(7hrs)

Measuring Instruments

Module-III

Introduction:

The measurement of a given quantity is the result of comparison b/w the quantity, & a predefined standard. The measuring process is one in which the property of an object or system under consideration is compared to an accepted std. unit.

Classification of Instruments:

Broadly instruments are classified into two categories:

(a) Absolute Instruments (b) Secondary Instruments

(a) **Absolute Instruments:** These instruments give the magnitude of the quantity under measurement in terms of physical constants of the instrument.

Ex: Tangent Galvanometer, Rayleigh's Current balance.

(b) **Secondary Instruments:** These instruments are so constructed that the quantity being measured can only be measured by observing the o/p indicated by the instrument. These instruments are calibrated by comparison with an absolute instrument or another sec. instrument which has already been calibrated against an absolute instrument.

Working with absolute instrument is time consuming, hence secondary instruments are commonly used.

Ex: voltmeter, pressure gauge, glass thermometer

Instruments can also be classified as Deflection & Null type Instruments.

(a) Deflection Type: The deflection of the instrument provides a basis for determining the quantity under measurement.

* The measured quantity produces some physical effect with deflects or produces a mech. displacement of the moving system of the instrument.

* An opposing effect is built in the instrument which tries to oppose the deflection.

* The balance is achieved when opposing effect equals to cause producing the deflection.

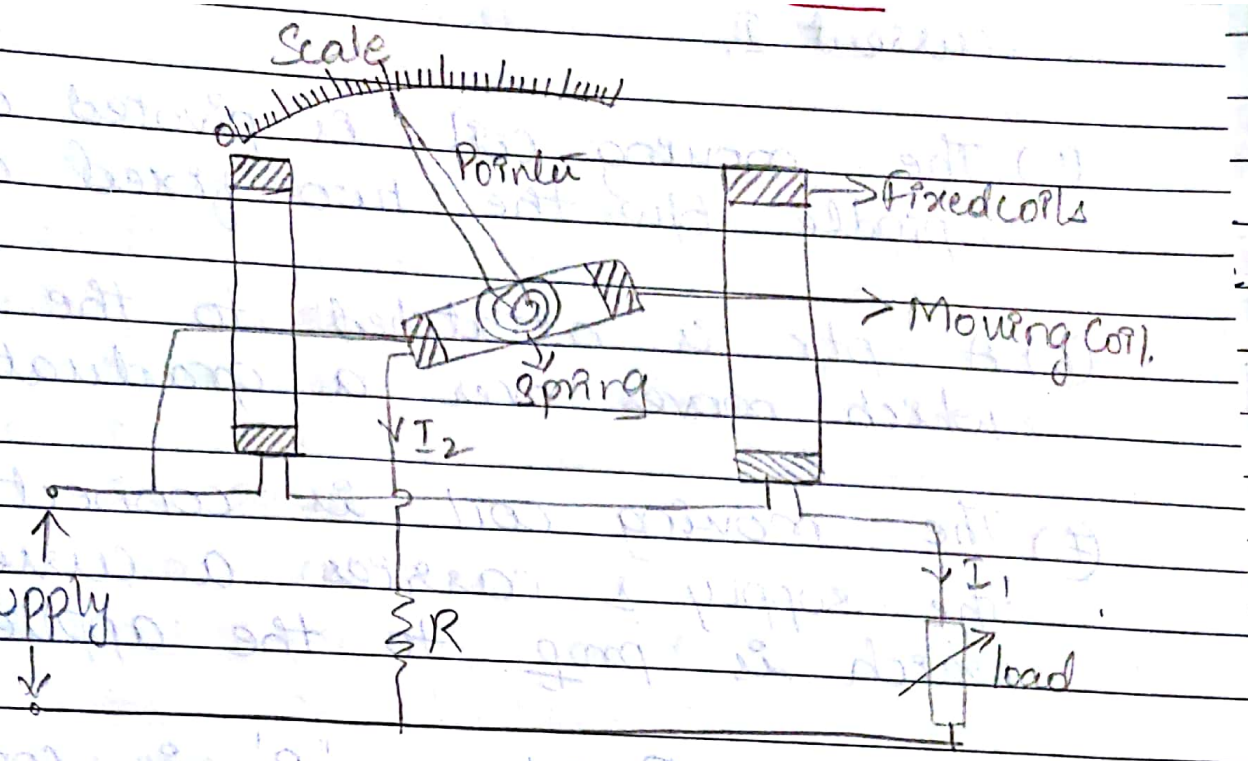
* Ex: Permanent Magnet moving coil (PMMC) ammeter.

* In deflection type, value of measured quantity depends upon the calibration of the instrument.

(b) Null Type: In this, measured quantity is balanced out.

* Detector need not be calibrated.

* Accuracy of null type instruments is higher than deflecti type.



* This type of wattmeter is used for the measurement of D.C as well as A.C. power.

* Construction:

(1) It consists of a fixed coil which forms the current coil & a moving coil which forms the potential coil of the wattmeter.

(2) The fixed coil is split into two equal parts, placed at a distance in parallel with each other.

(3) They are air-cored to avoid hysteresis loss, when used for the measurement of AC power.

with the load & carry the load current I_1.

(5) The moving coil is pivoted on the spindle b/w the two fixed coils.

(6) A ptr is attatched to the spindle which moves over a graduated scale.

(7) The moving coil is connected across the supply & carries a current I_2 which is prop to the applied vltg.

(8) A high Resistance 'R' is connected in series with the moving coil to limit the current flowing thro' it.

(9) The ctrlling torque is provided by two phosphor-bronze hair springs, which also act as leads to the current flowing thro' the moving coil.

Working principle:

* When a current carrying moving coil is placed in the magnetic field produced by another current carrying fixed coil, a force is exerted on the coil sides of the moving coil.

* Due to this, a deflection torque is produced & the moving coil deflects.

(432, 440)

* The deflecting torque is controlled by the controlling torque produced by the springs.

* While measuring A.C. power, when current is reversed in both the coils during the -ve half cycle, the dirn of deflecting torque produced remains the same & hence can be used to measure both a.c & d.c. power.

* The ptr directly reads the power consumed by the load.

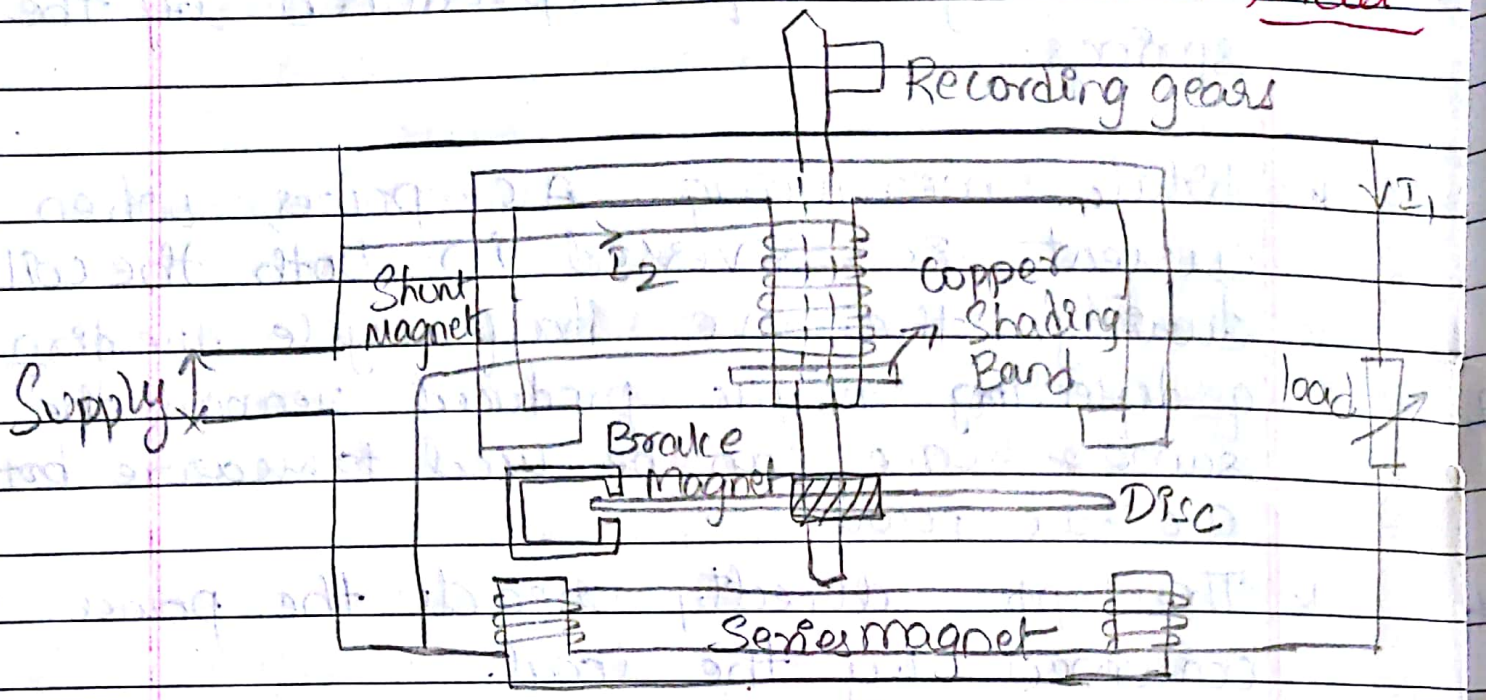
Advantages:

(1) Can be used for both DC & AC power measurements.
(2) Have a uniform scale.
(3) Accurate & reliable.

Disadvantages:

(1) At lpf's the inductance of the potential coils causes serious errors
(2) Reading of the meter is affected by stray mag field acting on the moving coil.

Single Phase Induction Type Energy Meter



* Induction type of instruments are used only for AC measurements.

* Hence used to measure energy consumed in AC ckts. only.

Construction: Its consists of (a) Driving system (b) a moving system (c) braking system (d) recording mechanism.

(a) The Driving System: This consists of two electromagnets (a) Series magnet (b) Shunt magnet.

* Series magnet consists of U shaped laminations of silicon steel, which are insulated from one another & pressed together to form the core.

* A coil of thick wire having a few turns, is wound on both the legs of the core & is connected in series with the load.

* This is known as current coil. The load current I_1 flows thro' this coil & hence produces flux ϕ_1 which is in phase with I_1

* Shunt magnet consists of no of 'm' shaped silicon steel laminations which are insulated from one another

* A coil of thin wire, having a large no of turns is wound on the central limb of the shunt magnet.

* This is known as vltg coil & is connected across the supply.

* It is excited by I_2 prop to applied vltg.

* Cu shading band is provided to obtain the deflecting torque which is caused due to lagging of current in pressure coil.

* Shading band acts as a short ckt'd secondary.

(b) Moving System: This consists of a light aluminium disc, mounted on the spindle.

* The spindle is supported on jewel bearings. As there is no control torque, the disc rotates continuously under the action of deflecting torque produced due to resultant magnetic field.

(c) Braking System: A permanent magnet known as brake magnet, is positioned near the edge of Al. disc.

* When the disc rotates, emf is induced in the disc, due to which eddy currents circulate in the disc, such that it produces a torque, opposing the rotation of the disc.

* This is known as braking torque. This torque is prop. to the speed.

(d) Recording Mechanism: The function of the recording mechanism is to record continuously, a no. prop to no. of revolutions made by the disc.

Working Principle:

* When the energymeter is connected to the supply of v/tg 'V', I_2 flows

to the potential coil, producing a flux ϕ_2.

* As the potential coil is highly inductive, I_2 & ϕ_2 lags 'V' by 90°.

* When energymeter is connected to a load, I, flows thro' current coil, & ϕ, is produced.

* The ϕ (ph. angle) b/w 'V' & I, depends on the nature of load.

* If the load is inductive, I, lags 'V' by an angle ϕ.

* E_{sh} & E_{se} are emf's induced in disc by ϕ_2 & ϕ, resp.

* These 2 emf's lag behind by 90°.

* The I_{sh} & I_{se} are set up by these induced emf's & are assumed to be in phase w.r.t. emf's.

* Two opp directed torques are produced Power X 't' represents energy consumed in 't' seconds. Thus no of revolutions of the disc is directly prop to the energy consumed.

Two - Way Control of lamps:

* The lamp ckts used for house wiring are quite simple & they are generally controlled from one pt.

* But in staircase wiring, it is necessary to control the lamp ckt from two pts.

* Usually in big halls, corridors, bedrooms, it is necessary to control the lamp from two pts.

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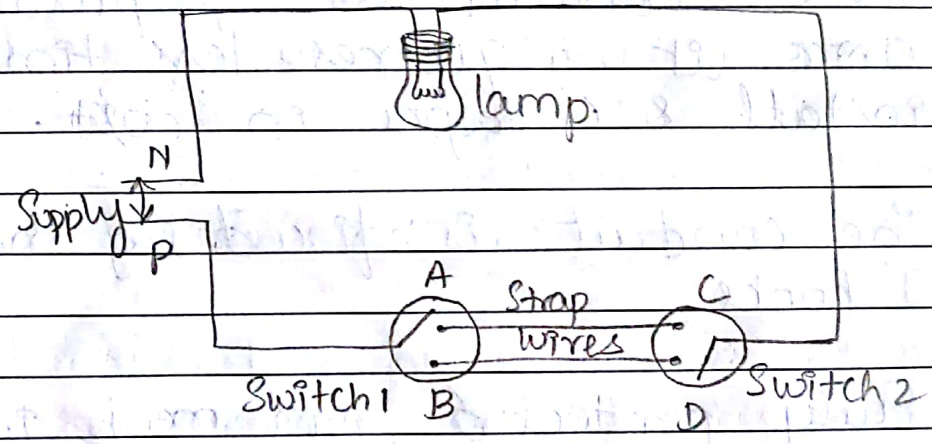


* Above diagram shows two - way control of lamp from two pts.

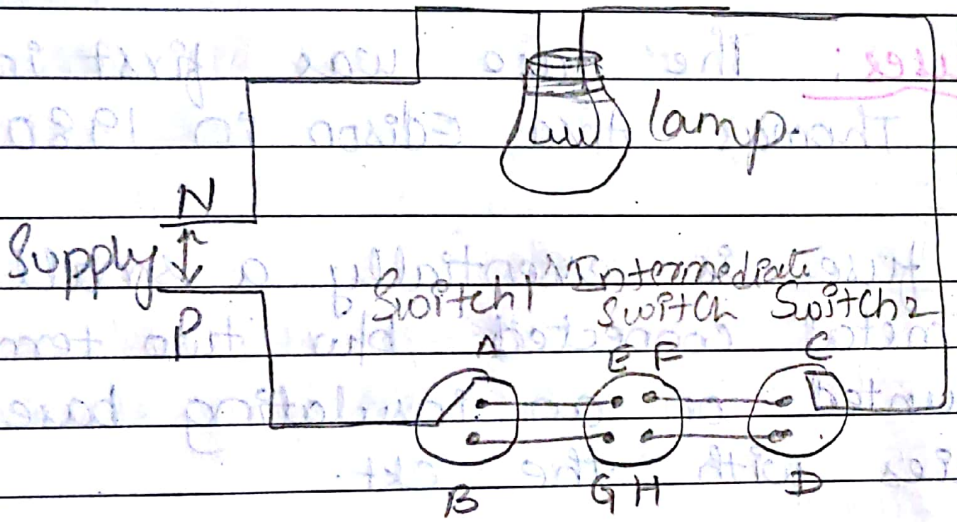
* The wires used b/w the switches are called strap wires.

* Position of Switch 1	Position of Switch 2	Lamp ON or OFF
A	D	OFF
A	C	ON
B	C	OFF
B	D	ON

Three - Way Control of lamps:-

*. In godowns, workshops, big corridors, it is necessary to control a lamp from 3 pts.

*. In such cases, the ckt connection requires two, two-way switches & an intermediate switch.



* An intermediate switch is a combination of two, two-way switches coupled together.

* It has 4 terminals EFGH. For one position it connects pts EF & GH which is called straight connection

* for another position, it connects EH & GF - cross connection.

Electric Shock: When a person comes in contact with the live wire supplying electricity, he receives a shock.

The severity of the shock received depends on the vltg of the wire & the body resistance of the person.

The max. current the human body can withstand for a short time is 30mA.

If the body is totally wet, the body resistance is 1000Ω, If it is neither wet nor dry, it is about 5000Ω & if it is totally dry it is 100000Ω.

Mild shocks produce nervousness. Severe shocks may produce convulsions which lead to unconsciousness & death.

The damage caused due to an electric shock depends on the vltg, the route of the current thro the body, person's health, ~~etc~~ time for which the current is ⇒ body, freq. of current, physical & psychological condition of the person.

Precautions against Electric Shock.

(1) Insulation of the conductors used must be proper & in good condition.

(2) Megger tests should be conducted & insulation must be checked.

(3) Earth connection should be always maintained in proper condition.

(4) Fuses must have correct ratings.

(5) Use rubber soled shoes while working.

(6) Use rubber gloves while touching any terminals or removing insulation layer from a conductor.

(7) Use line testers to check whether a 'live' terminal carries any current.

(8) Never touch two different terminals at the same time.

(9) Never remove the plug by pulling the wires connected to it.

(10) Sockets should be fixed at a ht. beyond the reach of children.

Earthing: Earthing or Gnding is to connect the body of an electrical equipment to the general mass of the earth by a wire of negligible resistance.

* It brings the body of the equipment to zero potential & avoids shocks to pessonnel;

* The neutral wire of an a.c. supply & middle wire of three wire d.c. distribution system are always earthed.

Necessity of Earthing:

* When the insulation becomes weak or defective, the insulation resistance becomes almost zero.

* Then resistance of body & earth are not very high & hence, I_{body} is to high value that the person receives shock. Such current is called leakage current.

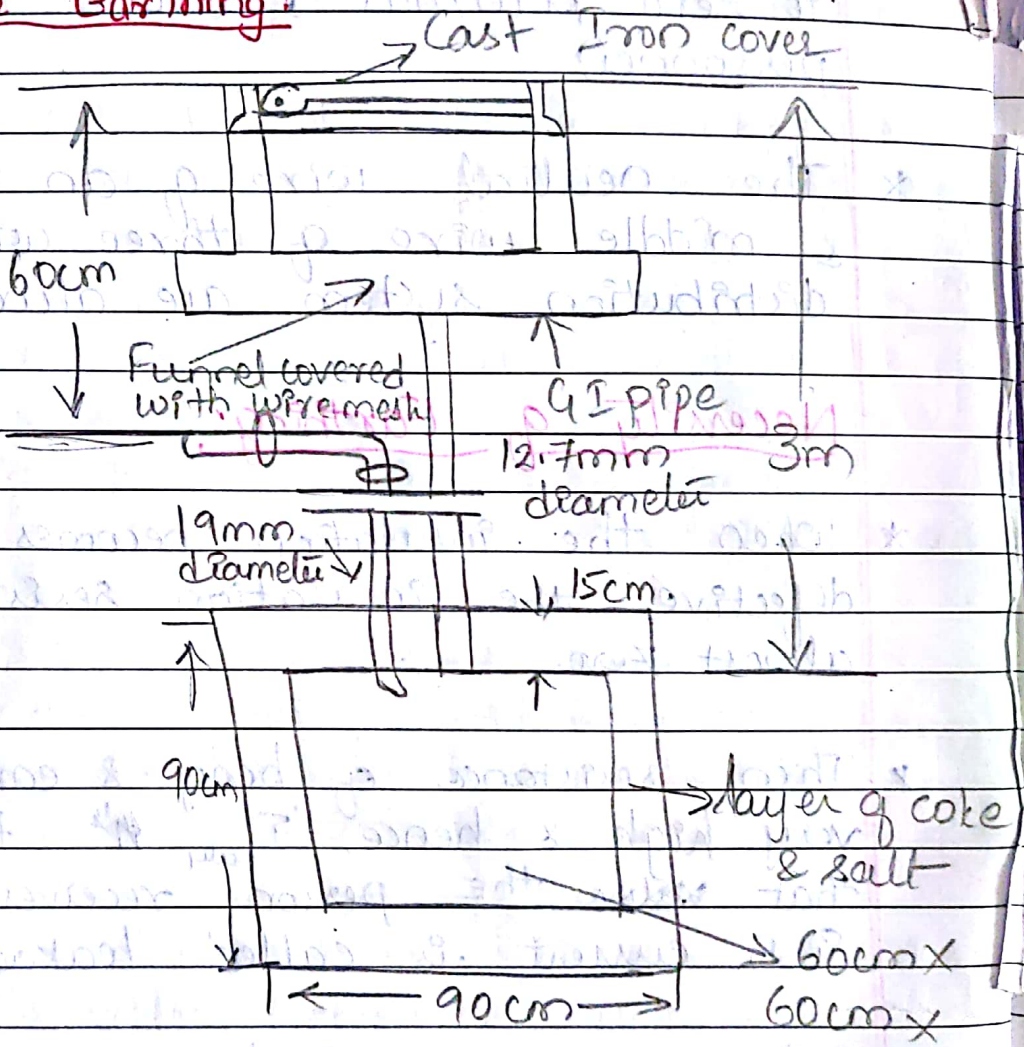
* When earthing, is done, the resistance of the path from frame to earth is very very low.

* As earthing resistance is very very low compared to the body of the person, current prefess low resistance path.

Methods of Earthing: Various methods of earthing are

(a) Plate Earthing (b) Pipe Earthing (c) Earthing through main (d) Horizontal strip earthing (e) Rod earthing.

Plate Earthing:



* The earth connection is provided with the help of Cu plate or Galvanised Iron (GI) plate.

* The plate is surrounded by alternate layer of coke & salt for min. thickness of about 15cm.

* The earth wire drawn thro' G.I pipe & is bolted to the earth plate.

* The GI pipe is fitted with a funnel on the top.

* In order to have an effective earthing, salt water is poured periodically thro' the funnel.

* Earthing efficiency ↑'s with ↑ of plate area & depth of embedding.

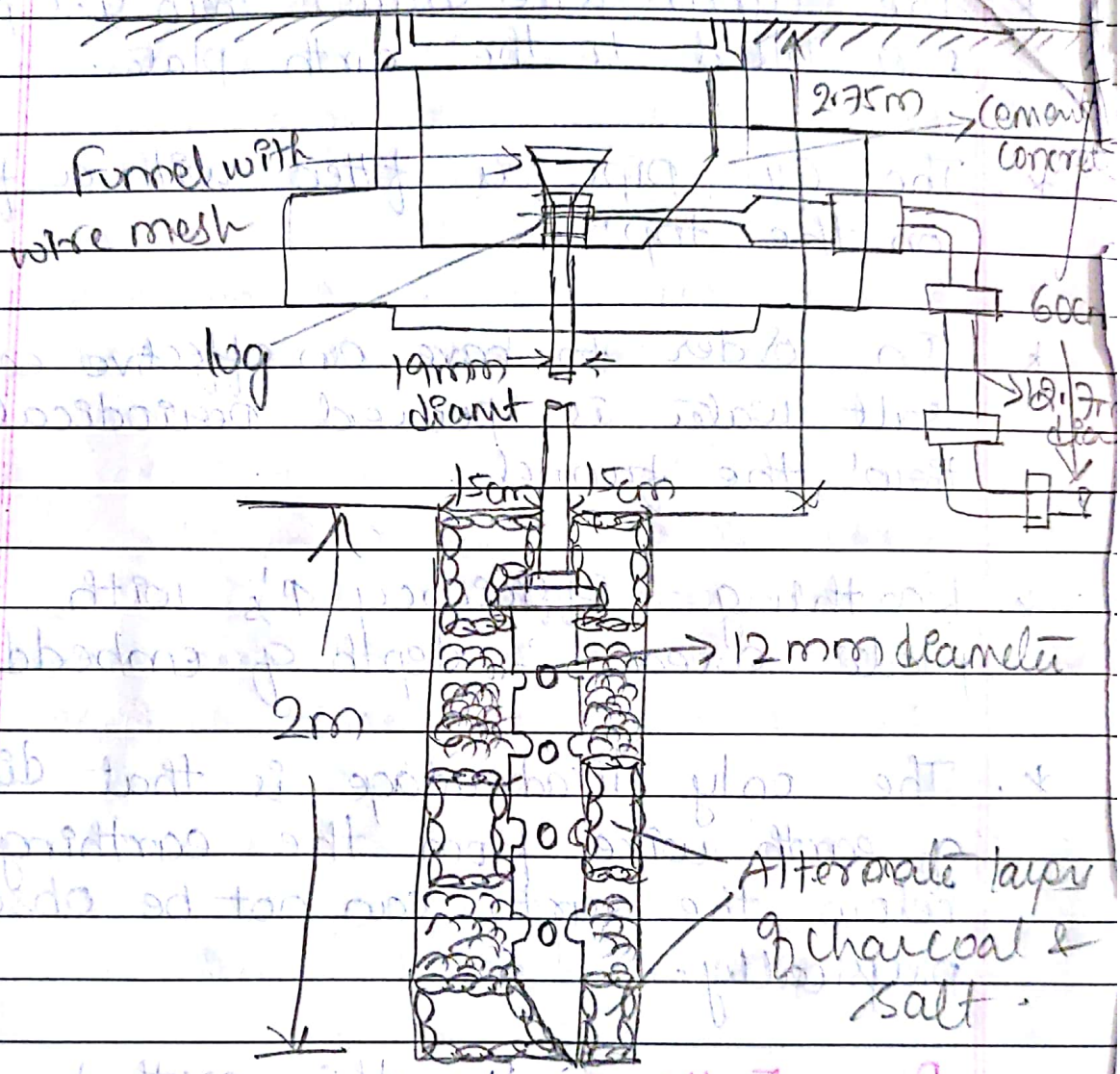
* The only disadvantage is that discontinuity of earth wire from the earthing plate below the earth can not be observed physically.

Pipe Earthing: In this method, GI pipe of given length in diagram is embedded vertically into the gnd.

* This pipe acts as an earth electrode

* The earth wires are fastened to the top section of the pipe above gnd level with nut & bolts.

* The pit area around the pipe is filled with salt & coal mixture for improving the condition of the soil & earthing efficiency.



* Generally alternate layers of salt & coke are used for best results.

* This is done coke with salt ↓'s the earth resistance.

* During summer season, soil becomes dry, hence salt water is poured thro' the funnel connected to main G.I pipe.

* The earth wires are connected to G.I pipe above the gnd level.

* The earth lead is a G.I wire which is not < electrical equivalent of Cu conductor.

* The only disadvantage is embedded pipe length has to be rd sufficiently with high order specific resistivity.

* Hence cost will be high. This type is not suitable for rocky soil places.

Contd: Essential Features of Measuring Instruments.

(1) Deflecting device: A mech. force is produced by the electric current, vltg or power. i.e. a deflecting torque is caused by any one of the effects (i.e. thermal, chemical, electrostatic etc.)

(2) Controlling device: The value of deflection is dependent upon the magnitude of the quantity being measured. There are 2 types:- (a) Spring control (b) Gravity control.

(3) Damping device: To prevent oscillation of the moving system & enable the latter to reach its final position quickly. Damping is provided by 3 methods
(a) Air damping (b) Eddy current damping
(c) Fluid friction damping

(1) According to the quantity of being measured
Ammeters, voltmeters, ohmmeters & resistance bridges (measuring resistances), wattmeters, Watt-hr meters (energy measurements), freq. meters (freq. measurements), Pf meters (pf measurments)

(2) According to kind of current: DC, AC, AC/DC instruments.

(3) According to accuracy limits

(4) According to principle of operation
Moving coil, moving iron, electrodynamic, Induction, Hot-wire, Thermo-electric, Rectifier types.

(5) According to type of indication
wattmeter, voltmeter, ammeter — x ray. eg
Indicating type, Recording type.
Integrating → energymeter

(6) According to application
Switch board, Portable.
energy meter — phase meter, power