Oct. 29, 1946. E. E. TURNER, JR 2,410,112

OSCILLATOR

Filed May 8, 1936 2 Sheets-Sheet 1

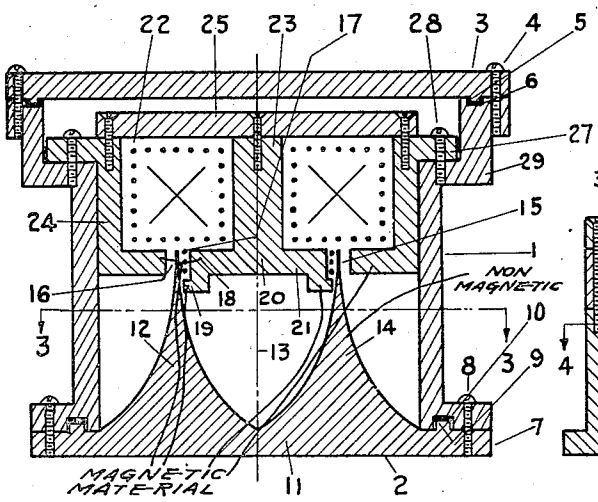


FIG. 1

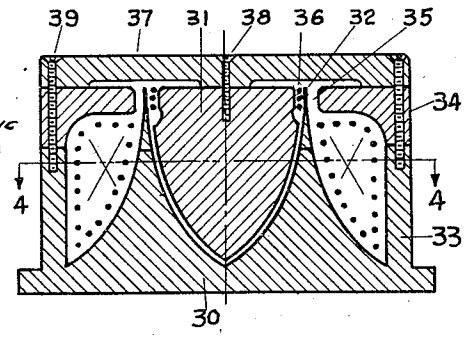


FIG. 2

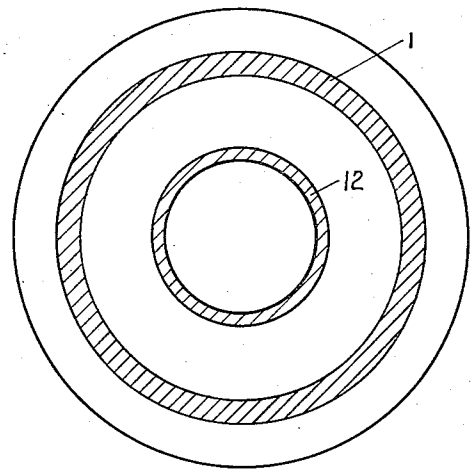


FIG. 3

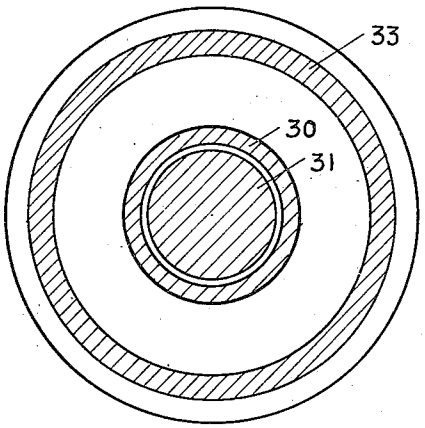


FIG. 4

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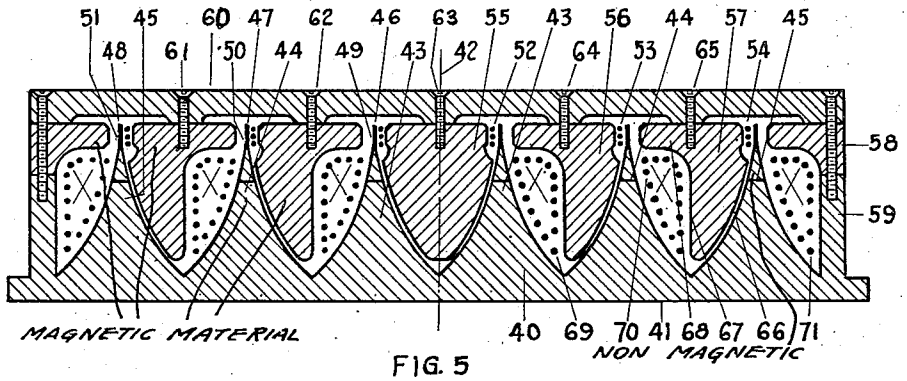


FIG. 5

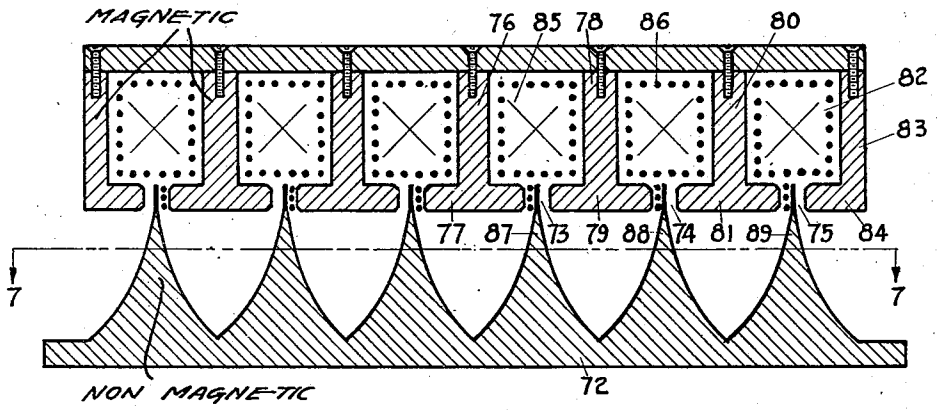


FIG. 6

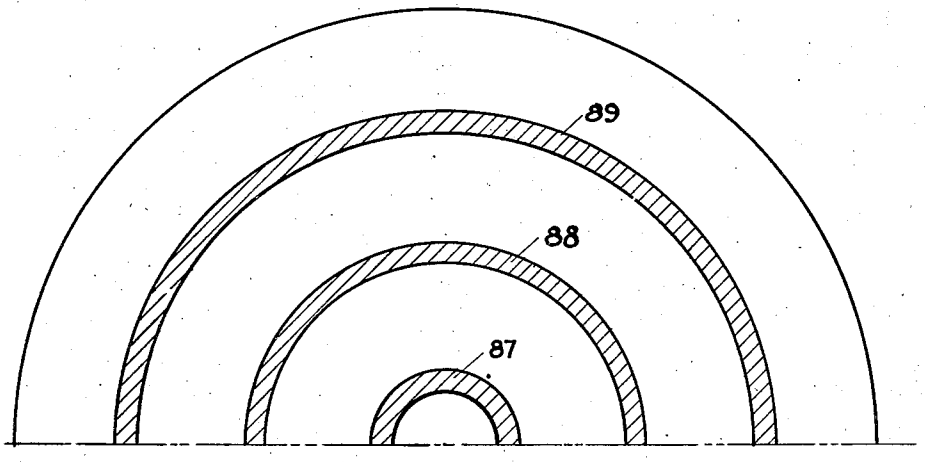


FIG. 7

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UNITED STATES PATENT OFFICE

2,410,112

OSCILLATOR

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Application May 8, 1936, Serial No. 78,719

6 Claims. (Cl. 177—386)

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The present invention relates to a device for producing mechanical vibrations, in particular vibrations of high frequencies such as are used for compressional wave signaling, particularly in water.

In this form of signaling mechanical vibrations of a very high frequency are used above the range of ordinary audibility to the human ear and a beam of vibratory energy is obtained with such frequencies by making the radiating area large in all linear directions as compared with the wave length of the compressional waves that are produced. In the production of such a beam of compressional wave energy it is customary to employ a large heavy mass and drive such mass at a plurality of points so close to one another that a plane uniform wave is produced at the surface of the mass abutting the propagating medium.

In systems of the nature described above, certain limitations exist to the dimensions of the mass which is driven at a plurality of points. The important limitation is the limitation of thickness. If the plate becomes thicker than one-half wave length of the compressional energy that is transmitted through it or even approaches such a thickness, the plate itself acts as a propagating medium for the compressional waves, and under such circumstances transverse waves may easily result in the plate destroying true piston action. In fact, it may also be true that the wave motion on one side of the plate is different from that on the other side of the plate with the result that a pure plane wave is not produced and the sharpness of the beam is interfered with.

Attempts have been made to remedy this difficulty by grooving the plate from the inside outward in the form that is often seen in slicing a pie. This, however, hardly overcomes the difficulties, for reflections are present from the groove surfaces such as to cause other transverse vibrations that seriously affect the mass as an efficient radiating element. One method of avoiding this difficulty is not to make the plate too thick and to ensure that the nodal plane of motion for longitudinal vibration falls in the driving tubes or elements and not in the mass itself. This is accomplished by using a plate as the mass which is less than one-quarter wave length thick at the frequency of the transmitted compressional energy in the material of which the plate is made and preferably less than one-eighth wave length thick.

In the present invention a still further method is presented whereby transverse vibrations may

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be avoided. The present invention has also, however, other features that provide important elements in the combination as presented.

In the present invention the mechanical energy developed from the electrical system is efficiently converted from a relatively high linear amplitude to a relatively low linear amplitude over a large surface in such a manner that practically no compressional wave energy is lost in the transfer. The device also can be made to produce and receive such vibrational energy with a marked degree of selectivity which can be controlled within a desired frequency range by means of the specific design of the units themselves.

In carrying out the present invention the radiating element is formed with a large radiating surface as compared with the dimensioning of the wave length that is to be propagated. This radiating element may be made up of a cylinder of revolution in which the section of the cylinder taken radially along the axis is the same shape as a longitudinal section along the axis of an exponential horn. In a small device a single cylinder of revolution may be used whereas when it is desired to produce a larger radiating surface the number of such cylinders of revolution may be used with their axes coincidental.

A further advantage in the present invention is that the arrangement of the electrical parts, particularly the magnetic circuit, is such as to produce an efficient electrical and magnetic system and makes it possible without special precautions to avoid electrical losses.

The other advantages and features of the invention will be understood from the description following in connection with the drawings in which Fig. 1 shows a section through a simple form of structure of the present invention; Fig. 2 shows a modification in section of the form shown in Fig. 1; Fig. 3 shows a sectional view taken on the line 3—3 of Fig. 1; and Fig. 4 shows a sectional view taken on the line 4—4 of Fig. 2; Fig. 5 shows a section of a further modification of the device in which a number of concentric units are employed; Fig. 6 shows a further modification of a plurality of units somewhat similar to that shown in Fig. 5; and Fig. 7 shows a half section taken on the line 7—7 of Fig. 6.

In Fig. 1 the entire unit may be contained in a casing 1 in which the radiating element 2 forms the front part of the casing. The back of the casing may be closed by a plate 3 held to the casing 1 by a series of bolts 4 positioned around the rim. The casing may be made watertight in the

usual manner by means of a tongue 5 and a groove 6 containing a gasket of rubber or some other material. The radiating element 2 may similarly be fastened to the casing in the flange 7 by means of the bolts 8 and be made watertight by means of the tongue 9 setting in the groove 10. The radiating element 2 is composed of a flat or plane face 11 and formed of a body of revolution, a section 12 of which taken through the axis of revolution is always an exponential horn. The body of revolution is formed with the axis 13 as the center so that the sections on either side of the axes, indicated by 12 and 14, are similar and symmetrically positioned with the center line 13. At the end of the body of revolution there is positioned a cylinder 15 of conductive material which may be of copper or may simply be a copper or conductive-plated surface at the inner end of the body 2. This conductive element is positioned in a circular or cylindrical magnetic field 16 in which is present a coil 17 held in position against the circular pole face 18 by means of the ring 19 fastened by the bolts or otherwise held to the face of the armature element 21. The coil 17 is made to supply the alternating current flux for varying the magnetic flux in the air gap. The constant flux is supplied by means of the coil 22 which is positioned in the shell formed by the center rod 23, the end plate 21 and the shell element 24 producing the cylindrical magnetic field 16 when the coil 22 is energized.

A plate 25 may be fastened over the end of the shell to complete the return magnetic path from the inside core 23 to the outside shell 24. The shell 24 may be supported by a flange 27 held by bolts 28 to a shoulder 29 in the casing 1.

In the operation of the device the direct current is applied continuously to the coil 22 and produces a constant magnetic field 16. Alternating current is supplied to the coil 18 and induces a corresponding current in the conductive ring 15 at the rear end of the radiating element. The alternating current in this coil, working in a constant magnetic field causes motion first downward in the plane of the paper when the current is in one direction and upward in the plane of the paper when the current is in the reverse direction, thus producing a complete cycle of vibration in both directions. This will set up vibrations in the exponential horn of revolution, producing a uniform plane wave at the large end of the horn 11, the volumetric amplitude being substantially the same, the linear amplitude, however, decreasing from the small end to the large end of the horn.

In the system shown in Fig. 2 the principle applied is the same as that in Fig. 1 except that the unit is made more compact by employing the space within the horn of revolution 30 for a portion of the magnetic circuit by the element 31. It should be noted, however, that in addition to this the element 30 must be of magnetic material. The horn 30 and the conductive ring 32 may be the same as shown in Fig. 1 except for the fact stated that the horn should be of magnetic material, so also the casing 33 and the ring element 34 completing the magnetic circuit for producing the cylindrical magnetic field 35 in which the conductive element 32 is placed. A coil 36, similarly to the coil 18, is placed in the magnetic field to produce current in the ring 32. A back plate of nonmagnetic material 37 may cover the end of the casing. The center core 31 may be held to this plate by means of the center bolt 38 passing through the plate 37, the plate itself being held to the casing by means of the bolts 39 threading through the ring 34 and holding this assembly in its proper position. The device as indicated in Fig. 2 is similar to that shown in Fig. 1.

In the arrangement shown in Fig. 5 the radiating element 40 has preferably a flat plane surface 41 formed by a series of horns of revolution having coincidental axes of revolution as indicated by the dotted line 42. The horn section 43 on the left of the line is the same section as 43 on the right and similarly 44 and 45. Each horn of revolution 43, 44 and 45 is provided with an end conducting ring 46, 47 and 48 positioned in the circular magnetic fields 49, 50 and 51, respectively. Also positioned in the magnetic field are the alternating current coils 52, 53 and 54 for inducing current into the conducting elements. The return magnetic path in the arrangement shown in Fig. 5 comprises the radiating horn sections 43, 44 and 45 which may be of magnetic material up to the horizontal lines in the sections, the core elements 55, 56, 57 and 58, the latter attached to the casing 59, all of which may be of magnetic material. The top plate 60 need not be of magnetic material and may hold the center cores 55, 56 and 57 by means of the series of bolts 61, 62, 63, 64 and 65 placed around the top of the plate.

The element 55 is a center core in which all sections through the center line 42 appear the same as shown in the drawings. The cores 56 and 57 show sections in Fig. 5 which are elements of revolution of the core members. These, as indicated in the figure, have one surface 66 that runs parallel to the surface of the horn and another surface 67 that is substantially vertical, it being curved over at the top to form a flange 68 the edge of which is one side of the air gap. The direct current coils 69, 70 and 71 are placed in the space to the left of the cores between the horn and the core so that the magnetic path is completed around the coil through the horn, the core which serves really as an external shell and the top flange adjacent the air gap.

The device is assembled by inserting the direct current coils in the spaces provided and then putting in place the top assembly which includes the shell or cores fastened to the top plate 60. The device may be made watertight similarly as indicated in Fig. 1. In the operation of the system each unit is separately excited by means of the conducting cylinders or tubes 46, 47 and 48. The compressional vibrations generated in each one of these units are in general transmitted with the plane wave front perpendicular to the plane of the paper as shown in Fig. 5. The energy propagated from the first horn does not come in contact with the energy propagated from the other horns until the line of junction is reached at which point a distance to the outer surface of the radiating element is small so that no substantial transverse travel of the waves occurs. The horns also furnish a natural stiffness for the radiating element, and while it may be true that there is in a very large radiating surface, such as indicated in Fig. 5, a low point of resonance, this is so far out of range of the operation of the system that no substantial effect is produced by it.

In the modification shown in Fig. 6 the principle is substantially similar to that indicated in Fig. 5, it being carried out, however, by arranging the magnetic circuits over the horn elements and free from the same. The arrangement in Fig. 6 is shown somewhat schematically but indicates a lower radiating element 72 similar to that

shown in Fig. 5. The upper element provides the plurality of cylindrical magnetic fields comprising the fields 73, 74 and 75. At the center of the system there is provided a core element 76 with a cap 77 forming with the cylinder 78 and the end plate 79 the magnetic path which provides the air gap 73. A similar magnetic path is provided by the cylindrical element 80 and a plate 81 while the magnetic path for the outside coil 82 is completed by means of the casing element 83 and the inwardly extending flange 84. The direct current coils 85, 86 and 82 are placed in the spaces as indicated, being completely surrounded by the elements just described in completing the magnetic circuit.

A sectional view of the arrangement shown in Fig. 6 is indicated in Fig. 7 and shows sections on the individual horn elements as 87, 88 and 89.

I claim:

1. Means for producing compressional waves substantially near or above the audibility of sound to the human ear for producing a beam of compressional wave energy, said means comprising a radiating element composed of concentric bodies of revolution having longitudinal sections taken on the axis of revolution formed as exponential horns, means holding said radiating elements only at the edge thereof and means provided at the small end of said bodies for vibrating the same in a direction normal to the radiating surface.

2. Means for producing a beam of compressional wave energy including a radiating element having a plane surface at one side and the other side formed with concentric elements, each having sections taken through the concentric axis formed of the same exponential horn, and electromagnetic means provided at the small end of said bodies for producing mechanical vibrations in the direction of the axes of said bodies.

3. Means for producing a beam of compressional wave energy comprising a radiating element having a plane surface at one side and formed at the rear with concentric elements of revolution having as a section an exponential horn, a coil surrounding each element of revolution and means positioned over said coil for bringing the magnetic flux to the small end of the horn, said elements of revolution and said last-named means forming with the elements of revolution an annular air gap, means positioned at the ends of said elements of revolution within

said air gap comprising a conductive ring and means for inducing alternating current into said conductive ring for vibrating the same.

4. Means for producing a beam of compressional wave energy comprising a radiating element having a large mass and supported by a comparatively thin edge at its periphery, said mass comprising bodies of revolution having coincidental axes and sections taken through said axes formed as an exponential horn, the large end of said sections merging into each other to form a continuous integral mass having a minimum thickness not substantially larger than one-quarter wave length of the wave energy in the propagating medium, said bodies of revolution having at their small ends means adapted to be electrically vibrated for producing mechanical motion and means cooperating with said means to supply energy for producing said vibrations.

5. Means for producing a beam of compressional wave energy comprising a large radiating mass formed with a plane surface at one side and surfaces of revolution at the other side having coincidental axes and sections formed as an exponential horn, electrodynamic means for driving said elements individually, said means comprising a constant current coil positioned around said body, magnetic means positioned over said coil and having at its outer side a surface extending parallel and adjacent the surface of said bodies and on its inner side forming a covering for said coil and providing a pole element for said flux, the return path of the flux being completed by the external surface of the next magnetic body, said bodies of revolution also being magnetic, and a conductive element provided at the small end of said bodies of revolution and means for energizing said conductive element by means of a source of alternating current.

6. Means for producing compressional waves comprising a radiating element having a plane surface on one side and the rear thereof formed of a plurality of bodies of revolution covering the entire rear surface, said bodies having concentric axes of revolution and longitudinal sections on said axes of the same shape as a longitudinal section along the axis of an exponential horn and means positioned at the small end of said bodies of revolution for vibrating the same in a direction longitudinal with the axis of the body.

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