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Permanent Magnet Moving Coil (PMMC) instrument

Construction

- A moving coil instrument consists basically of a permanent magnet to provide a magnetic field & a small lightweight coil is wound on a rectangular soft iron core that is free to rotate around its vertical axis.
- When a current is passed through the coil windings, a torque is developed on the coil by the interaction of the magnetic field and the field set up by the current in the coil.
- The aluminum pointer attached to rotating coil and the pointer moves around the calibrated scale indicates the deflection of the coil.
- To reduce parallax error a mirror is usually placed along with the scale. A balance weight is also attached to the pointer to counteract its weight as shown in Fig. (b).
- To use PMMC device as a meter, two problems must be solved

1. a way must be found to return the coil to its original position when there is no current through the coil.
2. a method is needed to indicate the amount of coil movement.

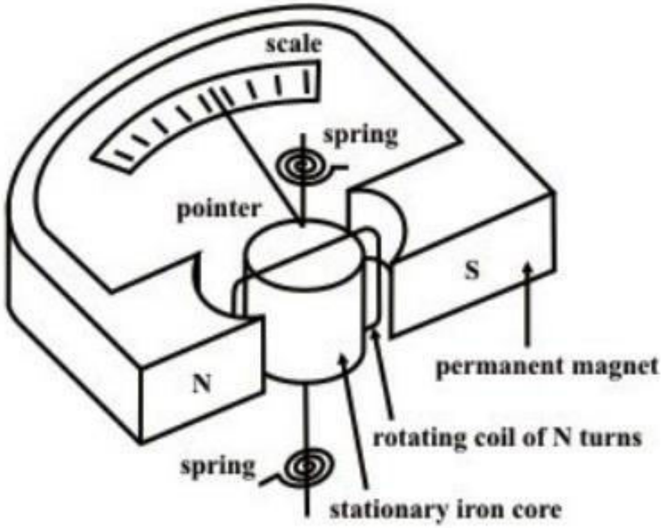


Fig.(a)

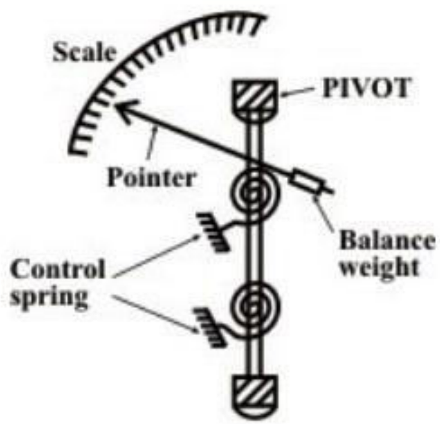


Fig.(b)

- The first problem is solved by the use of hairsprings attached to each end of the coil as shown in Fig. (a). These hairsprings are not only supplying a restoring torque but also provide an electric connection to the rotating coil. With the use of hairsprings, the coil will return to its initial position when no current is flowing though the coil. The springs will also resist the movement of coil when there is current through coil. When the developing force between the magnetic fields (from permanent magnet and electro magnet) is exactly equal to the force of the springs, the coil rotation will stop. The coil set up is supported on jeweled bearings in order to achieve free movement.
- Two other features are considered to increase the accuracy and efficiency of this meter movement. First, an iron core is placed inside the coil to concentrate the magnetic fields. Second, the curved pole faces ensure the turning force on the coil increases as the current increases

Principle of operation

It has been mentioned that the interaction between the induced field and the field produced by the permanent magnet causes a deflecting torque, which results in rotation of the coil. The deflecting torque produced is given by

$$T_d = NBWLI$$

where N = number of turns,
B = magnetic flux density in air gap,
L = length of moving coil,
W=width of the moving coil,
I =electric current.

Now for a moving coil instruments deflecting torque should be proportional to current, mathematically we can write T_d = GI. Thus on comparing we say G = NBWL.
At steady state we have both the controlling and deflecting torques are equal. T_c is controlling torque, on equating controlling torque with deflection torque we have GI = K.x where x is deflection .
Thus current is given by Since the deflection is directly proportional to the current therefore we need a uniform scale on the meter for measurement of current.

$$I = \frac{K}{G}x$$

AMMETERS & VOLTMETERS

Advantages

- Torque/weight is high
- Power consumption is less
- Scale is uniform
- Damping is very effective
- Since operating field is very strong, the effect of stray field is negligible
- Range of instrument can be extended

Disadvantages

- Use only for D.C.
- Cost is high
- Error is produced due to ageing effect of PMMC
- Friction and temperature error are present

Extension of range of PMMC instrument

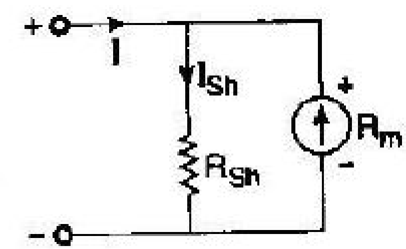
Shunts are used for the extension of range of Ammeters. So a good shunt should have the following properties:-

- The temperature coefficient of shunt should be low
- Resistance of shunt should not vary with time
- They should carry current without excessive temperature rise
- They should have thermal electromotive force with copper
- ‘Manganin’ is used for DC shunt and ‘Constantan’ as AC shunt

Ammeter

PMMC is used as indicating device. The current capacity of PMMC is small. It is impractical to construct a PMMC coil, which can carry a current greater than 100 mA. Therefore a shunt is required for measurement of large currents.

R_m = Internal resistance of movement (coil) in Ω
R_{sh} = Resistance of shunt in Ω
$I_m = I_{fs}$ = Full scale deflection current of movement in Amperes
I_{sh} = Shunt current in Amperes
I = Current to be measured in Amperes



Since the shunt resistance is in parallel with the meter movement, the voltage across shunt and movement must be same.

$$I_{sh}R_{sh} = I_m R_m$$

$$R_{sh} = \frac{I_m R_m}{I_{sh}}$$

$$I_{sh} = I - I_m$$

$\therefore$ We can write $R_{sh} = \dfrac{I_m R_m}{(I - I_m)}$

$$\frac{I}{I_m} - 1 = \frac{R_m}{R_{sh}}$$

$$\frac{I}{I_m} = 1 + \frac{R_m}{R_{sh}}$$

$\dfrac{I}{I_m} = m$ is known as 'multiplying power' of shunt

Resistance of shunt $R_{sh} = \dfrac{R_m}{(m-1)}$

Or $R_{sh} = \dfrac{R_m}{\left(\dfrac{I}{I_m} - 1\right)}$

Multi Range Ammeter:- Let m_1, m_2, m_3, m_4 be the shunt multiplying powers for current I_1, I_2, I_3, I_4.

$$R_{sh1} = \frac{R_m}{(m_1 - 1)}$$

$$R_{sh2} = \frac{R_m}{(m_2 - 1)}$$

$$R_{sh3} = \frac{R_m}{(m_3 - 1)}$$

$$R_{sh4} = \frac{R_m}{(m_4 - 1)}$$