

**RECOVERY METHOD FOR RECOVERING AN UNDERWATER
VEHICLE, RECOVERY DEVICE, SUBMARINE WITH RECOVERY
DEVICE, UNDERWATER VEHICLE FOR THIS PURPOSE, AND
SYSTEM EQUIPPED THEREWITH**

The invention relates to a recovery method for recovering an underwater vehicle by means of a recovery device for a submarine. The invention further relates to this recovery device and to a submarine with the recovery device. Additionally,
5 the invention relates to the underwater vehicle and to a system with the recovery device or with the submarine and with the underwater vehicle.

As a rule, underwater vehicles that are repeatedly usable for missions are recovered after completion of their respective mission. To this end, it is well known to
10 let the underwater vehicle float to the surface of a water body where it is captured and lifted on board of a surface ship by means of a crane.

It is further known to recover underwater vehicles in the water, or rather under the surface of a water body by means of a submarine. To this end, a separate
15 surface ship must be provided. This is more specifically advantageous when the underwater vehicle has been launched by means of an underwater vehicle or needs to be launched for a subsequent mission. In addition, in contrast to recovery at the surface of the water body, recovering the vehicle in the water is not complicated by swell at the surface of the water body.

20 The problem underlying the invention consists in improving the recovery of an underwater vehicle in the water.

The invention solves this problem with a recovery method according to claim 1,
25 with a recovery device according to claim 12, with a submarine according to claim 13, with an underwater vehicle according to claim 14 and with a system according to claim 15.

The underwater vehicle is more specifically an unmanned underwater vehicle, preferably an autonomous underwater vehicle (AUV). However, the invention is also adapted for recovering remotely operated vehicles (ROV).

5 In order to allow for a precise approach of the underwater vehicle to the docking device, the invention provides sensing waves propagating from several markings toward at least one sensor between the underwater vehicle and the docking device. The waves are or comprise more specifically light waves, i.e. for example visible light. Alternately or additionally, the light waves are or comprise more specifically sound waves that are preferably actively generated by a sonar device.
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By sensing the waves, or rather by means of signals or data thus obtained, the disposition of the recovery device and the underwater vehicle relative to each other is determined more specifically by means of a computing device. Particularly
15 ly the positions and the orientations of the recovery device and the underwater vehicle relative to each other are determined. Thereby, the direction, orientation and distance between the recovery device and the underwater vehicle or of the underwater vehicle relative to the recovery device are determined.

20 The invention allows for a precise approach of the AUV to the docking device of the recovery device on a course that lets the underwater vehicle land on the docking device from an appropriate angle and reduces the risk of unintended collisions with parts of an equipment carrying the recovery device, more specifically with a tower of submarine carrying the recovery device.

25 According to an advantageous embodiment of the invention, the total propagation of the waves from their source, i.e. for example a light source or active sonar, to the sensor that ultimately senses the waves comprises a propagation of the waves from the underwater vehicle to the recovery device. Thus, an arrangement
30 of the source on the recovery device and of the sensor on the underwater vehicle with a propagation of the waves only from markings on the recovery device to the underwater vehicle is not provided in this specific embodiment of the invention.

According to an advantageous embodiment, the markings serving as reflectors
35 reflect the waves from their source to the sensor. The source of the waves and

the sensor are more specifically disposed on the underwater vehicle and the markings on the recovery device. Alternately the source and the sensor are disposed the other way around on the recovery device and the markings on the underwater vehicle. A propagation of the waves from the underwater vehicle to the recovery device takes place in any case, namely either from the source disposed on the underwater vehicle to the markings disposed on the recovery device or from the markings disposed on the underwater vehicle to the sensor disposed on the recovery device. Arranging the source of the waves and the sensor together on the underwater vehicle or together on the recovery device is advantageous in that the source and the sensor can be operated in a coordinated manner without an additional data exchange between the underwater vehicle and the recovery device.

According to another preferred embodiment, the markings acting as a source actively generate the waves. According to this embodiment, the markings are for example light sources such as lamps or lasers or active sound sources, more specifically active sonars or installations for generating underwater sound signals. The markings configured as source of the waves can be provided alternately or in addition to the markings configured as reflectors of the waves.

The markings, and thus the source of the waves can be provided on the underwater vehicle, whereas the sensor is disposed on the recovery device. In that case, the propagation of the waves takes place from the underwater vehicle toward the recovery device. The underwater vehicle has for example several light sources that are captured by means of a camera of the recovery device comprised in the sensor.

Designing the markings as a source is advantageous in that the waves are emitted with high intensity, wherein the direction of the emission can also be favorably adjusted if required. Arranging the sensor on the recovery device is advantageous in that the determination of the disposition of the underwater vehicle and the recovery device relative to each other or rather of their relative positions and orientations can be carried out by the powerful computing devices already provided as a rule on the recovery device or on the submarine. In addition, the data or signals of the sensor can be combined if necessary with other data or signals

that are available due to the comprehensive sensor equipment provided on board the submarine. In that case, it is advantageous that only control signals need to be transmitted to the underwater vehicle, in order to guide the underwater vehicle toward the docking device.

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According to another advantageous embodiment, the markings designed either as a source and/or as reflectors of the waves are featured on the recovery device, the waves being sensed by the underwater vehicle.

10 According to a development of this embodiment several markings provide a path, more specifically in the manner of a runway marking, along which the underwater vehicle orients itself and is thus guided toward the docking device. For example, the markings are disposed individually or in pairs next to each other and in a row preferably on the deck of the submarine featuring the recovery device. In this
15 manner, the underwater vehicle is safely guided to the docking device.

According to an alternative embodiment, the markings are featured on the underwater vehicle. According to this embodiment, the waves are sensed on the recovery device.

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According to a preferred embodiment, the waves comprise or are light waves. According to another embodiment, the waves comprise or are sound waves, more specifically of a sonar device.

25 According to a particular embodiment, the position determination means for determining the disposition or rather the position and/or the orientation of the recovery device and the underwater vehicle relative to each other use previous knowledge about a known disposition of at least two markings. Based on the knowledge of the distance or of the orientation of the underwater vehicle relative
30 to the recovery device, different bearing angles allow determining their distance or orientation, respectively. In order to determine the relative disposition, the invention even preferably uses at least three markings that are not disposed on the same straight line and whose disposition relative to each other is known, in order to be able to determine the distance as well as the orientation and thus to be able

to carry out a complete determination of the positions and orientations of the underwater vehicle and the recovery device relative to each other.

According to another preferred embodiment, the invention uses at least four
5 markings that are not disposed in a common plane in order to simplify the determination or to increase its accuracy.

According to an advantageous embodiment, the sensor of the recovery device features a camera, a picture or an image of the markings being created by
10 means of the camera. More specifically, a spatial image of the markings is created, so that the disposition, or rather the positions or the orientations of the recovery device and the underwater vehicle relative to each other can be deduced from this image, more specifically when the orientation of the camera fastened on the underwater vehicle relative to the underwater vehicle, respectively of the
15 camera fastened to the recovery device relative to the recovery device is known.

According to a preferred embodiment, the camera is an optical camera. According to another embodiment, the camera is an acoustic camera that generates an image based on underwater sound signals. In order to increase the accuracy and
20 to be on the safe side in case a system should fail, the determination of the positions and orientations of the waves can take place optically as well as acoustically and, if necessary, also magnetically. Thus, the sensor can comprise an optical camera as well as an acoustic camera and if necessary a magnetic sensor.

25 According to a preferred embodiment, the underwater vehicle maneuvers toward a garage of the recovery device featuring the docking device or of a submarine featuring the recovery device by means of the determined disposition, or rather the positions and orientations of the recovery device and the underwater vehicle relative to each other. Thereby, the underwater vehicle can dock on the docking
30 device either within a garage or the docking device can be alternately designed in such a manner that it extends out of the garage, that the underwater vehicle docks on the docking device outside of the garage and is subsequently pulled into the garage by means of the docking device. In both cases, the underwater vehicle is received in the garage, or rather enters the garage or is pulled into the
35 garage. The garage allows for a safe accommodation of the underwater vehicle,

more specifically on a submarine. The garage is advantageously disposed at the bow of the submarine, more specifically at a distance from a tower of the submarine.

5 The underwater vehicle can approach the docking device above the hull of the submarine between the tower and the garage. According to a particular embodiment, however, the underwater vehicle approaches the garage from the side of the submarine. The lateral approach reduces the risk of collisions between the underwater vehicle and superstructures of the submarine.

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According to a preferred embodiment, the underwater vehicle takes a bearing to the recovery device or the recovery device takes a bearing to the underwater vehicle, which is merely horizontal and not vertical or takes a vertical bearing only below a predetermined minimum distance between the underwater vehicle and
15 the recovery device. In this case, taking a bearing allows determining a horizontal position of the underwater vehicle and the recovery device relative to each other, respectively determining a bearing angle and a distance.

In order to determine the vertical position of the recovery device and the underwater vehicle relative to each other, it is preferable to compare the diving depths
20 of the recovery device, or rather of the submarine with the recovery device, and of the underwater vehicle. The diving depth of the underwater vehicle as well as preferably the diving depth of the recovery device, or rather of the submarine is advantageously determined by measuring the water pressure. A sufficiently precise determination of the position, or rather of the relative positions in the vertical
25 direction is thus possible. The vertical position determined in this manner is preferably used for determining the disposition of the underwater vehicle and the recovery device relative to each other, so that only the horizontal position needs to be determined by taking a bearing.

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The recovery device according to the invention and the underwater vehicle according to the invention respectively feature the means attributed to the recovery device or to the underwater vehicle for implementing the recovery method according to the invention. In doing so, the recovery device and the underwater
35 vehicle cooperate.

The submarine according to the invention features the recovery device according to the invention.

- 5 The system according to the invention features the recovery device, or rather the submarine with the recovery device as well as the underwater vehicle.

Further embodiments of the invention can be gathered from the claims and from the exemplary embodiments described in more detail based on the drawings.

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Fig. 1 shows a lateral view onto a system with a submarine having a recovery device and with an underwater vehicle approaching the recovery device according to a first exemplary embodiment of the invention;

- 15 Fig. 2 shows a lateral sectional representation of the underwater vehicle and the recovery device according to the first exemplary embodiment of fig. 1, the underwater vehicle being received in the recovery device;

20 Fig. 3 shows a perspective view onto a system with a submarine having a recovery device and with an underwater vehicle approaching the recovery device according to a second exemplary embodiment of the invention;

25 Fig. 4 shows a lateral view onto a system with a submarine having a recovery device and with an underwater vehicle approaching the recovery device according to a third exemplary embodiment of the invention;

Fig. 5 show a lateral view onto a system with a submarine having a recovery device and with an underwater vehicle approaching the recovery device according to a fourth exemplary embodiment of the invention and

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Fig. 6 shows a recovery method for recovering the underwater vehicle by means of a recovery device according to an exemplary embodiment of the invention.

Fig. 1 shows a system 2 with a recovery device 4, or rather with a submarine 6 that is only partially shown and features the recovery device 4, as well as with an unmanned underwater vehicle 8 exemplarily designed as an autonomous underwater vehicle (AUV). The recovery device 4 serves to recover the underwater vehicle 8 in the water or under the surface of the water. Thereby, the underwater vehicle 8 automatically maneuvers toward the recovery device 4 and docks on that recovery device 4. To this end, the recovery device 4 has a docking device 10.

The recovery device 4 further comprises a transponder 12 attached to the body of the submarine 6 as well as a first emitter 14, the transponder 12 and the first emitter 14 being parts of an underwater navigation system together with a second emitter 16 disposed on the underwater vehicle 8 and several transducers 17 disposed on the underwater vehicle 8.

In addition to a drive and a controller, the underwater vehicle 8 further has an active sonar device 20 as a source 18 of waves 19 or rather an active source of sonar waves or rather underwater sound waves 21. The underwater vehicle 8 additionally has an acoustic camera 22 that is part of a sensor 24 and has computing means 26, in addition to hydrophones 25, that process data or signals from the hydrophones 25. The underwater vehicle 8 finally has a water pressure sensor 28, by means of which the diving depth of the underwater vehicle 8 can be determined based on the water pressure.

The sonar waves 21 emanating from the active sonar 20 are shown only in the vicinity of the underwater vehicle 8 but they also reach the recovery device 4. The sonar waves or underwater sound waves 21 encounter markings 32 on the recovery device 4 designed as reflectors. The markings 32 are exemplarily disposed at free ends of guide rails 34 of the docking device 10. The markings are more specifically disposed on two guide rails lying next to each other in a horizontal plane and, in a mirror image, on the left and right side of a centering axis Z, around which the guide rails 34 are disposed in a radially symmetrical manner, the guide rails 34, which form a funnel 36 being spread open relative to the centering axis Z. The guide rails 34 are flexible and therefore able to guide the underwater vehicle 8 after contact without damage into the docking device 10 or to

a negative shell 38 or to coupling means of the docking device 10 for coupling the underwater vehicle 8 with the docking device 10.

The guide rails 34 are fastened to the negative shell 38, which is displaceable in the direction of the centering axis Z. The shape of the negative shell 38 is adapted to the bow of the underwater vehicle 8. Once contact has been established between the underwater vehicle 8 and the negative shell 38, the negative shell 38 can be displaced together with the underwater vehicle 8 along the centering axis Z. The displacement can thereby occur by means of a motor or a hydraulic system. Alternately or additionally, the underwater vehicle 38 can provide for the displacement. During the displacement, the guide rails 34 are pulled through a guiding ring 40, which presses the guide rails against the underwater vehicle 8, or rather in the direction of the centering axis Z and thus closes the funnel 36, so that the underwater vehicle 8 is centered along the central axis Z. The underwater vehicle 8 is thus enclosed by the guide rails 34 and is held or fixed in its position.

Fig. 2 shows the recovery device 4 of the first exemplary embodiment according to fig. 1 together with the underwater vehicle 8 received by the recovery device 4. The underwater vehicle 8 is docked on the docking device 10, or rather mechanically connected to the docking device 10 and is held by guide rails 34 oriented substantially parallel to the longitudinal axis of the underwater vehicle 8. In the shown exemplary embodiment of the recovery device 4, the underwater vehicle 8 is disposed at a distance from a body of the submarine 6, after having been received by the docking device 10. However, alternative exemplary embodiment are conceivable according to which the negative shell 38 is guided in the area of the body of the submarine 6, is disposed within an outer hull of the submarine 6 or can be pivoted relative to this outer hull. Alternative embodiments of the docking device 10, e.g. without the negative shell 38, can also be provided.

Fig. 3 shows a system 2' with a docking device 4' of a submarine 6' and with an underwater vehicle 8'. Instead of the docking device 10 of the first exemplary embodiment according to fig. 1, a garage 42 with a docking device 10' for docking or coupling the underwater vehicle 8' or for receiving the underwater vehicle 8' on board the submarine 6' is provided. The garage 42 is part of the recovery

device 4' and comprises a gate or an opening 44 through which the underwater vehicle 8' can enter the garage 42, or rather a space of the garage 42 enclosed by walls and flooded. Markings 32' are disposed on both sides of the opening 44. As opposed to the markings 32 of the first exemplary embodiment of fig. 1, these markings are not designed as reflectors but as active sources 18', more specifically as light sources 46 for actively emitting waves 19, more specifically for actively emitting light. Other light sources or lamps 47 are disposed in pairs, preferably at regular intervals, in front of the garage 42 on the outer hull of the submarine 6' in the manner of runway markings 48.

The docking device 10' can be configured similarly to the docking device 10 according to figures 1 and 2. The docking device 10' alternately comprises nozzles for example for generating a positioning current, which positions or rather centers the underwater vehicle 8' during its entry into the garage 42.

The underwater vehicle 8' comprises an optical camera 49 as part of a sensor 24', preferably at its bow, by means of which the light sources 46 and 47 can be optically detected in order to guide the underwater vehicle 8' along an intended heading into the garage 42 or rather toward the docking device 10'.

Fig. 4 shows a lateral view onto a system 2'' with a recovery device 4'' of a submarine 6'' and with an underwater vehicle 8''. The submarine 6'' has a tower 50. A garage 42' of the recovery device 4'' is disposed at the bow 52 in front of the tower 50 on the deck of the submarine 6''. The source 18 with an active sonar 20' and the sensor 24'' with an acoustic camera 22' are also associated to the recovery device and the garage 42'. The underwater vehicle 8'' has several markings 32'' that are designed as reflectors 30', more specifically as sonar reflectors, or that comprise reflectors 30'.

The active sonar 20', the markings 32'' and the acoustic camera 22' cooperate during the approach of the underwater vehicle 8'' onto the garage 42'. The active sonar 20' thereby emits underwater sound signals, which impinge on the reflectors 30', are reflected by these reflectors 30' and are eventually sensed by means of the acoustic camera 22' in such a manner that an image of the reflectors 30', or rather of the markings 32'' is created by means of the recovery device 4'',

more specifically by means of a computing device of this recovery device 4". The disposition of the underwater vehicle 8" and the recovery device 4" relative to each other is determined based on this image. More specifically, the positions of the underwater vehicle 8" and the recovery device 4" are determined, the orientation of the underwater vehicle 8" relative to the recovery device 4" being also determined.

In a variant of the shown exemplary embodiment, the source 18 can alternately or additionally have a spotlight and the sensor 24" can comprise an optical camera or light sensors. In that case, the markings 24" are or include light reflectors.

Fig. 5 shows a lateral view onto a system 2''' with a recovery device 3''' of a submarine 6''' together with an underwater vehicle 8". The exemplary embodiment according to fig. 5 differs from the exemplary embodiment according to fig. 4 in that on the one hand markings 32''' on the underwater vehicle 8''' are designed as light sources 46', which therefore actively generate light and must therefore be considered as sources 18 of waves 19 as defined by the invention. On the other hand, the recovery device 4''' is disposed behind the tower 50 or at the stern of the submarine 6'''. The recovery device 4''' comprises an optical camera 49', by means of which the recovery device 4''' creates an image of the markings 32''' and can determine the positions and orientations of the underwater vehicle 8''' and of the submarine 6''' or rather the recovery device 4''' relative to each other.

The figs. 1-5 merely exemplarily illustrate possible embodiments of the invention. In addition, any combination of the systems 2, 2', 2" and 2''' are possible, wherein a combination 32''' of light and underwater sound can also be provided for determining the positions and/or the orientations of the underwater vehicle 8, 8', 8", 8''' and of the recovery device 4, 4', 4" and 4''' relative to each other. Thereby, the markings 32, 32', 32" can be designed as reflectors or as sound or light sources.

Fig. 6 shows a simplified block diagram for illustrating a recovery method 53 according to an exemplary embodiment of the invention. The recovery method 53 begins with a step 54 during or before a mission to be carried out by an underwater vehicle, more specifically the underwater vehicle 8, 8', 8", 8''' according to one of the exemplary embodiments 1-4 of figs 1-5. In the following, when reference is

made to apparatus features of the systems 2, 2', 2" and 2''' according to figures 1-5, the reference numbers are used without prime symbols for simplification, e.g. 32 for the markings 32, 32', 32" and/or 32'''.

5 According to a step 56, a time and place are determined for a meeting of the underwater vehicle 8 and the recovery device 4. This can occur before carrying out the mission, the time and place being stored in a mission plan on board the underwater vehicle 8 by means of storage means of the underwater vehicle 8. Alternately or additionally, the underwater vehicle 8 can receive data during its mission that appoints a place and/or a time for such a meeting, for example by
10 means of underwater signals. The underwater vehicle 8 can more specifically receive an abort signal for aborting its mission. If necessary, such an abort signal overwrites a place and/or time previously defined in the mission plan with a new place or time.

15 As soon as the underwater vehicle 8 has received the abort signal or aborts its mission in order to reach the defined place at the appointed time, the underwater vehicle 8 establishes an acoustic contact with the recovery device 4 or rather the submarine 6 according to a step 58. According to a step 60 a subsequent approach of the underwater vehicle 8 onto the recovery device 4 takes place. As
20 soon as the underwater vehicle 8 has reached the recovery device 4, this underwater vehicle 8 docks onto the recovery device 4 or rather on the docking device 10 of the recovery device 4 according to a step 62. The end of the method as shown is thus achieved in a step 64.

25 In the following, the approach of the underwater vehicle 8 onto the recovery device 4 according to step 60 is described in more detail. Step 60 includes a step 66, according to which the direction, or rather the bearing angle of the recovery device 4 relative to the underwater vehicle 8 or of the underwater vehicle 8 relative to the recovery device 4 as well as the distance of the recovery device 4 and
30 the underwater vehicle 8 relative to each other are determined during the approach. Thereby, according to a step 68 the recovery device 4 or the underwater vehicle 8 takes a bearing of the underwater vehicle or the recovery device, respectively, in a merely horizontal direction. More specifically, a horizontal direction is determined according to a step 70 and a distance according to a step 72.
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The direction is preferably determined by means of a direction finder, more specifically a so-called USBL (Ultra Short Base Line) direction finder, which comprises several converters, or rather transducers. The distance is determined according to step 72 preferably by means of transponder signals, preferably by means of a USBL modem, which is preferably also used for data transmission.

The vertical position of the recovery device 4 and the underwater vehicle 8 relative to each other is determined according to a step 74 by first measuring the water pressure on the underwater vehicle 8 according to a step 76, by determining the resulting diving depth of the underwater vehicle 8 according to a step 78, and by subsequently comparing the diving depths of the underwater vehicle 8 and of the recovery device 4, or rather the submarine 6 according to a step 80. Thereby, the diving depth of the submarine 6 or of the recovery device 4 can also be determined by determining the water pressure in its respective environment or in another way. In order to compare the determined diving depth, data, or rather signals with the appropriate information are exchanged between the recovery device 4 and the underwater vehicle 8.

The recovery device 4, or rather the submarine 6 with the recovery device 4 can move during the approach of the underwater vehicle 8 onto the recovery device 4. Alternately however it can be advantageous for the submarine 6 to stay stationary or motionless in the water while the underwater vehicle 8 approaches the submarine 6, more specifically in order to avoid a collision of the underwater vehicle 8 with the tower 50 of the submarine 6.

The disposition or rather the positions and orientations of the underwater vehicle 8 and the recovery device 4 relative to each other are determined according to step 82. This takes place for example by means of light and sight, the markings 32 being designed as active light sources 46, 47 or light markings designed as reflectors 30, which are detected by means of the optical camera 49. Thereby, the camera 49 can be provided either on the recovery device 4 or on the underwater vehicle 8. If required, the markings 32 are also used for determining the elevation, several of these markings 32 being disposed in different heights on the underwater vehicle 8 or on the recovery device 4.

Alternately or additionally, the disposition or rather the relative positions and orientations are determined by means of the active sonar 20, which is preferably provided on the underwater vehicle 8 and is designed in this case as a so-called
5 "Forward Looking Sonar", which looks forward from the bow of the underwater vehicle 8 or rather receives waves 19 from the front. In this case, the markings 32 are configured as sonar reflectors that are disposed preferably left and right of the garage 42 as well as above the garage, more specifically for determining the vertical distance.

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Alternately or additionally, bearings are taken acoustically and an acoustic camera 22 is provided on the recovery device 4 or on the underwater vehicle 8. In addition, the bearings as well as the distance are preferably determined in a high resolution, more specifically when the distance between the underwater vehicle 8
15 and the recovery device 4 is below a maximum distance.

Step 82 includes a block 84 in which a source 18, more specifically a sound or light source 20 generates waves 19, more specifically sound waves 21 or light according to a step 86, these waves 19 being reflected by the markings 32 according to a step 88. Alternately, according to a step 90, the markings 32 are the
20 source 18, which actively generates the waves 19. Depending on whether the markings 32 are designed as sources 18 or as reflectors 30, the total propagation of the waves 19 extends from the source 18 to the markings 32 and back to the sensor 24 or from the markings 32 to that sensor 24. This total propagation preferably includes a propagation of the waves 19 from the underwater vehicle 8 to
25 the recovery device 4, as illustrated in a step 94.

The block 84 is followed by a sensing of the waves 19 according to a step 96, the waves 19 being sensed either on the underwater vehicle 8 according to a step 98
30 or on the recovery device 4 according to a step 100. An image of the markings 32 is created based on the data or signals thus sensed according to a step 102.

The step 82 or 102 is followed by a step 104 in which the underwater vehicle 8 is guided to the docking device 10 or rather to the garage 42 of the recovery device

4 by means of the determined disposition, or rather positions and orientations of the underwater vehicle 8 and the recovery device 4 relative to each other.

5 The subsequent docking according to step 62 preferably comprises a mechanical capture of the underwater vehicle 8 by means of the guide rails 34 spread open to form the funnel 36, which guide the underwater vehicle toward the negative shell 38, the guide rails 34 subsequently clasping or fixing the underwater vehicle 8 by closing the funnel 36 by pushing the guide rails 34 through the guide ring 40.

10 All the features mentioned in the above description and in the claims are usable individually and in several combinations. Therefore, the disclosure of the invention is not limited to the described or claimed feature combinations. Rather, all the feature combinations must be considered as disclosed.

Claims

1. A recovery method for recovering an underwater vehicle (8) by means of
5 a recovery device (4) for a submarine (6), which comprises a docking de-
vice (10) for docking the underwater vehicle (8), wherein waves (19),
more specifically light waves and/or sound waves (21), which propagate
between the underwater vehicle (8) and the recovery device (4) from sev-
eral markings (32) toward at least one sensor (24), are sensed (96) for a
10 precise approach (60) of the underwater vehicle (8) onto the docking de-
vice (10) and a disposition, more specifically the positions and orienta-
tions, of the recovery device (4) and the underwater vehicle (8) relative to
each other is determined thereby (82), wherein the source (18) of the
waves (19) is related to the underwater vehicle (8) or the submarine (6);
15 wherein a total propagation of the waves (19) from their source (18) to the
sensor (24) comprises a propagation of the waves (19) from the underwa-
ter vehicle (8) to the recovery device (4); and wherein the source of waves
and the sensor are arranged together on the underwater vehicle or
together on the recovery device.
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2. The recovery method according to claim 1, wherein the markings (32)
designed as reflectors (30) reflect (88) the waves (19) from their source
(18) to the sensor (24).
- 25 3. The recovery method according to one of the afore-mentioned claims,
wherein the markings (32) designed as a source (18) of the waves (19)
actively generate (90) the waves (19).
4. The recovery method according to one of the afore-mentioned claims,
30 wherein the recovery device (4) features the markings (32) and the waves
(19) are sensed (98) on the underwater vehicle (8).
5. The recovery method according to claim 4, wherein several markings (32)
specify a path, more specifically in the manner of runway markings (48),

along which the underwater vehicle (8) orients itself and is thereby guided toward the docking device (10).

- 5 6. The recovery method according to one of the claims 1-3, wherein the underwater vehicle (8) features the markings (32) and the waves (19) are sensed (100) on the recovery device (4).
- 10 7. The recovery method according to one of the afore-mentioned claims, wherein previous knowledge about a known disposition relative to each other of at least two, more specifically at least three markings (32) not disposed on a common straight line or at least four markings not disposed in the same plane is used to determined the disposition of the recovery device (4) and the underwater vehicle (8) relative to each other.
- 15 8. The recovery method according to one of the afore-mentioned claims, wherein a more specifically spatial image of the markings (32) is generated by means of a more specifically optical and/or acoustic camera (49, 22) of the sensor (24) and this image is used for determining the disposition of the underwater vehicle 8 and the recovery device 4 relative to each other.
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9. The recovery method according to one of the afore-mentioned claims, wherein the underwater vehicle (8) maneuvers toward a garage (42) of the recovery device (4) featuring the docking device (10) by means of the
25 determined disposition of the recovery device (4) and the underwater vehicle (8) relative to each other and is received in the garage (42).
- 30 10. The recovery method according to one of the afore-mentioned claims, wherein in order to determine (74) the vertical position of the recovery device (4) and the underwater vehicle (8) relative to each other, the diving depths of the recovery device (4), more specifically of a submarine (6) with the recovery device (4), and of the underwater vehicle are compared (80), the diving depth of the underwater vehicle (8) being determined by measuring (76) the water pressure, and the determined vertical position is

used for determining the disposition of the recovery device (4) and of the underwater vehicle (8) relative to each other.

- 5 11. A recovery device with means for implementing the recovery method (53) according to one of the afore-mentioned claims by cooperating with an underwater vehicle (8).
12. A submarine with the recovery device according to claim 11.
- 10 13. An underwater vehicle with means for implementing the recovery method (53) according to one of the claims 1-10 by cooperating with a recovery device (4) according to claim 11, or with a submarine (6) according to claim 12.
- 15 14. A system with a recovery device (4) according to claim 11, or with a submarine (6) according to claim 12, with a recovery device (4), and with an underwater vehicle (8) according to claim 13, wherein the recovery device (4) and the underwater vehicle (8) are configured in such a manner that they can cooperate in order to implement the recovery method (53) according to one of the claims 1 to 10.
- 20