Lect.-1
Sources of farm power and its status in India and Rajasthan.

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Power

Power is defined as the amount of energy transferred or converted per unit time.

The SI (Standard International) unit of power is the watt, equal to one joule per second.

1 joule is equal to 1 Newton- metre. (N·m)

One Newton is the force needed to accelerate one kilogram of mass at the rate of one metre per second squared in the direction of the applied force.

$F=m\cdot a$ *or* $N=1\ kg\cdot 1\ m/s^2$

1 calorie = 4.184 J (Energy unit)

Horse power

- If the rate of doing work is equivalent to 75 kg m/sec, it is said to be one horse power.
- The electrical equivalent of one horsepower is 746 watts.
- One unit of electricity = 1000 Watt.hr = 1 KWh

Example: If an electric motor of 3 hp is operated for 6 hours per day, then monthly electricity consumption will be:

$$\frac{3 \times 746 \times 6 \times 30}{1000} \text{ units} = 402.84$$

Farm Power

- Farm power is an essential input in agriculture for timely field operations for operating different types of farm equipment and for stationary jobs like operating irrigation equipment, threshers/shellers/cleaners/ graders and other post harvest equipments.
- With the increase in intensity of cropping the turn round time is drastically reduced and it is not possible to harvest and thresh the standing crop, on one hand, and prepare seedbed and do timely sowing operations of subsequent crop, on the other hand, in the limited time available, unless adequate farm power is available.

- Availability of adequate farm power is very crucial for increasing production and productivity and handling the crop produce to reduce losses.
- The power productivity relationship shows that those states having higher farm power availability per hectare have higher productivity.
- Type of power sources available on Indian farms are:

  Human Power, Animal power, mechanical power, electrical power and power from renewable energy sources like solar, wind, biomass etc.

Various types of agricultural operations performed on a farm can be broadly classified as

(1)**Tractive work** such as seed bed preparation, cultivation, harvesting and transportation and

(2)**Stationary work** like silage cutting, feed grinding, threshing, winnowing and lifting of irrigation water, operating threshers,shellers/decorticators,cleaners, graders and other post harvest operations.

The **mobile farm power** (for tractive work) comes from human, draught animals, power tillers, tractors and self propelled machines; whereas the **stationary power** is obtained from oil engines (diesel, petrol and kerosene), electric motors and renewable energy sources (solar energy, biogas, biomass and wind energy).

Sources of Farm Power

The different sources of power available on the farm for doing various mobile and stationary operations are as under:

Mobile Power

1. Human (men, women, children)
2. Draught animals (bullocks, buffaloes, camels, horses and ponies, mules and donkeys)
3. Tractors
4. Power tillers
5. Self propelled machines (combines, dozers, reapers, sprayers etc.)

Stationary Power

1. Diesel/oil engines (for pump sets, threshers, sprayers and other stationary operations)
2. Electric motors (for pump sets, threshers, sprayers and other stationary operations)

Human Power

- It is main source of power for operating small tools and implements.
- It is employed for doing stationary work like threshing, winnowing, chaff cutting etc.
- On an average a man develops nearly 0.1 hp. Or 0.075kW (female worker 80% of man worker)
- Availability of human power in agriculture sector is decreasing day by day due to better payment in industrial sector MNAREGA.
- Labour use efficiency can be improved by engaging labour in gang where sequence of operation demands a team work for effective output.

Human power

✓Costliest power compared to all other forms of power.
✓ Very low efficiency.
✓ Requires full maintenance even when not in use.
✓ Affected by weather condition and seasons.

Animal Power

- Mainly, bullocks and buffaloes happen to be the principle sources of animal power on Indian farms. However, camels, horses, donkeys and elephants are also used for the farm work.
- India is having the highest cattle population in the World.
- The utilization of animals for draft purposes as well as the power developed by them depends mainly as how they are tamed, trained and harnessed.
- The traditional double neck yoke mostly employed by Indian farmers is an inefficient device as comparison to light weight collar type padded harness. The use of improved harness can give 20% additional power by reducing the strain on animals.

- Utilization of draft animals on Indian farm is affected by type of animals, climatic conditions and supplementary power source available on the farms.
- The power available from draught animals is related to its body weight.

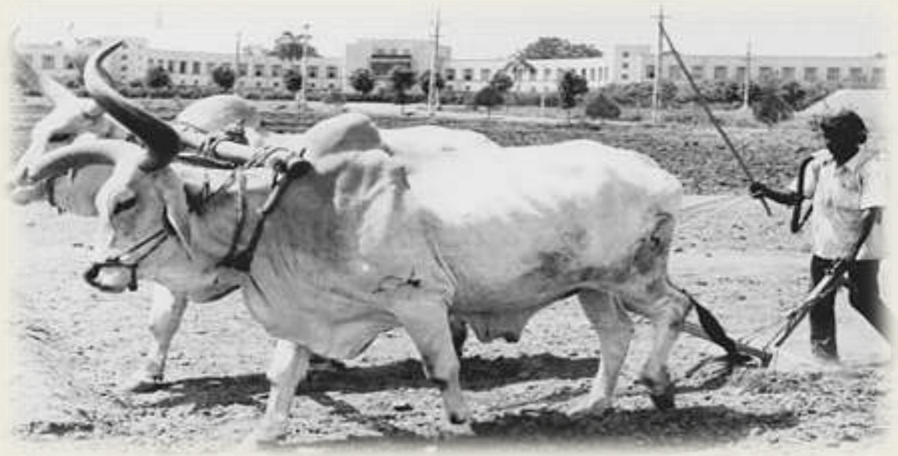
Bullocks: 10-12% of body weight in summer and 12-14% in winter (about one tenth of its body weight)

Buffaloes: 12% of body weight in all seasons.

On the basis of the body weight draught animals are categorized as

- Small (200-300 kg)
- Medium (300-400 kg)
- Large (400-500 kg) and
- Heavy (above 500 kg) animal.

ANIMAL POWER



1. Easily available in villages.
2. Used for all types of work.
3. Low initial investment.
4. Supplies manure to the field and fuels to farmers.
5. Live on farm produce.

But

1. Not very efficient.
2. Seasons and weather affect the efficiency.
3. Cannot work at a stretch.
4. Require full maintenance when there is no farm work.
5. Creates unhealthy and dirty atmosphere near the residence.

- From a good pair of animals weighing between 900-1000 kg we can get about 0.75-0.78 KW power.
- But in most of the States the pair weight of draught animals ranges between 600-800 kg/pair and power availability from them is only about 0.50-0.55 KW/pair.
- **Power developed by an average pair of bullocks is about 1 hp for usual farm work.**
- **The average command area of a pair of draught animals is considered to be 2 ha.**

Mechanical Power

- Mechanical power is available through tractors, power tillers and oil engines.
- In oil engines the fuel is converted into useful work. The thermal efficiency of diesel engine varies between 32 to 38 per cent whereas that of petrol engine (carburettor engine) the efficiency is 25 to 32%.
- Generally, stationary diesel engines are in demand for pumping irrigation water (3-10 hp), flour mills, oil ghanis, cotton gins (14-20 hp), chaff cutter, sugarcane crusher, threshers and winnowers etc.

Advantages: Efficiency is high; not affected by weather; can run at a stretch; requires less space and cheaper form of power.

Disadvantages: Initial capital investment is high; fuel is costly and repairs and maintenance needs technical knowledge.

MECHANICAL POWER

Advantages:

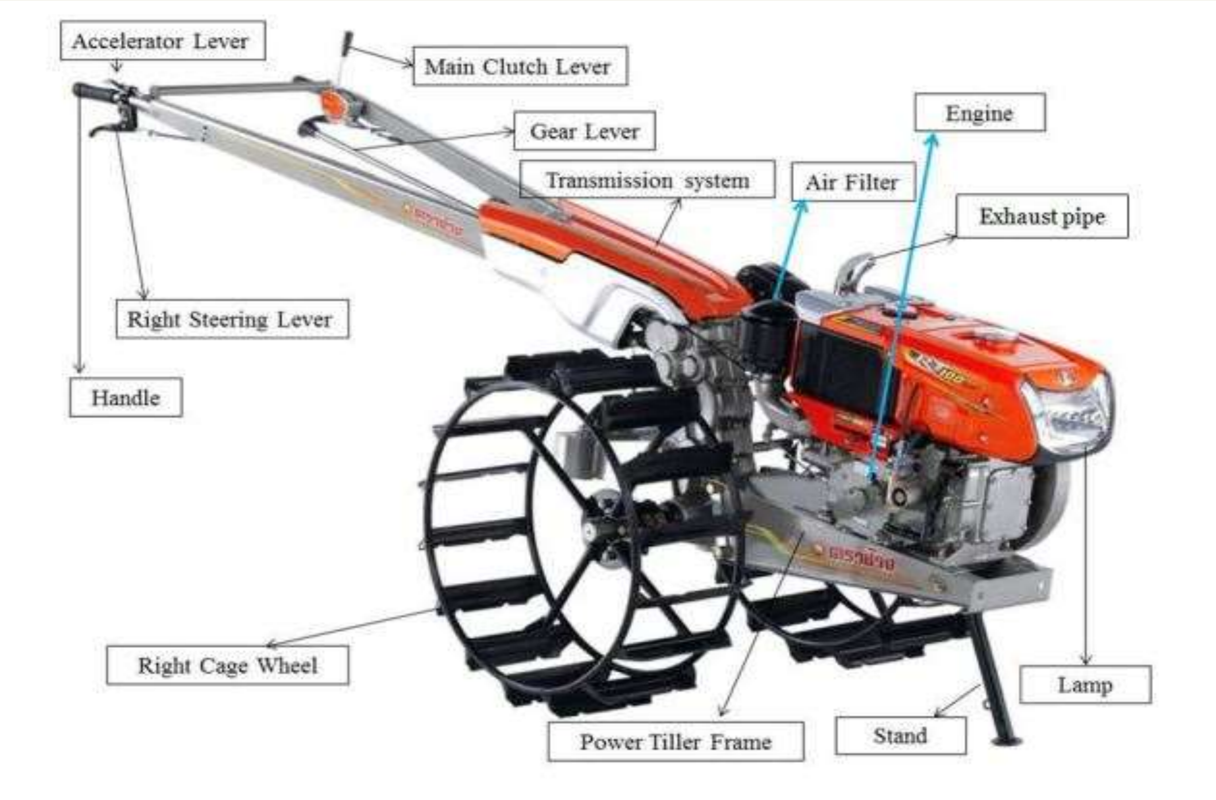
- Efficiency is high;
- Not affected by weather;
- Can run at a stretch;
- Requires less space.

Disadvantages:

- Initial capital investment is high;
- Fuel is costly and
- Repairs and maintenance needs technical knowledge.

- **In India tractor and power tiller production started in 1961** with the establishment of **first plant by Massey Fergusson and subsequently known as Tractor And Farm Equipment (TAFE), Limited by Madras (Chennai)**
- India has emerged as number one producer of small tractors in the world.
- For calculating power availability from tractors on the farm, a weighted average of 26.1 kW per tractor can be taken.
- The replacement rate is 10 bullocks /tractor of about 20 kW power output.

Power tiller



Power tiller is a prime mover in which the direction of travel and its control for field operation is performed by the operator walking behind it. It is also known as *hand tractor or walking type tractor.*

- Average size of holding in India is about 1.08 hectares. Small holders now cultivate 42 percent of operated land and constitute 83 percent of total land holdings.Under such conditions, power tiller may be useful as a power unit.
- **The average command area of a power tiller of 7.46 kW is considered to be 6 ha and that of a tractor of about 26.1 kW it is 15 ha.**
- For calculating power availability from power tillers on the farm, a weighted average of 7.0 kW per unit can be taken.

Diesel engines

- For calculation purposes the average weighted power of diesel engines can be taken as 5.6 kW and for electric motors as 3.7 kW and 7.46 kW for small pump sets and submersible pumps respectively.
- **The low, medium and high power range machines can be categorized to represent 3 kW, 10 kW and 28 kW machines serving the needs of Indian agriculture**.

Electrical power

- Electricity is the most efficient and clean source of power used on agricultural farms.
- In India, availability of electricity per capita is extremely low as compared to the developed nations.
- The major sources of generated power in the country are from Thermal, Hydro, Nuclear and wind sources. Efforts are being made to generate electricity from solar, ocean, geo-thermal biomass and biogas.
- **On an average $1/10^{th}$ of the total electrical power generated in India is used for farm work**.
- The use of electrical power in agriculture is mainly for pumping of irrigation water, threshing, dairy industry, agro processing units, rice mills, cold storage, cattle feed grinding etc.

Renewable sources of energy

- Energy sources which are continuously and freely produced in the nature and are not exhaustible are known as the renewable sources of energy.
- In farming system the main renewable sources are (a) solar (b) wind (c) biomass, and (d) biogas.
- Renewable energy can be used for lighting, power generation, water heating, drying, greenhouse heating, water distillation, refrigeration and diesel engine operation.

Advantages of renewable energy

a) These sources of energy are renewable and there is no danger of depletion. These reoccur in nature and are in-exhaustible.

b) Renewable energy sources are more site specific and are used for local processing and application. There is no need for transmission and distribution of power.

c) Most of the devices and plants used with the renewables are simple in design and construction which are made from local materials, local skills and by local people. The use of renewable energy can help to save foreign exchange and generate local employment.

d) The rural areas and remote villages can better use the locally available renewable sources of energy. There will be huge savings from transporting fuels or transmitting electricity from long distances

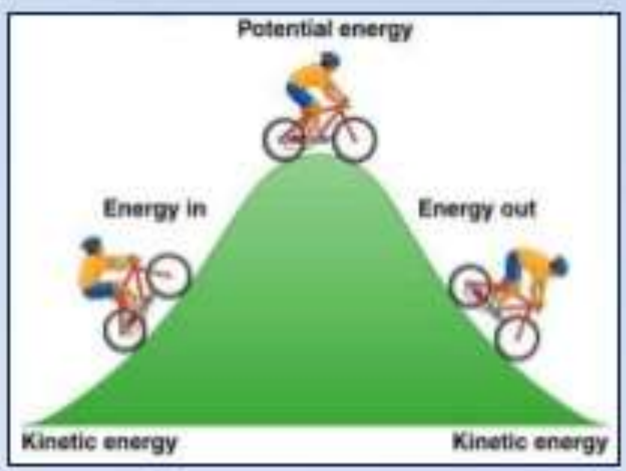
Wind power

- The development of wind power in India began in the 1990s.
- Air in motion is called wind. i.e. A moving mass of air.

- The winds on earth surface are caused primarily by the unequal heating of the land and water by the sun.
- The differences in temperature gradients induce the circulation of air from one place to another place. The hot air being lighter, rises upwards. The cooler air starts flowing towards the space vacated by the rising air.
- Experimental results show that a wind mill having 3.6 m dia wheel, mounted on 12.0 m tower is able to produce from 0.1 hp to 0.9 hp with the wind velocity varying from 6.4 to 37 km/hr. Thus **the average capacity of a wind mill would be about 0.50 hp**.

Wind energy

- Wind Energy is kinetic energy from the wind that can be directly converted to electrical or mechanical energy by reacting to the atmospheres pressure slope.
- The windmill was invented in 200 BC in China and was used to pump water and grind grain
- In modern days, wind energy has doubled through the years

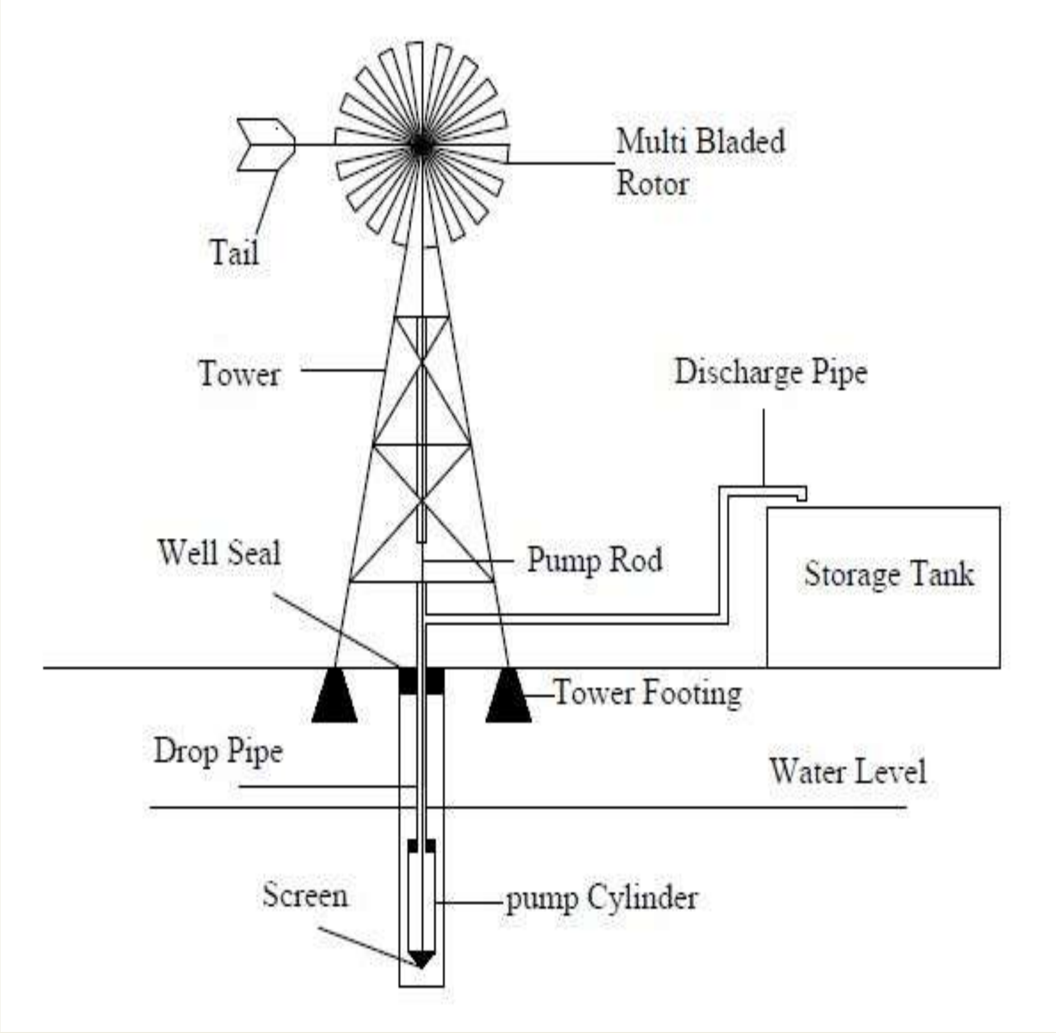


$$E_k = \frac{1}{2}mv^2$$

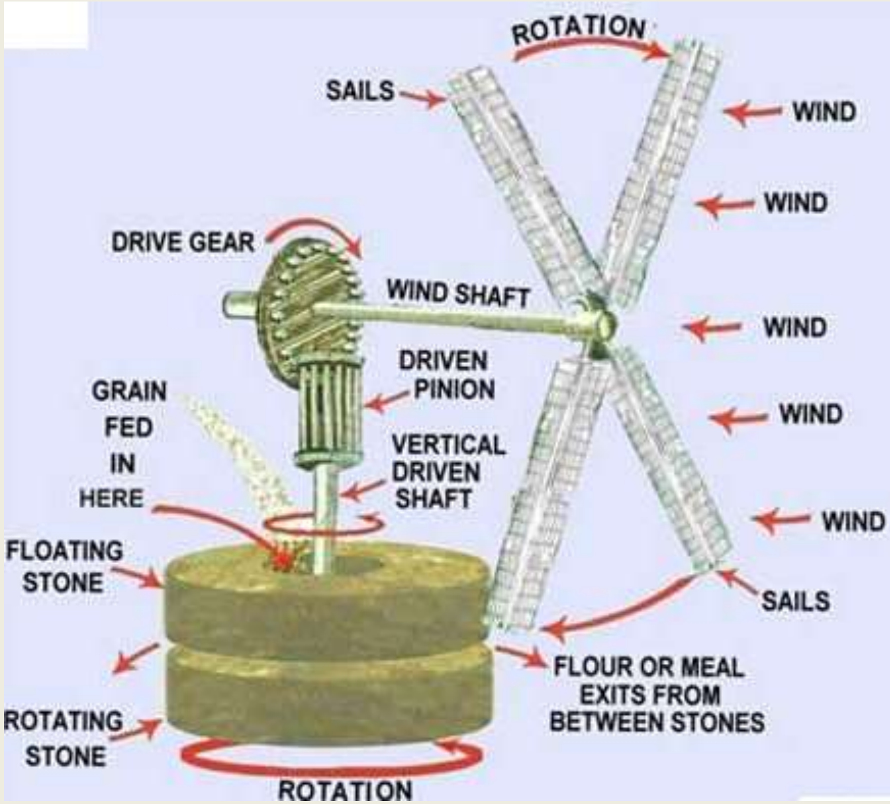
Wind mill

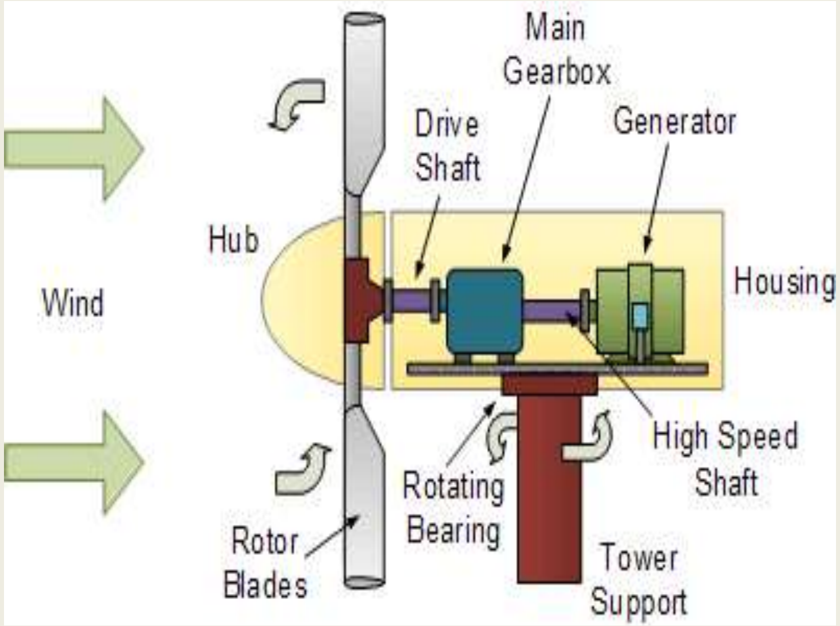
A wind mill is a machine which works with the energy of blowing wind.

It can be used for water lifting, grain grinding and electricity generation.



Gristmills





The other use of wind mills is for grinding grains into flour. These are called gristmills, corn mills or flour mills.

Biomass

- Plant matter created by the process of photosynthesis is called biomass (or) all organic materials such as plants, trees and crops are potential sources of energy and are collectively called biomass.
- Biomass also includes forest crops and residues after processing. The residues include crop residues (such as straw, stalks, leaves, roots etc.) and agro-processing residues (such as oilseed shells, groundnut shells, husk, molasses, coconut shells, saw dust, wood chips etc.,).
- The term biomass is also generally understood to include human waste, and organic fractions of sewage sludge, industrial effluents and household wastes.

Biomass as farm power

- The biomass can be used **by thermo-chemical conversion**. Thermo-chemical conversion includes processes like combustion, gasification and pyrolysis.
- **Combustion** refers to the conversion of biomass to heat and power by directly burning it, as occurs in boilers.
- **Gasification** is the process of converting solid biomass with a limited quantity of air into producer gas.
- **Pyrolysis** is the thermal decomposition of biomass in the absence of oxygen. The products of pyrolysis are charcoal, condensable liquid and gaseous products.

- The second approach is **Biochemical conversion** includes anaerobic digestion to produce biogas and fermentation to obtain alcohol fuels.
- The third approach is **oil extraction**.

Edible and non-edible oils can be extracted from a variety of grains and seeds. They can be directly used as **bio-diesel**, which is **a good substitute for conventional diesel oil.**

Biogas

- Biogas is a by-product of the decomposition of organic matter by anaerobic bacteria.
- The biogas is a mixture of methane (CH_4): 55-65% and Carbon dioxide (CO_2) : 30-40%. It also contains traces of H_2, H_2S and N_2. It is a clean and renewable energy that may be substituted to natural gas to cook, to produce vapour, hot water or to generate electricity.
- The methane gas produced by the bacteria inside biogas system may be used for cooking, lighting, and other energy needs. Waste that has been fully digested exits the biogas system in the form of organic fertiliser.

FAMILY SIZE BIOGAS PLANT

Deenbandhu biogas plant

- The calorific value of biogas ranges from 4700 kcal/cum.
- The biogas can be upgraded to synthetic natural gas (SNG) by removing CO_2 and H_2S.
- The production of biogas is of particular significance in India because of its large scale cattle production.
- The biogas is used for cooking, domestic lighting and heating, run I.C. engines and generation of electricity for use in agriculture and rural industry.
- Family biogas plants usually of 2-3 m^3 capacity.
- The by-products – biogas plant spent slurry is rich in nitrogen, phosphorus and potash compared to FYM.

Biogas - Uses

- For cooking: Gas requirement is 0.24 cum per person per day

  (efficiency of cook stove is 60%)

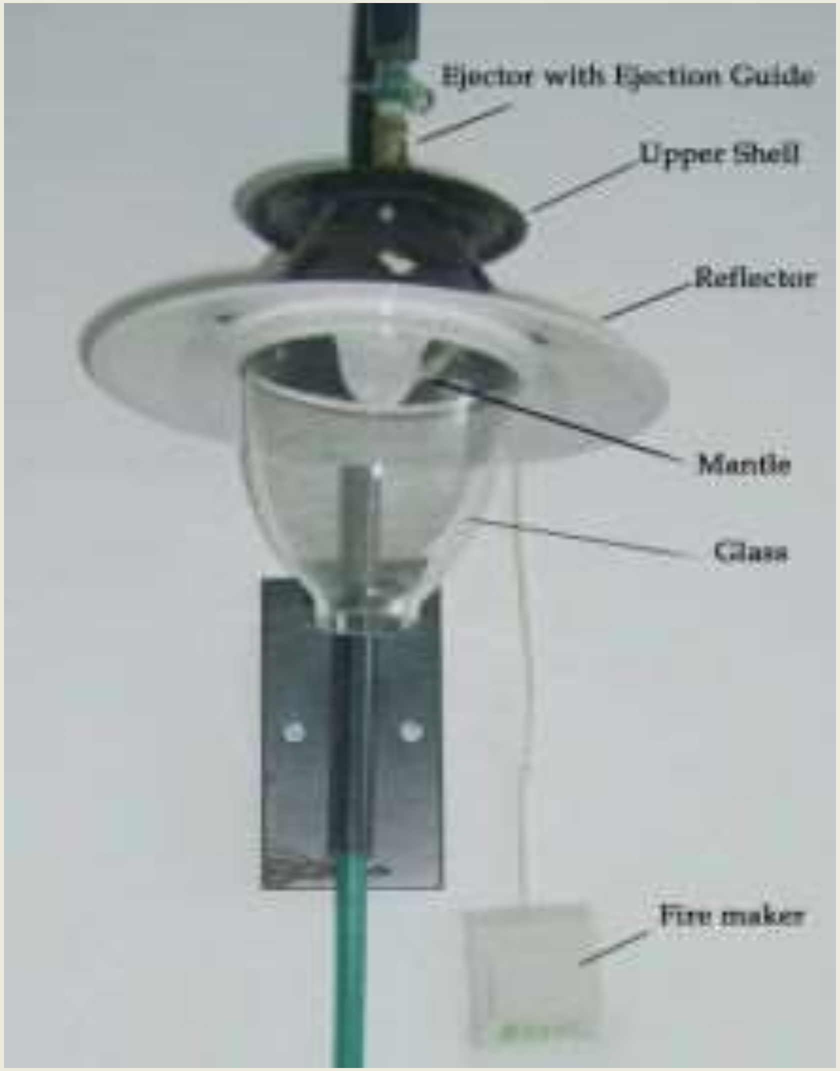
- For lighting: Gas requirement is 0.13 cum per 100 candle power mantle lamp (= 40 w bulb) per hour.
- For motive power: Gas requirement is 0.5 cum per hp per hour. (80% gas and 20 % diesel)
- For electricity generation: 1.25 KW /cum of biogas

Biogas burner

Lighting

Lighting can be provided by means of a gas mantle, or by generating electricity.

Biogas mantle lamps consume 0.13 cum gas per hour having illumination capacity equivalent to 40 W electric bulbs at 220 volts. This application is predominant in rural and un-electrified areas.



Biogas lamps

Biogas as an Engine Fuel

Biogas can be used as a fuel in stationary and mobile engines.

It can be used to operate four stroke diesel and spark ignition engines.

Electricity generation using biogas is a commercially available and proven technology.

When biogas is used to fuel such engines, it may be necessary to reduce the hydrogen sulphide content if it is more than 2 percent otherwise the presence will lead to corrosion of engine parts.

For electricity production, small internal combustion engines with generator can be used to produce electricity.

Biogas Generator

Solar Energy

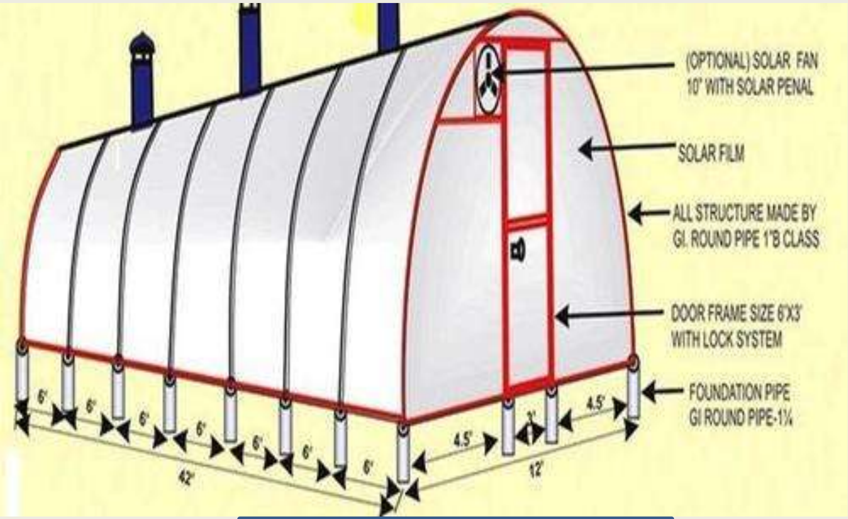
- All kinds of energy on earth originate in solar energy.
- it is non-polluting.
- Solar energy has an intensity of about 1367 W/m^2 at the outer surface of the atmosphere i.e. the rate at which energy flows through every sq.m.of area directly facing the sun.
- The solar radiant energy has been utilized in a number of ways for various purposes through solar thermal and photovoltaic routes.

- In thermal mode, heat is used for cooking, heating, drying, distillation, or generating electricity.
- A traditional and wide spread use of solar energy is **for drying** particularly of agricultural products. The solar photovoltaic route is being used for electricity generation, telecommunication, street lightning, domestic lightning, and water pumping.
- On an average 5 kW/m^2 per day solar energy is falling on the land for nearly 300 days in a year.

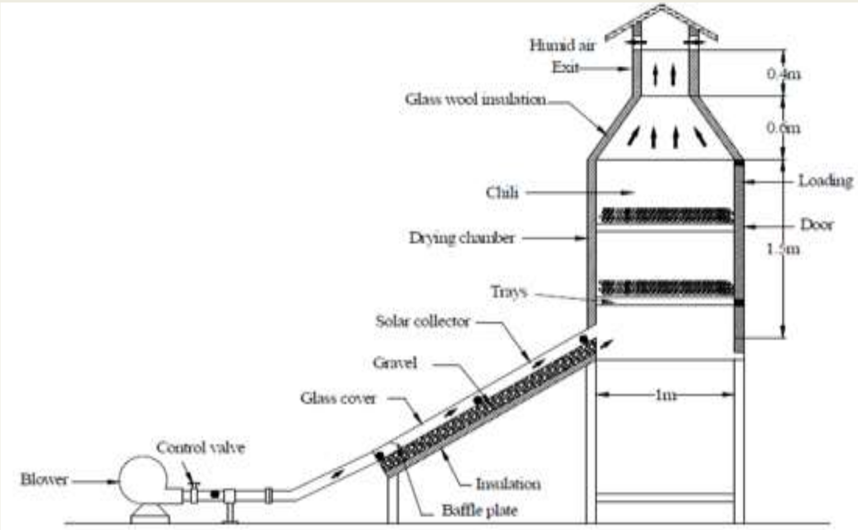
Drying

Direct heating

In direct heating



Solar tunnel dryer



Forced convection solar dryer

Solar Animal Feed Cooker

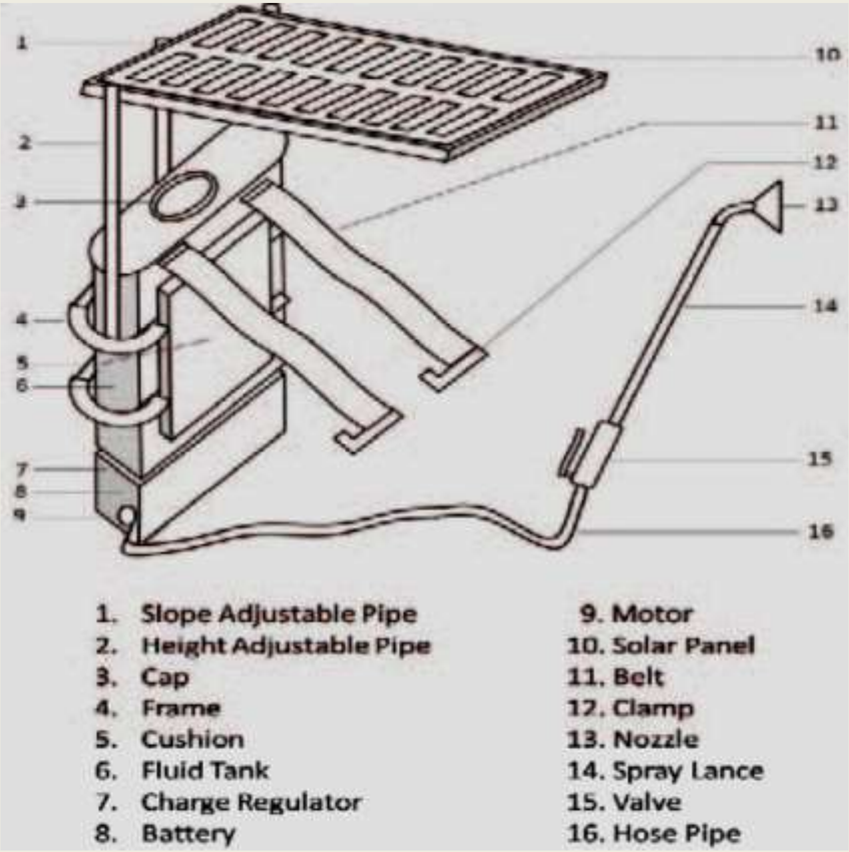
- Solar photovoltaic field is getting priority in India due to heavy pressure on conventional fuels and electricity.
- Solar cells directly convert the solar radiation into electricity using photovoltaic effect. SPV cell is a semi-conductor system made of silicon or similar materials.
- The system generates electricity when it is exposed to sunlight. Power is generated by connecting thousands of tiny solar cells which forms modules. Solar cells are quite compatible with almost all environments, respond instantaneously with solar radiation and have an expected lifetime of 25 years. These cells can be located at place of use and hence no distribution network is required.

Solar water pumping system

Features :

1. Noise and pollution free operation.
2. Does not require any fuel
3. Simple to install, operate and maintain.
4. Designed to give optimum output even during low sunshine period.

Solar Photovoltaic Sprayer



Solar panel of 20 W capacity, a 12V DC battery, a DC motor, a pump, to spray the pesticide and a tank to hold the pesticide.

Solar Photovoltaic Duster

Solar PV duster is a novel device suitable for aerial application of pesticides and insecticides in the powder form.

Duster is an impeller type centrifugal blower, gear reduction mechanism, dispensers with D.C motor.

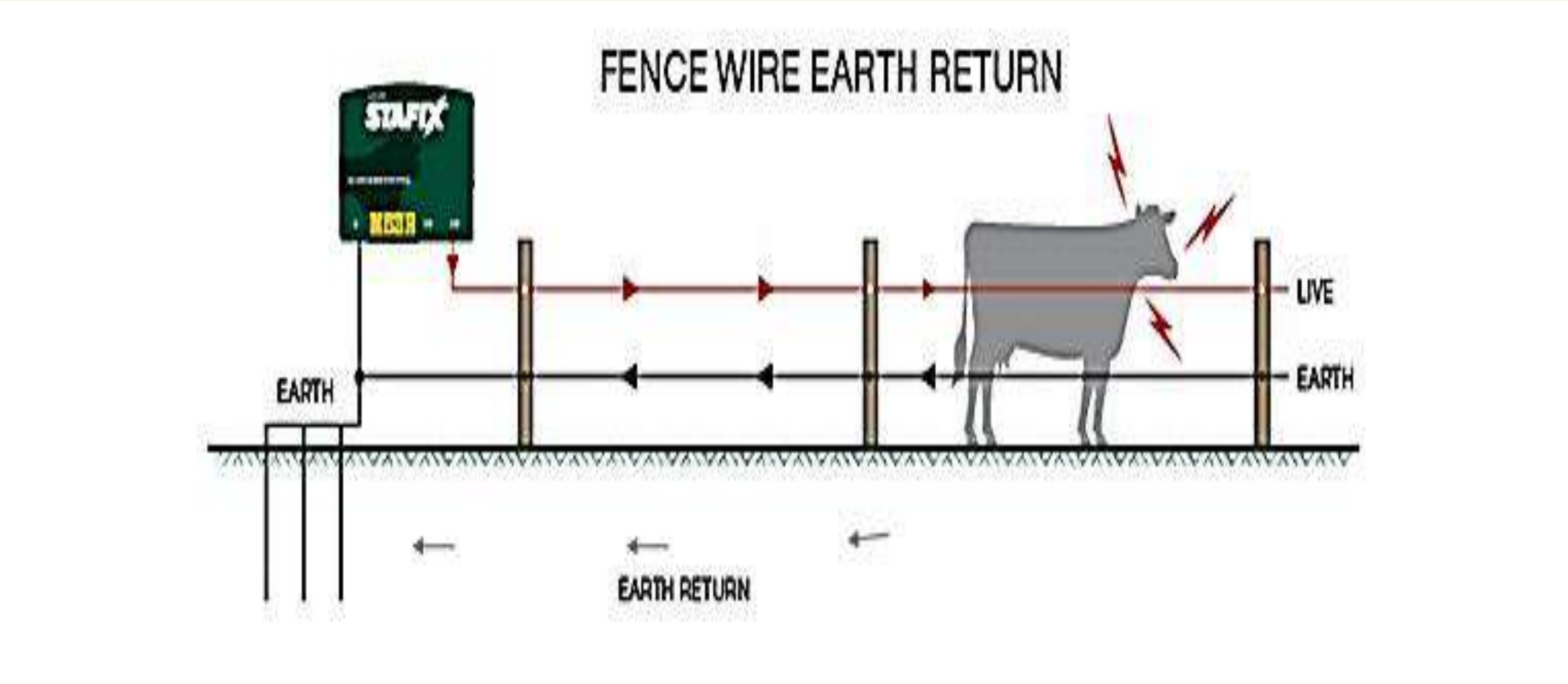
Solar Power Electric Fence

- One of the risks in Indian farming is damage to crops by stray/ wild animals and also theft of the produce especially in orchards.
- Proper fencing is one of the solutions to overcome such type of risks.
- The fencing of barbed wire with multiple strands of plain wires or woven wire and metal/cement/ wooden posts is common. A channel linked fencing costs about Rs 950 per running meter for a height of 1.5 m using angle posts of 50 x50 x 6 mm at 3 m spacing and plain wire channel of 75 x 75 x3.15 mm.

Solar powered electric fence

- It gives a sharp shock to create psychological fear, against any tampering. Electricity is generated by 75 watts solar panel which charges a 12 volt, 40 AH battery and ensures that the battery remains charged at all times.

- As current is pulsating (not live) and passing at every 1 to 1.2 second and only for a milli-second of time, the animal gets enough time to get away from the fence. The pulsating current does not grab the animal which generally happens in continuous current which causes contraction of muscles/cramps.



In solar fencing, even if an animal is trapped in the fence, after 10 consecutive shocks the system will trip and hooter will sound so that farmer can intervene and no death causes.

Farm power - Present Scenario

- Average farm power availability for the cultivated areas of the country has been increased from 0.295 kW/ha in 1971-72 ,2.02 kW/ha in 2016-17. and 2.761 kW/ha in the year 2020-21.
- In India, medium and large scale industries manufacture tractors, power tillers, diesel engines, electric motors, land development machinery, field preparation equipment, weeders, sprayers and dusters, irrigation pumps, post-harvest and processing machinery and dairy equipment.
- The overall level of farm mechanization in India is 40-45 per cent (i.e. tillage about 40 per cent, seeding and planting about 30 per cent, plant protection 35-45 per cent and harvesting and threshing about 60-70 per cent for rice and wheat and less than 15 per cent for other crops).

Table Share of different sources of available power during different periods in the country

Year	Share of Different Sources of Power Availability, %						Net Sown area, million ha	Available power per ha, kW	Productivity, t/ha
	Farm workers	Draft animal	Tractors	Power tillers	Diesel engines	Electric motors			
1961-62	16.09	75.26	2.37	0.00	3.91	2.36	135.4	0.301	0.7096
1971-72	10.68	53.48	7.45	0.11	17.36	10.92	139.72	0.421	0.858
1981-82	9.11	34.24	17.06	0.12	23.33	16.15	141.93	0.572	1.032
1991-92	7.31	21.08	24.54	0.17	21.56	25.34	141.63	0.895	1.382
2001-02	6.12	11.29	36.79	0.36	19.11	26.33	140.73	1.358	1.734
2011-12	5.00	6.43	45.19	0.73	17.49	25.15	140.98	1.865	2.078
2020-21	2.97	3.03	59.37	1.02	14.03	19.58	140	2.761	2.39

Declining trend of human and draft animal in the country suggests for availability of small power source (walk-behind type) at catchment or household level for reduction of drudgery of farm worker with overall increase in productivity.

- The share of mechanical power is 74.42 per cent of total available power of 386.576 million KW in year 2020-21.

- The level of farm mechanization varies greatly region to region. Northern states such as Punjab, Haryana and western Uttar Pradesh have high level of mechanization (70-80 per cent overall; 80-90 per cent for rice and wheat) due to high productive land as well as declining number of agriculture workers and also full support by state government.

- The eastern and southern states have lower level of mechanization (35-45 per cent) due to smaller and scattered land holdings.

- In the north-eastern states, the level of farm mechanization is extremely low mainly due to hilly topography, high transportation cost, and socio-economic conditions of the farmers.

Farm Power - Rajasthan Scenario

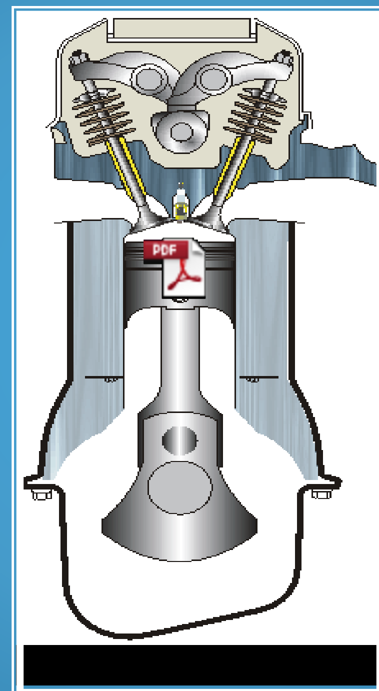
- Rajasthan contributes about 10% of India's geographical area and about 14% of the total India's Agriculture land.
- Rajasthan Agriculture is witnessing a significant movement from manual to mechanical power; the shift is mainly because of unavailability and high cost of labor at farms. Further, use of mechanical power has a direct influence on quality of farm operation which in turn increases the productivity of crops, apart from reducing the drudgery and facilitating timeliness of agricultural operations.
- Mechanical power is largely consumed in big land holdings and is still beyond the reach of small/marginal farm holders, which constitute around 75 to 80% of total land holdings.
- In order to make farm machinery with modern technologies available to small and marginal farm holders, collective ownership or Custom Hiring Centers is being promoted.

Farm Power - Rajasthan Scenario

- In the year 2001, the power availability on the farms of Rajasthan state was 0.65 KW/ha, very less as compared to 2.96 KW of Punjab state and 1.61 KW of Haryana state at that time.
- In Rajasthan, the equipment and machinery for planting some of the coarse cereals like pearl millet, their harvesting and threshing need to be introduced.
- Deep placement of seeds to make use of the receding soil moisture for proper germination is necessary. Therefore, equipment for deep tillage to increase moisture intake needs introduction.

Lect.- 2

I.C. engines, working principles of I. C. engines. Comparison of two stoke and four stroke cycle engines.



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Heat engine

A **heat engine** is a machine that converts heat developed by burning fuel into mechanical work output, thus it transforms chemical energy into mechanical energy.

On the basis of how thermal energy is being delivered to working fluid of the heat engine, heat engine can be classified as external combustion engine, and internal combustion engine.

External combustion engine:

- It is the engine designed to derive its power from the fuel, burnt outside the engine cylinder.
- Steam engine is an example of external combustion engine, where the working fluid is steam which is generated in a boiler, placed entirely separate from the working cylinder.

Internal combustion engine (I. C. engine):

- It is the engine designed to derive its power from the fuel, burnt within the engine cylinder. Here combustion of fuel and generation of heat takes place within the cylinder of the engine.
- Petrol engine is an example of internal combustion engine, where the working fluid is a mixture of air and fuel.

Classification of I C engines

Internal combustion engines are classified as given below:

1. Type of mobility:

stationary or automotive (mobile) engines.

Stationary engines are designed without transmission system.

These engines are generally used in the situations where it is not required to move the engine. For example for pumping water, to operate thresher.

2. Type of piston movement:

Reciprocating and wankel rotary.

When the piston moves up and down or from left to right, they are called reciprocating engines.

A Wankel rotary engine uses rotary design to convert pressure into a rotating motion instead of using reciprocating pistons.

3, Number of cylinders:

Single or multiple cylinder engines.

A single cylinder engine requires a large flywheel (for having more momentum) to move the piston up and down during idle strikes and to overcome the friction between moving parts.

A multi cylinder (more than one) is a combination of several single cylinders which have a common crankshaft, camshaft etc.

4. Engine speed:

Low, medium or high speed engine

Low speed – below 350 rpm,

Medium- 350 to 1000 rpm,

High speed- over 1000 rpm

5. Position of engine:

Horizontal or vertical engine.

Generally, the engines used now- a- days are vertical engines.

6.No of strokes:

Depending on the number of strokes required to complete one cycle the engines are classified as *two stroke or four stroke engine.*

When the cycle is completed in two revolutions of the crankshaft, it is called *four stroke cycle engines*.

When the cycle is completed in one revolution of the crankshaft, it is called *two stroke cycle engines*.

7. **With regard to the fuel used in them:**

(i) Petrol or gasoline engines in which petrol or petrol gas is used;

(ii) Diesel engines in which diesel is used as fuel.

8. **With regard to the method of ignition in the engines:**

(i) Spark ignition engines in which ignition takes place by means of an electric spark.- Petrol engines are spark ignition engines.

(ii) (ii) Compression ignition engines in which the injected fuel is ignited due to the temperature of compressed air in the cylinder. Diesel engines are compression ignition engines.

9. With regard to their cycle of operation:

(a) **Otto cycle engines** or constant volume cycle engines.

- The engines which work on this cycle are known as Otto Cycle engines. In Otto Cycle, combustion takes place at constant volume as whole of the fuel is burned instantaneously as an explosion.
- Petrol engines are Otto cycle engines.
- The fuel is ignited in the cylinder by an electric spark.
- These engines are generally simple and lighter and are used predominantly in automobiles requiring high speeds.
- But these engines are not good for pulling purpose or for works requiring higher torque.

- (b) **Diesel Cycle Engines**
- or Constant Pressure Cycle Engines which work on diesel cycle or constant pressure cycle.
- In diesel cycle, the combustion takes place at constant pressure because burning takes place gradually without an explosion as the fuel enters. Hence this cycle is known as constant pressure cycle.
- Diesel engines work on this cycle.
- In C.I. engine the fuel is injected at high pressure through fuel injectors and ignited by heat of compression.

10. With regard to the type of cooling system of the engine:

(i) **Air cooled engines** which are cooled by air. Air cooled engines contain fins around the cylinders, cylinder heads and exhaust ports etc. to provide more area for better radiation of heat.

(ii) **Liquid or water cooled engines** in which some liquid or water is used to cool them. These engines contain water jackets around the cylinders, combustion chambers and valve ports etc. A radiator is provided to cool down hot water.

Spark ignition engine

- It is designed on the basis of Otto cycle.
- In this engine fuel is atomized, vaporized and mixed with air in correct proportion before inducing into the cylinder through inlet manifold.
- It is also known as Carburetor type, or petrol or gasoline engine.
- The fuel is ignited in the cylinder by an electric spark.
- These engines are generally simple and lighter and are used predominantly in automobiles requiring high speeds.
- But these engines are not good for pulling purpose or for works requiring higher torque.

Compression ignition engine

- It is designed on the basis of Diesel cycle that is why it is also known as diesel engine.
- In this engine, during suction stroke, only air is entered into the cylinder and compressed.
- The fuel is injected at high pressure through fuel injectors and ignited by heat of compression.

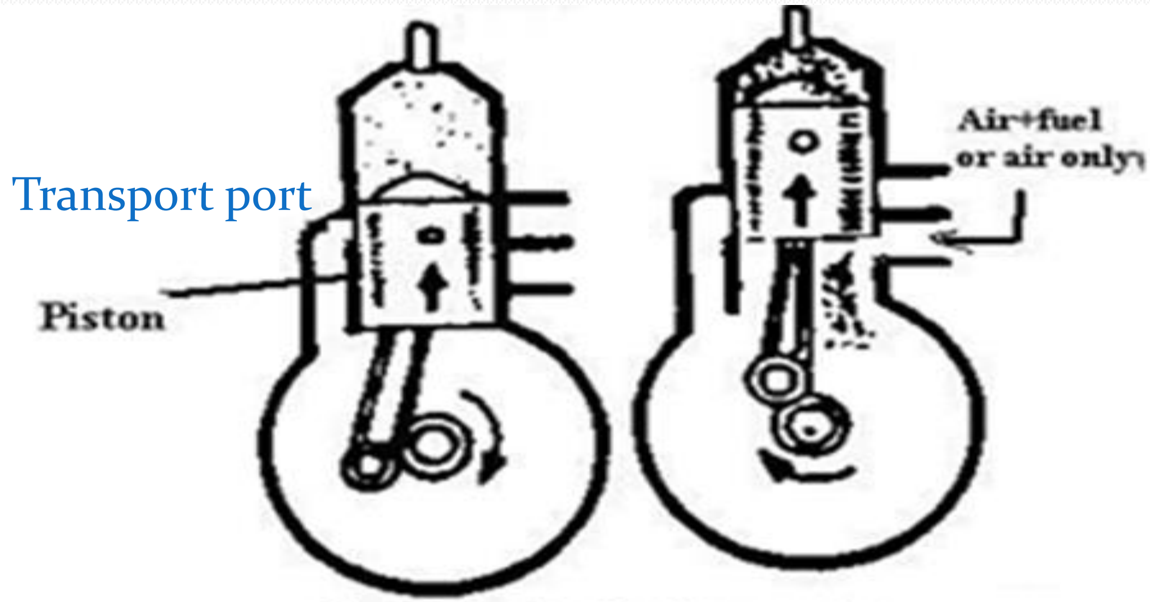
In tractors- automotive, multi cylinder, high speed (1500rpm), water cooled, vertical engines are mostly used.

Working of Two stroke cycle engine

- In such engines, the whole sequence of events i.e. suction, compression, power and exhaust are completed in two strokes of the piston and in one complete revolution of the crankshaft.
- There is no valve in this type of engine. Gas movement takes place through holes called ports in the cylinder.
- The crankcase of the engine is gas tight in which the crankshaft rotates.

First stroke (suction + compression):

- The piston moves up the cylinder, it covers two of the ports, the exhaust port and the transfer port, which are normally almost opposite to each other.
- Further movement of the piston uncovers a third port in the cylinder- suction port. Fresh mixture is drawn through this port into the crankcase.



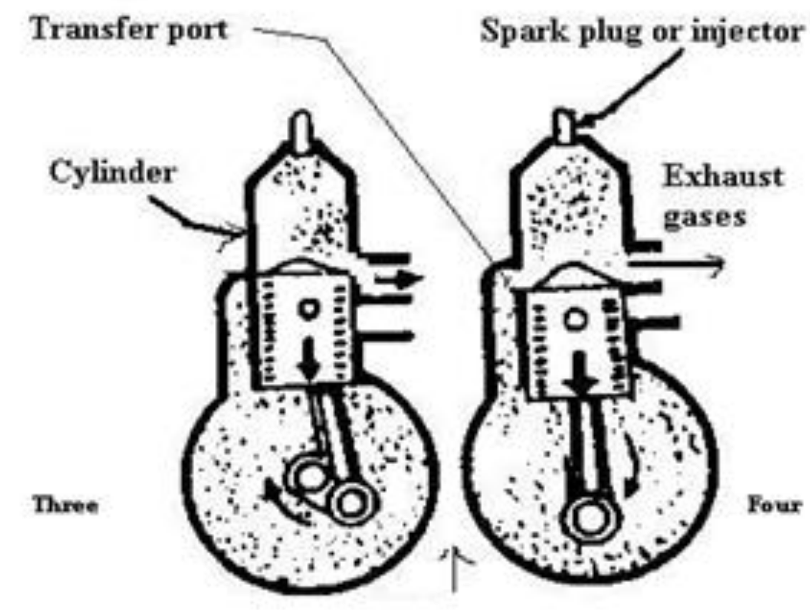
First stroke (Suction+Compression)

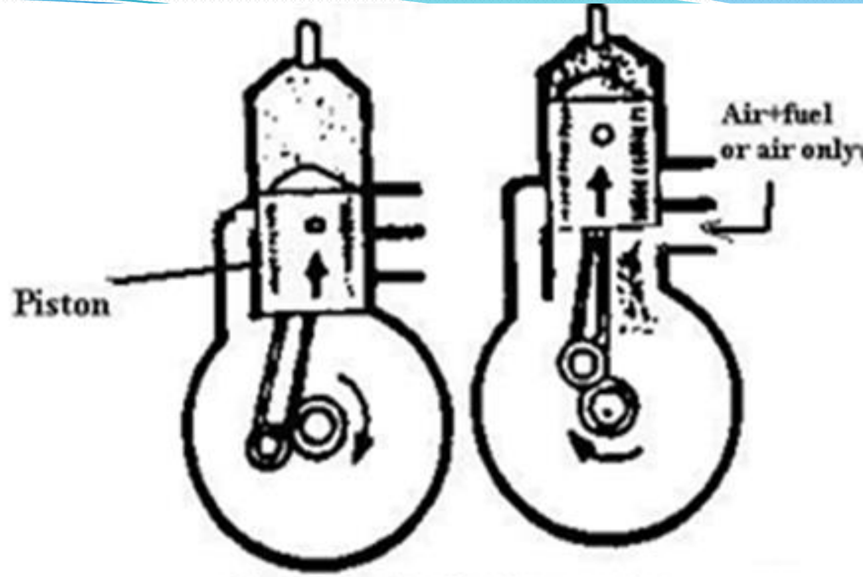
- This trapped charge of fresh mixture in the cylinder is compressed by the further upward movement of the piston.
- Just before the end of this stroke, the mixture in the cylinder is ignited as in the four stroke cycle.

Second stroke (Power + exhaust):

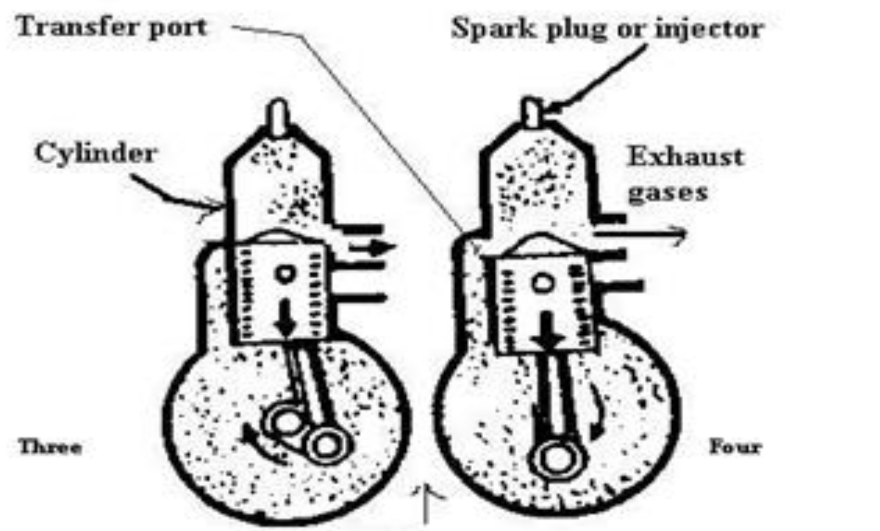
- The rise in pressure in the cylinder caused by the burning gases forces the piston to move down the cylinder.
- When the piston goes down, it covers and closes the suction port.
- Further downward movements of the piston uncover first the exhaust port and then transfer port.
- This allows the burnt gases to flow out through exhaust port.

- When the piston is at the top of its stroke, it is said to be at the top dead centre (TDC).
- When the piston is at the bottom of its stroke, it is said to be at its bottom dead centre (BDC).
- In two stroke cycle engine, both the sides of the piston are effective, which is not the case in case of four stroke cycle engine.



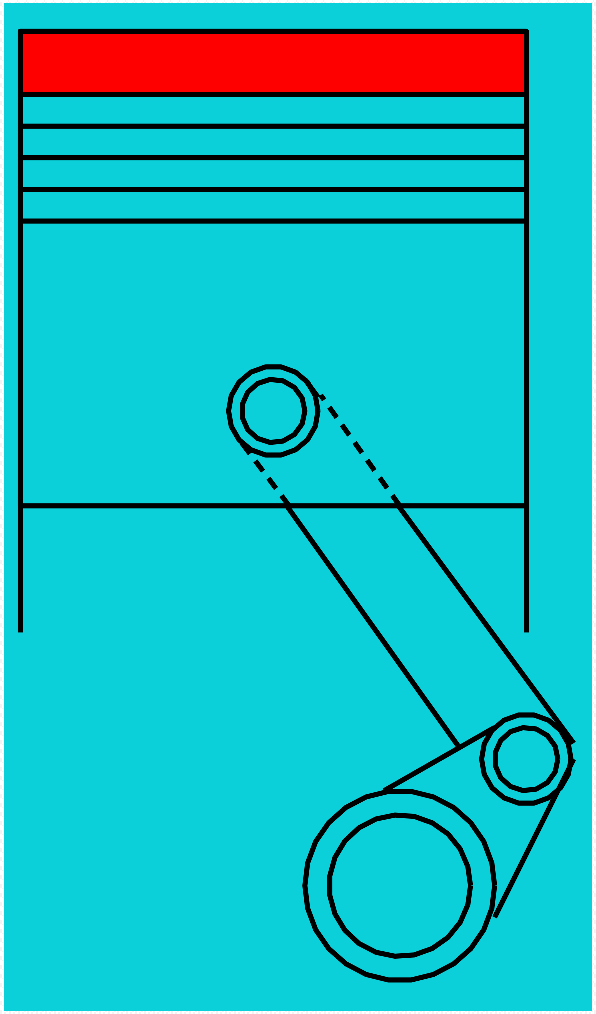


First stroke (Suction+Compression)



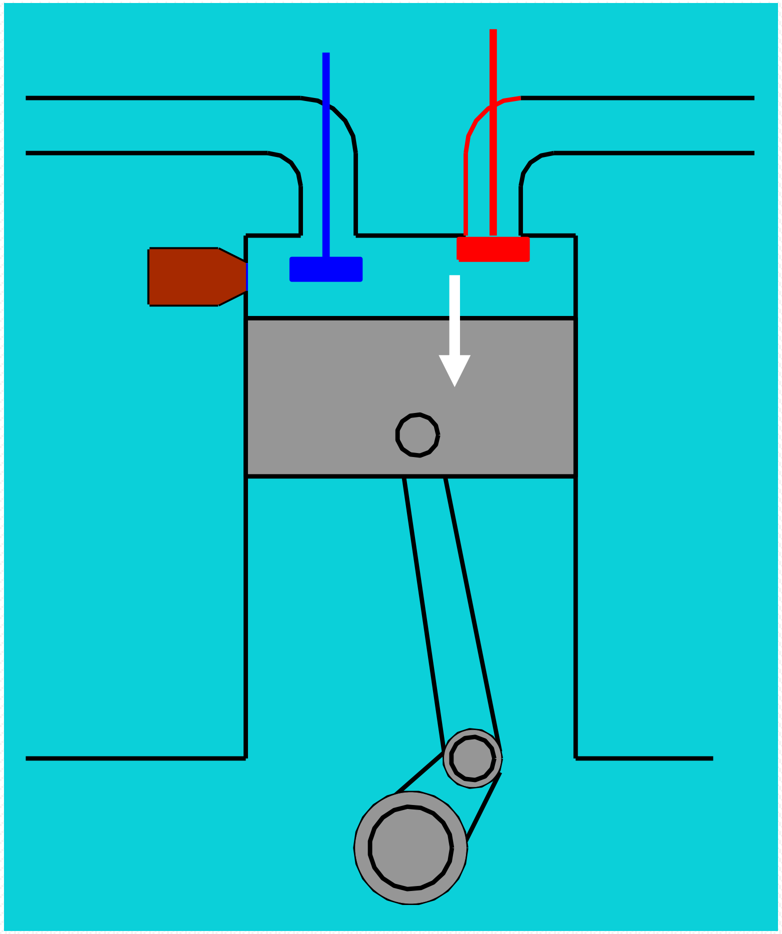
Second stroke (power % exhaust)

4-Stroke Cycle Engine Operation



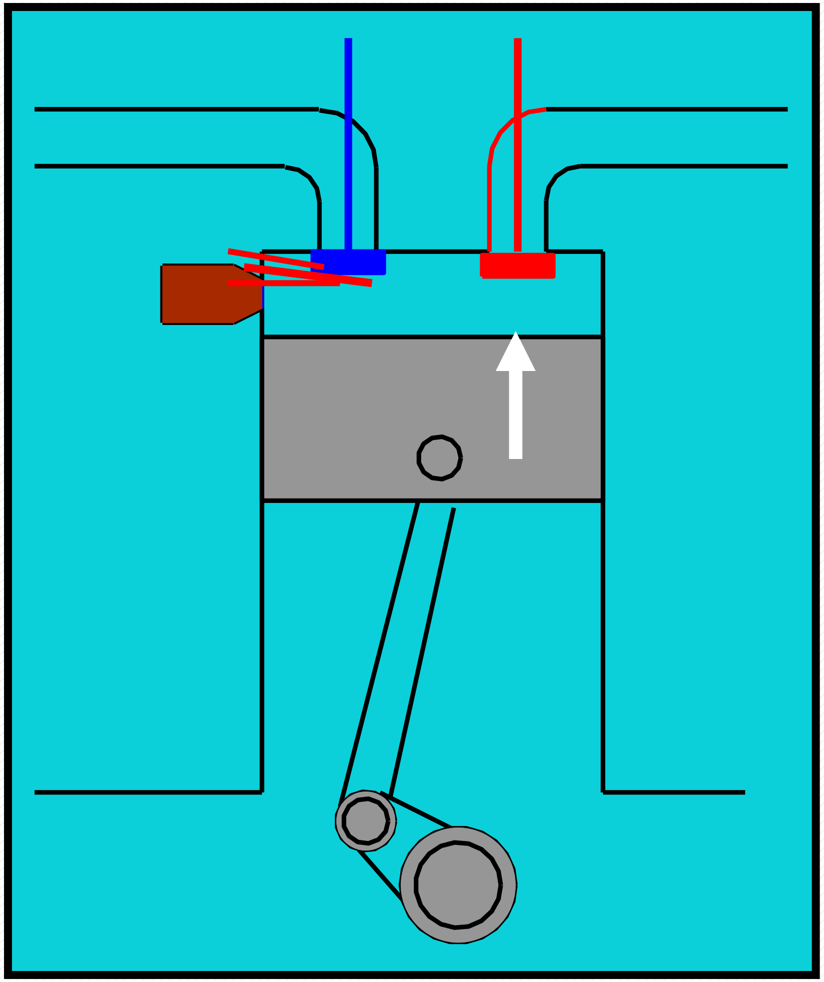
- 4-stroke cycle engines require four strokes of the piston to complete the five events necessary for engine operation.
  - 1 piston stroke = ½ crankshaft revolution.
  - 4 piston strokes = 2 crankshaft revolutions.

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.

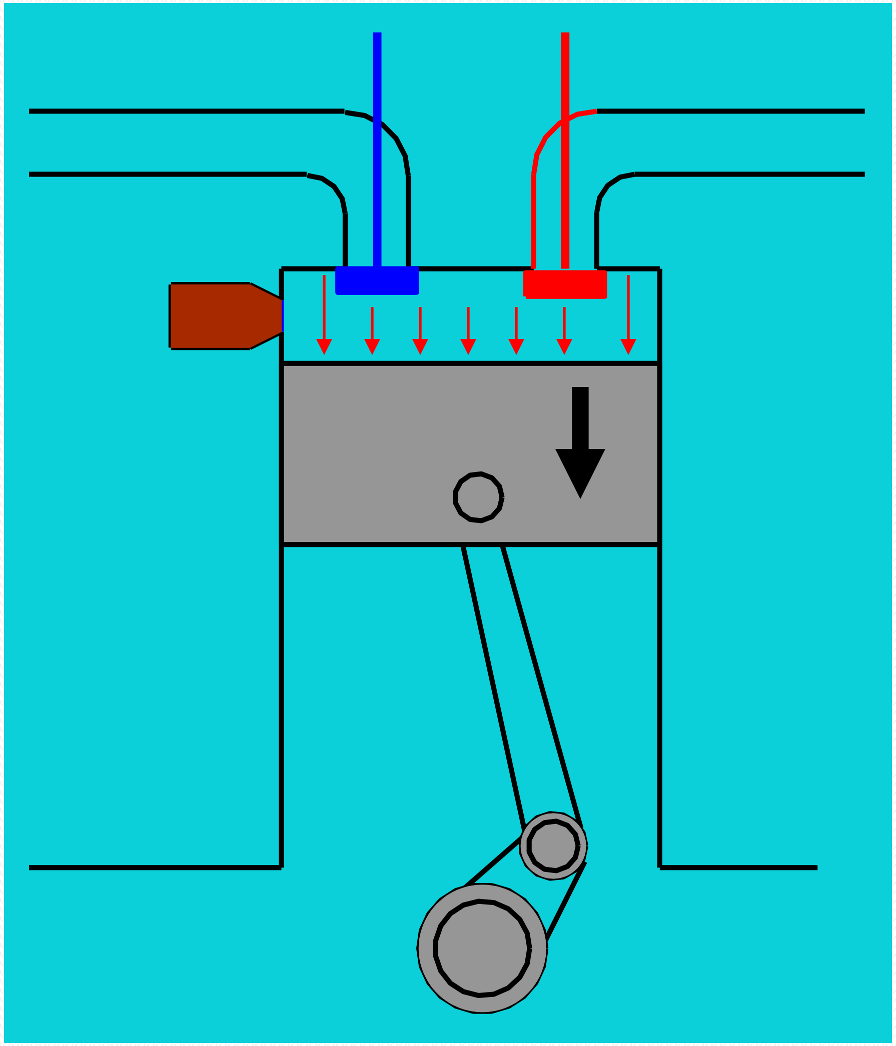
4-Stroke Cycle Engine Operation



Compression Stroke

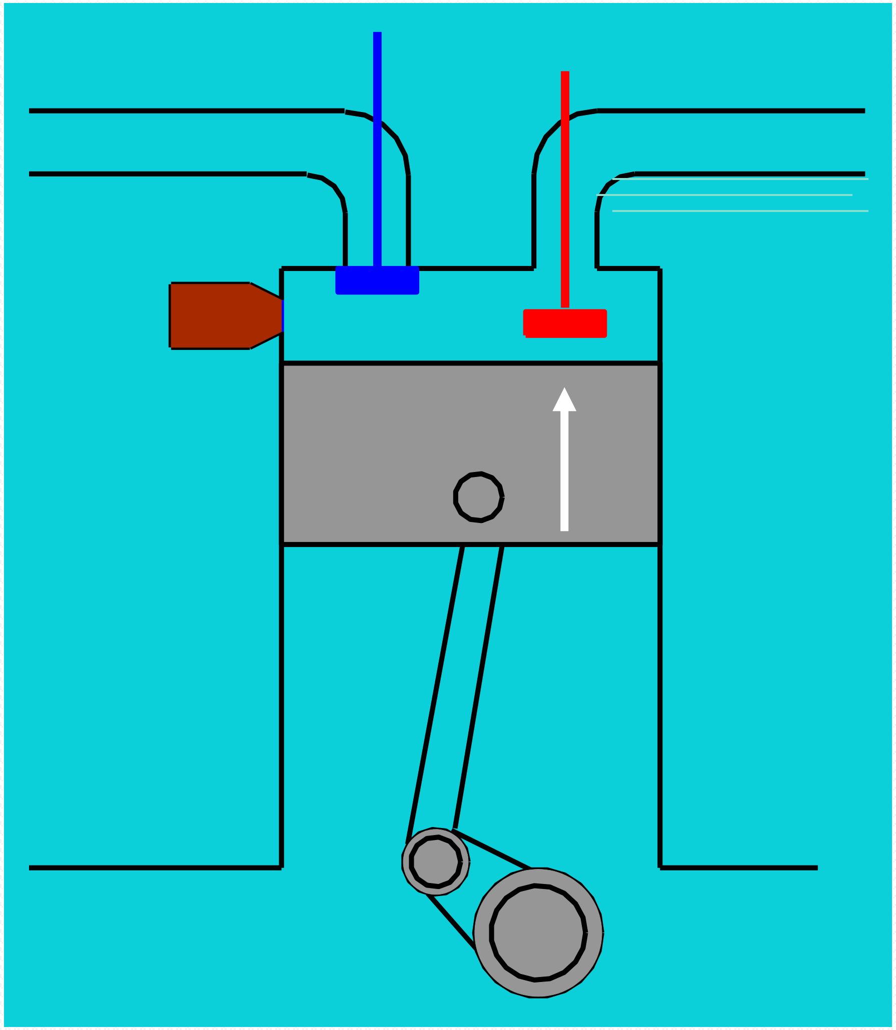
- Both valves closed.
- Piston moves from BDC to TDC
- Air in combustion chamber is compressed, raising its temperature.
- Near TDC of Compression stroke, diesel fuel is injected into the combustion chamber.

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.

Firing order

Means the sequence of power strokes occurring in the cylinder of an engine.

In a four cylinder engine the firing order may be 1-2-4-3, or 1-3-4-2.

In a six cylinder engine it will be 1-5-3-6-2-4

Comparison between diesel and petrol engine

S.No.	Parameter	Diesel engine	Petrol engine
1.	Fuel used	Diesel	Vapourizing fuel- Petrol or Kerosene
2.	Intake during suction stroke	Air alone	Mixture of air and fuel
3.	Fuel ignition	Due to high compression of air (heated)	By an electric spark.

S. No.	Parameter	Diesel engine	Petrol engine
4.	Air fuel ratio	Not constant (the quantity of air drawn into the cylinder is always the same but the quantity of fuel injection is to be changed as per load and speed.)	Air and fuel ratio is constant (15:1). To vary the engine power, quantity of mixture is varied.
5.	Compression ratio	14:1 to 20:1.	4.5:1 to 8:1.
6.	Specific fuel consumption	About 0.2 kg per BHP per hour.	About 0.29 kg per BHP per hour.

Comparison between diesel and petrol engine

S.No.	Parameter	Diesel engine	Petrol engine
7.	Thermal efficiency	32 and 38%.	25 and 32%.
8.	Engine weight per horse power	Comparatively more heavily loaded.	Comparatively less
9.	Torque characteristics	more uniform (Better top gear performance)	Comparatively less uniform
10.	Initial cost	High.	Low

S. No.	Parameter	Diesel engine	Petrol engine
11.	Operating cost	Low	High
12	Operating pressure	Ranges from 30 to 50 bar. The maximum BMEP is about 20 bar.	Ranges between 17 and 15 bar. The maximum BMEP is about 10 bar.
13.	Fire risk	Minimum due to the absence of the ignition system	Comparatively more

Comparison between two stroke and four stroke engine

S.No.	Parameter	Two stroke engine	Four stoke engine
1.	Power impulse or working stroke	There is one power impulse for every two strokes of piston.	There is one power impulse for every four strokes of piston.
2.	Power developed by same size engine	About twice than 4 stroke engine.	About half the power of 2 stroke engine.
3.	Valve mechanism	Valves are not required for intake and exhaust operations. (Ports instead of valves.)	Valves are essential.

Comparison between two stroke and four stroke engine

S.No.	Parameter	Two stroke engine	Four stoke engine
4.	Weight per bhp	Low	Comparatively higher
5.	Fuel consumption	High (about 15% more) because some of the fuel passes directly to the exhaust.	Comparatively less
6.	Size of fly wheel	Comparatively smaller	Comparatively larger
7.	Thermal efficiency	Low	Comparatively higher

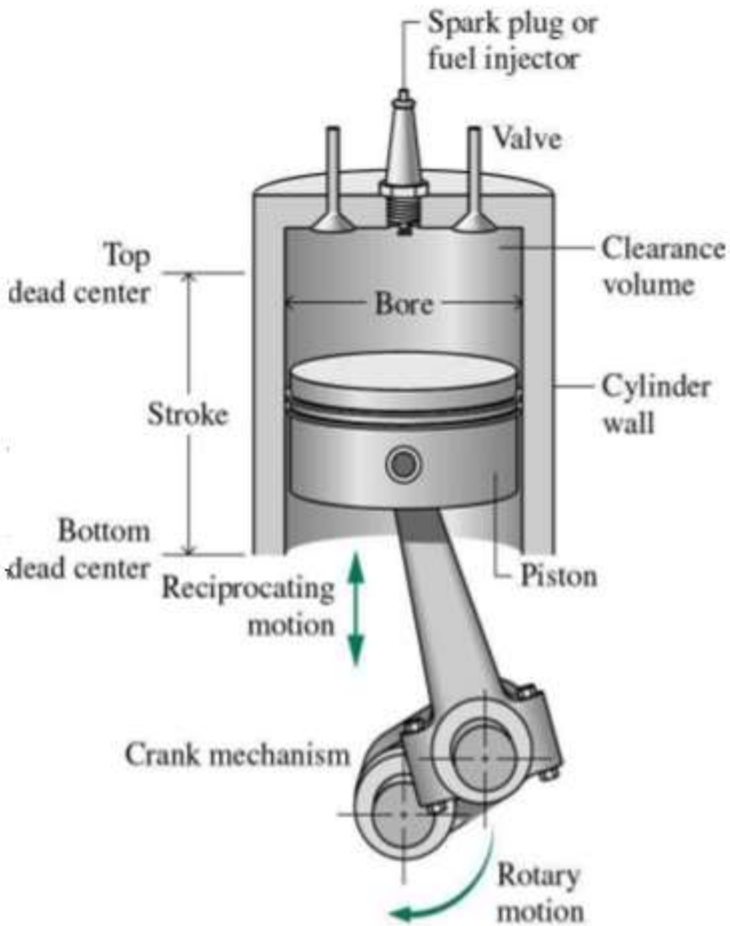
Comparison between two stroke and four stroke engine

S.No.	Parameter	Two stroke engine	Four stoke engine
8.	Construction and cost	Simple, cheap	Complicated and expensive
9.	Lubrication system	Not much effective, lubricating oil is mixed with the fuel. It consumes more lubricating oil because of the greater amount of heat generated.	Effective system, has a separate lubricating system. less tear and wear of engine parts
10.	Direction of engine operation	Both, clockwise and anticlockwise	In only one direction
11.	Carbon deposit inside cylinder	Much because of mixed fuel	Not so much

Comparison between two stroke and four stroke engine

S.No.	Parameter	Two stroke engine	Four stoke engine
12.	Mechanical efficiency	Higher due to absence of cam, camshaft, rockers etc.	Comparatively less
13.	Crankcase	Must be sealed (Air tight)	Sealing not necessary
14.	Engine availability as per speed	Only high speed type engines are available.	All types (low, medium and high speed) are available.
15.	Compression ratio	Lower than 4 stroke engine of the same dimensions.	Higher than 2 stroke engine of the same dimensions.

Lect.- 3
Study of different components of I. C. engine. I. C. engine terminology and numerical.



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Deptt. of Ag. Engineering
College of Agriculture Bikaner

Internal Combustion Engine

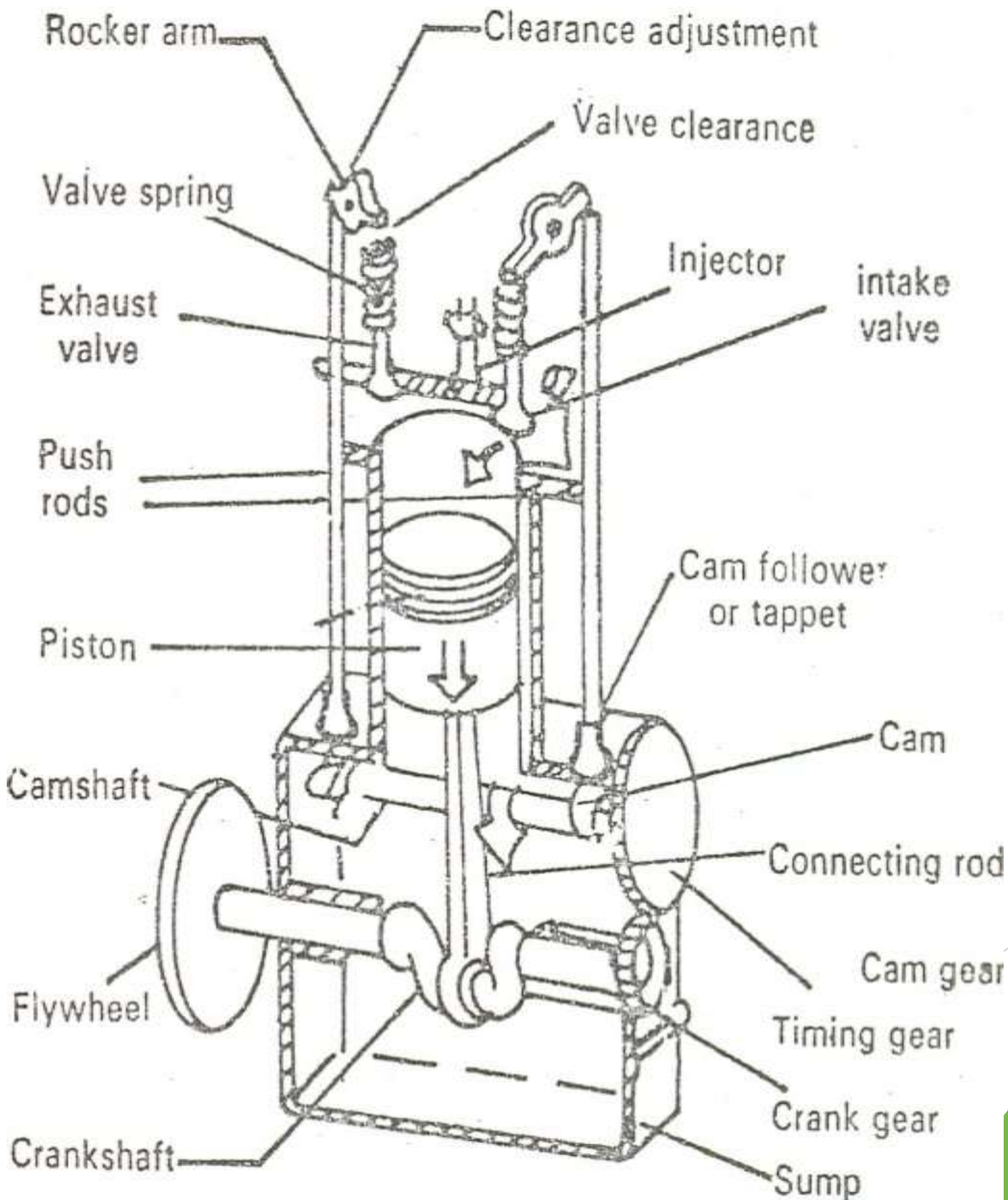
- Function - Converts potential chemical energy in fuel into heat energy then to mechanical energy to perform useful work.

Chemical

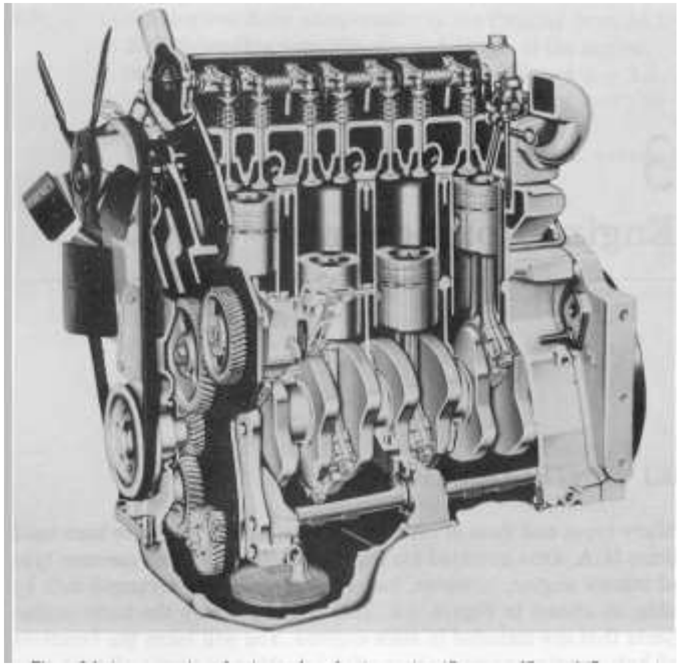
Heat

Mechanical

I C Engine- Parts

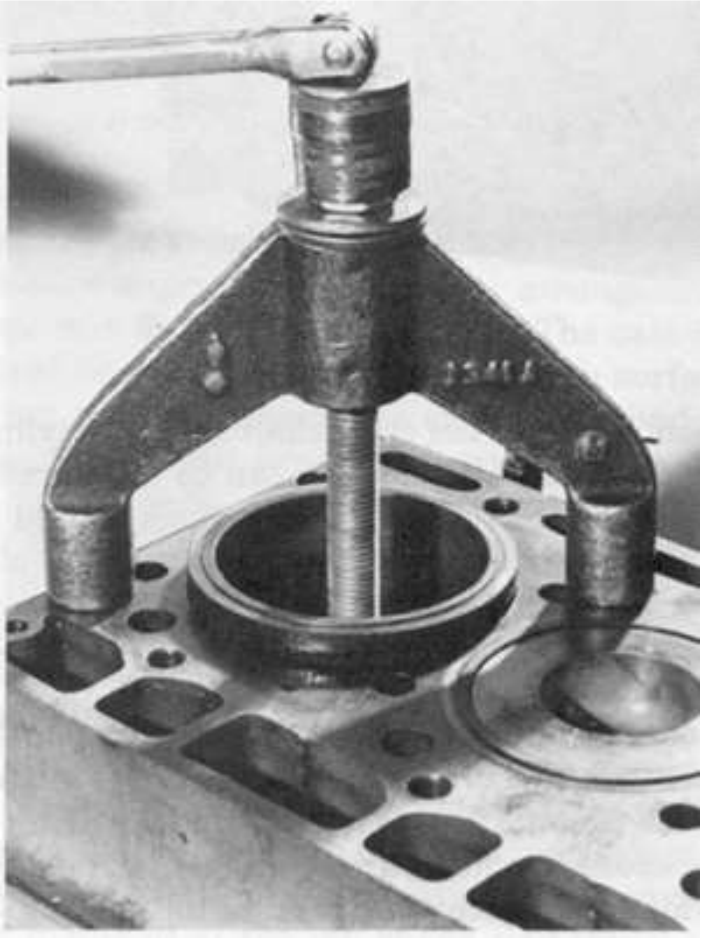


Engine Block



- "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

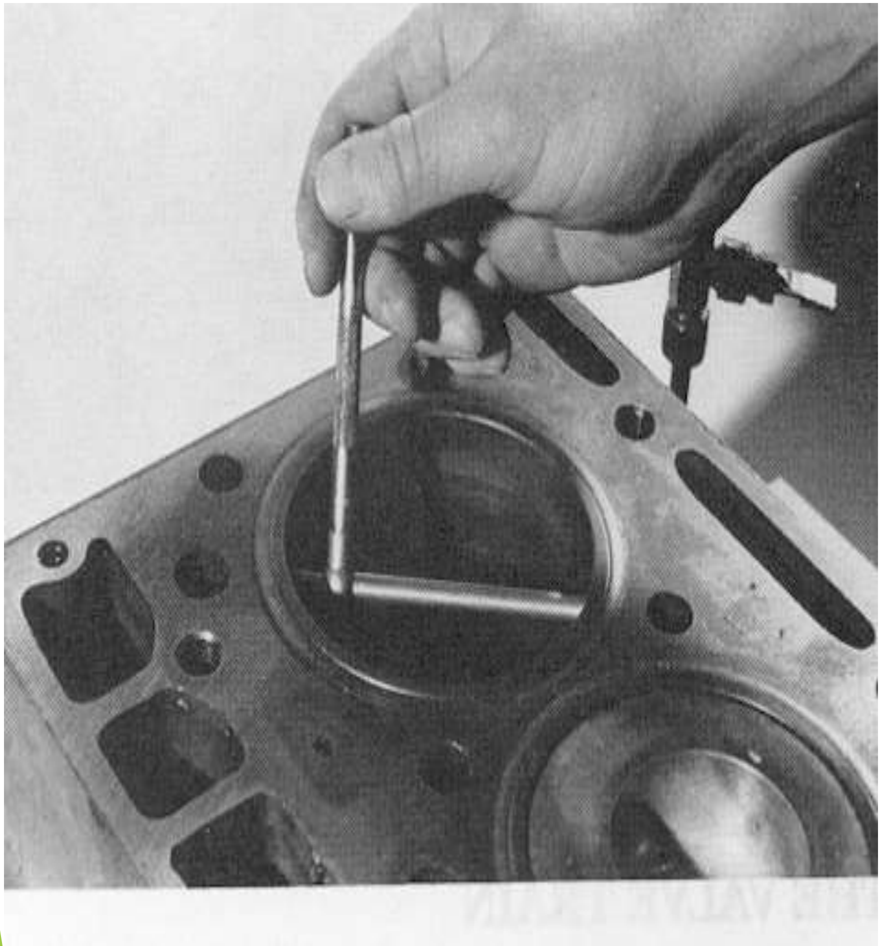


- Cylindrical holes in which the pistons reciprocate.
- May be:
  - Enblock
  - Liners
    - Wet liners
    - Dry liners
- Cylinder bore – diameter of cylinder

Cylinder liners

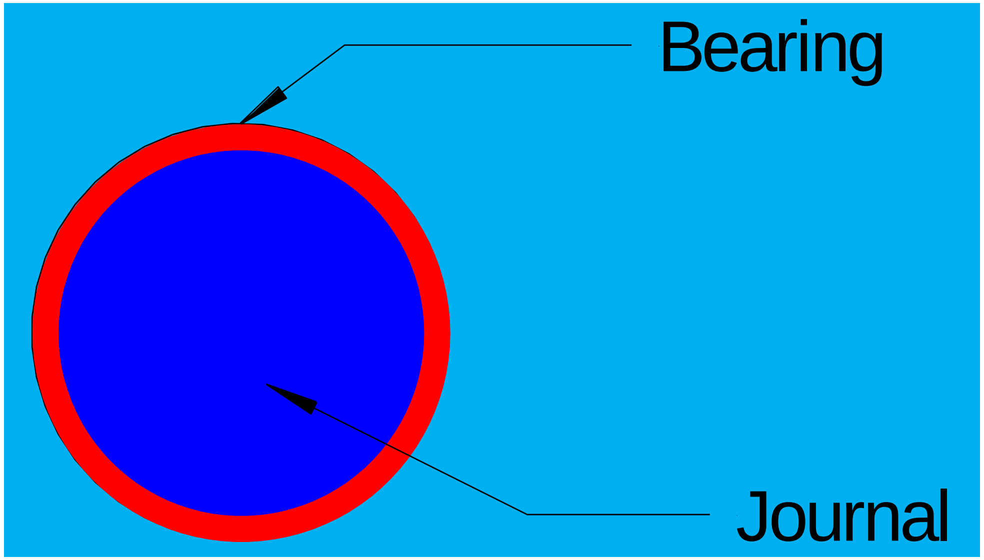
- They are fitted inside the cylinder block and are subjected to piston side thrust and high combustion temperatures. They are constructed for resistance to wear and adequate cooling. The liners are of two types: dry type and wet type.
- Dry type liners make metal to metal contact with the cylinder block casting. Cooling water does not come in direct contact between the dry liners as it does with the wet type.

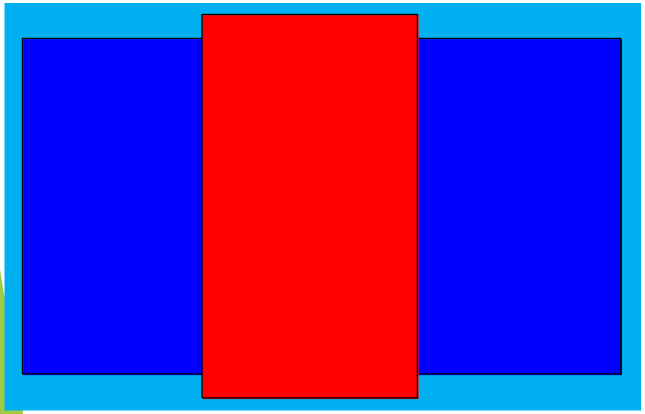
Checking Cylinder Condition



- 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.

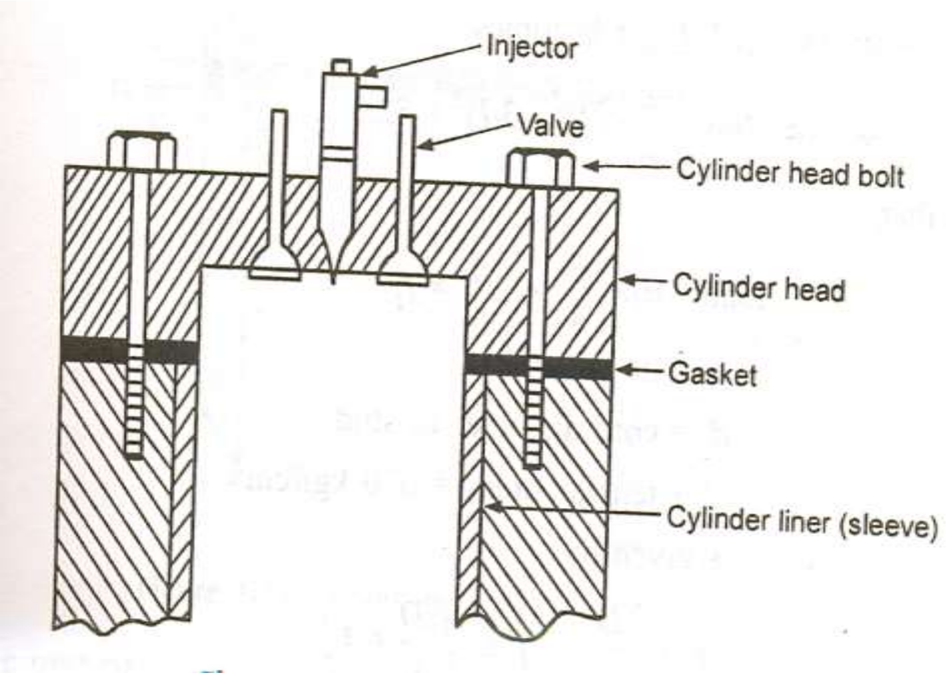
Cylinder Head

One-piece castings of iron alloy.

Cylinder head gasket

- 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.

Components of cylinder head

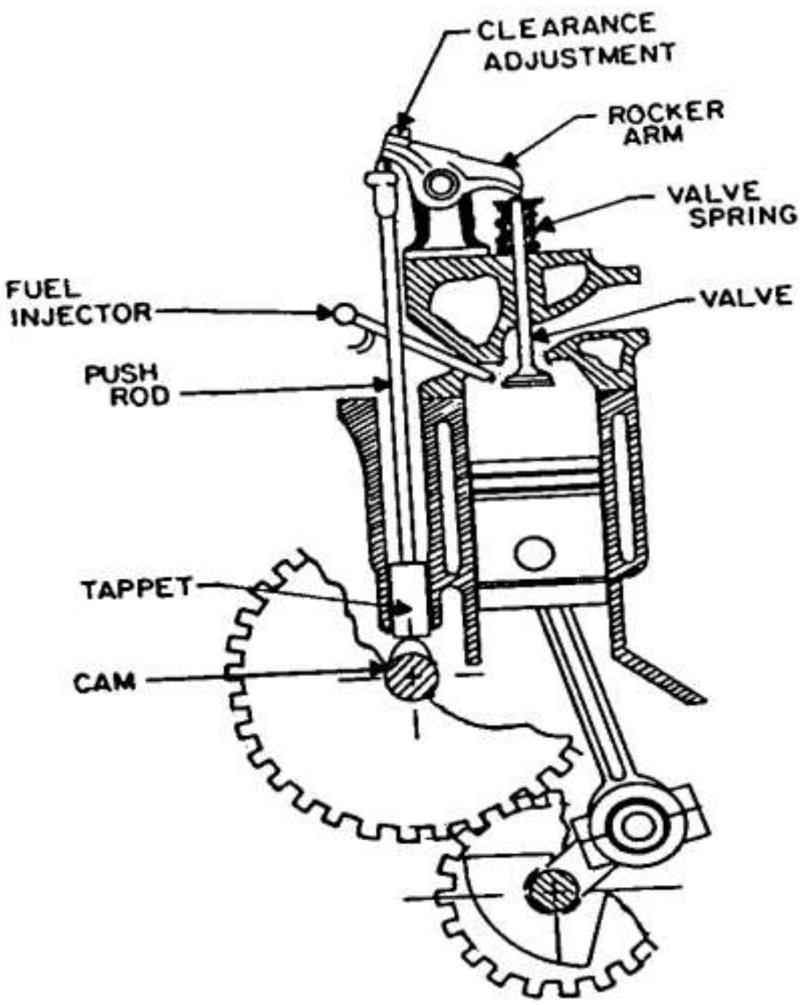


- It is designed to withstand firing pressure and heat of combustion. Their design must provide openings for valves, spark plug or injection nozzles and passage for cooling water. The cylinder head is made of cast iron or cast aluminium

Inlet and Exhaust manifold

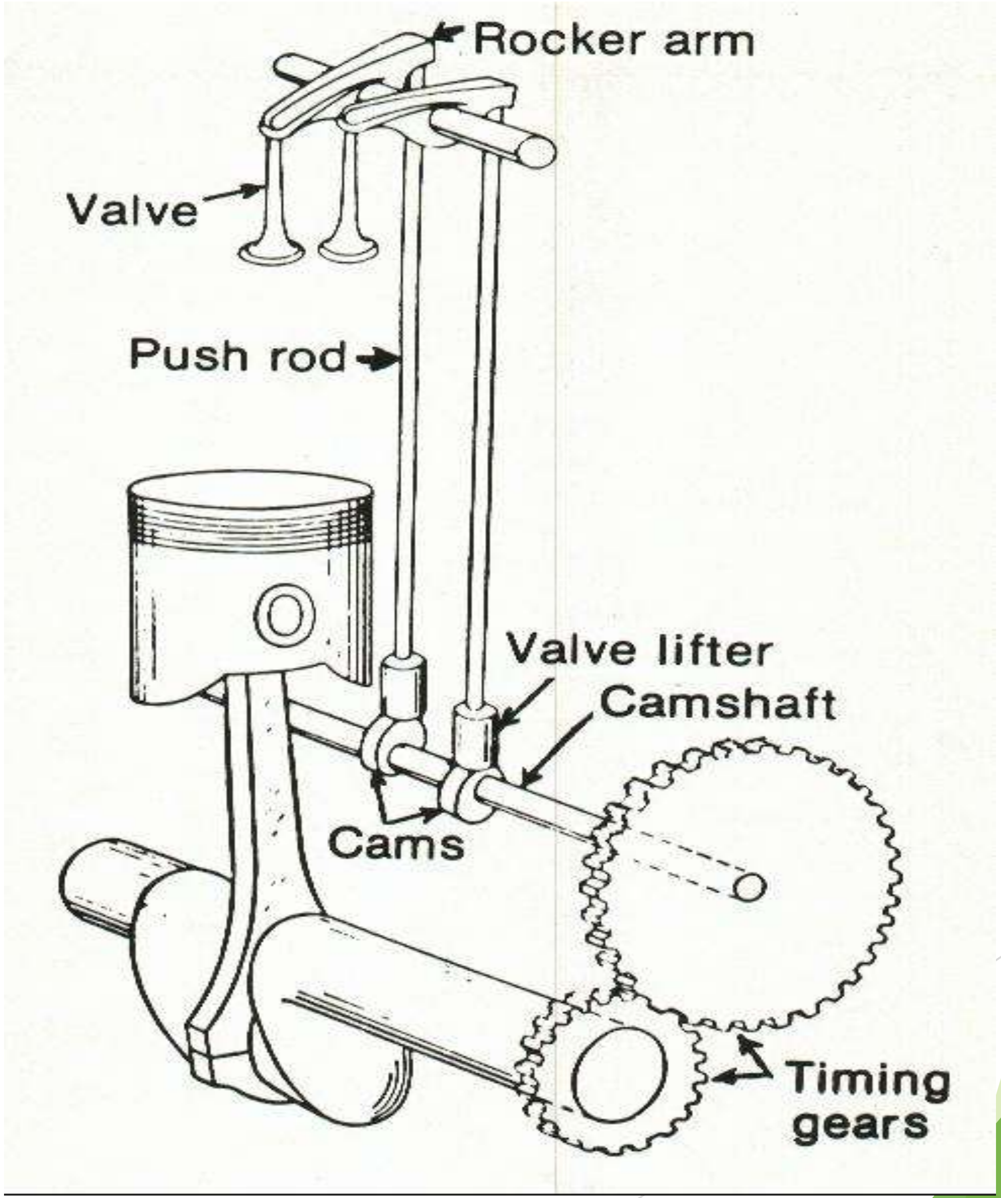
- **Inlet manifold**: It is that part of the engine through which air or air-fuel mixture enters into the engine cylinder. It is fitted by the side of the cylinder head.
- **Exhaust manifold**: It is that part of the engine through which exhaust gases go out of the engine cylinder. It is capable of with-standing high temperature of burnt gases. It is fitted by the side of the cylinder head.

Valve Train



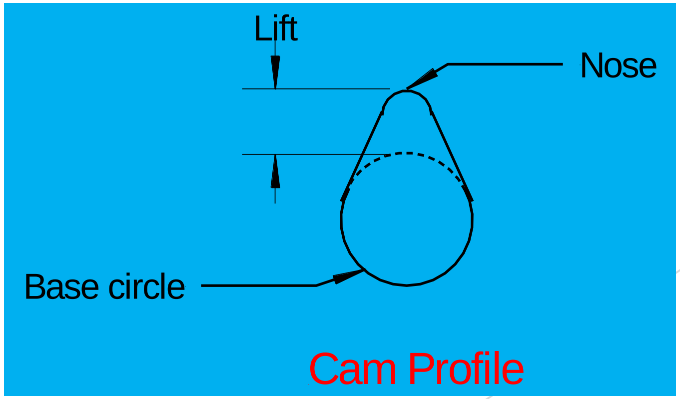
- Controls flow into and out of the combustion chamber.
  - **Time and Duration**
- Tractor engines use "Overhead Valve (OHV)" configuration.
- Components
  - **Camshaft**
  - **Valve tappets**
  - **Push rods**
  - **Rocker arm**
  - **Valves**
  - **Valve springs**
  - **Valve rotators**
  - **Valve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

Valve operation

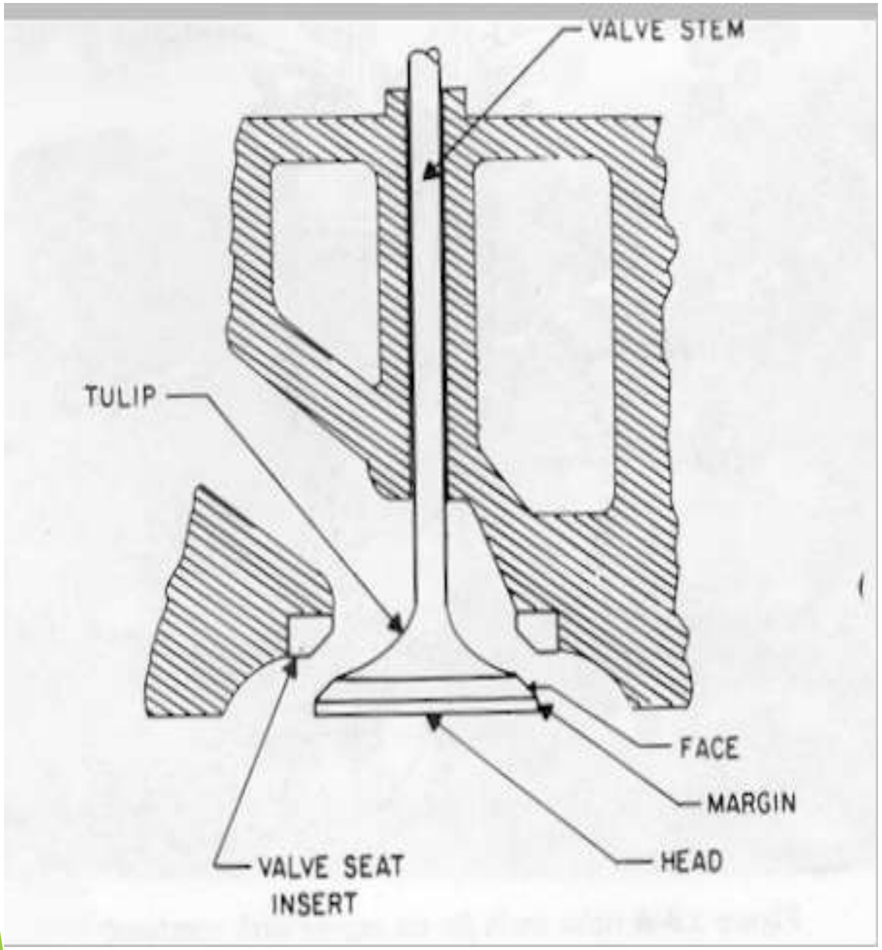


Camshaft

- **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.**



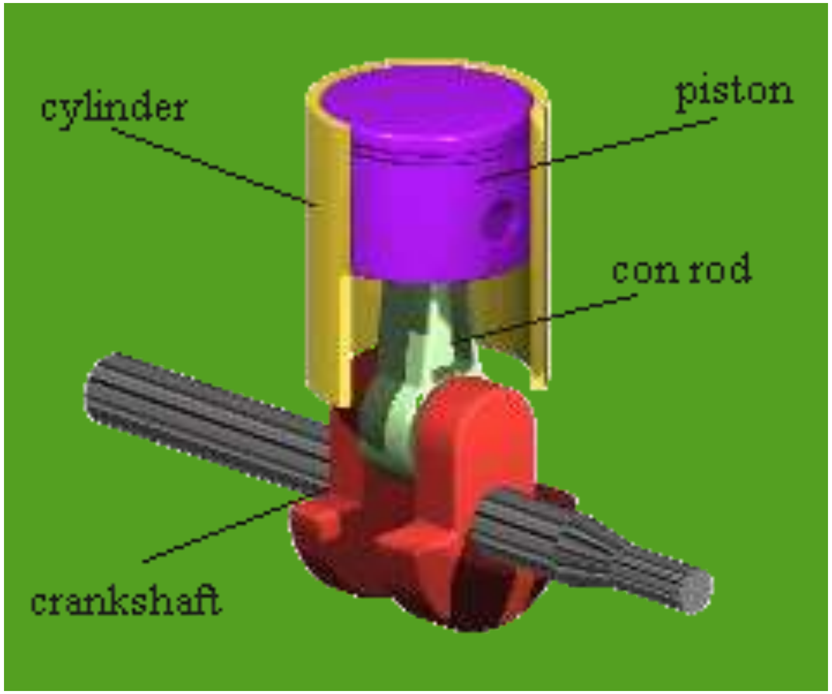
Valves



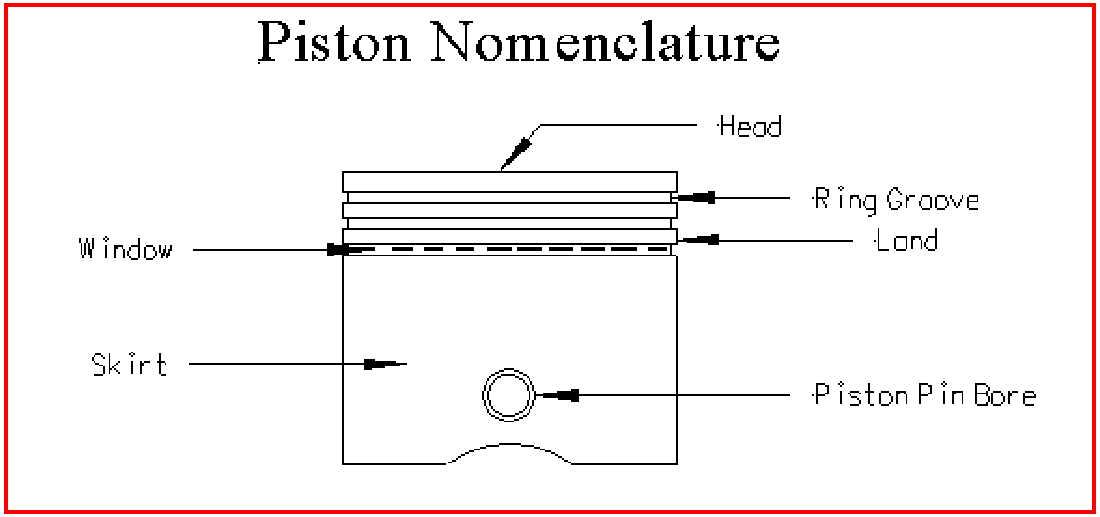
- Each cylinder will have:
  - Intake valve
  - Exhaust valve
- Valve nomenclature
  - Head
  - Margin
  - Face
  - Tulip
  - Stem

Piston and Rings

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


cylinder
piston
con rod
crankshaft

Piston

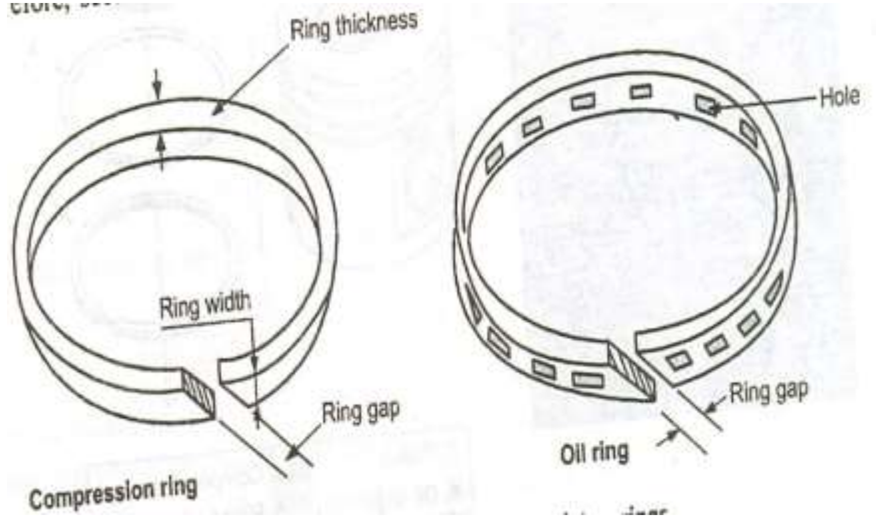

Piston Nomenclature
Head
Ring Groove
Land
Window
Skirt
Piston Pin Bore

Piston pin

- It links the piston and the connecting rod. It is generally hollow and accurately ground and polished for tight fit in the piston bosses.
- There are three different ways to use piston pin:
  1. Pin is fixed in the piston and free in the connecting rod
  2. Pin is fixed in the connecting rod and free in the piston
  3. Pin is free in both piston and connecting rod.

  The last arrangement is mostly used in modern engines and is called *full floating design.*
- The piston pin is made of case-hardened alloy steel or forged steel.

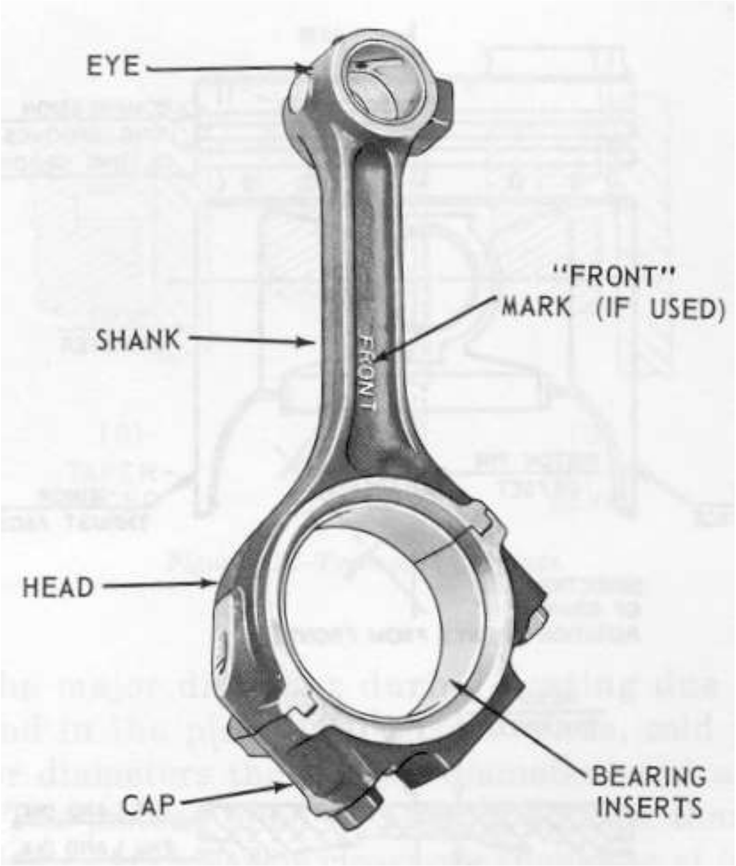
Piston rings



Piston rings are made of cast iron and are fitted on piston. Piston rings perform the following three functions;

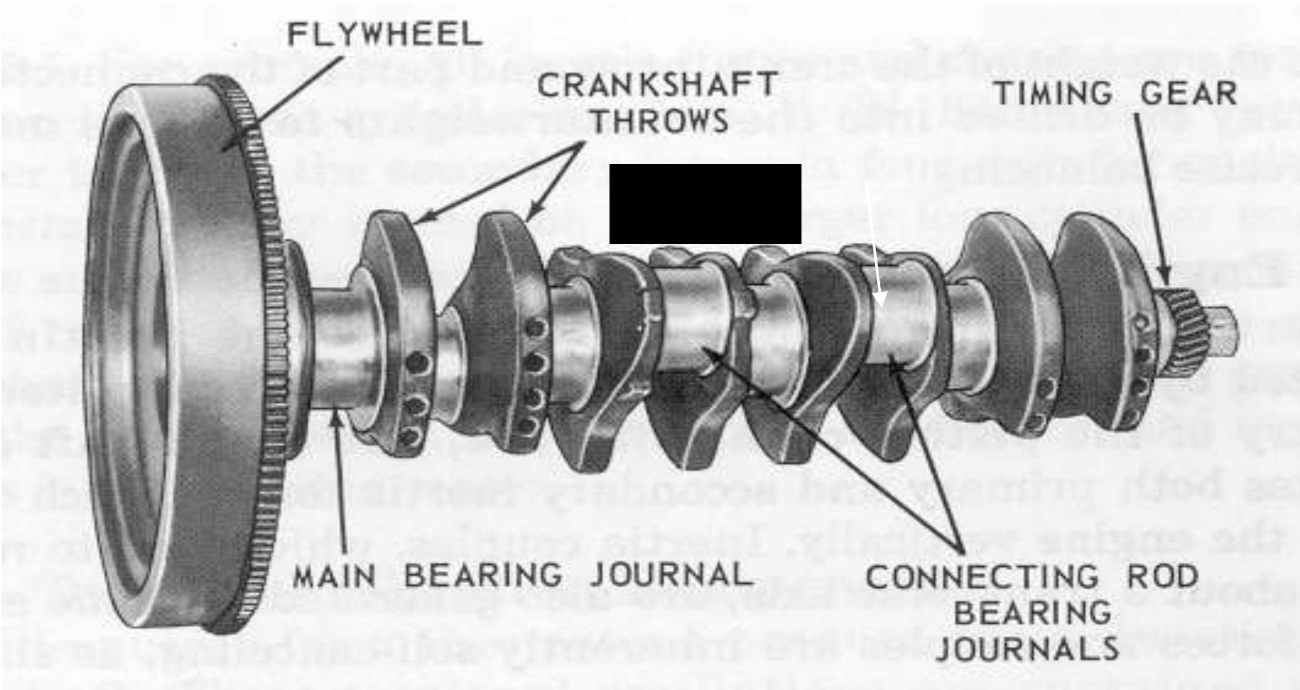
- Seal the gas pressure above the piston
- Provide a path or heat flow from the piston to the cylinder walls.
- Control the cylinder wall lubrication

Connecting rod



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

Crankshaft

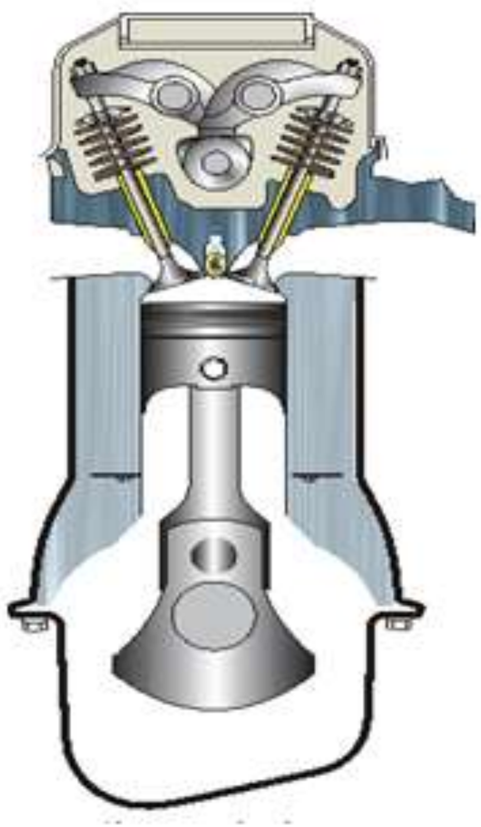


- Works with connecting rod to change reciprocating to rotary motion.
- Transmits mechanical energy from the engine.
- Made of heat-treated steel alloys.

Fly wheel

- It is made of cast iron. It is mounted on crankshaft and serves the following purposes;
- It absorbs the excess energy during the power stroke and supplies back a part of the energy during other strokes.
- It assists in engine balancing
- transmitting engine power. It serves as starting aid for the engine.
- It serves sometimes as a pulley for transmitting engine power.

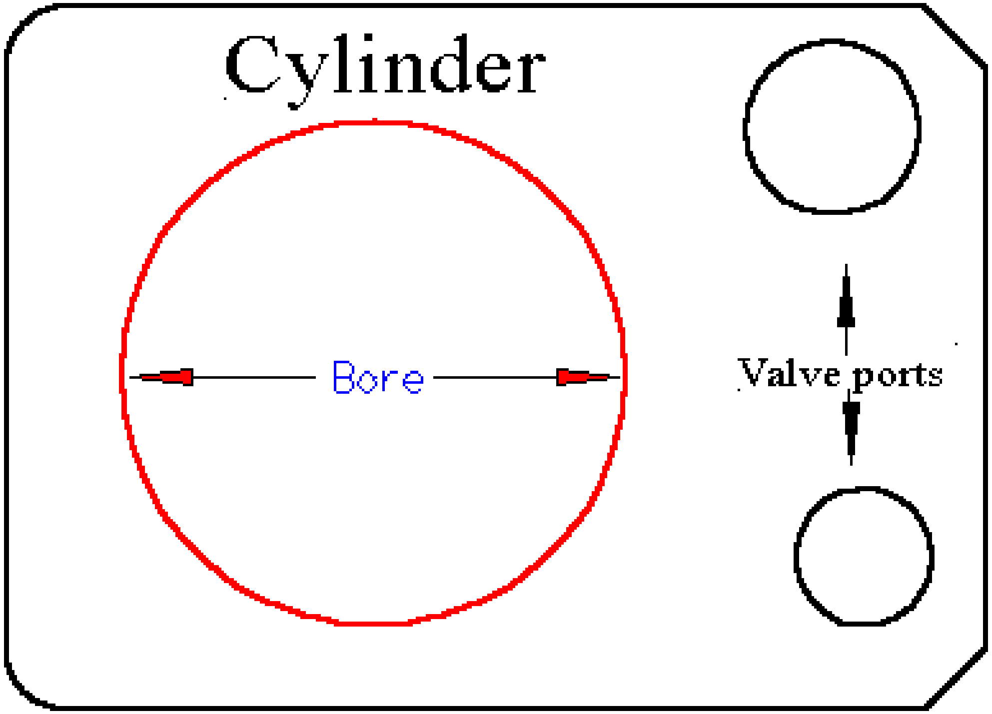
I C Engine terminology



Bore

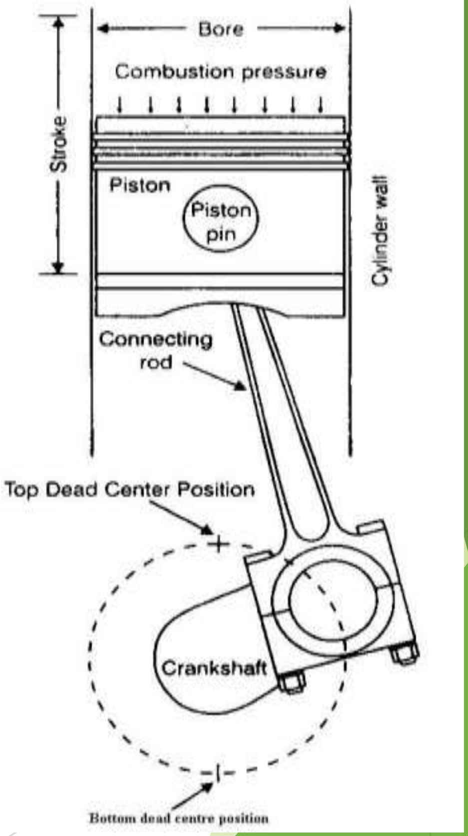
Bore is the diameter of the engine cylinder.

Top-View of Engine Block



Stroke

It is the linear distance travelled by the piston from Top Dead Centre (TDC) to Bottom Dead Centre (BDC).



Stroke-bore ratio

The ratio of length of stroke (L) and diameter of bore (D) of the cylinder is called stroke-bore ratio (L/D).

In general, this ratio varies between 1 to 1.45 and for tractor engines this ratio is about 1.25.

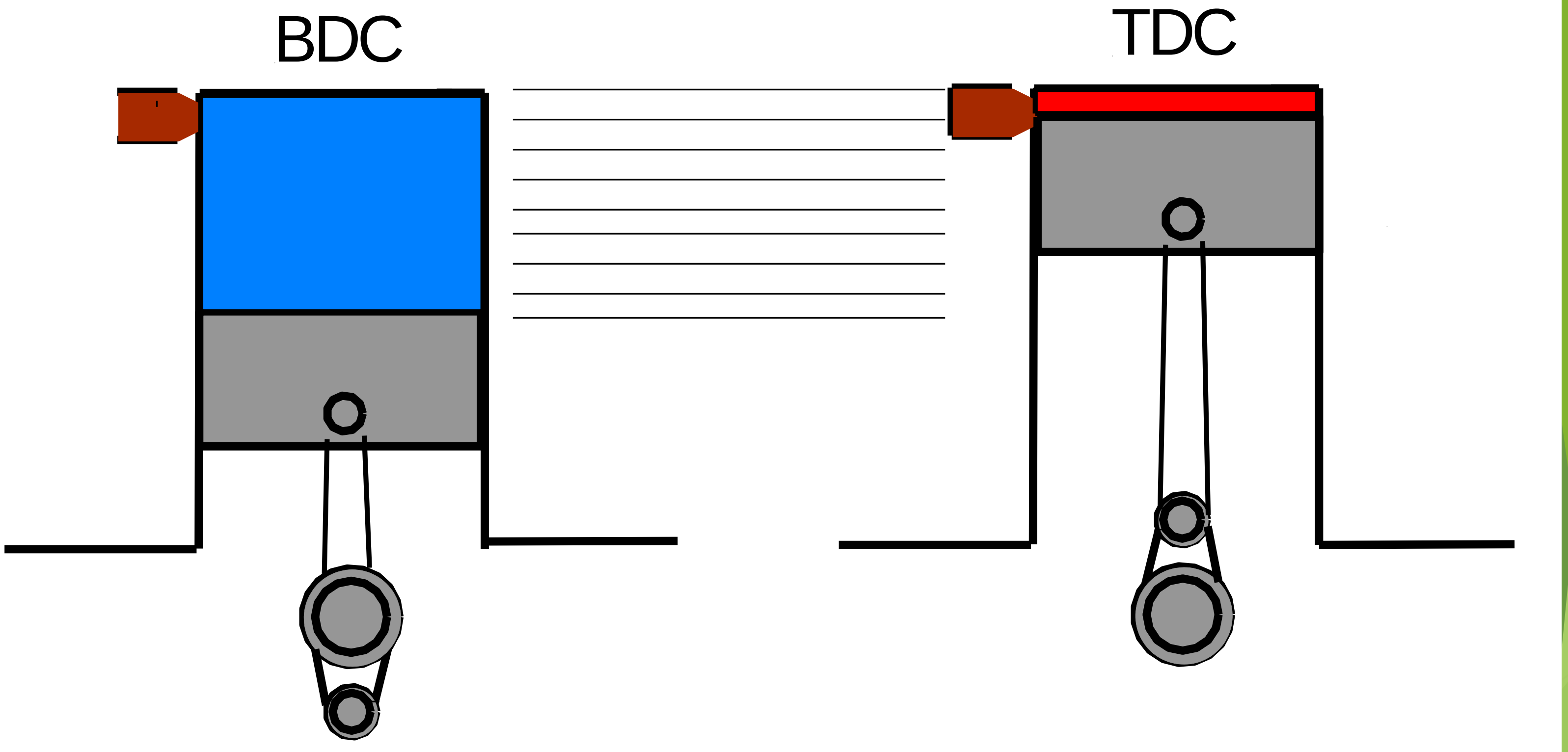
Compression ratio

It is the ratio of the volume of the charge at the beginning of the compression stroke to that at the end of compression stroke, i.e., ratio of total cylinder volume(in c.c) to clearance volume (in c.c).

Compression ratio of diesel engine varies from 14:1 to 20:1; carburetor engine varies from 4:1 to 8:1.

Clearance volume is measured between piston at TDC and cylinder head.

Compression Ratio



C.R. = (Pd + CV) / CV

Swept volume (Piston displacement)

It is the volume displaced by the piston during one stroke.

It is expressed in cubic cm or cubic inches.

$P_d = AL$

Where P_d = Piston displacement per stroke (c.c.)

A = Cross sectional area of piston (cm^2) and

L **=** The length of piston travel or piston stroke (cm)

Displacement volume

It is the total swept volume of all the pistons during power strokes occurring in a period of one minute.

V_d = ALn x (N/2) for 4 stroke engine

V_d = ALn x (N) for 2 stroke engine

Where V_d = Displacement volume (c.c)

A = piston area (cm^2)

L = piston stroke (cm)

n= No. of cylinders

N = Engine rpm

Piston speed

It is the total length of travel of piston in cylinder during a period of one minute.

Sp =2LN

Where S_p = piston speed in m/min.

L = piston stroke (m)

N = Engine rpm

Piston speeds of the high speed tractor engine range between 300 to 500 m/min.

Piston speed

It is the total length of travel of piston in cylinder during a period of one minute.

$S_p = 2LN$

Where S_p = piston speed in m/min.

L = piston stroke (m)

N = Engine rpm

Piston speeds of the high speed tractor engine range between 300 to 500 m/min.

Numerical

Q.1 A diesel tractor has a three cylinder, four stroke engine, cylinder bore = 88.9 mm, stroke = 127 mm, compression ratio = 16.5 :1, belt horse power = 32 and engine speed = 2000 rpm.

Calculate:

(i) Piston displacement

(ii) Displacement volume

(iii)Piston speed

(iv) Stroke bore ratio

Solution:

Data given: Cylinder bore (D) = 88.9 mm= 8.89 cm

Length of the stoke (L) = 127 mm = 12.7 cm

No. of cylinders (n) = 3

Engine rpm (N) = 2000

Area of the piston (A) = $(\pi/4) \times D^2$ = $(\pi/4) \times (8.89)^2$

= 62 sq. cm.

Piston displacement (P_d) = AL

= 62 x 12.7 =787.4 c.c.

Displacement volume (Vd) = A.L.n (N/2)

= 62 x 12.7 x 3 x (2000/2)

= 2362200 c.c. = 2362.2 lit

Piston speed (S_p) = 2LN

Where S_p = Piston speed m/min

L = Piston stoke in metres = 0.127m

N = Engine RPM = 2000

Therefore, Sp = 2 x 0.127 x 2000

= 508 metres per minute

Stroke bore ratio = (L/D)

= (127/88.9) = 1.43

Q 2. Calculate the displacement volume of a four cylinder 4 stroke engine. The diameter of cylinder is 12 cm, stroke length 14 cm and engine speed 2000 rpm.

Solution:

Data given: Cylinder bore (D) =12 cm

Length of the stoke (L) = 14 cm

No. of cylinders (n) = 4

Engine rpm (N) = 2000

$$\text{Area of the piston (A)} = (\pi/4) \times D^2$$
$$= (\pi/4) \times (12)^2$$
$$= 113.14 \text{ sq. cm}$$
$$\text{Displacement volume } (V_d) = A \times L \times n \times (N/2)$$

for 4 stroke engine

$$V_d = 113.14 \times 14 \times 4 \times (2000/2)$$
$$= 6335840 \text{ c.c.} = 6335.8 \text{ lit.}$$

Q 3. Calculate compression ratio and clearance volume of an IC engine if size of engine is 100 x120 mm and clearance space at TDC is 8 mm.

Solution:

Data given: Cylinder bore (D) =100 mm = 10 cm

Length of the stoke (L) = 120 mm = 12 cm

Space at TDC = 8 mm or 0.8 cm

Total length of cylinder = 12 + 0.8 = 12.8 cm

$$\text{Total volume of cylinder} = (\pi/4) \times (10)^2 \times 12.8$$
$$= 1005.7 \text{ c.c.}$$

$$\text{Clearance volume} = (\pi/4) \times (10)^2 \times 0.8 = 62.85 \text{ c.c.}$$

$$\text{Now CR} = \frac{\text{Total volume of cylinder}}{\text{Clearance volume}} = \frac{1005.7}{62.85} = 16$$

Therefore, CR = 16:1

Q 4. A four stroke 4 cylinder engine having 10 cm stroke is working on a compression ratio of 15.

Identify whether this is a petrol or diesel engine and also give reason for it. If the volume displaced in one time is 1520 cm^3, calculate the diameter of the piston.

Solution: Since the engine is operating at a compression ratio of 15 which indicates that it is a diesel engine.

Displacement volume in one time = Piston displacement (P_d) = AL = 1520 cm^3

Where A = Area of the piston = $(\pi/4) \times D^2$

and L = Length of stroke = 10 cm

Therefore; $(\pi/4) \times D^2 \times 10 = 1520$

$$\text{Or } D^2 = \frac{1520 \times 4}{10 \times \pi} = \frac{1520 \times 4 \times 7}{10 \times 22} = 193.45$$

Or D = = 13.9 cm

Q 5. A four stroke engine is having its diameter and stroke length equal. The piston displacement is 299.5 cm^3 and compression ratio is 15. Calculate

(i)The stroke length

(ii) Total volume of the cylinder

Solution:

Piston displacement $(P_d) = AL = (\pi/4) \times D^2 \times L$

Where D = Bore diameter, cm and L = Length of stroke, cm and D = L

Therefore; $(\pi/4) \times L^3 = 299.5$

$$\text{Or } L^3 = \frac{299.5 \times 4}{\pi} = \frac{299.5 \times 4 \times 7}{22} = 381.18$$

Or L = = 7.25 cm

Therefore stroke length = 7.25 cm

$$\text{Compression ratio} = \frac{P_d + C_v}{C_v} = 15$$

Where P_d = Piston displacement, = 299.5 c.c.

C_v = Clearance volume, c. c

$$\text{Therefore;} \quad 15 = \frac{299.5 + C_v}{C_v}$$

Or $15C_v = 299.5 + C_v$

Or $14\ C_v = 299.5$

Or $C_v = (299.5/14) = 21.4$ c.c

Total volume = $P_d + C_v = 299.5 + 21.4 = 320.9$ c.c

Lect. – 3 Part II
Engine power related terms & numerical

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Power: It is the rate of doing work. That is how much work can be done in a given unit of time. Unit of power in SI units - Watt (Joule/sec).

Or Energy over time.

Horse power: If the rate of doing work is equivalent to 75 kg m/sec, it is said to be one horse power.

Indicated Horse Power (IHP): it is the total horse power developed by all the cylinders and received by pistons, disregarding friction and losses within the engine.

$$IHP = \frac{P \times L \times A \times n \times (N/2)}{75 \times 60} \text{ for 4 stroke engine,} = \frac{P \times L \times A \times n \times (N)}{75 \times 60}$$

For 2 stroke engine

Where P - Indicated mean effective pressure in Kg/cm^2

L- Length of the piston stroke in meters

A -Cross sectional area of piston in cm^2

n= No. of cylinders

N = Engine rpm

(Indicated mean effective pressure is the average pressure in kg/cm^2 on the piston during the power stroke only.

It is measured by an engine indicator.)

Brake horse power (B.H.P): It is the horsepower delivered by the engine and is available at the end of the crankshaft and it is measured by suitable dynamometer.

Frictional horse power (F.H.P): It is the power required to run the engine at a given speed without producing any useful work. It represents the friction and pumping losses of the engine.

$$F.H.P = I.H.P - B.H.P$$

Drawbar horse power (DBHP): It is the power of a tractor measured at the end of the drawbar. It is the power required to pull the loads.

Brake mean effective pressure (BMEP): It is the average pressure acting throughout the entire power strokes which are necessary to produce BHP of the engine.

$$BMEP\ (kg/cm^2) = \frac{BHP \times 75 \times 60}{L \times A \times n \times (N/2)} \quad \text{for 4 stroke engine}$$

$$\text{BMEP}\ (\text{kg/cm}^2) = \frac{\text{BHP} \times 75 \times 60}{L \times A \times n \times (N)}$$ for 2 stroke engine

Where n= No. of cylinders, N = Engine rpm

Also, BMEP = IMEP x Mechanical efficiency

BMEP can not be measured in an engine.

Mechanical efficiency: It is the ratio of the brake horse power to the indicated horse power.

$$\text{Mechanical efficiency} = \frac{\text{BHP}}{\text{IHP}} \times 100$$

Thermal efficiency: It is the ratio of the horse power output of the engine to the fuel horse power.

$$\textbf{Brake thermal efficiency} = \frac{641 \times 10^2}{\text{Kg per BHP hr} \times \text{calories per kg}}$$

: It is the ratio of bhp to fuel power

Specific fuel consumption: the quantity of fuel consumed by an oil engine on the basis of per horse power hour. It is expressed in terms of lb per BHP hr or lb per IHP hr.

Note: 1 lb = 0.4536 kg

Numerical

Q.1 A four cylinder gas engine has a cylinder 25 cm diameter, 50 cm stroke and runs at 154 rpm. If the engine fires ones per two revolutions and shows an indicated mean effective pressure of 7.5 kg/cm^2

Calculate:

(i) IHP

(ii) BHP

(iii)B.M.E.P.

(iv) Stroke bore ratio

Assume the mechanical efficiency of the engine as 86.4 %

Solution:

Data given: Cylinder bore (D) =25 cm

Length of the stoke (L) = 50 cm = 0.5 m

No. of cylinders (n) = 4

Engine rpm (N) = 154

Mech. Eff. (η_m) = 86.4 % = 0.864

Indicated mean effective pressure (P) = 7.5 kg/cm^2

Area of the piston (A) = $(\pi/4) \times D^2 = (\pi/4) \times (25)^2 = 491.07$ sq. cm.

(i) $$IHP = \frac{P\ L\ A\ n \times (N/2)}{4500}$$

$$= \frac{7.5 \times 0.5 \times 491.07 \times 4 \times (154/2)}{4500} = \frac{567185.85}{4500} = 126.04$$

(ii) BHP = IHP x η_m = 126.04 x 0.864 = 108.9

(iii) B.M.E.P. = I MEP x η_m = 7.5 x 0.864 = 6.4

(iv) Stroke bore ratio = (L/D) = (50/25) = 2

Q 2. Calculate the mechanical efficiency of a single cylinder 2 stroke engine operating 34.8 BHP with the following observations:

Cylinder bore = 20 cm

Stoke length = 30 cm

IMEP = 6 kg/cm^2

Engine speed = 400 rpm

Solution:

Data given: Cylinder bore (D) =20 cm

Length of the stoke (L) = 30 cm = 0.3 m

No. of cylinders (n) = 1

Engine rpm (N) = 400

Indicated mean effective pressure (P) = 6 kg/cm^2

Mech. Eff. = ?

Area of the piston (A) = $(\pi/4) \times D^2 = (\pi/4) \times (20)^2$

= 314.28 sq. cm.

$$IHP = \frac{P\ L\ A\ n\ (N)}{4500}$$

$$= \frac{6 \times 0.3 \times 314.28 \times 1 \times 400}{4500} = \frac{226281.6}{4500} = 50.28$$

Mech. Eff. (%) = (BHP/IHP) x100 = (34.8/50.28) x 100 = 69.21%

Q 3. A gas engine works as 4 stroke engine and has the following dimensions:

Cylinder diameter = 25 cm

Stoke bore ratio = 1.8

Clearance volume = 4440 c.c

Engine speed = 240 rpm

IMEP = 7 kg/cm^2

Mech. Eff. = 75%

Find out - (a) IHP

(b) BHP

(c) Piston displacement

(d) Compression ratio

Solution:

Data given: Cylinder bore (D) =25 cm

Stoke bore ratio (L/D) = 1.8 Therefore, L = 1.8 x 25 cm

=45 cm = 0.45 m

No. of cylinders (n) = 1, Engine rpm (N) = 240

Indicated mean effective pressure (P) = 7 kg/cm^2

Mech. Eff. (η_m) = 75 % = 0.75

Clearance volume (C_v) = 4440 c.c

Area of the piston (A) = (π/4) x D^2 = (π /4) x $(25)^2$ = 491.07 sq. cm

$$\text{(a)}\quad IHP = \frac{P\,L\,A\,n\,(N/2)}{4500}$$

$$= \frac{7 \times 0.45 \times 491.07 \times 1 \times (240/2)}{4500} = \frac{226281.6}{4500} = 41.25$$

(b) BHP = IHP x η_m = 41.25 x 0.75 =30.94 hp

(c) Piston displacement per stroke P_d = = AL

Where **A =** Cross sectional area of piston (cm^2) and

L **=** The length of piston travel or piston stroke (cm)

Therefore P_d = 491.07 x 45 = 22098.15 c.c.

$$\text{(d) Compression ratio} = \frac{P_d + C_v}{C_v}$$

$$\text{Compression ratio} = \frac{22098.15 + 4440}{4440} = 5.97$$

Q 4. Calculate BHP of a 4 cylinder 2 stroke I C engine whose size is 12 x 15 cm. IMEP is 7 kg/cm^2 and engine rpm is 600. The mechanical efficiency is 80 %. Also calculate frictional horse power.

Solution:

Data given: Cylinder bore (D) =12 cm

Length of the stoke (L) = 15 cm

No. of cylinders (n) = 4

Engine rpm (N) = 600

Indicated mean effective pressure (P) = 7 kg/cm^2

Mech. Eff. (η_m) = 80 % = 0.80

Area of the piston (A) = $(\pi/4) \times D^2 = (\pi/4) \times (12)^2$

= 113.14 sq. cm

$$IHP = \frac{P\ L\ A\ n\ (N)}{4500} = \frac{7 \times 0.15 \times 113.14 \times 4 \times 600}{4500} = 63.35 \text{ hp}$$

$BHP = IHP \times \eta_m = 63.35 \times 0.80 = 50.68$ hp

$FHP = IHP - BHP = 63.35 - 50.68 = 12.67$ hp

Q 5. Calculate the diameter of 2 stroke cycle IC engine. The number of cylinders is 2, number of explosion is 2000 per minute, stroke bore ratio is 1.5 and IMEP is 7 kg/cm^2, IHP =25

Solution:

Data given: Stroke bore ratio (L/D) = 1.5
therefore length of stoke (L) = 1.5 D

Indicated mean effective pressure (P) = 7 kg/cm^2

No. of cylinders (n) = 2

Engine rpm (N) = 2000

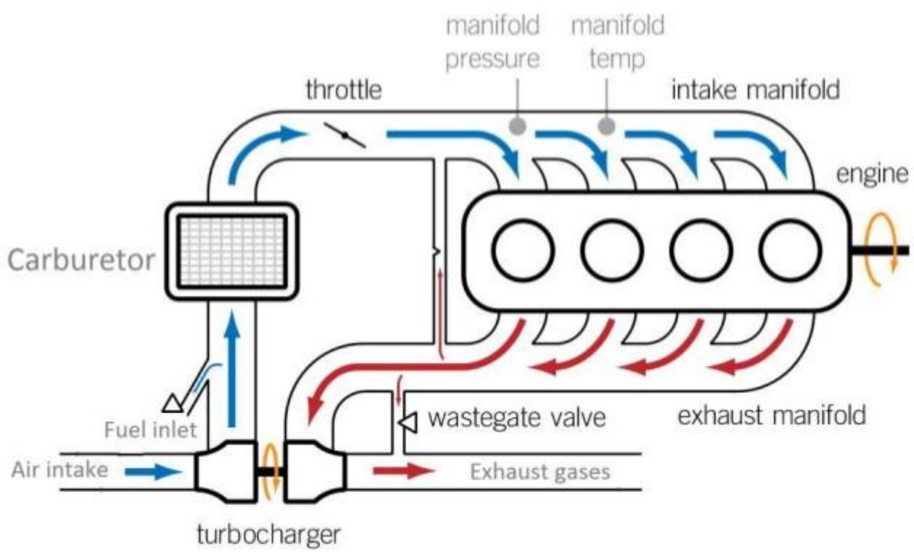
IHP =25

$$\text{IHP} = \frac{P\ L\ A\ n\ (N)}{4500} = \frac{7 \times (1.5\ D/100) \times (\pi/4) \times D^2 \times 2 \times 2000}{4500} = 25$$

Or $0.0733\ D^3 = 25$ or $D^3 = 341.$ Therefore D = 7 cm

Lect.- 4

Air supply and exhaust system- Pre cleaners, oil soaked element type and oil bath type air cleaners; Fuel supply system.



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Air supply system

An IC engine uses large quantities of air for combustion, the ratio being 14 -15:1 (air fuel ratio).

The main components of air intake system are:

(i) air cleaner

(ii) supercharger (auxiliary unit)

(iii) intake manifold

(iv) intake valve/intake port.

- **Air cleaner** – It is a device, which filters and removes dust, moisture and other foreign matter from the air before if reaches the engine cylinder.
- There are many types of air cleaners but the types commonly used in tractors are (a) Oil wetted mesh type (b) Dry air type and (c) Wet type or oil bath air cleaners.

Pre –cleaner

- A pre -cleaner is provided in the upper portion of the main cleaner. When the engine is running, the air is first drawn through the pre-cleaner. Here large dust particles are removed from air stream, thus reducing much of the load (90%) on the main cleaner.
- The pre-cleaner functions on the centrifugal principle. By means of vans and baffles it gives a rotary motion to the air, thus causing the heavier dust particles to be thrown out due to centrifugal force and the pre-cleaned air is allowed in the air cleaner.

Pre- cleaner

Pre - cleaner cap assembly

Oil wetted mesh air cleaner

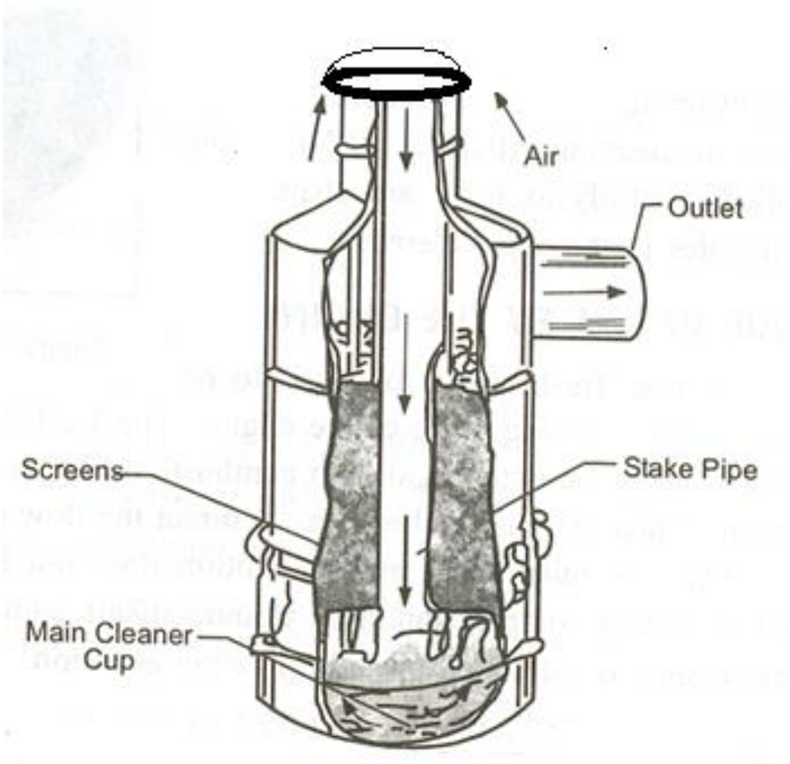
- It consists of a copper mesh or nylon wire, wetted with oil to catch the dust particles from the air which are made to pass through it.
- This type of filter, however, gets clogged with dust quickly, thus, seriously affecting the air flow through it and rendering it inefficient in removing the fine particles of dust from air.

Dry air cleaner

- The main cleaning element is usually of multi-wire netting or nylon hair or paper (resin- impregnated paper element).
- The element is of larger surface area, reduces the air speed while passing through and consequently particle or dirt in the air is deposited on or stopped by its surface.
- It is quite efficient in dust removal and easy to service but costlier to maintain because the filter element requires replacement very often.
- It maintains air cleaning efficiency at all engine speeds.

Oil bath type air cleaner

It has a bowl type container in its bottom filled with mobile oil and above it, a strainer is placed.



Air makes a sharp 180º turn.

The bowl has one oil level mark.

In dusty working conditions, the oil of bowl should be changed after every 10-12 hours otherwise, change the oil after every 40-50 hours. Mostly SAE 30 or 40 lubricating oils are used

Supercharger

- This is an auxiliary unit and only high horsepower range engines are provided with superchargers.
- A supercharger is a device for increasing the air pressure into the engine so that more fuel can be burnt and the engine output is increased. The pressure inside the manifold of a supercharger engine will be greater than the atmospheric pressure.
- Supercharged air is provided either by positive displacement rotary blowers or by centrifugal blowers driven by engine itself.

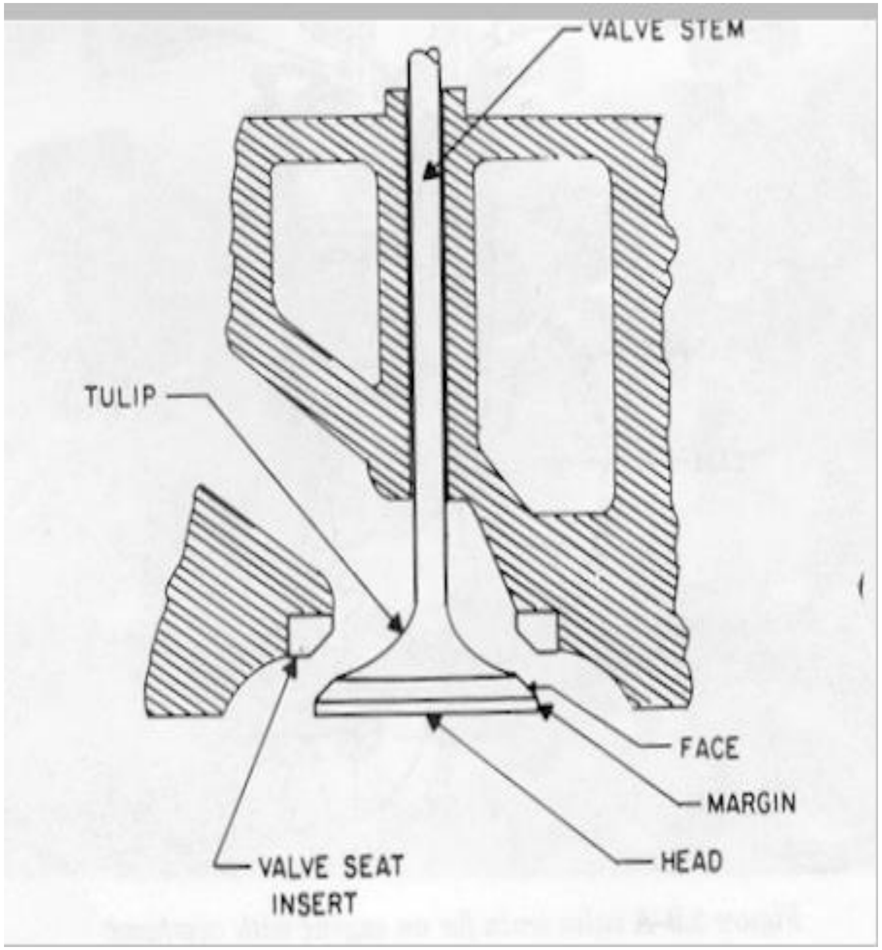
Intake manifold

- The inlet manifold is required to deliver into the cylinders either fuel from air cleaners or a mixture of fuel and air from the carburetor.
- It is made in one or two pieces either from cast iron or aluminum alloy.

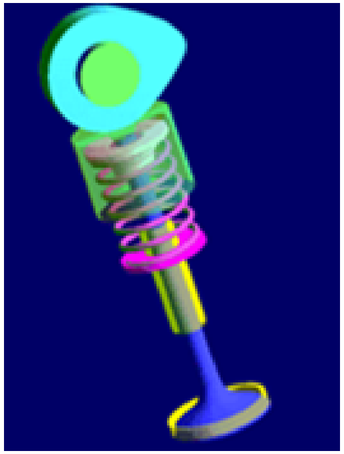
Intake valve and intake port

- The intake valve of an IC engine is meant to admit air or air fuel mixture into the cylinder.
- The valves used in tractor engines are of the poppet or mushroom type. The poppet valve consists of a valve head and a valve stem.
- The face ground at an angle of 30^o to 45^o at the outer edge to match the valve seat in the cylinder block.
- In two stroke engine intake port is provided instead of inlet valve.

Valves



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



Exhaust system

The exhaust system comprises of following parts:

1. **Exhaust Valve**- opens to allow burnt gases to escape during exhaust stroke and closes to seal combustion.
2. **Exhaust Manifold**- Combines cylinders together to form one pipe for the elimination of exhaust gases.

4. **Turbocharger-**The objective of a turbocharger is to improve an engine's volumetric efficiency by increasing density of the intake gas (usually air) allowing more power per engine cycle.

This is an exhaust driven turbine, which drives a centrifugal compressor wheel. The compressor passage is usually located between the air cleaner and engine intake manifold, while the turbine is located between the exhaust manifold and muffler.

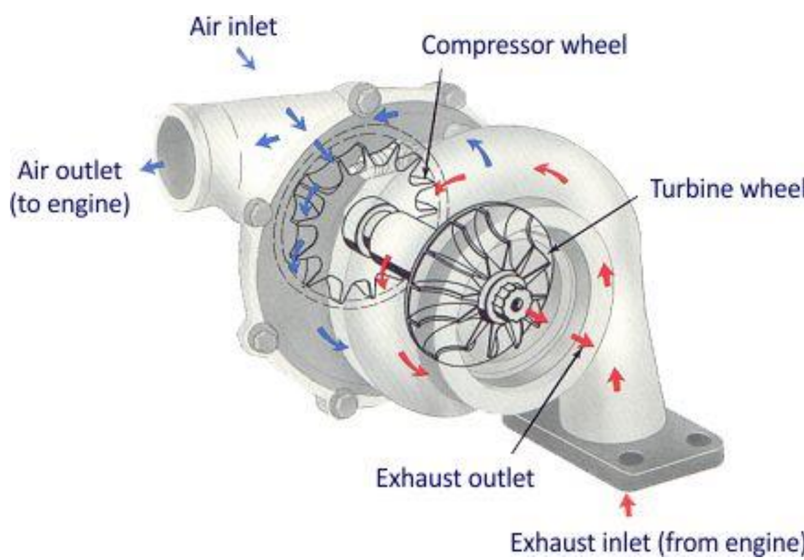
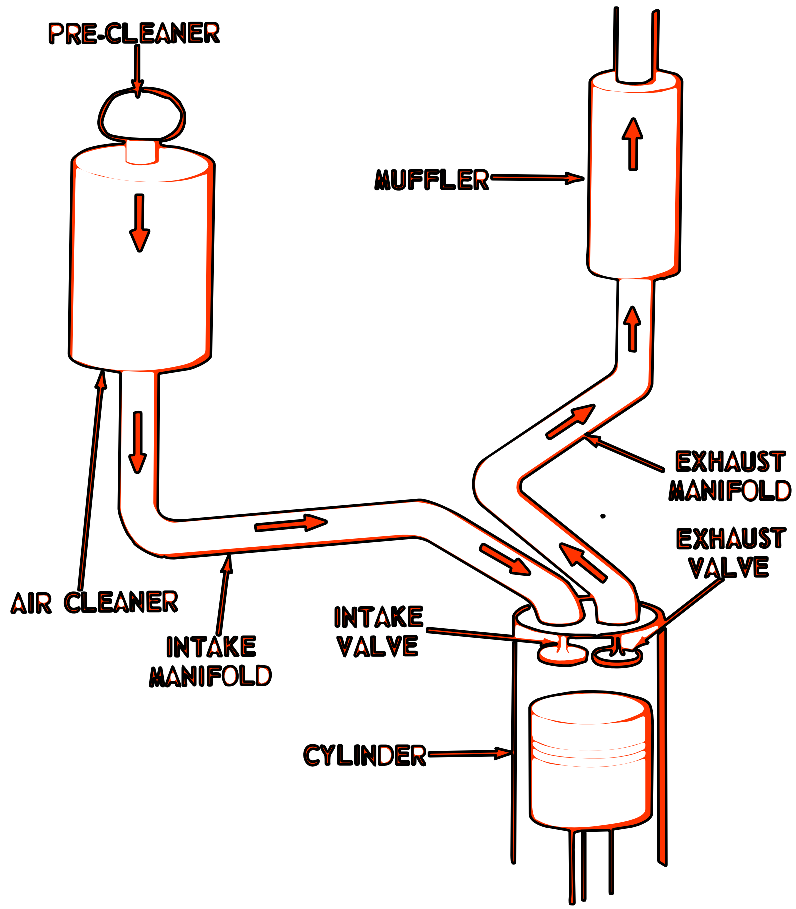


Fig. Turbocharger

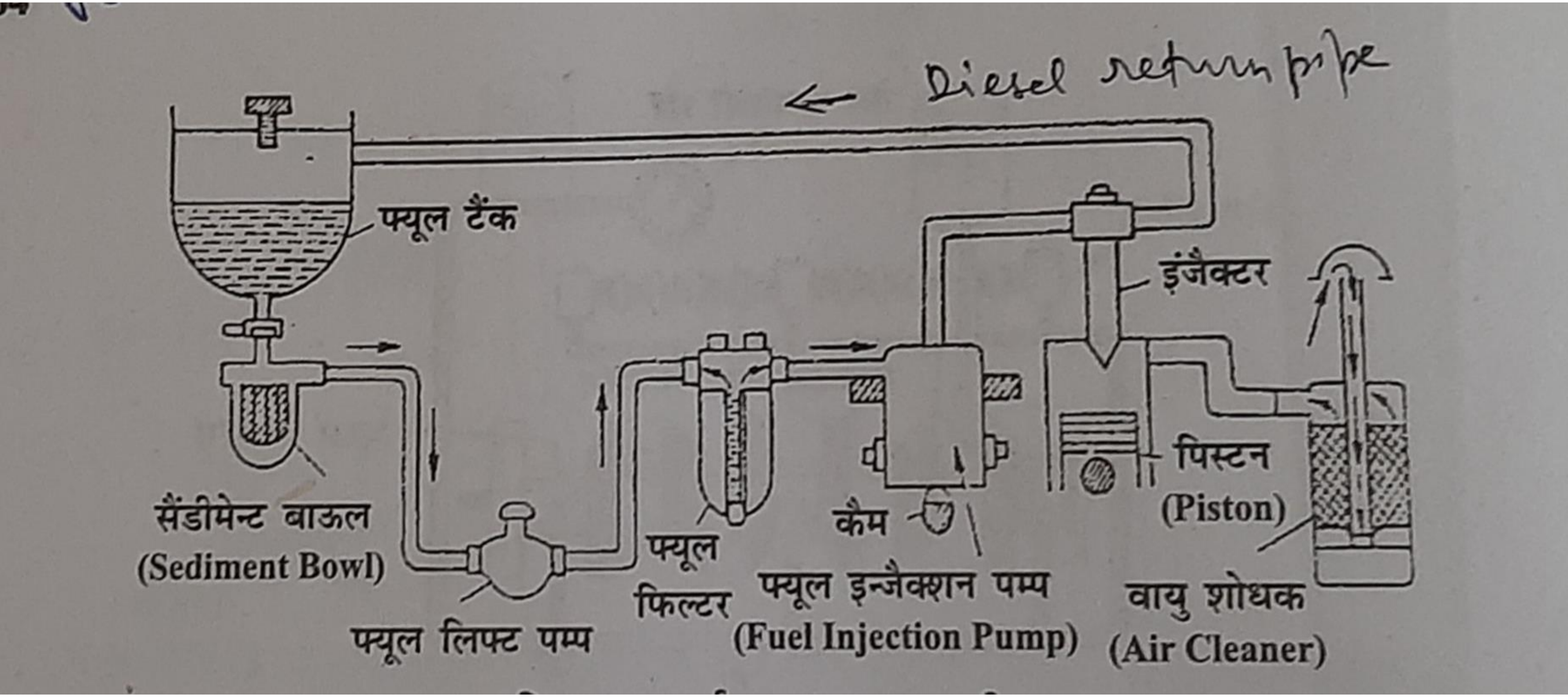
4. **Muffler**- Quiets engine noise and eliminates sparks.

5. **Exhaust Cap** (if used)- Prevents rain, insects, debris, etc. from entering engine while at rest.

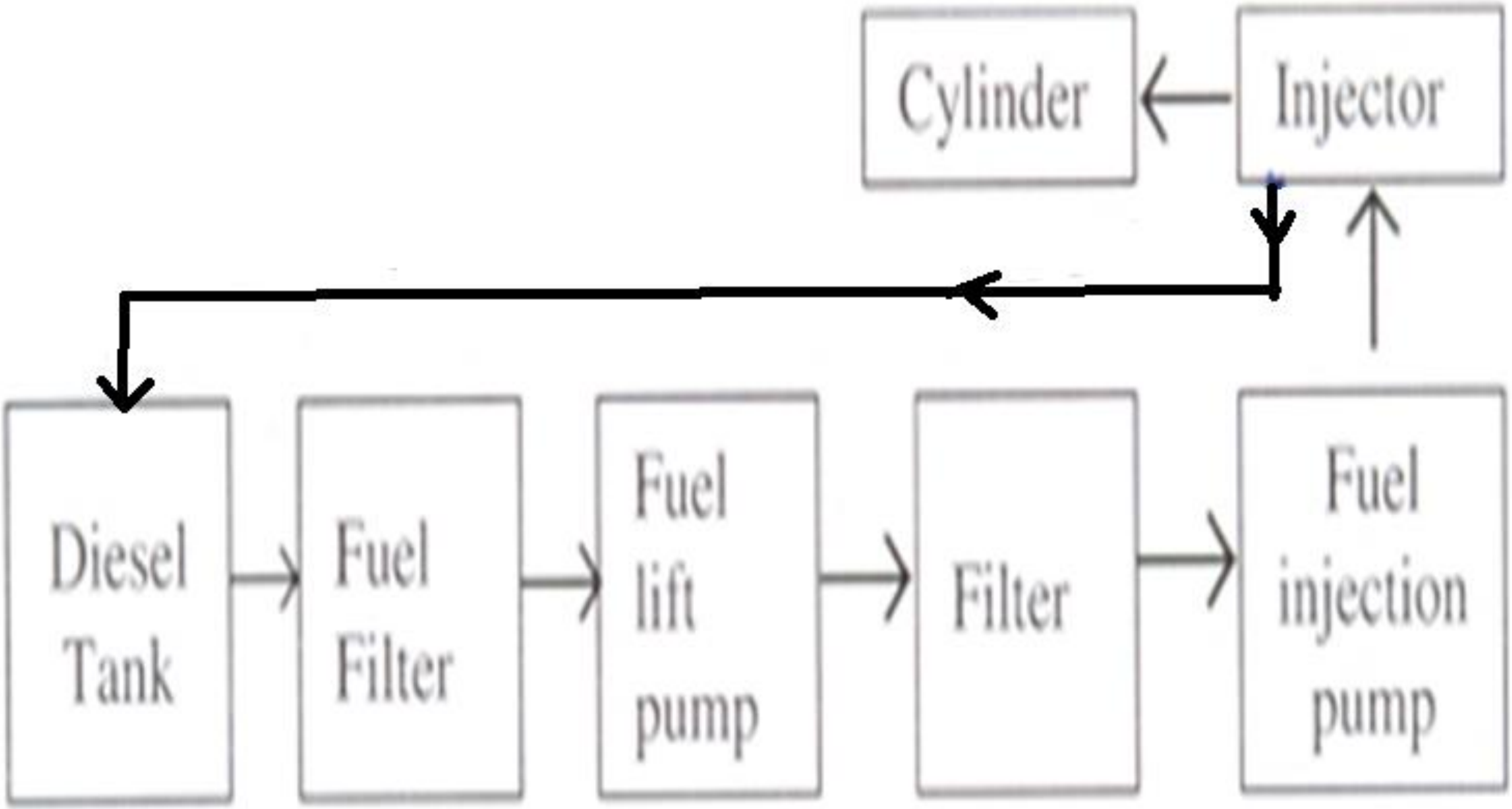
Air intake and exhaust system



Fuel supply system in diesel engine



Flow diagram of fuel system

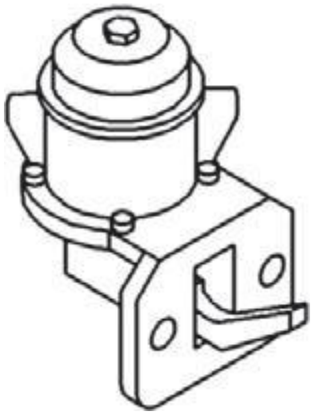


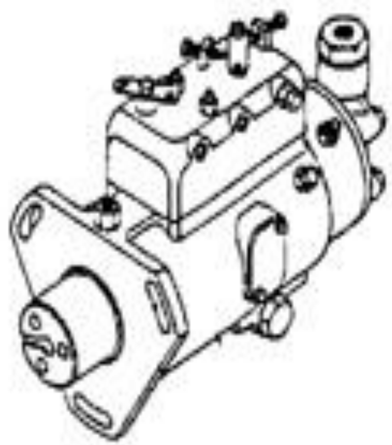
Fuel system operation

- During engine operation, the fuel is supplied by gravity from fuel tank to the primary filter where coarse impurities are removed.
- From the primary filter, the fuel is drawn by fuel transfer pump. This pump is also known as fuel lift pump, is activated by a cam on the engine camshaft.
- The fuel lift pump forces fuel under low pressure (2.5 kg/cm^2) through the secondary fuel filter to the injection pump, which is generally driven by the camshaft.

- The purpose of fuel injection pump is to deliver a metered quantity of fuel at a predetermined time under pressure (120 to 175 kg/cm^2 or more) through the high pressure tubes to the injection nozzles or injectors.
- Fuel injector is the component which delivers finely atomized fuel under high pressure to combustion chamber of the engine. Modern tractor engines use fuel injectors which have multiple holes.
- The fuel that leaks out from the injection nozzles passes out through leakage pipe and returns to the fuel tank through the over flow pipe.

Fuel system components

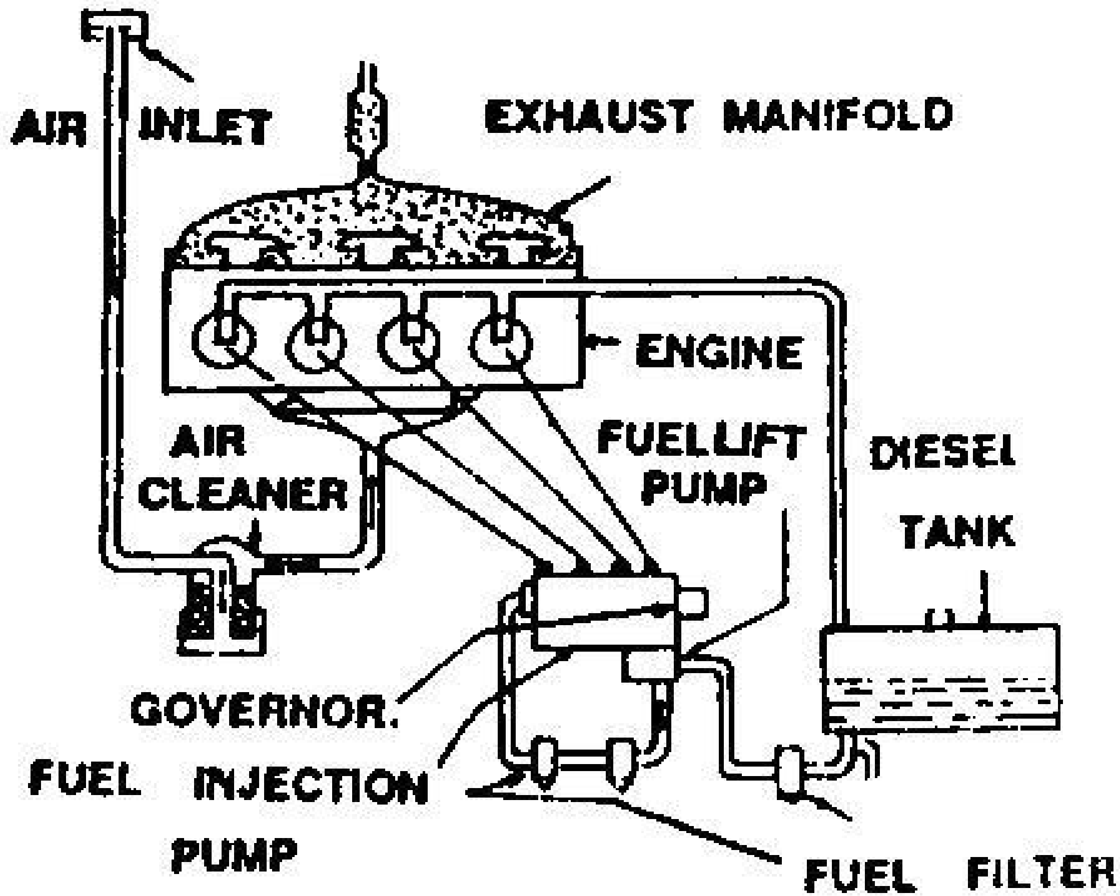




Fuel lift pump	Fuel injector pump	Spark plug

Sediment bowl assembly

Air and fuel supply system in diesel engine



FUEL SUPPLY SYSTEM IN SPARK IGNITION ENGINE

FUEL SUPPLY SYSTEM IN SPARK IGNITION ENGIN

The fuel supply system of spark ignition engine consists of

- Fuel tank
- Fuel filter
- Sediment bowl
- Fuel lift pump
- Carburettor
- Fuel pipes

Fuel supply in spark ignition engine

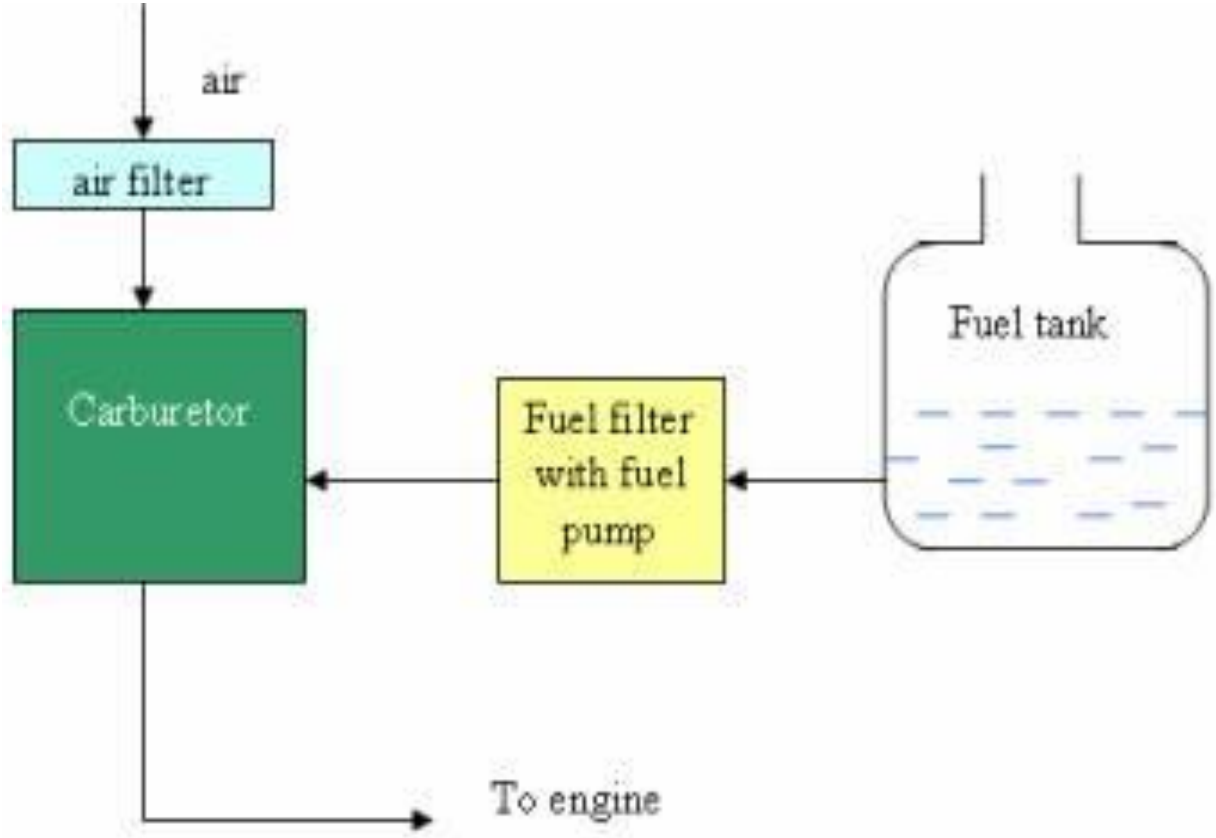
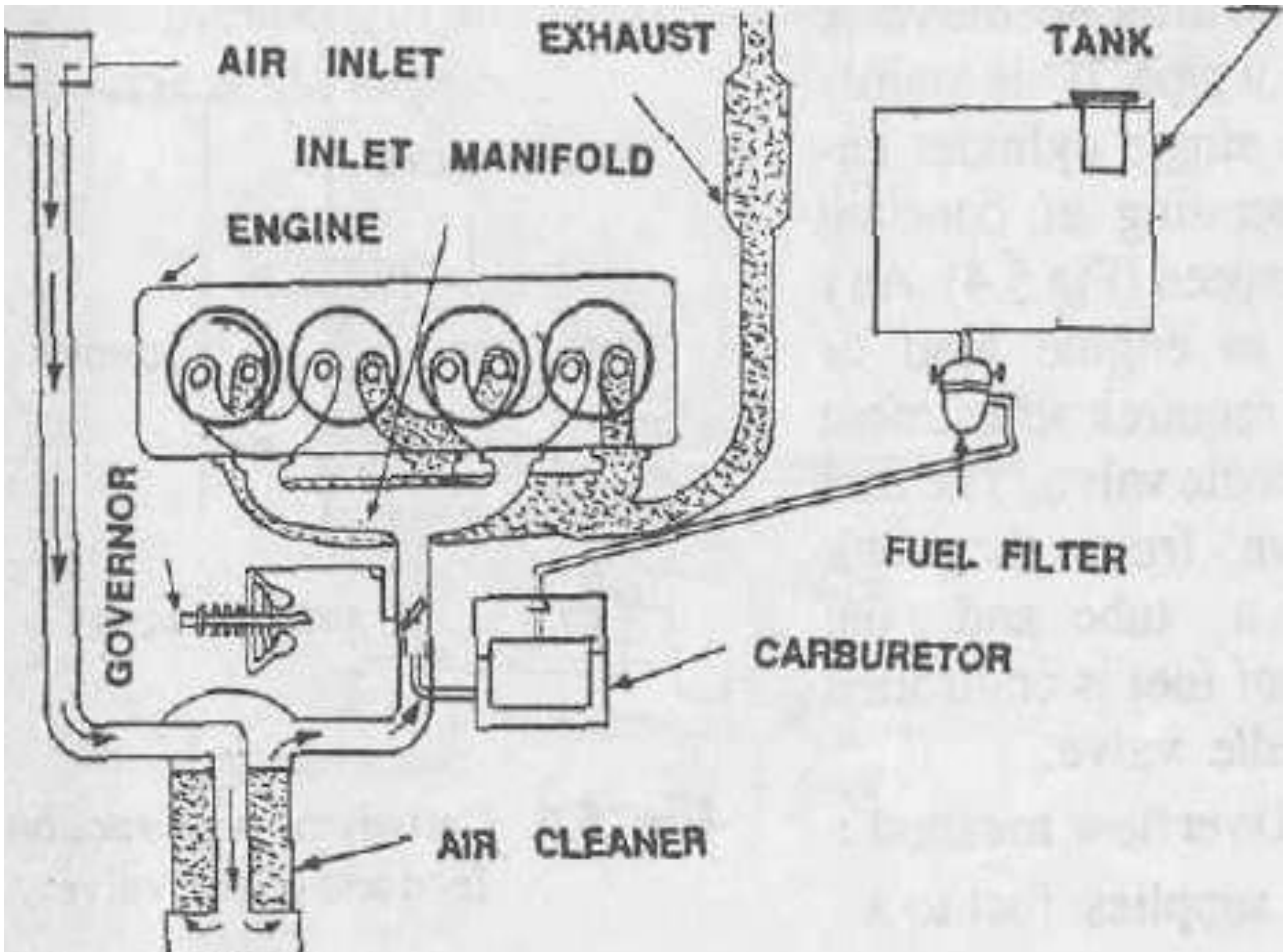


Diagram of fuel system of spark ignition engine.



Lect.- 5

Lubrication System – splash system and forced feed system; Cooling system – thermosiphon system and forced circulation system

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LUBRICATION

To supply lubricating oil between the moving parts is simply termed as "lubrication".

- IC Engine is made of many moving parts.
- The moving components of IC engine operate at varying temperature, pressure, load and speed.
- Due to continuous movement of two metallic surfaces over each other, there is wearing of moving parts, generation of heat and loss of power in the engine.
- Lubrication of moving parts is essential to prevent all these harmful effects.

Lubrication of IC engine is accomplished by circulating suitable grade of oil through passages drilled in the engine components at appropriate pressure with the help of a pump.

Oil spurt holes in crankshaft

Purpose of lubrication

Lubrication of the moving parts of an IC Engine performs the following functions:

(i) Lubrication of moving parts: It provides thin oil film between moving parts of engine and minimizes friction and their tear and wear. Also prevents seizure of rubbing surfaces.

(ii) Cooling of critical components: The lubricating oil is largely responsible for cooling of piston by direct heat dissipation to cylinder walls and then to cooling system. It also removes heat from engine bearings, thus acts as cooling agent.

(iii) Engine noise reduction: The lubricating oil film acts as a cushion and absorbs shock between the bearings and other engine parts, thus reduces the noise and extends engine life.

(iv) Sealing of compression pressure: It forms a good seal between the piston rings and cylinder walls and prevents leakage of gases from combustion chamber.

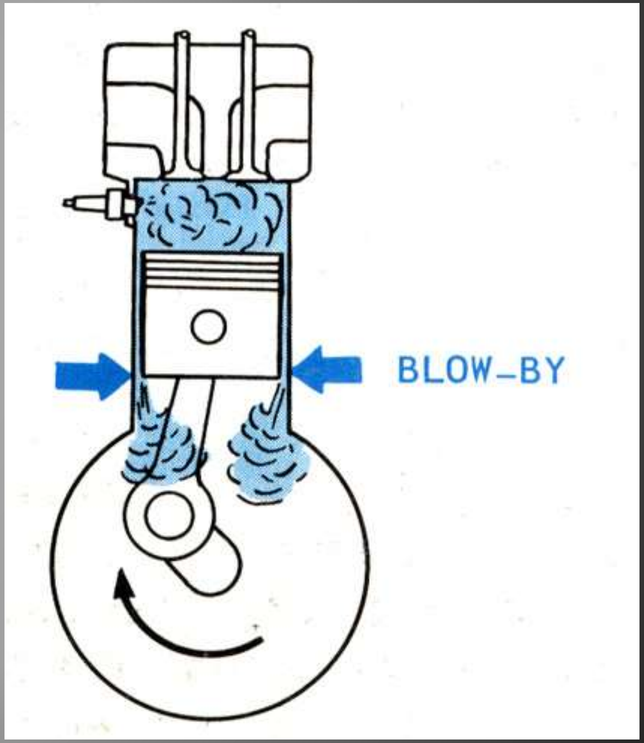
(v) Cleaning of foreign materials: It acts as a cleaning agent to carry away dirt, particles of carbon and other foreign matter to sump.

(Vi)Frictional power reduction: It reduces frictional resistance of moving parts thus reduces power required to overcome friction. It also prevents corrosion of bearings which offer resistance while moving.

Purpose of Lubrication System

<u>Seals</u>

The oil helps form a gastight seal between piston rings and cylinder walls (*Reduces Blow-By)*



Types of Lubricants

Lubricants are obtained from animal fat, vegetables and minerals.

Lubricants made of animal fat, does not stand much heat. It becomes waxy and gummy which is not very suitable for machines.

Vegetable lubricants are obtained from seeds, fruits and plants. Cotton seed oil, Olive oil, linseed oil and Castor oil are used as lubricant in small simple machines.

Mineral lubricants are most popular for engines and machines. It is obtained from crude petroleum found in nature. Petroleum lubricants are less expensive and suitable for IC Engines.

Lubricating oils are marked by their SAE viscosity number recommended by the Society of Automotive Engineers U.S.A.

The low engine oil viscosity grades end with a “W” and are usually suited for winter use. For example: 20W. The high engine oil viscosity grades are not marked “W” and are suitable for summer use.

For ex. SAE 30 , SAE 40.

Higher viscosity grade is recommended for summer use.

Oil classifications

The American Petroleum Institute (A.P.I.) had adopted in 1952 the following classification of engine oils.

The three classes for diesel engines are

DG- diesel general service,

DM- moderately severe service and

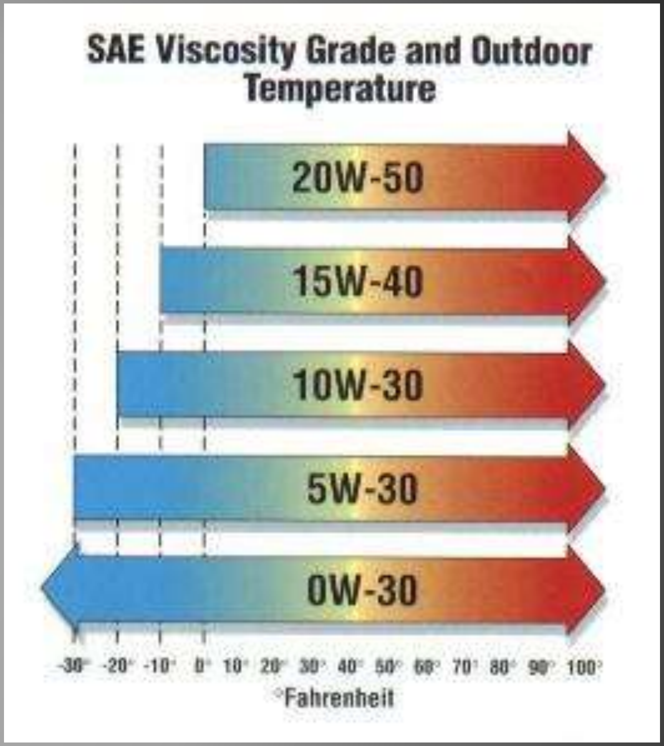
DS- very severe service.

DG and MS oils have a high additive content which helps to keep the engine clean.

When the diesel fuel contains high sulphur content, it is best to use DS lubricating oils.

VISCOSITY

Viscosity is a measure of oil's resistance to flow.



• A low viscosity oil is thin and flows easily

• A high viscosity oil is thick and flows slowly.

• As oil heats up it becomes more viscous (*Becomes thin)*

• Single viscosity oils SAE 5W, SAE 10W (Winter) and SAE30 … (Summer)

• Multiple viscosity oils SAE 10W-30.
This means that the oil is same as SAE 10W when cold and SAE30 when hot.

Engine lubricating system

The lubricating system of an engine is an arrangement of mechanism and **devices** which maintains supply of lubricating oil to the rubbing surface of an engine at correct pressure and temperature.

The parts which require lubrication are:

(i) cylinder walls and piston,

(ii) piston pin

(iii) crankshaft and connecting rod bearings

(iv) cam shaft bearings

(v) valves and valve operating mechanism

(vi) cooling fan

(vii) water pump and

(viii) ignition mechanism.

There are three common systems of lubrication used on stationery engines, tractor engines and automobiles:

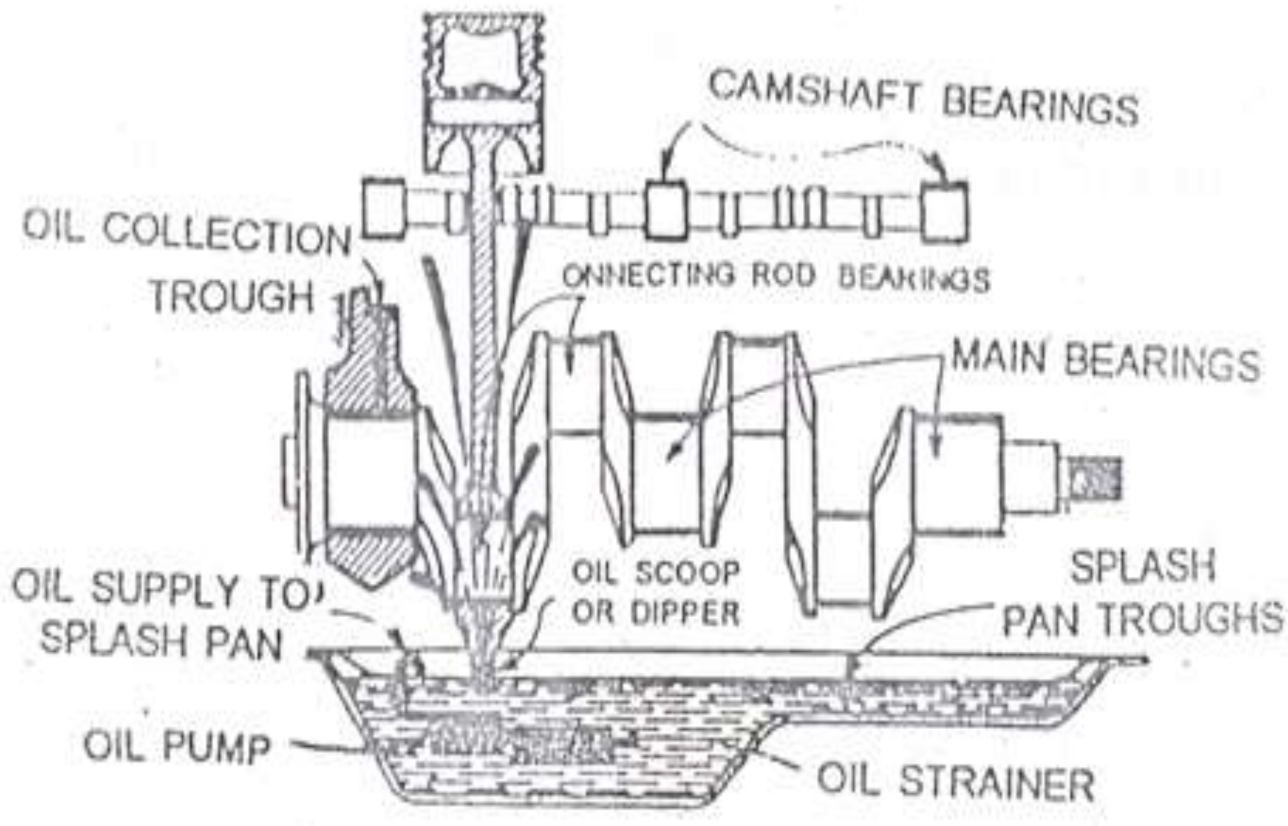
(i) splash system,

(ii) forced feed system, and

(iii) combination of splash and forced feed system.

Splash system

In this type of lubricating system a dipper provided at the bottom end of connecting rod, scoops out of the pan placed below the crank shaft.



- This pan receives its oil supply from the crankcase, either by means of a pump or by gravity through equalizer holes drilled in the pan.
- The connecting rod scoops up oil as it passes over the BDC. The splash is produced due to rotation of crankshaft in oil sump.
- This splashed oil mist formed in crankcase housing lubricates :

main bearing, crankshaft bearing,

timing gear, push rod and cylinder liner walls etc.

However, the valve mechanism is lubricated with the help of oil cans manually at regular intervals.

This type of lubricating system is generally provided in single cylinder engine with closed crankcase.

Force feed system:

The system mainly consists of:

- oil sump
- oil strainer
- oil pump
- oil pressure regulator (pressure relief valve)
- oil filter
- oil lines
- drilled oil passages through moving parts and
- oil pressure gauge.

- The oil pump is driven by camshaft (through belt and pulley arrangement).

- It draws oil from the sump through strainer and supplies to the oil filter with high pressure.

- An oil pressure regulator ensures that oil pressure level is maintained properly.

- The oil filter removes any dirt particle present in oil and supplies clean oil to the oil lines.

- The pump delivers oil to the main gallery from where it passes through holes drilled inside the crankshaft and main bearings, camshaft bearings and partially to connecting rod bearings to lubricate them.

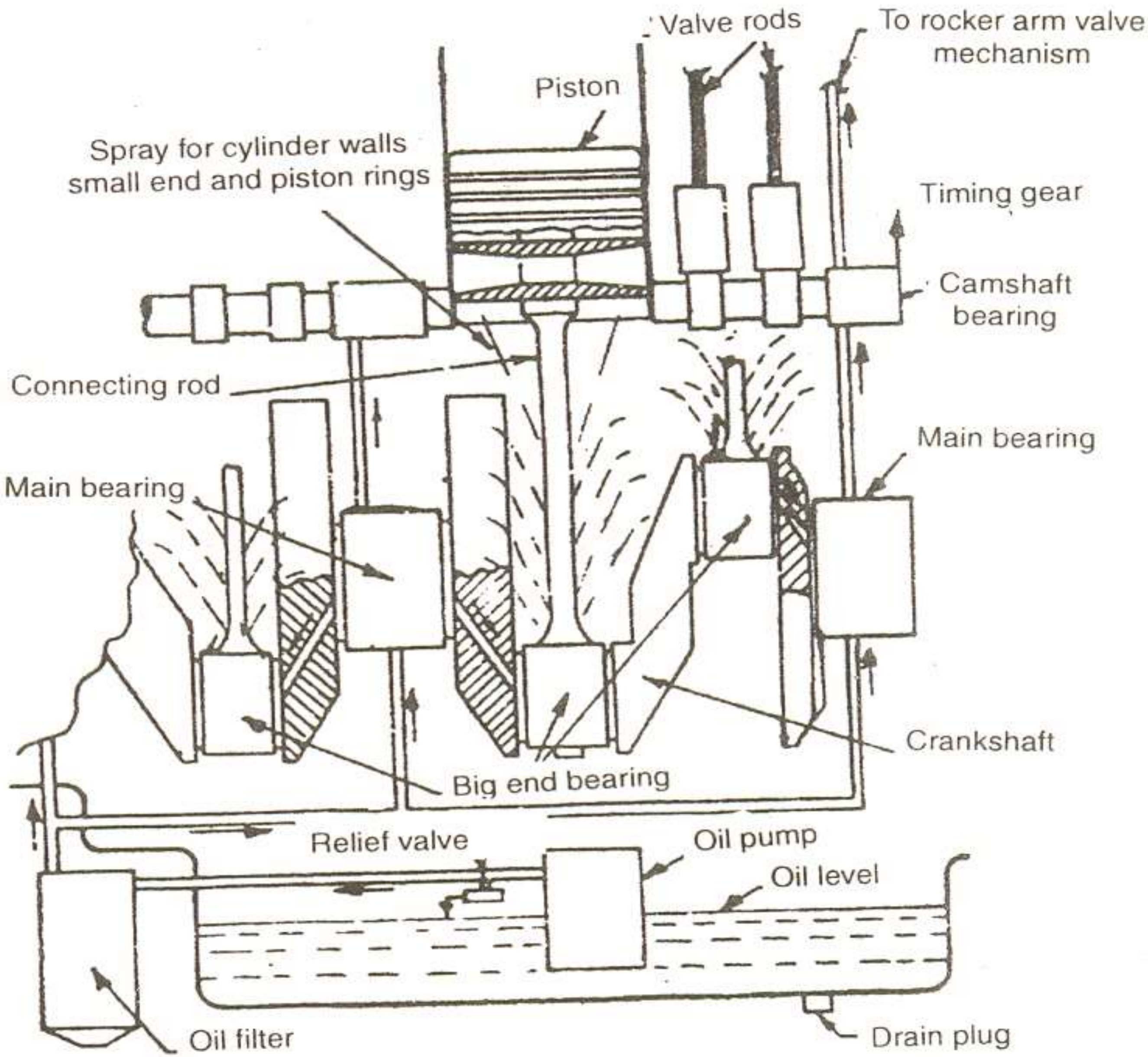
- Cylinder walls, piston pins and small end bearings of connecting rod are lubricated by the oil coming out from the big end bearing through holes drilled through connecting rod.

Surplus oil then flows back to crankcase (sump). This also washes extraneous impurities i.e. wear out products of bearings and clearance between mated parts to the sump by scrapping oil.

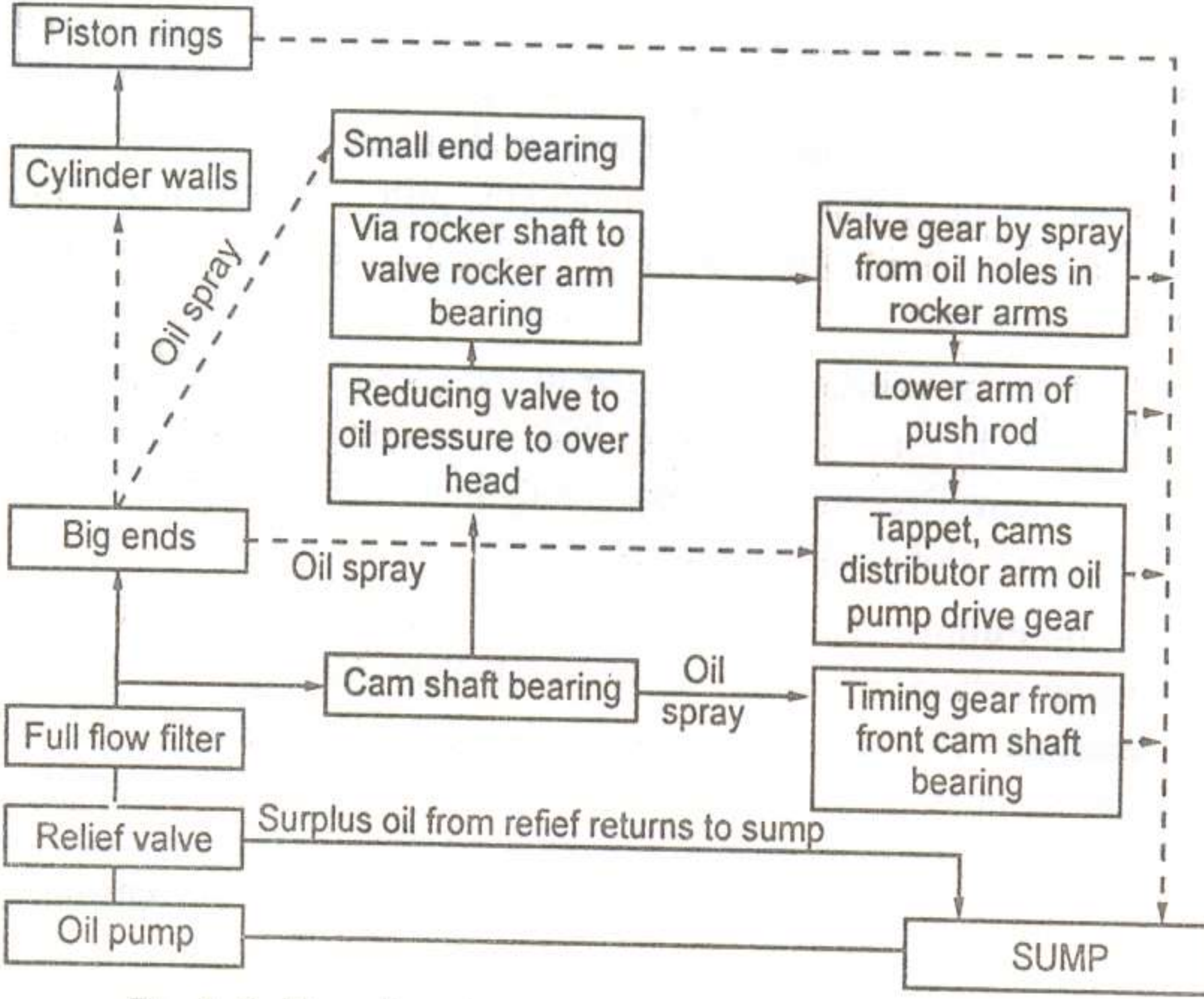
From cam shaft, the oil under pressure goes to the valve mechanism (rocker arm, shaft and tappet).

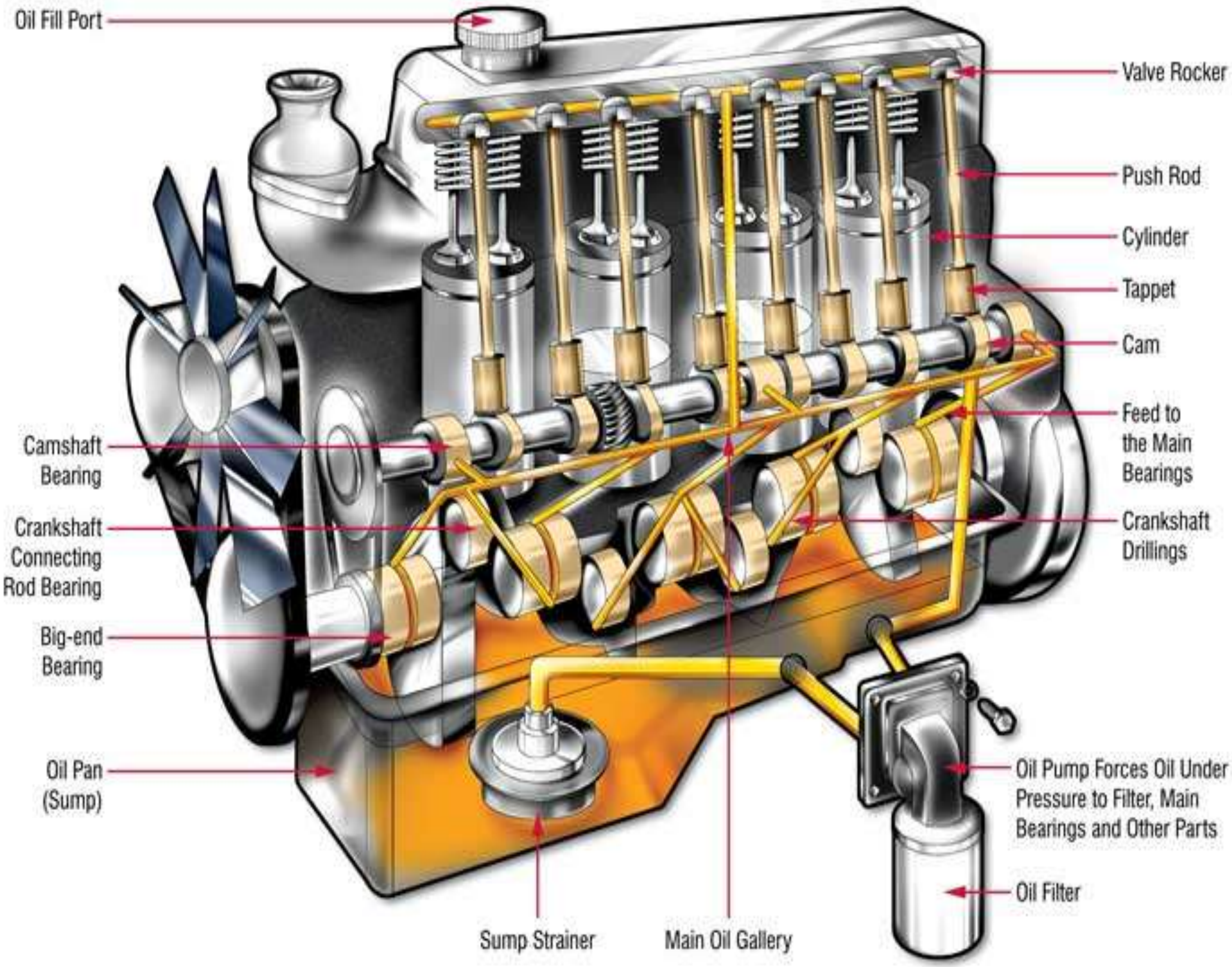
An oil pressure gauge is fitted with system to indicate the lubricating oil pressure in the system.

The forced feed type lubricating system is commonly used on high speed multi-cylinder tractor engines.



Forced feed type lubricating system


Piston rings
Cylinder walls
Small end bearing
Oil spray
Via rocker shaft to valve rocker arm bearing
Valve gear by spray from oil holes in rocker arms
Reducing valve to oil pressure to over head
Lower arm of push rod
Big ends
Oil spray
Tappet, cams distributor arm oil pump drive gear
Cam shaft bearing
Oil spray
Timing gear from front cam shaft bearing
Full flow filter
Relief valve
Surplus oil from refief returns to sump
Oil pump
SUMP


Oil Fill Port
Valve Rocker
Push Rod
Cylinder
Tappet
Cam
Feed to the Main Bearings
Camshaft Bearing
Crankshaft Connecting Rod Bearing
Crankshaft Drillings
Big-end Bearing
Oil Pan (Sump)
Oil Pump Forces Oil Under Pressure to Filter, Main Bearings and Other Parts
Oil Filter
Sump Strainer
Main Oil Gallery

Oil filters

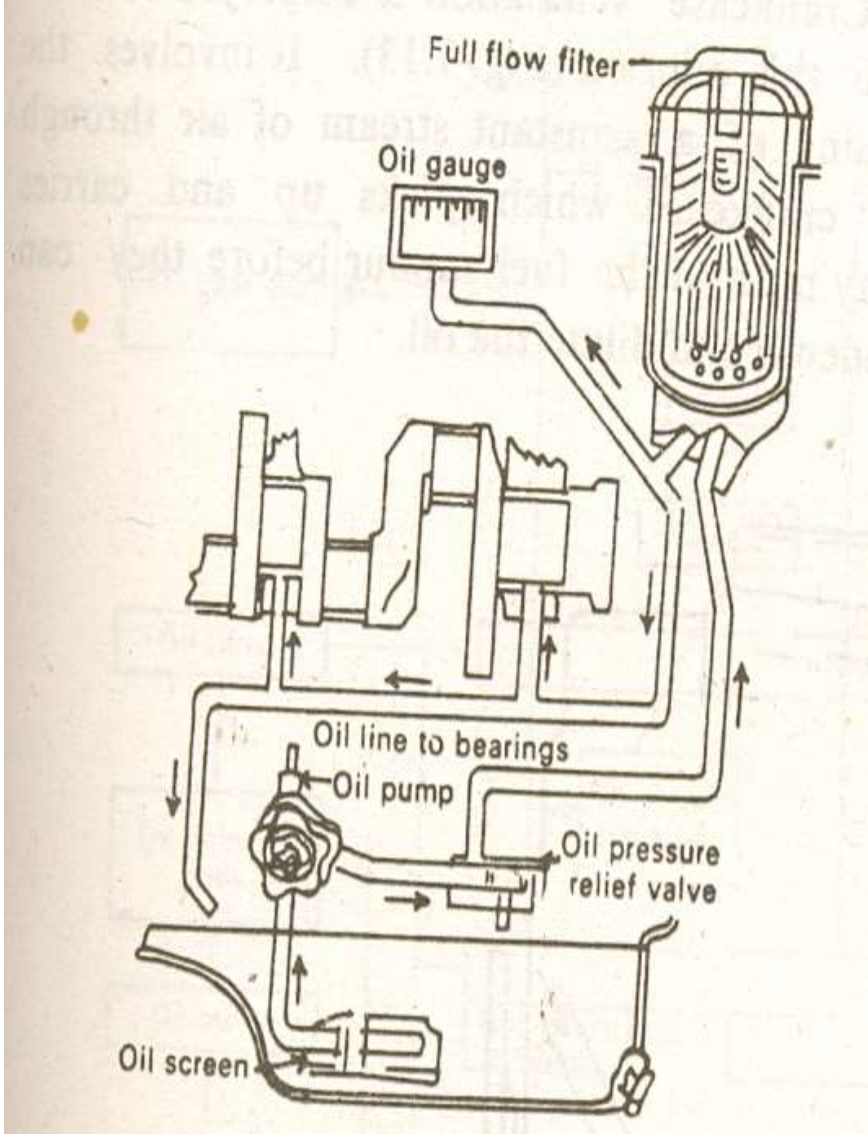
- Lubricating oil in an engine becomes contaminated with various materials such as dirt, metal particles and carbon.
- An oil filter removes all the dirty elements of the oil in an effective way.
- It is a type of strainer using cloth, paper, felt, wire screen or similar elements.
- Some oil filters can be cleaned by washing, but in general old filters are replaced by new filters at specified interval of time.
- It is normally changed after about 120 hours of engine operation.
- Oil filters are of two types: (i) full-flow filter, and (ii) by-pass filter

Full flow filter

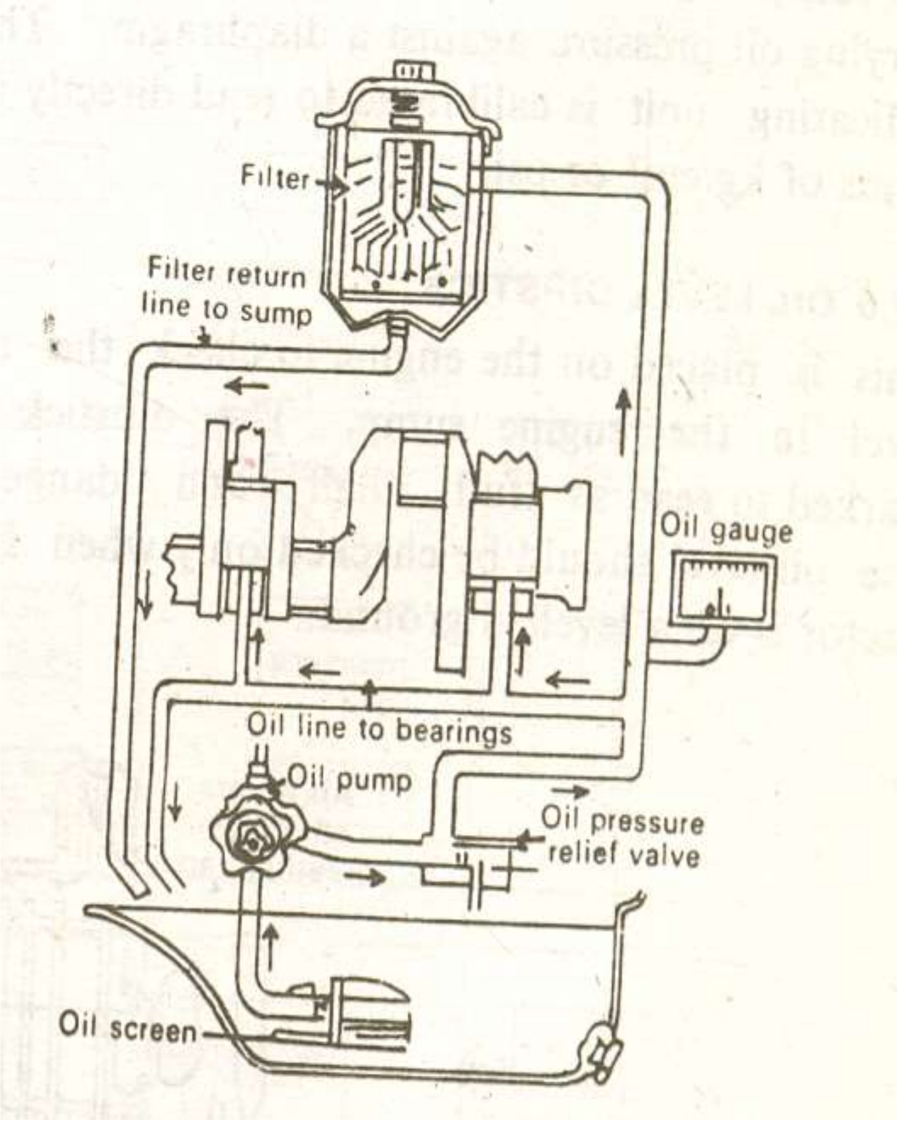
In this filter, the entire quantity of oil is forced to circulate through it before it enters the engine. A spring loaded valve is usually fitted in the filter as a protection device against oil starvation in case of filter getting clogged.

By pass filter

By pass filters take a small portion of oil from the pump and return the filtered oil into the sump. Over a period of operation, all the oil in the crankcase passes through the filter. Through the filter, the balance oil reaches directly to the engine parts.



Full flow type oil filter system



By pass type oil filter system

Oil Pump

Lubricating oil pump is a positive displacement pump, usually **gear or vane type.**

The gear pump (external meshing) consists of a set of two helical gears to develop about 3 kg/cm^2 pressure.

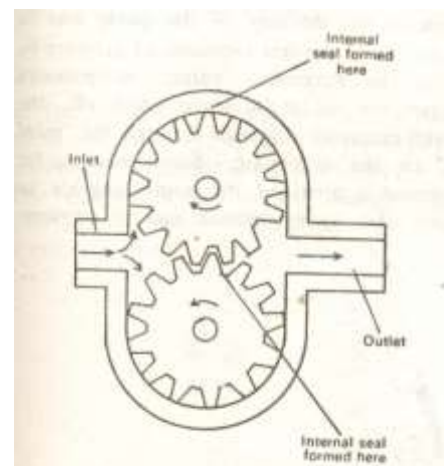
The pump is driven by the camshaft of the engine.

The lower end of the pump extends down into the crankcase, which is covered with a screen to check foreign particles.

An oil pressure gauge fitted in the line, indicates the oil pressure in the lubricating system.

About 3 kg/cm2 pressure is developed in the lubrication system of a tractor engine.

Star shaped rotor pump



Gear type oil pump

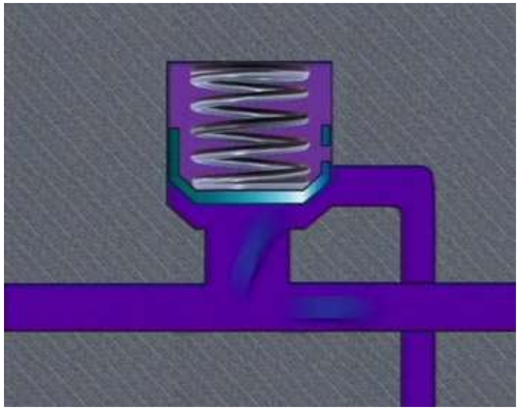
Oil pressure relief valve

A normal pump is capable of delivering more oil than an engine needs. It's a safety measure to ensure the engine is never starved for oil.

As the pump rotates, and engine speed increases, the volume of oil delivered also increases.

The fixed clearances between the moving parts of the engine prevent oil escaping back to the sump, and pressure builds up in the system.

An oil pressure relief valve stops excess pressure developing. It's like a controlled leak, releasing just enough oil back to the sump to regulate the pressure of the whole system.



Oil Pressure Indicator

- Light or a Gauge

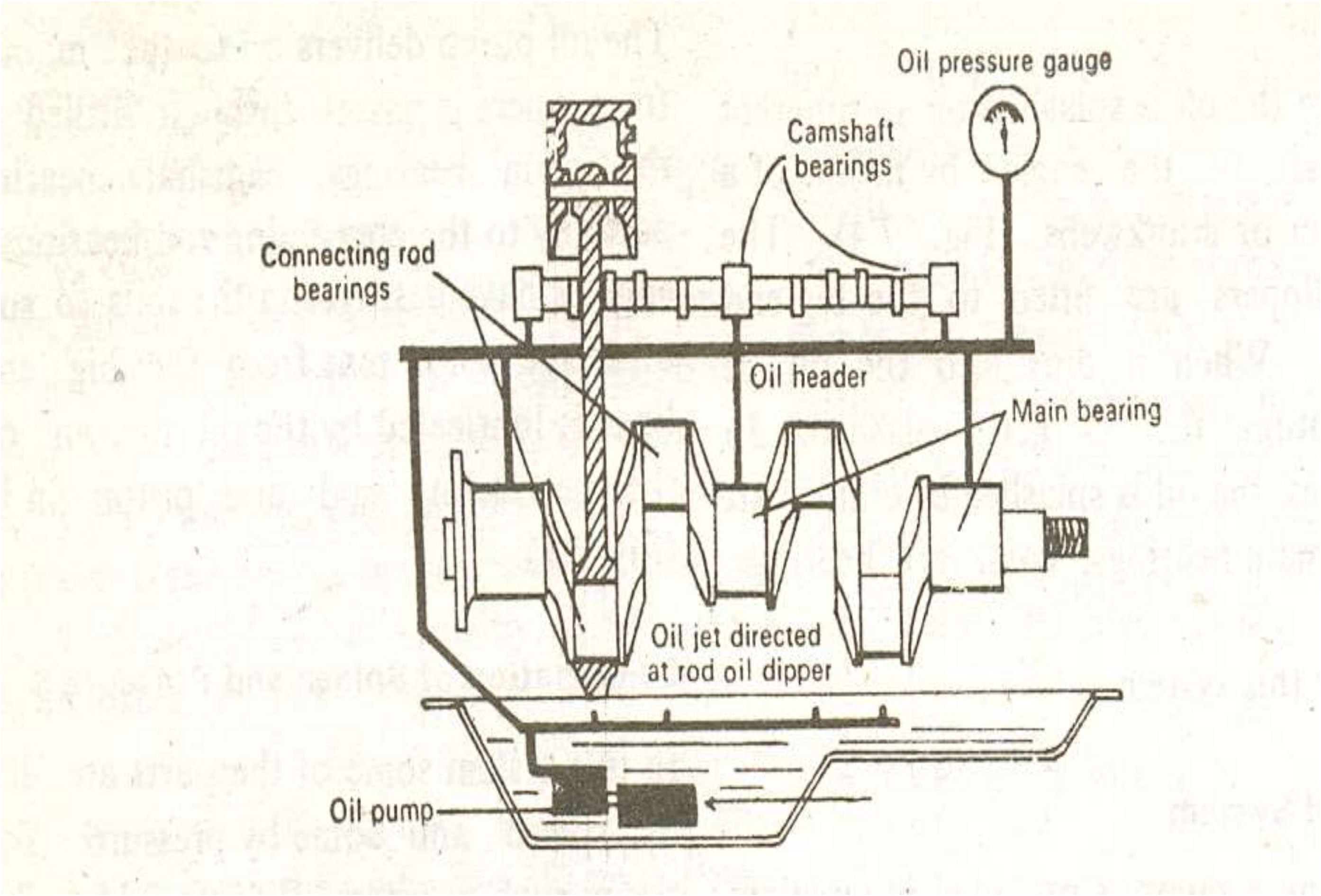
The light turns on or gauge reads low when
the pressure drops.

Common causes of low oil pressure are:

- Low oil level
- Worn out pump

Combination of Splash and pressure system

In this system some of the parts are lubricated by splash and some by pressure.



Cooling system

- In internal combustion engines, combustion of air and fuel takes place inside the engine cylinder and hot gases are generated.
- The temperature of gases will be around 2300-2500°C. This is a very high temperature and may result into burning of oil film between the moving parts and may result into seizing.
- Too much cooling is also not desirable since it reduces the thermal efficiency.
- So, the object of cooling system is to keep the engine running at its most efficient operating temperature.
- **Correct operating temperature range**

For petrol engine: 71^0C to 82^0C

For heavier fuel: 88^0C to 90^0C

Need / purpose of cooling:

- To maintain correct engine operating temperature.
- To dissipate surplus heat resulting from the combustion of the fuel in the cylinders.
- Properly cooling also results in maintaining proper lubrication between engine parts.
- Cooling reduces the possibility of loss of power due to pre- ignition and valve burning.
- Cooling also ensures proper fuel combustion and prevents dilution of the crankcase oil.

Based on cooling media, engines are classified as air cooled and water cooled engines.

Engines are also cooled by a combination of air and water.

Air cooling:

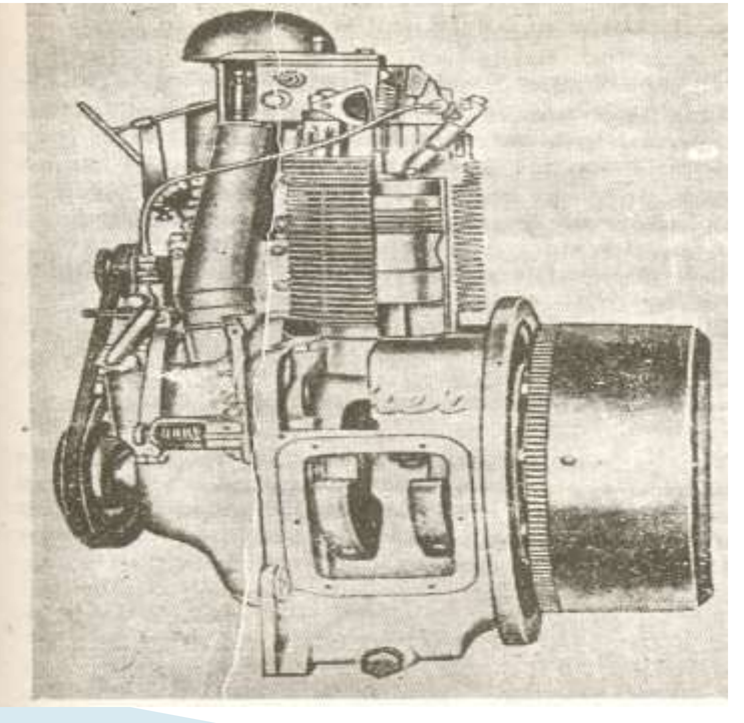
- This method is used on small size stationary engines and garden tractors.
- In this method of cooling, a strong blast of air is forced all around cylinder walls and cylinder head which are provided with fins to increase the surface area. Heat generated due to combustion in the engine cylinder will be conducted to the fins and when the air flows over the fins, heat will be dissipated to air.
- The amount of heat dissipated to air depends upon:

(a) Amount of air flowing through the fins.

(b) Fin surface area.

(c) Thermal conductivity of metal used for fins.

- The fly wheel of the air cooled engines is generally equipped with fan blades to create the air blast.
- Air cooled engines run hotter than water cooled engines and heavier lubricating oil is recommended.



Advantages of air cooled system:

(a) Radiator/pump is absent hence the system is light.

(b) In case of water cooling system there are leakages, but in this case there are no leakages.

(c) Coolant and antifreeze solutions are not required.

(d) This system can be used in cold climates, where if water is used it may freeze.

Disadvantages of air cooled system

(a) Comparatively it is less efficient.

(b) It is used in aero planes and motorcycle engines where the engines are exposed to air directly.

Water cooling:

There are three types of water cooling systems for engines

- Hopper system
- Thermo siphon system
- Forced circulation system

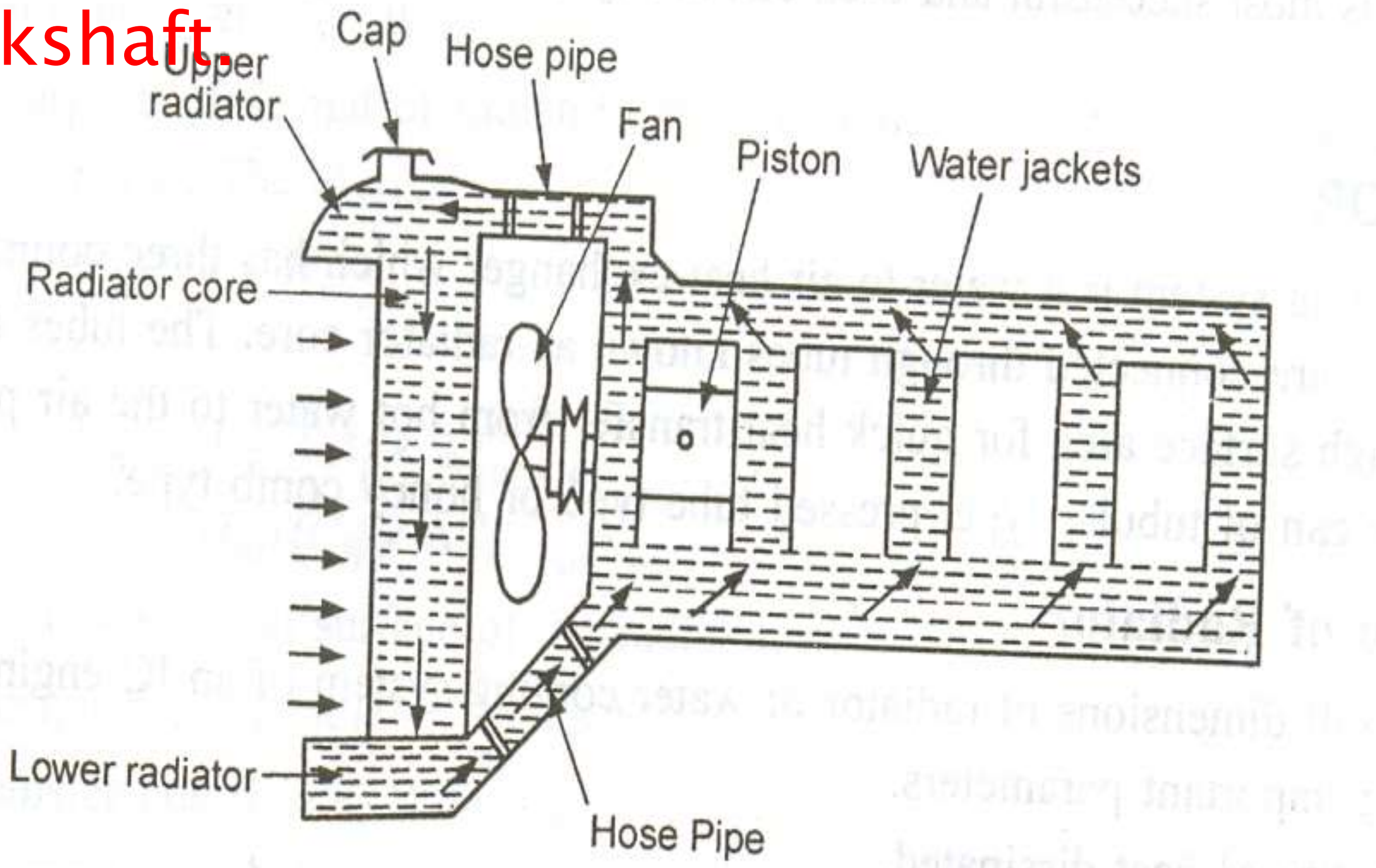
In hopper system a small water reservoir is placed just above the water jacket as their integral part. It was in use in old stationary engines and now completely replaced by the other two systems.

Thermo siphon system:

Thermo siphon (a property of physics) refers to a method of passive heat exchange based on natural convection, which circulates a substance (liquid, or gas such as air) without the necessity of a mechanical pump.

- Thermo siphon system is used on tractors and on stationary engines.
- It consists of a radiator, water jacket, fan, temperature gauge and hose connections.
- It works on the principle that heated water surrounding the cylinder gets lighter in weight and rises. Hot water goes to the radiator where it passes through tubes surrounding by air. Water is circulated because of density difference only.

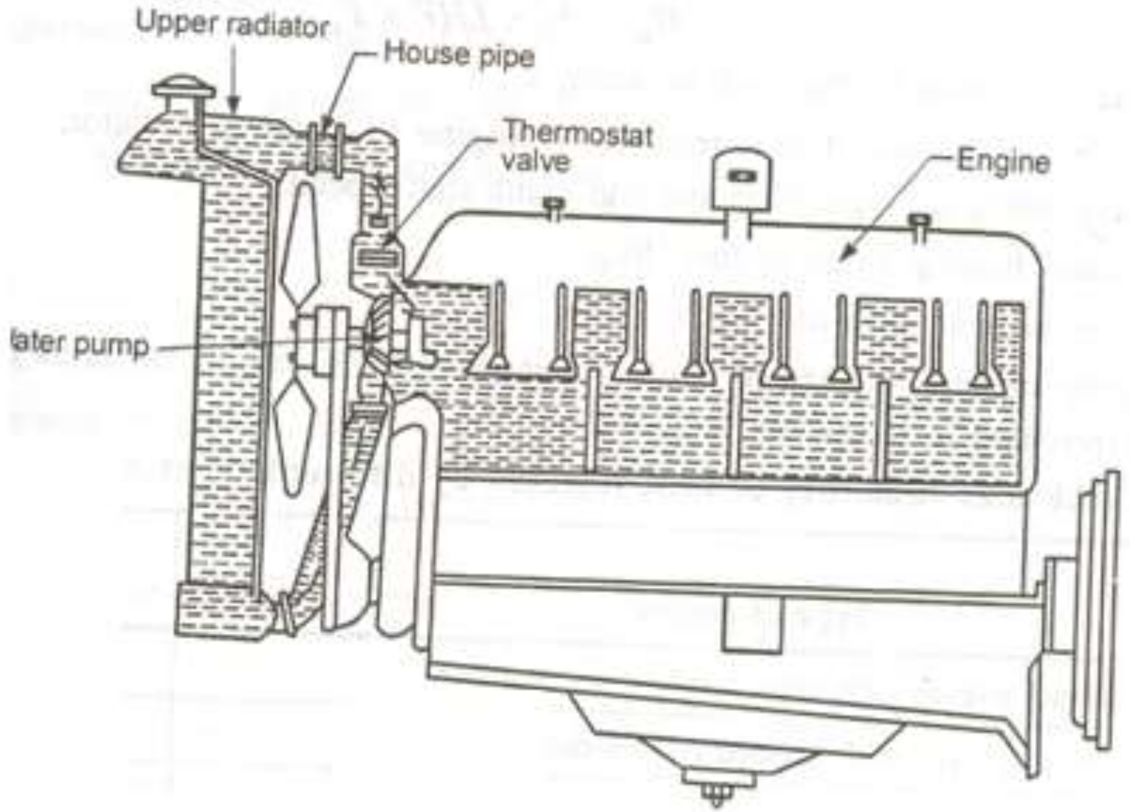
- A fan located between the radiator and engine sucks air through the radiator tubes thus cooling the radiator water. The fan is driven by a pulley mounted on the crankshaft.



Thermo siphon type cooling system

Forced circulating system:

It consists of a radiator, water pump, water jacket, thermostat valve, fan, fan belt, temperature gauge and sufficient hose to complete the cooling system.



Radiator

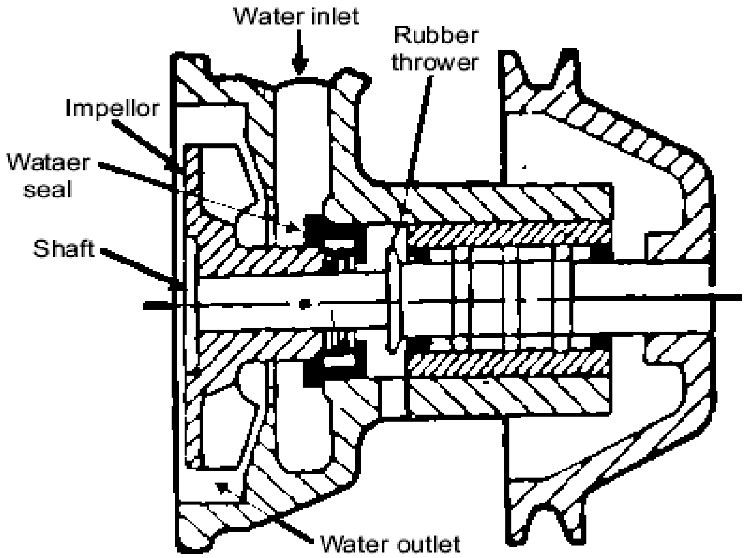
It mainly consists of an upper tank and a lower tank and between them is a core.

The upper tank is connected to the water outlets from the engines jackets by a hose pipe and the lower tank is connect to the jacket inlet through water pump by means of hose pipes.

A spring loaded sealed radiator cap is provided to create 0.34 to 0.4 kg/cm^2 pressure and thereby boiling temperature of water in the radiator is raised to about 110^{o}C.

Water pump

- In this system a pump is used to lift the water from the bottom of radiator and force it through the water jackets provided around the cylinders and in the cylinder head.
- The pump consists of an impeller mounted on a shaft and enclosed in the pump casing.
- The pump casing has inlet and outlet openings.
- The pump gets drive from the engine crank shaft through V- belt.



Water jackets

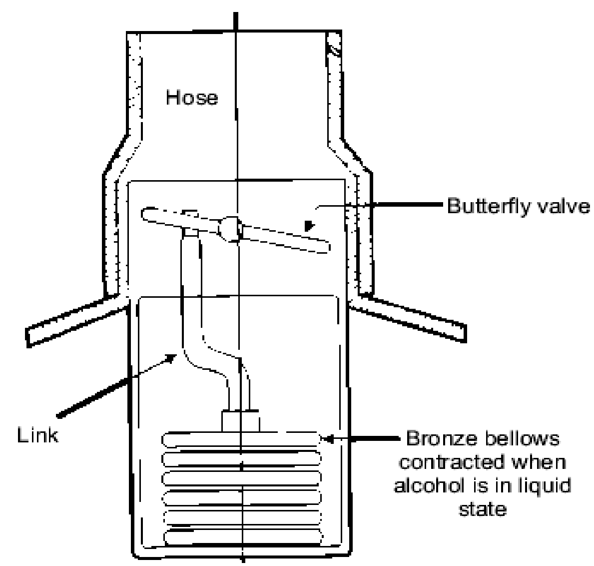
- Cooling water jackets are provided around the cylinder, cylinder head, valve seats and any hot parts which are to be cooled.
- Heat generated in the engine cylinder, conducted through the cylinder walls to the jackets.
- The water flowing through the jackets absorbs this heat and gets hot.
- This hot water will then be cooled in the radiator.

Thermostat valve

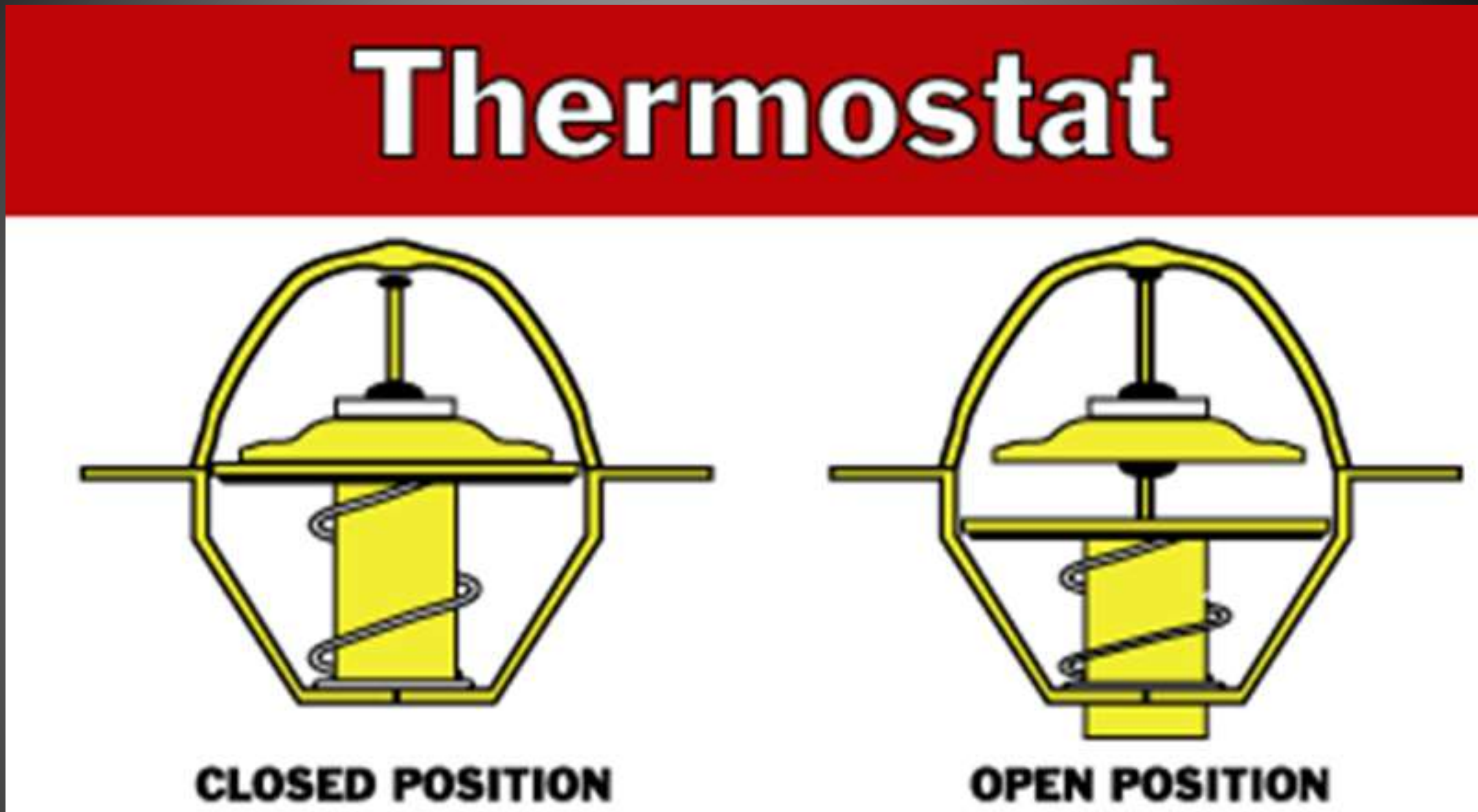
- A thermostat valve is placed at the forward end of the cylinder head to maintain the correct engine operating temperature.
- It restricts the flow of water through the radiator and bypasses it till it gets warmed up after cold start of engine.
- The thermostat then opens, closing the bypass and allowing the water to circulate through the radiator.
- Generally the **bellows** type thermostat is used on the tractors.
- Generally the thermostat begins to open at about 74^0C and opens widely at about 80^0C.

It contains a bronze bellow containing liquid alcohol which has a narrow boiling range.

When the temperature of water increases, the liquid alcohol evaporates and the bellow expands and in turn opens the butterfly valve, and allows hot water to the radiator, where it is cooled.



Thermostat valve


Thermostat
CLOSED POSITION
OPEN POSITION

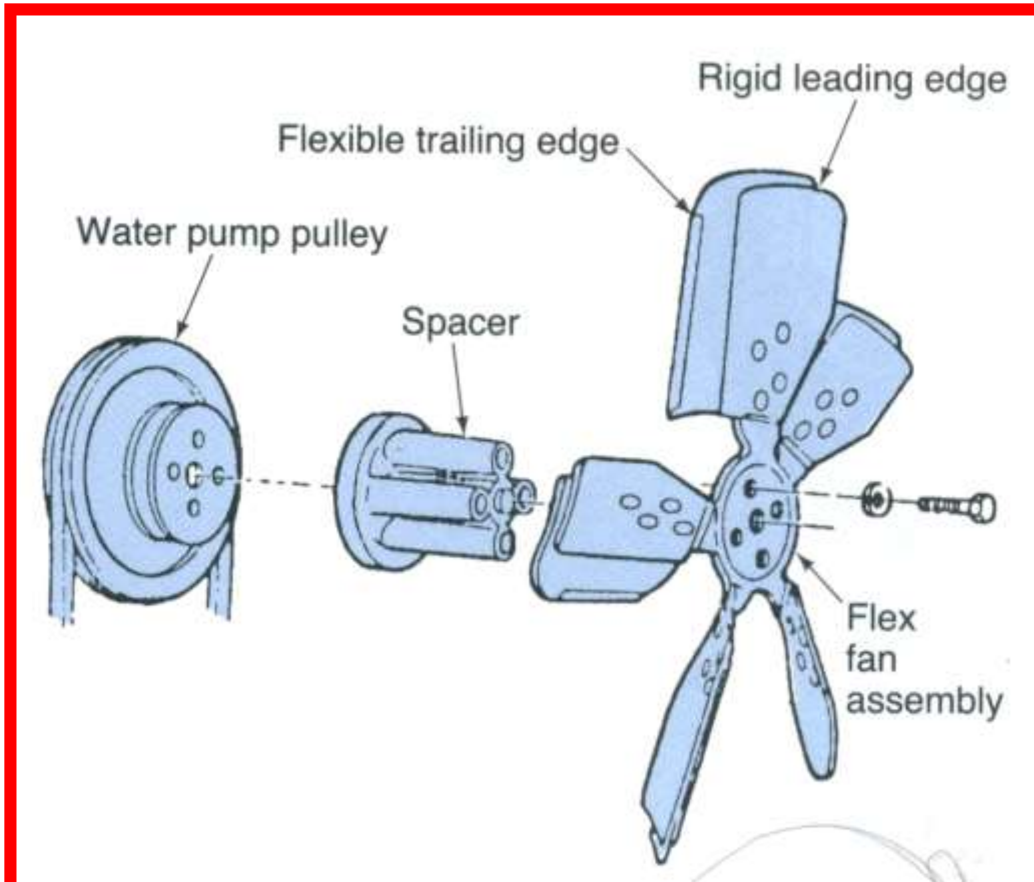
Fan

It is driven by the engine output shaft through same belt that drives the pump.

It is provided behind the radiator and it blows air over the radiator for cooling purpose.

Flex Blade Fan

- Fan blades flatten out at high speeds, reducing noise, increasing horse power



Advantages of Water Cooling System:

(a) Uniform cooling of cylinder, cylinder head and valves.

(b) Specific fuel consumption of engine improves by using water cooling system.

(c) If we employ water cooling system, then engine need not to be provided at the front end of moving vehicle.

(d) Engine is less noisy as compared with air cooled engines, as it has water for damping noise.

Disadvantages:

(a) It depends upon the supply of water.

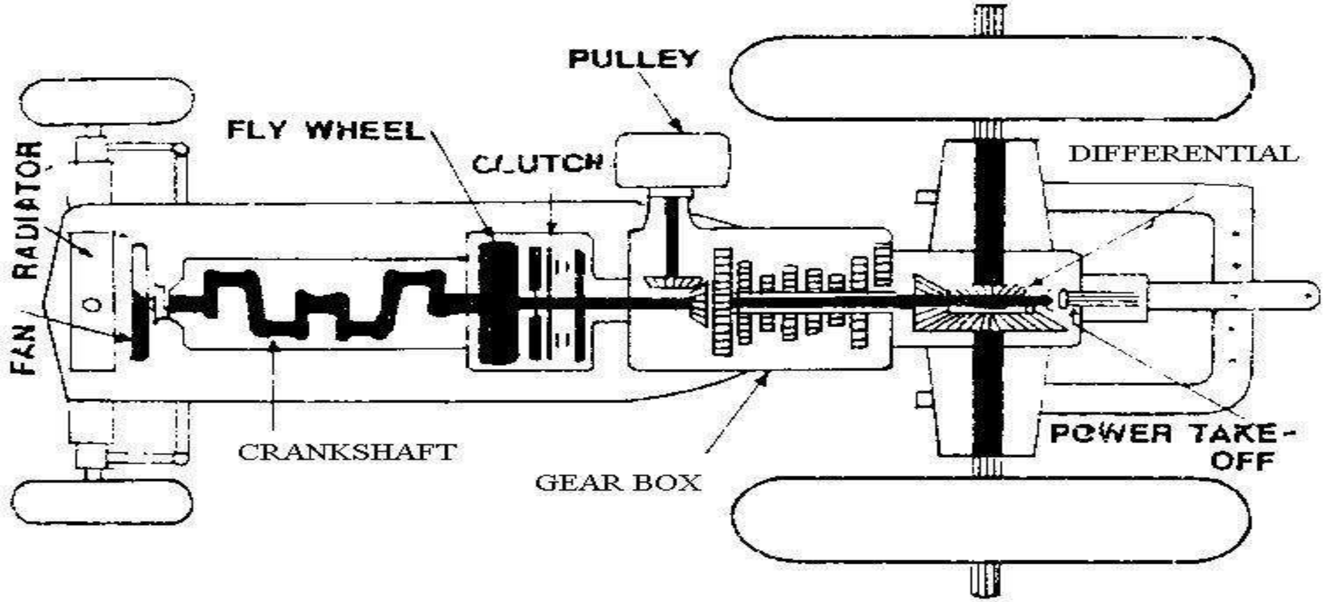
(b) The water pump which circulates water absorbs considerable power.

(c) If the water cooling system fails then it will result in severe damage of engine.

(d) The water cooling system is costlier as it has more number of parts. Also it requires more maintenance and care for its parts.

Lect.-6

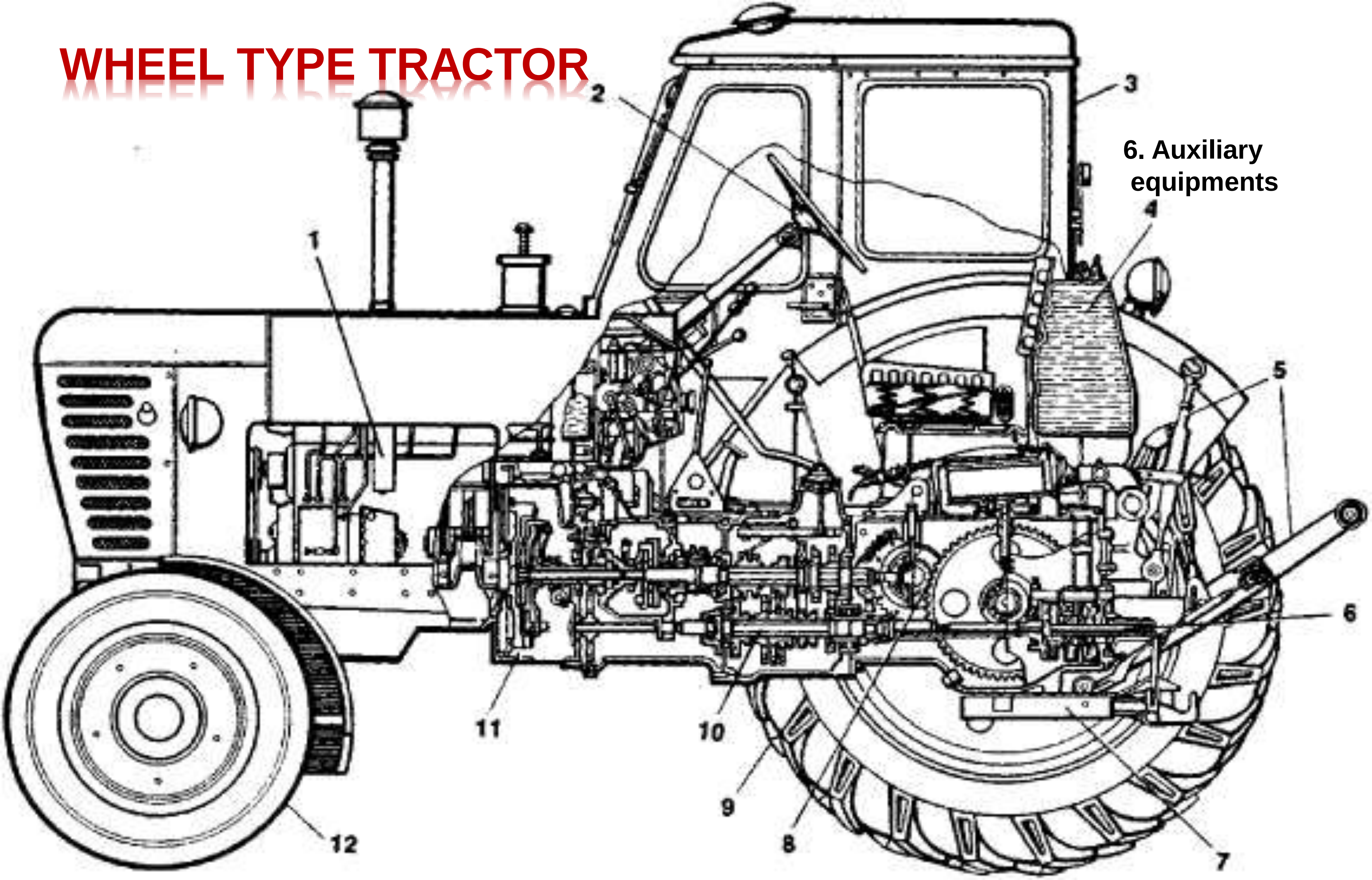
Transmission system- Clutch, Gear box, Differential, Final drive, P.T.O. shaft and Hydraulic control system.



TRACTOR POWER TRANSMISSION SYSTEM

Er. J. K. Gaur
Associate Professor and Head
Deptt. of Ag. Engineering
S. K. R. A. U., Bikaner

WHEEL TYPE TRACTOR

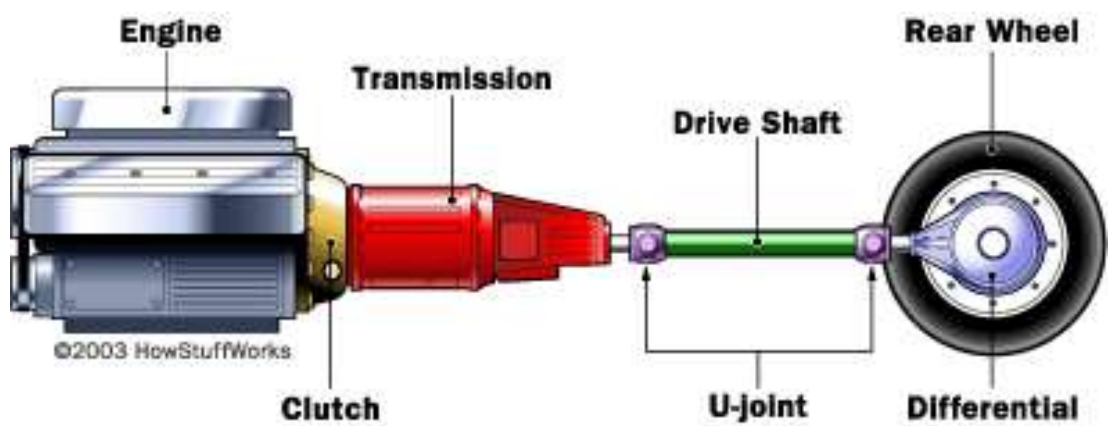


(1) engine, (2) steering wheel, (3) cab, (4) fuel tank, (5) levers of toolbar assembly. (6) power takeoff shaft, (7) hitch, (8) main drive, (9) driving wheel, (10) gear box, (11) clutch, (12) front (steerable) wheel

The transmission system is provided to perform following functions:

- To transmit engine brake power from its fly wheel to tractor rear drive wheels and to multiply the torque developed by the engine.
- To engage or disengage engine power with rest of tractor power trains as per load and speed.
- To select appropriate speed ratio according to type of work and draw bar load on the tractor.

- To distribute the power to the rear drive wheels of tractor for turnings.
- To provide means of reversing the tractor.
- To transmit engine power to P. T. O. shaft and belt pulley for operation of implements requiring rotary power.
- To drive the pump of hydraulic system of tractor.



Engine brake power

$$W = \frac{2N_eT_e}{4500}$$

Where W = engine brake power, hp (Power delivered to rear wheels)

N_e = engine rpm

T_e = engine torque, kg.m

For constant value of W, N_e will be less if T_e is high.

Draw bar power of tractor

$$W_d = \frac{P \times S}{75}$$

Where W_d = Draw bar power, hp

P = Draw bar pull, kg

S = Speed m/s

Clutch

- It is fitted between engine and gear box and is used to connect or disconnect the tractor engine from its power trains and for changing gear ratios.
- The clutch transmits power by means of friction between driving and driven elements.
- There are two main types of friction clutches used on tractor; i.e.

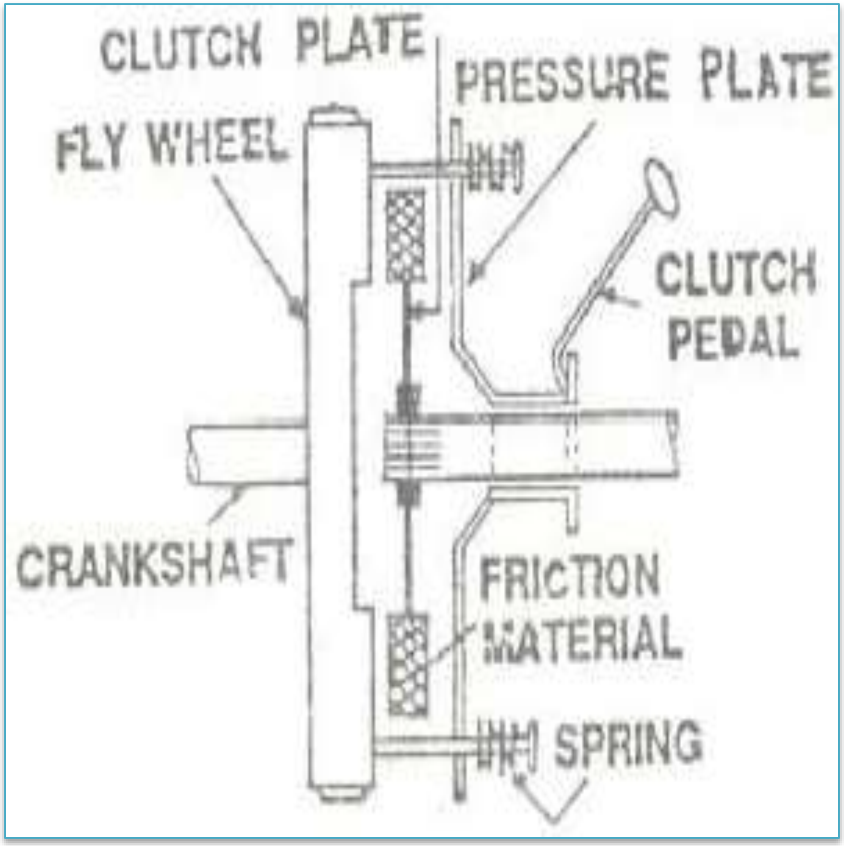
  single disc type and

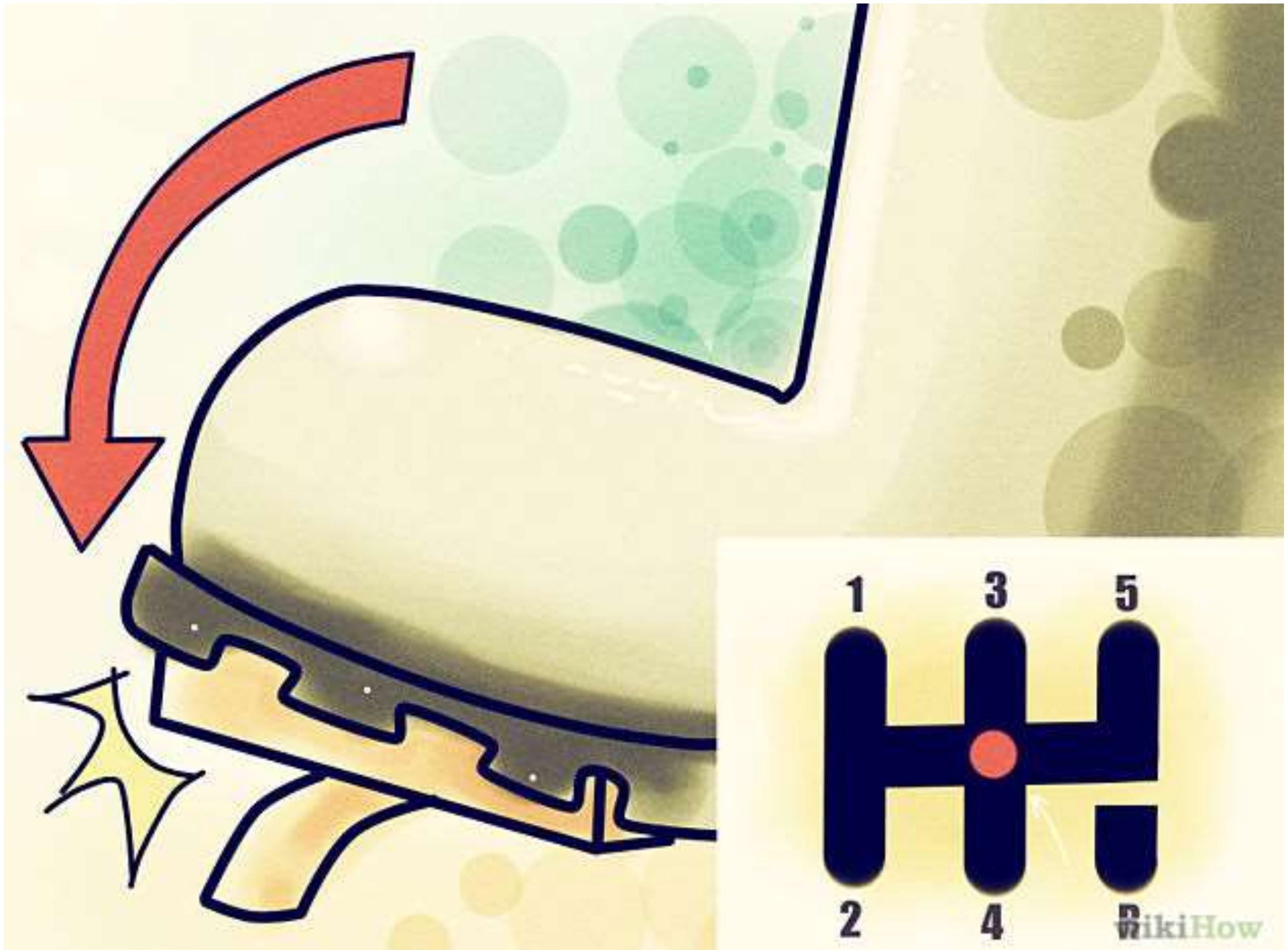
  multiple disc type.

The single plate clutch is dry type clutch.

When the clutch pedal is depressed, release fingers push the power plate back against the spring pressure, thus releasing the pressure from the clutch plate. Then the driven plate stops, whereas, flywheel continues to rotate.

When the clutch pedal is released the pressure plate forces the clutch plate against the flywheel with sufficient force to cause the clutch plate and flywheel to turn together as one unit.




1
3
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Gearbox system

It is fitted in the tractor to increase the driving torque so as to enable tractor to pull more load.

Transmission systems of modern tractors are mostly of the **selective sliding gear** type.

Selection of gear is made with a gear shifting lever mounted above the transmission housing and very close to the operator’s seat.

A transmission allows the operator to increase or decrease the speed and reverse the direction of the tractor.

The lower the gear, the more weight the tractor can pull, but at the slower speed.

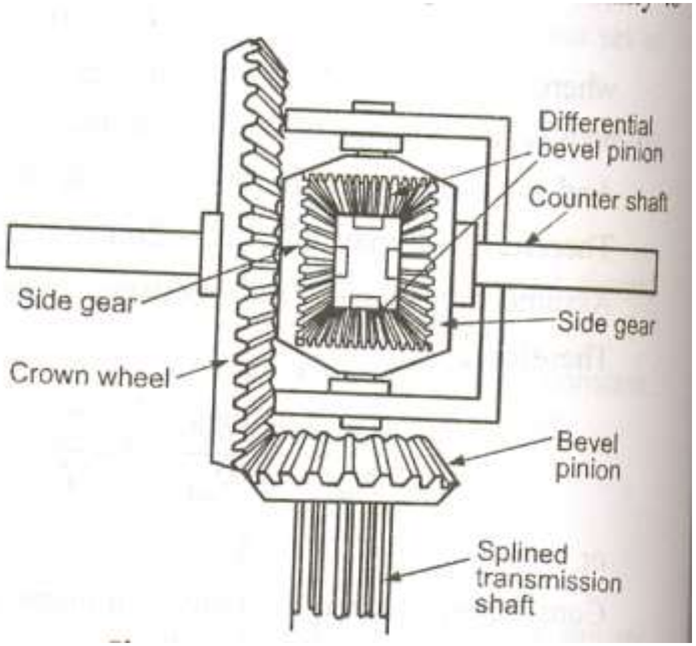
Differential

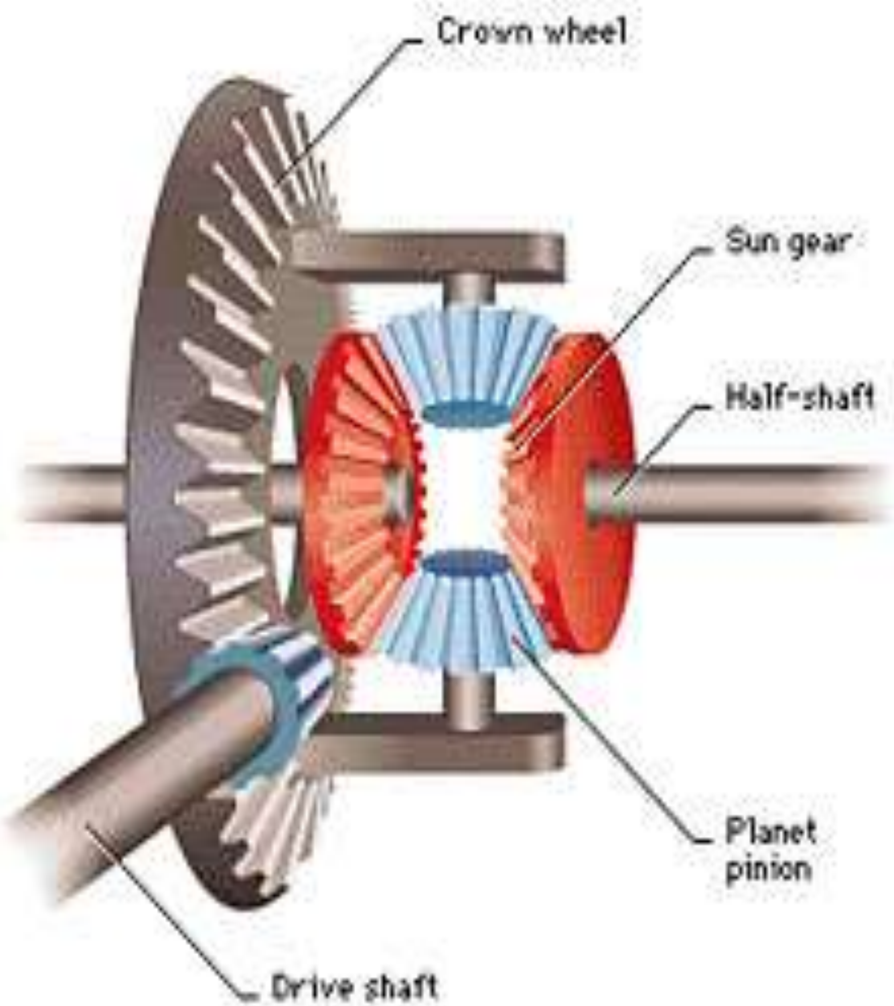
- The main purpose of differential unit is to work as compensating mechanism so that when the tractor takes a turn, the outer wheel may move faster than the inner one and still share the load equally.
- It also functions as a second speed reduction point in the tractor power trains.
- The differential assembly is fitted in the center of rear axle.

Design detail and working of differential

The standard differential used on tractor has planetary gear system which has four bevel gears (two side gears and two pinions).

It also has a bevel pinion and a crown wheel fitted at right angles to each other to transmit the power received from the gear box to the rear axles .The bevel pinion mounted at the end of the output shaft of the gear box drives crown gear.





Differential of a tractor

It acts as a speed reduction and transmission of power at 90^0. The differential divides the power into equal parts and finally to the rear wheels.

When the tractor is moving straight ahead, the bevel pinions of differential do not rotate on their carrier shafts and both the side gears rotate at same speed.

When the tractor turns, the outer rear wheel must travel faster than the inner one. **This is accomplished by differential pinion being rolled over the differential side gears as well as by rotating on their own axles.**

While turning a short corner, the inner wheel is slowed down and the outer one is speeded up. If one wheel is locked, the speed of the other one is increased by two times.

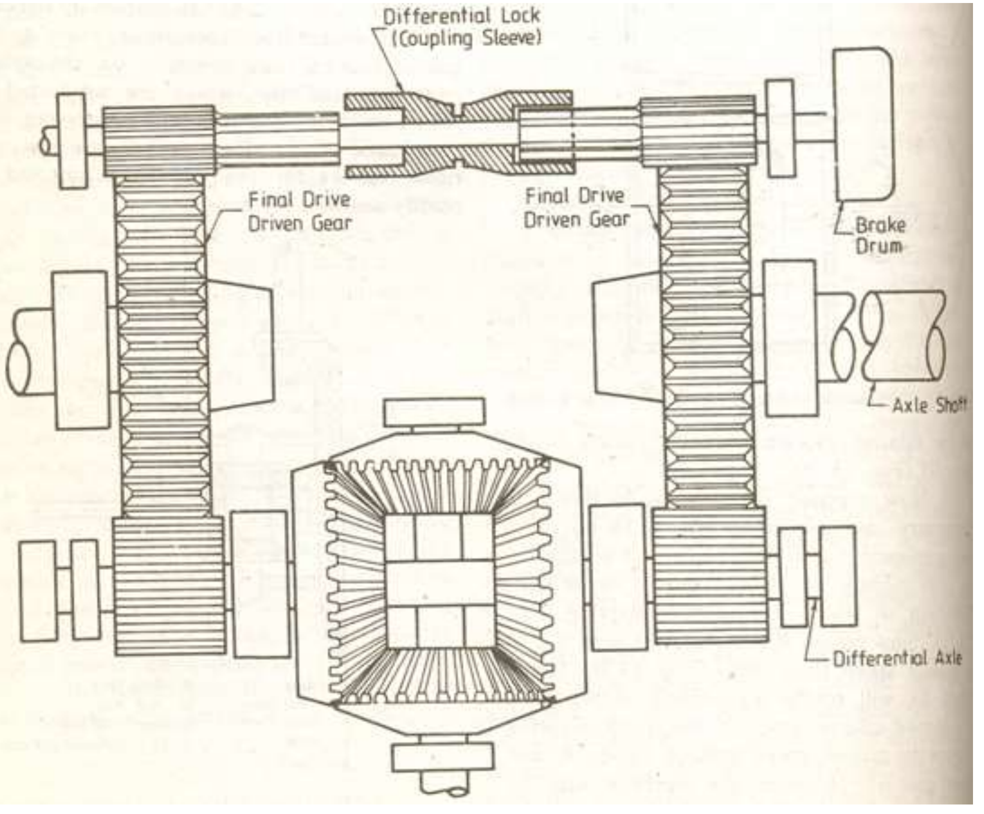
Differential lock

Whenever one wheel offers less resistance it turns faster causing a loss of traction.

If one wheel gets in the mud or loose soil, the wheel on the solid ground will not be driven while the other spins around due to the differential action.

To overcome this problem, all tractors are provided with a locking system known as differential lock. The purpose of lock is to join both half axles so that even if one wheel is under less resistance, the tractor comes out from the mud, etc. as both wheels move with the same speed and apply equal traction.

In its simplest form, differential lock consists of a movable collar which can be shifted along the splines of the two half shafts. As soon as the half shafts are locked, they give the effect of a straight – through rear axle, resulting in full traction on both the wheels.



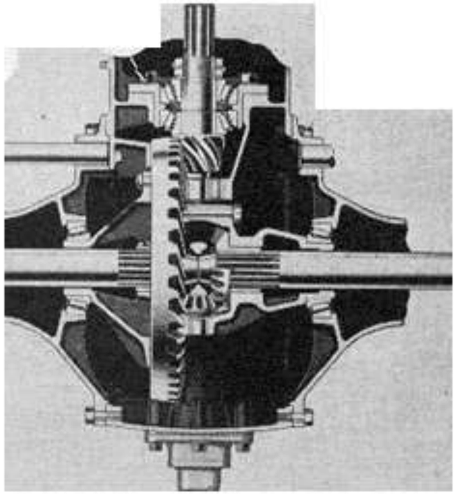
Final drive

The final drive is mounted near the rear- drive wheels of the tractor.

It helps in minimizing the number of gears and shaft in the gear box to achieve higher torque with less speed on driving wheels.

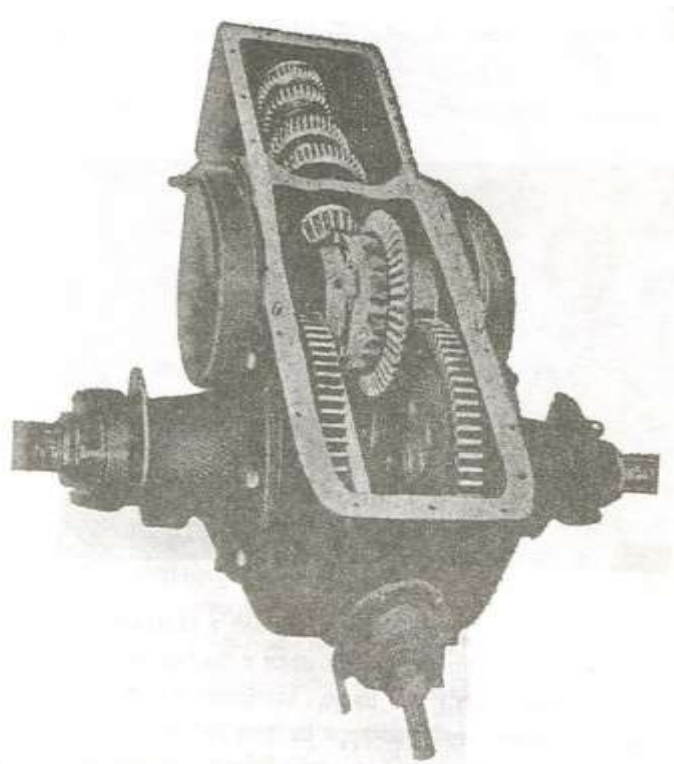
The final drive is driven by the differential through the final drive - shaft and spur/bull gears (2, one on each axle) trains or chains and sprockets which provide about

3 to 5: 1 reduction.



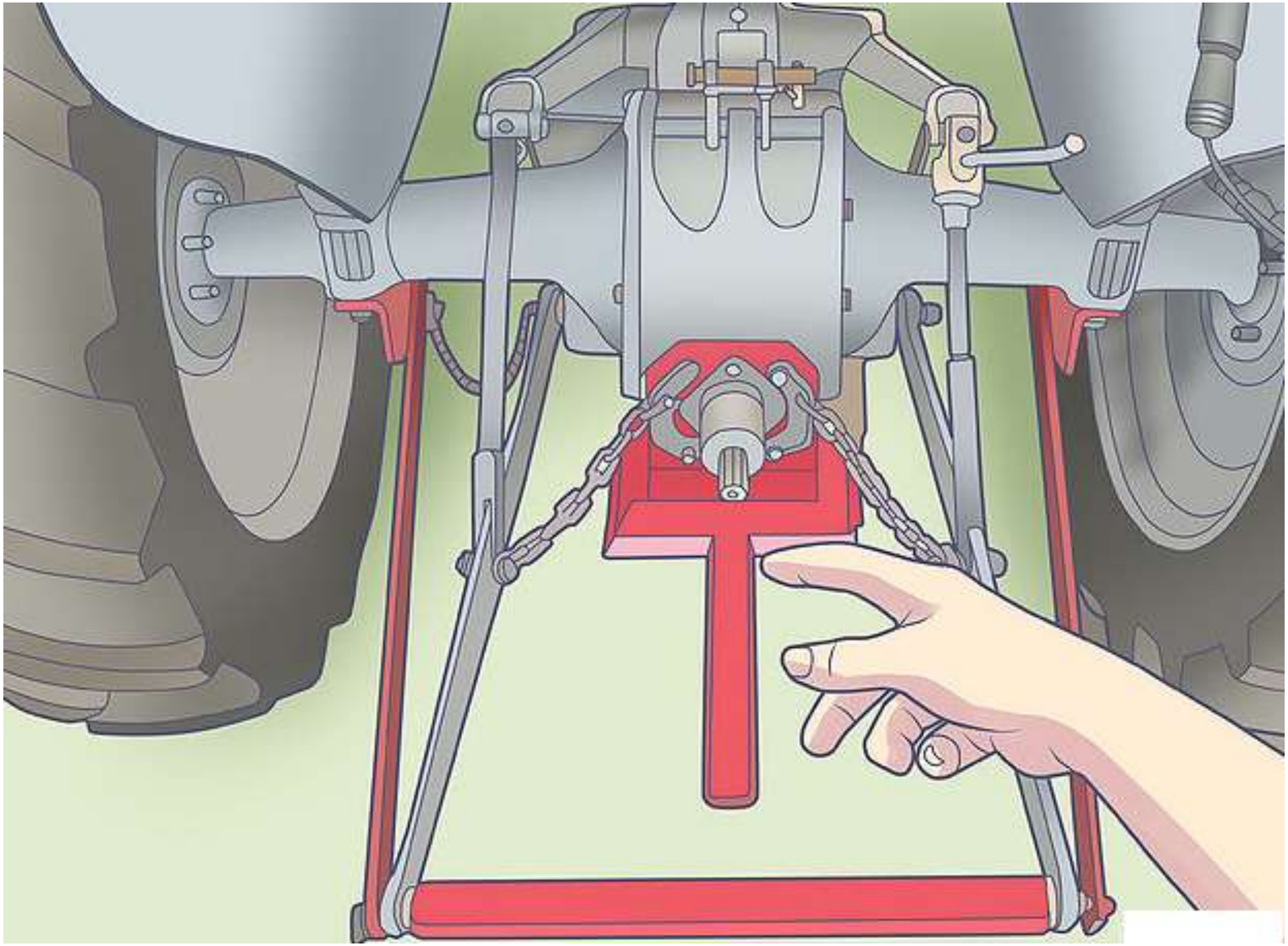
It is provided in the transmission system of tractor for following main reasons:

- To provide a permanent gear reduction between engine and rear wheels.
- To transmit the power from the gear box through 90^0.



Power take off:

- Power take off is a part of the tractor transmission system.
- It is provided with a standard splined shaft at the rear of the tractor to operate the P. T. O. operated machines like mowers, sprayers, etc.
- The power for the PTO comes from the engine through the dual clutch.
- The two transmissions of power are usually independent. For example, an operator can stop or move the tractor without affecting the use of the PTO, or can stop the PTO yet still move the tractor.



P. T. O.

PTO shaft types: 3 Types

- Continuous Running type - operates when master clutch is engaged
- Independent - transmission and PTO powered through separate clutches
  - PTO will still run when tractor is stopped or in motion.
- Transmission Driven - PTO runs only when tractor is in motion.

PTO Speed

Type	**PTO Speed**	**Shaft Size**	**Teeth**
Continuous	540 r.p.m.	1 3/8”	6
Independent	1000 r.p.m.	1 3/8”	21
Transmission	1000 r.p.m.	1 ¾”	20

Tractor pulley

- It is located either on the left, right or rear side of a tractor for operating stationary machines like silage cutter, centrifugal pump, thresher etc.
- The rear mounted pulley is driven by P.T.O. shaft.
- The diameter of pulley depends upon the rpm of the shaft on which it is mounted. The pulley diameter should be such that it gives the belt speed of about 950 m per minute at full throttle.
- Pulley drive is engaged or disengaged from the engine by means of a clutch provided for the job.

Hydraulic control system

- Hydraulic control system used on tractor makes it possible to lower or raise the implements without much effort whereas, greater effort is required in doing the same job with mechanical linkages.
- They also shift transmissions, pull clutch plates, apply brakes, operate steering wheels etc.

- A simple hydraulic system consists of a hydraulic pump which pumps oil to a hydraulic ram. This pump may be driven from tractors transmission system or it may be mounted on its engine.
- This system consists of a cylinder with a close fitted piston like an engine cylinder.
- As the oil is pumped into the closed end of the cylinder, the piston is forced along with it. The movement of the piston is transmitted to the lower links by means of a cross shaft and lift rods.
- A fluid control valve controls the flow of oil and directs it back to the reservoir. It allows the oil in the cylinder to flow out again when the links are to be lowered. It also traps the oil in the cylinder when the links are to be held at any height.

The basic components of a hydraulic system are:

- Hydraulic pump
- Hydraulic cylinder and piston
- Fluid reservoir (Hydraulic tank)
- Fluid control valve
- Pressure relief valve
- Hose pipe and fittings and
- Lifting arms.

Operation: The hydraulic pump draws up oil from the oil reservoir and sends it to the control valve under high pressure. From the control valve, the oil goes to the hydraulic cylinder to operate the piston, which in turn, raises the lifting arms. The lifting arms are attached with implements. The hydraulic pump is operated by suitable gears, connected with engine. There are two types of arrangements for storing hydraulic oil in the system:

- There is a common oil reservoir for hydraulic system and the transmission system in some tractors,
- There is a special tank for hydraulic oil. It is separate from the transmission chamber.

Lect.-7

Tractor types. Estimation of operational cost of a tractor.

Tractor

The word *tractor* appeared first on record in 1890 in a patent issued on a tractor or tractor engine invented by George H.Harris of Chicago.

Tractor classification

Tractors can be classified into three classes on the basis of structural design:

- Wheel tractor
- Crawler tractor (track type or chain type) and
- Walking tractor (power tiller).

Wheel tractor: Tractors, having three or four pneumatic wheels are called *wheel tractors.* Four wheel tractors are most popular everywhere.

Crawler tractor: This is also called *track type tractor or chain type tractor.* In such tractors, there is endless chain or track in place of pneumatic wheels.

Power tiller: Power tiller is a walking type tractor. This tractor is usually fitted with two wheels only. The direction of travel and its control for field operation is performed by the operator, walking behind the tractor.

On the basis of purpose, wheeled tractors may be classified into three groups:

- General purpose
- Row crop and
- Special purpose.

General purpose tractor: It is used for major farm operations such as ploughing, harrowing, sowing, harvesting and transporting work. Such tractors have

(i) low ground clearance

(ii) increased engine power

(iii) good adhesion and

(iv) wide tyres.

- **Row crop tractors:** It is mainly designed to work in rows like planting, interculture etc. Such tractor is provided with replaceable driving wheels of different thread widths. It has high ground clearance to save damage of crops. Wide wheel track can be adjusted to suit inter row distance.
- **Orchard tractors:** These are special type of tractors, are mainly used in orchards. Such tractors have (i) less weight (ii) less width and (iii) no projected parts.

Operational cost of tractor

- The operational cost of tractor includes the fixed costs and variable costs.

➢ Fixed costs generally include depreciation, interest on investment, insurance, taxes overhead charges and housing.

➢ Variable costs include cost of repair and maintenance, fuel, oil and labour.

Depreciation: It is loss in value with the passing of time. Its rate depends on the length of useful life of the tractor. For calculation of depreciation we can select any one out of these methods:

- Straight line method
- Compound interest method
- Constant percentage method
- Estimated method

Most commonly used method is straight line method which reduces the value of a machine by equal amount each year during its useful life.

Salvage value or junk value:

It is the estimated value that an asset will realize upon its sale at the end of the useful life. The value is used in accounting to determine depreciation amount and in the tax system to determine the deductions.

Calculation of fuel and oil consumption (for operating cost)

Fuel and oil consumption is calculated on the basis of $3/4^{th}$ load from the tractor test data (average yearly load on the tractor does not exceed 75% of its rated load).

Cost of oil may be taken as $1/3^{rd}$ of the fuel cost.

Considerations for various calculations: Standard measures-

1.Registration charges may be taken as 2% of purchase cost on annual basis.

2. Insurance charges may be taken as 1.5 % of $\frac{(purchase\ cost + junk\ value)}{2}$ on annual basis.

3. Housing charges may be taken as 1% of purchase cost on annual basis.

4. Repair and maintenance charges may be taken as 8% of purchase cost, annually.

Numerical:

Determine the hourly cost of operation of a 35 hp tractor costing Rs 4, 80,000/- Assume the useful life of tractor as 12 years, when operated about 1000 hours every year. Assume that there is no overhead charge on the tractor. The junk value is 10% of the original cost. The driver cum mechanic is paid Rs 4000/- per month. The tractor consumes 3.5 lit of diesel per hour. Fuel cost is Rs 44 per lit.

Solution:

(a) Calculation of fixed cost:

(i) Junk value: Rs 4,80,000 x 0.1 = Rs 48,000

(ii) Depreciation: $\dfrac{4,80,000 - 48,000}{12}$ = Rs 36,000

(iii) Annual interest @ 10% pa

$$= \frac{4,80,000 + 48,000}{2} \times 0.1 = \text{Rs } 26400$$

$$\text{(iv) Insurance:} = \frac{4,80{,}000 + 48{,}000}{2} \times 0.015$$

$$= \text{Rs } 3960$$

(v)Registration @ 2% = Rs 4,80,000 x 0.02 = Rs 9600

(vi) Housing @ 1% = Rs 4,80,000 x 0.01 = Rs 4800

Total of fixed cost (ii to vi) Rs
= 36000 + 26400 + 3960 + 9600 + 4800 = Rs 80,760

Calculation of operating cost:

(i) Repair and maintenance @ 8%

= Rs 4,80,000 x 0.08 = Rs 38,400

(ii)Fuel cost @ Rs 44 per lit for 1000 hours

= 1000 x 3.5 x 44 = Rs 1,54, 000

(iii)Oil cost = 1/3rd of fuel cost = Rs (1,54,000/3)
= Rs 51333.33 = Rs 51,300

(iv) Labour cost = 4000 x 12 = Rs 48,000

Total of operating charges: (i to iv) = Rs 2, 91,700

Grand total = Rs 80,760 + Rs 2, 91, 700
= Rs 3, 72,460

$$\text{Hourly cost} = \frac{\text{Rs } 3,\, 72{,}460}{1000}$$

= 372.46 say Rs 372/- per hour

Or Rs 372/35 i.e. Rs 10.6 per bhp per hour

Implement operational costs

Operational costs of implements or attachments that depend on tractor power are estimated in the same way as the tractor, except that there are no fuel, lubrication or labour costs involved.

Total Cost per Operation

Tractor operating cost must be added to the implement operating cost to determine the combined total cost per hour of operating the machine.

Numerical

Determine the hourly cost of operation of a 35 hp tractor costing Rs 5, 80,000/- Assume the useful life of tractor as 15 years, when operated about 1000 hours every year. Assume that there is no overhead charge on the tractor. The junk value is 10% of the original cost. The driver cum mechanic is paid Rs 6000/- per month. The tractor consumes 3.0 lit of diesel per hour. Fuel cost is Rs 74 per lit.

Solution:

(a) Calculation of fixed cost:

(i) Junk value: Rs 5,80,000 x 0.1 = Rs 58,000

$$\text{(ii) Depreciation: } \frac{5,80,000 - 58,000}{15} = \text{Rs } 34,800$$

(iii) Annual interest @ 8% pa

$$= \frac{5,80,000 + 58,000}{2} \times 0.08 = \text{Rs } 25520$$

(iv) Insurance: $= \dfrac{5,80,000 + 58,000}{2} \times 0.015$

$= \text{Rs } 4785$

(v)Registration @ 2% = Rs 5,80,000 x 0.02 = Rs 11600

(vi) Housing @ 1% = Rs 5,80,000 x 0.01 = Rs 5800

Total of fixed cost (ii to vi) Rs

= 34800 + 25520 + 4785 + 11600 + 5800 = Rs 82505

Calculation of operating cost:

(i) Repair and maintenance @ 8%

= Rs 5,80,000 x 0.08 = Rs 46,400

(ii)Fuel cost @ Rs 74 per lit for 1000 hours

= 1000 x 3.0 x 74 = Rs 2,22, 000

(iii)Oil cost = 1/3rd of fuel cost = Rs (2,22,000/3)
= Rs 74,000

(iv) Labour cost = 6000 x 12 = Rs 72,000

Total of operating charges: (i to iv) = Rs 4, 14,400

Grand total = Rs 82,505 + Rs 4, 14, 400
= Rs 4, 96,905

$$\text{Hourly cost} = \frac{\text{Rs } 4{,}96{,}905}{1000}$$

= 496.90 say Rs 497/- per hour

Or Rs 497/35 i.e. Rs 14.2 per bhp per hour

Lect.- 8
Familiarization with primary and secondary tillage implements.

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Tillage

- Tillage is the first and the most important operation in crop production generally carried out before sowing or planting.
- Tillage is the physical or mechanical manipulation of the soil with tools and implements resulting in good tilth for seed placement, better germination and subsequent growth of crops.
- Tillage needs to be done at the right time with the right implements to get good tilth, which is pre-requisite for better crop production.
- These operations include ploughing, harrowing, and mechanical destruction of weeds and soil crust.
- Layout for seedbed preparation is also inseparable process with tillage, a practice made before sowing or planting of crop.

Objective of tillage

1. Incorporation of plant residues, manures, fertilizers, etc.
2. Seedbed preparation
3. To destroy the weeds and to prevent their growth
4. To leave the soil in a condition to retain moisture from rain.
5. To destroy insects and their eggs, larvae and their breeding places.
6. To leave the surface in such a condition that air will circulate freely
7. To leave the surface in a condition to prevent erosion by wind.
8. Precision leveling of land for irrigation and other operations

Classification and types of tillage

Tillage is divided into two classes:

1. **Primary tillage**
2. **Secondary tillage**

Primary tillage: These are often the first operations done after harvesting a crop. Primary tillage often inverts the surface soil and buries most of the plant residues.

- **Implements may be tractor drawn or animal drawn implements.**
- **Animal drawn implements mostly include indigenous plough and mould- board plough.**
- **Tractor drawn implements include mould-board plough, disc plough, subsoil plough, chisel plough and other similar implements.**

Secondary tillage

- Lighter or finer operations performed on the soil after primary tillage is known as secondary tillage.
- After ploughing, the fields are left with large clods with some weeds and partially uprooted stubbles.
- Harrowing is to be done to a shallow depth to crush the clods and to uproot the remaining weeds and stubbles.
- Disc harrows, cultivators, blade harrows etc., are commonly used for this purpose.
- Planking is done to crush the hard clods to smoothen surface soil and to compact the soil lightly.
- Thus, the field can be made ready for sowing after ploughing by harrowing and planking. Sowing operations are also combined with secondary tillage.

Optimum time for ploughing

- **The right time for ploughing depends on availability of soil moisture.**
- **When the soil is too dry, it is difficult to open the soil, more energy is required and large sized clods are resulted.**
- **When the soil is ploughed under wet conditions, with more soil moisture, the soil sticks to the plough, the soil below the plough-sole becomes compacted.**
- **Upon drying, hard pan is created, soil structure is destroyed and the clods on drying become very hard.**
- **The optimum range of soil moisture for better ploughing is 25 to 50% depletion of available soil moisture.**
- **Light soils can be ploughed at wider range of soil moisture conditions, while; the range is narrow for heavy soils.**

Depth of ploughing

- **Depth of ploughing mainly depends on the effective root zone depth of the crops.**
- **Generally, crops with tap root system require greater depth of ploughing, while fibrous and shallow rooted crops require shallow ploughing.**
- **Tree crops are needed deeper soil ploughing whereas; field crops generally needed only shallow tillage.**

Number of ploughing

- **The number of ploughing necessary to obtain a good tilth depends on soil type, weed problem and crop residues on the soil surface.**
- **In heavy soils, more (3-5) number of ploughing is necessary, but, light soils require 1 to 3 ploughing to obtain good tilth of the soil.**
- **When weed growth and plant residues are higher, more number of ploughing is necessary.**

Types of primary tillage

- Depending on the purpose or necessity, different types of tillage are carried out.

They are

- **Deep ploughing**
- **Sub soiling and**
- **Year-round tillage.**

Deep Tillage

- **Ploughing of 5-6 cm depth is classified as shallow, 15-20 cm depth as medium deep and 25-30 cm depth as deep ploughing.**

- **Deep tillage is necessary for tap rooted crop like redgram and perennial crops, while moderate deep tillage is preferred for fibrous rooted crops like maize and sorghum.**

- **Deep ploughing results in large sized clods, which are scorched by the hot sun when it is carried out in summer.**

(Cont)..

- **These clods crumble due to alternate heating and cooling and also due to occasional summer showers and process of gradual disintegration of clods improves soil structure.**
- **The rhizomes and tubers of perennial weeds die due to exposure to hot sun.**
- **Summer ploughing reduces pest incidences by exposing pupae to hot sun.**
- **Deep tillage also improves soil moisture content by retaining more moisture during rainy period.**
- **However, the advantage of deep tillage in dry farming areas may not be assured and depends on rainfall pattern and crop.**

Year-round tillage

- **Tillage operations carried out throughout the year are known as year–round tillage.**
- **In dry farming regions, field preparation is initiated with the help of summer showers.**
- **Repeated tillage operations are carried out until sowing of the crop.**
- **Even after harvest of the crop, the field is repeatedly ploughed or harrowed to avoid weed growth during the off–season.**

Tillage implements

According to the source of power used, tillage implements may be classified as:

- Hand operated tools
- Animal drawn implements
- Tractor drawn implements
- **Hand operated tools:**
  - These are operated by the muscles of human beings with a pulling, pushing or swinging action.
  - These are further classified as (i) Handle type tools like spade, shovels, hand hoe, Kodali (narrow spade) etc. and (ii) Wheel type tools such as wheel hoes.

Animal drawn implements:

These are generally of two types: Walking type and riding type.

- All the indigenous ploughs, cultivators, harrows and seed drills are walking type implements
- Riding type implements have seating provision for the operator and the frame is supported on two wheels.

Tractor drawn implements:

Tractor drawn implements are operated at higher speeds, cover a larger width and penetrate deeper than implements operated by animals.

Tractor drawn implements are further classified as trailed, semi mounted and mounted type.

- **Trailed implement** is one that is attached to the tractor draw bar by a pin joint. The main body of the implement is supported on the ground. Such an implement can be quickly attached and detached from the tractor.

- **Semi mounted implement** is one that is rigidly attached to the tractor and has a rear wheel or wheels to support part of its weight. Attachment and detachment take more time but the control is much easier.

- **Mounted implement:** It is attached to the tractor as an integral part. It is hydraulically controlled and is kept raised during transport. These may be rear or front mounted .

According to tillage operations implements are classified as:

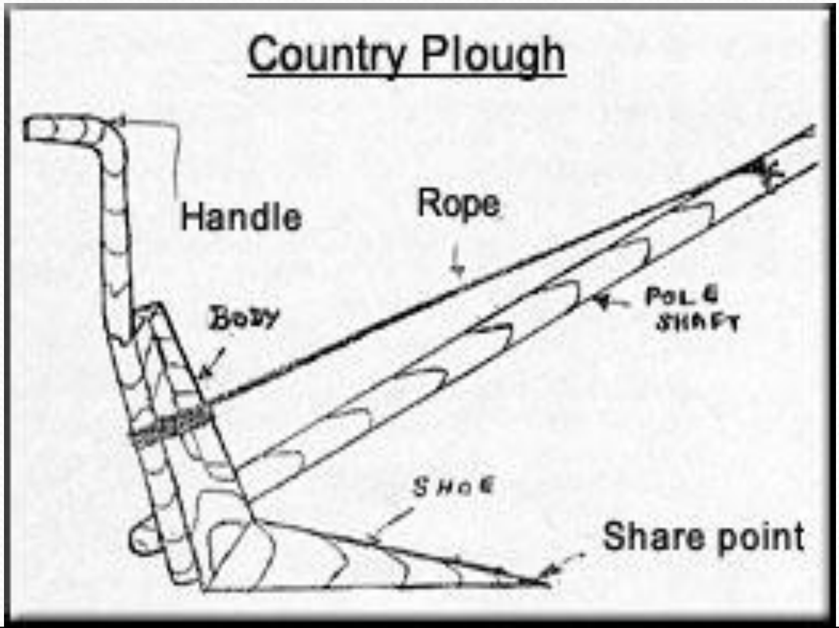
- Ploughs
- Harrows
- Cultivators
- Hoes
- Clod crusher or levelers.

Ploughs

- Ploughs are primary tillage implements used for opening and loosening of the soil.
- Ploughs are of three types:
    - Wooden ploughs
    - Iron or inversion ploughs and
    - Special purpose ploughs.

Wooden plough or Indigenous plough

- Indigenous plough is an implement which is made of wood with an iron share point.
- The main parts of the plough are (1) body (2) Shoe (3) share (4) beam and (5) handle.
- The body is the main part of the plough to which the shoe, beam and handle are generally attached.



- The share is the working part of the plough and is attached to the shoe with which it penetrates the soil and breaks it open.
- The shoe also supports and stabilizes the plough at the required depth.
- The working of the share to the ground varies from 10^o to 30^o.
- The beam is generally a long wooden piece which connects the main body of the plough to the yoke. The inside angle between the shoe and the body varies from 116^o to 160^o
- The handle is a wooden piece which is attached vertically to the body to enable the operator to control the plough

- An indigenous plough cuts a trapezoidal furrow cross section and leaves some unploughed land between the two adjacent furrows.
- To plough every bit of land soil in the field, the indigenous plough has to be used three times, first ploughing, then cross ploughing and finally ploughing along the corners. .
- A ploughman has to walk 34 kms in ploghing half hectare of land.

- Generally two types of adjustments are done with indigenous plough
  - Lowering or raising the axis of shoe with respect to the body, resulting in the change of angle of the share with the horizontal plane.
  - Changing the angle of beam with horizontal.

Soil Turning Ploughs

Soil turning ploughs are made of iron and drawn by a pair of bullocks or two depending on the type of soil. These are also drawn by tractors.

Mould board plough

A mould board plough is very common implement used for primer tillage operations. This plough performs several functions at a time such as

(1) Cutting the furrow slice

(2) Lifting the furrow slice

(3) turning the furrow slice

(4) Pulverizing the soil.

- These ploughs are used in fields of heavy weed growth which needs to be turned under.
- It is also used to turn under heavy growth of green manure crop to help proper decay, and additions of humus to the soil.
- It is also used for turning and mixing FYM or lime in the soil.
- This type of plough leaves no unploughed land as the furrow slices are cut clean and inverted to one side resulting in better pulverization.

- The animal drawn mould board plough is small, ploughs to a depth of 15 cm, while two mould board ploughs which are bigger in size are attached to the tractor and ploughed to a depth of 25 to 30 cm.

- Mould board ploughs are used where soil inversion is necessary.

- *Victory plough* is an animal drawn mould board plough with a short shaft.

The size of MB plough

It is expressed by the width of furrow that it is designed to cut.

It can be measured by measuring the perpendicular distance from the share to the landside.

Types of M B ploughs:

1. **One way or two way ploughs**

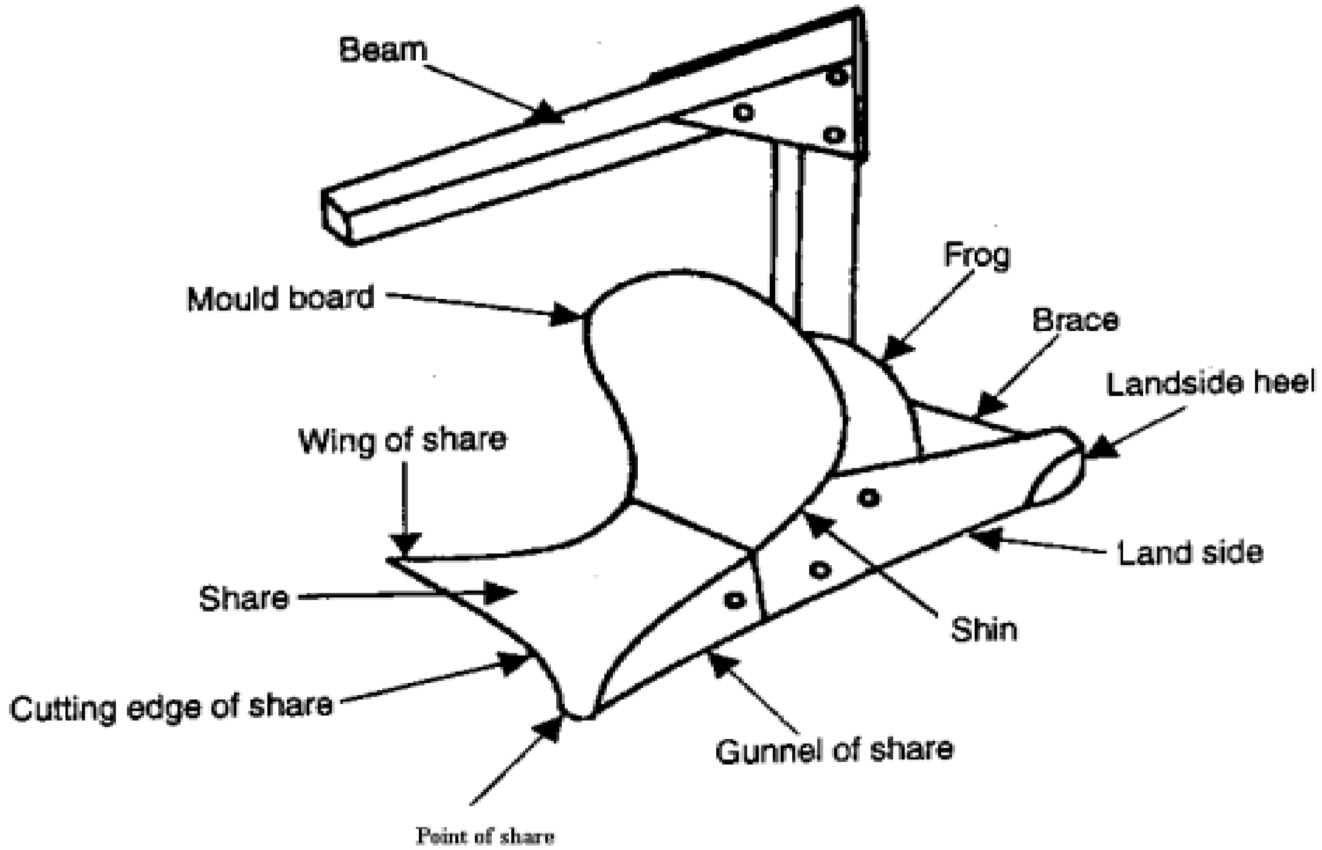
- One way ploughs are designed to throw the furrow slice to only one side in the direction of motion.
- Two way ploughs do not upset the slope of land nor leave dead or back furrows in the middle of the narrow fields.
- The two way plough is also useful for ploughing irrigated land where it is required that the land be left level without the depression of the dead furrows and ridges of back furrows.

2. Left hand or right hand ploughs

These names refer to the direction of the throw of furrow slice. Most of the mould board ploughs are right hand plough, throwing the furrow slice to the right.

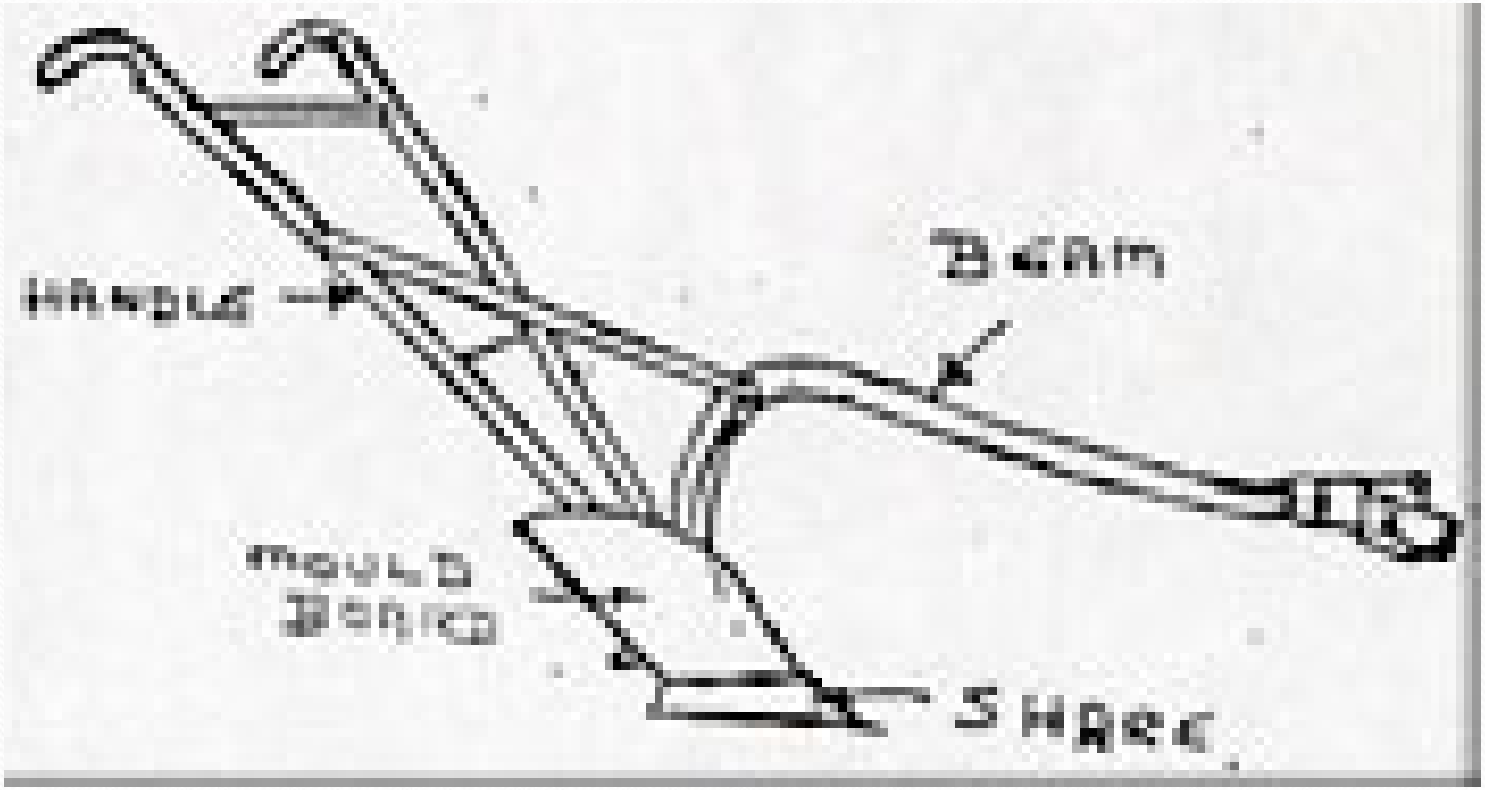
Components

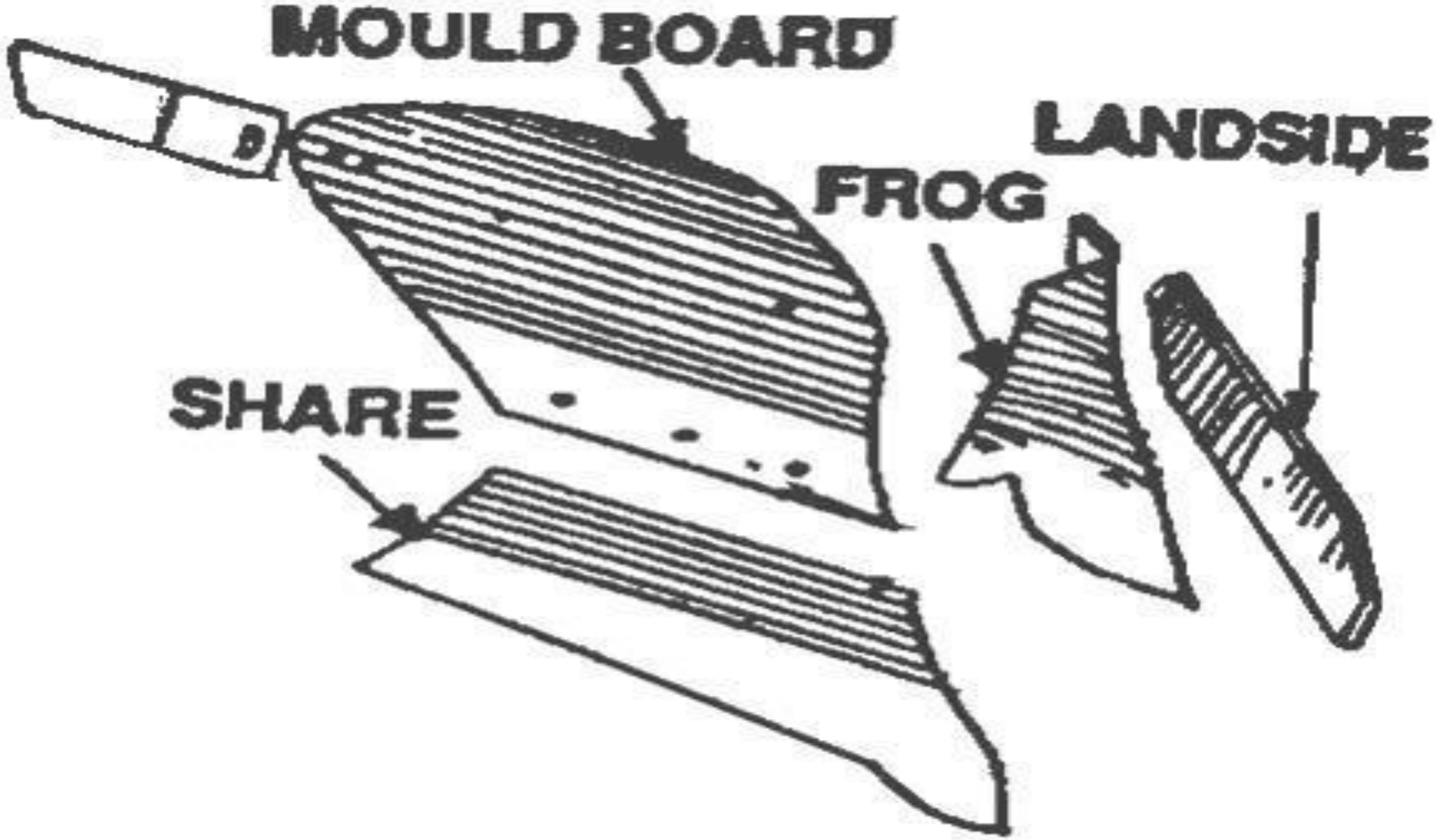
M.B. Plough consists of (a) Share, (b) Mould Board, (c) Landside and (d) Frog



Animal drawn M.B. plough

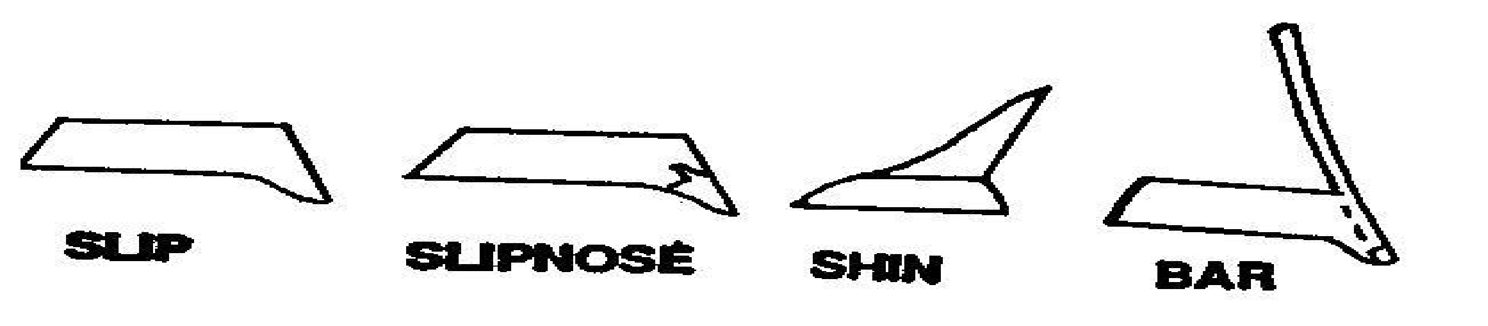
M B Plough –Single bottom




MOULD BOARD
LANDSIDE
FROG
SHARE

Share

- This is the part of the plough which penetrates into the furrow slice and passes it on to the mould board.
- It is fastened to the frog commonly with the help of counter sunk bolts (plough bolts).
- It is made of high carbon steel.
- Five common types of shares are in use namely *slip share, slip nose share, shine share, bar share and bar point share.*



Share:

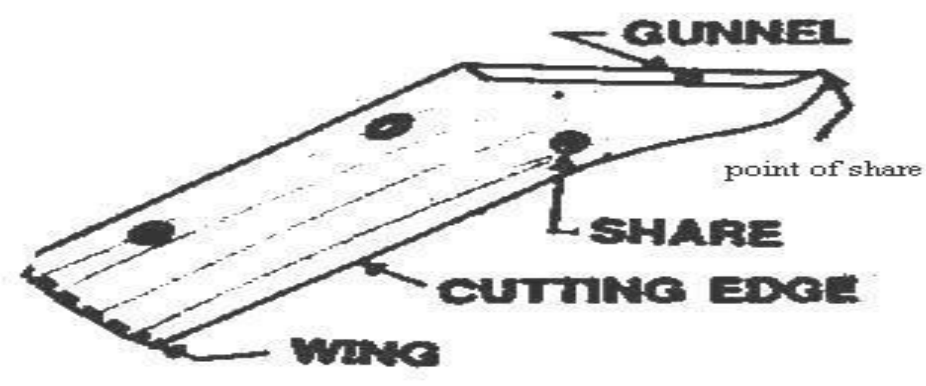
It has four main parts:

Point of share: This part enters first in to the soil and also supports the plough bottom.

Throat of share: It cuts the furrow slice from the main soil body.

Wing of share: It supports the plough bottom.

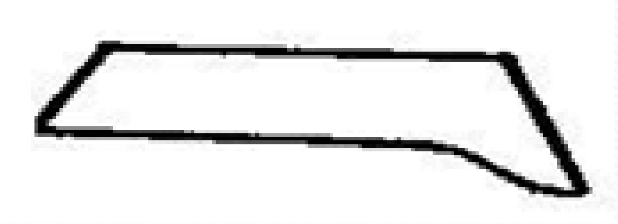
Gunnel of share: It supports the plough bottom against the furrow wall



Parts of share

Types of share

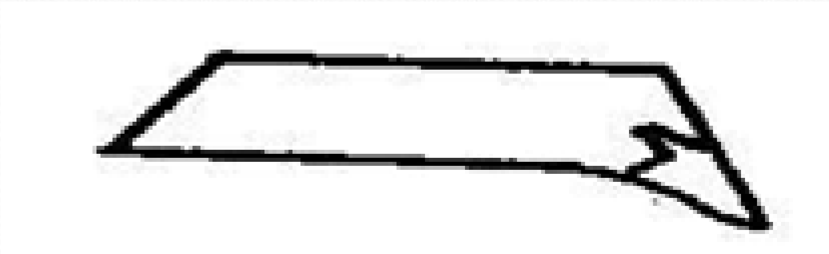
Slip share: It is one piece with curved cutting edge having no additional part. It is a common type of share, mostly used by the farmers.



It is simple in design, but it has got the disadvantage that the entire share has to be replaced if it is worn out due to constant use.

b) Slip nose share:

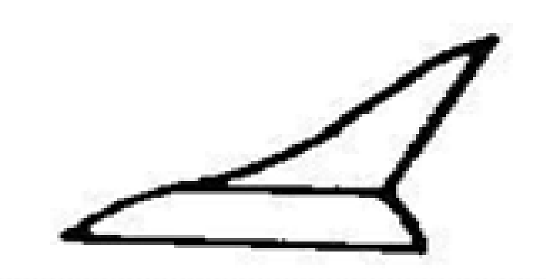
- It is a share in which the point of the share is provided by a small detachable piece.



- It has the advantage that the share point can be replaced as and when required .
- If the point is worn out, it can be changed without replacing the entire share, effecting considerable economy.

c) Shin share:

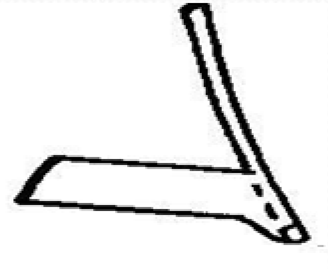
It is a share, having a shin as an additional part.



It is similar to the slip share with the difference that an extension is provided to fit by the side of the mould board. This prevents the mould board from wearing along its cutting edge.

d) Bar share :

It is provided with an extension on its gunnel side which acts as the landside of the plough bottom. It does not offer any advantage over the other types.



e) **Bar point share:** it is a share, in which the point of the share is provided by an adjustable and replaceable bar.

This bar serves the purpose of point of the share and landside of the plough. As the point wears out, it is pushed forward.

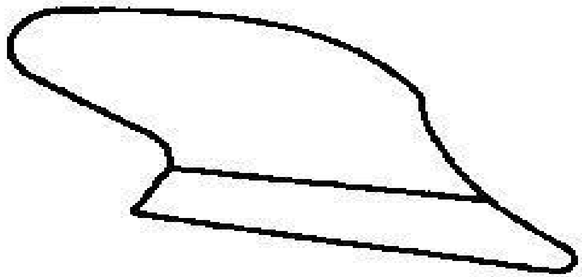
Mould Board

- Mould board is the part of the plough, which receives the furrow slice from the share, it lifts, turns and breaks the furrow slice.

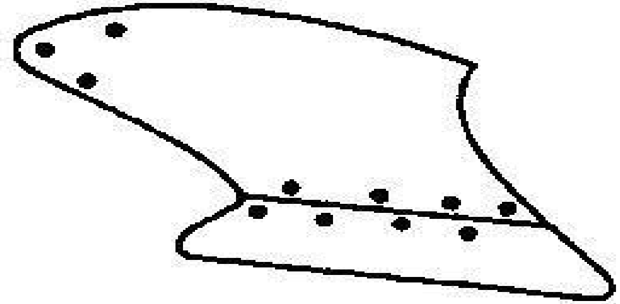
- Different soil conditions require mould boards of varying shapes and sizes to carryout a good job of ploughing.
- Mould boards are made of cast iron.

The mould boards are of following types :

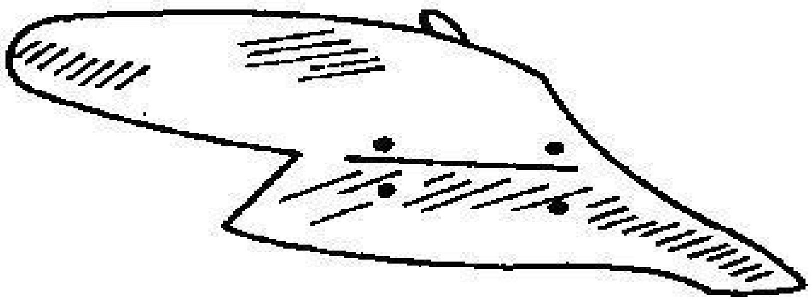
(i) General purpose
(ii)Stubble
(iii) Sod and breaker
(iv) Slat and
(v) High speed



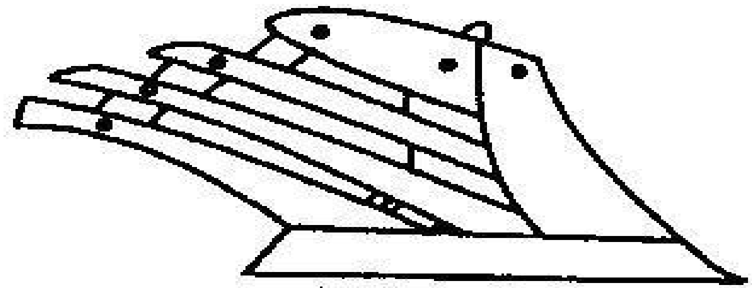
Stubble bottom



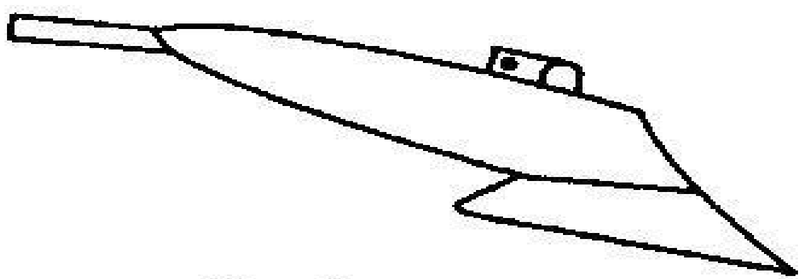
General purpose bottom



High speed general purpose bottom

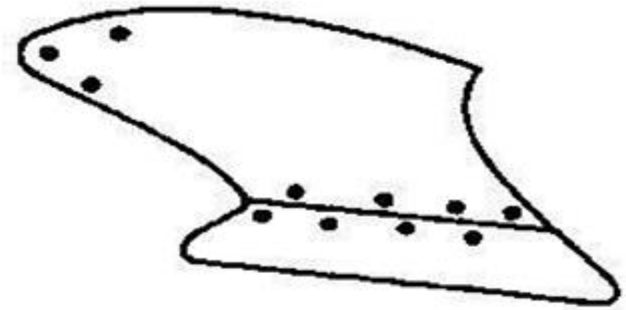


Slatted general purpose bottom

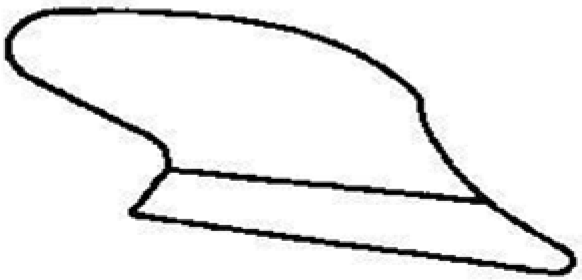


Breaker or sod bottom

General purpose: For thorough pulverization in all general purpose farm use.



Stubble: It has relatively short and broad mould board that is curved rather abruptly near the top. It is adopted for ploughing an old ground where good pulverization is required.

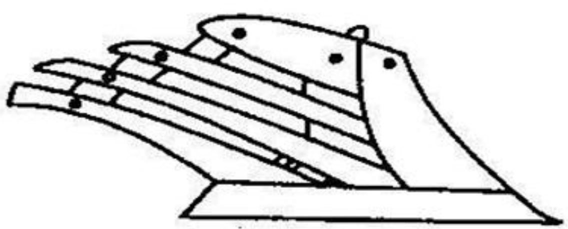


Sod or breaker: The breaker bottom is used in tough sod (grass land) where it desired to turn the furrow slice completely so that the grass may not continue to grow.

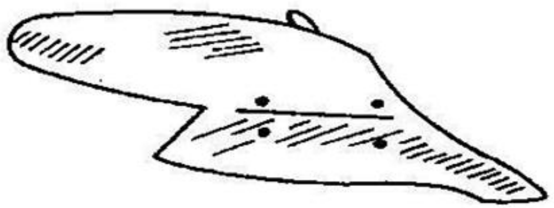
Slat: It is preferred for more sticky soils where it is difficult to get the mould board to scour.

High speed: Most of the high speed bottoms are used on tractor ploughs for general farm use.

Sod or breaker



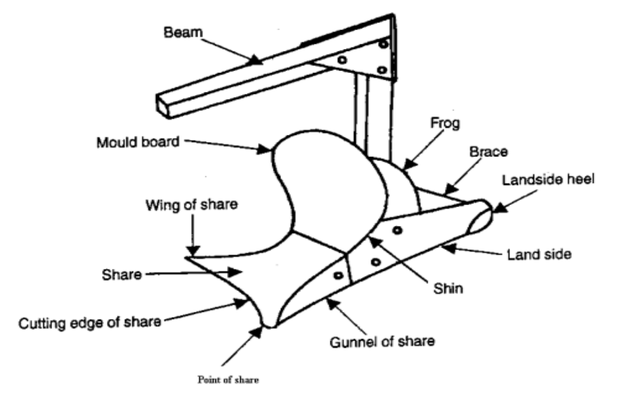
Slat

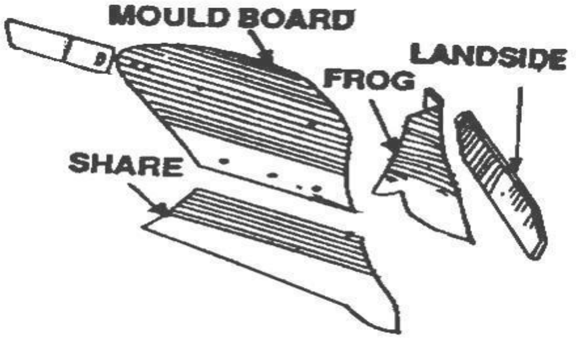


High speed:

Land side

- Landside is the part of the plough bottom, which **slides** along the furrow wall, providing stability against tilting sideways, due to soil pressure acting on the mould board.
- The width of the landside of animal drawn plough varies between 5 and 10 cm. It also helps in stabilizing the plough while in operation. Landside is fastened to the frog with the help of plough bolts. The rear bottom of the landside is known as heal.

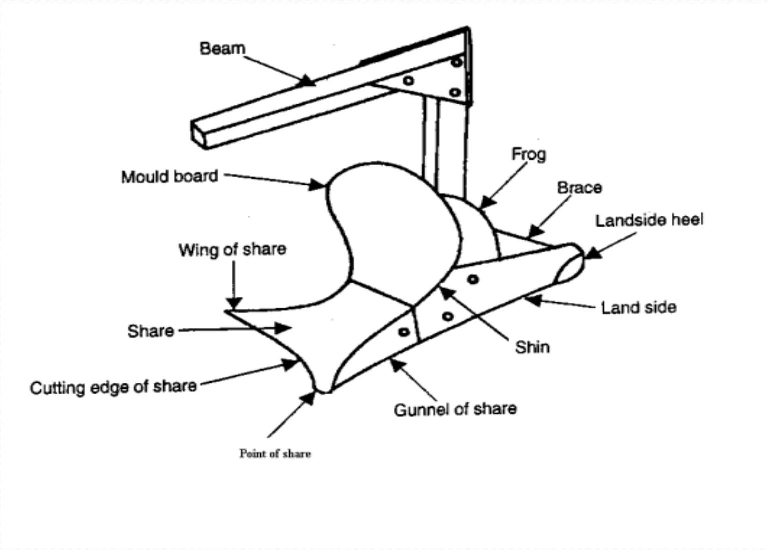


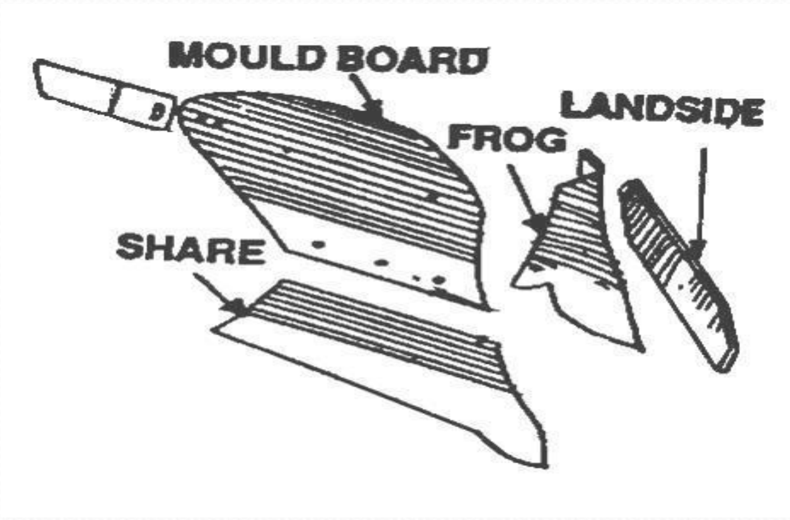


Frog

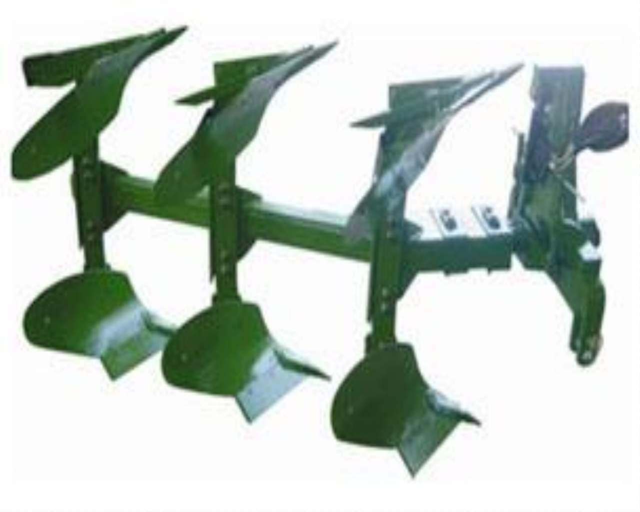
➢Frog is the part of the plough bottom to which the share, mould board and land side are attached rigidly.

➢It is an irregular piece of metal casting and heart of the plough bottom. It may be made of either cast iron or steel.





Tractor drawn M.B. Plough



Tractor drawn reversible M.B. Plough

Hydraulic reversible M.B. plough

Plough accessories

For walking type ploughs, the beam, hitch and handles are considered as accessories.

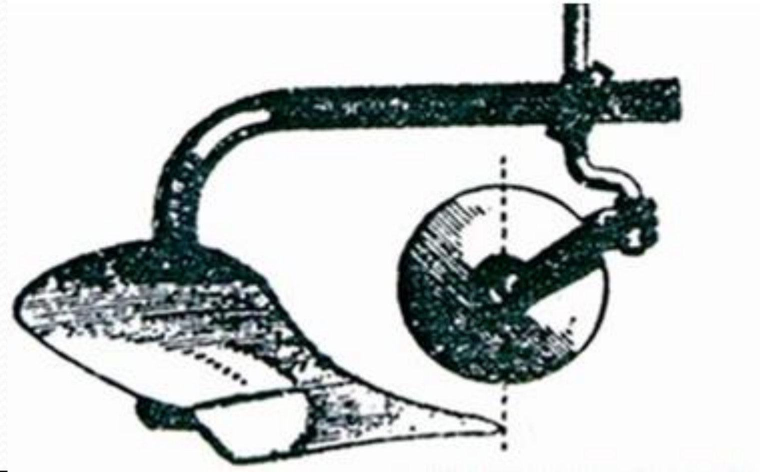
- These parts help considerably in bringing better performance from the plough.
- Generally straight wooden beams are used. A steel handle with round grip is most common.
- All the short beam ploughs are provided with horizontal and vertical hitches at the end of the beam so as to hitch the plough to the yoke properly.
- The horizontal hitch is provided to adjust the width of furrow, whereas, the vertical hitch is meant for the adjustment of the depth of ploughing.

Attachment for MB ploughs:

(i) coulter (ii) jointer and (iii) gauge wheel.

Rolling **Coulter**

Rolling **coulters** on plough are used to cut trash and help to keep the plough from clogging. For average ploughing the coulter should be directly over the share point and cut half the depth of ploghing. In general the coulter should be set about 5 cm shallower than the depth of ploughing but never deeper than 10 cm.

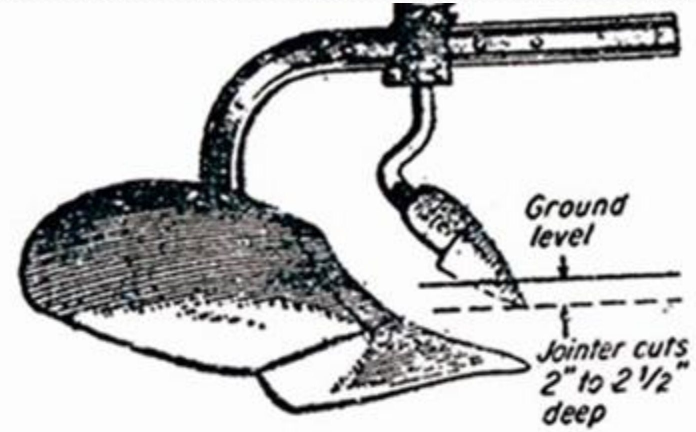


- It is a device used to cut the furrow slice vertically from the land ahead of the plough bottom.

- It cut the furrow slice from the land and leaves a clear wall. It also cuts trashes which are covered under the soil by the plough.

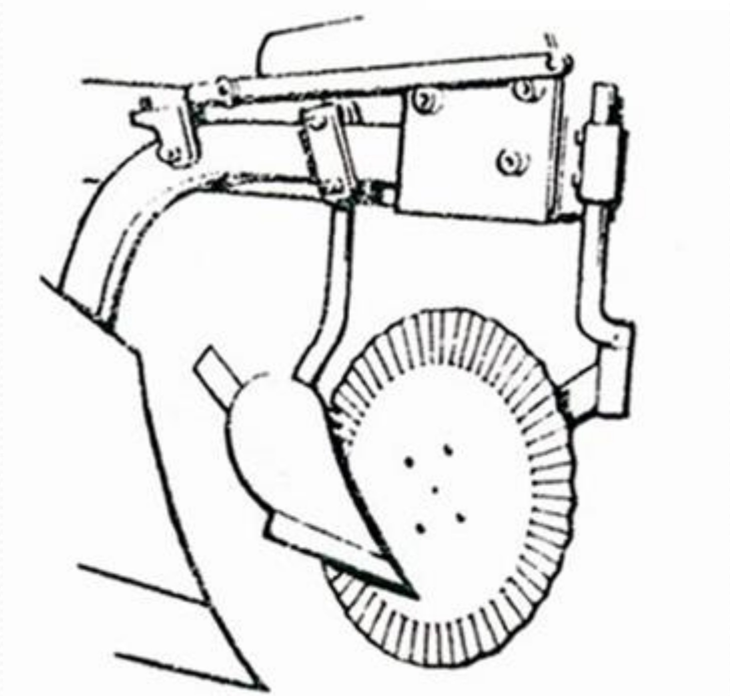
Jointer

- It is a small irregular piece of metal having a shape similar to an ordinary plough bottom. **It looks like a miniature plough**.
- The jointer should be set to cut 4 to 5 cm deep. The purpose of the jointer is to cut a small furrow off the main furrow slice and throw it towards the furrow.
- The jointer should be set as near the coulter as possible.



Gauge wheel

- It is an auxiliary wheel of an implement, helps to maintain uniformity in respect of depth of ploughing in different soil conditions.
- it is usually placed in hanging position.



Adjustments of mould board plough

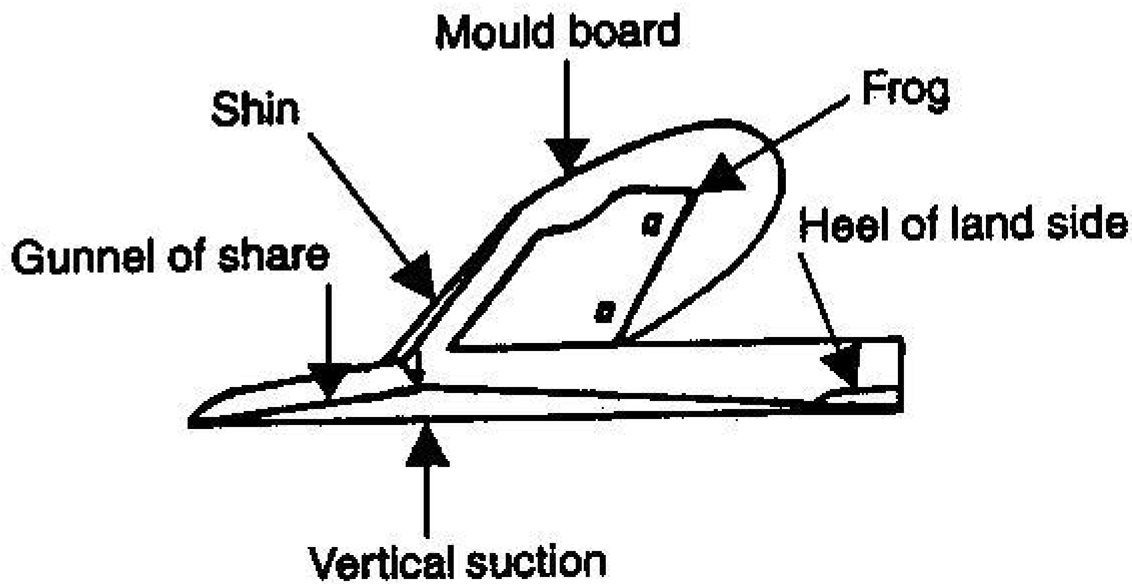
For proper penetration and efficient work, the mould board ploughs need some clearance where the share joins the landside. This clearance is called suction of the plough. Suction in mould board plough is of two types

(i) Vertical suction and

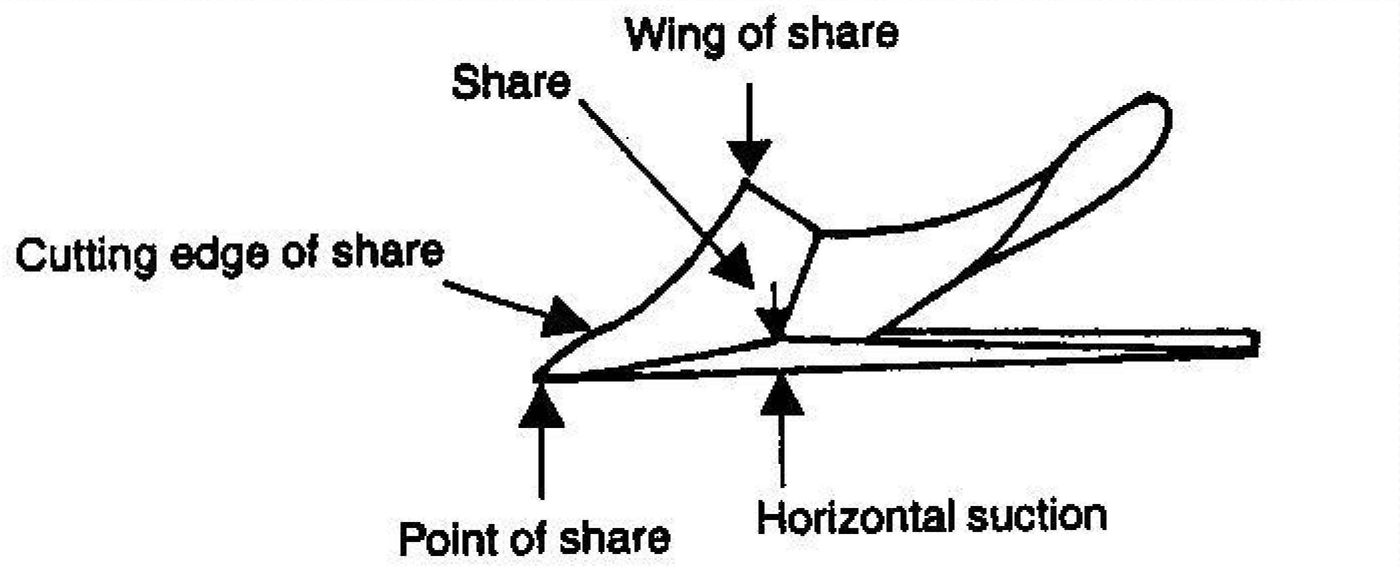
(ii) Horizontal suction.

Vertical suction of the plough:

It is the clearance where the share joins the land side. For proper penetration and efficient operation, the mould board plough (walking type) needs 3 to 5 mm clearance. This is known as the vertical suction of the plough.



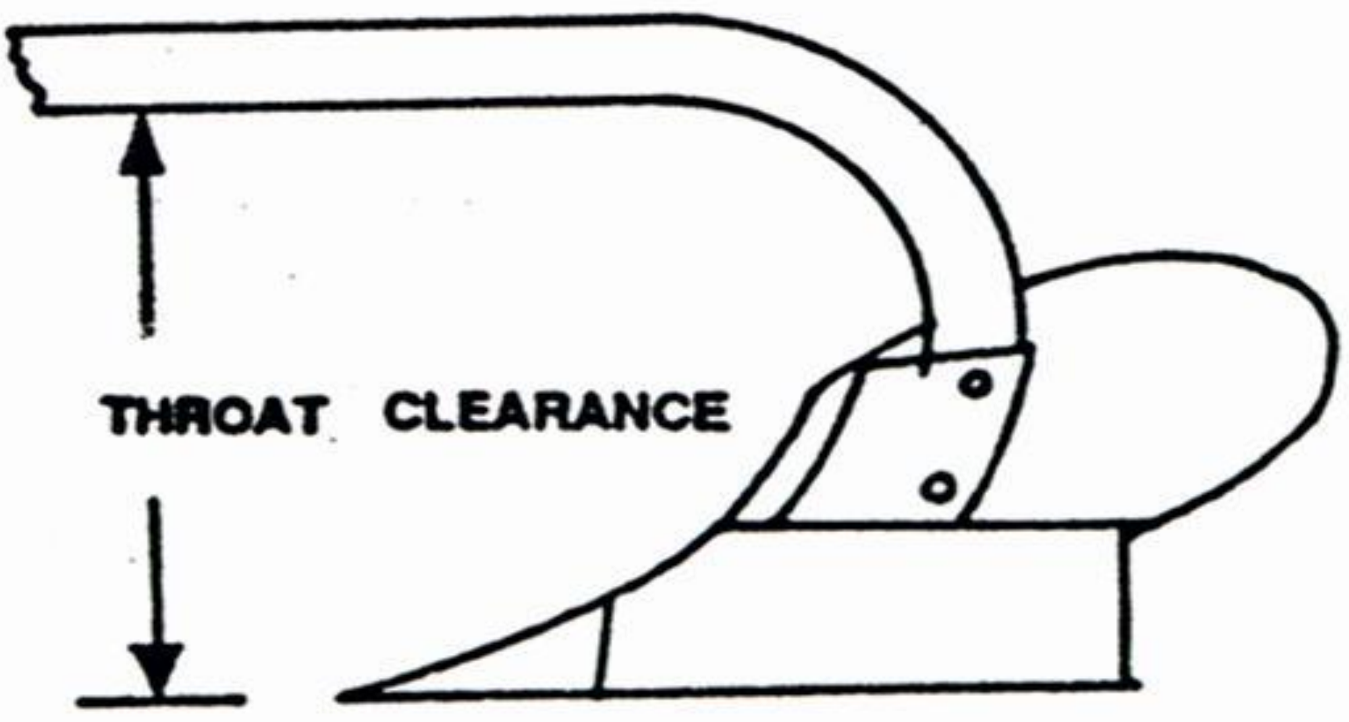
Horizontal suction of the plough: It is also known as side clearance. It should be 5 mm in such ploughs. If the share wears out, this clearance is very much reduced, with the result that the plough does not penetrate properly into the soil.



Throat clearance

It the vertical distance measured from the point of share to the beam.

Sufficient throat clearance is required so that the plough may not get chocked while ploughing under the green manures.



DISC PLOUGH

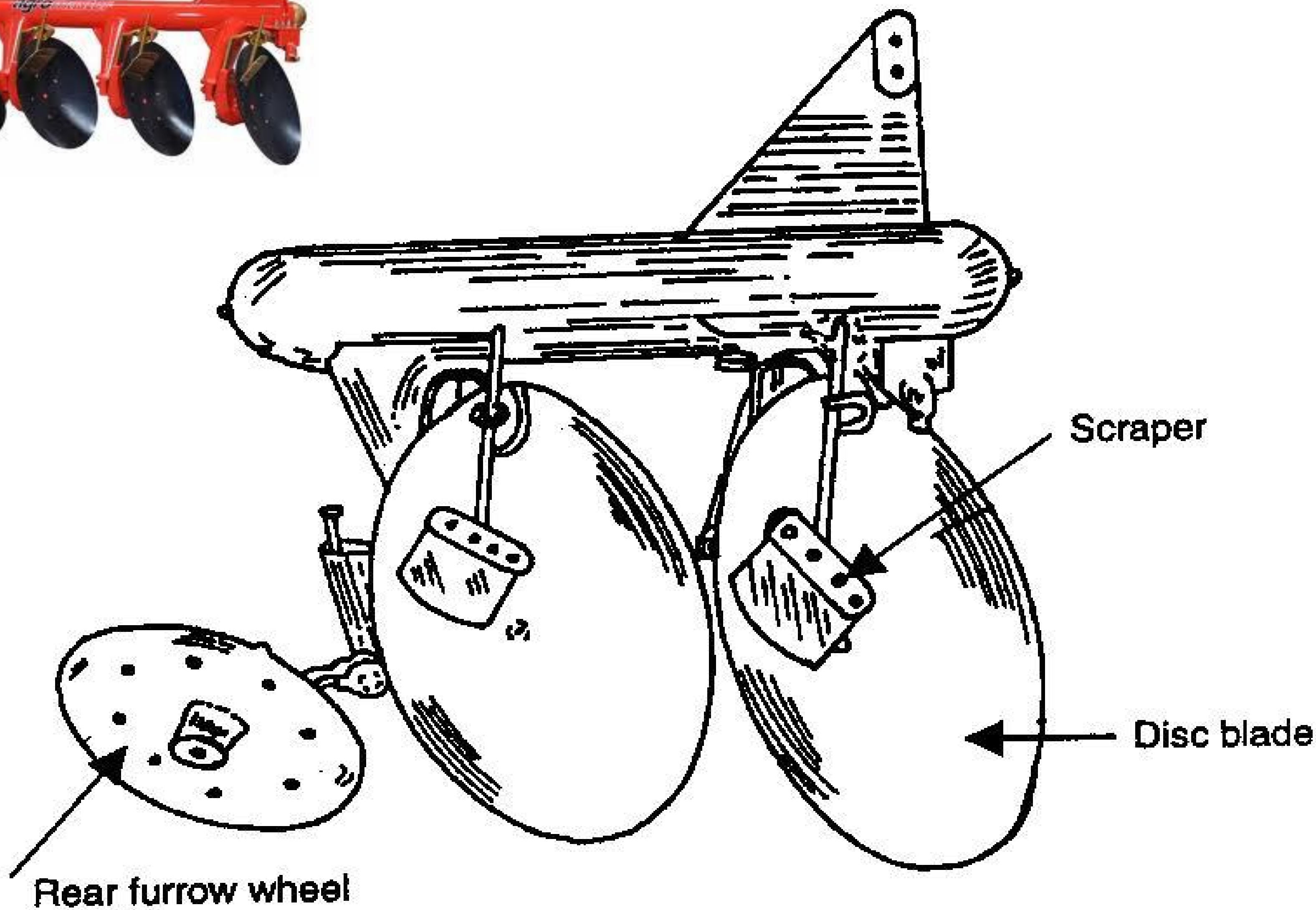
- Disc plough is used for primary tillage and is especially useful in hard and dry, trashy, stony or stumpy land conditions and in soil where scoring is a major problem.
- A disc plough is designed with a view to reduce friction by making a rolling plough bottom.
- A disc plough works well in the conditions where mould board plough does not work satisfactorily.

Disc ploughs are broadly classified as:

Standard disc plough - animal drawn and tractor drawn

Vertical disc plough or harrow ploughs

- The disc plough is having little resemblance to the common mould board plough.
- A large, revolving, concave steel disc replaces the share and the mould board.
- The disc turns the furrow slice to one side with a scooping action.
- The usual size of the disc is 60 cm in diameter and this turns a 35 to 30 cm furrow slice.
- The disc plough is more suitable for land with much fibrous growth of weeds, as the disc cuts and incorporates the weeds.
- The disc plough works well in soils free from stones.


Scraper
Disc blade
Rear furrow wheel

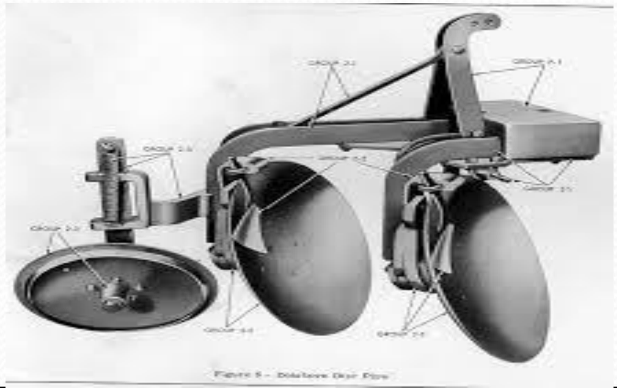
Advantages of disc plough

(i) A disc plough can be forced to penetrate into the soil which is too hard and dry.

(ii) It works well in sticky soil in which a mould board plough does not scour. It is more useful for deep ploughing.

(iii) A disc plough works well even after a considerable part of a disc is worn off in abrasive soil.

(iv) It works in loose soil also (such as peat) without much clogging.



Disadvantages of disc plough

(i) It is not suitable for covering surface trash and weeds affectively as mould board plough does.

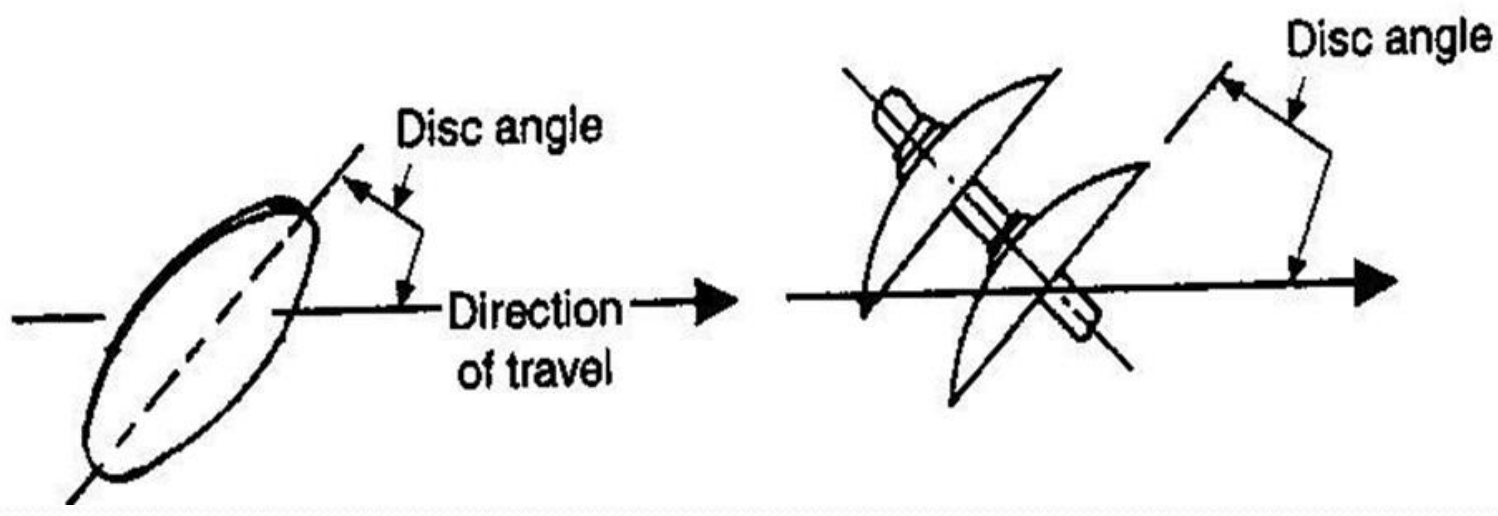
(ii) Comparatively, the disc plough leaves the soil in rough and cloddy condition than that of mould board plough.

(iii) Disc plough is much heavier than mould board plough for equal capacities because penetration of this plough is affected largely by its weight rather than suction.

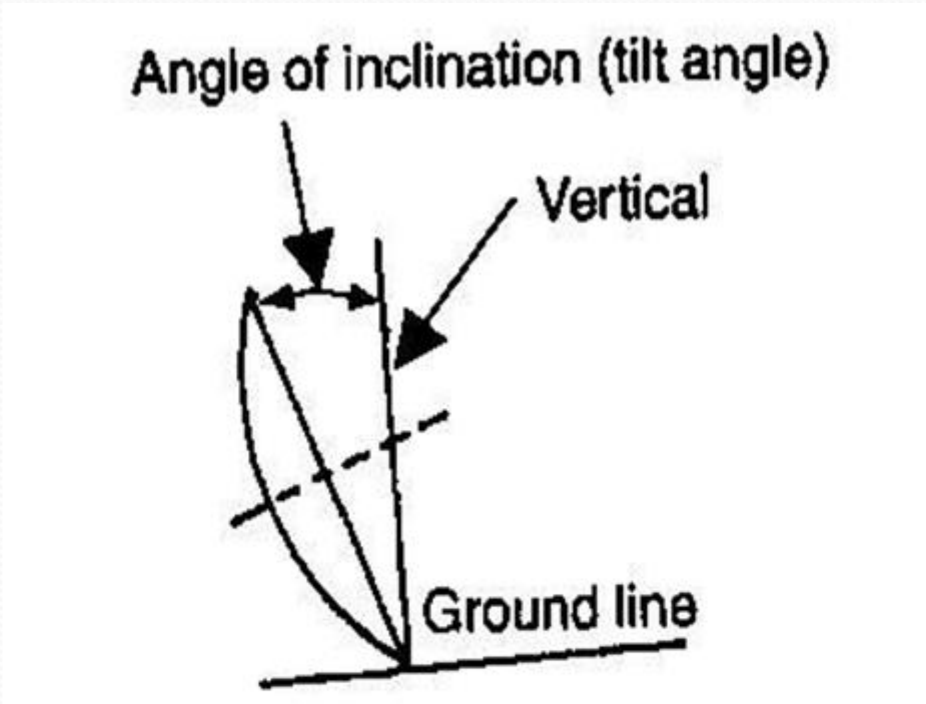
There is one significant difference between mould board plough and disc plough i.e., mould board plough forced into the ground by the suction of the plough, while the disc plough is forced into the ground by its own weight.

Disc: It is a circular, concave revolving steel plate used for cutting and inverting the soil. It is made of heat treated steel of 5 to 10 mm thickness. The edge of the disc is well sharpened to cut the soil.

Disc angle: It is the angle at which the plane of the cutting edge of the disc is inclined to the direction of travel. Usually, the disc angle of good plough varies between 42 and 45 degrees.



Tilt angle: It is the angle at which the plane of the cutting edge of the disc is inclined to vertical plane. Usually, the tilt angle of good plough varies between 15 and 25 degrees.



Scraper: It is a device to remove soil that tends to stick to the working surface of a disc.

Concavity: It is the depth measured at the center of the disc by placing its concave side on a flat surface.

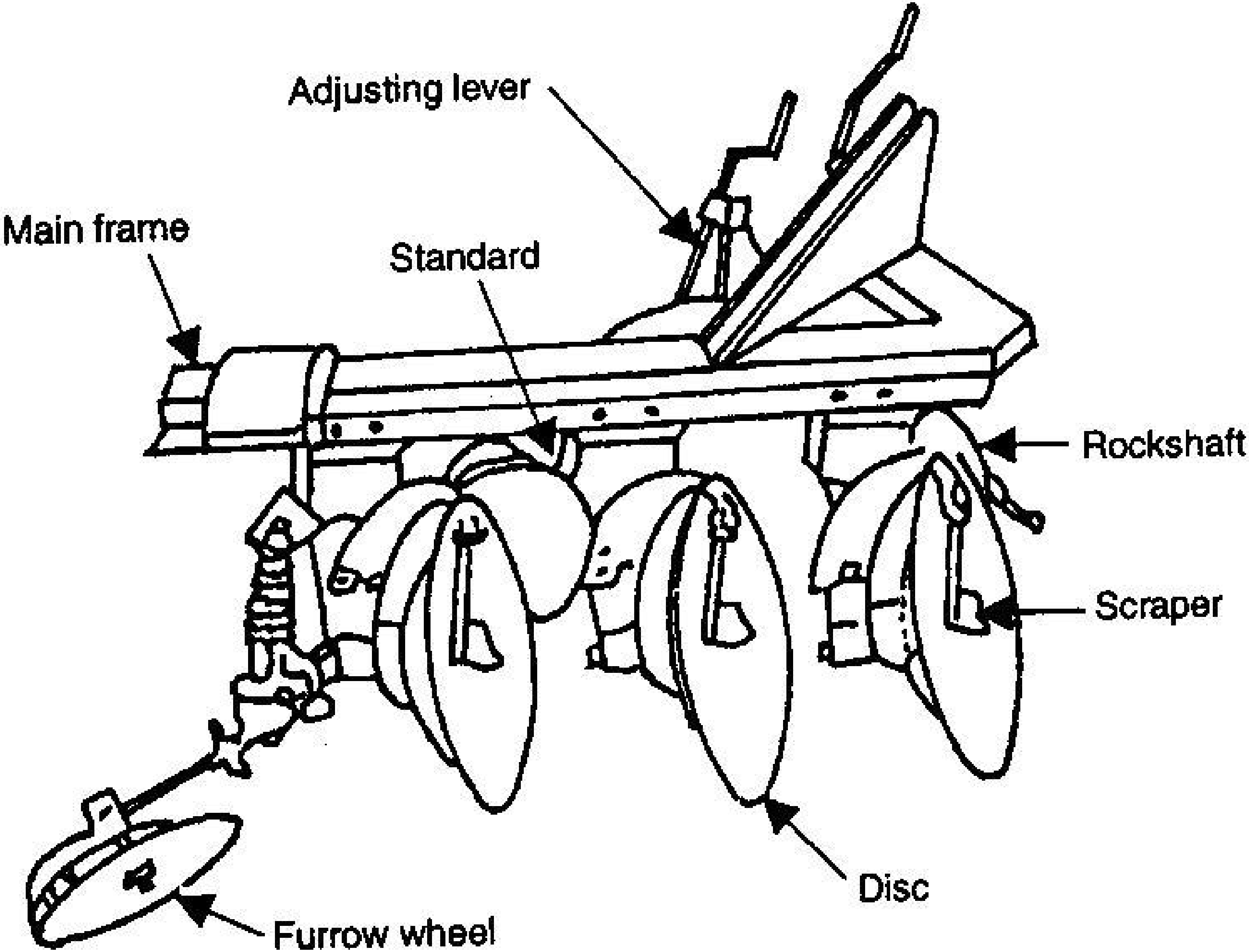
Animal drawn standard disc plough

- It is attached to a universal frame which is mounted on two wheels.
- The frame is pulled by a pair of bullocks and it is provided with a seat for the operator.
- There is only one disk blade on these ploughs. The diameter of the disk is 45 cm.
- A rear furrow wheel provided with the plough takes care of the side thrust of the plough.
- The animal drawn plough weighs about 30 kg per disk.

Tractor drawn standard disc plough

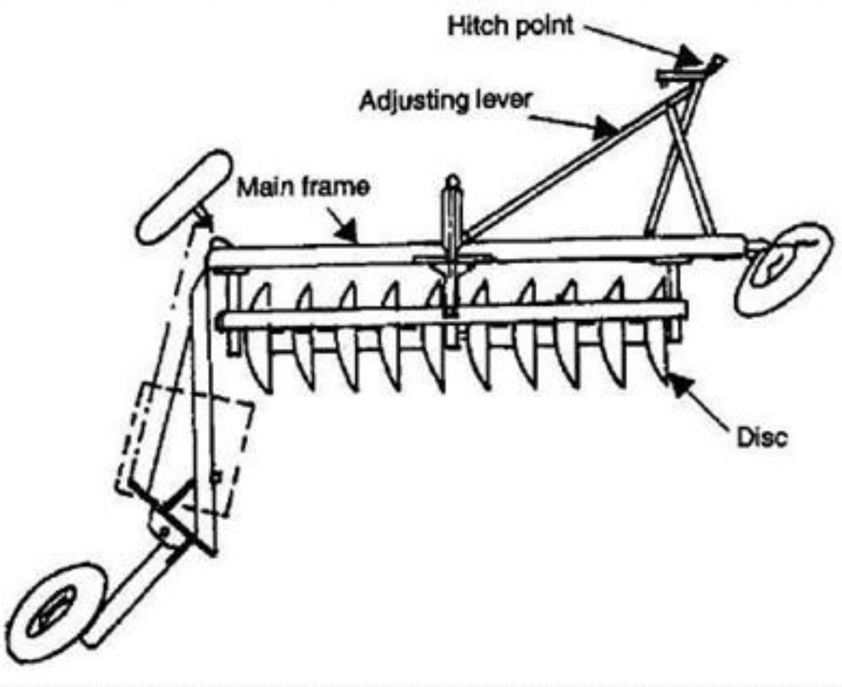
- ➢It consists of **one to seven** disk blades.
- ➢The diameter of the disk blades varies between **60 and 90 cm.**
- ➢The perfectly round concave steel disks sharpened on the edges are bolted to the cast iron supports which are individually suspended from the main frame.
- ➢Taper roller bearings or thrust type ball bearings are used on the ploughs.
- ➢These ploughs are provided with a front furrow wheel, a rear furrow wheel and a land wheel.
- ➢There are also provided with depth adjusting levers, drag links and scrapers on the plough.
- ➢Tractor drawn disk ploughs weigh between **180 and 540 kg** per disk.

- When the plough is pulled forward, the individual disk rotates on its own axis.
- The furrow slice rides along the curvature and is pulverized to some extent.
- In order to cut a deeper furrow slice, the tilt angle of the disk is reduced.
- The other method of increasing the penetration is by adding weights to the plough frame.
- If the soil condition is favourable, the tilt angle should be increased to achieve better turning of the furrow slice.
- If the soil condition is not favourable, the disk angle should be increased to improve the penetration, but the width of cut should be reduced.


Adjusting lever
Main frame
Standard
Rockshaft
Scraper
Disc
Furrow wheel

Vertical disk plough

- It is known as harrow plough or one way disc plough.
- Its action is intermediate between regular disc plough an disc harrow.
- It is similar to standard disk plough, major difference is that, all the disk blades are mounted on a common axle and they rotate as one unit.
- The diameter & curvature of the individual disk of the plough is slightly smaller.
- All the disks are fixed to throw the furrow slice is only one direction.



- It may have **2 to 32** disks, spaced about 20 to 25 cm apart on a gang.
- These are used for shallow ploughing and are preferred in wheat growing areas, where moisture conservation for winter crops is the main objective.
- Diameter of the disk varies between **50 and 65** cm and the disk angle ranges from 40 to 45^0.
- Disc angle of 40 to 45° gives the minimum draft for a given width of cut.

Special ploughs

- ***<u>Sub-soil plough (sub soiler)</u>***
- **The subsoil plough is designed to break up hard layers or pans without bringing them to the surface.**
- **The body of the subsoil plough is wedge shaped and narrow.**
- **I**t breaks the ground at greater depth, breaks the hard pan but not pulverizes the surface soil as much as other tools.
- This is provided with a heavy beam to which a sweep or chisel is attached.
- It improves the moisture and air permeability of the soil.

Chisel plough

- It is mainly used for breaking hard pans and for deep ploughing (60-70 cm) with fewer disturbances to the top layers.
- Its body is thin with replaceable cutting edge, have minimum disturbance to the top layers.
- It contains a replaceable share to shatter at the lower layers.

RIDGE PLOUGH

- **This plough has two mould boards, one for turning the soil to the right and another to the left.**
- **The share is common for both the mould boards i.e. double winged.**
- **These mould boards are mounted on a common body.**
- **The ridge plough is used to split the field into ridges and furrows and for earthing up of crops like sugarcane, cotton etc.**
- **Ridge ploughs are used to make broad-bed and furrows by attaching two-ridge ploughs on a frame at 150 cm spacing between them.**

Animal drawn Ridge plough

Sweeps

These are sub – surface tillage tools that work at a shallow depth and do not turn the soil.

Lister

A lister works much like a M. B. plough except that it has double mould boards and through the soil in two directions. It leaves a furrow.

Secondary tillage implements

- Secondary tillage implements perform lighter and finer operations on the soil after primary tillage, these may be used before as well as after seed placement.
- These implements disturb less soil and bury fewer residues.
- Secondary tillage implements include the harrows, cultivators, hoes, etc.

Cultivator

- A cultivator refers to a frame with teeth (also called shanks) that pierce the soil as they are dragged through it linearly.
- Cultivators stir and pulverize the soil; either before planting (to aerate the soil and prepare a smooth, loose seedbed) or after the crop has begun growing to kill weeds.
- In four-wheel tractors they are attached by means of a three- point hitch and driven by a power take off (PTO).

A cultivator is used for

- Controlling weeds so that they do not compete with crops for water and nutrients.
- Breaking the clods. It also maintains seedbed in good tilt and helps in achieving rapid infiltration of rainfall and adequate aeration.
- To prevent surface evaporation losses by creating mulch on the surface of the field.
- Sometimes used for sowing operation.
- Interculturing, especially when the seedlings have emerged. The row to row distance may be varied according to the requirement.

According to source of power used, cultivators may be classified as:

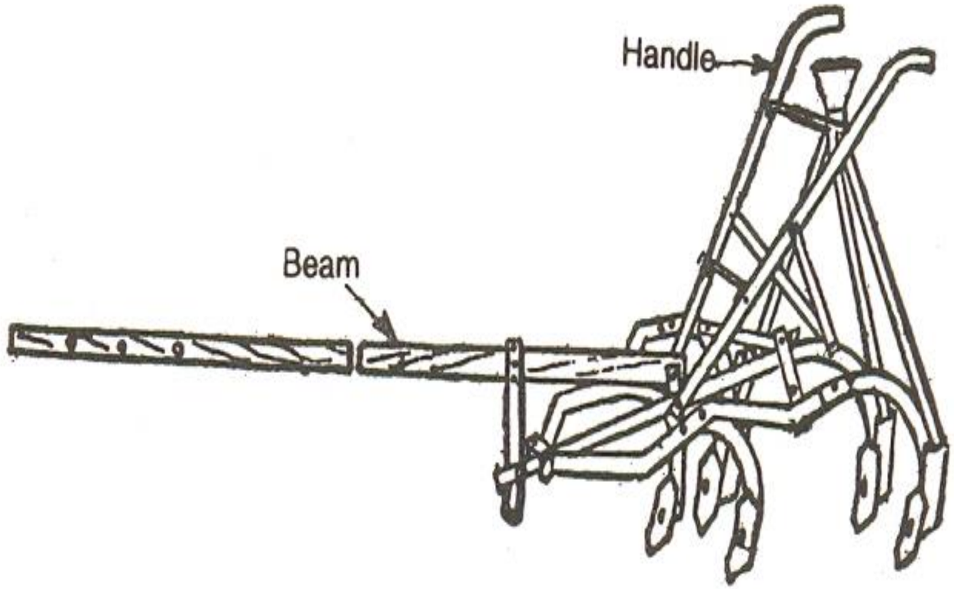
- Hand operated
- Animal drawn
- Tractor drawn

Hand operated cultivators

- Hand operated cultivators are provided with small cultivator teeth as cutting tool.
- The frame is supported by single or double wheels and pushed forward by means of two handles.
- The depth of cultivation is limited to about 4 to 5 cm only.
- A man can cover 0 04 to 0 .05 ha in a day (8 hrs).
- The spacing is adjustable and is about 23 cm.

Animal drawn cultivator

- Animal drawn cultivators are provided either with a long beam or only a hook in the front.
- The long beam is preferred because the ploughman finds it convenient for transport and hitching.



Animal drawn cultivator with seeding attachment

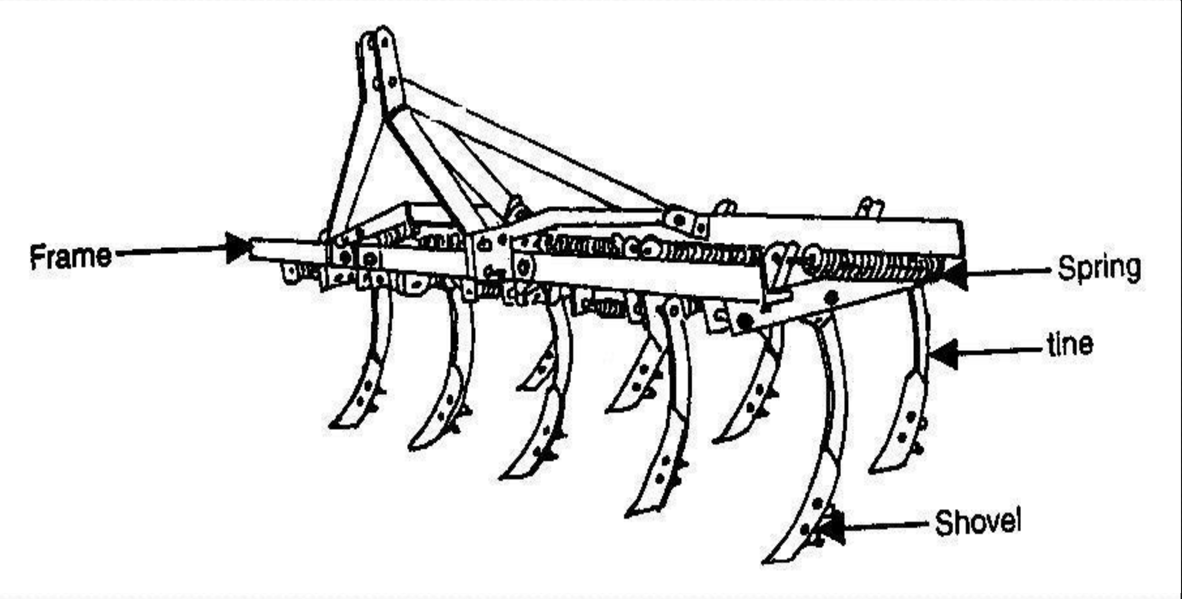
- These are adjustable type.
- Most of the shovel cultivators are provided with 5 to 7 staggered tynes to attach the cultivating tools like shovels, sweeps.
- The whole implement is supported by its tynes on the ground.
- Some of the shovel cultivators are also provided with the seeding attachment.

Tractor drawn cultivator

- Tractor drawn cultivators are mostly mounted type.
- Spacing of 7.5 cm or in its multiple can be maintained.
  - They are of two types:

  (1) Spring loaded tynes cultivator and

  (2) Cultivator with rigid tynes



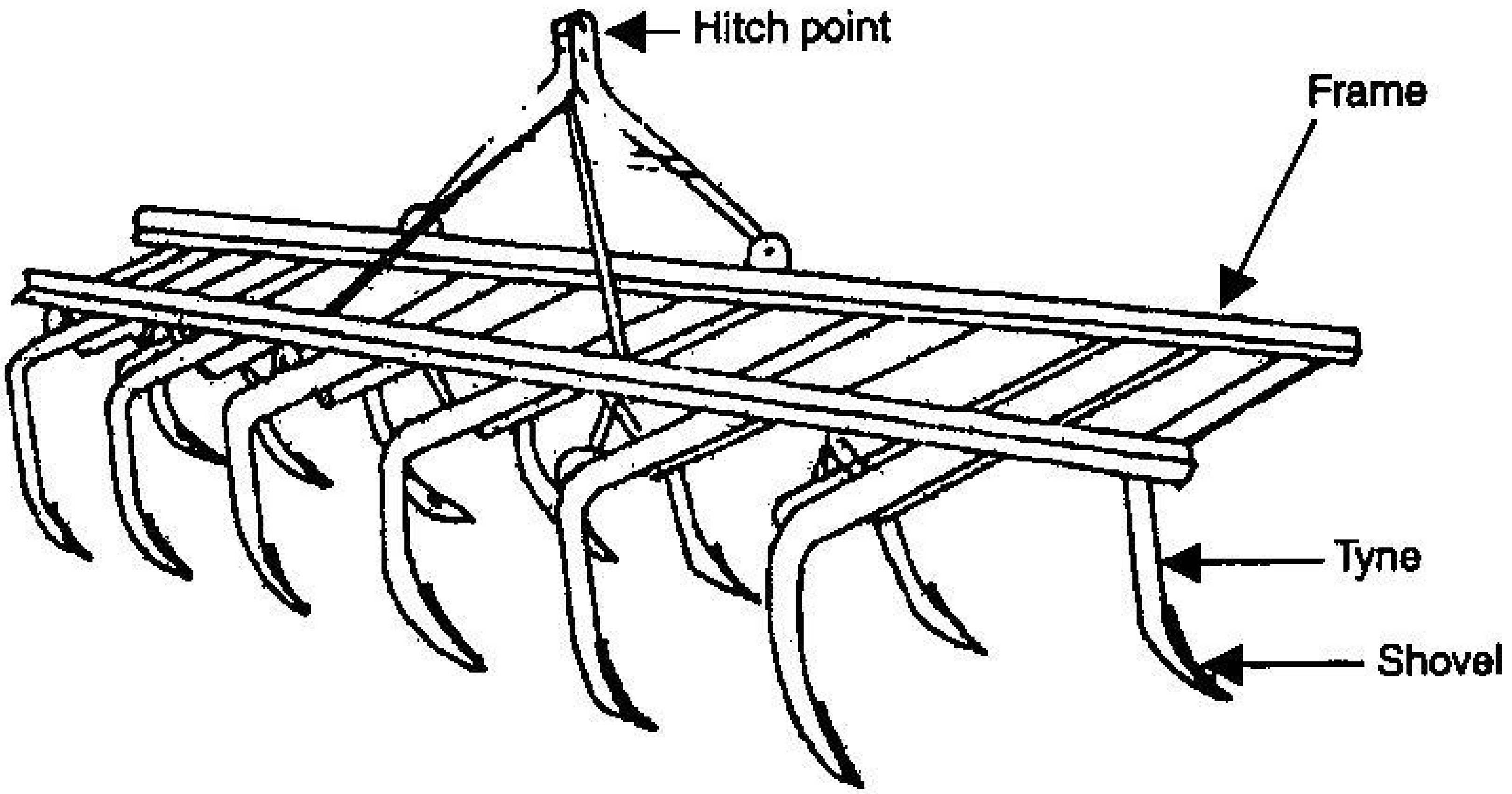
Spring loaded tynes cultivator

Spring loaded tynes cultivator

- Each tyne of this cultivator is provided with two heavy coil springs, tensioned to ensure minimum movement except when an obstacle is encountered.
- The springs operate, when the points strike roots or large stones by allowing the tynes to ride over the obstruction, thus preventing damage.
- On passing over the obstruction, the tynes are automatically reset and work continues without interruption.
- The tynes are made of high carbon steel.
- This type of cultivator is particularly recommended for soils which are embedded with stones or stumps.
- A pair of gauge wheel is provided on the cultivator for controlling the depth of operation.
- The cultivator may be fitted with 7, 9, 11, 13 tynes or more depending upon the requirement.

Cultivator with rigid tynes

- Rigid tynes are those tynes which do not deflect during the work in the field.
- Spacing of the tynes is changed simply by slackening the bolts and sliding the braces to the desired position.
- Since rigid tynes are mounted on the front and rear tool bars, the spacing between the tynes can be easily adjusted.
- A pair of gauge wheel is used for controlling the depth of operation



Cultivator with rigid tynes

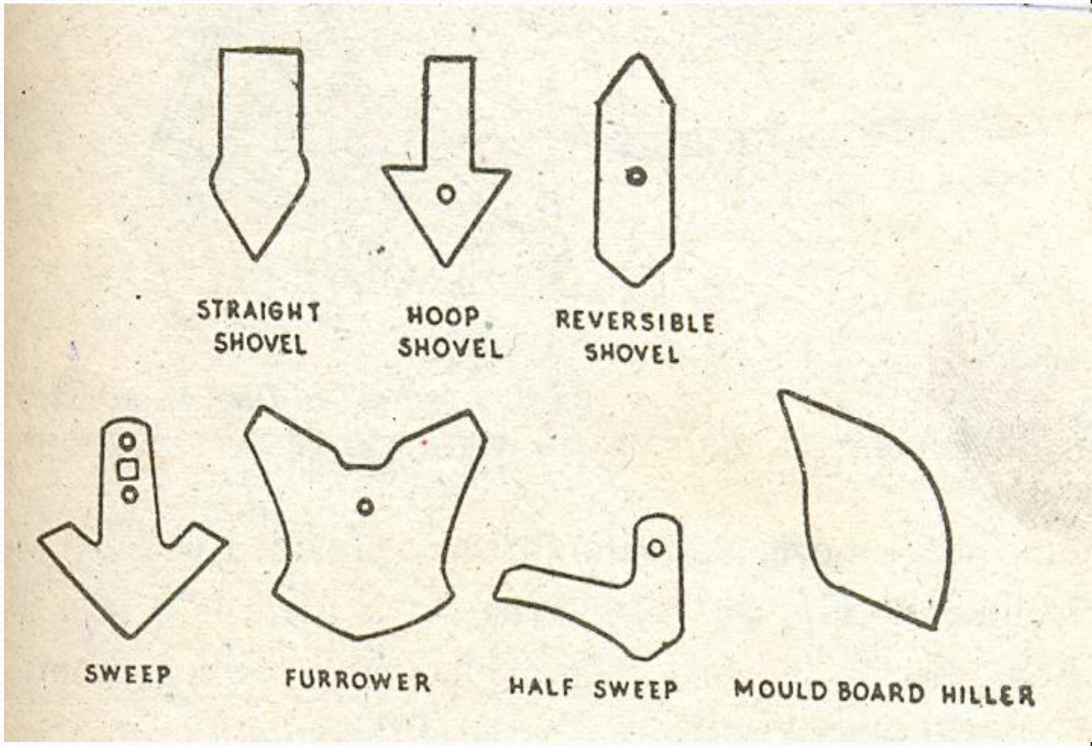
According to type of the working parts they may be classified as:

- Shovel cultivators
- Disk cultivators
- Surface cultivators

Shovel cultivators are much popular and often used.

Disk cultivators are not very much in use in India.

Surface cultivators are not much in use. They are meant for cutting the weeds and for loosening the surface soils.



Different type of tools used on cultivators

Sweep cultivator

- **In stubble-mulch farming, it is difficult to prepare the land with ordinary implements due to clogging and sweep cultivator is the implements useful under this condition.**
- **It consists of large inverted ‘V’ shaped blades attached to a cultivator frame.**
- **These blades run parallel to soil surface at a depth of 10 to 15 cm.**
- **They are arranged in two rows and staggered.**
- **Sweep cultivator is used to cut to a depth of 12 to 15 cm soil during the first operation and still shallower during subsequent operations.**
- **It is used frequently to control weeds.**
- **It is also used for harvesting groundnut in many parts of the world.**

Adjustments on cultivators

- Setting for proper row width.
- Setting for depth or leveling.
- Turning the shovel on the tyne to throw the desired amount of soil.

Care and maintenance of cultivators

- Periodically check the condition of shovels or sweeps. If points are blunt either sharpen or change.
- Check the setting of shovels or sweeps; adjust for uniform depth of penetration.
- Tight the loose nuts and bolts of frame. If missing replace them.
- Oil and adjust the tension of spring trips.
- In case of trailed or riding cultivators lubricate wheel bearings and replace worn out wheel bearings.

Numerical

Calculate the time required to cultivate one hectare field by a five tyne cultivator of 8 cm tyne spacing, operated at a speed of 3 km/hr. The working depth is 5 cm and 10 % time is lost in turning. If soil resistance is 0.6 kg/cm^2 find the maximum draft and required horse power. The width of furrow is 5 cm.

Solution:

Width of cultivator (W)= 5 x 8 cm = 40 cm = 0.4m

Speed(S) = 3 km/hr

$$\text{Effective field capacity in ha/hr (C)} = \frac{W \times S}{10} \times \text{Field efficiency (frac.)}$$

$$C = \frac{0.4 \times 3}{10} \times 0.9 = 0.108 \text{ ha/hr}$$

Therefore, time taken to cover 1 ha

= (1/0.108) hrs = 9.26 hrs

Total cross sectional area of cut by five tynes

= 5 cm x 40 cm = 200cm^2

Maximum draft =

Total soil resistance 0.6 kg/cm^2 x 200 cm^2 = 120 kg

$$\text{Horse Power} = \frac{\text{Draft in kg x Speed in m/min}}{4500}$$

$$\text{Horse Powe r} = \frac{120 \times 3000}{4500 \times 60} = 1.33 \text{ hp}$$

Harrows

- Harrowing is secondary tillage operation which pulverizes, smoothens and packs the soil in seedbed preparation and/or to control weeds.
- A harrow is an implement that cuts the soil to a shallow depth for smoothening and pulverizing the soil as well as to cut the weeds and to mix materials with soil.
- Harrow is an implement used to break the clods after ploughing, to collect trash from the ploughed land and to level the seedbed.

Disc harrow

It performs the harrowing operations by means of a set (or a number of sets) of rotating steel discs, each set being mounted on a common shaft.

Disc harrows are of two types depending upon the sources of power:

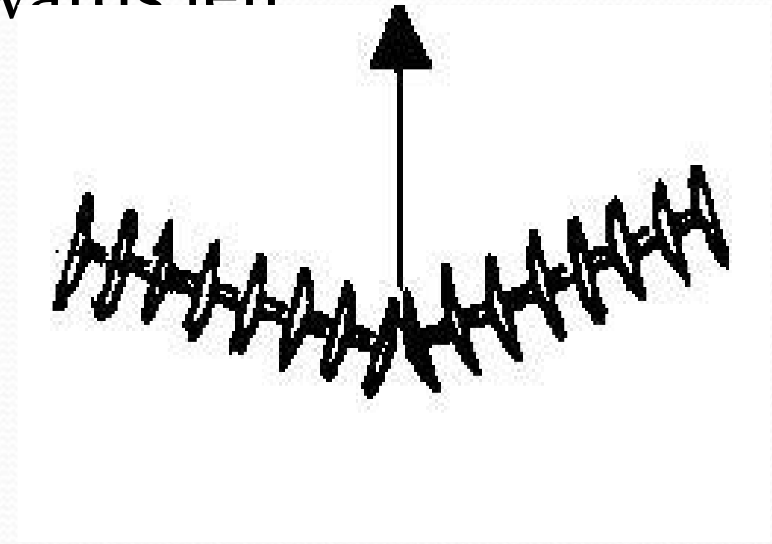
- Tractor drawn
- Animal drawn.

Tractor drawn disc harrow

- Disc harrow is found very suitable for hard ground, full of stalks and grasses.
- It cuts the lumps of soil, clods and roots.
- Discs are mounted on one, two or more axles which may be set at a variable angle to the line of motion.
- As the harrow is pulled ahead, the discs rotate on the ground.
- Depending upon the disc arrangements, disc harrows are divided into two classes (i) single action, and (ii) double action.

Single action disc harrow

- It is a harrow with two gangs placed end to end that are pulled by a tractor.
- The two gangs throw the soil in opposite directions.
- The discs are arranged in such a way that right side gang throws the soil towards right, and left side gang throws the soil towards left.



Tractor drawn single action disc harrow

Double action disc harrow

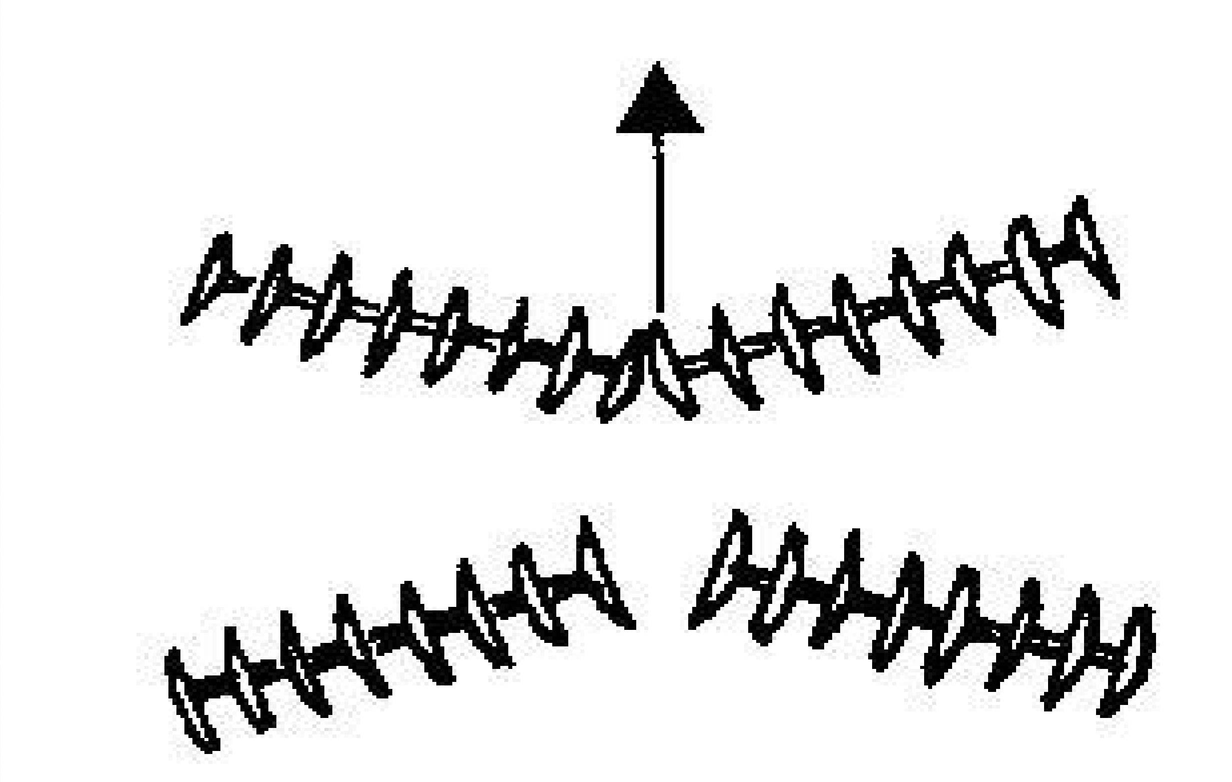
A disc harrow consisting of two or more gangs, in which a set of one or two gangs follow behind the set of the other one or two, arranged in such a way that the front and back gangs throw the soil in opposite directions. Thus the entire field is worked twice in each trip.

It may be of two types:

- Tandem, and
- Off-set.

Tandem disc harrow

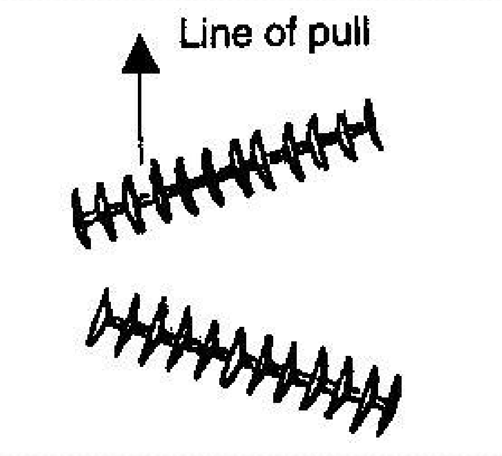
It is a disc harrow comprising of four gangs in which each gang can be angled in opposite direction.



Tractor drawn tandem disc harrow

Off-set disc harrow

- It is a disc harrow with two gangs in tandem, capable of being off-set to either side of the centre line of pull.
- Two gangs are fitted one behind the other.
- The soil is thrown in both directions because discs of both gangs face in opposite directions. It is very useful for orchards and gardens.
- The line of pull is not in the middle, that's why it is called off-set disc harrow



Tractor drawn right hand offset disc harrow

Components of disc harrow

A disc harrow mainly consists of:

(i) disc
(ii) gang
(iii) gang bolt or arbor bolt
(iv) gang control lever
(v) spools or spacer
(vi) Bearings
(vii) transport wheels
(viii) scraper and
(ix) weight box.

(i) Disc

- It is a circular, concave revolving steel plate used for cutting and inverting the soil.
- Disc is made of high grade heat treated hardened steel.
- Tractor drawn disc harrows have concave discs of size varying from 35 to 70 cm diameter.
- Usually two types of disc are used in disc harrows: (a) Plain disc and (b) Cut-away disc.
- Cut-away discs have serrated edges and they cut stalks, grasses and other vegetative matter better than plain discs.
- Cut-away discs are not very effective for pulverization of soil but it is very useful for pudding the field especially for paddy cultivation.

(ii) Gang

It is an assembly of concave discs mounted on a common shaft with spools in between.

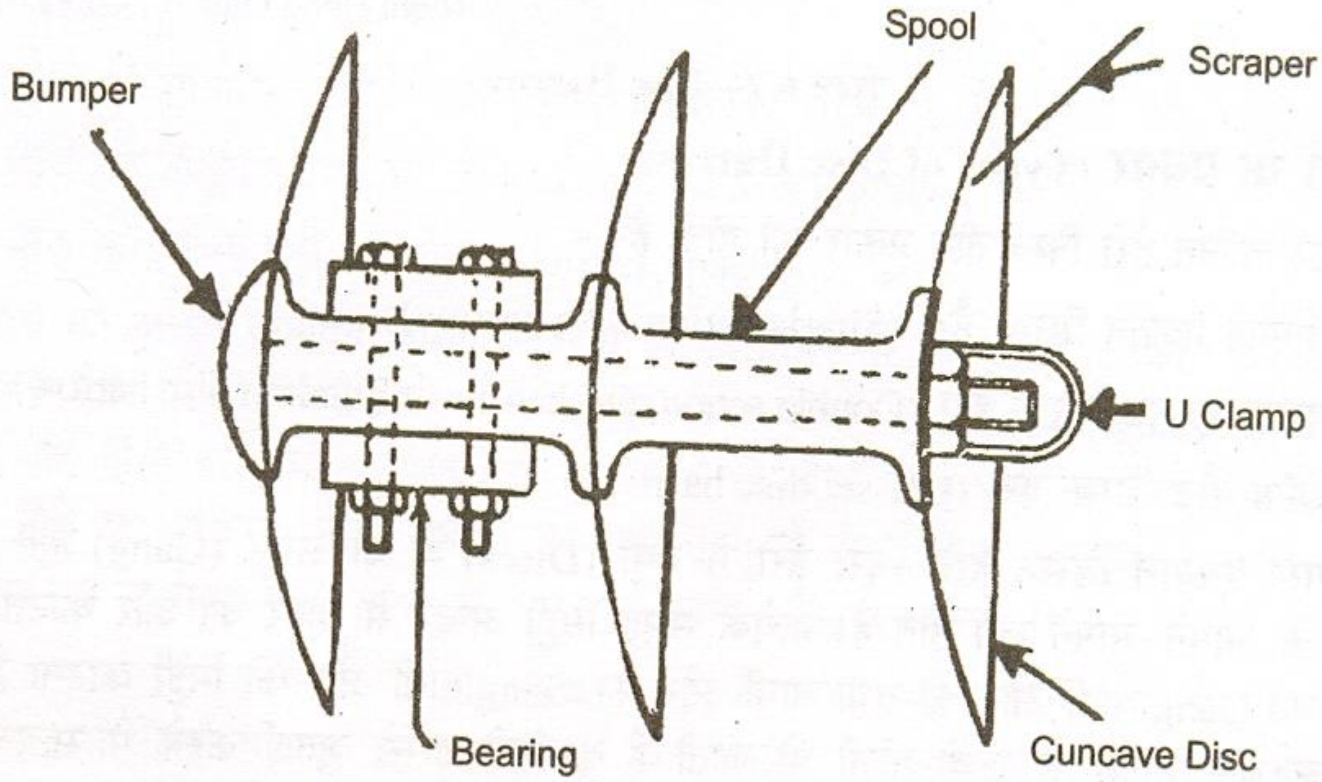


Fig. Parts of disc harrow gang

(iii) Gang axle or arbor axle

It is a shaft on which a set of discs are mounted. The spacing between the discs on the gang bolt ranges from 15cm to 23cm for light duty harrows and 25 to 30 cm for heavy duty harrows.

(iv) Gang control lever

A lever which operates the angling mechanism of disc harrow is called *Gang control lever.*

(v) Spool or Spacer

The flanged tube, mounted on the gang axle between every two discs to retain them at fixed position laterally on the shaft is called spool or spacer.

It is just a device for keeping the discs at equal spacing on the axle.

It is usually cast in special shapes and sizes and is generally made of cast iron.

(vi)Bearing

- Bearing is essential to counteract the end thrust of the gangs due to soil thrust.
- Chilled cast iron bearings, ball bearings or tapered roller bearings may be used on disc harrows.

(vii) Transport wheel

- In trailing type discs harrows, transport wheels are provided for transport work on roads and for preventing the damage of the roads.
- This also helps in protecting the edges of the discs.
- Mounted type disc harrows do not require wheels for transport purpose.

(viii) Scraper

- Scraper prevents the discs from clogging.
- It removes the soil that may stick to the concave side of the disc.

(ix) Weight box

- A box like frame is provided on the main frame of the harrow for putting additional weight on the implement.
- Additional weight helps in increasing the penetration of the discs in the soil.

Gang angle

The angle between the axis of the gang and the line perpendicular to the direction of travel is called *Gang angle*.

Penetration of disc harrow

- A sharp edged disc has more effective penetration compared to blunt edged disc.
- It is observed that penetration is better in low speed than in high speed.

Adjustments for obtaining higher penetration.

- By increasing the disc angle.
- By adding additional weight on the harrow.
- By lowering the hitch point.
- By using sharp edged discs of small diameter and lesser concavity and
- By regulating the optimum speed.

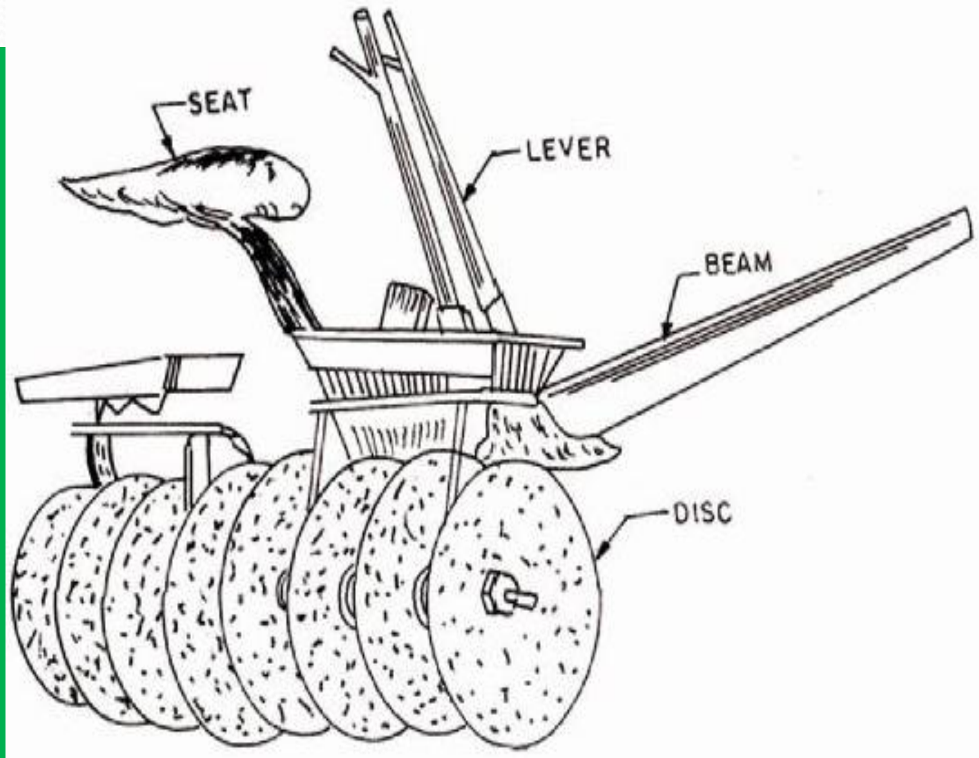
Care and maintenance of disc harrow

- Bearing must be thoroughly greased at regular intervals.
- All the nuts and bolts must be checked daily before taking the implement to the field.
- Blunt edges of the discs should be sharpened regularly.
- During slack season, the worn parts including bearings should be fully replaced.
- It is better to coat the outer and inner surfaces of the discs when the harrow is lying without use in slack season.

Animal drawn disc harrow

Beam

- It is that part of the harrow which connects the implement with the yoke.
- The rear end of the beam has a clevis to fix its height of hitching to suit the size of animals.
- It is made of wood which is locally available in the area.



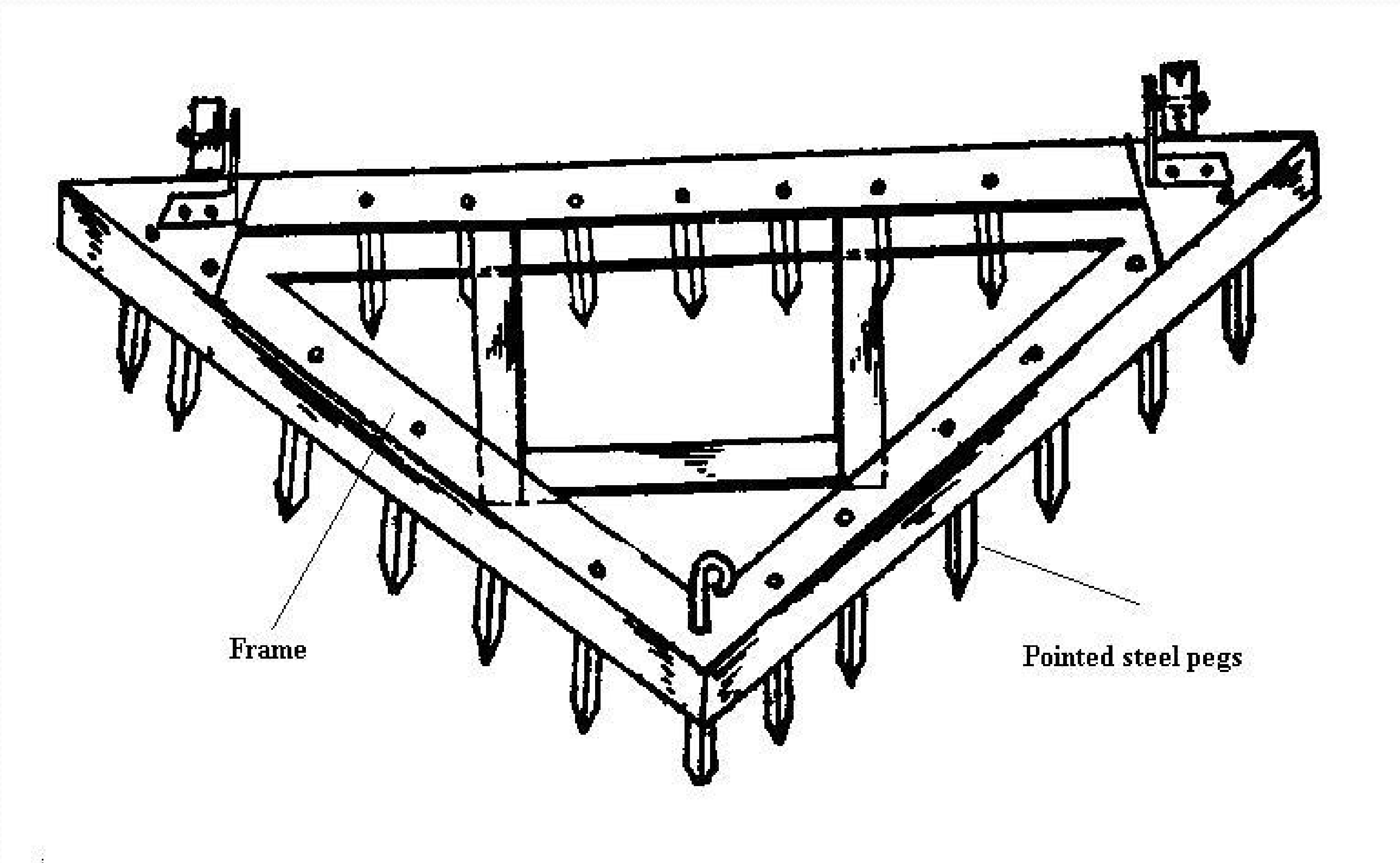
Clevis: Clevis is the part fitted to the beam and the frame which permits vertical hitching of the harrow.

Drag harrows

There are two kinds of drag harrows, namely,

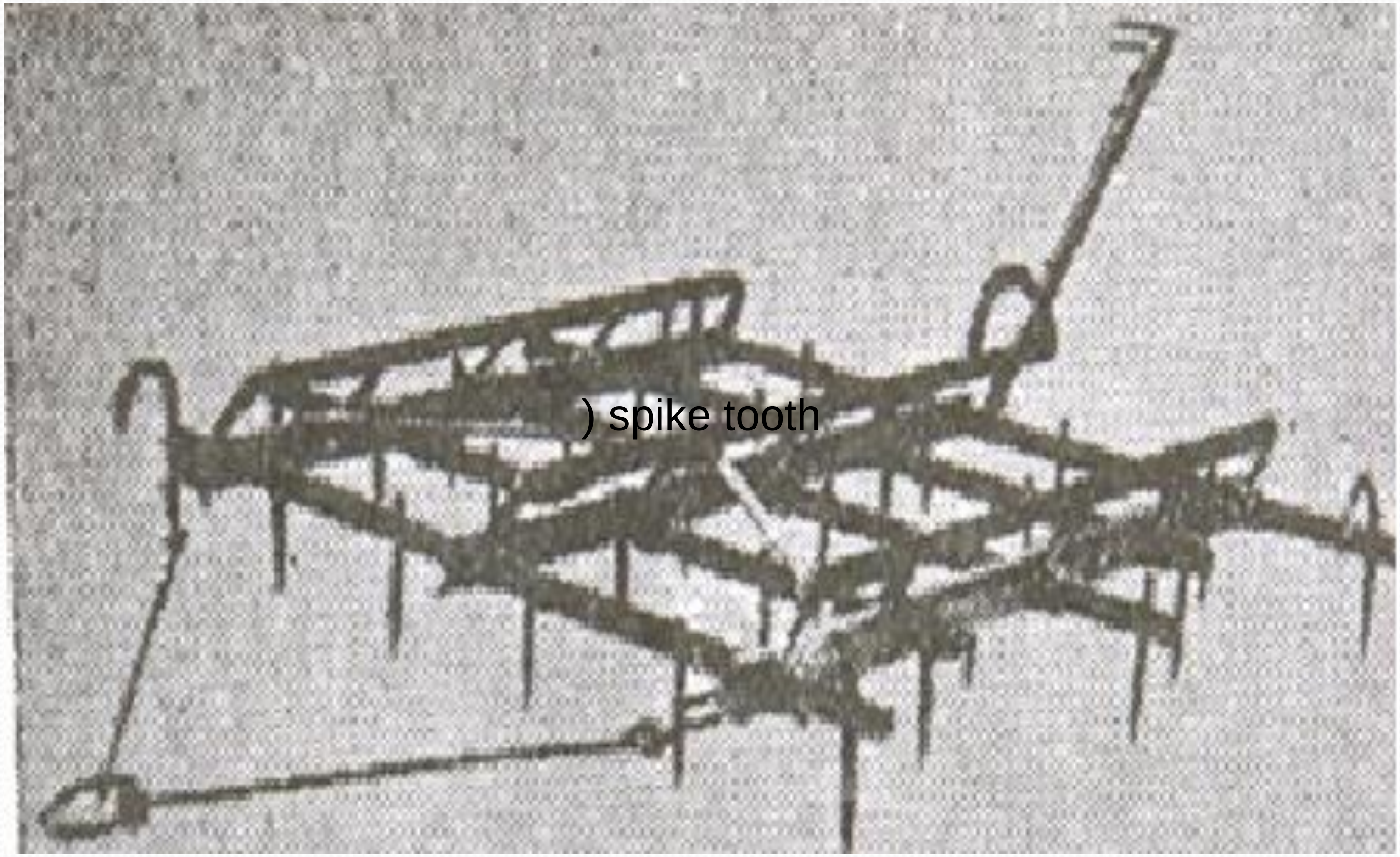
(1) spike tooth and (2) spring tyne harrow.

- Spike tooth harrows are either rigid or flexible.
- The flexible type tractor drawn can be rolled up for transporting.
- But the animal drawn harrows are always of rigid frame type.
- There may or may not be provision for changing the angle of the spikes while operating the harrow.
- The basic frame of the harrow may be triangular.
- It has pointed steel pegs (teeth) about 23 cm long with their pointed ends towards ground.
- Each peg is rigidly clamped with the help of a U-bolt to the cross bars of the frame



Peg tooth or triangular harrow

Spike tooth harrow



Spring tyne harrows

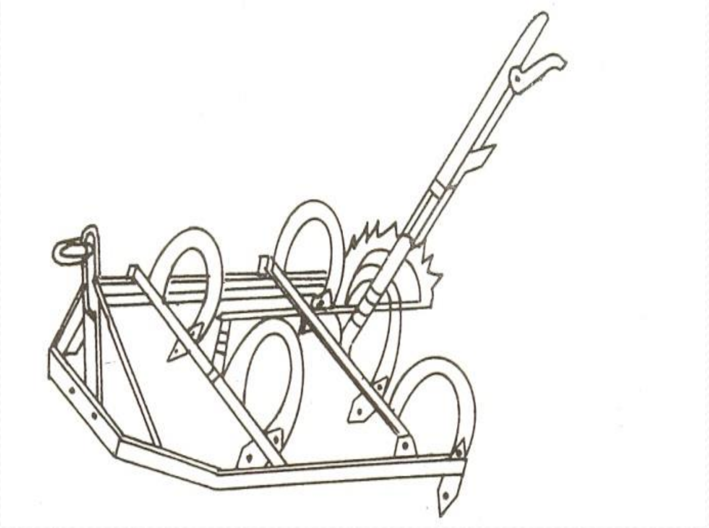
Spring tyne tractor drawn harrows have looping, elliptical or spring like tynes.

But the animal drawn unit is only provided with elliptical tynes.

They are used extensively to prepare ploughed land before planting.

They penetrate much deeper than spike tooth harrows and are generally used in the soil where obstructions like stones, roots and weeds are hidden a few centimeters below the surface.

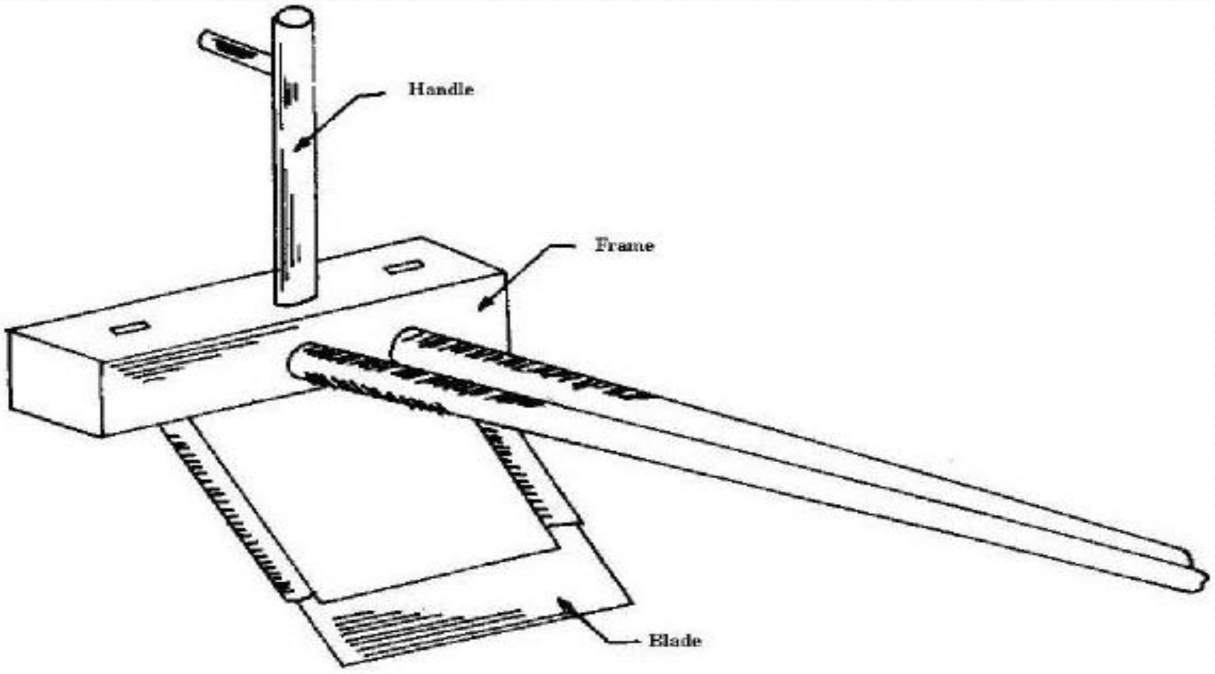
- The basic frame of the harrow is mostly rectangular.
- The spring tynes are bolted staggered on to the frame to avoid clogging during operation.
- Spike tooth and spring tyne harrows do not require lubrication.



Blade harrows (*bakhar)*

- It is generally used in clay soils for preparing seedbeds of both *kharif* (rainy season) and *Rabi* (winter) crops.
- It is also used for covering the seed in *Kharif* sowing. The action of blade harrow is like that of sweep, moving into the top surface of the soil without inverting it.
- Sometimes, it is used to chisel out the uncut portion left after ploughing by an indigenous plough.
- The width cut by the harrow varies from 38 to 105 cm.

***Blade harrows* are used for different purposes like removal of weeds and stubbles, crushing of clods, working of soil to shallow depth, covering the seeds, inter-cultivation and harvesting of groundnut etc.**



Blade harrow (Bakhar)

Hoes

A hoe is an ancient and versatile agricultural tool used to move small amounts of soil.

Common goals include weed control by agitating the surface of the soil around plants, piling soil around the base of plants (hilling), creating narrow furrows (drills) and shallow trenches for planting seeds and bulbs, to chop weeds, roots and crop residues, and even to dig or move soil, such as when harvesting root crops like potatoes.

The two common types of hoes used by Indian farmers are:

- Hand hoes, and
- Animal drawn hoes

Hand hoe

- Hand hoes are used to cultivate very small area of land by human labour. The most popular one is Kodali (narrow spade). About 0.04 ha can be covered in a day by one man.
- Hand hoes can further be classified as per force applied i.e. pull or draw hoes; and push or thrust hoes.

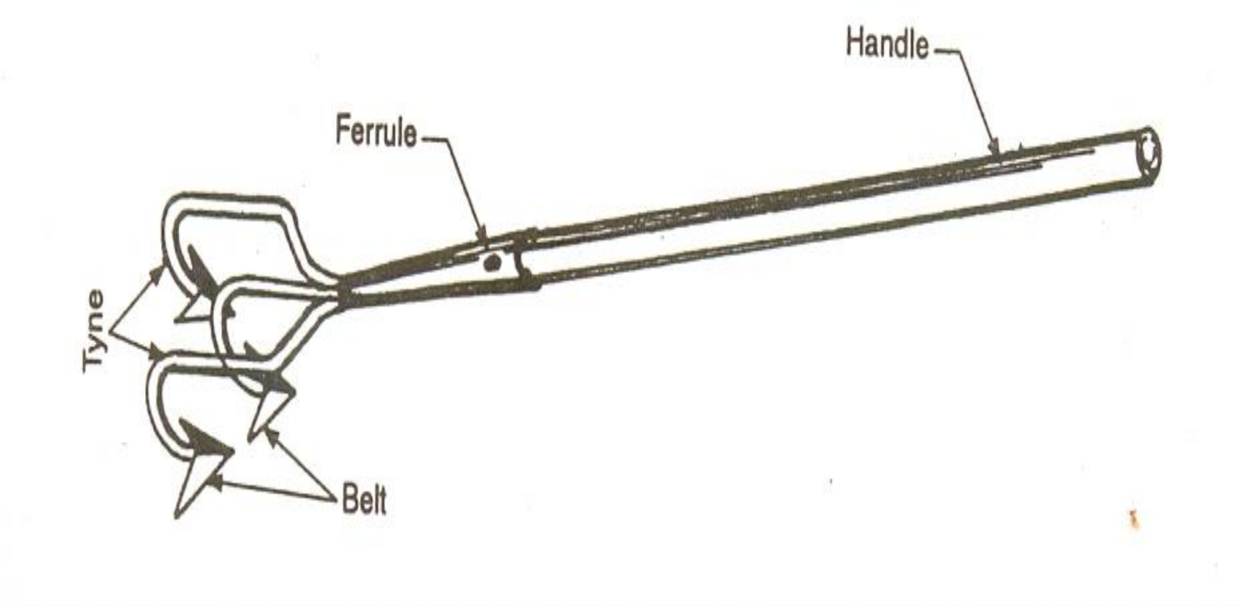
Pull hoe

Push hoe

Garden hoe

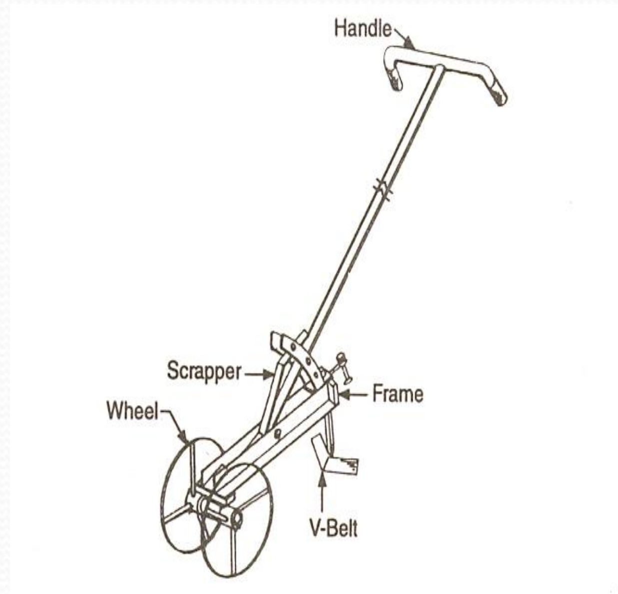
Grubber

The grubber is a manually pull type hoe having 3 blades. It is suitable for weeding and intercultural operation of upland row crops in black cotton soil regions. Its field capacity is 1/200 ha per hour.



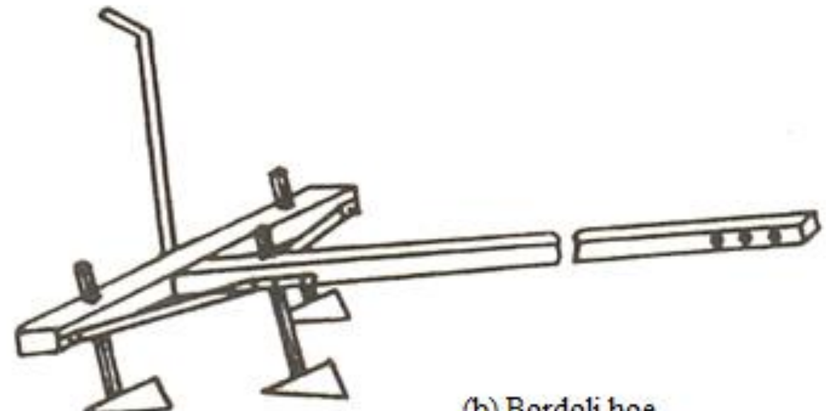
Wheel hoe

- A wheel hoe consists of a wheel, two handles and a tyne to place the cutting tool on it.
- Either a reversible shovel or a 3 prong fork or a sweep is used as a cutting tool, depending upon the weeds and moisture conditions.
- It is used for cultivating land between rows. Its field capacity is 0.04 ha/day.

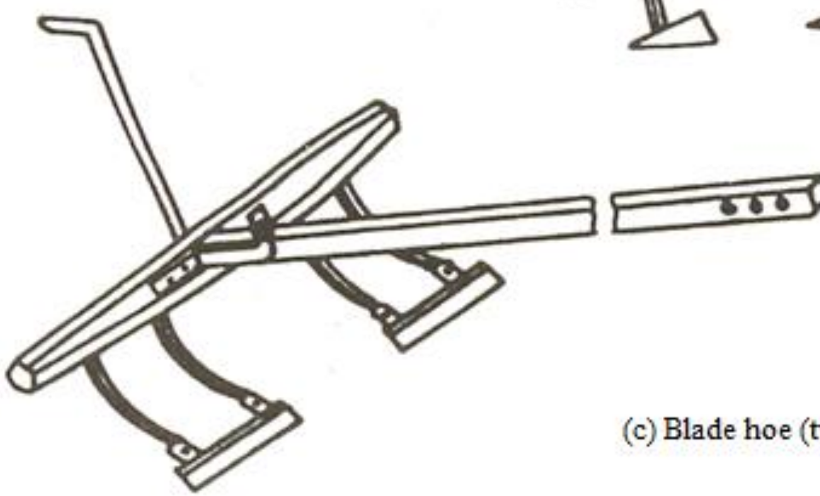


Animal drawn hoes

(a) Three tyne cultivator



(b) Bordoli hoe



(c) Blade hoe (two row type)

- Animal drawn hoes may be single row type or multi row units.
- The three tyne cultivator or 'Triphali', Akola hoe, Bardoli hoe or two blade hoe are some of the popular animal drawn hoes.
- It is essential to provide wider spacing (about 30 cm) for the movement of animals and implement if animal drawn hoes are to be used.
- In blade hoe the prong makes an angle of 45 degree downward with horizontal plane. At the end of each prong the blade is attached.
- It loosen the upper surface of soil and is generally used for interculturing sorghum, cotton, groundnut and other *kharif* crops.

Plank and Roller

- **Plank is a very simple implement and consists of a heavy wooden beam of 2 m in length.**
- **In addition, shafts and handle are fixed to the beams.**
- **When it is worked, most of the clods are crushed due to its weight.**
- **It also helps in micro-leveling and slight compaction necessary after sowing.**
- **Rollers are used mainly to crush the hard clods and to compact the soil in seed rows.**

Lect.- 9
Numerical on field capacity and power requirement of implements.

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Field Capacity

- The field capacity of a farm machine is the rate at which it performs its primary function,

  i.e., the number of hectares that can be ploughed per hour or the number of tons of hay that can be baled per hour.

  The most common measure of field capacity for agricultural machines is expressed in hectares covered per hour of operation.
- Measurements or estimates of machine capacities are used to schedule field operations, power units, and labour, and to estimate machine operating costs.

Theoretical Field Capacity

Theoretical field capacity (TFC) depends only on the full operating width of the machine and the average travel speed in the field.

It represents the maximum possible field capacity that can be obtained at the given field speed when the full operating width of the machine is being used.

It can be calculated from equation

$$\text{TFC (ha/hr)} = \frac{W \ x \ S}{10}$$

where W = Width of implement in m

S = Speed of travel in km per hr

Effective Field Capacity

- The effective field capacity (EFC) of a machine in the field can be easily calculated by dividing the hectares completed by the hours of actual field time. Recording hectares and hours for several fields over the whole season can be used to find an average field capacity in differing area and weather conditions.
- The effective field capacity of a machine in ha/hr is a function of operating width of machine (measured width and percentage of width actually used).

$$\text{EFC (ha/hr)} = \frac{W \; x \; S \; x \; Ef}{10 \; x 100}$$

where *Ef* = Field efficiency in percentage.

Field efficiency

- A machine cannot maintain its TFC for very long periods of time. The ratio of actual or effective field capacity (EFC) to TFC is called the machine's field efficiency (FE).
- Field efficiency is expressed as the percentage of a machine's TFC actually achieved under real conditions.
- It accounts for failure to utilize the full operating width of the machine (overlapping) and many other time delays. These might include turning, filling seed and pesticide in hoppers, emptying grain tanks, cleaning a plugged machine, checking a machine's performance and making adjustments, and operator rest stops.
- Delay activities that occur outside the field, such as daily service, travel to and from the field and major repairs are not included in a field efficiency measurement.

Machine’s material capacity

The working capacity of harvesting machines is often measured by the quantity of material harvested per hour. This capacity is called the machine’s material capacity (MC), expressed as tons per hour.

It is the product of the machine’s EFC and the average yield of crop (in tons) per ha.

Draft of plough

Total draft- The horizontal component of pull in the direction of motion is known as the total draft.

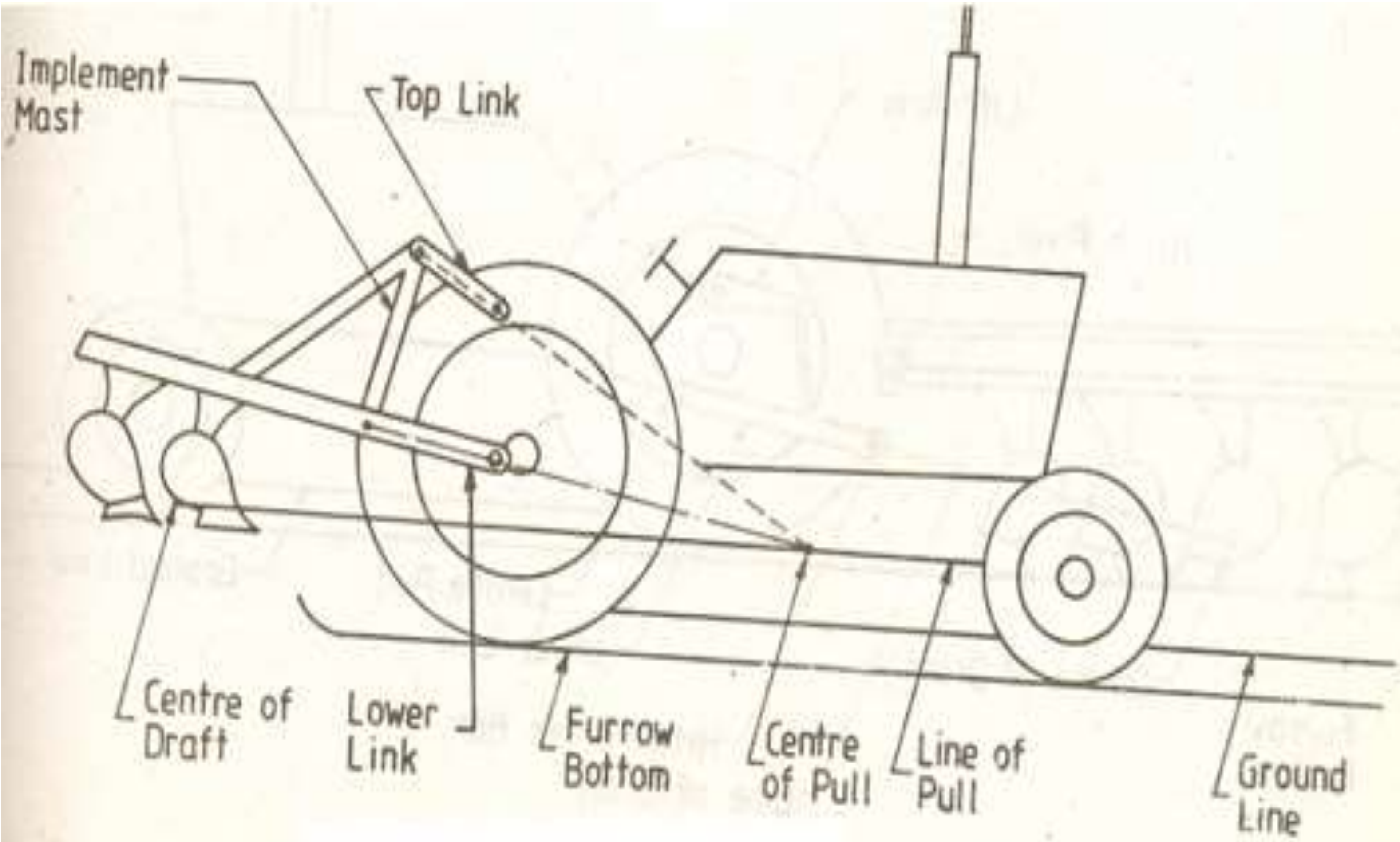
Unit draft- It is defined as the total draft per unit area of the furrow cross- section.

It is generally used to compare the draft requirements of various ploughs.

It is affected by type of plough, type and condition of soil, depth of ploughing, width of cut, sharpness of cutting edge, speed of ploughing and plough attachments.

$$\text{H.P. developed} = \frac{\text{Draft (kg)} \times \text{Speed (m/sec)}}{75}$$

Implement hitching



Numerical

Q.1 Find out the horse power developed by a pair of bullock in pulling a plough at the forward speed of 3 kmph. The plough makes a furrow 20 cm wide and 11 cm deep. The dynamometer indicates an average draft of 85 kg.

What will be the unit draft?

Solution:

$$\text{H.P. developed} = \frac{\text{Draft (kg)} \times \text{Speed (m/sec)}}{75}$$

Draft = 85 kg

$$\text{Speed} = \frac{3 \times 1000}{60 \times 60} = \frac{5}{6} \text{ m/sec} = 0.833 \text{ m/sec}$$

$$\text{H.P. developed} = \frac{85 \times 0.833}{75} = 0.944 \text{ hp}$$

$$\text{Unit draft} = \frac{\text{Total draft}}{\text{Cross section of the furrow } (\text{cm}^2)}$$

$$= \frac{85}{20 \times 11} = 0.386 \text{ kg/cm}^2$$

Q 2. While testing a two bottom tractor drawn MB plough the following observations were noted:

Total draft indicated by the dynamometer = 1200 kg

Distance moved by the tractor while ploughing = 50 m

Time taken to move 50 m by the tractor = 30 sec

Calculate the drawbar hp developed and the forward speed in km/hr.

Solution:

$$\text{H.P. developed} = \frac{\text{Draft (kg)} \times \text{Speed (m/sec)}}{75}$$

Draft = 1200 kg

Speed = $\frac{50}{30}$ m/sec = 1.666 m/sec

H.P. developed = $\frac{1200 \times 1.666}{75}$ = 26.66 hp

Forward speed (km/hr) = $\frac{50 \times 60 \times 60}{30 \times 1000}$ = 6 kmph

Q 3. Calculate the cost of ploughing a hectare of land by

(a) 15 cm wide indigenous plough

(b) 15 cm wide M.B. plough

pulled by a pair of bullocks walking at an average speed of 2.5 km/hr. Assume that only 80% of the time is effectively utilized in doing the job. Assume cost of ploughing per hour for indigenous plough and M. B. plough are 40 and 60 Rs, respectively.

Solution:

No. of hours to cover a hectare by indigenous plough

$$\frac{10000}{0.15} \times \frac{1}{2.5 \times 1000} \times \frac{100}{80} = 33.34 \text{ hrs}$$

Cost of ploughing by indigenous plough

= 33.34 x 40

= 1333.6 Rs/ha   Say Rs 1334 per ha

Similarly number of hours to cover one hectare by M. B. plough = 33.4 hrs

Therefore; cost of ploughing by M. B. plough = 33.34 x 60

= 2000.4 Rs/ha   Say Rs 2000 per ha

Q 4. A four bottom 35 cm plough is working at a speed of 5 kmph by a tractor. The resistance of the soil is 0.70 kg/cm^2. How much hp is required at draw bar if the plough is penetrating 20 cm deep?

Solution:

Size of plough = 4 x 35 = 140 cm

Depth of ploughing = 20 cm

Area of cross- section = 140 x 20 = 2800 cm^2

Total draft = 2800 cm^2 x 0.7 kg/cm^2 = 1960 kg

$$\text{Draw bar H.P.} = \frac{\text{Total draft (kg) x Speed (m/sec)}}{75}$$

$$= \frac{1960 \, x \, 5 \, x \, 1000}{75 \, x \, 60 \, x \, 60} \text{ hp} = 36.3 \text{ hp}$$

Q 5. A grass field was being cut using mower of width 2 m. The speed of the mower is 4 kmph and efficiency is 80%. How much time it will take to cut the field of 5 ha?

Solution:

Width of the mower cutter bar (w) = 2 m

Speed of mower (s) = 4 kmph

Efficiency = 80%

Effective field capacity = $\dfrac{w \text{ x } s \text{ x } Ef}{10 \text{ x } 100}$

$= \dfrac{2 \text{ x } 4 \text{ x } 80}{10 \text{ x } 100}$ ha/h = 0.64 ha/h

Time required for 5 ha = $\dfrac{5}{0.64}$ = 7.8 hr.

Lect.- 10

Familiarization with implements for intercultural operations.

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Associate Professor and Head
Deptt. of Ag. Engineering
College of Agriculture Bikaner

Intercultural operations:

- The operations performed in the field after sowing but before harvesting the crop are called as intercultural operations.
- Interculturing is described as breaking the upper surface of soil, uprooting the weeds (unwanted plants), aerating the soil, thereby promoting the activities of microorganism and making good mulch, so that moisture inside the field is properly retained from evaporation.
- These operations are accomplished by means of many tools and equipments, such as hoes, cultivators, harrows, rotary hoes etc.

Hoes

A hoe is an ancient and versatile agricultural tool used to move small amounts of soil.

Common goals include weed control by agitating the surface of the soil around plants, piling soil around the base of plants (hilling), creating narrow furrows (drills) and shallow trenches for planting seeds and bulbs, to chop weeds, roots and crop residues, and even to dig or move soil, such as when harvesting root crops like potatoes.

The two common types of hoes used by Indian farmers are:

- Hand hoes, and
- Animal drawn hoes

HAND HOE

Hand hoe is the most popular manually operated weeding tool use in the farm.
It consists of an iron blade and a wooden handle.
The operator holds the handle and cuts the soil with the blade to a shallow depth of 2-3 cm thereby weeds are cut and soil is stirred.
The handle is short (30-40cm long) hence the operator uses the tool in bending posture.
.

Hand hoe

Hand hoe

- Hand hoes are used to cultivate very small area of land by human labour. The most popular one is Kodali (narrow spade). About 0.04 ha can be covered in a day by one man.
- Hand hoes can further be classified as per force applied i.e. pull or draw hoes; and push or thrust hoes.

Pull hoe

Push hoe

Garden hoe

HOE CUM RAKE

- The hoe cum rake is multipurpose hand tool, which consists of a flat blade on one side like powrah and prongs on the other side.
- The blade and prongs are either made from single stock with an eye in the centre or joined to an eye by welding.
- A wooden handle is fitted to the eye for operation.
- The flat blade is used for digging and rake side for weeding and collection of weeds and trashes.

LONG HANDLE WEEDERS

- Hand hoes exert greater strain on the operator because of the short handle with necessitates the operator to do weeding job in bent posture. To avoid this nowadays long handles are used in hoes and hence they are called as long handle weeders.
- The popular long handle weeders available are

a) Star type weeder
b) Peg type weeder
c) Wheel Hoe

Star type weeder and Peg type weeder are also called as dry land weeders since they are used in dry lands.

a) Star type weeder :

- It is suitable for weeding in dry lands.
- It can be used in garden lands also when the soil moisture is low (10-15 %).
- One limitation is that it works well in line sown crops and not in broadcasted fields.
- It consists of a blade for cutting the weeds, a fulcrum wheel for push-pull movement and a long handle for easy operation. Long handle reduces strain on the operator.
- The radial arms of the fulcrum wheel is cut in to star like projections and hence the name star type weeder.
- Star wheel is designed for loamy soils. The operating width of the blade is 120 mm. The coverage is 0.05 ha/day.

b) Peg type weeder:

- There are pegs welded on the periphery of the wheel hence the name peg type weeder. Peg type wheel is designed for clayey soils. The operating width of the blade is 120 mm. The coverage is 0.05 ha/day.
- It is suitable for weeding in dry lands.
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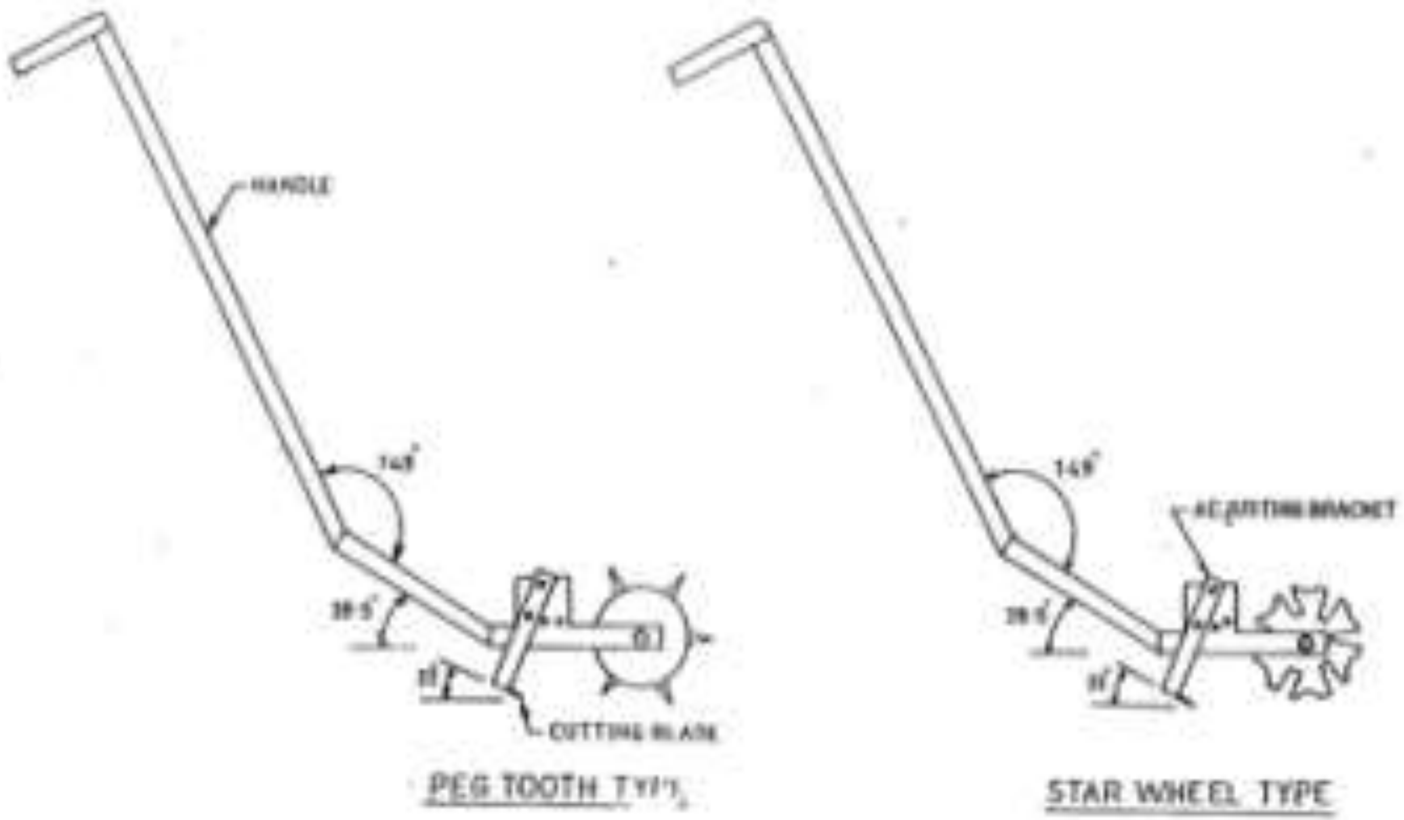
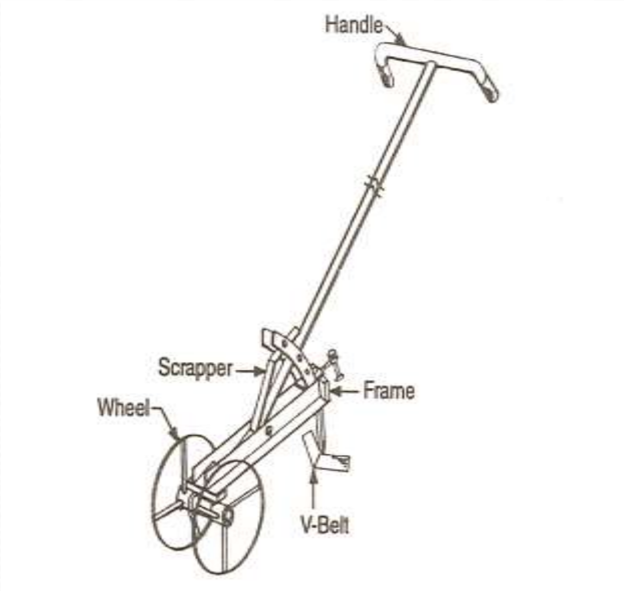
Dry land weeders



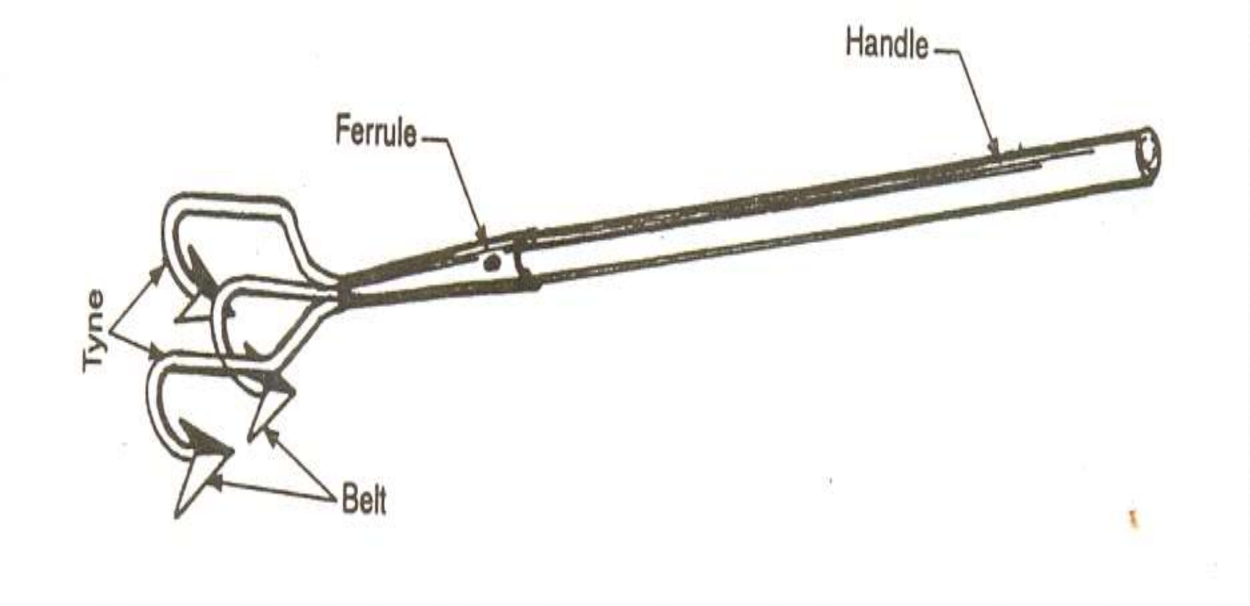
c) Wheel hoe

- A wheel hoe consists of a wheel, two handles and a tyne to place the cutting tool on it.
- Either a reversible shovel or a 3 prong fork or a sweep is used as a cutting tool, depending upon the weeds and moisture conditions.
- It is used for cultivating land between rows. Its field capacity is 0.04 ha/day.



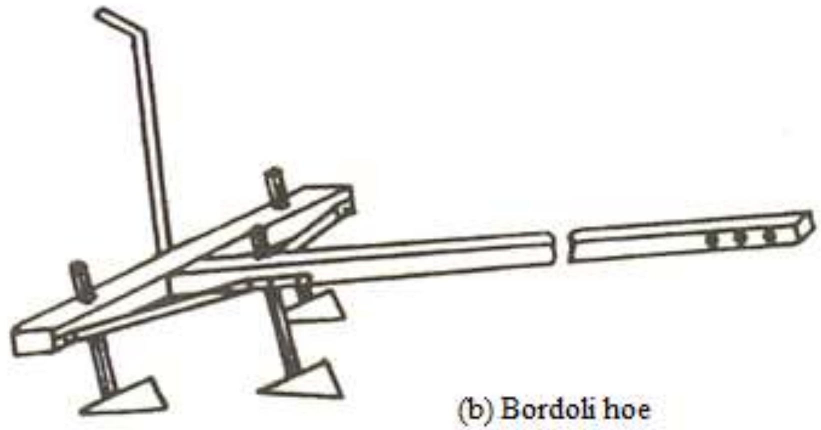
Grubber

The grubber is a manually pull type hoe having 3 blades. It is suitable for weeding and intercultural operation of upland row crops in black cotton soil regions. Its field capacity is 1/200 ha per hour.

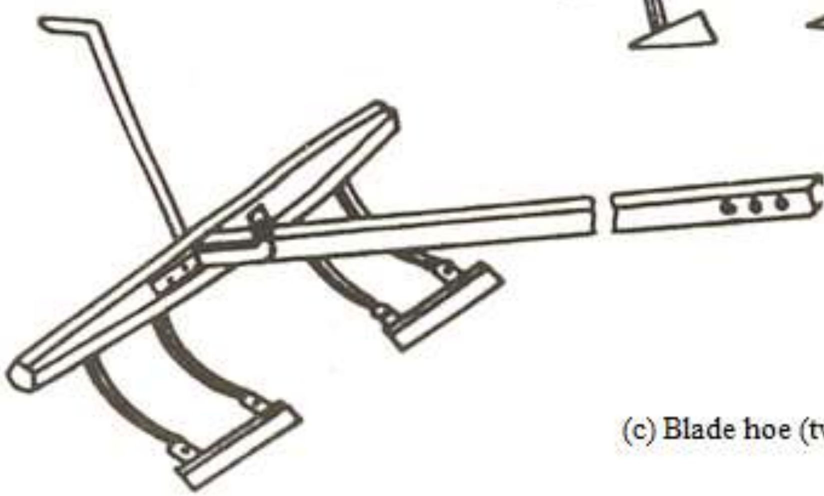


Animal drawn hoes

(a) Three tyne cultivator



(b) Bordoli hoe



(c) Blade hoe (two row type)

- Animal drawn hoes may be single row type or multi row units.
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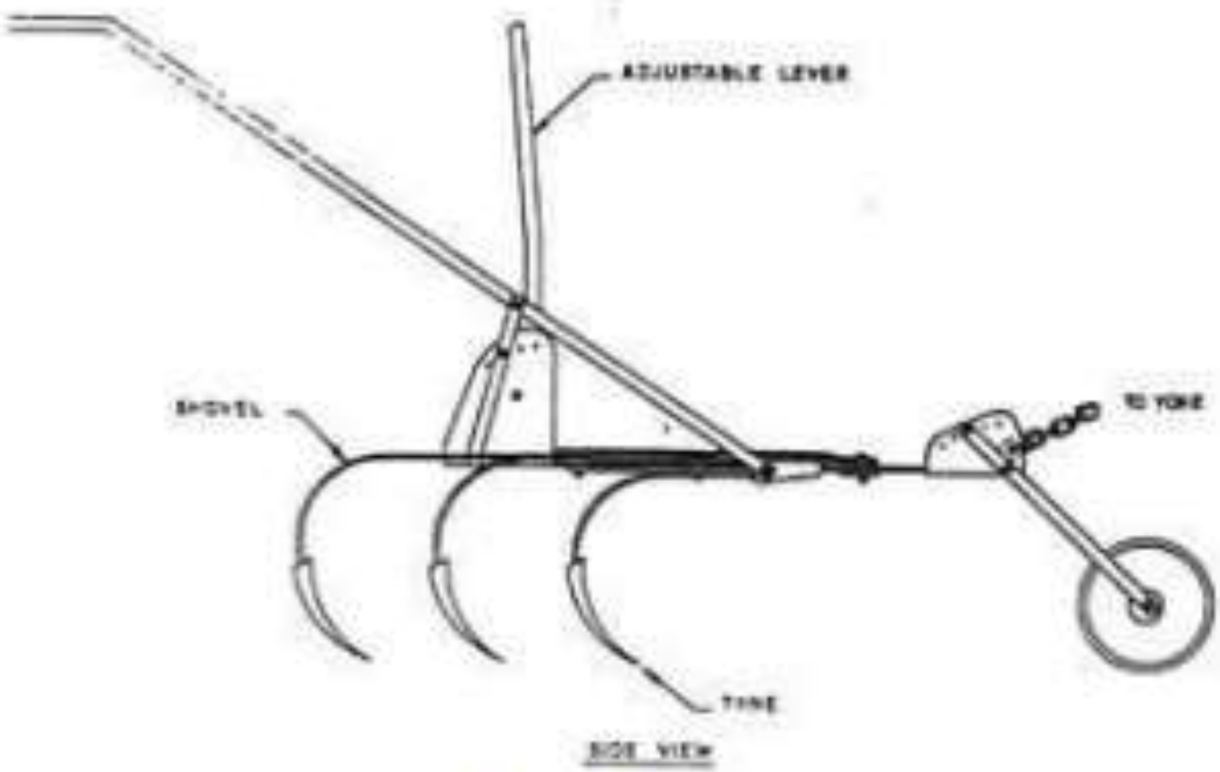
- It is essential to provide wider spacing (about 30 cm) for the movement of animals and implement if animal drawn hoes are to be used.
- In blade hoe the prong makes an angle of 45 degree downward with horizontal plane. At the end of each prong the blade is attached.
- It loosen the upper surface of soil and is generally used for interculturing sorghum, cotton, groundnut and other *kharif* crops.

Junior hoe

- It is intercultural equipment used for weeding between the rows of standing crops.
- It consists of six numbers of curved tynes fitted with reversible shovels and attached to a framework with hitching arrangement.
- The tynes are arranged in three rows in staggered way, A handle and beam are fixed to the framework for guiding and attaching the unit to the yoke of the animals.
- The spacing between the shovels can be adjusted according to the row spacing of the crop.
- The curved nature of tynes gives spring action when struck against stones or roots and releases the tines from the obstacle. The coverage is 1.5 ha per day.



Junior hoe

CULTIVATORS

- It is an implement for inter cultivation with laterally adjustable tines or discs to work between crop rows.
- This can be used for seed bed preparation and for sowing with seeding attachment.
- The cultivator can be 1) Disc cultivator, 2) Rotary cultivator, 3) Tine cultivator.
- Disc cultivator is a cultivator fitted with discs. Disk cultivators are not very much in use in India.
- Rotary cultivator is a cultivator with tynes or blades mounted on a power driven horizontal shaft.
- Tyne cultivator is a cultivator fitted with tynes having shovels.

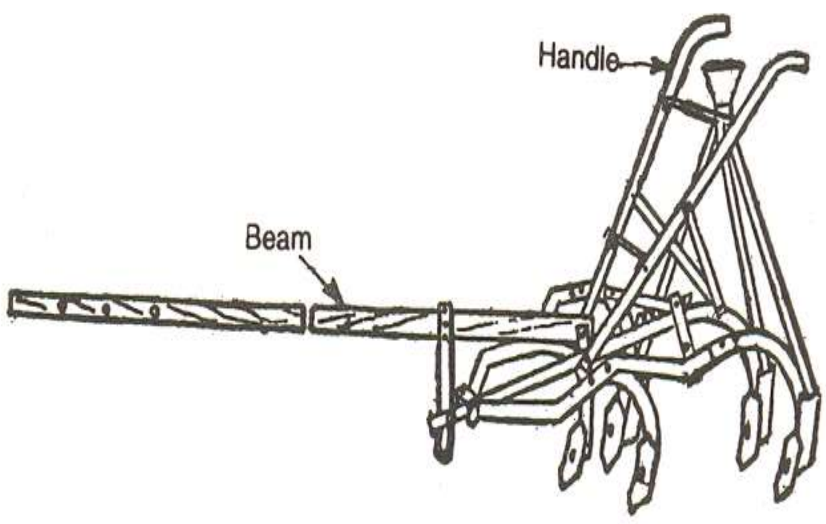
- The cultivator stirs the soil, and breaks the clods. The tynes fitted on the frame of the cultivator comb the soil deeply in the field.
- A cultivator performs functions intermediate between those of plough and the harrow. Destruction of weeds is the primary function of a cultivator.
- The following are a few important functions performed by a cultivator :

1. Destroy the weeds in the field.
2. Aerate the soil for proper growth of crops.
3. Conserve moisture by preparing mulch on the surface.
4. To sow seeds when it is provided with sowing attachments.
5. To prevent surface evaporation and encourage rapid infiltration of rain water into the soil.

Depending upon the type of power available for the implement, the cultivator can be classified as 1) Animal drawn and
2) Tractor drawn,

Animal drawn cultivator

- Animal drawn cultivators are provided either with a long beam or only a hook in the front.
- The long beam is preferred because the ploughman finds it convenient for transport and hitching.

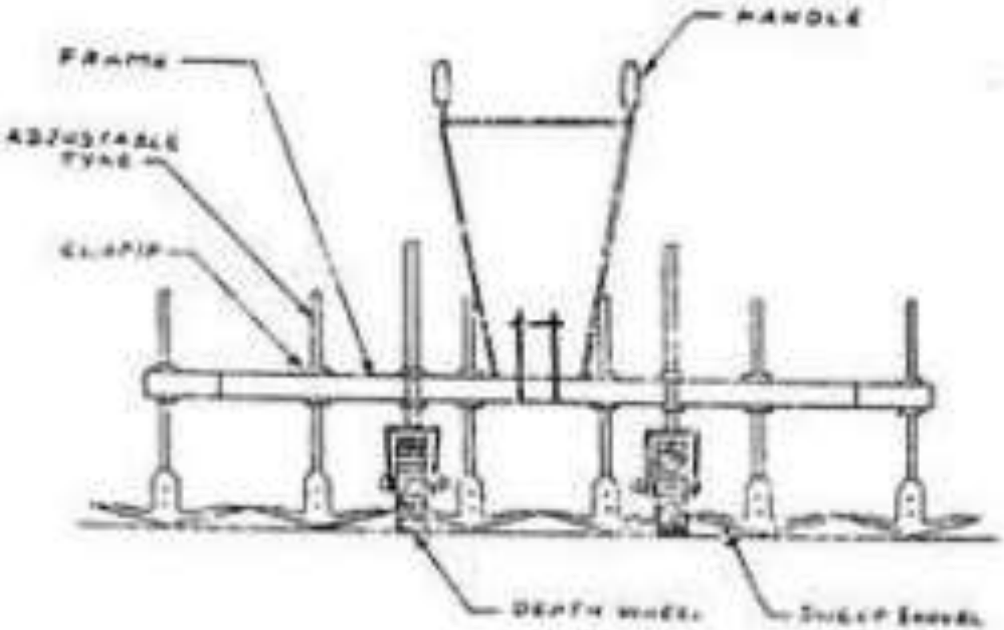


Animal drawn cultivator with seeding attachment

- These are adjustable type.
- Most of the shovel cultivators are provided with 5 to 7 staggered tynes to attach the cultivating tools like shovels, sweeps.
- The whole implement is supported by its tynes on the ground.
- Some of the shovel cultivators are also provided with the seeding attachment.

Sweep

- It is an intercultural implement used for removing shallow rooted weeds in between crop rows.
- It consists of V shaped blades with bevel edged wings called sweeps.
- The blades are fitted to the tynes by means of counter sunk bolts and nuts and the tynes are fitted to a frame.
- By skimming action under the soil at a shallow depth of 2 to 3 cm, the sweep blades cuts the weeds.
- By the cutting action the blades break the capillary passages in the soil and provide soil mulch for moisture conservation.
- The coverage is 1.75 to 2.5 ha/day.

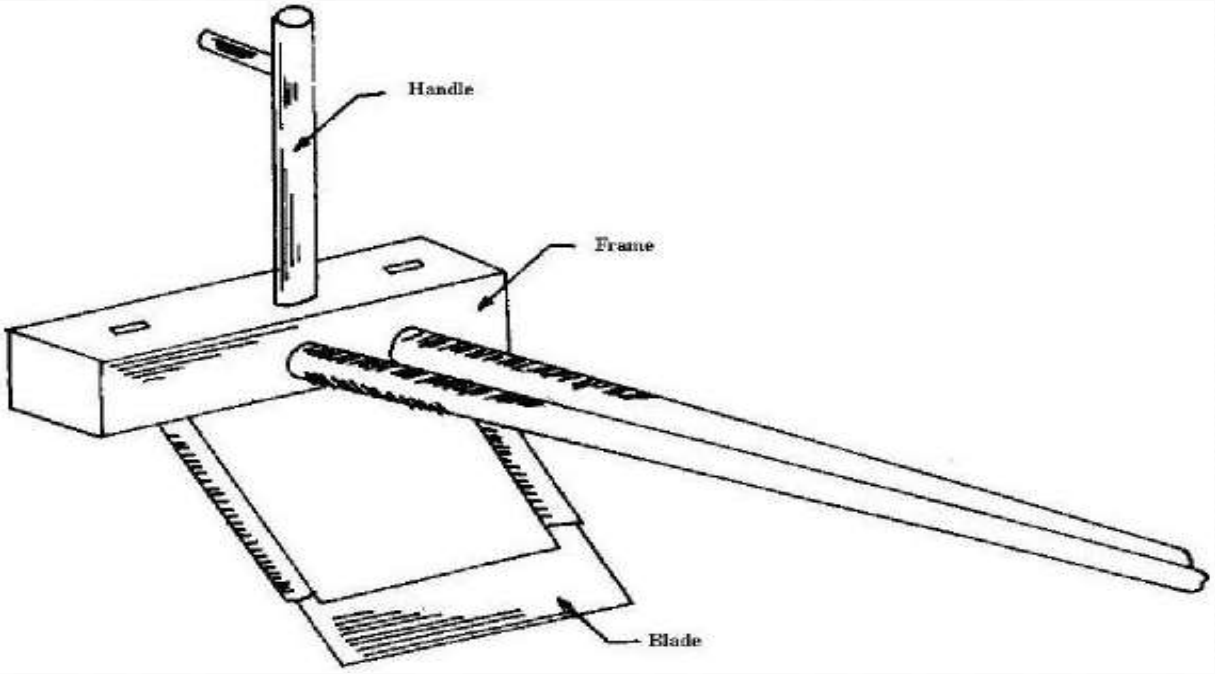


Animal drawn sweep

Blade harrows (*bakhar*)

- It is generally used in clay soils for preparing seedbeds of both *kharif* (rainy season) and *Rabi* (winter) crops.
- It is also used for covering the seed in *Kharif* sowing. The action of blade harrow is like that of sweep, moving into the top surface of the soil without inverting it.
- Sometimes, it is used to chisel out the uncut portion left after ploughing by an indigenous plough.
- The width cut by the harrow varies from 38 to 105 cm.

Blade harrows **are used for different purposes like removal of weeds and stubbles, crushing of clods, working of soil to shallow depth, covering the seeds, inter-cultivation and harvesting of groundnut etc.**



Blade harrow (Bakhar)

Tractor drawn cultivator

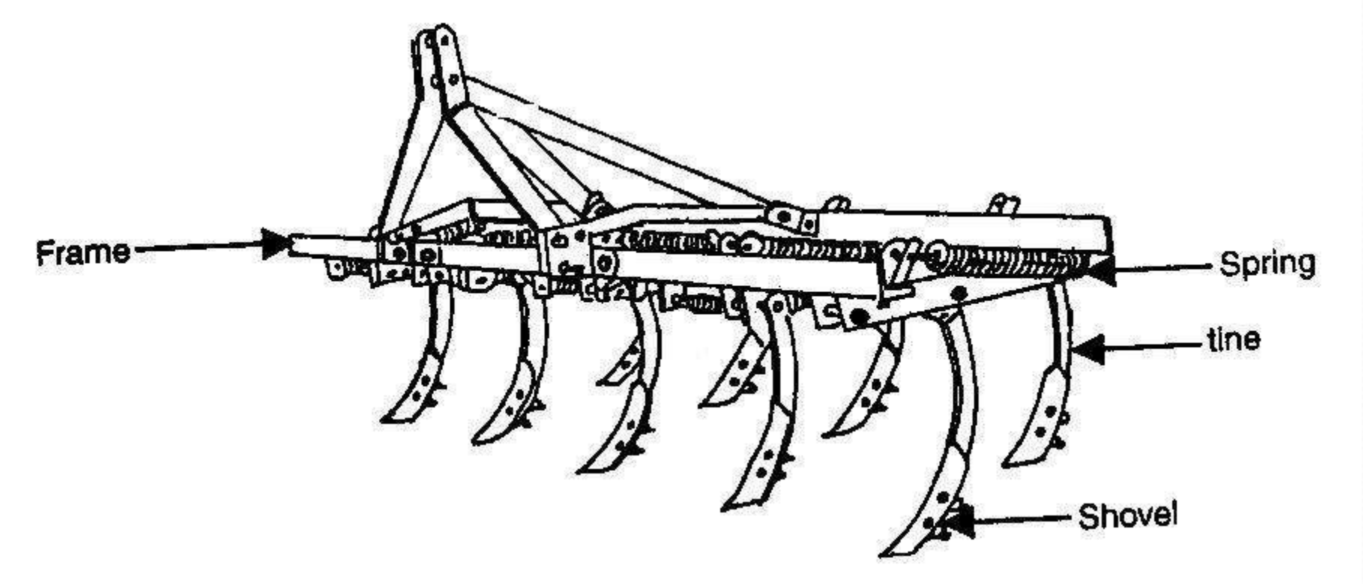
- They are of two types:

(1) Spring loaded tynes cultivator and
(2) Cultivator with rigid tynes

- Tractor drawn cultivators are mostly mounted type.
- Spacing of 7.5 cm or in its multiple can be maintained.

Spring loaded tynes cultivator

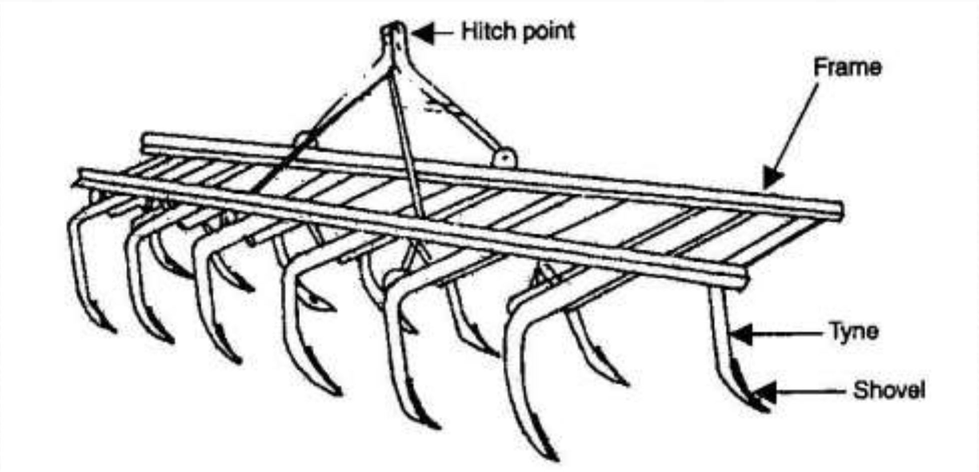
- Each tyne of this cultivator is provided with two heavy coil springs, tensioned to ensure minimum movement except when an obstacle is encountered.
- The springs operate, when the points strike roots or large stones by allowing the tynes to ride over the obstruction, thus preventing damage.



- On passing over the obstruction, the tynes are automatically reset and work continues without interruption.
- The tynes are made of high carbon steel.
- This type of cultivator is particularly recommended for soils which are embedded with stones or stumps.
- A pair of gauge wheel is provided on the cultivator for controlling the depth of operation.
- The cultivator may be fitted with 7, 9, 11, 13 tynes or more depending upon the requirement.

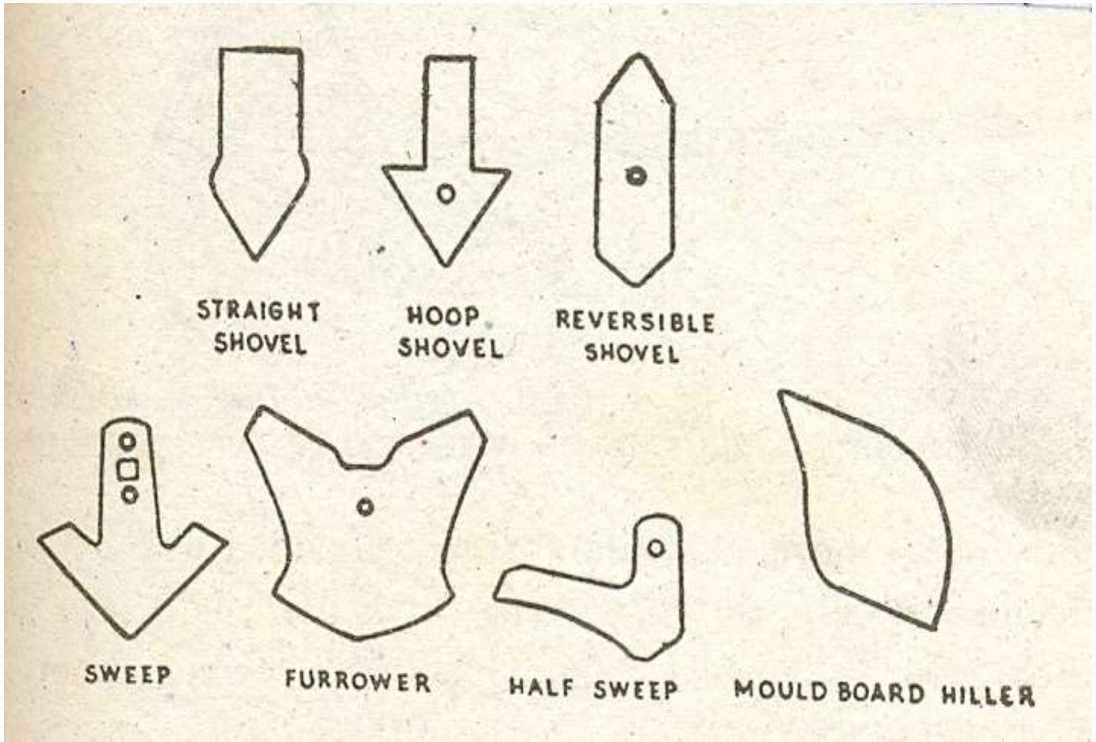
Cultivator with rigid tynes

- Rigid tynes are those tynes which do not deflect during the work in the field.
- Spacing of the tynes is changed simply by slackening the bolts and sliding the braces to the desired position.
- Since rigid tynes are mounted on the front and rear tool bars, the spacing between the tynes can be easily adjusted.
- A pair of gauge wheel is used for controlling the depth of operation.



Tyne or Shovel cultivators

Shovel cultivators are much popular and often used.



Different type of tools used on cultivators

Sweep cultivator

- **In stubble-mulch farming, it is difficult to prepare the land with ordinary implements due to clogging and sweep cultivator is the implements useful under this condition.**
- **It consists of large inverted 'V' shaped blades attached to a cultivator frame.**
- **These blades run parallel to soil surface at a depth of 10 to 15 cm.**
- **They are arranged in two rows and staggered.**
- **Sweep cultivator is used to cut to a depth of 12 to 15 cm soil during the first operation and still shallower during subsequent operations.**
- **It is used frequently to control weeds.**
- **It is also used for harvesting groundnut in many parts of the world.**

Adjustments on cultivators

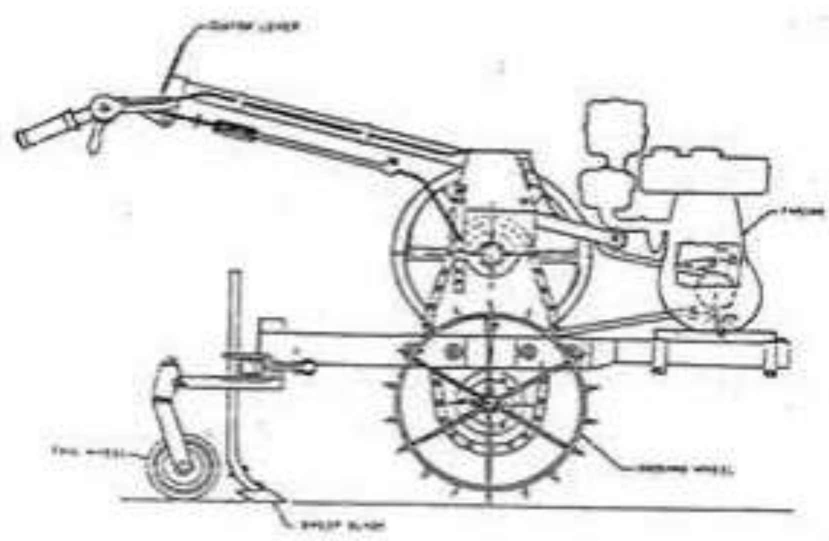
- Setting for proper row width.
- Setting for depth or leveling.
- Turning the shovel on the tyne to throw the desired amount of soil.

Care and maintenance of cultivators

- Periodically check the condition of shovels or sweeps. If points are blunt either sharpen or change.
- Check the setting of shovels or sweeps; adjust for uniform depth of penetration.
- Tight the loose nuts and bolts of frame. If missing replace them.
- Oil and adjust the tension of spring trips.
- In case of trailed or riding cultivators lubricate wheel bearings and replace worn out wheel bearings.

ENGINE OPERATED WEEDER

- It is used for both intercultural and secondary tillage operations namely stirring the soil, uprooting the weeds, breaking clods, covering seeds etc.
- It consists of a 3-hp engine (petrol start kerosene run), a pair of ground wheels, a cultivator frame with sweep or shovel blades, steering clutch, main clutch, handle , a tail wheel and other control levers.



- The engine power is transmitted to ground wheels through belt-pulley and chain- sprocket mechanisms.
- Ground wheels act as traction wheels and pull the cultivator when moving;
- The tynes to be set between rows with sufficient space away from plant stems.
- To avoid any damage to plants. The tail wheel is provided at the rear of the cultivator frame by raising or lowering of which the operating depth of the blades can be altered.
- The field capacity is 0.75 – 1.0 ha per day.

ENGINE OPERATED ROTARY TILLER

- It is a walking type tiller used for plains and hilly regions.
- It is used for both intercultural and secondary tillage operations namely stirring the soil, uprooting the weeds, breaking clods, covering seeds etc.
- It consists of a 3-hp engine (petrol start kerosene run), a rotor with L blades, rotor drive mechanism, handle and other control levers. When engine power is transmitted to rotor, the rotor rotates and till the soil.
- The rotor rotates in the forward direction and hence there is a forward push facilitating the forward movement of the tiller.
- The field capacity is 0.75 – 1.0 ha per day.

- The salient features of the unit are:
- Useful for weeding in row crops like cotton, sugarcane, maize, tomato and pulses whose rows spacing is more than 60 cm.
- Can be used for weeding in orchards, coconut and arecanut fields.
- Suitable for hilly regions also
- Depth of cut is 8-12 cm

Engine operated rotary tiller


Tractor operated rotary tiller

Lect.- 11
Familiarization with sowing and planting equipments

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Sowing

- Sowing is an art of placing seeds in the soil to have good germination in the field.
- A perfect sowing gives correct seed rate, proper depth of sowing and almost same spacing
- between row-to-row and plant to plant.

SOWING METHODS:

(i) Broadcasting
(ii) Dibbling
(iii) Drilling
(iv) Seed dropping behind the plough
(v) Transplanting
(vi) Hill dropping
(vii) Check row planting.

(i) Broadcasting

- Broadcasting is the method of random scattering of seeds on the surface of seedbed.
- It can be done manually or mechanically.
- W hen broadcasting is done manually, uniformity of seed placement depends upon the skill of the man scattering the seeds.
- Soon after broadcasting the seeds are covered by planking or some other devices.
- Higher seed rate is obtained in this system. Mechanically broadcasters are used for large-scale sowing. The device scatters the seeds on the surface of the seedbed at controlled rates.

Broadcast seeder machine

(ii) Dibbling

Dibbling is the process of placing seeds in holes made in the seedbed and closing the seed with soil.
In this method, seeds are placed in holes made at definite depth at fixed spacing.
The equipment used for dibbling is called dibbler. It is a conical shape instrument used to make proper holes in the field.
Small hand dibblers are made with several conical projections made in a frame. This is very time consuming process, so it is not suitable for small seeds, vegetables are generally sown in this way.

Dibbler

(iii) Seed dropping behind the plough

- It is a very common method of sowing followed by farmers in villages.
- This method is used for seeds like maize, gram, peas, wheat and barley.
- A woman/man walk behind a plough, ploughing the land and drop the seeds in the furrows made by the plough.
- Sowing behind the plough can be done by a device known as malobansa.
- It consists of a bamboo tube provided with a funnel shaped mouth. It is fitted to the handle of the plough.
- One man drops the seeds through the funnel and other man handles the plough and the bullocks. This method is a slow and laborious method.

(iv) Drilling

- Drilling consists of dropping the seeds in furrow lines in a continuous stream and covering them with soil.
- The spacing between the seeds is not uniform. Seed metering may be done either manually or mechanically.
- The number of rows planted may be one or more. This method is very helpful in achieving proper depth of sowing, proper spacing between seeds and proper seed rate.
- Drilling can be done by using seed drills of tractor drawn and animal drawn types.

(v) Transplanting

Transplanting consists of raising the seedlings in a nursery bed and then planting the seedlings in another field (main field).

It is commonly done for paddy, vegetables and flowers.

It is a time consuming operation.

Equipment used for planting the seedlings in the main field is called transplanter.

Rice trasplanter

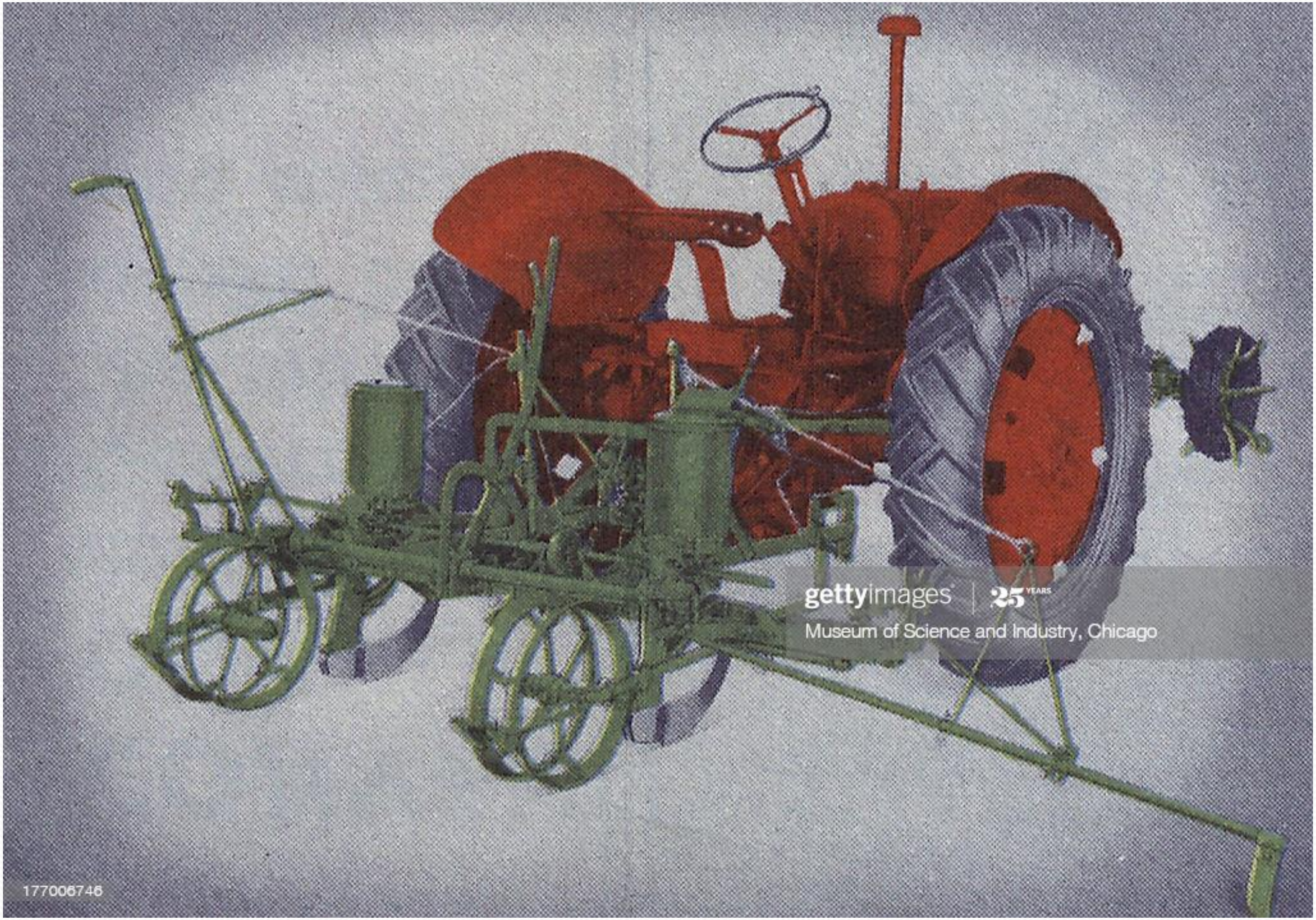
(vi) Hill dropping

- In this method, few seeds are dropped as a hill at a fixed place and not in a continuous stream.
- The spacing between hill to hill in a row is constant.
- The equipments are called planters.

(vii) Check row planting

- It is a method of planting, in which row-to-row and plant-to-plant distance is uniform.
- In this method, seeds are planted precisely along straight parallel furrows.
- The rows are always in two perpendicular directions.
- A machine used for check row planting is called check row planter.

Check row planter



Seed drill

- Seed drill is a machine used for placing the seeds in a continuous stream in furrows at uniform rate and at controlled depth with an arrangement of covering the seeds with soil. According to the power source used, seed drills may be classified into (i) Bullock drawn seed drills (ii) Tractor drawn seed drills.
- According to the type of seed metering done animal drawn seed drills may be classified into i) manually metered seed drills and ii) mechanically metered seed drill.
- In manually metered seed drills a person drops the seeds in the furrows, in mechanically metered seed drills a mechanical device called seed metering mechanism is used to meter the seeds.
- There are many designs of bullock drawn seed drills and tractor drawn seed drills which are used for sowing.

Gorru

Seed Drill for Wheat

Bullock drawn seed drill

Tractor drawn seed drill

Planter

- Planter is a sowing equipment used for sowing those seeds which are larger in size and cannot be handled by seed drills.
- Row to row and plant to plant spacing is maintained in a planter.
- Potato planter, maize planter, cotton planter are popularly used.

Function of a planter:

(i) to open the furrow
(ii) to meter the seed
(iii) to deposit the seed in the furrow
(iv) to cover the seed and compact the soil over the seed.

Components of a planter:

A planter consists of:

(i) Hopper
(ii) feed metering device
(iii) knock out mechanism
(iv) cut-off mechanism
(v) furrow opener
(vi) furrow closer
(vii)Drive mechanism
(viii) clutch etc.

A planter has separate seed hopper for each row. Hopper is usually made of mild steel or any other suitable material.

Seed metering device in a planter:

- There are a number of seed metering devices available for use in a planter.
- The most common device is a rotating circular plate with cells which is provided at the bottom of seed hoppers.

Cut-off mechanism:

- It cuts-off or brushes out or removes the excess seeds carried away by the cells thus allowing corrected number of seeds for delivery.

Knock out mechanism:

- It is a device which knocks out the seeds from the rotor cells .
- It consists of rollers or star wheels which by pressure releases the seeds from the cells.
- Seeds fall in to the seed tube and reach the furrow.

Spacing of seeds or hills:

The spacing of seeds or hills in the row is determined by the ratio of peripheral speed of the rotor to the forward speed of the planter and the spacing between the cells in the rotor.

The accuracy of the planter depends upon several factors such as:

(i) speed of seed plate
(ii) shape and size of cells
(iii) shape of hopper bottom and
(iv) uniformity of seed size.

Potato planters

Lect.-13
Familiarization with harvesting & threshing equipments.

Harvesting

It is the operation of cutting, picking, plucking digging or a combination of these operations for removing the crop from under the ground or above the ground or removing the useful part or fruits from plants.

Harvesting action can be done by four ways:

- Slicing action with a sharp tool.
- Tearing action with a rough serrated edge.
- High velocity single element impact with sharp or dull edge.
- Two elements scissors type action.
- The harvesting involves slicing and tearing action. The harvesting can be done either by manually operated tool or animal drawn equipment or mechanically operated machine.

NIPPING

PICKING

MECHANICALLY OPERATED MACHINE

canopy shake catch harvest system

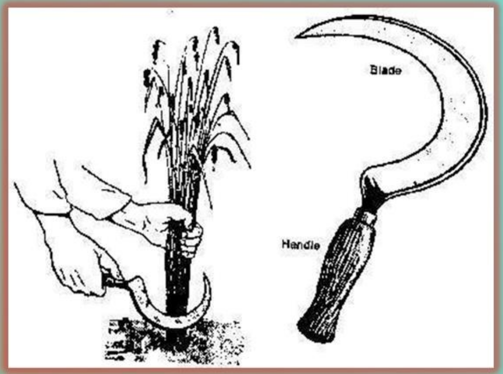
SICKLE

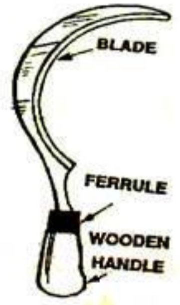
Sickle is a simple harvesting tool. It is used for harvesting crops and cutting other vegetations. It essentially consists of a metallic blade and a wooden handle.

- SICKLES ARE CLASSIFIED INTO TWO CLASSES,

  i) Plain

  ii) Serrated





Teeth of serrated sickle are made sharp for efficient working in the field. The handle of the sickle is made of well seasoned wood. The forged end of the blade for fixing the handle is called tang. Protective metallic bush fitted at the junction of the blade and the handle to keep the tang tight in the handle is called ferrule. Harvesting by sickle is a very slow and labour consuming device.

The plain or serrated edge in the inner side of the blade is used for cutting the crop and hence called cutting edge.

Manual cutting and hauling

- **Capacity:** 0.07 ha/person day
- **Advantages**
  - effective in lodged crop
  - less weather dependent
- **Problems**
  - high labor cost
  - labor dependent, competes with other operations in peak season
  - winnowing/cleaning necessary

MOWER:

It is a machine to cut herbage crops and leave them in swath.

- **There are different types of mower used in different ways such as,**

- Cylinder Mower.
- Reciprocating Mower
- Horizontal Rotary Mower:
- Gang Mower
- Flail Mower

Classification of mowers

According to the cutting tool mowers are classified in to the following types such as:

(i) Cylinder mower

(ii) Reciprocating mower

(iii) Horizontal rotary mower

(iv) Gang mower and

(v) Flail mower.

i) **Cylinder mower:** It has rotating helical blades arranged in cylindrical form. With the rotation of blades, forage or grasses are cut continuously.

It is used for trimming grass in lawns, golf grounds etc.

(ii) Reciprocating mower: It is a mower with a knife made of several serrated triangular sections that reciprocate against stationary fingers.

The knife cuts the crop by its reciprocating action. It is the most common type of mower used for harvesting forage crops and food grain crops like paddy and wheat.

iii) Horizontal rotary mower: It is a mower with high speed knife rotating in the horizontal plane. Due to rotation of knife, the grass and forage are cut uniformly. Used for trimming lawns , golf grounds etc.

(iv)Gang mower: It is an assembly of two or more ground driven cylinder mowers. It is used for trimming grass in lawns, golf grounds etc.

v) Flail mower: It is a mower with high speed swinging knives, operating either in the horizontal plane or in the vertical plane.

Used to cut herbaceous weeds like parthenium.

CONVENTIONAL MOWER

The conventional mower mainly consists of:

i) A metallic frame

(ii) Power transmitting unit and

(iii) Cutting bar

Frame

- The frame provides space for fitting gears, clutch, bearings, flywheel etc required for the operation of the harvester.
- A lever is used for lifting the cutting bar during road travel.
- A flywheel is used to store energy from the engine to supply steady energy to the cutting mechanism for uniform cutting.

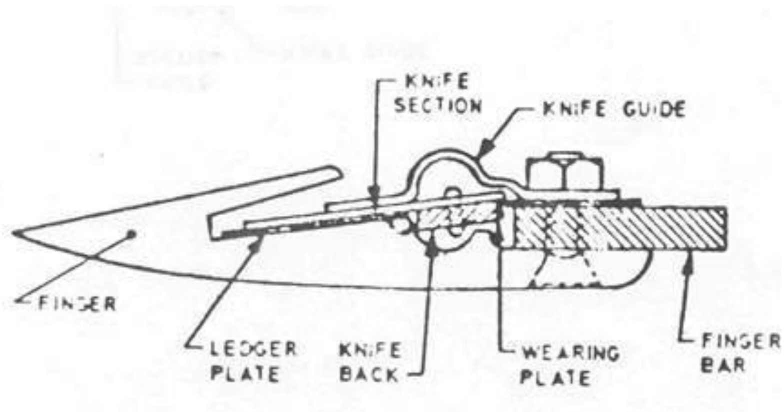
Power transmitting unit

It transmits the power from the power source either from the ground wheel in animal drawn mowers and from PTO for tractor drawn mowers to the cutting tool.

In tractor drawn semi-mounted or mounted type mowers the cutter bar is operated by P.T.O. shaft of the tractor. A carden shaft transmits drive from PTO to the V pulley of the harvester. From V pulley, drive reaches the knife through gears, crank wheel, connecting rod and pitman. The knife reciprocates and cuts the crop .

Cutter bar

- It is an assembly of several parts comprising of a knife, fingers, wearing plates, ledger plates, guides and shoes.
- The knife cuts the grass or grain crop by its reciprocating action.
- It is a metallic rectangular bar, on which triangular sections are mounted.
- The knife sections make reciprocating motion inside the fingers and cuts the plants.
- There are knife guides with clips to keep the knife sections very closely on the ledger plates for effective cutting action.
- The knife stops at the centre of the knife guard (finger) on each stroke which indicates good registration..



Shoe - A shoe is always provided on each end of the cutter bar to regulate the height of cut and to provide easy and smooth sliding of the cutter bar on the land.

Knife - It is the reciprocating part of the cutter bar, comprising of knife head, knife back and knife sections.

Pitman - Pitman is the link between the knife and crank wheel of the mower. It transmits motion to a knife. Wooden pitman is commonly used for the mowers which acts as safety device.

It breaks and protects the cutter bar from damage when ever the knife is locked by some obstacle or choked by the crop.

Connecting rod - It is placed between pitman and crank wheel. It converts rotary motion of crank wheel in to reciprocating motion of the knife.

Breaking of knives - Breaking of knives is a common trouble in operation of a mower. It is caused due to play in bearings and worn out knife head holders. Non-alignment is an important cause for breaking the knife because when the mower is out of alignment, it works on a certain angle which is always harmful.

Alignment of mower

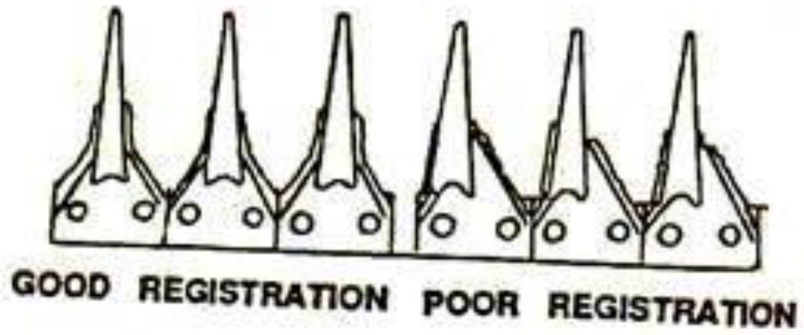
- **Under working condition, the standing crops exert pressure on the cutter bar tending to push it backward.**
- **In correct operating position, the crankpin, knife head and the outer end of the knife should be in a straight line.**
- **This line should be at right angle to the direction of travel of the mower.**
- **For achieving this object, the cutter bar is set at about 88° to the direction of motion i.e. inward lead of 2° is given to it in order to overcome the back pushing action of the crops.**
- **When the cutter bar is properly aligned, the knife and the pitman run in a straight line. This gives better cutting of the knife in the field.**
- **Generally 2cm lead per metre length of cutter bar is recommended.**

Registration of mower

A mower knife is said to be in proper registration when the knife section stops in the centre of its guard (fingers) on every stroke i.e. the centre of the knife section is at the centre line of the guard, when it is in operating condition.

Adjustment is commonly made by moving the entire cutter bar in or out with respect to the pitman.

If mower is not well registered, there is unbalanced load, uneven cutting and excessive clogging of crops on the knife.



REAPER

Reaper is a machine to cut grain crops.

- Animal drawn reaper is getting popular gradually in the country.
- It is pulled by a pair of animals.
- It can harvest nearly 5 to 8 cm above the ground.

- ✓ **Frame** is usually made of mild steel sections.
- ✓ **The cutter bar knife** is made of high carbon steel.
- ✓ **The shoes** are usually made of malleable casting.
- ✓ **Ball bearings** are used for efficient and durable working.

Mechanical reaping

- **Capacity**: 2-4 ha/d
- **Advantages**
  - Fast cutting
- **Problems**
  - Places crop in window back in the field
  - Problem with lodged crop
  - Complex cutter bar and conveying mechanism

Self walking type

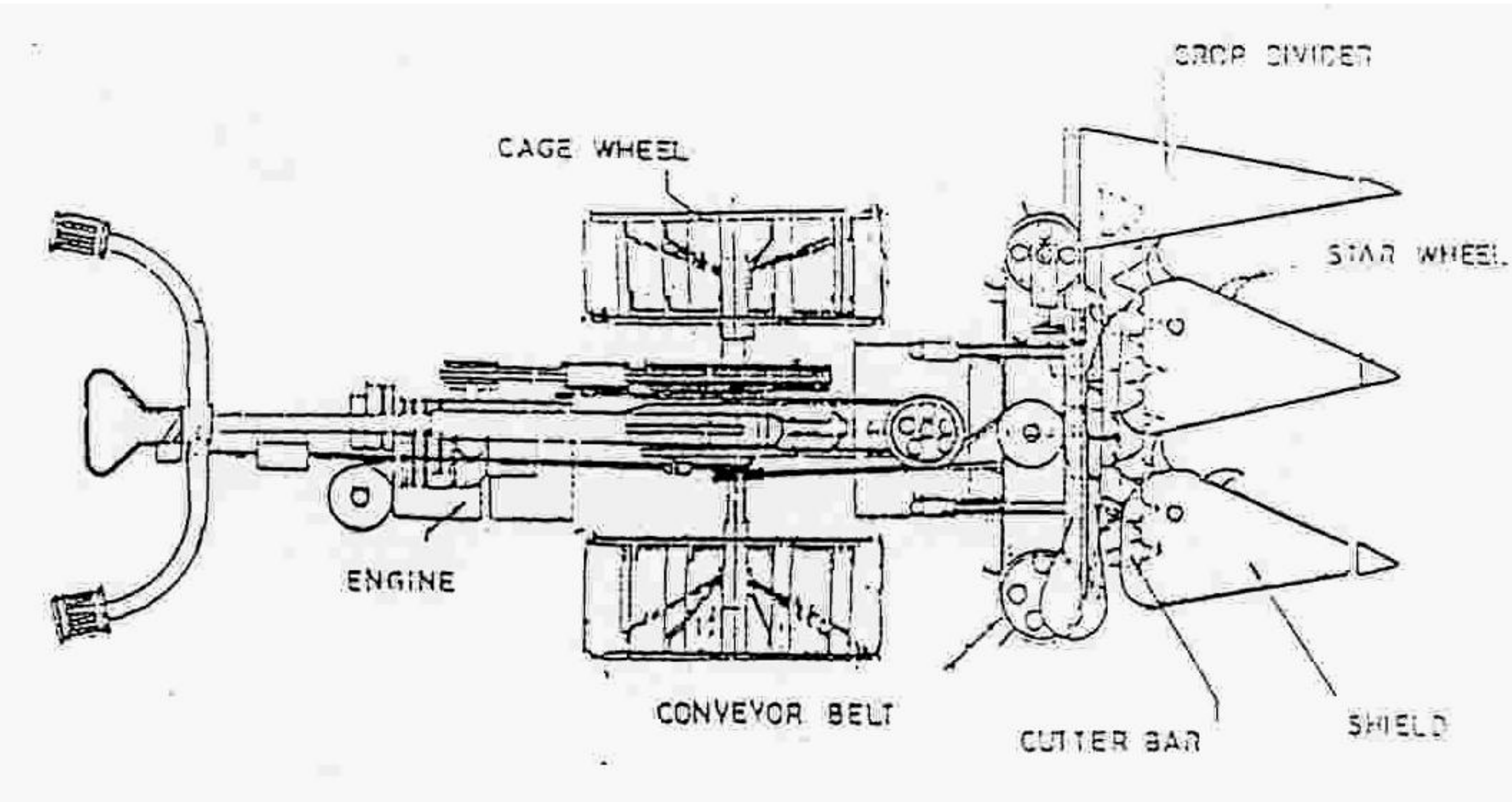
Tractor mounted reaper

Back mounted Reaper

Reaper (Self operated/Tractor mounted):

- It is mostly used for harvesting paddy and wheat. The reaper which is front mounted at the tractor, can be lowered and raised by the hydraulic control.
- It is powered by the PTO of the tractor. Crop *is guided by the star wheel to the cutter bar and held in* vertical position by the springs. The crop is conveyed to the side by the conveyer belt.
- Its capacity may be 0.4-0.6 ha/h.

Self propelled Reaper



Power tiller operated Reaper

- It can be used for harvesting wheat and paddy. T**he** reaper is front mounted on the power tiller. Power is transmitted from the engine fly wheel to the reaper either through V belt or by providing gear box and propeller shafts.
- Crop is guided by the star wheels to the cutter bar and held in vertical position by the springs. The crop is conveyed to the side by the conveyor belt.
- Cutter bar length may be 100-160 cm. The capacity may be 0.25-0.35 ha/h.

Self Reaper Binder

- Reaper-Binder is a unique harvesting machine that reaps the crop as well as binds it simultaneously.
- This Innovative Mechanical machine ensures 100% recovery of straw with negligible grain losses at a low cost of operation.
- This machine is mainly used in Wheat, Paddy, Oats, Barley and other grain crops.
- Used for Grain crops of Height up to 85 to 110 cm.
- Field capacity of 1 acre / hour can be achieved by

10.2 hp Diesel engine.

Care and Maintenance

1. Wheel hub bearings, flywheel shaft bearings and pitman bearings should be well lubricated.

2. Knife bar should be sharpened at regular interval. It is desirable to sharp the knife after about 30 working hours.

3. All the nuts bolts should be checked before taking the machine to the field.

Straw reaper

Potato Harvester

Potato Harvester

- On large size farms where potato cultivation is practiced on commercial scale, animal drawn cultivators or country ploughs were used for harvesting the potatoes. However, the implement consisting of a ridge bottom and a replaceable bar point share has been successfully employed for this purpose. The potato soil mass while moving on the rods provided at the back of the share, gets separated. The potatoes are then dropped on the ground which is later collected manually. The same implement has been modified and can be hitched by a power tiller also. The animal drawn groundnut digger can be successfully used for digging of potatoes.

Potato Harvester

- A potato digger suitably designed to be operated as a mounted machine by a tractor. The potato harvester is used extensively for harvesting potatoes in Northern States of India. The machine uses conventional digging blade and a shaker conveyor made of steel rods. As the tractor with the machine moves over the field, the soil and potatoes are dug out and lifted on the conveyor chain. The soil is shaken out by agitation where as the potatoes are collected in bags.
- The tractor operated potato digger consists of a three point hitch frame, main frame, and two column frames with blade. Blade is fixed to with two detachable ridge opening devices. On the sides of the columns, two furrow guides are provided for stability of the digger. Two replaceable high carbon steel shovels are fitted in front of the blade for easy penetration in dry field conditions and to prevent it from wear.

Tractor powered potato digger

The tractor powered potato digger can be conveniently divided into four broad categories:

- Blade type diggers,
- Single row spinner digger type machines,
- Single or double row elevator diggers,
- Oscillating / vibrator diggers.

The most common among the four designs as stated above is the elevator type digger. The commercial machines are of both single row and two row types. The machine consists of a shovel type digger and endless elevator to complete the total operation.

Potato harvester

Fixed height with wooden head and metal blade harvester

- This type of harvester has a light weight cutting mechanism made of a light bamboo pole.
- The components of the harvester include, a wooden head, a metal blade, a spring, a fruit collecting net, a wooden pole, a hand lever and nylon rope.
- The cutting mechanism of the harvester consists of the wooden head, the cutting blade and the retaining spring.

- At about 380 mm from the bottom end, a hand lever is fitted to the pole.
- The metal cutting blade on the top and the hand lever are connected by a nylon rope of 3.2 m length.
- By pushing the hand lever down, the blade moves against the head and cutting takes place.

Adjustable height with metal head and metal blade harvester

- In this type of harvester, the cutting mechanism is similar to the fixed height type harvester.
- The variations are only in head and pole length to achieve increased adjustable height up to 5.4m. An additional base plate is provided at the bottom of the pole.
- The cutting head was fabricated out of angle iron of 191 X 115 X 6 mm size. The pole is composed of two G.I. pipes of 12 mm and 18 mm sizes. One can be inserted in to the other.
- This telescopic arrangement of poles is helpful in varying the height. The pole can be fixed at any desired height by a clamp arrangement, thus making it flexible.

Thresher

Thresher is a machine to separate the grain from harvested crop. It may be foot operated (Pedal thresher) or engine/electric motor operated.

Threshing can be accomplished by any of the three methods or their combinations-

(1) rubbing action

(2) impact action and/or

(3) stripping action.

Foot operated thresher

- Most of these threshers are **‘hold on’ type thresher** where the operator grabs the bundle and holds the panicle end against the wire loop of the rotating drum.
- These threshers were originated in Japan and are now being used in most of the paddy growing countries. It’s output ranges from 40-45 kg/hr.

Power operated ‘hold on’ thresher

- The 'hold-on' thresher, is so-called because the bundles are held by a chain conveyor which carries them and presents only the panicles to the threshing cylinder, keeping the straw out. According to the condition of the crop, work rates can range between 300 kg and 700 kg per hour.

‘**Throw in’(or feed - in) type thresher:**

Whole plants are fed into the machine and a major portion of the grain is threshed by the initial impact of the bars or spikes on the cylinder.

General purpose thresher:

Application- Useful for wheat, barley, gram, peas, sorghum, jowar, bajra and mustard.

Power system- Electric motor of 3.5 KW or engine of 5 KW.

Capacity- For wheat- 200 kg/hr

Drive speed- 550- 850 rpm

Labour requirement- 3 labour at a time

Thresher components:

1. Feeding unit

It includes feed carrier, feed rack, bend cutter, governor (speed controller of cylinder or quantity controller.

2. Threshing unit

The unit comprises cylinder and concave. The cylinder speed is an important feature.

3. Separating unit

Grates-iron rods placed parallel to each other, grates are placed just behind the cylinder,

Straw racks – They are operated with the help of a crank (200-250 rpm). Its main function is to separate the grain from chaff.

Beater - It prevents the deposition of crop residues on the cylinder and help in throwing the threshed material on straw rack.

Grain pan – It is kept below straw rack

Check board – It is made of iron and prevents the grain to come out from the backside of machine.

4. *Grain cleaning unit*

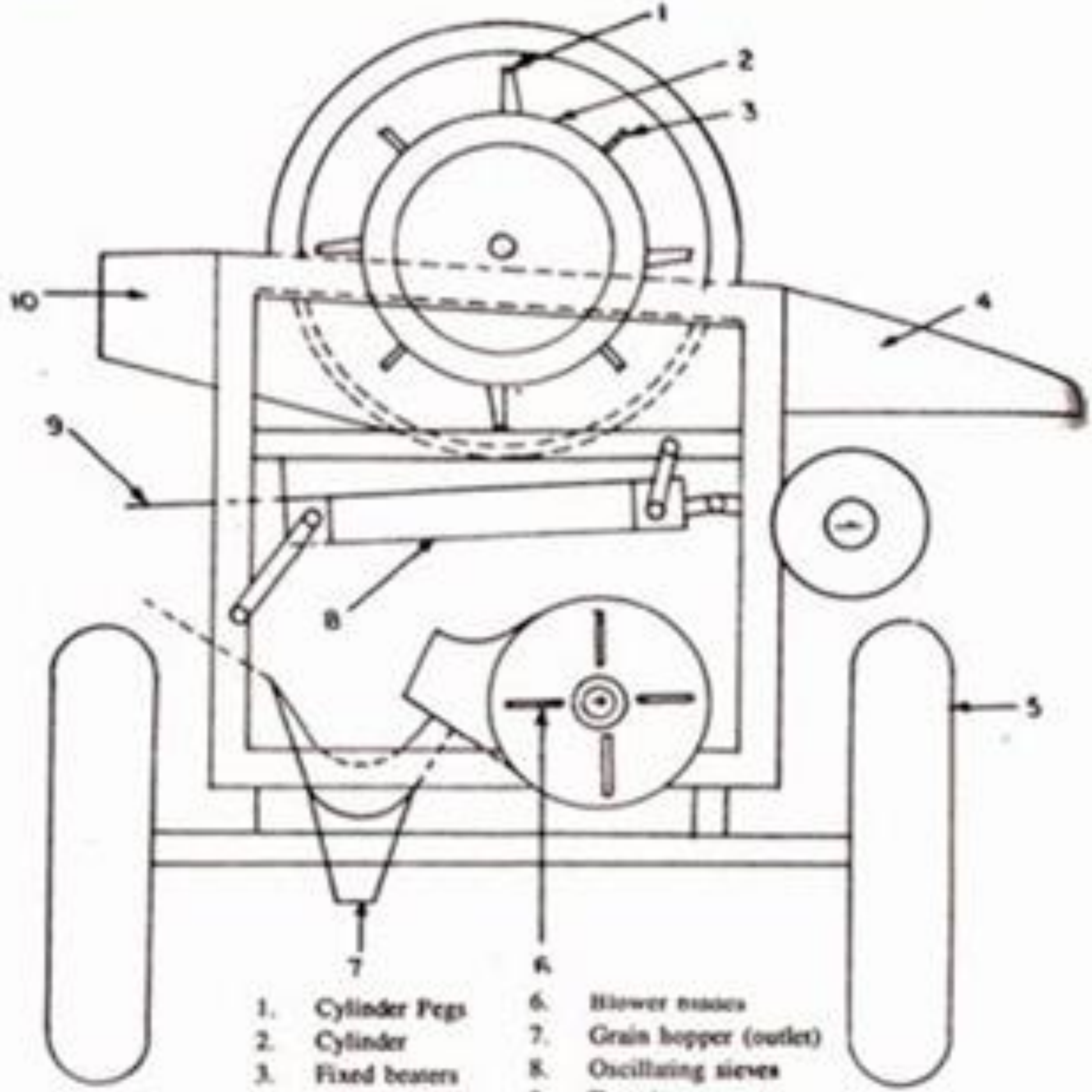
Shoe – Unit consists of sieves.

Chaffer – It is connected with gain pan. It separates the grain.

Chaffer extension- It is sieve of big holes and useful to separate unthreshed material.

Tailing auger elevator- Its function is to send unthreshed material to elevator which conveys them back to threshing.(optional)

Fan- It allows the separation of chaff and dust due to high velocity.



1.	Cylinder Pegs	6.	Blower blades
2.	Cylinder	7.	Grain hopper (outlet)
3.	Fixed beaters	8.	Oscillating sieves
4.	Feeding Schute	9.	Top sieve
5.	Transport Wheels	10.	Discharge outlet

Operational details/working of a thresher:

- The crop is fed to the threshing chamber through the feeding chute (trough).
- It is threshed due to the impact and rubbing action between the threshing drum loops (or spikes) and concave screen.
- The threshed grain fall through the holes of the concave screen on the grain slide plates and there it slides to fall free through the air stream generated by the blower for winnowing action.
- The grain then fall to the sieves where under sized seeds or weeds etc. are passed down due to shaking mechanism of the cleaning unit and the clean grain is ready to go through the out let.

Performance of a thresher

The performance of thresher is generally affected by crop factors, machine factors, operational factors and human factors affecting the other three factors of the system as a whole.

Bureau of Indian Standard (BIS) have specified that the total grain loss from a mechanical thresher should not be more than 5 per cent in which broken grain should be less than 2 per cent.

Also, the clean grain received after threshing should not have foreign matter more than 2 per cent.

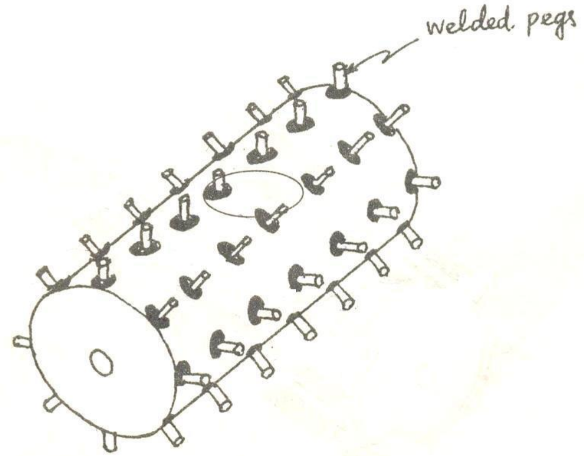
Size of power thresher

- The size of power thresher is expressed in terms of widths of cylinder and straw rack.
- For e.g. 0.60 m by 0.90 m means the thresher has 0.60 m wide cylinder and a0.90 m wide straw rack at the back.

Types of power thresher according to the type of threshing cylinder used

Spike tooth type:

- Spikes are mounted on the periphery of the cylinder.
- As the cylinder rotates, its teeth pass between the stationary teeth of the concave.
- The teeth tear and shred the material instead of rubbing them which cause threshing action.

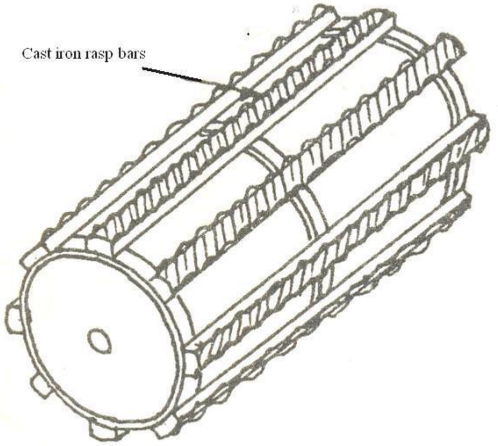


Rasp bar type:

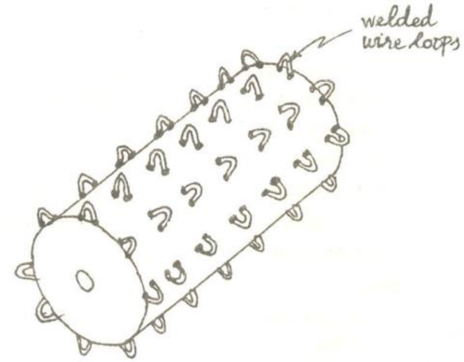
The rasp bar cylinder consists of a number of corrugated steel bars mounted axially on the periphery of the cylinder.

The corrugation on the bars run opposite on adjacent bars.

These corrugations provide rubbing action on the crop as it passes through the threshing area.



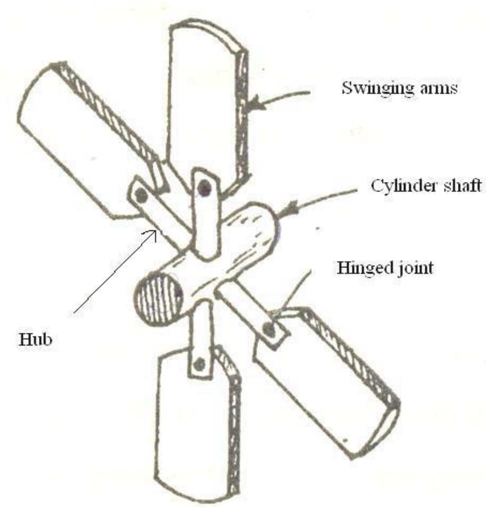
Wire loop type: Wire loops are provided on the periphery of a closed type cylinder and woven wire mesh is provided at the bottom.



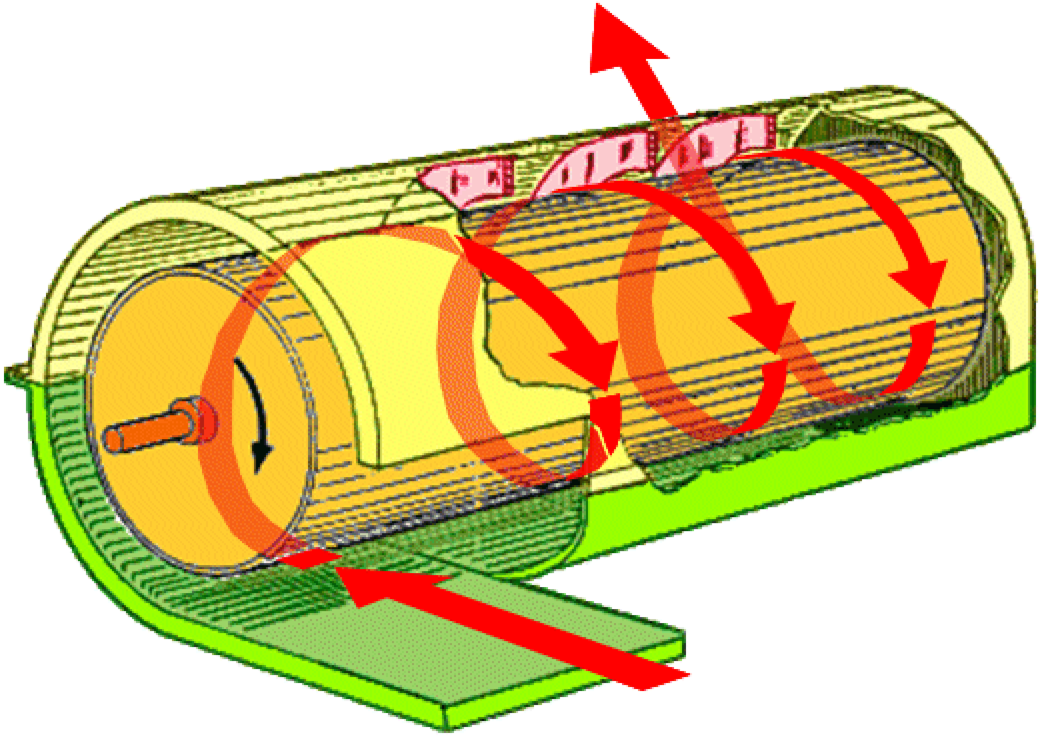
Drummy type: It consists of beaters mounted on a shaft which rotates inside a closed casing. The concave is made up of square bars.

Beater or hammer mill type: This is a modification of the drummy type and is provided with an aspirator blower at the main grain outlet for final cleaning.

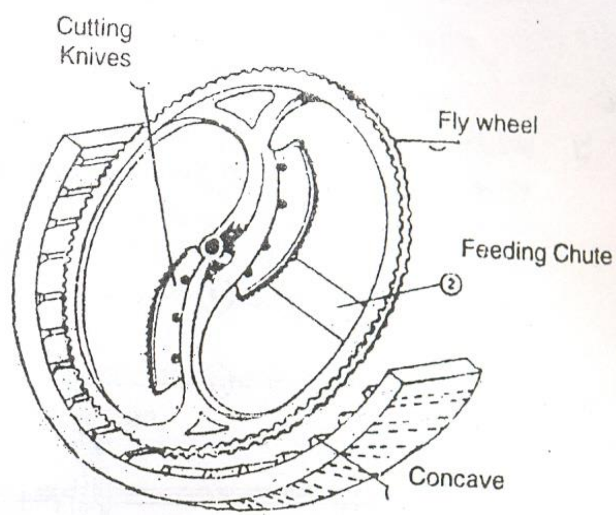
- It is suitable only for wheat and produces very fine bhusa but the power consumption is very high.



Axial flow type:
It consists of a spike tooth cylinder,
wire woven mesh concave and upper casing provided with
helical louvers in such a manner that the crop inside moves from one end to the other during threshing.



Syndicator type: The cylinder consists of a flywheel with corrugations on its periphery and sides which rotates inside a closed casing and concave. The cutter blades have serrated edge to prevent slippage of dry stalk while shearing through it.



SYNDICATOR TYPE

General problems and recommended adjustments

Problem	Adjustment
Un-threshed grain in ear heads	▪Increase cylinder speed ▪Reduce cylinder-concave clearance ▪Feeding should be uniform
Cracked or broken grains	•Reduce cylinder speed •Increase cylinder-concave clearance
Straw wrap around cylinder	•Increase cylinder speed
Grains blows with straw	•Decrease the fan speed •Clean the sieve holes
Straw is coming with grain	•Adjust the fan speed •Use proper size of sieves •Clean the concave •Adjust the straw rack speed
Vibration in thresher	•Install the thresher properly •Tighten the bearing

Precautions and care in the operation of a thresher.

- The machine should be installed at a leveled surface as far as possible.
- The direction of the machine should be set inconsonance with the direction of the prevailing wind.
- The machine should be fixed in the ground with the help of suitable pegs or by digging into the ground.
- The thresher should be operated at the speed recommended by the manufacturer.
- Suitable size of pulley should be provided on the thresher to operate the cylinder at recommended speed.

- The feeding should be continuous and uniform.
- Bearings and other working parts should always be properly greased and oiled.
- Before starting the machine, the main pulley should be driven by hand to ensure that there is no obstruction inside the machine.
- While feeding, care is to be taken that crop should be free from any wooden or iron pieces.
- It is desirable to dry the crops before feeding, as far as possible.

- The sieves should be inspected frequently and cleaned from time to time to avoid clogging.
- While feeding, the operator should not insert his hand deep in the feeding trough.
- After continuous working for 8 to 10 hours, the machine should be given some rest before it is put into operation again.
- After threshing season, all the belts should be removed and the machine should be kept in a covered place.

COMBINE HARVESTER AND THRESHER

- It is a machine designed for harvesting threshing separating cleaning and collecting grains while moving through the standing crops.

The main function are:

1. Cutting the standing crops
2. Feeding the cut crops to threshing unit
3. Threshing the crop
4. Operating and maintenance is costly.

Harvesting systems
Combine harvesting

- **Cutting, hauling, threshing, cleaning in one combined operation**
- **Capacity: > 0.5 ha/h**
- **Labor requirement: 1 Operator**

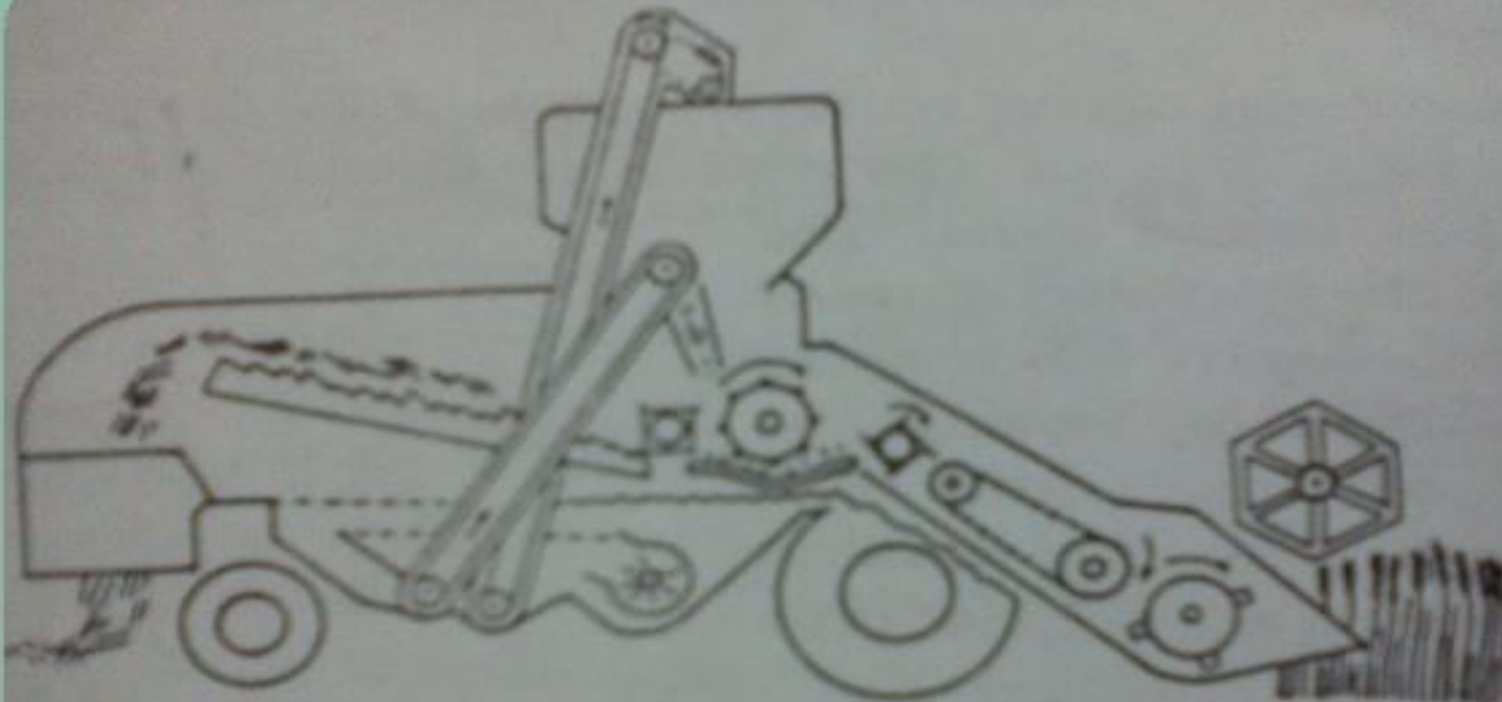


Fig. 17.18. Combine Harvester Thresher

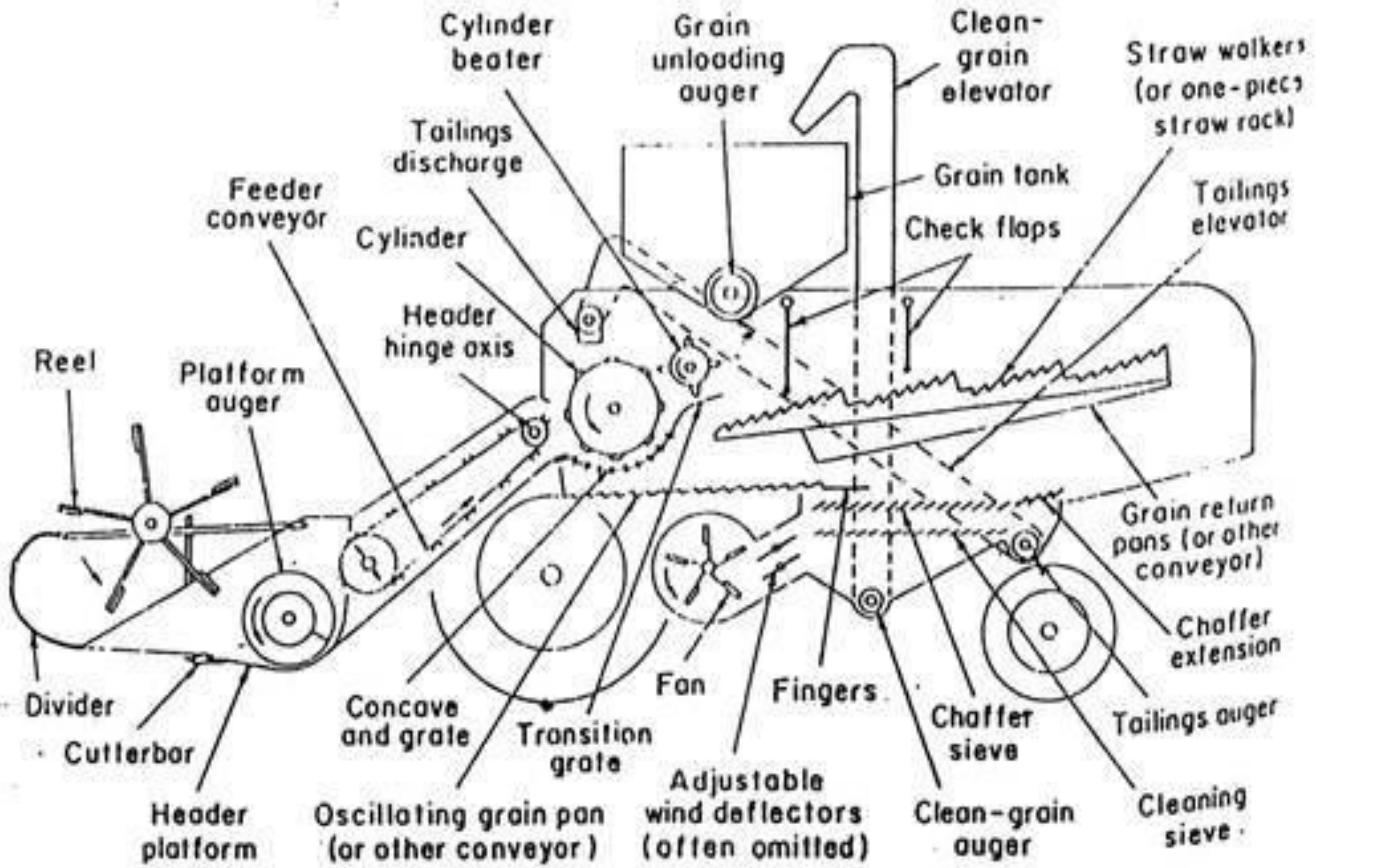


Fig. Schematic arrangement of the basic functional components of a typical self-propelled combine.

- **A combine may be self-propelled type and PTO driven type.**
- **Self propelled type This has got its own dependent engine. This engine gives power for operating all the mechanisms as well as for pulling the weight of the combine. Size varies from 2-4 m.**
- **PTO driven type This combine is pulled by a tractor. The tractor pulls the combine by its tractive power. The power takes off shaft of the tractor supplies power to the cutting and threshing mechanisms.**

ADVANTAGES OF COMBINE HARVESTER AND THRESHER

1. It save the cost of harvesting and threshing the crops.
2. It reduces the labor requirement of the field.
3. It clean the field the earlier , which permit easy dry weather farming.
4. As the grain come in hand earlier there is every possibilities to get good profit in the market.

DISADVANTAGES

1. Higher initial cost
2. Un-adoptable for mixed farming
3. It can not be used in fragmented piece of land
4. Heavy loss of grain.