

Sept. 30, 1969

F. R. ABBOTT

3,470,402

MAGNETOSTRICTIVE VIBRATION MOTOR

Filed Aug. 25, 1967

2 Sheets-Sheet 1

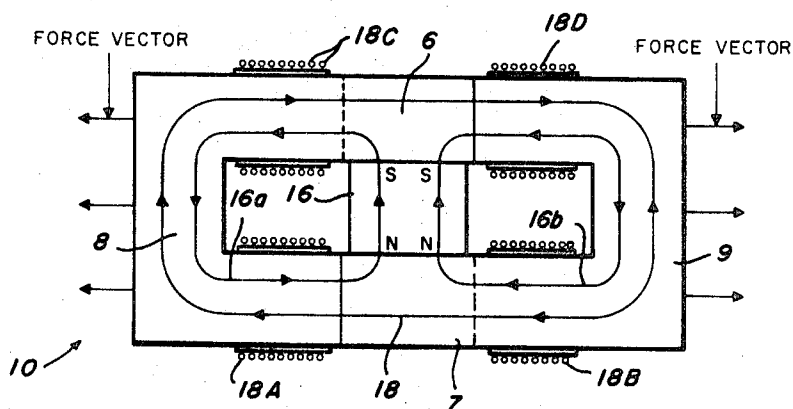


FIG. 1

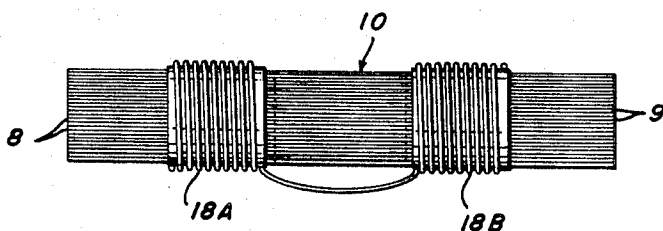


FIG. 2

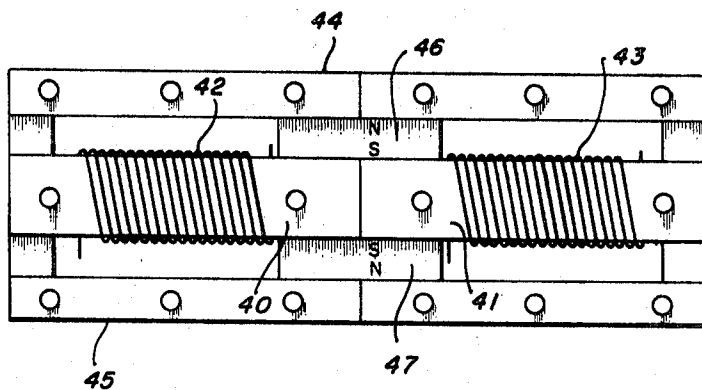


FIG. 3

INVENTOR

FRANK R. ABBOTT

BY

James A. Gibson
T. L. Stynes
ATTORNEYS

Sept. 30, 1969

F. R. ABBOTT

3,470,402

MAGNETOSTRICTIVE VIBRATION MOTOR

Filed Aug. 25, 1967

2 Sheets-Sheet 2

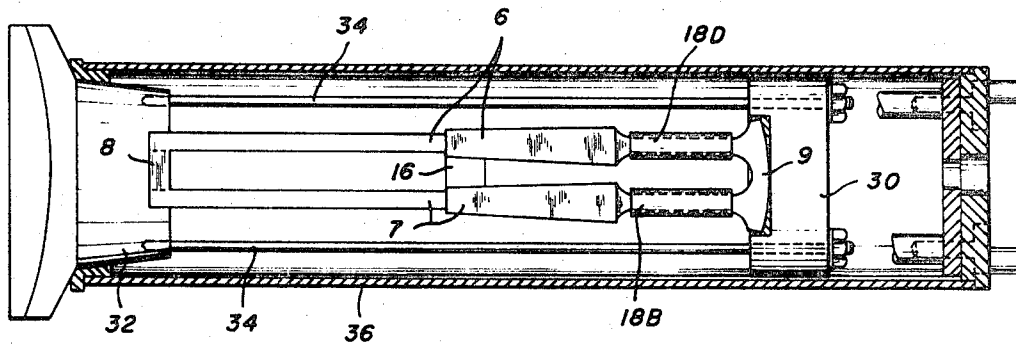


FIG. 4

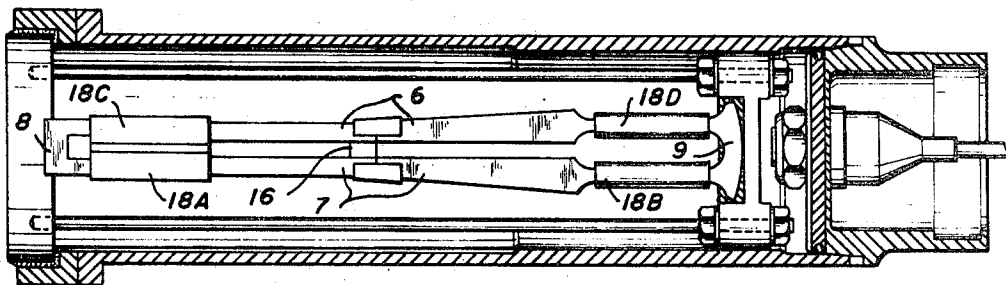


FIG. 5

INVENTOR.
FRANK R. ABBOTT

BY

BY *James A. Fitey*
T. L. Steyer
ATTORNEYS

1

3,470,402

MAGNETOSTRICTIVE VIBRATION MOTOR
 Frank R. Abbott, San Diego, Calif., assignor to the
 United States of America as represented by the
 Secretary of the Navy
 Filed Aug. 25, 1967, Ser. No. 663,455
 Int. Cl. H02k 9/19; H04r 15/00
 U.S. Cl. 310-26

5 Claims

ABSTRACT OF THE DISCLOSURE

The motor of a transducer comprises a core with two end-to-end portions of magnetostrictive metals of, respectively, positive and negative co-efficients of expansion. A magnetic bias is applied to the cores and the magnetic field of the signal current so applied to the two core portions as to, respectively, increase and decrease the lines of force in the two portions to cophasally add the elongation of the two core portions.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

Background

The efficiency of conversion of electric power to acoustic energy, or vice versa, in sea water is notoriously low. Some of the factors contributing to the low efficiency in electromagnetic transducers is short stroke, cavitation at the higher frequencies, and insensitivity of the motor to the signal current. Further, because of the water environment in which transducers must operate, mechanical ruggedness and massiveness is a prerequisite, particularly where deep submergence is expected.

The object of this invention is to provide an improved electromagnetic transducer.

A more specific object of this invention is to provide a transducer which is rugged in construction, has increased travel of radiating surface per unit of input electrical power, and increased overall stroke.

The objects of this invention are attained by mounting a core assembly of magnetostrictive metals between the head piece and tail piece of the transducer for imparting relative reciprocal motion therebetween. The core assembly includes two members of dissimilar metals coupled together end-to-end so that elongation of the two members add cophasally during operation to increase the displacement of the head piece with respect to the tail piece. The two members consist of magnetostrictive metals of, respectively, positive and negative coefficients of expansion and are provided with a unique magnet for biasing the magnetic field in the two portions. A coil for signal current is so coupled to the two-piece core as to, respectively, add to and subtract from the magnetic lines of force in the two members to cophasally expand or contract two members. Transducers thus constructed are particularly rugged and have increased travel of radiating surface per unit of input of electrical power and an increased overall length of stroke.

Other objects and features of this invention will become apparent to those skilled in the art by referring to the preferred embodiment described in the following specification and shown in the accompanying drawings in which:

FIGS. 1 and 2 are plan and elevational views of the preferred embodiment of this invention.

FIG. 3 is a plan view of an alternative embodiment of this invention,

2

FIG. 4 is a partial mechanical plan view of one actual transducer embodying this invention, and

FIG. 5 is an alternative actual transducer embodying the principles of this invention.

The motor or active portion of the transducer of this invention comprises the core 10 shown in FIGS. 1 and 2 which is generally of the O type. The magnetic circuit is generally rectangular in shape, is closed and has no air gap. The elongated legs 6 and 7 of the core are generally longer than the transverse arms 8 and 9 of the core. Intermediate the ends of and between the legs 6 and 7 is inserted the permanent polarizing magnet 16. The pole polarizing magnet extends diagonally across the loop and the faces at the ends of the magnet are of opposite polarity and are machined to snugly fit between the inner surfaces of the legs 6 and 7 to impart to the core 10 a magnetic bias. The magnetic lines of force 16a and 16b of magnet 16 extend, respectively, in clockwise and counter clockwise directions through the two halves of the core. The level of the magnetic bias is so selected as to maximize permeability.

Closely inductively coupled to the core is a signal coil. The coil is preferably although not necessarily divided into equal parts and wound on the two halves of the core on either side of the biasing magnet 16. When the two halves are U-shaped, as in FIG. 1, the coil may be wound on each leg as at 18A, 18B, 18C, and 18D, all connected in series or parallel aiding. The lines of force 18 in the core encircle the entire core in the clockwise direction as shown. The permeability of the magnet 16 is relatively low compared to the permeability of the core 10, and hence need not be considered as a short circuiting path for lines 18. It appears now that the lines of force 18 produced by signals are in the same direction as bias lines 16b in one half of the core but are opposed to the bias lines of force 16a in the other half of the core. This means that a change in signal current always produces a decrease in field in one-half of the core and an increase in the field in the other half of the core.

The next important feature disclosed in the FIG. 1 resides in the fact that the core metal on one side of the bias magnet is of a magnetostrictive alloy which has a positive coefficient of expansion whereas the other half of the core is of magnetostrictive metal with a negative coefficient of expansion. In operation, then, the end-to-end portions of the legs of the core both expand lengthwise, cophasally, with increased signal current and both contract with decreased signal current. The coil must, of course, be properly polarized with respect to the the biasing magnet.

Preferably, the core 10 is laminated, and conveniently the two halves of the core are U-shaped stampings. In the interest of reduced reluctance at the abutting ends of the leg portions of dissimilar metals, the stampings are overlapped a distance approximately equal to the width of the biasing magnet 16. One leg of each U-shaped stamping may be cut shorter than the other leg, and each lamination is laid down so that a short leg abuts the end of a long leg. Thus, the long legs of successive laminations can be made to overlap. The ends of the U-shaped stampings thus interleaved are substantially inseparable and indestructible when joined by the customary adhesive. Preferably, the contacting surfaces of the permanent magnet 16 and the inner surfaces of the laminated core 10 are precisely machined to size and polished and the core 16 driven into place.

As stated, the coefficient of expansion of the two magnetostrictive metals of the core are positive and negative, respectively. While many magnetic alloys are available on the market, good results have been obtained by forming the stampings of one core portion from 99% nickel iron while the other core portion is 50% nickel iron.

The specific percentages of constituents in the alloys is not critical. The two core materials used successfully comprised commercially obtainable "Permalloy 45" and "Permalloy 90." Both alloys have high permeability and low hysteresis loss as well as relatively high coefficients of expansion. Desirably, the permanent magnet 16 is of alnico which is capable of high magnetization and yet has relatively high magnetic reluctance. With optimum magnetic bias, the alternating signal current required for the transducer is small. The magnetically soft laminations are mechanically resistant to fracture while the moderately brittle alnico magnet 16 is protected from rough handling and shock by the laminations. It has been found that cracks in the alnico have little effect on the operation of the transducer.

In FIG. 4 is shown a heavy duty transducer presently known as AN/SQS-26 embodying the features of the motor of FIG. 1. The core portions 6-7-8 and 6-7-9 are laminated and joined end-to-end as in FIG. 1. Where the laminations are interleaved, the permanent alnico magnet 16 is inserted. The signal coil 18B and 18D are coupled to the two legs of core. The transverse arm portion 19 of the core bears against the tail piece 30 while the transverse arms 8 is seated in the head piece 32. Tension rods 34 extend between the tail and head piece to hold the assembly together in one unitary indestructible unit. Casing 36 enclosing the transducer may contain pressure release material and transformer oil, not shown.

In FIG. 5 the transducer AN/BQS-6 also incorporates the features of FIG. 1. The general configuration of the core stampings in FIGS. 4 and 5 are substantially alike. If desired, the signal coils 18A and 18C may be coupled to the core to supplement the coils 18B and 18D. In either case a capacitor within the casing of the transducer may be added to provide electrical resonance at the desired frequency. A capacitor for the transducers of FIGS. 4 and 5 was selected for electrical resonance at 3.5 kilocycles per second.

In FIG. 3 the magnetostrictive portions of the core are laid out to protect the windings from mechanical damage. Here, the two end-to-end legs 40 and 41 of dissimilar magnetostrictive alloys are each wound with signal coils 42 and 43. The magnetic circuit is split and completed through the armatures 44 and 45 while the biasing permanent magnet across the center of the core loop is in two parts 46 and 47. The cophasal contraction and expansion of the cores 40 and 41 in response to signal currents in coils 42 and 43 is the same as in FIG. 1.

What is claimed is:

1. A transducer comprising:

a tail piece, a head piece and a core assembly of magnetostrictive metals, said core assembly being connected between the head and tail pieces for imparting reciprocal motion to the head piece with reference to the tail piece,
said core assembly including two substantially straight

metal members aligned and disposed end-to-end between said head and tail pieces,

said two members consisting of magnetostrictive metals of respectively, positive and negative coefficients of expansion, and

coil means for signal current so coupled to said two core members as to, respectively, increase and decrease the magnetic field in said two members to cophasally expand and contract said two members.

2. The transducer defined in claim 1 further comprising:

means for establishing a predetermined static magnetic bias in said core assembly to maximize the magnetic permeability of said core assembly.

3. In the transducer of claim 2 said bias means including a magnet with pole faces so disposed with respect to the magnetic circuit of said core assembly as to oppositely magnetically polarize said two magnetostrictive members.

4. A transducer comprising:

a magnetic core having magnetostrictive characteristics, said core being a closed loop having two elongated parallel legs and relatively short transverse arms, a coil for signal current coupled to magnetic circuit of said closed loop,

a polarized biasing magnet extending diagonally across said core loop between intermediate portions of said parallel legs for establishing magnetic lines of force extending, respectively, in a clockwise and a counterclockwise direction to, respectively, add to and subtract from the lines of force of the current of said signal coil, and

the magnetostrictive coefficient of expansion of the portions of said core on opposite sides of said biasing magnet being, respectively, positive and negative so that both of said portions elongate in phase with change in signal current.

5. In the transducer defined in claim 4, the mentioned portions of said core having dissimilar coefficients each being laminated, the stampings of each lamination being U-shape and the ends of the stampings being interleaved to reduce magnetic reluctance.

References Cited

UNITED STATES PATENTS

2,411,911	12/1946	Turner	310—26	X
2,433,337	12/1947	Bozorth	340—11	
2,842,689	7/1958	Harris	310—26	
3,007,063	10/1961	Harris	310—26	

MILTON O. HIRSHFIELD, Primary Examiner

D. F. DUGGAN, Assistant Examiner

U.S. Cl. X.R.

340—11