ELECTRICAL 2ND YEAR

DATE -14/04/2020 SUBJECT- INDUSTRIAL INSTRUMENTATION AND CONTROL 11:20-12:10

TOPIC NAME- **Low-Pressure measurement (Thermal Conductivity Gages)**

Thermal Conductivity Gages

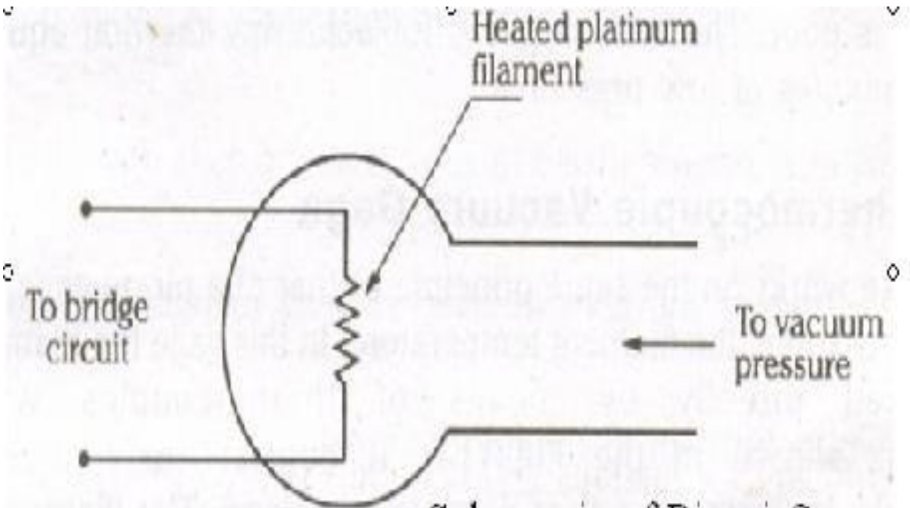
The temperature of a given wire through which an electric current is flowing depend, on (i) the magnitude of the current (ii) resistivity and (iii) the rate at which the heat is dissipated. The rate of heat dissipation largely depends on the conductivity of the surrounding media. As the pressure reduces, the thermal conducitivity also reduces and consequently the filament temperature becomes higher for a given electric energy input.

This is the basis for two different forms of gages to measure low pressures.

i). Pirani thermal conductivity gage
ii). Thermocouple vacuum gage

Pirani Thermal Conductivity Gages

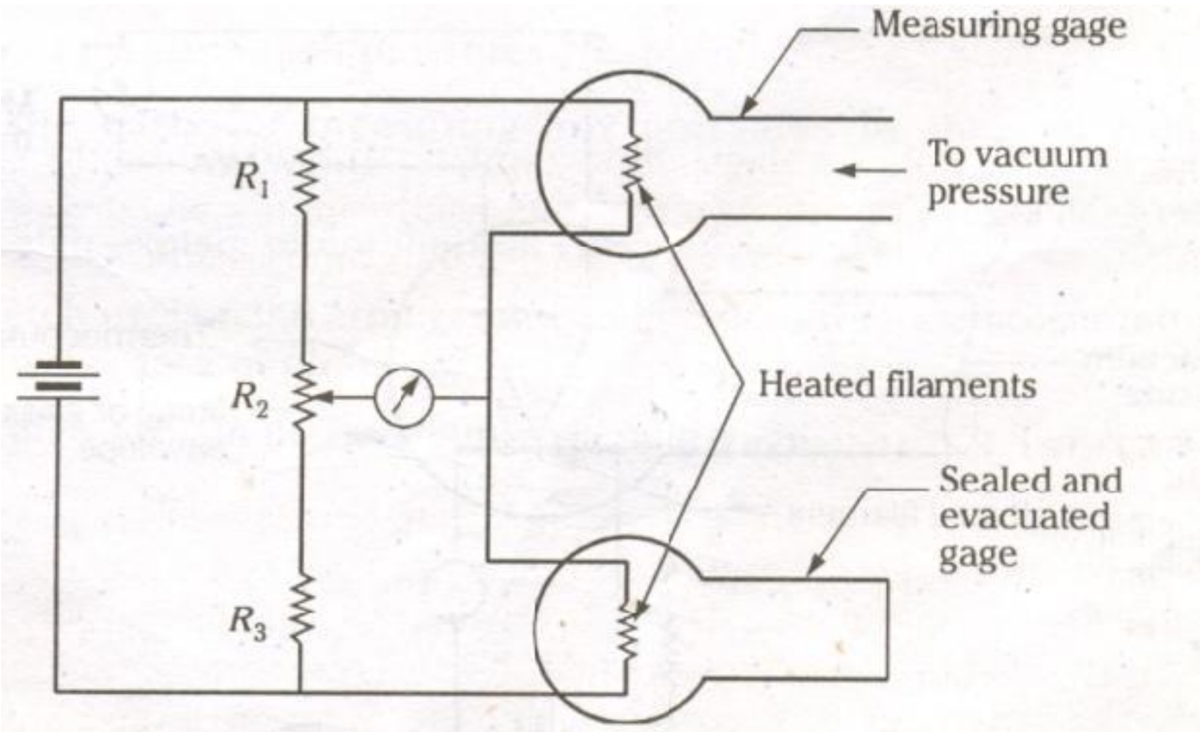
The pirani gage as shown in the Fig. operates on the principle that if a heated wire is placed in a chamber of gas, the thermal conductivity of the gas depends on pressure. Therefore the transfer of energy from the wire to the gas is proportional to the gas pressure. If the supply of heating energy to the filament is kept constant and the pressure of the gas is varied, then the temperature of the filament will alter and is therefore a method of pressure measurement.



Schematic of Pirani Gage

To measure the resistance of the filament wire a resistance bridge circuit is used. The usual method is to balance the bridge at some datum pressure and use the out-of-balance currents at all other pressures as a measure of the relative pressures.

Pirani



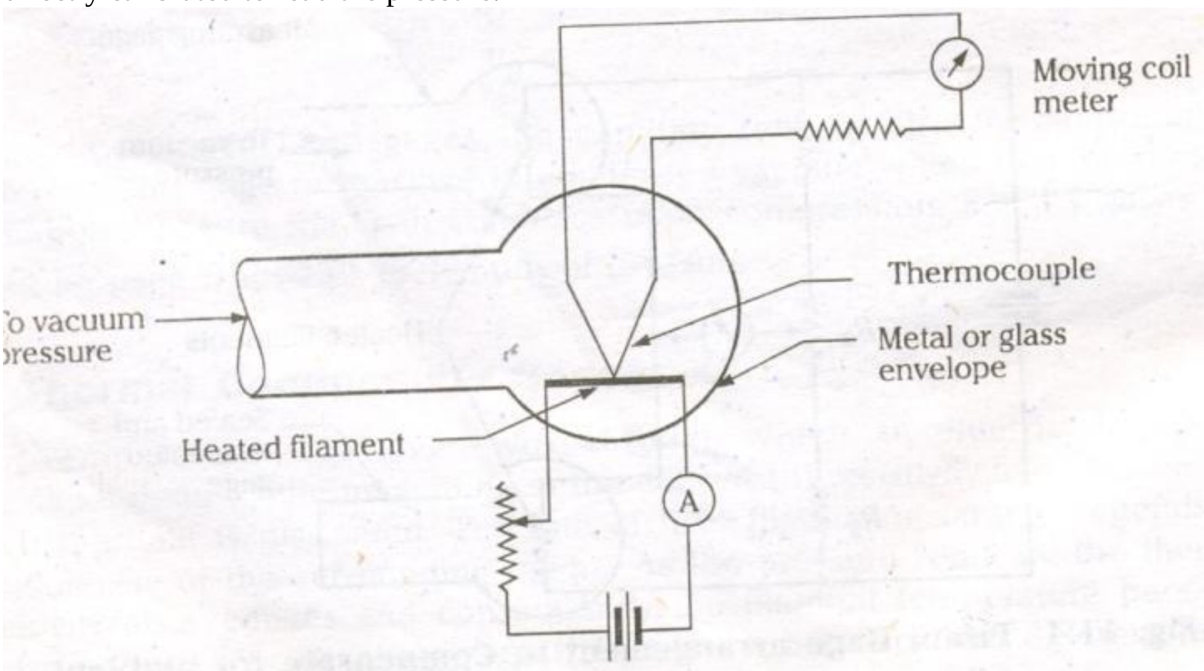
Pirani gage arrangement to compensate for ambient temperature Changes

The heat loss from the filament is also a function of ambinet temperature and compensation for this effect may be achieved by connecting two gages in series as shown in Fig. The measuring gage is first evacuated and both the measuring and sealed gages are exposed to the same environment conditions. The bridge circuit is then adjusted through the resistor *R2* to get a null condition. When the measuring gage is exposed to the test vacuum pressure, the deflection of the bridge from the null position will be compensated for changes in environment temperature.

Pirani gages require calibration and are not suitable for use at pressures below l)..lm and upper limit is about 1 torr. For higher pressures, the thermal conductivity changes very little with pressure. It must be noted that the heat loss from the filament is also a function of the conduction losses to the filament supports and radiation losses to the surroundings. The transient response of the pirani gage is poor. The time required for achieving thermal equilibrium may be of several minutes at low

Thermocouple Vacuum gage

This gage works on the same principle as that of a pirani gage, but differ in the means for measuring the filament temperature. In this gage the filament temperature is measured directly by mc;ans of thermocouples welded directly to them as shown in the Fig. 11.5. It consists of heater filament and thermocouple enclosed in a glass or metal envelope.
The filament is heated by a constant current and its temperature depends upon the amount of heat lost to the surroundings by conduction and convection. At low pressures, the temperature of the filament is a function of the pressure of surrounding gas. Thus, the thermocouple provides an output voltage which is a function of temperature of the filament and consequently the pressure of the surrounding gas. The moving coil instrument may be directly calibrated to read the pressure.



Thermocouple Vacuum Gage