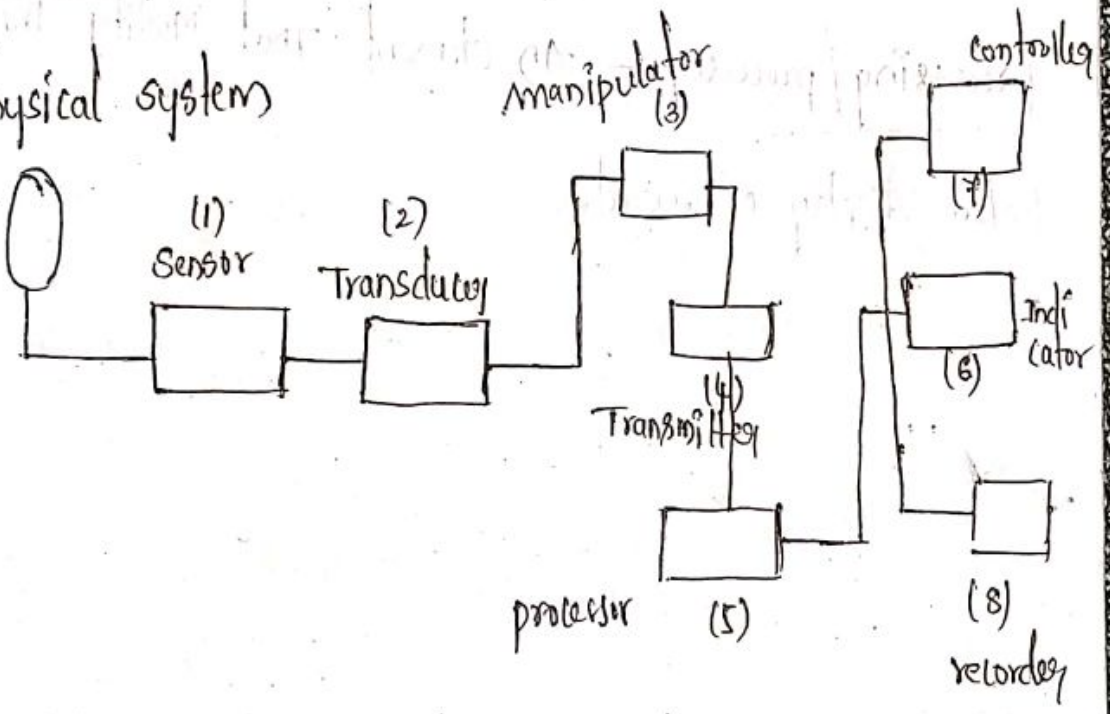
Measurement :- the Word Measurement refers used to tell length, Weight, Temperature and colour are changing one of this of the Materials.

Generalized System of Instruments / Generalized Measurement system :-



Sensor - An element that is Sense to the Measured variables It Senseing the condition state or value and produces output.

Transducer - An element that Converts Signals from one form to another form with out changing the information it may electrical, Mechanical, optical, electronics.

Manipulator – It operates on the signal according to some Mathematical rule. eg input x Constant = out put

$$I \times C = O.$$

Transmitter – An element that transmits the signal from one location to another location

eg – shafts and gears.

processing / processor – An element that modify the data before display or record.

Instrument static characteristics

i. Range and span

ii. Accuracy, error and correction

iii. calibration

iv. hysteresis

v. drift

vi. Threshold and resolution

vii. Tolerance

viii Sensitivity

Range and span — The region blw the limits with in an instrument for operate measuring indicating and recording is called range.

- Algebric difference blw the lower and upper values of the range is called span.

Accuracy, error and correction :— Accuracy of an Instrument define as closeness of Measured value to True value

eg — 98% of Accuracy

- Difference blw Measure value and true value.

V_m - measure value
V_t - True value

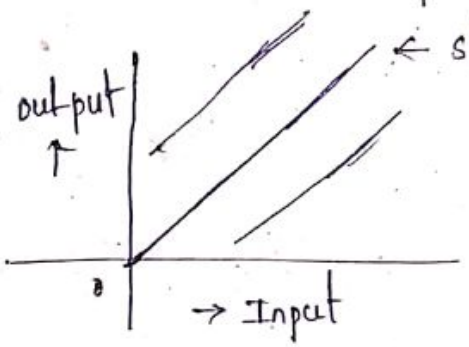
- Difference b/w True value and correction value.

$$E = V_m - V_t \quad , E = -C$$

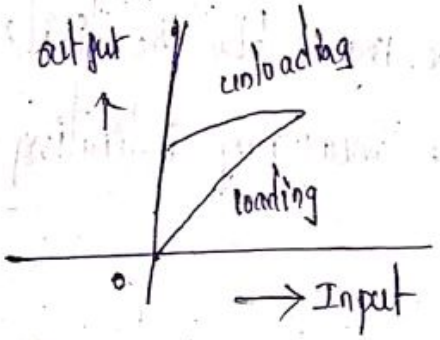
$$V_t - V_m$$

error - E
correction - C

Caliberation – the procedure laid down for making adjusting or checking by a scale so that readings of a Instrument confirm to an accepted standarded

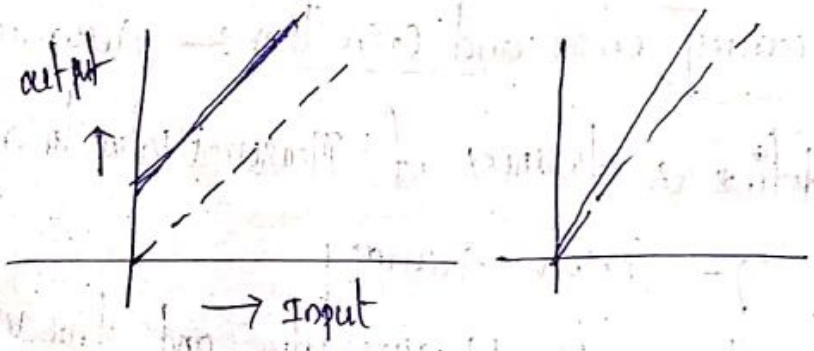


hysteresis :– The dependency of output upon previous Input is called hysteresis



departuire

Drift :– An undesired gradual departure of the Instrument output overa period of time is named as drift.



Sensitivity:– It is the ratio of the Magnitude of change of output signal to Input signal.

Threshold and Resolution:- When the Input signal of an Instrument is gradually increased from zero, there will be some Minimum value of input before which the instrument will not detect any output change. the Minimum value is called Threshold. eg:-

Input	output
0	0
1	0
2	0
3	0.5

Threshold - 2.

- When Input is increased from non zero value repeat the above condition i.e named as Resolution

input	output
1	0
2	0
3	0.5

Tolerance :- the range of accuracy which can be tolerated in Measurements of Instrumentation.

eg:- 10 bar pressure $\pm$ 0.01 bar. $10^{\pm 0.01}$

Dynamic characteristics:- (Mechanical)

i.) speed of response and Measuring lag

ii) Fieldlity and dynamic error..

iii) overar shoot

iv) dead time & dead zone

speed of response and Measuring lag –

→ It is defined as the repeadity which are instrument response to change in the value of quantity being Measure.

→ the delay oth the response of instrument for change in Input signal.

Fieldity and dynamic error:-

→ fieldity refers to the ability of the system to reproduce the output in same form as input

→ the difference blw indicated value and true value of the time varying quantity.

overshoot —

Because of Mass and inertia and Moving parts the pointer of instrument doesn't immeadiately comes to the rest. in the final deflection position. i.e named as overshoot.

Dead time and Dead Zone:—

→ Is defined as time required for instrument to begin to respond to a change in the Measured quantities.

→ Which is instrument doesn't response due to friction, ~~Inertia~~ Inertia ~~extra~~ etc.

Zero, first & second order Instrument system:—

the generalized Mathematical equation for any instrument is given below i.e

$$\left[A_n D^n + A_{n-1} D^{n-1} + \cdots + A_1 D + A_0\right] \theta_0 =$$

$$\left[B_m D^m + B_{m-1} D^{m-1} + \cdots + B_1 D + B_0\right] \theta_i$$

A_n, B_m are the Constant.

D — is differential parameter $D = \frac{d}{dt}$, $D^n = \frac{d^n}{dt^n}$

i) Zero order Instrument System —

-For zero order, $n=0$ & $A_n, A_{n-1} \text{ ----- } A_1=0$

$m=0$ & $B_m, A_{m-1} \text{ ----- } B_1=0$

θ_0 – out put

θ_i – Input

THEN $A_0 \theta_0 = B_0 \cdot \theta_i$

$$\theta_0 = \frac{B_0}{A_0} \cdot \theta_i$$

$$K = \frac{A_0}{B_0}$$

$$\boxed{\theta_0 = \frac{\theta_i}{K}}$$

mechanical levers, Amplifiers are obey's zero order Instrument system

ii) First order system :—

For first order. Mercury glass thermometer, pressure gauges – bellows, network of resistance capacitance and Inductors, velocity of free falling Mass are obey's first order

$n=1$ and $A_2, A_3, A_4 \text{ ---} A_0=0$ $\quad D=\frac{d}{dt}$

$m=1$ and $B_2, B_3, B_4 \text{ ---} B_m=0$, Then

$$(A_1 D + A_0)\theta_0 = B_0 \theta_i$$

$$A_1 \frac{d\theta_0}{dt} + A_0 \theta_0 = B_0 \theta_i$$

$$\frac{A_1}{A_0}\cdot\frac{d\theta_0}{dt}+\theta_0=\frac{B_0}{\theta_0}\cdot\theta_i$$

$$\tau\frac{d\theta_0}{dt}+\theta_0=K\cdot\theta_i$$

$$(\tau D+1)\,\theta_0=K\theta_i$$

$$\frac{\theta_0}{\theta_i}=\frac{K}{(\tau D+1)}$$

$$\left(\therefore \tau=\frac{A_1}{A_0}\right)\quad\left(\therefore K=\frac{B_0}{A_0}\right)$$

Displacement Transducers

Variable resistance Transistors —

$$R=\rho\cdot\frac{l}{A}$$

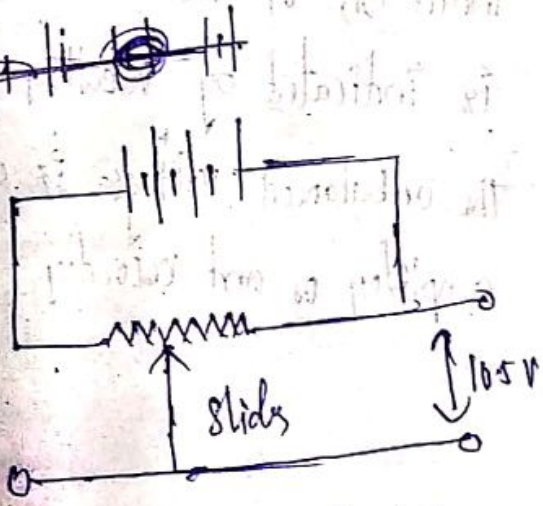
Here R = resistance

ρ – specific resistence

l – physical length

A – uniform crossectional area

linear displacement Transducers –



These are Converts the linear motion into changes in the resistence basically a resistence potentio meter are a variable resistors whose resistence varied by the Moment of slides

Advantages

Differentiate sizes, sizes and ranges are easily available

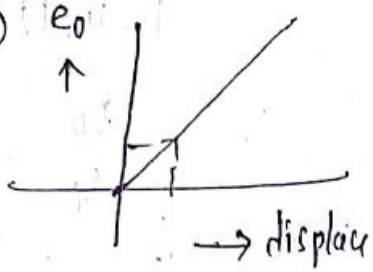
AC and DC both currents are used.

Insensivity of vibration and Temperature.

rough construction

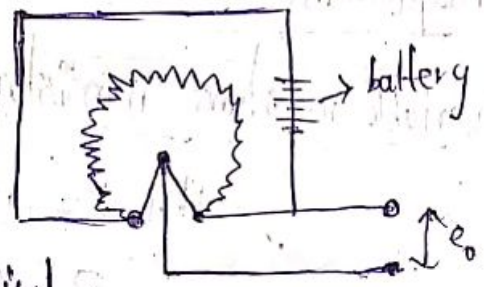
less expensive, high out put

(e_0 = emf)



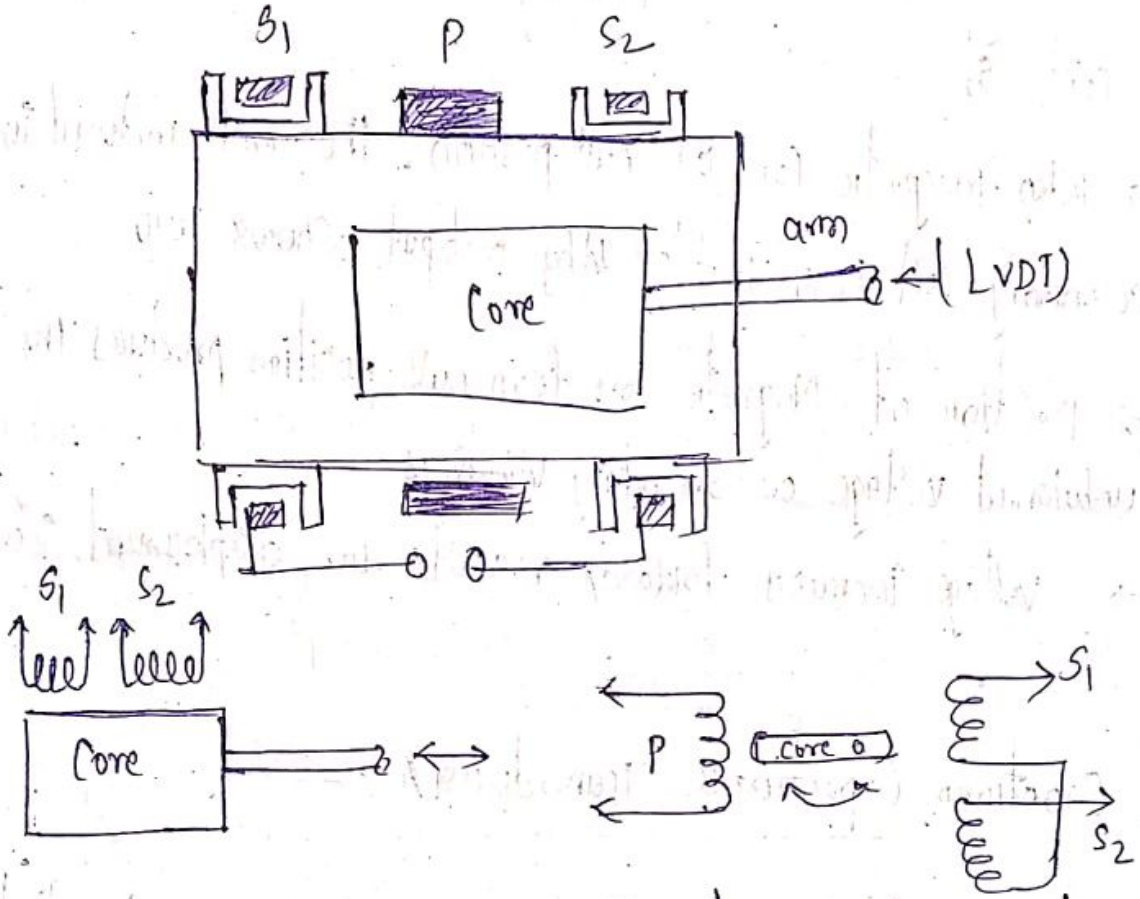
Angular potentiometers:-

If the both the linear and rotary displacement potentiometer as the slider is powered by the Mechanical part. on account of the arm moving the slider moves over the resistence element and the shot out a portion of the resistence. the resistence change in the potentiometer is the indication of the amount of motion and the direction of moment is indicated by wheather the resistence increasing or decreasing the unbalanced voltage is directly measured or sent to the amplifer or and recorder



Inductive Transducer [Displacement] :-

LVDT- [linear variable differential Transformer]



→ one of most useful variable inductive transducers is linear variable differential transformer (LVDT)

→ the device as one primary coil (P), two secondary windings (S_1, S_2) one Magnetic Core free to move inside the coils

→ Core is attached to the moving part on which displacement is Measure

→ When Ac current is supplied to the primary winding the magnetic flux Generated which voltage is induced in secondary coil

→ The secondary winding are symmetrically placed

→ the output from the Transformer is the difference between voltages of secondary coil 'S, and secondary primary coil 'S,

→ When magnetic core at null position. the emf induced in secondary coil zero that's why output shows zero

→ position of Magnetic Core from null position produces the unbalanced voltage on secondary Windings

→ voltage increases towards results core displacement increases

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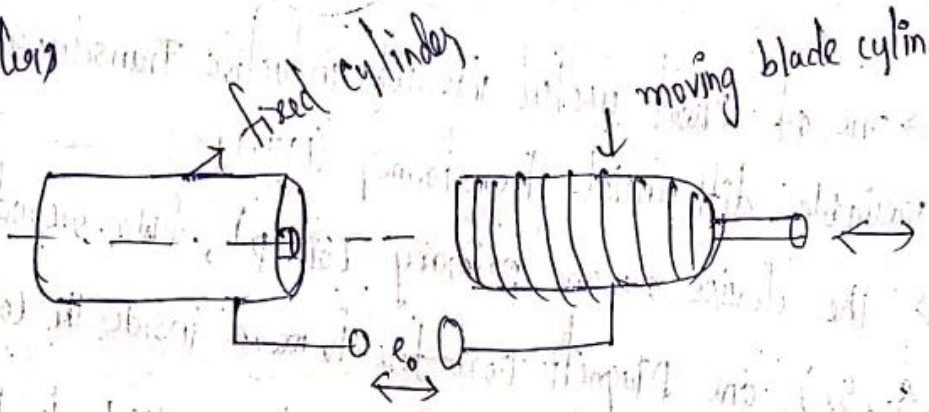
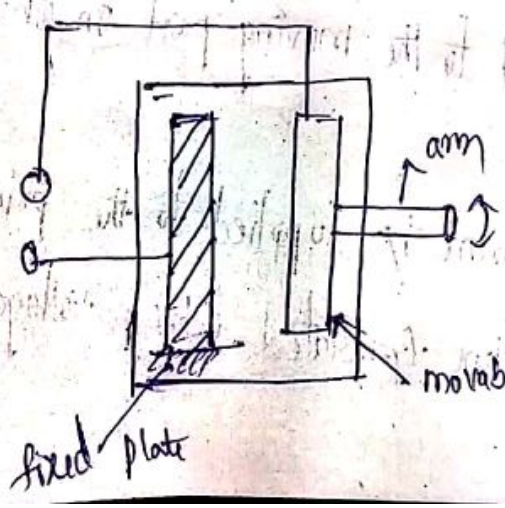
~~Capatiran~~ Capacitance Transducers :—

cylinders



plates



Formula for Instrument :-

→ $C = \varepsilon_0 \varepsilon_r \frac{A}{t}(N-1)$

here C = capacitance

t - thickness blw the plates | distance blw plates

N - No. of capacitors plates

ε_0 - permittivity ~~permeability~~ blw free plates

ε_r - relative ~~permeability~~ permittivity

$C \propto$ effective area of plates [A]

$C \propto$ Inversly proportional to thickness of free space (or) distance blw two plates $\left[\frac{1}{A}\right]$

$C \propto$ no. of plates

$\varepsilon_0, \varepsilon_r$ are capacitance constants.

→ Capacitor compresses two (or) more metal plates separated by an insulator

→ voltage is apply across the plates equal and opposite electronic charges are generated

→ A capacitance Transducers operates on the principle of variation in capacitance produced by the physical quantity being Measure.

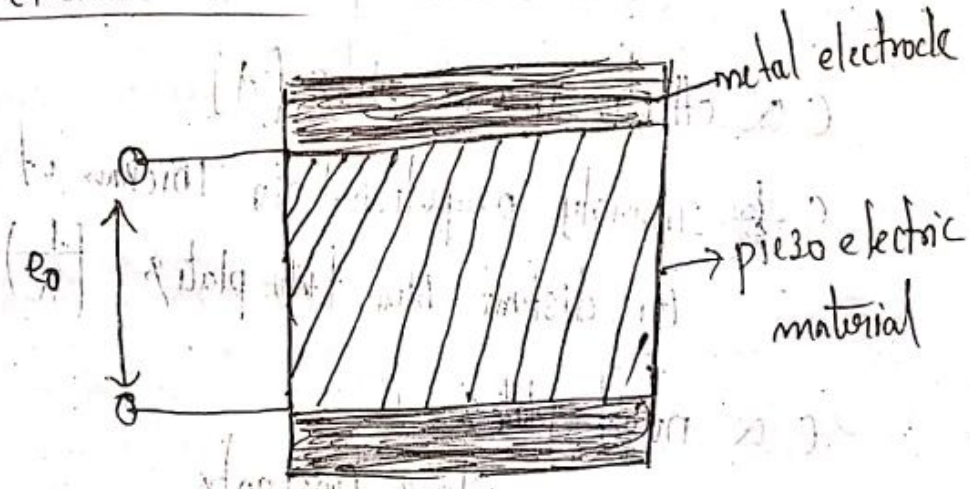
→ the capacitense can be vary by $\varepsilon_0, \varepsilon_r, A, t, N$

→ the detector can be measure up to 2.5×10^{-6} m

Advantages of parallel plates capacitive Transducers:-

→ easy fabrication
→ High frequency response
→ ability to measure static and dynamic quantity
→ low intial cost & maintaince cost.

piezo electric Transducer:-



$$F = AY\left(\frac{\Delta t}{t}\right)$$

where F - force generated / applied
A - c/s area of the plane
y - effective length
Δt - change in thickness
t - Thickness

→ It represents the property of no. of crystals · zations that cause the crystal to develop potential difference when subjected to mechanical forces along specific plates

→ Metal electrodes are attached to the select phase of crystal in order to detect the electric charge developed.

Advantages

→ high frequency response (beyound .2Hz – 20KHz)

→ High output

→ Rugged construction

→ ~~phase~~ Neglisible phaseship

Advantages of Natural piezo electric crystals:–

→ very low electrical value

→ It withstands for high Temp

→ ~~High~~ out put

→ ~~Rugged~~ construction [flexible construction]

→ ~~Neglisible~~ phaseship

→ operating at low frequency

→ with stand for high mechanical strain [high much force]

→ artificial crystals.

photo electric Transducers :-

There are ~~three~~ Type [measure the displacement]

(i) photo emission Cell

(ii) photo conductive Cell

(iii) photo voltaic Cell

(i) photo emission Cell -

→ These operates on photo emission effect, When certain Type of materials are exposed to light, electronics flow is emitted and current is produced.

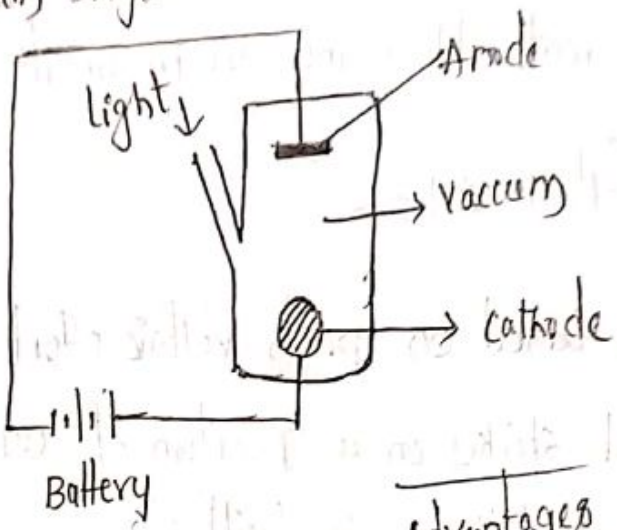
→ light information is Converted into Current

→ light emission Cell has photo cathod has a mix of silver, Selinium, Sesum. light strikes on cathode electrons emission is results

→ there are 3 Types of photo emission Shells

1. high vaccum single Cathodes
2. gas filled
3. multiplier Tubes.

1- high vaccum Single cathode -



Applications-

→ In control engineering
→ precision measuring devices
→ photo expo meters
→ Rockets and satellites

Advantages

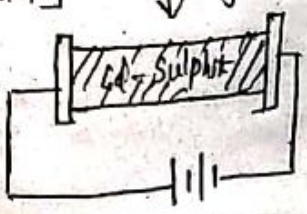
→ No direct contact is required
→ Infrared radiation also

(2) photo Conductive cell:-

→ photo Conductive cell operates on principle of photo Conductive effect
→ some special materials (Semi Conductor) change their Resistence when exposed to light

light Information → (emission cell) → Current Information / Resistence information

→ Materials are Cadmium, Sulphite [in the form of thin coating on glass plates]



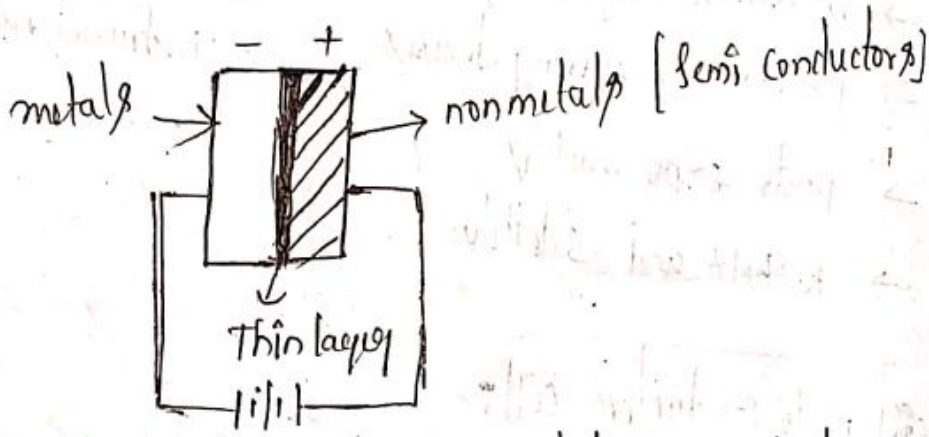
→ light strikes on the Material resistence of the Material decreases. Current flow increases in circuit

(iii) photo voltaic cell :-

→ It Works based on photo voltaic effort

→ When light strikes on a Junction of certain dissimilar metals potential difference is built-up

→ light information → emf information



→ It contains base metal plate, non metal semiconductor.

→ the layer formed with a technique of spread of a Thickness blw metals and non metals

→ It requires no voltage source

→ no vaccum or gas is required

Applications :-

→ light expo photographic Works.

" Source of errors, classification of errors, correction of errors "

1. Instrument error
2. Translation error and Transmission error
3. Observation error
4. environmental error
5. operational errors
6. System intraction error.

1. Instrument errors —

→ Many factors in the design and construction of instruments
→ poor maintainence of instruments
→ Wear, friction, rust, yielding of supports
→ physical phenomenon. Capilarity attraction [surface Tension]
→ Assembly errors
ex:- scales are not fit intial to zero

Correction of errors

→ Assembly errors are easily corrected by fit into correct position
→ Friction is corrected by lubricating oil by gental topic

2. Environmental Errors :-

Source of errors

→ When instrument assembly condition and working condition are not same

→ Temp results on elastic constant of Materials, dimensions of scale, resistance value of Materials -- etc

Correction of errors

→ caution about working condition is same as assembly condition

→ use automatic compensation values for final readings

3. Translation and Transmission errors :-

→ Instrument Mayno Cells to read the measuring effect with complete fieldity

→ Falls due to resonance.

→ Due to inertia and coil losses (Inductions) these results unwanted noise, line pickup humb etc

Correction :-

→ Monotoring system at 1 or more points along the Transmiertion path

4. Observational Error :-

Due to parallex error [line of vission not ⊥ar to scale]

→ Inaccurate destination of avg values, mean and standard deviation
→ Inaccurate conversion of units
→ personal bias

Correction

→ avoid inexperience and careless observers
→ Arrange two or More observers for that

5. operational error :-

→ pre-requisite [To presize. instrument is that should be properly used

ex:- Thermometer will not read accurately if sensitive portion is insufficiently immersed (or) Radiating to heat portion.

Correction

→ Conduct Experiments on pre requisite instrument.

6. System interaction errors :-

→ The Act of measurement may effect the Condition of instrument Thus leads uncertainity in the measurements reading of hand Tachometer should vary with pressure with which it. pressed against the shaft

Correction - repeat the measurement under different Conditions and different equipments.