

Underwater cable winch for coupling and/or uncoupling an
unmanned underwater vehicle, and underwater garage and
underwater vehicle

5 [01] The invention relates to an underwater cable winch for
coupling and/or uncoupling an unmanned underwater vehicle to a
winch cable end of a winch cable with a control device
associated with a winding device, the winch cable, and a
coupling device, wherein the coupling device is arranged at the
10 winch cable, as well as an underwater garage and an
(under)water vehicle.

[02] In modern reconnaissance scenarios, as well as in the
monitoring of undersea systems, the recovery of an exposed
unmanned underwater vehicle, such as an ROV (remotely-operated
15 vehicle) or an AUV (autonomous underwater vehicle), poses a
significant problem. In some cases, such an unmanned underwater
vehicle is first brought to the surface of the water, so that
it can then be recovered with a crane or some other device. In
so doing, the manned water vehicle must often adjust its course
20 and interrupt its usual journey.

[03] Furthermore, attempts are made to capture an unmanned
underwater vehicle under water. However, particularly when a
submarine is moving, the problem is that the moving speed of
the submarine is too fast for a stern-side approach, since the
25 unmanned underwater vehicle is not able to reach the submarine
because its drive system is too slow.

[04] It is also not possible to capture the underwater
vehicle on the bow side, due to the fact that the submarine
approaches the unmanned vehicle at too high a speed, and a
contact speed is too high and leads to damage. Moreover, the
30 unmanned vehicle must first be captured, usually in the
vicinity of its drive system, which means that the capture
routines have to be technically complicated because, for
example, the unmanned water vehicle's sonar cannot be used,

and the control and driving power must come from the submarine.

[05] The object of the invention is to improve the state of the art.

5 [06] The object is achieved by an underwater cable winch for coupling and/or uncoupling an unmanned underwater vehicle to a winch cable end of a winch cable with a control device associated with a winding device, the winch cable, and a coupling device, wherein the coupling device is arranged at
10 the winch cable end, and the control device and the winding device are designed in such a way that a pay-out speed of the coupling device can be set in relation to a winding speed of a fixed component of the underwater winch.

[07] A capturing device for unmanned underwater vehicles can
15 thereby be provided, especially on the stern side. In this way, the coupling device may, despite the mechanical connection to a submarine via, for example, a housing of the underwater winch and via the winch cable, have a different speed to the submarine.

20 [08] Thereby, for example, an unmanned water vehicle can be provided with a coupling device, which, for example, is removed only at a speed of 1 kN. This speed can be easily compensated for by the drive system of the unmanned underwater vehicle, so that a coupling operation can be
25 carried out by the unmanned underwater vehicle. At the same time, the submarine may, however, move along at a higher speed.

[09] The following terms need explanation:

[10] An "underwater cable winch" is a device which can make
30 an adjustable length of cable available. In particular, such underwater cable winches have rollers which wind and unwind a winch cable by means of rotation. In so doing, one end of the

winch cable is firmly connected to the roller. A reel or the like may also be used instead of a roller.

[11] An "unmanned underwater vehicle" is, in particular, an ROV (remotely-operated vehicle) or an AUV (autonomous underwater vehicle). An ROV usually has a data line and/or supply line which connects the ROV to , for example, a ship. The ROV can draw data and/or energy through this line. Various forms of such are possible. In the present case, an ROV is also assumed, if this is connected to the deployment ship for data exchange only by means of a fiber optic cable. In contrast, an AUV maneuvers autonomously, i.e., it does not have any physical connection to the deployment ship. Generally, therefore, an AUV has its own, mostly active, sonar, which acquires information about its environment.

[12] "Coupling and/or uncoupling" means, in particular, the operation with which a physical connection of the unmanned underwater vehicle to the coupling device is removed or established.

[13] A "winch cable" is a cable, the effective operating length of which is altered, particularly by winding.

[14] A "winding device" is a device which implements the change in the operating length of the winch cable. It can, for example, comprise a motor which impresses a rotation upon the roller or the reel and whereby a cable connected to the roller/reel is wound or unwound.

[15] A "coupling device" is a device which, on the one hand, is attached to an end of the winch cable and, on the other hand, is able to firmly receive the unmanned underwater vehicle. In so doing, the coupling device may have detachable holding elements which, for example, can couple into the unmanned underwater vehicle to arrest or release the unmanned underwater vehicle. The coupling device may also have possible data interfaces which facilitate communication, in

particular, between the deployment ship and the unmanned underwater vehicle. In particular, the coupling device can, in conjunction with the unmanned water vehicle, be a plug-socket system, wherein this system may in turn have individual plug-socket systems for energy supply and data transfer.

[16] "Pay-out speed" v_1, v_2 is, in particular, the speed at which changing the operating length of the cable removes the coupling device from the fixed component of the underwater cable winch or brings it closer.

[17] The "winding speed of the underwater cable winch" v_0 is, in particular, the speed of the fixed components of the underwater winch. In the event that the underwater cable winch is arranged on a deployment ship, the winding speed corresponds, in particular, to the sailing speed of the deployment ship. As a result of the fact that the pay-out speed can be adjusted in relation to the winding speed, an effective speed v_g of the coupling device can be provided, which the unmanned underwater vehicle "sees." The effective speed v_g can, in particular, have values of between -5 kN and +5 kN. The signs indicate here whether the coupling device is removed from the fixed components of the underwater winch or is moving towards them.

[18] A "fixed component" of the underwater cable winch is, in particular, the housing, the roller, and the motor. This does not include, for example, the coupling device, since this can be portable relative to the "remainder."

[19] In a further embodiment, the underwater cable winch has a speed sensor.

[20] In this way, the effective speed of the fixed components of the underwater cable winch may be determined. In so doing, standard speed sensors, in particular, such as a Pt100 resistor with respective analysis, may be deployed. In

particular, in the event that an underwater sound generator is arranged at the coupling device, and hydrophones are arranged at the fixed components of the underwater winch or, for example, of the deployment ship, the effective speed v_g may, for example, be determined by means of the Doppler effect. Depending upon whether the speed of the coupling device is determined directly, or whether just the winding speed is determined, the control for lengthening or shortening the operating length of the winch cable is set up accordingly.

[21] To set the depth below water level for the coupling device, the coupling device may have lift elements - in particular, adjustable lift elements - and/or a drive system.

[22] Therefore, the height may be adjusted to shorten the time taken for the coupling operation and/or for carrying out the coupling operation at different diving depths of the unmanned underwater vehicle, so that, for example, the height of the coupling device is optimally set for the unmanned underwater vehicle. Moreover, it is possible to maneuver the coupling device to the surface of the sea, where positioning data can be collected or a communication message can be sent or received. Also or alternatively, it is ensured by the altitude of the coupling device that there is sufficient distance between the coupling device and the stern of the submarine to prevent a collision between the coupling device and/or the unmanned underwater vehicle with the stern of the submarine.

[23] The "lift elements" may, for example, be adjustable wing-like components, which cause an upwards force or downwards force as a result of the flow. A separate drive system can, in particular, accelerate the process.

[24] In order for the active sonar of the unmanned underwater vehicle to receive an optimal signal for the docking maneuver, the coupling device may have an underwater sound

reflective material and/or a sound transducer and/or an optical reflective material and/or a light source - in particular, an LED. In the event that a sound transducer is used, the unmanned underwater vehicle may have only a passive sonar.

[25] An "underwater sound reflective material" reflects underwater sound particularly well in particular frequency ranges, so that the sonar of the unmanned underwater vehicle may optimally detect the coupling device. The sound transducer may, in particular, be a projector which generates a so-called ping at regular intervals. Because several of these sound transducers are arranged, a spatial "image" may be generated which facilitates the coupling maneuver.

[26] The "optical reflective material" is, in particular, a reflecting element, such as a cat's eye. The light source may, in particular, be formed by several individual light sources, which may create a spatial impression for a (twin) camera. The camera may, in particular, be arranged on the unmanned underwater vehicle.

[27] Therefore, an optical location and coupling may be realized, since, consequently, the underwater cable winch and/or the unmanned underwater vehicle, together or individually, have a light-emitting system for silently locating and coupling the unmanned underwater vehicle to the coupling device.

[28] In a further embodiment stage, light sources, e.g., lasers, may be arranged, such that the unmanned underwater vehicle (quietly) performs the docking operation based upon optical procedures and camera.

[29] In order to obtain a so-called "fix" or to send or receive messages, the coupling device may have a device for determining the position and/or a communication device.

[30] The device for determining the position here may, in particular, be a GPS sensor which analyzes the position based upon satellite data. Furthermore, the communication device may be a two-way radio which, for example, sends or receives messages via a satellite.

[31] In a further embodiment, the winch cable has a supply line and/or a data line.

[32] Therefore, it can be ensured that the unmanned underwater vehicle and/or the coupling device be supplied with, for example, energy or data.

[33] In order to inspect, in particular, whether the unmanned underwater vehicle has been damaged or has unwanted attachments, such as nets or accumulated scrap or the like, the underwater winch may have a monitoring system. In this case, the monitoring system may be arranged at both the fixed components and at the coupling device. In particular, the monitoring system has an optical camera and a respective illuminating device, so that optimal visibility may be ensured.

[34] In a further embodiment, the unmanned underwater vehicle is coupled to the coupling device.

[35] Therefore, a system of underwater winch and unmanned underwater vehicle may be made available.

[36] In an additional aspect, the object is achieved by means of an underwater garage which has an underwater cable winch as described above.

[37] By means of this underwater garage, dirt deposits, for example, may be prevented on the underwater cable winch and/or on the unmanned underwater vehicle. Furthermore, the flow properties may also be improved, in particular, in the event that the underwater garage is attached to a water vehicle, such as a submarine.

[38] In a further aspect, the object is achieved by a water vehicle - in particular, a submarine - which has an underwater cable winch as described above and/or an underwater garage as described above.

5 [39] The invention is further explained using an exemplary embodiment. Thus,

Figure 1 shows a schematic representation of an underwater cable winch arranged on a submarine, an AUV being coupled to said underwater cable winch.

10 [40] A cable winch 101 is firmly arranged on a submarine 131. The cable winch 101 is supplied with energy by the submarine 131 (not shown) and has a bi-directional data line (not shown).

15 [41] A pivoted roller 102 is arranged in the middle of the cable winch 101. One end of the cable 103 is firmly clamped in this roller 102. A coupling element 111 is arranged at the other end of the cable 103.

20 [42] Furthermore, the cable winch 101 has several hydrophones 109, a motor 105, and a control unit 107, which are fixed. The motor 105 is designed such that the roller 102 may have a defined rotational speed and/or torque. Furthermore, the cable winch 101 has a range sensor (not shown) which determines the change in length of the operating length of the cable 103. The path length sensor comprises markings
25 arranged on the roller, said markings being scanned optically by means of LED.

30 [43] The coupling element 111 is formed such that the bow of an AUV 121 may be optimally received. Furthermore, the coupling element 111 has several sound generators 113 on its ends, said sound generators regularly outputting sound signals of specific frequencies. In addition, a GPS antenna is arranged on the coupling element 111. Furthermore, rotating wings are arranged on the coupling element 111,

which wings effect an upwards force or downwards force with a given flow.

[44] The AUV 121 has an active sonar 125 and an AUV drive system 123.

5 [45] In the present case, the AUV 121 would be in transit on an autonomous mission and is to be brought up to the submarine 131 again.

[46] The speed of the submarine 131 is transmitted as a value through the data line to the control system 107. In
10 addition, the cable winch 101 determines the distance and the speed of the coupling element 111 with the aid of the underwater sound waves of a defined frequency emitted by sound generators. With the aid of the measured frequency and the known frequency, the distance speed is determined by
15 means of the Doppler effect.

[47] Furthermore, the coupling element 111 is discharged on the stern side with a first pay-out speed v_1 which is greater than the sailing speed of the submarine v_0 .

[48] As soon as the coupling operation is indicated, the
20 coupling speed v_2 is set by means of the motor 105 such that a resulting speed of v_g ensues, so that, from the perspective of the AUV 121, the coupling element 111 is removed at a speed of 1kN.

[49] In turn, the AUV 121 uses its sonar 125 to determine the
25 positioning data of the coupling element 111 emitted by the sound generators 113, and adjusts the height, as well as its speed V_{AUV} , via its own drive system 123. In so doing, the speed is slowly reduced from 5 knots to 1.5 knots, until the AUV 121 is in physical contact with the coupling element 111.

30 [50] As soon as this happens, the AUV 121 by means of the coupling element 111 is attached by a locking device (not shown). The motor 105 then impresses another rotational

direction upon the roller 102 and pulls the AUV 121 and its coupling element 111 up during the onward journey of the submarine 131. As soon as the coupling element 111 is in its final position, the AUV 121 is recovered and stowed in an
5 underwater garage (not shown).

List of reference symbols

	101 Cable winch
	102 Roller
	103 Cable
5	105 Motor
	107 Control system
	109 Hydrophone
	111 Coupling element
	113 Sound generator
10	115 GPS antenna
	121 AUV (autonomous underwater vehicle)
	123 Drive system
	125 Sonar
	131 Submarine

Claims:

1. Underwater winch (101) for coupling and/or uncoupling an unmanned underwater vehicle (121) to a winch cable end of a winch cable (103) with a control device (107) associated with a winding device (105), the winch cable, and a coupling device, wherein the coupling device (111) is arranged at the winch cable end, characterized in that the control device and the winding device are designed in such a way that a pay-out speed of the coupling device can be set in relation to a winding speed of a fixed component of the underwater winch.
2. Underwater winch according to claim 1, characterized by a speed sensor (113, 109).
3. Underwater winch according to one of the previous claims, characterized in that the coupling device has lift elements - in particular, adjustable lift elements - and/or a drive system.
4. Underwater winch according to one of the previous claims, characterized in that the coupling device has an underwater sound-reflective material and/or a sound transducer (113) and/or an optical-reflective material and/or a light source - in particular, an LED.
5. Underwater winch according to one of the previous claims, characterized in that the coupling device has a device for determining position (115) and/or a communication device.
6. Underwater winch according to one of the previous claims, characterized in that the winch cable has a supply line and/or a data line.
7. Underwater winch according to one of the previous claims, characterized by a monitoring system - in particular, an optical camera.

8. Underwater winch according to one of the previous claims, characterized by a light-emitting system for the silent location and coupling of the unmanned underwater vehicle to the coupling device.

9. Underwater winch according to one of the previous claims, characterized in that the unmanned underwater vehicle is coupled to the coupling device.

10. Underwater garage which has an underwater winch according to one of the previous claims.

11. Water vehicle (131) - in particular, submarine - which has an underwater winch according to one of claims 1 through 8 and/or an underwater garage according to claim 9.