

A T L A S E L E K T R O N I K G m . b H

Bremen

ELECTROACOUSTIC CONVERTER

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

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A known electroacoustic transducer arrangement for an underwater antenna (DE 43 39 798 A1) has a plurality of hydrophones which are arranged at equal intervals vertically one above each other on a mount and, in
15 order to simplify installation of the underwater antenna with good reception characteristics, are embedded together with a reflector, which is arranged behind them in the sound incidence direction, in acoustically transparent hard encapsulation composed of
20 an elastomer which can be processed using a casting method, preferably polyurethane. The reflector is in the form of a spring/mass system comprising a mass and a spring which is soft for sound, with the mass being provided by a metal plate and the spring which is soft
25 for sound being provided by a panel which is soft for sound and is arranged on the rear face (facing away from the hydrophones) of the metal plate, which is preferably composed of aluminum.

30 A known submarine with a boat body (DE 101 28 973 C1) which has a pressure body and an outer skin is equipped with a device for detection of torpedoes emitting sound pulses, which device has a large number of hydrophones which receive omnidirectionally, are distributed in an
35 undefined manner over the surface of the boat body, and are mounted directly on its outer skin. The hydrophones are connected to a signal processing unit, which determines the direction of the torpedo in order to detect the torpedo position from the delay time

differences between the output signals from selected hydrophones. The distance from the torpedo is determined by trigonometric calculation using direction angles which have been determined by various hydrophone groups which are preferably located a long distance
5 apart from one another on the boat body.

The invention is based on the object of designing an electroacoustic transducer having a hydrophone for
10 flush installation in the outer skin of a boat body and which, after installation, has a flat phase profile, without any sudden phase changing, and thus the free-field characteristic of a hydrophone, within its frequency range.

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

The electroacoustic transducer according to the
20 invention has the advantage that the provision of the reflector ring and its arrangement (matched to the hydrophone position) mean that the phase profile of the transducer is largely flat, and has neither any ripple caused by constructive interference nor any sudden
25 phase changes initiated by destructive interference. So-called phase-based signal analysis of the transducer signals is thus possible, that is to say signal evaluation which is based on the synchronicity of the selected transducers, for example the algorithms for
30 determination of the range and direction of a target, using at least three selected transducers. Furthermore, the transducer according to the invention provides the capability to shift the mid-frequency or main frequency of the transducer with the maximum reception
35 sensitivity to low frequencies or to higher frequencies as required by variation of the separation of the hydrophone with respect to the front face of the reflector ring facing the sound incidence direction, without the phase profile losing its linearity. The

transducer behaves in the same way as a hydrophone located in the free field over a broad frequency range, for example from 1 kHz to 100 kHz.

- 5 Expedient embodiments of the electroacoustic transducer according to the invention, together with advantageous developments and refinements of the invention, result from the further claims.
- 10 According to one advantageous embodiment of the invention, the reflector is composed of a metal plate, preferably a brass plate, and a hard foam panel, which is arranged in front of the metal plate in the sound incidence direction and rests on the metal plate. The
- 15 reflector is used to achieve a desired front-to-back ratio, the so-called reflection factor, of the transducer, and to suppress interference sound that is incident on the mount side.
- 20 The invention will be described in more detail in the following text with reference to one exemplary embodiment, which is illustrated in the drawing and in which:
- 25 Figure 1 shows a longitudinal section through an electroacoustic transducer, and
- Figure 2 shows a graph of the reception sensitivity of the transducer as a function of the
- 30 frequency, for various installation positions of the hydrophone in the transducer as shown in Figure 1.

The electroacoustic transducer for underwater use, as

35 is illustrated in the form of a longitudinal section in Figure 1, has a reflector 11 and a hydrophone 12 which is formed by a hollow ceramic sphere, a so-called spherical ceramic, which is arranged at a distance in front of the reflector 11 in the sound incidence

direction. The reflector 11 comprises a metal plate 13, in the exemplary embodiment a brass plate, on whose front face pointing in the sound incidence direction a hard foam panel 14 is fitted. The hydrophone 12 is
5 fitted to a spacer 15 composed of hard foam, which is supported on the hard foam panel 14 at the end remote from the hydrophone. The reflector 11 acts as a spring/mass system, and is used to achieve a desired front-to-back ratio, the so-called reflection factor,
10 of the transducer, and to largely suppress interference sound which is generated in a mount holding the transducer.

A reflector ring 16 which is concentric with respect to
15 the hydrophone 12 is arranged in front of the reflector 11, and its inner ring surface 161, which surrounds an annular space 163, is at a radial distance from the hydrophone 12. In this case, the reflector ring 16 and the hydrophone 12 are spatially associated such that
20 the hydrophone 12 is at a predetermined distance h from that end surface 162 of the reflector ring 16 which faces away from the reflector 11 and faces the sound incidence direction. If the distance h is positive, then the hydrophone 12 projects at least partially
25 beyond the end surface 162, while if the distance h is negative, then the hydrophone 12 is at least partially recessed behind the end surface 162. In this case, the reflector ring 16 is supported on the hard foam panel 14 of the reflector 11 via one or more spacers 17
30 composed of hard foam. In the exemplary embodiment shown in Figure 1, the hydrophone 12 partially projects beyond the front end surface 162 of the reflector ring 16, with the distance h indicating the distance between the foremost point in the sound incidence direction on
35 the sphere surface and the end surface 162. In this installation position, the transducer has a reception sensitivity G , as is illustrated schematically by the curve a in the graph in Figure 2, over its frequency range from, for example, 1 kHz to 100 kHz. The maximum

reception sensitivity of the transducer is at the main frequency or mid-frequency f^* .

The sensitivity maximum of the transducer can be shifted to higher or lower frequencies by variation of the installation position of the hydrophone 12, as is done mainly by variation of the height of the spacer 15. If the distance h is increased, then the maximum of the reception sensitivity is shifted towards lower frequencies, as is indicated by the arrow $+h$ in Figure 2. The reception sensitivity of the transducer as a function of the frequency then has a profile, for example, as shown by the curve b in Figure 2. The hydrophone 12 can also be recessed behind the front end surface 162 of the reflector ring 16 by shortening the height of the spacer 15, in which case the distance h assumes negative values. In this case, the maximum reception sensitivity of the transducer is shifted towards higher frequencies, as is indicated by the arrow $-h$ in Figure 2. If the hydrophone 12 is located entirely in the inner annular space 163 on the reflector ring 16 and it is recessed by a specific amount $-h$ behind the front end surface 162 of the reflector ring 16, then the transducer has a reception sensitivity as a function of frequency as is illustrated by way of example by the curve c in Figure 2. The thickness of the reflector ring 16 is matched to the frequency band of the transducer, so that the linearity of the reception sensitivity is maintained, that is to say the reflector ring 16 acts like a virtually ideal reflector over the entire frequency band.

The hydrophone 12 is connected in a known manner via electrical connecting conductors 18, which are passed centrally through the spacer 15, through the hard foam panel 14 and through the metal plate 13, to an electronics device 19, which itself can be made contact with via a plug 20 which is only indicated in Figure 1.

All of the components of the electroacoustic transducer described above are enclosed in an encapsulation 21 composed of sound-transparent plastic. An elastomer
5 which can be processed using the casting method, preferably polyurethane, is used as the plastic. Attachment means 22 are provided in the encapsulation 21, in order to attach the electroacoustic transducer to a mount. Attachment means 22 such as these are, for
10 example, through-channels formed in the encapsulation 21, through which mounting bolts can be passed.

The electroacoustic transducer described above is designed in particular for fitting to the boat body of
15 a submarine, with the transducer, to be more precise the front face of the encapsulation 21 pointing in the sound incidence direction, being inserted into the outer skin of the submarine body such that it is flush with the outer skin, and being attached to the pressure
20 body of the submarine body. The outer skin of the boat body is indicated by 23 in Figure 1.

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PATENT CLAIMS

1. An electroacoustic transducer having a reflector
10 (11) and a hydrophone (12) which is arranged at an
axial distance from the reflector (11), is
arranged in front of the reflector (11) in the
sound incidence direction and is in the form of a
ceramic hollow sphere, characterized in that a
15 reflector ring (16) which is concentric with
respect to the hydrophone (12) is arranged in
front of the reflector (11) and its inner ring
surface (161) is at a radial distance from the
hydrophone (12), and in that the hydrophone (12)
20 and the reflector ring (16) are physically
associated such that the hydrophone (12) is
arranged at a predeterminable distance (h) from
that end surface (162) of the reflector ring (16)
which faces away from the reflector (11).
- 25 2. The transducer as claimed in claim 1,
characterized in that the hydrophone (12) projects
by a positive distance (h) at least partially
beyond the end surface (162) of the reflector ring
(16).
- 30 3. The transducer as claimed in claim 1,
characterized in that the hydrophone (12) is
recessed by a negative distance (h) behind this
end surface (162) of the reflector ring (16).
- 35 4. The transducer as claimed in one of claims 1-3,
characterized in that the hydrophone (12) is
supported on the reflector (11) by means of a

spacer (15) composed of hard foam for spatial association.

5. The transducer as claimed in one of claims 1-4,
5 characterized in that the reflector ring (16) is supported on the reflector (11) via at least one spacer (17) composed of hard foam.
6. The transducer as claimed in one of claims 1-5,
10 characterized in that the thickness of the reflector (11) is matched to the frequency range covered by the hydrophone (12).
7. The transducer as claimed in one of claims 1-6,
15 characterized in that the reflector ring (16) is composed of hard foam.
8. The transducer as claimed in one of claims 1-7,
20 characterized in that the reflector (11) comprises a metal plate (13), preferably a brass plate, and a hard foam panel (14), which covers the metal plate (13) on its front face facing the sound incidence direction.
9. The transducer as claimed in one of claims 1-8,
25 characterized in that all of the transducer components, such as the reflector (11), the reflector ring (16), the spacer (15) and the hydrophone (12) are enclosed in encapsulation (21)
30 composed of sound-transparent plastic, in particular of an elastic elastomer which can be processed using the casting method, and in that attachment means (22) for attachment of the transducer are cast in the encapsulation (21).
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10. The transducer as claimed in claim 9, characterized by the transducer being fitted to a boat body, which has a pressure body and an outer skin (23), of a submarine in such a way that the

front face of the encapsulation (21), which faces the sound incidence direction, is flush with the outer skin of the boat body.