Transducer

It is a small device that converts any physical quantity into measurable electrical signals and vice versa.

Functions of Transducers

- Detects or senses the present and changes in physical quantity being measured.
- Provided a proportional output signal..

❖ Classification of Transducer

Transducers are broadly classified into Three groups :

1. Classification Based on Power Source
   - Active transducers (self-generating type)
   - Passive transducers (Externally powered)

2. Classification based on type of Output
   - Analog Transducer
   - Digital Transducer

3. Classification based on the electrical principle involved

- Variable resistance type
- Variable inductance type
- Variable capacitance type
- Voltage generating type
- Voltage divider type

❖ Transducer for the Measurement of Displacement:

I. Variable resistance transducer

II. Variable inductance transducer

III. Variable capacitance transducer

IV. Piezo electric transducer

V. Photo electric or light detecting transducer

    I. Photo conductive

    II. Photo voltaic

    III. Photo emissive

VI. Ionization transducers.

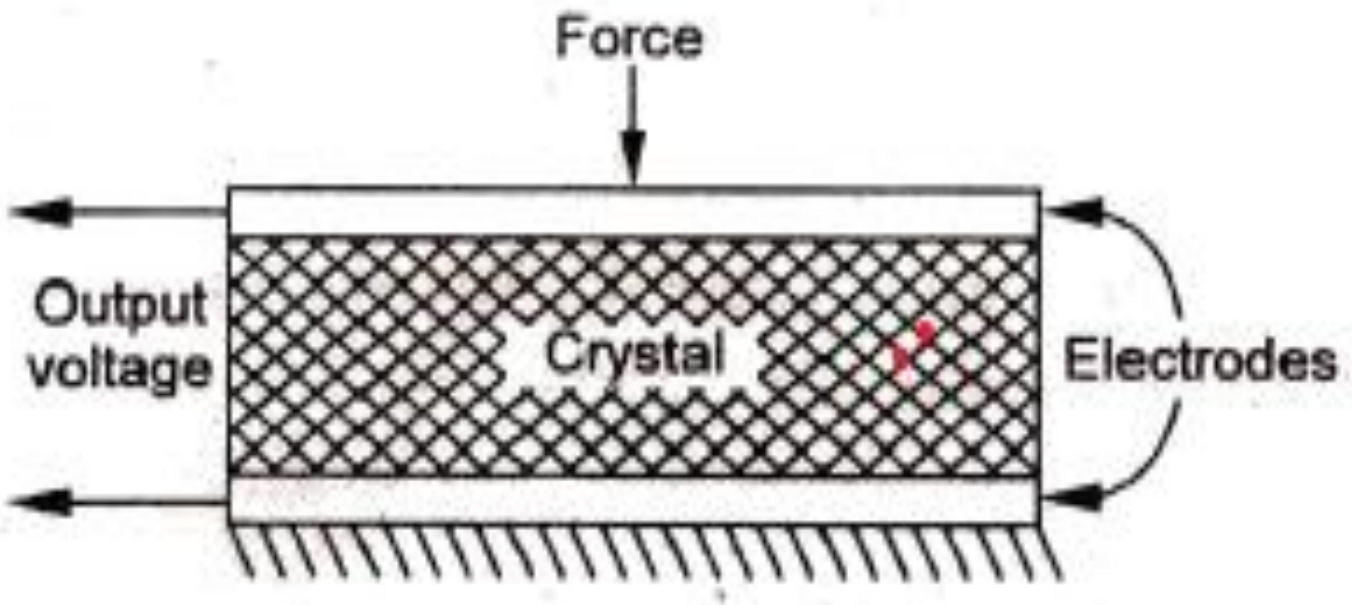
❖ Advantages of electrical transducers over other transducers

- Mass and inertia effects are minimized
- Amplification or attenuation is minimized
- Effect of friction is minimized
- They are compact in size
- Remote indication is possible
- Power consumption is less and loading errors are minimized.

❖ Limitations

- They need external power supply, and are of High cost
- Instrument electrical properties may change the actual reading of the variable which is to be measured.

❖ Piezo Electric transducers



$$Q \alpha F$$

$$Q = K F$$

Where,

Q is the Charge (in coulombs)

F = Impressed Force (in Newtons)

K = Crystal Sensitivity = C/N

The relationship between the force F and the change t in the crystal thickness t is given by the stress-strain relationship.

$$\text{Young's modulus} = \frac{\text{stress}}{\text{strain}} \quad ; \quad Y = \frac{F/A}{\delta t/t}$$

$$F = A\,Y\frac{\delta t}{t}$$

The charge at electrode gives rise to voltage, such that

$$V_0 = \frac{Q}{C}$$

where C is the capacitance between electrodes. Further more

$$C = \epsilon_0 \epsilon_r \frac{A}{t} \text{ farads}$$

Combining the above equations, we obtain :

$$V_0 = \frac{K}{\epsilon_0 \epsilon_r} t \frac{F}{A}$$

$$= g\,t\,P$$

where g is the crystal voltage sensitivity in Vm/N and P is the applied pressure in N/m^2.

Advantages of Piezoelectric transducers are:

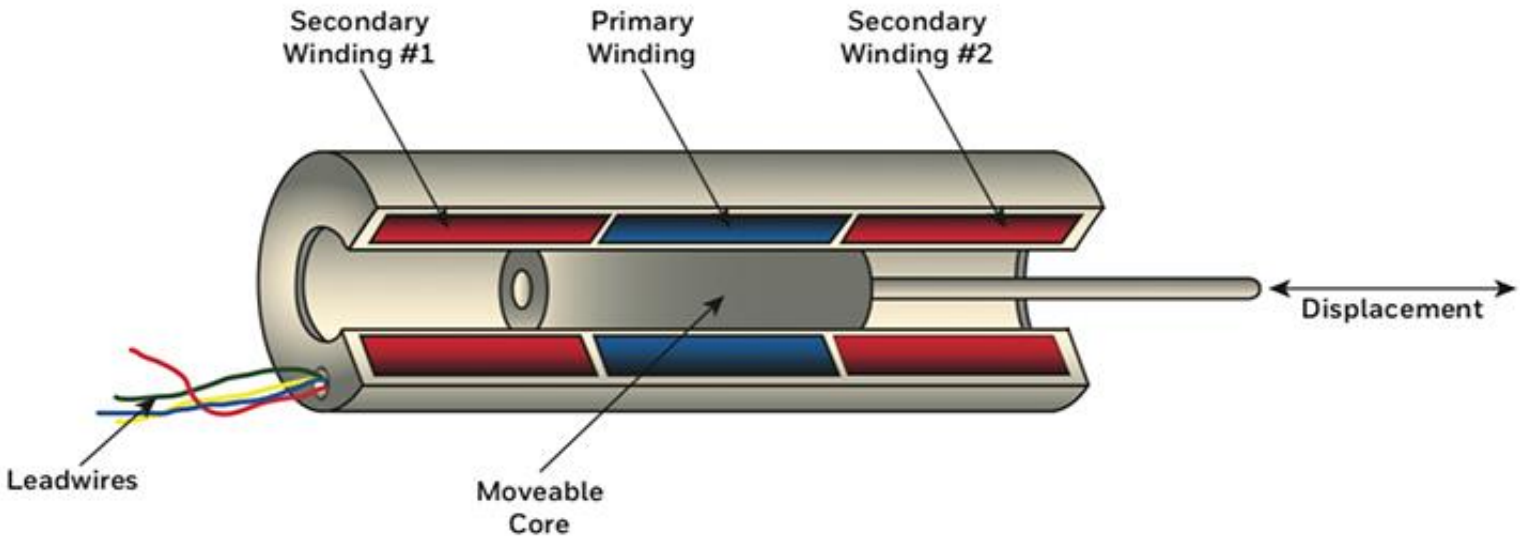
- High frequency response,
- High output,
- Rugged construction
- Negligible phase shift, and
- Small size.

Applications:

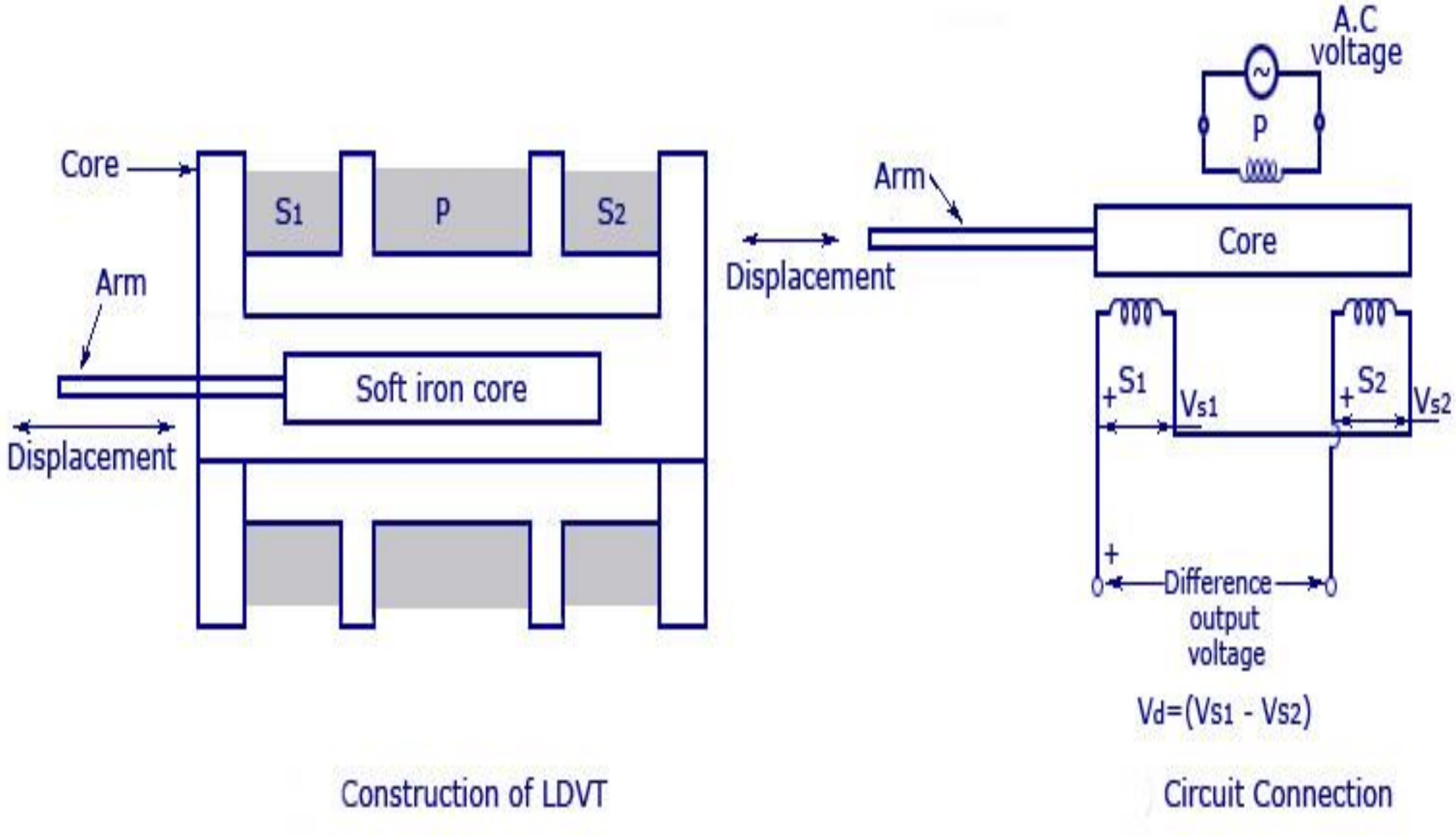
Piezo-electric transducers are most often used for accelerometers, pressure cells and force cells in that order.

❖ Variable Inductance transducers

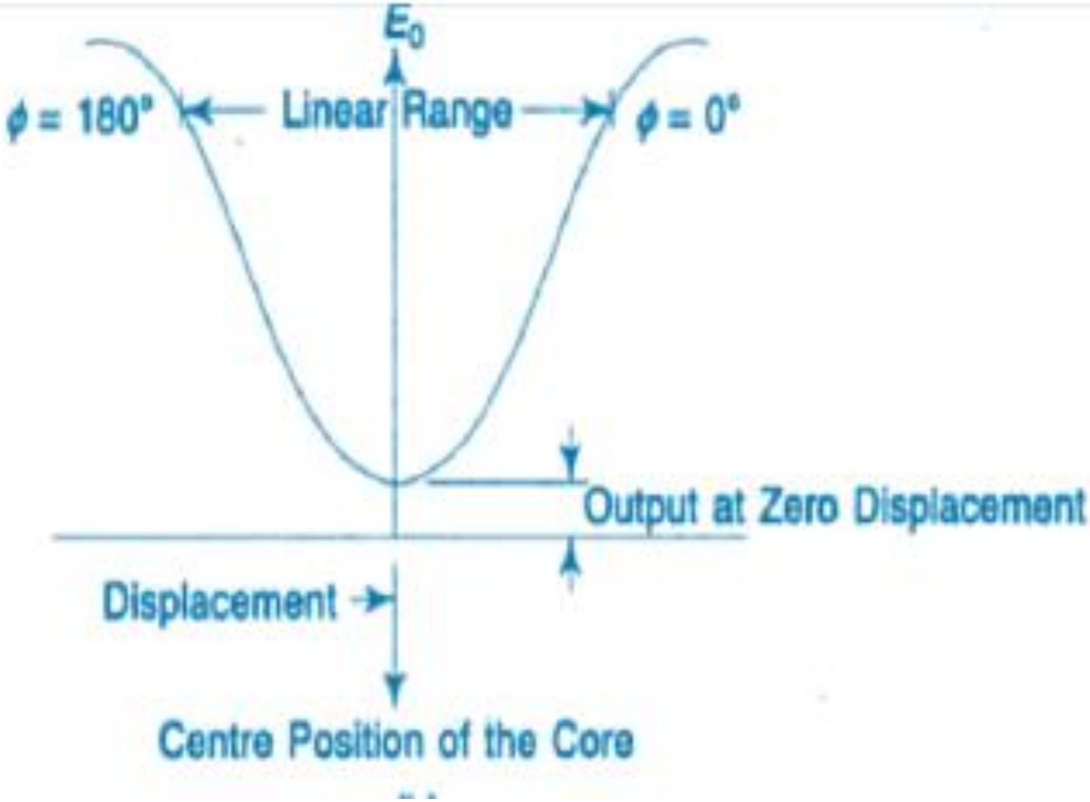
1. Linear Variable Differential Transducer (LVDT)



The linear variable-differential transformer (LVDT) is the most widely used inductive transducer to translate linear motion into electrical signal.



Construction and Circuit of a typical LVDT


E_0
ϕ = 180°
Linear Range
ϕ = 0°
Output at Zero Displacement
Displacement
Centre Position of the Core

Advantages

- The output voltage is practically linear for displacements upto 5 mm.
- Have infinite resolution.
- Can possess a high sensitivity.
- These usually tolerate a high degree of shock and vibration without any adverse effects.
- Simple, light in weight, and easy to align and maintain.

Applications:

- Sensitive to stray magnetic fields but shielding is possible
- Inherently low in power output.

2. Rotary Variable Differential Transducer (RVDT)

- It is used to convert rectangular displacement into electrical signal.
- It is same as that of LVDT except that is employs a cam shaped core.

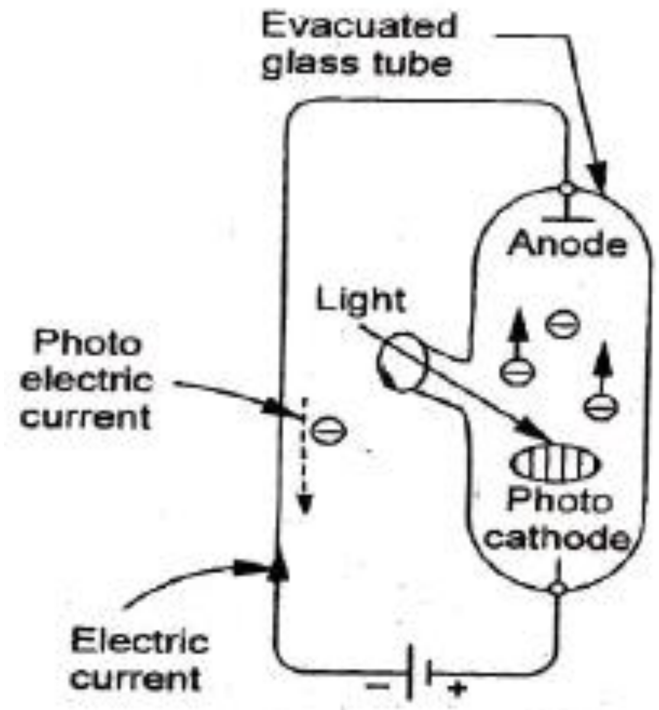
3. Synchros

- The devices by which the angular position of shaft is converted into electrical signal. The synchros are electromagnetic transducers..

4. Resolvers

- Resolving is nothing but converting from one co-ordinate system to another coordinate system.
- These converts the shafts angular position into Cartesian coordinates i.e., converted into those signals which are proportional to the sine and cosine of the rotor position

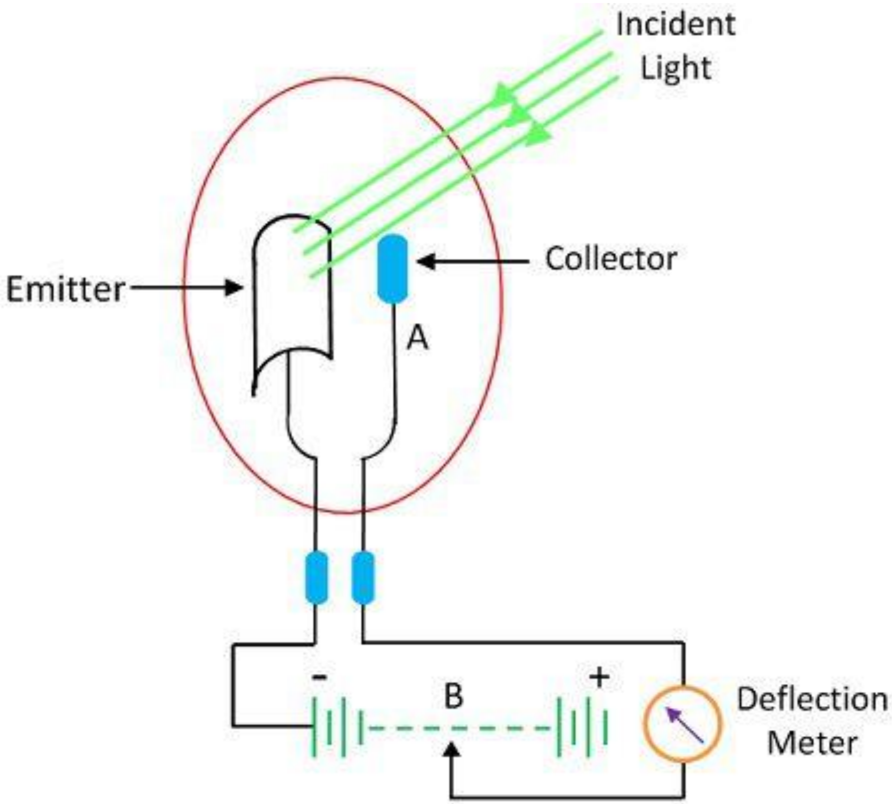
PHOTO ELECTRIC TRANSDUCERS



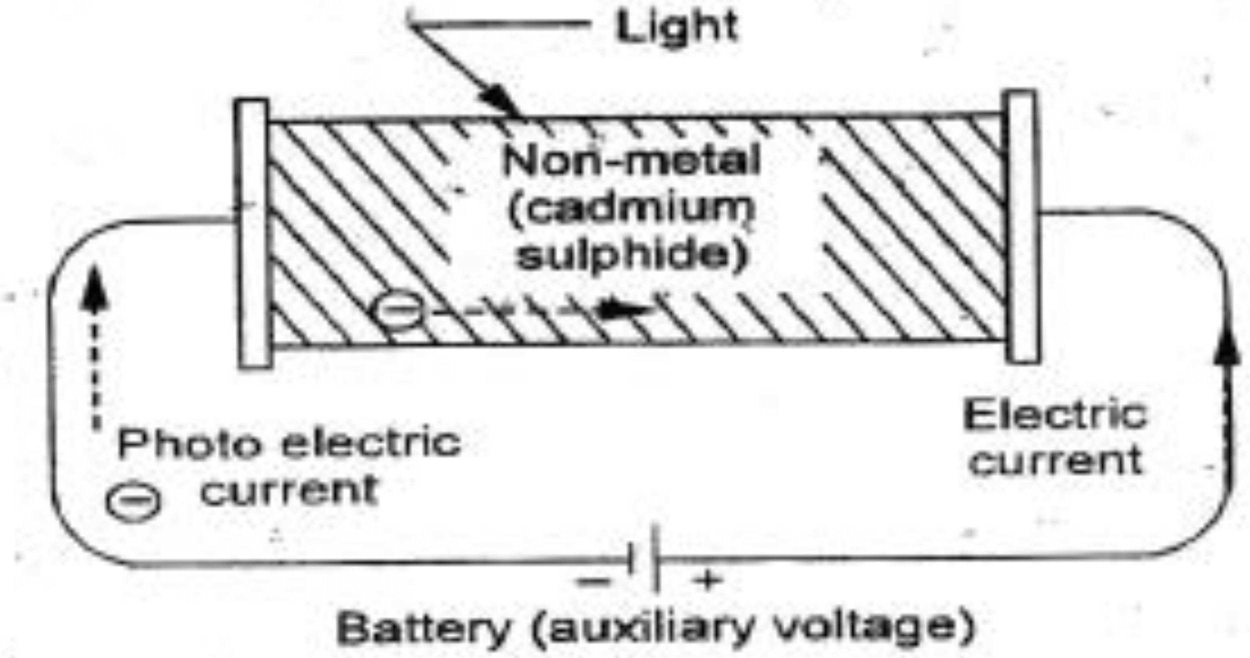
These transducers operate on the principle that when light strikes special combination of materials, a voltage may be generated, a resistance change may take place, or electrons may flow.

Based on the principle of rotation photo electric transducers are classified into the 3 types.

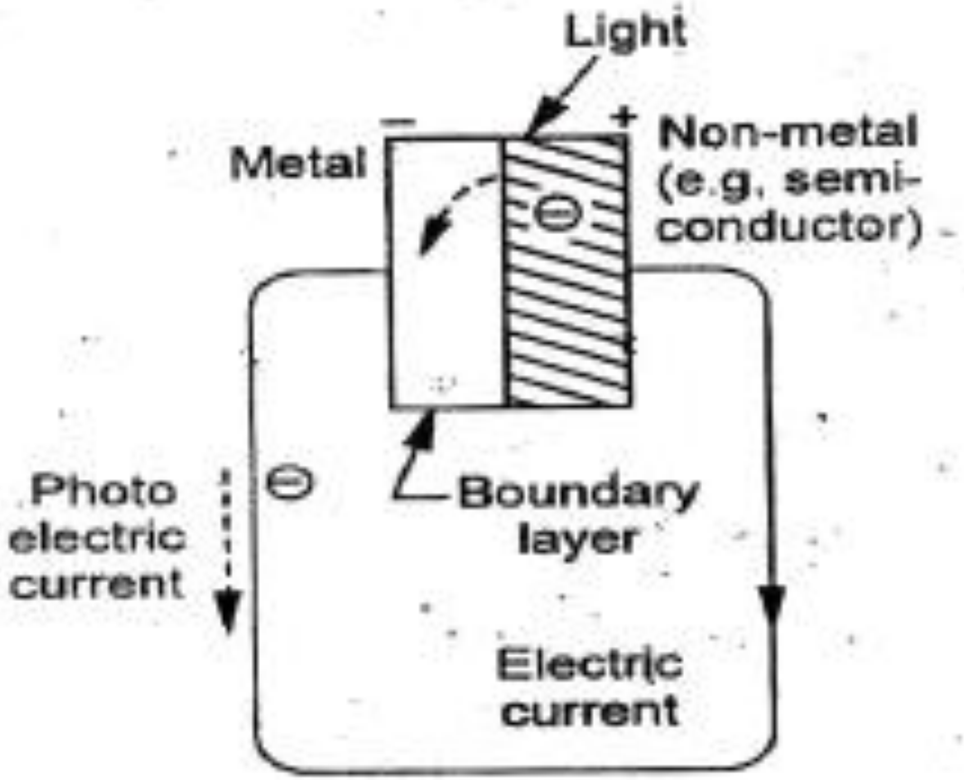
- Photo – Emissive Cell



- Photo – Conductive Cell



- Photo – Voltaic Cell



These transducers operate on the photo-valtaic effect, i.e., when light's trikes a junction of certain dissimilar metals, a potential difference is built up.

Applications:

- Used for a wide variety of purposes in control engineering for precision measuring devices, in exposure meters used in photography.
- They are also used in solar batteries as sources of electrical power for rockets and satellites used in space research.

CAPACITIVE TRANSDUCERS

It works on the principle of a capacitor which comprises of two or more dissimilar metal plate conductors separated by an insulator.

Capacitance is defined as the ratio of the charges to the applied voltage and for a parallel plate capacitor

$$C = \epsilon_o \epsilon_r \frac{A}{t}(N-1)\, farads$$

Where,

A = overlapping area b/w plates (m^2)

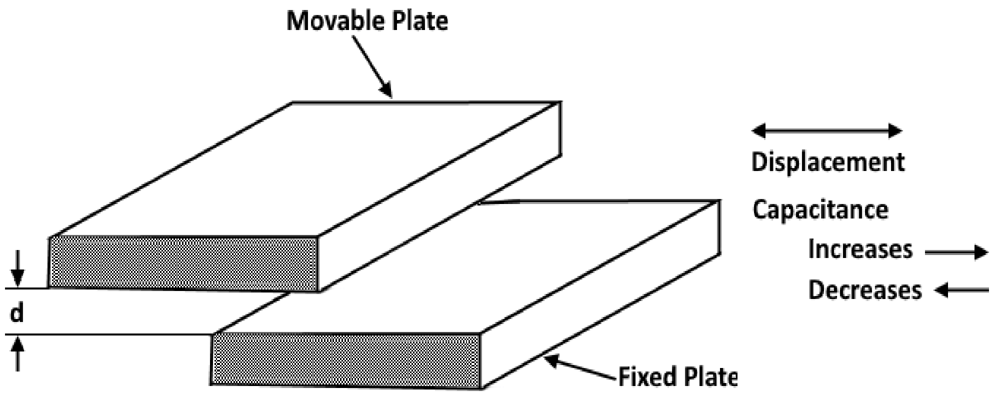
t = distance b/w plates (m)

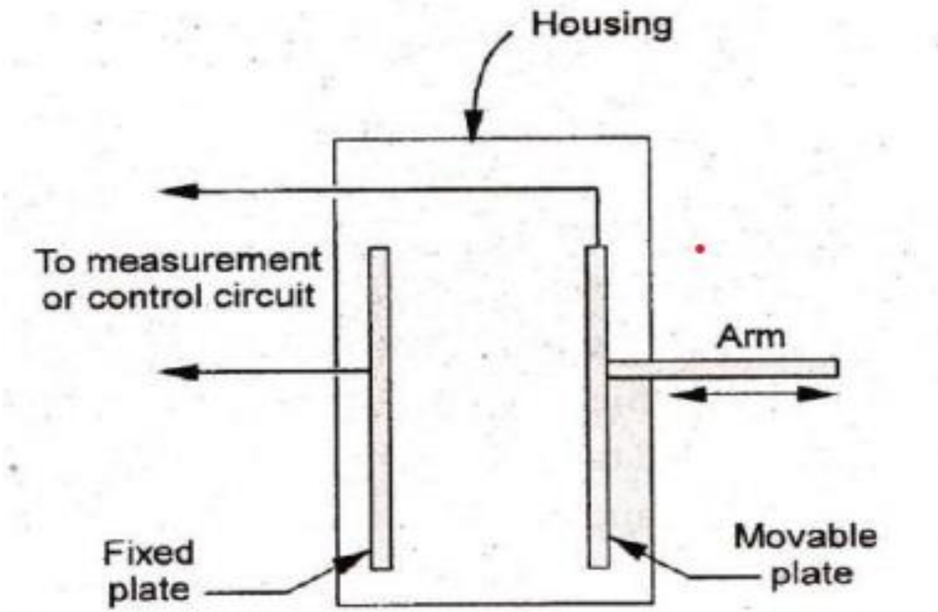
N = No. of plates

ϵ_o = permittivity of free space = 8.854 x 10^{-12} F/m

ϵ_r = = relative permittivity of the material b/w plates

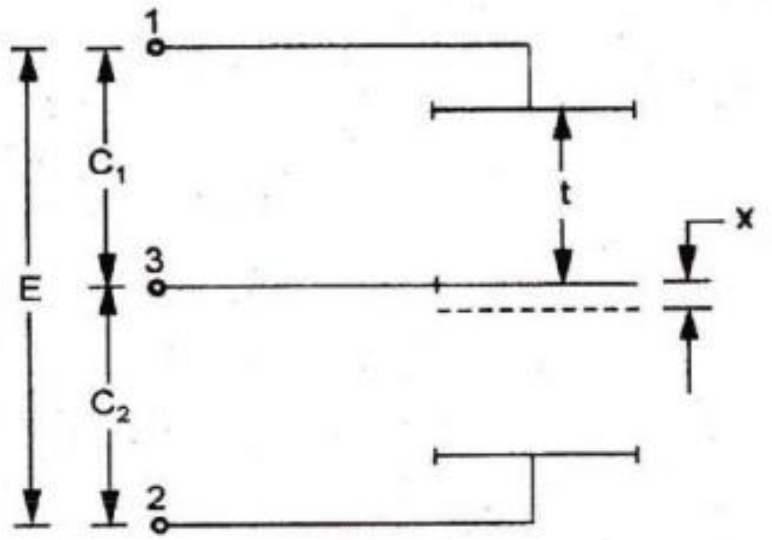
Differential Capacitor:





Let the normal position of the central plate be a line as shown, the capacitances C_1 & C_2 are then identical.

$$C_1 = C_2 = C = \epsilon_o \epsilon_r \frac{A}{t}$$



When the plate is displaced parallel through a distance x, then:

$$C_1 = \epsilon_o \epsilon_r \frac{A}{t+x} \qquad C_2 = \epsilon_o \epsilon_r \frac{A}{t-x}$$

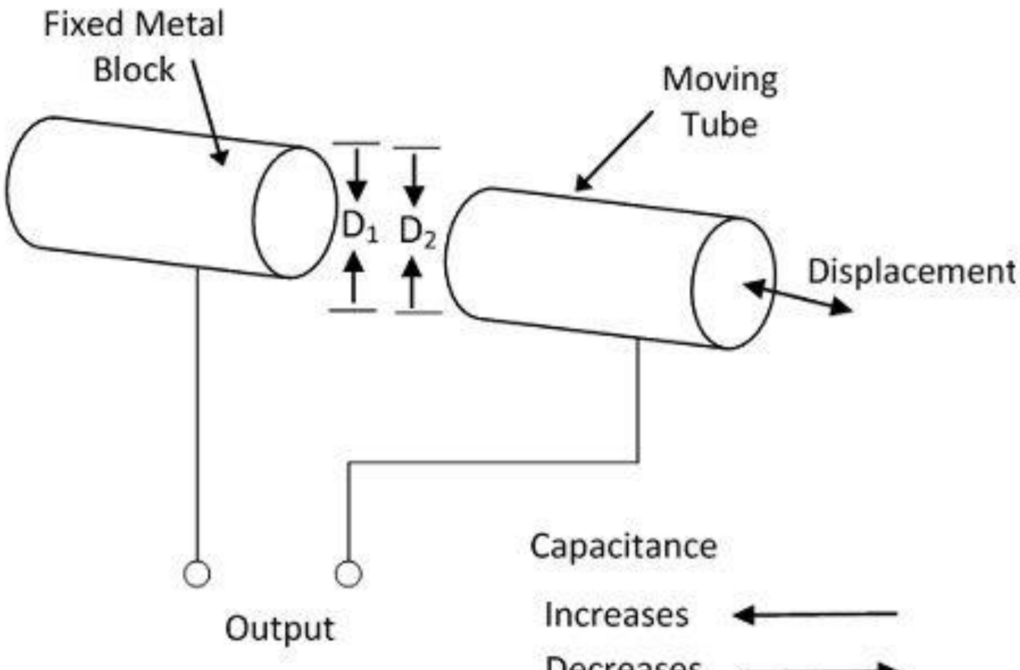
For an alternating Voltage E applied b/w 1 & 2 then C_1 & C_2 are :

$$E_1 = \frac{E\,C_2}{C_1 + C_2} = E\frac{t+x}{2t} \qquad E_2 = \frac{E\,C_1}{C_1 + C_2} = E\frac{t-x}{2t}$$

Therefore, the output from the terminal pairs 1, 3 & 2, 3 is fed into differential measurement

$$E_1 - E_2 = E\frac{x}{t}$$

Cylindrical Capacitor:



$$C = \epsilon_o \epsilon_r \frac{2\pi l}{\log_e(\frac{r_2}{r_1})} \; farads$$

Where,

l = length of overlapping part of cylinder (m)

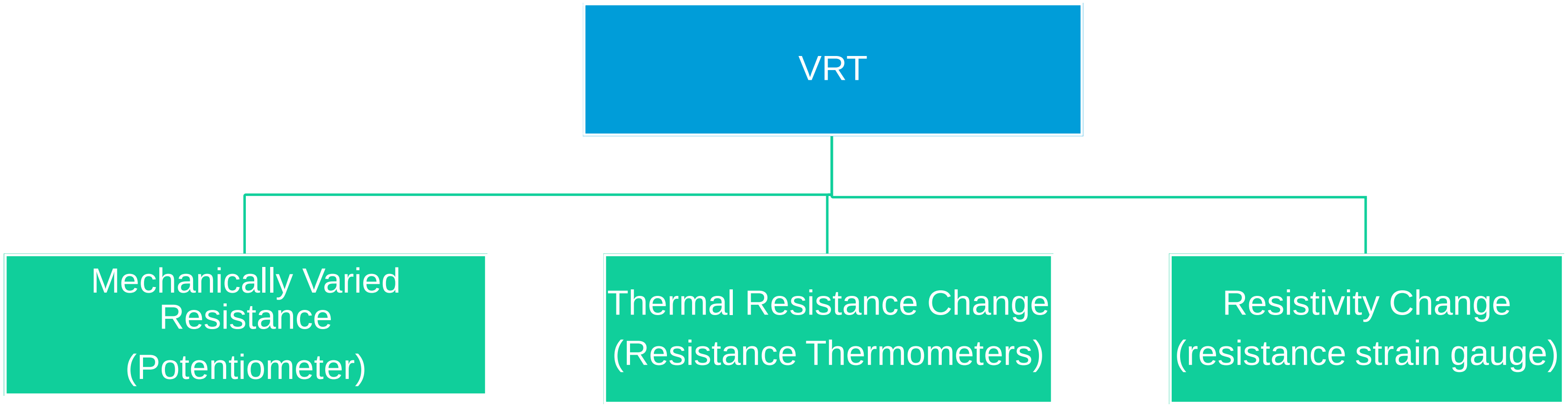
r_1 = radius of inner cylinder conductor(m)

r_2 = radius of outer cylinder conductor(m)

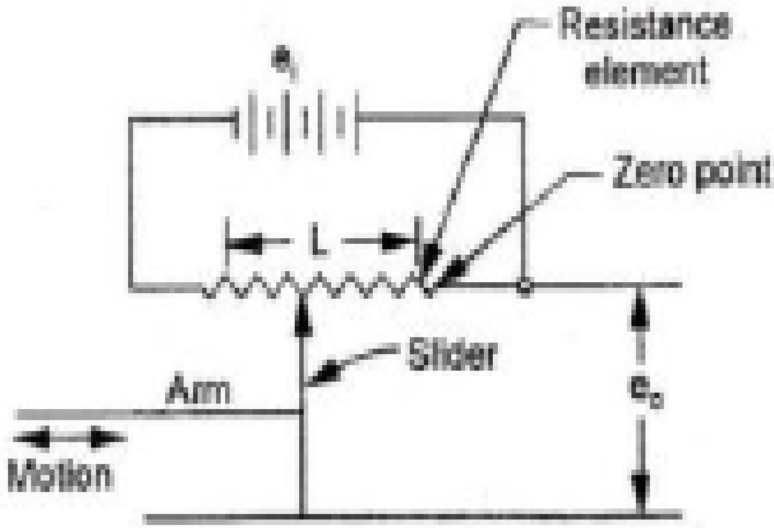
ϵ_o = permittivity of free space = 8.854 x 10^{-12} F/m

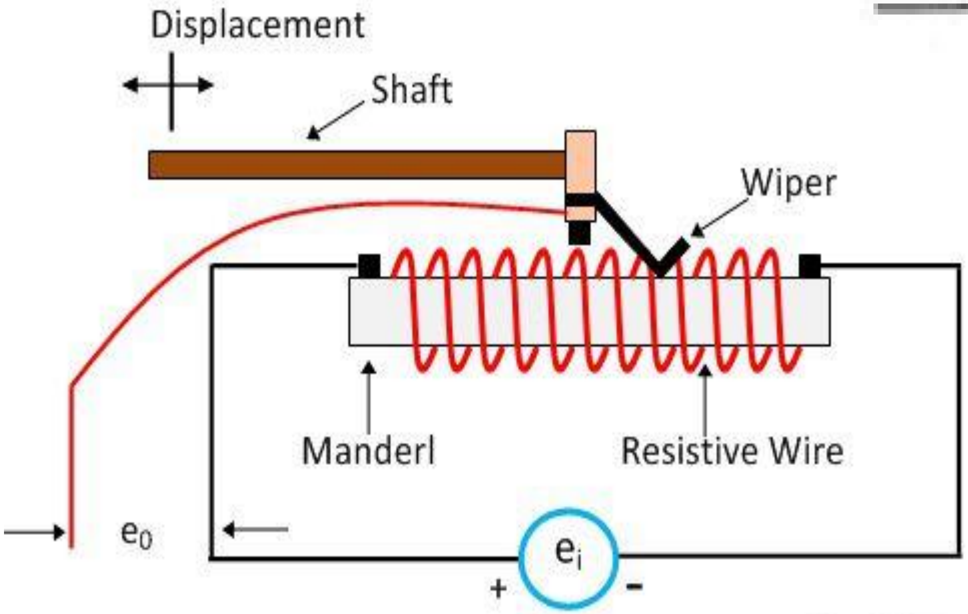
ϵ_r = = relative permittivity of the material b/w plates

VARIABLE RESISTANCE TRANSDUCERS



❖ Linear Motion Potentiometers





❖ Rotary Motion Potentiometers