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ACOUSTIC APPARATUS

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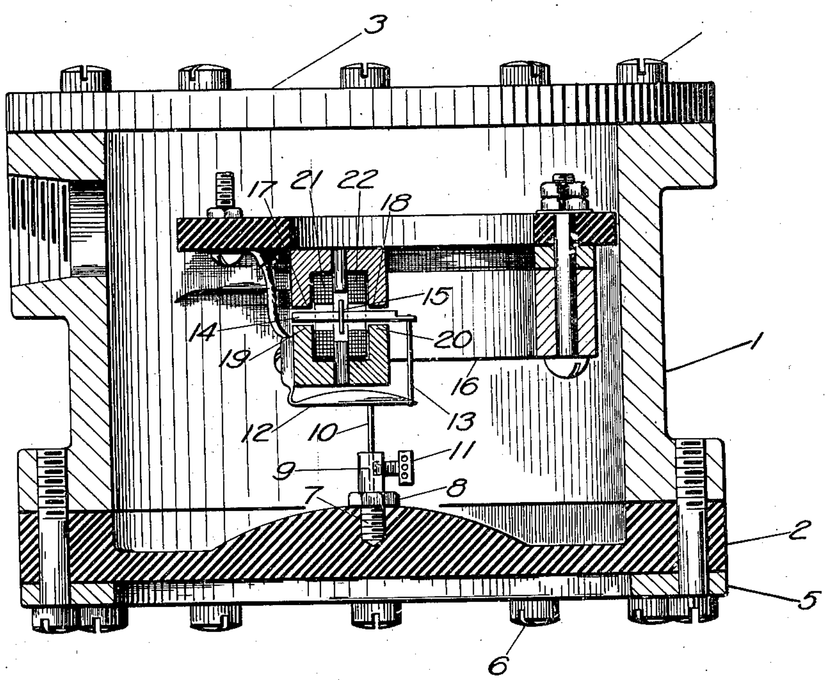

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2,003,284

ACOUSTIC APPARATUS

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3 Claims. (Cl. 177—386)

The present invention relates to sound receivers and more in particular to hydrophones for receiving sound in water.

For many purposes it is desirable to have a sound receiver which will respond with equal intensity over a broad range of frequencies. Such a receiver is useful in listening to noises of a boat in the water where there is no single pitch of the sound but a general mingling of many sounds of different frequencies and characteristics. It is also useful in the transmission of speech under water and in the air. It has, indeed, many other uses which will not be enumerated here.

Receivers of this character have been built, some of which have been fairly successful and others of which have failed in operation in many places where it has been attempted to use them. One type of receiver which has been used combines the balanced armature drive or detector unit with a soft rubber diaphragm. While this type of receiver has proved to be better than the earlier types used, nevertheless the rubber diaphragm is not stiff enough to make a sensitive receiver, since it has a tendency to yield to the sound vibrations impinging on it and passing through it without imparting a definite amplitude to the detecting unit. In other words, not all the energy picked up by such a diaphragm is available to operate the detector unit. Such a combination is, therefore, rather insensitive. Then again, when used in deep water the static pressure on the diaphragm is sometimes sufficient to alter the diaphragm characteristics or its physical relation to the pick up unit, bringing about both acoustic and mechanical difficulties.

Other types of receivers have been tried, such as combinations of coupled and tuned circuits, some with fair success in operation, but as a rule such receivers require careful workmanship in construction to make two alike. Further, very often changes in material through use or change in temperature so change the characteristics of the unit that it no longer performs the function for which it was designed. Again, where tuned circuits are employed there are always resonant points which continue to persist by virtue of the resonant structure. These are, in many cases, partially smoothed out, but it is never possible to iron them out completely.

In my device I have entirely eliminated all resonance indications in the operating range and further have obtained a remarkably sensitive device. This has been possible, not only because of the material which I have used for a diaphragm, but also because of the combination of diaphragm and structure, as will appear later.

In the hydrophone which I have invented, all the vibrating members are rigid structures and act as levers. Further, these levers are rigidly connected to one another and to the diaphragm in such a manner that they all must move in the same direction at any one moment. They are, therefore, not free, and depend upon the diaphragm entirely. Thus, there is really only one vibratory structure and this is so chosen that it has high viscous losses, yet picks up such an enormous amount of sound energy from the medium that it is a highly sensitive device, as will appear later.

I have discovered that the diaphragm should be a piston type diaphragm in which practically the entire bending is confined to a small annular section of the diaphragm near its periphery and further that the material should be of the nature of so called linen bakelite; that is, linen sheets impregnated with a phenol resinous product and united in a rigid structure. Such a material presents an extremely rigid element which yields only as a whole and not in spots, as soft rubber might, and further has a high viscous loss which makes the diaphragm practically non-resonant.

An embodiment of the invention is shown in the figure. The hydrophone comprises a casing 1, which, when used in water, should be watertight and entirely enclosed, a diaphragm 2 and the detector unit which is operatively connected to the diaphragm. The top end of the casing, as shown, is closed by a plate 3 bolted to the casing by machine bolts 4. The lower end of the casing is closed by the diaphragm 2, which is firmly held to the rim of the casing by the clamping member 5 and the bolts 6. The diaphragm 2 is composed of so called linen bakelite or the like and is shaped to be thicker at the middle portion than the edges, so that all the bending which takes place is in a small circular strip near the clamping edge of the diaphragm. At the center of the diaphragm is a stud 7, embedded therein and held firmly in place by the nut 8. The stud 7 has a hole 9 drilled at the top thereof, in which the rod 10 fits. A set screw 11, threading in the piece 7 is provided so that the rod 10 might be held firmly in place.

The rod 10 is soldered or welded to a horizontally mounted cross lever 12 between its pivot and its outer edge. At the outer edge of the lever 12 there is a rod 13 which may be welded or riveted to the lever 12 at its end, as indicated in the drawing, and which extends vertically to the armature 14. The armature 14 and the rod 13 may be clamped together by means of a bolt or nut at the end of the rod 13, the rod 13 passing through the end of the armature 14. Or the rod 13 and the armature 14 may be firmly joined together in any other well-known manner. The armature 14 is of the balanced type, balanced by the center support 15. It operates in the air gap of the permanent magnet 16 between four poles formed by the magnet. The poles 17 and 18 may be regarded as north and 19 and 20 as south. When a current is sent in the one direction in the coils 21 and 22, the armature would rock one way and when this current is reversed the armature would rock the other way. This rocking motion of the armature 14, which is really a lever, would move longitudinally the rod 13 and transversely the lever 12. By the action of the lever 12 the rod 10 is vibrated longitudinally and the diaphragm 2, transversely.

In most cases the apparatus works inversely; that is, the sound energy is picked up by the diaphragm and through the lever system just described rocks the armature, thus changing the field through the coils 21 and 22 and thereby inducing a current in them.

As shown in the figure, the amplitude at the diaphragm is increased by the lever system about in the ratio of 3 to 2.

The diaphragm 2 is designed when used in water to be comparatively large, of the order of four inches, and further is relatively thick at the middle with a bending area near the clamping rim. The diaphragm is built up of layers of linen impregnated with a phenol resinous condensation product such as bakelite and is, furthermore, very hard and unyielding to local pressure on points on the diaphragm, but will yield and bend slightly as a whole, the whole yielding and bending taking place at the edge and furnishing, by means of the friction between successive layers, very high viscous losses.

The diaphragm, however, being made large, this viscous loss is very small as compared with the energy picked up by the diaphragm, so that the sensitivity of the diaphragm is not affected except perhaps to cut out the resonant point, which is just what is desired.

As a matter of fact, the exact operation of the diaphragm in this respect is not known, but it is believed that the diaphragm is non-resonant, since it is composed and constructed in such a manner that as the amplitude increases the viscous losses increase very appreciably, so that while the diaphragm has only a small amplitude, the losses are small, but as soon as the amplitude increases, the losses increase and therefore act as a governor of the amplitude of the diaphragm. This feature is believed to be brought about by confining the yielding of the diaphragm to a small area and further having this portion composed of layers of linen which rub against each other as the diaphragm bends. While, therefore, the diaphragm is sensitive to weak sounds, it builds up in a resistance against strong sounds or resonance.

It should be noted also that none of the lever structures is free at its end and that the diaphragm is so much stiffer than the pivots or the bending points of the lever system that they cannot possibly resonate at any frequency but must follow exactly the motion of the diaphragm, giving no greater amplitude than the product of the diaphragm amplitude and the mechanical transformer ratio at all frequencies.

To insure against any freedom of the lever structures, except in their proper motion, not only are they stiff, but they are mounted in substantially parallel planes and form a parallelogram structure with the connecting rods so that no bending strain is placed on the rods or levers themselves by distortion of the parallelogram structure.

It should be noted that while the levers are rigid they bend easily at their pivots and that therefore no restoring force and no resonance is set up. To insure this to a further degree the diaphragm is so stiff and elastic that whatever restoring force is set up in the lever joints is very small and practically negligible with respect to that set up in the diaphragm.

Having now described my invention, I claim:

1. A magnetophone for submarine sound reception comprising a watertight casing, a plate of woven textile fabric impregnated with phenol resinous condensation product covering the end of said casing forming an acoustic piston diaphragm having an annular bending section, a magnetophone unit mounted within said casing having a magnet and an armature associated therewith pivoted at a point between its ends, a lever pivoted at one end, said armature and lever being disposed parallel to said diaphragm and perpendicularly disposed means connecting one end of said lever with said armature and connecting said lever to said diaphragm, whereby substantially the entire restoring force of the system is in the diaphragm.

2. A submarine sound receiving device comprising a watertight casing having a diaphragm at one side thereof, said diaphragm being composed of a plurality of layers of relatively thin woven textile fabric impregnated with a phenol resinous condensation product and having an annular bending section with a thicker stiffer central portion, an electromagnetic pick-up means including a movable current inducing element and means connecting the latter with the center of the diaphragm, substantially all of the restoring force for the device being furnished by said diaphragm.

3. A submarine sound receivng device comprising a watertight casing having a diaphragm at one side thereof, said diaphragm being composed of a plurality of layers of relatively thin woven textile fabric impregnated with a phenol resinous condensation product and having an annular bending section with a thicker stiffer central portion, an electromagnetic pick-up means including a magnet, a pivoted armature associated therewith and means connecting the latter to the center of said diaphragm, substantially all of the restoring force for the device being furnished by said diaphragm.

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