

Pneumatics and Hydraulics

Lecture 13: Pneumatic system design and development part 4

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In the previous lecture

- Abbreviated notation
- Function chart
- Circuit diagram
- The lifecycle of pneumatic systems
- Development of Pneumatic circuits
- Sizing of pneumatic valves

Outline

- Development of Pneumatic circuits
 - Development of single actuator circuits

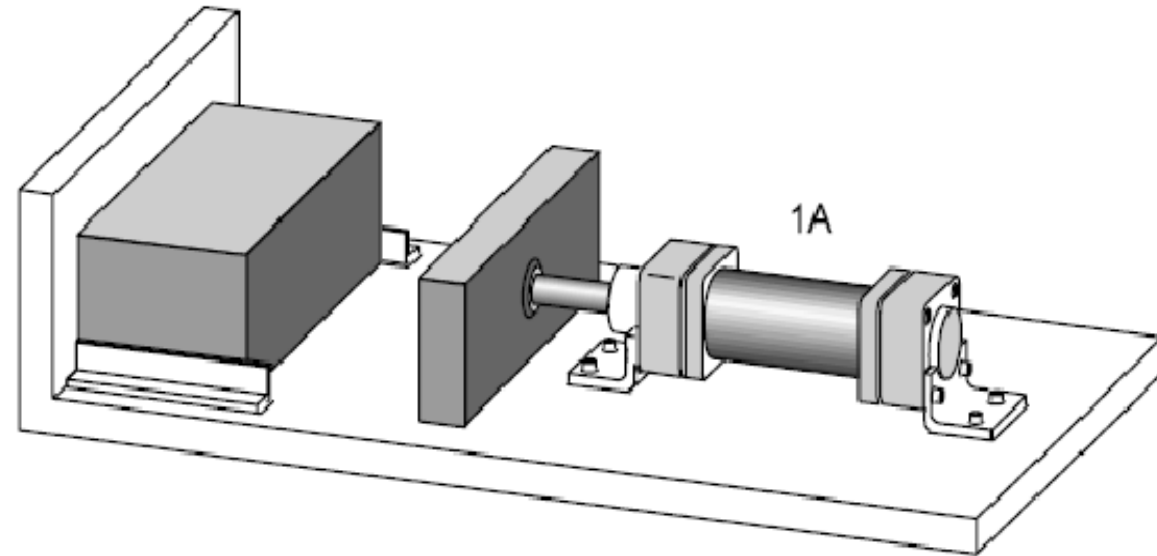
Development of Pneumatic circuits

- - **Development of single actuator circuits:**
 - Direct control of a pneumatic cylinders.
 - Indirect control of a pneumatic cylinders.
 - Logic functions: AND, OR, ...
 - Memory circuit and speed control of a cylinder.
 - The quick exhaust valve.
 - Pressure dependent control.
 - The time delay valve.
- - **Development of multiple actuator circuits**

Example 1: Direct control of single acting cylinder

- A single-acting cylinder of 25 mm diameter is to clamp a component when a push button is pressed.
- As long as the push button is activated, the cylinder is to remain in the clamped position.
- If the push button is released, the clamp is to retract.

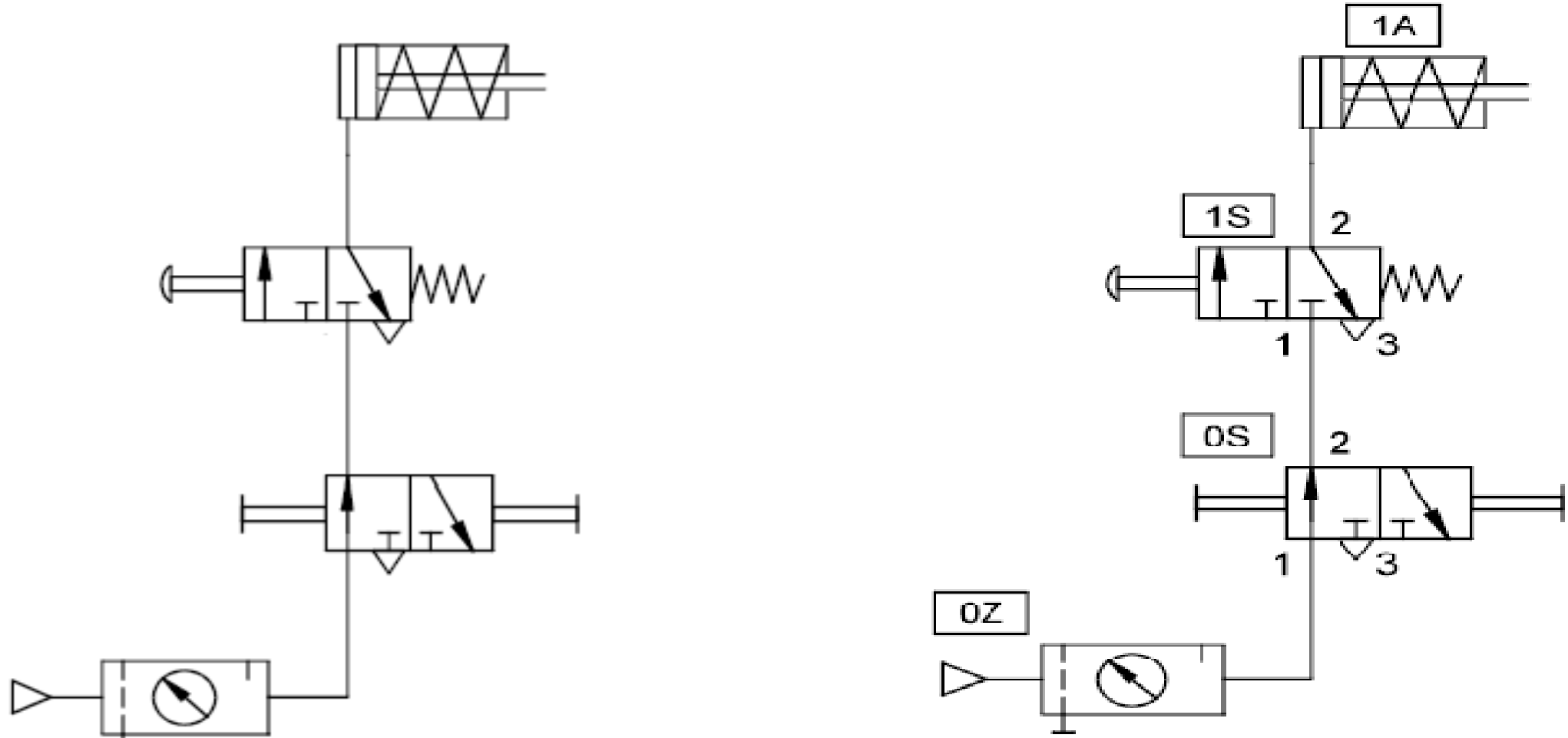
Positional sketch



Solution

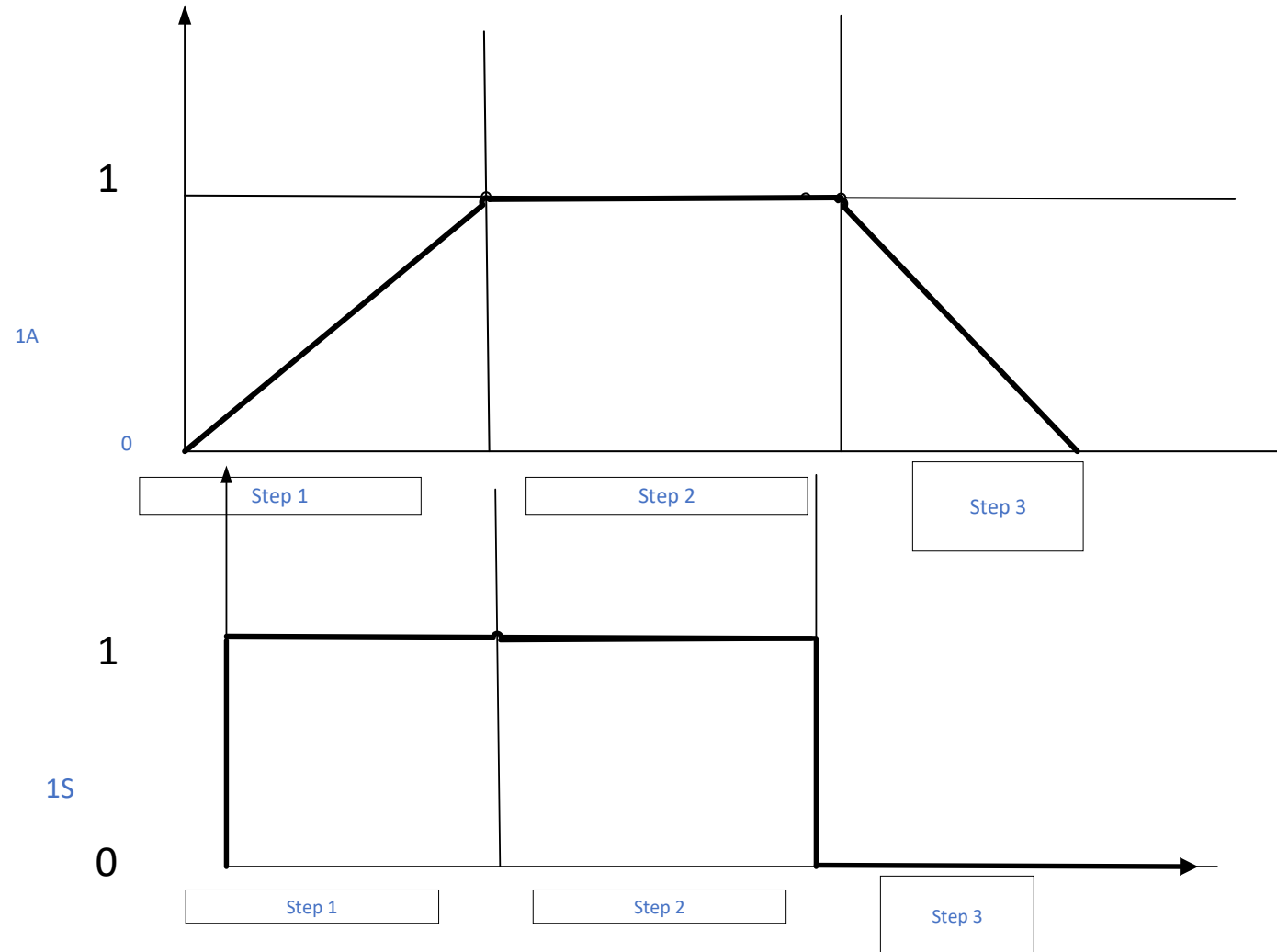
- The control valve used for the single-acting cylinder is the 3/2-way valve.
- In this case, since the cylinder is of small capacity, the operation can be directly controlled by a push button 3/2-way directional control valve with spring return.
- On operating the push button the air passes through the valve from port 1 to 2 via the valve 1S into the piston chamber of the cylinder 1A.
- The pressure builds up and advances the piston rod against the force of the cylinder return spring.
- On release of the button, the valve spring returns the 3/2-way valve to its initial position and the cylinder retracts.
- The air returns from the cylinder via the exhaust port 3.
- Components which are the only one of their type are designated without 2 supplementary number Since the cylinder is the only working element in the circuit, it is designated 1A.
- In this and the following circuit diagrams, the service unit (0Z) and the start-up valve (0S) have also been drawn in.

Example 1: Direct control of single acting cylinder



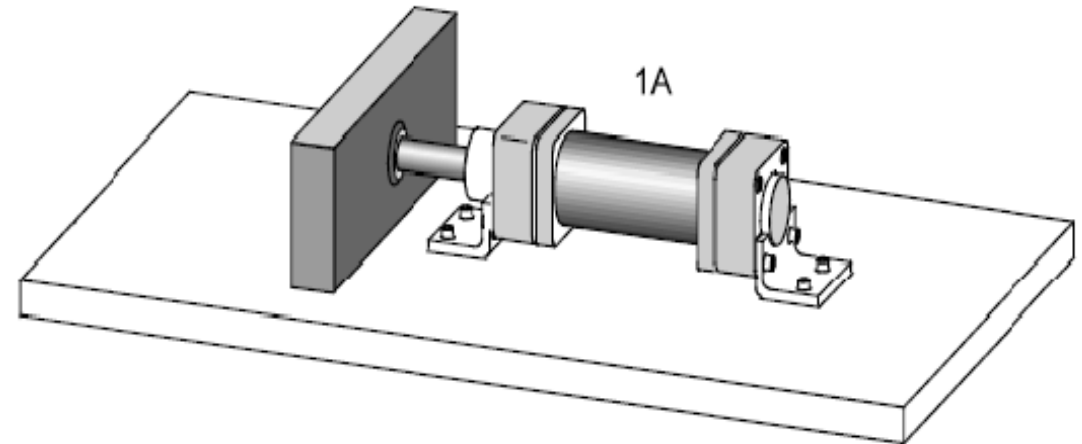
Try to draw the following:

- Motion diagram:
 - Displacement-Step Diagram.
 - Displacement-Time Diagram.
- Control chart
- Function diagram
- Function chart



Example 2: Direct control of double acting cylinder

- A double-acting cylinder is to extend when a push button is operated.
- Upon release of the push button the cylinder is to retract.
- The cylinder is of small bore (25 mm diameter) requiring a small flow rate to operate at the correct speed.

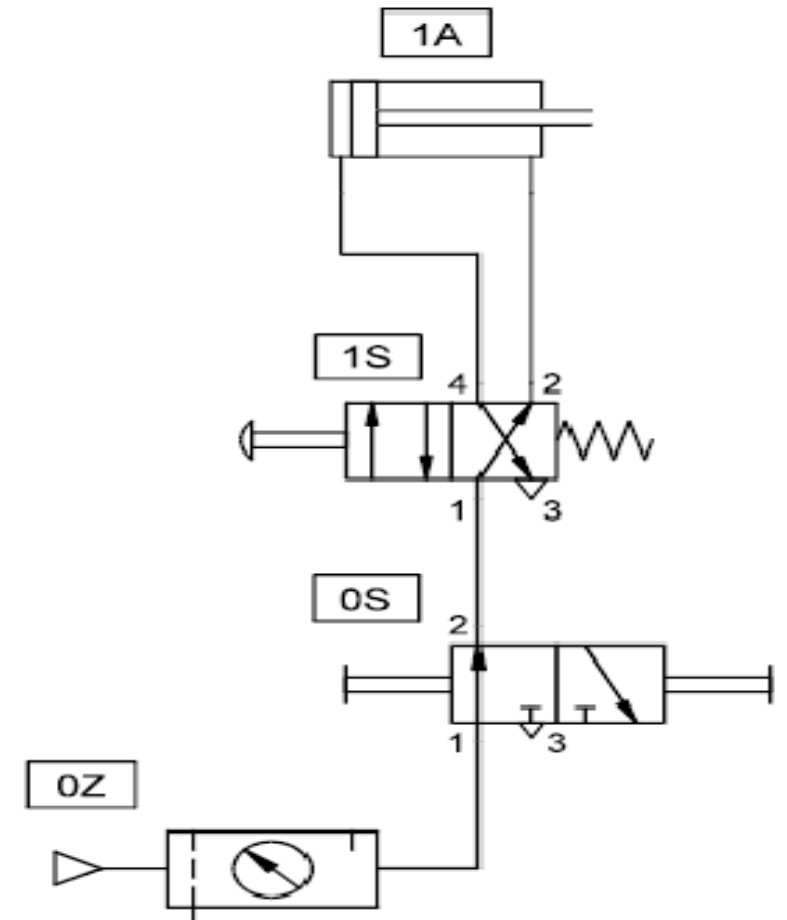
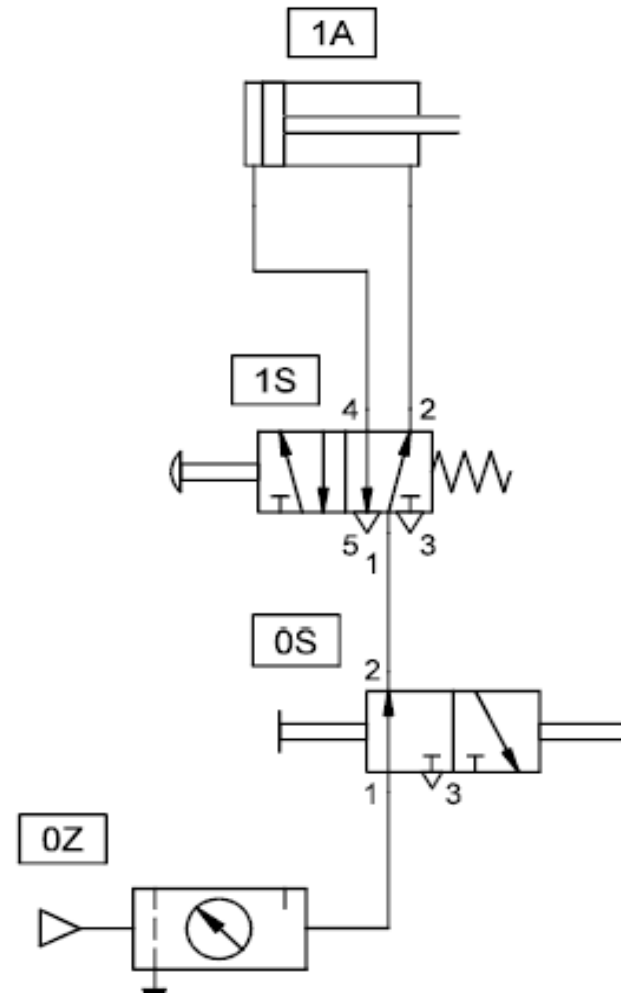
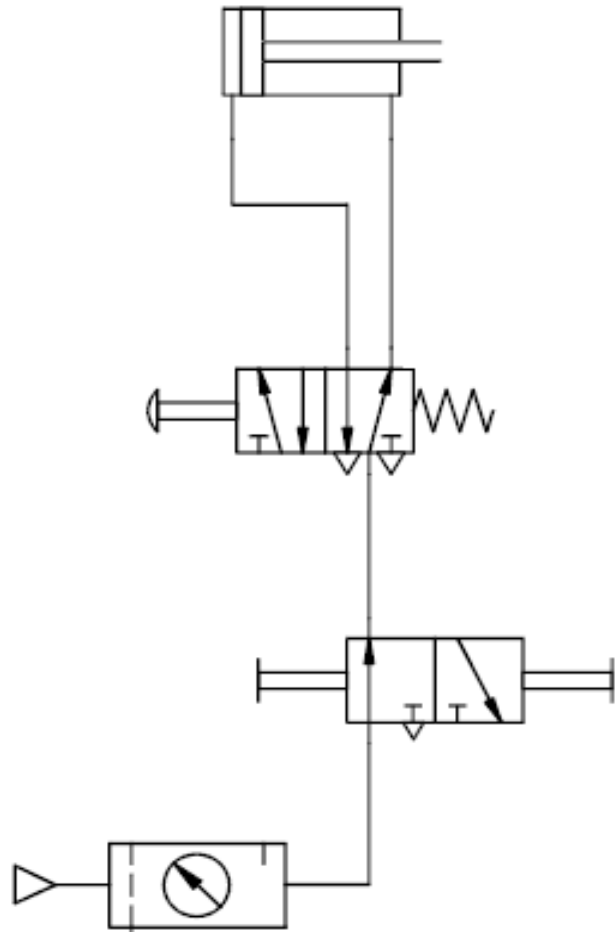


Solution

The following manually operated directional control valves can be used as control elements:

- 5/2-way valve.
- 4/2-way valve
 - In the initial position, the valve is unactuated, pressure is applied at the piston rod side and the piston rod of the cylinder is retracted.
- On operating the push button, the air passes through the valve from 1 to the 4 port and advances the piston rod.
- The displaced air flows to atmosphere via the ports 2 and 3.
- On release of the push button, the valve spring returns the control valve to its initial position and the cylinder retracts.
- Air returns from the cylinder via the exhaust port 5.
- The push button is released, the direction of movement is immediately reversed and the piston rod retracts.
- It is therefore possible to change the direction of movement without the piston rod reaching its initial or end position.

Circuit diagram



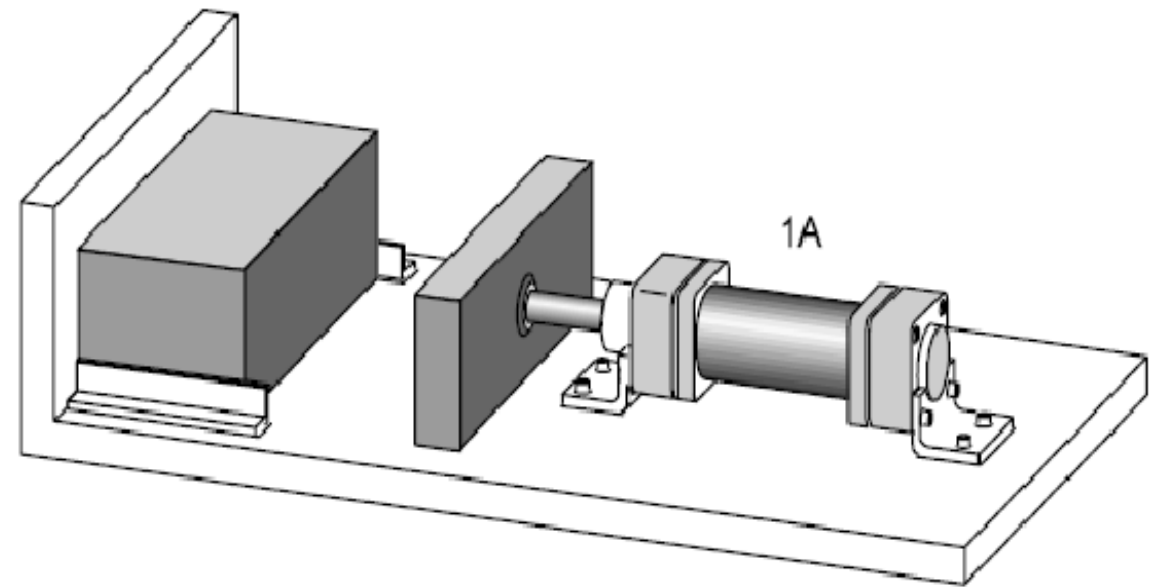
- Try to draw the following:
 - Motion diagram:
 - Displacement-Step Diagram.
 - Displacement-Time Diagram.
 - Control chart
 - Function diagram
 - Function chart
 - Circuit diagram

Indirect control of a pneumatic cylinder

- Cylinders with a large piston diameter have a high air requirement.
- A control element with high nominal flow rate must be used to actuate these.
- If the force should prove too high for a manual actuation of the valve, then an indirect actuation should be constructed, whereby a signal is generated via a second smaller valve, which will provide the force necessary to switch the control element.

Example 3: Indirect control of single acting cylinder

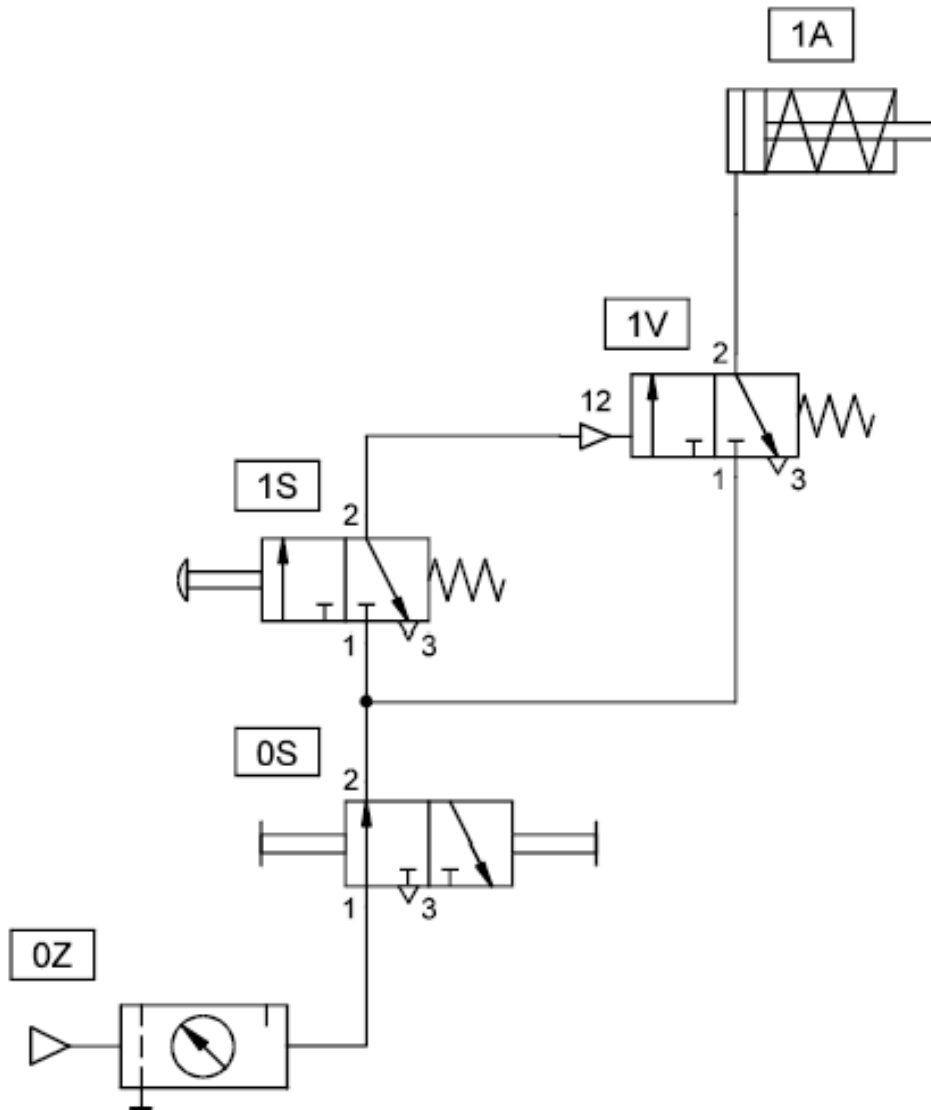
- A single-acting cylinder with a large piston diameter is to clamp a workpiece following actuation of a push button.
- The cylinder is to retract once the push button is released.



Solution:

- In the initial position, the single-acting cylinder 1A is retracted.
- A spring return 3/2-way pneumatic valve is used to actuate the cylinder.
- Connection 1 of the valve 1V is closed, connection 2 is exhausted to atmosphere via connection 3.
- The valve 1S is actuated when the push button is activated and pressure is applied to the control port 12 of the control valve 1V.
- The control valve 1V is actuated against spring force and is thus switched to flow. The pressure building up at the cylinder piston causes the cylinder piston rod of the single-acting cylinder to extend.
- The signal at the control port 12 remains as long as the push button is operated.
- Once the piston rod has reached end position, it returns only after the push button has been released.
- When the push button is released, the valve 1S returns to its initial position.
- **Control port 12 of the control valve 1V exhausts to atmosphere and the signal is reset.**
- The control valve also returns to initial position.
- The return spring causes the cylinder to retract.
- The air from the cylinder chamber is exhausted to atmosphere via the control valve

Circuit diagram

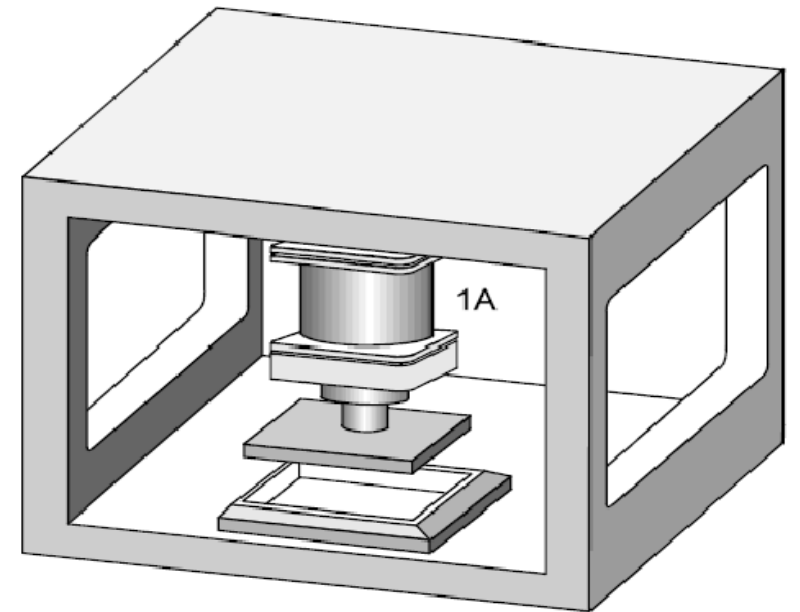


Try to draw the following:

- Motion diagram:
 - Displacement-Step Diagram.
 - Displacement-Time Diagram.
- Control chart
- Function diagram
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Example 4: Indirect control of double acting cylinder

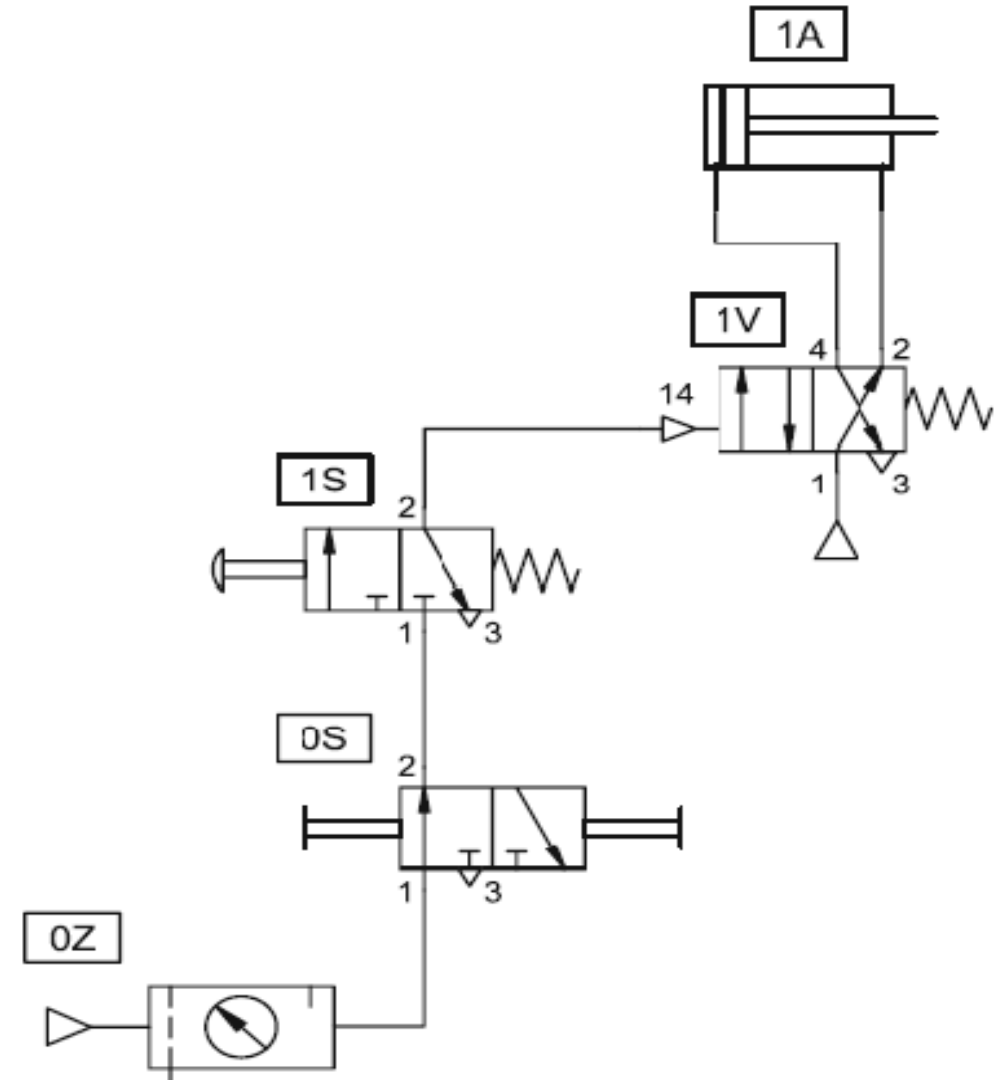
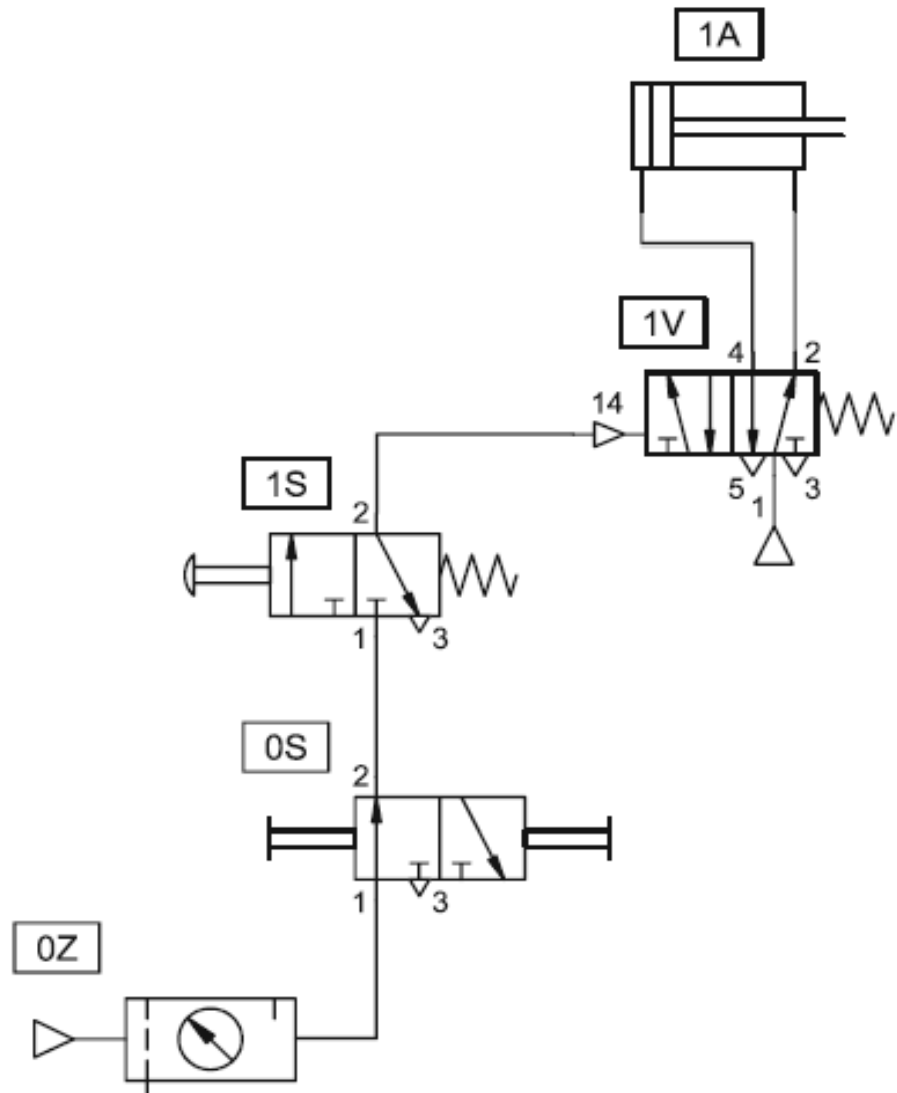
- A double-acting cylinder is to advance when a push button is operated.
- Upon release of the push button the cylinder is to retract.
- The cylinder is 250 mm diameter and consumes a large volume of air.



Solution:

- For controlling cylinders at high speed or of large diameter, the air flow required determines that a large size control valve should be used.
- The operating force to actuate the valve may be relatively large and in this case indirect control is preferable.
- The valve 1S when operated by a push button supplies a pilot signal to the 14 port of the control valve 1V.
- The valve 1V reverses, the piston rod of the cylinder is pressurized and the piston rod of cylinder 1A advances.
- If the push button is released, the control port of valve 1V exhausts to atmosphere. The valve 1V then reverses and the cylinder retracts.
- If the push button is released, the direction of movement is immediately reversed and the piston rod retracts.
- A change in the direction of movement is therefore possible without the piston rod reaching its initial or end position.
- Since the valve 1V is without memory function, it changes its switching position immediately after the push button of valve 1S has been pressed.

Circuit diagram



- Try to draw the following:

- Motion diagram:

- Displacement-Step Diagram.

- Displacement-Time Diagram.

- Control chart

- Function diagram

- Function chart

- Circuit diagram

Logic Functions: AND-OR

- The pneumatic shuttle valve (OR) and the dual pressure valve (AND) have logic functions.
- Both have two inputs and one output each.
- The shuttle valve has the characteristic of an OR function, whereby at least either of two inputs 1 or 1(3) are required to generate an output at port 2 of the valve.
- In the case of the dual pressure valve, the characteristic is that of the AND function, whereby both inputs 1 and 1(3) are required to initiate an output 2.

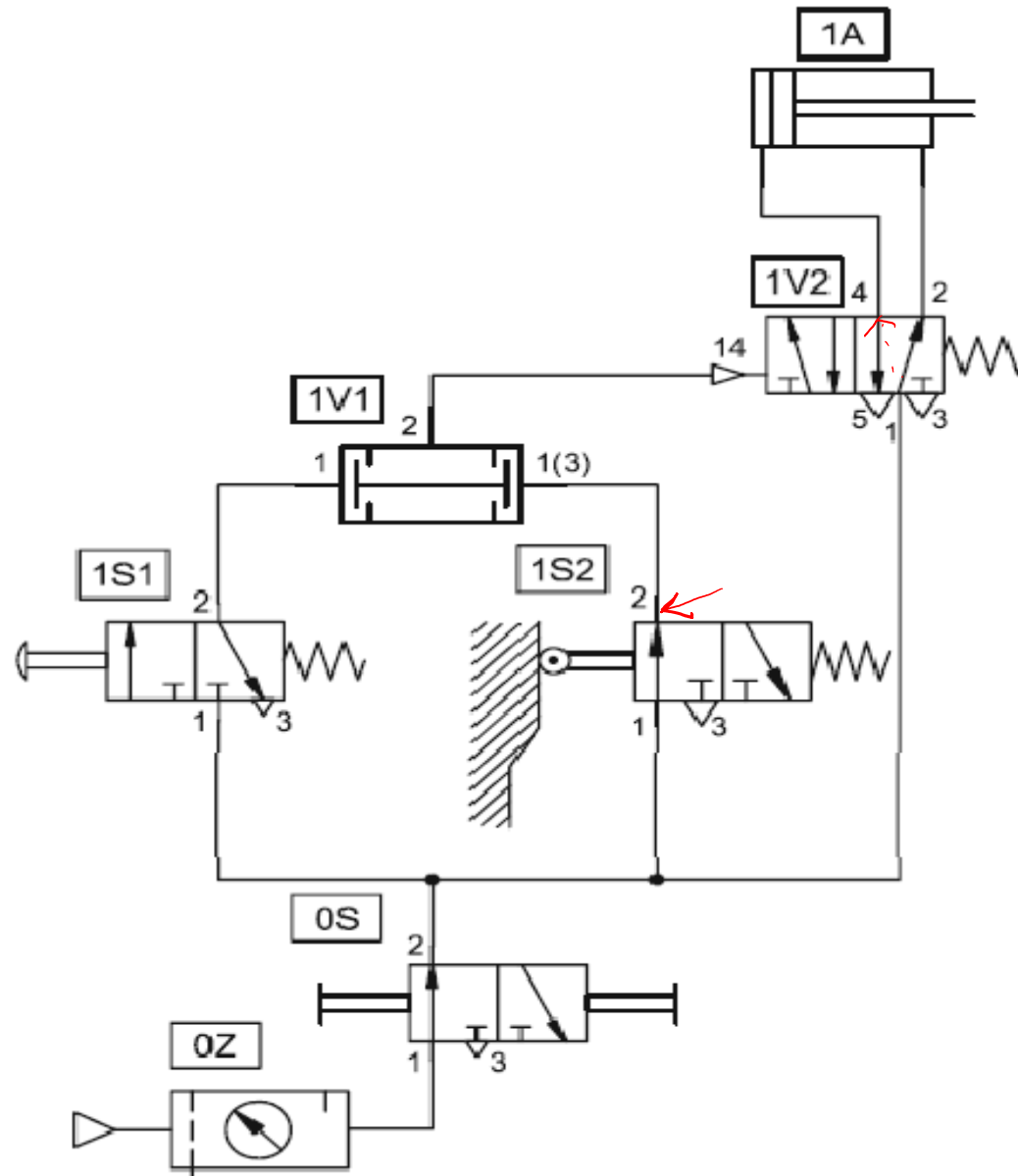
Example 5: The logic AND function

- The piston rod of a double-acting cylinder is to advance when the 3/2-way roller lever valve 1S2 is actuated and the push button of the 3/2-way valve 1S1 is actuated.
- If either of these are released, then the cylinder is to return to the initial position.

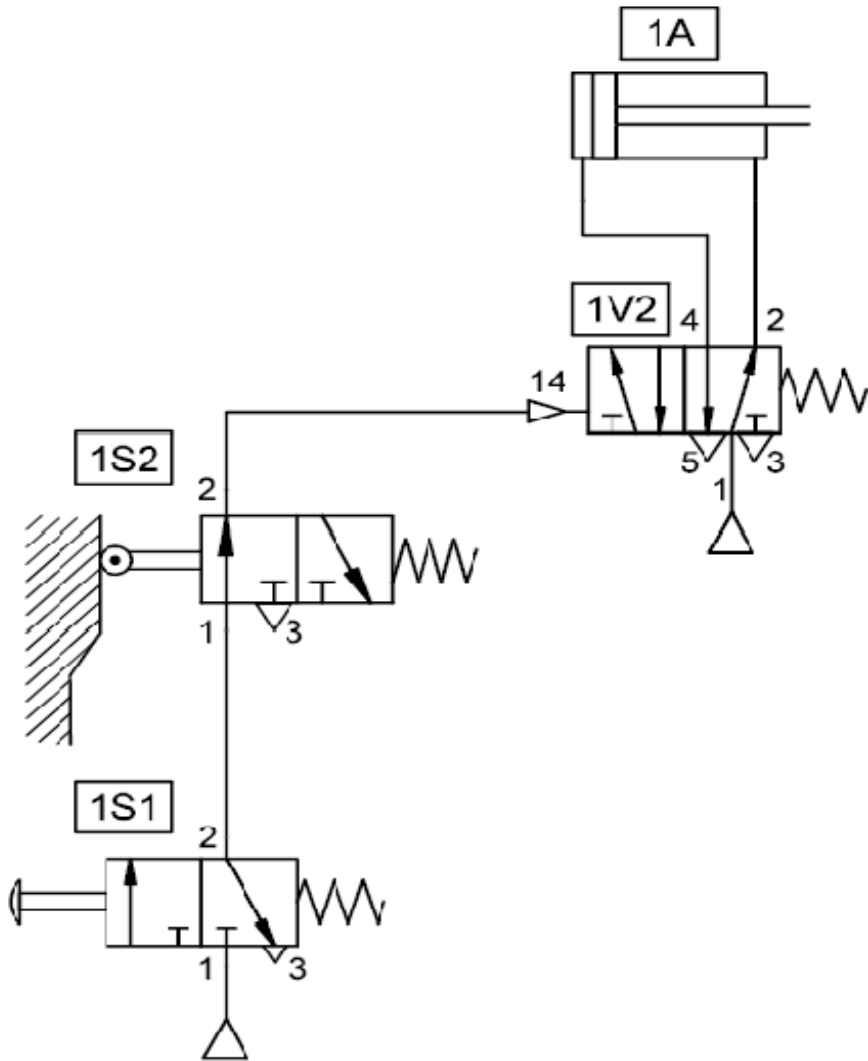
Solution:

- The inputs 1 and 1(3) of the dual-pressure valve 1V1 are connected to the working ports 2 of the valves 1S1 and 1S2.
- The 3/2-way roller lever valve 1S2 is actuated by the insertion of a workpiece and then creates a signal at one input of the dual-pressure valve.
- Since only one input is actuated, the AND condition has not been fulfilled and the output of the dual-pressure valve remains closed.
- If the push button of the 3/2-way valve 1S1 is now also actuated, a signal will also be applied at the second input.
- The AND condition is now fulfilled and a signal is generated at the output 2 of the dual-pressure valve.
- The 5/2-way pneumatic valve 1V2 switches, the piston side of the cylinder is pressurized and the piston rod advances.
- If one of the two valves 1S1 or 1S2 is no longer actuated, then the AND condition will no longer be fulfilled and the signal at the output of the dual pressure valve will be reset.
- The signal pressure at the control port 14 of the control element 1V2 is exhausted to atmosphere via the reset valve 1S1 or 1S2.
- The control element 1V2 switches back. The pressure building up on the piston rod side ensures the retraction of the piston rod.

Circuit diagram



Circuit diagram



Alternative solution

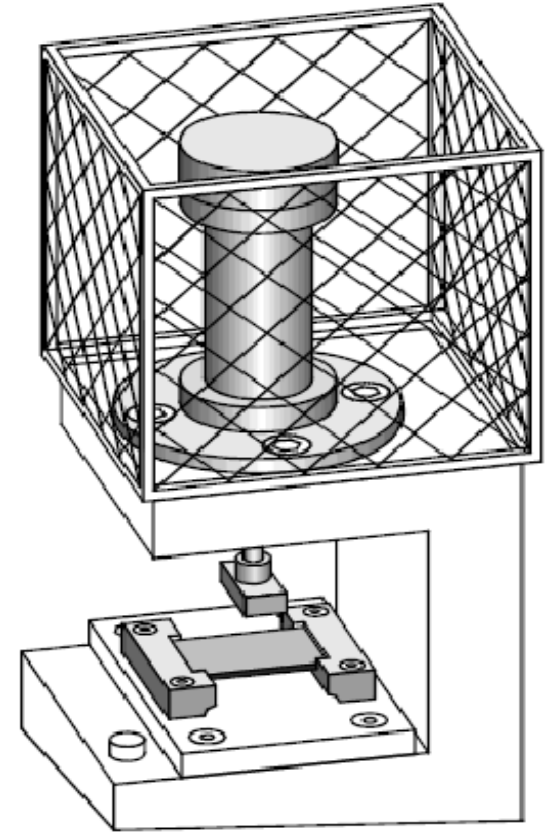
- An alternative solution to using the dual pressure valve is to use two 3/2- way valves in series.
- Here the signal is passed from push- button valve 1S1 to the roller lever valve 1S2 and then on to the control element 1V2 but only if both valves 1S1 and 1S2 are operated, i.e. when the AND condition is met.
- When a valve is released, the signal at the control element is reset and the piston rod retracts.

Try to draw the following:

- Motion diagram:
 - Displacement-Step Diagram.
 - Displacement-Time Diagram.
- Control chart.
- Function diagram.
- Function chart.

Example 6: The logic AND function

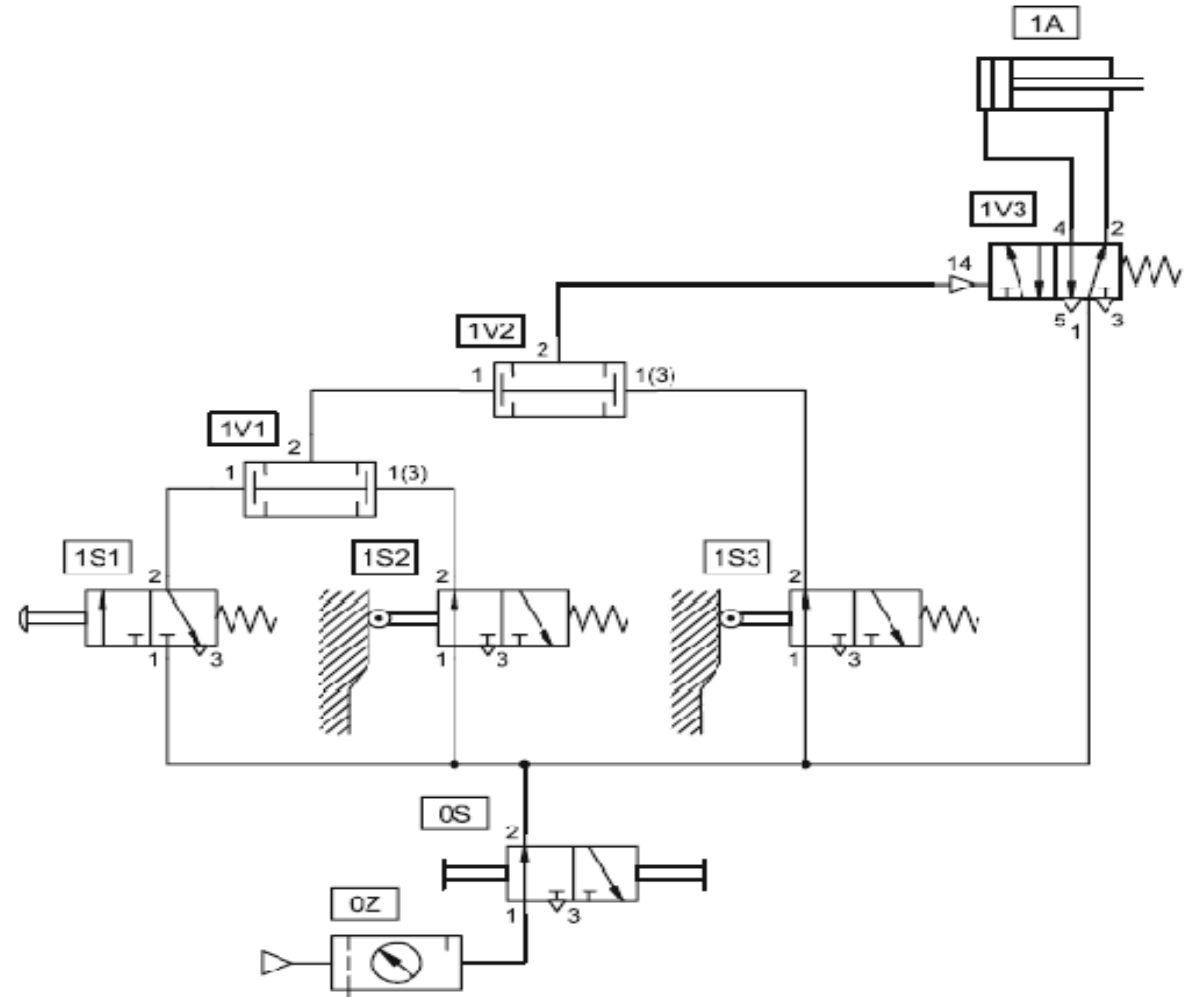
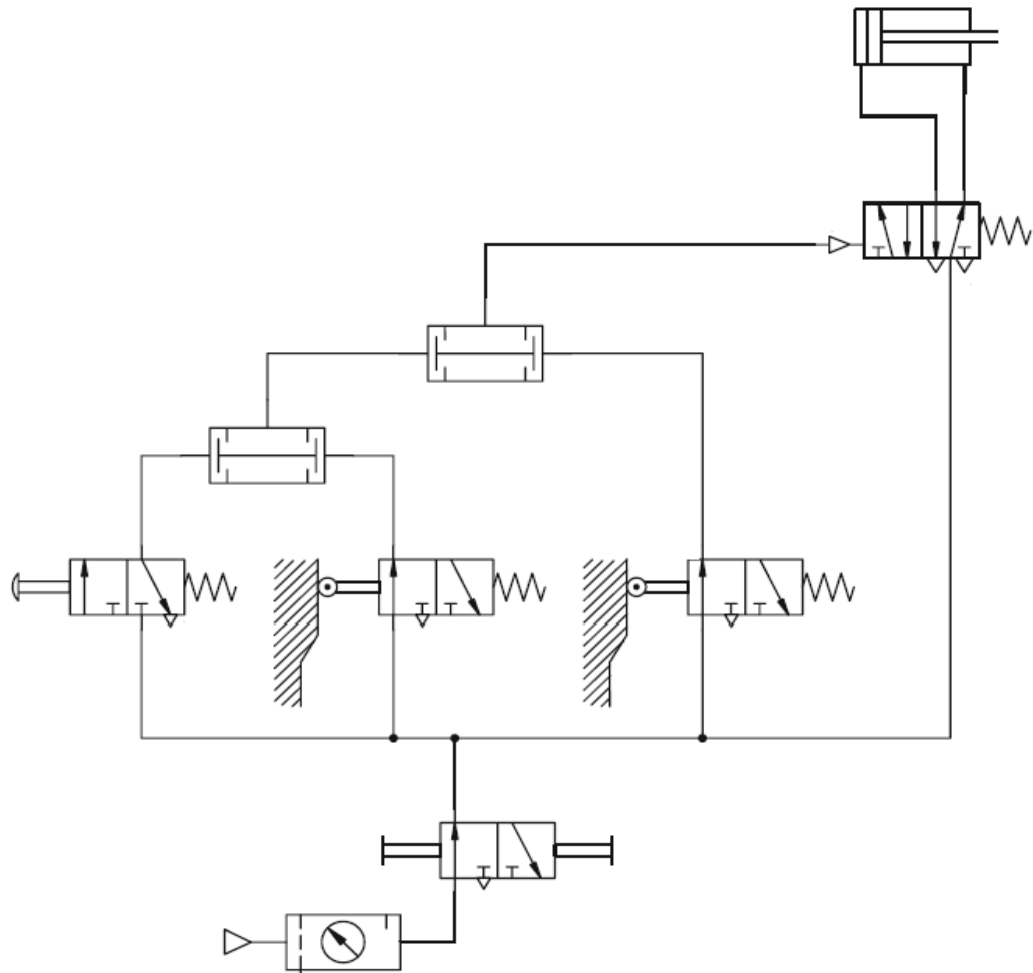
- The piston rod of the cylinder 1A is to advance only if a workpiece is inserted in the workpiece retainer, a guard has been lowered and the operator presses the push button valve.
- Upon the release of the push button or if the guard is no longer in its lower position, the cylinder 1A is to retract to the initial position.



Solution:

- The logic AND operation of the output signals of valves 1S1, 1S2 and 1S3 is checked by the dual-pressure valves 1V1 and 1V2.
- If the valves are actuated, i.e. 1S2 (via the workpiece), 1S3 (via the guard) and 1S1 (via the operator), a signal is applied at output A of the dual-pressure valve 1V2.
- This signal is passed on to the control port 14 of the control element 1V3. The valve 1V3 reverses, pressure is applied at the piston side of the cylinder 1A and the piston rod advances.
- If the push button is released or the guard opened, this means that the AND conditions are no longer met.
- The control port 14 of the valve 1V3 is unpressurised. The valve 1V3 switches and the piston rod retracts.

Circuit diagram



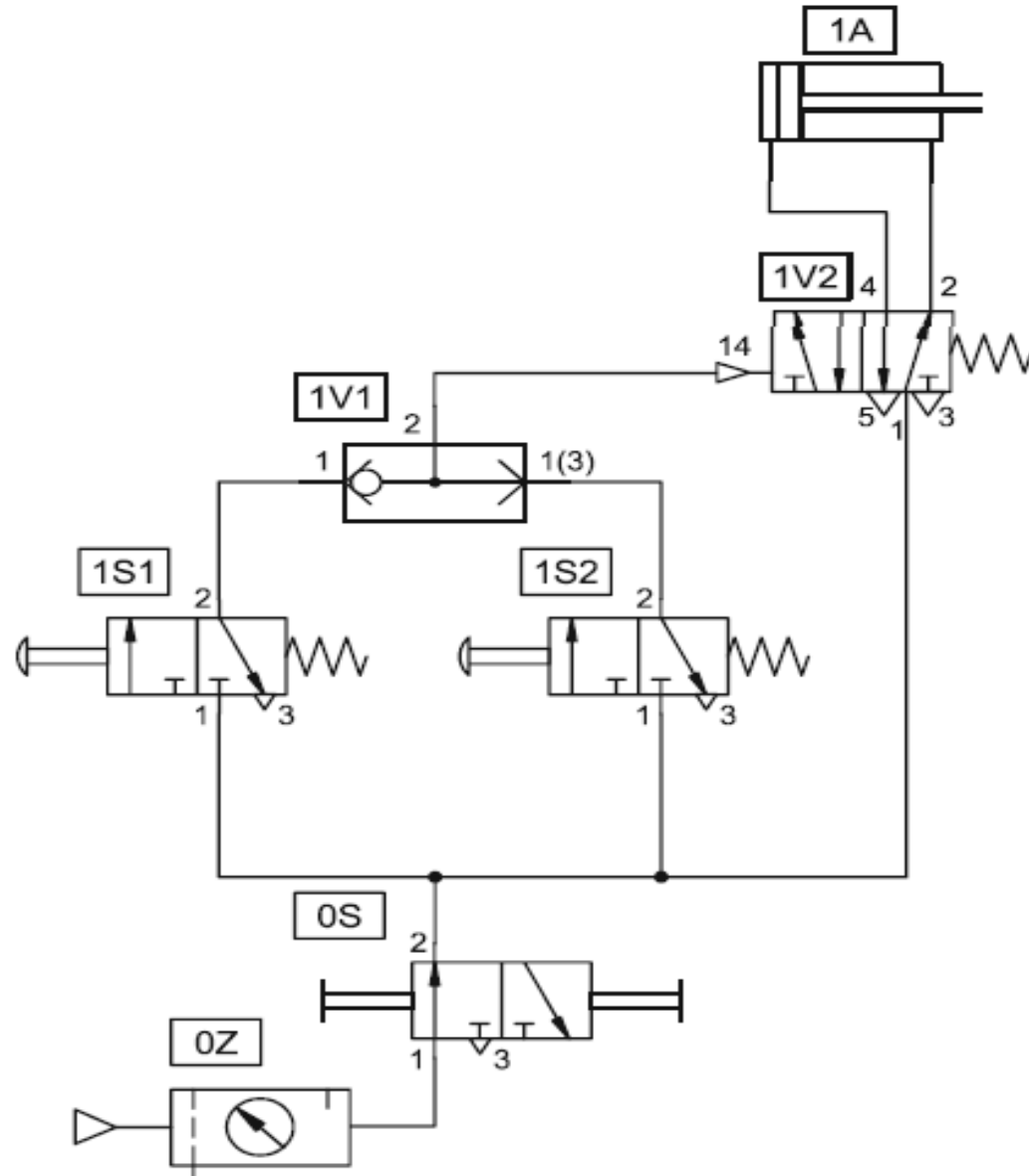
Example 7: The logic OR function

- A double-acting cylinder is to advance if one of two push buttons is operated.
- If the push button is then released, the cylinder is to retract.

Solution

- The inputs 1 and 1(3) of the shuttle valve 1V1 are connected to the working connections of the valves 1S1 and 1S2.
- Upon operation of one of the push buttons, the corresponding valve 1S1 or 1S2 is actuated and a signal is generated at the 1 or 1(3) side of the shuttle valve.
- The OR condition is fulfilled and the signal passes through the shuttle valve and is emitted at port 2.
- The signal pressure is prevented from escaping via the exhaust of the unactuated valve by closing the line in the shuttle valve.
- The signal effects the switching of the control element 1V2. The piston side of the cylinder is pressurized, and the piston rod advances.
- When the actuated push button is released, the signal pressure is relieved via the valves 1S1 and 1S2 and the control element is switched back to its initial position.
- The pressure now building up on the piston rod side ensures the retraction of the piston rod.

Circuit diagram



Try to draw the following:

- Motion diagram:
 - Displacement-Step Diagram.
 - Displacement-Time Diagram.
- Control chart.
- Function diagram.
- Function chart.

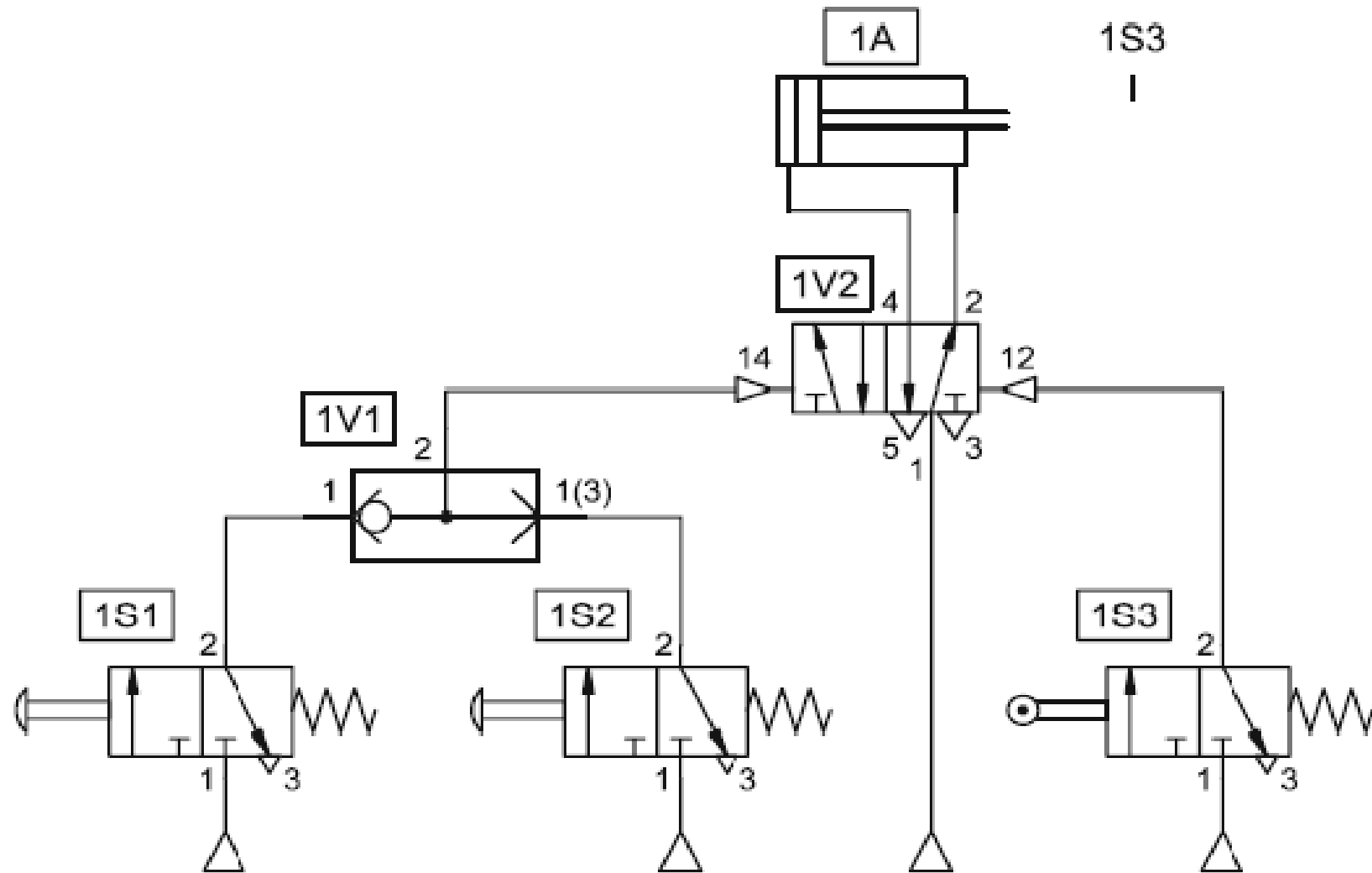
Example 8: The logic OR function

- A double-acting cylinder is to advance if one of two push buttons is operated.
- When reaching its fully extended position, the cylinder is to retract.

Solution

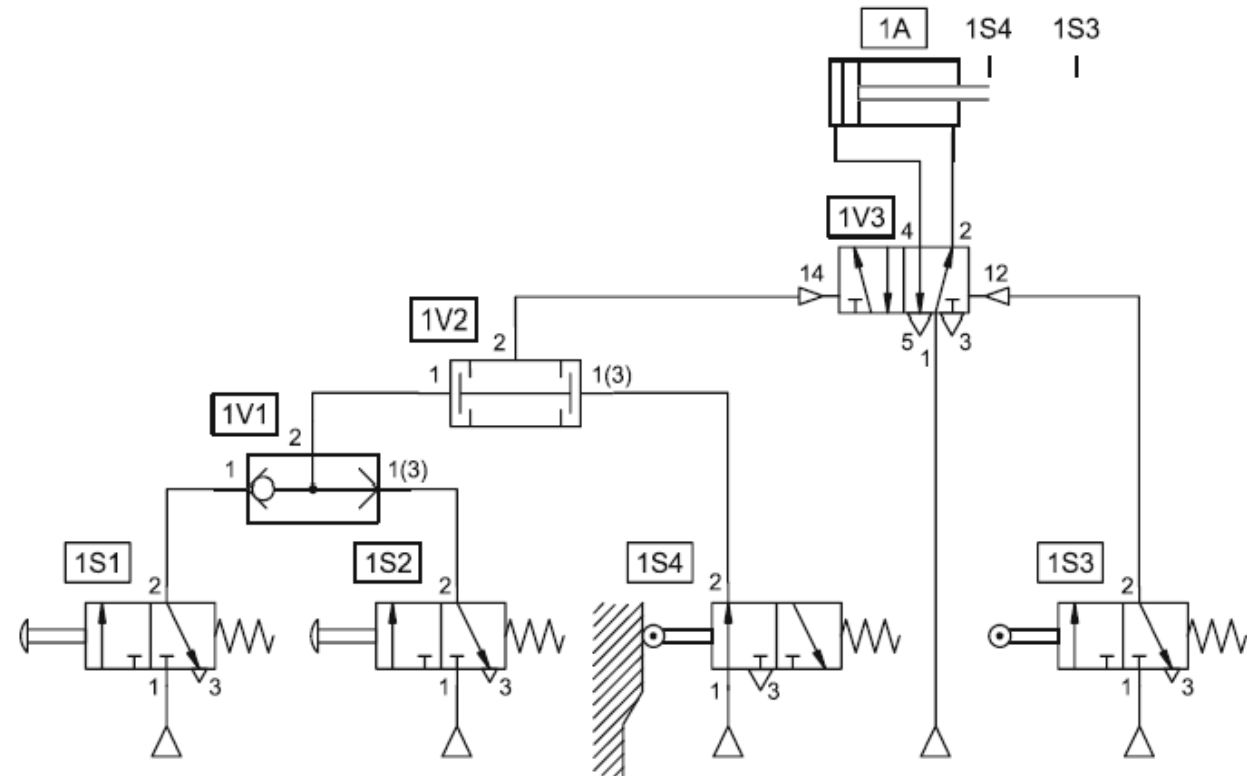
- A double pilot valve should be fitted for the control of the cylinder.
- If the cylinder is to retract on reaching its fully extended position, roller lever valves should be used as limit valves to confirm that this position has been reached.
- One of the push buttons need only be operated for a short duration and the cylinder will fully extend, since the effect of the signal at input 14 of the 5/2-way double pilot valve 1V2 is maintained until a signal is applied at input 12.
- As soon as the piston rod has reached the forward end position, the limit switch 1S3 generates a signal at input 12, and the valve 1V2 is reversed.
- The retracted end position of the piston rod can also be sensed. This requires an additional limit switch

Circuit diagram



Alternative solution

- The addition of the dual pressure valve 1V2 and the roller limit switch 1S4 ensures that the cylinder is fully retracted before the cylinder can be extended again.
- The condition for a renewed advancing of the piston rod is the actuation of one of the valves 1S1 or 1S2 and the limit switch 1S4.
- When the cylinder is advanced at position 1S3, the cylinder retracts even if the valves 1S1 and 1S2 are still operated since the limit switch 1S4 is inactive.



- Try to draw the following:
 - Motion diagram:
 - Displacement-Step Diagram.
 - Displacement-Time Diagram.
 - Control chart.
 - Function diagram.
 - Function chart.