Wave machine

11211-00

PHYWE Systeme GmbH & Co. KG
Robert-Bosch-Breite 10
D-37079 Göttingen

Telefon +49 (0) 551 604-0
Fax +49 (0) 551 604-107
E-mail info@phywe.de

Operating instructions

Fig. 1: 11211-00 Wave machine

CONTENT

1 SAEFTY PRECAUTIONS

Cautions!

- Read the operating instructions thoroughly and completely prior to using this instrument. This is important for your own protection and for avoiding damage to the unit.
- Do not start up this instrument should there be visible signs of damage to it.

2 PURPOSE AND CHARACTERISTICS

The wave machine is used to demonstrate wave propagation using the example of coupled pendulums and to carry out quantitative measurements, e.g. of wave length and frequency with the aid of light barriers.

Topics:

- Propagation and development of an equilibrium disturbance
- Propagation of a periodically excited continuous wave
- Superposition of waves
- Standing waves and natural oscillations

3 FUNCTONAL AND OPERATING ELEMENTS

3.1 The oscillatory systems

The oscillatory system consists of 48 identical, ring-shaped oscillators 1, whose centres lie equidistant apart on a horizontally taughtened, thin steel wire 3, and which are coupled to each other by continuous elastic bands. Coloured numbered discs mark the zero line when the system is at rest, and make the wave train which results from excitation visible even from some distance.

3.2 Excitation

The excitation of the oscillatory system is normally carried out on the first oscillator. This oscillator is therefore furnished with two pins 2, which each have a circular groove for holding connecting rod 4 for mechanical excitation. The top pin is normally used for this purpose. Fig. 3 enables the movement to be described: The drive rod 6 is turned back and forth by the rotation of the tappet 8 and the resulting movement of the tappet shaft 8.1. This back and forth turning movement is transmitted to the first oscillator via the driving lever 5 and the connecting rod 4. The extent to which the drive rod turns, and so also the amplitude of the oscillator displacement, can be changed by adjustment of the position of the tappet shaft in the longitudinal slit 7.1 in turning lever 7. The shorter the distance from the drive rod, the greater the extent to which the drive rod turns. In some experiments, it is necessary to mechanically excite the last oscillator, this is therefore also furnished with a grooved pin above the centre of the oscillator, and the mode of its movement on excitation is as described for the first oscillator. Drive rod 6 consists of two rods, the inner ends of which are held in the coupling counterpart 9. The end of the drive rod leading to the first oscillator is firmly connected in the coupling by an Allen screw 9.1 and the end of the drive rod leading to the last oscillator is fixed by a milled screw 9.2. The wave machine is factory adjusted so that when the driving lever 5 is vertically upright, the turning lever 7 points exactly vertical downwards.

When the first and last oscillators are to be excited simultaneously - when the phase relationship between the two propagated waves are to be varied - it is necessary to change the relative position of the two driving levers 5 to each other. As these are fixed on the drive rods, this change must be made by loosening the milled screw 9.2 and appropriately turning the drive rod to the last oscillator. Do not loosen the Allen screw 9.1. Three connecting rods are supplied with the wave machine, two of these are identical straight rods and the other is an angled rod. The straight connecting rods are used - apart from the excitation of the first oscillator – to fix the last oscillator or also for two-sided, cophasal excitation.

3.2.1 One-sided excitation of the oscillating system

Connect the first oscillator to the motor with a straight connecting rod 4. When experiments are to be carried out with a „fixed end“, lock the last oscillator at its zero position with the second straight connecting rod; to do this, clip the inclined slit of the rod to the back of the housing.
For experiments with a „free end“, do not engage a connecting rod to the last oscillator.

3.2.2 Excitation from both sides

The phase relationship between the waves propagated at the start and at the end is dependent on the relative positions of the two driving levers 5 to each other. It is exactly 0° or 180° when the levers are exactly parallel to each other.
The required phase angle between the first and last oscillator can be set after milled screw 9.2 has been loosened.

- Cophasal excitation: Connect straight connecting rods to the first and last oscillators.
- Opposite phase excitation: Connect the last oscillator to the turning lever with a straight connecting rod; for excitation of the first oscillator, use the angled connecting rod with its longer arm fitted to the driving lever and the shorter arm to the lower pin of the oscillator.

3.3 Braking system and drive clutch

The braking system enables all of the oscillators to be simultaneously arrested in the position they are in at any moment on time, so that the oscillators depict the wave as it was at the instant of arrest, or the displacement from equilibrium. When the brake is rapidly applied using the brake arm 10, a braking strip with a spongy covering suddenly blocks the oscillators, the lever is arrested in this position. At the same time, the motor clutch is disengaged. Screw 7.6 allows the clutch to be optimally adjusted, so that whereas disengagement can occur with certainty, the displacement of the turning lever 7 is not unnecessarily large, i.e. tension in the tappet shaft 8.1 is avoided. The brake arm is locked by a clamp in the „hold“ position, and can only be freed manually after lifting up the clamp. The brake system then automatically returns to its initial state and releases the oscillating system. At the same time, the drive is again engaged.

3.4 Damping system

To avoid unwanted reflections at the end of the oscillating system, the wave machine can be operated with liquid damping which is proportional to the speed. For this, the last five oscillators (44 ... 48) are fitted with damping plates of gradated size. The plates are at their deepest point when the oscillators are in their rest position, and then dip into water in a water-filled trough which is inserted under the oscillators. The numbered discs on oscillators 42 and 43 have the sides towards each other slightly cut back, so that they do not hit the side wall of the damping trough. When experiments are to be carried out with particularly energy-rich waves, damping can be increased by adding glycerol to the water as required. When experiments have been completed, allow the damping liquid to run out through the tubing into a sufficiently large vessel (2 l capacity).

4 HANDLING

When unpacking the wave machine, be sure to take the two packages containing accessories out of the packaging. They contain three connecting rods (two straight, one angled), a tappet with tappet shaft, two attachable diaphragms, a damping trough with drainage tubing and tubing clips as well as an Allen key (SW 2). The wave machine can be excited manually or with a motor.

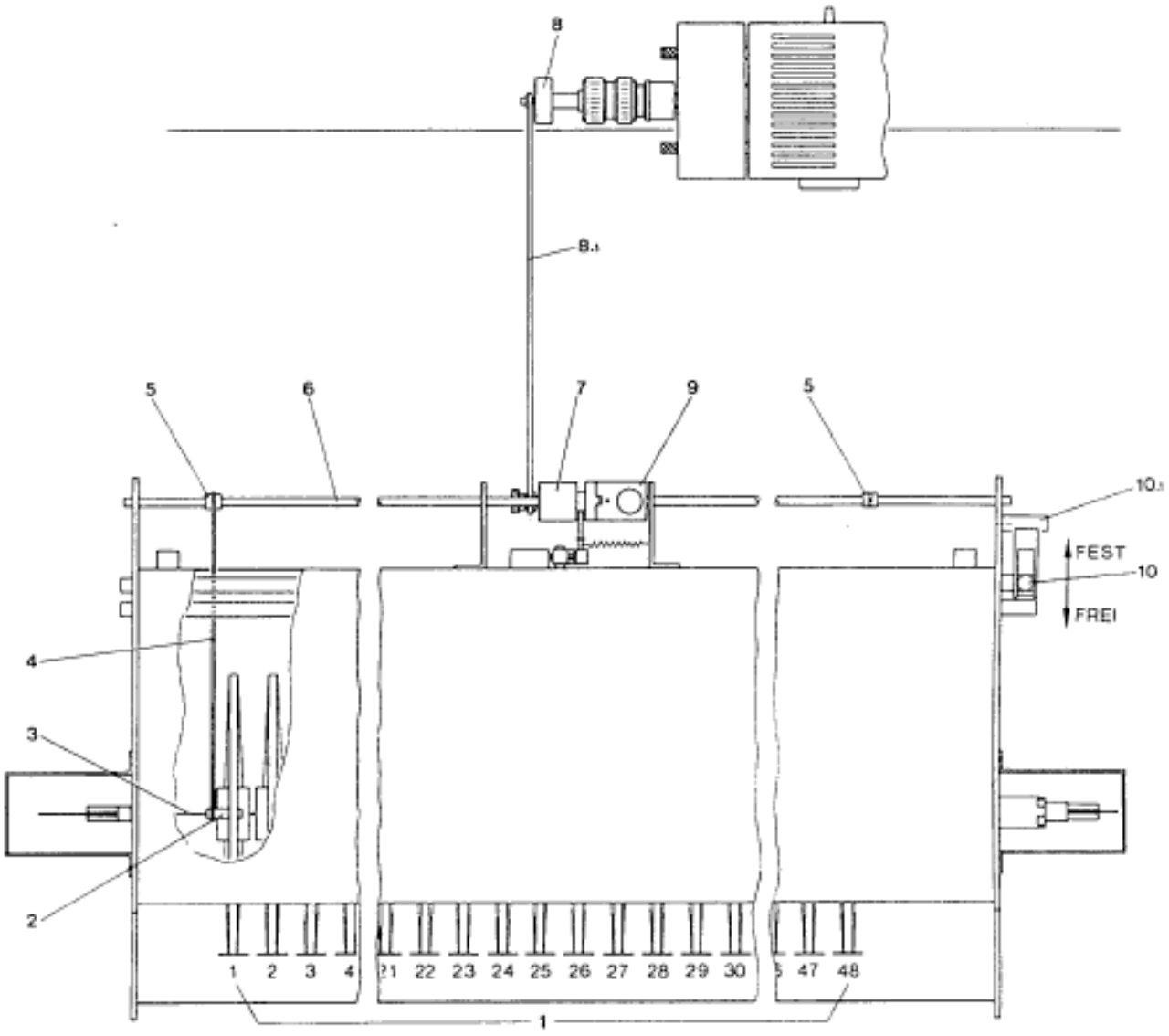

Abb. 2

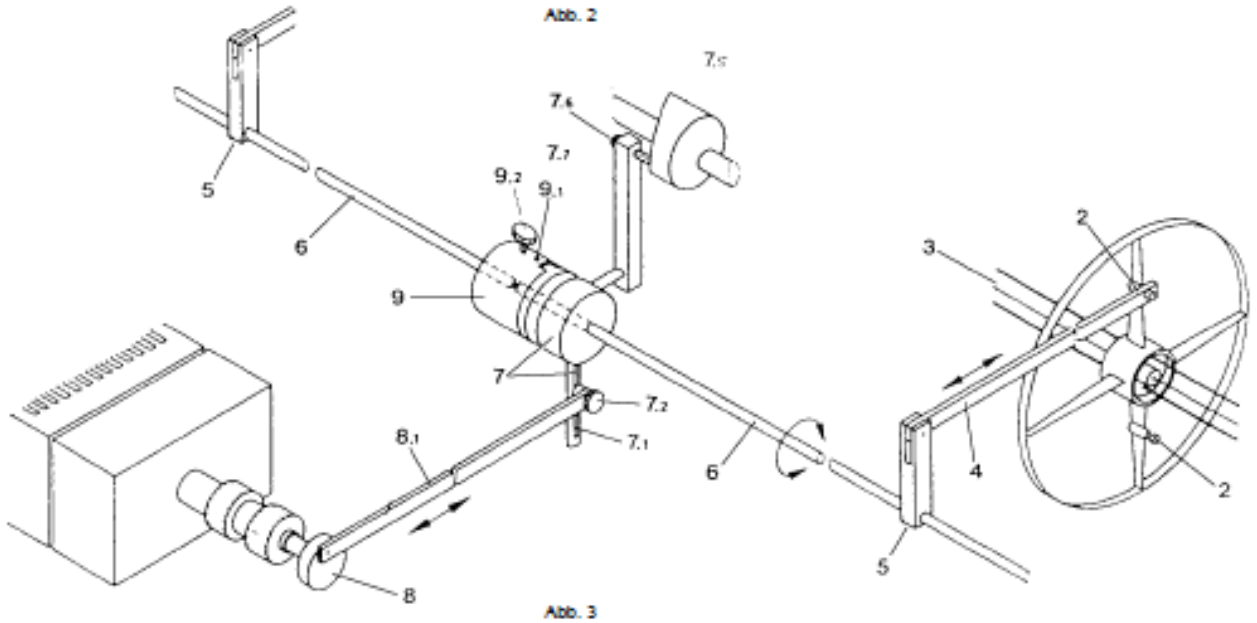

Abb. 3

4.1 Positioning

The footprint of the wave machine is 132 cm wide and 35 cm deep. Place it on a surface which is stable and as horizontal as possible. When it is to be used with automatic periodic permanent excitation, position it approximately 30 cm away from the back edge of the table, to leave space for the mounting of the motor behind the wave machine (see Fig. 2).

4.2 Motor drive

First fix the tappet shaft 8.1 to turning lever 7. To do this, completely loosen milled screw 7.2 to free the guide pin with thread 7.4 (Fig. 4). Position the tappet shaft on the guide pin and fix it about halfway up the longitudinal slit with the milled screw.

Fit out the laboratory motor with the appropriate gearing, holding the shaft of it in the motor grip (refer to the Operating Instructions supplied with the motor for details on how to handle it!).
Hold the motor at the back edge of the table with a table clamp, with the motor positioned so that the axis of rotation is parallel to the edge of the table and at the same height as the point of application chosen for the tappet shaft in the longitudinal slit 7.1. When the table is very low, the laboratory motor can also be held in a support base. Fix the 10 mm bolt of the tappet in the grip of the motor or gearing. The position of the tappet shaft should be vertical to the motor axis and to the drive rod, which have been set parallel to each other, with turning lever 7 engaged; if necessary, appropriately reposition the motor along the table edge.
When it is important to you that the oscillating system is excited with a symmetrical amplitude, the following two conditions must be fulfilled:

- Driving lever 5 must point vertically upwards when turning lever 7 points vertically downwards.
- Turning lever 7 must point vertically upwards when the eccentically turning holding pin for tappet shaft 8.1 is at the highest and lowest points of its circulatory movement.

The first condition is fulfilled by the factory adjustment; should this adjustment has been changed at any time, loosen the Allen screw to appropriately turn the turning lever on the drive rod.
The second condition is fulfilled when the motor is at the correct distance from the wave machine.

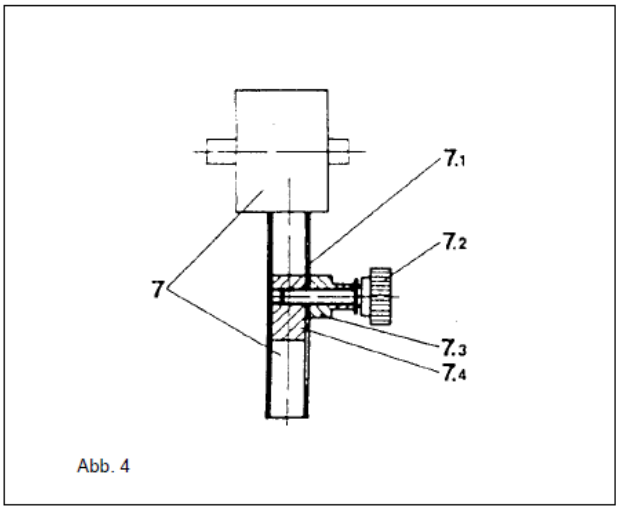

Abb. 4

Fig. 4

4.3 Measurement devices

Light barriers and electronic counters can be used with the wave machine to demonstrate and perform measurements of periods and frequency, without any mechanical retroaction on the oscillating system. Each wave machine is supplied with two diaphragms which serve as switching diaphragms for light barriers. For this purpose, spread them out and clip their slit onto the numbered plates of the oscillators of your choice.

4.4 Storage

When the wave machine is not used for some time, we recommend that it be stored somewhere where it - and in particular the oscillating system - is not exposed to direct sunlight. Ensure that the brake arm is not applied, as the bearing wire of the oscillating system is then additionally burdened.

4.5 Service

The wave machine requires no service. Only when „free end“ experiments are carried out, increased friction resulting from rubber rubbings can make itself disturbingly noticeable. In this case, we recommend that you clean the elastic band seating behind the last oscillator. To do this, draw the elastic band clamp off to the right and clean the bearing surfaces of the oppositely moving parts with a clean cloth and oil them a little (e.g. with a few drops of sewing machine oil).
Caution: Never abruptly let go of a bearing plate, as the recoiling of this would damage the sensitive ball bearings.

5 EXPERIMENTS

Propagation of a periodically excited continuous transverse wave	P2133210
Propagation of a periodically excited continuous transverse wave with light barrier and timer 2-1	P2133220

6 TECHNICAL DATA

- 48 numbered pendulums drawn on steel wire and coupled via 2 rubber cords
- Excitation of one or two sides with variable amplitude
- Possibility to fix momentary wave images
- Shutter plates for time measurements
- Oscillating radius 90 mm
- Dimensions (cm): 148 x 35 x 35
- Weight 20 kg

7 SCOPE OF DELIVERY

Adapter for wave machine	11616-00

8 OPTIONAL ACCESSORIES

PHYWE Power supply, 230 V,	13506-93
Motor, with gearing, 12 VDC	11610-11
Safety connecting cable, 32A, l = 100cm, blue	07337-04
Safety connecting cable, 32A, l = 100cm, blue	07337-01
Bench clamp expert	02011-00

9 SPARE PARTS

Square rubber strap f. wave machine, *l* = 2 m	SP-1121101
Stop foam film for wave machine, *l* = 2 m	SP-1121102

10 WARRANTY

We give a warranty of 24 months for units that are supplied by us inside the EU, and a warranty of 12 months outside the EU. The following is excluded from the warranty: damage that is due to non-compliance with the operating instructions, improper use, or natural wear.

The manufacturer can only be held liable for the function and safety-relevant properties of the unit, if the maintenance, service, and modifications of the unit are performed by the manufacturer or by an institution that is expressly authorized by the manufacturer.

11 DISPOSAL

The packaging mainly consists of environmentally-friendly materials that should be returned to the local recycling stations.

Do not dispose of this product with normal household waste.

If this unit needs to be disposed of, please return it to the address that is stated below for proper disposal.

PHYWE Systeme GmbH & Co. KG
Customer Service
Robert-Bosch-Breite 10
37079 Göttingen
Germany

Phone +49 (0) 551 604-274
Fax +49 (0) 551 604-246