This experiment consists of two parts. In the first part of the experiment, two different wave generators are used to show that the ripple tank can be used to produce both **circular** waves and waves with straight line wave fronts (**plane** waves).
In the second part, the example of circular and parallel waves is used to demonstrate the generation of wave beams through shading with the help of apertures.

Material

from the accessory set of 11260-99

- 1 Wave generator, single
- 1 Holder for plane wave generator
- 1 Plane wave generator
- 1 Dipper

Method

Experiment 1:

Circular waves emanate from a single dipper, which periodically dips into the surface of the water. If it is replaced with a linear oscillator, the result is plane waves with parallel wave crests and troughs.

Experiment 2:

A slit diaphragm can be used to shade a beam from an area of the wave field; the edges are divergent in circular waves and parallel in plane waves. By choosing large apertures compared to the wavelength, diffraction phenomena which disrupt shadowing can be suppressed to a large extent.

Note:
It is advisable to carry out the two experiments for circular waves first and then carry out the two experiments for plane waves. This saves time while not having to change the generator.

Experiment 1

Setup

1. Circular waves:
   The mounting rod with single dippers is fixed to the integrated generator (see Chapter 0.1) and is adjusted towards the centre of the wave tank (Fig. 1).

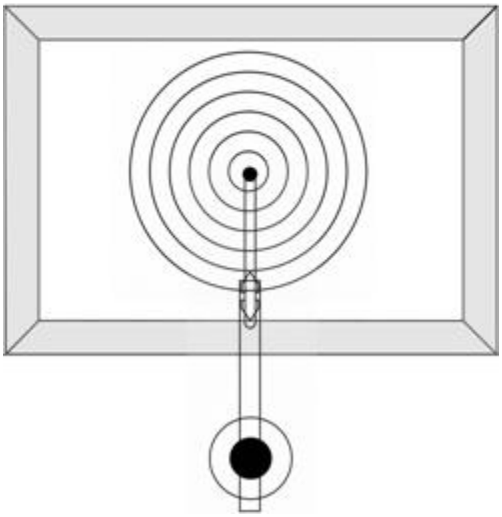

Figure 1:
Experiment arrangement for generating circular waves with one single dipper.

2. Plane waves:
The mounting rod with plane wave generator is fixed to the integrated generator (see Chapter 0.1) and is moved to the lower edge of the wave tray (Fig. 2).

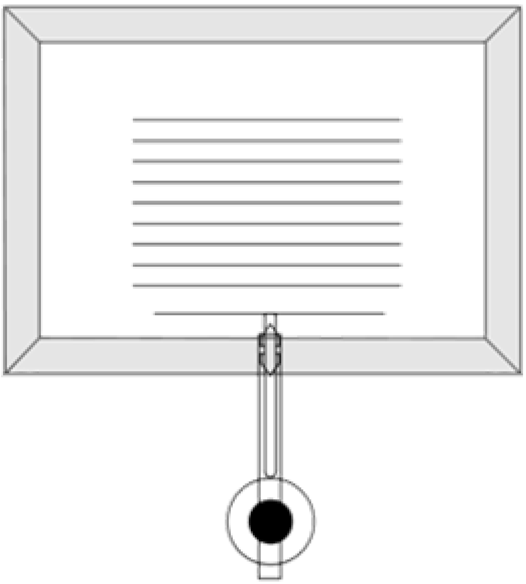

Figure 2: Experiment arrangement for generation of plane waves. The edge of the plane wave generator should be aligned parallel to the surface of the water to prevent distortion.

Procedure

1. Circular waves:
the following settings at the ripple tank are recommended:

Generator frequency:	5–20 Hz
Generator amplitude:	Step 1–2
Lighting mode:	continuous

The wave generator (dipper) should dip roughly vertically into the water in the wave tank, in order to prevent distortion of the circular shape of the wave crests and troughs.

2. Plane waves:
Precise adjustment of the plane wave generator and the wave tray is required when generating plane waves. Notes on correct adjustment are given in Chapter 0.1.

Generator frequency:	15–25 Hz
Generator amplitude:	Step 1–2
Lighting mode:	continuous

Any irregularities that occur in the course of the wave crests and troughs are possibly due to incomplete wetting of the plane wave generator (air bubbles). If necessary, any adhering air bubbles should be removed from the generator by hand. 1 to 2 drops of soap solution can be added to the water for improved wetting.

Experiment 2

Setup

1. Circular waves:
   The mounting rod with single dipper as wave generator is moved to the bottom edge of the tank. The two barriers are placed in the wave tank as shown in Fig. 3.

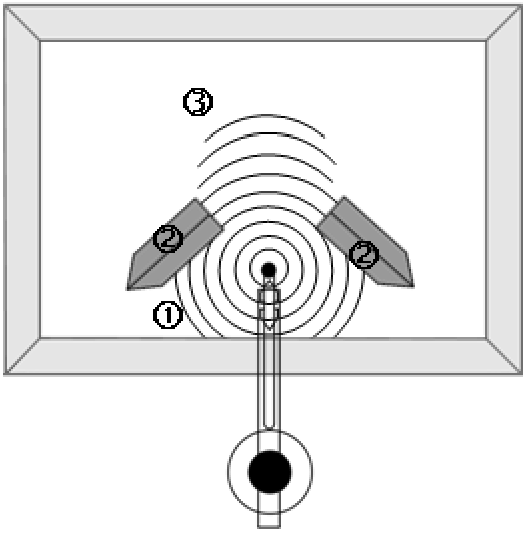

Figure 3: Experiment arrangement for removal of a wave beam with circular waves. The wave front produced by the single wave generator① hits the slit diaphragm formed by the two barriers ②, whereby a wave beam ③ is blocked out or removed.

2. Plane waves:
   The single dipper as generator is now replaced by the plane wave generator. The two barriers are arranged in the wave tray so that they form a slit diaphragm (Fig. 4).

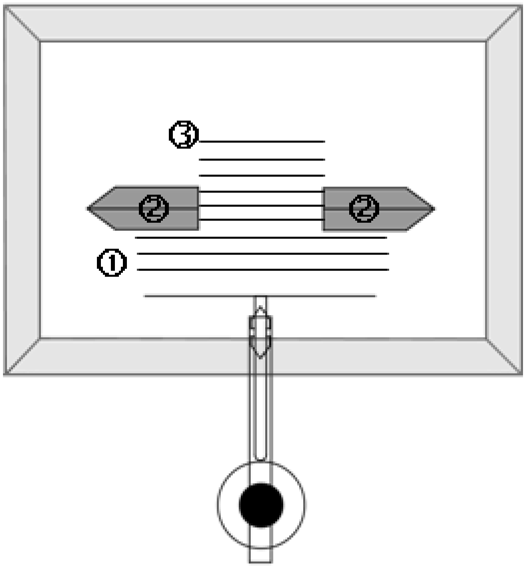

Figure 4: Experiment arrangement for removal of a wave beam with plane waves. The wave front emanating from the planar wave generator① hits the slip aperture ②, whereby a wave beam ③ is passing the barrier.

Procedure

1. Circular waves:
   For this experiment the same setting options apply at the ripple tank as for experiment 1 (see above).
   The position of the two barriers is corrected if necessary so that their longitudinal axes tangentially continue the circular wave passing the slit. In this way, disruptive interferences which can occur due to reflections at the front and rear edge of the slit are avoided.

2. Plane waves:
   The plane wave generator is carefully adjusted (see Chapter 0.1). The same setting options apply to the ripple tank as in experiment 1 (see above). A clear wave pattern should result.

Experiment 1

Results

1. Waves emanate from the single dipper whose crests and troughs form concentric circles with the wave generator as the centre (Fig. 5).

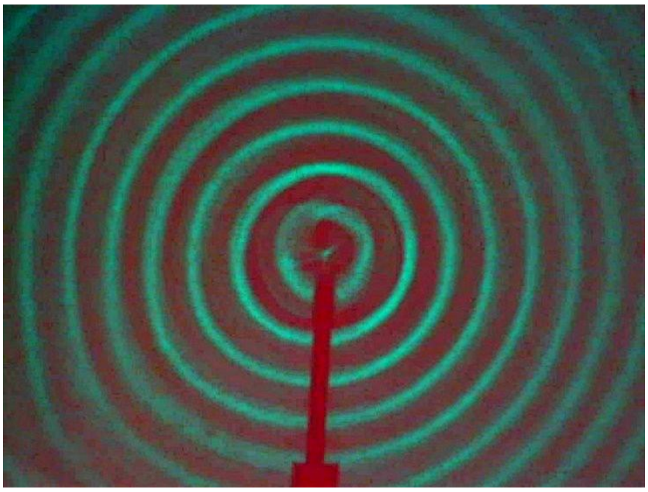

Figure 5: Snapshot according to the arrangement from Fig. 1. The circular waves produced by the single wave generator can be clearly recognised.

2. Waves emanate from the plane wave generator whose crests and troughs travel in a straight line and parallel to the generator (Fig. 6; minor irregularities in the wave pattern are virtually unavoidable).

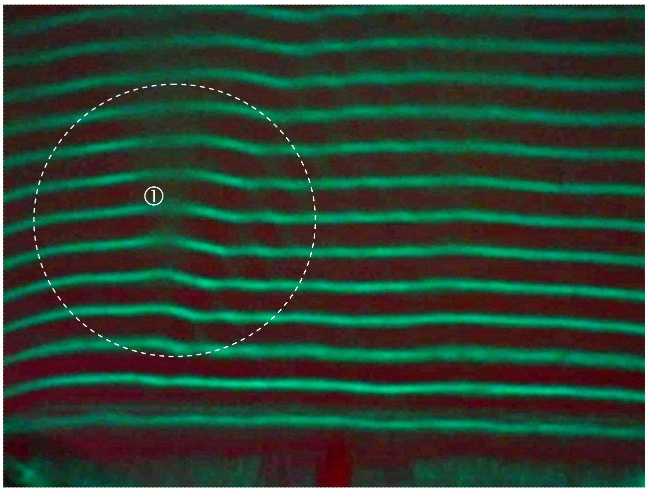

Figure 6: Snapshot in accordance with the arrangement from Fig. 2. The plane waves produced in the bottom part of the figure can be clearly recognised; the area ① is identified as an artefact.

Interpretation

1. The single dipper moving down in the water locally distorts the surface of the water surrounding it downwards due to the persistent wetting (contact) line at the dipper. This disruption of the water surface moves in all directions away from the dipper with the same speed as the circular wave trough. During the subsequent upward movement the surface of the water surrounding the dipper is raised as well. An annular wave crest forms, which follows the wave trough in the form of a concentric circle. The periodic up and down movement of the dipper causes the continuous wave pattern shown in Fig. 5.

2. The plane wave generator behaves approximately like a large number of linearly arranged point wave generators lying close to each other. According to Huygen's principle the plane waves shown in Fig. 6 can be interpreted as being superimposition of the circular waves emanating from these point generators.

Experiment 2

Results

1. The aperture blocks out or removes a wave beam from the complete circular wave area. The boundaries of this beam are divergent and their origin is at the wave generator. The wave beam is no longer sharply bound (Fig. 7).

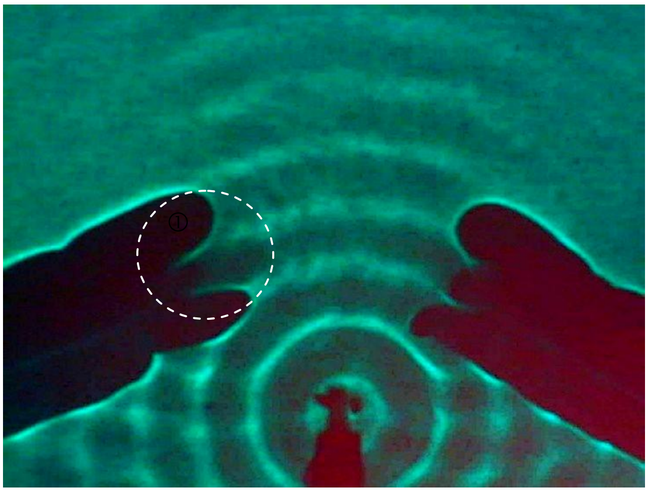

Figure 7: Experiment results as shown in Fig. 3. The passing wave beam and its divergent boundaries can be easily identified. (The barriers ① do not always appear in the wave pattern with a rich contrast, as could be supposed from their appearance. Reasons for this can be incomplete wetting by the water.)

2. A wave beam is blocked out or removed from the wave area.
The boundaries of this beam are parallel.
The wave beam is no longer sharply bound but instead the waves in the shadow area of the aperture continue in the form of a weak fraction of non-planar waves (Fig. 8).

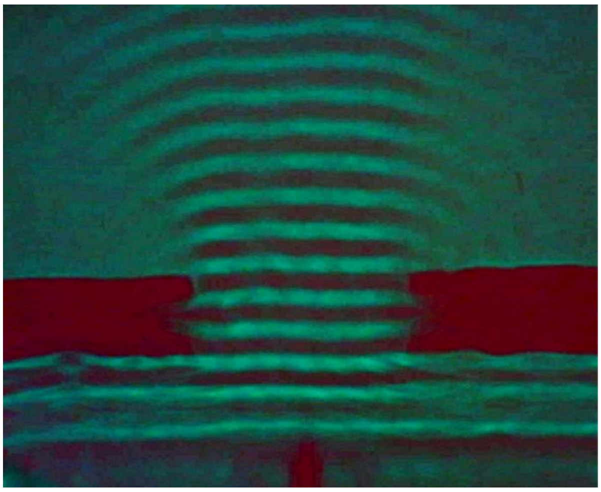

Figure 8: Experiment results as shown in Fig. 4. The passing wave beam can be clearly identified, its boundaries are not longer sharply defined and in the geometric shadow area behind the barriers the waves continue in the form of a fraction of non-planar waves.

Interpretation

Geometric optics uses the terms "divergent" and "parallel" beam. In the wave model the circular wave beam corresponds to the divergent beam and the multiple plane waves correspond to the parallel beam.
The experiment shows that these geometric optics terms represent an idealisation, which is not fully compatible with the wave nature of light: There are no sharp boundary lines due to the constantly occurring diffraction resulting when wave beams are bound by apertures. Such diffraction phenomena can be clearly seen in Fig. 7 and Fig. 8. (Diffraction phenomena are covered in greater depth in the experiments OW 4.1 and OW 4.2.)

