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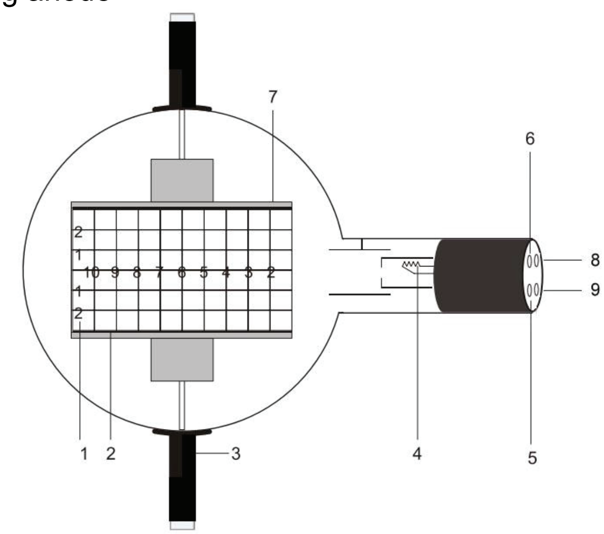
KSCI-DT Deflection Tube

1 Fluorescent screen
2 Lower deflection plate
3 Ø4mm sockets for connecting deflection plates
4 Electron gun
5 4-mm sockets for connecting anode
6 Grounding
7 Upper deflection plate
8 Ø4mm sockets for connecting filament (cathode)
9 Ø4mm sockets for connecting filament



1. Safety instructions

Hot cathode tubes are thin-walled, highly evacuated glass tubes. Treat them carefully as there is a risk of implosion.

- Do not subject the tube to mechanical stresses.
- Do not subject the connection leads to any tension.
- The tube only may be used with tube holder KSCI-THDR.

If voltage or current is too high or the cathode is at the wrong temperature, it can lead to the tube becoming destroyed.

- Do not exceed the stated operating parameters.

When the tube is in operation, the terminals of the tube may be at high voltages with which it is dangerous to come into contact.

- Only use safety experiment leads for connecting circuits.
- Only change circuits with power supply switched off.
- Set up or dismantle the tubes only when the power supply unit is switched off.

When the tube is in operation, the stock of the tube may get hot.

- Allow the tube to cool before putting away the apparatus.

The compliance with the EC directive on electromagnetic compatibility is only guaranteed when using the recommended power supplies.

2. Description

The deflection tube is intended for investigating the deflection of electron beams in electrical and magnetic fields. It can be used to estimate the specific charge of an electron e/m and to determine the electron velocity v. The deflection tube comprises an electron gun which emits a narrow, focused ribbon of cathode rays within an evacuated, clear glass bulb. A tungsten filament hot cathode is heated directly and the anode takes the form of a cylinder. The deflection of rays can be achieved electrostatically by means of a built-in plate capacitor formed by the pair of deflection plates or magnetically with the help of the Helmholtz coils P338002 magnetically. The cathode rays are intercepted by a flat mica sheet, one side of which is coated with a fluorescent screen and the other side of which is printed with a centimeter graticule so that the path of the electrons can be easily traced. The mica sheet is held at 15° to the axis of the tube by the two deflecting plates.

3. Technical data

Filament voltage: 6.3 V AC/DC
Max. anode voltage: 5000 V DC
Anode current: 0.1 mA approx. at 4000 V
Deflector plate voltage: 5000 V max.
Distance between plates: 54 mm approx.
Fluorescent screen: 90 mm x 60 mm
Glass bulb: 130 mm Ø approx.
Total length: 260 mm approx.
Weight: 0.3kg

4. Basic principles

4.1 Magnetic deflection

The path of the luminous beam is circular, the deflection being in a plane perpendicular to the electromagnetic field.
At fixed anode voltage the radius decreases with increasing coil current.
With a fixed coil current the radius increases with increasing anode potential, indicating a higher velocity.
An electron of mass m and charge e moving perpendicular to a uniform magnetic field B at velocity v is deflected by the Lorentz force B e v onto a circular path of radius r.

$$B \cdot e \cdot v = \frac{m \cdot v^2}{r} \qquad (1)$$

4.2 Electric deflection

An electron with velocity v passing through the electric field E produced by a plate capacitor held at a voltage U_P with a plate spacing d is deflected into the curved path of a parabola governed by the equation:

$$y = \frac{1}{2} \cdot \frac{e}{m} \cdot \frac{E}{v^2} \cdot x^2 \qquad (2)$$

where y is the linear deflection achieved over a linear distance x.

4.3 Calculating e/m and v

4.3.1 Means of magnetic deflection

The velocity is dependent on the anode voltage U_A such that:

$$v = \sqrt{2 \cdot \frac{e}{m} \cdot U_A} \qquad (3)$$

Solving equations 1 and 3 simultaneous gives the following expression for the specific charge e/m:

$$\frac{e}{m} = \frac{2 \cdot U_A}{(B \cdot r)^2} \qquad (4)$$

U_A can be measured directly, B and r can be determined experimentally.

4.3.1.1 Calculating r

The radius of curvature r is obtained geometrically as in Fig. 1:

$$r^2 = x^2 + (r - y)^2$$

so that: $$r = \frac{x^2 + y^2}{2y} \qquad (5)$$

4.3.1.2 Calculating B

The magnetic flux B of a magnetic field generated by the Helmholtz coils in Helmholtz geometry and the coil current I can be calculated:

$$B = \left(\frac{4}{5}\right)^{\frac{3}{2}} \cdot \frac{u_o \cdot n}{R} \cdot I = k \cdot I \qquad (6)$$

where k = in good approximation 4,2 mT/A with n = 320 (windings) and R = 68 mm (coil radius).

4.3.2 By means of electric deflection

e/m can be calculated from equation 2:

$$\frac{e}{m} = \frac{2y}{E} \frac{v^2}{x^2} \qquad (7)$$

where $E = \frac{U_P}{d}$

with U_P = deflector plate voltage and d = plate spacing.

4.3.3 By means of field compensation

The magnetic field compensates the deflection of the electron beam caused by the electric field:

$$e \cdot E = e \cdot v \cdot B$$

The velocity v can be calculated:

$$v = \frac{E}{B} \qquad (8)$$

where $E = \frac{U_P}{d}$. For the calculation of B refer to point 4.3.1.2.

The specific charge e/m can be calculated:

$$\frac{e}{m} = \frac{1}{2 \cdot U_A} \cdot \left(\frac{E}{B}\right)^2 \qquad (9)$$

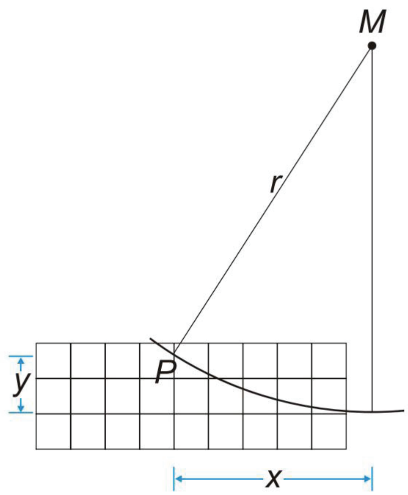


Fig.1 Determining r

5. Additionally required equipment

1 DC power supply	KSCI-SP303E
2 DC power supply	KSCI-HV5000A
1 Pair of Helmholtz coil	KSCI-HCL
1 Tube holder	KSCI-THDR

6. Operation

6.1 Setting up the tube in the tube holder

• The tube should not be mounted or removed unless all power supplies are disconnected.

• Insert the tube stock into the boss head of the tube holder, and let the tube in an appropriate position. Screw the boss head tightly.

• Plug in all leads correctly.

6.2 Removing the tube from the tube holder

• Disconnect all leads

• Unscrew the boss head and take the tube out.

6.3 Magnetic deflection steps

• Set up the tube as in Fig. 2. Connect the anode, the cathode and the filaments to high voltage power supply with test leads.

•Insert the Helmholtz coils into the holes of the tube holder and screw tight the heads to set up the coils in Helmholtz geometry.

• Turn on the high voltage power supply.

• energize the Helmholtz coils and observe the path of the beam.

6.4 Electric deflection steps

• Set up the tube as in Fig 3. Connect the anode, the cathode and the filaments to a high voltage power supply with test leads. Connect deflection plates to another high voltage power supply.

• Turn on the high voltage power supply.

• Switch on the deflector plate voltage and observe the path of the beam.

6.5 Calculate e/m and v

6.5.1 By means of magnetic deflection

• Set up the experiment as in Fig 2.

• Measure U_A, B and r, and then calculate e/m and v.

6.5.1.1 Calculate r

• Read out x and y from the scale and calculate r with equation 5.

6.5.1.2 Calculate B

• Calculate B with equation 6.

6.5.2 By means of electric deflection.

• Set up the experiment as in Fig 3.

• Calculate e/m with equation 7.

6.5.3 By means of field compensation

• Set up the experiment as in Fig 4.

• Turn on the high voltage power supply unit and deflect the beam electrically.

• Energize the Helmholtz coils and adjust the voltage in such a way that the magnetic field compensates the electric field and the beam is no longer deflected.

• Calculate B as 6.3.1.2, measure U_p and calculate E as $E = \frac{U_p}{d}$, calculate v with equation 8.

• Measure U_A, and then calculate e/m with equation 9.

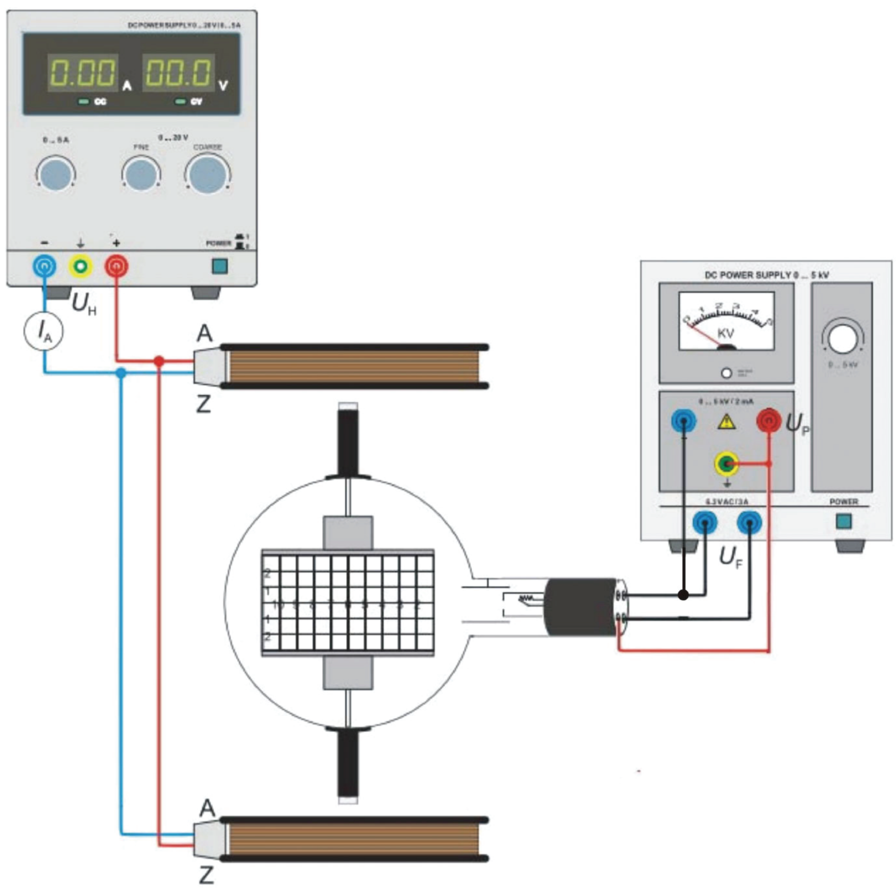


Fig.2 Magnetic deflection

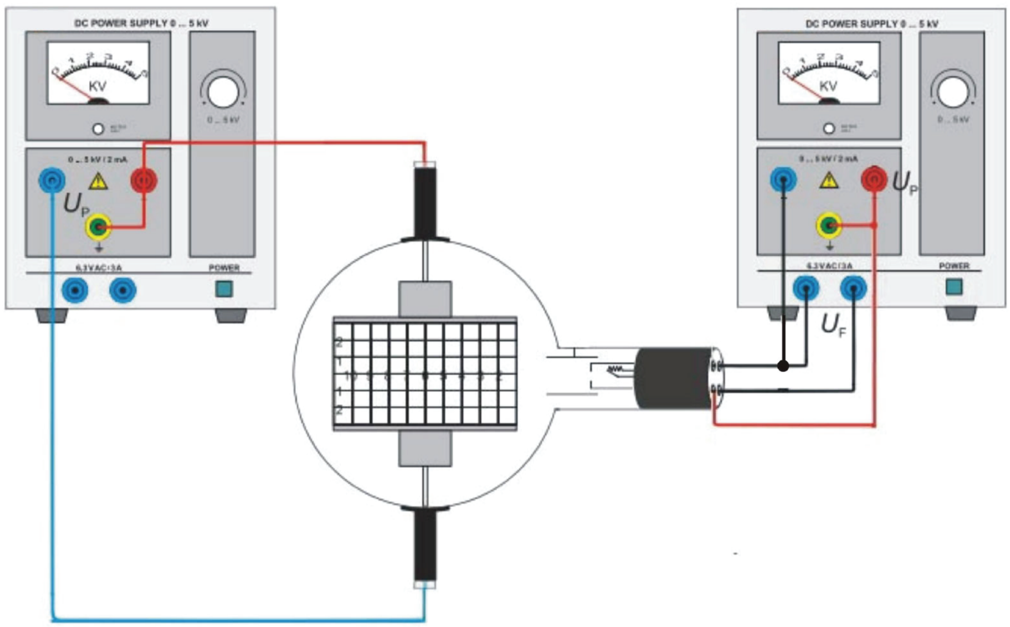


Fig.3 Electric deflection

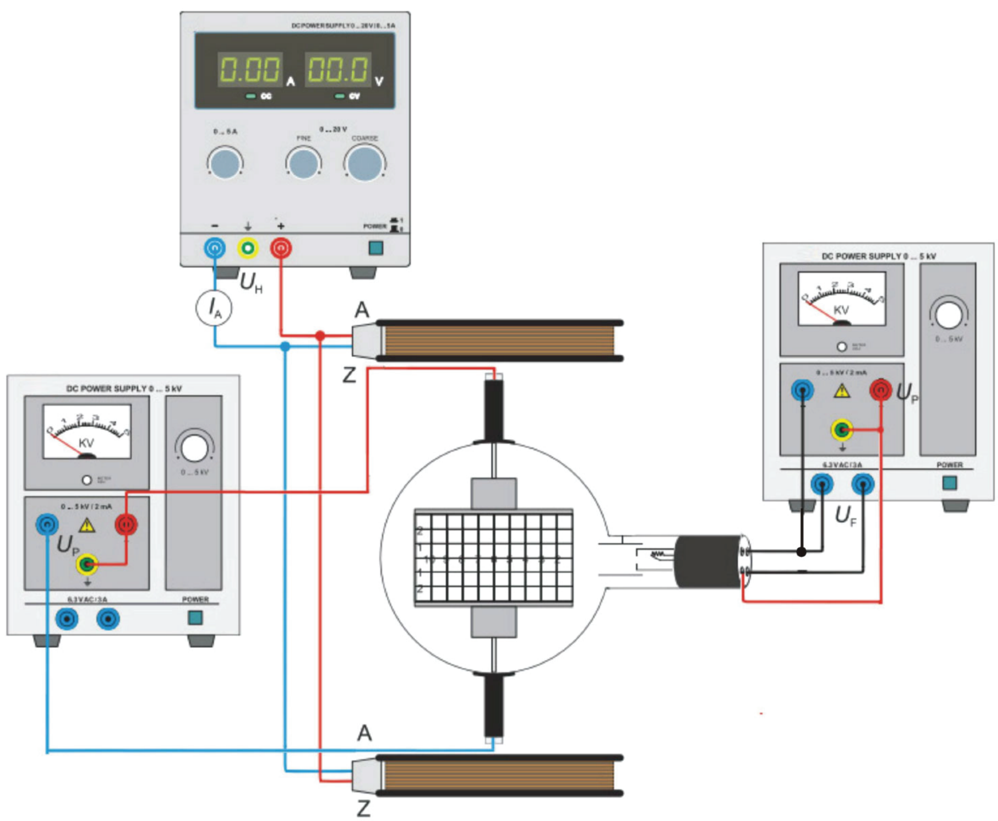


Fig.4 Determine e/m by means of field compensation