

ELECTROACOUSTIC TRANSDUCER ARRANGEMENT FOR UNDERWATER
ANTENNAS

The invention relates to an electroacoustic transducer
5 arrangement for underwater antennas of the generic type
defined in the precharacterizing clause of claim 1.

In one known electroacoustic transducer arrangement
(EP 0 654 953 B1), the reflector is a spring mass
10 system comprising a mass, which is formed by the metal
plate, and a spring, which is formed by the foam panel
and carries sound poorly. The foam panel is in the form
of an elastic soft-material panel composed of
polyurethane foam. The metal plate is designed to
15 suppress natural disturbance resonances by means of a
sandwich structure with a film which is inserted
between two metal sheets and damps bending waves. The
individual transducer elements in the transducer
arrangement are in the form of hydrophones. In order to
20 produce the transducer arrangement, the reflector and a
plug for connection of the hydrophones are inserted in
a casting mold. The hydrophones are adhesively bonded
to spacers in order to maintain an accurately
toleranced distance from the reflector. The spacers are
25 fixed accurately in position on the reflector, to be
precise on its metal plate, for example by means of
small indentations in the metal plate, or else by
adhesive bonding. The spacers are produced from the
same material as the hard encapsulation, which is
30 preferably composed of polyurethane. Once the
polyurethane has been injected into the casting mold
and it is cured, the complete transducer arrangement is
removed from the casting mold.

35 The invention is based on the object of providing a
transducer arrangement of the type mentioned initially
which has low weight with good performance data that is

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not changed, in order to increase the options and fields for its use.

According to the invention, the object is achieved by
5 the features in claim 1.

The transducer arrangement according to the invention has the advantage that the honeycomb structure of the metal plate, in particular aluminum plate, achieves an
10 enormous weight saving with the transducer arrangement having the same bending stiffness as that which is ensured by a solid plate. The arrangement of the thin double layer composed of a foam layer on the one hand and a material layer with a low acoustic impedance and
15 low density, preferably a cork layer, on the other hand results in a reflector which is a good approximation to an ideal reflector and has a very good back-to-front ratio, despite the honeycomb structure of the metal plate. In comparison to an embodiment without any
20 double layer between the honeycomb structure and the foam panel, the back-to-front ratio is increased by more than 25 dB for a transducer arrangement frequency range from 10 to 30 kHz.

25 Owing to its light weight, the transducer arrangement is most suitable for fitting to autonomous or remotely controlled underwater vehicles, for example as a receiving and/or transmitting antenna for a mine sonar for detection of mines around which sediment flows.

30 Expedient embodiments of the transducer arrangement according to the invention, together with advantageous developments and refinements of the invention, are specified in the further claims.

35 According to one advantageous embodiment of the invention, the foam panel is replaced by an air-filled cavity. In this case, the increase in the back-to-front

ratio resulting from the double layer is even more than 45 dB, with respect to the same transducer arrangement frequency range of 10 to 30 kHz.

5 According to one advantageous embodiment of the invention, the transducer elements are attached to the metal plate by means of spacers composed of plastic. The height of the spacers is designed such that the distance between the acoustic center of the transducer
10 elements and the reflector is small in comparison to the mean wavelength λ of a broadband transducer arrangement, and is less than one quarter of the wavelength λ of a narrowband transducer arrangement. This ensures that the sound which is reflected on the
15 reflector is constructively superimposed on the sound which is directly received or transmitted by the transducer elements.

According to one preferred embodiment of the invention,
20 that surface of the metal plate which points toward the transducer elements is coated with a thin layer composed of a material whose acoustic impedance is very much less than that of water, and is as close as possible to 1 kg/m²s. This material layer, which has
25 quite a low density and is preferably in the form of a cork layer, acts like an ideal reflector on the transducer elements, thus increasing the reception sensitivity of the transducer arrangement, being operated as a receiver, by up to 6 dB in comparison to
30 the transducer elements in a free field. This also applies to the transmission level and the efficiency of the transducer arrangement when this is operated as an acoustic transmitter.

35 The invention will be described in more detail in the following text with reference to exemplary embodiments which are illustrated in the drawing, in which, illustrated schematically:

Figure 1 shows a longitudinal section through an electroacoustic transducer arrangement having three transducer elements at a distance from one another,

Figure 2 shows a perspective illustration of a metal plate, in the form of a honeycomb structure, in the transducer arrangement shown in Figure 1, and

Figure 3 shows the same illustration as in Figure 1 of a modified transducer arrangement.

The electroacoustic transducer arrangement which is sketched schematically in the form of a longitudinal section in Figure 1 and is intended for an underwater antenna has, by way of example, three transducer elements 11 and a reflector 12 which is arranged behind the transducer elements 11 in the sound incidence direction. The transducer elements 11 may be not only transmitting transducers but also receiving transducers or hydrophones. In the latter case, the hydrophones are in the form of spherical ceramics, preferably ceramic hollow spheres, such as those described in US 6 029 113 A. The transducer elements 11 and the reflector 12 are embedded in acoustically transparent hard encapsulation 13 composed of essentially viscous elastomer which can be processed using a casting method. By way of example, polyurethane (PUR) is used as the elastomer. The electrical connections which necessarily lead to the transducer elements 11 are not shown in the illustrations, for the sake of clarity.

The reflector 12 comprises a metal plate 13 which faces the transducer elements 11 and has a honeycomb structure, and a foam panel 14 which faces away from

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the transducer elements 11 and is composed of pressure-resistant foam. The metal plate 13 together with the honeycomb structure, a plan view of which can be seen in the form of a detail, by way of example, in Figure 2, is preferably manufactured from light metal, such as aluminum. A thin double layer 15 is arranged between the metal plate 13 and the foam panel 14 and comprises a foam layer 16 (which rests on the metal plate 13 and is composed of pressure-resistant foam) and a material layer 17, which rests on the foam panel 14 and is composed of a material whose acoustic impedance is very much lower than that of water, that is to say it has a very low density. Cork is preferably used as the material for the material layer 17, so that the following text refers only to a cork layer 17. The double layer 15 is relatively thin in comparison to the foam panel 14. By way of example, the layer thickness of the foam layer 16 is 4 mm, and the layer thickness of the cork layer 17 is 2 mm. In contrast, the layer thickness of the foam panel 14 composed of pressure-resistant foam is chosen to be 15-20 mm.

In order to maintain an accurately toleranced distance from the reflector 12, each of the transducer elements 11 is adhesively bonded to a spacer 18. The spacers 18 are fixed accurately in position to the metal plate 13 with a honeycomb structure, for example by means of small indentations in the metal plate 13, or else by adhesive bonding. The spacers 18 are preferably produced from the same material as the hard encapsulation 20. That surface of the metal plate 13 which points toward the transducer elements 11 is covered with a thin material layer 19 composed of a material whose acoustic impedance is very much lower than that of water. Cork is also used in the same way as in the case of the material layer 17 as a layer material with a low density for the material layer 19. The layer thickness of the cork layer 19 is, for

example, approximately 2 mm. The cork layer 19 is cut out in the area of the spacers 18.

The height of the spacers 18 is chosen such that the distance between the acoustic center of the hydrophones and the metal plate 13 is small in comparison to the mean wavelength λ for a transducer arrangement which transmits or receives with a broad bandwidth. For a transducer arrangement which transmits or receives with a narrow bandwidth, the height of the spacers 18 is chosen to be less than one quarter of the wavelength λ , that is to say less than $\lambda/4$.

The transducer arrangement according to a further exemplary embodiment, which is illustrated in the form of a longitudinal section in Figure 3, has been modified in comparison to the transducer arrangement described above by replacing the foam panel composed of pressure-resistant material by a closed cavity 21. A frame 22 with a U-shaped cross section and with a base plate 221 and a circumferential frame limb 222 is provided in order to create the cavity 21. On the side opposite the base plate 221, the frame 22 is covered by the cork layer 17 of the double layer 15, which rests on the free end of the frame limb 221 and thus encloses the cavity 21 together with the frame 22. The frame 22 is composed of a stiff material, for example of a light metal, in particular aluminum, or a pressure-resistant plastic or foam. The cavity 21 is preferably filled with air and, in addition to increasing the back-to-front ratio, is also used to accommodate electronic and electrical components for connection to the transducer elements 11.

The hard encapsulation 20 which encloses the transducer elements 11 and the reflector 12 is not in the form of a cuboid body as in Figure 1, but is readjusted in the area of the sound incidence direction of the surface

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contour of the spherical transducer elements 11 by hemispherical bulges there covering a hemispherical part of the transducers with an approximately constant material thickness. This matching of the hard
5 encapsulation 20 to the transducer contour results in the antenna arrangement having a wider beam angle.

PATENT CLAIMS

1. An electroacoustic transducer arrangement for underwater antennas, having transducer elements (11) which are at a distance from one another, having a reflector (12) which is arranged behind the transducer elements (11) in the sound incidence direction and has a metal plate (13) (which faces the transducer elements (11)), in particular an aluminum plate, and a foam panel (14) which is located on the side of the metal plate (13) facing away from the transducer elements (11), and having hard encapsulation (20) composed of an elastomer which surrounds the transducer elements (11) and the reflector (12), characterized in that the metal plate (13) has a honeycomb structure, and in that a double layer (15) (which is composed of a foam layer (16) which rests on the metal plate (13) and of a material layer (17) which rests on the foam panel (14) and is composed of a material whose acoustic impedance is very much less than that of water) is arranged between the metal plate (13) and the foam panel (14).

2. The transducer arrangement as claimed in claim 1, characterized in that the double layer (15) has a layer thickness which is small in comparison to the thickness of the foam panel (14) and is preferably approximately 6 mm.

3. The transducer arrangement as claimed in claim 1 or 2, characterized in that the transducer elements (11) are fixed to spacers (18), which are attached to the metal plate (13) and are composed of plastic, preferably polyurethane, and in that the height of the spacers (18) is chosen such that the distance between the acoustic center of the transducer elements (11) and the reflector (12) for a broadband transducer arrangement is small in comparison to the mean wavelength λ , and for a narrowband transducer

arrangement is less than one quarter of the wavelength λ .

4. The transducer arrangement as claimed in one of
5 claims 1-3, characterized in that that surface of the
metal plate (13) which points toward the transducer
elements (11) is coated with a thin material layer (19)
composed of a material whose acoustic impedance is very
much less than that of water.

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5. The transducer arrangement as claimed in one of
claims 1-4, characterized in that the material layer
(17, 19) composed of the material with a low acoustic
impedance is a cork layer.

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6. The transducer arrangement as claimed in claim 5,
characterized in that the layer thickness of the cork
layer (17, 19) is approximately 2 mm.

20 7. The transducer arrangement as claimed in one of
claims 1-6, characterized in that the foam panel (14)
is composed of pressure-resistant foam.

8. The transducer arrangement as claimed in one of
25 claims 1-7, characterized in that the foam panel (14)
has a closed cavity (21), which is directly adjacent to
the double layer (15), or is replaced by a cavity (21)
such as this.

30 9. The transducer arrangement as claimed in claim 8,
characterized in that the cavity (21) is air-filled.

10. The transducer arrangement as claimed in claim 8
or 9, characterized in that the cavity (21) is enclosed
35 by a frame (22) which has a U-shaped cross section with
a base plate (221) and a circumferential frame limb
(222) and the double layer (15) which rests on the free

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ends of the frame limb (222) and covers the base plate (221), at a distance from it.

11. The transducer arrangement as claimed in one of
5 claims 8-10, characterized in that electrical and
electronic components which are connected to the
transducer elements (11) are accommodated in the cavity
(21).

10 12. The transducer arrangement as claimed in one of
claims 1-9, characterized in that the transducer
elements (11) are in the form of spherical ceramics,
preferably ceramic hollow spheres.