

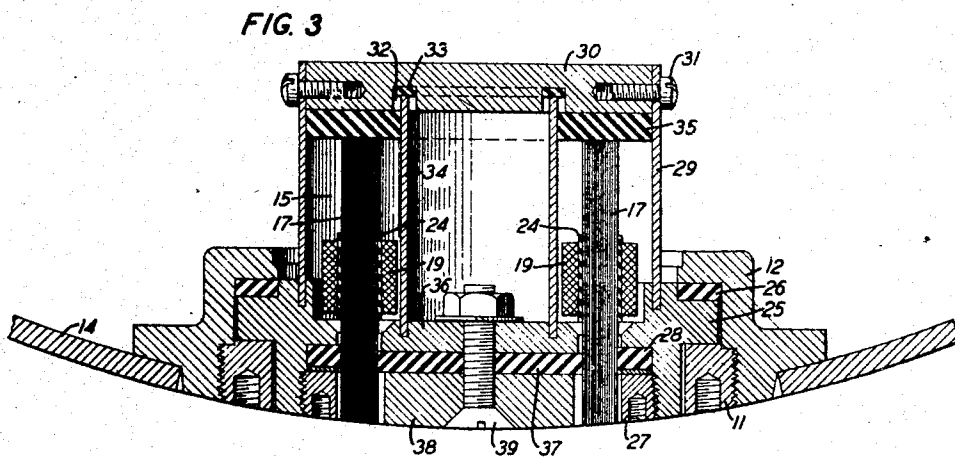
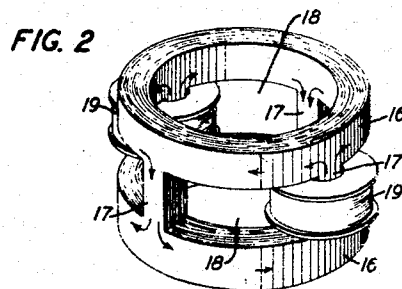
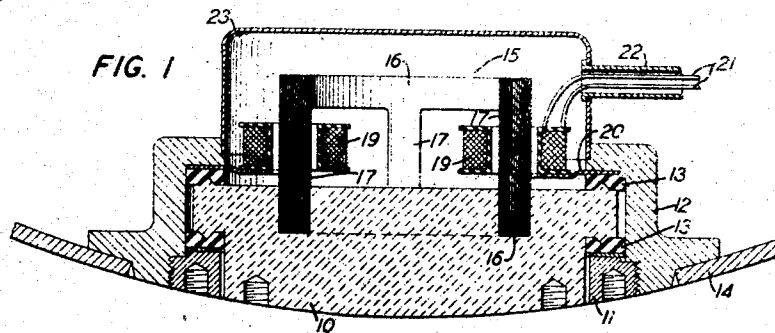
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COMPRESSIONAL WAVE TRANSLATING DEVICE

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COMPRESSIONAL WAVE TRANSLATING
DEVICE

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This invention relates to compressional wave translating devices and more particularly to supersonic submarine signaling devices of the magnetostrictive type.

One general object of this invention is to improve the operating characteristics and construction of compressional wave translating devices. More specifically, objects of this invention are to:

Increase the sensitivity of magnetostrictive signal translating devices;

Improve the magnetic efficiency of magnetostrictive devices;

Reduce eddy current losses in such devices;

Obtain a high and efficient interchange of energy between the magnetostrictive element in a compressional wave translating device and the medium in which the device operates;

Increase the power capacity of magnetostrictive submarine signaling devices; and

Simplify and facilitate the construction of compressional wave signaling devices of the magnetostrictive type.

In one illustrative embodiment of this invention, a submarine signaling device adapted for operation as both a projector and receiver of supersonic compressional waves comprises a magnetostrictive core or element and a coil or coils electromagnetically associated with the magnetostrictive element to translate vibrations thereof into electrical vibrations or, conversely, to translate signal currents into vibrations of the element. In one form, the core or element is cylindrical and is mounted in such manner as to allow substantially free longitudinal vibration thereof.

In accordance with one feature of this invention, the core or element is so constructed as to constitute in itself an efficient closed magnet circuit having low reluctance and small eddy current losses. More specifically, in accordance with one feature of this invention, the core is generally cylindrical and is formed of a plurality of turns of thin strip magnetostrictive material wound upon one another to form a laminated assembly composed of circular end portions and a plurality of parallel, equally spaced arms connecting the end portions. Signal coils are provided about two or more arms and are so poled that, when suitable energized, they produce polarizing fluxes of substantially equal magnitude and opposite direction in adjacent legs of the core or element.

In accordance with another feature of this invention, the legs of the core are made of small cross-sectional dimensions relative to the spacing between adjacent legs whereby the end portions

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of the core or element are of relatively high mass and, consequently, a high amplitude of motion of the legs in response to compressional wave or electrical energy effective thereon is obtained.

In accordance with a further feature of this invention, the core or element is mounted resiliently to allow substantially free longitudinal vibration thereof and one end of the core or element is exposed directly to the medium by which compressional wave energy is transmitted to or from the core or element.

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 view in section of a supersonic signaling device illustrative of one embodiment of this invention;

Fig. 2 is a perspective view of the magnetostrictive element and the coils associated therewith included in the device shown in Fig. 1; and

Fig. 3 is a sectional view of a submarine signaling device illustrative of another embodiment of this invention.

Referring now to the drawing, the devices illustrated therein are suitable for use both as projectors and receivers and either as single frequency or band frequency instruments. They are especially suitable for operation at supersonic frequencies, for example, frequencies of the order of 25 kilocycles per second.

The device illustrated in Fig. 1 comprises a circular base or support 10 of non-magnetic material and capable of transmitting efficiently supersonic compressional wave energy. A mounting frame 12 supports the base 10, the latter, together with suitable washers 13, for example of soft rubber, being secured in water-tight relation to the frame by a clamping ring 11. The frame 12 is secured, as by welding, to a water-tight housing, a portion of which is shown at 14, adapted to be submerged in the sea.

The base or support 10 serves to transmit energy to or from a magnetostrictive element, designated generally as 15, having one end portion embedded therein. The magnetostrictive element 15, as shown clearly in Fig. 2, is generally cylindrical and comprises circular end portions 16 and a plurality of equally spaced legs 17 connecting the end portions 16. The element may be formed, in a particularly advantageous construction, of a plurality of turns of thin strip magnetostrictive material, adjacent turns being insulated from one another and the entire element being impregnated

with a suitable cementing material to hold the several turns together. In one construction, the element is wound from a tape of a nickel-iron alloy known commercially as "Permalloy" to form a solid walled cylinder and portions of the cylinder wall are cut or milled out to form the windows 18 between the legs. Alternatively, rectangular openings may be punched in the tape before or during the winding operation, the openings being appropriately located so that corresponding openings in adjacent turns of the core are aligned to define the windows between the legs 17. Adjacent turns of the element are insulated from one another, for example by "Alundum," and the element is impregnated, for example with a phenolic condensation product.

The magnetostrictive core or element 15 is polarized longitudinally by one or more pairs of coils 19 which are poled in such manner that the fluxes produced in adjacent legs 17 are equal and opposite in direction. Typical flux directions in the core shown in Fig. 2 are illustrated by the arrows. The coils 19 are supported upon an annular, non-magnetic member 20 which is clamped against the base of the frame 12 as shown in Fig. 1, and are of such inner diameter as to be free of the legs 17 they encompass and, thus, to offer no impediment to motion of these legs. Electrical connection to the coils 19 may be established by suitable conductors 21, two of which are shown in Fig. 1, extending through a sleeve 22 projecting from a non-magnetic cover 23 secured to the frame 12.

In the operation of the device as a receiver, the energy of compressional waves impinging upon the outer face of the base or support 10 is transmitted thereby to the magnetostrictive element 15 so that the latter is subjected to varying longitudinal stresses. Consequently, the reluctance of the paths linked by the coils 19, and particularly of the legs 17, is varied accordingly due to magnetostrictive action and signal currents corresponding to the impinging waves are induced in the coils. Conversely, when the device is operated as a projector, signal currents supplied to the coils 19 produce changes in the magnetization of the core and the core elongates and contracts longitudinally to drive the base or support 10, whereby compressional waves corresponding to the signal currents are propagated by the support. Of course, polarizing coils separate from the coils 19 may be provided if desired.

The base or support 10 may be of thermoplastic material and have the magnetostrictive element 15 positioned therein during the molding of the base so that the element 15 is bonded to the base. Alternatively, the base or support 10 may be of metal and the element 15 may be firmly secured thereto, for example by cementing the lower end portion 16, in Fig. 1, in an annular groove in the base or support. In either case, advantageously the base or support 10 and the element 15 are dimensioned so that together they vibrate longitudinally as a half-wave resonator at a preassigned frequency. The absolute dimensions requisite to obtain such vibration will be determined, of course, by the cross-sectional areas of the base 10 and element 15 and the densities and elastic constants of the materials employed.

If the device is intended for single frequency operation, this single frequency is the preassigned frequency. If the device is intended for operation throughout a band of frequencies, the preassigned frequency is the mean frequency in this band.

In another form, the base or support 10 may be of a resilient material, such as rubber, having substantially the same impedance to the transmission of compressional wave energy as sea water and the magnetostrictive element 15 made of such dimensions as to vibrate longitudinally as a half wave-length resonator at the preassigned frequency.

It will be noted that the magnetostrictive element 15 constitutes in itself completely closed, metallic magnetic paths for both the polarizing and varying fluxes and that these paths are of very low reluctance so that high operating efficiencies are obtained. Because of the laminated construction of the core or element 15, eddy current losses therein will be small. Furthermore, it will be seen that the legs 17 are of small cross-sectional dimensions as compared with the windows 18. In an illustrative construction, each leg 17 may, for example, subtend an angle of the order of one-fifth that subtended by each window 18. Consequently, the end portions 16 of the core or element constitute relatively weighty members providing end loading on the legs 17 and a relatively high amplitude of motion of the legs 17 in response to wave energy transmitted thereto obtains. Further, the small leg-to-window ratio reduces the over-all length requisite to obtain the half wave-length condition of vibration noted heretofore. Also the legs 17 are of relatively small cross-sectional dimensions compared to the end portions 16 so that the flux density in the legs is greater than in the end portions and the reluctance of these portions is low. Moreover, it will be appreciated that the core or element 15 is of relatively simple construction and is readily fabricated and mounted.

Although in the construction shown in Figs. 1 and 2 the core or element 15 comprises four legs 17 and a single pair of coils 19, a different number of legs or a different number of coils or both may be employed. The number of legs provided may be two or any multiple thereof, one coil being provided for each pair of legs.

In the device illustrated in Fig. 3, the magnetostrictive core or element 15 is of the same form and construction as that shown in Fig. 2, has two coils 19 encompassing diametrically opposite legs 17 thereof, and is supported resiliently so that it may vibrate freely longitudinally. Advantageously, this core or element is made of a length substantially equal to one-half wave-length of the operating frequency, or mean operating frequency, to provide a vibrational node at the portion of the legs 17 encircled by the coils. The coils may be supported from the legs 17 by resilient, e. g. soft rubber, sleeves 24 cemented to the legs and the coils.

The mounting frame 12 has clamped thereto by the ring 11 an annular, non-magnetic supporting member 25, a resilient gasket 26 being provided to effect a water-tight seal between the frame 12 and member 25. The supporting member 25 has secured thereto, by a clamping ring 27, a resilient annulus 28, for example of soft rubber, and mounts a magnetic or non-magnetic cylinder 29 having one end secured thereto and closed at the other end by a magnetic or non-magnetic plate 30 which may be secured to the cylinder 29 by a plurality of screws 31. The plate 30 is provided with an annular groove 32 in which an annular, resilient, for example soft rubber, ring 33 is secured.

Abutting the ring 33 is a cylindrical magnetic or non-magnetic member 34 which is positioned

coaxially within the cylinder 29 by a resilient, e. g., soft rubber, annulus 35 and which carries a circular, non-magnetic plate 36. The plate 36 mounts a circular, resilient, e. g. soft rubber pad 37, which is clamped thereagainst by a non-magnetic plate 38 and bolt 39 and engages the magnetostrictive core or element 15.

When the clamping ring 27 is screwed into the supporting member 25 and the bolt 39 is tightened, the soft rubber members 28 and 37 are compressed and thus forced into intimate engagement with the magnetostrictive core or element 15. The core or element 15 abuts the rubber annulus 35 and is thus resiliently supported for substantially free longitudinal vibration by the rubber members 28, 37 and 35.

The outer end face, that is the lower end face in Fig. 3, of the magnetostrictive core or element 15 is exposed directly to sea water and serves as the wave receiving or propagating surface. The device illustrated in Fig. 3 operates in the same manner as that shown in Figs. 1 and 2. As in the device illustrated in Figs. 1 and 2, the core 15 in that shown in Fig. 3 may comprise other than four legs 17 and other than two coils 19.

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 without departing from the scope and spirit of this invention as defined in the appended claims.

What is claimed is:

1. A compressional wave translating device comprising a cylindrical core including circular end portions and a plurality of parallel legs of magnetostrictive material connecting said end portions, said legs being of small cross-sectional dimensions relative to the spacing between adjacent legs, means mounting said core for longitudinal vibration, and a coil electromagnetically coupled to said core.

2. A compressional wave translating device comprising a cylindrical core including circular end portions and a plurality of parallel legs connecting said end portions, said legs being of small width relative to the spacing between adjacent legs and said core being composed of a plurality of turns of thin sheet magnetostrictive material, adjacent turns being in face-to-face relation and insulated from one another, means mounting said core to allow substantially free longitudinal vibration thereof, and signal coils on certain of said legs and poled to produce, when energized, fluxes in opposite directions in adjacent legs.

3. A compressional wave translating device comprising a support member responsive to compressional wave energy, a hollow core having end portions and a plurality of spaced legs connecting said end portions, said legs being of small cross-sectional dimensions relative to the spacing between adjacent legs and said core comprising a plurality of layers of thin magnetostrictive material, one of said end portions being fixed to said support member and the other of said end portions being free, and a signal coil in electromagnetic coupling relation with said core.

4. A compressional wave translating device comprising a support member responsive to compressional wave energy, a cylindrical magnetostrictive core having circular end portions and a plurality of spaced legs connecting said end portions, said legs being of small cross-sectional dimensions relative to the spacing between adjacent legs, one of said end portions being fixed to said support member and the other end portion

being free, and means for polarizing adjacent legs longitudinally and in opposite directions.

5. A submarine signaling device comprising a support plate responsive to compressional wave energy and having one face adapted to be exposed directly to the sea, a cylindrical core formed of a plurality of turns of thin, sheet magnetostrictive material, adjacent turns being in face-to-face relations and insulated from one another, said core comprising circular end portions and a plurality of parallel legs of small cross-sectional dimensions and widely spaced connecting said end portions, one of said end portions being fixed to the opposite face of said plate and the other end portion being free, and coils encompassing certain of said legs and poled to produce, when energized, fluxes in opposite directions in adjacent legs.

6. A magnetostrictive signal translating device comprising a hollow magnetostrictive core having end portions and a plurality of parallel legs connecting said end portions, resilient means engaging one of said end portions, other resilient means engaging said core at a region spaced from said one end portion, said first and other resilient means constituting the sole support for said core, and a signal coil electromagnetically coupled to said core.

7. A compressional wave translating device comprising a cylindrical magnetostrictive core formed of a plurality of turns of thin sheet material, adjacent turns being in face-to-face relation, said core comprising circular end portions and a plurality of parallel legs of small cross-sectional dimensions and widely spaced connecting said end portions, means supporting said core for substantially free longitudinal vibration comprising a resilient member engaging one of said end portions and juxtaposed resilient members engaging inner and outer surface portions of said core remote from said one end portion, and signal coils encompassing certain of said legs and poled to produce, when energized, fluxes in opposite direction in adjacent legs.

8. A submarine signaling device comprising a housing having a wall provided with an annular aperture, a cylindrical magnetostrictive core including circular end portions and a plurality of parallel arms extending between said end portions, said core being encompassed by said housing and one end portion thereof extending through said aperture, signal coil means linked to said core, and means supporting said core for substantially free longitudinal vibration thereof, said means comprising resilient means engaging said core adjacent said one end portion thereof and sealing the space therebetween and the apertured wall of said housing.

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