

July 24, 1928.

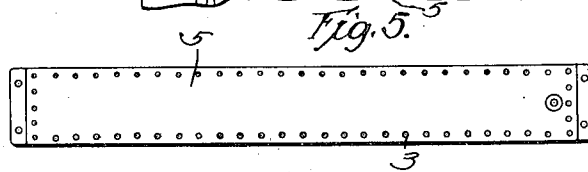
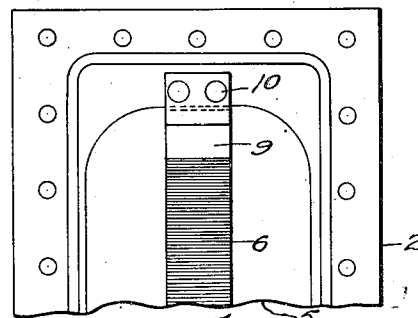
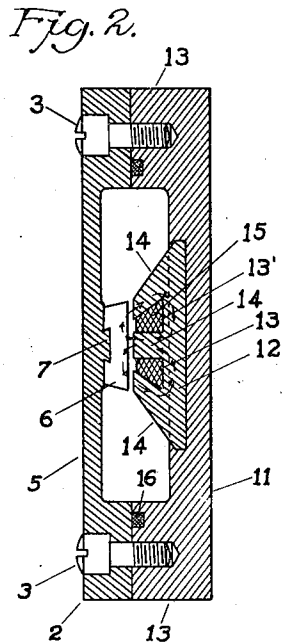
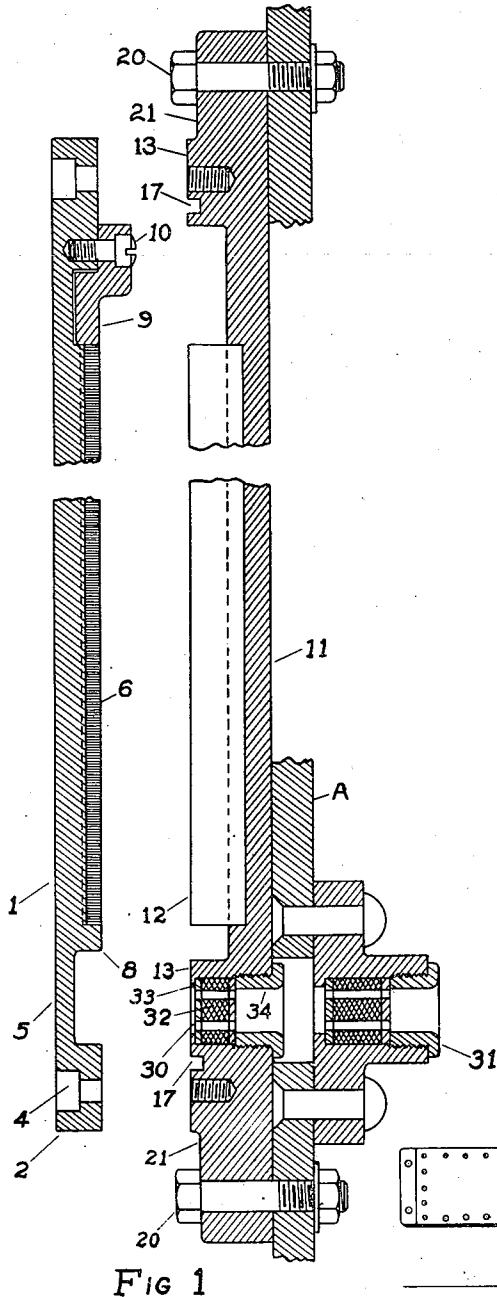
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R. L. WILLIAMS

METHOD AND APPARATUS FOR SOUND TRANSMISSION

Filed June 20, 1924

3 Sheets-Sheet 1



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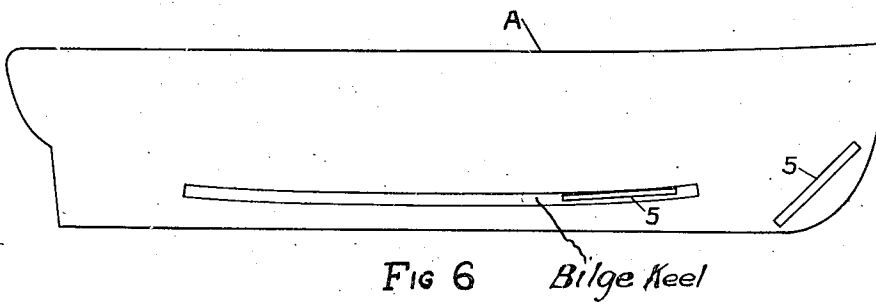
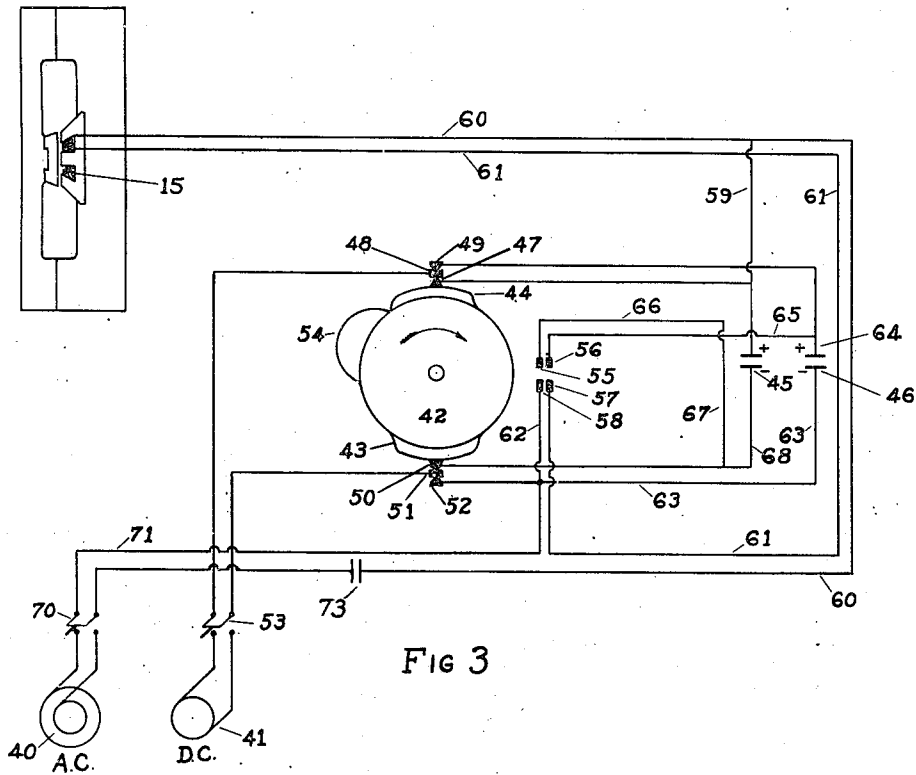
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3 Sheets-Sheet 3

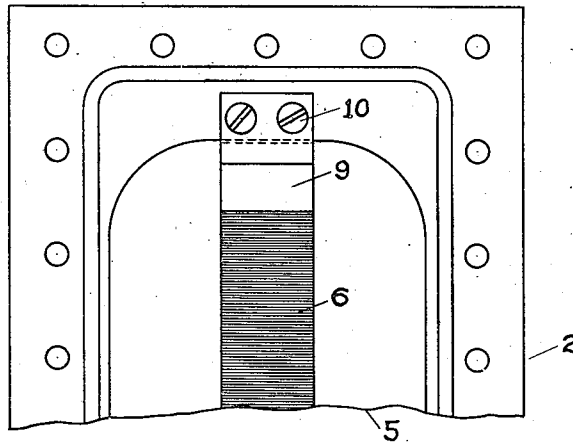


FIG 4

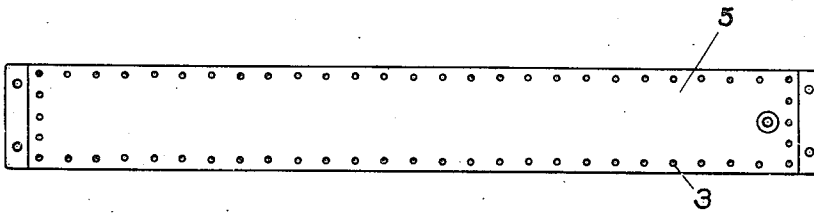


FIG 5

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METHOD AND APPARATUS FOR SOUND TRANSMISSION.

Application filed June 20, 1924. Serial No. 721,231.

My invention relates to an improvement in a sound transmitting device and more particularly to an electromagnetic means of emitting subaqueous sounds.

5 A purpose of my invention is to obtain a submarine sound sender which may be controlled accurately by no other means than those usually employed in simple sound emitting devices.

10 A further purpose of the present invention is to construct a sounding device which will be suitable for use in determining water depths by the agency of a sound echo. For such a purpose, various essentials are necessary in the design of a sound emitting device. It is highly essential to have a device which has a large damping constant so that as great an amount of energy as possible may be put into the initial vibratory cycle and decreased to a negligible value in a very few following cycles. It is also highly desirable to have as efficient a transmitter as possible since in deep depths a considerable volume of sound is sometimes necessary to produce an echo and, therefore, a sufficient generating plant would be needed to supply the power. In the present invention the apparatus is so constructed as to be easily adaptable to a small size generator which is a great advantage in the cost of auxiliary apparatus necessary for proper operation.

Another advantage in the present construction is the easy manner in which the sound emitter, sometimes called an oscillator, can be installed in a ship, either bolted on the bilge keel or on any convenient place upon the skin of the vessel.

Further advantages and purposes will be seen from the following description and the drawings in which:

Figure 1 shows a section of length of the oscillator.

Figure 2 shows a section of the width of the device.

45 Figure 3 shows a manner of operation suitable for emitting short sounds.

Figure 4 shows a part of the upper half of the oscillator.

Figure 5 shows a view of the complete oscillator.

50 Figure 6 shows the device installed upon a vessel.

The oscillator shown in Figure 1 com-

prises two distinct parts, that shown in the left of the figure, and that in the right. As suggested by the figure, these pieces bolt together to form the complete sounding device. In general the oscillator is long and narrow, being in the ratio of about eight to one, so that for a length of about four feet the width of the oscillator would be about six inches. The front part of the oscillator consists preferably of a piece of steel which is nonmagnetic and at the same time resistive to corrosion and other action by the sea water. There are a number of steels of this type but it is preferable to use those which do not rust and which are not alloys of nickel, as the latter have a tendency to be magnetic. Such steel has the advantage of good wear and also of reducing the eddy current losses in the diaphragm and the base practically to zero, since the steel is not permeable to magnetic flux. By using steel which is non-magnetic it is possible to confine the path for the magnetic flux within the laminations shown in Figure 2. Since the path in the steel which is non-magnetic offers such a great reluctance to the magnetic lines of force that no flux flows through this part of the diaphragm and since there are no lines of flux flowing through the non-magnetic diaphragm, even though the diaphragm is a conductor of electricity, there can be no eddy current losses. The diaphragm or front part is shown at 1, at the left of Figure 1, and consists of a heavy outer edge 2, which appears better in Figures 2 and 4. This outer edge serves as a clamping surface to clamp securely the upper and lower pieces by means of the machine bolts 3, which are distributed as shown in Figure 4, and countersunk as shown in Figure 1 at 4. The diaphragm proper 5 is somewhat thinner than the outer rim and constructed in such a way to hold firmly at its center laminations 6 which fit into a dovetail piece 7 at the middle of the diaphragm. The length of the middle portion of the diaphragm is bossed somewhat where the laminations fit upon the diaphragm for the purpose of strengthening the diaphragm and eliminating rubbing at that point. The laminations are shaped as shown in Figure 2 and fit closely to form a firm joint with the diaphragm. In assem-

bly the laminations are forced in at one end against a block 8 and wedged at the other end after all the laminations are in place by the wedge 9 secured by the machine screws 10.

The lower portion of the oscillator is shown in lengthwise section in Figure 1. This is preferably a casting 11 in which the laminations 12 are cast and therefore no wedges or other devices are necessary in order to hold the laminations in place. The casting 11 is furthermore made considerably thicker and heavier than the upper portion of the oscillator. This gives to the lower half of the oscillator a very high tuning compared to the diaphragm. In view of the large mass of the lower half and the small mass of the diaphragm, the acoustic coupling between the two is extremely small and hence practically no vibratory energy is transferred from the diaphragm to the lower portion of the oscillator. This construction assists the other device herein set forth in producing an oscillator of high damping and at the same time of good efficiency. The casting 11 has a heavy outer rim 13 which serves as a clamping surface for the upper piece 1. To insure a watertight joint a gasket 16 is forced into a groove 17 and spread by the pressure in clamping the upper and lower portions of the sounder. The lamination 12 which is shown in Figure 2 is slotted by two slots 13', 13' to form three poles 14, 14, 14 sloping somewhat towards the middle so that the pole face area is somewhat smaller and concentrated more closely to the central portion of the diaphragm than would otherwise be possible. The coil is shown at 15 which in the present embodiment is used for alternating current, but in other designs there may be two coils, one a direct current for polarizing the oscillator, and one an alternating current. It will be evident from Figure 2 that the magnetic flux path is exceedingly short since the flux circulates merely about the laminations as shown in Figure 2 and does not pass through the diaphragm or base. It is to be noted further that the pole face area is exceedingly large as compared with the volume of the magnetic path and also as compared with the length of the magnetic path while the cross section area of the magnetic path can be sufficiently large to keep the reluctance of the path to a small value. Since the iron is laminated the eddy current losses are practically reduced to zero and since the flux density is normal for a small volume of iron the hysteresis losses may be made proportionately small. Provision is made as shown in Figure 1 to bolt the oscillator to the side of the vessel A by the bolts 20 in the flange 21 extending from the base.

The manner of conducting the leads into

the oscillator is shown by the stuffing box 30 in the base of the oscillator and the stuffing box 31 in the ship. The leads are drawn through a rubber plug or packing washer 32 which rests upon a shoulder 33 in the inner side of the base so that when the packing nut 34 is forced down the joint becomes watertight. The stuffing box 31 is constructed in the same manner as 30 with a packing washer and packing nut to effect a watertight joint. It will be noted that each watertight joint is separate so that if through some accident the oscillator should be forced loose the water tight joint in the ship will be sufficient to prevent any leakage of water in the vessel.

The oscillator as shown in Figure 5 may be bolted upon the plates of the vessel or upon the bilge keel as shown in Figure 6. In this connection it has a distinct advantage over the type of oscillator in which two opposed diaphragms are used, in that there is no need of having both sides exposed to the water and thus making it necessary to have special provisions to take care of such an installation.

A convenient manner of operation is shown in Figure 3 in which the oscillator may be operated directly by alternating current or by a direct current which charges a condenser and discharges through an oscillatory circuit containing the oscillator. The embodiment shown in Figure 3 has an additional feature in that there are two condensers which are charged in parallel and discharged through the oscillator in series, thus doubling the voltage of the generator when applied to the oscillator. A plurality of condensers can be used in this way and a multiple value of the generator voltage can be obtained depending upon the number of condensers.

As shown in Figure 3, 40 represents the alternating current source, 41 the direct current source, either of which may be used in the operation of the sounder. 42 is a code wheel, shown as rotating clockwise, which may be the code wheel of a depth sounding machine to emit a sound at a definite position of the rotating wheel or a code wheel for use on lightships and the like. As shown there are two dogs 43 and 44 which serve to connect the generator 41 with the two condensers 45 and 46 by means of the switches 47, 48, 49 and 50, 51, 52. The switch 48 connects with one side of the generator 41, the switch 51 connects with the opposite side, both through a switch 53. To discharge the condensers through the oscillator, the dog 54 closes the contacts between 55 and 56 and between 57 and 58 all four contacts remaining closed during the same instant. The circuit through the coil 15 of the oscillator is then as follows: the positive side of condenser 45, leads 59, 60, coil 15 lead 61, contacts 57, 58,

leads 62, 63, condenser 46, leads 64, 65, contacts 56, 55 leads 66, 67, 68 to the negative side of the condenser 45. Before the dog 54 closes the contacts to discharge the condensers through the oscillator, the dogs 43 and 44 close the contacts 50, 51, 52 and 47, 48, 49 to charge the condensers.

If it is desired to use the alternating current source 40 for current supply, the switch 70 may be closed instead of the switch 53, in which case the dog 54 closes the oscillator coil 15 through the following circuit; source 40, lead 71, contacts 58, 57, lead 61, coil 15, lead 60, condenser 73, and back to the source 40 again. The condenser 73 is used to tune the circuit to resonance and thus produce a unity power factor. The dogs on the code wheel should be placed so that the dogs 43 and 44 operate simultaneously but that the dog 54 closes its contact at a different time than the other two dogs so that when the oscillator is operated by direct current the condensers will not be discharged until after they have received their full charge, and when alternating current is used a short circuit will not be placed on the alternator. This may be accomplished a number of ways, as by offsetting the dogs in different rotating planes or by proper spacing as indicated in the present case.

When the oscillator is operated by alternating current the dog 54 closes the circuit whereby the voltage of the alternating source is applied directly to the coil, while when the device is operated through the source 41 the dog 54 acts to discharge the condensers 45 and 46 in series through the coil. It will be evident that in the present arrangement it will prove useful to use the condensers when a short note of maximum power is desired and to use the alternating current when a sustained and longer note is desired, since when the condensers are used a high voltage oscillatory discharge may be obtained which can be damped as desired. Such an arrangement is distinctly advantageous for determining depths as a very short note is essential for small depths and a somewhat prolonged note for measuring deep depths.

This has been known in the art of depth finding but no apparatus up to the present time has been able to give a short enough sound to measure shallow depths of water and at the same time powerful enough to be used for deep water. The present apparatus is useful not only in shallow but in deep water. The difficulty arises from the fact that sound travels about five times as fast in sea water as in air. In sea water of four fathoms, or twenty-four feet, the sound emitted at the surface will return reflected from the bottom of the water in about one hundredth of a second. Thus a signal sent, if one hundredth of a second long, or over,

would overlap the signal received and no distinct impression of the received signal could possibly be received. In the present case the oscillatory discharge can be made so rapid and the damping so great that all the sound energy is dissipated in less than one hundredth of a second. Also due to the efficiency of the sender a fair proportion of the energy gets into the water so that a sound of sufficient strength is sent and returned to give an indication on a receiver.

The operation of the oscillator itself to emit a sound follows directly from the description of the apparatus. The coil 15 extends the complete length of the poles and is therefore very much elongated. The current flowing through the coil sets up a magnetic flux as shown in Figure 2 which in all cases causes an attracting force between the opposing poles. When the current decreases to zero this force becomes zero, which is twice every cycle. Thus the frequency of the sound is double the frequency of the alternator. When the direction of the current changes, the direction of the flux changes but the forces remain in the same direction. It will be seen therefore that if the force is sinusoidal the sound will be a sinusoidal wave of double the frequency of the source.

Due to the use of a long and narrow diaphragm the thickness may be made comparatively small for the pitch commonly used in submarine sound generators. It is thereby possible to obtain a light diaphragm which is of great assistance in increasing the damping constant and use in the art of depth sounding. If necessary the radiating surface may be increased without a change of the thickness of the diaphragm by lengthening the oscillator. Under such conditions since the radiating surface is increased the radiating capacity is also increased producing a sounder of greater power. As regards the ability to make the membrane oscillate in phase this is easily accomplished since the pull in the air gap is uniform throughout at any instant and the same pull will be exerted uniformly over the whole membrane.

There will be a directional effect, which may or may not be advantageous in accordance with the use to which the oscillator is to be put, when it becomes long as compared with the wave length. In such a case the sound intensity will be decreased in the direction of the length of the oscillator as at certain points in this direction the sound coming from various points on the radiating surface of the oscillator will be out of phase due to the varying length of the water path from those points on the radiating surface. This effect should become apparent when the oscillator is more than one half the wave length of the sound emitted and can be advantageously used in directing the emission

of a sound wave in a general direction where as limited a direction as a beam is not desired.

Various other modifications in the method of operation and the apparatus may be used in my invention as will readily appear to one skilled in the art and thus I do not limit myself to the exact details described but claim:

1. A sound emitting device for subaqueous sound signaling comprising an elongated diaphragm said diaphragm being approximately eight times or greater in length than in width with a laminated armature extending across the middle thereof, said diaphragm forming a portion of the upper half of said sound emitter, a lower half of said emitter fitting securely to said upper half comprising a heavy base, laminations rigidly secured in said base forming poles opposite to said upper armature, a coil associated with the laminations of said upper and said lower halves for energizing said oscillator.

2. In an oscillator of the type described, an elongated laminated armature, three laminated elongated poles opposed to the said first armature said poles to be spaced apart from said armature to form a suitable air gap a coil, said coil enclosed by the outer of said three poles forming a closed magnetic circuit but for the air gap said oscillator having approximately a ratio of length to width of eight and said armature and poles extending substantially the length of the oscillator.

3. In an oscillator of the type described, a nonmagnetic diaphragm, an elongated laminated armature secured to said diaphragm, three laminated elongated poles opposed to said armature and spaced apart from said poles to form an air gap, a coil, said coil enclosed by the outer of said three poles forming a closed magnetic circuit but for the air gap.

4. In combination with the bilge keel of a vessel an elongated base of substantially rectangular shape mounted thereon, a diaphragm secured watertight to said base and means within the space between the diaphragm and the base to energize said diaphragm.

5. In combination with the bilge keel of a vessel an elongated base of substantially rectangular shape mounted thereon, a diaphragm secured watertight to said base, a block of laminations forming an armature secured rigidly to the inner surface of said diaphragm and extending substantially the length thereof, a block of laminations forming a magnet secured rigidly to said base and extending substantially the length thereof, and a coil for energizing said magnet, whereby said armature will be uniformly pulled and said diaphragm vibrated uniformly throughout its length.

6. A submarine sound signaling device comprising a watertight casing composed of two vibratory plates recessed to provide heavy outer rims forming space for the sound generating mechanism, and means contained within said space operating directly upon the two plates for generating the sound vibrations, said plates being tuned to different frequencies.

7. A submarine sound signalling device comprising a watertight casing composed of two vibratory plates recessed to provide heavy outer rims forming space for the sound generating mechanism, and means contained within said space operating directly upon the two plates for generating the sound vibrations, said front plate being tuned to a much lower frequency than said back plate.

8. A submarine sound signaling device comprising a watertight casing composed of an upper vibratory plate and a lower vibratory plate, said lower plate being thicker than said upper plate, and both of said plates being recessed to provide heavy outer rims forming space for the sound generating mechanism, and means contained within said space, operating directly upon the two plates, for generating sound vibrations, and means to support said sounder only at said heavy outer rim.

9. A submarine sound signaling device comprising a watertight casing composed of an upper vibratory plate and a lower vibratory plate, said lower plate being of greater thickness than said upper plate, both of said plates being recessed to provide heavy outer rims forming space for the sound generating mechanism, and means contained within said space operating directly upon the two plates for generating the sound vibrations, said outer rim being of sufficient weight compared to the other portions of the plates so that substantially no sound energy is transferred from the front to the rear plate.

10. A submarine sound signaling device comprising a watertight casing composed of two vibratory plates recessed to provide heavy outer rims forming space for the sound generating mechanism, and means contained within said space operating directly upon the two plates for generating the sound vibrations, said vibrations being tuned to the same frequency as that of the front plate and said back plate being tuned to a higher frequency.

11. A submarine sound signaling device comprising a watertight casing composed of an upper vibratory plate and a lower vibratory plate, said lower plate being tuned to a higher frequency than said front plate and both of said plates being recessed to provide heavy outer rims forming space for the sound generating mechanism, laminated

blocks mounted rigidly and directly upon the inner center portions of said plates, and a coil embedded in the blocks on one of said plates to carry the alternating current for producing sound vibrations.

12. A submarine sound signaling device comprising a watertight casing composed of two vibratory plates recessed to provide heavy outer rims forming space for the sound generating mechanism, said front vibratory plate including the sound radiating diaphragm and being tuned to the pitch of the sound vibrations, said rear plate being tuned considerably above the pitch of the sound to be produced and having mounted directly upon the interior center portion laminated blocks having embedded therein a current carrying coil, and a second set of laminated blocks mounted upon the interior center portion of said front plate and acting as an armature.

13. A subaqueous oscillator comprising a diaphragm, a block of laminations dovetailed into said diaphragm and forming an armature, said diaphragm together with said laminations forming the upper half of said oscillator, a lower half of said oscillator fitted securely to said upper half comprising a heavy base, laminations rigidly secured to said base forming poles opposite

to said upper armature, and means associated with said poles and armature for energizing said oscillator.

14. In a subaqueous oscillator, a diaphragm having a raised portion, a block of laminations dovetailed to said diaphragm and abutting said raised portion, a solid metal block fastened to said diaphragm and abutting said laminations, whereby said laminations are securely fixed to said diaphragm.

15. A subaqueous sound emitter comprising in combination an elongated diaphragm approximately eight times or greater in length than in width with a raised portion at one end, a laminated armature dovetailed to said diaphragm and abutting the raised portion thereof, a solid block fastened to said diaphragm at its opposite end and abutting said armature laminations, said armature and said diaphragm forming a portion of the upper half of said emitter, a lower half of said emitter fitting securely to said upper half and comprising a heavy base, laminations cast into said base forming poles opposite to said armature, a coil associated with said upper and said lower halves for energizing said oscillator.

In testimony whereof I affix my signature.
ROBERT LONGFELLOW WILLIAMS.