Jan. 25, 1966 F. M. FREIS 3,231,853

SUBAQUEOUS AUDIO-SOUND TRANSMITTER

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FIG. 1

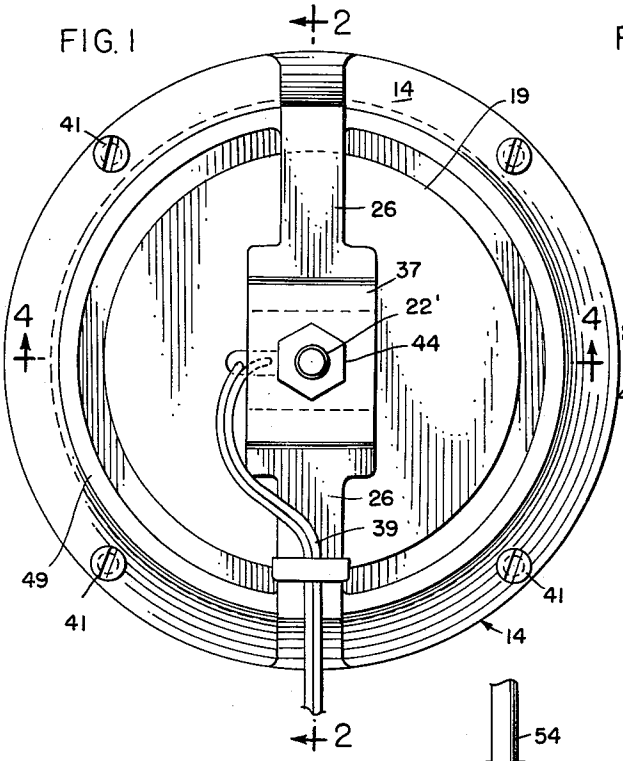


FIG. 2

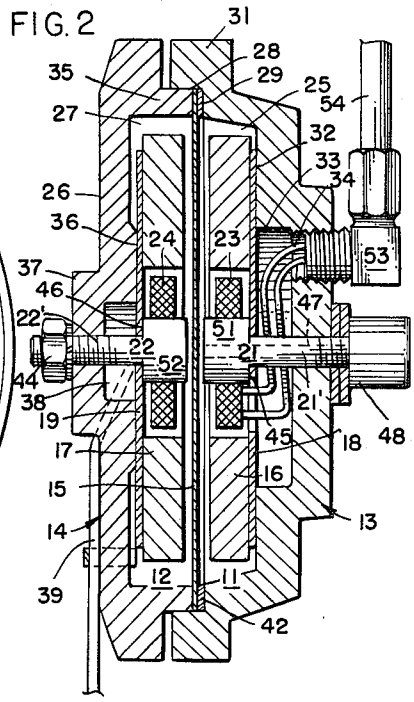
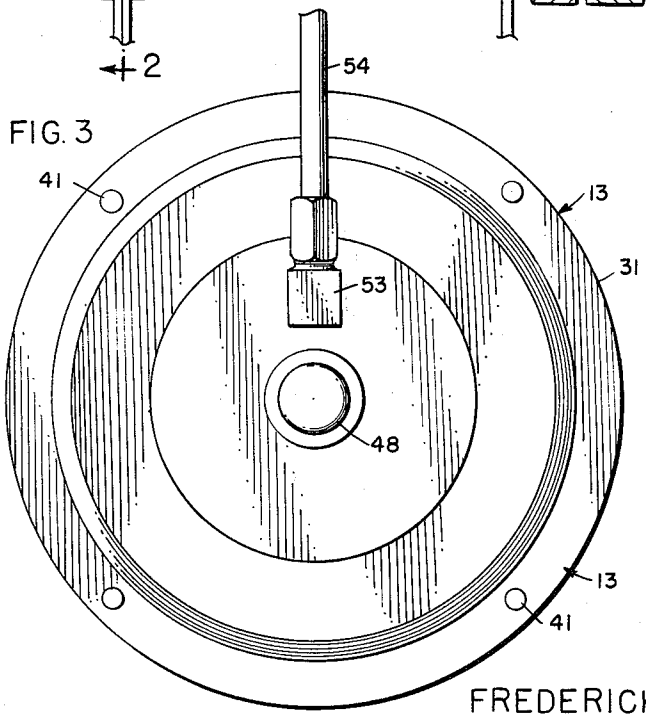


FIG. 3



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FIG. 4

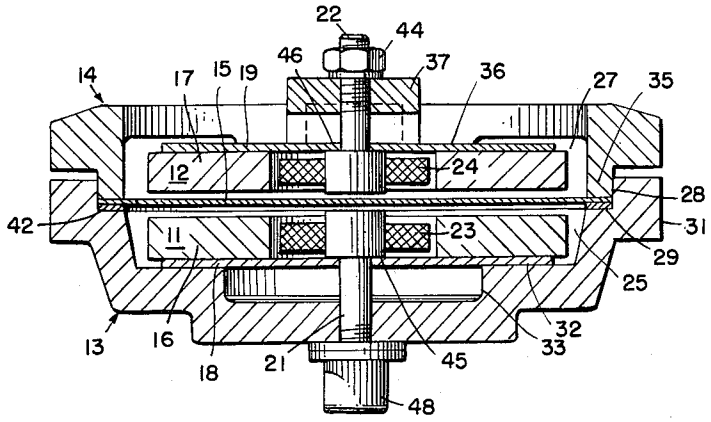


FIG. 5

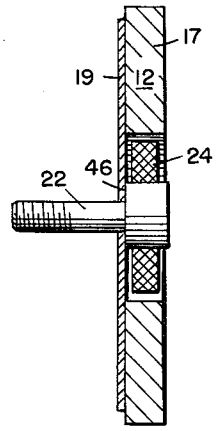
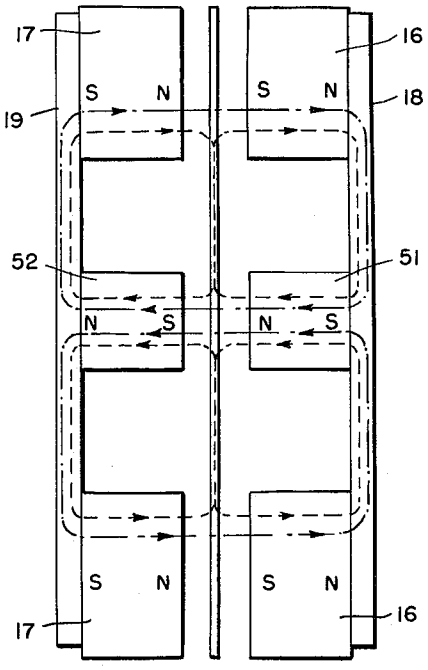


FIG. 6



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SUBAQUEOUS AUDIO-SOUND TRANSMITTER

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5 Claims. (Cl. 340—8)

This invention relates to the structuring of subaqueous, audio-sound transmitters.

The main objects of this invention are: to provide an improved structuring of audio-sound transmitters for subaqueous use; to provide an improved form and arrangement of identically-structured permanent magnet assemblies juxtaposed in axial opposition to a diaphragm within an improved-form two-piece housing assembly; to provide a specially suited material and formed arrangement of the diaphragm between the opposed permanent magnet assemblies; and to provide an improved subaqueous audio-sound transmitter of this kind of such simple construction as to make its manufacture and marketing very inexpensive and its use highly effective in varying depths of water.

In the adaptation shown in the accompanying drawings:

FIG. 1 is a water-side face view of an audio-sound transmitter constructed in accordance with this invention;

FIG. 2 is a sectional view of the same taken on the plane of the line 2—2 of FIG. 1;

FIG. 3 is an opposite face view of the transmitter shown in FIGS. 1 and 2;

FIG. 4 is another sectional view of the transmitter, constructed in accordance with this invention, taken on the plane of the line 4—4 of FIG. 1;

FIG. 5 is a detail, sectional view of the permanent magnet assemblies, forming a part of this invention; and

FIG. 6 is a diagrammatic view of the dominating magnetic lines of flux indicative of the functioning of this transmitter.

The essential concept of this invention involves a pair of similarly-structured, voice-coil-activated magnet assemblies each concentrically secured in one of two recessed housing elements opposedly interconnected with the magnet assemblies axially juxtaposed to the opposite faces of a diaphragm secured in place by the interconnected housing elements and forming an air-tight chamber embracing one magnet assembly and a water-open chamber embracing the other magnet assembly.

A subaqueous audio-sound transmitter embodying the foregoing concept comprises a pair of practically identically-structured permanent magnet assemblies **11** and **12** mounted in closely opposed relationship on and within a pair of differently-structured, interconnected housing elements **13** and **14**, respectively, with an interposed diaphragm **15**.

The magnet assemblies **11** and **12** comprise, respectively, a magnet ring **16** and **17**, on one side of which is adhered the respective ferrous disks **18** and **19** supported on center stud shafts **21** and **22** and embracing voice coils **23** and **24**, respectively.

Each ring magnet is of the permanent type and made from materials which retain a high residual inductance and is magnetized through its thickness, i.e. axially. Hence, one face presents the N-pole and the other face

presents the S-pole. The disks **18** and **19** are formed of steel or other highly magnetic conducting materials. The disks are of somewhat smaller size than the external diameter as the rings **16** and **17** to prevent magnetic shunting over its outer edges; and are bonded in direct and firm contact with one face of the respective rings **16** and **17**. Such bonding may be by a suitable adhesive or by non-magnetic fasteners, such as screws or rivets. The stud shafts **21** and **22** also are formed of steel or other highly magnetic conducting materials. These stud shafts **21** and **22** have reduced diameter-threaded shanks **26** and **27**. As will be explained presently, these stud shafts are secured concentrically of and in firm contact with the respective disks **18** and **19**.

The housing elements **13** and **14**, formed of non-magnetic materials (aluminum, bronze, stainless steel, or plastics) are differently structured to fit face-to-face to enclose the two juxtaposed magnet assemblies **11** and **12** with the interposed diaphragm **15**. The element **13** is a machine-recessed disk, the details of which will be explained presently. This disk element **13** when assembled with the element **14** provides an air-tight chamber **25** around the magnet assembly **11** and at one side of the diaphragm **15**. The element **14** is a machined ring with a diametrical bridge **26**, the details of which will be explained presently. It provides an open chamber **27** around the magnet assembly **12** and the other side of the diaphragm **15**.

The housing element **13** is dish-like in cross-section and circumferentially recessed, inwardly of its outer perimeter, to form an axially-disposed machined-surface **28** and a right angle, radially-disposed machined-surface **29** directly inward of an annular rim **31**. Further inwardly the element **13** is recessed to produce an offset radially-disposed machined-surface **32**. Still further inwardly on this element **13** is a smaller-diameter recess **33** which forms a pocket for the lead wires **34** from the voice coil **22**, as will be explained presently.

The ring-like housing element **14** is circumferentially recessed directly inward of its perimeter to form an axially-disposed annular rim **35** adapted to telescope into the recess formed by the right-angle surfaces **28** and **29**. Inwardly of this rim **35** the element **14** is further recessed to provide a radially-disposed, machined surface **36**. The bridge **26** on this element **14** mounts a concentric hub **37** which is recessed at **38** to form a pocket for the lead wires **39** from the voice coil **24**.

In this complete assembly these thusly-structured housing elements **13** and **14** are set in opposed relationship as shown in FIG. 2 and secured together by a series of screw fasteners **41** (FIG. 1). The diaphragm **15** is clamped between the machined surface **29** and to that of the rim **35** with a neoprene gasket **42** (FIG. 2) interposed between the diaphragm **15** and the machined surface **29**.

The thin diaphragm **15** is formed of steel or other ferric alloys which have a relative high magnetic resistance to the flux. It is advantageous to minimize the strength of the magnetic flux in radial direction through the thickness of the diaphragm, in order to prevent magnetic short circuit of the juxtaposed magnet assemblies.

However, the magnetic lines of flux, perpendicular to the thickness of the diaphragm do not find high magnetic resistance, due to the thin section of the diaphragm. The

magnetic field in perpendicular direction to the plane of the diaphragm becomes intense. This is the same direction the diaphragm moves in excursions caused by voice-coil attenuation.

Therefore it is possible to make the flat and rigid diaphragm responsive to voice coil attenuations with relative small electric energy.

A flat and rigid diaphragm represents a wall in contact with the water. Sound vibrations of the diaphragm act like undamped shock-waves capable of propagating enormous distances in water.

The stud shafts **21** and **22** are formed of steel or some suitable ferric-powdered composition. The heads **51** and **52** on these stud shafts **21** and **22** mount the respective voice coils **23** and **24**, with the shank parts **21'** and **22'** inserted through the aligned axial bores in the respective housing elements **13** and **14**. Nut **44** and cap **48** with an interposed lock washer inwardly of the nut **44** and a water-tight gasket inwardly of the cap **48**, are threaded onto the respective stud shanks **21'** and **22'** and turned up against the exterior faces of the housing elements **13** and **14** to draw the shoulders **45** and **46**, of the stud-shaft heads **51** and **52**, up against the disks **18** and **19** and thereby secure the disks in fluid-tight contact with the machined surfaces **32** and **36** of the respective housing elements **13** and **14**. The heads **51** and **52** of the stud shafts **21** and **22** are of an axial length such that in their fixed positions on the housing elements **13** and **14** the gaps between the heads **51** and **52** and the diaphragm **15** are approximately .040".

The stud shaft **21** has a central bore **47** extending throughout its length to provide communication with the chamber **25** established by the diaphragm **15** interposed between the assembled housing elements **13** and **14**. The outer end of the shank **21'** is fitted with an air-sealing cap **48**. Such a cap is in place when the transmitter is to be used in shallow water depths around 30 feet. When the transmitter is to be used in deeper water, the cap **48** is replaced by a pressure-compensating air-bag (not shown).

The transmitter being thusly completely assembled, the chamber **25** is sealed off from the ambient water when the transmitter is in use. It is imperative that no water whatever be allowed to enter the trapped air in this chamber **25**. Trapped air is necessary to furnish the acoustical impedance for the diaphragm. Since the acoustical impedance between water and air is 3000:1 such a small amount of trapped air in the chamber **25** is ample for the effective functioning of such a structured transmitter as herein shown and described.

The chamber **27**, in the ring-shaped housing element **14**, is open to the ambient water, when the transmitter is in use, through the opening **49** (FIG. 1) defined by the inner wall of the element **14**.

As shown in FIG. 2 the leads from the voice coil **23** extend out from the housing element **13** through a coupling **53**, screwed into the housing element **13**, and into a conduit **54** leading from the coupling to the power-pack, not shown, the location of which is usually carried on the diver's suit or belt. The leads **39** from the voice coil **24** are also connected with a cable to the water type power-pack and miter connected with conduit **54** so that both voice coils may be connected in series or parallel, as desired.

A very important factor of the above-described form and arrangement of the magnet assemblies **11** and **12** in the housing elements **13** and **14** has to do with the polarity created by the opposed rings **16** and **17** and the stud-shaft heads **51** and **52**, as shown by the magnetic lines of FIG. 6. As indicated in this FIG. 6, the N-pole face of the ring **16** is in contact with the disk **18** whereas the S-pole face of the ring **17** is in contact with the disk **19**. Thus, the S-pole of the ring **16** is opposed to the N-pole of the ring **17**. The opposite obtains with the heads **51** and **52**. The S-pole of the head **51** is in contact with the disk **18** and the N-pole of the head **52** is in contact with the disk **19**. Thus the N-pole of the head **51** is opposed

to the S-pole of the head **52**. Consequently, an ideal magnetic configuration exists to drive the diaphragm **15**. That configuration is diagrammed by the dotted arrow lines of the flux path in FIG. 6, however they have a long path radially through the thickness of the diaphragm. Also as shown in FIG. 6 by the dash-dot lines these represent the shorter axial flux path. Both flux paths contribute to a large percentage the function of this device. The important and desirable result is that the magnetic lines of force, at any point of the magnetic fields, are traversing the diaphragm **15** perpendicular to the plane thereof. This is the same direction as the flexing of the diaphragm **15** will take, caused by signal attenuation of the magnetic fields.

The voice coils **23** and **24**, being inserted over the stud shaft **51** and **52**, respectively, may be connected in series or parallel, and the signal arrives in both heads **51** and **52** simultaneously. The voice coils **23** and **24** are connected in such a way that if one coil strengthens and adds to its magnetic field the other coil will diminish or subtract from the magnetic field. This allows for one direction flexing of the diaphragm **15**. A reverse signal will cause an opposite flexing of the diaphragm **15**. Such a structured subaqueous audio-sound transmitter opens up a new field of use. It is capable of pocket size production for underwater communication between divers. For close range operation in turbulent water of any depth, an energy input of 3 watts is sufficient. In shallow quiet water communication can be effective for hundreds of feet. However, with an increase in power to 30 watts communication can be effected at greater distances without the likelihood of damage to the instrument, provided matching voice coils are used. The water facing voice coil is cooled by direct contact with the water. The inner voice coil is cooled by a lesser degree, by heat transfer to its center stud, with its outer end exposed to water.

It will be understood that details of the construction shown may be altered or omitted without departing from the spirit of the invention as defined by the following claims.

I claim:

1. A subaqueous audio-sound transmitter comprising, a pair of recessed housing elements secured in axially-opposed relationship, a diaphragm interposed between the housing elements and forming chambers between the diaphragm and the inner recessed faces of the respective housing elements, one of which chambers is fluid-sealed, a pair of stud shafts fixed on the respective housing elements with the inner ends of the shafts concentrically juxtaposed on opposite sides of the diaphragm, a pair of permanent axially-magnetized annuli bonded to a respective pair of disks and anchored against the inner recessed faces of the respective housing elements, a pair of voice coils embracing the inner ends of the respective stud-shafts within the respective annuli, and cables extending outwardly of the respective housing elements for connection of the voice coils to a power pack.

2. A subaqueous audio-sound transmitter as set forth in claim **1** wherein the inner ends of the respective stud-shafts have heads whereon the respective voice coils are mounted and whereby the disks are anchored in the respective housing elements.

3. A subaqueous audio-sound transmitter as set forth in claim **1** wherein the housing element other than the one having the fluid-sealed chamber is in the form of a ring with an exterior integrated bridge whereon is supported the respective stud shafts.

4. A subaqueous audio-sound transmitter as set forth in claim **3** wherein the opposed portions of the housing elements are internally machined to form telescopically-interfitting annular rims with the portions inwardly of the respective rims machined to provide flat surfaces against which the respective disks are anchored by the respective stud shafts.

5. A subaqueous audio-sound transmitter comprising,

(a) a pair of housing elements the opposed faces of which are internally machined to provide telescopically-interfitting rims with the portions inwardly of the respective rims machined to provide radially-disposed annular flat surfaces and axially-inward radially-disposed flat circular surfaces,

(b) a diaphragm interposed between the flat annular surfaces and forming chambers on opposite sides of the diaphragm and the opposed faces of the respective housing elements,

(c) a pair of stud shafts fixed on the respective housing elements with the inner ends having integrated heads concentrically juxtaposed on opposite sides of the diaphragm,

(d) a pair of permanent axially-magnetized annuli bonded to a respective pair of disks and anchored to the respective radially-disposed flat circular surfaces of the respective housing elements by the engagement of the stud-shaft heads with the disks,

(e) a pair of coils embracing the heads of the respective stud shafts within the respective annuli, and

(f) cables extending outwardly of the respective housing elements for connection of the coils to a power pack.

No references cited.

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