Basic Electrical Controls for Fluid Power Circuits

Electro-pneumatics

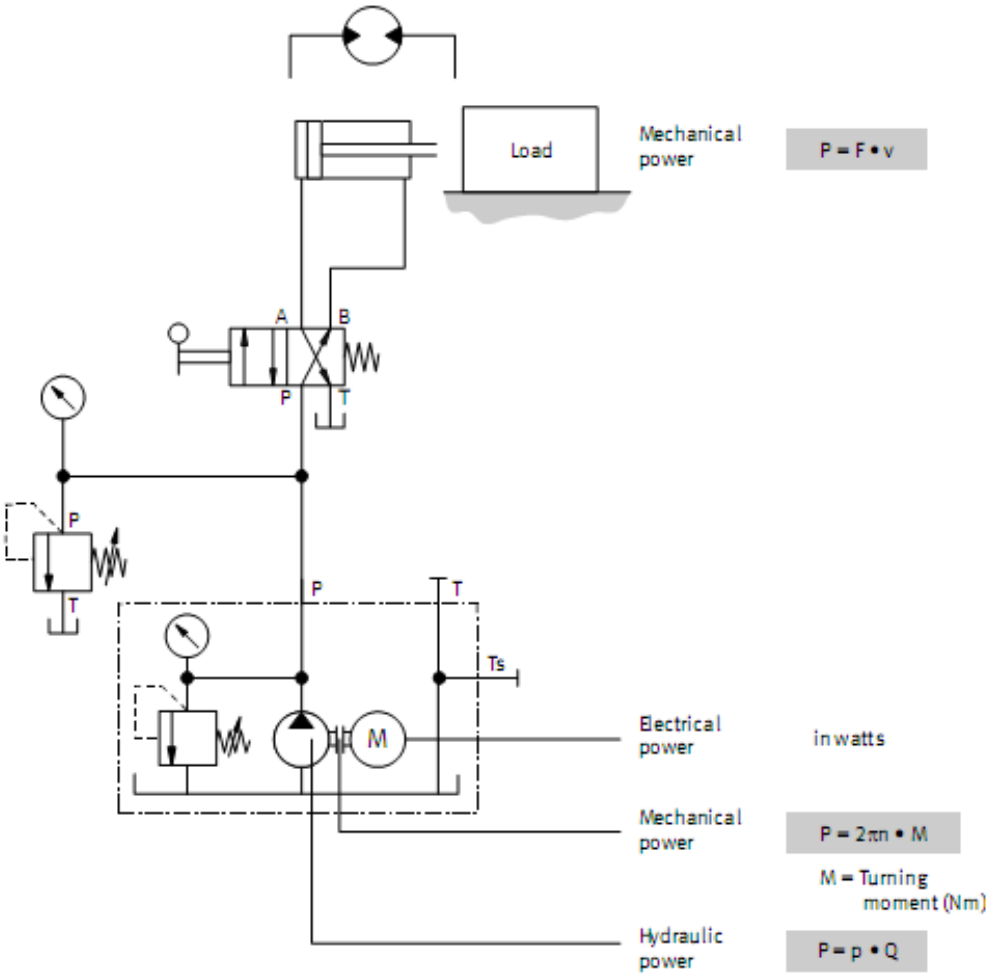
Electro-hydraulics

Introduction

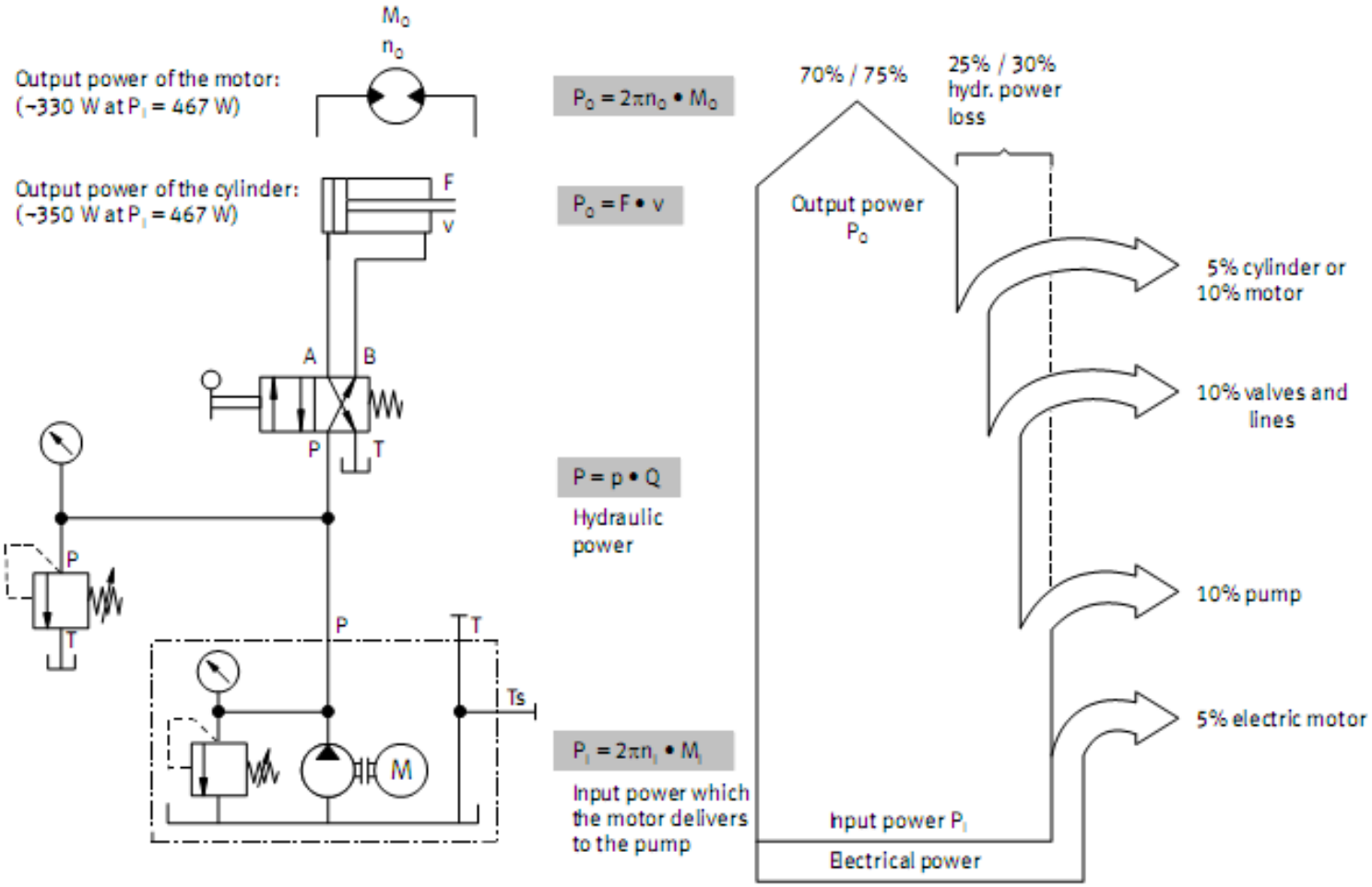
Why do we have to use it ?

- **More machines are designed using electrical signals from computer**
- **Soft-wired rather than hard-wired systems**
- **Simpler systems than pure pneumatic or hydraulic systems**
- **Development for advanced systems are more achievable using this systems**

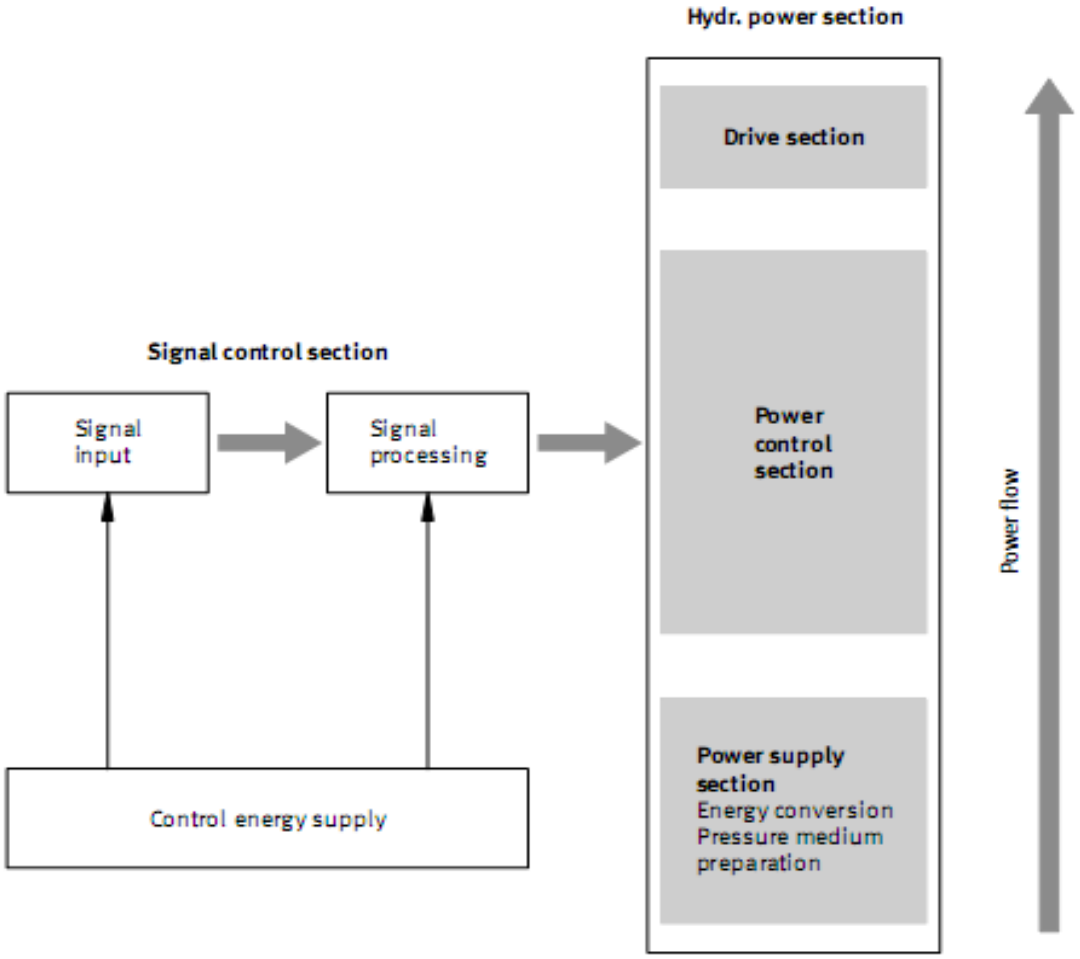
Power in hydraulic systems



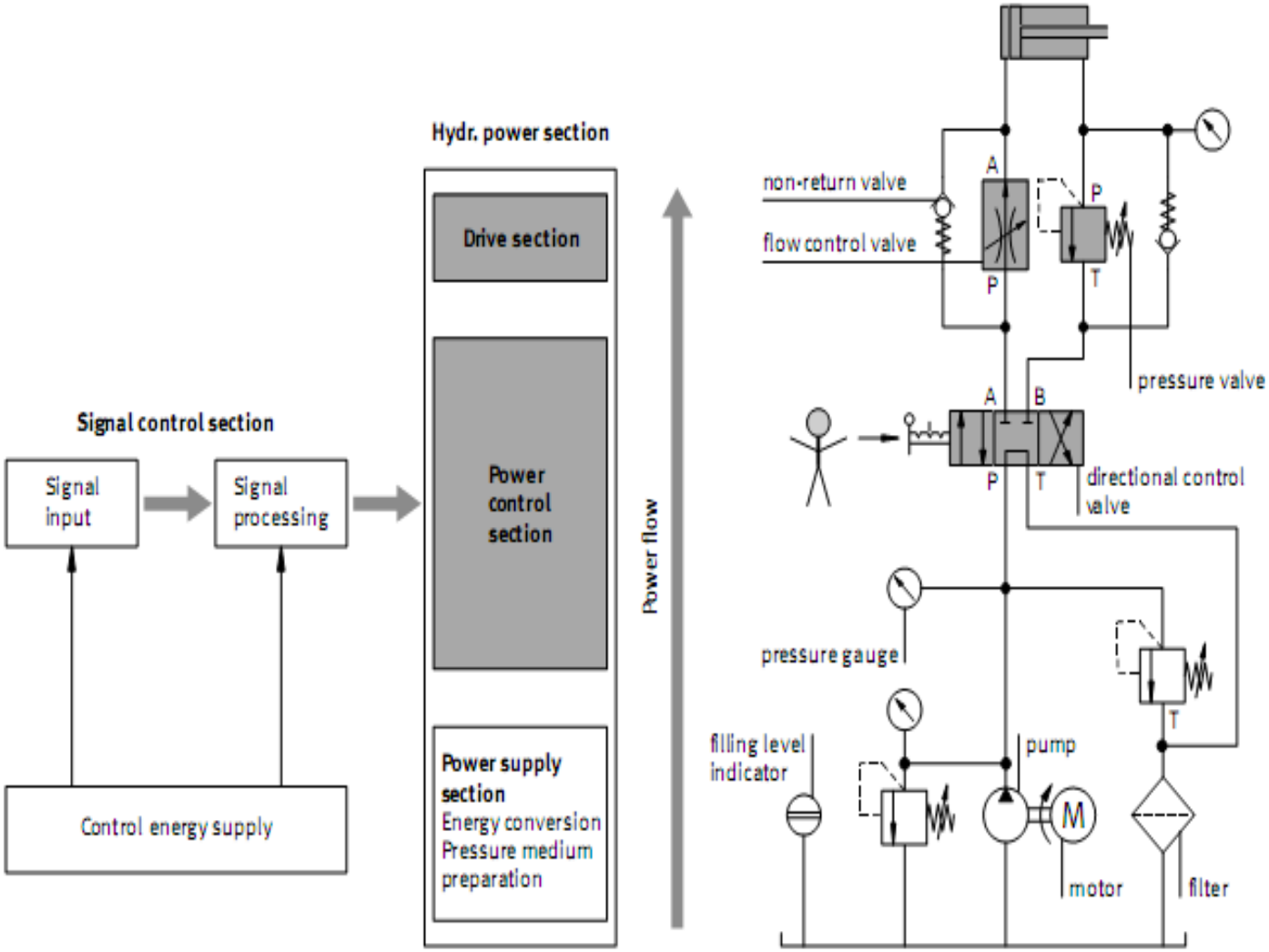
Calculation of input and output power



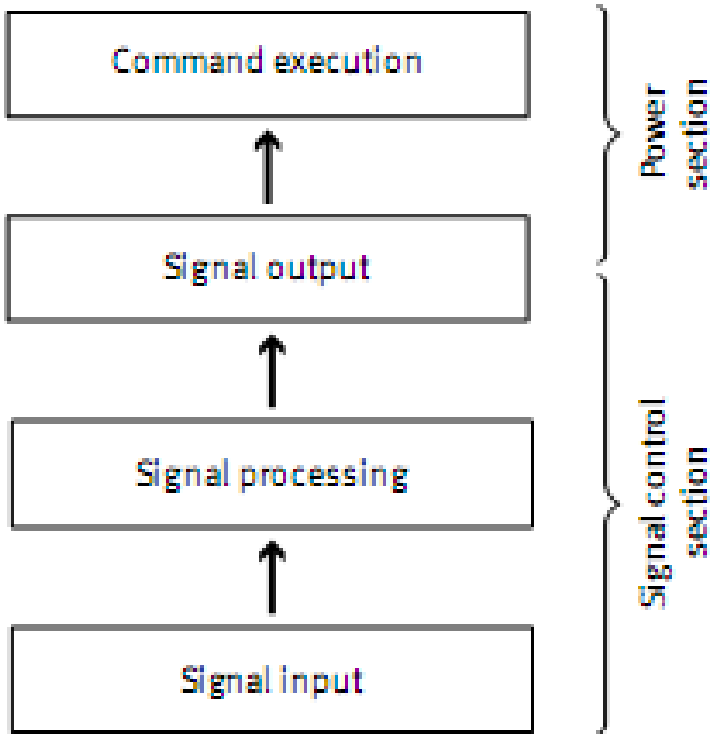
Diagrammatic representation of the structure of a hydraulic system



Hydraulic system and its components name

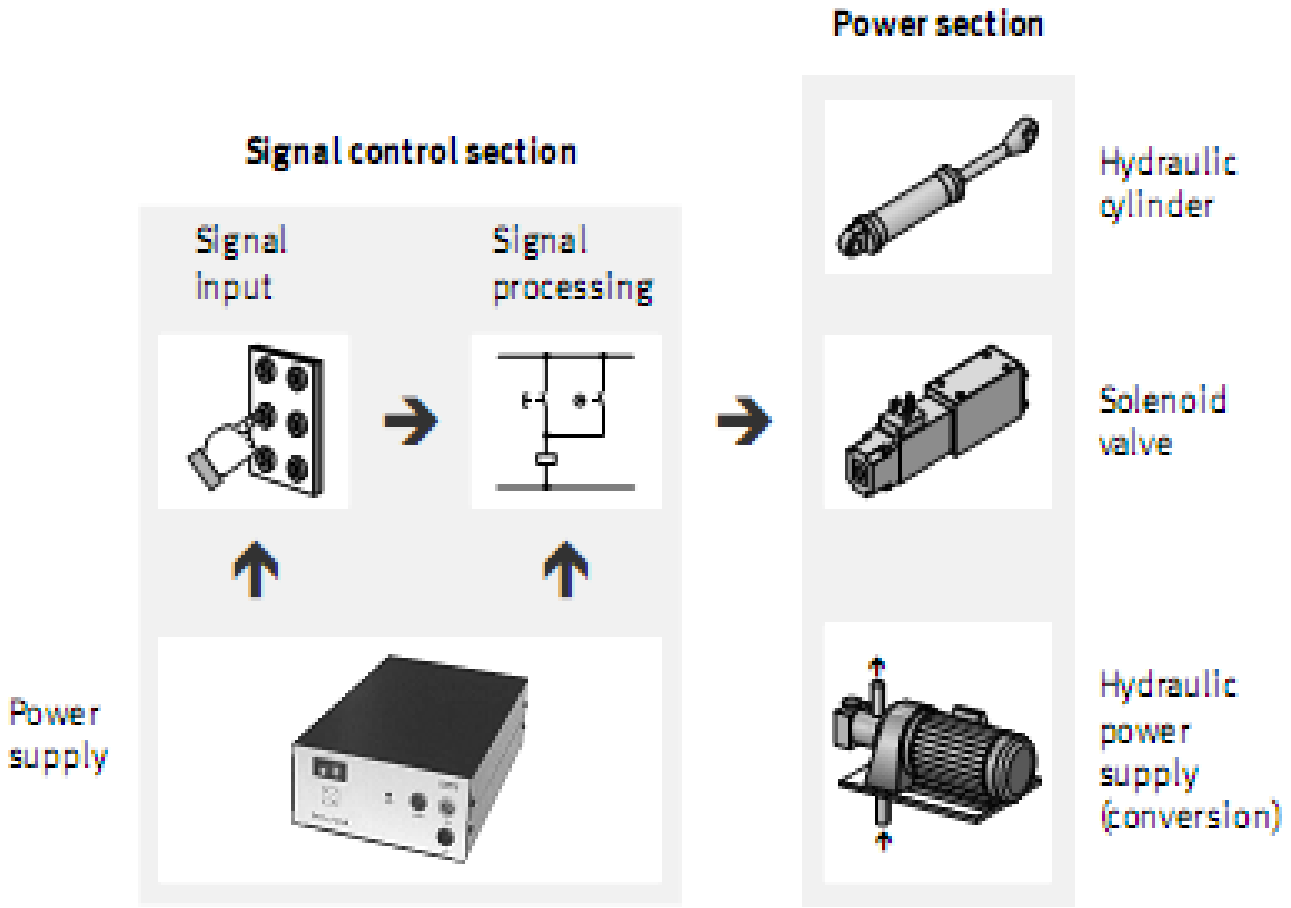


Signal Flow in Control System

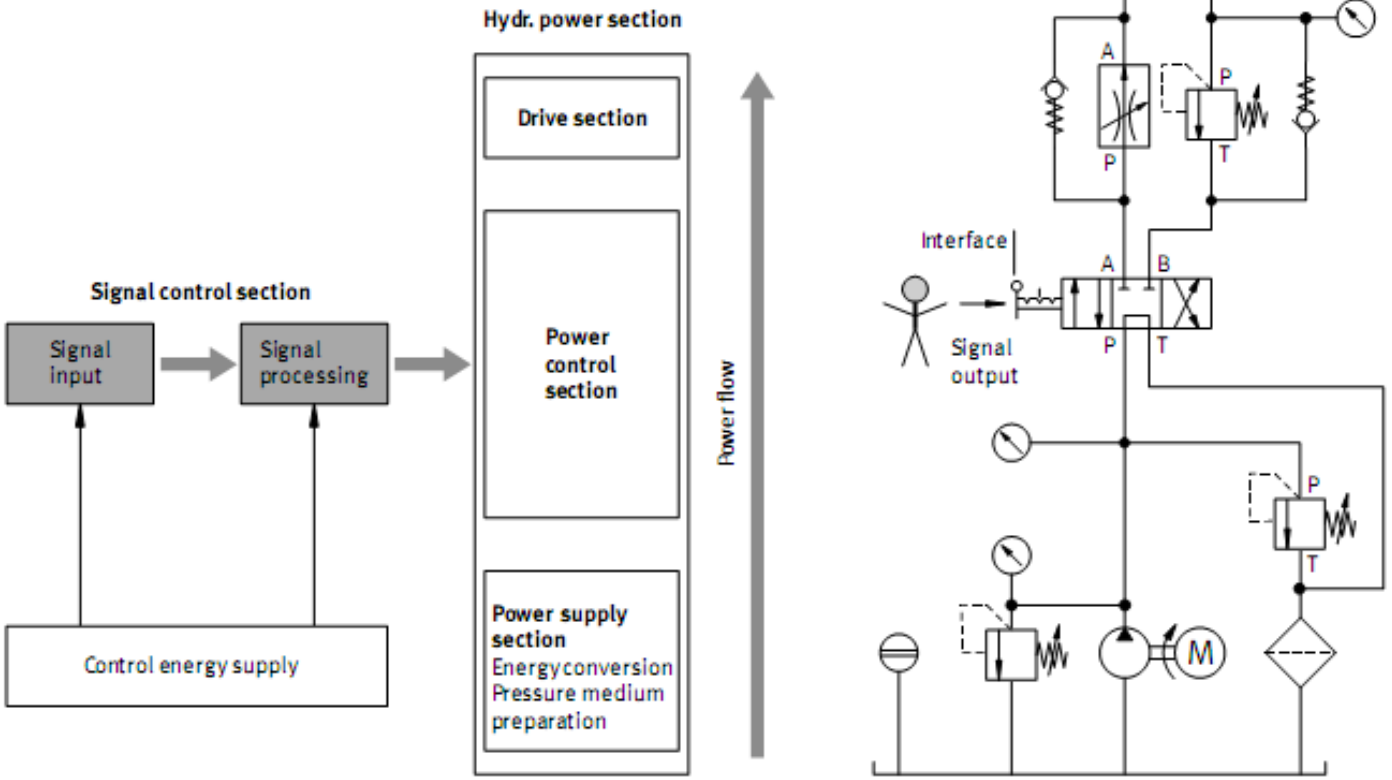


- **Controller can be divided into signal input, signal processing, signal output and command execution**
- **The mutual influence can be shown using signal flow diagram**

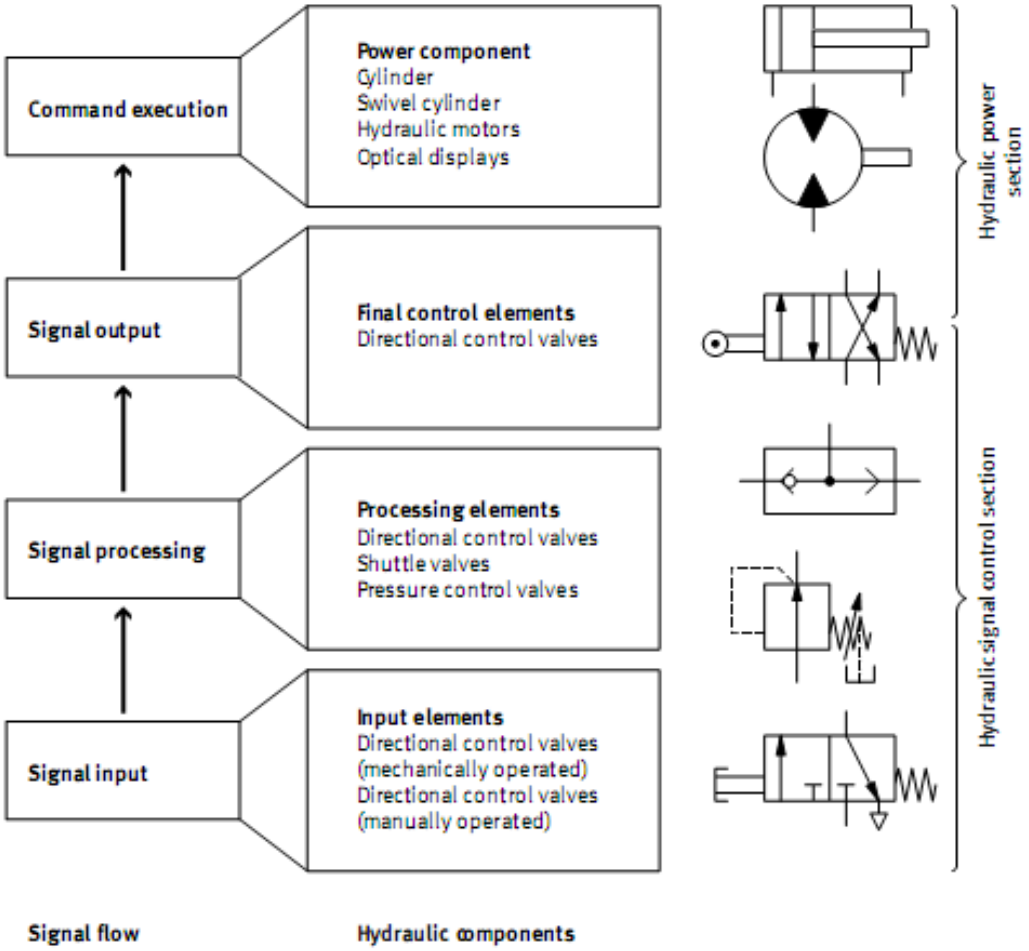
Schematic layout of an electro-hydraulic installation



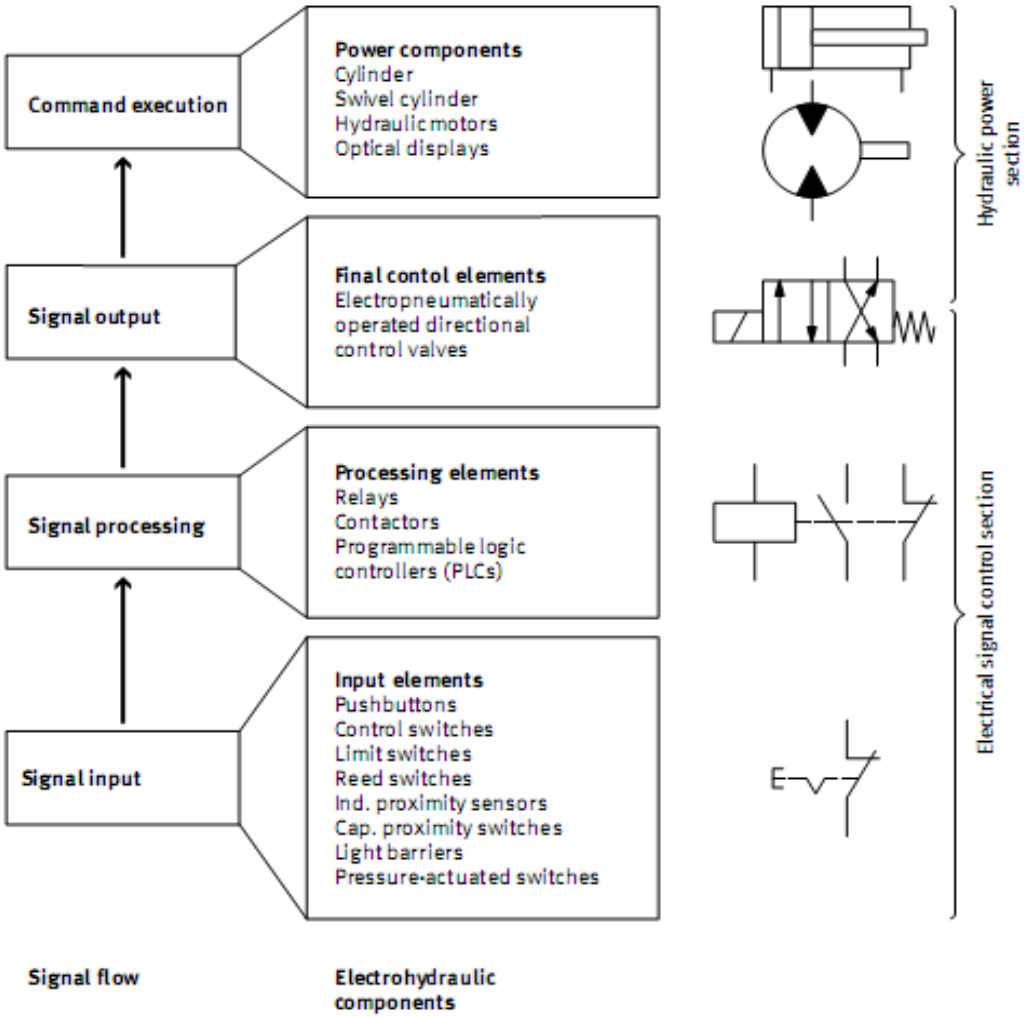
Hydraulic systems and its control system



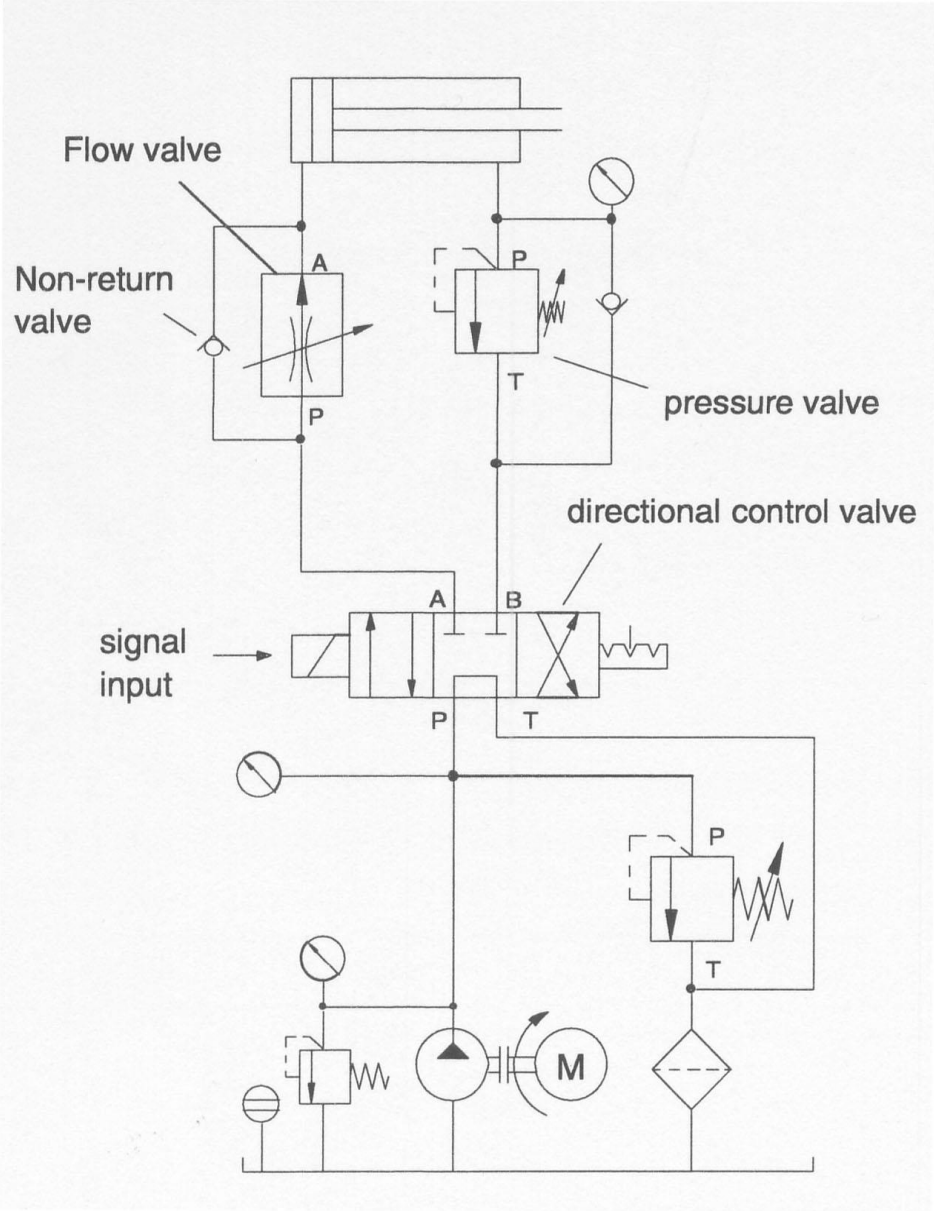
Signal flow and components of a hydraulic control system



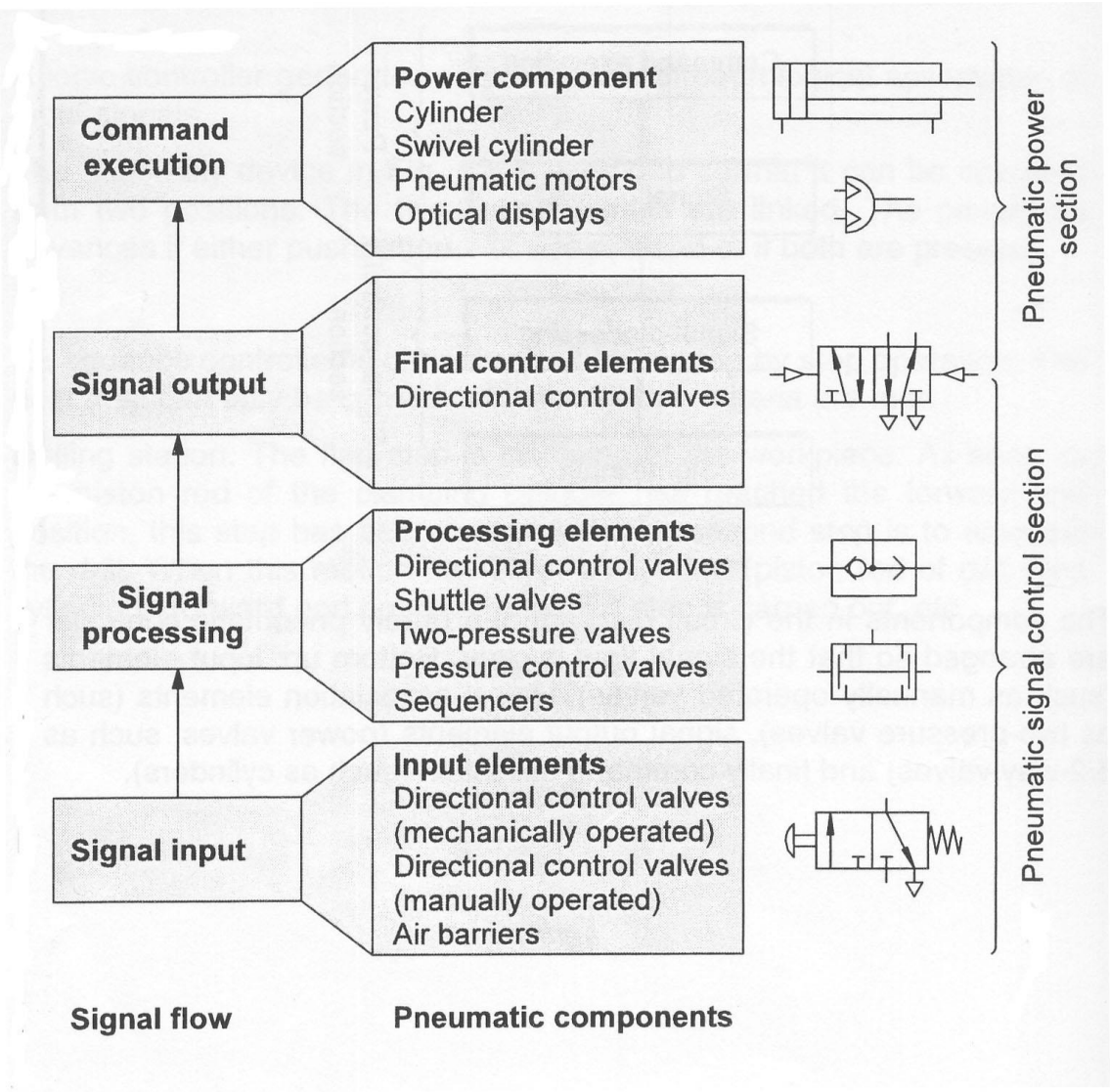
Signal flow and components of an electro-hydraulic control system



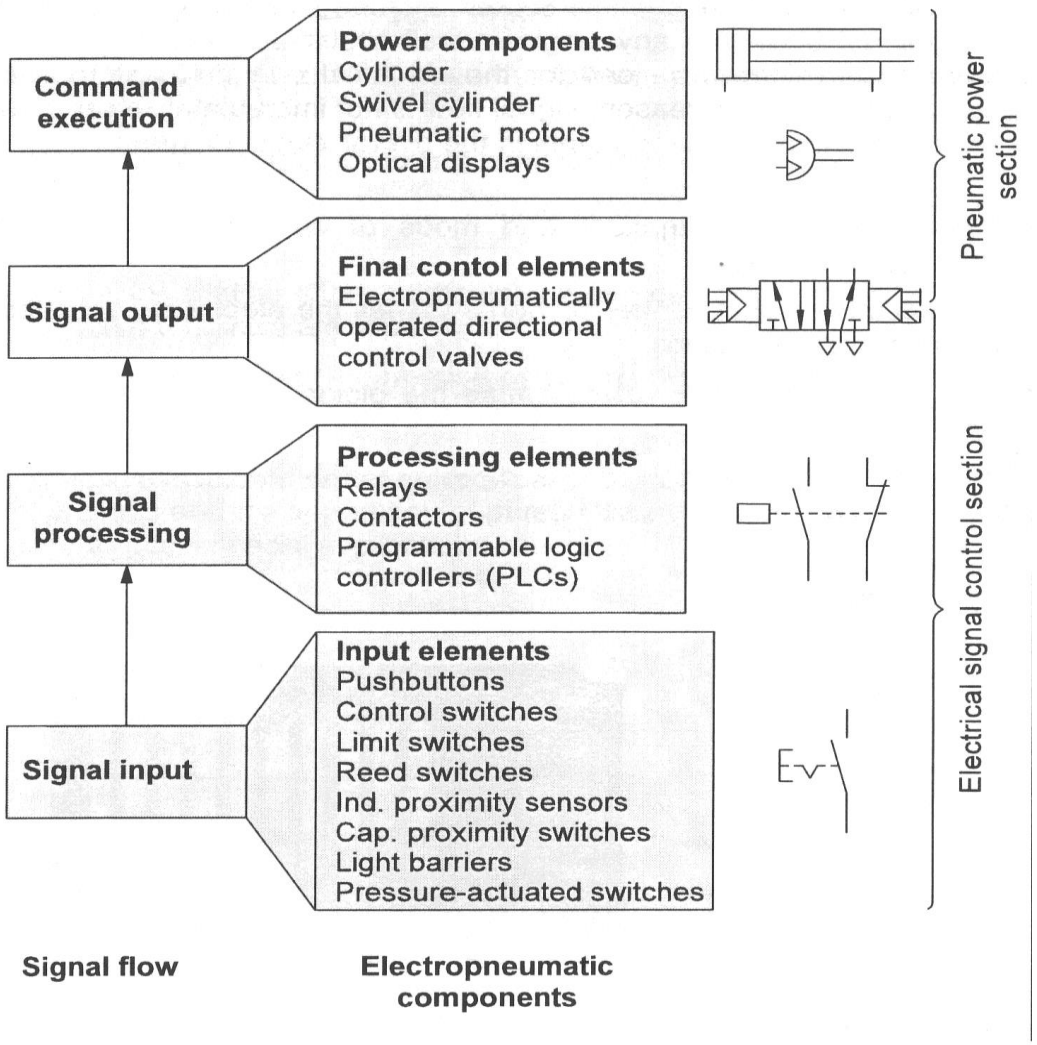
Electro-hydraulics System



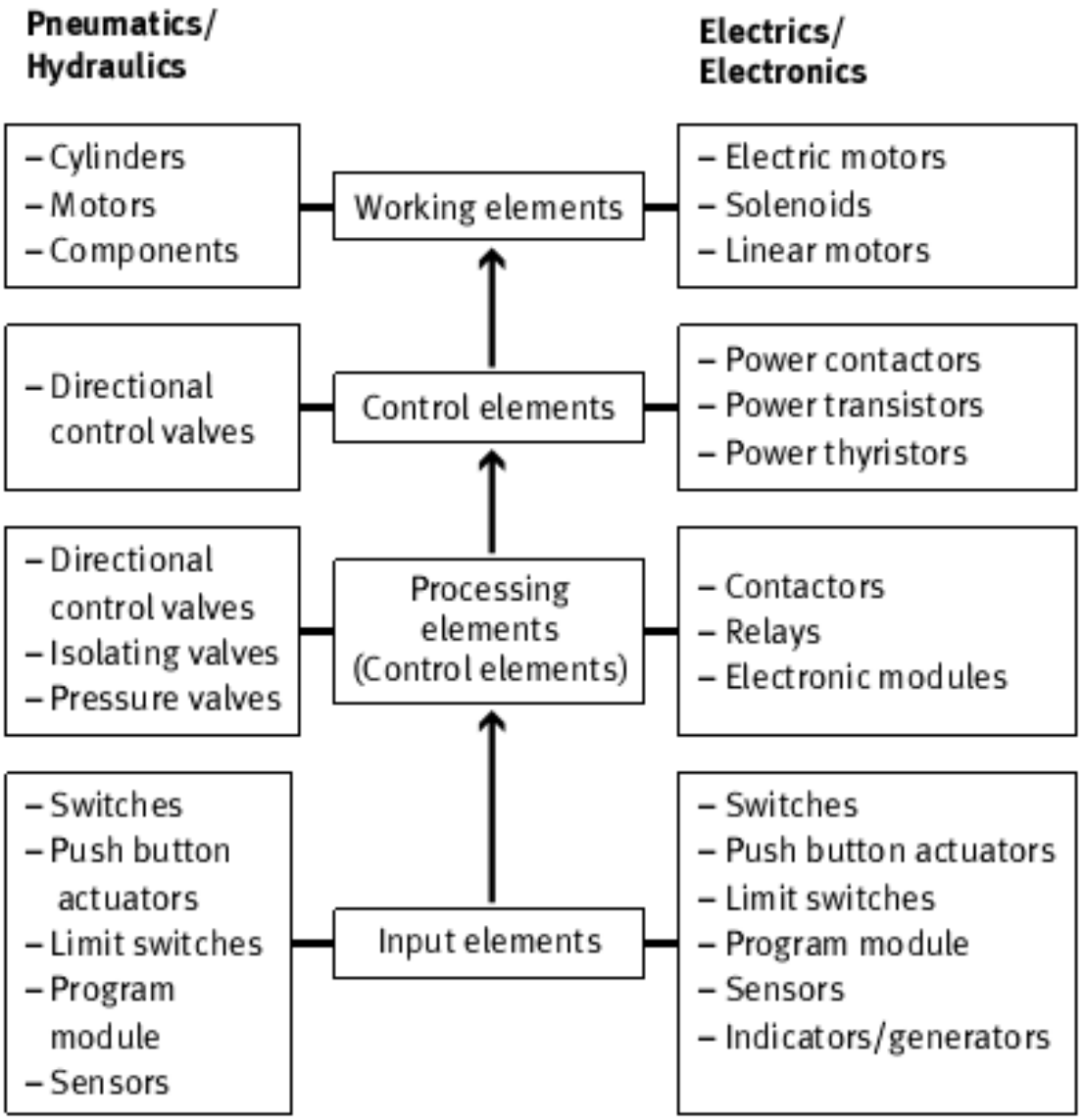
Signal flow and components of a pneumatic control system



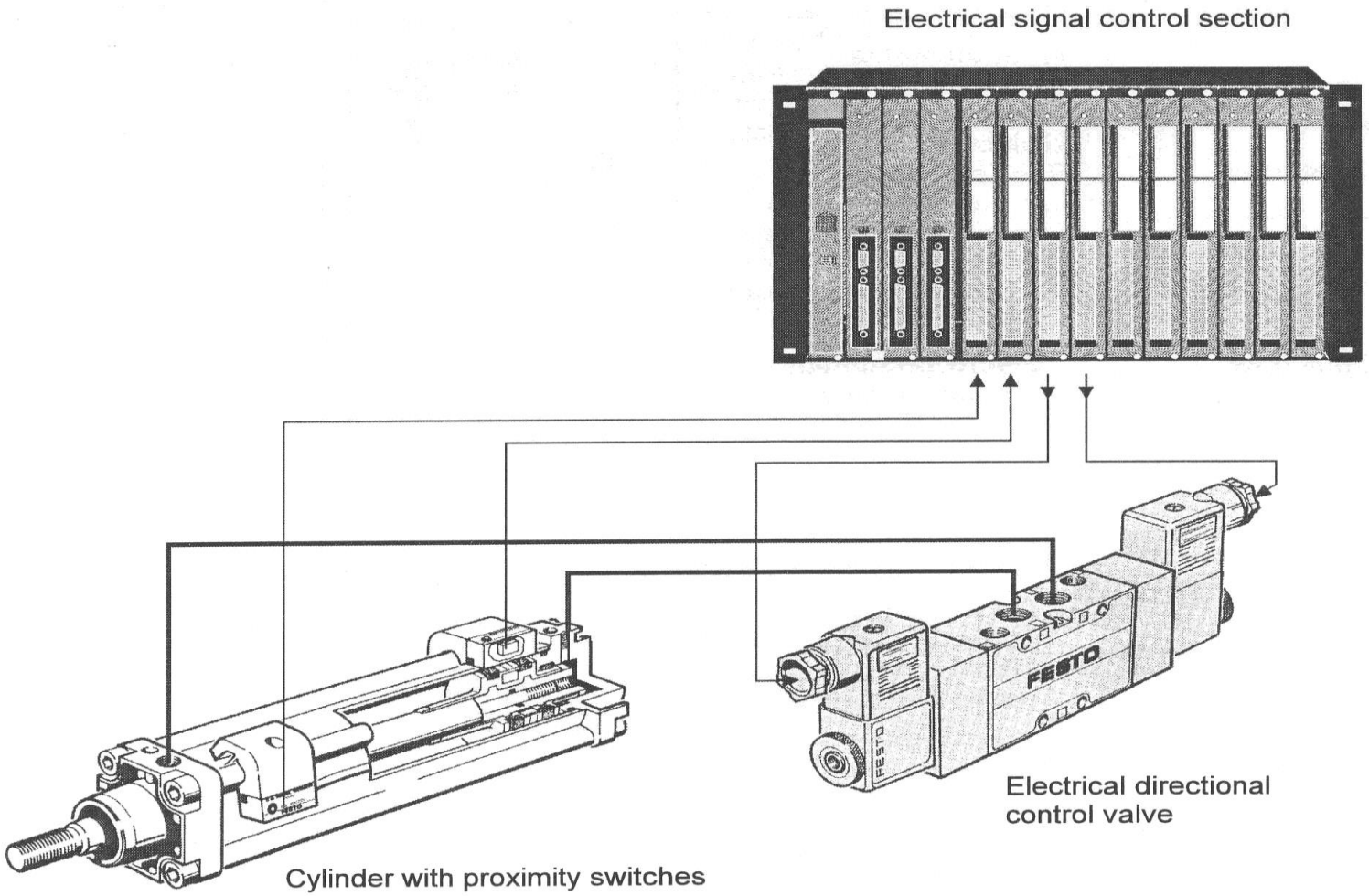
Signal flow and components of an electro-pneumatic control system



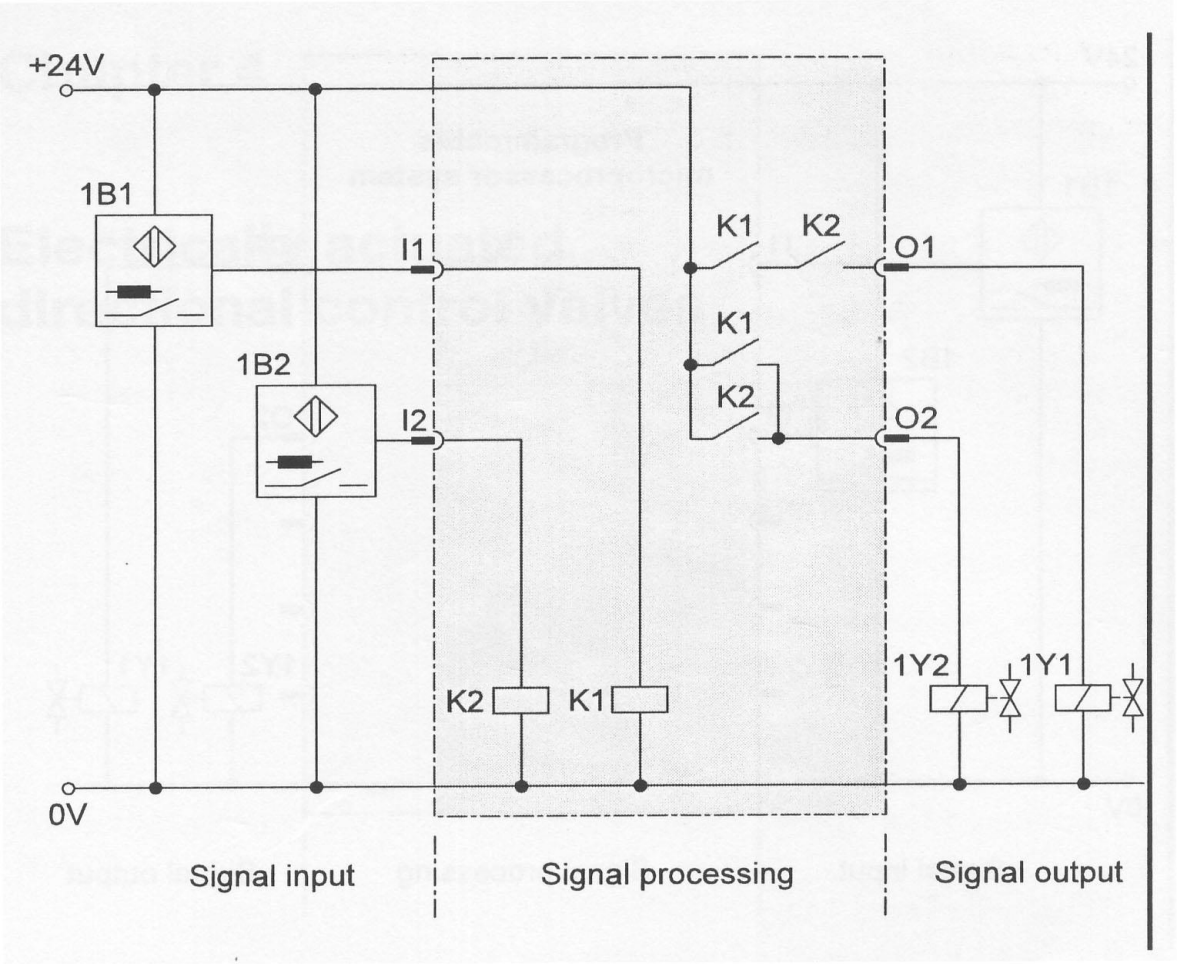
Elements of Control Chain



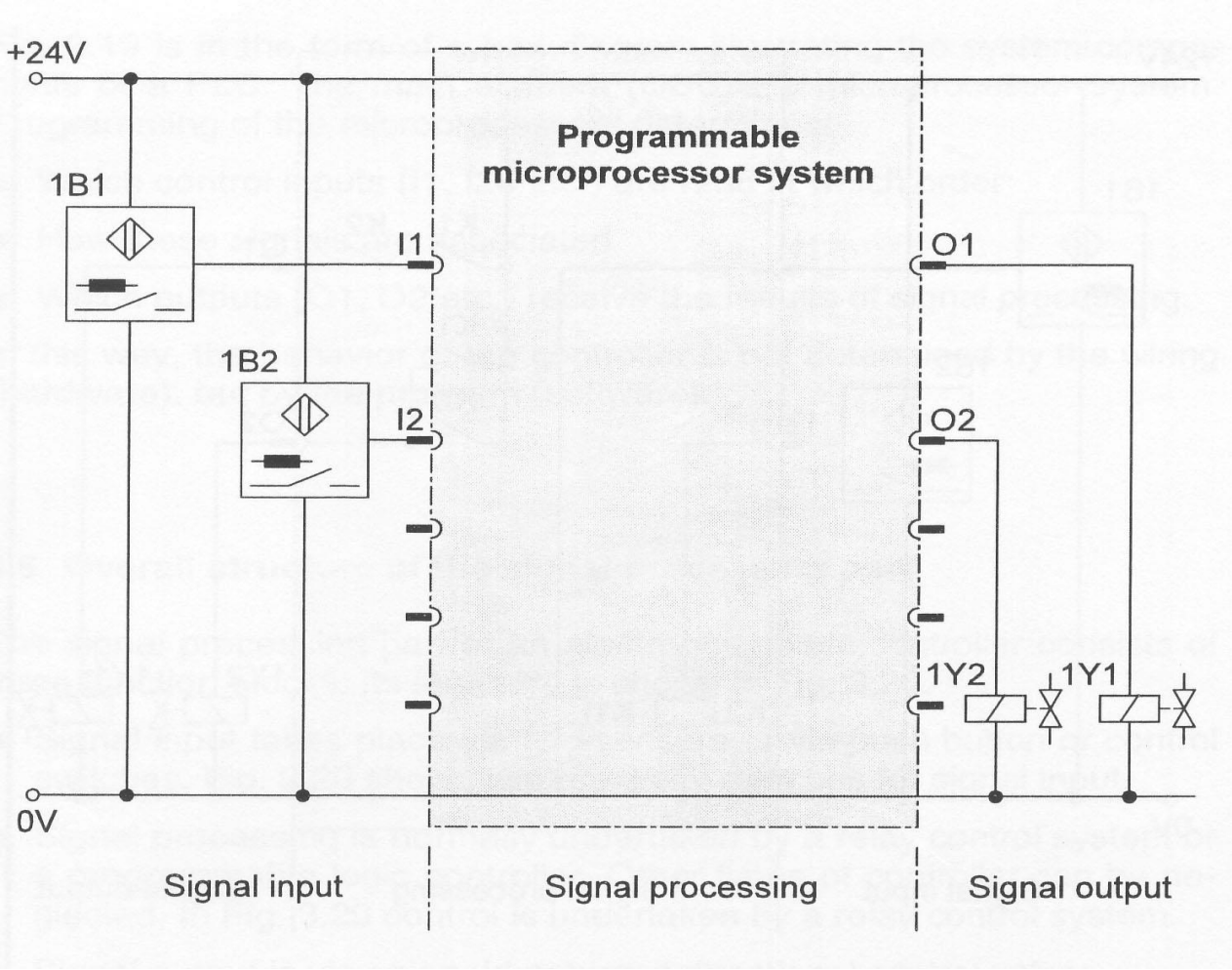
Structure of an electro-pneumatic controller



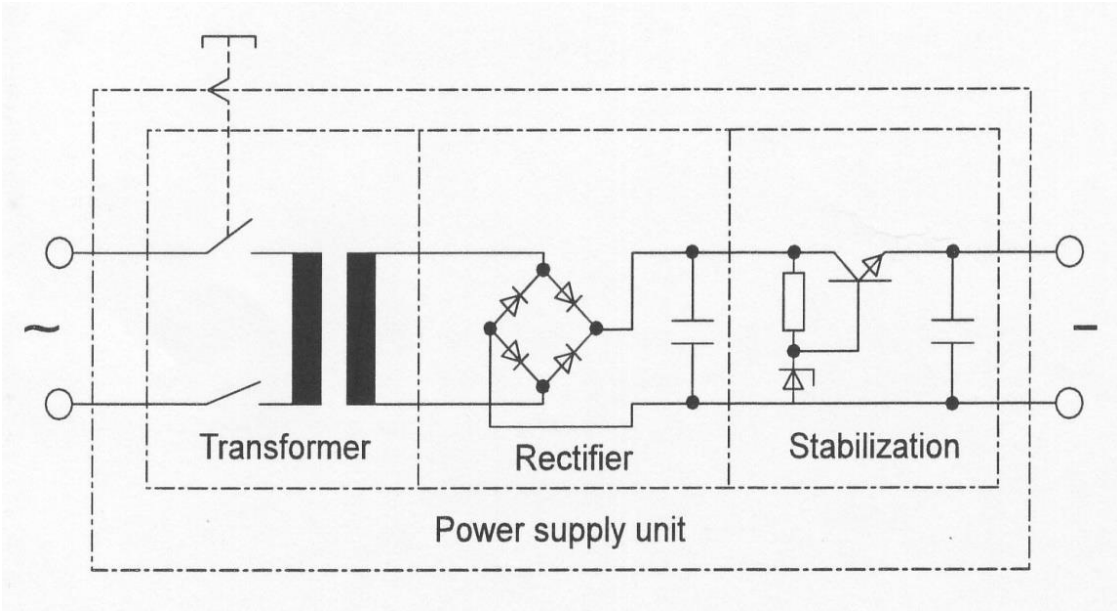
Signal control section of relay control system



Signal control section with PLC



Power supply



- Connection to mains supply
- Supplies signal control section with specified or maximum voltage and current values includes.
  - Voltage transformation
  - Rectification
  - Stabilization
  - Fuse protection
- In mobile hydraulic systems, rechargeable battery systems or generators are used as a power supply for the signal control section.

Switching Contacts and Types of Actuation

The following switch contact designs are used as input and processing elements:

- Normally-open contact
- Normally-closed contact
- Changeover contact

Types of actuation for switching elements are:

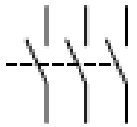
- Manual
- Mechanical
- Relay
- Magnet field

Normally-open contacts

Normally-closed contacts

Changeover switch

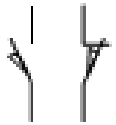
Mechanically connected contacts



Push-button with normally open contacts manually actuated by pushing

Rotary switch with normally open contacts manually actuated by turning

Limit switch with normally open or normally closed contacts, mechanically actuated



Types of Actuation of Switching Elements

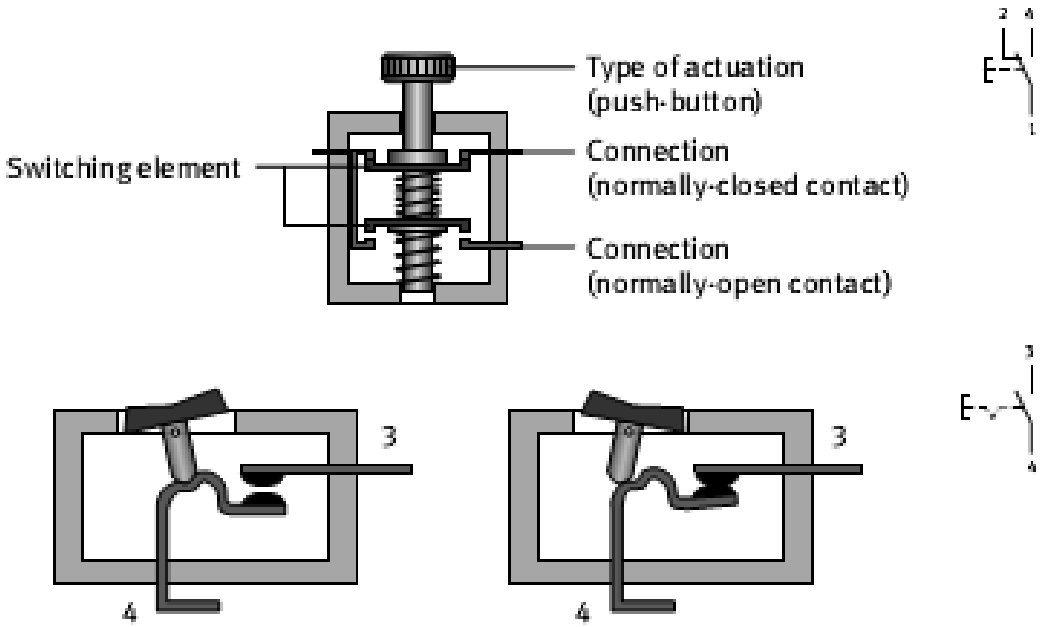
Frequently used types of actuation are

- Pushbuttons
- Roller levers
- Roller lever with idle return

Two types of actuation are shown

- Pushbutton, as changeover switch
- Latching rocker switch, as normally-open contact

Identifying letters in electrical circuit diagrams: S (S1, S2, ...)



Switching Symbols for Solenoid Coils and Relays

In electropneumatics, the solenoid coil is the element that switches the valves.

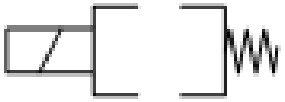
Identifying letters in electrical circuit diagrams: Y (Y1, Y2, ...)

A relay switches 1, 2 or more contacts. The relay can also be a time or temperature-controlled element.

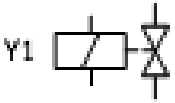
Identifying letters in electrical circuit diagrams: K (K1, K2, ...)

Electro-magnetically actuated on both sides

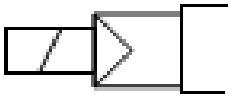
Electro-magnetically actuated on one side, with spring return



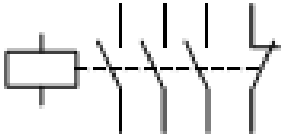
Representation in electrical circuit diagrams

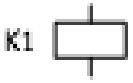


Electro-magnetically actuated, with pilot control

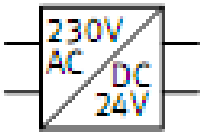


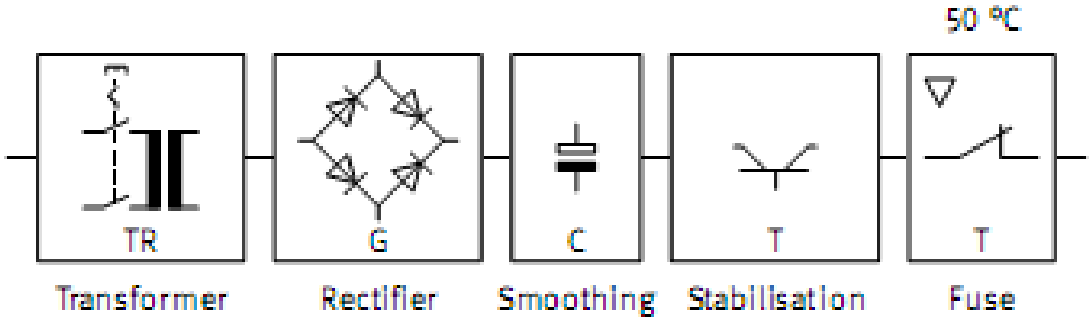
Contactor or relay with 3 normally open contacts and 1 normally closed contact





Electrical power supply unit





Sensor

Have the task of measuring information and passing this on to the signal processing part

Fungsi dari sensor :

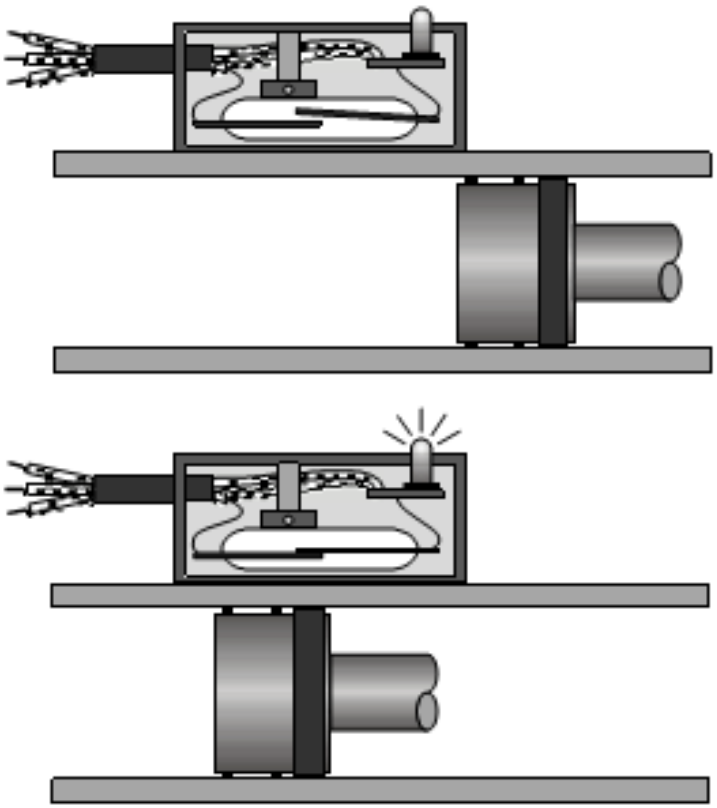
1. Detect the advanced and retracted end position of the piston rod in cylinder drives
2. Detect keberadaan dan posisi benda
3. Measure and monitor pressure

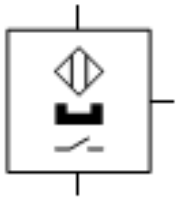
Jenis – Jenis Sensor

1. Limit Switch (Mechanically Actuated)
2. Proximity Switch (Non-contact switching) or contactless switch
   - Reed switch
   - Inductive proximity switch
   - Capacitive proximity switch
   - Optical proximity switch
3. Pressure Sensor

Reed Switch

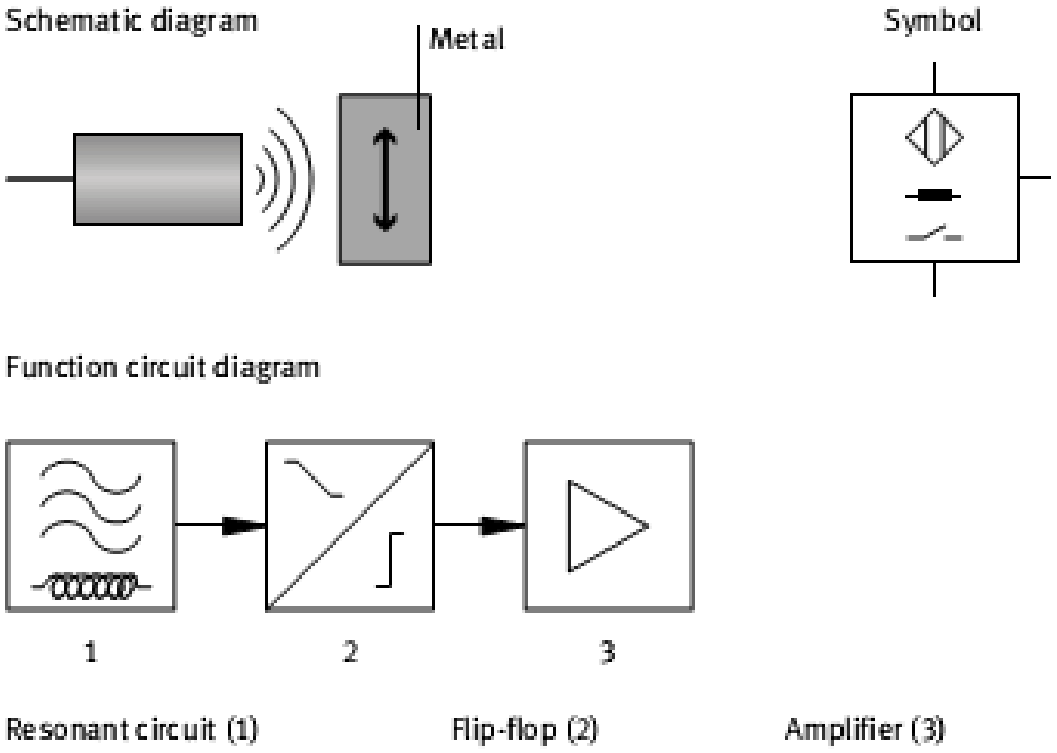
Reed switches are magnetically-actuated proximity sensors. They consist of two contact blades in a small glass tube filled with protective gas. The action of a magnet causes the contact between the two blades to close so that an electrical current can flow





Inductive proximity switch

Inductive proximity sensors consist of an electrical resonant circuit (1), a flip-flop (2) and an amplifier (3). When voltage is applied to the connections, the resonant circuit generates a (high-frequency) magnetic alternating field that escapes from the front side of the sensor. Inductive proximity sensors can be used to detect all materials with good electrical conductivity, for example graphite as well as metals.

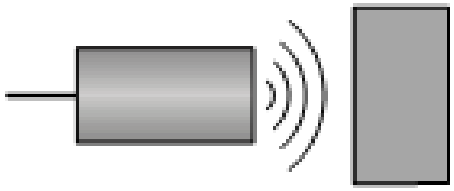


Capacitive proximity switch

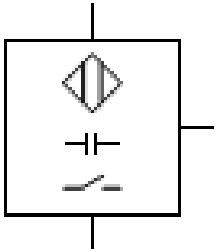
Capacitive proximity sensors not only respond to materials with a high electrical conductivity (e.g. metals),

but also to all insulators with a high dielectric constant (e.g. plastics, glass, ceramic, liquids and wood).

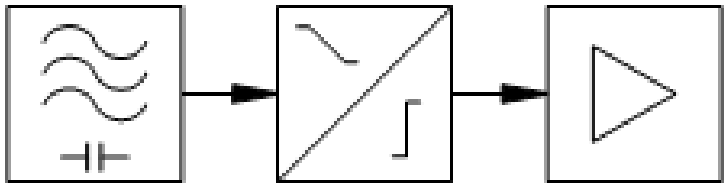
Schematic diagram



Symbol



Function circuit diagram



Resonant circuit (1) Flip-flop (2) Amplifier (3)

Optical Proximity Switch

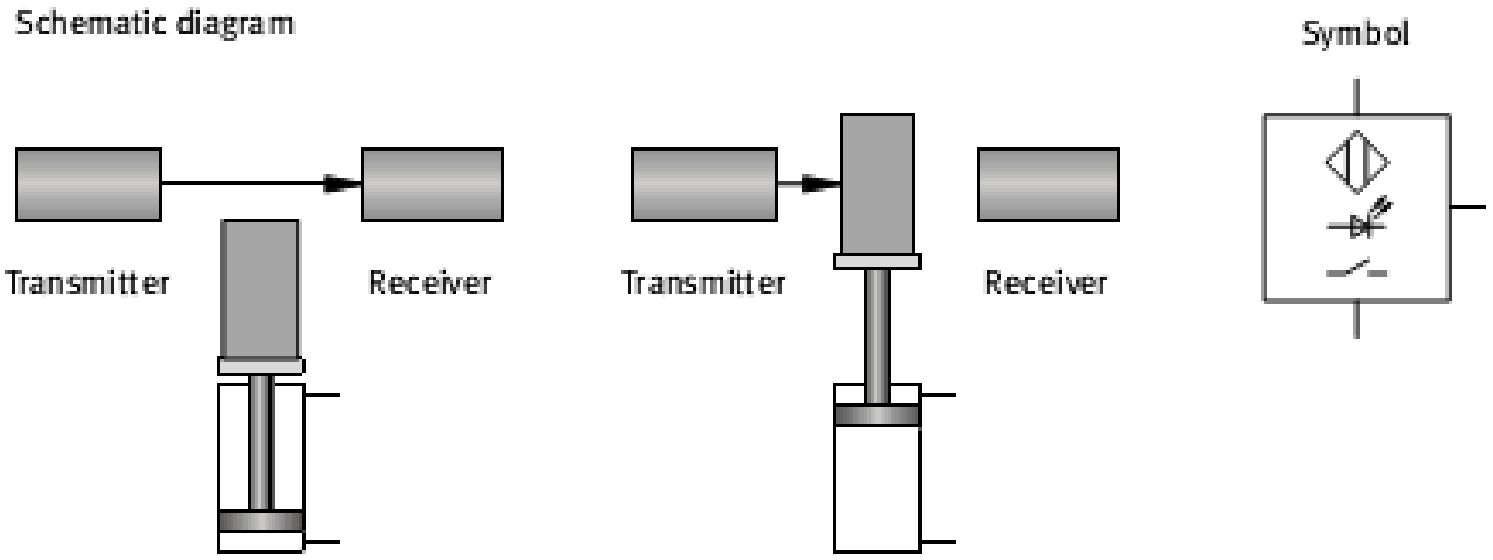
Optical proximity sensors always have a transmitter and a receiver. They use optical (red or infrared light) and electronic components and modules to detect an object located between the transmitter and receiver

A distinction is made between three types of optical proximity sensor:

- through-beam sensors,
- retro-reflective sensors,
- diffuse sensors.

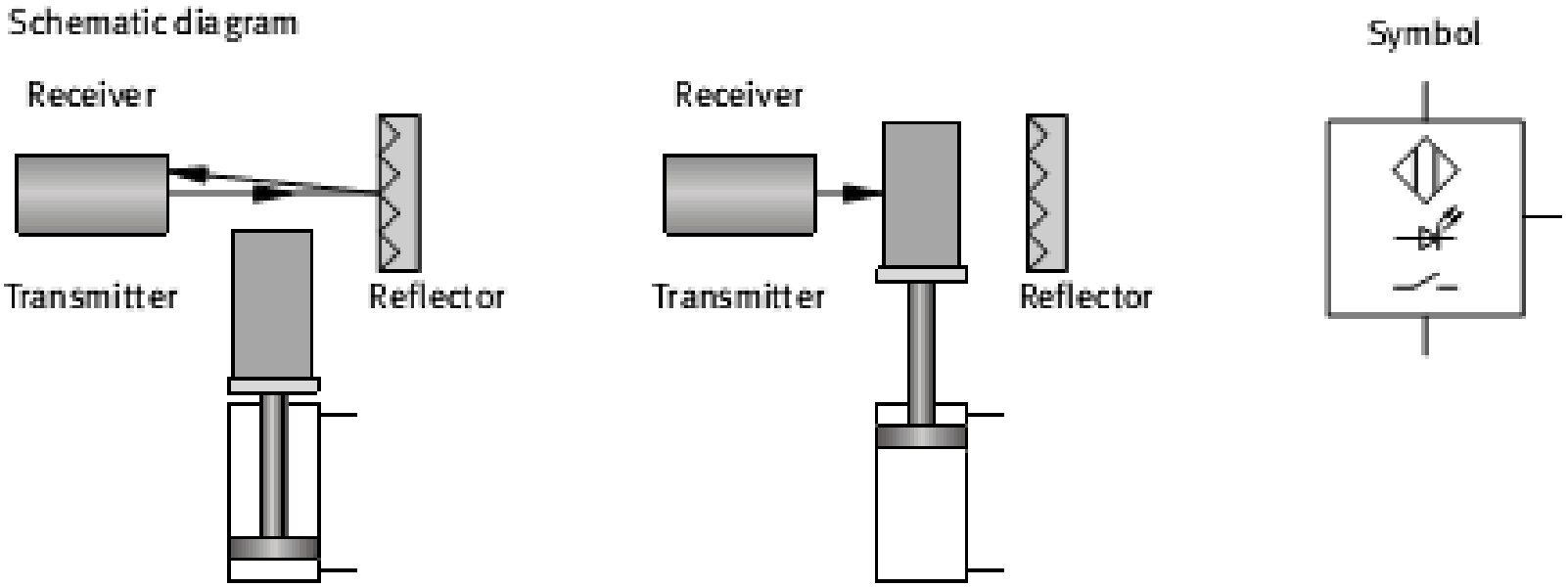
Through-Beam Sensors

If an object, workpiece or even a person enters the path between the transmitter and receiver, the light beam is interrupted and a signal is triggered that initiates a switching operation at the output (ON/OFF).



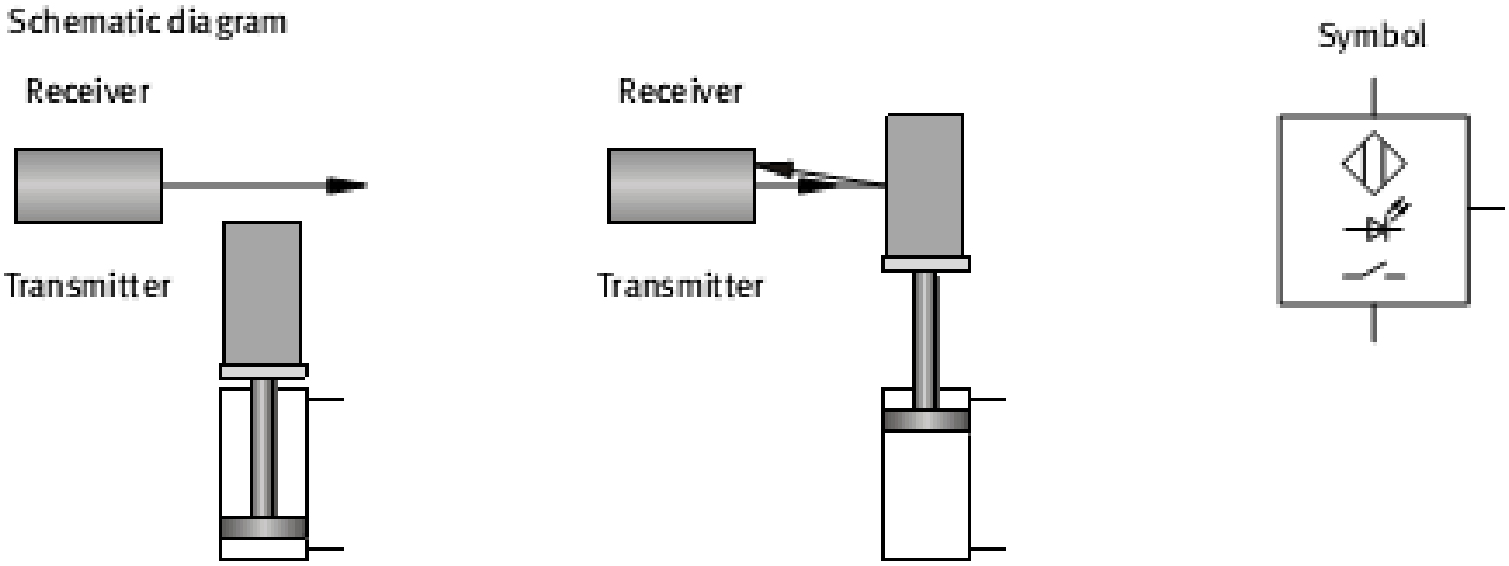
Retro-Reflective Sensor

If an object, workpiece or even a person enters the path between the transmitter and reflector, the light beam is interrupted and a signal triggered that initiates a switching operation at the output (ON/OFF).



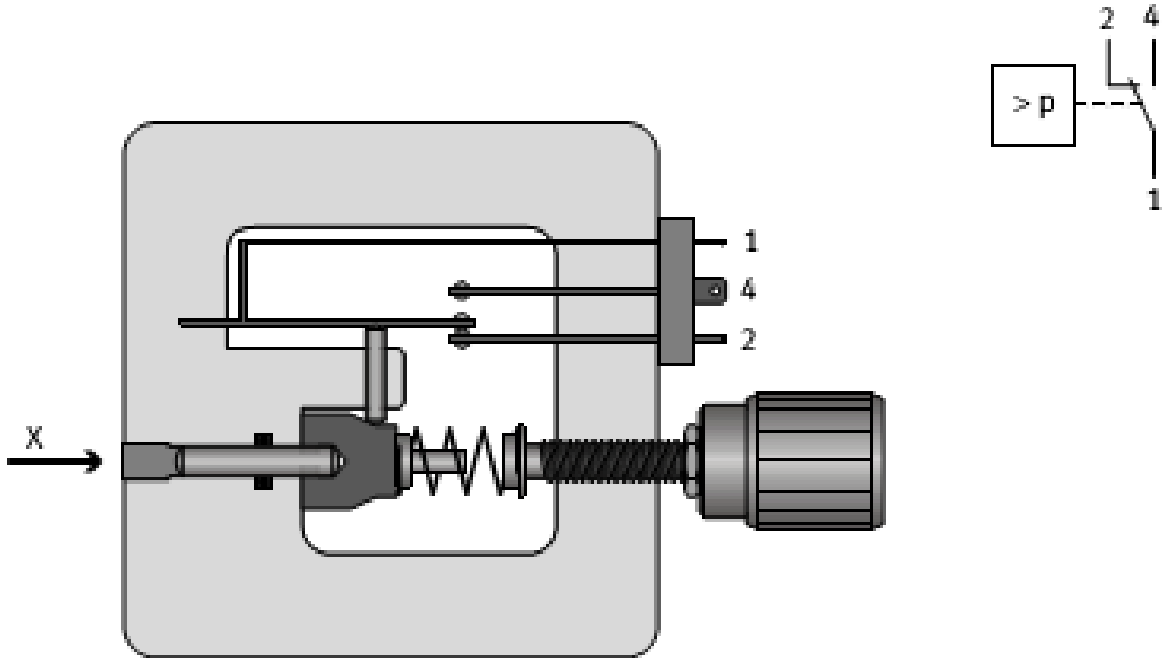
Diffuse Sensors

This operational principle means diffuse sensors can only be used if the workpiece or machine part to be detected is highly reflective (e.g. metallic surfaces, light colours)



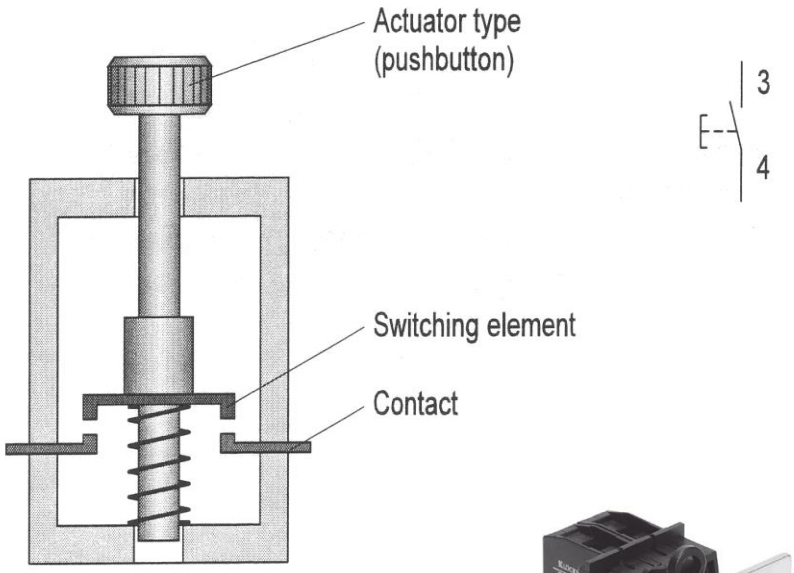
Pressure Sensor

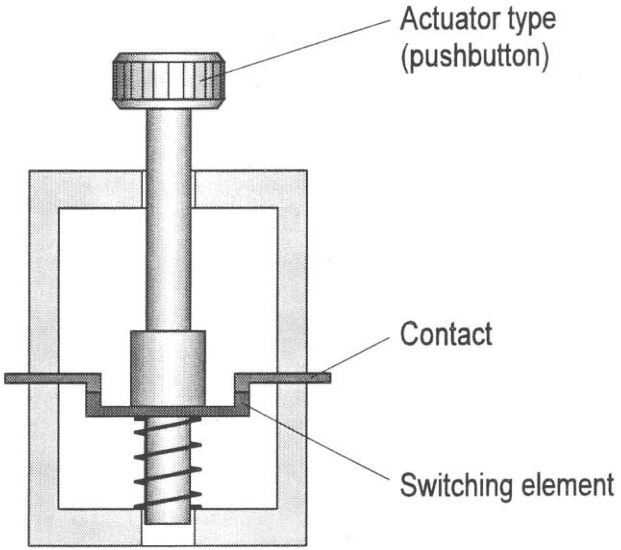
In a mechanical pressure switch, the pressure acts on a piston area. If the force exerted by the pressure exceeds the spring force, the piston moves and actuates the contacts of the switching elements

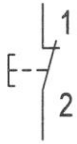


Push Button Switch (Manually – Actuated)

- **Normally open contact**
- **Normally closed contact**

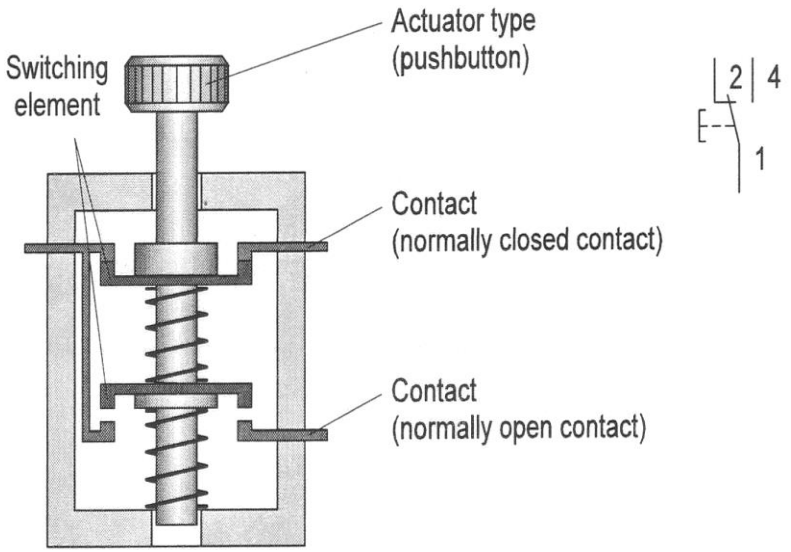


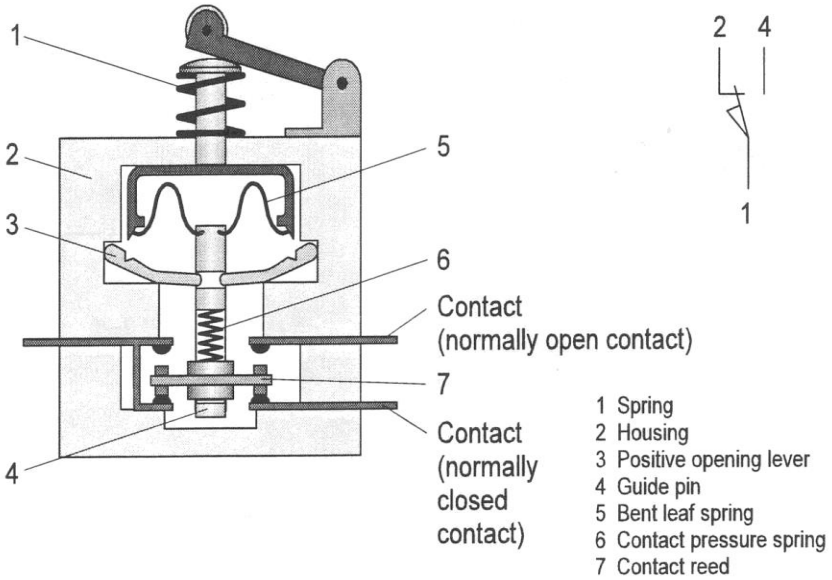




Push button switch and Limit switch (Mechanically – Actuated)

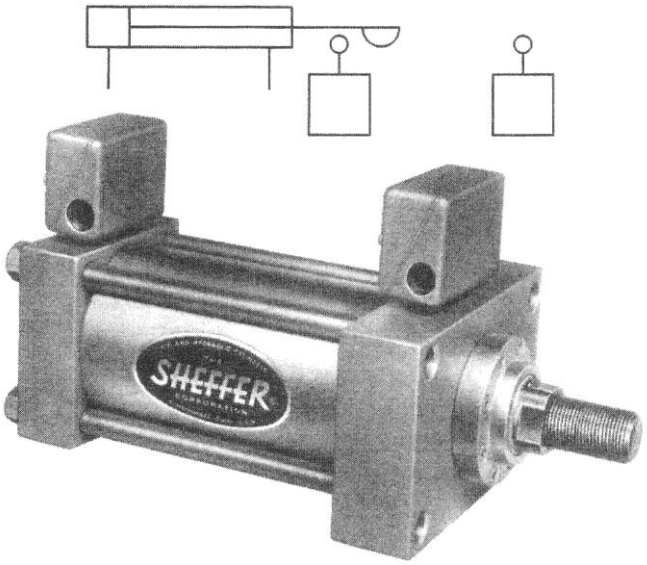
- Changeover contact
- Limit switch



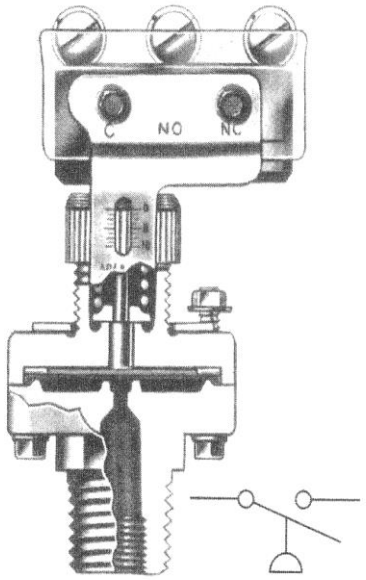


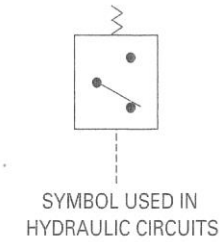
Basic Electrical Devices

- **Limit switch**



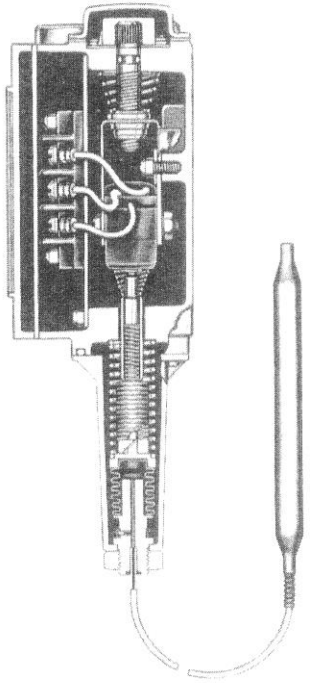
- **Pressure switch**

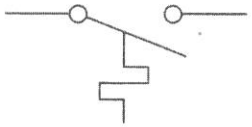




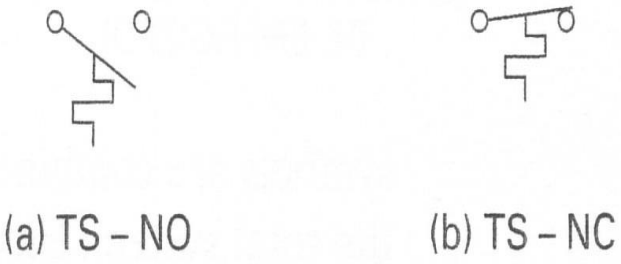
Basic Electrical Devices

- **Temperature switch**



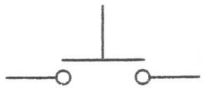


- **Temperatures switch symbol**

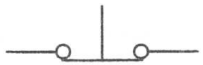


Basic Electrical Devices

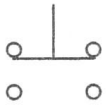
- **Push button symbol**
- **Limit switch symbol**



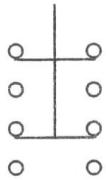
(a) SPST – NO



(b) SPST – NC



(c) DPST – NO/NC



(d) DPDT – NO/NC

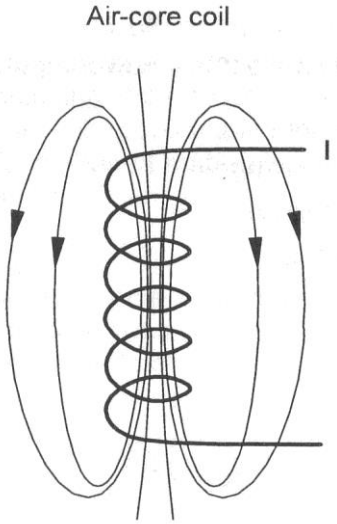
(a) LS – NO

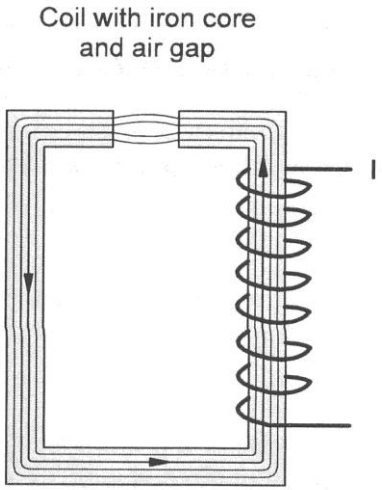
(b) LS – NO (HELD CLOSED)

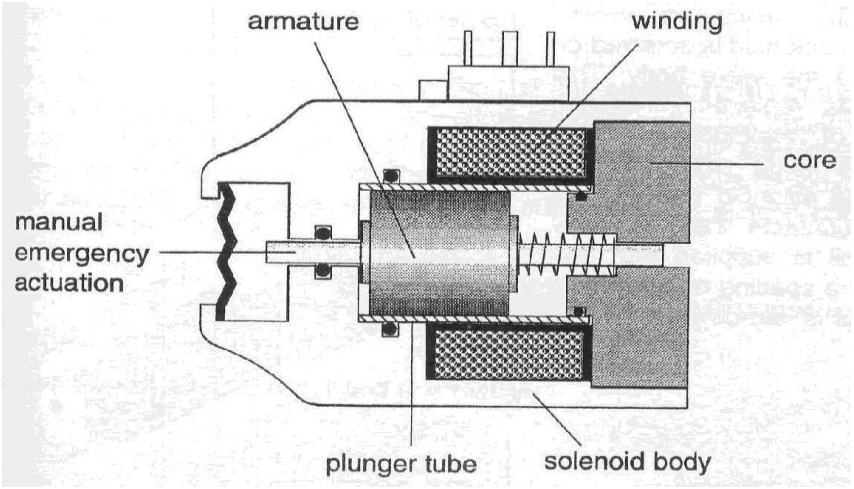
(c) LS – NC

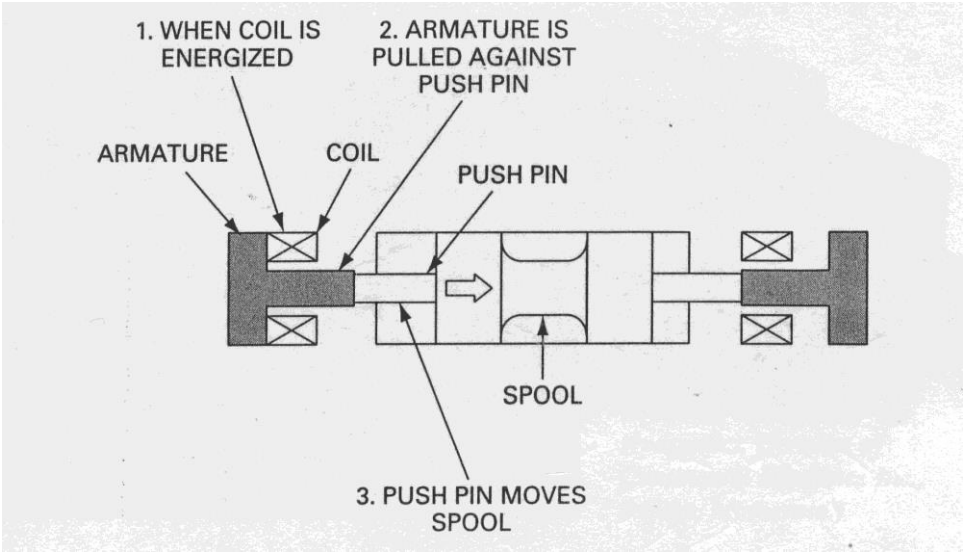
(d) LS – NC (HELD OPEN)

Solenoid


Air-core coil
I


Coil with iron core
and air gap
I

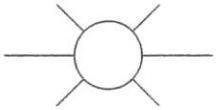

armature
winding
core
manual
emergency
actuation
plunger tube
solenoid body


1. WHEN COIL IS ENERGIZED
2. ARMATURE IS PULLED AGAINST PUSH PIN
ARMATURE
COIL
PUSH PIN
SPOOL
3. PUSH PIN MOVES SPOOL

Basic Electrical Devices

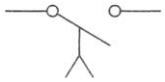
- **Solenoid and lamp indicator symbol**

(a) SOLENOID



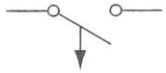
(b) INDICATOR LAMP

- **Timer switch symbol**



(a) NO (TIMED CLOSED WHEN ENERGIZED)

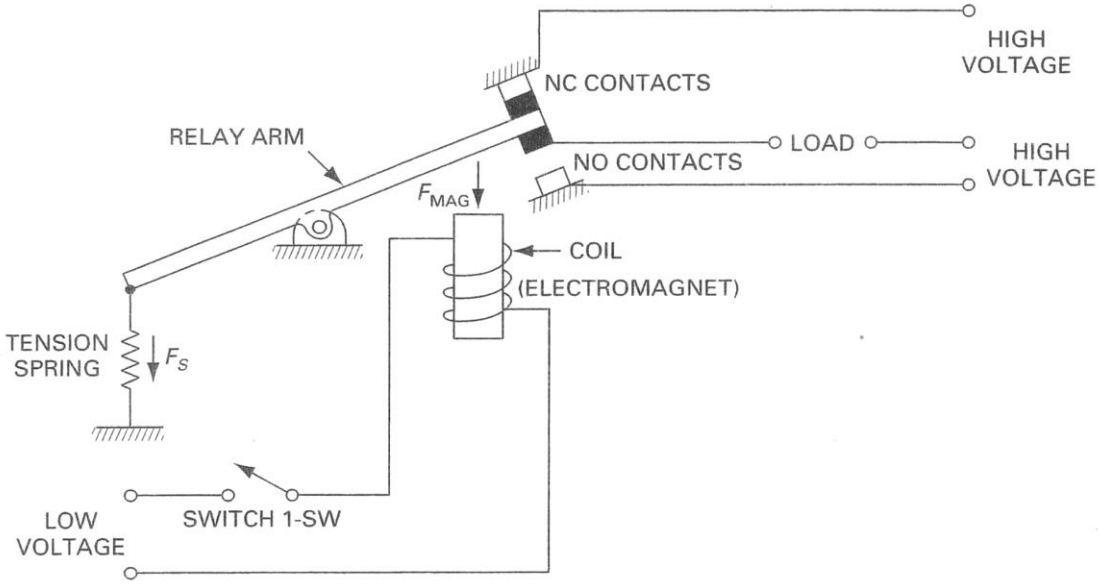
(b) NC (TIMED OPEN WHEN ENERGIZED)



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

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

Relay (Electrically – Actuated) and Its Symbol



(a) SCHEMATIC DRAWING

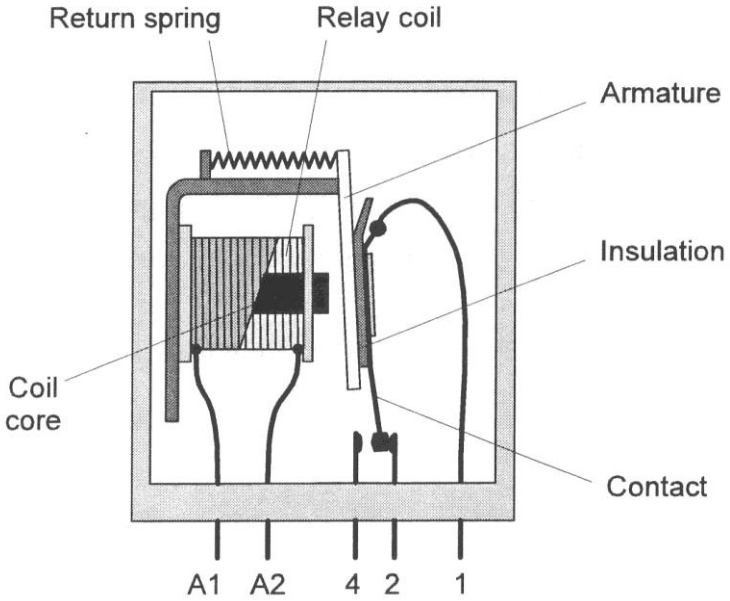
RELAY COIL

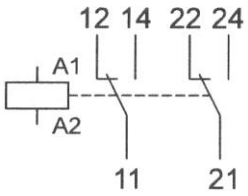
NORMALLY OPEN CONTACTS

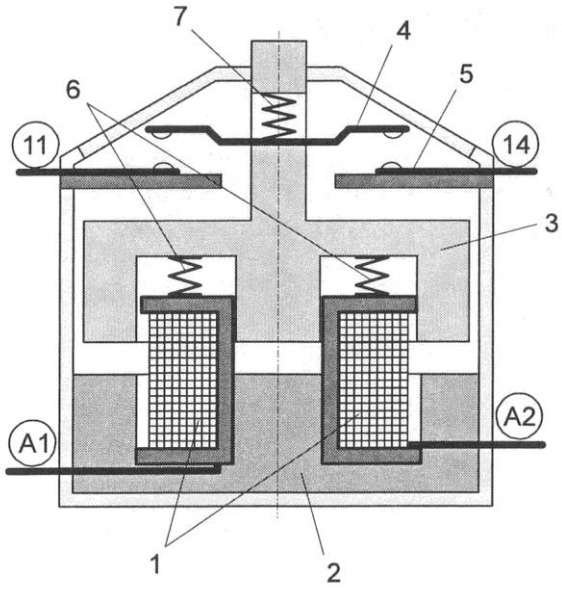
NORMALLY CLOSED CONTACTS

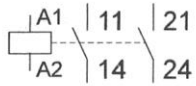
(b) COMPONENT SYMBOLS

Relay dan Contactor









1 Coil
2 Iron core (magnet)
3 Armature
4 Moving switch element with contacts
5 Static switch element with contacts
6 Pressure spring
7 Contact pressure spring

Solenoid Valve

2/2-Way Solenoid Valve without Pilot Control

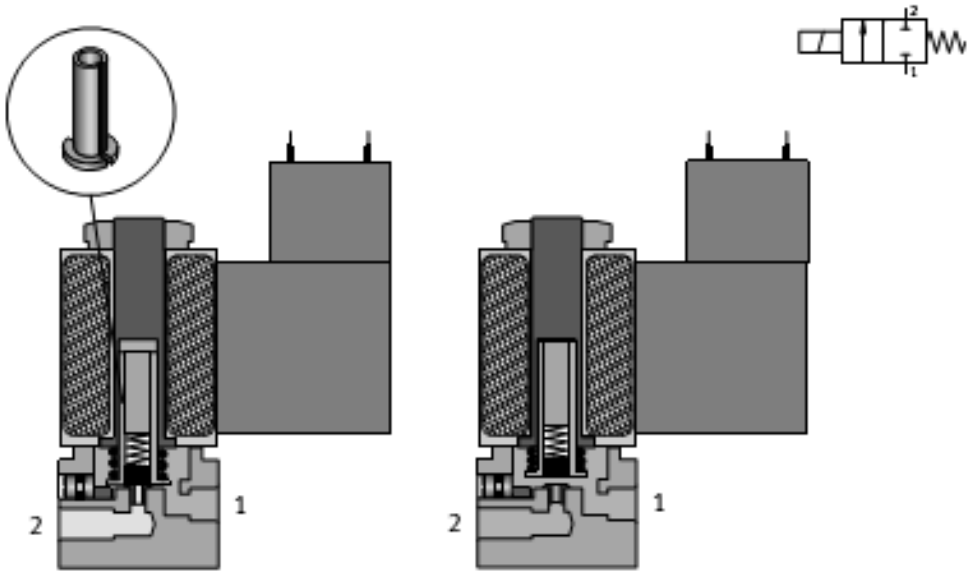
Normally-closed position, spring return

Solenoid coil deenergized

- Port 1 is blocked.
- Port 2 is blocked.
- Exhausting is not possible.

Solenoid coil energized

- The armature is raised.
- Compressed air flows from port 1 to port 2.



Solenoid Valve with Pilot Control

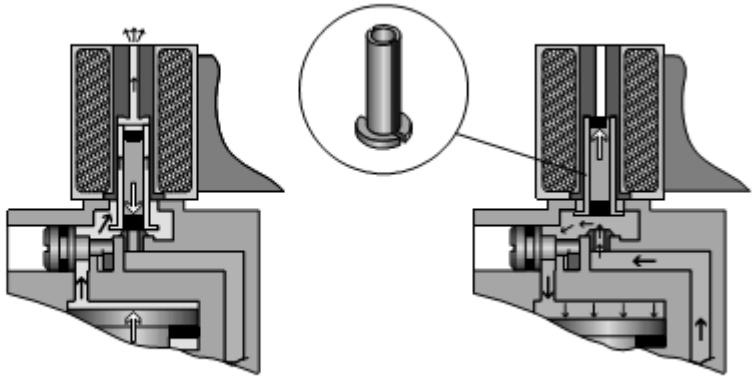
An electrical signal is applied to the solenoid coil

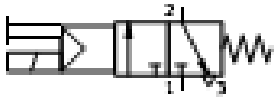
↓

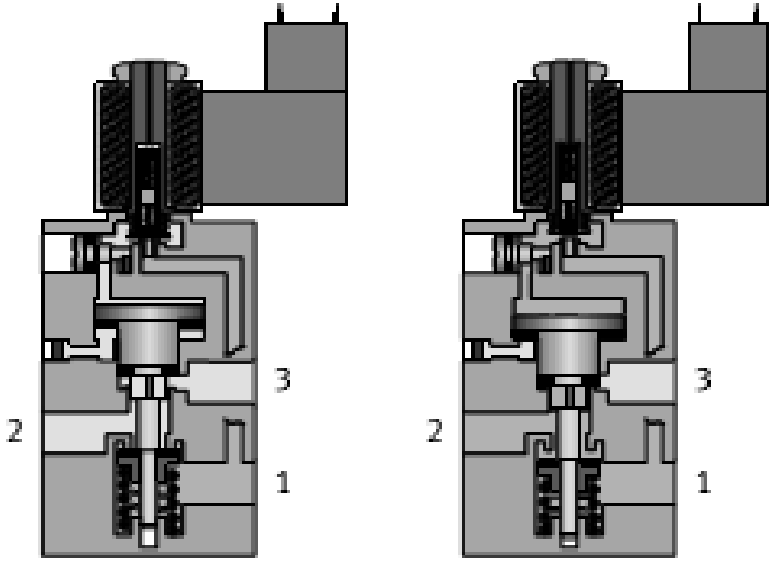
The solenoid coil actuates the pilot control valve

↓

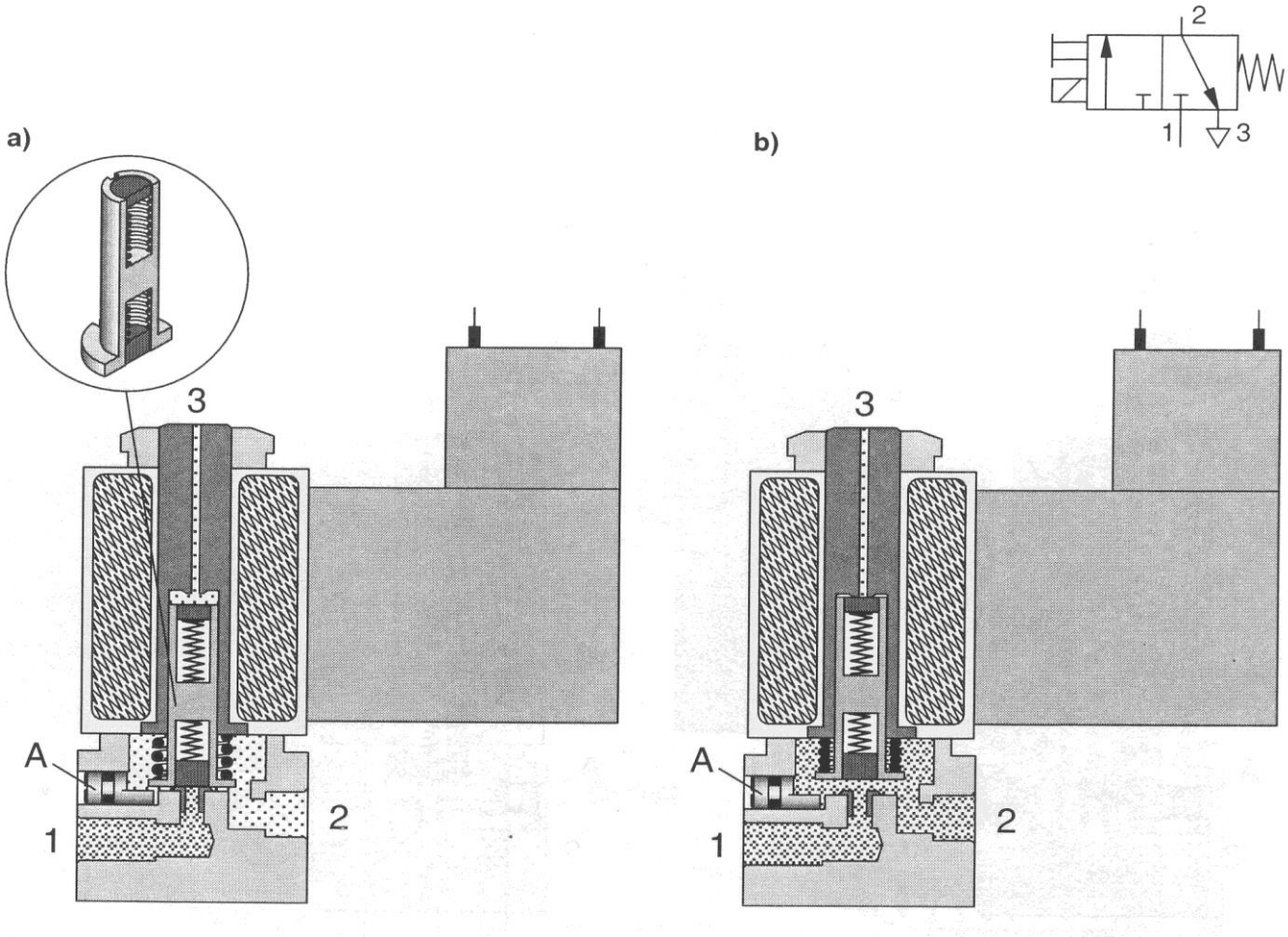
The pilot control actuates the valve



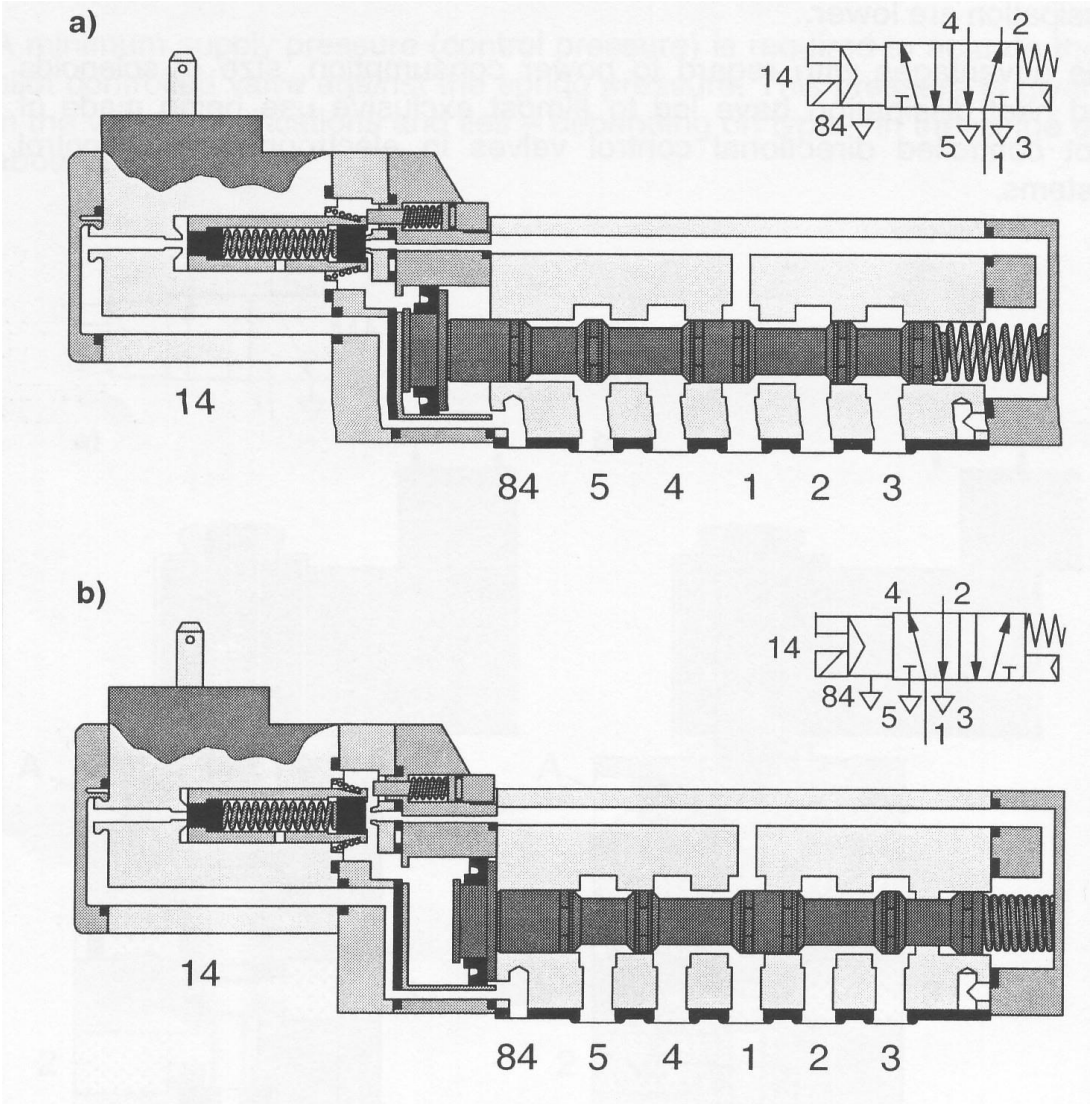




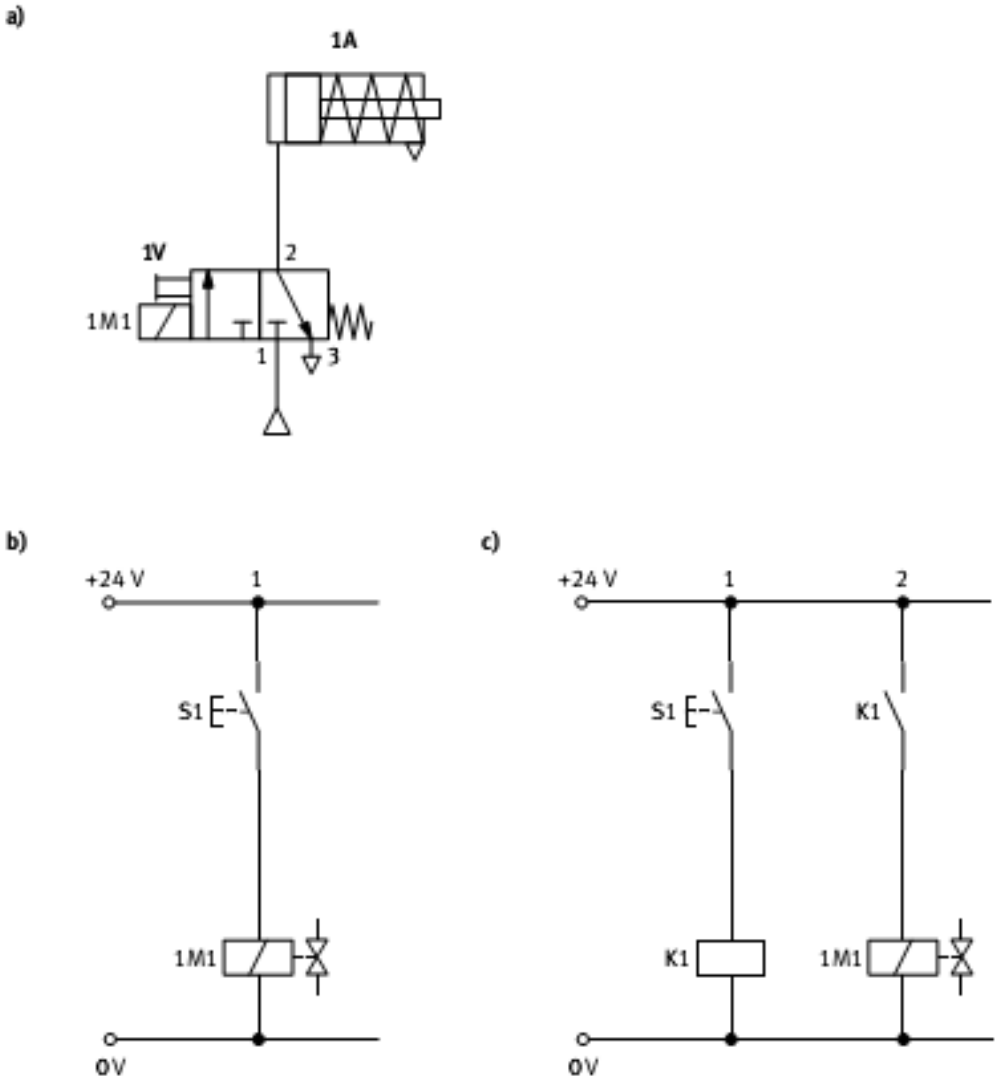
3/2 Way-Solenoid Valve



5/2 Way-Solenoid Valve

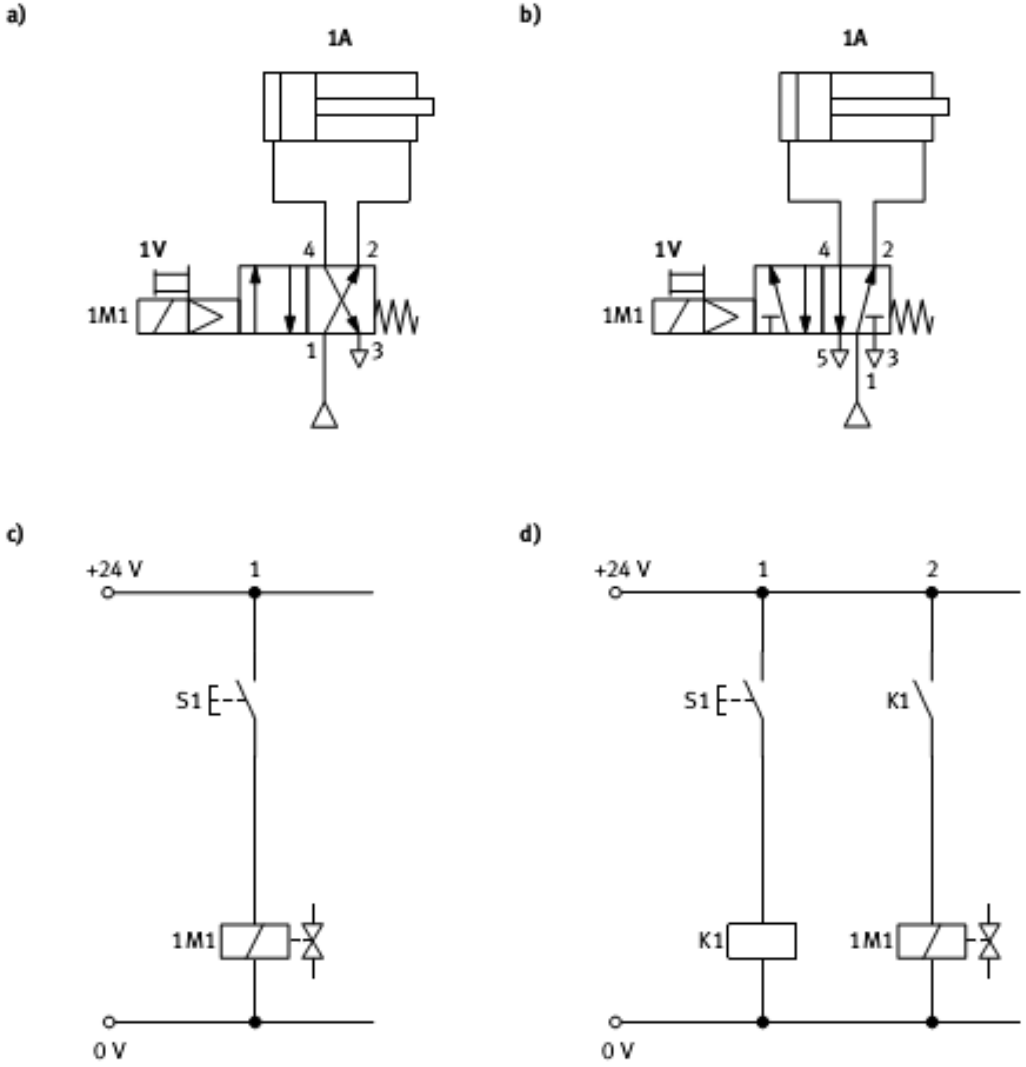


Direct and Indirect Control Using Relays



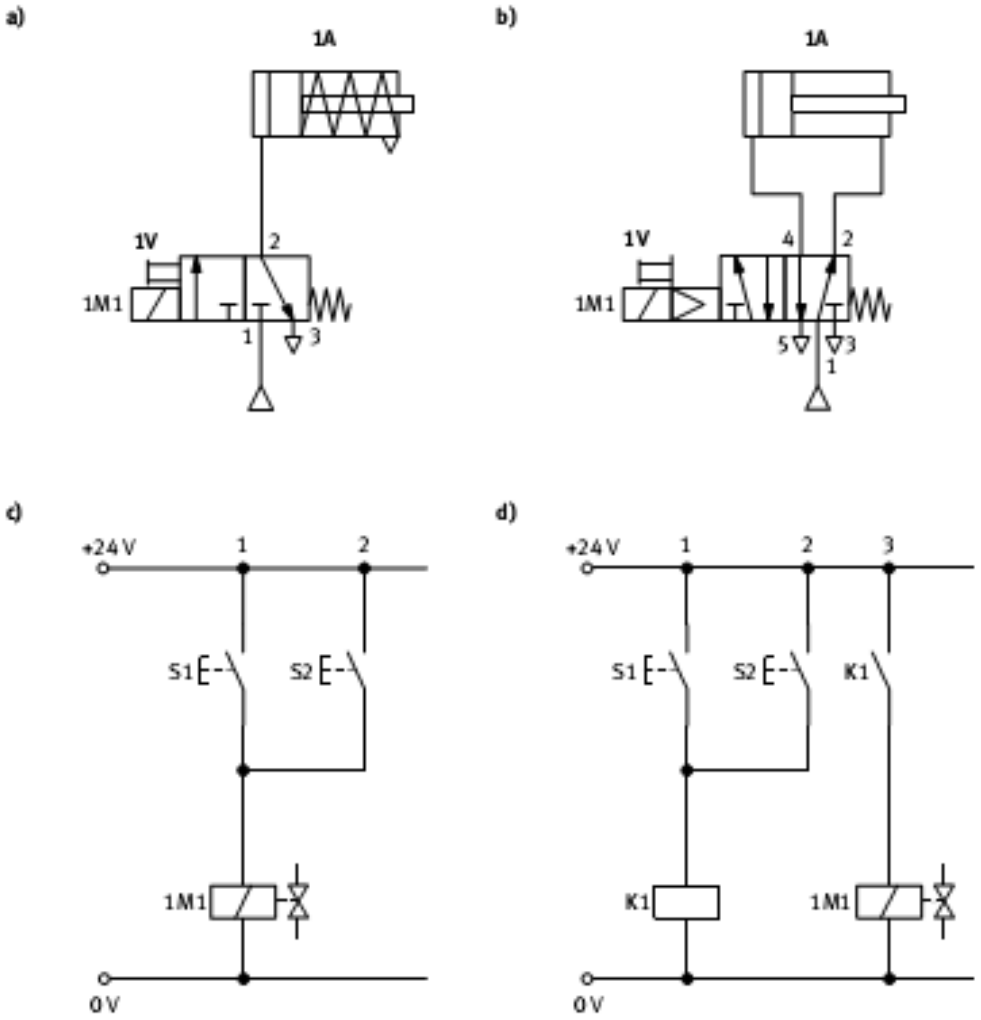
a) Pneumatic circuit diagram
b) Electrical circuit diagram for direct control
c) Electrical circuit diagram for indirect control

Controlling a Double-Acting Cylinder



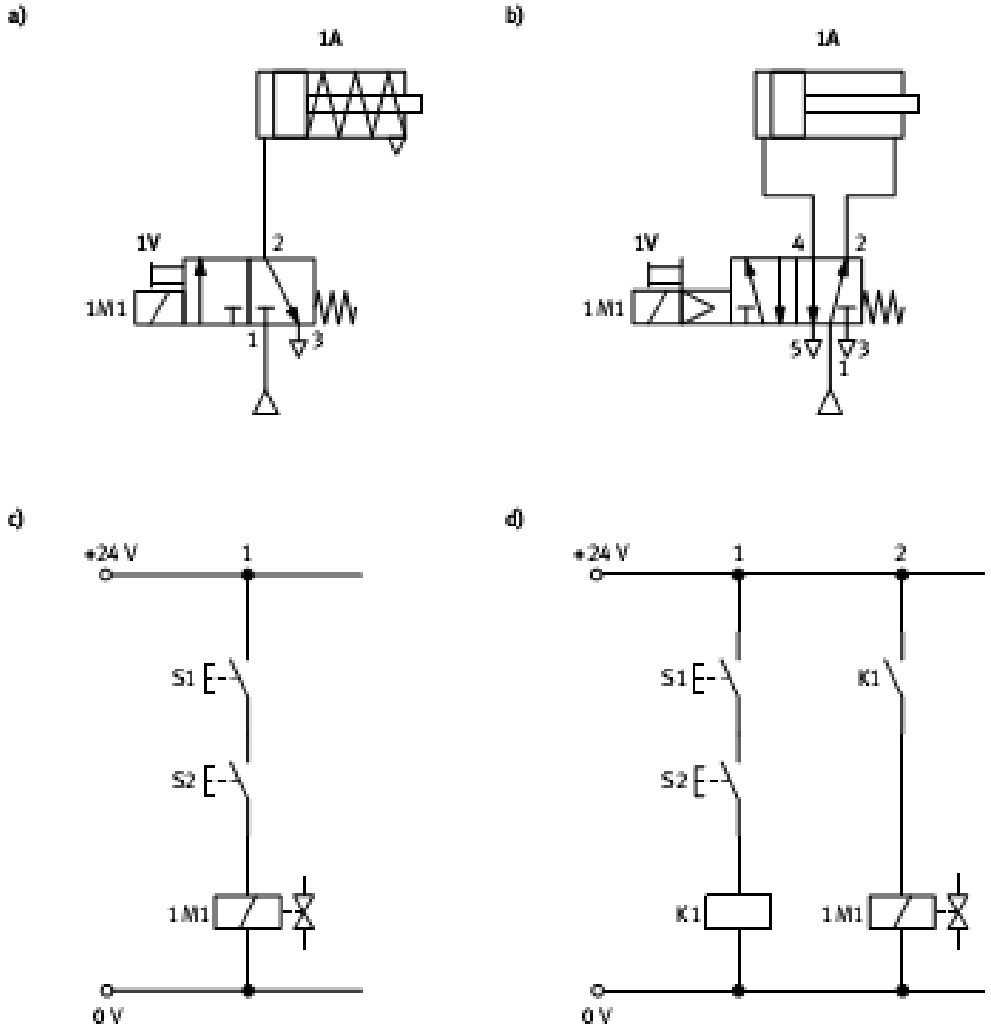
a) Pneumatic circuit diagram with 4/2-way valve
b) Pneumatic circuit diagram with 5/2-way valve
c) Electrical circuit diagram with direct control
d) Electrical circuit diagram with indirect control

Parallel connection (OR operation)



a) Pneumatic circuit diagram with single-acting cylinder
b) Pneumatic circuit diagram with double-acting cylinder
c) Electrical circuit diagram with direct control
d) Electrical circuit diagram with indirect control

Series connection (AND operation)



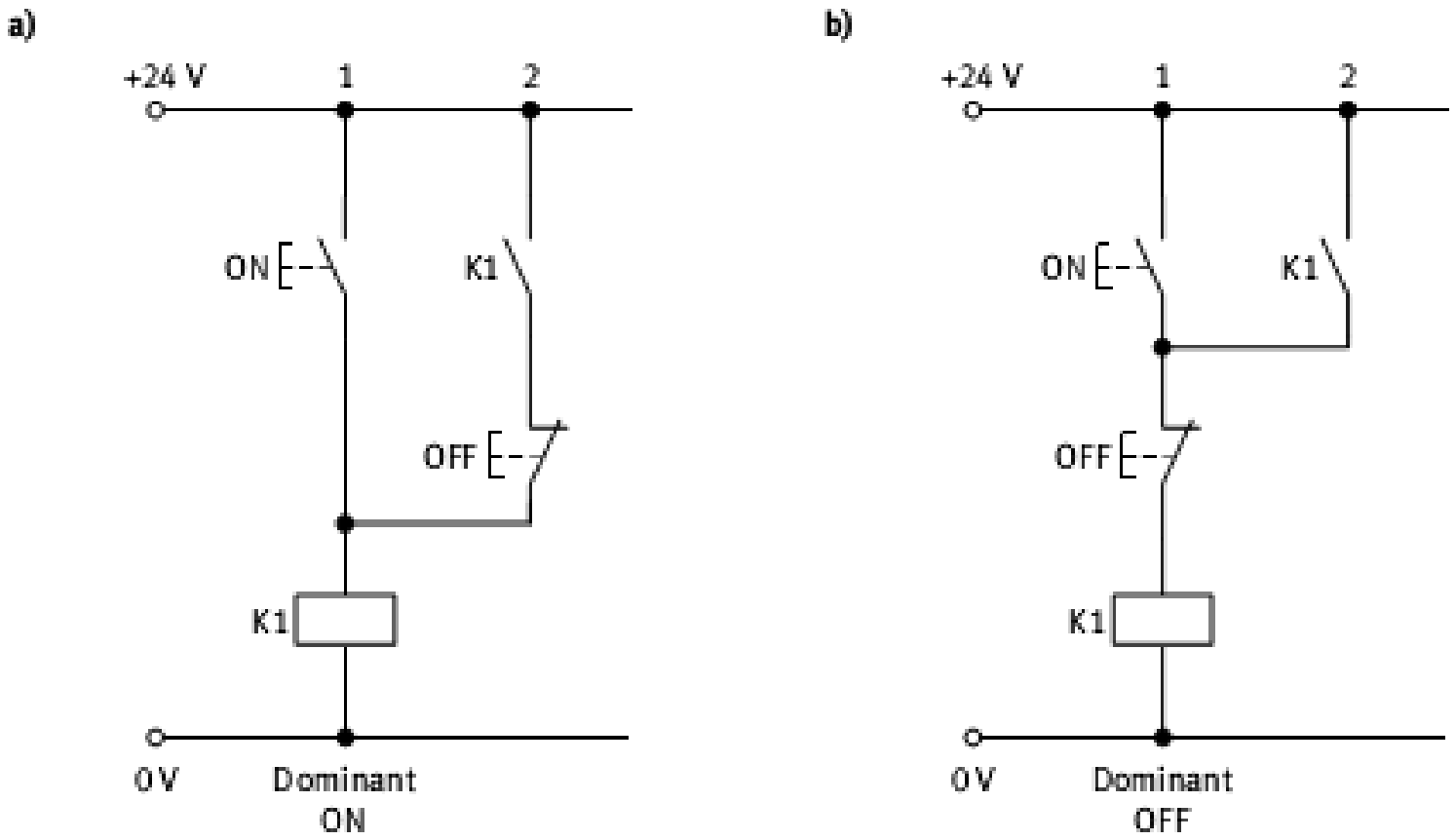
a) Pneumatic circuit diagram with single-acting cylinder

b) Pneumatic circuit diagram with double-acting cylinder

c) Electrical circuit diagram with direct control

d) Electrical circuit diagram with indirect control

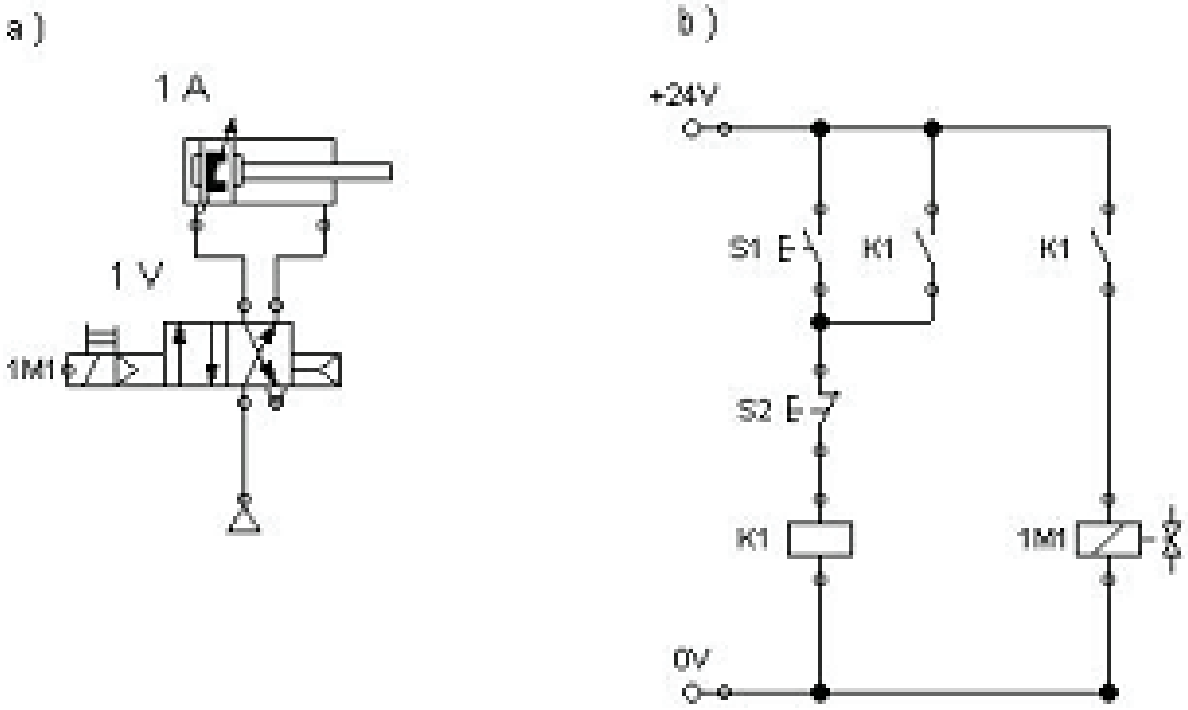
Signal storage by means of a relay circuit with self-latching loop



a) Dominant setting

b) Dominant resetting

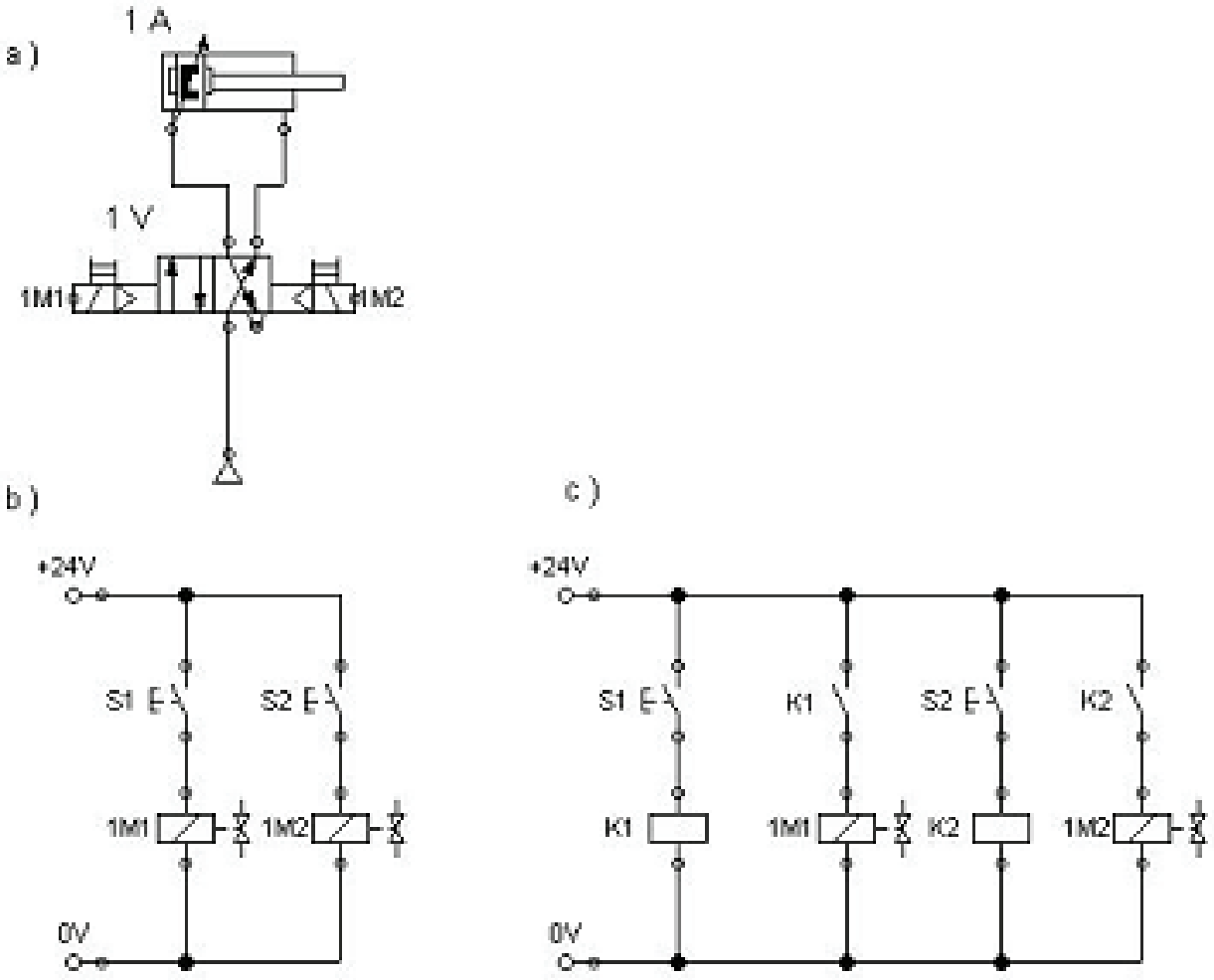
Manual forward and return stroke control using relays with self-latching loop



a) Pneumatic circuit diagram with double-acting cylinder

b) Electrical circuit diagram

Signal storage by means of a double solenoid valve

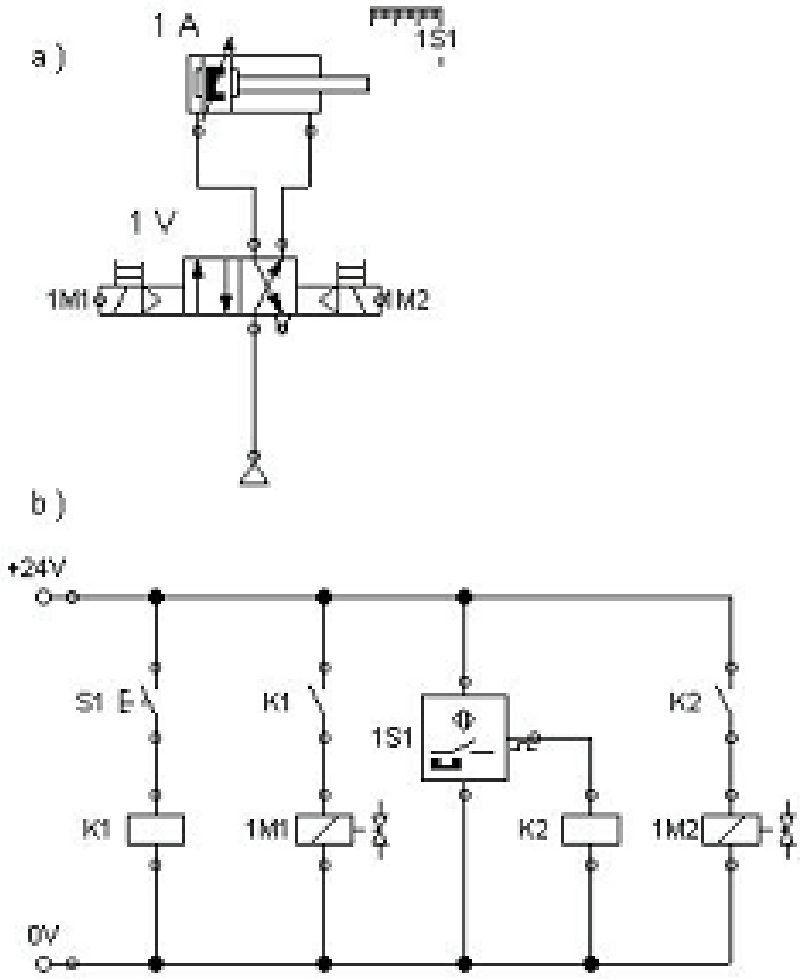


a) Pneumatic circuit diagram with double-acting cylinder

b) Electrical circuit diagram with direct control

c) Electrical circuit diagram with indirect control

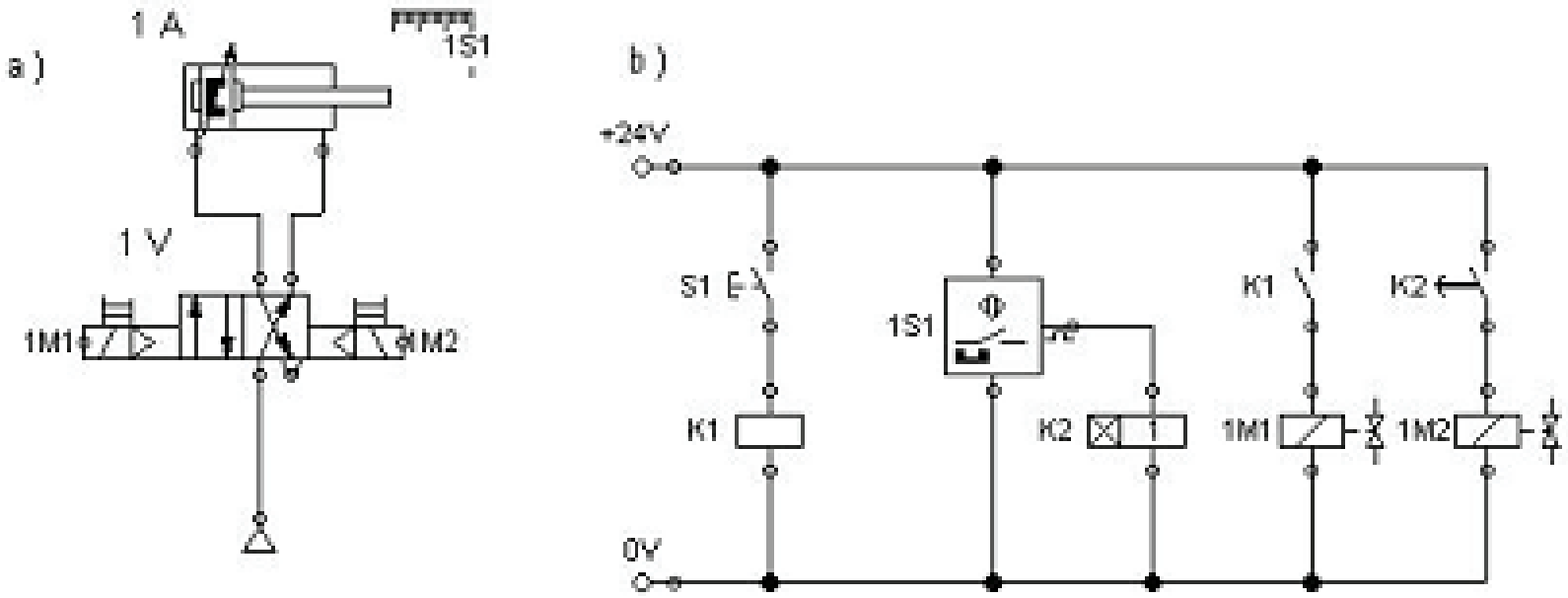
Automatic return stroke control using double solenoid valves



a) Pneumatic circuit diagram

b) Electrical circuit diagram with indirect control

Controlling a cylinder via timing

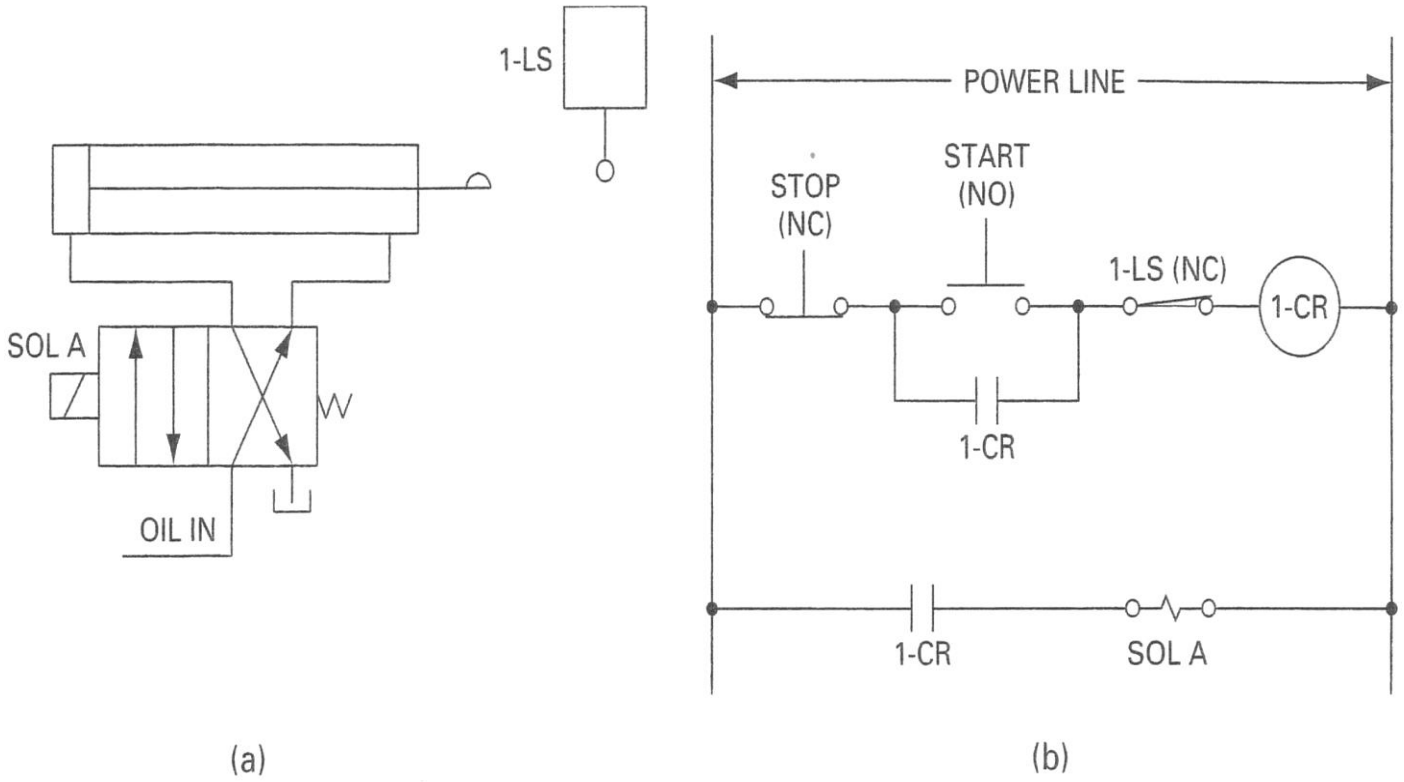


a) Pneumatic circuit diagram

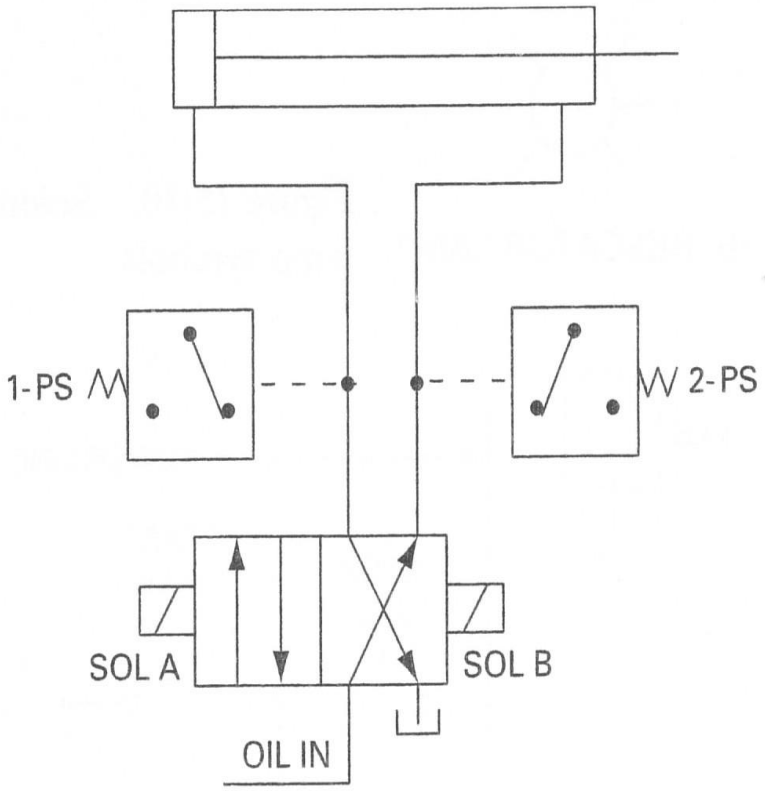
b) Electrical circuit diagram

Control of hydraulic cylinder using single limit switch

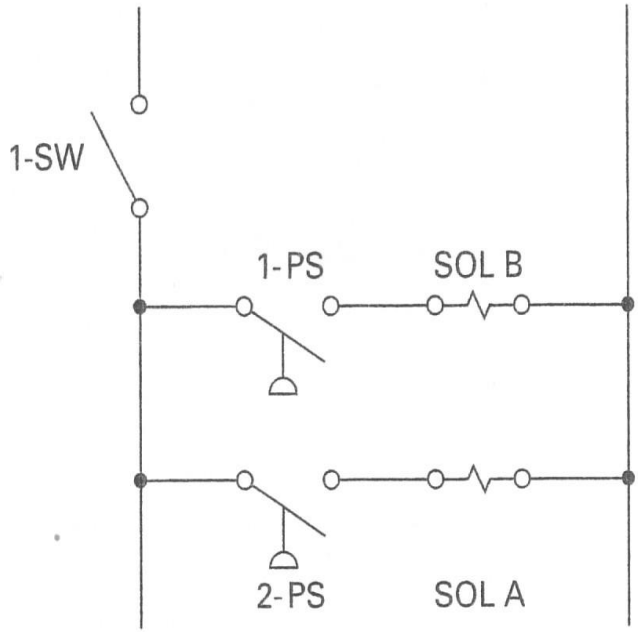
- **Hydraulic and electrical circuit**



Reciprocation of cylinder using pressure switch



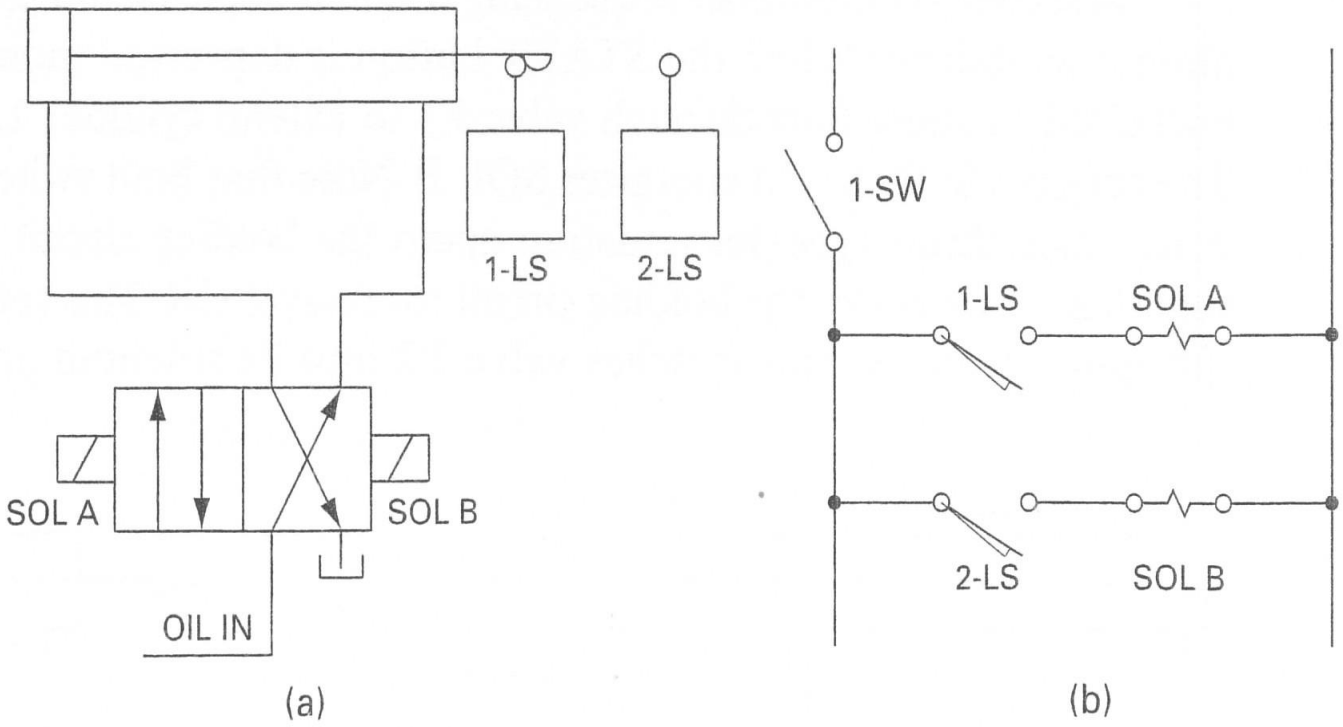
(a)



(b)

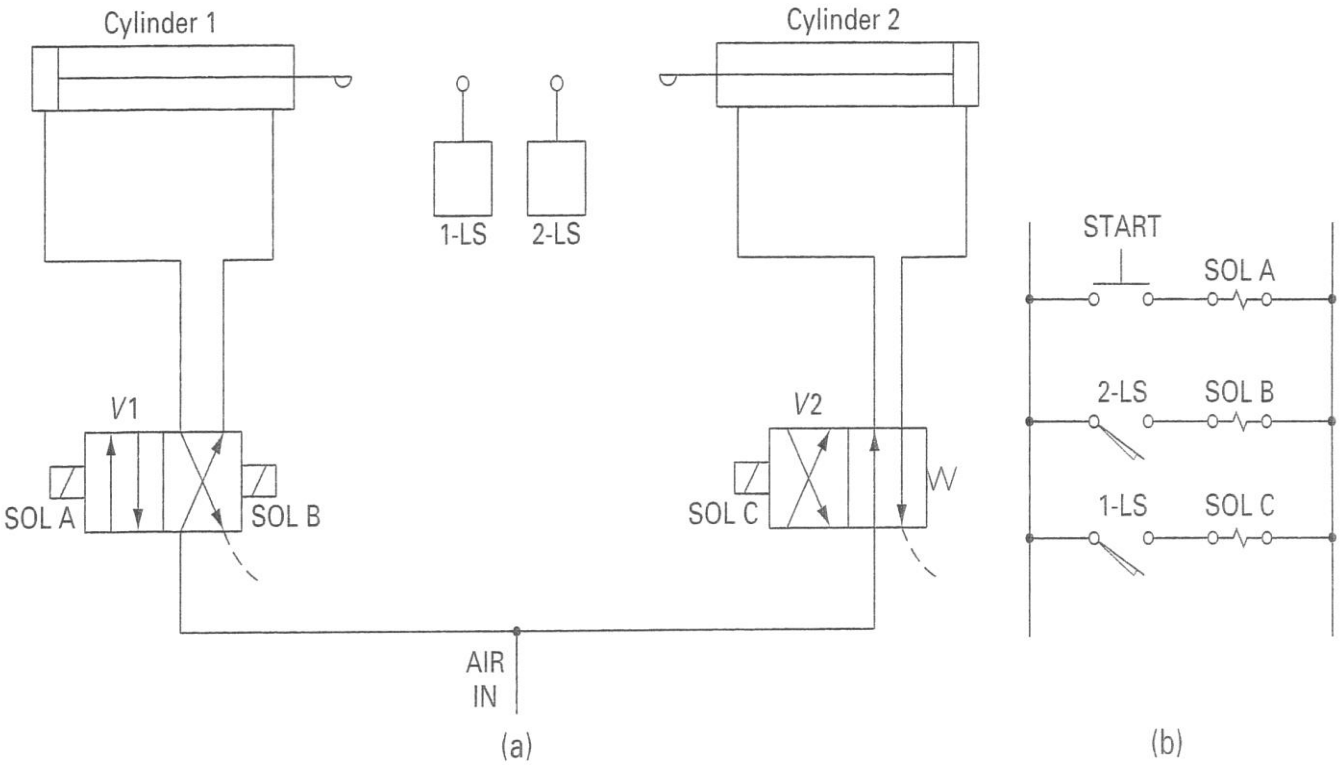
Reciprocation of cylinder using limit switches

- **Hydraulic and electrical circuit**



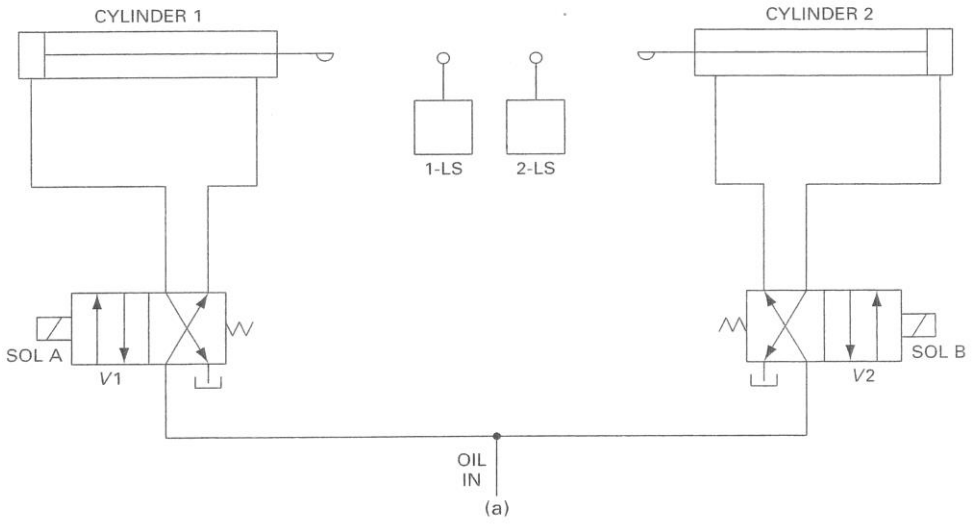
Dual cylinder sequencing circuit

- **Hydraulic and electrical circuit**

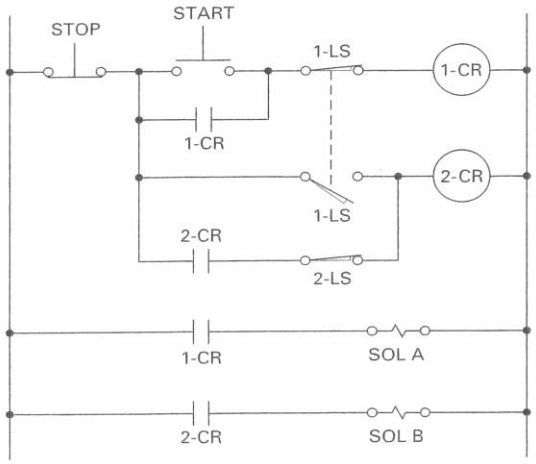


Second dual cylinder sequencing circuit

- **Hydraulic and electrical circuit**



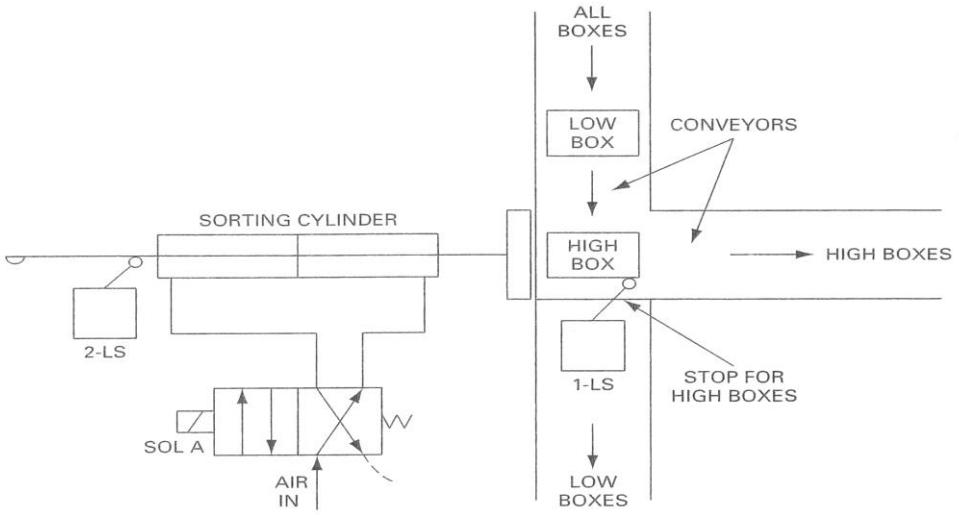
(a)



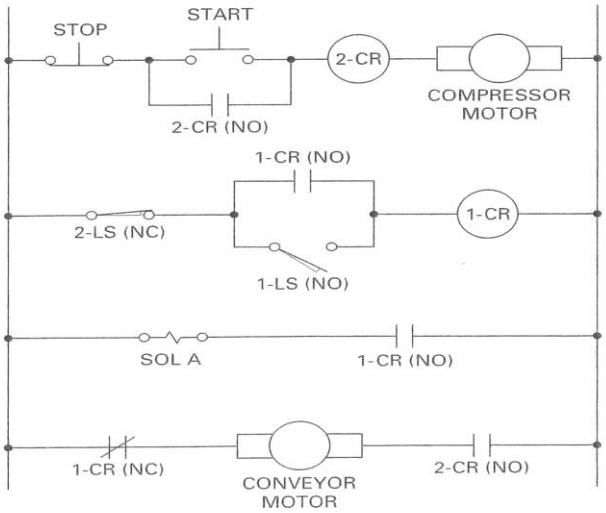
(b)

Electro-pneumatic box – sorting system

- **Hydraulic and electrical circuit**



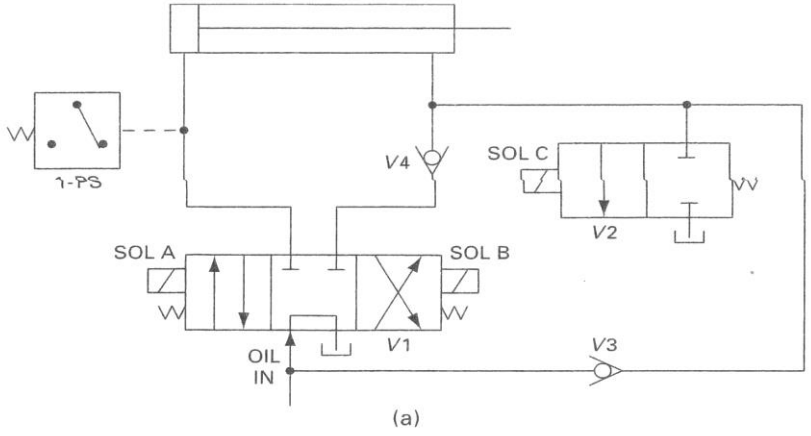
(a)



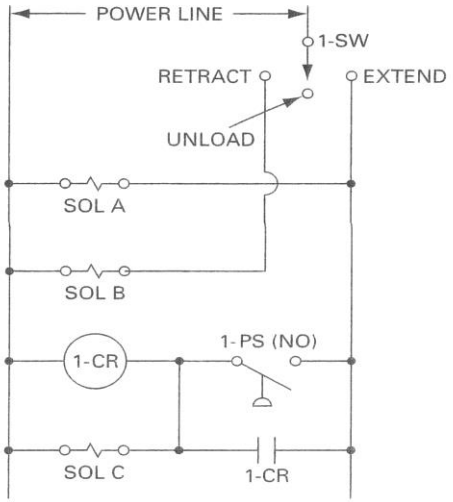
(b)

Electrical control of regenerative circuit

- **Hydraulic and electrical circuit**



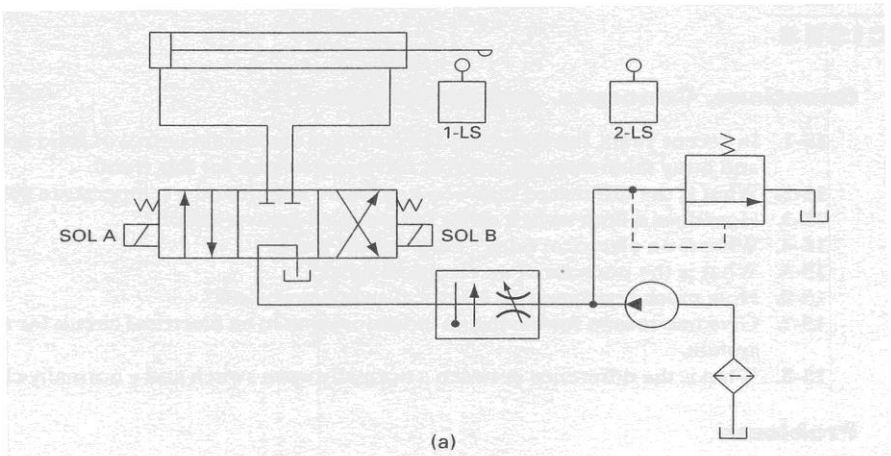
(a)



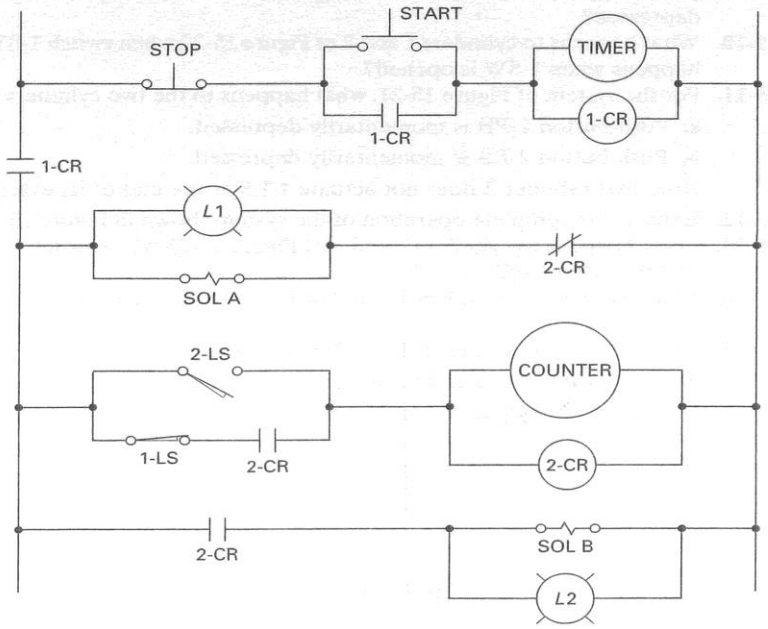
(b)

Counting, timing and reciprocation of a hydraulic cylinder

- **Hydraulic and electrical circuit**

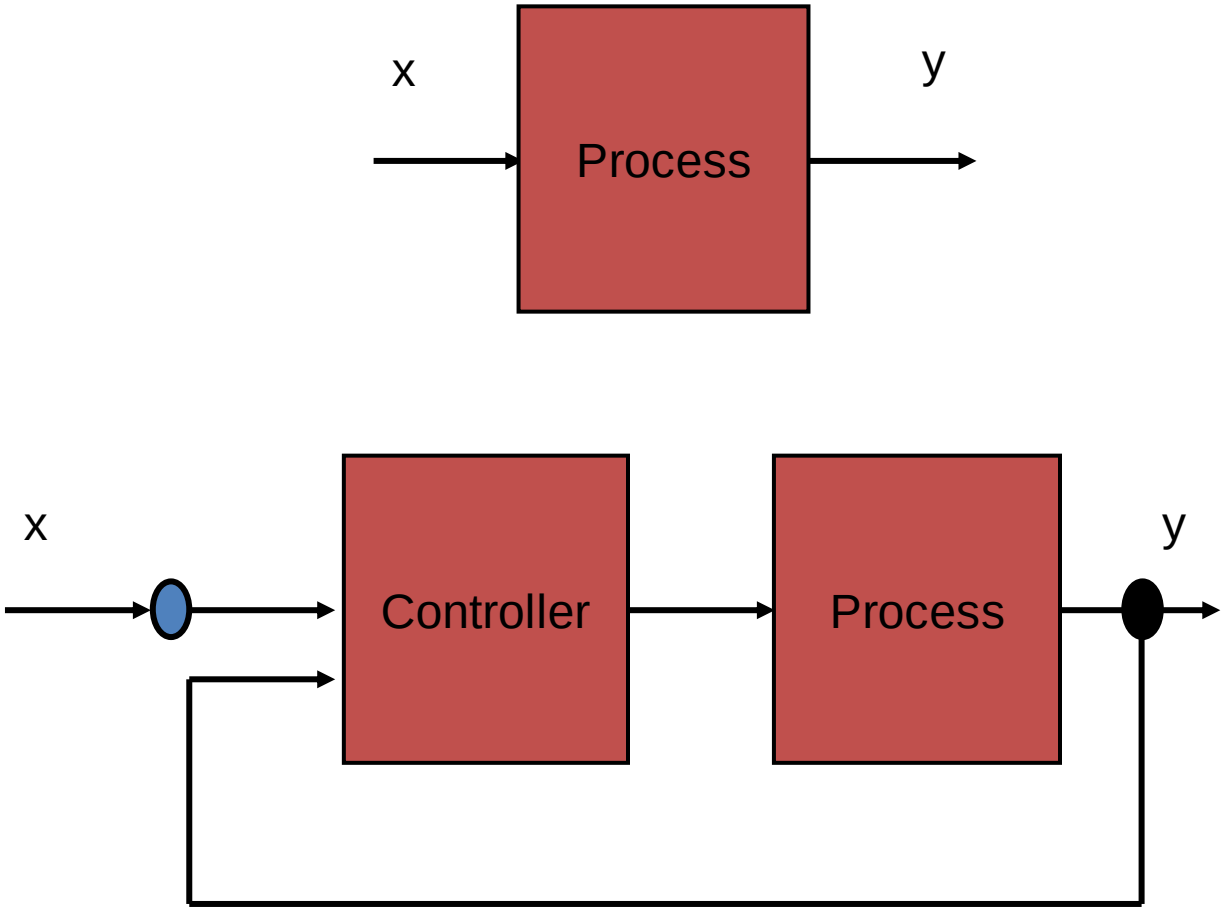


(a)



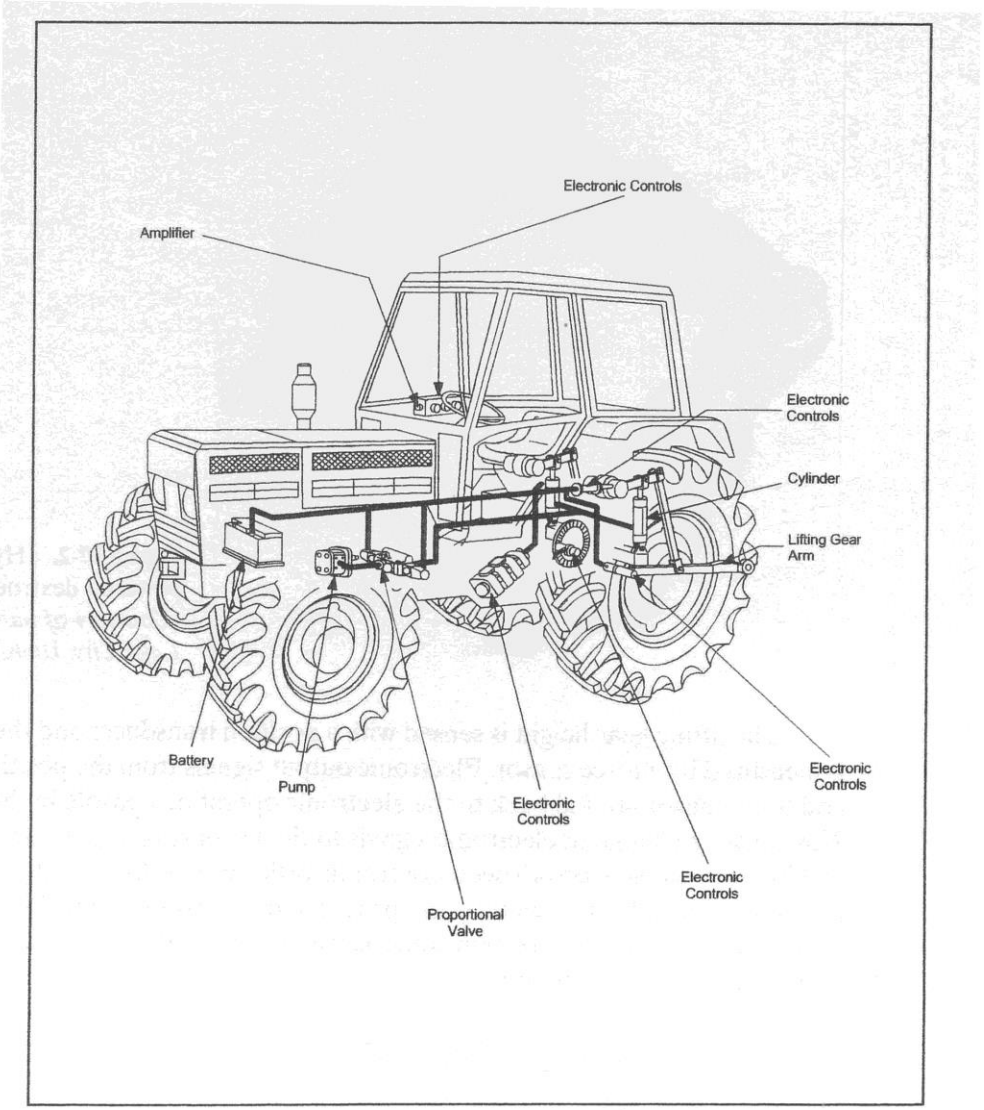
(b)

Open and Closed Loop Control



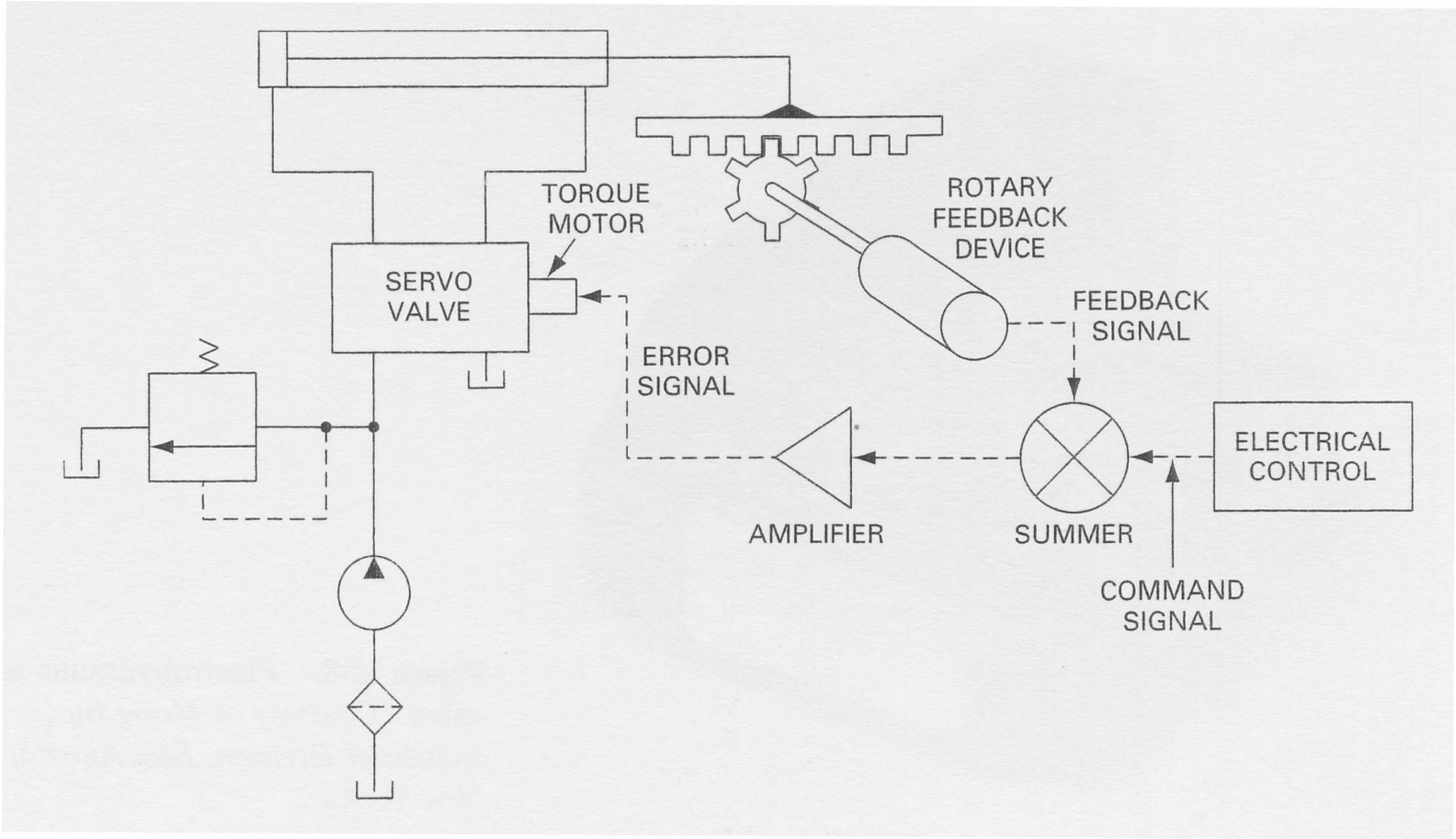
Tractor using electro-hydraulic servo system

- **Schema and its component**



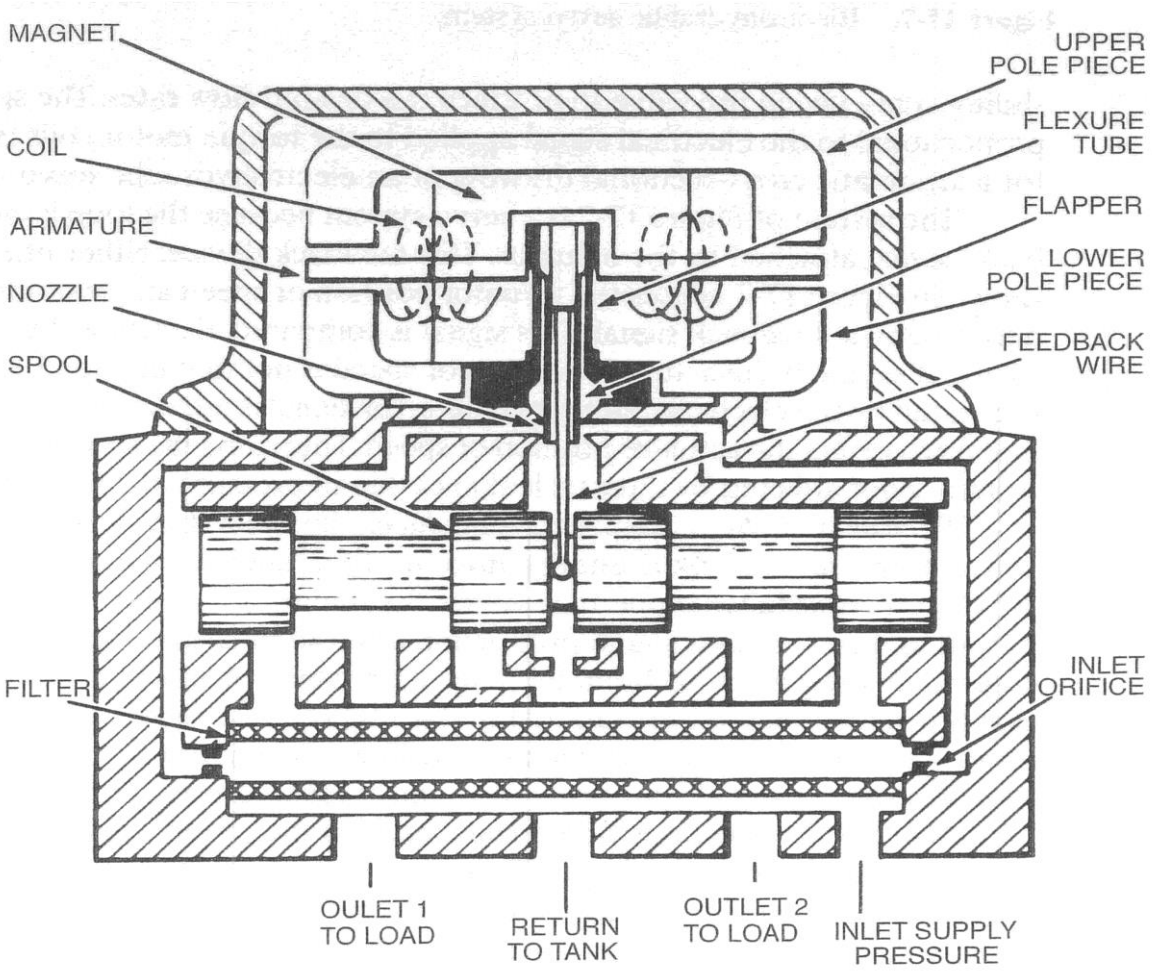
Electro-hydraulic servo system

- **System components**



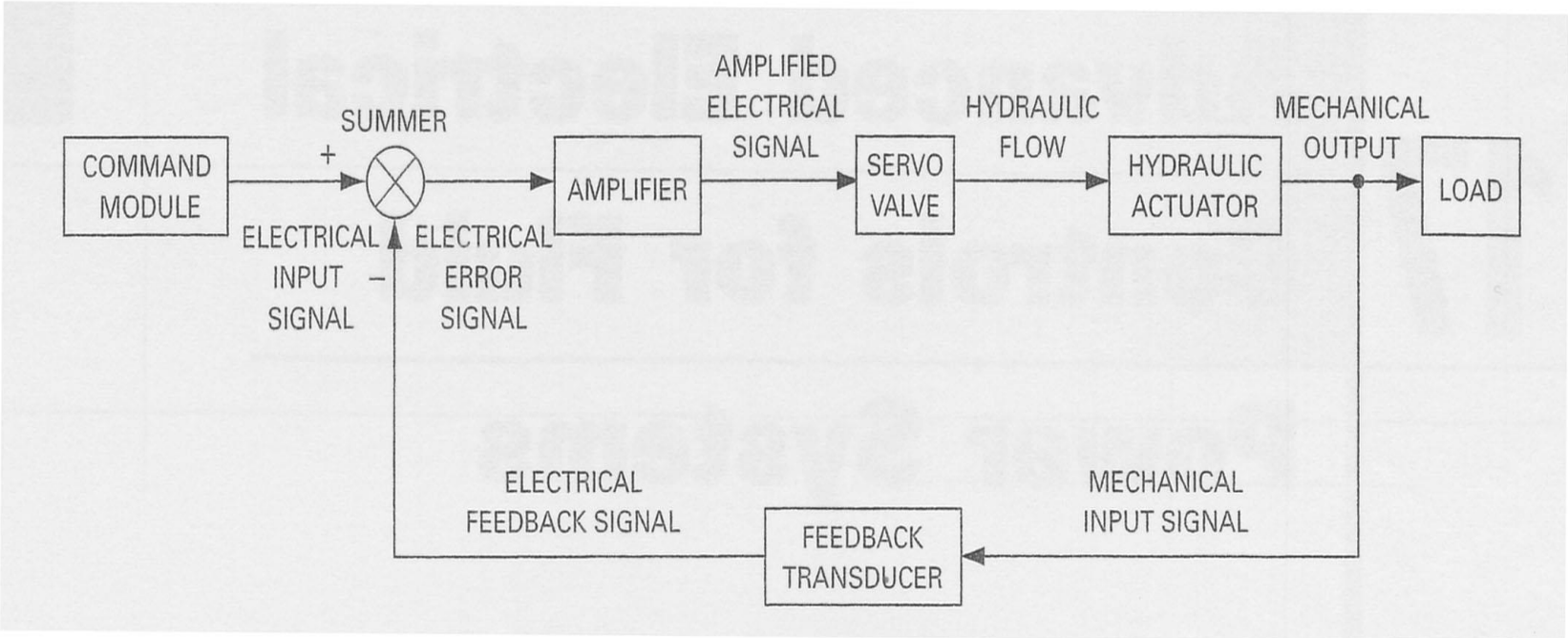
Servo valve

- **Components of servo valve**



Closed – loop system

- **Block diagram of an electro-hydraulic servo system**



Electro-hydraulic positional closed – loop system

- **System Block diagram**