IB.Tech- I Semester
SUBJECT:BEEE(R23)
UNIT-II (PART2)

Measuring instruments:

Measurements are the basic means of acquiring knowledge about the parameters and variables involved in the operation of a physical system. Measurement, generally involves using an instrument as a physical means of determining a quantity or variable. An instrument or a measuring instrument is, therefore, defined as a device for determining the value or magnitude of a quantity or variable. The electrical measuring instrument, as its name implies, is based on electrical principles for its measurement function.

Here we will discuss about the basic construction of PMMC and MI instruments and their operation

1.Permanent Magnet Moving Coil Instrument (PMMC) :

The permanent magnet moving coil instrument is the most accurate type for D.C. Measurements. The working principle of these instruments is the same as that of the D'Arsonval type of galvanometers, the difference being that a direct reading instrument is provided with a pointer and a scale

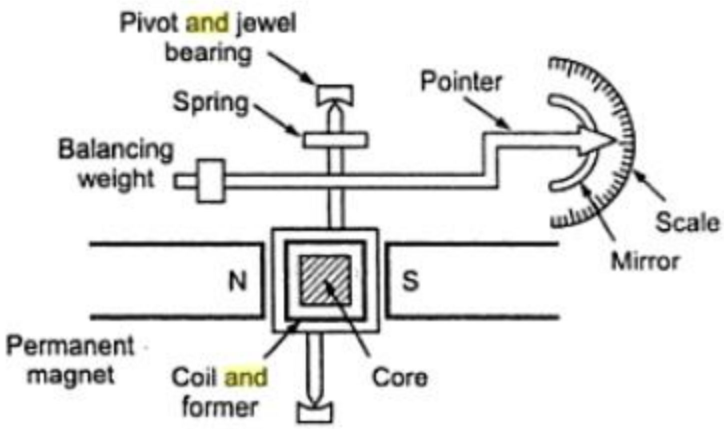

Fig. Construction of PMMC Instrument

Construction of PMMC Instruments

The constructional features of this instrument are shown in Fig. The moving coil is wound with many turns of enameled or silk covered copper wire. The coil is mounted on rectangular aluminum former, which is pivoted on jeweled bearings. The coils move freely in the field of a permanent magnet. Most voltmeter coils are wound on metal frames to provide the required electro-magnetic damping. Most ammeter coils, however, are wound on non-magnetic formers, because coil turns are effectively shorted by the ammeter shunt. The coil itself, therefore, provides electromagnetic damping. Magnet Systems Old style magnet system consisted of relatively long U shaped permanent magnets having soft iron pole pieces. Owing to development of materials like Alcomax and Alnico, which have a high co-ercive force, it is possible to use smaller magnet lengths and high field intensities. The flux densities used in PMIMC instruments vary from 0.1 Wb/m to 1 Wb/m.

Control

When the coil is supported between two jewel bearings two phosphor bronze hairsprings provide the control torque. These springs also serve to lead current in and out of the coil. The control torque is provided by the ribbon suspension as shown. This method is comparatively new and is claimed to be advantageous as it eliminates bearing friction.

Damping

Damping torque is produced by movement of the aluminum former moving in the magnetic field of the permanent magnet.

Pointer and Scale

The pointer is carried by the spindle and moves over a graduated scale. The pointer is of lightweight construction and, apart from those used in some inexpensive instruments has the section over the scale twisted to form a fine blade.

This helps to reduce parallax errors in the reading of the scale. When the coil is supported between two jewel bearings two phosphor bronze hairsprings provide the control torque. These springs also serve to lead current in and out of the coil.

Advantages of Permanent Magnet Moving Coil Instruments

1. The scale is uniformly divided as the current is directly proportional to deflection of the pointer. Hence it is very easy to measure quantities from these instruments.
2. Power consumption is also very low in these types of instruments.
3. Higher value of torque is to weight ratio.
4. These are having multiple advantages, a single instrument can be used for measuring various quantities by using different values of shunts and multipliers.

Instead of various advantages the permanent magnet moving coil instruments or PMMC Instrument posses few disadvantages.

Disadvantages of Permanent Magnet Moving Coil Instruments

1.These instruments cannot measure ac quantities.

2.Cost of these instruments is high as compared to moving iron instruments

2.Moving Iron Instrument:

Moving Iron Instruments are the most common type of ammeter and voltmeter used at power frequencies in laboratories. These instruments are very accurate, cheap and rugged as compared to other AC instruments.

Working Principle of Moving Iron Instruments:(MI Attraction type instrument):

In Moving Iron Instruments, a plate or van of soft iron or of high permeability steel forms the moving element of the system. The iron van is so situated that it can move in the magnetic field produced by a stationary coil. Figure below shows a simple moving iron instrument.

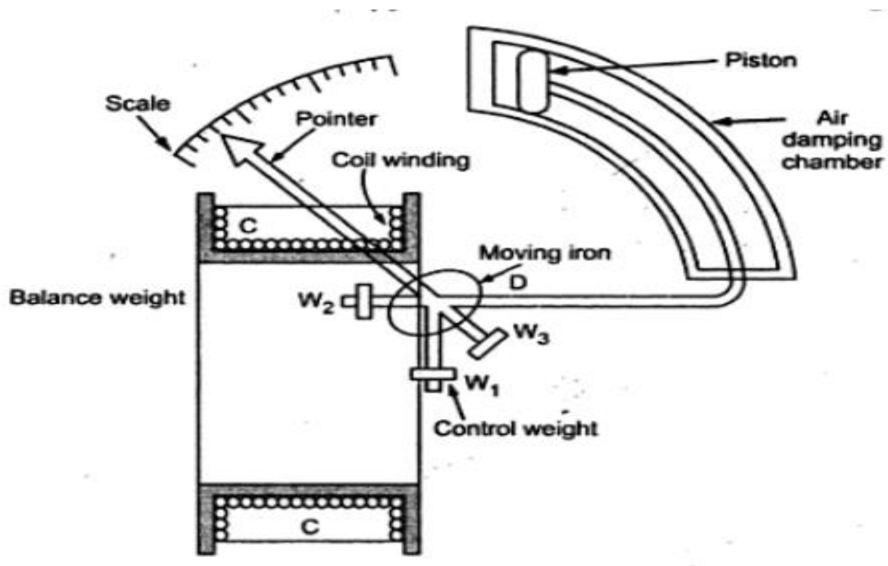

Fig. Moving Iron Attraction type instrument

The stationary coil is excited by the current or voltage under measurement. When the coil is excited, it becomes an electromagnet and the iron van moves in direction of offering low reluctance path. Thus the force of attraction is always produced in a direction to increase the inductance of coil. Mind that as the van follows the low reluctance path, the net flux in air gap will increase which means increased flux linkage of coil and hence inductance of coil will increase. It shall also be noticed that, the inductance of coil is variable and depends on the position of iron van.

Repulsion Type

One vane is rigidly attached to the coil frame while the other can rotate coaxially inside the stationary vane, as shown in Fig.. Both vanes are magnetized by the current in the coil to the same polarity, causing the vanes to slip laterally under repulsion. Because the moving vane is attached to a pivoted shaft, this repulsion results in a rotational force that is a function of the current in the coil. As in other mechanisms the final pointer position is a measure of the coil current. Since this movement, like all iron vane instruments, does not distinguish polarity, the concentric vane may be used on dc and ac, but it is most commonly used for the latter.

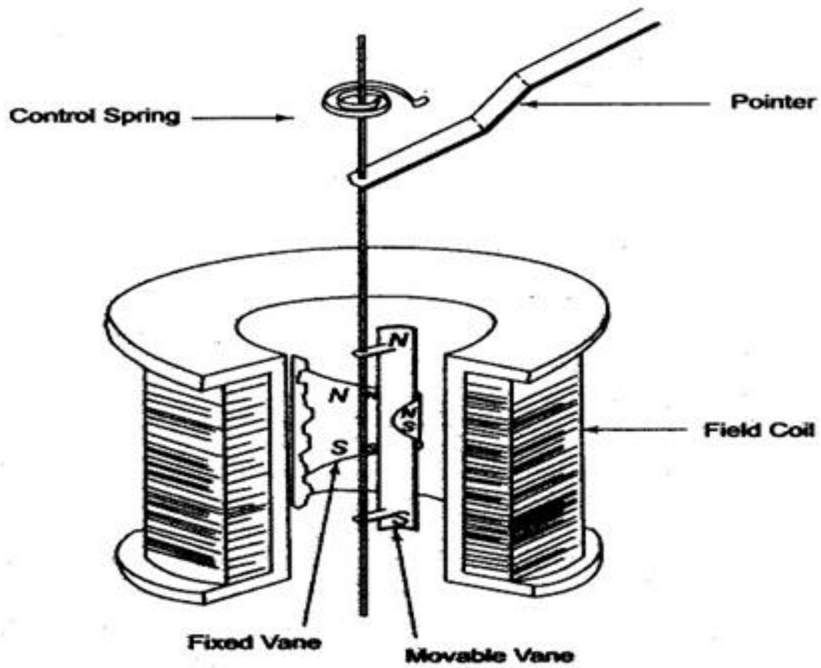

Fig.Moving iron repulsion type instrument

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Classification of resistance

- Low resistance is the range of 0.1ohm to 1 ohm.
- Medium resistance is the range of 1 ohm to low mega ohm.
- High resistance is 0.1 mega ohm to a higher range.

Methods for the measurement of low resistance

- Kelvin double bridge
- Ammeter – voltmeter method

Methods for the measurement of medium resistance

- Ammeter – voltmeter method
- Wheat stone bridge method
- Ohm meter method

Methods for the measurement of high resistance

- Direct deflection methods
- Loss of charge methods

Wheatstone Bridge:

Wheatstone bridge is a very important device used in the measurement of medium resistances . A Wheatstone bridge has been in use longer than almost, any electrical measuring instrument. It is still an accurate and reliable instrument and is extensively used in industry. **Wheatstone bridge** is an instrument for making comparison measurements and operates upon a null indication principle. This means the indication is independent of the calibration of the null indicating instrument or any of its characteristics. For this reason, very high degrees of accuracy can be achieved using Wheatstone bridge.

The figure below shows the basic circuit of a **Wheatstone bridge**. It has four resistive arms, consisting of resistances P, Q R and S together with a source of emf (a battery) and a null detector, usually a galvanometer G or other sensitive current meter. The current through the galvanometer depends on the potential difference between points b and d. The bridge is said to be balanced when there is no current through the galvanometer or when the potential difference across galvanometer is zero.This occurs when the voltage from point b to point a equals the voltage from point d to point a or by referring to the other battery terminal,when the voltage from point d to point c equals the voltage from point b to point c.

For balanced condition, we can write,
$I_1 P = I_2 R$
the figure below shows the circuit for *Wheatstone bridge* for the **measurement of medium resistance.**

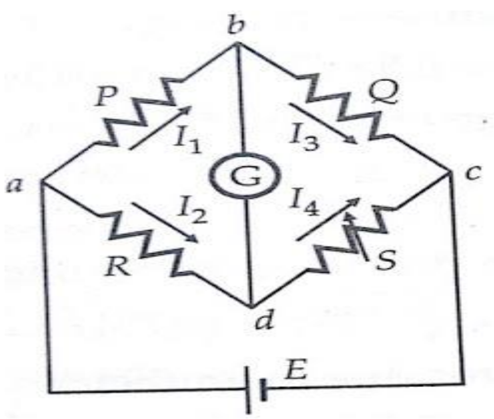

Fig.3

For the galvanometer current to be zero, the following conditions also exist:

$$I_1 = I_3 = \frac{E}{P+Q}$$

$$I_2 = I_4 = \frac{E}{R+S}$$

where E=emf of the battery
Combining above three equations we get ,

$$\frac{P}{P+Q} = \frac{R}{R+S}$$

From which

Q.R = P.S ---> (1)

Equation-1 is the well-known expression for the balance of **Wheatstone bridge**. If three of the resistances are known, the fourth may be determined from equation-1 and we obtain

R = S*(P/Q)

Where R is the unknown resistance, S is called the ‘standard arm' of the bridge and P and Q are called the 'ratio arms'.