

# Radiation Methods of Temperature Measurement

# Pyrometer Working Principle:

Radiation Pyrometer Working Principle measures the radiant energy/heat emitted or reflected by a hot object. Thermal radiation is an electro magnetic radiation emitted as a result of temperature and lies in the wavelength of 0.1 – 100  $\mu\text{m}$ .

According to the principle of thermal radiation, the energy radiated from a hot body is a function of its temperature. The heat radiated by the hot body is focused on a radiation detector. The radiation detector is blackened and it absorbs all or almost all radiation falling on it (if the temperature is very small compared with that of hot body, then

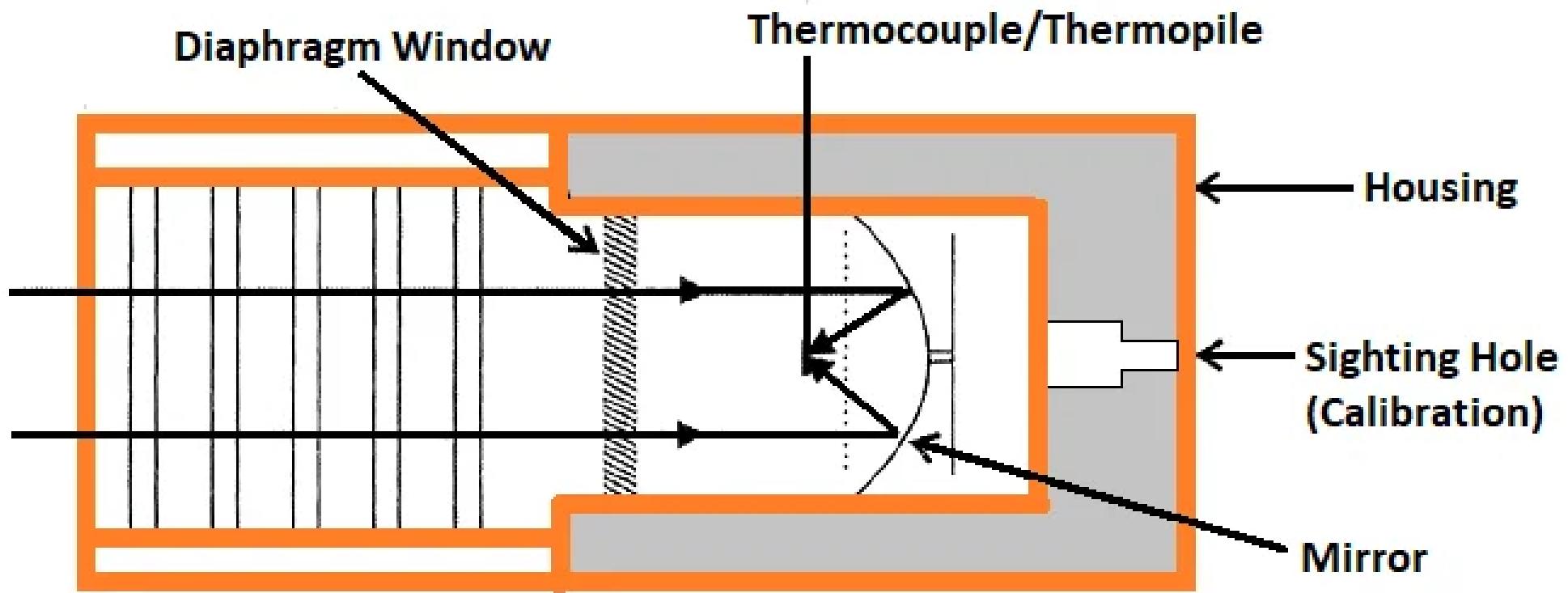
$$q \propto T^4$$

**Radiation Pyrometer are of Three types.**

- Total Radiation Pyrometers
- Infrared Pyrometers
- Optical Radiation Pyrometer

# Total Radiation Pyrometer (TRP):

- The total radiation pyrometer receives virtually all the radiation from a hot body and focuses on a sensitive temperature transducer such as thermocouple, bolometer, thermopile, etc. Total radiation includes both visible and infrared radiation.
- The total radiation Pyrometer Working Principle consists of a radiation receiving element and a measuring device to indicate the temperature directly. Figure shows a mirror type radiation pyrometer.
- In this Types of Pyrometer, a diaphragm unit along with a mirror is used to focus the radiation on a radiant energy sensing transducers. The lens (mirror) to the transducer distance is adjusted for proper focus. The mirror arrangement has an advantage that since there is no lens, both absorption and reflection are absent.
- Presence of any absorbing media between the target and the transducers, reduces the radiation received and the pyrometer reads low.

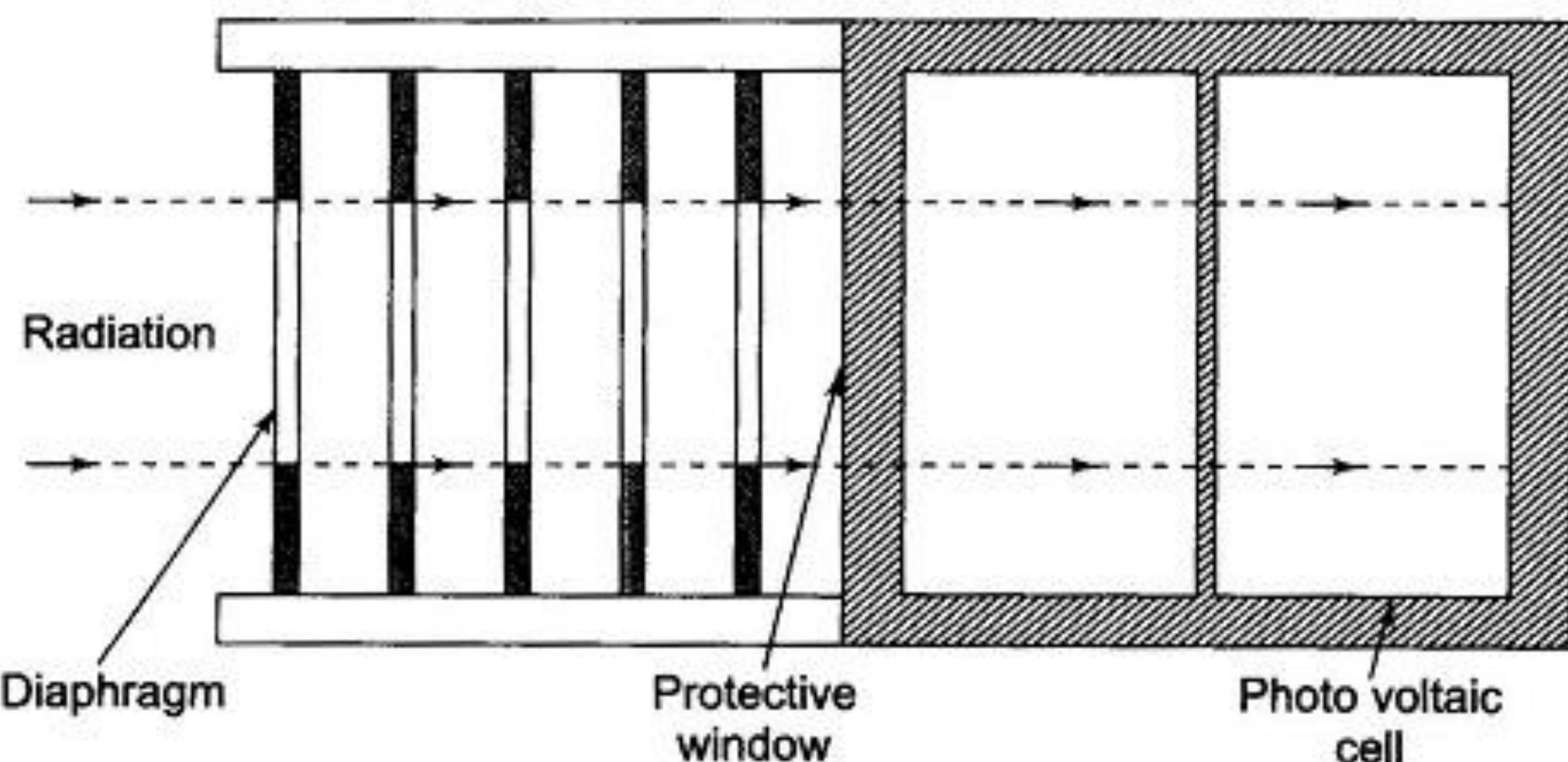


## Total Radiation Pyrometer

- Due to the fourth Power Law ( $q$  is proportional to  $T^4$ ) the characteristics of total radiation pyrometer are non-linear and has poor sensitivity in lower temperature ranges. Therefore, total radiation pyrometers cannot be used for measurement of temperature lower than 600 °C, since errors are introduced at lower temperatures.
- Hence, total radiation pyrometers are used mostly in the temperature range of 1200 °C – 3500 °C.
- The output from a total radiation pyrometers whether amplified or not, is usually taken to a PMMC instrument or to a self-balancing potentiometer. The output may be fed to a recorder or controller.

# Infrared Pyrometers:

- Infrared Pyrometer Working Principle are partial or **selective radiation pyrometers**. Above temperatures of 550 °C, a surface starts to radiate visible light energy and simultaneously there is a proportional increase in the infrared energy.
- Infrared principles using thermocouples, thermopile and bolometers are used. Also various types of photo-electric transducers are most commonly used for infrared transducers. The most useful transducers used for industrial application are the Photo-voltaic cells. These cells used in radiation pyrometers, respond to wavelength in infrared region and may be used to measure temperature down to 400 °C.



**Fig.13.56 ■ Infrared pyrometer**

- The infrared radiation is focused on a photo-voltaic cell as shown in Fig. It is necessary to ensure that the cell does not become overheated. The core of radiation passing to the cell is defined by the area of the first diaphragm.
- The protective window is made of thin glass and serves to protect the cell and filter from physical damage. The filter is used on the range of 1000 °C to 1200 °C in order to reduce the infrared radiation passed to the photo cell. This help in preventing the photo cell from being overheated.

- All infrared systems depend on the transmission of the infrared radiant energy being emitted by a heated body to a detector in the measuring system. The sensor head is focused on the object whose temperature is being measured and/or controlled.
- The infrared energy falling on the detector either changes the detector resistance in proportion to the temperature as in the case of thermistor or generates an emf in the detector such as a thermopile. The change in resistance or generated emf is then indicated on a meter.

# Optical Pyrometer

- Optical Pyrometer Working Principle – Any metallic surface when heated emits radiation of different wavelengths which are not visible at low temperature but at about 550 °C, radiations in shorter wavelength are visible to eye and from the colour, approximate temperature is measured. The approximate values of temperature for colour (colour scale) is given

**Table 13.4** Colour Scale

Dark Red	540°C
Medium Cherry Red	680°C
Orange	900°C
Yellow	1010°C
White	1205°C

- Within a visible range, a given wavelength has a fixed colour and the energy of radiation is interpreted as Intensity or Brightness. Hence if we measure the brightness of the light of a given colour emitted by a hot source, we have an indication of temperature. This is the principle of optical pyrometer.
- In an optical pyrometer, the wavelength of radiation accepted is restricted by means of a colour filter and brightness is measured by comparison with a standard lamp.
- The most common type of optical pyrometer working principle used is the disappearing filament pyrometer.

# Optical Pyrometer

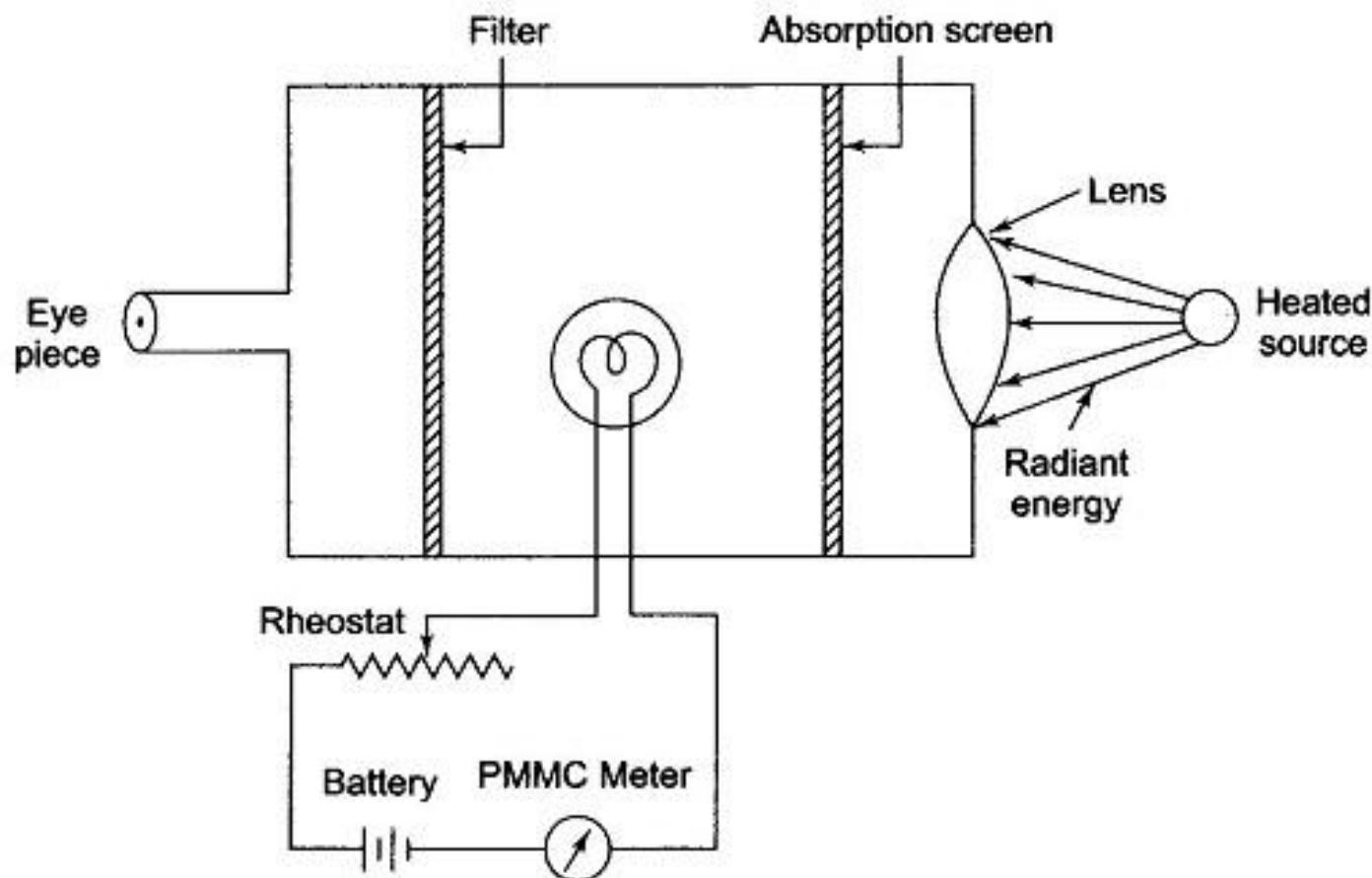
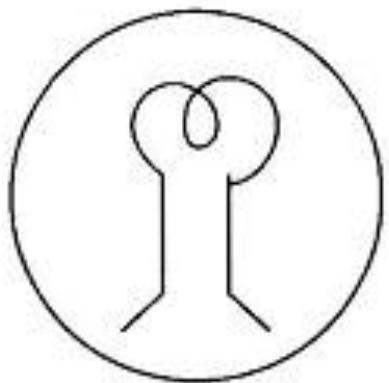
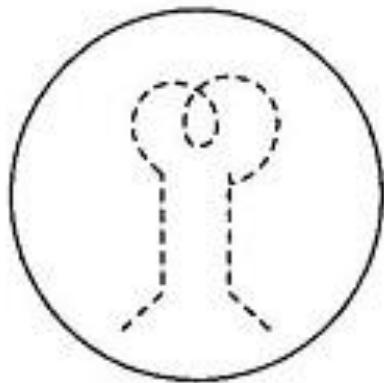


Fig.13.58

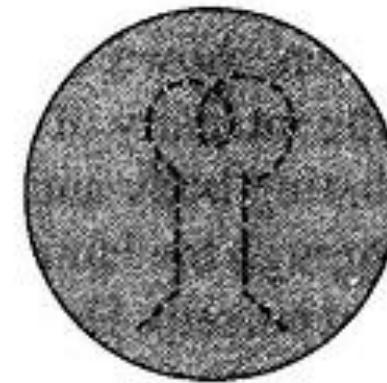
- An image of the radiating source is produced by a lens and made to coincide with the filament of an electric lamp.
- The current through the lamp filament is made variable so that the lamp intensity can be adjusted. The filament is viewed through an eye piece and filters. The current through the filament is adjusted until the filament and the images are of equal brightness.



(a) Filament colder than  
background



(b) Filament invisible  
against background



(c) Filament and background  
having equal brightness

**Fig.13.57**

- When brightness of image produced by the source and brightness produced by the filament are equal, the outline of the filament disappears as shown in Fig.
- However, if the temperature of the filament is higher than that required for equality of brightness, filament becomes too bright as shown in Fig.13.57(b).
- On the other hand if the temperature of filament is lower, the filament becomes dark as shown in Fig.13.57(a).
- Since the intensity of light of any wavelength depends upon the temperature of the radiating body and the temperature of filament depends upon the current flowing through the lamp. The instrument may be directly calibrated in terms of the filament current. However, the filament current depends upon the resistance of the filament, modern pyrometers are calibrated in terms of resistance directly.

- The range of temperature, which can be measured by an instrument of this type depends on the maximum allowable temperature of the lamp which is around 1400 °C.
- The range can be extended by using an absorption type screen placed near the objective [lens](#). Hence a known fraction of radiant energy enters the pyrometer for comparison. The range can be extended to 3000 °C by this technique.
- Optical Pyrometer working principle is widely used for accurate measurement of temperature of furnaces, molten metals and other heated materials.