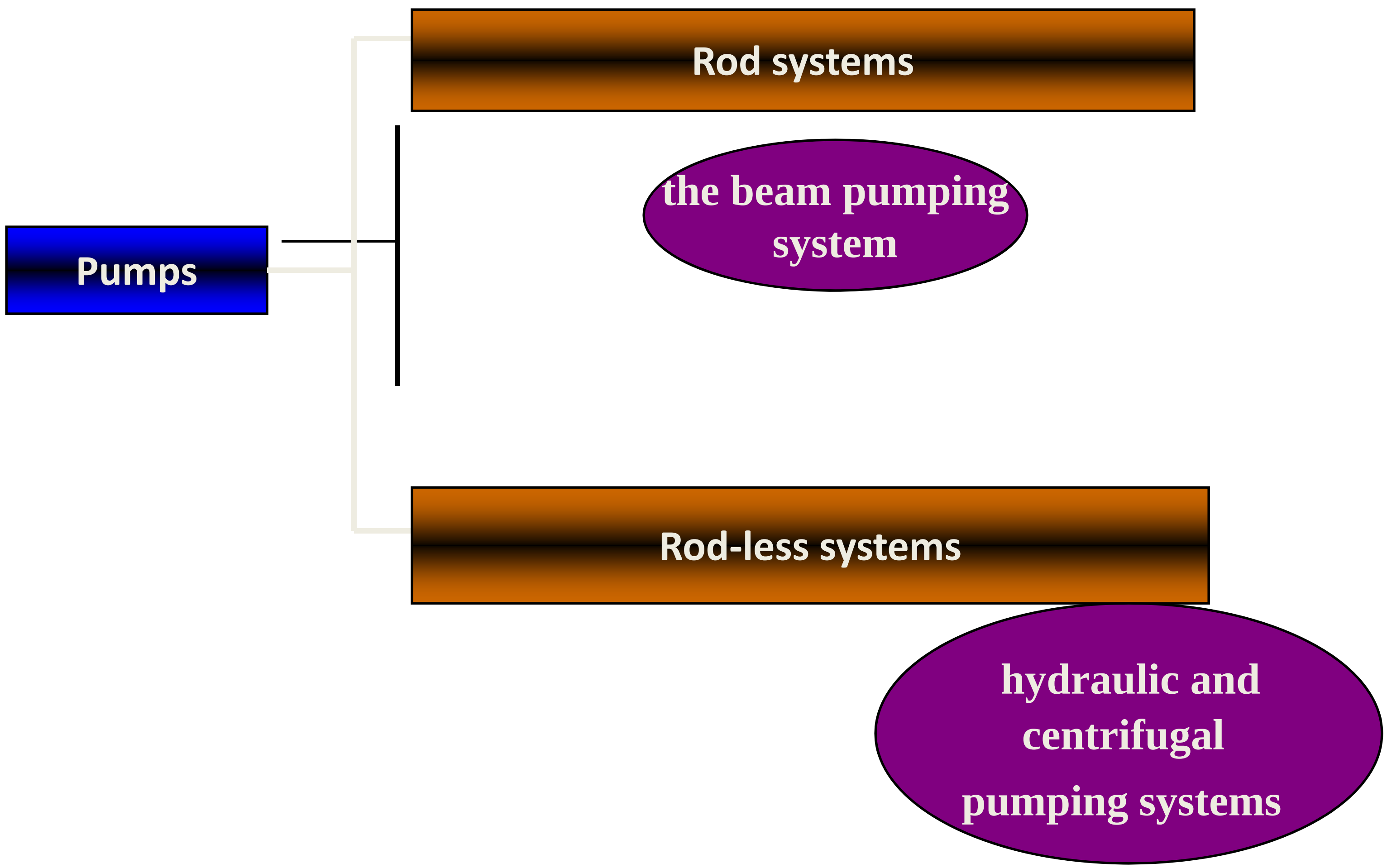
PUMP CLASSIFICATION



PUMP CLASSIFICATION

Pumps

- **kinetic Pumps**

  Represented by centrifugal pumps

- **positive displacement Pumps**

  Represented by reciprocating pumps

Character of the kinetic pump

1. In a kinetic pump energy is added continuously to increase the fluid's velocity within the pump to values in excess of those that exist in the discharge pipe.
2. Passageways in the pump then reduce the velocity until it matches that in the discharge pipe. From
3. Bernoulli's law, as the velocity head of the fluid is reduced, the pressure head must increase.

- **Bernoulli's Theorem**

1. It is customary to express the energy contained in a fluid in terms of the potential energy contained in an equivalent height or "head" of a column of the fluid.
2. Using this convention, Bernoulli's theorem breaks down the total energy at a point in terms of
3. 1. The head due to its elevation above an arbitrary datum of zero potential energy.

4. A pressure head due to the potential energy contained in the pressure in the fluid at that point.
5. A velocity head due to the kinetic energy contained within the fluid.

Assuming that no energy is added to the fluid by a pump or compressor, and that the fluid is not performing

(Elevation Head)$_1$ (Elevation Head)2 + (Pressure Head)$_1$ =
+ (Pressure Head)2+ (Velocity Head)$_1^2$
+ (Velocity Head)2^2 + (Friction Head Loss)

Or

$$Z_1+144P_1/\rho_1+V1^2/2g= Z_2+144P_2/\rho_2+V2^2/2g+H_F$$

where Z = elevation head, ft

P = pressure, psi ρ = density, lb/ft3

V = velocity, ft/sec

g = gravitation constant

H_F = friction head loss, ft

BASIC PRINCIPLES

1. Head

The pressure that a pump must put out is usually expressed in head, or the pressure generated by an equivalent height of liquid. The head required to pump a fluid between two points in a piping system can be calculated by rearranging Bernoulli's law:

Hp = H 2 + H f -H 1 where Hp = head required for the pump, ft

H1 = total fluid head (elevation plus pressure plus velocity) at point 1, ft

H2 = total fluid head at point 2, ft

Hf = head lost due to friction between points 1 and 2, ft

H p =144/ρ(P2-P1)+ (Z_2-Z_1)+$(V2^2-V1^2)$/2g+Hf (where p = density of the fluid, lb/ft3

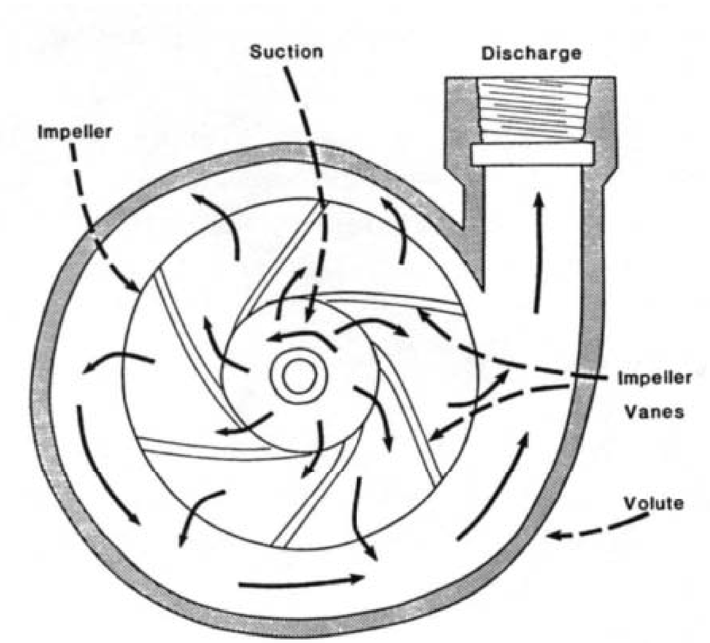
P1, P2 = pressure, psi
Z1, Z2 = elevation, ft
V1, V2 = velocity, ft/sec g = 32.2 ft/sec2

1. Therefore, in a kinetic pump the kinetic or velocity energy of the fluid is first increased and then converted to potential or pressure energy.

2. Almost all kinetic pumps used in production facilities are centrifugal pumps in which the kinetic energy is imparted to the fluid by a rotating impeller generating centrifugal force.

Centrifugal Pumps

1. Centrifugal pumps are classified as either radial flow or axial flow..
2. Flow enters the center of the rotating wheel (impeller) and is propelled radially to the outside by centrifugal force.
3. Within the impeller the velocity of the liquid is increased, and this is converted to pressure by the case.



Radial flow pump

1. Most pumps are neither radial flow nor completely axial flow but have a flow path somewhere in between the two extremes.
2. Radial flow pumps develop a higher head per stage and operate at slower speeds than axial flow pumps.
3. Therefore, axial flow designs are used in very high flow rate, very low head applications.

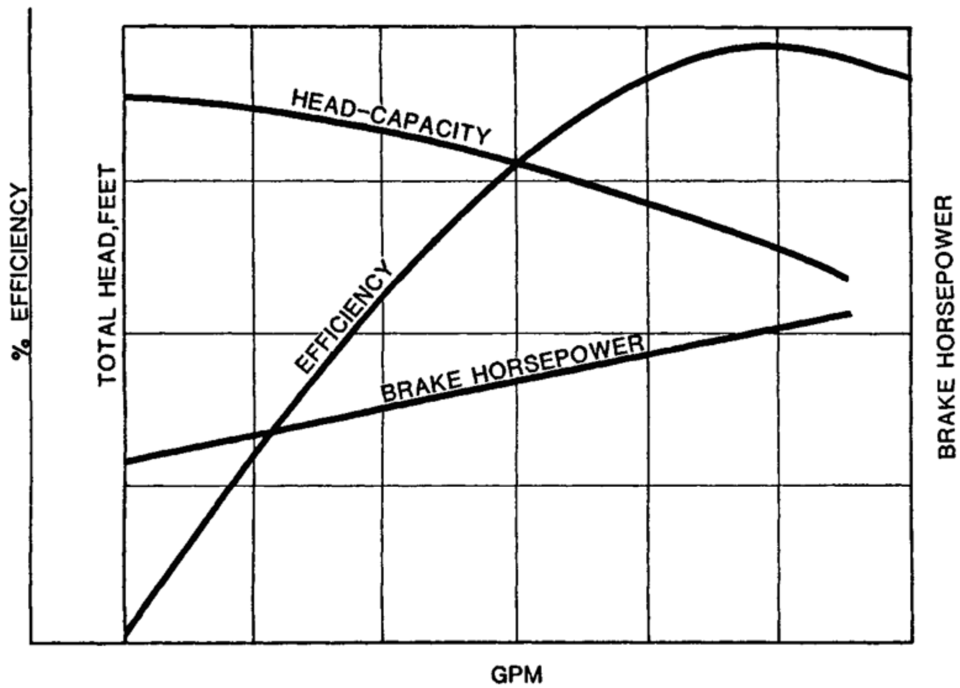
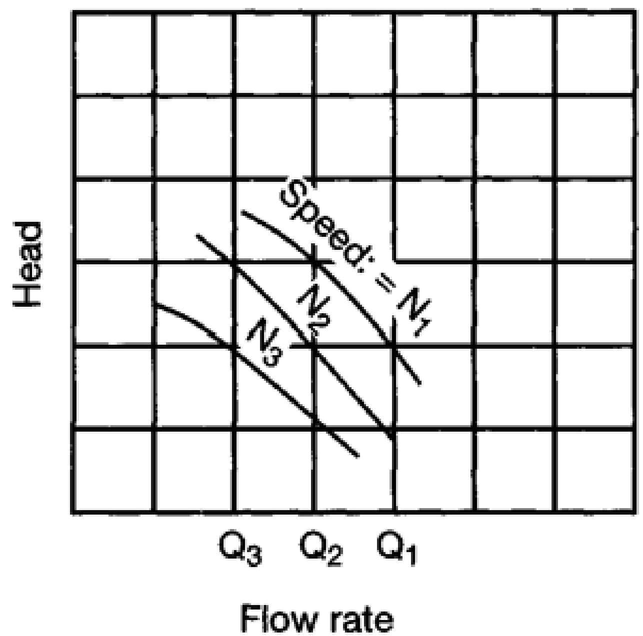


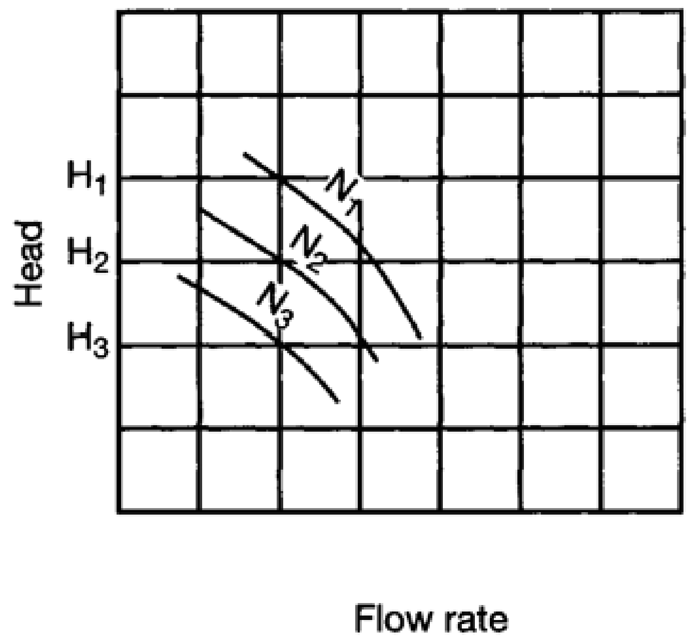
Figure shows a typical head-capacity curve for a centrifugal pump

1. At a constant speed (i.e., rotational velocity), as the head required
2. to be furnished by the pump efficiency curve. For a given impeller shape, the efficiency is a maximum at a design throughput rate.
3. As the rate varies upward and downward from this point the efficiency decreases.
4. By varying the pump speed the throughput at a given head or the head for a given throughput can be changed.
5. In Figure as the speed decreases from N1 to N2 to N3 , the flow rate decreases if the head required is constant, or the head decreases if the flow rate is constant.

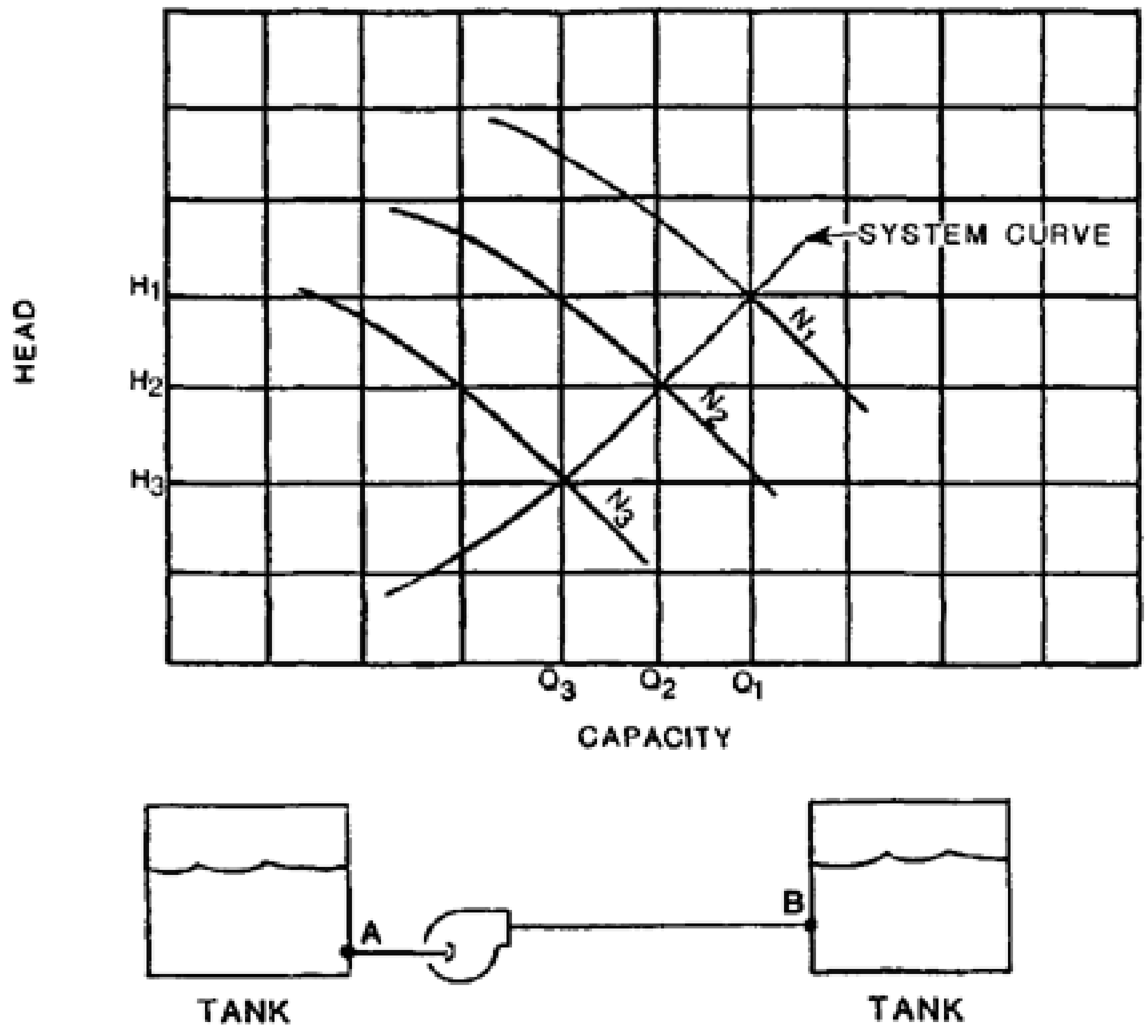
$N_1 > N_2 > N_3$



Effect on flow rate
of varying speed



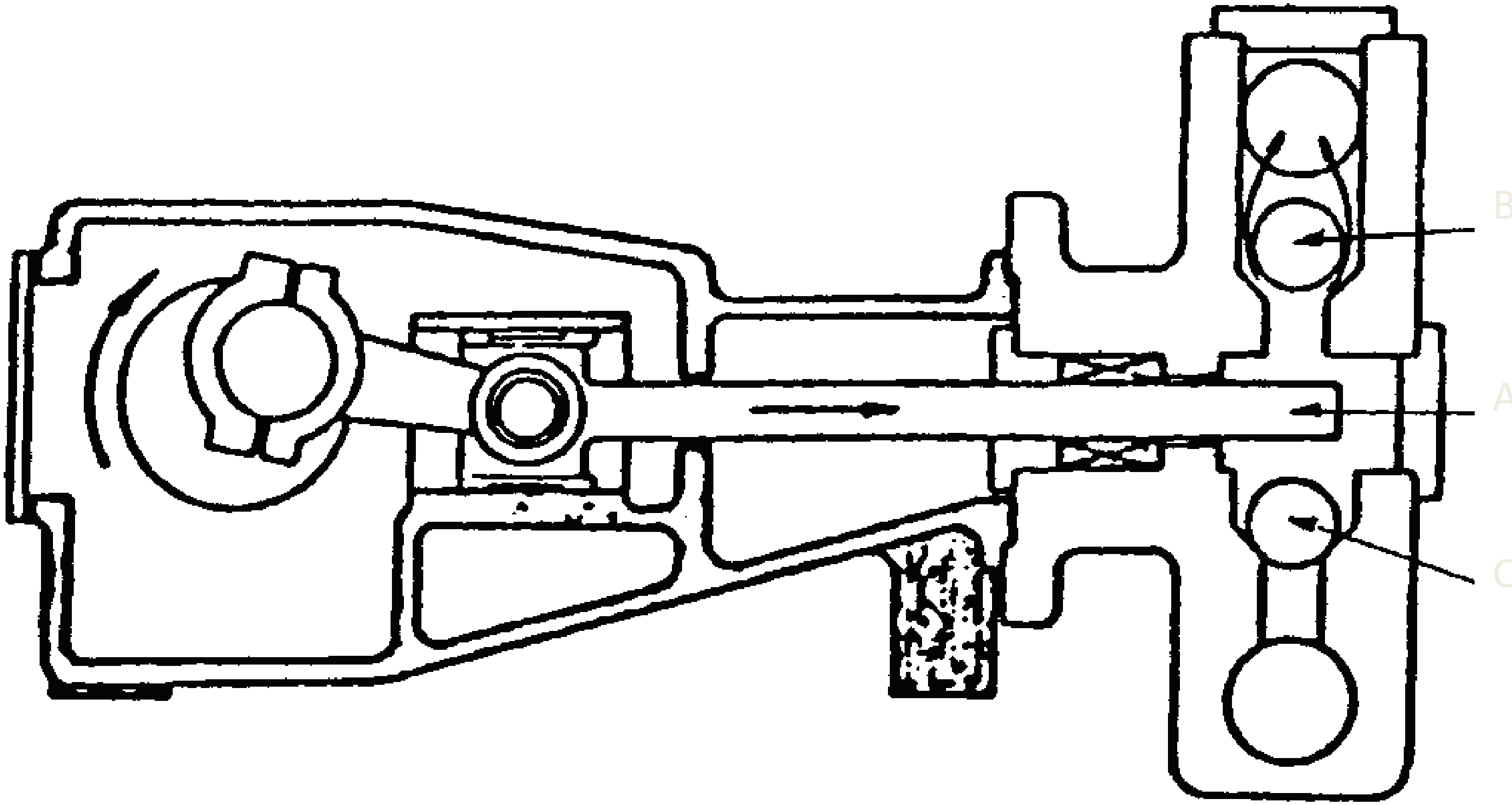
Effect on head
of varying speed



HEAD
CAPACITY
SYSTEM CURVE
H1
H2
H3
Q3
Q2
Q1
N1
N2
N3
A
B
TANK
TANK

RECIPROCATING PUMPS

1. In reciprocating pumps, energy is added to the fluid intermittently by moving one or more boundaries
2. linearly with a piston, plunger, or diaphragm in one or more fluid-containing volumes.
3. If liquid is pumped during linear movement in one direction only then the pump is classified "single acting."
4. If the liquid is pumped during movement in both directions it is classified as "double acting."



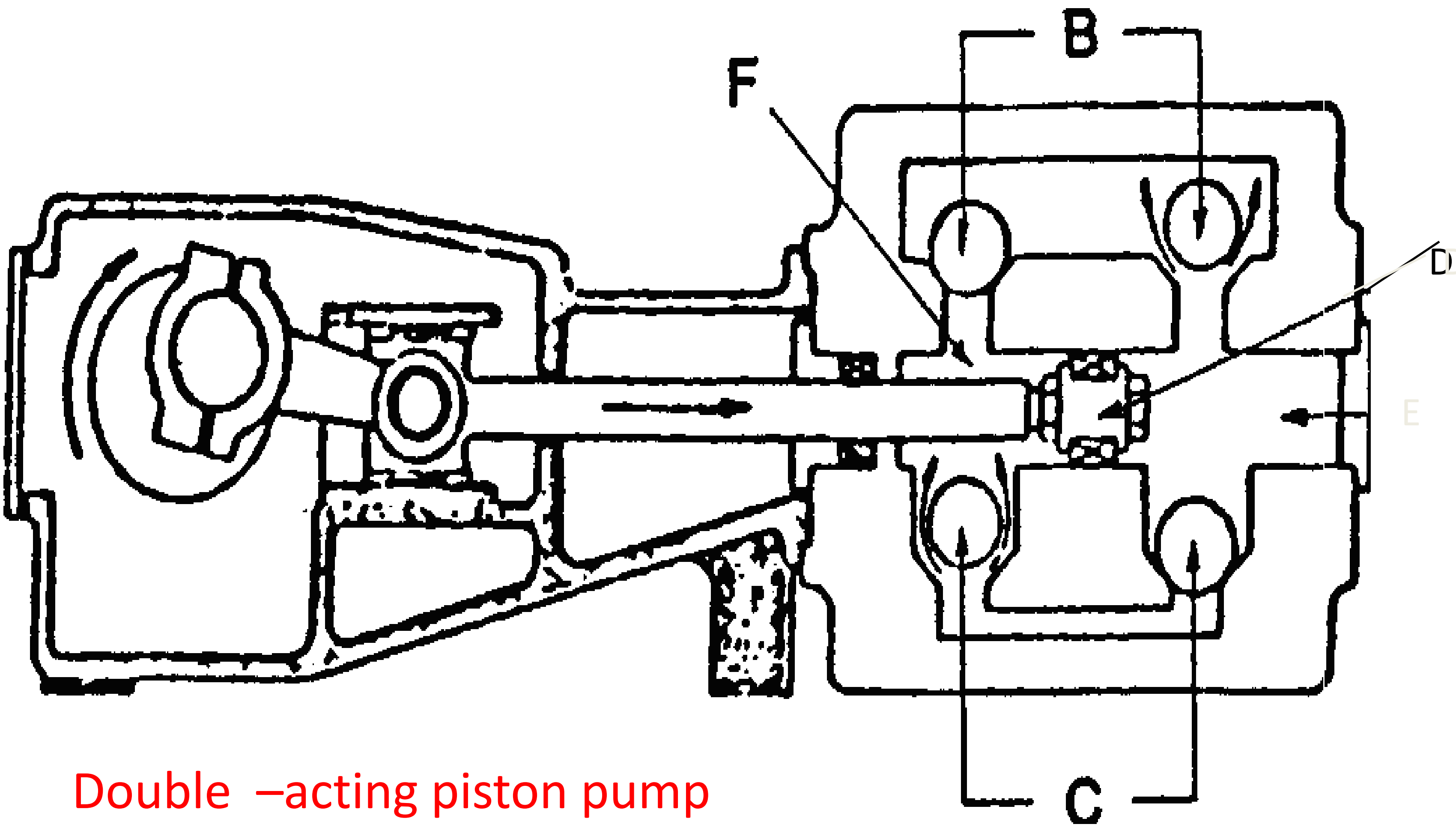
Single –acting plunger pump

1. As the plunger, A, moves to the right in the single acting pump the fluid is compressed until its pressure exceeds the discharge pressure and the discharge check valve, B, opens.

2. The continued movement of the plunger to the right pushes liquid into the discharge pipe.

3. As the plunger begins to move to the left, the pressure in the cylinder becomes less than that in the discharge pipe and the discharge valve closes.

3. Further movement to the left causes the pressure in the cylinder to continue to decline until it is below suction pressure.



Double –acting piston pump

In a double-acting pump the plunger is replaced by a piston, D. When the piston moves to the right,

1. When the direction of the piston is reversed the liquid in F is discharged and the cylinder at E is filled with suction fluid.

2. Reciprocating pumps are also classified by the number of cylinders they have. If the liquid is contained in one cylinder it is called a simplex pump, two cylinders a duplex

1. Three cylinders a triplex, five cylinders a quintuplex, seven cylinders a septuplex, and so forth.

1. The flow rate through the pump can only be varied by changing the pump speed.
2. A throttling valve that changes the system head-flow-rate curve will have no effect on the flow rate through the pump.

Slip of a Reciprocating Pump

The slip of a pump is defined as the difference between the theoretical discharge and actual discharge of the pump.

$$Slip = Q_{th} - Q_{act}$$

Discharge through a reciprocating pump

Consider a single acting reciprocating pump.

Let, D = diameter of the cylinder

A = cross-sectional area of the piston or cylinder

r = radius of crank

N = r. p. m of the crank

L = length of the stroke = 2 x r

h_s = height of the axis of the cylinder from water surface in sump

h_d = height of delivery outlet above the cylinder axis

Volume of water delivered in one revolution or discharge of water in one revolution = area x length of stroke = A X L

No of revolutions/sec = N/60

Discharge of the pump /s Q = discharge in one revolution x no of revolution/s

= A X L x N/60

Weight of water delivered/s W = ρ x g x Q = ρ x g x ALN/60