SNS COLLEGE OF ENGINEERING

Kurumbapalayam (Po), Coimbatore – 641 107

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Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE NAME : 19EE404 MEASUREMENT &INSTRUMENTATION

II YEAR /IV SEMESTER

Topic 1 :**Resistive Transducers**

REVIEW – CLASS-37

Transducers – Definition, Advantages, Requirements, Classification and Selection

RESISTANCE TRANSDUCER

- Resistance changes due to change in some physical phenomenon
- Resistance of any metal conductor is

$$R = \rho l/a$$

- How to measure displacement? – By varying l
- How to measure force & pressure? – By varying R of conductor or semiconductor
- How to measure temperature? – ρ changes with temperature

TRANSDUCERS - DEFINITION

- **A device that receives energy from one system and transmits it to another, often in a different form.**
- **A device Which converts energy from one form to another.**
- **A device which converts a physical quantity or a physical condition in to an electrical signal. It is also known as pickup.**

POTENTIOMETERS (POT)

- Sliding contact – wiper
- Passive Transducer - Requires external power source
- Motion of wiper – Translatory / Rotational / Both
- Translatory devices – linear (straight) – Stroke of 2 mm to 0.5 m.
- Rotary devices – circular – used for measurement of angular displacement
- Helipots? – Resistive element in the form of helix – Both Translatory & Rotational motion

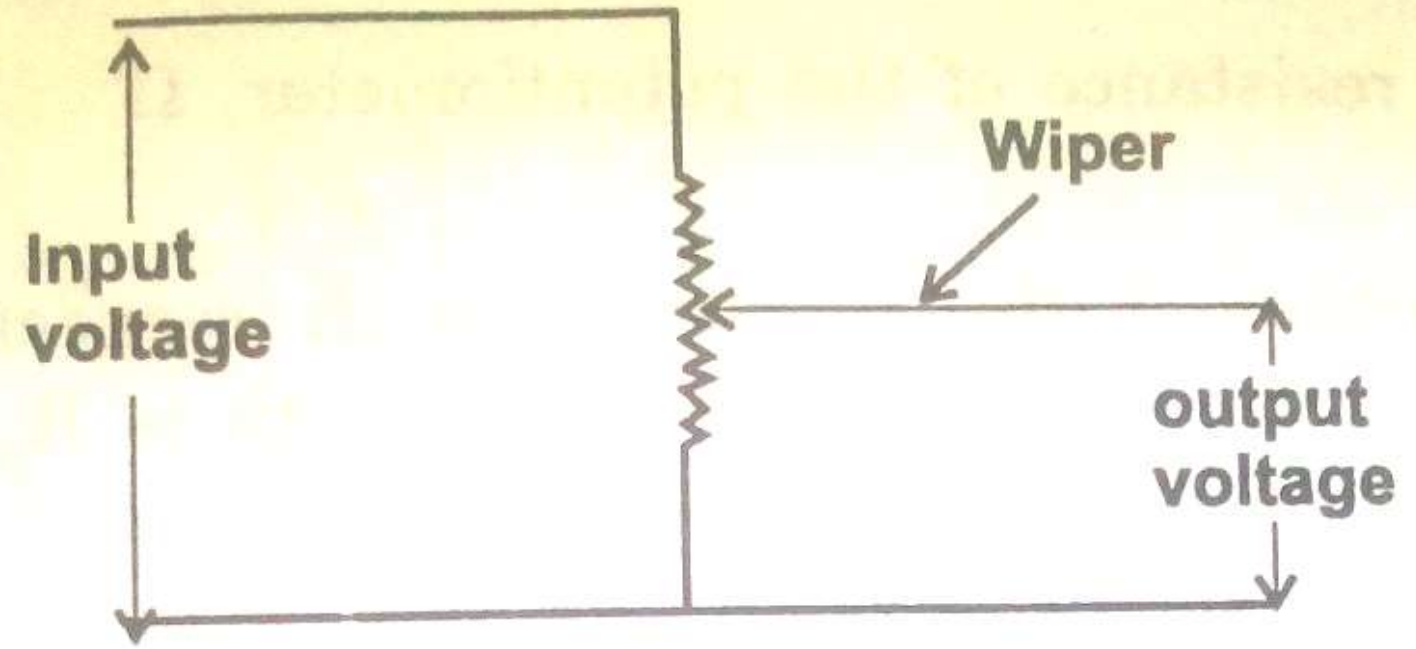

Fig. 1(a): Translatory potentiometer

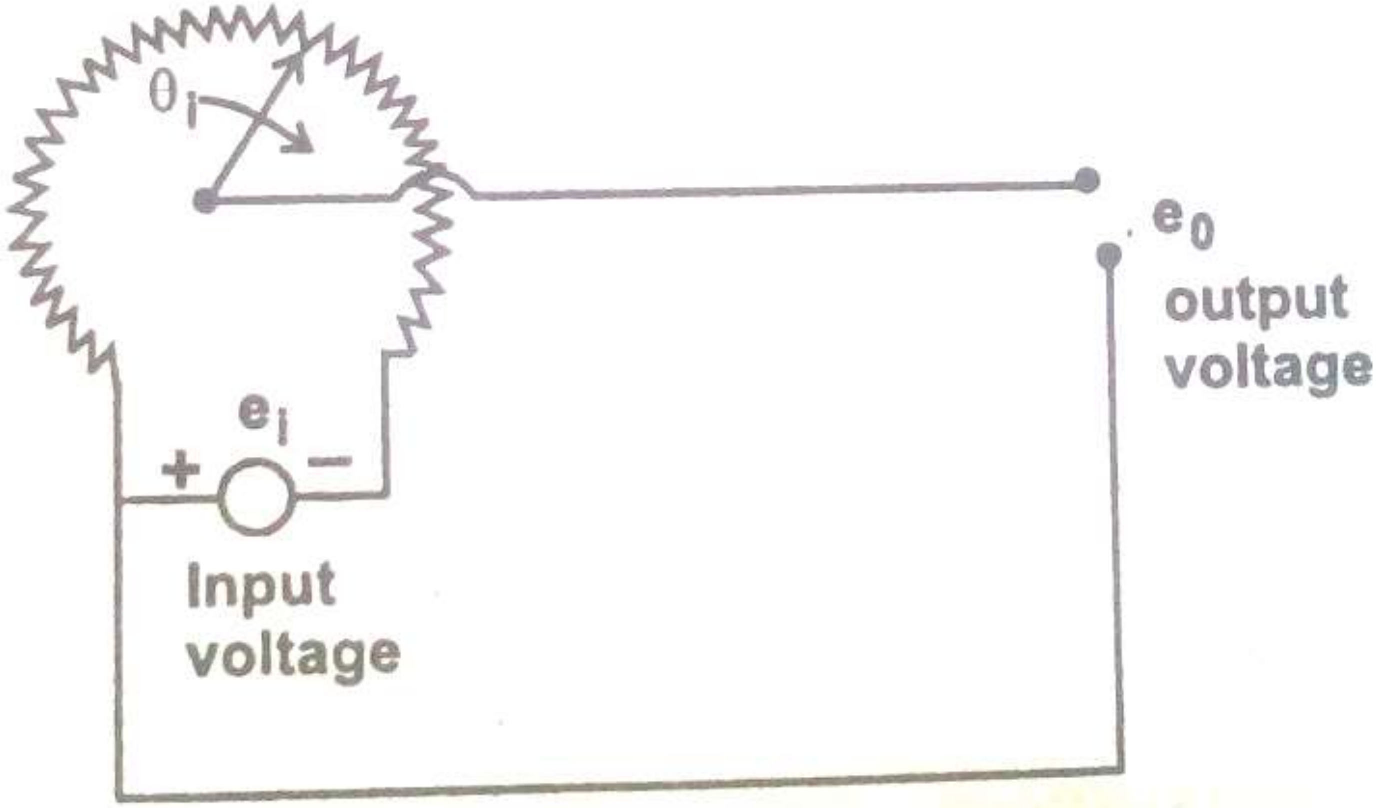

Fig. 1(b): Rotary potentiometer

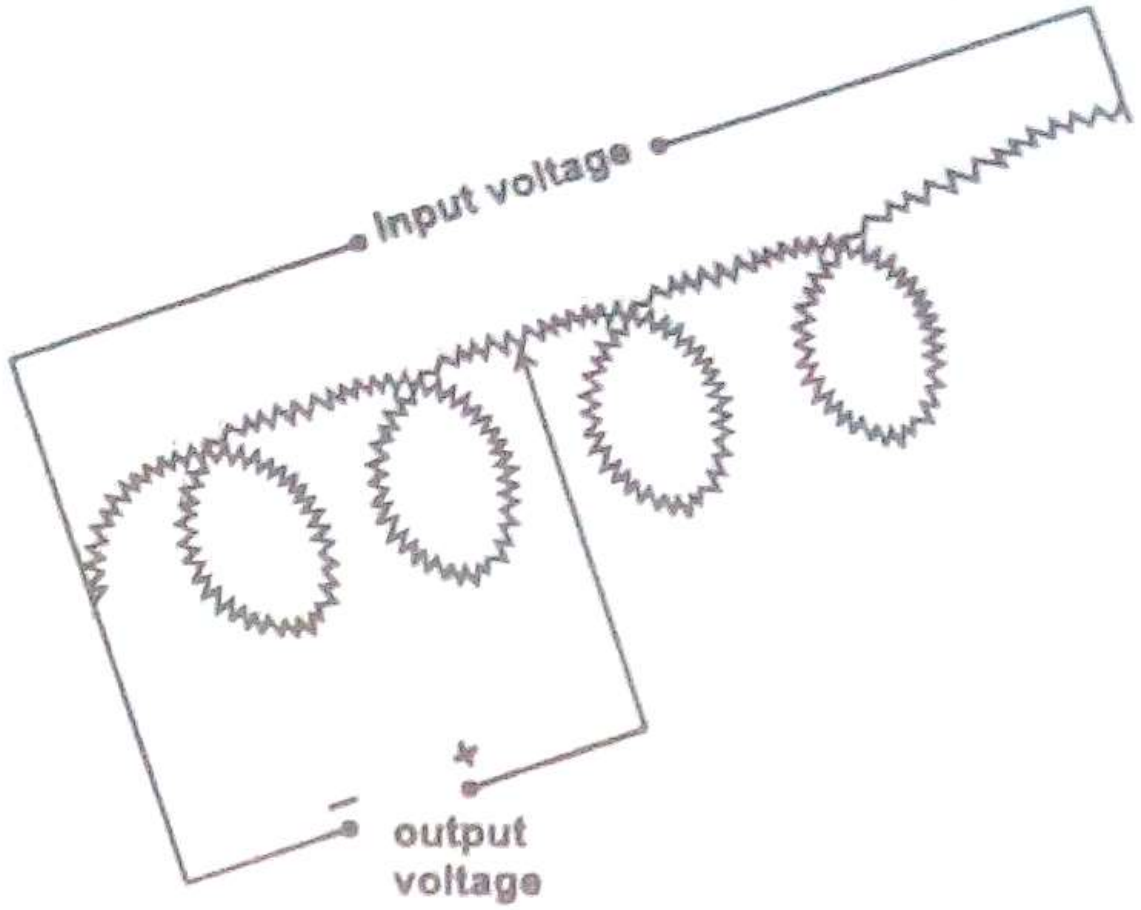

Fig. 1(c): Helipot

Let us confine our discussion to d.c excited potentiometers. Consider a translational potentiometer.

Let e_i = input voltage, V

e_0 = output voltage, V

x_t = total length of translation pot, m

x_i = displacement of wiper from its, m zero position.

R_p = total resistance of the potentiometer, Ω

If the distribution of the resistance with respect to translational movement is linear, the resistance per unit length is R_p/x_t.

The output voltage under ideal conditions is

$$e_0 = \left(\frac{\text{resistance at the output terminals}}{\text{resistance at the input terminals}}\right) \times \text{input voltage}$$

$$= \left[\frac{R_p\,(x_i/x_t)}{R_p}\right] e_i = \frac{x_i}{x_t} \times e_i$$

Under ideal circumstances, the output voltage varies linearly with displacement as shown in figure.

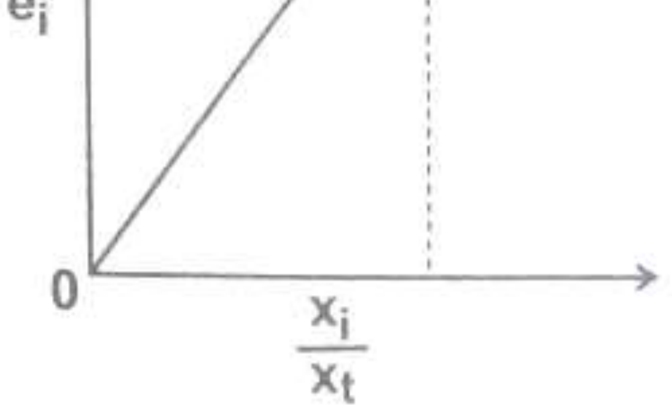

Fig. 1(d): Unloaded potentiometer

$$\text{Sensitivity } S = \frac{\text{output}}{\text{input}} = \frac{e_0}{x_i} = \frac{e_i}{x_t} \quad \text{.... (1)}$$

Under ideal conditions the sensitivity is constant and the output is faithfully reproduced and has a linear relationship with input. The same is true for rotational motion.

Let θ_i = input angular displacement in degrees

θ_t = total travel of the wiper in degrees

$$\therefore \text{ Output voltage } e_0 = e_i \left(\frac{\theta_i}{\theta_t} \right) \quad \text{.... (2)}$$

This is true of single turn potentiometers only.

POTENTIOMETERS (POT)

- Why in practical case the characteristics is not a straight line?
- What is loading error?
- Loading effect of input impedance on the output device deviates the straight line characteristics
- Sensitivity changes – Error introduced
- Expression for % error?
- Variation of error due to loading effect?

Loading Effect:

Let us consider the case of a transnational potentiometer as shown in figure. Let the resistance of a meter or a recorder monitoring the output be R_m.

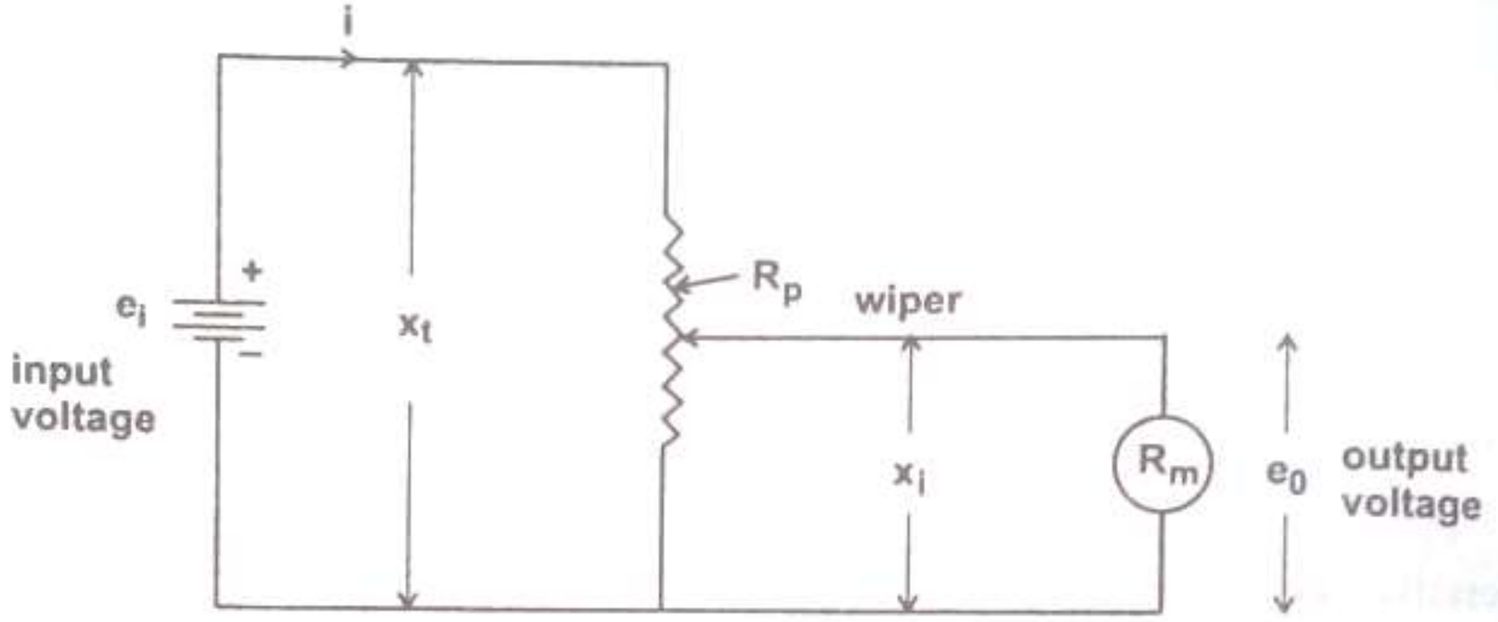

Fig. 5.2: Loaded potentiometer

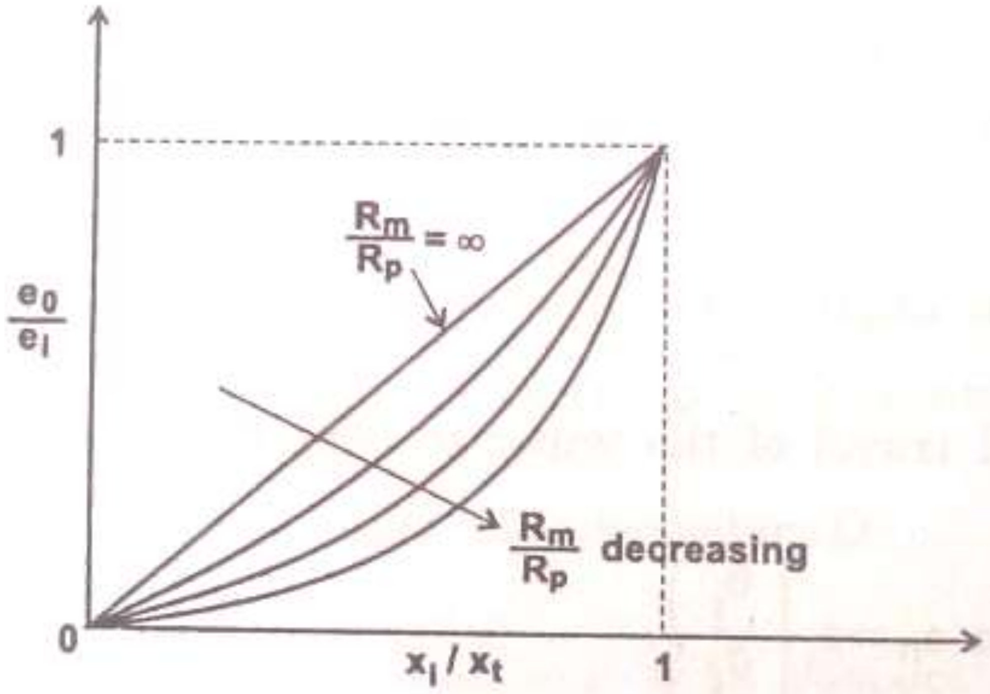

Fig. 5.3

The ratio of output voltage to input voltage under load conditions is

$$\frac{e_0}{e_i} = \frac{K}{K(1-K)(R_p/R_m)+1}$$

The above equation shows that there exists a non-linear relationship between output voltage e_0 and input displacement x_i. Since $K = \frac{x_i}{x_t}$. In case -

$$R_m = \infty, \quad \frac{e_0}{e_i} = K$$

Error = output voltage under load − output voltage under no load

$$= \left[\frac{e_i K}{K(1-K)(R_p/R_m)+1}\right] - e_i K$$

$$= -e_i \left[\frac{K^2(K-1)}{K(1-K)+R_m/R_p}\right]$$

Based upon full-scale output, this relationship may be written as

$$\% \text{ Error} = -\left[\frac{K^2(K-1)}{K(1-K)+\left(\frac{R_m}{R_p}\right)}\right] \times 100$$

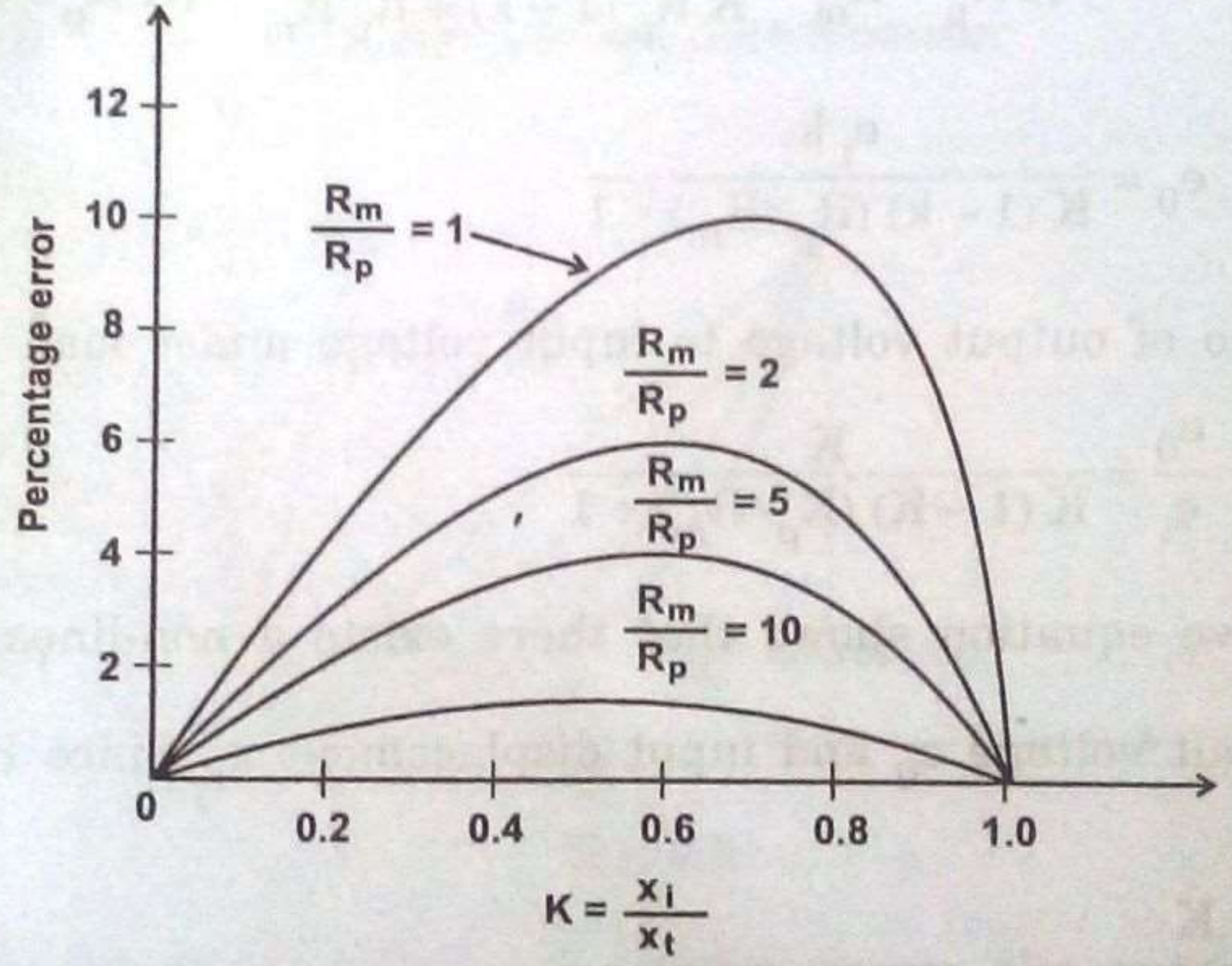

Fig. 5.4: Variation of error due to loading effect of a potentiometer

$$\text{Maximum percentage error} = 15 \times \left(\frac{R_p}{R_m}\right).$$

$$(e_i)_{max} = \sqrt{P\,R_p} \text{ volt}$$

TYPES OF POTENTIOMETERS (POT)

- Wire wound POTs
- Non-wire POTs
  - Carbon film POT
  - Thin metal POT
  - Hot molded POT
  - Cermet POT
- What are the advantages of POT?
- What are the disadvantages of POT?

STRAIN GAUGES

- Passive Transducer
- Uses the variation in electrical resistance in wires to sense the strain produced by a force on the wires
- Used for measurement of strain and stress
- Load cells, Torque meters, pressure gauges, temp. sensors employ strain gauges as secondary transducers
- What is piezo-resistive effect? – Change in the value of resistivity when the conductor is under stress
- What are piezo-resistive gauges?
- What happened if a metal conductor is stretched or compressed?

STRAIN GAUGES – OPERATING PRINCIPLE

ΔL = change in length

ΔA = change in area

ΔD = change in diameter

ΔR = change in resistance

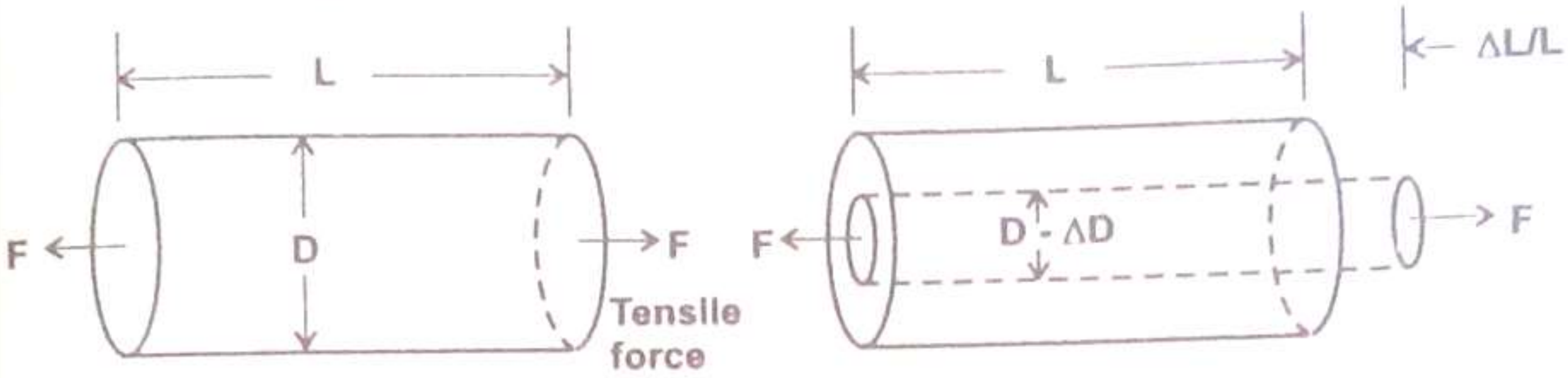

Fig. 5.6: Tensile force

TYPES OF STRAIN GAUGES

- Wire Strain gauges
  - Un bounded wire strain gauge
  - Bonded wire strain gauge
- Foil Strain gauges
- Thin film Strain gauges
- Semiconductor Strain gauges

SEMICONDUCTOR STRAIN GAUGES

- High sensitivity – high gauge factor
- 50 times greater than wire strain gauges
- Resistance of semiconductor changes with applied strain
- Germanium and silicon

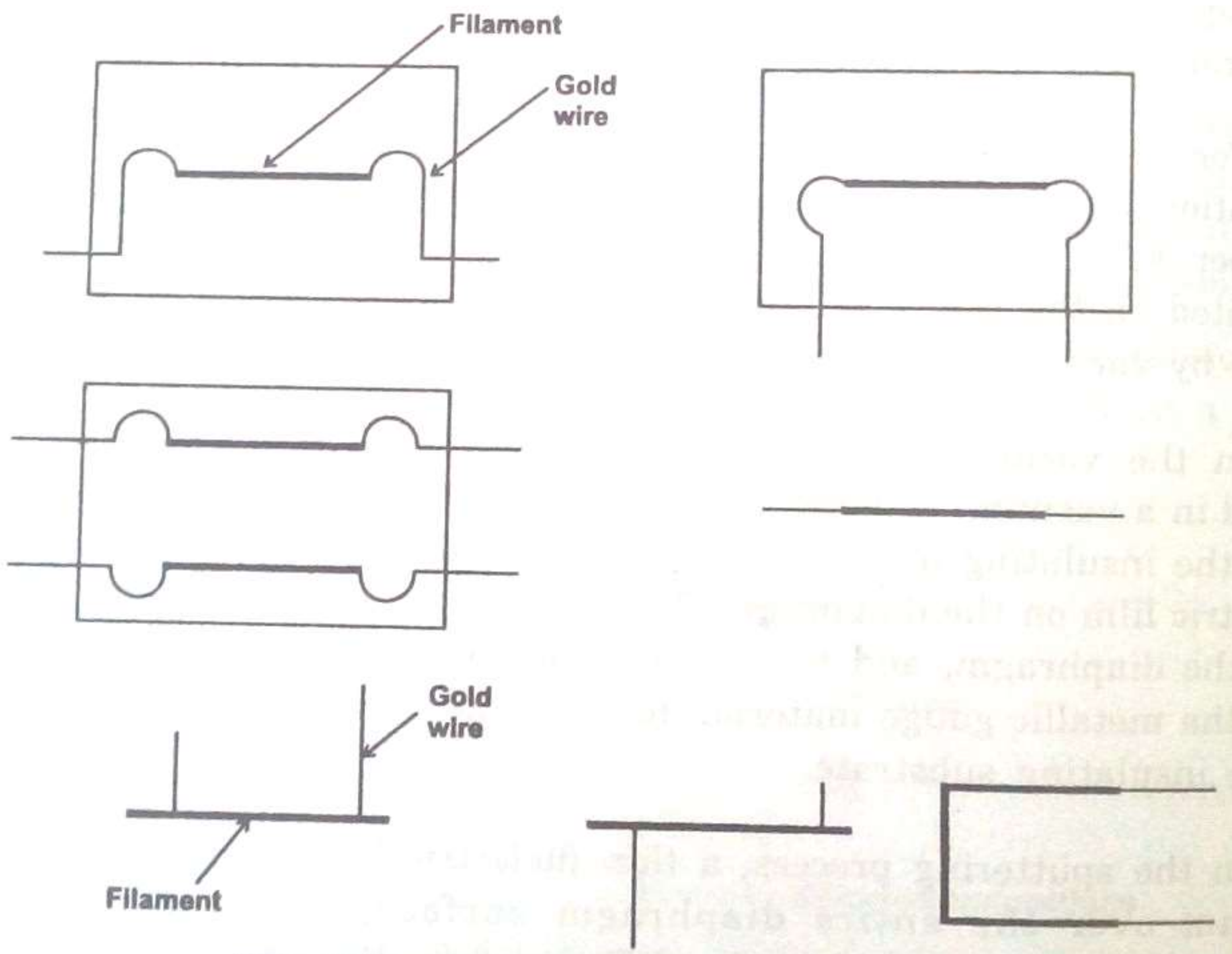

Fig. 5.10: Semiconductor strain gauges

RESISTANCE THERMOMETER (RTD)

- Requirements of RTD?
- Does not generate own voltage. Requires separate voltage source
- Used with wheatstone bridges
- Advantages?
- Disadvantages?

THERMISTOR

- Thermally sensitive resistor
- Negative Temperature coefficient
- Temperature Range?
- Resistance Range?

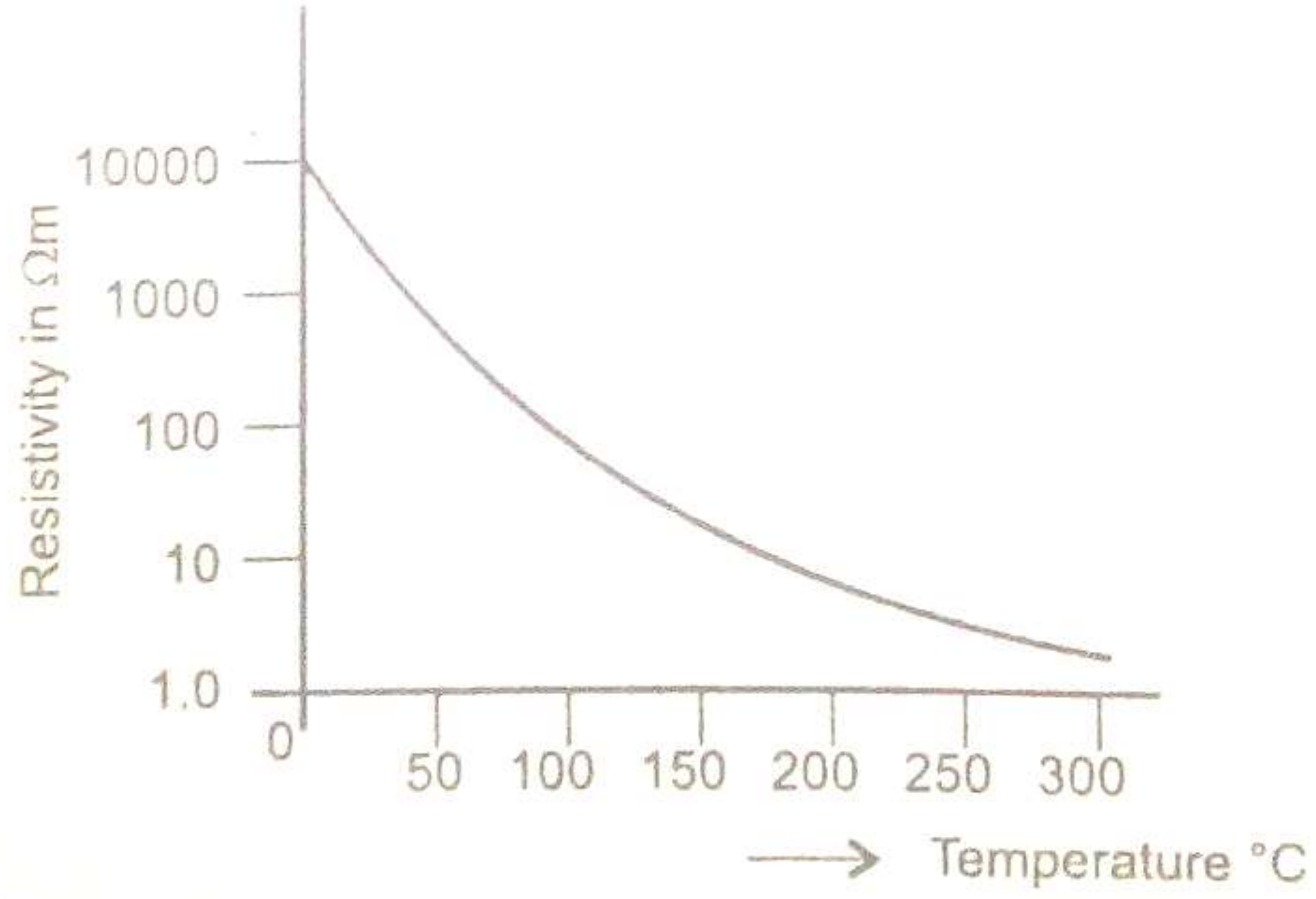

Fig. 5.12: Resistance versus temperature graph of a thermistor

THANK YOU