The interference pattern of three or more equidistant wave generators arranged linearly shows additional, alternating stripes of rest and maximum wave generation between the order of interference observed with two wave generators.

Material

from the accessory set of 11260-99

1 Wave generator, comb, 10 teeth
10 Dipper
1 Wave generator, double

Method

The interference patterns of a large number of exciter centres with fixed exciter frequency and a fixed distance between adjacent equidistant wave generators.

Setup

Two dippers are attached to the comb-shaped wave generator; each of the dippers are the same distance from each other and are pushed onto the comb. It is advisable to use the first two comb teeth, viewed from the middle of the screen. The mounting rod with comb is then fixed to the exciter arm and moved to the bottom edge of the tank (Fig. 1).

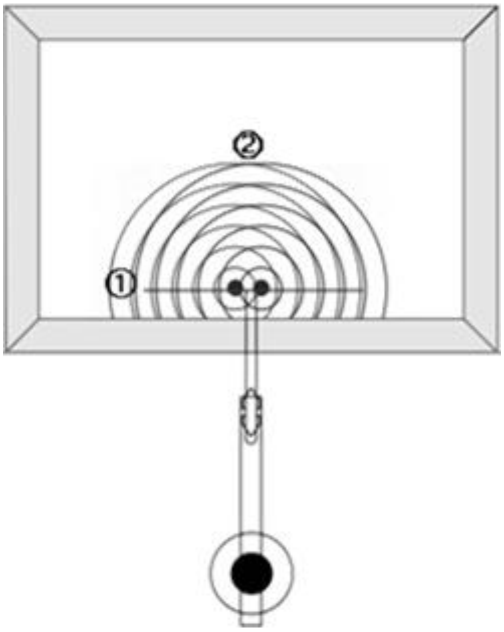

Figure 1: Arrangement for interference with two dippers. The two circular waves generated by the comb-shaped wave generator ① superimpose to form a characteristic interference pattern ②.

Procedure

A exciter frequency of around 20 Hz to 25 Hz is set and the amplitude is selected so that a clear wave pattern results. The interference pattern is then observed.
The interference patterns for three, four and ten circular wave generators are then observed accordingly (Fig. 2 to Fig. 4). The exciter frequency remains the same for all observations.

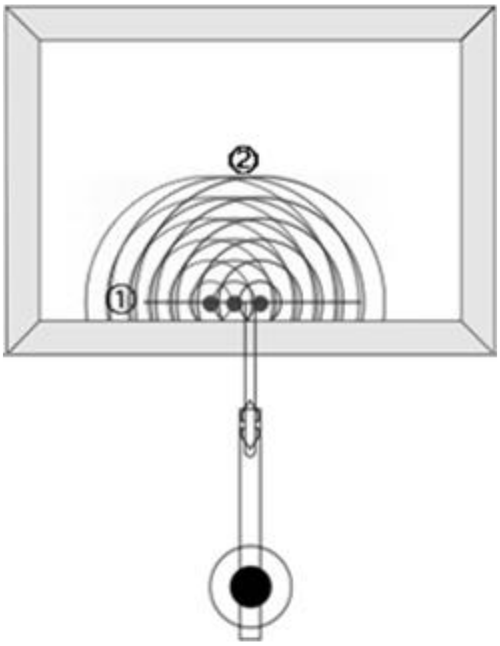

Figure 2: Arrangement for interference formation with **three** dippers. The three circular waves generated by the comb-shaped wave generator ① superimpose to form a characteristic interference pattern ②.

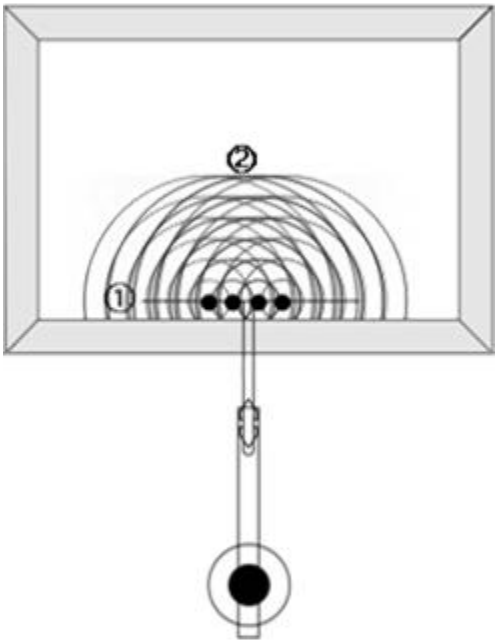

Figure 3: Arrangement for interference with **four** dippers. The four circular waves generated by the comb-shaped wave generator ① superimpose to form an interference pattern ②, which appears denser compared to the interference pattern with two or three dippers (Fig. 1 and 2).

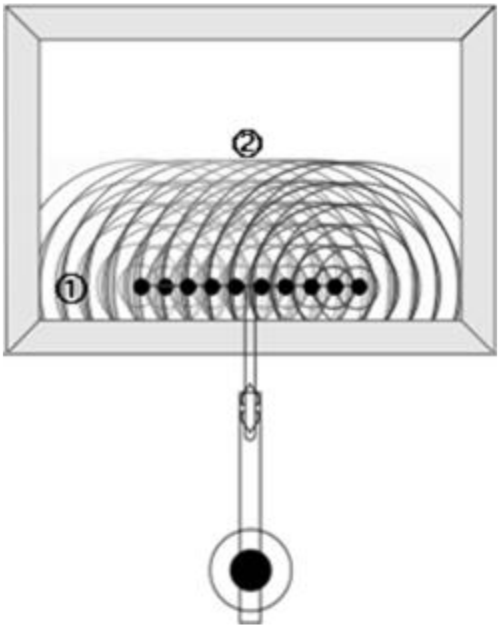

Figure 4: Arrangement for interference with **ten** dippers. The circular waves produced by the comb-shaped wave generator ① superimpose to form an interference pattern ②, which appears even closer and denser compared to the preceding interference patterns.

Results

The wave patterns observed are shown in the following figures. (These figures show photographic images, which give the same impression as the eye would have with stroboscopic lighting, if the stroboscope and exciter frequency are the same. If the observation distance is not too large, the interferences without stroboscopic lighting become more clearly identifiable in the progressing wave pattern.)

With two wave generators (Fig. 5) three wavebands of roughly the same width are identified. These wavebands can be observed with three wave generators in the same location; however, they are narrower and an additional, narrower waveband can be identified between these bands (Fig. 6). It is clearly separated from the main wavebands by two stripes.

With four exciter centres (Fig. 7) two additional, narrow wavebands can be observed between each of the three main wavebands of Fig. 5. The main wavebands have become even narrower.

If ten exciter centres (Fig. 8) are used the number of wavebands is increased still further and they become even narrower. The interference pattern near the exciter centres is similar to the wave pattern of a plane wave.

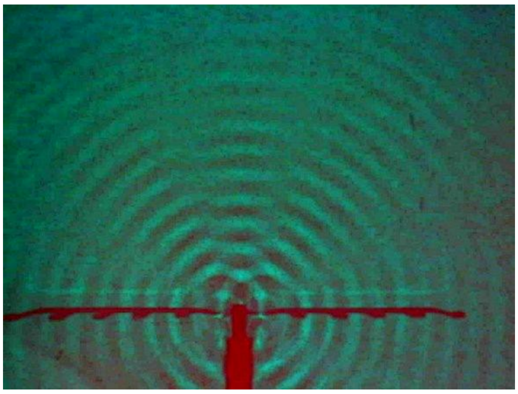

Figure 5: **Two** generators – snapshot as shown in Fig. 1. Three wavebands with roughly the same width can be clearly seen, which are separated from each other by two stripes without wave generation.

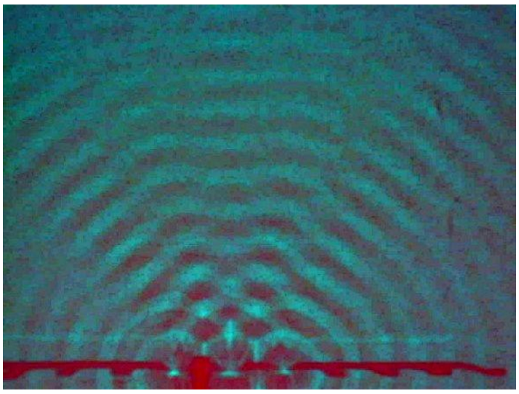

Figure 6: **Three** generators – snapshot as shown in Fig. 2. An additional waveband compared to Fig. 5 can be clearly identified in the middle. Overall, the wavebands are narrower.

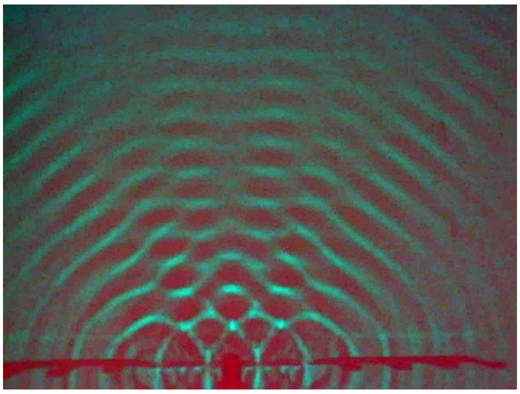

Figure 7: **Four** generators – snapshot as shown in Fig. 3. The number of wavebands has increased and they are narrower than in the interference of two circular waves. At the rear the waves are no longer as circular as with two generators (Fig. 2).

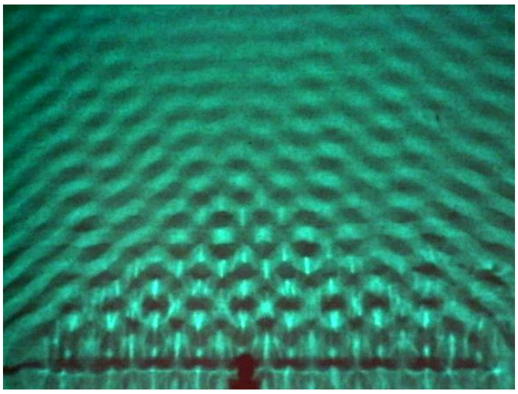

Figure 8: **Ten** generators – snapshot as shown in Fig. 4. The interference pattern of the ten superimposed circular waves can be identified. The number of wavebands has again increased so that the interference pattern directly behind the wave generator is similar to the wave pattern of a plane wave.

Interpretation

The three wavebands identifiable in Fig. 5 (two dippers) are the zeroth order and the two wavebands symmetrically following these are the first interference orders. For reasons of simplification we want to exclude the immediate surroundings to clarify the formation of additional interference bands between the zeroth and first order when the number of wave generators is increased. For locations whose distances from the generators are large compared to the distance d between the generators, the following applies to two wave generators (Fig. 9) for the path difference Δl between the two interfering waves:

$$\Delta l = d \cdot \sin\alpha.$$

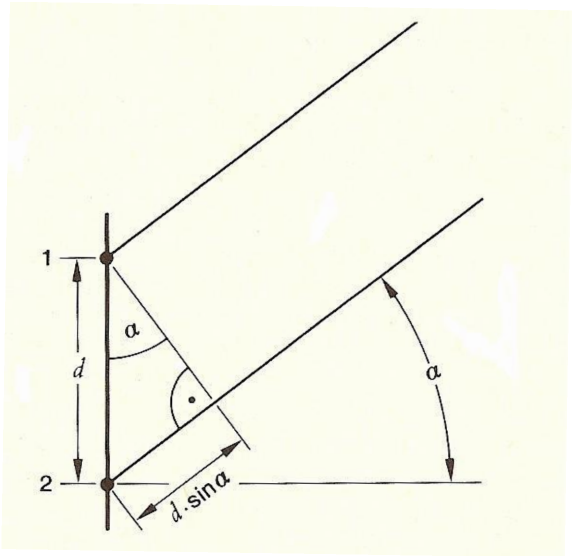

Figure 9: Schematic diagram of the formation of maxima and minima with two wave generators.

For the first order maximum, $\Delta l = \lambda$ must be true so that (irrespective of the number of generators!):

$$\sin\alpha = \frac{\lambda}{d}$$

is true.

Accordingly the angle between the zeroth and first order for which complete destruction (destructive interference / cancelling out of waves) results ($\Delta l = \lambda/2$) is:

$$\sin\alpha = \frac{1}{2} \cdot \frac{\lambda}{d}.$$

From Fig. 10 it can be seen that complete destruction does not occur with three generators with the same angle, because as a result of the complete deletion, e.g. the waves emanating from generators 1 and 2, the wave from the third generator which reaches the observation location remains fully undisturbed. However, three sinus waves completely cancel each other out if they are out of phase by either 1/3 or by 2/3 of a period. This can be clearly shown in a particularly graphic way in the vector (phasor) diagram.

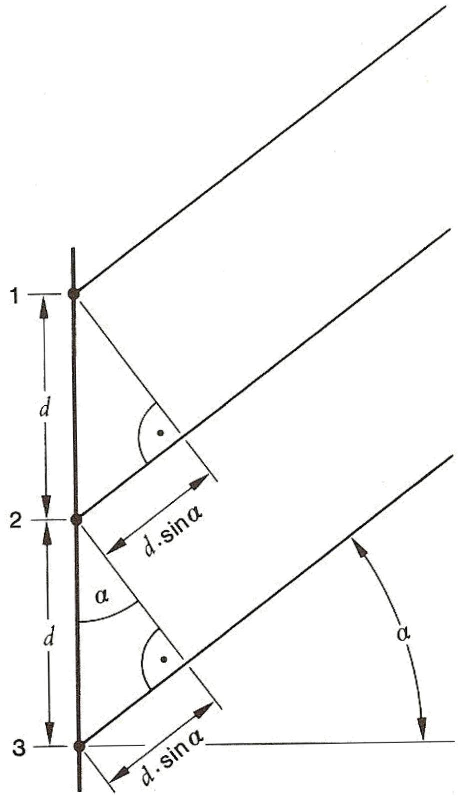

Figure 10: Schematic diagram of the formation of maxima and minima with three wave generators.

Thus, two secondary minima result, as can be seen in Fig. 6:

1st Secondary minimum:

$$d \cdot \sin\alpha = \frac{1}{3}\lambda \;\Rightarrow\; \sin\alpha = \frac{1}{3} \cdot \frac{\lambda}{d}$$

2nd Secondary minimum:

$$d \cdot \sin\alpha = \frac{2}{3}\lambda \;\Rightarrow\; \sin\alpha = \frac{2}{3} \cdot \frac{\lambda}{d}$$

The formation of three secondary minima with four wave generators can be using Fig. 11. Cancellation occurs if the waves emanated from generators 1 and 2 compensate for each other like the waves emanated from generators 3 and 4. On the other hand the waves emanated from generators 1 and 3 and those from the generators 2 and 4 can also cancel each other.

Thus, starting from the zeroed order, the following secondary minima result:

1st Secondary minimum:

$$2 \cdot d \cdot \sin\alpha = \frac{1}{2}\lambda \;\Rightarrow\; \sin\alpha = \frac{1}{4} \cdot \frac{\lambda}{d}$$

2nd Secondary minimum:

$$d \cdot \sin\alpha = \frac{1}{2}\lambda \;\Rightarrow\; \sin\alpha = \frac{1}{2} \cdot \frac{\lambda}{d}$$

3rd secondary minimum:

$$2 \cdot d \cdot \sin\alpha = \frac{3}{2}\lambda \;\Rightarrow\; \sin\alpha = \frac{3}{4} \cdot \frac{\lambda}{d}.$$

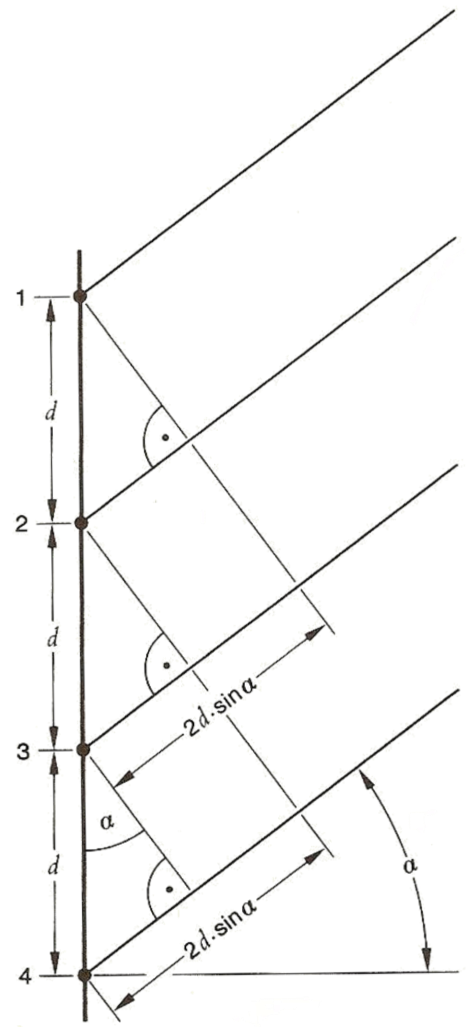

Figure 11: Schematic diagram of the formation of maxima and minima with four wave generators.

If the number of generators is increased further, the circular waves are superimposed according to the principle described above. The larger the number of circular wave generators the more the resulting interference pattern resembles that of the wave pattern of a plane wave.

In this experiment this phenomenon is indicated by the ten wave generators (Fig. 8). Of course, this number is not sufficient to achieve a plane wave, but on the basis of Fig. 8 it is very easy to imagine how the interference pattern would look if there was an infinite number of exciter centres. Then the resulting image is that of a plane wave. Precisely this is stated by Huygen's principle.