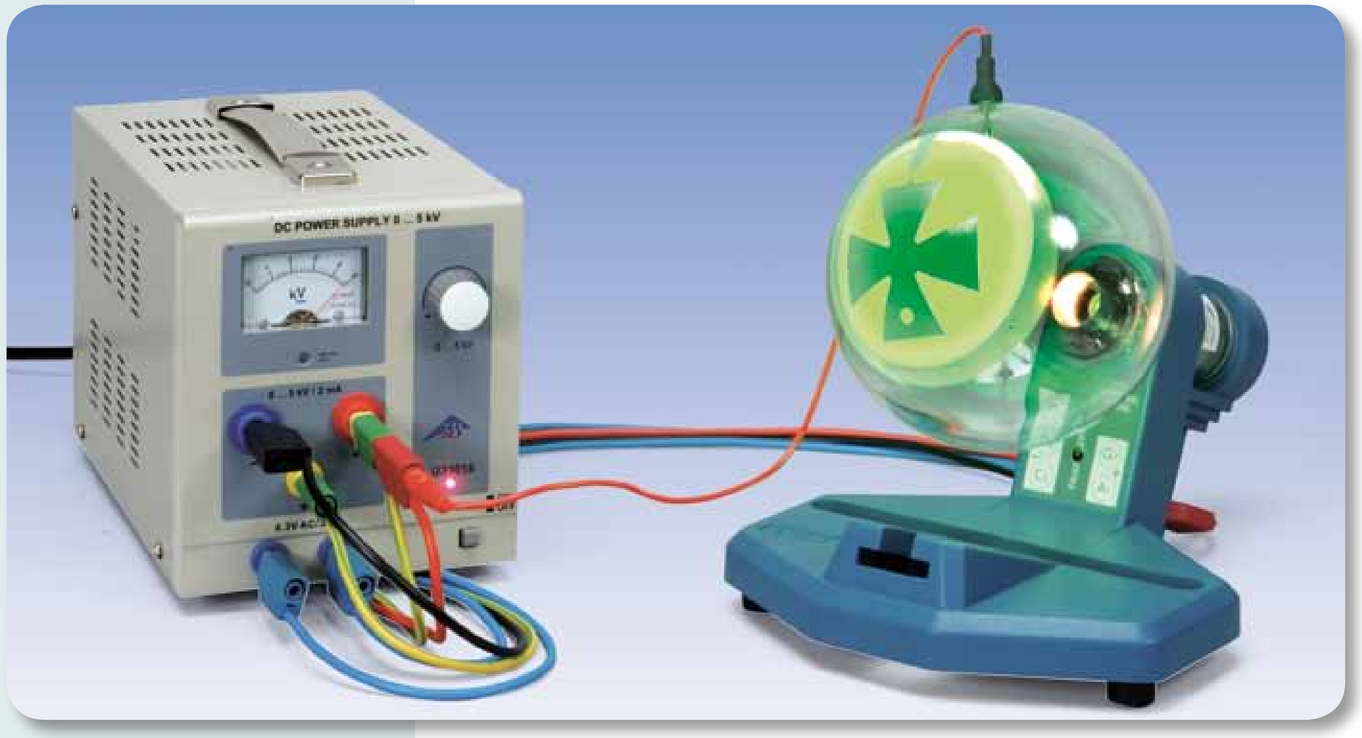
MALTESE-CROSS TUBE



EXPERIMENT PROCEDURE

- **Demonstrate the straight-line propagation of electrons in the absence of a field.**
- **Demonstrate the deflection of electrons by a magnetic field.**
- **Introduction to electron optics.**

OBJECTIVE

Demonstrate the straight-line propagation of electrons in the absence of any field.

SUMMARY

Straight-line propagation of electrons in the absence of a field can be demonstrated in a Maltese-cross tube by showing how the shadow of the electron beam coincides with the shadow due to a light beam. Any deviation from the straight-line propagation of the beam, due to a magnetic field for example, can be seen since the shadow is then caused to move.

REQUIRED APPARATUS

Quantity	Description	Number	
1	Maltese Cross Tube S	**1000011**	
1	Tube Holder S	**1014525**	
1	High Voltage Power Supply 5 kV (230 V, 50/60 Hz)	**1003310**	**or**
	High Voltage Power Supply 5 kV (115 V, 50/60 Hz)	**1003309**	
1	Set of 15 Safety Experiment Leads, 75 cm	**1002843**	

Additionally recommended for generating an axially aligned magnetic field

Quantity	Description	Number	
1	Helmholtz Pair of Coils S	**1000611**	
1	DC Power Supply 0 – 20 V, 0 – 5 A (230 V, 50/60 Hz)	**1003312**	**or**
	DC Power Supply 0 – 20 V, 0 – 5 A (115 V, 50/60 Hz)	**1003311**	

UE3070300

BASIC PRINCIPLES

In a Maltese-cross tube, a divergent electron beam from a cathode ray gun can be seen on a fluorescent screen by observing the shadow on the screen of an object (a Maltese cross) that is opaque to cathode rays. The position of the shadow changes when the straight-line propagation of the electrons towards the screen is disturbed.

If the anode and the Maltese-cross are at the same potential, there will be no field within the tube and electrons will propagate in a straight line. The electron shadow of the cross will then be coincident with its shadow in the light that is emitted from the glowing cathode.

How this straight-line propagation is disturbed when a field is present within the tube can be easily seen by disconnecting the lead between the anode and the cross. The cross then becomes statically charged and the electron shadow on the screen becomes blurred.
If the electrons are deflected by a magnetic field on their way to the screen, the electron shadow can be seen to shift or rotate.

The deflecting force ***F*** depends on the velocity ***v*** of the electrons, on the magnetic field ***B*** and is a result of the Lorentz-force:

(1) $$\mathbf{F} = -e \cdot \mathbf{v} \times \mathbf{B}$$

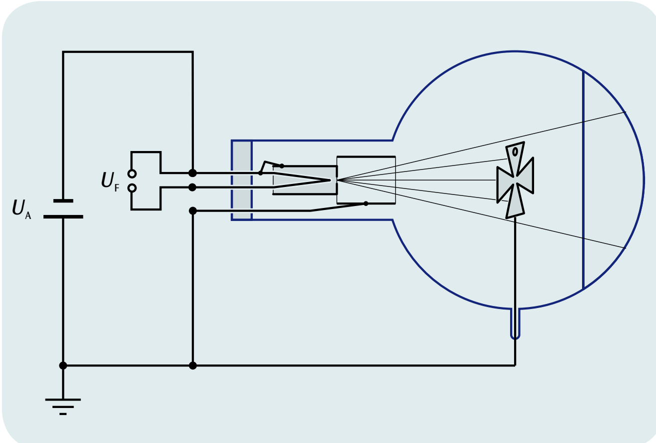


Fig. 1: Schematic of Maltese cross tube.

EVALUATION

In the absence of a field the electrons propagate in a straight line. The electron shadow exactly matches the shadow from the light.
In a magnetic field electrons are deflected and the electron shadow is shifted with respect to the shadow from the light. The deflecting force is perpendicular to the direction of motion of the electrons and to the magnetic field itself.
If the magnetic field is aligned axially, the electrons are deflected into spiral paths and the shadow rotates and becomes smaller.

Fig. 2: Rotation of the electron shadow through deflection of electrons in the axially aligned magnetic field.