Dec. 30, 1947. R. M. BOZORTH 2,433,337

MAGNETOSTRICTIVE SIGNAL TRANSLATING DEVICE

Filed Jan. 19, 1943

FIG. 1

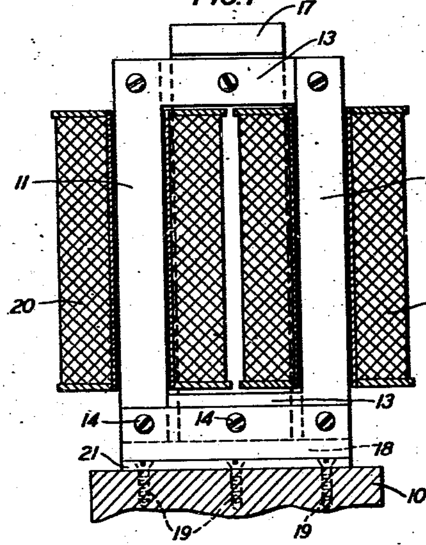
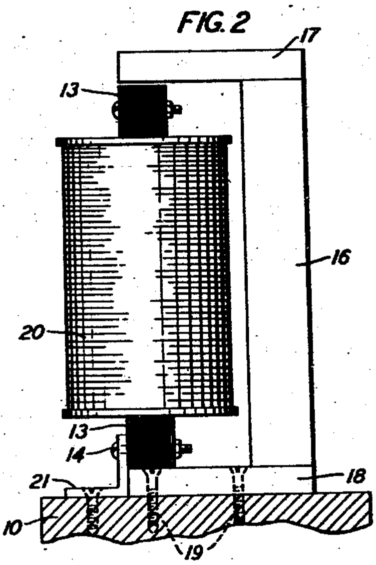


FIG. 2



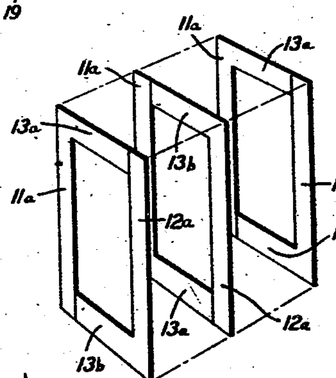
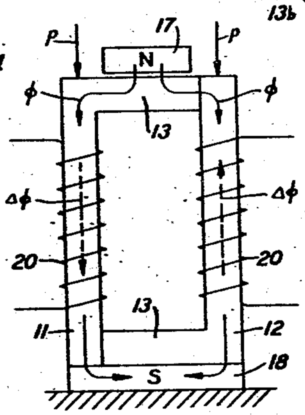


FIG. 3

FIG. 4



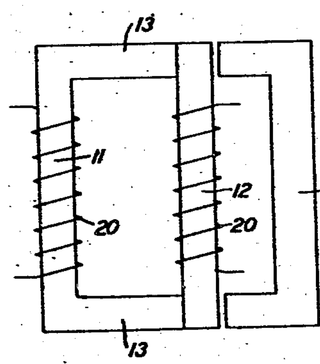


FIG. 5

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MAGNETOSTRICTIVE SIGNAL TRANSLATING DEVICE

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10 Claims. (Cl. 177—386)

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This invention relates to magnetostrictive signal translating devices and more particularly to such devices especially suitable for use as transmitters and receivers in supersonic submarine signaling equipment.

One object of this invention is to increase the sensitivity of magnetostrictive signal translating devices.

Another object of this invention is to simplify the construction of magnetostrictive hydrophones of substantial power capacity.

A further object of this invention is to obtain substantially rectilinear elongation and contraction of a magnetostrictive core constituting a closed magnetic loop.

In one illustrative embodiment of this invention, a hydrophone comprises a magnetostrictive core in the form of a closed magnetic loop having two parallel legs, a magnet for polarizing these legs and a signal coil electromagnetically coupled to the core, the core being mounted to allow expansion and contraction of the parallel legs whereby the core vibrates in response to signal currents in the coil or conversely currents are induced in the coil in accordance with elongations and contractions of the core.

In accordance with one feature of this invention, the parallel legs of the core are constructed of different magnetostrictive materials, one leg being of a material having a negative magnetostrictive coefficient and the other of a material having a positive magnetostrictive coefficient, and the two legs are polarized longitudinally and in the same direction. For example, one leg may be of nickel or a Permalloy containing more than 81 per cent nickel and the other leg may be of a Permalloy containing from about 30 to 80 per cent of nickel and the balance principally iron, and characterized by a high initial permeability.

When the core is subjected to stresses longitudinally of the legs, as in response to compressional waves, the flux in these legs varies in accordance with the stresses produced therein. Because of the different magnetostrictive characteristics of the materials of which the two legs are composed, the flux variations in the two legs are likewise different. That is, when the flux in one leg increases, that in the other decreases, and vice versa. Inasmuch as the two legs are polarized in the same direction, the flux changes in the two legs are cumulative considered around the closed magnetic loop, so that a low reluctance series path for the varying flux is realized with attendant high sensitivity.

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Conversely when the flux in the loop is varied in accordance with a signal current supplied to the signal coil, the path for the varying flux being serially around the loop, the two legs elongate and contract cophasically in the same direction.

In accordance with another feature of this invention, the core is formed of rectangular laminae, each lamination being composed of two L-shaped portions, the end of the shorter arm of each portion being joined to the end of the longer arm of the other portion, and the laminae are mounted in alternate, interleaved face to face relation, that is, in such manner that the shorter or transverse arms of the core are composed of equal numbers of parts of the different magnetostrictive materials.

The invention and the aforenoted and other features thereof will be understood more clearly and fully from the following detailed description with reference to the accompanying drawing in which:

Fig. 1 is a front elevational view of a magnetostrictive translating device illustrative of one embodiment of this invention, the coil windings being shown in section;

Fig. 2 is a side elevational view of the device shown in Fig. 1;

Fig. 3 is a diagrammatic, perspective exploded view illustrating the construction and alternate interleaved relation of the laminae constituting the core of the device shown in Fig. 1;

Fig. 4 is a diagrammatic view illustrating the paths of the polarizing and varying fluxes in the core in the device shown in Fig. 1; and

Fig. 5 is an elevational view of a modification of the device shown in Fig. 1.

Referring now to the drawing, the translating device illustrated in Figs. 1 to 4 comprises a rigid, fixed mount or support 10 to which the core is fixedly secured. The core, which is of laminated construction, is rectangular in form and comprises parallel, longitudinal legs 11 and 12 and transverse arms 13. Each lamination of the core, as shown clearly in Fig. 3, is composed of two L-shaped sections, the shorter arm of each section abutting and being joined to the longer arm of the other section, and the several laminae being clamped together as by bolts 14 extending therethrough.

The two L-shaped sections of each lamination are formed of materials having different magnetostrictive coefficients. For example, the section having the long arm 11a and shorter arm 13a may be of nickel, which contracts when the flux therethrough increases, the contraction being in the direction of the flux change; the section having the long arm 12a and shorter arm 13b may be of 45 per cent Permalloy, which expands, in the direction of the flux change, when the flux therethrough increases. The magnetostrictive coefficients of the two materials are opposite in sign and substantially equal in magnitude. As illustrated in Fig. 3, the laminae are arranged in such manner that the arms 13 of the core are composed of equal numbers of alternately related arms 13a and 13b of the two magnetostrictive materials so that, in these arms 13, the magnetostrictive effects of the constituent parts 13a and 13b substantially neutralize each other. The core, then, comprises, in effect, longitudinal arms 11 and 12 of opposite magnetostrictive character connected by transverse arms 13 having no substantial magnetostrictive effect. Further, because of the intimate and large area contact of adjacent laminae, the core provides a closed loop of very low reluctance.

The core is polarized by a permanent magnet 16 having connected thereto pole-pieces 17 and 18, the pole-piece 17 overlying one of the arms 13 and the pole-piece 18 being interposed between the other arm 13 and the mount 10 and secured thereto by the mounting screws 19.

The longitudinal legs 11 and 12 are encompassed by windings 20, which are connected in series aiding and are free from the legs so as not to impede elongation and contraction of the latter.

As is apparent from the drawing, one end of the core is secured to the mount or support 10, by the mounting screws 19 and bracket 21, and thus is fixed against movement. The other end of the core may be connected in suitable ways to a diaphragm, not shown, for subjecting the legs 11 and 12 to longitudinal stresses.

The operation of the device will be understood from the following analysis with particular reference to Fig. 4. If the magnet 16 is poled as shown in this figure, the polarizing direct current flux will traverse the legs 11 and 12 in the same direction as indicated by the full arrows ϕ. If the core is subjected to a varying pressure, indicated by the arrows P, corresponding for example to a compressional wave, the legs 11 and 12 will elongate and contract in unison. Hence, the flux in the legs 11 and 12 will vary in accordance with the pressure, the flux changes, at any instant, in the two legs being opposite in direction, as indicated for one instant by the dotted arrows $\Delta\phi$, due to the difference in the magnetostrictive coefficients of the materials of these two legs. Hence, the varying flux component flows serially around the loop defined by the core and corresponding currents, in series aiding, are developed in the windings 20. It will be noted that the varying flux traverses a closed magnetic circuit of low reluctance. The arms 13, because of their construction, are substantially neutral magnetostrictively as pointed out heretofore.

If the device is operated in the reverse manner, that is if a signal current is supplied to the windings 20, the flux changes produced in the two legs 11 and 12 are opposite in direction at any instant, and the two legs will change in length cophasically and in the same direction. For example, if the flux in the leg 11 is increased, this leg will contract; at the same time the flux in the leg 12 is decreased and this leg likewise contracts. The arms 13 being magnetostrictively inert, the legs 11 and 12 will execute rectilinear elongation and contraction and this motion may be conveyed in suitable manner to a diaphragm or other radiating member to propagate signal waves corresponding to the signal current supplied to the windings 20.

In the modification illustrated in Fig. 5, the laminae of the core are composed of C-shaped and I-shaped portions joined to form a rectangular loop, the two portions being of different magnetostrictive materials as in the device illustrated in Figs. 1 to 4. Also, as in the latter device, the laminae of the core in the device shown in Fig. 5 are interleaved in alternate relation so that each of the arms 13 is composed of alternate sections of the different materials.

Although specific embodiments of the invention have been shown and described, it will be understood that they are but illustrative and that various modifications may be made therein. For example, although the core has been shown mounted fixedly at one end, it may be suspended, as at the end of a wire, or mounted in a yieldable body such as sponge rubber. Also it may be supported fixedly at a median plane thereof or at some other plane or point. Other modifications may be made in the particular construction disclosed without departing from the scope and spirit of this invention as defined in the appended claims.

What is claimed is:

1. A magnetostrictive signal translating device comprising a core having spaced parallel legs, one of said legs being of a material having a negative magnetostrictive coefficient and the other leg being of a material having a positive magnetostrictive coefficient, means for polarizing said legs longitudinally and in the same direction, and means for driving said legs longitudinally and in the same direction.

2. A magnetostrictive signal translating device comprising a hollow rectangular core two parallel legs of which are of materials having magnetostrictive coefficients different in sign, means for polarizing said two legs longitudinally and in the same direction, and signal coil means electromagnetically coupled to the flux path around said core including said legs magnetically in series.

3. A magnetostrictive signal translating device comprising a core having two parallel legs, one of said legs being of nickel and the other of said legs being of an alloy composed of the order of 45 per cent nickel and balance chiefly iron, means for polarizing said legs longitudinally and in the same direction, means for driving said legs longitudinally and in the same direction.

4. A magnetostrictive signal translating device comprising a hollow rectangular core one leg of which is composed of a material having a negative magnetostrictive coefficient, the opposite leg of which is of a material having a positive magnetostrictive coefficient and the other two legs of which are laminated, alternate laminae being of said first material and the remaining laminae being of said second material, means for polarizing said first and opposite legs longitudinally and in the same direction, and a signal coil electromagnetically coupled to said core.

5. A magnetrostrictive signal translating device comprising a laminated core having two parallel longitudinal legs and transverse arms connecting said legs, each of the laminations of said core being formed of two sections of different materials the magnetrostrictive coefficient of one of which is negative and the magnetostrictive co-

efficient of the other of which is positive, said laminations being arranged in interleaved relation such that one of said longitudinal legs is composed of laminae sections of one of said materials, the other of said legs is composed of laminae sections of the other of said materials and each of said arms is composed of laminae sections of both of said materials, means for polarizing said legs longitudinally and in the same direction, and a signal coil electromagnetically coupled to said core.

6. A magnetrostrictive signal translating device comprising a hollow rectangular core composed of a plurality of laminae, each of said laminae comprising two L-shaped sections of different materials one of which has a positive and the other of which has a negative magnetostrictive coefficient, said laminae being oriented such that one leg of said core is composed of laminae sections of one of said materials, the opposite leg is composed of laminae sections of the other of said materials and the other two legs are composed of laminae sections of both of said materials in interleaved relation, means for polarizing said one and opposite legs longitudinally and in the same direction, and a signal coil electromagnetically coupled to said core.

7. A magnetrostrictive signal translating device comprising a core having parallel legs, one of said legs being of a material having a negative magnetrostrictive coefficient and the other of a material having a positive magnetostrictive coefficient, means for fixing one end of each of said legs against motion, the other end of each of said legs being free to move, means polarizing said legs longitudinally and in the same direction, and means for effecting elongation and contraction of said legs simultaneously and in the same direction.

8. A magnetostrictive signal translating device comprising a rigid mount, a hollow rectangular core one leg of which is of a material having a negative magnetostrictive coefficient, the opposite leg of which is of a material having a positive magnetostrictive coefficient, and the other two legs of which are composed of laminae, alternate laminae being of one of said materials and the remainder of the other of said materials, one of said other two legs being fixed to said mount, means for polarizing said first and said opposite legs longitudinally in the same direction, and a signal coil electromagnetically coupled to said core.

9. A magnetostrictive signal translating device comprising a hollow rectangular core two opposite legs of which are of different magnetostrictive materials, one having a negative and the other having a positive magnetostrictive coefficient, the other two legs of said core being composed of laminae of both said materials in alternate relation, a permanent magnet having its pole-pieces opposite said other two legs, a signal coil electromagnetically coupled to said core, and support means for said core secured to one of said other two legs and fixing this leg against movement.

10. A magnetostrictive signal translating device comprising a hollow rectangular core, composed of rectangular laminae, each of said laminae being formed of two L-shaped portions one of which is of nickel and the other of an alloy comprising of the order of 45 per cent nickel and balance chiefly iron, said laminae being so oriented that one leg of said core consists of nickel sections, the opposite leg consists of sections of said alloy and the other two legs comprise laminae of nickel and said alloy alternately arranged, rigid support means for said core fixed to one of said other legs, a permanent magnet having polepieces opposite said other two legs, and a signal coil electromagnetically coupled to said core.

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