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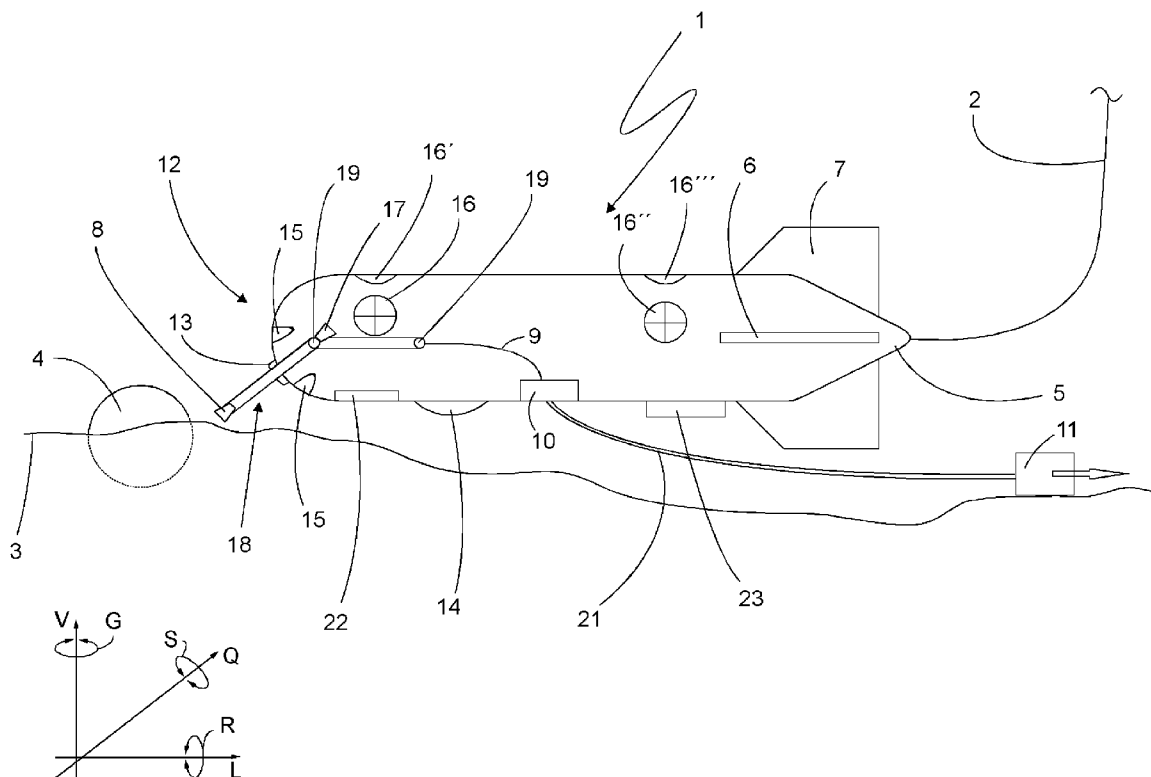


Fig. 1

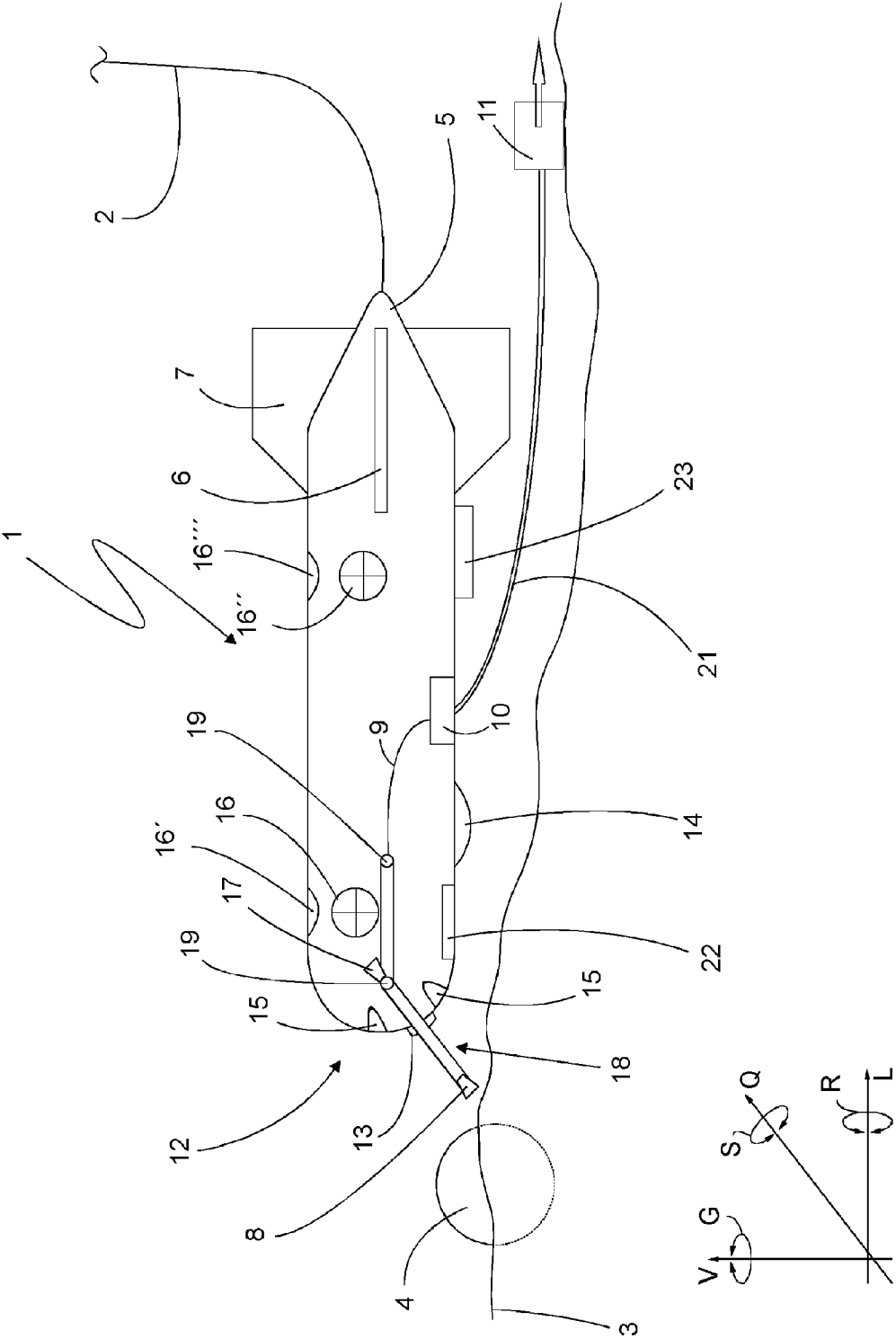


Fig. 2

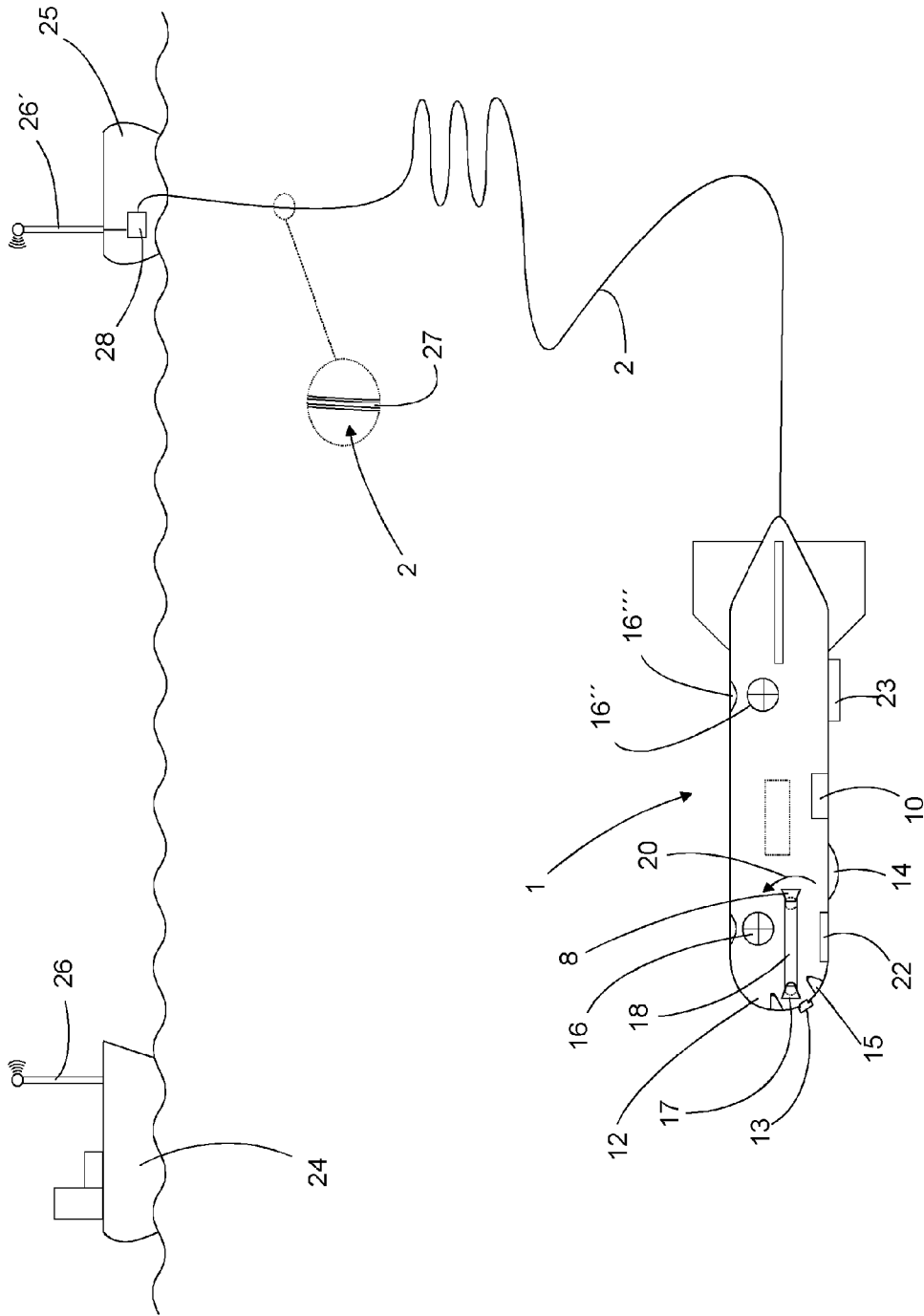
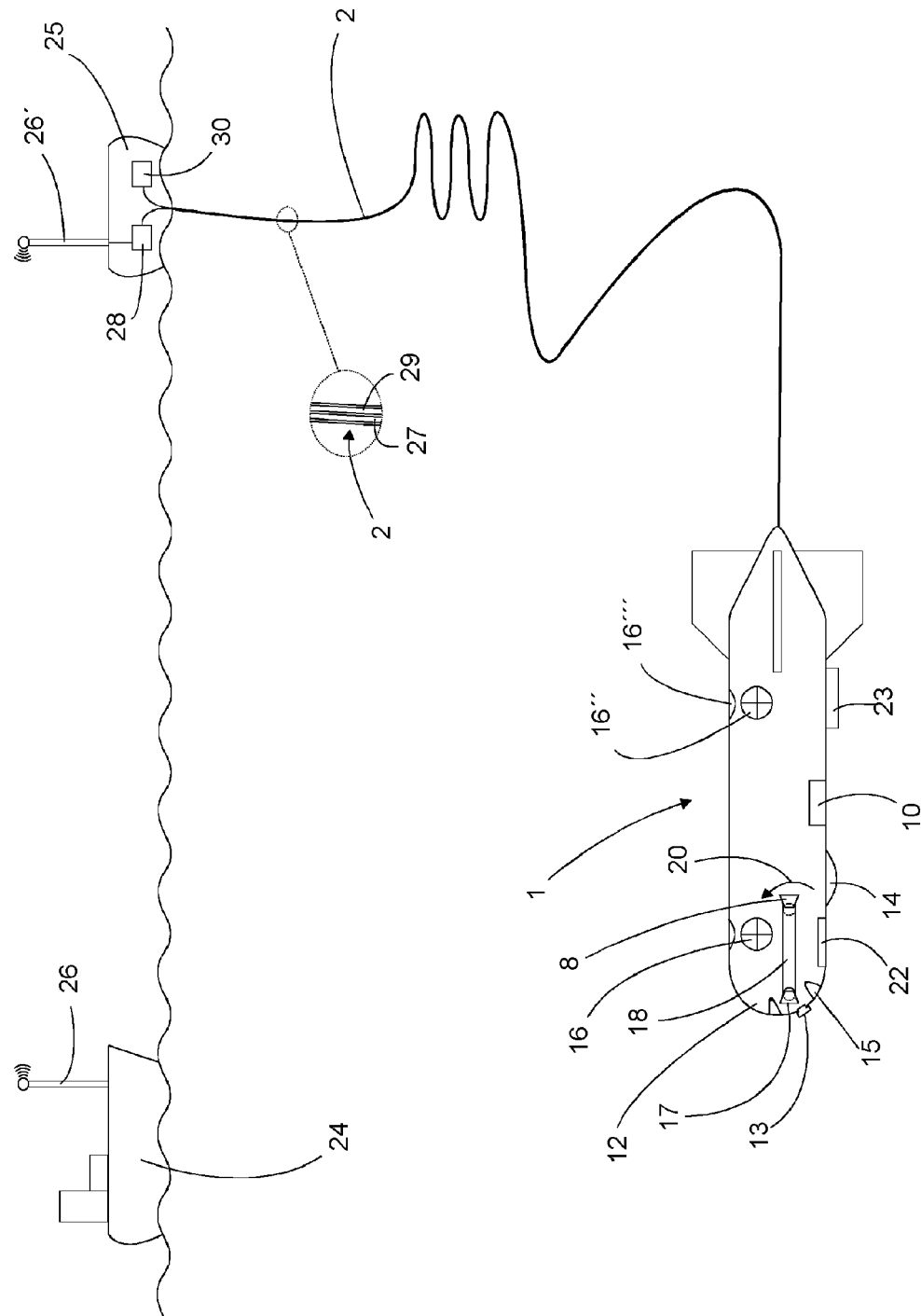


Fig. 3



UNDERWATER VEHICLE FOR UNCOVERING SUBMERGED OBJECTS AND UNDERWATER SYSTEM WITH AN UNDERWATER VEHICLE OF THIS TYPE

CROSS REFERENCE TO PRIOR APPLICATIONS

[0001] This application is a U.S. National Phase application under 35 U.S.C. §371 of International Application No. PCT/EP2011/069575, filed on Nov. 7, 2011 and which claims benefit to German Patent Application No. 10 2010 051 491.8, filed on Nov. 15, 2010. The International Application was published in German on May 24, 2012 as WO 2012/065875 A1 under PCT Article 21(2).

FIELD

[0002] The present invention relates to a remote-controllable underwater vehicle and to an underwater system with an underwater vehicle, and to a system platform.

BACKGROUND

[0003] Many objects exist on the bottom of water bodies for which an interest exists in finding them and either salvaging or clearing them. More specifically, warfare material located in water bodies such as sea mines or submerged ammunition constitute a potential danger for navigation and the environment. There is therefore need for an efficient, cost-effective and safe clearance of such warfare material. Underwater vehicles, mostly unmanned underwater vehicles, are frequently used for finding and identifying objects on the one hand and for salvaging or clearance on the other hand. On the one hand, the use of unmanned underwater vehicles allows for missions in depths which are not accessible for divers. On the other hand, the danger for divers is often not justifiable especially during missions for clearing warfare material.

[0004] It has been seen that objects on the bottom of a water body, which, in the case of warfare material, are to be salvaged or cleared, are often so difficult to reach that known underwater systems are no longer able to ensure salvaging or clearance. Using divers in these difficult conditions should, however, be avoided as much as possible because of increased risks.

[0005] US 2002/0129694 A1 describes an arrangement for mine clearance on the seabed with a plough, through which water flows, which is disposed with movable arms at the bow of a surface ship and which is lowered into its operating position on the seabed by lowering the movable arms. The water plough comprises a duct into which water is received from the surroundings of the water plough and is discharged in front of the surface vehicle downward towards the seabed. The water flow of the water plough is supposed to remove buried explosives or other obstacles from the path of the surface vessel.

[0006] U.S. Pat. No. 7,363,844 B2 describes a remote-controlled underwater system for salvaging explosives where a remote-controllable gripping tool for salvaging the ammunition is set down on the seabed. The gripping tool is connected by a signaling cable to an emission/reception device which floats on the surface of the water and which is connected by radio to a base station.

[0007] Other underwater vehicles with arrangements for uncovering submerged objects have been described which are, however, not adapted for a safe removal of warfare material.

[0008] U.S. Pat. No. 3,354,658 discloses an underwater vehicle with a torpedo-like shape which is remote-controllable by a cable and which is supplied with compressed air by a compressed air line. This underwater vehicle comes with a magnetic head by which it can be fastened to the hull plating of a shipwreck, a hole being blown in the hull plating by means of an explosive charge in order to subsequently pump air through the hull plating. An adapter can be attached to the compressed air line which can aspirate material from the decks of a shipwreck or from the seabed by means of the compressed air. With another adapter, compressed air can be discharged from the compressed air line through a nozzle.

[0009] U.S. Pat. No. 7,765,725 B2 describes an arrangement for removing the excavated material from a bore hole by means of an ejector, a pump, and a suction pipe to be inserted into the bore hole. The pump is part of a remote-controllable underwater vehicle and is connected to the ejector for removing excavated material.

[0010] The article Marschner, Heinz and Marsland, G. E. "DAVID, Ein neues Unterwasser-Arbeitsgerät für Freitaucher", Meerestechnik mt Band 13 (1982), Nr. 2, pp. 31-35, describes a diving support vehicle which can be fixed with a gripping device to the workplace of a diver and which provides a work platform and underwater tools, such as water jet cleaning appliances or ejector pumps.

[0011] A manned underwater vehicle with tools to be operated from the inside, which is movable by means of crawler tracks, is described in DE 346 857 A. This underwater vehicle is equipped with a suction pump and attached articulated digging or suction pipes for digging purposes.

[0012] WO 01/32503 A2 describes an arrangement for removing stones and sediments underwater which is attached to a remote-controlled underwater vehicle (ROV) outside of the underwater vehicle. This arrangement comprises a suction pipe through which the sediments are transported and an ejector nozzle acting on the suction pipe, to which a water pump is attached, and which generates a suction pressure at the operating end of the suction pipe.

[0013] Other underwater vehicles or underwater tools are described in U.S. Pat. No. 6,928,947 B1, JP 2006/224863 A, US 2003/0167998 A1, GB 169 421, AT 168 300, DE 944 708 B, DE 2 163 727 A, DE 699 11 884 T2 and U.S. Pat. No. 4,010,619.

[0014] JP 62008895 A describes a radio-controlled underwater robot with a manipulation arrangement configured as a gripping arm. The underwater robot is connected by a cable connection to a radio buoy, which is connected per radio to a base station on board of a seagoing vessel.

[0015] WO 91/13800 describes a system for underwater exploration with two identical underwater vehicles and a surface ship, respectively, one of the underwater vehicles being used and submerged for underwater exploration, while the other underwater vehicle is located at the surface of the water and to maintain radio contact with the base station on board a surface ship. The two underwater vehicles communicate with each other so that communicating with the submerged underwater vehicle is possible via the radio connection with the underwater vehicle floating at the surface.

SUMMARY

[0016] An aspect of the present invention is to provide a remote-controlled underwater vehicle and an underwater system which allows for a cost-effective and a safe removal of

objects that are difficult to access, such as warfare material, from the bottom of a water body.

[0017] In an embodiment, the present invention provides an underwater vehicle configured to be remote-controllable and maneuverable which includes a device configured to uncover a submerged object. The device comprises a working nozzle configured to conduct a water flow and a counter pressure nozzle configured to counteract the working nozzle.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] The present invention is described in greater detail below on the basis of embodiments and of the drawings in which:

[0019] FIG. 1 shows a lateral view of a remote-controllable underwater vehicle with a device for uncovering submerged objects;

[0020] FIG. 2 show an embodiment of an underwater system with an underwater vehicle for uncovering submerged objects; and

[0021] FIG. 3 shows an exemplary embodiment of an underwater system with an underwater vehicle for uncovering submerged objects.

DETAILED DESCRIPTION

[0022] The present invention is based on the finding that the difficult accessibility of objects on the bottom of water bodies is often the consequence of sedimentation on the object or because the object has sunk in so deeply after often decades of dwelling on the bottom of the water body that customary underwater vehicles are no longer able to implement salvage or clearance. The present invention has found that in most cases, salvaging or clearance would be possible if the sediment in the surroundings of the submerged object can be removed and the submerged object thus be uncovered enough to be subsequently salvaged or cleared. In most cases, the underwater vehicle according to the present invention can remove so much sediment, sand or small objects with its arrangement for uncovering submerged objects that the object can be gently uncovered for subsequent salvaging or clearance. The device for uncovering submerged objects thereby comprises one or several tools in order to act on the sediment.

[0023] The underwater vehicle has an arrangement for uncovering submerged objects by means of a water flow which comprises a working nozzle conducting the water flow. With the water flow, sediments which enclose the object to be uncovered, can be aspirated in a contact-less and preserving manner.

[0024] Uncovering submerged objects by means of a water flow can occur by rinsing as well as by aspirating the sediments in the surroundings of the submerged object, such as a mine. In a device designed for rinsing, the water flow is oriented via the nozzle onto the object to be uncovered and the sediments are thus rinsed off. In a suction device, the water, and thus the sediments in the surroundings of the object to be uncovered, are aspirated and discharged through a suction pipe, such as a hose pipe.

[0025] A counter pressure nozzle counteracting the working nozzle is provided during the mission in order to partially or completely compensate for the forces generated by the water flow on the working nozzle. A water flow is thereby generated in the counter pressure nozzle just as in the working nozzle, but in the opposite flow direction. The water flow

through the counter flow nozzle thereby generates impulse forces which are opposed to the impulse forces occurring at the working nozzle so that a resulting force acting on the underwater vehicle is smaller in terms of amount than without a compensation by the counter pressure nozzle. The underwater vehicle can thereby be maintained stable in its working position on the bottom of the water body so that undesired approaches of the underwater vehicle toward the object to be uncovered are counteracted. The risk of a spontaneous detonation is thereby reduced particularly during dangerous work on objects with explosives.

[0026] Disposing a counter pressure nozzle is more specifically advantageous during a rinsing operation of the working nozzle in order to at least partially and, for example, completely, compensate for the impulses acting on the working nozzle as a consequence of the water flow impacting on the object to be uncovered or its surroundings.

[0027] The underwater vehicle is remote-controllable by way of wireless communication means, for example, by sound or (in case of short transmission distances) by radio or similar means, and/or by way of a connection cable. As a rule, a human operator gives control commands to the underwater vehicle from a control station of a system platform. The underwater vehicle is brought close to the object to be uncovered by corresponding remote control of its drive or maneuvering devices. The operating devices of the underwater vehicle, for example, the devices for navigation, for control of the drive, and for maneuvering the underwater vehicle, are controlled by way of the transmitted control commands. Uncovering the object is also remote-controlled by way of the control commands by positioning the working nozzle. The underwater vehicle furthermore transmits measuring data via communication with the system platform, thus allowing for real time control of the underwater vehicle by the operator.

[0028] An underwater vehicle is to be understood as any mobile means that is adapted to transport the device for uncovering submerged objects by means of a water flow and the working nozzle under water. This can be an underwater vehicle that is movable in the three-dimensional space but also any type of underwater vehicle that is movable on the bottom of the water body, for example, by means of a chain or wheel work or in any other manner.

[0029] Alternately or in addition to the working nozzle, the device for uncovering submerged objects has one or several, more specifically, rotatory drivable tools such as brushes and the like. Besides sediments, coatings of the object to be uncovered can also be removed with tools such as brushes, thus considerably facilitating further work steps. The tools are advantageously configured and disposed in such a manner that the repulsive forces or moment acting on the underwater vehicle during operation are as small as possible. The generated repulsive forces are thereby smaller than with a rinsing device by means of a water flow. The impulses acting on the underwater vehicle are reduced by means of an advantageous arrangement of the tool so that little energy is required for correction maneuvers of the underwater vehicle aiming at maintaining its position. Several rotatory tools, such as brushes, are advantageously disposed in such a manner that the respectively generated forces compensate each other, for example, due to opposed rotation directions.

[0030] In an embodiment of the present invention, the underwater vehicle is trimmed for neutral buoyancy and has maneuvering devices configured and disposed in such a manner that the underwater vehicle is steerable in the directions of

its spatial axes, namely, the longitudinal axis, the transverse axis and the vertical axis, as well as in the direction of a rotation about at least one of the spatial axes. The maneuvering devices are coordinated in such a manner that precise maneuvers are possible in any direction. The underwater vehicle can hover at the operation site by means of neutral trimming and is precisely maneuverable in order to also allow for position corrections during dangerous missions, such as working on mines, and to precisely guide the tool for uncovering the submerged object, more specifically, the working nozzle, along the contour of the underwater object to be uncovered.

[0031] The underwater vehicle advantageously has means for adjusting the trim. A neutral trim can thereby be adjusted at any time and the hover of the vehicle can be maintained even in case of changes of the underwater surroundings, for example, currents or thermal or chemical changes. The trimming means and the maneuvering devices are used in a coordinated manner in order to provide a hover of the underwater vehicle with the lowest possible energy expenditure.

[0032] The maneuvering devices of the remote-controllable underwater vehicle are advantageously disposed and matched in such a manner that movements in rotational directions about several or all spatial axes of the underwater vehicle are possible. The maneuverability of the underwater vehicle with yawing (rotation about the vertical axis) and with pitching (rotation about the transverse axis) have thereby proven particularly advantageous. The maneuvering devices of the underwater vehicle are remote-controllable in a coordinated manner in order to execute the intended maneuver of the underwater vehicle. The maneuvering devices also permit dynamic correction measures for stabilizing the underwater vehicle in the desired work position by coordinated control of the maneuvering devices.

[0033] The maneuvering devices of the underwater vehicle are formed by a rear drive as well as at least one lateral propulsion drive which is disposed in the area of the prow of the underwater vehicle. The lateral propulsion drives are thereby, for example, disposed in pairs with respectively different operating directions. In an embodiment of the remote-controlled underwater vehicle, two or several pairs of lateral propulsion drives are disposed in a spaced relationship in the longitudinal direction of the underwater vehicle in order to provide precise maneuvers of the underwater vehicle exclusively in the intended directions.

[0034] The device for uncovering submerged objects by means of a water flow comprises a pump assembly acting on the working nozzle and the counter pressure nozzle, wherein during a rinsing operation, the working nozzle directs the water flow toward the object to be uncovered and rinses off sediments. The device for uncovering submerged objects by means of a water flow is alternatively configured as a suction device. The working nozzle is thereby connected to the suction side of the pump assembly. By aspirating the sediments from the area of the submerged object, line-of-sight obstruction due to raised sediments in the working area is counteracted. Optimal visibility conditions can thus be created in the working area. A spacer which prevents the working nozzle from suctioning to the object to be uncovered during aspiration of sediments, is advantageously disposed on the working nozzle.

[0035] When dealing with submerged warfare material, rinsing is advantageous in order to avoid aspirating explosives and thereby endangering the mission. On the other hand,

aspirating is advantageous for work in optimal visibility conditions. In an embodiment, the device for uncovering submerged objects is equipped with an explosives detector in order to prevent aspiration of explosives. An explosives detector more specifically configured as an underwater explosives sniffer probe is able to detect the presence of explosives in its surroundings. If explosive substances are detected, a signal of the explosives detector is used to reduce the suction power or to stop the suction operation. The explosives detector and an analysis device connected to the explosives detector on board the underwater vehicle allow for identification of any danger to the underwater vehicle that may stem from the detected object. Intervening in the ongoing suction operation due to identification of danger can be carried out autonomously by the underwater vehicle or via remote control.

[0036] In an embodiment of the present invention, the device for uncovering submerged objects by means of a water flow is configured to be switchable with regard to the work direction of the water flow and operable in suction or rinsing mode depending on the adjustment of the work direction. In the rinsing mode, the surroundings of the submerged object can be uncovered with a high efficiency. It is particularly advantageous that the output of the pump assembly is adjustable, wherein the output is controlled or adjusted or manually adapted based on sensor measurements. The pressure in the working nozzle, for example, can thereby be used as a control or regulation value.

[0037] The adjustability of the output of the pump assembly is advantageous with a combination of a working nozzle and additional rotatory tools such as brushes and the like. The pump output can thereby be adjusted according to the current effectiveness of the other tools. In order to adapt the pump output to the effectiveness of the brushes, a motion sensor or other measurement devices are advantageously provided on the underwater vehicle or its manipulation device.

[0038] The underwater vehicle advantageously comprises one or several devices for surveying its surroundings, the measurements or recordings of which can be displayed to a human operator, so that a real time remote control of the uncovering process of the submerged object is possible. As a device for surveying its surroundings, the underwater vehicle comprises, for example, a sonar and/or a camera. The work area of the working nozzle can be captured with a camera that is oriented toward the work area of the working nozzle to efficiently control the working nozzle. A sonar allows for safe navigation during the approach to the object and additionally allows capturing the work area of the working nozzle in poor optical conditions, for example, in murky water. Acoustic signals from individual positioning processes can thereby be analyzed in order to guide the underwater vehicle toward the detected object (acoustic tracking). To this end, the underwater vehicle has an acoustic signaling device, such as a pinger. Such an acoustic signaling device can, however, also be disposed away from the underwater vehicle in order to locate the object to be uncovered and to guide the underwater vehicle. Disposing such an acoustic signaling device on the object to be uncovered is also possible in order to guide the underwater vehicle.

[0039] The operator steers the underwater vehicle toward the object to be uncovered via the available drives with simultaneous consideration of the sonar and/or camera and subsequently controls the uncovering process of the object by means of the working nozzle.

[0040] In order to provide an immobilization of the underwater vehicle at or in the area of the object to be uncovered during sensitive or dangerous work, such as, for example, clearance of warfare material, the underwater vehicle comprises an anchoring device. The anchoring device provides an additional possibility for stabilization of the work position of the underwater vehicle in addition to dynamic interventions via the activation of the maneuvering drives of the underwater vehicle. The underwater vehicle can thus be held steady in its work position by means of on-board means, namely, via the anchoring device, through controlled drive impulses of its drives or a combination of these means.

[0041] The anchoring device advantageously comprises an anchor with a plurality of anchor flukes in the manner of a harrow, which provide a safe holding for uncovering work in most possible bed conditions. The anchor is brought down from the anchoring device, for example, upon a control command of the operator of the underwater vehicle.

[0042] In an embodiment of the present invention, the anchoring device comprises an electro-magnet and/or a negative pressure apparatus in order to fix the underwater vehicle during uncovering of the submerged object on the object itself or on an object in its surroundings. The anchoring device can also have a clamping device for clamping the object to be uncovered, respectively, its parts and/or objects in the surroundings of the object or the underwater vehicle.

[0043] In an embodiment of the underwater vehicle of the present invention, a nail gun is provided as an anchoring device with which the underwater vehicle is fastened by way of delivered nails or bolts. The nails are released by way of an ignition device in the nail gun and fasten the underwater vehicle, for example, via ropes to the bottom of the water body. The fastening nails can, however, also be driven into the object to be cleared or any other adapted object in the surroundings of the object to be uncovered or of the underwater vehicle in order to fix the underwater vehicle directly or via ropes.

[0044] In an embodiment of the present invention, the underwater vehicle has a controllable manipulation device which carries the working nozzle. The working nozzle can thereby be positioned in the surroundings of the object to be uncovered in a particularly precise manner by way of the manipulation device, for example, a robot arm. The working position of the working nozzle can furthermore be modified without requiring energy-intensive maneuvers of the underwater vehicle.

[0045] In an embodiment of an underwater vehicle destined for clearance of warfare material of the present invention, the underwater vehicle carries an explosive charge for clearance of the warfare material. In this manner, sending another underwater vehicle equipped for clearance of warfare material can be dispensed with. As opposed to customary underwater vehicles with explosive charges for clearance of warfare material, the efficiency of the clearance can be substantially increased with an underwater vehicle according to the present invention which additionally comprises a device for uncovering submerged objects. With each submerged warfare material, such as a submerged bottom mine, the explosive charge can be attached in an optimal position after uncovering the bottom mine so that a clearance of the mine is provided in any case.

[0046] In an embodiment of the present invention, the underwater vehicle carries one or several explosive charges with a directed effect, more specifically, hollow charges. The

use of hollow charges increases the efficiency of the used explosive charge and contributes to reduce the amount of explosives to be transported on board the mother ship. This is conducive to the safety of the transport and storage of the underwater vehicle(s) on board the mother ship.

[0047] The hollow charge can be optimally placed on the object to be cleared when the underwater vehicle is fixed by its anchoring device.

[0048] Spotlights are provided on the underwater vehicle for lighting the working area of the working nozzle, the underwater vehicle comprising, in an embodiment, two or several spotlights disposed in a spaced-apart relationship and oriented toward the working area of the working nozzle. The working area is illuminated in this manner without casting shadows so that the surroundings of the object to be uncovered and, more specifically, its surface can be reliably identified.

[0049] In an embodiment of a suction device for uncovering submerged objects of the present invention, the suction device comprises a suction pipe connected to the working nozzle which is led away from the underwater vehicle and the working area of the working nozzle and has a length up to an outlet of the water flow so that no particle load discharged at the outlet returns to the working area of the working nozzle and to there affect visibility conditions. Determining the dimension of the length of the suction pipe occurs by taking account of the suction power and, if required, of the current conditions at the site of operation. If the working nozzle is disposed in the area of the prow of the underwater vehicle, the aspirated emulsion of sediments is, for example, discharged in the direction of the stern and the outlet of the suction pipe is positioned accordingly.

[0050] A separation distance of the outlet of the water flow from the working area of the working nozzle with a corresponding length of the suction pipe is provided when the outlet of the suction pipe is fixed to the bottom of the water body away from the underwater vehicle. Such a fixation of the suction pipe to the bottom of the water body can be achieved by connecting the outlet of the suction pipe to a weight that is adapted to be deposited by the underwater vehicle. A pump assembly with the suction pipe can alternatively also be detached from a corresponding support device on the underwater vehicle and deposited on the bottom of the water body. The outlet of the water flow, for example, lies on the side of the underwater vehicle opposite to the working area of the working nozzle so that the line-of-sight obstruction by raised sediments in the working area can be as little as possible.

[0051] A human operator controls the underwater vehicle from a system platform, which is connected with the underwater vehicle in a signal-transmitting manner. The system platform can thereby be a seagoing vessel or an underwater vehicle. However, the system platform can also be stationary. The underwater system according to the present invention comprises, in addition to a system platform and the underwater vehicle with the device for uncovering submerged objects, an intermediate vehicle to which the underwater vehicle is connected in a signal-transmitting manner, for example, via a connection cable. Wireless communication means can also be provided for the connection. Wireless communication can thereby occur by sound or radio, specifically in case short distances exist between the intermediate vehicle and the underwater vehicle to be steered. In an embodiment of the

present invention, the underwater vehicle is optionally remote-controllable via a connection cable or via a wireless communication means.

[0052] The intermediate vehicle itself is connected with the system platform in a signal-transmitting manner, more specifically, via a radio connection. By using an intermediate vehicle, the range of the underwater vehicle designed for uncovering submerged objects is increased and/or more energy is available for longer missions. The intermediate vehicle is advantageously a vehicle that is adapted to float on the surface so that a wireless communication between the intermediate vehicle and the system platform via sound or radio is also provided across greater distances.

[0053] The present invention uses the intermediate vehicle as a relay station, the intermediate vehicle transmitting information via radio transmission from the underwater vehicle and to the underwater vehicle from the mother ship, which is possibly located far away. While the underwater vehicle for uncovering submerged objects is controlled across a small distance via the intermediate vehicle by way of a corresponding communication means, the radio connection between the mother ship and the intermediate vehicle allows for communication across greater distances, thus achieving greater ranges of the underwater system starting from the location of the system platform. Moreover, due to the great distance between the mother ship and the operation site of the underwater vehicle, the mother ship and its crew, respectively, are protected from the effects of detonations when handling explosives at the bottom of the water body. The small distance between the intermediate vehicle and the underwater vehicle allows for optimal communication via wireless communication channels, for example, via sound or radio.

[0054] Interference-free communication between the intermediate vehicle and the underwater vehicle is provided by a connection cable. The connection cable advantageously comprises a fiber glass line (fiber optics) for efficient communication with the underwater vehicle for uncovering submerged objects and work in real time.

[0055] The intermediate vehicle is moreover used for transport of the underwater vehicle for uncovering submerged objects to the operation site. The intermediate vehicle is thereby steered into the vicinity of the operation site so that the underwater vehicle requires less energy for its mission. The on-board energy supply of the underwater vehicle can therefore be small and cost-effective. Efficient lithium-polymer batteries are, for example, disposed on board of the remote-controlled underwater vehicle.

[0056] The intermediate vehicle can be a surface ship which floats at the surface of the water body and is in radio contact with the system platform. However, it is also possible to use an unmanned underwater vehicle as an intermediate vehicle, more specifically, an autonomous underwater vehicle (AUV). The intermediate vehicle can be used as a bringing vehicle which brings the underwater vehicle for uncovering submerged objects to the operation site and transmits communication with the mother ship via the connection cable. As soon as the intermediate vehicle has deposited the underwater vehicle for uncovering submerged objects in the operation area, the intermediate vehicle withdraws from the operation site and can return to the surface of the water body in order to take up radio contact with the system platform.

[0057] In an embodiment of the present invention, the intermediate vehicle controls the underwater vehicle without a cable. It is therefore possible to use an autonomously operat-

ing underwater vehicle for controlling the underwater vehicle with the device for uncovering submerged objects.

[0058] In an embodiment of the underwater system according to the present invention, the connection cable between the intermediate vehicle and the underwater vehicle for uncovering submerged objects also comprises a power line in addition to the glass fiber signal line. The intermediate vehicle thereby carries a power source, for example, a generator or a battery, with a correspondingly great capacity for supplying the underwater vehicle for uncovering submerged objects by way of the connection cable. In this manner, the underwater vehicle can also be used for a longer mission time period during missions with a high power requirement, for example, for uncovering several objects.

[0059] FIG. 1 shows the lateral view of an underwater vehicle 1, which is remote-controllable via a connection cable 2 from a system platform, more specifically by a human operator at a control station of the system platform. The underwater vehicle has a device for uncovering submerged objects by means of a water flow, which is described in more detail below.

[0060] On the seabed 3 there are a multitude of different objects which, after resting for a more or less long time on the seabed 3, have often sunk in so deep that salvaging or clearance or other manipulation processes are not possible or at least very difficult. In the shown embodiment, the underwater vehicle 1 is used for clearance of a bottom mine 4 submerged in the seabed 3. The underwater vehicle 1 is an unmanned underwater vehicle that is steerable in a three-dimensional underwater space and which comprises a rear drive 5 and is maneuverable by means of elevators 6 and side rudders 7. The underwater vehicle 1 is remote-controllable by way of the connection cable 2. The connection cable 2 is connected in the area of the stern of the underwater vehicle 1 and led away aft in order to prevent the connection cable 2 from getting caught on the underwater vehicle and thus avoiding damage.

[0061] In order to uncover the submerged bottom mine 4, the sediment in the direct surroundings of the bottom mine 4 is removed by means of a water flow. The water flow is produced by a pump of the underwater vehicle and brought to act in the intended working area in the surroundings of the bottom mine 4 by means of a working nozzle 8 conducting the water flow. In the shown embodiment, the device for uncovering submerged objects by means of a water flow is configured as a suction device, the working nozzle 8 aspirating water from the working area and thereby carrying sediments along accordingly to the suction pressure. In an embodiment not shown here, the working nozzle 8 is configured as a rinsing nozzle, the water flow being discharged into the working area by way of the working nozzle. The water flow discharged by the rinsing nozzle carries sediments along in the area of the submerged object and rinses the object.

[0062] In an embodiment not shown here, the device for uncovering submerged objects is configured to be switchable with regard to the work direction of the water flow and is operable in a suction mode or in a rinsing mode depending on the setting of the work direction.

[0063] The device for uncovering submerged objects by means of a water flow comprises, in addition to a working nozzle, a suction pipe 9 connected to the working nozzle 8 as well as a pump assembly 10, which generates a negative pressure at the working nozzle 8. The pump assembly 10 generates a water flow, the working nozzle 8 being connected to the suction side of the pump assembly 10 via the suction

pipe 9. The pump assembly 10 can be configured in such a manner that it aspirates directly through the working nozzle 8. In an embodiment of the present invention, the pump assembly 10 aspirates water from the surroundings of the underwater vehicle 1, the suction pipe 9 of the working nozzle 8 being connected behind the pump assembly 10 in the pumping direction, in such a manner that a negative pressure is generated in the suction pipe 9 by using the Bernoulli Effect. The aspirated sediments are thereby prevented from flowing through the pump assembly 10. In fact, the aspirated emulsion is discharged from the working area of the working nozzle 8 directly through an outlet 11 into the surroundings of the underwater vehicle 1.

[0064] The pump output of the pump assembly 10 is configured to be adjustable, the pump output being regulated or controlled. In the shown embodiment, the control or regulation value is the pressure in the working nozzle which is measured by means of a sensor, not shown, and input into a control or regulation unit of the underwater vehicle. By adjusting the optimal working pressure, the working nozzle 8 is prevented from getting attached. Alternately or additionally, in an embodiment not shown here, a spacer is disposed on the working nozzle 8 for preventing the working nozzle 8 from getting attached.

[0065] The working nozzle 8 is disposed in the area of the prow 12 of the underwater vehicle 1. In the area of the prow 12, a camera 13 is disposed for surveying the working area, the signals of which are transmitted to the system platform via the connecting line 12, so that a human operator can survey the working area of the working nozzle 8 in real time and control the underwater vehicle 1. For the purpose of navigation, the underwater vehicle 1 further comprises a sonar 14 which also transmits information via the connection cable 2 to the system platform. During a mission of the underwater vehicle, the underwater vehicle can be steered into the working area based on the information from the sonar 14. The approach to the bottom mine 4 for uncovering the bottom mine 4 advantageously occurs by using the information of the camera 13.

[0066] In order to optimally light the working area, the underwater vehicle comprises two spotlights 15 disposed in a spaced apart relationship and oriented onto the working area of the working nozzle 8. The spotlights 15 are advantageously configured as LEDs and, due to their spaced apart arrangement, allow for coverage of the working area without casting shadows. The working area of the working nozzle 8 is thus optimally lighted, thereby counteracting an erroneous detection and identification of shadows as objects. In order to further improve the survey of the working area, several cameras 13 can also be provided.

[0067] In order to precisely position the underwater vehicle 1 in the working area, the underwater vehicle 1 has a neutral trim and comprises maneuvering devices that are configured and disposed in such a manner that the underwater vehicle is steerable in the directions of its spatial axes, namely the longitudinal axis L, the transverse axis Q and the vertical axis V as well as in rotation directions about the spatial axes L, Q, V. To this end, the maneuvering devices of the underwater vehicle comprise the rear drive 5 as well as lateral propulsion drives 16, 16' disposed in pairs with respectively different operating directions. In the shown embodiment, a pair of lateral propulsion drives 16, 16' are disposed in the area of the prow 12 and another pair of lateral propulsion drives 16'', 16''' are disposed in a spaced-apart relationship in the direction of

the longitudinal axis L. With this arrangement of the maneuvering devices, the underwater vehicle is maneuverable in the direction of each of the spatial axes L, Q, V, precise yawing movements G (rotation about the vertical axis V) and pitch movements S (rotation about the transverse axis Q) being additionally possible, as well as roll movements R, if needed.

[0068] Due to the neutral trim, the underwater vehicle 1 hovers at its working position. If up and down forces form, for example due to modified environmental conditions, the trim is adjusted. In case of impacting lateral forces, the underwater vehicle 1 is positioned in its hovering position via coordinated activation of the maneuvering devices and its orientation is adapted if needed. The lateral propulsion drives 16, 16', 16'', 16''' are thereby activated in a coordinated manner and the action of the environment on the underwater vehicle is compensated for by activation of the lateral propulsion drives. A control device, which determines the corresponding correction measures based on sensor values, is provided for dynamic stabilization of the working position of the underwater vehicle during the mission via activation of the maneuvering drives. The control device thereby captures sensor values, for example, sensor values with information about the position and the orientation of the underwater vehicle 1.

[0069] The device for uncovering submerged objects by means of a water flow has a counter pressure nozzle 17 counteracting the working nozzle 8. During operation of the working nozzle 8, the water flow passing through it generates a force, which is compensated for or at least weakened by the counteracting counter pressure nozzle 17. The counter pressure nozzle is thereby put under pressure by the pump assembly 10 simultaneously with the working nozzle 8. The forces due to the suction effect on the working nozzle 8 are compensated for, or at least partially compensated for, by the counter pressure nozzle 17 so that the resulting force acting on the underwater vehicle 1 is small. The water vehicle can thus be maintained stable in its working position with little, or in case of full compensation by the counter pressure nozzle 17, without additional steering measures so that the explosion hazard during works on a bottom mine 4 is reduced.

[0070] The working nozzle 8 is disposed on a manipulation device 18, which in the shown embodiment consists of extendable robot arms. The manipulation device 18 can be pivoted via articulations 19 from the underwater vehicle 1 into the working area close to the bottom mine 4 to be uncovered. With the manipulation device 18, the energy demand of the underwater vehicle 1 can be considerably reduced since it is not necessary to move the underwater vehicle itself for a movement of the working nozzle in the working area, the working nozzle 8 being brought into the appropriate position with the manipulation device 18.

[0071] The manipulation device 18 is disposed in the area of the prow 12 of the underwater vehicle 1 and allows for free movements of the working nozzle 8 in the intended working area in front of the spotlights 15. The pivotable robot arms of the manipulation device 18 are advantageously disposed in such a manner that in the swiveled in initial position (FIG. 2) of the manipulation device 18, one of the two nozzles (working nozzle 8 or counter pressure nozzle 17) points toward the prow 12 or toward the working area. Since the water flow acts on both nozzles, in order to compensate the generated forces, the nozzle oriented toward the prow 12 works as a working nozzle and uncovers the bottom mine 4. If the manipulation device 18 is swiveled out in the direction of the arrow 20, the

nozzle which initially lies offside can be brought into the working area and act there as a working nozzle.

[0072] The underwater vehicle 1 advantageously has a metal detector or another auxiliary sensor for locating the object, more specifically, the bottom mine 4. This metal detector is advantageously disposed at a distance from the hull of the underwater vehicle 1. The metal detector is, for example, disposed on the working nozzle 8. This is advantageous if the hull of the underwater vehicle 1 is made of metal in order to resist to high pressures. Due to the distanced arrangement of the metal detector relative to the hull, the signal delivered by the metal detector, which indicates the presence of metal, is less disrupted or less interference-sensitive. The working nozzle 8 is therefore advantageously made of a non-metallic material, more specifically, plastic. This also applies, for example, for a possible counter pressure nozzle 17 and/or manipulation device 18.

[0073] The suction pipe 9 flows into a suction hose 21 at the end of which the outlet 11 for the water flow is located. The length of the suction hose 21 is calculated in such a manner that the outlet 11 lies at a distance from the underwater vehicle 1 so that the aspirated sediments discharged at the outlet 11 can no longer return to the working area of the working nozzle 8. To this end, the suction hose 21 can be configured in such a manner that it is fixed on the bottom by the underwater vehicle 1 in the surroundings of the bottom mine 4 to be uncovered and the underwater vehicle 1 is subsequently steered toward the bottom mine 4.

[0074] The underwater vehicle 1 has an anchoring device 22 with which the underwater vehicle 1 can be fixed in its working position. In an advantageous configuration, the anchoring device 22 is an anchor with a plurality of anchor flukes in the manner of a harrow. Such an anchor is brought down from the underwater vehicle 1 upon reaching the selected anchoring position. Releasing the anchor from the underwater vehicle thereby occurs upon a corresponding control command via the connecting cable 2 or is autonomously implemented by the underwater vehicle according to the parameters of a pre-determined mission program.

[0075] The configuration of the anchor with a plurality of anchor flukes in the manner of a harrow allows for a solid anchoring of the underwater vehicle 1 even in difficult seabed conditions.

[0076] In an alternative configuration, the anchoring device 22 is configured as an electro-magnet and/or a negative pressure apparatus, the underwater vehicle 1 being fixed onto the bottom mine 4 or onto another object in the surroundings of the object to be uncovered. In order to fasten the underwater vehicle, the anchoring device 22 can also be configured as a clamping device for clasping the object to be uncovered or objects in the surroundings of the object or of the underwater vehicle 1.

[0077] In an embodiment of the present invention, the anchoring device 22 comprises a nail gun, fastening nails or bolts being released upon a corresponding control command. With the help of the fastening nails, ropes or other holding means can be fastened to the seabed 3 and the underwater vehicle 1 can thus be fixed. A fixation of the underwater vehicle 1 on the object to be uncovered or on another object in the surroundings of the object to be uncovered is moreover also possible.

[0078] In the shown embodiment, the underwater vehicle 1 is equipped with an explosive charge 23, which is detachably disposed on the hull of the underwater vehicle 1. Upon a

corresponding control command via the connecting cable 2, the explosive charge 23 can be deposited or attached to the bottom mine 4 for mine clearance. The explosive charge 23 is thereby a hollow charge which is attached to the bottom mine 4 after it has been uncovered. The anchoring device can be advantageously used for appropriate positioning of the explosive charge 23, for example, the explosive charge 23 can be fastened to the bottom mine 4 by means of a nail gun.

[0079] In an embodiment not here shown, the explosive charge 23 is disposed inside the underwater vehicle 1. During the mission, the underwater vehicle 1 is thereby fastened in the area of or onto the object to be cleared, and after uncovering the object 4, oriented into an optimal orientation for detonation. An efficient mine-hunting drone is thereby provided which is also effective with mines that are difficult to clear.

[0080] FIG. 2 shows an underwater system with an underwater vehicle 1 according to FIG. 1, which is controlled from a system platform by way of a connection cable 2. In the shown embodiment, the system platform is a surface ship 24. In the shown underwater system, the connecting cable 2 is connected to a more specifically unmanned intermediate vehicle 25, which is in turn connected to the surface ship 24 in a signal transmitting manner. In the shown embodiment, the intermediate vehicle 25 is also a surface vehicle, so that a signal transmission between the intermediate vehicle 25 and the human operator on board the surface ship 24 is possible by radio at high range. The intermediate vehicle 25 and, together with the intermediate ship 25, also the underwater vehicle 1, can therefore also operate at a great distance from the mother ship without endangering the mother ship by unexpected detonations. An emission/reception device 26, 26' for radio signals is provided on the surface ship 24 as well as on the intermediate vehicle 25 for transmitting information between the surface ship 24 and the intermediate vehicle 25.

[0081] The connecting cable 2 between the intermediate vehicle 25 and the underwater vehicle 1 contains a signal line 27 through which information is transmitted between the intermediate vehicle 25 and the underwater vehicle 1. The signal line 27 is thus part of the signal path between the surface ship 24 with the human operator and the underwater vehicle 1. The signal line 27 is configured as a glass fiber cable (fiber optics). The intermediate vehicle 25 carries a control unit 28 with which the communication with the mother ship is transformed into optical signals.

[0082] In the shown embodiment, the underwater vehicle 1 comprises its own energy source and receives or sends information exclusively via the connecting cable 2. Since, due to the manipulation device 18 (FIG. 1), uncovering submerged objects by guiding the working nozzle is implemented without energy expenditure for modifying the position of the underwater vehicle, the energy source of the underwater vehicle 1 can be configured small and in a space-saving manner.

[0083] In the shown embodiment with a connecting cable 2 which has a signal line 27 for data transmission, the intermediate vehicle 25 forms a relay station which relays the data communication between the mother ship and the underwater vehicle 1. The underwater vehicle 1 with which objects submerged in the seabed are uncovered is advantageously transported to the operation site by the intermediate vehicle 25.

[0084] The energy demand of the underwater vehicle 1 can in this way be further reduced. Only the amount of energy that

is actually needed for the operation on site must be provided on board the underwater vehicle 1.

[0085] FIG. 3 shows an embodiment of an underwater system with an underwater vehicle 1, a surface ship 24, which constitutes the carrier platform and an intermediate vehicle 25. As already shown in FIG. 2, the intermediate vehicle 25 is in radio contact with the surface ship 24. As opposed to the embodiment according to FIG. 2, in the embodiment of the underwater system according to FIG. 3, the connecting cable 2 contains a power line 29 in addition to the signal line 27. The underwater vehicle 1 is supplied by the intermediate vehicle 25 via the power line 29. An energy source 30 is housed on board the intermediate vehicle 25 for supplying the underwater vehicle 1 with energy. The energy source 30 can be a generator or a battery with a correspondingly high capacity for supplying the underwater vehicle 1 so that missions with a high energy demand can be implemented and, more specifically, missions with a longer mission time.

[0086] The present invention is not limited to embodiments described herein; reference should be had to the appended claims. All the features mentioned in the above description and in the claims are further usable individually as well as in any combination. The disclosure of the present invention is therefore not limited to the described, respectively claimed, feature combinations. In fact, all feature combinations must be considered as disclosed.

What is claimed is:

1-15. (canceled)

16. An underwater vehicle configured to be remote-controllable and maneuverable, the underwater vehicle comprising:

- a device configured to uncover a submerged object, the device comprising:
 - a working nozzle configured to conduct a water flow; and
 - a counter pressure nozzle configured to counteract the working nozzle.

17. The underwater vehicle as recited in claim 16, wherein the device further comprises at least one tool configured to be rotationally drivable.

18. The underwater vehicle as recited in claim 17, wherein the at least one tool is a brush.

19. The underwater vehicle as recited in claim 16, wherein the underwater vehicle is configured to be trimmed neutral and further comprises maneuvering devices configured and arranged so that the underwater vehicle is steerable in a longitudinal axis, in a transverse axis, and in a vertical axis, and in a direction of a rotation about at least one of the longitudinal axis, the transverse axis, and the vertical axis.

20. The underwater vehicle as recited in claim 19, wherein the underwater vehicle further comprises a prow, and the maneuvering devices comprise a rear drive and at least one lateral propulsion drive arranged in an area of the prow.

21. The underwater vehicle as recited in claim 20, wherein the at least one lateral propulsion drive is arranged in pairs and have different operating directions.

22. The underwater vehicle as recited in claim 16, wherein the device further comprises a pump assembly configured to act on the working nozzle and to be adjustable with regard to a pump output, wherein a work direction of the water flow is configured to be switchable so as to operate in a suction mode or in a rinsing mode.

23. The underwater vehicle as recited in claim 16, further comprising an anchoring device configured to fix the under-

water vehicle on or in an area of the submerged object, the anchoring device comprising at least one of:

- an anchor comprising a plurality of anchor flukes provided as a harrow,
- a nail gun,
- an electromagnet,
- a negative pressure apparatus, and
- a clamping device configured to clasp to at least one of the submerged object to be uncovered, to a part of the submerged object to be uncovered, to objects in a surrounding of the submerged object to be uncovered, and to the underwater vehicle.

24. The underwater vehicle as recited in claim 16, wherein the underwater vehicle further comprises a survey device configured to survey a surrounding.

25. The underwater vehicle as recited in claim 24, wherein the survey device is at least one of an acoustic device, a sonar, an optical device, and a camera.

26. The underwater vehicle as recited in claim 16, wherein the underwater vehicle further comprises a controllable manipulation device configured to carry the working nozzle.

27. The underwater vehicle as recited in claim 16, wherein the underwater vehicle further comprises an explosive charge.

28. The underwater vehicle as recited in claim 16, wherein the explosive charge is a hollow charge.

29. The underwater vehicle as recited in claim 16, wherein the underwater vehicle further comprises at least two spotlights arranged in a spaced-apart relationship, the at least two spotlights being oriented toward a working area of the working nozzle.

30. The underwater vehicle as recited in claim 29, further comprising a suction pipe connected to the working nozzle, and an outlet of the water flow, the suction pipe being arranged so as to extend away from the underwater vehicle in a direction remote from the working area of the working nozzle, the suction pipe being configured to have a length to the outlet of the water flow so that no particle load discharged at the outlet flows back into the working area of the working nozzle.

31. An underwater system comprising:

- an underwater vehicle as recited in claim 16;
 - a system platform connected to the underwater vehicle in a signal-transmitting manner;
 - an intermediate vehicle connected to the system platform;
 - a wireless communication device; and
 - at least one connecting cable,
- wherein, the underwater vehicle is connected to the intermediate vehicle via at least one of the wireless communication device and the at least one connecting cable.

32. The underwater system as recited in claim 31 wherein the intermediate vehicle is connected to the system platform via a radio connection.

33. The underwater system as recited in claim 31, wherein the at least one connecting cable comprises a signal line.

34. The underwater system as recited in claim 33, wherein the signal line is a glass fiber line.

35. The underwater system as recited in claim 31, wherein the at least one connecting cable comprises a power line, and the intermediate vehicle comprises an energy source, the energy source being connected to the underwater vehicle via the power line.