CENTRAL SCIENTIFIC COMPANY

OPERATING INSTRUCTIONS

e/m Complete Unit, Fine Beam Method
No. 32053

1. Introduction

The e/m Complete Unit, Fine Beam Method (32053), makes it possible to determine the charge-to-mass ratio of the electron, based on the path of an electron beam in a magnetic field. The tube may also be used to study other aspects of electron beam behavior, such as:

- mean free path and unstable beams
- velocity of focusing and gas multiplication
- primary and higher orders of ionization
- secondary emission and phosphor screen “blanking”
- plasma technology

2. Description

The apparatus consists of the Universal Stand (31307), a pair of Helmholtz coils (31308), and a gas-filled double beam tube. The tube contains two adjacent, independent diode electron guns. The guns project narrow electron beams diametrically across and tangential to the spherical bulb. Helium at low pressure, contained in the tube, makes it easy to follow the path of the diametrical beam; green light is given off as electrons collide with the helium atoms.

Heaters for the gun cathodes are connected to a two-way switch and two 4mm sockets, located in the base cap. These heaters should be connected to the filament output of a power supply such as the Discharge Tube Power Supply (31384). The angle of projection of the beams from the guns can be modified by applying a potential across miniature deflection plates, located just past the emission apertures. Plastic caps mounted on the neck of the tube contain 4mm plugs for connection of the anode and of the deflector.

The end of the tube directly across from the electron guns is coated with a luminescent screen.

The Universal Stand is included for supporting the tube. Gray plastic jaws, 16cm long and 14cm apart, hold the sides of the bulb securely. These jaws may be rotated 360° around their horizontal axis. They are constructed of a durable, heat-resistant material that provides high electrical insulation in the regions where power supplies are connected to the apparatus.

The jaws are attached to a sturdy blue enameled stand, made of a light alloy. The base of the stand also has sockets for mounting the Helmholtz coils supplied with the apparatus. These coils create a uniform magnetic field within the experimental area. Each coil has 320 turns of 22-gauge enameled copper wire wound on a plastic form, 13.6cm in diameter. The coils are mounted on stainless steel support rods.

3. Assembly

Caution: High voltage is used to power this apparatus. Complete all assembly steps before plugging in or turning on the power supply. It is also important to observe all cautions listed with your power supply.

To mount the tube in the stand, begin by squeezing the jaws. With slight pressure, the jaws will open enough to allow insertion of the tube. When the tube is securely in place, release the pressure on the jaws and slide the jaw clamps forward, locking the tube in position.

The Helmholtz coils must also be assembled into the stand. They can easily be mounted in the holes in the base using the plastic sleeve which slides along the rod. Two 4mm sockets are located on the side of each coil.

Connect the power supply to each of the sockets marked **A**, with the Z sockets interconnected.

4. Operation

Caution: Always reduce the anode voltage to zero before switching on a heater supply.

Anode current used with this apparatus is determined largely by the temperature of the cathode. Some adjustment to the filament voltage of a particular gun may be advantageous. Voltage may be decreased to 5, for example, if this proves better for overall performance. In general, optimum operating voltages are as follows:

Filament voltage	6.3V, 0.3A
Anode voltage	0 to 300VDC, 30mA
Deflector voltage	0 to 25VDC

Additional voltage for the Helmholtz coils depends on the magnetic field. The field may be calculated as follows:

$$H = \frac{8n\,I}{\sqrt{125}\,r} \quad \frac{\text{amp}}{\text{meter}}$$

where **n** = number of turns (320)
r = mean radius (0.068m)
I = current in amps

The flux density may also be calculated:

$$B = \frac{32\pi\,n\,I}{\sqrt{125}\,r} \times \frac{10^{-7}\text{weber}}{m^2}$$

To obtain a continuous field of about 30 amp/m, an input of 12V and 1.0A should not be exceeded. The maximum short-duration field of 45 amp/m from an input of 18V and 1.5A should not be applied for more than 10 minutes.

Connect the Helmholtz coils as described above and attach them to the 0-20V jack on the power supply. Connect the deflector to the 80VDC source and the anode to the 0-600VDC output. The

filament should be connected to the filament supply. Use the circuit diagram below (Figure 1) as a guide to connecting the tube.

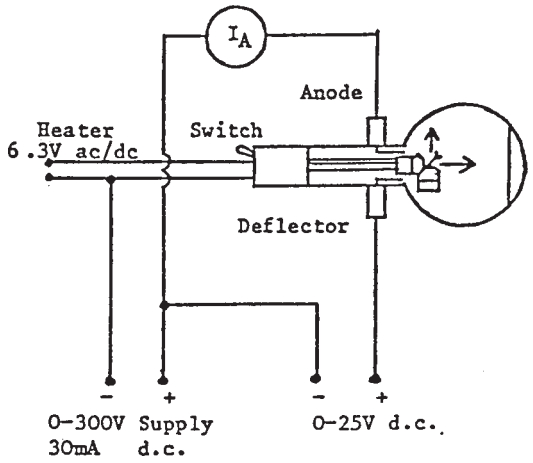

Figure 1

Be certain that the anode (0-600VDC) voltage is zero — the control knob should be turned counterclockwise as far as possible. The anode voltage should always be zero before any filament supply is activated. Turn on the power supply.

Allow at least one minute for the cathode to warm up. Gradually increase the voltage to the anode. The length of the electron beam depends on this voltage; about 100V is required to create a beam which reaches across the entire bulb. If the voltage is less than 100V, the phosphorescent screen on the far side of the bulb may not luminesce. In addition, due to charge buildup on the surface of the screen, luminescence may not be observed until the beam path is altered.

The anode current should always be monitored. Keep the current as low as possible while retaining good intensity and path length.

Proper electrical connection can be checked by deflecting the beam with a magnet. The negative lead should be connected to the common filament and cathode socket. If the connections are incorrect, the modulation of the anode voltage by the AC filament current will cause the beam to fan out slightly.

If the beam seems too diffuse or fuzzy, try applying a slight voltage between the deflector plates. This may enhance the sharpness of the beam. While a deflector voltage of 25V is suggested, higher voltages may be used.

Either straight or curved beams may be studied. The diametrical beam will be slightly curved due to the earth's magnetic field. The tangential beam, seen when the Helmholtz coils are activated, creates the circular path used to determine e/m. To measure the diameter of the curved path, adjust the field current and the anode voltage so that the beam touches the plane defined by the circular edge of the phosphor screen. The distance between this plane and the gun can be measured with a traveling microscope or by the mirror and ruler technique. If desired, the plane of the circular path can be adjusted by rotating the jaws of the Universal Stand within the coils.

5. Additional Experiments

Detailed descriptions of many experiments possible with the e/m Complete Unit are available in issues of The Physics Teacher. See issues from February through November 1984 and May 1985 for complete procedures.

6. Maintenance

The e/m Complete Unit should always be operated within the described parameters. Otherwise, it needs no special maintenance. If you should experience any difficulty with this apparatus, please contact Central Scientific Company, giving details of the problem. To ensure better service, please do not return any item to Central Scientific Company until we have sent you authorization.

7. Accessories

Description	Cat. No.
Discharge Tube Power Supply	31384

8. Copyright Notice

Revised 3/92