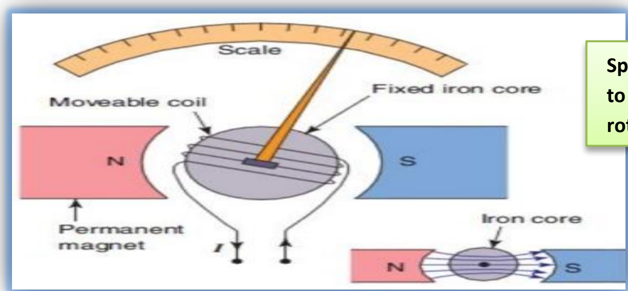
Qualitatively describe the application of the motor effect in;

- **The Galvanometer**
- **The Loudspeaker**

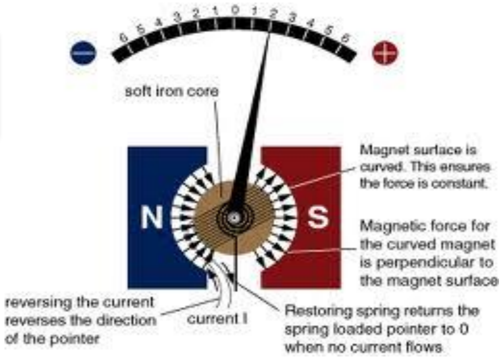
The Galvanometer:

- **Galvanometers utilise the motor effect to measure magnitude and direction of DC passing through a particular point in a circuit**
- **Consists of a rotor (attached to a sprint and pointer) and a scale, surrounded by stator**
- **The rotor has external electrical input and is wound around a soft iron core to increase the B field strength, which increases magnitude of force and torque produced. By increasing the magnitude of the force, the soft iron core allows for more precise readings**

A coil of wire is placed in an external magnetic field thus it experiences a force as current flows through it (motor effect F=nBILsinθ). Hence it experiences a torque making the coil and attached pointer rotate. The radial magnet ensures the magnetic field is always at right angles to the coil, and the plane of the coil is always parallel to the field, ensuring force and torque are uniform and maximum. This allows the scale of the pointer's movement to be linear/uniform as there is no cosθ (amount of deflection ∝ magnitude of current). The spring provides an opposition torque, balancing the torque created on the pointer and forcing the coil back to 0 when no current flows through. A larger current creates larger torque ($\tau \propto I$) thus moving the needle across scale more.



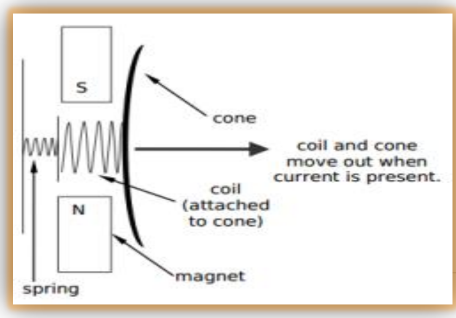
Spring is attached to axis to oppose rotation

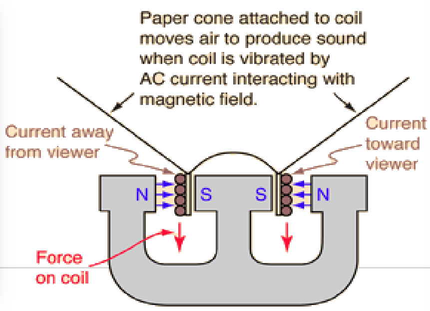


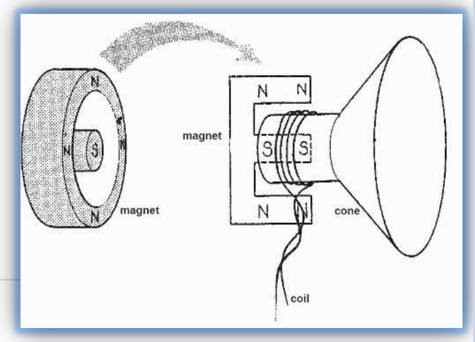
The Loudspeaker:

- **Loudspeakers utilise the motor effect to transform electrical energy into sound energy**
- **Consist of a circular magnet (with radial poles), with a moveable coil positioned in the middle of it → this wire is connected to an amplifier that produces an AC**

A coil is connected to an AC source and placed in an external magnetic field. Depending on AC input signal, it experiences a force either to the right or the left (motor effect). As coil is connected to a paper speaker cone, the cone vibrates producing longitudinal sound waves (what we eventually hear). The amplitude of the current fed through coil determines loudness of sound (F ∝ I). Frequency at which AC alternates determines rate which coil moves in and out & thus pitch of sound (higher frequency = higher pitched sound).Thus depending on nature of input AC (amplitude and frequency), different sounds can be produced by the motor effect.







Discuss how difficulties of heating caused by eddy currents in transformers may be overcome –

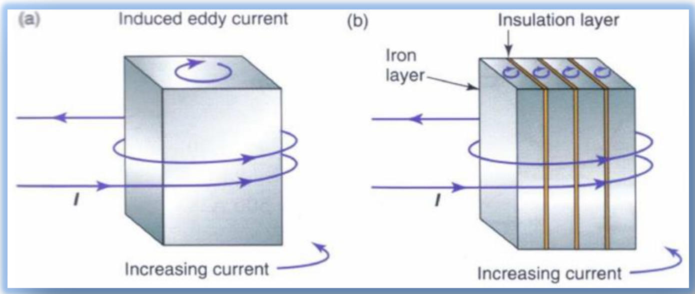
ISSUE: **Due to collisions between charge and atoms, eddy currents cause conversion of electrical energy to thermal energy, reducing efficiency. The thermal energy increases resistance of metal coils, causing more electrical energy to be converted to heat as current passes through the coil, reducing efficiency more. Thus strategies are used to reduce the production of eddy currents thereby maintaining good transformer efficiency.**

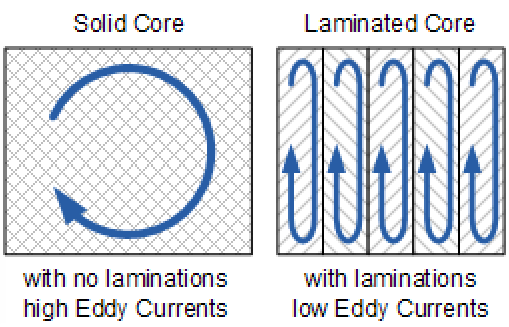
Production of Eddy Currents in Transformers:

- **Eddy currents are induced in the iron core, creating heat and reducing efficiency (EM Induction)**
- **Heating occurs because of the high resistance of the iron to the eddy currents. This heat causes power loss to the electrical system and excessive heat damages/destroys the transformer**

Overcoming these Eddy Currents:

- **Constructing the core from thin sheets of soft, laminated iron, rather than one solid piece:**
  - **The iron core is cut into many thin layers, laminated and then put back together**
  - **This reduces the size of eddy currents to 1 lamina as opposed to the whole core**
  - **Thus reduces energy losses due to eddy currents thus raising efficiency**
- **Using soft iron in the core rather than magnetic "hard" materials e.g. steel:**
  - **Soft iron has high magnetic permeability thus allowing magnetic field lines to pass through easily (acts like a 'guide')**
  - **Ensures maximum amount of flux lines cut the secondary coil → higher efficiency**
  - Iron is a ferrite → constructing transformers from ferromagnetic materials reduces the heating effect as they are magnetically permeable (Ferrites have low electrical conductivity thus prevents eddy currents and have very high magnetic permeability)
- **Winding the secondary coil on top of the primary coil:**
  - **Minimises distance flux has to travel to cut the secondary and hence induce an EMF → ensures a higher number of flux lines cut the secondary, increasing efficiency (minimises incomplete flux linkage)**





Keeping Transformers Cool to Prevent Overheating:

1. **Cooling fins on outside of transformer allow heat to dissipate faster over larger SA**
2. **Electric fan to assist air circulation and removes excess heat faster (thermostatically controlled → starts working when air gets to a certain temperature (e.g. 50°C)**
3. **Large transformers are located in well-ventilated areas to maximise airflow around them for cooling**