



Pneumatic and Hydraulic Actuation Systems

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Textbook: W. Bolton, "Mechatronics --- Electronic control systems in mechanical and electrical engineering," 5th edition, Pearson Education Limited 2012, Chap 7

Ref. book: J. Edward Carryer, R. Matthew Ohline, Thomas W. Kenny, "Introduction to Mechatronic Design," Prentice Hall 2011, Chap 27

PowerPoint 中部分圖片擷取和修改自教科書和網路圖片

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1

Actuation Systems

□ Definition

- ◆ The elements of control systems which are responsible for transforming the output of a microprocessor or control system into a controlling action on a machine or device

□ Pneumatics

- ◆ Compressed air is used

□ Hydraulics

- ◆ Liquid, typically oil, is used

Actuation Systems

□ Pneumatics (compressed air)

◆ Drawback

- Compressibility of air, difficult to control accurately

□ Hydraulics (liquid, typically oil)

◆ High power, large force in a compact package

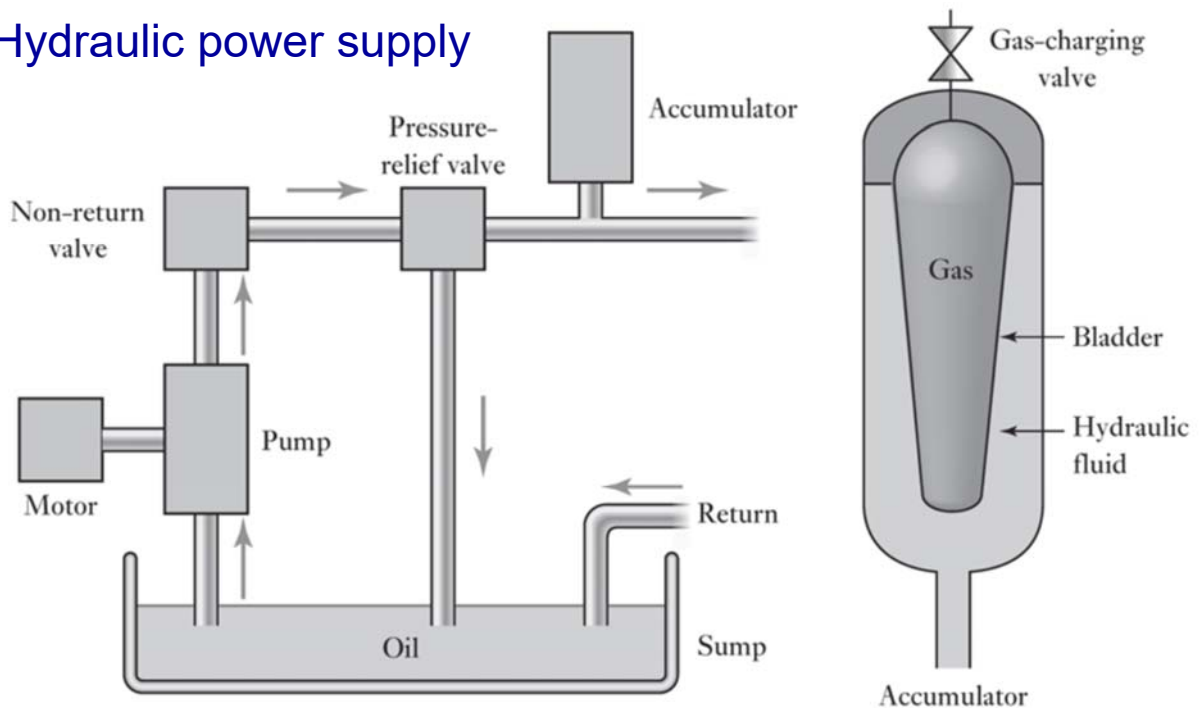
◆ Drawback

- Oil leak
- Lots of equipment (pumps, accumulators, hoses, servo valves...), kind of messy



Hydraulic Systems -1

□ Hydraulic power supply

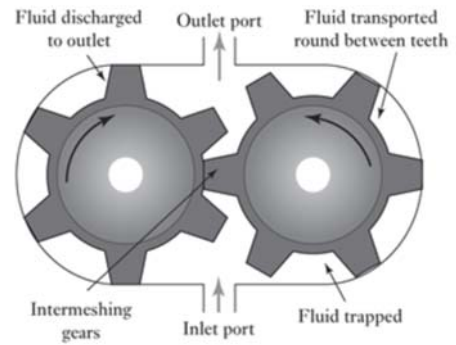


Accumulator: To smooth out any short-term fluctuations in the output oil pressure

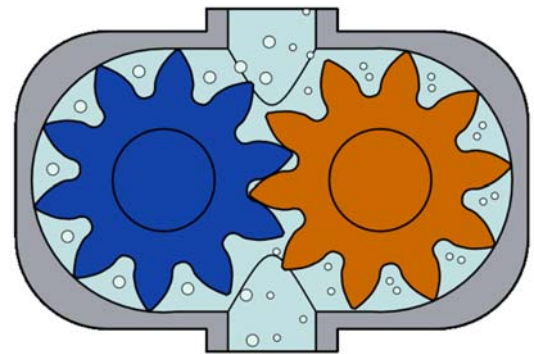
Hydraulic Systems -2

□ Pumps

- ◆ Gear pump (齒輪)
 - Low cost and robust
 - ~15MPa, 0.5 m³/min
 - Leakage



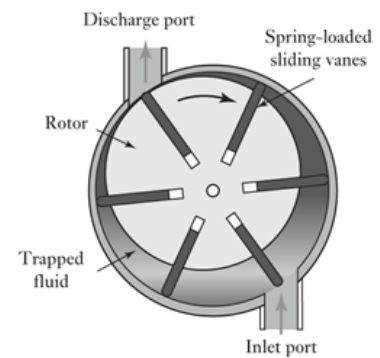
Gear pump



Hydraulic Systems -3

□ Pumps

- ◆ Vane pump (輪葉)
 - Spring-loaded sliding vanes
 - Less leakage than the gear pump



Vane pump

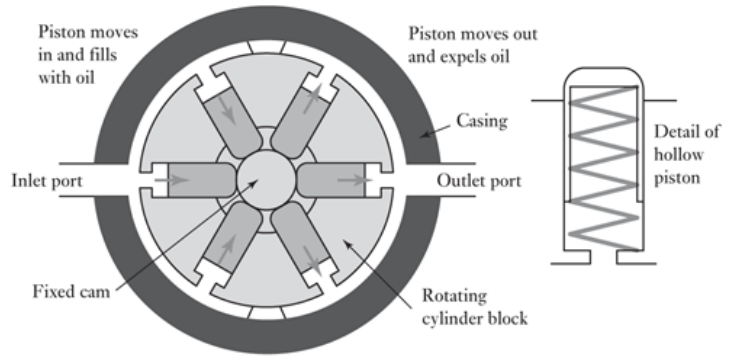


Hydraulic Systems -4

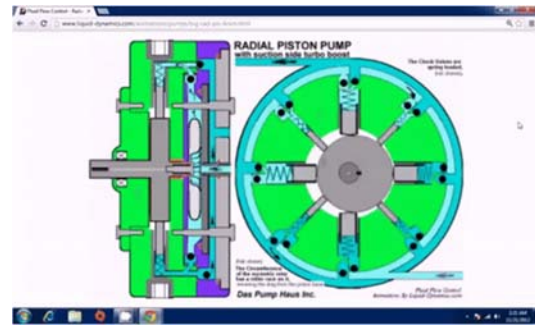
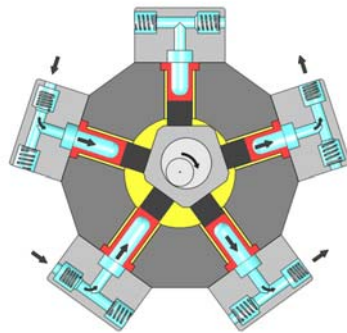
□ Pump

◆ Piston pump (活塞)

- High efficiency
- High hydraulic pressure



Radial piston pump

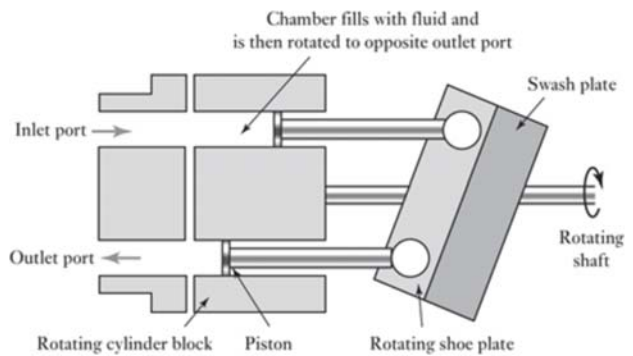


Hydraulic Systems -5

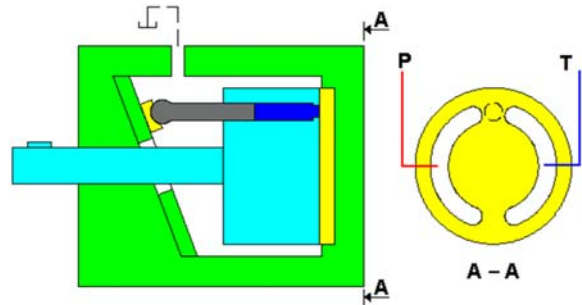
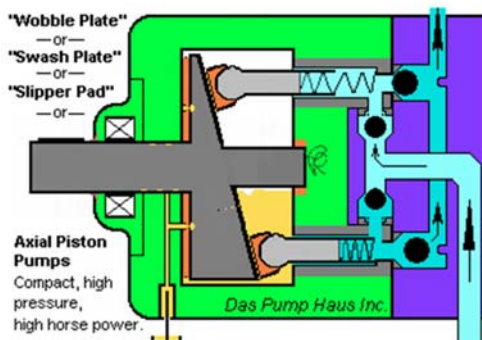
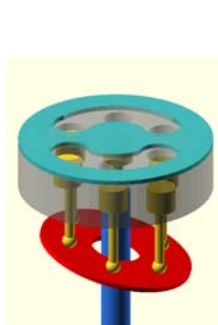
□ Pump

◆ Piston pump

- High efficiency
- High hydraulic pressure

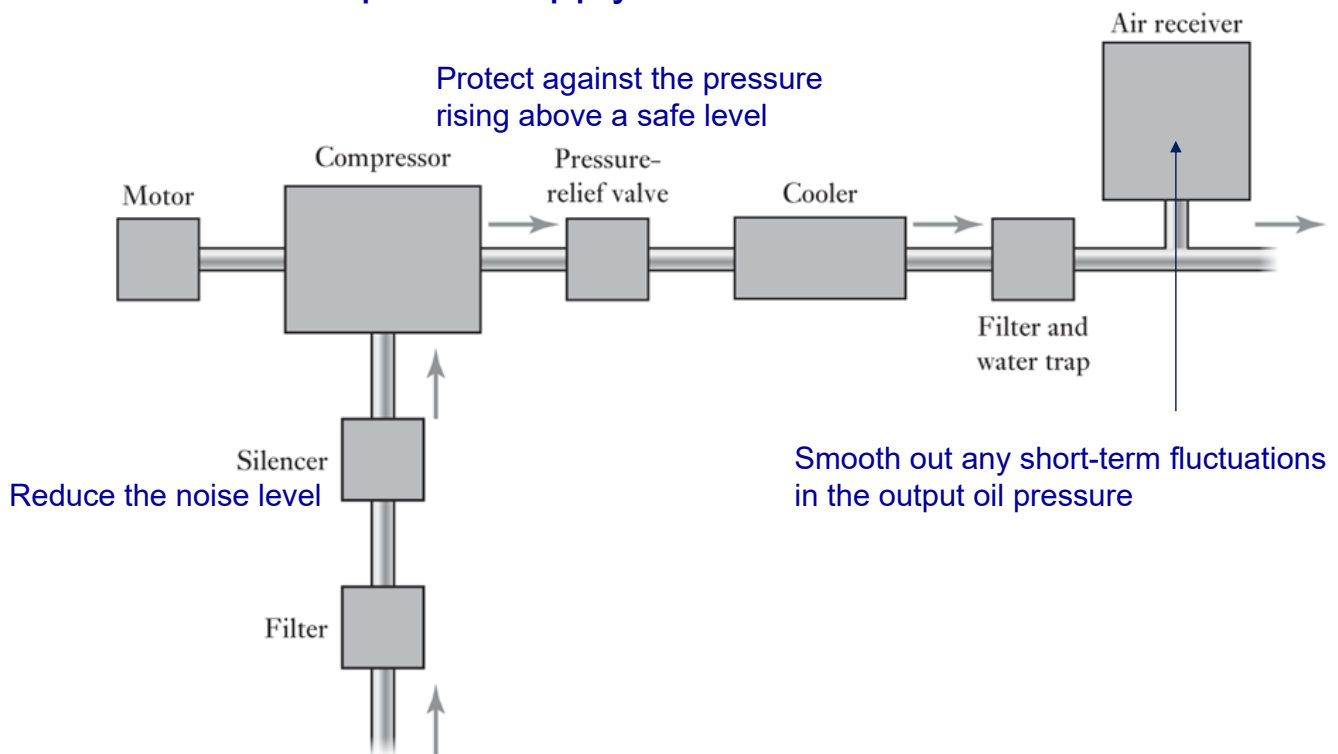


Axial piston pump



Pneumatic Systems -1

□ Pneumatic power supply

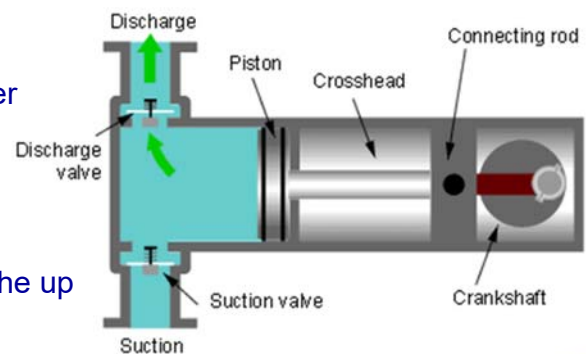
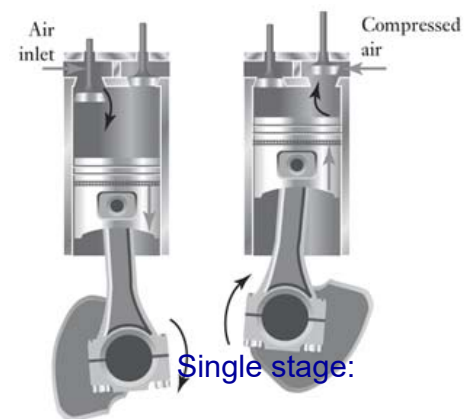


Pneumatic Systems -2

□ Air compressor

◆ Reciprocating compressor

- Single stage: few bars
 - The compressor goes directly from atmosphere pressure to the required pressure in a single operation
- Two stages: 10-15 bars
- Single acting
 - One pulse of air is produced per piston stroke
- Double acting
 - Produces pulse of air on both the up and down strokes of the piston

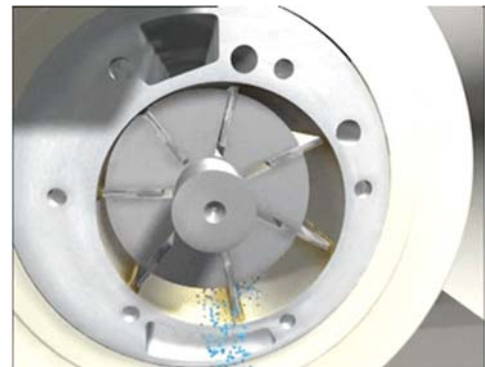
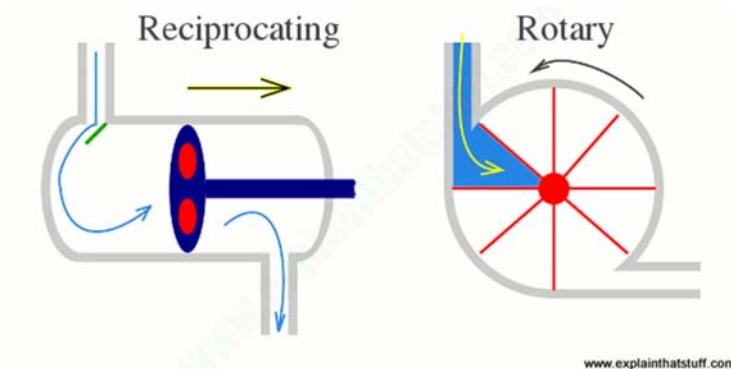
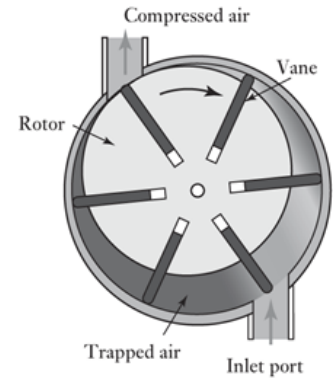


Pneumatic Systems -3

□ Air compressor

◆ Rotary vane compressor (輪葉)

- Single stage up to 800kPa, 0.3 – 30 m^3/min

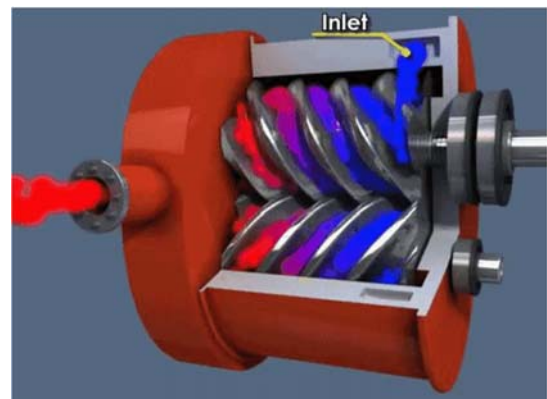
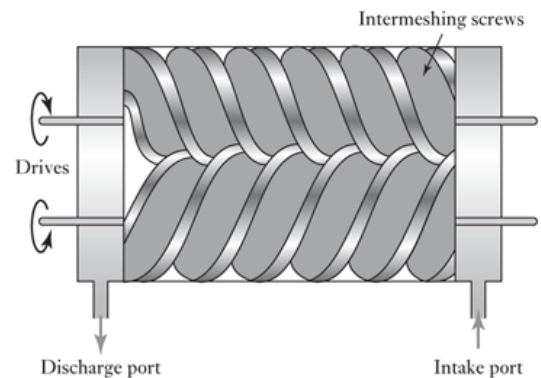


Pneumatic Systems -4

□ Air compressor

◆ Rotary screw compressor

- Single stage up to 1000kPa, 1.4 – 60 m^3/min



Valves

□ Forms

◆ Finite position

- Just to allow or block fluid flow and so can be used to switch actuators on or off
- Used to switch actuators on or off

◆ Infinite position

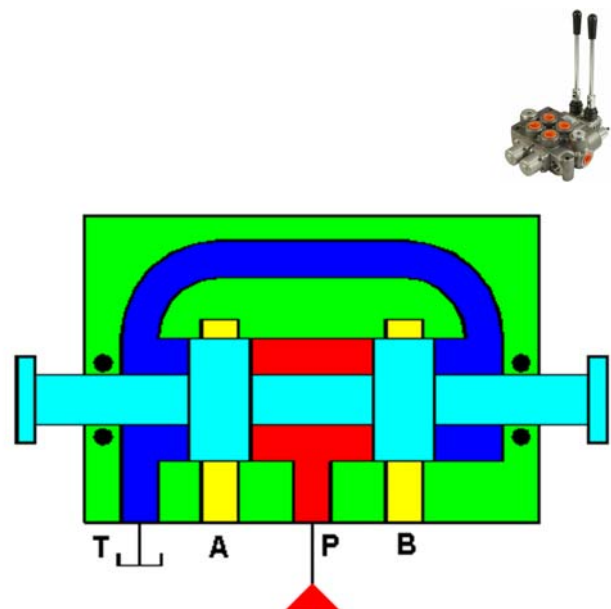
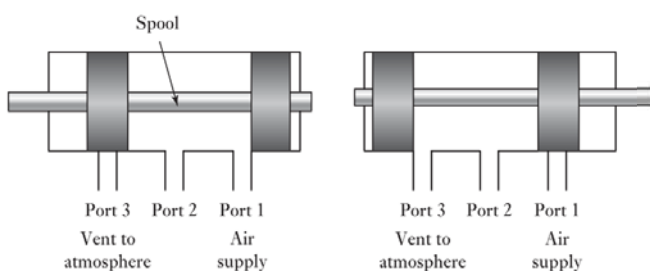
- Able to control flow anywhere between fully on and fully off
- Used to control varying actuator forces or the rate of the fluid flow for a process control situation

Directional Control Valves -1

□ Function

- ◆ To direct the flow of fluid through a system
- ◆ Completely open or closed

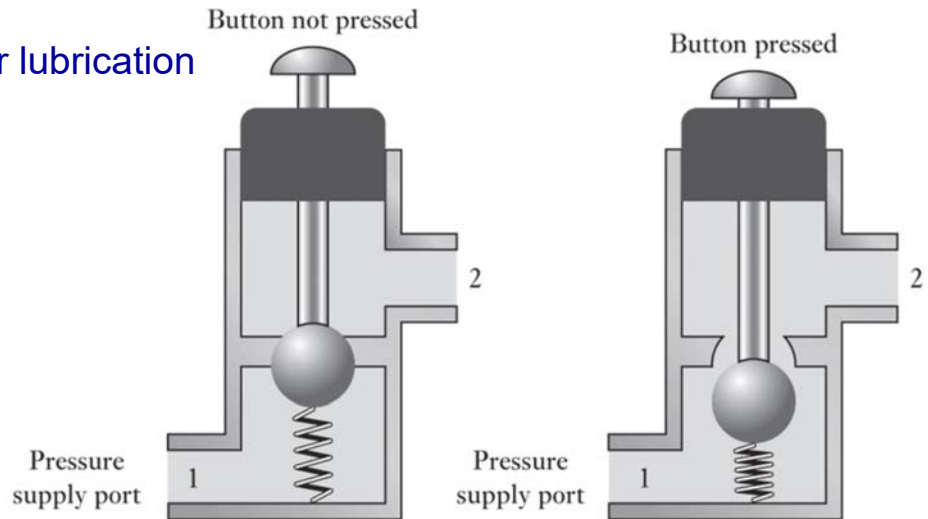
□ Spool valve



Directional Control Valves -2

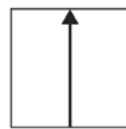
□ Poppet valve

- ◆ Normally closed
- ◆ Faster response
- ◆ Less flow
- ◆ No need for lubrication

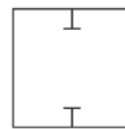


Valve Symbols -1

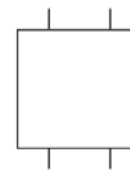
□ Square = number of positions (位)



Flow path

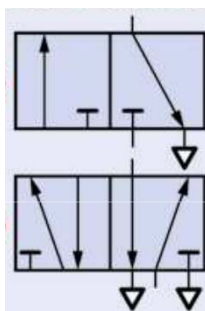


Flow shut-off



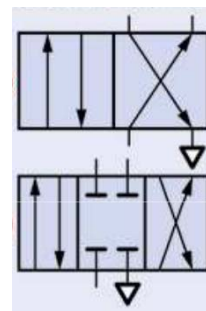
Initial connections

□ Lines outside the square = number of connections (□)



3□2位

5□2位



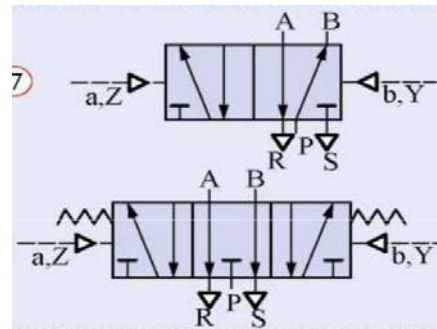
4□2位

4□3位

Valve Symbols -2

□ Letters

- ◆ A, B: working lines
- ◆ P: air supply
- ◆ R, S, T: exhaust
- ◆ X, Y, Z: control

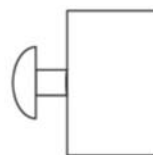


Valve Symbols -3

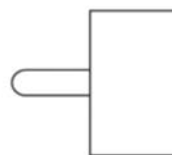
□ Actuation symbols



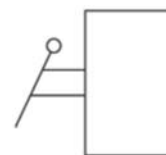
Solenoid valve



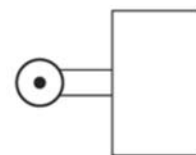
Push-button



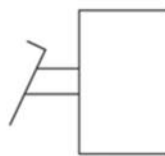
By plunger



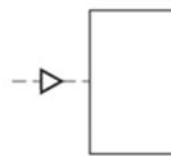
By lever



By roller



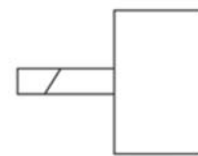
By pedal



By application of pneumatic pressure



By spring



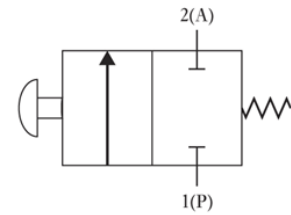
By solenoid

Valve Symbols -4

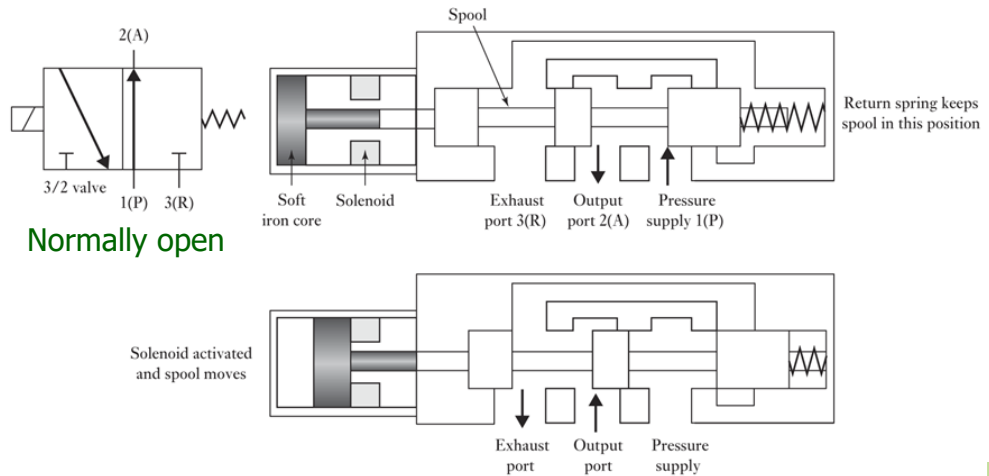
Examples

Ex 1

- Two-port, two-position poppet valve
- Actuated by a push-button and a spring

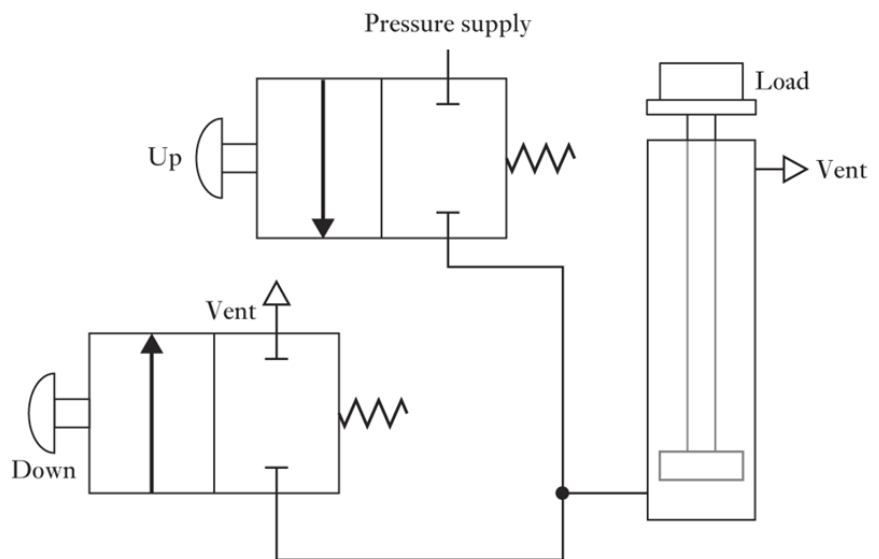


Ex 2



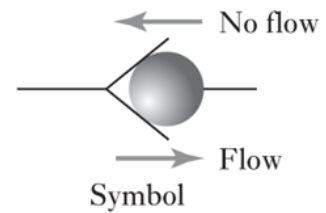
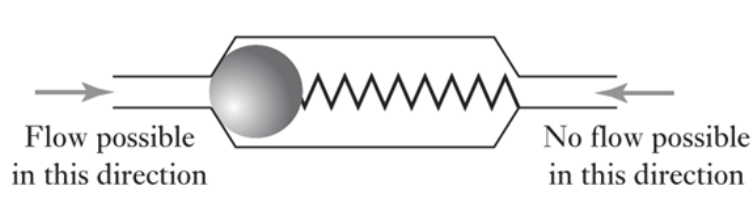
Valve Symbols -5

Ex: A lift system



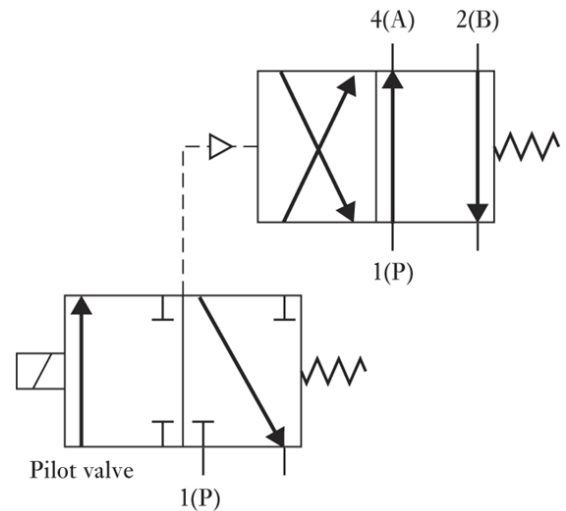
Valve Symbols -6

□ Directional valve



□ Pilot-operated valve

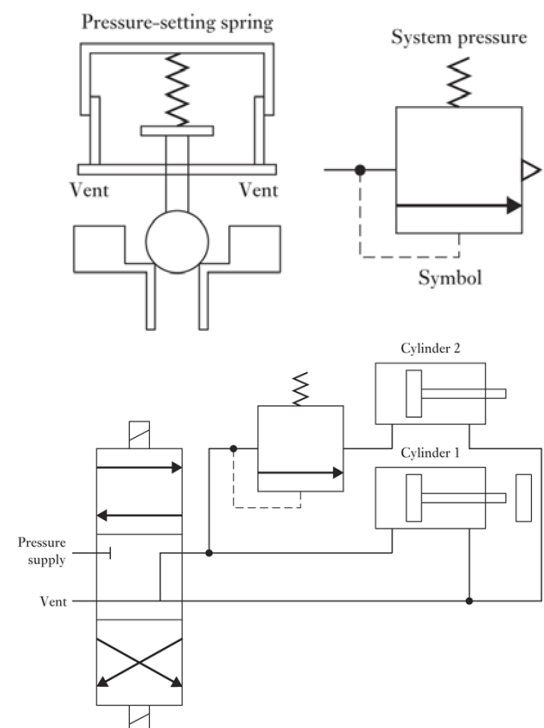
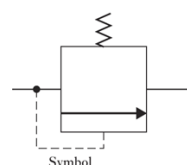
- ◆ One valve is used to control a second valve



Pressure Control Valves

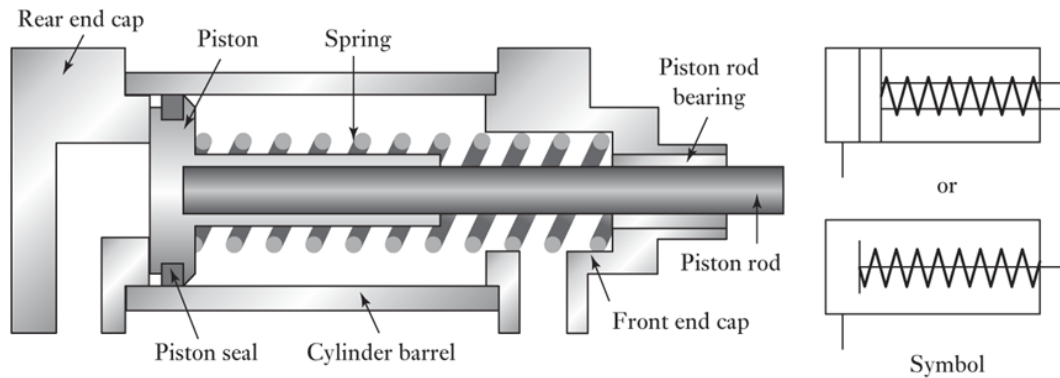
□ Types

- ◆ Pressure-regulating valves
- ◆ Pressure-limiting valves
- ◆ Pressure sequence valves
 - Used to sense the pressure of an external line and give a signal when it reaches some preset value



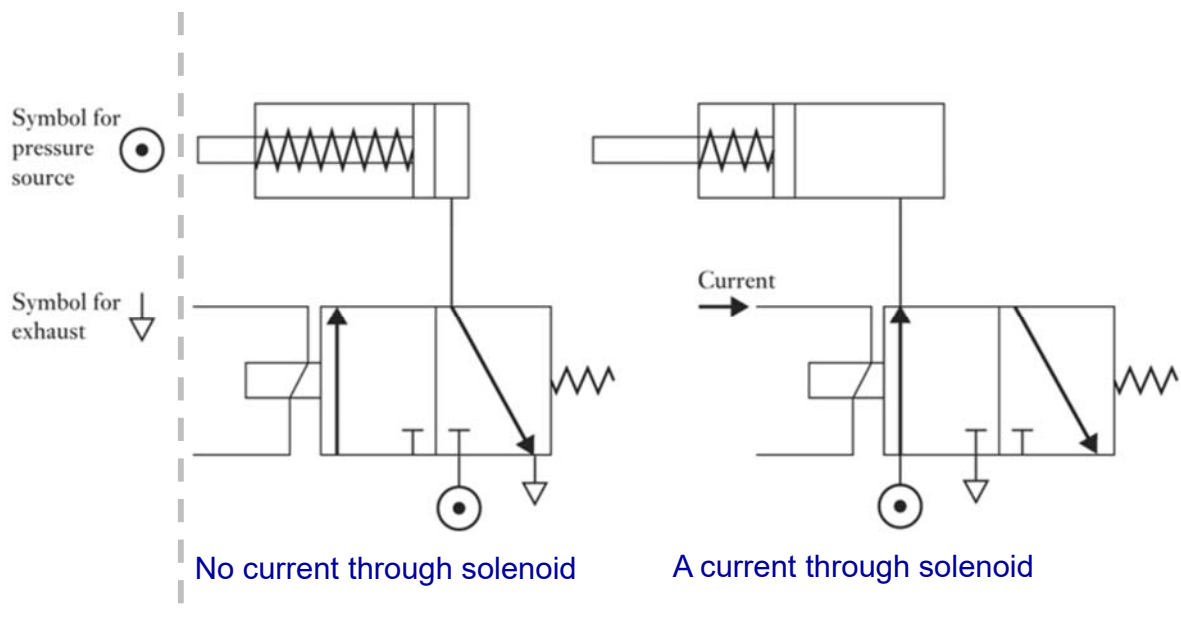
Cylinders -1

- An example of a linear actuator
- Single acting
 - ◆ The control pressure is applied to just one side of the piston, a spring often being used to provide the opposition to the movement of the piston



Cylinders -2

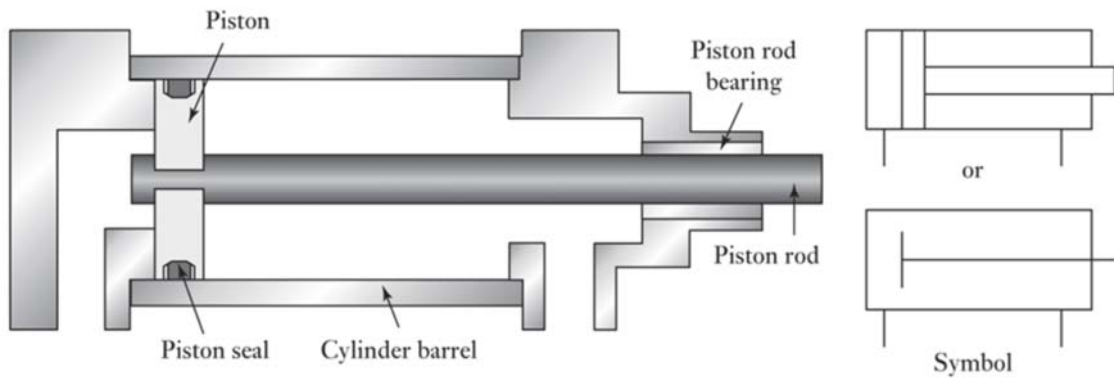
- Ex: Single acting (單動)



Cylinders -3

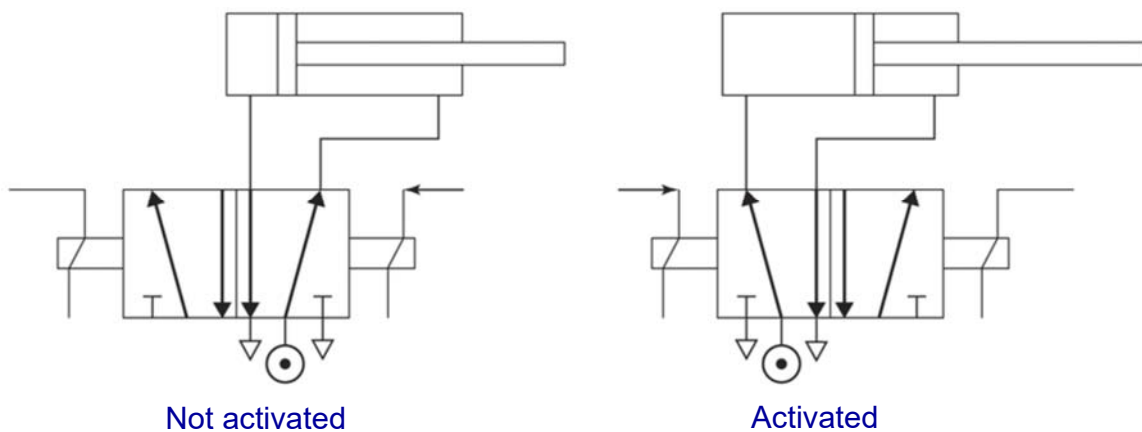
□ Double acting (雙動)

- ◆ The control pressures are applied each side of the piston



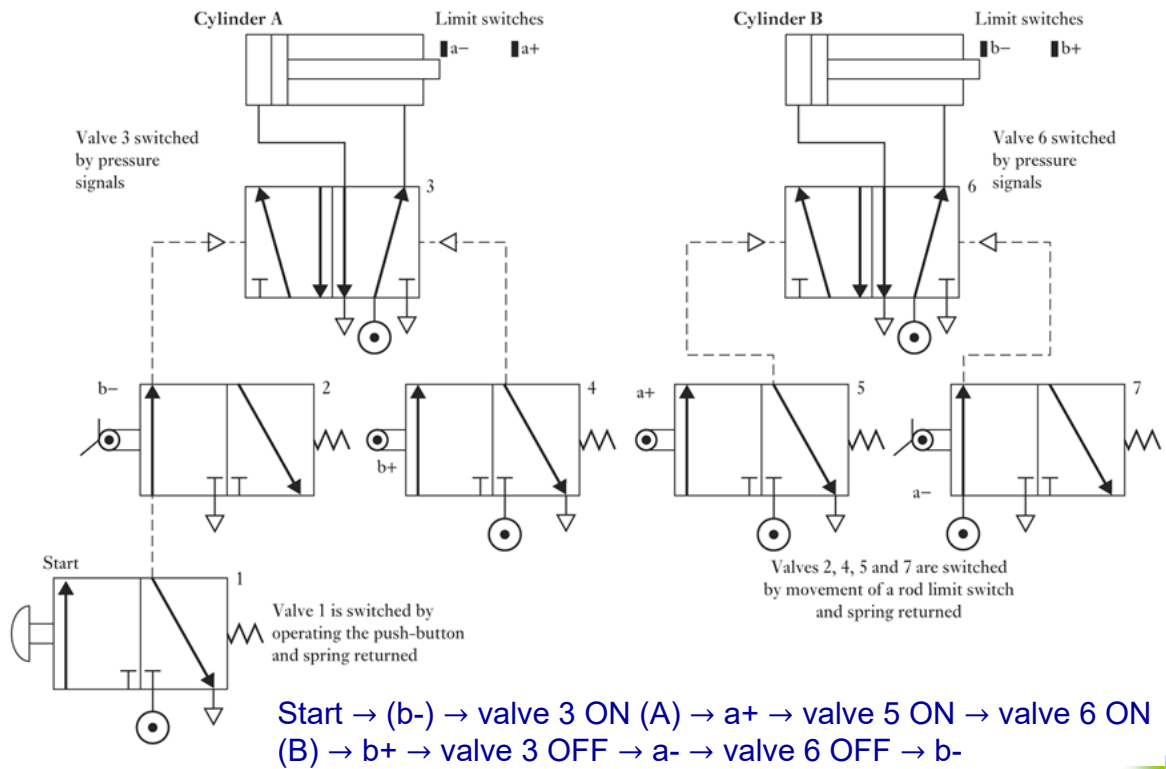
Cylinders -4

□ Ex: Double acting



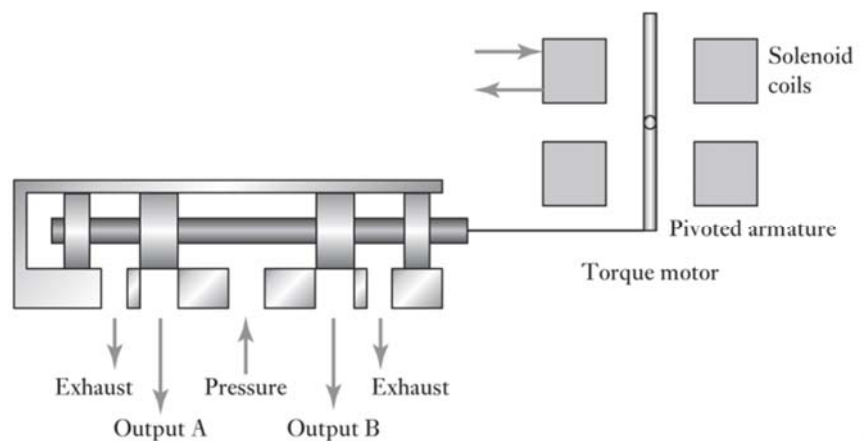
Cylinders -5

Sequencing



Servo and Position Control Valves -1

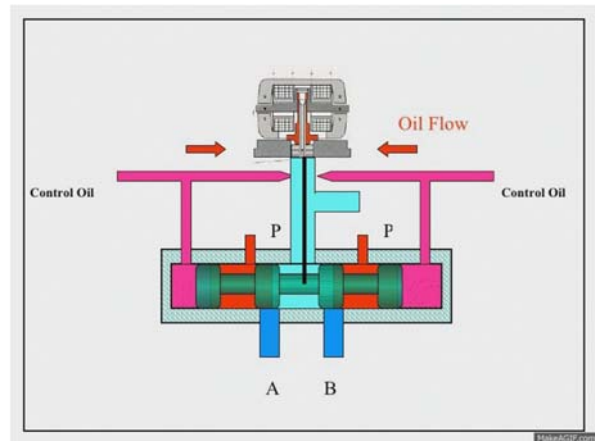
- Are infinite position valve
- Servo valves
 - ◆ A torque motor to move the spool within a valve



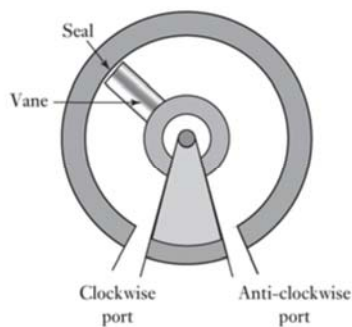
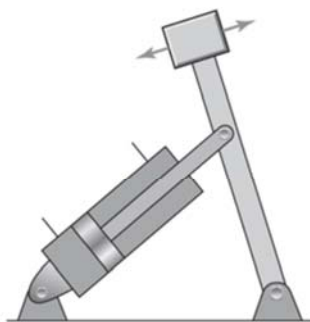
Servo and Position Control Valves -2

□ Position control valves

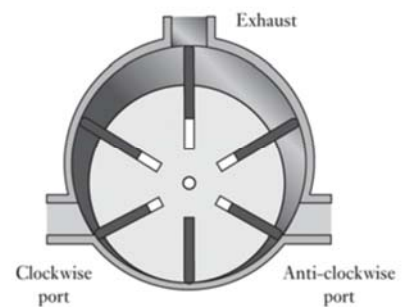
- ◆ Valve spool displacement proportional to the current supplied to a solenoid
- ◆ Less expensive than the servo valve



Rotary Actuators



Semi-rotary actuator



Vane motor

Applications -1

- BigDog – using hydraulic system



Applications -2

- BigDog Beta





End

□ Questions?

