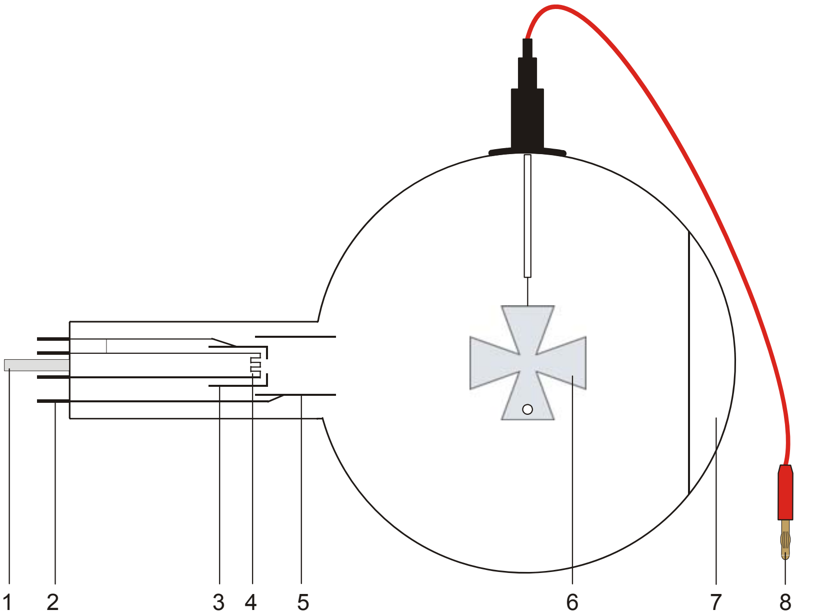
3B SCIENTIFIC® PHYSICS

...going one step further

Maltese Cross Tube S 1000011

Instruction sheet

12/12 ALF



1 Guide pin
2 Connection pins
3 Cathode
4 Heater filament
5 Anode
6 Maltese cross
7 Fluorescent screen
8 4-mm plug connected to Maltese cross

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 may only be used with tube holder S (1014525).

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.
- Only use safety experiment leads for connecting circuits.
- Only change circuits with power supply equipment switched off.
- Only exchange tubes with power supply equipment switched off.

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

- If necessary, allow the tube to cool before dismantling.

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

2. Description

The Maltese cross tube is used to demonstrate how cathode rays propagate in straight lines in the absence of any electric or magnetic field. This is shown by placing a Maltese cross in the path of the beam to throw a shadow on a fluorescent screen. The tube is also used to show how beams can be focussed by magnetic fields. This serves as an introduction to electron optics.

The Maltese cross tube is a highly evacuated tube with an electron gun consisting of a pure tungsten, 'hairpin' heater filament and a cylindrical anode all contained in a clear glass bulb. The electron gun emits a diverging beam which is detected by a fluorescent screen. An aluminium Maltese cross is suspended in the centre of the bulb. The lower limb of the cross has a small hole 3-mm in diameter so that the orientation of the shadow can be distinguished when it is affected by a magnetic field.

3. Technical data

Filament voltage:	≤ 7.5 V AC/DC
Anode voltage:	2000 V to 5000 V
Anode current:	typ. 20 µA at U_A 4500 V
Voltage at cross:	2000 V to 5000 V
Current at cross:	typ. 75 µA at U_A 4500 V
Glass bulb:	130 mm diam. approx.
Total length:	260 mm approx.

4. Operation

To perform experiments using the Maltese cross tube, the following equipment is also required:

1 Tube holder S 1014525

1 High voltage power supply 5 kV (115 V, 50/60 Hz) 1003309

or

1 High voltage power supply 5 kV (230 V, 50/60 Hz) 1003310

1 Coil from Helmholtz pair of coils S 1000611

1 DC Power Supply 20 V, 5 A (115 V, 50/60 Hz) 1003311

or

1 DC Power Supply 20 V, 5 A (230 V, 50/60 Hz) 1003312

1 Bar magnet 1003112

4.1 Setting up the tube in the tube holder

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

- Press tube gently into the stock of the holder and push until the pins are fully inserted. Take note of the unique position of the guide pin.

4.2 Removing the tube from the tube holder

- To remove the tube, apply pressure with the middle finger on the guide pin and the thumb on the tail-stock until the pins loosen, then pull out the tube.

5. Example experiments

5.1 Linear propagation of cathode rays

- Set up the tube as in Fig 1.
- First apply only the filament voltage.

Observe that the Maltese cross casts a sharp shadow on the luminescent screen in the visible light emitted by the glowing cathode.

- Turn on the high-tension supply to the anode.

Observe that an equally sharp and exactly overlapping shadow is cast on the screen by the charged particles.

The experiment demonstrates that the charges, cathode rays, are propagated linearly and produce shadows in exactly the same manner as visible light.

5.2 Electrostatic charging effects

- Set up the circuit as in Fig 1.
- Isolate the metal cross from the anode potential.

Negative charges accumulate on the cross and when equilibrium is reached, they oppose the collection of any further charge. Cathode rays passing close to this opposing field are deflected and produce a distortion of the luminescent shadow (refer to Fig. 3).

Connecting the cross to the cathode potential results in such a distortion that the image is magnified beyond the limits of the fluorescent screen.

5.3 Deflection by a magnetic field

- Set up the circuit as in Fig 1.
- With the tube operating, bring a magnet close to the tube.

Observe that the shadow moves. The amount of deflection depends on both the strength of the magnetic field and the accelerating voltage applied to the electron gun.

Relate the direction of deflection, the field and the motion of the charges using Fleming's law of motion (left-hand rule). Cathode rays under the influence of magnetic fields appear to behave in a similar manner to electric currents in conductors.

5.4 Introduction to electron optics

- Set up the experiment as in Fig. 2.
- Insert the base of the coil into the groove of the tube holder from the front so that the fluorescent screen is enclosed by the single Helmholtz coil. Make sure that the connectors point forwards.
- Turn on the power supply for the tube and observe the shadow.
- Turn on the coil current and slowly increase it.

By increasing the magnetic field (raising the voltage to the coil) the image is seen to rotate, diminish to a spot and then enlarge again in inverted form.

Anode voltage variations provide a further element of control.

Cathode rays and deflecting fields can thus be used to magnify shadow images in a manner analogous to an optical lens system.

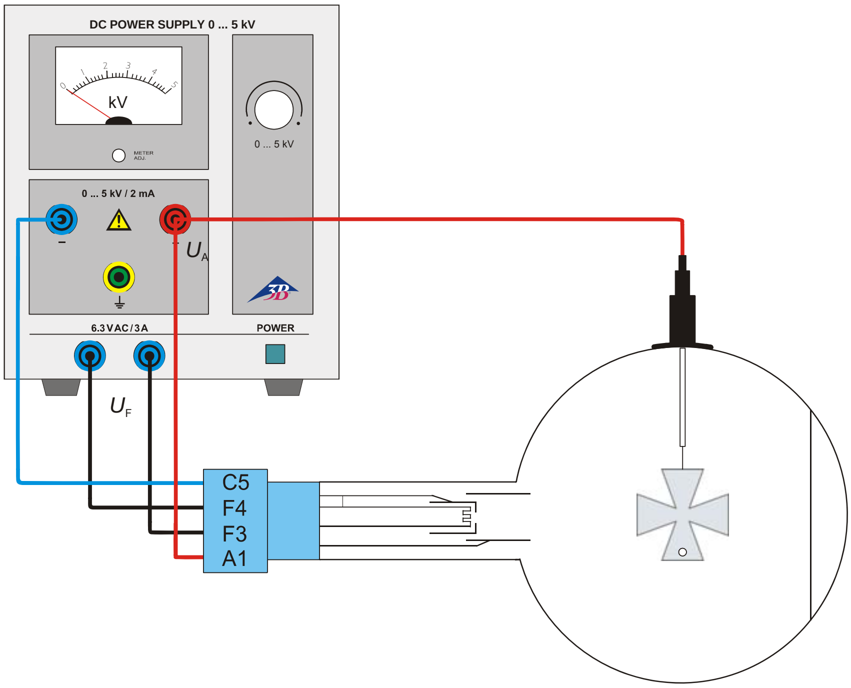


Fig. 1 Linear propagation of cathode rays

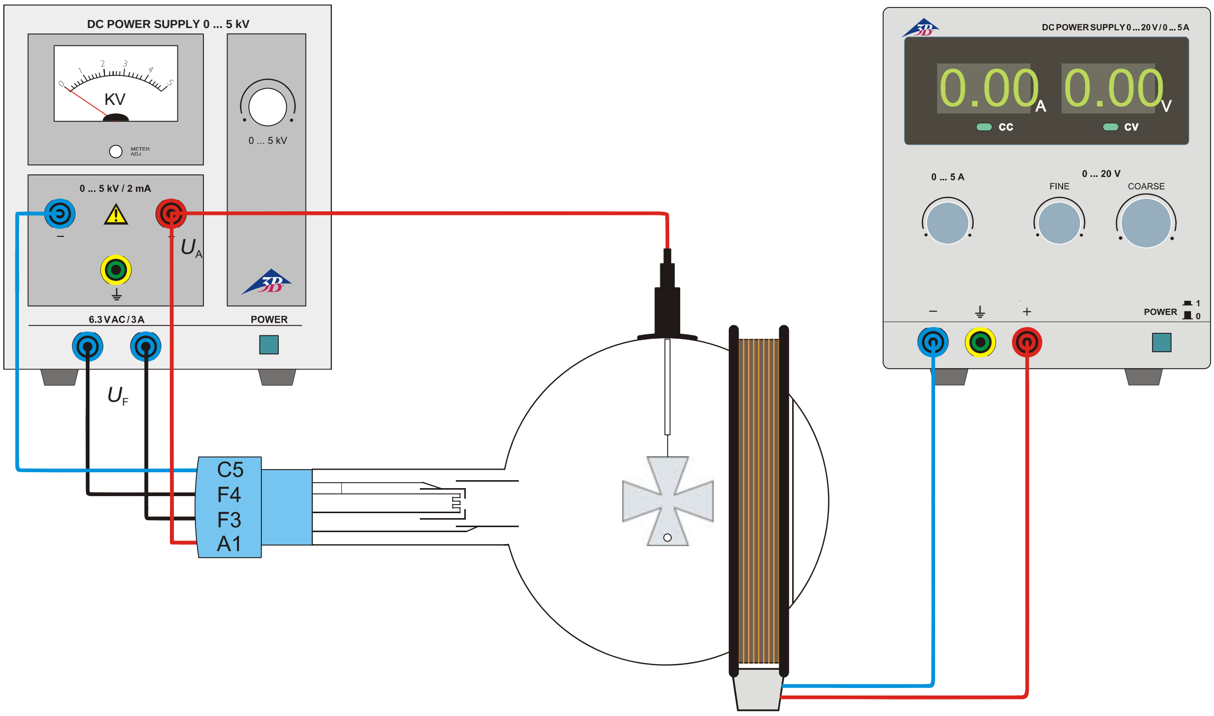


Fig.2 Introduction to electron optics

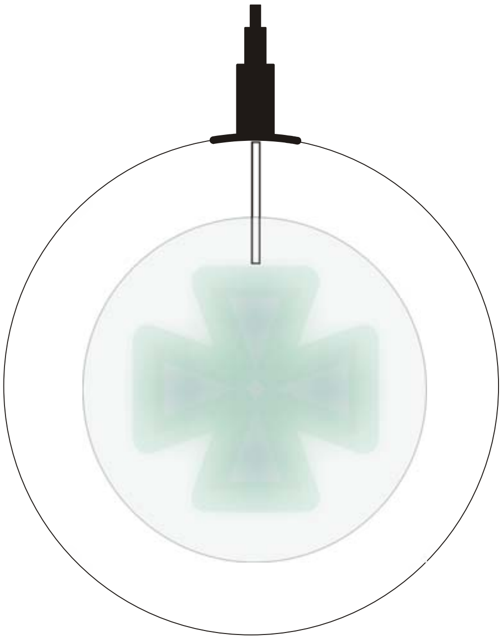


Fig. 3 Electrostatic charging effects