

June 30, 1970

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3,518,463

LOW INERTIA HIGH THRUST VIBRATOR

Filed Aug. 26, 1969

2 Sheets-Sheet 1

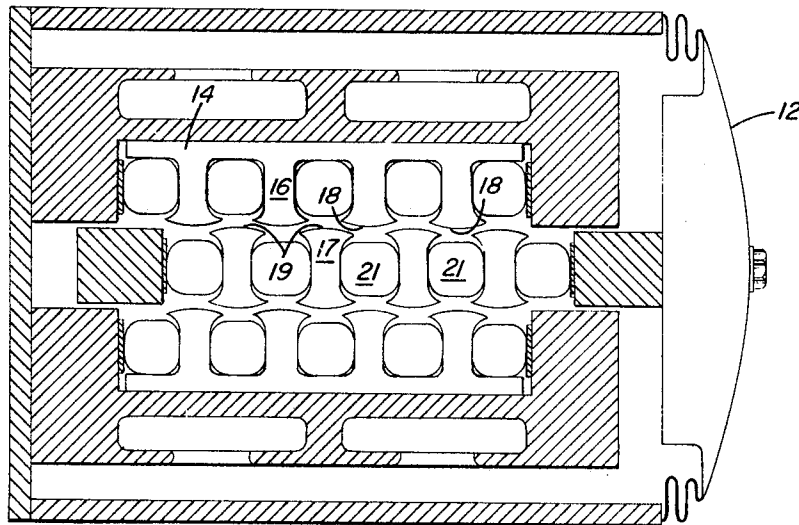


FIG. 1

(PRIOR ART)

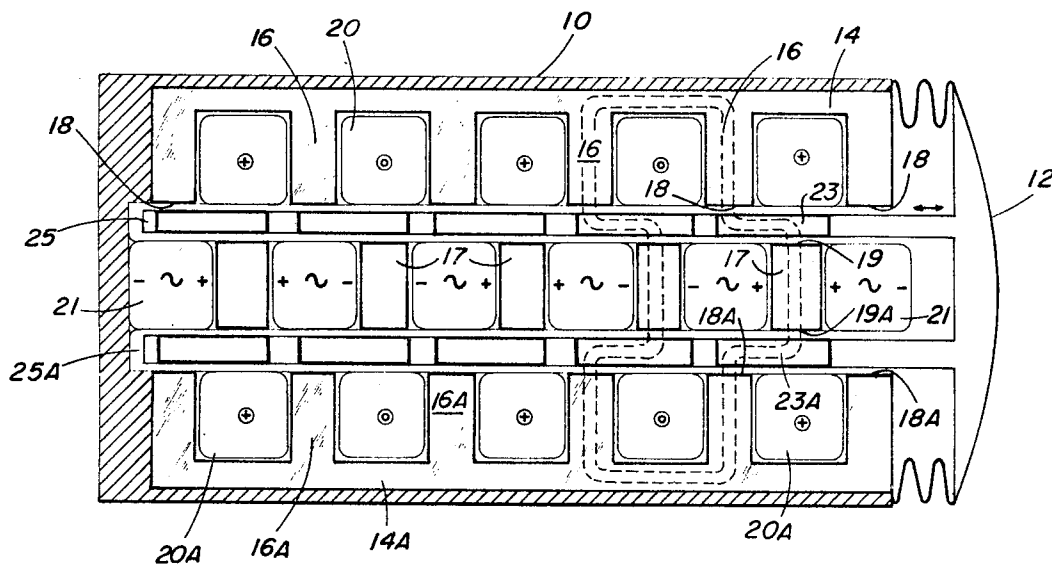


FIG. 2

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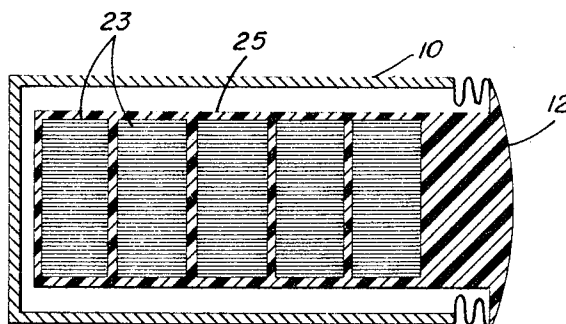


FIG. 3

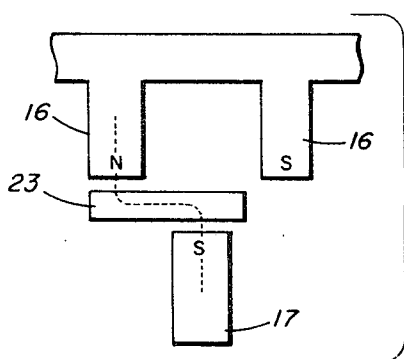


FIG. 4

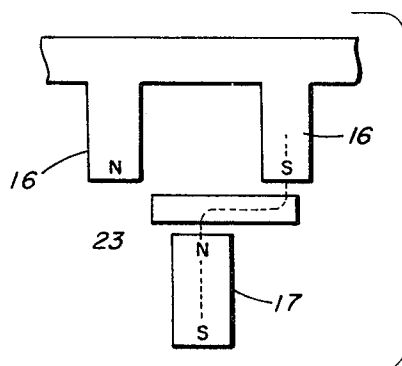


FIG. 5

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LOW INERTIA HIGH THRUST VIBRATOR

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4 Claims

ABSTRACT OF THE DISCLOSURE

A thin non-magnetic sheet is reciprocable between the coplanar pole faces of two flat stators. The pole faces of one stator is intermediate the pole faces of the other so that iron bars embedded in the sheet will reciprocate between two adjacent poles of the stator as an AC signal is applied. The result is a much reduced mass of reciprocating parts and increased natural frequency of oscillation without reducing the thrust of the vibrator.

STATEMENT OF GOVERNMENT INTEREST

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 OF THE INVENTION

Early electrodynamic vibrators with sufficient power to vibrate the piston of a submerged transducer employ an alternating current coil of wire suspended in a radial magnetic field. These structures require a large magnetic air gap and a correspondingly large permanent magnet or large direct current excitation field windings. Considerable improvement was accomplished by embedding transformer iron between the turns of the windings as disclosed in U.S. Pat. 3,126,520 or 3,353,040 and as shown schematically in cross section in FIG. 1. A disc at one or both ends of a tubular cylinder can be pushed outwardly against high hydrostatic pressure by the reciprocating motor shown. Two of the three magnetic cores of the field or stator structure are attached together and to the casing and the remaining core of the armature structure is attached to the piston. Heavy conductors are wound between the pole pieces and when energized by large low voltage field currents and by alternating signal current the piston reciprocate. The bellows functions as a spring which is adjusted statically to hold the AC poles at mid position between the DC poles. With an associated spring constant, K, and an armature mass M, the practical minimum resonant frequency, F, of the oscillating assembly is:

$$\frac{1}{2\pi} \sqrt{\frac{K}{M}}$$

The object of this invention is to lighten the armature of a vibrator and to increase the resonance frequency F of the vibrator.

SUMMARY OF THE INVENTION

The objects of this invention are attained by reducing the mass, M, of the movable armature in the above formula so as to increase the frequency F. The weight is reduced by replacing the rather massive core structure with a thin sheet of non-magnetic material in which are embedded flattened laminated iron bars.

The field or stationary portion of said vibrator comprises two core assemblies each with a plurality of uniformly spaced pole pieces, the faces of said pieces being aligned and in parallel spaced planes, the pole faces of one

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core assembly being intermediate the pole faces of the other core assembly. The thin sheet with embedded bars reciprocates in the narrow space between pole faces when alternating current magnetizes the cores.

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 as shown in the accompanying drawings in which:

FIG. 1 is a sectional view of a prior art vibrator;

FIG. 2 is a cross section of one vibrator according to this invention;

FIG. 3 is a planned view of the thin non-magnetic sheet employed as the reciprocable armature of the vibrator of FIG. 2; and

FIGS. 4 and 5 show the changing magnetic circuit of the stator and armature of the vibrator of FIG. 2.

As stated, the prior art transducer, shown in FIG. 1, comprises an armature plate built up of relatively heavy pole pieces 17 interleaved with the turns 21 of signal current windings. The spring constant of the bellows for the piston heads 12 is adjusted to normally hold the pole pieces of the armature plate midway between the pole pieces 16 of the field plate. As the signal current reverses, the direction of the magnetic pull on the armature reverses. The principal disadvantage of this structure is the considerable weight of the movable portions of the armature.

In the specific embodiment of this invention shown in FIG. 2, the mass of the reciprocating parts of the vibrator are materially reduced. The cylindrical cage 10 is closed at one end with the piston head 21 and a bellows as in the prior art. Two field magnet cores 14 and 14A are each provided with a plurality of pole pieces 16 and 16A and are each fixed to the cage 10. The pole faces 18 of one core are smoothed and are carefully aligned in a common plane as are the pole faces 18A of the pole pieces 16A of the other core. The windings 20 and 20A are wound in the slots between the pole pieces and if connected to a direct current source will keep the alternate pole faces similarly polarized magnetically. The windings 20A wound about the pole pieces 16A oppositely polarized pole faces 18A.

According to an important feature of this invention the magnetic and electric circuits of the signal circuits of the vibrator are added to the mass of the field structure where the direct current bias is provided. The housing 10 is fixedly joined to the central core structure comprising the windings 21 interspersed with the core pieces 17. The turns of the windings 21 are preferably connected to an alternating signal source. However, the connections of the windings 20 and 21 to direct current and alternating current may be reversed, or as desired, divided in any manner with the sources.

The end faces 19 of the pole pieces 17 are disposed intermediate the pole faces 18 of the outer cores 14. Likewise, the end faces 19A are intermediate faces 18A. As the alternating signal current reverses, the polarity of the faces of the core 17 reverses. If, say, the polarity of two adjacent pole faces 18 are positive and negative, or north and south, respectively, the near pole face of core 17 will alternately be attracted to one field piece and then the other. Stated differently, a strong magnetic field alternately is established between one end of core 17 and the two adjacent ends of core 16. Likewise, magnetic attraction is alternatively established between any one face 19A and the two adjacent faces 18A.

Now, the only movable portion of the assembly shown in FIG. 2 which will be called the armature, are the thin sheets 25 and 25A of non-magnetic material such as any one of the commercial plastics with the requisite strength

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and rigidity. Embedded in each sheet are spaced iron bars 23 and 23A. The number of bars correspond to the number of pole pieces 17. The bars 23 are sufficiently wide, left to right in FIG. 2, to substantially cover one pole face 19 of core 17 and one only of two adjacent pole faces 18 of the field magnet. This means that as the polarity of the field coil 17 reverses the movable bar 23 shifts from one fixed position over one pole face 18 to a position over the other pole face 18. That is, as the magnetic polarity of the pole face 17 reverses, the magnetic attraction of the pole face 19 will transfer at signal frequency from one pole face 18 to the other which means that the movable bars 23 of the armature will shift to alternately cover one pole face 18 of one polarity or the pole face of the other polarity, as shown in FIGS. 4 and 5, respectively. The right hand edges of the two sheets 25 may be cast integrally with or otherwise attached to the piston head 12. By attaching the two sheets 23 symmetrically to the piston head 12, the piston is reciprocated in a straight line. Conveniently, the sheets 25 and 25A may be spaced from the pole faces by thin shims or sheets of lubricating-type plastic such as Teflon.

According to another important feature of this invention the magnetic bars 23 and 23A are fabricated with iron laminations as suggested in FIG. 3 from stampings corresponding in size and shape to the cross section of the bars seen in FIG. 2. The stampings are adhesively joined and are embedded in the plastic sheet 25 preferably in a casting technique.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A low inertia vibrator comprising:
 - a first core assembly having at least two pole pieces, with coplanar pole faces,
 - a second core assembly with a pole piece having a pole face parallel too, spaced slightly from said coplanar pole faces and disposed intermediate the pole faces of said first assembly,
 - a thin sheet of non-magnetic material, reciprocable in the space between the pole faces of said first and second assembly and adapted for driving a reciprocable load,
 - an iron bar embedded in said sheet, said bar being flat and sufficiently wide in one dimension to overlay only one pole face of said first assembly and the pole face of said second assembly,
 - means for oppositely magnetically biasing said two pole faces, and
 - means coupled to an alternating signal current for reversing at signal frequency the magnetic polarity of said one pole face to alternately shift the position of the reciprocable thin armature.

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2. In the low inertia vibrator defined in claim 1, said first and second core assemblies each comprising an array of aligned, uniformly spaced magnetic pole pieces, the faces of the pole pieces of one array being coplanar and in closed spaces parallel relation with the coplanar faces of the other array,
- said thin sheet of nonmagnetic material being coextensive in size and shape with said pole faces and reciprocable between the pole faces, and
- a plurality of magnetic bars embedded in said sheet, said bars being rectangular, elongated, parallel and spaced apart distances comparable to the spacing of said pole pieces,
- said arrays being relatively offset, so that one set of pole faces are approximately opposite the spaces between the poles of the other array.
3. A low inertia vibrator comprising,
 - three interleaved plates with opposed surfaces secured in fixed parallel spaced relation,
 - the two outer plates each comprising a magnetic core with a plurality of spaced pole pieces having coplanar pole faces in said opposed surfaces,
 - the middle plate comprising a plurality of separate rectangular spaced pole pieces extending through the plate with the exposed faces disposed intermediate the pole faces in the opposed surfaces of the outer plates,
 - a reciprocable sheet of non-magnetic material between each pair of plates,
 - from bars embedded in each sheet opposite the pole faces in the middle plate,
 - means for changing the magnetic polarity of the pole faces of the middle-plate pole pieces to magnetically contact said bars to a position over the pole faces on either side of said middle-plate pole pieces.
4. In the vibrator defined in claim 3,
- direct current windings between the pole pieces of said outer plates, and
- alternating current windings between the pole pieces of said middle plate.

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U.S. Cl. X.R.

319—124; 340—8; 310—30