Patent Specification: 10,000m-Class Deep-Sea Underwater Drone & Natural-Force Mining System

[Document Name] Patent Application (English Translation & Specification)

[Title of Invention] 10,000m-Class Deep-Sea Underwater Drone and Natural-Force Mining System

---

[Technical Field]

[0001] The present invention relates to underwater exploration apparatuses, and more particularly, to an underwater drone capable of performing autonomous attitude control, seabed soft-landing control, and various observations in extreme high-pressure environments at the 10,000-meter-class deep-sea level.

[Background Art]

[0002] Conventional deep-sea exploration vehicles, although equipped with pressure hulls and buoyancy materials, suffer from insufficient attitude stability and soft-landing performance near the seabed, where impact damage upon landing has posed a critical challenge. Furthermore, room for improvement has remained regarding the long-term durability of propulsion mechanisms and high-precision observation capabilities in extreme environments.

[Summary of Invention]

[Problem to be Solved by the Invention]

[0004] In order to maintain long-term and stable exploration activities under harsh deep-sea environments, an object of the present invention is to provide an underwater drone equipped with the following elements:

- Autonomous attitude control powered by Artificial Intelligence (AI)
- Weight and buoyancy body control realizing impact-free soft-landing
- Highly durable screw propulsion mechanisms

- High-precision observation equipment

[Means for Solving the Problem]

[0005] The underwater drone according to the present invention is characterized by the following configurations:

1. **Pressure-Resistant Structure**:
    - Titanium alloy spherical pressure hull.
    - FRP layer and syntactic foam covering the outer periphery of the spherical pressure hull.
    - Strain gauges disposed at multiple locations inside the hull to constantly monitor structural stress via AI.
2. **Propulsion Mechanism**:
    - A total of 8 screws comprising 4 vertical, 2 lateral, and 2 longitudinal screws.
    - Titanium screw shafts coated with Diamond-Like Carbon (DLC).
    - Non-contact rotational power transmission motor utilizing magnetic coupling via neodymium magnets.
    - Low-friction bearings formed through the interposition of ambient seawater and the DLC layer.
3. **Seabed Landing Control Mechanism**:
    - Landing control structure coordinated by a conical weight (600kg) and a buoyancy body (300kg).
    - Weight separation structure combining an electromagnetically actuated detachment mechanism and a rod mechanism.
    - AI control system that detects approach to the seabed from video captured by Camera A and controls screw RPM and weight descent speed in real time to achieve soft-landing.
4. **Observation Equipment**:
    - **Camera A**: Ultra-telephoto zoom lens with an autofocus mechanism, ultra-high-sensitivity color camera, and spot LED illumination.
    - **Camera B**: Wide-angle lens, color camera, and LED illumination.
    - Pressure-resistant optical window made of sapphire glass.
5. **Sensing & Communication**:
    - Self-position detection via active sonar.
    - Real-time analysis of pressure, strain, and attitude data by AI.

[Advantageous Effects of the Invention]

[0006] According to the present invention, the following superior effects are achieved:

- Extremely stable attitude control is enabled even under ultra-high water pressure environments of the 10,000-meter deep sea.

- AI-driven soft-landing control mitigates impact during landing and reliably prevents airframe damage.
- Bearing structures coated with DLC ensure long-term durability in seawater environments.
- The combination of sapphire pressure windows and high-sensitivity cameras enables high-precision observations in extreme environments and the construction of 3D seabed maps by AI.

[Brief Description of Drawings]

[0007]

- **Figure 1**: Schematic diagram illustrating the overall configuration of the 10,000m-class deep-sea underwater drone according to an embodiment of the present invention.
- **Figure 2**: Explanatory diagram showing the operational flow of the natural-force seabed resource mining system utilizing the underwater drone.

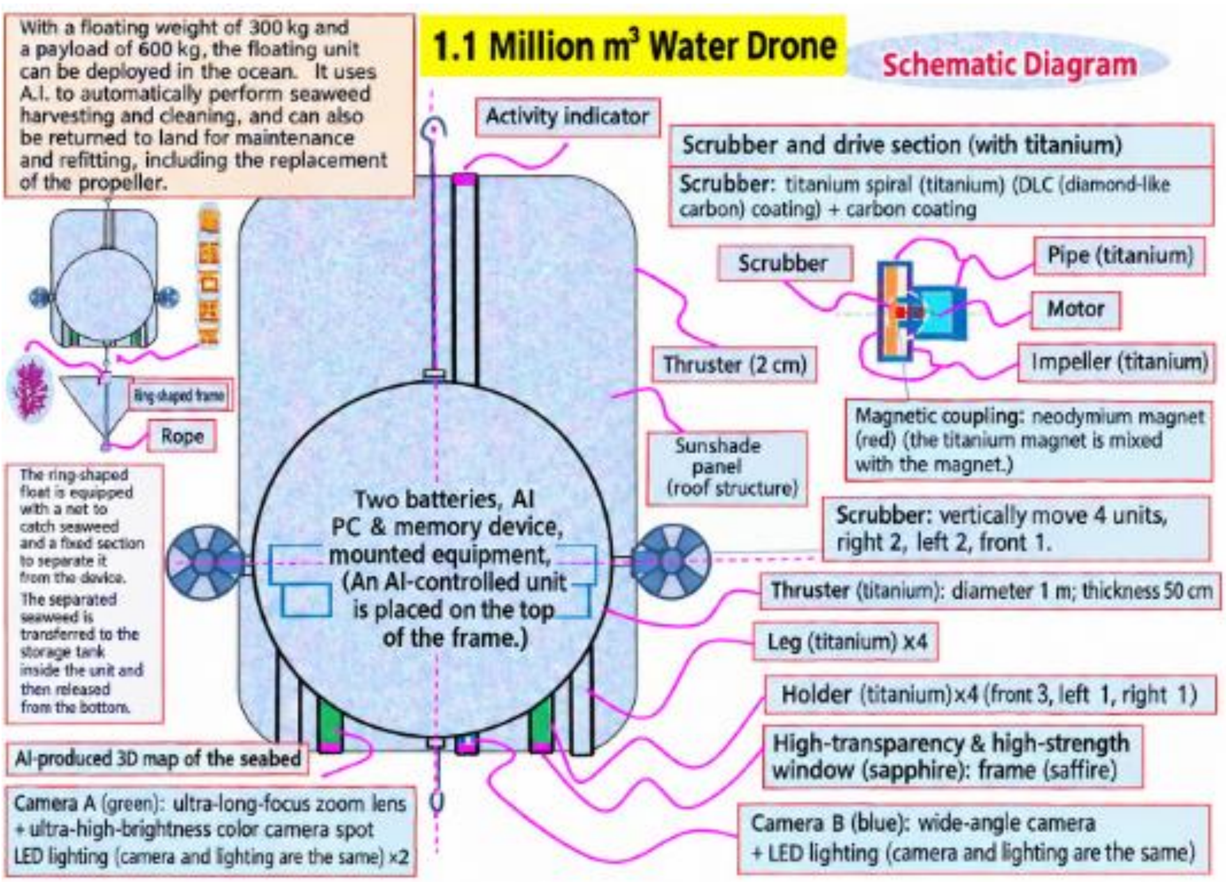
[Detailed Description of Embodiments]

[0008] Figure 1 shows the detailed configuration of the deep-sea underwater drone according to the present embodiment. Dual-redundant batteries, an AI processing PC and memory device, and a switchboard are housed within a titanium alloy spherical pressure hull (1m in diameter, 5cm in thickness) to protect them from the ultra-high water pressure of the 10,000-meter deep sea. Furthermore, to secure the buoyancy (300kg) required for exploration, a syntactic foam layer is formed around the outer periphery of the spherical pressure hull, which is further covered with an FRP (fiber-reinforced plastic) protective cover (2cm thick). In addition, two Camera A units and one Camera B unit are disposed at the bottom of the underwater drone through sapphire pressure-resistant windows, and an active sonar for self-position detection is mounted at the top.

To monitor whether the titanium alloy spherical pressure hull maintains sound conditions under ultra-high water pressure, multiple strain gauges are affixed across the inner wall of the spherical pressure hull. The onboard AI constantly monitors the outputs of all these strain gauges, and if it determines that a critical hazard level has been reached due to local increases in strain or the like, it immediately releases the conical weight held by electromagnets and transitions to an emergency surfacing sequence.

The underwater drone is designed to generate approximately 300kg of positive buoyancy when the weight is detached. Conversely, by attaching a 600kg conical weight, negative buoyancy is attained to rapidly descend to the seabed. By shaping the weight into a conical profile (sharpened downward), fluid resistance is suppressed, enabling rapid descent.

Figure 1



The underwater drone is equipped with a total of 8 screws: 4 vertical, 2 lateral, and 2 longitudinal. Each screw shaft is made of titanium, and its surface is vapor-deposited with a DLC (Diamond-Like Carbon) coating. This achieves smooth rotational drive with low friction while utilizing ambient seawater as a lubricant. The drive motor is isolated inside a sealed titanium enclosure, while the screw shaft is located in the external seawater. Therefore, to transmit the motor's rotational power non-contact through the titanium partition, a magnetic coupling configuration is adopted in which strong neodymium magnets are oppositely disposed on both the motor-side drive shaft and the screw shaft.

The two Camera A units scan seabed topography and conditions in detail and play the role of generating 3-dimensional (3D) images of the seabed. Each Camera A comprises an ultra-telephoto zoom lens with autofocus, an ultra-high-sensitivity color camera, and spot LED illumination, optically designed such that the imaging optical axis of the camera and the optical axis of the illumination coincide on the same optical axis via a half mirror. On the other hand, Camera B is disposed to frame the peripheral area of the hook mechanism provided at the bottom of the underwater drone. This aims to visually confirm and control remote connection or detachment relative to the hook portions of weights or other relay equipment based on AI commands, and comprises a wide-angle lens, a color camera, and LED illumination, with its imaging and illumination optical axes similarly set coaxially via a half mirror.

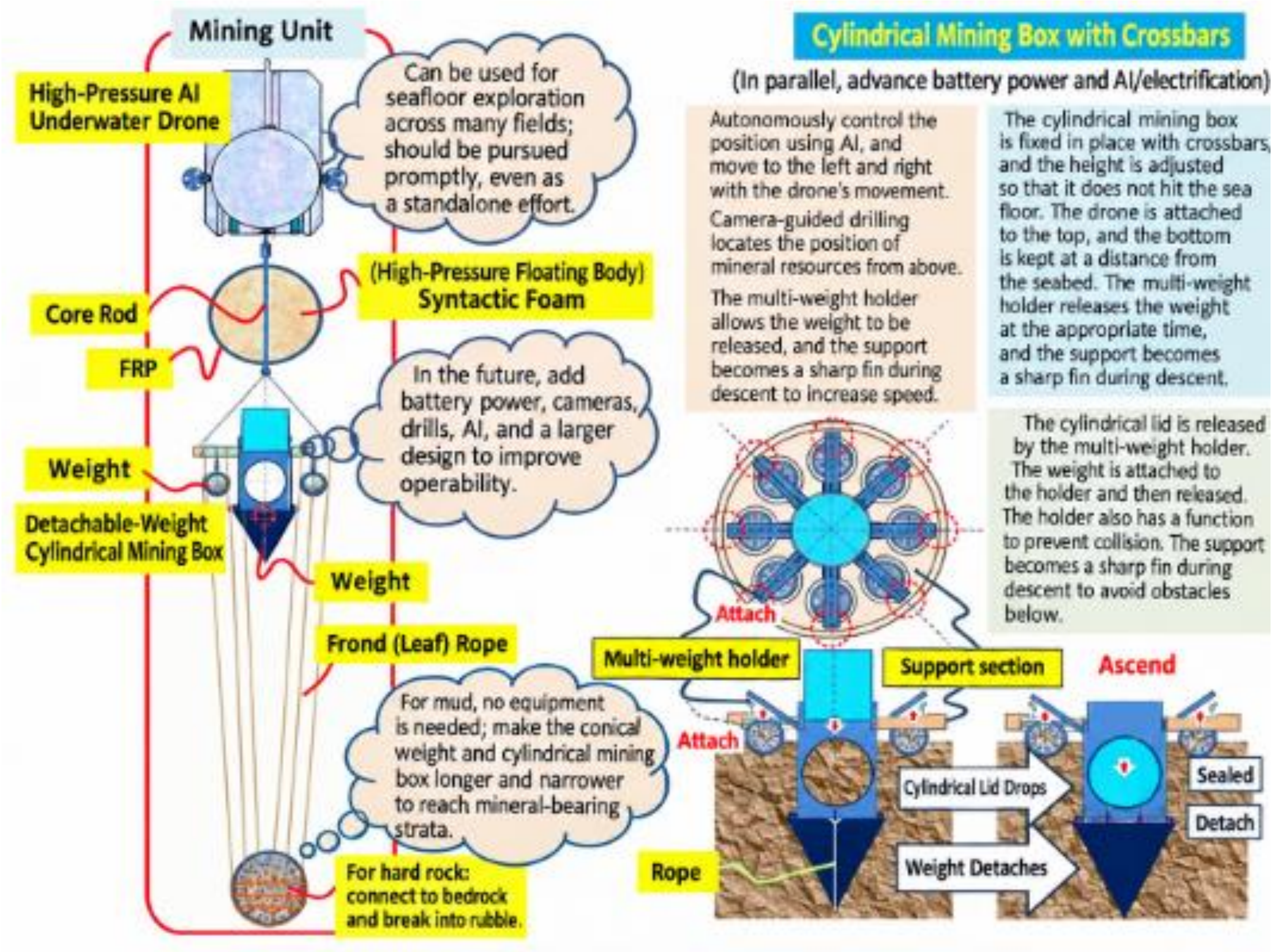
During descent, AI automatically detects approach to the seabed based on real-time video obtained from Camera A, and cooperatively controls screw RPM and weight descent speed to realize impact-free soft-landing. Upon landing, the reaction force from the conical weight that collides with the seabed ahead pushes the rod mechanism inward toward the airframe, mechanically releasing the engagement of the hook portion and separating the weight. However, considering the possibility that mechanical release may fail if the seabed sediment is soft, as an alternative means, a dual weight-separation mechanism (redundant design) is provided to forcibly disconnect the weight from the lower hook portion by cutting off magnet excitation through electrical commands from AI.

[Morphological Classification of Deep-Sea Mineral Resources & Natural-Force Mining System]

[0009] The right side of Figure 2 illustrates the operational flow of the natural-force seabed resource mining unit and system utilizing the underwater drone. The "Deep-Sea Mineral Natural-Force Mining System," which utilizes only natural mechanical actions of buoyancy, gravity, and inertia, is executed through the following processes:

1. **Seafloor Hydrothermal Deposits (Hard Bedrock Containing Gold, etc.)**:
    - **Features**: Formed mainly in active volcanic zones at depths of 1,000m to 3,000m. Because they consist of hard bedrock, mining requires pre-blasting and fragmentation into 'rubble' prior to collection.
2. **Manganese Nodules (Surface Nodules/Clumps)**:
    - **Features**: Distributed across deep-sea plains at depths of 4,000m to 6,000m as potato-like clumps scattered on the seabed surface. Remarkably, they remain unburied in the sediment and rest on the surface (No blasting required: easy to discover and easy to mine).
3. **Rare Earth-Rich Mud (Sedimentary Mud Layers a Few Meters Below the Seabed)**:
    - **Features**: Located in deep-sea environments such as around Minami-Torishima at depths of 5,000m to 6,000m, where high concentrations of rare earths are contained within soft mud and sediment layers approximately 2 to 6 meters beneath the seabed surface. (No blasting required: the mining box can be made longer and narrower to reach depths of 6m to 10m, and the overall system can be scaled up to harvest larger quantities of mud).

- **Figure 2**



Process Steps (a) to (h):

- (a) **Descent Phase**: Rapid descent toward the seabed with the weight attached to the buoyancy body.
- (b) **Exploration Phase**: Searching and scanning the target resource-bearing area.
- (c) **Crushing Phase**: Blasting and fragmenting the bedrock.
- (d) **Re-exploration Phase**: Re-searching the fractured zone.
- (e) **Installation Phase**: Embedding and setting the mining box into the seabed.
- (f) **Storage Phase**: Storing mineral-bearing crushed gravel and mud into the interior from the side of the mining box.
- (g) **Sealing & Release Phase (Applying Inertia)**: Mechanically releasing the weight using impact energy upon seabed collision while simultaneously closing the mining box lid.
- (h) **Autonomous Surfacing Phase**: Autonomously surfacing the gravel-sealed mining box to the surface via buoyancy.

3D Mapping Procedure:

Stereoscopic images (stereo images) of the seabed are captured and recorded by the two Camera A units mounted on the underwater drone. When the airframe surfaces to the sea level and communication links are established, the onboard AI transmits the recorded stereoscopic image data to appropriate internal/external institutions or related AI-equipped facilities. Consequently, a system is established in which seabed 3D images collected from such underwater drones worldwide are centrally managed and accumulated at data aggregation hubs such as the "AI Seabed 3D Image Aggregation Center," and provided to public or private institutions that have obtained disclosure permission.

[Industrial Applicability]

[0010] The present invention enables the crushing of resource-bearing bedrock in the deep seabed and the efficient transport and recovery of resulting resource-bearing gravel or muddy matter to the sea surface—tasks previously considered extremely difficult with conventional technology—thereby finding wide application in the marine resource development sector.

[Claims]

[Claim 1]

An underwater drone comprising an artificial intelligence (AI) control unit and configured to cooperatively control operations of a buoyancy body and a weight upon seabed approach to perform a soft-landing, wherein:

- said underwater drone comprises a titanium alloy spherical pressure hull and an FRP layer covering an outer periphery of said spherical pressure hull, and is configured to constantly monitor structural stress via strain gauges disposed inside said spherical pressure hull;
- further comprises a screw propulsion mechanism having titanium screw shafts coated with Diamond-Like Carbon (DLC) on their surfaces and a rotational power transmission structure via magnetic coupling using neodymium magnets; and
- comprises high-precision observation equipment including high-sensitivity cameras and illumination devices disposed via pressure-resistant optical windows made of sapphire glass, characterized by performing high-precision observations in a deep-sea environment and generating and recording a 3-dimensional map of the deep seabed.