Sept. 17, 1946. R. L. WILLIAMS 2,407,697

APPARATUS FOR SUBMARINE SIGNALING

Filed Sept. 14, 1935 2 Sheets-Sheet 1

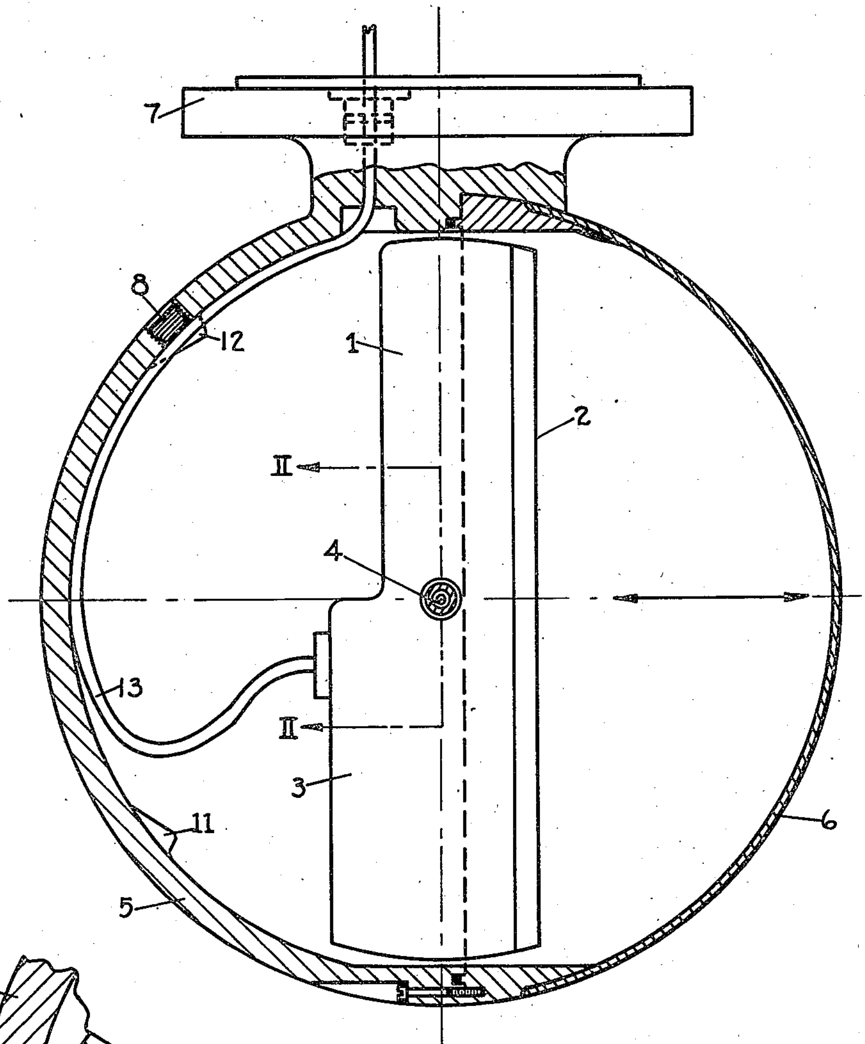

FIG. 1

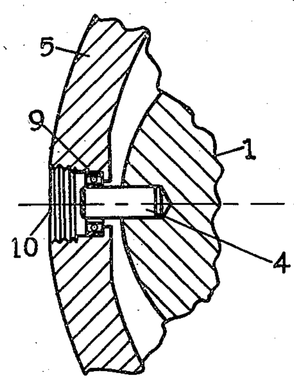

FIG. 2

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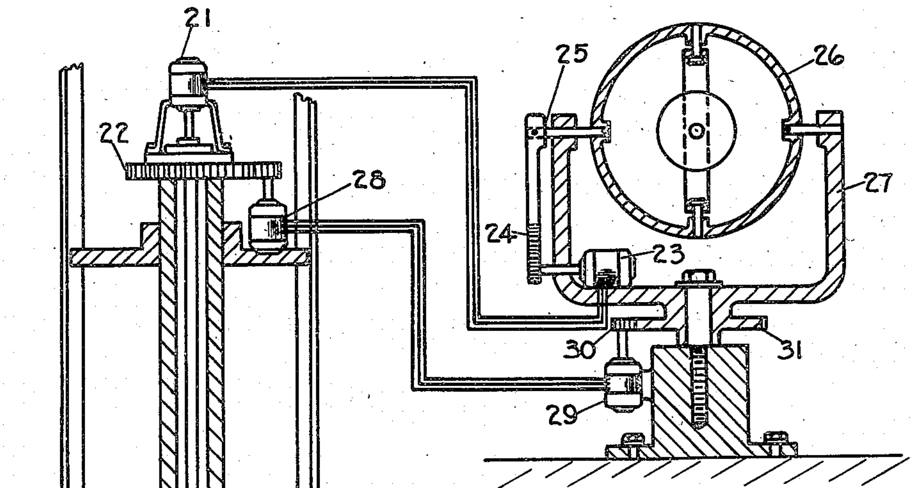
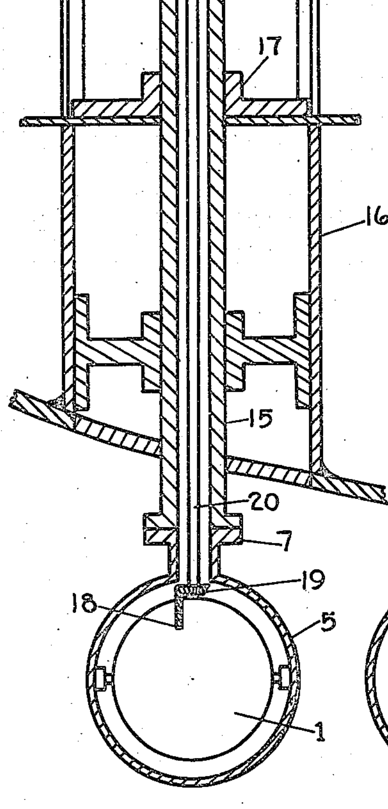


FIG. 3



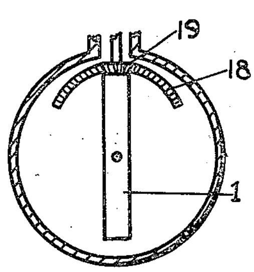


FIG. 4

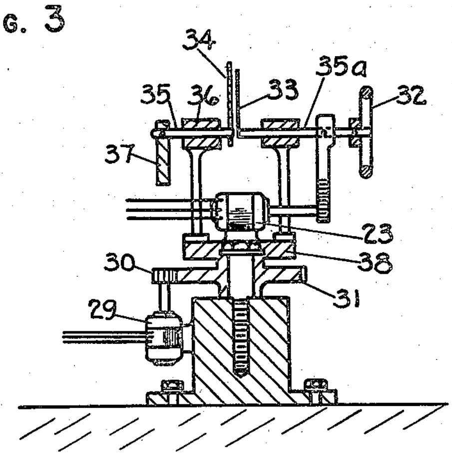


FIG. 5

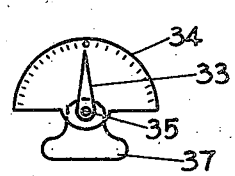


FIG. 6

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APPARATUS FOR SUBMARINE SIGNALING

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Application September 14, 1935, Serial No. 40,587

9 Claims. (Cl. 181—0.5)

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The present invention relates to improvements in apparatus for submarine signaling. More particularly the invention relates to apparatus for controlling the position of and for mounting a submarine signaling device such as a wave energy sender or a receiver.

For some purposes it is desirable to mount submarine signaling apparatus, such as sending or receiving devices, on a ship so that they may be projected through a suitable opening in the skin of the ship into the water beneath. This type of mounting is particularly advantageous for high frequency compressional wave producing and receiving devices. Devices of this type are generally called "oscillators" and their radiating faces usually have dimensions large compared to the wave length so that they send or receive compressional waves in a well-defined beam. Such arrangements are used for communication purposes between ships, for echo ranging and for other purposes. For this reason the oscillator is usually mounted on a rigid rotatable support so that its radiating face may be turned about a vertical axis to face in any desired direction.

It will be evident, however, that if the ship rolls, the axis of the wave beam which is being produced or along which reception takes place will not remain horizontal or in its normal plane, but will be tipped at an angle to the horizontal and raised or lowered from its normal position. Furthermore, the roll of the ship will not only throw the sound beam up and down, but will also deflect the beam sidewise. Both communication and echo ranging are difficult under such conditions.

Furthermore, water conditions are sometimes encountered where the temperature gradient is such as to cause a deflection of the compressional wave energy from a straight line and to make it take an upwardly or downwardly curved path. With the usual type of mounting such as has been described above, the range through which signaling may be successfully accomplished will be considerably reduced under such water conditions.

According to the present invention an improved mounting for the oscillator is provided whereby it automatically keeps its radiating face in a vertical plane. A further feature of the present invention is the provision of means for positively controlling the position of the radiating face of the oscillator with respect to the vertical.

Other features of the invention will appear from the following description taken in connection with the drawings in which Fig. 1 shows an oscillator mounting in accordance with the present invention; Fig. 2 is an enlarged sectional view of a portion of Fig. 1; Fig. 3 shows a modified

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arrangement; Fig. 4 is an end view of the oscillator shown in Fig. 3; Fig. 5 is a modification of a portion of the arrangement shown in Fig. 3; and Fig. 6 is a detail of the dial and pointer shown in Fig. 5.

Fig. 1 shows an end view of the oscillator 1 for sending and receiving compressional wave energy. The radiating face 2 of the oscillator is circular in shape and its diameter is large compared to the wave length of the compressional waves whereby the oscillator has a directional characteristic. Compressional wave energy is therefore sent and received chiefly in the direction indicated by the arrow. The back plate of the oscillator is provided with a weight 3 which may be an integral part of the oscillator cover. The oscillator is mounted by means of pivots 4 in a watertight spherical casing composed of a relatively heavy back half 5 and a thin front half 6 facing the diaphragm. Integral with the back half 5 of the spherical shell is a flange 7 by means of which the oscillator is mounted on the vessel or attached to a suitable hoisting and lowering and/or rotating gear. The interior of the spherical casing is after assembly filled with sea water or other suitable liquid through an opening closed by the plug 8. Thus compressional wave energy can pass freely from the radiating surface 2 through the spherical shell 6 and into the outer water. Also the oscillator is protected from the force of the water due to the motion of the vessel.

The pivots 4 are preferably mounted in ball bearings so that friction is reduced to a minimum. An enlarged section along the line II—II of one of the pivots 4 is shown in Fig. 2. The pivot 4 consists of a steel stud mounted in the body of the oscillator 1 above its center of gravity and supported in the stainless steel ball bearing 9 which is driven through a hole in the shell 5 and rests against the shoulder as shown in Fig. 2. In assembly the ball bearing is fitted into the hole in the shell 5 and after the oscillator has been fitted into the shell 5, the pin 4 is driven through the ball bearing into the oscillator. The hole is then closed by the plug 10.

It will now be noted that the oscillator as suspended in the pivots forms a compound pendulum and its radiating face 2 will consequently be kept in a vertical plane by the action of gravity. The compound pendulum has a number of advantages over a simple pendulum. The weight which keeps the oscillator vertical is concentrated on the oscillator itself and consequently the spherical casing surrounding the oscillator need be made no larger than it would be if the pendulum arrangement were not used. Keeping the size of the casing small is important when the oscillator housing is exterior to the ship, since the water resistance against it, when the ship moves through the water, must be kept at a minimum. Furthermore, it is also important to keep the oscillator housing small in cases where it is to be drawn up inside the vessel when not being used for signaling. A mounting arrangement for this purpose as well as for rotating the oscillator diaphragm to face in different horizontal directions is known to those skilled in the art and is schematically indicated in Fig. 3.

An additional feature of the compound pendulum is that it is very much less affected by the lateral motion of the ship when it rolls. There are two motions to be considered which affect a pendulum when mounted on a ship. One is the roll of the ship and the other is the lateral motion of the ship, which increases with the distance from the point about which the ship rolls.

Since the greater part of the weight of the oscillator in the compound pendulum mounting in accordance with the present invention is balanced on the axis, it is not affected at all by a lateral motion of the ship. The weight which keeps the oscillator vertical and lowers the center of gravity below the axis is small in proportion to the total weight of the oscillator and the kinetic energy stored up in it by the lateral motion of the ship has to overcome the inertia of the heavy oscillator before it will turn it. The compound pendulum mounting, as shown, will therefore remain substantially vertical regardless of the motion of the ship.

It will, of course, be understood that the weight of the mass **3** must be properly proportioned with respect to the weight of the rest of the oscillator and also with respect to the distance of the pivots **4** above the center of gravity of the combined oscillator and mass so that the period of swing of the compound pendulum is sufficiently less than the period of roll of the ship to insure that the oscillator remains stationary when the ship rolls. In considering the weight of the oscillator the effect of the liquid within the spherical casing must also be taken into account.

The turning of the oscillator with respect to its spherical housing is limited by the stops **11** and **12**, shown in Fig. 1, so that the oscillator is prevented from accidentally making a complete revolution which would injure the electric conductors **13**. The space between the periphery of the oscillator and the interior of the spherical shell is made as small as possible so that the liquid within the shell will turn with the oscillator. By this means the damping effect of the liquid upon the pendulum is considerably reduced.

The spherical shell which houses the oscillator provides a stream-lined exterior for the oscillator regardless of the direction in which it may be facing, thereby reducing its resistance of the ship's motion through the water. More important still is the spherical housing in connection with the pendulum suspension of the oscillator just described, for by this means the oscillator is in a dead water space so that the ship's motion will not cause deflection of the oscillator. So also, in the modifications mentioned below, the force required to turn the oscillator on its pivots is reduced.

As mentioned above, it may be desirable at times to alter the position of the radiating surface of the oscillator and to hold it in some plane other than the vertical. It may also under some conditions be desirable to have a more positive control over the position of the oscillator than that which is given by the pendulum arrangement just described. For this purpose the position of the oscillator may be controlled by a gyroscope instead of the pendulum arrangement. Such a modification of my invention is shown in Fig. 3.

In this Figure 3 the oscillator **1** in its spherical casing **5** is shown mounted by means of its flange **7** upon a tubular shaft **15** which projects through a cylindrical well **16** at the bottom of the ship. The shaft **15** passes through a watertight bearing **17** and is usually arranged so that it may be rotated and/or raised and lowered. Suitable arrangements for raising and lowering and for rotating the shaft **15** are known in the art and are, therefore, not shown in the drawings. A gear **22** to which suitable rotating apparatus may be connected is, however, shown mounted at the upper end of the shaft **15**.

At the top of the oscillator **1** an arcuate gear **18** is mounted which meshes with a pinion gear **19** fixed to the end of a shaft **20** which passes through the inside of the hollow shaft **15** to the motor **21**. A front view of the gear **18** is shown in Fig. 4. The motor **21** is preferably a self-synchronous motor driven by a self-synchronous generator **23** which, in turn, is operated by the sector gear **24** fastened to the shaft **25** of a gyroscope **26**. The gyroscope is hung in a frame **27** mounted in any convenient place on the ship.

Since the angle by which the axis of the sound energy beam is tipped when the ship rolls is dependent upon the direction in which the diaphragm is facing with respect to the axis of roll, it is necessary that the frame **27** be automatically kept at all times in a position corresponding to the direction in which the radiating surface of the oscillator **1** faces.

This is accomplished by means of a self-synchronous generator **28** driven by the gear **22** which controls the rotation of the oscillator in the horizontal plane. The generator **28** drives the self-synchronous motor **29** which through gears **30** and **31** rotates the frame **27**. Thus the gyroscope, maintaining a definite position with respect to the vertical, will keep the radiating surface of the oscillator in a corresponding position regardless of the roll of the vessel or the direction in which the oscillator may have been turned in the horizontal plane. It will be understood that the gyroscope can be adjusted to keep the radiating surface of the oscillator always in the vertical plane or in any desired plane inclined to the vertical.

In order to avoid the expense of a gyroscope a simplified modification of this arrangement may be used as shown in Fig. 5. Only the control arrangements are shown in this figure and it will be understood that the oscillator mounting is otherwise the same as shown in Figs. 3 and 4. According to this figure the self-synchronous generator **23** is manually operated by means of the handwheel **32**. To the shaft of the wheel **32** a pointer **33** is fixed whose position corresponds to the plane of the radiating surface of the oscillator and indicates the position of the oscillator diaphragm with respect to the vertical.

A scale **34**, a front view of which is shown in Fig. 6, is mounted on a shaft **35** free to turn in bearing **36**. At the end of the shaft **35** a weight **37** is fixed. This weight acts as a pendulum and serves to keep the zero mark on the scale in a vertical plane when the ship rolls. Consequently if an operator by turning the handwheel **32** keeps the pointer **33** exactly opposite the zero mark on the scale, the radiating surface of the oscillator will remain in a vertical plane.

It will be noted that if the oscillator is being rotated in a horizontal plane, the framework **38** supporting the motor **23** and the shafts **35** and **35a** must likewise be rotated. This can be accomplished by the motor **29** in a similar manner as shown in Fig. 3 with respect to the frame **27**. In this case it will be necessary for the operator who is controlling the handwheel **32** to follow the apparatus around or alternatively he may be provided with a platform which moves with the supporting framework **38**.

It will be observed that with the modifications of my invention described with reference to Figures 3 to 6 inclusive, the oscillator can be mounted with its diaphragm somewhat tilted from the vertical plane. For example, if the temperature gradient is such as to cause a deflection of the compressional wave energy in an upwardly curved path, the signaling range can be increased by tilting the oscillator downward, and vice versa, and the oscillator can readily be maintained in such a position regardless of the rolling of the ship. However, even with the arrangement shown in Fig. 1 where the oscillator is automatically maintained with its radiating face vertical, an improvement is noted when the ship rolls since by means of the present invention a signaling range will remain constant and will not vary with each roll of the ship.

Having now described my invention, I claim:

1. In a submarine signaling system, a submarine oscillator adapted to send and receive compressional waves in a direction substantially perpendicular to its radiating surface, means for mounting the oscillator on the vessel in a signaling position including a pivotal suspension along an axis perpendicular to said signaling direction and normally horizontal, the weight of the oscillator being distributed so as to bring its center of gravity sufficiently below said axis of suspension to form a compound pendulum, and means for immersing the entire oscillator in a liquid medium.

2. A submarine signaling system including a submarine oscillator having a substantially circular cross section, means for mounting the oscillator on a vessel including a housing having a substantially spherical interior cavity, means for mounting the oscillator within said housing pivotally on a diameter of said circular cross section and means cooperating with said oscillator and adapted to rotate it about said diameter to maintain the same in a predetermined signaling position independent of rolling of the vessel and a liquid filling the residual space in said housing.

3. In a submarine signaling system, a submarine oscillator having a thin cylindrical shape, watertight spherical housing therefor having a diameter only slightly larger than that of the oscillator, pivot means for mounting the oscillator along a normally horizontal diameter concentrically within said housing, the weight of said oscillator being so distributed as to bring its center of gravity below said mounting axis and a liquid filling the residual space in said housing.

4. In a submarine signaling system, a submarine oscillator having a radiating surface, means for mounting said oscillator on a vessel in operative relation to the outer water, including a hollow shaft extending through the ship's skin into the interior of the vessel, means for rotating said shaft and thereby said oscillator about a normally vertical axis, and means for rotating the oscillator about a normally horizontal axis including a shaft extending through said hollow shaft.

5. In a submarine signaling system, a submarine oscillator adapted to send and receive compressional waves along substantially a single directional axis, a stream-lined housing therefor, means for mounting said oscillator within said housing with the oscillator's directional axis substantially horizontal, means for mounting the housing on a vessel in contact with the outer water, means for rotating said housing and thereby said oscillator and its directional axis about a vertical axis and means for rotating said oscillator within said housing about a horizontal axis to a degree sufficient to compensate for the variation of position of the oscillator produced by rolling of the vessel.

6. A submarine signaling system including a submarine oscillator having a substantially circular cross section, means for mounting the oscillator on a vessel including a housing having a substantially spherical interior cavity, means for mounting the oscillator within said cavity pivotally on a diameter of said circular cross section, said oscillator being constructed to have a center of gravity substantially below said diameter and a liquid filling the residual space in said housing.

7. In a submarine signaling system, a submarine oscillator having a radiating surface, means for mounting said oscillator on a vessel in operative relation to the outer water, including a hollow shaft extending through the ship's skin into the interior of the vessel, a spherical housing fixed to the end of said hollow shaft, means for pivotally mounting the oscillator within said housing on a normally horizontal axis, means for rotating said shaft and thereby said oscillator about a normally vertical axis, and means for rotating the oscillator about a normally horizontal axis including a shaft extending through said hollow shaft, a pinion gear fixed to the end of said shaft within said housing and an arcuate gear fixed to said oscillator and adapted to cooperate with said pinion.

8. In combination, a submarine signaling oscillator, a casing, means pivotally journaling said oscillator in said casing, independent means for rotating said casing and rotating said oscillator about its pivot, means externally positioned of said casing and similarly constructed as said oscillator and mounting, and a plurality of self-synchronous motor controls operatively connected between said externally positioned means and said casing and oscillator for maintaining the same relative position of said externally positioned means and said oscillator and casing.

9. In combination, a submarine signaling oscillator, means mounting said oscillator to permit its inclination from a vertical position, a casing in which said oscillator is mounted, means for rotating said casing about a vertical axis, means externally positioned of the casing and mechanically simulating said oscillator and casing, and means interconnecting said externally positioned means with said oscillator and casing whereby the positions of said external means and said oscillator and casing are maintained relatively the same.

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