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Abbott

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[54] **VERY LOW FREQUENCY SONAR PROJECTOR**

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[73] Assignee: **The United States of America as represented by the Secretary of the Navy,** Washington, D.C.

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[21] Appl. No.: **335,640**

[52] **U.S. Cl.** ..... **340/8 R,** 114/235 B

[51] **Int. Cl.** **H04b 13/00**

[58] **Field of Search** ..... 340/7–14, 17; 114/235 R, 235 B; 9/8 R

[56] **References Cited**

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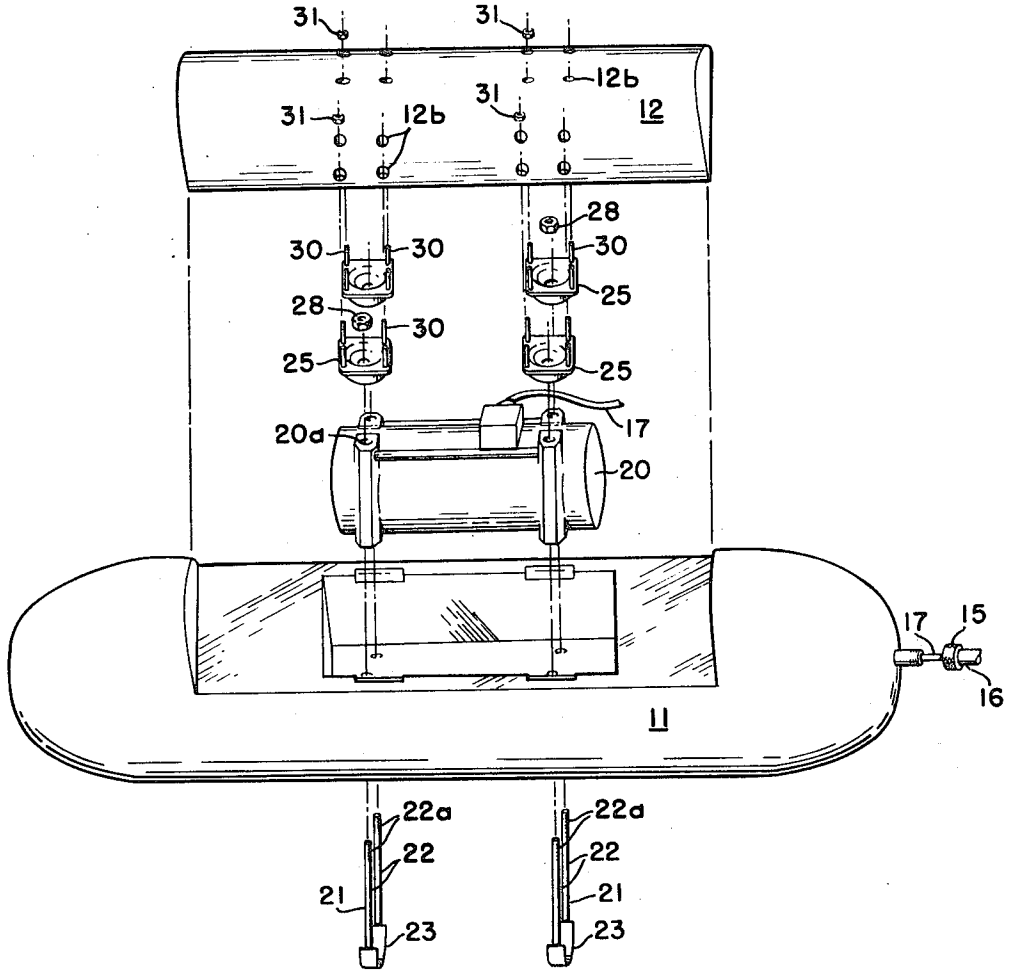
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Assistant Examiner—H. J. Tudor
Attorney, Agent, or Firm—Richard S. Sciascia; Ervin F. Johnston; Thomas Glenn Keough

[57] **ABSTRACT**

A low-cost projector of acoustic energy is fabricated from an elongate block of wood provided with a cavity. A cover, also made of wood, is fitted over the cavity and a motor-driven rotary electric vibrator is secured to the elongate block via a plurality of bolts. The wooden cover is coupled to the vibrator by several resilient vibration isolation mounts and the block and cover are encased in a resilient sleeve clamped at opposite ends. Thusly constructed and additionally provided with a coaxial duct through which the towing and power cables reach, a low-cost, high-energy projector of acoustic energy is provided which is capable of being operated at very low frequencies due to the selectivity of vibrator driving speeds and of the stiffness of the resilient vibration mounts.

5 Claims, 4 Drawing Figures



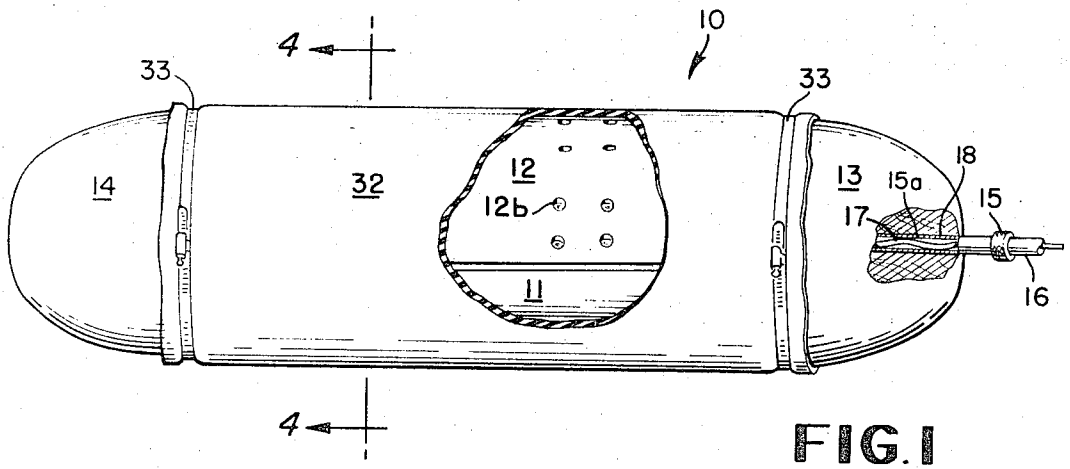

4
10
33
33
14
32
12
12b
11
13
15a
18
17
15
16
4

FIG. 1

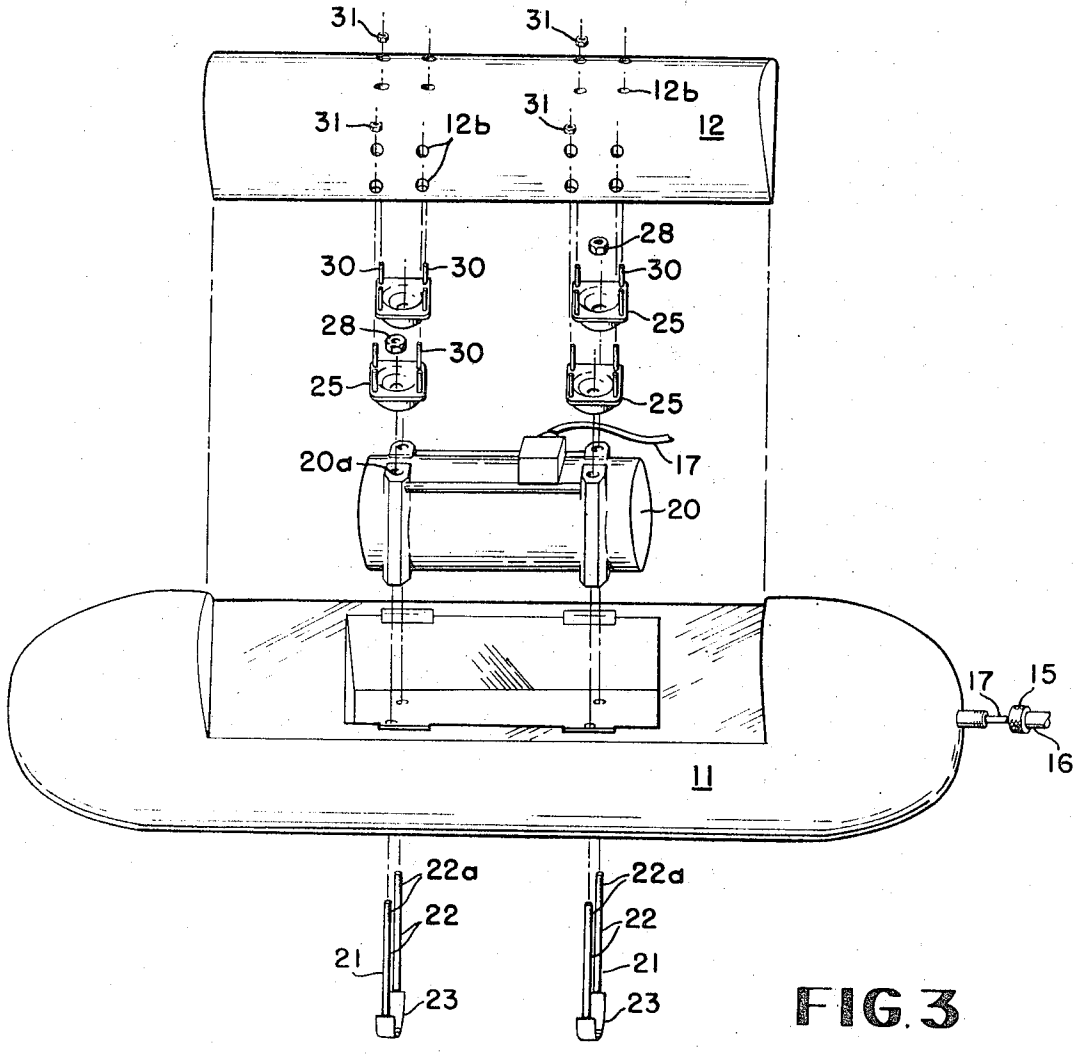

31
31
12b
31
31
12b
12
28
30
30
30
28
25
30
25
25
17
20a
20
17
15
16
11
22a
22
21
23
22a
22
21
23

FIG. 3

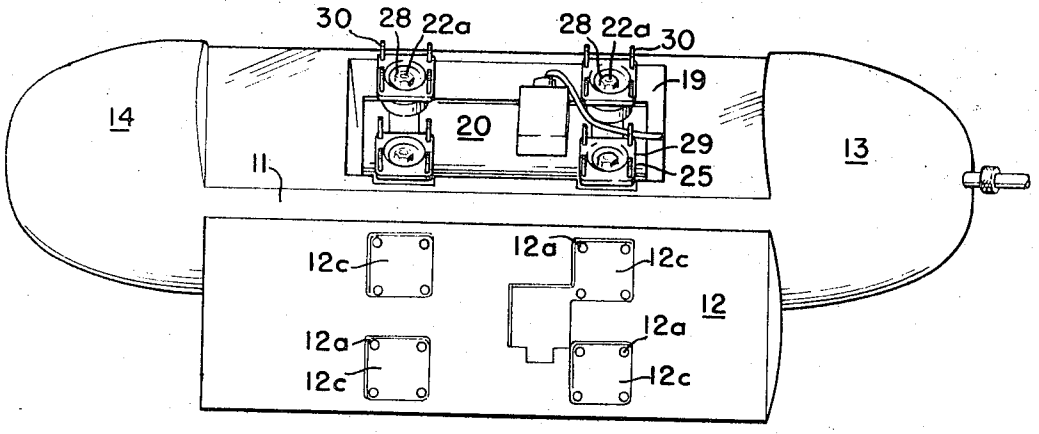

30
28
22a
28
22a
30
19
14
20
29
13
25
11
12c
12a
12c
12
12a
12a
12c
12c

FIG. 2

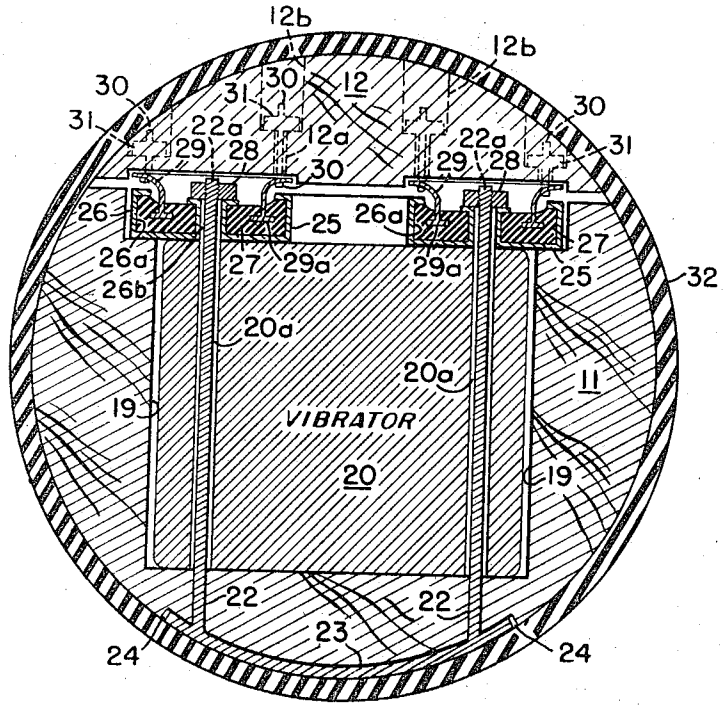

12b
12b
30
30
31
12
30
31
22a
12a
22a
29
28
29
28
30
26
25
26a
27
26a
27
29a
29a
25
32
26b
20a
20a
11
19
VIBRATOR
20
19
22
22
23
24
24

FIG. 4

VERY LOW FREQUENCY SONAR PROJECTOR

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

Transducers of acoustic energy are many and varied in design. Most of these conventional designs inherently suffer from either one or two limitations, namely, excessive cost per unit or the inability to operate at very low frequencies. Ferroelectric and magnetostrictive transducers have been built having configurations and mass-loadings to achieve a somewhat acceptable level of performance within the low-frequency range; however, most of these transducers are expensive. Furthermore, the ferroelectric designs, vulnerable to damage and, consequent costly safeguards further complicate the design. On the other hand, transducers relying on magnetostrictive energy converters usually are heavy. Providing adequate buoyancy compensation greatly increases the dimensions of the magnetostrictive transducers. If, in addition to low-cost per unit and a very low-frequency operation capability, we add the criteria of being an uncomplicated, highly reliable towable transducer, all contemporary transducers are lacking in one respect or another. There is a continuing need in the state of the art for the development of a transducer satisfying the aforeidentified design criteria.

SUMMARY OF THE INVENTION

The invention is directed to provide a transducer of acoustic energy including an elongate first member having its opposite ends shaped to reduce hydrodynamic interaction and a coaxial duct extending out from a cavity to one of the ends. A second member is sized to cover the cavity and shaped to further reduce the hydrodynamic interaction. A tensile load-bearing means is disposed in the coaxial duct and serves to pull the transducer through the water. A means for producing vibratory motion is disposed in the cavity and is rigidly connected to one member and resiliently coupled to the other member to ensure the protection of the acoustic energy via the first and second members.

It is a prime object of the invention to provide a low-cost acoustic transducer.

Another object of the invention is to provide a transducer capable of projecting acoustic energy in the very low-frequency range.

Still another object is to provide a transducer possessing a high degree of reliability due to its simplicity in design.

Yet another object is to provide a transducer which is hydrodynamically-shaped allowing its use in the towed mode.

Still another object is to provide a nearly neutral buoyant transducer of acoustic energy.

Another object of the invention is to provide a transducer which is air droppable, water immersible, and adaptable for nuclear and non-nuclear warfare.

These and other objects of the invention will become more readily apparent from the drawings when taken with the ensuing specification.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an isometric depiction of the invention shown partly in section.

FIG. **2** is an isometric depiction of the invention without the resilient sleeve and with the second member removed.

FIG. **3** is an exploded view of the invention.

FIG. **4** shows details of the invention generally taken along lines **4—4** in FIG. **1.**

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings the preferred form of a sonar projector **10** is shown suitably adapted for deployment under water to ensonify remote targets or to serve as an acoustic beacon, for example. The sonar projector includes, as principal components, an elongate, cigar-shaped first member **11** and a rectangularly-shaped second member **12.** These members have outer surfaces shaped to reduce the problems associated with towed transducers and which function to radiate acoustic energy in a manner to be elaborated on below. Exposed opposite ends **13** and **14** of the first member are tapered to reduce hydrodynamic inneraction as the sonar projector is towed through the water. A sealed connector fitting **15** is mounted on the forwardmost position of end **13** to serve as an anchor point for a combination power-and-towing cable **16** reaching to the towing vessel.

A preferred material from which the first and second members are fabricated is wood. Wood does not overly mass-load the transducer, resists the effects of external shock and and routine abuse, and because it is buoyant, it helps offset the weight of other components. In addition, choosing wood greatly lowers the cost of the transducer since as a raw material it is relatively inexpensive and it is easily machined to a desired configuration. However, because wood tends to deteriorate in water a suitable preservative such as paint is coated on all exposed surfaces.

A coaxial duct **18** is bored through exposed end **13** and driving power is fed to the sonar projector on leads **17** reaching from the power-and-towing cable. By noting FIG. **1** of the drawings an inner extension **15a** of sealed connector fitting **15** is suitably mounted in coaxial duct **18** to couple power-and-towing cable **16** to the sonar projector. At the inner end of the coaxial duct a cavity **19** is routed from the interior of the wooden first member **11** and the power leads are pulled through the duct to communicate with the cavity. The dimensions of the cavity are at least sufficient to accommodate an energy converter, such as a rotary electric vibrator **20.**

Vibrators of this type are commercially available under a wide variety of designs and configurations. A typical vibrator successfully employed in the present invention is a "Model SCR-1000 Rotary Electric Vibrator" marketed by Vibco, Incorporated of Lodi, N.J. This vibrator is capable of being operated from 0 to 2,500 vibrations per minute and, when functionally cooperating with other, components of the sonar projector discussed below, discrete tones are projected as a matter of choice.

Vibrator motion from vibrator **20** is coupled to the surfaces of first member **11** and second member **12** responsive very low frequency acoustic energy is pro-

jected due to the manner by which the vibrator is rigidly attached to one member and resiliently attached to the other. A pair of U-shaped elements **21**, each having a pair of leg portions **22** are joined to the vibrator by the legs passing through larger diametered parallel mounting bores **20***a*, disposed at the four corners of the vibrator. A curved portion **23** of each of the U-shaped elements interconnects a pair of leg portions by being welded or bolted onto a pair of the leg portions. Each of the curved portions are sized and shaped to fit within one of two circumferentially disposed recesses **24** formed on the outer surface of first member **11.** Distal ends **22***a* of each of the parallel legs are threaded to allow their being secured to a vibration isolation mount **25** which serves as a resilient coupling between vibrator **20** and rectangularly-shaped second member **12.**

Looking to FIG. **4** the vibration isolation mount has a metal outer member **26** having a generally W-shaped cross-sectional configuration. An annular recess **26***a* formed within the confines of the outer member is substantially filled with a compliant compound **27,** such as rubber, bonded onto the inner surface of the outer member. A hole **26***b* extending through the outer member has an inner diameter slightly larger than the outer diameter of parallel legs **22** to allow their free-passage through the vibration isolation mount.

After each of the legs has been inserted through a hole **26***b*, a nut **28** is tightened onto threaded ends **22***a* of each of the parallel legs. These the rotary electric vibrator **20** is gripped between nut **28,** outer member **26,** parallel legs **22** and curved portion **23** to rigidly engage the outer surface of elongate first member **11.**

Resilient mounting of rectangularly-shaped second member **12** is assured by the inclusion of an annular metal flange member **29** having a projection **29***a* bonded in compliant compound **27.** Thus, between rigid outer member **26** and rigid annular flange member **29,** the compliant compound is interposed to resiliently couple the outer member and the flange member together. Compliant coupling of vibration **20** to rectangularly-shaped second member **12** merely calls for inserting a plurality of threaded bolts **30** through holes spaced at the corners of the flange member and through appropriately spaced bores **12***a* in the rectangularly shaped second member. Next, nuts **31** are tightened on bolts **30** to secure annular flange member **29** to rectangularly shaped second member **12.** Here it is noted that larger holes **12***b* are provided in the second member to allow nuts **31** being threaded onto bolts **30** within the outer contours of the second member. A closer fitting between the rectangularly shaped second member and the elongate first member was owed to the shaping of square recesses **12***c*, see FIG. **2,** in the inner side of the rectangularly shaped second member. Holes **12***b* and recesses **12***c* cooperate with aforedescribed elements to streamline the transducer's profile.

A resilient sleeve **32** covers all but the exposed opposite ends **13** and **14** of elongate first member **11** and the entire length of rectangularly shaped second member **12.** Watertight integrity of the sonar projector is assured by the mounting of adjustable stainless steel bands **33** near the opposite extremes of the resilient sleeve and tightening them in-place.

The high reliability and low cost of the invention is largely owed to its simplicity of design. Since the vibrator **20** by containing numerous windings and counterweights is relatively heavy, the dimensions of cavity **19** are made larger to create additional buoyancy to retain a degree of neutral buoyancy.

A sonar projector constructed in accordance with the foregoing teachings is capable of being driven to project discrete low-frequency tones.

A vibrator **20** of the type identified above is adjusted to a desired speed range from 0 to 2,500 cycles per minute. Vibration isolation mounts **25** are selected or fabricated to possess a desired degree of stiffness to optimize the resonance of the sonar projector at the preselected frequencies. However, it has been discovered that the minimum usable frequency is established by the resonant frequency of the vibration mounts under the load of second member **12** and the water load reactance. The water load reactance is a mass roughly equal to the second member's surface area, times the radius of gyration of the surface of the second member, times the density of the water medium. Because the second member's surface area and the water's density are known and the radius of gyration can be computed. Therefore selection of the proper vibration isolation mounts **25** and tuning vibrator **20** is all that is necessary to produce a desired working frequency.

A rugged, low-frequency sonar projector has been disclosed herein. This projector may, of course, be constructed from a variety of materials other than those described above. The aforedescribed design, however, lends itself toward being neutrally buoyant and employed as a towed sonar projector having a reduced hydrodynamic interaction.

Obviously, many modifications and variations of the present invention are possible in the light of the above teachings, and, it is therefore understood that within the scope of the disclosed inventive concept, the invention may be practiced otherwise than specifically described.

What is claimed is:

1. A projector transducer of acoustic energy comprising:

means for providing a radiating surface for said acoustic energy including an elongate first member having a cavity therein, having its opposite ends shaped to reduce hydrodynamic interaction, and shaped with a coaxial duct extending from said cavity to one of the ends and a second member sized to cover said cavity and shaped to further reduce hydrodynamic interaction, said second member is adapted for independent opposite vibratory motion with respect to said first member;

a resilient sleeve enclosing a portion of the elongate first member and all of said second member;

means for bearing the tensile load created as said transducer is pulled through the water disposed in said coaxial duct;

a motor-driven rotary electric vibrator having two sets of parallel mounting bores disposed at opposite ends for producing vibratory motion disposed in said cavity, said first member and said second member are selected from materials and said cavity is dimensioned to render said transducer neutrally buoyant;

means for rigidly securing the motor-driven rotary electric vibrator to said first member; and

means for resiliently mounting the motor-driven rotary electric vibrator onto said second member to ensure the projection of said acoustic energy responsively to said vibratory motion.

2. A transducer according to claim 1 in which the bearing means is a sealed fitting carried in said coaxial duct coupled to a towing cable having the capability for feeding electric power to the vibratory motion means.

3. A transducer according to claim 2 in which the first member is cigar-shaped and is provided with a pair of circumferentially disposed recesses each having holes reaching into said cavity and aligned with said two sets of parallel mounting bores and the rigidly securing means is a center portion of a vibration isolation mount and a pair of U-shaped elements, the curved portions of which are formed to fit into the circumferentially disposed recesses and the legs of which are threaded and formed to extend through said holes into said cavity and through said mounting bores in the motor-driven rotary electric vibrator, upon being so extended and disposed a separate securing nut is threaded onto each leg and brought to bear on each said rigid center portion to rigidly secure said motor-driven rotary electric vibrator to said first member.

4. A transducer according to claim 3 in which the resiliently securing means is an annular resilient portion and a rigid outer portion of said vibration isolation mount, said annular resilient portion is bonded between said rigid center portion and said rigid outer portion and a plurality of mounting bolts interconnect the rigid outer portion to the rectangular second member thereby resiliently coupling said motor-driven rotary electric vibrator to the rectangular second member.

5. A transducer according to claim 4 in which there are four vibration isolation mounts each coupled as aforedescribed to rigidly and resiliently couple the motor-driven rotary electric vibrator to the first member and second member, respectively.

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