

ACOUSTIC UNDERWATER ANTENNA

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The invention relates to an acoustic underwater antenna of the generic type defined in the precharacterizing clause of claim 1.

10 One known underwater antenna, which is referred to as a marine-seismic streamer and forms the acoustic part of a towed-array antenna (DE 42 08 178 A1), has a skeleton with two traction cables and moldings which are arranged separated from one another in the longitudinal
15 direction of the traction cables and are fixed such that they cannot move axially on the two traction cables, which run diametrically opposite on the moldings. The skeleton is drawn into an antenna casing, which is in the form of an elastic flexible tube, with
20 the molding jacket of each molding being supported via two annular strips, which are separated axially, composed of open-cell PU foam on the inner wall of the antenna casing and/or of the flexible tube. An electroacoustic transducer, which is provided by means
25 of a single hydrophone, is inserted in a central aperture hole in each molding and is surrounded by a sleeve composed of open-cell foam. Each transducer is connected to an electrical line which is passed through the moldings in the flexible tube interior. The
30 electrical lines lead to electronic assemblies for signal processing of the electrical transducer output signals. The amplified, digitized output signal, with interference removed from it, is produced at the output of each electronic assembly, also referred to as a
35 channel. The flexible tube is closed at the end and is filled with a liquid. The moldings are used to provide the dimensional stability of the flexible tube, of the holder, which cannot move axially, for the transducers

in the flexible tube, and for damping the liquid flow in the flexible tube, and therefore for reducing interference signals at the transducers.

5 In the case of towed-array antennas, a change has very recently been made to packaging the electronic assemblies in pressure-resistant housings and to arranging them together with the transducers in the underwater antenna, that is to say in the acoustic part
10 of the towed-array antenna. In this case, each electronic assembly, which defines a channel, is associated, in terms of space, with one transducer, in such a way that one transducer and one electronic housing always follow one another alternately in the
15 longitudinal direction of the underwater antenna. By way of example, one such towed-array antenna is disclosed in DE 198 11 335 C1. Here, hydrophones and electronic modules are arranged in one or more rows alternately one behind the other in a gel body which
20 fills the antenna casing. With this configuration, an adequate longitudinal distance is required between adjacent transducers in which, on the one hand, the electronic housing must be accommodated and, on the other hand, free space must be provided for strain
25 relief of the electrical lines and cables, and which therefore cannot be made indefinitely small. Since the longitudinal distance between the transducers is matched to the reception frequencies or transmission frequencies of the underwater antenna in the acoustic
30 part in order to form directional characteristics, the reception frequency or transmission frequency of the underwater antenna is subject to an upper limit when the aim is to ensure transmission or reception via a single main lobe of the directional characteristic.

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One known transducer module (DE 196 12 503 A1) has two transducers which are separated from one another, a separating wall which is arranged between the

transducers and is composed of reflector and absorber material, and an electronic circuit in which the signals received by the two transducers are amplified and digitized for transmission. The transducer
5 elements, separating wall and electronic circuit are arranged in a cylindrical form, encapsulated with polyurethane. The separating wall has a T-profile and separates the transducer elements and the electronic circuit from one another in such a way that the two
10 transducer elements are placed on the left and right of the center web of the separating wall, and the electronic circuit is placed above the lateral web of the separating wall. The separating wall achieves acoustic shadowing of the two transducer elements, in
15 such a way that each transducer element receives only sound waves from a hemisphere in front of the separating wall.

The invention is based on the object of designing the
20 physical configuration of an underwater antenna such that the space required within the antenna casing between the electroacoustic transducers which follow one another in the longitudinal direction of the antenna casing can be kept small.

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

The underwater antenna according to the invention has
30 the advantage that there is an empty space after every alternate transducer in the transducer chain as a result of the combination of in each case two electronic assemblies, which are associated with adjacent transducers, to form an electronic module,
35 which empty space increases the flexibility of the underwater antenna, for example when it is being wound up, and can be used for strain relief for electrical lines and cables, for example by crossing them over.

The distance between the two transducers of a transducer pair associated with the electronic module can be utilized completely for accommodation of the electronic module and can be minimized by an appropriate design configuration of the electronic module. A separation which can be minimized between the transducers in turn results in the advantage that the operating frequency (transmission frequency and/or reception frequency) of the underwater antenna can be shifted towards higher frequencies, and directional characteristics can be provided for unambiguous transmission in or reception from just one main direction for operating frequencies to well above 10kHz, while avoiding grating lobes. The design of the electronic modules as moldings which are supported on the antenna casing and their fixing, such that they cannot move axially, on the traction cables not only saves the cost-increasing, sound-transparent holders which are otherwise used for the transducers, but, by their absence, also creates space in the longitudinal direction of the antenna casing. At the same time, this results in the antenna casing being stiffened.

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.

According to one advantageous embodiment of the invention, the electronic modules are advantageously supported on the antenna casing via circumferential strips, preferably via two strips which are arranged circumferentially with an axial separation and are composed of plastic. These plastic strips result in acoustic decoupling between the antenna casing and the electronic modules, in particular the transducers held on them. If the plastic strips are manufactured from open-pore PU foam, then the electronic modules - like

the known moldings described initially - can at the same time be used to damp the liquid flow in the antenna casing, which is normally closed at the end and is filled with a liquid, and thus to reduce interference signals at the transducers.

According to one advantageous embodiment of the invention, each electronic module has at least two printed circuits which are fitted with electronic components, are aligned transversely with respect to the module axis, and are each fitted with one transducer on a board surface which points outwards. This manufacturing design of the electronic module allows a very short axial physical length and therefore the possibility of a very short distance between the transducers in order to produce a high-frequency underwater antenna. The printed circuit population, which is designed using surface-mounted device technology, with the electronic components resting directly on the populated printed circuits, which are aligned transversely with respect to the longitudinal axis of the underwater antenna, not only makes it possible to further reduce the axial length of the electronic module but also results in the electronic module being sufficiently pressure-resistant for use of the underwater antenna at a greater water depth.

The electrical connections between the electronic assemblies on the populated printed circuits are designed to be flexible for space-saving installation in the module housing. A so-called rigid-flexi printed circuit is advantageously used, which comprises at least two rigid printed circuits for population and a mechanically firmly connected flexible conductor-track connection in the form of a non-detachable flexible cable.

According to one advantageous embodiment of the invention, the populated printed circuits have groove-like cutouts, which are arranged distributed over the circumference at the edge of the board, for the traction cables and electrical lines and cables to pass through. The populated printed circuits are held at the edge in grooves, which are axially separated from one another, in a module housing which is composed of two housing halves and is open at one end. This design configuration of the electronic modules results in a skeleton, which is supported on the inner wall of the antenna casing and is composed of traction cables and electronic modules with transducer pairs, in which case the individual electronic modules with transducer pairs can be inserted into the skeleton or withdrawn from the skeleton in a manner which is advantageous for assembly and repair of the towed-array antenna, without having to disassemble the remaining electronic modules or the entire skeleton. Furthermore, twisting of the underwater antenna, which is subject to tension, could be restricted by the arrangement of the traction cables.

According to one advantageous embodiment of the invention, the transducers of each transducer pair in the electronic modules lie on the module axis. The directional characteristic which is formed from the transducer signals has a horizontally narrow beam angle all round. Target positions which are located using an underwater antenna such as this are, however, ambiguous since it is not possible to distinguish whether the target that has been located is to starboard or port of the longitudinal axis of the antenna casing.

According to one alternative embodiment of the invention, all the transducers are arranged with respect to the module axes with a radial separation on the populated printed circuit. The transducers which

follow one another in the longitudinal direction of the antenna casing are offset with respect to one another through a circumferential angle which is of any desired magnitude and is defined stochastically. If the transducer signals are now processed in a manner such as that described in DE 44 45 549 C1, then this results in the underwater antenna having a directional characteristic which points to only one side of the towed-array antenna.

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According to one advantageous embodiment of the invention, each electroacoustic transducer comprises three transducer elements with an omnidirectional directional characteristic, which are arranged at the same radial distance from the module axis and offset through the same circumferential angle with respect to one another externally in the module housing. Each transducer element is preferably a hydrophone. Depending on the instantaneous orientation of the hydrophones which, for example, may be detected by means of an orientation sensor, output signals from in each case two of the three transducer elements are combined, after passing through suitable time-delay elements, to form the output signal of the electroacoustic transducer, which signal corresponds to the transducer having a cardioid-shaped natural directional characteristic. These output signals from all the electroacoustic transducers are used to form directional characteristics whose main reception directions each point to one side of the towed-array antenna and thus produce unambiguous bearing results. The signaling combination of the output signals from the three transducer elements of an electroacoustic transducer is described, for example, in Figure 9 of DE 31 51 028 A1.

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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:

- 5 Figure 1 shows a side view of a towed-array antenna towed by a surface vessel,
- Figure 2 shows a side view of a deployed vertical antenna,
- 10 Figure 3 shows a detail of a longitudinal section of an acoustic section of an acoustic part in the towed-array antenna shown in Figure 1, or in the vertical antenna
- 15 shown in Figure 2,
- Figure 4 shows an enlarged illustration of the detail IV in Figure 3, with longitudinally-sectioned electronic
- 20 modules,
- Figure 5 shows a plan view of populated printed circuits, placed on the plane of the paper, of an electronic module in Figure
- 25 4,
- Figure 6 shows a view in the direction of the arrow VI in Figure 5 of the populated printed circuits fitted in the
- 30 installation position, and
- Figure 7 shows an identical illustration to that in Figure 5, according to a further exemplary embodiment.

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The underwater antenna, which in Figure 1 is integrated in a towed-array antenna 10 and in Figure 2 is integrated in a vertical antenna 11, in each case

represents an elongated acoustic part 12, in the form of a flexible tube, of the antennas 10, 11, which is fitted with electric acoustic transducers. In both exemplary embodiments, the acoustic part 12 is in the form of a receiving antenna for reception of the sound waves which are propagated in the water. The acoustic part 12 may, of course, also be used for transmission of sound. The acoustic part 12 is composed of a plurality of acoustic sections 121, which are detachably connected to one another via couplings 13.

In the case of the towed-array antenna 10, which is illustrated schematically in Figure 1, the acoustic part 12 is attached via a damping module 14 to a towing cable 15 which is fixed at its end remote from the damping module 14 to a drum 17 which can be driven and is located on board a watercraft 16. A further damping module 18 is attached to the other end of the acoustic part 12, and a towing brake 19 acts on its end that is remote from the acoustic part 12. The towed-array antenna 10 is deployed into the water and is recovered by means of the drum 17. The watercraft 16 may be a surface vessel or an underwater vessel, for example a submarine.

In the case of the vertical antenna 11, which is illustrated schematically in Figure 2, the acoustic sections 121, which are fitted to one another via couplings 13, of the acoustic part 12 are once again attached at the ends to respective damping modules 14 and 18. The damping module 14 is connected to a buoyant body 20, and the damping module 18 is connected to a stabilization element 21, with stabilization fins 22 and a ballast weight 23. The acoustic part 12 is connected via an electrical cable 24 or an optical waveguide to a control center, which is integrated in the anchoring watercraft 16, or by radio to an evaluation unit.

Figure 3 shows a detail of an acoustic section 121 of the acoustic part 12, partially in the form of a longitudinal section. All the acoustic sections 121 of the acoustic part 12 are designed identically. The acoustic section 121 has an antenna casing in the form of an elastic, strain-resistant flexible tube 25, for example composed of polyurethane with inserted carbon fibers or Kevlar fibers. A skeleton with two supporting or traction cables 26, 27 and electronic modules 28 which are attached to the traction cables 26, 27 such that they cannot move axially is drawn into the flexible tube 25. The electronic modules 28 are in the form of moldings for stabilizing the shape of the flexible tube 25 and are used to accommodate the transducers 29 (Figure 4) and electronic assemblies for signal processing of the electrical output signals from the transducers 29. In this case, each transducer 29 has an associated electronic assembly, which essentially contains operational amplifiers, filters, a sample-and-hold circuit and A/D converters or sigma-delta A/D converters. The amplified and digitized output signal, with interference removed from it, is produced at the output of each electronic assembly, also referred to as a channel. The channels are connected to electrical lines 31 which are passed through the towed-array antenna 10 or the vertical antenna 11 to an electronic control center, which is arranged in the watercraft, or to a radio transmission path. The flexible tube 25 is closed at the couplings 13 and is filled with an electrically insulating substance, for example gel or oil. Each transducer 29 is provided by a single hydrophone.

Figure 4 shows one of the electronic modules 28, in the form of a longitudinal section and in detail. Each electronic module 28 has a module housing 32 which comprises two housing halves and has a circular cross

section, which is open at the end. The two housing halves are formed by two semicircular housing shells 321, 322, whose shell edges rest on one another and produce the cylindrical module housing 32. The module housing 32 is supported via two plastic strips 33, which run around the module housing 32 separated axially from one another, on the inner wall of the flexible tube 25, and thus ensure the stability of its shape. The plastic strips 33 are inserted into two annular grooves 43, which are axially separated from one another, in the outer jacket of the module housing 32 and project radially beyond the module housing 32, as a result of which an annular gap remains between the modular housing 32 and the flexible tube 25. The plastic strips 33 are composed of open-pore or open-cell PU foam and act as damping elements for acoustic decoupling between the flexible tube 25 and the module housing 32.

Two transducers 29 are accommodated in the module housing 32 and are held, separated, on mutually averted module faces of the electronic module 28. Each transducer 29 has an associated electronic assembly which produces the output signal of the transducer 29 or the channel for the transducer 29, such that the electronic module 28 is formed with two channels. Each electronic assembly comprises one or more populated printed circuits 35. The populated printed circuits 35 are arranged axially separated from one another and aligned laterally with respect to the module axis - and thus with respect to the axis of the acoustic section 121 - and are fixed in the module housing 32. For this purpose, the populated printed circuits 35 engage at the edge in annular grooves 36, which are introduced, axially separated from one another, into the inner wall of the two housing shells 321, 322 and are circumferential through 360° in the module housing 32. The two populated printed circuits 35 which are located

on the outside in the electronic module 28 are each fitted with one of the transducers 29.

In the described exemplary embodiment, a total of four
5 populated printed circuits 35 are provided in the module housing 32. One of the electronic assemblies is in each case provided by two populated printed circuits 35, and these are associated with the transducers 29 arranged on the outer board faces. The populated
10 printed circuits 35 are mechanically non-detachably electrically connected by means of conductor tracks which are integrated in a flexible strip. Individual components 38, which are arranged on the populated printed circuits 35, on the electronic assemblies are
15 indicated schematically in Figure 4. These are surface-mounted devices and rest directly on the printed circuits. The number of populated printed circuits 35 in the electronic module 28, with their flexible conductor-track connections, may, of course,
20 vary.

Figure 5 shows a plan view of a populated rigid-flexi printed circuit comprising four populated printed circuits 35 with connections by means of flexible
25 conductor-track strips 39, before being fitted into the module housing 32. Of the four printed circuits 35, which are populated on both sides, those surfaces which face away from one another in the fitted position (Figures 4 and 6) of the two printed-circuit pairs can
30 in each case be seen. The two transducers 29 are arranged on the two outer populated printed circuits 35. Each transducer 29 is in the form of a single hydrophone which is placed centrally on the respective populated printed circuit 35, in such a way that all
35 the hydrophones lie on the longitudinal axis of the flexible tube 28. The printed circuits 35, which are fitted with components 38 on both sides, form the electronic assemblies. As can be seen in Figure 5, the

populated printed circuits 35 are connected to one another by means of the flexible conductor-track strips 39. When the populated printed-circuit chain that is created in this way is being installed in the module housing 32, the populated printed circuits 35 are pushed directly against one another and the conductor-track strips 39 are bent outwards, as can be seen in Figure 6. In this case, Figure 6 illustrates an arrangement which has been rotated through 90° in comparison to the illustration in Figure 4.

A plurality of cutouts 40, 41, 42 are incorporated on the edges in the populated printed circuits 35 in such a way that, after the populated printed circuits 35 have been fitted into the module housing 32, said cutouts are axially aligned with one another. In this case, the two cutouts 40, 41 which are arranged diametrically opposite one another are used for the traction cables 26, 27 to pass through the electronic module 28, and the other cutouts 42 are used to pass electrical lines 31 through, for the connection of the channels of the electronic modules 28.

During assembly of the acoustic section 121, the skeleton is produced in such a way that each electronic module 28 is hooked into the two traction cables 26, 27, and each channel of the electronic module 28 is connected to the electrical lines 31. For this purpose, the traction cables 26, 27 are inserted into the cutouts 40, 41, and the electrical lines 31 are inserted into the cutouts 42, in the populated printed circuits 35 in the electronic module 28. The module housing 32 is then closed by placing the two housing shells 321, 322 one on top of the other, with the edges of the populated printed circuits 35 engaging in an interlocking manner in the grooves 36 in the housing shells 321, 322. The module housing 32 then has the two circumferential plastic strips 33 fitted to it, which

are each inserted into the annular grooves 43 on the upper face of the module housing 32. All the electronic modules 28 are fixed, such that they cannot move axially, via the module housing 32 on the traction
5 cables 26, 27, although this is not illustrated in any more detail in Figure 4. The axial separation between the electronic modules 28 is chosen such that the axial separation between the mutually facing transducers 29 of two successive electronic modules 28 in the skeleton
10 is equal to the transducer separation between the two transducers 29 which are integrated in the electronic module 28. The empty space 44 between two adjacent electronic modules 28 is used for strain relief for the electrical lines 31, by routing them in the empty space
15 41 such that, in the next electronic module 28, they are located in physically differently located cutouts 42 in the populated printed circuits 35 of the electronic module 28. By way of example, the exemplary embodiment illustrated in Figure 4 shows, for this
20 situation, that the lines 31 which can be seen in successive electronic modules 28 run in cutouts 42, which are diametrically opposite one another, in the populated printed circuits 35.

25 Since the number of populated printed circuits 35 which are used to provide the electronic modules 34, and the axial separation between them and, otherwise, the size of the module housing 32 can also be varied, the separation between the two transducers 29 which are
30 associated with one electronic module 28 can be chosen to correspond to a desired transmission or reception frequency of the acoustic section 121, and can also be sufficiently small that the reception frequency of the acoustic section 121 can be shifted to the
35 higher-frequency range. The separation between two electronic modules 28 must then in turn be chosen to correspond to the separation between the two transducers 29 which are integrated in one electronic

module 28, in such a way that all the transducers 29 in the acoustic section 121 are separated from one another by the same axial distance.

5 In one alternative embodiment of the acoustic section 121, the transducers 29 are not placed on the longitudinal axis of the flexible tube 25, as in the case of the exemplary embodiment illustrated in Figures 3 and 4, but are arranged at a radial distance from the
10 longitudinal axis, on the two outer populated printed circuits 35 of the individual electronic modules 28. Each transducer 29 is in this case also formed by a single hydrophone. All the transducers 29 within the acoustic section 121 are offset with respect to one
15 another through a circumferential angle, with the offset angle being different, and with the sequence of the offset being chaotic. An acoustic section 121 such as this allows clear distinction between a port or starboard position of the target when finding the
20 bearing of a target. The signal processing for transducer placing such as this along the flexible tube 25 is described, for example, in DE 44 45 549 C1.

The modified rigid-flexi printed circuit, which can be
25 seen in the form of a plan view in the initial fitting state in Figure 7, of the electronic module 28 differs from the rigid-flexi printed circuit illustrated in Figure 5 only in that each electroacoustic transducer
45 which is arranged on the two outer populated printed
30 circuits 35 has three omnidirectional transducer elements 451, 452 and 453, which are placed at the corner points of an equilateral triangle on the printed circuit level. Each electroacoustic transducer element
451, 452, 453 is formed by means of a hydrophone. The
35 components of the electronic assembly are arranged on the separate printed circuits that are connected to one another, and are each associated with one of the two electroacoustic transducers 45. In addition, an

orientation sensor (not illustrated) is also integrated in the electronic module 28. In each of the electronic assemblies which are associated with one transducer 45, the output signals from in each case two transducer element pairs of the transducer elements 451, 452 and 453 are emitted as output signals from the transducer 45, which output signals are passed, as in the case of the exemplary embodiment in Figures 3 to 6, via the output as digitized signals to the electrical lines 31.

5 The respective pair of transducer elements 451, 452, 453 is governed by the output signal from the orientation sensor. Each electronic assembly thus has two outputs or channels, and each electronic module 28 is thus formed with four channels and is connected via

10 the four channels to the lines 31. The two pairs of transducer elements each create one transducer 45 with a cardioid directional characteristic, which has a null point on one side of the connecting line between the transducer elements in the transducer pair, with the

15 null point in the case of one pair of two of the three transducer elements pointing to one side, and in the case of the other pair of two of the three transducer elements pointing to the other side, of the connecting line. A configuration such as this of the

20 electroacoustic transducer 45 on the two mutually averted end faces of the electronic module 28 makes it possible to distinguish unambiguously between port and starboard bearings when determining the bearings of targets. An exemplary embodiment for the signal

25 processing of the output signals from the transducer element pairs is described in DE 31 51 028 A1 (Figure 9).

In one alternative embodiment of the acoustic section,

35 it would be possible to arrange the two transducers separately on both faces of the electronic module, rather than integrating them in the electronic module. In this case as well, the advantage of design with

short separations between transducers and the high reception and/or transmission frequency of the underwater antenna associated with this could then be achieved by the combination of the channels of two
5 adjacent electroacoustic transducers.

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PATENT CLAIMS

1. An acoustic underwater antenna having
electroacoustic transducers (29), which are arranged in
one or more rows at a fixed distance from one another,
10 having electronic assemblies, which are associated with
the transducers (29), for signal processing of the
electrical transducer signals, and having an antenna
casing which surrounds the transducers (29) and the
electronic assemblies, characterized in that two
15 electronic assemblies which are associated with
adjacent transducers (29) are in each case combined in
one electronic module (28) which is in the form of a
molding supported on the antenna casing and is fitted
on each of its two mutually averted free module faces
20 with one of the two adjacent transducers (29), and in
that the electronic modules (28) are fixed, such that
they cannot move axially, on traction cables which run
parallel to the module axis, preferably on two traction
cables (26, 27) which are arranged diametrically
25 opposite with respect to the module axis.

2. The underwater antenna as claimed in claim 1,
characterized in that the electronic module (28) has at
least two printed circuits (35) which are fitted with
30 electronic components (38), are aligned transversely
with respect to the module axis, and are each fitted
with one of the two transducers (29) on a board surface
which points outwards.

35 3. The underwater antenna as claimed in claim 2,
characterized in that a flexible strip (39), which
contains conductor tracks, leads from the printed
circuit (35) to the printed circuit (25).

4. The underwater antenna as claimed in claim 2 or 3, characterized in that the conductor tracks (35) have groove-like cutouts (40, 41, 42), which are arranged distributed over the circumference at the edge, for the traction cables (26, 27) and electrical lines (31) to pass through.

5. The underwater antenna as claimed in one of claims 2 to 4, characterized in that the electronic module (28) has a module housing (32) which is in the form of a molding, is composed of two housing halves and is open at one end, and in that the printed circuits (35) are held in an interlocking manner at the edge in grooves (36), which are axially separated from one another, in the module housing (32).

6. The underwater antenna as claimed in claim 5, characterized in that the antenna casing has a circular cross section, the printed circuits (35) are circular, and the housing halves of the module housing (32) are semicircular housing shells (321, 322).

7. The underwater antenna as claimed in claim 5 or 6, characterized in that each electronic module (28) is supported on the antenna casing via plastic strips (33) which are inserted into two annular grooves (43), which are separated from one another in the module housing (32) and are externally circumferential, and project radially beyond the outer face of the module housing (32).

8. The underwater antenna as claimed in one of claims 1 to 7, characterized in that the electroacoustic transducers (29) lie on the module axis.

9. The underwater antenna as claimed in one of claims 1 to 7, characterized in that the electroacoustic

transducers (29) are arranged at a radial distance from the module axis and are offset with respect to one another through a circumferential angle, and in that electronic modules (28) which follow one another in the antenna casing are rotated with respect to one another such that all the electroacoustic transducers (29) are aligned offset through the circumferential angle with respect to one another.

10 10. The underwater antenna as claimed in one of claims 1 to 7, characterized in that each electroacoustic transducer (45) has three omnidirectional transducer elements (451, 452, 453), which are arranged at the same radial distance from the module axis and offset
15 through the same circumferential angle with respect to one another.

11. The underwater antenna as claimed in one of claims 1 to 10, characterized in that the antenna casing is a
20 flexible tube (25).

12. The underwater antenna as claimed in claim 11, characterized in that the underwater antenna forms at least one acoustic section (121) of a towed-array
25 antenna (10) which can be towed in the water.

13. The underwater antenna as claimed in one of claims 1 to 12, characterized in that the underwater antenna forms at least one acoustic section (121) of a vertical
30 antenna (11) which is arranged aligned vertically in the water.