Oct. 6, 1931. P. E. KLOPSTEG 1,825,739

WAVE MACHINE

Filed May 16, 1929

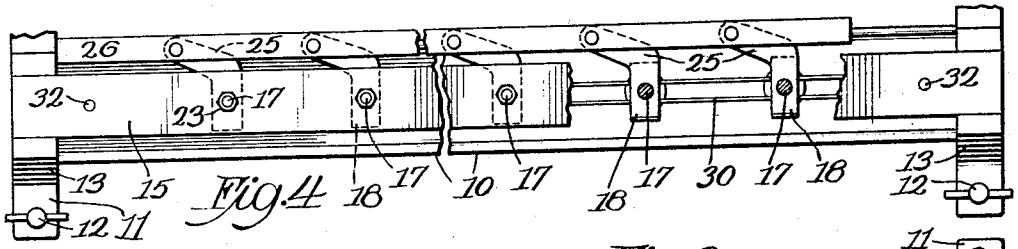


Fig. 4

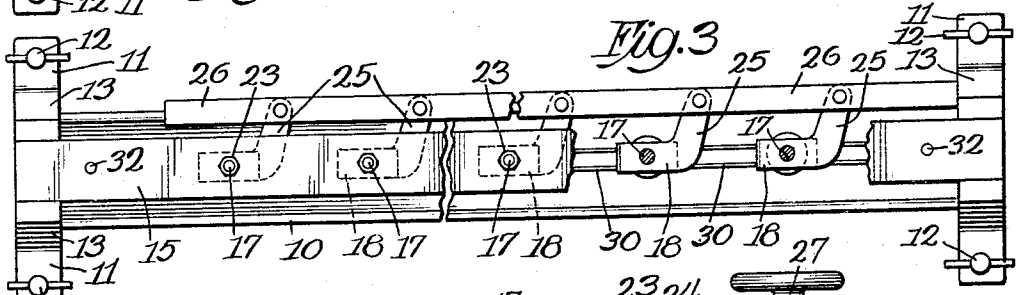


Fig. 3

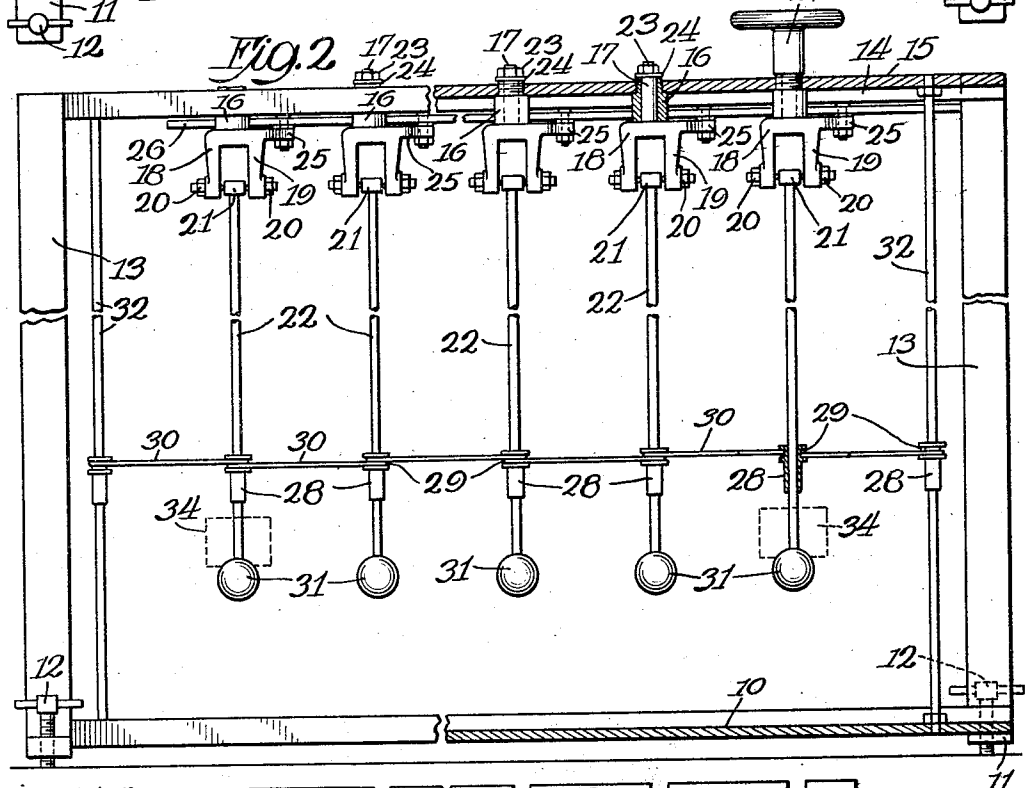


Fig. 2

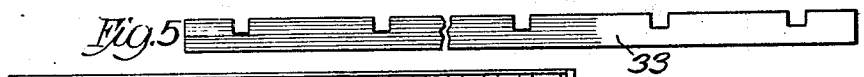


Fig. 5

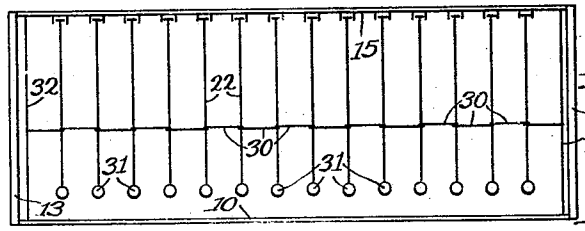


Fig. 1

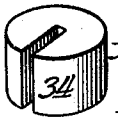


Fig. 6

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UNITED STATES PATENT OFFICE

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WAVE MACHINE

Application filed May 16, 1929. Serial No. 363,689.

The well recognized need which has long existed for apparatus capable of demonstrating all or nearly all the different aspects of wave motion including the propagation of energy through the medium of waves has, so far as I am aware, been very inadequately met. To be sure, wave machines have been described in technical literature and some of them have been made available to the trade.

For example, there was one known as the Columbia wave machine with which "artificial" transverse, longitudinal and water waves could be demonstrated. S. P. Thompson devised a wave apparatus to give a clear idea of the propagation of energy in an elastic medium through the agency of transverse waves, the apparatus being intended for objective representation of wireless wave transmission and reception. Weinhold describes a machine which, though very large and cumbersome, may be used to demonstrate "actual" longitudinal waves with great clearness and beauty.

Perhaps the only other wave machine worthy of mention is that of Mach which enables one to produce "artificial" waves, either longitudinal or transverse, and either progressing or standing. It, however, had a very serious drawback in that the waves were merely simulated by the balls of bifilar pendulums, and any idea of an elastic medium had to be supplied subjectively in the student's mind. There have been, of course, wave troughs for demonstrating water waves, but they are of no particular interest in this connection.

A wave machine is necessarily of considerable proportion and, because of the small number required to saturate the market, its production is relatively costly. It is, therefore, the principal object of this invention to produce a machine that will be inexpensive to manufacture and will have such complete adaptability as to eliminate the necessity of supplying more than one type of machine to a single institution. The present invention permits a mechanical arrangement enabling the demonstrator to change the wave type from longitudinal to transverse, or vice versa, at will, and thereby conclusively show that the difference between the two wave types is merely one of relative direction of oscillation of the particles.

The preferred embodiment of the invention is illustrated in the accompanying drawings, in which

Fig. 1 is a diagrammatical side elevation;

Fig. 2 is a side elevation with the intermediate portions broken away;

Figs. 3 and 4 are plan views showing the pendulums arranged in different positions;

Fig. 5 is a plan view of an instrument used to adjust the elastic connections between the pendulums, and

Fig. 6 is a perspective view of a weight or mass suitable for use in connection with one or more of the pendulums in certain demonstrations.

The base of the machine includes a channel bar 10, having a cross piece 11 at its ends each fitted with a pair of level screws 12 which serve as feet. Rising from each end of the beam 10 is a column composed of bars 13, having their upper ends secured to the downturned flanges 14 of a top channel bar 15.

The web of this bar has a series of threaded perforations into which bushings 16 are fitted. Each bushing serves as bearings for a short shaft 17, forming the shank of a fork 18, the arms 19 of which are equipped with adjustable pivot bearings 20, adapted to receive and support the short bar 21, forming the upper end of a pendulum 22. The shafts are held in place by suitable nuts 23 which have the side flanges 24 resting on the upper ends of the bushings 16.

Each fork 18 is provided with an angular arm 25, all of which are pivotally connected to a bar 26 of such length that when the axes of the pendulums are in one extreme position the right end of the bar strikes the right column, and when those axes are in another extreme position the opposite end of the bar strikes the opposite column 13, the two positions being illustrated in Figs. 3 and 4.

One of the nuts 23 is extended and pro-

vided with a knob 27 forming a handle by which the several pendulums may be rotated to change their positions simultaneously.

Each pendulum 20 is equipped with a friction collar 28 having a deep groove 29, and adjacent pendulums are flexibly connected by rubber bands 30 looped about the collars and seated in the grooves.

Two rods 32 are fixed to the webs of the channels 10 and 15 at a distance from the end pendulums corresponding to the space between the several pendulums, and each rod is fitted with a collar 28, having a groove 29, like those on the pendulums. The collars may be simultaneously and uniformly adjusted with the aid of a notched bar 33, shown in Fig. 5.

The parts 30 introduce elasticity into the medium represented by the several pendulums, and make it possible to produce "actual" as distinguished from "artificial" waves. When all the collars are at the same height there is uniform elasticity which is increased by moving them downwardly, and decreased by moving them upwardly.

The use of ordinary rubber bands between sliding collars or pendulums makes it possible to obtain this elasticity without interfering with the mechanism for turning the pendulums from one position to another. Introducing the elastic connection between an end pendulum and a fixed rod 32 has the effect of introducing a "dense" medium at the end of the series of pendulums.

With the collars about half way down the pendulum rods, transverse or longitudinal, progressing, or standing waves may be produced with the greatest facility. Displacing an end pendulum a suitable amount starts a progressing wave, displacing an end pendulum suddenly either outwardly or inwardly, produces rarefactions and condensations. Simultaneously releasing end pendulums after equal displacement in opposite directions produce a beautiful illustration of destructive interference, the middle pendulum, or particle, receiving the progressing impulses from opposite directions remains stationary. If, on the other hand, pendulums are displaced in the same direction the impulses reach the medium particle simultaneously, and are additive, which results in its having a very large amplitude.

Two slotted masses 34 (Fig. 6) are provided for application to the end pendulums, as indicated in dotted lines in Fig. 2, to give them greater energy and vibration when it is desired to demonstrate the S. P. Thompson experiment to illustrate the transmission and reception of energy through wave motion. In this instance the collars 28 should be about one-third of the distance from the top of the pendulums.

Displacing one of the end pendulums causes a wave to travel slowly to the other end of the series and after some seconds a series of equally timed impulses reaches the other end pendulum and it is set swinging with an amplitude not appreciably less than the first or transmitting pendulum.

These suggestions will be sufficient to illustrate the possible demonstrations and those familiar with wave motions will readily adopt others producing the desired effect.

In order to make the demonstrations completely objective, and leave practically nothing to the imagination of the student, the lower ends of the pendulums are fitted with balls 31, representing particles whose wave motions are to be studied.

In the preferred commercial embodiment of the invention the pendulum rods 22 are made of light aluminum alloy, the bars 21 have hardened cones receiving the pivot bearings, the forks 18 are castings, the bushings 16 are bronze, and the frame is composed of commercial sections. Consequently, the device is very rugged, very simple to manufacture, and requires a minimum of attention to maintain.

The rods are painted or enameled black and the balls painted white or plated with bright metal to obscure the rods and make the balls more conspicuous.

I claim as my invention:

1. In a device of the class described, a horizontal beam, a plurality of vertical shafts journaled in the beam in a row, a pendulum mounted on each shaft, and including a rod and an adjustable collar thereon, an elastic connection between adjacent pendulums associated with said collars, and means to rotate the several shafts and retain the axis of the pendulums in a selected relative position.

2. In a device of the class described, a horizontal beam, a plurality of vertical shafts journaled in the beam in a row, a pendulum carried by each shaft and including a slender rod of light material, a weight attached to the lower end of the rod and a collar adjustable along the rod above the weight, an elastic connection between the collars of adjacent pendulums, and means for rotating the shafts in unison and retaining them in a selected relative position.

3. In a device of the class described, a horizontal beam, a plurality of vertical shafts journaled in the beam in a row, a pendulum mounted on each shaft, an elastic connection between adjacent pendulums adjustable vertically with respect thereto, and means to rotate the several shafts in unison and hold them in a selected relative position.

4. In a device of the class described, a series of pendulum forks, each mounted to rotate about a vertical axis, a pendulum mounted in each fork, an elastic connection between adjacent pendulums, and means for

rotating the forks in unison and retaining the axes of the several pendulums in a selected relative position.

5. In a device of the class described, a series of pendulums in a row, means to mount the pendulums to swing about horizontal axes on a level, and to rotate on vertical axes, and an elastic connection between adjacent pendulums.

6. In a device of the class described, a series of pendulum forks, each mounted to rotate about a vertical axis, a pendulum mounted in each fork, an elastic connection between adjacent pendulums, and means for rotating the forks in unison and retaining the axes of the several pendulums in a selected relative position.

7. In a device of the class described, a series of pendulums, in a row, means to mount the pendulums to swing about horizontal axes on a level, and to rotate on vertical axes, an elastic connection between adjacent pendulums, and means for rotating the pendulums simultaneously and retaining their axes in a selected relative position.

8. In a device of the class described, a horizontal beam, a series of weights suspended from the beam by rigid pendulum arms, means associated with the beam restricting the arms to parallel planes of oscillation, and an elastic connection between adjacent pendulums.

9. In a device of the class described, a horizontal beam, a series of weights suspended from the beam by rigid pendulum arms, means associated with the beam causing the pendulums to oscillate in parallel planes and means for varying the angularity of the parallel planes with respect to the beam.

In testimony whereof I affix my signature.

PAUL E. KLOPSTEG.