Miscellaneous

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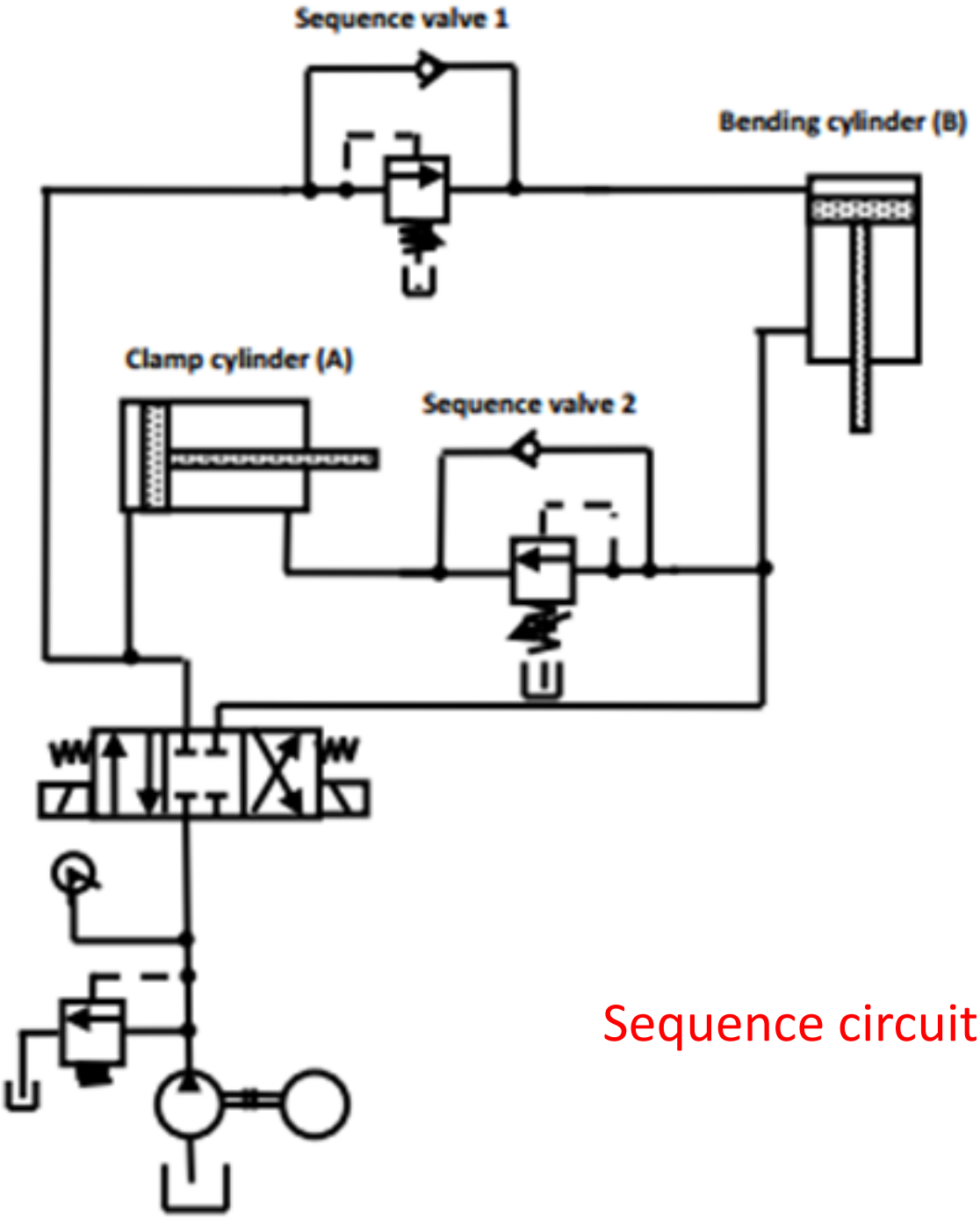
Hydraulic Cylinder Sequencing Circuits

- Hydraulic cylinders can be operated sequentially using a sequence valve.
- When the DCV is actuated to its right-envelope mode, the bending cylinder (B) retracts fully and then the clamp cylinder (A) retracts.
- This sequence of cylinder operation is controlled by sequence valves.
- This hydraulic circuit can be used in a production operation such as drilling.
- Cylinder A is used as a clamp cylinder and cylinder B as a drill cylinder.
- Cylinder A extends and clamps a work piece.
- Then cylinder B extends to drive a spindle to drill a hole.
- Cylinder B retracts the drill spindle and then cylinder A retracts to release the work piece for removal.



Sequence circuit

Sequence valve

- The primary function of this type of valve is to divert flow in a predetermined sequence.
- It is used to operate the cycle of a machine automatically.
- A sequence valve may be of direct-pilot or remote-pilot operated type.

- Its construction is similar to the direct relief valve. It consists of the two ports; one main port connecting the main pressure line and another port (secondary port) is connected to the secondary circuit.

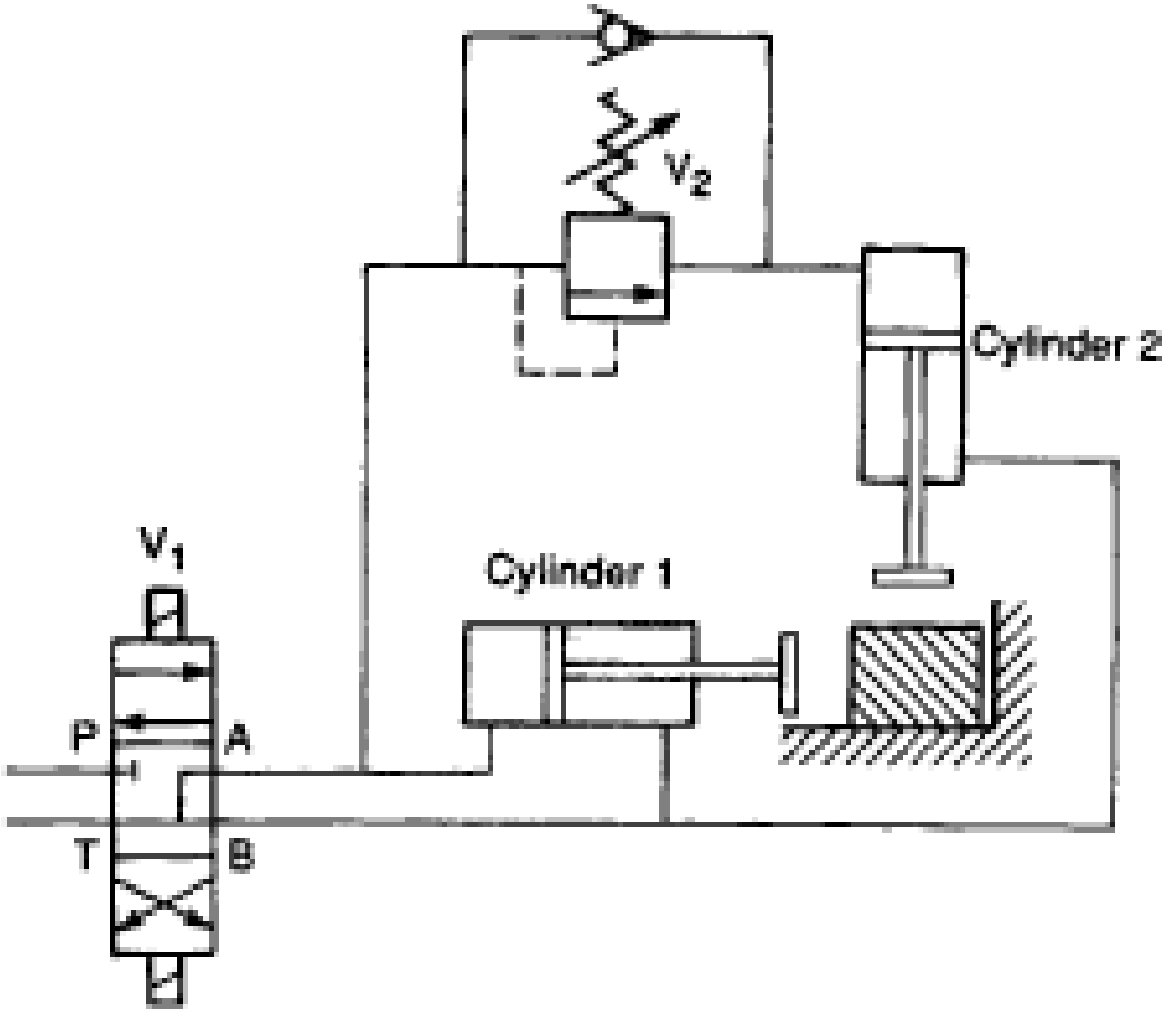
- The secondary port is usually closed by the spool. The pressure on the spool works against the spring force.

Sequence valve

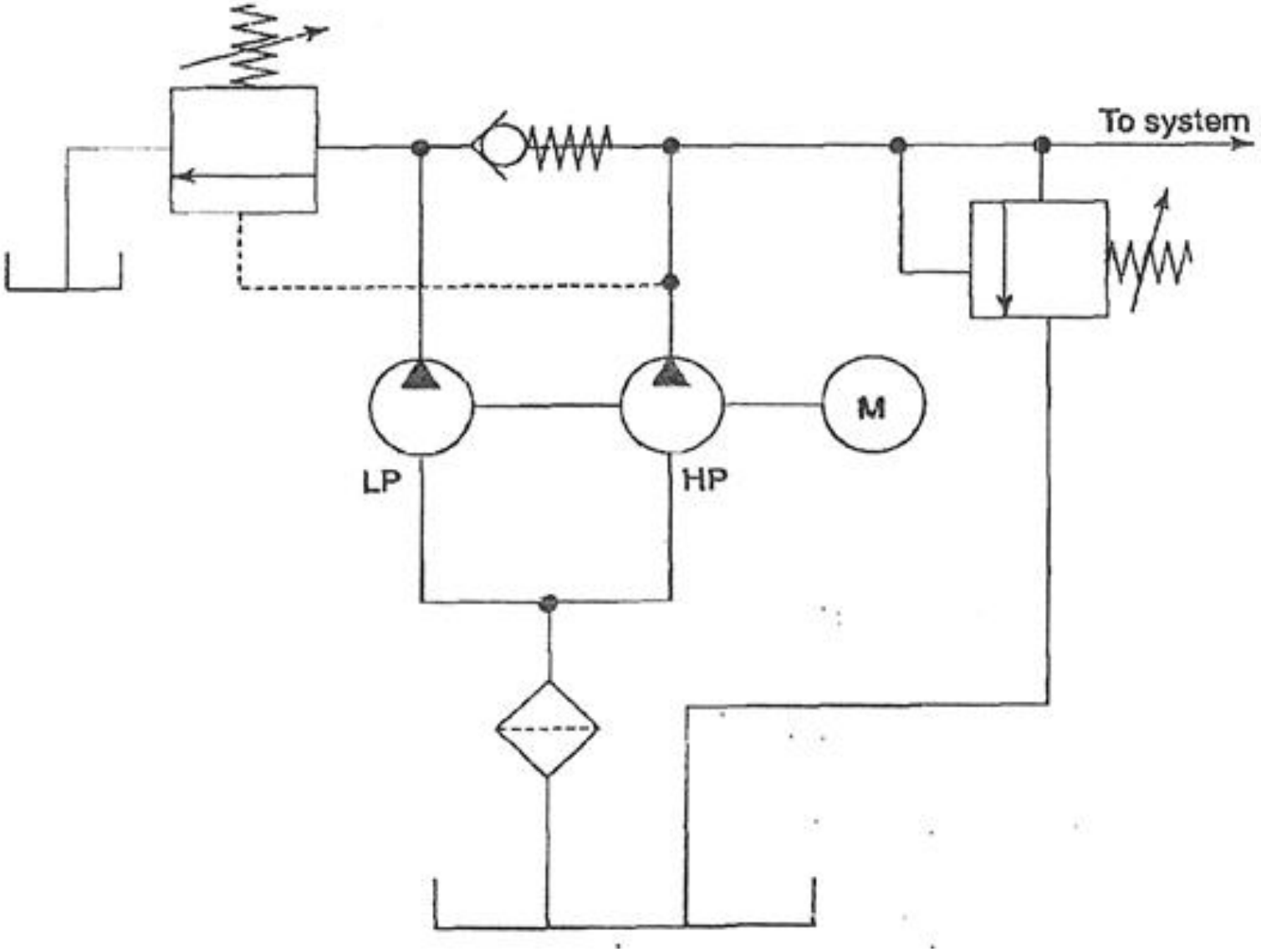
- When the pressure exceeds the preset value of the spring; the spool lifts and the fluid flows from the primary port to the secondary port.

- For remote operation; the passage used for the direct operation is closed and a separate pressure source for the spool operation is provided in the remote operation mode.

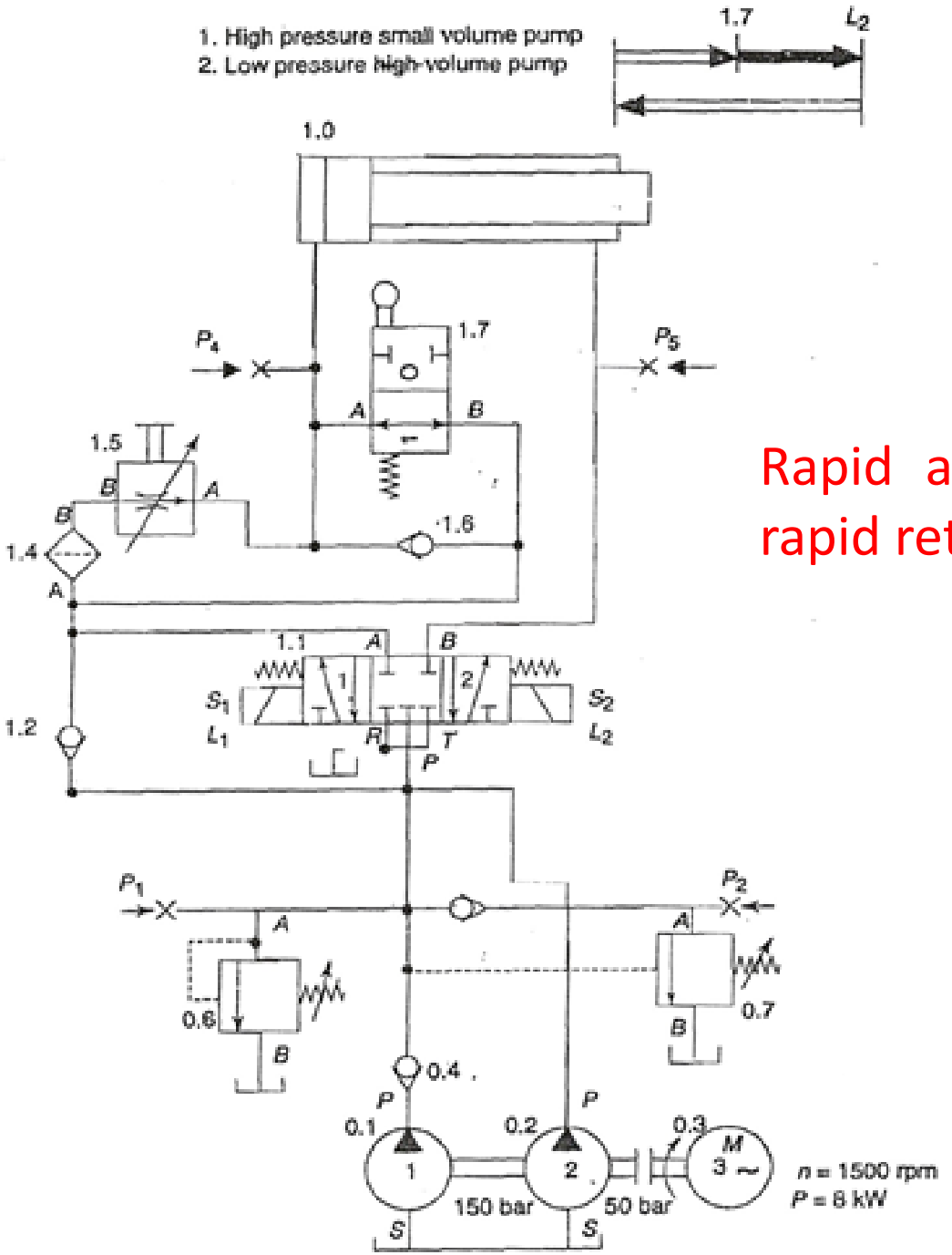
Sequence



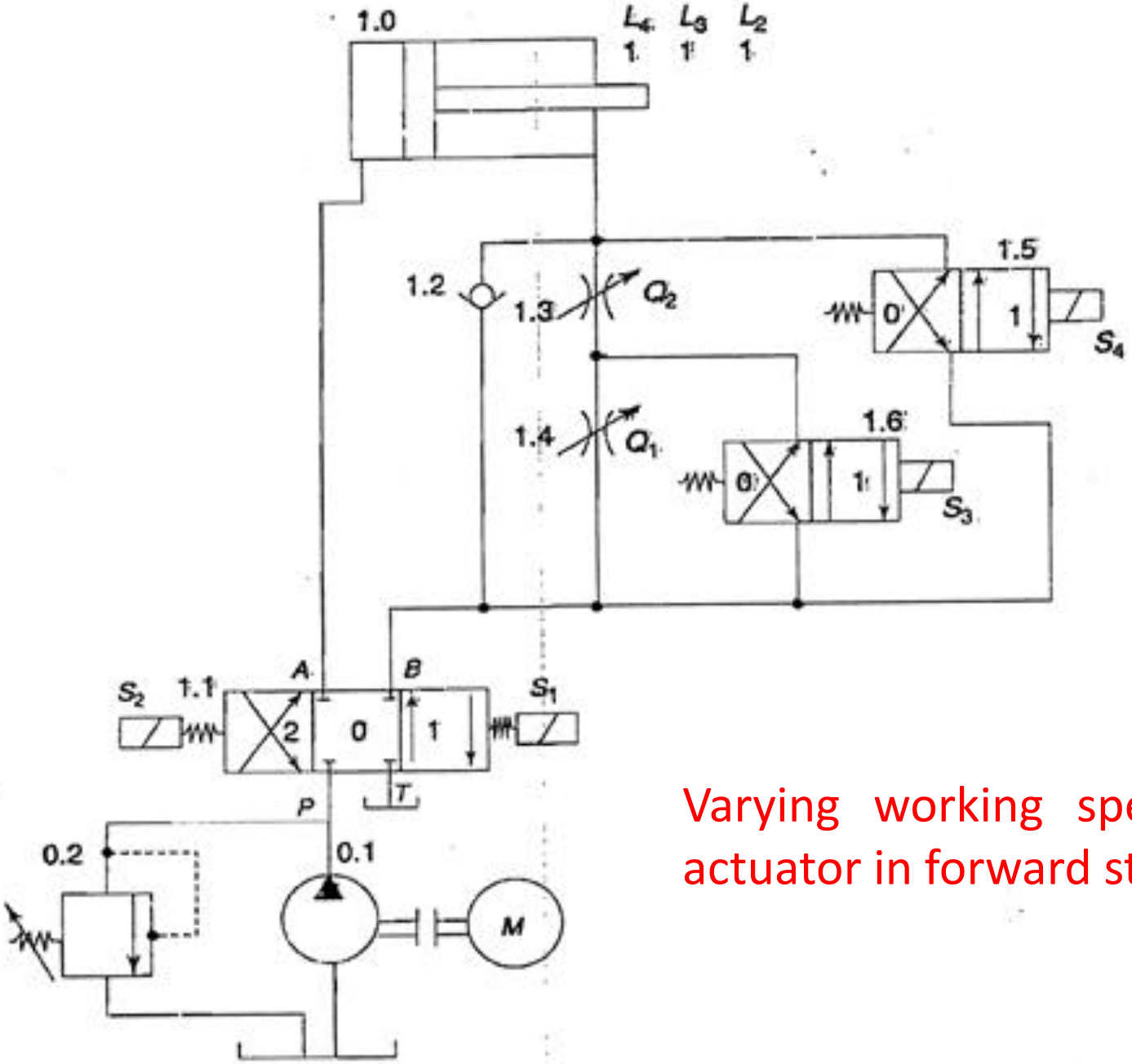
Sequence valve



A hi-low system



Rapid advance, slow feed, rapid return

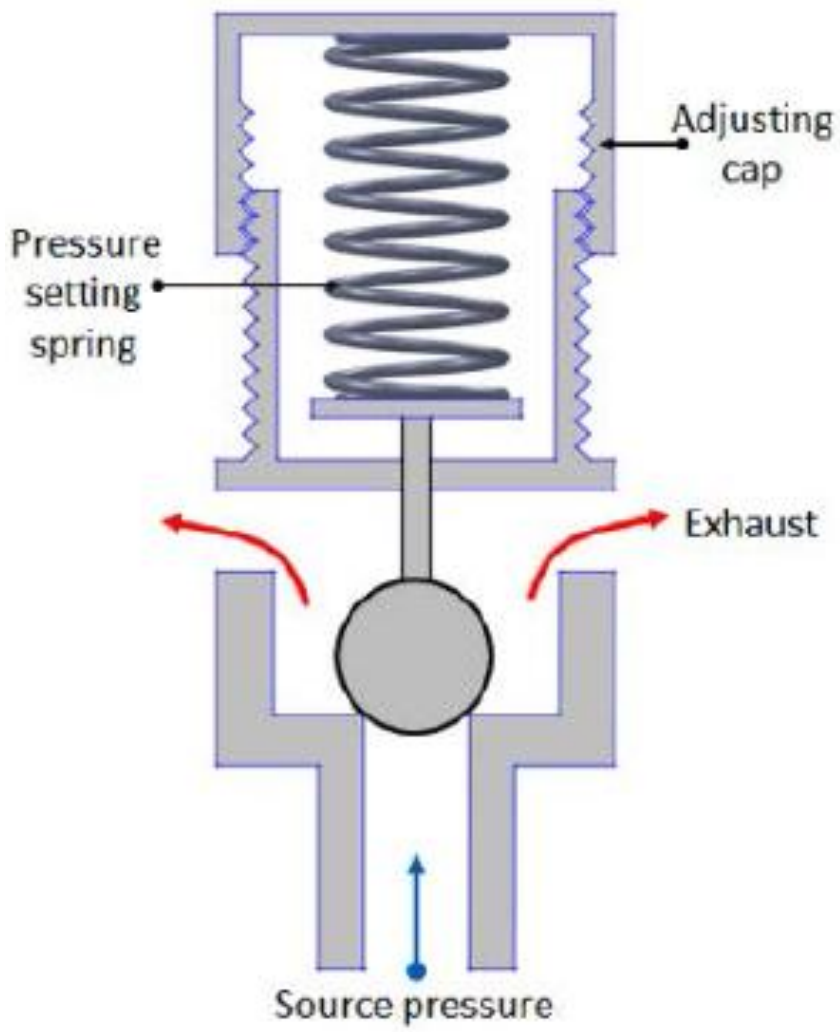


Varying working speed of actuator in forward stroke

Relief Valve

- Relief valve is the simplest type of pressure regulating device. The schematic of its construction and working is shown in the Figure.
- It is used as a backup device if the main pressure control fails. It consists of ball type valve held on to the valve seat by a spring in tension.
- The spring tension can be adjusted by using the adjusting cap. When the air pressure exceeds the spring tension pressure the ball is displaced from its seat, thus releasing the air and reducing the pressure.
- Once the valve opens (cracking pressure), flow rate depends on the excess pressure.
- Once the pressure falls below the cracking pressure, the valve seals itself.

Relief Valve



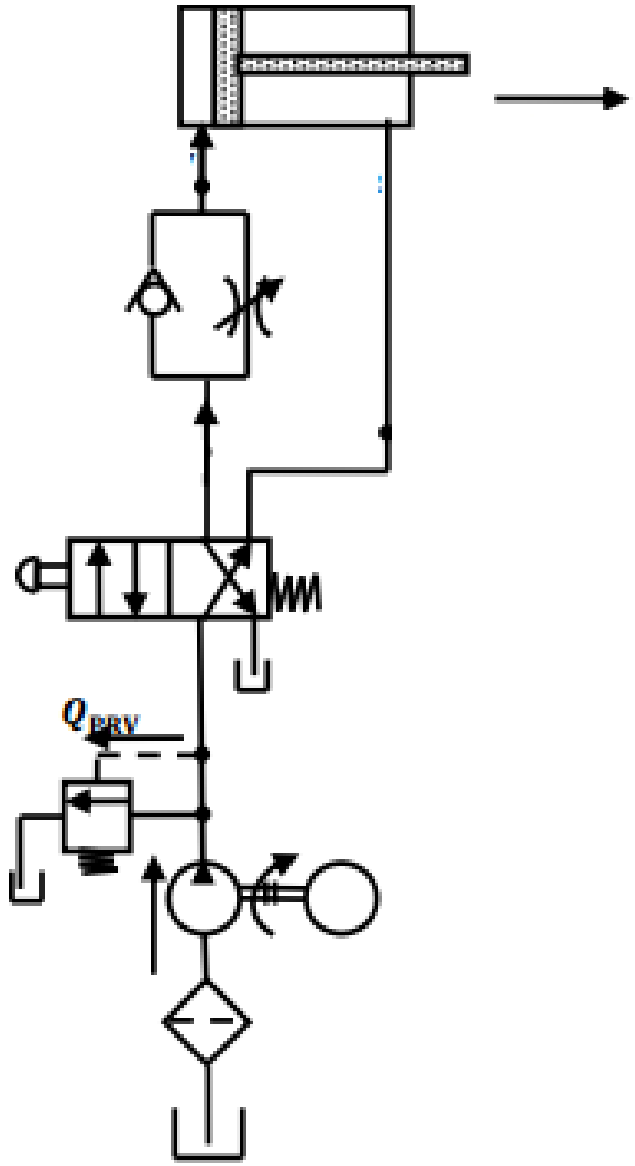
Speed Control of a Hydraulic Cylinder

- Speed control in hydraulic is possible through following:
  - Meter in circuit
  - Meter out circuit
  - Bleed off circuit

Meter in circuit

- If the flow control valve (FCV) is not located, the extension and retraction of the actuator, will proceed at an unrestricted rate.
- FCV is placed in such a manner that there is a restriction in the amount of fluid flowing to the actuator.
- FCV is placed in in the pressure line.
- Pump delivery in excess of metered amount is delivered to tank through pressure relief valve.
- This is used where load characteristics are constant and positive
- Presence of the FCV enables restriction in the fluid flow to the cylinder and thereby slowing down its extension.
- During return stroke, the check valve ensures that the return flow bypasses the flow control valve.

Speed Control of a Hydraulic Cylinder



- When the DCV is actuated, oil flows through the FCV to extend the cylinder.
- The extending speed of the cylinder depends on the FCV setting.
- When the DCV is deactivated, the cylinder retracts as oil from the cylinder passes through the check valve.
- Thus, the retraction speed of a cylinder is not controlled.

- A meter-in circuit is ideal in applications where a load always offers a positive resistance to flow during a controlled stroke.

- Examples would be feeding grinder tables, welding machines, milling machines, and rotary hydraulic motor drives, cross-feed in centreless grinding.

Advantage of meter in circuit

- Finer speed control is possible
- Suitable for high pressure applications
- Low level of friction – longer service life of components

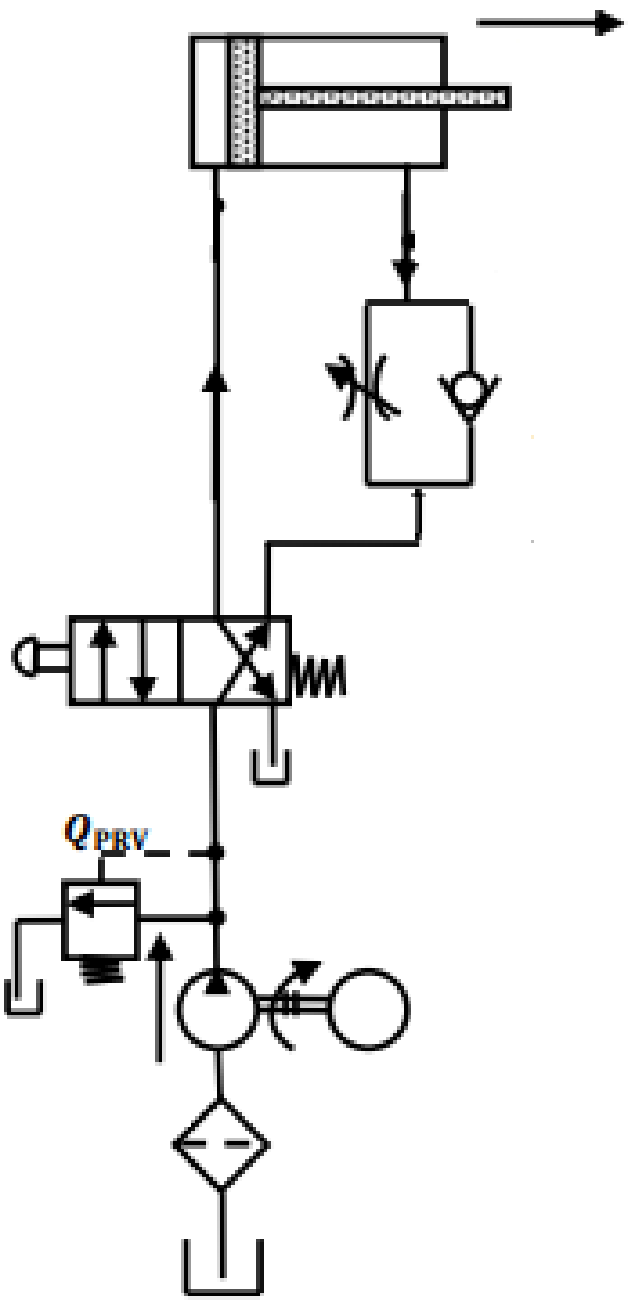
Disadvantage of meter in circuit

- Pressure drops across due to throttle and hence the pressure of the fluid fed into the actuator will be less than required.
- Inefficient because excess flow goes to tank
- Cannot prevent the load from running away as in the case of drilling machine
- Heat generated due to throttling is fed to the actuator.

Meter out circuit

- In meter in circuit flow control is placed in in return line so that it controls a cylinder's actuation by metering its discharge flow.
- This is used in machine tools like drilling in which tools is dragged suddenly at the end of drilling.
- The method has a precise control of fluid on the discharge side of cylinder.
- It is used when a free falling load or overhauling load tends to get out of control.
- Thus a drilling operation that provides resistance to flow, meter out circuit is used.
- This helps in minimising the uncontrolled forward movement of tool caused by sudden release of work load.

Meter-Out Circuit



- This type of circuit is ideal for overhauling load applications in which a workload tends to pull an operating piston faster than a pump's delivery would warrant.

- Examples would be for drilling, reaming, boring, turning, threading, tapping, cutting off, and cold sawing machines.

- A flow-control-and-check valve used in this circuit would allow reverse free flow, but it would not provide a control of return stroke speed.

Advantage of meter out circuit

- No loss of pressure of the oil at the head end of the cylinder
- The actuator movement is more stable
- Suitable for controlling the speed of both cylinder and motor
- Heat generated during throttling goes to the tank
- Provide positive speed control of cylinder
- Pump works against the maximum pressure
- Positive speed control and stable

Disadvantage of meter out circuit

- Even at no load the cylinder is subjected to maximum pressure
- Piston rod side is subjeted to counter pressure which increases as area ratio increases
- The friction is higher
- If the flow control is installed after the DCV, leakage in DCV will affect the accuracy

Meter-In Versus Meter-Out Flow-Control Valve Systems

- FCV is placed in the line leading to the inlet port of the cylinder. Thus, it is called the meter-in control of speed. Meter-in flow controls the oil flow rate into the cylinder.

- A meter-out flow control system is one in which the FCV is placed in the outlet line of the hydraulic cylinder. Thus, a meter-out flow control system controls the oil flow rate out of the cylinder.

Meter-In Versus Meter-Out Flow-Control Valve Systems

- Meter-in systems are used primarily when the external load opposes the direction of motion of the hydraulic cylinder.
- When a load is pulled downward due to gravity, a meter-out system is preferred.
- If a meter-in system is used in this case, the load would drop by pulling the piston rod, even if the FCV is completely closed.

- **Meter-In Versus Meter-Out Flow-Control Valve Systems**

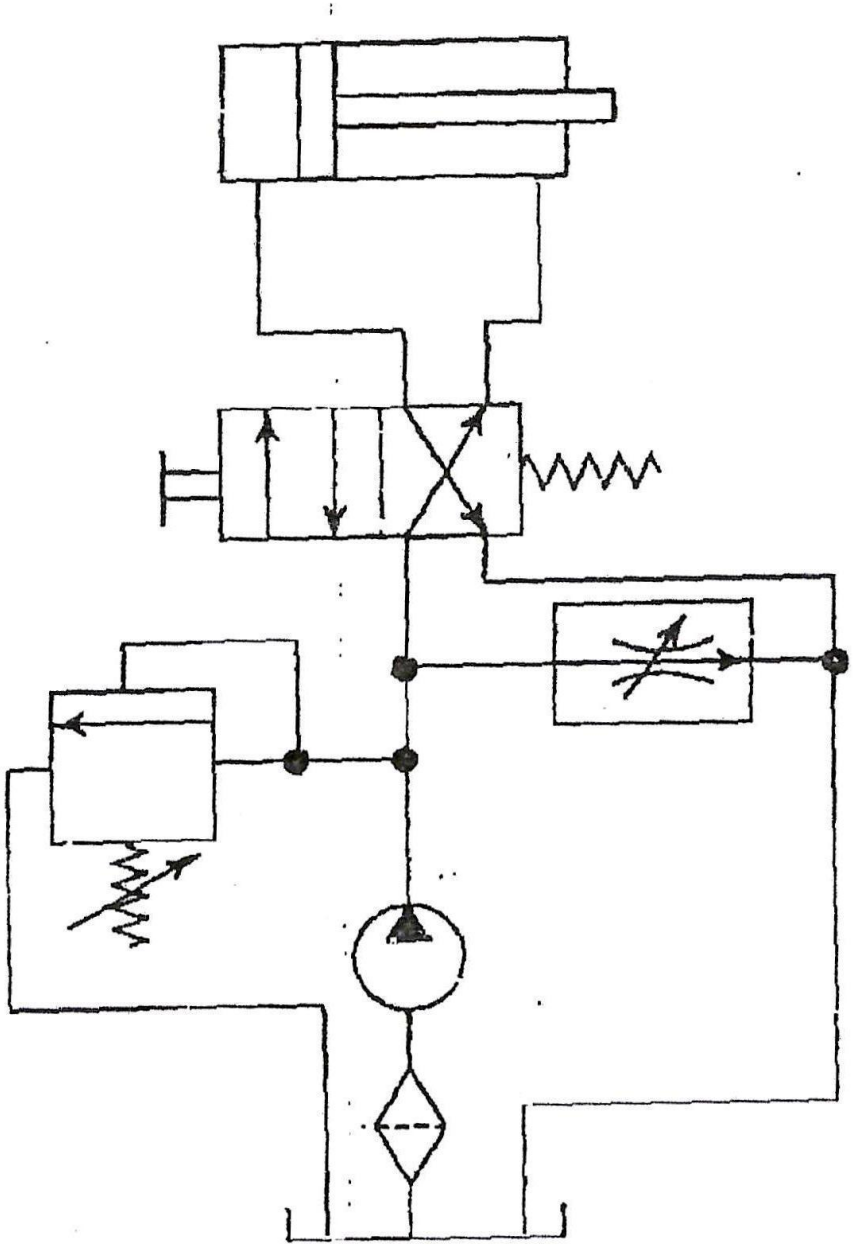
- One drawback of a meter-out system is the excessive pressure build-up in the rod end of the cylinder while it is extending.

- In addition, an excessive pressure in the rod end results in a large pressure drop across the FCV.

- This produces an undesirable effect of a high heat generation rate with a resulting increase in oil temperature

Bleed-Off Circuit

- Bleed-off circuit is not installed directly in a feed line.
- It is connected into this line with its outlet connected to a return line.
- A valve regulates flow to a cylinder by diverting an adjustable portion of a pump's flow to a tank.
- Since fluid delivered to a work cylinder does not have to pass through a flow-control valve, excess fluid does not have to be dumped through a relief valve.
- This type of circuit usually involves less heat generation because pressure on a pump equals the work resistance during a feed operation.



Bleed Off

Advantage of By pass or bleed off circuit

- Efficiency is better
- Heat generated due to throttling is fed into the tank

Disadvantage of By pass or bleed off circuit

- Positive speed control is not possible
- Not suitable for accumulator circuit
- Fluctuation of flow rate in pump affects the speed of the actuator
- Pump works against the load
- Can be used for fixed displacement pump and motor
- The motor continues to rotate even when the pump delivery is cut off from the fluid motor
- Not efficient with variable displacement pump

Regenerative circuit

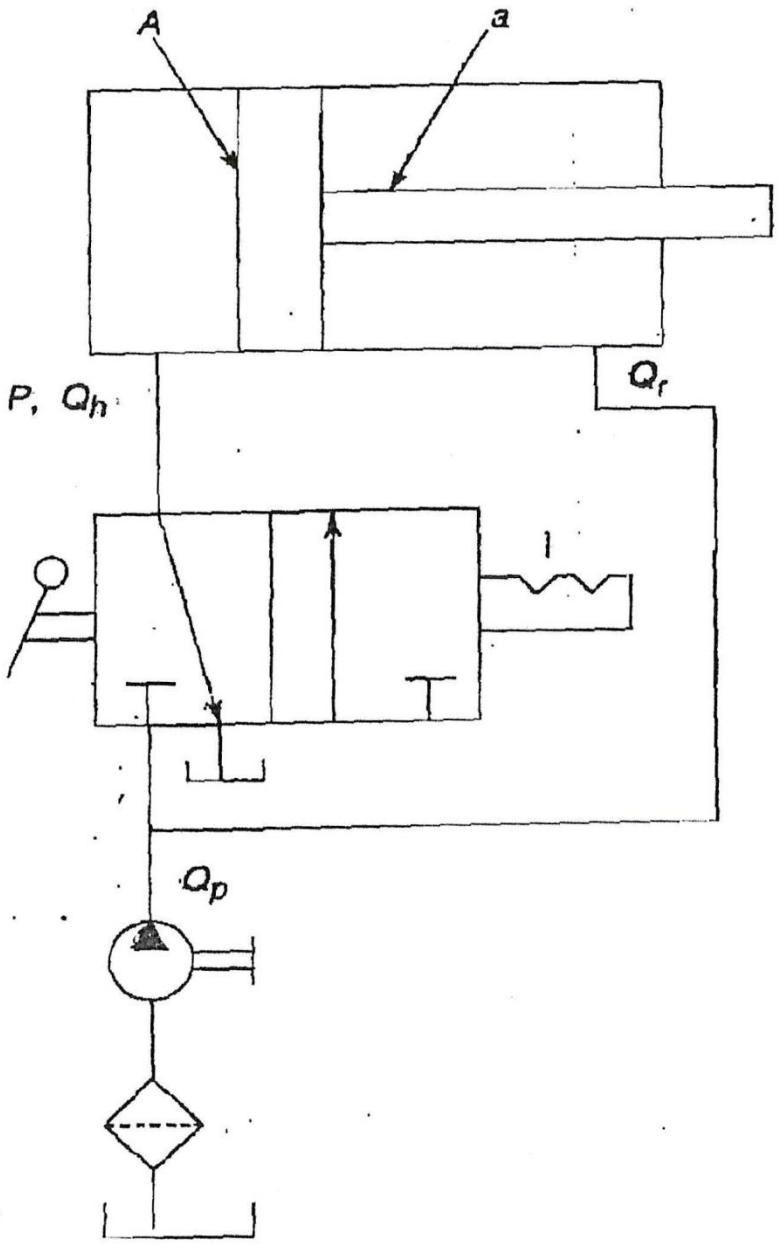
- RC are used to obtain equal speed in both direction.
- DCV is used such that the return line from cylinder is not connected to tank.
- Instead it is connected to supply line of DCV.
- Such system may appear to lock the piston hydraulically.
- But in actual practice the return oil from rod end adds up to pump delivery to piston end.
- This increases the speed of cylinder in forward stroke.

- If a 2:1 cylinder is used in the system, the cylinders speed will be same in both direction.
- A 2:1 cylinder has a piston rod with c/s area equal to one half of the piston area.

Regenerative circuit

- Since in a 2:1 cylinder the discharge fluid from the rod end is always half the volume entering the cap end, only the volume which is filled by pump flow is half of cap end volume..

- To retract the piston, the DCV is actuated and the cap end of cylinder is drained to tank
- Since the pump is filling the same volume as the cap end side, the rod retracts at the same speed.
- The 2:1 cylinder also reduced the output force of the cylinder.



A = Piston area
a = Rod end piston area
Q_h = Flow entering the head end
Q_r = Flow leaving the rod end
P = Pressure
Q_p = Pump output flow

Regenerative

Model Calculation of Regenerative Circuits

Force available to push rod against a load $= F = P \cdot (A - a)$

where A = area of cylinder piston,

a = area of rod cross section

As the piston moves, the fluid from the rod end (Q_r) is pushed out and joins the pump flow.

The speed of the piston is proportional to Q_h/A

where Q_h is the quantity of flow to the head-end side which includes the flow leaving the rod end.

$\therefore$ The flow entering the head end (piston end) of the cylinder

$= Q_h = Q_p + Q_r$

But $\dfrac{Q_h}{A} = \dfrac{Q_r}{a}$ or $Q_r = Q_h \cdot \dfrac{a}{A}$

$\therefore\ Q_h = Q_p + Q_r \ \therefore\ Q_h = Q_p + Q_h \cdot \dfrac{a}{A} \ \therefore\ Q_h - Q_h \cdot \dfrac{a}{A} = Q_p$

$$Q_p = Q_h\left(1 - \frac{a}{A}\right) \qquad Q_p = Q_h \cdot \frac{A - a}{A}$$

$$\therefore\ Q_h = Q_p \frac{A}{A - a} \quad \text{or}$$

$$\frac{Q_h}{A} = \frac{Q_p}{A - a} = \frac{\text{Pump supply}}{\text{annular area}} = \text{regenerated speed}$$

TIME DELAY VALVES

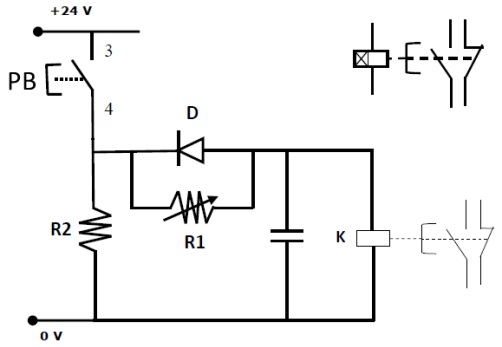
- In many pneumatic/hydraulic systems, deliberate time delays are required to be introduced between specific operations.
- It is achieved using time delay valves.
- Such valve either generate or cancel an output signal after a specified interval of time with reference to the application or removal of the time signal.

Time delay valves are classified as :

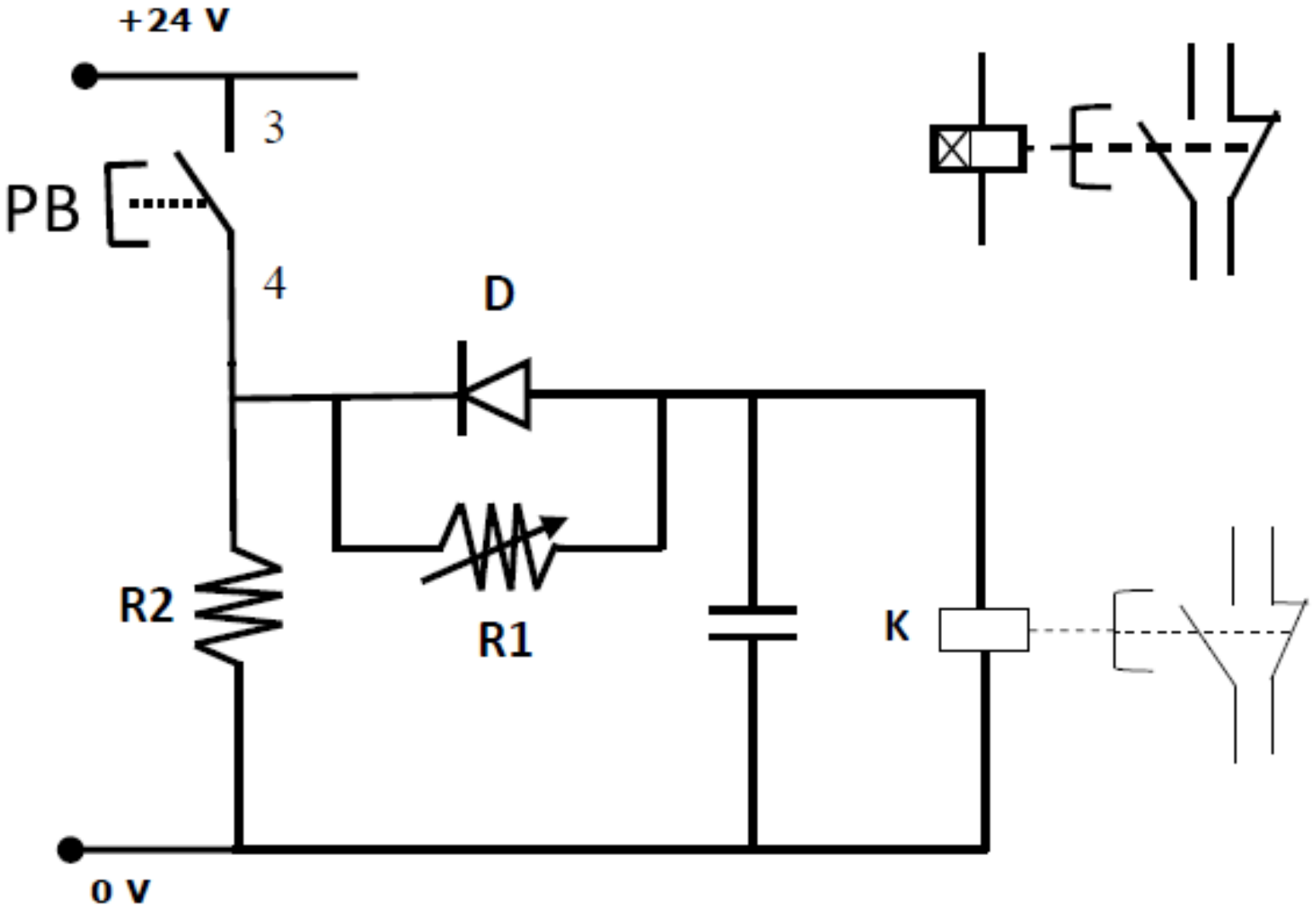
1. On delay timers
2. Off delay timers

On-delay timer

- When push button PB is pressed (ON), capacitor C is charged through potentiometer R1 as diode D is reverse –biased.
- The time taken to charge the capacitor, depends on the resistance of the potentiometer (R1) and the capacitance(C) of the capacitor.
- By adjusting the resistance of the potentiometer, the required time delay can be set.
- When the capacitor is charged sufficiently, coil K is energised, and its contacts are operated after the set time delay.
- When the push button is released (OFF), the capacitor discharges quickly through a small resistance (R2) as the diode by passes resistor R1, and the contacts of relay (K) return to their normal position without any delay.

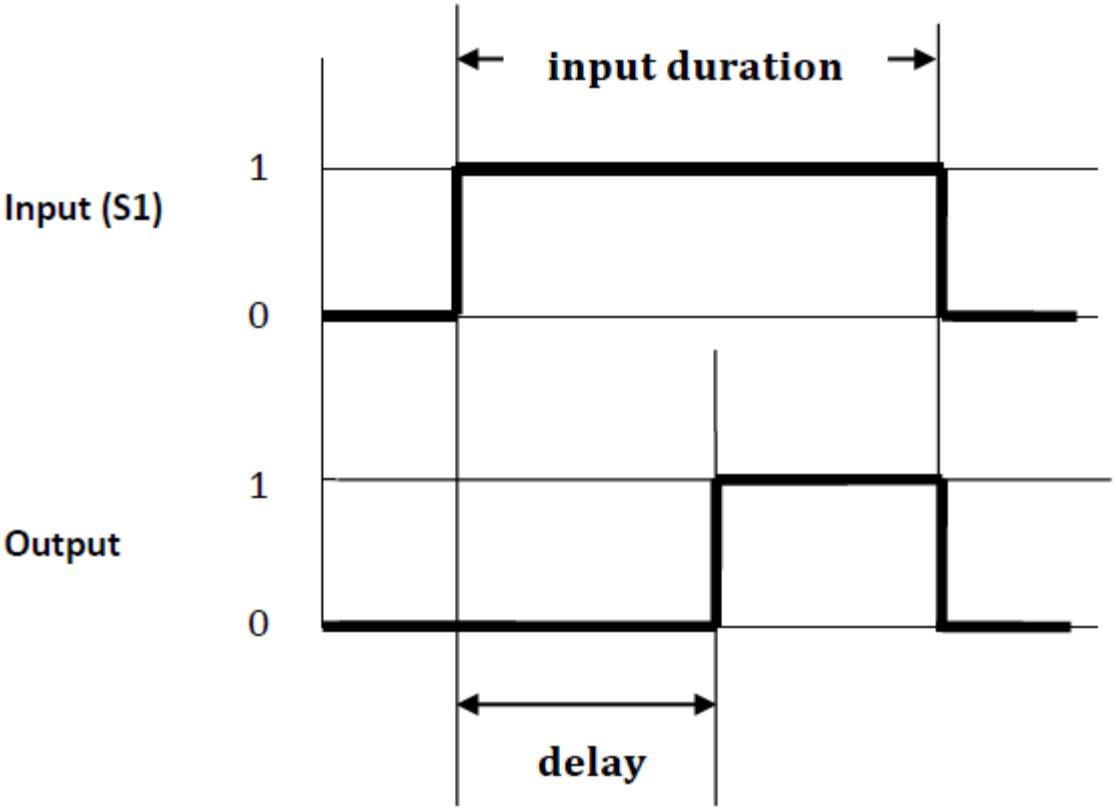


On-delay timer

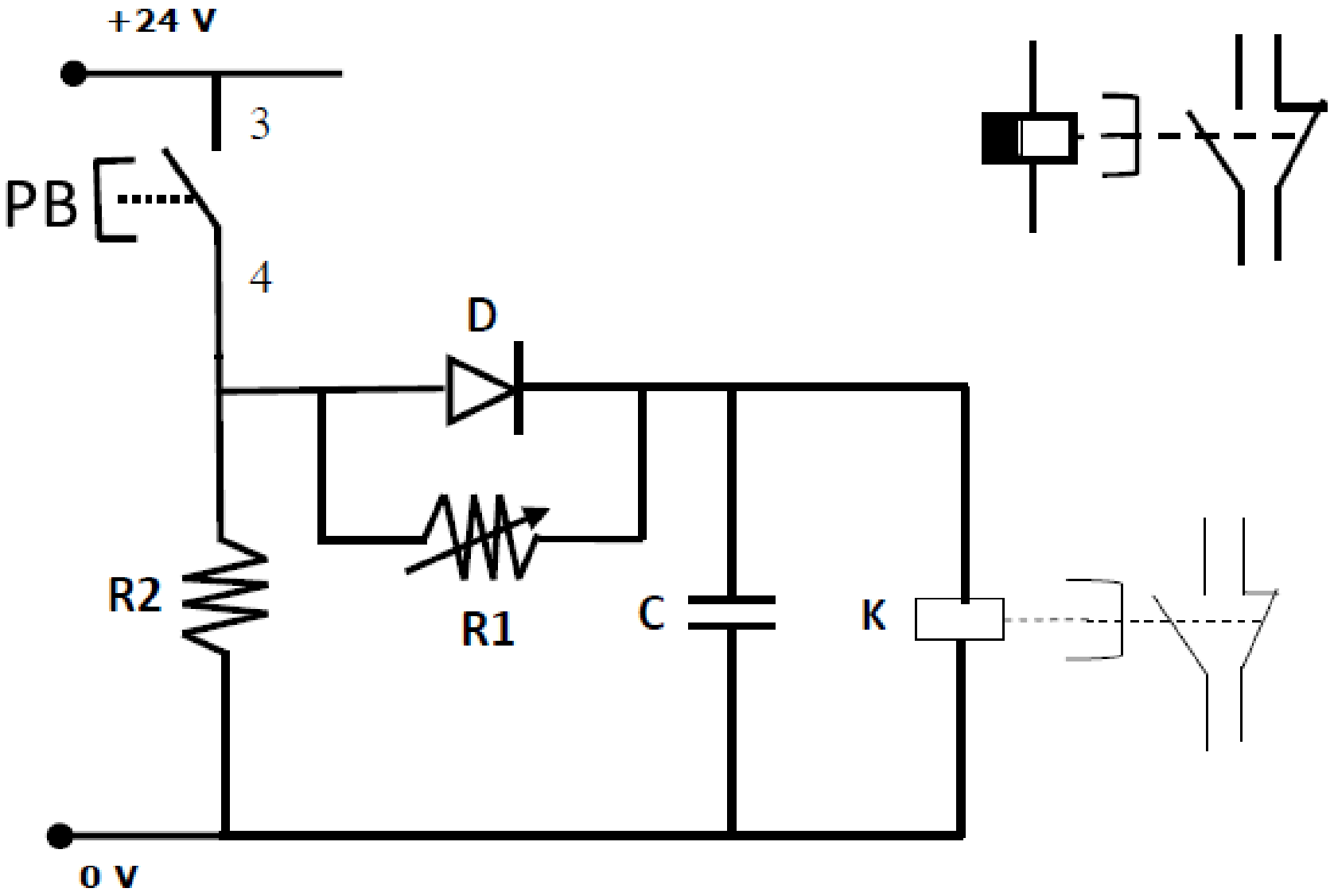


Pull in delay (on –delay timer)

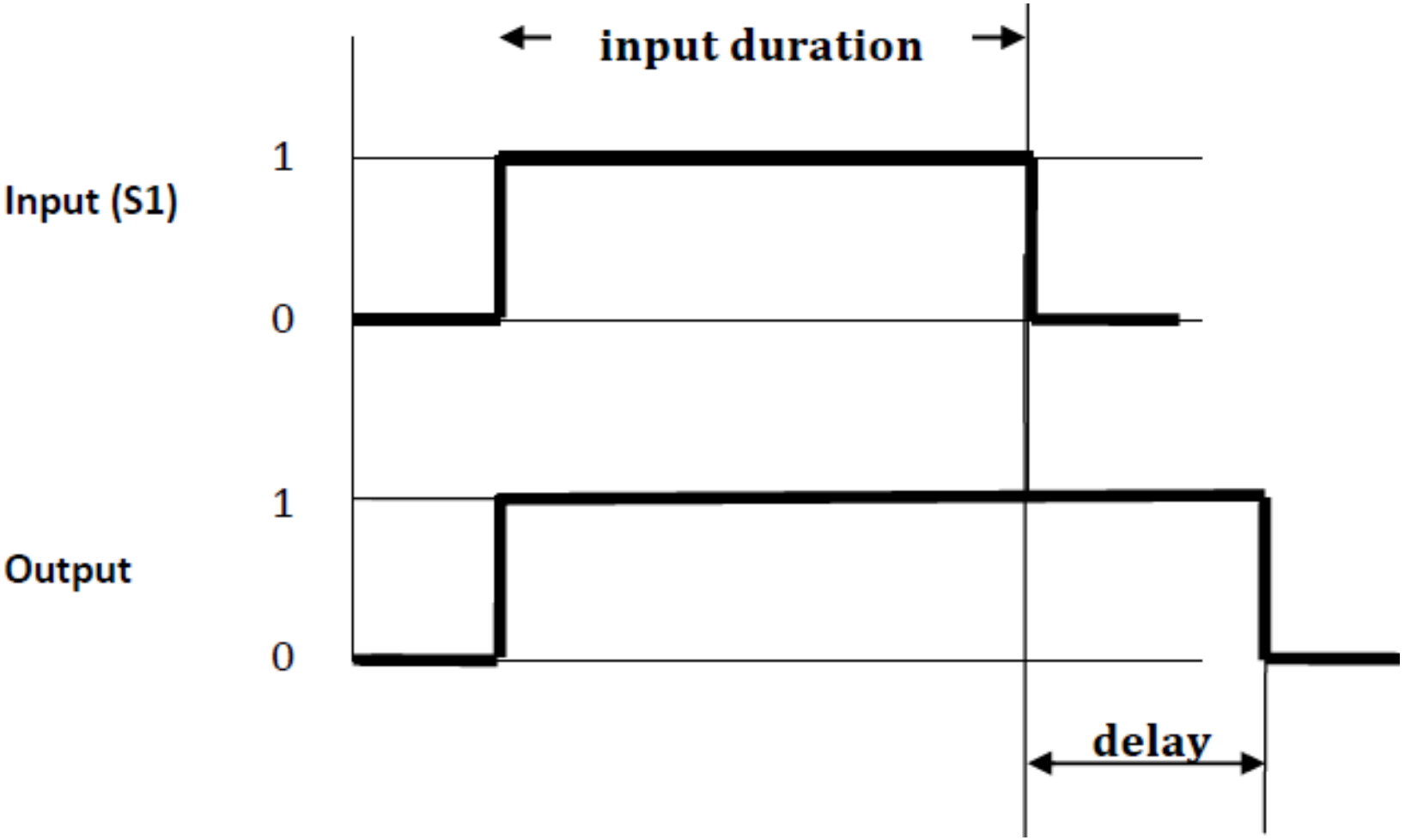
On-delay timer



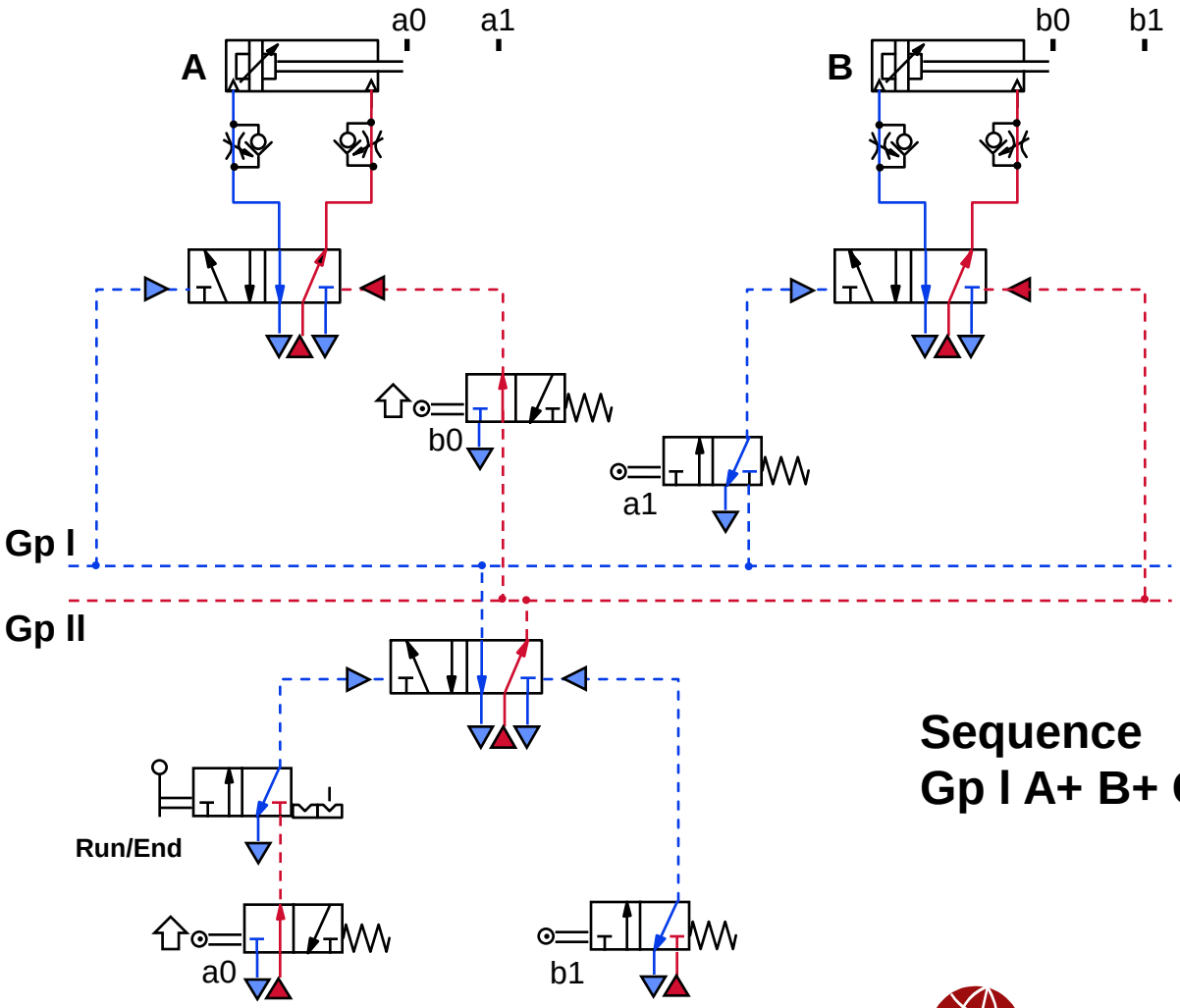
Off-delay timer



Off-delay timer



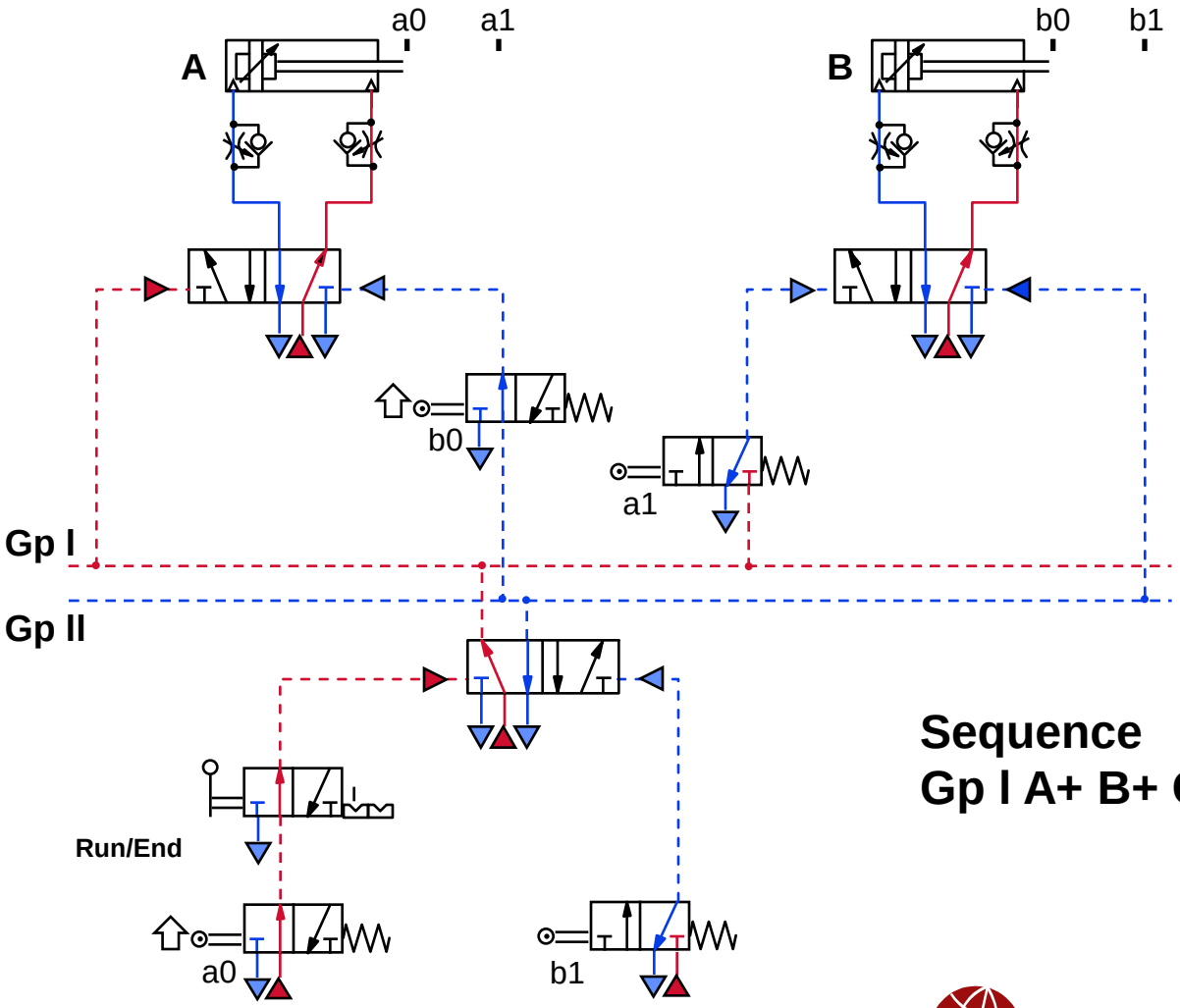
Cascade (two group)



Sequence
Gp I A+ B+ Gp II B- A-

NORGREN

Cascade (two group)



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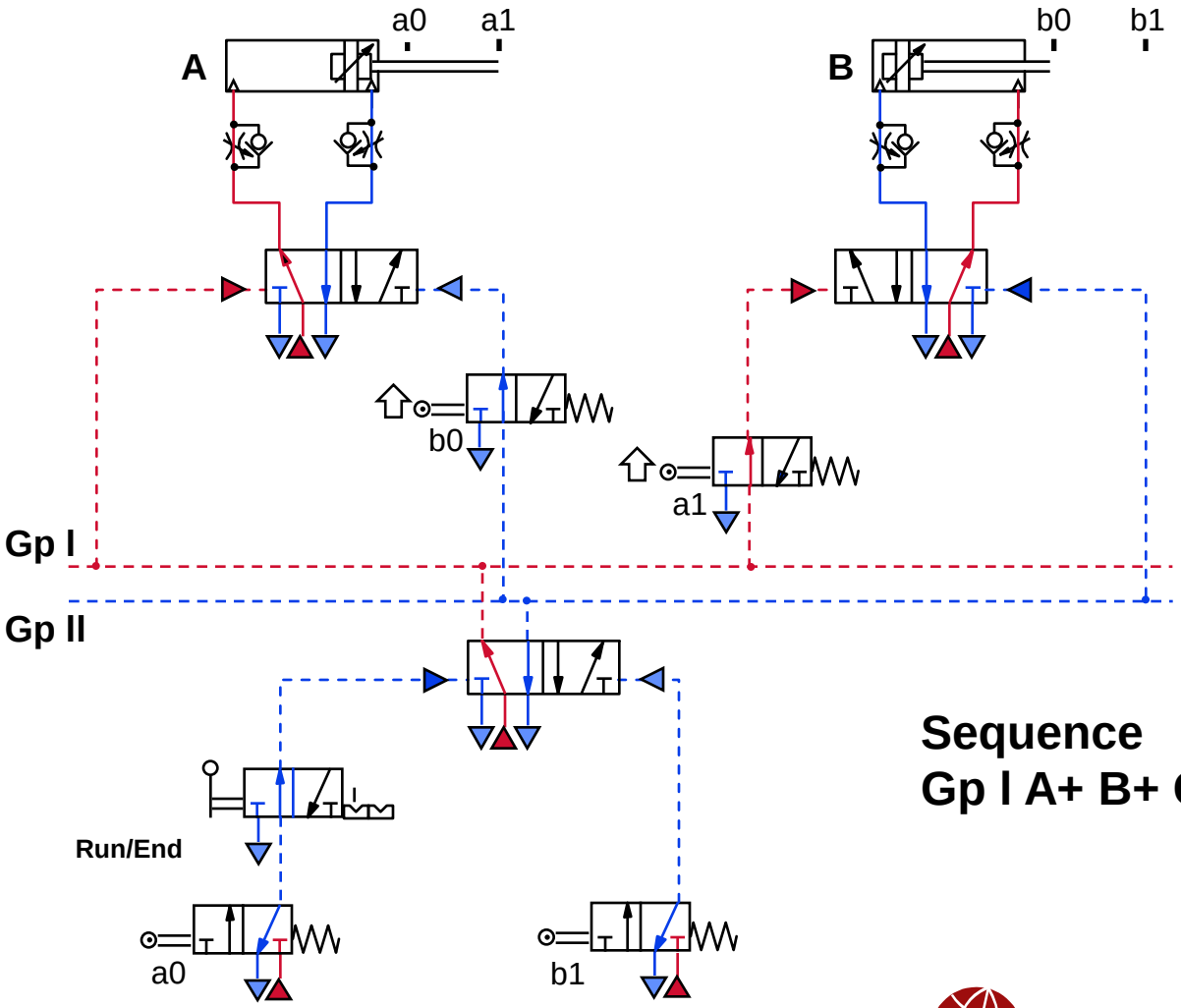

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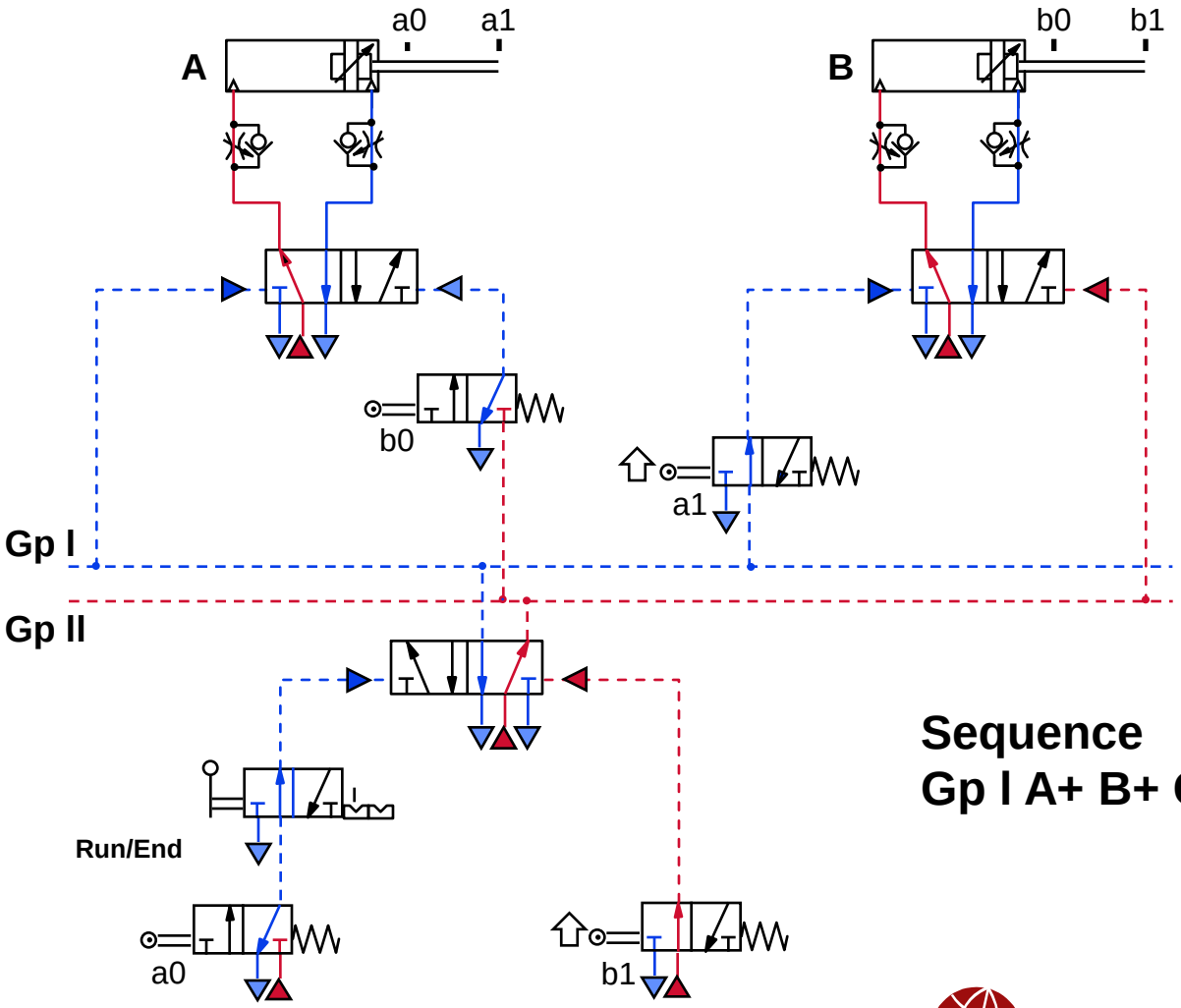

Sequence
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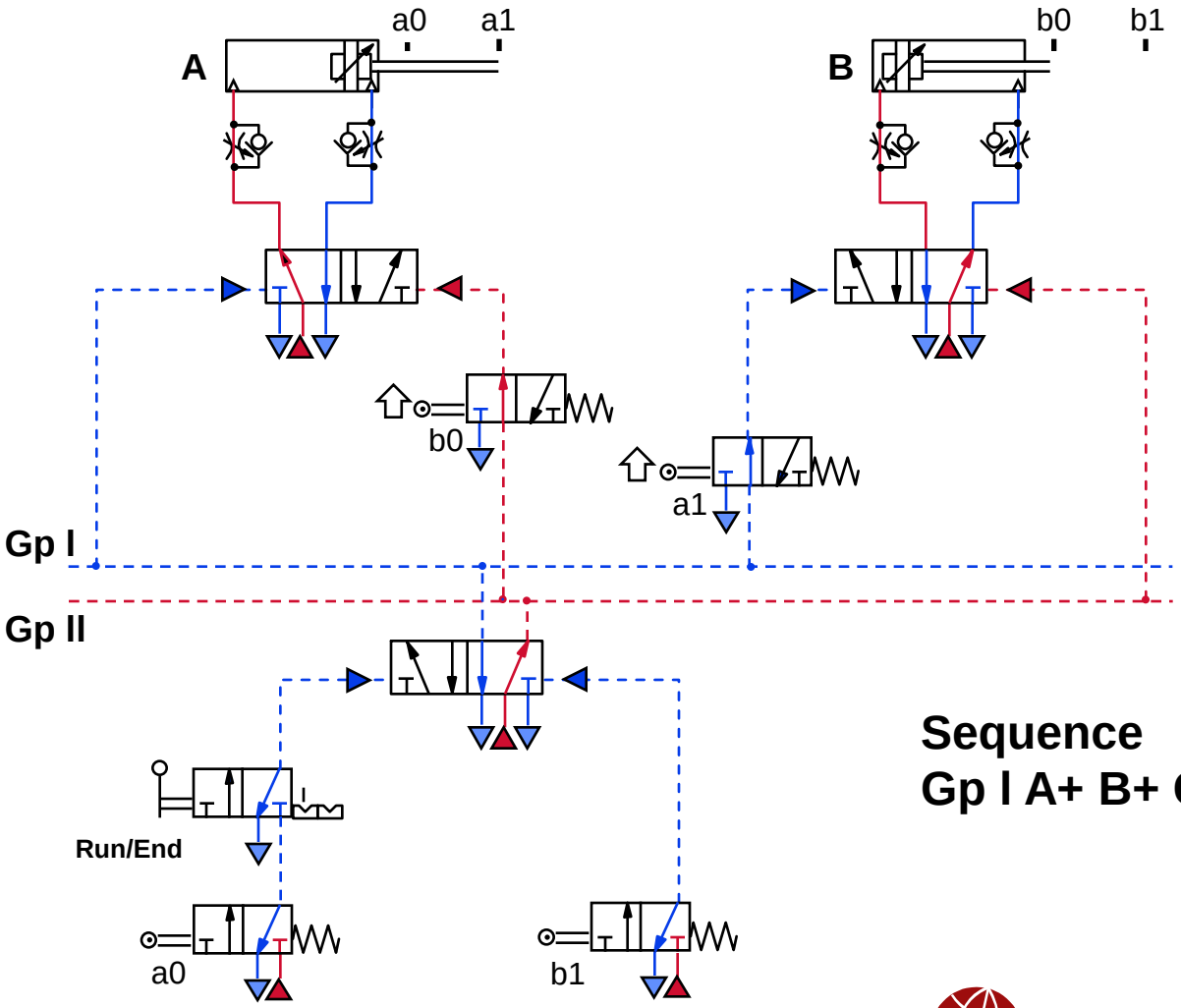

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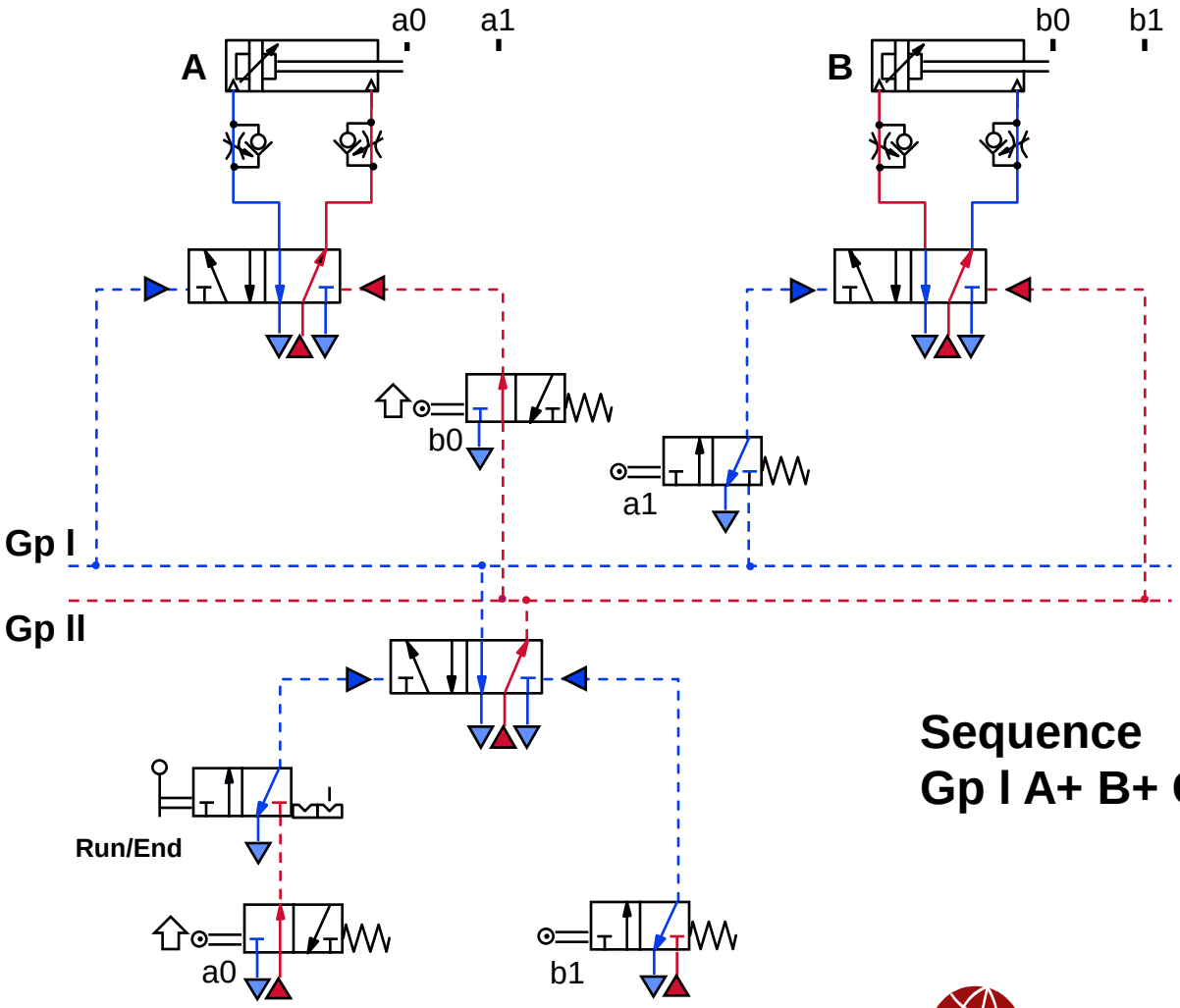

Sequence
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NORGREN