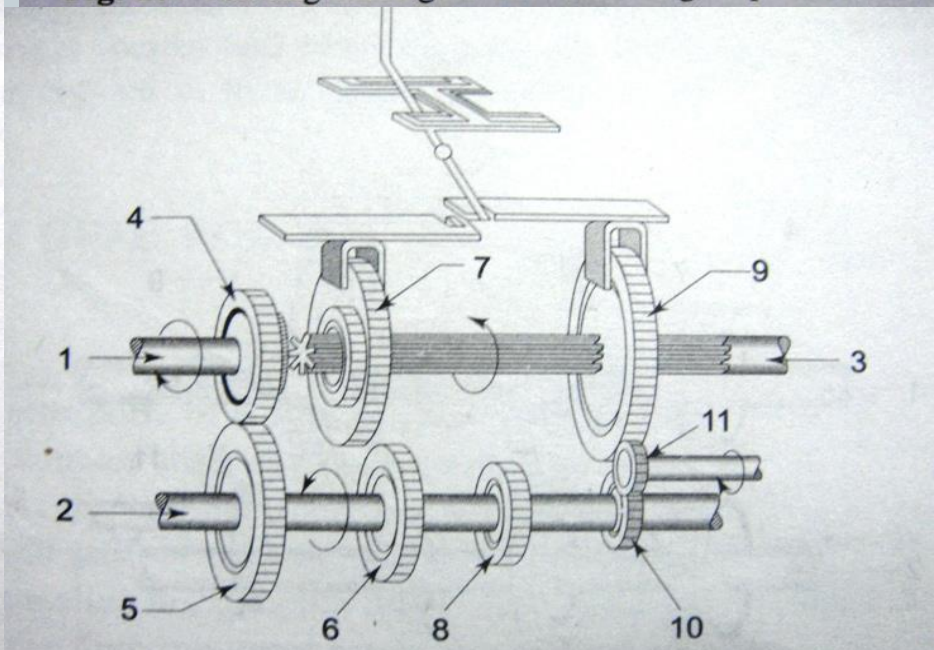


Fig. 2.6 Sliding mesh gear box—reverse gear position

CONSTANT MESH GEARBOX

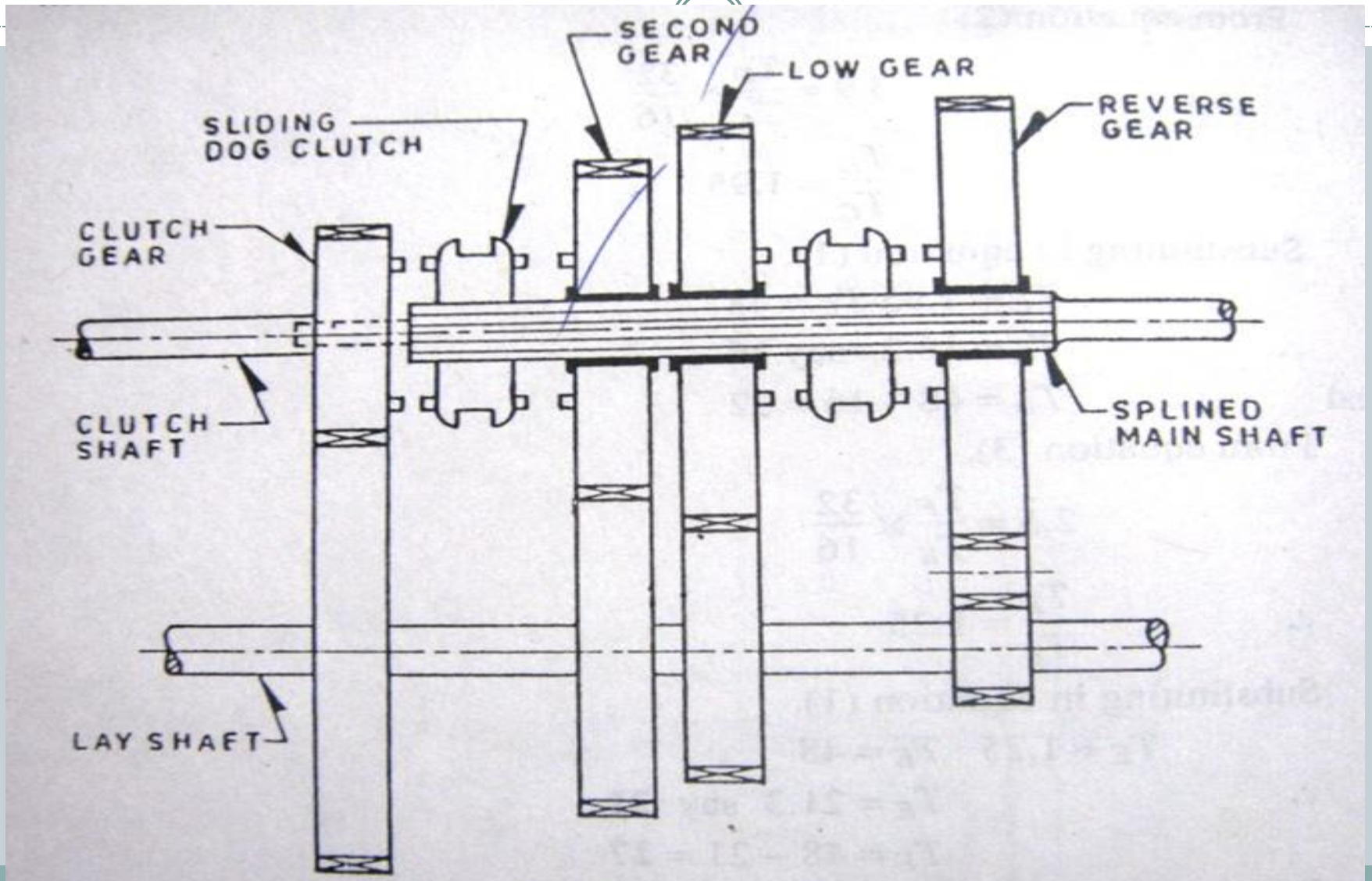


Fig. 4.9. Constant mesh gear box.

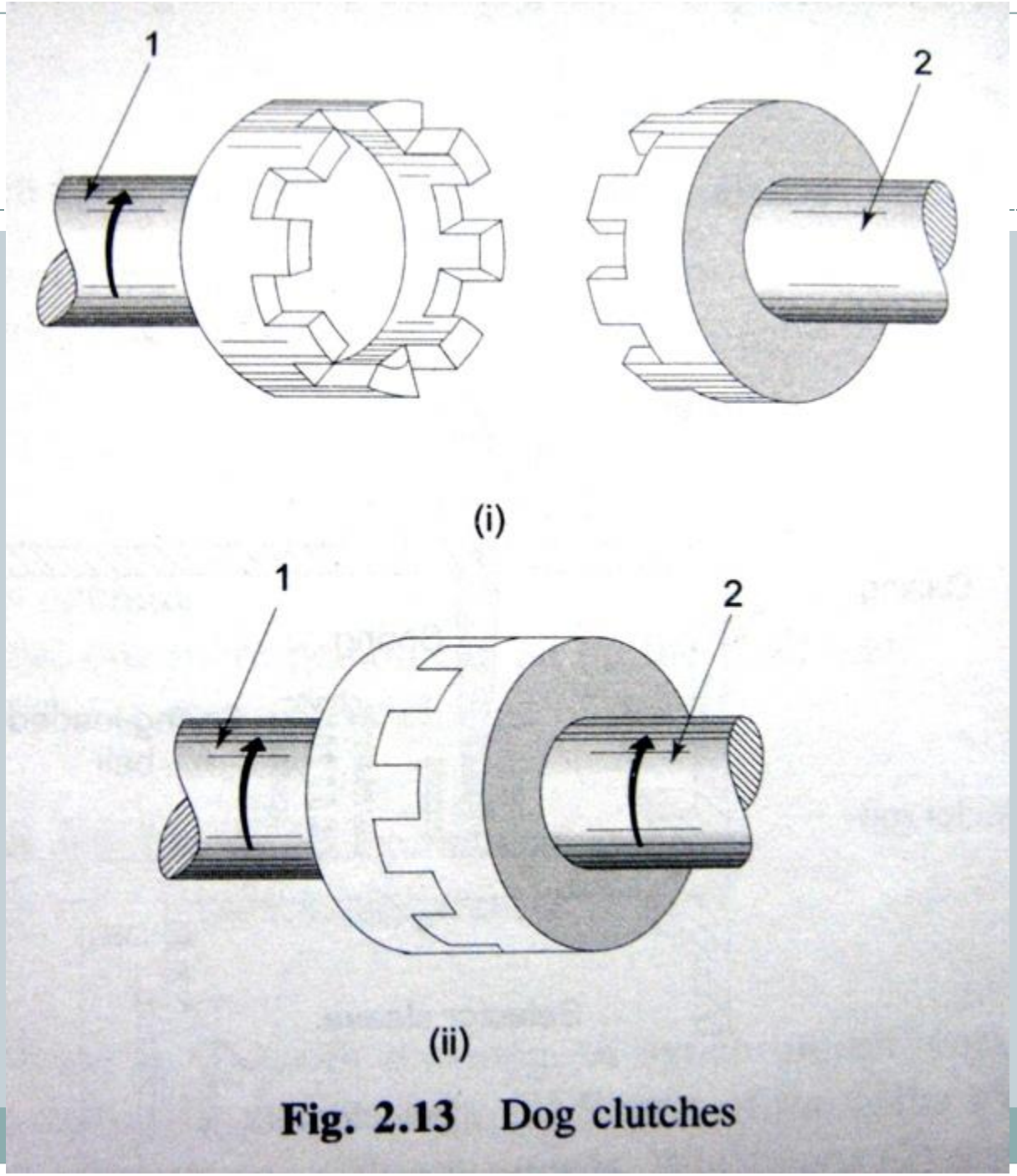


Fig. 2.13 Dog clutches

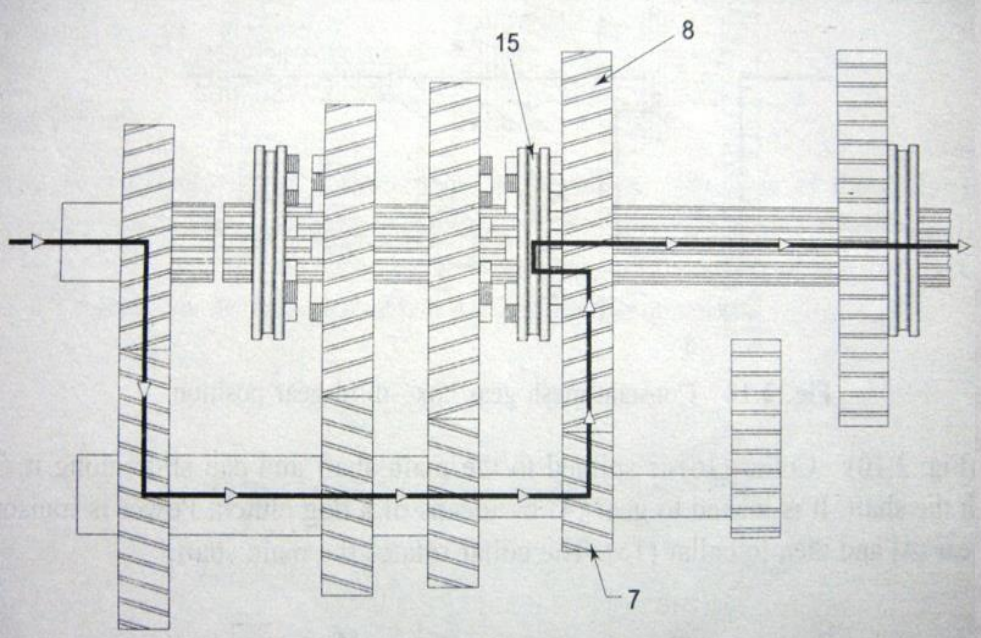


Fig. 2.8 Constant mesh gear box—first gear position

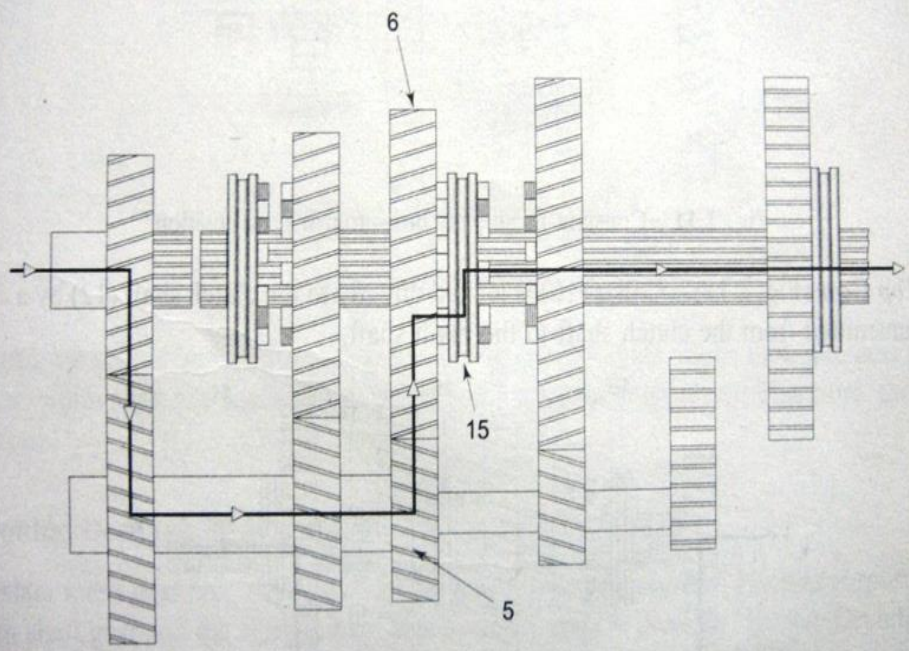


Fig. 2.9 Constant mesh gear box—second gear position

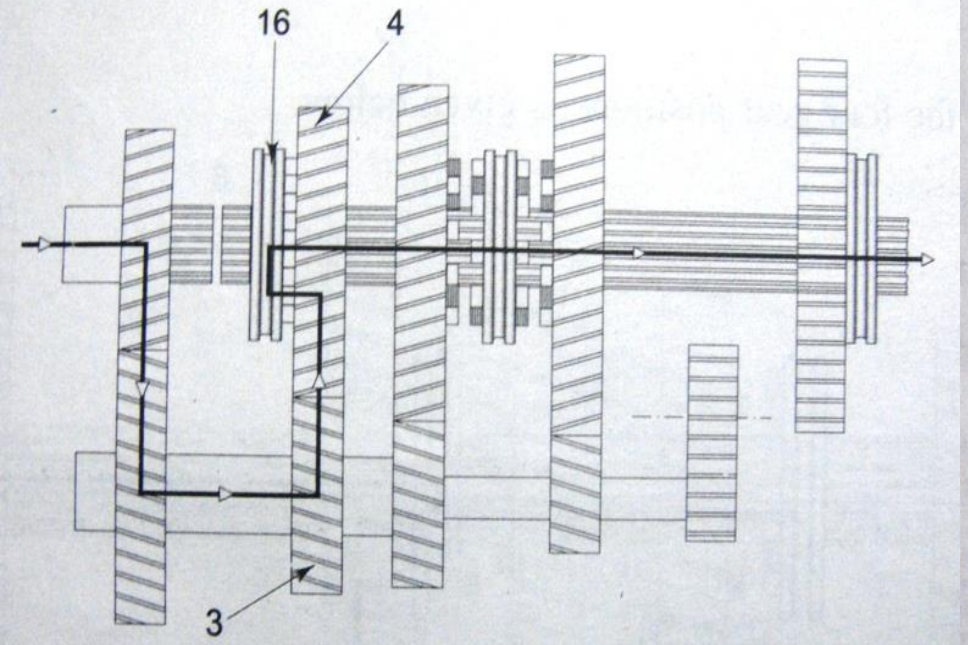


Fig. 2.10 Constant mesh gear box—third gear position

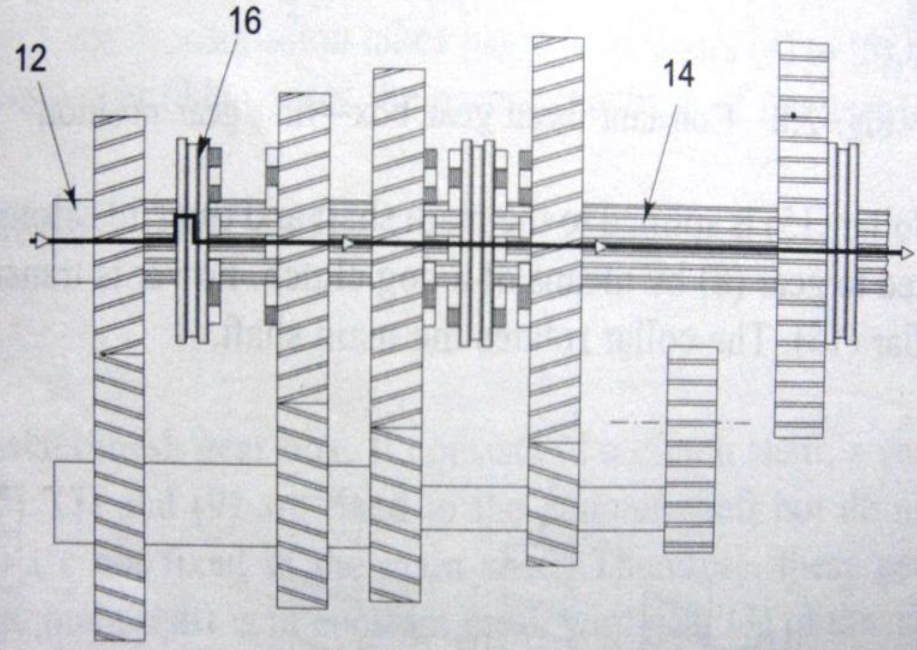


Fig. 2.11 Constant mesh gear box—fourth gear position

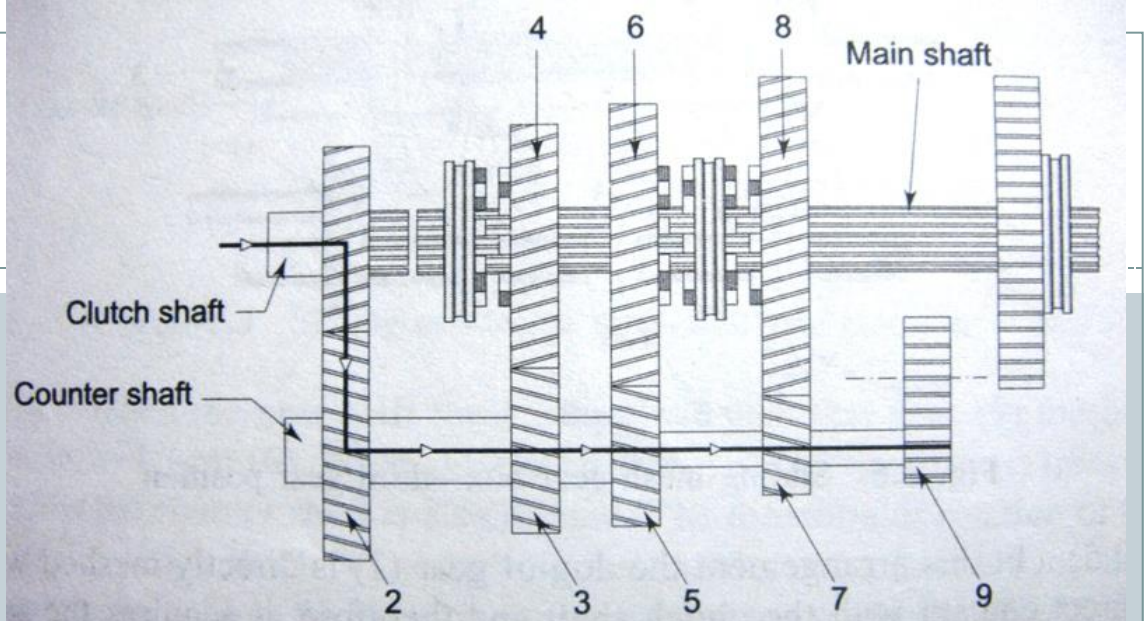
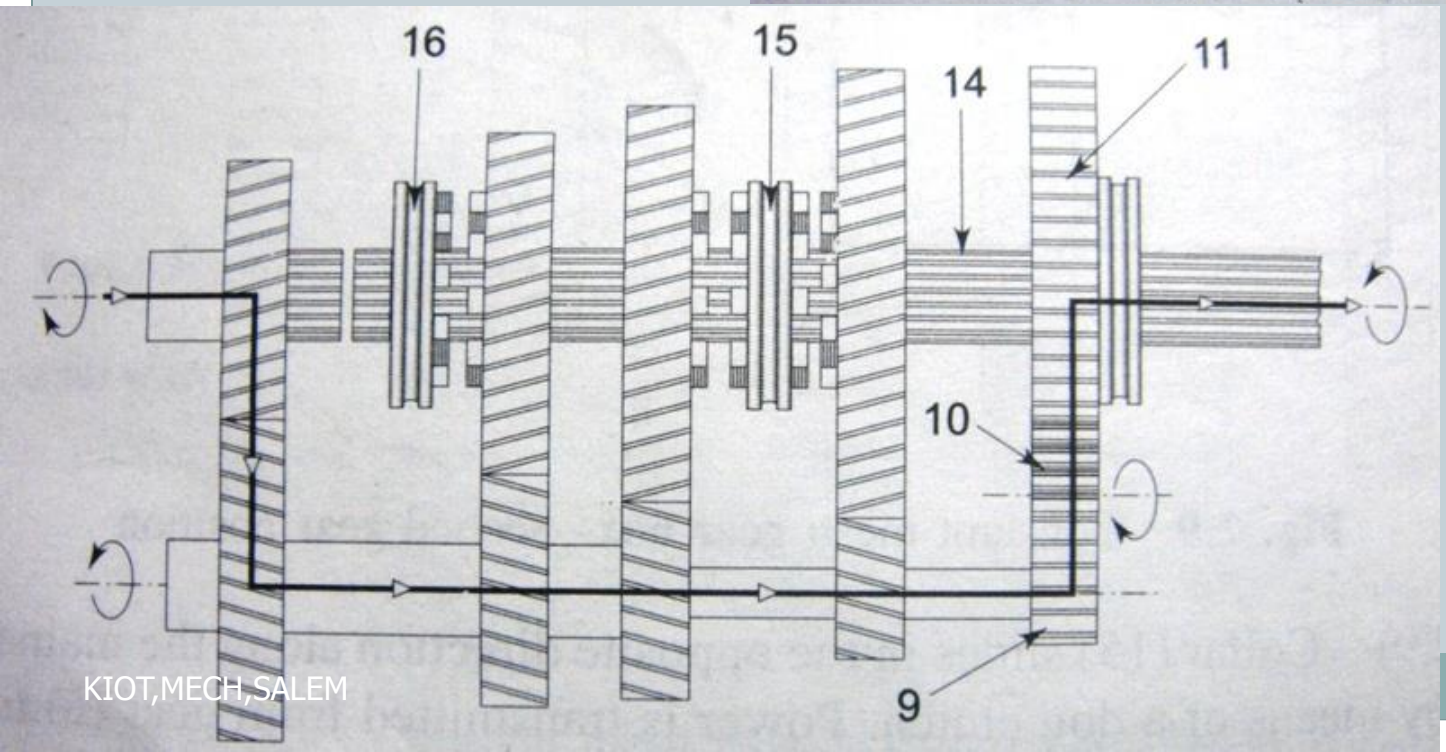


Fig. 2.7 Constant mesh gear box—neutral position



Constant mesh gearbox - Reversed position

SYNCHRONOUS MESH GEARBOX

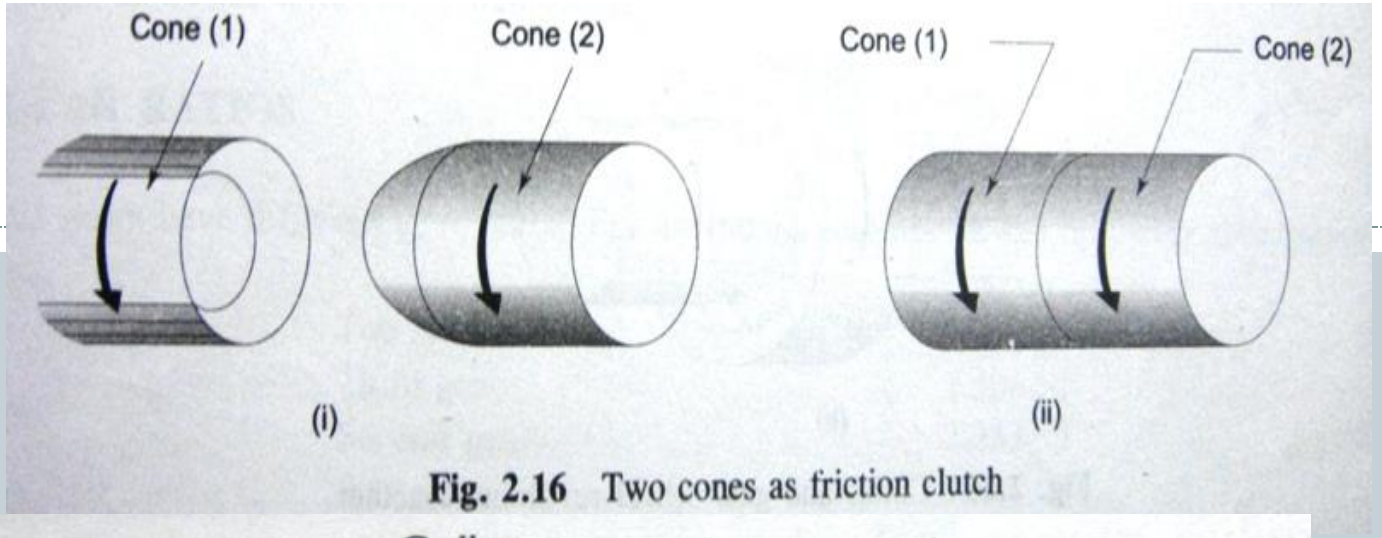


Fig. 2.16 Two cones as friction clutch

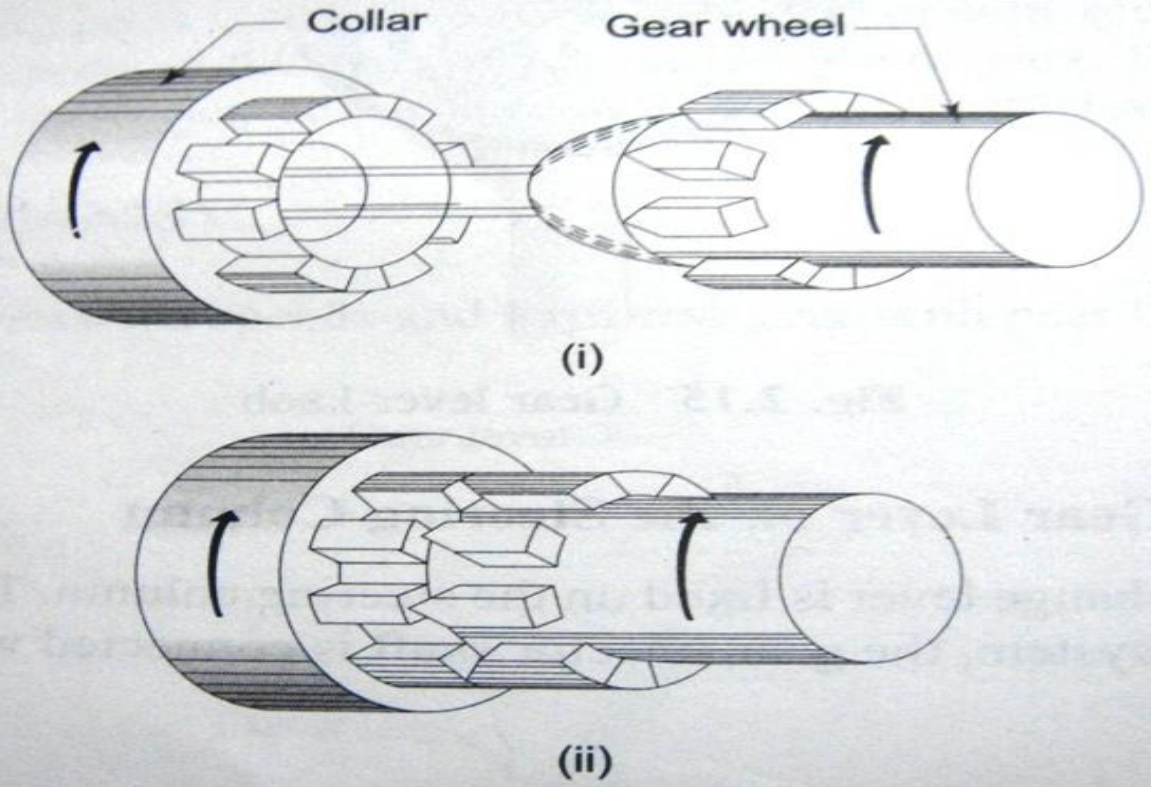


Fig. 2.17 Coltar meshing with the gear wheel

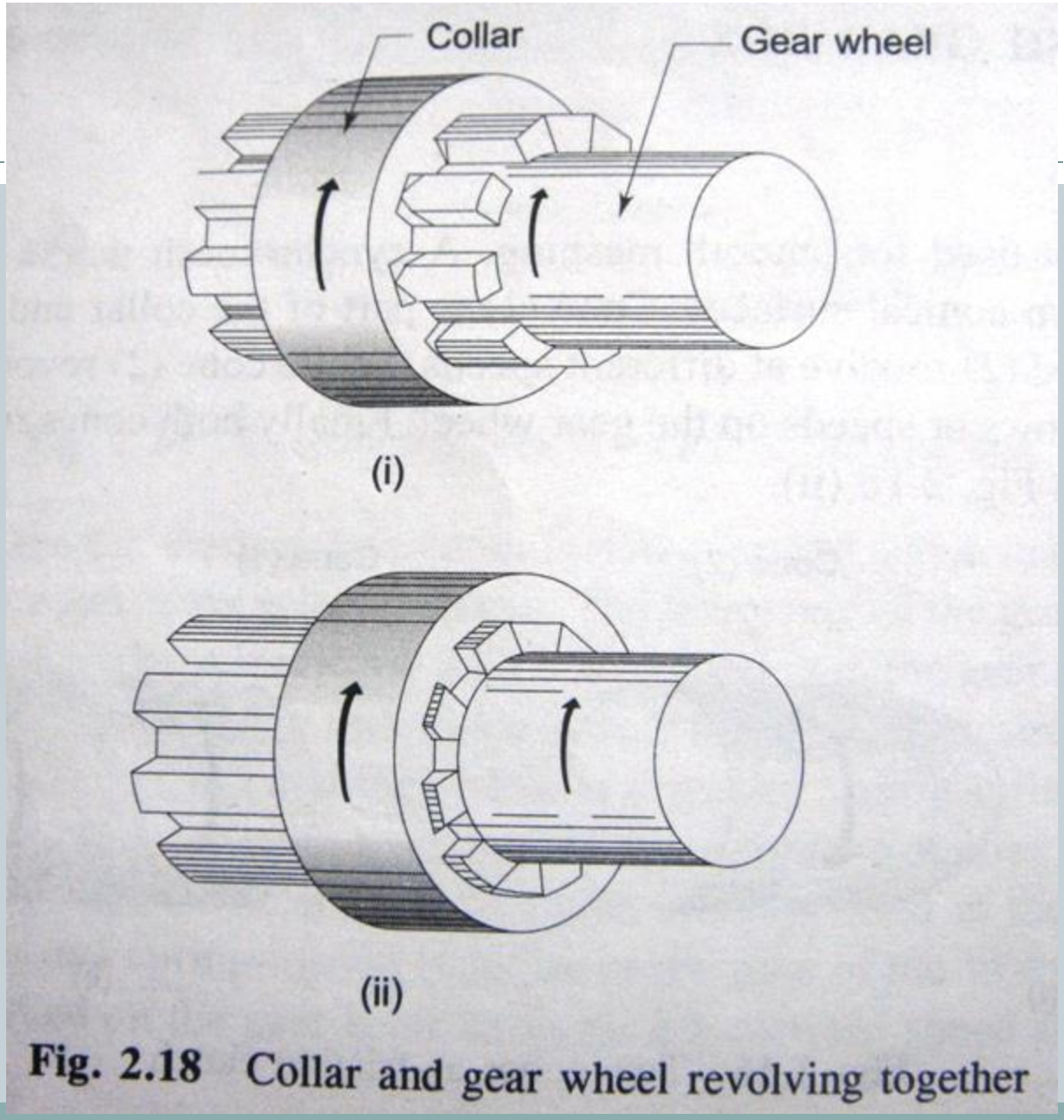
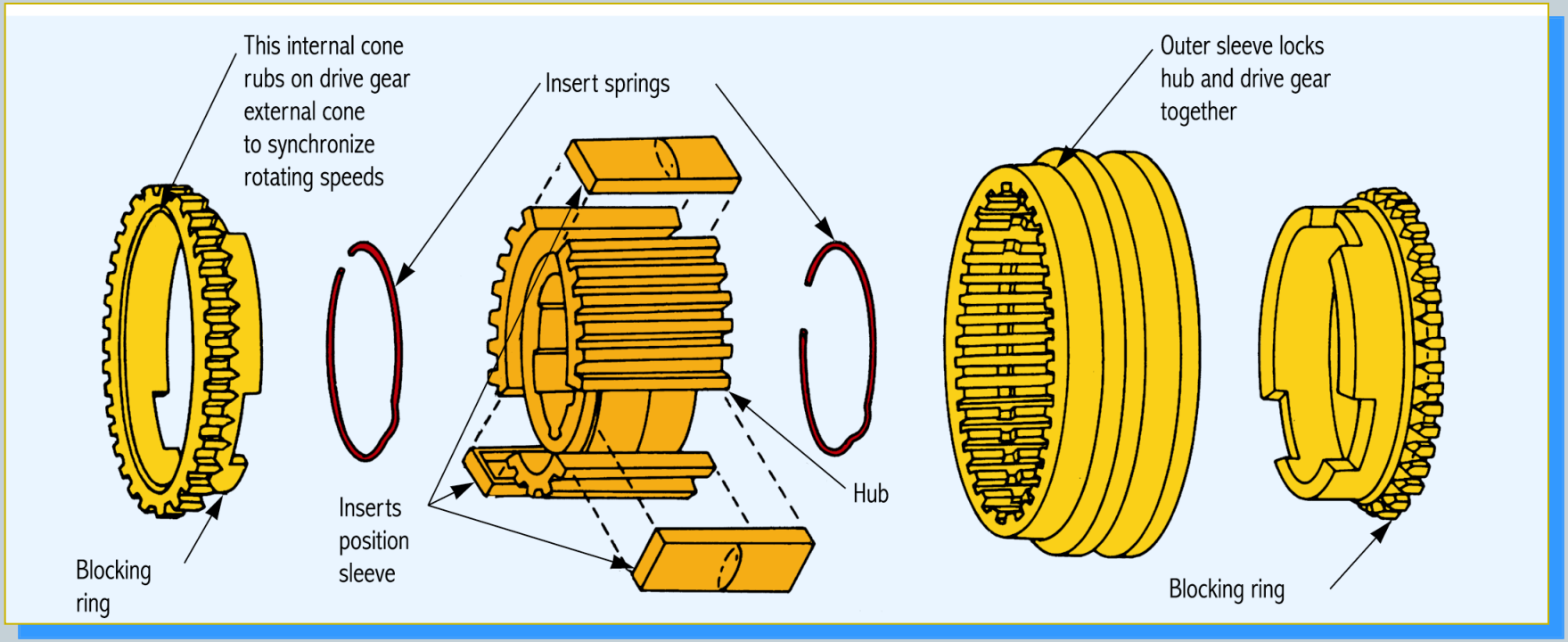


Fig. 2.18 Collar and gear wheel revolving together

Synchronizers



- Synchronizers have two functions:
  - prevent the gears from clashing (grinding) during engagement
  - lock the output gear to the output shaft

DRIVE LINES

- An automobile drive line is an assembly of one or more drive shafts, universal joints and slip joints.
- It transmits torque through varying angles and distances from one shaft to another.
- It has three main parts.
  - **A propeller shaft / drive shaft**
  - **Universal joints**
  - **Slip joints**

UNIVERSAL JOINTS

- A universal joint is a particular type of connection between two shafts, whose axes are inclined to each other.
- The purpose of universal joints is to transmit power

ler

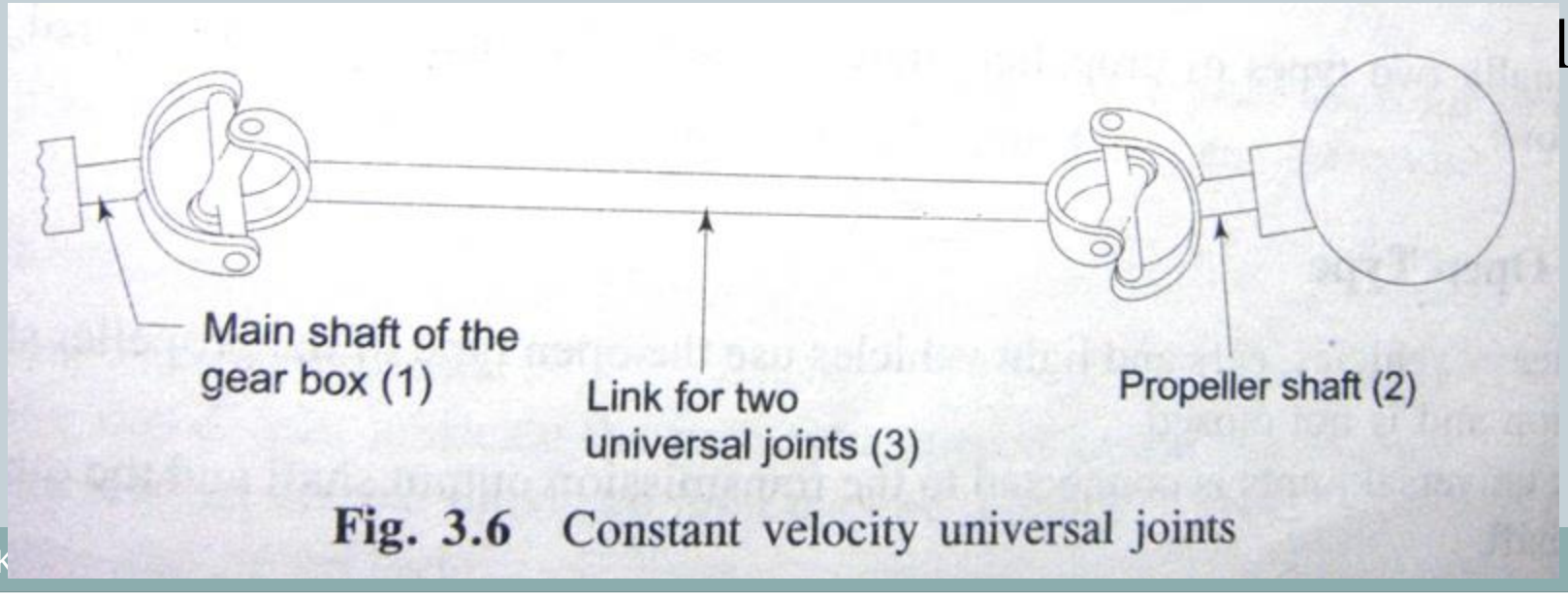


Fig. 3.6 Constant velocity universal joints

- The most simple type of universal joint is the Hook's joint which is mostly used because of the fact that it is simple and compact in construction and reasonably efficient at small angles of propeller shaft movement up and down say 18 deg.

Principle:

- When the differential rises or falls, the distance between the gear box and the differential changes. Correspondingly, the effective length of the propeller shaft also changes.
- This is permitted by the outside splines on the propeller shaft and matching internal splines on the universal joint yoke.

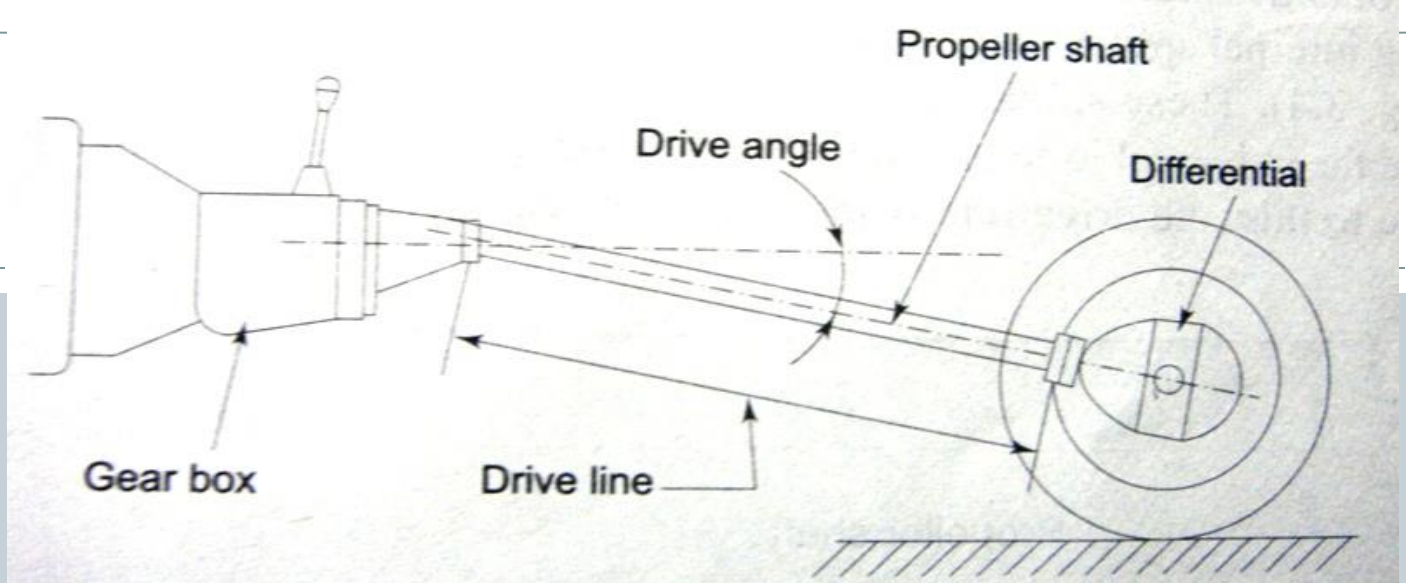


Fig. 3.1 Length of drive line decreased

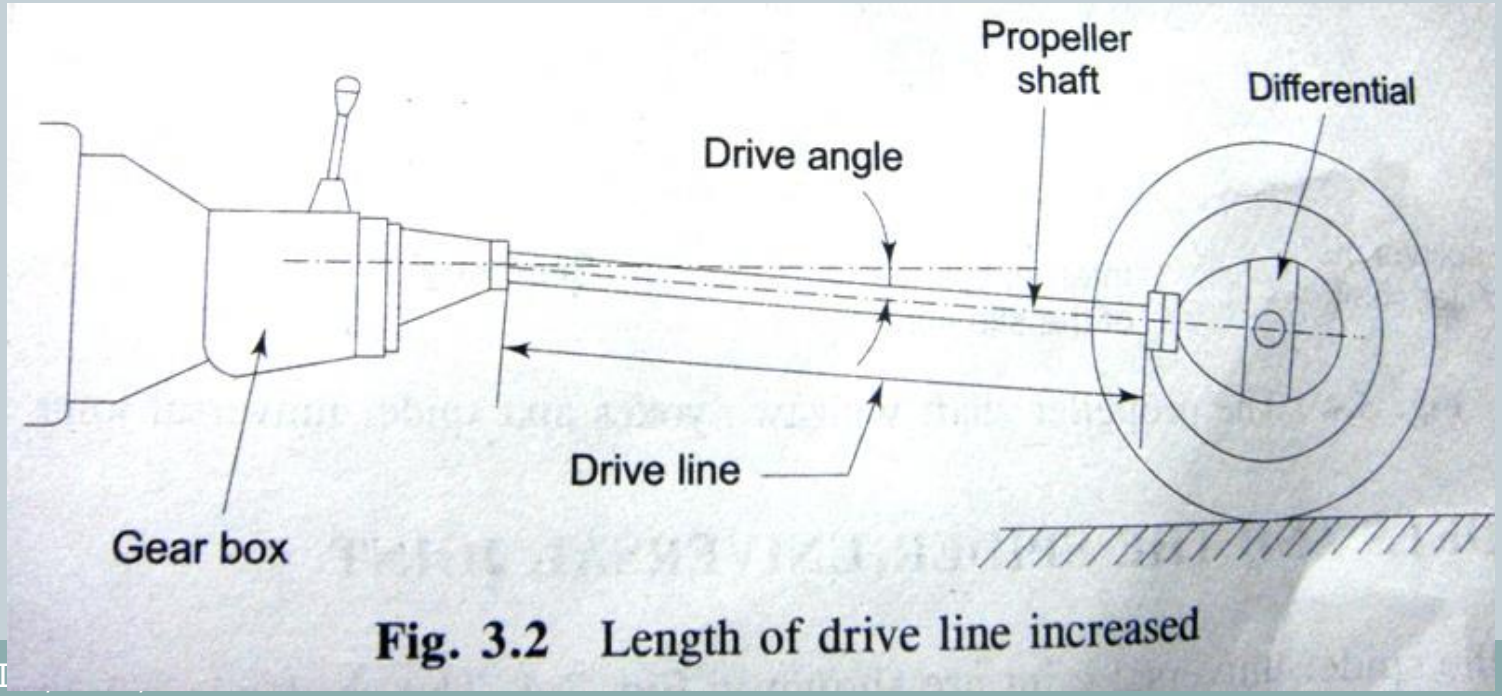


Fig. 3.2 Length of drive line increased

SLIP JOINT

- The slip joint has outside splines on the propeller shaft and matching internal splines on the universal joint yoke.

- These splines cause the propeller shaft and universal joint to rotate together, but permit the two to move endwise in relation to each other. Due to this the drive line is increased or decreased.

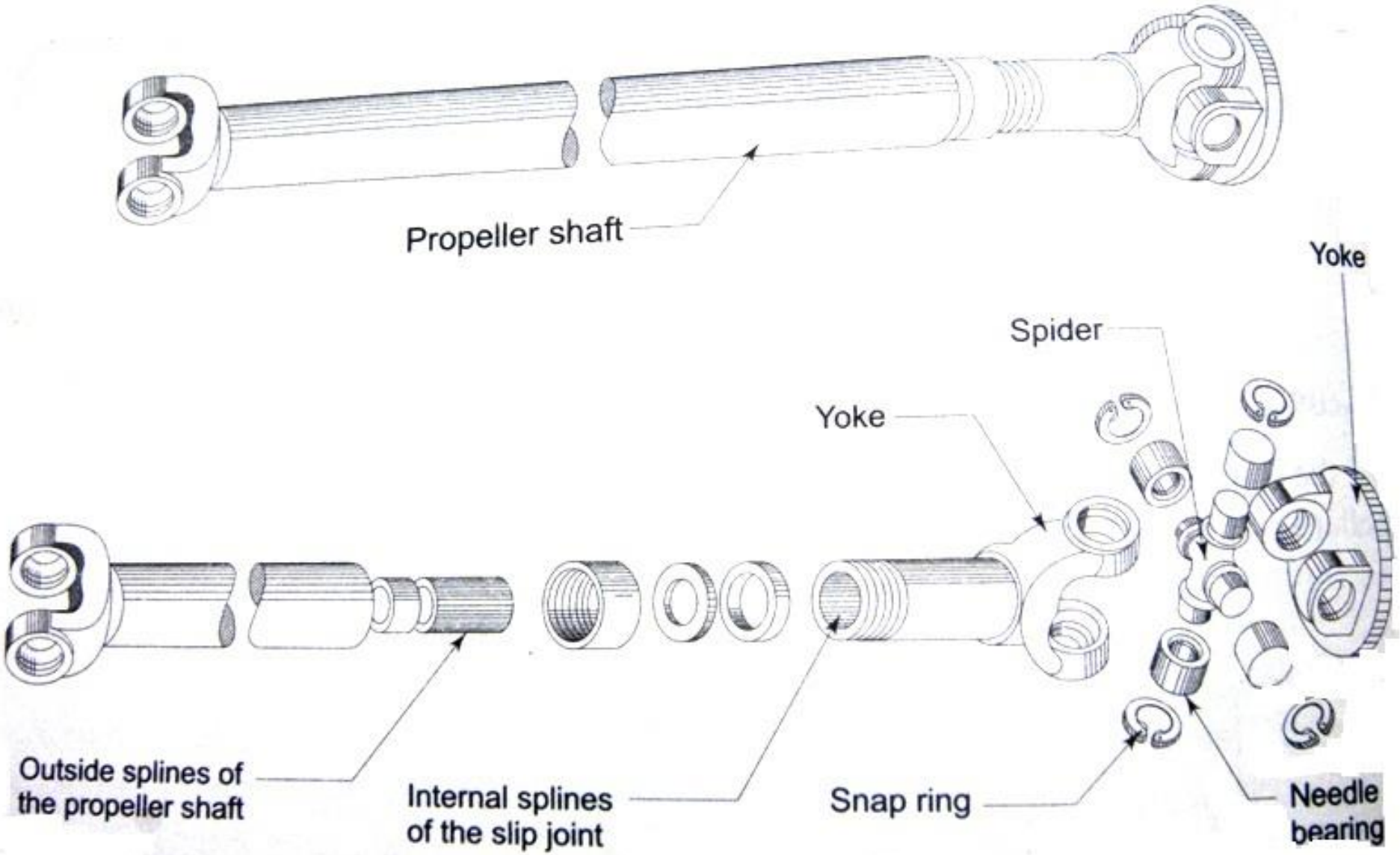


Fig. 3.4 The propeller shaft with two yokes and spider universal joint

FINAL DRIVE AND DIFFERENTIAL

- The functions of the final drive are
  - To provide a permanent speed reduction
  - To turn the drive round 90 degrees.
- The final drive in practice consists of a bevel pinion and a crown wheel
- Types of final drive gears
  - Straight bevel gears
  - Spiral bevel gears
  - Hypoid bevel gears

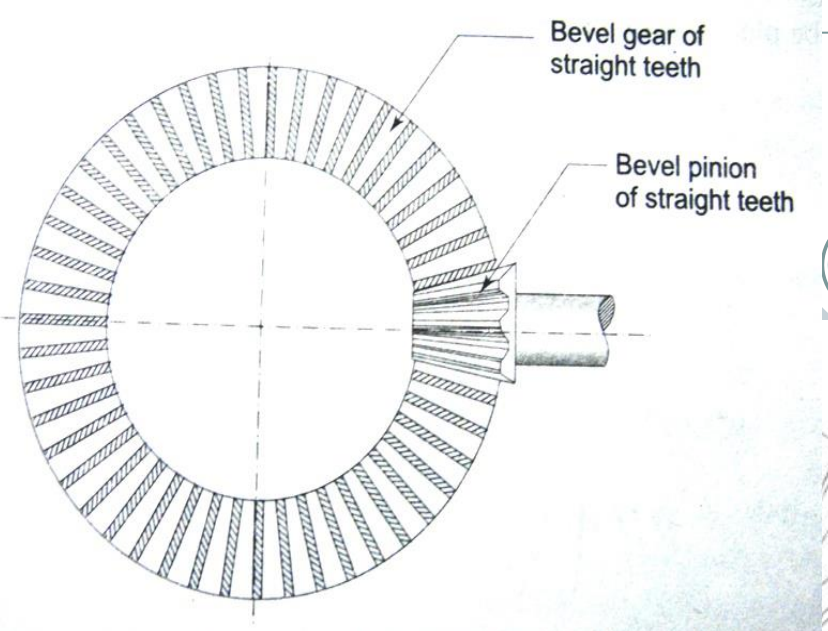


Fig. 4.4 Meshing of straight bevel gears

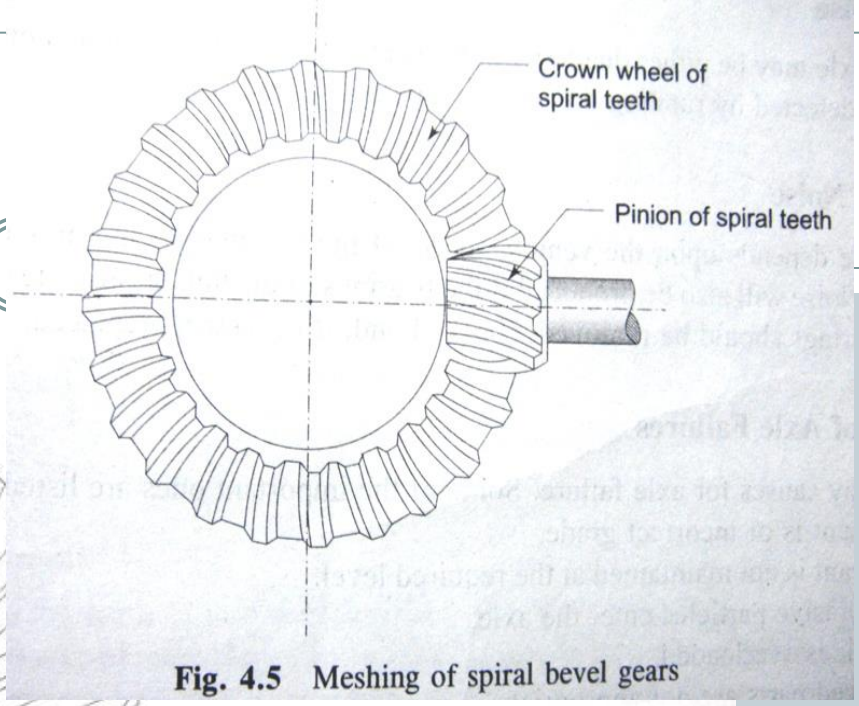


Fig. 4.5 Meshing of spiral bevel gears

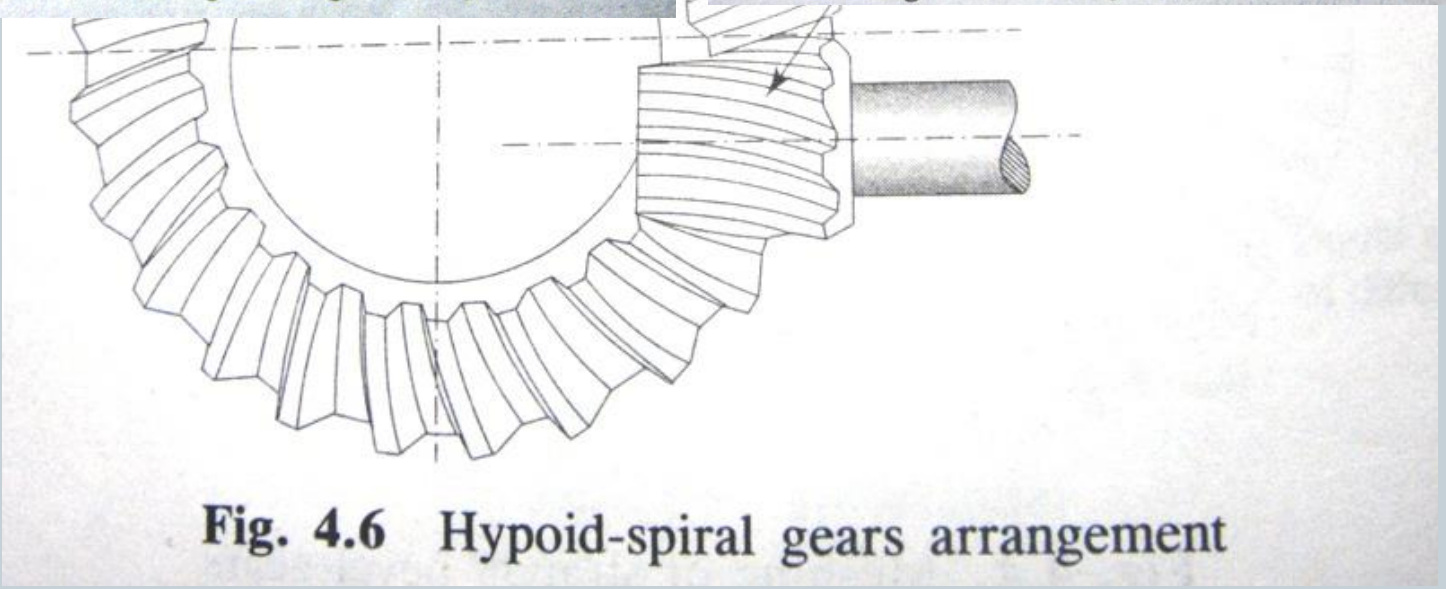
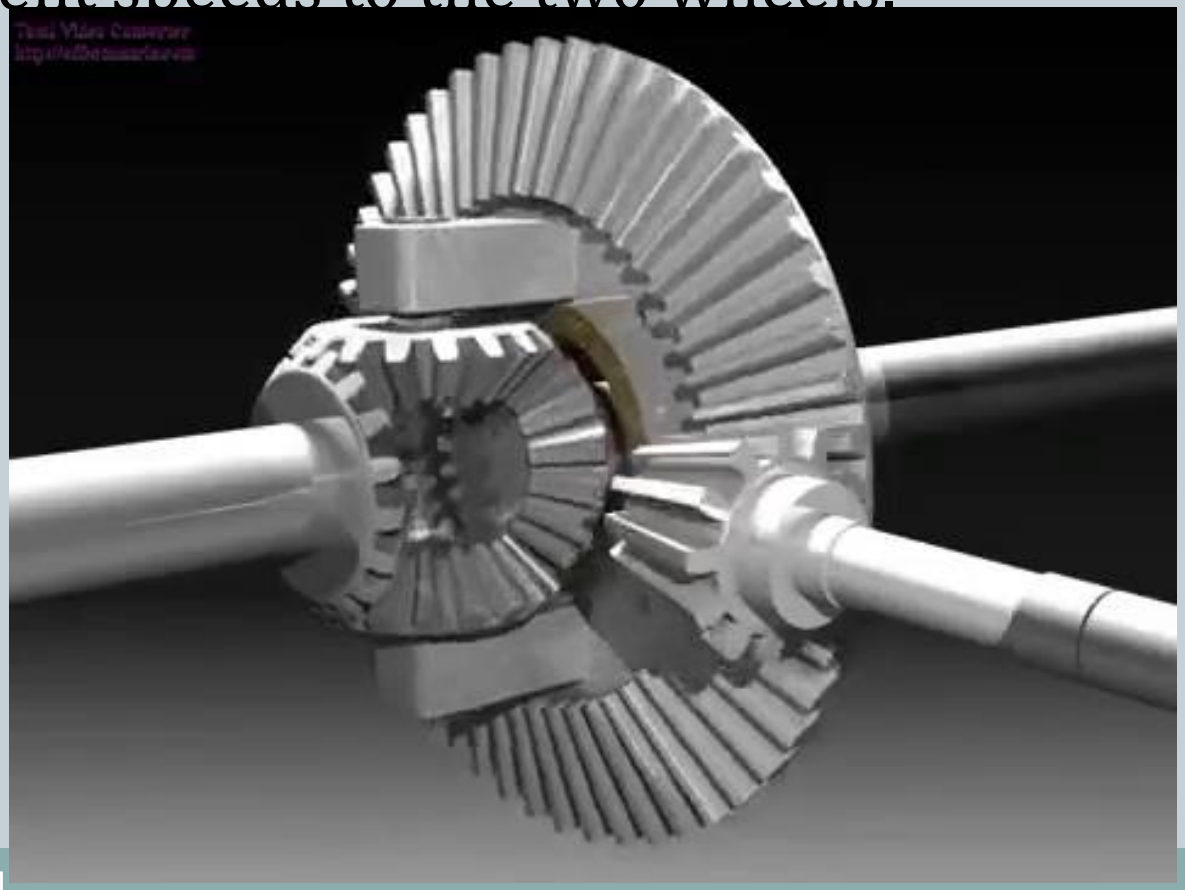


Fig. 4.6 Hypoid-spiral gears arrangement

DIFFERNTIAL

- The function of differential unit is to allow different speeds to the two wheels.



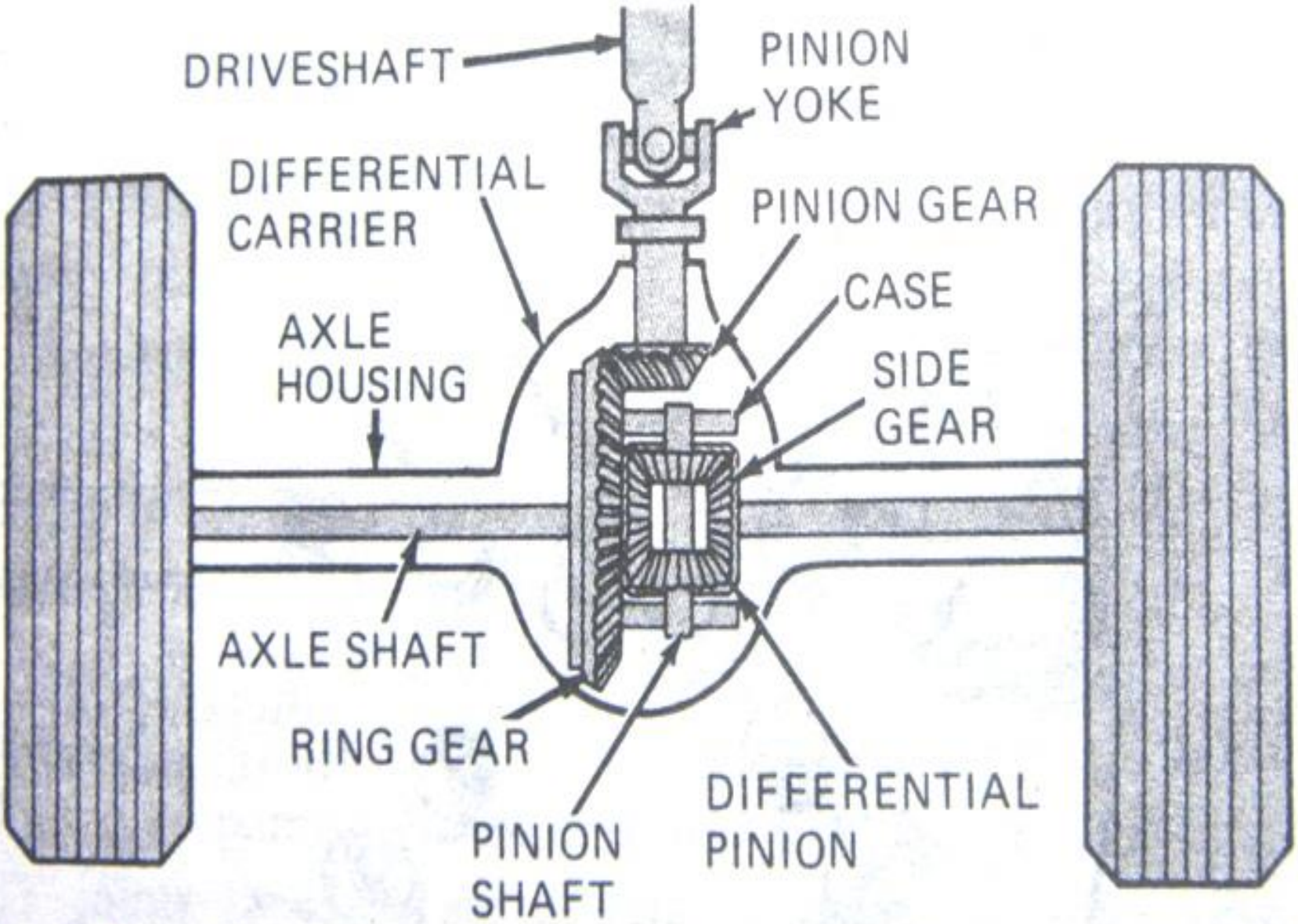


Fig. 45-13 Rear drive axle, showing the gears and shafts in the final drive and differential. (*ATW*)

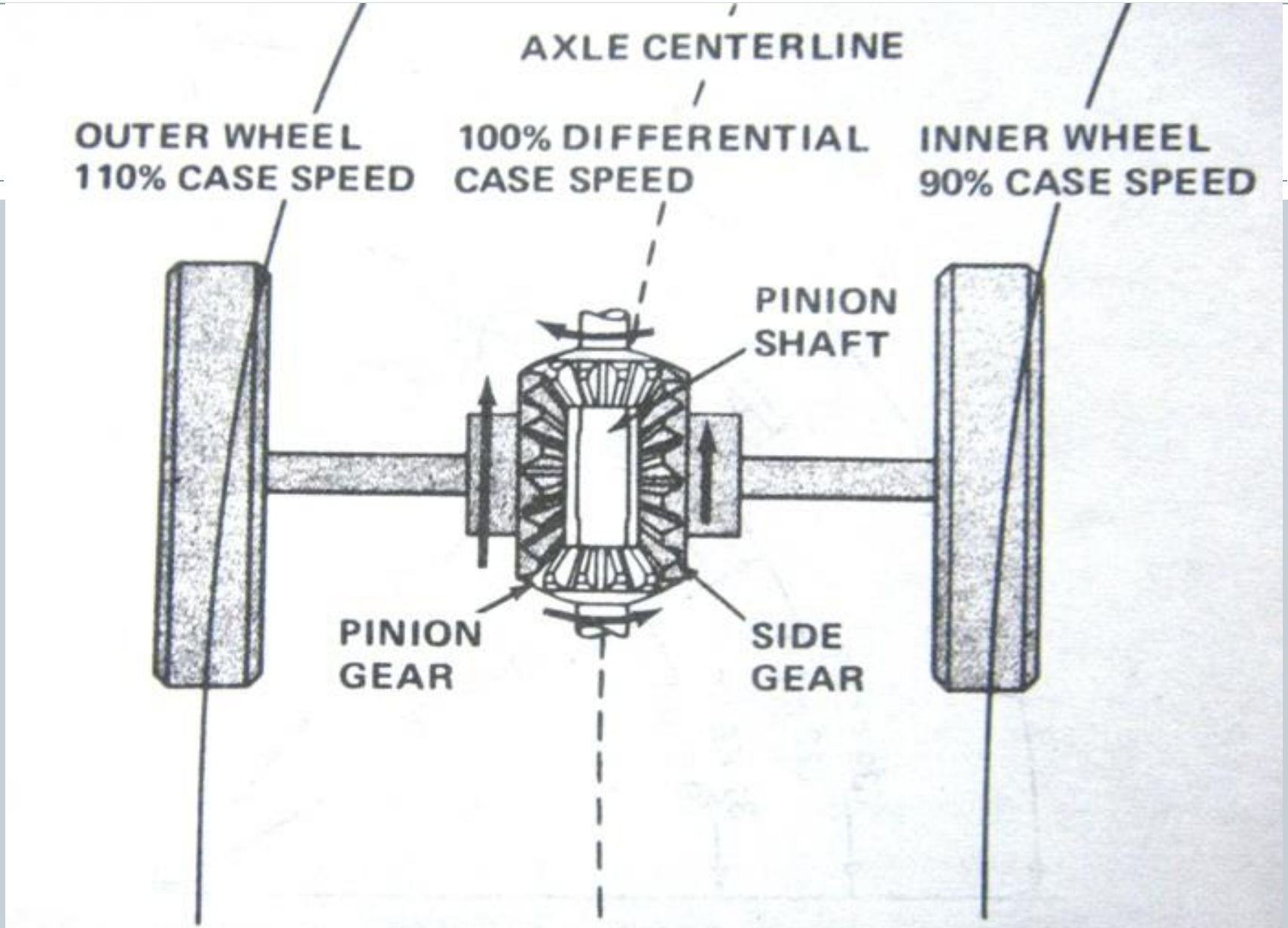


Fig. 45-18 Differential action on turns. (*Chevrolet Division of General Motors Corporation*)

UNIT – IV STEERING, BRAKES AND SUSPENSION SYSTEMS

STEERING LINKAGES

Steering linkages depends on

- Vehicle with rigid axle type front suspension
- Vehicle with independent front suspension

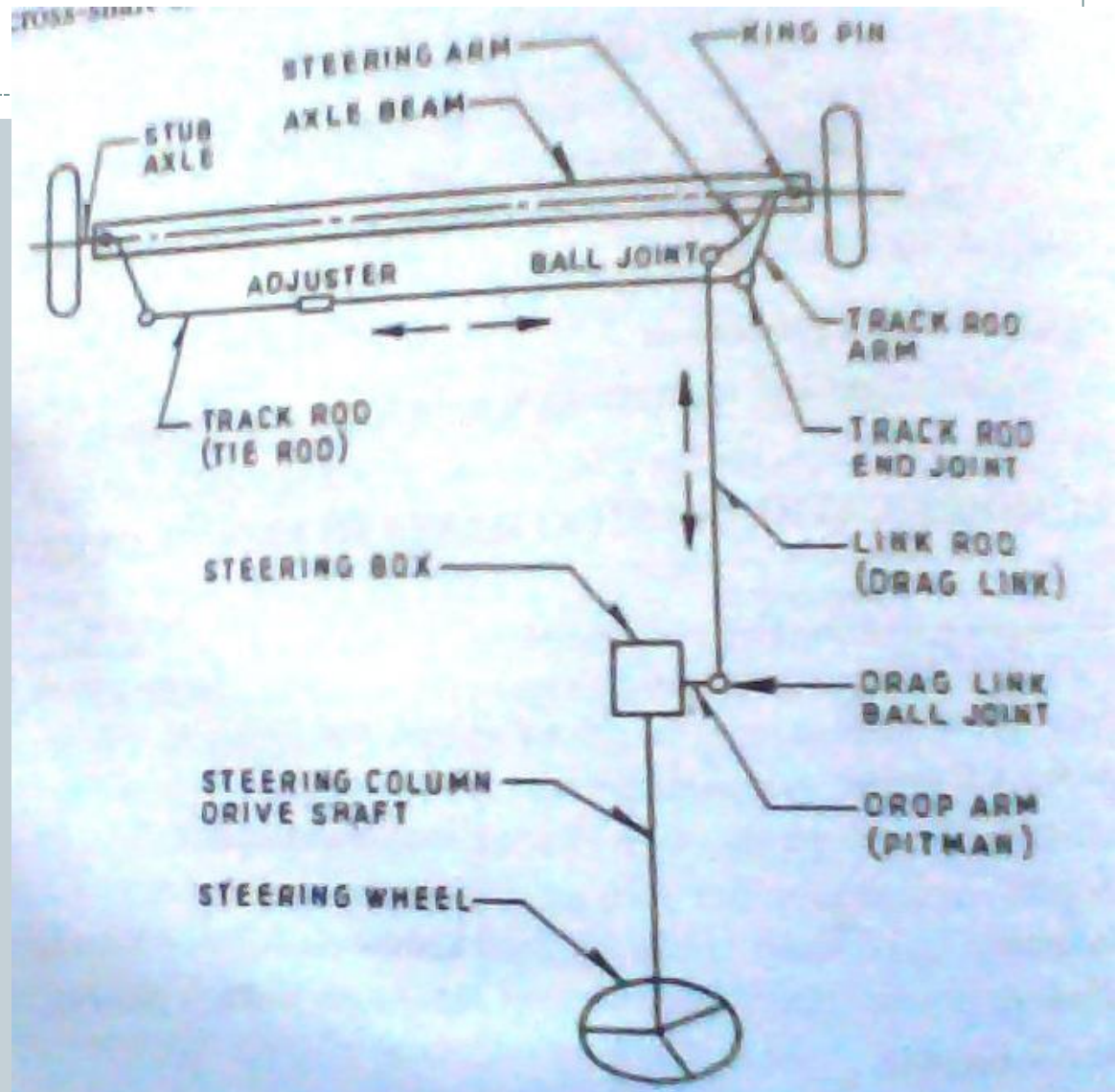


Fig. 8.33. Steering linkage for rigid axle suspension

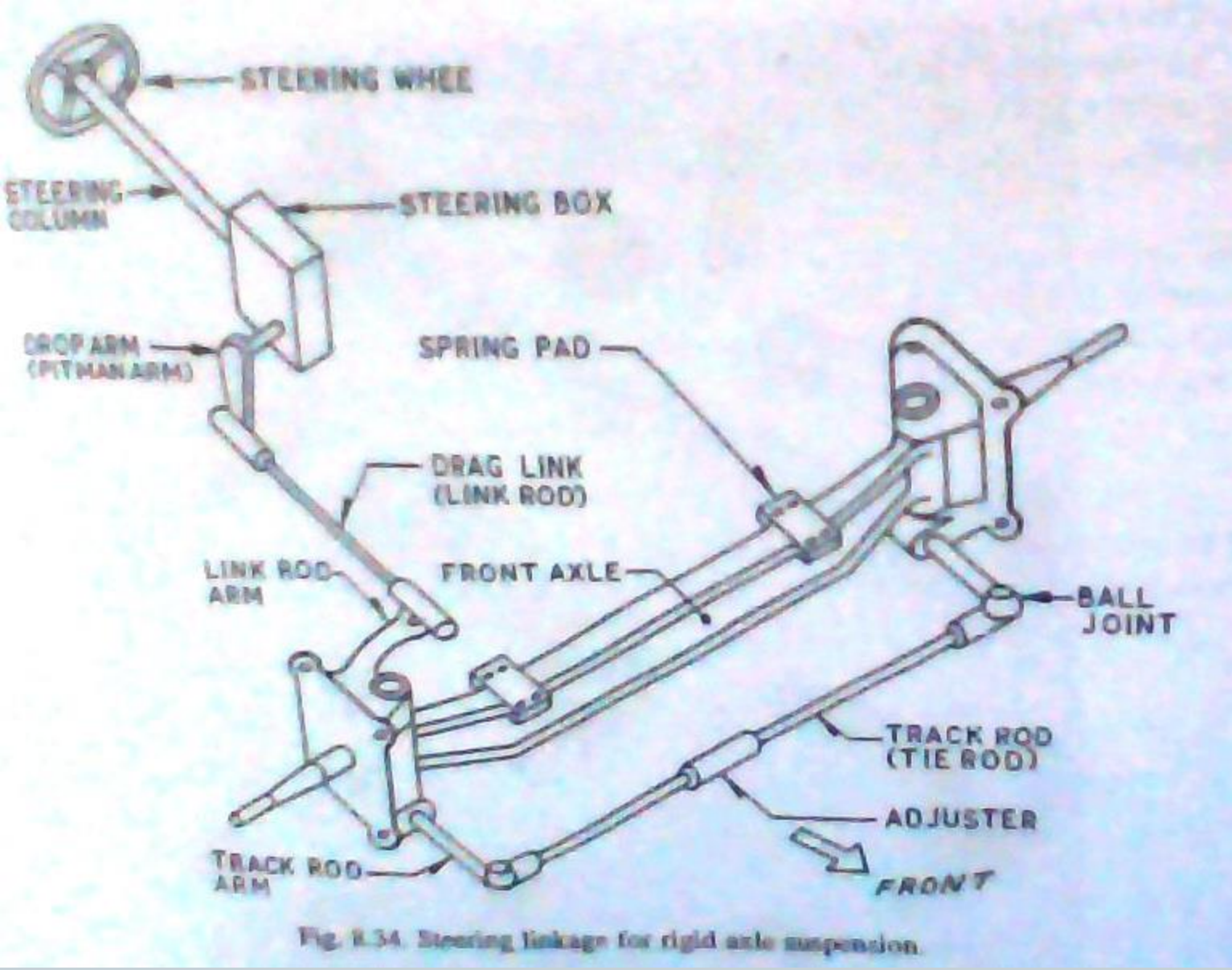


Fig. 8.34 Steering linkage for rigid axle suspension

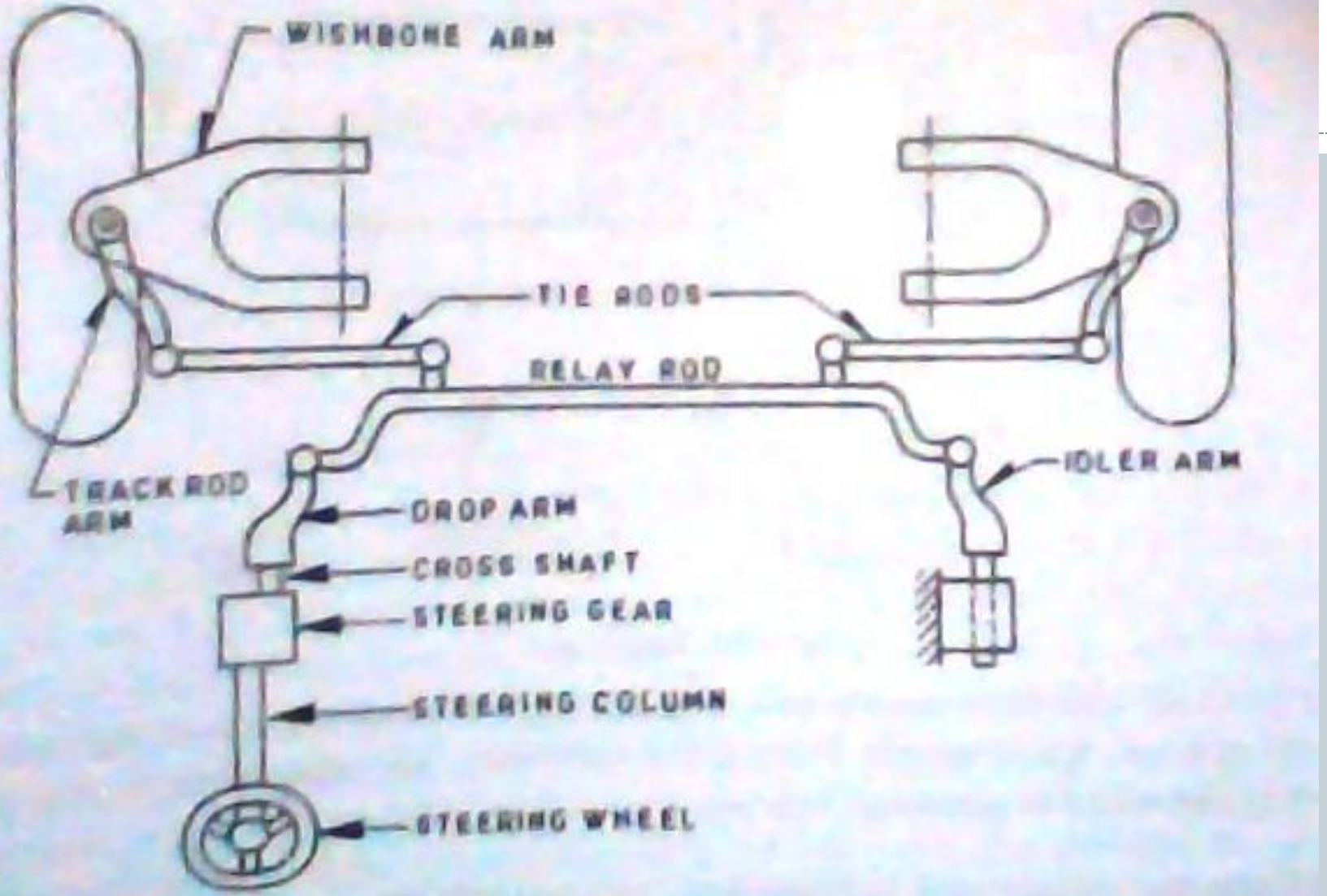


Fig. 8.37 Steering linkage for independent suspension.

STEERING GEARS

- The steering gear converts the turning motion of the steering wheel into the to-and-fro motion of the link rod of the steering linkage.
- It also provides the necessary leverage so that the driver is able to steer the vehicle without fatigue.

Types:

1. **Worm and wheel steering gear**
2. **Cam and double roller steering gear**
3. **Worm and nut steering gear**
4. **Re-circulating ball type steering gear**
5. **Rack and pinion steering gear**

1. WORM AND WHEEL STEERING GEAR

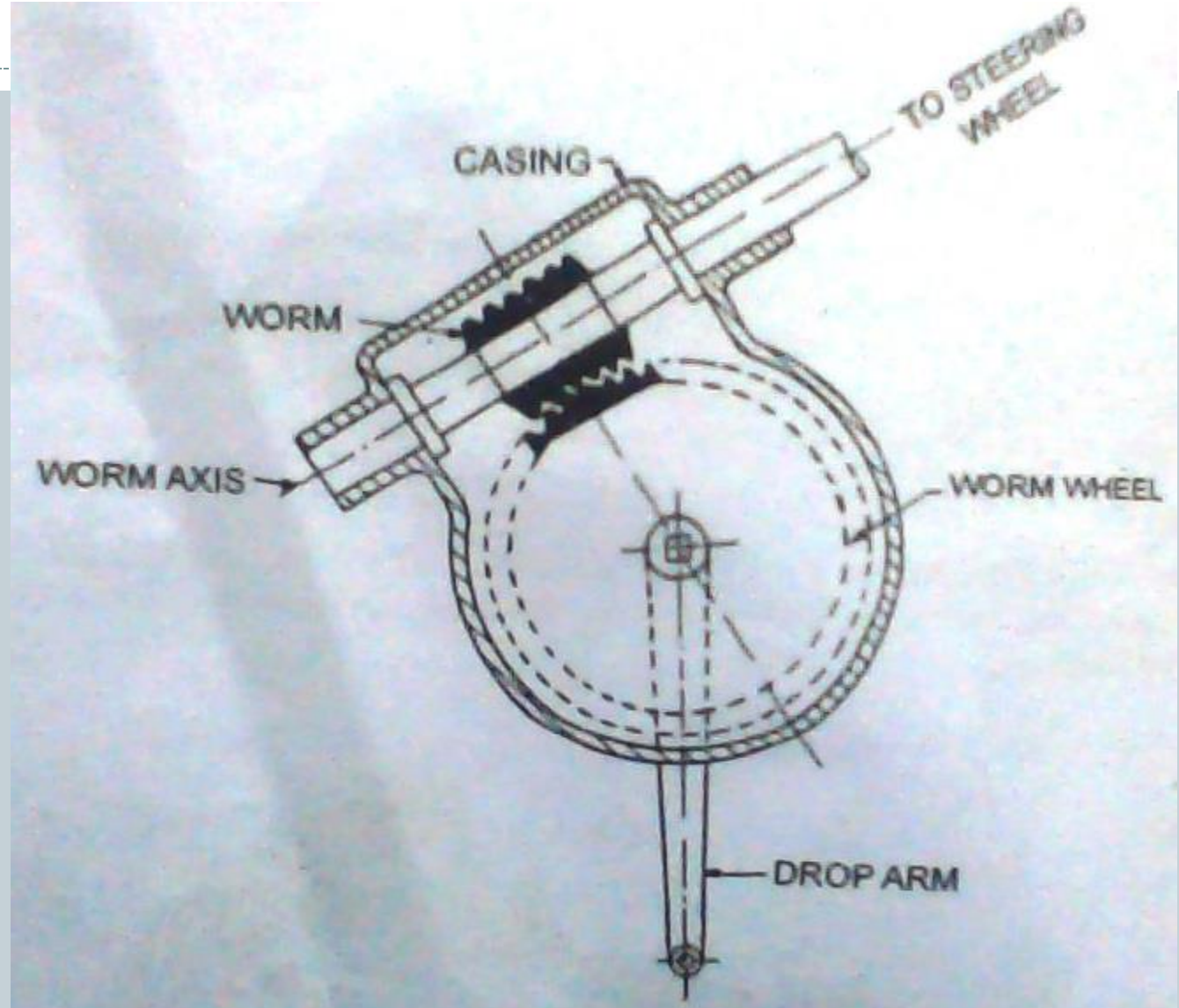


Fig. 8.39. Worm and wheel steering gear.

2. CAM AND DOUBLE ROLLER STEERING GEAR

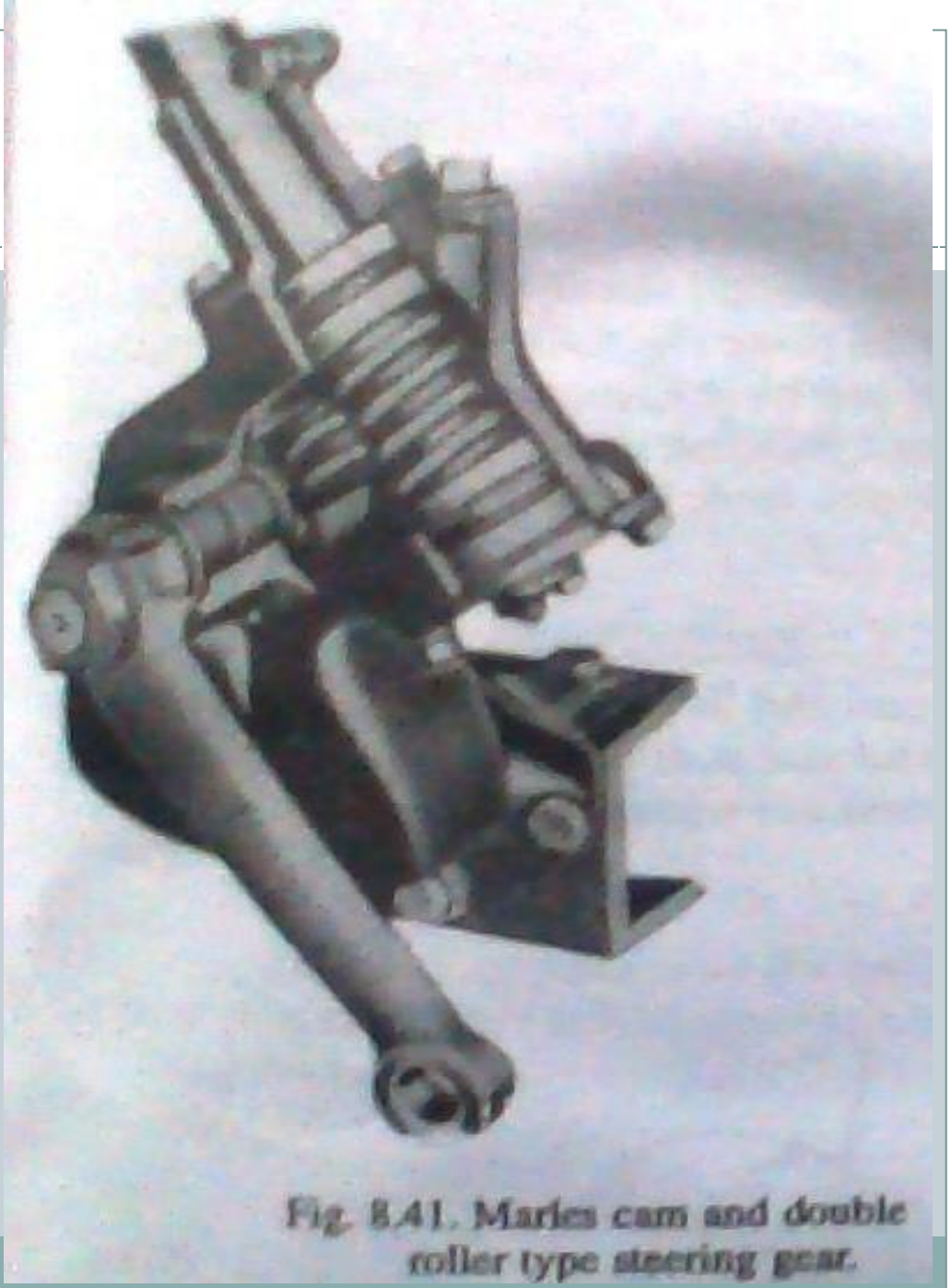


Fig. 8.41. Marles cam and double roller type steering gear.

3. WORM AND NUT STEERING GEAR

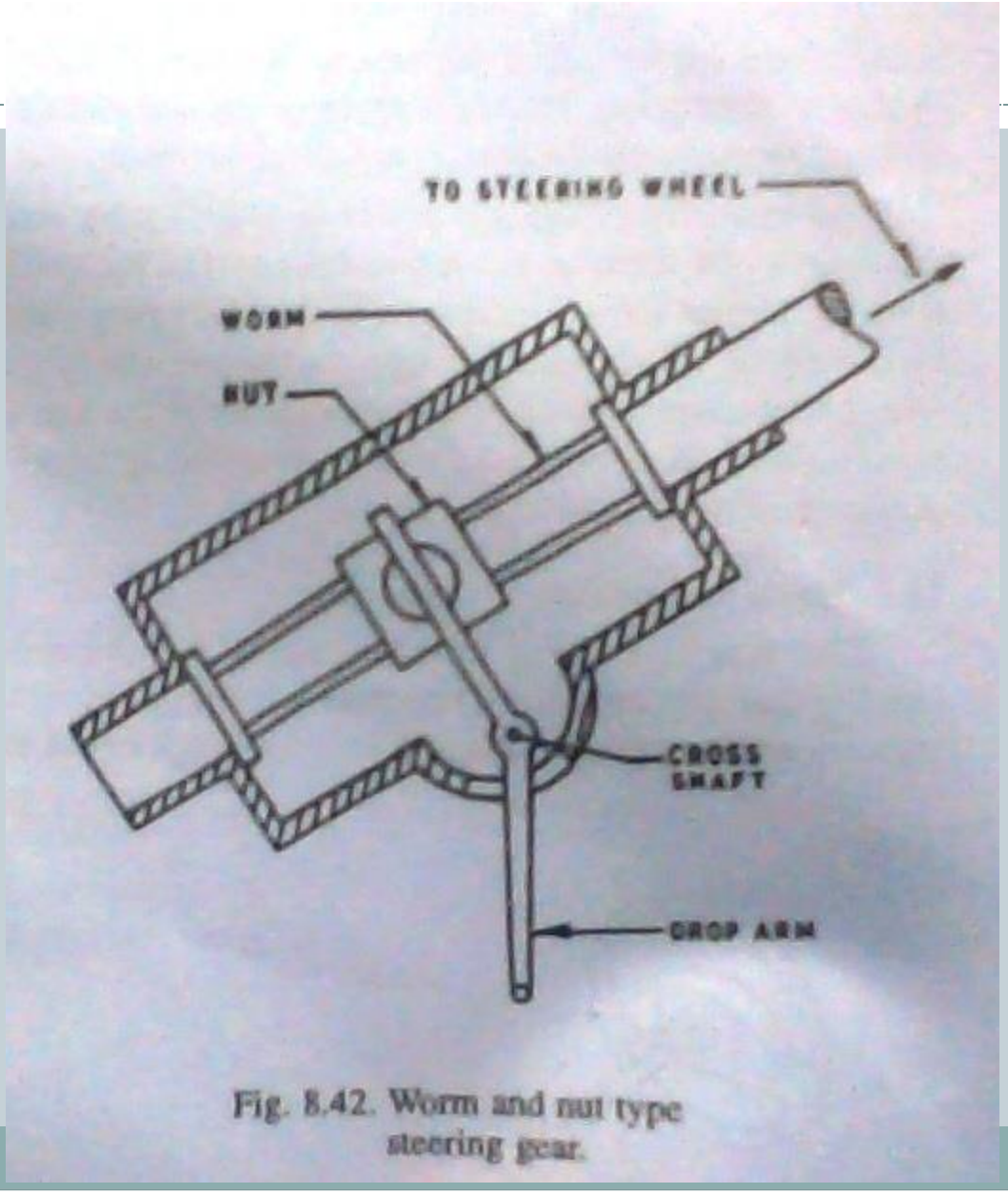


Fig. 8.42. Worm and nut type steering gear.

4. RECIRCULATING BALL TYPE STEERING GEAR

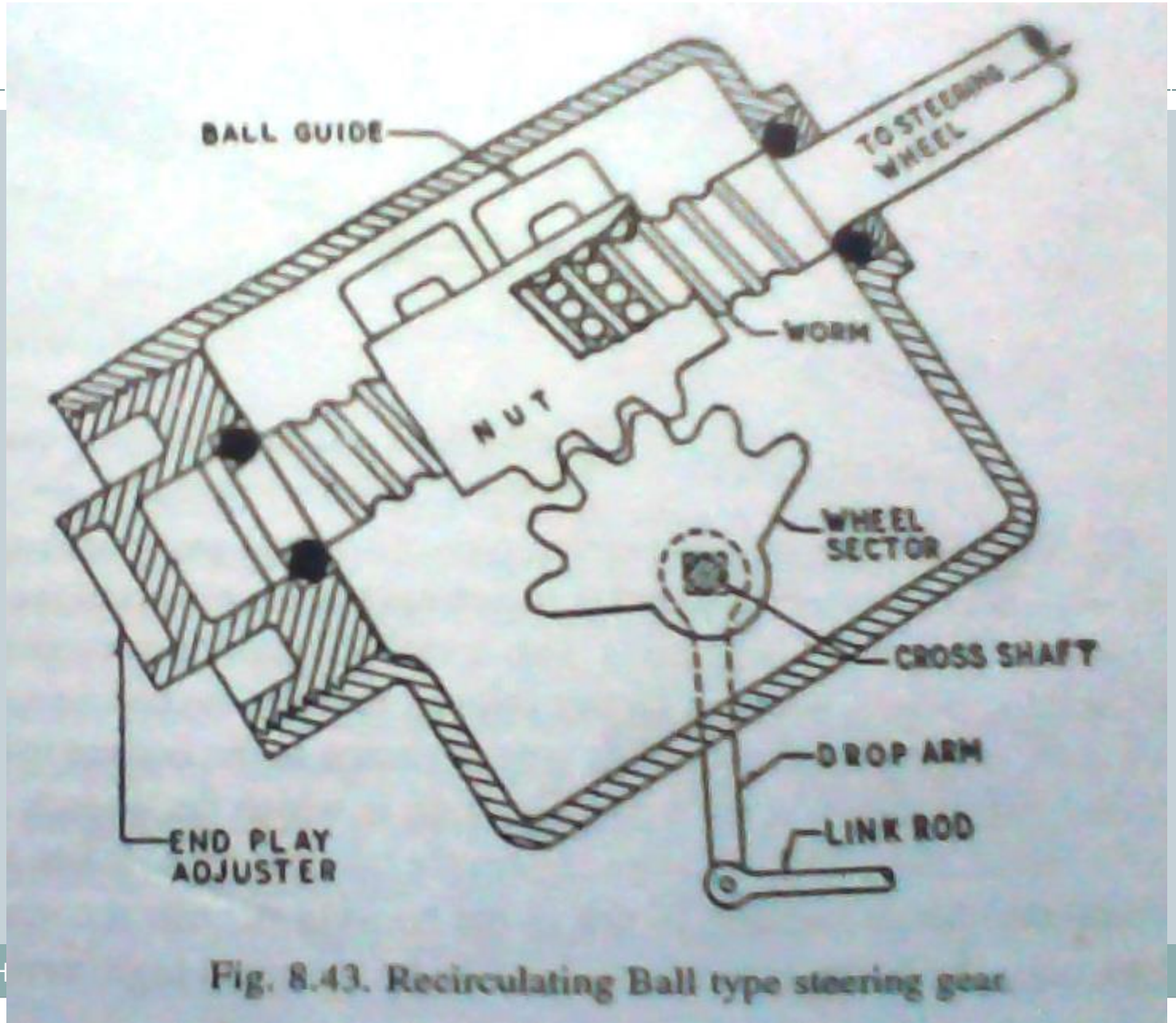


Fig. 8.43. Recirculating Ball type steering gear

5. RACK AND PINION STEERING GEAR

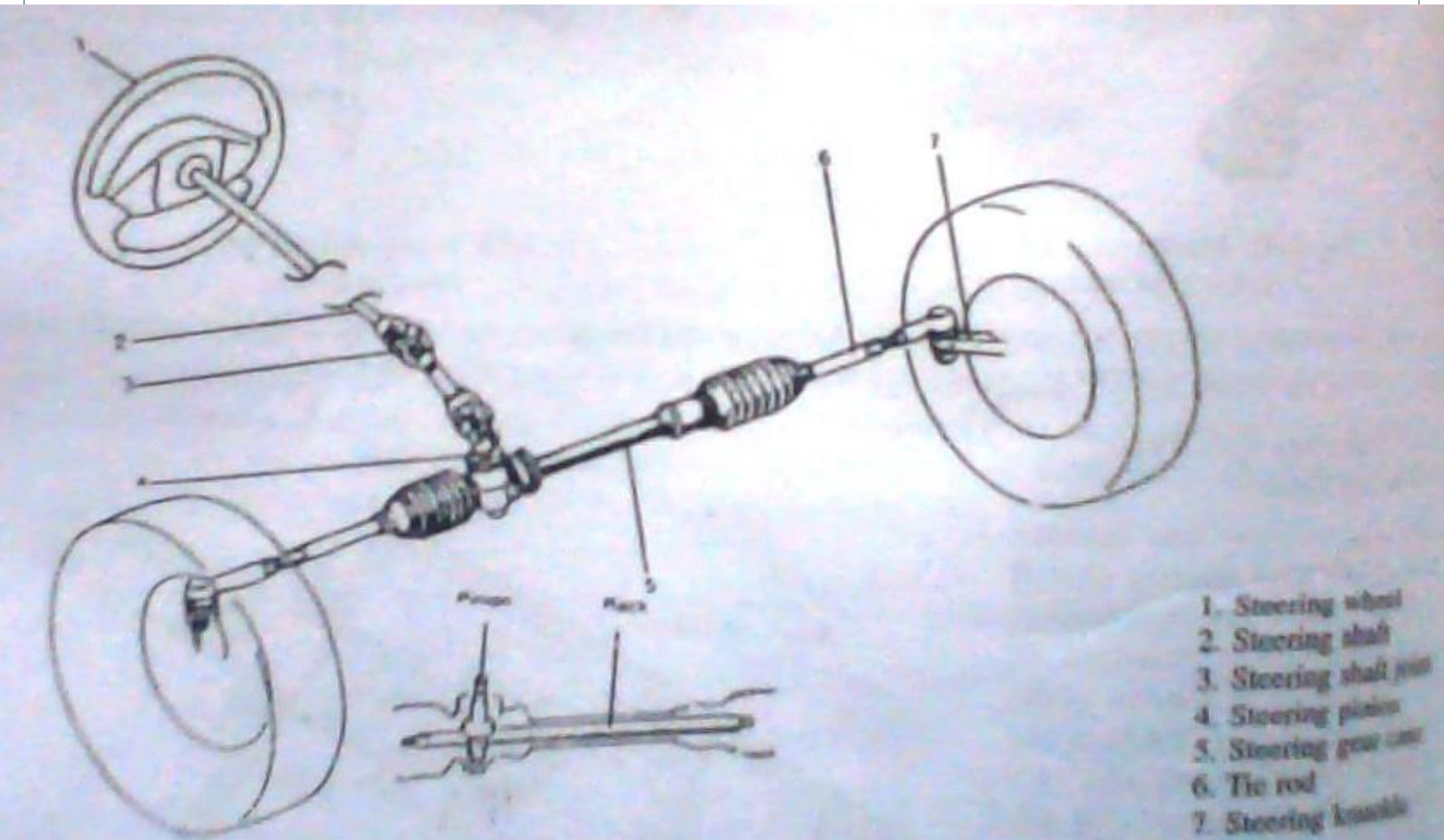


Fig. 8.44. Rack and pinion steering system
(Courtesy—Maruti Udyog Ltd., India)

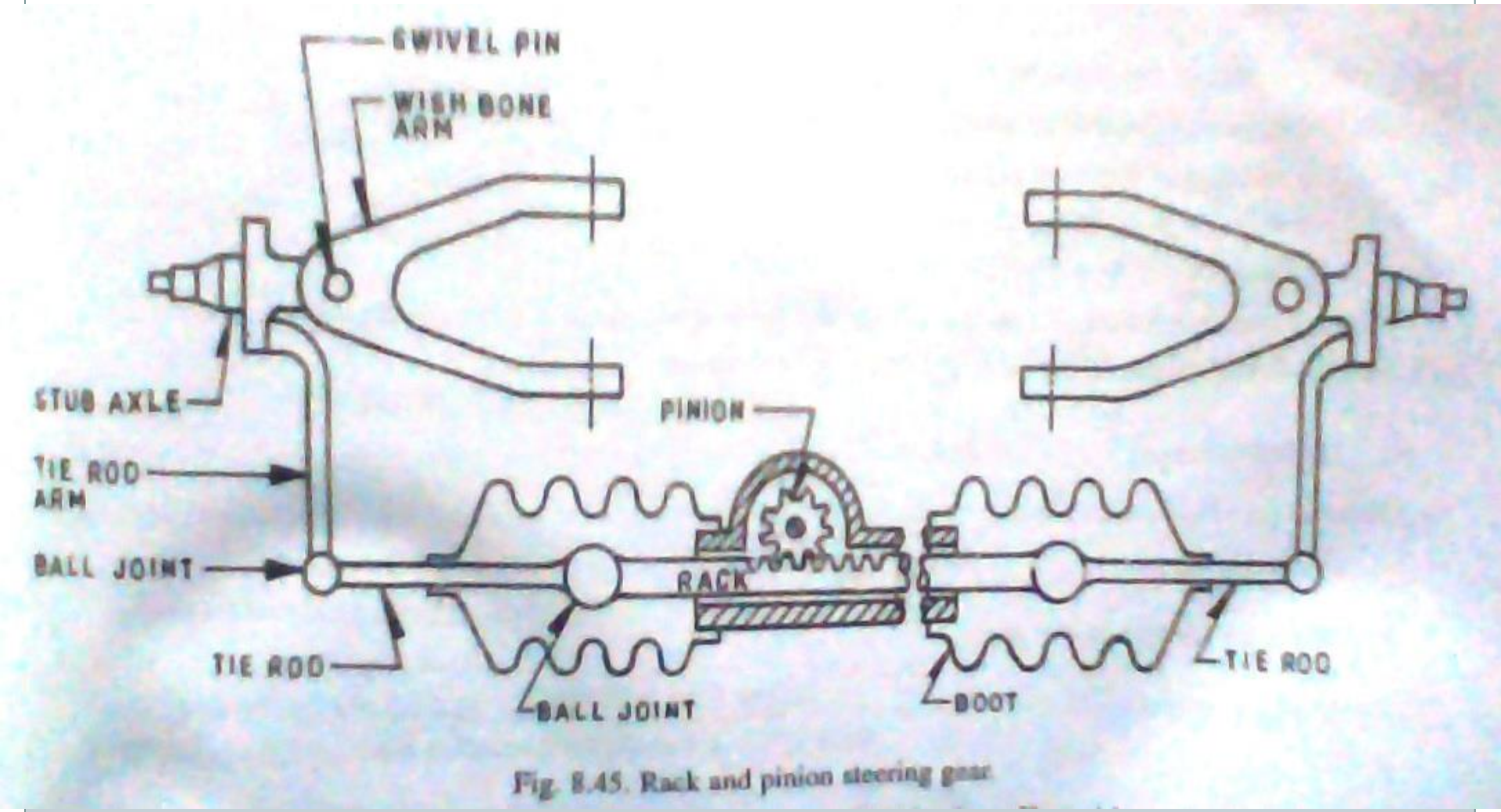


Fig. 8.45. Rack and pinion steering gear

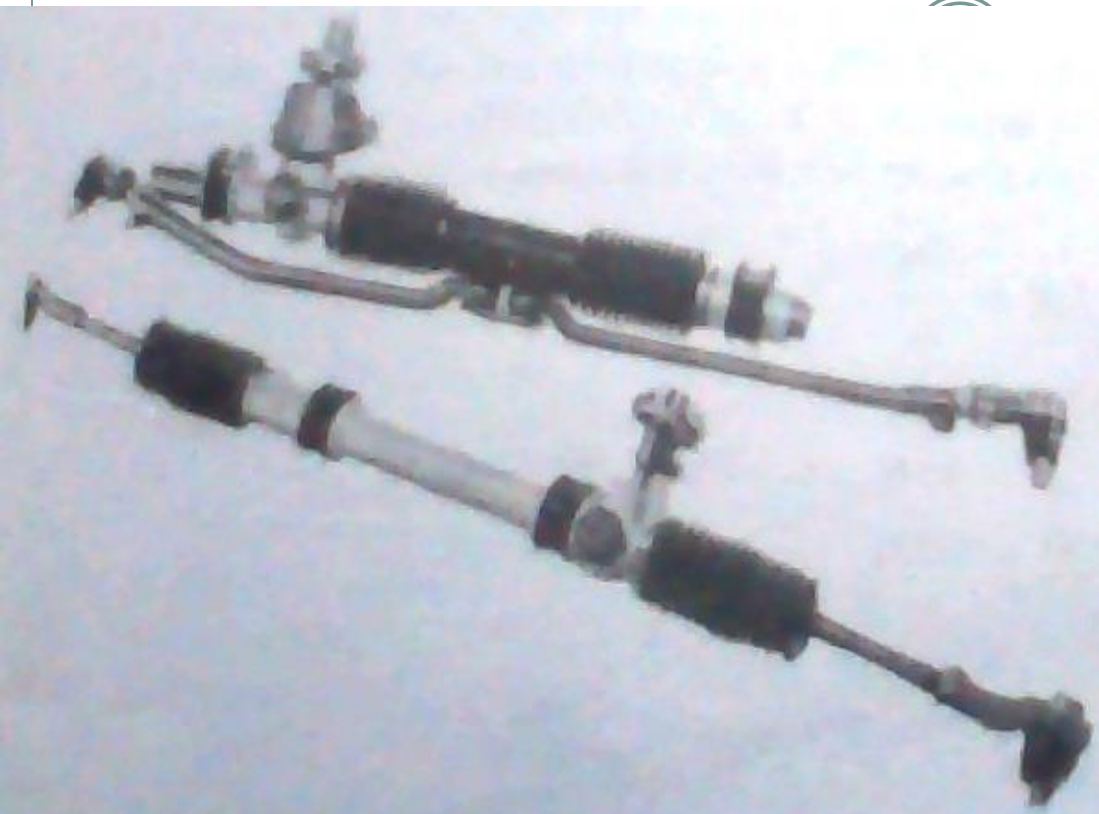


Fig 8.46. Saginaw Rack and pinion steering gears
Top-centre take off. Bottom-end take off.

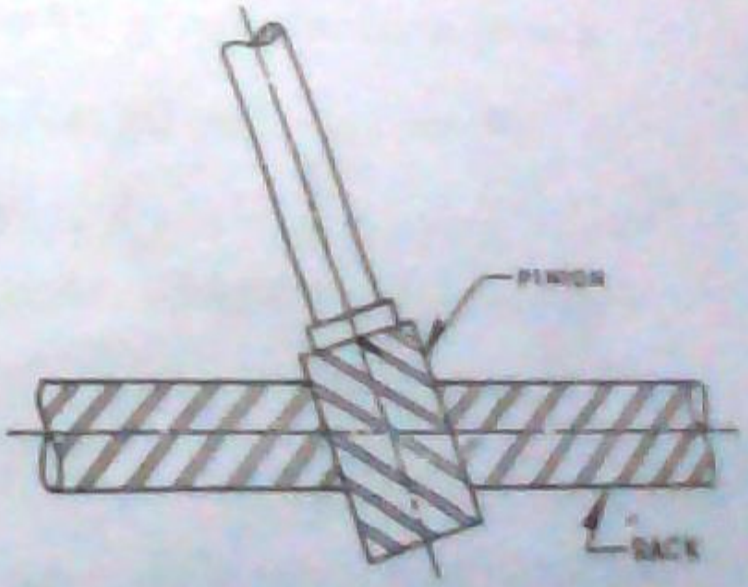


Fig. 8.47. Tilting the pinion axis

POWER STEERING

- Large amount of torque is required to steer the medium and heavy vehicles.
- The power steering system provides automatic hydraulic assistance to the turning effort applied to the manual steering system.

Advantages

- Steering effort is reduced
- Turning of steering wheel is reduced
- Excellent maneuverability
- The hydraulics absorbs the road shocks instead of its transmission to steering wheels as in manual system. So there is less driver fatigue.

Types of Power Steering

- Power steering is either
  - **rack-and-pinion (or)**
  - **conven-tional recirculating ball and nut units (or)**
  - **electronic**

  -- Most power steering systems are integral

- **Recirculating ball power steering**

  -- Gear boxes use pivot lever or torsion bar acting on spool valve

- **Rack-and-pinion systems**

  -- Fluid is directed to a chamber on either side of the rack

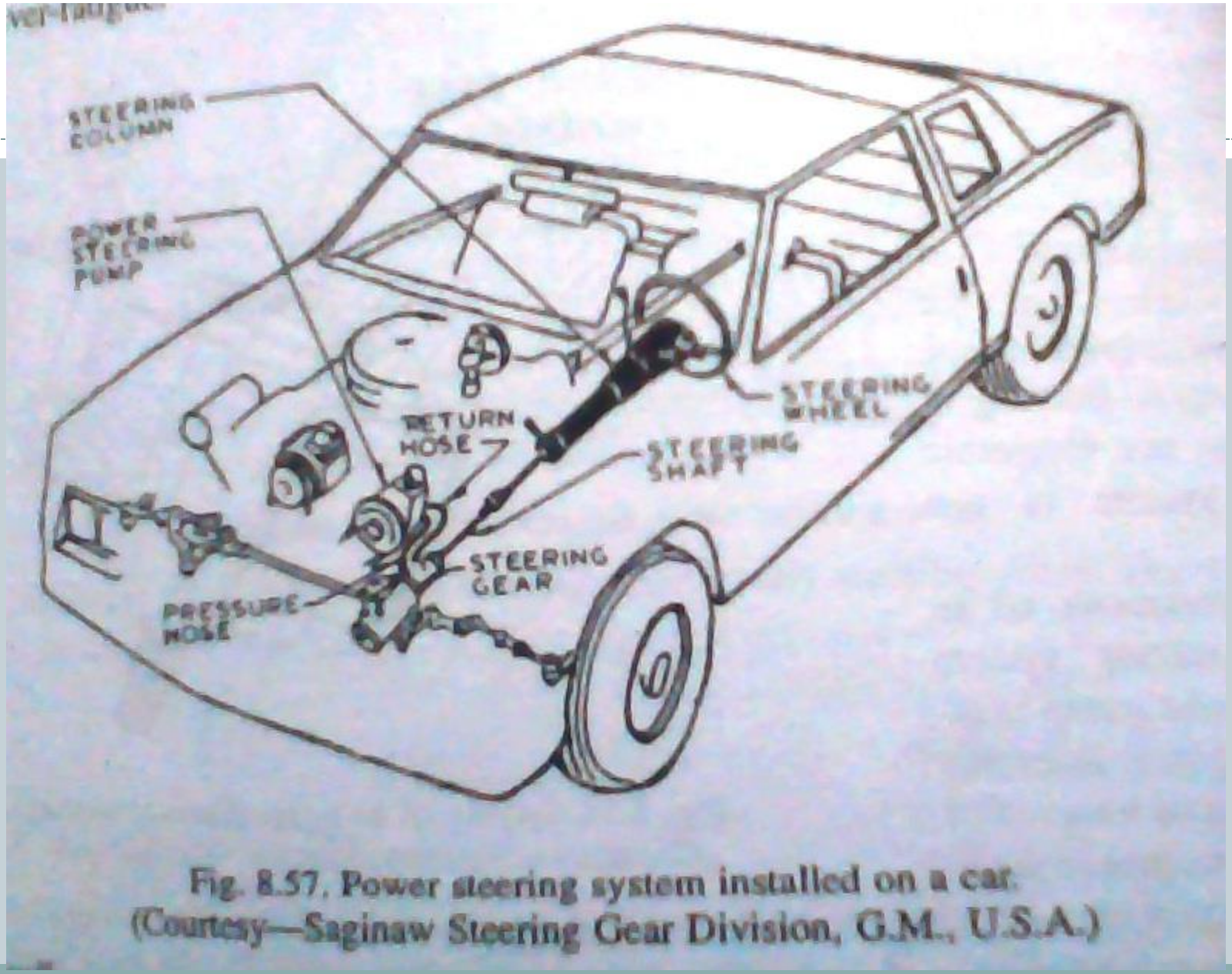


Fig. 8.57. Power steering system installed on a car.
(Courtesy—Saginaw Steering Gear Division, G.M., U.S.A.)

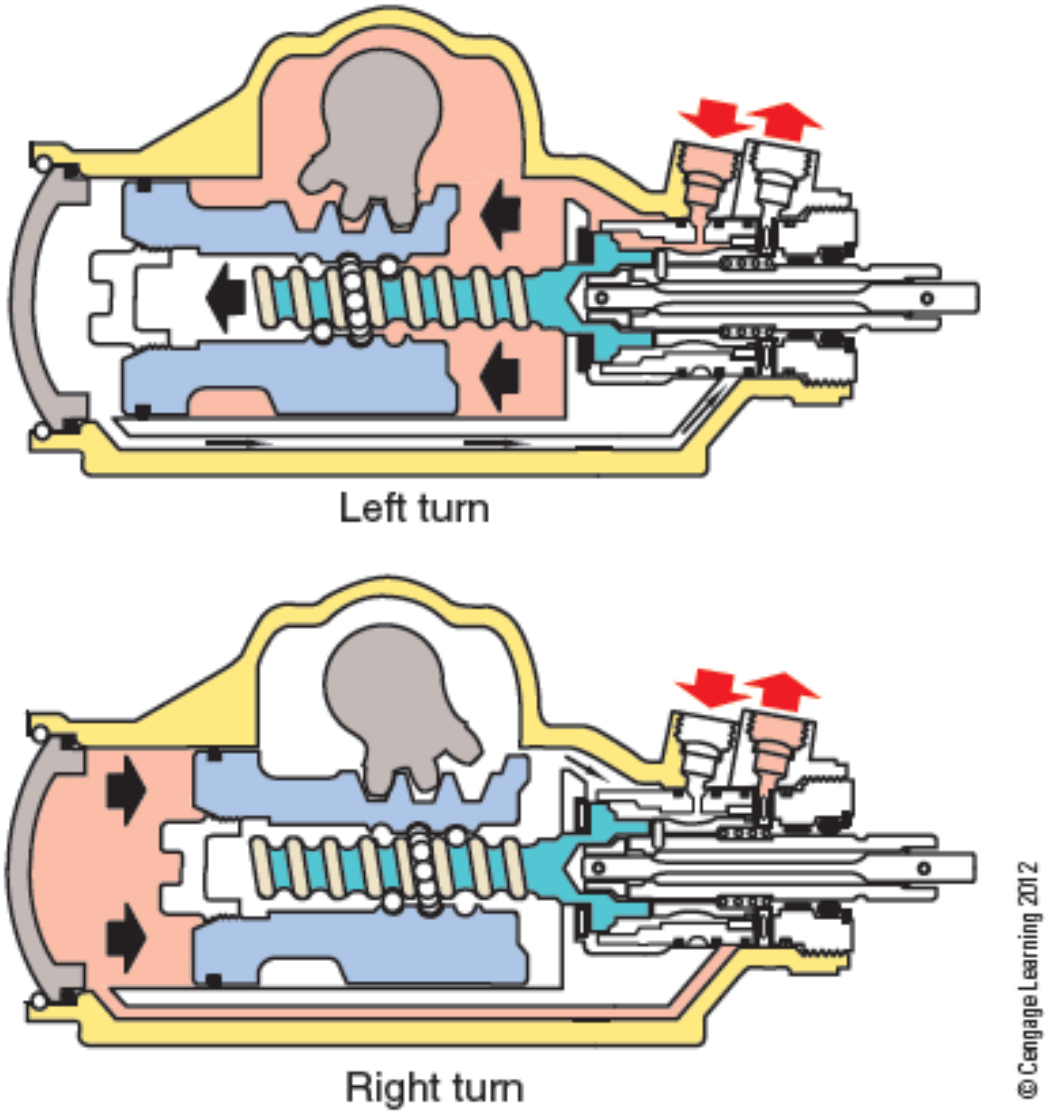


Figure 65.29 Pressurized oil enters a chamber on either side of the power piston to provide steering assist.

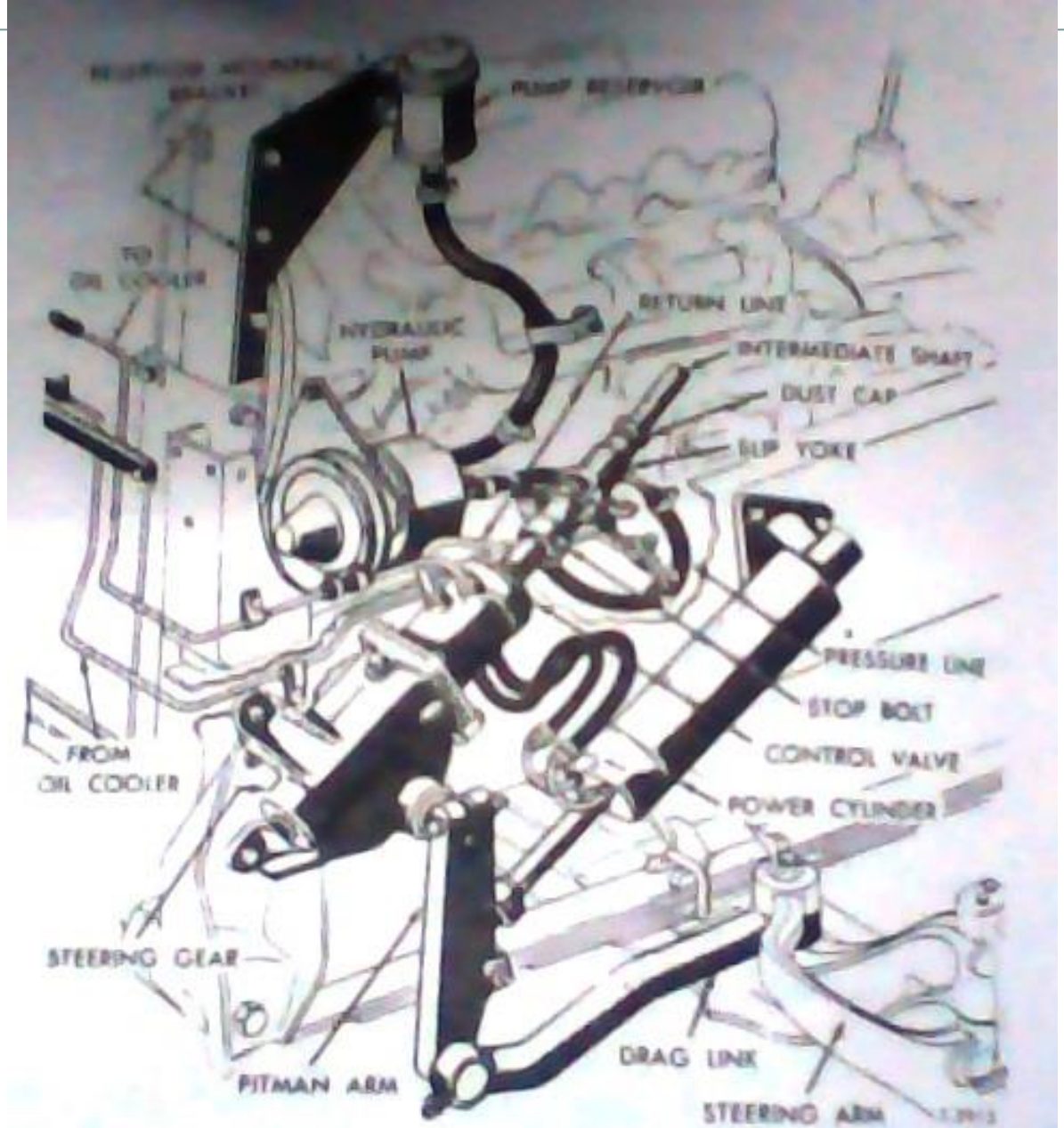


Fig. 8.62. Semi-integral power steering system.
(Courtesy—Saginaw Steering Gear Division, U.S.A.)

ELECTRONIC POWER STEERING

- It consists of 2 sensors located in the input shaft of the steering gear box
  - “torque sensor” which converts the steering torque input and its direction into voltage signals,
  - “rotation sensor” which converts the rotation speed and direction into voltage signals.

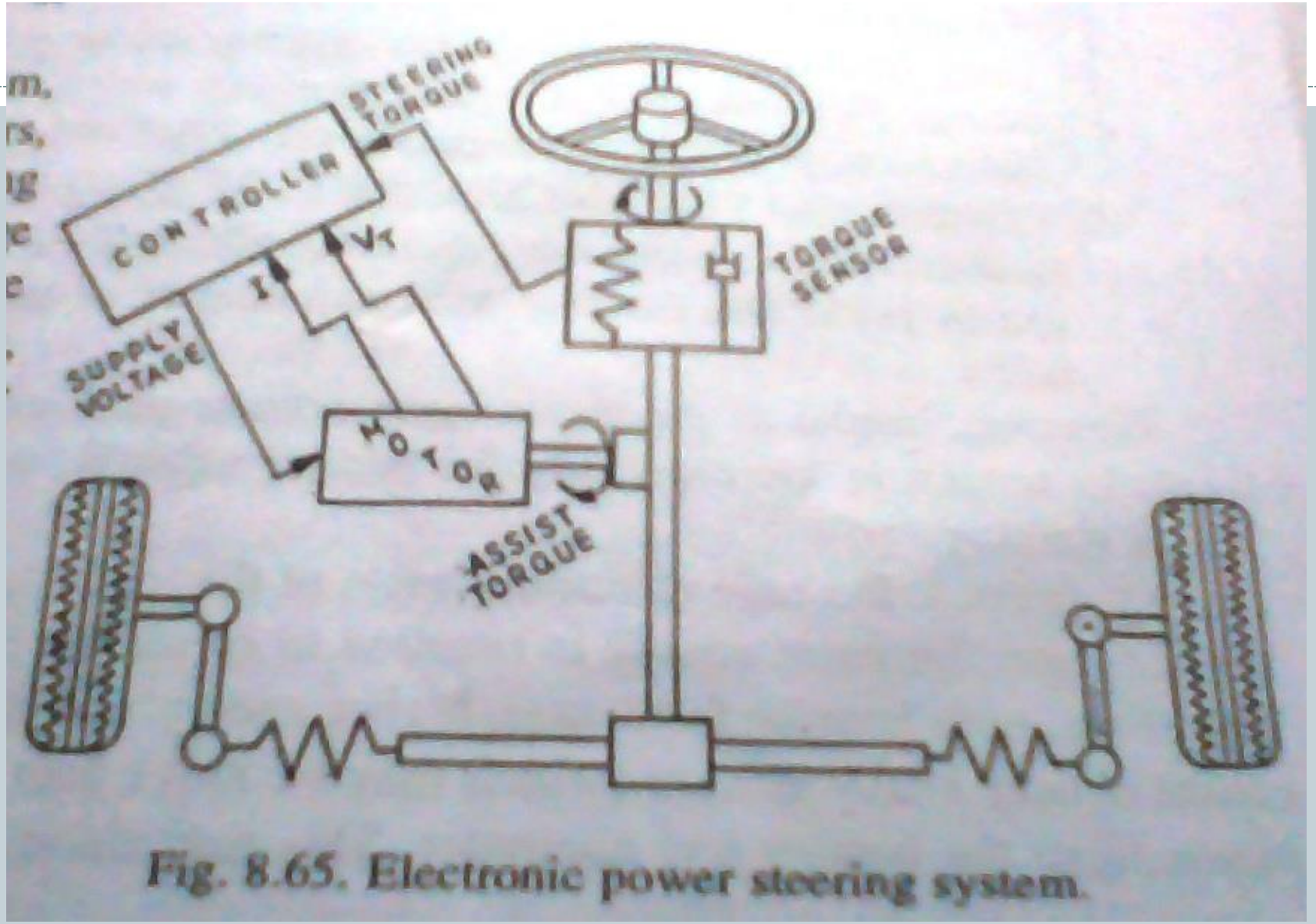


Fig. 8.65. Electronic power steering system.

STEERING OVER HYDRAULIC POWER STEERING

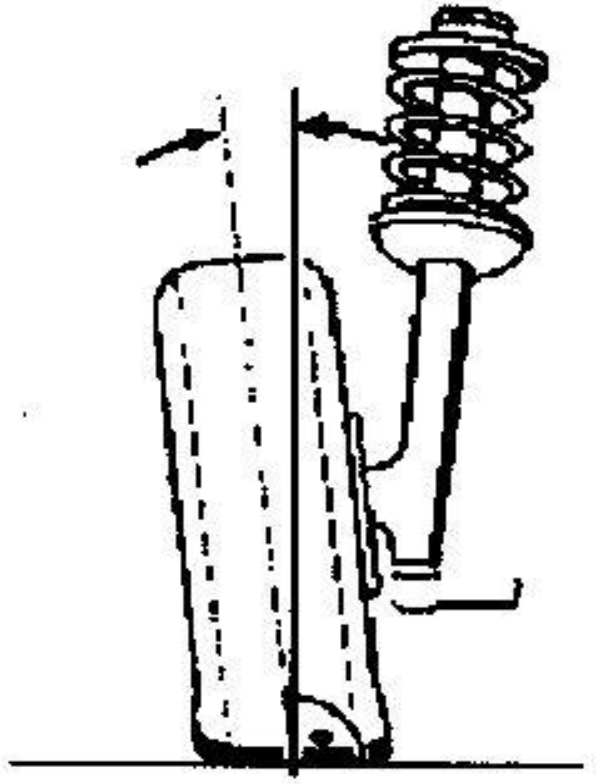
- Elimination of pumps, hoses, hyd. Fluid, drive belt and engine pulley.
- No need for the engine to provide mechanical power for steering.
- No problem of leakage of fluid.
- Steering assistance is available even when the engine is not running.
- Less force is required.
- Cost effective

WHEEL ALLIGNMENT PARAMETERS

- CAMBER
- CASTER
- TOE
- STEERING AXIS INCLINATION
- TURNING RADIUS

CAMBER

- Inward or outward tilt of the wheel at the top when viewed from the front of the car.
- It is measured in degrees of a circle.
- Camber places the tire tread flat on the road reducing tire wear and improving vehicle handling
- Excessive camber will cause wear on the edge of the tire's tread



Positive Camber

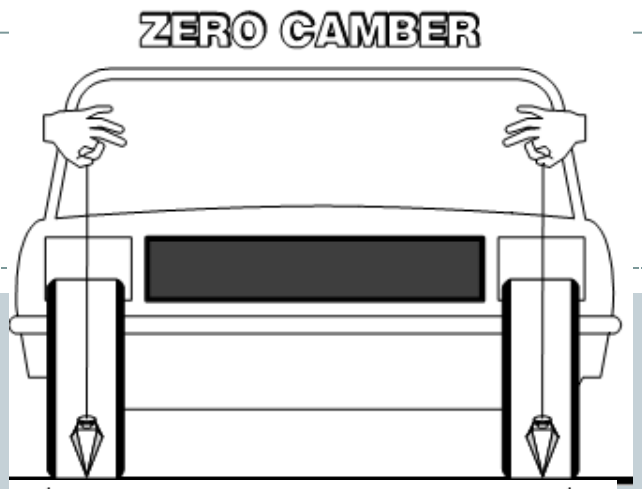
- When camber is positive the tire leans out away from the vehicle at the top.

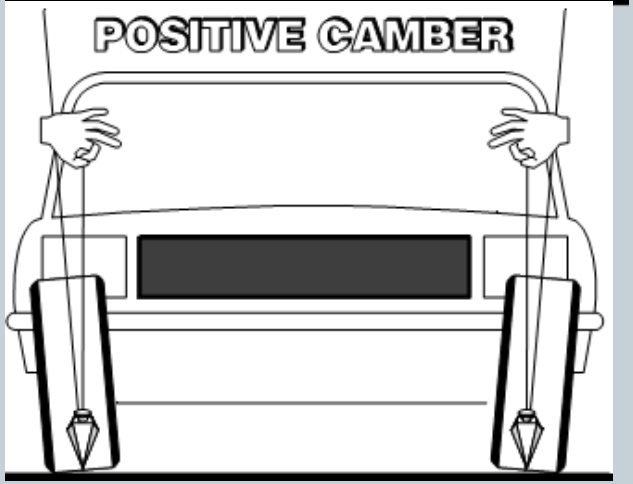
Negative Camber

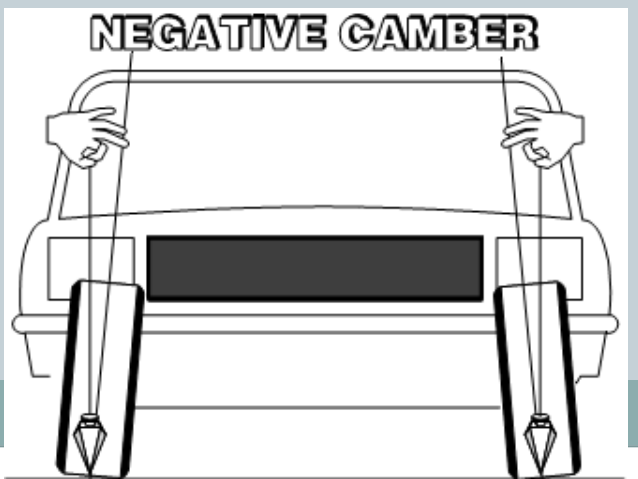
- When camber is negative the tire leans in toward the car at the top.

Camber Pull

- When the camber is more than ½ degree different from one side to the other **(camber split),** the car will pull or drift.







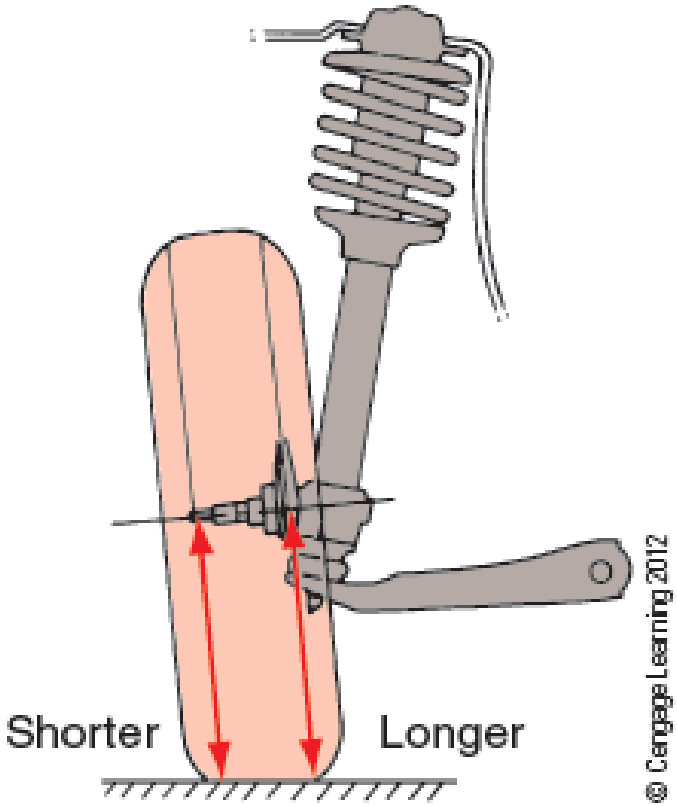
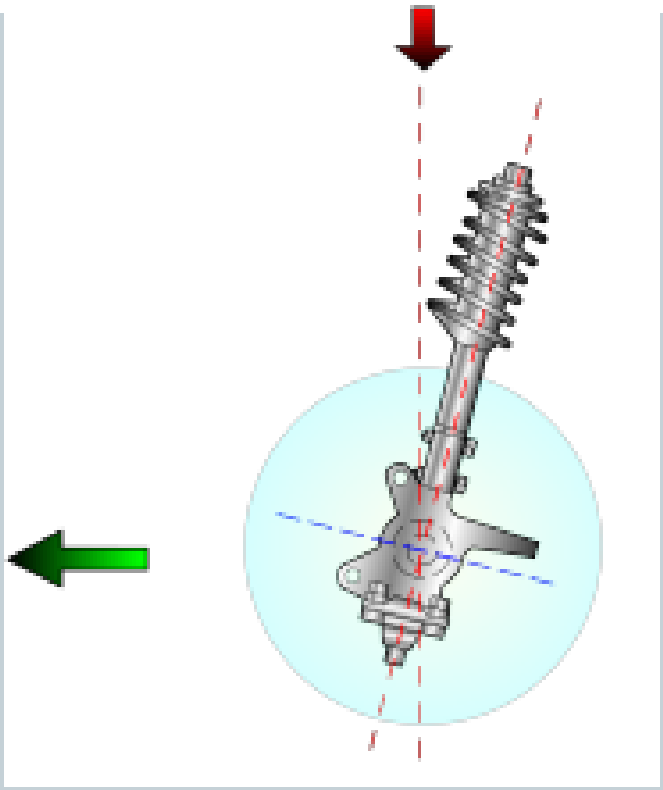


Figure 67.3 The tread will wear on the shorter side as the smaller diameter of the tire squirms against the road surface.

CASTER

- The function of CASTER is to aid proper steering stability. Caster provides this function by tilting the vehicle's steering pivots (axis) to the front or rear.
- This axis is an imaginary line drawn through the upper and lower steering pivot points when the vehicle is viewed from the side. These pivot points can be upper and



- Positive caster is the rearward tilt of the steering axis
- Negative caster is the forward tilt of the steering axis
- If the difference in the caster angle is more than ½ degree from side to side, the car will *pull* to the side of the most negative caster.
- Not a tire wear angle
- Caster aides in **directional stability and steering wheel return AND** Caster has ***no*** **effect on tire wear**.
- **Increasing caster toward positive will increase directional stability and increase steering effort. Decreasing caster will reduce directional stability and decrease steering effort.**

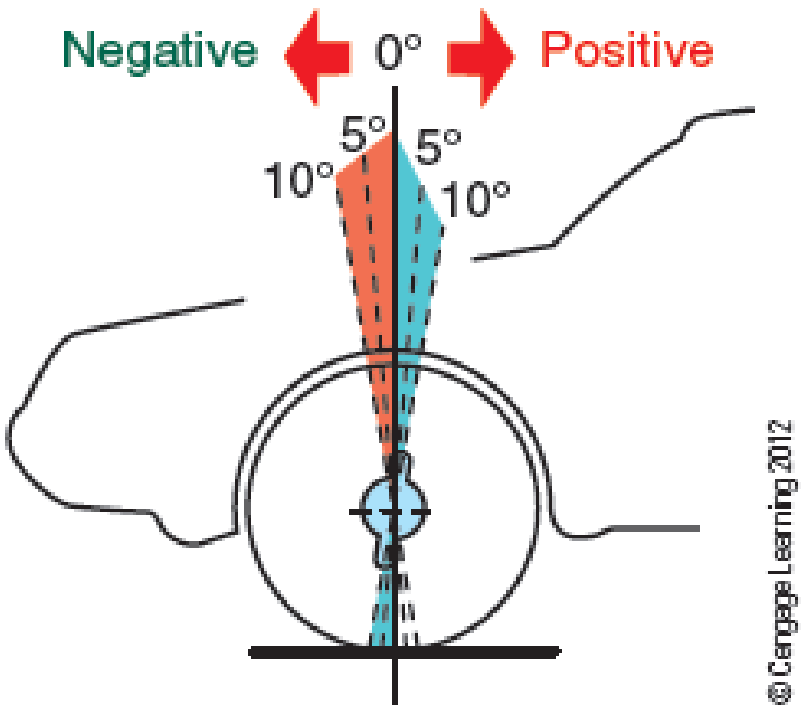
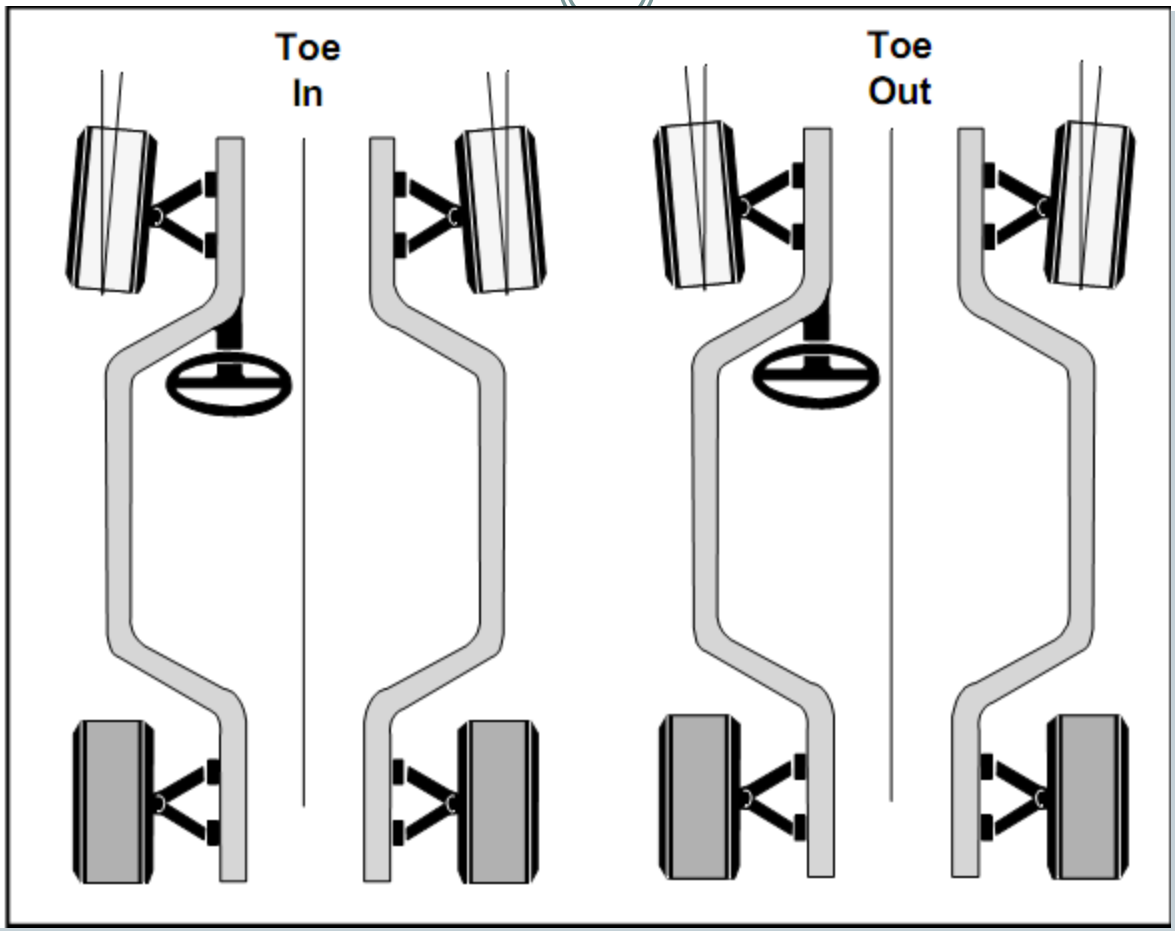


Figure 67.8 Comparison between positive and negative caster.

TOE-IN TOE-OUT

- Inward or outward variation of tires from a straight ahead position
  - Toe in is referred to as positive toe
  - Toe out is referred to as negative toe
- Not a directional control angle
- Toe is a critical tire wear angle that commonly causes feathered tire tread wear


Toe
In
Toe
Out

- The toe setting is designed to compensate for the amount the tires will turn away from straight ahead.
- If you adjust toe incorrectly, the tires will not turn enough, or turn too much. In either case, the tires will no longer be going straight down the road.
- If they are not going straight, they are being "scrubbed" or scraped against the road surface. This will to cause the tires to wear out.

STEERING AXIS INCLINATION

- Amount the spindle support arm leans in at top
  - Not a tire wearing angle
- Three functions
  - After a turn, SAI helps vehicle return to straight
  - SAI keeps vehicle going straight down the road
  - Allows car to have less positive caster
- Included angle
  - Combination of SAI and camber
- Some cars with large SAI wear outsides of tires

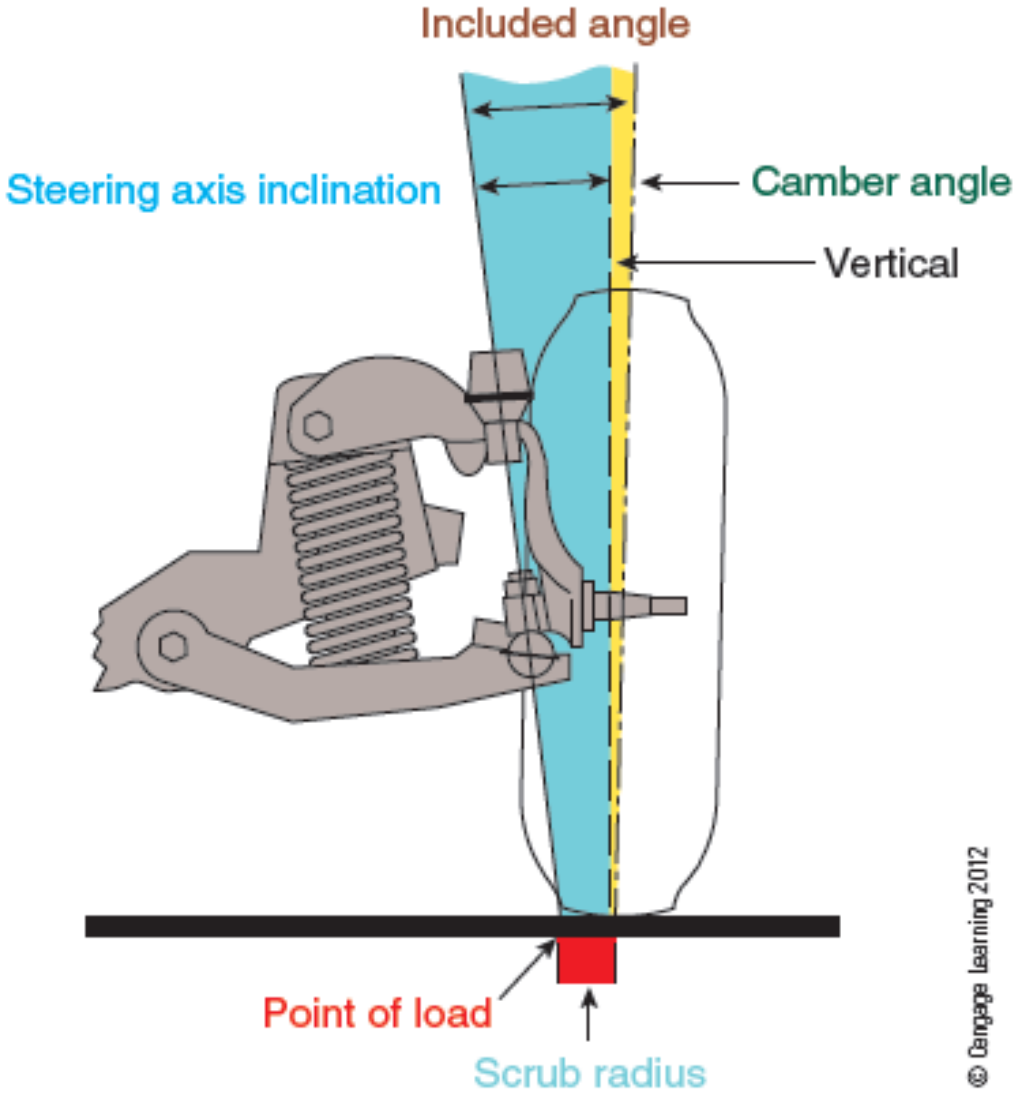


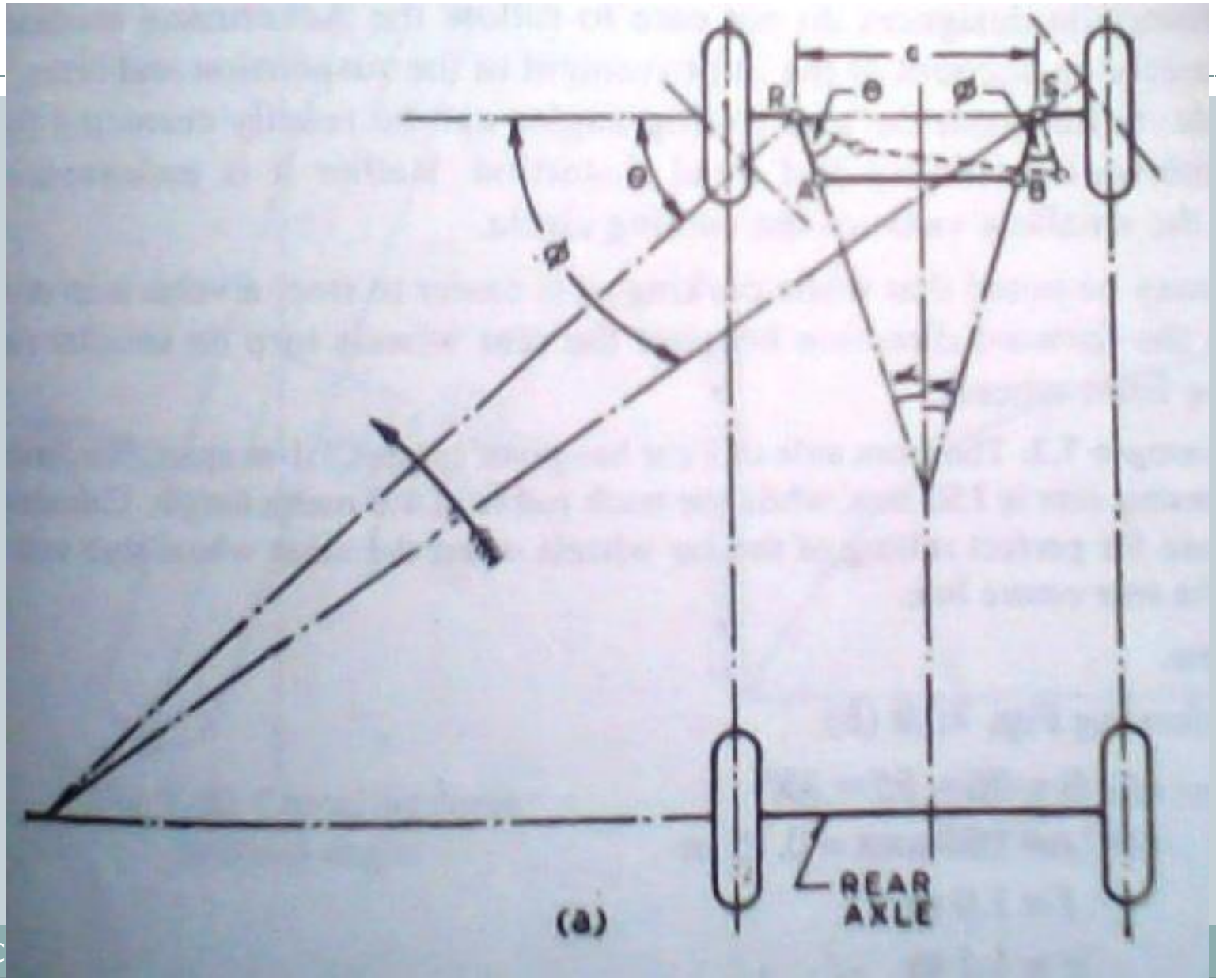
Figure 67.12 Steering axis inclination puts the pivot point under the tire.

STEERING MECHANISM

- WKT for perfect steering we must always have an instantaneous centre about which all the wheels must rotate. For this purpose the inner wheel has to turn more than the outer wheel.
- To achieve this condition, two types of mechanisms have been devised.

1. **Davis steering Mechanism**
2. **Ackermann steering Mechanism**

ACKERMANN STEERING MECHANISM



CORRECT STEERING ANGLE

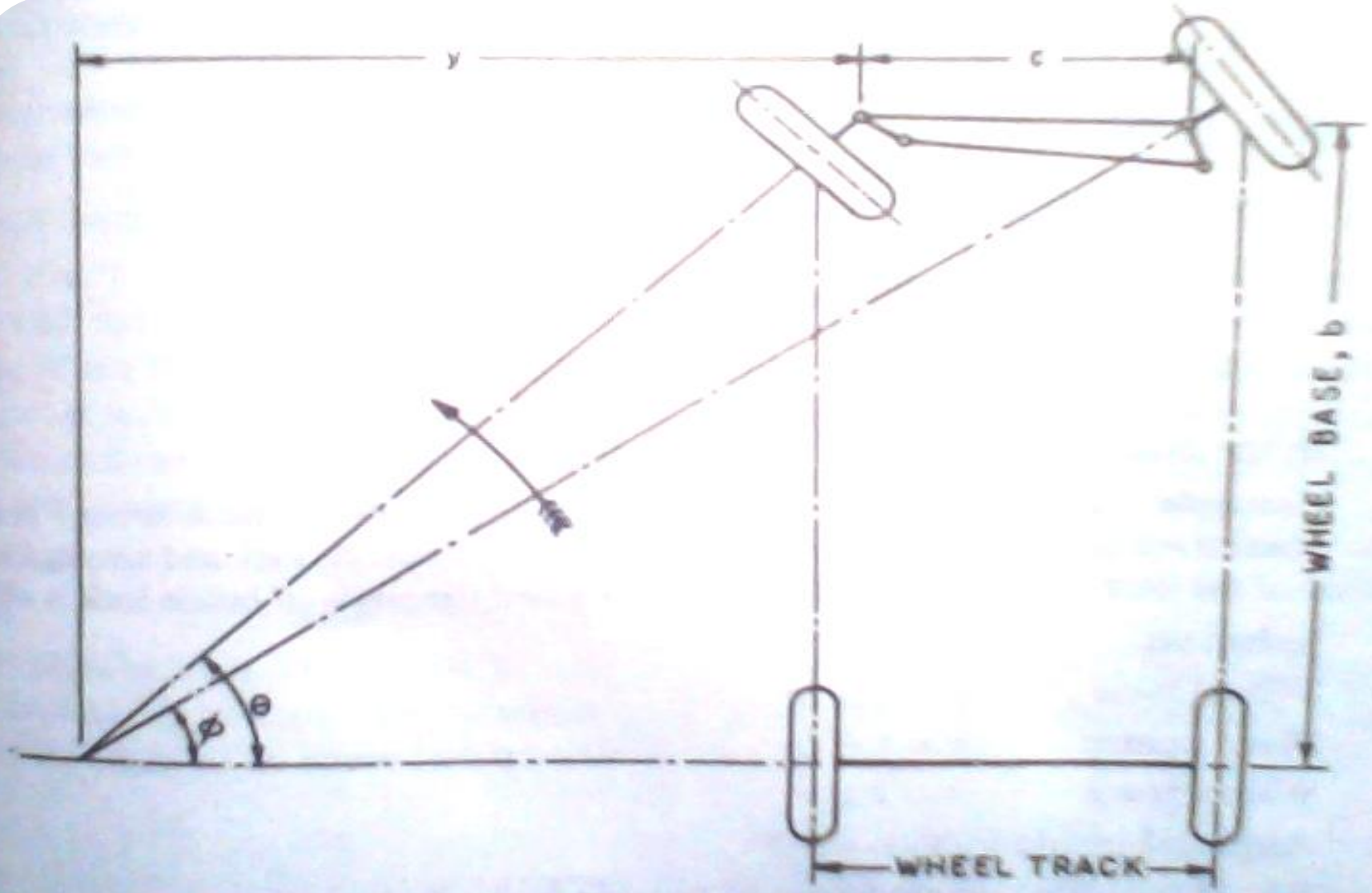
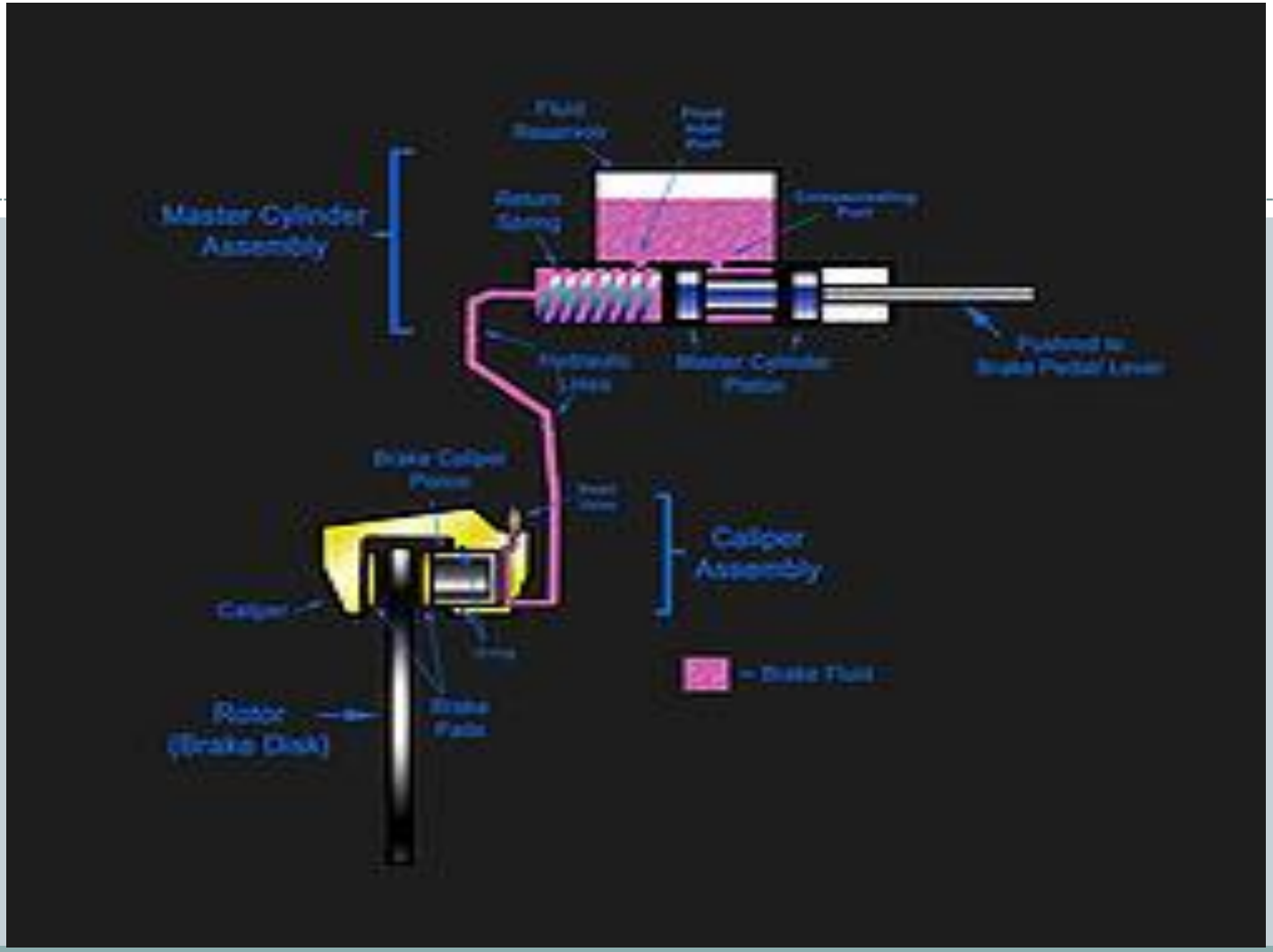


Fig. 7.18. Correct steering angle.

HYDRAULIC BRAKES……..



Hydraulic braking constituted a significant advance in comfort and safety.

The principle consists of replacing brake cables by a hydraulic circuit.

As it is easier to act on fluid pressure than on cable tension, this technology rapidly enabled the appearance of power-assisted braking, also originally called "servo-brake", and then complex systems such as ABS and ESC.

The basic concept of the hydraulic braking system is to replace the cables which originally connected the pedal to the brakes with a hydraulic system containing an oil of very low viscosity.

This solution also enables wheel braking to be optimised and balanced.

This was a delicate or impossible operation using cable systems. Finally, after the force boosters used in assisted braking,

The hydraulic braking system has enabled current systems such as ABS and ESC to be developed.

It is much easier for an electronic system to act on fluid pressures by means of solenoids (electronically controlled valves) than to pull on cables

The heart of the system is the master cylinder:

It is this cylinder which compresses the brake fluid when the driver presses on the pedal. It operates similarly to a syringe

Compression is obtained by a moving piston. The system includes a special feature which enables automatic adjustment of wear on the brake pads or linings. As these parts wear down, their thickness diminishes.

They have to be pushed "further and further" during braking. Again, as it is pistons which command this movement, this means that the quantity of brake fluid contained increases gradually as the wear on the pads or linings increases.

Without an adjustment system, the driver has to push the brake pedal further and further to compensate for this wear in order
to brake effectively.

The automatic wear adjustment system is a response to this phenomenon.

The end of the master cylinder, where the piston lies when the brake pedal is fully released, includes a light. It is connected to a small tank of brake fluid.

Hence, when the pedal is fully released,
the piston gives off light and, if necessary, the braking circuit automatically tops up the fluid.

In order to be effective and above all to ensure proper stability of the rear suspension, braking must be distributed unevenly between the car's front and rear wheels.

Generally, the front wheels carry about 70% of braking and the rear wheels only participa 30%. A pressure distributor follows the master cylinder and adjusts the pressure applied o each suspension.

A set of rigid pipes and hoses carry the braking fluid to the wheels. If the wheels are fitte with disk brakes, pistons housed in the callipers move in to tighten the pads.

For drum brakes, the principle is identical. The only difference is that here, the pistons operate the jaws.

ANTI LOCK BRAK

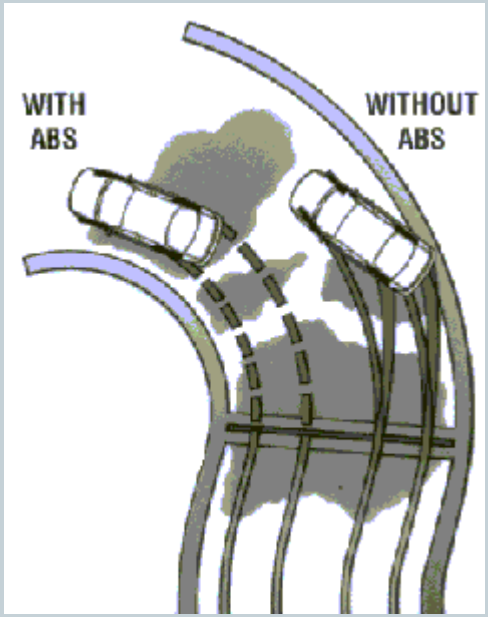
Introduction

- Wheel lockup during braking causes skidding which in turn cause a loss of traction and vehicle control
- This reduces the steering ability to change direction. So the car slides out of control
- With ABS system, the driver can brake hard, take the evasive action and still be in control of the vehicle in any road condition at any speed and under any load.

Concept of ABS

- A **skidding wheel** (where the tire contact patch is sliding relative to the road) has less **traction** than a non-skidding wheel
- By keeping the wheels from skidding while you slow down, anti-lock brakes benefit you in two ways:
- You'll stop faster, and you'll be able to steer while you stop

comparison

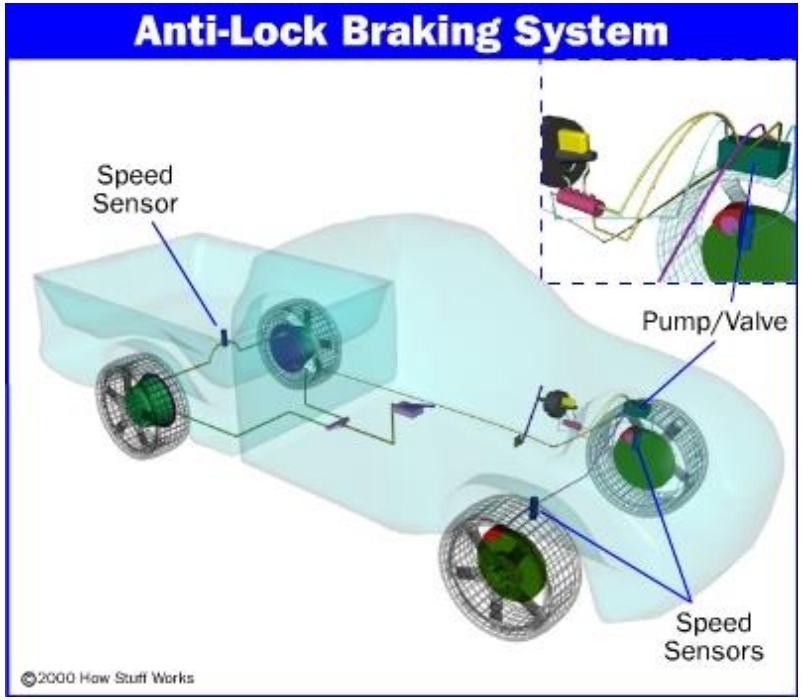


Pressure modulation

- 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 tyre and it there by ensures maneuverability and stability of the vehicle

Principles of ABS

- The skidding and lack 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.



ABS components

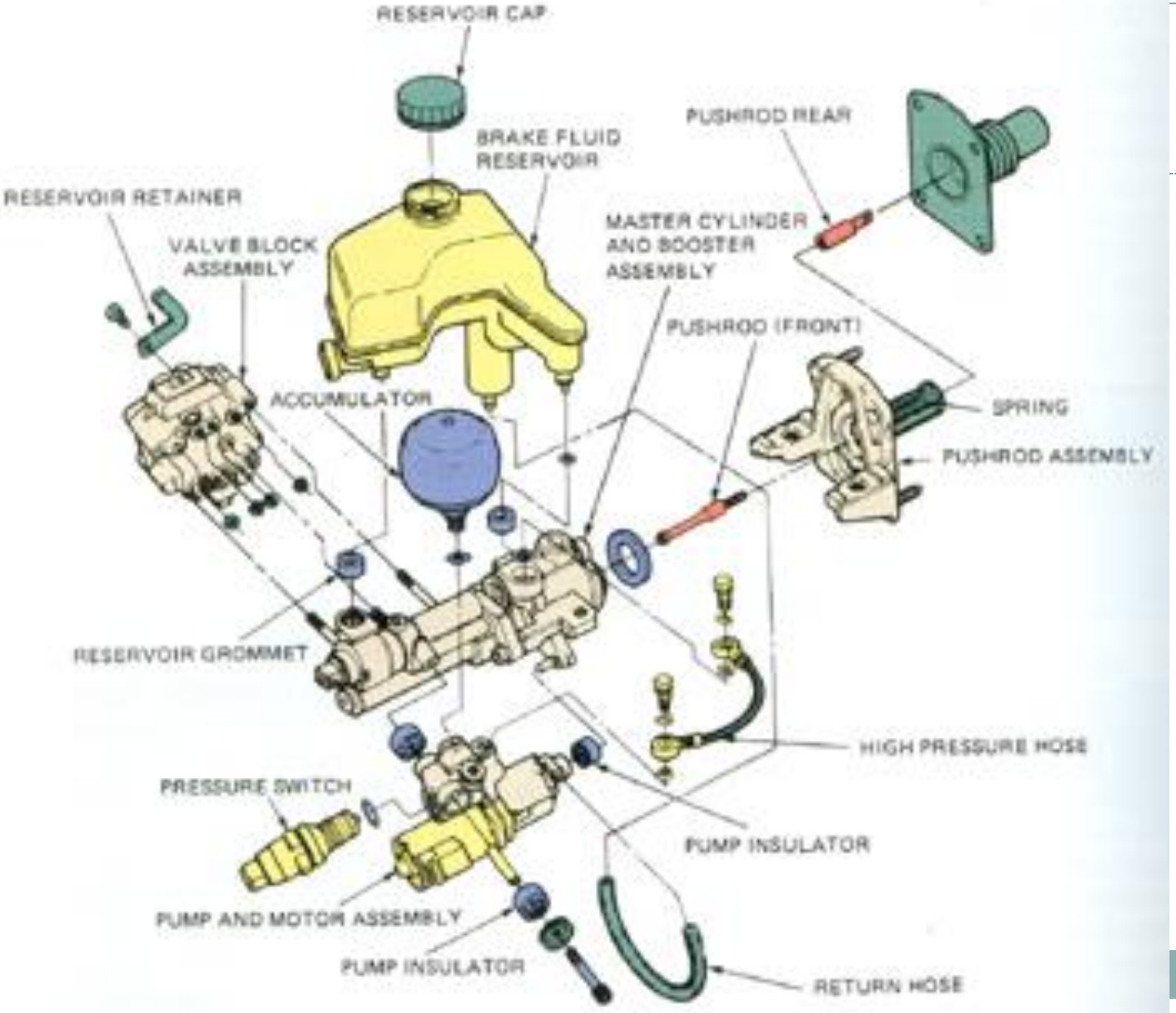
- **Hydraulic components**

1. **Accumulator**

   An accumulator is used to store hydraulic fluid to maintain high pressure in the brake system and provide the residual pressure for power assisted braking

2. **Antilock hydraulic control valve assembly**

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


RESERVOIR CAP
BRAKE FLUID RESERVOIR
PUSHROD REAR
RESERVOIR RETAINER
VALVE BLOCK ASSEMBLY
MASTER CYLINDER AND BOOSTER ASSEMBLY
PUSHROD (FRONT)
ACCUMULATOR
SPRING
PUSHROD ASSEMBLY
RESERVOIR GROMMET
HIGH PRESSURE HOSE
PRESSURE SWITCH
PUMP INSULATOR
PUMP AND MOTOR ASSEMBLY
PUMP INSULATOR
RETURN HOSE

Electrical\ electronic components

1. **ABS control module**

   This small computer is normally mounted inside the trunk on the wheel housing ,mounted to the master cylinder or is part of the hydraulic control unit. It monitors system operation and controls antilock function when needed

2. **Brake pedal sensor**

   The antilock brake pedal sensor switch is normally closed. when the brake pedal exceeds the antilock brake pedal sensor switch setting during an antilock stop , the antilock brake control module senses that the antilock brake pedal sensor switch is open

3. **Wheel speed sensor**

   It is mounted near the different toothed ring . as the rings teeth rotate past the sensor an ac voltage is generated

Types of antilock brake systems

- **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 **.**

Four wheel system

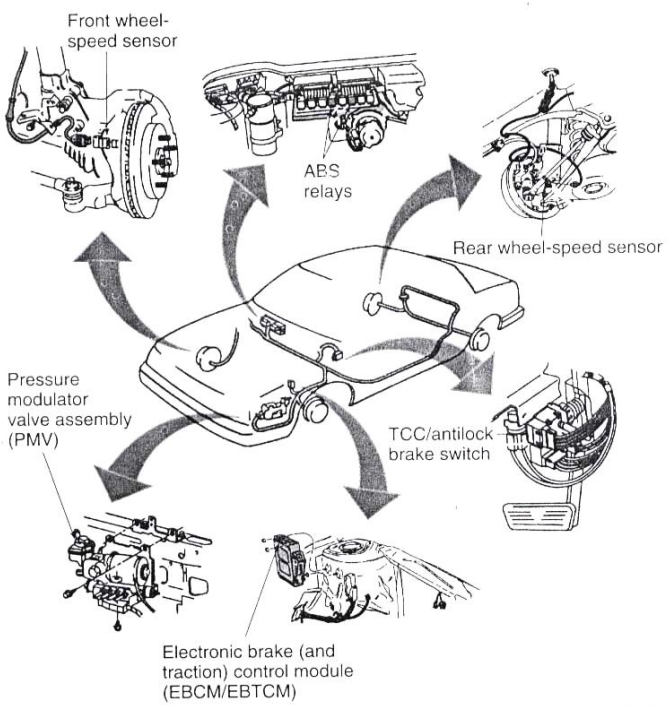
- The hydraulic circuit for this type of system is an independent four channel type. One for each wheel. The hydraulic control unit is a separate unit
- The system prevents wheel lock up during an emergency stop by modulating brake pressure

Advancements

- **AUTOMATIC TRACTION CONTROL (ATC)**
- **AUTOMATIC STABILITY CONTROL**

AUTOMATIC TRACTION CONTROL (ATC)

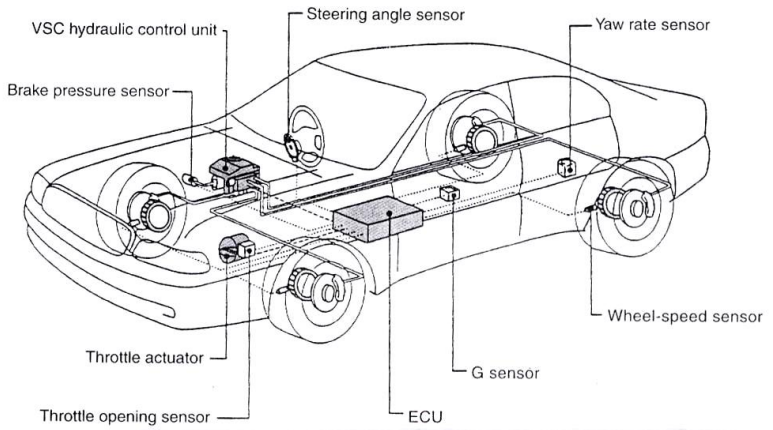
- Automatic traction control systems apply the brakes when a drive wheel attempts to spin and lose traction.
- The system works best when one drive wheel is working on a good traction surface and the other is not.
- The system also works well when the vehicle is accelerating on slippery road surfaces,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



A typical ATC system. *Courtesy of General Motors Corporation—Service Operations*

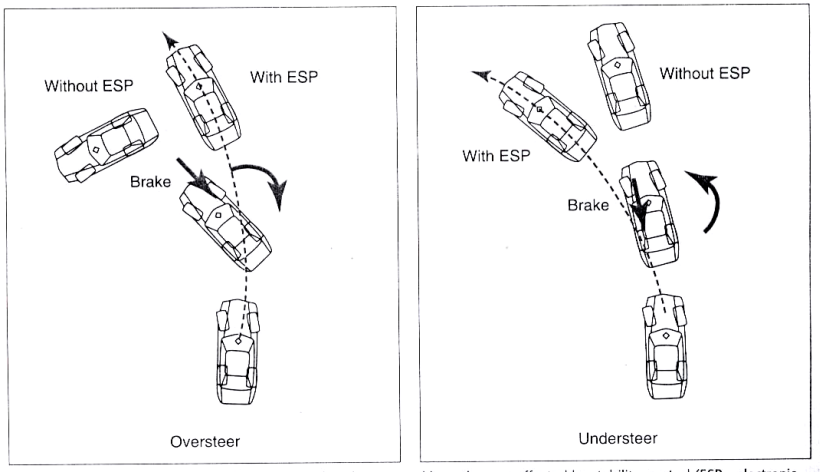
AUTOMATIC STABILITY CONTROL

- 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

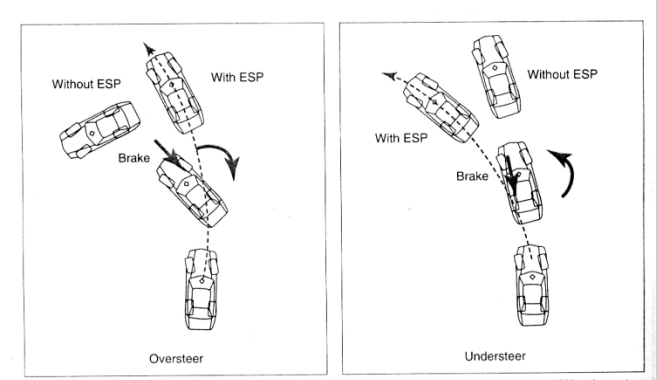


The components of a typical vehicle stability control system. *Courtesy of Lexus of America Co.*

ESP



The effects of oversteer and understeer and how they are affected by stability control (ESP—electronic stability program) systems. *Courtesy of Mercedes-Benz of N.A., Inc.*



The effects of oversteer and understeer and how they are affected by stability control (ESP—electronic stability program) systems. *Courtesy of Mercedes-Benz of N.A., Inc.*

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.

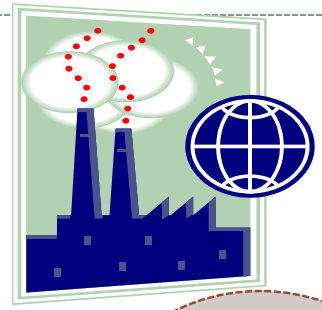
ALTERNATIVE ENERGY

RESOURCES

CLASSIFICATION OF FUELS

- Conventional fuels such as Fossil fuel (petroleum and coal) and nuclear material such as uranium.
- Alternative fuels ,also known as non-conventional fuel. Any material or substance that can be used as fuels other than conventional fuels.

NEED FOR ALTERNATE FUELS



Growing energy demand

Population growth

Environm-ent pollution

Need

Increasing Industriali-sation

Fossil fuel depletion

Emission Norms

Vehicular population

- World today is facing the pinch of rising energy consumption.
- Green house gas emission and global warming is also in forefront of critical issue.
- India is ranked 6^{th} in terms of energy demands . But the crude oil produced satisfies only $1/4^{th}$ of current demand.

SOME WELL KNOWN ALTERNATIVE FUELS

- BIODIESEL
- ELECTRICTY
- LPG

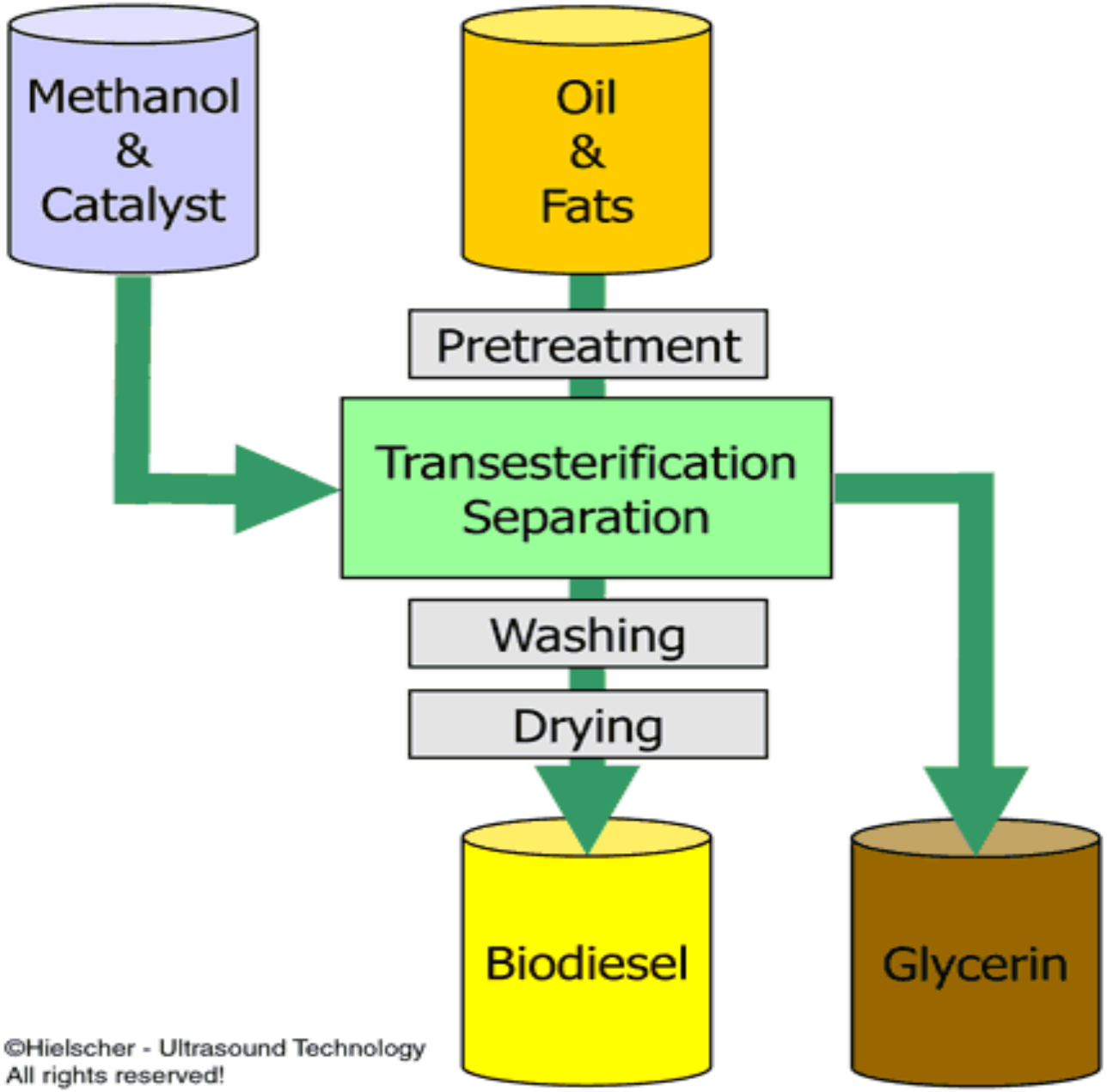
BIODIESEL

- Biodiesel is the alkyl ester of fatty acids, made by the transesterification of oils or fats, from plants or animals, with short chain alcohols such as methanol and ethanol.
- It can be manufactured from vegetable oils such as palm,rapeseed,jatropha,coconut,etc…
- Avoiding the need for expensive additional infrastructure.
- Reduction of unburned hydrocarbon ,carbon monoxide, and oxides of Nitrogen.
- Biodiesel contains no sulphur .

METHODS TO REDUCE THE VISCOSITY OF VEGETABLE OIL

- Preheating
- Dilution
- Pyrolysis
- Micro emulsification
- Transesterification
  - ✓ Homogeneous catalyst
  - ✓ Heterogeneous catalyst
  - ✓ Bio catalyst
  - ✓ Supercritical process
  - ✓ Ultrasonic reactor method
  - ✓ Microwave assisted

TRANSESTERIFICATION



Chemistry of transesterification reaction

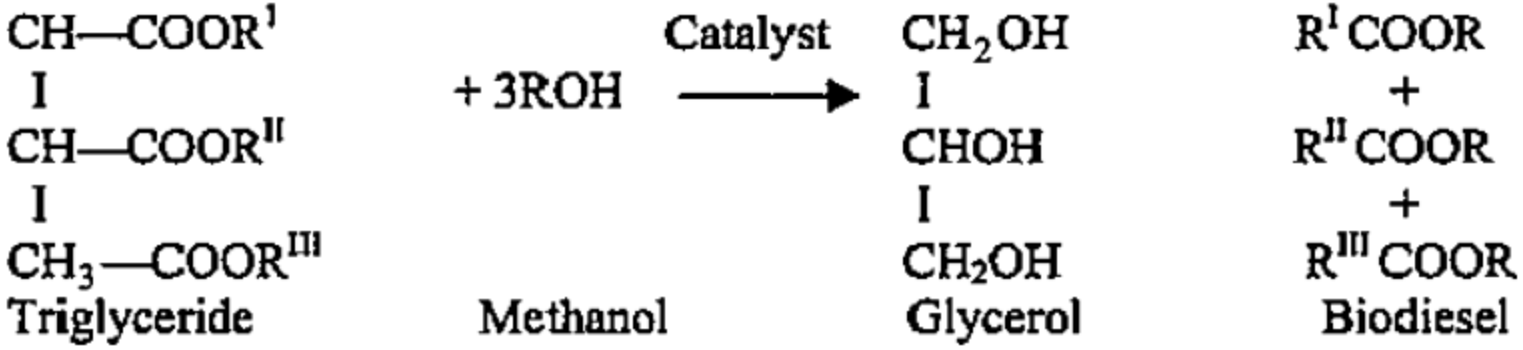
catalyst

Triglyceride + ROH ⟷ Diglyceride + $\mathbf{R^{I}COOR}$

Diglyceride + ROH ⟷ Monoglyceride + $\mathbf{R^{II}COOR}$

Monoglyceride + ROH ⟷ Glycerol + $\mathbf{R^{III}COOR}$

The overall chemical reaction of the transesterification process is:



The Biodiesel Cycle

ELECTRIC VEHICLE

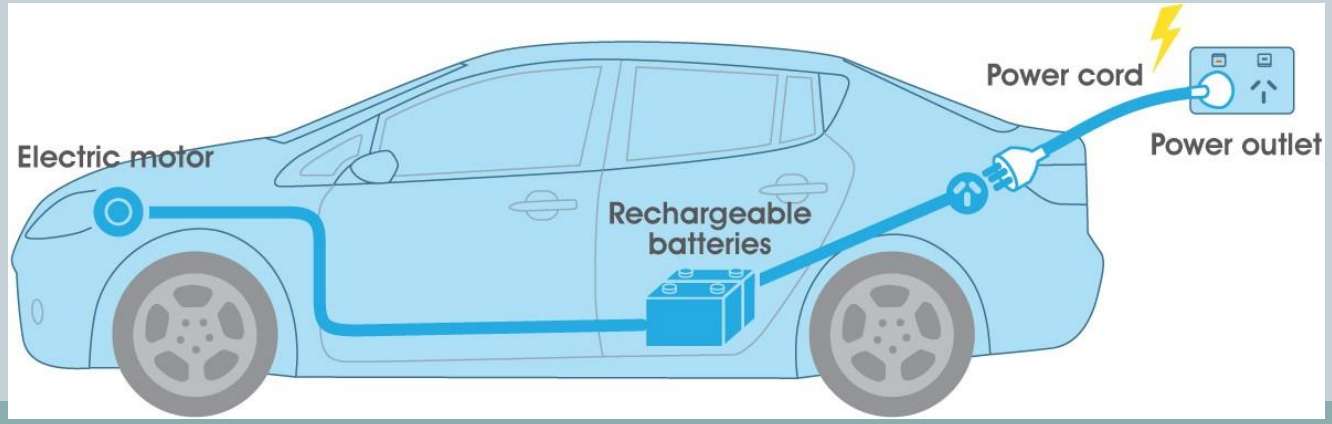
- A car that runs on electricity is called as electric vehicle.

TYPES OF ELECTRIC VEHICLE

- Hybrid Electric Vehicles (HEV)
  petrol engine + battery (never plugged in).
- Plug-in Hybrid: petrol engine + electric motor (plugged in).
- Full Electric: electric motor + battery
  (plugged in).

How do they work?

- Use electricity not petrol
- Energy comes from a power outlet via a cord to the car
- Energy stored in a battery
- Energy powers the electric motor, moving the car.



Alternative #2 - Electric Vehicles (EVs)

- Why not generate electricity in a large central power plant and distribute to charge batteries to power electric motors?
- EV NiMH battery - 26.4 kW-hours, 1147 pounds = 1.83×10^5 J/kg (http://www.gmev.com/power/power.htm)
- Gasoline (and other hydrocarbons): 4.3×10^7 J/kg
- Even at 30% efficiency (gasoline) vs. 90% (batteries), gasoline has 78 times higher energy/weight than batteries!
- 1 gallon of gasoline ≈ 481 pounds of batteries for same energy delivered to the wheels
- Other issues with electric vehicles
  - "Zero emissions" ??? - EVs export pollution
  - Replacement cost of batteries
  - Environmental cost of battery materials
  - Possible advantage: EVs make smaller, lighter, more streamlined cars acceptable to consumers

Alternative #3 - Hydrogen fuel cell

- Ballard HY-80 “Fuel cell engine” (power/wt = 0.19 hp/lb)
- 48% efficient (fuel to electricity)
- MUST use hydrogen (from where?)
- Requires large amounts of platinum catalyst - extremely expensive
- Does NOT include electric drive system (≈ 0.40 hp/lb thus fuel cell + motor at ≈ 90% electrical to mechanical efficiency)
- Overall system: 0.13 hp/lb at 43% efficiency (hydrogen)
- Conventional engine: ≈ 0.5 hp/lb at 30% efficiency (gasoline)
- Conclusion: fuel cell engines are only marginally more efficient, much heavier for the same power, and require hydrogen which is very difficult and potentially dangerous to store on a vehicle
- Prediction: even if we had an unlimited free source of hydrogen and a perfect way of storing it on a vehicle, *we would still burn it, not use it in a fuel cell*

Hydrogen storage

- Hydrogen is a great fuel
  - High energy density (1.2 x 10^8 J/kg, ≈ 3x hydrocarbons)
  - Much faster reaction rates than hydrocarbons (≈ 10 - 100x at same T)
  - Excellent electrochemical properties in fuel cells
- But how to store it???
  - Cryogenic (very cold, -424˚F) liquid, low density (14x lower than water)
  - Compressed gas: weight of tank ≈ 15x greater than weight of fuel
  - Borohydride solutions
    - $NaBH_4 + 2H_2O \rightarrow NaBO_2$ (Borax) + $3H_2$
    - (mass solution)/(mass fuel) ≈ 9.25
  - Palladium - Pd/H = 164 by weight
  - Carbon nanotubes - many claims, few facts…
  - Long-chain hydrocarbon $(CH_2)_x$: (Mass C)/(mass H) = 6, plus C atoms add 94.1 kcal of energy release to 57.8 for H_2!
- MORAL: By far the best way to store hydrogen is to attach it to carbon atoms and make hydrocarbons, even if you're not going to use the carbon as fuel!

Alternative #4 - Solar vehicle

- Arizona, high noon, mid summer: solar flux ≈ 1000 W/m^2
- Gasoline engine, 20 mi/gal, 60 mi/hr, thermal power = (60 mi/hr / 20 mi/gal) x (6 lb/gal) x (kg / 2.2 lb) x (4.3 x 10^7 J/kg) x (hr / 3600 sec) = 97 kilowatts
- Need ≈ 100 m^2 collector ≈ 32 ft x 32 ft - lots of air drag, what about underpasses, nighttime, bad weather, northern/southern latitudes, etc.?

Do you want to drive this car every day (but never at night?)

The Concept of Green Car

- In any case, all-electric cars are green only if the electricity to recharge them is generated in low-carbon ways.
- In nuclear-powered France the electricity to drive a battery car one kilometre causes carbon-dioxide emissions of just 8g.
- Yet in China and India, which generate much of their electricity from coal, those emissions are over 120g.
- It would be greener to drive a new petrol/Diesel-engined car instead.

Solar Car

Alternative #5 - nuclear

- Who are we kidding ???
- Higher energy density though
  - U_{235} fission: 8.2×10^{13} J/kg ≈ 2 million x hydrocarbons!
  - Radioactive decay much less, but still much higher than hydrocarbon fuel