EXPERIMENT 14

TEMPERATURE DEPENDENCE OF ELECTRICAL RESISTANCE

PURPOSE

- To study the effect of the temperature on resistance of metal conductors.
- To establish the thermal coefficient of resistivity of metal.

APPARATUS

Laboratory board with mounted enclosed-dial type Wheatstone's bridge, resistance decade box, galvanometer, low voltage power supply, heated aluminium block with examined resistor, thermometer.

DESCRIPTION OF THE MEASUREMENTS

The electrical resistance of all substances depends on the temperature. In metals and alloys the resistance increases with the temperature. The temperature dependence of resistance of a substance is expressed in terms of its temperature coefficient of ressistivity.
In the present experiment the temperature dependence of resistance and the temperature coefficient of metal will be determined.

The Wheatstone's bridge is applied to measure the unknown resistance by providing a balance between two parallel circuits - Fig.1. One branch of the circuit is a uniform resistance path of potentiometer - P. The other branch contains the unknown resistance and known resistance of decade box - R_D . Balanced bridge (with zero galvanometer deflection) gives the opportunity to find the unknown resistance - R_x - from the potentiometer's scale readings – n - Eq.1.:

$$R_x = \frac{n}{(N-n)} \cdot R_D \qquad (1)$$

where N is the total number of scale marks.

Since the examined resistor is placed inside the heated aluminium block , it is possible to observe changes of its resistance due to the temperature.
Within narrow temperature range one may assume (for the majority of metals) linear type of ressistivity vs. temperature dependence- Eq.2.:

$$\rho_T = \rho_o \cdot [\ 1 + \alpha \cdot (\ T - T_0\ )\ ] \qquad (2)$$

where :

α - thermal coefficient of resistivity
ρ_0 - resistivity for T_0 = 273 [K]

ρ_T - resistivity for temperature T [K]
Neglecting the thermal expansion of metal one could obtain the following expression describing temperature dependence of the resistance:

$$R_T = R_o\left[\ 1 + \alpha \cdot (T - T_0)\ \right] \qquad (3)$$

Therefore, from R(T) experimental data set it is possible to establish the thermal coefficient of resistivity of material - α

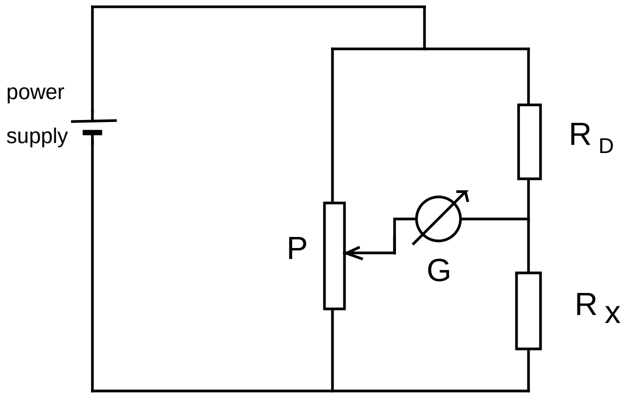

Figure 1. Experimental circuit

MEASUREMENTS

1. Place the tested resistance (mounted inside the aluminium block) as the unknown resistance of Wheatstone's bridge circuit as diagrammed in Fig. 1.
2. Connect all elements of circuit.
   Ask for supervisor's approval !!
3. Turn on the electric heater of aluminium block and heat it up until temperature about 373 K is reached . Be aware of hot surfaces. Watch your hands !!
   Turn the heater off.
4. Adjust the potentiometer - P- pointer at the middle of the scale .
5. Adjust the resistance decade box on 100 [Ω] value.
6. Balance the bridge precisely (to reach zero galvanometer - G - deflection) with the potentiometer's hand wheel.
   Record the position of the pointer - n - and the absolute error - Δn of the readings.
7. Record the aluminium block temperature value from the thermometer.
   Repeat the procedure 4 -7 for series of 12-15 temperature values
   (from 373[K}-303[K] range).

   Record all results on the data table.

CALCULATIONS AND PRESENTATION OF RESULTS

1. Calculate from Eq.1. the resistance value R for each temperature point.
2. Plot the R(T) dependence.
3. Calculate from the linear regression method coefficients A – slope and B – intercept and the correlation coefficient and errors of the slope ΔA and intercept $\Delta B = \Delta R_0$
4. Calculate R_0 and α from A and B values (use the Eq. 3.)
4. Calculate the absolute error of the temperature coefficient α from:

$$\Delta\alpha = \alpha\left(\frac{\Delta A}{A} + \frac{\Delta B}{B}\right)$$

5. Present the result in a form:

$$\alpha = \alpha \pm \Delta\alpha$$

$$R_0 = R_0 \pm \Delta R_0$$

ANALYSIS AND INTERPRETATION

1. Discuss the linearity of the established R(T) equation.
2. Compare the obtained - α - value with data from physical tables.

DATA TABLE 1.

scale readout n	Total scale N	resistance R [Ω]	temperature T [K]

REQUIREMENTS

1. Principles of electrical conductivity of metals. Electron gas model
2. Temperature dependence of resistance of different materials. Superconductivity.
3. Description of Wheatstone’s bridge method.