OPERATING INSTRUCTIONS

FOR

APPARATUS TO MEASURE
"e/m" BY BAR MAGNET METHOD
(THOMSON METHOD)
OMEGA TYPE EM- 30

Manufacturer & Exporters

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OMEGA TYPE EM - 30 has been designed to Measure "e/m" by Bar Magnet Method. This is a versatile but simple apparatus to measure the value of e/m experimentally. The unit employs Thomson's method and hence the working is simple.

FEATURES

- The apparatus consists of the following :

1. Cathode Ray Tube.
2. High Voltage Power supply for C.R.T. and D.C. Volts for deflection of Electron Beam
3. Voltmeter to Read Voltage
4. Three Wooden stands
5. Magnetometer.
6. Bar Magnets and Centimeter Scales.
7. Tube is mounted on a wooden stand which has a grove cut at its bottom to fit into another stand with platform for placing two bar magnets. The third wooden stand provides a platform for magnetometer for measuring the magnetic field along with the axis of the Cathode Ray Tube.
8. The deflection can be measured with sufficient accuracy on the perpex centimeter scale provided with the Cathode Ray Tube.
9. The Magnetic Field required for Magnetic Deflection of the Electro Beam is produced by two bar magnets

CATHODE RAY TUBE CHARACTERISTICS

1	Cathode	:	Unipotential oxide
2	Heater Voltage	:	6.3 Volts AC or DC
3	Heater Current	:	0.15 ± 0.015 Amp
4	Focusing Method	:	Electrostatic
5	Deflection Method	:	Electrostatic
6	Phosphor		
	Fluorescence	:	Green
	Persistence	:	Medium

CAUTION

1. The breaking of the Cathode Ray Tube may cause explosion and result in personal injury from flying glass particles. Utmost care should, therefore, be taken when handling the tube.
2. Dangerous potentials as high as 1000V are employed in the power supply unit. They should be treated with proper care
3. **POWER REQUIREMENT** : 230V ± 10% at 50 Hz A.C. Main

THEORY

The apparatus used to calculate e/m of electron is shown in Fig.1. It consists of a cathode ray tube (CRT) which is highly evacuated to eliminate collisions of electrons with air molecules. C and A are the electrodes and A_1 and A_2 are the slits that collimate the electrons. A pair of deflecting plates M and N are placed symmetrically around the path of the electrons.

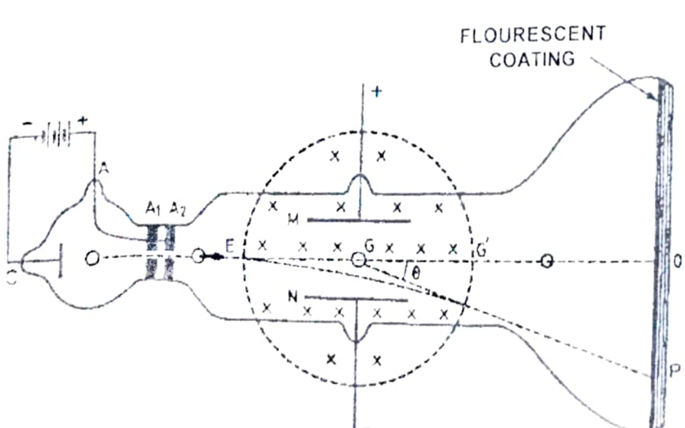

FIG. 1 CATHODE RAY TUBE

Uniform magnetic field is applied in the region where electric field is produced by the deflecting plates. The electric field, magnetic field and the electron path are mutually perpendicular.

The inner surface of the discharge tube at the right end is coated with a fluorescent material. The electron strike the screen and produce a glow at point O on the screen when the electric and magnetic fields are not switched on. Under the action of magnetic field alone, the electrons are deflected downward. Initially only the magnetic field B is switched on. The electron experience a force which is equal to centripetal force

$$evB = \frac{mv^2}{R}$$ (R is the radius of circular arc)

$$\frac{e}{m} = \frac{v}{BR} \qquad \text{.......... (1)}$$

Now the electric field E is switched on. Then

$$eE = evB \qquad v = \frac{E}{B} \qquad \text{.......... (2)}$$

$$\frac{e}{m} = \frac{E}{B^2R} \qquad \text{.......... (3)}$$

In fig. 2 the path of electrons is shown as in the circular arc EP, CE and CF are radii of the circular ar[illegible]

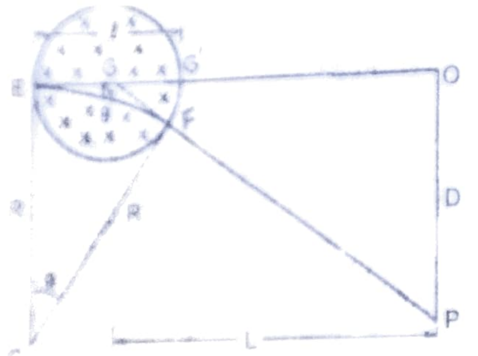

FIG. 2 PATH OF AN ELECTRON

[illegible] figure it is seen that ∆CEG and OGP are similar

.... (4)

Where E = Electric field

d = separation between the deflecting plates

V = applied voltage

ℓ = length of the deflecting plates

B = applied magnetic field

L = distance of the screen from the edges of the Y- plates

D = total deflection of the spot on the screen

B = applied magnetic field

Where V in volts, B in Tesla and D, L, ℓ and d in meters. e/m is in coulomb / kg.

PANEL DESCRIPTION

1 Power Switch, fuse and neon bulb:-

On the front panel of the power supply there is a power switch, power switch is located on the left hand side marked POWER on the top.

Fuse is located just above the power ON/OFF switch for protection of power supply to sudden change in line voltage.

Neon jewel light is located above the fuse holder. When the power switch is at 'ON' position, the jewel light will glow, Indicating that the Instrument is ready for use.

2 *CONTROLS*

There are four controls on the front panel of the power supply. These are located on the right hand side of the voltmeter marked as DEFLECTION, X SHIFT, BRILLIANCE and FOCUS.

2.1 *DEFLECTION CONTROL (y - shift)*

It is located at the lower right hand side of the voltmeter, this control is used for shifting the spot on the screen along Y-axis. A voltmeter of 50V-0-50V is provided to read the Y-deflecting voltage

2.2 *X SHIFT CONTROL*

It is located at the above side of y - shift deflection control. It is used for shifting the spot on the screen along X-axis.

2.3 *BRILLIANCE CONTROL*

It is located at right hand side of x shift control. It is used for charging the Brightness of spot on CRT screen. Brightness of spot is increased when the control is rooted clockwise direction.

2.4 *FOCUS CONTROL*

It is located at left Hand Side of Brilliance control. It is used for focus the spot. Just below the focus control two terminals Red and Black for measuring the Accelerating voltage. Octal valve base marked as CR TUBE is located in the right hand bottom corner.

An PIN plug (PM-8) supplied with CRT to insert in this octal valve base which will feed the appropriate voltage to the CRT.

PROCEDURE

The wooden frame & the wooden bench are coupled together as shown in Fig. 3. A magnetometer is kept on the wooden bench such that the 90° – 90° diameter of its circular scale is parallel to the length of the bench

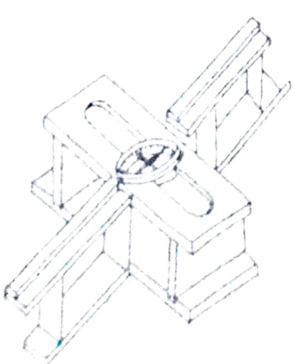

FIG. 3 FINDING OUT MAGNETIC MERIDIAN

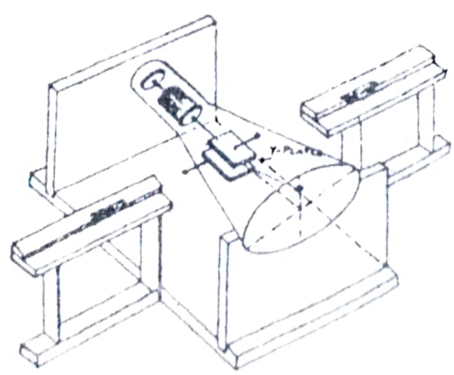

FIG. 4 ARRANGMENT OF APPARATUS FOR e/ EXPERIMENT

The entire set up is oriented such that the pointer of the magnetometer coincides with 0°–0° markings
2 This setting ensures that when CRT is placed instead of the wooden bench, the electron beam will travel along the magnetic meridian. As a result the horizontal component of the earth's magnetic field will be ineffective to influence the electron beam. Once the position is adjusted, it is left undisturbed till the experiment is completed.

3 The wooden bench is removed and the CRT is introduced in its place as shown in Fig. 4. The CRT is connected to the power supply. The power supply is switched on. Adjusting the intensity and focus controls, a spot of sufficient brightness is obtained using X – and Y – shift controls it is brought to the centre of screen.

4 Now apply a suitable deflecting voltage so that the luminous spot is deflected by about 0.5 to 1.0 cm. Note the deflecting voltage V and the position of the spot. Measure the distance through which the spot has moved and let it be D.

5 Place the bar magnets symmetrically on either side of the cathode ray tube along the arms of the wooden stand on which the tube is fitted such that their opposite poles face each other and their common axis is exactly at right angles to the axis of the cathode ray tube. Adjust the polarity as well as the distance of the magnets so that the luminous spot comes back to its initial position. When the adjustment is perfect note the distance of the poles of the magnets on the side nearer to the cathode ray tube. Let the distance be r_1 and r_2

6 Remove the bar magnet, switch off the electric field applied to the deflecting plates and again note the initial position of the luminous spot. Reverse the polarity of the potential difference applied to the electric deflecting plates thereby reversing the electric field. Again note the final position of the luminous spot and calculate D.

Again place the bar magnets on the arms of the wooden stand as in the previous step and adjust their polarity as well as distance so that the spot comes back to its initial position. When the adjustment is perfect again note the distances of the poles of the magnets on the side nearer to the cathode ray tube. Let the distance be r_1' and r_2'. Switch off the power supply.

7 To find the value of the magnetic field B, carefully remove the magnets and the cathode ray tube from the wooden stand. Place the compass box such that its centre lies exactly on the point where the common axis of the bar magnets and the axis of the cathode ray tube interest. Rotate the compass box about its vertical axis so that the pointer lies along the 0–0 line.

Place the magnets exactly in the same position as in step 5 at distances r_1 and r_2. This produces a deflection in the magnetometer compass box and the two ends of the pointer give the deflection. Let the readings be θ_1 and θ_2.

Now place the magnets exactly in the same positions as in step 6 at distances r_1' and r_2' again note the deflections θ_1' and θ_2' from the two ends of the pointer of the compass box. The mean of these four deflections θ_1, θ_2, θ_1' and θ_2' gives the mean deflection θ. If B_H is the horizontal component of earth's magnetic field then

$$B = B_H \tan\theta$$

Where B_H is the earth's horizontal component of the field. It is different at the different places (see Annexure - I) for B_H value at different places.

8 Take two more sets of observations by changing the value of V and hence that of the electric field.

Note :

As value of $\tan\theta$ at 0° is 0 and at 90° it is ∞, so keep bar magnets at such a distance at which deflection of magnetometer is near about 45° to get the best results. Also take readings 8 times of θ_1 and θ_2 by maintaining same distance and take the mean value of θ.

The 8 positions are :

1. Two bar magnets at a distance to give deflections of about 45° and take readings of θ_1 and θ_2
2. Keep the two bar magnets upside down and take readings of θ_1 and θ_2
3. Change the polarity of both the bar magnets and take readings of θ_1 and θ_2
4. Repeat step no. 2
5. Interchange the two bar magnets from one side to the other and take readings of θ_1 and θ_2
6. Repeat step no. 2
7. Repeat step no. 3
8. Repeat step no. 2.

Observations

Length of the deflecting plates l = 0.045 metres

Separation between the deflecting plates d = 0.0245 metres

Distance of the screen from the edges of the Y- plates L = 0.125 metres

Horizontal component of earth's field B_H = Wb/sq m (Tesla)

Sl No	Applied Voltage V	DIRECT FIELD							REVERSED FIELD						
		Position of Spot			Magnetic Pole and Distance				Position of Spot			Magnetic Pole and Distance			
		Initial	Final	Deflection D in met	Pole	r_1	Pole	r_2	Initial	Final	Deflection D in met	Pole	r_1	Pole	r_2
1	V_1 =			D_1 =							D_1 =				
2	V_2 =			D_2 =							D_2 =				
3	V_3 =			D_3 =							D_3 =				

For determination of B

Sl No	Applied Voltage V	Reading of two ends of pointer when magnetic poles are at r_1 and r_2		Reading of two ends of pointer when magnetic poles are at r_1' and r_2'		Mean θ	$B=B_H \tan\theta$
		θ_1	θ_2	θ_1'	θ_2'		
1	V_1						B_1
2	V_2						B_2
3	V_3						B_3

Calculations

(1) $e/m = \frac{V_1 D_1}{L\, d\, B_1^2}$ = Ckg^{-1}

(2) $e/m = \frac{V_2 D_2}{L\, d\, B_2^2}$ = Ckg^{-1}

(3) $e/m = \frac{V_3 D_3}{L\, d\, B_3^2}$ = Ckg^{-1}

Mean (e/m) = Ckg^{-1}

REFERENCE :

B.Sc. Practical Physics : By C. L. ARORA

Eng. Practical Physics : By NAVNEET GUPTA

ANNEXURE - 1

Place	Horizontal component $B_H \times 10^{-4}$ tesla
Agra	0.358
Ajmer	0.358
Allahabad	0.370
Amritsar	0.300
Bangalore	0.405
Bombay	0.372
Calcutta	0.389
Delhi	0.350
Hyderabad (Deccan)	0.397
Lahore	0.330
Lucknow	0.362
Ludhiana	0.335
Nagpur	0.385
Patna	0.373
Jaipur	0.347
Kanpur	0.363
Meerut	0.339
Varanasi	0.364
Aligarh	0.356
Deharadun	0.332
Gwalior	0.353
Gorakhpur	0.358

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ACCESSORIES : NIL.

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