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(54) **UNDERWATER VEHICLE FOR TIGHT-SPACES**

(57) The present disclosure relates to an underwater vehicle for tight-spaces comprising a stabilizer comprising a rotatable ring comprising a first sector and a second sector regions arranged circularly on said ring; wherein second sector region has lower density than water.

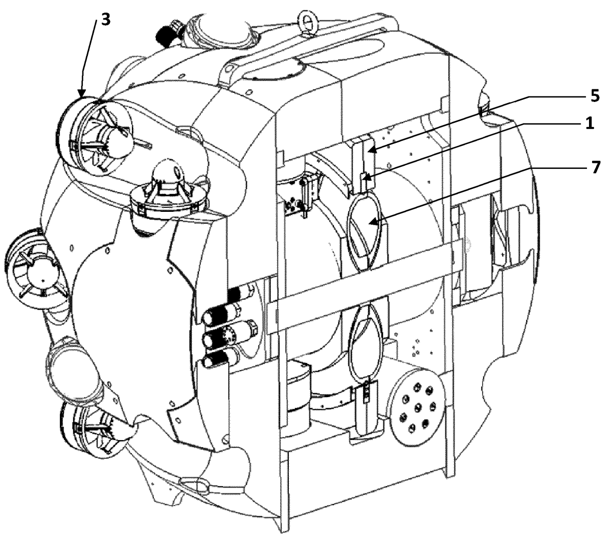

Fig. 3

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Description

TECHNICAL FIELD

[0001] The present disclosure relates to an underwater vehicle for 3D mapping of underwater confined environments. More particularly, relates to an autonomous underwater vehicle for exploring and mapping tight-spaces such as underwater tunnels, caves, wells, among others.

BACKGROUND

[0002] Most of the development in underwater robotics is intended for open water scenarios, where the restrictions on shapes and sizes of the vehicle are not rigorous. Existing AUV are not adequate for tunnels, shafts and caves due to their shape, size and umbilical cord. For these kinds of scenarios, which would take advantage of an almost spherical design, some AUV's were already proposed, such as the UX-1 robot.

[0003] A few works can be found in the literature focusing on spherical Autonomous Underwater Vehicle AUVs. A μ AUV (micro autonomous underwater vehicle) of 0.075m radius and 6 propellers around the hull was developed by S. A. Watson, D. J. P. Crutchley and P. N. Green, " The design and technical challenges of a micro-autonomous underwater vehicle (μAUV) ", Proc. IEEE Int. Conf. Mechatronics Automat., pp. 567-572, Aug. 2011. and S. A. Watson and P. N. Green, " Design considerations for micro-autonomous underwater vehicles (μAUVs) ", Proc. IEEE Conf. Robot. Automat. Mechatronics, pp. 429-434, Dec. 2010] for monitoring nuclear storage ponds.

[0004] The authors A. Agrawal, B. Prasad, V. Viswanathan and S. K. Panda, "Dynamic modeling of variable ballast tank for spherical underwater robot", Proc. IEEE Int. Conf. Ind. Technol. (ICIT), pp. 58-63, Feb. 2013, A. Agrawal, B. Prasad, V. Viswanathan and S. K. Panda, "Dynamic modeling of variable ballast tank for spherical underwater robot", Proc. IEEE Int. Conf. Ind. Technol. (ICIT), pp. 58-63, Feb. 2013, and Y. Li, S. Guo and Y. Wang, "Design and characteristics evaluation of a novel spherical underwater robot", Robot. Auton. Syst., vol. 94, pp. 61-74, Aug. 2017 make use of the spherical UUV SUR-II, which is equipped with water-jet thrusters as propulsion, to design and develop attitude stabilization methods as well as buoyancy control with a variable ballast tank.

[0005] In H. T. Choi, A. Hanai, S. K. Choi and J. Yuh, "Development of an underwater robot ODIN-III", Proc. IEEE/RSJ Int. Conf. Intell. Robots Syst. (IROS), pp. 836-841, Oct. 2003, the underwater robot ODIN-III is presented.

[0006] It has a hollow metal sphere housing of 0.63m in diameter and a propulsion system that consisted of 8 thrusters fixed outside the hull.

[0007] A key disadvantage of these AUV designs is the presence of external propulsion systems, which could become entangled with objects such as ropes or cables encountered during operation.

[0008] In 2017 Lopes et al UNEXMIN: A new concept to sustainably obtain geological information from flooded mine, European Geologist Journal, issue 44 pg 54-57 presented a AUV for exploration of confined underwater spaces with an almost spherical shape with a set of 8 thrusters distributed in two lateral cross shaped thruster manifolds.

[0009] US2021089031 discloses an autonomous underwater vehicle (AUV) that includes a frame and tunnel thrusters for propelling and orientating the AUV, where the tunnel thrusters have inlets and outlets, each of outlets being directed in a different orientation, and are mounted to the frame. The AUV further includes fasteners for connecting the frame to a hull, where the fasteners have an orientation that is substantially parallel to the tunnel thrusters. The hull has a substantially spherical shape and further includes a bottom plate with inlet openings a top plate with outlet openings, where the top plate and the bottom plate are affixed to the fasteners and hold plate rings of the hull in place, and each of the plate rings that further includes a corresponding retention ring and corresponding central plates.

[0010] All the referred systems still have several disadvantages like, for example, they still lack effective active pitch control and stability for any angle, and in the particular case of the UX-1 it doesn't have effective lateral motion (SWAY).

[0011] These facts are disclosed in order to illustrate the technical problem addressed by the present disclosure.

GENERAL DESCRIPTION

[0012] The present disclosure relates to an underwater vehicle able to be manoeuvre in open water or in underwater tunnels, or underwater wells or underwater galleries. Particularly, relates to an underwater vehicle for exploration and 3D mapping of underwater confined environments. More particularly, relates to an autonomous underwater vehicle for exploration and mapping tight-spaces such has underwater tunnels, caves, wells, among others.

[0013] The present disclosure allows the stabilization and control of the pitch in any angle, avoiding the use of a high number of sensors.

[0014] The present disclosure is designed to be able to navigate, explore and map both in environments with good visibility and in environments with low or even no visibility due to an unique combination of visual sensors plus structured light in all directions, with multibeam sonar for mapping and mechanical scanning sonars for navigation, and cameras/SLS that allow 360 mapping around the vehicle's longitudinal axis, plus one at the front and one at the back.

[0015] The present disclosure can be used in saltwater or freshwater.

[0016] The present disclosure relates to an underwater modular vehicle for tight-spaces comprising:
a stabilizer comprising a rotatable ring comprising:

a first sector and a second sector regions arranged circularly on said ring;
wherein second sector region has lower density than water.

[0017] The rotatable ring, that has the heavy part in one point and a lighter part in a opposite side, creates the difference between centre of mass and centre of buoyancy that will stabilize in roll and pitch.

[0018] In an embodiment, the first sector region has higher density than water, preferably higher density than saltwater or freshwater.

[0019] In an embodiment, the second sector region has lower density than water, preferably higher density than saltwater or freshwater.

[0020] In an embodiment, a weighting body is arranged peripherally on said ring in said first sector.

[0021] In an embodiment, a floating body is arranged peripherally on said ring in said second sector.

[0022] In an embodiment, the floating body is a foam.

[0023] In an embodiment, the ring is rotatably attached to a variable buoyancy part.

[0024] In an embodiment, the variable buoyancy part is shaped as a ring torus.

[0025] In an embodiment, the variable buoyancy part is a pressurised tank.

[0026] In an embodiment, the pressurised tank is an oil tank or water tank.

[0027] In an embodiment, the stabilizer further comprises a container with a pump for releasing oil to the oil tank or water to the water tank. For better results, it is released oil to the oil tank.

[0028] In an embodiment, the stabilizer further comprises a further container comprising oil or water, preferably a bladder or a syringe.

[0029] In an embodiment, the stabilizer comprises a locking system comprising an actuator device for releasing a locking protrusion.

[0030] In an embodiment, the actuator device is a solenoid or motor.

[0031] In an embodiment, the rotatable ring comprises a recess for receiving the locking protrusion.

[0032] In an embodiment, the rotatable ring comprises rollers.

[0033] In an embodiment, the water is saltwater or freshwater.

[0034] In an embodiment, the vehicle further comprises a plurality of thrusters for controlling the vehicle pitch. Preferably the position and orientation of the thrusters allows to improve the vehicle pitch control. Preferably, four thrusters are positioned on the vehicle's YZ plane (at the aft) pointing forward in a square disposition, two thrusters pointing vertically on each side of the vehicle's YZ symmetry plane and other two or four thrusters positioned on the vehicle's XY symmetry plane on the sides of the vehicle and with an angle of 45 degrees with relation to the robot's longitudinal axis.

[0035] In an embodiment, the vehicle comprises only two thrusters on the vehicle's XY plane in an asymmetric configuration, only on one side of the vehicle (starboard or port) allowing a preferable observation side in the vehicle where additional instruments can be mounted and less flow from the thrusters is provided which can cause turbidity.

[0036] In an embodiment, the number of thrusters is 2 to 15, preferably 6 to 10, more preferably 8.

[0037] In an embodiment, the underwater vehicle further comprises one or more cameras for capturing underwater images.

[0038] In an embodiment the underwater vehicle further comprises one or more sonar, preferably a multibeam sonar.

[0039] In an embodiment, the underwater vehicle further comprises one or more sensors.

[0040] In an embodiment, the sensors are one or more inertial sensors, one or more acoustic sensors and one or more pressure sensors.

BRIEF DESCRIPTION OF THE DRAWINGS

[0041] The following figures provide preferred embodiments for illustrating the disclosure and should not be seen as limiting the scope of invention.

Figure 1: Schematic representation of an embodiment of an underwater vehicle comprising a stabilizer.

Figure 2: Schematic representation of an embodiment of an underwater vehicle comprising a stabilizer.

Figure 3: Schematic representation of a cross-section of an embodiment of an underwater vehicle comprising the stabilizer.

Figure 4: Schematic representation of an embodiment of the stabilizer of the underwater vehicle.

Figure 5: Schematic representation of a cross-section of an embodiment of stabilizer with the deposit of the underwater vehicle.

Figure 6: Schematic representation of an embodiment of a stabilizer with a bladder of the underwater vehicle.

Figure 7: Schematic representation of an embodiment of the locking system of the stabilizer.

DETAILED DESCRIPTION

[0042] The present disclosure relates to an underwater vehicle able to be manoeuvre on underwater tunnels or open waters. More particularly, relates to an underwater vehicle for exploration and 3D mapping of flooded underground on-shore environments.

[0043] It relates to an underwater vehicle for tight-spaces comprising:

a stabilizer comprising a rotatable ring comprising:

- a first sector and a second sector regions arranged circularly on said ring;
- wherein second sector region has lower density than water.

[0044] The combination of passive pendulum and 6DoF actuation allows stable movement in any inclination. This allows proper surveying of horizontal corridors, ramps or vertical shafts. Sensor configuration allows a survey for inspection and mapping with high resolution 360° around the longitudinal axis of the robot. As the robot can adopt any inclination and move efficiently in that direction, it is endowed with this unique survey capability.

[0045] Buoyancy variation system does not affect the direction of the vector from the center of mass to the center of buoyancy. That is, buoyancy compensation/adjustment does not make the vehicle unstable. This is achieved with an oil deposit, shaped as a donut (also known as a ring torus) around the electronics cylinder that is located in the central transverse axis of the vehicle. Thus, the change in mass in this donut does not affect the center of mass, transversely, only affecting in Z (approaching or moving away from the center of impulsion (of fluctuation)).

[0046] In an embodiment, the underwater vehicle comprises a control software that allows stable movement in any direction, with robust and intuitive parameterization. Also, it serves as the basis for various semi-autonomous and autonomous movement strategies.

[0047] The present disclosure is designed to be able to navigate, explore and map both in environments with good visibility and in environments with low or even no visibility due to a unique combination of visual sensors plus structured light in all directions, with multibeam sonar for mapping and mechanical scanning sonar for navigation, and cameras that allow 360° mapping around the vehicle's longitudinal axis, plus one at the front and one at the back.

[0048] In an embodiment, the vehicle comprises structured light system SLS System. In an embodiment, this modular and versatile system is composed of cameras, light systems and laser projectors with a rotating mechanism, which allows to synchronize and simultaneously control multiple systems in order to obtain images under white light and ultra violet light (for observation of Fluorescence phenomena) and distance measurements with millimetre resolution allowing high resolution mapping.

[0049] The present disclosure comprises high accuracy positioning-navigation system: the fusion of information from IMU, DVL, pressure sensors using sensor and motion models allows exploration and mapping without reliance on perception sensors.

[0050] In an embodiment, it is used energy system with pressure-tolerant batteries that allow 8 hours of operation, and its replacement in a few minutes.

[0051] In an embodiment, the vehicle comprises a device that allows energy efficient stabilization of an underwater vehicle in any pitch attitude/configuration, allowing simultaneously the buoyancy regulation of the vehicle.

[0052] In an embodiment, this stabilization mechanism includes:

- a passive pendulum;
- a variable buoyancy system; and
- a thruster configuration with pitch control / 6DoF thruster actuation configuration.

[0053] In an embodiment, an instantiation of this mechanism with these three components can be seen **Figure 1.** In an embodiment, Figure 1 discloses the rotatable ring **1,** the electronic cylinder **2,** thrusters **3,** and the tank **7.**

[0054] In an embodiment, an instantiation in an underwater vehicle is depicted in the **Figure 2** and **Figure 3.**

[0055] In an embodiment, the stabilizer (or passive pendulum component) comprises a rotating ring (or cylinder shaped) comprising:

- a floating element (floating body), lighter than water; and
- a heavier than water segment;
- both segments are hold by a structure, that slides over a fix base.

[0056] In an embodiment, the floating element has a density from 100 to 600 Kg/m^3, preferably 200 to 500 Kg/m^3, more preferably from 300 to 450 Kg/m^3.

[0057] In an embodiment, the rotating ring is built around the centre of buoyancy, and rotate over the y-axis (depending of the pitch of the mobile platform to stabilize).

[0058] In an embodiment, the rotating ring should have the maximum diameter that the platform restriction allows to maximize the stabilization performance and robustness to disturbances.

[0059] In an embodiment, the stabilizer further comprises a fix base, over which the mobile ring rotates. The rotating friction between the two parts should be low but enough to avoid the rotation with small disturbances in the platform.

[0060] In an embodiment, the stabilizer can have an optional locking system, that will fix the ring, endowing the platform with extra stabilization under high disturbances. This can be composed by an actuator device, such a solenoid or motor that releases a locking protrusion or locking dent from a dented ring attached to the rotating ring.

[0061] In an embodiment, **Figure 4** shows the stabilizer (or passive pendulum component) comprising a rotatable ring. It can be seen the rotatable ring **1,** the first sector region **4,** the second sector region **5** and the locking actuator **6.**

[0062] Following it will be explained the variable buoyancy system (VBS).

[0063] In an embodiment, a variable buoyancy system (VBS), comprises:

a fluid deposit which is preferably a pressurised oil tank or a pressurised water tank **7;**
pressurised container with pumping system **8;**
external bladder that will hold the fluid **12.**

[0064] In an embodiment, the fluid deposit **7,** typically comprising oil or water, has its centre of buoyancy coincident or close to the platform centre of buoyancy.

[0065] This deposit's shape should be such that:

maximises the supported external pressure for its weigh;
simultaneous acts as an additional stabilizer pendulum and does not affect the vertical projection of the centre of mass;
allows the possibility for the platform to have components close to its centre.

[0066] An example of a specific configuration of the deposit is depicted in the **Figure 5** where it shows a ring shape. **Figure 5** shows the second sector region **5,** preferably a foam, an oil tank **7,** preferably a pressurized oil tank fixed in relation to the main electronics; a container for oil for pump and control **8,** preferably a pressurized container; support parts to hold the assembly in the center of the Y axis of the vehicle **9;** a valve manifold **10** and rollers **11** attached to the rotatable ring to facilitate rotation.

[0067] In an embodiment, the pressurised container with pumping system may present two configurations, one with a bidirectional pump or one with a one way directional pump plus a set of valves to reverse the pumping direction. In both cases there are additionally an external access valve, pressure sensors and control electronics.

[0068] This pumping system is capable of pumping the fluid from the fluid deposit in and out to and external bladder that holds the fluid, in that way increasing or decreasing the total volume, and so the buoyancy of the platform.

[0069] In an embodiment, the external bladder holds the fluid that is pumped in and out from the fluid deposit by the pumping system. This is typically a flexible bladder or a syringe that can be located in any part of the vehicle because the fluid that is pumping has similar weight than the surrounding water. In an embodiment, the VBS allows the platform to control its buoyancy in order to be completely neutral and therefore avoiding unnecessary energy consumption to compensate any over or under weigh (see Figure 6). **Figure 6** shows a further container **12,** preferably a bladder, more preferably a flexible outer bladder comprising varying oil quantity; a flexible tubbing **13.**

[0070] Following it will be explained the thruster configuration with pitch control and 6DoF thruster actuation configuration.

[0071] The previously described elements of the complete system allow the passive stabilization of the current pitch of the platform, but to change the platform reach it is required to have control actuation in the pitch axis. This way the platform will only spend energy whenever it changes the pitch and therefore enhancing the energy efficiency.

[0072] So, a thruster **3** setup that allows pitch control is a minimal requirement for the energy efficient pitch control with stabilization of an underwater vehicle.

[0073] The specific 6DoF thruster **3** actuator configuration depicted in the **Figure 2** and **Figure 3** allows redundant level of pitch control that associated with the other apparatus will allow the energy efficient, and self-stable pitch control.

[0074] And, associated with the buoyancy control, the thrust energy in Z axis is minimised with the capability of becoming neutral buoyant.

[0075] Following with will be explained the pitch rotation. The rotation in pitch about the Y axis (X is for the front of the Robot and Y is for the side) is carried out through the following steps:

unlock the sprocket that is attached to the pendulum (pendulum consisting of flotation and a weight at the bottom);
act on the rear motors that will cause the rotation movement on the same axis, up to the desired angle;
lock the sprocket in order to keep the pendulum in this new position.

[0076] Preferably, the mechanical actuation is done through a solenoid that causes the cogwheel to jam, blocking the movement of the pendulum.

[0077] From this moment on, the vehicle maintains its attitude on that axis without wasting energy. The only step where there is significant energy expenditure is in the second step (act on the rear motors that will cause the rotation movement on the same axis, up to the desired angle) (Figure 7). **Figure 7** shows a locking actuator **14,** preferably solenoid; a locking protrusion **15,** preferably a locking dent actuated by the solenoid to lock the rotatable ring; a recess **16** on the ring, preferably a dented ring attached to the rotatable ring.

[0078] In an embodiment, the underwater modular vehicle further comprises a camera/SLS configuration that allows a 360-degree field of view around the x axis of the robot, which points to the front of the robot, and adds high resolution 3D mapping capabilities. An example of this embodiment is show in Fig 2.

[0079] In an embodiment, the underwater modular vehicle further comprises a camera/SLS configuration composed by one or more cameras and SLS, that allows frontal perception for 3D mapping or obstacle detection.

[0080] In an embodiment, the underwater modular vehicle further comprises a sonar configuration that allows the 360-degrees perception around the X axis, to ensure perception capability in low visibility scenarios, while moving along tunnels or vertical shafts.

[0081] In an embodiment, the underwater modular vehicle further comprises a sonar configuration that allows the frontal perception for obstacle detection in low visibility scenarios, while moving along tunnels or vertical shafts

[0082] In an embodiment, the underwater modular vehicle further comprises a multibeam sonar configuration that allows the frontal perception for longer range 3D mapping in low visibility scenarios.

[0083] In an embodiment, the underwater modular vehicle further comprises a set of navigation sensors to allow accurate and high-resolution dead reckoning capabilities. Preferably one or more High grade IMU inertial measurement system, typically a FOG or RLG IMU; one or more DVL Dopler velocity logger, one or more Highly accurate pressure sensor. The dead reckoning system that fuses together all sensors data to achieve an high resolution navigation system.

[0084] In an embodiment, the dead reckoning data is fused with a factor graphs slam solution that incorporate visual and sonar measurements of relevant features (landmarks) in the environment to improve the navigation solution in longer missions, by creating relations between previous poses and landmarks.

[0085] In an embodiment, it has all motors controllers and main power control system in another housing pressure tolerant cylinder, that allows easy replacement, and allow a batteries power distribution through standard underwater connectors.

[0086] In an embodiment, the underwater modular vehicle further comprises one or several pressure tolerant batteries that can be quickly replaced in field and in operation.

[0087] The term "comprising" whenever used in this document is intended to indicate the presence of stated features, integers, steps, components, but not to preclude the presence or addition of one or more other features, integers, steps, components or groups thereof.

[0088] The disclosure should not be seen in any way restricted to the embodiments described and a person with ordinary skill in the art will foresee many possibilities to modifications thereof. The above described embodiments are combinable.

[0089] The following claims further set out particular embodiments of the disclosure.

Claims

1. An underwater vehicle for tight-spaces comprising a stabilizer comprising a rotatable ring (1) comprising a first sector (4) and a second sector (5) regions arranged circularly on said ring, wherein the second sector region (5) has lower density than water.

2. Underwater vehicle according to the previous claim wherein the first sector region (4) has higher density than water.

3. Underwater vehicle according to any of the previous claims wherein a weighting body is arranged peripherally on said ring in said first sector (4).

4. Underwater vehicle according to any of the previous claims wherein a floating body is arranged peripherally on said ring in said second sector (5).

5. Underwater vehicle according to the previous claim wherein the floating body is a foam.

6. Underwater vehicle according to any of the previous claims wherein the ring is rotatably attached to a variable buoyancy part.

7. Underwater vehicle according to any of the previous claims wherein the variable buoyancy part is shaped as a ring torus.

8. Underwater vehicle according to any of the previous claims 6 to 7 wherein the variable buoyancy part is a pressurised tank (7), preferably an oil tank or water tank.

9. Underwater vehicle according to any of the previous claim wherein the pressurised tank is an oil tank or water tank wherein the stabilizer further comprises a container (8) with a pump for releasing oil to the oil tank or water to the water tank.

10. Underwater vehicle according to any of the previous claims wherein the stabilizer further comprises a further container (12) comprising oil or water, preferably a bladder or a syringe.

11. Underwater vehicle according to any of the previous claims wherein the stabilizer comprises a locking system comprising an actuator device (6) for releasing a locking protrusion, preferably the actuator device is a solenoid or motor.

12. Underwater vehicle according to any of the previous claims wherein the rotatable ring (1) comprises a

recess for receiving the locking protrusion.

13. Underwater vehicle according to any of the previous claims wherein the rotatable ring (1) comprises rollers (11).

14. Underwater vehicle according to any of the previous claims further comprising a plurality of thrusters (3) for controlling the vehicle pitch.

15. Underwater vehicle according to any of the previous claims further comprising a plurality of sensors, preferably the sensors are one or more inertial sensors, one or more acoustic sensors and one or more pressure sensors, and/or one or more cameras for capturing underwater images and/or at least one sonar.

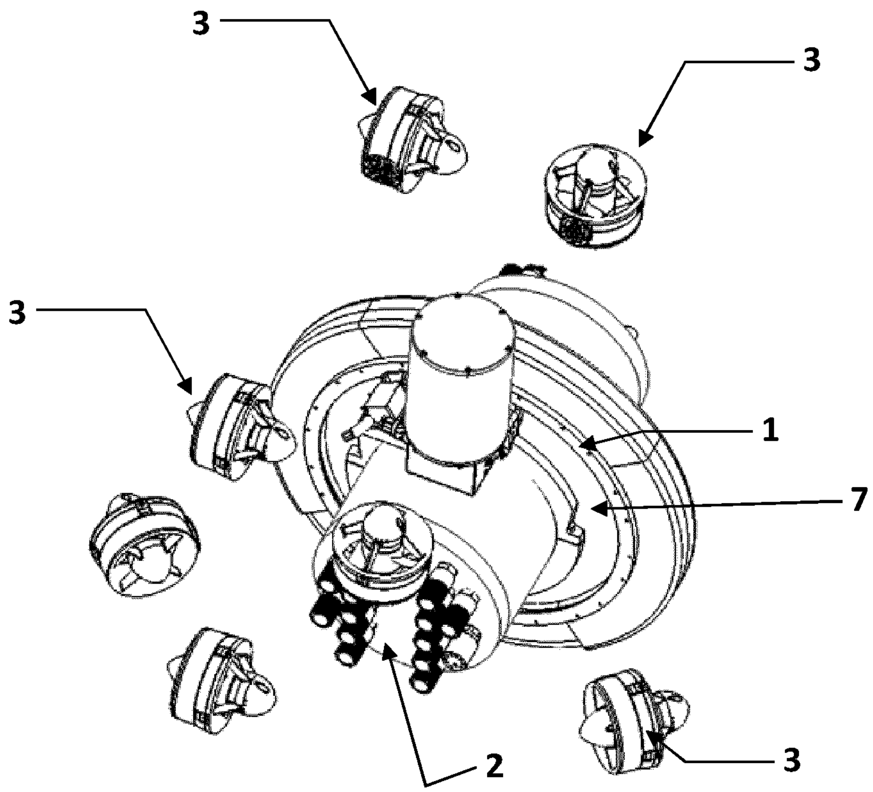

Fig. 1

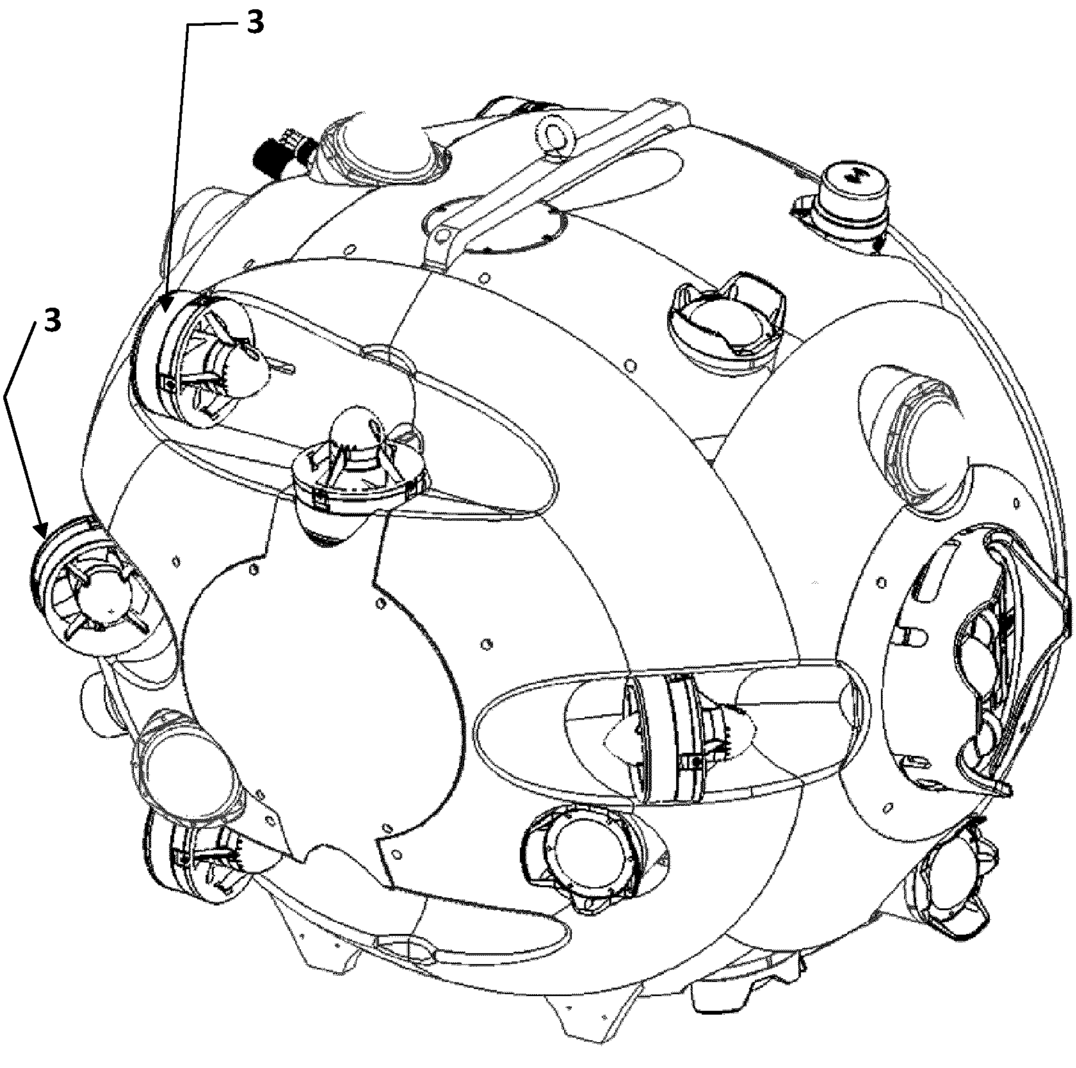

Fig. 2

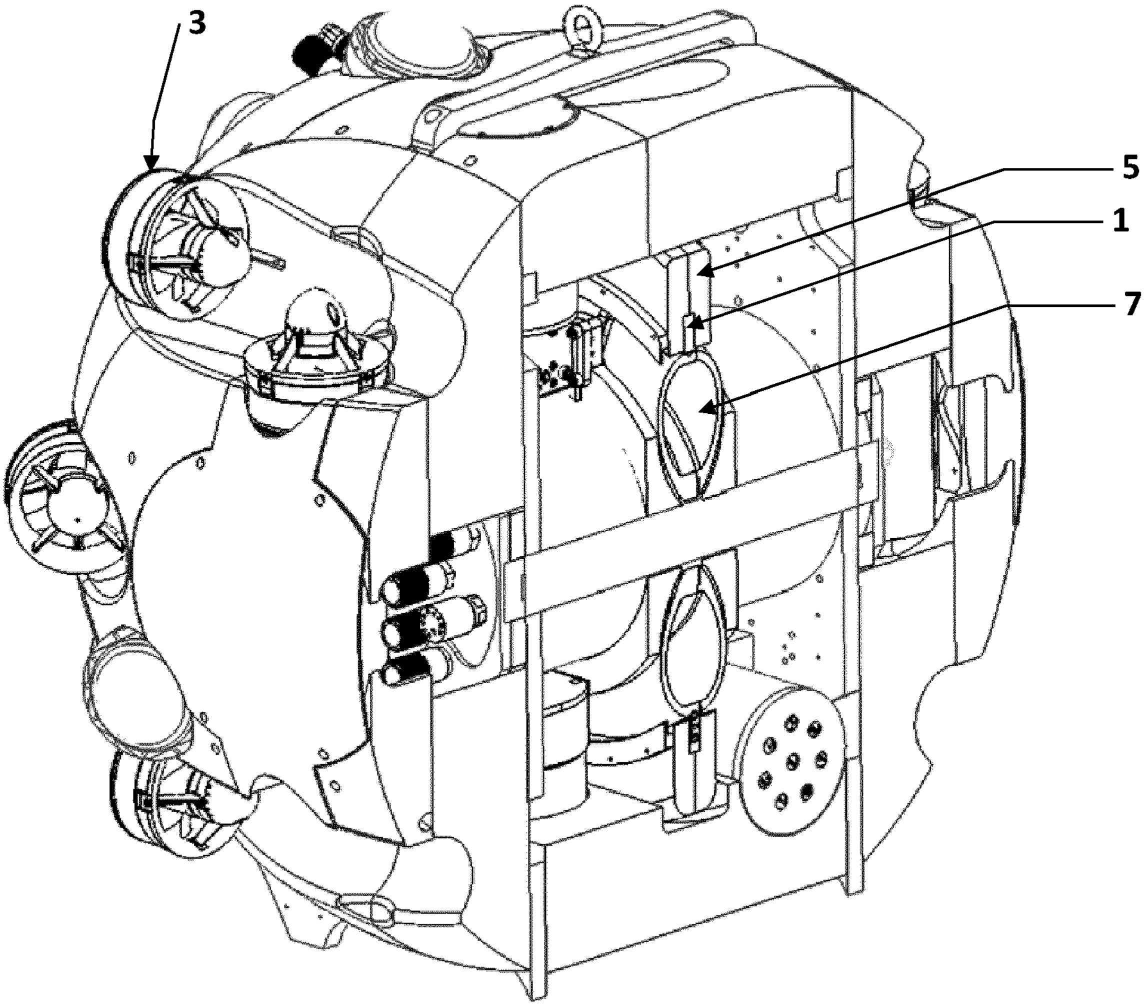

Fig. 3

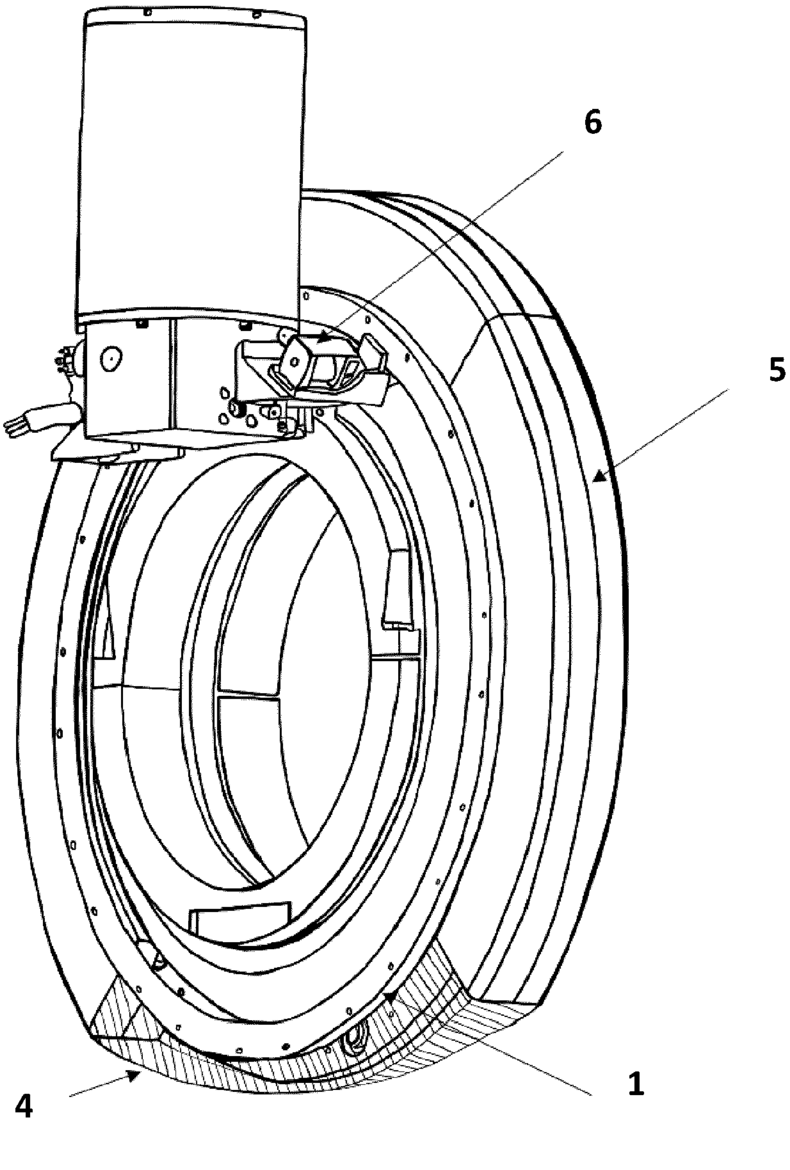

Fig. 4

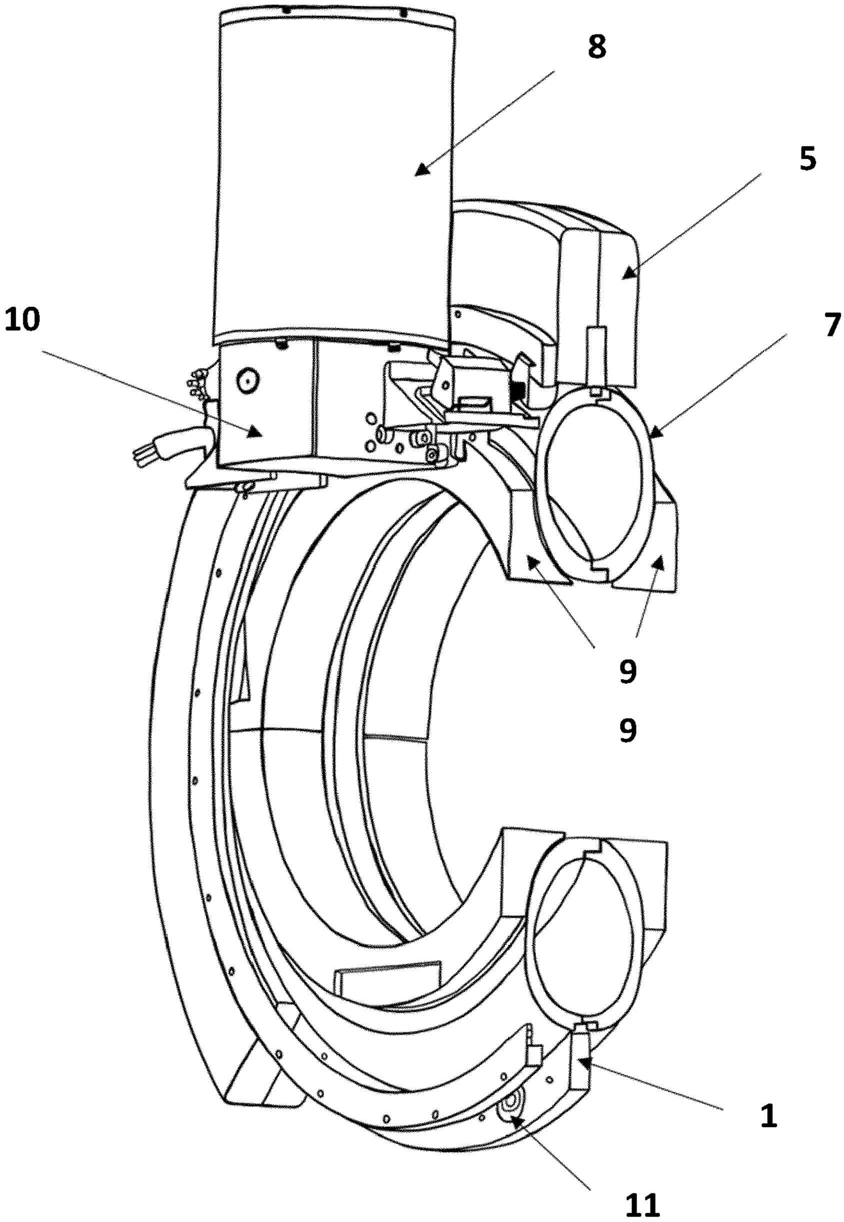

Fig. 5

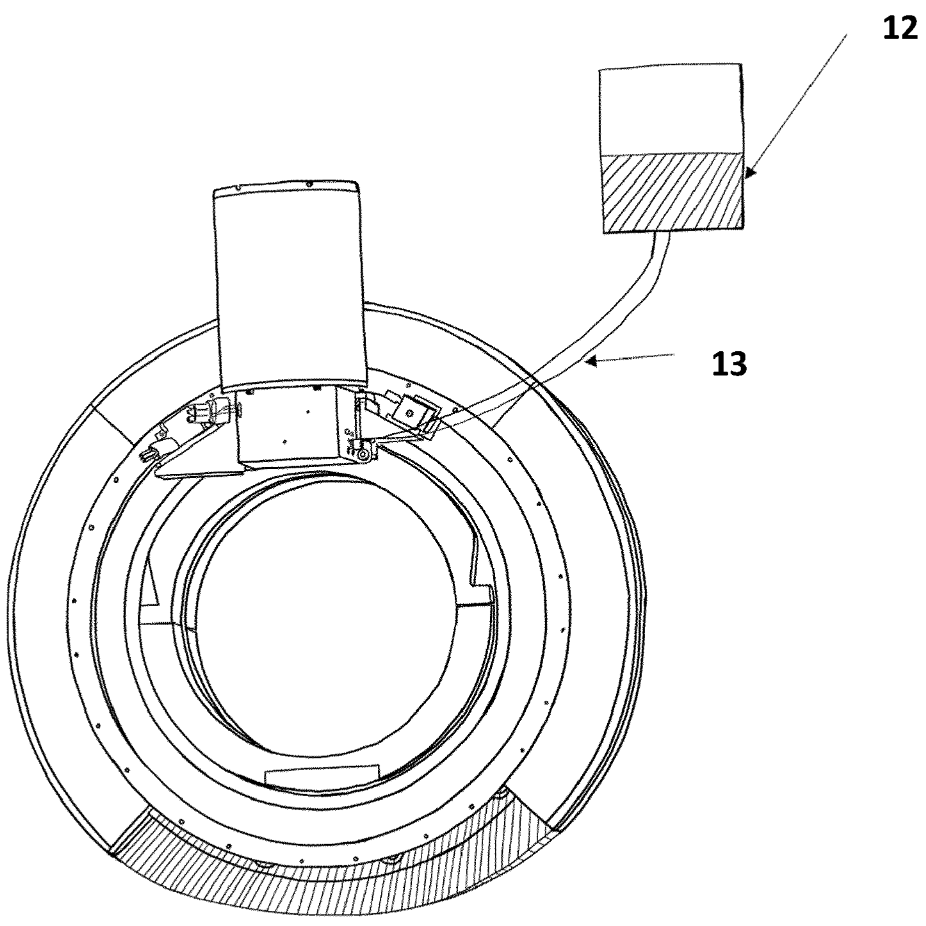

Fig. 6

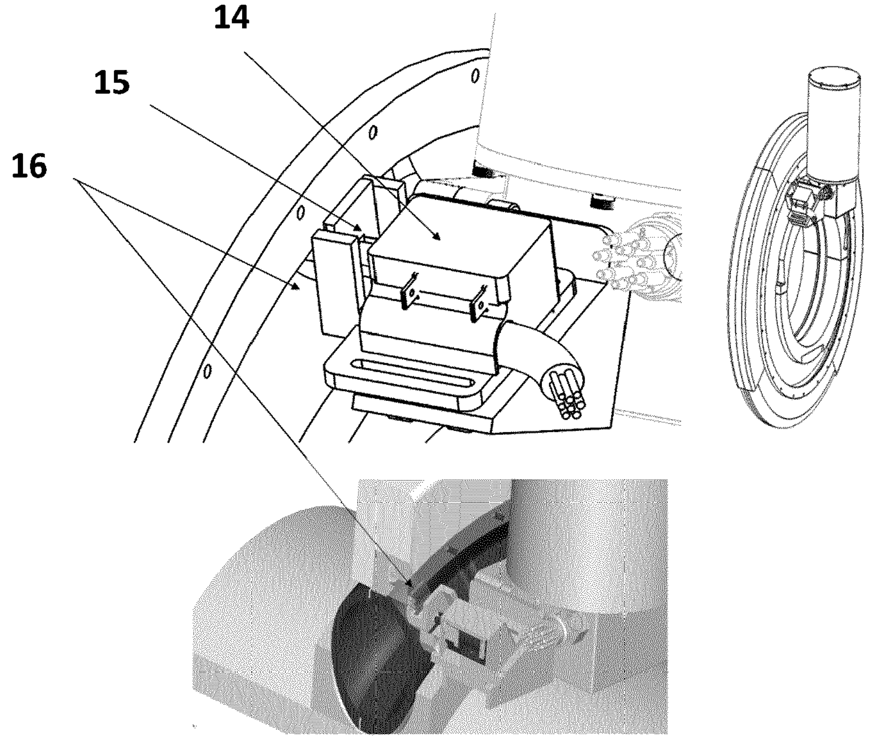

Fig. 7

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EUROPEAN SEARCH REPORT

Application Number
EP 23 18 9601

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	JP H05 254485 A (CHUBU DENRYOKU KK) 5 October 1993 (1993-10-05) * figures 1-9 * -----	1-15	INV. B63G8/00 B63G8/20 B63G8/22 B63G8/26
A	ZAVARI SOHEIL ET AL: "Propulsion system development and power consumption in an autonomous underwater vehicle", 2019 23RD INTERNATIONAL CONFERENCE ON SYSTEM THEORY, CONTROL AND COMPUTING (ICSTCC), IEEE, 9 October 2019 (2019-10-09), pages 521-524, XP033652728, DOI: 10.1109/ICSTCC.2019.8885503 [retrieved on 2019-10-28] * the whole document * -----	6,8-10	
A	FERNANDEZ RAMON A SUAREZ ET AL: "Motion Control of Underwater Mine Explorer Robot UX-1: Field Trials", IEEE ACCESS, vol. 7, 23 July 2019 (2019-07-23), pages 99782-99803, XP011738081, DOI: 10.1109/ACCESS.2019.2930544 [retrieved on 2019-08-02] * the whole document * -----	1-15	TECHNICAL FIELDS SEARCHED (IPC) B63G B63C B63J F42B
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A	CN 106 379 505 A (UNIV CHONGQING POSTS & TELECOM) 8 February 2017 (2017-02-08) * figure 2 * -----	1-15	
A	CN 103 832 565 A (UNIV BEIJING POSTS & TELECOMM) 4 June 2014 (2014-06-04) * figure 4 * ----- -/--	1-15	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	12 February 2024	Ibarrondo, Borja

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
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Application Number
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DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 2017/190396 A1 (COLE GREGORY A [US] ET AL) 6 July 2017 (2017-07-06) * figures 1, 3, 6, 7 * -----	1-15	

TECHNICAL FIELDS SEARCHED (IPC)

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The Hague	12 February 2024	Ibarrondo, Borja

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