Department of Electronics & Communication Engg.

Course : Electronic Instrumentation.(17EC032) **Sem.: 3rd (2018-19)**

Course Coordinator:

Prof. M M Gadag

Electronic Instrumentation

Module 5

Transducers

Introduction

- Defination-
- Applications-

  Measurement- e.g. temperature, pressure etc.

  Control – e.g.-AC, Auto light control etc.

Introduction(cont'd)

- Thus the transducer is a device, which provides a usable output in response to specific input measured, which may be physical or mechanical quantity, property or condition. The transducer may be mechanical, electrical, magnetic, optical, chemical, acoustic, thermal nuclear, or a combination of any two or more of these.
- Types-

1. Mechanical transducers
2. Electrical transducers

Mechanical transducers

- are simple and rugged in construction, cheaper in cost, accurate and operate without external power supplies but are not advantageous for many of the modern scientific experiments and process control instrumentation owing to their poor frequency response, requirement of large forces to overcome mechanical friction, in compatibility when remote control or indication is required, and a lot of other limitations. All these drawbacks have been overcome with the introduction of electrical transducers.

ELECTRICAL TRANSDUCERS

- Mostly quantities to be measured are non-electrical such as temperature, pressure, displacement, humidity, fluid flow, speed etc., but these quantities cannot be measured directly. Hence such quantities are required to be sensed and changed into some other form for easy measurement.
- Electrical quantities such as current, voltage, resistance. inductance and capacitance etc. can be conveniently measured, transferred and stored, and therefore, for measurement of non-electrical quantities these are to be converted into electrical quantities first and then measured.

ELECTRICAL TRANSDUCERS

- An electrical transducer must have the following parameters:
  Linearity
  Sensitivity
  Dynamic Range
  Repeatability
  Physical size
- Advantages
  Amplification and attenuation
  Mass inertia effect
  Friction
  Indicable & recordable remotely
  Output Modification
  Signal combination
  Less power consumption
  Easily used, transmitted, and processed.

Classification Of Transducers

- The transducers may be classified in various ways such as on the basis of electrical principles involved, methods of application, methods of energy conversion used, nature of output signal etc.

  1-Active and Passive Transducers.

  Passive transducer - Device which derive power reqd. for transduction from auxiliary power source - externally powered

  Ex : resistive, inductive, capacitive

  Without power they will not work

  Active transducer - No extra power reqd. to produce I/p Self generating

  Draw power from input applied

  Eg. Piezo electric x'tal used for acceleration measurement

Classification Of Transducers (cont…)

- ***2-Primary and Secondary Transducers:***

  When the input signal is directly sensed by the transducer and physical phenomenon is converted into the electrical form directly then such a transducer is called the primary transducer.

  e.g.- In case of pressure measurement, bourdon tube is a primary sensor which converts pressure first into displacement, and then the displacement is converted into an output voltage by an LVDT. In this case LVDT is secondary transducer.

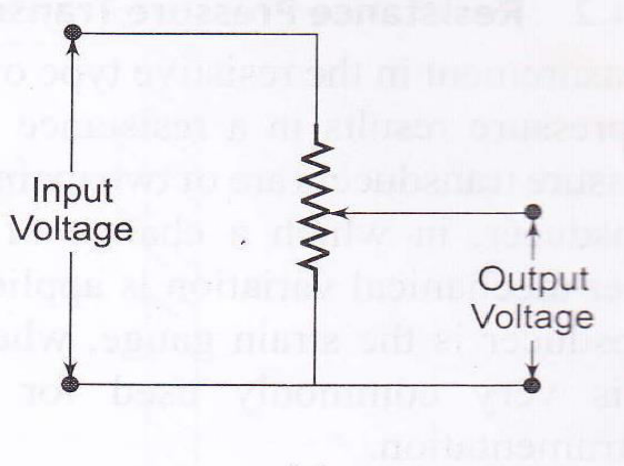
Selection Of Transducers

- In a measurement system the transducer (or a combination of transducers) is the input element with the critical function of transforming some physical quantity to a proportional electrical signal. So selection of an appropriate transducer is most important for having accurate results.

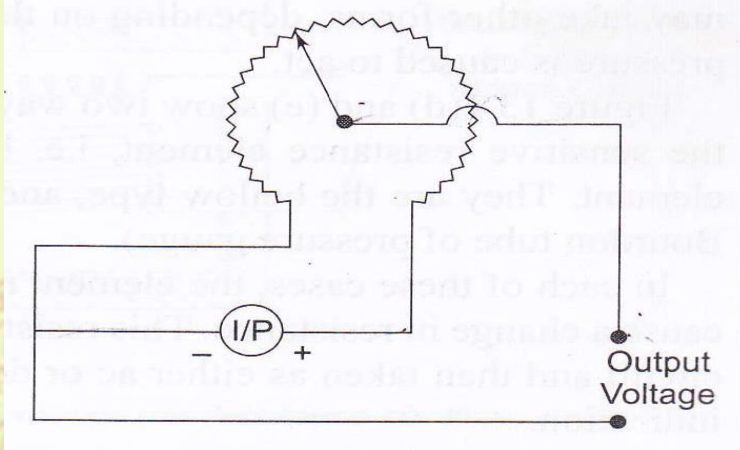
Selection Of Transducers(cont'd)

- **Physical Environment**. The transducer selected should be able to withstand the environmental conditions to which it is likely to be subjected while carrying out measurements and tests.
- Such parameters are temperature, acceleration, shock and vibration, moisture, and corrosive chemicals might damage some transducers but not others.
- Minimum sensitivity to other parameters
- Accuracy- repeatability & calibration
- Usage and ruggedness – mechanical and electrical stress
- Electrical parameters – length & type of cable, S/N ratio, frequency response etc.

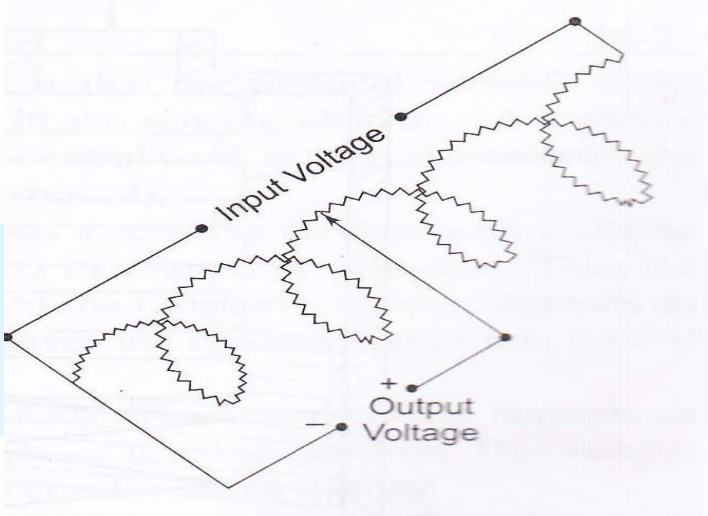
RESISTIVE TRANSDUCER
Potentiometer



(a)



(b)



(c)

(a) Translatory Type

(b) Roational Type

(c) Helipot

RESISTIVE TRANSDUCER
Potentiometer

- **Advantages of Potentiometers**

1. They are inexpensive.
2. Simple to operate.
3. They are useful for the measurement of large displacement.
4. Electrical efficiency is very high, and they provide sufficient output to allow control operations.

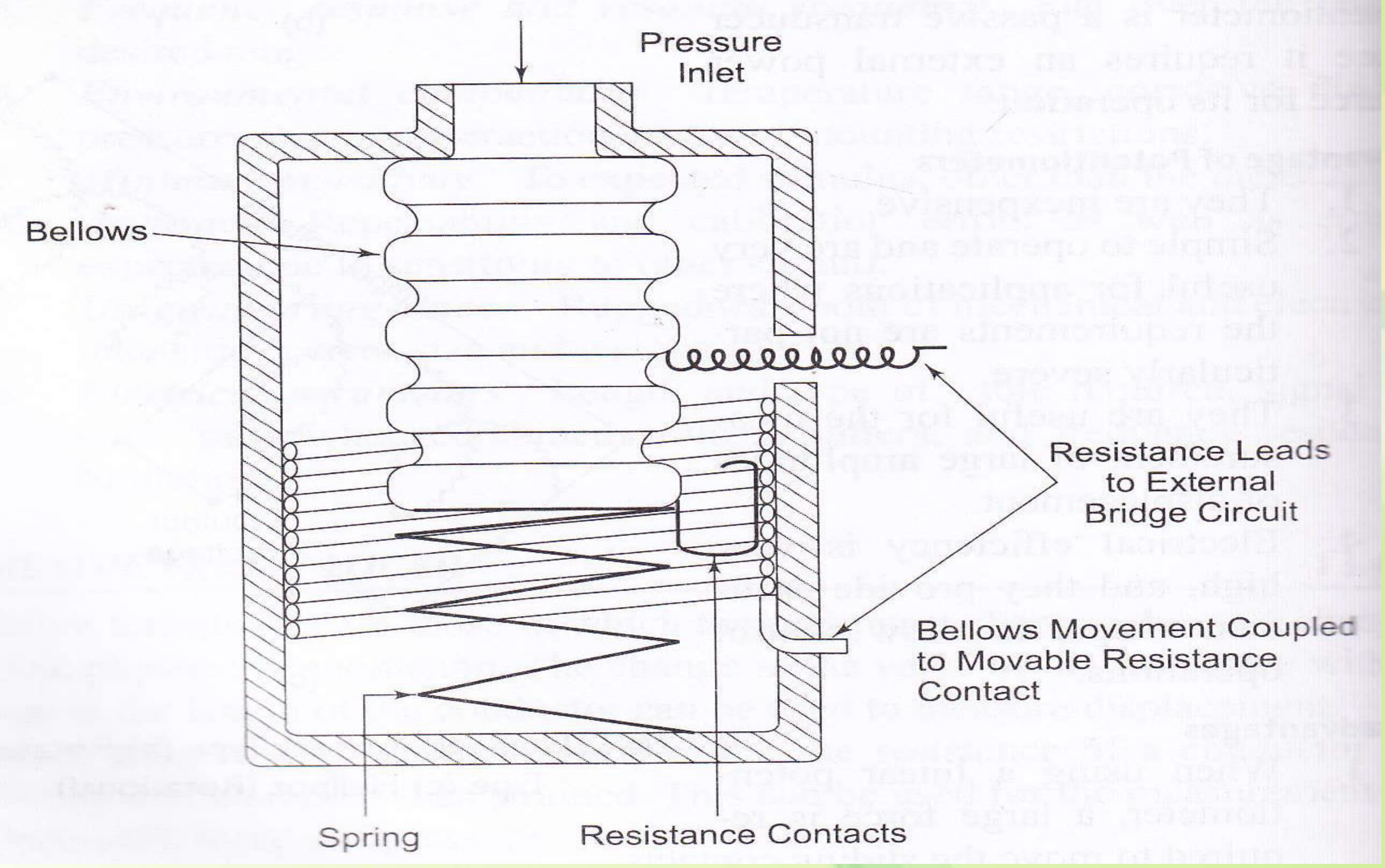
- **Disadvantages**

1. Large force is required to move the sliding contacts.
2. The sliding contacts can wear out, become misaligned and generate noise.

Resistance Pressure Transducer

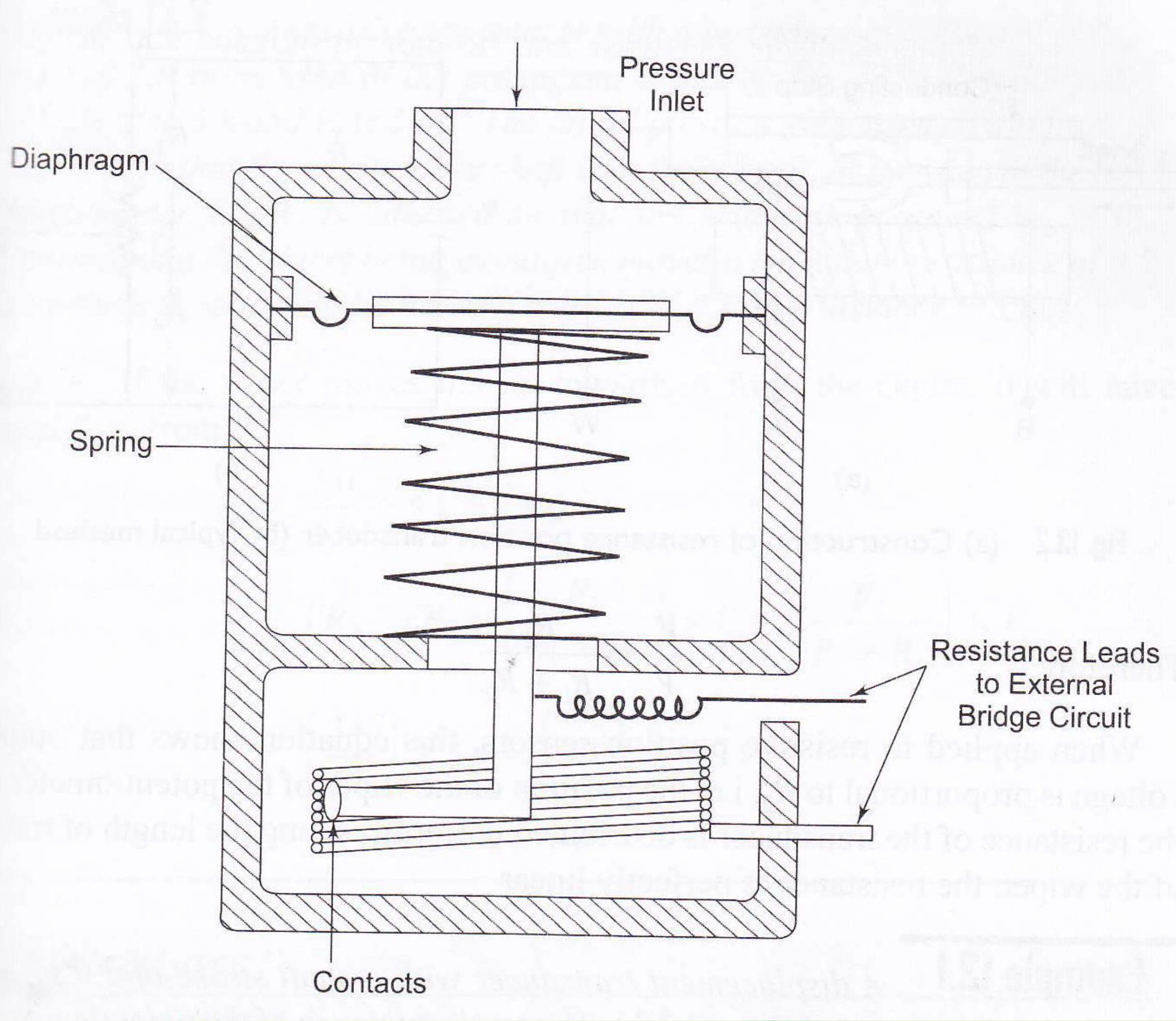
- Electromechanical resistance pressure transducer
- Strain gauge

1. Bellow type resistance pressure transducer



Resistance Pressure Transducer

2. Diaphragm type resistance pressure transducer



STRAIN GAUGES

- **Types of strain gauges**

1. Wire strain gauges
2. Foil strain gauges
3. Semiconductor strain gauges

- **Resistance Wire Strain Gauge**

1. Unbounded Resistance wire Strain Gauge
2. Bounded Resistance wire Strain Gauge

Unbounded Resistance wire Strain Gauge

- D=25μmeter.
- Displacement=50μmeter

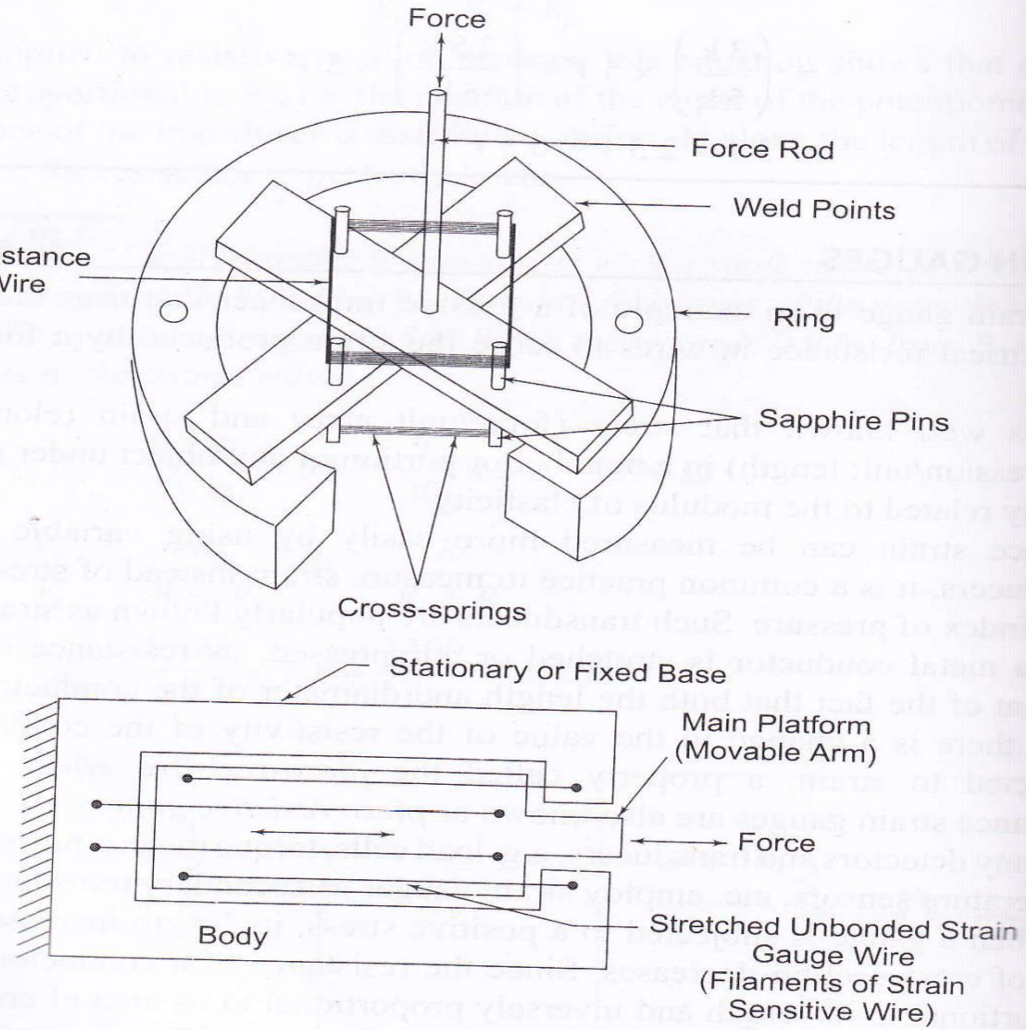
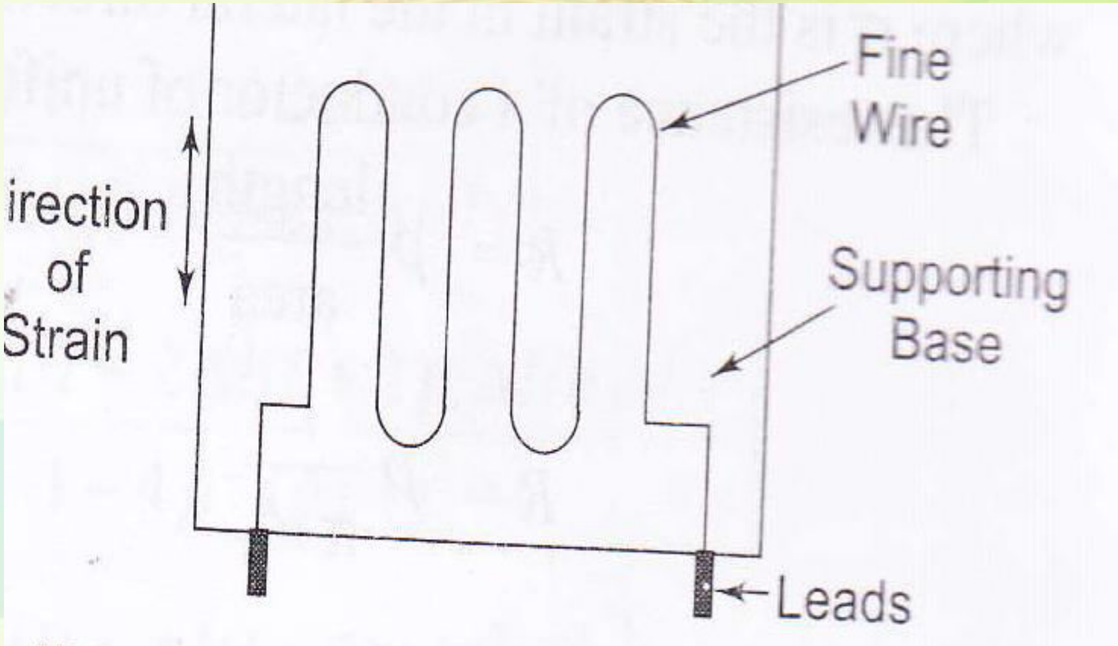


Fig. 13.3 Unbonded strain gauge

Bounded Resistance wire Strain Gauge

- D=25μmeter.
- Carrier – thin sheet of paper/bakelite/teflon.



. 13.4 Bonded resistance wire strain gauge

Types of Strain Gauges (wire)

1. Grid type
2. Rossette type
3. Torque type
4. Helical type

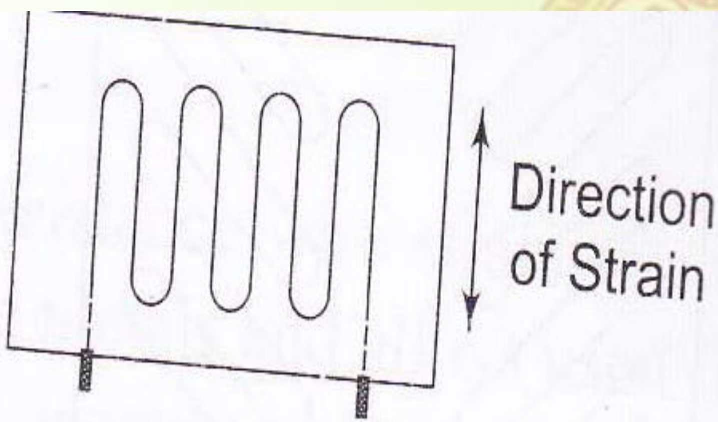


Fig. 13.6 Grid type strain gauge

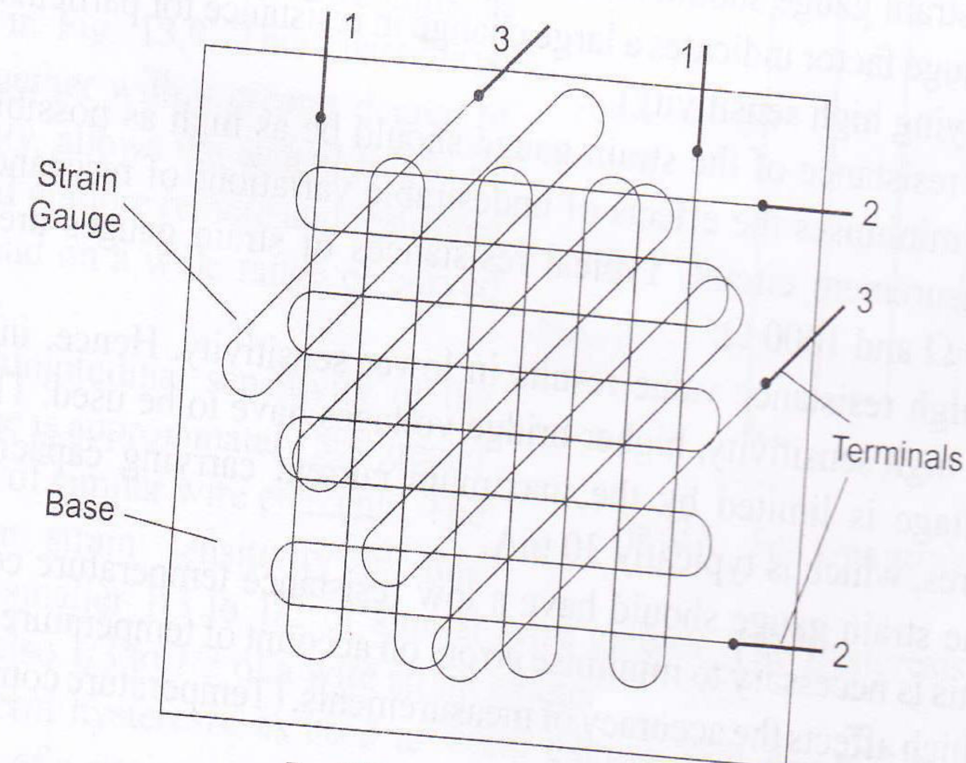


Fig. 13.7 Rossette gauge

Types of Strain Gauges (wire)

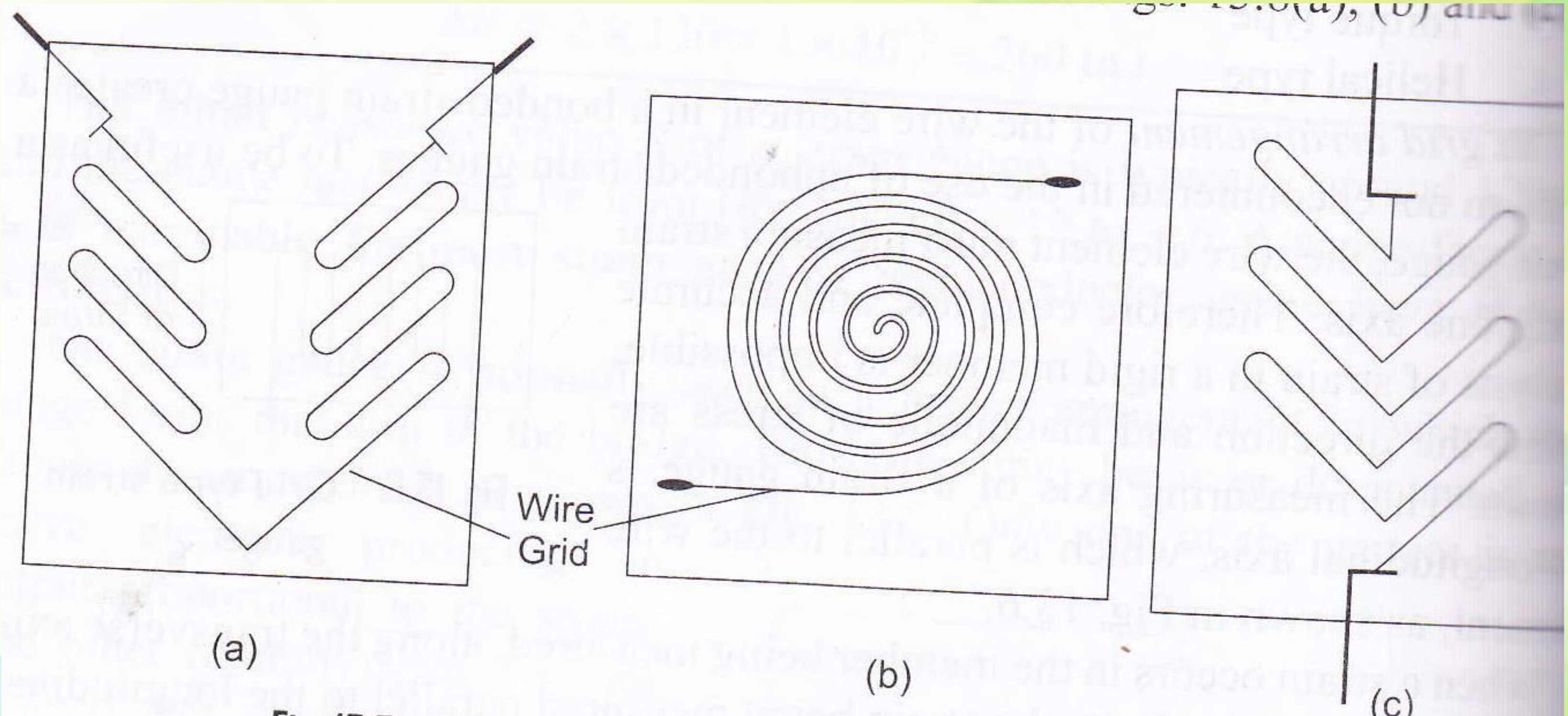


Fig. 13.8 (a) and (c) Torque type gauge (b) Helical gauge

Foil Strain Gauge

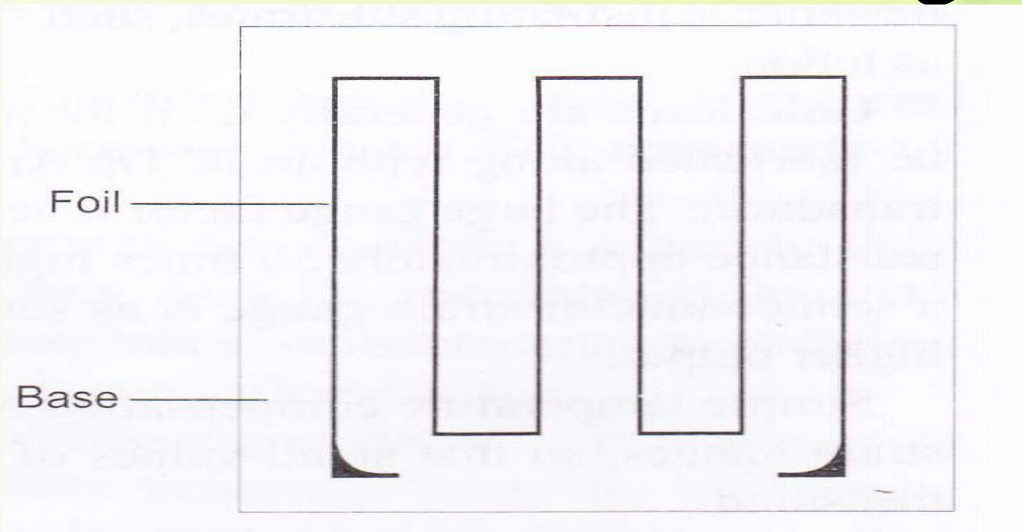


Fig. 13.9 Foil type strain gauge

- The metals and alloys used for foil and wire are nichrome, constantan (Ni + Cu), isoelastic (Ni + Cr + Mo), nickel and platinum.
- Foil gauges have a much greater dissipation capacity than wire wound gauges, they can be used for a higher operating temperature range.
- Foil type strain gauges have similar characteristics to wire strain gauges. Their gauge factors are typically the same.

Foil Strain Gauge

- The advantage of foil type strain gauges is that they can be fabricated on a large scale, and in any shape. The foil can also be etched on a carrier.
- Fabrication process is easy like PCB making.
- Layer can be make thinner than wire.
- They give more flexibility to designer.
- They can be mounted in more remote and restricted places with wide range of curved surfaces.
- The longitudinal sensitivity of the foii1 gauge is approximately 5% greater than that of similar wire elements.
- The hysteresis of the foil gauge is also 1/3 to l/2 of a wire strain gauge.

Semiconductor Strain Gauge

- High gauge factor i. e. high sensitivity.
- Piezo-resistive property of semiconductor
- Thickness of semiconductor is 0.05mm.
- Used to measure micro strain up to 0.01 to 500 micro strain.
- Gauge factor = 130 ±10 with 350Ω.

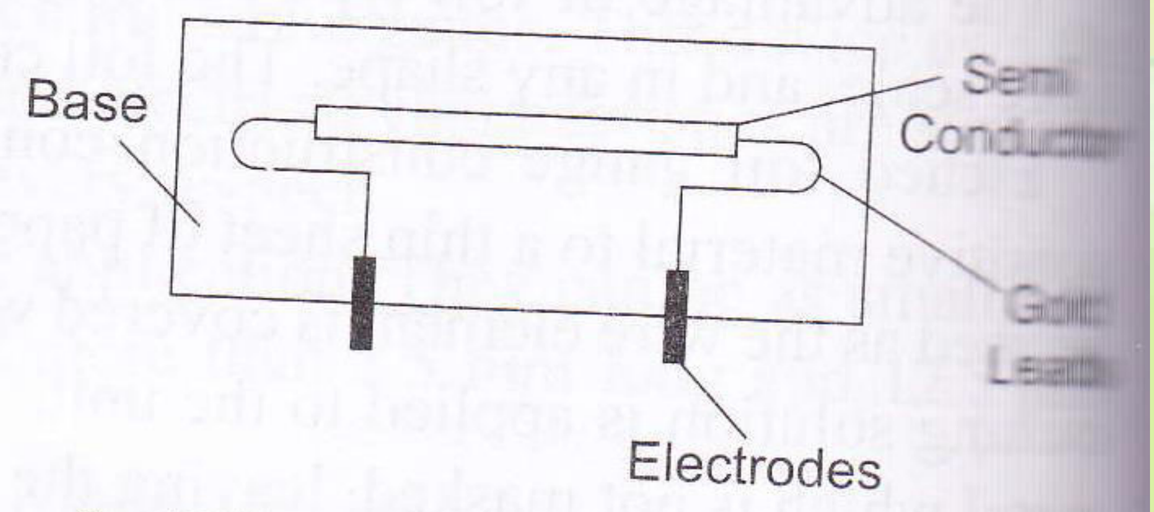


Fig. 13.10 Semiconductor strain gauge

Advantages & Disadvantages

- **Advantages of Semiconductor Strain Gauge**

1. Semiconductor strain gauges have a high gauge factor of about + 130. This allows measurement of very small strains, of the order of 0.01micro strain.
2. Hysteresis characteristics of semiconductor strain gauges are excellent, i.e. less than 0.05%.
3. Life in excess of l0x10^6 operations and a frequency response of 10^{12} Hz.
4. Semiconductor strain gauges can be very small in size, ranging in length from 0.7 to 7.0 mm.

- **Disadvantages**

1. They are very sensitive to changes in temperature.
2. Linearity of semiconductor strain gauges is poor.
3. They are more expensive.

RESISTANCE TH ERMOMETER

- Sensing elements - wire wound resistance, the thermistor and the PTC semiconductor resistance.
- Large resistance change with change in temperature.
- Platinum, nickel and copper.
- Temperature range platinum - 260-1100^{0}C of platinum.

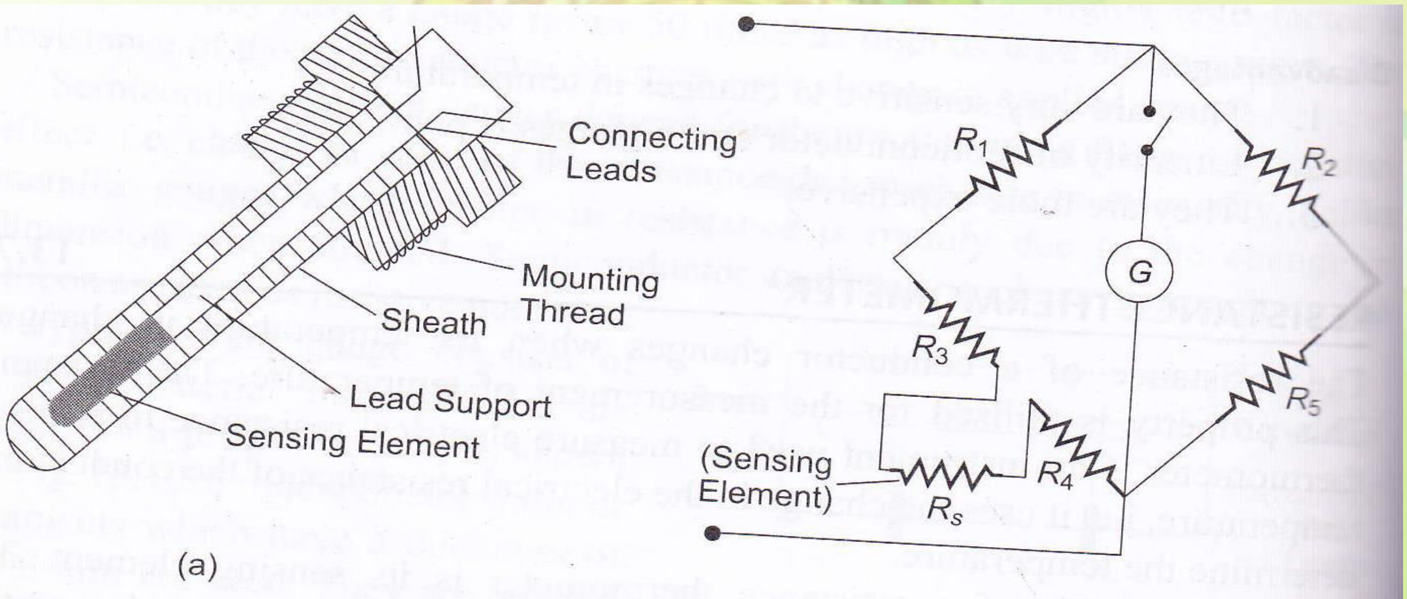


Fig. 13.11 (a) Industrial platinum resistance thermometer (b) Bridge circuit

THERMISTOR

- Non-metalic resistors made by sintering mixtures of metallic oxides such as manganese, nickel, cobalt, copper and uranium.
- NTC, R=300Ω-100MΩ
- Disc thermistors about l0 mm in diameter,

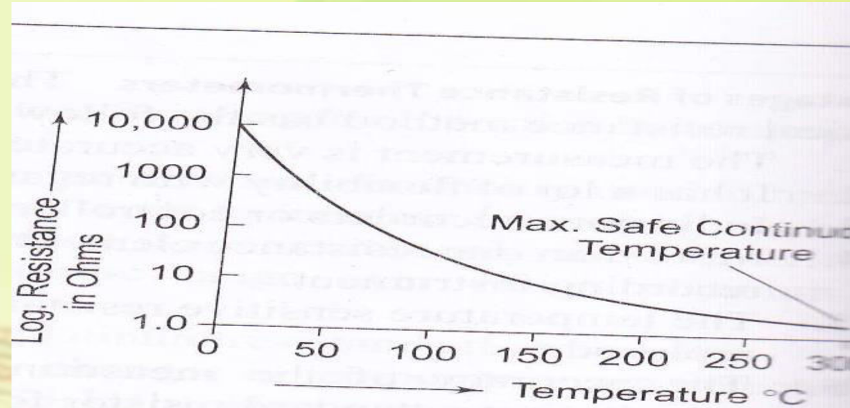
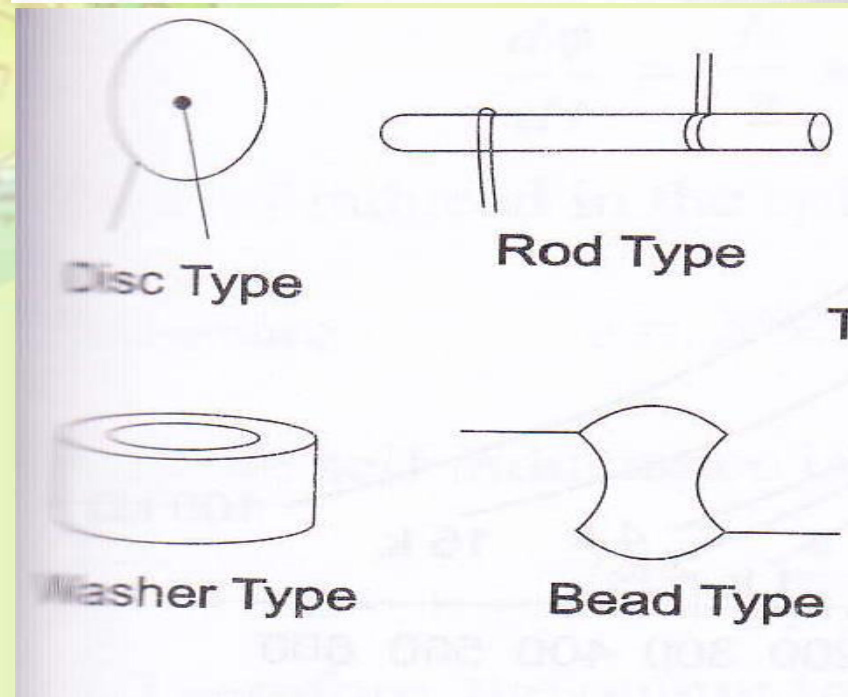


Fig. 13.12 Resistance vs temperature
of a thermistor



LINEAR VARIABLE DIFFERENTIAL TRANSDUCER (LVDT)

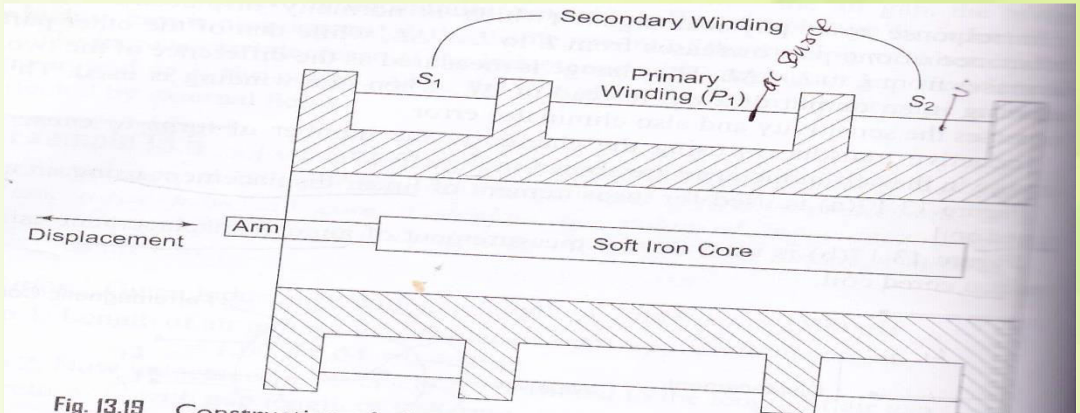


Fig. 13.19 Construction of a linear variable differential transducer (LVDT)

The transformer consists of a single pri...

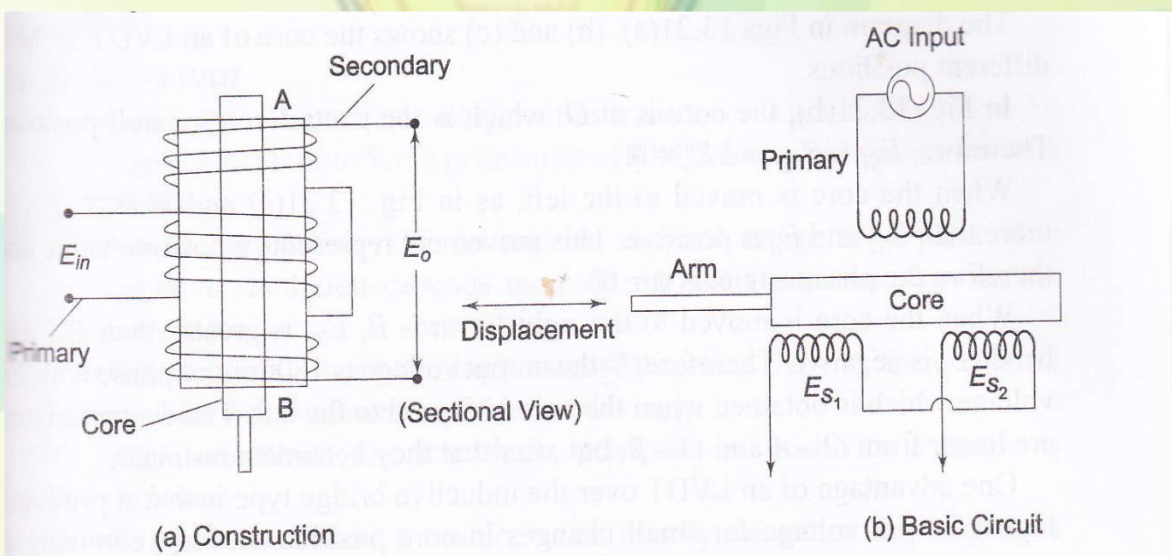


Fig. 13.20 Secondary winding connected for differential output

LINEAR VARIABLE DIFFERENTIAL TRANSDUCER (LVDT)

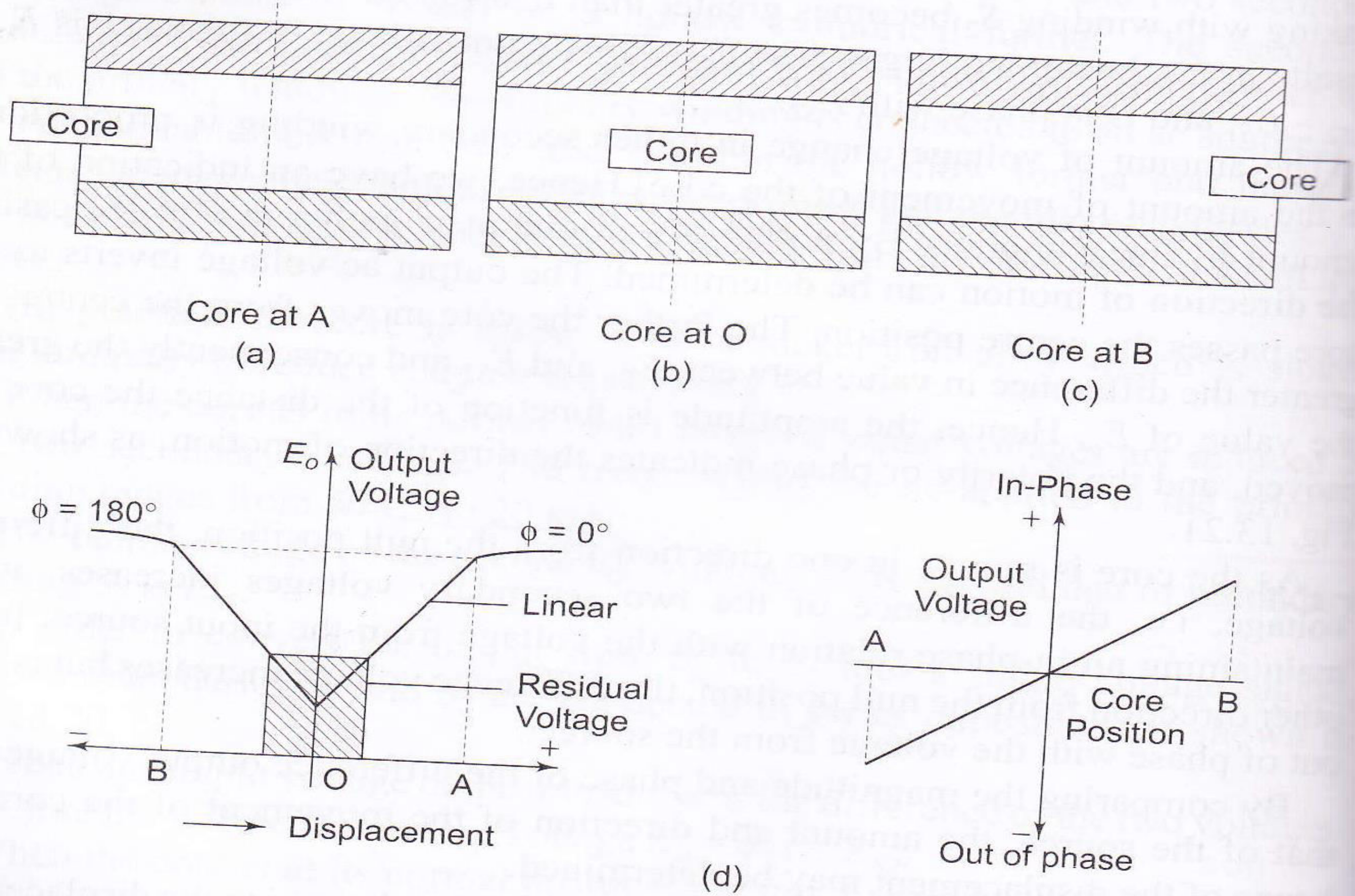


Fig. 13.21 (a), (b), (c) Various core position of LVDT
(d) Variation of output voltage vs displacement

LVDTs are available wit

PIEZO ELECTRICAL TRANSDUCER

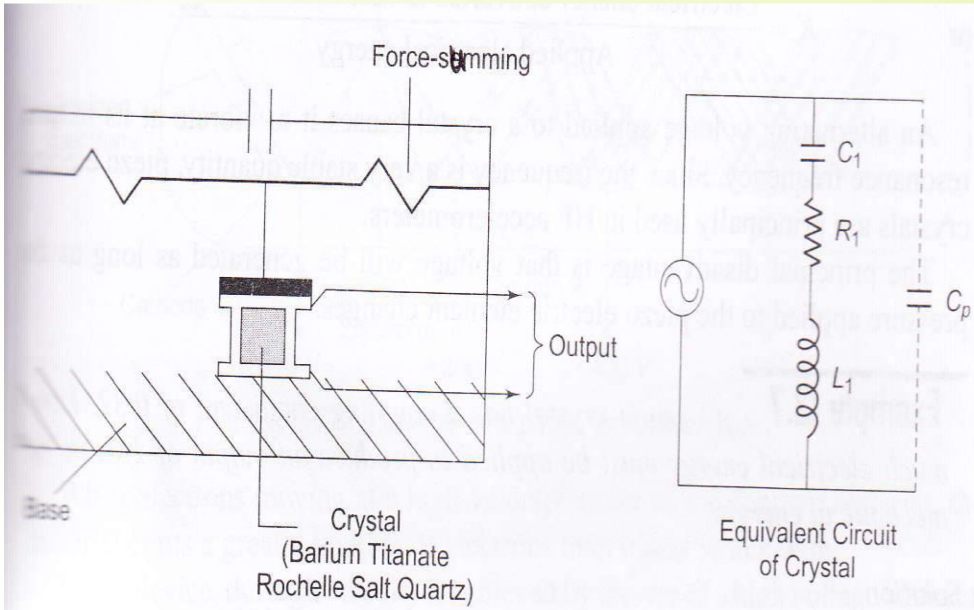


Fig. 13.32 Piezo electric transducer

$$E = \frac{Q}{C_p}$$

where Q = generated charge

C_p = shunt capacitances

$$K = \frac{\text{Mechanical energy converted to electrical energy}}{\text{Applied mechanical energy}}$$

$$K = \frac{\text{Electrical energy converted to mechanical energy}}{\text{Applied electrical energy}}$$

PHOTO ELECTRIC TRANSDUCER

- photo emissive,
- photo-conductive,
- photo-voltaic.

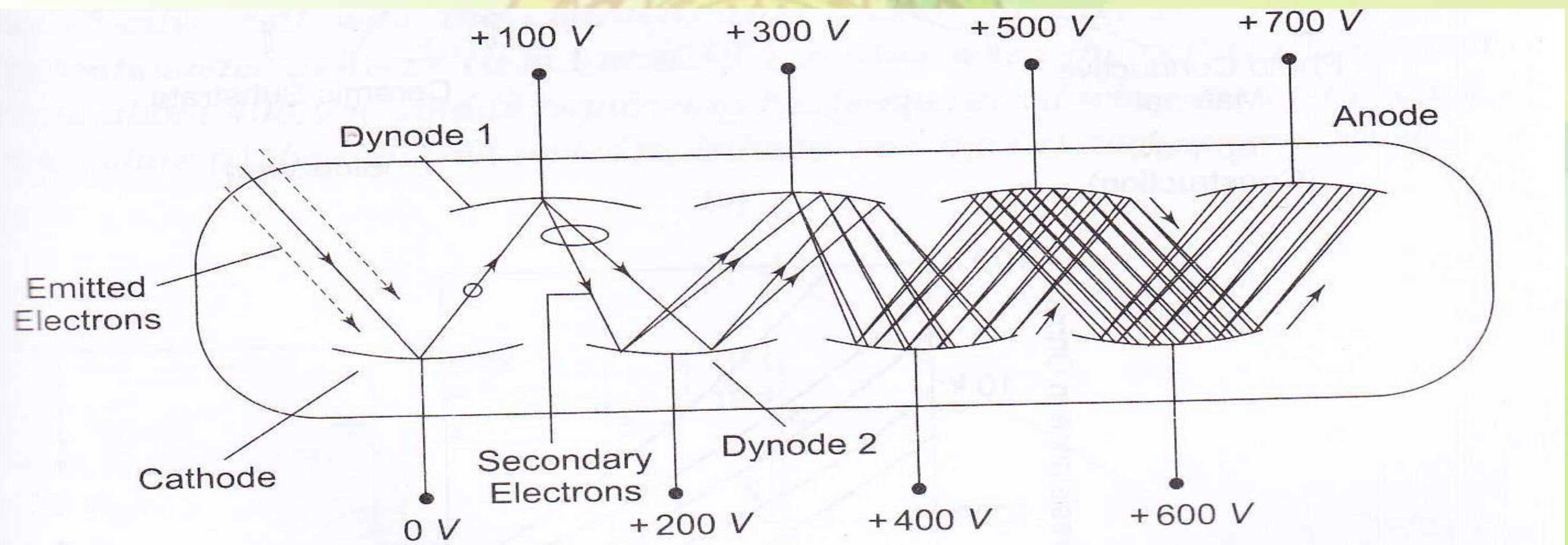


Fig. 13.33 Principle of a photo multiplier tube

Photo Conductive Cells or photo Cells

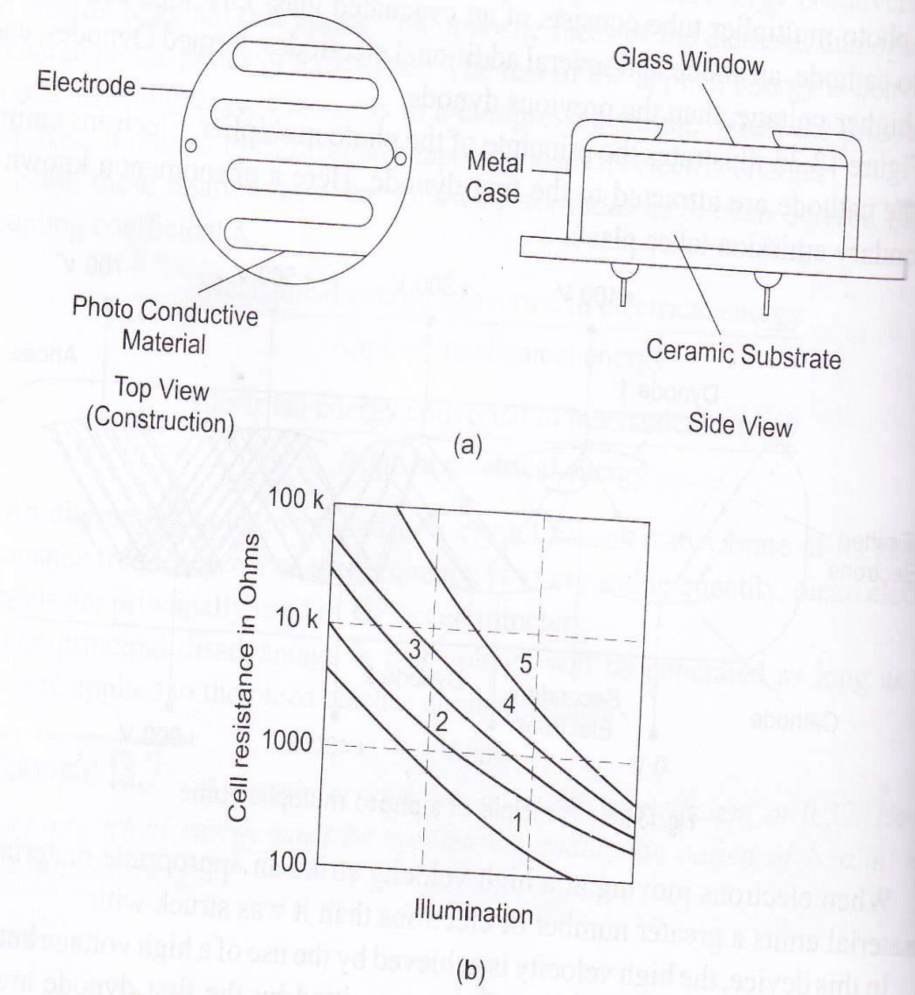


Fig. 13.34 The photo conductive cell (a) construction (b) Typical curves of resistance vs illumination

- The photo conductive material- Cadium sulphide, Cadium selenide or Cadium sulpho-selenide.

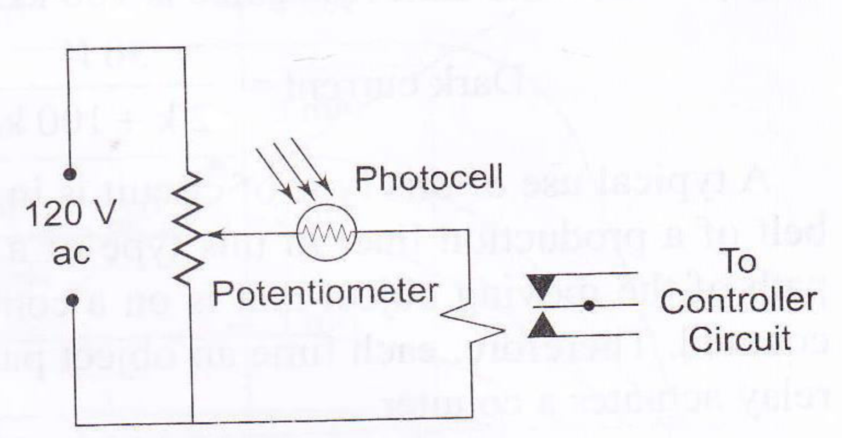


Fig. 13.35 Photo cell and relay control circuit

- PHOTO-VOLTAIC CELL
- Silicon(Si), Sesenium(Se)
- solar cell converts the radiant energy of the sun into erectile power.
- SEMICONDUCTOR PHOTO DIODE

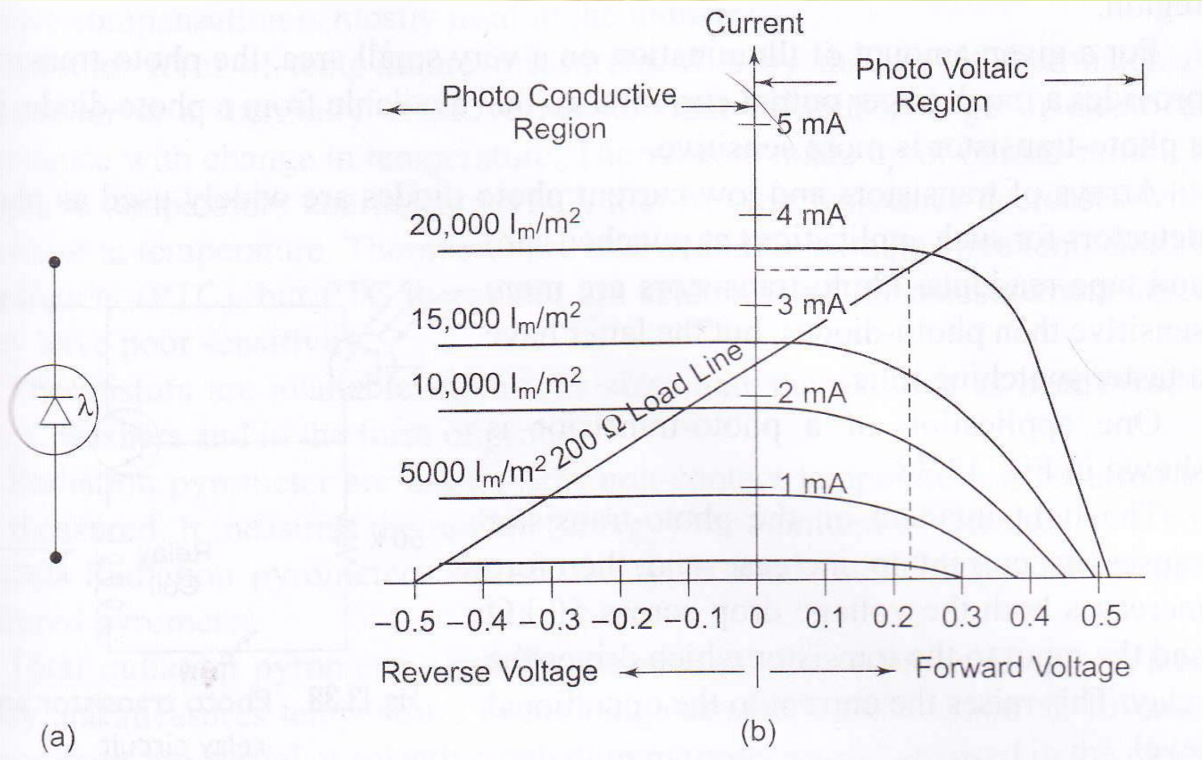


Fig. 13.36 (a) Photo diode symbol (b) Illumination characteristics

PHOTO-TRANSISTOR

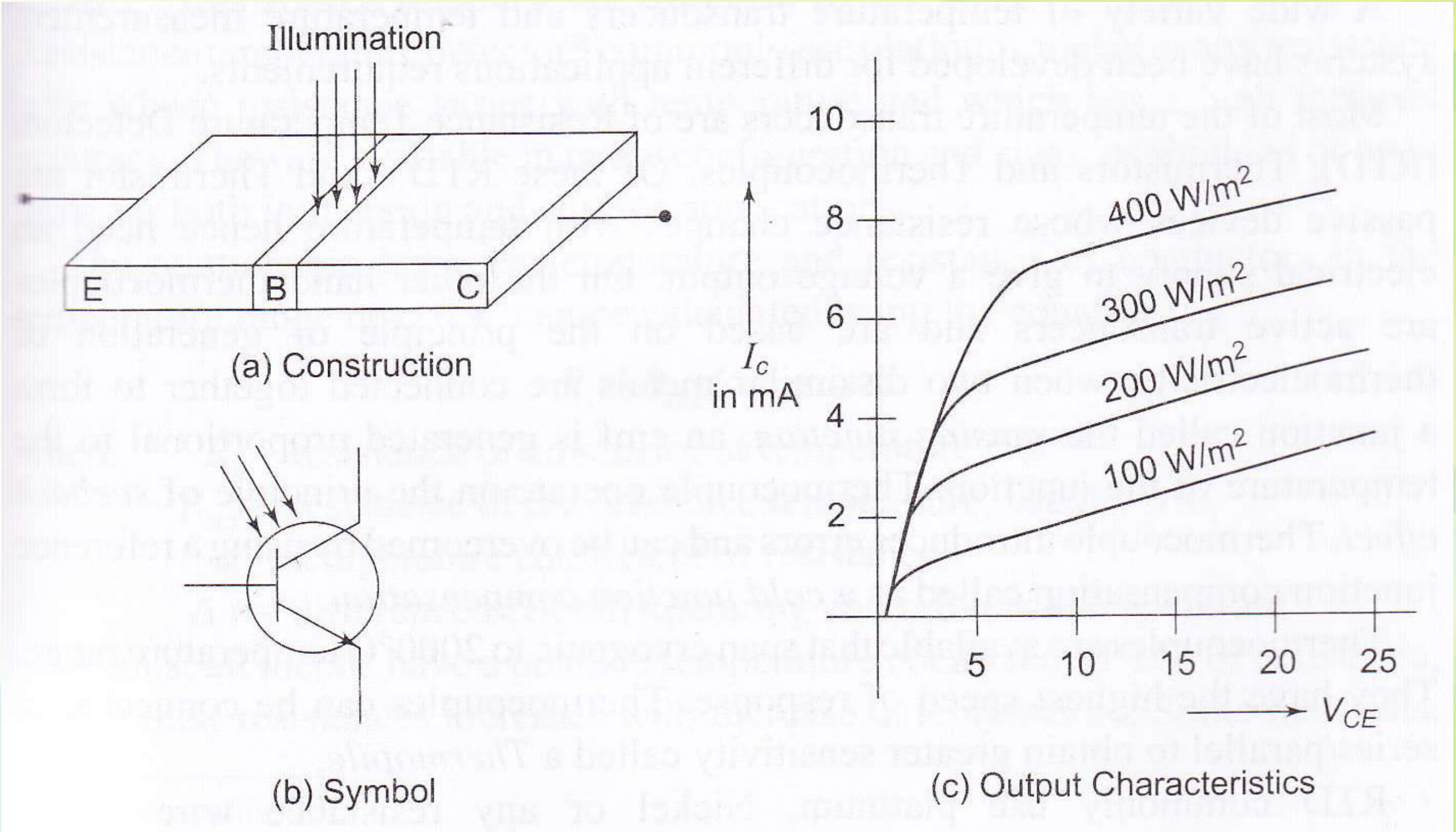


Fig. 13.37 Photo-transistor

Resistance Temperature Detector (RTD)

$$R_t = R_{ref}(1 + \alpha \Delta t)$$

where R_t = resistance of conductor at temperature t°C

R_{ref} = resistance of the reference temperature, usually 0°C

α = temperature coefficient of resistance

Δt = difference between operating and reference temperature

Platinum	– 200°C – 850°C
Copper	– 200°C – 260°C
Nickel	– 80°C – 300°C

Queries …?