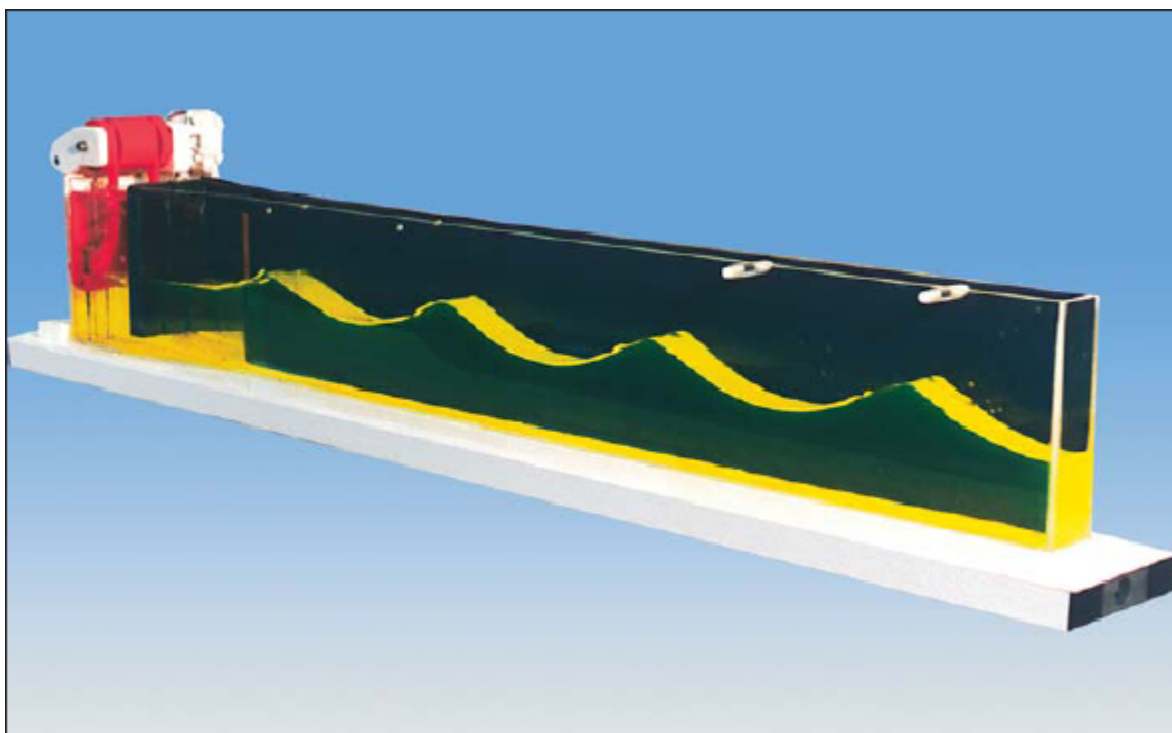


Water Wave Channel U8431411

Instruction sheet

11/08 ELWE/ALF



1. Description

The water wave channel serves for the demonstration and investigation of surface waves in water. It consists of a large transparent oblong trough, which is two-thirds filled with water.

The waves are produced in the short V-shaped section and studied in the I-shaped section. For the generation of the waves a motor with transmission is attached at the end of the V-shaped channel. It propels two wave exciters, which move up and down in the water. Each exciter produces a wave in a section of the V-shaped channel. Depending upon the setting, the two exciters can move in the same direction or in contra motion. The frequency of these waves can be varied by changing the operating voltage of the motor.

In both partial channels there is a frame with a fleece directly in front of the wave exciters which the waves must pass through. Thus to a large extent a sinusoidal process is achieved. Then the waves enter the I-shaped part of the channel and move along to its end. If the absorbing frame with fleece is introduced at the end of this channel, then they are dissipated as far as possible. Thus a continuous wave pattern develops in the channel. If the absorber is not inserted, the waves travel to the end of the I-shaped channel and are reflected.

With a short switch-on time of the motor, a wave train develops which travels through the channel and is reflected and travels back towards the exciter. With continuous operation of the motor the arriving and the reflected waves overlap, producing an image of a motionless standing wave.

If the wave absorbed at the end of the I-channel is produced by only one wave exciter (by blocking the second partial channel), then its amplitude is small. If both partial waves arrive into the I-shaped part of the channel, then the amplitude increases.

By inserting the separator into the transient area between the V-shaped channel and the I-shaped channel, the two partial waves run separately in the I-shaped channel and their motions can be compared with one another. If the two wave exciters are operated in contra motion then the phase shift from $\lambda/2$ can be clearly observed in the area of the inserted glass plate. The overlap of these two partial waves leads to the fact that after they enter the rear part of the I-channel they cancel each other out to the greatest extent possible.

The following experiments can be carried out with the water wave channel:

- Production of a non-periodic wave
- Production of a periodic wave
- Proof that waves transport energy, but not material
- Phase and group velocity of a wave
- Determination of the phase velocity
- Demonstration of the relationship between frequency and wavelength
- Reflection of a wave
- Standing waves
- Same-phase overlapping of waves
- Overlapping of waves with a phase shift of $\lambda/2$

1.1 Accessories

- 2 Conical frames with fleece for the homogenisation of the waves (primary absorber)
- 1 Frame with fleece for the absorption of the wave (secondary absorber)
- 1 Tube for the temporary blocking of a partial channel
- 1 Transparent separator 40x170x6 mm with spacer pieces for inserting into the I-shaped channel
- 2 Plastic balls with thread for the proving the up and down movement

1.2 Additionally required apparatus

- 1 Power supply unit for DC voltage, 0 ... 20 V, continuously variable
 - 1 Reflector lamp
- Fluoreszein for colouring the water

2. Technical data

Operating voltage of motor:	12 V DC
Dimensions:	1500 mm x 150 mm x 290 mm
Mass:	approx. 12.6 kg

3. Operation

- Fill up the water wave channel to the marked height with water, to which some fluoreszein has been added (fig. 1).
- The lighting with the reflector lamp takes place diagonally from above, so that a fluorescent layer appears on the water surface.
- Connect the motor to the power supply unit.
- Into the two partial channels of the V-shaped part, a conical frame with fleece is introduced.
- At the end of the I-shaped part, the absorber frame with fleece is introduced at such an angle that the waves at the surface travel very flatly over it.
- Switch on the motor.

The image of a spreading wave develops.

In order to change the phase position of the two partial waves, one of the rollers on the wave exciter is rotated through 180° until it engages.

The voltage for the motor can be increased briefly to approximately 13 V. The amperage is smaller than 0.5 A. The switch for the motor has three positions. In the middle position the motor is switched off. When pressed to one side, the motor is switched on and remains on until the switch is returned to the off position (continuous mode). When pressed in the other direction, the motor is switched on and remains on only whilst pressure is maintained (pulse mode). In this mode short wavelengths can be produced.

- When the experiments are completed put a water bucket under the end of the I-shaped channel.

To empty the channel a fatigue proof plastic tube connected to the channel inside is stored in the grey box at the end of the channel.

- To drain the water, carefully take the tube out of the box (one end is fixed to the drain nozzle).
- Slightly stretch the tube and place the free end into the bucket.

The water will be drained automatically.

- After draining the channel fold the tube in its original zigzag configuration and push it back into the box.

4. Sample experiments

4.1 Generation of a non-periodic wave

Firstly, adjust both exciters so as to produce the same phase movement.

- Introduce the absorber frame at the end of the I-shaped part of the wave channel.
- Switch on the motor for approx. 1 s.

A short wave train develops which moves through the wave channel (fig. 2).

4.2 Generation of a periodic wave

- Switch on the motor for a longer time.

A progressive periodic wave develops at the exciter and travels to the end of the I-channel.

4.3 Proving that waves transport energy, but not material

- Attach the two plastic balls in the middle part of the I-shaped channel by their threads to different places on the channel wall.
- Switch on the motor briefly

When the balls are met by the wave train, they move rhythmically over and back like the water particles. After the wave train moves through, the balls are still in the same position.

4.4 Determining the phase velocity of a wave

- Measure the time which a wave peak needs to travel from the entrance of the I-shaped channel to the absorber with motor running.

The speed is calculated as a quotient of distance and time.

4.5 Relationship between frequency and wavelength

- First operate the motor with a low voltage.
- Measure the wavelength.
- Then increase the frequency of the motor and again determine the wavelength.
- Repeat the experiment with a still greater number of revolutions of the motor.

The greater the frequency of the wave, the smaller is the wavelength.

4.6 Reflection of the water wave

- Remove the absorber frame from the end of the I-channel.
- Switch on the motor for approx. 1 s.

A short wave train develops, which moves up to the end of the I-channel. There it is reflected and travels back towards the wave exciter.

4.7 Phase velocity and group velocity

- Switch on the motor for approx. 2 s.

It is clearly visible that the wave peaks move with greater speed to end of the I-channel and after the reflection, from there towards the wave exciter than the entire group of waves.

4.8 Standing waves

- Switch on the motor.

The wave is reflected at the end of the I-channel. The reflected wave overlaps with the arriving wave. A standing wave develops. A convincing image of a standing wave can be achieved with a slight adjustment of motor speed.

4.9 Same-phase overlapping of waves

- Introduce the wave absorber again at the end of the I-channel.
- Switch on the motor.
- First block the exit of the partial channels with the cylindrical body.
- Determine the amplitude of the wave after it enters the I-channel (fig. 3).
- Open the second partial channel again and determine the amplitude again at the same location.

It is now greater than in the first instance by a factor of $\sqrt{2}$. (fig. 4).

4.10 Overlap of waves with a phase-shift of 1/2

- Rotate the sleeve on the exciter paddle in such a way that the exciters move in contra-motion.
- Introduce the separator plate into the area between the V-shaped section and the I-shaped section.
- Switch on the motor.

Where the separator is situated, the out of phase situation of the two partial waves is clearly visible. In the I-shaped part of the channel which is not separated by the plate, the two partial waves meet and cancel each other out (fig. 1).

The fact that standing waves are formed in the area of the channel with the separator plate is to be due to the reflection of the partial waves behind the separating plate. If the exciter is only switched on briefly, then it is noticed that the two partial waves move up to the overlapping position. There they are then reflected back into both channels.

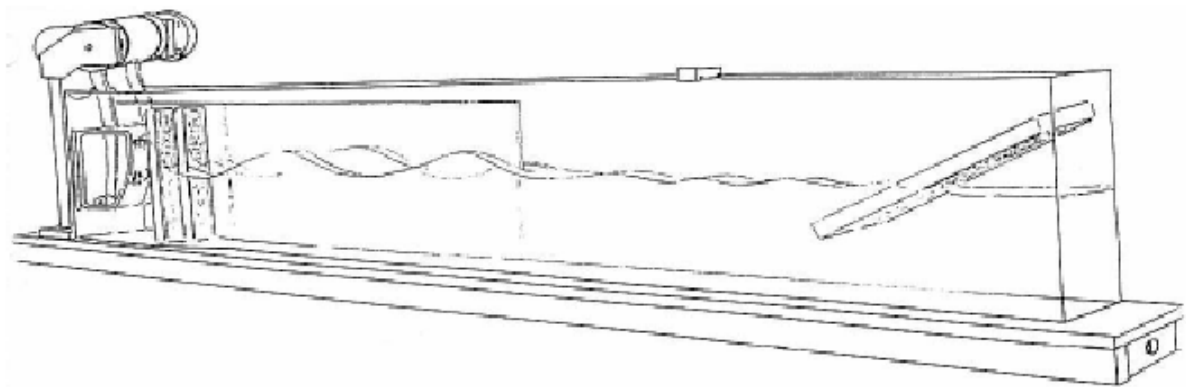


Fig. 1 Experimental set-up of the wave channel

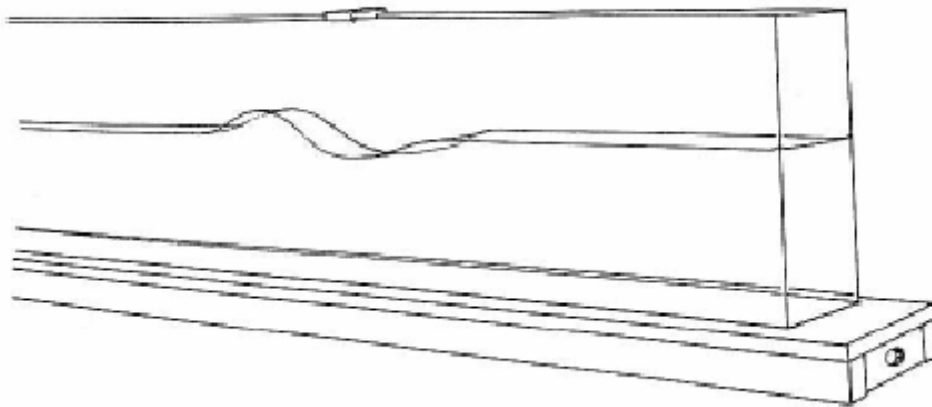


Fig. 2 Generation of a non-periodic wave

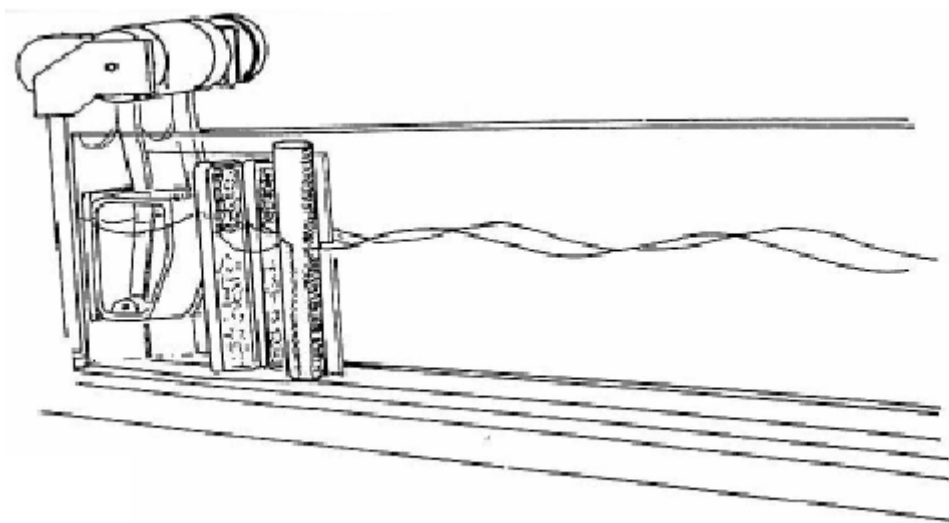


Fig. 3 Same-phase overlapping of waves

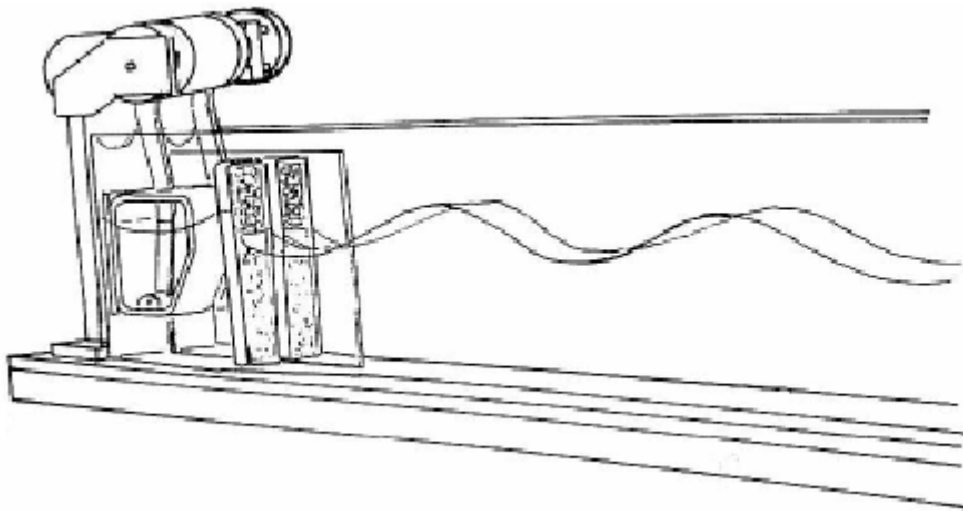


Fig. 4 Same-phase overlapping of waves