June 29, 1948. R. L. PEEK, JR 2,444,061

MAGNETOSTRICTIVE DEVICE

Filed May 26, 1944

FIG. 1

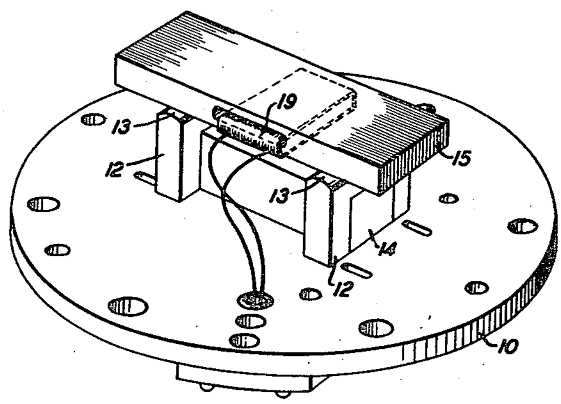



FIG. 2

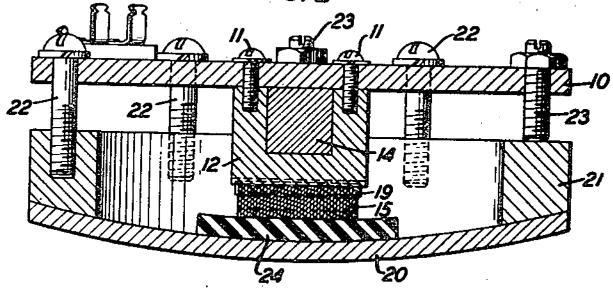



FIG. 3

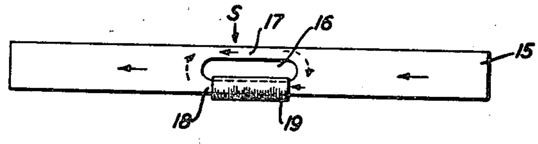
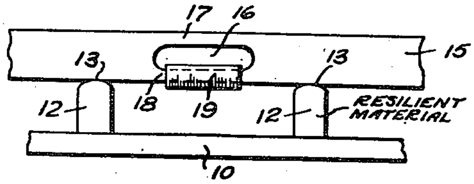



FIG. 4

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Patented June 29, 1948

2,444,061

# UNITED STATES PATENT OFFICE

2,444,061

## MAGNETOSTRICTIVE DEVICE

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Application May 26, 1944, Serial No. 537,503

11 Claims. (Cl. 177—386)

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This invention relates to magnetostrictive devices and more particularly to submarine signaling devices of the magnetostriction type.

One object of this invention is to simplify the construction of magnetostrictive devices and more particularly of magnetostrictive sonic transducers intended for operation in the audio frequency range.

Another object of this invention is to improve the efficiency of submarine signaling devices of the magnetostriction type.

In one illustrative embodiment of this invention, a submarine signaling device comprises a magnetostrictive bar mounted for free vibration in its fundamental flexural mode and a signal coil electromagnetically coupled to the bar for effecting vibration thereof in accordance with signal currents supplied to the coil or, conversely, for translating vibrations of the bar into electrical signals.

In accordance with one feature of this invention, the magnetostrictive bar is polarized longitudinally and is provided adjacent its center with a transverse longitudinally extending slot whereby the central portion of the bar comprises two parallel arms polarized in the same direction. The signal coil encompasses only one of these arms. When the bar vibrates, as in response to forces due to compressional waves effective thereon, one of the arms is placed under tension when the other is under compression, and vice versa, so that the flux changes in the two arms are opposite in sign and a signal flux traverses a series path through the portions of the bar surrounding the slot. Similarly, when signal currents are supplied to the coil, the flux changes produced in the two arms are opposite in sign and the bar is caused to vibrate flexurally.

In accordance with another feature of this invention, the bar is supported at the nodes of its fundamental flexural mode by resilient mounts, whereby mechanical losses are reduced and improved efficiency is realized.

The invention and the above-noted 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 perspective view of a magnetostrictive transducer unit illustrative of one embodiment of the invention;

Fig. 2 is a sectional view of a submarine signaling device including a transducer unit of the construction shown in Fig. 1;

Fig. 3 is a side view, to an enlarged scale, of the core assembly included in the unit illustrated in Fig. 1; and

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Fig. 4 is a side view illustrating a modification of the unit shown in Fig. 1.

Referring now to the drawing, the transducer unit illustrated in Fig. 1 comprises a non-magnetic foundation member or supporting plate 10 having affixed thereto, as by screws 11 as shown in Fig. 2, a pair of U-shaped supports 12 having rounded bearing surfaces 13. In one construction, the supports 12 may be of magnetic iron and constitute pole-pieces of a bar magnet 14 the ends of which are fitted in the supports.

Seated upon the bearing surfaces 13 and held thereon initially by magnetic attraction is a magnetostrictive beam or bar 15 which, in a particularly advantageous construction, comprises a plurality of thin laminations insulated from one another and bonded together by an impregnating compound such as a phenolic condensation product. As shown more clearly in Fig. 3, the beam or bar 15 is provided at its central portion with a transverse slot 16 so that this portion comprises substantially identical, longitudinally extending parallel arms 17 and 18. A signal coil 19 is wound about the arm 18.

The beam or bar 15 is polarized longitudinally by the magnet 14, the polarizing flux traversing the two arms 17 and 18 in the same direction as indicated by the solid arrows on the core in Fig. 3. When the bar is flexed, as by compressional waves effective thereon in the direction indicated by the arrow S in Fig. 3, the two arms are stressed in opposite sense, that is when the arm 17 is placed under compression the arm 18 is placed under tension. Hence, the flux changes in the two arms due to magnetostriction are opposite in sign and a circulating flux flows in the core around the slot 16, for example as indicated by the dotted arrows in Fig. 3, and a signal current is induced in the coil 19. Conversely, when signal currents are supplied to the coil 19, the flux changes in the two arms are opposite in sign so that one arm contracts while the other expands and, as a result, the bar is vibrated in accordance with the signal currents.

The transducer unit is particularly suitable for operation as a single frequency device, that is one sharply resonant at a prescribed frequency. In this case, the beam or bar length is made such in relation to the beam thickness that the fundamental flexural mode corresponds to the prescribed frequency and the supports 12 are so spaced that the contact between the bearing surfaces 13 and the beam or bar are each substantially 0.22 times the length of the beam from the nearest end of the beam, whereby the magnetostrictive element is freely supported at its nodes for its fundamental flexural mode. It will be appreciated that for such single frequency devices, relatively short cores may be employed. For example, in a device intended for operation at 5 kilocycles the core length is approximately 2½ inches.

The unit illustrated in Fig. 1 may be used to particular advantage in a submarine signaling device as shown in Fig. 2. The device shown in the latter figure comprises a diaphragm 20, for example of metal, affixed to a mounting ring 21. The unit is secured to the ring 21 by a plurality of screws 22 threaded into the ring and is spaced therefrom by other screws 23 threaded into the plate 10 and bearing against one face of the ring 21. The magnetostrictive core 15 is coupled to the diaphragm 20 by a body or block 24, for example a block of a commercially available form of rubber having good compressional wave energy transmission characteristics, affixed, as by cement, to the core. In the assembly of the device, the screws 23 are adjusted so that they will engage the ring 21 only when the block 24 has been compressed to be in intimate contact with the core and the diaphragm by tightening of the screws 22.

In a particularly advantageous construction, the beam or bar 15 is made of a magnetic material having high remanence so that the beam or bar is capable of self-polarization and the magnet 14 may be omitted. The supports 12, in such construction, may then be of a resilient material, such as soft rubber, as illustrated in Fig. 4, suitably affixed to the foundation plate 10. The beam or bar, in such construction, is held in position between the supports 12 and the block 24 when the plate 10 is secured to the mounting ring 21. A special feature of this construction is that the beam is in effect floatingly mounted so that mechanical losses are reduced and improved efficiency is obtained.

Although specific embodiments of this invention have been shown and described, it will be understood that they are but illustrative and that various modifications may be made therein without departing from the scope and spirit of this invention as defined in the appended claims.

What is claimed is:

1. A magnetostrictive device comprising a magnetostrictive bar polarized longitudinally and having a transverse slot therein, extending normal to the thickness of said bar and dividing an intermediate portion only thereof into a pair of longitudinally extending arms, means mounting said bar for flexural vibration in the direction of its thickness, and a signal coil in electromagnetic coupling relation with one of said arms.

2. A magnetostrictive device in accordance with claim 1 wherein said mounting means comprises supports engaging said bar at the nodes of its fundamental flexural mode.

3. A magnetostrictive device comprising a magnetostrictive bar having a transverse slot in its center portion dividing said portion into a pair of longitudinally extending arms, means for polarizing said arms magnetically in the same direction, means mounting said bar for flexural vibration in the direction normal to said slot, and signal coil means in electromagnetic coupling relation with one of said arms.

4. A magnetostrictive device in accordance with claim 3 wherein said mounting means comprises supports engaging said bar at regions substantially 0.22 times the bar length from the ends thereof.



5. A magnetostrictive device comprising a longitudinally polarized magnetostrictive bar having intermediate its ends, two longitudinally extending, substantially coextensive spaced portions which together with portions adjacent thereto define a closed magnetic loop, resilient supports engaging said bar at the nodes thereof for its fundamental flexural mode, means for flexing said bar in the direction to vary the stresses in said two portions in opposite sense, said flexing means comprising a diaphragm coupled to said bar, and a signal coil in electromagnetic coupling relation with one of said spaced portions.

6. A magnetostrictive device comprising a magnetostrictive bar having a pair of adjacent, spaced, longitudinally extending arms intermediate its ends and defining a closed magnetic path with portions of said bar adjacent the ends of said longitudinally extending arms, means for polarizing said arms in the same direction, a signal coil linked to one of said arms, and means for stressing said arms simultaneously and in opposite sense.

7. A magnetostrictive device comprising a magnetostrictive bar having a pair of parallel longitudinally extending arms in the mid-portion thereof and defining a closed magnetic path with portions of said bar at the ends of said arms, means for polarizing said arms magnetically in the same direction, means mounting said bar for free flexural vibration in the direction to alter the stresses in the two arms in opposite sense, and a signal coil encompassing one of said arms.

8. A magnetostrictive device comprising a magnetostrictive bar having a pair of parallel longitudinally extending arms in the mid-portion thereof and defining a closed magnetic path with portions of said bar at the ends of said arms, means mounting said bar at the nodes thereof for its fundamental flexural mode of vibration in the direction to stress said arms in opposite sense, means for polarizing said arms magnetically in the same direction, a vibratile member coupled to said bar, and a signal coil in electromagnetic coupling relation with one of said arms.

9. A submarine signaling device comprising a magnetostrictive bar having a transverse slot therein dividing an intermediate portion thereof into two longitudinally extending portions, a signal coil encompassing one of said portions, a pair of spaced magnetic supports engaging said bar beyond opposite longitudinal extremities of said intermediate portion and mounting said bar for flexural vibration in the direction to stress said longitudinally extending portions in the opposite sense, a magnet for which said supports constitute pole-pieces, and a diaphragm coupled to said intermediate portion.

10. A submarine signaling device comprising a magnetostrictive bar having a transverse slot in its mid-portion dividing said portion into a pair of longitudinally extending arms, a pair of magnetic supports engaging said bar at the nodes of its fundamental flexural mode and mounting said bar for flexural vibration in the direction to stress said arms in opposite sense, a permanent magnet extending between said supports, a signal coil encompassing one of said arms, and a diaphragm coupled to said mid-portion.

11. A magnetostrictive device comprising a

magnetostrictive bar of a high remanence material and polarized longitudinally, said bar having therein a transverse slot dividing the central portion of said bar into a pair of arms extending longitudinally with respect to said bar, means supporting said bar at its nodes for free flexural vibration in the direction to vary the stresses in said arms in opposite sense, said supporting means comprising resilient members engaging said bar at said nodes, and a signal coil in electromagnetic coupling relation with one of said arms.

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