Radiation Methods (Pyrometry)

- For temperatures above 650^0C, the heat radiations emitted from the body are of sufficient intensity to be used for measuring the temperature.

- Advantages- used for high temp, moving bodies, temp. over surfaces.

- Types of instruments

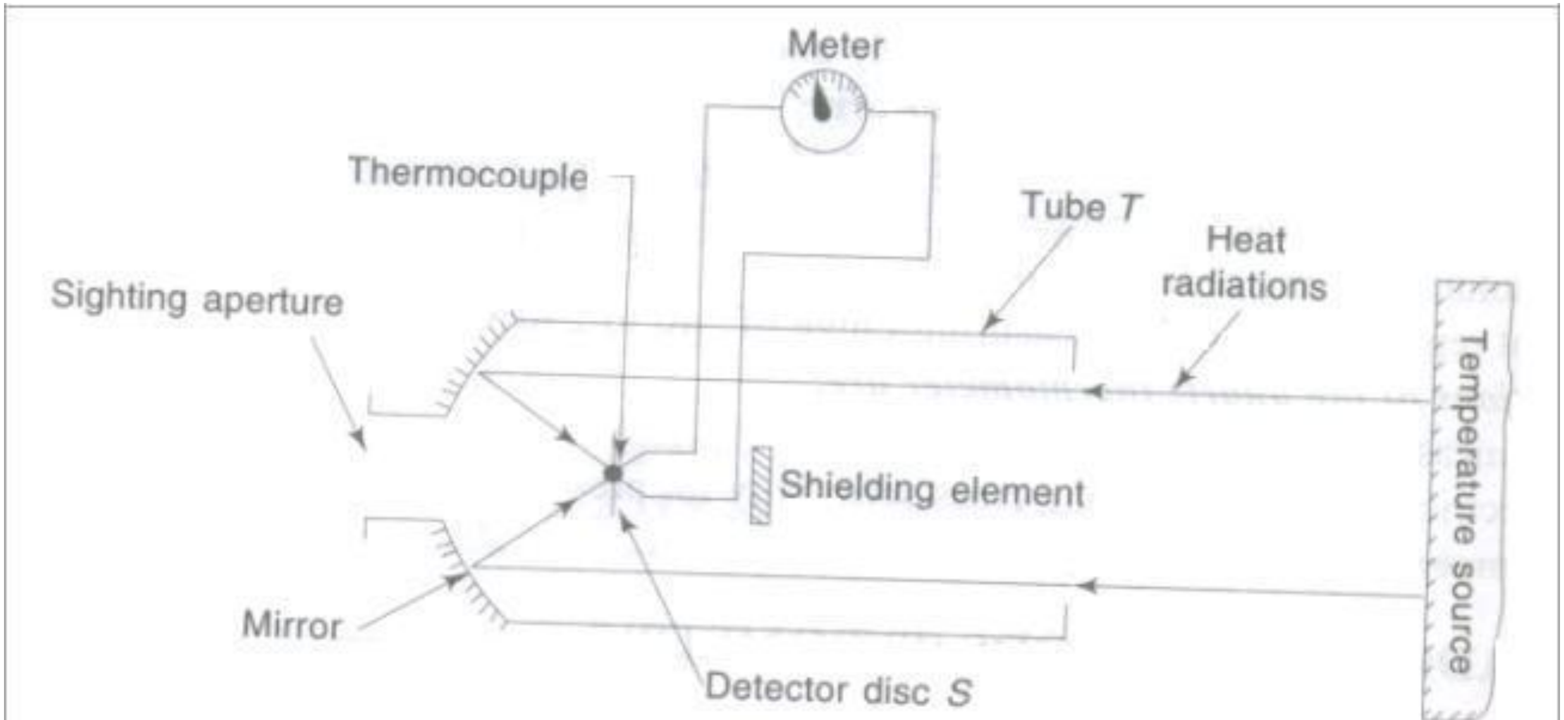
1. Total radiation pyrometer – sensitive to all radiations entering the instrument.
2. Selective (or partial) radiation pyrometer – sensitive to radiations of a particular wavelength.
3. Infrared (IR) pyrometer – employ the infrared portion of spectrum by using a thermal detector to measure temperature on the surface of the body.

Total Radiation Pyrometer

- Receives a controlled sample of total radiation of a hot body (eg. Furnace) and focuses it on to a temperature sensitive transducer.
- Radiation includes visible (0.3 to 0.72 μm wavelength) (light) and invisible (0.72 to 1000 μm wavelength) (infrared) radiations.
- Ordinary glass is unsatisfactory, as it absorbs infrared radiations.
- The practical radiation pyrometers are sensitive to a limited wavelength band of radiant energy (0.32 to 0.40 μm)

Fery's total radiation pyrometer:-

- Blackened tube T open at one end and at other end it has a sighting aperture with adjustable eyepiece.
- concave mirror can be adjusted with rack & pinion arrangement.
- Detector disc S blackened with platinum sheet/foil is connected to a thermocouple/thermopile junction or to a resistance thermometer bridge circuit.



Schematic of Fery's total radiation pyrometer

The theory underlying the operation of total radiation pyrometers is that the rate of radiation from a body A (the source) to a body B (the pyrometer), i.e. $E_{A/B}$ is given by the Stafan-Boltzmann law as follows:

$$E_{A/B} = C\varepsilon\sigma\left[T_A^4 - T_B^4\right]$$

were $E_{A/B}$ is the energy received by the pyrometer in W/m^{-2}

C is a geometrical factor to adjust the relative shapes of the two bodies

ε is the emissivity of the detector disc which varies from 0.05 to 1.0 for the theoretical black body

σ is the Stefan-Baltzmann constant and its value is 56.7×10^{-12} kW/($m^2 \cdot K^4$)

T_A and T_B are the steady state absolute temperature of the source and pyrometer detector disc

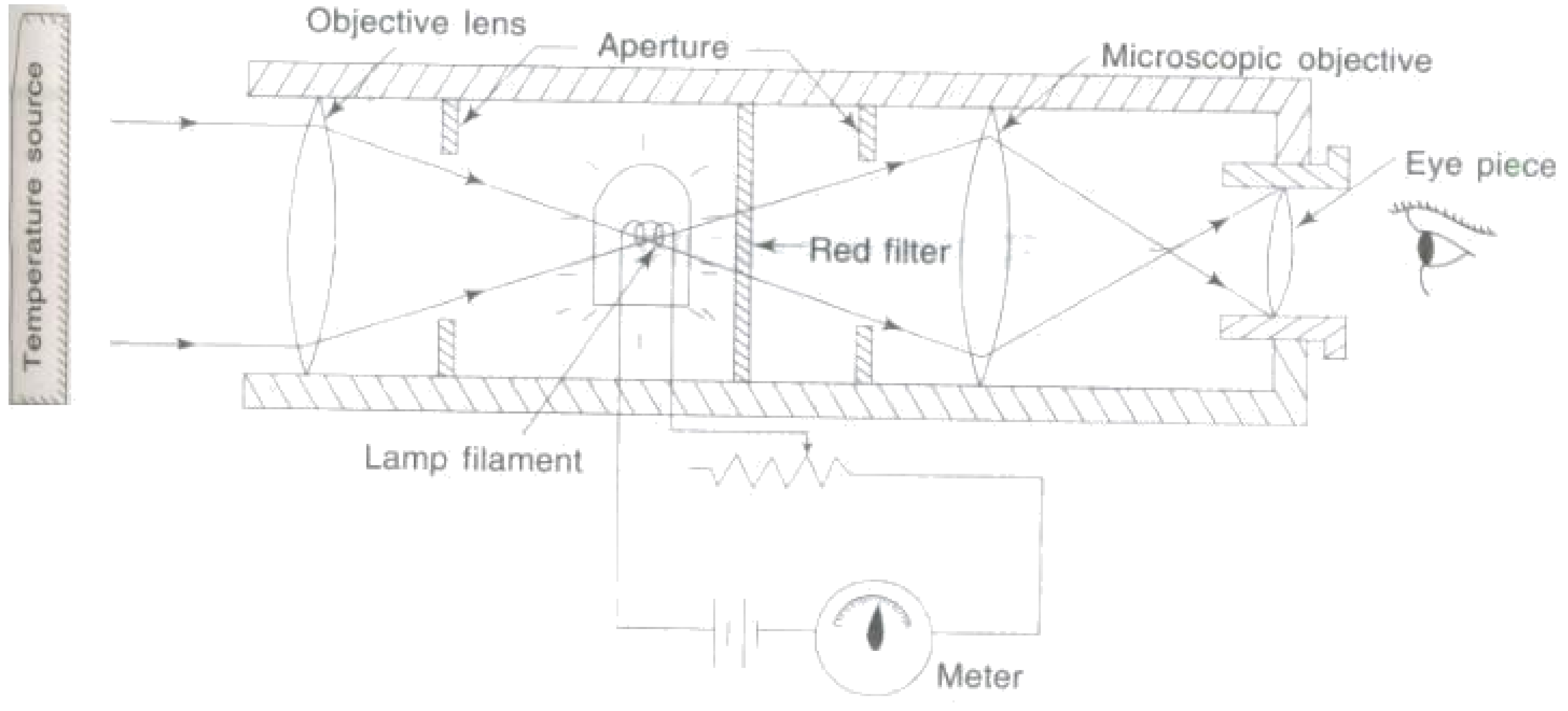
- Calibrated against known temperatures in the range of 700-2000^{0}C.
- Useful in fixed locations where the emissivity and optical paths are well known and constant.
- Useful to measure temp. of large furnace in metal industries.
- The signal is electrical so can be used for control applications.

Selective Radiation Pyrometer

- The principle is based on Planck's law which states that the energy level in the radiations from a hot body are distributed in the different wavelengths.
- As the temperature increases, the emissive power shifts to shorter wavelengths.
- The Planck's distribution equation is:

$$W = \frac{c_1 \lambda^{-5}}{e^{c_2 \backslash \lambda T} - 1}$$

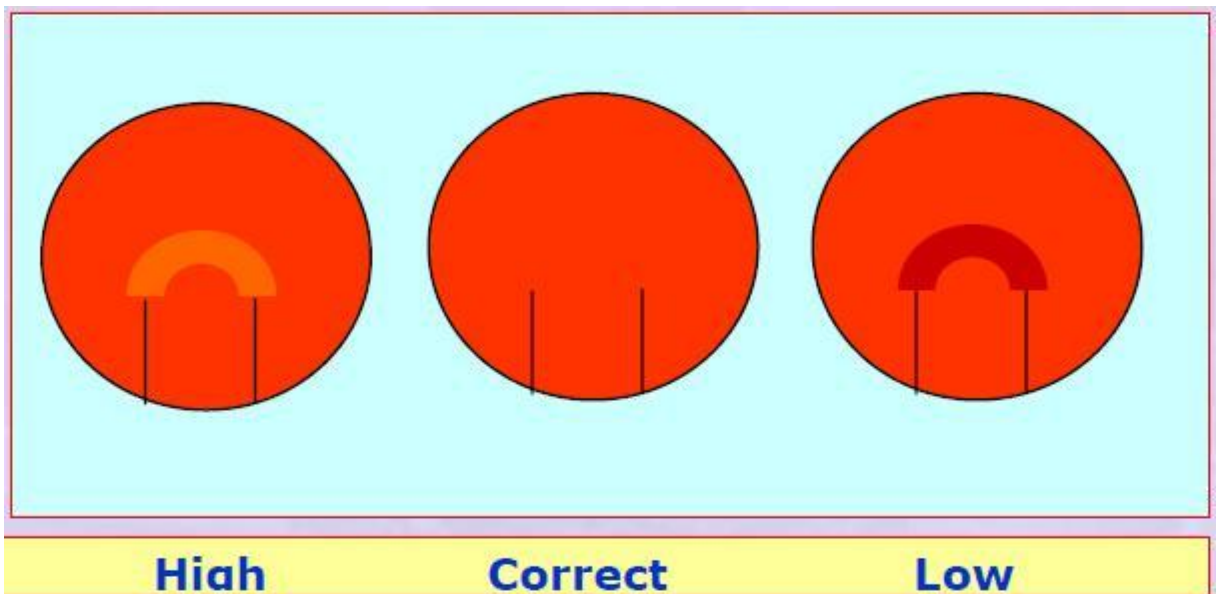
$c_1 = 3.740 \times 10^{-12}$ (W–cm^2)
$c_2 = 1.4385$ (cm –°C)
λ = wavelength (cm)
T = absolute temperature in (K)
W = energy level associated with wavelength at temperature T (W/cm^3)

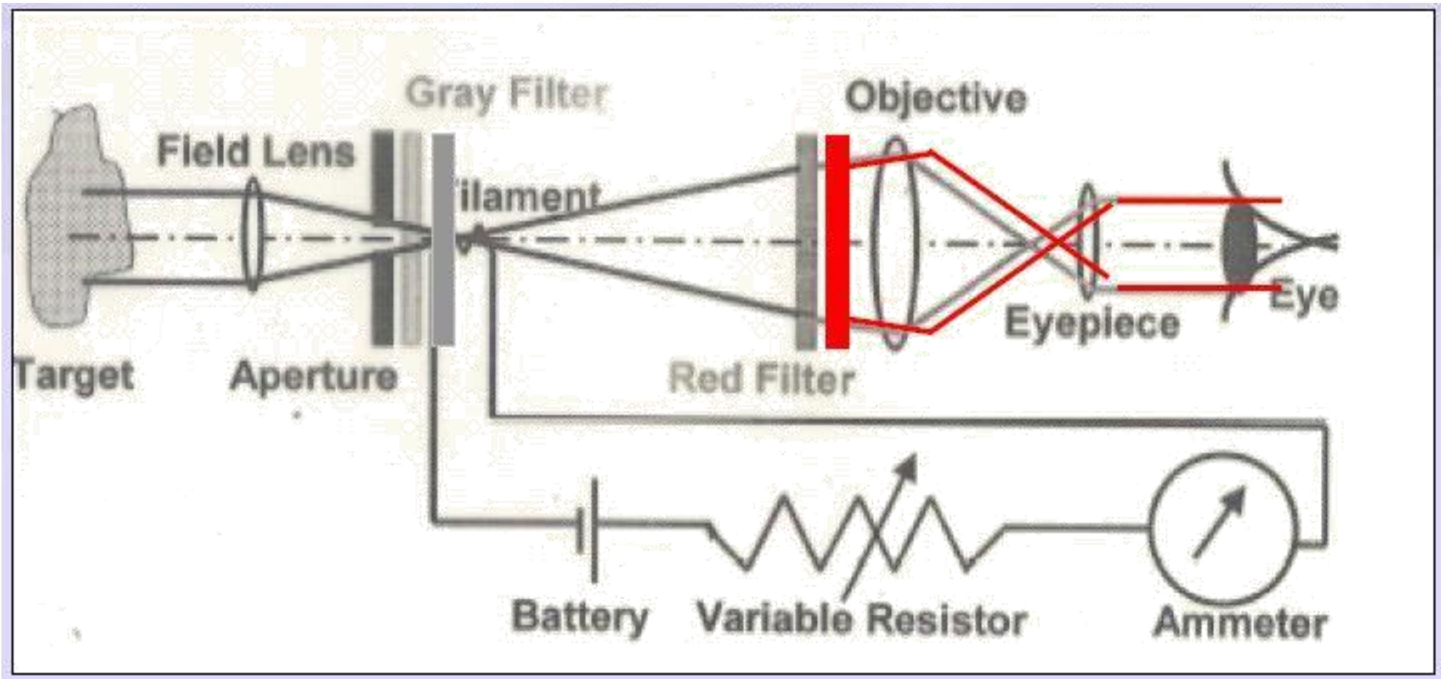


Schematic of the disappearing filament type of optical pyrometer

- Also called monochromatic brightness radiation pyrometer.
- Most accurate of all radiation pyrometers.
- Used at temp. greater than 700^0C.
- Used to realize International Practical Temperature Scale above 1064^0C.
- Accuracy is $\pm$ 5^0C in the range of 850-1200^0C.
- And for extended range of 1100 - 1950^0C, accuracy is better than $\pm$ 10^0C.

(a) Filament too dark (b) Filament too bright (c) Equal brightness




Gray Filter
Objective
Field Lens
Filament
Eye
Eyepiece
Target
Aperture
Red Filter
Battery
Variable Resistor
Ammeter