

ACOUSTIC SUBMARINE ANTENNA

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The invention relates to an underwater antenna for fitting to a hull of a submarine according to the precharacterizing clause of claim 1.

10 A known linear underwater antenna (DE 38 34 669 A1), which is referred to as a flank array, has a transducer arrangement which is arranged at a distance from the hull of a submarine, referred to for short in the original German as a "U-Boot" [U-boat], with a  
15 multiplicity of hydrophones which are at a distance from one another and are arranged one behind the other horizontally in one or more rows along the hull when the underwater antenna is in the installed position, and has a damping plate, in order to provide a  
20 shielding effect from sound emitted from the hull, which damping plate is arranged behind the hydrophones in the sound incidence direction, is designed on the spring-mass principle and acts as a reflector which is acoustically soft in the lower frequency range. The  
25 hydrophones are held on the damping plate via a clamping structure, and the damping plate is mounted on the structure wall of the hull by means of sprung elements, via a damping layer.

30 A linear flank antenna, which is likewise known, on a submarine (EP 0 214 525 B1) has a so-called hydrophone streamer with a plurality of hydrophones which are arranged at a distance from one another in an elastic, oil-filled, flexible tube. The hydrophone streamer is  
35 held at a distance from the hull over its longitudinal extent by holding elements which are attached to the hull at a distance from one another. The holding elements are attached to a base, for example by screw

connection, which base is connected to the hull, and are fitted on their free end face with shell-like attachment elements, which clasp the hydrophone streamer around its flexible tube casing. An elastic  
5 insert, composed of plastic or rubber for example, and which provides sound decoupling, is arranged between each attachment element and the flexible tube casing of the hydrophone streamer. The hydrophone streamer and the holding elements together with their attachment  
10 elements are covered by a sheath body, which is closed off on both end faces and is attached to attachment lugs which are connected to the base.

The directivity characteristic of linear underwater  
15 antennas such as these has a narrow beam angle in the horizontal direction, depending on the antenna length, and an extremely large beam angle in the vertical direction, which is governed by the natural characteristic of the hydrophones.

20 One known, flat underwater antenna, also referred to as a flat antenna (DE 10 2004 037 987 A1), is composed of a plurality of panel-like antenna segments. Each antenna segment has an acoustically transparent plastic  
25 body like a plate, in which hydrophones arranged in rows and columns, and an inflexible plate, which is used as a reflector and is arranged behind the hydrophones in the sound incidence direction, are embedded. A flat antenna such as this which is designed  
30 for receiving antennas in the medium to relatively high frequency range has a good front-to-back ratio and also provides good beam formation for the directivity characteristic in the vertical reception range, and therefore an improved signal-to-noise ratio, because of  
35 the capability to additively combine the output signals from the hydrophones which are arranged vertically one above the other in columns when the antenna is in the installed position. A flat antenna such as this, arranged on both sides of the submarine, can be

employed in underwater detection with significant advantages over linear underwater antennas arranged alongside the submarine as the wet end of a panorama sonar.

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The invention is based on the object of designing the fitting of the underwater antenna, which extends over an area, to the hull when designing a flat antenna for a submarine such that the reflector is acoustically  
10 decoupled from the hull and can absorb impacts and oscillating loads without damage.

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

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The underwater antenna according to the invention has the advantage that the screw connections or screw unions for fixing the reflector are loaded exclusively in tension, and lateral and shear forces which occur as  
20 a result of oscillations and impacts are absorbed by the stiff sleeves, which are produced from steel or glass-fiber-reinforced plastic, such that these forces do not load the threaded connections, and therefore cannot damage them. The two resilient elements between  
25 which the reflector is clamped in allow the reflector to oscillate relative to the screw connections, allowing the reflector to be largely acoustically decoupled.

30 Expedient embodiments of the underwater antenna 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 mount has a base which is attached to the hull and a buoyant body which is arranged between the reflector and the base and preferably contains hard foam, and the second resilient element is supported on

the reflector and on the upper face, facing the reflector, of the buoyant body. The buoyant body largely compensates for the weight of the heavy reflector. Furthermore, the interference sound level  
5 that reaches the transducer arrangement can be reduced by means of the buoyant body and the relatively great distance between the reflector and the hull which this results in.

10 According to one advantageous embodiment of the invention, a spacing sleeve is arranged between the first resilient element and the buoyant body, produces a gap separation between the reflector and the buoyant body, and is seated on the stiff sleeve. This spacing  
15 sleeve creates a defined, water-filled gap between the buoyant body and the reflector, contributing to the acoustic decoupling of the reflector. Furthermore, the second resilient element can be designed exclusively for the desired spring characteristic if the axial  
20 length of the spacing sleeve is of appropriate size.

According to one advantageous embodiment of the invention, the second elastic element is held in an interlocking manner in a recess which is incorporated  
25 in the reflector from its rear face, which faces the buoyant body. This allows the installation area for the spacing sleeve and the second elastic element to be kept relatively short.

30 According to one advantageous embodiment of the invention, the second elastic element is in the form of a hollow cylinder composed of rubber or polyurethane. Axial aperture channels are introduced therein in order to adjust the spring characteristic of the hollow  
35 cylinder. The desired spring constant of the hollow cylinder can be set by the number and the size of the unobstructed cross sections of these aperture channels. The cross-sectional shape of the aperture channels is

preferably circular or trapezoidal. Other cross-sectional shapes are possible.

According to one advantageous embodiment of the invention, the screws which hold the reflector are screwed into threaded holes which are provided in the base that is connected to the hull. In this case, the stiff sleeves which surround the screw shanks pass through the buoyant body and are supported between the screw heads and the base.

If the buoyant body has a great depth, which would require unacceptably long screw shanks for direct anchoring of the reflector in the base, according to one alternative embodiment of the invention, the stiff sleeves which surround the screw shanks are provided with an internal thread and are anchored in the buoyant body, for example by being adhesively bonded into holes which are incorporated in the buoyant body, or their being encapsulated in the buoyant body. The screws are screwed into the internal thread in the sleeves such that the screw head is in each case supported on the sleeve, preferably via a flat washer.

According to one advantageous embodiment of the invention, each sleeve is supported on the screw head via a flat washer which is seated on the screw shank and is arranged between the first resilient element and the screw head. When the screw is screwed in and tightened, this washer prevents the first resilient element, which is preferably in the form of an O-ring composed of rubber or polyurethane, from being loaded in shear, and therefore prevents it from being prematurely damaged.

According to one advantageous embodiment of the invention, the attachment means for the reflector are arranged exclusively close to the upper and lower longitudinal edges of the reflector when the reflector

is in the installed position. This design measure provides the reflector, which is supported only by the attachment means and is otherwise unsupported, with the greatest possible support width, thus shifting the  
5 natural frequency of the reflector to the low frequency range. In consequence, there is a considerable mismatch between the energy from pressure waves in the relatively high frequency range, caused by detonations for example, and the natural frequency of the  
10 reflector, as a result of which the reflector absorbs considerably less energy, greatly reducing the holding forces which have to be applied by the attachment means.

15 According to one advantageous embodiment of the invention, the reflector is subdivided into reflector plates which are arranged adjacent to one another horizontally and without any gaps in the installed position and have a considerably greater vertical size,  
20 and in each case one attachment means is arranged close to the upper and lower edges of a reflector plate in the installed position. The subdivision of the flat reflector into reflector plates which are quite narrow in comparison to their length prevents low-frequency  
25 natural oscillation forms of the reflector in the horizontal direction; this is because the natural oscillation forms of the narrow reflector plates occur in a considerably higher frequency range, as a result of which the reflector plates can be excited  
30 considerably less well by low-frequency interference.

The invention will be described in more detail in the following text with reference to one exemplary embodiment, which is illustrated in the drawing, in  
35 which:

Figure 1 shows a perspective view of an antenna segment of an electroacoustic underwater

antenna which is attached to a hull of a submarine,

5       Figure 2 shows an enlarged detail of the antenna segment in Figure 1, in the form of a longitudinal section, in the area of an attachment point,

10       Figure 3 shows a perspective illustration of a resilient element at the attachment point in Figure 2,

15       Figure 4 shows the same illustration as in Figure 2, of a modified exemplary embodiment, and

      Figure 5 shows a perspective illustration of an attachment base in Figure 4.

20       Figure 1 shows a perspective view of an antenna segment 11, which is fixed to a structure wall 12 of a hull of a submarine, of an underwater antenna which is used as a flat flank antenna. Depending on the antenna length, a plurality of such antenna segments 11 are placed adjacent to one another along the hull and, in their  
25       totality, result in the flank antenna, which is elongated in the horizontal direction and has an extent in the vertical direction. There is normally one flank antenna in each case on the port and starboard sides. The antenna segment 11 has a reflector 13 which is  
30       composed of a plurality of reflector plates 131, with four being shown in the exemplary embodiment in Figure 1. When the antenna segment 11 is in the installed position as shown in Figure 1, the reflector plates 131 are adjacent to one another without any gaps  
35       horizontally, with their considerably greater size extending in the vertical direction and corresponding to the vertical size of the antenna segment 11. A transducer arrangement 14 with a flat extent is positioned in front of the reflector 13 in the sound

incidence direction and consists of a multiplicity of electroacoustic transducers which are arranged in one or more rows horizontally and vertically, in each case at a distance from one another, when the antenna  
5 segment 11 is in the installed position. In the illustrated exemplary embodiment, the transducer arrangement 14 has a plurality of vertically aligned so-called staves 16, which are arranged at a distance from one another in the horizontal direction. In the  
10 exemplary embodiment shown in Figure 1, two staves 16 are in each case arranged in front of a reflector plate 131, and are fixed to it. A plurality of electroacoustic transducers are arranged at a distance from one another, vertically one above the other, in  
15 each staff 16. The number of electroacoustic transducers which are arranged vertically one above the other determines the vertical beam angle of the directivity characteristic of the antenna segment 11, by additive combination of the transducer output  
20 signals.

A buoyant body 15 is arranged on the rear face of the reflector 13, facing away from the transducer arrangement 14, and the rear face of this buoyant body  
25 15, which faces away from the reflector 13, is matched to the curved profile of the structure wall 12 of the hull. In order to achieve buoyancy to largely compensate for the weight of the reflector 13 with the transducer arrangement 14, the buoyant body 15 -  
30 although this cannot be seen here - has a hard foam core which is surrounded by an encapsulation compound. A composite material consisting of an epoxy resin and pressure-resistant hollow bodies incorporated in it, for example hollow glass bodies, is preferably used as  
35 the encapsulation compound. In order to increase the load-bearing capability of the hard foam core, elongated stiff plates 17 composed of glass-fiber-reinforced plastic are also encapsulated in the buoyant body 15, extending over the entire horizontal length of

the antenna segment, when the antenna segment is in the installed position. The buoyant body 15 is connected to a base 18, which is attached to the hull. The buoyant body 15 and the base 18 form a mount for the reflector 5 13, which is fixed to the mount by attachment means which are placed close to the upper and lower edges of the reflector 13 when the antenna segment 11 is in the installed position. In this case, two attachment points are in each case associated with one reflector plate 10 131, and are arranged close to the upper and lower edges.

Screws 19, preferably threaded bolts, are used as attachment means, having a screw head 191, a screw 15 shank 192 and a screw thread 193 which is formed at the end of the screw shank 192 that is remote from the screw head 191. The attachment means also include stiff sleeves 20 composed of glass-fiber-reinforced plastic or steel, each of which holds a screw shank 192 and is 20 supported at the end on the screw head 191. Each sleeve 20 is passed through a corresponding aperture hole 21 in the reflector 13, and passes partially or entirely through the buoyant body 15. For acoustically decoupled suspension of the reflector 13, to be more precise of 25 each reflector plate 131, a first resilient element 22, a second resilient element 23 and a spacing sleeve 24 are pushed onto each sleeve 20. The first resilient element 22, which is in the form of an O-ring 27 composed of rubber or polyurethane, is arranged between 30 the screw head 191 and the upper face of the reflector 13 facing it, with a flat washer 25, which is likewise pushed onto the sleeve 20 and is composed of metal, also being inserted between the first resilient element 22 and the screw head 191. The second resilient element 35 23, which is in the form of a hollow cylinder 28 composed of rubber or polyurethane, is inserted in an interlocking manner into a recess 26, which is incorporated in the reflector 13 from the rear face of the reflector 13, facing away from the screw head 191.

The rubber or polyurethane hollow cylinder 28 is illustrated in perspective form in Figure 3. Its internal diameter is slightly larger than the external diameter of the stiff sleeve 17. In order to set the desired spring elasticity, the hollow cylinder 28 is provided with axial aperture channels 29, which are arranged at equal intervals in the circumferential direction. The number and the cross section of the aperture channels 29 governs the stiffness or softness of the second resilient element 23. In the illustrated exemplary embodiment, the aperture channels 29 are in the form of aperture holes with a circular cross section. The cross-sectional shape of the aperture channels 29 may, however, be chosen as required, preferably also to be trapezoidal. The spacing sleeve 24, which is pushed onto the stiff sleeve 20, is supported on the one hand on the second resilient element 23 and on the other hand on that surface of the buoyant body 15 which faces the reflector 13. Its appropriately chosen axial length results in a gap 30 with a defined axial width being produced between the reflector 13 and the buoyant body 15, and this is filled with water when the underwater antenna is in use.

In the exemplary embodiment in Figure 2, the reflector 13 is attached to the buoyant body 15 of the mount. The stiff sleeves 20 are anchored in the buoyant body 15 and are provided, at least in places, with an internal thread 31. The sleeves 20 are either also encapsulated during the production of the buoyant body 15, or are retrospectively adhesively bonded into blind holes 32 which are provided in the buoyant body 15. The screw threads 193 on the screws 19 are screwed into the internal thread 31 in the sleeves 20, with the sleeves 20 being braced between the screw head 191 and the bottom 321 of the hole by a certain amount of prestressing. For manufacturing reasons, the internal thread 31 may be moved from the sleeve 20 to a metallic

threaded bush adjacent to the sleeve 20, which bush is adhesively bonded in the buoyant body 15 at the bottom 321 of the blind hole 32, or is also encapsulated in the buoyant body 15 during its manufacture. When the  
5 screw 19 is screwed into the threaded bush, the sleeve 20 which has been inserted into the blind hole 32 in the buoyant body 15 is braced between the threaded bush and the screw head 191.

10 The described anchoring of the sleeves 20 in the buoyant body 15 is used when the size of the buoyant body 15 is too large in the screw direction to allow screws 19 to be used which have a reasonable screw shank length extending as far as the base 18. However,  
15 if the buoyant body 15 is narrower, then the attachment of the reflector 13 to the base 18 of the mount is screwed in, preferably by screwing the screws 19 directly into the base 18, as is illustrated in Figure 4. For this purpose, the base 18 has threaded  
20 holes 33, into which the screw thread 193 is screwed. The sleeves 20, which then have smooth internal walls - that is to say in which there is no internal thread as shown in Figure 2 - are supported directly on the base 18 and are clamped in by the prestressing of the screws  
25 19 between the screw heads 191, to be more precise between the flat washers 25, and the base 18.

As can be seen from Figure 1, the base 18 has two U-profile rails 34 which are arranged with a vertical  
30 distance between them on the structural wall 12 of the hull. Each U-profile rail 34 is attached to so-called cleats, which are fixed to the hull with a defined horizontal distance between them in two rows located vertically one above the other. The term cleats means  
35 cylindrical or cuboid attachment supports which project beyond the structural wall 12 of the hull, and are each provided with a threaded hole. Bolts 35 with heads (Figures 1 and 5) which are passed through the U-profile rail 34 are screwed into these threaded

- holes. Threaded holes 33 (Figure 5) are provided in the yoke of the U-profile rails 34, between the aperture holes for the bolts with heads 35. In the exemplary embodiment shown in Figures 1 and 2, the buoyant body
- 5 15 is attached to the U-profile rails 34, for which purpose - although this is not illustrated here - screws which are anchored in the buoyant body 15 are screwed into the threaded holes 33.
- 10 In the exemplary embodiment shown in Figure 4, the screw thread 193 on the screw shanks 192 of the screws 19 is screwed into the threaded holes 33. To do this, the profile yoke of the U-profile rails 34 must be aligned at right angles to the screw axes. In order to
- 15 achieve this on the curved structure wall 12 of the hull, the U-profile rail 34 has different limb lengths, as can be seen in Figure 5.

PATENT CLAIMS

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1. An underwater antenna for fitting to a hull of a submarine, having at least one antenna segment (11) which has a transducer arrangement (14) which extends over an area and comprises a plurality of electro-  
10 acoustic transducers, which are at a distance from one another and are arranged in one or more horizontal and vertical rows in the installed position, and has a reflector (13), which is like a plate and is arranged behind the transducer arrangement (14) in the sound  
15 incidence direction, characterized in that the reflector (13) is fixed by attachment means to a mount which is connected to the hull, in that the attachment means have screws (19) with a screw head (191) and a screw shank (192) which is passed through a stiff  
20 sleeve (20) and has a screw thread (193), and in that a first resilient element (22) is arranged between the screw head (191) and the reflector (13), and a second resilient element (23) is arranged between the reflector (13) and the mount, and the two elements (22  
25 and 23) are seated on the stiff sleeve (20).

2. The underwater antenna as claimed in claim 1, characterized in that the mount has a base (18) which is attached to the hull, and has a buoyant body (15)  
30 which is connected to the base (18), and in that the second resilient element (23) is supported on the reflector (13) and on the upper face, facing the reflector (13), of the buoyant body (15).

35 3. The underwater antenna as claimed in claim 2, characterized in that a spacing sleeve (24) is arranged between the second resilient element (23) and the buoyant body (15), produces a gap (30) with a defined

axial width between the reflector (13) and the buoyant body (15) and is seated on the stiff sleeve (20).

4. The underwater antenna as claimed in one of  
5 claims 1 to 3, characterized in that the second resilient element (23) is inserted in an interlocking manner in a recess (26) which is incorporated in the reflector (13) from its rear face, which faces the buoyant body (15).

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5. The underwater antenna as claimed in one of  
claims 1 to 4, characterized in that the second resilient element (23) is a hollow cylinder (18) composed of rubber or polyurethane, which has a  
15 plurality of axial aperture channels (29) which are arranged alongside one another, preferably at equal intervals, in the circumferential direction.

6. The underwater antenna as claimed in one of  
20 claims 1 to 5, characterized in that the first resilient element (22) is an O-ring composed of rubber or polyurethane.

7. The underwater antenna as claimed in one of  
25 claims 1 to 6, characterized in that the screws (19) are screwed into threaded holes (33), which are contained in the base (18), or into threaded bushes, which are fixed in the buoyant body (15), and in that the stiff sleeves (20) are clamped in between the screw  
30 heads (191) and the base (18) or the threaded bushes.

8. The underwater antenna as claimed in one of  
claims 2 to 6, characterized in that the stiff sleeves (20) are anchored, preferably adhesively bonded, in the  
35 buoyant body (15) and have an internal threaded section (31), and in that the screws (19) are screwed into the internal threaded sections (31) of the sleeves (20) such that the sleeves (20) are supported on the screw heads (191).

9. The underwater antenna as claimed in claim 7 or 8, characterized in that the sleeves (20) are in each case supported on the screw heads (191) via a flat washer  
5 (25) which is pushed onto the screw shank (191) and is arranged between the first resilient element (22) and the screw head (191).

10. The underwater antenna as claimed in one of  
10 claims 1 to 9, characterized in that the attachment means are arranged exclusively close to the upper and lower longitudinal edges of the reflector (13) when the reflector (13) is in the installed position.

15 11. The underwater antenna as claimed in claim 10, characterized in that the reflector (13) is subdivided into reflector plates (131) which are arranged adjacent to one another horizontally without any gaps in the installed position and have a considerably greater  
20 vertical size, and in that in each case one attachment point, which is produced by the attachment means, is provided close to the upper and lower edges of a reflector plate (131) in the installed position.

25 12. The underwater antenna as claimed in one of claims 1 to 11, characterized in that the base (18) has two U-profile rails (34) which are aligned parallel to one another with a vertical separation and are mounted on cleats which are arranged on the hull.

30 13. The underwater antenna as claimed in one of claims 1 to 12, characterized in that a plurality of antenna segments (11) are arranged adjacent to one another horizontally in the installed position.