PYROMETER

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Introduction

❑ A **pyrometer is a type of thermometer used to measure high temperature** without any physical contact.
It depends upon the relationship between the **temperature of object's surface** and **thermal radiation emitted by the object.**

❑ Various forms of pyrometers have historically existed. In the modern usage, it is a non - contacting device that measures thermal radiation, a process known as **pyrometry.**

❑ The word pyrometer comes from the Greek word for **fire, "πυρ" (pyro),** and **meter, meaning to measure.**

❑Pyrometer was originally coined to denote a device capable of measuring temperatures of objects above incandescence (i.e. objects bright to the human eye).

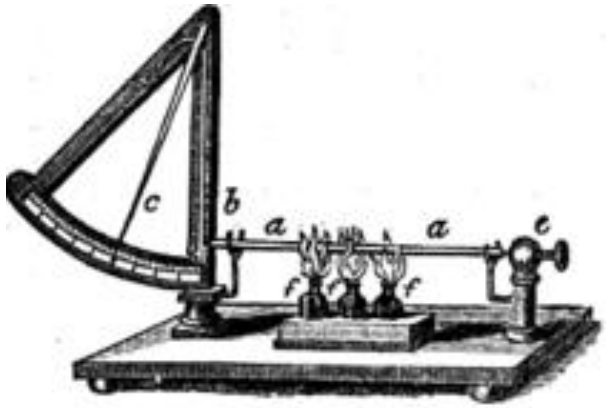
History

- **The potter Josiah Wedgwood** invented the **first pyrometer** in **early 18th century** to measure the temperature in his kilns, which first compared the color of clay fired at known temperatures, but was eventually upgraded to measure the shrinkage of pieces of clay, which depended on the heat of the kiln.

- In **1830, John Frederic Daniell** invented accurate types of pyrometer.

- In **1852,** expansion of a **metal bar** was used as a pyrometer.

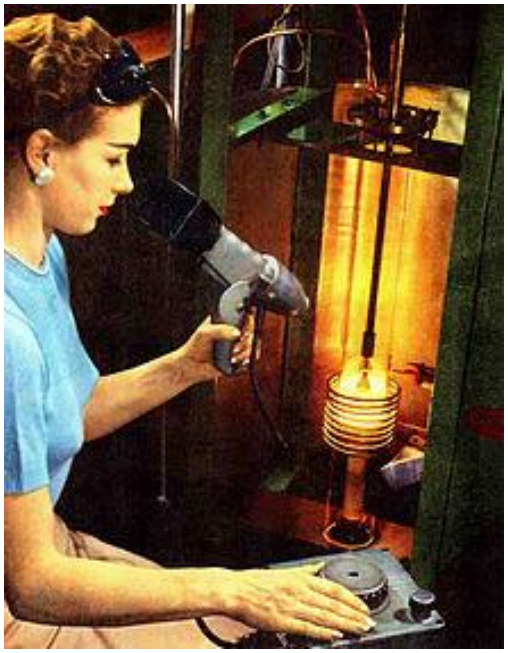
Heating the metal bar (a) presses against a lever (b), which moves a pointer (c) along a scale that serves as a measuring index. (e) is an immovable prop which holds the bar in place. A spring on (c) pushes against (b), causing the index to fall back once the bar cools.



A pyrometer from 1852

- Modern pyrometers became available when the first **disappearing filament pyrometer** was built by **L. Holborn and F. Kurlbaum in 1901**.

- This device superimposed a thin, heated filament over the object to be measured and relied on the operator's eye to detect when the filament vanished. The object temperature was then read from a scale on the pyrometer.



Technician measuring the temperature of molten silicon at 2650°F with a disappearing-filament pyrometer, in 1956. The knob she is turning (bottom right) controls current through the filament.

- The temperature returned by the vanishing filament pyrometer called brightness pyrometers, is dependent on the emissivity of the object.

- Then the ratio or two-color pyrometer was developed in the 1920s and 1930s, and they were commercially available in 1939.

Principle of operation

A pyrometer has an optical system and detector. The optical system focuses the thermal radiation onto the detector.

The output signal of the detector(Temperature T) is related to the thermal radiation or irradiance *j* of* the target object through the Stefan–Boltzmann law, the constant of proportionality σ, called the Stefan- Boltzmann constant and the emissivity ε of the object.

$$j^* = \varepsilon \sigma T^4$$

This output is used to infer the object's temperature. Thus, there is no need for direct contact between the pyrometer and the object.

Working of a pyrometer

There are two basic kinds of pyrometers:

1. optical pyrometers (where you look at a heat source through a mini-telescope and make a manual measurement).
2. electronic, digital pyrometers that measure completely automatically.

Types of pyrometers

The following are some of the most commonly and widely used pyrometers.

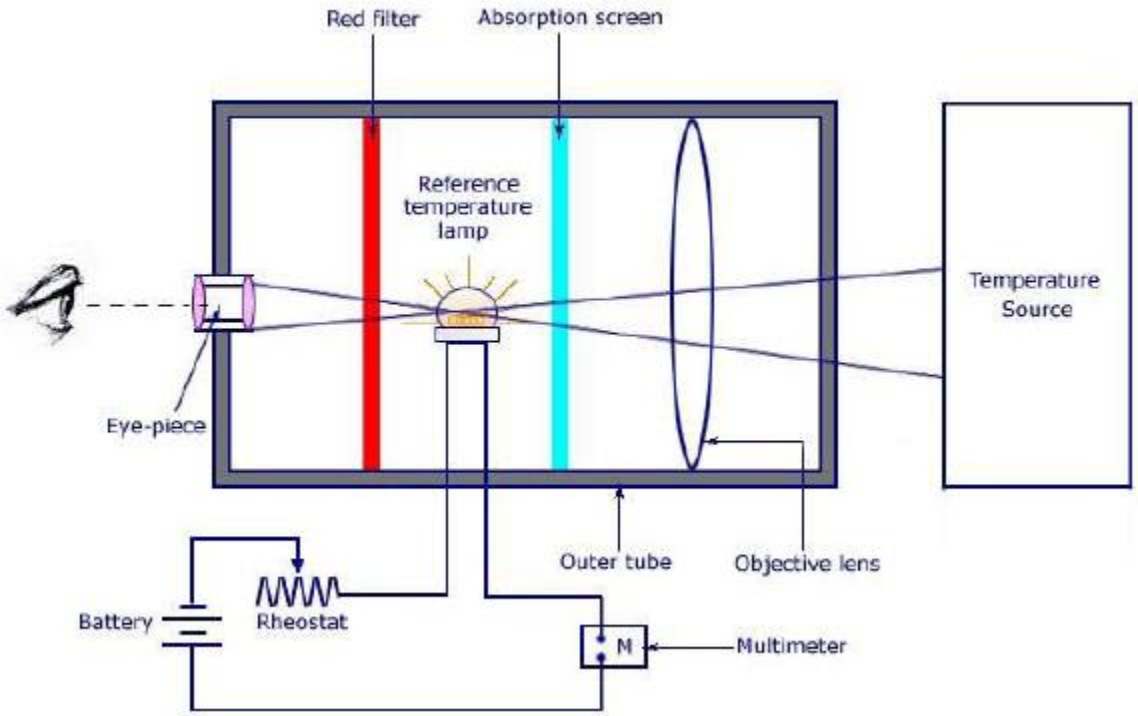
- OPTICAL PYROMETER
- RADIATION PYROMETER

OPTICAL PYROMETER

➢ Optical Pyrometers work on the basic principle of using the human eye to match the brightness of the hot object to the brightness of a calibrated lamp filament inside the instrument.

➢ The optical system contains filters that restrict the wavelength-sensitivity of the devices to a narrow wavelength band around 0.65 to 0.66 microns (the red region of the visible spectrum).

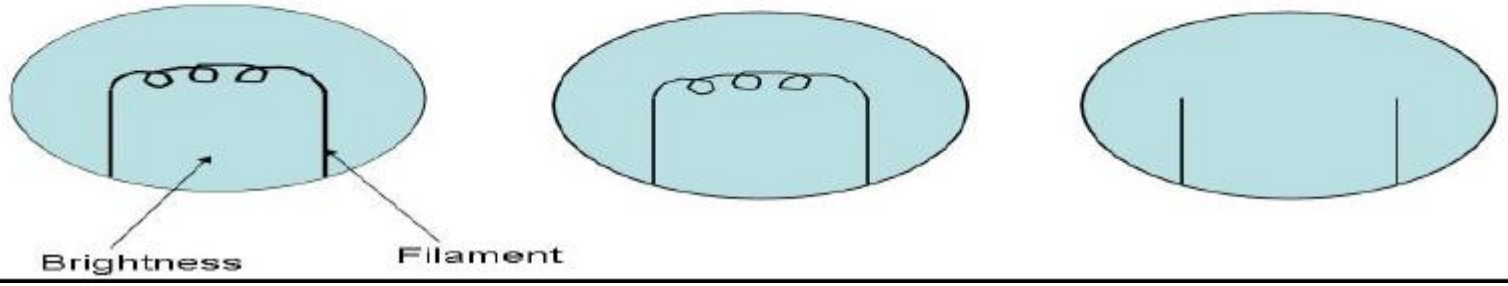
➢ By restricting the wavelength response of the device to the red region of the visible, it can only be used to measure objects that are hot enough to be incandescent, or glowing. This limits the lower end of the temperature measurement range of these devices to about 700 °.



A, filament (dark)
Cooler than temperature source

B, filament (BRIGHT)
hotter than temperature source

C, filament (Disappears)
Equal brightness of filament & Temperature source



Advantages

- Portable
- Convenient to use
- Light weight
- Can monitor movable object
- Non contact type

Disadvantages

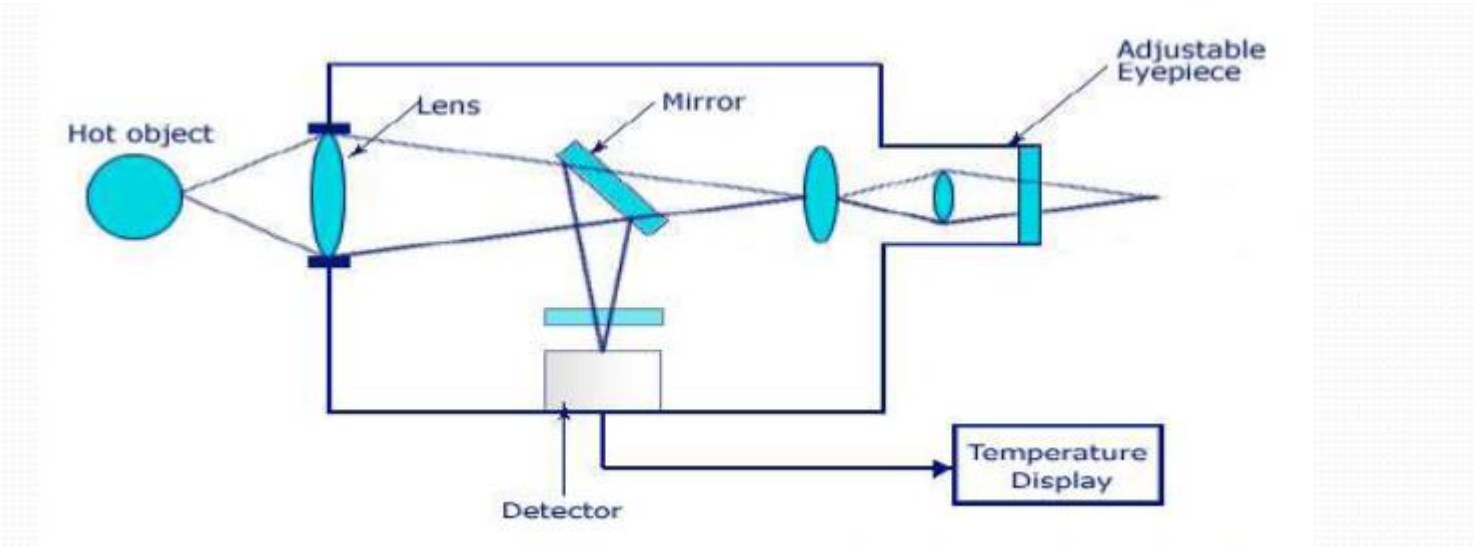
- Expensive
- Human errors
- At high temp. filament erodes frequently
- The device is not useful for obtaining continuous values of temperatures at small intervals.

RADIATION PYROMETER

The main theory behind a radiation pyrometer is that the temperature is measured through the naturally emitted heat radiation by the body.
This heat is known to be a function of its temperature.

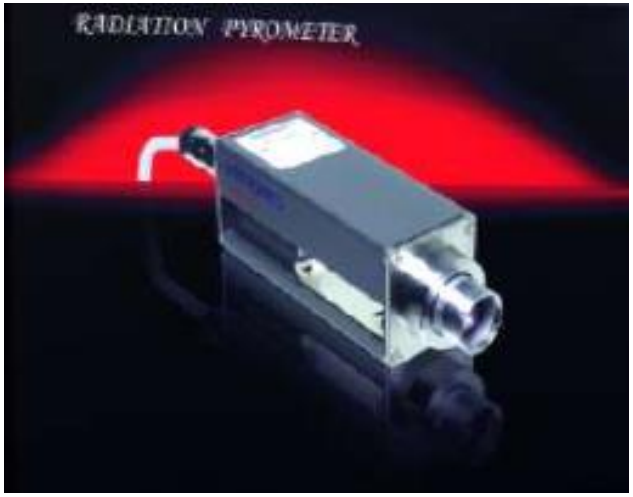
According to the application of the device, the way in which the heat is measured can be summarized into two:

☐ **Total Radiation Pyrometer – In this method, the total heat emitted** from the hot source is measured at all wavelengths.
☐ **Selective Radiation Pyrometer – In this method, the heat radiated** from the hot source is measured at a given wavelength.



Advantages

- Ability to measure high temp.
- No need for contact
- Fast response speed
- Moderate cost



Disadvantages

- Emissivity of target affect measurement
- Errors due to the absorption of radiation by carbon dioxide, water or other apparently transparent gases

Applications

- They are used for temperatures above the practical operating range of thermocouples.
- They can be used in the environments which contaminate or limit the life of thermocouple.
- Used for moving targets.
- They are used for measurement of average temperature of large surface areas.
- A steam boiler can be fitted with a pyrometer to measure the steam temp. in the superheater

Thank you