The present invention relates to sound receiving apparatus in which it is desired to receive and convert sound energy into electric energy with true reproduction whatever the nature or characteristics of the sound might be.

The present invention is perhaps more applicable to submarine signaling and to the receipt of signals having a tuned or untuned character. It is applicable, in particular, to the detection of underwater noises such as those radiating from a vessel being propelled through the water.

In the present invention an embodiment will be described in which the sound diaphragm operates an armature or moving coil and this is the preferable construction in accordance with the present invention. However, other forms of electrical transducing devices, such as current operating devices or electrostatic means, may be used in connection with the present system.

It is particularly desirable in the field of submarine listening where a ship is listening by means of a group of sound receivers to determine in connection with a compensating device the direction of the sound source. In systems of this nature it is quite essential to have the sound pick-up devices alike in all respects so that the character of the sound as well as its phase, intensity and other characteristics might be impressed without modification in its true form on the electric circuit working into the compensator.

In the case of systems of this nature using hydrophone-microphone devices it is necessary to match carefully the group of receivers making up an installation and this is done usually by selecting from a group the desired number which respond closely in the same manner.

In the prior art for work of this nature hydrophones have been developed which employed rubber diaphragms. These diaphragms are substantially aperiodic or at least have such a low resonance frequency that the noises picked up in the water are faithfully reproduced. Such receivers have proved to be quite useful and successful in the art of so-called multispot direction determination.

They have, however, certain disadvantages. One is that the rubber is too soft to allow the diaphragm to respond as a whole and produce the necessary motion of the coil or microphone which it operates. This together with other features make such diaphragms somewhat insensitive. It is also true that such devices are usually not sufficiently rugged to stand great depths and due also to the cold flow of the rubber are apt not to remain watertight. It is also true that when the outside surface of the rubber diaphragm is exposed to water and therefore remains in the same state practically as when installed, the inside of the diaphragm is exposed to air and may harden and deteriorate with age. The tendency at the present time is to depart from rubber diaphragms as sound receivers, although they still find many good uses in many cases.

The present invention uses a metallic diaphragm and by particular new means and methods employed the diaphragm is damped in such a manner that its characteristic resonance is suppressed. This damping is obtained by semiviscous means in intimate contact with the rear of the diaphragm. Added to this the diaphragm itself is of such a design in size and pattern that it is not broadly resonant itself, but, on the other hand, is tuned over a considerable range of frequencies. The diaphragm preferably vibrates a moving coil in a magnetic field.

The invention will be more clearly understood by consideration of the embodiment shown in the drawings annexed hereto.

Fig. 1 shows a section through a sound receiver according to the present invention; and Fig. 2 is an enlarged view of the central portion of the diaphragm showing more clearly the mounting of the moving coil thereon.

The diaphragm 1 forms the front portion of the case comprising a heavy back ring 2 and an outwardly extending cylindrical flange 3. This flange may be mounted in a hole in the skin of a ship in the usual manner so that the diaphragm is flush with the skin. The diaphragm as indicated in the figure has a tapering center portion tapering in thickness to the point designated as 4 which is the thinnest point in the diaphragm. From this point the diaphragm is thinned to the outer edge of the flange 3. At the center of the diaphragm is a boss 5 to which is fastened a threaded ring 6 holding the disc element 7 fitting over the boss 5 and having an outwardly extending flange 8 touching the inner diaphragm surface. The flange 8 touching the diaphragm and the ring 7 provide a chamber 9 behind the diaphragm 1. Mounted also on the boss 5 is a frame 10 having a horizontally projecting cylinder 11 on which a coil 15 is wound. The frame 10 and coil 15 are held in place by the nut 12 and the lock washer 13 screwing into a stud formed or fixed in the boss 5.

Mounted on the right side of the disc 7, as indicated in the figure, is a leather ring 14 which is held fast to the disc 7 by means of the clamping ring 15 secured to the disc through the screws 16. This leather ring passes over an inwardly projecting flange 11 of the disc 7 and is fastened at its periphery to the heavy ring 18 by means of the clamping ring 19 secured to the ring 18 through the screws 20. The heavy ring 18 substantially closes the chamber 9. It has a shoulder 21 which rests against an inwardly projecting flange 22 in the side wall 3 of the casing. The shoulder of the ring 20 is held tightly against the
flange 22 by means of the ring 23 threading into the side of the casing as indicated at 24.

The chamber 9 is filled with a mixture 50 of chalk and castor oil in 1:1 proportion. This forms a paste which has a damping of the nature of a viscous liquid mass and yet is not liquid in such a manner that it will easily leak out of the chamber. It will be noted that the chamber is of a particularly new construction in that it has a portion of a wall which is fixed with respect to the sound vibrations and a portion of the same wall extension which is movable with it. This makes it possible to provide not only a shearing damping as in the vicinity of the point 4 behind the diaphragm, but also a plain damping due to the compression in the portion of the chamber farther from the center than adjacent the point 4. Since also the disc 1 is substantially rigid on account of its thickness with reference to the portion of the diaphragm 1 opposite it, there will be some compression damping in the chamber within the area of the disc 1. By choosing the ring portion 18 and the disc portion 17 the desired magnitude, it is possible to design a diaphragm and receiving system to have a definite and desired damping.

The coil 25 carried by the diaphragm moves in a magnetic field between the outer circular pole 28 and the inner circular core 27. A magnetic field is impressed across the air gap between these two poles by means of the coil 28. The magnetic circuit for producing the field is formed by the core 27 which has integral with it an end piece 29 upon which the cylinder 30 fits at the periphery and which itself is integral with the plate 31 having the circular pole 28. An end plate 32 is provided for making a close contact between the plate 28 and the cylinder 30 in the shoulder 32. This plate 32 threads into the casing as indicated at 34. The casing may be closed by a back plate 35 held tightly to the heavy ring 2 by means of the bolts 36 and made watertight by means of the gasket 37.

It will be noted that the whole interior of the receiver may be assembled and disassembled from the rear without removing the apparatus as a whole. By this means it is possible in event a coil should burn out or connection break to make a repair without docking the vessel. The current for energizing the field may be led through the stuffing box 38 and this connection may also serve to conduct the current generated in the moving coil 25 to the compensator or listening device.

It may be remarked in connection with the construction of the diaphragm, in addition to what has been said above, that the special tapering of the diaphragm is chosen to give maximum resistance to an outward pressure combined with a maximum deflection of the center of the diaphragm for a certain pressure, that is, maximum sensitivity.

The outer diameter of the disc or the inner diameter of the ring closing the damping chamber, that is ring 18, is given a definite value for which the volume of the damping chamber remains constant if the diaphragm is deformed by an external pressure. There is, therefore, no movement of the damping mass through the slit between the disc and the ring with varying external pressure.

Having now described my invention, I claim:

1. A sound receiver comprising a casing having a diaphragm at one side thereof, a rigid disc carried at the center of the diaphragm and spaced apart therefrom, a rigid ring positioned adjacent and concentric with said disc and means fixing said ring rigidly to said casing opposite the diaphragm but spaced apart therefrom, said diaphragm, ring, and disc thus forming a chamber, viscous damping means positioned in said chamber in intimate contact with said diaphragm and means carried by said diaphragm for producing electrical indication of the acoustic vibrations thereof.

2. A sound receiver comprising a casing having a diaphragm at one side thereof, a chamber formed behind said diaphragm and contiguous thereto and having a portion thereof stationary and a portion moving with said diaphragm and damping means being provided in said chamber.

3. A sound receiver comprising a casing having a diaphragm at one side thereof, said diaphragm having thickened center and edge portions tapering uniformly to thinner section approximately half way between the center and edge of the diaphragm.

4. A sound receiver comprising a casing having a diaphragm at one side thereof, a chamber positioned within said casing, behind and contiguous to said diaphragm and having a stationary portion and a portion moving with the diaphragm, viscous damping means positioned in said chamber and dielectric covering means closing the space 30 between the stationary and moving portions of the chamber.

5. A submarine sound receiver comprising a casing having a diaphragm at one side thereof, said diaphragm having thickened center and edge portions tapering uniformly to a thinner section approximately half way between the center and edge of the diaphragm, a chamber formed behind, abutting and substantially co-extensive with said diaphragm and being closed on the side opposite the diaphragm by a wall having a portion movable with said diaphragm and a portion stationary with respect to said diaphragm, the division between said stationary and movable portions of said wall lying opposite the thinnest section of said diaphragm and damping means positioned within said chamber.

6. In a sound receiver having a diaphragm damping means for said diaphragm including a chamber and a damping medium within said chamber comprising a plastic mass consisting of a suspension of finely divided insoluble solid in a liquid.

7. In a sound receiver having a diaphragm damping means for said diaphragm including a chamber and a damping medium within said chamber comprising a plastic mass consisting of a suspension of finely divided insoluble solid in a viscous oil.

8. In a sound receiver having a diaphragm damping means for said diaphragm including a chamber and a damping medium within said chamber comprising a plastic mass consisting of a suspension of finely divided chalk in castor oil.

9. In a sound receiver having a diaphragm damping means for said diaphragm including a chamber and a damping medium within said chamber comprising a plastic mass consisting of a suspension of finely divided chalk in castor oil in the proportion of one part chalk to one part castor oil.

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