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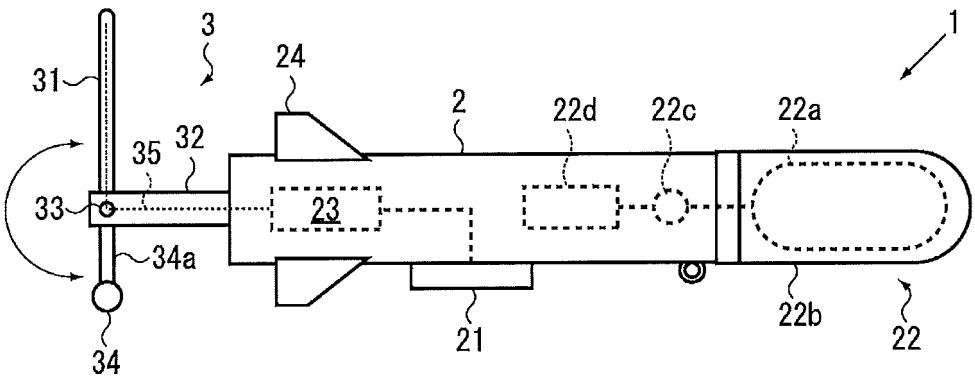
(54) **UNDERWATER MOBILE BODY**

(57) An underwater mobile body capable of acquiring information on hydrosphere and moving between a position under water and a water surface includes: a body unit (2) provided with a data acquisition device (21) that acquires hydrosphere information, and a specific gravity adjusting device (22) that adjusts the position of the underwater mobile body under water; and an antenna unit (3) arranged at a tail of the body unit (2) and provided with an antenna (31) that transmits the acquired hydrosphere information, wherein the antenna unit (3) holds the antenna (31) such that the antenna is able to turn in a vertical direction.

FIG. 1A



EP 3 009 341 A1

Description

Technical Field

[0001] The present disclosure relates to an underwater mobile body, and more particularly, to an underwater mobile body capable of moving between a position under water and the water surface.

Background Art

[0002] The hydrosphere (seas, lakes, rivers) occupies approximately 70% of the earth's surface, and its thermal capacity is said to be about 1000 times that of the atmosphere. A major change in the water temperature of, in particular, the vastest ocean exerts an enormous influence upon the state of the atmosphere, causing substantial changes of the weathers and climates of various parts of the world (e.g., El Niño effect). It is therefore necessary to survey marine information including water temperatures, in order to grasp variations of the marine information. It is also necessary to observe tidal currents and crustal changes of the seabed and to investigate active faults of the seabed, continental shelves and so forth for purposes of navigation safety, disaster prevention, environmental conservation, protection of maritime rights and interests, and the like.

[0003] In such marine surveys, underwater mobile bodies such as a buoy submersible under water, an underwater traveling body or underwater glider capable of traveling under water without external propulsion, and an underwater towed body that can be towed under water are often used. The underwater mobile bodies are generally equipped with antennas for transmitting collected marine information to ground base stations (see, for example, Patent Document 1, Patent Document 2, etc.).

[0004] Patent Document 1 discloses an unmanned, autonomous submersible underwater traveling body having a body unit with a pressure hull structure and a GPS (Global Positioning System; satellite navigation system) antenna attached to the bow of the body unit. Patent Document 2 discloses a glide type underwater traveling body having a body unit, and a radio antenna and a GPS antenna attached to the tail of the body unit and disposed along the fore-and-aft direction. The latter traveling body is configured to be erected with its bow down so that the antenna may project above the water surface for communication.

Citation List

Patent Literature

[0005]

Patent Document 1: Japanese Unexamined Patent Publication No. H10-86894

Patent Document 2: Japanese Unexamined Patent Publication No. 2006-232070

Summary

Technical Problem

[0006] In the case of an underwater traveling body having an antenna attached to an upper surface of the body unit like the one disclosed in Patent Document 1, the antenna is usually fixed so as to project upright above the water surface by the balance of the body unit, neglecting in many cases the fluid resistance of the antenna during submerging or traveling. Also, since the antenna is fixed to the body unit, the posture of the antenna is liable to be ruined by external force exerted by a mooring cable, towing cable, waves and the like, giving rise to a problem that the orientation of the antenna becomes unstable.

[0007] In the underwater traveling body disclosed in Patent Document 2, the antenna is fixed in such a manner that the fluid resistance during submerging and traveling is small. While the attitude of the body unit is for submerging or traveling, however, the antenna cannot be exposed to the atmosphere above the water surface, and it is necessary that attitude control for the body unit should be performed. However, the attitude control of an underwater traveling body requires a mechanism for adjusting the balance as well as a mechanism for generating propulsive force, such as a propeller, posing a problem of structural complexity, heavy weight, and increased consumption of electric power.

[0008] An object of the present disclosure was created in view of the aforementioned problems, and an object thereof is to provide an underwater mobile body which is simple in structure, low in fluid resistance, and capable of stabilizing the posture of an antenna during communication.

Solution to Problem

[0009] An aspect of the present disclosure provides an underwater mobile body capable of acquiring information on hydrosphere and moving between a position under water and a water surface, the underwater mobile body including: a body unit provided with a data acquisition device that acquires the hydrosphere information, and a specific gravity adjusting device that adjusts the position of the underwater mobile body under water; and an antenna unit arranged at a tail of the body unit and provided with an antenna that transmits the acquired hydrosphere information, wherein the antenna unit holds the antenna such that the antenna is able to turn in a vertical direction.

Advantageous Effects

[0010] In the underwater mobile body according to the present disclosure, the antenna unit holds the antenna such that the antenna is able to turn in a vertical direction,

and therefore, in all situations such as during observation, during ascent and during descent, the antenna is allowed to turn with the flow of water, making it possible to reduce the fluid resistance. Also, even in cases where the attitude of the underwater mobile body changes due to external force exerted by waves, tension of a mooring cable or the like when the underwater mobile body has ascended to a position near the water surface for purposes of communication, the antenna can move relative to the underwater mobile body, and thus, the posture of the antenna can be stabilized.

Brief Description of Drawings

[0011]

FIG. 1A is a side view of an underwater mobile body according to a first embodiment of the present disclosure.

FIG. 1B is a top view of the underwater mobile body according to the first embodiment of the present disclosure.

FIG. 2 illustrates an observation state of the underwater mobile body.

FIG. 3A illustrates an ascent of the underwater mobile body.

FIG. 3B illustrates a communication state of the underwater mobile body.

FIG. 3C illustrates a descent of the underwater mobile body.

FIG. 4A is a top view of an underwater mobile body according to a second embodiment of the present disclosure.

FIG. 4B illustrates a section B-B as viewed from a direction indicated by arrows in FIG. 4A.

FIG. 4C is a side view of an underwater mobile body according to a third embodiment of the present disclosure.

FIG. 4D is a side view of an underwater mobile body according to a fourth embodiment of the present disclosure.

FIG. 4E is a side view of an underwater mobile body according to a fifth embodiment of the present disclosure.

Description of Embodiments

[0012] Embodiments of the present disclosure will be described below with reference to FIGS. 1A through 4E. FIGS. 1A and 2A illustrate an underwater mobile body according to a first embodiment of the present disclosure, wherein FIG. 1A is a side view and FIG. 1B is a top view. FIG. 2 illustrates an observation state of the underwater mobile body. FIGS. 3A to 3C illustrate behavior of the underwater mobile body, wherein FIG. 3A shows an ascent, FIG. 3B shows a communication state, and FIG. 3C shows a descent.

[0013] As illustrated in FIGS. 1A and 1B, the underwater mobile body 1 according to the first embodiment of the present disclosure, which is capable of acquiring information on hydrosphere and moving between a position under water and a water surface, includes: a body unit 2 provided with a data acquisition device 21 that acquires the hydrosphere information, and a specific gravity adjusting device 22 that adjusts the position of the underwater mobile body 1 under water; and an antenna unit 3 arranged at a tail of the body unit 2 and provided with an antenna 31 that transmits the acquired hydrosphere information, wherein the antenna unit 3 holds the antenna 31 such that the antenna 31 is able to turn in a vertical direction.

[0014] The underwater mobile body 1 is, for example, a buoy, underwater traveling body, underwater glider, underwater towed body or the like placed in the hydrosphere including seas, lakes and rivers, and is an underwater apparatus that is movable between a position under water and the water surface, namely, capable of sinking under water and floating to the water surface. The underwater mobile body 1 acquires data (hydrosphere information) about the body of water where it is placed, such as current position, water temperature, salinity concentration, water pressure, magnetic force, and radioactive concentration. The following describes a case where the underwater mobile body 1 is placed in the sea to acquire marine information (hydrosphere information).

[0015] The body unit 2 has a housing with a nearly cylindrical shape, for example, of which the front portion, namely, the head, is tapered to reduce fluid resistance. The body unit 2 houses the specific gravity adjusting device 22, a controller 23, a storage battery (not shown), and the like. The data acquisition device 21, stabilizing fins 24, the antenna unit 3 and the like are disposed on the outside of the body unit 2.

[0016] The data acquisition device 21 includes various sensors and devices for measurement and observation, such as a CTD sensor for acquiring basic information including salinity concentration (sensor for measuring Conductivity, Temperature and Depth), a pressure sensor, a magnetic sensor, a radiation meter, and a sonar. Suitable sensors and devices are selected according to the kinds of marine information to be acquired from the sea, which is the target of observation or measurement. In the example illustrated in FIG. 1A, the data acquisition device 21 is disposed on a lower surface of the body unit 2, but the location of the data acquisition device is not particularly limited, and the data acquisition device may be disposed on an upper surface, side surface or at a rear tail portion of the body unit 2.

[0017] The specific gravity adjusting device 22 includes, for example, an expandable and contractible buoyancy bag 22a, a cover 22b surrounding the outer periphery of the buoyancy bag 22a, an oil pump 22c disposed within the body unit 2, and an oil tank 22d containing an operating fluid (e.g., silicone oil) that is supplied to and discharged from the buoyancy bag 22a. The buoyancy bag 22a is made of a soft material (e.g., resin or

the like) having tolerance to seawater. The cover 22b is a component for preventing damage to the buoyancy bag 22a and has a plurality of openings (not shown) formed in an outer periphery thereof. Accordingly, the interior of the cover 22b is filled with seawater.

[0018] When the oil pump 22c is operated to supply the operating fluid from the oil tank 22d to the buoyancy bag 22a, the buoyancy bag 22a expands within the cover 22b and forces out the seawater within the cover 22b. As a result, the apparent volume of the underwater mobile body 1 increases, so that the specific gravity of the underwater mobile body 1 decreases and the buoyant force of the mobile body 1 increases, enabling the underwater mobile body 1 to ascend.

[0019] On the other hand, when the oil pump 22c is operated to discharge the operating fluid from the buoyancy bag 22a into the oil tank 22d, the buoyancy bag 22a contracts within the cover 22b, allowing the seawater to flow into the cover 22b. As a result, the apparent volume of the underwater mobile body 1 decreases, so that the specific gravity of the underwater mobile body 1 increases and the buoyant force of the mobile body 1 decreases, enabling the underwater mobile body 1 to descend.

[0020] The controller 23 controls the operations of the sensors and devices constituting the data acquisition device 21, the storing of data acquired by the data acquisition device 21, the operation of the oil pump 22c, and the communications (transmission and reception of data) via the antenna unit 3. Specifically, a storage (memory) connected to the controller 23 stores an operation schedule for the individual sensors and devices of the data acquisition device 21 as well as a sink-float schedule for the underwater mobile body 1, and in accordance with the schedules, the controller 23 performs predetermined operations necessary for the measurements and the floating and sinking.

[0021] The antenna unit 3 is a communication device that transmits the marine information acquired by the data acquisition device 21 to the main equipment at a ground base station or an observation ship. The antenna unit 3 may send data directly to the antenna of the main equipment or may communicate with the main equipment via a communication satellite.

[0022] The antenna unit 3 includes, for example, a pair of supporting members 32, 32 extending rearward from the body unit 2, a pivot shaft 33 rotatably connected to the supporting members 32, 32, an antenna 31 projecting from a peripheral surface of the pivot shaft 33, and a weight member 34 joined to the pivot shaft 33 and located opposite the antenna 31. A communication cable 35 connected to the antenna 31 is passed through the interiors of the antenna 31, pivot shaft 33 and supporting member 32 and connected to the controller 23 within the body unit 2. Since the communication cable 35 is passed through the interior of the antenna unit 3, it is possible to prevent the communicating cable 35 from entwining or interfering with the antenna 31 even if the antenna 31 turns over a large angle.

[0023] The pair of supporting members 32, 32 are fixed to the rear end face of the body unit 2 substantially horizontally and substantially parallel to each other, and the pivot shaft 33 connects distal end portions of the two supporting members to each other such that the pivot shaft is rotatable relative to the supporting members. The antenna 31 and the weight member 34 are joined to the peripheral surface of the pivot shaft 33 so as to be aligned substantially vertically. The weight member 34 is held by a support 34a to be located at a fixed distance from the pivot shaft 33 and serves to keep the antenna 31 balanced under water.

[0024] While no load acts upon the antenna unit 3 as shown in FIG. 1A, the weight member 34 is located at its lowermost position due to gravity, so that the antenna 31 is held standing substantially in a vertical direction. On the other hand, when the antenna unit 3 is subjected to fluid resistance due to sea current or the floating or sinking of the underwater mobile body 1, the antenna 31 turns about the pivot axis 33 in directions indicated by the arrow in the figure.

[0025] FIG. 2 illustrates an example of a marine information collection system using the underwater mobile body 1. The marine information collection system includes, for example, an anchor 4 put on the bottom of the sea, an intermediate buoy 5 connected to the anchor 4 and floating under water, a mooring cable 6 having one end connected to the intermediate buoy 5, and the underwater mobile body 1 connected to the other end of the mooring cable 6.

[0026] The anchor 4 is a component for connecting the underwater mobile body 1 to the bed of the sea. The intermediate buoy 5 is a component that serves as a fulcrum for the floating and sinking of the underwater mobile body 1. The intermediate buoy 5 is connected to the anchor 4 by a mooring cable 51. The mooring cable 6 is a component that connects the intermediate buoy 5 and the underwater mobile body 1. The length of the mooring cable 6 is set according to diverse conditions, such as the depth of an underwater standby position of the underwater mobile body 1, the velocity of current of the sea where the underwater mobile body 1 is placed, and the magnitude of the sea current resistance of the mooring cable 6, so that the underwater mobile body 1 can ascend and reach the surface of the sea.

[0027] Also, the mooring cable 6 is connected to such a portion of the underwater mobile body 1 that the connection point is located forward from the middle of the overall length of the mobile body 1 and at the same time is located rearward from the nose of the mobile body 1. By connecting the mooring cable 6 in this manner, it is possible to make it easier for the underwater mobile body 1 to be supported nearly in parallel with the direction of sea current.

[0028] In the observation state illustrated in FIG. 2, the underwater mobile body 1 remains submerged in seawater and is located downstream of the intermediate buoy 5 due to sea current. At this time, since the underwater

mobile body 1 is situated in the sea current flowing in a direction indicated by the arrow in the figure, the antenna 31 is pushed by the sea current and tilted downstream. Although the antenna 31 is tilted substantially horizontally in the figure, in practice the antenna is tilted within a range of about 45 to 135 degrees from the vertical direction shown in FIG. 1A, depending on the velocity of sea current and pitching of the underwater mobile body 1.

[0029] After predetermined marine information is acquired by the underwater mobile body 1, the antenna 31 needs to be exposed to the atmosphere above the sea surface, in order to transmit the acquired data to the ground side. Accordingly, the underwater mobile body 1 ascends from the observation state shown in FIG. 2. To cause the underwater mobile body 1 to ascend, the oil pump 22c has only to be operated to supply the operating fluid from the oil tank 22d to the buoyancy bag 22a. During ascent, the seawater flows downward relative to the antenna unit 3, and therefore, the antenna 31 is tilted downward as shown in FIG. 3A.

[0030] While the antenna 31 is exposed to the atmosphere above the sea surface as illustrated in FIG. 3B, the antenna 31 starts communication with a communication satellite or the like to send the acquired marine information to the ground base station. At this time, the underwater mobile body 1 is floating near the sea surface, so that the underwater mobile body rocks up and down due to waves or the tension of the mooring cable 6. However, since the antenna 31 is connected to the body unit 2 via the pivot shaft 33, it is movable relative to the body unit 2. Accordingly, the substantially vertical posture of the antenna 31 can be maintained, so that the antenna can perform communication with its posture stabilized.

[0031] Then, to return to the observation state, the underwater mobile body 1 needs to descend. To cause the underwater mobile body 1 to descend, the oil pump 22c has only to be operated to discharge the operating fluid from the buoyancy bag 22a into the oil tank 22d. During descent, the seawater flows upward relative to the antenna unit 3, and thus, the antenna 31 is tilted upward as illustrated in FIG. 3C.

[0032] The antenna 31 is required to turn at least in response to the ascent shown in FIG. 3A and the descent shown in FIG. 3C. Preferably, therefore, the antenna 31 is configured so as to be able to turn through an angle of at least 180 degrees or more.

[0033] In the underwater mobile body 1 of the aforementioned embodiment, the antenna unit 3 is configured to hold the antenna 31 such that the antenna is able to turn in a vertical direction, and therefore, in all situations such as during observation, during ascent and during descent, the antenna 31 is allowed to turn with the flow of water, whereby the fluid resistance can be reduced.

[0034] Also, even in cases where the attitude of the underwater mobile body 1 changes due to external force exerted by waves, tension of the mooring cable 6 or the like when the underwater mobile body has ascended to a position near the water surface for communication, the antenna 31 can move relative to the underwater mobile body, and thus, the posture of the antenna 31 can be stabilized.

[0035] Referring now to FIG. 4, other embodiments exemplifying the underwater mobile body 1 will be described. FIGS. 4A to 4E illustrate underwater mobile bodies according to other embodiments of the present disclosure, wherein FIG. 4A is a top view of a second embodiment, FIG. 4B illustrates a section B-B as viewed from a direction indicated by arrows in FIG. 4A, FIG. 4C is a side view of a third embodiment, FIG. 4D is a side view of a fourth embodiment, and FIG. 4E is a side view of a fifth embodiment. In the figures, like reference signs denote like component parts already explained above with reference to the first embodiment, and detailed explanation of such component parts is omitted. Also, in the individual figures, the specific gravity adjusting device 22 is illustrated in a simplified manner.

[0036] In the underwater mobile body 1 of the second embodiment illustrated in FIGS. 4A and 4B, the communication cable 35 connected to the antenna 31 is disposed in a different way. Specifically, the communication cable 35 is passed through the interior of the antenna 31, then led out from the peripheral surface of the pivot shaft 33 and guided to the controller 23 within the body unit 2. In this manner, the communication cable 35 may be partly exposed to the outside at a location between the antenna 31 and the body unit 2. It is possible that the weight member 34 will pass between the supporting members 32, 32 of the antenna unit 3, and thus, the communication cable is preferably slackened so as not to obstruct the movement of the weight member 34.

[0037] In the underwater mobile body 1 of the third embodiment illustrated in FIG. 4C, a shock absorber 7 is disposed around the outer periphery of the tail of the body unit 2. Where the antenna 31 is long, it is possible that the antenna 31 will contact the body unit 2 while turning. Thus, the shock absorber 7 is disposed around the outer periphery of the tail of the body unit 2, thereby preventing damage to the antenna 31.

[0038] In the underwater mobile body 1 of the fourth embodiment illustrated in FIG. 4D, a shock absorber 7 is disposed around the outer periphery of the antenna 31. This configuration also serves to prevent damage to the antenna 31.

[0039] The underwater mobile body 1 of the fifth embodiment illustrated in FIG. 4E is configured such that the antenna 31 can make a 360-degree turn. Specifically, the supporting members 32 have a length longer than that of the antenna 31. This configuration permits the antenna 31 to make a 360-degree turn about the pivot shaft 33 without contacting the body unit 2, whereby damage to the antenna 31 can be prevented.

[0040] In the foregoing embodiments, the underwater mobile body 1 is used in a marine information collection system for fixed-point observation, but the configuration thereof is not particularly limited. The underwater mobile body 1 may be an unmoored buoy, an underwater

traveling body, an underwater glider, or an underwater towed body.

[0041] The present disclosure is not limited to the foregoing embodiments and may of course be modified in various ways without departing from the scope of the disclosure.

(Aspects of the disclosure)

[0042] In a first aspect of the present disclosure, an underwater mobile body capable of acquiring information on hydrosphere and moving between a position under water and a water surface includes: a body unit provided with a data acquisition device that acquires the hydrosphere information, and a specific gravity adjusting device that adjusts the position of the underwater mobile body under water; and an antenna unit arranged at a tail of the body unit and provided with an antenna that transmits the acquired hydrosphere information, wherein the antenna unit holds the antenna such that the antenna is able to turn in a vertical direction.

[0043] In a second aspect of the present disclosure, the underwater mobile body according to the first aspect is configured such that the antenna unit includes a pair of supporting members extending rearward from the body unit, a pivot shaft rotatably connected to the supporting members, the antenna projecting from a peripheral surface of the pivot shaft, and a weight member joined to the pivot shaft and located opposite the antenna.

[0044] In a third aspect of the present disclosure, the underwater mobile body according to the second aspect is configured such that a communication cable connected to the antenna is passed through interiors of the antenna, the pivot shaft and the supporting member to be guided to the body unit.

[0045] In a fourth aspect of the present disclosure, the underwater mobile body according to any of the first to third aspects is configured such that the antenna is able to turn through an angle of at least 180 degrees or more.

Reference Signs List

[0046]

1: underwater mobile body
2: body unit
3: antenna unit
22: specific gravity adjusting device
31: antenna
32: supporting member
33: pivot shaft
34: weight member
35: communication cable

Claims

1. An underwater mobile body capable of acquiring information on hydrosphere and moving between a position under water and a water surface, comprising:

a body unit provided with a data acquisition device that acquires the hydrosphere information, and a specific gravity adjusting device that adjusts the position of the underwater mobile body under water; and
an antenna unit arranged at a tail of the body unit and provided with an antenna that transmits the acquired hydrosphere information,
wherein the antenna unit holds the antenna such that the antenna is able to turn in a vertical direction.

2. The underwater mobile body according to claim 1, wherein the antenna unit includes a pair of supporting members extending rearward from the body unit, a pivot shaft rotatably connected to the supporting members, the antenna projecting from a peripheral surface of the pivot shaft, and a weight member joined to the pivot shaft and located opposite the antenna.

3. The underwater mobile body according to claim 2, wherein a communication cable connected to the antenna is passed through interiors of the antenna, the pivot shaft and the supporting member to be guided to the body unit.

4. The underwater mobile body according to any one of claims 1 to 3, wherein the antenna is able to turn through an angle of at least 180 degrees or more.

FIG. 1A

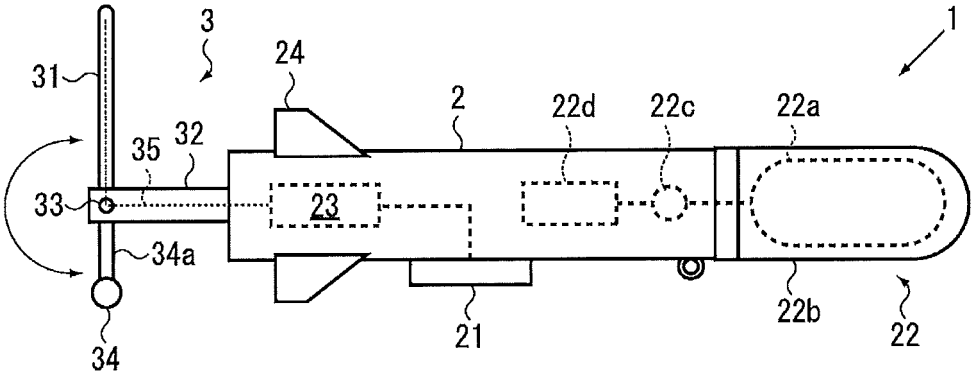


FIG. 1B

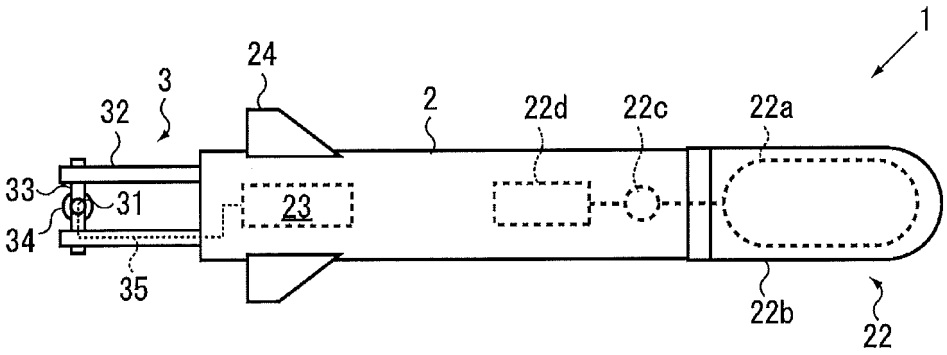


FIG. 2

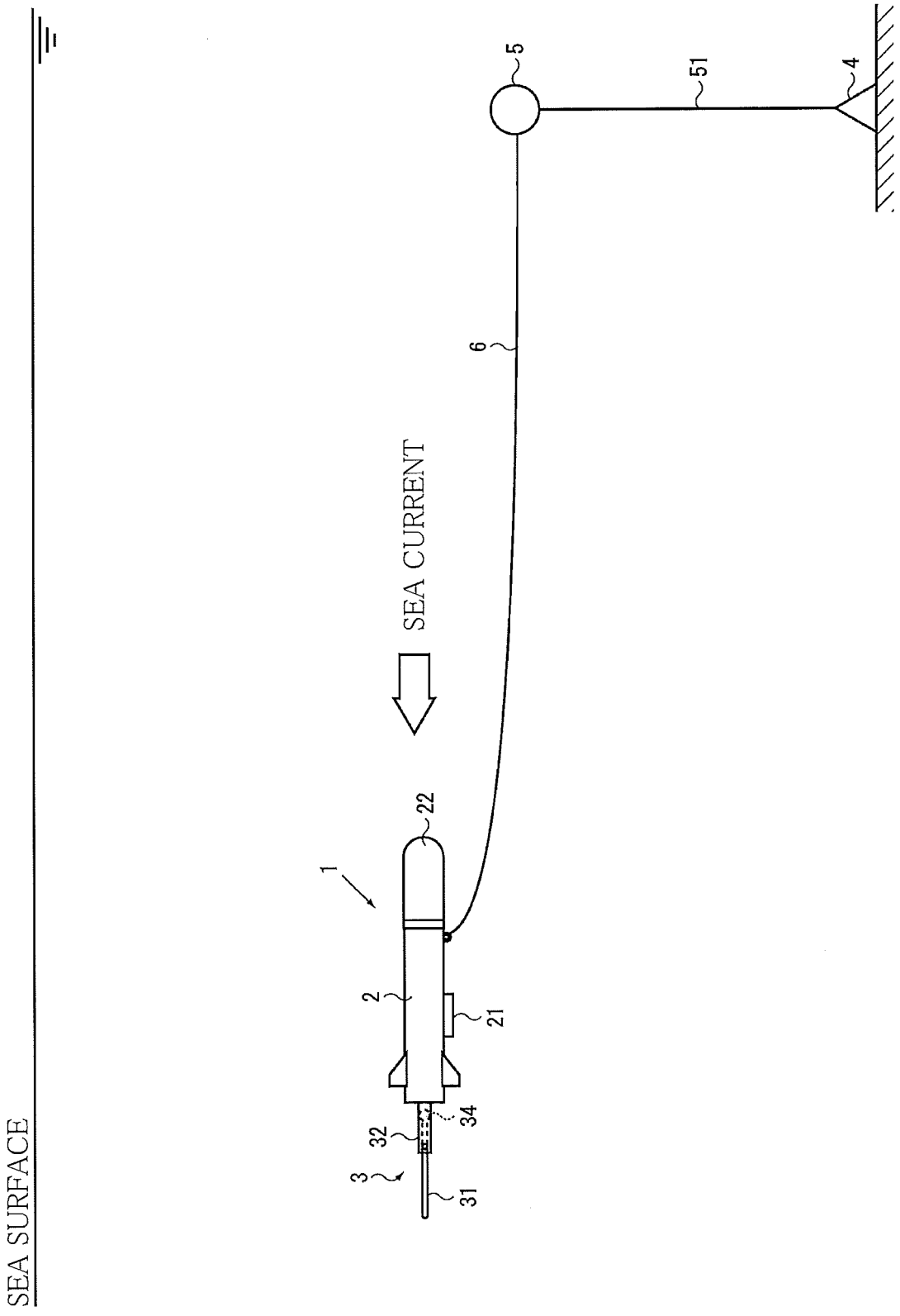


FIG. 3A

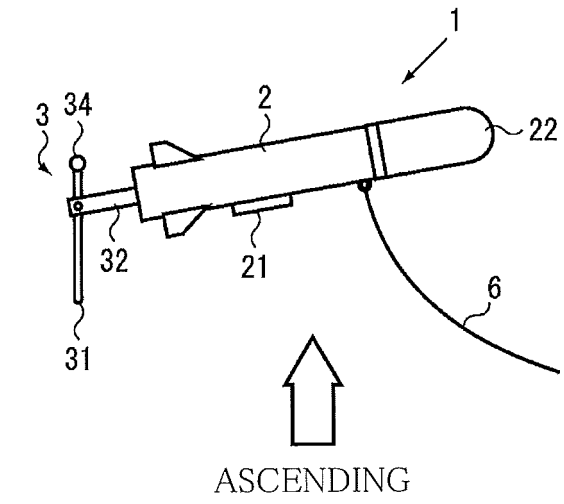


FIG 3B

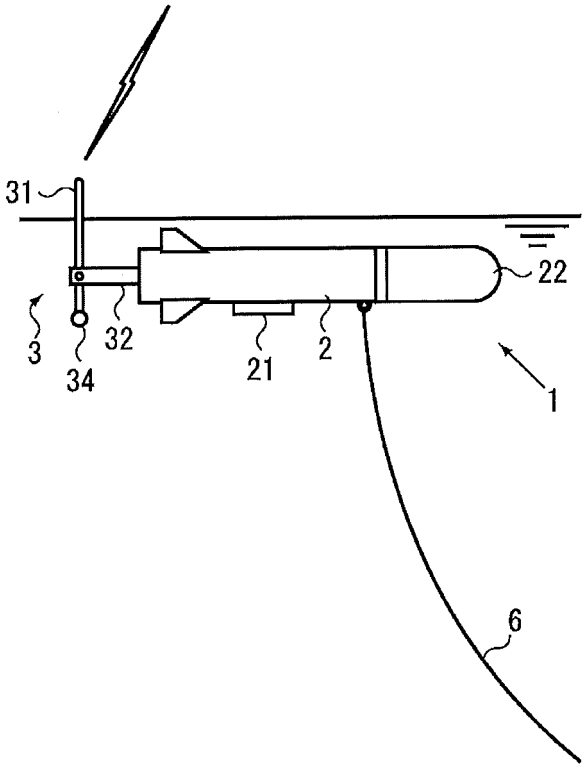


FIG. 3C

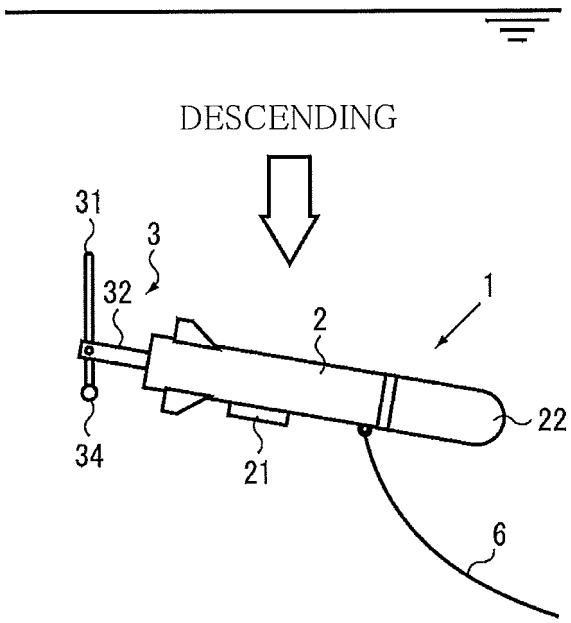


FIG. 4A

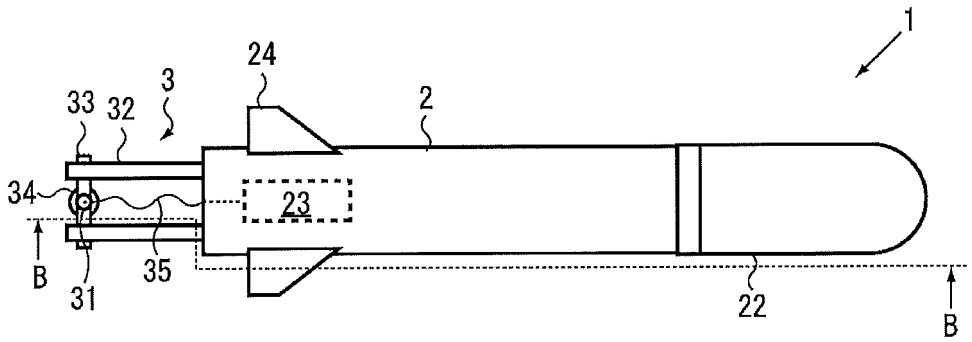


FIG. 4B

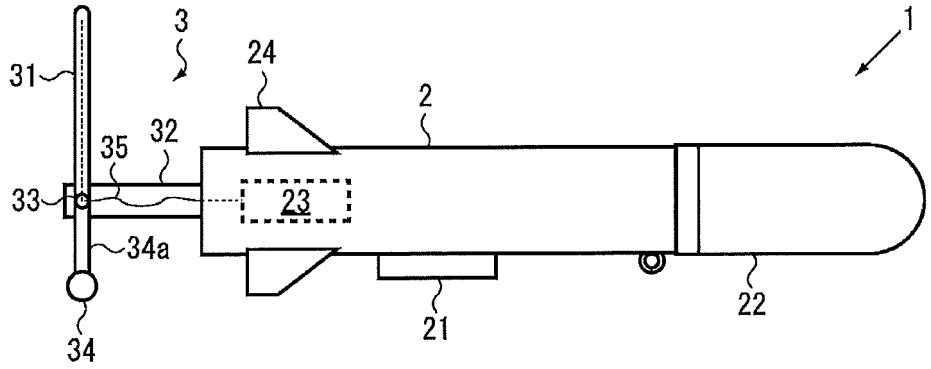


FIG. 4C

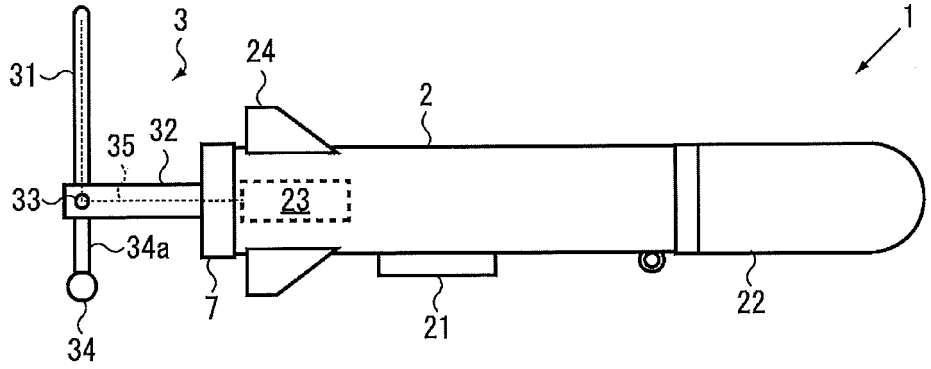


FIG. 4D

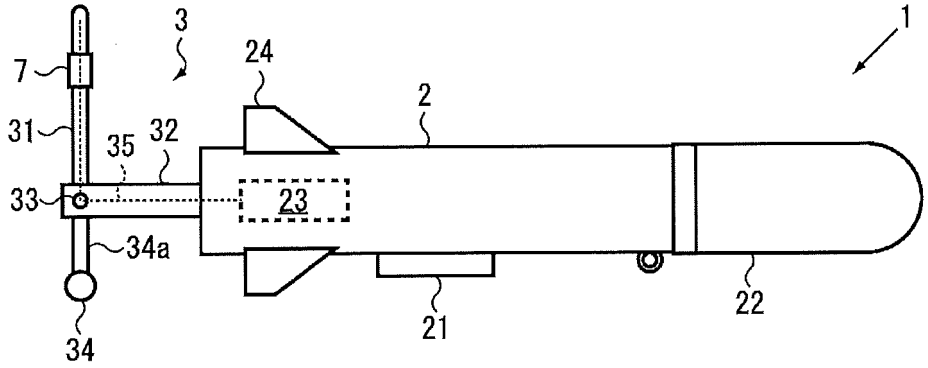
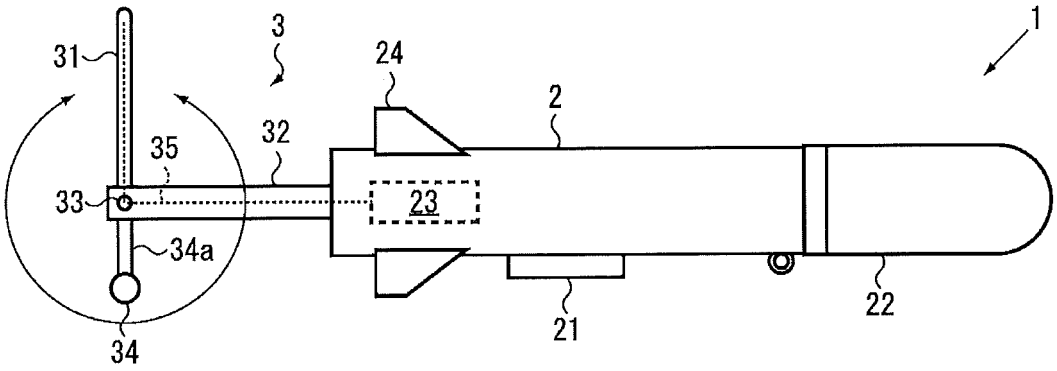


FIG. 4E



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2014/064626

A. CLASSIFICATION OF SUBJECT MATTER
B63C11/48(2006.01)i, *B63B22/00*(2006.01)i, *B63B22/08*(2006.01)i, *B63G8/42*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B63C11/48, B63B22/00, B63B22/08, B63G8/42, H01Q1/34

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2014
Kokai Jitsuyo Shinan Koho 1971-2014 Toroku Jitsuyo Shinan Koho 1994-2014

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Thomson Innovation

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 3229295 A (Theodore WATKIN), 11 January 1966 (11.01.1966), columns 2 to 4; fig. 1 to 4 (Family: none)	1-4
Y	JP 2006-232070 A (Mitsui Engineering & Shipbuilding Co., Ltd.), 07 September 2006 (07.09.2006), paragraphs [0018] to [0028]; fig. 1 to 3 (Family: none)	1-4

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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11 June, 2014 (11.06.14)	24 June, 2014 (24.06.14)
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 85183/1975(Laid-open No. 163837/1976) (Komatsu Ltd.), 27 December 1976 (27.12.1976), pages 5 to 7; fig. 1, 4 (Family: none)	2-3
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P,Y	KR 10-1293828 B1 (HANWHA CORP.), 07 August 2013 (07.08.2013), paragraphs [0006] to [0044]; fig. 1 to 4 (Family: none)	1

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REFERENCES CITED IN THE DESCRIPTION

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