Pneumatics and Hydraulics

Lecture 11: Pneumatic system design and development

Dr. Ahmad Al-Mahasneh

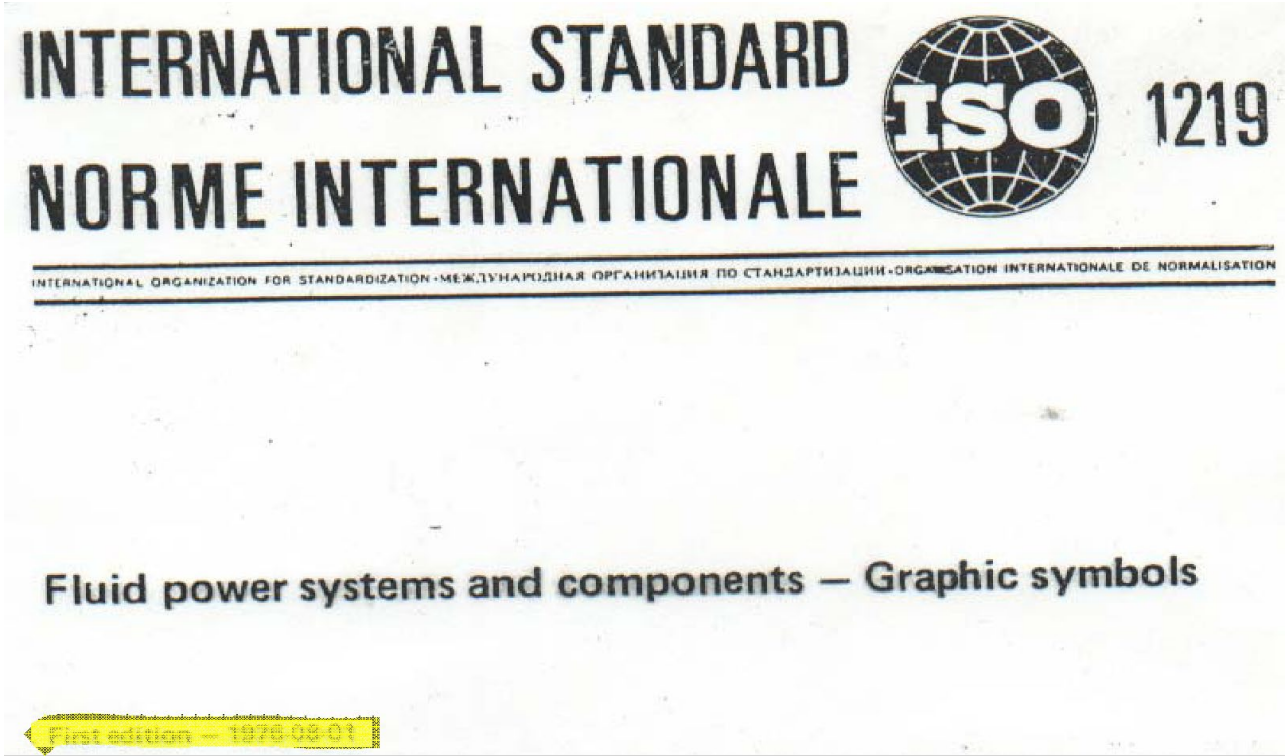
Symbols And Standards In Pneumatics

- The development of pneumatic systems is assisted by a uniform approach to the representation of the elements and the circuits.
- The symbols used for the individual elements must display the following characteristics:

- Actuation and return actuation methods.
- Number of connections.
- Number of switching positions.
- General operating principle.
- Simplified representation of the flow path.

Symbols And Standards In Pneumatics

- The technical construction of the component is not taken into account in the abstract symbol form.
- The symbols used in pneumatics are detailed in the standard ***DIN ISO 1219***, "Circuit symbols for fluidic equipment and systems".



INTERNATIONAL STANDARD

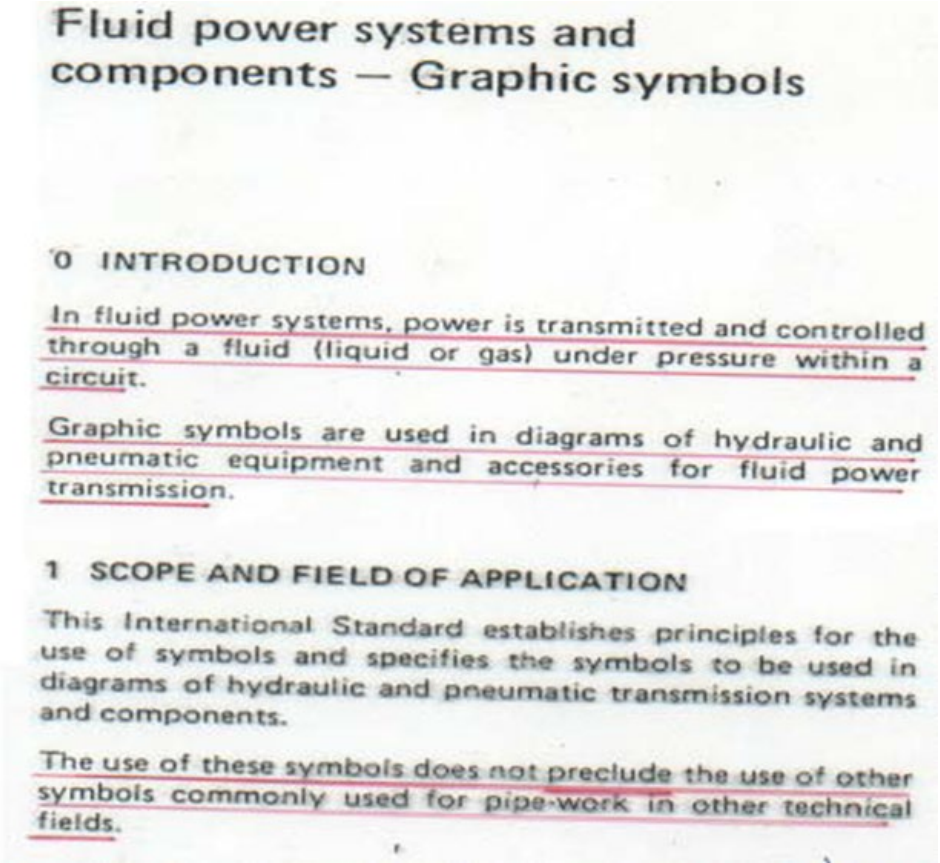
NORME INTERNATIONALE

ISO 1219

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION · МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ · ORGANISATION INTERNATIONALE DE NORMALISATION

Fluid power systems and components — Graphic symbols

First edition — 1976-08-01



Fluid power systems and components — Graphic symbols

0 INTRODUCTION

In fluid power systems, power is transmitted and controlled through a fluid (liquid or gas) under pressure within a circuit.

Graphic symbols are used in diagrams of hydraulic and pneumatic equipment and accessories for fluid power transmission.

1 SCOPE AND FIELD OF APPLICATION

This International Standard establishes principles for the use of symbols and specifies the symbols to be used in diagrams of hydraulic and pneumatic transmission systems and components.

The use of these symbols does not preclude the use of other symbols commonly used for pipe-work in other technical fields.

Symbols And Standards In Pneumatics

5 GENERAL (BASIC AND FUNCTIONAL SYMBOLS)

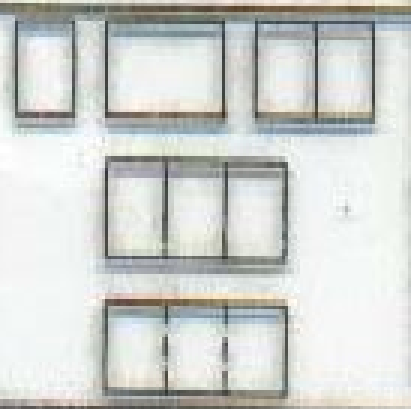
The symbols for hydraulic and pneumatic equipment and accessories are *functional* and consist of one or more *basic symbols* and in general of one or more *functional symbols*. The symbols are neither to scale nor in general orientated in any particular direction. The relative sizes of symbols in combination should correspond approximately to those in clauses 11 and 12.

Description	Application	Symbol Signe
Basic symbols		
Line : – continuous – long dashes – short dashes – double – long chain thin (optional use)	flow lines Mechanical connections (shafts, levers, piston-rods) Enclosure for several components assembled in one unit	1) 

1) L = Length of dash
E = Thickness of line
D = Space between lines

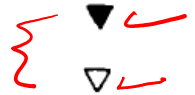
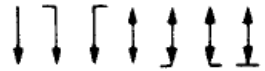
Symbols And Standards In Pneumatics

Circle, semi-circle	As a rule, energy conversion units (pump, compressor, motor)	
	Measuring instruments	
	Non-return valve, rotary connection, etc.	
	Mechanical link, roller, etc.	
	Semi-rotary actuator	

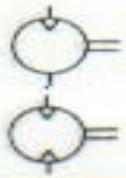
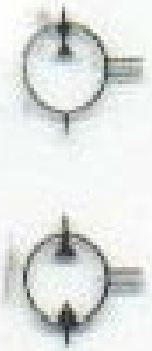
Square, rectangle	As a rule, control valves (valve) except for non-return valves	
Diamond	Conditioning apparatus (filter, separator, lubricator, heat exchanger)	

Symbols And Standards In Pneumatics

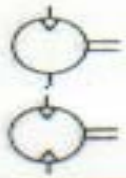
Description	Application	Symbol Signe
Miscellaneous symbols		1)
	Flow line connection	
	Spring	
	Restriction :	
	– affected by viscosity	
	– unaffected by viscosity	

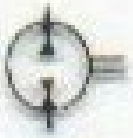
Description	*Application*	*Symbol*
Triangle:	The direction of flow and the nature of the fluid.	
– solid	Hydraulic flow.	
– in outline only.	Pneumatic flow or exhaust to atmosphere.	
Arrow	Indication of: – direction	
	– direction of rotation	
	– path and direction of flow through valves.	
	For regulating apparatus as in Pressure Control Valves both representations with or without a tail to the end of the arrow are used without distinction.	
	As a general rule the line perpendicular to the head of the arrow indicates that when the arrow moves the interior path always remains connected to the corresponding exterior path.	
Sloping arrow.	Indication of the possibility of a regulation or of a progressive variability.	

Symbols And Standards In Pneumatics

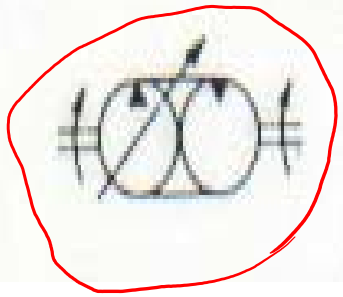
Description	Use of the equipment or explanation of the symbol	Symbol Symbole
Fixed capacity pneumatic motor : – with one direction of flow – with two directions of flow		
Variable capacity pneumatic motor : – with one direction of flow – with two directions of flow	The symbol is a combination of 6.2.3.1 and 5.2.3 (sloping arrow) The symbol is a combination of 6.2.3.2 and 5.2.3 (sloping arrow)	
Oscillating motor : – hydraulic – pneumatic		
Pump/motor units	Unit with two functions, either as pump or as rotary motor	
Fixed capacity pump/motor unit : – with reversal of the direction of flow – with one single direction of flow – with two directions of flow	Functioning as pump or motor according to direction of flow Functioning as pump or motor without change of direction of flow Functioning as pump or motor with either direction of flow	

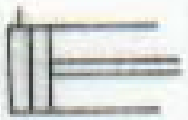
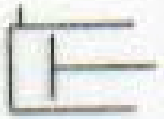
Symbols And Standards In Pneumatics

Description	Use of the equipment or explanation of the symbol	Symbol Symbole
Fixed capacity pneumatic motor : – with one direction of flow – with two directions of flow		
Variable capacity pneumatic motor : – with one direction of flow – with two directions of flow	The symbol is a combination of 6.2.3.1 and 5.2.3 (sloping arrow) The symbol is a combination of 6.2.3.2 and 5.2.3 (sloping arrow)	
Oscillating motor : – hydraulic – pneumatic		

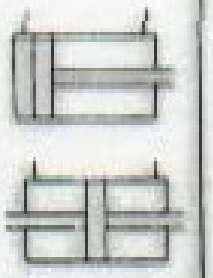
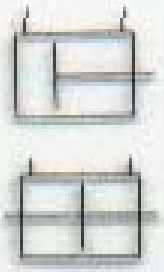
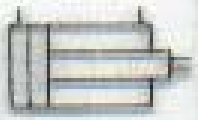
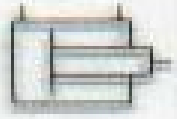
Pump/motor units	Unit with two functions, either as pump or as rotary motor	
Fixed capacity pump/motor unit : – with reversal of the direction of flow	Functioning as pump or motor according to direction of flow	
– with one single direction of flow	Functioning as pump or motor without change of direction of flow	
– with two directions of flow	Functioning as pump or motor with either direction of flow	

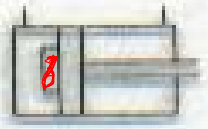
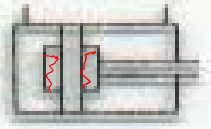
Symbols And Standards In Pneumatics

Variable capacity pump/motor unit :		
– with reversal of the direction of flow	The symbol is a combination of 6.3.1.1 and 5.2.3 (sloping arrow)	
– with one single direction of flow	The symbol is a combination of 6.3.1.2 and 5.2.3 (sloping arrow)	
– with two directions of flow	The symbol is a combination of 6.3.1.3 and 5.2.3 (sloping arrow)	
Variable speed drive units	Torque converter. Pump and/or motor are of variable capacity. Remote drives, see 12.2	

Single acting cylinder :	Cylinder in which the fluid pressure always acts in one and the same direction (on the forward stroke)	Detailed Détaillé	Simplified Simplifié
– returned by an unspecified force	General symbol when the method of return is not specified		
– returned by spring	Combination of the general symbol 6.5.1.1 and 5.1.5.2 (spring)		

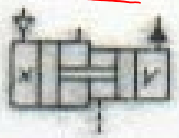
Symbols And Standards In Pneumatics

Double acting cylinder : – with single piston rod – with double-ended piston rod	Cylinder in which the fluid pressure operates alternately in both directions (forward and backward strokes)		
Differential cylinder	The action is dependent on the difference between the effective areas on each side of the piston		

Cylinder with cushion : – with single fixed cushion	Cylinder incorporating fixed cushion acting in one direction only	
– with double fixed cushion	Cylinder with fixed cushion acting in both directions	
– with single adjustable cushion	The symbol is a combination of 6.5.4.1 and 5.2.3 (sloping arrow)	
– with double adjustable cushion	The symbol is a combination of 6.5.4.2 and 5.2.3 (sloping arrow)	

Symbols And Standards In Pneumatics

Description	Use of the equipment or explanation of the symbol	Symbol Symbole
Telescopic cylinder :		
– single acting	The fluid pressure always acts in one and the same direction (on the forward stroke)	
– double acting	The fluid pressure operates alternately in both directions (forward and backward strokes)	

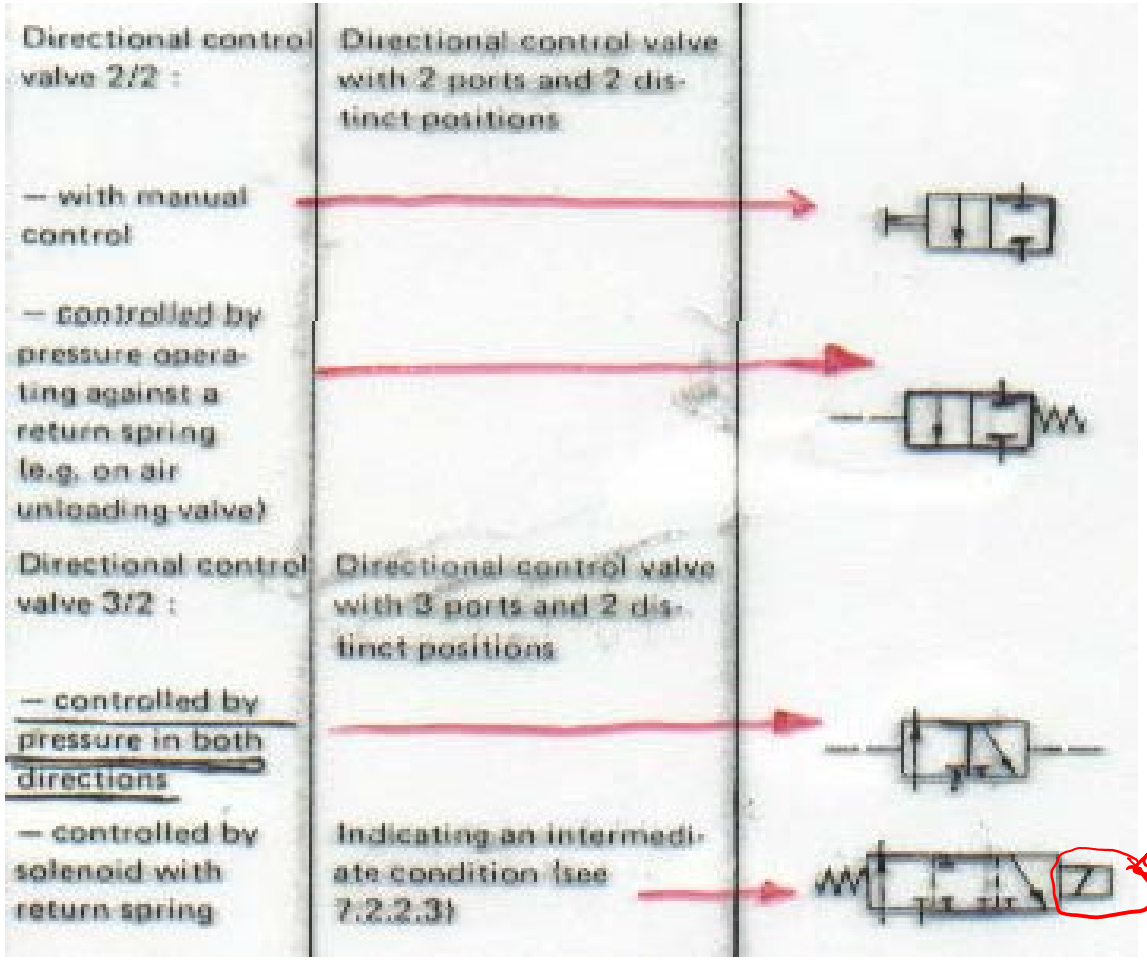
		Detailed Détaillé	Simplified Simplifié
Pressure intensifiers :	**Equipment transforming a pressure *x* into a higher pressure *y***		
– for one type of fluid	E.g. a pneumatic pressure *x* is transformed into a higher pneumatic pressure *y*		
– for two types of fluid	E.g. a pneumatic pressure *x* is transformed into a higher hydraulic pressure *y*		
Air-oil actuator	**Equipment transforming a pneumatic pressure into a substantially equal hydraulic pressure or vice versa**		

Symbols And Standards In Pneumatics: Control valves

Method of representation of valves (except 7.3 and 7.6)	Made up of one or more squares 5.1.3 and arrows *In circuit diagrams hydraulic and pneumatic units are normally shown in the unoperated condition*	
One single square	Indicates unit for controlling flow or pressure, having in operation an infinite number of possible positions between its end positions so as to vary the conditions of flow across one or more of its ports, thus ensuring the chosen pressure and/or flow with regard to the operating conditions of the circuit	□

Description	Use of the equipment or explanation of the symbol	Symbol Symbole
	Basic symbol for 3-position directional control valve A transitory but significant condition between two distinct positions is optionally represented by a square with dashed ends A basic symbol for a directional control valve with two distinct positions and one transitory intermediate condition	 

Symbols And Standards In Pneumatics :Control valves



Port Designation for Valves

Port designations for valving	Alphabetical	Numerical
Working lines	A, B, C . . . O (excludes L)	2, 4, 6 . . .
Supply air, compressed air connection	P	1
Drain, exhaust points	R, S, T . . . W	3, 5, 7 . . .
Leakage fluid	L	9
Pilot lines	Z, Y, X	12, 14, 16, 18 . . .

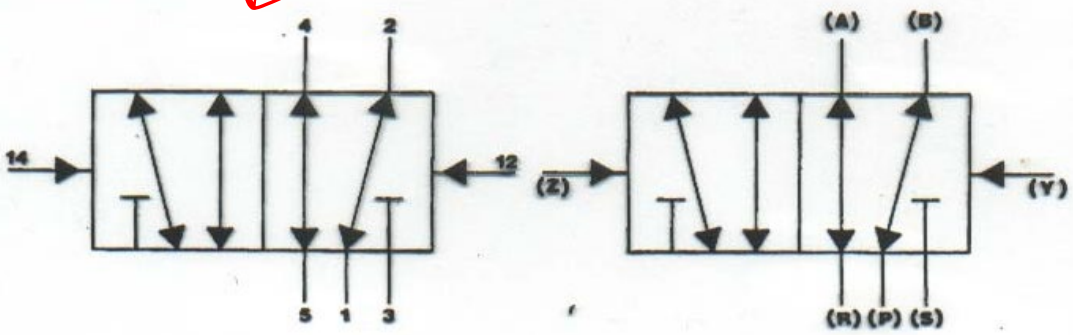
Symbols And Standards In Pneumatics :Control valves

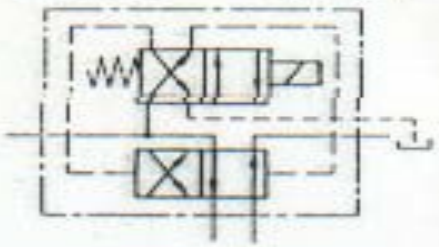
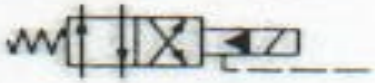
ISO 5599/II

This Standard which supplements ISO 5599/I, lays down the port designations.
This is no longer done by letters but by numbers.
Numbers are the same all over the world and can be read by anybody anywhere.

Example:
This Standard only applies to 5/2-way valves.
old ISO 5599/II
P → 1 = Supply port
A → 4 = Working or outlet line
B → 2 = Working or outlet line
R → 5 = Exhaust
S → 3 = Exhaust
Z → 14 = Pilot line for flow 1 → 4
Y → 12 = Pilot line for flow 1 → 2

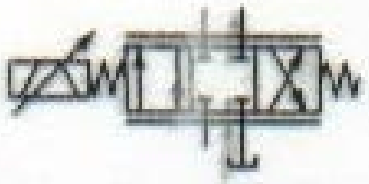
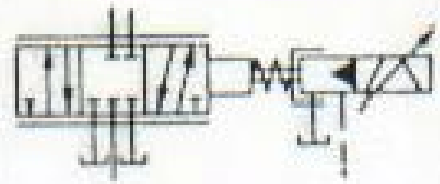
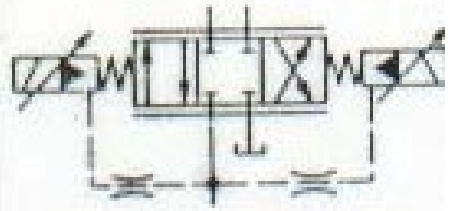
Example:



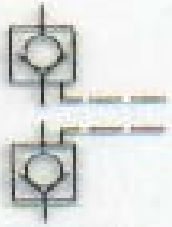
Description	Use of the equipment or explanation of the symbol	Symbol Symbole
Directional control valve 4/2 : – controlled by pressure in both directions by means of a pilot valve (with a single solenoid and spring return)	Directional control valve with 4 ports and 2 distinct positions	Detailed Détaillé  Simplified Simplifié 
Directional control valve 5/2 : – controlled by pressure in both directions	Directional control valve with 5 ports and 2 distinct positions	

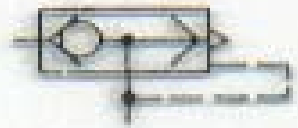
Symbols And Standards In Pneumatics: Control valves

Throttling directional control	The unit has 2 extreme positions and an infinite number of intermediate conditions with varying degrees of throttling	
	All the symbols have parallel lines along the length of the boxes. *For valves with mechanical feedback see 9.3*	
	Showing the extreme positions	
	Showing the extreme positions and a central (neutral) position	
— with 2 ports (one throttling orifice)	For example : Tracer valve plunger operated against a return spring	
— with 3 ports (two throttling orifices)	For example : Directional control valve controlled by pressure against a return spring	
— with 4 ports (four throttling orifices)	For example : Tracer valve, plunger operated against a return spring	

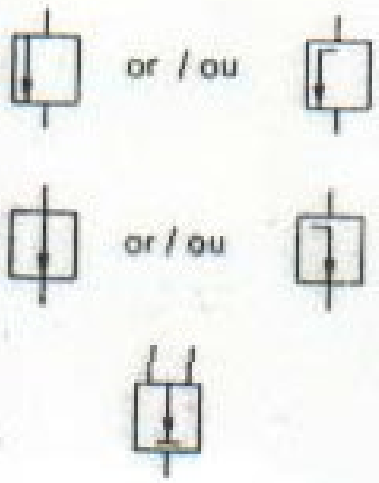
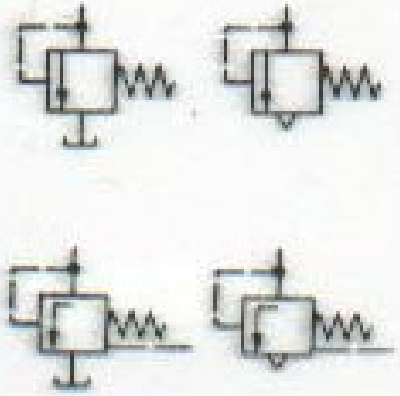
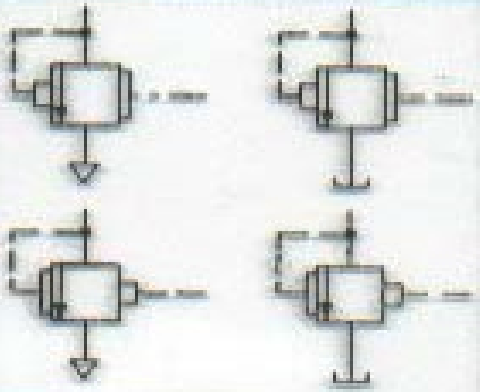
Electro-hydraulic servo valve : Electro-pneumatic servo valve :	A unit which accepts an analogue electrical signal and provides a similar analogue fluid power output	
— single stage	— with direct operation	
— two stage with mechanical feedback	— with indirect pilot operation	
— two stage with hydraulic feedback	— with indirect pilot operation	

Symbols And Standards In Pneumatics: Control valves

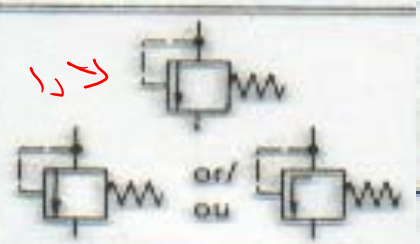
Non-return valve :		
– free	Opens if the inlet pressure is higher than the outlet pressure	
– spring loaded	Opens if the inlet pressure is greater than the outlet pressure plus the spring pressure	
– pilot controlled	As 7.3.1.1 but by pilot control it is possible to prevent : – closing of the valve – opening of the valve	
– with restriction	Unit allowing free flow in one direction but restricted flow in the other	

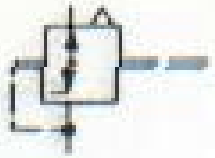
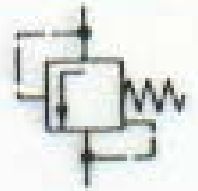
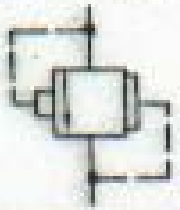
Shuttle valve	The inlet port connected to the higher pressure is automatically connected to the outlet port while the other inlet port is closed	
Rapid exhaust valve	When the inlet port is unloaded the outlet port is freely exhausted	
Pressure control valves	Units ensuring the control of pressure. Represented by one single square as in 7.1.1 with one arrow (the tail to the arrow may be placed at the end of the arrow). For interior controlling conditions see 9.2.4.3	

Symbols And Standards In Pneumatics :Control valves

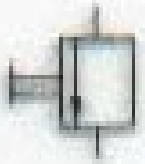
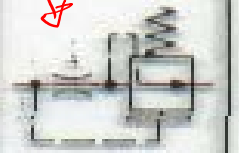
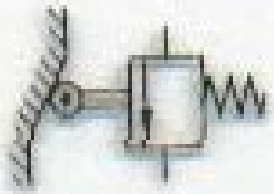
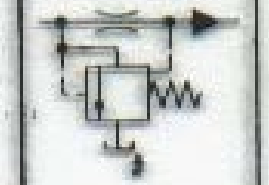
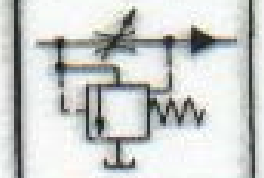
Description	Use of the equipment or explanation of the symbol	Symbol Symbole
Pressure control valve : – 1 throttling orifice normally closed – 1 throttling orifice normally open, = 2 throttling orifices, normally closed	General symbols	
Pressure relief valve (safety valve) – with remote pilot control	Inlet pressure is controlled by opening the exhaust port to the reservoir or to atmosphere against an opposing force (for example a spring) *The pressure at the inlet* port is limited as in 7.4.2 or to that corresponding to the setting of a pilot control	
Proportional pressure relief	Inlet pressure is limited to a value proportional to the pilot pressure (see 9.2.4.1.3)	

Symbols And Standards In Pneumatics :Control valves

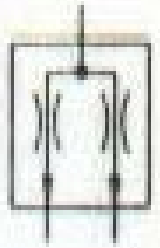
Sequence valve	When the inlet pressure overcomes the opposing force of the spring, the valve opens permitting flow from the outlet port	
Pressure regulator or reducing valve (reducer of pressure) :	A unit which, with a variable inlet pressure, gives substantially constant output pressure provided that the inlet pressure remains higher than the required outlet pressure	
— without relief port		
— without relief port with remote control	As in 7.4.5.1 but the outlet pressure is dependent on the control pressure	
— with relief port		

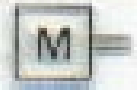
Description	Use of the equipment or explanation of the symbol	Symbol Symbole
— with relief port, with remote control	As in 7.4.5.3 but the outlet pressure is dependent on the control pressure	
Differential pressure regulator	The outlet pressure is reduced by a fixed amount with respect to the inlet pressure	
Proportional pressure regulator	The outlet pressure is reduced by a fixed ratio with respect to the inlet pressure (see 9.2.4.1.3)	

Symbols And Standards In Pneumatics :Control valves

Throttle valve :	Simplified symbol (Does not indicate the control method or the state of the valve)		*Flow control valve* :	Variations in inlet pressure do not affect the rate of flow	Detailed Détaillé	Simplified Simplifié
— with manual control	Detailed symbol (indicates the control method or the state of the valve)		— with fixed output			
— with mechanical control against a return spring (braking valve)			— with fixed output and relief port to reservoir	As 7.5.2.1 but with relief for excess flow		
			— with variable output	As 7.5.2.1 but with arrow 5.2.3 added to the symbol of restriction		
			— with variable output and relief port to reservoir	As 7.5.2.3 but with relief for excess flow		

Symbols And Standards In Pneumatics :Control valves

Description	Use of the equipment or explanation of the symbol	Symbol Symbole
Flow dividing valve	The flow is divided into two flows in a fixed ratio substantially independent of pressure variations	
Shut-off valve	Simplified symbol	

Sources of energy		
Pressure source	Simplified general symbol	
Hydraulic pressure source	Symbols to be used when the nature of the source should be indicated	
Pneumatic pressure source		
Electric motor	Symbol 113 in IEC Publication 117.2	
Heat engine		

Symbols And Standards In Pneumatics: flow lines and connections

Flow lines and connections		
Flow line :		
– working line, return line and feed line		
– pilot control line		
– drain or bleed line		
– flexible pipe	Flexible hose, usually connecting moving parts	
– electric line		
Pipeline junction		
Crossed pipelines	not connected	
Air bleed		

Exhaust port :		
– plain with no provision for connection		
– threaded for connection		
Power take-off :	On equipment or lines, for energy take-off or measurement	
– plugged		
– with take-off line		

Symbols And Standards In Pneumatics: flow lines and connections

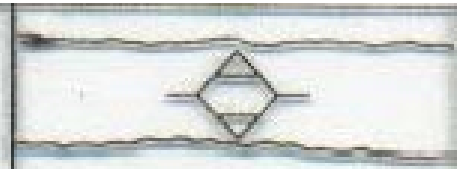
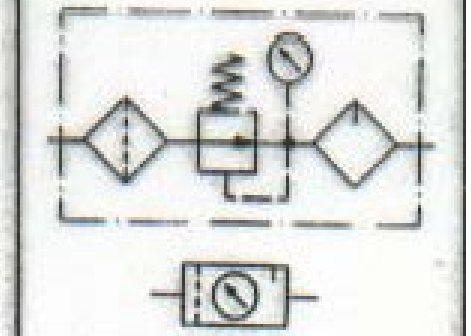
Quick-acting coupling :		
– connected, without mechanically opened non-return valve		
– connected, with mechanically opened non-return valves		
– uncoupled, with open end		
– uncoupled, closed by free non-return valve (see 7.3.1.1)		
Rotary connection; Line junction allowing angular movement in service		
– one way		
– three way		
Silencer		
Reservoirs		
Reservoir open to atmosphere :		
– with inlet pipe above fluid level		

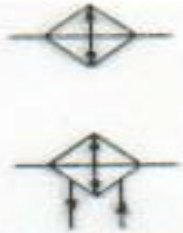
Symbols And Standards In Pneumatics: flow lines and connections

– with inlet pipe below fluid level		
– with a header line		
Pressurized reservoir		
Accumulators	The fluid is maintained under pressure by a spring, weight or compressed gas (air, nitrogen, etc.)	

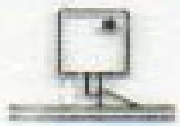
Filters, water traps, lubricators and miscellaneous apparatus		
Filter or strainer		
Water trap :		
– with manual control		
– automatically drained		
Filter with water trap :		
– with manual control	Combination of 8.5.1 and 8.5.2.1	
– automatically drained	Combination of 8.5.1 and 8.5.2.2	

Symbols And Standards In Pneumatics: flow lines and connections

Air dryer	A unit drying air (for example by chemical means)	
Lubricator	Small quantities of oil are added to the air passing through the unit, in order to lubricate equipment receiving the air	
Conditioning unit	Consisting of filter, pressure regulator, pressure gauge and lubricator – Detailed symbol – Simplified symbol	

Heat exchangers	Apparatus for heating or cooling the circulating fluid	
Temperature controller	The fluid temperature is maintained between two predetermined values. The arrows indicate that heat may be either introduced or dissipated	
Cooler	The arrows in the diamond indicate the extraction of heat – without representation of the flow lines of the coolant – indicating the flow lines of the coolant	
Heater	The arrows in the diamond indicate the introduction of heat	

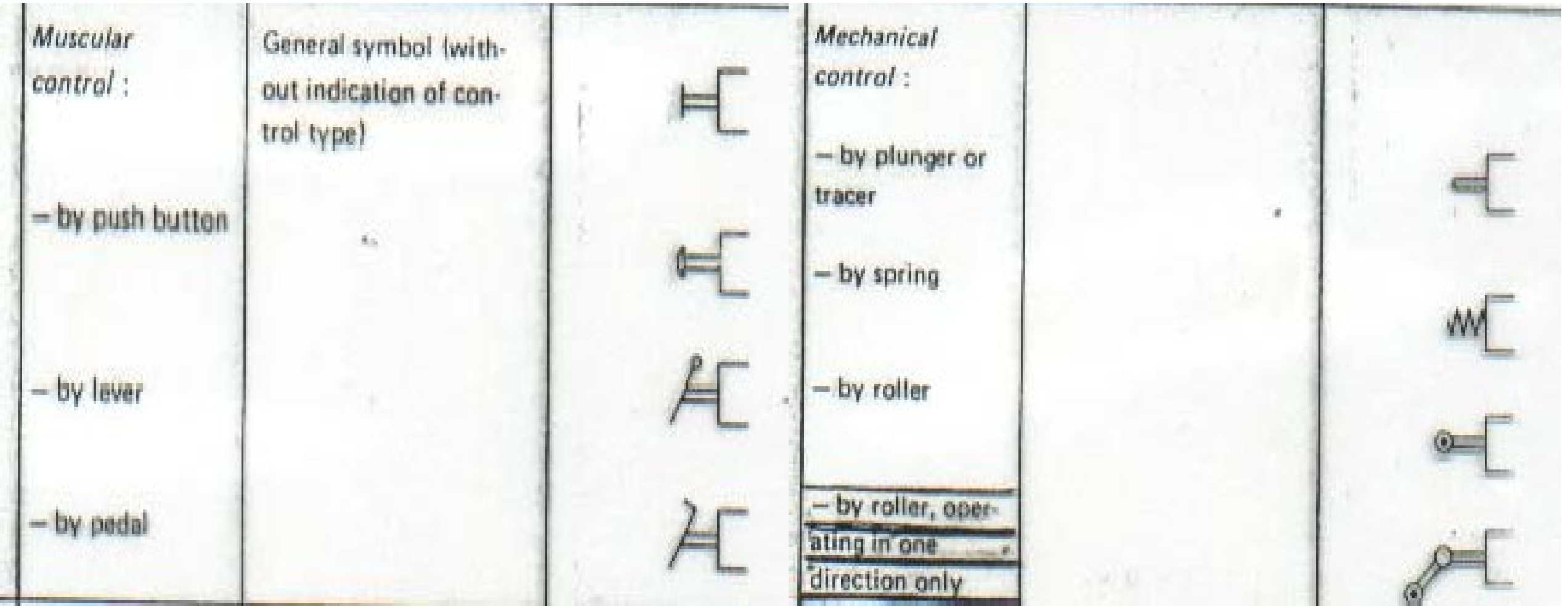
Symbols And Standards In Pneumatics: mechanical components

Mechanical components		
Rotating shaft : — in one direction — in either direction	The arrow indicates rotation	
Detent	A device for maintaining a given position	
Locking device	* The symbol for unlocking control is inserted in the square	
Over-centre device	Prevents the mechanism stopping in a dead centre position	
Pivoting devices : — simple		

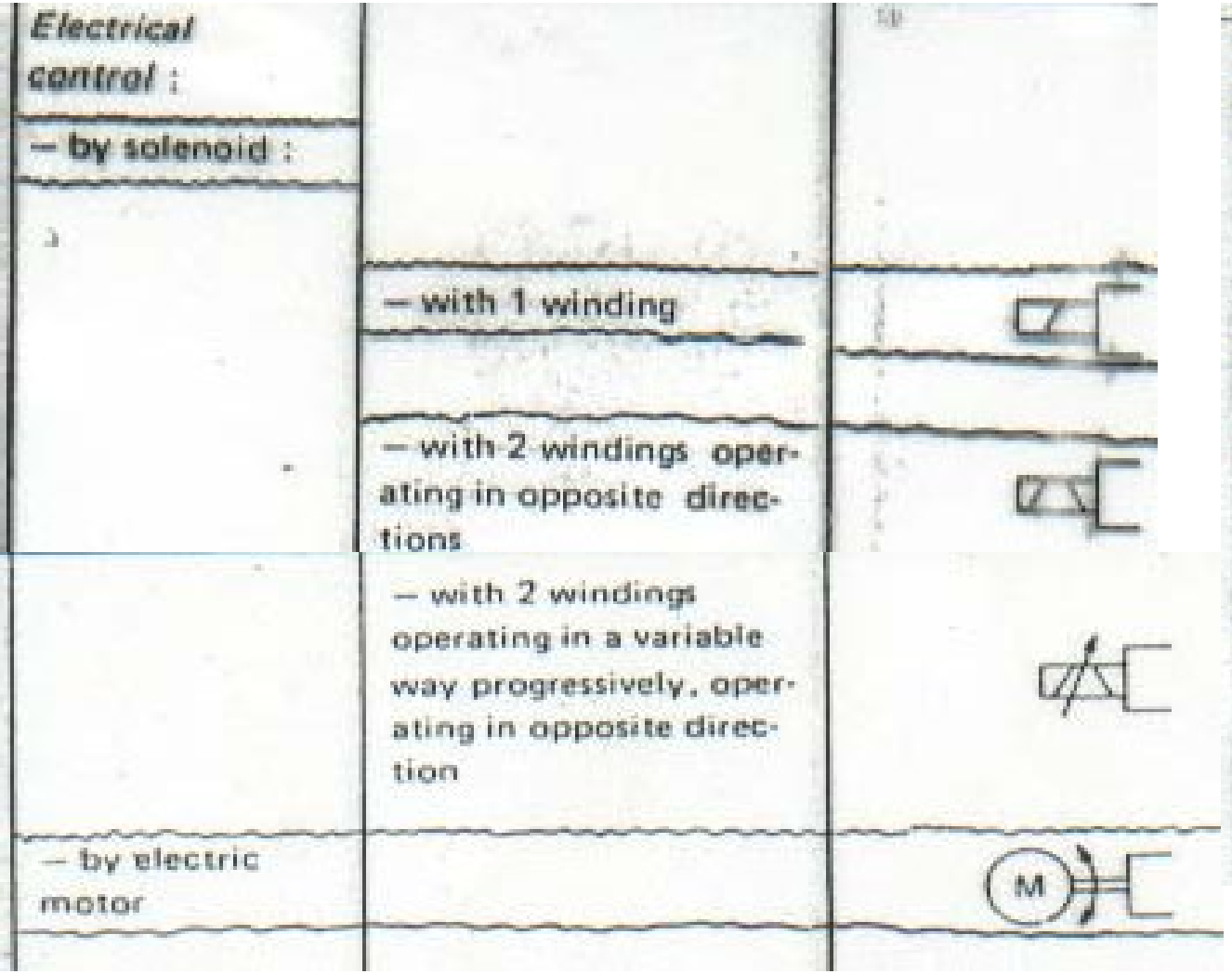
Description	Use of the equipment or exp'anation of the symbol	Symbol Symbole
— with traversing lever — with fixed fulcrum		
Control methods	The symbols representing control methods are incorporated in the symbol of the controlled apparatus to which they should be adjacent. For apparatus with several squares the actuation of the control makes effective the square adjacent to it	

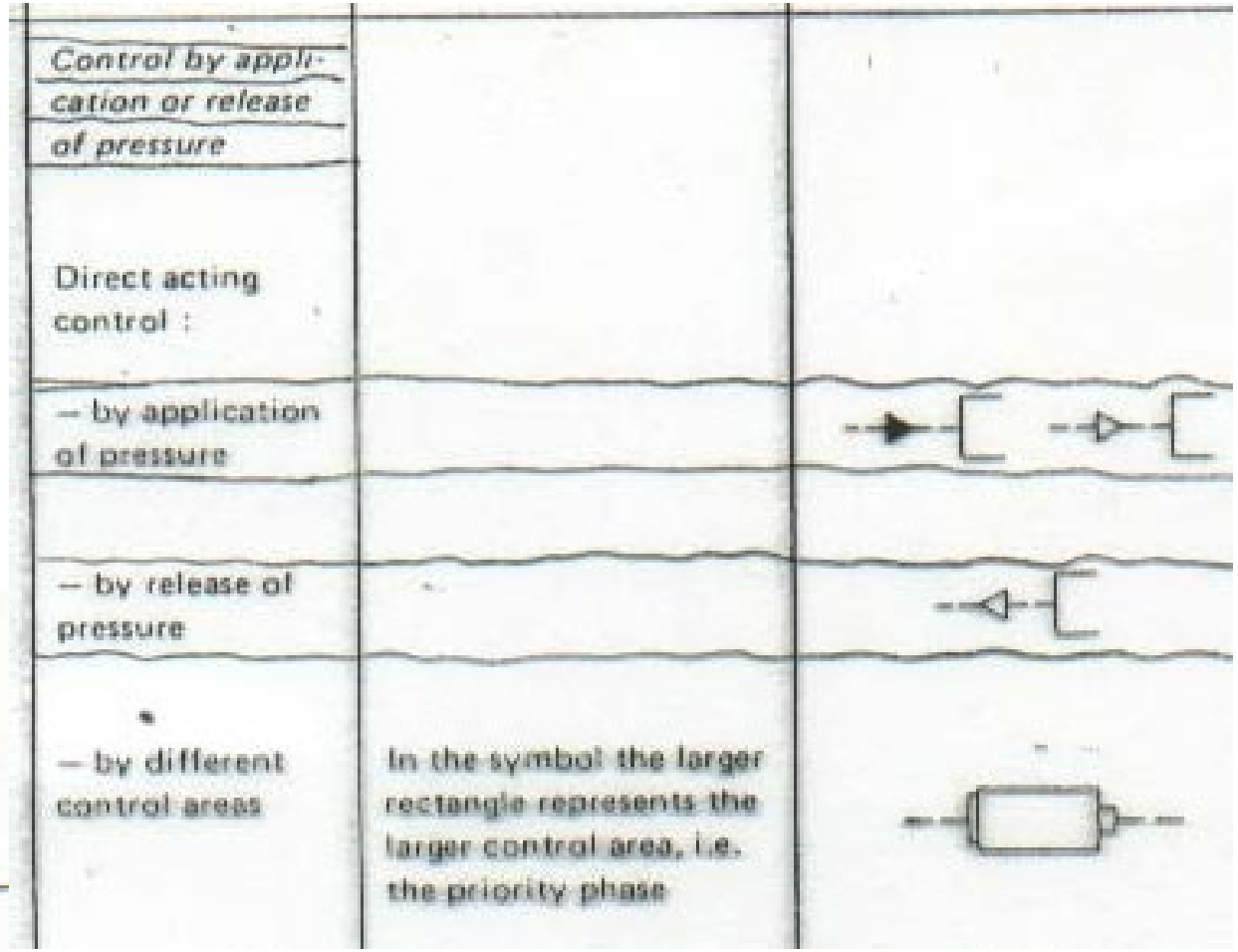
Symbols And Standards In Pneumatics: mechanical components

Muscular control :	General symbol (without indication of control type)	
– by push button		
– by lever		
– by pedal		
Mechanical control :		
– by plunger or tracer		
– by spring		
– by roller		
– by roller, operating in one direction only		



Symbols And Standards In Pneumatics: electrical control





Control valves

Indirect control, pilot actuated :	General symbol for pilot directional control valve	
— by application of pressure		
— by release of pressure		
Interior control paths	The control paths are inside the unit	
Combined control :		
— by solenoid and pilot directional valve	The pilot directional valve is actuated by the solenoid	
— by solenoid or pilot directional valve	Either may actuate the control independently	

Description	Use of the equipment or explanation of the symbol	Symbol Symbole
Mechanical feedback	The mechanical connection of a control apparatus moving part to a controlled apparatus moving part is represented by the symbol 5.1.1.4 which joins the two parts connected. (For examples see 11.1.2 and 12.1.1)	1) 2) 1) Controlled apparatus Appareil commandé 2) Control apparatus Appareil de commande

Control valves

Indirect control, pilot actuated :	General symbol for pilot directional control valve	
— by application of pressure		
— by release of pressure		
Interior control paths	The control paths are inside the unit	
Combined control :		
— by solenoid and pilot directional valve	The pilot directional valve is actuated by the solenoid	
— by solenoid or pilot directional valve	Either may actuate the control independently	

Description	Use of the equipment or explanation of the symbol	Symbol Symbole
Mechanical feedback	The mechanical connection of a control apparatus moving part to a controlled apparatus moving part is represented by the symbol 5.1.1.4 which joins the two parts connected. (For examples see 11.1.2 and 12.1.1)	1) 2) 1) Controlled apparatus Appareil commandé 2) Control apparatus Appareil de commande

Measuring instruments

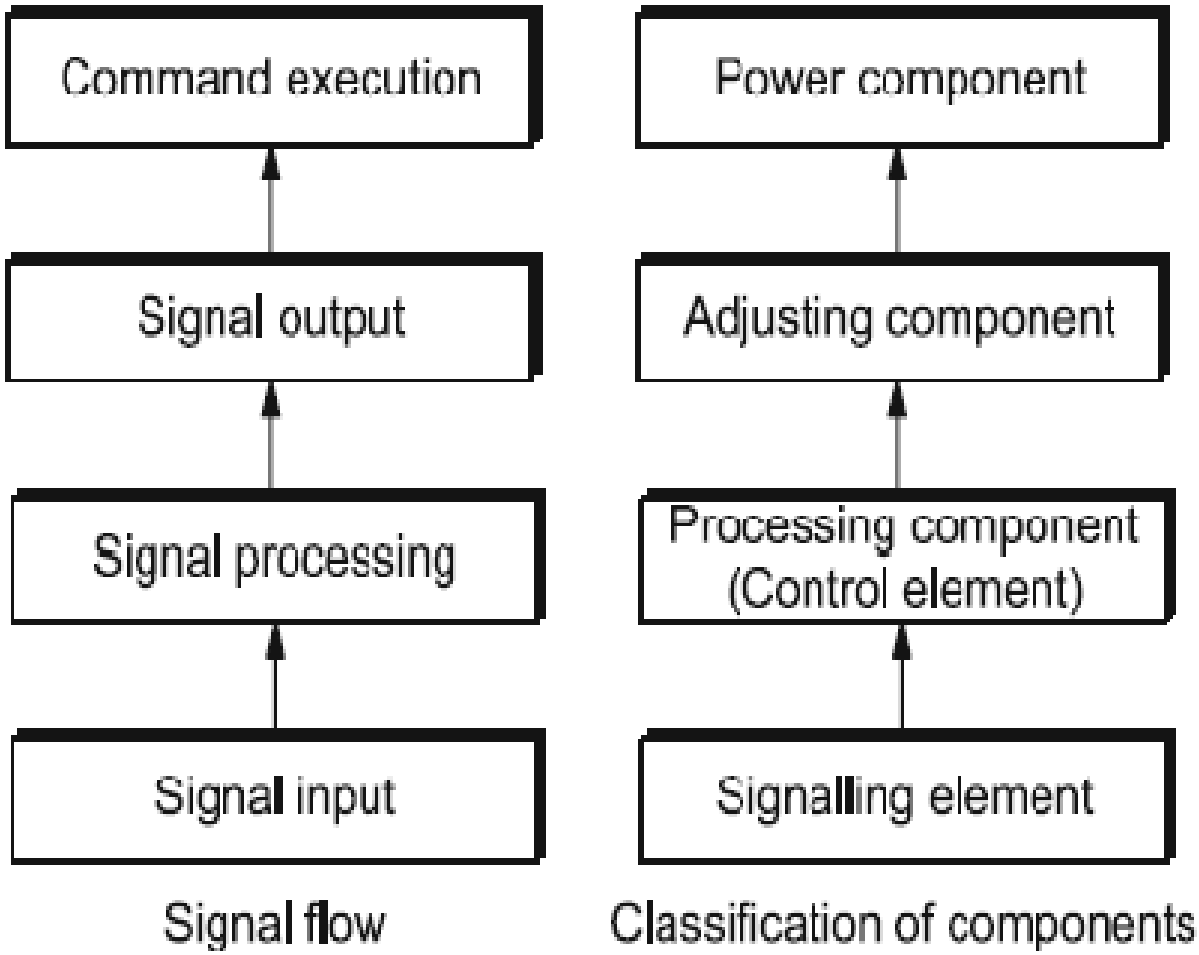
Measuring instruments		
Pressure measurement : — pressure gauge	The point on the circle at which the connection joins the symbol is immaterial	
Temperature measurement : — Thermometer	The point on the circle at which the connection joins the symbol is immaterial	
Measurement of flow :		
— Flow meter		
— Integrating flow meter		
Other apperatus		
Pressure electric switch		

Development of pneumatic systems

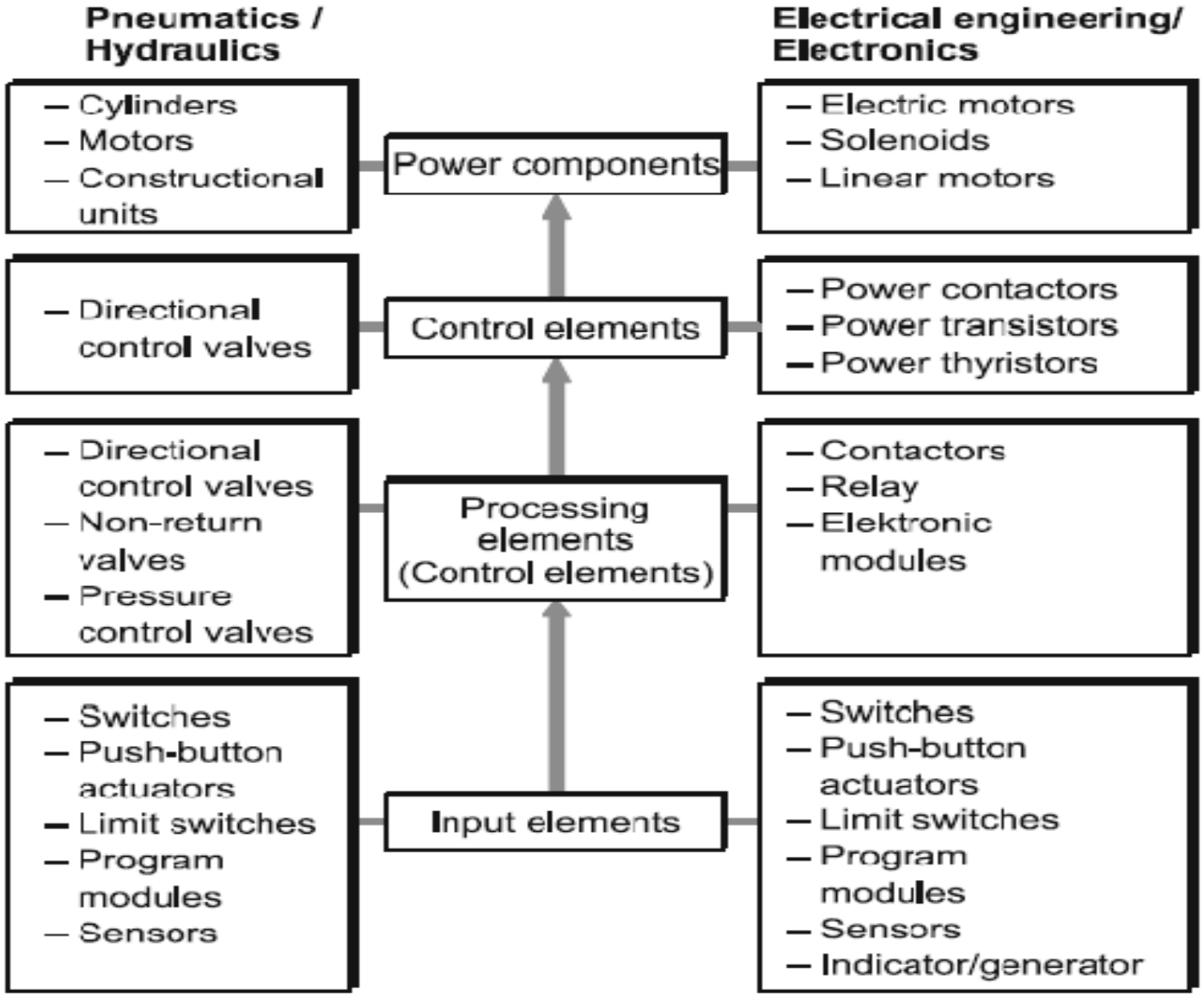
- The solution to a control problem is worked out according to a system with documentation playing an important role in communicating the final result.
- The circuit diagram should be drawn using standard symbols and labeling. Comprehensive documentation is required including most of the following:
- Function diagram
- Circuit diagram
- Description of the operation of the system
- Technical data on the components Supplementary documentation comprising:
- Parts list of all components in the system
- Maintenance and fault-finding information
- Spare parts list

Design of the circuit diagram

Control Chain(Control System Representation)



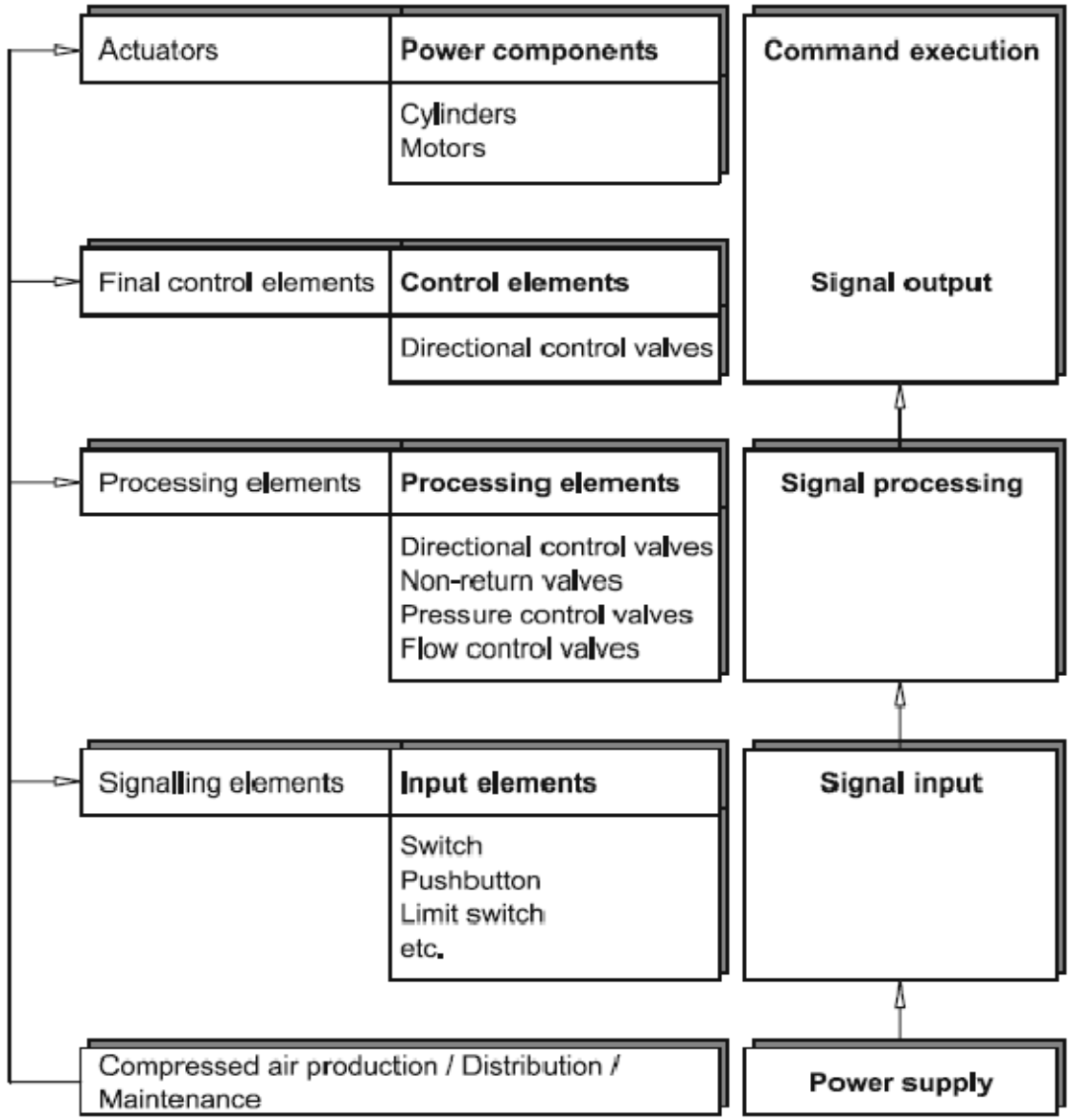
Design of the circuit diagram



Design of the circuit diagram

- The circuit diagram shows signal flow and the relationship between components and the air connections.
- The structure of the circuit diagram should correspond to the control chain, whereby the signal flow is represented from the bottom to the top.
- Simplified or detailed symbols may be used for the representation of the circuit diagram.
- In the case of larger circuit diagrams, the power supply parts (service unit, shut-off valve, various distributor connections) are shown on a separate page of the drawing for the purpose of simplification

Design of the circuit diagram



Design of the circuit diagram

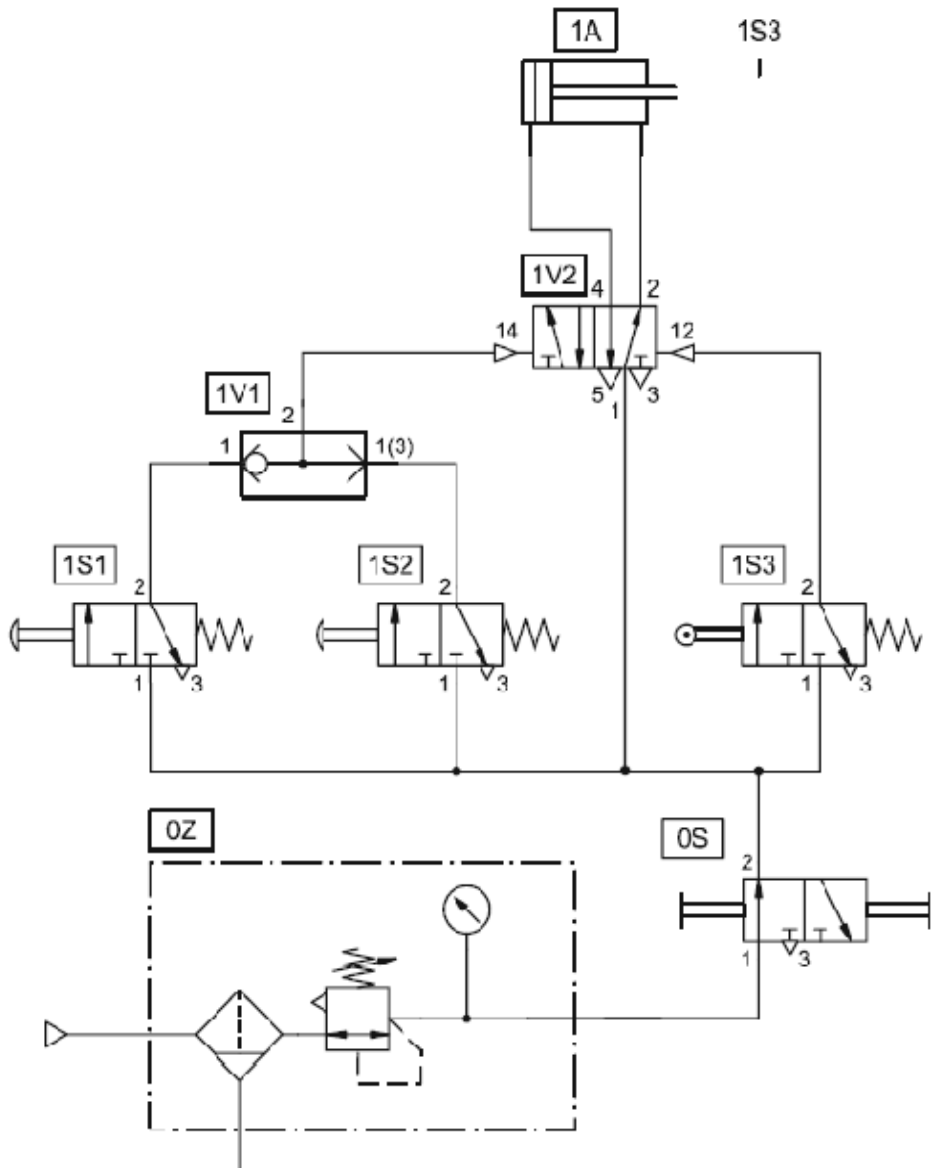
Power component

Control element

Processing element

Input elements

Supply elements



Designation of individual elements

- Signal elements should be represented in the normal position in the circuit diagram.
- If valves are actuated in the initial position as a start precondition, this must be indicated by the representation of a trip cam.
- In this case, the actuated switching position must be connected.

Designation by numbers

- With this type of designation, elements are divided into groups. Group 0 contains the elements for the power supply, groups 1,2,... Designate the individual control chains. One group number is generally allocated for each cylinder.

0Z1, 0Z2 etc.	Energy supply unit
1A, 2A, etc.	Power components
1V1, 1V2, etc	Control elements
1S1, 1S2, etc	Input elements (manually and mechanically actuated valves)

Designation by Letters

- This type of designation is used primarily for a systematic development of circuit diagrams. Here, limit switches are allocated to the cylinder, which acknowledges them.

1A, 2A, etc.	Power components
1S1, 2S1, etc.	Limit switches, activated in the retracted end position of cylinders 1A, 2A
1S2, 2S2, etc.	Limit switches, activated in the forward end position of cylinders 1A, 2A

Example:

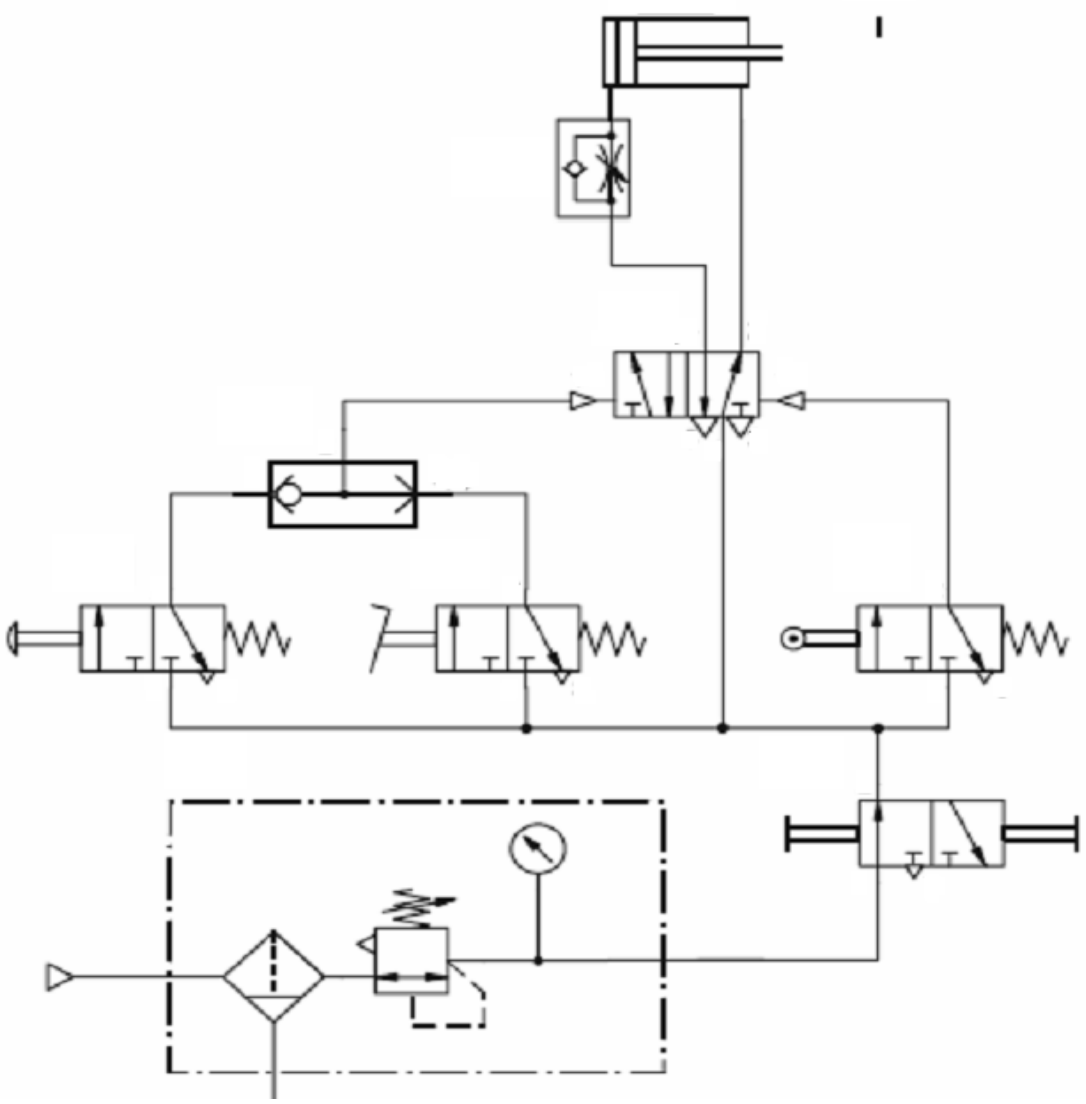
- ***Typical problem:***

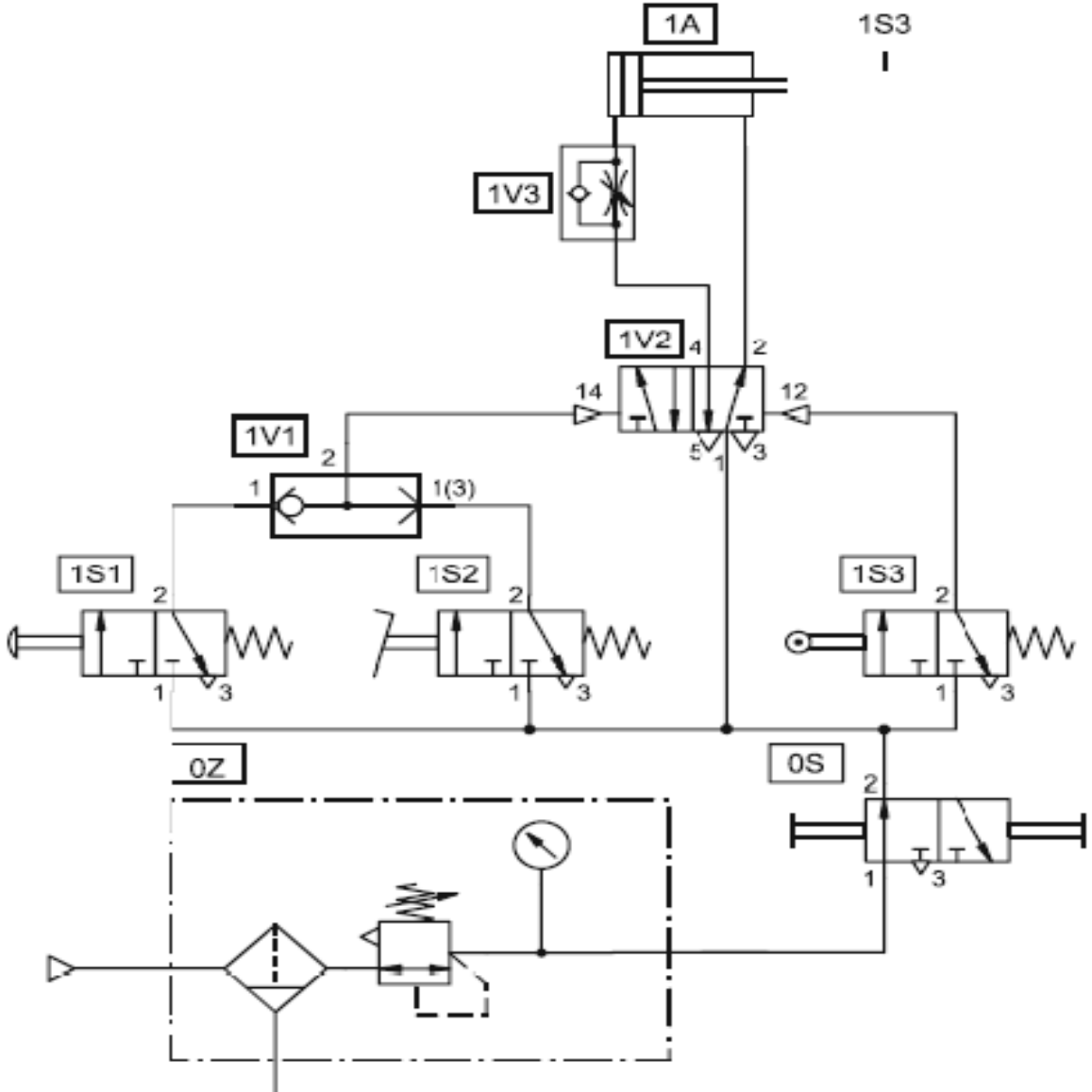
  •The piston rod of a double-acting pneumatic cylinder advances if either a manual push button or a foot pedal is operated. The cylinder returns to its starting position slowed down after fully extending. The piston rod will return provided the manual actuators have been released.

Example:

- ***Solution:***
  - The roller lever valve 1S3 is positioned as a limit switch in the forward end position of the cylinder.
  - The circuit diagram shows this element situated at the signal input level and does not directly reflect the orientation of the valve.
  - The mark on the circuit at the extended cylinder position indicates the physical position of the limit switch 1S3 for circuit operation.
  - If the control is complex and contains several working elements, the control should be broken down into separate control chains, whereby a chain is formed for each cylinder.
  - Wherever possible, these chains should be drawn next to each other in the same order as the operating sequence.

Example:




1A
1S3
1V3
1V2
4
2
14
12
5
1
3
1V1
2
1
1(3)
1S1
2
1
3
1S2
2
1
3
1S3
2
1
3
0Z
0S
2
1
3

Summary

- Physical arrangement of the elements is ignored.
- Draw the cylinders and directional control valves horizontally wherever possible.
- The energy flow within the circuit moves from the bottom to the top.
- Energy source can be shown in simplified form.
- Show elements in the initial position of the control. Identify actuated elements by a cam.
- Draw pipelines straight without cross-over wherever possible.

Control System Development

•The development of the control system solution requires that the problem is defined clearly. There are many ways of representing the problem in a descriptive or graphical form.

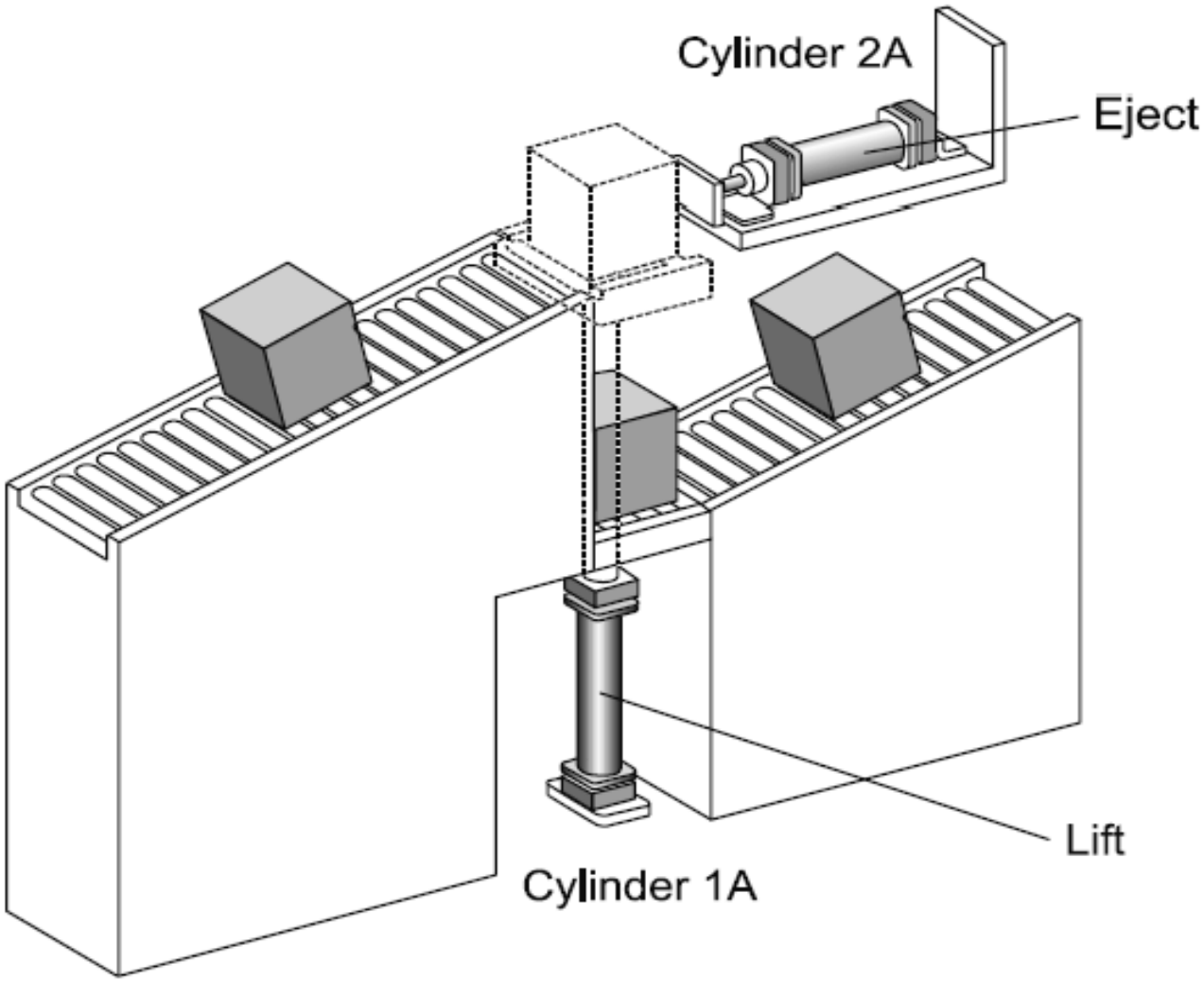
The methods of representing the control problem include:

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

Positional sketch

- The positional sketch shows the relationship between the actuators and the machine fixture.
- The actuators are shown in the correct orientation. The positional sketch is not normally to scale and should not be too detailed.
- The diagram will be used in conjunction with the description of the machine operation and the motion diagrams.

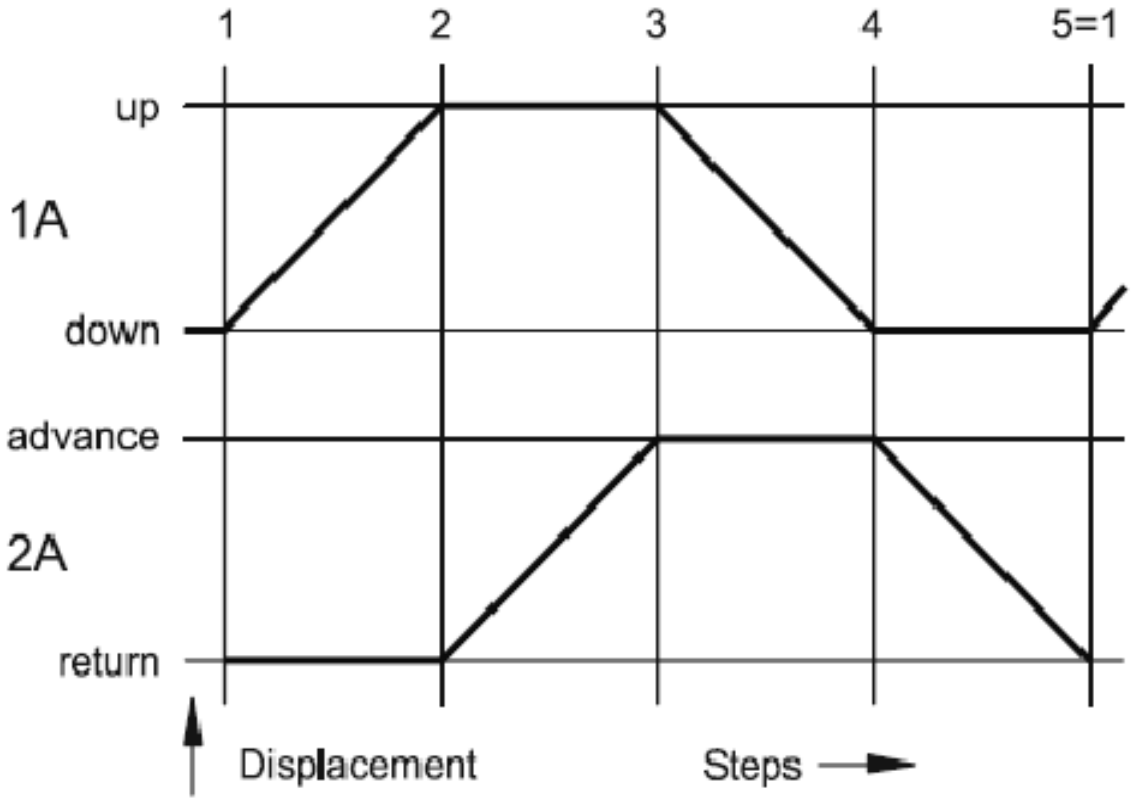
Positional sketch



Motion diagram

• The displacement-step diagram and the displacement-time diagram are used for motion sequences. The displacement-step diagram represents the operating sequence of the actuators; the displacement is recorded in relation to the sequence step. If a control system incorporates a number of actuators, they are shown in the same way and are drawn one below the other. Their interrelation can be seen by comparing the steps.

Motion diagram

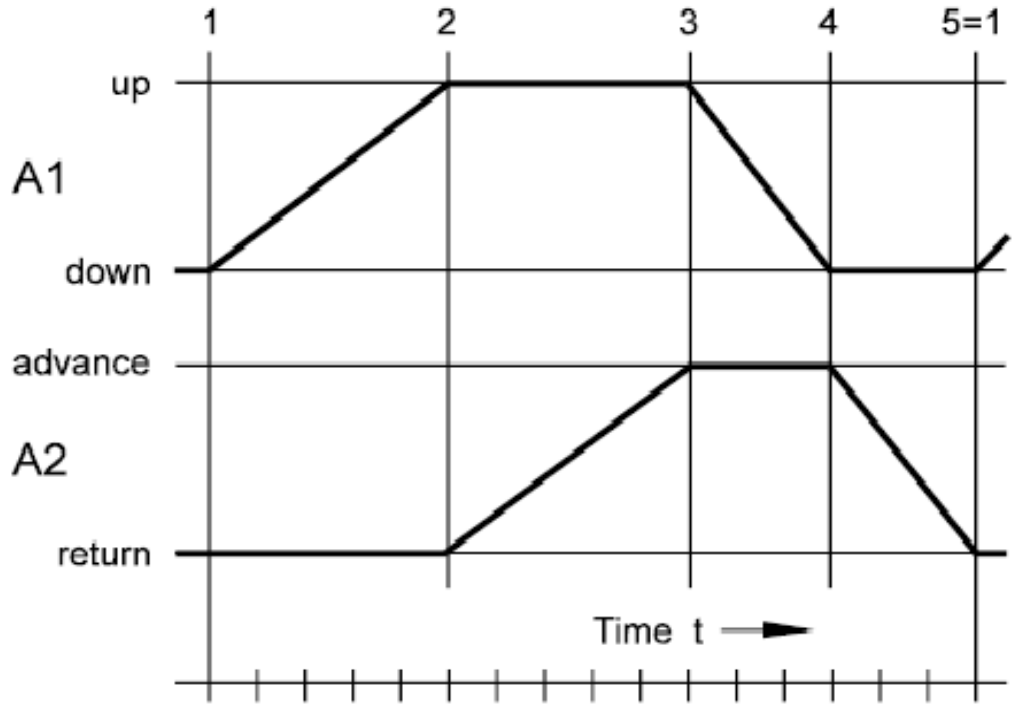


Displacement-step diagram

In this case there are two cylinders 1A and 2A. In step 1 cylinder 1A extends and then cylinder 2A extends in step 2. In step 3 cylinder 1A retracts and in step 4 cylinder 2A retracts. Step number 5 is equivalent to step 1.

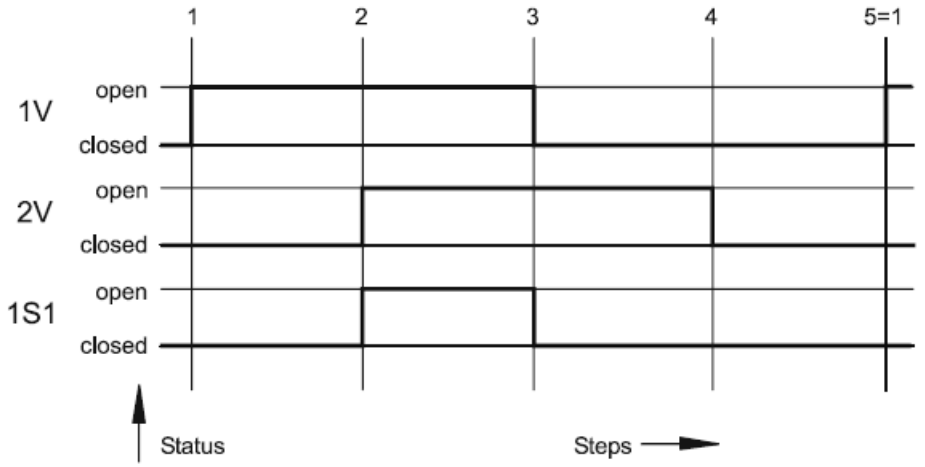
Displacement-time diagram

In the case of a displacement-time diagram, the displacement is plotted in relation to the time.



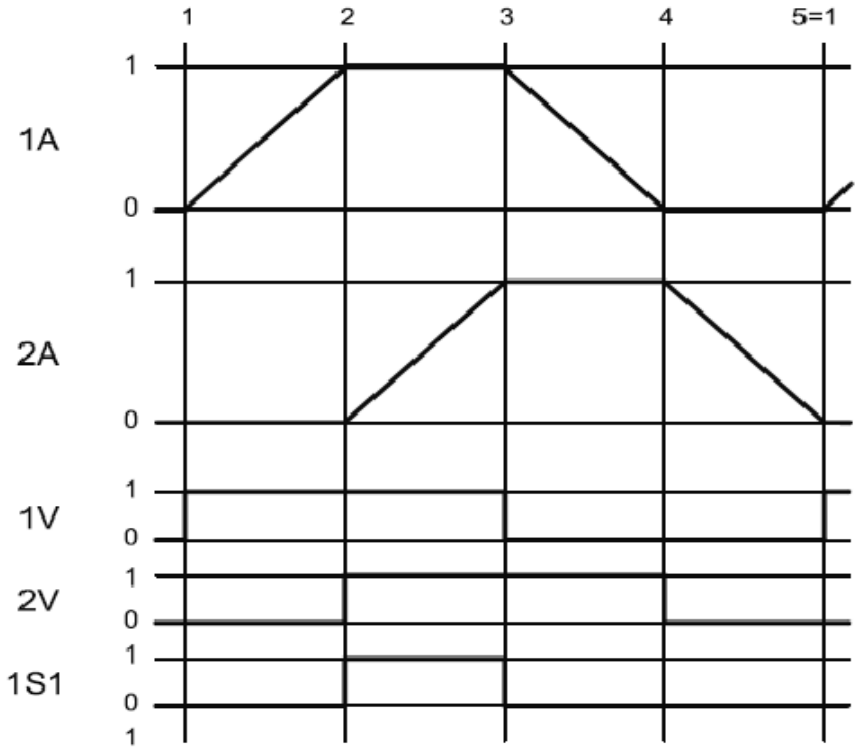
Control chart

- In the control chart, the switching status of the control element is represented in relation to the steps or the time.
- The switching time is not taken into account.
- The control diagram in the following figure shows the statuses of the control components (1V for cylinder 1A and 2V for cy1inder 2A) and the status of the limit switch 1S1 fitted at the front end position of the cylinder 1A.



Function diagram

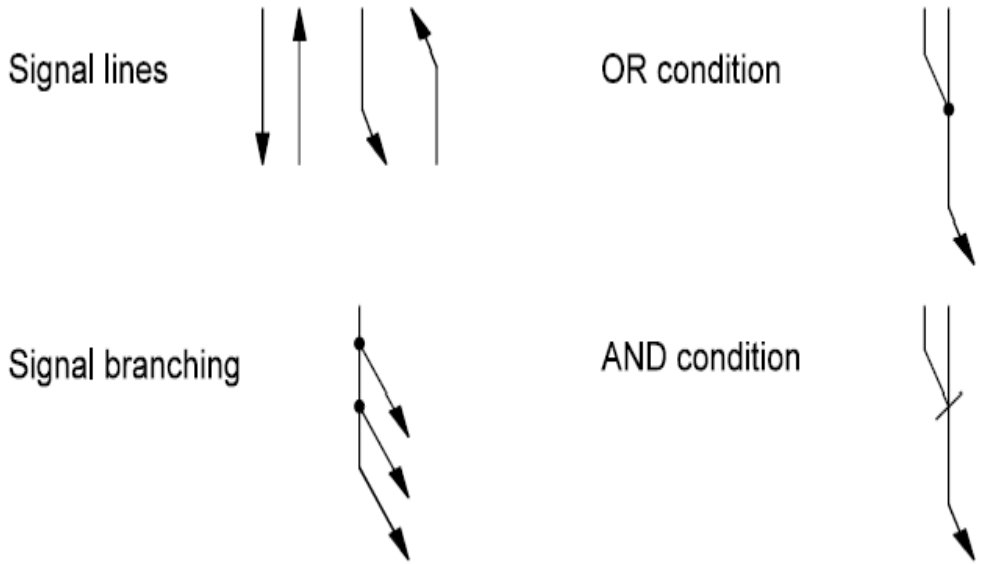
- The function diagram is a combination of the ***motion diagram*** and ***the control chart***.
- The lines representing the individual states are referred to as ***function lines***.



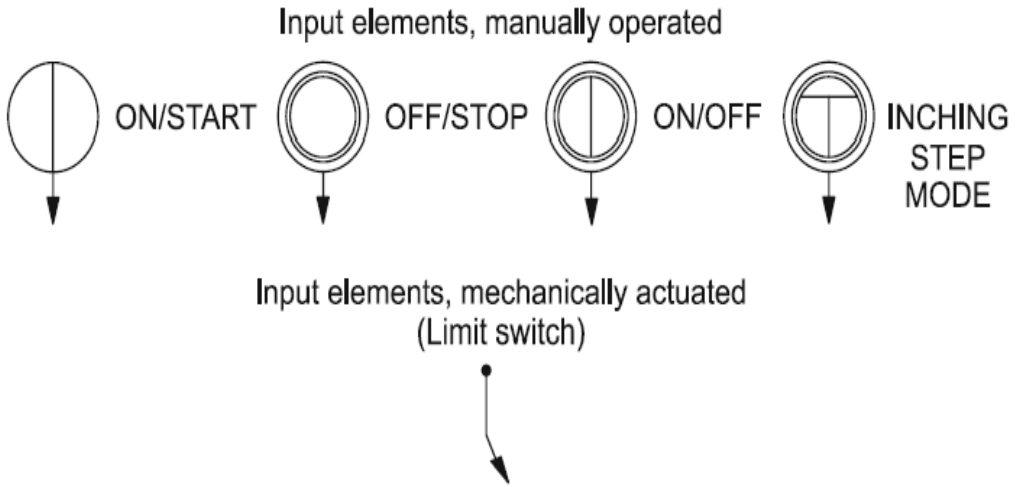
Function diagram

- Apart from the function lines, signal lines can also be entered in the function diagram.
- The signal line output is at the signal element and the end at the point, where a change in status occurs, dependent on this signal.
- Arrows on the signal lines indicate the direction of signal flow.
- Signal branching are denoted by a dot at the point of branching. Several changes in status of components are introduced by a signal output.
- In the case of the OR condition, a dot is placed at the point of conjunction of the signal lines.
- Several signal outputs effect the same change in status irrespective of one another.
- The AND condition is designated by means of an oblique stroke at the point of conjunction of the signal lines.
- A change in status only occurs, if all signal outputs are present.

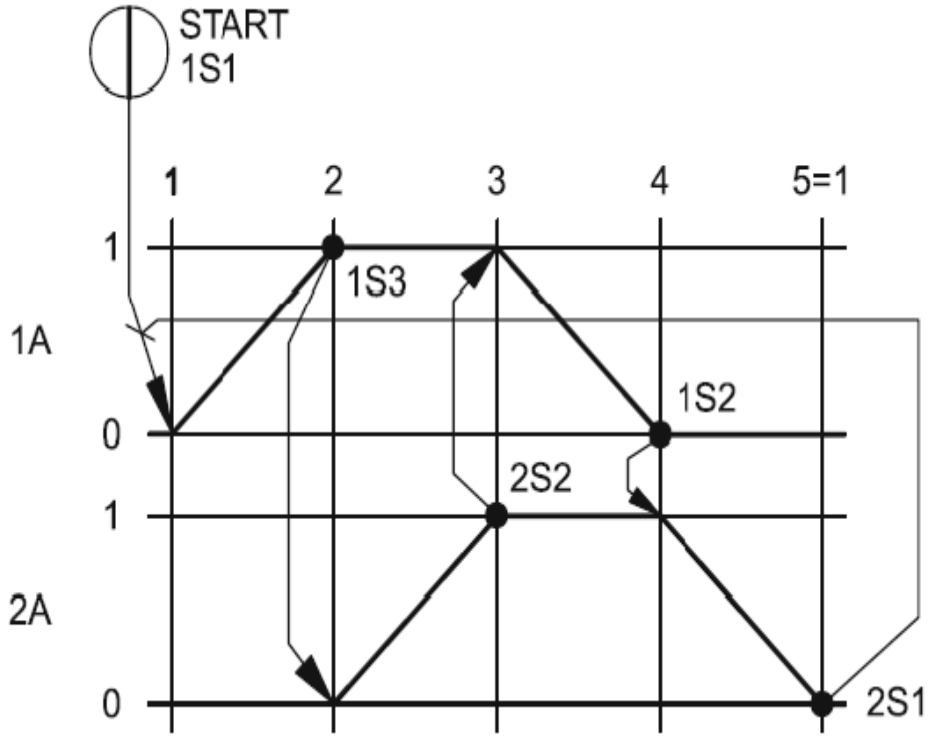
Representation of signal lines



Representation of input elements



example



The diagram illustrates the following sequence:

- If the limit switch 2S1 is actuated ***and*** the push button 1S1 is pressed by the operator, the piston rod of cylinder 1A extends.
- When the cylinder 1A reaches its forward end position, the limit switch 1S3 is actuated and the piston rod of cylinder 2A advances.
- When the cylinder 2A reaches its forward end position, the limit switch 2S2 is actuated and the piston rod of cylinder 1A retracts.
- When the cylinder 1A reaches its retracted end position, the limit switch 1S2 is actuated and the piston rod of cylinder 2A retracts.
- When cylinder 2A reaches its retracted end position, the limit switch 2S1 is actuated and the initial position is reached again.