K.D.K.COLLEGE OF ENGINEERING

DEPARTMENT OF ELECTRICAL ENGINEERING

THIRD SEMESTER ELECTRICAL ENGINEERING

SUBJECT:

EMI (ELECTRICAL MEASUREMENT AND INSTRUMENTATION)

STAFF NAME: Dr.G.H.Agrawal

Measurement of High Resistance:

High Resistance is of the order of hundreds or thousands of megaohm. It is encountered in electrical equipment. Some Common examples are:

i) Insulation resistance of components like machines, cables etc.

ii) Leakage resistance of capacitors.

iii) Resistance of high circuit elements like vacuum tubes.

iv) Volume resistivity of material i.e. the resistance between two faces of unit area separated by unit distance with all conduction from face to face being through the body of material.

Difficulties in Measurements of High Resistance:

High accuracy is rarely required for measurement of high resistance hence simple circuit are used.

1) Since the resistance is of very high value, hence very low current will flow in the measurements of circuit. This aspect to lead to several difficulties.

2) Surface leakage is the main difficulty observed while measuring high resistance. The resistivity of resistance under measurement may be high enough for flow of current but due to moisture, dust etc., the surface of the resistor may provide a lower resistance path for the current to pass between two measuring electrodes which is called a leakage current. The effect of leakage current can be eliminated by using Guard Circuits.

Fig. No.1 Shows the operation of guard circuit.

- A high resistance is mounted on a piece of insulating material.
- The resistance is measured by ammeter-voltmeter method.

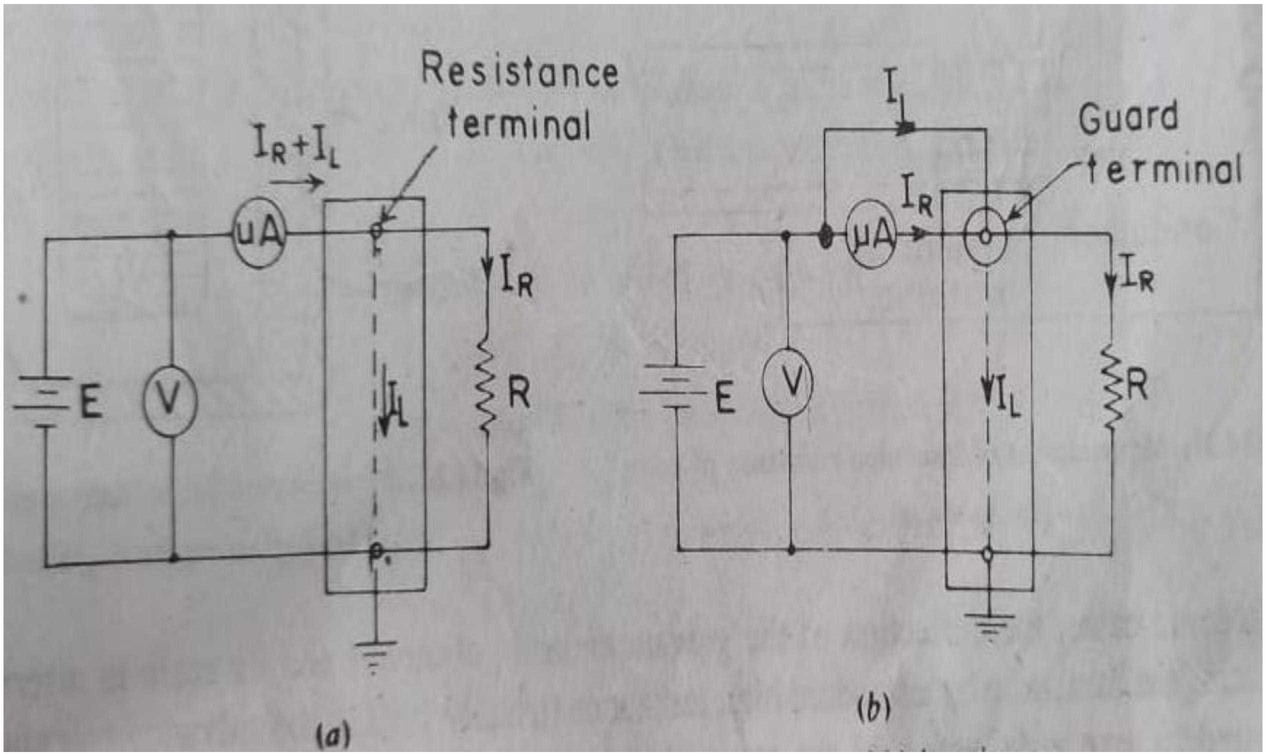

Fig. No. 1 Application of Guard Circuit for measurement of high resistance.

- The micro-ammeter measure the current through resistor (I_R) and the current through the leakage path around the resistor (I_L).

- The measured value will be indicated on voltmeter and micro-ammeter. But this reading will have error as shown in Fig. No. 1 (a).

In Fig. No. 1 (b) guard terminal is added to resistance terminal block.

- This guard terminal surrounds resistance terminal entirely and it is connected to the battery side of micro-ammeter.
- The leakage current I_L will now bypass micro-ammeter and allows the correct measurement.

3) Due to electrostatic effects, stray charges may be induced in measuring circuit. Flow of these charges can constitute current this cause error in measurement.

4) High resistance measurement results are also affected by tempreture, Fighumidity, and applied voltage inaccuracies.

Taking above factors in consideration the following methods are used for measurement of high resistance.

1) Direction deflection method.

2) Loss of Charge method

3) Megaohmeter OR Megger

Loss of Charge Method:

- Fig. No.1 shows the loss of charge method.

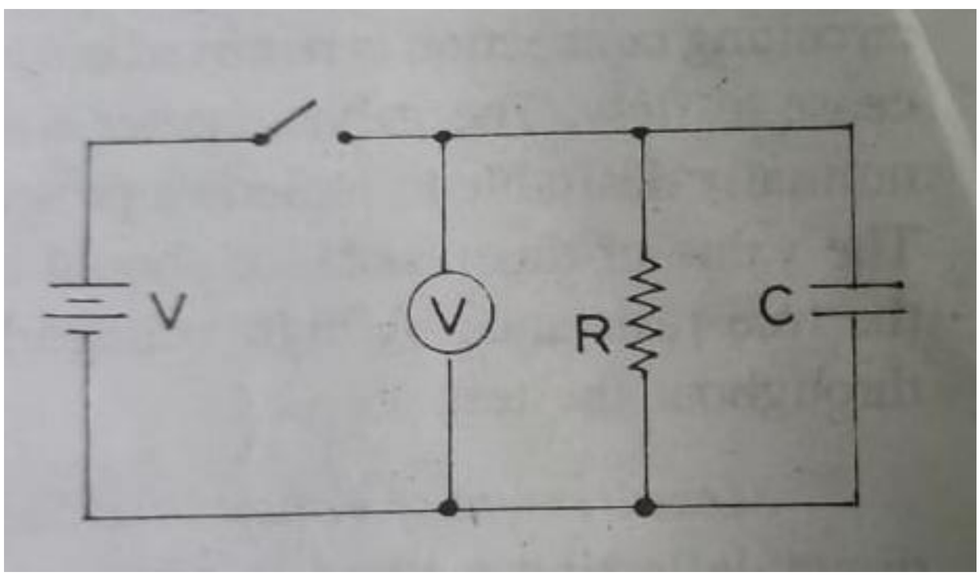

Fig . No. 1 Loss of Charge method

- The insulation resistance R to be measured is connected in parallel with a capacitor C and a electrostatic voltmeter.

- The capacitor is charged to some suitable voltage by means of battery voltage V.

- The capacitor is then allowed to discharge through resistance.

- The terminal voltage across the resistance- capacitance combination is observed for a period of time during discharge with the help of voltmeter.

- The value of unknown resistance is calculated from discharge time constant of circuit.

- In Fig. No.1 when switch is closed capacitor charges to the supplied battery voltage V.

- When Switch is open the capacitor start discharges through resistance R.

- During Discharging the Capacitor voltage V_C at any time is given by the following equation:

  $V_C = V\, e^{(-t/RC)}$ Where RC is the time constant.

  OR $e^{(-t/RC)} = V_C / V$

  - $t / RC = \log_e V_C / V$

  On Solving we get Resistance $R = t / C\, [\log_e (V / V_C)]$

  Please refer Fig . No. 2

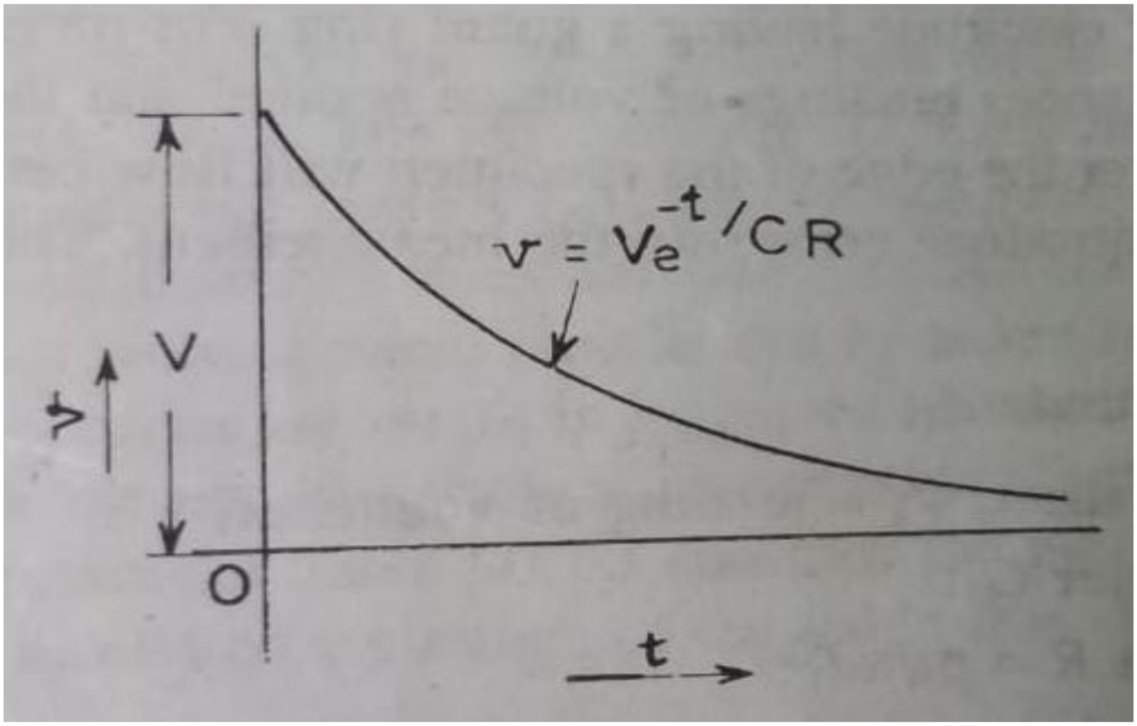

Fig No. 2 Variation of voltage with time

- This method is very simple but it needs careful selection of capacitor.
- If the Resistance R is very high value then time required for appreciable fall in voltage is very large and then this process is time consuming.
- The resistance of Voltmeter should have a very high value to get more accurate results.

Problem: A Cable is tested by loss of charge method. An Electrostatic Voltmeter is connected between cable conductor and earth. Capacitance between conductor and earth found to 800 pico Farad. It is observed that after charging the cable with 500 V, the voltage drops to 160 V in 1 minute. Calculate the insulation resistance of the cable.

Solution:

Time = t = 1 minute = 60 Seconds.

Resistance $R = (t / C) [\log_e (V / V_C)]$

$R = (60 / 800 \times 10^{-12}) [\log_e (500/ 160)]$

$R = 65000\ M\Omega$ …Answer…

MEASUREMENT OF EARTH RESISTANCE:

Necessity:

The provision of earth electrode for an electrical system is necessary by the following reason:

- All the parts of electrical equipment, casing of machines, switches and circuit breaker, armouring of cable, tanks of transformer etc. which have to be at earth potential must be connected to earth electrode.

- By Connecting body of equipment to earth electrode we protect the various parts of installation as well as the person working against damage in case of insulation failure.

- Earth Electrode provides continuous low resistance path for leakage current to flow to earth, this current operates the protective devices and faulty circuit is isolated in case of fault occurs.

- The earth electrodes ensures in case of over voltages due to lightening discharges.

- In a three phase circuit the neutral of system are earthed in order to stabilize the potential of circuit with respect to earth.

- An earth electrode is effective only when it provides a low resistance path and carry large current without deteriorating. Since it is very difficult to measure the amount of current, the resistance value of earth electrode is taken as sufficiently reliable for its effectiveness.

Factors affecting the resistance of Earthing system:

- Shape and material of earth electrode.

- Depth of the soil at which the electrodes are buried.

- Specific resistance of soil surrounding and in the neighbourhood electrodes.

- The Specific resistance of soil is not constant but it varies from one type of soil to other.

- The amount of moisture present in the soil affects the specific resitance of soil

- The specific resistance of soil varies in wide limit from 80×10^3 Ωm for moist clay to 80×10^6 Ωm for sand of normal moisture content.

- A decrease of 30% of moisture content is capable of producing an increase of 300% to 400% in specific resistance.

- Thus it is necessary to make regular checks for earth resistance.

Methods of Measuring Earth Resistance:

Fall of Potential method:

Fig. No. 1 shows the circuit for the measurement of earth resistance with fall of potential method.

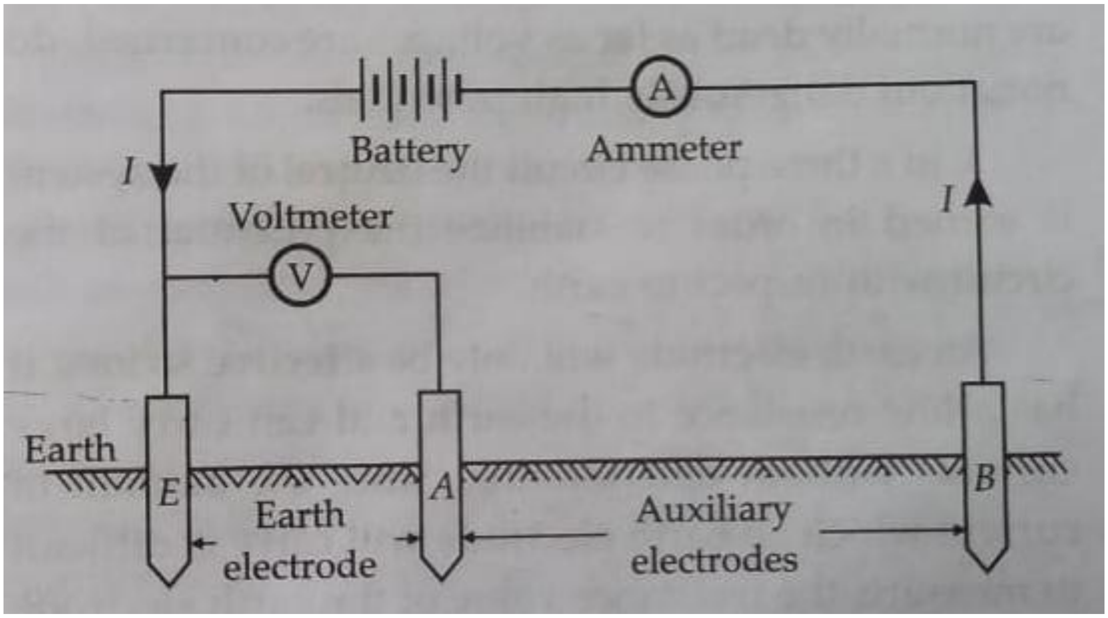

Fig. No. 1 Measurement of earth resistance by fall of potential method

- A current is passed through earth electrode an auxiliary electrode B (Which is generally an iron spike) inserted in earth at a distance away from earth electrode.

- A second auxiliary electrode A is inserted in earth between E and B.

- The potential difference V between E and A is measured for a given current I.

- The Flow of ground current is shown in Fig. No.2.

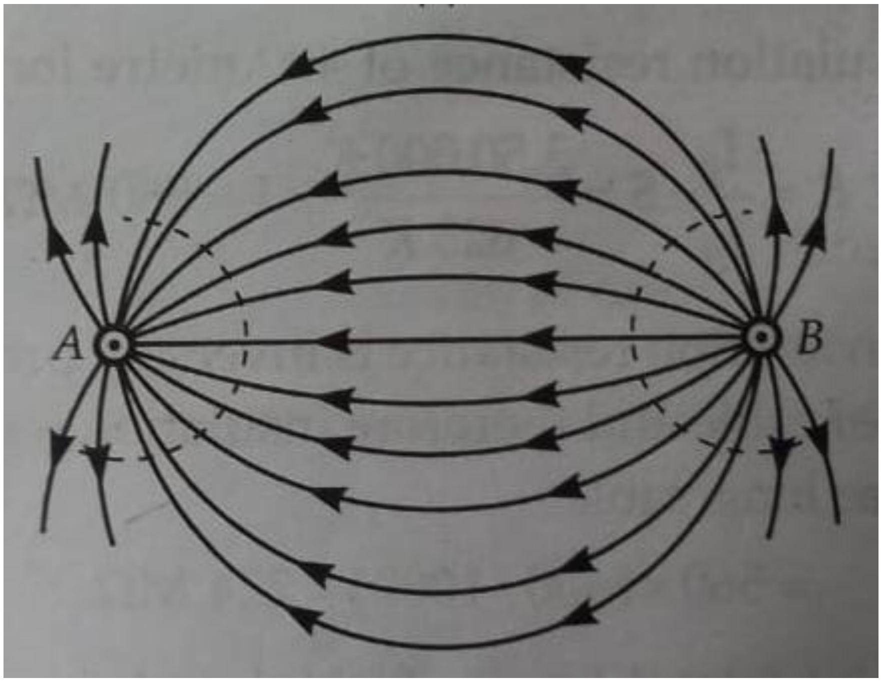

Fig. No.2 Flow of ground current

- The lines of first electrode diverge and those of second electrode current converge. As a result the current density is much greater in the vicinity of the electrode than at a distance from them.

- The potential distribution between the electrodes is shown in Fig. No. 3.

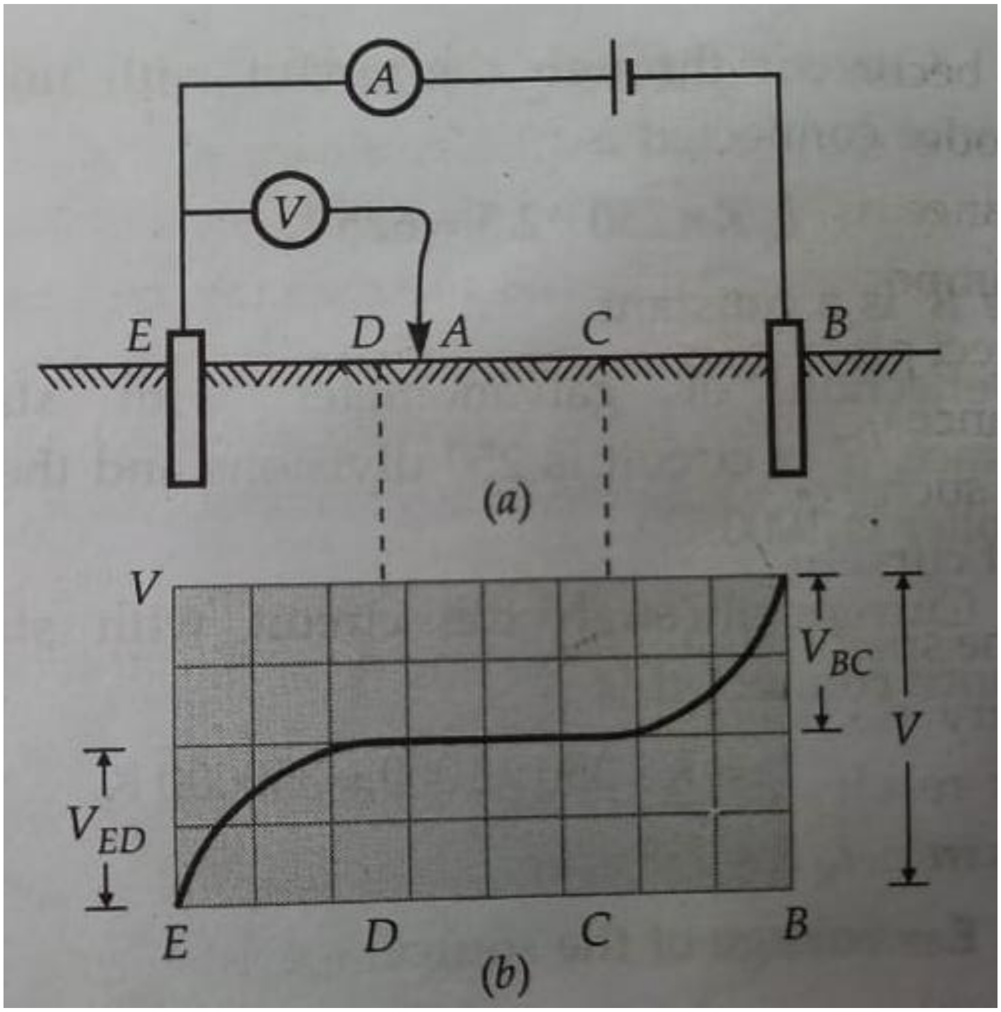

Fig .No. 3 Distribution of potentials between two earthing electrodes

- By observing the curve in Fig. No.3 it is clear that potential rises in the proximity of electrodes E and B and it is constant along the middle section.

- The resistance of earth R_E is given by :

$$R_E = V/I \qquad \text{OR} \qquad R_E = V_{EA} / I$$

- The position of electrode E and B is fixed and the position of electrode A is changed and resistance measurement is done for various positions of electrode A.

- A graph is plotted between earth resistance against the distance between E and A as shown in Fig. No. 4.

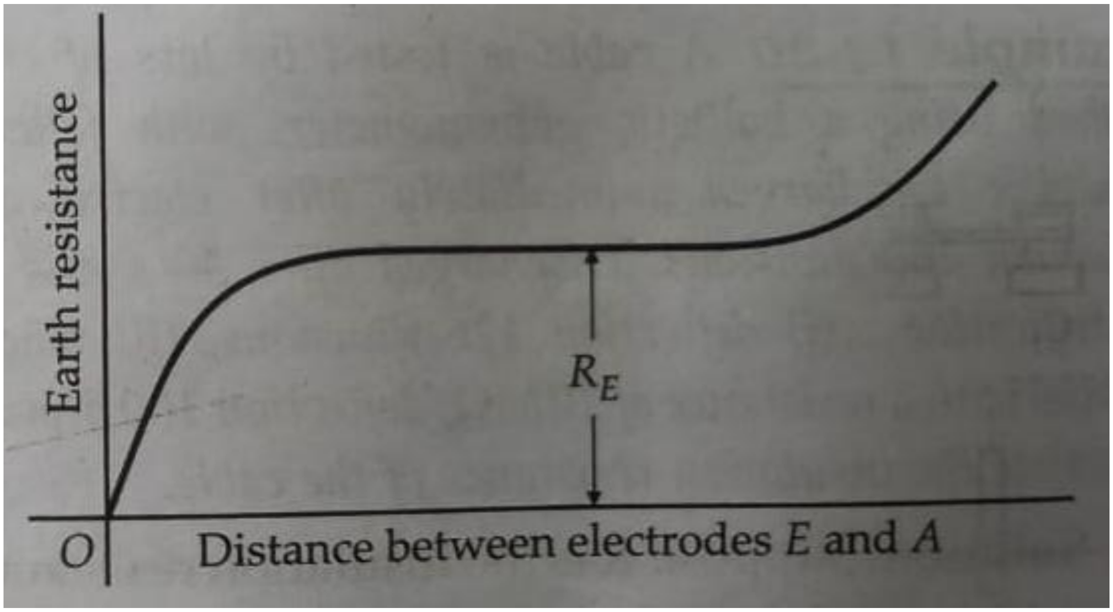

Fig. No. 4 Variation of earth resistance with distance between electrode E and A.

- From Fig. No. 4 it is clear that the measured value of earth resistance depends upon the position of the auxiliary electrode A.

- The earth resistance rises initially.

- When the distance between earth electrode E and auxiliary A is increased then Earth Resistance R_E becomes constant.

- When auxiliary electrode reaches near electrode B earth resistance R_E again increases.

- The correct value of earth resistance R_E, is when resistance lies on the flat portion of curve.

- The spacing between earth electrodes and the auxiliary electrodes A,B should be large to get proper result.

- The distance may be a few hundred meters in case of the earth resistance is low.

Earth Tester (MEGGAR) :

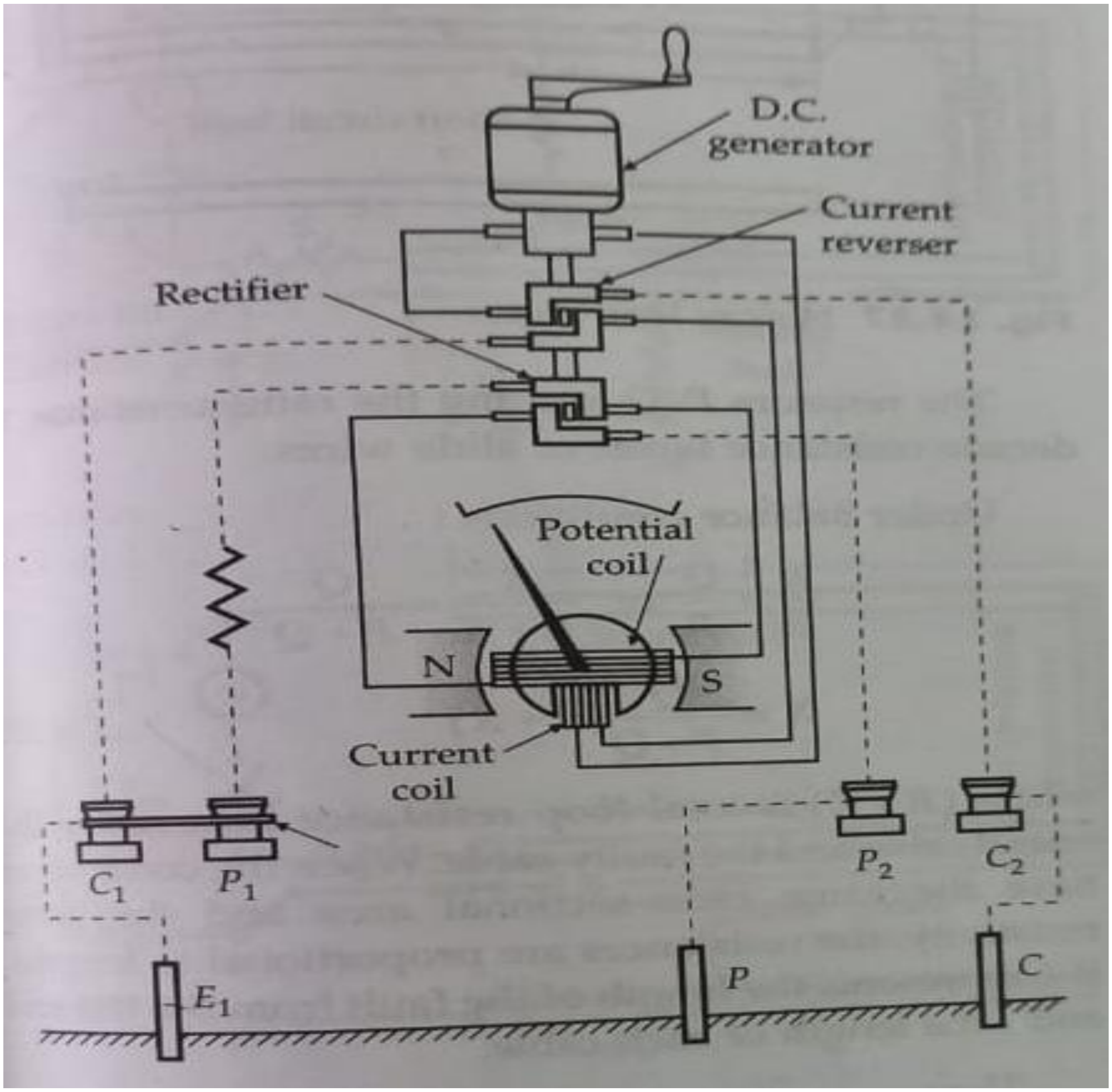

Fig. No.1 Earth Tester (MEGGAR)

- The resistance of earth can be measured by an earth tester as shown in Fig. No.1.
- The earth tester is a special type of meggar.

- The Constructional feature of Earth tester (Megger) consists of
  i) A rotating current reverser.
  ii) A rectifier.

- Both rotating current reverser and rectifier consists of commutator made up of L shaped segments.

- They are mounted on hand driven generator.

- Each Commutator has four fixed brushes.

- One pair of each set of brushes are so positioned that they make contact alternatively with one segment and then with the other as the commutator rotates.

- The second pair of each set of brushes is positioned on the commutator so that continuous contact is made with one segment whatever will be the position of the commutator.

- The earth tester has four terminals P_1, P_2, C_1, C_2.

- Terminals P_1 and C_1 are shorted to form a common point to be connected to earth electrode E.

- The other two terminals P_2 and C_2 are connected to auxiliary electrodes P and C respectively.

- The indication of earth tester depends upon the ration of the voltage across the pressure coil and the current through the current coil.

- The deflection of its pointer directly indicates the resistance of earth.

- The Earth tester is PMMC permanent magnet moving coil instruments and can operate on dc only, but by including reverser and the rectifying device it is possible to make the measurements with ac flowing in the soil.

****