# Introduction to Hydraulics and Pneumatics

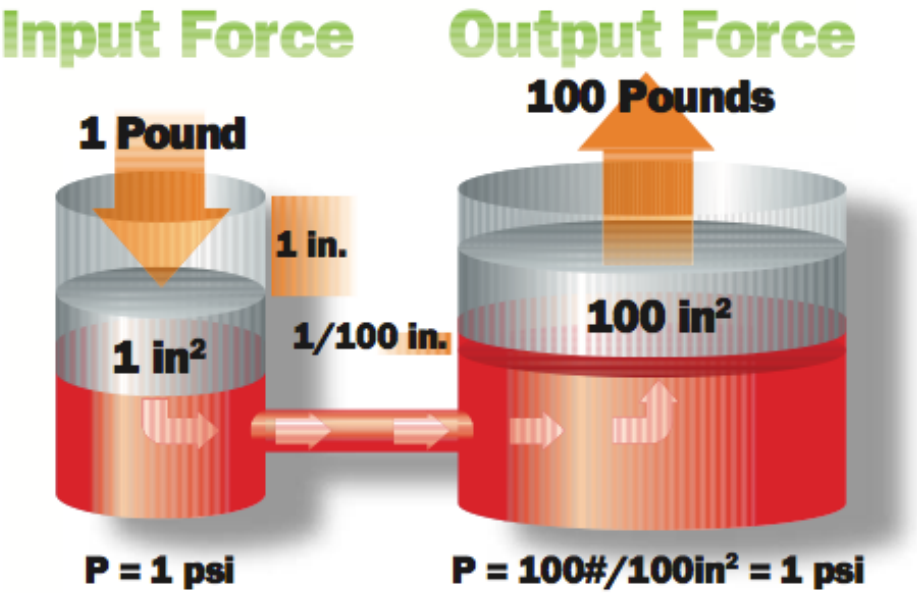
# Principles of Hydraulics

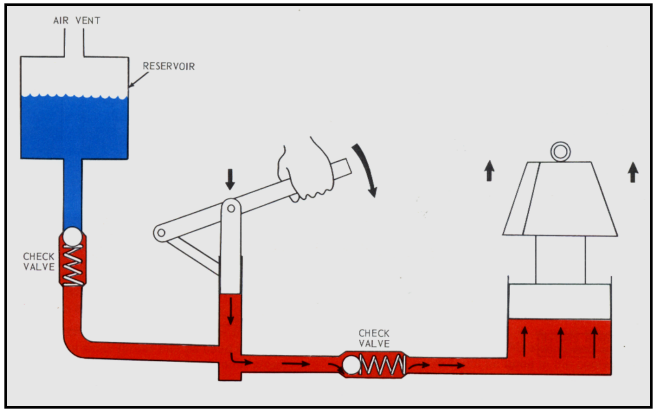
- The word “hydraulics” generally refers to power produced by moving liquids. Modern hydraulics is defined as the use of confined liquid to transmit power, multiply force, or produce motion.

- Pascal: “Pressure applied on a confined fluid is transmitted in all directions with equal force on equal areas”.

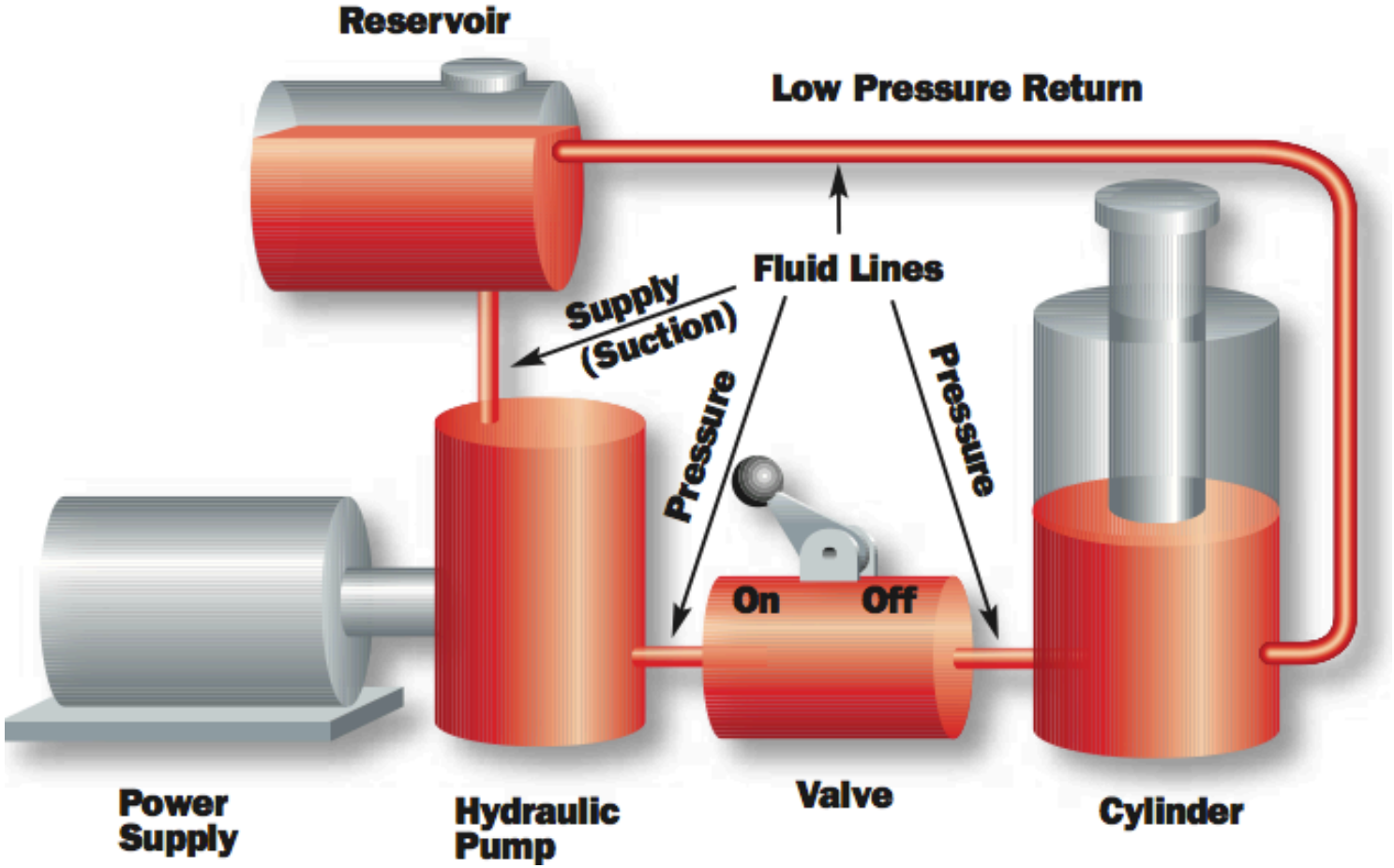
# Multiplication of Force

- Since liquid transmit 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

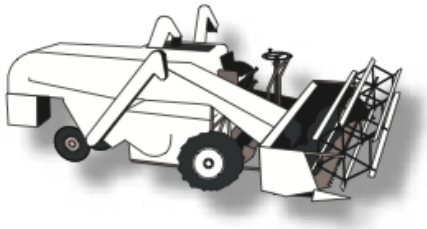
1. Fluid: oil for hydraulic systems, air for pneumatics.
2. Reservoir: storage tank.
3. Hydraulic pump (compressor in pneumatics): converts the mechanical energy into hydraulic energy by forcing fluid from the reservoir into the system.
4. Fluid lines: transport the fluid to and from the pump through 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



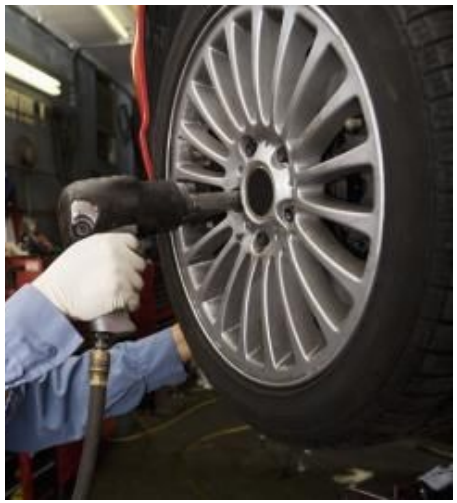
Combines/Harvesters

Midsize to Large Tractors

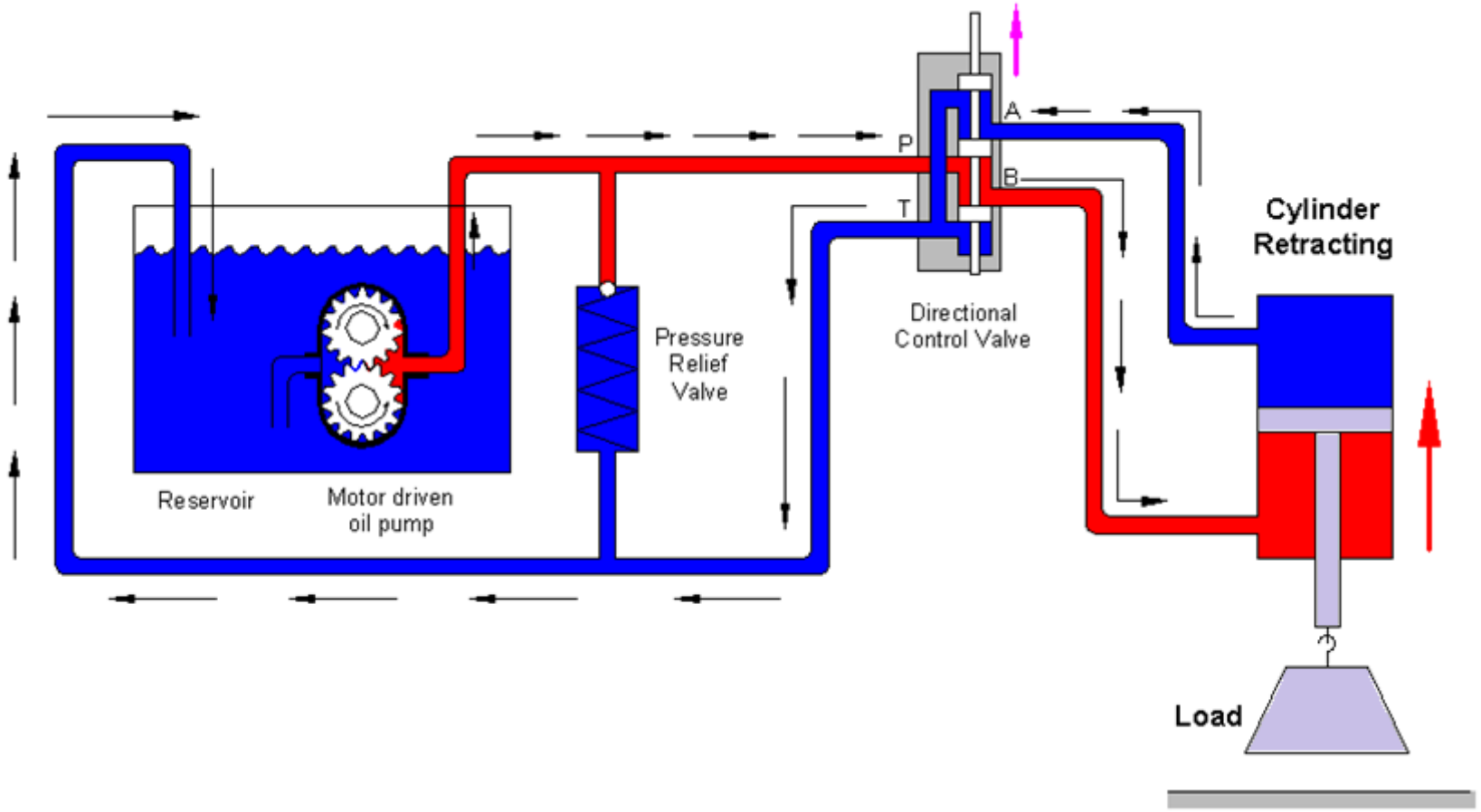
Dozers/Crawlers

Hauler Trucks

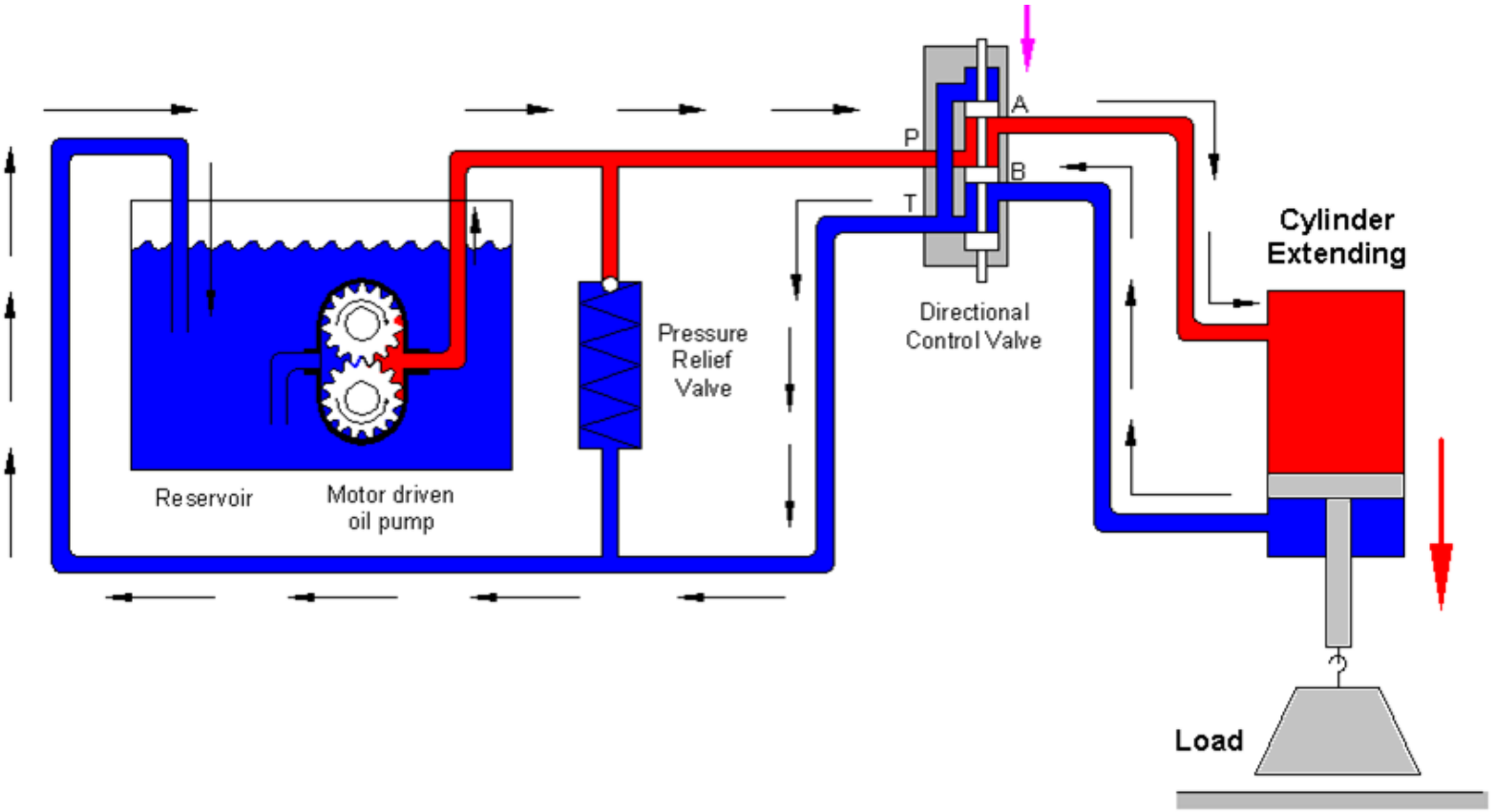
Excavators



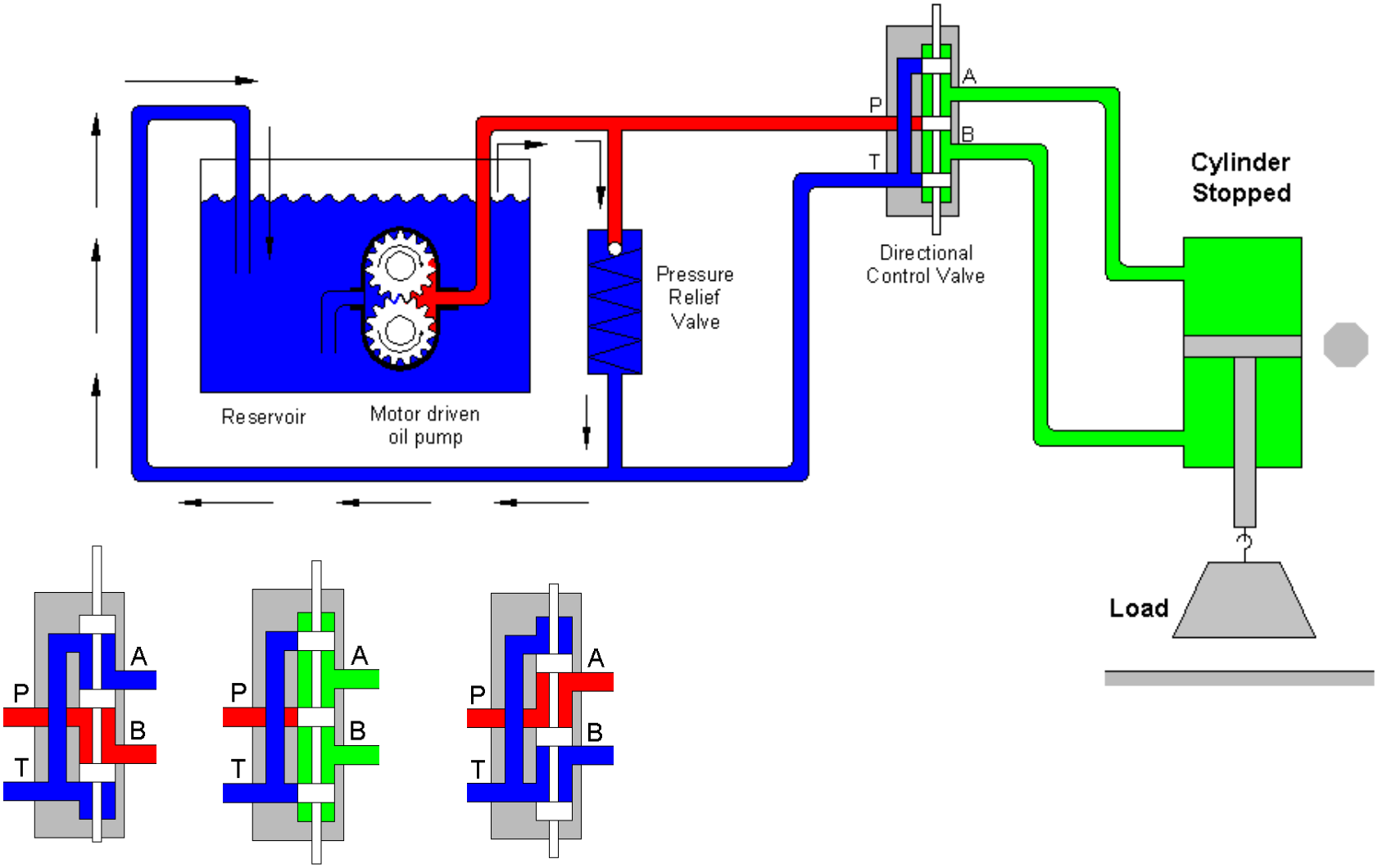
# Example: lifting a load



# Example: lifting a load



# Example: lifting a load

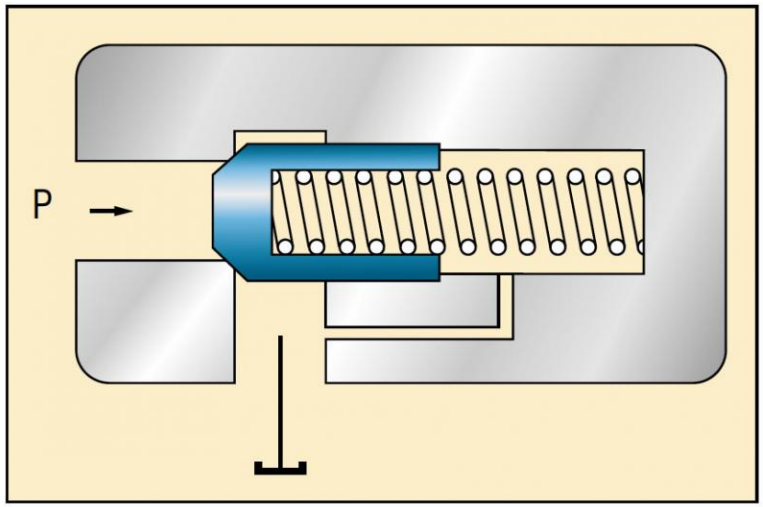


# Control valves

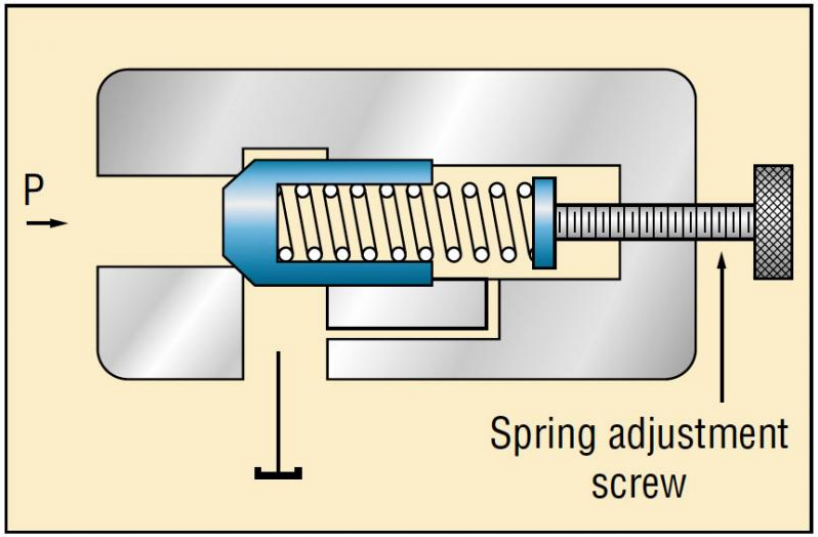
**Control valves:** are valves used to control conditions such as flow, pressure, and direction of flow.

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

# Pressure Control Valves

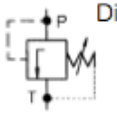
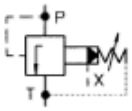
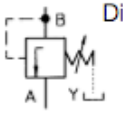
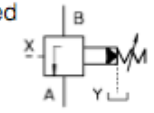
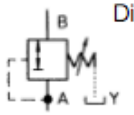
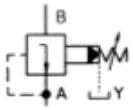
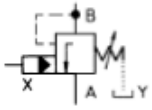



A pressure control valve is used to reduce the amount of pressure in a tank or system of pipes.

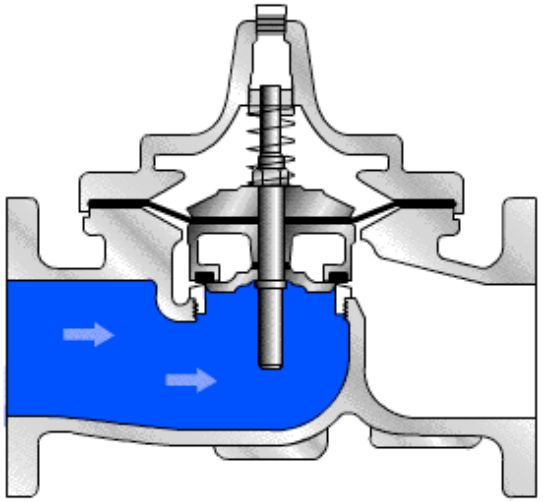


# Pressure Control Valves

**PRESSURE CONTROL VALVES**

| | |
|---|---|
| **Pressure relief valve**<br>Direct operated  <br>Pilot operated  | **Sequence valve**<br>Direct operated  <br>Pilot operated  |
| **Pressure reducing valve**<br>Direct operated  <br>Pilot operated  | **Counterpressure valve**<br>  |

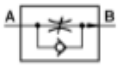
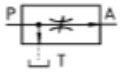
# Flow Control Valves



Used to control fluid flow

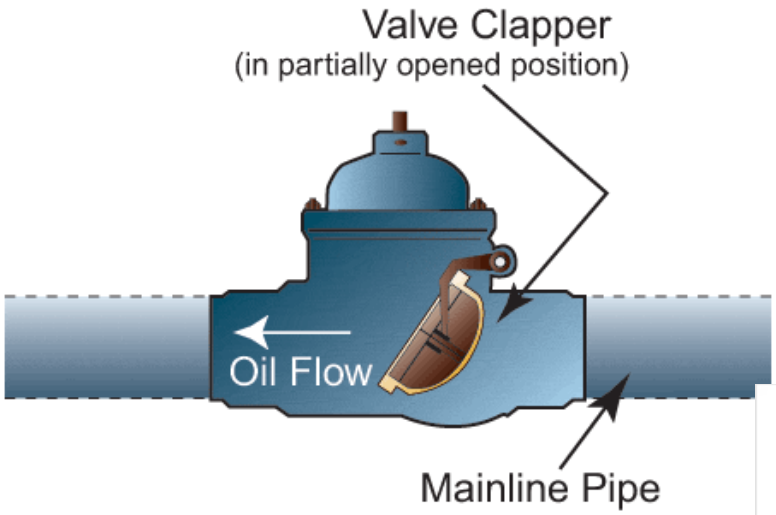
# Flow Control Valves

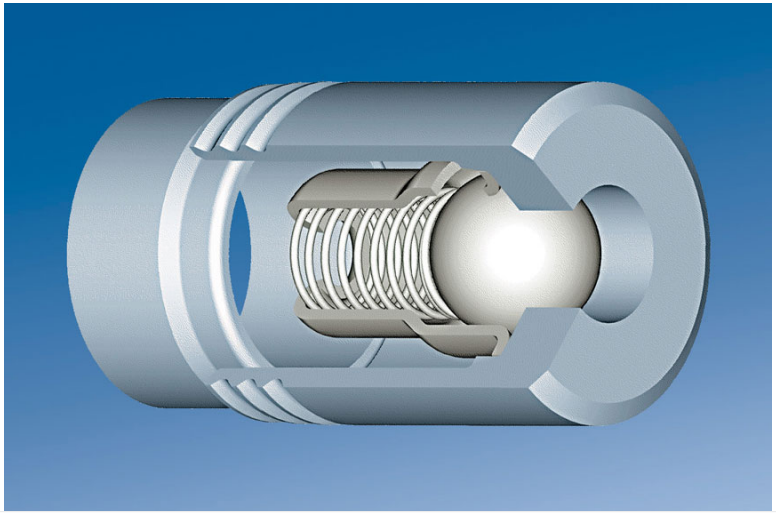
**FLOW CONTROL VALVES**

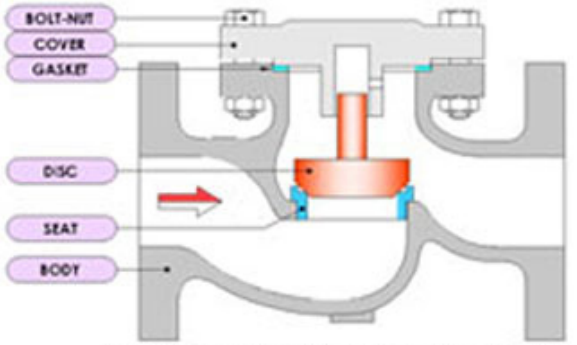
| Variable throttling valve | | Compensated flow regulator | |
|---|---|---|---|
| Two way | With check | Two-way | Three-way |
|  |   |   |   |

# Directional control valves

- Check Valves



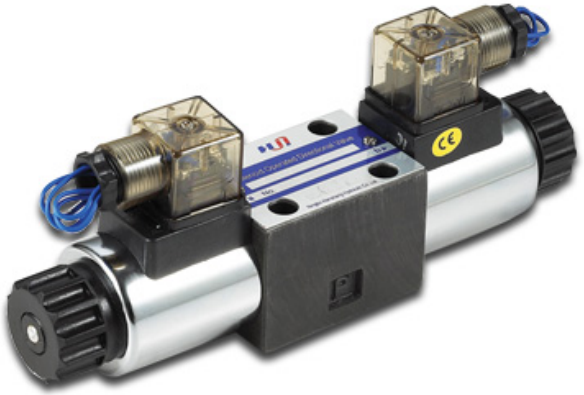



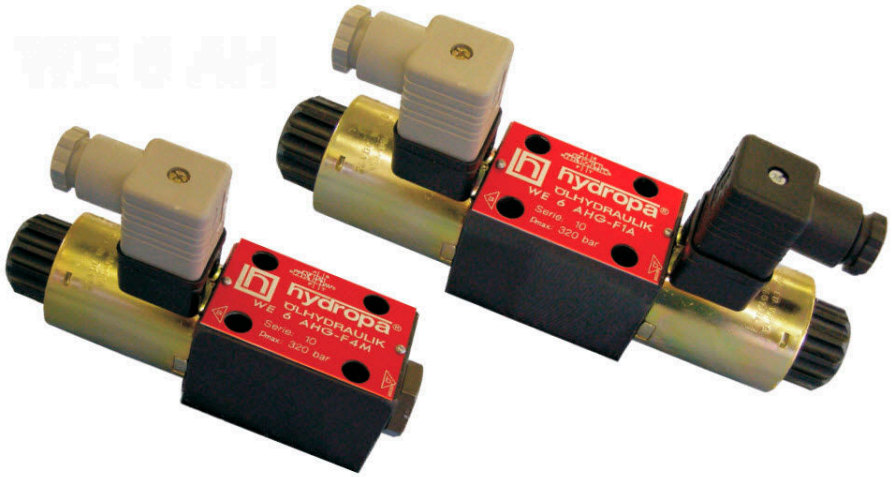


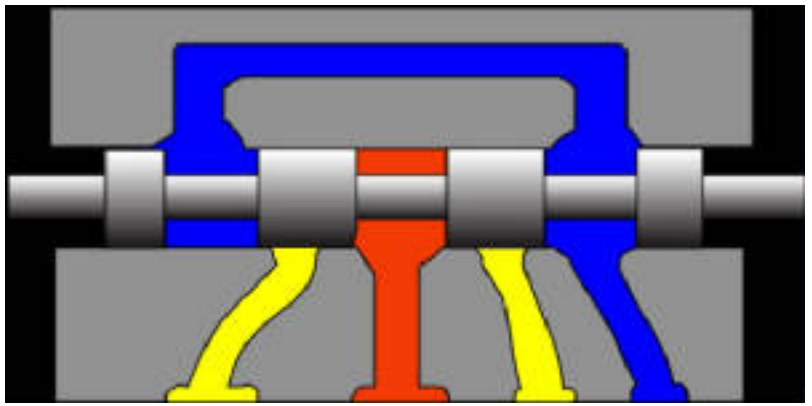

Check Valve Lift Type ND -Model

# Directional control valves

- Directional valves

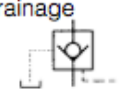





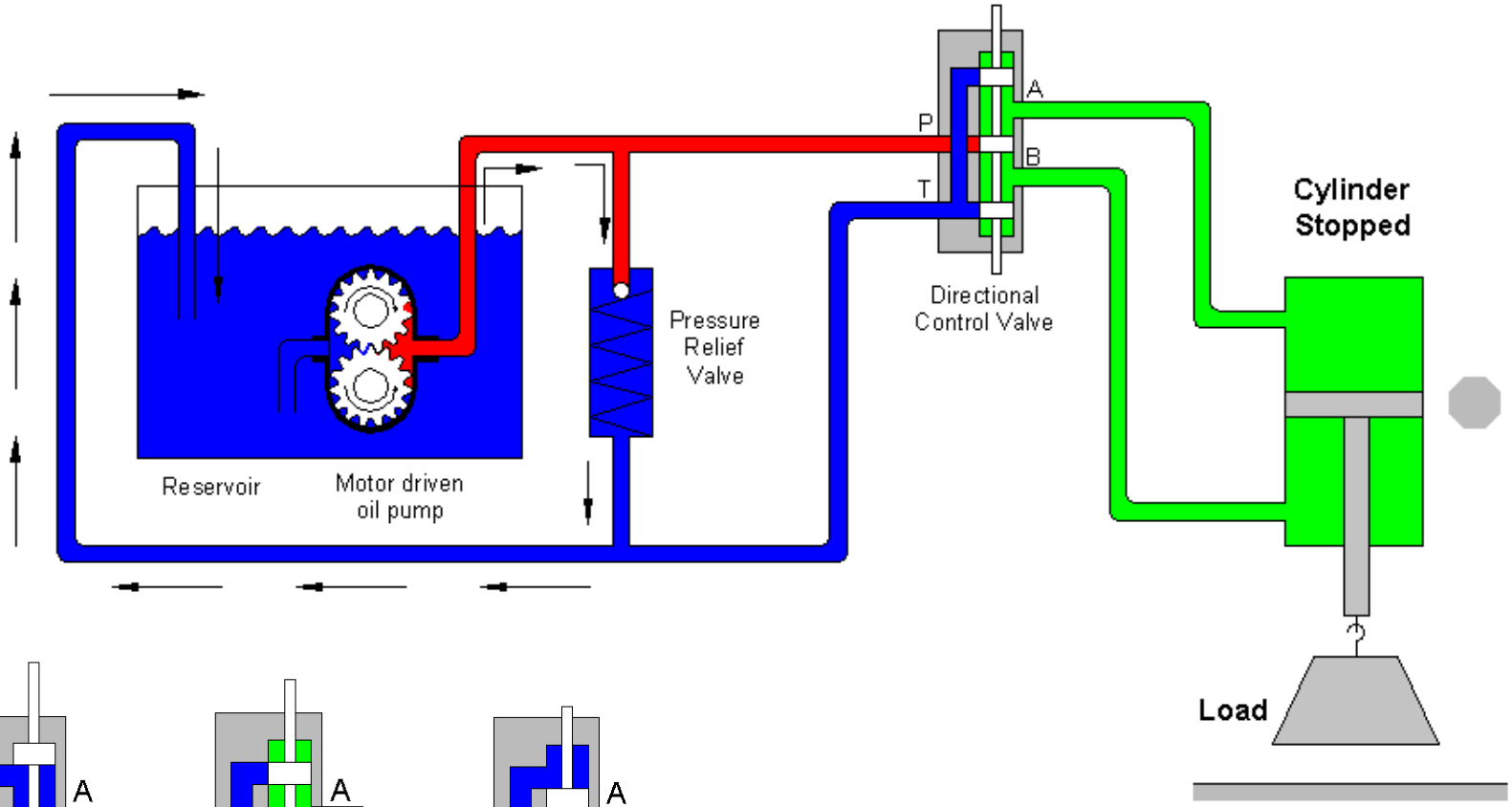



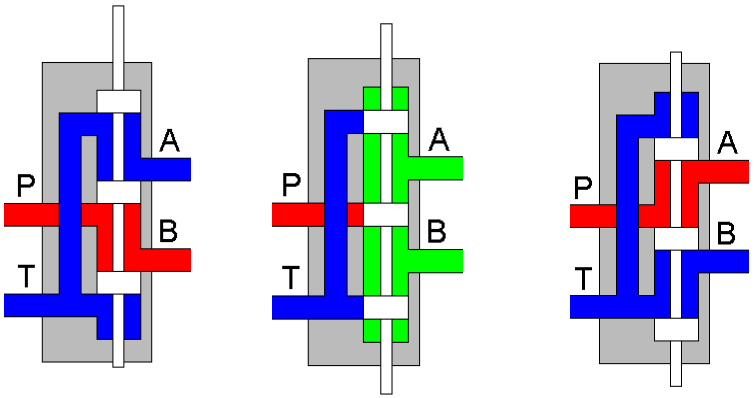
# Directional valves

**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



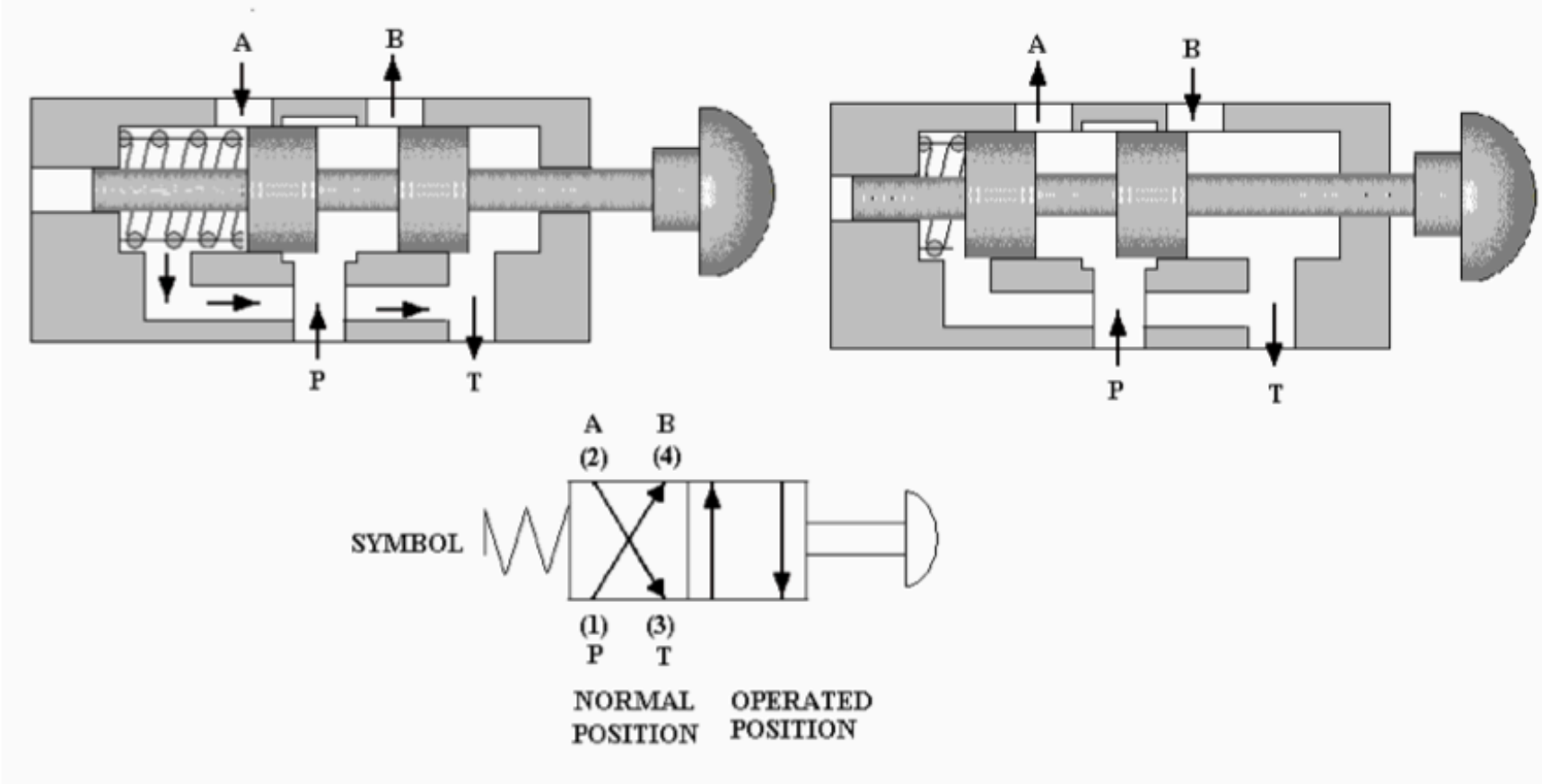




The valve shown has 4 ports and 3 positions so it is designated as a 4/3 directional control valve.

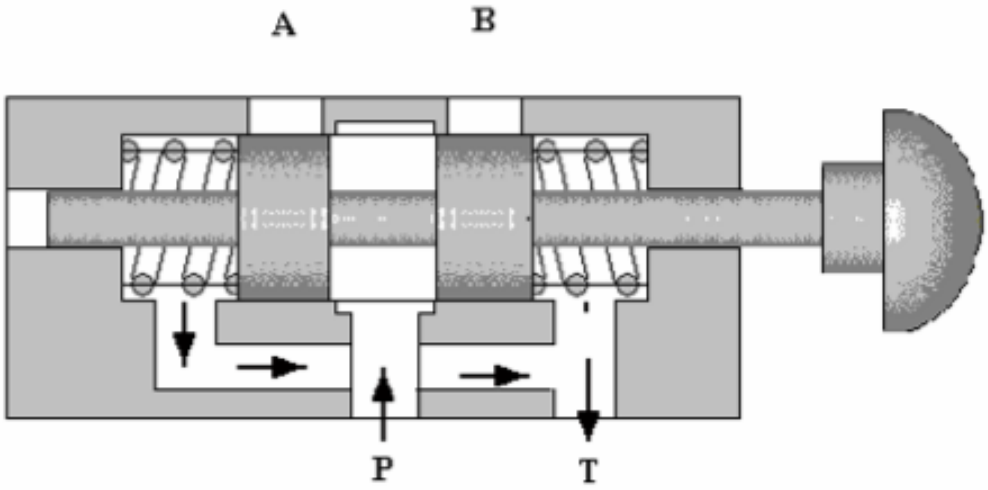
# Symbols

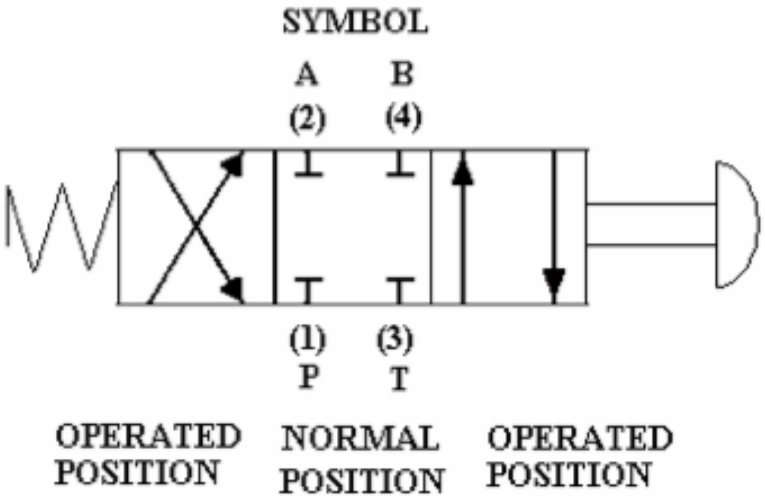
- In hydraulics the pressure port is designated P and the return port R or T (for tank). The two other ports are designated A and B.
- Boxes to identify normal and operating positions.
- Arrows to identify flow directions.
- In Pneumatics the pressure port is numbered (1) and the exhaust port (3). The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

# Example: 4-ports 2-position directional control valve

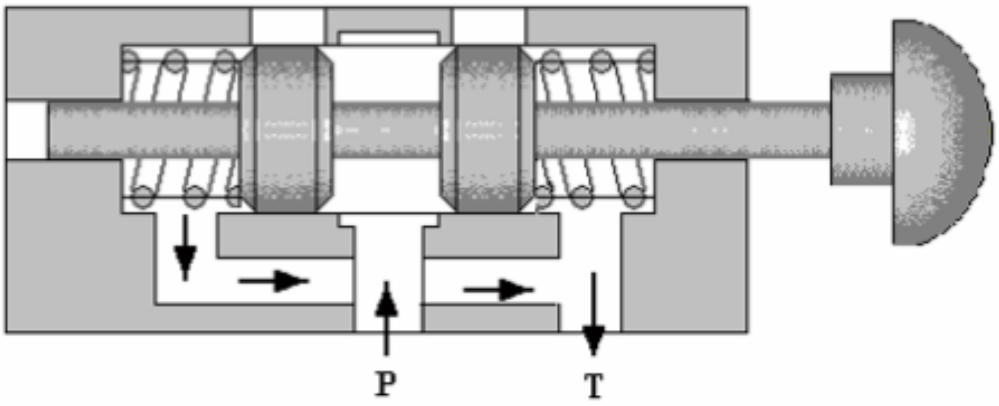


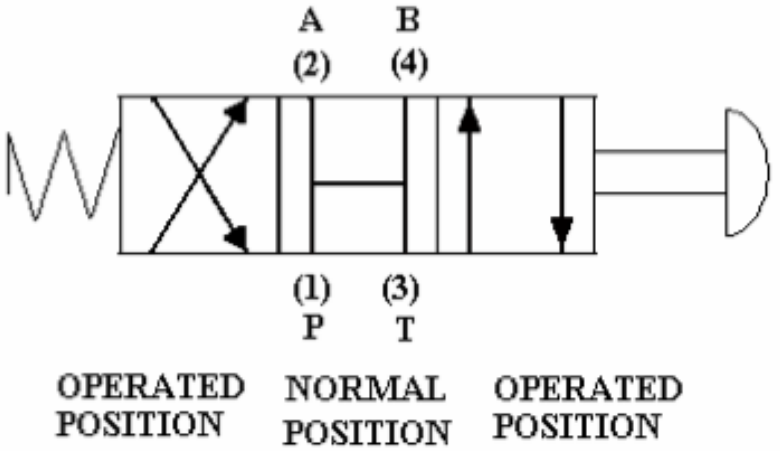
# Example: 4-ports 3-position directional control valve



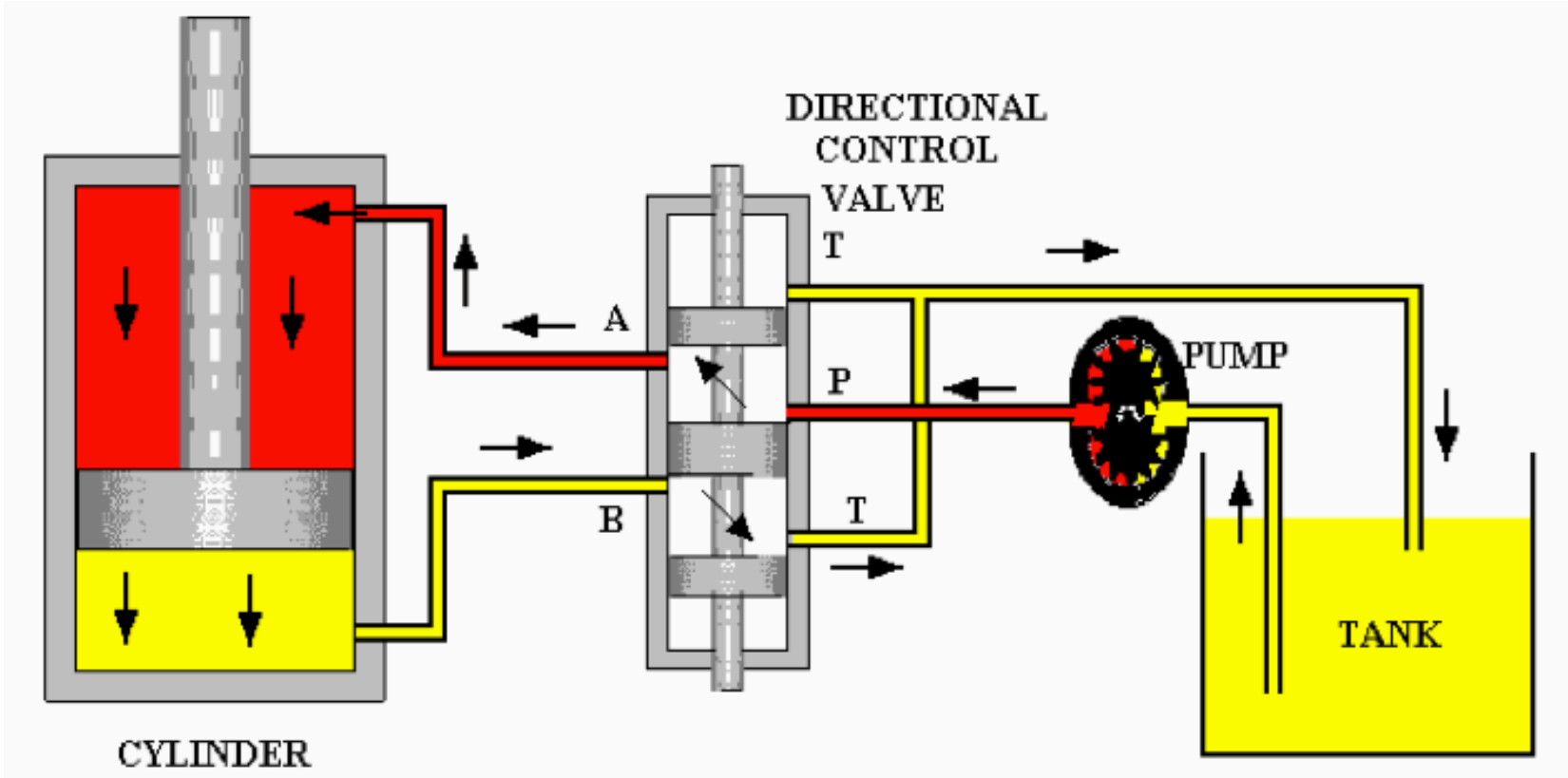



# Example: 4-ports 3-position directional control valve



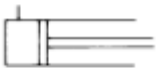
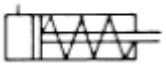
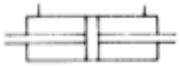
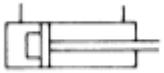
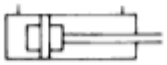
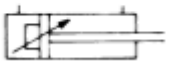
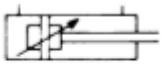
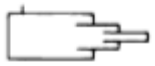



# Example: 5-ports 3-position directional control valve



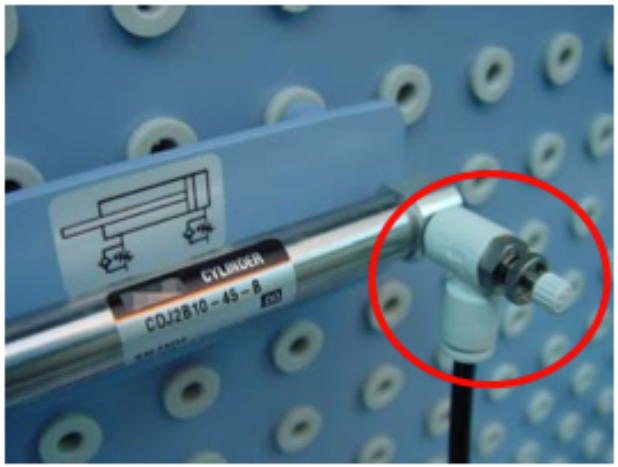
# Cylinders

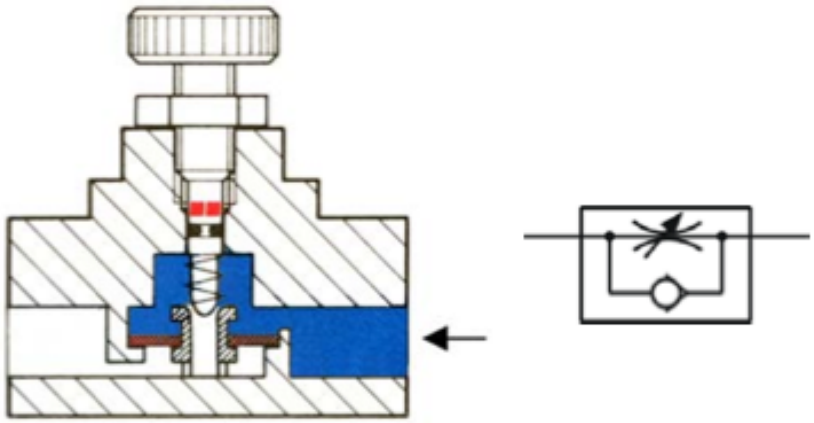
**CYLINDERS**

| 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

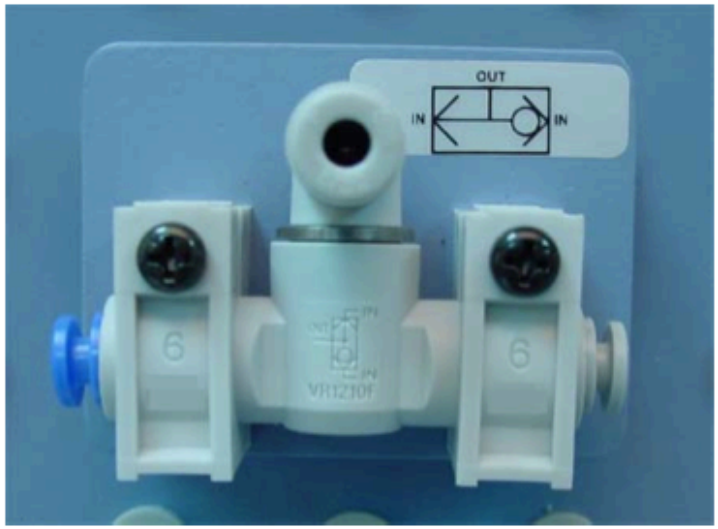
# Flow control valve (with check)

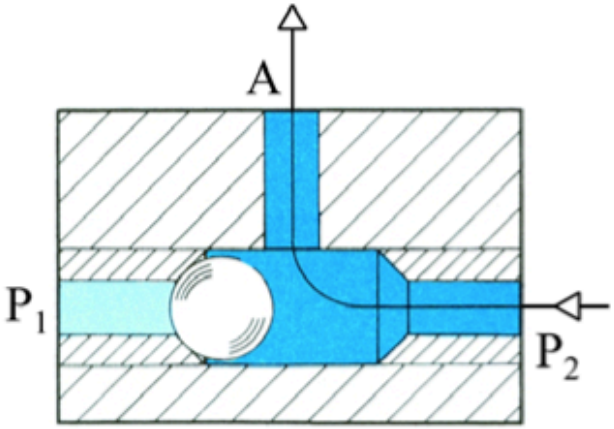


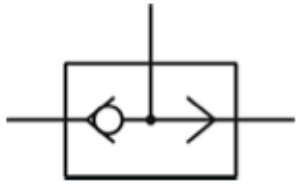



# Shuttle valve

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.



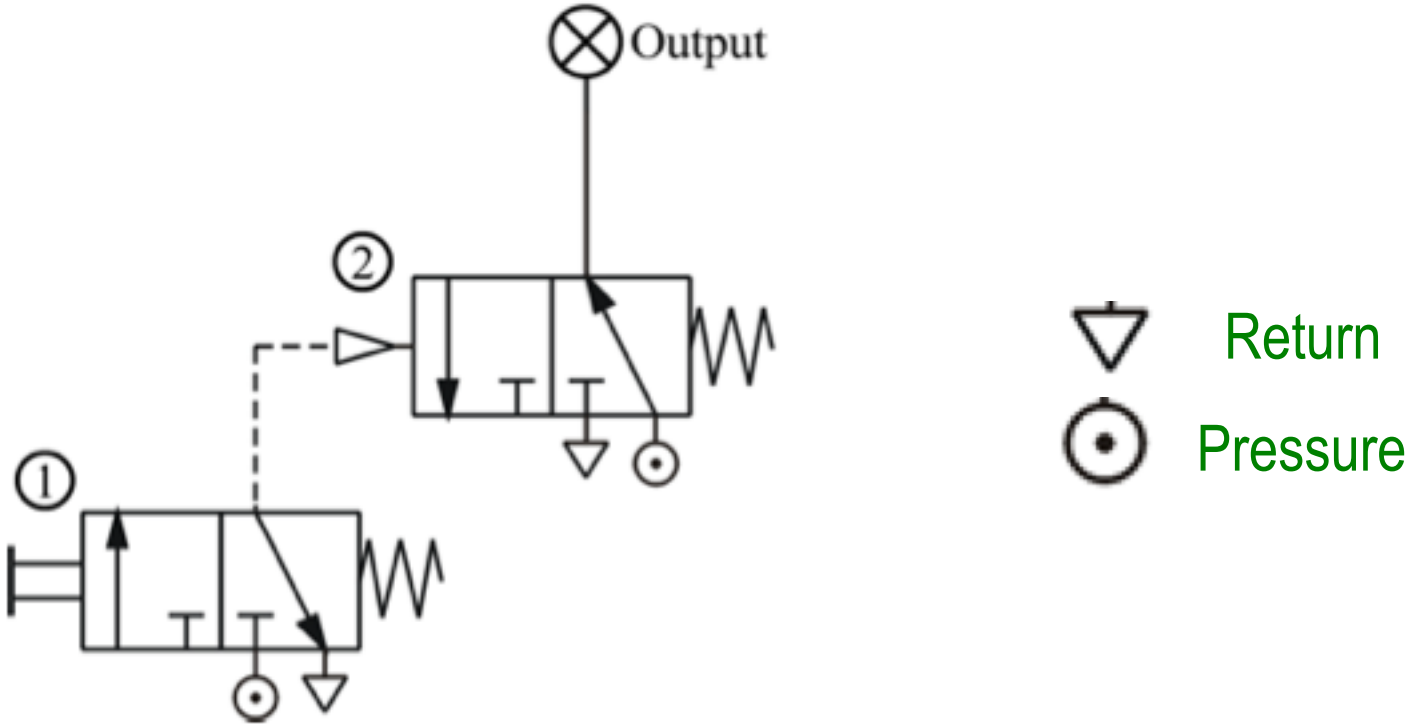
# Pneumatic circuits

- 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.

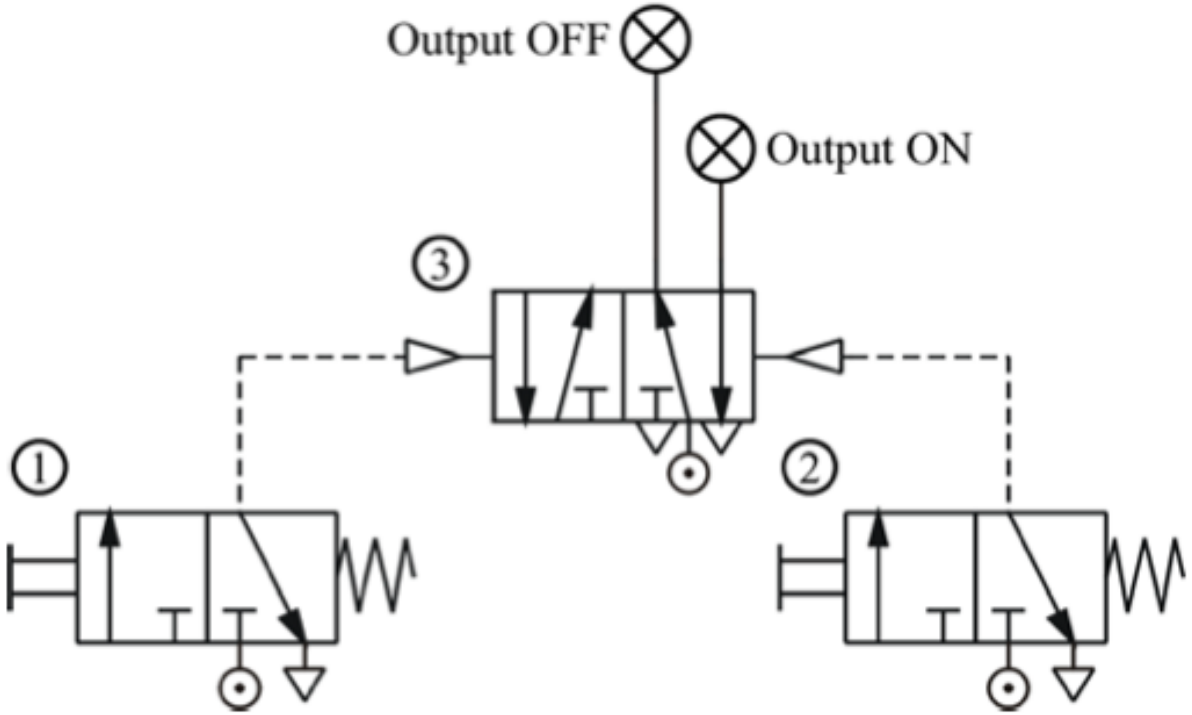
- Displayed as Pneumatic circuit diagram.

# Example: Signal inversion



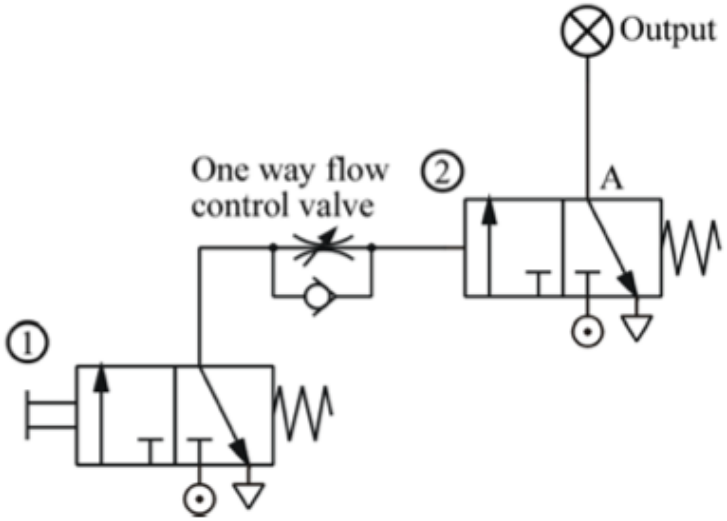

When valve in operation mode output is off

# Example: Memory Function

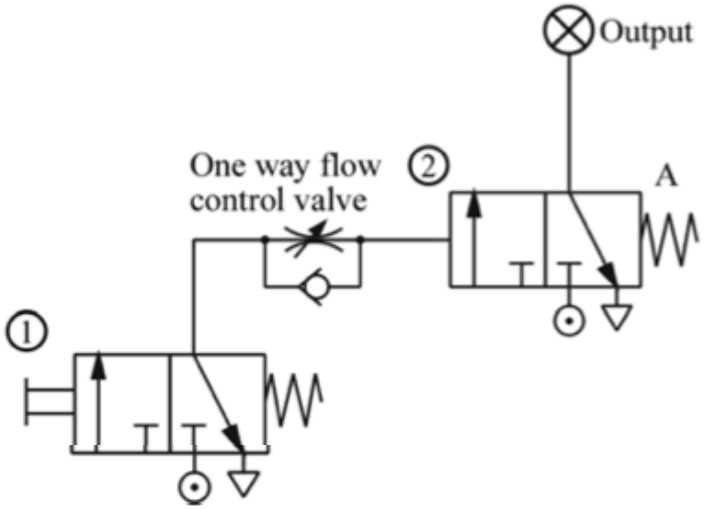



When valve 1 is operated output is on until valve 2 is on then output is off.

# Example: Delay function

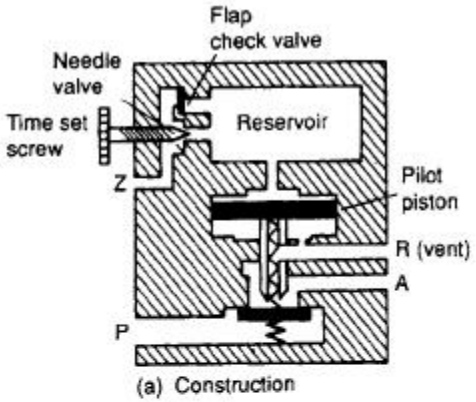



ON-signal delay

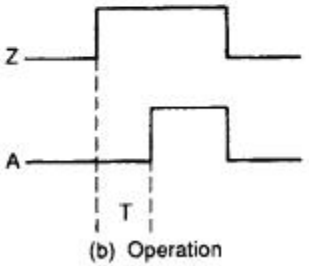



OFF-signal Delay

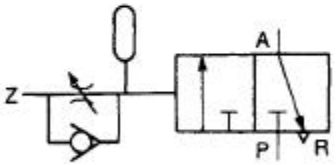
# Example: Delay function cont.



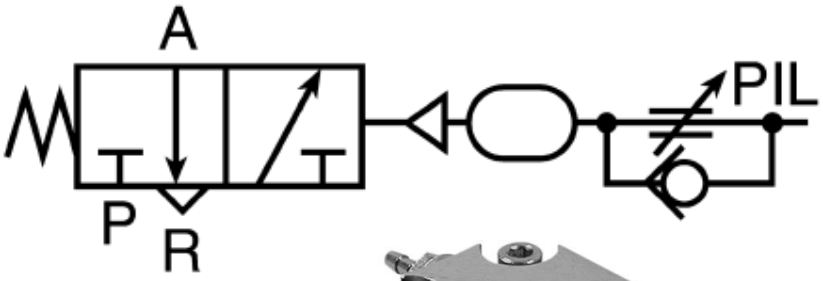
(a) Construction

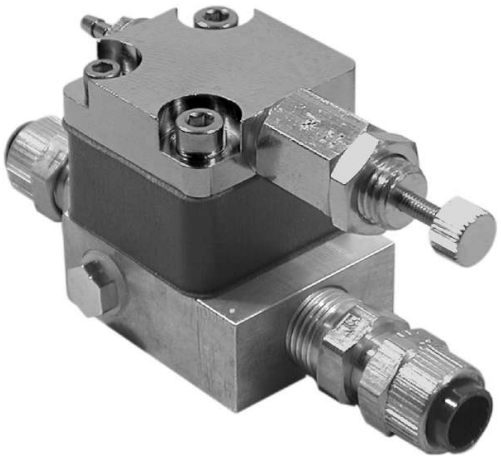


(b) Operation



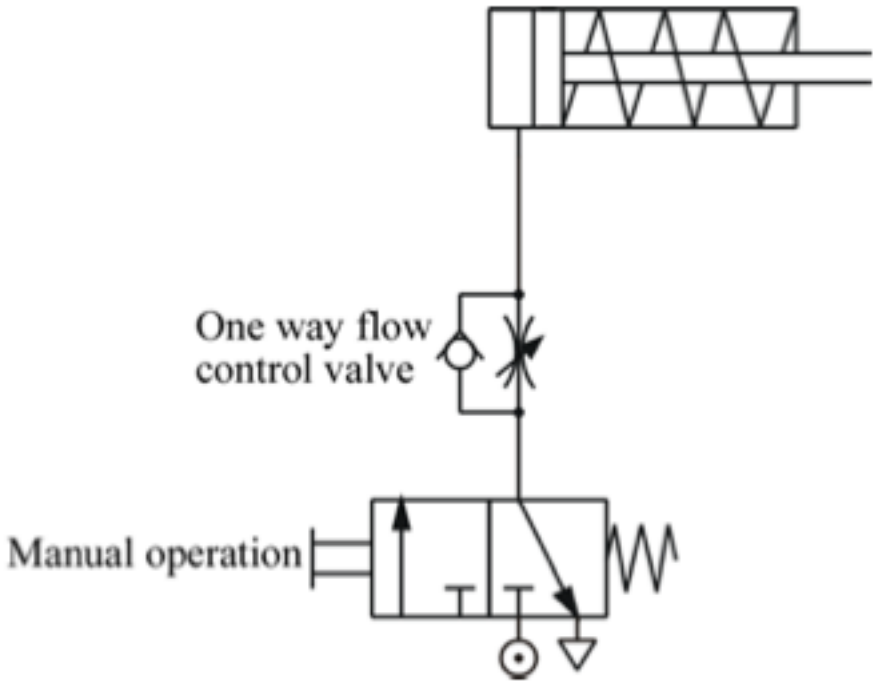
(c) Symbol



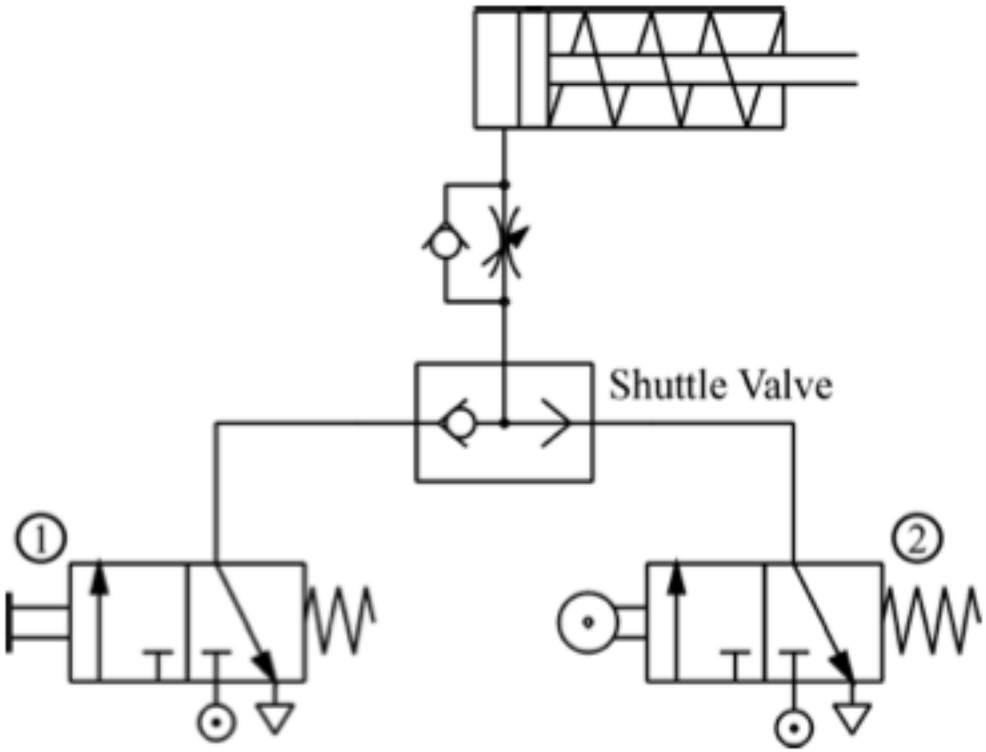




Time delay valve

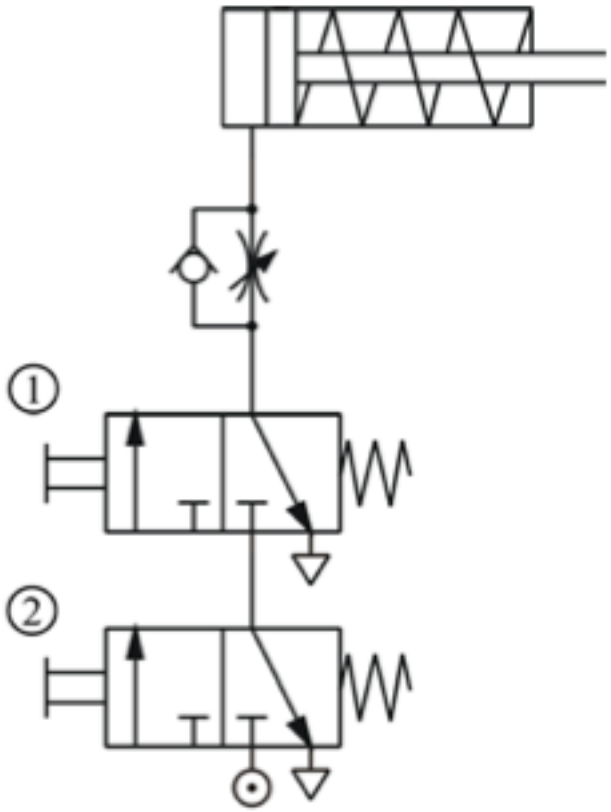
# Example: Speed control



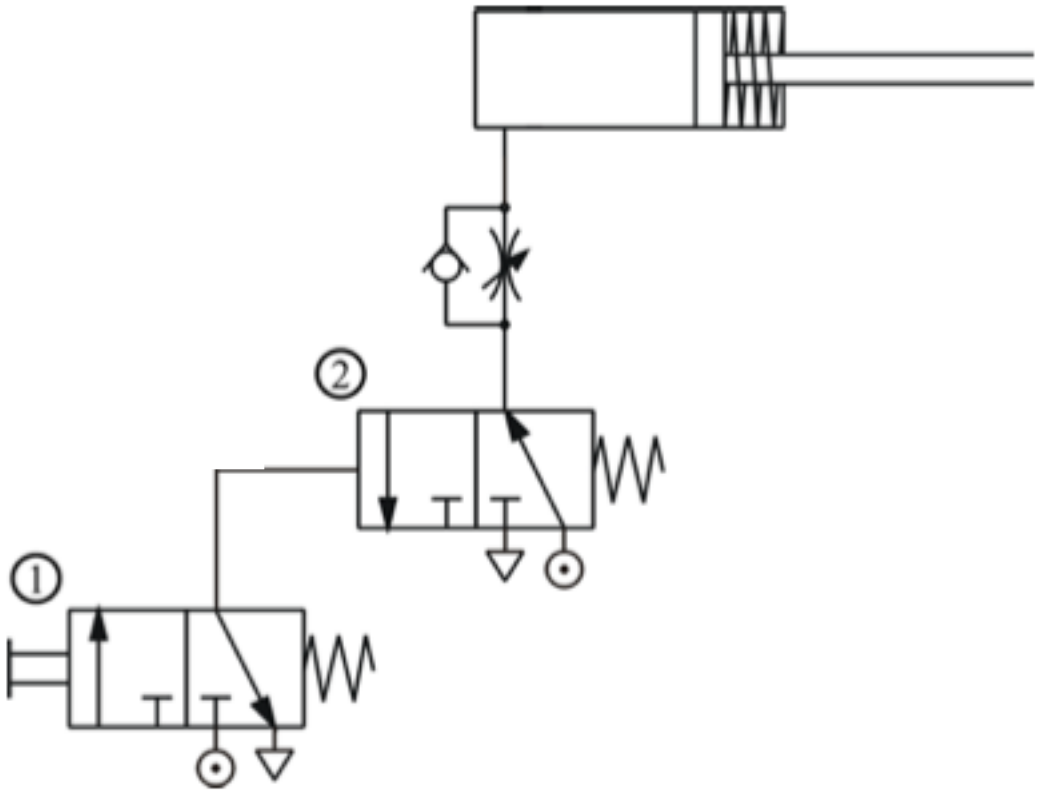
# Example: OR Function



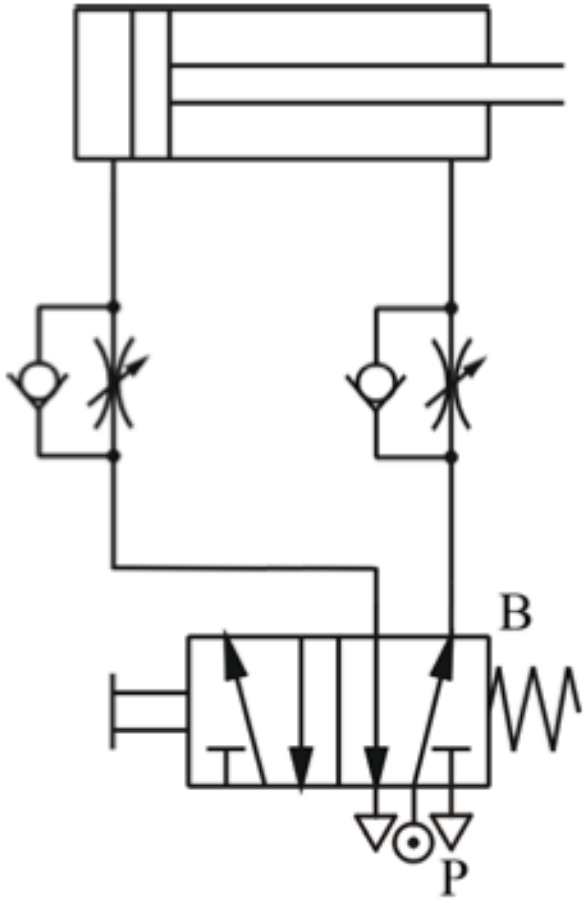
# Example: AND Function



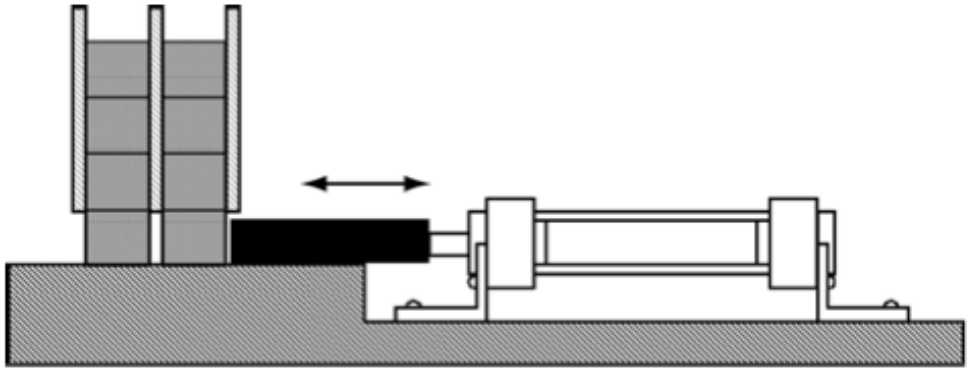
# Example: NOT Function

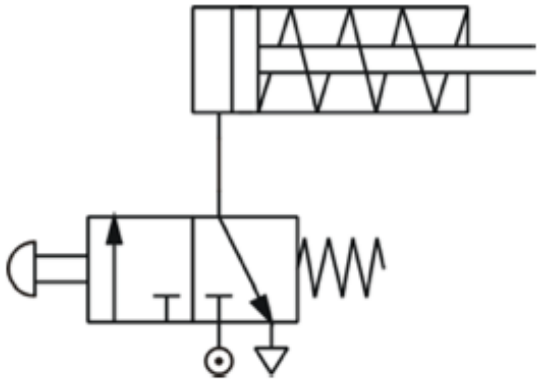


# Example: Double acting cylinder

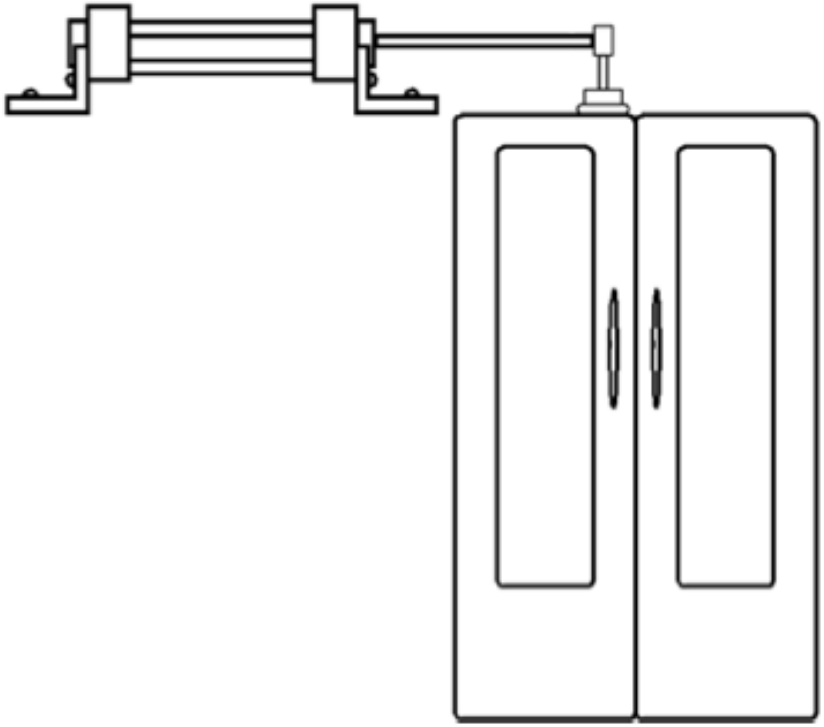


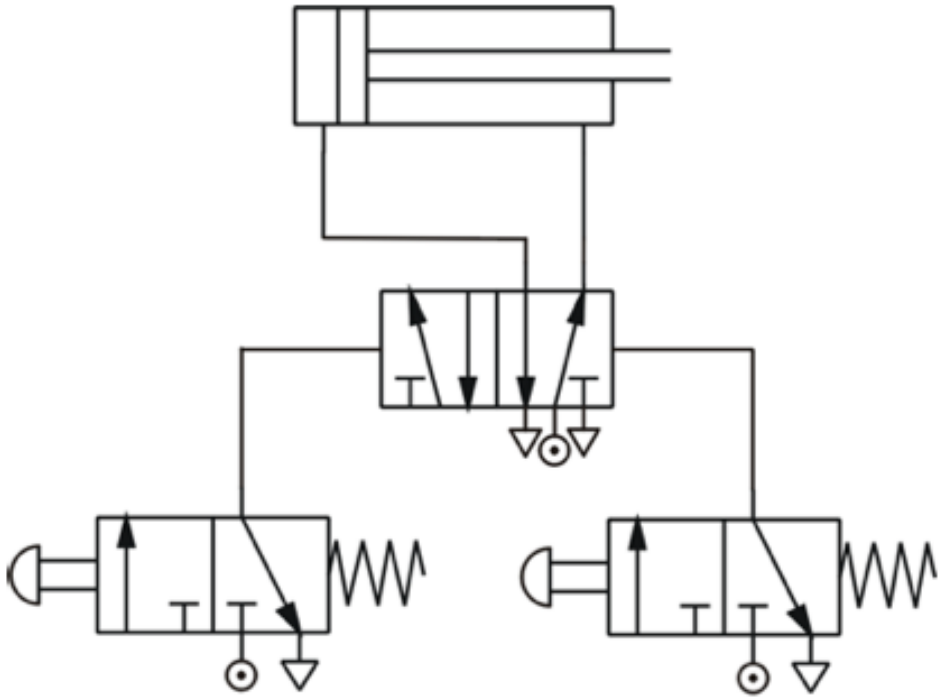
# Example: Transport system





# Example: Vehicle door operation system

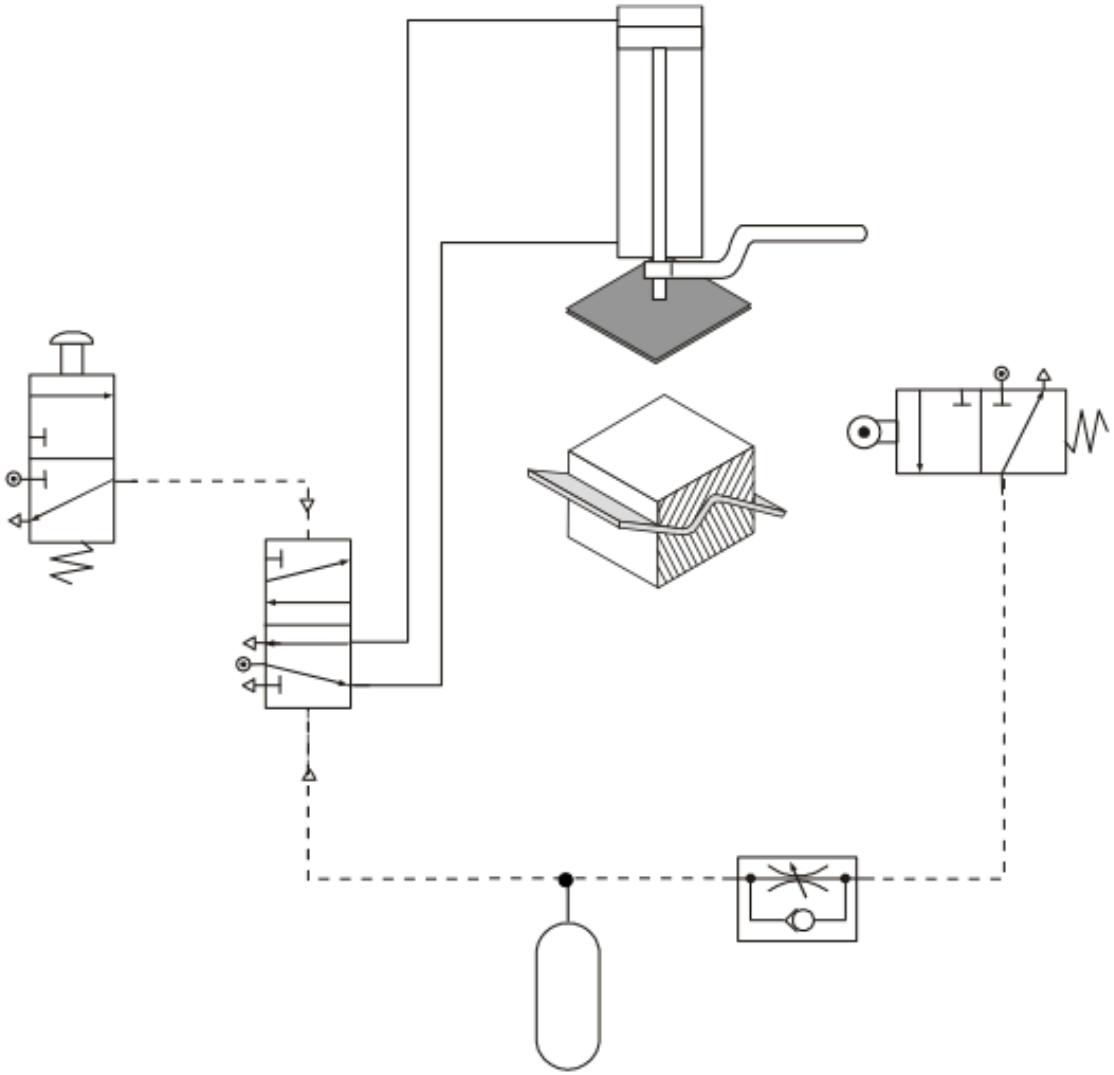




Controlling the movement of the vehicle doors (OFF)

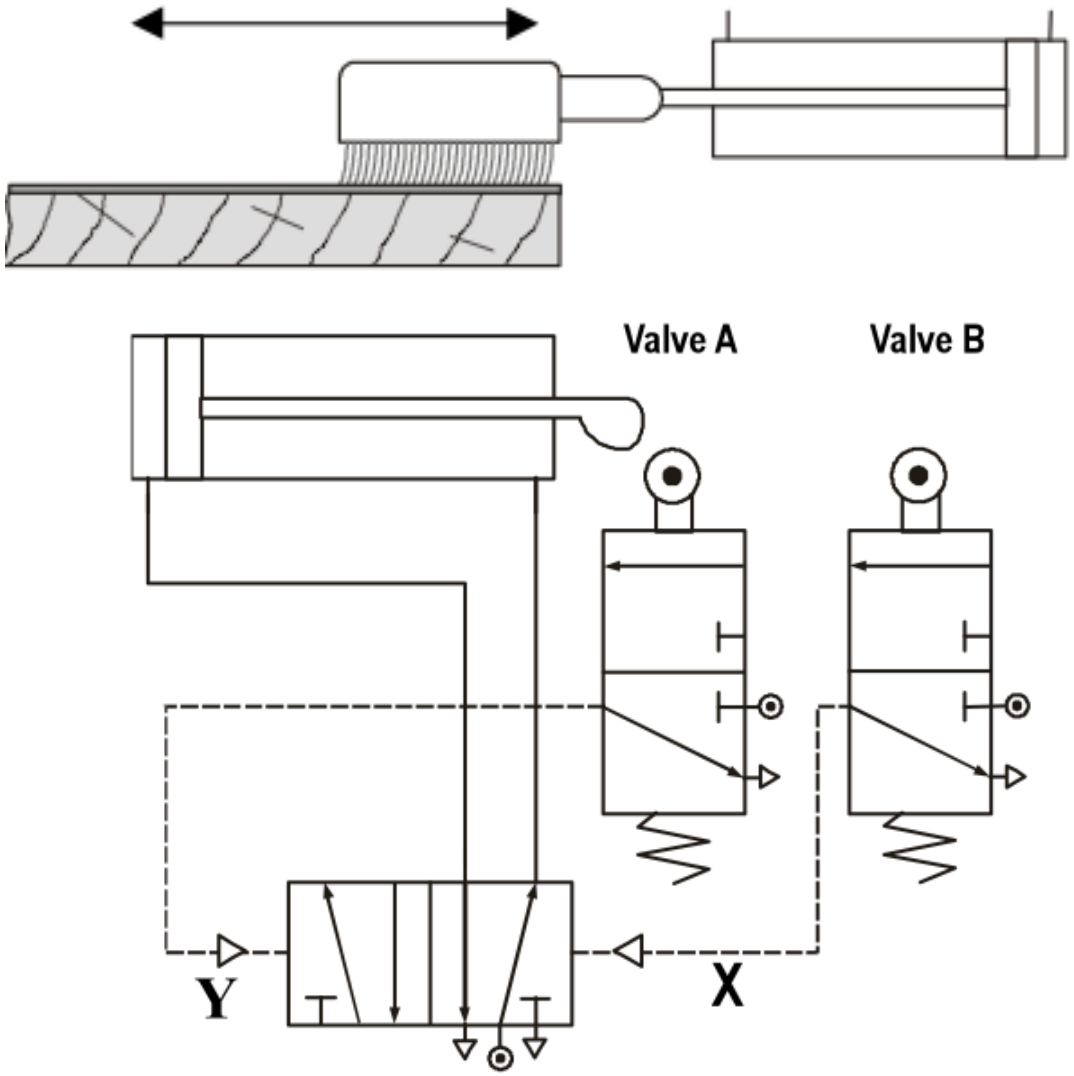
Controlling the movement of the vehicle doors (ON)

# Example: Plastic forming



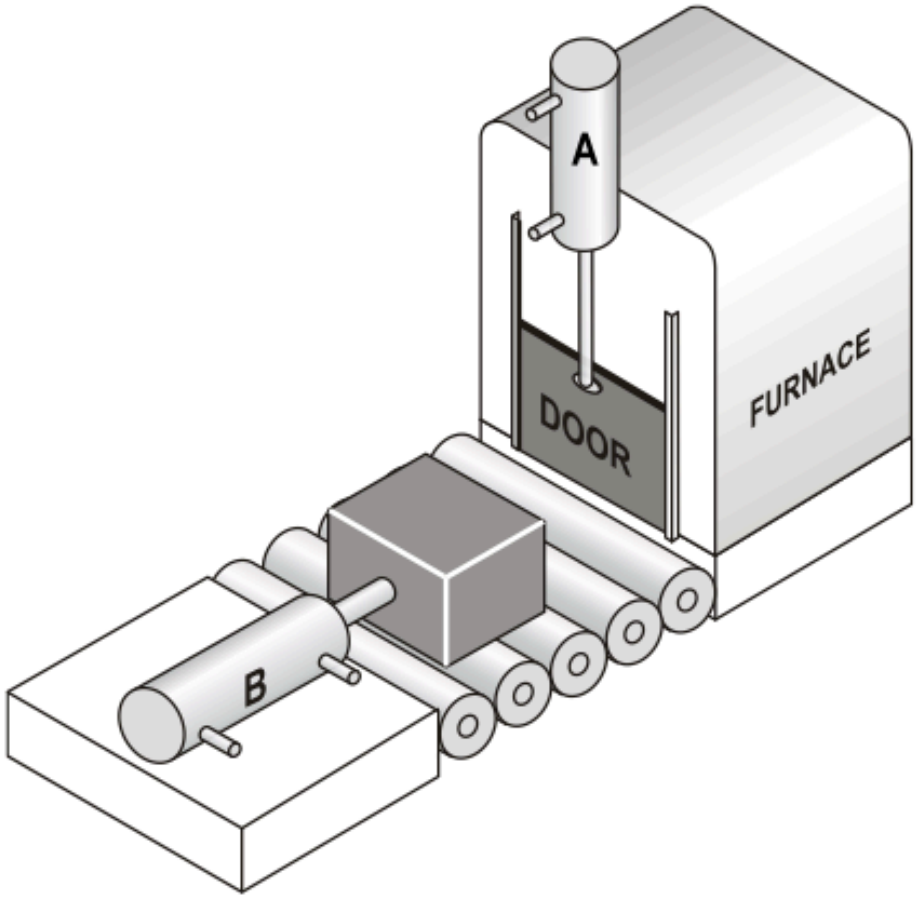
When the push button is pressed, the 5/2 valve changes state and the cylinder outstrokes. As it outstrokes, it pushes the former together and the hot plastic sheet is pressed into shape. As this happens it also actuates the roller. Air now flows through the restrictor and starts to fill up the reservoir.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



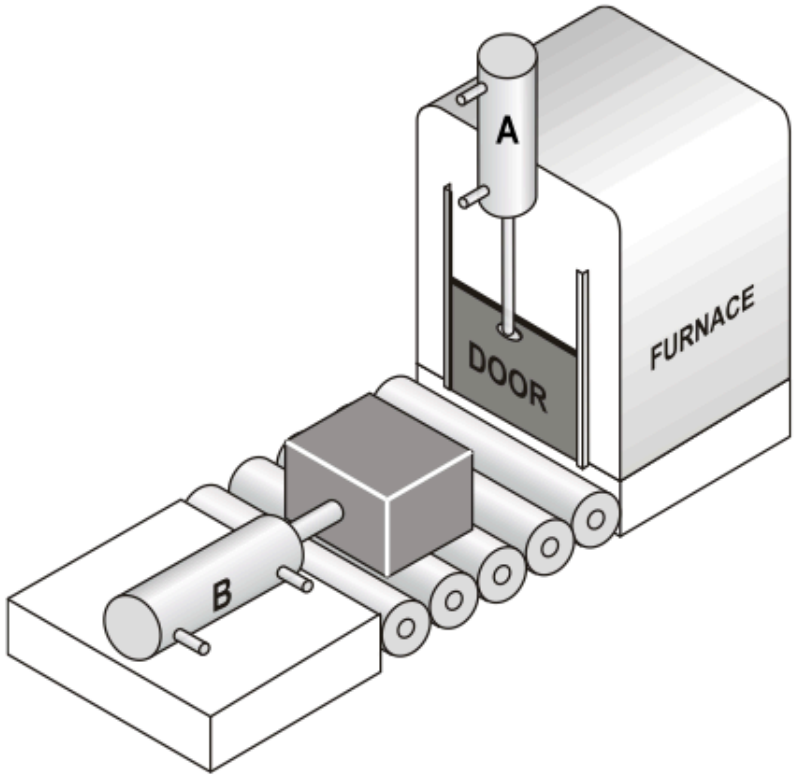

As the piston instrokes, it trips valve A and the 5/2 valve changes state and the piston is sent positive. When it is fully outstroked, it trips valve B and the 5/2 valve returns to its original position, allowing the piston to instroke. The process begins all over again and continues to operate.

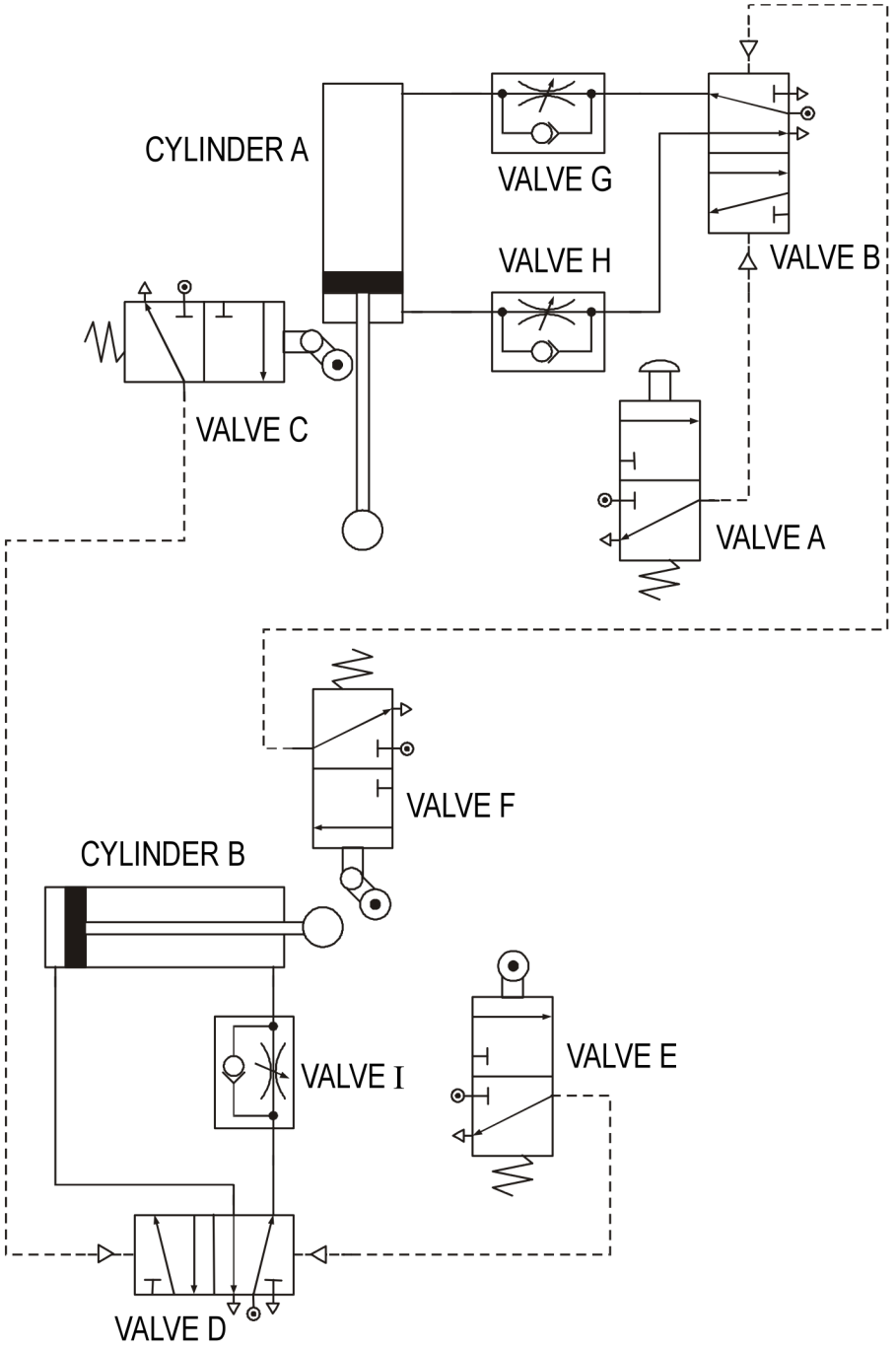
# Example: Sequential control (furnace for heat treatment)




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.


A
DOOR
FURNACE
B


CYLINDER A
VALVE G
VALVE B
VALVE H
VALVE C
VALVE A
VALVE F
CYLINDER B
VALVE I
VALVE E
VALVE D