Instruction Sheet 555 622

Perrin Tube (555 622)

1 Pin base (for electron gun contacting)
2 Getter mirror (for maintaining the vacuum)
3 Screen
4 Connection for Faraday’s cup
5 Faraday’s cup
6 Deflection plates
7 Anode
8 Cathode cap

Safety notes

When the Perrin tube is operated at high voltages over 5 kV, X-rays are generated.

- Do not operate the Perrin tube with high voltages over 5 keV.

Danger of implosion: The Perrin tube is a high-vacuum tube made of thin-walled glass.

- Do not expose the Perrin tube to mechanical stress, and connect it only if it is mounted in the tube stand.
- Treat the contact pins in the pin base with care, do not bend them, and be careful when inserting them in the tube stand.
- Treat the connection for the Faraday’s cup with care and do not cascade the plug.

When the Perrin tube is operated, among others, hazardous contact voltages may be applied:

- Connect the Perrin tube only with the safety connection leads.
- Connect only when the supply devices have been switched off.

During operation, the Perrin tube is heated by the cathode heating:

- If necessary, allow the Perrin tube to cool down before dismounting.

The Perrin tube may be destroyed by voltages or currents that are too high:

- Keep to the operating parameters given in the section on technical data.

1 Description

The Perrin tube enables the demonstration of the negative polarity of electronic charge by magnetic deflection of a focussed electron beam in a Faraday’s cup, that is arranged laterally and the estimation of the specific electron charge. Moreover, the deflection of a electron beam in alternating magnetic and electric fields can be studied on the screen (Lissajous figures).

2 Technical data

Heating voltage $U_F$: 6-6.5 V~
(recommended: 6.3 V~)
Heating current $I_F$: approx. 1.5 A at 6.3 V
Anode voltage $U_A$: 1.5-5 kV
Deflection voltage $U_P$: -350 ... 350 V
Inclination of the Faraday’s cup: 45°
Bending radius of the trajectory to the Faraday’s cup: 16 cm
Beam current in the Faraday’s cup: 0.4 µA
Pressure: $<10^{-6}$ hPa
Diameter: 90 mm
Total length: 270 mm
Weight: 250 g
3 Putting into operation

Additionally required:

1 tube stand 555 600
1 high voltage power supply 10 kV 521 70

3.1 Mounting in the tube stand:

- Hold the Perrin tube horizontally, and turn it so that the hole in the pin base points downward.
- Carefully insert the pin base in the socket of the tube stand until it stops.

Pin connection:

F₁, F₂ heating filaments
A anode
C cathode cap
X deflection plate

3.2 Connection to the high-voltage power supply 10 kV:

- For the cathode heating connect the sockets F₁ and F₂ of the tube stand to the output on the back of the high-voltage power supply 10 kV.
- Connect the socket C of the tube stand (cathode cap) to the negative pole and the socket A (anode) to the positive pole of the high-voltage power supply 10 kV and ground the positive pole.

To functional test:

- Connect the socket X (deflection plate) to the socket A (anode).
- Slowly increase the high voltage and observe the beam spot in the middle of the screen that becomes increasingly brighter.
4  Experiment examples

4.1  Negative polarity of electrons and estimation of the specific electron charge:

- Set up the Helmholtz coils to the positions marked H (Helmholtz geometry) and connect to the direct voltage so that they are parallel.
- Connect socket X (deflection plates) with socket A (anode).
- Select anode voltage between 2.5 and 5 kV.
- Connect the electroscope to the Faraday's cup.

Additionally required:

1 pair of Helmholtz coils 555 604
1 DC power supply 0 ... 16 V, 5 A 521 541
1 electroscope 540 091
1 set of safety adapter sockets, red 500 95

\[ e = \frac{2 \cdot U_A}{(r \cdot B)^2} \]
with \[ B = \mu_0 \left( \frac{4}{5} \right) \cdot \frac{N \cdot I}{R} \]

\( r = 16 \text{ cm}:\) bending radius of the trajectory
\( N = 320: \) number of turns
\( R = 6.25 \text{ cm}: \) radius of Helmholtz coils
\( I = \) current through a Helmholtz coil

4.2  Deflection in crossed alternating magnetic fields  (Lissajous figures):

- Connect socket X (deflection plate) to socket A (anode).
- Arrange coil with 500 turns directly under the Perrin tube and connect to alternating voltage 0 – 15 V.
- Set Helmholtz coils symmetrically around the coil with 500 turns and connect them to the function generator so that they are parallel.
- Select anode voltage between 3 and 5 kV.
- Select alternating voltage on the coil with 500 turns up to 15 V and observe horizontal deflection.
- Set suitable frequency (e.g. 50 Hz) on the function generator, increase sinusoidal signal amplitude and observe the Lissajous figures on the screen.

Additionally required:

1 pair of Helmholtz coils 555 604
1 coil with 500 turns 562 14
1 variable extra low voltage transformer S 521 35
1 function generator S12 522 621
or
1 power function generator 522 63
1 set of blocks 300 761
4.3 Deflection in parallel alternating magnetic and electric field (Lissajous figures)

additionally required:

1 Pair of Helmholtz coils 555 604
1 Variable low voltage transformer, 0 ... 250 V 521 40
1 Function generator S12 522 621
or
1 Power function generator 522 63

- Use safety connection leads (!) to connect the output of the variable low voltage transformer, that is turned off (!) to socket X (deflection plate) and socket A (anode).
- Arrange pair of Helmholtz coils symmetrically to the Perrin tube and connect them to the function generator so that they are parallel.
- Select anode voltage between 3 and 5 kV.
- Increase the alternating voltage from the variable low voltage transformer and observe the horizontal deflection.
- Set suitable frequency (e.g. 50 Hz) on the function generator, increase sinusoidal signal amplitude and observe the Lissajous figures on the screen.