Hydraulic & Pneumatics

By
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In the industry three methods are used for transmitting power from one point to another.

1. Mechanical transmission - shafts, gears, chains, belts, etc.
2. Electrical transmission - wires, transformers, etc.
3. Fluid power - liquids or gas in a confined space.

Fluid Power: Fluid power is the technology that deals with the generation, control and transmission of forces and movement of mechanical element or system with the use of pressurized fluids in a confined system.

Classification of Fluid Power Systems

1. Based on the control system

I. Open loop system:- There is no feedback in the open system and performance is based on the characteristics of the individual components of the system.

II. Closed loop system:- The output of the system is fed back to a comparator by a measuring element. The comparator compares the actual output to the desired output and gives an error signal to the control element.

2. Based on the type of control

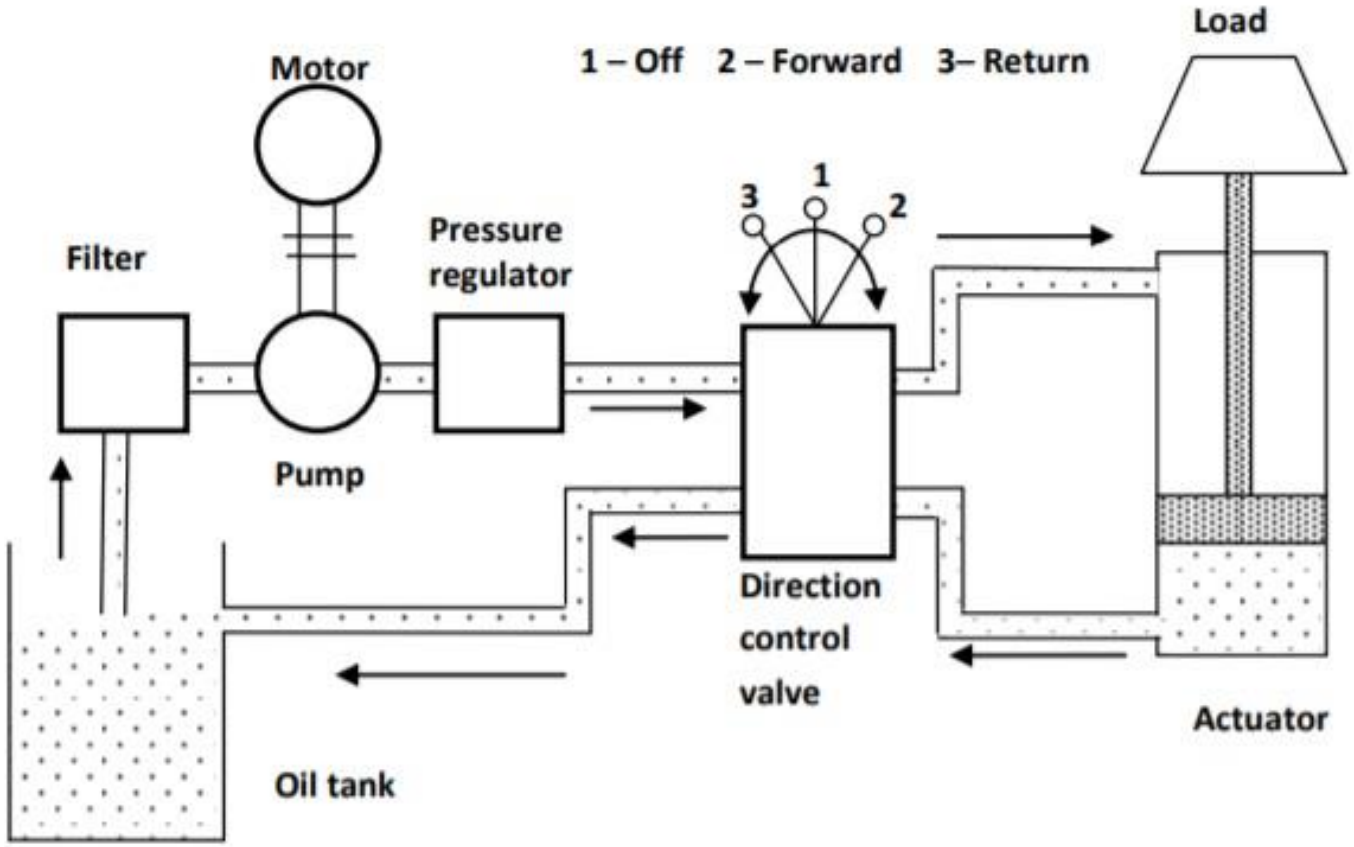
I. Fluid logic control:- This type of system is controlled by hydraulic oil or air. The system employs fluid logic devices such as AND, NAND, OR, NOR, etc.

II. Electrical Control:- This type of system is controlled by electrical devices. Four basic electrical devices are used for controlling the fluid power systems: switches, relays, timers and solenoids.

III. Electronic Control:- : This type of system is controlled by microelectronic devices.

i.e PLC, microprocessor, etc.

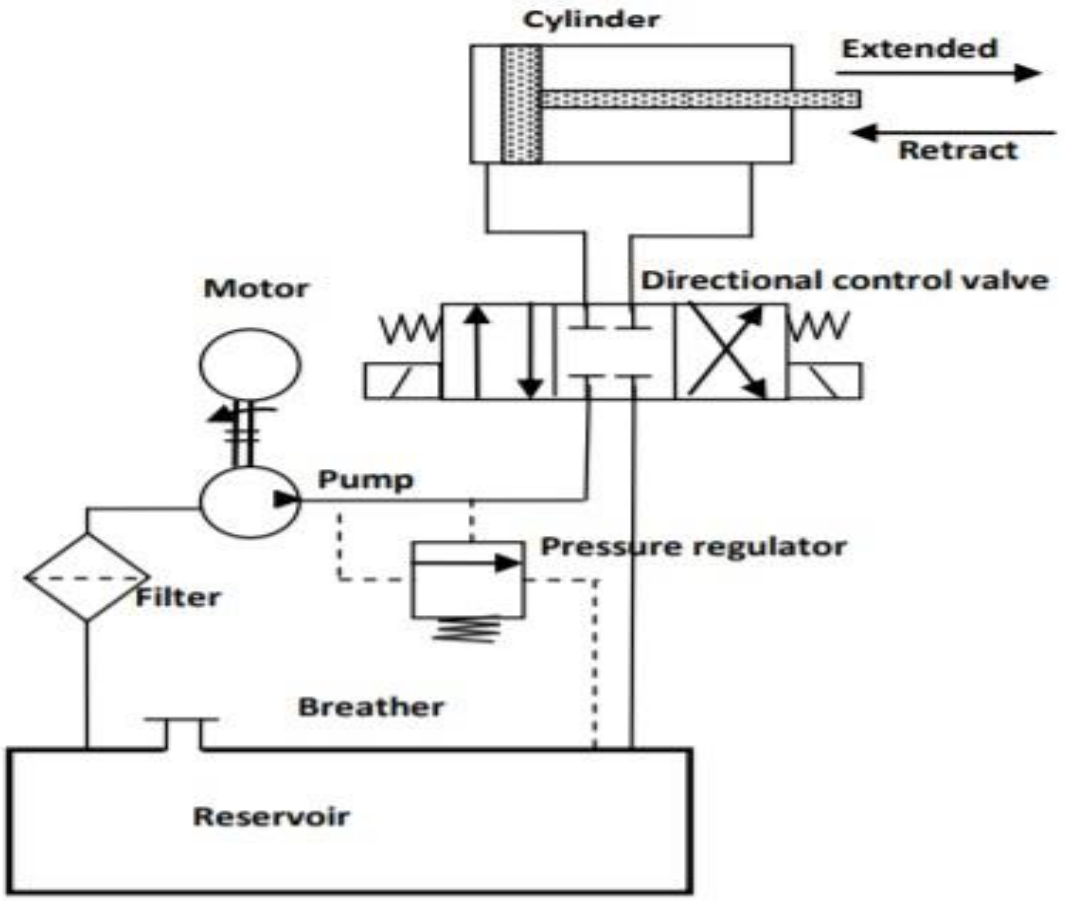
Basic components of Hydraulic system



Components of a hydraulic system

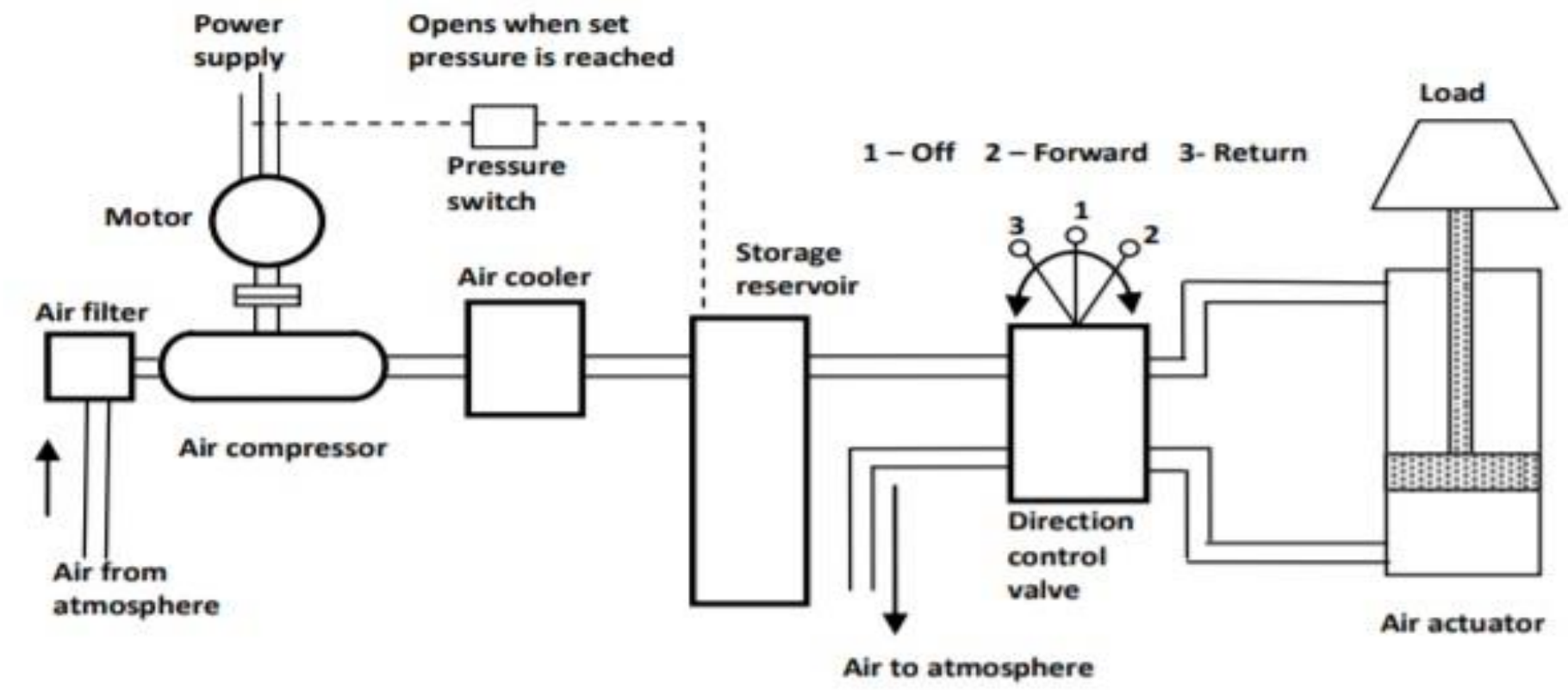
- Actuator: The hydraulic actuator is a device used to convert the fluid power into mechanical power to do useful work. The actuator may be of the linear type (e.g., hydraulic cylinder) or rotary type(e.g., hydraulic motor) to provide linear or rotary motion, respectively.
- Hydraulic pump: It is used to force the fluid from the reservoir to rest of the hydraulic circuit by converting mechanical energy into hydraulic energy.
- Valves: They are used to control the direction, pressure and flow rate of a fluid flowing through the circuit.
- Motor: It is required to drive the pump
- Reservoir: It is used to hold the hydraulic liquid, usually hydraulic oil.
- Piping system: It carries the hydraulic oil from one place to another.
- Filters: They are used to remove any foreign particles so as keep the fluid system clean and efficient, as well as avoid damage to the actuator and valves.
- Pressure regulator: It regulates the required level of pressure in the hydraulic fluid.

Components of hydraulic systems using circuit diagram



Components of a hydraulic system (shown using symbols).

Basic components of Pneumatic systems



The functions of various components shown are:

1. The pneumatic actuator converts the fluid power into mechanical power to perform useful work.
2. The compressor is used to compress the fresh air drawn from the atmosphere.
3. The storage reservoir is used to store a given volume of compressed air.
4. The valves are used to control the direction, flow rate and pressure of compressed air.
5. External power supply (motor) is used to drive the compressor.
6. The piping system carries the pressurized air from one location to another

Working

- Air is drawn from the atmosphere through an air filter and raised to required pressure by an air compressor.
- As the pressure rises, the temperature also rises; hence, an air cooler is provided to cool the air with some preliminary treatment to remove the moisture.
- The treated pressurized air then needs to get stored to maintain the pressure.
- With the storage reservoir, a pressure switch is fitted to start and stop the electric motor when pressure falls and reaches the required level.

Hydraulic System

- It employs a pressurized liquid as a fluid
- Generally designed as closed system
- The system slows down when leakage occurs
- Valve operations are difficult
- Heavier in weight
- Pumps are used to provide pressurized liquids
- The system is unsafe to fire hazards
- Automatic lubrication is provided
- Pressure range is 5 - 10 bar.

Pneumatic System

- It employs a compressed gas, usually air, as a fluid
- Usually designed as open system
- Leakage does not affect the system much
- Valve operations are easy
- Lighter in weight
- Compressors are used to provide compressed gases
- The system is free from fire hazards
- Special arrangements for lubrication are needed
- Pressure range is near 700 - 1000 bar

Valves

There are three types of valves:

a. Directional Control Valve – They determine the path thorough which fluid transverses in a given circuit.
b. Pressure control Valve – They protect the system against overpressure
c. Flow control Valve – It controls the flow rate of fluid

Directional control Valves:

A valve is a device that receives an external signal (mechanical, fluid pilot signal, electrical or electronics) to release, stop or redirect the fluid that flows through it.

The function of a DCV is to control the direction of fluid flow in any hydraulic system. A DCV does this by changing the position of internal movable parts.

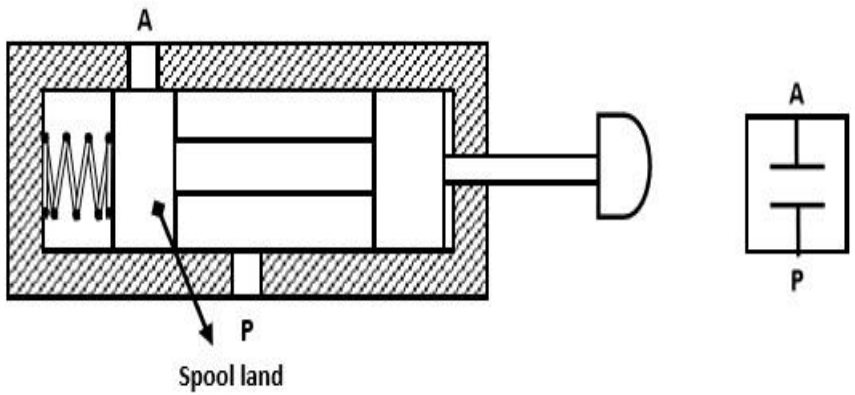
Its purposes are following:

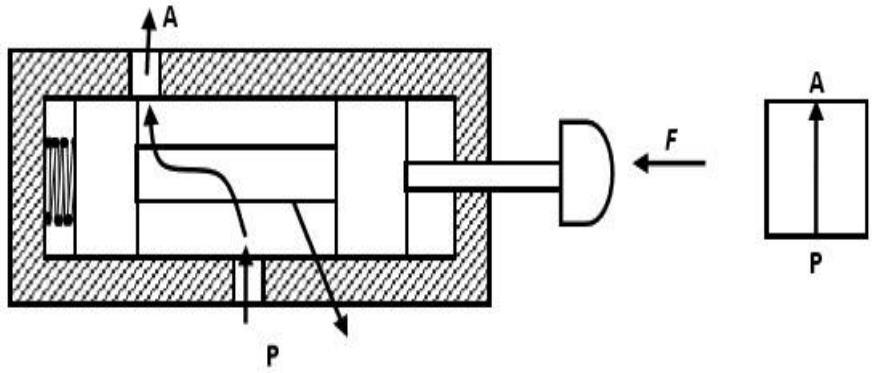
- To start, stop, accelerate, decelerate and change the direction of motion of a hydraulic actuator
- To permit the free flow from the pump to the reservoir at low pressure when the pump's delivery is not needed into the system
- To vent the relief valve by either electrical or mechanical control
- To isolate certain branch of a circuit

Rules to draw DCV symbol:

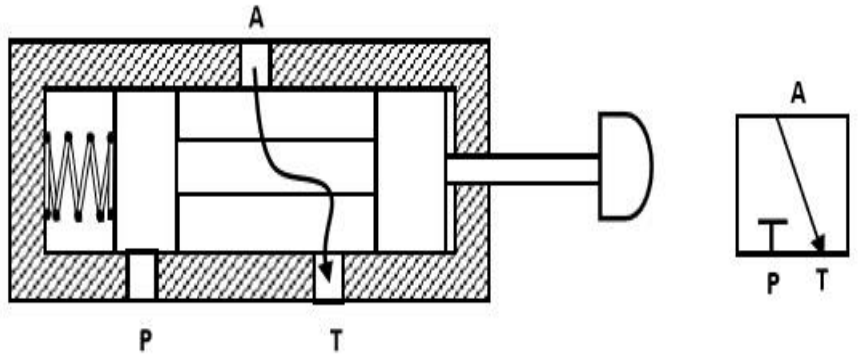
1. Each different switching position is shown by a square.
2. Flow directions are indicated by arrows.
3. Blocked ports are shown by horizontal lines.
4. Ports are shown in an appropriate flow direction with line arrows

2/2 normally closed valve

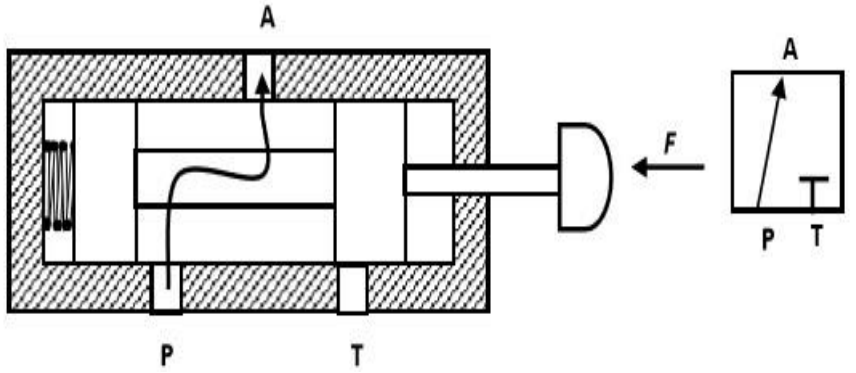




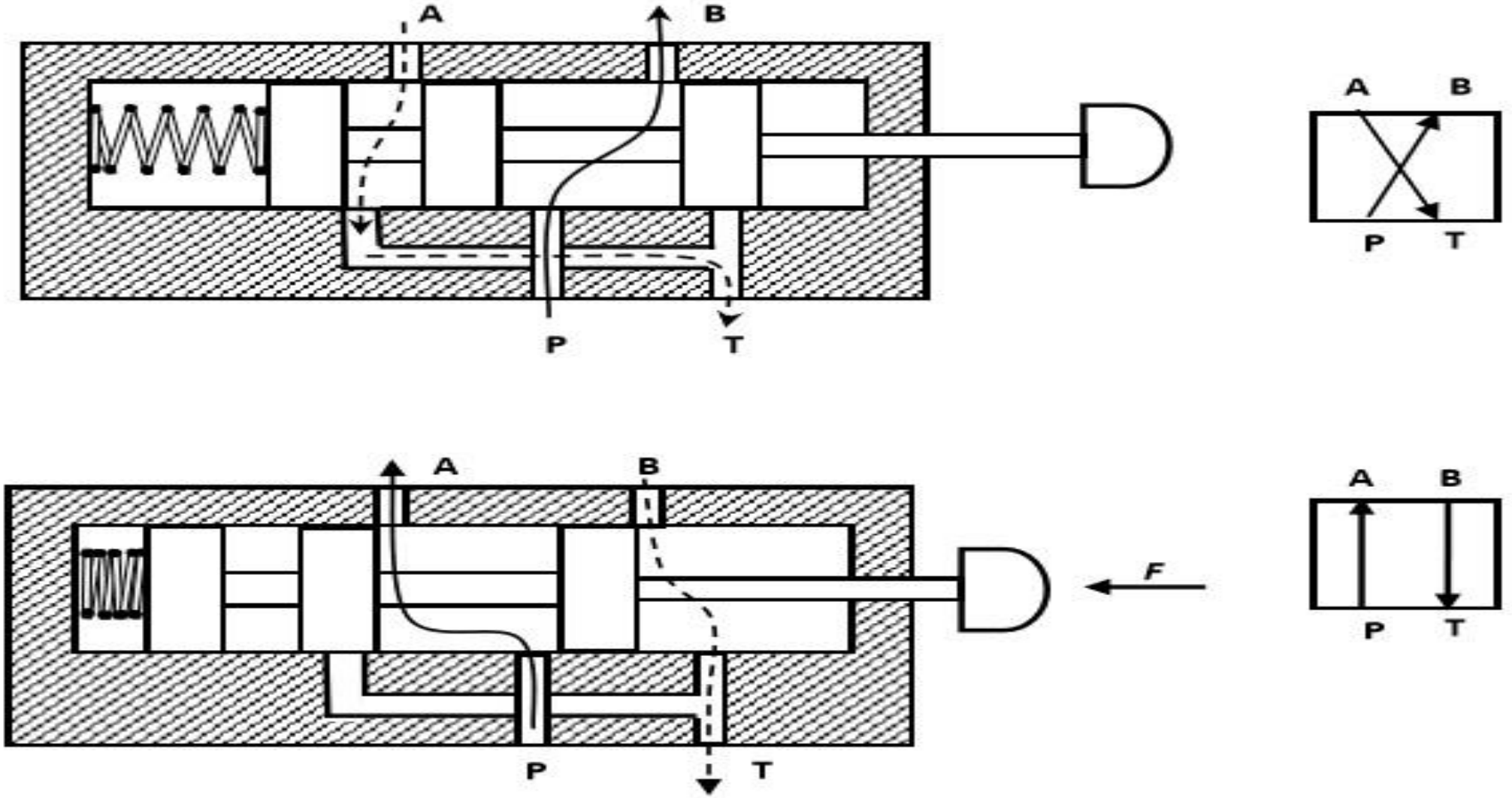
3/2 valve



(a)



4/2 valve



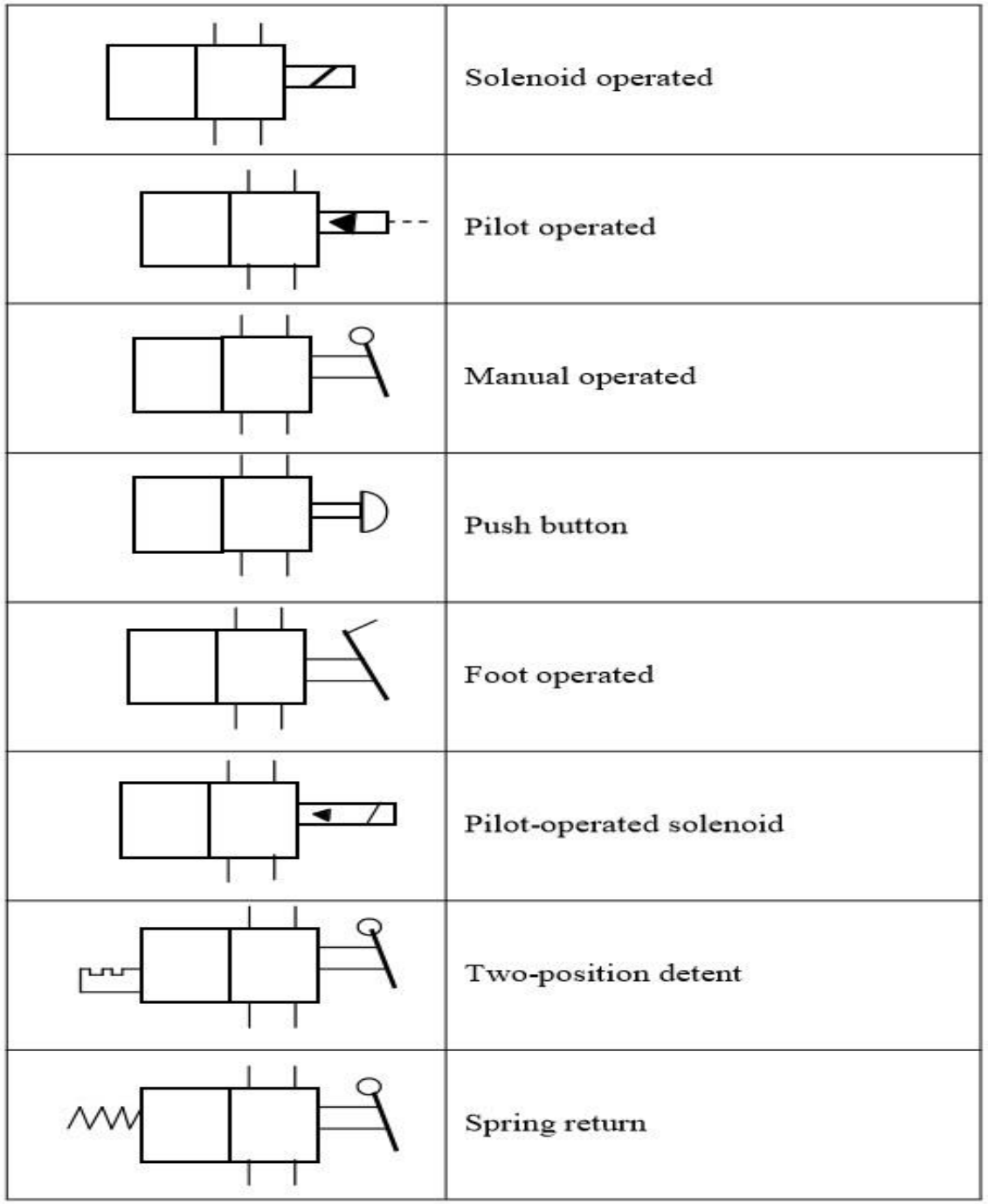
Actuating devices for DCV

Manually operated: In manually operated DCVs, the spool is shifted manually by moving a handle pushing a button or stepping on a foot pedal. When the handle is not operated, the spool returns to its original position by means of a spring.

Mechanically operated: The spool is shifted by mechanical linkages such as cam and rollers.

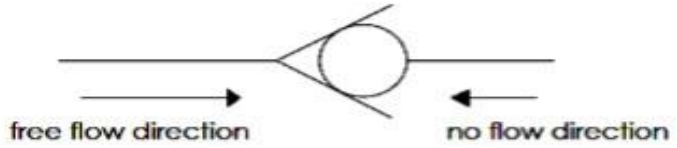
Solenoid operated: When an electric coil or a solenoid is energized, it creates a magnetic force that pulls the armature into the coil. This causes the armature to push the spool of the valve.

Pilot operated: A DCV can also be shifted by applying a pilot signal (either hydraulic or pneumatic) against a piston at either end of the valve spool. When pilot pressure is introduced, it pushes the piston to shift the spool

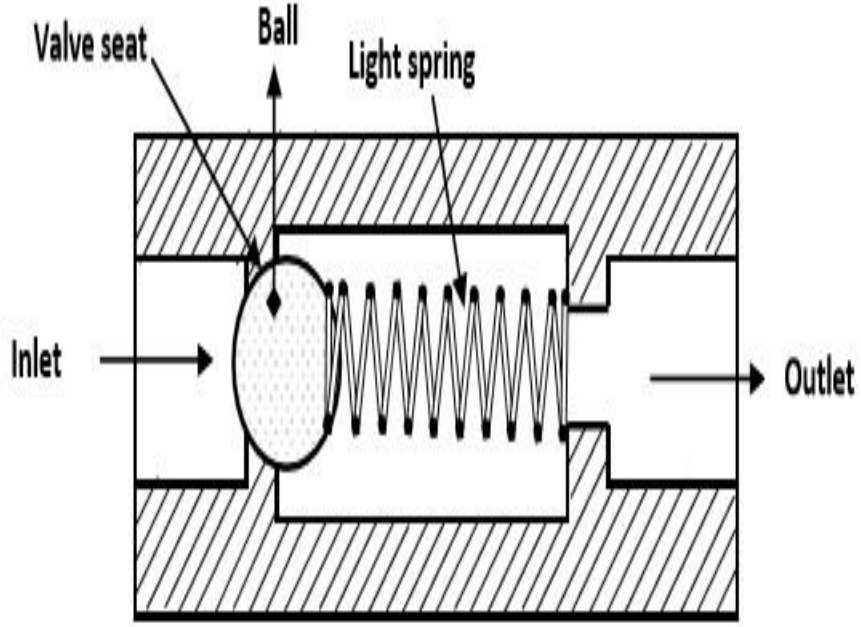


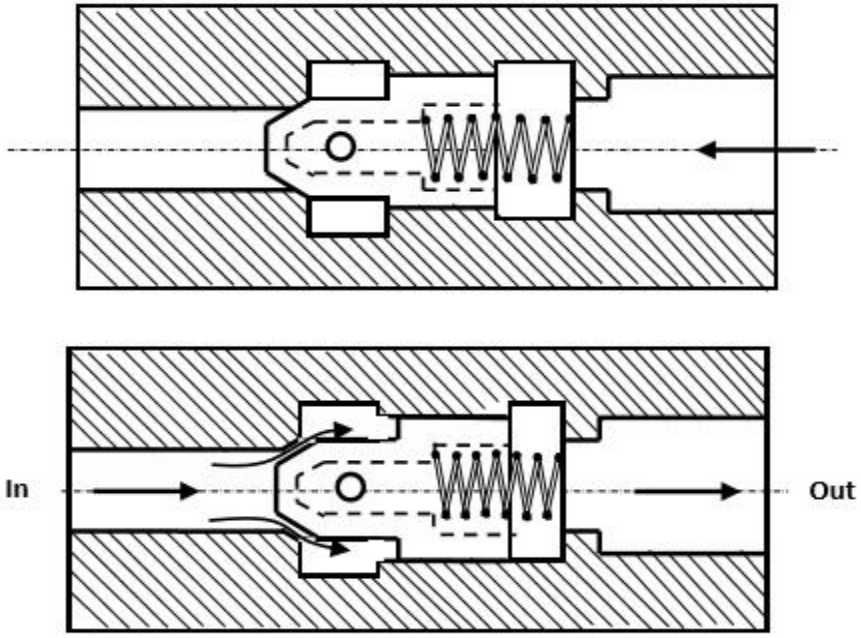
Check Valve

A check valve allows flow in one direction, but blocks the flow in the opposite direction.



Check Valve Symbol

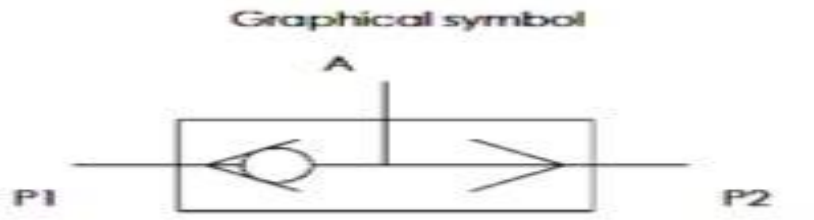




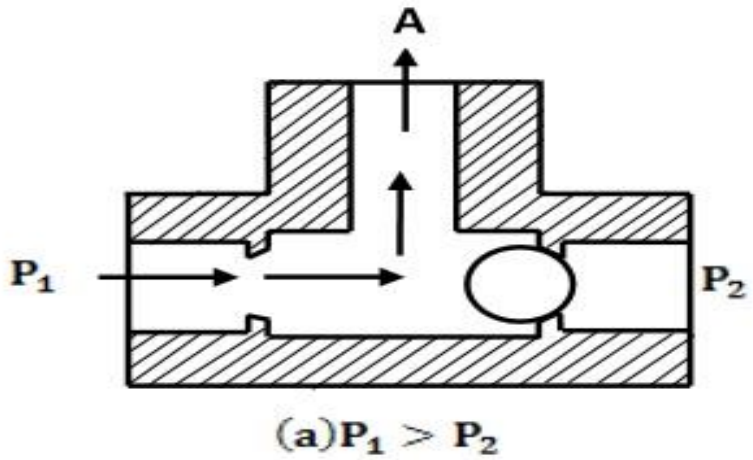
Poppet check Valve

Shuttle valve

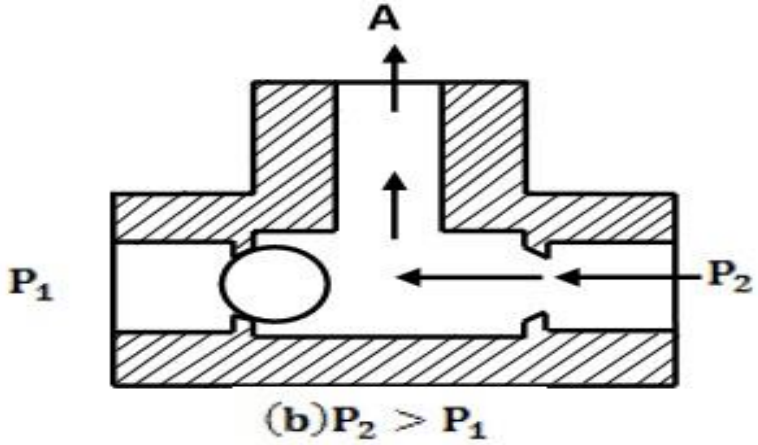
- Shuttle valve is a device which allows alternate flow sources to be connected in a one branch circuit.



Symbol of shuttle valve



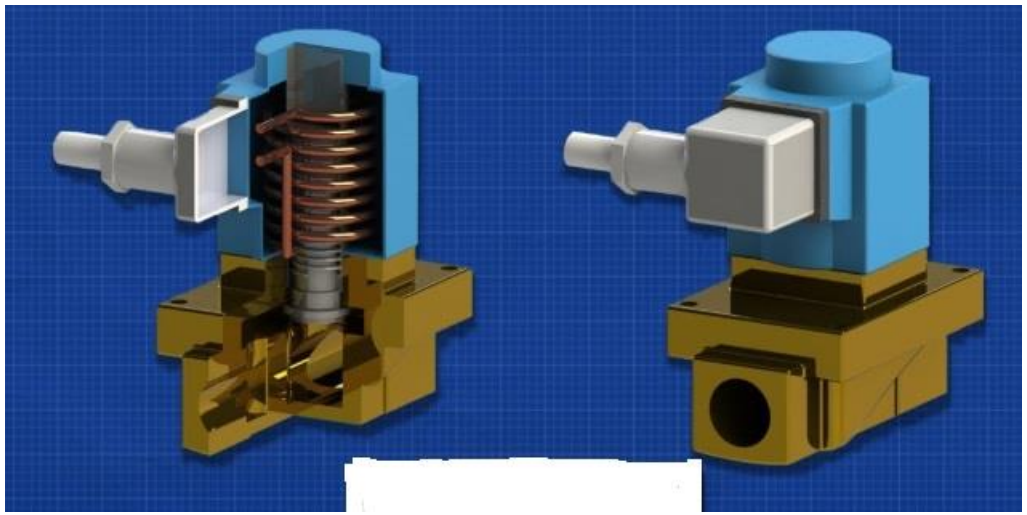
(a)$P_1 > P_2$

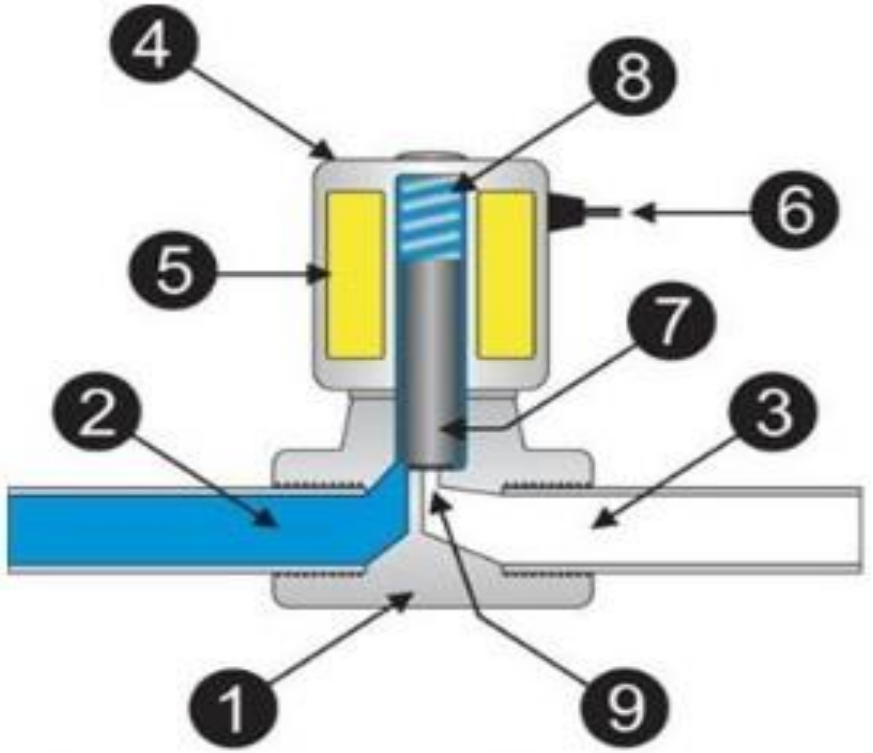


(b)$P_2 > P_1$

Solenoid valve

1. **Valve Body** – This is the body of valve to which solenoid valve is connected. This valve is connected in the process flow pipeline
2. **Inlet port** – Fluid enters into process
3. **Outlet port** – Fluid exits out of the process
4. **Coil/Solenoid** – This body of solenoid coil is in cylindrical shape and is hollow from inside. It has steel covering and it has metallic finish
5. **Coil Windings** – It consists of several turns of enamelled wire wound around the ferromagnetic material like steel or Iron.





Parts of Solenoid Valve

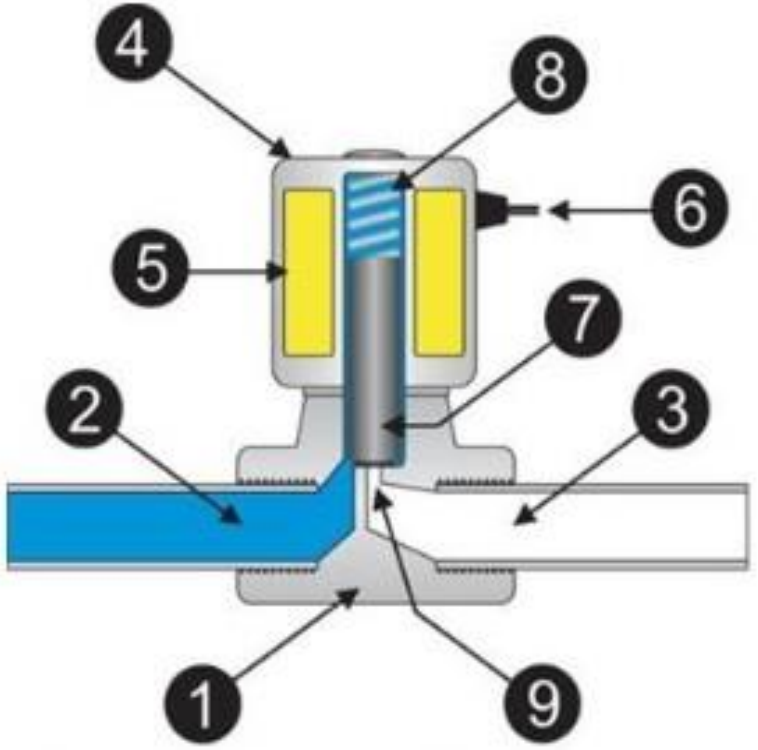
1) Valve body
2) Inlet port
3) Outlet port
4) Coil / Solenoid
5) Coil winding
6) Lead wires
7) Plunger or piston
8) Spring
9) Orifice

6. **Lead Wire** - These are external connections of the solenoid valve that are connected to the electrical supply. The current is supplied through these wires.

7. **Plunger/piston** – It is solid round metallic shape cylindrical in shape and placed in hollow portion of solenoid valve.

8. **Spring** – Purpose of spring is to restrict movement of plunger

9. **Orifice** – It is a part through which fluid is flowing, it is connection between inlet and outlet port.



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7) Plunger or piston
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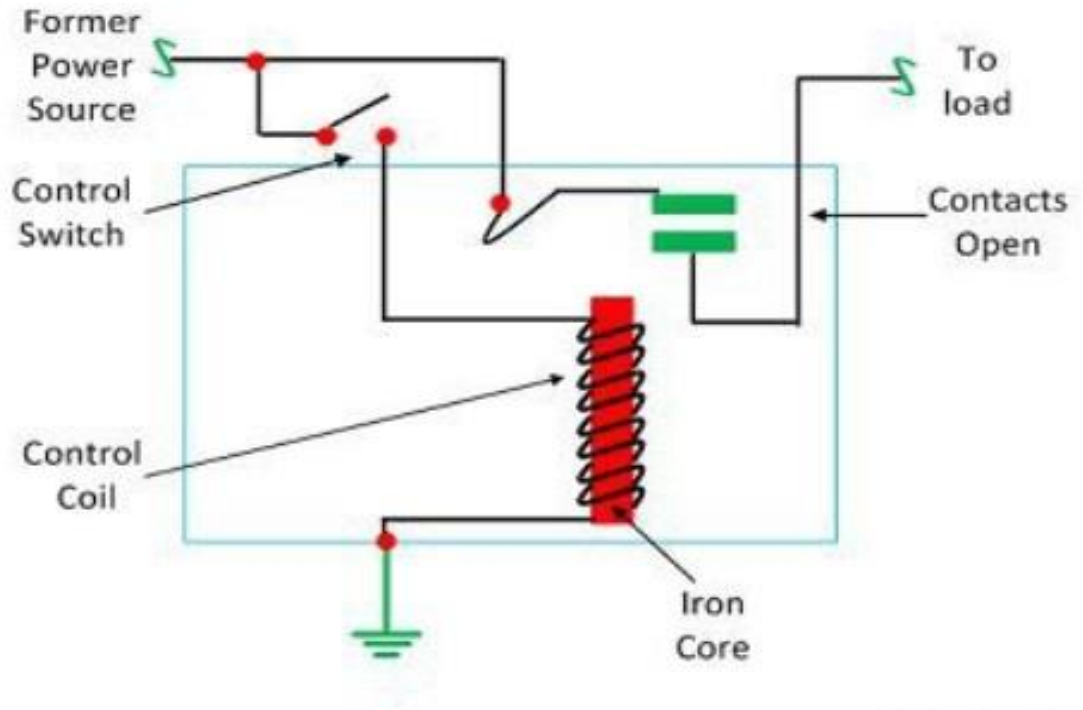
Relay

The relay is the device that open or closes the contacts to cause the operation of the other electric control.

It detects the intolerable or undesirable condition with an assigned area and gives the commands to the circuit breaker to disconnect the affected area. Thus protects the system from damage



Construction of relay

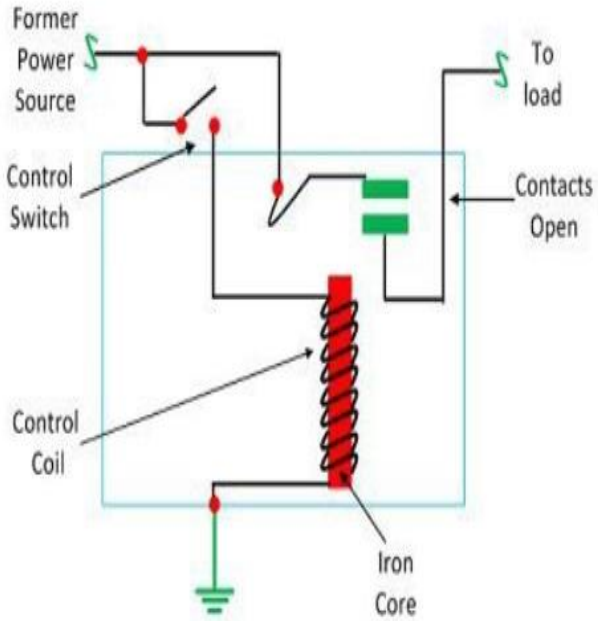
Contacts - The contacts are the most important part of the relay that affects the reliability. The good contact gives limited contact resistance and reduced contact wear.

The selection of the contact material depends upon the several factors like nature of the current to be interrupted, the magnitude of the current to be interrupted, frequency and voltage of operation

Bearing - The bearing may be a single ball, multi-ball, pivot-ball and jewel bearing. The single ball bearing is used for high sensitivity and low friction. The multi-ball bearing provides low friction and greater resistance to shock

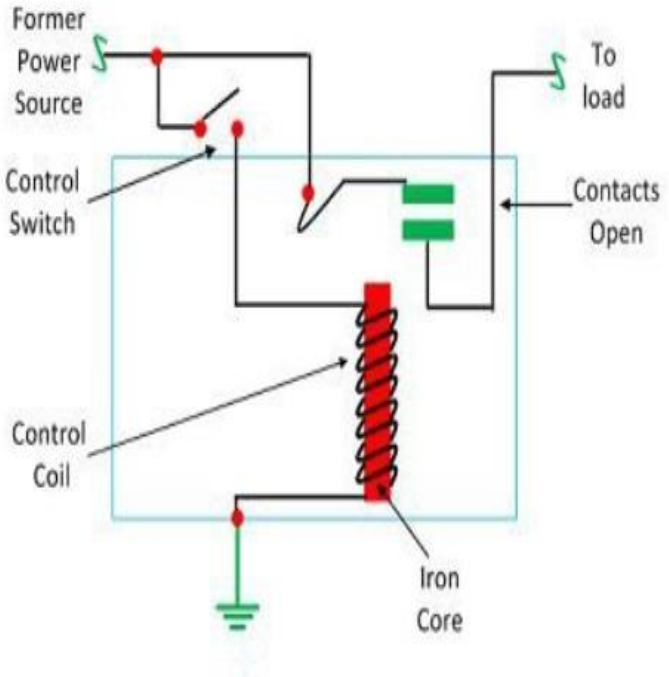
Electromechanical design - The electromechanical design includes the design of the magnetic circuit and the mechanical attachment of core, yoke and armature

Terminations and Housing – The assembly of an armature with the magnet and the base is made with the help of spring. The spring is insulated from the armature by moulded blocks which provide dimensional stability.



Working

- It works on the principle of an electromagnetic attraction. When the circuit of the relay senses the fault current, it energises the electromagnetic field which produces the temporary magnetic field.
- Due to this magnetic field, the upper arm of the magnet attracts the lower arm. Hence close the circuit, which makes the current flow through the load



Switches

The switch is an electrical device that is used to break or make an electrical circuit manually or automatically. The working principle of switch depends on ON/ OFF mechanism.

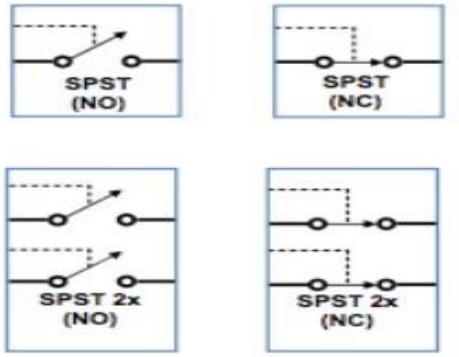
Two essential components in switch

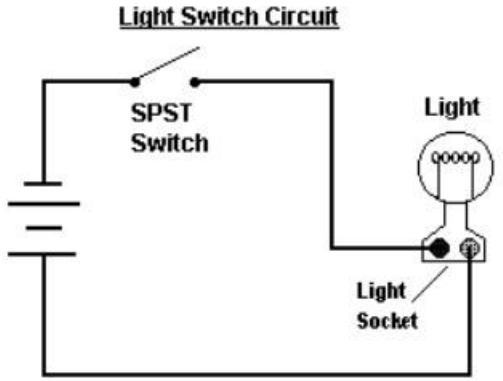
1. Poles – Number of circuit controlled by switch
2. Throw – Number of position the switch can adopt

Types of switches:

- SPST (Single Pole Single throw)
- SPDT (single pole double throw)
- DPST (double pole, single throw)
- DPDT (double pole double throw)

1. SPST (Single pole single throw): The SPST is a basic ON/OFF switch, that is used to connect or break the connection between two terminals

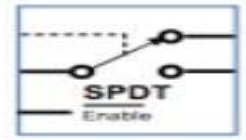


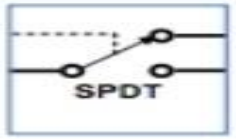


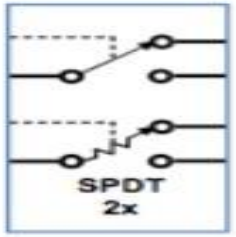
- The application of SPST switch is light switch mentioned above and it is also called as a toggle switch.
- This type of switch has one input and one output.
- This light switch circuit controls one wire and makes one connection

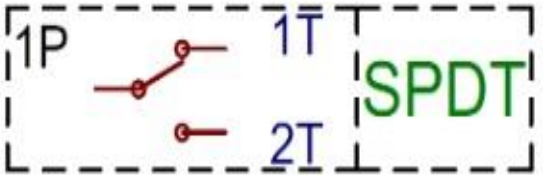
2. SPDT (Single Pole Double Throw) :

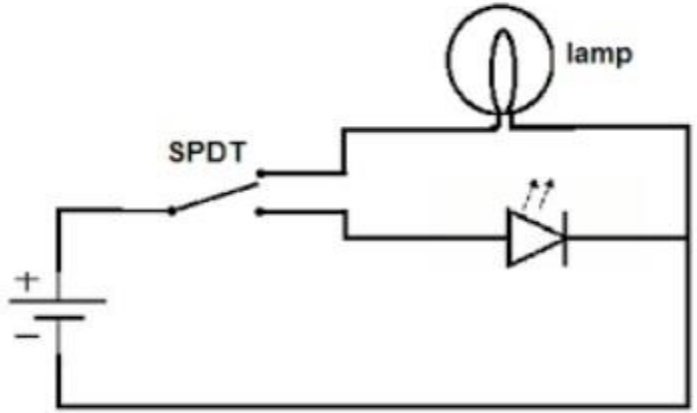
The SPDT switch is a three terminal switch, one terminal is used as input and remaining two terminals are used as outputs





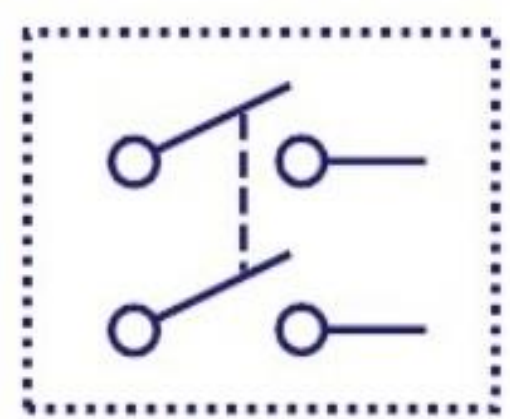






3. DPST (Double pole single throw)

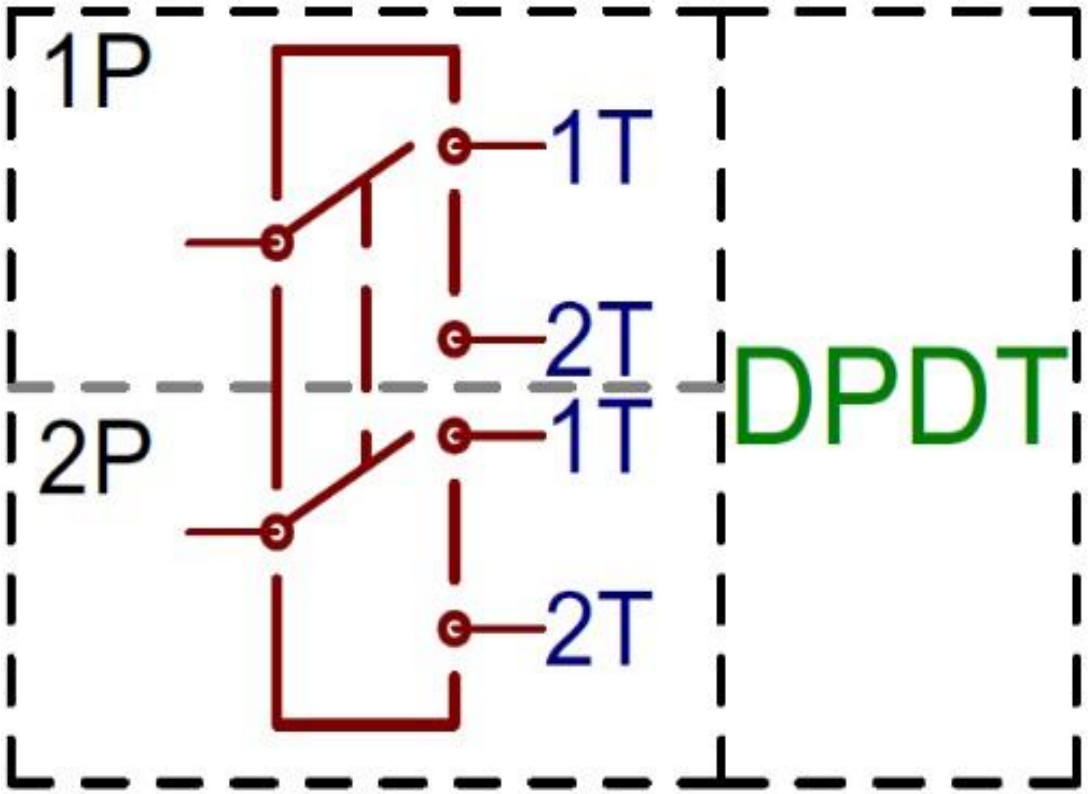
The DPST switch consists of two poles that means it includes two identical switches located on side by side



Symbol

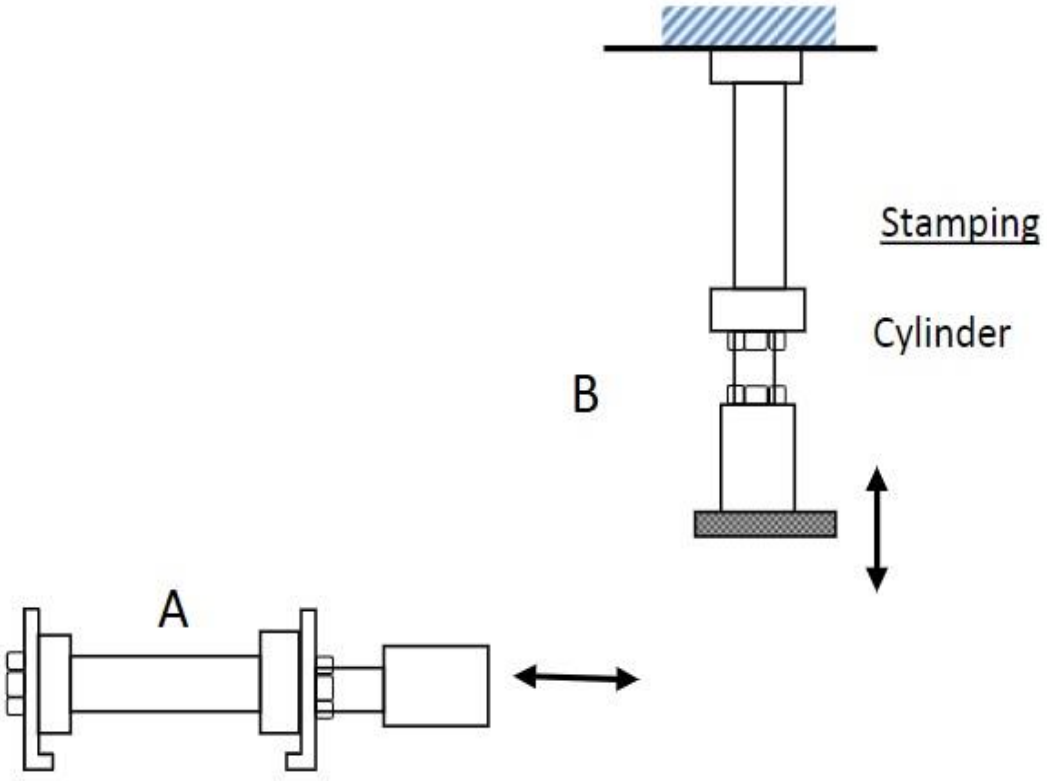
DPST Switch

4. DPDT (Double pole Double throw):



The statement of the problem:

Let A be the clamping cylinder and B be the stamping cylinder. First cylinder A extends and brings under stamping station where cylinder B is located. Cylinder B then extends and stamps the job. Cylinder A can return back only cylinder B has retracted fully.

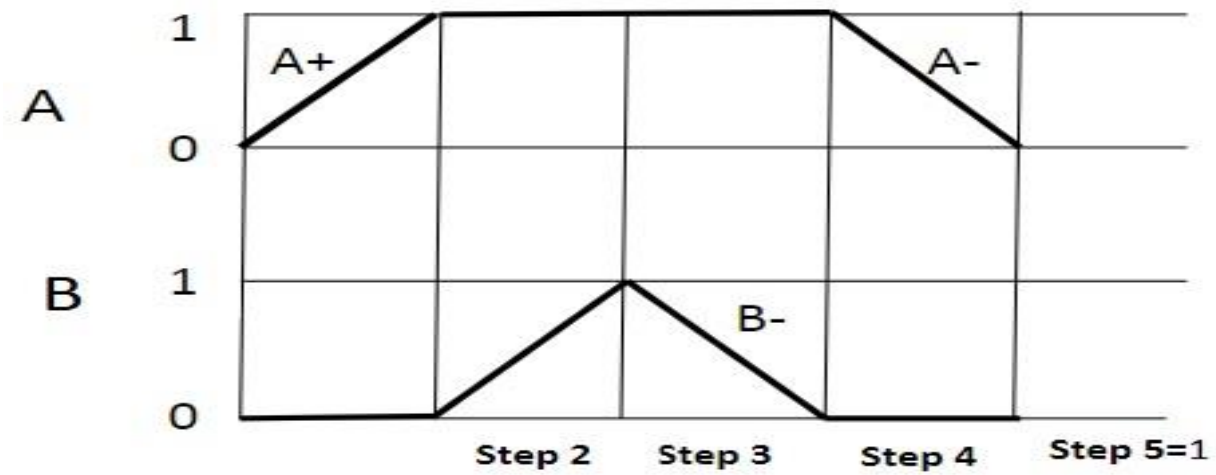


The notational form representation

- Cylinder A advancing step is designated as A+
- Cylinder A retracting step is designated as A-
- Cylinder B advancing step is designated as B+
- Cylinder B retracting step is designated as B-

Given sequence for clamping and stamping is A+B+B-A-

Displacement step diagram:



Input Signals

Cylinder A — Limit switch at home position ao
Limit switch at home position a1
Cylinder B - Limit switch at home position bo
Limit switch at home position b1

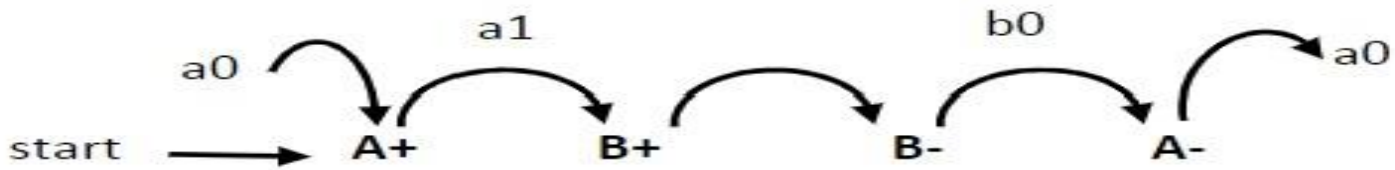
Output Signal

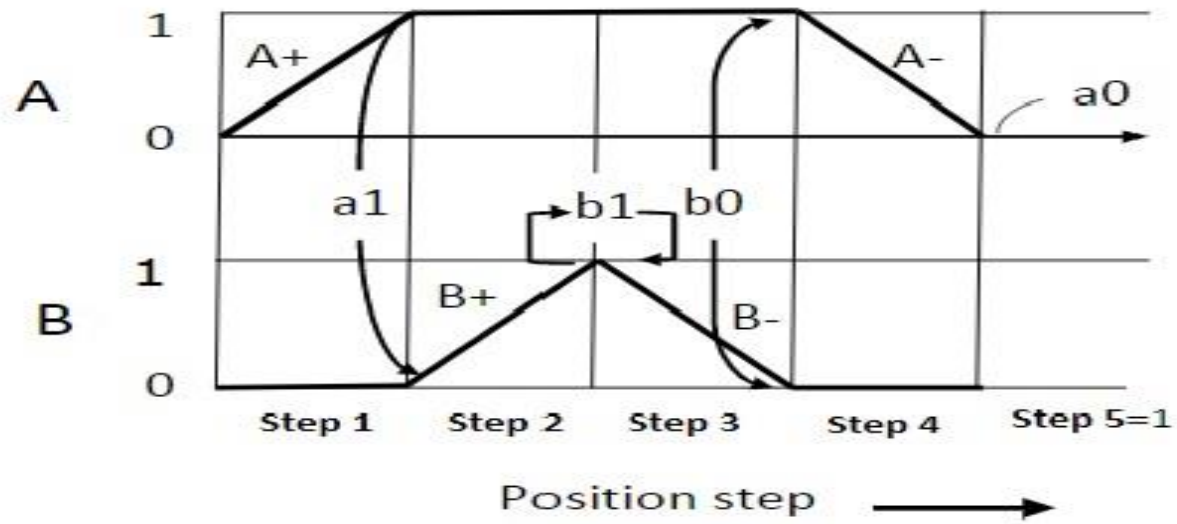
Forward motion of cylinder A (A+)
Return motion of cylinder A (A-)
Forward motion of cylinder B(B+)
Return motion of cylinder B(B+)

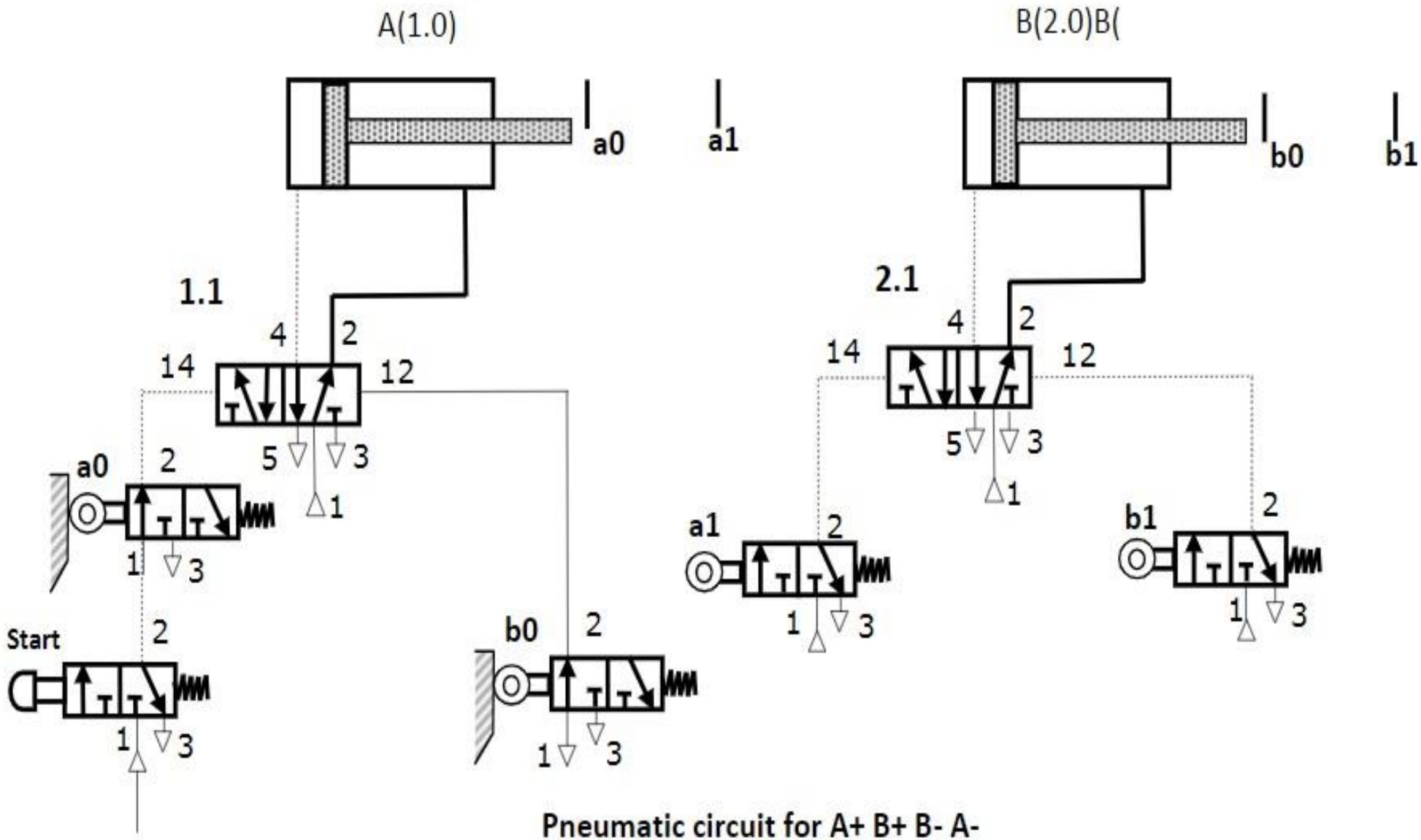
Usually start signal is also required along with a0 signal for obtaining A+ motion.

1. A+ action generates sensor signal a1, which is used for B+ motion
2. B+ action generates sensor signal b1, which is used for B- motion
3. B- action generates sensor signal b0, which is used for A- motion
4. A- action generates sensor signal a0, which is used for A+ motion

Above information (given in 6.2) is shown below graphically

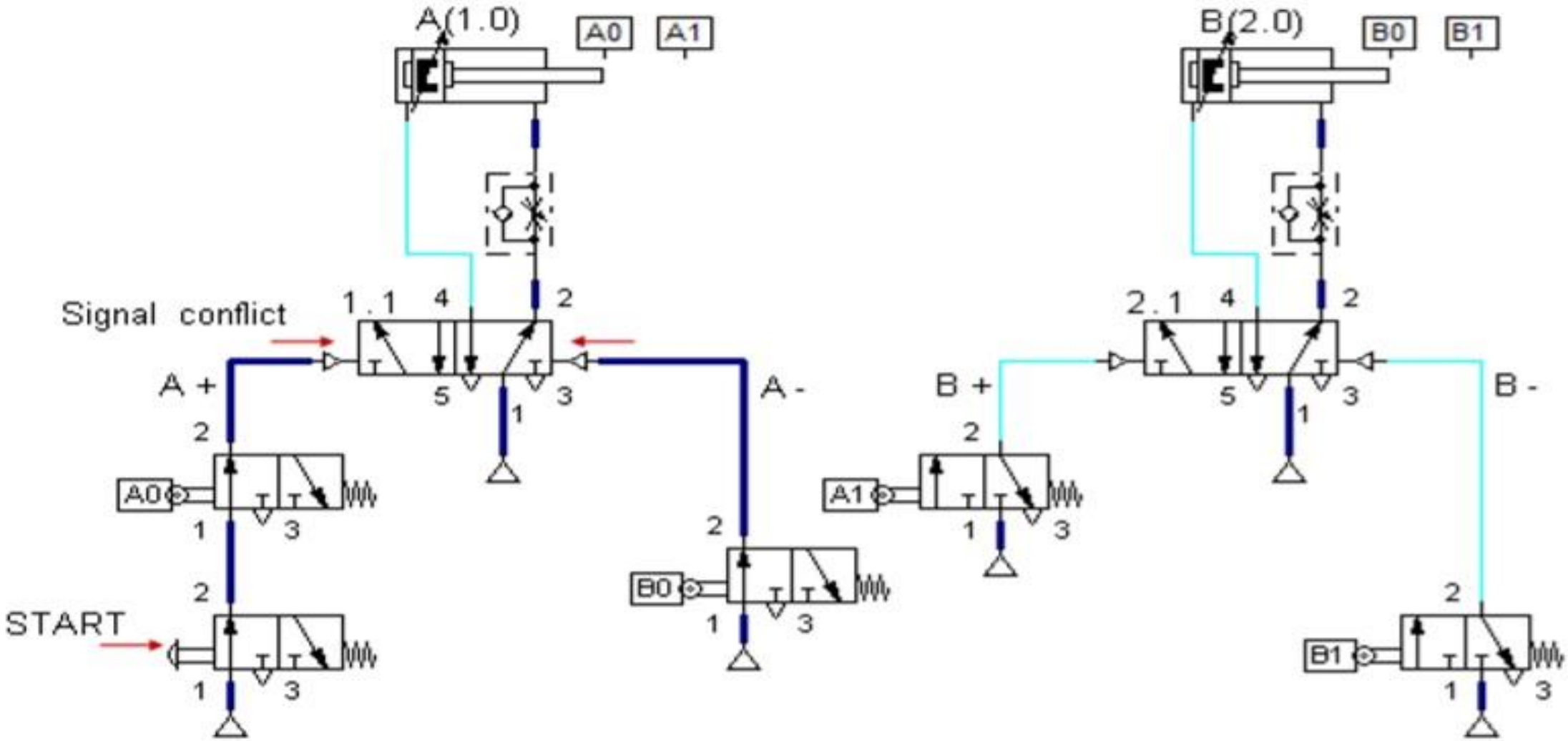




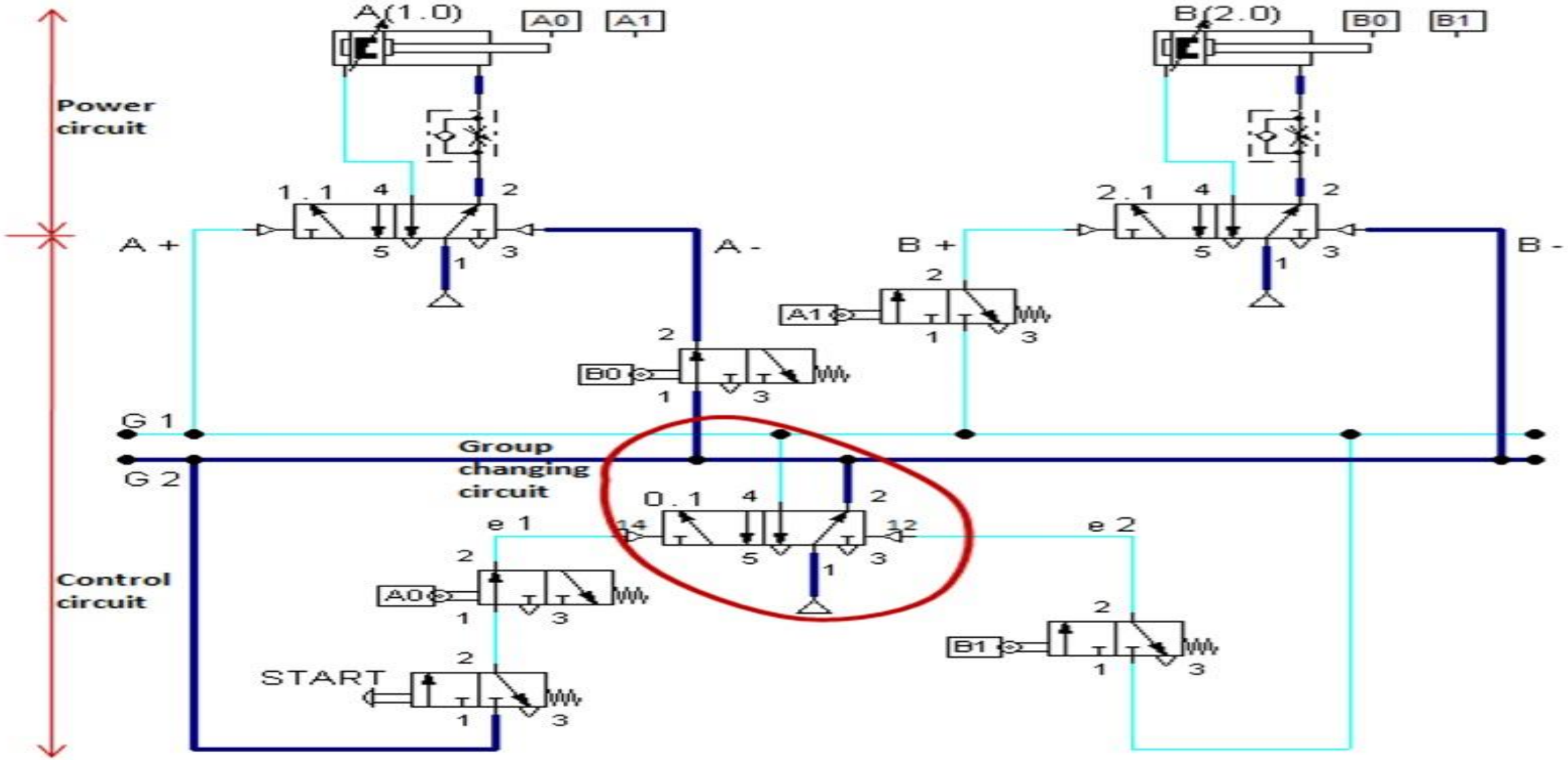


Pneumatic circuit for A+ B+ B- A-

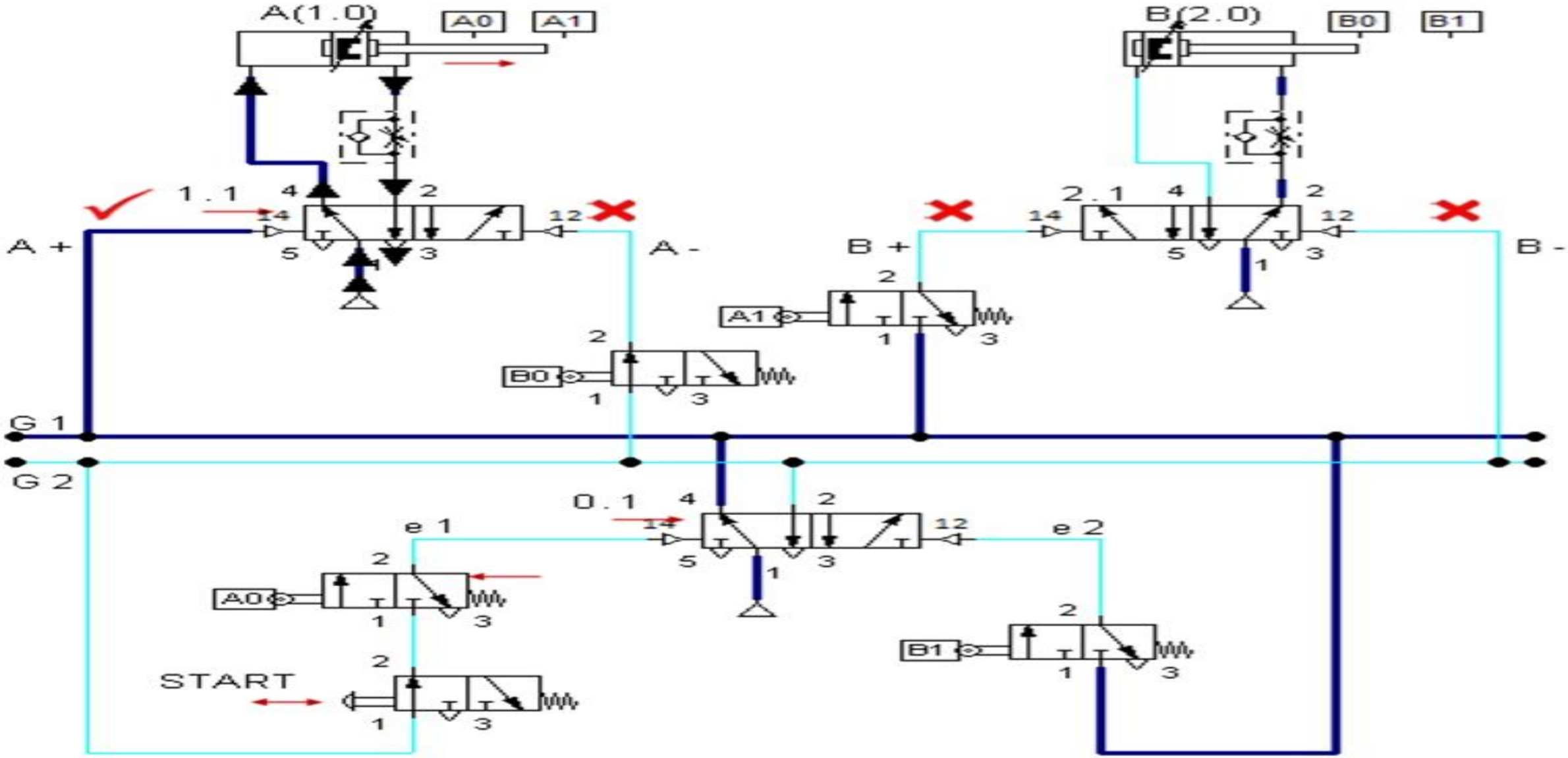
Signal Conflict



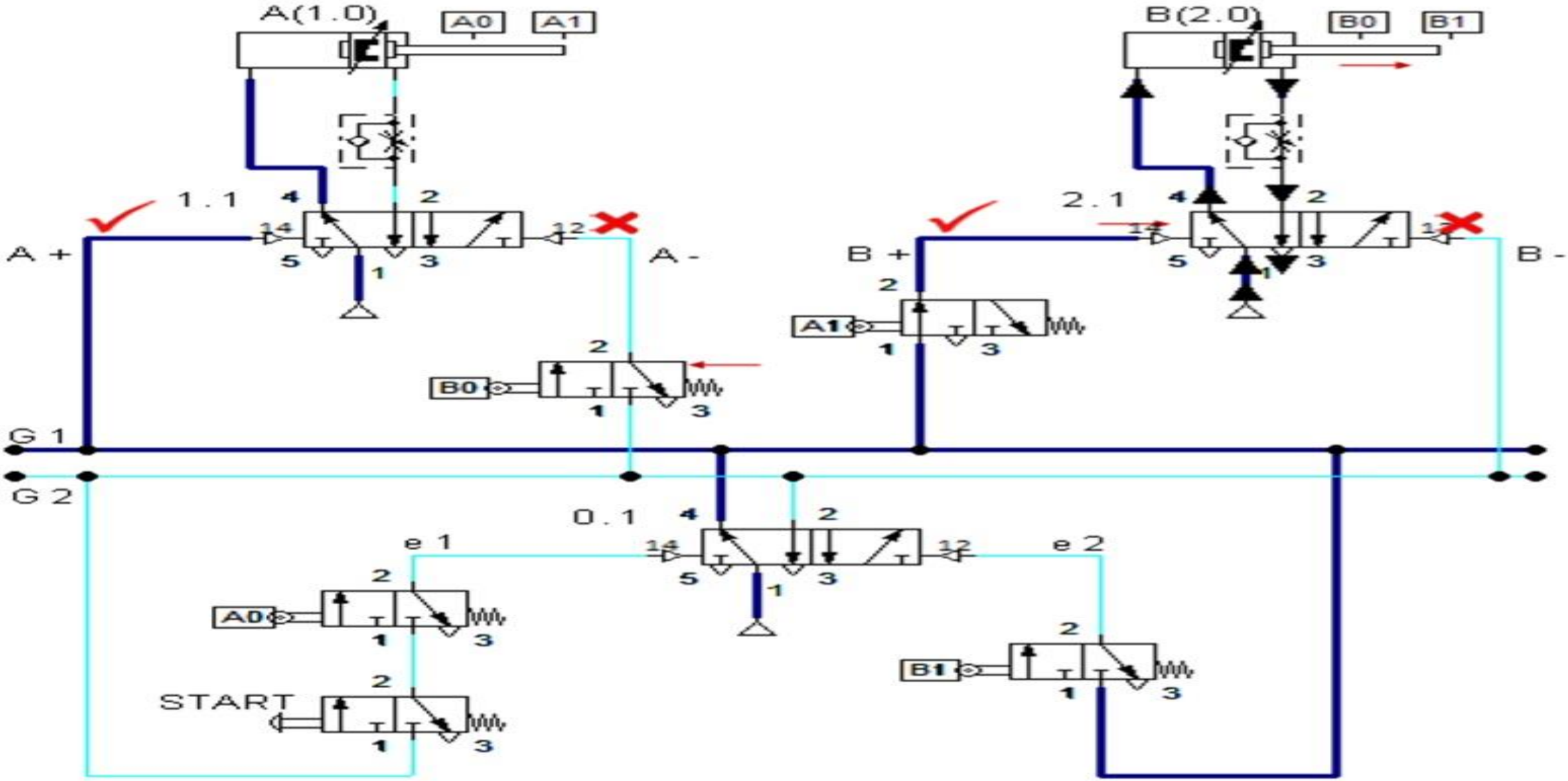
Cascade circuit diagram



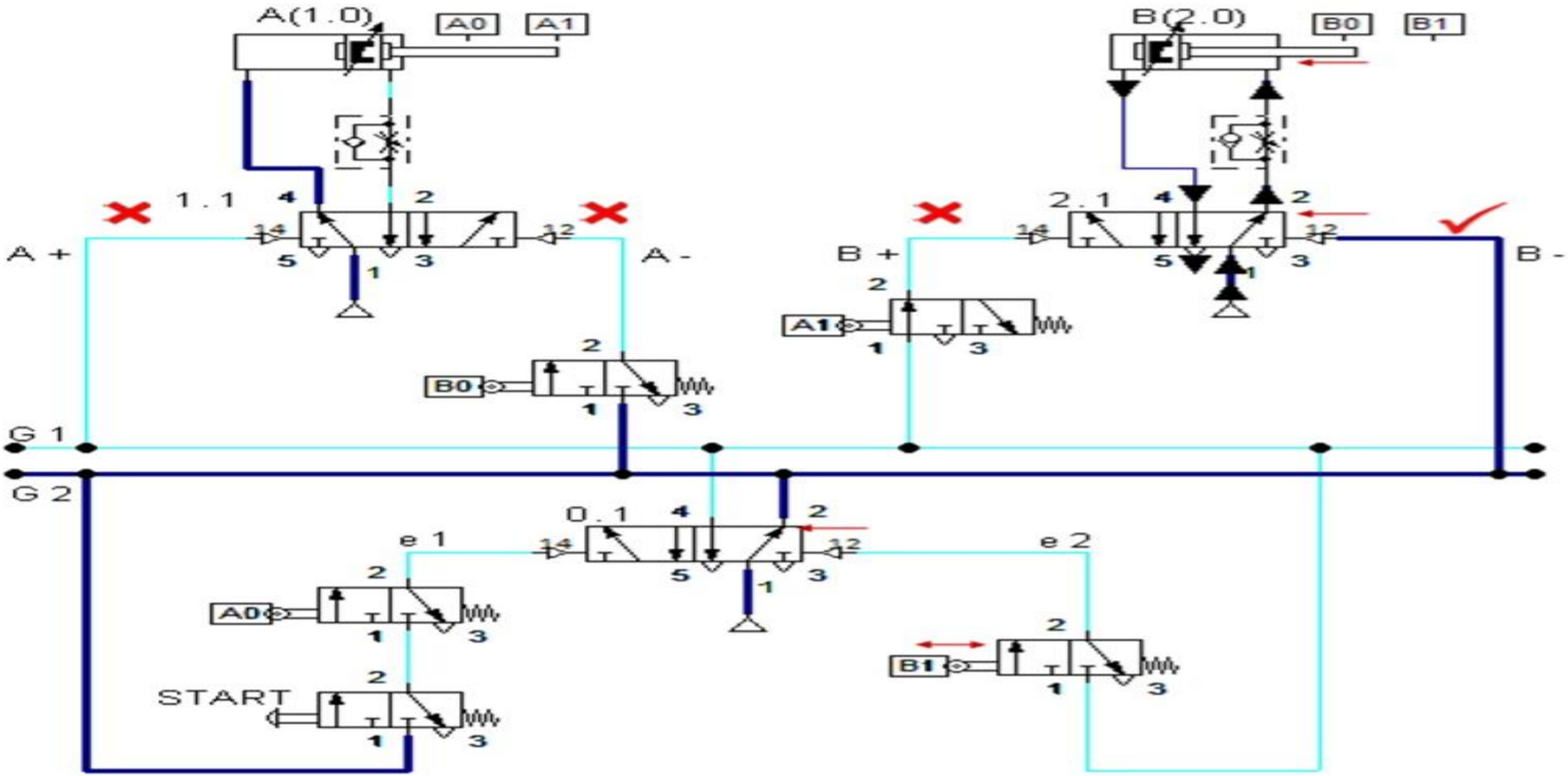
Circuit position during A+



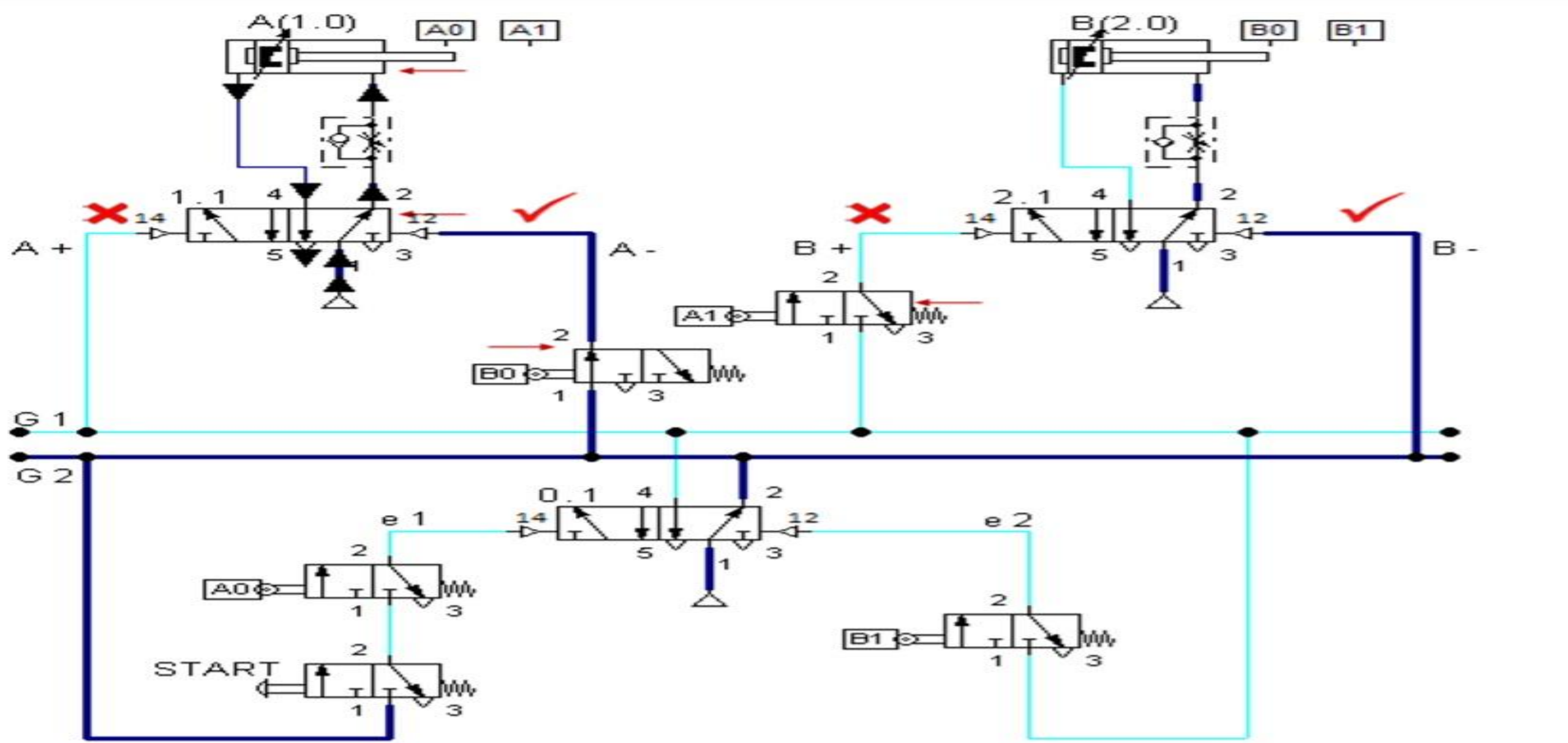
Circuit position during B+



Circuit position during B-

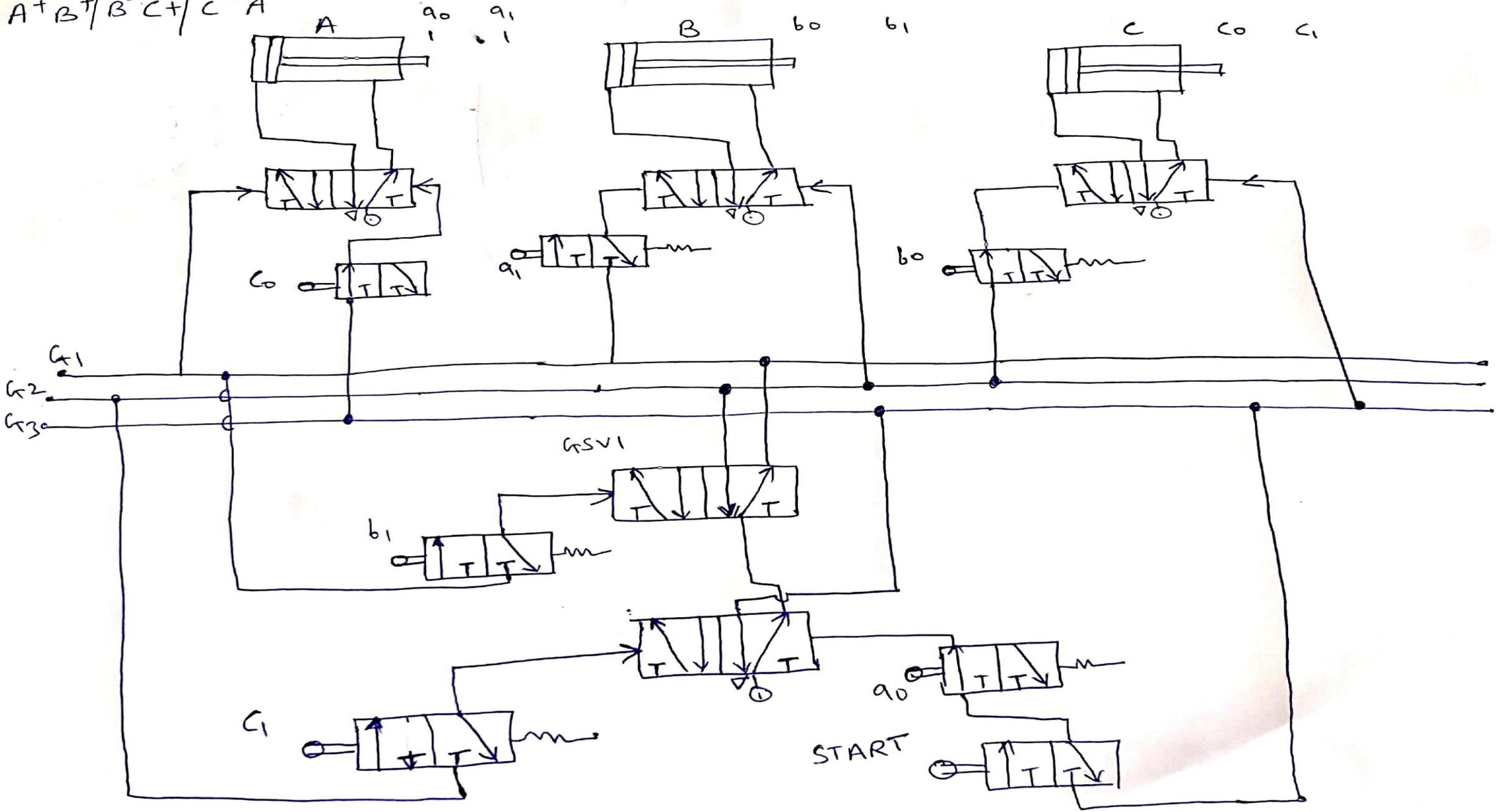


Circuit position during A-

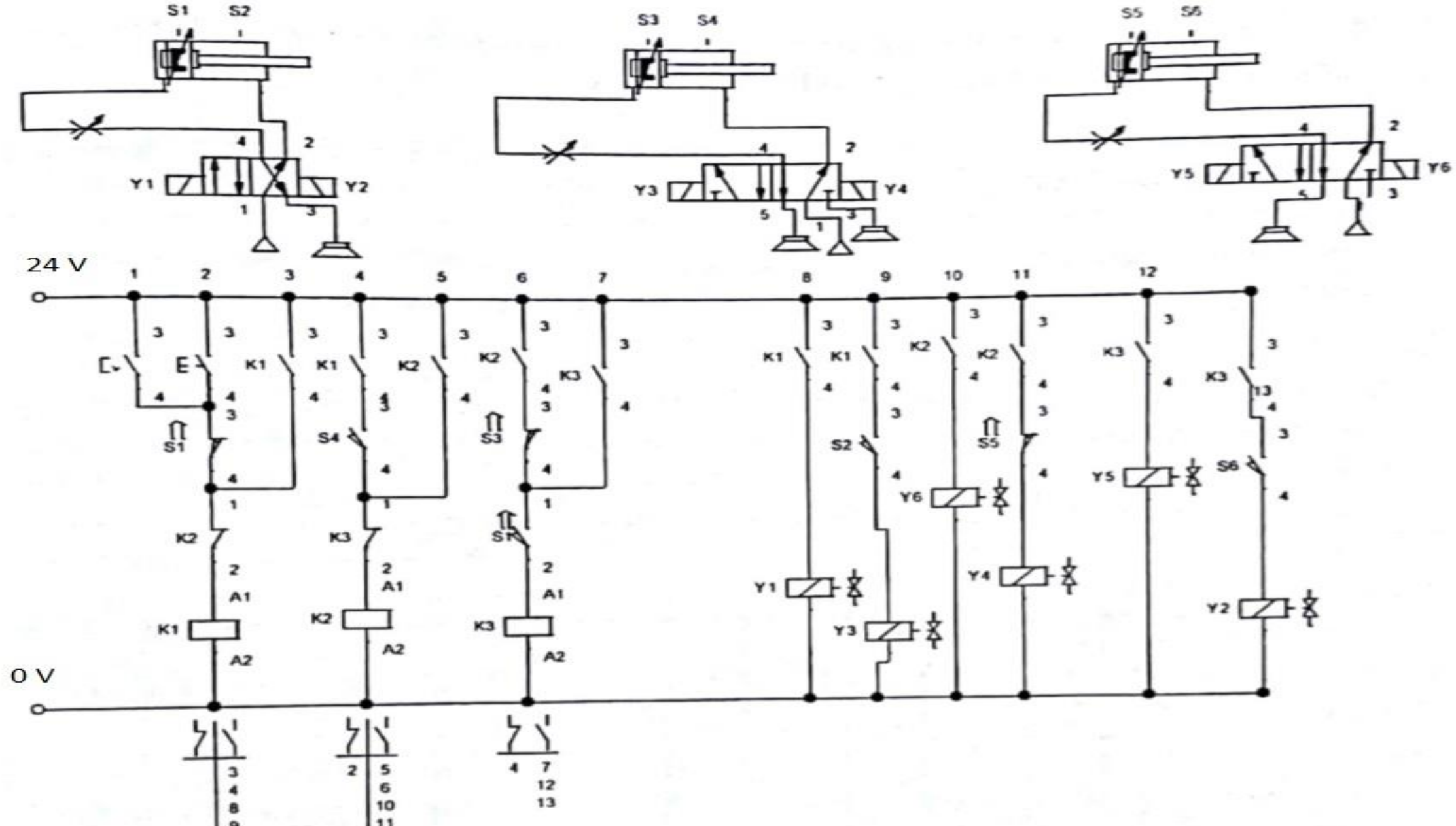


I II III

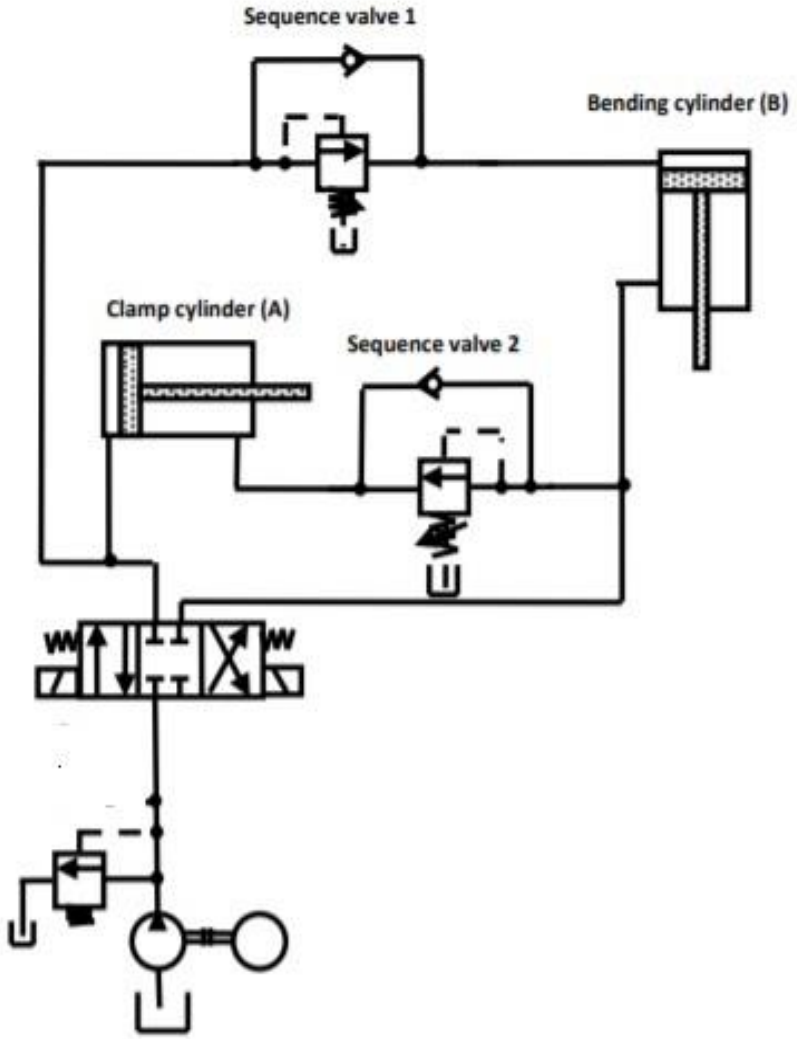
$A^+B^+/B^-C^+/C^-A^-$



A+B+C-B-C+A-



Sequential Circuit



- Cylinder A is used as a clamp cylinder and cylinder B as a drill cylinder
- Cylinder A extends and clamps a work piece. Then cylinder B extends to drive a spindle to drill a hole
- Cylinder B retracts the drill spindle and then cylinder A retracts to release the work piece for removal