Oct. 24, 1967 M. M. HANFF 3,349,366

ELECTRO-ACOUSTIC SUBMARINE TRANSDUCER

Filed Nov. 30, 1965

Fig.1.

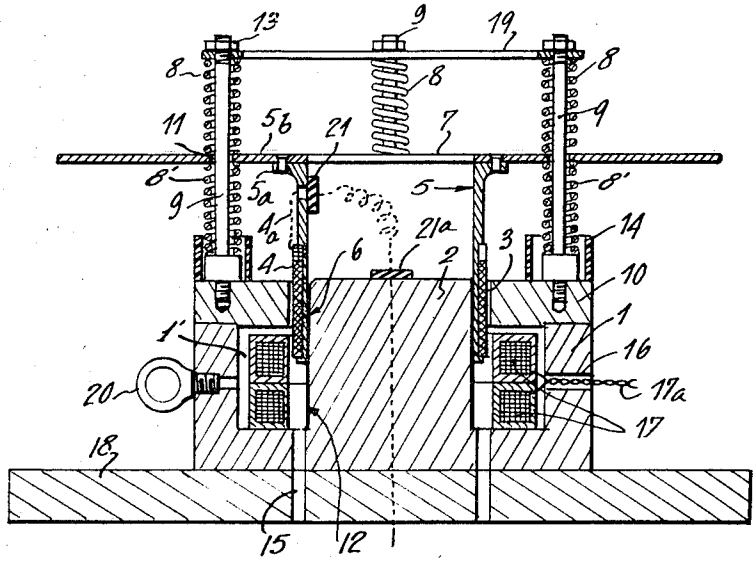


Fig.2.

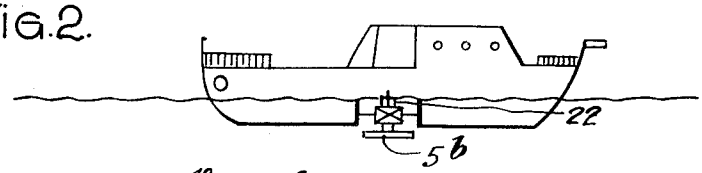
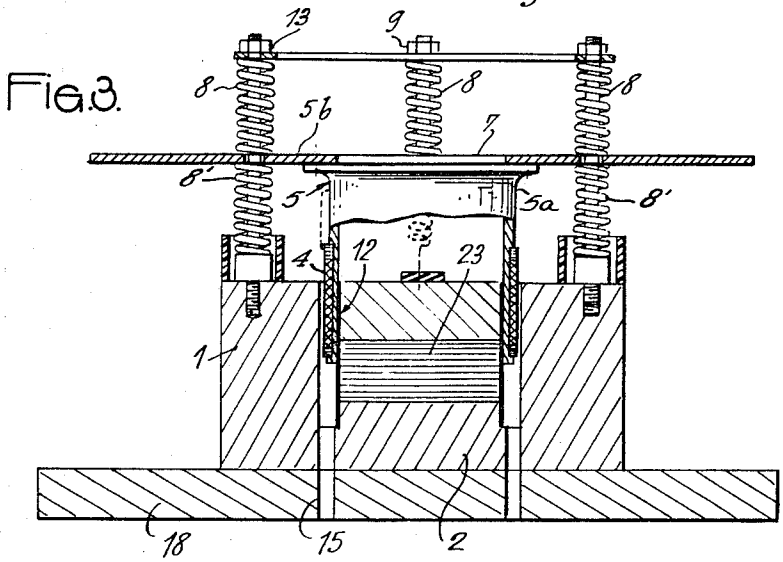


Fig.3.



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ELECTRO-ACOUSTIC SUBMARINE TRANSDUCER

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9 Claims. (Cl. 340—8)

The present invention relates to electro-acoustic submarine transducers intended to be immersed in the sea for transmitting sound waves with especially very low frequencies ranging from a few cycles per second.

In numerous submarine applications, such as communication, detection, prospection, acoustical dredging, etc. there is necessary to realize rather powerful transmission of sound waves under sea.

The known devices for electro-acoustical conversion generally are not suitable to operate under water as they have various disadvantages. Owing to the energy required for starting up vibrations in the diaphragm of the transducer located in the liquid medium, very large currents are also required. Windings thus are difficult to cool. Moreover at low frequencies such devices transmit like pulsating spheres, with no directive power contrarily to what is required in some applications. In the last place they are designed to be heavy and expensive.

The invention relates to an electro-acoustical transducer by which such disadvantages are substantially reduced.

The transducer according to the invention being of the electro-dynamical type, including a free-flooding magnetic yoke with a central core having an annular airgap in which a radial magnetic field drives an axially movable coil disposed on a horn, is particularly characterized by the following features:

(a) The yoke is drilled with holes providing circulation of the water in which the transducer is immersed so as to allow direct and efficient cooling of coils.

(b) The coil is placed around a cylindrical part of the horn which slides with along the core by an easy fitting.

(c) The horn also includes a suitable plate, generally perpendicular to the axis of the transducer, connected to the yoke by adjustable resilient guiding means.

A magnetic field in the airgap may be produced by a permanent magnet located, for instances, in place in the core, or by a winding carrying direct current, surrounding the core, also cooled by direct contact with water.

Other characteristics of the invention will be revealed by the following description together with the attached drawings showing, by way of non-restrictive examples, two forms of embodiment of the transducer according to the invention as seen by means of axial sectional views.

FIG. 1 is a cross-sectional elevation of one embodiment of the transducer according to the invention.

FIG. 2 is a diagram of a ship carrying the transducer of FIG. 1.

FIG. 3 is a cross-section elevation similar to FIG. 1, showing another form of embodiment.

In FIG. 1, **1** designates the magnetic yoke being in the form of a cylindrical pot and **2** the central cylindrical core which together with an annular magnetic plate **10**, fitted on the yoke, establishes an annular airgap **3** therebetween. The magnetic yoke **1** is "free-flooding" in the sense that it lies in direct contact with the water in which it is immersed.

4 designates a movable coil, mounted on a tubular sheath made integrally with the horn **5**, which is made of two parts *5a*, *5b*, for instance, from a light metal secured to each other by any suitable fixing means. Part

5a with a cylindrical shape is made at its lower end into a wide flange **6** in which coil **4** is mounted; part *5b* is a flat circular plate in the center of which there is provided a circular hole **7** having a diameter of essentially the same size as that of core **2**.

Coil **4** is fed with current by way of leads *4a* which are supported in hermetically sealed insulating plugs **21** and *21a* respectively fitted in part *5a* and the core **2** into which leads *4a* are advantageously passed.

The assembly of movable elements **4–5** is yieldingly connected to yoke **1** by means of, for instance, four upper compression springs **8**, and four lower compression springs **8'**. The upper and lower helical springs **8**, **8'** are in axial alignment and are spaced uniformly apart, i.e. at 90°, around the cylindrical yoke **1**. The springs are carried on rods **9** having lower threaded end portions which are screwed into threaded holes in the annular plate **10**, and the upper ends of the rods **9** are likewise threaded and receive a stabilizing ring **19** to maintain the rods **9** parallel to each other. Nuts **13** screwed onto the upper ends of the rods **9** against ring **19** serve to hold the ring in place and also to adjust the springs **8**, **8'**. The annular plate part *5b* of the horn is provided with four apertures **11** to enable this part to be supported on rods **9** between the upper and lower sets of springs **8**, **8'**, so as to guide the movable assembly **4–5**. Further guiding around core **2** is ensured in providing an easy fitting between the lower portion **6** of part *5a* and a sheath **12** applied to the periphery of core **2** and which is made of some material like superpolyamid that is, for example, known under the name of nylon or Rilsan. Compression springs **8**, **8'** when adjusted by means of nuts **13** serve to set coil **4** in a suitably high position within airgap **3**. Flexible stops **14** limit movement of the transducer horn element **5**.

Holes **15** are provided in yoke **1** so that when coil **4** is supplied with an alternating current thus causing assembly **4–5** to reciprocate it induces water to be circulated around coils **4** and **17** which thus provides efficient cooling thereof. Further holes such as **16**, are provided as lateral passages for leads *17a* feeding excitation coils **17**. Coils **17** located within an annular recess **1'** in the yoke **1** and communicating with the annular gap **3** are fed with direct current so that a continuous biasing magnetic field is produced in airgap **3**. Coil **4** on the contrary is fed with alternating current for the production of an alternating field causing horn **5** and coil **4** thereon to be reciprocated in an axial direction at a frequency which is the same as that of said alternating current. A hoist ring **20** is screwed into the periphery of the yoke **1** in order to enable the transducer to be raised and lowered.

A stabilizer **18** consisting for instance of a wood plate with large diameter is advantageously attached to the transducer the plate **18** being held against and fixed to the bottom of yoke **1** by any suitable means. When coils **4** and **17** are energized the reciprocating flat plate *5b* of the horn stirs up water, but contrarily to what occurs in known devices, does not compress it. It thus functions as a transducer which behaves like an acoustic dipole allowing transmission of sound waves produced therefrom to be directed to some extent. Due to its structure the improved transducer does not require pressure compensation; on this account, it can be immersed at considerably variable depths.

The frequency range of this type of transducer starts from below 5 Hz., whereas the resonant frequency thereof is at about 150 Hz., without being highly expressive. Since, owing to these frequencies being very low, baffles should be of very considerable dimensions (several tens of metres), there is provision for the transducer according to the invention to be mounted on the ship's hull the latter thus being substituted for a baffle. This can be seen

in FIG. 2 where a recess 22 is provided in ship's hull for the transducer to be partly attached thereto.

FIG. 3 shows a further embodiment of the invention wherein the electrically energized biasing coils 17 of FIG. 1 are replaced by a permanent magnet 23 which is shown as being a radially biasing magnet inserted in the cylindrical core 2 and being of the same diameter as the core. Operation of such as modified transducer is obviously similar to that of FIG. 1.

What I claim is:

1. In an electro-acoustic transducer structure for submarine use in the transmission of sound waves through the water, the combination comprising a free-flooding annular yoke member of magnetic material in direct contact with the water when said transducer structure is immersed therein, a core of magnetic material located concentrically within said annular yoke member and spaced radially therefrom to establish an annular gap therebetween, means for producing a continuous biasing field in a magnetic circuit through said yoke and core, a horn comprising a plate-like member and a downwardly extending tubular portion projecting into said annular gap, resilient means carried by said yoke member and supporting said horn for permitting a reciprocating motion thereof, a driver coil applied to said tubular portion of said horn within said gap and adapted to be energized with alternating current thereby to effect reciprocation of said horn, and cooling means comprising a passageway extending through said yoke from the exterior thereof to said annular gap to provide for free circulation of the water in which said transducer structure is immersed into said annular gap thereby to remove heat from said driver coil.

2. A submarine electro-acoustic transducer structure as defined in claim 1 and which further includes a thin sheath of material such as a superpolyamid applied to the periphery of said core to establish an easy sliding fit with said tubular portion of said horn.

3. A submarine electro-acoustic transducer structure as defined in claim 1 wherein said plate-like member of said horn is supported by said resilient means and includes a central opening therein of a diameter corresponding to that of said tubular portion and communicating with the interior thereof to facilitate reciprocation of said horn.

4. A submarine electro-acoustic structure as defined in claim 1 wherein said resilent means supporting said horn for reciprocatory movement is comprised of a plurality of circumferentially spaced rods secured at one end thereof to said yoke and extending axially of the yoke, said plate-like member of said horn being provided with spaced apertures to establish pass-through points for said rods, a first set of compression springs located on said rods between said yoke and one side of said plate-like member, a second set of springs located on said rods between the opposite side of said plate-like member and the opposite ends of said rods, a centering ring for said rods having apertures therein establishing pass-through points for said opposite ends of said rods to engage the corresponding ends of said springs of said second set, and means for applying an adjustable pressure to said centering ring and thence to said springs to effect a corresponding adjustment in the position of said horn member relative to said yoke and core.

5. A submarine electro-acoustic transducer structure as defined in claim 4 and which further includes flexible stop means surrounding respectively the springs of said first set and which serve to limit movement of said plate-like member of said horn in the direction of said yoke.

6. A submarine electro-acoustic transducer structure as defined in claim 1 and which further includes a flat mounting plate of non-magnetic material of larger area than said yoke, said mounting plate being secured to said yoke at the side opposite said annular gap and including passageways therethrough in alignment with said passageway means extending through said yoke and which provide for circulation of water into said annular gap.

7. A submarine electro-acoustic transducer structure as defined in claim 1 wherein said yoke is provided with an annular recess and wherein said means for producing said continuous biasing field is constituted by coil means located in said annular recess and adapted to be energized with direct current, said annular recess being in communication with said annular gap thereby to also establish therein a circulation of water for cooling said coil means.

8. A submarine electro-acoustic transducer structure as defined in claim 1 wherein said means for producing said continuous biasing field is constituted by a permanent magnet inserted in said core.

9. A submarine electro-acoustic transducer structure as defined in claim 1 and which further includes baffle means constituted by the hull of a ship to which said transducer structure is secured.

References Cited

UNITED STATES PATENTS

1,808,149	6/1931	Smith.	
2,432,218	12/1947	Vang.	
2,510,815	6/1950	Granche.	
2,977,573	3/1961	Mott	340—14

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