Permanent Magnet Moving Coil (PMMC) Instrument

There are two types of moving coil instruments namely, permanent magnet moving coil type which can only be used for direct current (Dc), voltage measurements
and the dynamometer type which can be used on either direct (Dc)or alternating current(AC), voltage measurements.

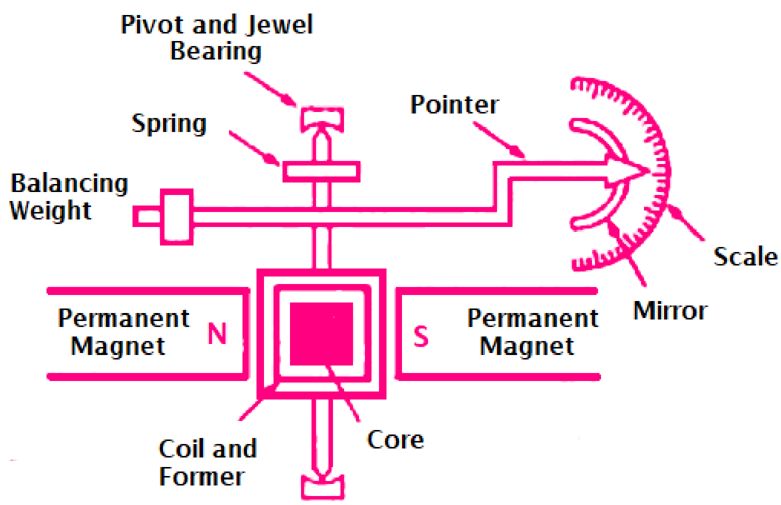
Principle of PMMC Instruments

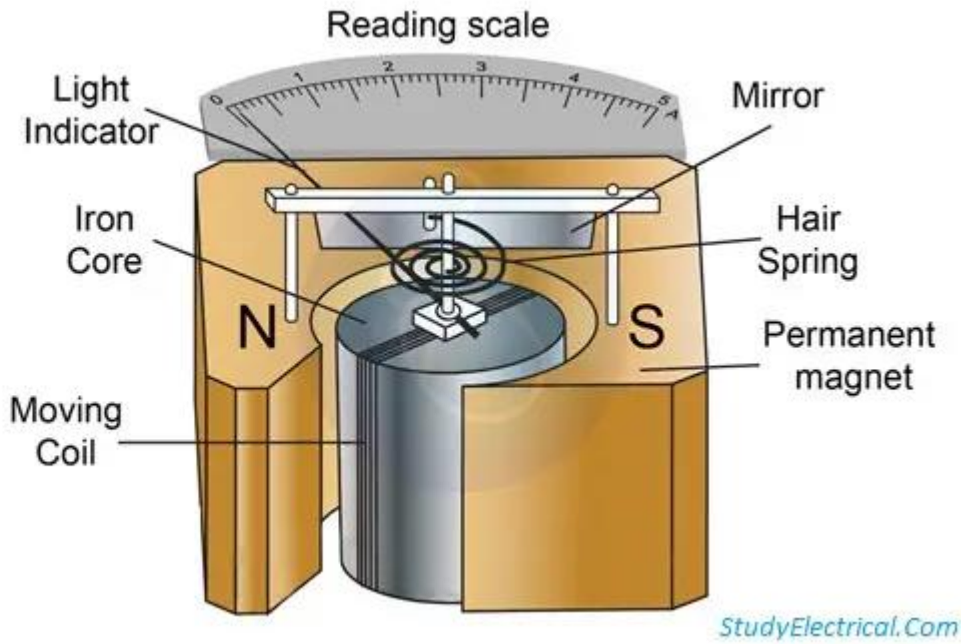
In PMMC meter or (D'Arsonval) meter or galvanometer all are the same instrument, a coil of fine wire is suspended in a magnetic field produced by permanent magnet. According to the fundamental law of electromagnetic force, the coil will rotate in the magnetic field when it carries an electric current by electromagnetic (EM) torque effect.

A pointer which attached the movable coil will deflect according to the amount of current to be measured which applied to the coil.

The (EM) torque is counterbalance by the mechanical torque of control springs attached to the movable coil also. When the torques are balanced the moving coil will have stopped and its angular deflection represent the amount of electrical current to be measured against a fixed reference, called a scale. If the permanent magnet field is uniform and the spring linear, then the pointer deflection is also linear

Construction of PMMC Instruments





The moving coil is either rectangular or circular in shape. It has a 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 a uniform, horizontal and radial magnetic field of a permanent magnet in the shape of a horse-shoe.

The iron core is spherical if the coil is circular and is cylindrical if the coil is rectangular. Due to the iron core, the deflecting torque increases, increasing the sensitivity of the instrument.

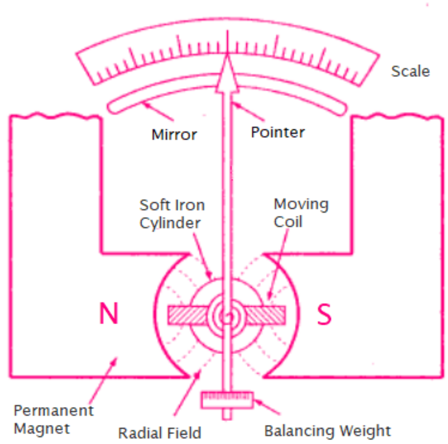
E-mail:zainab.kadum.jaber@uomus.edu.iq

The controlling torque is provided by two phosphor bronze hairsprings. The damping torque is provided by eddy current damping. It is obtained by movement of the aluminum former, moving in the magnetic field of the permanent magnet.
The pointer is carried by the spindle and it moves over a graduated scale. The pointer has lightweight 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 counterbalanced by the weights situated diametrically opposite and rigidly connected to it.

The scale markings of the basic DC PMMC instruments are usually linearly spaced as the deflecting torque and hence the pointer deflection is directly proportional to the current passing through the coil.

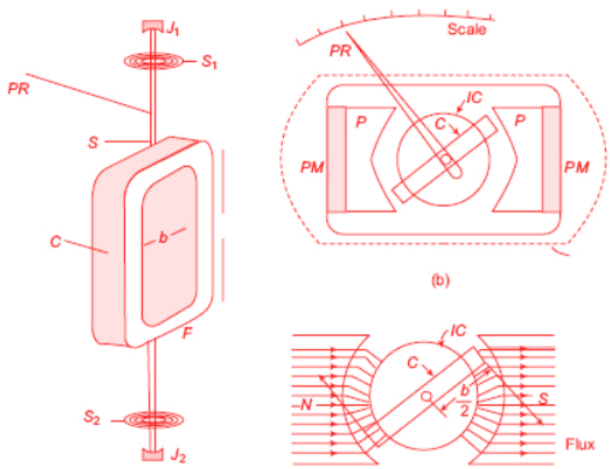


E-mail:zainab.kadum.jaber@uomus.edu.iq

In a practical PMMC instrument, a Y shaped member is attached to the fixed end of the front control spring. An eccentric pin through the instrument case engages the Y shaped member so that the zero position of the pointer can be adjusted from outside.

Working of PMMC Instruments

A Permanent Magnet Moving Coil (PMMC) instrument is shown in the figure.

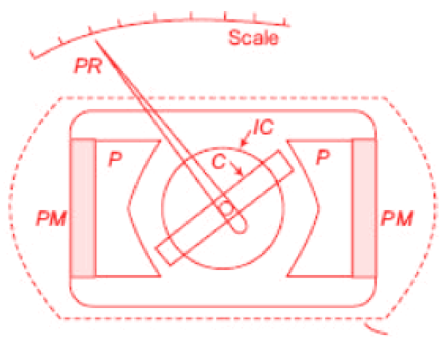


E-mail:zainab.kadum.jaber@uomus.edu.iq

The coil C has a number of turns of thin insulated wires wound on a rectangular aluminum former F. The frame is carried on a spindle S mounted in jewel bearings J_1, J_2.

A pointer PR is attached to the spindle so that it moves over a calibrated scale. The whole of the moving system is made as light in weight as possible to keep the friction at the bearing to a minimum.

The coil is free to rotate in air gaps formed between the shaped soft-iron pole piece (pp) of a permanent magnet PM and a fixed soft-iron cylindrical core IC



The core serves two purposes

a. it intensifies the magnetic field by reducing the length of the air gap
b. it makes the field radial and uniform in the air gap.

Thus, the coil always moves at right angles to the magnetic field

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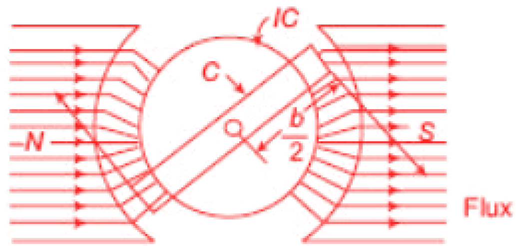


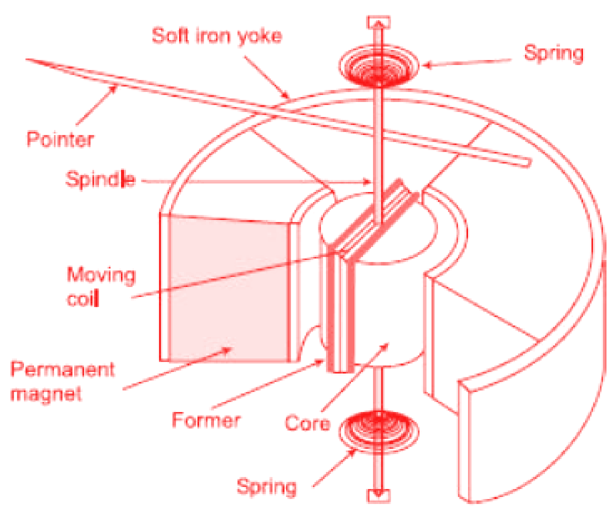
Modern permanent magnets are made of steel alloys which are difficult to machine. Soft-iron pole pieces (pp) are attached to the permanent magnet PM for easy machining in order to adjust the length of the air gap.

The figure below shows the internal parts of the Permanent Magnet Moving Coil (PMMC) instrument.

In the above figure, the components off PMMC instrument are shown as below,

1. External Shield
2. Permanent magnet
3. Moving Coil
4. Control Spring
5. Pointer
6. Arrangement for zero balance of the pointer

The next figure shows a schematic of the internal parts of a moving-coil instrument.



A soft-iron yoke (Y) is used to complete the flux path and to provide shielding from stray external fields.

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Advantages of PMMC

The following are the advantages of a permanent magnet moving coil instrument.

1. Sensitive to a small current
2. Very accurate and reliable
3. Uniform scale up to 270° or more
4. Very effective built-in damping
5. Low power consumption, varies from 25 µW to 200 µW
6. Free from hysteresis and not affected by external fields because its permanent magnet shields the coil from external magnetic fields
7. Easily adapted as a multirange instrument

Disadvantages of PMMC Instruments

Here are some of the disadvantages of PMMC instruments

1. The biggest disadvantage is this type of instrument can be operated in direct current only. In alternating current, the instrument does not operate.

It is because, in the positive half, the pointer experiences a force in one direction and in the negative half the pointer experiences the force in the opposite direction.

- Due to the inertia of the pointer, it retains its zero position.

2. Their moving system is very delicate and can easily be damaged by rough handling.
3. The coil being very fine, cannot withstand prolonged overloading.
4. PMMC instruments are costlier.
5. Aging of the instrument (permanent magnet and control spring) may introduce some errors.

Application of PMMC Instruments

Permanent-magnet moving-coil instruments can be used
as ammeters (with the help of a low resistance shunt) or
as voltmeters (with the help of a high series resistance).
The principle of permanent-magnet moving-coil type instruments has been utilized in the construction of the following:

1. AC galvanometer
2. Flux meter
3. Ballistic Galvanometer

E-mail:zainab.kadum.jaber@uomus.edu.iq

Mathematical Representation of PMMC Mechanism

Assume there are (N) turns of wire and the coil is (L) in long by (W) in wide. The force (F) acting perpendicular to both the direction of the current flow and the direction of magnetic field is given by:

field is given by:

$F = N \cdot B \cdot I \cdot L$ where N: turns of wire on the coil, I: current in the movable coil, B: flux density in the air gap, L: vertical length of the coil

Electromagnetic torque is equal to the multiplication of force with distance to the point of suspension

$T_{I1} = NBIL\frac{W}{2}$ in one side of cylinder $\qquad T_{I2} = NBIL\frac{W}{2}$ in the other side of cylinder

The total torque for the two cylinder sides

$$T_I = 2\left(NBIL\frac{W}{2}\right) = NBILW = NBIA$$

where A: effective coil area

This torque will cause the coil to rotate until an equilibrium position is reached at an angle θ with its original orientation. At this position

Electromagnetic torque = control spring torque

$$T_I = Ts$$

Since $\quad Ts = K\theta$

So $\quad \theta = \frac{NBA}{K} I \quad$ where $\quad C = \frac{NBA}{K} \quad$ Thus $\quad \theta = CI$

The angular deflection proportional linearly with applied current

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