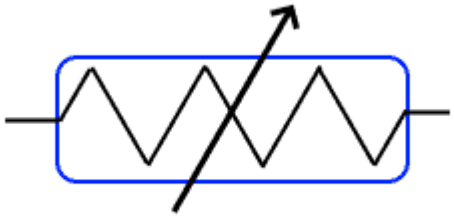
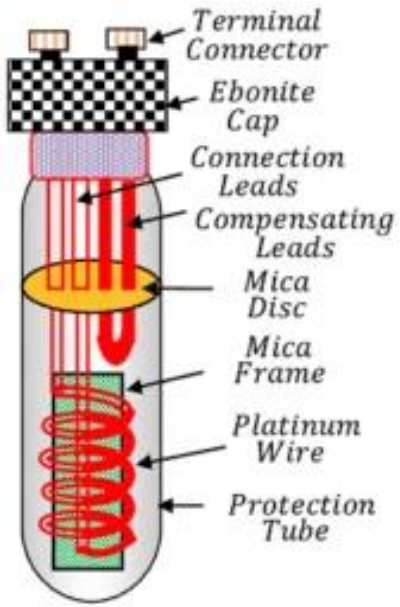
ELECTRICAL-RESISTANCE THERMOMETER, OR RESISTANCE TEMPERATURE DETECTOR (RTD)



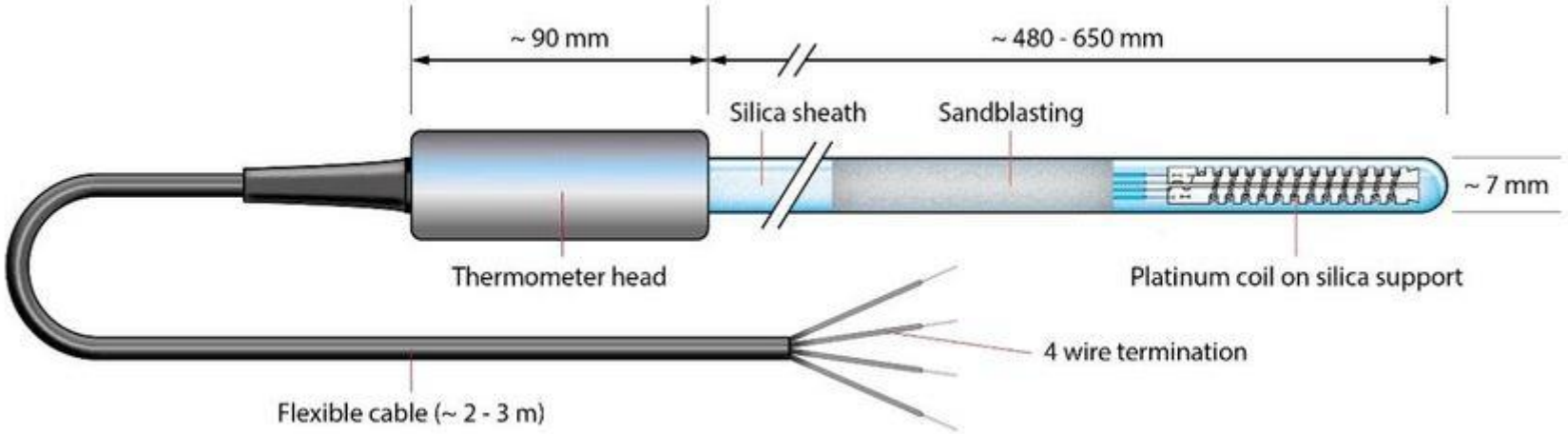
RTD - Resistance Temperature Detector



Resistance Temperature Detector

- **Resistance thermometers**, also called **resistance temperature detectors (RTDs)**, are sensors used to measure temperature.
- Many RTD elements consist of a length of fine wire wrapped around a heat-resistant ceramic or glass core but other constructions are also used.
- The RTD wire is a pure material, typically platinum (Pt), nickel (Ni), or copper (Cu).
- The material has an accurate resistance/temperature relationship which is used to provide an indication of temperature.

A platinum resistance thermometer (PRT) is constructed from a high purity platinum element (wire-wound coil or thin film) placed in a tube of metal or glass and sealed with an inert atmosphere and/or mineral insulator.



Standard platinum resistance thermometers: -196°C to 962°C

Working Principle of Resistance Temperature Detector

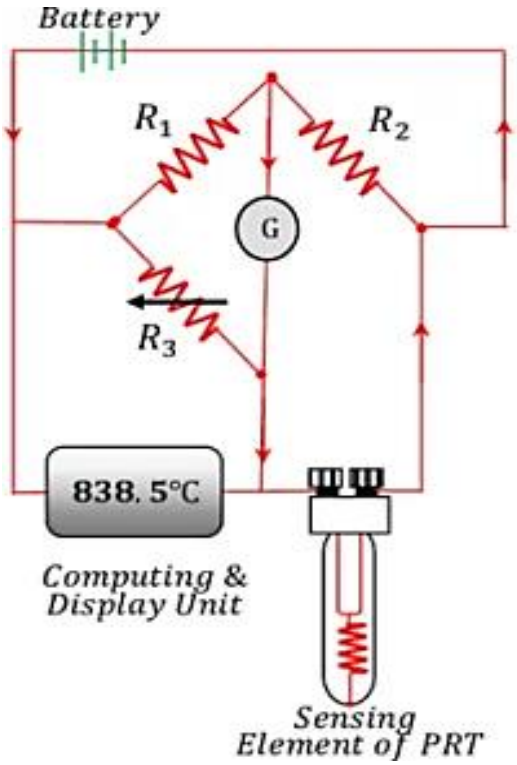
The RTD device works on the principle that the resistance of a conductor changes due to a change in temperature.

$$R = \rho \, l / a$$

As we know the resistance of a given conductor having length "l" & area "a" is given by;

$$R_t = R_o (1 + \alpha t)$$

- R_t = Resistance at temperature t
- R_o = Resistance at a reference temperature
- α = coefficient of temperature



Working Principle of Resistance Temperature Detector

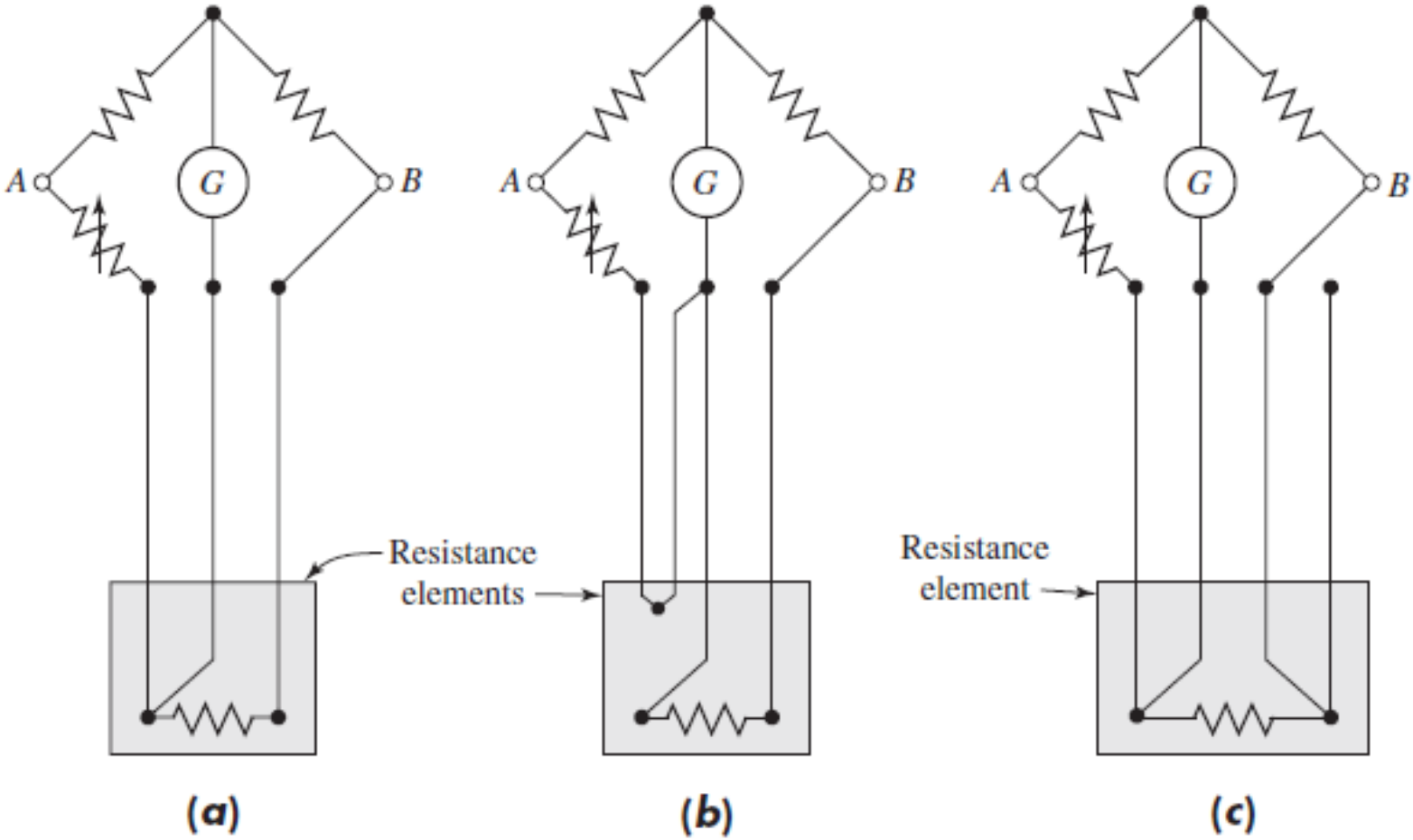


Figure 8.7 Methods of correcting for lead resistance with electrical-resistance thermometer. (*a*) Siemen's three-lead arrangement; (*b*) Callender four-lead arrangement; (*c*) floating-potential arrangement. Power connections made at *A* and *B*.

Applications of RTD's

RTD is generally used for continuous monitoring of temperature in various applications..

•It is used in applications where temperature control is important.

•It is used to measure the temperature of the engine & the air intake in automotive.

•In different industrial processes such as food handling and manufacturing, it is used to monitor the temperature.

•In different power electronics, medical & military electronics use RTD.

•It is also used in multiple communication and instrumentation for temperature measurement.

Advantages

- It can operate at a wide range of temperatures.
- Its readings are consistent and highly repeatable at high temperature.
- They are resistant to corrosion & best for extreme environments.
- It has more linear characteristics.
- It has excellent accuracy over a wide range of temperatures.
- It is stable & has a longer life span at high temperature measurement.

Disadvantages

- It requires a current source.
- Its accuracy depends on the battery's health.
- Heat is generated due to I^2R losses in the element also known as self-heating which inflicts error in the measurement thus affecting the accuracy.
- It has a large size, therefore, unable to sense temperature at small points.
- It is affected by physical shock and vibration.
- It has a limited temperature operating range as compared to thermocouple.

Resistance Temperature Detector

The linear temperature coefficient of resistance α is defined by

$$\alpha = \frac{R_2 - R_1}{R_1(T_2 - T_1)}$$

where R_2 and R_1 are the resistances of the material at temperatures T_2 and T_1.

$$R = R_0(1 + aT + bT^2)$$

where R = resistance at temperature T
R_0 = resistance at reference temperature T_0
a, b = experimentally determined constants

Resistance Temperature Detector

Table 8.2 Resistance-temperature coefficients and resistivity at 20°C[1]

Substance	α ($°C^{-1}$)	ρ ($\mu\Omega \cdot cm$)
Nickel	0.0067	6.85
Iron (alloy)	0.002 to 0.006	10
Tungsten	0.0048	5.65
Aluminum	0.0045	2.65
Copper	0.0043	1.67
Lead	0.0042	20.6
Silver	0.0041	1.59
Gold	0.004	2.35
Platinum	0.00392	10.5
Mercury	0.00099	98.4
Manganin	±0.00002	44
Carbon	−0.0007	1400
Electrolytes	−0.02 to −0.09	Variable
Semiconductor (thermistors)	−0.068 to +0.14	10^9

Resistance Temperature Detector

SENSITIVITY OF PLATINUM RESISTANCE THERMOMETER. A platinum resistance thermometer is used at room temperature. Assuming a linear temperature variation with resistance, calculate the sensitivity of the thermometer in ohms per degrees Fahrenheit.

Solution

The meaning of a linear variation of resistance with temperature is

$$R = R_0[1 + \alpha(T - T_0)]$$

where R_0 is the resistance at the reference temperature T_0. The sensitivity is thus

$$S = \frac{dR}{dT} = \alpha R_0$$

R_0 depends on the length and size of the resistance wire. At room temperature $\alpha = 0.00392^\circ C^{-1} = 0.00318^\circ F^{-1}$ for platinum.