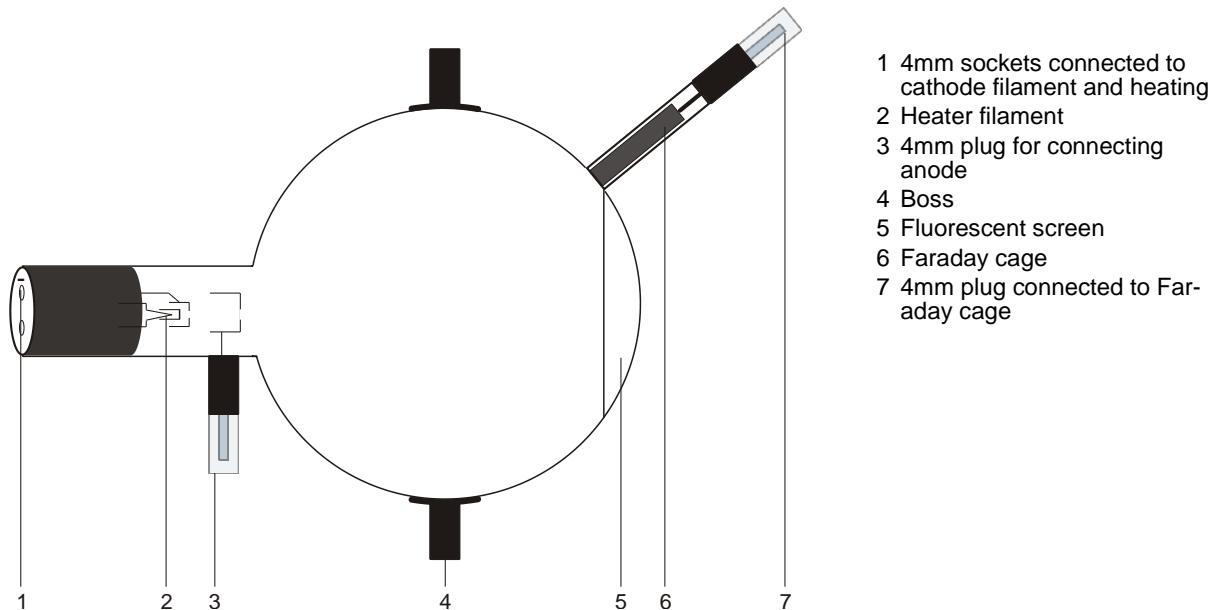


## Perrin Tube D 1000650

### Instruction sheet

10/15 ALF



- 1 4mm sockets connected to cathode filament and heating
- 2 Heater filament
- 3 4mm plug for connecting anode
- 4 Boss
- 5 Fluorescent screen
- 6 Faraday cage
- 7 4mm plug connected to Faraday cage

### 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 D (1008507).

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 change circuit 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 Perrin tube serves to demonstrate the negative polarity of electrons and to estimate the specific electron charge  $e/m$  by magnetic deflection into a Faraday cage, which is connected to an electro-scope. It is also possible to investigate the deflection of electrons in two perpendicular magnetic alternating fields and to demonstrate the effects, for example by generating Lissajous figures.

The Perrin tube is a highly evacuated tube with an electron gun, consisting of a pure tungsten heater filament and a cylindrical anode contained in a clear glass bulb, partly coated with a fluorescent screen. The electrons emitted by the electron gun form a narrow circular beam that can be seen as a spot on the fluorescent screen. A glass tube with a Faraday cage is set on the glass bulb at about  $45^\circ$  to the undeflected beam.

### 3. Technical data

Filament voltage:	$\leq 7.5$ V AC/DC
Anode voltage:	2000 V - 5000 V
Anode current:	typ. 1.8 mA at $U_A = 4000$ V
Beam current:	4 $\mu$ A at $U_A = 4000$ V
Glass bulb:	130 mm dia. approx.
Total length:	260 mm approx.

### 4. Operation

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

1 Tube holder D	1008507
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 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 Electroscope	1001027
1 Analogue multimeter AM50	1003073

Additionally recommended:  
Protective Adapter, 2-Pole 1009961

#### 4.1 Setting up the tube in the tube holder

- The tube should not be mounted or removed unless all power supplies are disconnected.
- Push the jaw clamp sliders on the stanchion of the tube holder right back so that the jaws open.
- Push the bosses of the tube into the jaws.
- Push the jaw clamps forward on the stanchions to secure the tube within the jaws.
- If necessary plug the protective adapter onto the connector sockets for the tube.

#### 4.2 Removing the tube from the tube holder

- To remove the tube, push the jaw clamps right back again and take the tube out of the jaws.

### 5. Example experiments

#### 5.1 Evidence of the particle nature of cathode beam and establishment of their polarity

- Set up the experiment as in fig. 1.
- Apply a voltage to the anode between 3 kV and 5 kV.

On the fluorescent screen the cathode beams

are visible as a round spot.

- Set up the Helmholtz coils and use them to deflect the beam so that it falls within the end of the Faraday cage. Alternatively the beam can be deflected using a magnet placed on one of the stanchions of the tube holder.

The electroscopes will open to indicate the presence of a charge.

- Turn off the voltage to the heater filament and the anode.

The electroscopes remain open.

If the charge on the Faraday cage were due to the cathode beam being some kind of wave radiation, the charge should disappear when the filament ceases to radiate. Because the experiment shows that the charge remains on the cage when the filament is cold, the conclusion must be that the beam comprises some constituent of matter which is electrically charged. These particles are called electrons.

The negative polarity of the cathode beam can be demonstrated if the electroscopes are charged by rubbing a plastic or a glass rod (so that they are negatively and positively charged respectively).

#### 5.2 Estimation of the specific electron charge $e/m$

- Set up the experiment as in fig. 3.

When the electron beam is deflected into the Faraday cage, the following applies to the specific charge  $e/m$ :

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

$U_A$  can be read out directly, the curvature radius  $r$  derives from the geometric data of the tube (bulb diameter 13 cm, Faraday cage at  $45^\circ$  to the beam axis) to  $r = 16$  cm approx. (refer to fig. 2).

With the coils at Helmholtz-geometry and the coil current  $I$ , the following applies to the magnetic flux density  $B$  of the magnetic field

$$B = \left(\frac{4}{5}\right)^2 \cdot \frac{\mu_0 \cdot n}{R} \cdot I = k \cdot I \quad (2)$$

with  $k =$  at good approximation 4.2 mT/A,  $n = 320$  (no. of turns) and  $R = 68$  mm (coil radius).

- Substitute  $U_A$ ,  $r$  and  $B$  in equation 1 and calculate  $e/m$ .

#### 5.3 Deflection in crossed magnetic alternating fields (Lissajous figures)

The following equipment is also required:

1 Auxiliary coil	1000645
1 AC/DC power supply 12 V, 3 A (115 V, 50/60 Hz)	1002775

or

1 AC/DC power supply 12 V, 3 A (230 V, 50/60 Hz)	1002776
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1 Function generator FG100 (115 V, 50/60 Hz)  
1009956

or

1 Function generator FG100 (230 V, 50/60 Hz)  
1009957

- Set up the experiment as in fig. 4.
- Place the auxiliary coil on the upper fork of the tube holder. Push the jaw clamp over the lip of the coil to secure it in place.

- Connect the auxiliary coil to the alternating current source.
- Connect the Helmholtz coils to the function generator and choose a sinusoidal signal.
- Apply a voltage to the anode between 3 kV and 5 kV.
- Apply an alternating voltage up to 15 V to the auxiliary coil and observe the horizontal deflection.
- Set a frequency of e.g. 50 Hz at the function generator, vary the amplitude of the sine-signal and observe the Lissajous figures on the fluorescent screen.

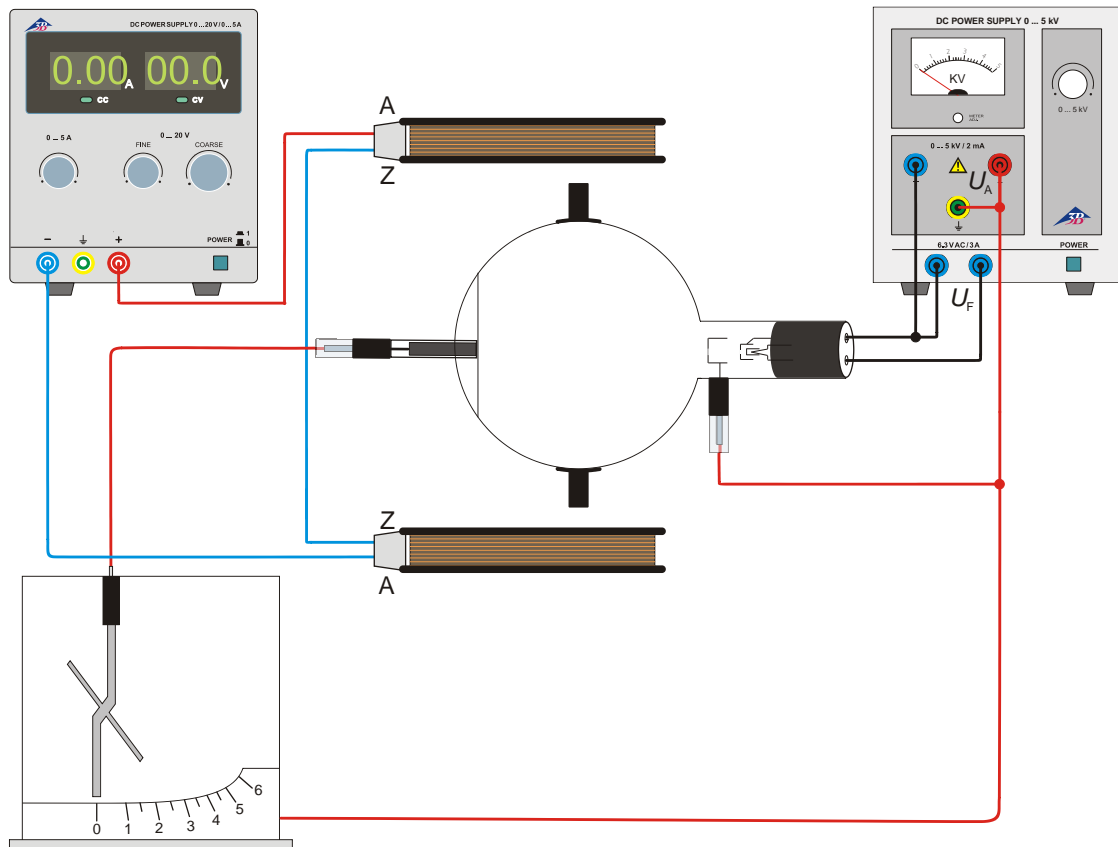


Fig. 1 Evidence of the particle nature of cathode beam and establishment of their polarity

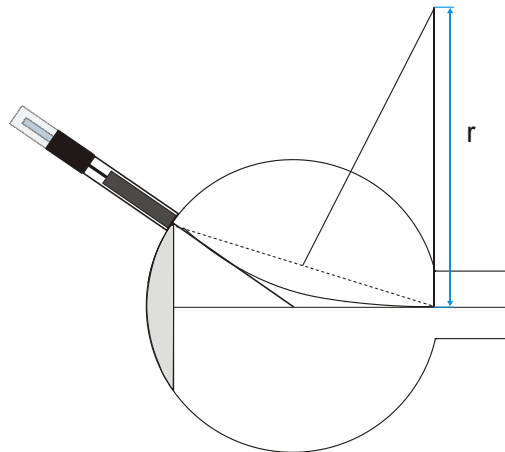


Fig. 2 Definition of the curvature radius  $r$

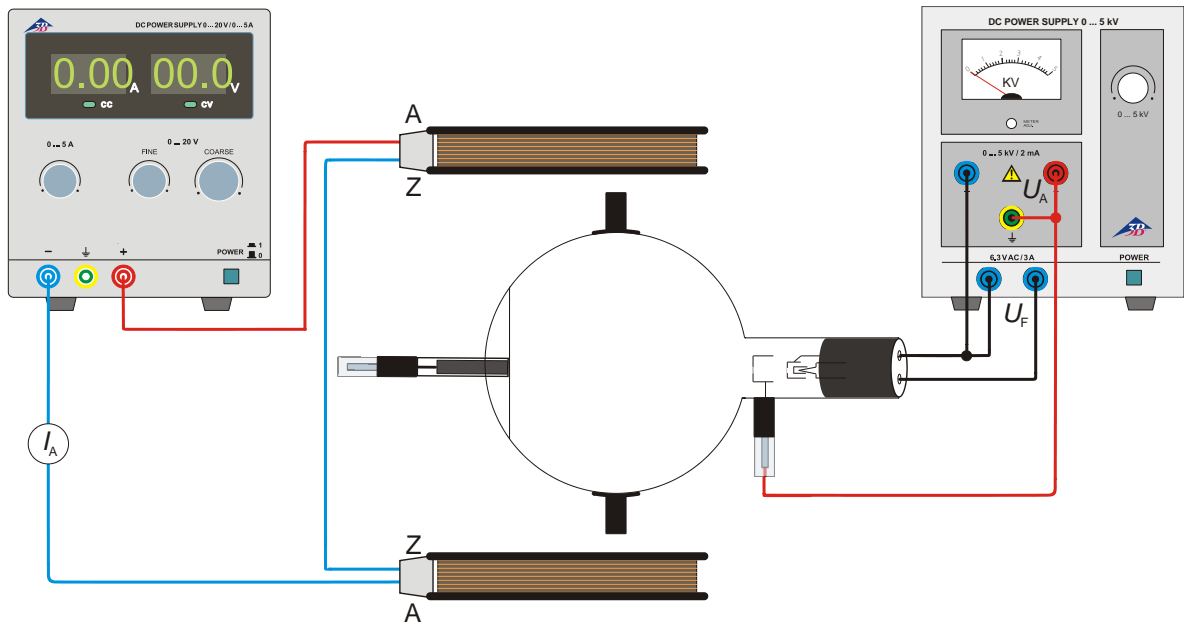


Fig. 3 Estimation of the specific electron charge  $e/m$

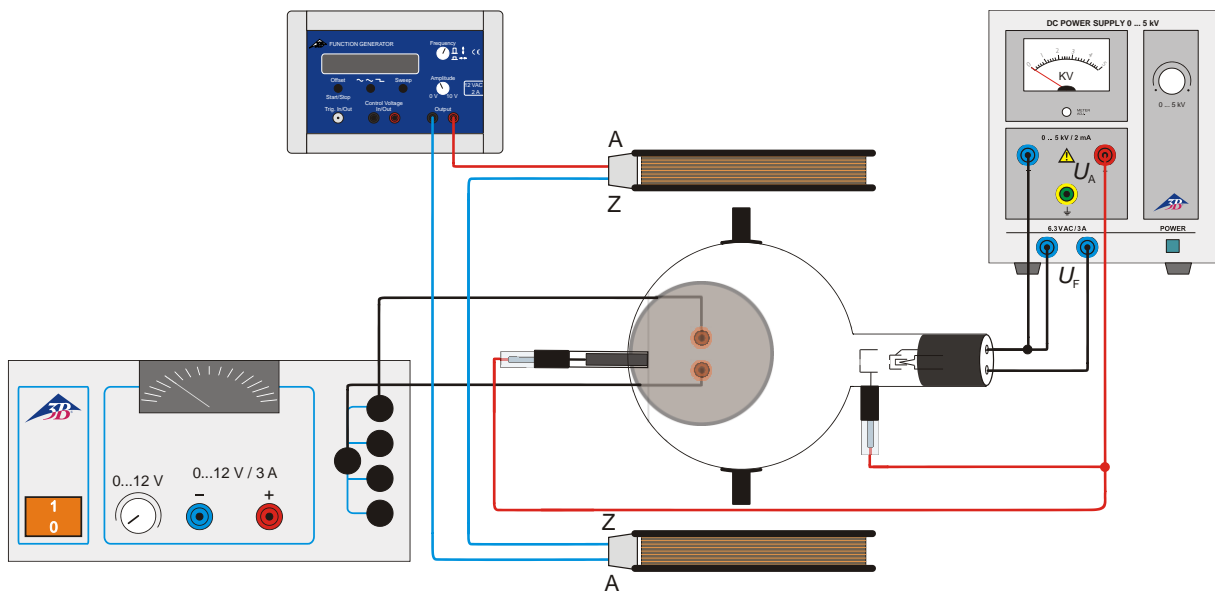


Fig.4 Deflection in crossed magnetic alternating fields (Lissajous figures)