EXCERCISE 30	MEASUREMENT OF TEMPERATURE USING OPTICAL PYROMETER

Measurement procedure

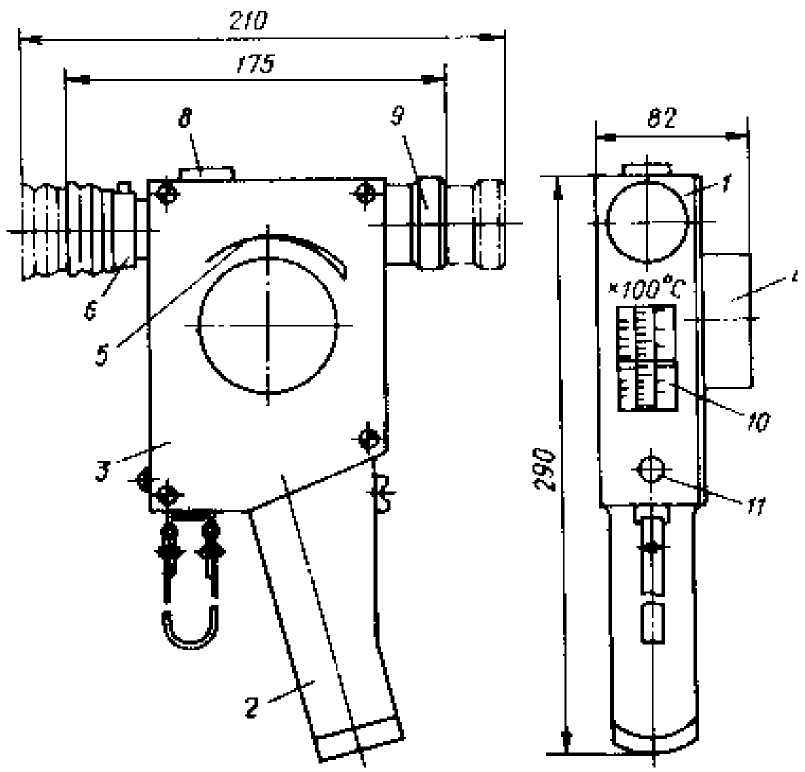
1. List of equipment

1) Optical pyrometer
2) Stabilized power supply P340
3) Ammeter DC
4) Voltmeter DC
5) Halogen bulb 55W/12V

2. Goal

To determine the temperature of a bulb filament according to the supplied power.

3. Measurement setup



2 – grip handle
4 - knob to twist (scale)
5 - indicator of the rotation
6 – eye piece
8 - range switch
9 – optical lens
10 – scale

Fig.1. Pyrometer scheme

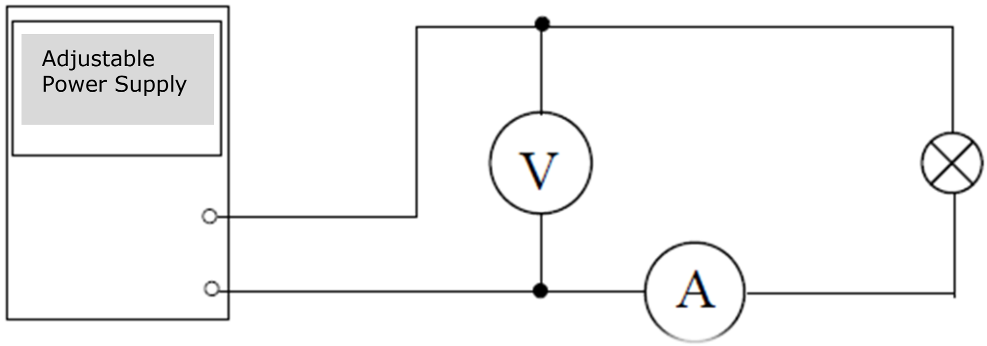


Fig.2 Measurement setup to determine the power of the bulb

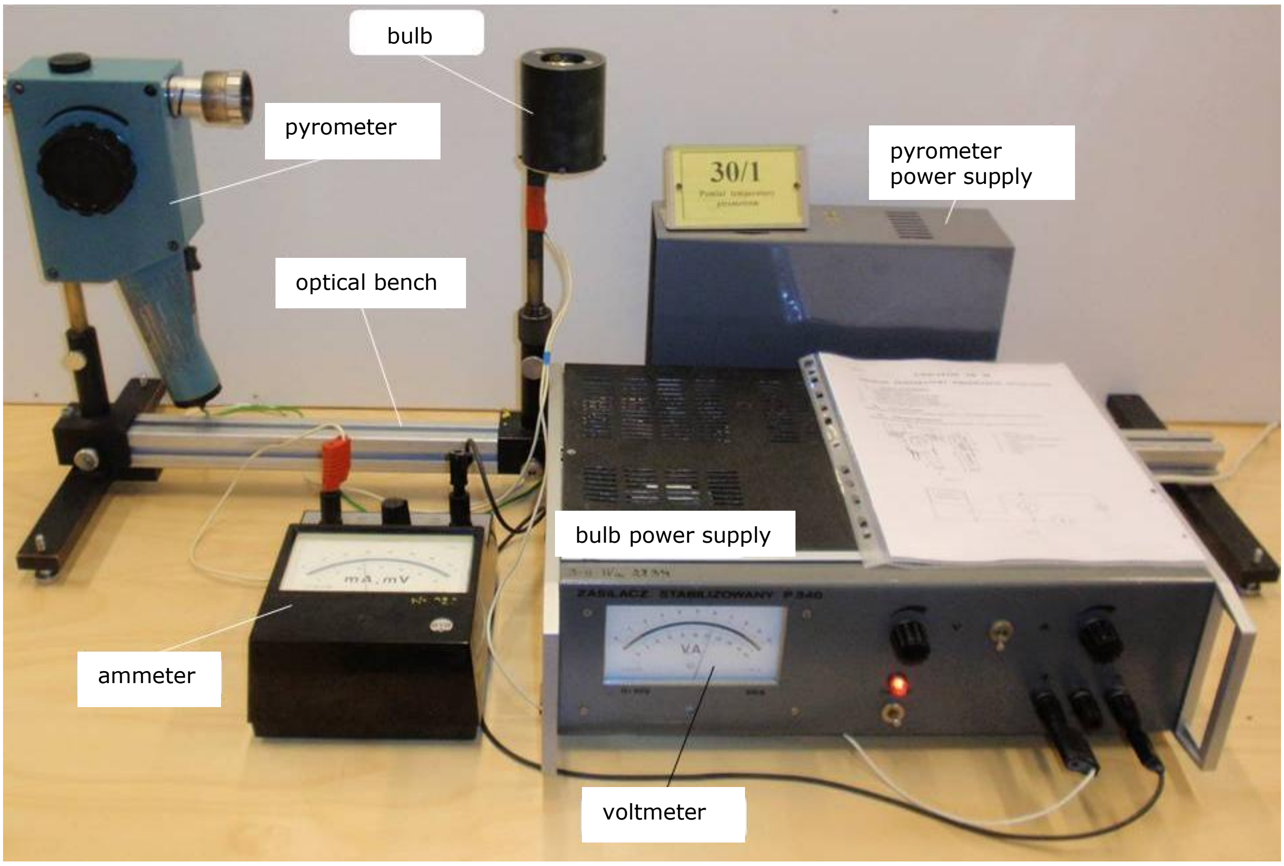


Fig. 3 Measurement setup

rectangular

4. Measurements plan

1. Set the pyrometer at a distance of about 80 cm from the examined bulb.
2. Switch on the pyrometer using button (11) and rotate the eye piece (6) to obtain the sharp picture of the pyrometer filament.

3. Enter the red filter into the field of view using the switch at the eye piece.
4. Switch on the power of the halogen bulb.
5. Point the pyrometer lens (9) on the examined bulb filament to get the picture of bulb filament against the pyrometer filament.
6. Set the proper range of measured temperature using the range switch (8):
- position 1 - 800-1400 °C
- position 2 - 200-2000 °C
- position 3 - 1800-5000 °C.
7. Vary the temperature of the pyrometer filament using the pyrometer power supply (12) to find the *black temperature* at which the brightness of both the filaments (bulb and pyrometer) are equal (*when the filament is dark it is cooler than the temperature source, when it is bright it is hotter – the aim is to establish when the pyrometer filament disappears, it means when the brightness of the filament and the temperature source is equal*). Read this black temperature T_b from the appropriate pyrometer range.
8. Varying the power of the bulb make 10 single measurements of the black temperature of its filament in the whole pyrometer range (from 800 up to 5000 Celsius degrees).
9. For an arbitrary chosen one single measurement from each pyrometer range make 10 measurements of the same black temperature.
CAUTION! Do not touch the halogen bulb cover since it is extremely hot.

5. Analysis of the results

1. For three black temperatures measured 10 times find their uncertainty $u(T_b)$.

2. In the case of the remaining black temperatures measured only once take as the uncertainty the value of the smallest scale in a given measuring range.

3. Calculate the real temperatures for each power of the bulb according to the formula (1)

$$\frac{1}{T_r} = \frac{1}{T_b} + \frac{\lambda}{C_2}\ln(A)$$

where A stands for the absorption of the bulb filament given by the equation:

$$A = 0.4752 - 2 \cdot 10^{-5}\left[\frac{1}{K}\right] \cdot T_b[K], \quad \text{and} \quad C_2 = 1.44 \cdot 10^{-2}[m \cdot K].$$

The applied filter transmits light of the wavelength $\lambda = 650[nm]$. Remember, that the black temperature should be given in Kelvins.

4. Calculate the uncertainty of the real temperature for each power applied.

5. Calculate the particular powers $P = U \cdot I$ and s their uncertainties from the classes of the used meters, where:

U - voltage read from the voltmeter
I – current read from the ammeter

6. Read the real temperatures based on the nomogram and compare them with the real temperatures calculated from the formula.

7. Make the plot of the real temperature of the bulb filament in function of the supplied power

$$T_r = f(P)$$

8. Mark the rectangular of the uncertainty for the chosen measurement points.

6. Proposed tables (to be confirmed by the teacher)

Table 1. is dedicated to record the parameters of the bulb power as well as the black temperatures read from the pyrometer. When the measurements are repeated for the same power (read U and I) you can merge the table cells (the Protocol)

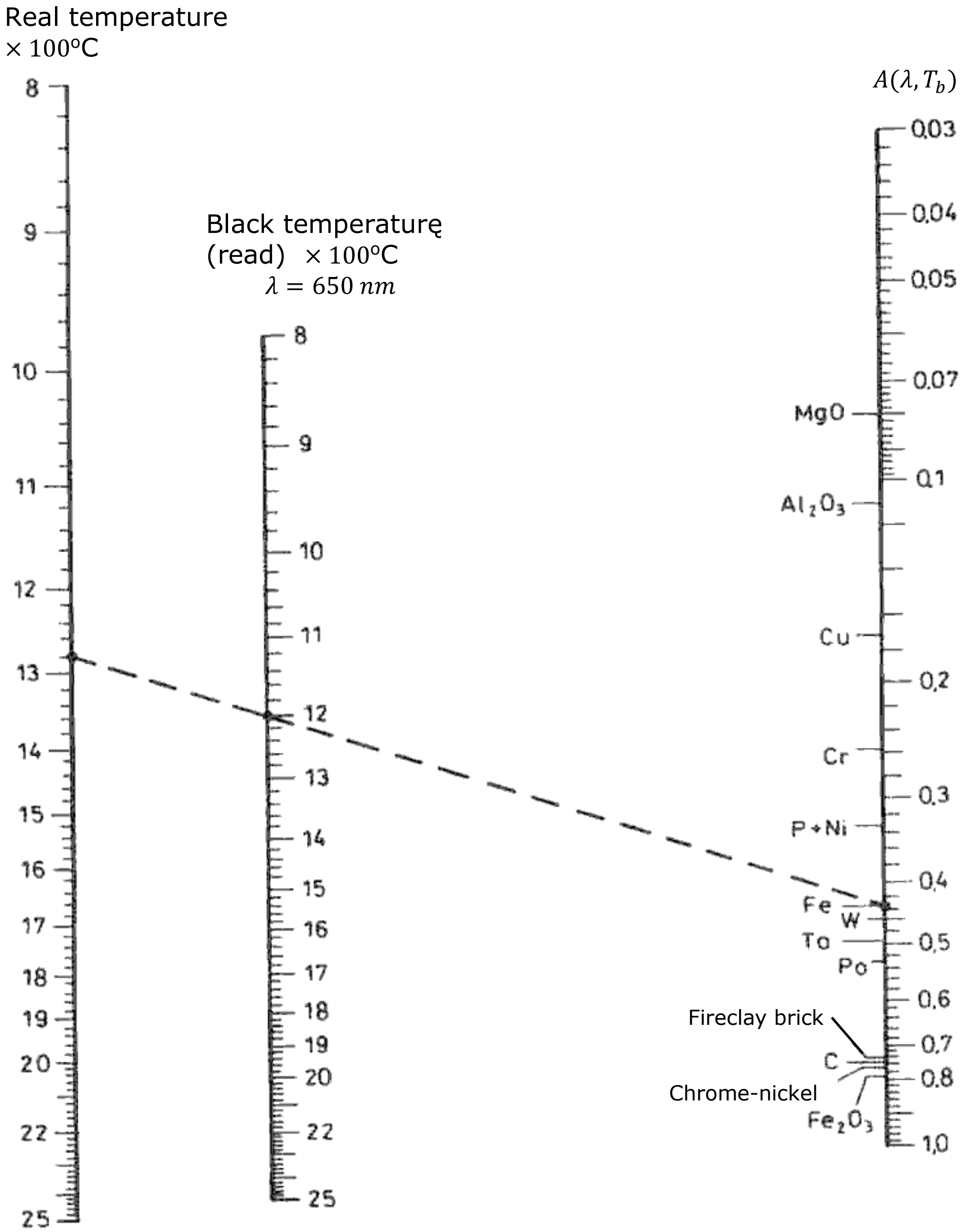
No	$\boldsymbol{U}[\boldsymbol{V}]$	$\boldsymbol{I}[\boldsymbol{mA}]$	$\boldsymbol{T_b}[\,^{\boldsymbol{0}}\boldsymbol{C}]$
1			
2			
3			
. . .			
n			

Table 2. An example of the table used in the analysis of the results (the Report)

No	$\boldsymbol{U}[V]$	$\boldsymbol{I}[mA]$	$\boldsymbol{P}[W]$	$\boldsymbol{T_b}[\,^{0}C]$	$\boldsymbol{T_b}[K]$	$\boldsymbol{T_r}[\,^{0}C]$	$\boldsymbol{T_r}[K]$
1							
2							
3							
. . .							
10							
$\overline{\boldsymbol{X}}$							
ΔX							
$u(X)$							
$u_c(X)$							
...	...	...	...	...	...	...	...

7. Additional information

A. In order to find the real temperature as well as to control the calculations you can refer to the nomogram given below



B. The radiation from the source is emitted and the optical objective lens captures it. The lens helps in focusing the thermal radiation on to the reference bulb. The observer watches the process through the eye piece and corrects it in such a manner that the reference lamp filament has a sharp focus and the filament is super-imposed on the temperature source image. The observer starts changing the reference lamp intensity. This can be observed in three different stages: