ME8694 - HYDRAULICS & PNEUMATICS

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UNIT I FLUID POWER PRINICIPLES AND HYDRAULIC PUMPS

- Introduction to Fluid power – Advantages and Applications – Fluid power systems – Types of fluids – Properties of fluids and selection – Basics of Hydraulics – Pascal's Law – Principles of flow – Friction loss – Work, Power and Torque Problems, Sources of Hydraulic power : Pumping Theory – Pump Classification – Construction, Working, Design, Advantages, Disadvantages, Performance, Selection criteria of Linear and Rotary – Fixed and Variable displacement pumps – Problems.

UNIT I FLUID POWER PRINICIPLES AND HYDRAULIC PUMPS

- FLUID POWER
- Fluid power is energy transmitted and controlled by means of a pressurized fluid either liquid or gas.
- ADVANTAGES OF FLUID POWER
- Multiplication and variation of force
- Easy ,accurate control
- Multifunction control
- High horse power, low weight ratio
- Constant torque
- Safety in hazardous environments
- Low speed with high torque

FLUID POWER PRINICIPLES AND HYDRAULIC PUMPS

- Easy to maintain and operate
- High accuracy
- No breakage of parts

DISADVANTAGES

- Hydraulic oils are messy
- Impossible to eliminate leakage
- Improper design - burst the system & injurious to operator
- Loud noise
- Highly flammable

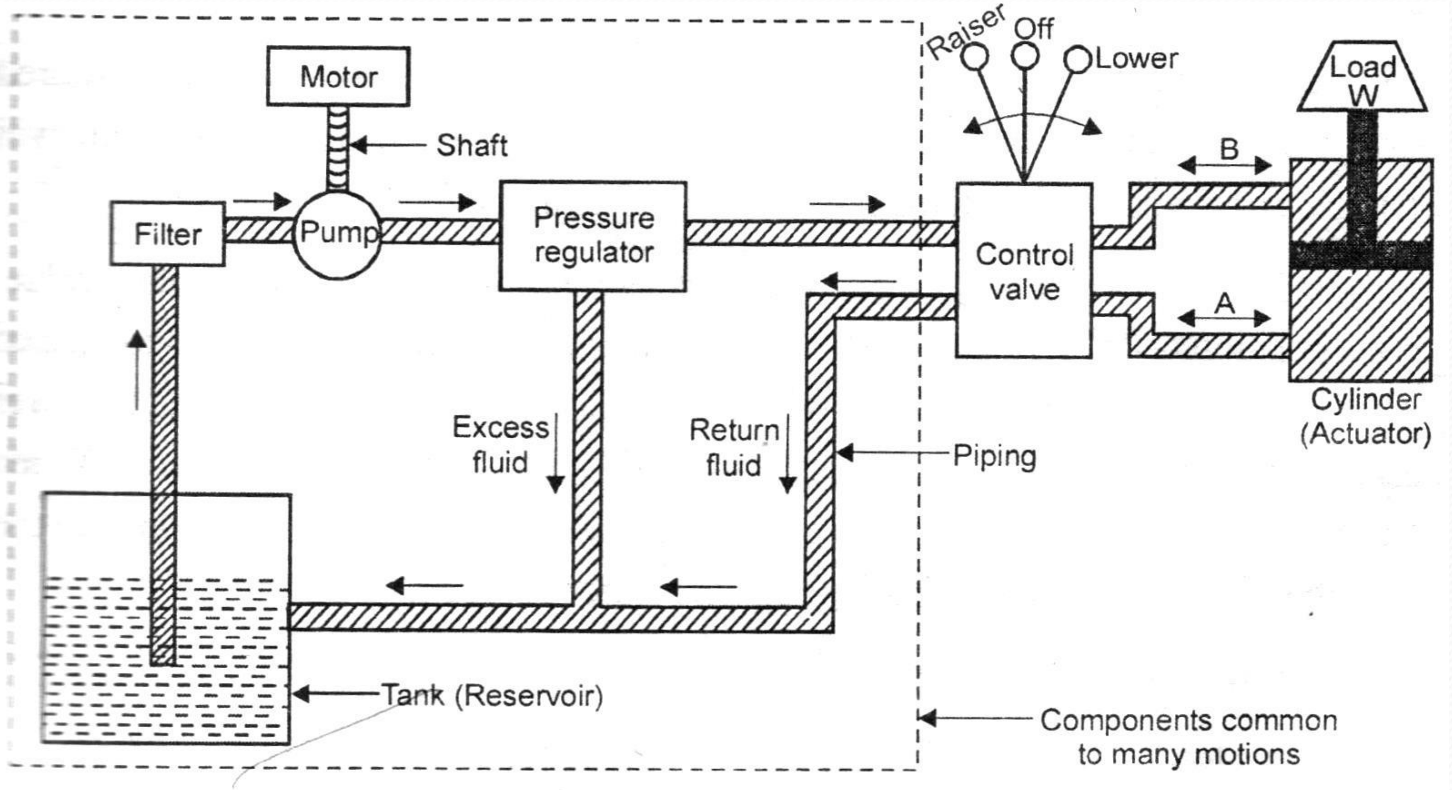
APPLICATION OF FLUID POWER SYSTEM

- Manufacturing industry
- Automobile industry
- Automation
- Defense
- Agriculture industry
- Naval industry
- Aviation and Aerospace industry
- Mechatronics field
- Material handling field
- Construction field
- Transportation

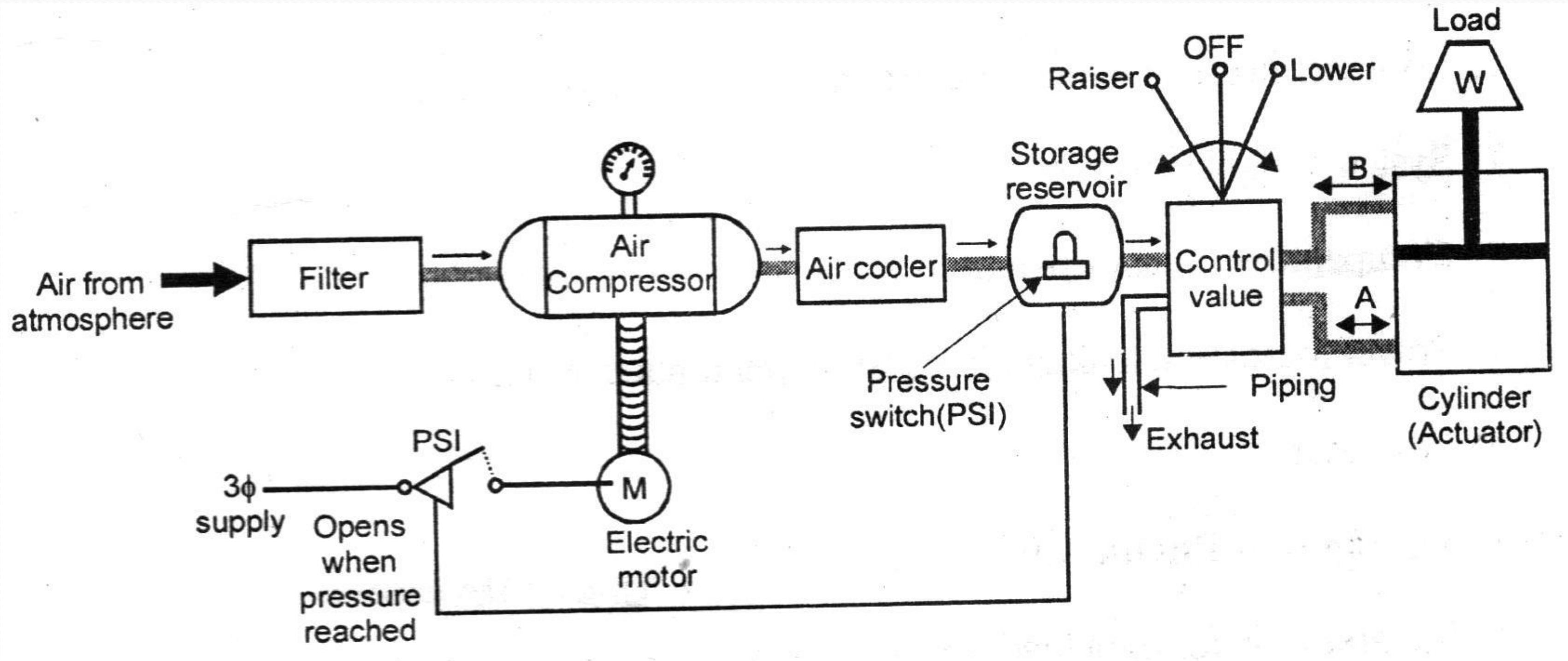
TYPES OF FLUID POWER SYSTEM

- Hydraulic power system
- Pneumatic power system

HYDRAULIC SYSTEM



PNEUMATIC SYSTEM



COMPARISION OF HYDRAULIC PNEUMATIC & ELECTRO MECHANICAL POWER SYSTEM

HYDRAULIC	PNEUMATIC	ELECTRICAL / ELECTRO MECHANICAL
Electrical energy is used to drive the hydraulic pumps	Electrical energy is used to drive the compressor motor	Electrical energy is used to drive the electric motor
Pressurized liquid	Air /Gas	No medium only through the mechanical components
Energy stored in the Accumulator	Energy stored in the Reservoir	Energy stored in the Battery
Energy transmitted through Hydraulic cylinders	Energy transmitted through Pneumatic cylinders	Energy transmitted through Gears , Cams, Screw jack etc,.

Operating speed low (0.5 m/sec)	Operating speed High (1.5 m/sec)	ELECTRICAL / ELECTRO MECHANICAL
High accuracy	Low accuracy	High accuracy
Large forces can be generated (F <3999 KN)	limited forces can be generated (F <30 KN)	Low forces can be generated
Hazardous	Noise y	Danger
Closed loop circuit	Open loop circuit	---
High cost	Cheep cost	Low cost
High weight	Medium weight	Less weight
Lubricant is not required	Separate lubricant is required	Separate lubricant is required

Properties of hydraulic fluids

- Mass density (mass / volume)
- Weight density or Specific Weight (weight / volume , $w = \rho g$)
- Specific gravity (density of fluid/ density of standard fluid)
- Specific volume (volume / mass)
- Viscosity ($\tau = \mu \, du/dy$)
- Kinematic Viscosity (ν = Dynamic viscosity / density , $= \mu/\rho$)
- Viscosity index
- Cohesion & Adhesion
- Surface tension
- Capilarity

- Cavitations
- Compressibility
- Bulk modules
- Cloud , Pour, Flash & fire points
- Demulsibility
- Oxidation stability
- Volatility
- Neutralization number
- Corrosiveness

Properties of fluids

- PROPERTIES OF FLUIDS: Viscosity: It is a measure of the fluid's internal resistance offered to flow. Viscosity is the most important factor from the stand point of flow. If the viscosity of the hydraulic oil is higher than recommended, the system will be affected in the following manner.
- 1. The viscous oil may not be able to pass through the pipes. 2. The working temperature will increases because there will be internal friction.

Properties of fluids

- 3. The consumption of power will increase If the viscosity of the oil is lesser than recommended then, 1. The internal and external leakage will increase 2. It cannot lubricate properly and will lead to rapid wear of the moving parts.
- 2. Viscosity Index: This value shows how temperature affects the viscosity of oil. The viscosity of the oil decreases with increase in temperature and vice versa. The rate of change of viscosity with temperature is indicated on an arbitrary scale called viscosity index (VI). The lower the viscosity index, the greater the variation in viscosity with changes in temperature and vice versa.

Properties of fluids

- 3. Oxidation Stability: The most important property of an hydraulic oil is its oxidation stability. Oxidation is caused by a chemical reaction between the oxygen of the dissolved air and the oil. The oxidation of the oil creates impurities like sludge, insoluble gum and soluble acidic products. The soluble acidic products cause corrosion and insoluble products make the operation sluggish.
- 4. Demulsibility: The ability of a hydraulic fluid to separate rapidly from moisture and successfully resist emulsification is known as Demulsibility. If oil emulsifies with water the emulsion will promote the destruction of lubricating value and sealant properties. Highly refined oils are basically water resistance by nature

Properties of fluids

- 5. Lubricity: Wear results in increase clearance which leads to all sorts of operational difficulties including fall of efficiency. At the time of selecting a hydraulic oil care must be taken to select one which will be able to lubricate the moving parts efficiently.
- 6. Rust Prevention: The moisture entering into the hydraulic system with air causes the parts made ferrous materials to rust. This rust if passed through the precision made pumps and valves may scratch the nicely polished surfaces. So additives named inhibitors are added to the oil to keep the moisture away from the surface

Properties of fluids

- 7. Pour Point: The temperature at which oil will clot is referred to as the pour point i.e. the lowest temperature at which the oil is able to flow easily. It is of great importance in cold countries where the system is exposed to very low temperature.
- 8. Flash Point and Fire Point: Flash point is the temperature at which a liquid gives off vapour in sufficient quantity to ignite momentarily or flash when a flame is applied. The minimum temperature at which the hydraulic fluid will catch fire and continue burning is called fire point.

Properties of fluids

- **9. Neutralization Number:** The neutralization number is a measure of the acidity or alkalinity of a hydraulic fluid. This is referred to as the PH value of the fluid. High acidity causes the oxidation rate in an oil to increase rapidly.

- **REQUIRED QUALITIES OF GOOD HYDRAULIC OIL:**
- 1. Stable viscosity characteristics
- 2. Good lubricity
- 3. Compatibility with system materials
- 4. Stable physical and chemical properties
- 5. Good heat dissipation capability
- 6. High bulk modulus and degree of incompressibility
- 7. Good flammability

Properties of fluids

- 8. Low volatility
- 9. Good demulsibility
- 10. Better fire resistance
- 11. Non toxicity and good oxidation stability
- 12. Better rust and corrosion prevent qualities
- 13. Ready availability and inexpensive

Types of Hydraulic fluids

- Gases
- Liquids

LIQUIDS

- Water
- Petroleum based fluids
- Fire resistance fluids

i. Water in oil emulsion
ii. Water glycol mixture
iii. Synthetic fluids
iv. High water content fluids

Hydraulic fluid types

1. Water:

- Clear water
- Water with additives

- Oldest fluid but nowadays there is a renaissance
- Used where there is an explosion or fire danger or hygienic problem: Food and pharmaceutical industry, textile industry, mining

Advantages:

- No environmental pollution
- No disposal effort
- Cheap
- No fire or explosion danger
- Available everywhere
- 4 times larger heat conduction coefficient than mineral oils
- 2 times higher compression module than mineral oils
- Viscosity does not depend strongly on temperature

Hydraulic fluid types (contd.)

1. Water:

Disadvantages:

- Bad lubrication characteristics
- Low viscosity (problem of sealing, but has good sides: low energy losses)
- Corrosion danger
- Cavitation danger (relatively high vapour pressure)
- Limited temperature interval of applicability (freezing, evaporating)

Consequences: needs low tolerances and very good materials (plastics, ceramics, stainless steel) $\Rightarrow$ components are expensive

Hydraulic fluid types (contd.)

2. Mineral oil:

- Without additives
- With additives

- „Conventional" use, stationary hydraulics
- Always mixtures of different oils, often with additives

  Additives:
  - decrease corrosion
  - increase life duration
  - improve temperature dependence of viscosity
  - improve particle transport

Advantages:

- Good lubrication
- High viscosity (good for sealing, bad for losses)
- Cheap

Disadvantages:

- Inflammable
- Environmental pollution

4. Biologically degradable fluids:

- Natural
- Synthetic

- o Environmental protection, water protection
- o Agricultural machines
- o Mobile hydraulics

Characteristics similar to mineral oils but much more expensive.

If the trend continues its usage expands, price will drop.

PASCAL'S LAW :

- This law states that the pressure generated at any point in a confined fluid acts equally in all directions.
- **CONTINUITY EQUATION:** It states that if no fluid is added or removed from the pipe in any length then the mass passing across different sections shall be same.

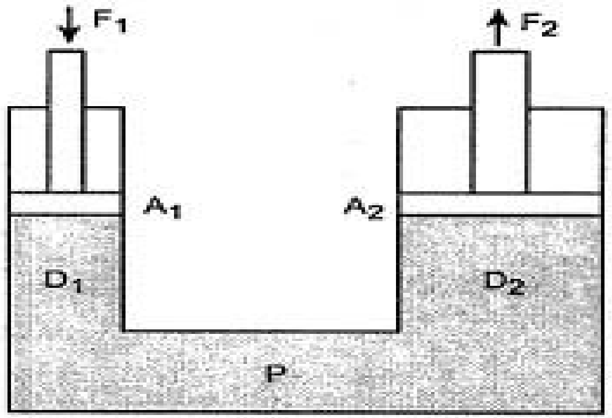
  $$A_1 V_1 = A_2 V_2$$

BERNOULLI'S EQUATION: It states that in a ideal incompressible fluid when the flow is steady and continuous the sum of potential energy, kinetic energy and pressure energy is constant across all cross sections of the pipe.

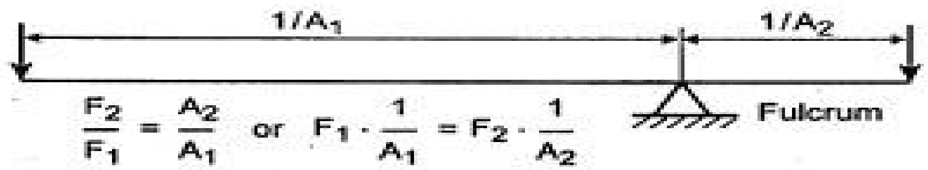
$$Z_1 + \frac{V_1^2}{2g} + \frac{P_1}{w} = Z_2 + \frac{V_2^2}{2g} + \frac{P_2}{w}$$

PASCAL'S LAW :

Consider two oil containers both in cylindrical form and connected together contain some oil, as shown Both the cylinders have a piston having different diameters says D_1 and D_2 respectively, where D_1 is smaller than D_2.



Principle of Bramah's press



A hydraulic lever

If a force F_1 is applied to the small-diameter piston, then this will produce an oil pressure P_1 at the bottom of the piston 1. Now this pressure is transmitted through the oil to the large-diameter piston 2. Because the piston 2 has a larger area (A_2), the pressure at the bottom of the piston 2 will be P_2. Now this pressure P_2 will push up the piston 2 to create an output force F_2.

We know that according to Pascal's law, $P_1 = P_2$

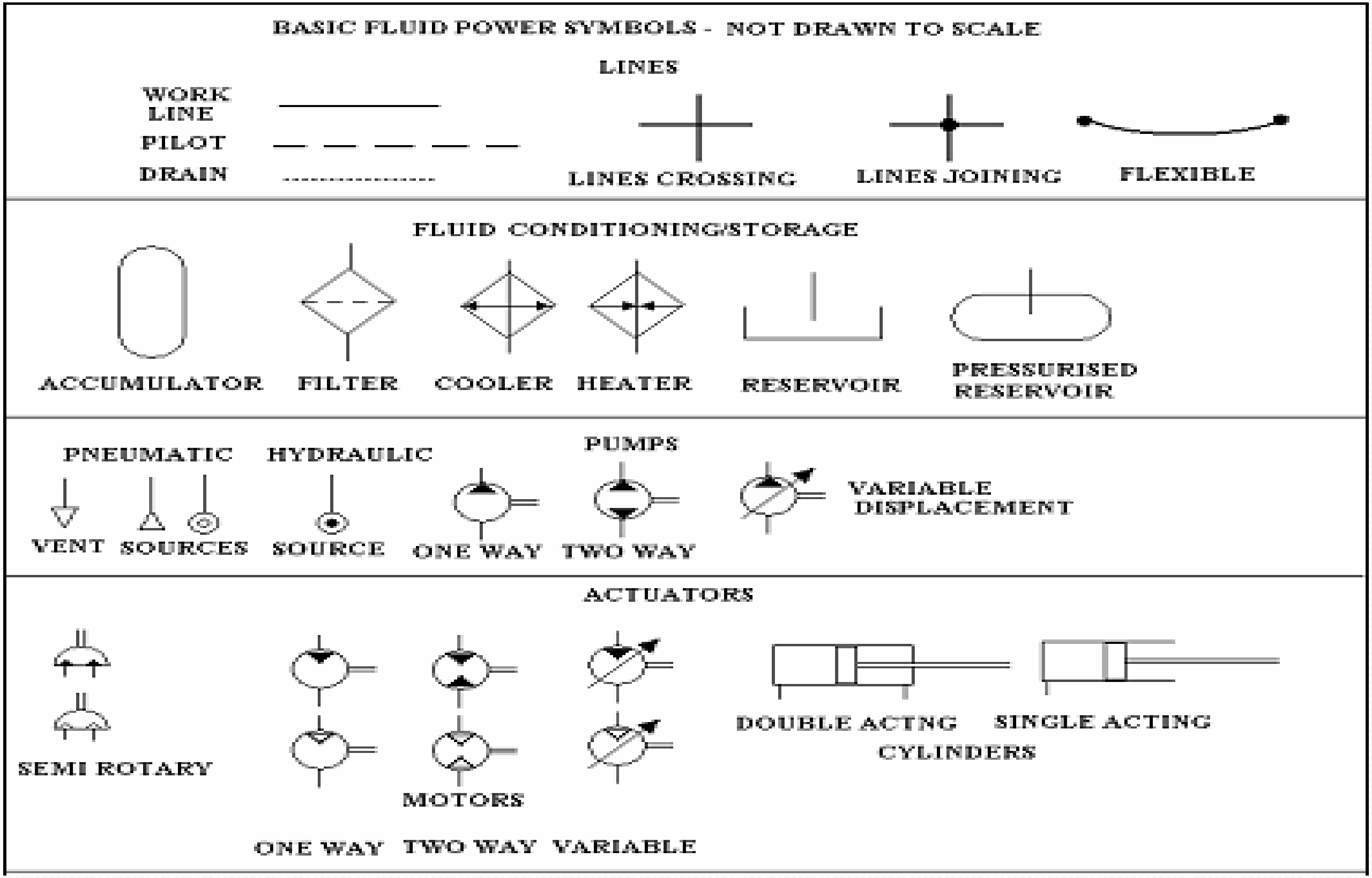
or $$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

or $$\boxed{\frac{F_2}{F_1} = \frac{A_2}{A_1}}$$

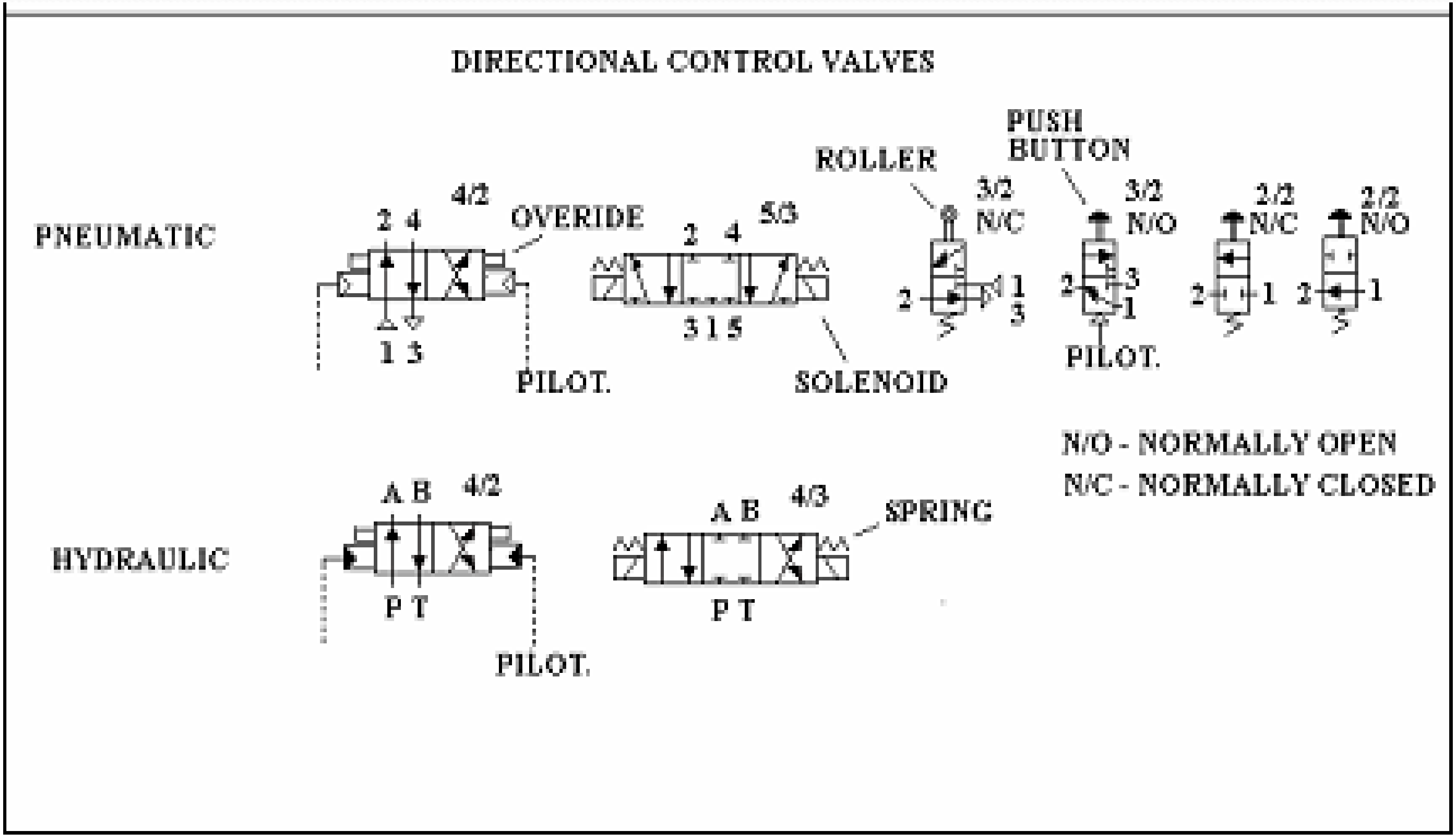
where A_1 = Area of the smaller piston $= \frac{\pi}{4} D_1^2$, and

A_2 = Area of the larger piston $= \frac{\pi}{4} D_2^2$.

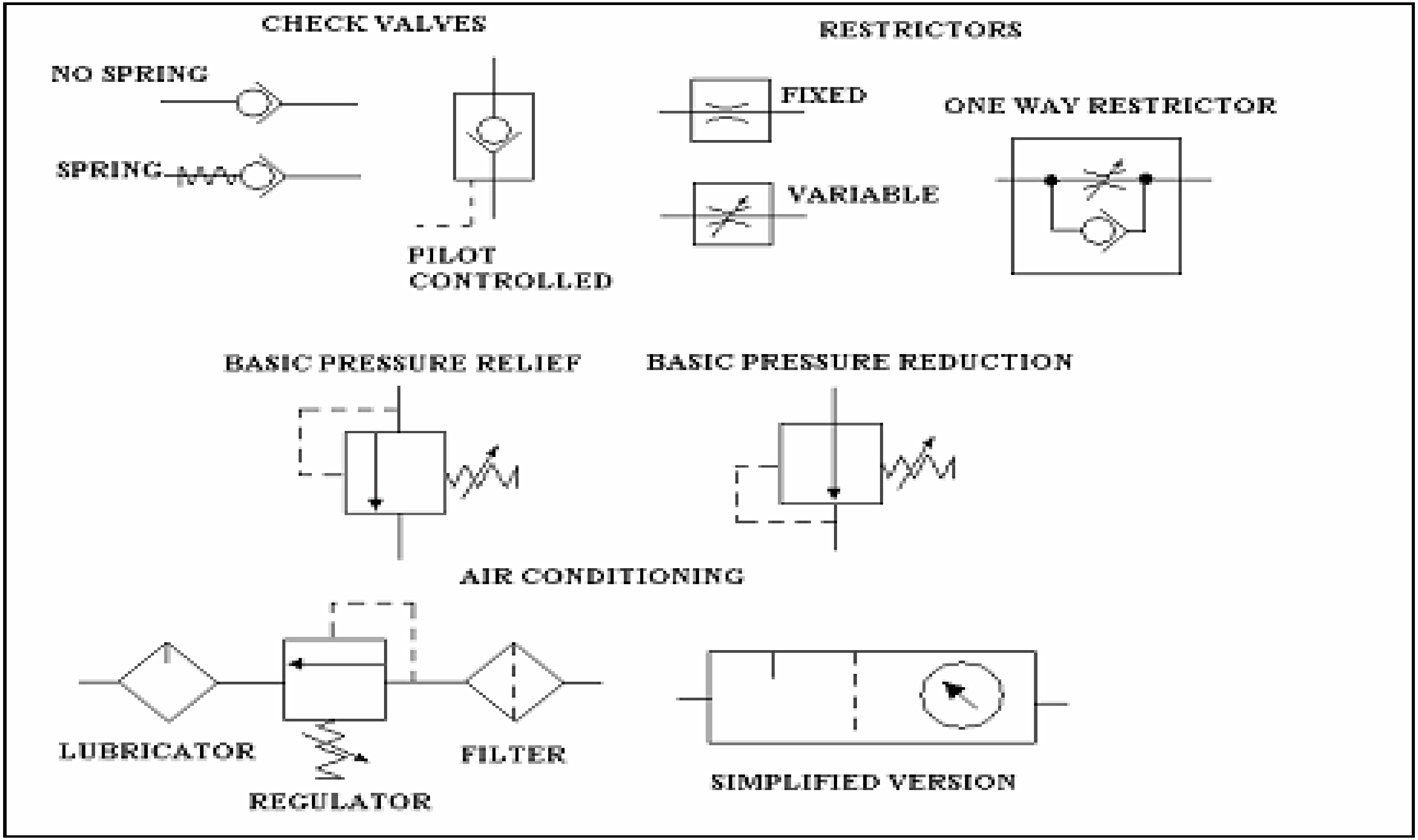
Fluid power symbols



Fluid power symbols



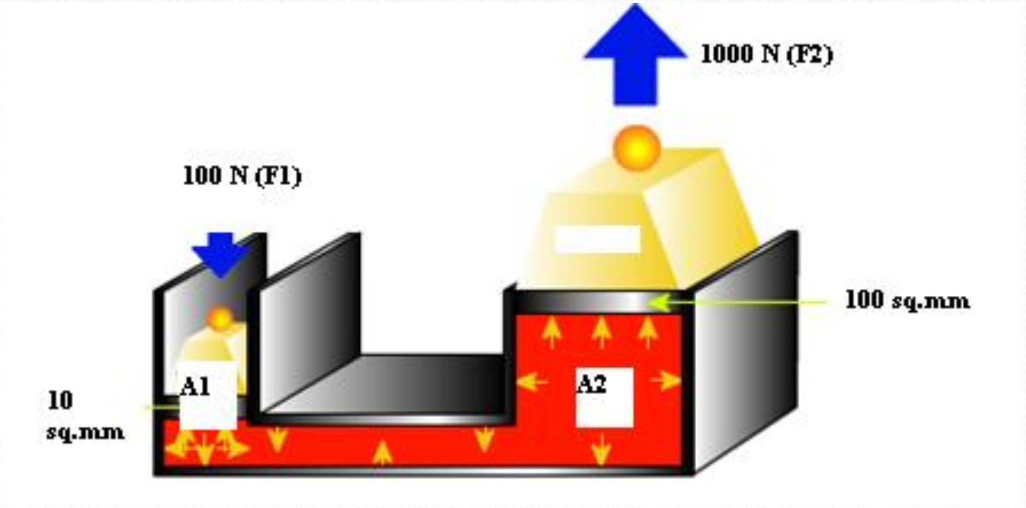
Fluid power symbols



Basics of Hydraulics

- Pascal's law:

  The pressure generated on a confined fluid at rest is transmitted equally undiminished in all directions throughout the fluid and acts at right angles to the containing surfaces



According to Pascal's law,

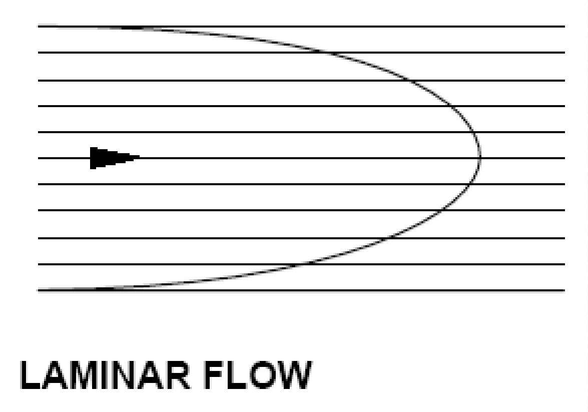
$P_1 = P_2$

$(F_1/A_1) = (F_2/A_2)$

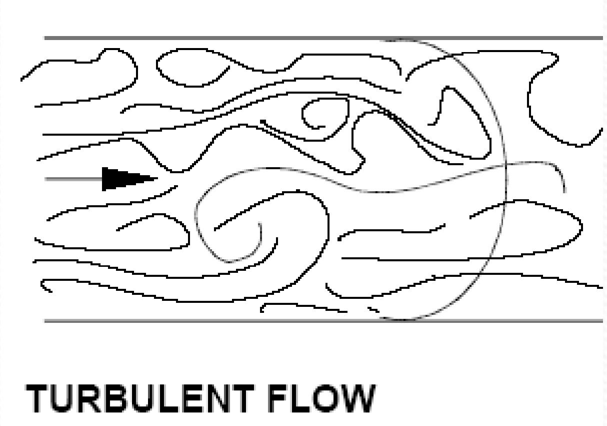
$100/10 = F_2/100$

$F_2 = 1000N$

Laminar and Turbulent flow



- It is a stream line flow as all the fluid particles moves in a parallel path



- It is a irregular flow
- Some fluid particles move parallel and some move perpendicular to the mean flow direction

Reynold's Number

It is a dimensionless number.

$Re = vD\rho / \mu = vD/\nu$

Where,

v = Fluid velocity m/s

ρ = density of fluid kg/m^3

D = Pipe inside diameter, m

μ = Absolute viscosity Ns/m^3

ν = Kinematic viscosity m^2/s

For Laminar flow, $Re < 2000$

For Turbulent flow, $Re > 4000$

Darcy's Equation

- It is used to calculate the head loss (Major Loss) due to friction in pipes for both Laminar and Turbulent flows.

$H_L = fLv^2/2gD$

For Laminar flow, $f = 64 / Re$

$H_L = 64\ Lv^2/Re\ 2gD$

$H_L = 32\ vL\mu\ /D^2g$

Minor Loss:

Minor Loss:

Minor losses due to valves, fittings, bends, enlargements & contractions

$H_L = kv^2 / 2g$

HYDRAULIC PUMP

Sources of Hydraulic powers:

Pumping theory or working principle of pump:

when the input energy is applied the internal operation of pump creates negative pressure. This pressure difference creates a partial vacuum at inlet which draws the fluid in to the pump. Then the pump mechanically pushes the fluid in to rest of the hydraulic circuit.

HYDRAULIC PUMP

Function of hydraulic pump

The function of a pump is to convert mechanical energy into hydraulic energy. It is the heart of any hydraulic system because it generates the force necessary to move the load. Mechanical energy is delivered to the pump using a prime mover such as an electric motor. Partial vacuum is created at the inlet due to the mechanical rotation of pump shaft. Vacuum permits atmospheric pressure to force the fluid through the inlet line and into the pump. The pump then pushes the fluid mechanically into the fluid power actuated devices such as a motor or a cylinder.

HYDRAULIC PUMP

Pumps are classified into three different ways as follow …

I. Classification based on displacement:

1. Non-positive displacement pumps
2. Positive displacement pumps

II. Classification based on delivery:

1. Constant delivery pumps.
2. Variable delivery pumps.

III. Classification based on motion:

1. Rotary pump.
2. Reciprocating pump.

HYDRAULIC PUMP

I. Classification Based on Displacement

1. Non-Positive Displacement Pumps

Non-positive displacement pumps are primarily velocity-type units that have a great deal of clearance between rotating and stationary parts. Non-displacement pumps are characterized by a high slip that increases as the back pressure increases, so that the outlet may be completely closed without damage to the pump or system. Non-positive pumps do not develop a high pressure but move a large volume of fluid at low pressures. They have essentially no suction lift. Because of large clearance space, these pumps are not self-priming.

HYDRAULIC PUMP

I. Classification Based on Displacement conti…

2. Positive Displacement Pumps

Positive displacement pumps, in contrast, have very little slips, are self-priming and pump against very high pressures, but their volumetric capacity is low. Positive displacement pumps have a very close clearance between rotating and stationary parts and hence are self-priming. Positive displacement pumps eject a fixed amount of fluid into the hydraulic system per revolution of the pump shaft. Such pumps are capable of overcoming the pressure resulting from mechanical loads on the system as well as the resistance of flow due to friction. This equipment must always be protected by relief valves to prevent damage to the pump or system. By far, a majority of fluid power pumps fall in this category, including gear, vane and piston pumps.

HYDRAULIC PUMP

Differences between positive displacement pumps and non-positive displacement pumps

Positive Displacement Pumps	Non-positive Displacement Pumps
1. The flow rate does not change with head.	1. The flow rate decreases with head.
2. The flow rate is not much affected by the viscosity of fluid.	2. The flow rate decreases with the viscosity.
3. Efficiency is almost constant with head.	3. Efficiency increases with head at first and then decreases.

Classification of pumps

- Hydro dynamic (non positive displacement)
- Hydro static (positive displacement)

Hydro dynamic pump:

it is used to carry the fluid from one location to another location (low pressure 17 – 21 Bars)

Example: centrifugal pump

Hydro static pump:

it is used to transmit fluid pressure to fluid power. It is whether fixed or variable displacement pump

HYDRAULIC PUMP

Fixed displacement pump:

- The amount of fluid delivered per revolution cannot be varied.

Variable displacement pump:

- The displacement can be varied by changing the physical conditions of various pump elements.
- The amount of fluid delivered per revolution can be varied.

Classification of Positive displacement pump (Hydro static)

1. Gear pumps (fixed displacements only)
   a. External
   b. Internal
   c. Lobe
   d. Screw
   e. Gerotor
2. Vane pump (Fixed or Variable)
   a. Balanced
   b. Unbalanced

HYDRAULIC PUMP

3. Piston pump (Fixed or Variable)

   a. Axial design

   b. Radial design

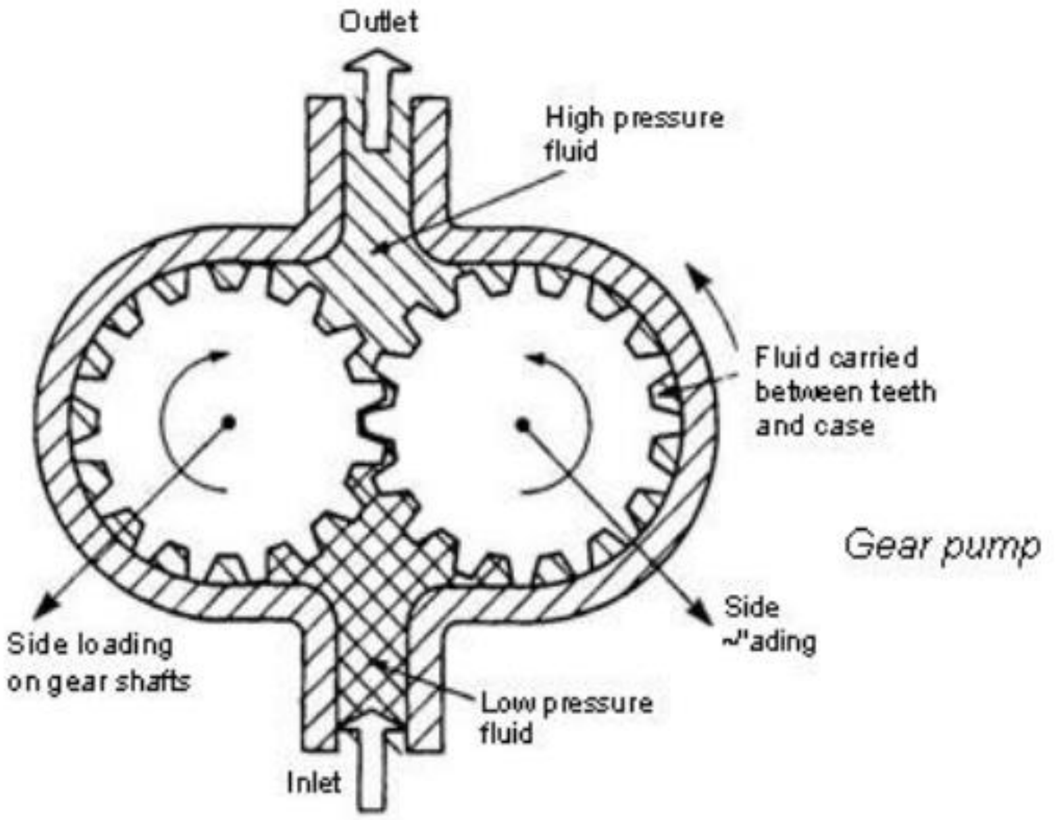
Gear pumps

- Simplest and robust type
- Operating speed is 4000 rpm
- Operating pressure is 15 Mpa
- Delivery 6751 Lpm
- Volumetric efficiency 90%
- ADVANTAGES:
- Long life
- High efficiency
- Simple in design & low cost

External gear pump

- DISADVANTAGES
- Four bushings in liquid area
- No solids allowed
- Fixed End Clearances
- ADVANTAGES:
- High speed
- High pressure
- No overhung bearing loads
- Relatively quiet operation
- Design accommodates wide variety of materials

External gear pump

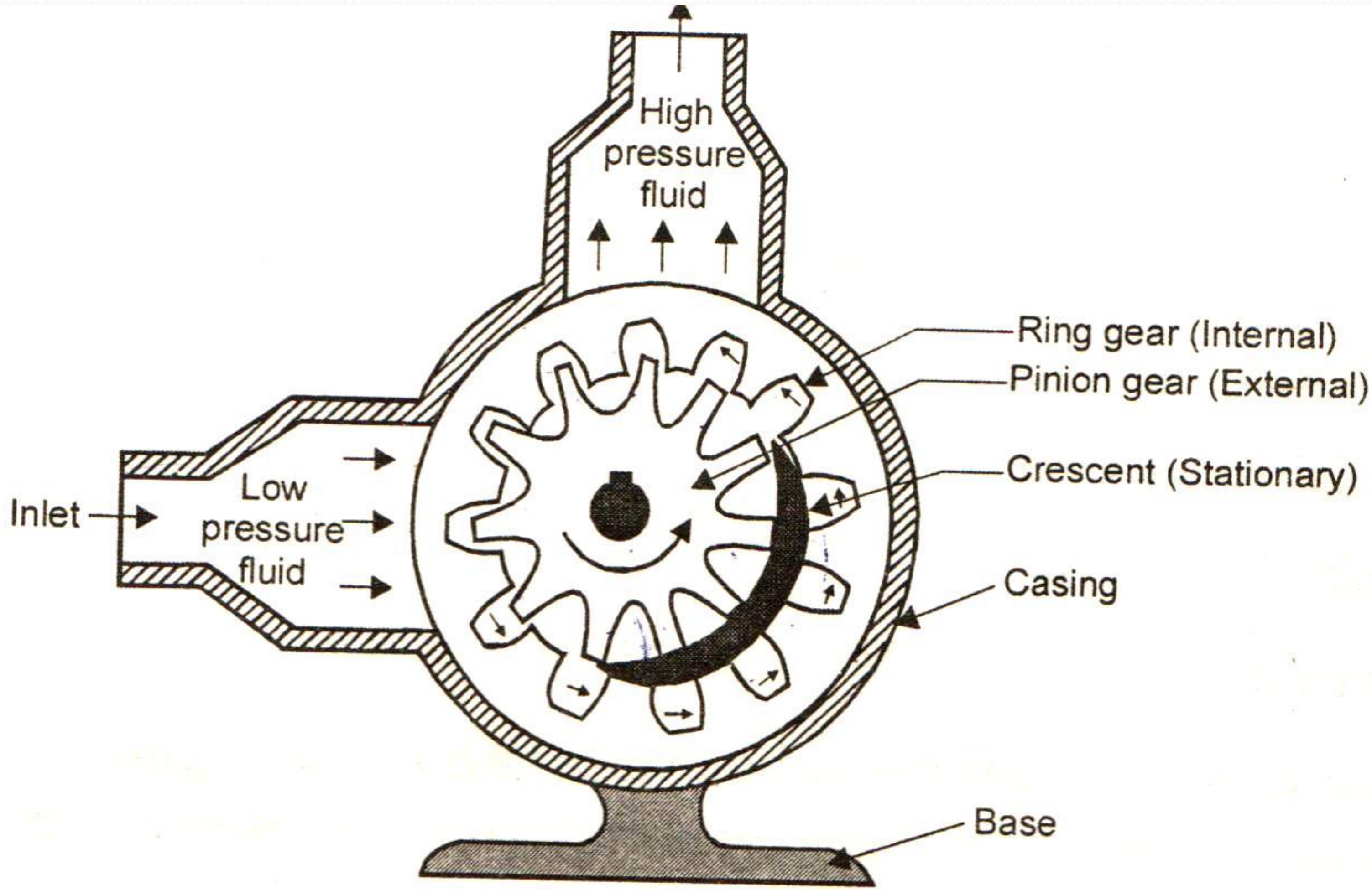


External gear pump

- Two spur gears rotating in opposite direction
- Rotation of these gear wheels open and closes the inlet and outlet
- Suction side where the gear teeth comes out of mesh expands the volume bringing out reduction in pressure
- Fluid from reservoir is drawn in to the pump
- In the discharge side reduction in volume increase the pressure

- Due to this the fluid is forced out of the system

INTERNAL GEAR PUMP



- Two gears rotate in same direction internal(ring gear)and external(pinion gear)
- Crescent is act as a seal between suction and discharge side

LOBE PUMP

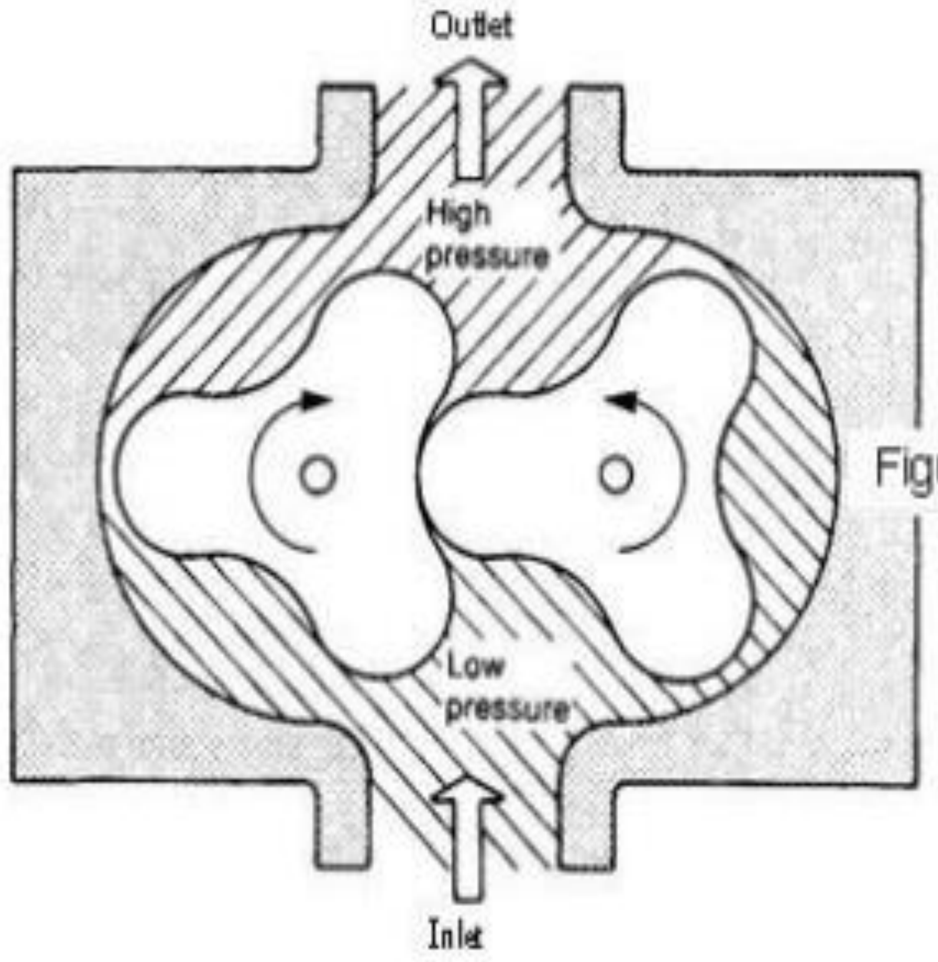
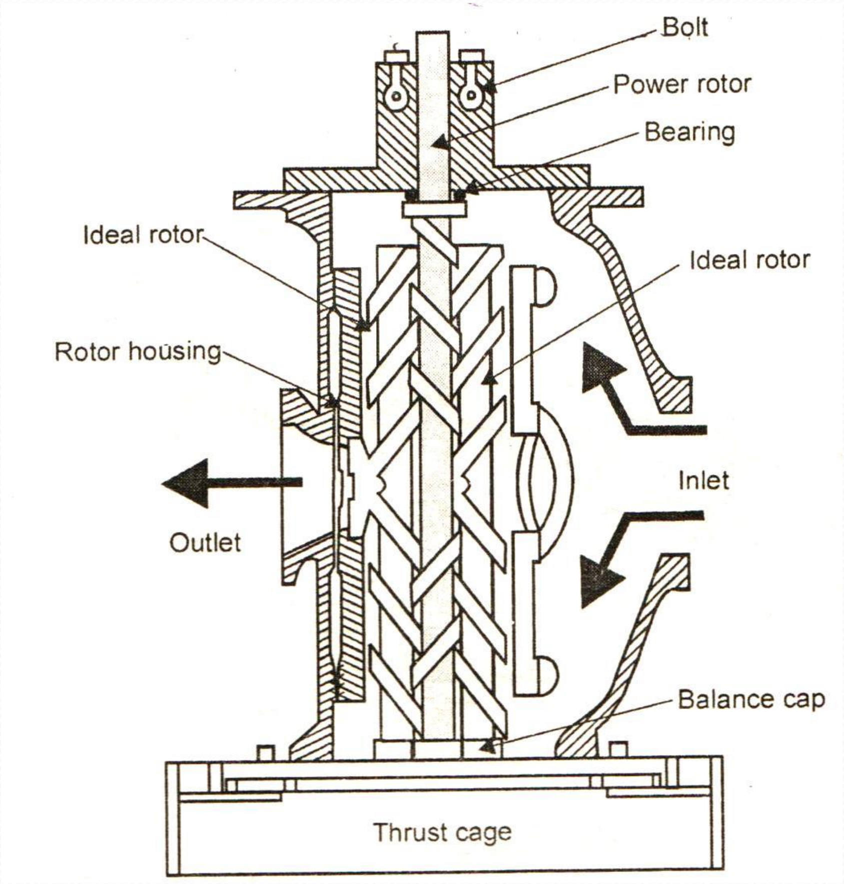


Figure 2.8 *The lobe pump*

- Similar to external gear pump
- Gears are replaced by lobes
- Both lobes are driven externally they are not in actual contact with each other
- Quiter in operation

Screw pump

- Axial flow type uses meshing screws to develop desired pressure.
- The driving and driven screw(ideal rotor) are connected by timing gears.
- Timing gears provides the timing force between the meshing screws.
- In this pump fluid not rotate but moves as nut on thread, hence smoothest flow at high speed.

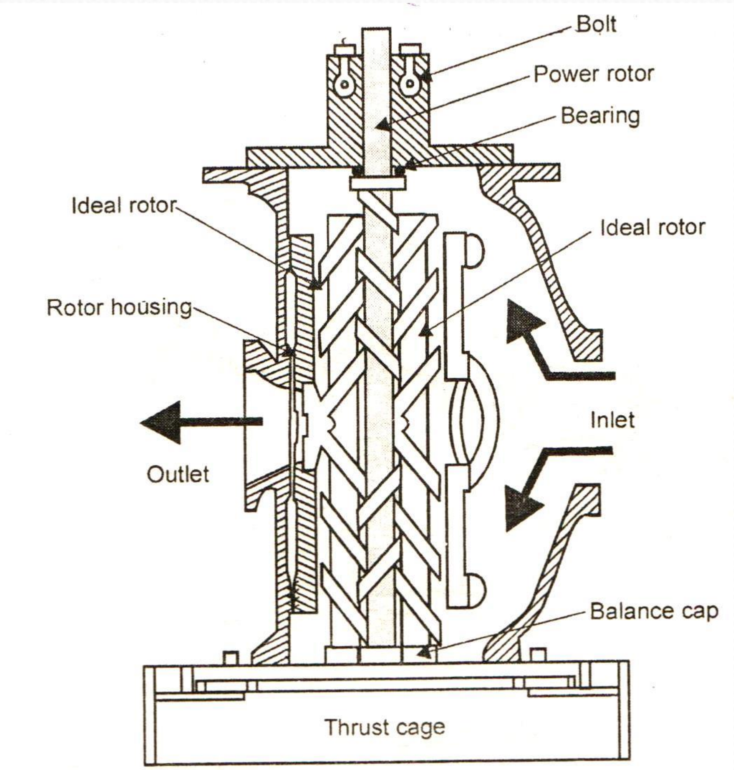


Screw pump

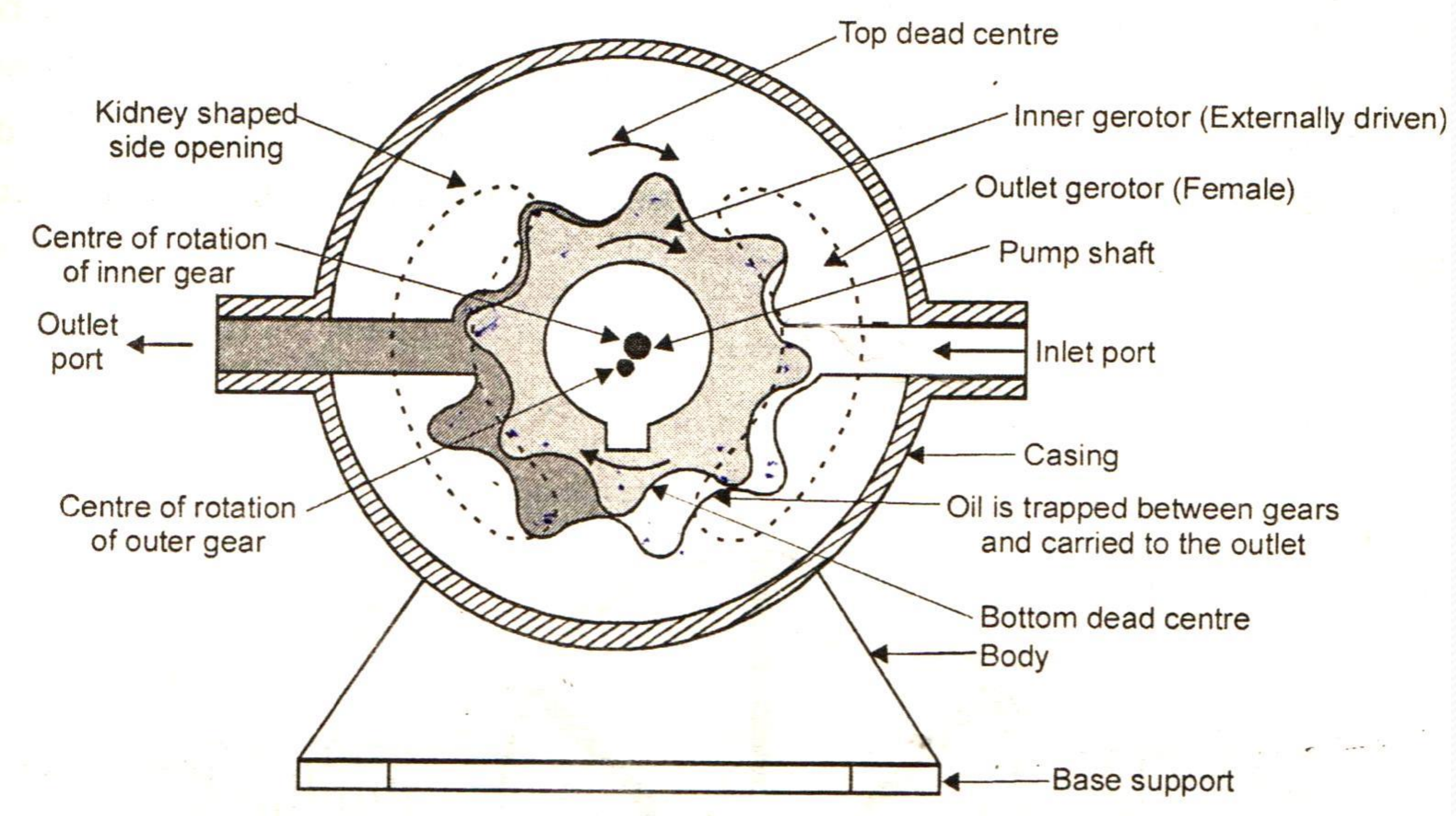
Working

When screw turns,

- Space between the threads are divided into compartment.
- During this vacuum created fluid forced through the inlet
- As the screw rotate fluid travels between meshing element
- When screw turns normal, fluid discharged along outlet port

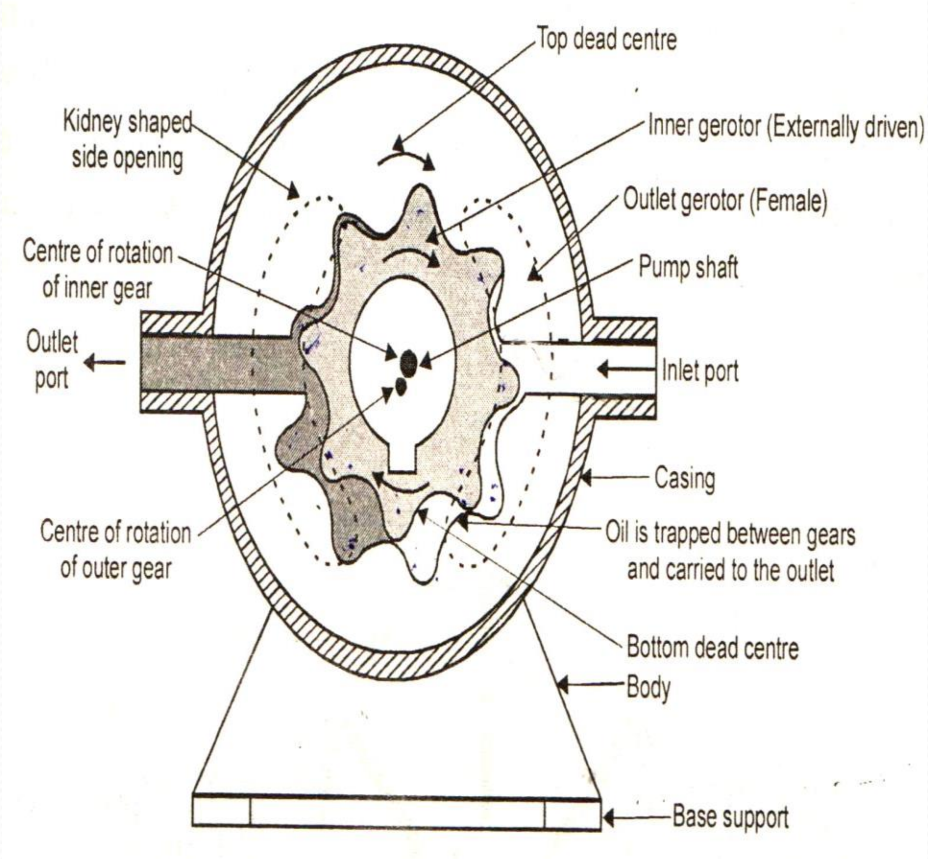


GEROTOR PUMP



GEROTOR PUMP

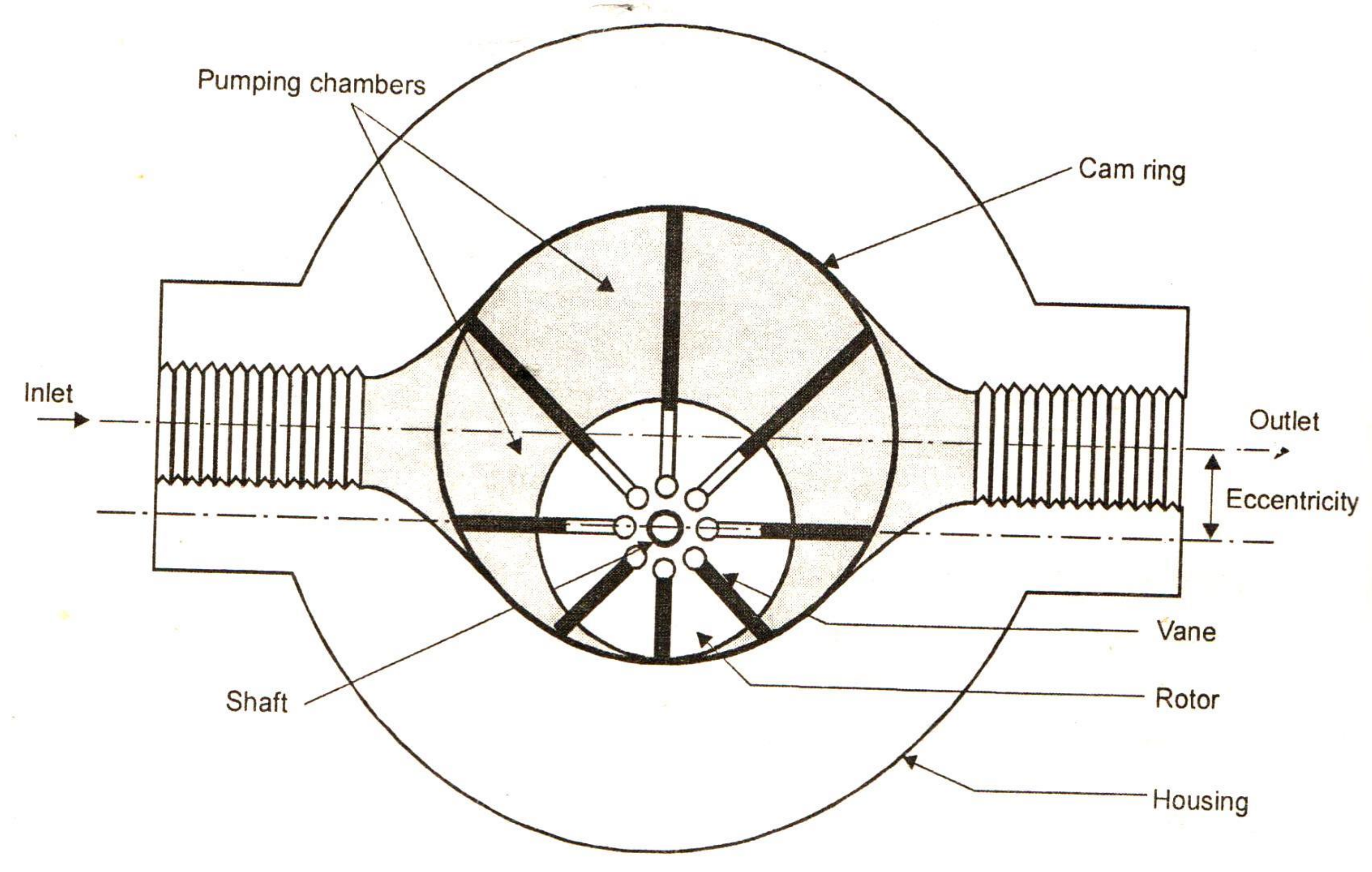
- Inner gear has one teeth lesser than external
- The inner gear rotor drives the outer gear rotor around, as they mesh.
- Vacuum created at inlet port when the right side is meshed, fluid drawn in.
- In the left side chamber, area decreases causing increase in pressure, forces fluid through outlet



VANE PUMP

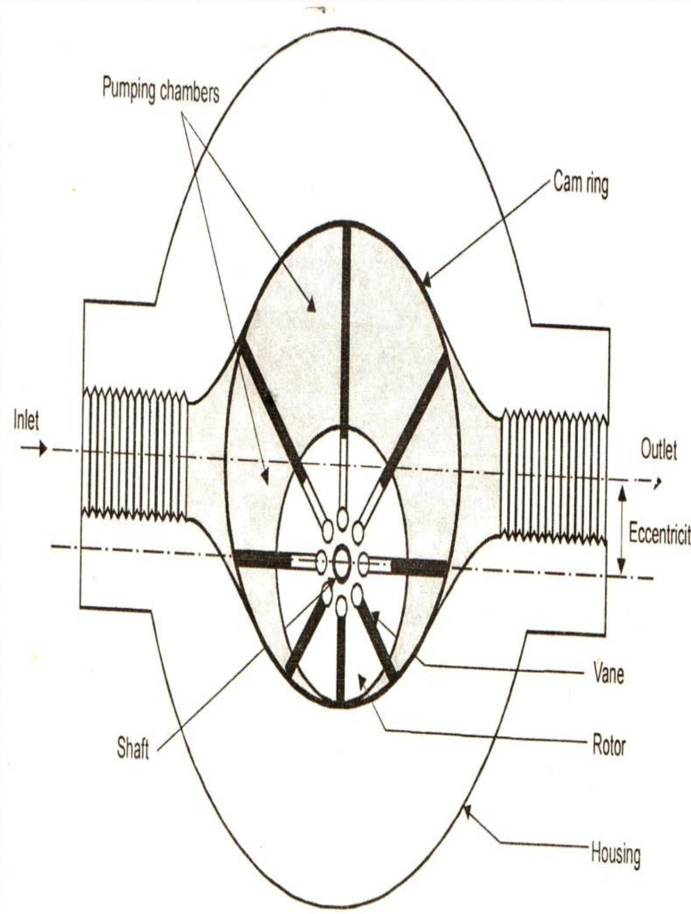
- Vane pump operating speed is4500 rpm
- Delivery flow rate 270 lpm
- Operating pressure is 25 Mpa
- Volumetric efficiency is 92%
- **ADVANTAGES:**
- High reliable
- Reversible pump
- It reduces the leakage losses

UN BALANCED VANE PUMP

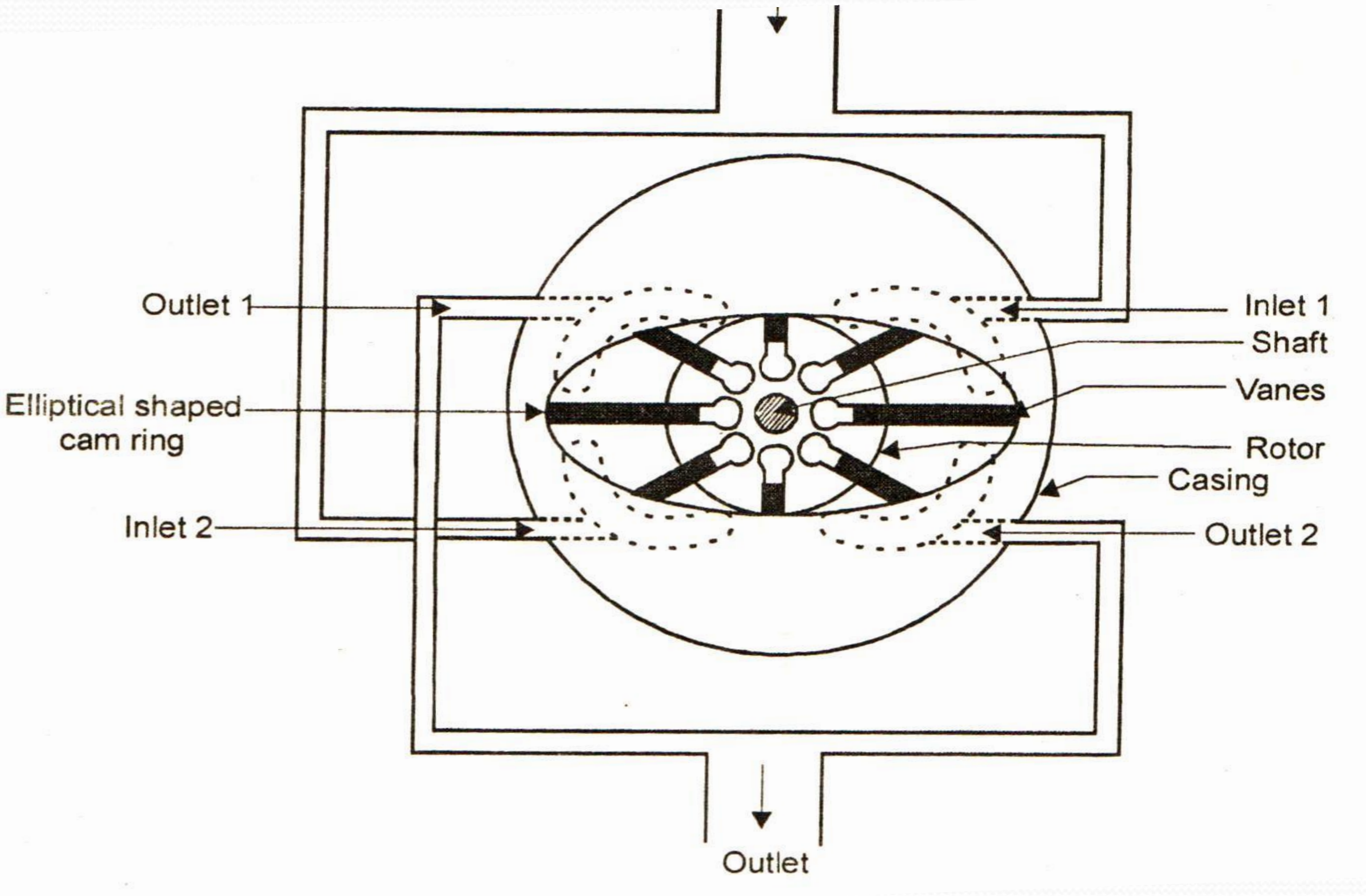


UN BALANCED VANE PUMP

- As rotor rotates vanes pushed out against cam ring surface by centrifugal force, which in turn vane kept in contact with the cam surface.
- Vanes divide the space between rotor and cam ring into serial of small chambers.
- During one half of rotor rotation vacuum created and fluid drawn inside
- During second half vanes pushed back pressure increased, forces fluid outside

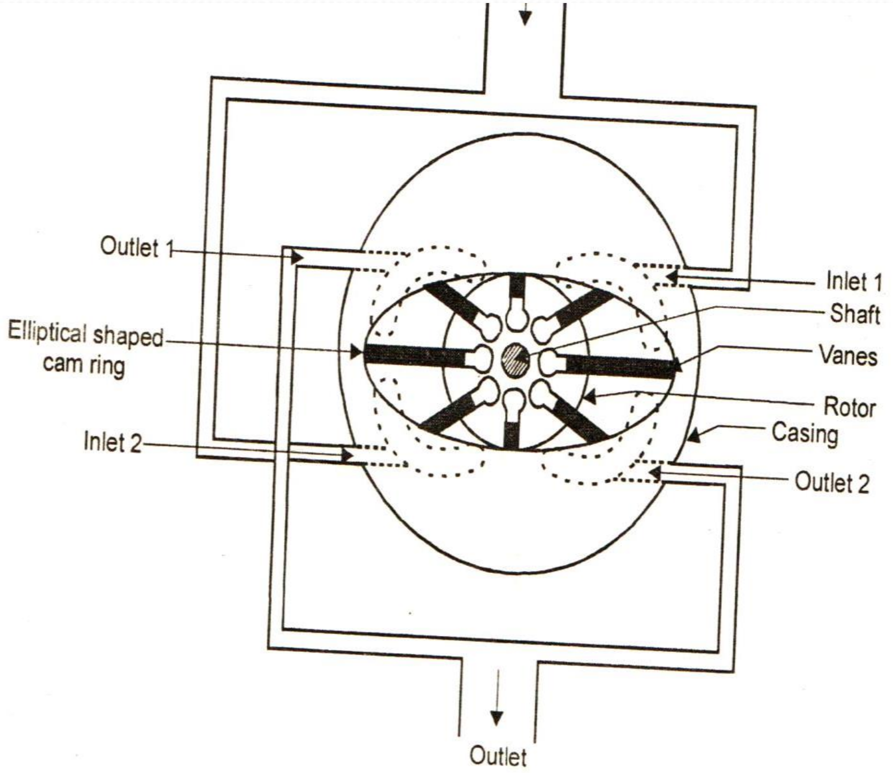


BALANCED VANE PUMP



BALANCED VANE PUMP

- When rotor rotates inside elliptical cam ring, the vanes strokes twice/rev of pump shaft.
- Resulting in increase or decrease in volume of pumping chambers twice per cycle.
- For increase in volume fluid drawn through inlet port and for decrease fluid forced out through outlet port.



PISTON PUMPS

- Operating speed is 6000 rpm
- Delivery flow rate 600 lpm
- Operating pressure 70Mpa
- Volumetric efficiency 98%
- **ADVANTAGES:**
- Simple and compact design
- High Volumetric efficiency
- High pressure with high flow rate
- Least tolerant of contamination

BENT AXIS TYPE PISTON PUMP TYPE

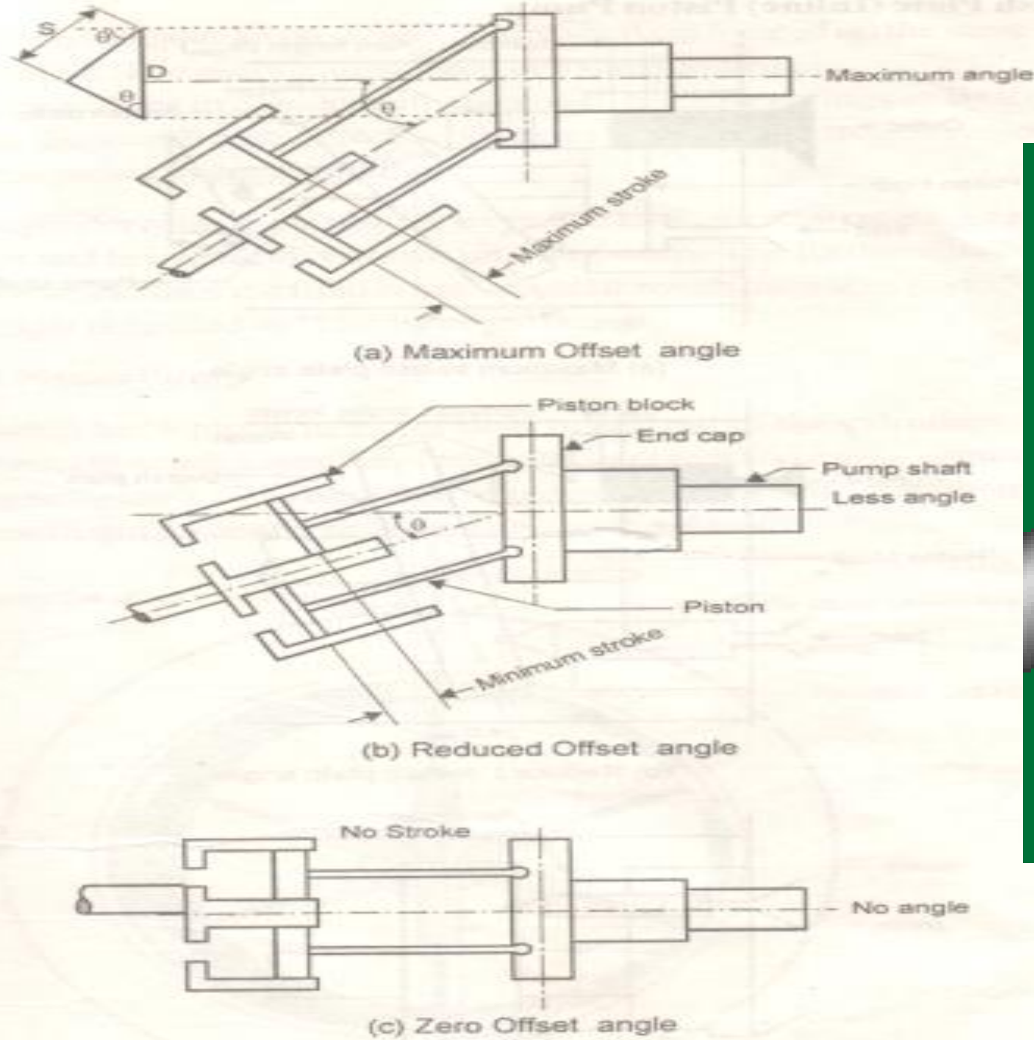
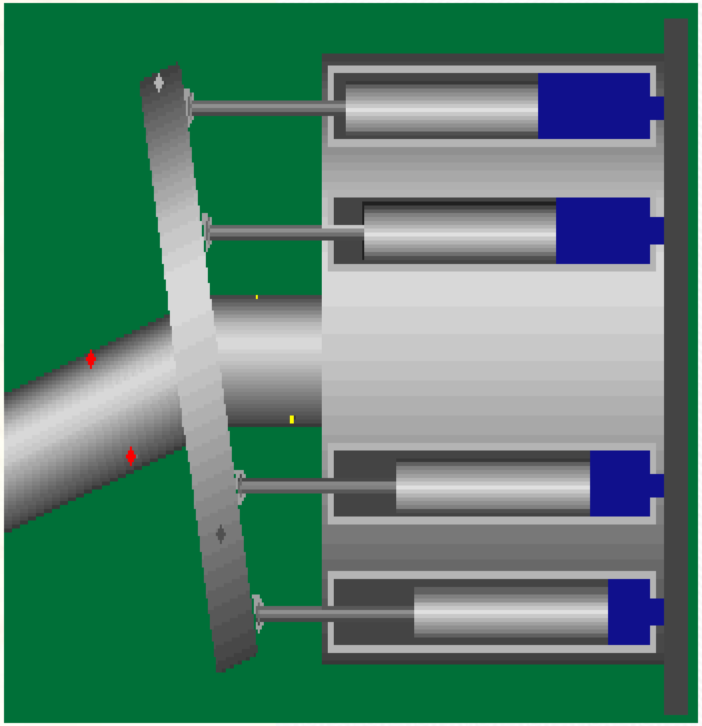


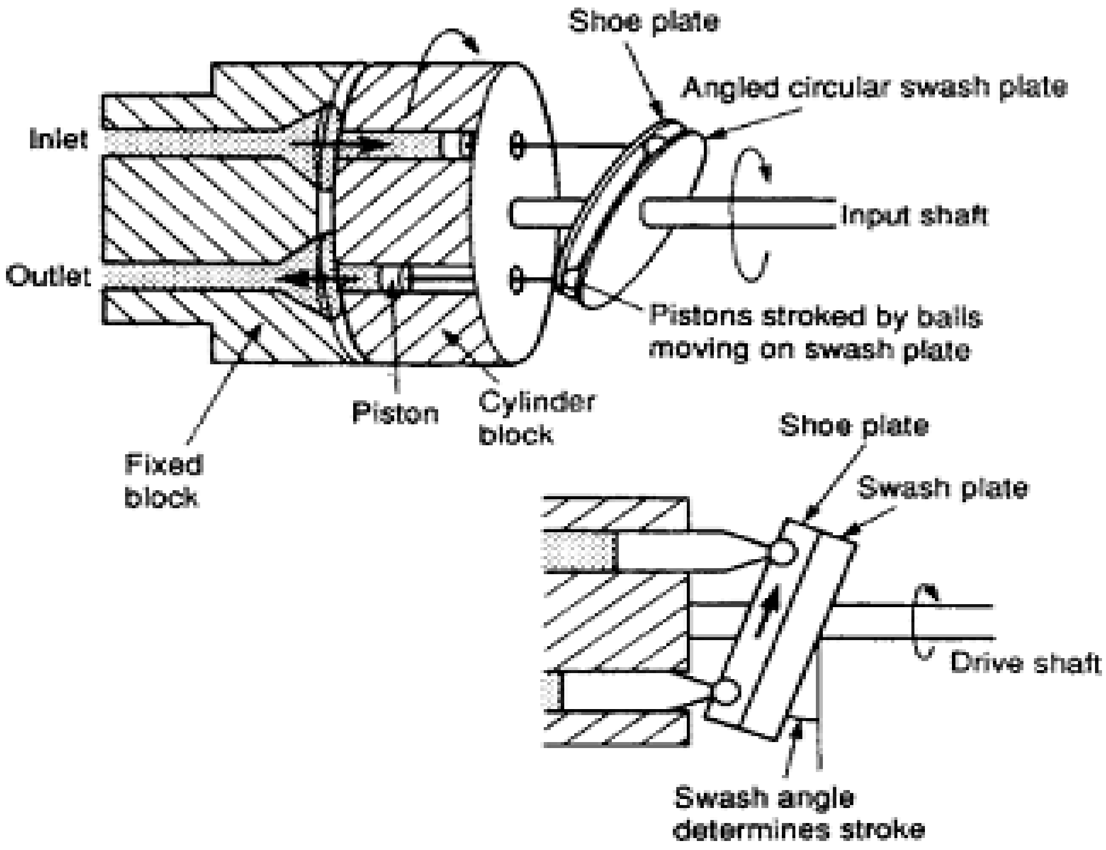
Figure 2.8: Bent axis type piston pump

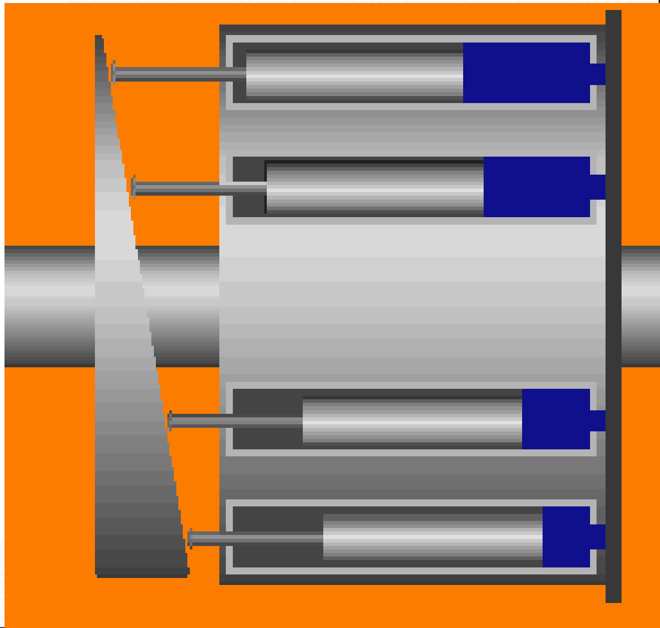


BENT AXIS TYPE PISTON PUMP TYPE

- When the pump shaft rotates the piston and piston block also rotates.
- This causes piston to reciprocate in their bores.
- When piston pulls back fluid drawn in, during 180° of rotation, fluid drawn out during other 180° of rotation

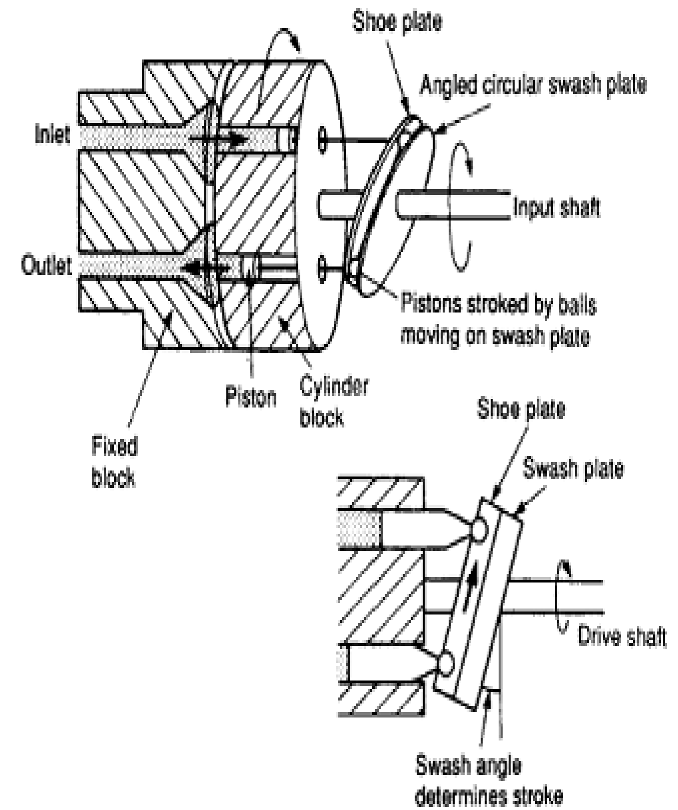
SWASH PLATE PISTON PUMP





Swash plate piston pump

- The cylinder block and driven shaft are located on the same centreline.
- The pistons are stroked by a fixed angled plate called the swash plate.
- Each piston can be kept in contact with the swash plate by springs or by a rotating shoe plate
- As cylinder rotated piston pulled back, vacuum created in inlet port and hence fluid drawn in. further rotation of cylinder pushes piston and fluid discharged through outlet port.
- Max swash plate angle limited to 17.5° by construction.



RADIAL PISTON PUMP

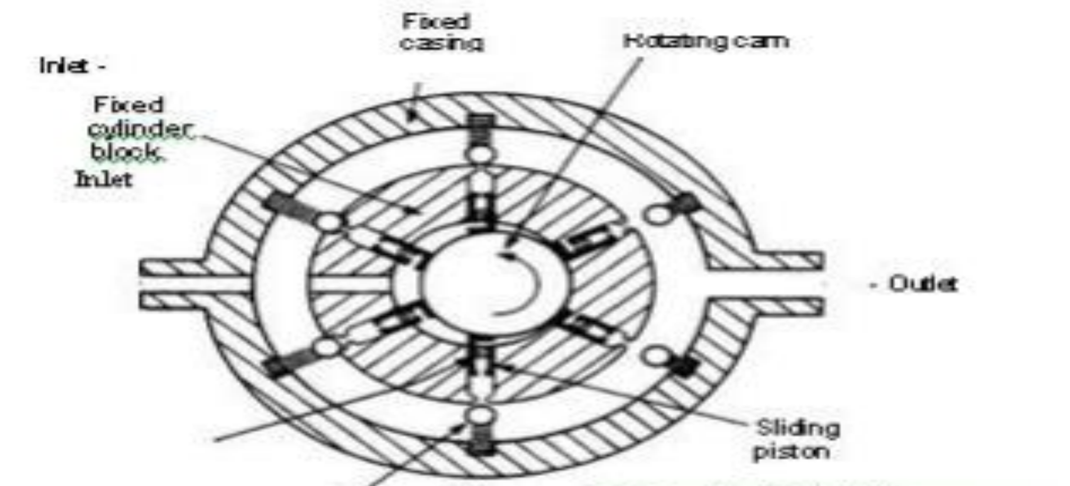
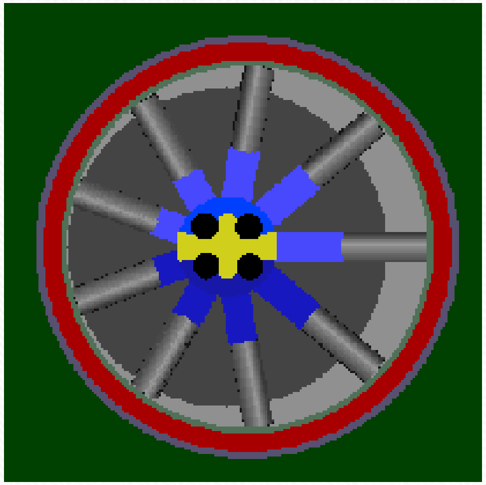


Figure 2.12 *Radial piston pump*



RADIAL PISTON PUMP

- Has pistle to direct fluid in and out of the cylinder.
- Consists of cylindrical barrels in which no. of plates reciprocates and rotor containing a reaction ring.
- The piston remains always in contact with the reaction ring due to centrifugal force and back pressure on the pistons

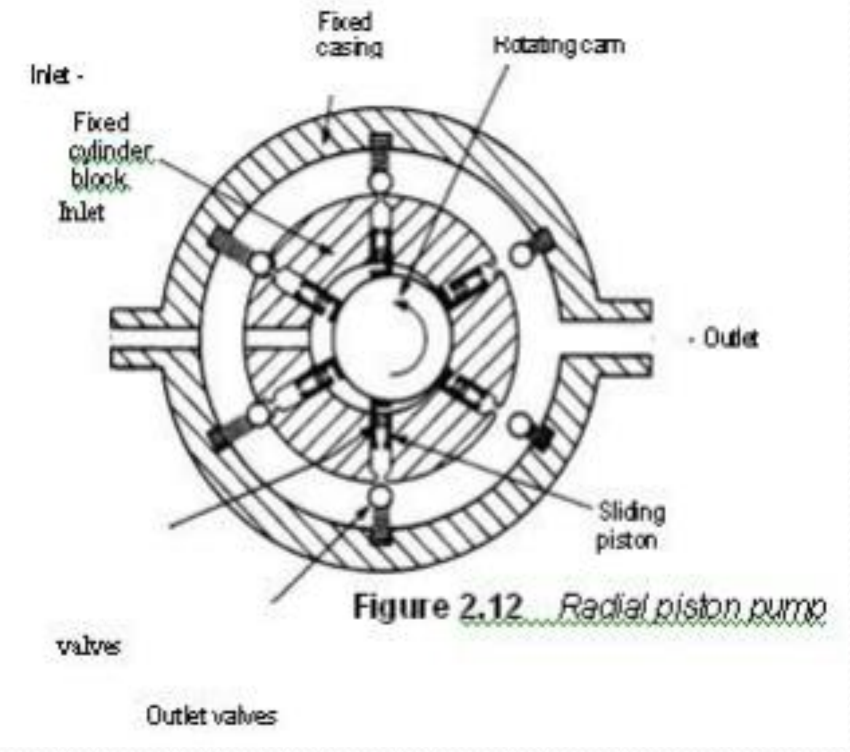


Figure 2.12 Radial piston pump

RADIAL PISTON PUMP

working

- As cylinder barrel rotates the reaction ring moved eccentrically to the pistle axis and this eccentric change causes the piston to stroke
- When piston outside – fluid drawn in.
- When the piston at max eccentricity, it is forced inward and forces the fliud out of the casing.

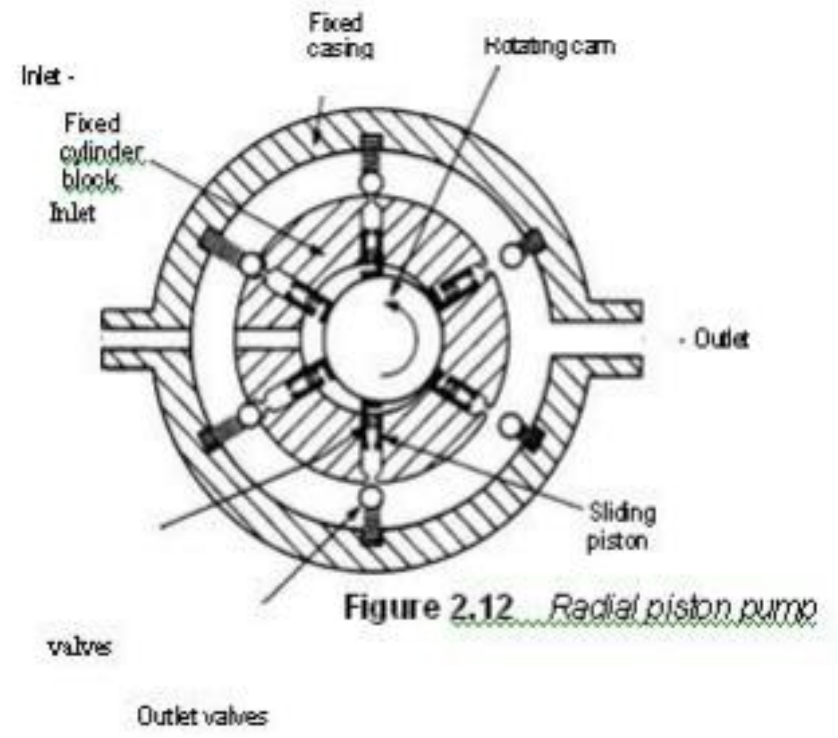
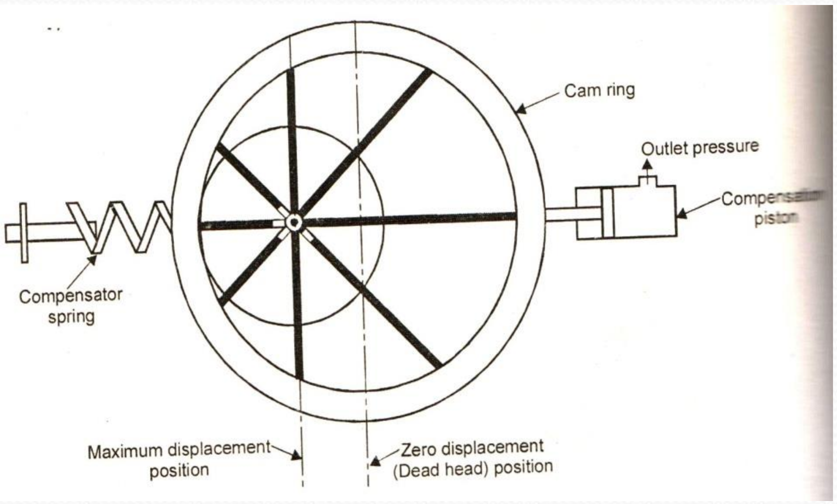
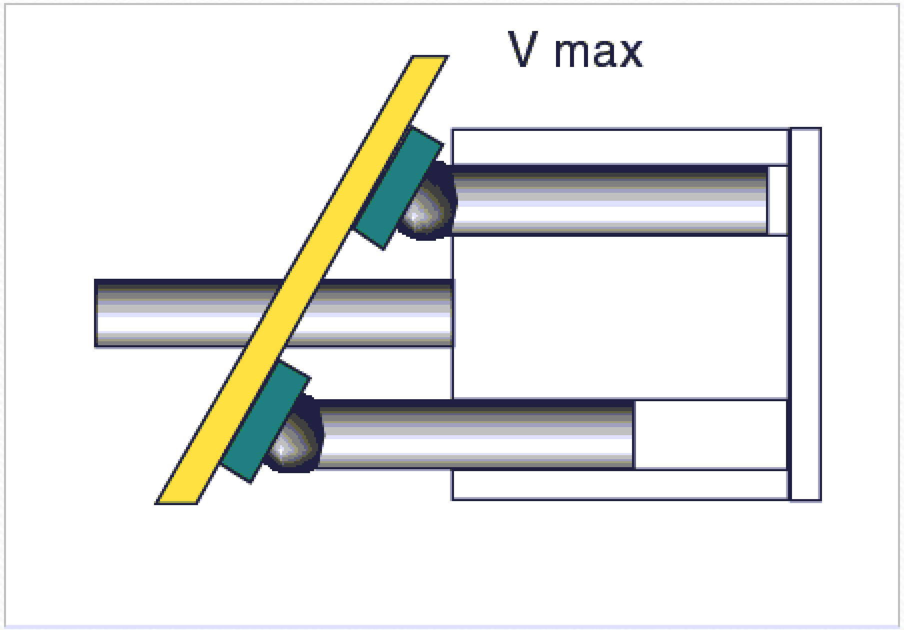


Figure 2.12 *Radial piston pump*

VARIABLE DISPLACEMENT PUMP





PUMP PERFORMANCE

- **Volumetric efficiency:**
- ηv = Actual Flow Rate/Theoretical flow rate $= Qa / Qt$
- The amount of leakage occurred with in the pump under design operating condition.
- **Mechanical efficiency (η_m):**

  it indicates the amount of energy losses(friction, fluid turbulence etc.,) occurred other than leakage.

$$\eta_m = \frac{\text{Output power}}{\text{Input power}} = \frac{P_o}{P_i} = \frac{\text{Theoretical torque}}{\text{Actual torque}} = \frac{T_t}{T_a}$$

η_m varies from 90% to 95%

Over all efficiency η_o

- It indicates all the energy losses occurred in the pump

$$\eta_o = \frac{\text{Actual power delivered by the pump}}{\text{Actual power delivered to the pump}} = \frac{\text{Hydraulic Power}}{\text{Brake Power}}$$

$$\eta_o = \eta_m \times \eta_v$$

Pump Characteristic curves

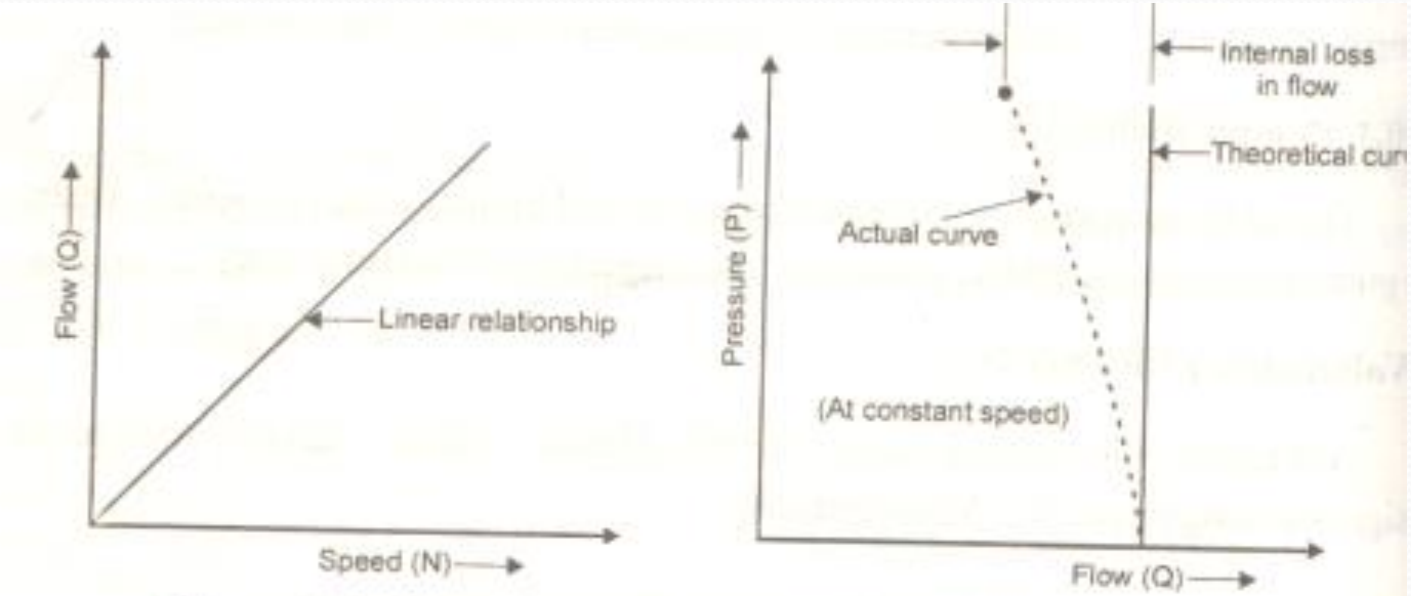


Figure 2.12: Characteristics curves for positive development pumps

CAVITATION

- When partial vacuum become excessive at inlet, air in the fluid comes out and forms bubbles.
- When these bubbles travels with high velocity and high impact force, erode metallic life and reduces the pump life.

Effects of cavitation

- Vibration
- Damage to bearing due to poor lubrication
- overheating

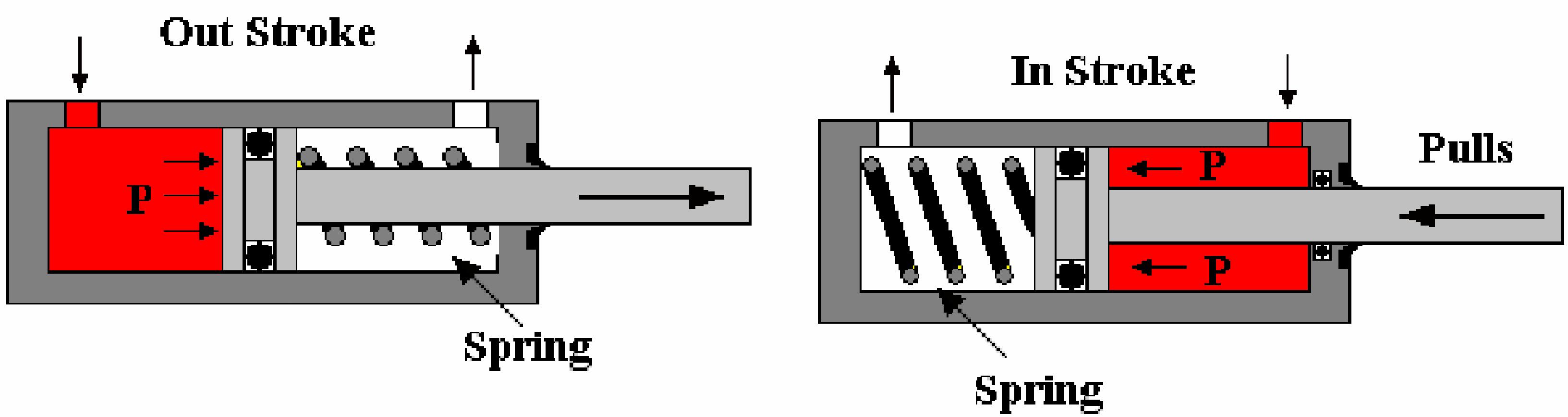
UNIT II
HYDRAULIC ACTUATORS AND CONTROL COMPONENTS

- Hydraulic Actuators: Cylinders — Types and construction, Application, Hydraulic cushioning — Hydraulic motors — Control Components : Direction Control, Flow control and pressure control valves — Types, Construction and Operation — Servo and Proportional valves — Applications — Accessories : Reservoirs, Pressure Switches — Applications — Fluid Power ANSI Symbols — Problems.

FLUID POWER ACTUATORS

- Extracting energy from the fluid and convert it to mechanical energy.
- Types of actuators; linear actuators ,rotary actuators
- linear actuators:[Cylinder]Which converts the fluid power in to linear mechanical force and provide straight line motion
- Types of hydraulic cylinders:
- 1.Single acting
- 2.Double acting

Single acting cylinder

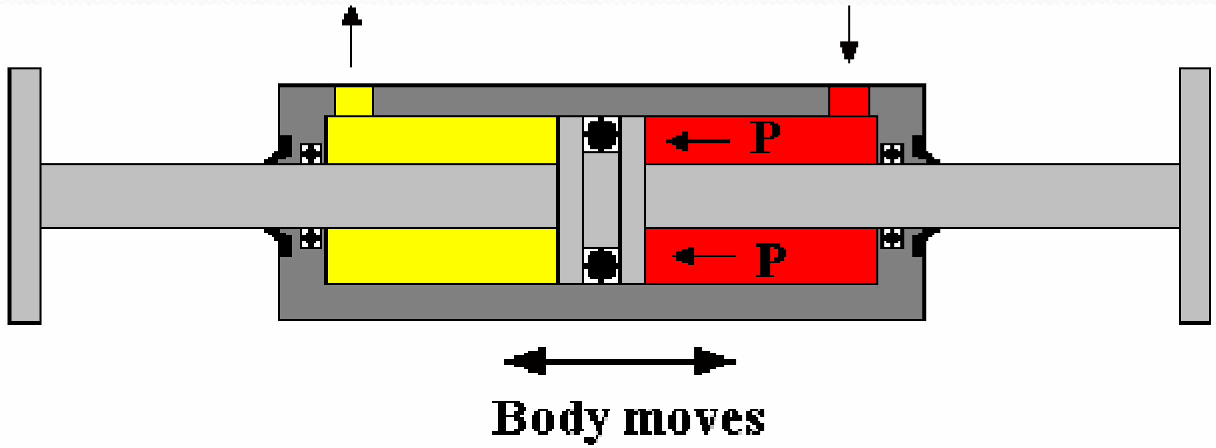


Single Acting Cylinder for Pushing

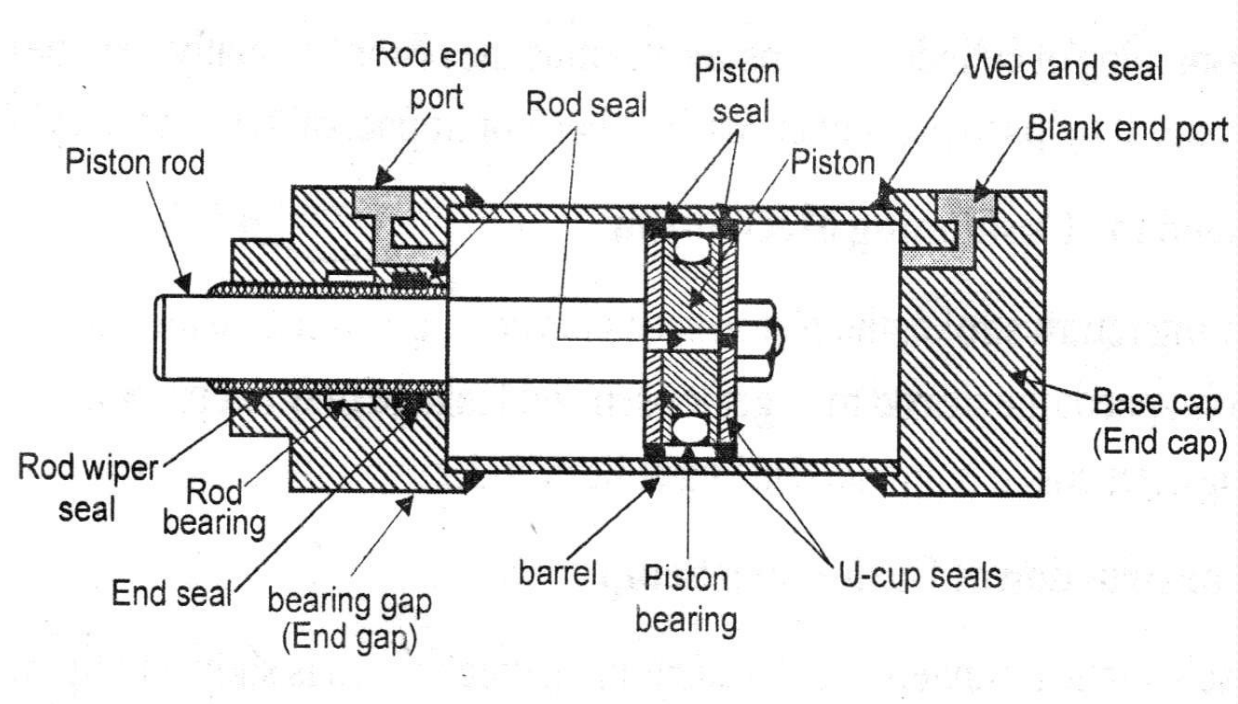
Single Acting Cylinder for Pulling

Figure 2

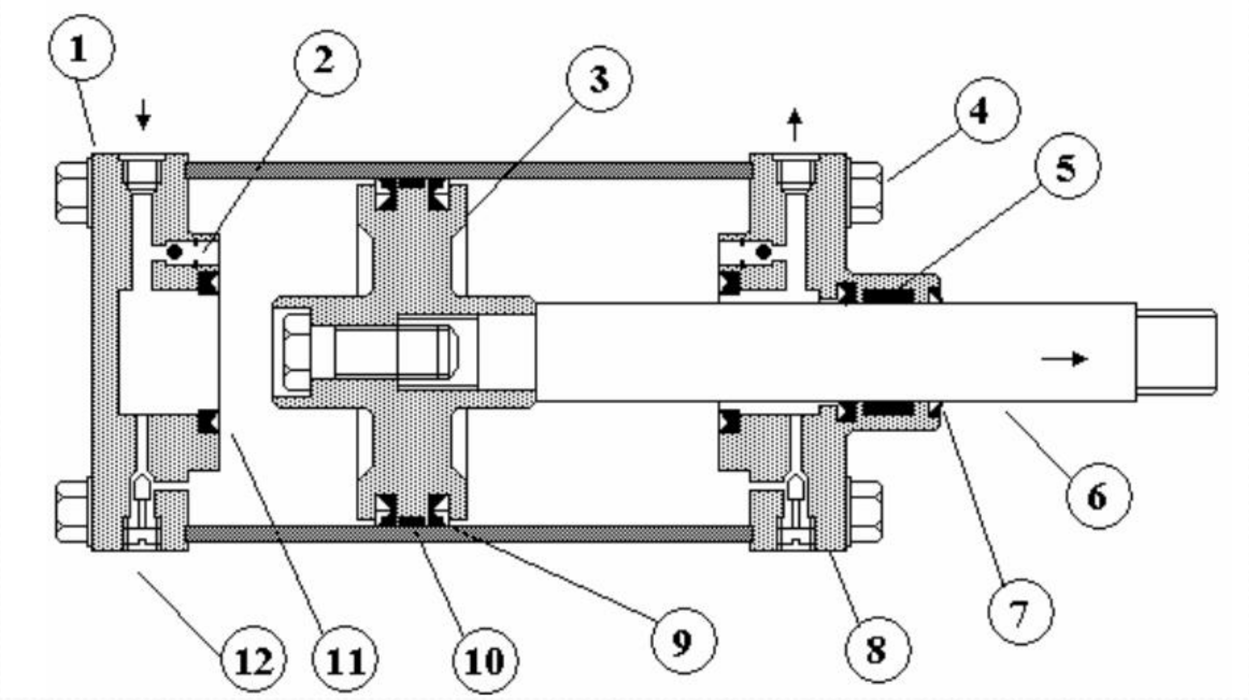
DOUBLE ACTING CYLINDER



Construction of Double acting cylinder



Construction of double acting cylinder



Double acting cylinder

1. Rear end cap
2. Quick start valve
3. Piston
4. Draw bolts
5. Rod bearing
6. Rod
7. Wiper ring
8. Front end cap
9. Piston seal
10. Low friction bearing ring
11. Cushioning boss seal
12. Cushioning valve

cylinder

4. SYMBOLS

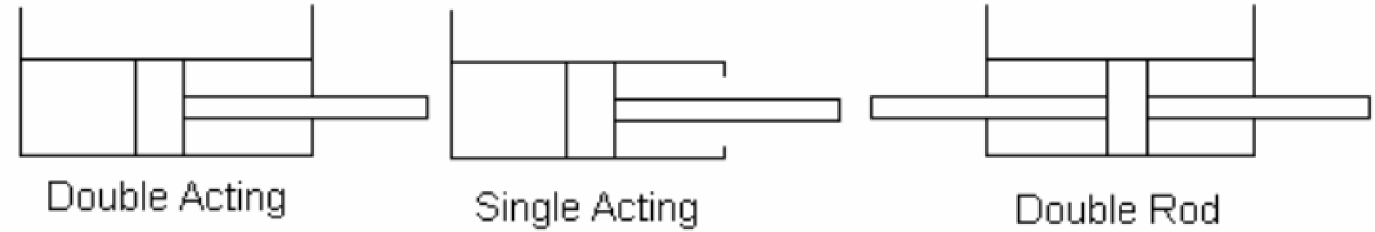
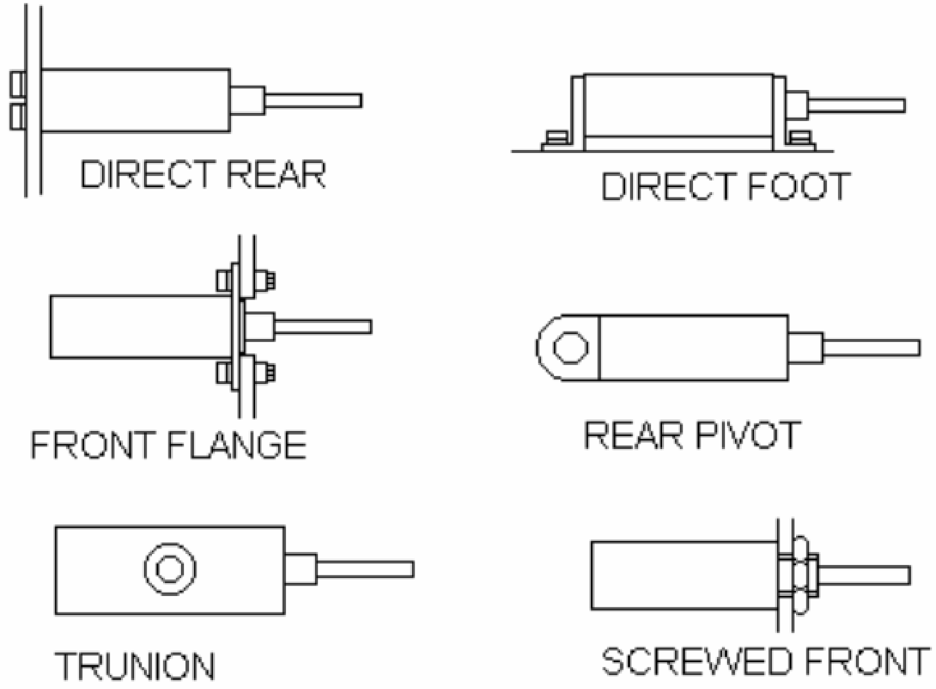


Figure 6

Cylinder mounting

8. END FIXINGS

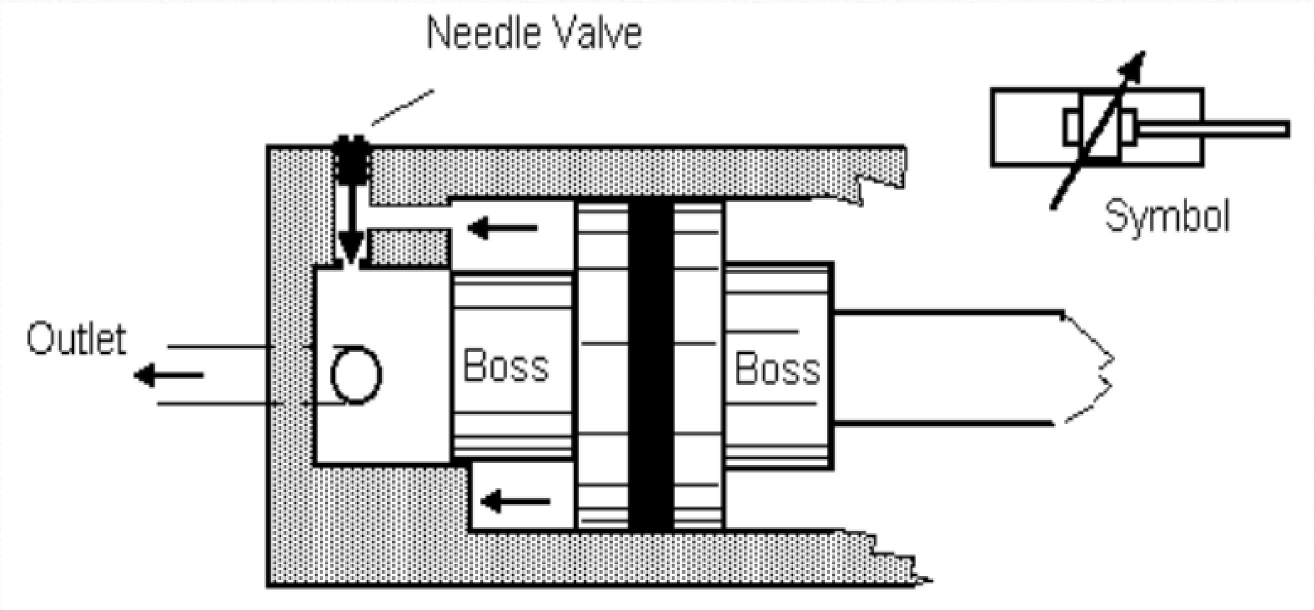
The diagram shows typical ways of mounting cylinders and attaching them to machines.



Cushioning Mechanism

- Cushioning of cylinder means decelerating the piston gradually near the end of the return stroke.
- It helps to prevent excessive shock or impact of load on the cylinder
- During return stroke the piston speed is very high. If the piston hits the cylinder head at this speed. The tie rod may get loosen and leakage may occur.
- To avoid this cushioning mechanism is provided in hydraulic cylinder.

Working - Cushion assembly



Special Cylinders

A. Tandem Cylinder
B. Telescopic Cylinder
C. Rod less Cylinder

Tandem Cylinder

- Two or more cylinders with inter connecting piston assemblies with a common piston rod to increase the output

Tandem Cylinder

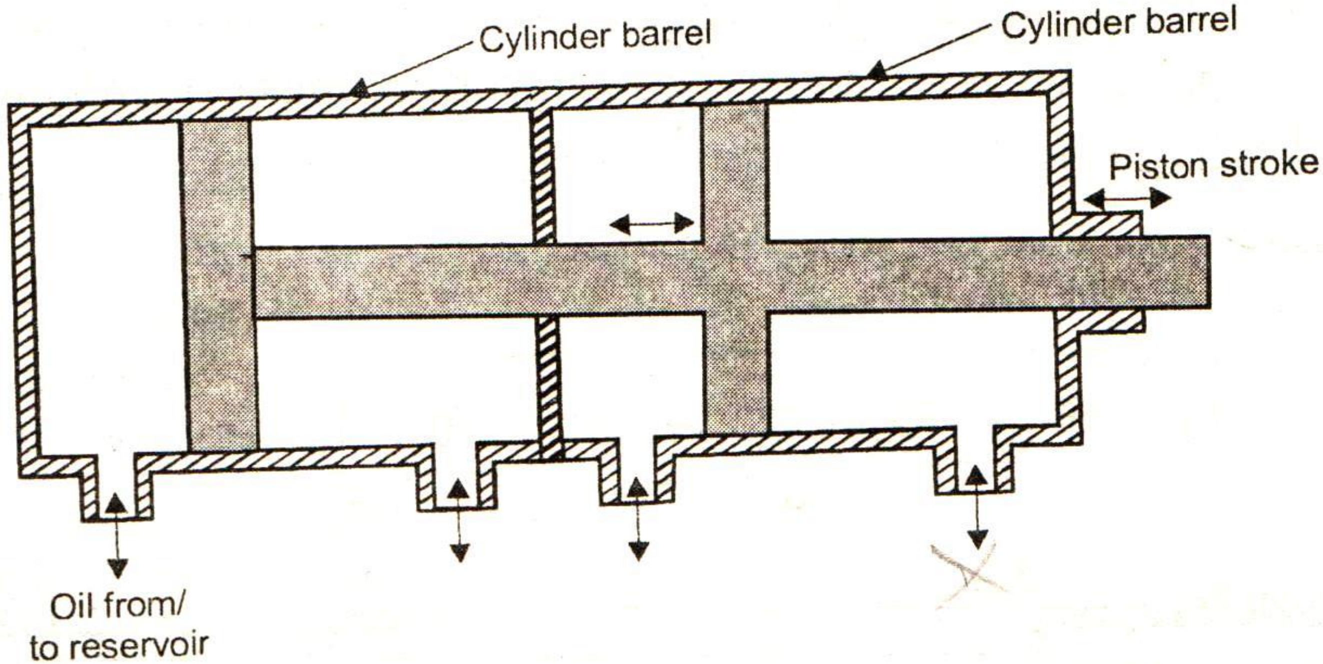
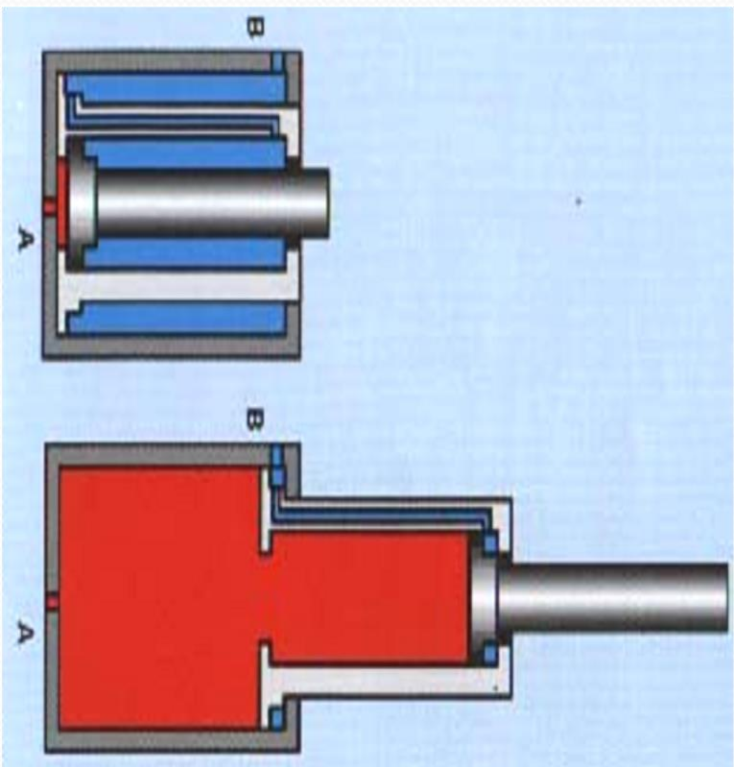


Figure 2.17: Tandem Cylinder

Telescopic cylinder

- Telescopic cylinder used where long work strokes are needed in a short envelop.



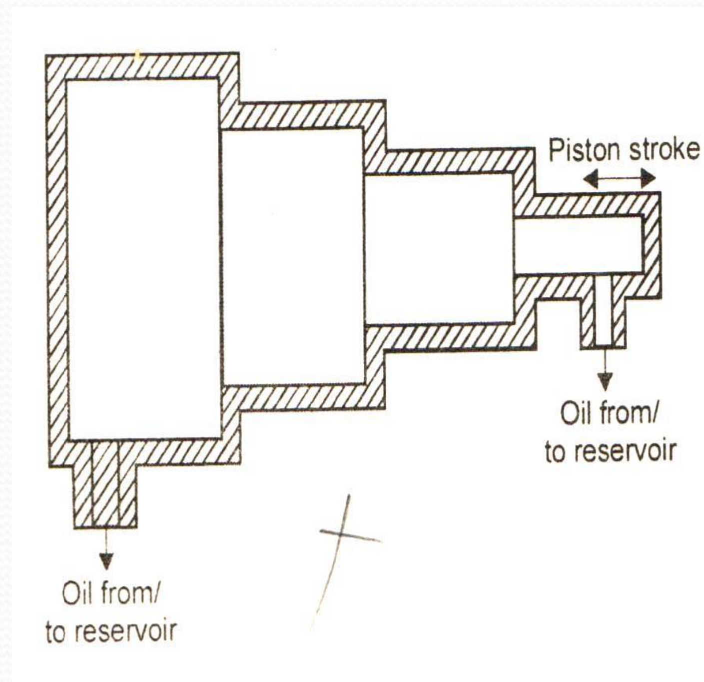


Figure 2.18: Telescopic cylinders

Rod less cylinder

•Rod less cylinders are linear devices that use pressurized fluid to move a load with in power transfer operations.

•It uses a patented cylinder tube with two chambers to minimize leakage and improve flexural and torsional stiffness

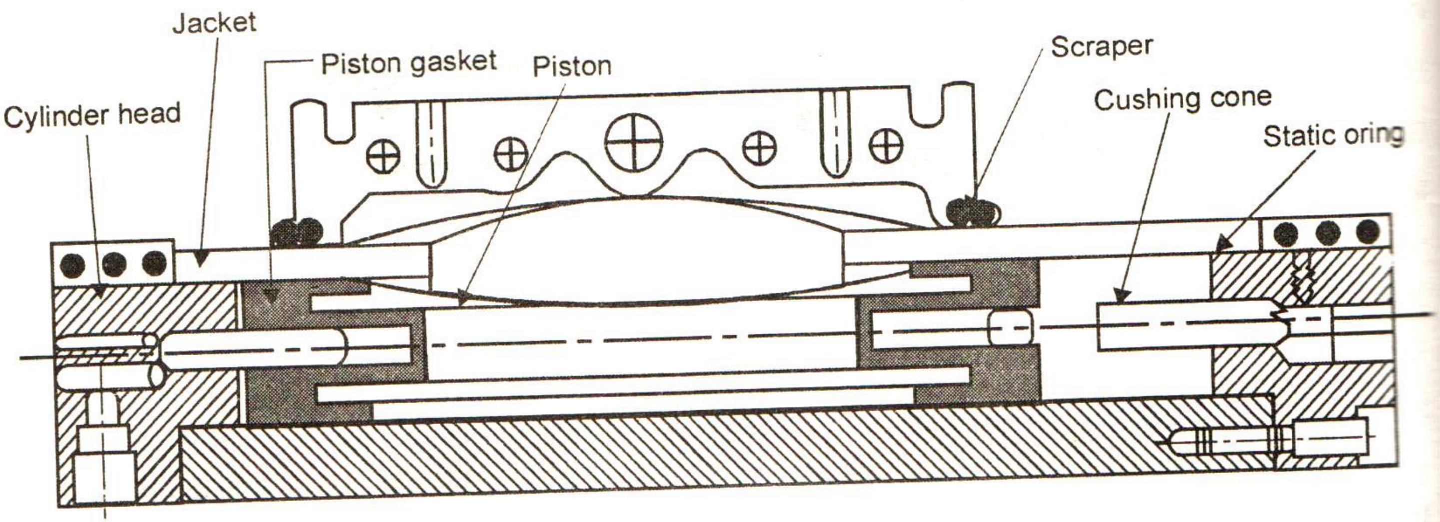


Figure 2.19: Rodless Cylinder

Fluid motors

- A fluid motor is a device which converts fluid power into mechanical force and motion and provides rotary mechanical motion.
- Types of fluid motors
- Gear motors
- Gerotor motors
- Vane type fluid motors
- Piston motors

Servo and Proportional valves

The construction and operation of a typical mechanical-type servo valve is illustrated in Fig.14.2. The shape of the porting in the sleeve may be square, rectangular, round, or full annulus.

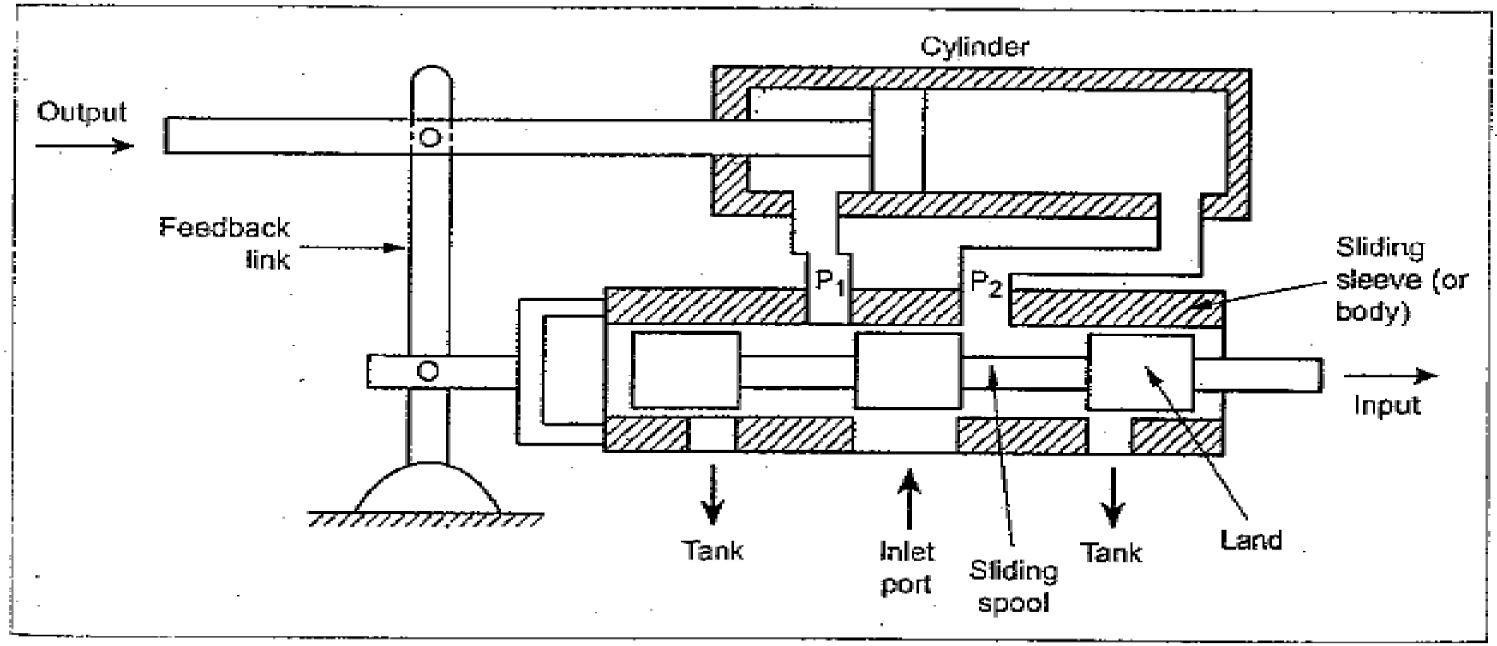


Fig. 14.2. Hydromechanical servo valve

Servo and Proportional valves

The construction ad operation of a typical single-stage electrohydraulic servo valve is illustrated in Fig.14.4.

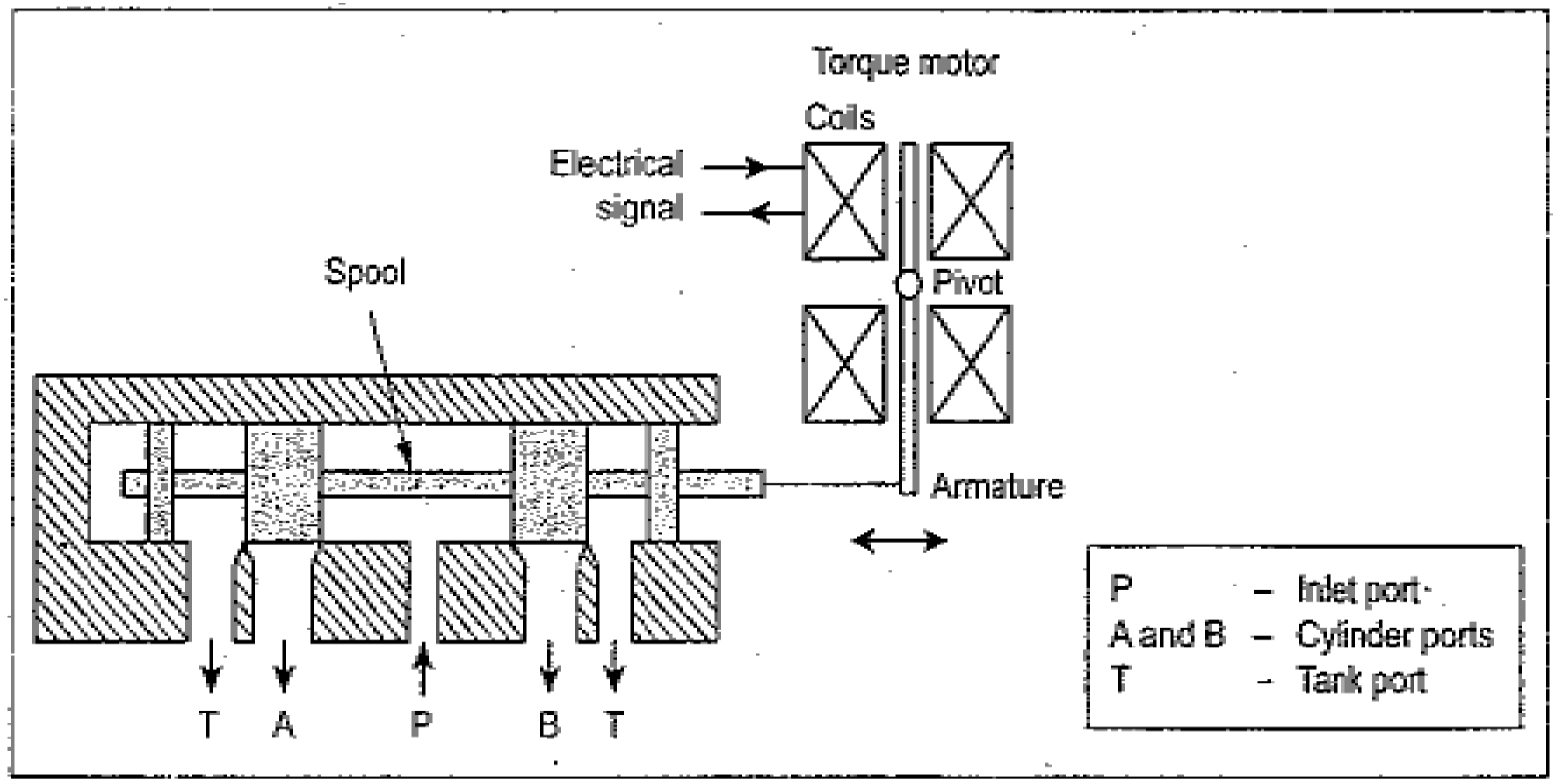


Fig. 14.4. Single-stage electrohydraulic servo valve

Servo and Proportional valves

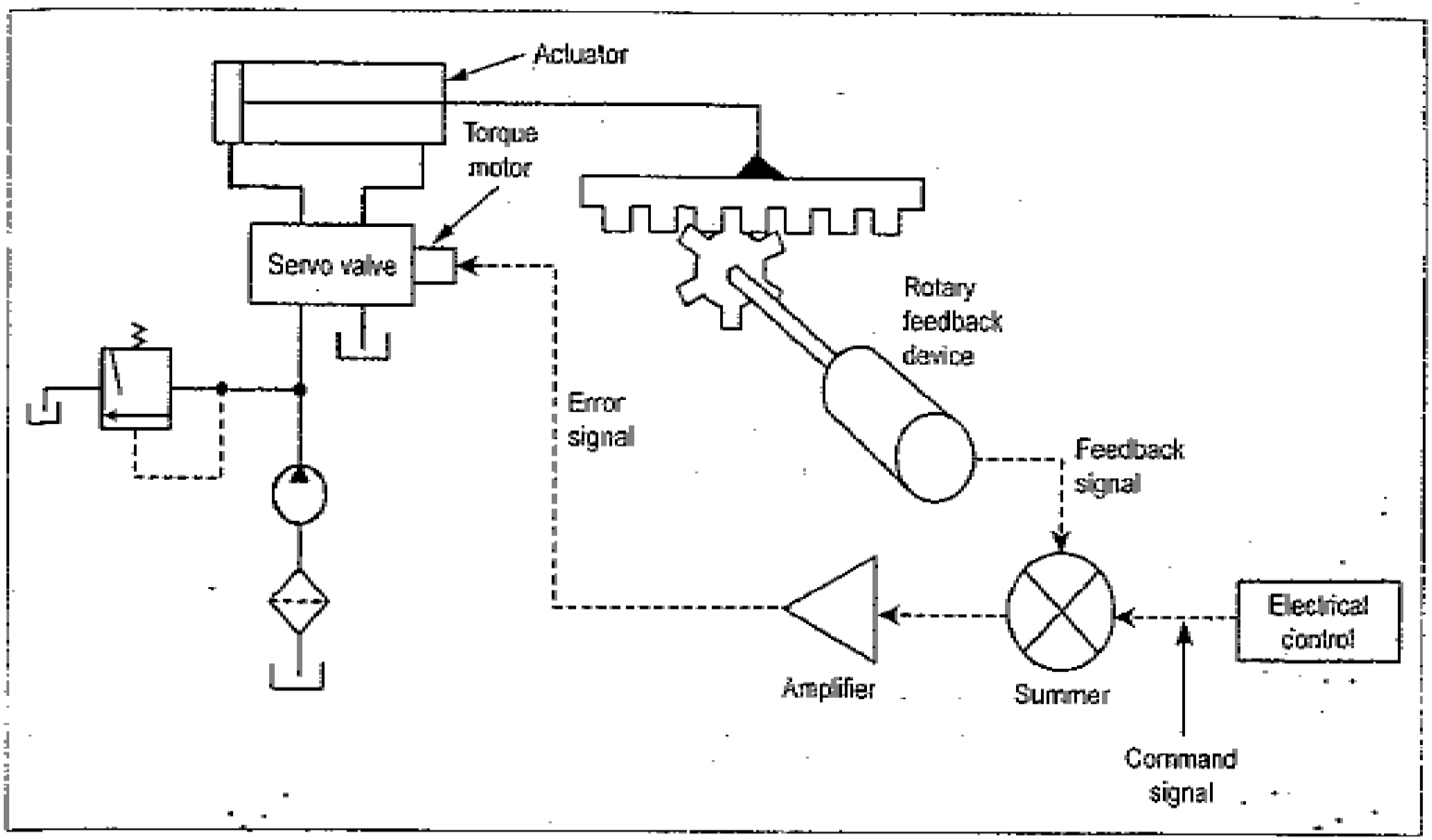
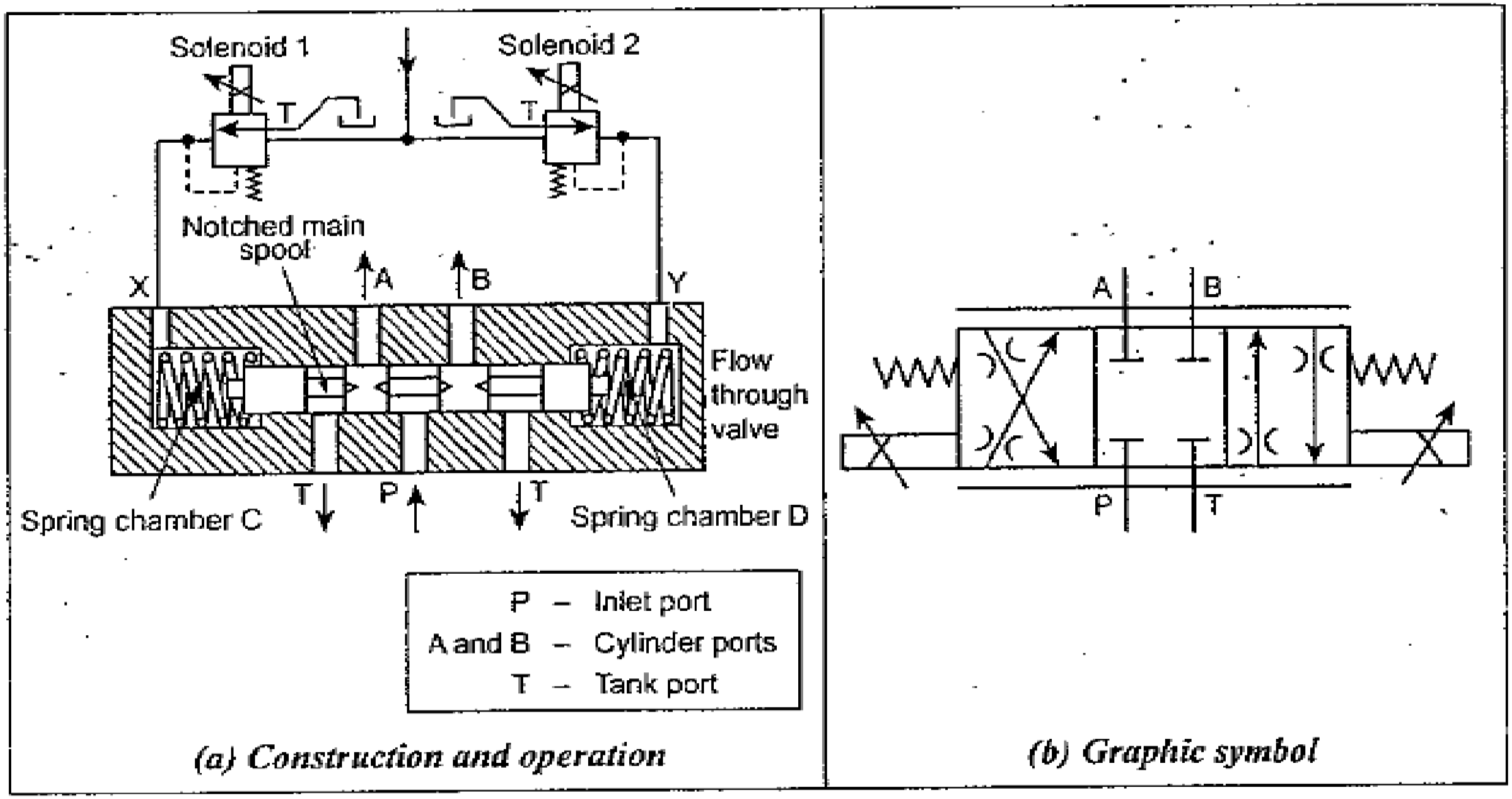


Fig. 14.9. Electrohydraulic servo system

Servo and Proportional valves

The construction and operation of a typical proportional direction control valve is illustrated in Fig.14.12(*a*).



(a) Construction and operation

(b) Graphic symbol

Fig. 14.12. Proportional direction control valve

UNIT III

Design of hydraulic circuits

INTRODUCTION

- Hydraulic circuit
  - **Graphical representation** shows the arrangement of interconnected components performing useful work.

- Hydraulic circuit comprises mainly of

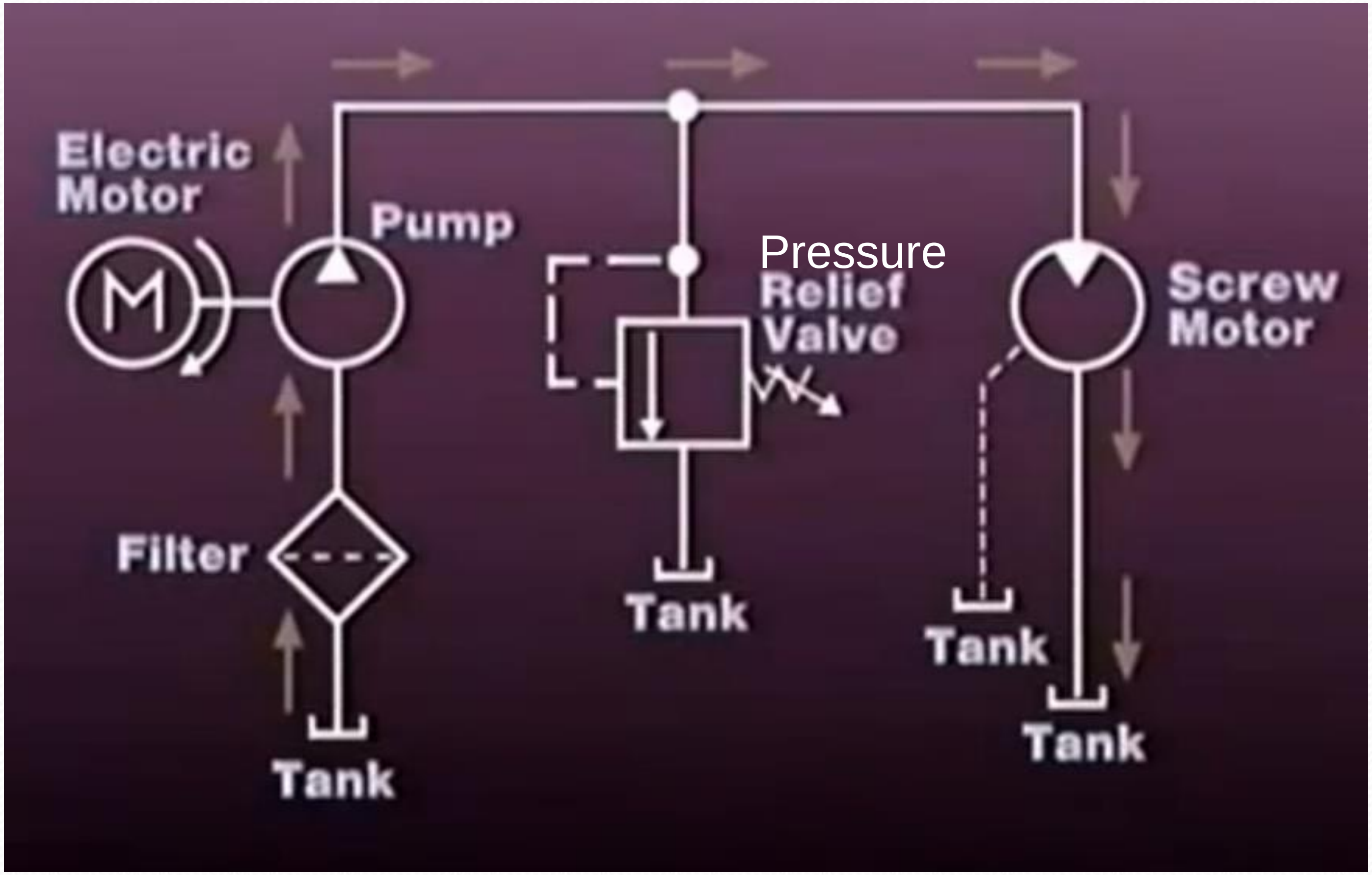
  Power input-pump

  Power output- motor

  Control Valves-FCV, DCV, PCV etc.

INTRODUCTION

- Hydraulic circuit example



VALVES – CONTROL COMPONENTS

Hydraulic valves are device used to control pressure, flow direction or flow rate in hydraulic circuits .

Classification of control valves

- Direction Control Valves
- Pressure control valves
- Flow control valves

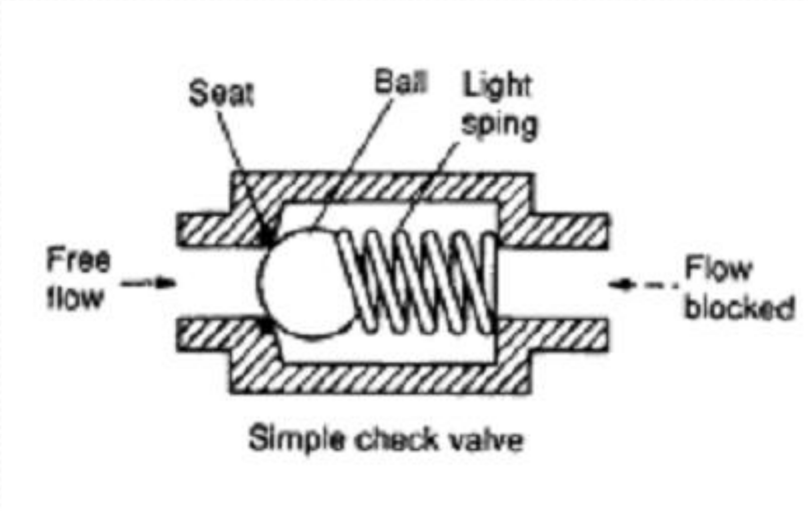
Classification of DCV

2 way DCV, 3 way DCV and 4 way DCV.

Apart from these three type there are check and shuttle valve comes under DCV.

Check valve

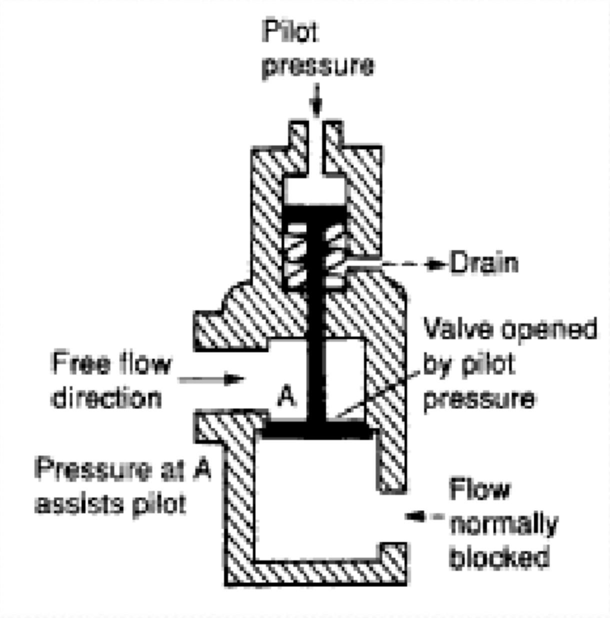
- One way valve
- Allows flow in one direction only



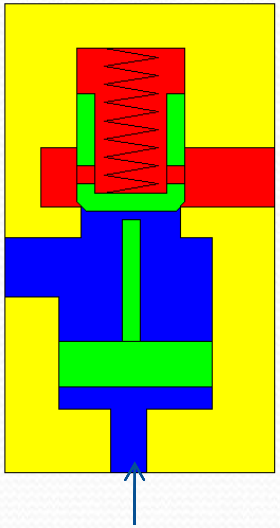
Check valve

Pilot check valve (2/2 DCV)

Check valve is modified and designed as pilot check valve- two way type



Pilot check valve



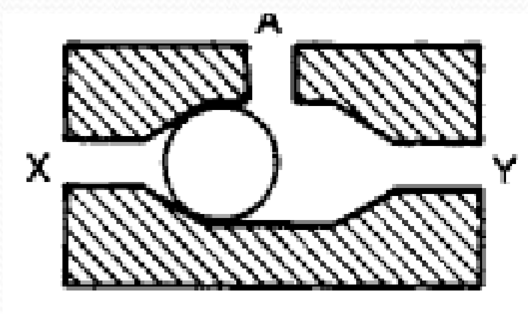
Pilot pressure

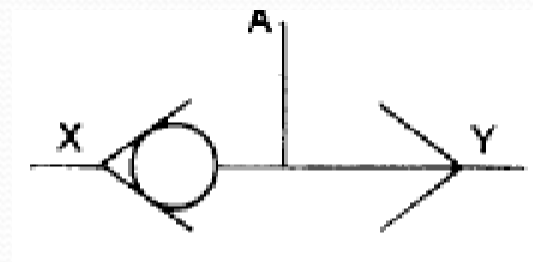
Pilot check valve animation
(Reverse to left one)

Simplest DCVs

Shuttle valve

- Allows two circuit(X,Y) to be connected to one branch circuit(A). If flow pressure X>Y, then the direction of flow will be from X→A and vice Versa for Y→A .



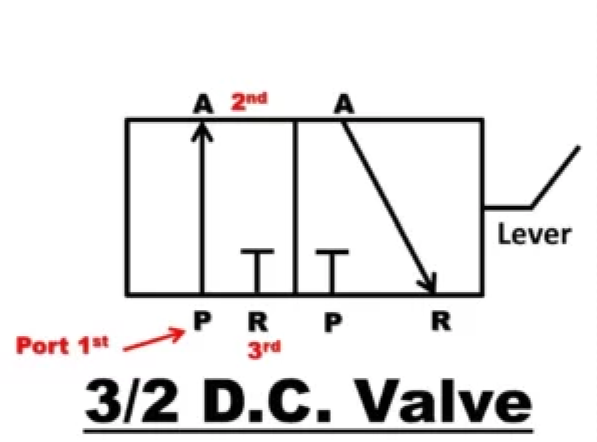


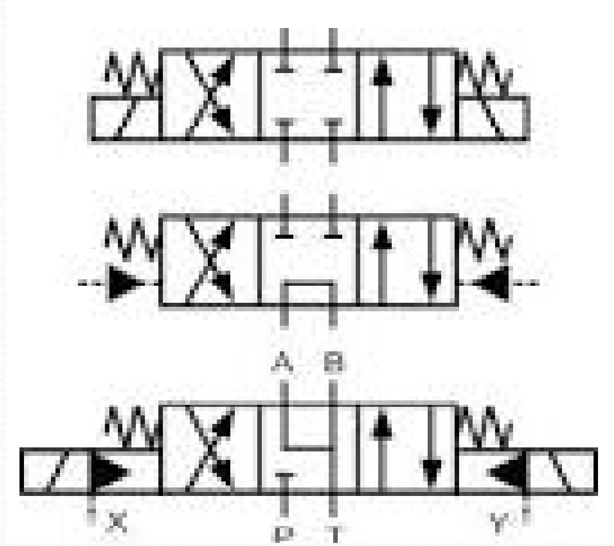
(b) Symbol

Shuttle valve

Direction control Valve

3/2 and 4/3 way valve



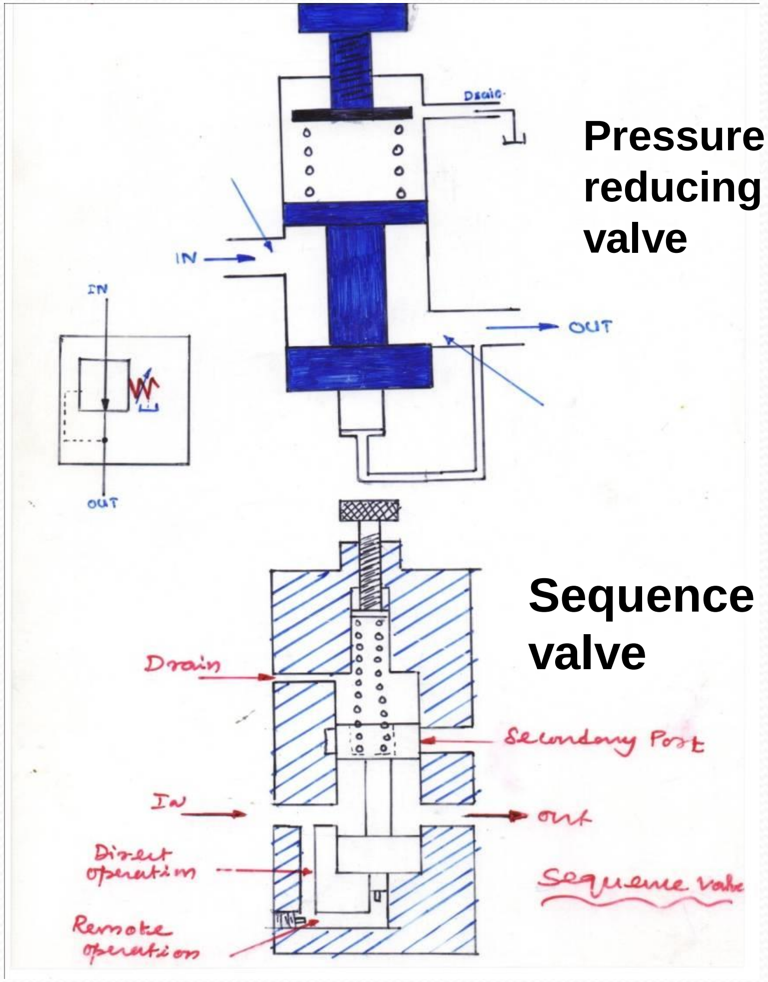


4/3 way valve

Pressure reducing valve

Pressure reducing valve

- Normally open
- Used to maintain reduced pressure.
- If IN is of normal, flow will also be normal to outlet.
- If IN flow pressure is more spool blocks outlet, enough to maintain normal flow.



Sequence valve

- Normally closed.

In normal position,

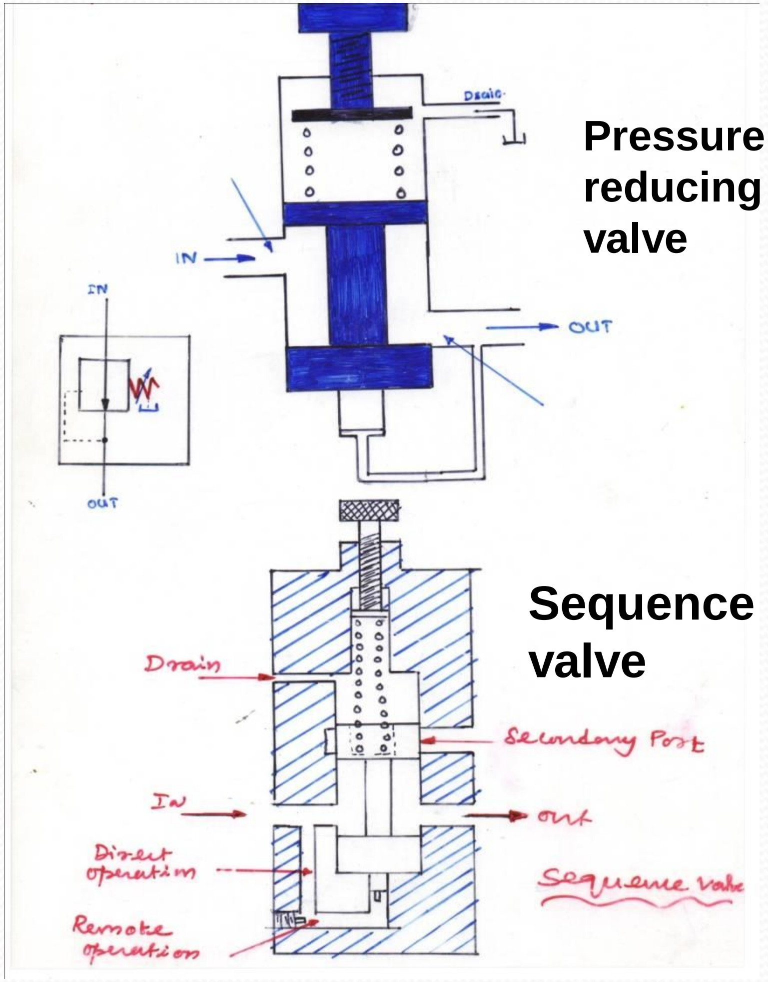
- Fliud flow from IN to out (cylinder 1)

When cylinder 1 work is done,

- Further flow is not possibe, thus increases pressure in system.

When this pressure overcomes the valve setting, spool moves up and flow is to secondary port (cylinder 2).

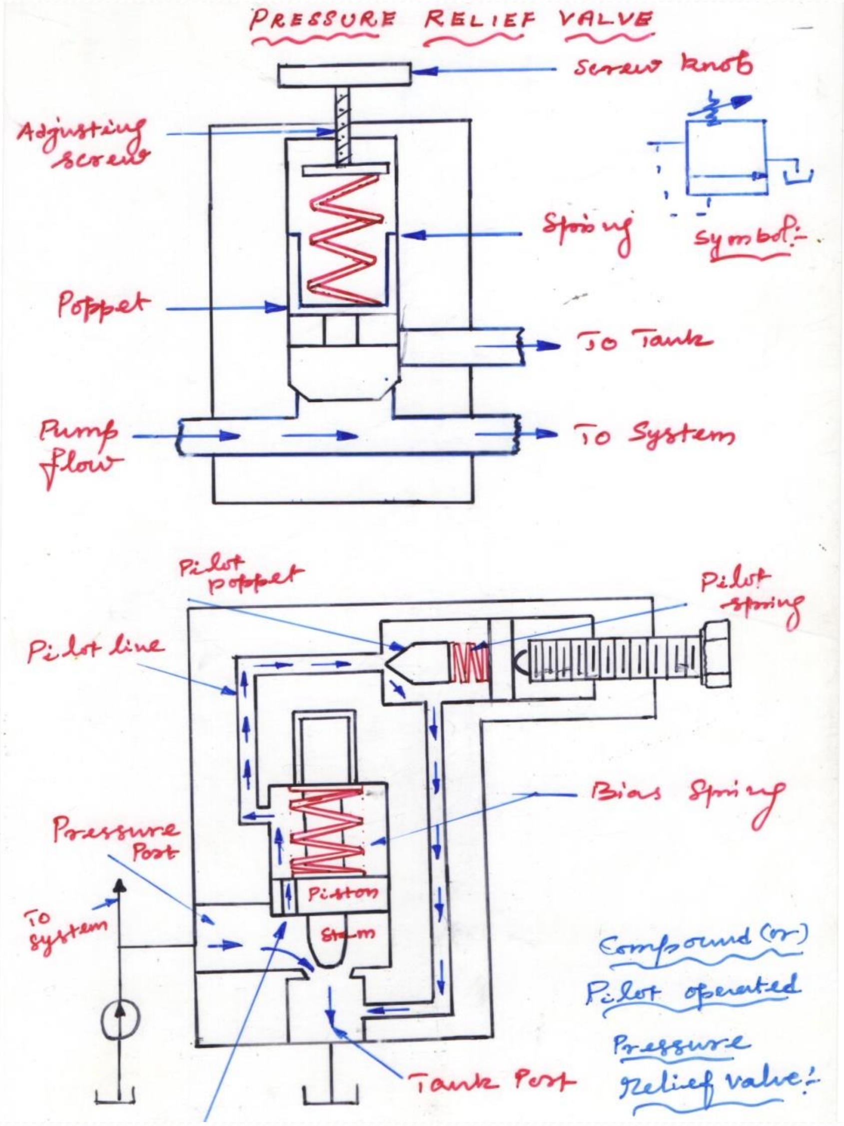
Sequence may be direct or pilot operated



Pressure relief valve

- Pressure relief valve animation

http://www.opwftg.com/www/en/opwftg/products/cargotank/overview/pressurerelief.jsp



Flow control valve

- Controls the rate of fluid flow, thereby allows us to control the velocity of cylinder or actuators.
- Applications
  - Tool speeds
  - Spindle speed
  - Surface grinder speeds etc.
- Classification
  - Fixed devices(with orifice plate)
  - Adjustable device (Needle, Global and gate valve)
    - Needle valve

    Needle Valve Animation click below

    http://www.oilennium.com/2010/08/19/e-learning-course-needle-valve-animation/

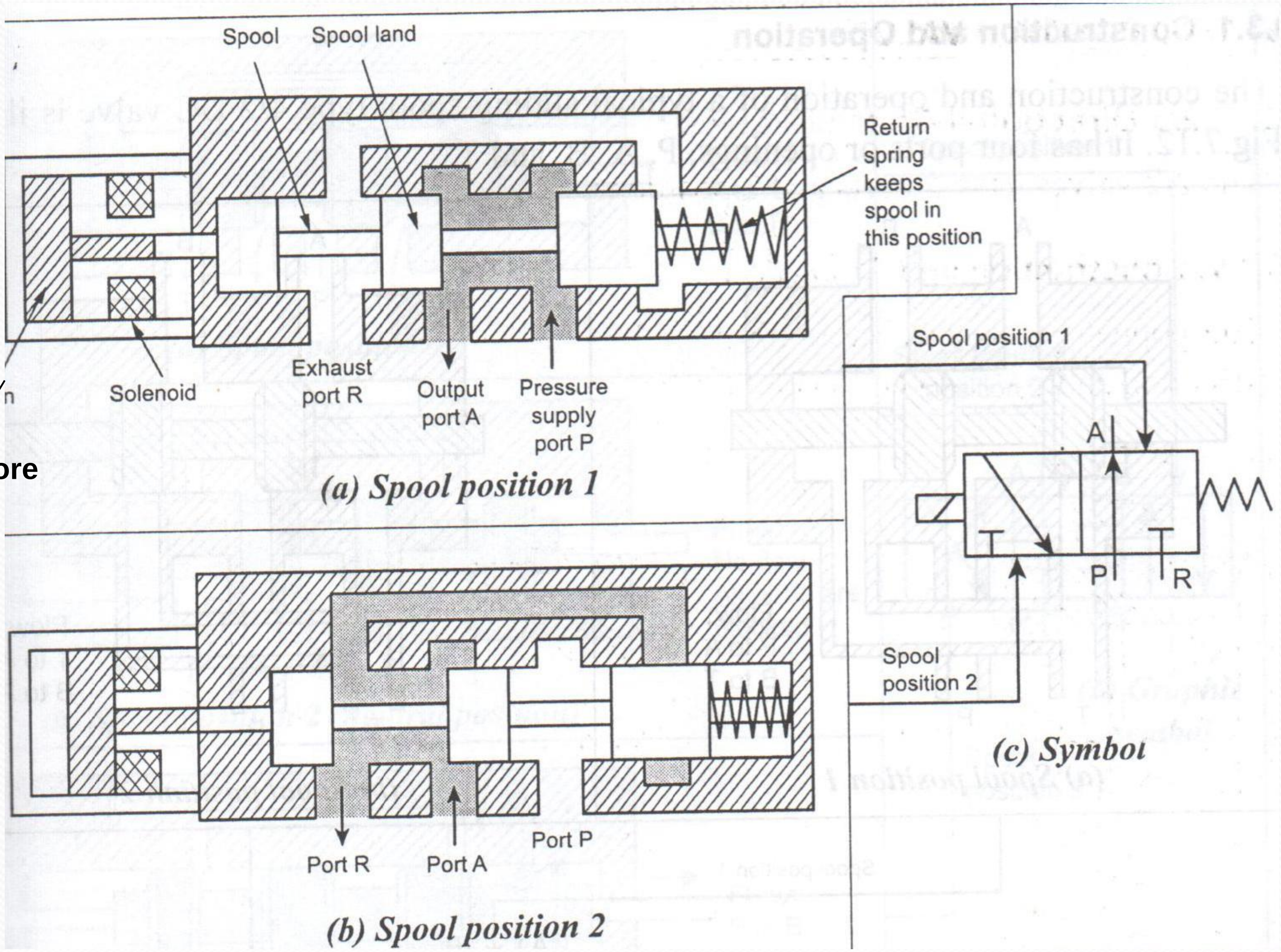
    - Globe valve (http://www.youtube.com/watch?v=yTr4kpkHovg) and
    - Gate valve (http://www.youtube.com/watch?v=-5OuXJXOSHE)

Electrical control solenoid valve

Basic solenoid valve animation (http://www.youtube.com/watch?v=SwqM8zpmAD8&feature=related)

Soft iron core

Solenoid activated and spool moves to right



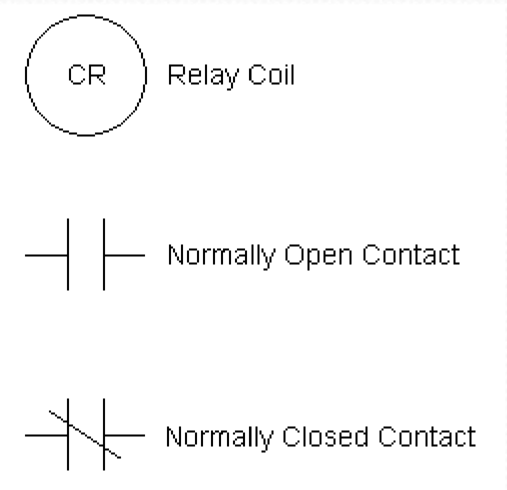
Construction and operation of a solenoid activated 3/2 vane

Relays

- Electrically actuated switch, open or close when corresponding coil energize.
- Commonly used to energize/de energize solenoid.

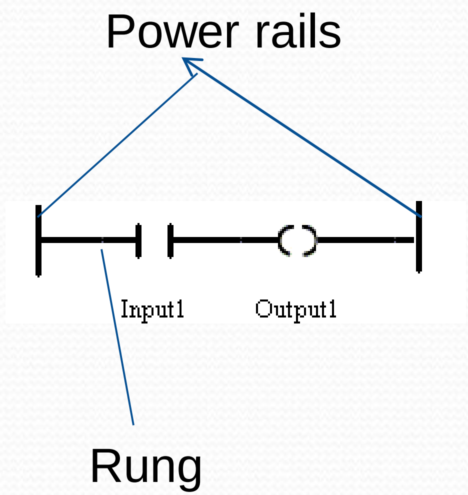
When energized,

Normally open will close and vice versa.



Ladder diagram

- Schematic representation of physical components arrangements and its way of connection.
- Power connected to left side and ground connected to right side.



Accumulators

- Temporary potential energy (Fluid) storage device under high pressure.
- Also acts as a secondary source when demanded by the system.

Types of Accumulators

- Weight or gravity loaded accumulators
- Spring loaded accumulators

Mechanical accumulator

- Gas loaded accumulators

Pneumatic accumulator

Weight-loaded Accumulators

- Temporary potential energy (Fluid) storage device under high pressure.
- Also acts as a secondary source when demanded by the system.

Types of Accumulators

- Weight or gravity loaded accumulators
- Spring loaded accumulators
- Gas loaded accumulators

Mechanical accumulator

Pneumatic accumulator

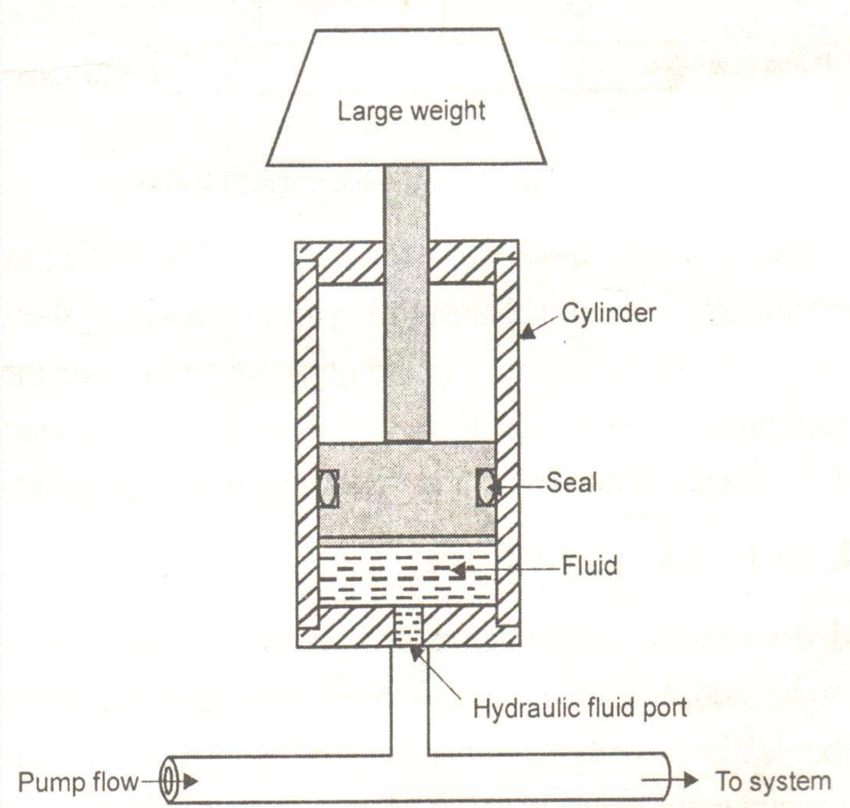
Weight loaded accumulators

- A vertically mounted cylinder with weight attached at its top.
- Consists of piston with packaging to prevent leakage.

When fluid is pumped into the accumulators,

- The weight is raised- exerts a force to the piston generates a pressure on the fluid side of the piston.

Advantage of this type – constant pressure on the fluid throughout the volume

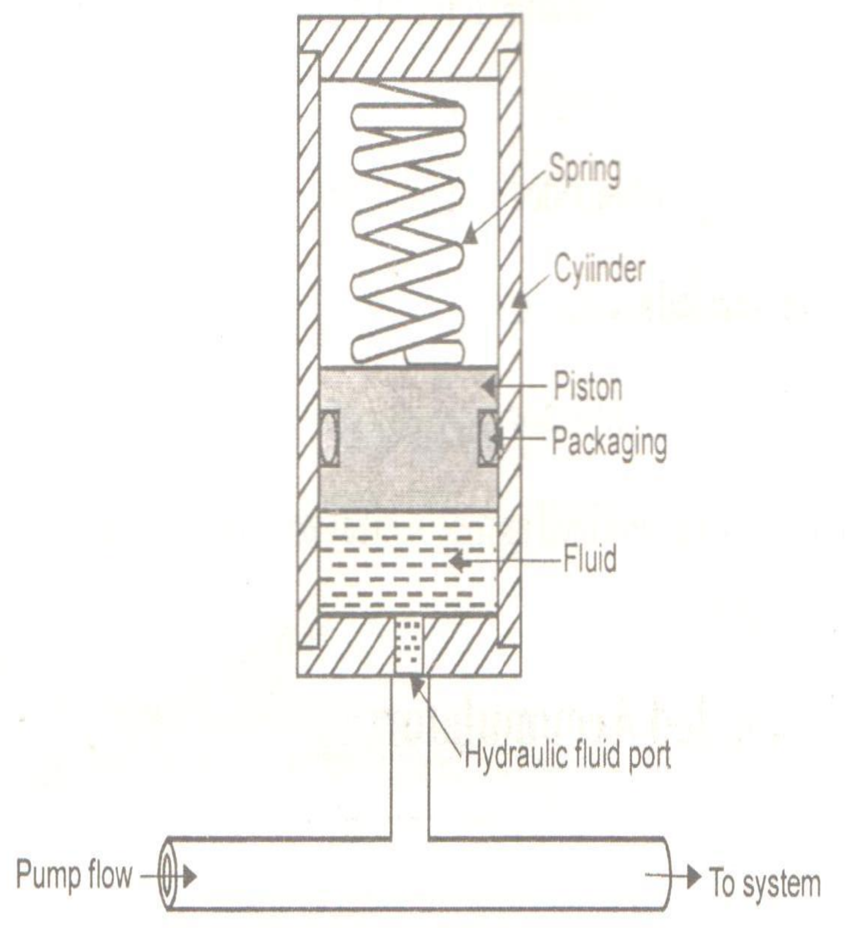


Spring loaded accumulators

- Uses spring to store energy.

When excess pressure,

Hydraulic fluid is pumped into the accumulator, moving the piston against the spring. Thus the spring exerts a force to the piston, generates pressure on the fluid.



Gas loaded accumulators

- Operates by using compressed gas to store energy.
- Only dry nitrogen is used (As air oil may explode when compressed)
- Working principle based on,

Boyles law: At constant volume,

$$\text{Pressure of gas} \propto \frac{1}{\text{Volume}}$$

Classification,

- Non separator type
- Separator type

Gas loaded accumulators

Separator type

Some flexible material is used to separate the gas from the oil.

Separator may be

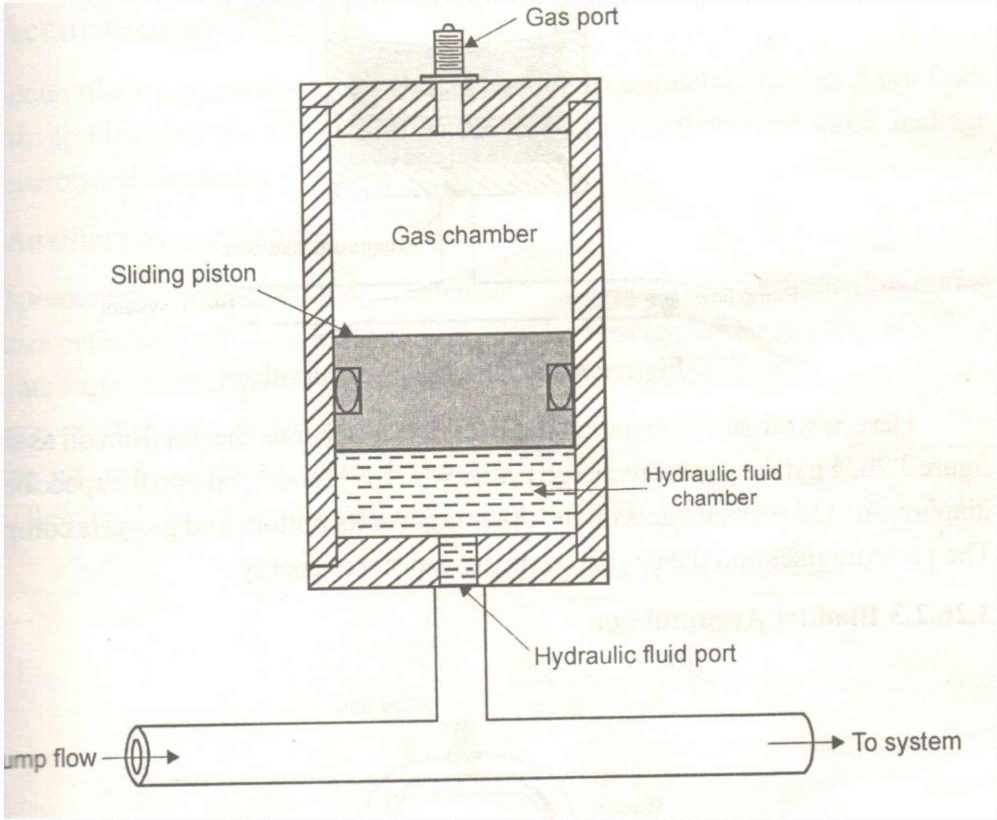
- Piston, Diaphragm or Bladder.

Gas loaded accumulators

Separator type

Piston Accumulator

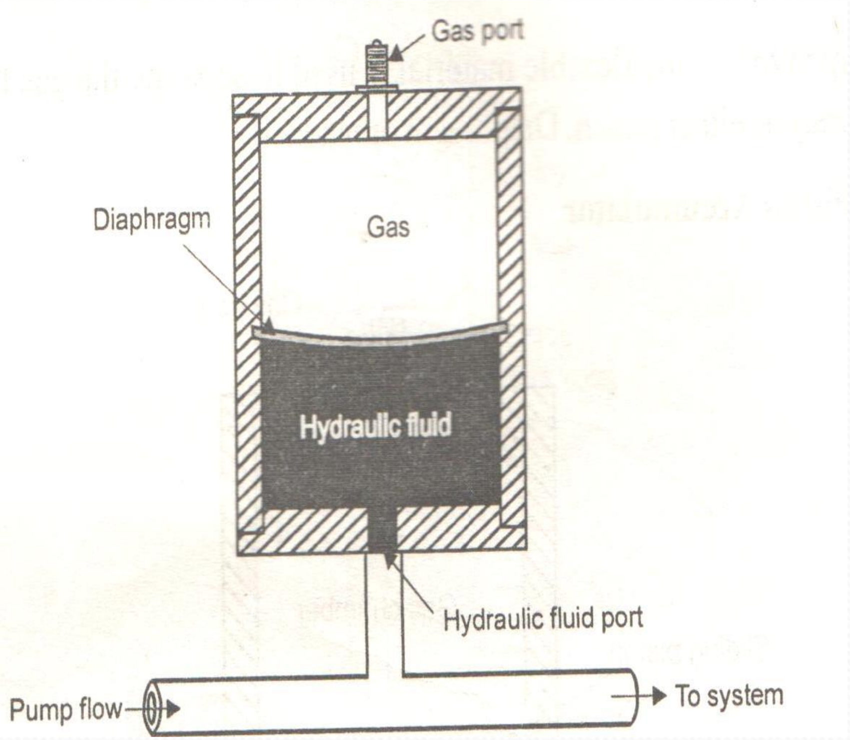
- Free floating piston is used to separate the gas from oil



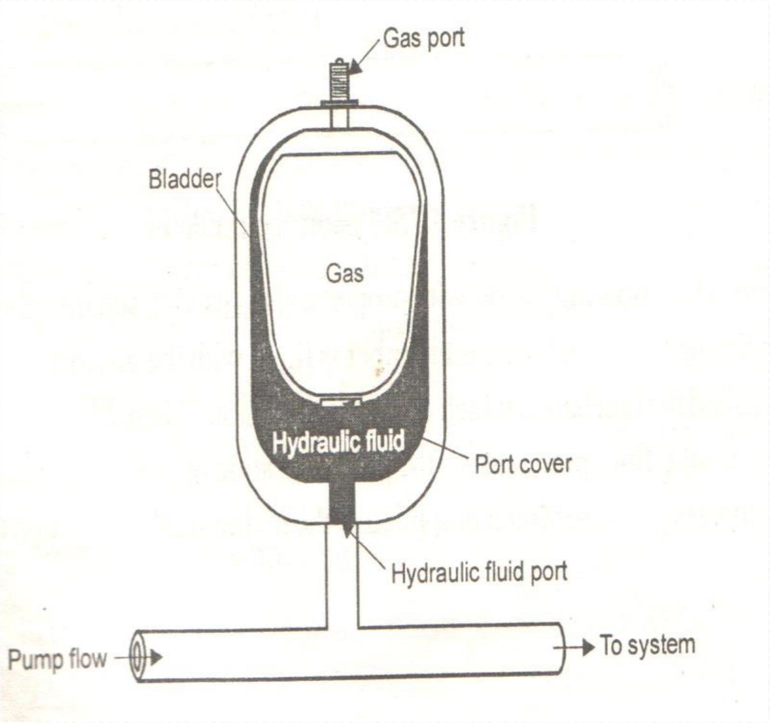
Piston Accumulator

Gas loaded accumulators

Diaphragm Accumulator



Bladder Accumulator



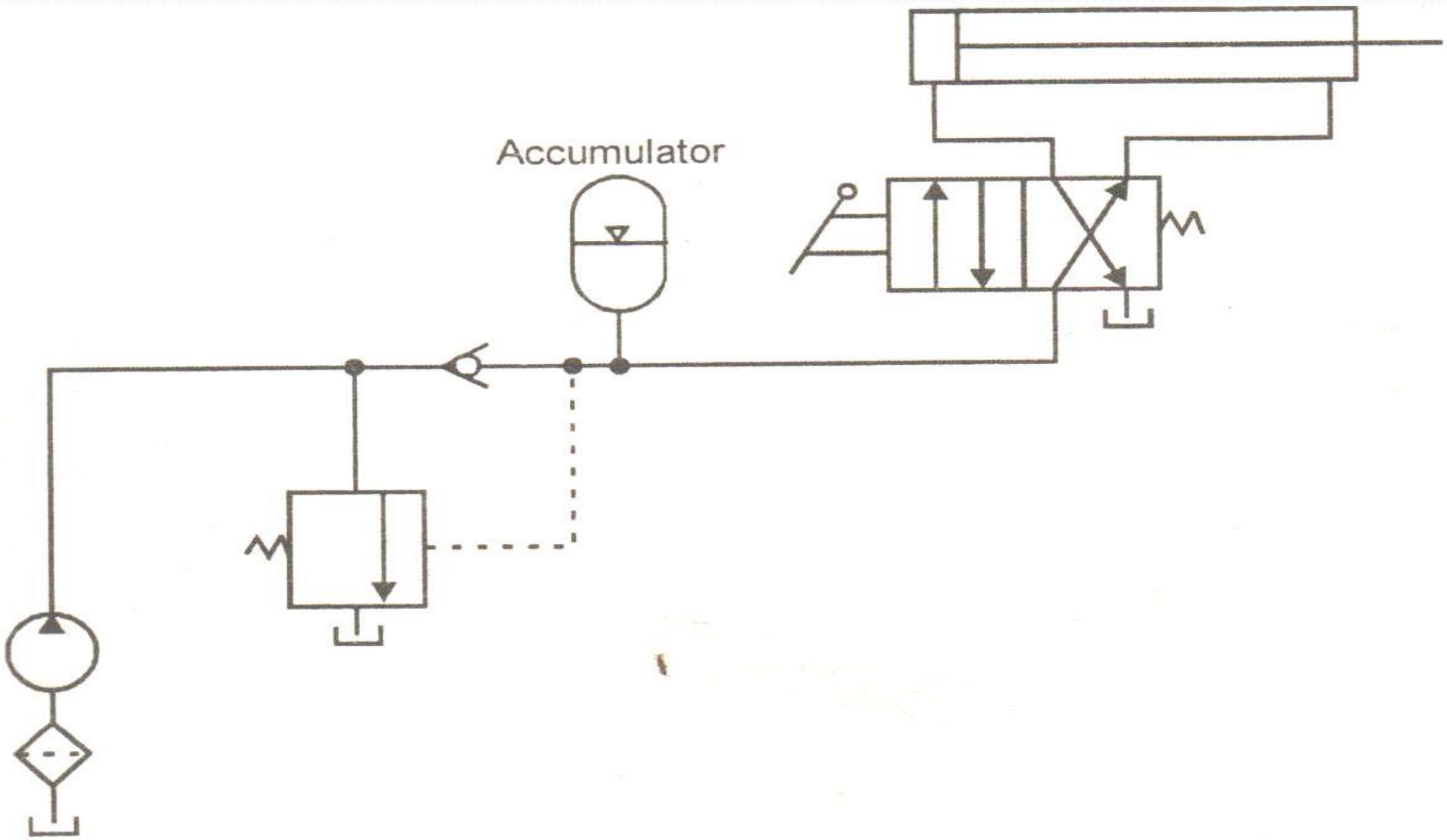
Application of Accumulators

Application of Accumulators

- Auxiliary power source
- Emergency power source
- Leakage compensation and
- Shock absorber.

Accumulator Circuits

Auxiliary power source

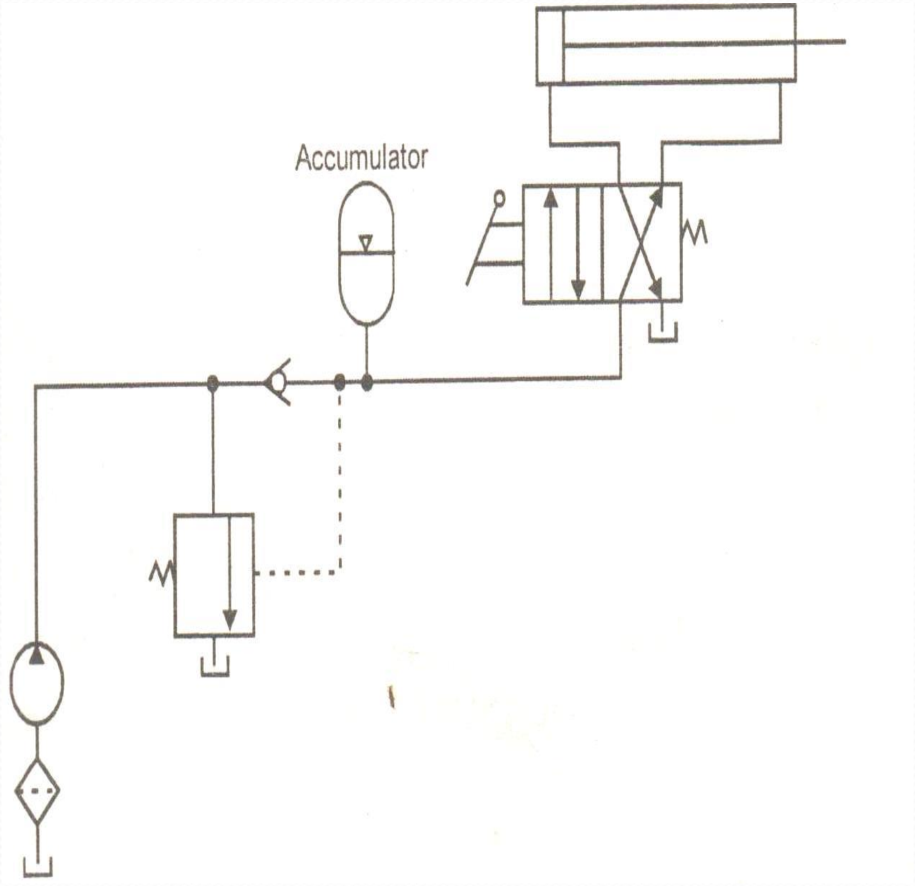


Accumulator Circuits

Auxiliary power source

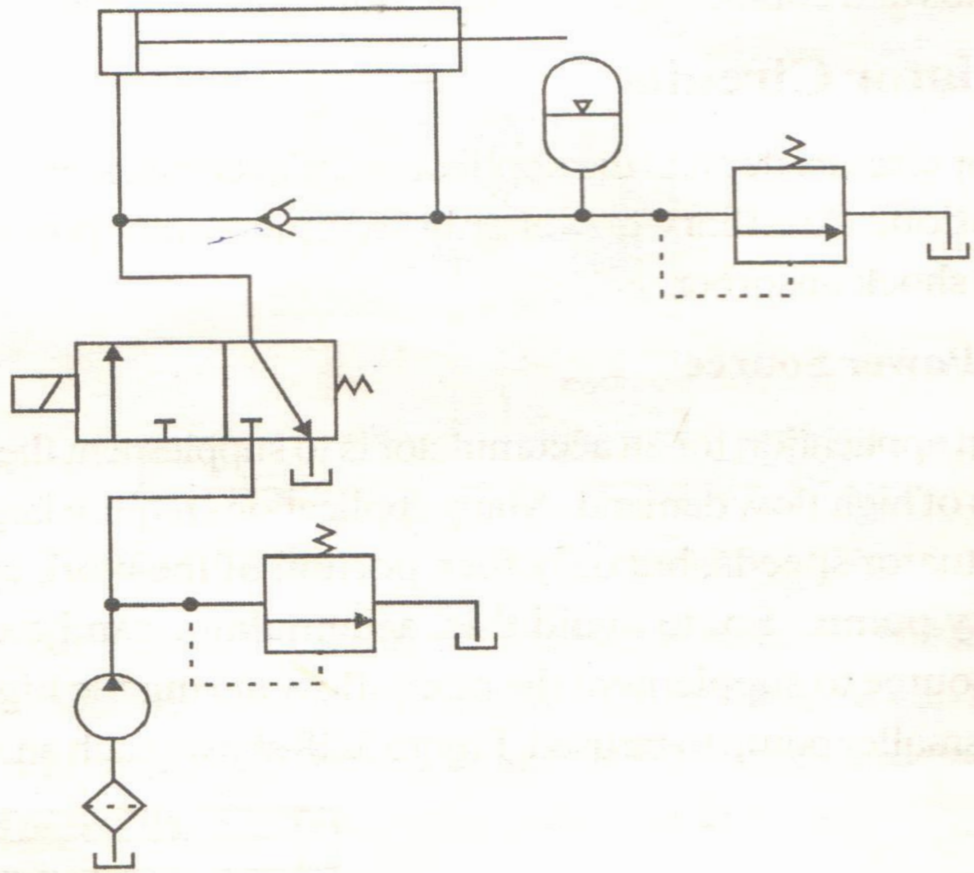
Many applications require large amounts of flow to generate fast actuator speeds for a portion of work alone.

In this instead of large capacity pump, accumulators can be used as secondary power source.



Accumulator Circuits

Emergency power source



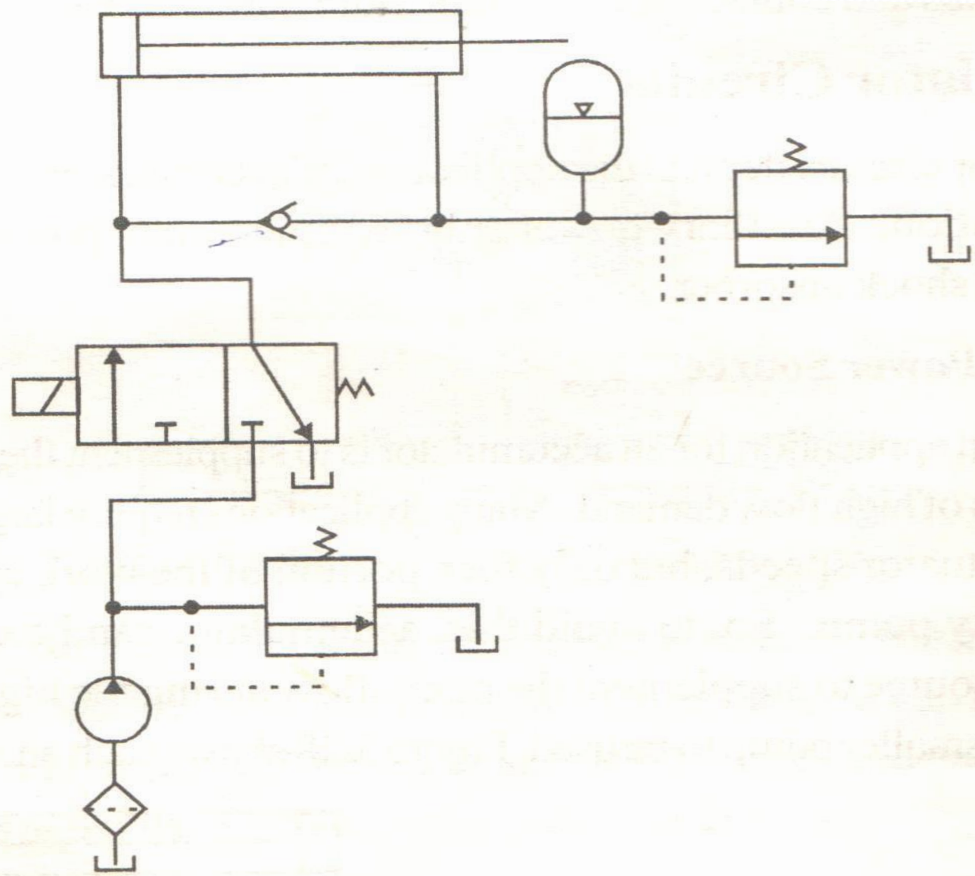
Accumulator Circuits

Emergency power source

Emergency- power failure

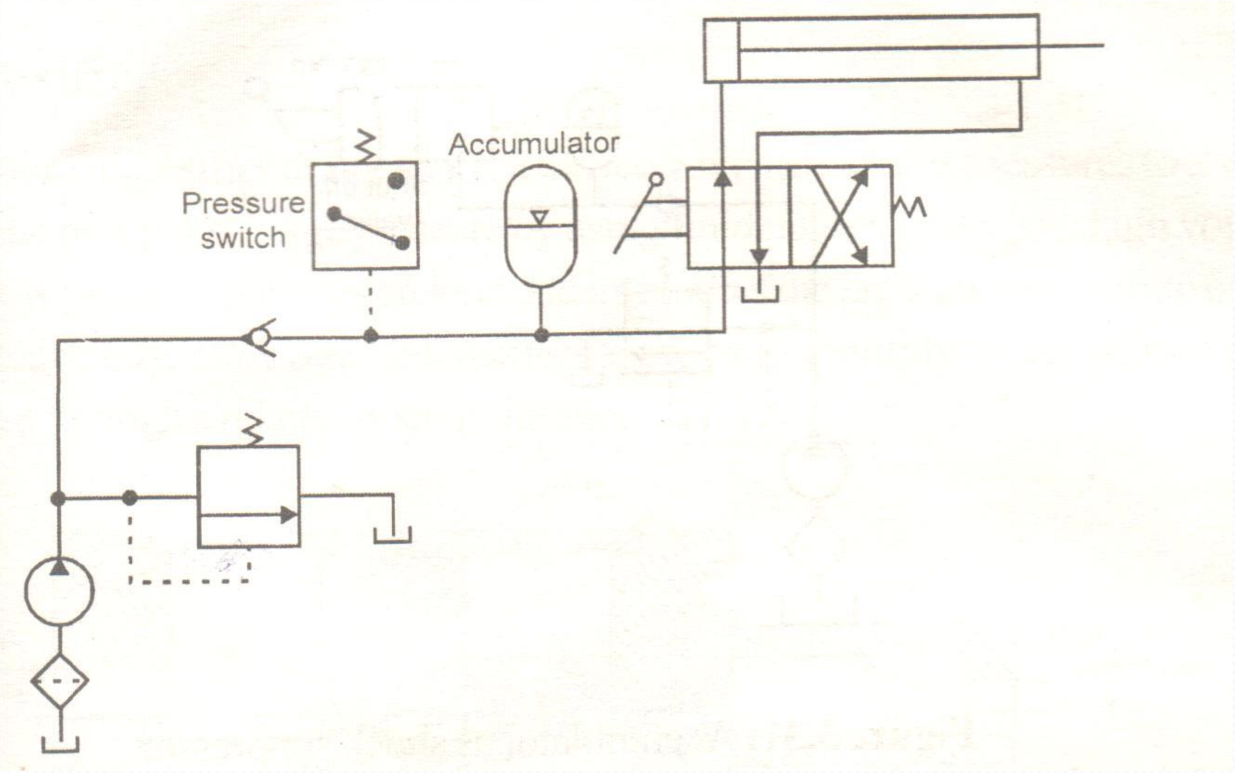
When three way valve is energized, oil flows from pump to the blank end of the cylinder and also to accumulator.

When power failure occurs, solenoid deenergize-shifting the valve to its spring offset mode & oil stored in accumulator makes retraction of piston.



Accumulator Circuits

Leakage compensator



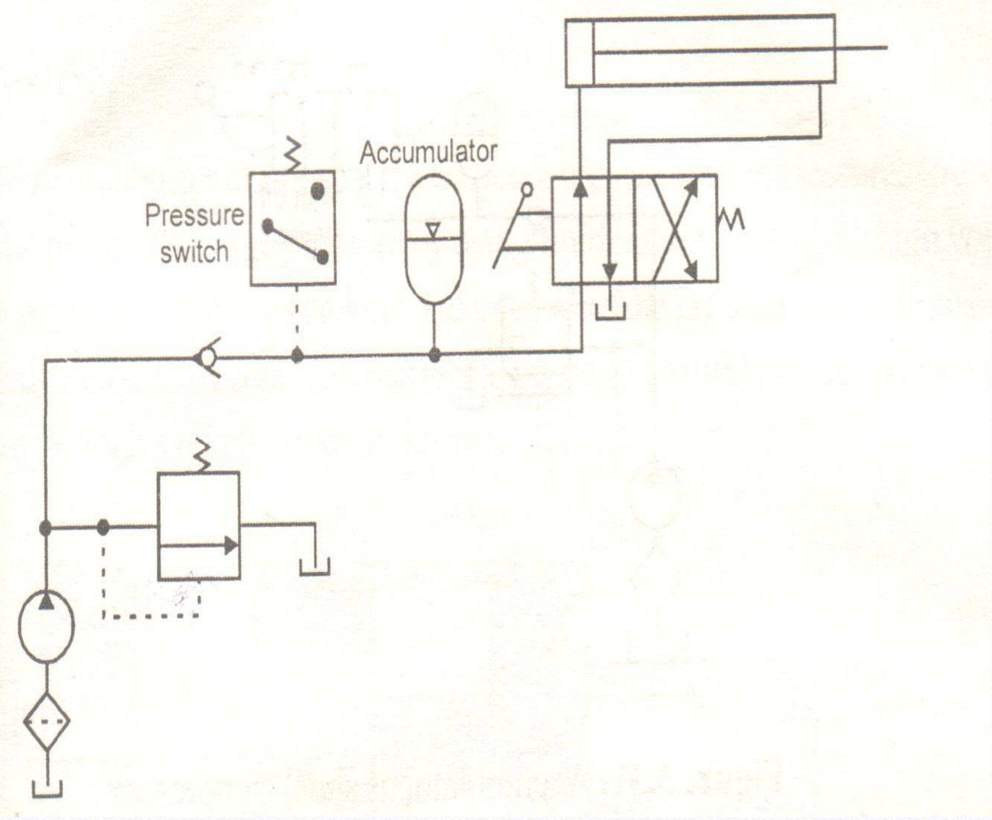
Accumulator Circuits

Leakage compensator

Pressure switch is used to OFF the electric motor that drives the accumulator, when it is desired to shut down the pump completely once the accumulator has been fully charged.

When the valve is actuated – oil flow to blank end of the cylinder & fills the accumulator.

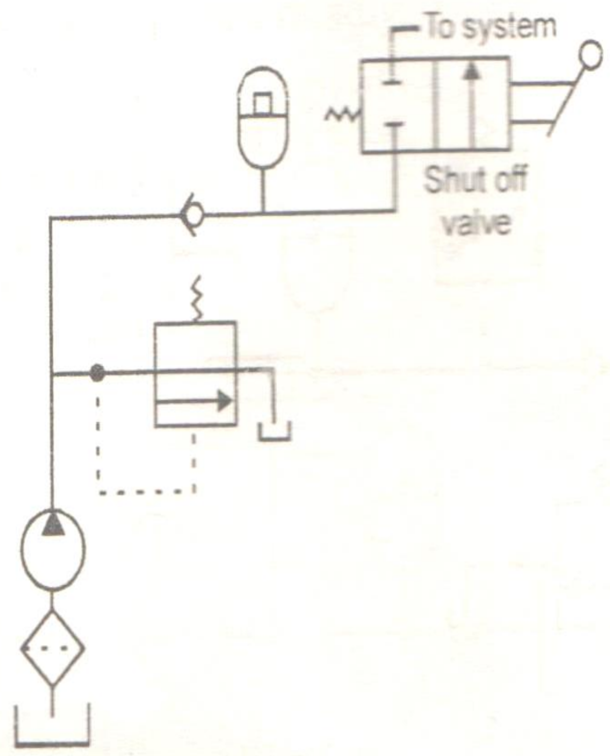
When accumulator is fully charged – pressure switch activated and stops the pump. Accumulator supplies enough flow to compensate for leakage.



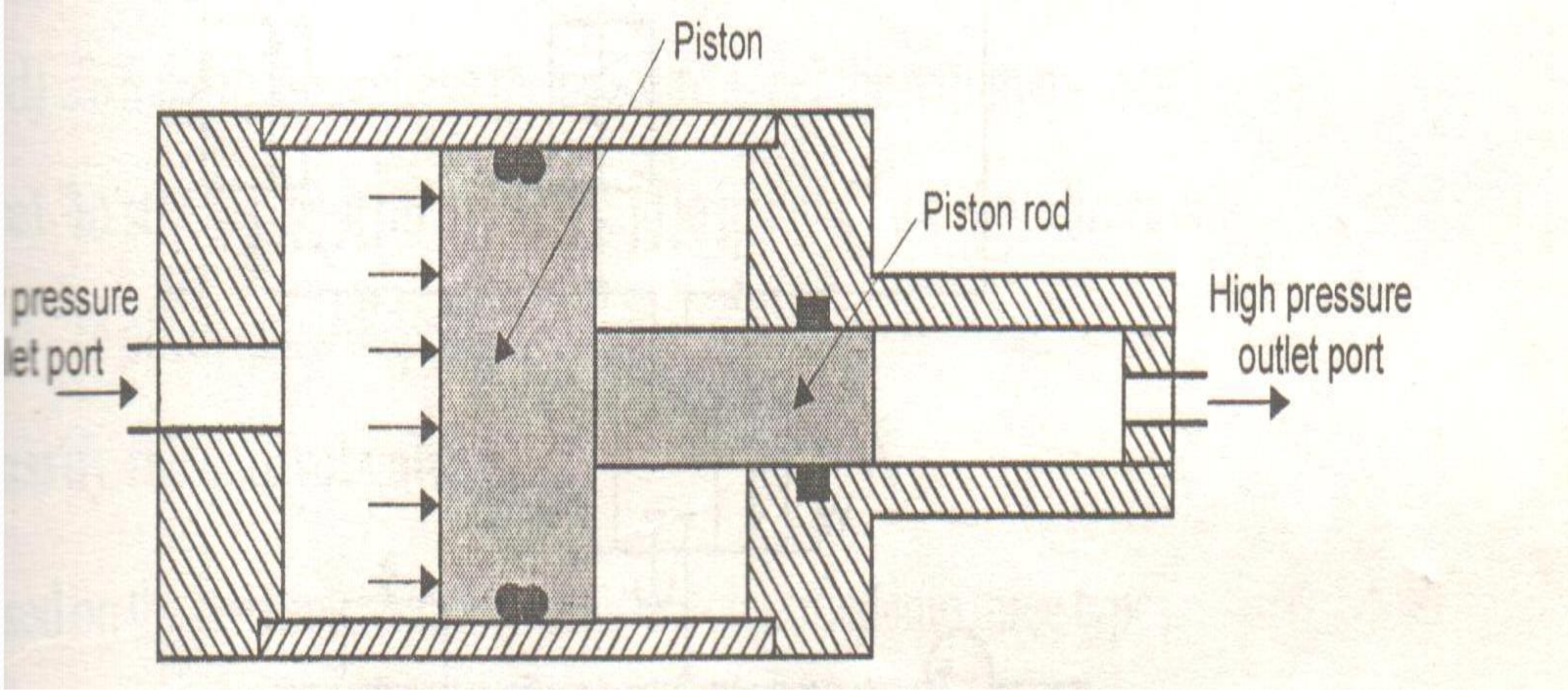
Accumulator Circuits

Accumulator as shock suppressor

Another application of accumulator is to damp out high pressure spikes or hydraulic shock.



Intensifier



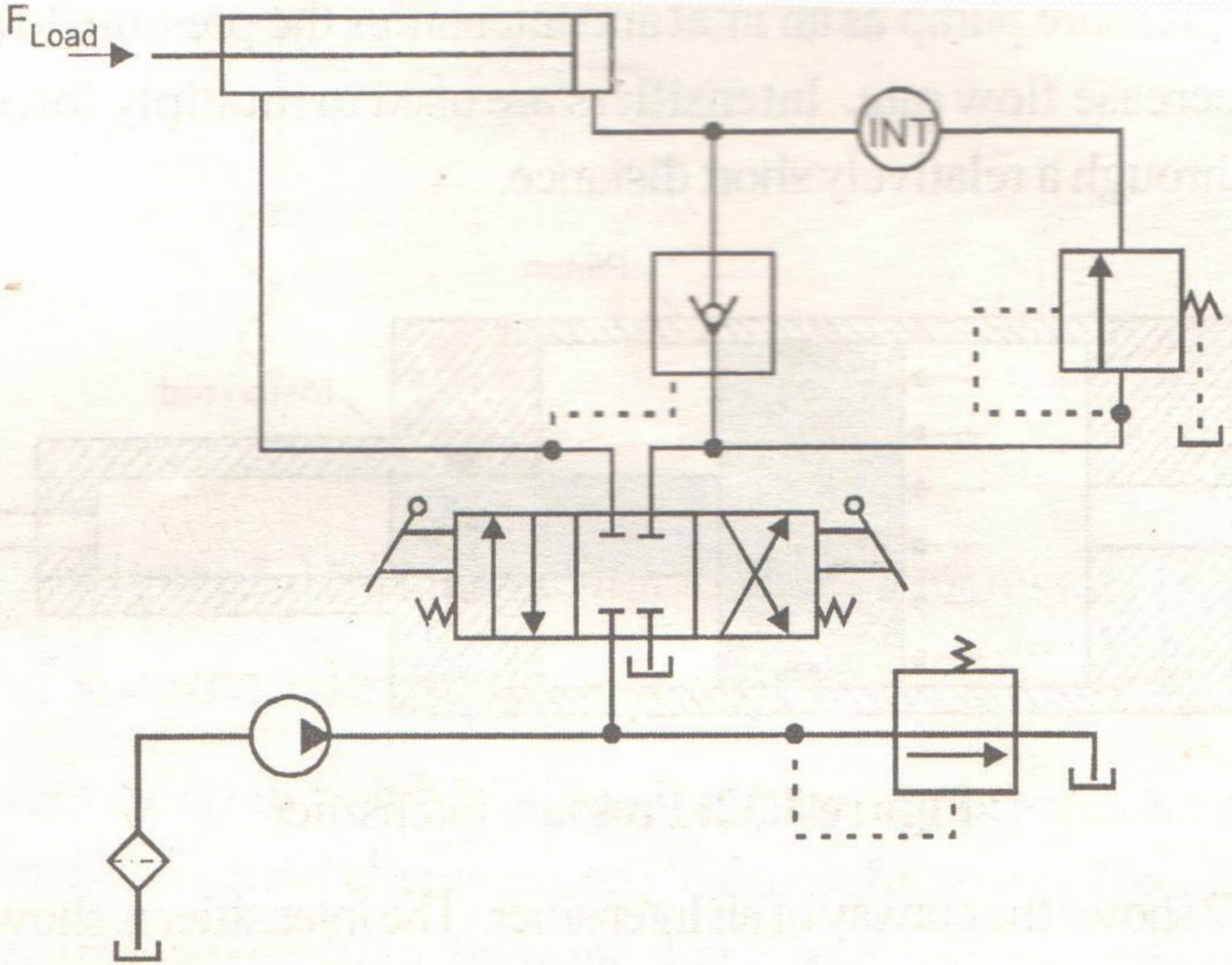
Intensifier

$$I_R = \frac{\text{Output Pressure}}{\text{Inlet Pressure}} = \frac{\text{Area of Piston}}{\text{Area of rod}} = \frac{\text{Inlet flow rate}}{\text{Discharge flow rate}}$$

Application of Intensifier

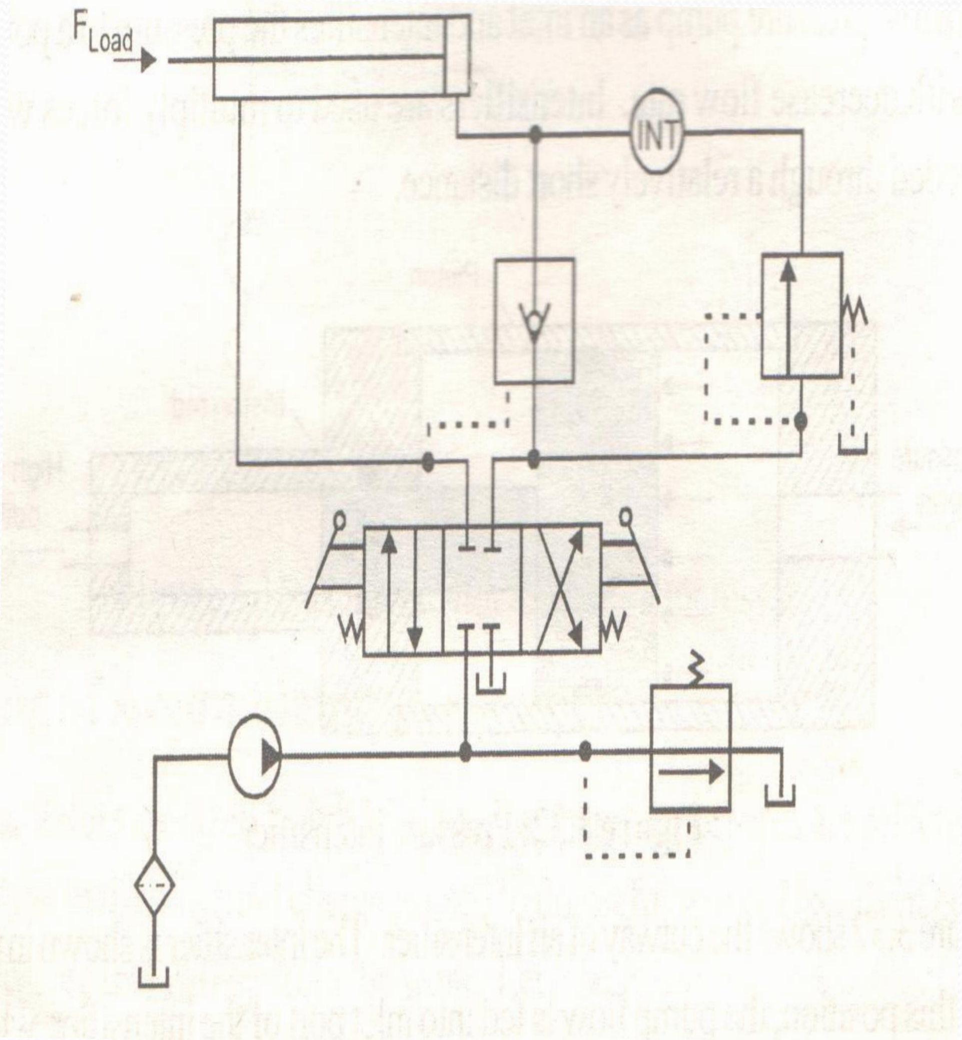
- Burst testing machines
- High pressure clamping devices
- Moulding machines
- Spot-welding machines
- Riveting machines
- Hydraulic pressing and punching machines etc.,

Intensifier circuits



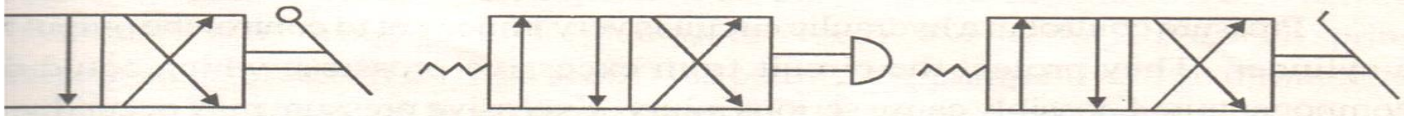
Intensifier circuits

- When DCV is shifted to right mode, piston extend.
- When pressure setting value of sequence valve reached intensifier starts to operate.
- This in turn intensifies the pressure at blank end and perform punching operation



Intensifier press circuit

Actuation devices



a) Handle lever (b) Push button (c) Foot pedal

Figure 3.6: Manual Actuation Devices

Mechanical Actuation Devices

includes cam, roller, plunger, roller tappet etc; In figure 3.7, the spool end containing that is typically actuated by a cam-type mechanism. These valves shift when ed by some mechanical component of the machine.

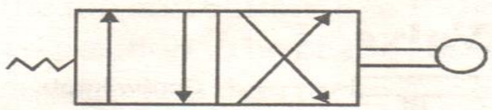


Figure 3.7: Mechanical (roller) Actuation Devices

Pilot Operated Actuation Devices

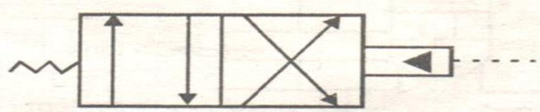


Figure 3.8: Pilot operated actuation devices

hese valves are shifted with system pressure. When a pilot signal (oil or air) is against a piston at either end of the valve spool, it pushes the piston to shift the

Solenoid Operated Actuation Devices

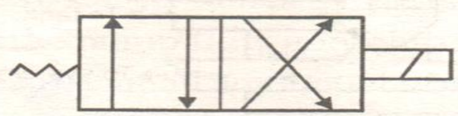


Figure 3.9: Solenoid actuation

UNIT 4 Pneumatic systems and components

UNIT 4 Pneumatic systems and components

1. Properties of Air

- It is a mechanical mixture of gases
- By volume 78 % Nitogen , 21% oxygen And 1 % other gases Argon, carbon di oxide and etc
- Air is heavier than other gases
- No definite shapes
- Specific weight 11.8 N/m^3 , density of Air is 1.69 Kg/m^3 at 20^oC.

Presentation on Compressors

What is Compressor

……....a device used for pumping compressible fluids i.e,

air, gas & steam

What is the basic difference between Compressor & Blower

… acc. to API pressure rise above 0.35 bar is compressor and below is blower

Compressor Classification

a) By principle of operation

b) By construction type

c) By staging

d) By service duty

e) Lubricated/ non lubricated

Classification

Operation Principle — Positive Displacement/ Dynamic or Turbo

Staging — Single / Multi stage

Service — Critical service or non critical duty

Lubricated / Non Lube

Positive Displacement

(Increase press. by reducing volume)

Types are -

- Reciprocating
- Rotary - Screw, Vane , Liquid Ring & Lobe
- Diaphragm

Dynamic or Turbo Compressors

(By imparting K.E. to air/gas and then converting it into pressure)

Types are -

- Centrifugal or Radial Compressors
- Axial Flow Compressors

Classification by staging of compressors

Single Stage (compression of gas in one stage)

Multi-stage (compression of gas in more then one stage)

Lubricated or Non Lube Compressors

Lubricated Compressors : Where the gas is mixed with lubricant

Non Lubricated Compressors: Where process gas or air remains uncontaminated by the the lubricant during the compression process

Parameters for selection of compressor-

Application:

Gas handled:

Gas analysis:

Flow rate:

Suction Pressure :

Suction Temperature:

Mol wt. of Gas:

Z (Compressibility) & Cp/Cv:

Discharge Pressure:

Drive System:

Reciprocating Compressors-

Advantages:

- simple & open in construction
- site repairs possible
- do not require specialist at site
- not effected by changes in ambient conditions
- no adverse effect due to changes in the gas mol. Wt.
- single and multistage with inter-cooling
- achieve very high pressure ratios
- low & medium speed machines (250 - 1200 rpm), low noise level
- cooling of cylinder jackets & inter-cooling keeps temp. down and saves power
- non lubricated cylinders by using special piston/ rider rings

Reciprocating Compressors-

Disdvantages:

-Maintenance prone mainly valves, piston/rider rings

-Large bulky foundation

-Long installation time

-In fact large compressors are assembled at site

-Hooking up of auxiliaries such lube oil console, tempered c/w console for cyl. Jacket cooling, mounting of pulsation separators etc.

-Pulsating flow requires costly piping and flow analysis

-Step-less capacity regulation not possible

-Loss in capacity with operation

-Standby machines required

Rotary Screw Compressors-

Advantages:

- fewer components

- compact design, very good for portable applications

-package skid mounted concept

-quick site installation & no heavy foundation

-not effected by changes in ambient conditions

-no adverse effect due to changes in the gas mol. Wt. , infact good examples with dirty gases like in soda ash , coke oven plants

-non lube design possible

-streamlined flow

Rotary Screw Compressors-

Disdvantages:

-Not very reliable. Mainly anti-friction bearings used and these have limited life

-Close tolerances between screw elements

-Site repairs not possible

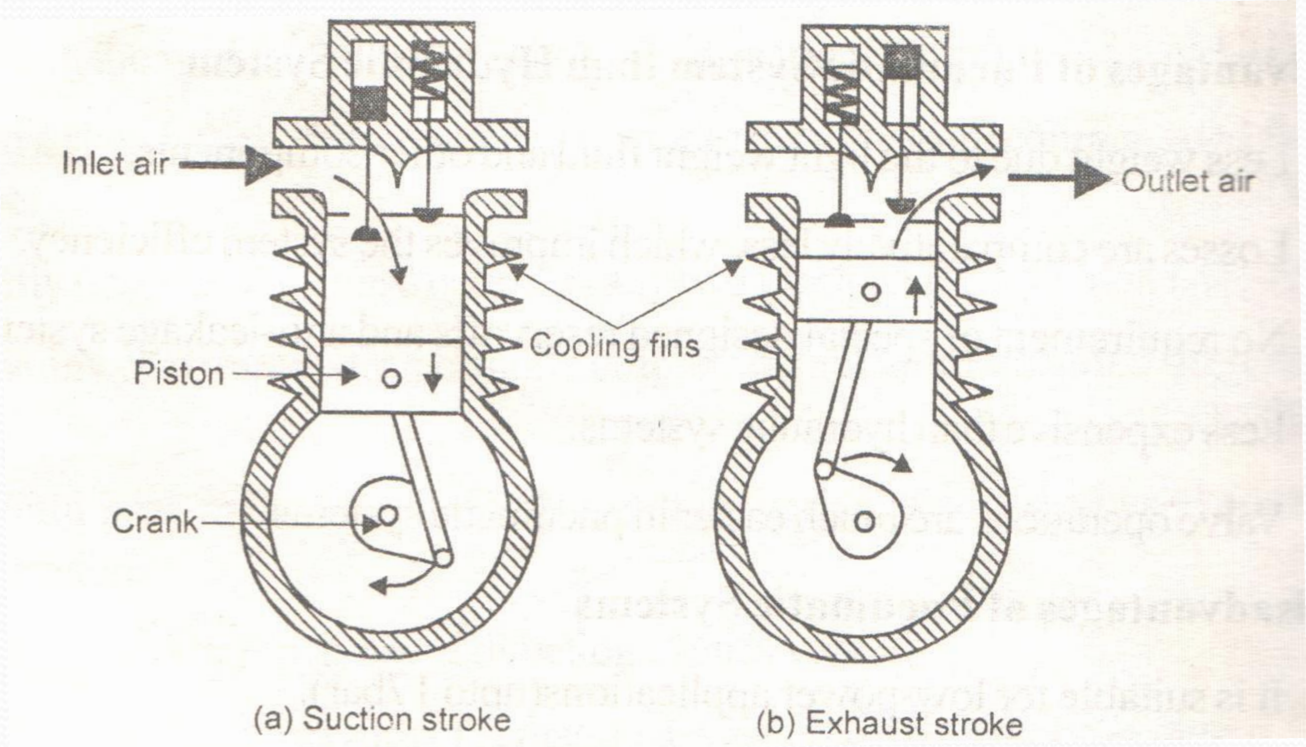
-Higher power consumption in lube design and also due to leakage between rotors.

-Process gas / air mixed with lube oil hence very effeicient oil separator is required which requires frequent maintenance

-Multi-staging not very easy

-High speed and high noise level

Single stage reciprocating compressor

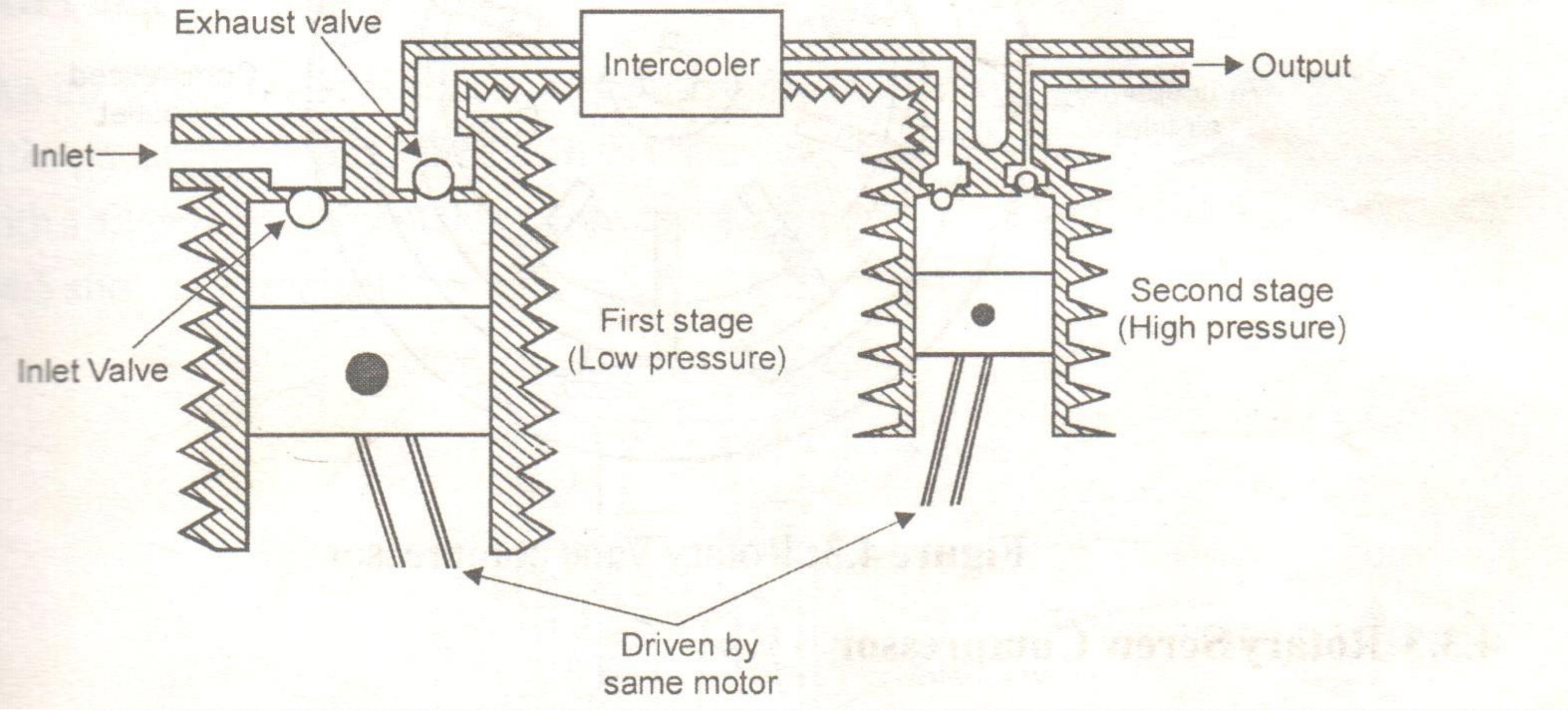


Single stage reciprocating compressor

Single stage reciprocating compressor

1. During the downward movement of the piston Air from the atmosphere at low pressure is drawn into the cylinder through the inlet then the inlet valve closes.
2. During the upward movement of the piston the pressure raises continuously up to a desired level then the delivery valve opens.

Two stage reciprocating compressor

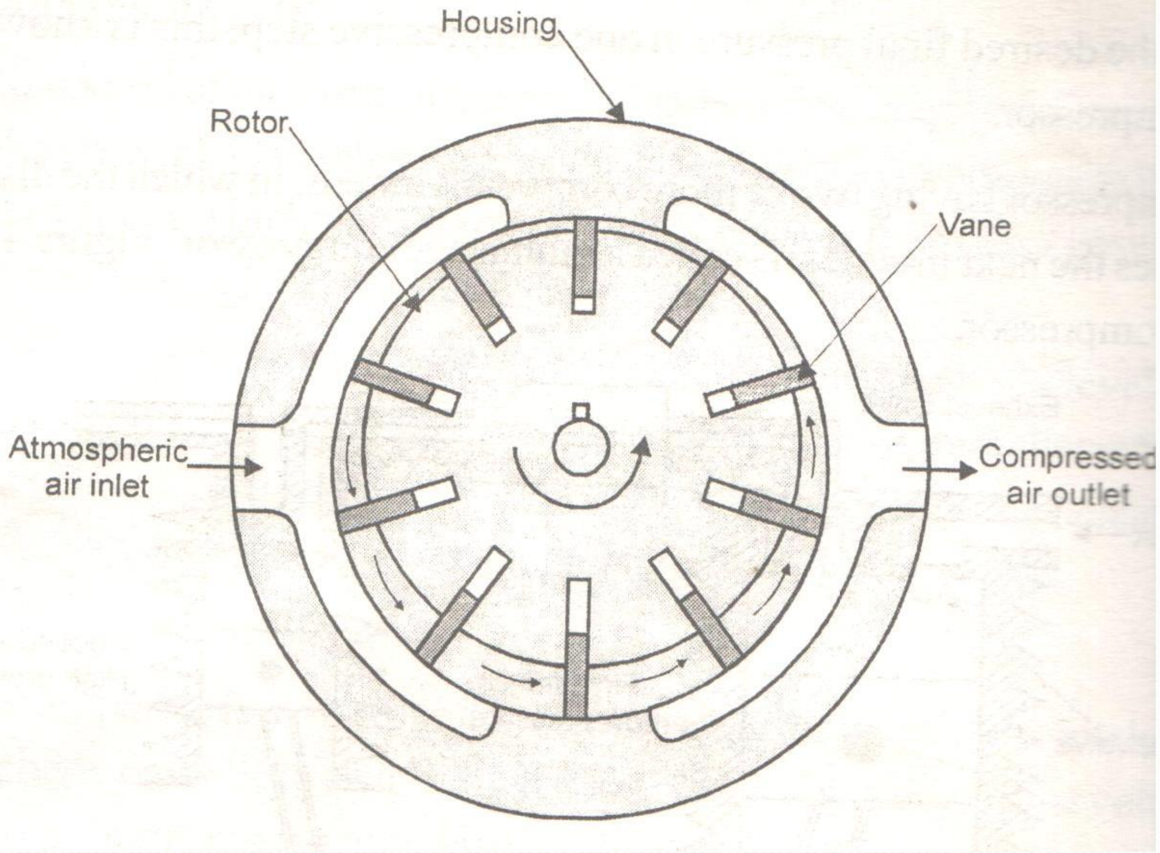


Two stage reciprocating compressor

Two stage reciprocating compressor

1. During the downward movement of the piston air from the atmosphere at low pressure is drawn into the cylinder through the inlet then the inlet valve closes.
2. During the upward movement of the piston the pressure raises continuously up to a desired level then the delivery valve opens.
3. If single cylinder is used for high pressure air the cylinder size will be two large and temperature raise will be high which damages the cylinder.
4. So it is necessary to two stage or multi compressor.
5. In this two stage compressor first cylinder outlet is passes through the intercooler and intercooler outlet air is passes through the second cylinder inlet and then compressed into high pressure.
6. To reduce the temperature of the air and power consumption we are using intercooler.

Rotary vane compressor

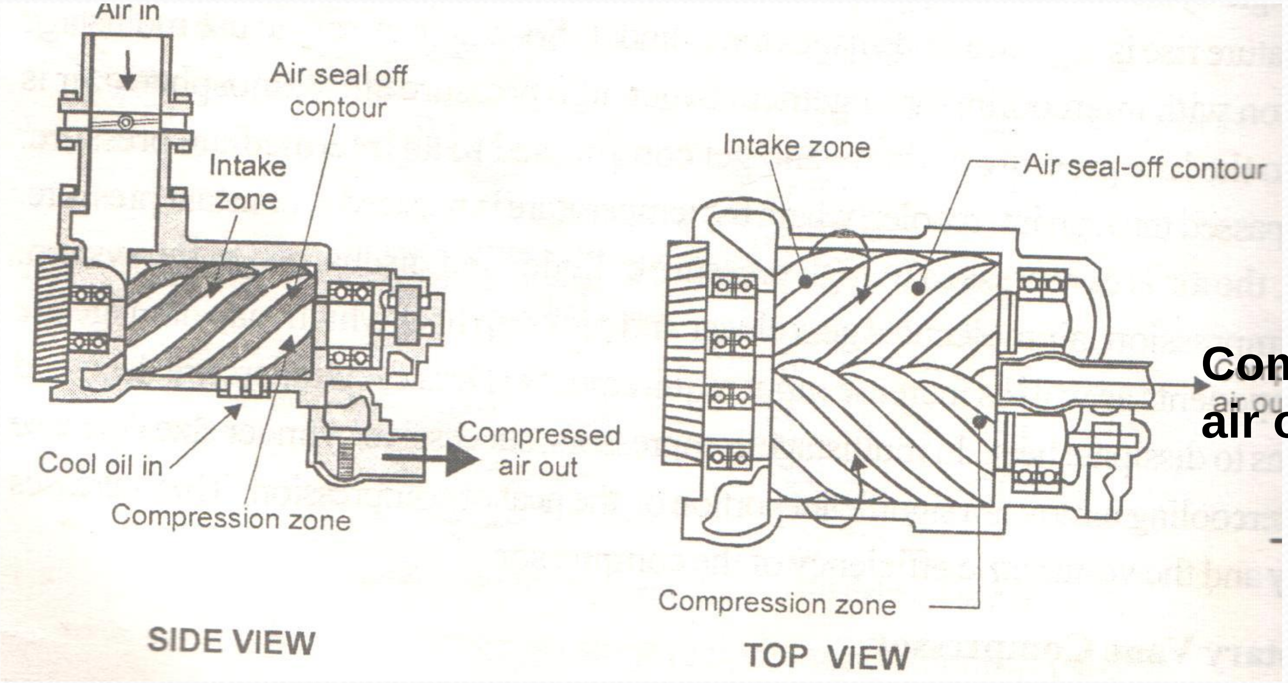


Rotary vane compressor

Rotary vane compressor

1. This rotary vane compressor is working due to the centrifugal force created. Due to the centrifugal force the vanes slides out.
2. As the rotor turns air is dropped between the vanes during one half of each revolution And compressed the vanes
3. Air is pushes out during the other half of each revolution.

Rotary screw compressor

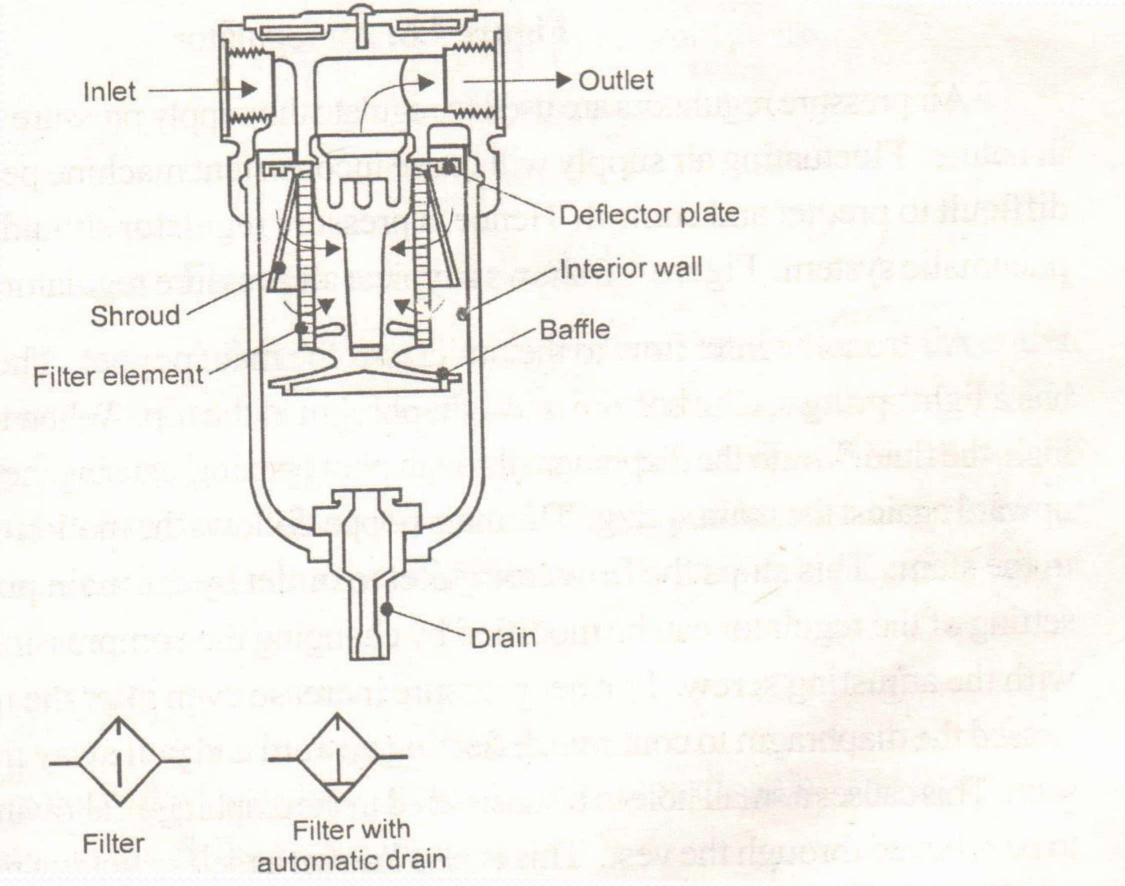


Rotary screw compressor

Rotary screw compressor

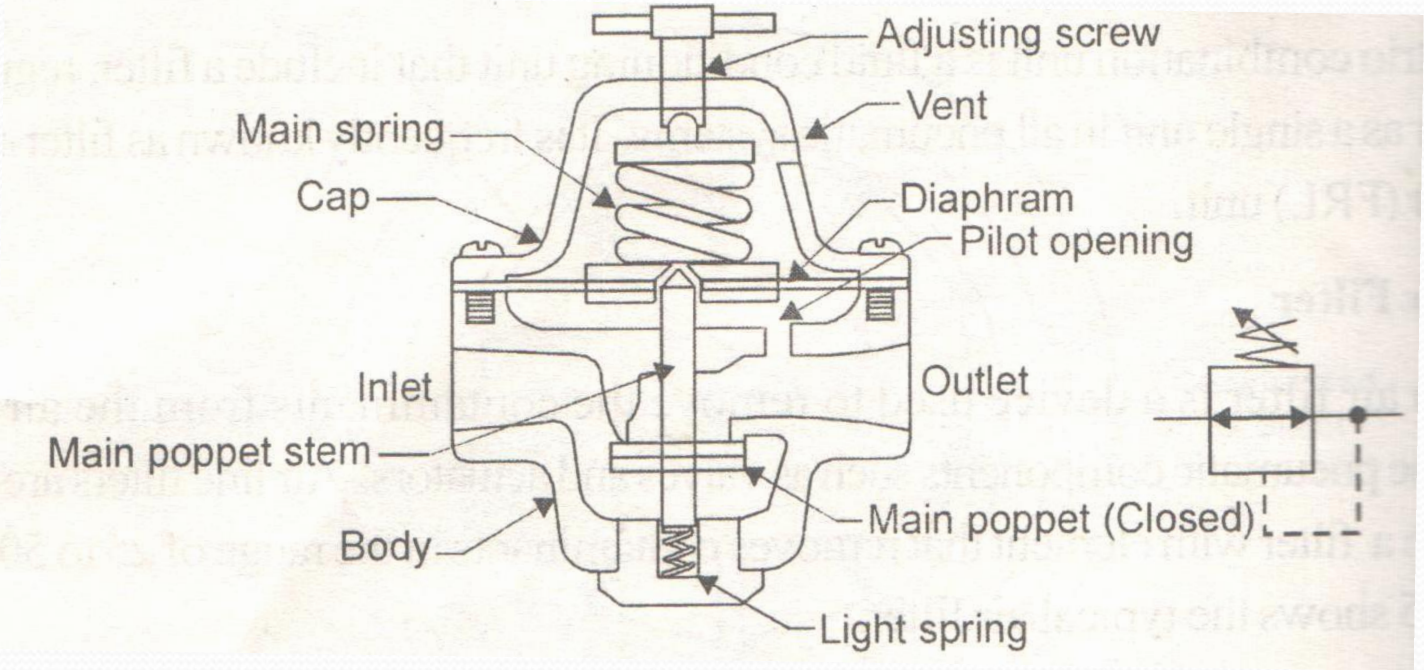
1. A rotary screw compressor compresses air between two inter meshing screws
2. Oil is used as a coolant to remove some of the heat dissicipating due to compression.

Air filter



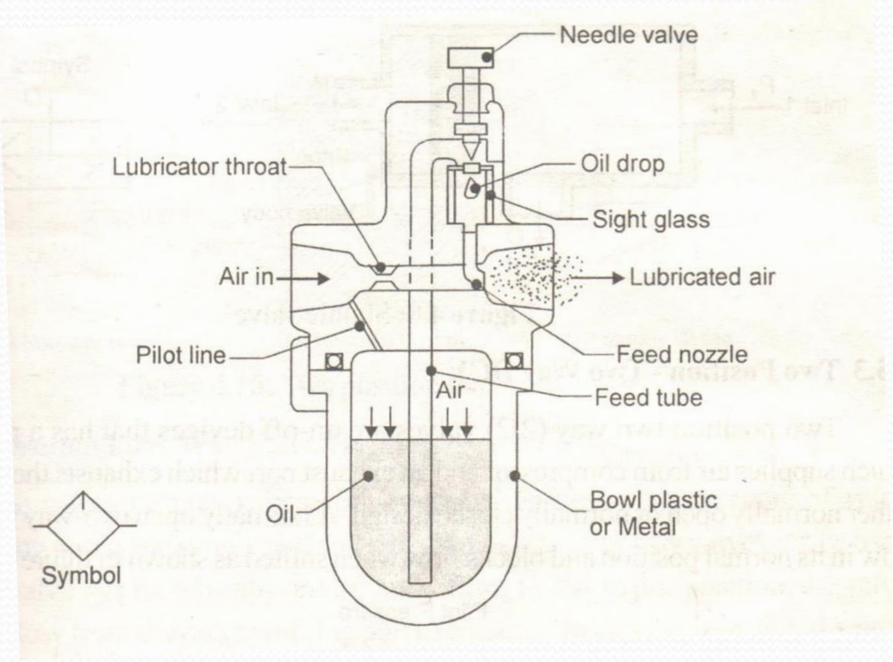
Air filter

Air regulator



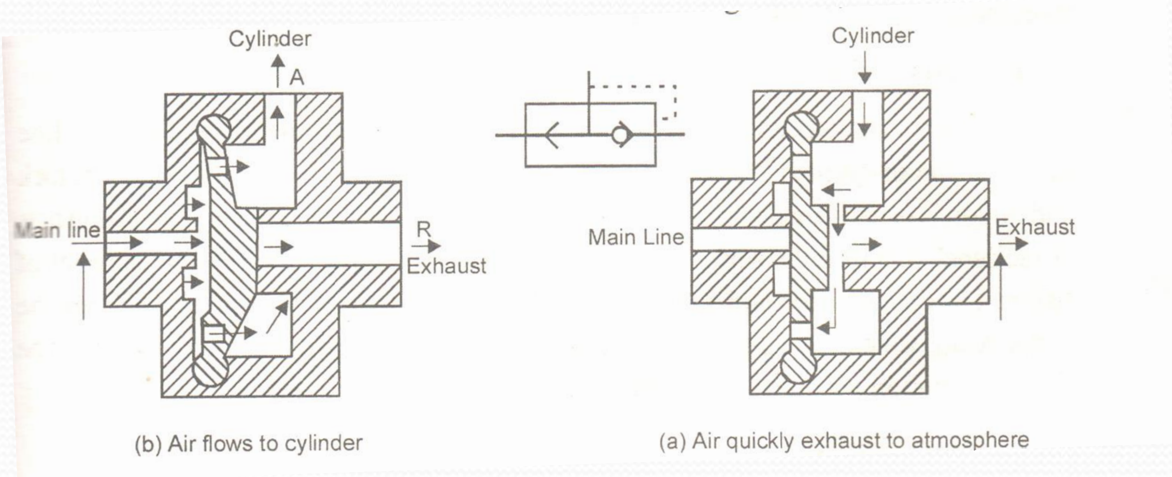
Air regulator

Air lubricator



Air lubricator

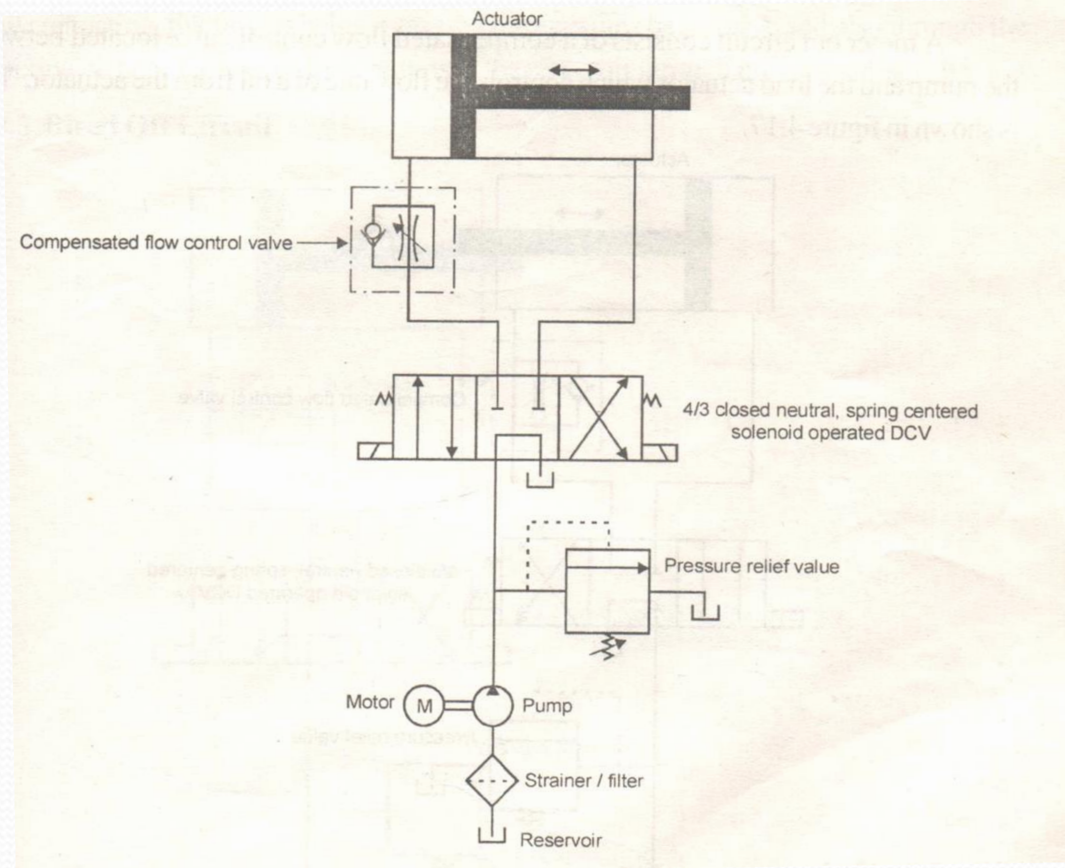
Quick exhaust valve



Quick exhaust valve

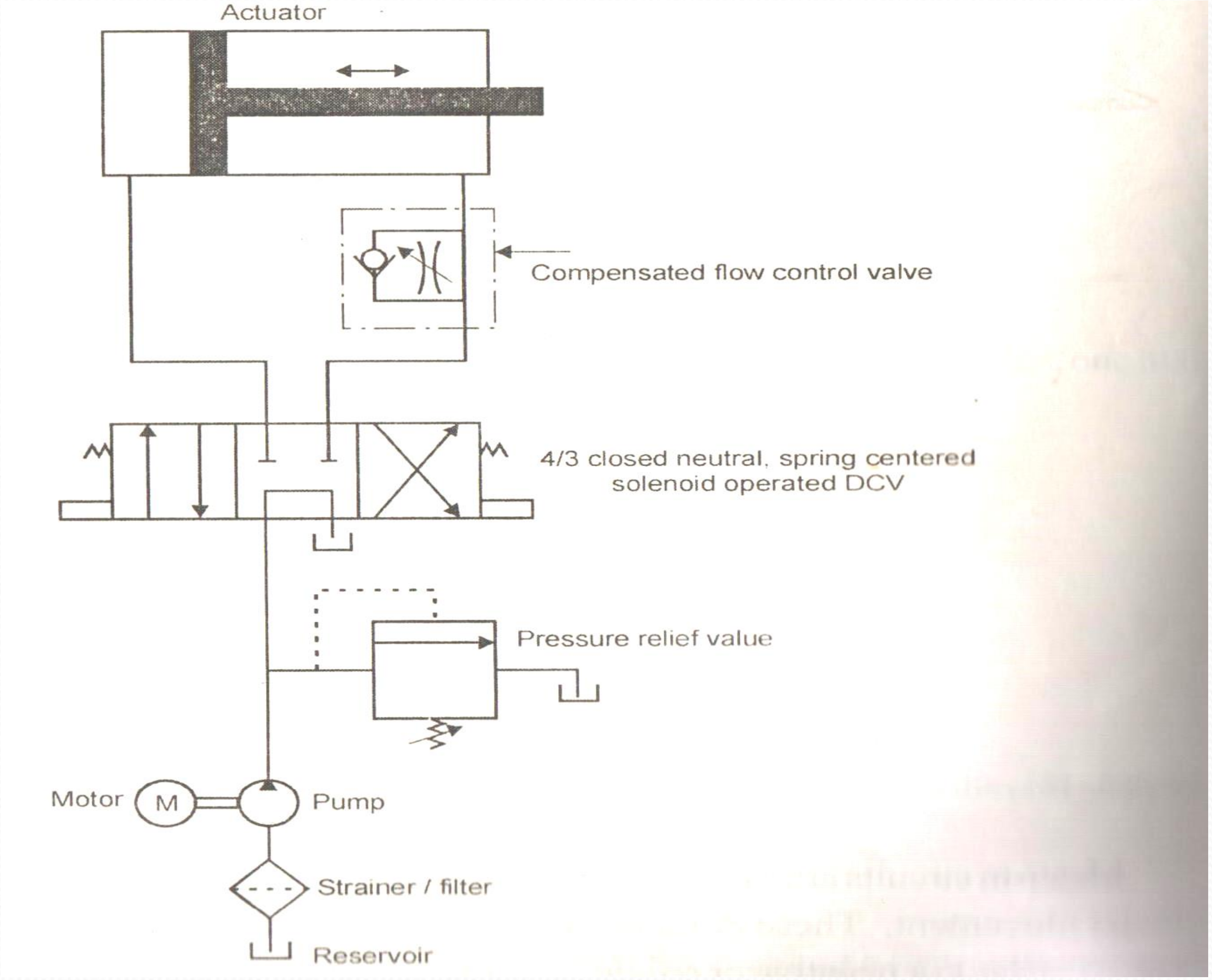
Speed control circuits

Meter in circuit



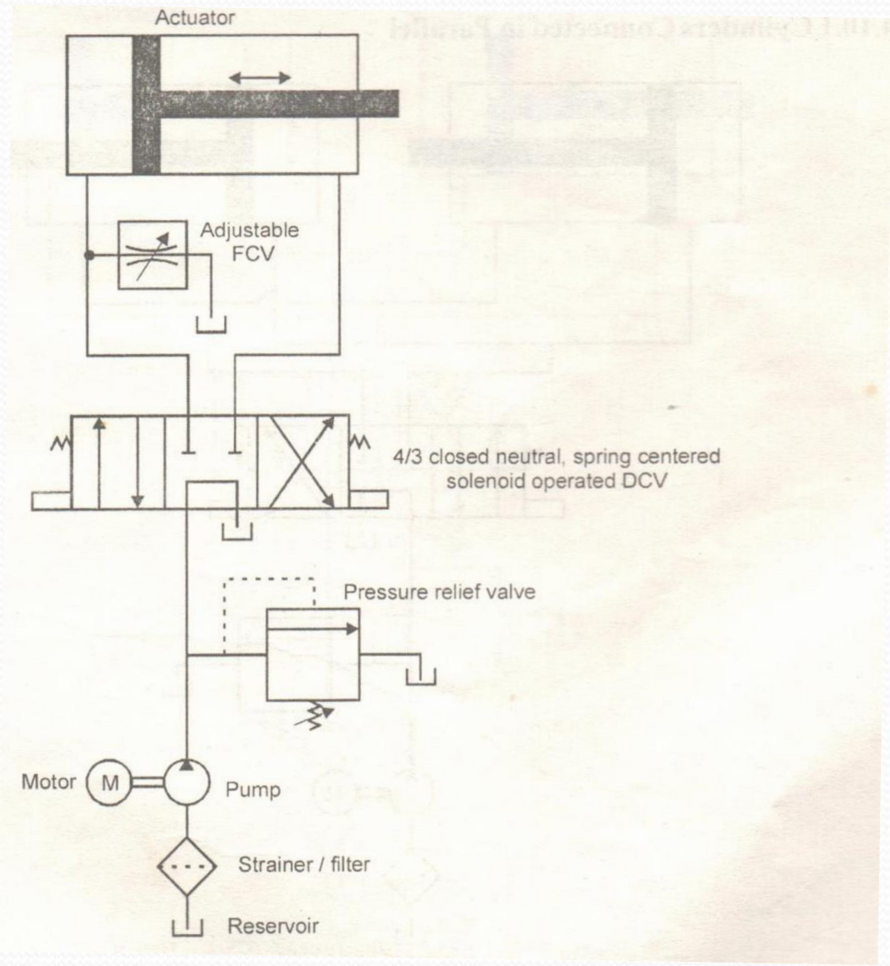
Meter-in-circuit

Meter out circuit



Meter out circuit

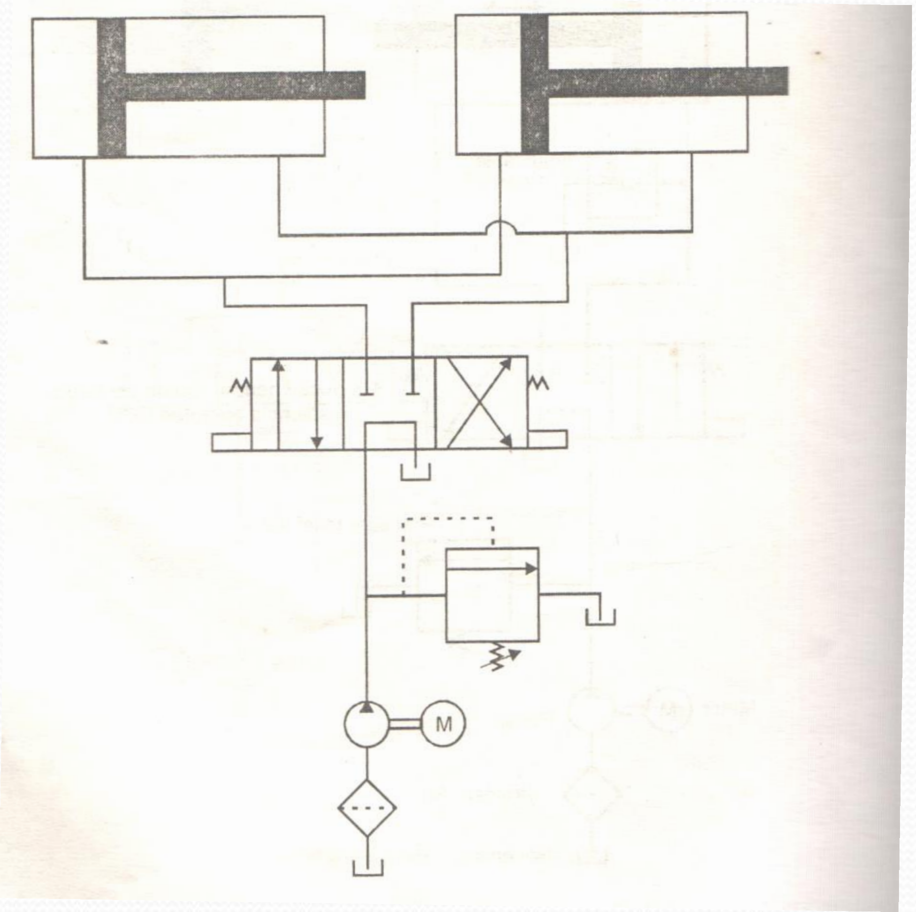
Bleed off circuit



Bleed off circuit

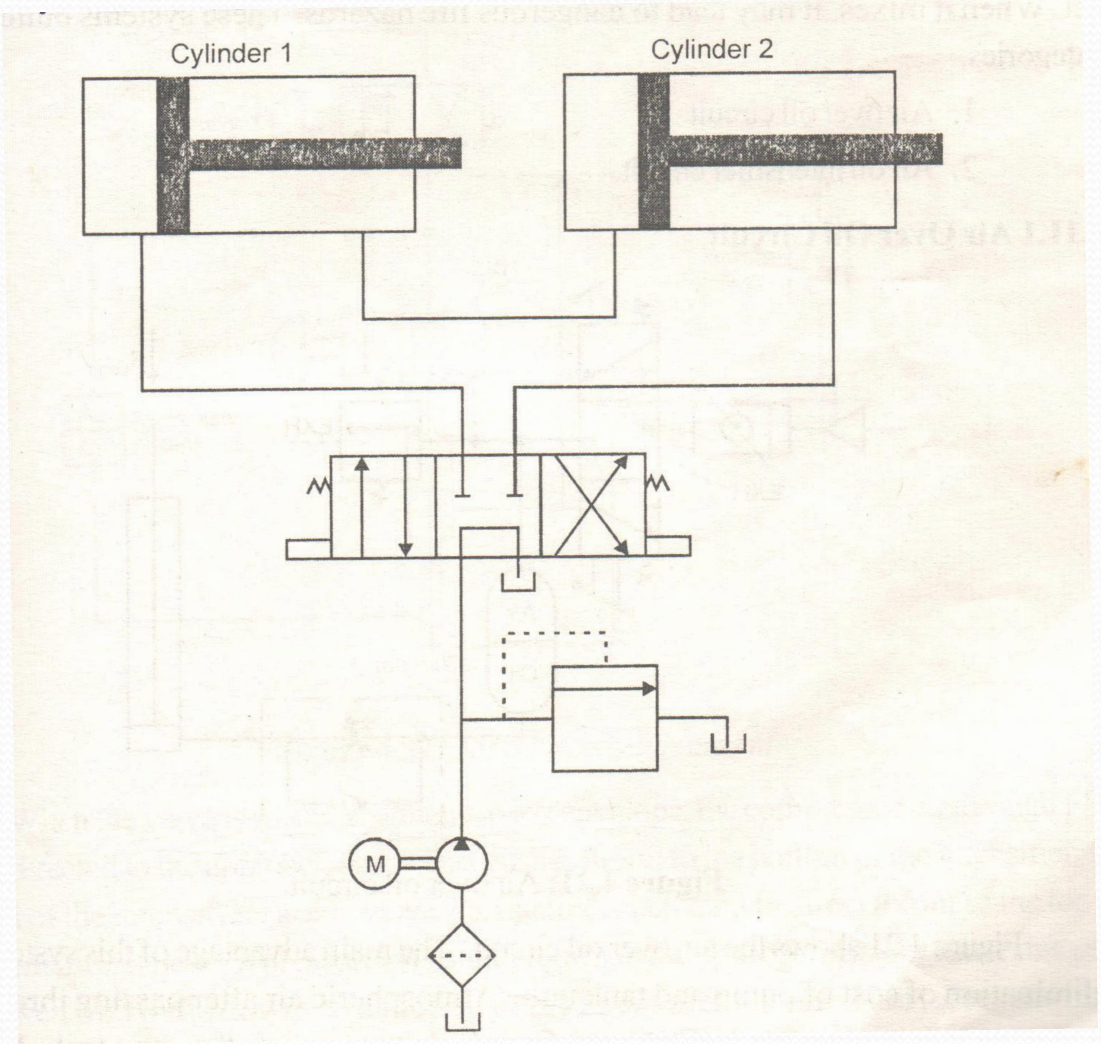
Synchronizing circuits

Cylinders connected in parallel



Synchronizing by parallel piping

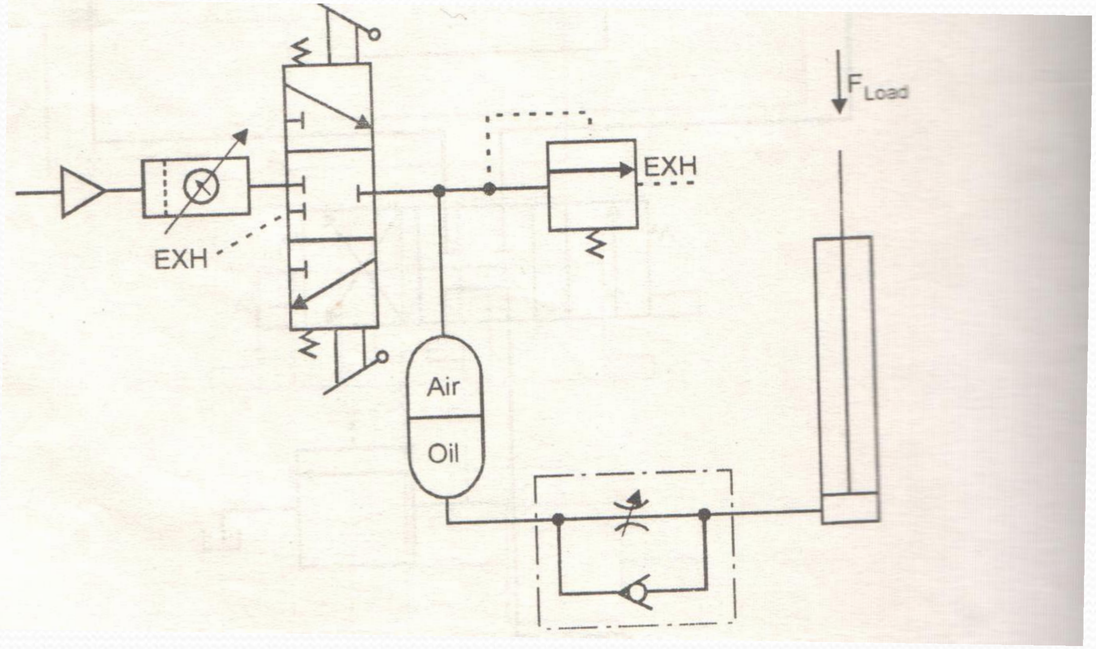
Cylinders connected in series



Synchronizing by series piping

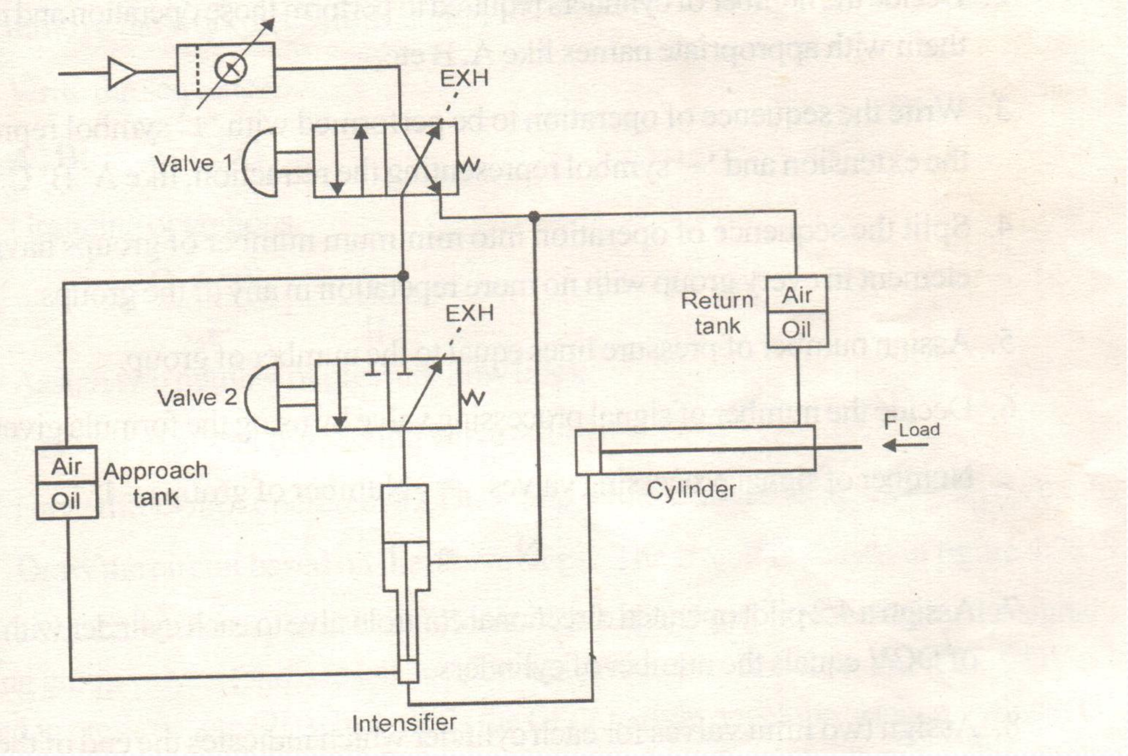
Pneumo Hydraulic circuits

Air over oil circuit



Air over oil circuit

Air over oil intensifier circuit



Air over oil intensifier circuit

PNEUMATIC LOGIC CIRCUITS

13.26. DESIGN OF PNEUMATIC LOGIC CIRCUITS

In the preceding sections, we have discussed few basic pneumatic circuits. It should be noted that a pneumatic circuit for a particular application can be designed in various methods. The five methods commonly used by engineers are :

1. Cascade method,
2. Classic or intuitive method,
3. Step-counter method,
4. Karnaugh-Veitch (K-V) mapping method, and
5. Combinational circuit design.

However, the design of pneumatic logic circuits using cascade method is more important from our subject point of view.

13.26.1. Cascade Method of Pneumatic Circuit Design

The cascade method is found to be the simplest and easiest method of designing pneumatic logic circuits.

13.26.1.1. Procedure

The following step by step procedure may be followed while using the cascade method.

Step1 : Each cylinders are given, for convenience, individual letters (say A, B, C, *etc.*). The given sequence is written first with '+' representing extension (forward) stroke of the cylinder and '–' representing retraction (return) stroke of the cylinder. (For example A^+, B^+, A^-, B^-, *etc.*)

Step 2 : The given sequence is split into minimum number of groups. The grouping can be done as below :

(*i*) The first group is split where the change in stroke occurs.

(*ii*) The second, third and subsequent groups are formed such that maximum of one change occurs within the group.

(*iii*) No letter should be repeated within any group.

(*iv*) The groups are identified by letters like I, II, III, *etc.*

Illustration : Let us assume the sequence A^+ B^+ B^- C^+ C^- A^-. This sequence can be splitted into three groups as shown below :

$$\frac{A^+ B^+}{I}, \frac{B^- C^+}{II}, \frac{C^- A^-}{III}$$

Step 3 : Each group is assigned a pressure manifold line which must be pressurised only during the time the particular group is active.

$\therefore$ *Number of pressure lines* = *Number of groups*

Step 4 : Selection of valves :

(*i*) Each cylinder is provided with a pilot operated 4/2 DC valve.

$\therefore$ *Number of pilot control valves* = *Number of cylinders*

(*ii*) Limit valves are positioned at either end actuated by the piston rod to identify the extension and retraction of cylinders. The limit valves are denoted by a_0, a_1, b_0, b_1, *etc.*, where the suffix '0' corresponds to valves which are actuated at the end of return stroke and the suffix '1' corresponds to valves which are actuated at the end of forward stroke. Each cylinder requires two limit valves.

$\therefore$ *Number of limit valves* = *2 × Number of cylinders*

Each manifold line supplies air pressure to those limit valves within its particular group.

(*iii*) In order to pressurize the various manifold lines in the proper order, one or more group changing valves or cascade valves are used.

$\therefore$ *Number of cascade (or group changing) valves* = *Number of groups – 1*

Step 5 : The valve connections are made as follows :

(*i*) The output of each limit valve is connected to the pilot input corresponding to the next sequence step.

(*ii*) The limit valve corresponding to the last step of the given group is 'not' connected to the pilot actuation of the DC valve of next cylinder. Instead, it is connected to the pilot line of the group changing or cascade valve so as to pressurize the manifold of the subsequent group.

This manifold line is then connected to the pilot line corresponding to the first step of the next group.

13.26.2. Advantages of Cascade Method

1. Circuit design, drawing and checking can be accomplished very quickly.
2. Fault diagnosis and trouble-shooting are very simple.
3. Required task by each cylinder and their signal elements is fully ensured.
4. This avoids a problem that may occur because of air becoming trapped in the pressure line to control a valve and so preventing the valve from switching.

Example 13.2 *Three pneumatic cylinders A, B, and C are used in an automatic sequence of operation. A cylinder extends, B cylinder extends, B cylinder retracts and then A cylinder retracts, C cylinder extends and C cylinder retracts. Develop pneumatic circuits by cascade method.*

☺ ***Solution :*** The steps involving during the design of this circuit is explained as below :

Step 1 : Given sequence is $A^+ B^+ B^- A^- C^+ C^-$

Step 2 : The given sequence can be initially splitted into three groups as

$$\underset{\text{I}}{\underline{A^+ B^+}}, \quad \underset{\text{II}}{\underline{B^- A^- C^+}}, \quad \underset{\text{III}}{\underline{C^-}}$$

In order to keep the number of groups minimal, the C^- can be assigned to group I. So the ideal grouping is as follows :

$$\underset{\text{I}}{\underline{C^- A^+ B^+}}, \quad \underset{\text{II}}{\underline{B^- A^- C^+}}$$

Step 3 : Number of pressure lines = Number of groups = 2

Step 4 : Selection of valves :

(*i*) Number of pilot operated 4/2 DC valve = Number of cylinders = 3

Thus three cylinder actuation—VA, VB, VC—are provided.

(*ii*) Number of limit valves = 2 × Number of cylinders = 2 × 3 = 6

Thus six limit valves—a_0, a_1, b_0, b_1, c_0, c_1—are provided.

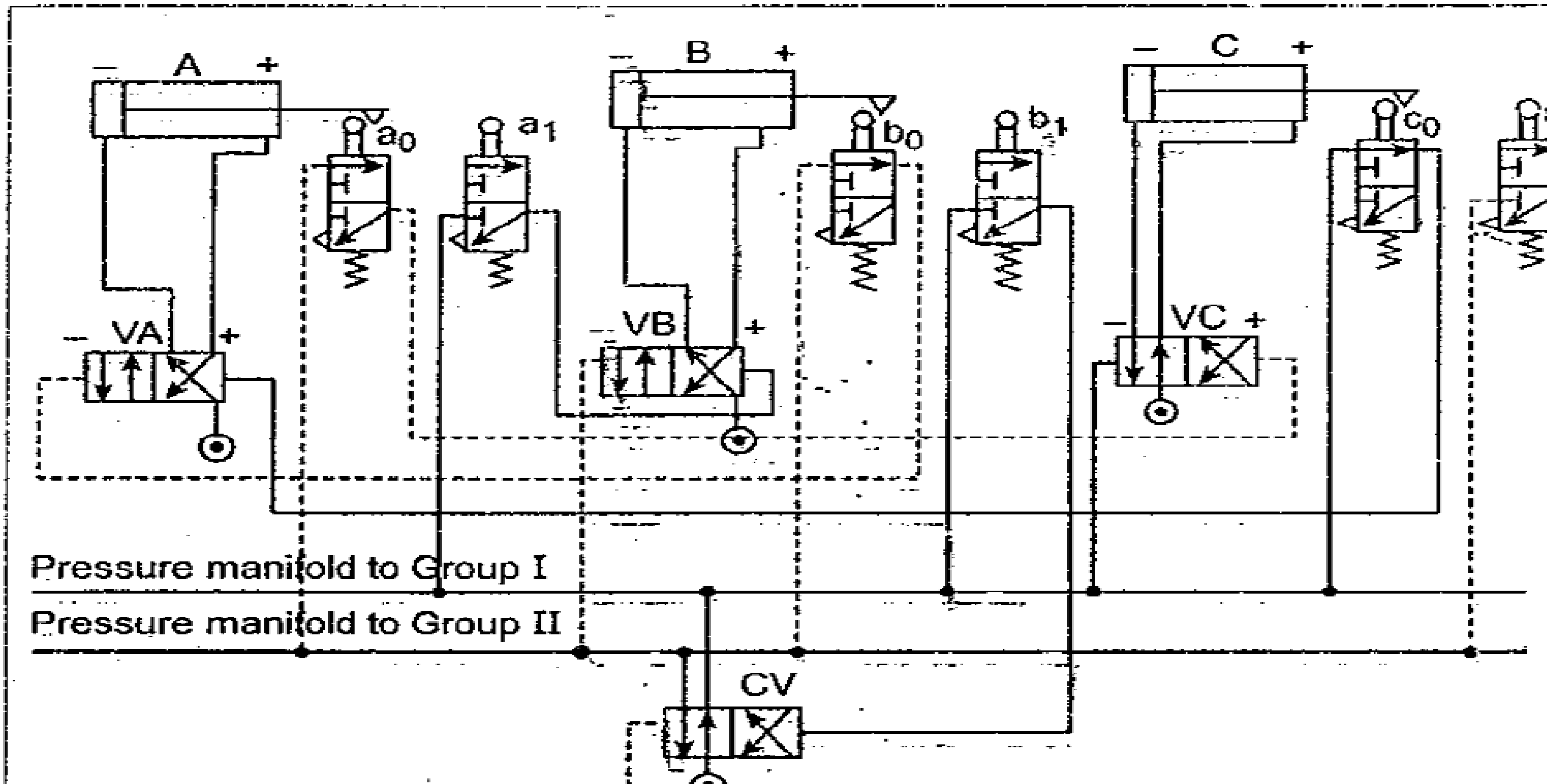
(*iii*) Number of cascade (or group changing) valves = $\left\{ \begin{array}{c}\text{Number of} \\ \text{groups}\end{array} \right\} - 1 = 2 - 1 = 1.$

So for this circuit, only one cascade valve is sufficient.

Step 5 : The valve connections are made as follows :

(*i*) The cascade valve CV is shifted to its left envelop flow path configuration so that the pressure manifold to group I is pressurized. First line I is connected directly to the pilot line (–) of 4/2 DC valve VC. So retraction of C (C^-) starts when group I is pressurized.

At the end of retraction of C, the limit valve c_0 is actuated. Now the pressu manifold line I passes through c_0 to the pilot line (+) of 4/2 DC vale V result, cylinder A extends (A^+) and actuates limit valve a_1. Pressure then from manifold line I through a_1 to the pilot line (+) of 4/2 DC valve VB; thi cylinder B to extend (B^+) and actuates limit valve b_1. Thus the sequencing o I is completed.



(*ii*) ***Pressure manifold*** : Now the pressure line should be shifted from Group I to Group II. The pressure from limit valve b_1 shifts the cascade valve CV to its right envelope flow path configuration and thus the pressure manifold II is pressurised. Line II is connected directly to the pilot line (–) of 4/2 DC valve VB. So retraction of B (B^-) starts when a group II is pressurized.

At the end of retraction of B, the limit valve b_0 is actuated. Now the pressure from manifold line II pass through limit valve b_0 to the pilot line (–) of 4/2 DC valve VA.

As a result, cylinder A retracts (A^-) and actuates limit valve a_0. Pressure then passes from manifold line II through limit valve a_0 to the pilot line (+) of 4/2 DC valve VC; this causes cylinder C to extend (C^+) and actuates limit valve c_1.

(iii) Now the pressure from limit valve c_1 shifts the cascade valve CV to its left envelop flow path configuration and thus the pressure manifold I is pressurised again. Thus the automating sequencing of $C^-A^+B^+B^-A^-C^+$ can be achieved.

The cascade circuit for the above $A^+B^+B^-A^-C^+C^-$ sequencing is drawn as shown in

UNIT V

TROUBLE SHOOTING AND APPLICATIONS

Installation, Selection, Maintenance, Trouble Shooting and Remedies in Hydraulic and Pneumatic systems, Design of hydraulic circuits for Drilling, Planning, Shaping, Surface grinding, Press and Forklift applications. Design of Pneumatic circuits for Pick and Place applications and tool handling in CNC Machine tools – Low cost Automation – Hydraulic and Pneumatic power packs.

Installation:

Many industrially equipment and tools need compressed air or hydraulic fluid to function.

Hydraulic Equipment:

Hydraulic equipment uses high pressure fluids to accomplish a multitude of machinery operations. A motor or engine drives pumps which pressures the hydraulic fluid. The pressurized fluid is sent through tubes to the machine actuators, which use the fluids pressure to complete their assigned task.

Where Hydraulic Power is used:

Hydraulic power is used to drive a variety of devices in a variety of industries. Most heavy construction equipment is powered by hydraulic power. Equipment such as cranes, lifts, bulldozers, and diggers use gas engines to power hydraulic pumps, which pressurize the hydraulic fluid. In many industrial facilities, hydraulic power is used. Robotic arms, presses, and laths all include hydraulics into their design and operations.

Components of Hydraulic Equipment:

Hydraulic equipment operates with the help of valves, pumps, filters, and actuators. Check valves are used to prevent the backflow of hydraulic fluid; counterbalance valves, which provide flow resistance in specific situations. Hydraulic cylinders, which convert the fluid pressure into mechanical forces.

Pump filters clean small debris and particles in the fluid, which could possibly cause a clog. The hoses, tubes and seals must be able to withstand high pressures, which still allow for some flexibility. Hydraulic cylinders, pumps, and power units are designed to be replaced to help keep the system operating. Instrumentation and switches are added to help gain more control and understanding of the hydraulic system

Pneumatic Equipment:

Pneumatics is a branch of mechanics that uses compressed air or pressurized gas to produce mechanical motion for tools and equipment.

Pneumatic equipment consists of several different components. All of these components are required for pneumatic equipment to function. The basic components of a pneumatic system are the air compressor, hoses, pipes, and the tools.

Pneumatic air compressors are the main component of a pneumatic air system. The compressors create the compressed air that is used to create the mechanical action. A booster is used to create a boost of air which will provide increased power.

Vacuum pumps are used to eliminate moisture from lines and air conditioning systems. Pneumatic systems should have a way of monitoring and filtering the air regularly in order to ensure proper operations and efficiency. To maintain a system in good working condition it is important to use proper air regulators and air filters.

Pressure gages are important to measure the pressure and flow reading in pneumatic systems. The proper gages from the designated systems is important because incorrect gauges could give inaccurate readings.

Pneumatic equipment and technology is useful in material handling, robotics, entertainment and many other industries. Pneumatic tubes are used to carry items long distance. Air brakes for trucks and buses, exercise machines, pressure regulators and sensors, pipe organs, chairs, vacuum pumps, pneumatic tires, and power tools all use pneumatic technology.

Selection:

Parameters for selection & sizing pneumatic and hydraulic components:

In today's typical manufacturing facility, hydraulic and pneumatic systems serve as the primary means of power for most cylinders, tooling and even some drive systems. They can be operated in high-temperature as well as high-radiation industrial environments where most electronic instruments will not function properly.

Volumes of material exist on proper system design, proper sizing of components, circuit design, valve and control technologies, as well as other design considerations

1. **Flow vs. pressure.** When dealing with pneumatics it is critical to understand the difference between pressure and flow. Too often operators compensate for starved flow with increased pressure. It is often best to install over-sized supply lines to a process in order to ensure the appropriate volume of air.

2. **Use electric actuators.** With ever-increasing energy costs, designers should consider using energy-efficient electric movement, provided the application requirements fall within an electric actuator's performance capabilities. This technology has advanced rapidly over the last five to 10 years, with vast improvements in functionality, including more precise movement and even built-in sophisticated controls

3. **Valve sizing.** Correct sizing of components, including piping, valves and actuators, can improve the productive capacity of pneumatic systems. Valve sizing is particularly important. If the flow capacity is too small, it can have a negative impact on production cycles. If you want to improve production cycle time and quality, then proper sizing is critical.

4. **Align pipelines.** If pipelines are not aligned properly at the correct angle, as indicated in the installation drawings, there is a great possibility of equipment damage.

5. **Choose 3-position valves.** Wherever operators will be working near an operation, a 3-position valve is a better choice than a 2-position valve. This is because a 3-position valve will stop the equipment instantly in the event of an emergency. This is in contrast to a 2-position valve, which will first complete the operation before stopping.

6. **Check temperatures.** Be sure to check the surface temperatures of equipment during preventive maintenance time and make a record. High temperatures could damage the viscosity properties of the hydraulic oil.

7. **Built-in flow control.** When you are using a pneumatic cylinder in a project, especially In high cycle count projects, use a fitting that has a flow control valve built in to make the cylinder last longer.

8. **Use feedback sensors.** Don't rely on software interlocks to control pneumatic devices unless you account for the delay caused by physical actuation. 100msec is a long time in the computer world. Always back up actuators with electrical feedback sensors, redundant if possible.

9. **Parallel air.** Make sure you have an adequate air supply when using pneumatic technology. Costly leaks are often hard to detect in a noisy plant environment. To avoid failure in the supply of compressed air on a network, it is important to verify that the distribution is closed so that the compressed air comes in parallel and not in series. Inspect tubing, ferrule, connection and joints for leakages. Make sure the air being produced is dry. All air filters should be checked periodically for accumulated water drainage.

10. **Choose quality tubing.** To prevent leaks, use nylon tubing on machines rather than push-on fittings and PE tubing. The leakage often found with soft tubing is hard to detect in a plant environment.

11. **Inlet side flow control.** In a pneumatic logic circuit controlling a double-acting cylinder, place the flow controls on the inlet side of your cylinder depending on the direction of travel. Air is compressible and positioning will float if controlled on the outlet. This will also create back pressure.

12. **Low fire risk.** One of the advantages of pneumatic technology is that it can operate without using electricity. This minimizes the risk of fire or explosions from sparks or arc flash events. This technology is particularly useful in a plant making edible oils or hydrogenating oils or when using flammable gases in the production process.

Maintenance:

Maintenance of hydraulic systems Most companies spend a great deal of money training their maintenance personnel so that they can troubleshoot and correct failures of a hydraulic system. If the focus was shifted to the prevention of system or component failures, less time and money could be spent on troubleshooting. We normally expect hydraulic system failure, rather than deciding not to accept hydraulic failure as the norm. Let’s spend the time and money to eliminate hydraulic failure, rather than to prepare for it. I worked for Kendall Company in the 1980s, and we changed our focus from reactive to proactive maintenance on our hydraulic systems, thus eliminating unscheduled hydraulic failure. We will talk about the right way to perform maintenance on a hydraulic system utilizing the Maintenance Best Practices.

Lack of maintenance of hydraulic systems is the leading cause of component and sys tem failure, yet most maintenance personnel don’t understand the proper maintenance techniques of a hydraulic system. There are two aspects to the basic foundation for proper maintenance of a hydraulic system. The first is preventive maintenance, which is key to the success of any maintenance program, whether for hydraulics or for any equipment of which we require reliability. The second aspect is corrective maintenance, which in many cases can cause additional hydraulic component failure when it is not performed to standard.

PREVENTIVE MAINTENANCE

Preventive maintenance (PM) of a hydraulic system is very basic and simple, and if followed properly it can eliminate most hydraulic component failure. PM is a discipline and must be followed as such in order to obtain results. We must view a PM program as performance-oriented and not activity-oriented. Many organizations have good PM procedures, but do not require maintenance personnel to follow them or hold them accountable for the proper execution of these procedures. In order to develop a preventive maintenance program for your system, you must follow the steps outlined here.

As in all preventive maintenance programs, we must write procedures required for each PM task. Steps or procedures must be written for each task, and they must be accurate and understandable by all maintenance personnel from entry-level to master.

Preventive maintenance procedures must be a part of the PM Job Plan, which includes the following:

- Tools or special equipment required to perform the task
- Parts or material required to perform the procedure with storeroom number
- Safety precautions for this procedure
- Environmental concerns or potential hazards

A list of preventive maintenance tasks for a hydraulic system could include the following:

1. Change the (could be the return or pressure filter) hydraulic filter.
2. Obtain a hydraulic fluid sample.
3. Filter hydraulic fluid.
4. Check hydraulic actuators.
5. Clean the inside of a hydraulic reservoir.
6. Clean the outside of a hydraulic reservoir.
7. Check and record hydraulic pressures.
8. Check and record pump flow.

9. Check hydraulic hoses, tubing, and fittings.
10. Check and record voltage reading to proportional or servo valves.
11. Check and record vacuum on the suction side of the pump.
12. Check and record amperage on the main pump motor.
13. Check machine cycle time and record.

Maintenance of pneumatic systems:

The person maintaining air systems in today's modern plant must know the following:

1. Compressed air safety
2. The function of each pneumatic component. This includes compressors, after coolers, dryers, cylinders, valves, filters, regulators and lubricators.
3. The effects of water vapor and moisture in an air system and how to control it.
4. How temperature affects pressure and air volume.
5. How to adjust the system control devices such as pressure switches, regulators, lubricators and dew points for dryers.
6. How to troubleshoot and test compressors, receivers, relief valves, dryers, valves and cylinders.
7. How to read the pneumatic symbols for troubleshooting from the schematic.

Trouble shooting & remedies in hydraulics & pneumatics systems:

Troubleshooting a pneumatic system has been considered an art, a science, or just hit-or-miss luck. In the minds of maintenance personnel, production managers, and plant managers, the word troubleshooting conjures up images of hours of downtime and lost production.

However, when reduced to its basic elements, troubleshooting a pneumatic system is a step-by-step procedure. Using this process can speed up the ability to determine what the problem is, the probable cause of the malfunction or failure, and a solution.

Every pneumatic circuit has a logical sequence of operation that can involve timing logic, pressure sensing, position sensing, and speed regulation. Troubleshooting is initiated when the circuit does not operate properly.

Certain general diagnostic and testing steps can be applied to any troubleshooting problem, whether the problem occurred at startup of a new system or at a breakdown of an existing system.

12 Steps to troubleshooting pneumatic systems

Troubleshooting a pneumatic system is neither art, nor science, nor should it be viewed as hit-or-miss; it is a procedural effort requiring 12 steps to accomplish.

1. Think safety first. 2. Ask the three Ws – What, When, and Where.

3. Visually inspect the machine. 4. Have a thorough understanding of the system. Use a schematic. 5. Operate the machine. 6. Recheck all services to the machine. Think safety.

7. Isolate subsystems on the machine. 8. Make a list of probable causes.

9. Reach a conclusion about the problem. 10. Test the conclusion. 11. Repair or replace as necessary. 12. Report the findings.

Trouble shooting hydraulic systems:

When hydraulic system degradation is obvious or suspected, there are many cost effective inspection methods and testing techniques to aid the troubleshooter in locating the cause or causes of the problem. Generally, improper hydraulic system operation can be traced to one of the following deficiencies:

a) Insufficient fluid level.
b) The presence of air in the system.
c) Contamination by foreign material.
d) Incorrect adjustment of components.
e) Internal or external fluid leakage.
f) Mechanical damage to components.
g) Wrong fluid type or viscosity.
h) Excessive temperatures.

There are two fundamental principles that must be understood when troubleshooting hydraulic system problems.

1. Pumps (which may be vane, gear, or piston types) are used in hydraulic systems to produce sufficient flow to obtain the speed required from cylinders or motors. This speed (oil flow) can be increased or decreased by using a pump of higher or lower capacity, or by changing the relative size of the cylinder or motor, but the flow of oil (speed of the cylinder) will not be significantly increased or decreased by altering system pressure.

2. The resistance to oil flow is directly related to the load which the cylinder is carrying or lifting, therefore resistance to oil flow results in pressure. The heavier the load, the higher the resulting pressure (subject to the maximum pressure setting of the pressure relief valve).

If a system is not maintaining correct pressures while the pump is maintaining its specified flow rate, then only two conditions may exist; either an external leak is occurring, which should be obvious by the oil spill, or an internal leak is occurring which may not be so obvious.

If on the other hand, the system is developing excessive pressures during operation, the cause is excessive resistance to flow. This may be the result of excessive load, restricted components, such as plugged filters or hoses, or some mechanical problem such as a bent cylinder rod.

Technicians and troubleshooters would be well advised to remember these two principles and learn to correctly use flow meters and pressure gauges during their diagnostic procedures.

Today, this lack of understanding the principles and/or an unwillingness or inability to use the necessary diagnostic tools, cannot be tolerated. How many times have we heard a plant manager or production supervisor suggest that no repair action is necessary because a “hydraulic leak is not serious.” This is a huge error in judgment.

If a cylinder is leaking even a small amount of oil, the result may be the equivalent amount of air and dust particles entering the cylinder as it retracts, resulting in an unacceptable level of internal contamination or spongy action of components.

If the hydraulic pump is the heart of the system, then the hydraulic oil is the life blood and the functions of hydraulic oil can be summarized:

a) Transmit power from one point to another,

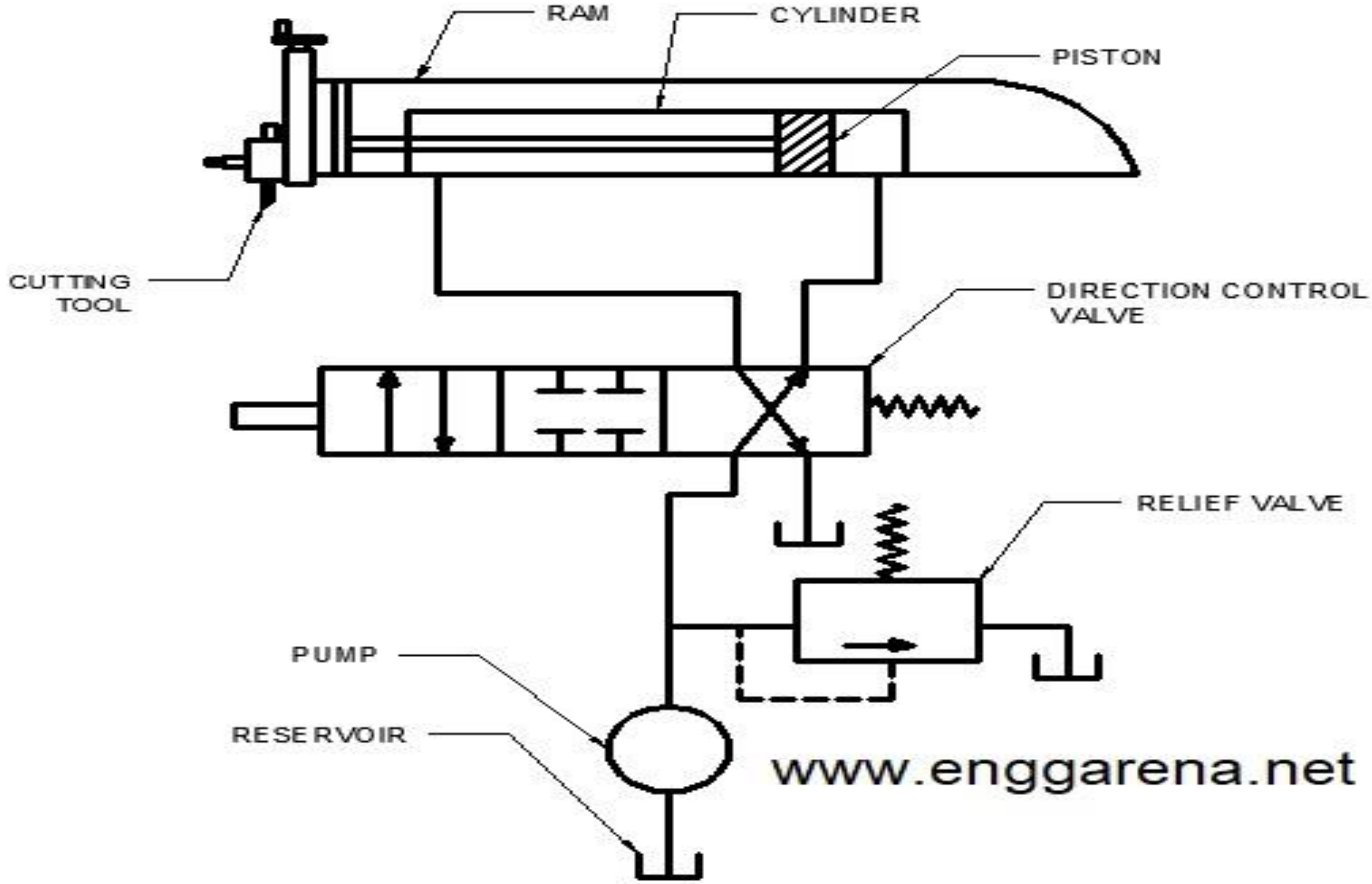
b) Lubricate system components,

c) Transfer and dissipate heat,

d) Provide a seal to maintain pressure.

Design of hydraulic circuit for drilling operation:

1. Pump capacity
2. Working pressure
3. Horse power
4. Reservoir size


RAM
CYLINDER
PISTON
CUTTING TOOL
DIRECTION CONTROL VALVE
RELIEF VALVE
PUMP
RESERVOIR
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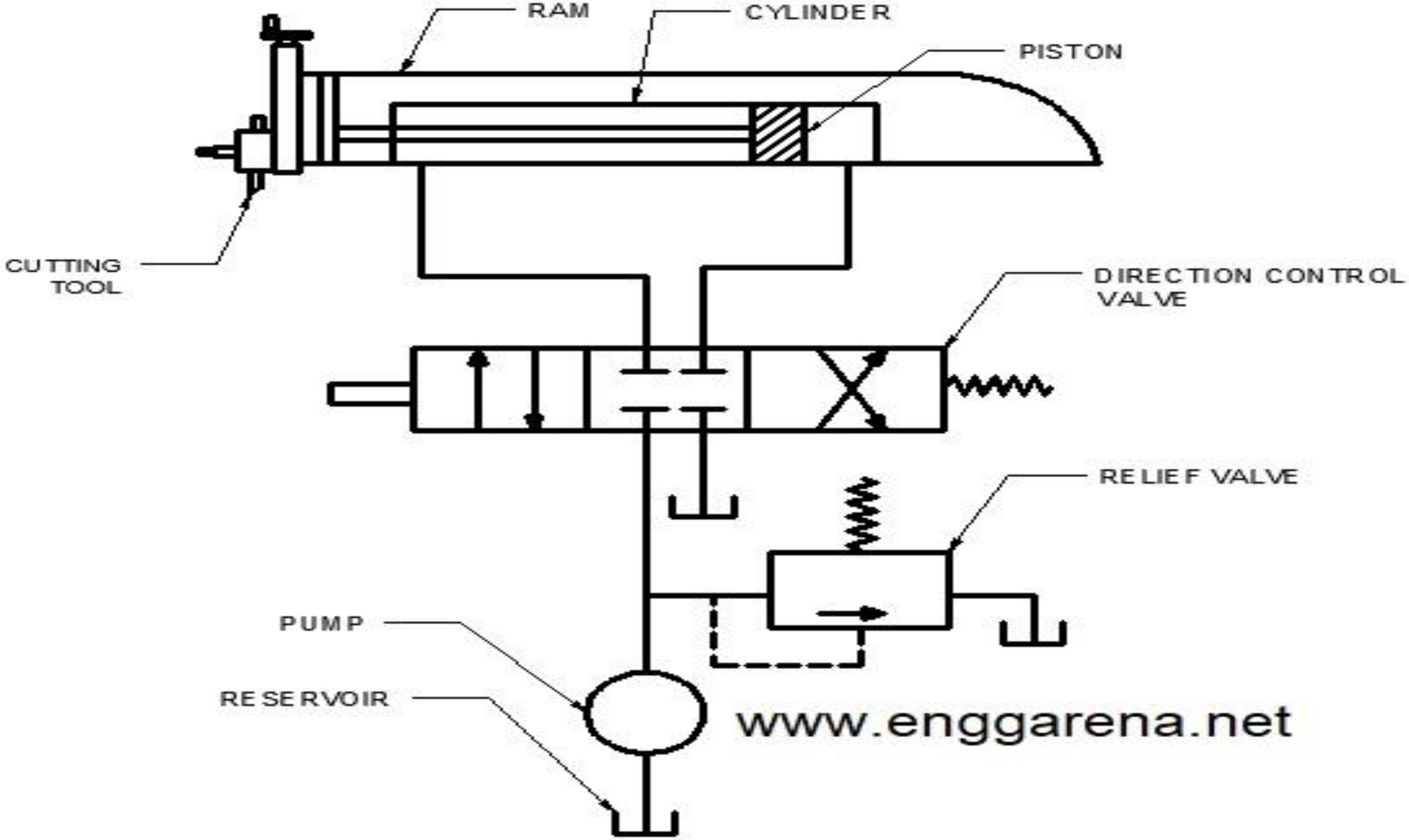
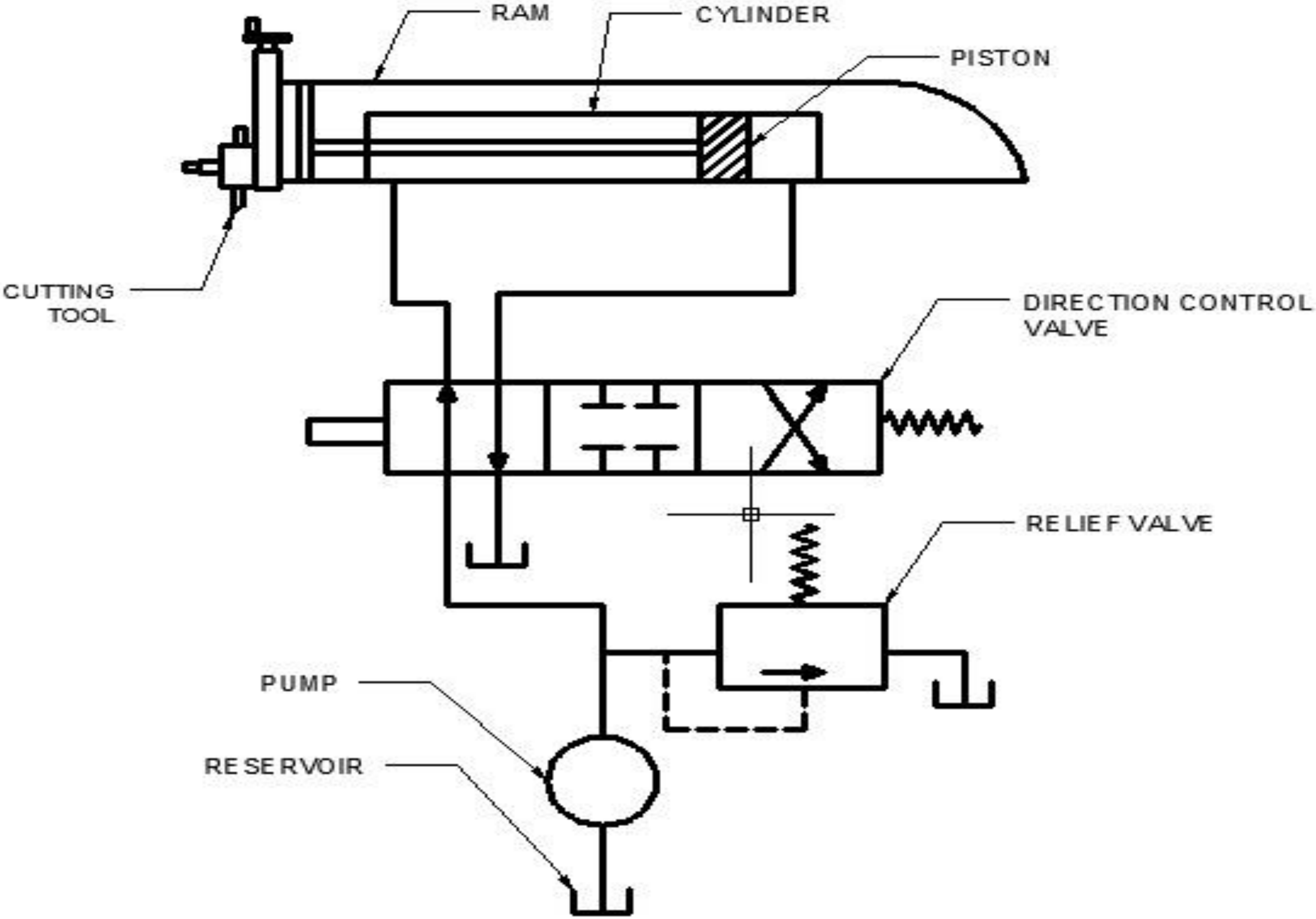
Due to the difference in annular areas of head-end and piston rod end, the return stroke is faster than the forward stroke.





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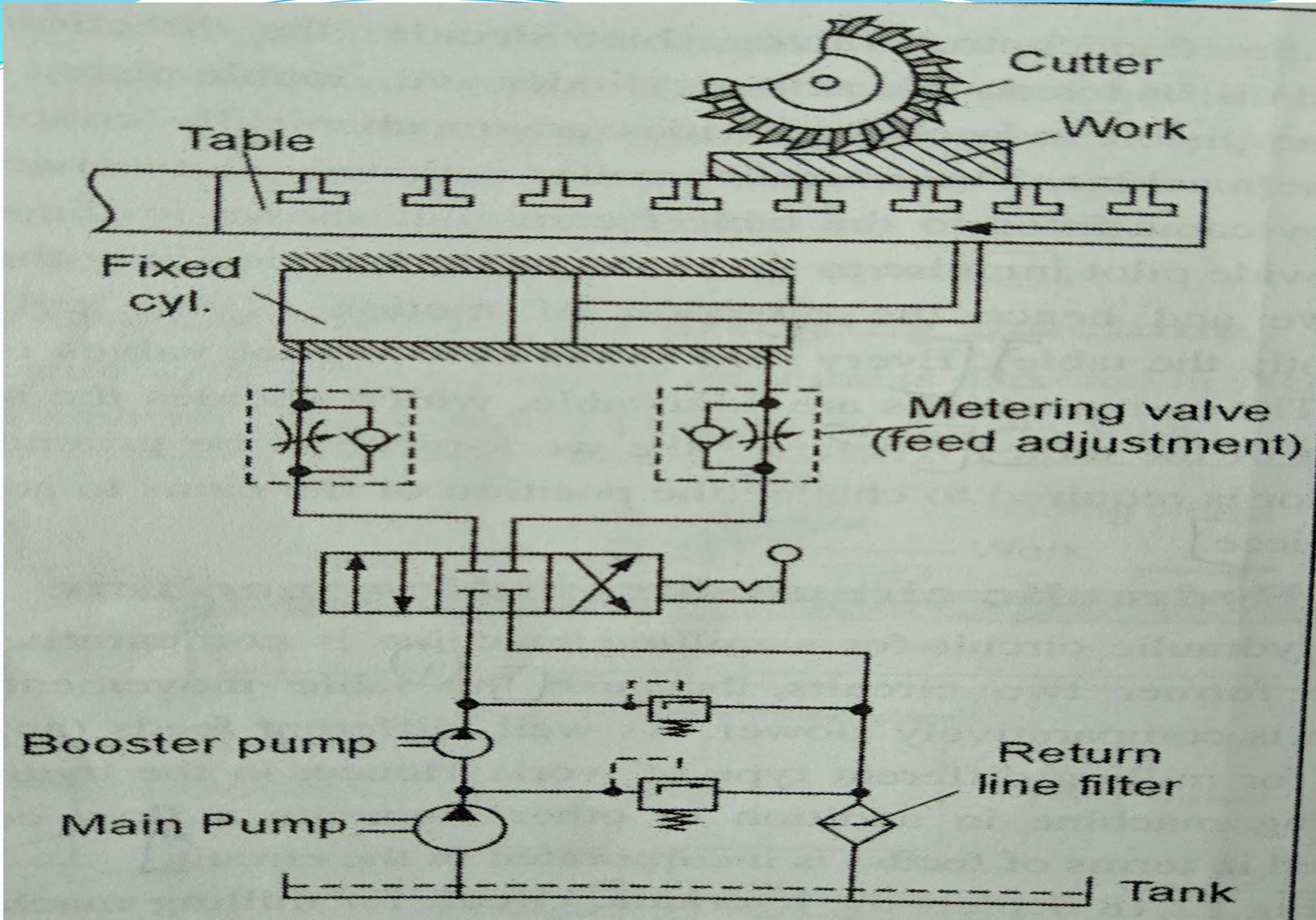
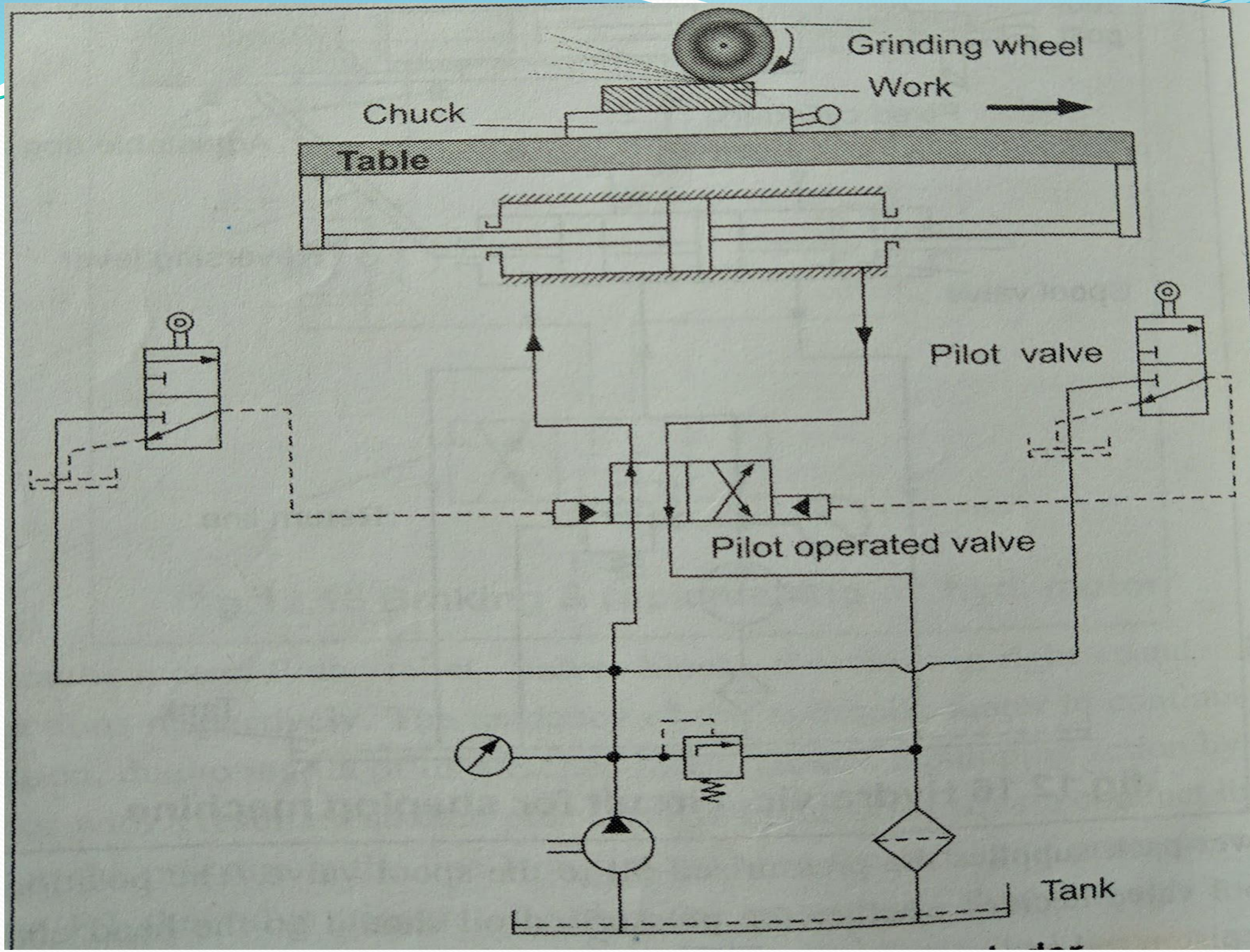
CUTTING TOOL
DIRECTION CONTROL VALVE
RELIEF VALVE
PUMP
RESERVOIR


Cutter
Work
Table
Fixed
cyl.
Metering valve
(feed adjustment)
Booster pump
Main Pump
Return
line filter
Tank


Grinding wheel
Work
Chuck
Table
Pilot valve
Pilot operated valve
Tank

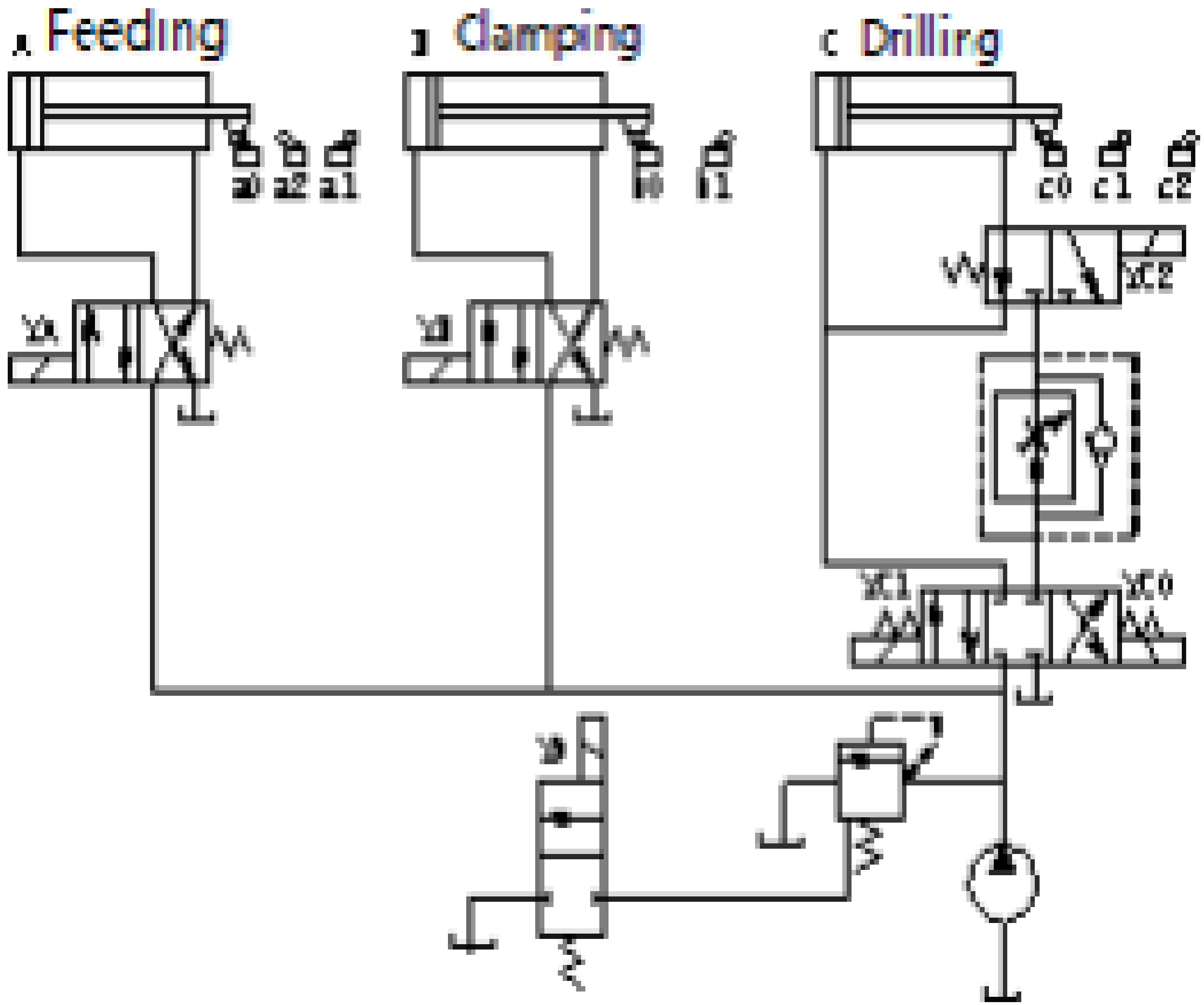
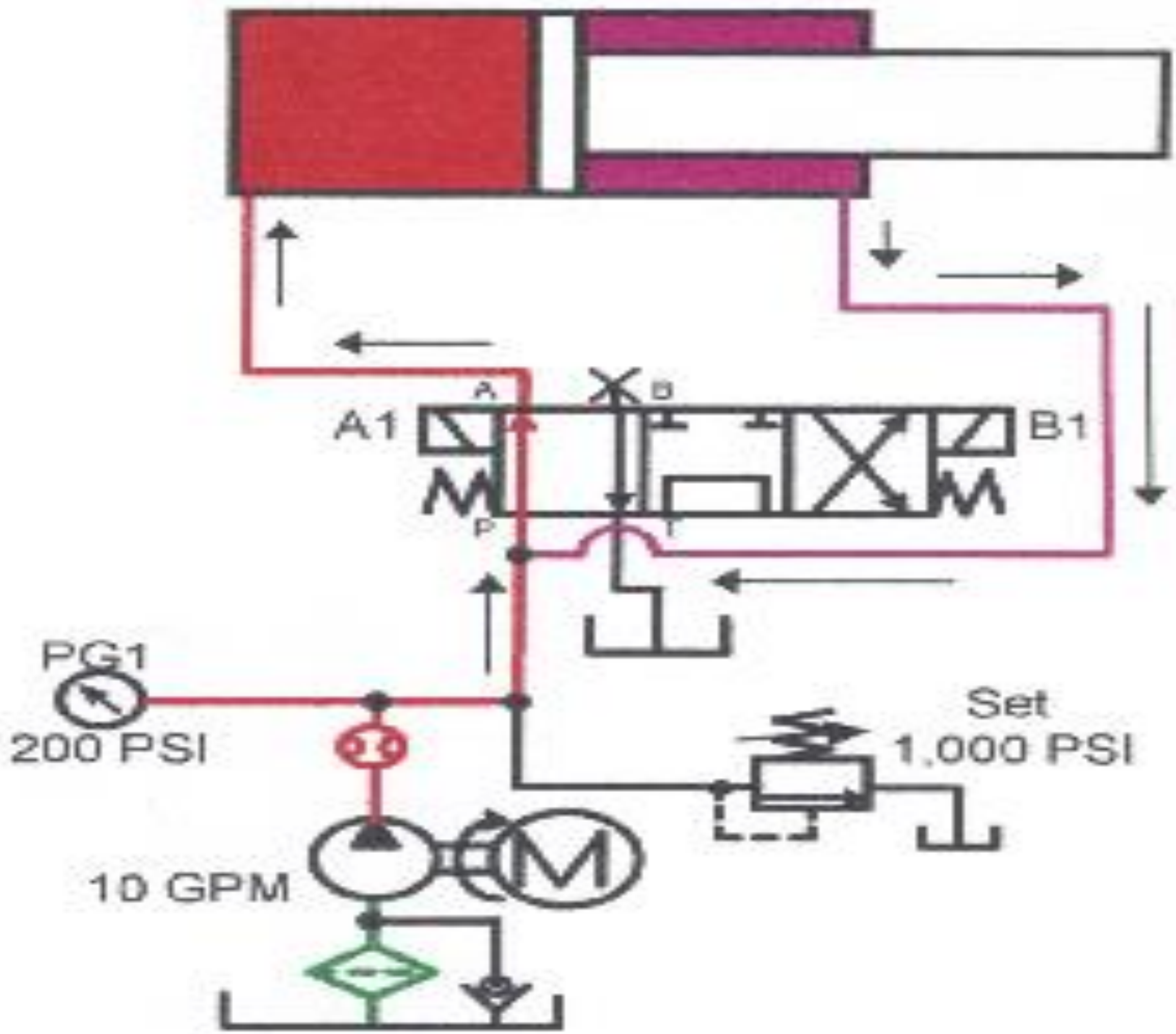
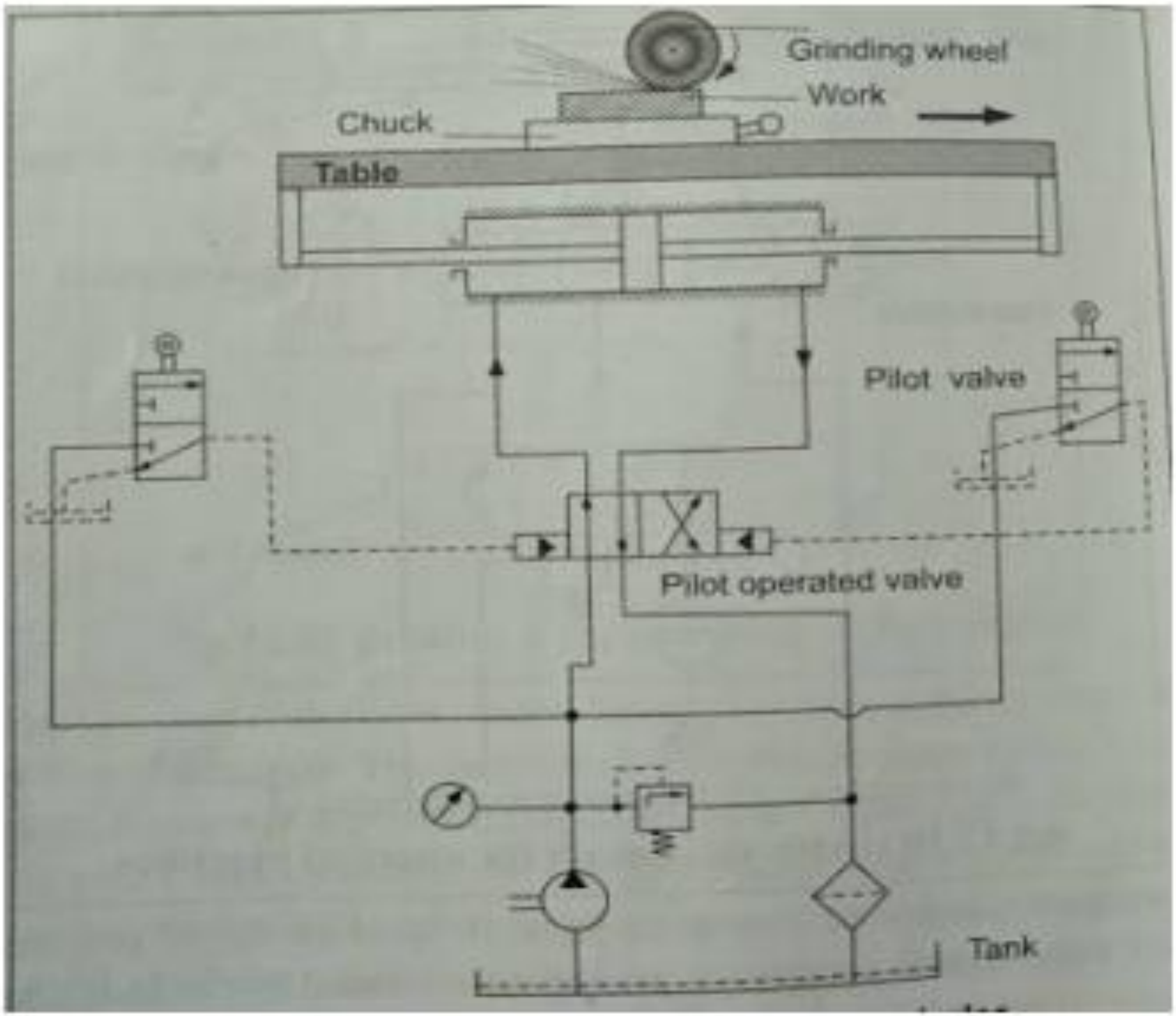


Fig. 2 Full-automatic special drill hydraulic system loop


A
B
A1
B1
P
T
PG1
200 PSI
Set
1,000 PSI
10 GPM


Grinding wheel
Work
Chuck
Table
Pilot valve
Pilot operated valve
Tank