

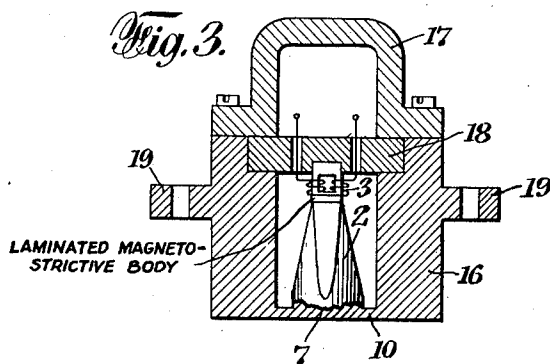
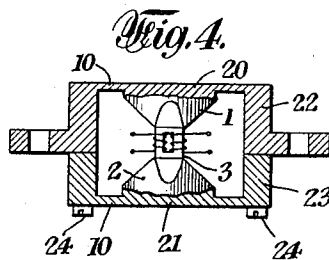
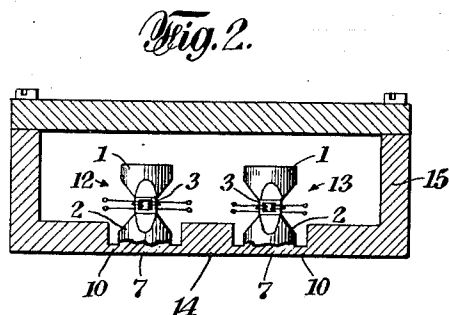
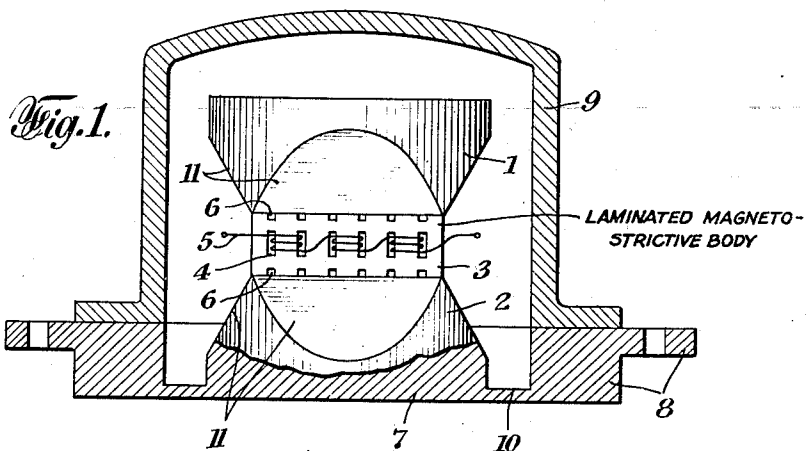
July 27, 1937.

U. JOHN

2,088,324

MAGNETO-STRICTIVE ELECTROMECHANICAL SOUND DEVICE

Filed May 22, 1935



INVENTOR
Ulich John
 BY *M. J. G. H. H.*
 his ATTORNEYS

UNITED STATES PATENT OFFICE

2,088,324

MAGNETO-STRICTIVE ELECTROMECHANICAL SOUND DEVICE

Ulrich John, Kiel, Germany, assignor to Electroacoustic, Gesellschaft mit beschränkter Haftung, Kiel, Germany, a firm

Application May 22, 1935, Serial No. 22,694
In Germany May 28, 1934

2 Claims. (Cl. 177—386)

The subject matter of the present invention refers to a magneto-strictive electro-mechanical sound device for transmitting and receiving sound, especially submarine sound oscillations. The device consists of one or several rods or rod elements oscillating longitudinally at the frequency of the transmitted or received sound, the length of the rods or rod elements amounting to any desired odd multiple of one-quarter wave length of the sound. When these rod elements are connected at the end at which a nodal point of the motion amplitude prevails (i. e. the point at which the power amplitude prevails) either to a practically infinitely large mass, or if two of such rods are connected together at their butt ends, at which motion nodal points prevail. In the first case the free end of such a rod element, (i. e. the end at which the maximum motion amplitude prevails) can be developed into a radiating surface (one-sided transmitter or receiver), and in the second case the free ends of both rods (at which maximum motion amplitudes prevail) may be developed as radiating surfaces (double transmitter or receiver). If the cross-sectional area of such rod ends is sufficiently large, as shown in the present case, a special radiator may be dispensed with. In case several rod systems are used in parallel the radiating surfaces of the rod ends which are located on the same side may be combined into a common radiating surface.

The idea on which the present invention is based is, that not the entire length of a longitudinally oscillating rod or rod system need be made of magneto-strictive material as heretofore, but such magneto-strictive material should be provided only at the portion or portions of the oscillating rod element at which a nodal point of the longitudinal motion prevails (and accordingly at which the power amplitude prevails). Thus the designer is at liberty to choose the material for the remaining portions of the rod system with a view of fulfilling to best advantage its other requirements. He need not be concerned about its particular magnetic properties, and he may make these portions of the system of solid material, instead of laminations as heretofore required. By this expedient in the first place a very considerable saving in magneto-strictive material results. Further, there also results in consequence a considerable saving in the amount of copper for the winding and thus also a considerable saving of the copper losses, and magnetizing losses.

If one would consider alone the energy required, the length of the magneto-strictive mate-

rial in the direction of the rod system axis might even be infinitely short, since the magneto-strictive force K is entirely independent of the length of the magneto-strictive material in that direction. This is true because of the existing relation

$$K = a.B.q$$

in which B represents the magnetic induction, q the cross-section of the rod system and a a material constant dependent to a certain extent from B . The necessary force for exciting the system is, therefore, always present no matter how short the axial length of the magneto-strictive material may be. Since, however, at the end of the oscillating rod element which is excited at the force K and at which end the motion nodal point exists theoretically, also a certain amount of motion amplitude would exist in practice, which depends upon the required power output, and upon the power applied, and since the stretching of the magneto-strictive material occurring during the operation must lie below the proportional limit of extension, it becomes apparent that in practice the axial length of the magneto-strictive material must have a certain finite value depending upon the required motion amplitude and proportional extension limit. At the smallness of the motion amplitudes prevailing at the radiating surface (being of the order of 10^{-4} to 10^{-3} mm.) a material length of from 1 to at most 10 mm. would be sufficient which in case the sound device is tuned to about 20,000 cycles would amount to from $\frac{1}{60}$ to at most $\frac{1}{6}$ of the total length of an oscillating rod assuming the length to be one quarter of the wave length corresponding to the frequency of 20,000. Aside from this, however, in actual practice a certain appreciable axial length of the magneto-strictive material is necessary in order to provide the necessary space for the energizing winding, which space is surrounded by the magneto-strictive lines of force.

As a magneto-strictive material pure nickel is used for instance, or a nickel-alloy containing a small percentage of manganese.

My invention is illustrated in the accompanying drawing in which—

Fig. 1 represents in semi-diagrammatic form an elevation, partly in section, of a one-sided sender, in which only one free end of a longitudinally oscillating rod is connected to a sound radiating surface.

Fig. 2 represents a similar view of a modification in which the free ends of two oscillating rods act upon a common sound radiating surface.

Fig. 3 represents a similar view of a modifica-

tion in which one end of an oscillating rod is connected to a sound radiating surface and the other end to a practically infinitely large mass, and

5 Fig. 4 represents a similar view of a modification in which each end of an oscillating rod is connected to a sound radiating surface.

Referring to Fig. 1, the oscillating rod system which is attached only at one of its ends to a radiating surface, consists in substance of two rod elements 1 and 2 of material which while it is not magneto-strictively utilized should have approximately similar elastic properties at the prevailing sound frequencies to the magneto-strictive material. The lengths of these rods amount to one quarter or its odd multiples of the wave length of the transmitted or received sound and are connected together endwise by a magneto-strictively responsive body 3, which is laminated in the direction parallel to the drawing surface of Fig. 1. Body 3 is provided with a suitable number of transverse slots 4 symmetrically distributed over the body, through which the energizing winding 5 is threaded. For the purpose of obtaining well soldered joints between body 3 and rods 1 and 2, body 3 is provided at its abutting ends with slots 6 through which air and superfluous soldering flux can escape. In order that the large circumferential contour of the outer ends of rod elements 1 and 2 may merge gradually into the rectangular contour of body 3, the rod contours are gradually tapered and shaped, as shown at 11, from their normal cylindrical into the rectangular circumferential contour of body 3.

15 The lower end of rod element 2 is in Fig. 1 developed into a radiating surface or diaphragm 7 which is in contact with the sound transmitting medium, in this case water being assumed. Rod 2 forms with the fastening flange 8 a single body, which for convenience may be disc-shaped as shown, so that when this flange is attached to housing 9 which surrounds and protects the oscillating rod system, a perfectly water-tight hollow body may be formed. The annular zone 10 between rod element 2 and flange 8 is made sufficiently thin walled so that its elasticity is much greater than the elasticity of the oscillating rod system. By these provisions the effect is attained that the system may freely oscillate, notwithstanding its enclosure in a water-tight casing.

Since as previously stated rod elements 1 and 2 need not be made of magneto-strictive material it would be possible to supplement magneto-strictive oscillating portion 3, which may consist of a nickel body, by elements 1 and 2 made of steel. This would not entail acoustically, (i. e. so far as the elasticity is concerned) a gap at the junction points between 1 and 3, and 2 and 3. But even materials may be used for rod elements 1 and 2 which have appreciably different elasticity as compared with the magneto-strictive material if the material with the smaller elasticity has a correspondingly larger cross-section. If it should not be possible to avoid gaps in the elastic characteristic of the material, such as for instance at the slots 4 in the magneto-strictive material, it is necessary at least to arrange such places symmetrically to the point of excitation, in order to avoid coupled oscillations between the individual portions of the rod system.

Fig. 2 shows diagrammatically a modification in which two oscillating rod systems 12 and 13, each constructed as shown in Fig. 1 are joined to operate at one of their ends upon one com-

mon radiating surface 14 which is composed of the individual radiating surfaces 7, 7. Surface 14 forms at the same time the bottom of the tightly closed casing 15. 3, 3 is the magneto-strictive material of the two rod systems and 1, 2, as in Fig. 1 represent the individual rod elements of each system. Also in this case thin annular wall portions 10 are provided so as to increase the elasticity at these points.

In Fig. 3 is shown an arrangement in which 10 the inner, free end of the rod system is attached to a mass which in effect may be considered as practically infinitely great. In this case 3 represents again the magneto-strictive material which is connected at one end to the rod element 2 15 which is developed as in Fig. 1 into a radiating surface 7, a thin walled annular wall 10 being provided also in this case. In this modification, however, the comparatively light mass of the upper portion of the system is fixed to a practically infinitely large mass, composed of the very heavy walled casing 16, cover 17 and bridge 18, clamped tightly between the casing and the cover, and to which the free end of the magneto-strictive portion 3 of the oscillating system is attached. By means of flanges 19 this mass is attached to its support, for instance to the hull of a vessel or other objects serving as carriers for submarine sound communication devices. Also this modification, as the previously described forms of Figs. 1 and 2 operates as a "single-sided" transmitting or receiving system.

In Fig. 4 a double-sided system is shown. In this form each of the rod elements 1 and 2, 35 between which the magneto-strictive element 3 is mounted, is developed into a radiating surface 20, 21 respectively, the necessary highly elastic portions of these surfaces being again provided by the thin annular walls 10. Each of the radiating surfaces is fixed to a portion of the casing 40 22 and 23 respectively which are fastened together by bolts 24. When a rod system thus mounted oscillates in axial direction both radiating surfaces 20 and 21 transmit oscillations simultaneously to the surrounding medium.

I claim:—

1. A magneto-strictive longitudinal oscillator for submarine sound signalling, composed of a heavy oscillatory mass divided longitudinally into two relatively large solid end portions having 50 large substantially parallel end surfaces and a relatively small short middle portion consisting of longitudinally laminated magneto-strictive material, united directly with said end portions to form an integral oscillatory body therewith 55 resonant to the frequency used, and means for energizing said magneto-strictive material, said magneto-strictive material being only long enough to accommodate said energizing means.

2. A magneto-strictive longitudinal oscillator 60 for submarine sound signalling, composed of a heavy oscillatory mass divided longitudinally into two relatively large solid end portions having large substantially parallel end surfaces, at least one of said end portions being tapered toward 65 the other, and a relatively small short middle portion consisting of longitudinally laminated magneto-strictive material, united directly with said end portions to form an integral oscillatory body therewith resonant to the frequency used, 70 and means for energizing said magneto-strictive material, said magneto-strictive material being only long enough to accommodate said energizing means.

ULRICH JOHN. 75