Jan. 27, 1948. H. C. HAYES 2,434,926

UNDER-WATER SOUND TRANSMITTER OR RECEIVER

Filed March 8, 1937 2 Sheets-Sheet 1

Fig. 1

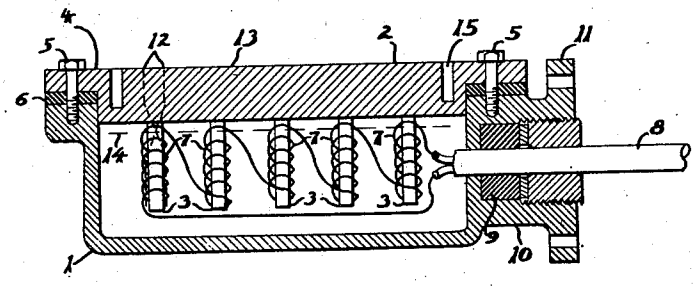
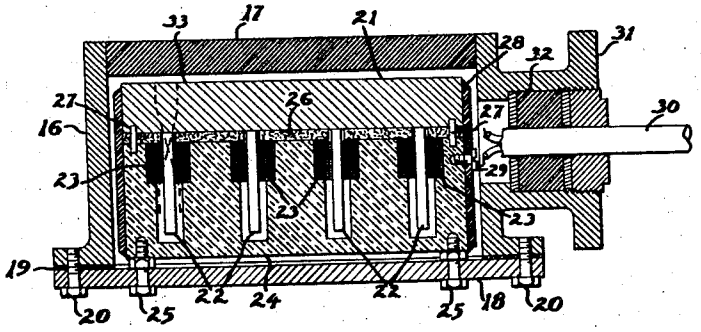


Fig. 2



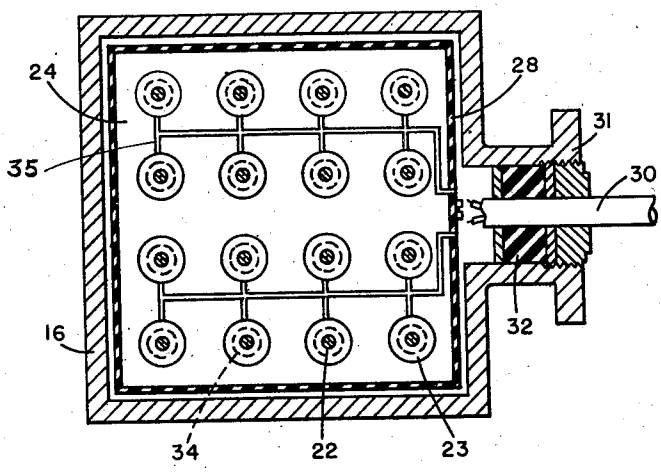
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UNDER-WATER SOUND TRANSMITTER OR RECEIVER

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FIG. 3



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UNDERWATER SOUND TRANSMITTER OR RECEIVER

Harvey C. Hayes, Washington, D. C.

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8 Claims. (Cl. 177—386)

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1

My invention relates to an acoustical apparatus and more particularly to an apparatus of this character for directively generating and/or receiving sound in a desired fluid medium.

The generation of directive sound signals, particularly high pitched under-water sound signals, is best accomplished by providing an active or sound generating, plane, surface area of dimensions large with respect to the wave lengths generated; and for the directive reception of sound signals the active or receiving surface should likewise have dimensions large with respect to the wave lengths received. The production of such high frequency oscillations is usually accomplished by the use of piezo-electric crystals or magnetostrictive elements. To provide the required large generating or receiving area a number of the active crystals or magnetostrictive elements is coupled to one side of a plate or disc having the aforesaid requisite area, the whole combination being designed and dimensioned to give proper pitched mechanical resonance and proper acoustical impedance for the purpose to be served. The several active crystals or magnetostrictive elements are electrically energized by a circuit tuned to the natural mechanical resonant frequency of the system. For such a sound generator or receiver to function directively and effectively it is necessary that all elemental areas of the active generating or receiving surface shall oscillate with like phase and amplitude. The prior art sound generators and receivers are unsatisfactory in that the active generating or receiving surface does not vibrate in phase throughout its entire area nor is the amplitude of vibration uniform. It is the principal purpose of my invention to remedy these prior art deficiencies.

Broadly, my invention is concerned with the sound generating or receiving surface of the vibratory plate or body to which the piezo-electric crystals or magnetostrictive elements are coupled and more particularly to the mounting or arrangement of the aforesaid body so that its sound active surface can be made to oscillate with like phase and amplitude throughout. The prior art sound generators and receivers have been designed so that the sound active surface contacts the medium of propagation. Such a design makes necessary the employment of a flange integral with the vibratory body or plate, the flange being secured to a casing in a fluidtight manner to form an enclosure which protects the piezoelectric crystals or magnetostrictive elements and their associated instrumentalities from con-

2

tact with the medium of propagation. In carrying out my invention I have dispensed with the flange and the complications it introduces by mounting the aforesaid plate or body for unrestrained vibratory movement within a fluid impervious housing. This housing has a portion thereof or window which may be sound transparent and contains in addition to the vibratory plate and its associated instrumentalities a fluid medium preferably of an acoustical impedance substantially equal to that of the fluid medium or medium of propagation contacting the housing exterior. It is thus evident that in the apparatus of my invention the sound active surface of the vibratory plate or body contacts the medium of propagation indirectly through the intervening thin diaphragm or sound transparent window of the fluid impervious housing and the layer of fluid medium between this window and the sound active surface.

Some loss of intensity must always result from the introduction of different media across the sound path and this broadly recognized fact originally led to and has maintained the flange type of design. Researches, however, on the sound conductivity of materials, both liquid and solid, have led to a combination of sound window and enclosed liquid or fluid medium that has practically the same conductivity as sea water and thus reduces any loss in intensity to such a negligible quantity that the advantages gained by improved phasing and substantial equality in the amplitude of vibration far surpass any small intensity loss caused by the intervening sound window and liquid.

With the foregoing preliminary discussion in view it is among the several objects of my invention to provide an acoustical apparatus for generating and/or receiving sound wherein the sound generating or receiving surface vibrates substantially in phase and with substantially uniform amplitude throughout its area; to provide a vibratory mechanism of high acoustical efficiency for generating and/or receiving sound wherein the noted deficiencies of non-uniformity of amplitude of vibration and out of phase vibration of the sound generating or receiving surface are substantially eliminated or reduced to a negligible minimum; and to provide an acoustical apparatus wherein the vibratory body is mounted for unrestrained vibratory movement.

These and other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following descrip-

tion when considered in connection with the accompanying sheet of drawings wherein:

Fig. 1 is a sectional view of one form of prior art acoustical apparatus which embodies those previously mentioned undesirable features which it is the principal object of my invention to obviate; and,

Fig. 2 is a view in section of my improved acoustical apparatus embodying the instant invention.

Fig. 3 is a horizontal section taken in the plane of the top surface of support 24 of Fig. 2, looking down.

My invention can be best understood and appreciated by considering first the prior art structure of Figure 1 which in principle shows the assembly of a submarine, supersonic sound generator and/or receiver. In this figure the reference character 1 designates a watertight casing and the numeral 2 the vibratory plate or disc to which the several active elements 3 are secured. A flange 4 is integral with the vibratory plate 2 and is secured to the casing 1 by the bolts 5 or any other suitable means, a gasket 6 interposed between the flange and casing serving to provide a fluidtight joint. The active elements 3 are shown for illustrative purposes as of the magnetostrictive type and each is surrounded by a magnetizing coil 7. Electrical energy is supplied to these coils by a cable 8 which passes through a suitable watertight packing 9 within a recess of the neck 10 of the casing 1. The neck has a flange 11 integral therewith by means of which the casing 1 and its associated parts can be mounted on a cooperating tube support not shown. When the apparatus oscillates at its fundamental resonant frequency the nature of the standing wave system is indicated by the dotted lines 12. If the magnetostrictive elements 3 are identical and matched and the sound radiating surface 13 of the plate 2 is to oscillate in phase then the node in all the elements must be located in a plane parallel to the surface 13. Such a plane is indicated by the dotted line 14. Furthermore, if the several magnetostrictive elements 3 are alike and matched it follows that the whole assembly can oscillate in phase only when these elements are distributed so that each carries the same portion of the mass of plate 2. The loading and reaction which the anchored flange 4 exerts on the vibratory plate 2 cannot be computed and as a result makes it practically impossible to distribute the plate load equally between the active elements 3. A gash 15 is usually machined into the plate 2 to reduce the coupling to the flange 4 but there is some question as to whether it offers any improvement. The flange 4 which serves to mount the vibratory plate 2, therefore, operates to prevent the sound active surface 13 from oscillating in phase because it introduces loading, restraints and restoring forces that cannot be computed and hence compensated for. The flange mounting further tends to produce non-uniformity in the amplitude of vibration across the active area 13 of the vibratory plate, since through its use the sea pressure on the whole sound active face 13 is supported by the flange or web about its periphery and this introduces non-uniform bending strains in the plate. My invention dispenses with the flange type of mounting and its attendant complications and instead mounts the vibratory body for unrestrained vibratory movement in a manner which will now be described.

Turning now to Fig. 2 of the drawings there is shown depicted therein a fluid impervious housing

comprising a fluidtight casing 16 provided at one end with a diaphragm 17 of thin metal or other suitable material but which is preferably of a sound transparent material such as soft vulcanized rubber which latter as indicated in the drawing should be relatively thick. The portion 17 of the casing constitutes the front or sound transited side thereof, the back or rear of the casing being closed by means of the cover 18, gasket 19 and any suitable securing means such as the bolts 20. By the words "sound transparent" is meant that the sound waves incident upon the material of the window 17 are neither appreciably reflected nor absorbed, this desideratum being attained when the acoustical properties of the window material are substantially equal to those of the fluid medium in contact therewith. The acoustical properties or impedances of two substances are alike or different depending upon whether the products of the density and the velocity of sound in them are alike or different. While many materials will readily suggest themselves to those skilled in the art for fabricating the sound transparent window, I have found that certain rubber compounds may be conveniently used for this purpose. When fabricating the sound transparent window 17 of rubber compounds, the peripheral surface thereof is vulcanized to the walls of the casing 16 to effect a proper securement thereof as indicated in Fig. 2 of the drawings. The general types of soft vulcanized rubber, for example, when immersed in water or in another liquid having similar acoustical properties, will transmit compressional, longitudinal sound waves, the degree of transmission varying considerably with the compound used. The closer the acoustical impedance of the compound matches that of the medium in which it is immersed, the more effectively it will act as a propagational medium. Any one familiar with the physical properties required for sound transmission and versed in the art of compounding and processing elastic resilient insulating substances will readily perceive the many compounds which can be made from rubber alone.

For generating and/or receiving sound there is positioned within the fluid impervious housing previously described a vibratory body 21 to which there is secured a plurality of active elements 22 which here, for illustrative purposes, have been shown of the magnetostrictive type. Each of these magnetostrictive elements is provided with a solenoid 23. While I have shown magnetostrictive elements 22 for imparting vibratory energy to or receiving vibratory energy from the body 21 I do not desire to be restricted thereto since piezo-electric crystals may be employed instead, if desired, or any other means known to the prior art for imparting vibratory energy to or receiving vibratory energy from the body 21. For supporting or mounting the vibratory plate or body 21, I employ a member 24 which is suitably recessed as shown at 34 to receive the active elements 22 and their associated coils or solenoids 23. This member may be fabricated from any suitable material but is preferably made of a synthetic resin such as that known by the trade name Bakelite which may be easily machined or molded to provide the necessary recesses for accommodating the active elements 22 and their associated coils properly centered with respect thereto. The The member 24 is mounted within the fluid impervious housing by anchoring the same to the cover 18 thereof through any suitable securing means 25. A layer of resilient material 26 is

interposed between the vibratory body 21 and its supporting member 24 in the manner shown. This layer or compression pad 26 is of cork or felt or any equivalent material and serves to withstand the hydrostatic or fluid pressure which forces the body 21 and member 24 toward each other and at the same time permits the inner face of the vibratory body 21 to execute freely its small amplitude oscillations without appreciable loss of energy to the member 24. Studs 27 or their equivalents serve to hold the body 21 and member 24 properly centered or orientated with respect to each other. For keeping the active elements 22 and their associated coils 23 free from contact with a fluid medium within the housing and to be described subsequently, there is provided a sleeve or band 28 of fluid impervious material which surrounds the vibratory body 21 and its supporting member 24 in the manner shown. This band or sleeve 28 may be made of rubber or any other suitable material known to the prior art, and is associated with the body 21 in a manner so as not to impose any restraints thereon and hence not interfere with its freedom of vibratory movement. The cross-wiring between the coils 23 is carried through properly designed slots in the member 24 such as shown at 35 and the terminals leave the member 24 through suitable metallic screws or other means one of which is shown at 29. When the sleeve 28 is fabricated from rubber the screws 29 cause a compression thereof to thus provide a non-leaking joint. The electrical cable 30 serves to supply electrical energy to coils 23 and enters the apertured neck portion 31 of the casing 16 through a fluidtight packing 32.

The fluid impervious housing in which the previously described vibratory mechanism is mounted is pumped free from air and is then filled with castor oil or some other suitable fluid medium for conducting sound from the active surface 33 of the vibratory body 21 to the sound window 17 when the apparatus is functioning as a transmitter. The fluid medium within the housing has preferably an acoustical impedance substantially equal to the medium of propagation contacting the housing exterior so as to reduce to a minimum any loss in sound intensity.

It is to be emphasized that the vibratory body 21, in contradistinction to its prior art mounting as depicted in Figure 1, is free from securement with the supporting member 24 and by reason thereof is mounted for unrestrained vibratory movement. Thus, the mounting described provides a plate member 21 with a sound active surface 33 throughout which lack of homogeneity due to bending strains is avoided; and at the same time a plate member which is free from extraneous loadings and constrictions which result in destroying unity of phase and equality of amplitude over the entire sound active surface 33. Not only does the construction in Figure 2 of the drawings provide a highly directive sound generator or receiver which was heretofore impossible with the flange mounting, but also provides an arrangement that is resistant to pressure waves from depth charges because it is practically immune from bending strains.

The former practice, as shown in Figure 1 of the drawings, employed the flange enclosed casing to keep the water out of the casing and away from the enclosed mechanism. In the instant invention, however, I employ the casing with its enclosing flexible diaphragm or sound window 17 for keeping the fluid medium within the casing

from getting out. Since the casing is always filled with a fluid medium, such as oil, at a slightly positive pressure and retains this differential pressure at any depth because of the flexibility of the sound window 17, water can never leak into the casing, there being instead a slight tendency for the oil to leak out.

From the foregoing, it should be clear that the apparatus of my invention employs a rigid, liquidtight casing 16 with a flexible sound window 17 as a container for a fluid medium into which the sound is directly generated when the apparatus is used as a transmitter. The window 17 permits any sound to pass readily to the outside medium of propagation. The casing 16 takes the heavy strains encountered when the vessel is underway and shields the enclosed sound generating and/or receiving mechanism from all distorting influences except those arising from straight hydrostatic pressure. Such influences are much less destructive than those that produce bending and torsion strains and it is for this reason that my apparatus employing the flangeless mounting has consistently shown ability to withstand depth charges.

According to the provisions of the patent statutes I have set forth the principle and mode of operation of my invention and have illustrated and described what I now consider to represent its best embodiment. However, I desire to have it understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically illustrated and described.

The invention herein described and claimed may be used and/or manufactured by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

I claim:

1. Apparatus for emitting or receiving acoustical wave energy comprising a plate the top face of which is adapted to be placed in acoustic contact with a transmitting medium for said energy, electro-mechanical energy interchanging means secured to and supported by said plate for imparting acoustic wave energy to said plate when energized or receiving energy therefrom, a support member supporting said plate independently of said energy interchanging means, the supporting surface of which support is at least large enough to underlie the perimeter of said plate, and a layer of resilient material interposed between the supporting surface of said support member and the bottom face of said plate.

2. Apparatus for emitting or receiving acoustical wave energy comprising a plate the top face of which is adapted to be placed in acoustic contact with the transmission medium for said energy, electro-mechanical energy interchanging means contacting the bottom face of said plate and adapted to impart acoustic wave energy to said plate when energized or receive wave energy therefrom, a support member for said plate, said member having a plurality of recesses in the supporting top face thereof for receiving each of said energy interchanging means respectively, the supporting face of said support member being large enough to underlie the perimeter of said plate, and a layer of resilient material interposed between the supporting face of said support member and the bottom face of said plate.

3. The combination in claim 2 and further including a band member of resilient material ex-

tending around the edge portions of said plate and support member.

4. Acoustical apparatus adapted to be immersed in a fluid medium contained within a housing having a sound transparent portion for emitting or receiving acoustical wave energy comprising a plate the top face of which lies adjacent but spaced from the sound transparent portion of said housing, means contacting the bottom face of said plate and adapted to impart acoustical wave energy to said plate or receive energy therefrom, a support member supporting said plate independently of said energy interchanging means, said member having a supporting face portion which extends to at least the perimeter of the bottom face of said plate, and a layer of resilient material disposed between the bottom face of said plate and the supporting face portion of said support member.

5. Acoustical apparatus adapted to be immersed in a fluid medium contained within a housing having a sound transparent portion for emitting or receiving acoustical wave energy comprising a plate the top face of which is adapted to lie adjacent the sound transparent portion of said housing, means contacting the bottom face of said plate and adapted to impart acoustical wave energy to said plate or receive energy therefrom, a support member for said plate, said member having a supporting face portion which extends to at least the perimeter of the bottom face of said plate, a layer of resilient material disposed between the bottom face of said plate and the supporting face portion of said support member, and a band member of resilient material extending around the edge portions of said plate and support member.

6. Acoustical apparatus adapted to be immersed in a fluid medium contained within a housing having a sound transparent portion for emitting or receiving acoustical wave energy comprising a plate the top face of which is adapted to lie adjacent the sound transparent portion of said housing, a plurality of electro-mechanical energy interchanging means contacting the bottom face of said plate and adapted to impart acoustical wave energy to said plate when energized or receive wave energy therefrom, a support member for said plate, said member having a plurality of recesses in the supporting top face thereof for receiving each of said energy interchanging means respectively, said top face of said support member being at least large enough to underlie the perimeter of said plate, and a layer of resilient material interposed between the top face of said support member and the bottom face of said plate.

7. Acoustical apparatus adapted to be immersed in a fluid medium contained within a housing having a sound transparent portion for emitting or receiving acoustical wave energy comprising a plate the top face of which is adapted to lie adjacent the sound transparent portion of said housing, means contacting the bottom face of said plate and adapted to impart acoustical wave energy to said plate or receive energy therefrom, a support member for said plate, said member having a supporting face portion which extends to at least the perimeter of the bottom face of said plate, a layer of resilient material disposed between the bottom face of said plate and the supporting face portion of said support member, means securing said support member within said housing, and a band member of resilient material extending around the edge portions of said plate and support member.

8. Acoustical apparatus adapted to be immersed in a fluid medium contained within a housing having a sound transparent portion for emitting or receiving acoustical wave energy comprising a plate the top face of which is adapted to lie adjacent the sound transparent portion of said housing, a plurality of electro-mechanical energy interchanging contacting the bottom face of said plate and adapted to impart acoustical wave energy to said plate when energized or receive energy therefrom, a support member for said plate, said member having a plurality of recesses in the top face thereof for receiving each of said energy interchanging means respectively, said top face of said support member extending to the boundaries of said plate, a layer of resilient material interposed between the top face of said support member and the bottom face of said plate, a band member of resilient material extending around the edge portions of said plate and support member, and means securing said support member within said housing.

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