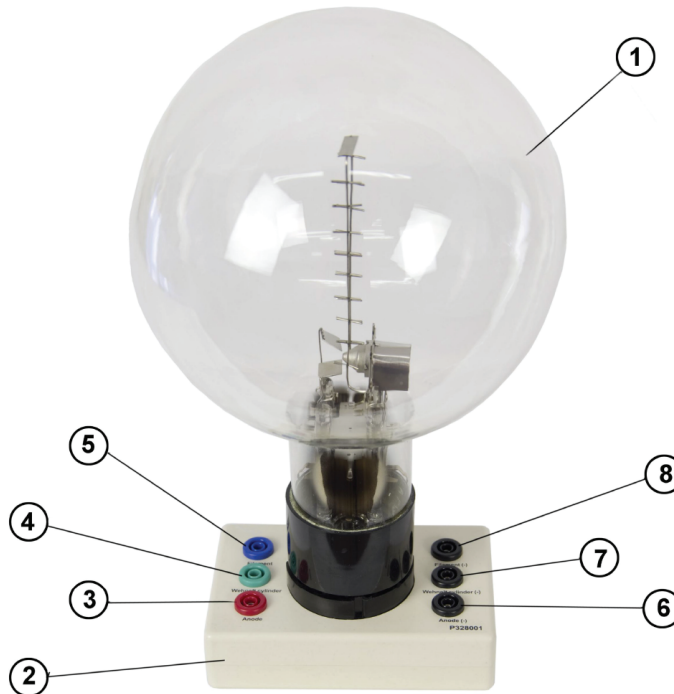


# KLINGER SCIENTIFIC

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## KSCI-FBTB Fine Beam Tube & Base

- |                                  |                                     |
|----------------------------------|-------------------------------------|
| 1 Fine beam tube                 | 5 Connector for filament (cathode)  |
| 2 Tube base                      | 6 Connector for anode(-)            |
| 3 Connector for anode            | 7 Connector for Wehnelt cylinder(-) |
| 4 Connector for Wehnelt cylinder | 8 Connector for 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.

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 Fine Beam Tube is used for investigating the deflection of cathode rays in a uniform magnetic field produced by a pair of Helmholtz coils (P338001). In addition, it can also be used for quantitative determination of the specific charge of an electron  $e/m$ .

Located inside a glass bulb with a helium residual gas atmosphere is an electron gun, which consists of an indirectly heated oxide cathode, a Wehnelt cylinder and a perforated anode. The gas atoms are ionized along the path of the electrons and a narrow, well-defined, luminescent beam is produced. Incorporated measurement marks facilitate a parallax-free determination of the diameter of the circular path of the beam deflected in the magnetic field.

The Fine Beam Tube is mounted on a base with colored connectors. In order to protect the tube, a protective circuit can be built into the base, which shuts off any voltage in excess of the base's preset cut-off voltage. The protective circuit prevents excessive voltages from damaging the heater filament and ensures a "smooth" switch-on response once the voltage is applied. (Optional function)

## 3. Technical data

Gas filling: Helium

Gas pressure:	$1.3 \times 10^{-5}$ bar
Filament voltage:	6.3 to 10 VDC
Filament current:	0.62~5.8 A
Wehnelt voltage:	0 to 50 VDC
Deflection voltage:	50 to 110 VDC
Anode voltage:	200 to 300 VDC
Anode current:	< 45 mA
Diameter of fine beam path:	20 to 120 mm
Division spacing:	10 mm
Tube diameter:	160 mm
Total height incl. base:	260 mm
Base plate:	125 x 80 x 45 mm
Weight: approx.	820 g

#### 4. Basic principles

An electron moving with velocity  $v$  in a direction perpendicular to a uniform magnetic field  $B$  experiences a Lorentz force in a direction perpendicular to both the velocity and the magnetic field

$$F = e \cdot v \cdot B \quad (1)$$

$e$ : elementary charge

This gives rise to a centripetal force on the electron in a circular path with radius  $r$ , where

$$F = \frac{mv^2}{r} \quad (2)$$

$m$  is the mass of an electron.

Thus,

$$eB = \frac{m \cdot v}{r} \quad (3)$$

The velocity  $v$  depends on the accelerating voltage of the electron gun:

$$v = \sqrt{2 \cdot \frac{e}{m} \cdot U} \quad (4)$$

Therefore, the specific charge of an electron is given by:

$$\frac{e}{m} = \frac{2 \cdot U}{(r \cdot B)^2} \quad (5)$$

If we measure the radius of the circular orbit in each case for different accelerating voltages  $U$  and different magnetic fields  $B$ , then, according to equation 5, the measured values can be plotted in a graph of  $r^2 B^2$  against  $2U$  as a straight line through the origin with slope  $e/m$ .

The magnetic field  $B$  generated in a pair of Helmholtz coils is proportional to the current  $I_H$  passing through a single coil. The constant of proportionality  $k$  can be determined from the coil radius  $R = 150$  mm and the number of turns

$N = 124$  per coil:

$B = k \cdot I_H$  where

$$k = \left(\frac{4}{5}\right)^{\frac{3}{2}} \cdot 4\pi \cdot 10^{-7} \cdot \frac{N}{R} = 0.756 \frac{\text{mT}}{\text{A}}$$

Thus, all parameters for the specific charge are known.

## 5. Additionally required equipment

1 DC power supply      KSCI-QP500E  
1 Pair of Helmholtz coil    KSCI-HCL

## 6. Operation

### 6.1 Set up

- Insert the fine beam tube to the tube base.
- Place the fine beam tube between the Helmholtz coils.
- To get a clearer view of the electron beam, conduct the experiment in a darkened room.
- Set up the tube as in fig. 1.

### 6.2 Adjusting the electron beam

- Apply a filament voltage of say 7.5 V.
- Wait about 1 minute for the heater temperature to be stable.
- Slowly increase the anode voltage to 300 V (the electron beam is initially horizontal and is visible as a weak, bluish ray).
- Select the Wehnelt voltage so that a very clear and narrow electron beam is visible.
- Optimize the focus and brightness of the electron beam by varying the filament voltage.
- Increase the current  $I_H$  passing through the Helmholtz coils and check that the electron beam curves upwards.

If the electron beam is not deflected at all:

- Reverse the polarity of one of the coils so that current passes in the same direction through both coils.

If the electron beam does not curve upwards:

- Swap the connections on the power supply unit to reverse the polarity of the magnetic field.
- Continue increasing the current passing through the coils and watch until the electron beam forms a closed circle.

If the path does not form a closed circle:

- Slightly turn the fine beam tube, along with its base, around its vertical axis.

## 7. Sample experiment

### Determination of the specific charge of an electron $e/m$

- Select the current passing through the coils so that the radius of the circular path is for example 5 cm. Note the set current value.
- Decrease the anode voltage in steps of 20 V to 200 V. In each case, set the coil current  $I_H$ , so that the radius remains constant. Take down these values.
- Record other series of measured values for radii of 4 cm and 3 cm.
- For further evaluation, plot the measured values in a graph of  $r^2 B^2$  against  $2U$  (see Fig. 2). The slope of the line through the origin corresponds to  $e/m$ .

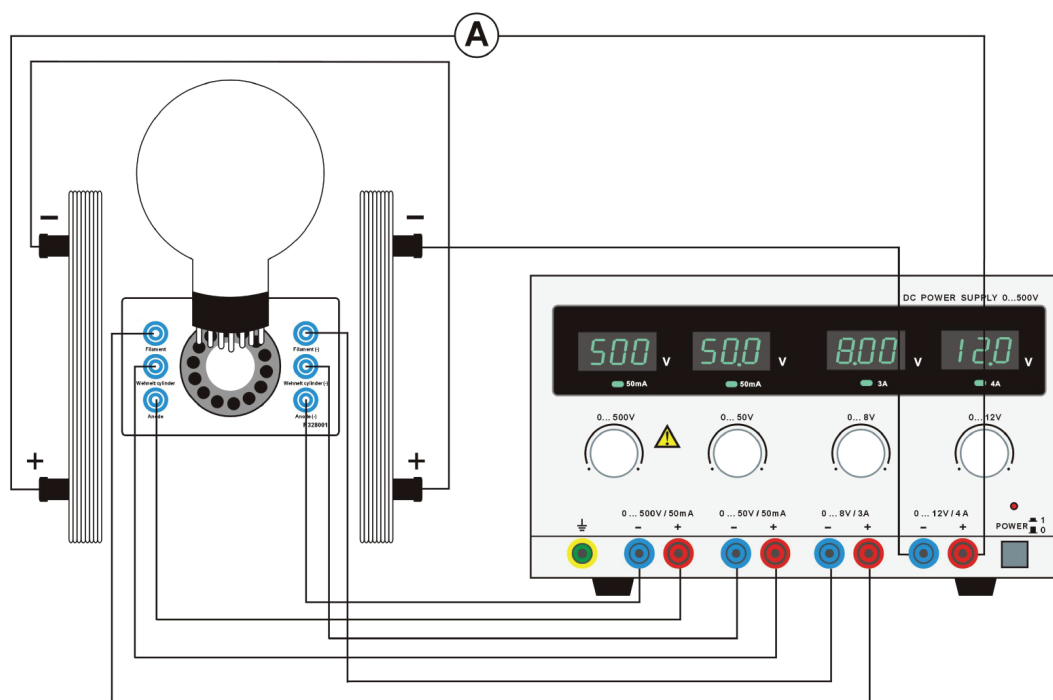


Fig. 1 Electrical connections from the fine beam tube and the pair of Helmholtz coils to the DC power supply unit

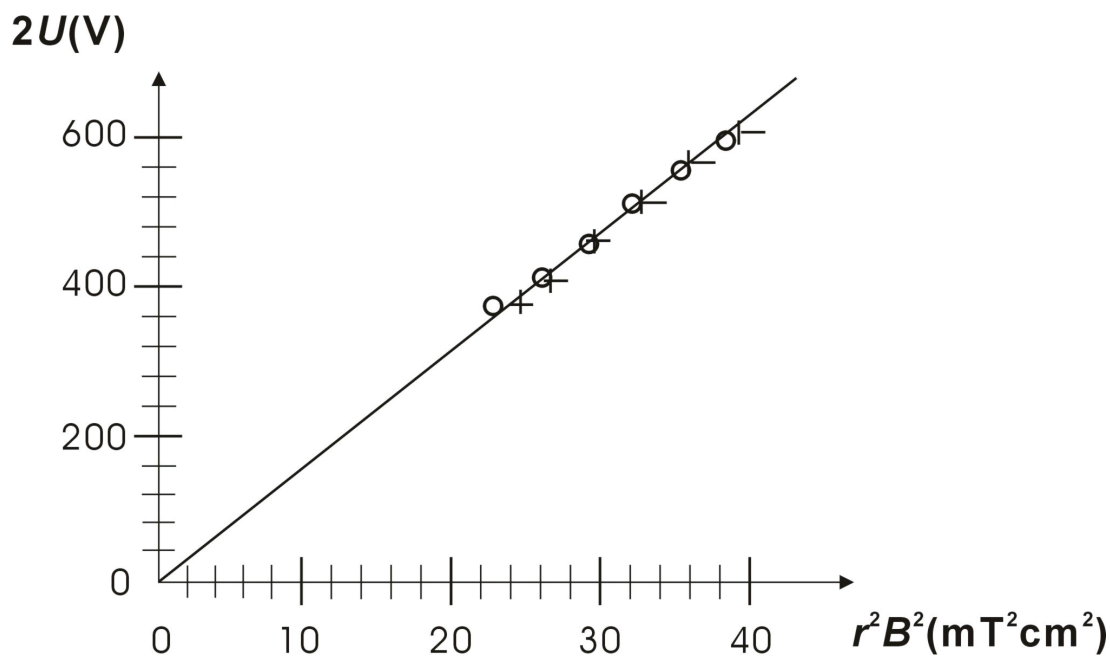


Fig. 2 Graph of  $r^2 B^2$  against  $2U$  for values as measured (○:  $r = 5$  cm, —:  $r = 4$  cm, |:  $r = 3$  cm)