RESISTANCE THERMOMETERS AND THEIR PRINCIPLES OF OPERATION

Bukhara Institute of Engineering and Technology
doctoral student **Kamolova Muxlisa Khudoyberdiyevna**
Bukhara Institute of Engineering and Technology
Student **Eshmurodova Sevinch Ilhom qizi**

Temperature measurement with resistance thermometers (RT) is based on the change in electrical resistance of conductors and semiconductors with temperature changes. Therefore, the electrical resistance of a conductor or semiconductor is a function of its temperature, i.e. R=f(t). They can reliably measure temperatures from -260 to +1100 °C.

The appearance of this function depends on the properties of the thermometer resistance material. The temperature is found by the resistance of resistance thermometers inserted into the measured medium or by the amount of current passing through it. The electrical resistance of most pure metals increases with temperature, while the resistance of metal oxides (semiconductors) decreases. Pure metals that meet the following requirements are used to make resistance thermometers:

1. The metal should not be oxidized and its chemical composition should not change in the environment being measured;
2. The temperature resistance coefficient of the metal should be sufficiently large and stabilized;
3. The resistance should change with temperature change on a straight or smooth curve without sharp deviations and without hysteresis;
4. The relative electrical resistance should be almost large. Metals such as platinum, copper, nickel, iron, tungsten meet the above requirements in the range of certain temperatures.

For metals whose temperature coefficient depends on temperature, it can be determined only for each value of temperature:

$$\alpha=(1/R_0)(dR_t/dt) \qquad (1.1)$$

in this: R_0 and R_t *-0* and t °C temperature resistance.

The temperature coefficient is expressed in $^{\circ C-1}$ or K-1. Copper, platinum, nickel and iron are now used to make resistance thermometers.

a) Copper resistance thermometer. Copper is a cheap material, and its resistance is practically linearly dependent on temperature, i.e $R_t=R_0(1+\alpha t)$.

in this R_t va R_0 -t va 0 °C resistance thermometer in temperature.

Temperature coefficient of α-copper wire:

$$\alpha=4,28*10^{-3}K^{-1}$$

They are designed for temperature measurement in the range from -50 to +200 °C and are made of copper wire with a diameter of 0.1 mm.

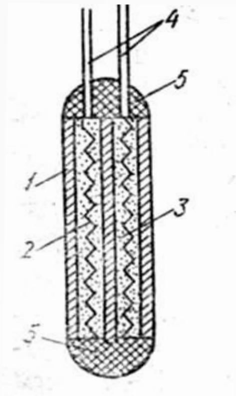
As the temperature increases, copper is actively oxidized, which is its main disadvantage.

b) Resistance thermometers made of platinum. Platinum QTs are extremely high precision transducers that are used as working, sample and reference thermometers. On the international temperature scale, temperatures in the range from -182.97 to 630.5 °C are measured. The disadvantage of platinum is the nonlinearity of the function Rt=f(t) and the fact that it is a very expensive metal. The sensitive element of resistance thermometers made of platinum is shown in figure 1.1.

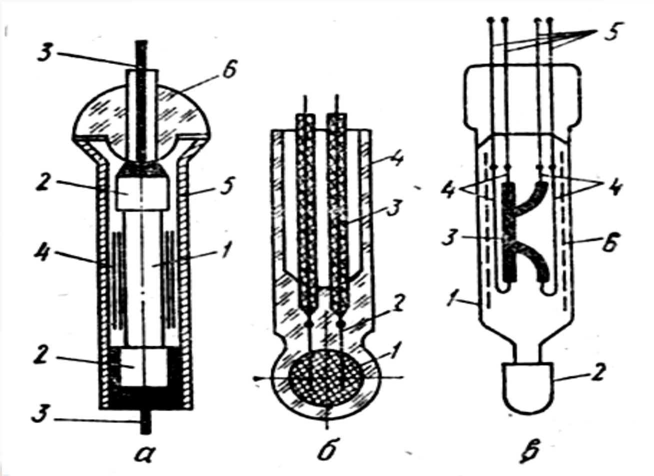
v) Nickel and iron have extremely high temperature coefficients and are used to measure temperatures from -50 to +250 °C. However, their non-linear graduation characteristics and rapid oxidation limit their use. Semiconductors (oxides of some metals) are also used to make resistance thermometers (thermistors). An important advantage of semiconductors is their high temperature coefficient (1.2).

These thermometers are used to measure temperatures from 1.5 to 50 K.

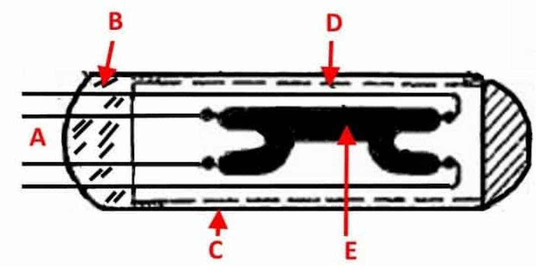
When measuring temperature MMT-1, MMT-4, MMT-6, KMT-1, KMT-4 type of thermoresistors are used. Semiconductor thermometers are widely used in automatic protection devices.



1.1- fig. The sensitive element of the platinum resistance thermometer: 1-platinum wire; 2- metal shell; 3- ceramine powder; 4- ears for connection (platinum or iridium-rhodium); 5-special glaze (or thermocement)



1.2 - fig. The sensitive element of the semiconductor germanium resistance thermometer: 1- copper sleeve, filled with helium; 2- stopper; 3- single crystal of germanium doped with antimony; 4- gold conductor glued to the crystal; 5- platinum earrings; 6- crystal insulating film.



1.3-figure Semiconductor resistance sensor.

A - The side to be connected to the meter; V – a glass stopper protected by a sleeve; S – protective sleeve filled with helium; D - electrical insulation film, the inner part of which is covered with a sleeve; E is an antimony-doped germanium semiconductor sensing element

When measuring the temperature with resistance thermometers, it is necessary to measure the resistance of the thermometer, which is connected to the measuring instrument with the help of measuring wires. Because the resistance connected to the measuring instrument is greater than the resistance of the thermometer. Various methods are used to reduce or eliminate the effect of this additional resistance on the measurement result. It depends on the connection scheme of the thermometer and the method of measurement or the scheme of the measuring instrument.

To measure the resistance, a current must pass through the thermometer. In this case, according to the Joule-Lens law, heat is released, which heats up the thermometer to a temperature higher than the temperature of the environment it is measuring. As a result, its resistance changes accordingly. In industrial conditions, the measuring current is calculated in such a way that the resulting error due to self-heating does not exceed 0.1% R_0 of the thermometer resistance in °C.

The disadvantage of resistance thermometers is the need for an additional current source.

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