GOVERNMENT POLYTECHNIC DHENKANAL

LECTURE NOTES ON

ELECTRICAL ENGINEERING MATERIAL

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ch-1 CONDUCTING MATERIALS

INTRODUCTION :-

- conducting material have very low value of resistivity as compared to insulating material to determined the extend to which a material has conducting or insulating property we should know the value of it's resistivity.
- conducting materials can further divided into low resistivity and high resistivity materials.

Resistivity and FACTOR Afecting resistivity :-

We already knows ohm's law which can be written as $V = IR$

where V = voltage between the two terminal of a current carrying conductor

I = current flowing through the conductor.

R = resistance of the conductor.

- The resistance are of any given material is directly proportional to it's 'l' and inversly proportionality to 'a'.

$$R \propto \frac{l}{a}$$

$$\text{or} \quad \boxed{R = \rho \frac{l}{a}}$$

where ρ = resistivity

* FACTOR AFFECTING RESISTIVITY :-

- The resistivity of material is not constant.
- The factors which affect the value of resistivity of the material are - Temp, alloying, mechanical stressing.

Effect of temprature on resistivity :-

- The most important factor which affect the value of resistivity is the temprature.
- The resistance of the most of the conducting materials increases with temprature.
- The change 'a' resistance of a material 'per ohm' 'per degree, change in temprature is called the temprature coefficient of resistance.
- The temp coefficient of resistance.
- The resistance of conductor changes with temprature

$$\boxed{R_t = R_0 \, (1 + \alpha t)} \quad \text{---- (I)}$$

where R_t = Resistance of conductor at 't' degree

R_0 = Resistance of " " '0°C.

α = temp. coefficient of resistances

$$\boxed{R_{t_1} = R_0 (1 + \alpha t_1)} \quad \text{---- (II)}$$

where t_1 = Another | External temp.

By dividing eqn '2' into '4'

$$\frac{R_{t_1}}{R_t} = \frac{R_0(1+\alpha t_1)}{R_0(1+\alpha t)}$$

$$\Rightarrow \frac{R_{t_1}}{R_t} = \frac{1+\alpha t_1}{1+\alpha t}$$

$$\Rightarrow \frac{R_{t_1}}{R_t} = \frac{1+\alpha t+\alpha t_1-\alpha t}{1+\alpha t}$$

$$\Rightarrow \frac{R_{t_1}}{R_t} = \frac{1+\alpha t}{1+\alpha t} + \frac{\alpha(t_1-t)}{1+\alpha t}$$

$$\Rightarrow \frac{R_{t_1}}{R_t} = 1 + \frac{\alpha(t_1-t)}{1+\alpha t}$$

$$\Rightarrow R_{t_1} = R_t\left\{1 + \frac{\alpha(t_1-t)}{1+\alpha t}\right\}$$

$$\Rightarrow \boxed{R_{t_1} = R_t\left\{1 + \frac{\alpha(t_1-t)}{1+\alpha t}\right\}}$$

Prob-1 → A coil of a relay is made of copper wire at a temp. of 20°c. The resistance of the coil is 400 Ω, calculate the resistance of the coil at a temp. of 80°c. Temp. coefficient of copper is 0.0038 Ω/°c.

Ans Here given
$R_t = 400\ \Omega$
$t = 20^\circ c$
$R_{t_1} = ?$
$t_1 = 80^\circ c$
$\alpha = 0.0038\ \Omega/^\circ c$

$$R_{t_1} = 400 \left\{ 1 + \frac{0.0038\,(80-20)}{1+0.0038 \times 20} \right\}$$

$$R_{t_1} = 400 \left\{ 1 + \frac{0.228}{1.076} \right\}$$

$$R_{t_1} = 400 \times 1.211$$

$$R_{t_1} = 484.4\ \Omega.$$ (Ans)

Prob-2 → Calculate the resistance of a wire at 50°c. which is 300 mtr. long and area of crossection of 25 mm². The wire is made of aluminium. Resistivity of Al at 15°c is 2.78 Ω. Temp coefficient of Al is 0.004 Ω/°c at 0°c.

Here give l = 300 mtr

$a = 25\ mm^2 = 25 \times 10^{-6}$ m.

$\rho = 2.78\ \Omega m.$

$R_t = ?$ $t = 15°c$

$R_{t_1} = ?$ $t_1 = 50°c$

according to question.

$$R_t = R_{15°c} = \rho \frac{l}{a}$$

$$= 2.78 \times \frac{300}{25 \times 10^{-6}}$$

$$= 2.78 \times \frac{300}{25} \times 10^{6}$$

$$= 33.36 \times 10^6\ \Omega$$

$$= 33.4\ M\Omega \quad (10^6\ \Omega = 1\ M\Omega)$$

$$R_{t_1} = R_t \left\{ 1 + \frac{\alpha(t_1 - t)}{1 + \alpha t} \right\}$$

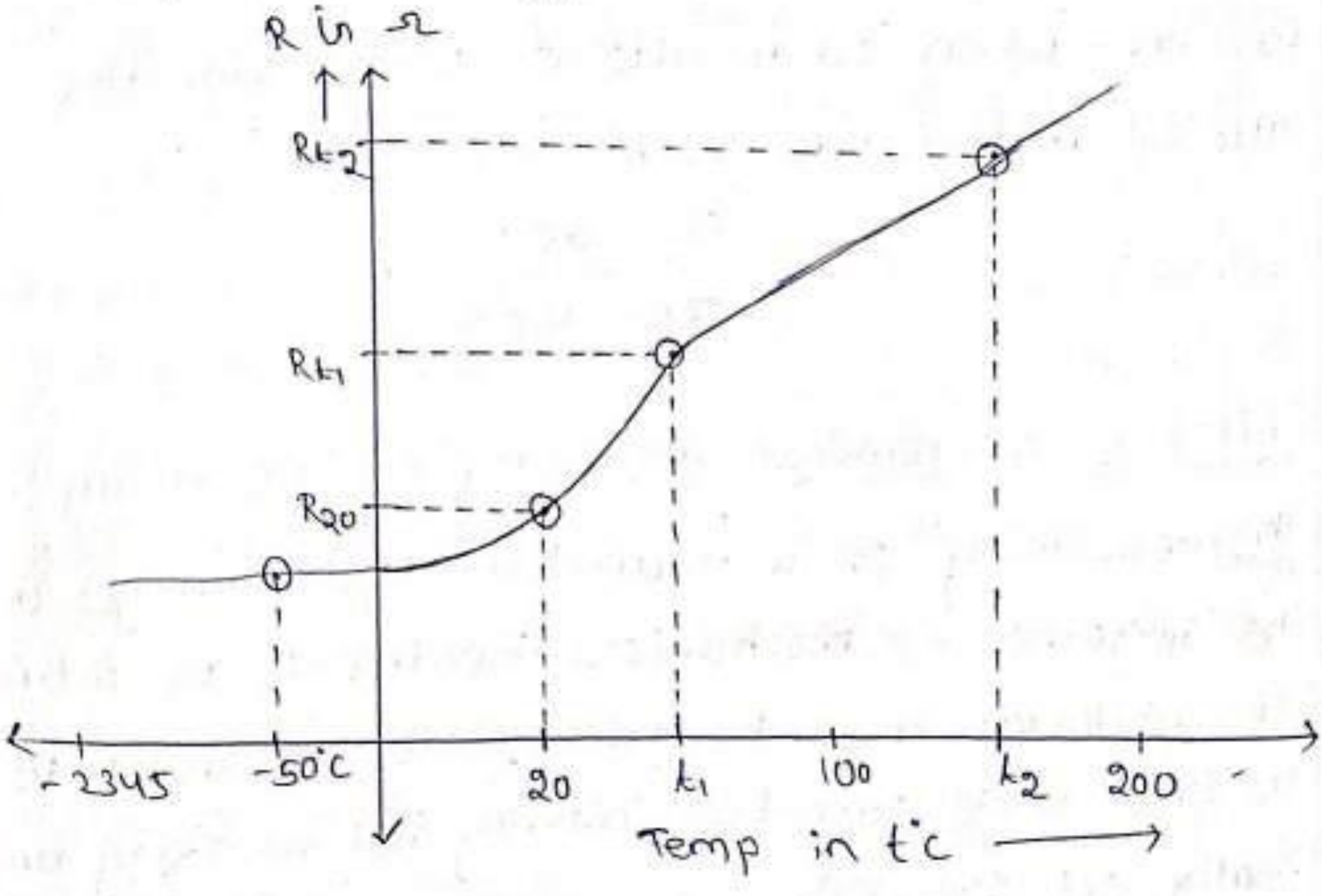
$$R_{t_1} = 33.4 \left\{ 1 + \frac{0.004(50 - 15)}{1 + 0.004 \times 15} \right\}$$

$$R_{t_1} = 37.811 \, M\Omega$$

$$R_{t_1} = 38 \, M\Omega$$ (Ans)

* VARIATION OF RESISTANCE :-

- The variation of resistance with temp for Annealead (~~impurity~~) copper.



At 20°C $\alpha_{20} = \frac{\Delta R}{R_{20}}$

At 0°C $\alpha_0 = \frac{\Delta R}{R_0}$

Effect of alloying on resistivity :-

- alloying is anather factor which affect the resistivity of a material by adding some impurity to a metal it's resistivity can be increased.
- Alloy have higher resistivity than the pure range metal at the same time when a metal is alloied. It also acquire properties like higher mechanical strength which needed for certain applications.
- for ex - when cu is alloied with zinc, the alloied material is called brass.

$$Cu = 60\%$$

$$Zn = 40\%$$

Effect of mechanical stressing on Resistivity :-

- The resistivity of a material also changes under the influence of mechanical treatment. The fabrication of conductor from the bar, plate or sheet to the final stage comprises initially hot working and finally old drawing.
- The increases in tensile strength is very useful for many purposes such as overhead conductor.

- Although, mechanical stressing increases the resistivity i.e, decreases the conductivity. Anneling (heat treatment process) restores the electrical conductivity by establishing regular heating.

Classification of conducting materials :-

There are two types of conducting material
(1) high resistivity.
(2) Low resistivity

(1) LOW RESITIVITY MATERIALS :-

- Low resistivity materials are used in house wiring. As conductors for power transmission and distribution. In the winding of transformers and machines like motors and generators.
- Infact low resistivity materials are used in all such applications where power loss and voltage drop should be low.
- Copper and Aluminium are examples of low resistivity materials. (Cu, Al, Ag)
- A low resistivity material possesing low value of resistivity should also poses the following additional properties for reason mentioned against each.

(A) Low temprature coefficient :-

This means that the change in resistance with change in temprature should be low.

- The windings of electrical machines and aparatu becomes hot when loaded, This cause temprature rise and if the conducting materials of the winding has high temp. coefficient of resistance the voltage drop and power loss in the winding will be high.

(B) Sufficient mechanical strength :-

- The overhead line conducter use for transmission and distribution of electrical power as subject to stresses, due to wind and their own weight.
- The conducting materials are used for the winding of transformers, motors and generators devlope mechanical forces when loaded, which can become very large if a high current flows due to a short circuit.
- ~~Their~~ Therefore withstand, the mechanical stresses devlope in the above mentions application the conducting material should posses sufficient mechanical strength.

(c) Ductility :-

- Ductility is that property of a material which allows it ~~tooo~~ to be drawn out into a wire.
- In some applications the round wire section is used while in other rectangular wire section is used.
- The conducting material should be ductile enough to enable itself being drawn into different size and shape.

(D) Solderability :-

- conductors have ~~obtea~~ often to be jointed.
- The joint should offered minimum contact resistance.
- A simple joint would be to twist the conductors with the materials to which it is to be jointed.

(E) Resistance to corrosion :-

- The conducting materials should be such that it is not corroded when use in outdoor atmosphere

(2) HIGH RESISTIVITY CONDUCTING MATERIAL :

- High resistivity material are used for making resistance elements for heating devices, startors, for electric motor, resistance used in precision measurement instruments, loading resistance and rheostate and filament for Incandecent Lamp.
- A high resistivity material besides possesing high value of resistivity should also posses the following additional properties -

(A) LOW TEMP. COEFFICIENT :-

- High resistivity materials are used as shunts (parallel) in electrical measuring instrument, in making wire ~~stored~~ wound precision (accuracy) resistance and resistance bones.
- For such precision application are important requirement is that the material of the element should have negligible temp. coefficient of resistance as otherwise the accuracy of the measurements will be reduced.

(B) HIGH MELTING POINT :-

- In application like loading rheostats and starters for electrical motors, the material of the resistance element should have able to withstand high temp. for a long time without melting.

(C) ~~LOW~~ NO TENDENCY FOR OXIDATION :-

- ~~No tend~~ materials used as high resistance elements in heating appliances should be able to withstand high temp for a long time without oxidation.
- This is because if an oxidation layer is formed on the heating element the amount heat radiation will be reduced

(D) DUCTILITY :-

- It is the property of a material in which high resistance materials are used in different shape and sizes.
- It is made in the shape of very thin wires in the case of precision wire wound resistor.
- The shape of thick wires in the case of the elements used in ovens, haters starters etc.

(E) HIGH MECHANICAL STRENGTH :-

- High resistivity materials to be used in such applications wire thin wire is used, if it has not any mechanical strength then it will break.
- So, mechanical strength be used very essential for high resistivity material.

→ LOW RESISTIVITY MATERIALS :-

COPPER :- (Cu)

- Among all the conducting materials 'cu' is most widely used metal because of it's high conductivity.
- Ag has lowest resistivity but because of it's high cause it is not used as a conducting material.
- Cu is Reddish in colour and can be available in hard drawn or Annealead form.
- Anneblead copper is soft and has less tensile strength than hard drawn copper.

- Hard- drawn copper become soft after annelead.
- Hard-drawn copper is springy but aneled copper is flexible.
- copper in pure form is much not used as an electrical contact material. when 10-30% nickel mixed with it, it becomes harder and cheaper.
- Due to it's high conductivity it is used in motor starter switches and tap changers.

SILVER (Ag):-

- pure silver has high electrical conductivity and corrosion resistance.
- In order to make it harder 15% of copper is added to it.

GOLD (Au):-

- Gold is best known electrical conductor. It is found all over the world but not in sufficient quantity to make it economical.
- It is also found in the form of dust and in the river beds.
- Gold has density of 19.3 times that of water at 20°c.
- It melts at 1063°c and boils at 2700°c.

- It is malleable and ductile and can be easily beaten into translucent sheet as thin as 0.00001 mm.
- It is used to make jewellery from it's alloy's.
- Its good corrosion resistance property makes its alloy very much useful as contact materials in electric field. It is alloy is also used as corrosive resistant brazing material.

ALUMINIUM (AL) :-

- It is next best to copper.
- It's resistivity is 2.8×10^{-8} ohm-m i.e, 1.6 times higher than copper.
- It's density is 2.68 which means that aluminium is much lighter than copper.
- It's melting point is 655 degrees centigrade like copper it is easily rolled and drawned out.
- It is annealed (heat treated) after it is hard drawn. It can be drawn into thin wires.
- Al is a soft metal but when alloy with some other material like mg, si and Fe, it acquires higher mechanical strength and can be used for overhead transmission lines.

- Like copper, aluminium also forms an oxide layer over it's surface when exposed to atmosphere and that layer prevents the material from further oxidation and act as a resistance layer to corrosion.
- Due to the insulating property of aluminium oxide formed on the surface, it is diffcult to solder aluminium wires.
- However, special flux is now being developed for soldering aluminium wires.
- As a substitute for copper, aluminium is quite extensively used for flexible wires, overhead transmission lines, bus-bars, squirrel cage induction motor rotor bars and in many other applications.
- This is because aluminium wires have tensile strength varying from 0.95 to 1.57 tonnes/cm2 which is much lower than that of copper.

STEEL :-

- Steel contains iron with small percentage of carbon added to it.
- Iron itself is not very storong but when carbon is added it assumes very good mechanical properties.

- steel is classified as follows -

(a) mild steel containing carbon about 0.25 %.

(b) Medium steel containing carbon about 0.45 %.

(c) High carbon steel containing carbon about 0.7% and above.

- The resistivity of steel is 8 to 9 times higher than that of copper.
- Steel is easily corroded when exposure to moisture
- when a zinc coating is provided on its surface it does not corrode.
- Galvanized steel wire are used as overhead telephone wires and as earth wires.

STANDARD CONDUCTORS :-

- when a single conductor of large cross section is used, it becomes rigid in construction and is liable kings and breaks while handing.
- To avoid this, conductors are made of a number of thing wires handing together called strands.
- Stranding makes the conductor flexible and eliminates to a large extent the risk of its breaking through the insulation.
- A standard conductors is made by bunch or twincasting together to form layers.

- A standard stranding consists of 6 wires around 1 wire, then 12 wires around the previous 6, then 18 wires around the 12, then 24 wires around the 18 and so on.

BUNDLE CONDUCTORS :-

- The adoption of bundled conductors is extra high tension power transmission enables stranded conductors to be employed and give and increase current carrying capacity compared with a single conductors of equivalent cross-section area.
- Since the voltage stress at the conductor surface is reduced using the bundled conductors, corona loss is smaller and the line is less small and line is less to cause radio interference.

LOW RESISTIVITY COPPER ALLOYS :-

(A) Brass :-

- When copper is alloyed with zinc, it is called Brass.
- It contains 60% of copper and 40% of zinc.
- Brass has high tensile strength but has lower conductivity than copper.
- It can be easily shaped by pressing and
- it lends itself to deep drawing.

(B) Bronze :-

- Copper when alloied with tine and a very small percentage of third element like cadmium Berylium, phosphorous, silicon etc, is called Bronze.
- It contains 8 % to 18 % tin.
- Bronze are given to their names based on the third element which is added to copper and tin to form the alloy.
- when the third element which is added to copper and phosphorous, the alloy is called phosphor ~~alloy~~ bronze.
- All bronzes have high mechanical strength but lower conductivity.
- Tin is more corrosion resistant than zinc.
- cadmium bronze is used for contacting conductor and commutator segment.
- Berilium Bronze whose mechanical strength is higher than cadmium bronze is used for making current carrying springs, sliding contacts knife which blades etc.

(c) Beryllium copper alloy :-

- The copper alloy containing beryllium is also called Bronze. It has high conductivity and mechanical strength.

- Its hardening and elasticity property can be changed by giving appropriate heat treatment.
- It is used for making current carrying springs brush holders, coil spring, sliding contacts and knife swit bldes.

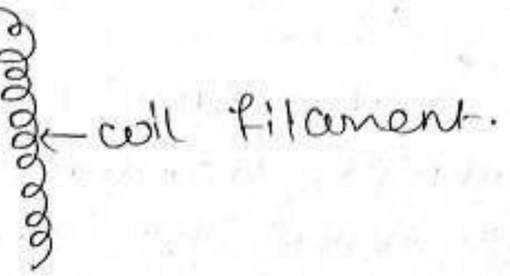
HIGH RESITIVITY MATERIALS AND THEIR APPLICATIONS :-

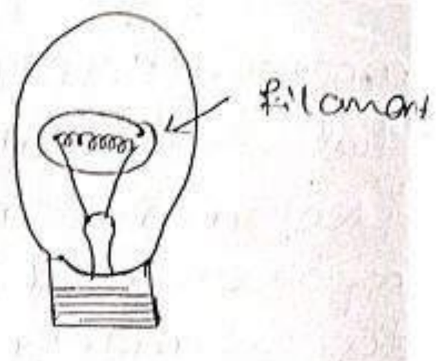
- materials used for making resistance elements for ~~fitt~~ heating devices, starterss, for electric motors, resistance for precision measurement, loading resistance, filament for incandexent lamp etc. are all made of special high resistivity materials.
- They are generally alloys of different materials.
- Depending upon the application ~~one of the above mentioned~~ high resistivity material is choosen to meet the specific requirement.

(A) Tungsten :-

- It is a very hard material.
- The resistivity of tungsten is about twice that of aluminium
- It's melting point is highest of all metals i.e, 330°c.
- Tungsten can be drawn into very thin wire require for making filaments.

- Thinner tungsten wires the greater is its tensile strength.
- In the atmosphere of inert gas or in vaccum tungsten can reliable warm at temp like 200°c and even higher.





- To summerise tungsten is used as filament material for the following reason-

(a) It has high melting point among all metals, can be drawn into very thin wire.

(b) It has very high tensile strength, it doesnot become brittle at high temp.

(c) Efficiency of filament lamp is low because a lot of input energy is wasted as heat during convertion electrical energy to light energy.

(3) Carbon :-

- carbon materials used in the field of electrical engineering as manufactured from graphite and other forms of carbon like coal.
- The manfacturing process of electrical carbon products consists of the following → grinding of the raw carbon materials → ~~facino~~ mixing of powdered carbon with a binding agent. ~~ex~~(coal tar) ⟶
- ~~In~~ To increases the conductivity of the carbon products different kinds of additive like copper or bronze powder are mixed with the carbon moulding compound.
- carbon has got the following characteristics -

(a) very high value of resistivity.

(b) The negative temp coefficient of resistance.

(c) low surface friction.

(d) carbon is used applications like process of electrical machines and aparatus, electrodes for electric earth furnaces.

(e) pressure sensitivity.

(c) plantinum :-

- plantinum is Greiyshg white metal.
- It is ~~neti~~ malleable and ductile and is resistance to most chemicals.
- plantinum is a heavy metal having specific weight of 21.4 gm/cm².
- It's melting point ~~that~~ 1775 'centigrade.
- The resistivity of plantinum is 0.1×10^{-6} ohm-m.
- It's temp coefficient is 0.00307 / °centigrade.
- plantinum can be drawn into thin wires and strips.
- plantinum finds application as a heating element in laberotary ovens and furnances. plantinum rhodium thermocouple is used for measurement temp. of 1600°c.
- plantinum is also used as electrical contact material and as material for grids in special purpose vaccum tubes.
- Corrosion cause a film of oxide to be deposited on the contacts, reducing the conductiv of the contact have to withstand acting whenev contacts are separated.
- when materials are used for this purpose they may have to operate under very sever conditions particularly whey they are subject to frequent make and break operations.

- Hence they deteriorate with time to because of (i) corrosion and (ii) erosion.
- corrosion cause a film of oxide to be deposited on the contacts, reducing the conductivity of the contact. poor contact, thus resulting, can be avoided using a high contact to contact pressure which will break up the oxide film whenever the contact is made and is broken.
- Erosion is caused due to fusing and weare of the working surfaces of the contact during operation. Erosion may cause growth to appear on one contact and cavity on the other.
- plantinum being highly resistant to corrosion and having a high melting point is often used for making lightly loaded contacts.

(3) Mercury :-

- It is a heavy/silver ~~metal~~ meta white in colour.
- It's specific weight is 13.55 gm/cm3.
- It is the only metal which is Liquied at room temprature.
- It's boiling point is 357 °C.
- It's resistivity and temp. coefficient of resistance are respectively 0.95×10^{-6} ohm-m. and 0.00027 per degree C. mercury is precious.
- In the field of electrical engineering mercury finds applications in mercury arc rectifier, gas

filled tubes, as liquied contact material in electr switches etc.

- An important example of mercury being used f. making and breakcup contact is Buchholz relay used for transformer protection.

SUPER CONDUCTIVITY :-

- It has been started earlier that the resistivity of most metals increases with increase in temprature and vice-versa.
- Their are some metals and chemical compound whose resistivity becomes zero. when their temprature is brought near zero degree(kelvin.
- For example mecury becomes super conducting at approximately 4.5 k.
- Their are two types of super conductor.

Type - 1 Soft super conductor	Type - 2 Hard super conductor
(i) Their are usually pure specimen of some element i.e, metals, they have very little use in technical application.	(i) They are usually alloys of metal with high value of resistivity in normal state

SUPER CONDUCTING MATERIALS :-

- many materials and compound have super conducting properties at very low temprature.
- super conductivity has been observed to occure in proper metalic conductor such as Tin (Sn) lead (pb) and tantalum rather than in better conductor such as coal, silver and copper.
- It has been found that super conductors may not only be pure metal but various alloys and chemical compound also.
- At present about 30 super conductor metals and more than 600 super conduction alloys are already known.

APPLICATIONS OF SUPER CONDUCTING MATERIAL

(A) Electrical machines.

(B) power cable.

(C) Electro magnet.

(D) Future prospects.

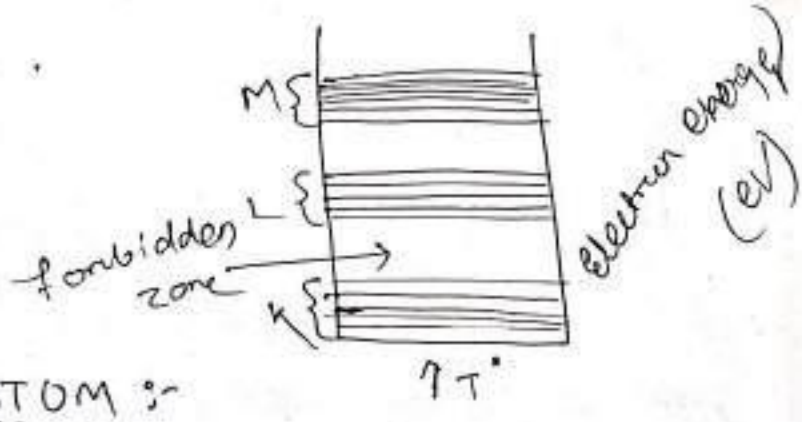
SEMI-CONDUCTING MATERIALS

As the name indicates a semi-conductor is neither a good conductor nor insulator.

- Typical semi-conductor materials are silicon germanium and Gallium.
- Electrical conductivity lies between a conductor an insulator.
- It's resistance decreases with increase in temprature conducting property can be change by adding impurities called doping.

ELECTRON ENERGY AND ENERGY BAND THEORY:-

- An electron revolving around the nucleus of an atom has potential energy, centrifugal energy, rotational energy and magnetic energy all of which together determined the total energy or the energy level of an electron. This is measured in electron volt commonly expressed as eV
- The larger the orbit in which an electron revolves, the greater is it's energy.

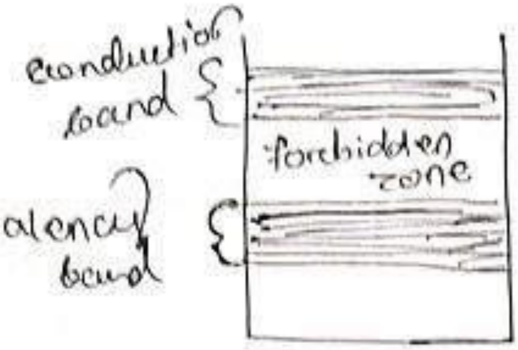


EXCITATIONS OF ATOM :-

- When each electron in an atom ~~each~~ is in it's normal orbit, the atom is said to be in an unexcited state. To move an electron further away from the nucleus required additional energy.
- The additional energy are - (1) light
  (2) Heat
  (3) electrostatic
  (4) magnetive
  (5) kinetic

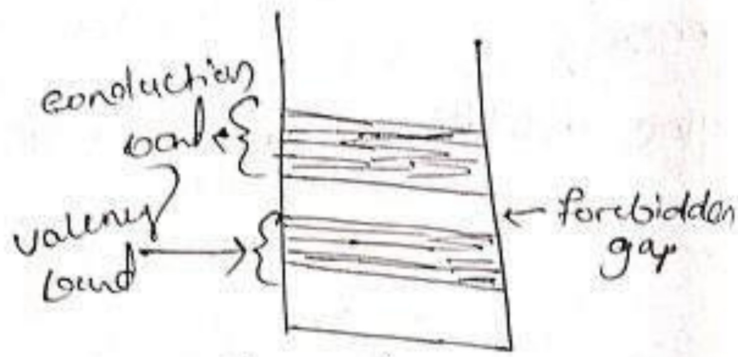
INSULATOR, SEMI CONDUCTOR, CONDUCTORS :-

- The forbidden zone between the valency band and conduction band is quite large.
- This indicates that electrons in the valency band require large amount of additional energy to move up and become free.
- As long as the valency electrons are unable to move up to the conduction band their can be no-electron flow.



(a) Insulator

- In case of semiconductor the forbidden zone is reduced thus, the valency electron require less energy to free themselves from the attraction of nucleus.



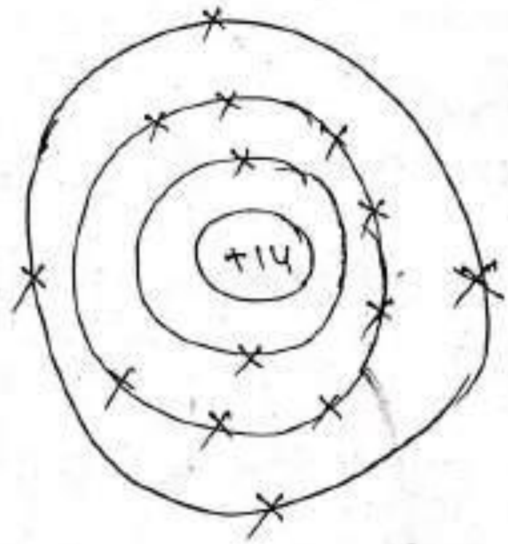
(b) Semi-conductor

- In case of conductor their is no gap between the valency band and the conduction band, for the better conductor the conduction and valency band may overlap.

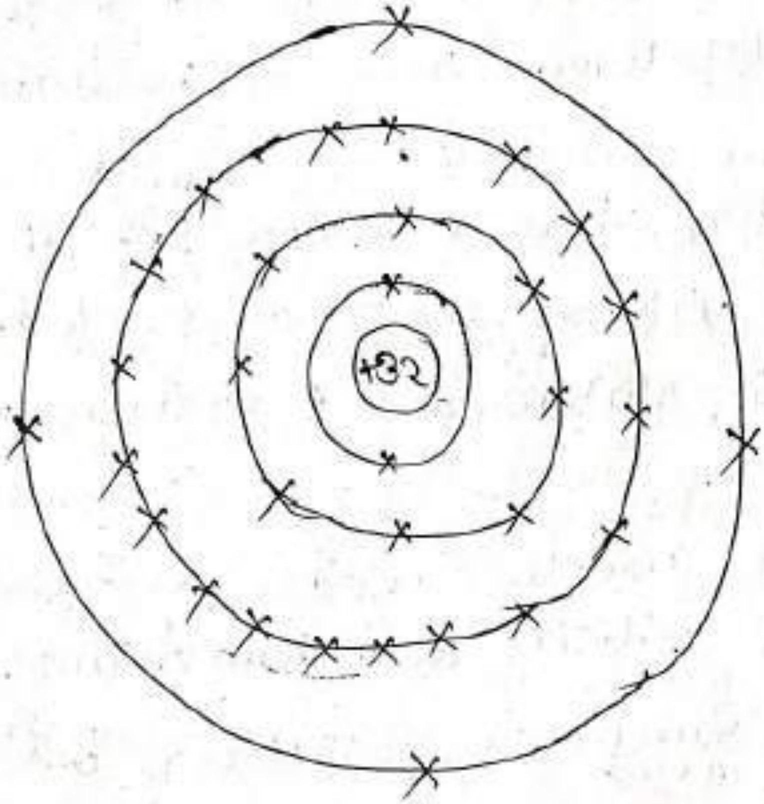
→ Electrons from the valency ring may be move into the conduction zone by a small amount of energy. thus, becoming free by applying a voltage across such a material a large flow of electron will be result.

SEMI-CONDUCTOR MATERIALS :-

- The electrical characteristicks of semi-conductor materials fall between those of insulators and conductors.
- A semiconductor has a valency rings of 4 as compared to valency rings of 8 electrons for the best insulators and 1 electron for the best conductors.
- The two most widely used semi-conductors materials are silicon and Germanium.
- The atomic structure of silicon and Germanium is shown below



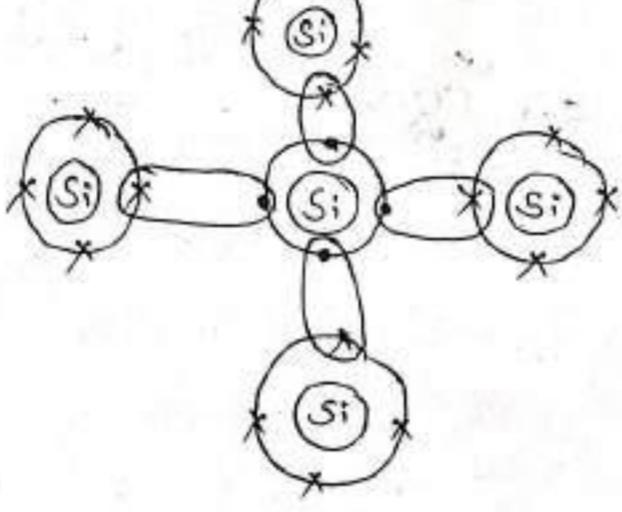
silicon



(Germanium)

COVALENT BOND :-

when each atom fills it's valency band by shairing electrons with neighbouring atoms, the covalent bond is formed, each bond with two electrons is electron pair bond.



- This structure in not a good insulation Because.

(i) Covalent bond leads to develop a imperfect crystal structure.

(ii) Due to the impurities, they are may be extra electrons which cannot be locked into covalent bond structure.

(iii) Energy in the form of heat, light can cause structure disorder.

→ Therefore the structure cannot be a good insulator but a semi-conductor.

Types of Semi-conductor

(I) Intrinsic Semiconductor

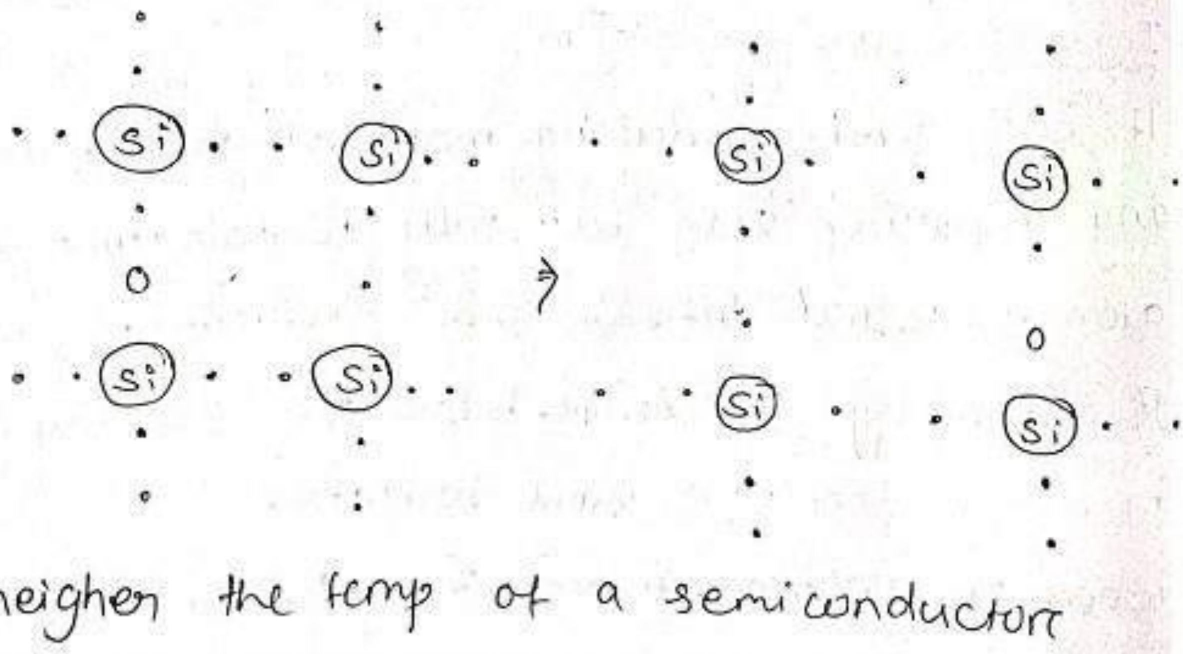
(II) Extrinsic Semiconductor

(I) Intrinsic semi-conductor

- It is a semi-conducting material doesnot contain any impurity atom but only contain one type of atom is called Intrinsic semi-conductor.
- If we bring it's temp, below 0°k this intrinsic material act as a good insulator.
- When an electron freed from the atom of an intrinsic material it breaks a covalent bond and left behind a ~~balance~~ valence which is called a hole. This is +ve charge.
- when temp increases the no. of e^- & hole pair

increases.

- when we increases temp above 0°k it acts as a conductor.
- when a covalent bond breaks an electron drift from -ve terminal of source to +ve terminal and create a hole. Then neighbour electron has sufficient energy to jump to that hole and so on.
- So it appears that holes move from +ve terminal to -ve terminal.
- This movement of holes which is a +ve charge constitute a current flow. So, current flow in a intrinsic semi-conductor is by both moment of electrons and holes.



→ The heigher the temp of a semiconductor material the lower it's resistance and better in conduction.

→ Thus intrinsic semi-conductor have -ve temp coefficient of resistance.

(II) Extrinsic semi-conductor :-

- In order that the material may function properly as a semi-conductor, we must add certain impurity in control quantity), this addⁿ of impurities called doping).
- A material which has been dopped is called an extrinsic material.
- According to addition of impurities the extrinsic semi-conductors are divided into 2 types -

(a)→ n-type semi conductor

(b)→ p-type semi-conductor

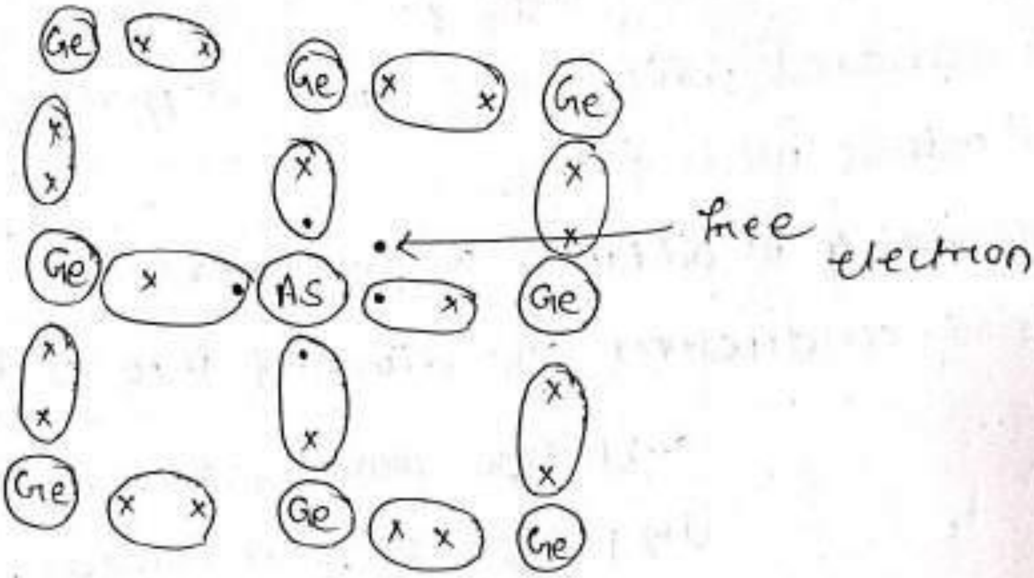
(a) n-type semi-conductor -

- when a pentavalent impurity is added to a semi-conductor to form an n-type semi-conductor.
- pentavalent impuritys has 5 valence e^-s.

Ex - Antimony, Arsenic and phosphorous.

→ Intrinsic material only have 4 valency e^-s so, when a pentavalent impurity is added to it. it forms covalent bond. The 5th valency e^- of the impurity atom is free to move randomly through the crystal.

- since pentavalent atoms provide are extra e^- they are called donner impurities. A material dopped with a donner impurity has excess of e^-s in it's structure and i.e, therefore known as -ve or n-type semi-conductor.

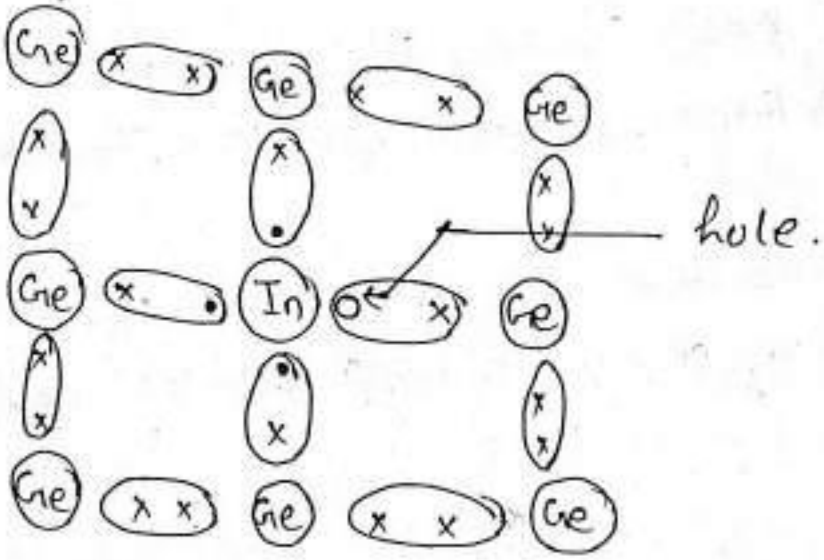


(b) p-type semi-conductor

- The impurity which has 3-valency electron is called trivalent impurity.

Ex - Aluminium, Galium. Indium.

- when trivalent impurity added to intrinsic semi-conductor, they Lack into the crystal structure. Since the impurity has 3-valency e^-, there is a hole in the covalent bond structure by the lack of an electron.
- The hole represents an incomplete covalent bond and exhibit a +ve charge, Hence, this type of impurity is known as acceptor.



Majority and minority carrier :-

- In n-type materials conduction takes place through free electrons created by dopping and a small no. created by thermal generation. The small no of holed created by thermal generation move in the opposite direction. since, the no. of free e⁻s is large and they are called majority carrier. The holes being small in no. are called minority carrier.
- In p-type material holes are the majority carrier and e⁻s are minority carriers.

Semi-conducting material :-

- From the point of view of band theory, semi-conductors are deffered from conductores and insulators in that they have narrow forbidden gap.

- In the periodic table 11 elements are semiconductor. these are Boron, Carbon, silicon, Germanium, phospho[rus], Arsenic, Antimony, sulphur, selenium, Tellurium and iodine.
- The resistance of a semi-conducting material can be controlled by changes in temp and by add? impurities.

APPLICATION OF SEMICONDUCTING MATERIALS :-

1. RECTIFIERS :-

Germanium and silicon rectifiers :-

- A p-type and n-type material are joined together to form a junction called the pn- junction. The pn junction offers high conductivity when foreward biased and no conductivity when reverse biased.
- Germanium has a melting point of 958°c and silicon has 1415°c.
- Due to economic and technological advantages especially in heavy current application silicon rectifiers find wider industrial application.
- Silicon rectifiers or diods have an advantage over Germanium diode in high frequency electronics circuits as they are more sensitive to work signals.
- Silicon rectifiers are available for very high PIV rating of the work order of 25kV and current rating of 1000 Amp.

not necessary

* CUPPER OXIDE AND SELENIUM RECTIFIERS :- (*)

- In cupper oxide rectifiers one side of the plate or electrode is soldered directly to the cupper and the 2nd electrode is soldered to the cuprus oxide film. when +ve potential is applied to the oxide layer and -ve to cupper, it corresponds to forward biasing a pn junction.
- Cupper oxide rectifiers are comparatively chipper than silicon rectifiers. They are used in rectifiers type instruments as an electronic multimeter.
- Selenium rectifier use pure selenium as purity is very important as pur in respect of permisible current density and reverse voltage. The barrier layer in the form of cadmium selenide is produced by a forming process.
- It is used in battery charges and electroplating supplys from low resistance to high resistance.

(2) TEMPRATURE SENSITIVE RESISTERS :- / THERMISTERS)

- Increasing the temp of semi-conducting materials causes their resistance to decrease this property used in devices called thermisters. They are made from oxides of certain metals such as copper, manganeese, cobalt, Iron, zinc.

- Thermistors used in temp. measurement and controlled. They sense temp variation and convert these into an electrical signal which is then used to control heating devices.

(3) PHOTOCONDUCTIVE CELLS :-

- The resistance of semi-conduction materials is [illegible] low under light and increase in darkness. This phenomenon is used in photoconductive cells where a semi-conductor material is connected in series with a voltage source. The resistance of the semi-conductor varies with the intensity of light and thus the current in the circuit is controlled.

Uses → Door opener, flame detection, smoke detectors.

(4) PHOTOVOLTAIC CELLS :-

- photovolatic cells are the devices that develop an e.m.f when illuminated. This they convert light energy directly into electrical energy. No outside sources of electrical energy is requied to produce current flow as a photoconductive cells.

(5) VARISTORS :-

- The resistance of a semiconductor varies with the applied voltage. This properties is used in device called the varistor.

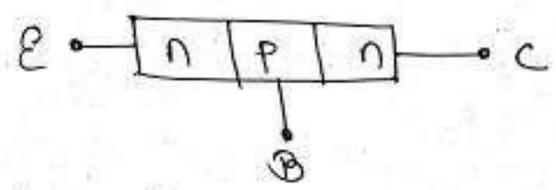
Uses

→ voltage stabilizer and motor speed controller

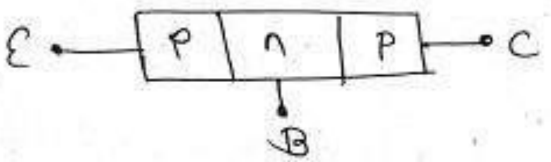
(6) TRANSISTOR :-

- A transistor consists of 2-pn junction formed by sandwitching either p-type or n-type semiconductor between a pair of opposite types. There are 2 types of transistor - (1) n-p-n transistor
(2) p-n-p transistor.

(i) n-p-n transistor

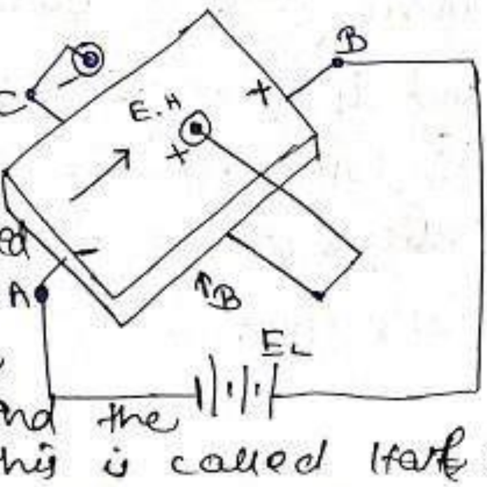


(ii) p-n-p transistor



- There are 3 terminals emitter, collector and base.
- Emitter is always foreward biased and collector always reverse biased.
- The foreward bias junction has a low resistance path where a reverse bias junction has a high resistance path. So transistor transfer signal from low resistance to high resistance.

(7) HALL EFFECT GENERATOR :-



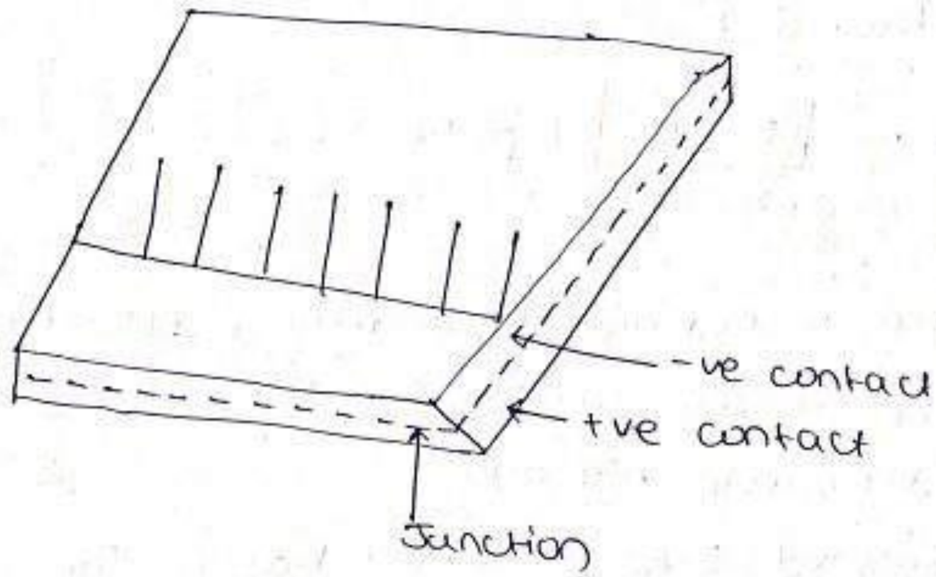
- When a current flows through a semiconduction bar placed to the magnetic field B, a voltage is developed at rightangle to both the current and magnetic field. This voltage is propersional to the current and the intensity of the magnetic field this is called Hall Effect.

- It is a voltage E_L is applied across the two opposite contact A and B current will flow. If the bar is placed ⊥r to the magnetic field B, an electric potential E_H is generated bet^n the other 2 contacts C and D. This voltage E_H is a direct measure of magnetic field strength and can be detected with a simple voltmeter.

USES →

→ It is used to measure magnetic field.

(5) **SOLAR POWER:-**



- Sun is a vast source of energy using photovoltaic devices solar power can be converted to electrical power.
- Solar cell is basically a thin disc of pn- junction and is then enclosed in a glass container with the top surfaces filled with sillcon grease (silicon on titanium oxide) to prevent loses by reflection.

- when light rays fall on the surface of this arrangement electrons starts flow·ing from n-plate to p-plate by means of the photoemission process. This gives rise to a potential difference and constitutes flow of an electric current.
- The output depends on the intensity of the sun rays. The optimum temp for getting a steady state conversion is about 600°C.
- overall efficiency of a solar cell is about 10-12%.

APPLICATION :-

1. Calculator, Solar pump and space reserch work.
2. Telephones.
3. Watches, solar water heater, In rural areas.

(8) STRAIN GAUGE :-

- Semiconductor are also sensitive to mechanical forces.
- If we pull two end of a thin silicon rod then its resistance will increase.
- Silicon and other semiconducting material make very sensitive strain gauge which is use to measure small change in length of solid.
- Its measure of draw back is its temp. sensitivity. But, this effect can be minimised by using a thermister in the circuit.