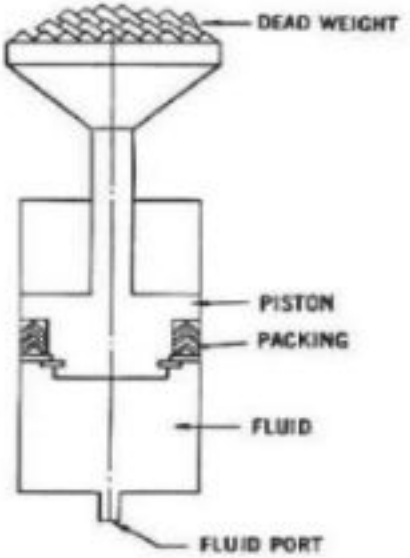
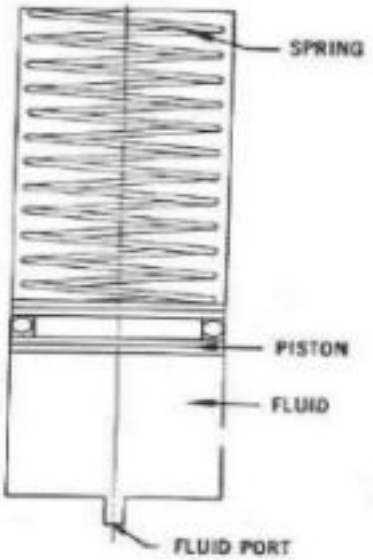
- Accumulator
  - A hydraulic accumulator is a device that stores the potential energy of an incompressible fluid held under pressure by an external source against some dynamic force
  - In other words, **accumulator is a device used to store energy of a liquid under pressure and make this energy available as a quick secondary source of power to hydraulic machines**

Types of accumulators

- ❖ Weight loaded or gravity type
- ❖ Spring loaded type
- ❖ Gas loaded type

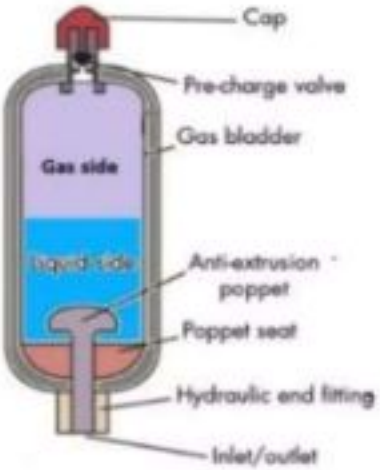
- Weight loaded or gravity
  - Oldest type
  - Consists of vertical heavy wall steel cylinder which contains a piston with packings to prevent leakage
  - A dead weight is attached to the top of the piston
  - The force of gravity of the dead weight provides potential energy in the accumulator
  - This creates a constant fluid pressure throughout the full volume irrespective of the rate and quantity of output
  - Disadvantage-large size and heavy weight makes mobility impossible

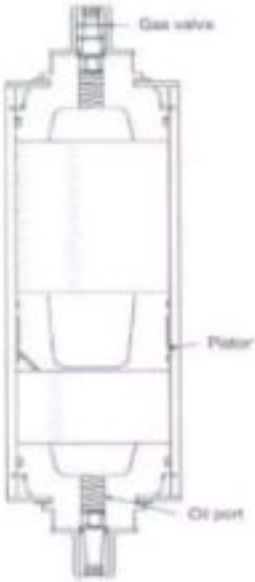




- Spring loaded accumulator
  - Similar to weight loaded except the piston is preloaded with a spring
  - The spring acting against the piston forces the fluid into the system
  - Pressure generated by this type is not constant and depends on size and preloading of the spring
  - Spring loaded accumulator delivers relatively small volume of oil at low pressures
  - Cannot be used for applications requiring high cycle rates as the spring will fatigue and lose its elasticity

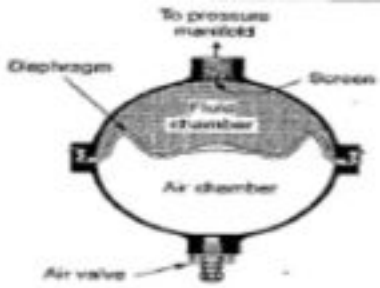
- Gas loaded accumulator
  - Operates on the principle of boyle's law of gases-pressure of a gas varies inversely with its volume
  - i.e., gas volume of the accumulator would be cut in half if the pressure is doubled
  - Gas loaded accumulators are classified into two types
    - Non separator type
    - Separator type
      - Piston type
      - Bladder type
      - Diaphragm type
- Non separator type
  - Consists of a fully enclosed shell containing an oil port at the bottom and a charging valve on the top
  - Gas is confined at the top and oil at the bottom with no physical separator between them
  - Advantage- can handle large volume of oil
  - Drawback- absorption of gas in oil due to lack of seperator

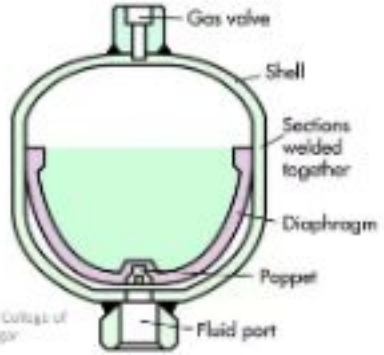


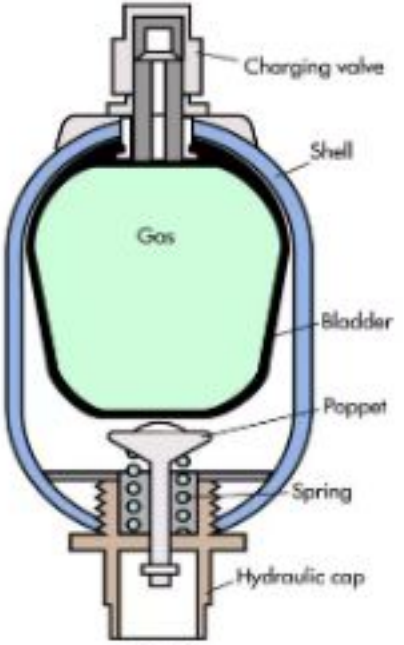


- Piston type
  - Consists of a cylinder containing a freely floating piston with seals
  - Piston serves as barrier between gas and oil
  - Threaded lock ring prevents disassembling of unit while it is precharged
  - Main drawback is expensive to manufacture
  - Notable leakage may occur due to operation over a long period of time
  - Advantage is that its ability to handle very high or low temperature system fluids through O-ring seals

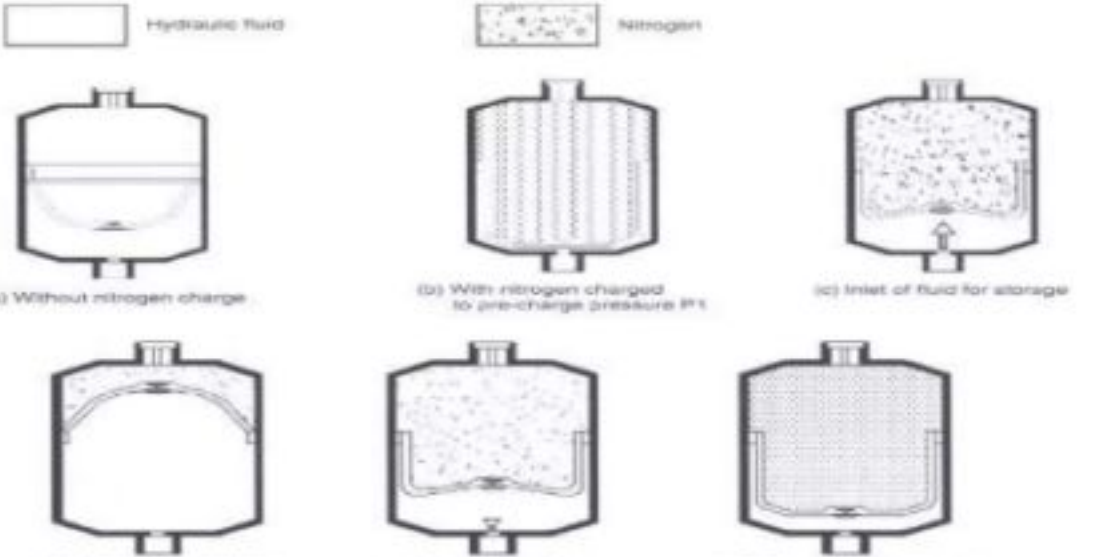
- Diaphragm type accumulator
  - A diaphragm secured in the shell serves as an elastic barrier between oil and gas
  - A shutoff button, placed at the base of the diaphragm covers the inlet when the diaphragm is fully stretched
  - On the gas side, a screw plug allows control of the charge pressure and charging of the accumulator by means of a charging and testing device
  - When the oil is delivered into the accumulator, it deforms the diaphragm. The gas is compressed when the charged oil pushes the diaphragm against it
  - This gas pressure is used as potential energy to force the oil out when it is required in the circuit
  - Drawback-doesnot provide constant fluid pressure







- Bladder type accumulator
  - Consists of an elastic barrier (bladder) between the oil and gas
  - This bladder is placed within the accumulator shell and the balance of the space is filled with oil
  - When the oil under pressure enters the accumulator, the gas in the bladder gets compressed
  - When the oil is called on, the bladder expands and forces the oil out into the circuit
  - The large poppet valve placed at the fluid entry port closes when the accumulator is exhausted. This prevents the bladder from extruding out into the inlet pipe.



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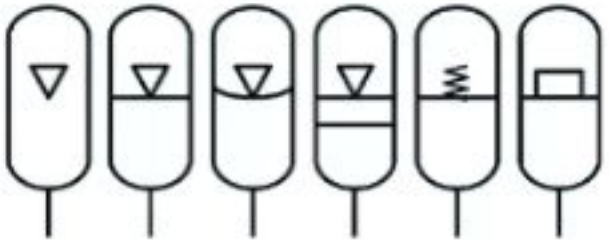
Accumulator

Spring Loaded Accumulator

Weighted Accumulator



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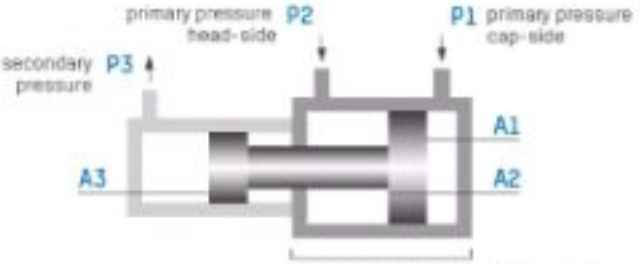
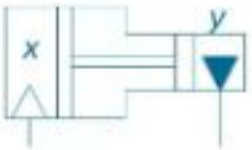
- Intensifier
  - Pressure intensifier or boosters are devices used to generate pressure greater than those achievable with standard hydraulic pumps alone
  - In other words, a hydraulic intensifier is a device which converts a large volume low pressure fluid into a proportionally small volume high pressure fluid outlet
  - The intensifier is usually placed in between the pump and the machine. It takes the inlet flow from the pump and intensifies the pressure
  - Its applications including hydraulic presses, riveting machine, spot welders etc.,



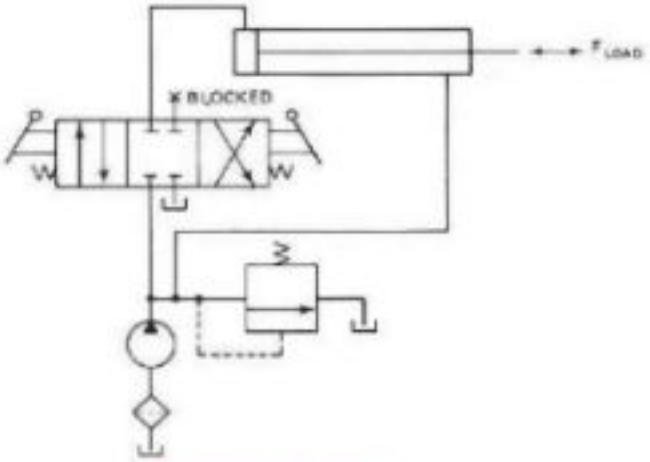


- It consists of two pistons low pressure and high pressure pistons having a common piston rod
- The larger piston is exposed to pressure from a low pressure pump. The low pressure oil forces the piston to move
- The smaller end of the piston exerts the same force on the fluid in the intensifier chamber
- **Intensifier ratio**

$$P_o \times A_o = P_i \times A_i$$

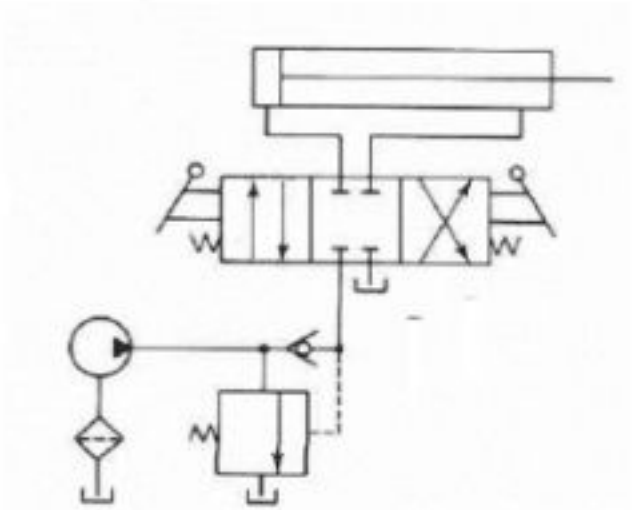
$$\frac{P_i}{P_o} = \frac{A_o}{A_i}$$

Industrial hydraulic circuit-regenerative



Regenerative Circuit

Industrial hydraulic circuit-pump unloading circuit



Pump Unloading Circuit

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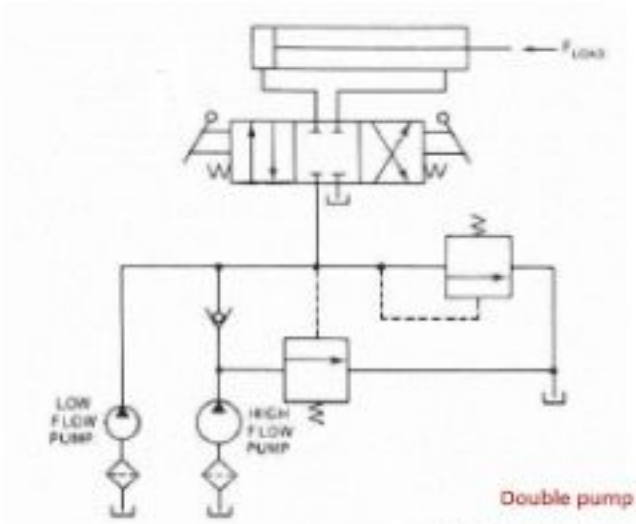
Industrial hydraulic circuit-Double Pump hydraulic system



Double pump hydraulic system

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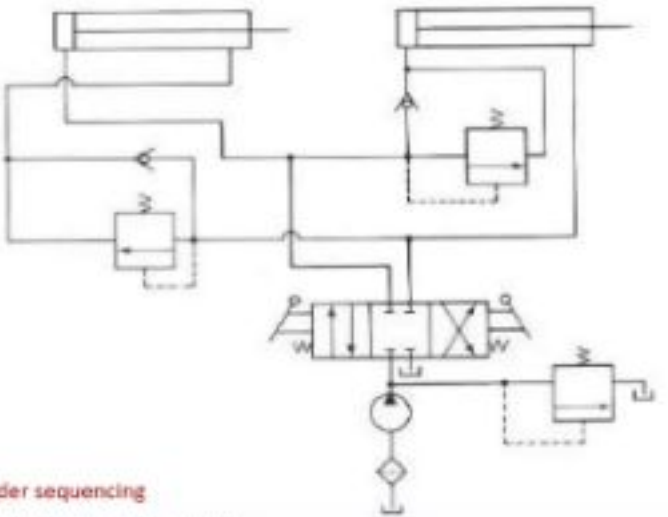
Industrial hydraulic circuit-Sequence cylinder



Cylinder sequencing

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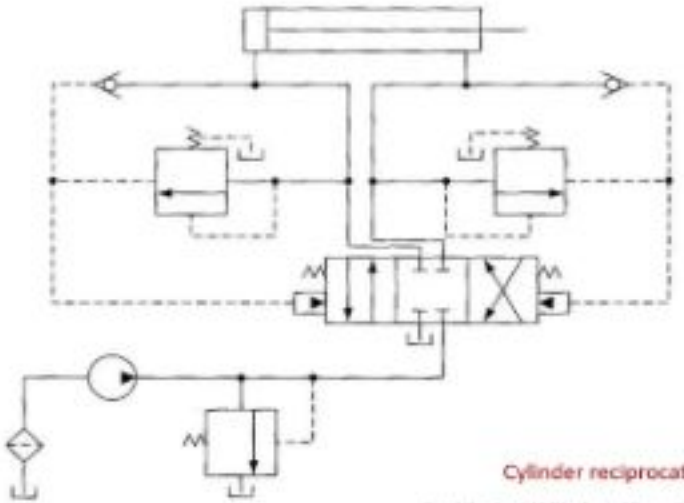
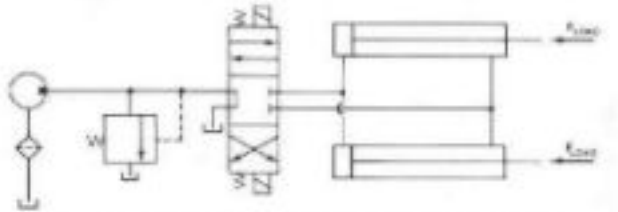
Industrial hydraulic circuit-Automatic Cylinder Reciprocation system



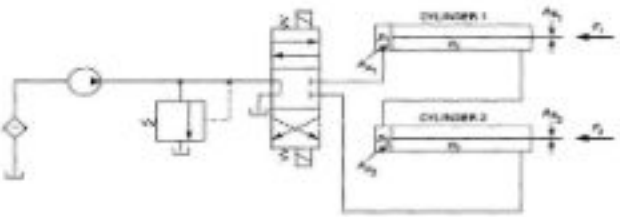
Cylinder reciprocation system

David Bhadra S AP/Mechanical Engg., Kalaivani College of Engineering and Technology, Virudhunagar

Industrial hydraulic circuit-Synchronizing Circuit



Cylinders hooked in parallel will not operate in synchronization.



Cylinders hooked in series will operate in synchronization.

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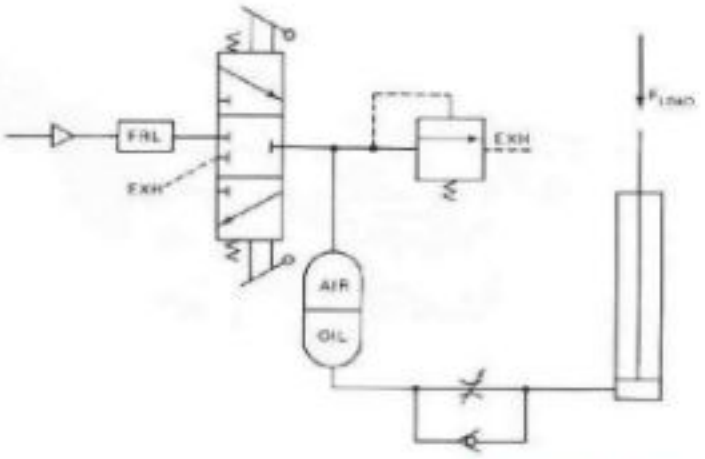
Industrial hydraulic circuit-air over oil circuit



Air over oil circuit

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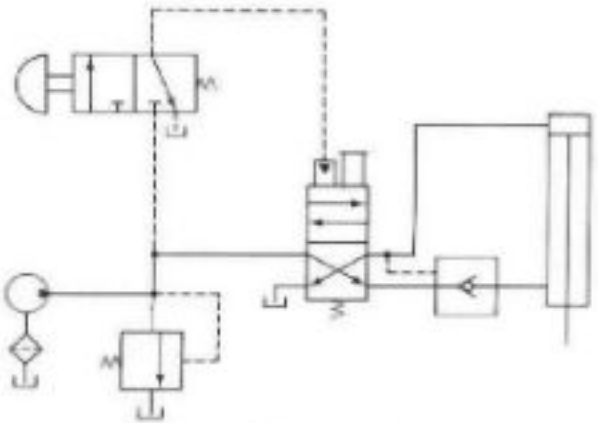
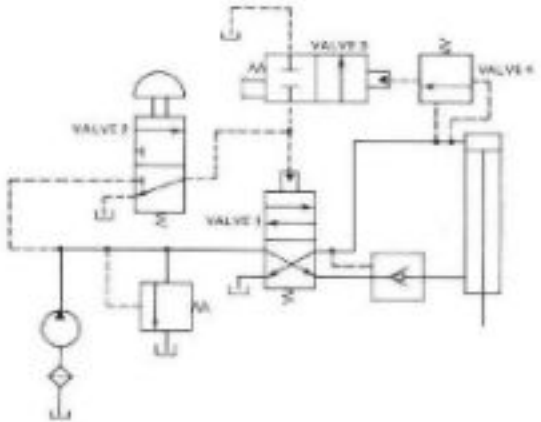
Industrial hydraulic circuit-Fail-safe circuits



Fail-safe circuit,

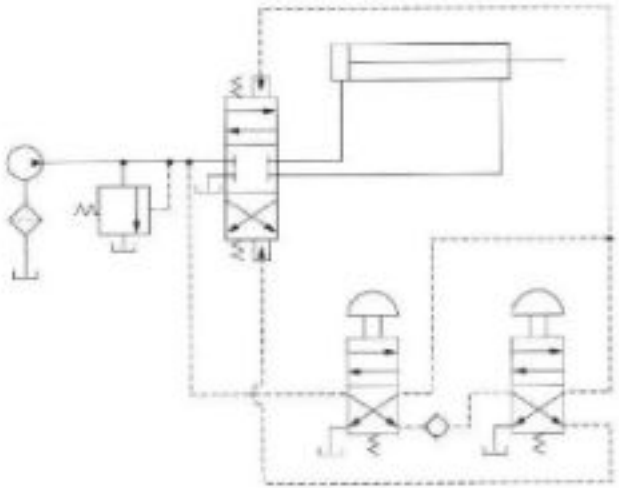
Protection from Inadvertent cylinder extension

Industrial hydraulic circuit-Fail-safe circuits-contd.,



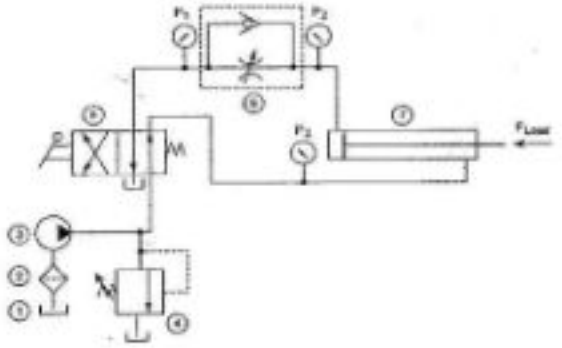
Fail safe system with overload protection

Industrial hydraulic circuit-Fail-safe circuits-contd.,

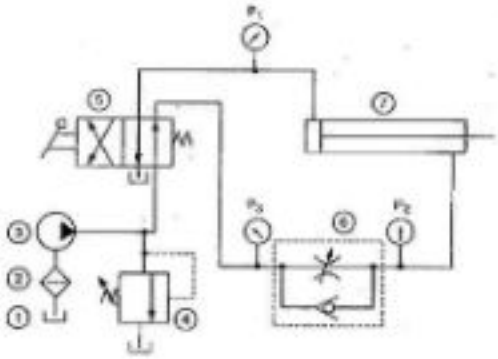


Two handed safety circuit

Industrial hydraulic circuit-Speed control

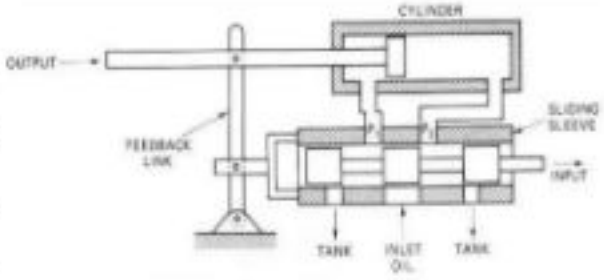


Speed control-Metre In circuit



Speed control-Metre Out circuit

- Hydromechanical servo valve
  - A small force applied on the main spool shifts it towards right which allows oil to enter through port P1 from inlet
  - Oil from inlet port enters P1 and causes the cylinder to retract towards right.
  - As shown in fig. a feedback link is connected to the piston rod and sliding sleeve which shifts the sliding sleeve towards right until it blocks off the flow to Port P1
  - Thus the given input motion has produced a specific output motion and the output motion is feedback to modify the input through feedback line

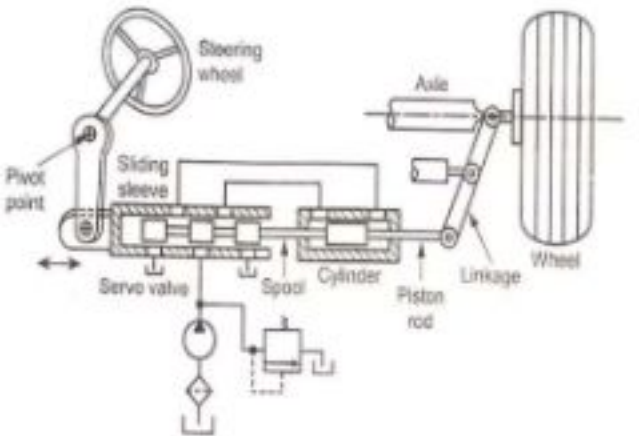


Lap conditions

Closed centre servo valve : lands are larger than ports

Open centre servo valve : lands are narrower than port

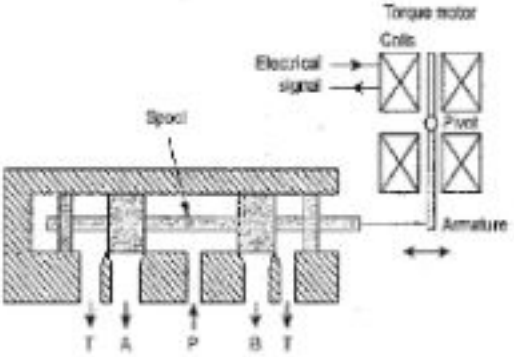
Zero lap servo valve : both lands and edges are made precise



- Hydromechanical servo valve in steering applications
  - Input force is the turning of the steering wheel
  - Steering wheel movement permits the sliding sleeve to allow oil from port to the steering cylinder which in turn moves the wheel through steering linkage
  - Since the valve spool is attached to the linkage, it also moves along with the linkage
  - When the valve spool has moved far enough, it cuts off the flow to the cylinder by blocking the port. Thus the motion of the cylinder is stopped

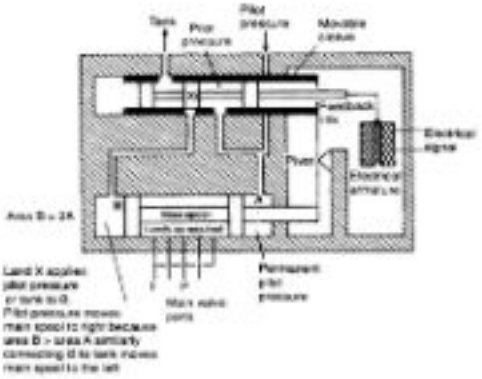
Thus the given input force (Steering wheel movement) has produced a specific output motion(wheel movement) and the output motion is feedback to modify the input through feedback line

- Electrohydraulic servo valve
  - The electrohydraulic servo valve operates due to an electric signal to its torque motor which positions the spool of the DC valve. In simple, the electrical signal is used as an input signal to control the hydraulic output
- Single stage electrohydraulic servo valve
  - An electric signal is passed through the coils of a torque motor
  - The torque motor produces an armature deflection depend on the input current
  - Since the armature of the torque motor is directly connected to the valve spool, the spool also shifts by a distance proportional to the change in current.

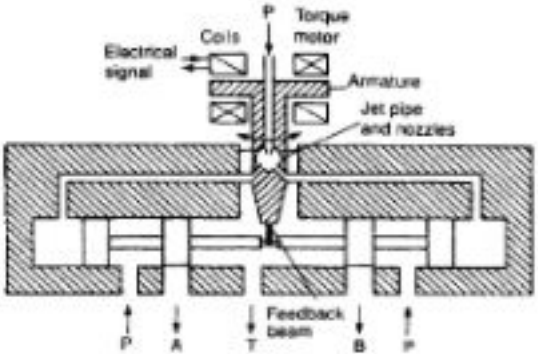


- Two stage electrohydraulic servo valve
  - It consist of a main stage and a pilot stage
  - The input signal produces an armature deflection proportional to the input current
  - The armature deflection is mechanically transmitted to the pilot spool by means of a stiff wire
  - If suppose the electrical signal causes the pilot spool to shift towards left, the land X allows oil flow to end B of the main spool which causes the main spool to move towards right, which in turn pushes the sleeve towards right
  - The main valve stops moving when the hole in the pilot sleeve exactly aligns with the land on the spool

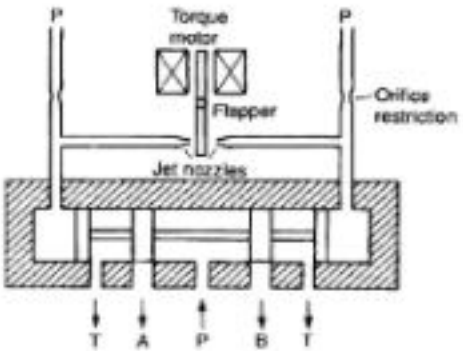
(a feedback link connects the main spool and pilot sliding sleeve. Thus any movement of the main spool is fed back to the pilot spool sleeve)



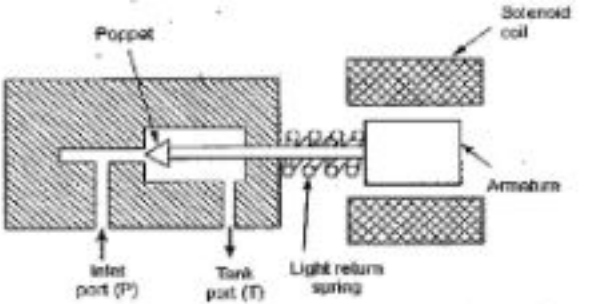
- Jet pipe electrohydraulic servo valve
  - A jet pipe is mechanically linked to the main spool as in fig.
  - The pilot pressure is applied to a jet pipe which directs the flow into two pilot lines
  - The amount of flow in these two pilot lines vary depending on the input electrical control signal i.e., the control signal diverts the jet flow into two unequal flows
  - The main spool moves towards less pressure side. The spool movement stops when the jet pipe is centrally located over the two pilot pipes



- Flapper jet electrohydraulic servo valve
  - A pilot pressure is applied to both the ends of the main spool
  - The sliding spool is actuated by pressure difference between each end
  - The pilot pressure lines are linked with two opposing jet nozzles against a flapper valve
  - The input signal produces and armature deflection which in turn deflects the flapper towards one of the jet nozzles causes the pressure imbalance
  - Now the main spool moves until the pressure is balanced on both the ends

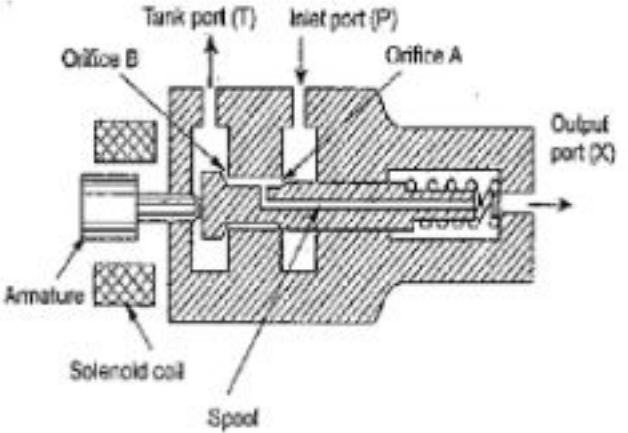


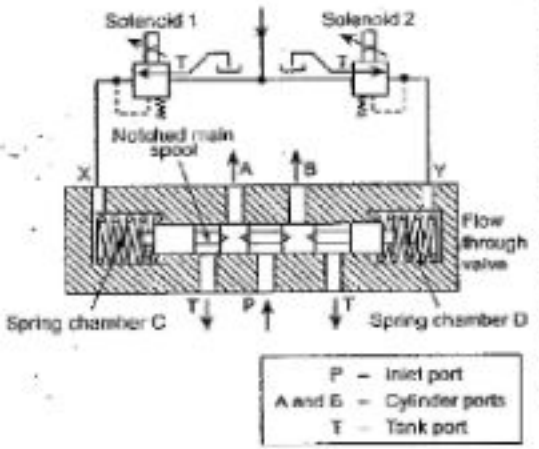
- Proportional valves
- Its types are
  - Proportional pressure relief valve
  - Proportional pressure reducing valve
  - Proportional direction control valve



- Proportional pressure relief valve
  - Works same as conventional pressure relief valve but springs are replaced by proportional solenoid
  - The input current to the solenoid energizes the coil and produces an armature deflection proportional to the input current
  - This armature deflection exerts a force on the poppet. The poppet keeps the valve closed until the inlet pressure at port P overcomes the force by armature deflection
  - When the inlet pressure overcomes this, the poppet valve opens and thus varies the pressure of the valve

- Proportional pressure reducing valve
  - Works same as conventional pressure reducing valve but the spring is replaced by proportional solenoid
  - When the solenoid is energized, the armature will deflect and move the spool towards right.
  - This action opens control orifice A and allow flow from A to port X
  - The outlet pressure of this valve depends on the opening of control orifices A and B which in turn depends on the input current to solenoid
  - Thus by proportionally varying the input current, the operating pressures can be reduced





- Proportional direction control valve
  - When solenoid 1 is energized, the pressure is applied to port X. This causes the spool to move towards right against spring pressure

    It allows fluid flow from port P to port B and from port A to T

    When the solenoid is deenergized, the control spring centralizes the spool back to normal position

    Similarly, when solenoid 2 is energized, the pressure is applied to port Y which causes spool to move towards left against spring pressure.

    Now fluid flows from port p to A and port B to T. when de-energizes, the spring centralizes the spool to normal