**EXPERIMENT PROCEDURE**

- Investigating the deflection of an electron beam in an electric field.
- Investigating the deflection of an electron beam in a magnetic field.
- Demonstrating the display of signals on an oscilloscope, using the periodic signal from a function generator.
- Calibrating the frequency control of the sawtooth generator.

**OBJECTIVE**

Study the physical principles of the time-resolved display of electrical signals using an oscilloscope

**SUMMARY**

The student oscilloscope can be used to study the physical principles of the time-resolved display of electrical signals on a fluorescent screen. In a Braun tube, a focused electron beam is generated, and the point at which it falls on the fluorescent screen is observed as a spot of green light. When the electron beam is deflected by a sawtooth voltage applied between a pair of plates, it moves at a constant speed from left to right across the screen, then flies back to the starting point. This process is repeated cyclically at a frequency that can be adjusted.

During its left-to-right movement, the electron beam can also be deflected vertically by a magnetic field, and for this a voltage is applied to the coils that are external to the tube. If this voltage is time-dependent, the time-resolved variations are displayed on the screen (see Fig. 2). Such time-dependent voltages might be, for example, the periodic output voltage from a function generator, or the amplified signals from a microphone.

In the experiment, the periodic signals from a function generator are investigated. The most useful display is obtained when the sawtooth frequency is adjusted so that its ratio to that of the function generator is a whole number.

**REQUIRED APPARATUS**

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Description</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Training Oscilloscope</td>
<td>1000902</td>
</tr>
<tr>
<td>1</td>
<td>DC Power Supply 0–500 V (230 V, 50/60 Hz)</td>
<td>1003308 or 1003307</td>
</tr>
<tr>
<td>1</td>
<td>Function Generator FG 100 (230 V, 50/60 Hz)</td>
<td>1000957 or 1009956</td>
</tr>
<tr>
<td>1</td>
<td>Set of 15 Safety Experiment Leads, 75 cm</td>
<td>1002843</td>
</tr>
</tbody>
</table>

**BASIC PRINCIPLES**

An important application of thermionic emission in a high vacuum is the cathode ray oscilloscope, in which the Braun tube is an essential component. In the form used in the student oscilloscope, the electron-optical system of the Braun tube, which is visible from the outside, consists of a thermionic cathode surrounded by a “Wehnelt cylinder” and a pinhole disc at the anode potential. A proportion of the electrons that are accelerated towards the anode pass through the pinhole disc and form a beam, which is observed on the tube’s fluorescent screen as a green spot of light. Because the tube is filled with neon at a low pressure, the electron beam is concentrated through collisions with gas atoms, and is visible as thin threads emitting reddish light. A negative voltage that is applied to the Wehnelt cylinder also contributes to the concentration of the beam. Technical oscilloscopes usually have additional arrangements for post-acceleration (intensification) and focusing of the beam, but for simplicity and clarity these are not present in the student oscilloscope.

Behind the anode, there is a pair of plates with their planes parallel to the electron beam, which can be connected to a sawtooth generator (see Fig. 1). The electric field produced by the sawtooth voltage deflects the beam horizontally, so that it moves across the fluorescent screen from left to right at a constant speed, then flies back to the starting point. This process is repeated cyclically at a frequency that can be adjusted.

During its left-to-right movement, the electron beam can also be deflected vertically by a magnetic field, and for this a voltage is applied to the coils that are external to the tube. If this voltage is time-dependent, the time-resolved variations are displayed on the screen (see Fig. 2). Such time-dependent voltages might be, for example, the periodic output voltage from a function generator, or the amplified signals from a microphone.

In the experiment, the periodic signals from a function generator are investigated. The most useful display is obtained when the sawtooth frequency is adjusted so that its ratio to that of the function generator is a whole number.