



Introduction to Hydraulics and Pneumatics



Principles of Hydraulics

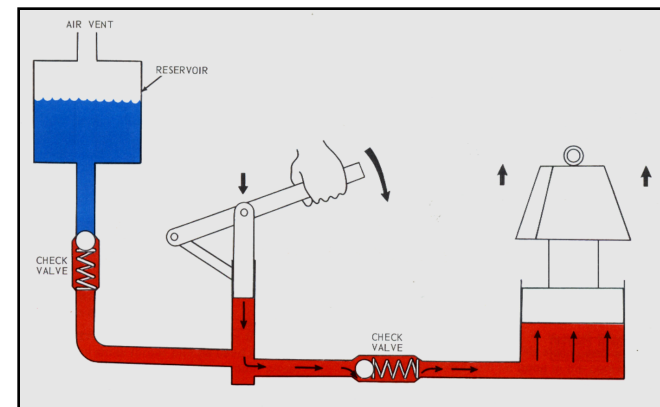
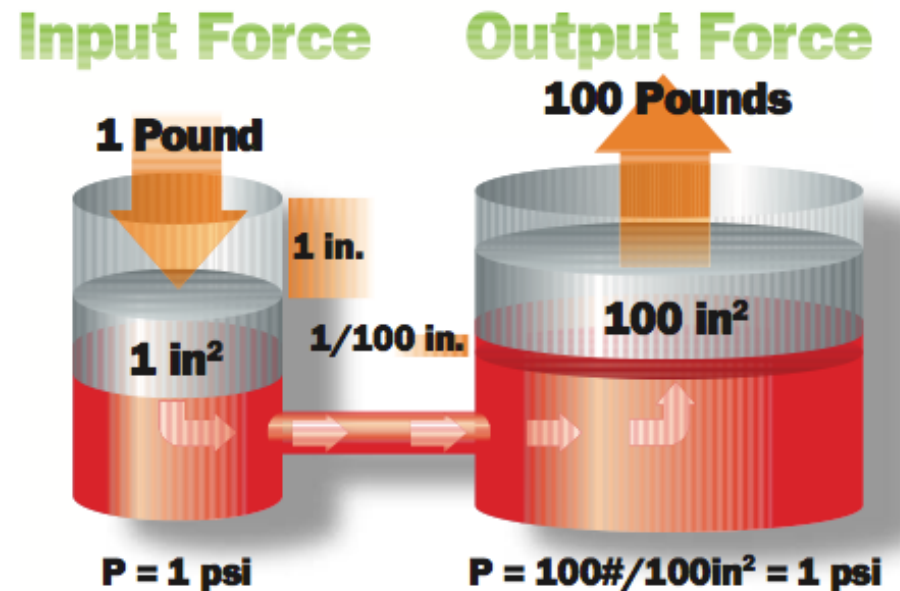
- The word “hydraulics” generally refers to power produced by moving liquids. Modern hydraulics is defined as the use of confined liquid to transmit power, multiply force, or produce motion.
- **Pascal:** “Pressure applied on a confined fluid is transmitted in all directions with equal force on equal areas”.





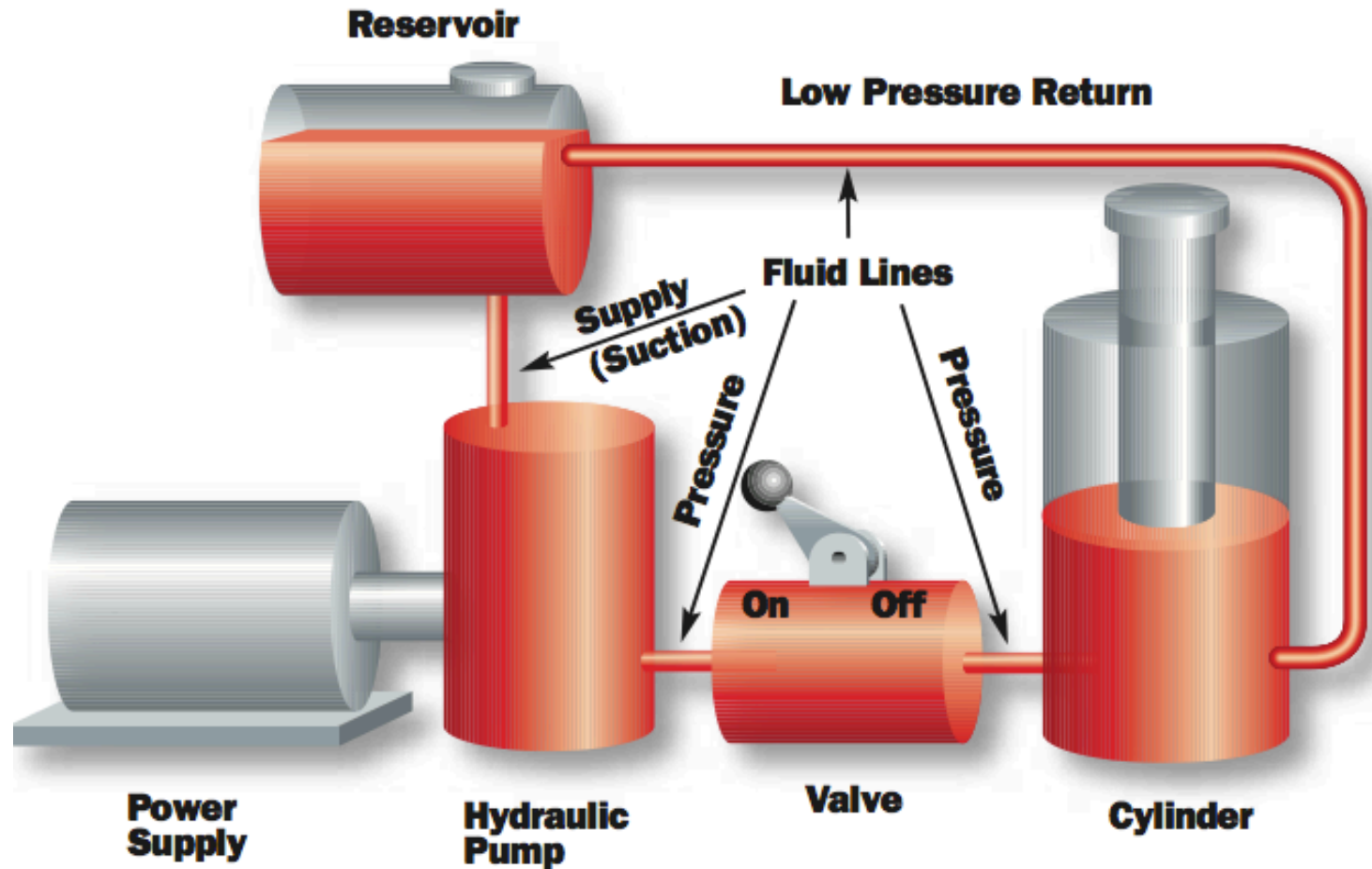
Multiplication of Force

- Since liquid transmits the same amount of pressure in all directions. The force transmitted to the output piston is multiplied by a factor equal to the area ratio of the output piston to the input piston





Components of Hydraulic/Pneumatic Systems





Components of Hydraulic/Pneumatic Systems

1. **Fluid**: oil for hydraulic systems, air for pneumatics.
2. **Reservoir**: storage tank.
3. **Hydraulic pump (compressor in pneumatics)**: converts the mechanical energy into hydraulic energy by forcing fluid from the reservoir into the system.
4. **Fluid lines**: transport the fluid to and from the pump through the hydraulic system.
5. **Valves**: control pressure, direction and flow rate of the hydraulic fluid.
6. **Actuator**: converts hydraulic energy into mechanical energy to do work.



Applications



Oil & Gas Drilling Rigs



Fork Lifts

**Machine Tools
Injection Molders
Presses**



Combines/Harvesters



Midsize to Large Tractors



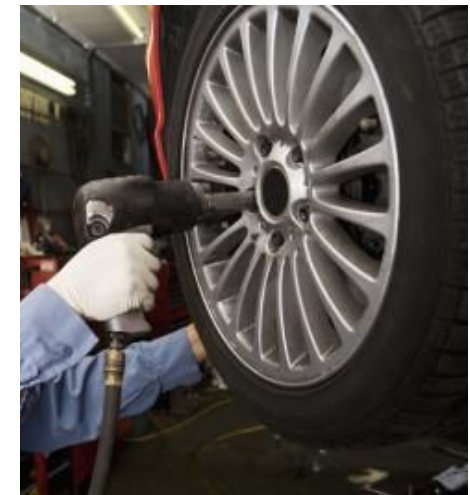
Dozers/Crawlers



Hauler Trucks

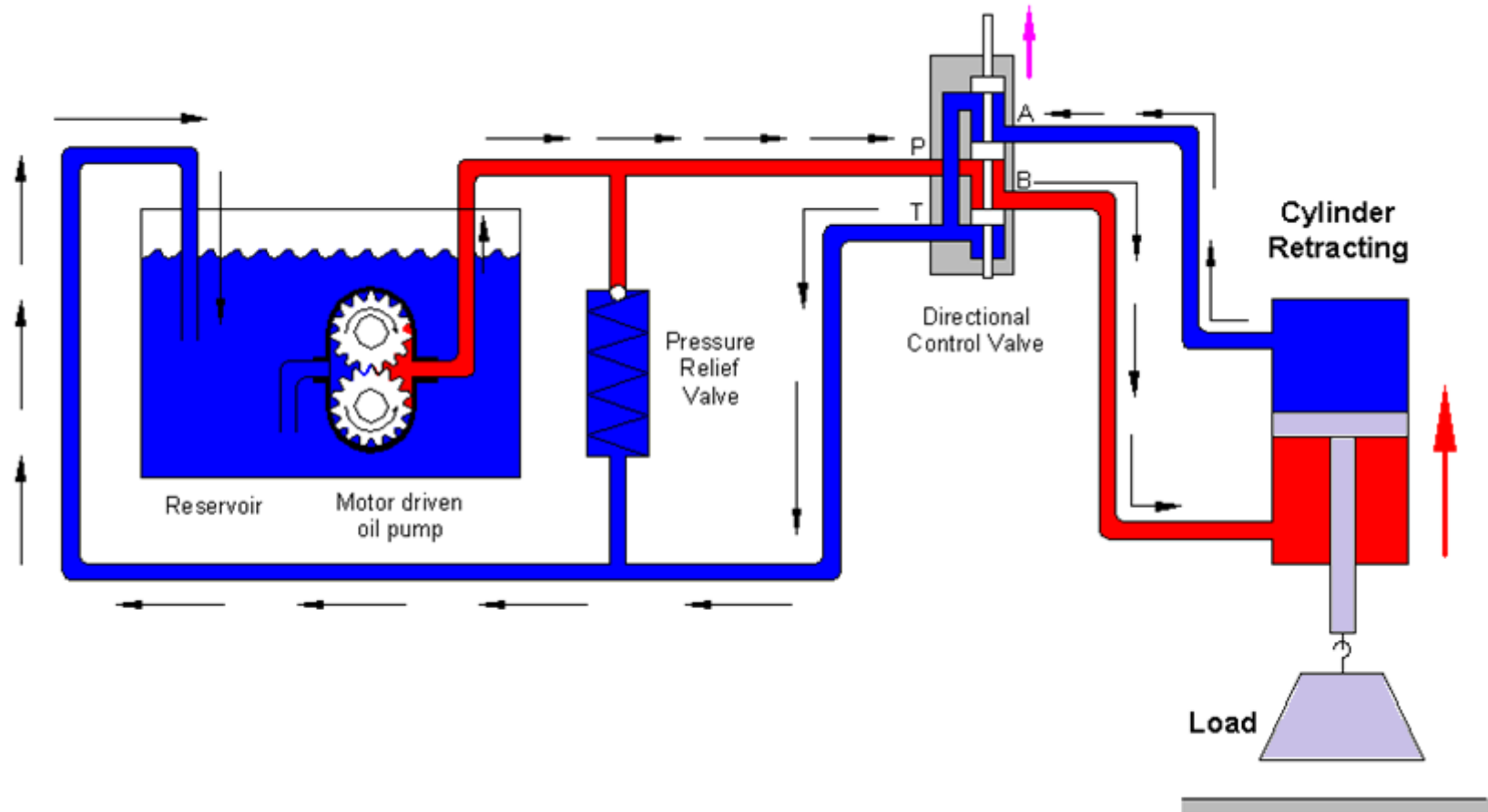


Excavators



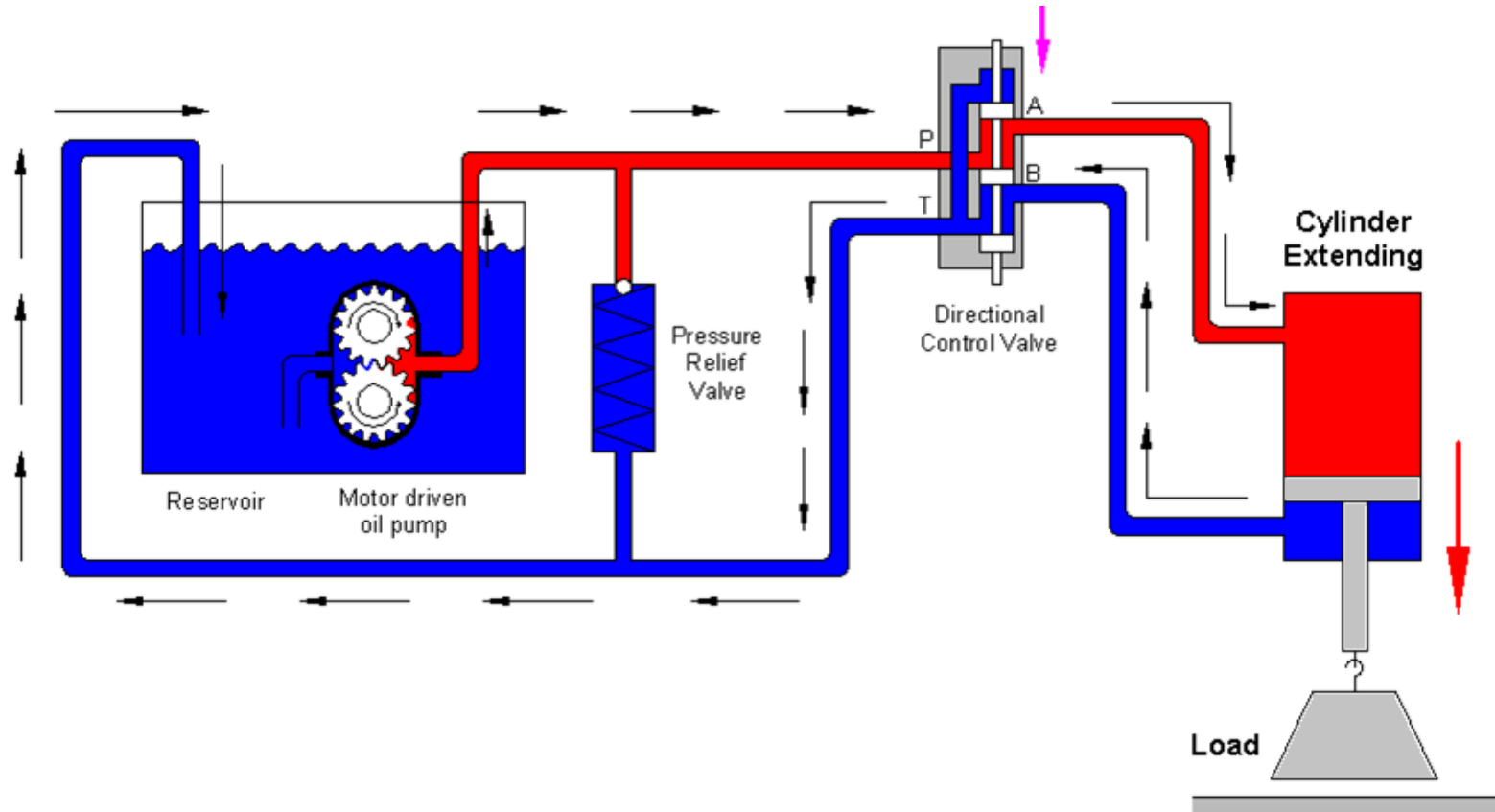


Example: lifting a load



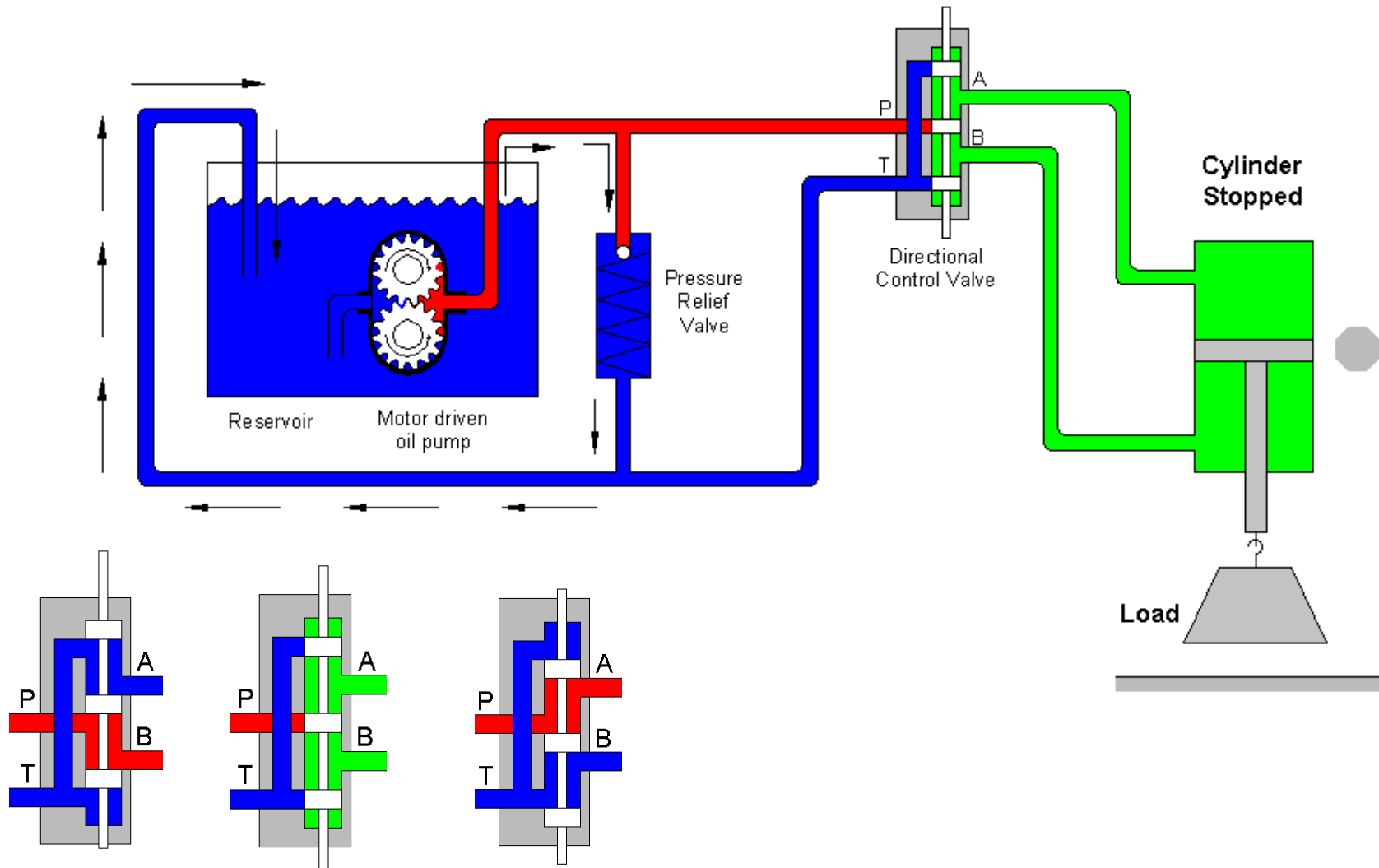


Example: lifting a load





Example: lifting a load





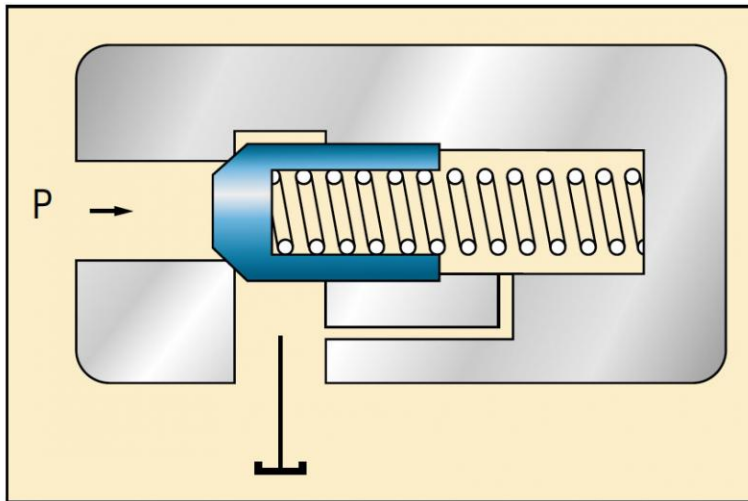
Control valves

Control valves: are valves used to control conditions such as flow, pressure, and direction of flow.

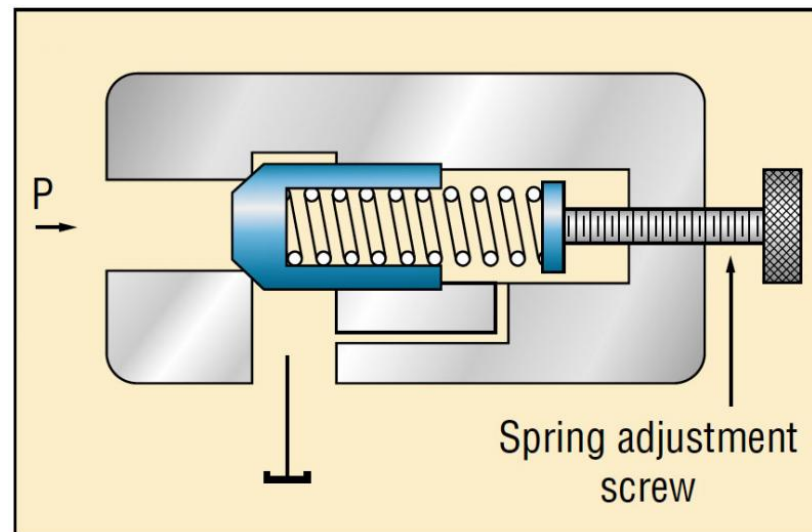
- Pressure control valves.
- Flow control valves.
- Directional control valves
 - Check Valves
 - Directional valves



Pressure Control Valves



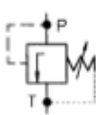
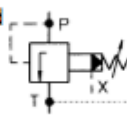
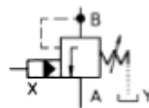
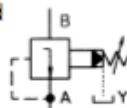
A pressure control valve is used to reduce the amount of pressure in a tank or system of pipes.





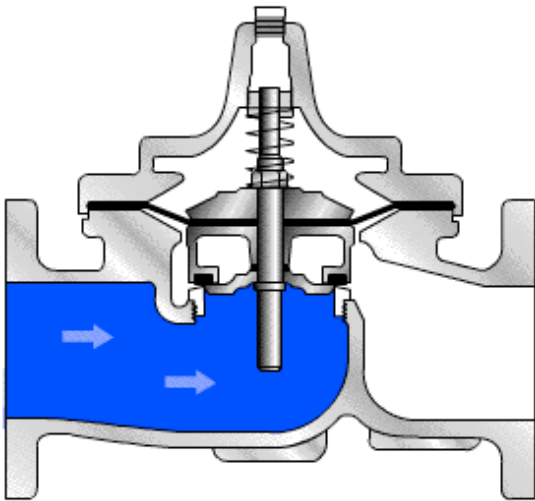
Pressure Control Valves

PRESSURE CONTROL VALVES

Pressure relief valve		Sequence valve	
	Direct operated		Pilot operated
Pressure reducing valve		Counterpressure valve	
	Direct operated		
	Pilot operated		



Flow Control Valves



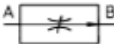
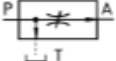
Used to control
fluid flow





Flow Control Valves

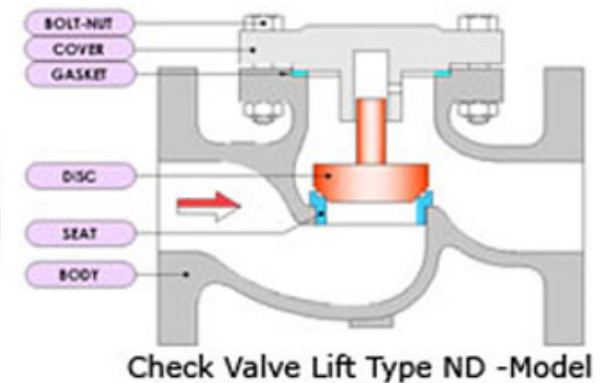
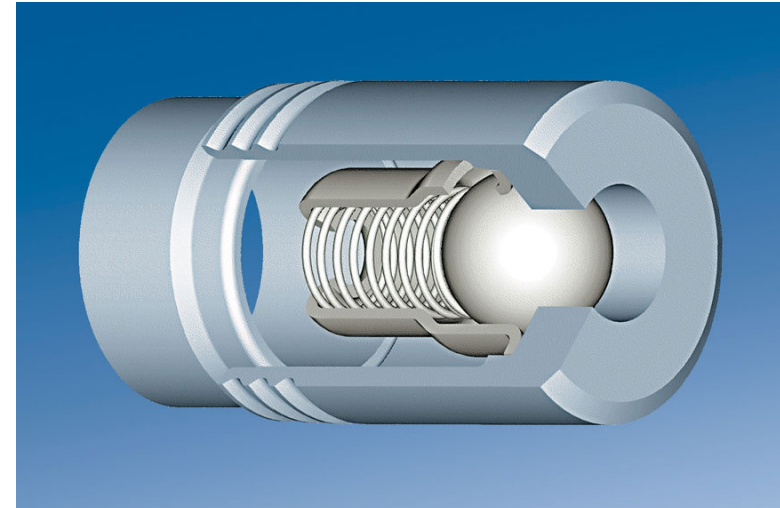
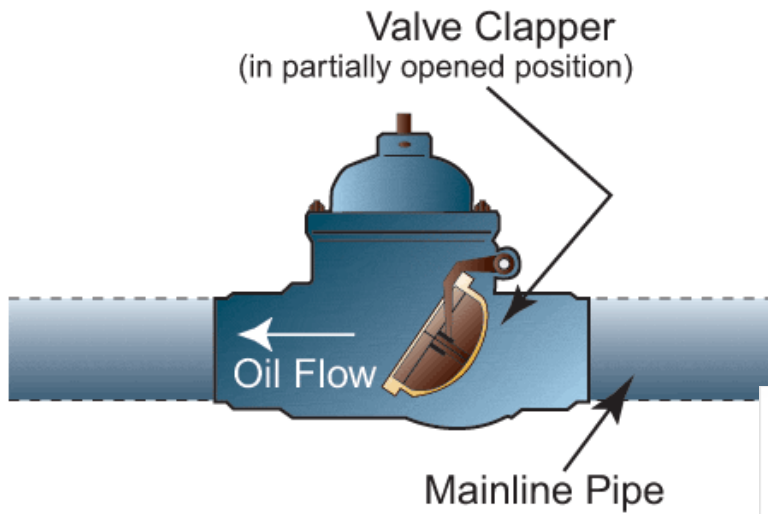
FLOW CONTROL VALVES

Variable throttling valve		Compensated flow regulator	
Two way	With check	Two-way	Three-way
			



Directional control valves

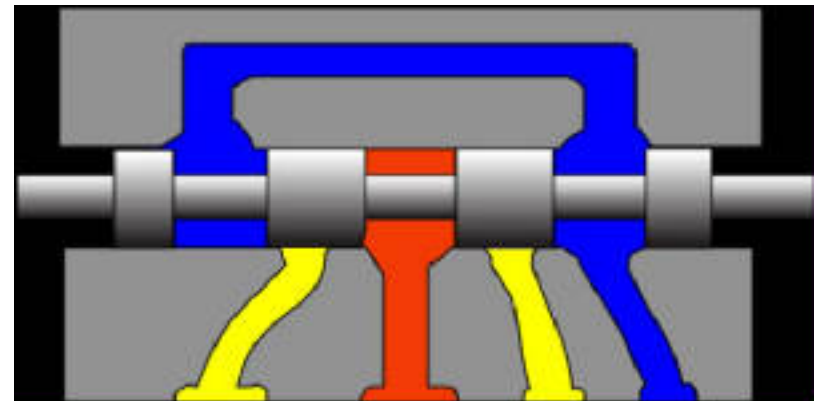
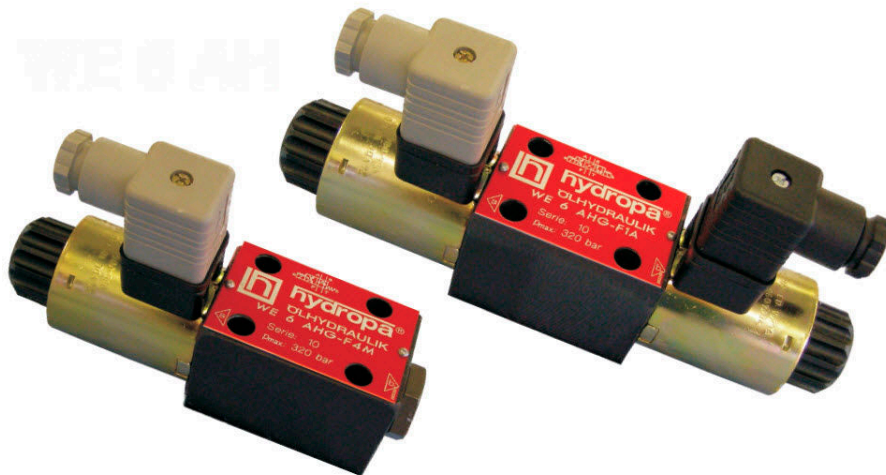
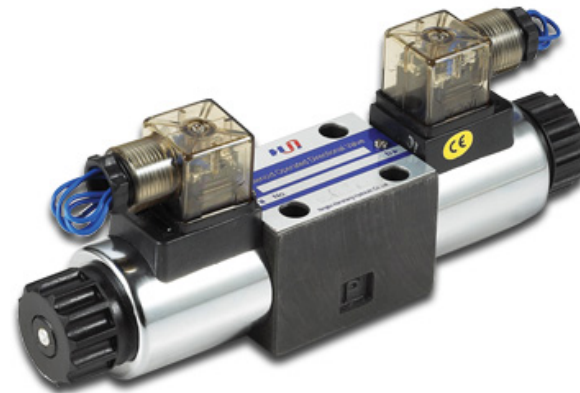
- Check Valves





Directional control valves

- Directional valves





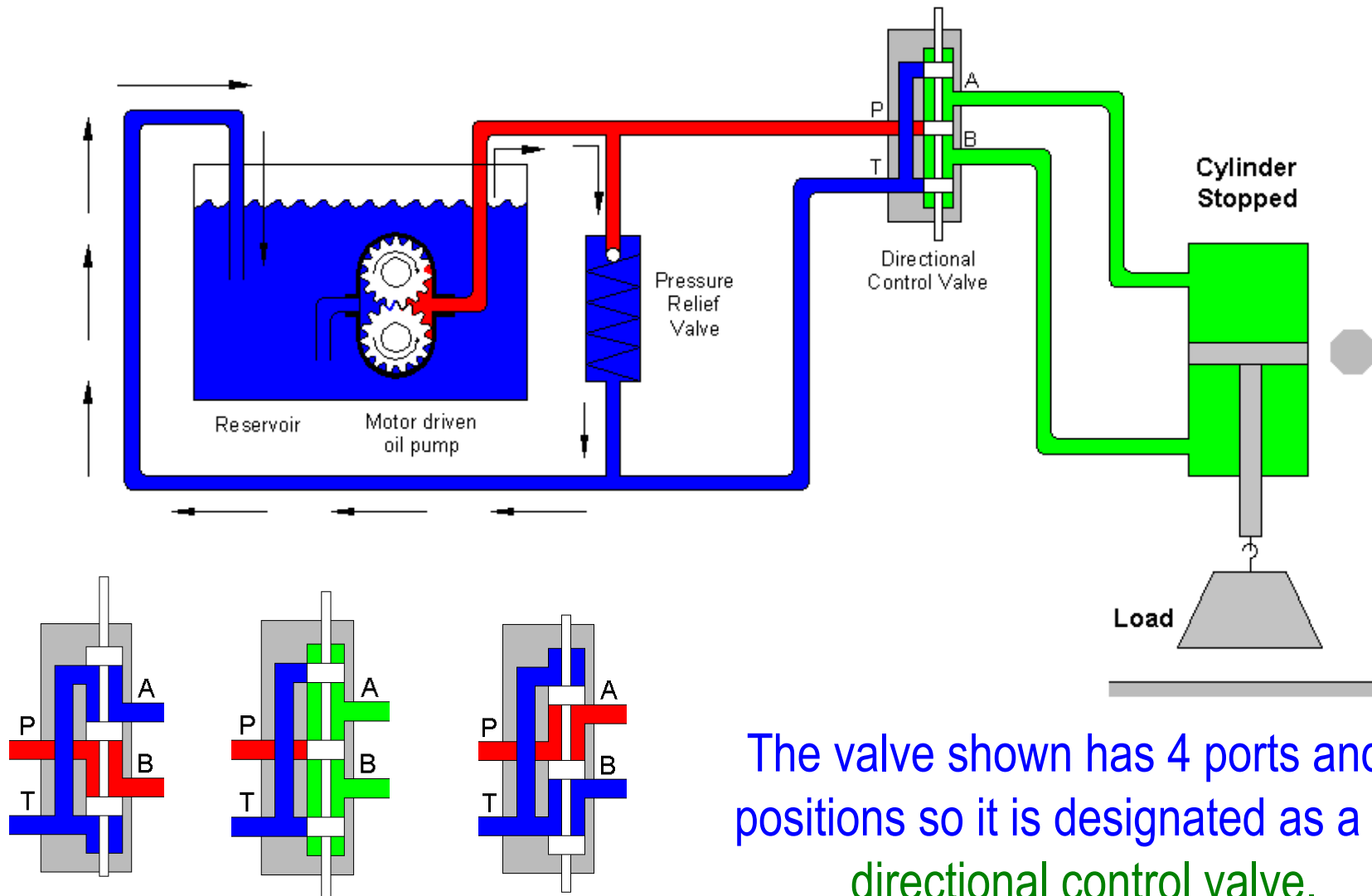
Directional valves

DIRECTIONAL CONTROL VALVES

Check valve			
Standard 	Calibrated 	Piloted operated 	Piloted with drainage 
Directional valves			
2 ways - 2 positions 	3 ways - 2 positions 	4 ways - 2 positions 	4 ways - 3 positions 
Controls for directional valves			
Mechanical 	Pushbutton 	Lever 	Pedal 
Controls for directional valves			
Spring 	Cam 	Electric (solenoid) 	Electro-hydraulic 
Controls for directional valves			
Pneumatic 	Hydraulic 	Electric (proportional) 	Electro-hydraulic (proportional) 



Example: Directional valves



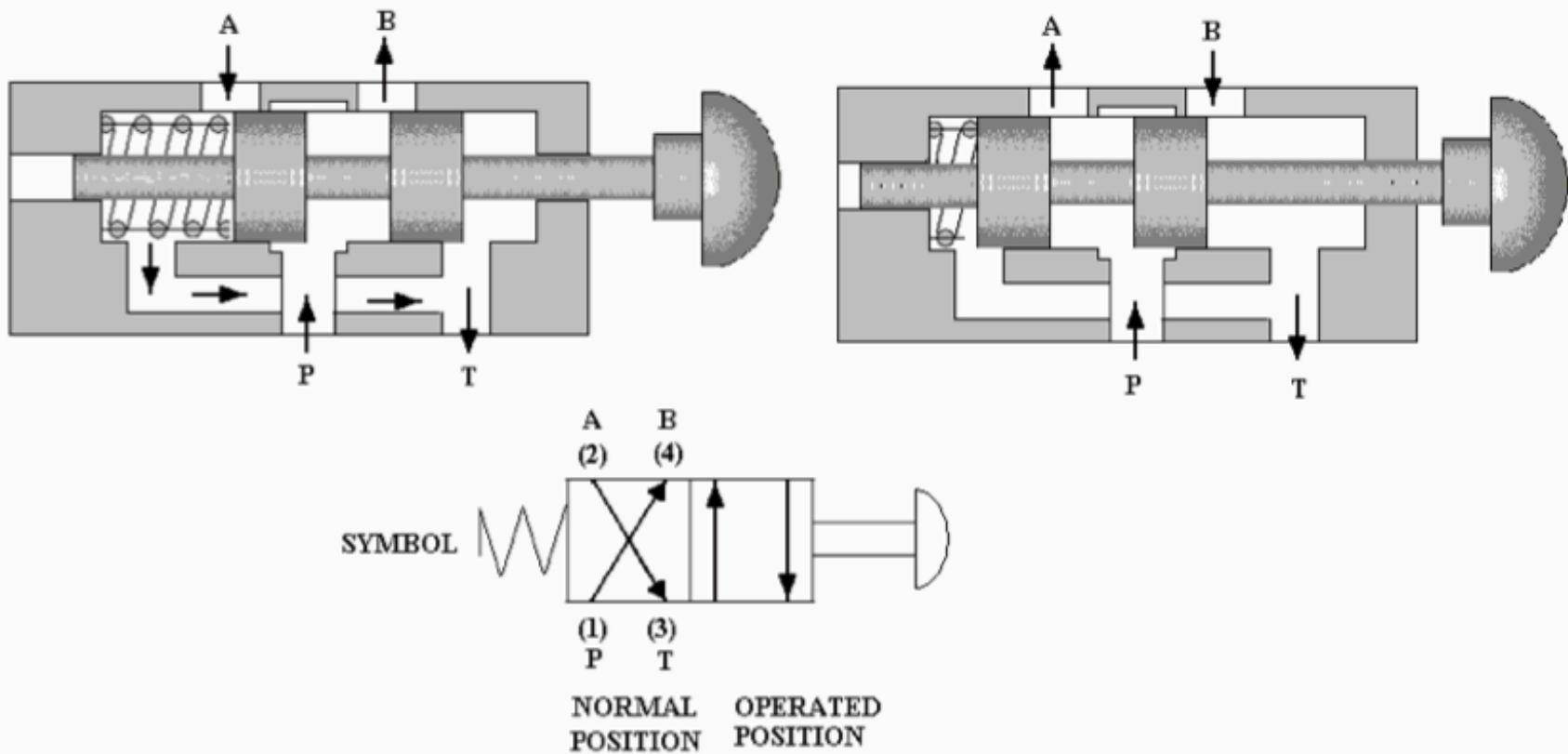


Symbols

- In hydraulics the pressure port is designated **P** and the return port **R** or **T** (for tank). The two other ports are designated **A** and **B**.
- Boxes to identify normal and operating positions.
- Arrows to identify flow directions.
- In Pneumatics the pressure port is numbered (1) and the exhaust port (3). The other two are numbered (2) and (4).

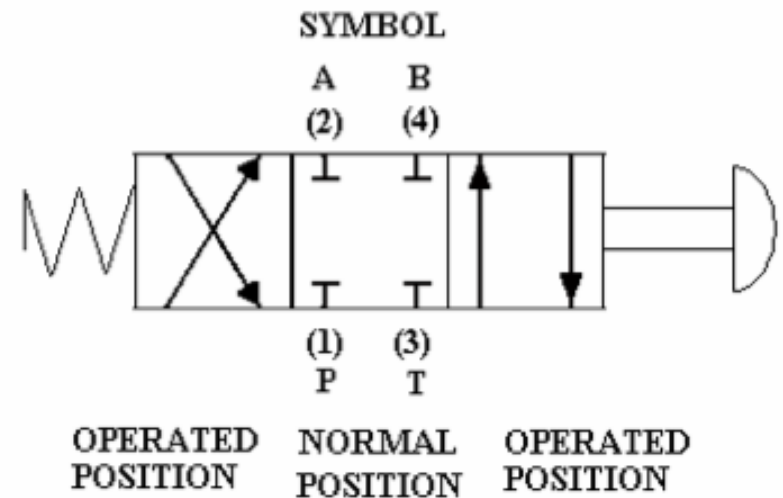
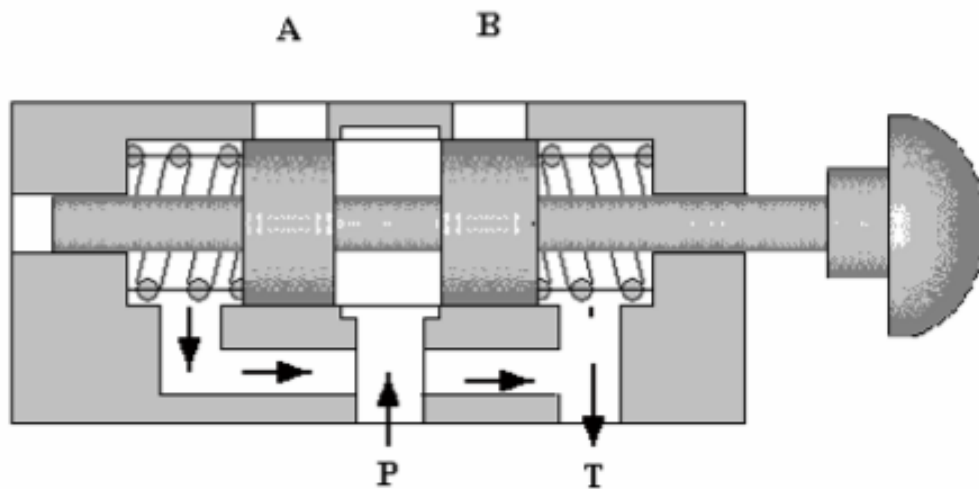


Example: 4-ports 2-position directional control valve



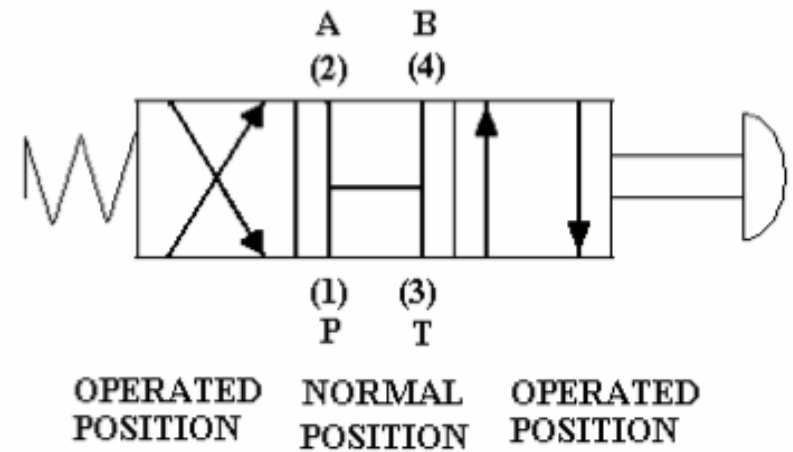
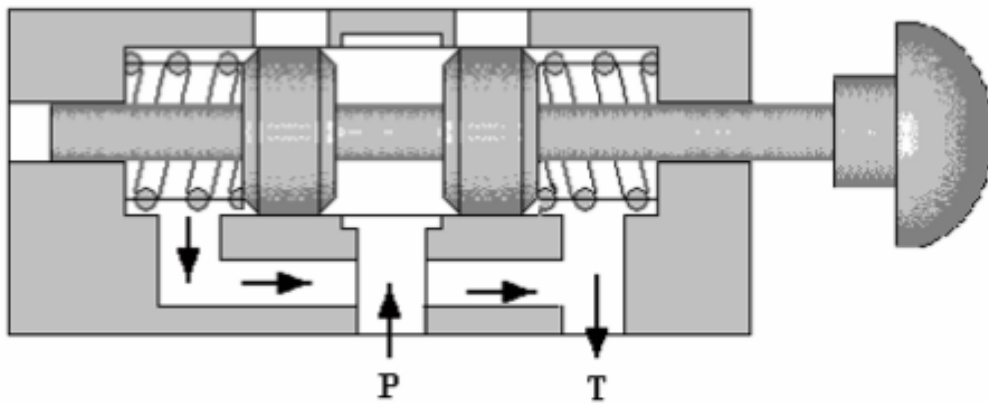


Example: 4-ports 3-position directional control valve



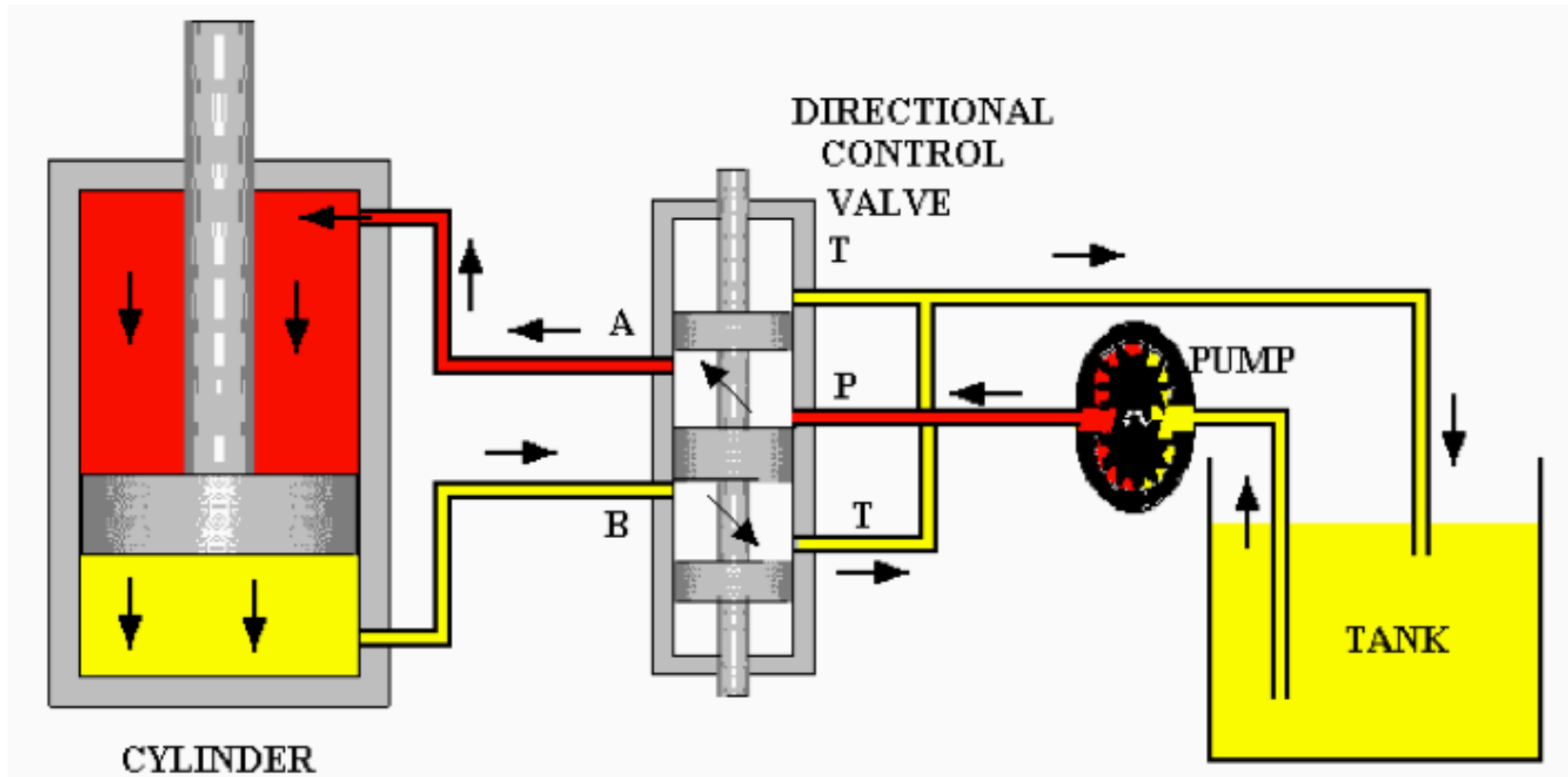


Example: 4-ports 3-position directional control valve





Example: 5-ports 3-position directional control valve





Cylinders

CYLINDERS

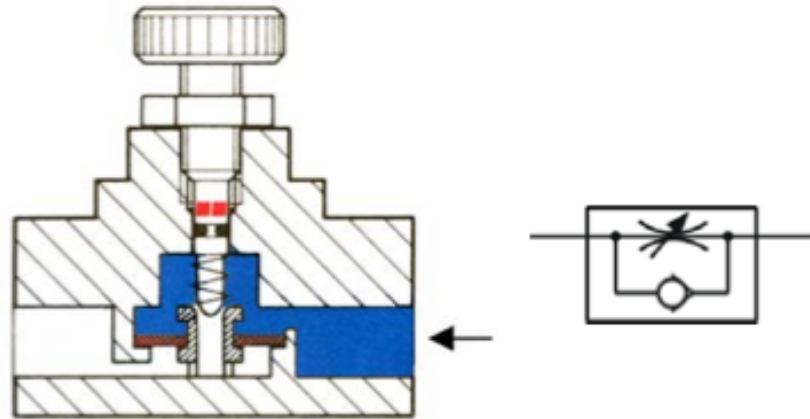
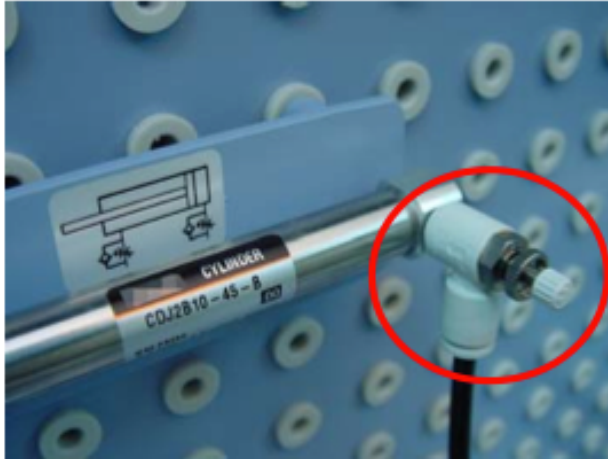
Graphic symbol	Item	Description
	Single-acting cylinder	Return stroke by external force
		Return stroke through a spring
	Double-acting cylinder	Single rod
		Double rod
	Cylinder with fixed stroke end cushioning	Cushioning on one side
		Cushioning on both sides
	Cylinder with adjustable stroke end cushioning	Cushioning on one side
		Cushioning on both sides
	Telescopic cylinder	Single-acting
		Double-acting



Pneumatic Circuits



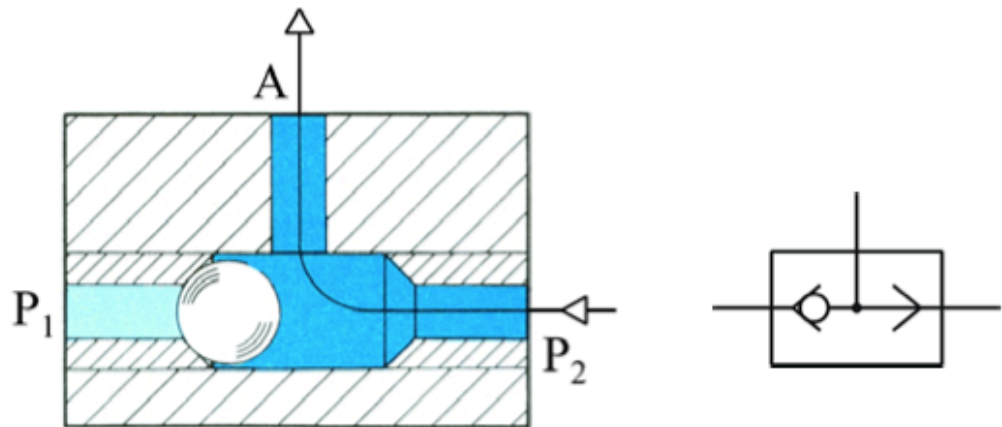
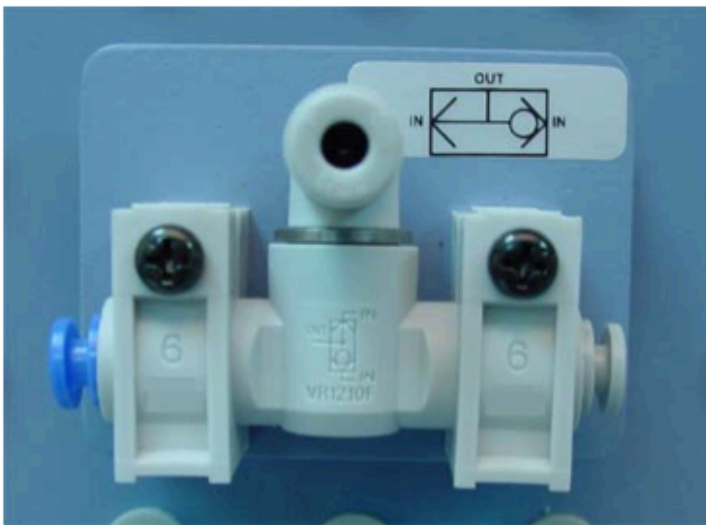
Flow control valve (with check)





Shuttle valve

A shuttle valve has two air inlets ' P_1 ' and ' P_2 ' and one air outlet ' A '. When compressed air enters through ' P_1 ', the sphere will seal and block the other inlet ' P_2 '. Air can then flow from ' P_1 ' to ' A '. When the contrary happens, the sphere will block inlet ' P_1 ', allowing air to flow from ' P_2 ' to ' A ' only.



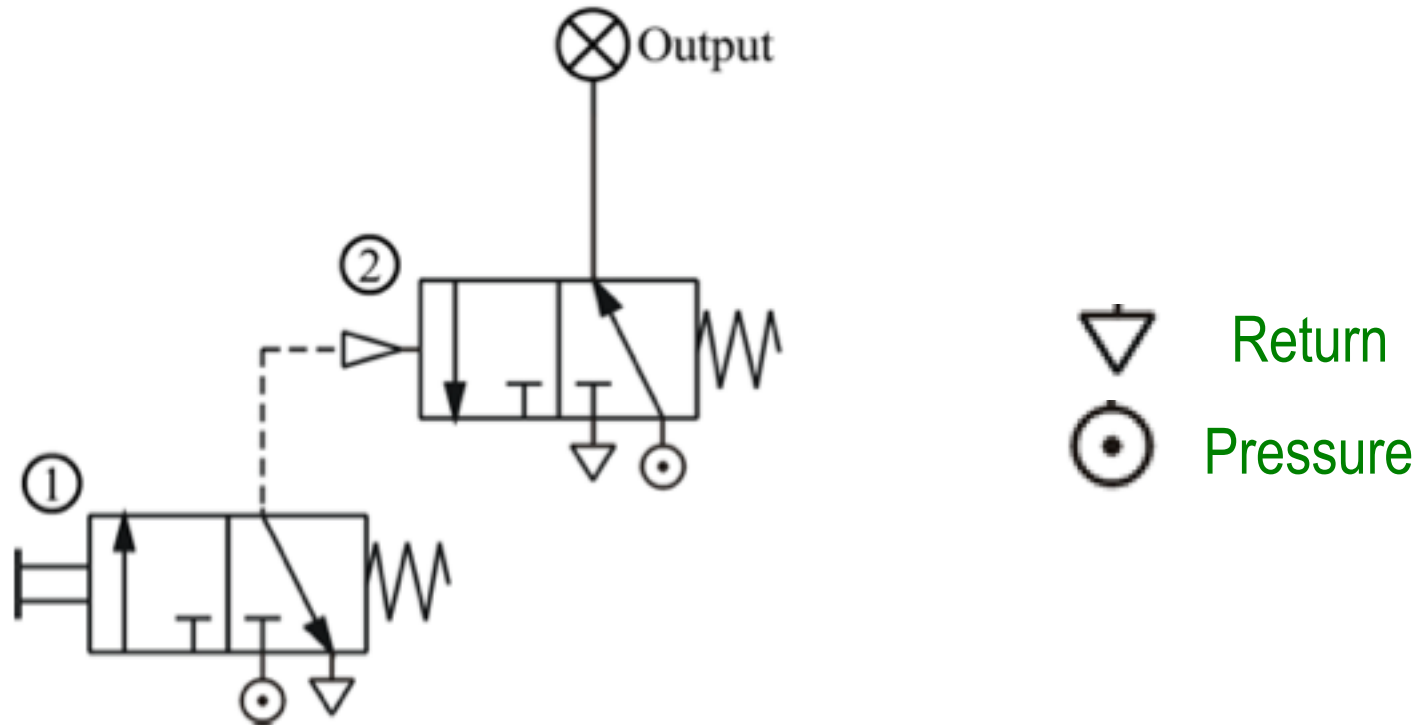


Pneumatic circuits

- Pneumatic control systems can be designed in the form of pneumatic circuits. A pneumatic circuit is formed by various pneumatic components, such as cylinders, directional control valves, flow control valves, etc.
- Pneumatic circuits have the following functions:
 1. To control the injection and release of compressed air in the cylinders.
 2. To use one valve to control another valve.
- Displayed as **Pneumatic circuit diagram**.



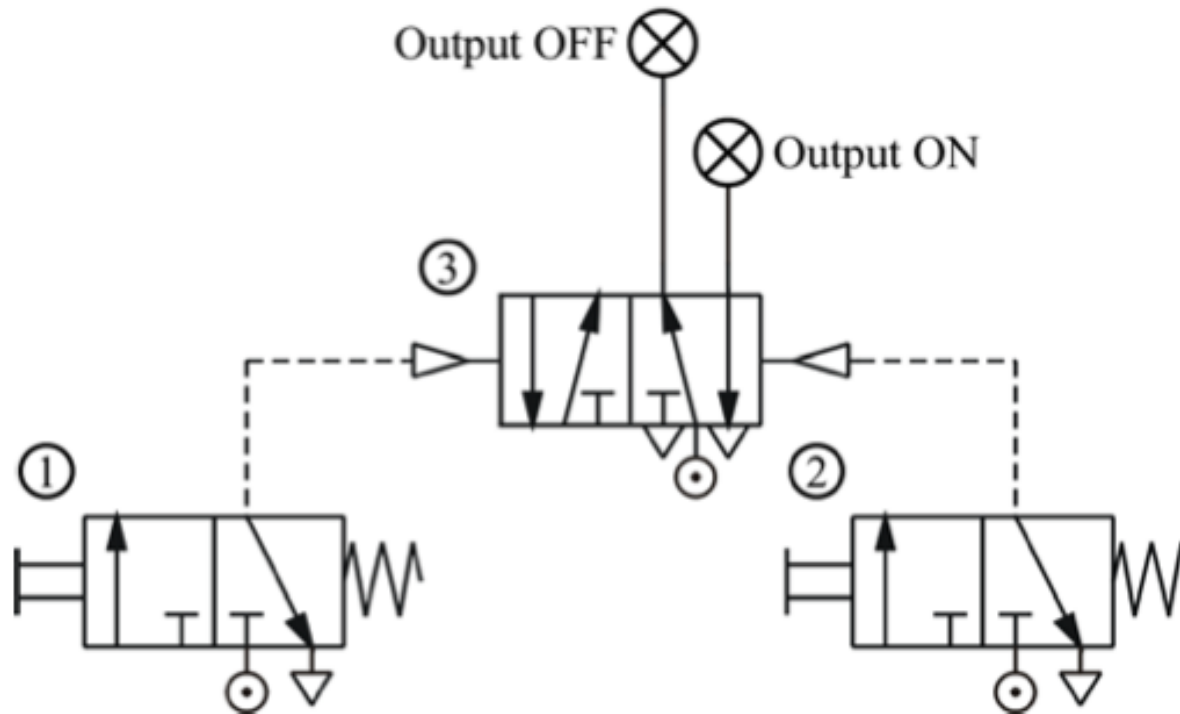
Example: Signal inversion



When valve in operation mode output is off



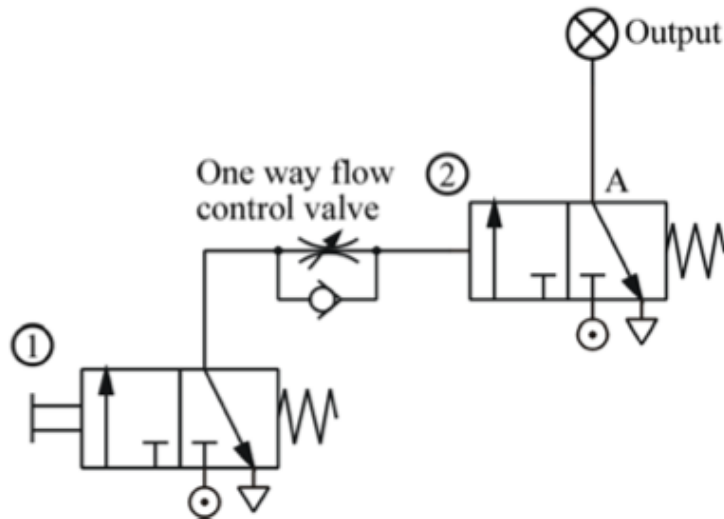
Example: Memory Function



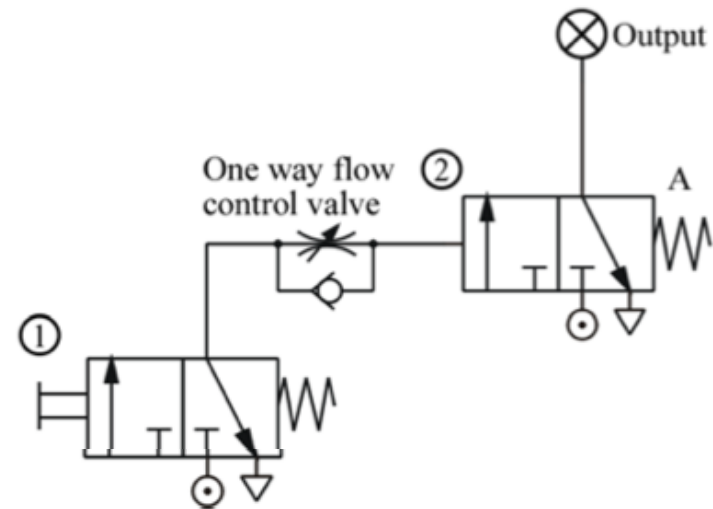
When valve 1 is operated output is on until valve 2 is on then output is off.



Example: Delay function



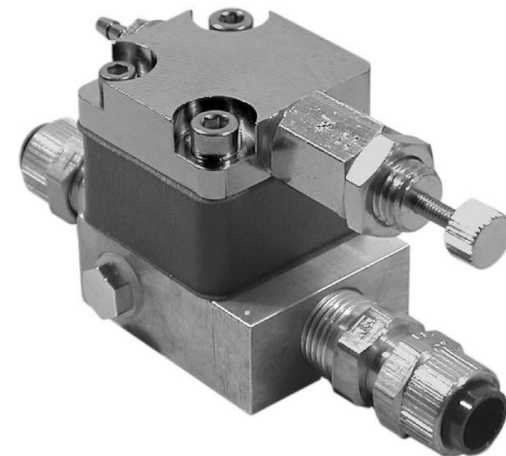
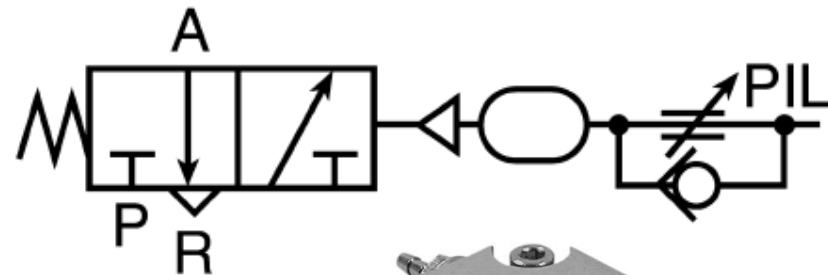
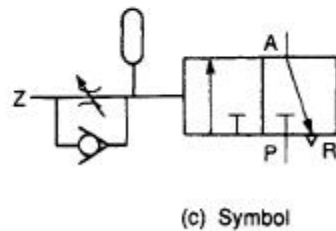
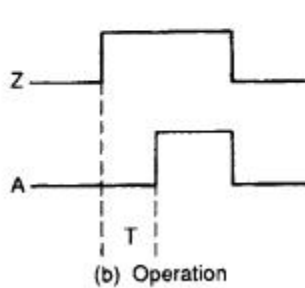
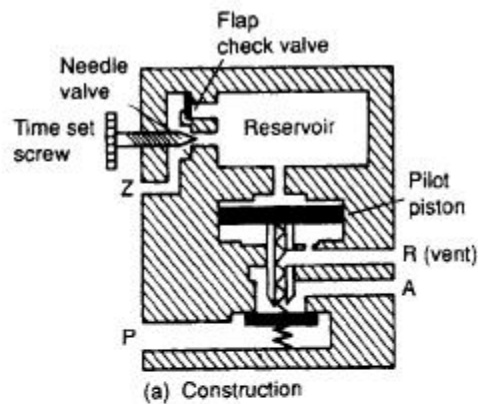
ON-signal delay



OFF-signal Delay



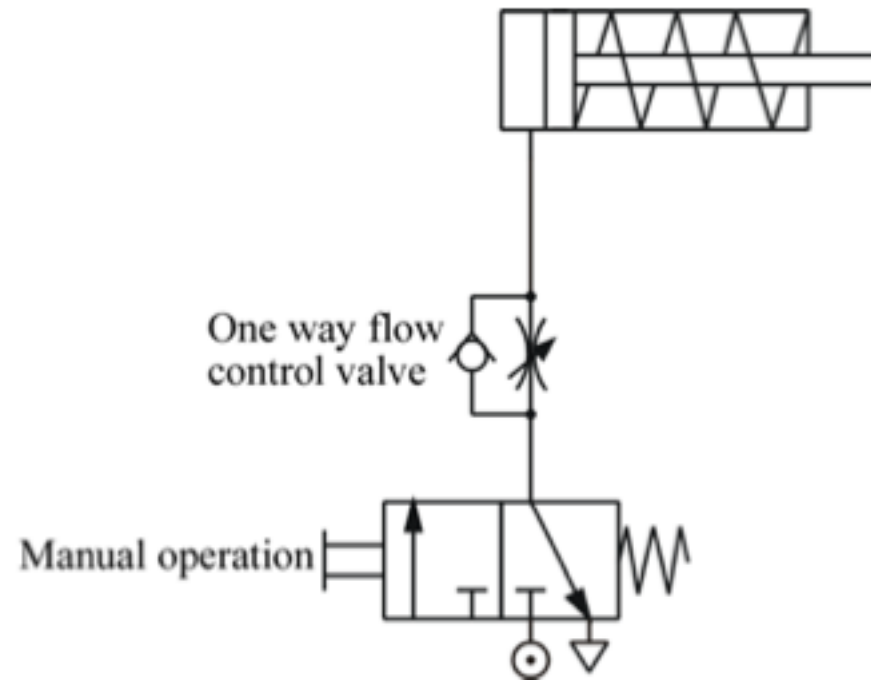
Example: Delay function cont.



Time delay valve

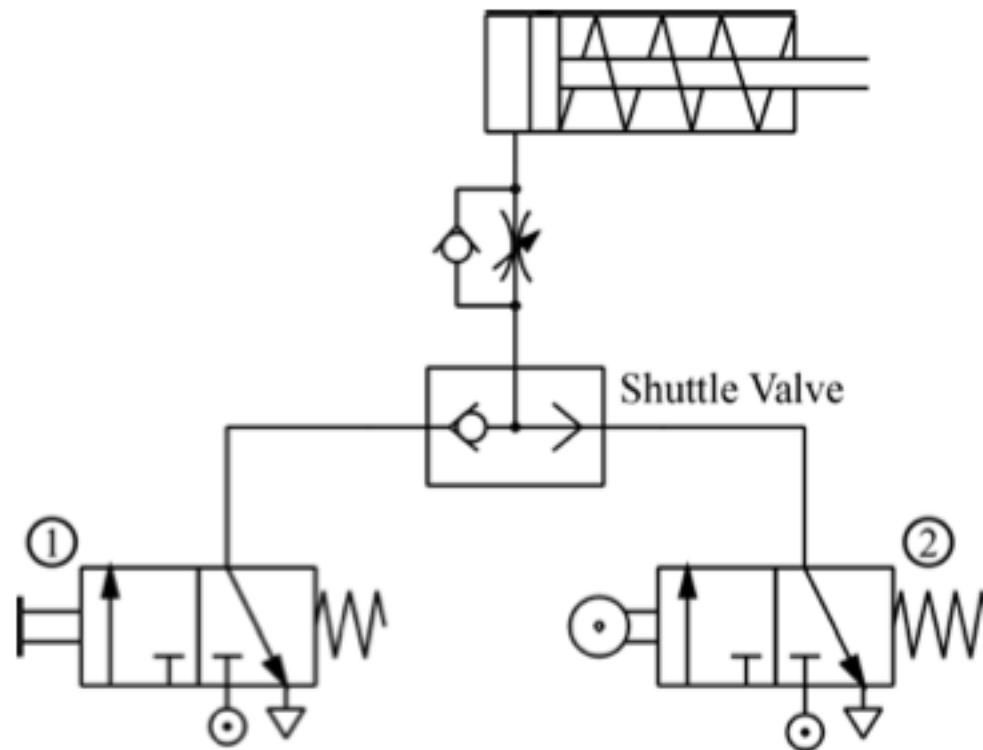


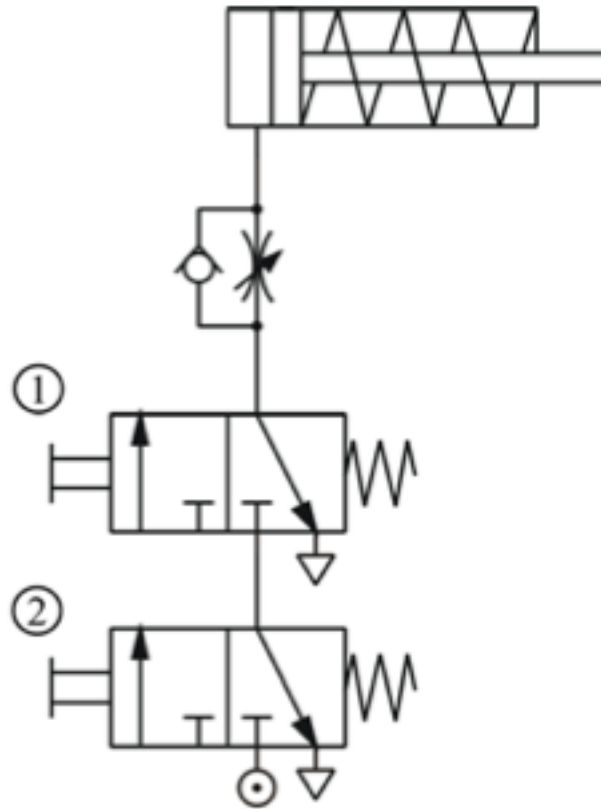
Example: Speed control





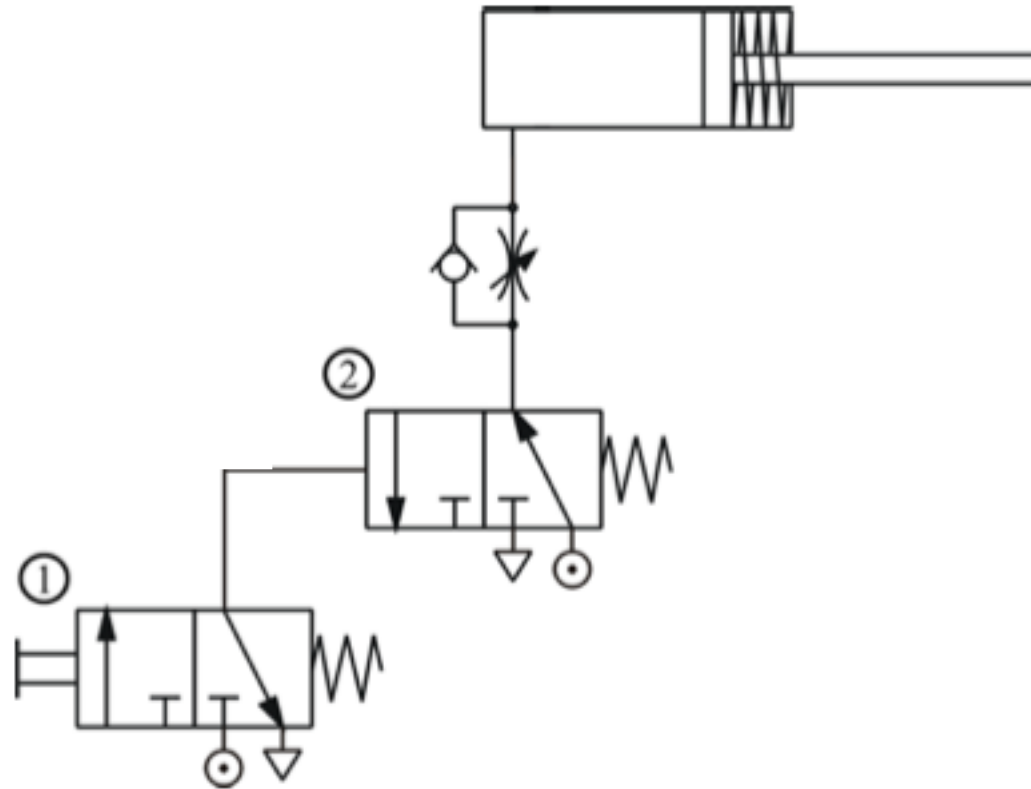
Example: OR Function





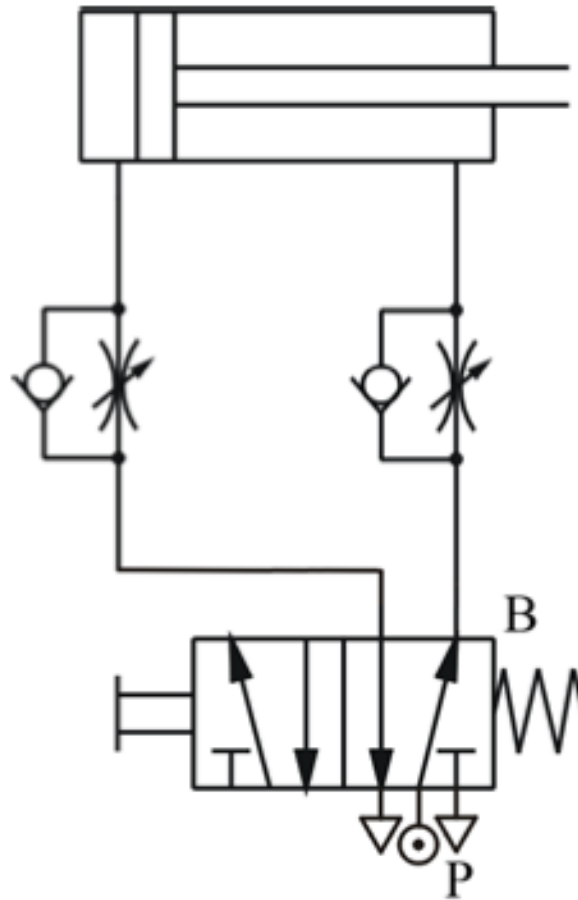


Example: NOT Function



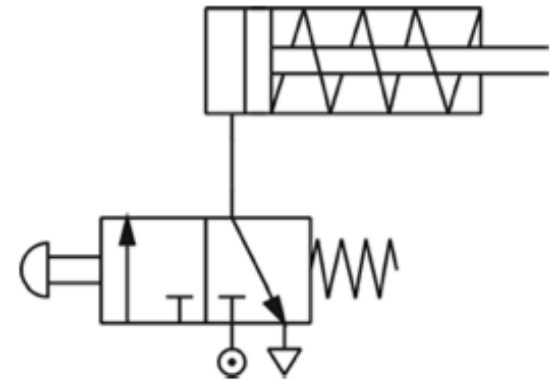
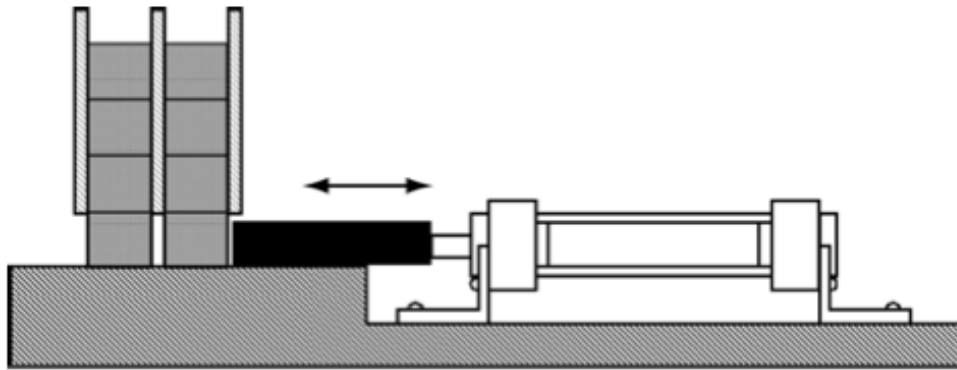


Example: Double acting cylinder



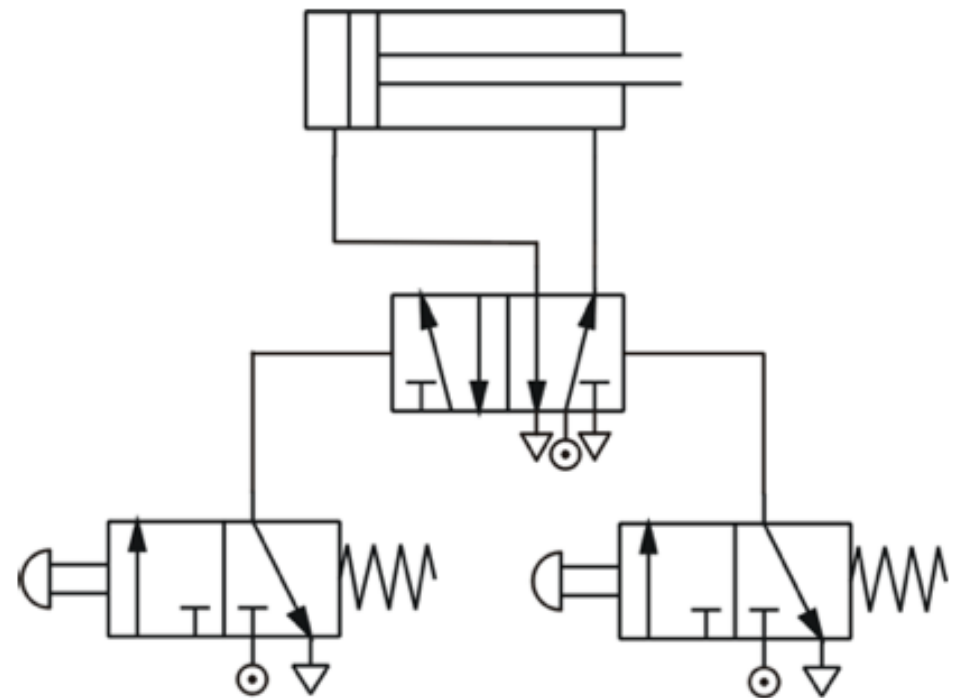
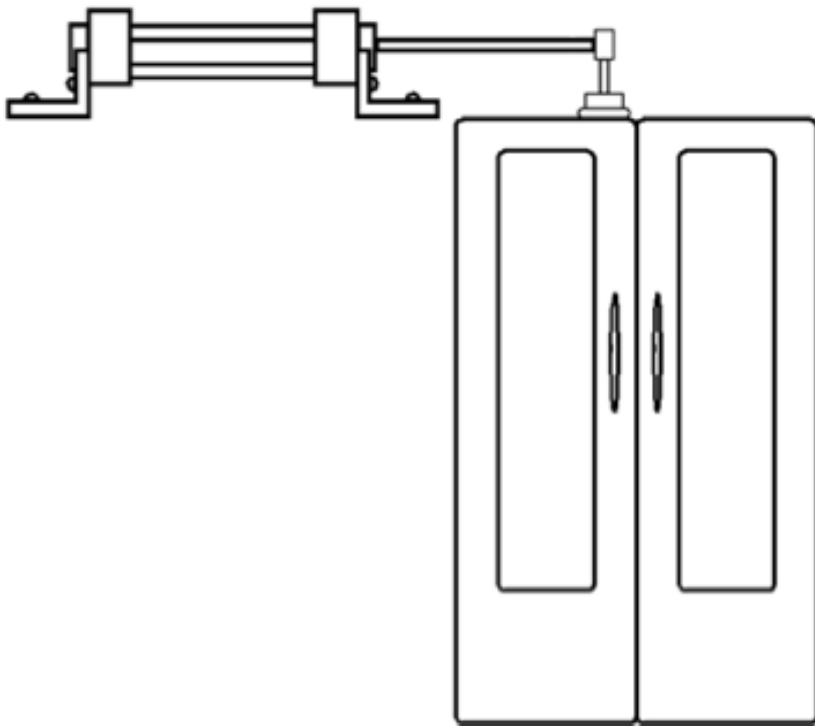


Example: Transport system





Example: Vehicle door operation system

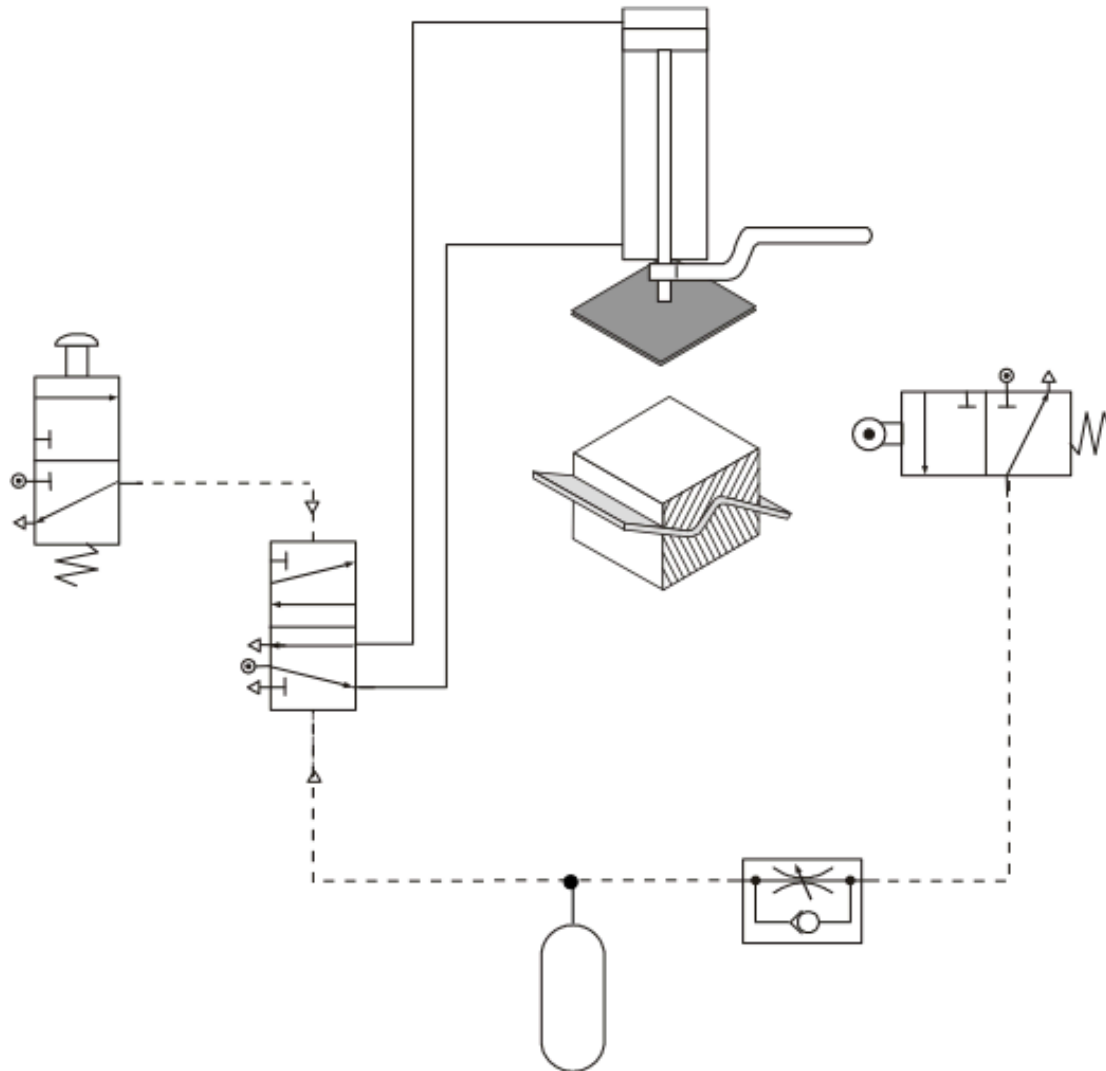


Controlling the movement
of the vehicle doors (OFF)

Controlling the movement
of the vehicle doors (ON)



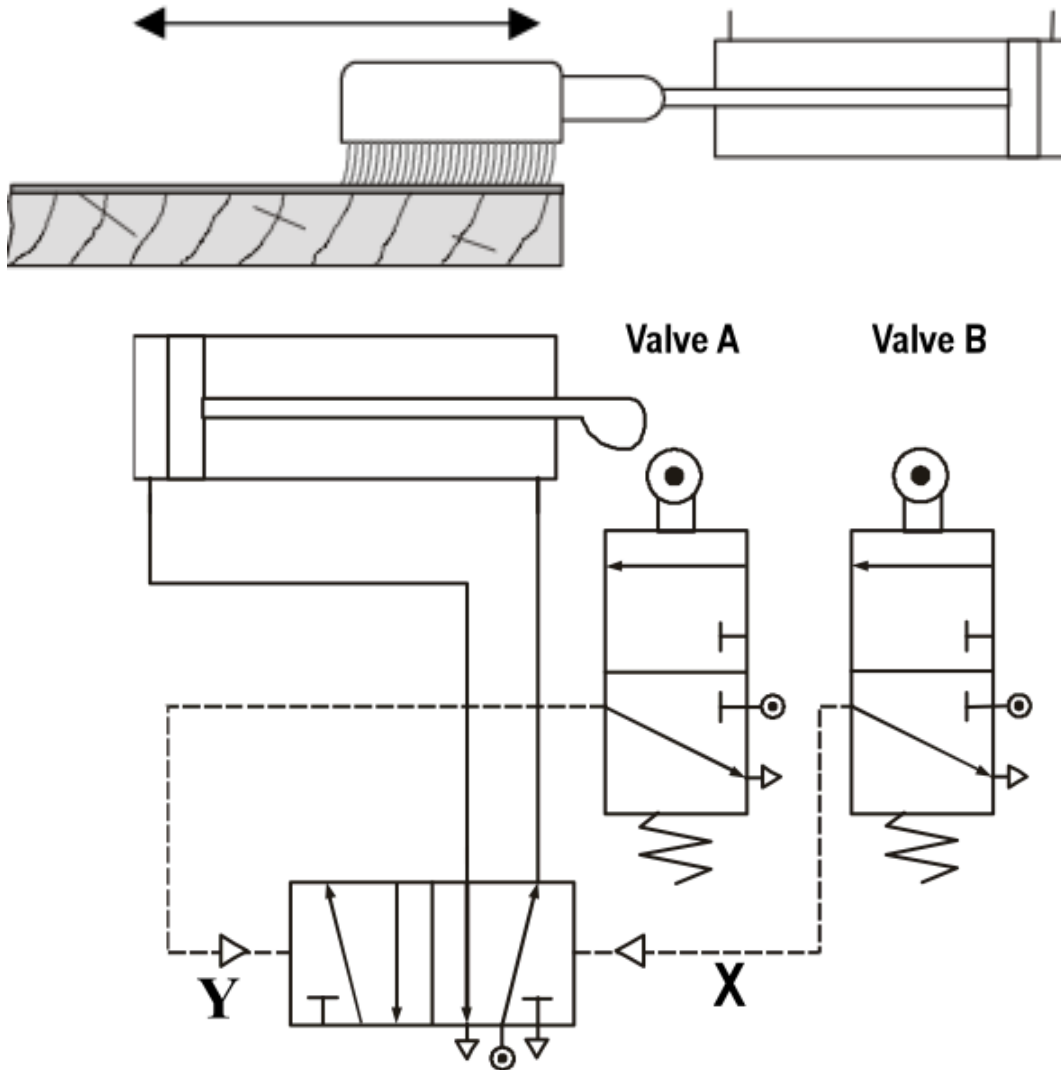
Example: Plastic forming



When the push button is pressed, the 5/2 valve changes state and the cylinder outstrokes. As it outstrokes, it pushes the former together and the hot plastic sheet is pressed into shape. As this happens it also actuates the roller. Air now flows through the restrictor and starts to fill up the reservoir. Once the reservoir is full, the 5/2 valve changes state and the cylinder instrokes, ready for the process to begin again.



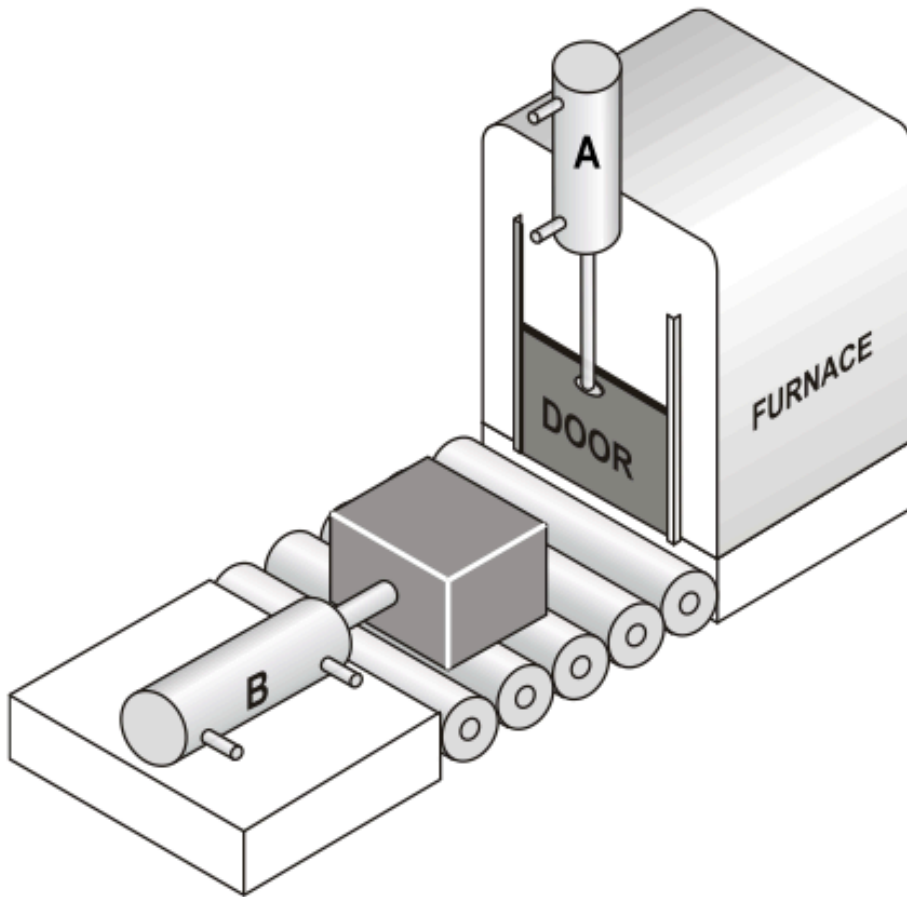
Example: full automatic circuit



As the piston instrokes, it trips valve A and the 5/2 valve changes state and the piston is sent positive. When it is fully outstroked, it trips valve B and the 5/2 valve returns to its original position, allowing the piston to instroke. The process begins all over again and continues to operate.



Example: Sequential control (furnace for heat treatment)



The sequence of operations for this process is as follows.

- (a) An operator pushes a button to start the process.
- (b) The furnace door is opened.
- (c) The block is pushed into the furnace and the piston instrokes.
- (d) The furnace door is closed.
- (e) The sequence stops.

