

Module IV MECHANICAL MEASUREMENT

* Pressure measurement :-

* Manometers :-

- > Manometers are differential pressure sensors.
- > The U-tube manometer consists of a clear glass or plastic tube shaped into the form of a 'U'.
- > The tube is partially filled with a liquid, such as water, alcohol or mercury.
- > The lower density of the liquid results in higher sensitivity of the manometer.
- > A pressure difference across the tube causes the liquid to shift position.
- > The change in position can be measured to give the pressure.
- > It is best suited to static pressure measurement.
- > It is difficult for small pressure changes and unsuitable for very large pressures.

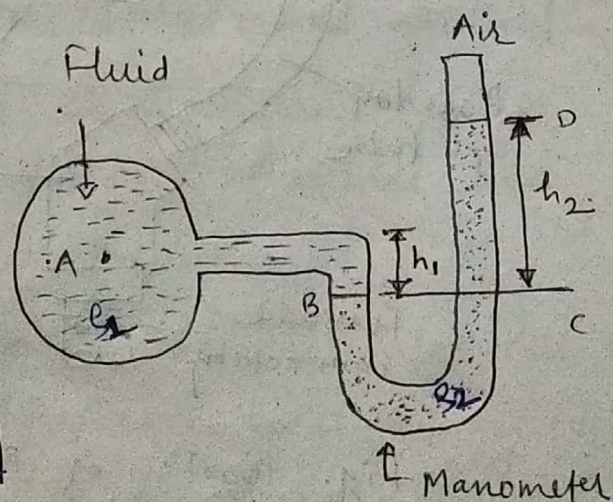
The pressure of the fluid can be measured as,

$$P_A = \rho_2 g h_2 - \rho_1 g h_1$$

At datum, $P_B = P_C$

$$P_A + \rho_1 g h_1 = \rho_2 g h_2$$

$$\therefore P_A = \rho_2 g h_2 - \rho_1 g h_1$$



* Bourdon tube pressure gauge :-

- > Bourdon tubes are made from metal alloys such as stainless steel or brass.
- > They consist of a tube of elliptical or oval cross-section, sealed at one end.
- > There are various shapes of Bourdon tube but a common design is the C-shape.
- > When increased pressure is applied to the open end, it deflects outwards in proportion to the pressure inside the tube.

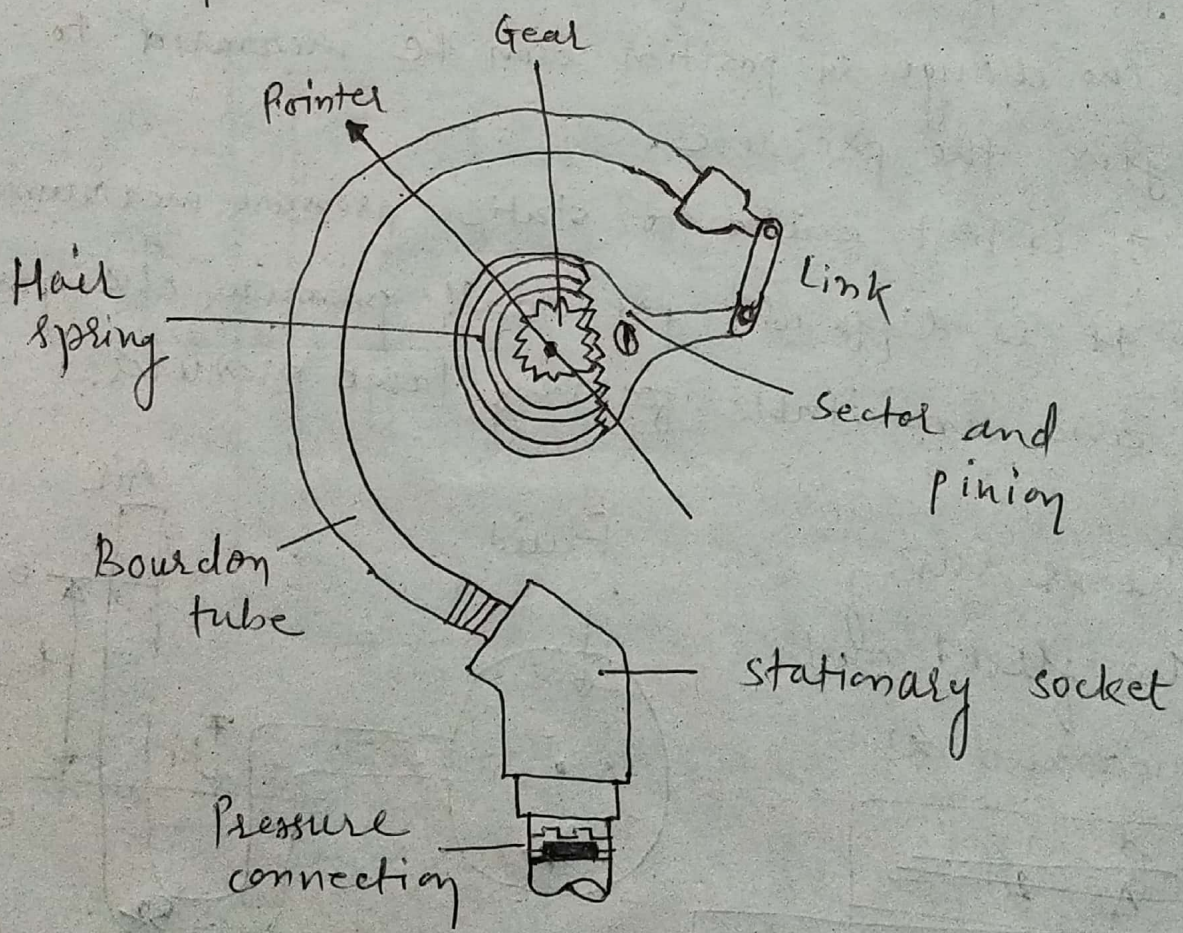


Fig. Working of Bourdon tube pressure gauge.

- > The pointer moves over a calibrated scale.
- > When pressure is applied, the movement of the tube is fairly small, so to increase the movement of the pointer it is mechanically amplified. This is usually by a connecting mechanism consisting of a lever, quadrant and pinion arrangement.

* Low pressure measurement :->

① Pirani gauge :-

- > The Pirani gauge is a roughing pressure vacuum gauge.
- > It uses the thermal conductivity of gases to measure pressure.
- > The Pirani gauge head is based around a heated wire placed in a vacuum system, the electrical resistance of the wire being proportional to its temperature.
- > At atmospheric pressure, gas molecules collide with the wire and remove heat energy from it.
As gas molecules are removed, there are fewer molecules and therefore fewer collisions.

- > Fewer collisions means that less heat is removed from the wire and so it heats up.
- > As it heats up, its electrical resistance increases.
- > A simple circuit utilizing the wire detects the change in resistance and once calibrated, can directly correlate the relationship between pressure and resistance.
- > It measures the pressure from atmosphere to 10^3 mbar. Therefore, other type of gauge should be used to measure pressure lower than this.

② Ion gauge :-

- > The ion gauge consists of three distinct parts i.e. that are the filament, the grid and the collector.
- > The filament produces electrons by thermionic emission.
- > A positive charge on the grid attracts the electrons.
- > Electrons circulate ~~at~~ around the grid passing through the fine structure

many times until eventually they collide with the grid.

> Gas molecules inside the grid may collide with circulating electrons.

> The collisions can result in the gas molecule being ionized.

> The collector inside the grid is negatively charged and attracts these positively charged ions. And they ^{are} repelled from the positive grid at the same time.

> The number of ions collected by the collector is directly proportional to the number of molecules inside the vacuum system.

By this method, measuring the collected ion current gives a direct reading of the pressure.

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