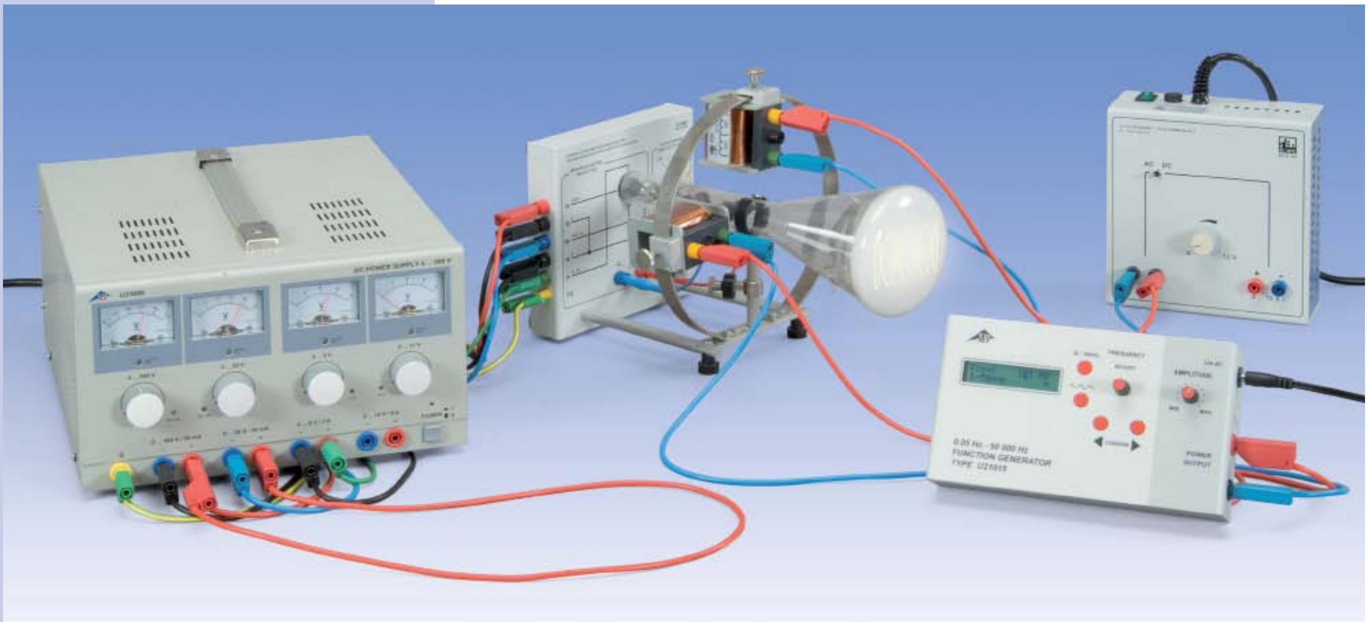
UE307085

Training Oscilloscope, II



EXPERIMENT PROCEDURE

- **Superposing magnetic fields with the same and different frequencies, and observing the displacement of the focused spot on the screen of the tube.**
- **Generating closed Lissajous' figures.**
- **Checking the frequency of the mains supply.**

OBJECTIVE

Demonstrate the superposition of magnetic fields in a vacuum.

SUMMARY

The absence of interference when magnetic fields are superposed in a vacuum is demonstrated using a Braun tube. This is done by observing the displacements of the focused spot on the fluorescent screen of the tube. The experiments can be extended to include alternating magnetic fields with identical and different frequencies. The Lissajous' figures observed on the screen depend critically on the relation between the frequencies of the two magnetic fields and on their phase relation.

REQUIRED APPARATUS

Quantity	Description	Number
1	Training Oscilloscope	**U8481350**
1	DC Power Supply 0 – 500 V (230 V, 50/60 Hz)	**U33000-230** or
	DC Power Supply 0 – 500 V (115 V, 50/60 Hz)	**U33000-115**
1	Function Generator F12 (230 V, 50/60 Hz)	**U21015-230** or
	Function Generator F12 (115 V, 50/60 Hz)	**U21015-115**
1	AC/DC Power Supply 0 – 12 V, 4 A (230 V, 50/60 Hz)	**U8521105-230** or
	AC/DC Power Supply 0 – 12 V, 4 A (115 V, 50/60 Hz)	**U8521105-115**
1	Set of 15 Safety Experiment Leads, 75 cm	**U138021**

2

Training Oscilloscope, II

BASIC PRINCIPLES

A Braun tube can be used to demonstrate the principle of superposition for magnetic fields in a vacuum, by observing the deflection of the beam in the magnetic field. It is especially instructive to also perform experiments with alternating magnetic fields, as the electron beam follows the changes of the magnetic field without a significant time-lag.

In the experiment, two identical current-carrying coils are placed outside the Braun tube, and the deflection of the electron beam in the magnetic fields of the coils is observed on the tube's fluorescent screen as shifts of the focused spot. The magnetic field of the horizontal coil causes a vertical shift of the beam, while that of the vertical coil causes a horizontal shift.

When an alternating magnetic field at the mains frequency is applied to one of the coils, the focused spot is stretched out to become a vertical or horizontal line. If both coils are then connected in parallel to the alternating voltage source, the screen shows a straight line at 45° to the vertical, whereas when the coils are connected in opposition the line is at -45°, as the shifts produced by the two magnetic fields are superposed.

The experiment can be extended to study the effects of alternating magnetic fields of different frequencies. The Lissajous' figures that then appear on the screen depend critically on the relationship between the frequencies of the two magnetic fields and on their phase relationship. When the ratio of the frequencies is an integer or a simple fraction, closed figures are generated. Their exact shape also depends on the phase difference between the magnetic fields. As an example, Figure 1 shows Lissajous' figures with a frequency ratio 5:1.

If the frequency ratio is only slightly different from a simple rational value, we observe a closed figure that changes with time, at a rate that becomes slower as the difference from a simple ratio is reduced. In the experiment, this behaviour is used to check the mains frequency. For this, one coil is connected to a transformer working at the mains frequency, while the second coil is connected to a signal generator whose output frequency can be read precisely.

EVALUATION

The generator frequency is adjusted relative to the mains frequency ν until we get the frequency ν_5 that gives the slowest change of a Lissajous' figure corresponding to the frequency ratio 5:1.
The mains frequency ν is then calculated as:

$$\nu = \frac{\nu_5}{5}$$

The measurement has a precision of ± 0.01 Hz, since ν_5 can be adjusted with a precision of ± 0.05 Hz.

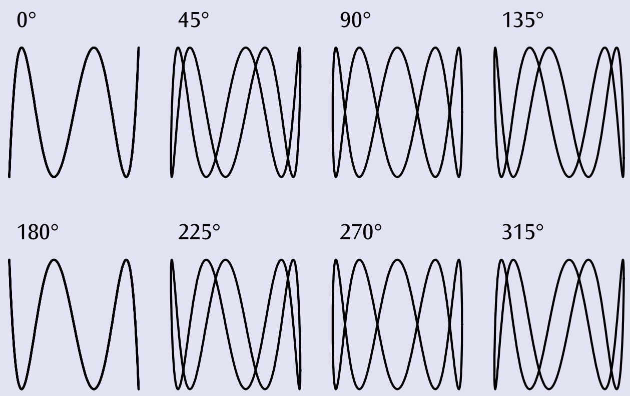


Fig. 1: Lissajous' figures for the frequency ratio 5:1 with phase differences 0°, 45°, 90°, …