UNIT – 2

SIGNAL RECORDERS

Permanent magnet moving coil type (PMMC)

Moving Coil Instruments

- Moving coil instruments (ammeter and voltmeter) are of two types:

1. Permanent magnet moving coil type (PMMC) used only for D.C.

Operation of Indicating Instruments

- For satisfactory operation of any indicating instrument, following three torques must act together appropriately:

1. Deflecting torque
2. Controlling torque
3. Damping torque

Continued…

1. **Deflecting Torque:**

- It causes the moving system of the instrument to move from its position of rest.
- Deflecting torque is produced by using any one of the following effects of electric current:
  - i. Magnetic effect
  - ii.Electromagnetic induction effect
  - iii.Heating effect
  - iv.Electrostatic effect

Continued…

2. Controlling Torque:

- It limits the movement of moving systems. It also ensures that magnitude of deflection is always the same for the given value of input quantity under measurement.
- Controlling torque acts in the opposite direction to that of the deflecting torque.
- At steady state,

Deflecting torque = Controlling torque

Continued…

3. Damping Torque:

- Due to deflecting torque, pointer moves in one direction while due to controlling torque pointer moves in opposite direction.
- Due to these opposite torques, the pointer may oscillate in the forward and backward direction if the damping torque is not present.
- Damping torque brings the moving system to rest quickly in its final position.
- Damping torque acts only when the moving system is actually moving. If moving system is at rest, damping torque is zero.

Continued…

- **Critical Damping:**

➢ Depending on the magnitude of torque, damping may be classified as underdamped, overdamped or critically damped. Effect of damping on the deflection of the instrument is shown in fig.(1).

➢ If the instrument is underdamped, the pointer will come to rest after some oscillations.

➢ If the instrument is overdamped, pointer takes considerable time to obtain its final deflected position.

➢ If the damping is critical, without oscillation and in short time the pointer reach its final steady position.

Continued…

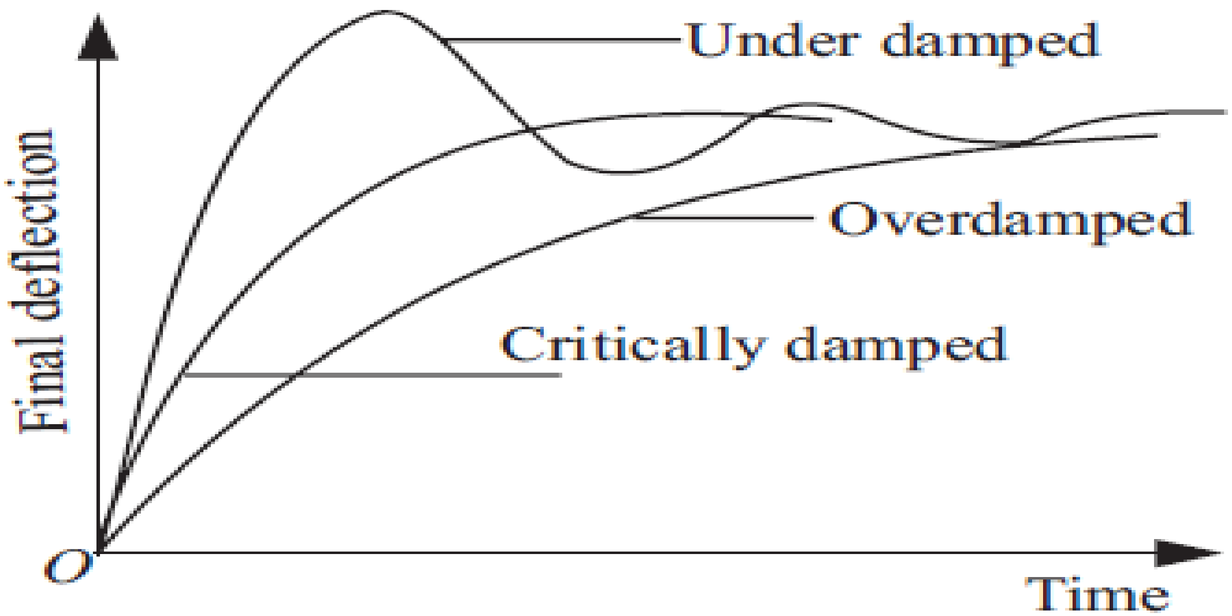
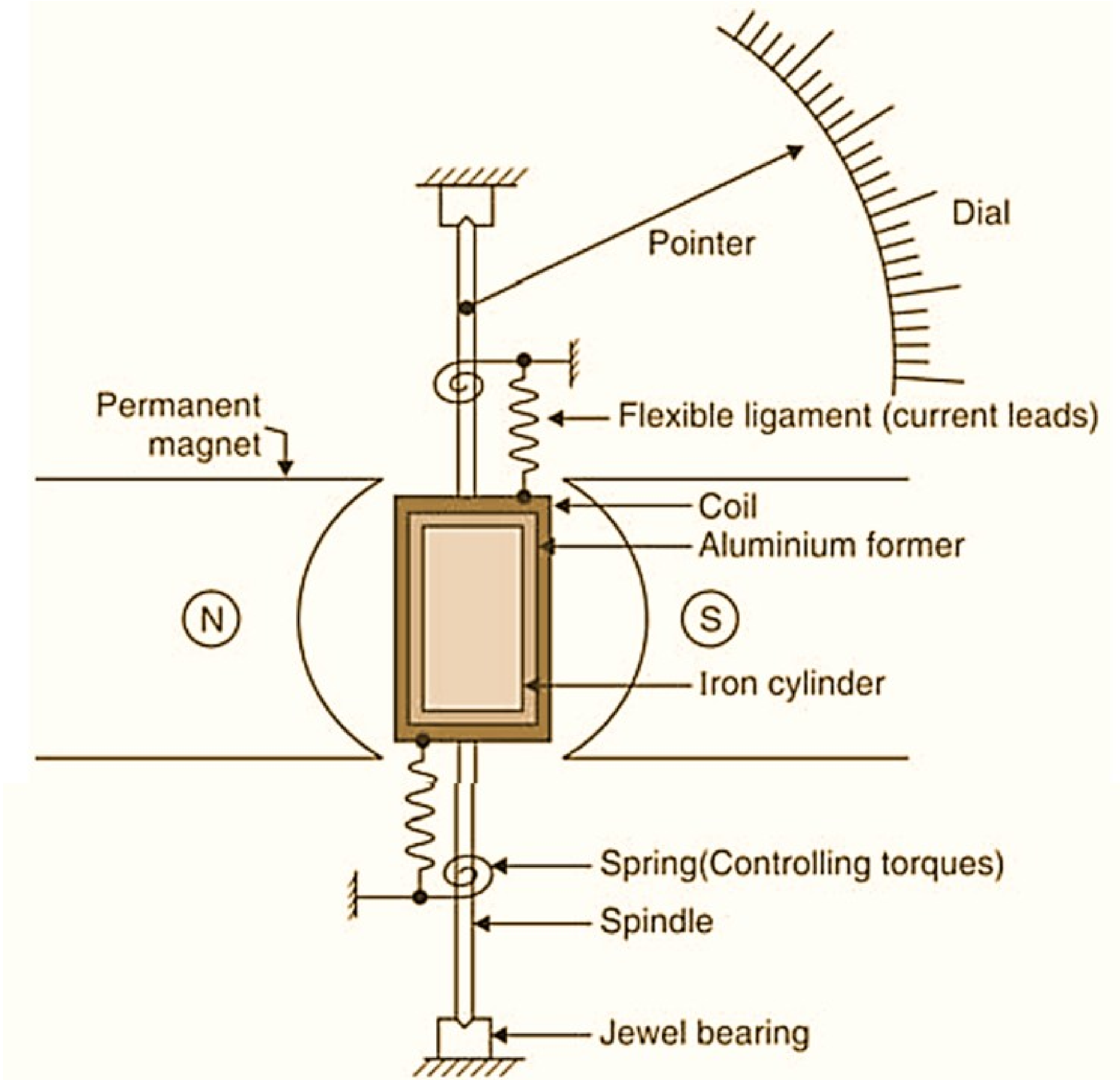


Fig.(1): Effect of damping on the deflection of instrument

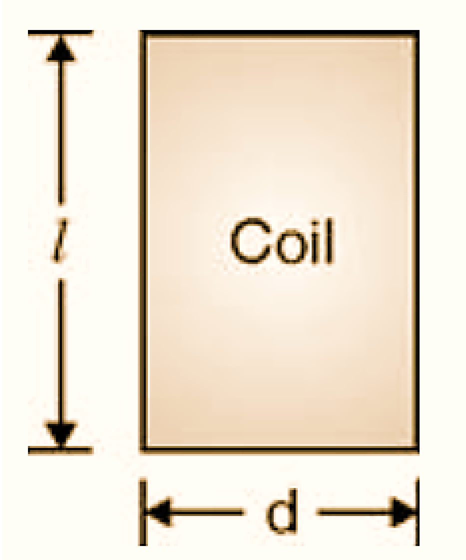


Permanent magnet moving coil type (PMMC)

PMMC Instrument Parts, Material and their Functions

Name of part	Material	Function
Permanent magnet	Ferromagnetic	To produce magnetic flux
Iron cylinder	Magnetic	To strengthen magnetic flux linkage
Coil	Copper	To carry current and produce deflection
Former	Aluminium	To support coil and to produce damping torque.
Spindle	Steel	To support the coil and to provide means for rotation.
Flexible ligament	Thin steel strips	To provide connection between meter terminal and coil.
Spring	Phospher bronze	To provide leads for incoming and outgoing connection to coil, To produce controlling torque.
Pointer	Aluminium	To show reading on calibrated scale.

Derivation of Torque Equation of PMMC Instrument



l – Length of the coil in meters
B — Flux density in air gap in Tesla
d – Width of coil in meters
i – Current through moving coil in Amp
k – Spring constant in Nm/rad
θ – Final state deflection in rad
α – Angle between direction of magnetic field and velocity vector of moving coil for radial field.

Expression for force on each coil side given by,

$$=N\,Bi\,l\sin\alpha$$

Due to radial flux the coil cuts flux at 90º always

$$\alpha=90^\circ$$

$$\text{Force} = N\,Bi\,l \ \text{........since}\ \alpha=90^\circ$$

Deflecting torque

$$T_d=(N\,Bi\,l)\times(d)=N\,\text{Bi A} \ \ldots(A=l\times d)$$

N, B, A are constants in instrument

$T_d = N\,B\,Ai = Gi$

Where,
G = NBA known as displacement constant
Controlling torque is provided by means of spring,

$T_c = k\theta$

Where k is spring constant unit : Nm / rad
θ= Final steady deflection in rad.

At final steady deflection

$T_c = T_d \; k\theta = Gi$
$\theta = Gik$

Thus deflection is proportional to i that is why scale is uniform.

Continued…

1. **PMMC Instruments:**

- ➢ They are also known as d'Arsonval instruments.
- ➢ These instruments works on the electromagnetic effect of current.
- ➢ A permanent magnet used to produce magnetic flux and coil that carries the current to be measures moves in this field.

Continued…

- **Working principle:**
- When a current carrying conductor is placed in a magnetic field, it experiences a force. It is given by expression,

$$F = BIL$$

Where F = Force in Newton,

B = Flux density is tesla,

I = Current is ampere,

L = Length of conductor in meter.

- The current I which is to be measured is passed through the moving coil and experiences a force which is directly proportional to this current.
- Due to this force the coil moves and the pointer attached to it will also move.
- The angle through which the pointer moves is proportional to current I.

Continued…

- **Construction of PMMC instrument:**

➢ A coil of thin wire is mounted on an aluminum frame (spindle) positioned between the poles of a U shaped permanent magnet which is made up of magnetic alloys like alnico.

➢ The coil is pivoted on the jewelled bearing and thus the coil is free to rotate. The current is fed to the coil through spiral springs which are two in numbers.

➢ The coil which carries a current, which is to be measured, moves in a strong magnetic field produced by a permanent magnet and a pointer is attached to the spindle which shows the measured value.

Continued…

- **Deflecting Torque:**

➢ It can be proved that the expression for the deflecting torque is given by,

$$T_d = G \times I$$

where G = constant

I = Current through the moving coil

- **Controlling Torque:**

➢ The controlling torque is given by,

$$T_c = C.\ \theta$$

where C = Control spring constant in N-m/rad

θ = Deflection of coil from zero position

Continued…

- For steady state, the controlling torque is equal to the deflection torque

$$\therefore T_c = T_d$$

$$\text{i.e. } C\theta = GI$$

$$\therefore \theta \propto I$$

- Thus deflection of the pointer is proportional to current passed through the coil.