In this experiment, the reflection of water waves at a flat wall and at a concave reflector is examined. The familiar geometric optics reflection laws can be observed.
The concave reflector can be used to show that plane waves are approximately merged at a point, the focus or focal point. Circular waves which emanate from this focal point are approximately reflected as plane waves.

Materials
from the accessory set of 11260-99

1 Holder for plane wave generator
1 Plane wave generator
1 Wave generator, single
1 Dipper
1 Barrier l = 71 mm
1 Barrier l = 190 mm
1 Concave/convex reflector

Method

Experiment 1 – planar reflector:

The demonstration of the reflection of water waves is impaired by the unavoidable superimposition of incoming and reflected waves. However, by taking suitable experimental measures the reflection of plane waves can be convincingly demonstrated. A barrier is used to block off part of an incoming wave beam so that the reflection takes place in an area of the wave tank not reached directly by incoming waves (Fig. 1).

Experiment 2 – concave reflector:

The merging of plane waves in the focal point of a concave reflector cannot be clearly shown with continuous wave trains as the original and reflected waves superimpose and disrupt each other. The same applies to the demonstration of the creation of plane waves from circular waves emanating from this focal point.

In this experiment the wave generator is therefore used for a brief time only using the "pulse" mode, so that short wave trains result whose form before and after the reflection can be observed. First the focal point of the concave reflector is determined with the help of plane waves. The reflector is then moved in the wave tank so that the focal point lies precisely on an imaginary line through the middle of the plane wave generator. The plane wave generator is then replaced with the single wave generator and this is then moved up to the focal point.

Experiment 1 – planar reflector

Setup

The plane wave generator is fixed to the internal generator unit, then moved to the bottom edge of the wave tray and is carefully adjusted (generator edge and water surface are parallel). The two barriers (190 mm and 71 mm) are placed in the wave tank as shown in Fig. 1.

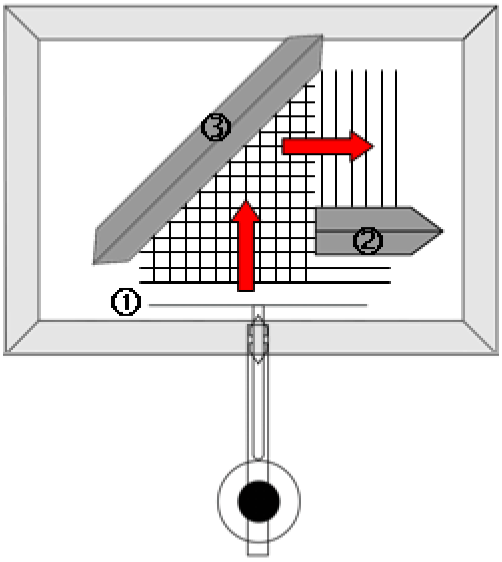

Figure 1: Experiment setup for reflection of plane waves at straight (planar) obstructions. The wave front produced by the plane wave generator ① is partly blocked off by the obstruction ② and hits the reflecting, planar object ③.

Procedure

A frequency f of around 20 Hz to 25 Hz is set at the ripple tank. The amplitude should be chosen so that a clear and undistorted wave pattern results.

The wave pattern is first observed for the case in which the reflecting obstruction (190 mm barrier) forms a 45° angle with the incoming waves (Fig. 1). The reflector is then moved to another position and the wave pattern is again observed.

Experiment 2 – concave reflector

Setup

Like experiment 1, only this time the concave reflector is placed in the wave tank as shown in Fig. 2.

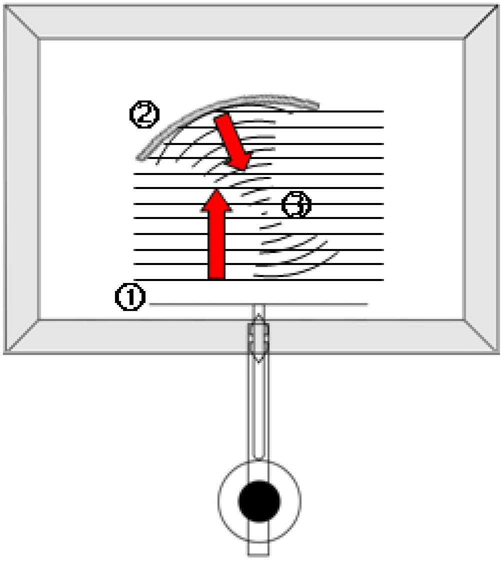

Figure 2: Arrangement for reflection of planar water waves at a concave mirror. The wave front produced by the plane wave generator ① hits the concave obstruction ② and is reflected in the form of circular waves. These circular waves merge at a focal point ③.

Procedure

After the plane wave generator has been carefully adjusted, the "pulse" mode of the ripple tank is used to generate a single wave train. This wave train can be used to determine the focal point of the concave reflector. The reflector should now be moved so that the focal point of the reflected waves lies on the imaginary extension of the exciter arm (see Fig. 2).

The plane wave generator is then removed and is replaced with the dipper for the generation of circular waves, whereby the dipper is now positioned in the same place as the previously determined focal point. The "pulse" mode is now used again to generate several wave trains and the waves reflected at the obstruction are observed.

Experiment 1 – planar reflector

Results

In the case where the reflecting obstruction is rotated through 45° relative to the incoming waves, the waves are reflected perpendicularly (at 90°) to the direction of their incidence (Fig. 3). In accordance with the geometric optics law of reflection, the incident angle and angle of reflection are the same size for other reflecting wall orientations also.

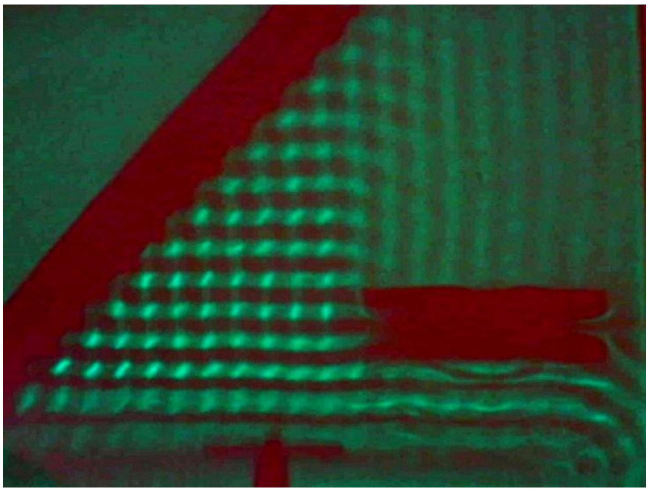

Figure 3: Snapshot according to the arrangement from Fig. 1 – the interference zone between the incident and outgoing wave can be clearly seen and the incident angle equals the angle of reflection of the wave train.

Interpretation

The law of reflection confirmed in this experiment can be explained within the scope of Huygen's principle by considering each point of the reflector to be a wave generator, which vibrates in phase with the incoming wave.

If an apparent phase step is identified between the incoming and reflected waves, this is solely due to the diffraction of light on the surface of the water, which causes the contours of the reflector to appear distorted.

Note:

For improved illustration of the validity, it is recommended to cut a piece of transparent film (transparency) matching the dimensions of the wave tray. The location of the obstructions and the incident and reflection angle in accordance with the law of reflection are drawn on the transparency with a waterproof felt pen and the film is placed underneath the wave tray. The reflecting obstruction is then placed precisely on the mark on the transparency. The conformity of the geometrically construed wave propagation directions with the observed directions are made especially clear this way.

Experiment 2 – concave reflector

Results

Plane waves are reflected at the concave mirror as circular waves. The wave crests and troughs travel toward a centre as concentric circles.

Circular waves emanated from this centre leave the mirror after reflection as approximately plane waves.

Interpretation

This experiment graphically illustrates the merging of parallel rays in the focal point of a concave mirror, known of from geometric optics, as well as the collimation of rays emanating from the focal point of the concave mirror in the wave pattern. An interpretation corresponding to the wave idea is also possible here within the scope of Huygen's principle. The distance between the focal point and reflector equals half the radius of curvature of the reflecting obstruction.

The concave mirror can also be used as a convex mirror in this experiment to demonstrate the divergence of the reflected waves and therefore to demonstrate the behaviour of light waves when they hit a convex mirror.

