1

INTRODUCTION

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1.1 Introduction

In the industry, we use three methods for transmitting power from one point to another. Mechanical transmission is through shafts, gears, chains, belts, etc. Electrical transmission is through wires, transformers, etc. Fluid power is through liquids or gas in a confined space. In this chapter, we shall discuss the structure of hydraulic systems and pneumatic systems. We will also discuss the advantages and disadvantages and compare hydraulic, pneumatic, electrical, and mechanical systems.

1.2 Fluid Power And It's Scope

- Fluid power is the technology that deals with the generation, control, and transmission of forces and movement of mechanical elements or systems with the use of pressurized fluids in a confined system. Both liquids and gases are considered fluids. The fluid power system includes a hydraulic system (hydra meaning water in Greek) and a pneumatic system (pneuma meaning air in Greek). Oil hydraulic employs pressurized liquid petroleum oils and synthetic oils, and pneumatic employs compressed air that is released to the atmosphere after performing the work.
- Perhaps it would be so that we clarify our thinking on one point. By the term "fluid" we refer to air or oil, for it has been shown that water has certain drawbacks in the transmission of hydraulic power in machine operation and control. Commercially, pure water contains various chemicals (some deliberately included) and also foreign matter, and unless special precautions are taken when it is used, it is nearly impossible to maintain valves and working surfaces in satisfactory condition. In the cases where the hydraulic system is closed (i.e., the one with a self-contained unit that serves one machine or one small group of machines), oil is commonly used, thus providing, in addition to power transmission, benefits of lubrication not afforded by water as well as increased life and efficiency of packings and valves. It should be mentioned that in some special cases, soluble oil diluted with water is used for safety reasons. The application of fluid power is limited only by the ingenuity of the designer, production engineer, or plant engineer. If the application pertains to lifting, pushing, pulling, clamping, tilting, forcing, pressing or any other straight line (and many rotaries) motions, it is possible that fluid power will meet the requirement.
- **Fluid power applications can be classified into two major segments:**
    - **Stationary hydraulics:** Stationary hydraulic systems remain firmly fixed in one position. The characteristic feature of stationary hydraulics is that valves are mainly solenoid operated. The applications of stationary hydraulics are as follows:
        - Machine tools and transfer lines.
        - Lifting and conveying devices.
        - Metal-forming presses.
        - Plastic machinery such as injection-molding machines.
        - Rolling machines.
        - Lifts.
        - Food processing machinery.
        - Automatic handling of equipment and robots.
        - Production and assembly of vehicles of all types.
    - **Mobile hydraulics:** Mobile hydraulic systems move on wheels or tracks such as a tower crane or excavator truck to operate in many different locations or while moving. A characteristic feature of mobile hydraulics is that the valves are frequently manually operated. The applications of mobile hydraulics are as follows:
        - Automobiles, tractors, airplanes, missiles, boats, etc.
        - Construction machinery.

- Tippers, excavators, and elevating platforms.
- Lifting and conveying devices.
- Agricultural machinery.

▶ Hydraulics and pneumatics have almost unlimited applications in the production of goods and services in nearly all sectors of the country. Several industries are dependent on the capabilities that fluid power affords.

Table 1.1 - More applications of fluid power

Agriculture	Tractors; farm equipment such as mowers, plows, chemical and water sprayers, fertilizer spreaders, harvesters
Automation	Automated transfer lines, robotics
Automobiles	Power steering, power brakes, suspension systems, hydrostatic transmission
Aviation	Fluid power equipment such as landing wheels in aircraft. Helicopters, aircraft trolleys, aircraft testbeds, luggage loading and unloading systems, ailerons, aircraft servicing, flight simulators
Construction industry/equipment	For metering and mixing of concrete rudders, excavators, lifts, bucket loaders, crawlers, post-hole diggers, road graders, road cleaners, road maintenance vehicles, tippers
Defense	Missile-launching systems, navigation controls
Entertainment	Amusement park entertainment rides such as roller coasters
Fabrication industry	Hand tools such as pneumatic drills, grinders, borers, riveting machines, nut runners
Food and beverage	All types of food processing equipment, wrapping, bottling,
Foundry	Full and semi-automatic molding machines, tilting of furnaces, die-casting machines
Glass industry	Vacuum suction cups for handling
Instrumentation	Used to create/operate complex

	instruments in space rockets, gas turbines, nuclear power plants, industrial labs
Jigs and fixtures	Work holding devices, clamps, stoppers, indexers
Machine tools	Automated machine tools, numerically controlled(NC) machine tools
Materials handling	Jacks, hoists, cranes, forklifts, conveyor systems
Medical	Medical equipment such as breathing assistors, heart assist devices, cardiac compression machines, dental drives, and human patient simulator
Movies	Special-effect equipment use fluid power; movies such as Jurassic Park, Jaws, Anaconda, Titanic
Mining	Rock drills, excavating equipment, ore conveyors, loaders
Newspapers and periodicals	Edge trimming, stapling, pressing, bundle wrapping
Oil industry	Off-shore oil rigs
Paper and packaging	Process control systems, special-purpose machines for rolling and packing
Pharmaceuticals	Process control systems such as bottle filling, tablet placement, packaging
Plastic industry	Automatic injection molding machines, raw material feeding, jaw closing, movement of slides of blow molder
Press tools	Heavy-duty presses for bulk metal formation such as sheet metal, forging, bending, punching, etc.
Printing industry	For paper feeding, packaging
Robots	Fluid power operated robots, pneumatic systems

Ships	Stabilizing systems, unloading and loading unit, gyroscopic instruments, movement of flatforms, lifters, subsea inspection equipment
Textiles	Web tensioning devices, trolleys, process controllers
Transportation	Hydraulic elevators, winches, overhead trams
Undersea	Submarines, undersea research vehicles, marine drives, and control of ships
Woodworking	Tree shearers, handling huge logs, feeding clamping and saw operations

- **The following are the two types of hydraulic systems:**

  Fluid transport systems: Their sole objective is the delivery of a fluid from one location to another to accomplish some useful purpose. Examples include pumping stations for pumping water to homes, cross-country gas lines, etc.

  Fluid power systems: These are designed to perform work. In fluid power systems, work is obtained by a pressurized fluid acting directly on a fluid cylinder or a fluid motor. A cylinder produces a force resulting in linear motion, whereas a fluid motor produces a torque resulting in rotary motion.

1.3 Classification of Fluid Power Systems

The fluid power system can be categorized as follows:

1.3.1 Based on the control system

- **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. The open-loop system is not accurate and error can be reduced by proper calibration and control.
- **Closed-loop system:** This system uses feedback. 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. The error is used to change the actual output and bring it closer to the desired value. A simple closed-loop system uses servo valves and an advanced system uses digital electronics.

1.3.2 Based on the type of control

- **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. Two types of fluid logic systems are available:
  - **Moving part logic (MPL):** These devices are miniature fluid elements using moving parts such as diaphragms, disks, and poppets to implement various logic gates.

- **Fluidics:** Fluid devices contain no moving parts and depend solely on interacting fluid jets to implement various logic gates.

- **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. These devices help to control the starting, stopping, sequencing, speed, positioning, timing, and reversing of actuating cylinders and fluid motors. Electrical control and fluid power work well together where the remote control is essential.
- **Electronic control:** This type of system is controlled by microelectronic devices. The electronic brain is used to control the fluid power muscles for doing work. This system uses the most advanced type of electronic hardware including programmable logic control (PLC) or microprocessor (P). In the electrical control, a change in system operation results in a cumbersome process of redoing hardware connections. The difficulty is overcome by programmable electronic control. The program can be modified or a new program can be fed to meet the change of operations. Many such programs can be stored in these devices, which makes the systems more flexible.

1.4 Hydrostatic and Hydrodynamic Systems

- A hydrostatic system uses fluid pressure to transmit power. Hydrostatics deals with the mechanics of still fluids and uses the theory of equilibrium conditions in the fluid. The system creates high pressure, and through a transmission line and a control element, this pressure drives an actuator (linear or rotational).
- The pump used in hydrostatic systems is a positive displacement pump. The relative spatial position of this pump is arbitrary but should not be very large due to losses (must be less than 50 m). An example of pure hydrostatics is the transfer of force in hydraulics.
- Hydrodynamic systems use fluid motion to transmit power. Power is transmitted by the kinetic energy of the fluid. Hydrodynamics deals with the mechanics of moving fluid and uses flow theory. The pump used in hydrodynamic systems is a non-positive displacement pump.
- The relative spatial position of the prime mover (e.g., turbine) is fixed. An example of pure hydrodynamics is the conversion of flow energy in turbines in hydroelectric power plants.
- In oil hydraulics, we deal mostly with the fluid working in a confined system, that is, a hydrostatic system.

1.5 Advantages of A Fluid Power System

- Oil hydraulics stands out as the prime moving force in machinery and equipment designed to handle medium to heavy loads. In the early stages of industrial development, mechanical linkages were used along with prime movers such as electrical motors and engines for handling loads. But the mechanical efficiency of linkages was very low and the linkages often failed under critical loading conditions. With the advent of fluid power technology and associated electronics and control, it is used in every industry now.
- The advantages of a fluid power system are as follows:

1. **Fluid power systems are simple, easy to operate, and can be controlled accurately:** Fluid power gives flexibility to equipment without requiring a complex mechanism. Using fluid power, we can start, stop, accelerate, decelerate, reverse, or position large forces/components with great accuracy using simple levers and push-buttons. For example, in earth-moving equipment, a bucket carrying a load can be raised or lowered by an operator using a lever. The landing gear of an aircraft can be retrieved to the home position by the push button.
2. **Multiplication and variation of forces:** Linear or rotary force can be multiplied by a fraction of a kilogram to several hundreds of tons.
3. **Multifunction control:** A single hydraulic pump or air compressor can provide power and control for numerous machines using valve manifolds and distribution systems. The fluid power controls can be placed at a central station so that the operator has, at all times, complete control of the entire production line, whether it be a multiple operation machine or a group of machines. Such a setup is more or less standard in the steel mill industry.
4. **Low-speed torque:** Unlike electric motors, air or hydraulic motors can produce a large amount of torque while operating at low speeds. Some hydraulic and pneumatic motors can even maintain torque at a very slow speed without overheating.
5. **Constant force or torque:** Fluid power systems can deliver constant torque or force regardless of speed changes.
6. **Economical:** Not an only reduction in required manpower but also the production or elimination of operator fatigue, as a production factor, is an important element in the use of fluid power.
7. **Low weight to power ratio:** The hydraulic system has a low weight to power ratio compared to electromechanical systems. Fluid power systems are compact.
8. **Fluid power systems can be used where safety is of vital importance:** Safety is of vital importance in air and space travel, in the production and operation of motor vehicles, in mining and manufacture of delicate products. For example, hydraulic systems are responsible for the safety of take-off, landing, and flight of airplanes and spacecraft. Rapid advances in mining and tunneling are the results of the application of modern hydraulic and pneumatic systems.

1.6 General Layout of Hydraulic System

Components of Hydraulic System

- A basic hydraulic system has the following components:

1. Oil reservoir	2. Rotary pump
3. Pressure relief valve	4. Direction control valve
5. Flow control valve	6. Double-acting cylinder
7. Pressure gauge	8. Filter

Oil Reservoir

- The main function of the "oil reservoir" is to store a sufficient amount of hydraulic oil in the system.
- Apart from this, it has other important functions such as:

(a) To cool the hot return oil.

(b) To settle down the contaminants.

(c) To remove air bubbles.

(d) To separate water from the oil.

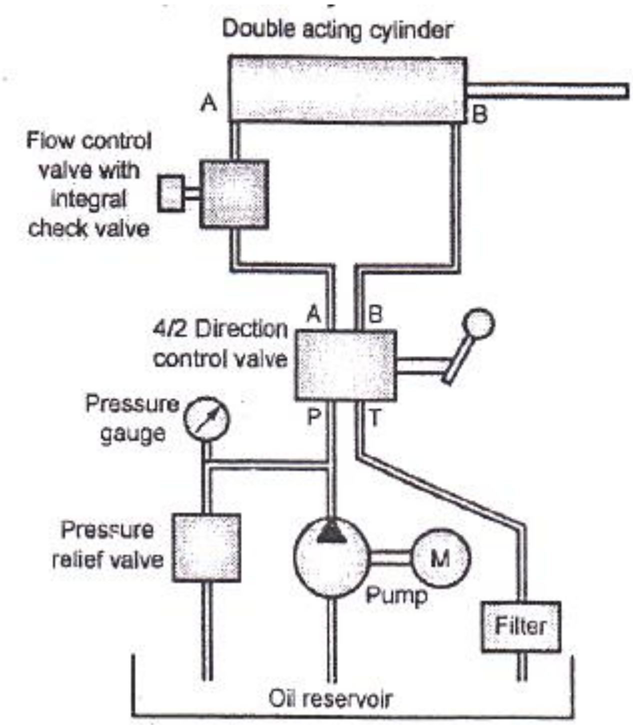

Fig.1.1 - Layout of general hydraulic system

Rotary pump

- The function of the rotary pump is to pump hydraulic oil to the hydraulic circuit'.
- It converts the mechanical energy (rotation of shaft) into hydraulic energy.
- A rotary pump is a positive displacement pump. It can deliver constant flow even at high pressure.

Pressure relief valve

- It is an important component which is required for every positive displacement pump
- This valve is connected to the outlet of the pump. Its main function is to release the oil back tank when the pressure increases beyond the pre-set value.

Direction control valve

- It controls the direction of the flow of oil, by which it performs extension and retraction of the actuator.

Flow control valve

- It Controls the rate of flow of oil by which the speed of extension or retraction of the actuator is controlled.

Actuator

- The actuator produces work. There are two types, linear actuator, and rotary actuator.

- The linear actuator is called a cylinder, the rotary actuator is called a motor.
- A double-acting cylinder develops force and motion. It converts hydraulic energy into mechanical energy.

Force developed = Pressure of oil x Area of a piston

Pressure gauge

- It is an important component of the hydraulic system.
- It shows the pressure reading.
- Pressure settings are made by looking at the pressure gauge.
- Without a pressure gauge, it is not possible to make the pressure relief valve setting, unloading valve settings, etc.

Filter

- Its main function is to remove suspended solid contaminants from the oil and to provide clean hydraulic oil to the system.

1.7 Advantages of Hydraulic System

- Hydraulic power is easy to produce, transmit, store, regulate and control, maintain, and transform.
- The weight to power ratio of a hydraulic system is comparatively less than that for an electro-mechanical system. (About 8.5 kg/kW for electrical motors and 0.g5 kg/kW for a hydro system).
- It is possible to generate a high gain in force and power amplification.
- Hydraulic systems are uniform and smooth, generate step-less motion and variable speed and force to greater accuracy.
- The division and distribution of hydraulic power are simpler and easier than other forms of energy.
- Limiting and balancing of hydraulic forces are easily performed.
- Frictional resistance is much less in a hydraulic system as compared to a mechanical movement.
- Hydraulic elements can be located at any place and controlled reversely.
- The noise and vibration produced by hydraulic pumps are minimal.
- Hydraulic systems are cheaper if one considers the high efficiency -of power transmission.
- Easy maintenance of a hydraulic system is another advantage.
- Hydraulics is mechanically safe, compact, and is adaptable to other forms of power, and can be easily controlled.
- Hydraulic output can be both linear, rotational, and angular. The use of flexible connections in the hydraulic system permits the generation of compound motion without gears etc.
- Hydraulics is a better over-load safe power system. This can be easily achieved by using a pressure relief valve.

- Accurate feedback of load, position, etc. can be achieved in a hydraulic system as an electro-hydraulic and digital electronic servo system. Because of high power and accurate control possibility, in modem engineering language hydraulics is termed as the muscle of the system and electronics its nerves.

1.8 Disadvantages of Hydraulic System

- Hydraulic elements have to be machined to a high degree of precision which increases the manufacturing cost of the system.
- Certain hydraulic systems are exposed to unfriendly climate and dirty atmosphere as the in case of mobile hydraulics like dumpers, loaders, etc.
- The leakage of hydraulic oil poses a problem for hydraulic users.
- Hydraulic elements have to be specially treated to protect them against rust, corrosion, dirt, etc.
- Hydraulic oil may pose problems if it disintegrates due to aging and chemical deterioration.
- Petroleum-based hydraulic oil may pose fire hazards thus limiting the upper level of working temperature. However, due to the availability of synthetic fire-resistant oils, this problem is of academic interest nowadays. To combat the environmental effects of petroleum and chemical-based oils, efforts are on to use biodegradable oils now.

1.9 Application of Hydraulic System

- Machine tools: CNC (computerized numerical control) machines, hydraulic presses, hydraulic shapers, etc.
- Material handling equipment: Elevators, forklifts, cranes, lifts, and hoists, etc.
- Construction field: Earthmoving machines such as excavators, cranes, dozers, loaders, dumpers, tippers, trucks, tractors, etc.
- Automobiles: Hydraulic brakes, hydraulic steering, hydraulic suspension, hydraulic clutch, hydraulic power transmission, hydraulic coupling,
- Material testing laboratory: UTM (universal testing machine) and other destructive testing Machines, BP (burst pressure) testing machine, etc.
- Aerospace: Landing gear, brakes, flight controls (such as), cargo loading door, rudder, elevator, flap, aileron, etc.
- Railways: Hydraulic brakes, hydraulic steering, hydraulic suspension, hydraulic clutch, hydraulic power transmission, hydraulic coupling hydraulic torque converter, etc.
- Marine field: Ship steering system, shipyards, shipbuilding.
- Medical equipment: Medical chairs and operating tables.
- Agricultural equipment: Harvesters, tractors, field sprayers, seeding machines, fertilizer, machines, etc.

1.10 Difference Between Hydraulic System and pneumatic System

Table 1.2 - Difference between Hydraulic System and pneumatic System

No.	Hydraulic system	Pneumatic system
1	The working fluid is hydraulic oil.	Working fluid is compressed air
2	As oil is incompressible, oil can be pressurized to very high pressure. (500 bar or even more)	Air is compressible; hence air can be pressurized to lesser pressure. (Only up to 10 bar approx.)
3	Since pressure is high, the force developed is also very high (thousands of tones).	Since pressure is very less, the force developed is very less (up to I ton)
4	Since pressure is high, components are very strong, made of steel, and are heavy.	Components of the pneumatic system are lighter in weight, are made of aluminum.
5	As oil has more viscosity, it cannot flow fast. Hence hydraulic systems are slower in operation.	Air has very less viscosity, it can flow fast. Hence pneumatic systems are quicker in operation.
6	Due to continuous recirculation, the temperature of oil increases.	The harder it runs, the cooler it works. Free expansion of air in cylinders and motors causes a chilling effect.
7	Hydraulic oils are petroleum-based oils; they are inflammable and there is every chance of fire hazard if neglected.	No chance of fire hazard. Hence pneumatic tools are preferably used inside mines, where flammable gasses may present.
8	leakage of oil results in dirty and slippery Surroundings may lead to accidents.	The very clean and dry surrounding is maintained.
9	The pump used is a positive displacement pump, So a pressure relief valve is necessary.	No need for a pressure relief valve.
10	There is no need for a separable lubrication System, because, hydraulic oil itself is a lubricant.	A lubricator is necessary. Oil is mixed with the compressed air in the lubricator and then supplied to the system.
11	Applications: CNC. Machine tools, earth moving machines, automobiles. aviation etc.	Applications: Material handling systems, hand tools mining works, automation, automobiles, etc.

1.11 Principles of Hydraulic Fluid Power

- In the language of physical science, anything that can flow is a fluid. Per the definition of fluid, air, oil, and water are nothing but fluids since all of them can flow. In our discussion here, we will concentrate only on oil as the present-day hydraulic system uses oil. The operation of a fluid power system, i.e. a hydraulic system using oil is governed by the basic physical laws of fluid flow as developed by a great-scientist Blaise Pascal (1648). This law is known as "Pascal's law".

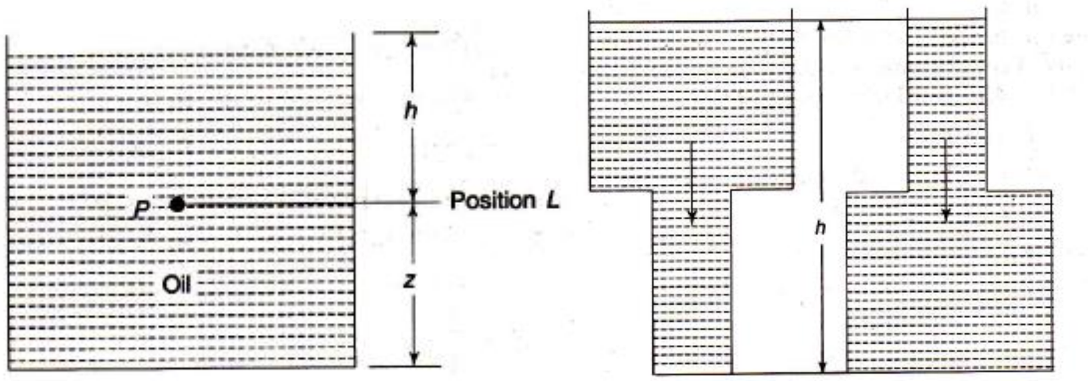

Fig.1.2 - Potential head is independent of shape and size

Law of Hydrostatics

- The law of hydrostatics states that the pressure p of a fluid at rest increases on increasing the depth. This means that,

  p = Pressure = **wh** where,

  w = specific weight of the liquid

  h = depth or 'head' of the fluid

- It refers to a specific datum, the head defined by position L is called the potential head, hand the total head represented by (h + z) is the piezometric head.

$$h + Z = \frac{p}{w} + Z$$

- From the above, we understand that every liquid exerts pressure on its base area by its weight. The pressure is dependent on the height of the liquid column and its density irrespective of the shape or geometry of the container.
- Mathematically Hydrostatic Pressure is equal to

$$p = h * \rho * g$$

h = height of fluid column

ρ = density of liquid

g = acceleration of free fall.

1.12 Basic Electrical Devices

- Seven basic electrical devices commonly used in the control of fluid power systems are:
  1. Manually actuated push button switches
  2. Limit switches
  3. Pressure switches
  4. Solenoids
  5. Relays
  6. Timers
  7. Temperature switches
- Other devices used in electro pneumatics are
  1. Proximity sensors
  2. Electric counters

1.12.1 Push-button switches

- A push-button is a switch used to close or open an electric control circuit. They are primarily used for starting and stopping of operation of machinery.
- They also provide manual override when the emergency arises. Push-button switches are actuated by pushing the actuator into the housing. This causes a set of contacts to open or close.
- Push buttons are of two types
  - **i) Momentary push button**
  - **ii) Maintained contact or detent push button**
- Momentary push buttons return to their un-actuated position when they are released. Maintained (or mechanically latched) pushbuttons have a latching mechanism to hold it in the selected position.
- The contact of the pushbuttons distinguished according to their functions,
  - **i) Normally open (NO) type**
  - **ii) Normally closed (NC) type**
  - **iii) Change over (CO) type**

1.12.2 Limit switches

- Any switch that is actuated due to the position of a fluid power component (usually a piston rod or hydraulic motor shaft or the position of load is termed as a limit switch. The actuation of a limit switch provides an electrical signal that causes an appropriate system response.
- Limit switches perform the same function as push button switches. Push buttons are manually actuated whereas limit switches are mechanically actuated.
- There are two types of classification of Limit switches depending upon the method of actuation of contacts
  - **i) Lever actuated contacts**
  - **ii) Spring-loaded contacts**
- In lever type limit switches, the contacts are operated slowly. In spring-type limit switches, the contacts are operated rapidly.

- Figure 1.3 shows a simplified cross-sectional view of a limit switch and its symbol.

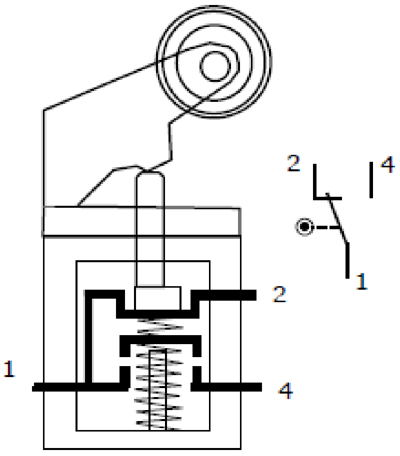

Figure 1.3 - Cross-sectional view of a limit switch

1.12.3 Pressure switches

- A pressure switch is a pneumatic-electric signal converter. Pressure switches are used to sense a change in pressure and opens or closes an electrical switch when a predetermined pressure is reached. Bellow or diaphragm is used to sense the change of pressure.
- Figure 1.4 shows a diaphragm type of pressure switch. When the pressure is applied at the inlet and when the pre-set pressure is reached, the diaphragm expands and pushes the spring-loaded plunger to make/break contact.

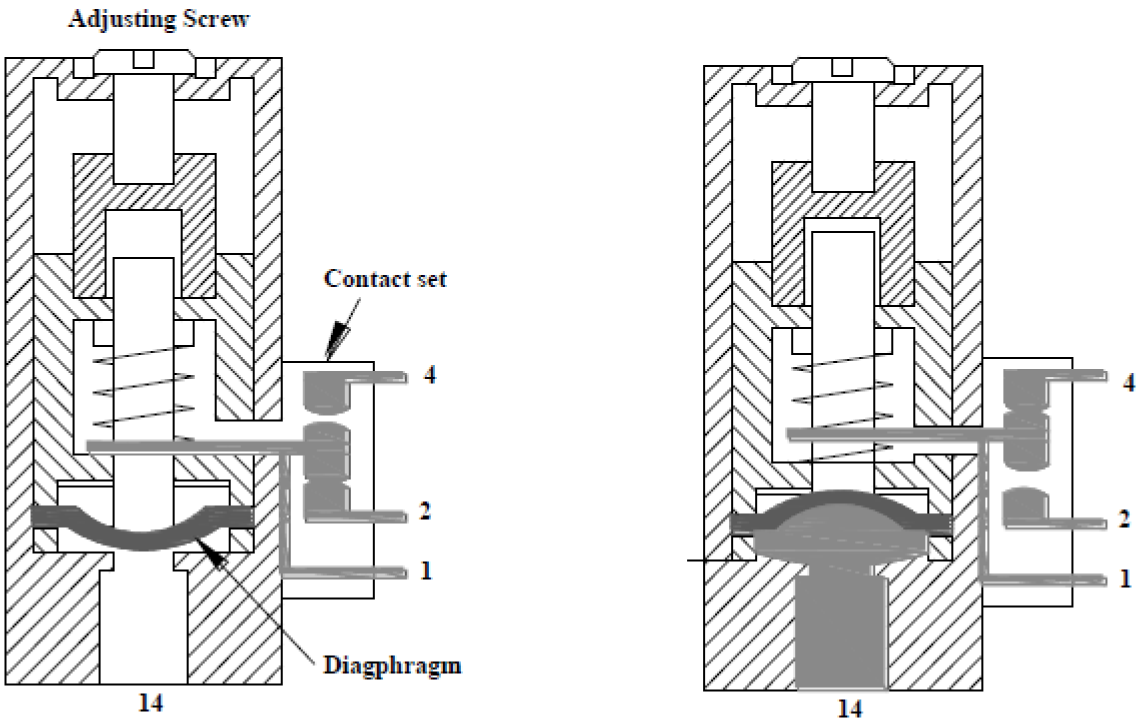

Figure 1.4 - Cross-sectional view of a pressure switch

1.12.4 Solenoids

- Electrically actuated directional control valves form the interface between the two parts of an electro-pneumatic control. The most important tasks of electrically actuated DCVs include.
  - **i) Switching supply air on or off**
  - **ii) Extension and retraction of cylinder drives**
- Electrically actuated directional control valves are switched with the aid of solenoids. They can be divided into two groups:
  - **i) Spring return valves only remain in the actuated position as long as current flows through the solenoid**
  - **ii) In the initial position, all solenoids of an electrically actuated DCVs are de-energized and the solenoids are inactive. A double valve has no clear initial position, as it does not have a return spring. Double solenoid valves retain the last switched position even when no current flows through the solenoid.**
- The possible voltage levels for solenoids are 12 V DC, 12V AC, 12 V 50/60 Hz, 24V 50/60 Hz, 110/120V 50/60 Hz, 220/230V 50/60 Hz.

1.12.5 Relays

- A relay is an electromagnetically actuated switch. It is a simple electrical device used for signal processing. Relays are designed to withstand heavy power surges and harsh environmental conditions. When a voltage is applied to the solenoid coil, an electromagnet field results. This causes the armature to be attracted to the coil core.
- The armature actuates the relay contacts, either closing or opening them, depending on the design. A return spring returns the armature to its initial position when the current to the coil is interrupted. A cross-sectional view of a relay is shown in Figure 1.5.
- A large number of control contacts can be incorporated in relays in contrast to the case of a push-button station. Relays are usually designated as K1, K2, and K3, etc. Relays also possess the interlocking capability that is an important safety feature in control circuits. Interlocking avoids the simultaneous switching of certain coils.

1.12.6 Timer or Time delay relays

- Timers are required in control systems to effect time delay between work operations. This is possible by delaying the operation of the associated control element through a timer. Most of the timers we use are Electronic timers.

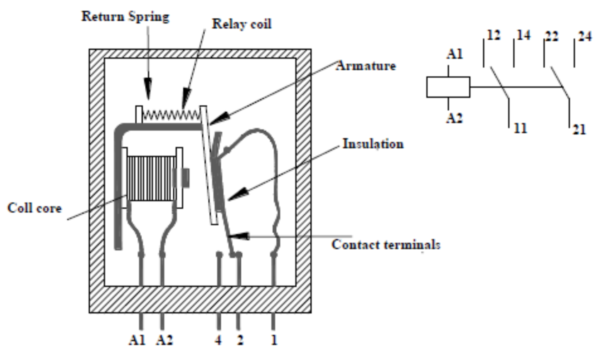

Figure 1.5 - Cross-sectional view of a relay

- There are two types of time relay
    - **i) Pull in delay (on –delay timer)**
    - **ii) Drop – out delay (off delay timer)**
- In the on-delay timer, shown in Figure cc, when push button PB is pressed (ON), capacitor C is charged through potentiometer R1 as diode D is reverse –biased. The time taken to charge the capacitor depends on the resistance of the potentiometer (R1) and the capacitance(C) of the capacitor. By adjusting the resistance of the potentiometer, the required time delay can be set. When the capacitor is charged sufficiently, coil K is energized, and its contacts are operated after the set time delay. When the push button is released (OFF), the capacitor discharges quickly through a small resistance (R2) as the diode bypasses resistor R1, and the contacts of relay (K) return to their normal position without any delay.
- In the off - delay timer, the contacts are operated without any delay when the push button is pressed (ON). The contacts return to the normal position after the set delay when the push button is released (OFF).
- The construction and symbols of the on-delay and off-relay timers are given in Figure1.6.

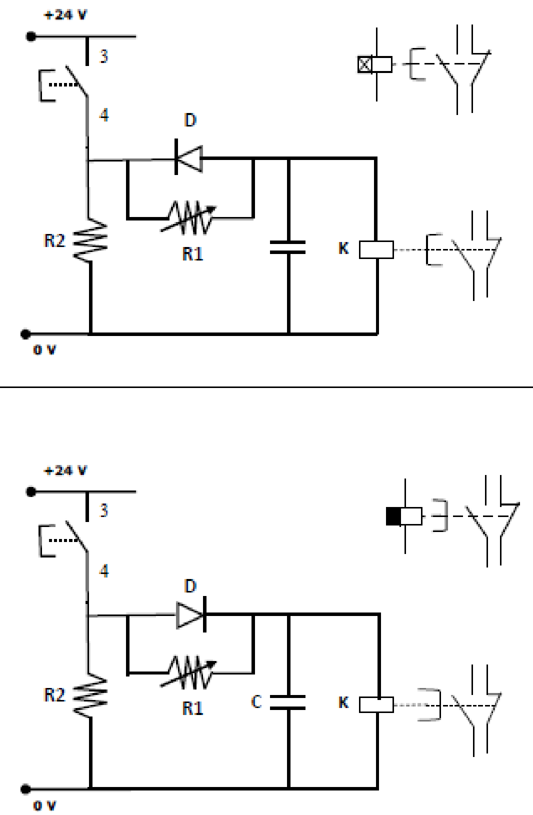

Figure 1.6 - Construction features of the timer and its symbols

1.12.7 Timer or Time delay relays

- Temperature switches automatically sense a temperature change and open or close an electrical switch when a predetermined temperature is reached. This switch can be wired either normally open or normally closed.
- Temperature switches can be used to protect a fluid power system from serious damage when a component such as a pump or a strainer or cooler begins to malfunction.

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