



Indian Inventions

Bhatnagar - Mathur Magnetic Interference Balance

The Bhatnagar-Mathur Magnetic Interference Balance is a scientific instrument invented in India in the 1930s by Dr Shanti Swarup Bhatnagar and Dr R. N. Mathur. It measures the magnetic susceptibility of materials, determining their attraction or repulsion by a magnetic field. The balance uses light interference and magnetic force to detect and measure these forces.

The invention was a significant achievement in experimental magnetochemistry, providing more accurate and reliable measurements than earlier methods like Gouy's balance. It also showcased India's growing strength in scientific research and instrument development. The Bhatnagar-Mathur balance is crucial in chemistry, physics, and material science, helping scientists study and understand the magnetic behavior of substances.

Inventors and Their Contributions

- **Dr Shanti Swarup Bhatnagar** - Founder Director of CSIR and pioneer of Indian scientific research.
- **Dr R. N. Mathur** - Collaborator and expert in magnetochemistry.

Their invention brought **international recognition** to Indian science and demonstrated India's early innovation in scientific instrumentation.

What is Magnetic Susceptibility?

Magnetic susceptibility (represented by the Greek letter χ , "chi") is a property that shows how a material behaves in a magnetic field:

- Paramagnetic substances → are weakly attracted to a magnet.
- Diamagnetic substances → are weakly repelled by a magnet.

The Bhatnagar-Mathur Balance helps scientists measure this behavior very accurately.

Principle: The instrument operates on the principle of light interference combined with the **magnetic force acting on a substance** in a magnetic field. When a material is placed in a non-uniform magnetic field, it experiences a small force depending on its magnetic properties. This force causes a slight deflection, which is detected through the **interference pattern of light**.

Construction/Parts of the Apparatus

The main parts of the instrument are

- **Magnetic system:** Produces a strong magnetic field.
- **Sample holder:** Holds the sample material securely.
- **Balance arm or quartz fiber:** Detects very small deflections due to magnetic forces.
- **Optical interference system:** Measures the displacement using light interference fringes.
- **Telescope or scale:** Helps observe and record the movement accurately.

Working/Experimental Procedure

The sample is placed in the magnetic field. Depending on its magnetic nature, it experiences a force that slightly moves the balance arm. This movement shifts the interference fringes of light. The shift in fringes is measured carefully, and from it, the magnetic susceptibility of the material is calculated.

Formula and Calculations

The magnetic susceptibility (χ) is calculated using the relation:

$$\chi = \frac{F}{H \cdot \nabla H}$$

$$\chi = \frac{F}{H \cdot \nabla H}$$

where

- FFF = magnetic force on the sample,
- HHH = magnetic field strength,
- ∇H = gradient of the magnetic field.
- This gives a quantitative value of how strongly the sample is attracted or repelled by the magnetic field.

Types of Materials Studied

- **Paramagnetic materials:** Weakly attracted by a magnetic field (e.g., Fe^{3+} , Mn^{2+} salts).
- **Diamagnetic materials:** Weakly repelled by a magnetic field (e.g., Cu^{2+} complexes, organic compounds).

Advantages

- **Very high sensitivity and accuracy.**
- It can be used for both **solids and liquids**.
- Requires only a **small quantity of sample**.
- More reliable than older methods like Gouy's balance.

Limitations

- Needs careful calibration and alignment.
- Sensitive to vibrations and air currents.
- Only suitable for small and lightweight samples.

Applications

- Used to study the magnetic properties of chemical compounds.
- Helps determine oxidation states and bonding in transition metal complexes.
- Useful in material science and solid-state research.
- Commonly used in advanced chemistry and physics laboratories.