Chapter 7 Pneumatic and Hydraulic Systems

Pneumatic Systems

- ✓ Pneumatic systems are designed to move loads by controlling pressurized air in distribution lines and pistons with mechanical or electronic valves.
- ✓ Air under pressure possesses energy which can be released to do useful work.
- ✓ Examples of pneumatic systems: dentist's drill, pneumatic road drill, automated production systems.

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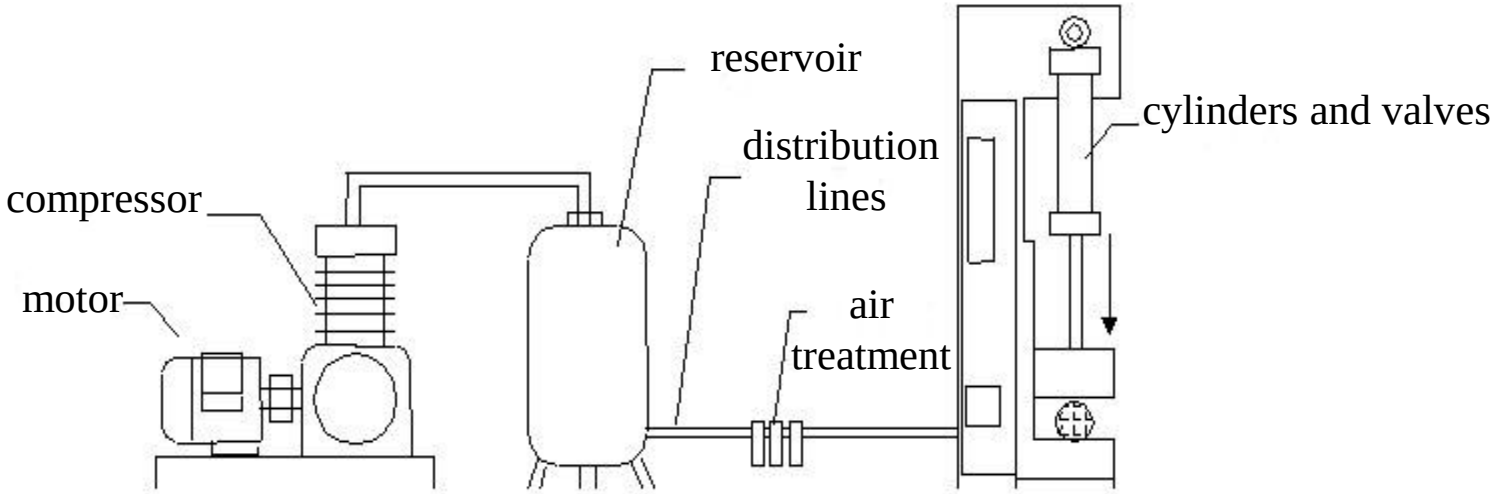
Components of a Pneumatic System



- ✓ Compressor is the power source of a pneumatic system. It is usually driven by a motor or an internal combustion engine. The compressed air is first stored in a strong metal tank called reservoir.
- ✓ Before entering the cylinders and valves, the compressed air has to pass through the air treatment devices, including air filter to remove dust and moisture, pressure regulator to adjust pressure, and lubricator to spray lubrication oil.

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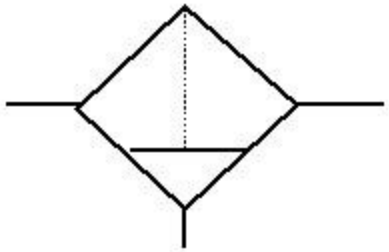
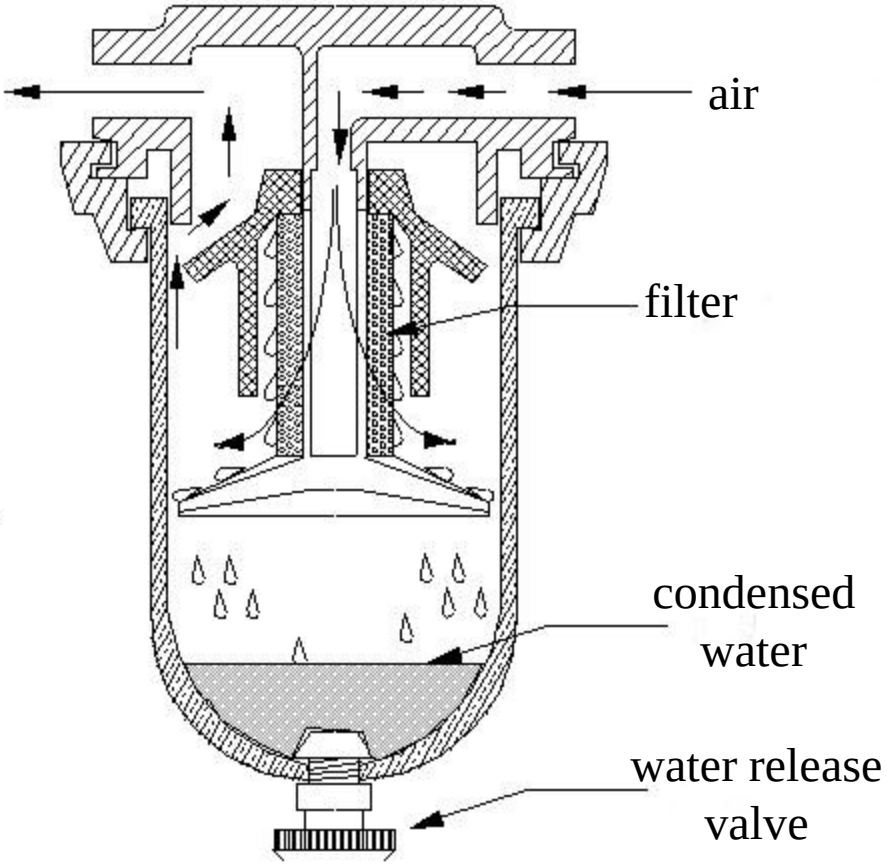
Air Filter -- to remove dust and moisture





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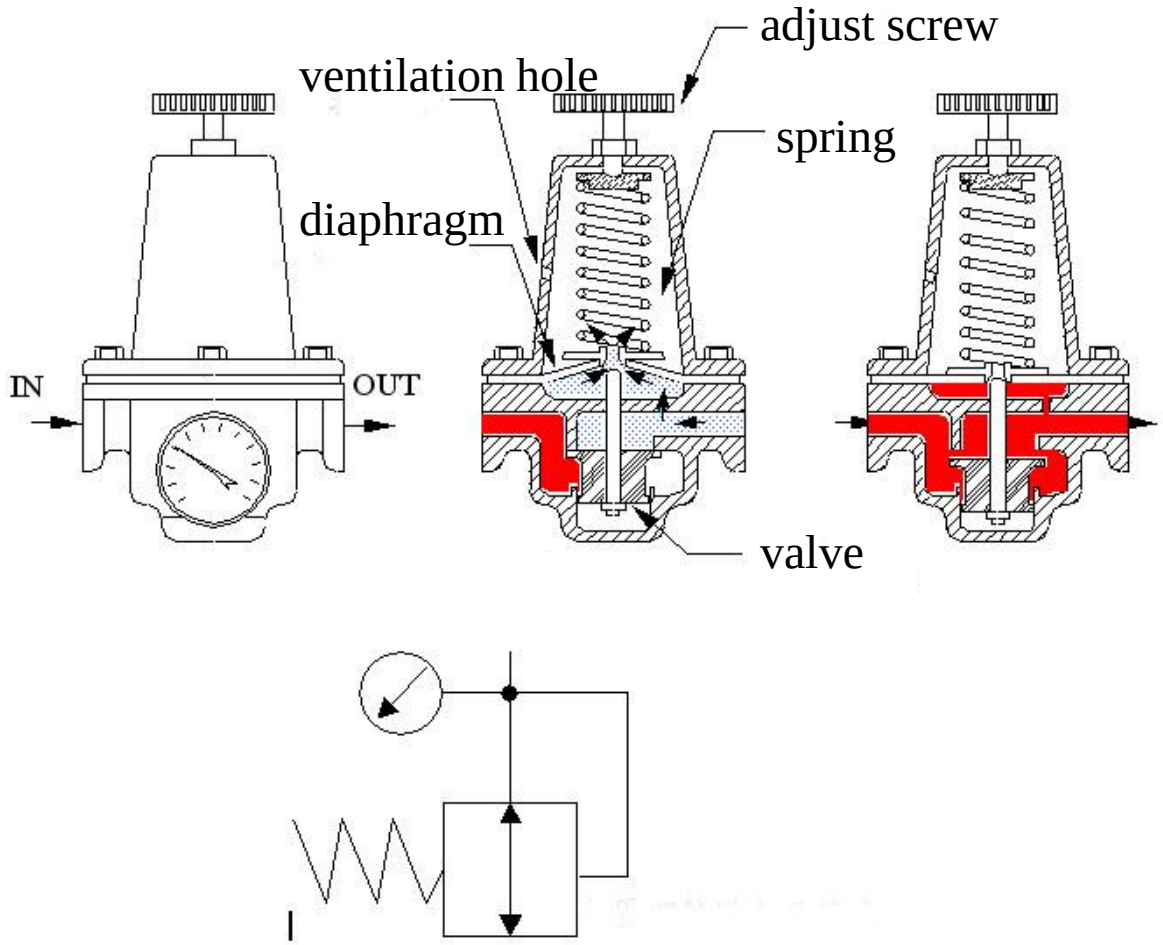
Pressure Regulator -- to adjust pressure



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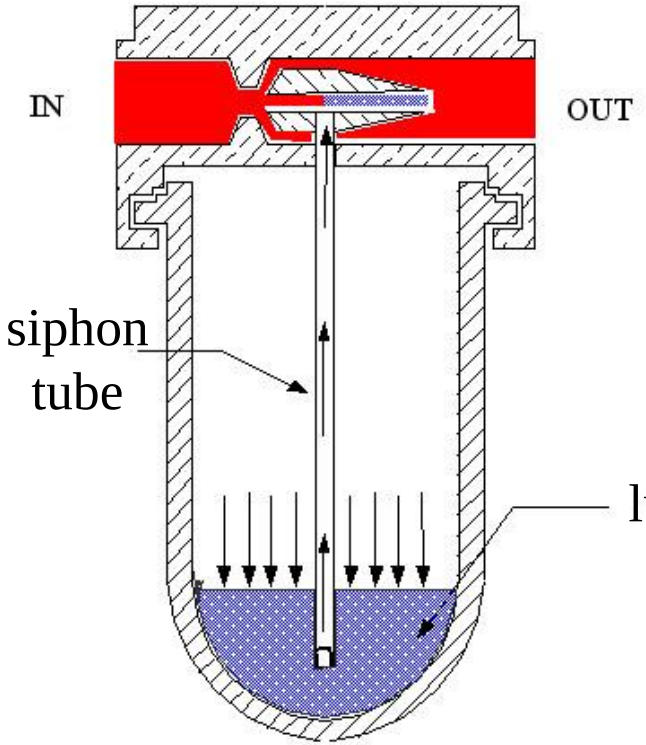
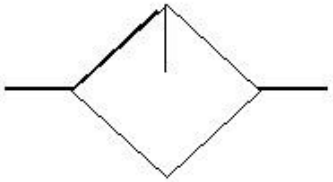
Lubricator -- to spray lubrication oil





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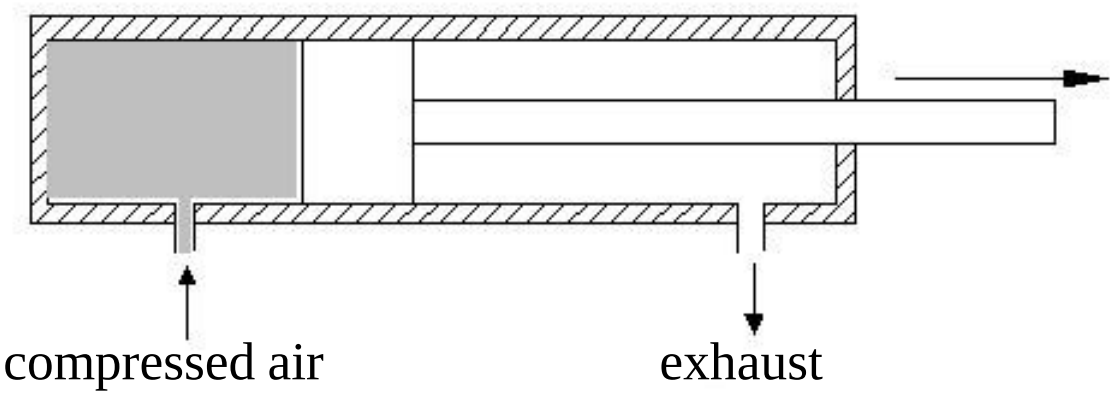
Pneumatic Actuator -- Cylinder

- ✓ Cylinder is the actuator in the pneumatic system. When compressed air flows into a cylinder, energy stored in the air will release, transferring into kinetic energy to do work.



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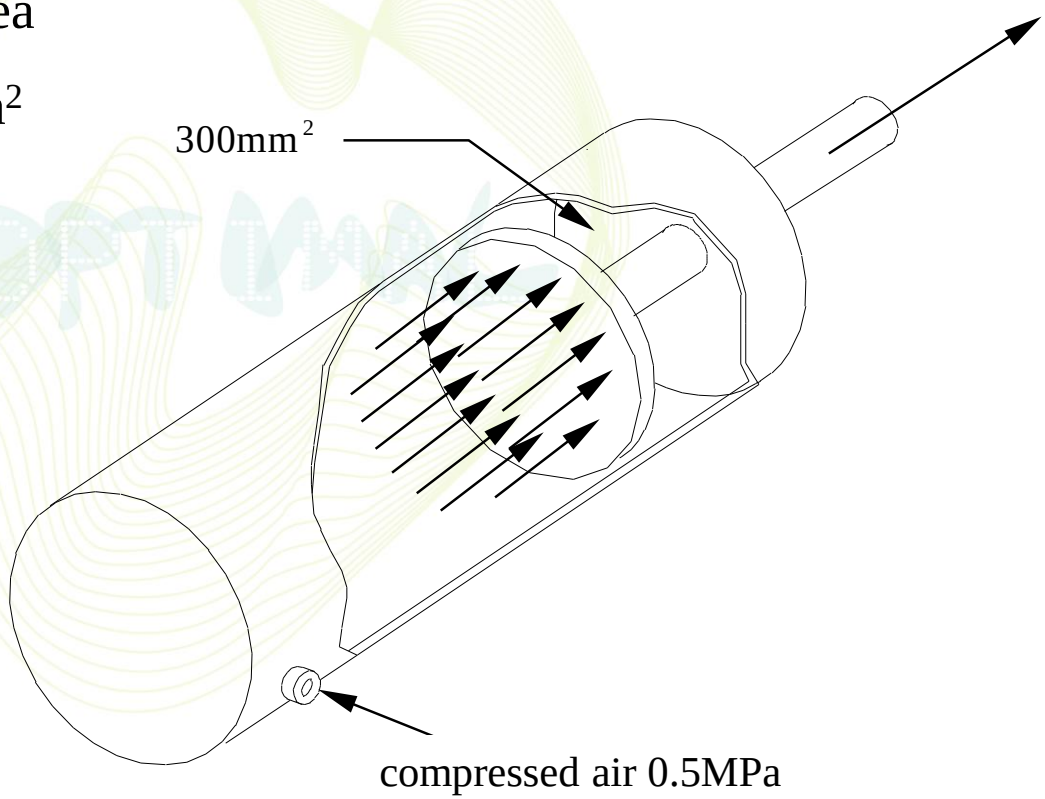
Example 1. Calculating the force produced by a cylinder

- ✓ The input air pressure is 0.5 MPa, which means the air would exert a force of 0.5N on each square millimeters. If the area of the piston is 300mm^2, then the total force produced by the cylinder will be:

force = pressure × piston area

= 0.5 N/mm^2 × 300mm^2

= 150 N



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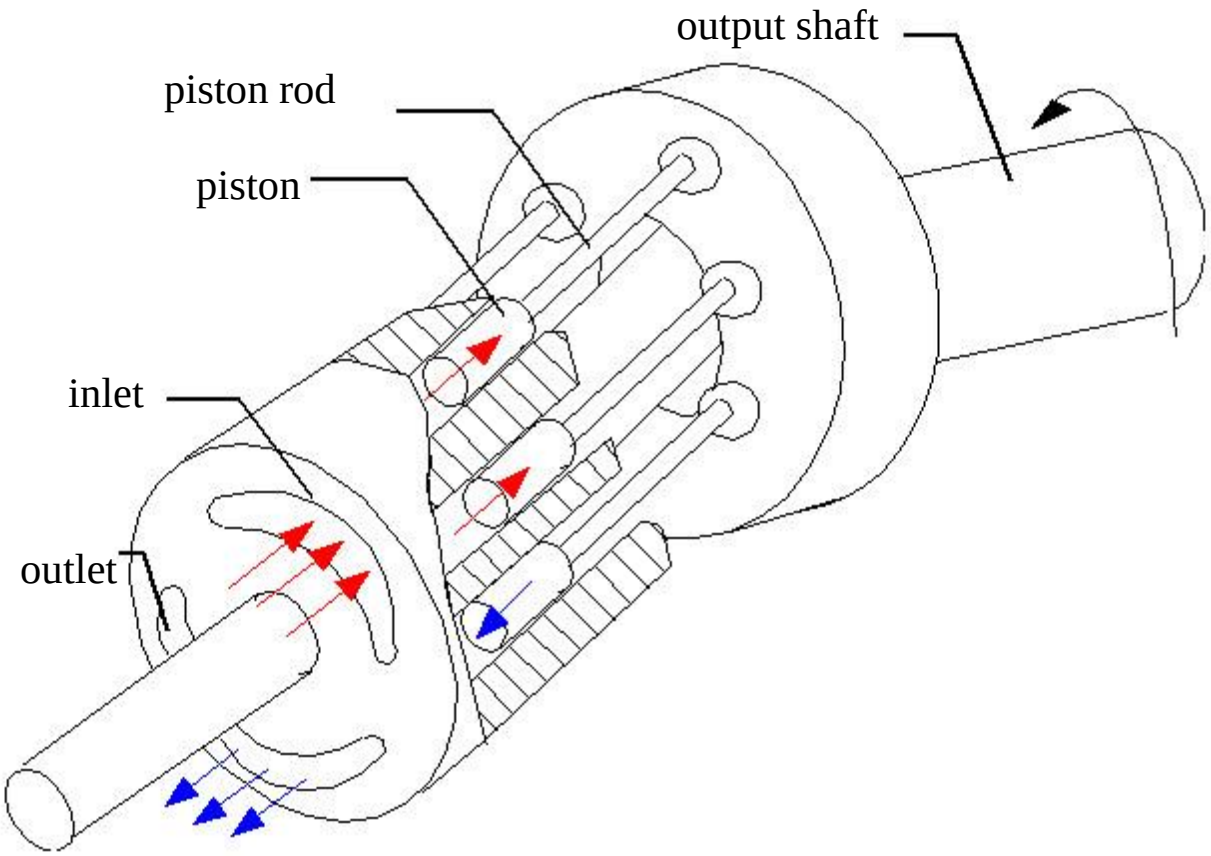
Pneumatic Motor – Piston Type and Vane Type



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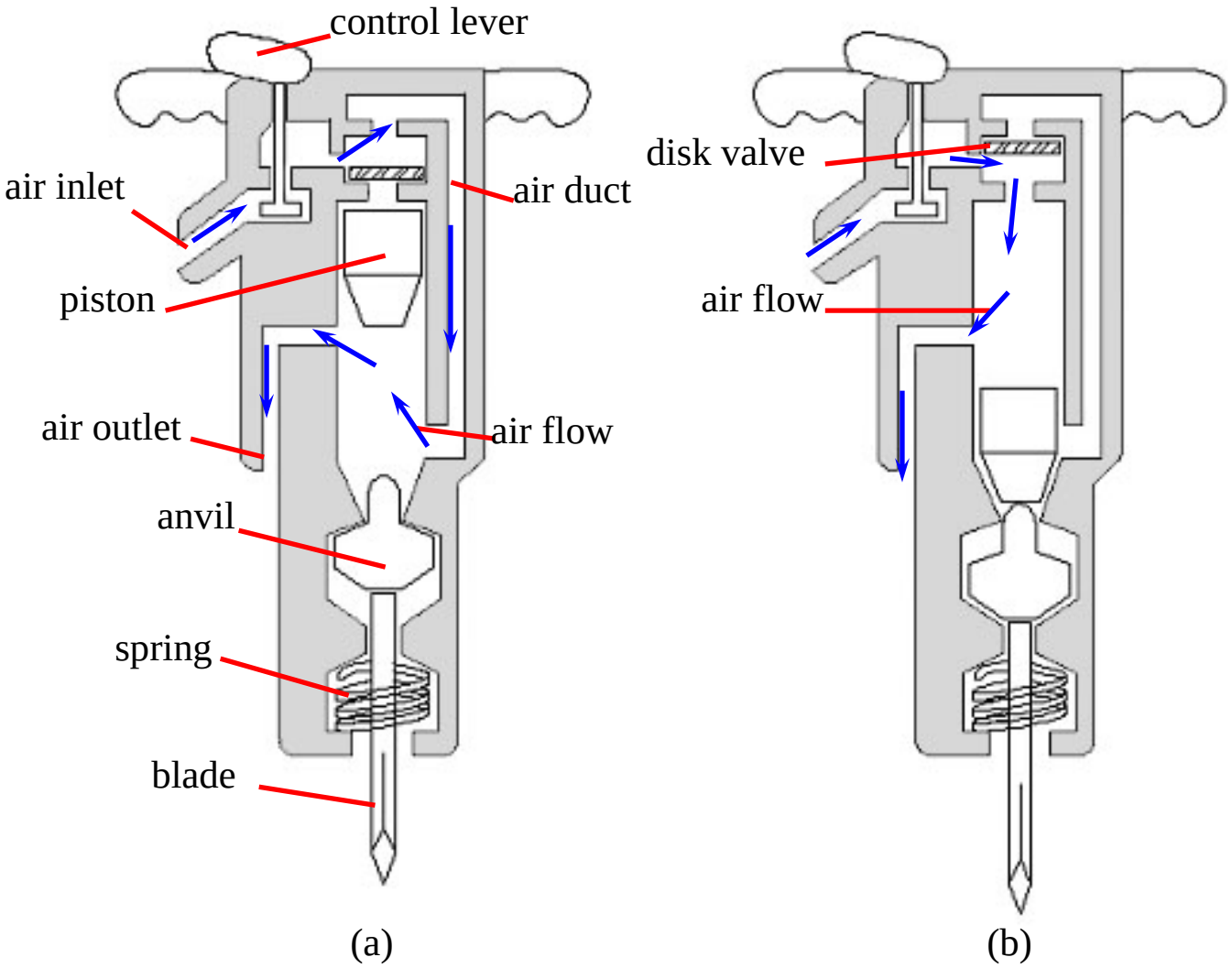
Example 2. Pneumatic Drill



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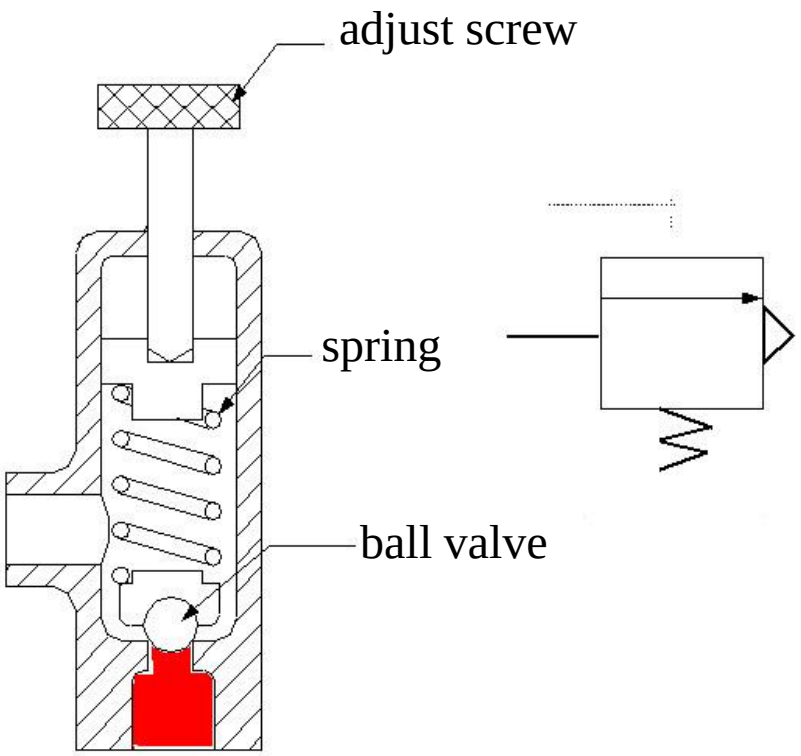
Pressure Control Valve – Relieve Valve

- ✓ Relief valve, also known as safety valve, is used to maintain the desired pressure.



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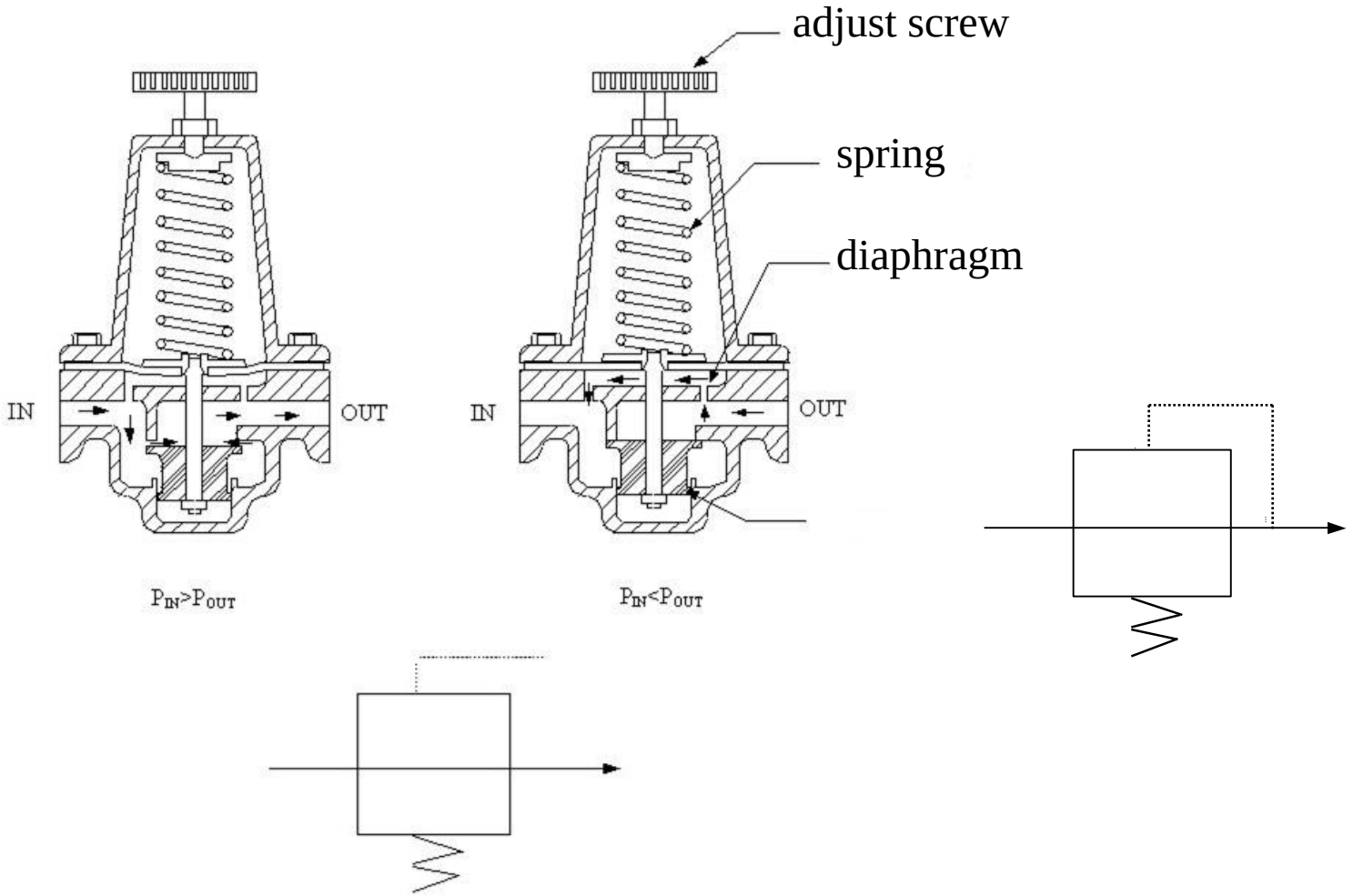
Pressure Control Valve—Reduce Valve



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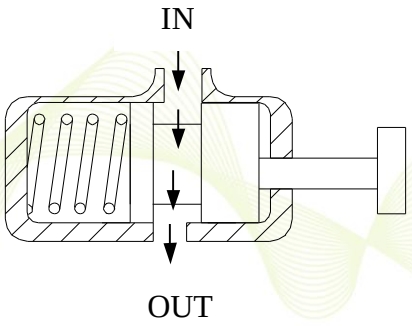
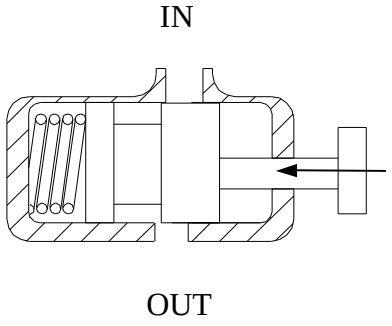
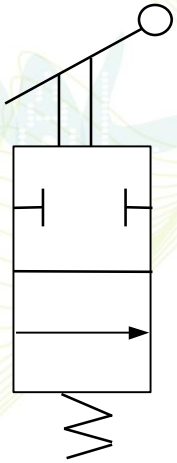
Directional Control Valve – Two Port Valve (2/2)







- ✓ Directional control valves are commonly described by an *x*/*y* designation, where *x* is the number of ports and *y* is the number of positions.
- ✓ 2/2 valve: 2 ports, 2 positions.
- ✓ The two port valve is similar to the single pole single throw switch in electric circuits.

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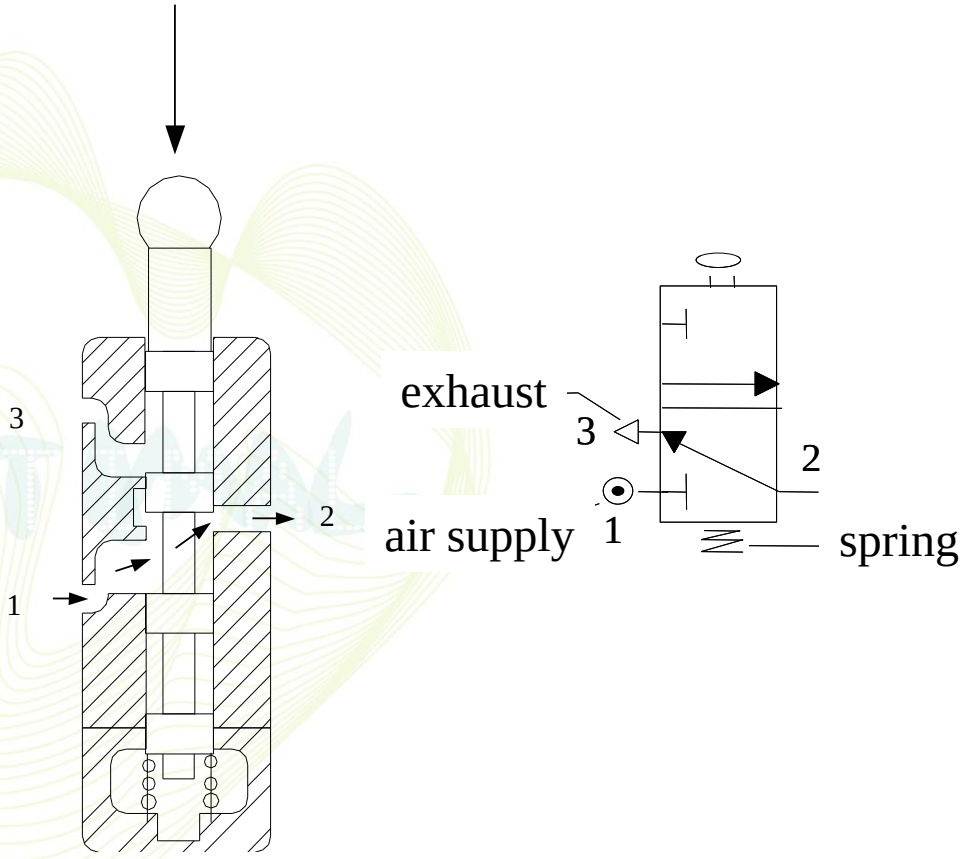
Directional Control Valve – Three Port Valve (3/2)

- ✓ The three port valve is similar to the single pole double throw switch in electric circuits.



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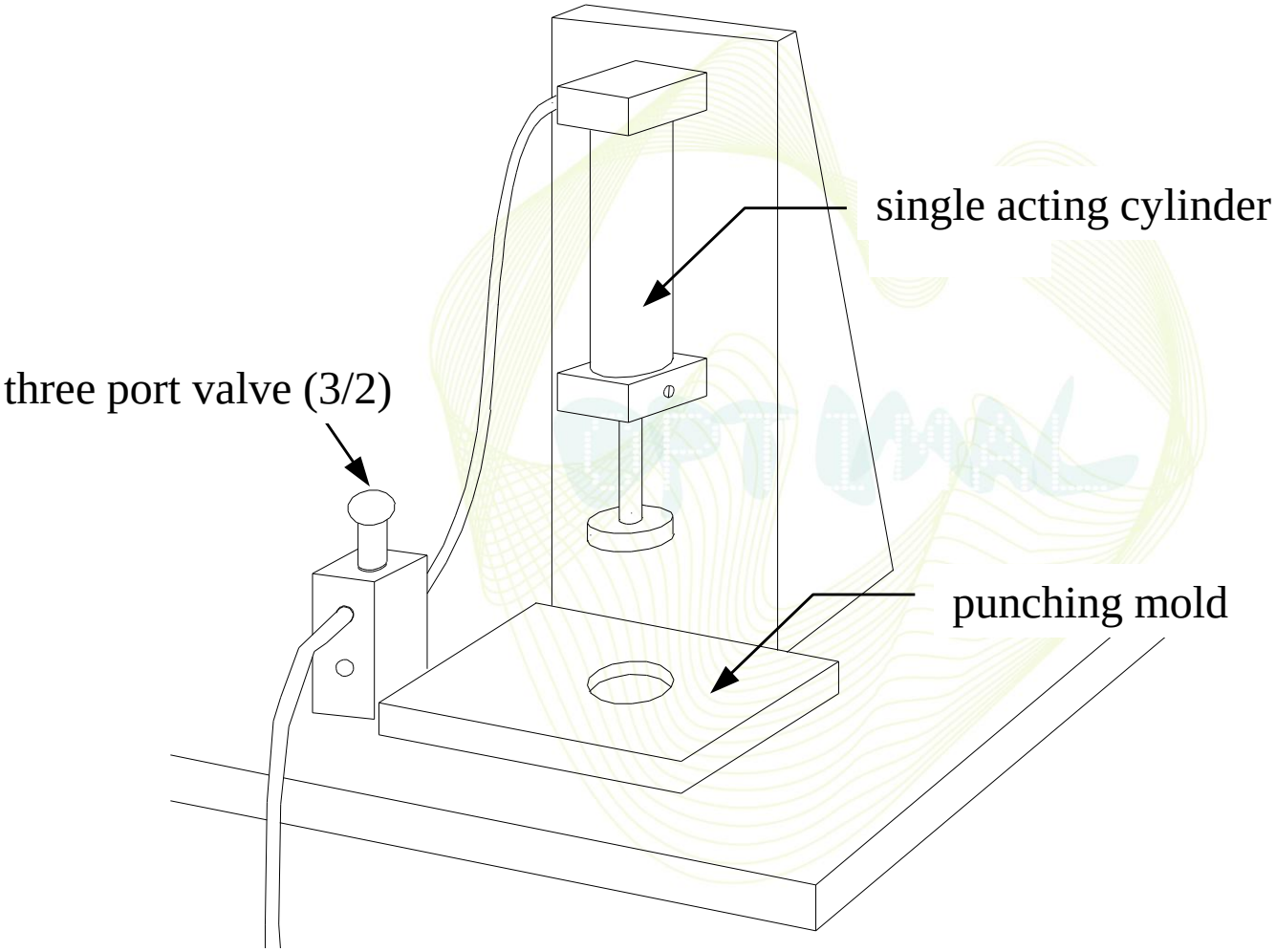
Example 3. Pneumatic Punching Machine (I)



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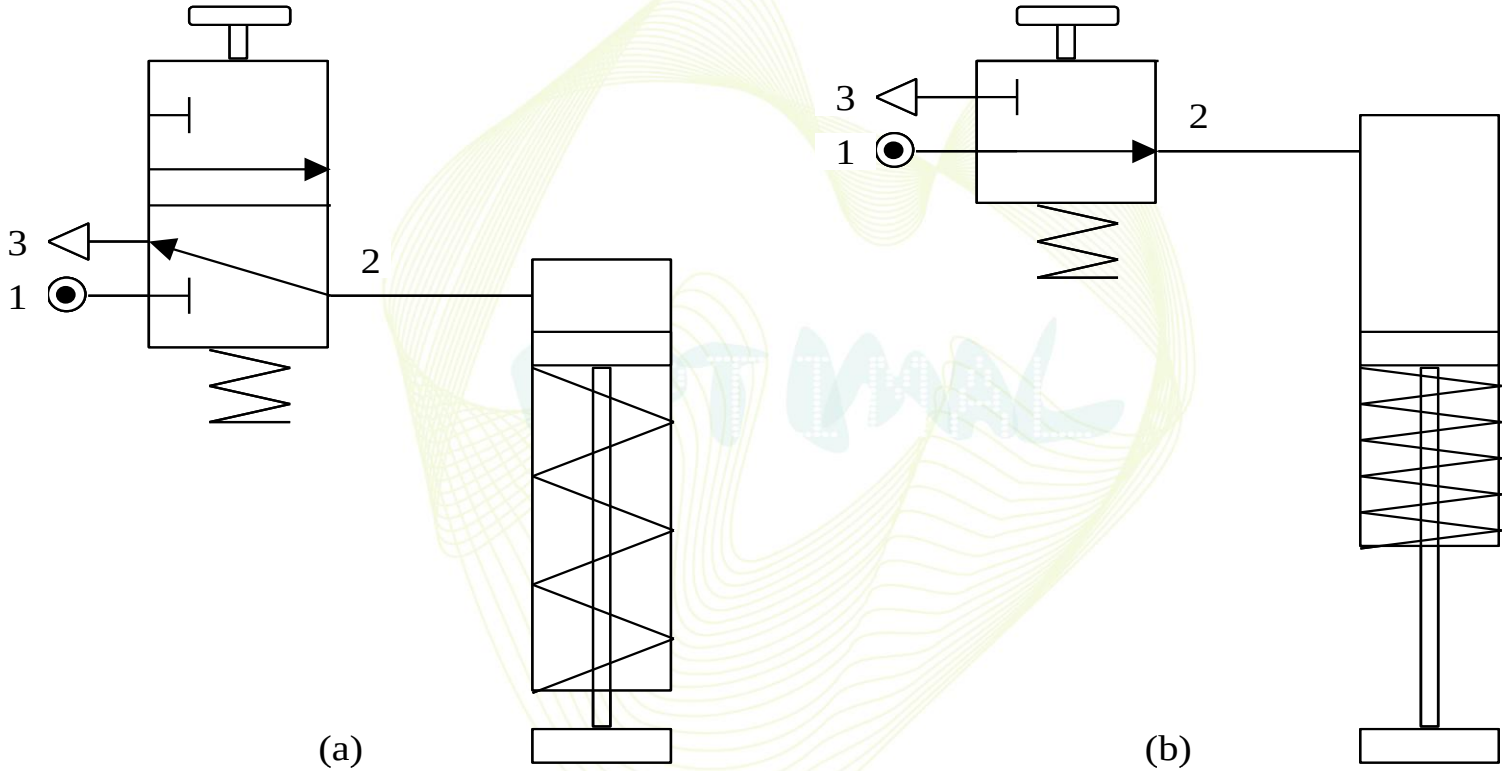
Example 3. Pneumatic Punching Machine (II)



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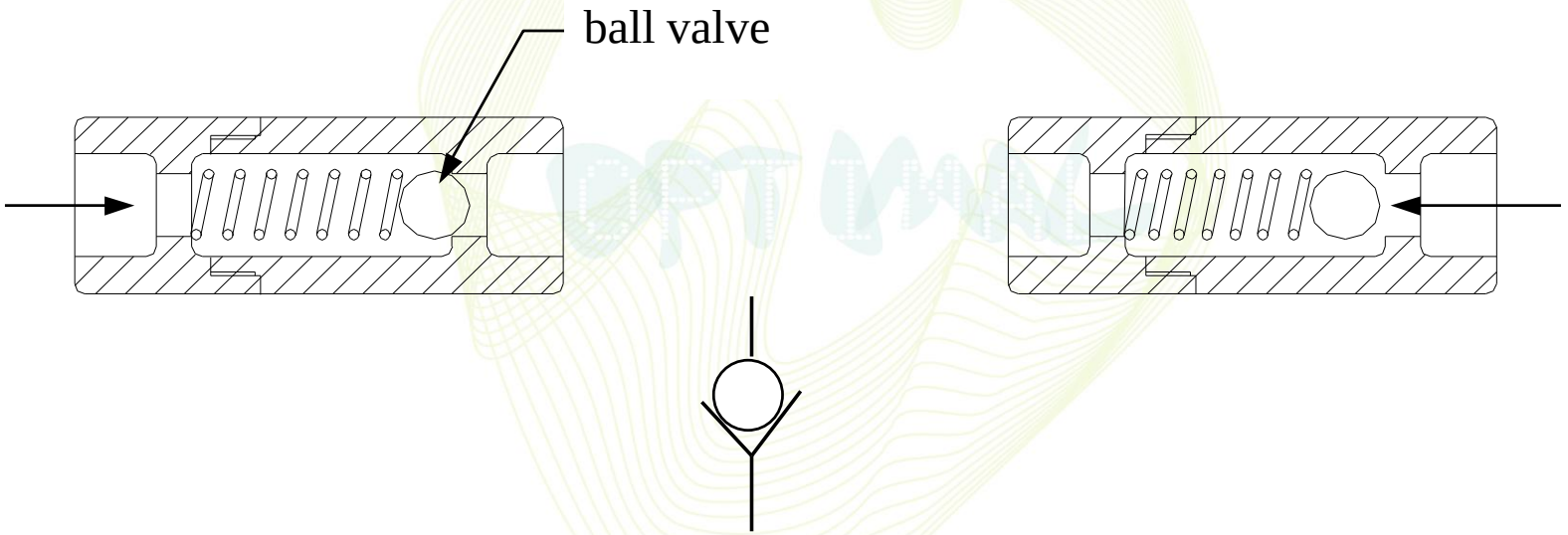
Directional Control Valve – One Way Valve

- ✓ The one way valve allows air flow from only one direction. It is similar to the diode in electric circuits.



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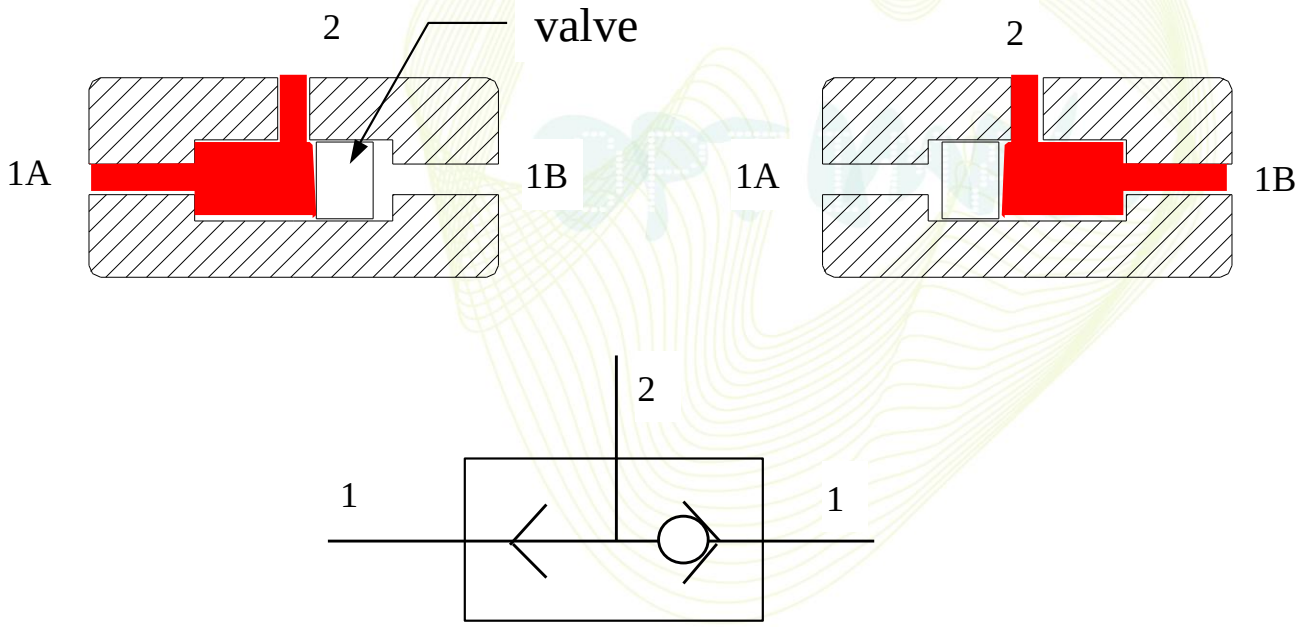
Directional Control Valve – Shuttle Valve

- ✓ A shuttle valve has three ports and contains a small rubber piston which is free to move between port 1A and 1B within the valve.
- ✓ If air enters the valve through port 1 A or 1B, the piston is pushed to the other side and air can only escape through port 2.



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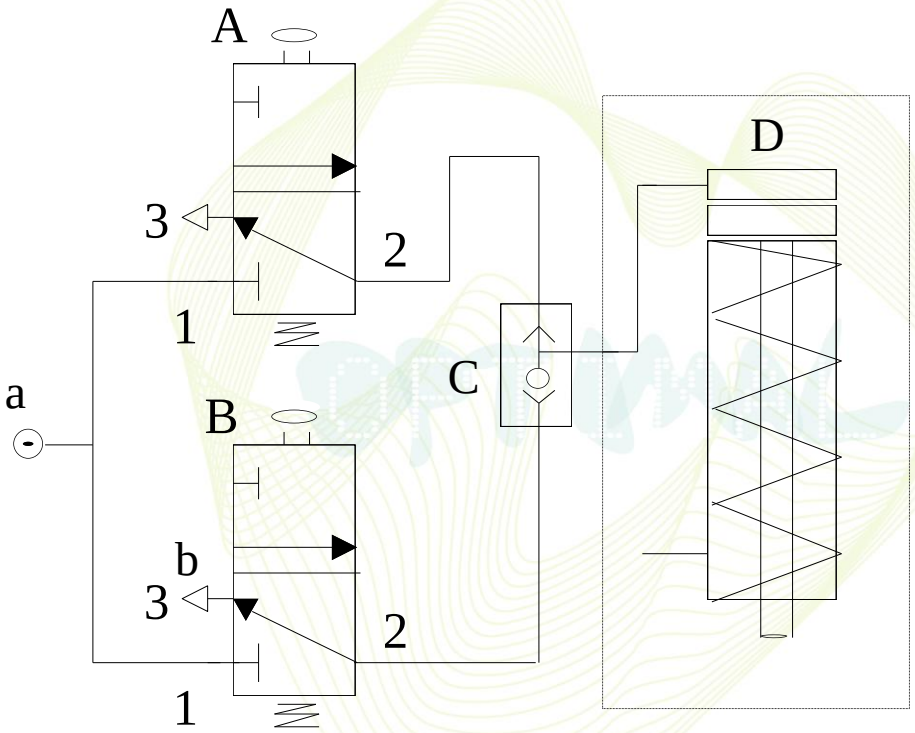
Example 4: Dual Control Pneumatic Punching Machine



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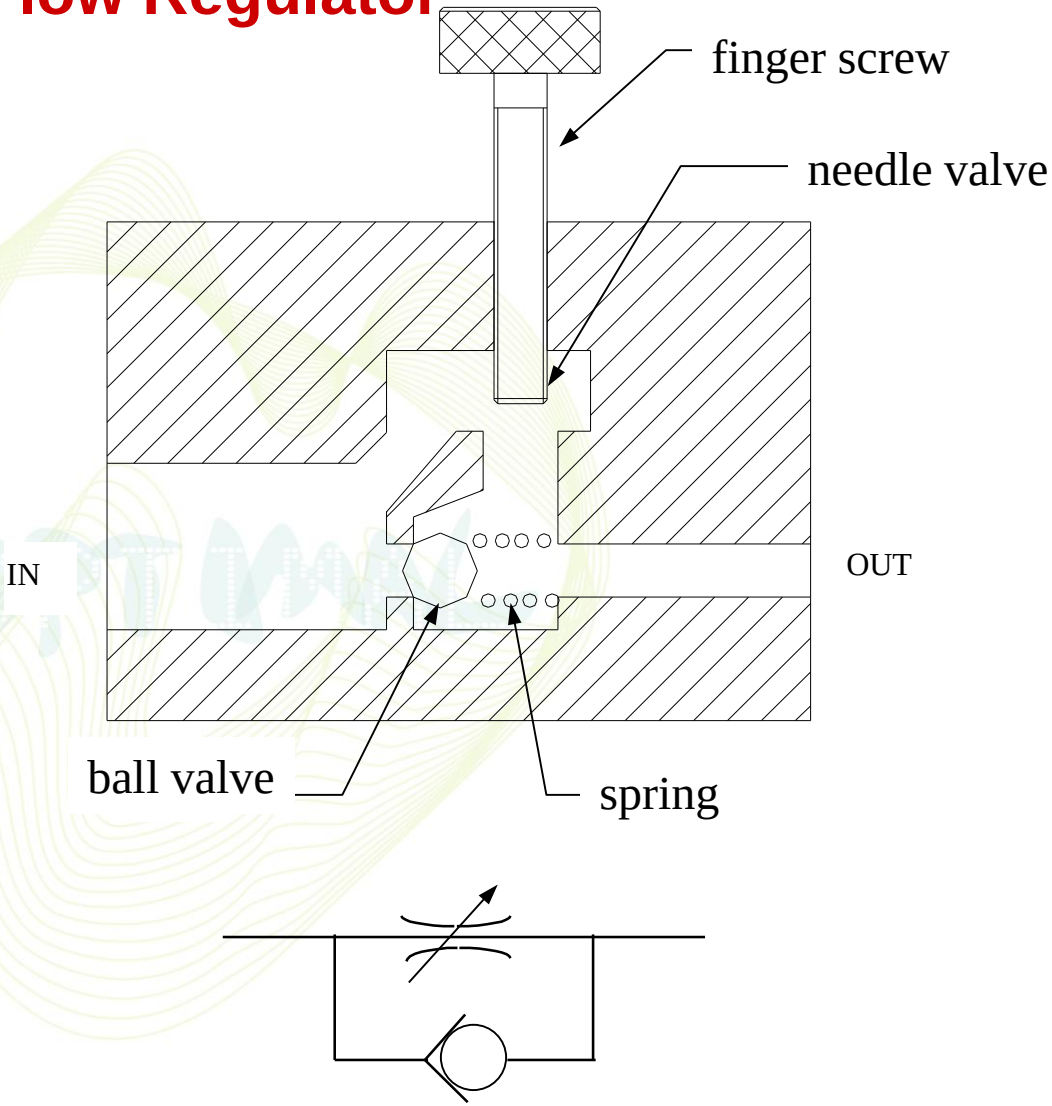
Flow Control Valve – the Flow Regulator

- ✓ Air can pass through the regulator in either direction.
- ✓ If air enters from left, the ball valve is pushed open and air can flow through the valve unrestricted.
- ✓ If air enters from right, the ball valve is closed so that air can only pass through the regulator.
- ✓ The flow of air can be controlled by turning a finger screw.



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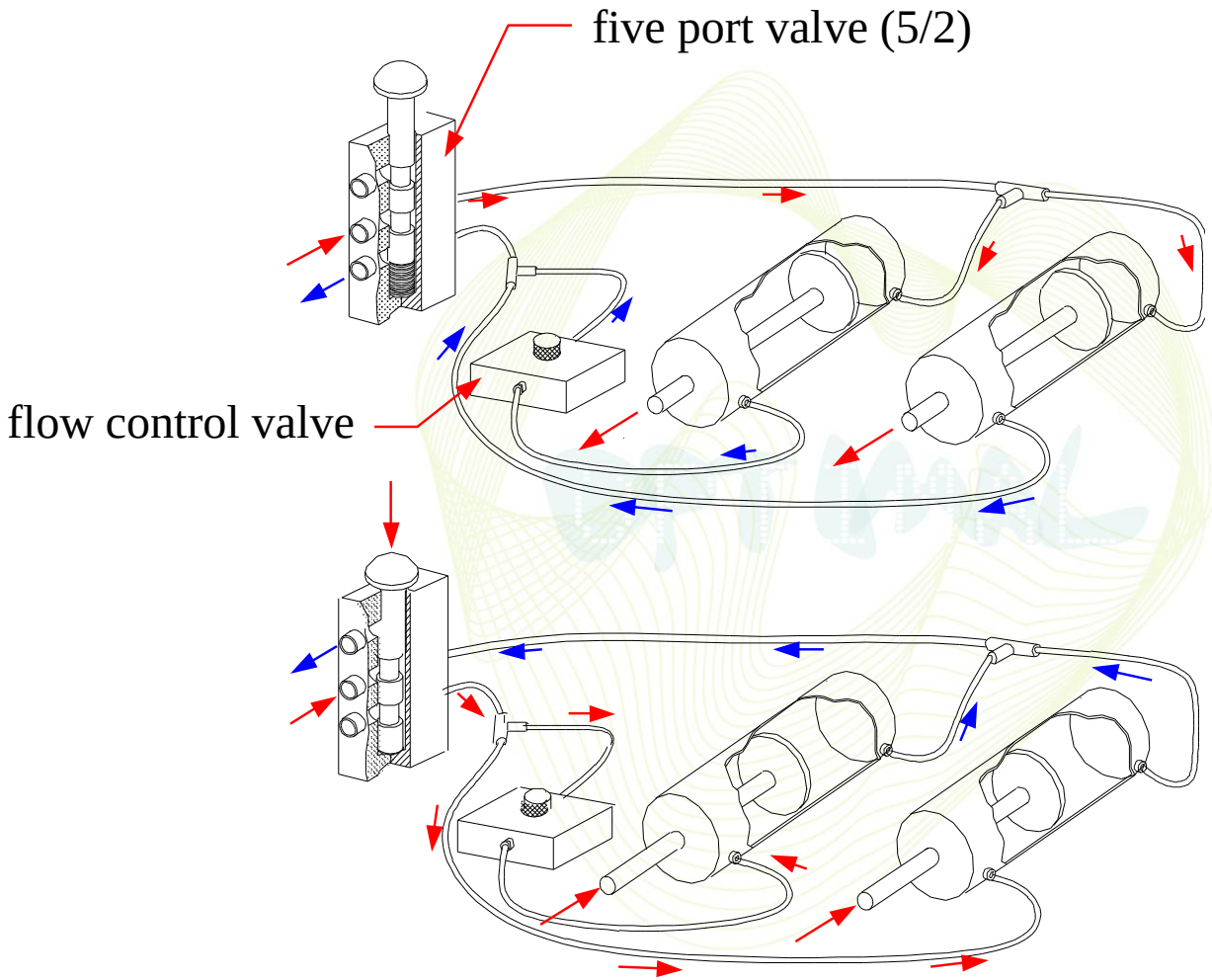
Control of Double Acting Cylinders (I)



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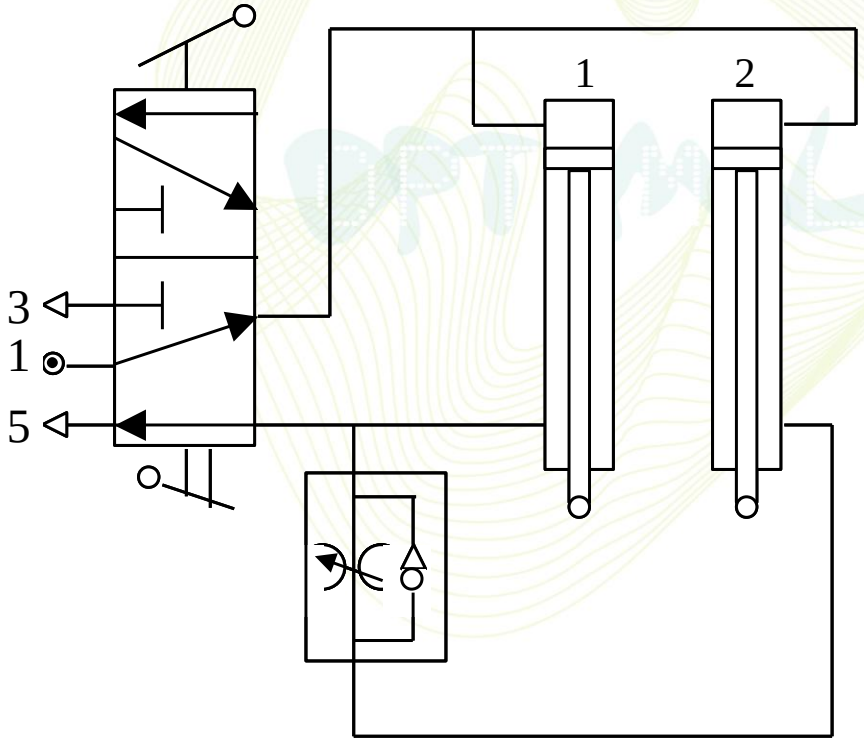
Control of Double Acting Cylinders (II)

- ✓ Unlike a single acting cylinder, a double acting cylinder does not contain a return spring. Movements in both directions are powered by compressed air.
- ✓ The flow control valve makes the downward movement of piston 2 slower than that of piston 1. However, both pistons move upward at the same speed.



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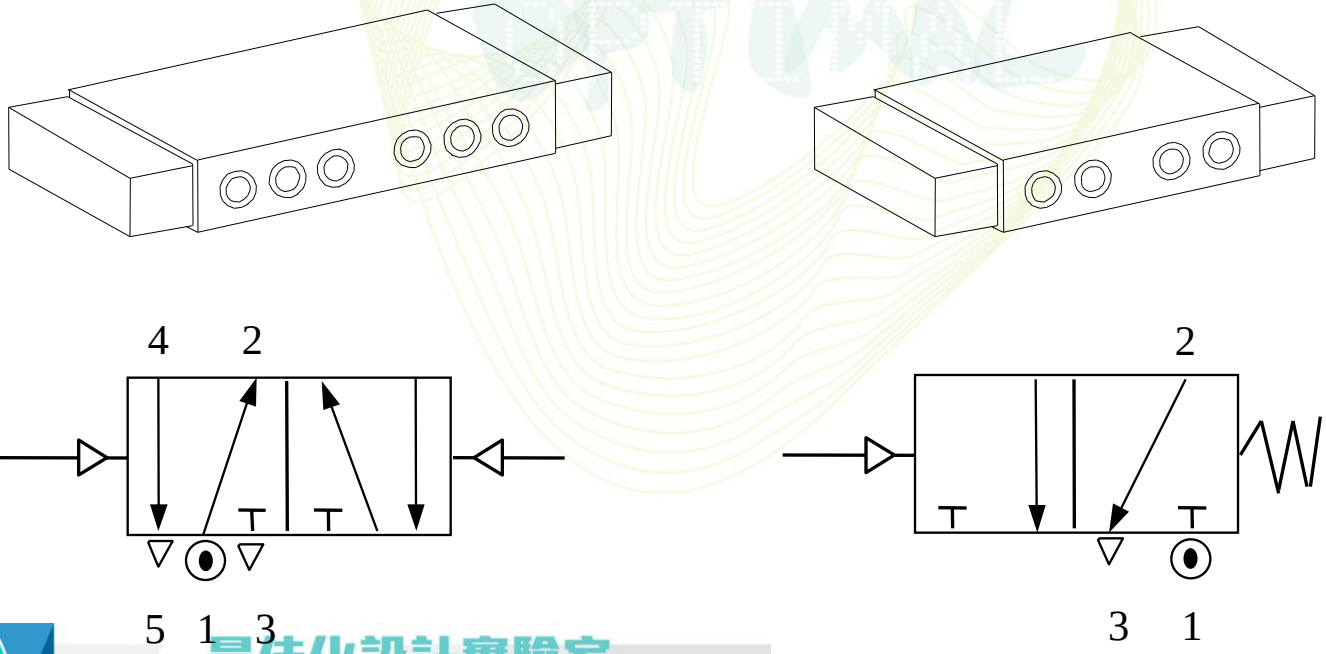
Air Operated Valves

- ✓ In the valves described so far, the spool which controls the flow of air is moved mechanically, by a button or lever.
- ✓ In order to be automated, direction control valves in the pneumatic systems have to be controlled by air pressure or electrical signals.
- ✓ In air operated valves, the spool is moved by air pressure.



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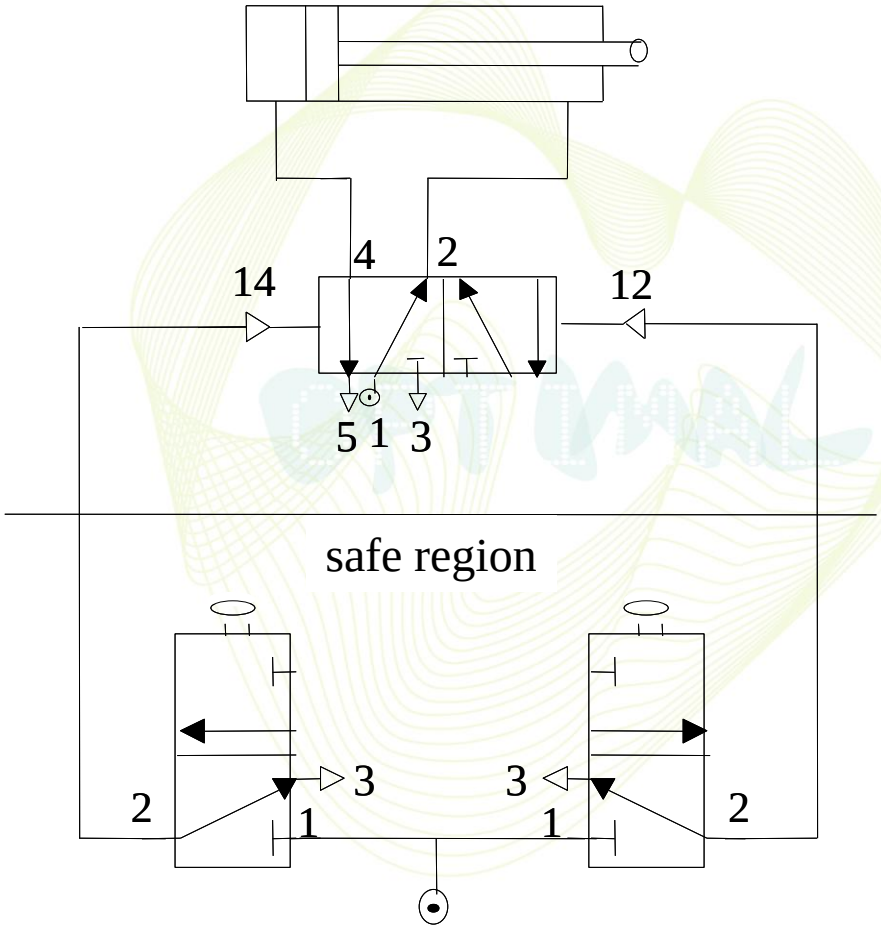
Example 5: Application of Air Operated Valves



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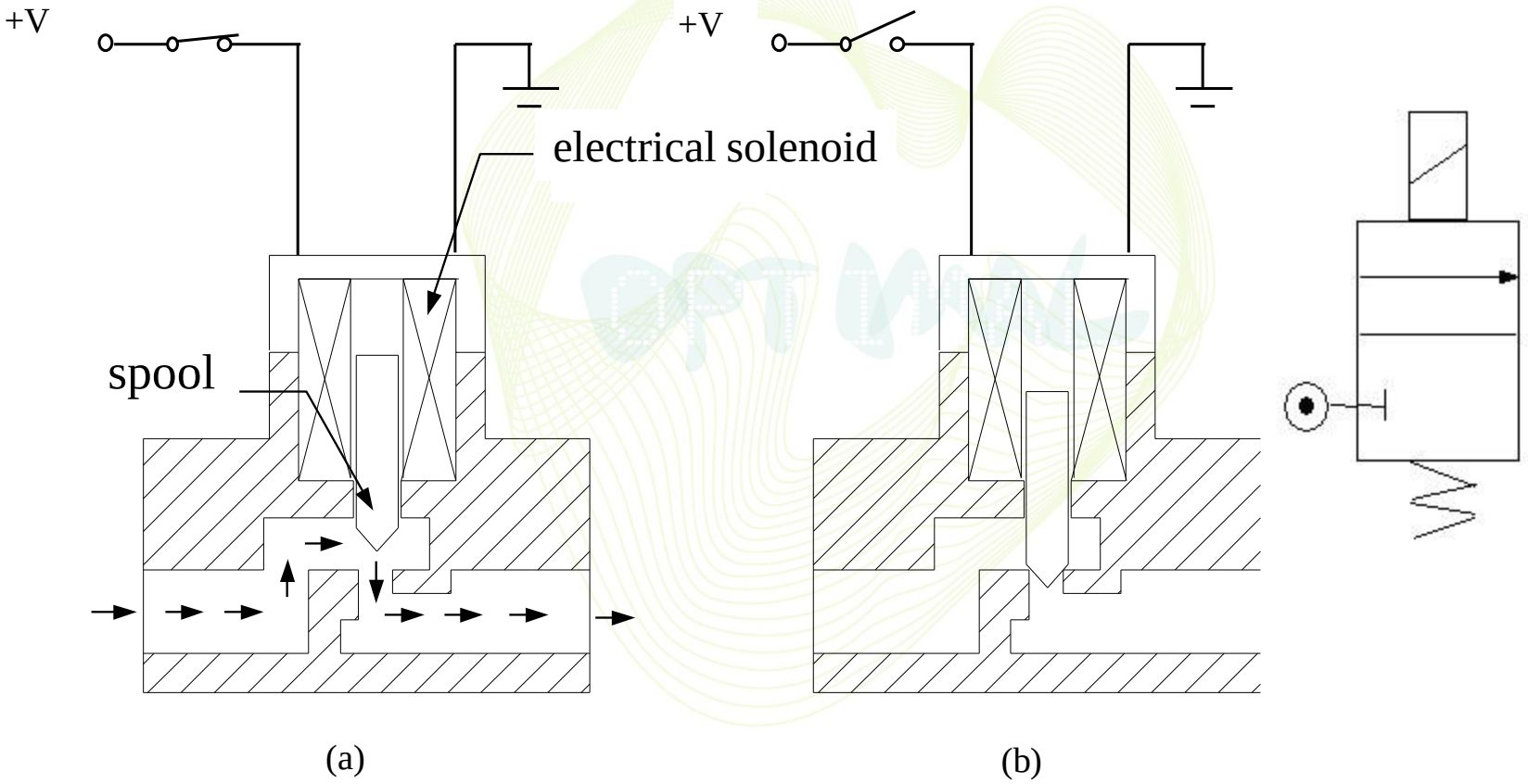
Pneumatic Solenoid Valves

- ✓ The spool position is moved by an electrical solenoid, and can controlled electronically.



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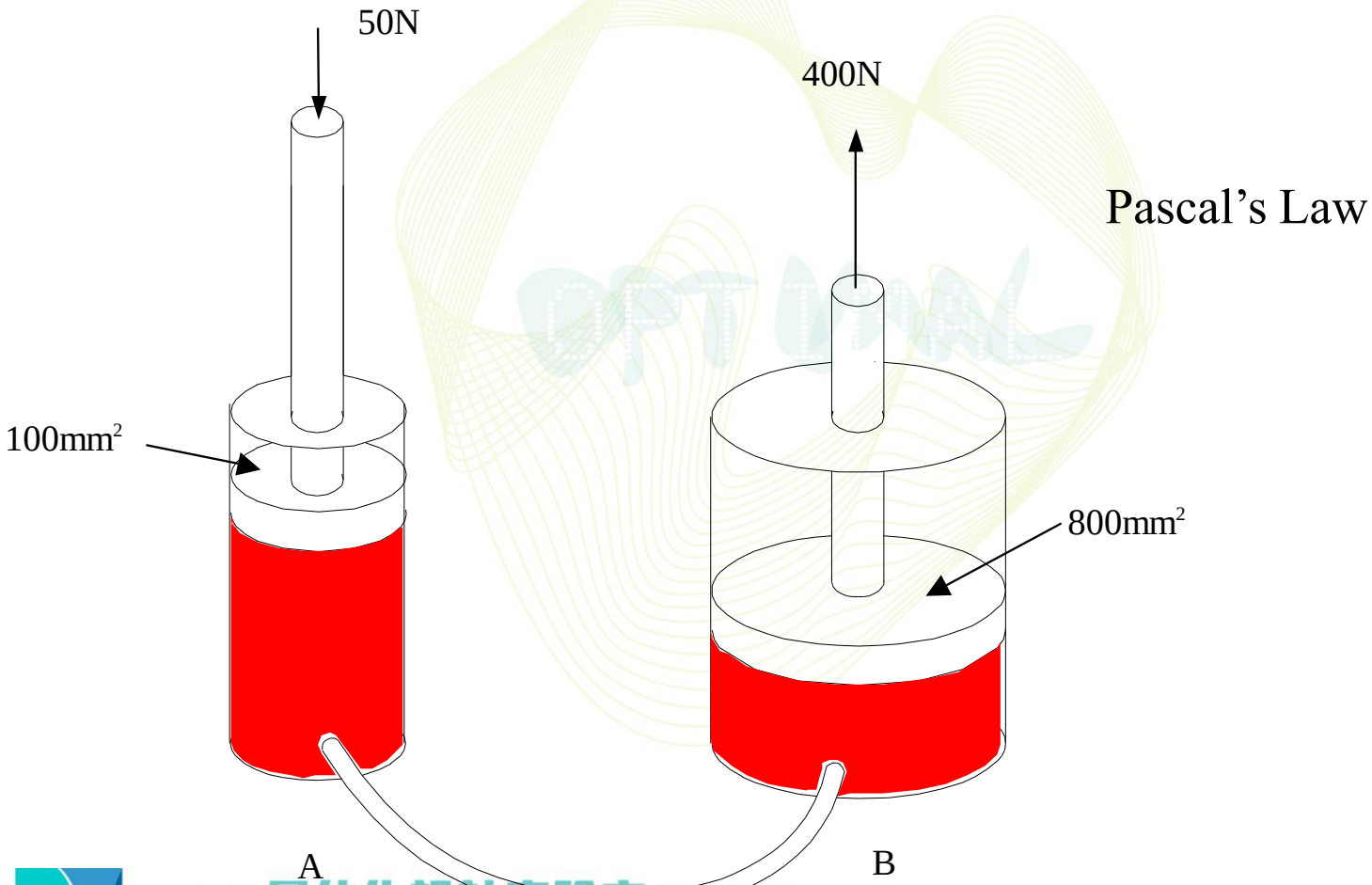
Hydraulics

- ✓ The working fluid in a hydraulic system is incompressible. Thus a hydraulic system can move large loads.



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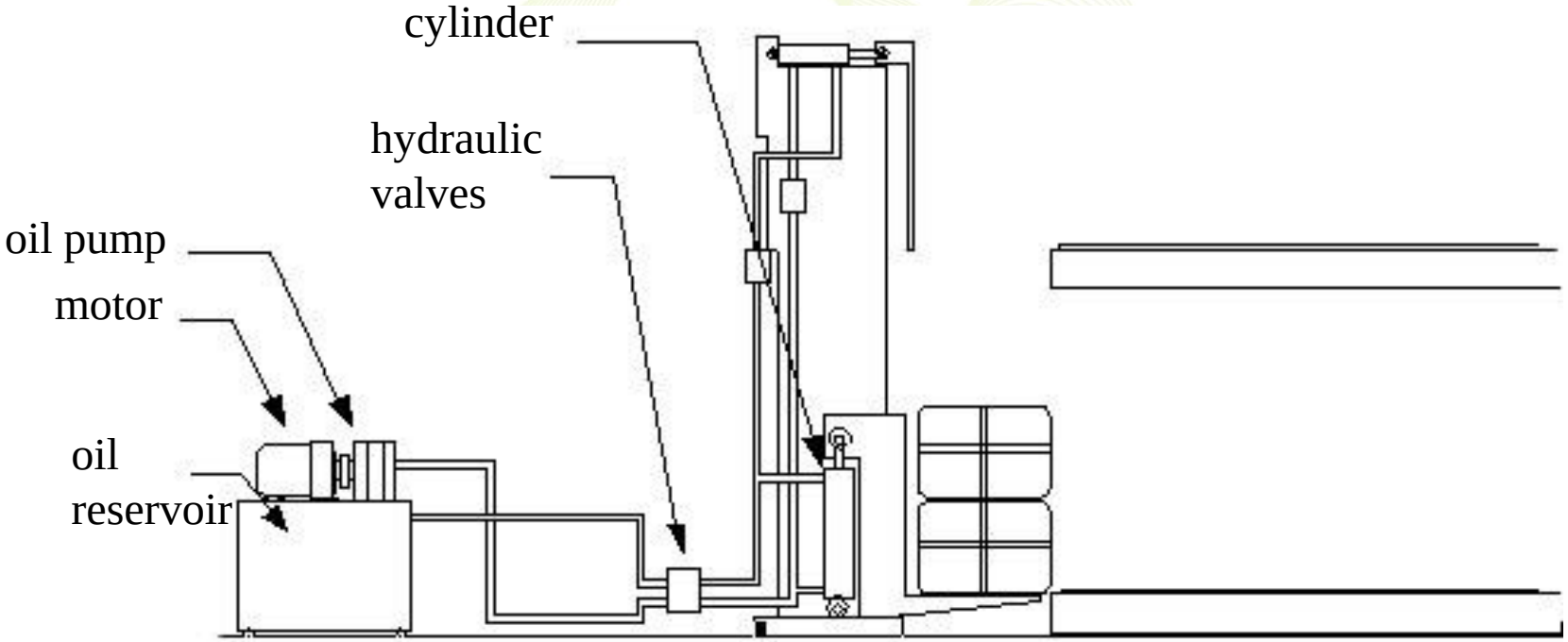
Hydraulic Systems

- ✓ Pneumatic systems are open systems, always processing new air, and air is simply exhausted to the atmosphere. Hydraulic systems are closed systems, always recirculating the same oil.



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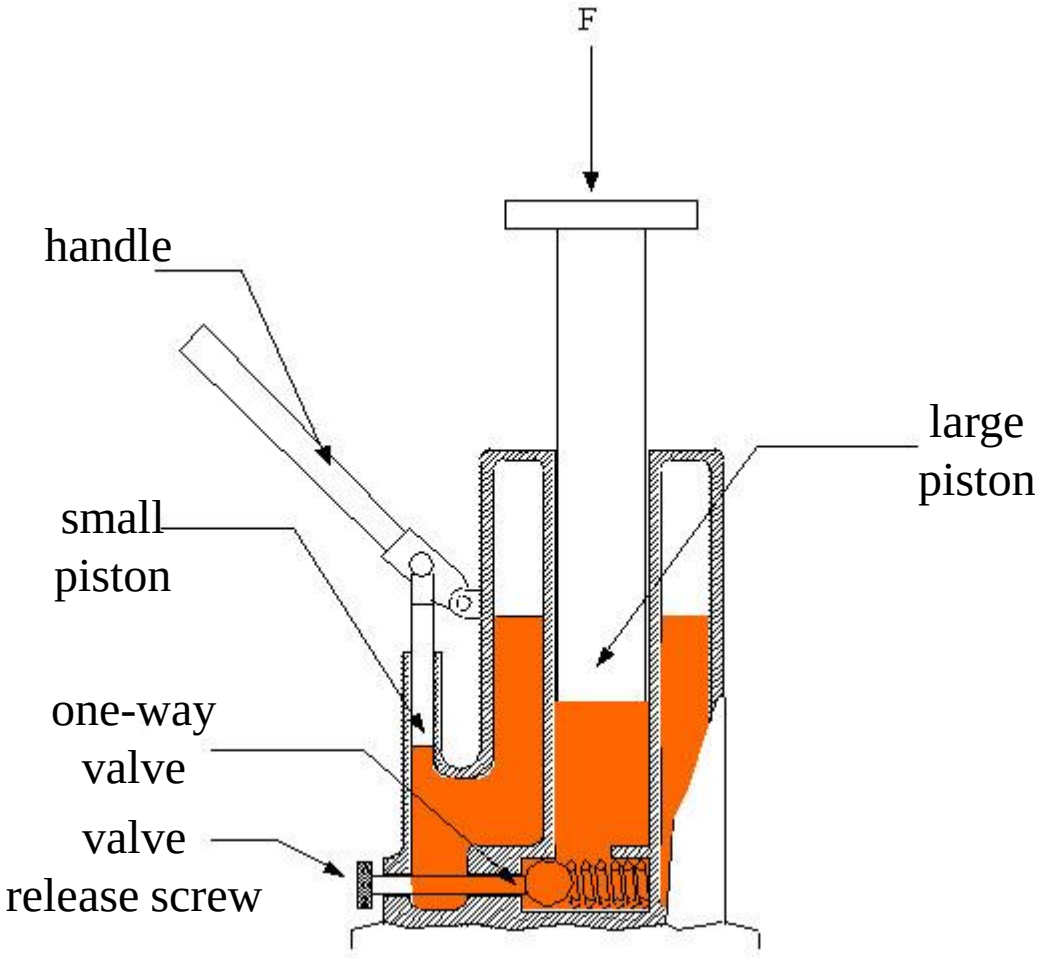
Example 6. Hydraulic Jack

- ✓ Only a small force is required by the operator to raise the heavy load. The large piston can be stopped at any point because the oil cannot be compressed.



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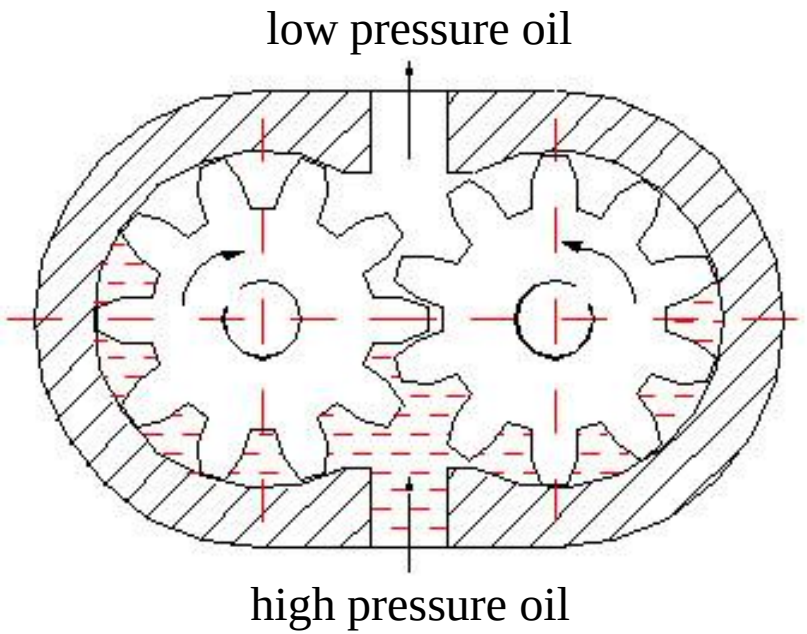
Hydraulic Actuators

- ✓ In a hydraulic system, the actuators transferring hydraulic energy into mechanical motion are hydraulic cylinders and hydraulic motors.
- ✓ There are 3 types of hydraulic motors : gear pump, vane pump and axial piston pump.



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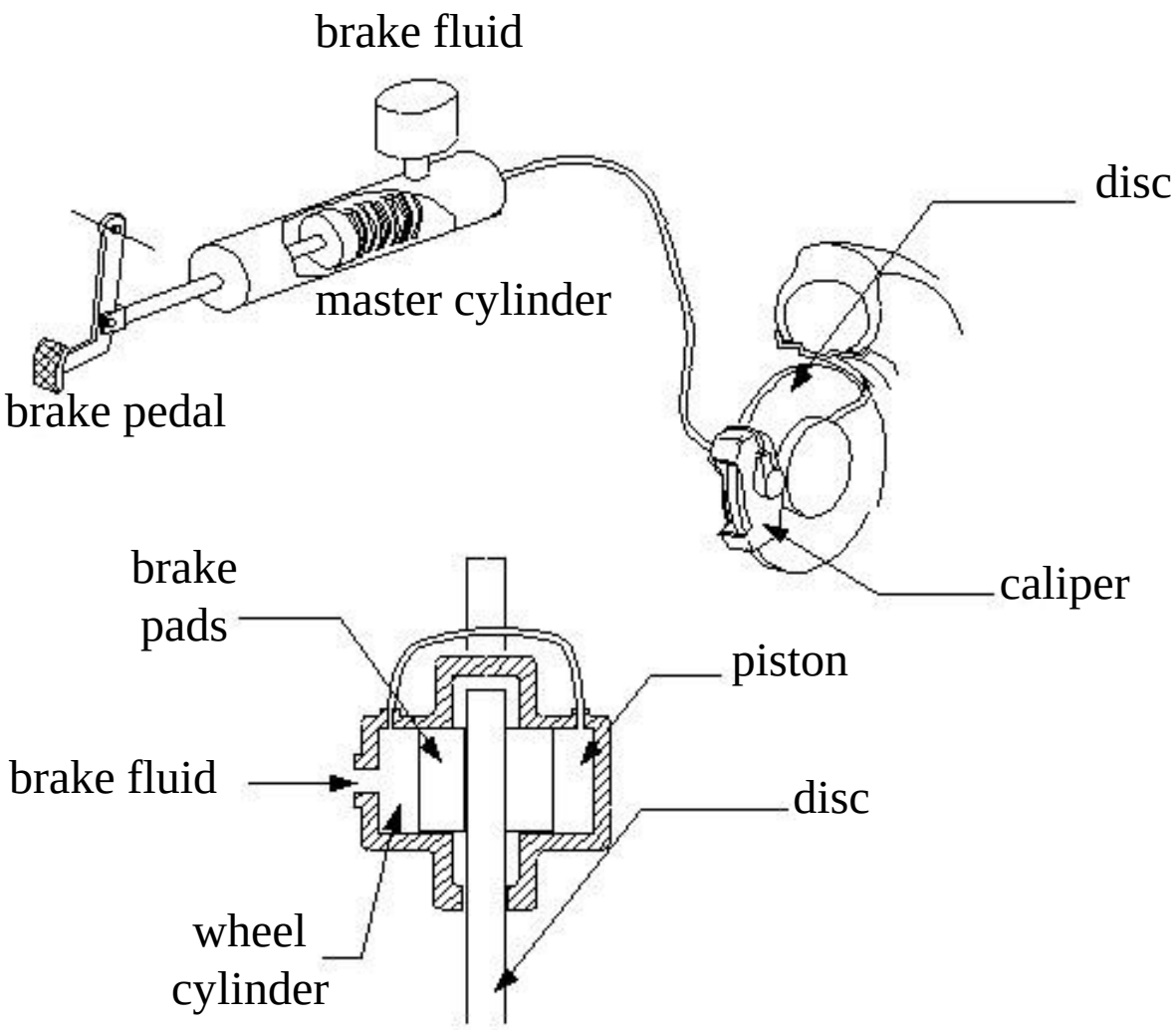
Example 7. Hydraulic Brakes



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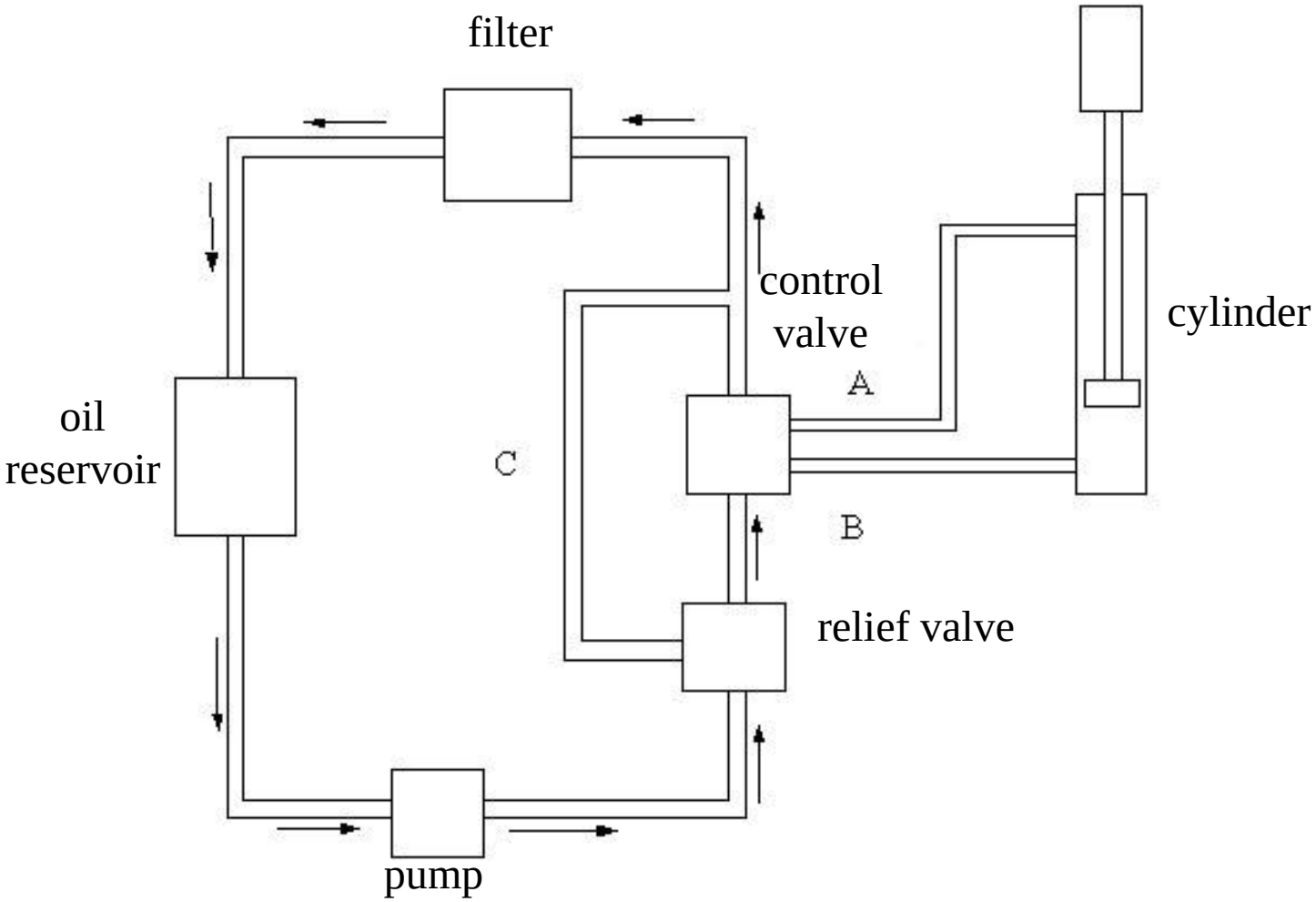
Example 8. Hydraulic Control loop



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Comparison between Pneumatic and Hydraulic Systems

Advantages

Pneumatic System

- ✓ Air is easily available
- ✓ Fast response
- ✓ Air is non-flammable
- ✓ Continuous variable transmission

Hydraulic System

- ✓ High output force
- ✓ Accurate hydraulic pressure
- ✓ No corrosion
- ✓ Continuous variable transmission

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Comparison between Pneumatic and Hydraulic Systems

Disadvantages

Pneumatic System

- Output force is limited
- Compressibility of air
- Corrosion may occur
- Pipe length is limited

Hydraulic System

- Fluid might leak out
- Fluid will degrade due to heat
- Fluid flow speed is limited
- Pipes are complicated
- Working fluid is often flammable.

Electrical Linear Actuator

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