MENG2520 Pneumatics and Hydraulics

Module 7 – Pneumatic System Design

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Pneumatic System Design

In this Module we complete the study of pneumatic system design.

In this Module we study

- **Pneumatic vs Electro-pneumatic Systems**
- **Electro-pneumatic devices; input and output**
- **Study of some examples**
- **PLCs and electro-pneumatics**

Pneumatic System

Air Compressor – reduces volume of atmospheric air and hence increases its pressure

Air Dryer – reduces moisture from air after compression

Air Tank – stores compressed air and acts an ‘infinite’ supply for the systems

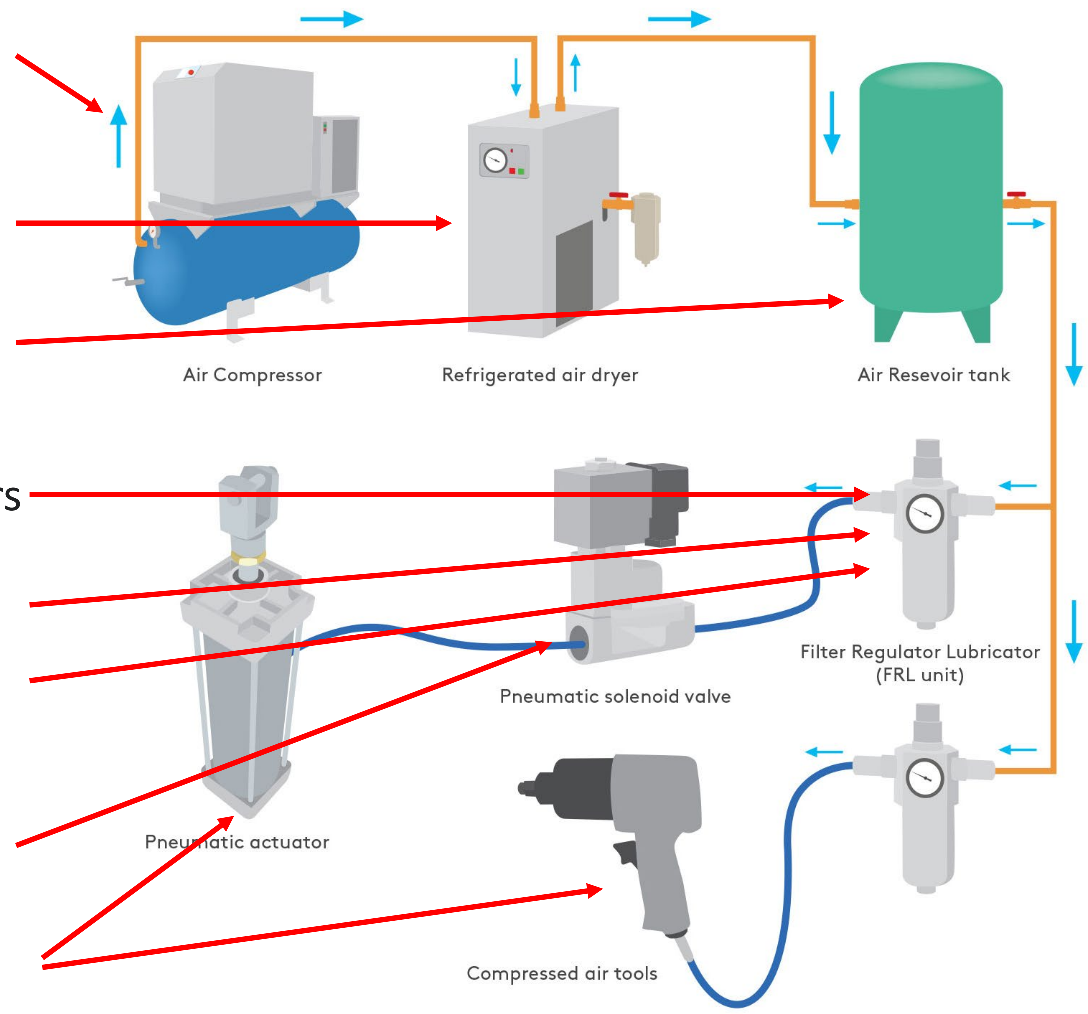
Filter – removes contaminants that can damage DCVs and actuators

Regulator – reduces the pressure to the actuator

Lubricator – adds a fine mist of oil for lubricating the DCV and actuator’s moving parts

Valve – controls the direction and movement of the air

Actuator – converts the pneumatic power into mechanical power

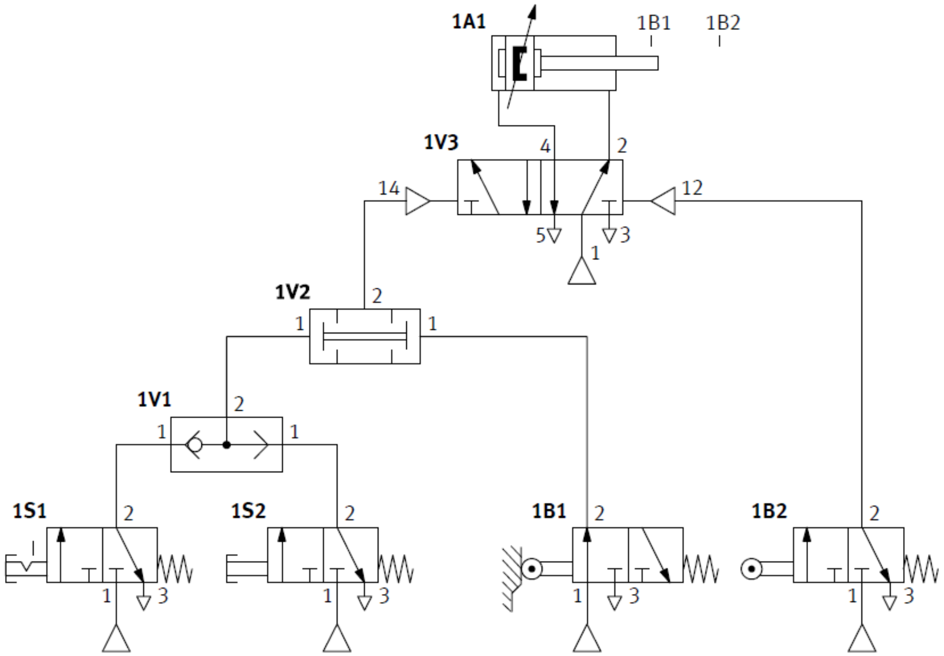


https://www.essentracomponents.com/en-gb/news/guides/hydraulics-versus-pneumatics

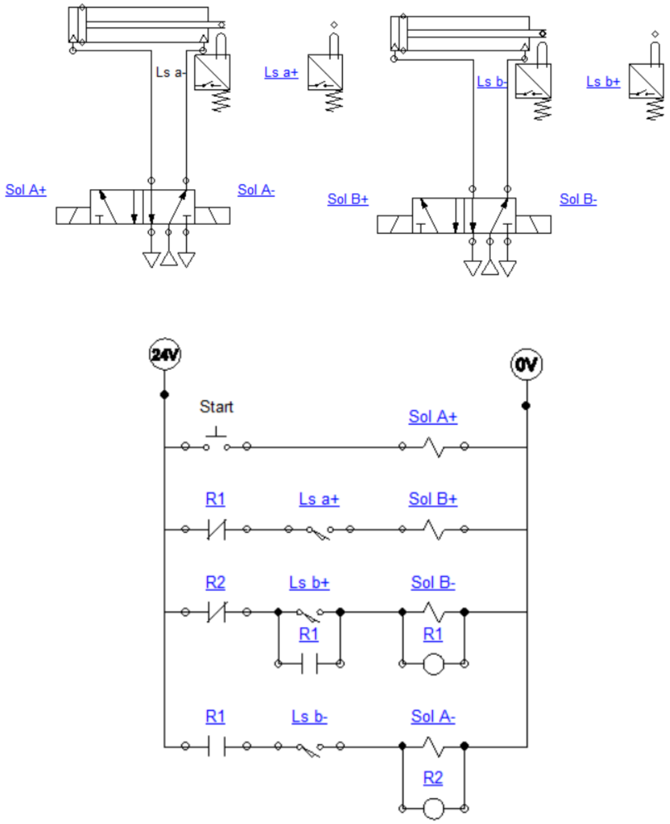
14 Pneumatic System Design

Recall from Week 1 Introduction to Fluid Power, we can design the control of a fluid power system using DCVs, switches, switches and other control devices which are exclusively fluid power operated, OR we can build systems using electrical control.

Pure pneumatic/hydraulic control



Electo-Pneumatic/hydraulic control



15 Pneumatic vs Electropneumatic Design

Pneumatic System

Used for simple control systems, e.g. hand tools
One type of medium (air) for power transfer *and* control
Can be used in explosive environments
Can be used underwater
Used when electricity not available, e.g. remote situations with gas powered compressor

Electropneumatic

Can build complex control schemes
Easy to reconfigure with simple wiring changes
Offers flexibility in system layout – e.g. without having to run fluid lines to control stations
Easily integrate electronic sensors such as capacitive or inductive proximity sensors
Easily manages 'conflict' - when DCV is being commanded both sides at the same time
Can integrate with a PLC or microcontroller adding greater design flexibility and plant integration

15 Electropneumatic Design

Electropneumatic systems are far more commonly found in automation systems than pure pneumatic systems
The flexibility and relatively low-cost of the electropneumatic systems makes them ideal for all pneumatic systems from simple single actuators to complex multi-actuator systems

The electrical components can be designed to operate on a range of voltages, although low voltage 24V DC is common

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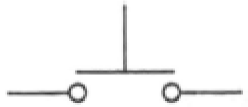
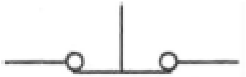
15.2 Input Devices

Push Buttons: By the use of a simple push-button switch, an operator can cause sophisticated equipment to begin performing complex operations. These push-button switches are used mainly for starting and stopping the operation of machinery as well as providing for manual override when an emergency arises. Push buttons can be placed anywhere they are accessible to the operator.

Electrical



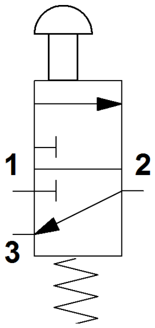
(a) SPST – NO

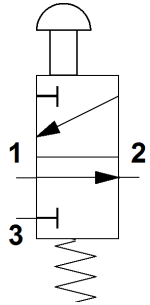


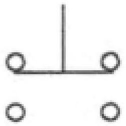
(b) SPST – NC

SPST: single pole, single throw

Pneumatic Equivalent

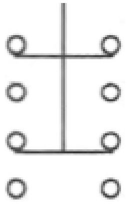






(c) DPST – NO/NC

DPST: double pole, single throw



(d) DPDT – NO/NC

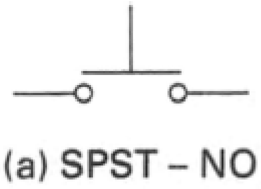
DPDT: double pole, double throw

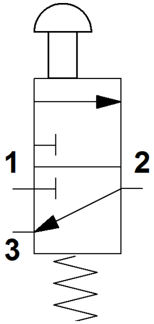
15.2 Input Devices

Nomenclature

In electrical, an OPEN switch blocks current flow

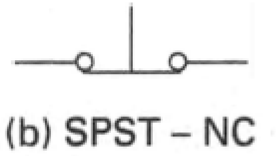
In Fluids, a CLOSED valve blocks the flow of air

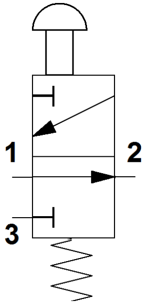




Switch: OPEN

Valve: CLOSED or NON-PASSING





Switch: CLOSED

Valve: OPEN or PASSING

15.2 Input Devices

Limit Switches: Limit switches open and close circuits when they are actuated either at the end of the retraction or extension strokes of pneumatic cylinders. The limit switch can be placed external to the cylinder and is activated when the cylinder rods extends or retracts and physically depress then cam of the switch.

Schematic

(a) LS – NO

(c) LS – NC

Electropneumatic Symbol

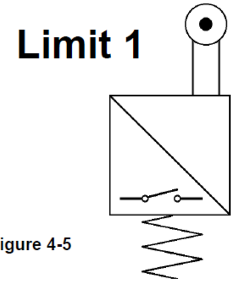
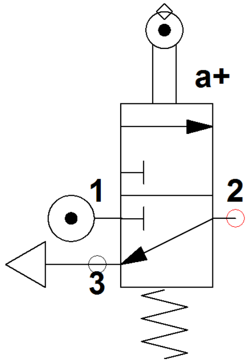


Figure 4-5

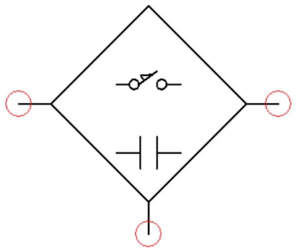
Pneumatic Equivalent



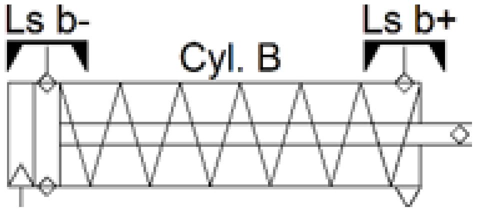
15.2 Input Devices

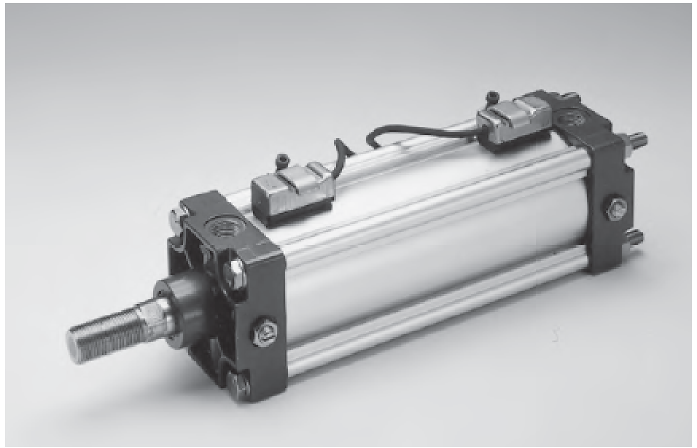
Reed Switches: limit switches that can be placed directly on the cylinder body, activated through detection of the moving piston in the cylinder, keeping them free from the movement of the rod in the system and less susceptible to accidental movement.

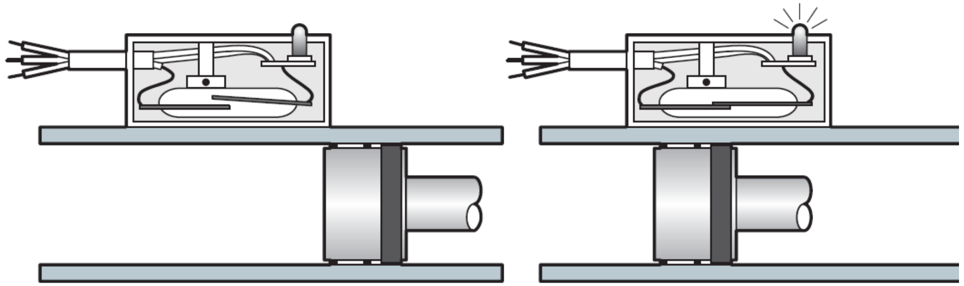
Schematic



Electropneumatic symbol







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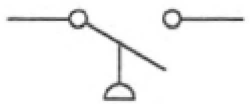
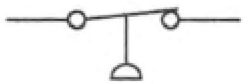
15.2 Input Devices

Pressure switches Used to detect a setpoint pressure. For example, to detect when an accumulator has reached desired pressure and opens a vent

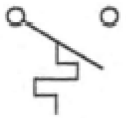


(a) PS – NO

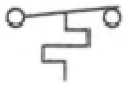


(b) PS – NC

Temperature switches Used to detect a setpoint temperature. For example, detect when the temperature of an oven has reached the setpoint and turn off the heater.



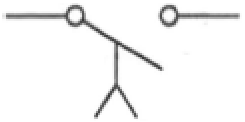
(a) TS – NO



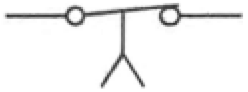
(b) TS – NC

15.2 Input Devices

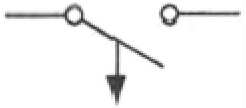
<u>Timers:</u> used to create a time delay between subsequent actions. For example, once the label has been applied to the part, wait 15 seconds for the adhesive to cure before moving the part down the line



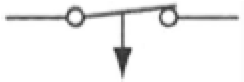
(a) NO (TIMED CLOSED WHEN ENERGIZED)



(b) NC (TIMED OPEN WHEN ENERGIZED)



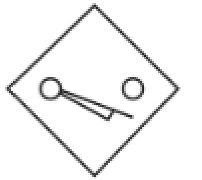
(c) NO (TIMED OPEN WHEN DE-ENERGIZED)



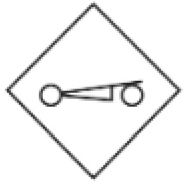
(d) NC (TIMED CLOSED WHEN DE-ENERGIZED)

15.2 Input Devices

Proximity Switches: used to detect the presence of an object.

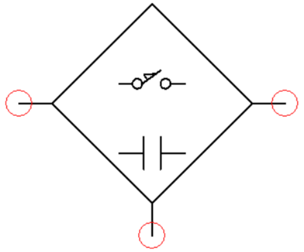


Proximity Switch
Normally Open

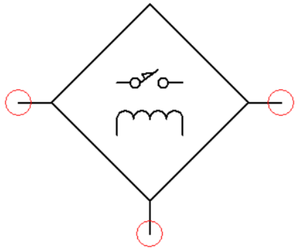


Proximity Switch
Normally Closed

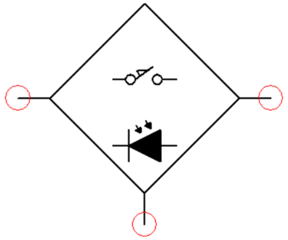
Capacitive Sensor: respond to materials with a high electrical conductivity (e.g. metals) and all insulators with a high dielectric constant (e.g. plastics, glass, ceramic, liquids and wood).



Inductive Sensor: respond to all good electrical conductors, for example graphite as well as metals



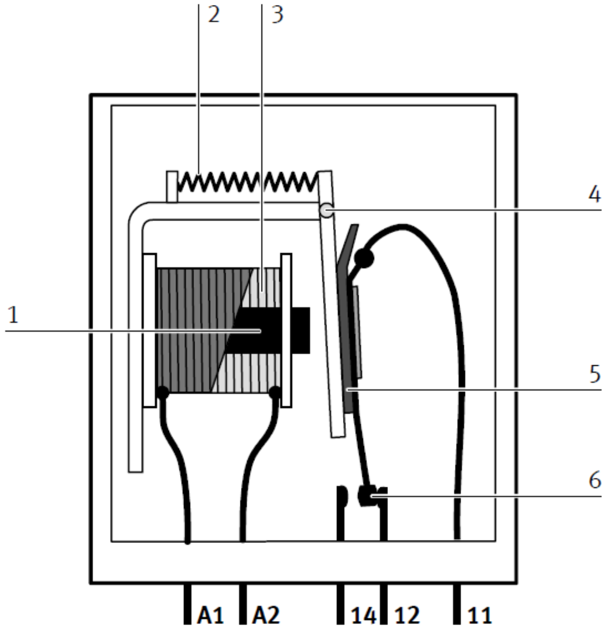
Optical Sensor: uses light to detect the presence of an object though either 1) Through-beam sensor 2) Retro-reflective sensor 3) Diffuse sensor

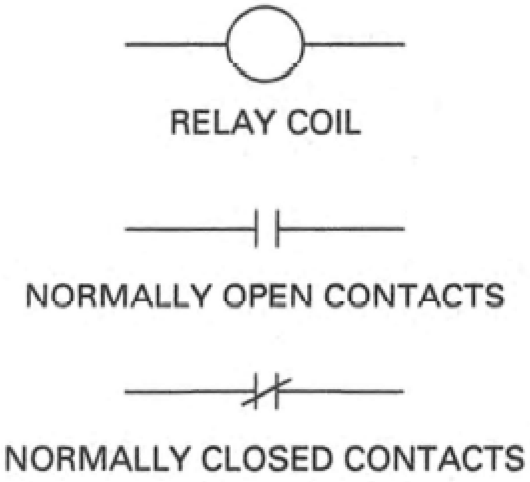


15.2 Output Devices

Electrical relays: A relay is an electrically actuated switch

When an activation signal is applied to the solenoid (3) through A1 and A2, the resulting electromagnetic field will cause the armature (5) to pull towards the solenoid core (1) changing the state of the contacts (6) NC (normally closed) 11-12 and NO (normally open) contacts 11-14





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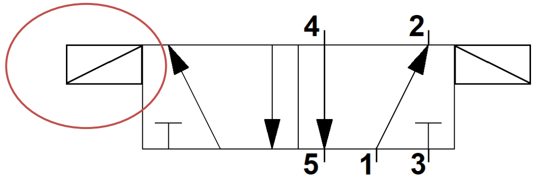
15.2 Output Devices

Solenoid: The electrical actuator of a control device such as a DCV.

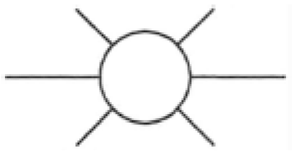
(a) SOLENOID

Schematic symbol



on the DCV

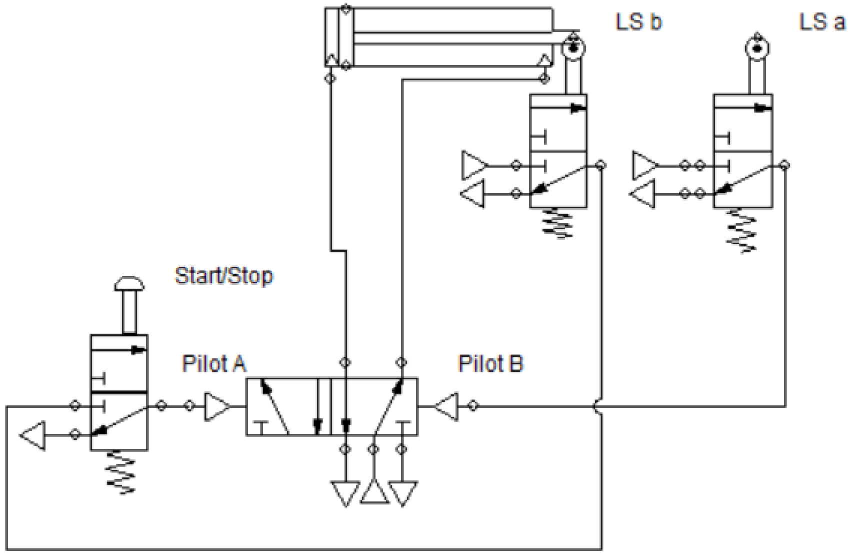
Lamp: A visual indicator to the operator. Can be used to indicate any state in a system including circuit enabled, cylinder extended



(b) INDICATOR LAMP

15.2 Circuit Design: Control of an Extend/Retract Circuit 1 Shot

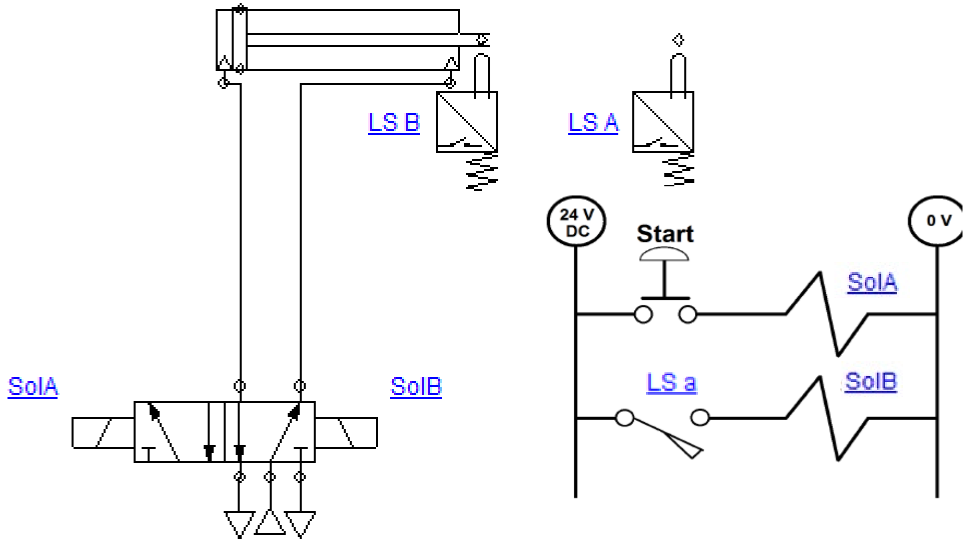
Pure Pneumatic Control



Circuit Function:

•Press Start and **Pilot A** energizes and moves DCV spool to left and Cylinder A extends.
•Limit Switch A closes at Cylinder A extension.
•**Pilot B** energizes and moves DVC spool to right and Cylinder A retracts.

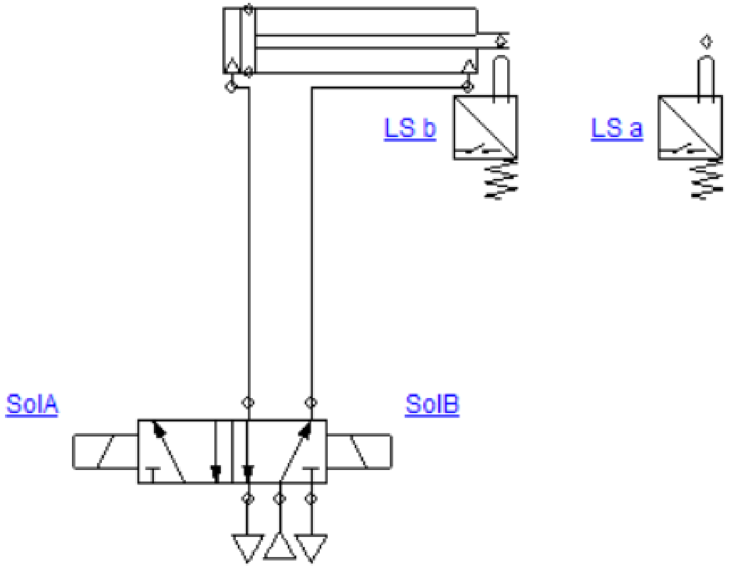
Electro-Pneumatic Control

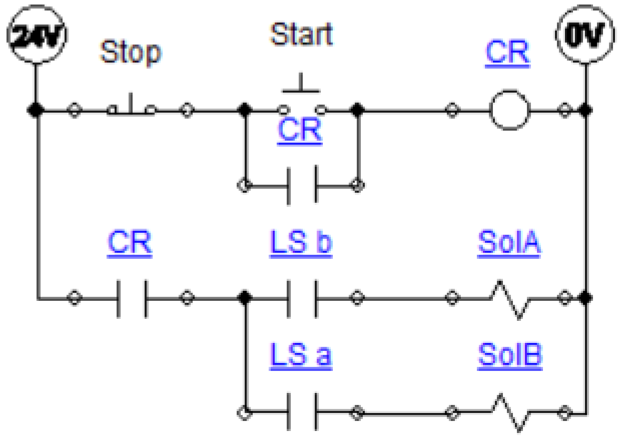


Circuit Function:

•Press Start and **Solenoid A** energizes and moves DCV spool to left and Cylinder A extends.
•Limit Switch A closes at Cylinder A extension.
•**Solenoid B** energizes and moves DVC spool to right and Cylinder A retracts.

15.2 Circuit Design: Control of an Extend/Retract Circuit Continuous

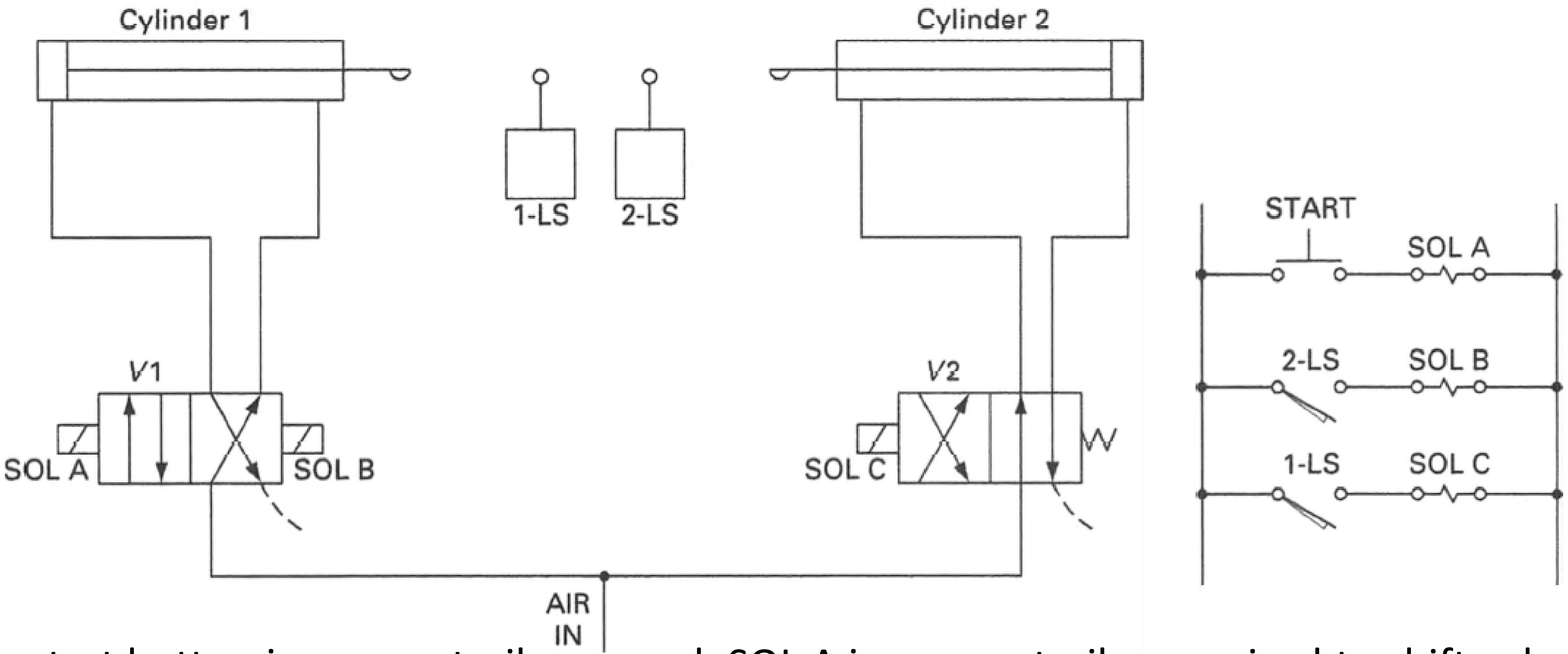




With the addition of Control Relay and a holding circuit, the cylinder will continuously cycle with one momentary press of the Start button

Pressing Stop will stop the cycling at the end of the current stroke

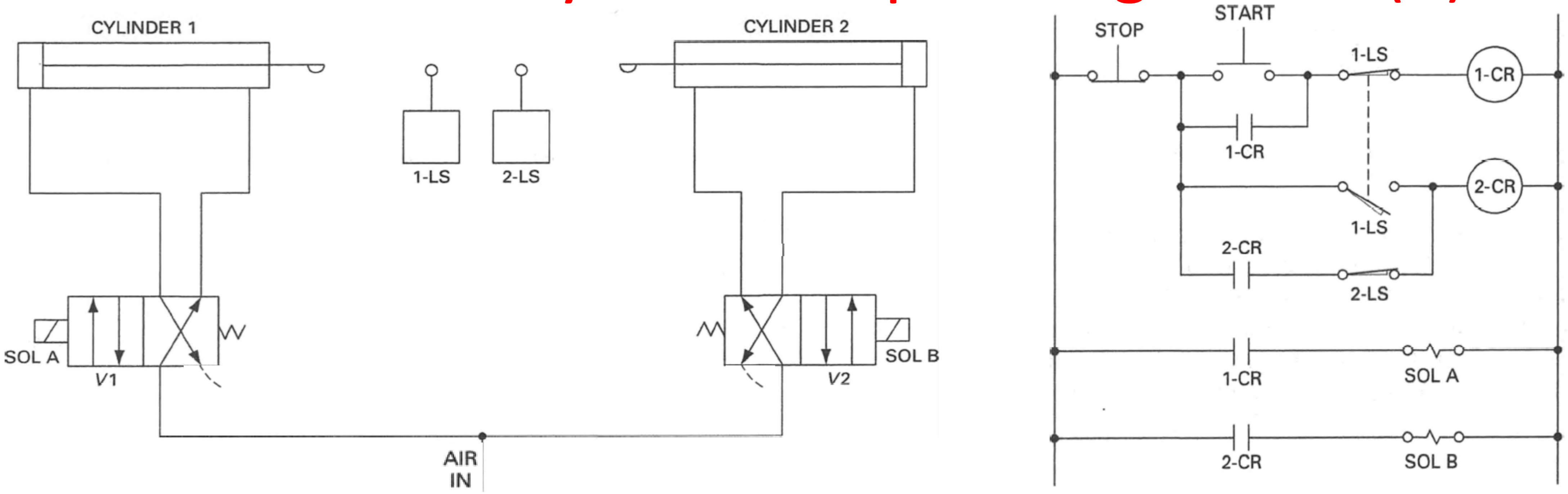
15.2 Dual Cylinder Sequencing Circuit (1)



When the start button is momentarily pressed, SOL A is momentarily energized to shift valve V1, which extends cylinder 1. When 1-LS is actuated, SOL C is energized, which shifts valve V2 into its left flow path mode which extends cylinder 2 until it actuates 2-LS. As a result, SOL B is energized to shift valve V1 into its right flow path mode. As cylinder 1 begins to retract which deactuates 1-LS and de-energizes SOL C allowing V2 into its spring-offset mode retracting cylinder 2 at the same time as cylinder 1

1. Cylinder 1 extends.
2. Cylinder 2 extends.
3. Both cylinders retract.
4. Cycle is ended.

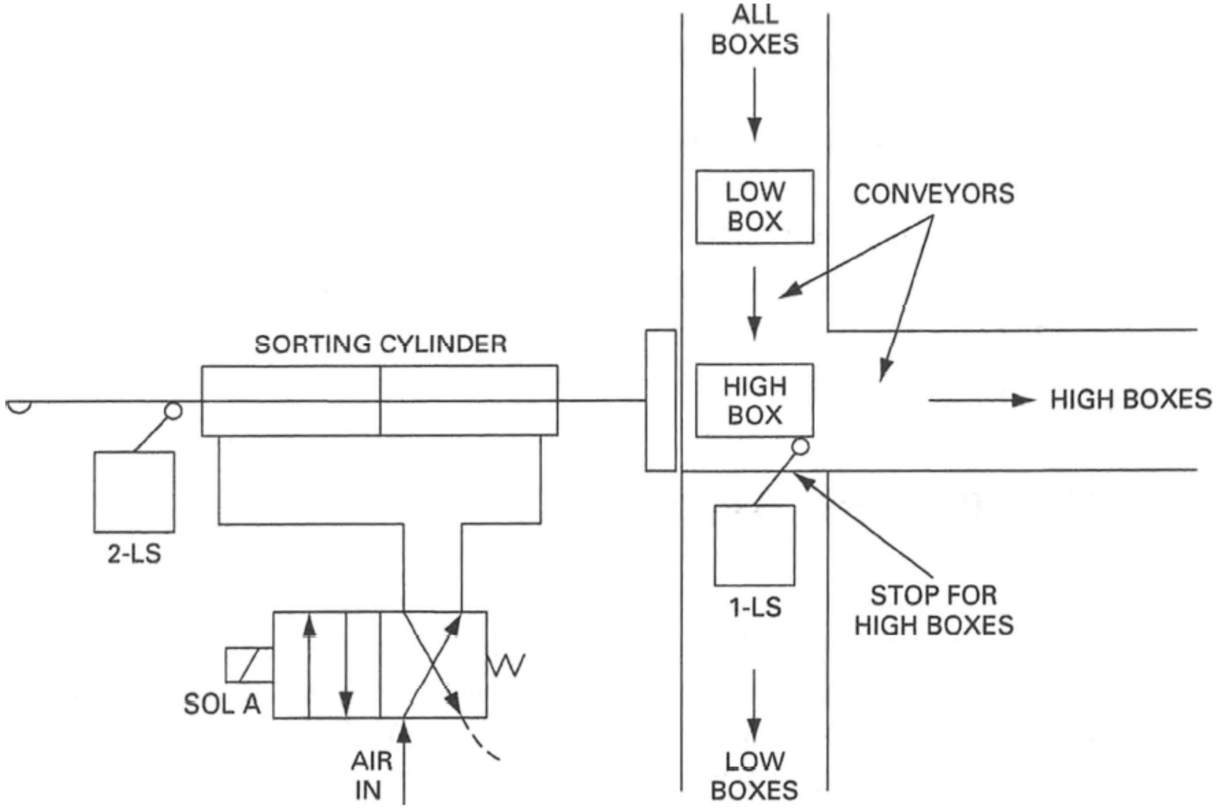
15.2 Dual Cylinder Sequencing Circuit (2)

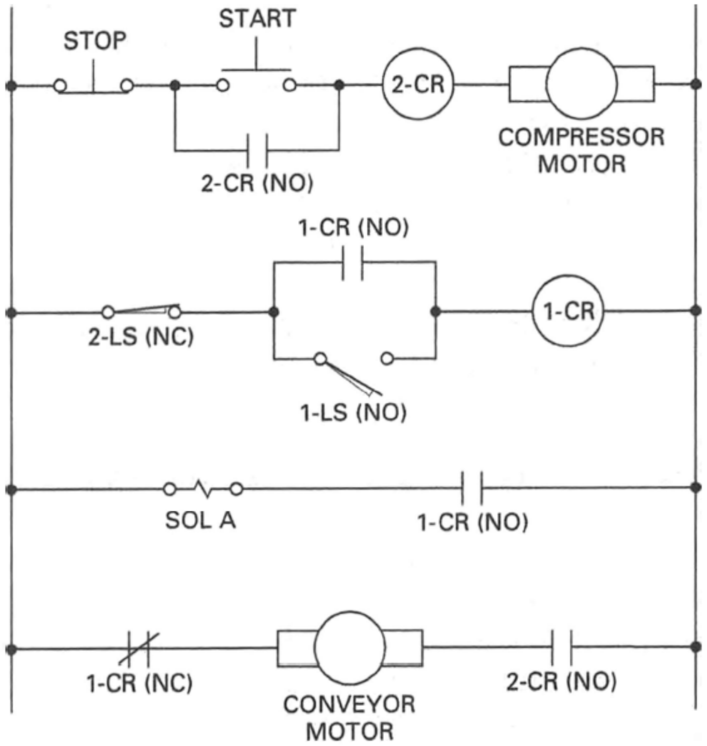


When the START button is depressed momentarily, SOL A is energized to allow flow through V1 to extend cylinder 1. Actuation of 1-LS de-energizes SOL A and energizes SOL B. Limit switch 1-LS is DPST and actuation opens the holding circuit for relay 1-CR and simultaneously closes the holding circuit for relay 2-CR. This returns V1 to its spring-offset mode which retracts cylinder 1, and also switches V2 into its solenoid-actuated mode which extends cylinder 2 at the same time. When 2-LS is actuated, SOL B is de-energized to return V2 back to its spring-offset mode to retract cylinder 2. The STOP button is used to retract both cylinders instantly at any time.

1. Cylinder 1 extends.
2. Cylinder 2 extends while cylinder 1 retracts.
3. Cylinder 2 retracts.
4. Cycle is ended.

15.2 Box Sorter





An electropneumatic system is used for sorting two different-sized boxes moving on a conveyor. Low boxes are allowed to continue on the same conveyor, but high boxes are pushed on to a second conveyor by a pneumatic cylinder. The high boxes are detected by 1-LS mounted higher than the low boxes, but lower than the high boxes

15.2 Box Sorter

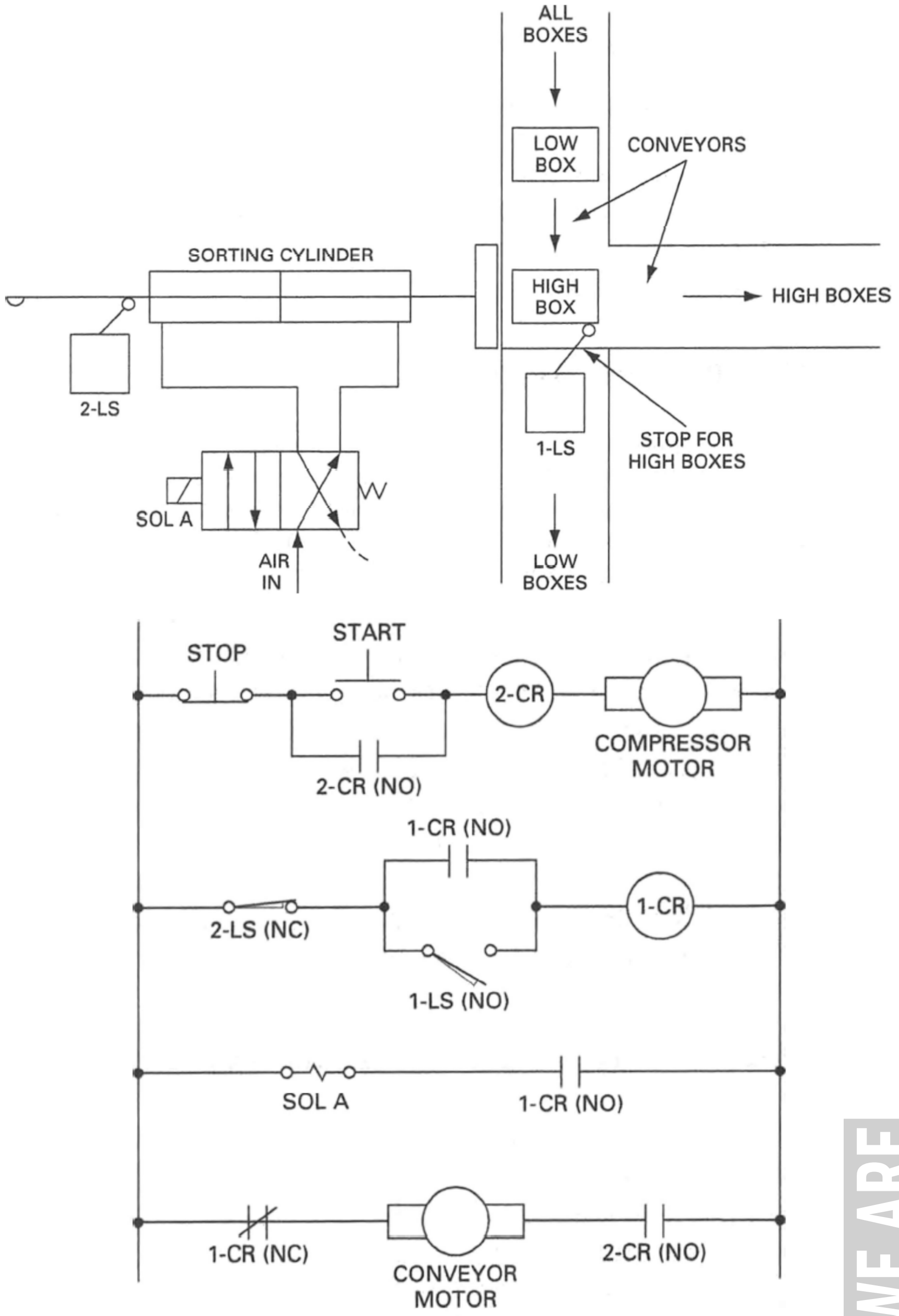
1) When the START button is momentarily depressed, coil 2-CR is energized to close its two NO sets of contacts turning on the compressor and conveyor motors.

2) Low boxes pass through unaffected. A high box will actuate 1-LS, and coil 1-CR is energized closing the 1-CR (NO) contacts and opens the 1-CR (NC) contacts which stops the conveyor and energizes SOL A.

3) The DCV extends the cylinder sorting the high box. The conveyor remains off, even after the box clears 1-LS because 1-CR is held active with 1-CR (NO) and 1-CR (NC) remains open.

4) After the high box has been completely positioned onto the second conveyor, 2-LS is actuated which de-energizes coil 1-CR and SOL A. The DCV returns to its spring-offset mode, which retracts the cylinder to the left. It also returns contact set 1-CR (NC) to its normally closed position to turn the conveyor motor back on to continue the flow of boxes.

5) Depressing the STOP button turns off the compressor and conveyor.



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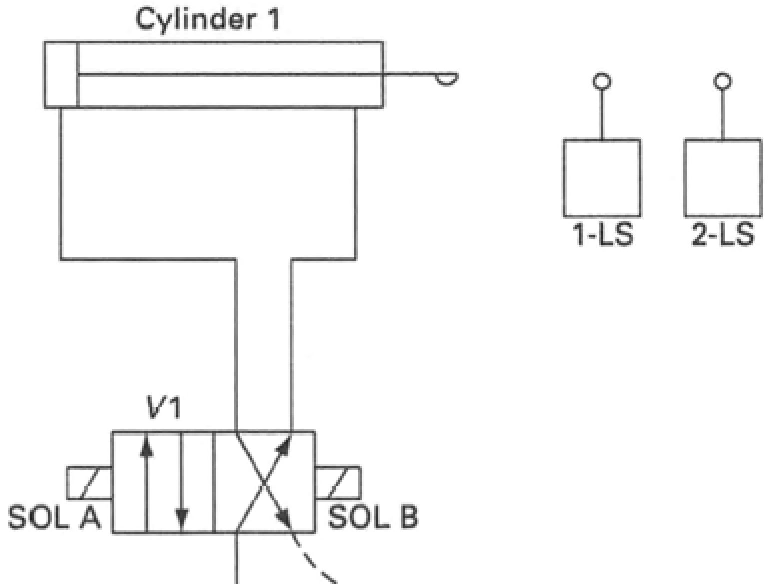
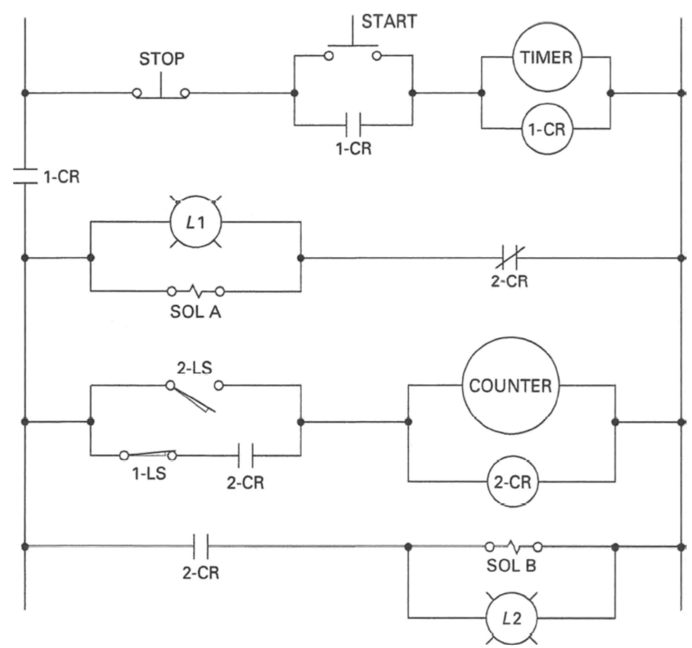
15.8 Counting, Timing and Reciprocation

1. A momentary START push button starts a cycle in which a cylinder is continuously reciprocated.
2. A STOP push button stops the cylinder motion immediately, regardless of the direction of motion.
3. If the START button is depressed after the operation has been terminated by the STOP button, the cylinder will continue to move in the same direction.
4. An electrical counter is used to count the number of cylinder strokes delivered from the time the START button is depressed until the operation is halted via the STOP button. The counter registers an integer increase in value each time an electrical pulse is received and removed.
5. An electrical timer is included in the system to time how long the system has been operating since the START button was depressed.
6. Two lamps indicate whether the cylinder is extending (L1) or retracting (L2)





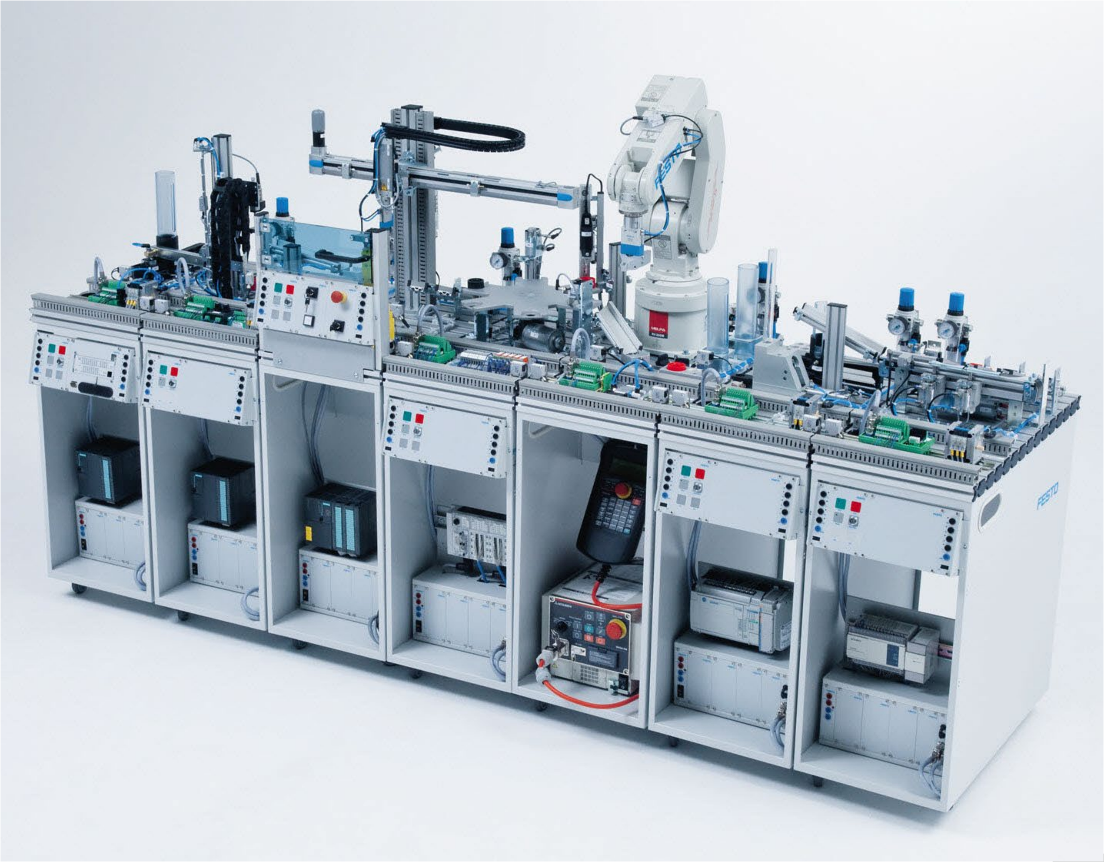
Pneumatics and PLC

Complex control systems involving multiple input and output device controlling many systems simultaneously are easily implemented using PLCs or other micro-controller architectures.

Direct wiring of the devices to the PLC dramatically simplifies the system wiring and removes any physical or electrical interconnection between the individual devices.

The system sequences are programmed into the PLC offering great flexibility to build, test, and troubleshoot complex systems.

Changes made to production can be easily implemented with changes in PLC code rather than needing to require complex wiring schemes.



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Chapter Reading

Chapter 15

All