

* Proportional Control Valves:

Proportional Control valves can be operated easily using a solenoid. Controls have a digital control system: A valve is opened when the solenoid is energized and is closed when it is de-energized & vice versa.

They are quick in their position and thus give rise to pressure and flow surges in the fluid power control units. They also decrease fluid power circuit complexity especially for processes requiring multiple speed or force outputs.

* Proportional Solenoids:

A directional control valve is the most common electro-hydraulic proportional control valves (EHPV). The general aspects of its operation can also be applied to pressure and throttle valves. Though they look like solenoid valves, there are significant differences between the two. Both types have solenoids, and both have a valve body with a movable spool part and other components. We will look at the difference beginning with solenoids.

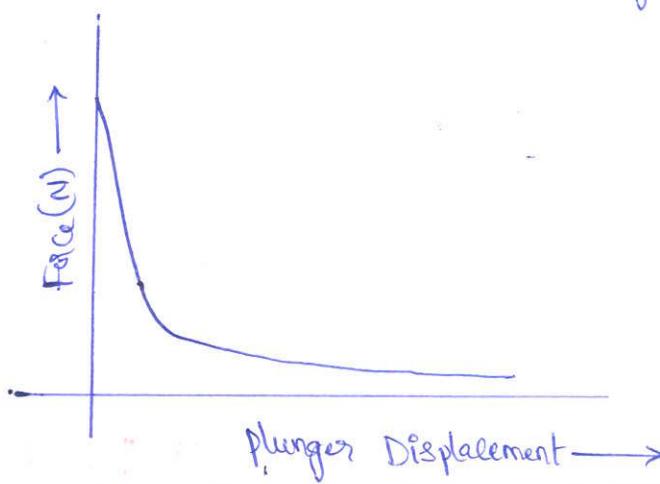


Fig: Solenoid force Vs stroke at constant current

The solenoid force is at its minimum when the plunger is at the maximum position. By incrementally increasing the current in a particular solenoid, we can generate a family of curves.

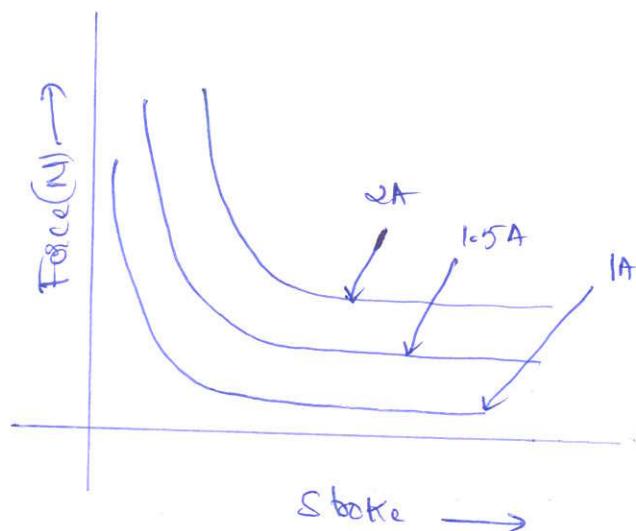
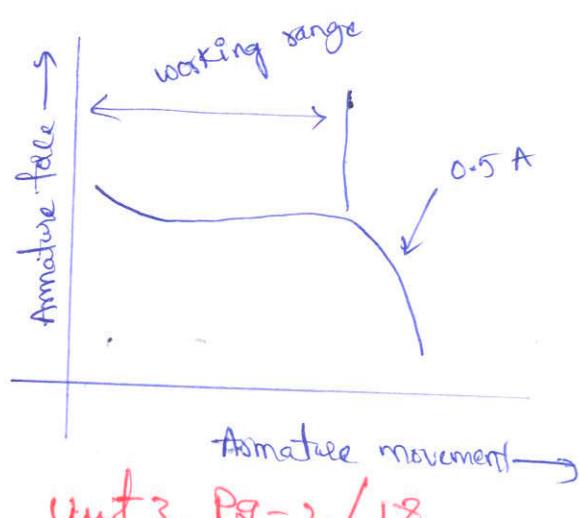
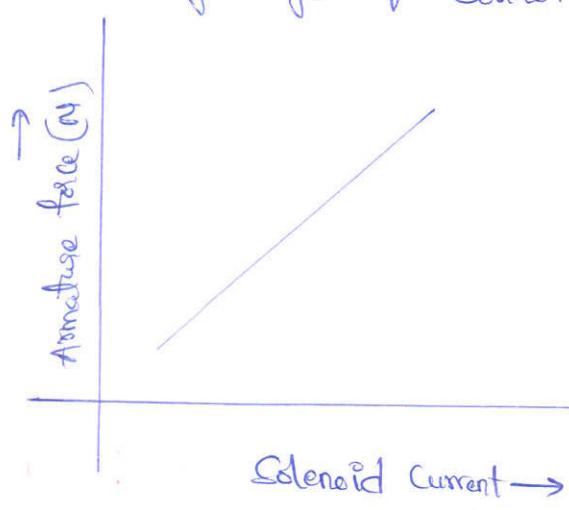


Fig: Solenoid force vs stroke Curves

* Design Considerations of proportional Control valves:-

The output force exerted by the armature of a DC solenoid depends on the current flowing through it. This fundamental concept can be used in the design of a proportional DC solenoid in which the force exerted by the armature is proportional to the current flowing through it and independent of the armature movement over the working range of solenoid.



* Force piston Control :-

The electrical control to the proportional valve normally uses a Variable Current rather than a Variable Voltage. If a voltage control system is adopted, any variation in coil resistance caused by temperature change will result in a change in current. This problem is eliminated by using a current control system. It is possible to control a force electrically. If the spool in a valve is acted on by a spring at one end and a proportional solenoid on the other, the orifice size can be varied along with control current.

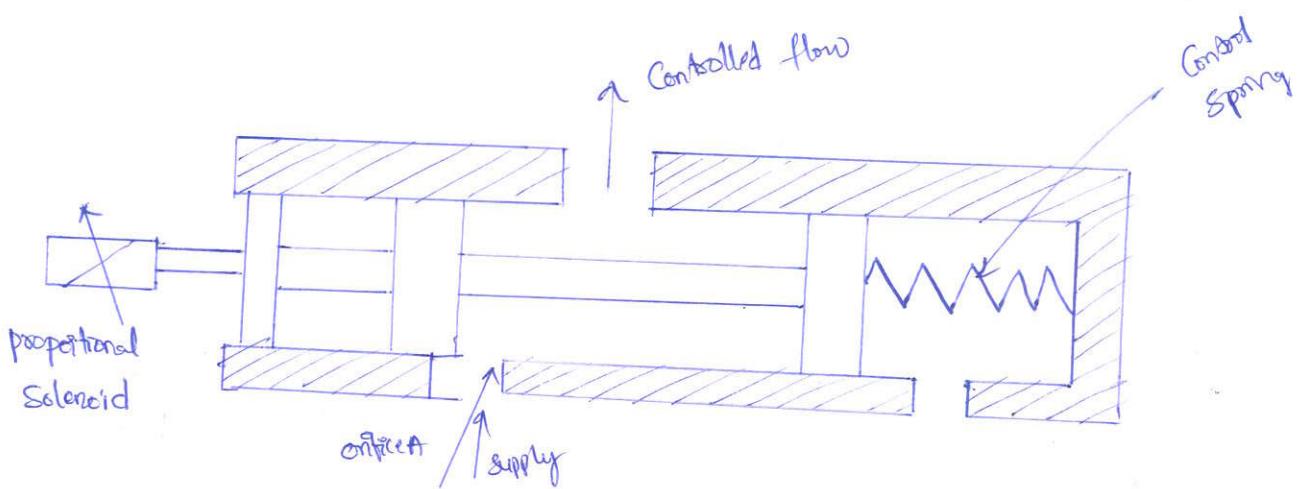


Fig: Diagrammatic section of proportional control valve.

The flow from the valve is proportional to the current flowing through the solenoid. Because of the difficulties in manufacturing a two lap spool, overlapped spools are used in proportional spool valves. This means that the spool have to move a distance equal to the overlap before any flow occurs through the valve, giving rise to a dead zone as shown in fig.

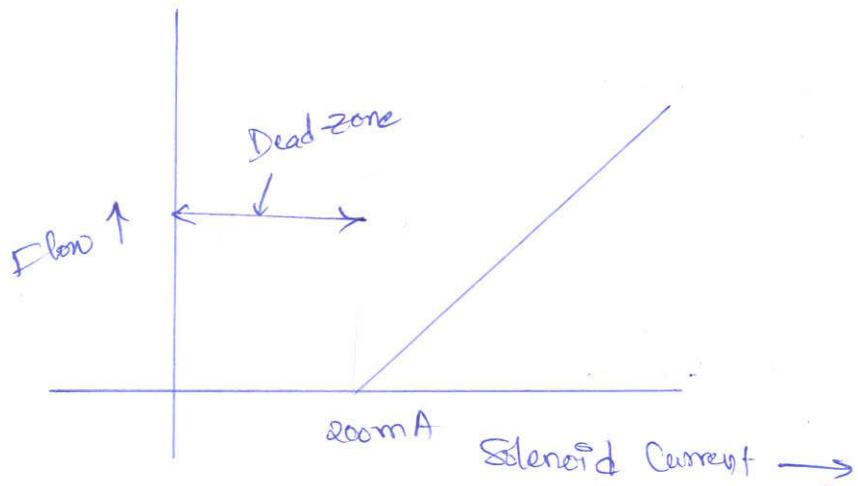
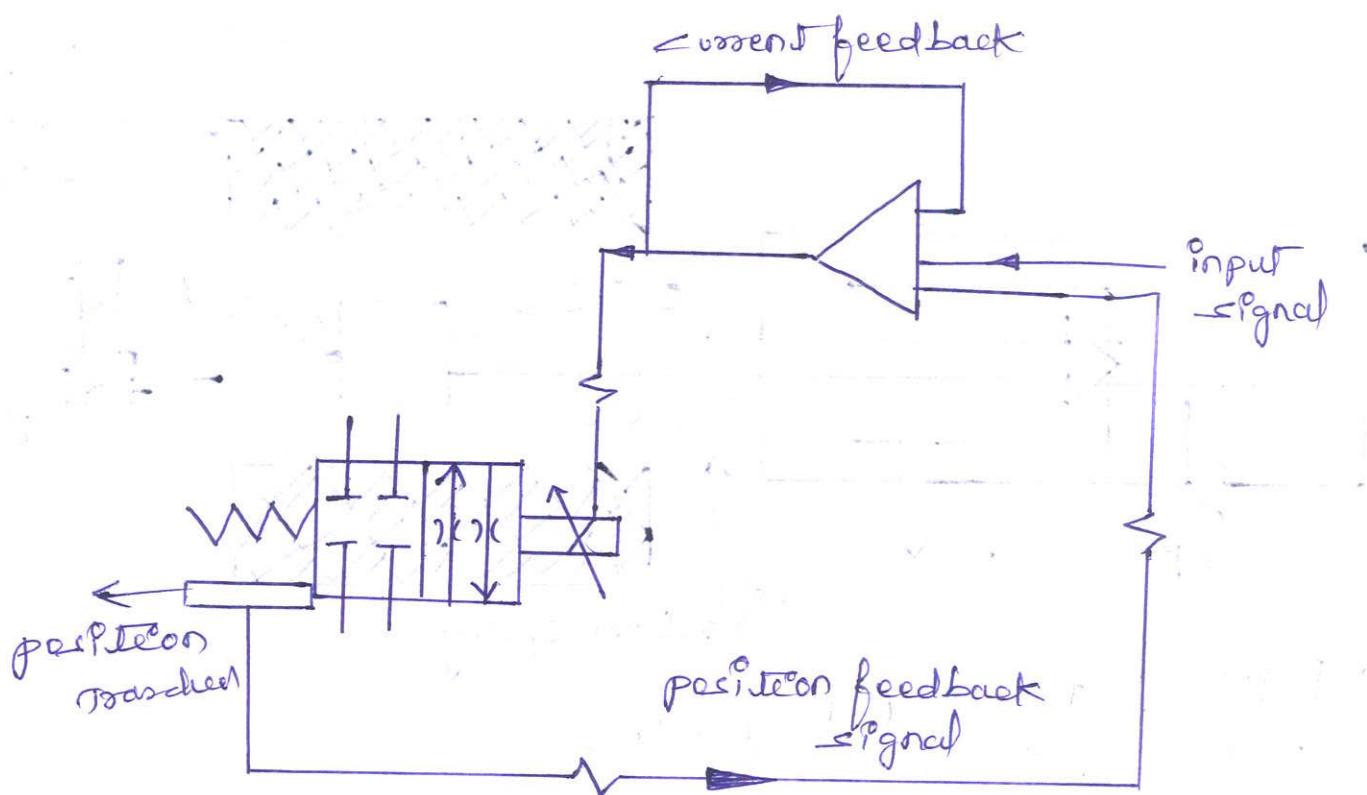


Fig: Flow Current Characteristics.

* Spool piston Control :

- In order to increase the accuracy and extend the range of applications of proportional Control Valves, a linear transducer may be fitted to measure Spool position.
- The output from the transducer is a Voltage that is proportional to the Spool displacement and it Continuously varies through the total Spool movement.
- The actual position of the Spool is fed back via the transducer to the electrical Control System and then compared with the required position.
- A tachogenerator or a similar device is used to measure the Speed, in which case the effect 'dead zone' must be considered.

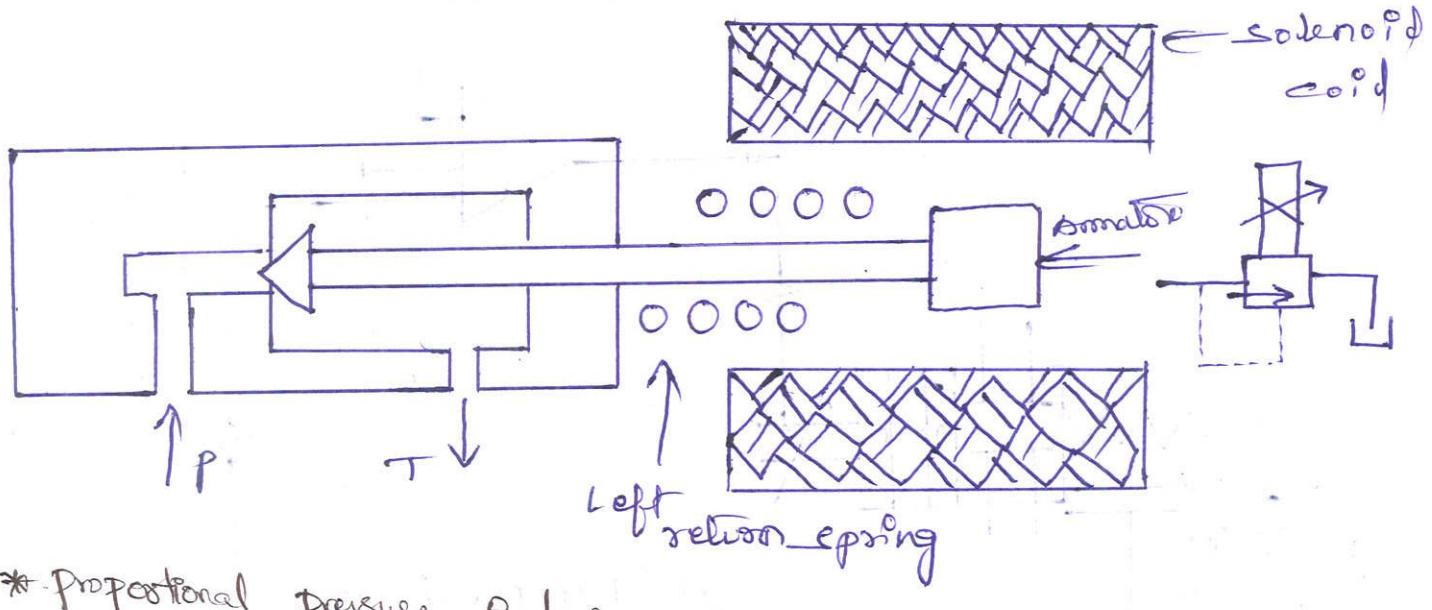


* Proportional pressure Control :

In a Conventional pressure Control valve, a Spring is used to Control the pressure at which the Valve operates. The Spring is replaced by a DC Solenoid in the Case of proportional valve.

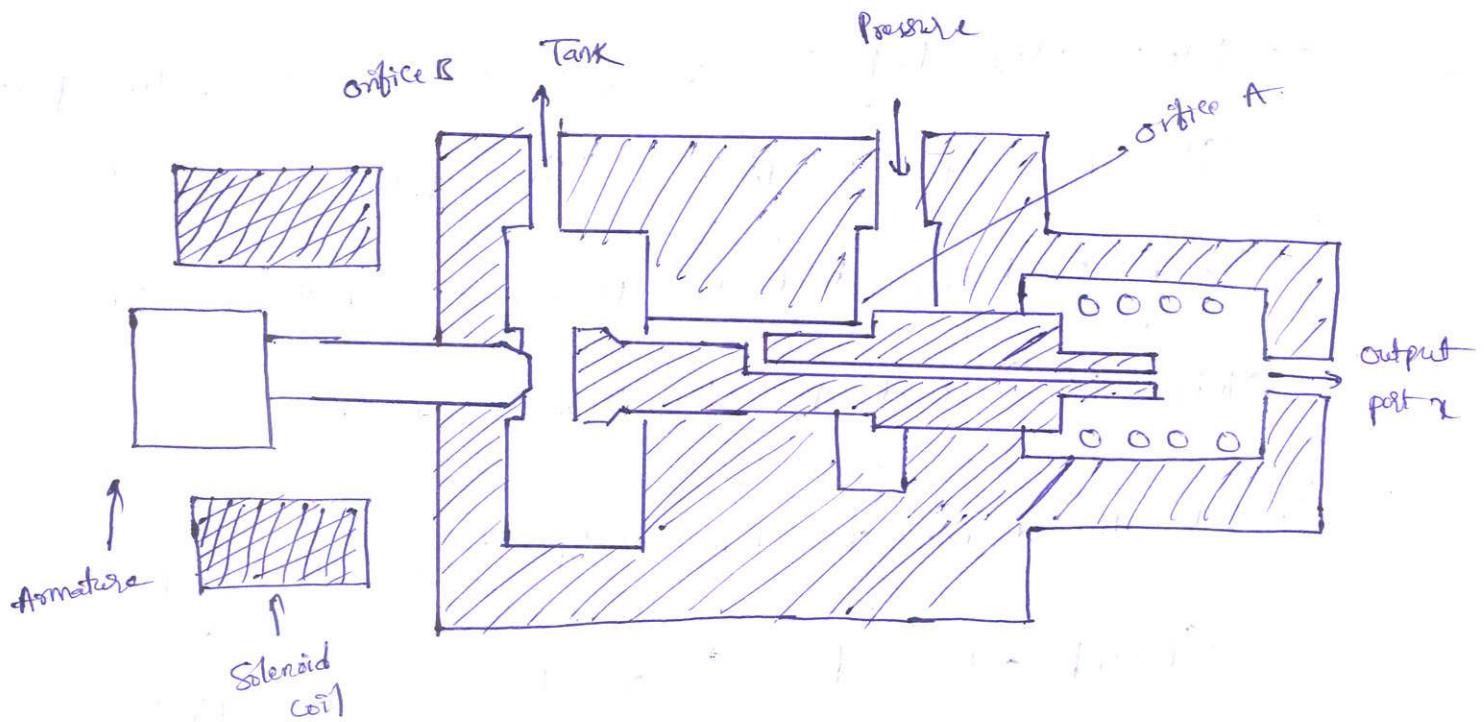
(i) Single-Stage Proportional Relief Valves:

- Direct-acting Proportional relief valves are shown. The proportional Solenoid exerts a force on the poppet keeping the valve closed, until the hydraulic pressure at port p overcomes this force and opens the valve.
- In the design of the relief valve, the proportional Solenoid acts directly on the valve poppet.



* Proportional pressure-reducing valves:

This operates in a manner similar to a conventional pressure-regulating valve, with the control spring being replaced by a proportional solenoid. When this solenoid is not energized the proportional valve is unlike the conventional pressure reducing, which is normally open.



* Two stage proportional valves :-

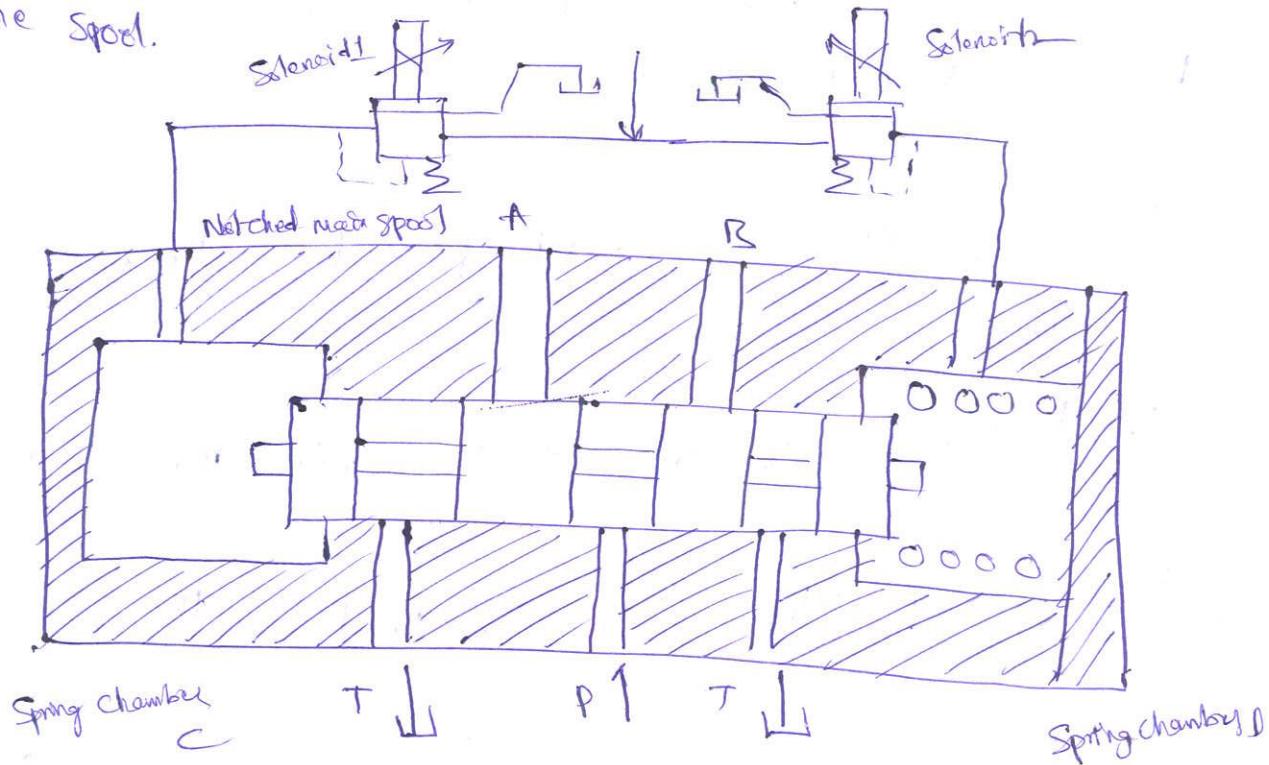
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The valves already discussed have a maximum flow capacity of 5 LPM; to obtain higher flow rates in valves, two-stage versions are available. A single-stage proportional pressure control valve is used to pilot the main valve. These operate in a manner similar to conventional two stage valves.

## \* Two-Stage Proportional Directional Control Valves :-

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The pressure output from a proportional pressure-reducing valve is directed to move the spool of the main valve against a control spring. Energizing Solenoid 1 causes pressure to be applied to port X and hence to current in Solenoid 1. De-energizing Solenoid 1 de-pressurizes Spring Chamber C. The control spring centralizes the spool.



* Hysteresis Effect:

- Spool position in a Servo Valve is Controlled by a nozzle and flapper or jet pipe system with a feedback link Correction for the spool position.
- A proportional valve relies on the force exerted by a DC coil acting against a spring to position the spool.
- There is a considerable difference in the valve output depending on whether the current is increasing or decreasing.

* Hydraulic Circuit Design & Analysis :-

A hydraulic circuit is a group of components such as pumps, actuators, control valves, conductors and fittings arranged to perform useful work. There are three important considerations in designing a hydraulic circuit:

1. Safety of machine and personnel in the event of power failures.
2. Performance of given operation with minimum losses.
3. Cost of the component used in the circuit.

* Control of a double-acting hydraulic cylinder:

The Control of a double-acting hydraulic cylinder is described as follows:

1. When the 4/3 valve is in its neutral position (tandem d/h) the cylinder is hydraulically locked and the pump is unblocked back to the tank.
2. When the 4/3 valve is actuated into the flow path, the cylinder is extended against its load as oil flows from port P through port A.
3. When the 4/3 valve is actuated into the right-envelope configuration, the cylinder retracts as oil flows from port P through port B.

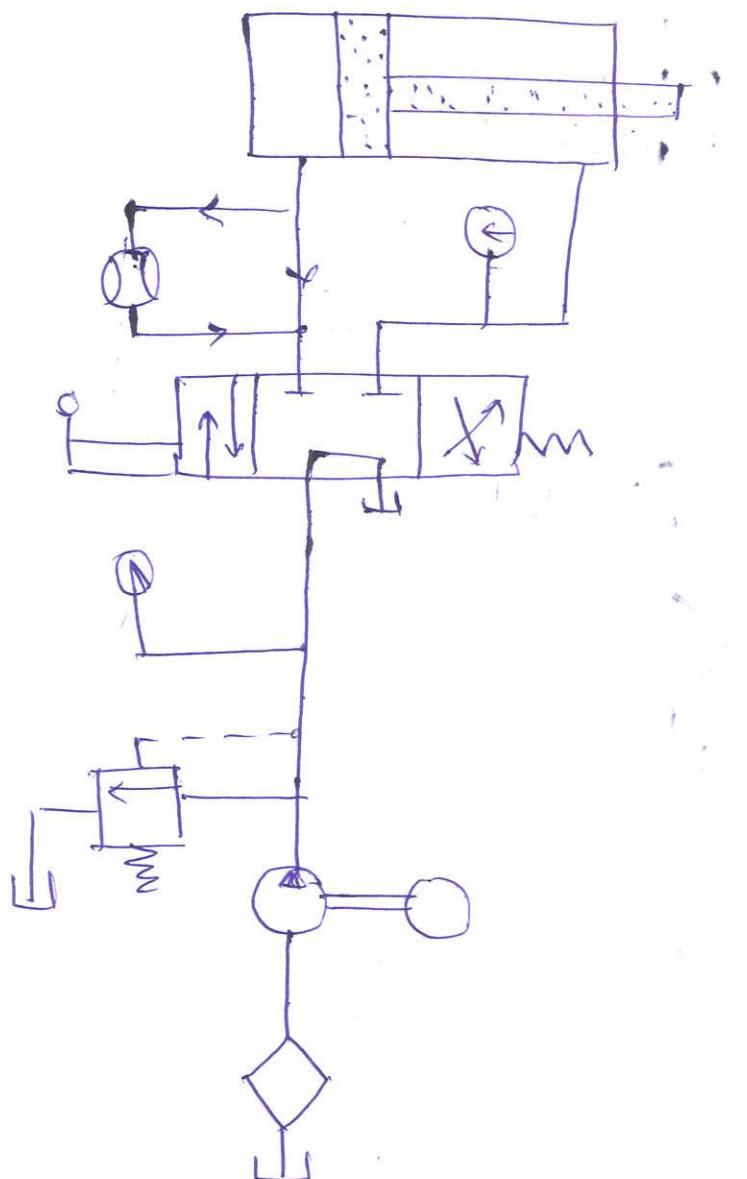


Fig: Control of a double-acting cylinder unit 3 Pg - 9 / 18

* Control of a single-acting hydraulic cylinder -

The Control of a Single-acting, Spring return cylinder using a three-way two-position manually actuated, spring offset direction control valve (DCV). The spring in the rod end of the cylinder retracts the piston as the oil from the blank end drains back into the tank. When the valve is manually actuated into full extension, pump flow extends the cylinder.

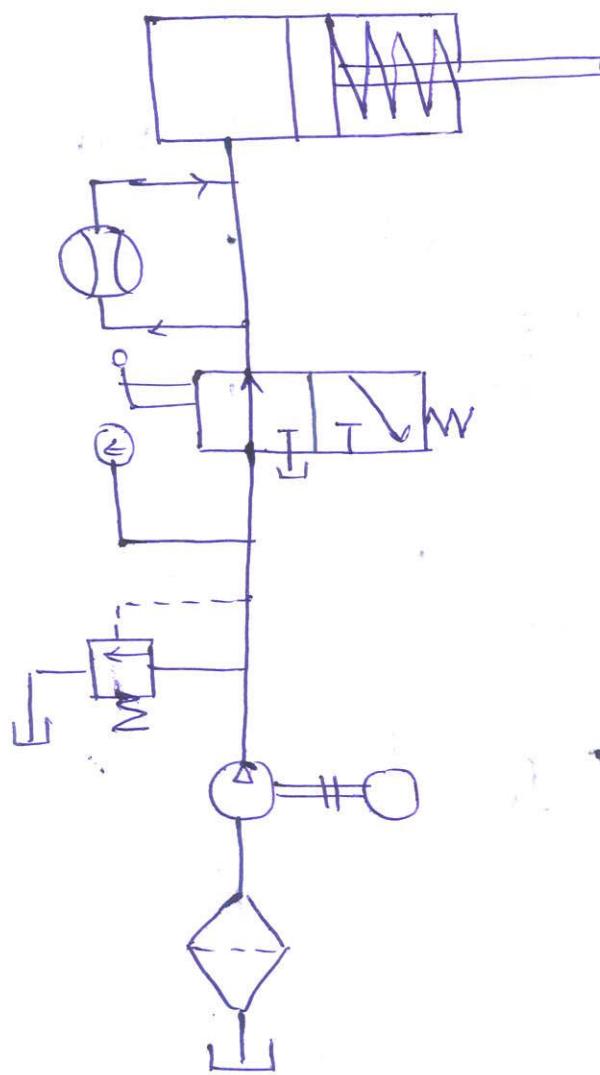


Fig: Control of a single-acting cylinder

* Regenerative Cylinder Circuit:

- A regenerative circuit that is used to speed up the extending speed of a double-acting cylinder.
- The pipelines both ends of the hydraulic cylinder were connected in parallel and one of the ports of the 4/3 valve is blocked by simply screwing in a thread plug into the opening.
- The speed extension is greater than that for a regular double-acting cylinder because the flow from the rod end regenerates with the pump flow up to provide a total flow at F_T .

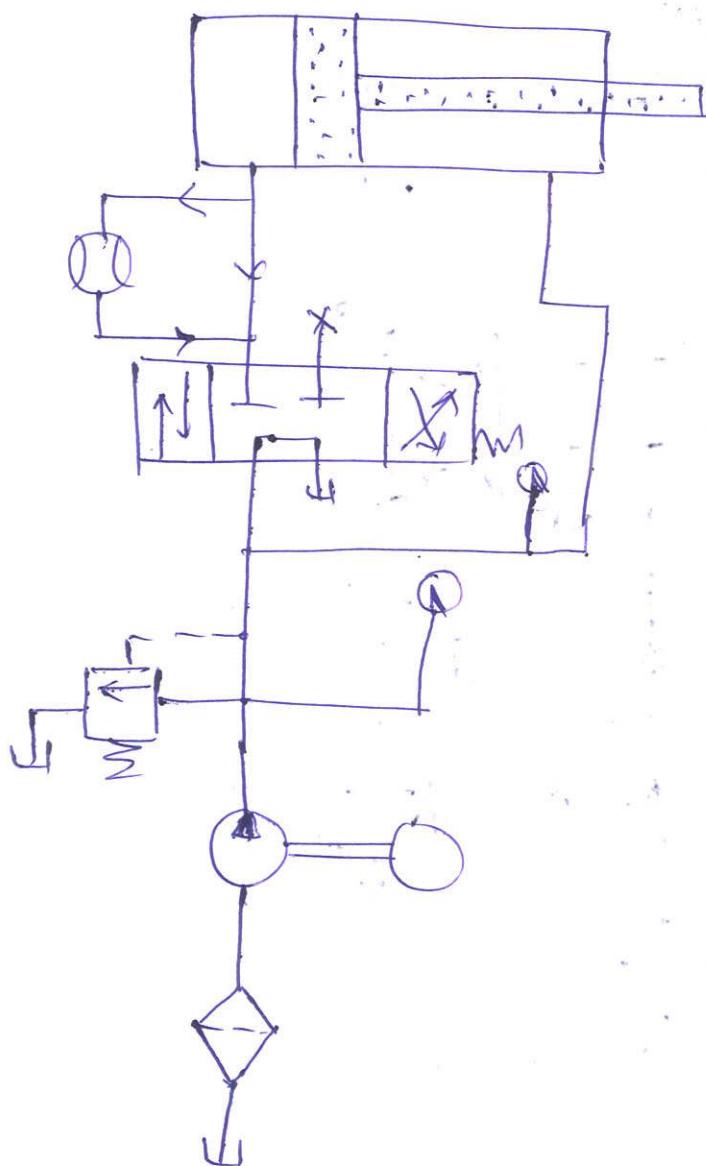


Fig: Regenerative Circuit

* Pump - Unloading Circuit:

- A hydraulic circuit to unload a pump using an unloading valve. When the cylinder reaches the end of its extension stroke, the pressure of oil rises because the check valve keeps the high pressure oil.
- Due to high pressure oil on the pilot of the unloading valve, it opens and unloads the pump pressure to the tank.
- The unloading valve unloads the pump at the ends of the extending and retraction strokes as well as in the spring centered position of the DCV.

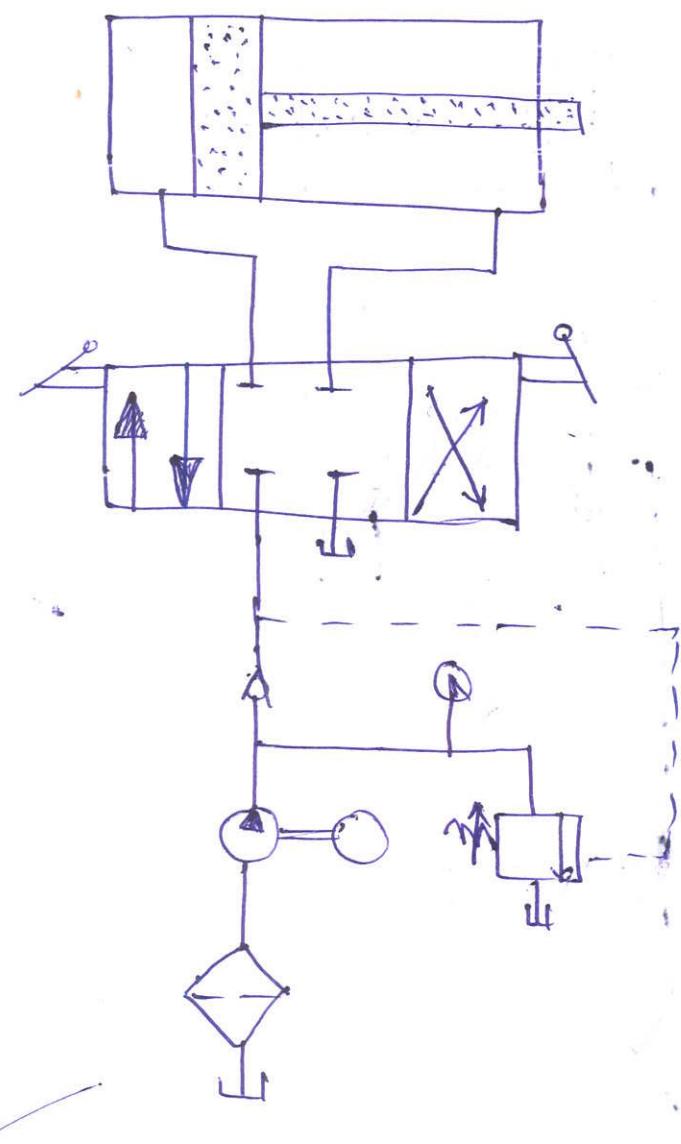
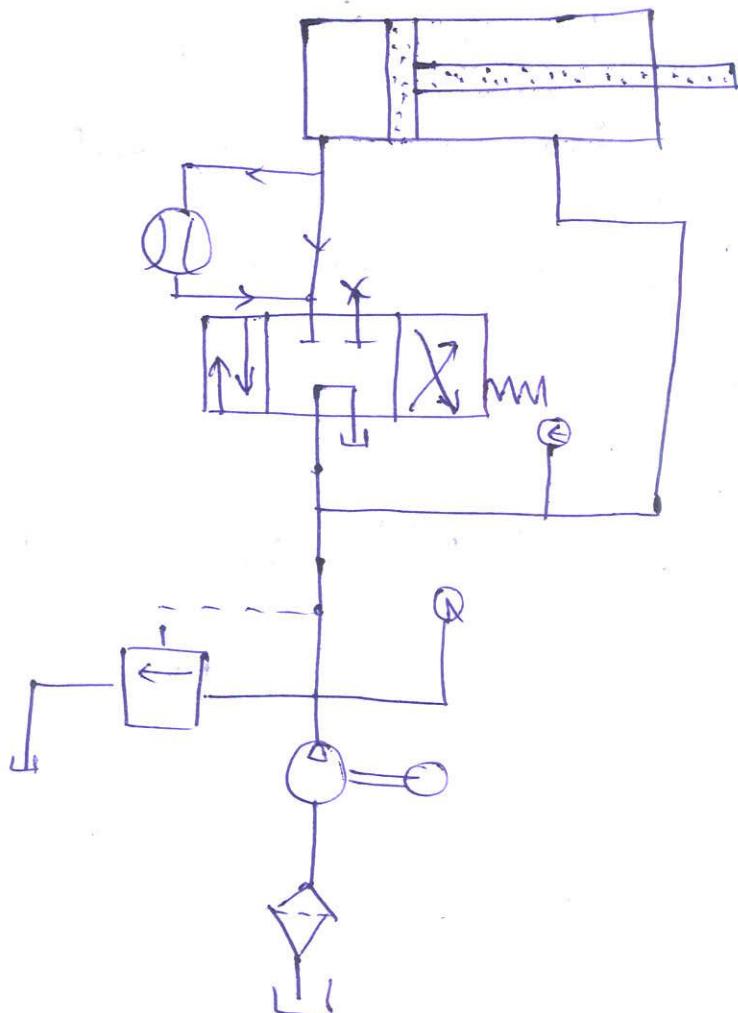


Fig: Pump - unloading Circuit

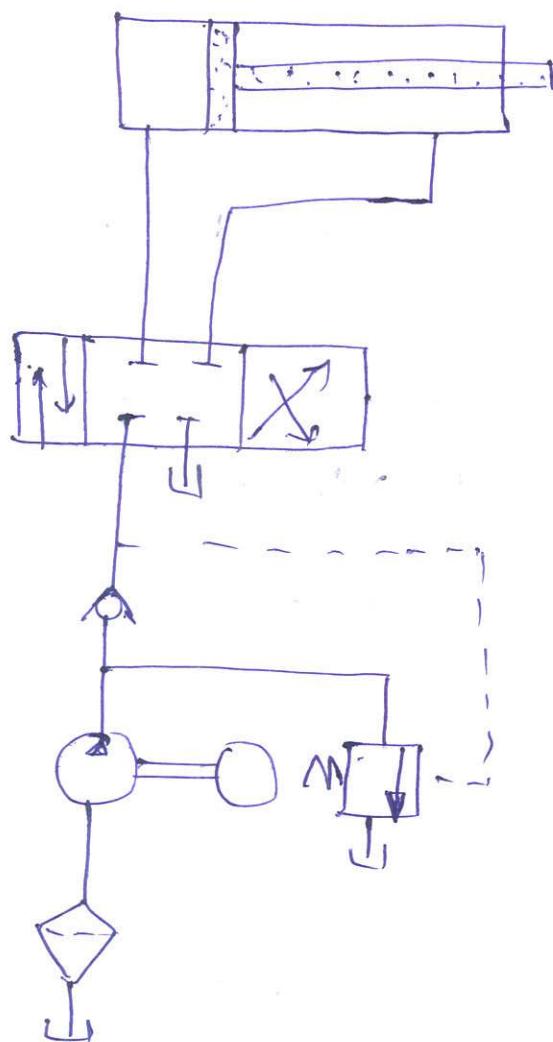
* Regenerative Cylinder Circuit:

A regenerative circuit that is used to speed up the extending speed of a double-acting cylinder. The pipelines on both ends of the hydraulic cylinder are connected in parallel and one or the ports of the 4/3 valve is blocked by simply screwing a thread plug into the port opening.

During retraction stroke, the 4/3 valve is configured to the right envelope. During this stroke, the pump flow bypasses the DCV and enters the rod end of the cylinder. Oil from the blank end then drains back to the tank through the DCV.

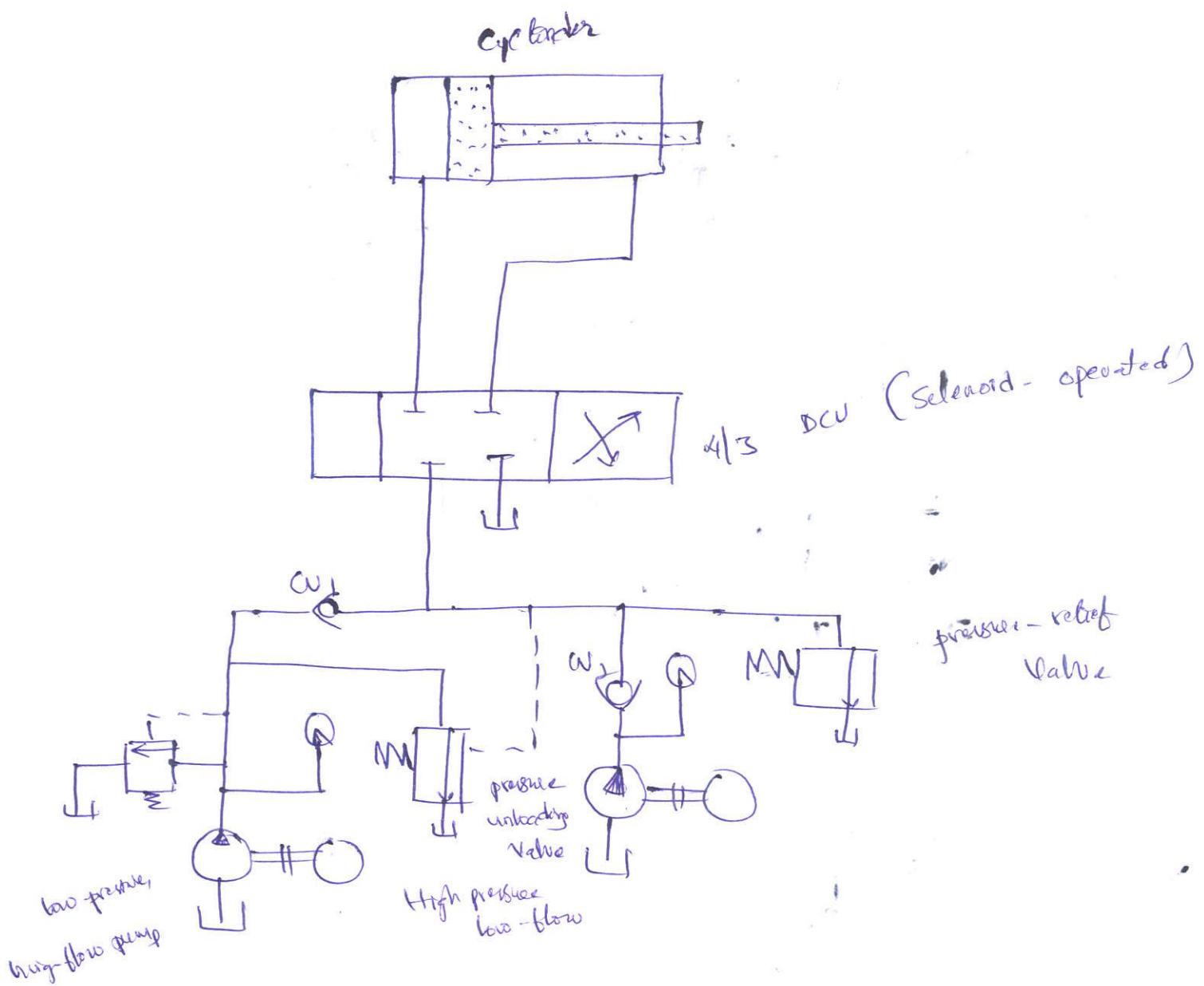


* Pump-unloading Circuit :



- A hydraulic circuit unloading a pump using unloading valve. When the cylinder reaches the extension stroke, the pressure of oil raises because the check keeps the high pressure oil.
- Due to high-pressure oil on the pilot line of the unloading valve, it opens and unload the pump pressure to the tank.

* Double-pump Hydraulic System:



→ An application of unloading valve.

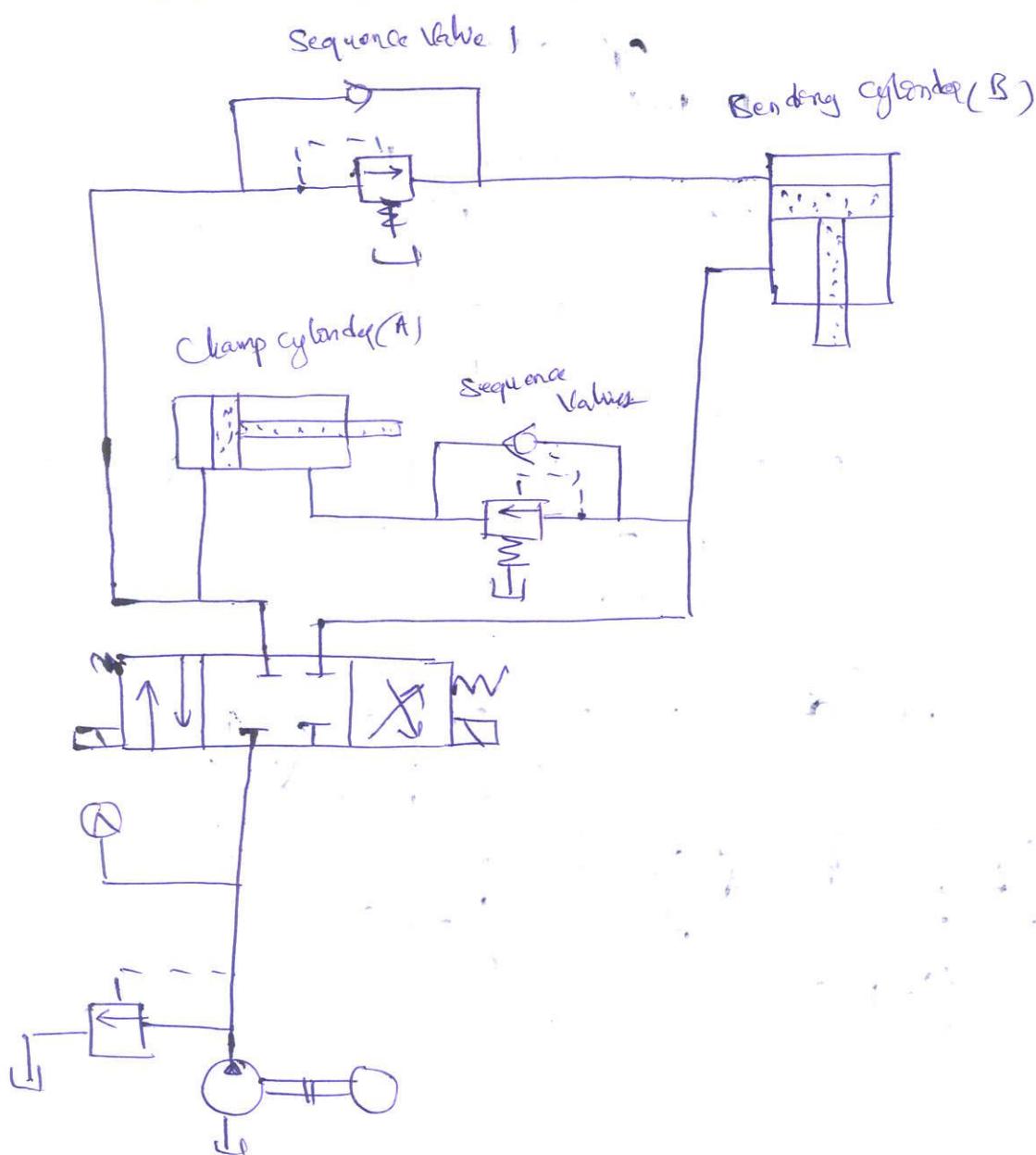
→ It is a circuit that uses high pressure, low flow pump in

conjunction with a low-pressure, high flow pump.

→ A typical application is a sheet metal punch press in which the hydraulic cylinder must extend rapidly over a great distance with low-pressure but high-flow requirement.

→ This occurs under no load.

* Hydraulic cylinder sequencing Circuits:

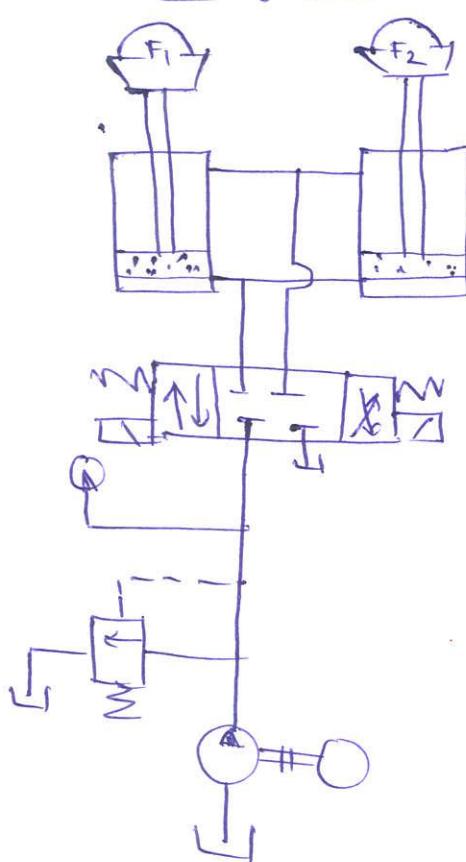


- hydraulic cylinder operates sequentially, using Sequence Valve.
- That two sequence valve are to Sequence the operation of two double-acting cylinders.
- When the DCV is actuated to its right-envelope mode, the bending cylinder (B) retracts fully and then the clamp cylinder (A) retracts.
- The Sequence of cylinder operation is controlled by Sequence valve.

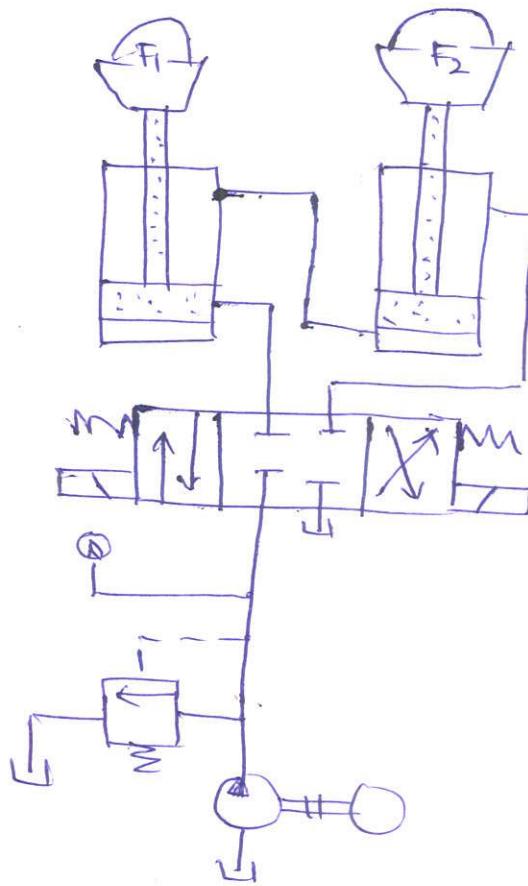
* Cylinder Synchronizing Circuits:-

- In Industry, there are instances when a large mass must be moved, and it is not feasible to move it with just one cylinder.
- In such cases we use two or more cylinders to prevent a moment or moments that might distort and damage the load.
- It can be designed with less material & it is presses down with two or more cylinders.
- These cylinders must be synchronized.
- There are two ways that can be used to synchronize cylinders.

① Cylinders in parallel & series:



parallel



unit 3, pg - 17/18 Series

- A hydraulic circuit in which two cylinders are arranged parallel.
- When the two cylinders are identical, the loads on the cylinder are identical, and retraction are synchronized.
- Hydraulic circuit in which two cylinders are arranged in series.
 - As cylinder 1 extends, fluid from its rod end is delivered to blank end of cylinder 2 causing the extension of cylinder 2.
 - As cylinder 2 extends, fluid from its rod end reaches the tank.