VARIABLE CAPACITANCE TRANSDUCER

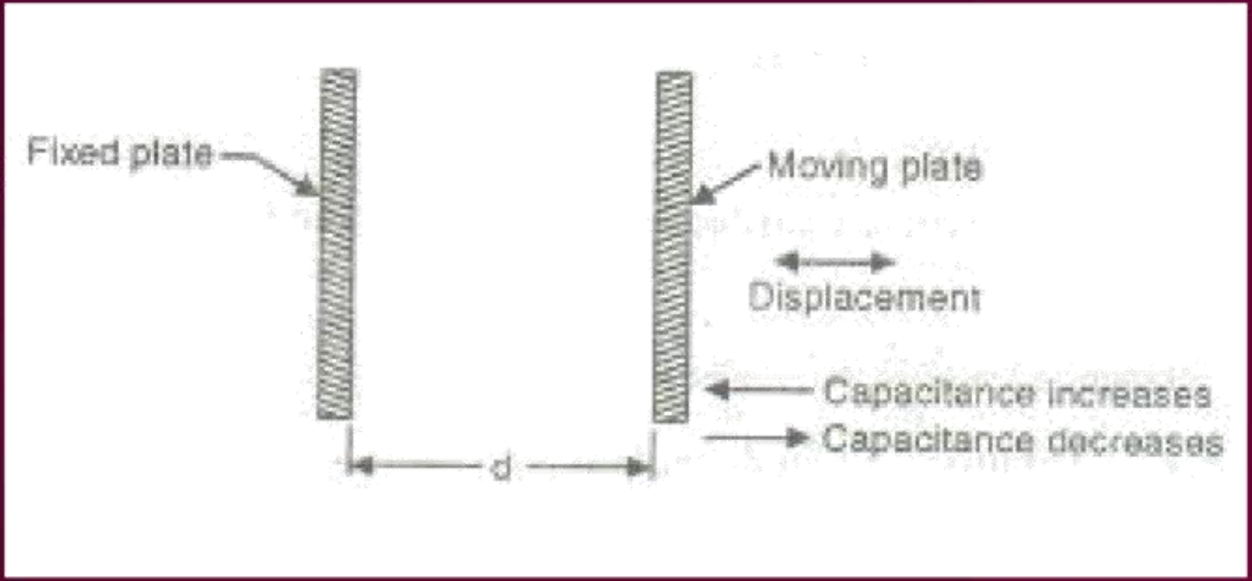
- Capacitance of a parallel plate capacitor is

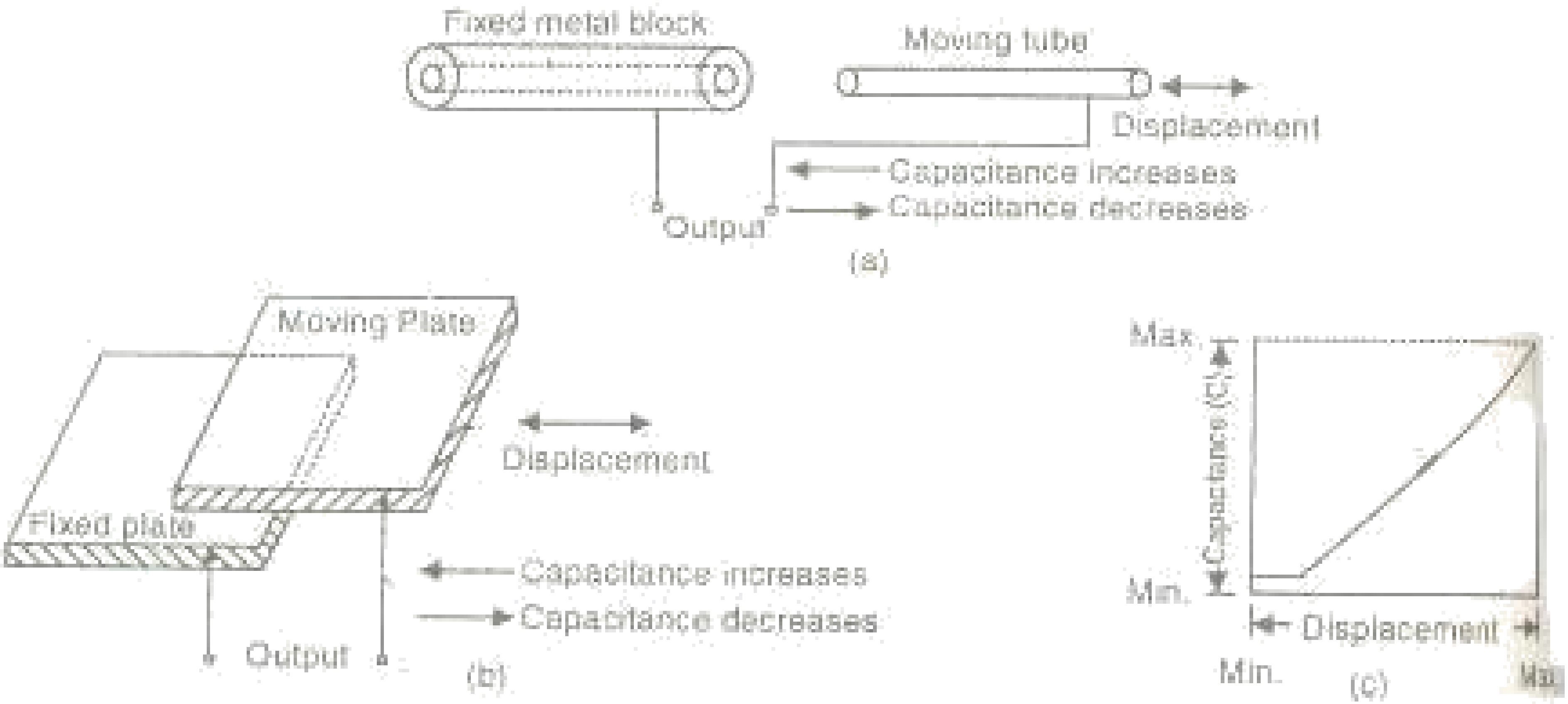
$$C = \varepsilon A / d$$

ε = permittivity of medium

A = overlapping area of plates

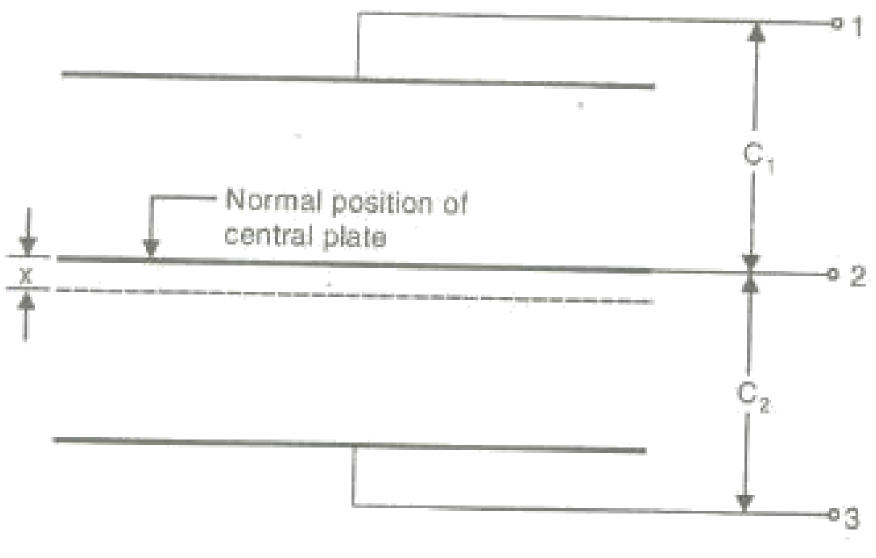
d = distance between two plates





Capacitive transducers working on the principle of change of capacitance with change of area.

Differential Capacitor System:



$$C_1 = C_2 = C = \frac{\in A}{d}$$

When central plate is displaced through distance x

$$C_1 = \frac{\in A}{d+x}, \quad C_2 = \frac{\in A}{d-x}$$

For an alternating voltage E applied between terminals 1 & 2 , the voltages across C1 and C2 are given by,

$$E_1 = \frac{EC_2}{C_1 + C_2} = E\frac{d+x}{2d}$$

$$E_2 = \frac{EC_1}{C_1 + C_2} = E\frac{d-x}{2d}$$

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

This method can be used for displacement of 10^{-8} mm to 10 mm with an accuracy of 0.1%

Advantages:

1. Require extremely small force for operation
2. Extremely sensitive
3. Minimum loading effects.
4. Good frequency response
5. Resolution can be 2.5 x 10^{-3} mm

Disadvantages:

1. Metallic parts must be insulated from each other
2. Many times show non-linear behavior
3. The cable connecting transducer to the measuring point is also a source of error.

Applications:

1. To measure linear and angular displacements.
2. To measure force and pressure.
3. To measure humidity in gases
4. Used in conjunction with mechanical modifiers for measurement of volume, density, weight, input level, etc.

PIEZO-ELECTRIC TRANSDUCER

The magnitude and polarity of induced charge on the crystal surface is proportional to the magnitude & direction of applied force. The charge at the electrodes gives rise to voltage (E), given by

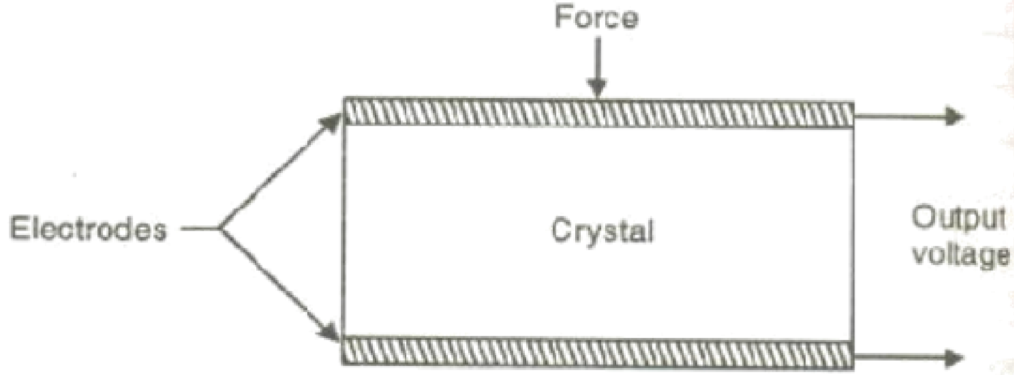


Fig. 5.20. Piezoelectric transducer.

$$E = \frac{gtF}{A} = gtp$$

where, g = Voltage sensitivity in Vm/N, $\left[g = \frac{K}{t},\ K = \text{Piezoelectric constant},\ t = \text{Thickness of the crystal.} \right]$

F = Force in N (newton),

A = Area of the crystal in m^2, and

p = Pressure $\left(= \frac{F}{A} \right)$ in N/m^2.

If a varying potential is applied to proper axis of the crystal, it will change the dimensions of crystal by deforming it. This effect is known as piezoelectric effect.

Natural crystals : quartz and tourmaline

Synthetic crystals : Rochelle salt, lithium sulphate, dipotassium tartrate, etc.

Natural crystals – higher mechanical & thermal stability.

- ability to withstand higher stresses.
- low leakage
- good frequency response.

Synthetic materials – higher voltage sensitivity.

Advantages:

1. High frequenc﹚ response.
2. Small size.
3. High output.
4. Rugged construction.
5. Negliible phase shift.

Disadvantages:

1. Output affected by changes in temperature.
2. Cannot measure static conditions.

Applications:

These transducers find the following *fields of application*:

1. Acceleroeters.
2. Pressure cells.
3. Force cells.
4. Ceramic microphones.
5. Phonograph pick-up.
6. Cartridges.
7. Industrial cleansing apparatus.
8. Under-water detection system.

Ionisation Transducer This works on the principle of development of voltage across two electrodes placed in an ionised gas, the magnitude of which depends on the electrode spacing and state of balance, which can change due to the motion to be measured.

The transducer consists of a glass tube (Fig. 4.54) containing gas under reduced pressure. A dc voltage is developed across the internal electrodes A, when the tube is subjected to an electric field due to external electrodes B, connected to a radio frequency (*RF*) voltage source. The gas in the tube gets ionised and the dc voltage produced depends on the electrode spacing, being zero at null position. As in Fig. 4.54, the motion x_i of the tube relative to the fixed external electrodes varies the output voltage. The balance between the electrodes may also be changed as in Fig. 4.55 by changing either capacitance C_1 or C_2 (C_1 in Fig. 4.55 shown), due to the motion x_i to be measured. This produces an output e_o.

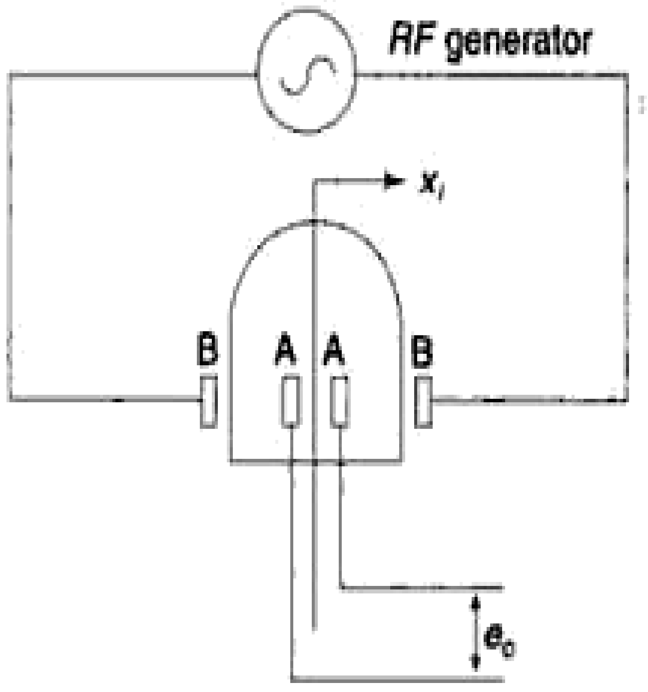


Fig. 4.54 *Moving tube type ionisation transducer*

MECHANO-ELECTRONIC TRANSDUCER

- This electronic displacement type transducer depends on the principle that the plate current depends on the spacing between an anode and a cathode in a diode or a triode.
- Cathode C is fixed in an evacuated tube and position of anode A can be changed by input motion Xi which causes deformation of an elastic diaphragm producing a change in plate current, which can be measured.
- Can be used for measuring displacement, pressure, force, etc.