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SUBMARINE SIGNALING APPARATUS

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8 Claims. (Cl. 177—386)

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The present invention relates to a magnetostriction oscillator and more particularly to the type of oscillator in which a directive beam of compressional wave energy is produced.

In the present invention the diaphragm or radiating element is operated by a plurality of tubes which with the load of the local radiating element forms a resonant structure in which the tube alone apparently is the resonant element unless the radiating element has a substantial thickness. These tubes are themselves preferably mounted on a heavy plate to which they are rigidly held. In the present type oscillator it should be noted that as the oscillator is submerged in the water to deeper depths, greater static pressure is applied to the front diaphragm of the oscillator which has a tendency to exert a similar pressure upon the magnetostriction tubes or elements driving the diaphragm. The applicant has discovered that under these conditions if these tubes are made of nickel, the increase of pressure on the diaphragm compresses the nickel to such a degree that its efficient operation as a magnetostriction device is greatly impaired. The applicant has further discovered that the magnetostrictive qualities of the nickel element itself are most sensitive and efficient when the element is substantially under no compressional strains. In order to accomplish this purpose the applicant has applied an internal pressure in the oscillator itself so as to relieve the compressional strains on the nickel element.

Further, in the present construction the ends of the tubes are welded to the diaphragm so that a slight tension, if desirable can be placed upon the nickel tubes when the air pressure within the oscillator is increased.

Further, in the present invention the radiating diaphragm by properly dimensioning the size and shape of the radiating element may be made resonant to the frequency to be transmitted so as to substantially compensate for the diaphragm mass. If this is accomplished, it is possible to give the magnetostrictive tube longer dimensions than otherwise would be possible for the same operating frequency and this materially helps in increasing the amplitude at the end of the tube and the efficiency of the application of the electrical forces. Further, if the resonant tube element is constructed as a three-quarter wave length tube, it is possible to provide two nodes at both points of which a driving coil may be placed. In order to avoid the adverse effects of the operation of these coils in series, the linkage flux may be diverted by a coil in between having a reverse po-

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larity. In this manner the application of the electrical force to produce the mechanical motion is easily obtained. Under conditions where the frequency to be generated is well within the sonic range, special design of the electromagnetic circuit is not necessary in order to obtain the desired energization of the magnetostrictive tube itself. However, where the frequencies are above the audible range and of a magnitude of 30,000 cycles per second, or greater, the physical dimensions of the oscillating elements become very short and therefore the available space for impressing the magnetic flux upon the tube is considerably reduced.

A further reduction of the size of the tube available at high frequencies is also imposed on account of the load carried by the tube which directly acts to reduce the resonant frequency of the tube itself. In addition to this it should also be noted that the vibrational amplitude of the tube is increased when a greater length of tube is used since the magnetostrictive effect in nickel in particular produces a contraction with an increase of flux in the tube which is substantially proportional to the linear length of the tube itself.

The transmitter or oscillator itself is provided with a heavy rim diaphragm to which the tubes placed in a uniform arrangement and covering substantially the whole diaphragm are secured, the free ends of the tubes having a solid frusto-conical shape and preferably tensioned in a heavy back plate which is protected from the sound-propagating medium.

The features of the invention will be fully described in connection with the embodiment of the invention described below as illustrated by the drawing in which Fig. 1 shows a sectional view of the oscillator; Fig. 2 shows a plan view of a portion of the face of the oscillator; Fig. 3 shows a modification of the oscillator construction; Fig. 4 shows a further modification and Fig. 5 shows a detail.

In Fig. 1 the oscillator is provided with a heavy plate 1 which has an upwardly extending collar 2 and an outwardly extending clamping ring 3. A back plate 4 applied to the collar 2 by means of the bolts 5 spaced about the whole oscillator serves with the usual packing elements to hermetically seal the back of the oscillator casing, forming a chamber in which air pressure may be maintained as desired. At the front of the plate 3 is a diaphragm 6 which has a heavy outer rim 7 held to the plate 3 by means of the bolts 14, 14 spaced about the plate. The diaphragm 6 has welded to it in the usual manner the tubes 8, 8, etc., which

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are spaced about the oscillator diaphragm as indicated in Fig. 2. The tubes 8 have conically shaped solid end elements 9 which are threaded to receive the bolts 10 passing through the heavy plate 1. The heavy plate 1 has perforations through it through which the bolts 10 pass, and on the diaphragm side of the plate these perforations are shaped with a similar conical shape to receive the ends 9 of the tubes 8.

A lock washer 11 is used with each bolt and in the assembly of the device the tubes 8 are taken up tightly into the heavy plate 1. Around each tube 8 is a coil 12 to which both the alternating current for vibrating the tube and the direct current for magnetizing the tube is applied. The direct-current circuit may have suitable choke coils 40 and 41, Fig. 5 therein in order to prevent the alternating current from coming back into the direct-current generator 42 or battery. While the back plate 1 may be made of magnetic material, it is preferable in preventing eddy-current losses to have it made of high resistive material such as the material known as "micalex" a mixture of mica and glass formed in a hard compound. Besides this it is also possible to use metals such as German silver, or the like.

The interior of the oscillator is maintained at a pressure so that no strain is put upon the oscillator tubes 8. This may be accomplished for a specific depth at which the oscillator is submerged by putting an internal air pressure in the oscillator through the valve 13. The pressure in the back of the oscillator will be communicated to the front either by a passage 50 or around the electrical connections to the coils.

In Figure 3 the oscillating tube 20 is approximately a three-quarter wave length tube with nodes as indicated at the points 21. The end of the tube may be similarly constructed as that illustrated in Fig. 1 and the tube may be held in a heavy back plate 22. The tube, as will be noted, is surrounded with three coils 23, 24 and 25, coils 23 and 25 generating flux in the same direction while the coil 24 generates flux in the opposite direction. The coils may be assembled, as indicated in Fig. 3, by forming the pieces 24' as rings separate from the elements 26 and holding them in place by means of the bolts 26' passing from the outside of the piece 26 through to the ring portions 24'.

A magnetic return path may be provided through magnetizable shell 26 and the back plate 22 which may likewise be of magnetic material. The tube 20, as in the modification of Fig. 1, is welded to a diaphragm 27 and similarly as in Fig. 1 tension may be placed between the back plate and the diaphragm to compensate for the mechanical pressure applied to the tube 20. In the operation of this figure the flux in the tube is concentrated where the nodes are positioned.

A return magnetic path is preferably supplied between the coil 23 and the coil 24, and the coil 24 and the coil 25, so that flux linking the tubes at the nodes will not pass through the center part of the tube. It should be noted that since the center part of the tubes is a region of expansion, flux passing through this point will really act in opposition to the action in the tube and tend to prevent the proper type of response for the best operation of the tube itself.

The arrangement shown in Fig. 3 allows a comparatively large coil for supplying power to drive the tube, and therefore to a great extent overcomes the difficulty present in generating magnetostrictive vibrations of high frequencies.

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Whereas a tube may ordinarily at 30,000 cycles be approximately one-half inch long, according to the system shown in Fig. 3 it can be nearer two inches long.

In the modification shown in Fig. 4 the tube 30 may be made substantially one-quarter wave length long, the node coming in this case at the end fixed to the plate 31. The tube 30 is securely attached by being welded or in some other similar manner secured to the front plate 32 which is preferably made one-half wave length of the frequency which is to be produced. In this manner a resonance is built up in the plate itself which furnishes an accelerating component compensating the load which would otherwise be impressed upon the tube itself. In this manner it is possible to design the tube 30 as a full-quarter wave length tube and the space, therefore, for the coil 33 surrounding the tube is increased, allowing greater efficiency in the application of electrical energy to vibrate the tube.

Having now described my invention, I claim:

1. A magnetostrictive oscillator comprising a casing, a heavy back plate supported within said casing, a plurality of substantially identical structurally and acoustically tuned magnetostrictive tubes, means detachably and rigidly mounting said tubes to project from one side of said plate, a coil about each of said tubes, a diaphragm covering the front of said casing and means rigidly securing the ends of said tubes to said diaphragm.

2. A magnetostrictive oscillator comprising a casing, a heavy back plate mounted within said casing, a diaphragm at the front of said casing, a plurality of magnetostrictive elements adapted to contract with an increase of magnetic flux, a coil individually surrounding each of said elements, means detachably and securely supporting said elements in said back plate, means for rigidly attaching the other ends of said elements to the diaphragm and means for putting fluid pressure within said casing whereby an initial tension is exerted on said magnetostrictive elements.

3. A magnetostrictive oscillator comprising a casing, a diaphragm closing the front end of said casing, a plurality of magnetostrictive elements, means rigidly securing said elements at one end to said diaphragm, a heavy back plate mounted within said casing behind said diaphragm, said plate being provided with conical perforations, said magnetostrictive elements each having a frusto-conical end drawn into said conical perforations in said plate means securely and completely drawing said ends into said perforations whereby said magnetostrictive elements may be tensioned within said casing.

4. A magnetostrictive oscillator comprising a casing having a diaphragm formed at one end thereof, means providing a heavy plate within said casing, a plurality of magnetostrictive tubes, means rigidly securing one end of each of said tubes to the diaphragm and means detachably and rigidly securing the other ends thereof to said plate.

5. A magnetostrictive oscillator comprising a casing having a diaphragm formed at one end thereof, a plurality of magnetostrictive tubes positioned in a uniform arrangement on said diaphragm and secured rigidly thereto, the other ends of said tubes having a solid element, a heavy plate positioned within said casing behind the solid ends of the tubes, each of said tubes being provided with a bolt extending through said plate and threaded into the solid end of the tube and rigidly securing the tube to the plate.

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6. A magnetostrictive oscillator comprising a casing having a diaphragm at one end thereof, a heavy plate positioned within said casing, a plurality of magnetostrictive tubes extending from said plate to said diaphragm, means rigidly securing one end of each of said tubes to said diaphragm, means rigidly and detachably securing the other end thereof to said plate, said latter means constituting a tensioning means for said tubes and means for providing pneumatic pressure within said casing.

7. A magnetostriction oscillator comprising a casing, a heavy back plate constituting a part of and supported in said casing, a plurality of substantially identical acoustically tuned magnetostrictive tubes, means for detachably and securely mounting said tubes on said plate, a separate coil for and surrounding each of said tubes, a diaphragm of such dimensions as to make with

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the magnetostrictive element a $\frac{3}{4}$ of a wave length longitudinal oscillator element at the frequency at which the entire system is to vibrate and means rigidly attaching each tuned member to said diaphragm.

8. A magnetostrictive oscillator comprising a casing, a heavy back plate constituting a part of and supported in said casing, a plurality of substantially identical acoustically tuned magnetostrictive elements, means detachably and rigidly mounting said elements on said plate, said elements being operated with two nodes therein, a separate coil being located at each nodal region in aiding direction and a separate coil for and applied between said nodes in opposition, a diaphragm covering the front of the casing and means for rigidly securing said elements to the diaphragm.

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