

1.6 Damping force

The deflection torque and controlling torque produced by systems are electro mechanical.

Due to inertia produced by this system, the pointer oscillates about its final steady position before

coming to rest. The time required to take the measurement is more. To damp out the oscillation

is quickly, a damping force is necessary. This force is produced by different systems.

- (a) Air friction damping
- (b) Fluid friction damping
- (c) Eddy current damping

1.6.1 Air friction damping

The piston is mechanically connected to a spindle through the connecting rod (Fig. 1.6).

The pointer is fixed to the spindle and moves over a calibrated dial. When the pointer oscillates in clockwise direction, the piston goes inside and the cylinder gets compressed. The air pushes the piston upwards and the pointer tends to move in anticlockwise direction.

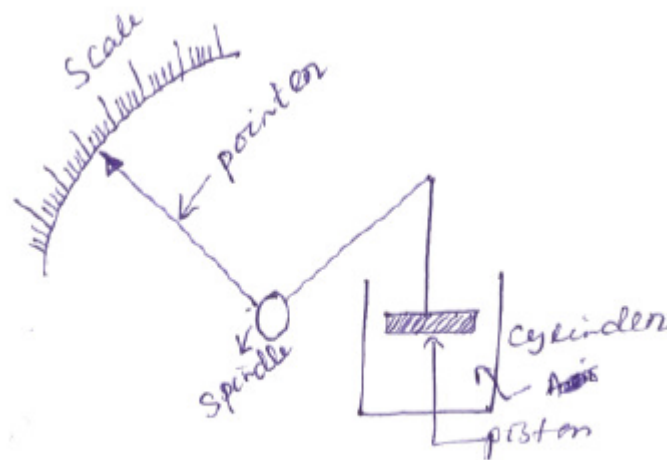


Fig. 1.6

If the pointer oscillates in anticlockwise direction the piston moves away and the pressure of the air inside cylinder gets reduced. The external pressure is more than that of the internal pressure. Therefore the piston moves downwards. The pointer tends to move in clockwise direction.

1.6.2 Eddy current damping

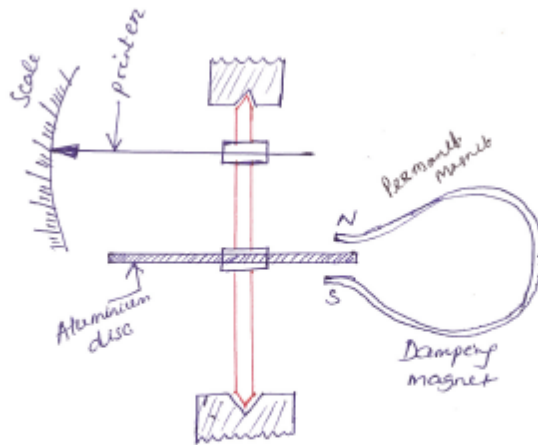


Fig. 1.6 Disc type

An aluminum circular disc is fixed to the spindle (Fig. 1.6). This disc is made to move in the magnetic field produced by a permanent magnet. When the disc oscillates it cuts the magnetic flux produced by damping magnet. An emf is induced in the circular disc by Faraday's law. Eddy currents are established in the disc since it has several closed paths. By Lenz's law, the current carrying disc produces a force in a direction opposite to oscillating force. The damping force can be varied by varying the projection of the magnet over the circular disc.

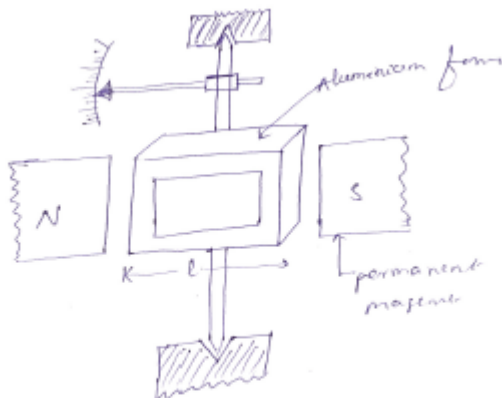


Fig. 1.6 Rectangular type

1.7 Permanent Magnet Moving Coil (PMMC) instrument

One of the most accurate type of instrument used for D.C. measurements is PMMC instrument.

Construction: A permanent magnet is used in this type instrument. Aluminum former is provided in the cylindrical in between two poles of the permanent magnet (Fig. 1.7). Coils are wound on the aluminum former which is connected with the spindle. This spindle is supported with jeweled bearing. Two springs are attached on either end of the spindle. The terminals of the moving coils are connected to the spring. Therefore the current flows through spring 1, moving coil and spring 2.

Damping: Eddy current damping is used. This is produced by aluminum former.

Control: Spring control is used.

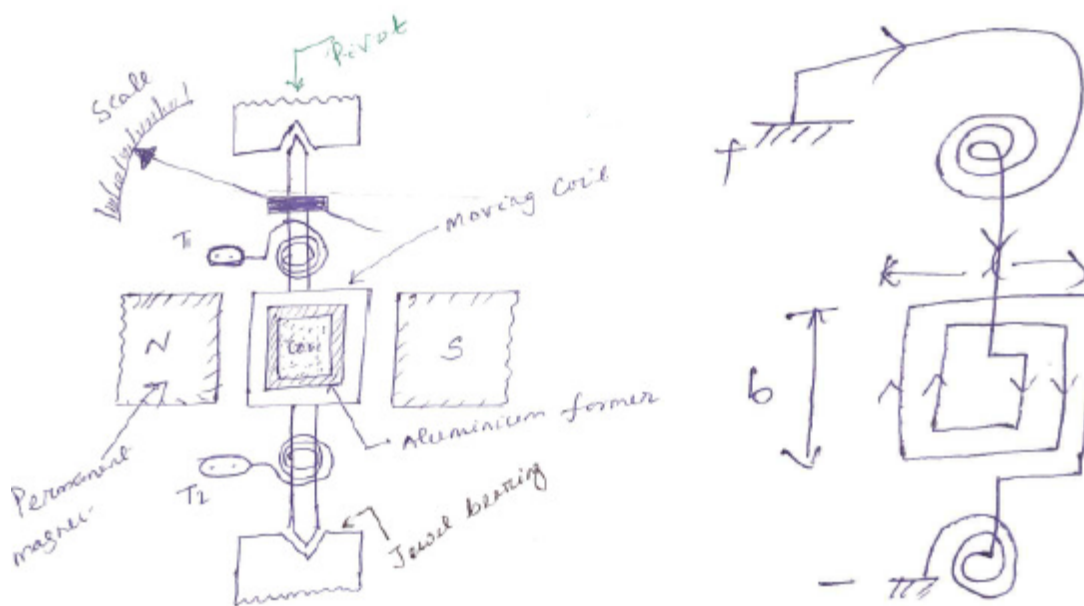


Fig. 1.7

Principle of operation

When D.C. supply is given to the moving coil, D.C. current flows through it. When the current carrying coil is kept in the magnetic field, it experiences a force. This force produces a torque and the former rotates. The pointer is attached with the spindle. When the former rotates, the pointer moves over the calibrated scale. When the polarity is reversed a torque is produced in the opposite direction. The mechanical stopper does not allow the deflection in the opposite direction. Therefore the polarity should be maintained with PMMC instrument. If A.C. is supplied, a reversing torque is produced. This cannot produce a continuous deflection.

Therefore this instrument cannot be used in A.C.

Torque developed by PMMC

Let T_d = deflecting torque

TC = controlling torque

q = angle of deflection

K = spring constant

b = width of the coil

l = height of the coil or length of coil

N = No. of turns

I = current

B = Flux density

A = area of the coil

The force produced in the coil is given by

$$F = BIL \sin\theta \quad (1.4)$$

When $\theta = 90^\circ$

$$\text{For } N \text{ turns, } F = NBIL \quad (1.5)$$

$$\text{Torque produced } T_d = F \times \perp_r \text{ distance} \quad (1.6)$$

$$T_d = NBIL \times b = BINA \quad (1.7)$$

$$T_d = BANl \quad (1.8)$$

$$T_d \propto I \quad (1.9)$$

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

1.7.1 Extension of range of PMMC instrument

Case-I: Shunt

A low shunt resistance connected in parallel with the ammeter to extend the range of current. Large current can be measured using low current rated ammeter by using a shunt.

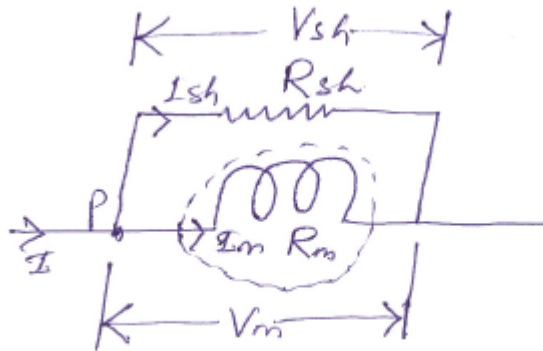


Fig. 1.8

Subject-EMAMI

Let R_m = Resistance of meter

R_{sh} = Resistance of shunt

I_m = Current through meter

I_{sh} = current through shunt

I = current to be measure

$$\therefore V_m = V_{sh} \quad (1.10)$$

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

$$\frac{I_m}{I_{sh}} = \frac{R_{sh}}{R_m} \quad (1.11)$$

Apply KCL at 'P' $I = I_m + I_{sh}$ (1.12)

Eqⁿ (1.12) ÷ by I_m

$$\frac{I}{I_m} = 1 + \frac{I_{sh}}{I_m} \quad (1.13)$$

$$\frac{I}{I_m} = 1 + \frac{R_m}{R_{sh}} \quad (1.14)$$

$$\therefore I = I_m \left(1 + \frac{R_m}{R_{sh}} \right) \quad (1.15)$$

$\left(1 + \frac{R_m}{R_{sh}} \right)$ is called multiplication factor

Shunt resistance is made of manganin. This has least thermoelectric emf. The change in resistance, due to change in temperature is negligible.

Case (II): Multiplier

A large resistance is connected in series with voltmeter is called multiplier (Fig. 1.9). A large voltage can be measured using a voltmeter of small rating with a multiplier.



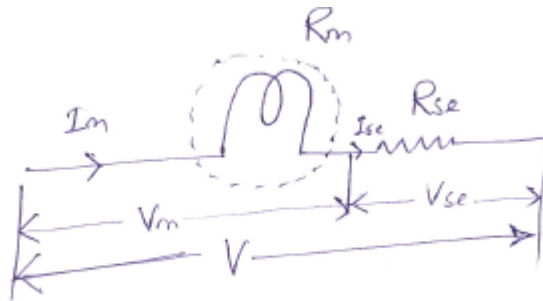


Fig. 1.9

Let

R_m = resistance of meter

R_{se} = resistance of multiplier

V_m = Voltage across meter

V_{se} = Voltage across series resistance

V = voltage to be measured

$$I_m = I_{se} \quad (1.16)$$

$$\frac{V_m}{R_m} = \frac{V_{se}}{R_{se}} \quad (1.17)$$

$$\therefore \frac{V_{se}}{V_m} = \frac{R_{se}}{R_m} \quad (1.18)$$

Apply KVL, $V = V_m + V_{se}$ (1.19)

Eqⁿ (1.19) $\div V_m$

$$\frac{V}{V_m} = 1 + \frac{V_{se}}{V_m} = \left(1 + \frac{R_{se}}{R_m} \right) \quad (1.20)$$

$$\therefore V = V_m \left(1 + \frac{R_{se}}{R_m} \right) \quad (1.21)$$

$$\left(1 + \frac{R_{se}}{R_m} \right) \rightarrow \text{Multiplication factor}$$