280 14/11/23

16 NOV-23

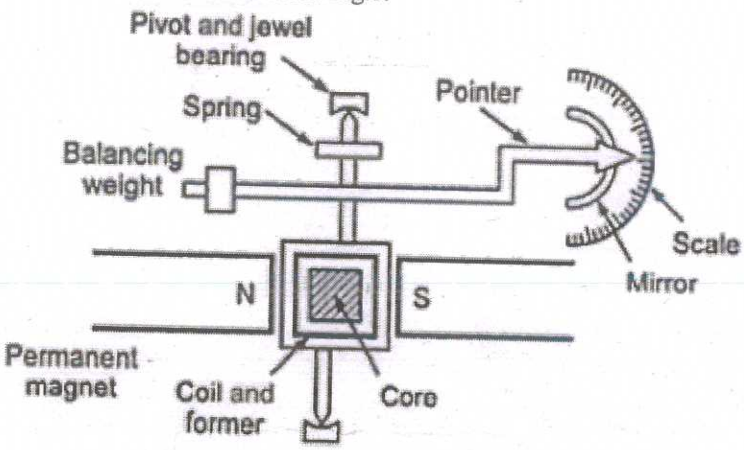
Scoring Indicators

Code:

Version: **A**

Qn No:1	Scoring Indicators	Split Score	Total Score (marks)
1	Thermal, electrostatic, induction, electro magnetic attraction and repulsion,hall effects etc [any two]	2*1	2
2	Phosphor bronze	2	2
3	[Sel.Voltage* Sel. Current* P.F]/ FSD	2	2
4	LCR meter	2	2
5	Voltage, current, frequency, time period measurements, To view wave forms, Repairing works etc	2*1	2

PART B

Qn No :II	Scoring Indicators	Split Score	Total Score (marks)
II.1	The permanent magnet moving coil instruments are most accurate type for d.c. measurements. The action of these instruments is based on the motoring principle. When a current carrying coil is placed in the magnetic field produced by permanent magnet, the coil experiences a force and moves. As the coil is moving and the magnet is permanent, the instrument is called permanent magnet moving coil. This basic principle is called D'Arsonval principle. The amount of force experienced by the coil is proportional to the current passing through the coil. The PMMC instrument is shown in the Fig.1.  **Fig. 2 Construction of PMMC instrument** The moving coil is either rectangular or circular in shape. it has number of turns of fine wire. The coil is suspended so that it is free to turn about its vertical axis. The coil is placed in uniform, horizontal and radial magnetic field of a permanent magnet in the shape of a horse-shoe. The iron core is spherical if coil is circular and is cylindrical if the coil is rectangular. Due to iron core, the deflecting torque increases, increasing the sensitivity of the instrument. The controlling torque is provided by two phosphor bronze hair springs. The damping torque is provided by eddy current damping. It is obtained by movement of the aluminium former, moving the magnetic field of the permanent emagnet. The pointer is carried by the spindle and it moves over a graduated scale. The pointer has light weight so that it can deflect rapidly. The mirror is placed below the pointer to get the accurate reading by removing the parallax. The weight of the instrument is normally counter balanced by the weights situated diametrically opposite and rigidly connected to it. The scale markings of the basic d.c. PMMC instruments are usually linearly spaced as the deflecting torque and hence the pointer deflection and directly proportional to the current passing through the coil.	Fig.3 Expl.3	6

<table>
<tr>
<td>11.2</td>
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<table>
<tr><td>M.C Instruments</td><td>M.I Instruments</td></tr>
<tr><td>1. more accurate.</td><td>1.Less accurate.</td></tr>
<tr><td>2Manufacturing cost is high.</td><td>2. Cheap</td></tr>
<tr><td>3. Reading scale is uniformly distributed.
(scale cramped at beginning and finishing)</td><td>3. Non-uniform scale</td></tr>
<tr><td>4. Very sensitive in construction & for input.</td><td>4. Robust in construction.</td></tr>
<tr><td>5. Low power consumption</td><td>5. Slightly high consumption.</td></tr>
<tr><td>6. Eddy current damping is used.</td><td>6. Air friction damping is used.</td></tr>
<tr><td>7. Can be used only for D.C measurements</td><td>7. Can be used for A.C as well as for DC measurements.</td></tr>
<tr><td>8. Controlling torqure is provided by spring</td><td>8.spring or gravity</td></tr>
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<td>11.3</td>
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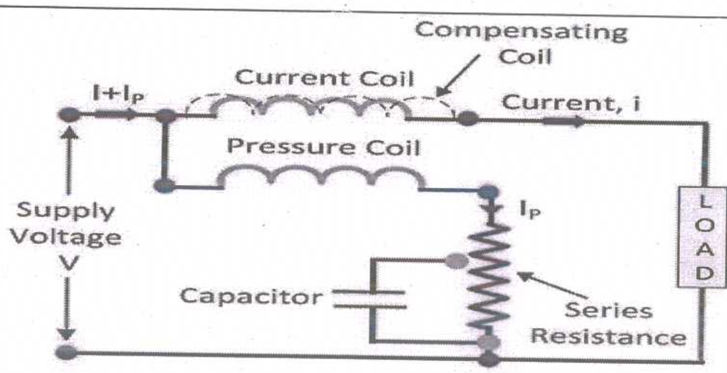

Compensation for Power Loss in Pressure Coil Circuit

Circuit Globe

In low power circuit, the value of current is high, and that of the power is low. The high-value current causes the error in the Wattmeter reading. For reducing the error, the compensation coil is used in the circuit. The compensating coil compensates the error in the circuit which induces because of low power factor.

The compensating coil and the pressure coil are in series with each other. The coil is coordinate with the current coil. The pressure coil current I_p flows through it. The field induces in the compensating coil is because of the current I_p. The field of the compensating coil and the current coil opposes each other. Thus the error occurs in the pressure coil is neutralized.

Compensation For Inductance of Pressure Coil

The small amount of inductances is present in the pressure coil of the Wattmeter. This inductance causes the error in the reading. The φ is the angle between the pressure and the current coil. For a small value power factor φ is large. The large value of φ causes a large error in the reading. The compensating coil is used in the circuit for compensating the inductance error occurs in the Wattmeter. Along with the compensating coil, the capacitor is used in the circuit. The capacitor is placed in parallel with the pressure coil resistance.
</td>
<td>Fig.3
Expl.3</td>
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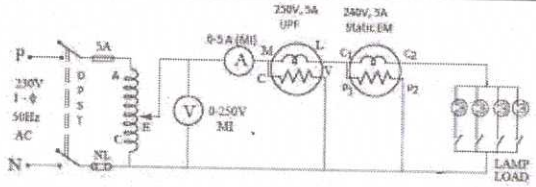
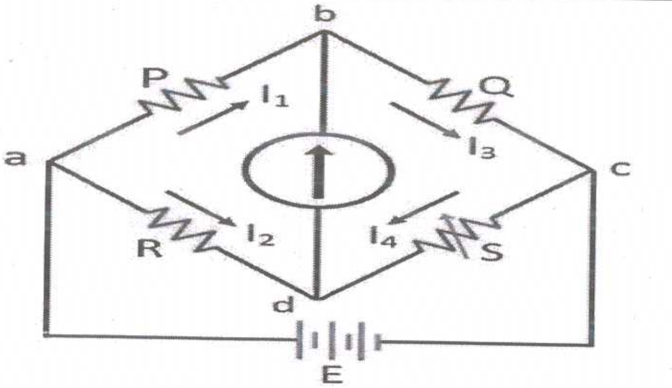
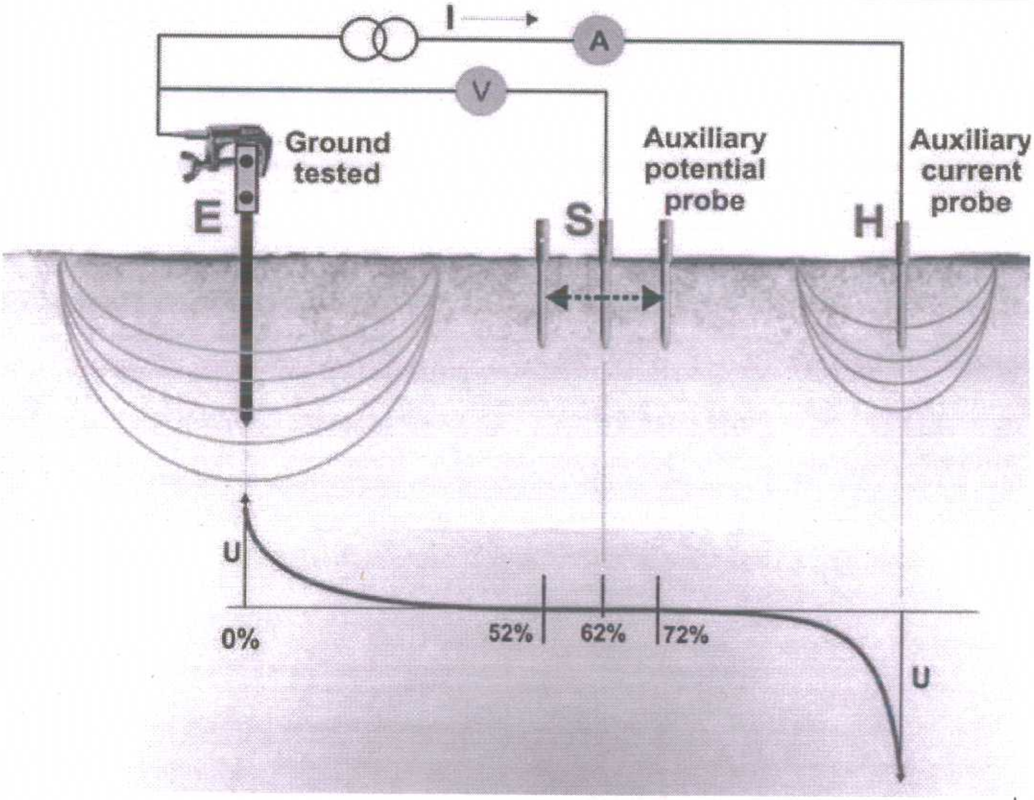
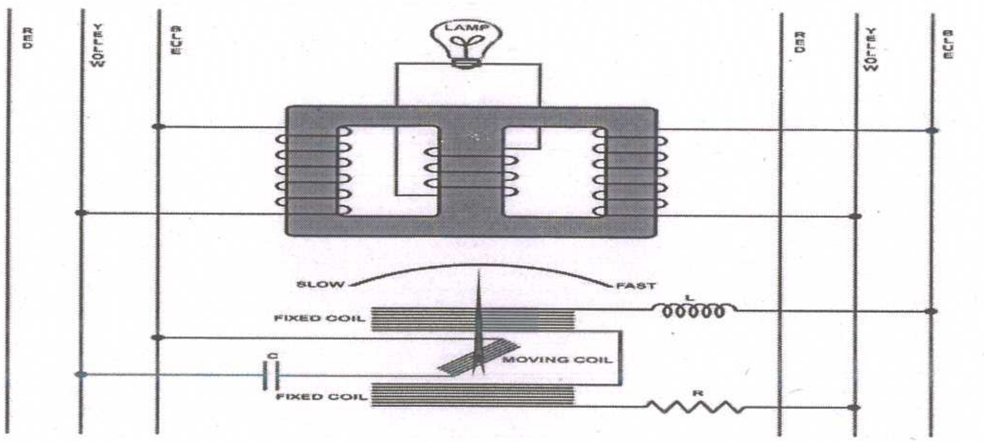
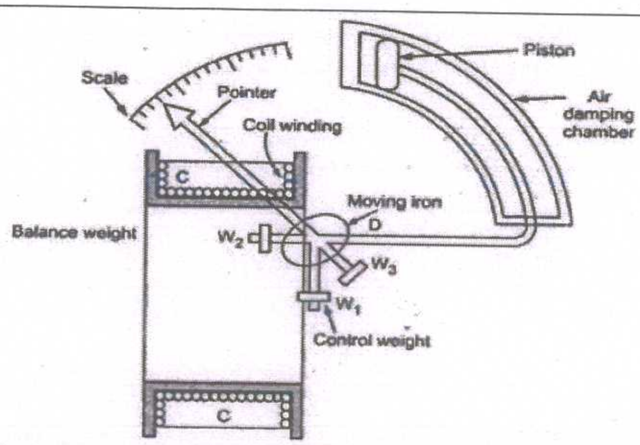
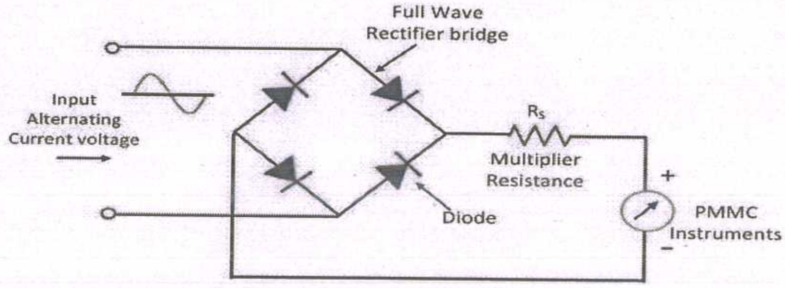
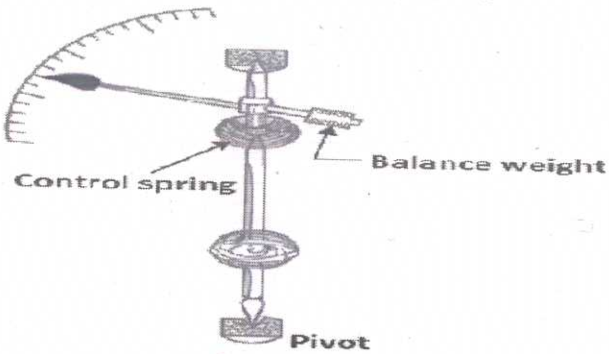
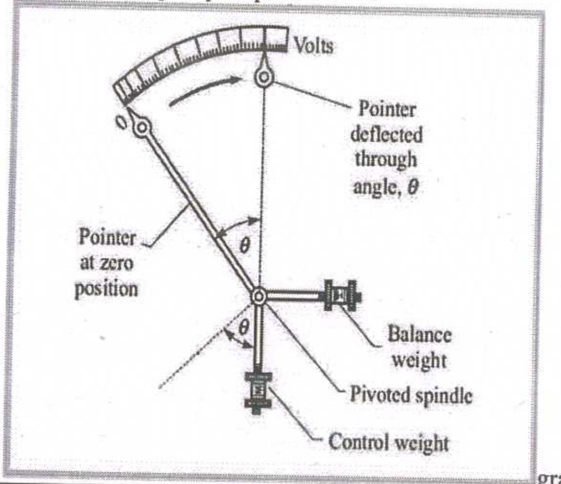
II.4		6	6
II.5	**Wheatstone Bridge** Circuit Globe The bridge is in balance condition when no current flows through the coil or the potential difference across the galvanometer is zero. This condition occurs when the potential difference across the a to b and a to d are equal, and the potential differences across the b to c and c to d remain same.The current enters into the galvanometer divides into I_1 and I_2, and their magnitude remains same. The following condition exists when the current through the galvanometer is zero. $I_1P = I_2R \ldots\ldots\ldots equ(1)$ The bridge in a balanced condition is expressed as $I_1 = I_3 = \frac{E}{P+Q}$ $I_2 = I_4 = \frac{E}{R+S}$ Where E – emf of the battery. By substituting the value of I_1 and I_2 in equation (1) we get. $\frac{PE}{P+Q} = \frac{RE}{R+S}$ $\frac{P}{P+Q} = \frac{R}{R+S}$ $P(R+S) = R(P+Q)$ $PR + PS = RP + RQ$ $PS = RQ \ldots\ldots\ldots equ(2)$ $R = \frac{P}{Q} \times S \ldots\ldots\ldots equ(3)$ The equation (2) shows the balance condition of the Wheatstone bridge. The value of unknown resistance is determined by the help of the equation (3). The R is the unknown resistance, and the S is the standard arm of the bridge and the P and Q are the ratio arm of the bridge.	Fig.3 Expl.3	6
II. 6	To measure the earth ground resistance of a single ground electrode at E in Fig. 1, a current is forced to flow to E by driving auxiliary test probe H into the ground at a certain distance from electrode E and connecting probe H to a current source.	Fig.3 Expl.3	6

	 Fig. 1: Earth ground resistance measurement. In this case, the ground resistance test meter is the current source which generates an alternating current. An electrical circuit is formed between H and E, with current flowing between them in the ground. Electrical potentials are created at points between E and H. A path of resistance between E and H causes a voltage to develop at points along this path, due to the current. A second auxiliary test probe, S, is driven into the ground between E and H to measure electrical potential (voltage). This voltage varies along the path between E and H; maximum voltage occurs at E and zero at H, hence the term "fall of potential": the voltage potential falls away when moving probe S away from E, towards H. With the voltage recorded at S, we can determine the earth resistance from the voltage and current values.		
II. 7	 It consists of a lamp transformer. Lamp transformer is a kind of transformers which has three limbs magnetic core. We connect the winding of one of the outer limbs between any two phases of the existing electrical system. Then we connect the winding of the other outer limbs across the same two phases of the incoming generator. Lastly, we connect an electric lamp with the winding of the central limb. Suppose at a certain condition there is no phase difference between the	Fig.3 Expl.3	6

	existing electrical system and the incoming generator. So, at that time resultant flux will be maximum at the central limb. Therefore, the lamp glows with its maximum brightness. If the phase difference between the existing electrical system and the generator is 180° (electrical), there will be zero flux in the central limb of the core of the **Weston type synchroscope.** Therefore, the lamp does not glow at all. But at any intermediate phase difference between these two systems, the bulb will glow with a certain brightness. If the frequency of those two systems differs, the bulb will flicker. The frequency of the flickering is exactly equal to the difference of the frequency of this existing electrical system and the incoming generator. As the time of synchronism, the flickering of the lamp becomes very slow. The correct instant of switching on the incoming generator is when the brightness of the lamp becomes maximum		

PART C

Qn No:III	Scoring Indicators	Split Score	Total Score (marks)
III.a	 Deflecting torque- magnetic attraction Controlling torque-gravity Damping torque- Pneumatic[air friction] This instrument is one of the most primitive forms of measuring and relay instrument. **Moving iron type instruments** are of mainly two types. Attraction type and repulsion type instrument. Whenever a piece of iron is placed nearer to a magnet it would be attracted by the magnet. The force of this attraction depends upon the strength said magnetic field. If the magnet is electromagnet then the magnetic field strength can easily be increased or decreased by increasing or decreasing current through its coil. Accordingly the attraction force acting on the piece of iron would also be increased and decreased. Depending upon this simple phenomenon attraction type **moving iron instrument** was developed.	Fig.4 Expl.4	8
III(b)	 Rectifier Type Instruments Circuit Globe **Rectifier type instrument** measures the alternating voltage and current with the help of rectifying elements and permanent magnet moving coil type of instruments. Practical rectifying element is having some finite forward blocking voltage and high reverse	Fig.4 Expl.3	7

	blocking voltage. We will apply the same procedure in order to obtain the voltage current characteristics of practical rectifying element. Now when we make the practical rectifying element forward biased it does not conduct till the applied voltage is not greater the forward breakdown voltage or we can say knee voltage. When the applied voltage becomes greater than the knee voltage then diode or rectifying element will come under conduction mode. Thus behaves as short circuited but due to some electrical resistance there is voltage drop across this practical diode. We can make the rectifying element forward biased by connecting the positive terminal of the battery with anode and negative terminal with cathode. The forward characteristic of practical rectifying element or diode is shown in the voltage current characteristic. Now when we apply negative voltage i.e. connecting the negative terminal of the battery with the anode terminal of the diode and positive terminal of the battery to the cathode terminal of the rectifying element. Due to reverse biased it offers finite resistance and the negative voltage till the applied voltage becomes equal to reverse break down voltage and thus it behaves as open circuit.			
IV(a)	○ Controlling torque.The controlling torque (T_c) opposes the deflecting torque and increases with the deflection of the moving system. The pointer comes to rest at a position where the two opposing torques are equal i.e. $T_d = T_c$. The **controlling torque** performs two functions. Controlling torque increases with the deflection of the moving system so that the final position of the pointer on the scale will be according to the magnitude of an electrical quantity (i.e. current or voltage or power) to be measured. Controlling torque brings the pointer back to zero when the deflecting torque is removed. If it were not provided, the pointer once deflected would not return to zero position on removing the deflecting torque.  spring control Spring made up of phosphor bronze  gravity control	Fig.4 Expl.4		8
IV(b)	Rm=0.5Ω, Im= 50mA, Voltage drop across meter= Im*Rm= 0.5*.05=.025V For 50A meter: Current through shunt Ish= 50-.05=49.95 Shunt resistance Rsh= Vm/Ish = .025/49.95= .0005Ω// For 100A meter: Current through shunt Ish= 100-.05=99.95 Shunt resistance Rsh= Vm/Ish = .025/99.95= .000251Ω//	3 2 2		7

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<td>V(a)</td>
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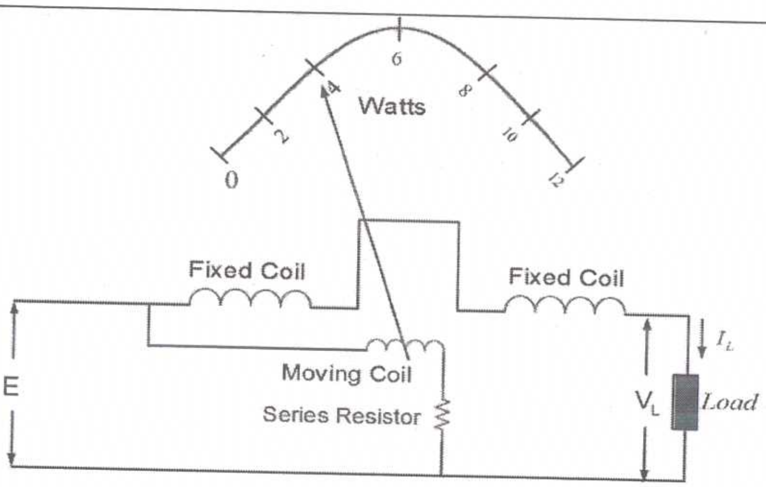
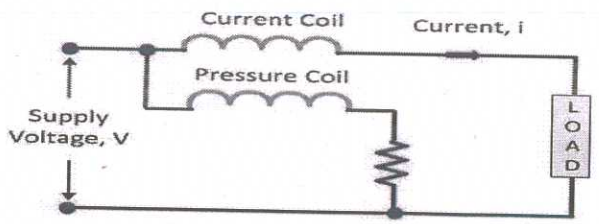


A *dynamometer type* <u>wattmeter</u> essentially consists of two coils called fixed coil and moving coil. The fixed coil is splitted into two equal parts which are placed parallel to each other. The two fixed coils are air-cored to avoid <u>hysteresis</u> effects when used on AC.

The fixed coil is connected in series with the load and carries the circuit current. It is, therefore, called current coil. The moving coil is pivoted between the two parts of the fixed coil and is mounted on the spindle. A pointer is attached to the spindle which gives deflection. The moving coil is connected in parallel with the load and carries the current proportional to the voltage. It is, therefore, called potential coil.

<u>When power is to be measured in a circuit, the wattmeter is connected in the circuit. The current coil is connected in series with the load, carries the load current and the potential coil, connected in parallel with the load, carries the current proportional to the voltage across the load. The fixed coil produces a field F_m and moving coil produces a field F_r. The field F_r tries to come in line with the main field F_m, which produces a deflecting torque on the moving coil.</u>

<u>Thus, the pointer attached to the spindle of the moving coil deflects. The deflection is controlled by the controlling torque produced by the springs</u>



(a). Wattmeter Connection

Circuit Globe

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<td>Fig.4
Expl.4</td>
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<tr>
<td>V(b)</td>
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1. Phase and Speed Errors:

The phase errors is introduced because the shunt magnet flux does not leg behind the supply voltage by exactly 90 degree due to some resistance of the coil and iron losses. the angle less slightly less then 90 degree.Because this errors the torque is not zero at zero power factor of the load.-----In order to remove this error, made supply voltage exact 90 degree . this is accomplished by adjusting the position of copper shading band provided on central limb of the shunt magnet. an error on the fast under these condition can be eliminated by bringing the shading and near to the disc and vice-versa

</td>
<td>[First three errors are dominant Erros-4 Remedies-3]</td>
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Sometimes, the speed of the disc of energy meter is faster or slower , when tested on a load having power factor. there, energy meter register either more or less energy and errors is introduced.----In order to remove this error, the redial position of the braking magnet is adjusted. movement of braking magnet , away from the centre of the disc increase the torque which decreases the speed of the Disc.

2. Frictional Error:

This error is introduce due to friction at the rotor bearing and the register mechanism. because this error is unwanted braking torque acts on the moving system and register less energy then the actual energy passing though it-----This error is compensated by placing two short circuited bands on the outer limbs of the shunt magnet. these bands embrace the flux contain in two outer limbs of of the shunt magnet. An emf induce circulating current though them. this causes phase displacement between the enclose flux and main flux. As a result of this , a small driving torque is exerted on the disc solely by pressure coil which compensate the friction torque.

3. Creeping error:

The slow but continuous rotation of energy meter , which only pressure coil is excited but no current flow though the current coil is called creeping.this error may be due to excessive friction compensation, excessive voltage supply and stray magnetic field etc. --In order to prevent creeping on no load , two holes are drilled in the disc on the opposite side of the spindle at the same radius , this causes sufficient distortion of the field to prevent continuous rotation.

4. Temperature Error:

By changing the temperature , the parameter of the coils change slightly which introduce a small error in meter. however , this error negligible small and there is no need to prevent any means to eliminate the error.

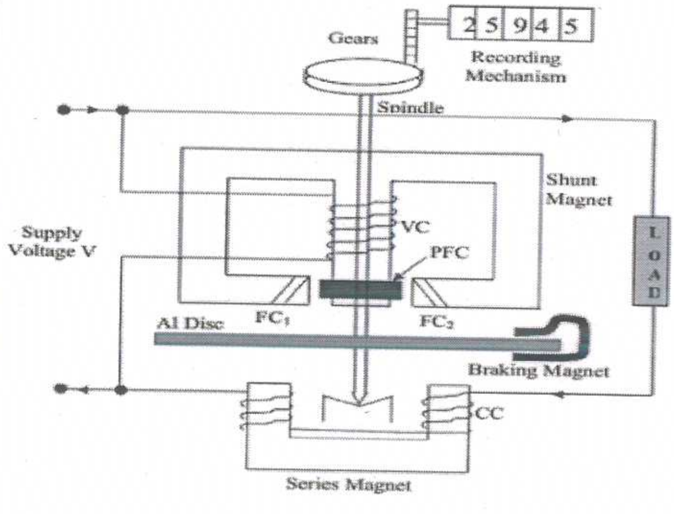
5. Frequency Error:

Since the energy meter are used normally at fixed frequency, therefore , they are designed and adjusted to have minimum error declared supply frequency Which is normally 50 Hz in India.

VI(a)

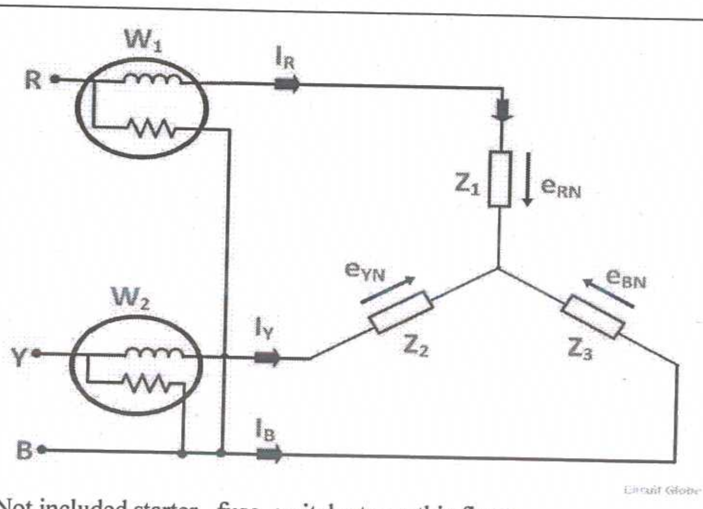
Fig.4
Expl.4

8



Fig

The basic principle of induction type energy meter is **electromagnetic induction**. When alternating current flow though two suitably located coils produces rotating magnetic field

	which is cut by the metallic disc suspended near to the coils thus emf induce in the disc which is circulates eddy current in it. by interaction of rotating magnetic field and eddy currents, torque is developed and cause the disc rotate. **1.Driving system.** It consists of two electromagnets, called ***"shunt" magnet*** and ***"series" magnet,*** **Series magnet:** it consists of a number of U-shaped laminations of silicon steel together to form a core.A coil of thick wire having a few turns is wounded in both legs of U-shaped magnet. the coil is known is current coil which is connected series with load.produce the magnetic field proportional and in phase with line current I. **Shunt magnet:** it consists of number of M-shaped laminations of silicon steel assembled together to form a core.A coil of thin wire having large number of turn in wound on central limb of the magnet. this coil is connected across the load. thus it is excited by current proportional to the supply voltage and known is potential coil. **2.Moving system.** The moving system essentially consists of a light rotating aluminium disk mounted on a vertical spindle or shaft. The shaft that supports the aluminium disk is connected by a gear arrangement to the clock mechanism on the front of the meter to provide information that consumed energy by the load. The time varying (sinusoidal) fluxes produced by shunt and series magnet induce eddy currents in the aluminium disc. The interaction between these two magnetic fields and eddy currents set up a driving torque in the disc. The number of rotations of the disk is therefore proportional to the energy consumed by the load in a certain time interval and is commonly measured in ***kilowatt-hours (kWh)***. **3.Breaking system.** Damping of the disk is provided by a ***small permanent magnet***, located diametrically opposite to the a.c magnets. The disk passes between the magnet gaps. The movement of rotating disc through the magnetic field crossing the air gap sets up eddy currents in the disc that reacts with the magnetic field and exerts a braking torque. By changing the position of the brake magnet or diverting some of the flux there form, the speed of the rotating disc can be controlled. **4.Recording mechanism.** The function of recording or registering mechanism is to record continuously a number on the dial which is proportional to the revolutions made by the moving system.the no of revolution on the disc is a measured the electrical energy passing though the meter. **Working of Single phase energy meter:** When the energy meter is connected in circuit, the current coil carries the load current and pressure coil carries the current proportional to the supply voltage. the magnetic field produced by series magnetic in phase with the line current and magnetic field produced by shunt magnet is in quadrature with the applied voltage.thus, a phase difference exists between the fluxes produce by the two coils. this setup rotating magnetic field which interacts with disc and produce a driving torque and thus, disc starts rotating.the number of revolutions made by the disc depend upon energy passing though the meter. the spindle geared to the recording mechanism so that energy consumed in the circuit is directly registered in **kWh**.		
VI(b)	 P=W1+W2 Not included starter , fuse, switch etc on this figure	7	7

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<td>VII(a)</td>
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The megger is a portable instrument used to measure insulation resistance. The megger consists of a hand-driven DC generator and a direct reading ohm meter. A simplified circuit diagram of the instrument is shown in below Figure.

The moving element of the ohm meter consists of two coils, A and B, which are rigidly mounted to a pivoted central shaft and are free to rotate over a C-shaped core (below Figure). These coils are connected by means of flexible leads. The moving element may point in any meter position when the generator is not in operation.

As current provided by the hand-driven generator flows through Coil B, the coil will tend to set itself at right angles to the field of the permanent magnet. With the test terminals open, giving an infinite resistance, no current flows in Coil A. Thereby, Coil B will govern the motion of the rotating element, causing it to move to the extreme counter-clockwise position, which is marked as infinite resistance.

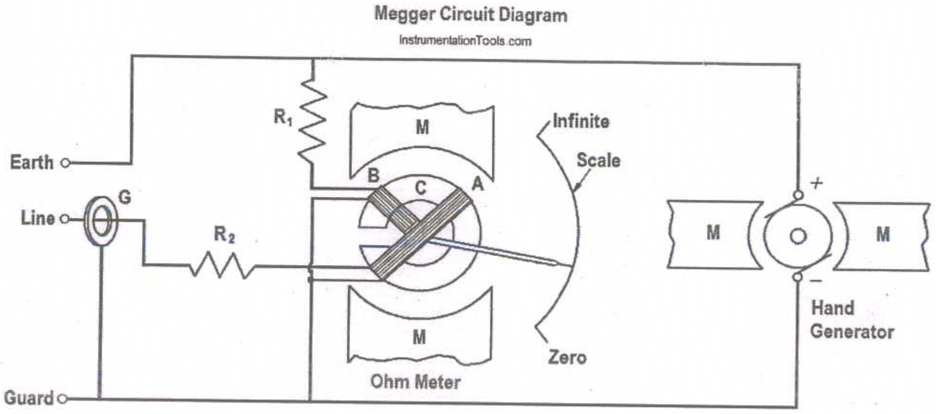

Figure : Simple Megger Circuit Diagram

Coil A is wound in a manner to produce a clockwise torque on the moving element. With the terminals marked "line" and "earth" shorted, giving a zero resistance, the current flow through the Coil A is sufficient to produce enough torque to overcome the torque of Coil B. The pointer then moves to the extreme clockwise position, which is marked as zero resistance. Resistance (R1) will protect Coil A from excessive current flow in this condition.

When an unknown resistance is connected across the test terminals, line and earth, the opposing torques of Coils A and B balance each other so that the instrument pointer comes to rest at some point on the scale. The scale is calibrated such that the pointer directly indicates the value of resistance being measured.

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<td>Fig.4
Expl.4</td>
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<td>VII(b)</td>
<td>Varley loop test is also for locating short-circuit and earth faults in underground cables. This test also employs the principle of the wheatstone bridge. However, the difference between Murray loop test and Varley loop test is that, in Varley loop test resistances R_1 and R_2 are fixed, and a variable resistor is inserted in the faulted leg. If the fault resistance is high, the sensitivity of Murray loop test is reduced and Varley loop test may be more suitable.</td>
<td>Fig.4
Expl.3</td>
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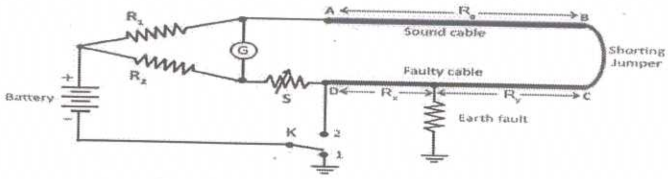


fig (iii) Varley loop test for earth fault

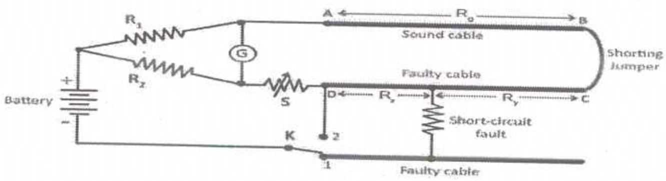


fig (iv) Varley loop test for short-circuit fault

To perform Varley loop test, connections are done as shown in the circuit diagram above. Resistors, R_1 and R_2 are fixed and the resistor S is variable. In this test, the switch K if first thrown to the position 1. Then the variable resistor S is varied till the galvanometer shows zero deflection (i.e. bridge is balanced). Lets say, the bridge is balanced for the value of S equal to S_1 Then,

$$\frac{R_1}{R_2} = \frac{R_g + R_y}{R_x + S_1}$$

$$\text{Let, } R_g + R_y = R_3$$

$$\frac{R_1 + R_2}{R_2} = \frac{R_3 + R_x + S_1}{R_x + S_1}$$

$$R_x + S_1 = \frac{R_2 (R_3 + R_x + S_1)}{R_1 + R_2}$$

$$\boxed{R_x = \frac{R_2 (R_3 + R_x) - R_1 S_1}{R_1 + R_2}} \quad \text{.........eq. (i)}$$

Now, the switch K is thrown to the position 2 and the bridge is balanced by varying the resistor S. Say, the bridge is balanced at the value of resistor S is equal to S_2. Then,

$$\frac{R_1}{R_2} = \frac{R_3 + R_x}{S_2}$$

$$\boxed{R_1 S_2 = R_2 (R_3 + R_x)} \quad \text{.........eq. (ii)}$$

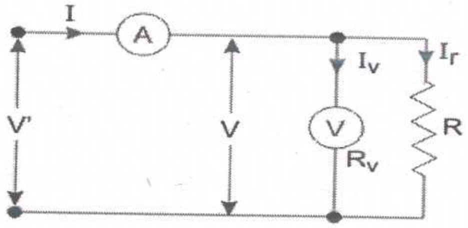
Now, putting the result of eq.(ii) in eq.(i),

$$R_x = \frac{R_1 (S_2 - S_1)}{R_1 + R_2}$$

Since the values of R_1, R_2, S_1 and S_2 are known, R_x can be calculated. When R_x is known, the distance from the test end to the fault point L_x can be calculated as,

$L_x = R_x/r$ Where, r = resistance of the cable per meter.

VIII(a) VOLT METER AMMETER METHOD(LOW RESISTANCE) The current is flown through load resistor while the potential drop is measured across load as shown. Hence we can find out the value of resistance under experiment in terms of V and I as indicated in the above figure. | Fig2*2=4 Expl.2*2=4 | 8



R=V/I ohms.

From low voltage variable DC supply, we can measure different readings and take the mean reistance value

MEDIUM RESISTANCE This is the most crude and simplest method of measuring resistance. It uses one ammeter to measure current, I and one voltmeter to measure voltage, V and we get the value of resistance

Now we can have two possible connections of ammeter and voltmeter, shown in the figure below.

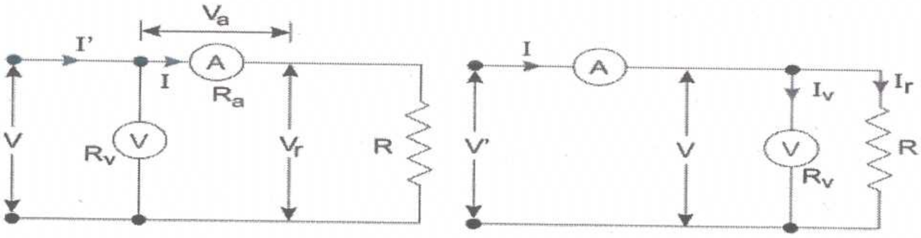


Figure-1 Figure-2

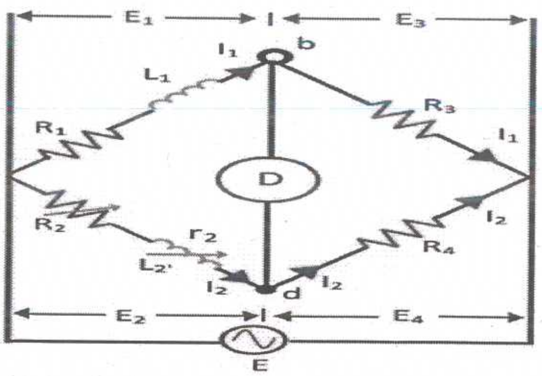
Ammeter Voltmeter Method

From medium voltage[say 230v dc] variable DC supply, we can measure different readings and take the mean reistance value. As in both cases errors will be there. BUT PREFER THE FIRST CIRCUIT

VIII(b) — Fig.4 Expl.3 — 7

Maxwell's Bridge ;Definition: **The** bridge **used for the** measurement **of** self-inductance **of the** circuit **is known as the Maxwell bridge. It is the advanced form of the Wheatstone bridge. The Maxwell bridge** works **on the** principle **of the** comparison, **i.e., the value of** unknown inductance **is determined by** comparing **it with the known value or standard value.**

Maxwell's Inductance Bridge: **In such type of bridges, the value of unknown resistance is determined by comparing it with the known value of the standard self-inductance. The connection diagram for the balance Maxwell bridge is shown in the figure below.**



Maxwell's Inductance Bridge

Circuit Globe

Let, L_1 – unknown inductance of resistance R_1.

L_2 – Variable inductance of fixed resistance r_1.

R_2 – variable resistance connected in series with inductor L_2.

R_3, R_4 – known non-inductance resistance

At balance, $$L_1 = \frac{R_3}{R_4} L_2$$

$$R_1 = \frac{R_3}{R_4}(R_2 + r_2)$$

The value of the R_3 and the R_4 resistance varies from 10 to

1000 ohms with the help of the resistance box. Sometimes for balancing the bridge, the additional resistance is also inserted into the circuit.

IX(a)

The cathode-ray oscilloscope (CRO) is a common laboratory instrument that provides accurate time and amplitude measurements of voltage signals over a wide range of frequencies. Its reliability, stability, and ease of operation makes it suitable as a general purpose laboratory instrument. Figure shows the basic block diagram of a general purpose CR oscilloscope.

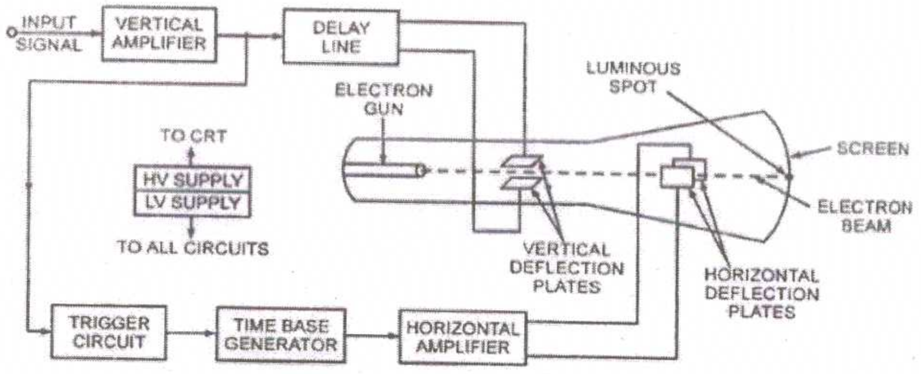


Figure - Block Diagram of General Purpose CRO

A general purpose oscilloscope consists of the following parts-- **Cathode Ray Tube** - It is the heart of the oscilloscope. When the electrons emitted by the electron gun strikes the phosphor screen, a visual signal is displayed on the CRT. **Vertical Amplifier** - The input signals are amplified by the vertical amplifier. Usually, the vertical amplifier is a wide band amplifier which passes the entire band of frequencies. **Delay Line** - As the name suggests, this circuit is used to delay the signal for a period of time in the vertical section of CRT. The input signal is not applied directly to the vertical plates because the part of the signal gets lost, when the delay time is not used. Therefore, the input signal is delayed by a period of time. **Time Base (Sweep) Generator** - Time base circuit uses a uni-junction transistor, which is used to produce the sweep. The saw tooth voltage produced by the time base circuit is required to deflect the beam in the horizontal section. The spot is deflected by the saw tooth voltage at a constant time dependent rate. **Horizontal Amplifier** - The saw tooth voltage produced by the time base circuit is amplified by the horizontal amplifier before it is applied to horizontal deflection plates. **Trigger Circuit** - The signals which are used to activate the trigger circuit are converted to trigger pulses for the precision sweep operation whose amplitude is uniform. Hence input signal and the sweep frequency can be synchronized. **Power supply** - The voltages required by CRT, horizontal amplifier, and vertical amplifier are provided by the power supply block. It is classified into two types –

Fig.4 Expl.4 | 8

(1) Negative high voltage supply

(2) Positive low voltage supply The voltage of negative high voltage supply is from -1000V to -1500V. The range of positive voltage supply is from 300V to 400V

Functioning –

- The cathode ray is a beam of electrons which are emitted by the heated cathode (negative electrode) and accelerated toward the fluorescent screen. The assembly of the cathode, intensity grid, focus grid, and accelerating anode (positive electrode) is called an electron gun
- Its purpose is to generate the electron beam and control its intensity and focus. Between the electron gun and the fluorescent screen are two pair of metal plates - one oriented to provide horizontal deflection of the beam and one pair oriented to give vertical deflection to the beam. These plates are thus referred to as the horizontal and vertical deflection plates
- The combination of these two deflections allows the beam to reach any portion of the fluorescent screen. Wherever the electron beam hits the screen, the phosphor is excited and light is emitted from that point. This conversion of electron energy into

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<td>light allows us to write with points or lines of light on an otherwise darkened screen

The linear deflection or sweep of the beam horizontally is accomplished by use of a sweep generator that is incorporated in the oscilloscope circuitry.
In the most common use of the oscilloscope, the signal to be studied is first amplified and then applied to the vertical (deflection) plates to deflect the beam vertically, and at the same time, a voltage that increases linearly with time is applied to the horizontal (deflection) plates, thus causing the beam to be deflected horizontally at a uniform rate
The signal applied to the vertical plates is thus displayed on the screen as a function of time. The horizontal axis serves as a uniform time scale
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<td>IX(b)</td>
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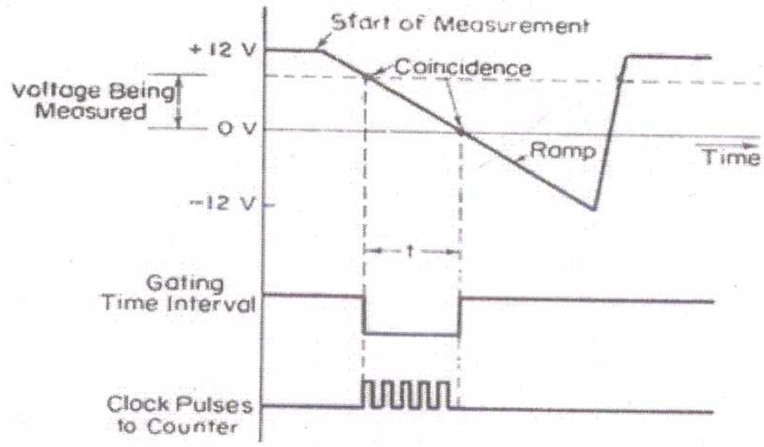
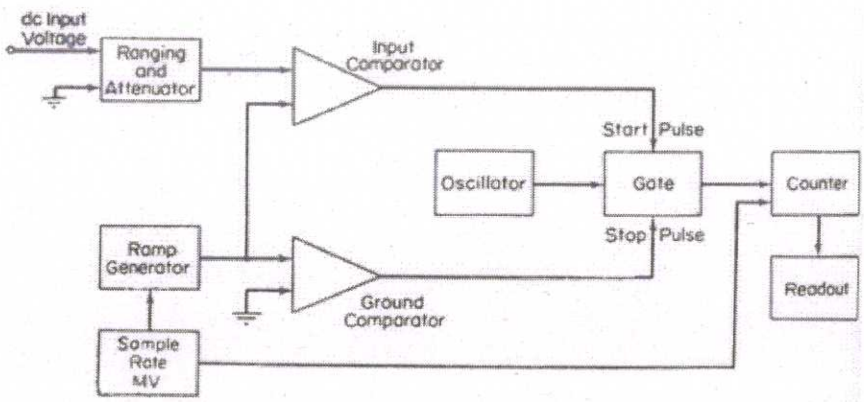
Ramp-Type DVM

The operating principle of the ramp-type DVM is based on the measurement of the time it takes for a linear ramp voltage to rise from 0 V to the level of the input voltage, or to decrease from the level of the input voltage to zero. This time interval is measured with an electronic time-interval counter, and the count is displayed as a number of digits on electronic indicating tubes.
Conversion from a voltage to a time interval is illustrated by the waveform diagram of Figure below.



At the start of the measurement cycle, a ramp voltage is initiated; this voltage can be positive-going or negative-going. The negative-going ramp, shown in Fig. , is continuously compared with the unknown input voltage. At the instant that the ramp voltage equals the unknown voltage, a coincidence circuit, or comparator, generates a pulse which opens a gate. This gate is shown in the block diagram of below figure. The ramp voltage continues to decrease with time until it finally reaches 0 V (or ground potential) and a second comparator generates an output pulse which closes the gate.



An oscillator generates clock pulses which are allowed to pass through the gate to a number of decade counting units (DC Us) which totalize the number of pulses passed through the gate. The decimal number, displayed by the indicator tubes associated with the DCUs, is a measure of the magnitude of the input voltage. The sample-rate multivibrator determines the rate at which the measurement cycles are initiated. The oscillation of this multi vibrator can usually be adjusted by a front-panel control, marked rate, from a few cycles per second to as high as 1,000 or more. The sample-rate circuit provides an initiating pulse for the ramp generator to start its next ramp voltage. At the same time, a reset pulse is generated which returns all the DCU s to their 0 state, removing the display momentarily from the indicator tubes.
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<td>Fig.4
Expl.3

Either Block diagram or waveform explanation</td>
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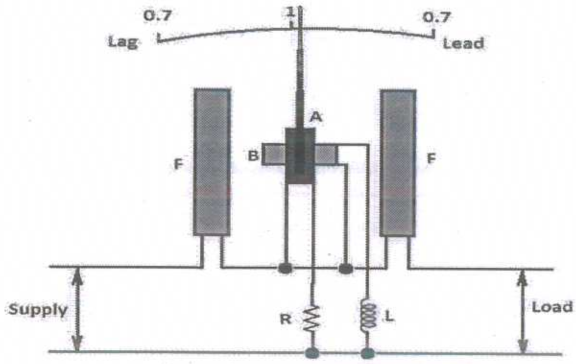
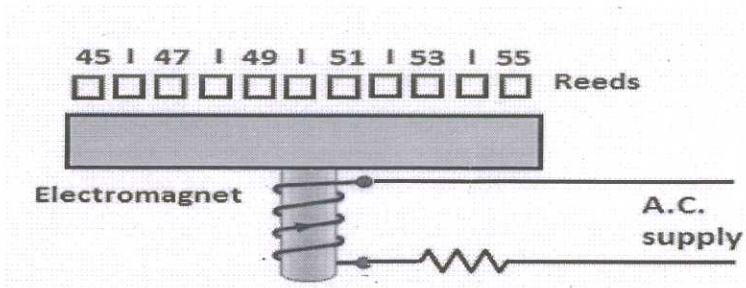
X(a)	 Single phase power factor meter https://yourelectricalguide.blogspot.in/ A dynamometer type power factor meter consists of two fixed coils *FF* connected in series carrying the load current (or a definite fraction of it) forming the current circuit, and two identical moving coils *A* and *B* fixed at the nearly right angle to each other pivoted on the same spindle forming the pressure circuit as shown in the figure. The current coils *FF* are wound with thick wire whereas pressure coils *A* and *B* are wound with fine wire. The pressure coils fixed on the same spindle, to which a pointer is attached, constitutes the moving system. The pressure coil *A* is connected across the supply through a non-inductive resistant and pressure coil *B* is connected across the supply through highly inductive choke coil of inductance *L*. The value of resistance *R* and inductance *L* are so chosen that for the main supply frequency, the current in the two pressure coils *A* and *B* is the same. Thus the fields produced by the two coils are of the same strength. The field produced by the coil *B* lags behind the field produced by the coil *A* slightly less than 90° because of resistance of the coil. Accordingly while fixing the coil *B* the plane of this coil is displaced from the plane of the coil A by the electrical angle which is slightly less than 90°. However while discussing the action (working) of the instrument it will be assumed that the phase difference between the two currents flowing through the coils A and B is 90° and same is the angle between the planes of the coils.	Fig.4 Expl.4	8
X(b)	A vibrating reed frequency meter consists of a number of thin steel strips called reeds. These reeds are placed in a row alongside and close to an electromagnet. The electromagnet consists of thin laminations and a coil is wound around it as shown in fig. The coil is connected in series with a resistance across the supply whose frequency is to be measured.  Viberating reed type frequency meter The approximate dimensions of the *vibrating reeds* are about 4 mm wide and ½ mm thick. The reeds are not similar to each other but differ either in their dimensions or weight or carry different flags at their tops. This is done to vary the natural frequency of vibration of each reed. The reeds are arranged in ascending order of natural frequency the difference in frequency is usually 1Hz. Thus the natural frequency of first reed may be 45 Hz, of the second 46 Hz, of the next 47 Hz and so on of the last may be 55 Hz. The reeds are fixed at the bottom end and are free at the top end. The flags at the top of reeds	Fig.4 Expl.3	8

	are -painted white, and the frequency is read directly from the instrument by observing the scale mark opposite to the reed which is vibrating most. **Mechanical Resonance Type Frequency Meter Working Principle** When the vibrating reed frequency meter or mechanical resonance type frequency meter is connected across the supply whose frequency is to be measured an alternating current ***I*** flows through the coil of an electromagnet which produces a force of attraction on the reeds. The force of attraction is proportional to the square of the current therefore it varies at twice the supply frequency. Hence a force of exerted on the reeds at every half cycle. All the reeds thus tend to vibrate, but only the one whose natural frequency is double that of supply will vibrate appreciably. Mechanical resonance is obtained in the case of this reed. The frequency is determined, therefore by noting the scale reading opposite the reed that vibrates with maximum amplitude.The tuning in these meters is so sharp that as the excitation frequency changes from resonant frequency the amplitude of vibration decreases rapidly becoming negligible for a frequency which is slightly away from resonant one.		