

Nov. 14, 1967

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3,353,040

ELECTRODYNAMIC TRANSDUCER

Filed July 20, 1965

2 Sheets-Sheet 1

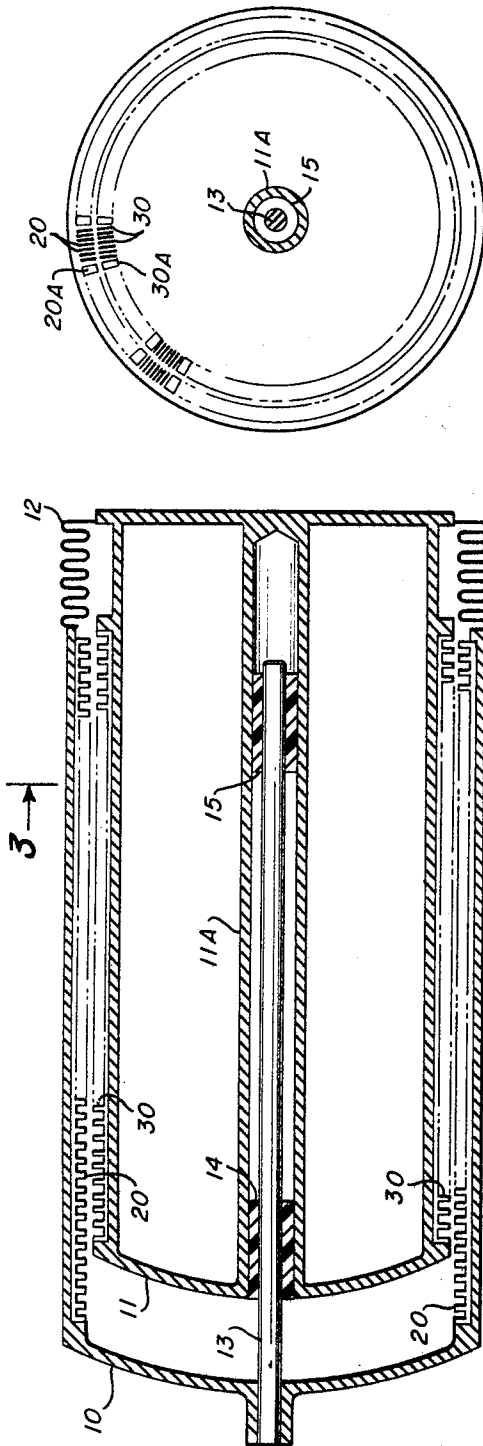


FIG. 1

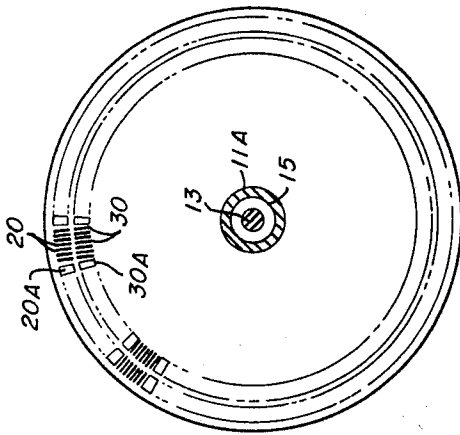


FIG. 3

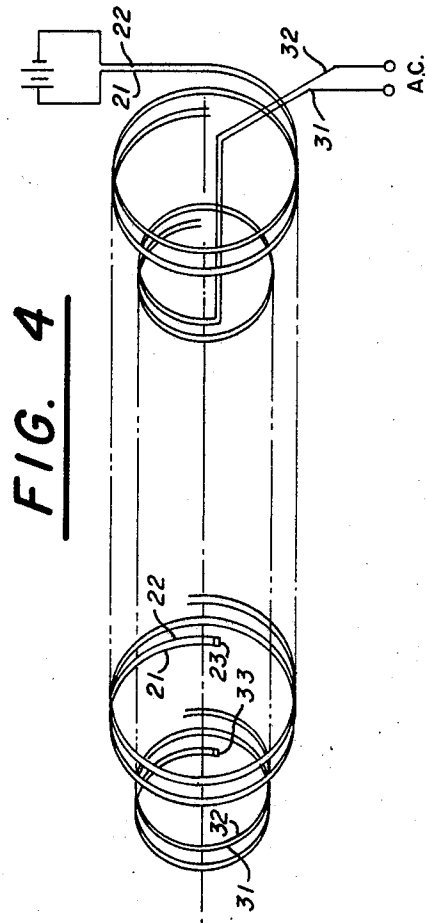


FIG. 4

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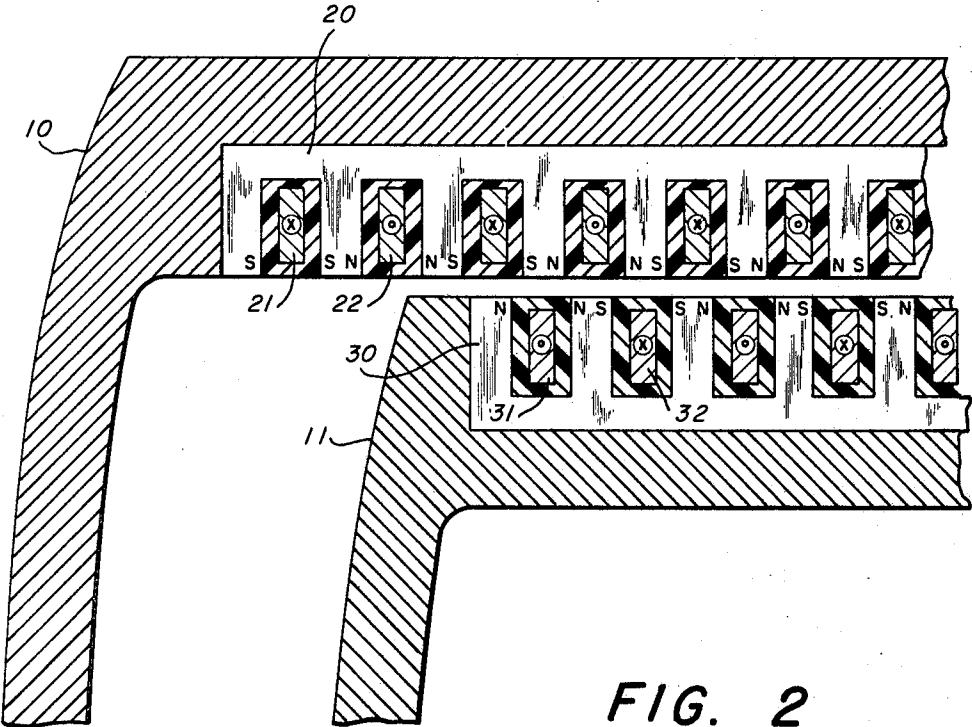


FIG. 2

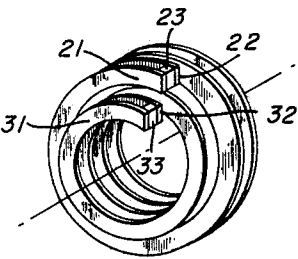


FIG. 5

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ELECTRODYNAMIC TRANSDUCER

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5 Claims. (Cl. 310—27)

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.

This invention relates to electrodynamic transducers and is particularly directed to reciprocating electromagnetic motors for converting electric power to reciprocating mechanical power.

Transducers for ensonifying the ocean with audible or super-audible sound waves are massive and are notoriously inefficient.

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

More specifically the object of this invention is to provide an improved transducer which is relatively small and compact and which is reasonably efficient in electrical-to-mechanical conversion of power.

The transducer of this invention comprises two cylinders of ferromagnetic material, one cylinder being telescoped into the other and mounted for limited relative reciprocation. The opposing surfaces of the telescope cylinders are both spirally grooved, the spirals being double helical so that the axial lead is twice the groove pitch. Then when bifilar windings are laid in said grooves the alternate ridges along the cylinder surfaces can be oppositely magnetically polarized. The surfaces of the ridges between the grooves thus provide long spiral pole faces, the length of which is limited only by the length and diameter of the cylinder. When direct current is applied to one bifilar winding and alternating current is applied to the other winding, the cylinder will reciprocate with a thrust proportional to current.

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:

FIG. 1 is a half section of the preferred embodiment of this invention;

FIG. 2 is a detailed quarter sectional view of the transducer of FIG. 1;

FIG. 3 is a sectional view taken on line 3—3 of FIG. 1;

FIG. 4 is a circuit diagram of the windings of the vibrator of FIG. 1; and

FIG. 5 is a perspective view of the positional relation of the two bifilar windings of the transducer of FIG. 1.

The transducer of FIG. 1 comprises two cylinders 10 and 11. The cylinders are coaxial with one telescoped within the other. Further, one cylinder is slideably mounted in low friction linear motion bearings so as to reciprocate axially with respect to the other. The particular axial guide means shown in FIG. 1 comprises a rigid shaft 13, rigidly affixed to the end plate of cylinder 10 and reciprocally mounted within the bearings 14 and 15 within tube 11A which is centrally disposed in the inner cylinder 11, and anchored at both ends to the end plates of cylinder 11. Bellows 12 are provided for sealing watertight the adjacent ends of the cylinders 10 and 11, yet permitting free relative reciprocation of the cylinders.

According to this invention spiral pole faces are provided on the interior surface of the outside cylinder 11 and on the exterior surface on the inside cylinder 10. The opposing surfaces of the two cylinders are of ferromagnetic material and are provided with ridges or

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"threads" the pitch of which is the same on the two cylinders so that the faces of the ridges may register throughout the length of the two cylinders. As shown in enlarged detail in FIG. 2 the cylinders 10 and 11 are so machined as to receive the ferromagnetic elements 20 and 30. Preferably the elements 20 and 30 are fabricated of laminations of good ferromagnetic material after the fashion of rotors, stators and transformer cores of alternating current machinery. If desired, the elements 20 and 30 of both cylinders may be fabricated from thin iron stampings produced from a single die. Each stamping comprises a comb-like strip. The combs are stacked in a circle about the cylinders 10 and 11 and are shrink-fitted, brazed, or otherwise fastened into the supporting cylinders. Taper rolled stampings may be used, or tapered wedges 20A and 30A can be inserted to establish the stampings in radial planes. An end view of the laminations or stampings are shown in FIG. 3. Conveniently, the laminations are slipped lengthwise slightly as they are stacked so as to provide the spiraling grooves mentioned above. Conductors 21 and 22 are then insulatingly disposed within the grooves of core 20. Conductors 31 and 32 are insulatingly disposed in the spiral grooves of cores 30. Insulating paper or thermosetting plastic may be employed for insulatingly supporting the windings in place. Low voltages only are contemplated.

It is an important feature of this invention that the grooves and the ridges and the conductors 21, 22 and 31, 32 within the grooves are bifilar in nature. That is, the lead of the spiral is equal to twice the pitch. By simply connecting the two conductors of the bifilar windings together at one end of the cylinder, current applied across the terminals at the other end will result in current flowing in opposite directions in adjacent grooves of the cylinder. This means that alternate ridges or pole faces are of opposite polarity. If the grooves or slots are rectangular in cross-section, as suggested in FIG. 2, it is preferable that the conductors be rectangular in cross-section so as to better fit the slots. Schematically, the circuits of the two telescopic windings may appear as in FIG. 4 while the rectangular conductors formed to fit the slots of FIG. 2 would appear as shown in perspective in FIG. 6. The two conductors of each winding are of relatively heavy copper, preferably, and may be joined at the bight by braced metal blocks 23 and 33. To the opposite ends of the bifilar windings are connected, respectively, a direct current source and an alternating current source. It is immaterial whether the outside winding be considered the stator or the armature winding.

In operation, the polarity of the pole faces of the armature reverses at the frequency of the applied frequency and the armature travels one-half the axial distance between pole faces in response to the alternate attractions and repulsions of the field pole faces. Since the pole faces of the two cylinders can be dressed on a lathe the clearance between the pole faces can be made very accurately and quite small. Now, since the length of the spiralled poles can be made long without limit the ultimate thrust of the armature within the field can be made very large. Opposite ends of cylinders 10 and 11 travel in opposite directions. It is immaterial which oscillating face is anchored.

Many modifications may be made in the constructional details of the transducer of this invention without departing from the spirit of the invention as defined in the appended claims.

What is claimed is:

1. A transducer comprising:

two coaxial cylinders, one telescoped in and reciprocally mounted within the other;

the opposing surfaces of the cylinders being of ferromagnetic material, and the opposing surfaces each

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being spirally grooved to define elongated narrow areas spiralled about said opposing surfaces, the grooves being doubled so that the axial lead is twice the groove pitch; and

bifilar windings in said grooves to oppositely magnetically polarize alternate spiralled cylindrical surfaces. 5

2. The transducer defined in claim 1 further comprising: means at one end of each cylinder in the bight of said bifilar windings for electrically joining the windings, and 10

terminals at the opposite ends of each winding for connection to a voltage source.

3. In the transducer defined in claim 1:

said ferromagnetic cylinders comprising elongated comb-shaped laminations disposed side-by-side in radial planes parallel to the axis of the cylinders, the notches of said comb-shaped lamination being brought into registry to define the spiralled grooves. 15

4. In the transducer defined in claim 3, wedges so spaced throughout the side-by-side laminations as to distort the laminations into the curvature of said cylinder.

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5. An electromagnetic transducer comprising: two telescoped cylinders, one being reciprocally mounted within the other;

a bifilar winding on each cylinder, the windings being of like pitch, and the conductors of each winding being connected together at one end so that current flows in opposite directions in adjacent turns; spiralled ridges of ferromagnetic material disposed between the windings to present spiralled pole faces on the exterior of the inside cylinder and on the interior of the outside cylinder.

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