4 Unit - II

Temperature Measurement

Temp measuring methods are classified into two types

(a) Non electrical

(b) electrical.

(a) Non electrical

~~(i) Liquid~~

~~(ii) Vapour~~

~~(iii) gas thermometer~~

(i) Liquid, vapour, gas

(ii) Bimetal strip Thermometer

(iii) refractory Cones

(b) electrical

(i) resistance pyrometers

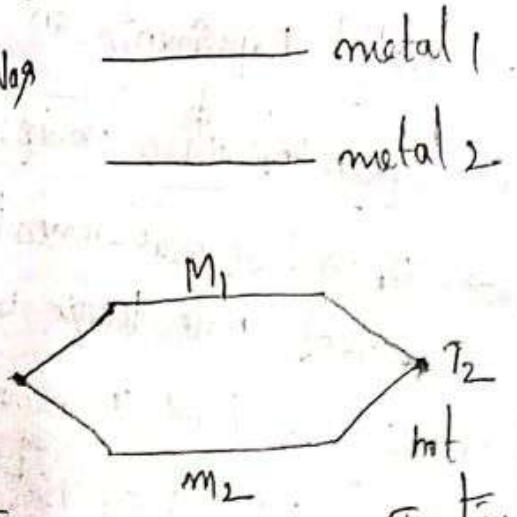
(ii) Thermocouples

(iii) radiation, photo electric thermo meters (optical pyrometers)

Thermo couples:- (disimilar metals)

→ It is based on thermo electricity also discovered by 'seebeck'

→ When two Conductors of dissimilar metals are joined to gether to form a loop and two unequal Temperatures T_1, T_2 are imposed at Junction an electric current flow Through the loop is happens.



→ potential difference always exists between two dissimilar metals with each other

→ According Thomson's effect a potential gradient exist in a single conductor having a temp gradient.

Laws of thermocouples :-

There are three laws of thermocouples

a) law of homogeneous circuit

b) law of Intermediate Temperatures

c) law of intermediate metals

(a) law of homogeneous circuit :-

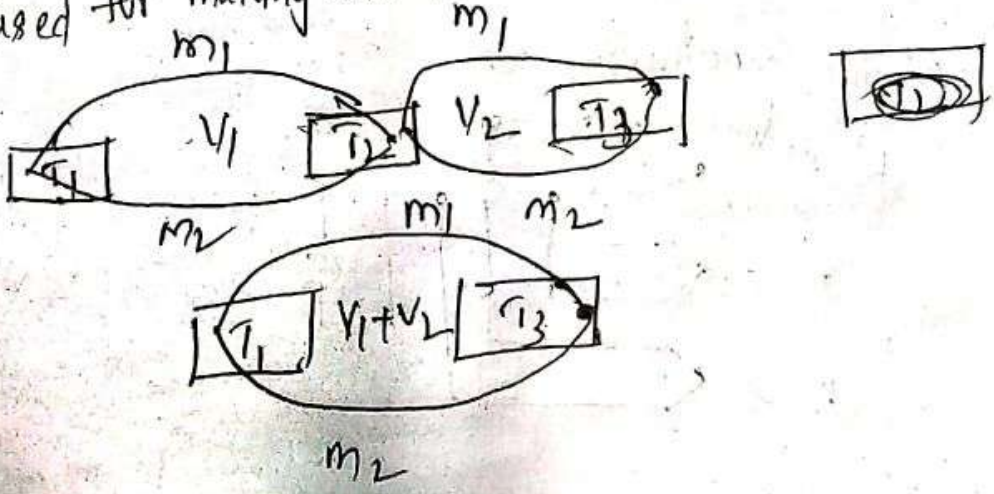
An electrical current can't be sustain in a circuit of a single metal by application of heat

(b) law of Intermediate Temperatures :-

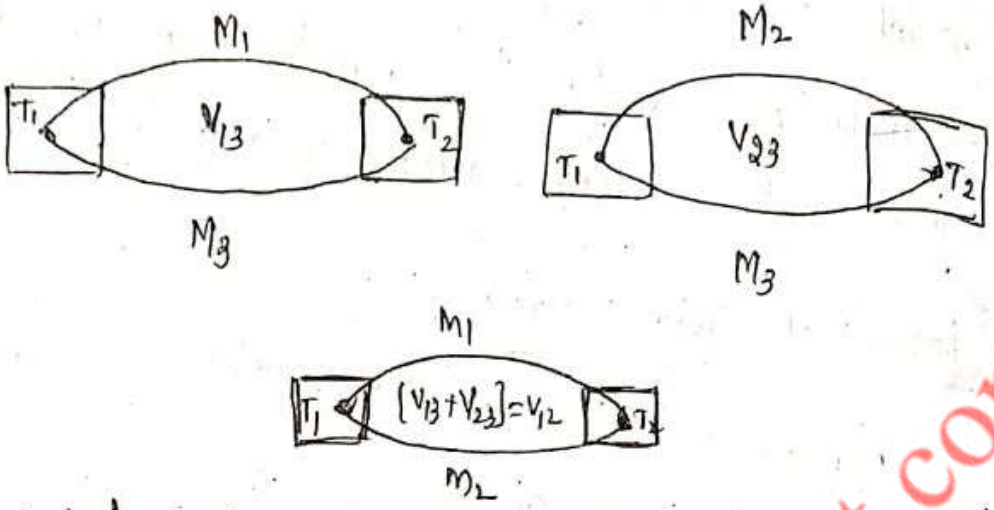
The emf generated with a thermocouple temperatures at T_1 T_3 is equal to the sum of emf generated by similar thermocouples at T_1, T_2 and T_2, T_3 i.e $V_1 + V_2$

→ It is used for making connection b/w Thermocouples

fig1.



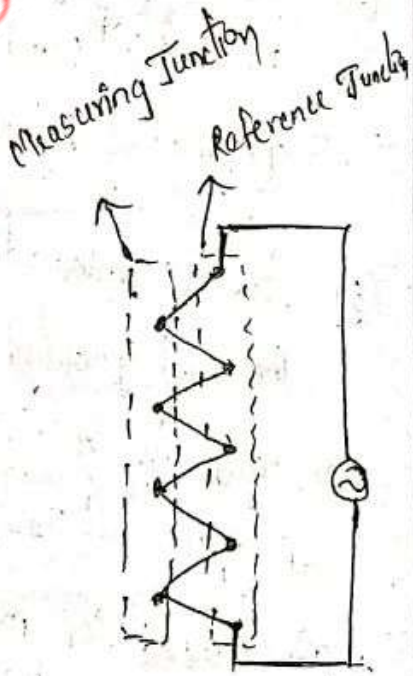
(c) law of Intermediate metals :-



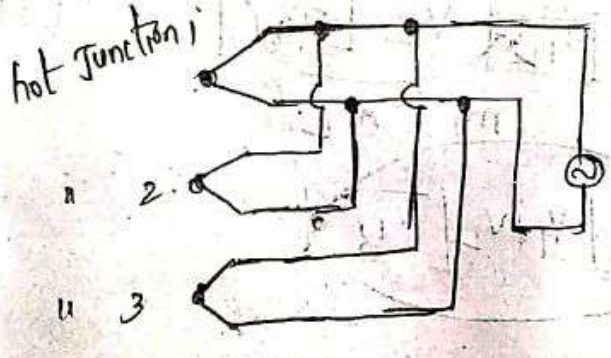
The introduction of third metal onto the Thermo couple circuit will have no effect on the emf generated as long as the Junction of the third metal with the thermo couple metals are at the same Temp.

Thermocouple combinations :-

Series Connection :-



Parallel Connection :-



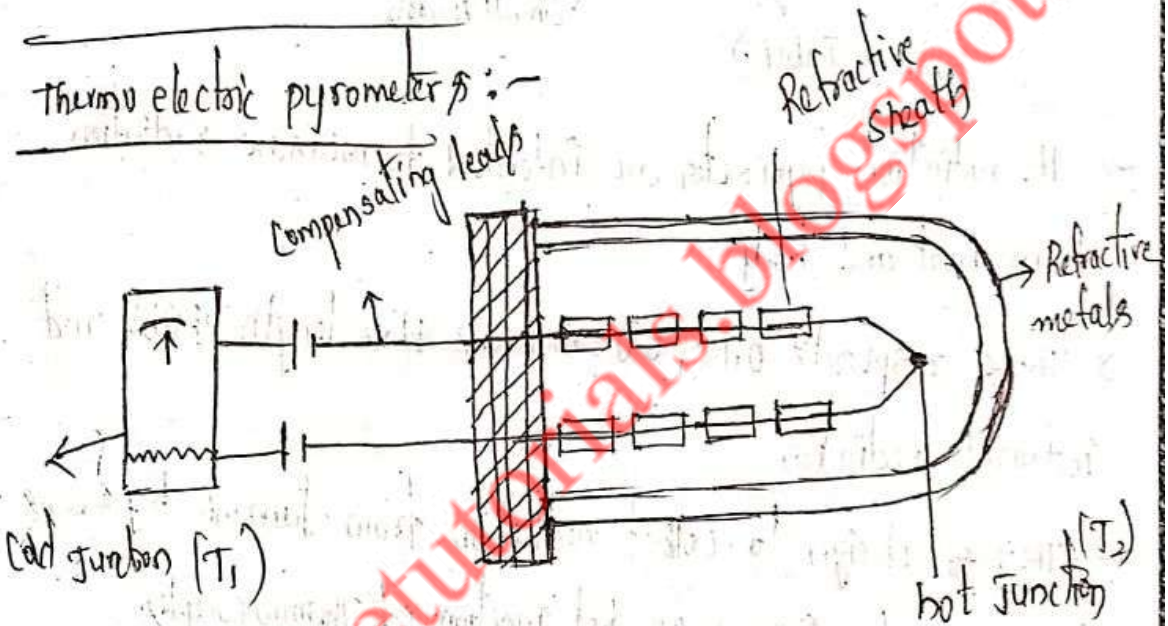
Thermocouple Materials:- They are three types

1. Base metals - pure form of iron, Copper, Nickel

2. Rare Metals - platinum. for temp upto 1725°C,
Tungston, molbedenum upto 2600°C

3. non metalic - like as Zinc and chromium.

Thermo electric pyrometers:-

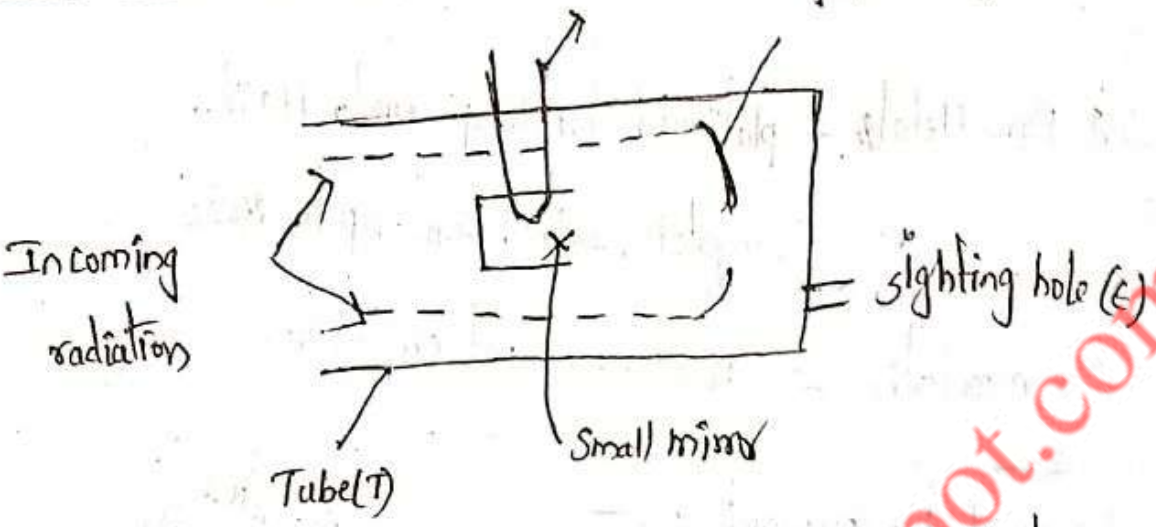


Where conductors may be solder or welded together.
Refractery metal sheet to protect the thermocouple from structural damage and injurious furnace gases.
Compensating leads which allows the Measuring instrument to be placed at a considerable distance from the thermocouple
Cold Junction or reference Junction provided by the instrument

used for Measuring voltage. (1) Radiation pyrometer

Radiation detectors :- Thermo couple

mirror (m)



→ the radiation pyrometer are intented to measure radiation from heat and body

→ Those responds 0.1 a, 6.0 microns wave length visible and infrared radiation

→ They are design to Collect radiation from furnace by means of focus of mirrors on hot Junction of Thermo couples

→ E.m.f generated on thermocouples is measured by milli voltmeter

→ It Consists of Tube 'T' open end to recieve radiation sighting have with eypes

→ Thermal radiation focused on adjustable mirrors to provide maximum radiation on thermocouples

→ Two small mirrors helps to focusing proces

pyrometric cones, paints, pellets

pyrometric Cones –

→ Composise narrow triangle Cones made of various materials

ex:- China Clay, Talc, quartz

→ measuring range 600°c to 2000°c by step of 25°c.

→ when melting Temp. is reach Cone no longer sastainable in solid state.

→ The furnance Temp should then be indicated when a particular Cone reach end point used for ceramic and steel making industries

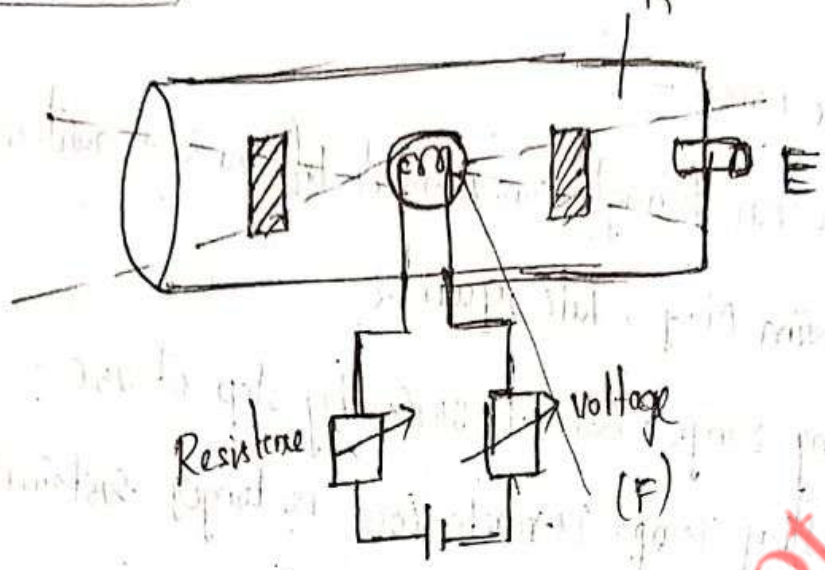
pyrometric paints –

→ Temp sensitive pairs are essentially minerals mixture of define melting points

→ Ranges of pairs b/w 50°c – 1200°c

→ These elements undergoes change of colour and exture of the point reached to particular value.

Those are used in pipeing, fusion devices are used as warning devices



→ The principle of Temp measurement by colour (or) brightness Comparision calibrated here the range of 700°c to 3000°c These Compare the energy emitted by the body at a given wavelength with that of block body calibrated lamp

→ Radiation from target surface are focused by observed length (L) upon the plane of filament (F) of electric length bulb. The eye piece (E) is also adjusted until filament in sharp focus under this condition the filament is seen superimposed on the image of target surface

→ the red filter (R) is placed blw eye piece and filament it allows only a narrow band of wave length 0.35 microns. If matching of brightness of the lamp filament changing temp is less than target Temp.

→ when filament Temp is less than target Temp

→ when filament temp is higher than the target temp

→ when filament Temp is exact match with Target temp

Pressure Measurement Devices :-

low pre. gauges — blw 760 to γ — 25 to γ

1) mcleod gauge
2) Thermal conductivity gauge
3) pirani gauge

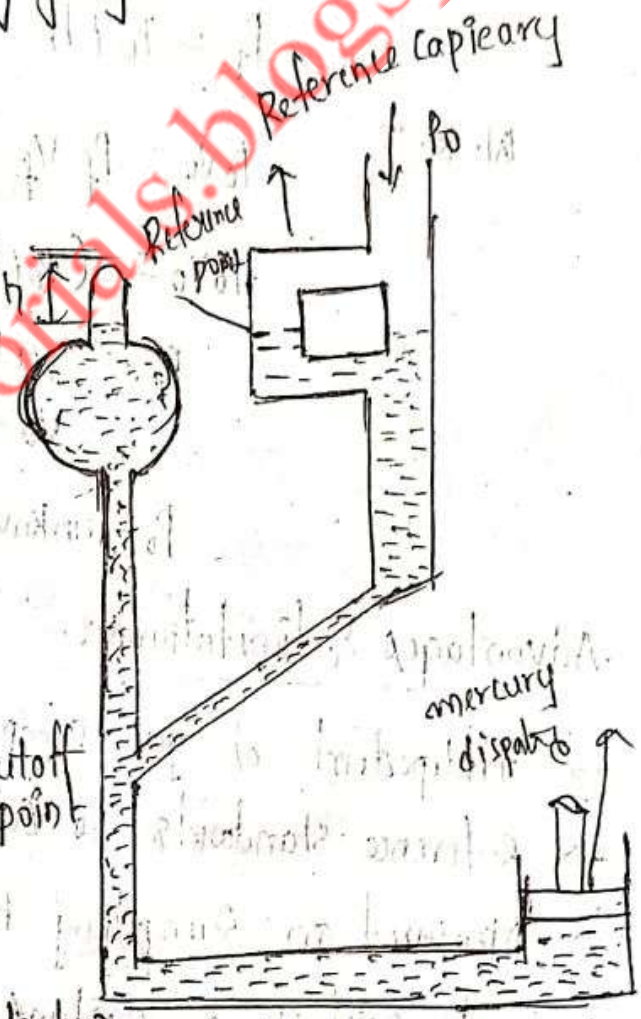
(1) mecloid gauge :-

$P_0V_0 = P_fV_f$

$P_f = P_0 + h$

$P_0V_0 = (P_0+h) \times ah$

$P_0 = \frac{ah^2}{V_0 - ah}$



It consists of system of glass tubing

1. plunger - (small piston & cylinder)

It is with drawn Mercury level is lower to the cut off position Then gas at unknown pressure (P_0) unknown volume (V_0) is admitting into the glass tube.

→ Mercury is pushed in and Mercury level is goes up it continous until mercury level in reference capillary reaches 'o' the mercury height of gas trap inserl the gas tube is 'h'

volume of gas trap $V_f = ah$

a – Crossectional area – $\frac{\pi}{4} d^2$

h – height glan trap in the gas tube

final P_f = unknown gas $P_r + h$

$$P_f = P_o + h$$

W.K.T $P_o V_o = P_f V_f$

$$P_o V_o = (P_o + h) V_f$$

$$P_o = \frac{ah^2}{V_o - ah}$$

P_o – unknown pre. of gas

Advantages & limitations :-

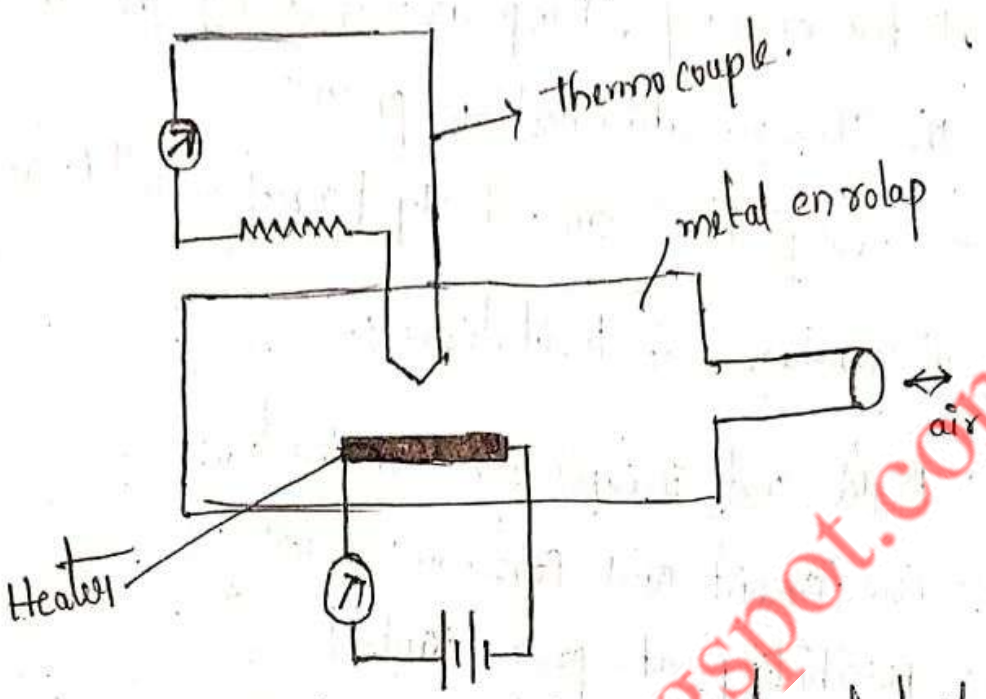
→ Indipedent of gas composition

→ Reference standards to Calculate other low pre-gauges

→ Measured on sampling basis

→ Not suitable on systems where mercury can't be tolerate

2.) Thermal Conductivity gauge :-



→ At low pre. the relation blw pre. & Thermal Conductivity

→ Temp of electrically heated filament depends upon

1. Magnitude of current
2. rate of heat dissipation

→ Current kept constant heat loss depends upon thermal Conductivity of gas its depends upon pre. of gas.

There are 3 basic elements

⇒ i) heater - 0.025 mm wire [tungsten Wire]
10 - 100 m/A Current
75 - 400°C rangle

ii) Thermo Couple - Welded to the metal envelop

iii) metal envelope - These maintain volume prenure

→ The heating element is supplied with constant electric energy, Temp measured by the Thermocouple the Temp. calibrated as pressure.

→ range is 1 mm of Hg [Torr] -10^{-4} to 1 Torr

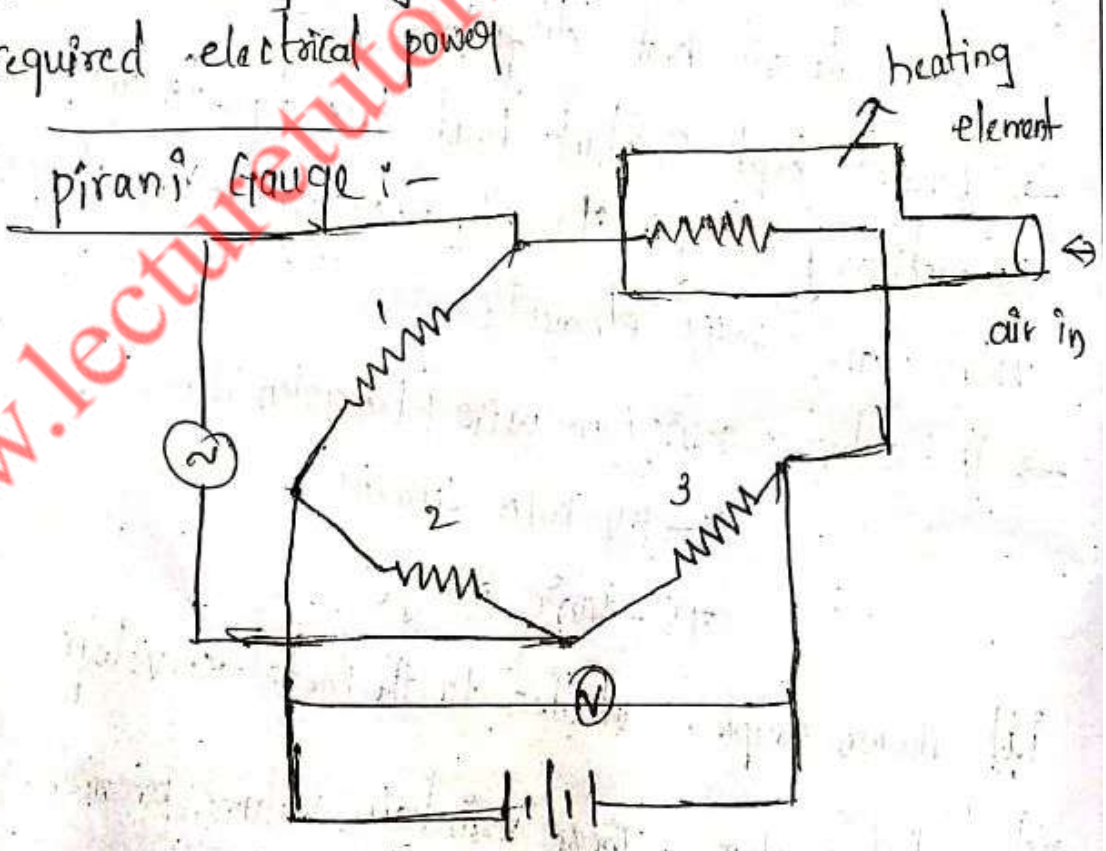
Advantages & limitations :-

→ Rigid and inexpensive construction
→ Convinient and Continous reading
→ possibility of proces control
→ possibility of remove readings

limitations :-

→ Narrow reading range
→ required electrical power

3) Pirani Gauge :-



→ When Maintaince of constant current observing change in filament resistence as a function of gas pre.

→ It is most sensitive pre. measurement range from 10^{-12} torr – 1 torr. resistence can be measured by ——

→ the effect of possible variation in ambient conditions is compensated by introducing a similar pirani element in opposite arm of bridge

Advantages:-

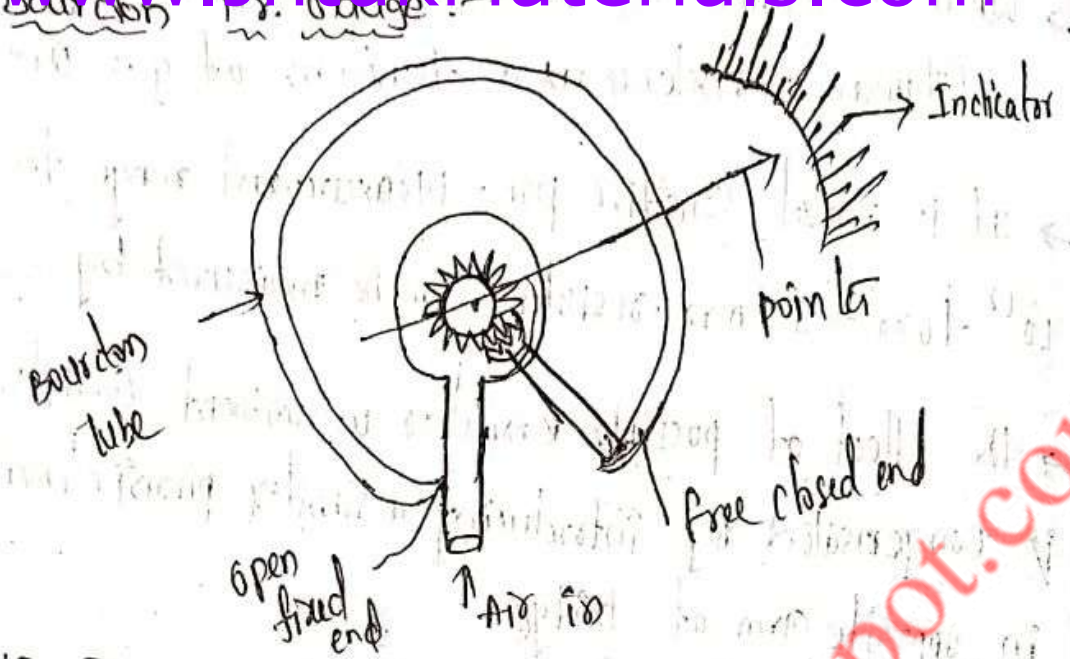
→ rugged and in expensive constructions
→ Wide pre. readings range
→ fast response to pre. changes
→ possibility of proces control

limitations:- Required electrical power.

Elastic pre. Transducers:-

1. Bourdon pre. gauge
2. Diaframe gauges
3. Bellows gauges

1) Bourdon Pr. Gauge :-



→ If Pr. exceeds 2 bar Generally Preferred Bourdon Gauge.

→ The pr. responsive element of a Bourdon gauge Consists of metal tube (Bourdon tube) form a Circular segment of 200° - 300°c it is fixed and opened at one end at other end, is ~~called~~ Closed free to displacement.

→ When Pr. is applied to the inside of tube its Cross - section tends to become Circular, free end is Connected to a spring loaded leakages where amplify the displacement.

→ It transmit its angular rotation of a pointer to calibrated scale.

Advantages

→ low cost and simple in construction.

→ Capacity to measure Gauge and absolute Pressures.

→ Simple and Straight forward Calibration is possible.

→ availability in several ranges.

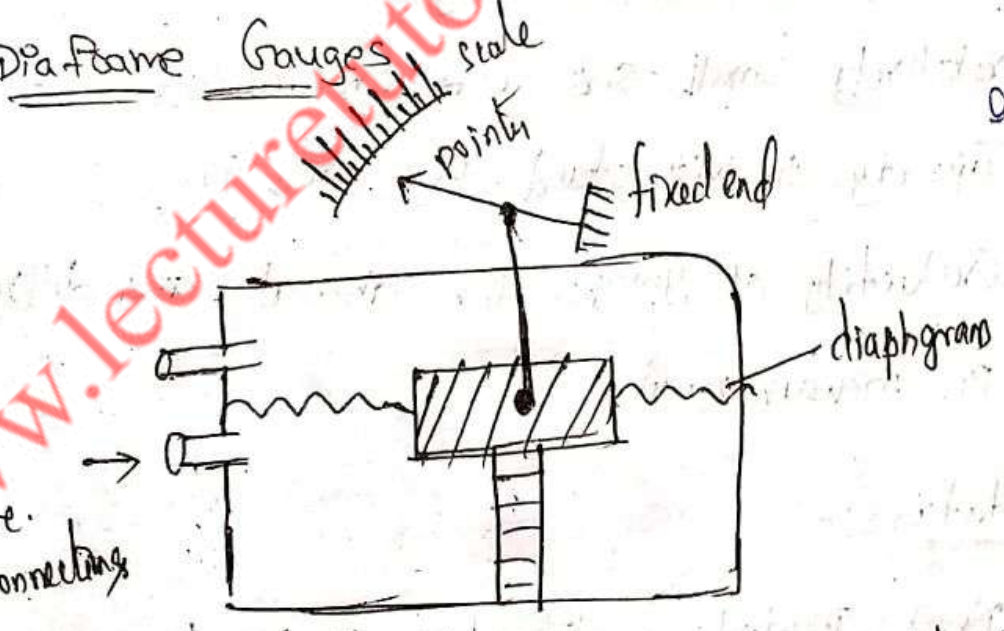
limitations

→ Slow response to Pr. changes

→ requires Gear trains to amplify the moment.

→ suspectability to shock and vibrations.

2) Diaphragm Gauges



→ The diaphragm gets deflected in a readings with Pr. difference across the sides.

→ the diaphragmes are 8 types.

a) metallic diaphragms
b) non-metalic diaphragms

1) metallic:-

→ which depends upon own resilience.

2) non-metallic:-

→ which ~~depends upon~~ employees a soft and flexible material.

→ The moment of diaphragm is opposed by a spring fixed to the case.

advantages:-

→ low and absolute pr. gauges

→ relatively small size and medium cost

→ capacity to withstand high over pr.

→ Evaluicity of gauge for absolute and differential pr. measurements.

limitations:-

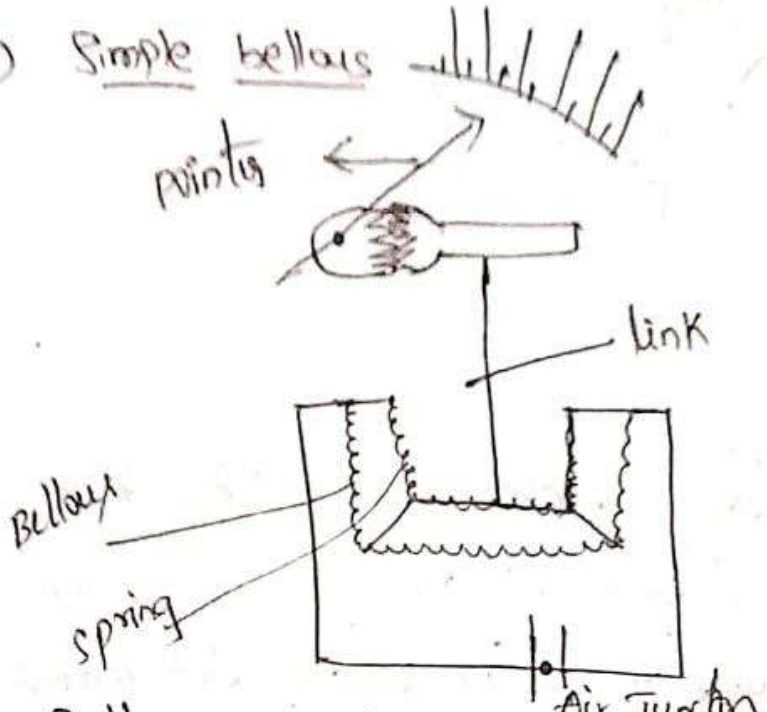
→ Need protection for shock & vibrations

→ difficult to repair.

→ Can't be used for high pressures.

3) Bellows Gauge

1) Simple bellows



→ Bellows are longitudinally expandable and collapsable members of several folds.

→ Material selection based on Pr. range.

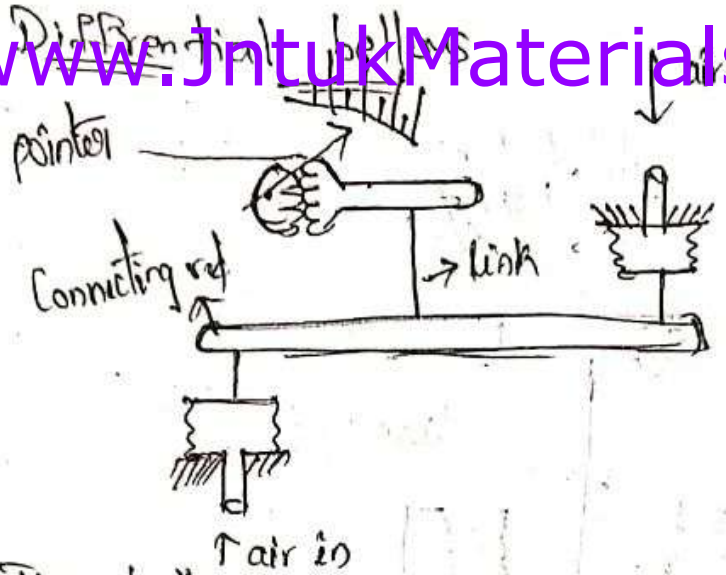
Ex:- Tempts brass, stainless steel, phosphrous bronze.

→ It is very sensitive for change of pressure Proportional to change of effective length.

→ Used. Pr is applied to one side of bellows and resulting deflection can be balanced by spring.

→ Suitable linkages magnifies displacement of bellow on calibrated scale.

*) Differential bellows



→ Two bellows are connected to the ends of a leaver under a differential pr. the deflection of bellows would be unequal and differential displacement of the connecting leaver would be indicated by pointer.

advantages

→ simple & rugged construction
→ Good for low & medium pr's
→ available for differential and absolute pr. measuring.
→ medium cost.

limitations

→ Needs springs for accurate readings
→ requires compensation for ambient temp change.