SPECIFICATION

NAME: SEABED RESOURCE LIFTING APPARATUS

TECHNICAL FIELD

[001] The present invention relates to a device for picking up objects from the seabed. In particular, the present invention relates to a system for collecting and collecting mineral resources on the sea floor, and relates to a device for collecting to the sea surface by using the buoyancy of a liquid having a lower specific gravity than water without inputting energy for collection. Eliminating from the components of the device balances the pressure inside and outside to avoid the need for pressure resistance in the underwater environment. Furthermore, this device is characterized by the fact that it does not require a structure between the sea surface and the sea floor by autonomously sailing underwater.

BACKGROUND ART

[002] Attempts to recover objects from the seabed have been made in the field of salvage, dredging, and drilling offshore oilfields. With regard to the collection of seabed minerals, trials have been started for collecting 1000m-level seafloor minerals, and recovery of seafloor resources at the 2000m-5000m level has not been established because there is no established methodological method or economic prospects. The present invention relates to an apparatus for economically recovering seabed resources up to a level of 6500 m, and provides state-of-the-art technologies for control engineering, space engineering, information engineering, and acousto-optics, which are other fields not conventionally used in ocean development. By combining them, it was newly devised to realize with existing hardware technology without mechanical challenge under high pressure environment.

[003] The conventional technique will be described below. The collection of seabed minerals has been conventionally discussed as an extension of salvage technology, dredging technology and offshore oil drilling technology. As for the salvage technique, as outlined in Non-Patent Document 1, there are a "major rotation system" in which a wire is pulled up, a "balloon system" utilizing buoyancy, and a "grab system" in which the wire is directly grasped.

"Large turning method" is not performed in the deep sea because it involves diving work with wires. In the "balloon system", metal or rubber balloons containing compressed air are used to pull up in the sea, but horizontal movement is the main cause because of gas expansion accompanying changes in depth, and the depth is 100 m or less. The “grab method” is a method of directly grasping the arm by extending it to the seabed. In the 1970s, the US CIA raised the Soviet sunken submarine from the bottom of the sea for the purpose of gathering nuclear strategic information. It is the only record that has been pulled up from the deep sea, and there are no examples. According to publicly available information, raising the sinking submarine in the Soviet Union is likely to be an extension of offshore oil drilling technology. Both methods are not suitable for collecting mineral resources from the deep sea, because the sea surface is indispensable because the workboats on the water are directly involved in the dynamics.

[004] At present, mineral extraction from the seabed is not economically feasible, and it is best to take samples by deep sea exploration boats, unmanned robot arms, or boring. Exceptionally, in oil fields and gas fields, if you make a hole, it will be ejected by being pushed out by the internal pressure, so by installing a recovery facility such as a pipe at the opening, you can mine at a relatively low cost. A method of pumping up hot water in which mineral resources are melted from a seabed hot water pool has been proposed (Patent Document 1). This method can also be carried out by pouring a special solvent into the ore deposit as in the case of shale gas mining, vacuuming the dissolved minerals onto the water, and then separating and collecting the minerals.

[005] As a method of recovering mineral resources from the seabed surface strata, as an extension of dredging technology, a test development of elemental technology for excavating a 1000m deep seabed hydrothermal deposit (such as chimney), making it into slurry and sending it to the sea by an underwater pump (Patent Document 2) (Non-Patent Document 5). A pilot project for mining and recovering hydrothermal deposits with a seabed of 1600 m was implemented in 2017, and 16 tons were recovered in 1.5 months, but no commercial prospects have been established. (Non-patent document 7)

[006] Mining and collecting of submarine minerals is the stage when the trial development of elemental technology for the submarine hydrothermal deposit at a depth of 1600 m has finally begun. Cobalt-rich crusts, manganese nodules, and rare earth deposits are distributed on the surface of the deep sea deeper than 1000 m, but they are still in the stage of resource survey, and resource recovery, including methodologies, has not been started. (Non-patent document 3) Similar to the present invention, there is Patent Document 3 of the same applicant as the present invention as a technique for collecting an object from the seabed without challenging the mechanical limit in a high-pressure environment. In Patent Document 3, by using the buoyancy of hydrogen gas generated on the seabed, the internal pressure of the lifting equipment and the surrounding seawater pressure are made the same to solve mechanical and structural problems such as pressure resistance technology under high pressure environment, and buoyancy is used. Furthermore, since hydrogen gas generated on the seabed becomes an excess during the collection process, it was absorbed by toluene and recovered as MCH (methylcyclohexane), and it was used as a hydrogen energy source to solve the problem of recovery energy efficiency.

[007] PATENT DOCUMENT 1 : WO2013118876A1 "Collection method and collection system of seabed hydrothermal mineral resources"
PATENT DOCUMENT 2 : Japanese Unexamined Patent Application Publication No. 2011-196047 "Delivery system and method"
PATENT DOCUMENT 3 : Japanese Patent Application Laid-Open No. 2017-066850 International Application PCT / JP2016 / 0836 "Pile resource harvesting device"

NON-PATENTS DOCUMENT 1 : “SALVAGE” Nobuo Shimizu, Journal of the Shipbuilding Society of Japan, May 2002
NON-PATENTS DOCUMENT 2 : "Evaluation of slurry transfer of large-sized particles in lift pipes related to the development of seabed mineral resources" Takano et al. 14th Maritime Research Institute of Technology Research Presentation, June 2014
NON-PATENTS DOCUMENT 3 : "Ocean energy and mineral resource development plan" Ministry of Economy, Trade and Industry December 2013
NON-PATENTS DOCUMENT 4 : “Latest trends in the development of the latest seabed mineral resources” Yoichi Oda, Mitsui & Co., Ltd. Strategic Research Institute, April 2013
NON-PATENTS DOCUMENT 5 : "Development of a seabed hydrothermal deposit drilling element technology testing machine" Mitsubishi Heavy Industries Technical Report 2013 No.2
NON-PATENTS DOCUMENT 6 : Satellite Attitude Tracking By Quaterion-Based Backstepping, Raymond Kristiansen, Norweigian University of Science and Technology, Norway, 2005
NON-PATENTS DOCUMENT 7 : "Submarine hydrothermal deposit mining / lifting pilot test" JOGMEC NEWS 2018, March
NON-PATENTS DOCUMENT 8 : Sound Metrics http://www.soundmetrics.com/

DISCLOSURE OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[008] Cobalt-rich crust, manganese nodules, and rare earth deposits are deposited on the sea floor, and if they are above ground, they can be collected by power shovels or bulldozers. Mining trials of hydrothermal deposits are preceded mainly by the fact that hydrothermal deposits are relatively shallow inside and outside the depth of 1000m, and the depth is an obstacle to the development of seabed mineral resources deeper than 1000m, and the conventional salvage technology and dredging technology , Extension of offshore oil drilling technology has not solved it.

In the world of living things, sperm whales do not use any special pressure resistance technology in living organisms, use almost no energy, dive up to 3000 m and prey on squid and return to the sea surface. The reason why sperm whales can easily go back and forth between the deep sea floor and the sea surface without obstructing the depth is that the internal and external pressures of liquid and solid are equalized in vivo to avoid structural problems in high pressure environment. Second, since it can move independently of objects on the sea floor or on the sea and is autonomous both structurally and as a moving body, there are few restrictions as a structure. Thirdly, whales move up and down using buoyancy to move up and down in a liquid such as underwater by adjusting the buoyancy using the change in the specific gravity of "brain oil" depending on the temperature and using almost no energy. It shows that it is the most energy efficient means.

[009] However, in view of the above problems, there is no other way than the following two ways to collect seabed mineral ores by obtaining buoyancy that counteracts the underwater weight of the seabed mineral ores on the seabed. The first is a method of generating buoyancy from nothing in water, and the method of Patent Document 3 by the same inventor as this patent has been addressed from this viewpoint. The most efficient method on the seafloor in a high-pressure environment is the generation of hydrogen, which has the smallest molecular weight due to the electrolysis of water. Can be done efficiently.
The most efficient method in the seabed under the high pressure environment is the generation of hydrogen with the minimum molecular weight by electrolysis of water. This method can efficiently bring in pure water from the source to the seabed, transmit power to the seabed, and recover surplus hydrogen in the floating process. Hydrogen gas is generated on the seabed and used as a buoyancy source for the collection of seabed resources. Toluene absorbs surplus hydrogen gas as it floats, becomes MCH, and is recovered and reused as a hydrogen energy source.

However, in this method, the following (a) to (d) are indispensable. (a) Electric power for generating hydrogen gas by electrolysis on the seabed, (b) Electrolysis device on the seabed, (c) Organic hydride reactor for hydrogen absorption during the floating process, (d) Recovery process Hydrogen reaction controller.

[010] The second is the method of the present invention. That is, buoyancy is canceled from the surface of the sea in the form of "buoyancy" + "ballast" to bring a buoyancy source to the seabed, and "ballast" is separated to generate buoyancy that does not exist until then.
Since ballast is a solid or liquid with a high specific gravity, it is not affected by water pressure during the process of bringing it from the sea surface to the sea floor, and its specific gravity is also constant. If the buoyancy source is liquid, it will not be affected by water pressure on the seabed. The most suitable substances as buoyancy sources are n-pentane (boiling point 36.1 ° C, specific

gravity 0.626), which is liquid at room temperature and has the lowest specific gravity, or gasoline (specific gravity 0.70), which is inexpensive in cost.
In the method of the present invention, the hydrogen-related equipment of items (a) to (d) required in the first method can be omitted. This has the advantage of reducing costs and is easy to handle as the buoyancy source of the liquid may be kept sealed from beginning to end. On the other hand, it is necessary to solve the following two points, which is the subject of the present invention.

（１） At the seabed, it is necessary to separate the ballast from the buoyancy source brought in with the ballast, and to switch the ballast and the seabed mineral ores to be collected by remote control to the buoyancy source generating large buoyancy.

（２） In order to commercially collect offshore resources, the process must be continuously repeated.If gas is brought from the sea surface to the bottom of the sea as a buoyancy source, it is necessary to use a pressure-resistant shell, and it is clear that efficiency and cost do not match this method, if it is calculated. Blowing high-pressure air from the sea surface with a pipe can be said to be this modification.

MEANS FOR SOLVING THE PROBLEM

[011] First, in order to fundamentally avoid the obstacles of the high pressure environment, the gas was excluded from the components, the inner and outer pressures were made equal, and the pressure resistant equipment was eliminated, thereby avoiding the pressure resistance requirement. For this reason, a liquid having a lighter specific gravity than water at room temperature (for example, n-pentane or gasoline) was used as a buoyancy source for collection. To reach the source of buoyancy to the bottom of the sea, sink it with ballast to counteract the buoyancy and replace the ballast with the recovered seabed mineral ores at the bottom of the sea. The method of the present invention facilitates scale-up of the apparatus because there is no mechanically high stress point.

[012] Second, the buoyancy-based collection method does not require a high-lift pump, as compared with a method in which mineral resources are slurried in the sea and pumped to the surface of the sea. The movable mechanism, the high-pressure pipe, the friction mechanism, and the pressure-resistant mechanism with a large pressure difference are eliminated, and the problems of abrasion and sealing of the transportation pipe due to slurry transportation do not occur. Further, according to the method of the present invention, since the object to be recovered is lifted from the seabed as it is, there is no restriction on the size and shape and physical properties of the recovered object. Since there is little information on seabed resources, visibility is poor on the seabed, and the means for collecting information is limited, it is possible to avoid energy input and seawater pollution due to ore crushing and slurry formation. There is a great

advantage to remove the ore processing on the sea floor, such as making it into a slurry on the sea floor, and to collect the raw ore as it is. In addition, high

[013] pressure pumping of minerals from the seabed was avoided to avoid energy waste.

Thirdly, the underwater weight of the component equipment was reduced so that all equipment could float on the sea surface by buoyancy as part of regular operation. As a result, maintenance and inspection of all equipment becomes easy. Furthermore, since it is possible to ascend and descend by autonomous navigation, there is no mechanical connection between undersea and undersea structures such as lifting pipes and marine vessels, and it is possible to ease the marine conditions and the position control conditions of surface command ships (mother ships) The cost of surface command ships will be reduced. At the same time, this facilitates the movement of equipment installed on the seabed, which makes it possible to realize maneuverability suitable for collecting thin and wide-spread ore/minerals on the seabed.

Fourth, while increasing the moving speed due to the difference in buoyancy to improve the facility utilization rate, the resistance blades are deployed to reduce the terminal speed by using the resistance of water, thereby landing on the seabed and issuing a sea command. It is also possible to secure the return to the surface command ship.

[014] However, the first to fourth means described above can be means for solving the problem only when they can be concretely realized in the real world. The method of ensuring realization is described below. The deep-sea crane 001 fills a ball-shaped buoyancy tank 002 with a liquid whose specific gravity is lighter than water, loads ballast in the cargo compartment, and descends from the offshore surface command ship 010 to the sea floor. On the seabed, the ballast and the collected ore are exchanged, and the deep sea crane 001 floats above the sea surface.

(1) Guaranteeing feasibility by weight reduction

In order to utilize the buoyancy, it is necessary to make the specific gravity of the device around 1.0, and it is essential to reduce the weight of the entire device. Therefore, a lightweight and tough material containing a tough carbon fiber resin having a specific gravity of about 1.8 is used as the structural material. In particular, when realizing a deep-sea crane that collects collected seabed mineral ores from the sea, it is important in terms of economy to increase the ratio of ballast = collected seabed mineral ores to the total weight while maintaining the total weight when traveling back and forth between the sea floor and the sea surface at around 1.0. Here, the specific gravity of around 1.0 means that it is possible to softly implant on the sea floor by free fall due to its own weight.

[015] The weight reduction of the deep-sea crane 001 is an important requirement that determines the success or failure of the realization, so it will be examined below.

(A) When ascending

As a trial calculation example, the specifications of a typical deep-sea crane (unit: mm) that recovers about 10 tons of resources from the bottom of the sea from 1,000 to 6,500 m in one time from the bottom of the sea, is shown in Fig. 1. The liquid to be filled is gasoline (specific gravity 0.70). As a buoyancy source, the capacity of the buoyancy tank 002 is 33.51 m3, and the weight is 5 mm when carbon fiber resin is used, the volume is 6.4 x 106 cm3, and the typical specific gravity is 1.8. Then, the underwater weight becomes 5.1 tons.

Volume V = 2.0x2.0x2.0xπx 4/3 = 33.51 m3

Buoyancy = 33.51x0.30 = 10.05 tons

Surface area S = 4x2.0x2.0xπ = 50.26m2

Underwater weight W = 50.26 x 0.005 x 0.8 = 0.20 tons

The maximum shear stress applied to the outer wall is 10.05 / 2 tons of buoyancy, which is applied to the outer wall of the center of the sphere in the vertical direction while climbing. The cross-sectional area of the outer wall columnar portion is 314.2 cm2 when the wall thickness is 5 mm, and the typical shear stress of carbon fiber resin is 150 kgf / mm2 and the compressive fracture stress is 100 kgf / mm2. It is 30 times stronger than the load. As described above, it can be said that the present invention is sufficiently feasible with the current technology.

[016] (B) When descending

Since the buoyancy unit was filled with 33.51 m3 of gasoline when descending, if the equipment weight of the deep sea crane is 33.51 tons together with the ballast in the cargo room 005, the overall specific gravity will be 1.0. By adding a small amount of weight and setting the specific gravity to 1.0 + α, it is possible to gently descend toward the sea floor, and it is possible to softly implant on the sea floor. (Fig 2) Since the buoyancy tank is estimated to be 0.2 tons, if the cargo compartment and additional equipment are up to 0.5 tons, the ballast is 9.35 tons and 9.3 tons of seabed mineral ores can be loaded on the seabed. Since the deep sea crane 002 has no physical restrictions, it can take resources freely. As shown in FIG. 03, if a buoyancy tank with a diameter of 9.0 m is used, 100 tons of seabed mineral ores can be collected from the seabed.

[017] (2) Realization of commercial operation

The system according to the present invention is a system that continuously collects mineral resources on the seabed, and thus such an operation must be specifically realized.

An operation form in accordance with this purpose is shown in FIG.4.

The deep-sea crane 001 plays the role of a crane that uses the buoyancy of gasoline to collect seabed resources from the seabed 009. In addition to the deep-sea crane 001, a function to collect seabed resources on the seabed and load them into the deep-sea crane 001. is necessary. For this purpose, a ore collecting device (also called as “seabed power shovel”) 015 is installed on the seabed.

Submarine resources are widely present on the seabed at a depth of 1000 m to
6500 m. The seafloor hydrothermal deposits are rock masses, and the
manganese nodules are scattered like gravel on the seabed. Cobalt-rich crust is
[018] deposited as thin pillow lava on the sea floor, and rare earth mud is deposited for
several to 10 m at a depth of several meters on the sea floor.

On the ground, these seabed resources can be collected with a power shovel. On the seabed, since there is no means for loading seabed resources into the deep sea crane 001, which is a collection means, a seabed mineral ore collection device (seabed power shovel) 015 is used for loading.

Visibility is generally not guaranteed on the seabed. As a countermeasure against this, an ultrasonic high-definition video camera is mounted on the seabed power shovel 015 and operated by remote control from the surface command ship 010. At the time of filing of the present invention, what has been put to practical use commercially is a visibility of 35 to 80 m, a field of view of 29 °, a beam number of 96 (resolution), and 20 frames / sec. (Non-patent document 8)

FIG. 29 is an example of an electric power shovel. The power shovel is driven by a hydraulic mechanism, but since the drive mechanism operates by a differential pressure, it does not depend on the surrounding pressure environment in principle. It can be operated even in a high-pressure environment on the seabed if the electro-hydraulic mechanism and the moving mechanism are motor-driven. Power supply and remote control are performed from the marine command 010.

The ultrasonic high-definition video camera 050 is installed on the remote control
platform 265 which is operated by remote control from the surface command ship
010, and a view in any direction can be obtained by the surface command ship
010. A recovery ring 037 is provided above the center of gravity of the seabed
(electric) power shovel 015 and is used for power shovel recovery operation from
[019] the seabed.

In FIG. 2, the deep-sea crane 001 that has left the seabed rises toward the surface command ship 010 on the levitation path 046 and arrives at the sea surface 032. The surface command ship 010 recovers the collected ore 018 from the deep sea crane 001. After the collection, the ballast is loaded in the cargo room 005 and the ballast is dropped to the seabed through the sinking route 044. The surface command ship 010 carries the ballast from the departure port, collects the collected ore 018 at the mine point sea, returns to the port of departure, and repeats this round trip.

[020] The surface command ship 010 is a base ship that serves as a core for collecting mineral resources on the sea floor. It occupies the upper part of the seabed where mineral resources are collected, and directs the collection of mineral resources, maintenance of equipment, and supply of power. The surface command ship 010 carries a plurality of deep-sea cranes 001 and a seabed seabed power shovel 015, advances to a seabed mineral ores collection point, and expands in the sea and on the surface of the sea. The Maritime Command

Vessel 010 controls the operation of all relevant equipment and is equipped with a system for that purpose.
The surface command ship 010 can change its position depending on the resource status of the seabed. Since the deep sea crane 001 can have a specific gravity of around 1.0, it can be deployed at a new location after being first levitated to the sea surface and collected.

EFECT OF INVENTION

[021] According to the present invention, since the material is collected from the seabed by buoyancy, the energy consumption is small, and the equipment that reciprocates on the seabed does not contain gas, so that the mechanical effect due to the seabed depth is small, and the range from less than 1000 m to more than 5000 m is wide. Applicable to further, since there is no structurally restricted portion for strength, scale-up is easy. Furthermore, since the collected ore is not pulverized, it does not cause pollution in the sea.

FORM FOR CARRYING OUT THE INVENTION

[022] Hereinafter, modes for carrying out the present invention will be described in detail with reference to the drawings. The present invention is not limited to the following description, and various modifications can be made without departing from the scope of the invention. In this document, a device that repeatedly collects resources by going back and forth between the deep sea floor and the surface of the sea is referred to as a "deep sea crane", and the entire system including peripheral support devices is called a "seabed resource collection system" ((Fig. 2 Overall view of the seabed resource collection system). The deep-sea crane adopts all of the following three points that should be learned from sperm whales.
(1) Balance internal and external pressure
(2) Use buoyancy
(3) Move autonomously (autonomous navigation)

[023] The collection of the present invention is carried out by operating the buoyancy of a liquid having a low specific gravity which is liquid at room temperature in combination with the gravity of a ballast. It is a system that exchanges ballast transported from land over the sea surface with almost equal weight of seabed mineral ores on the seabed, and is characterized by not inputting energy itself. Also, since the buoyancy source is sealed, it is not possible to newly generate a buoyancy source due to the method.
(1) Specific gravity control

a. It is possible to reduce the specific gravity by discarding the mounted ballast and reducing the underwater weight to reduce the specific gravity.
b. Specific gravity cannot be increased while ascending or descending.
(2) Terminal speed control

[024] When moving in a viscous fluid such as water under the influence of gravity or buoyancy, there is a terminal velocity that becomes a constant velocity in balance with the drag force. The specific gravity is set near the seawater specific gravity, but if α is set to be smaller than the seawater specific gravity, it will float at a constant final velocity specified by α and the shape of the deep-sea crane.
When the specific gravity of the deep-sea crane 001 is larger than the seawater specific gravity, if a large amount is taken as α, the descent at a constant final velocity defined by α and the shape of the deep-water crane. If α is adjusted and there is a speed reducer, the terminal speed is adjusted by increasing or decreasing the resistance by deploying the speed reducer.
(3) Descent from the sea surface and landing
a. When descending, set the specific gravity to seawater specific gravity + α. The larger α is, the shorter the descent time is, but the amount of consumed ballast is increased, and there is a drawback that the control described in the item b becomes difficult, and the optimum value is obtained by adjustment.
b. When the landing approaches, the ballast is discarded and the terminal speed is approached to 0 to softly land.
(4) Ascending from the sea floor to the sea surface
At the time of ascending, the specific gravity is set to seawater specific gravity -α to ascend, and the speed is adjusted by the control wing and landing leg 006 to reach the vicinity of the surface command ship 010. In the case of excessive buoyancy such as floating from the sea bottom with an empty load, the deceleration parachute 064 (Fig. 27) is used.

[025] I Seabed mineral ores collection equipment components
1. Deep sea crane
The deep-sea crane 001 has a structure similar to that of a balloon as shown in FIG. 1, and an unmanned submersible in which a cargo room 005 is suspended by a suspending net 003 and a suspending rope 004 in a spherical buoyancy tank 002 that reciprocates between the sea surface and the seabed. Then, the mineral ores are collected.
Employing a spherical buoyancy tank 002 is easy to manufacture, has a large volume relative to the surface area, can easily obtain strength compared to other shapes, has simple characteristics as an underwater vehicle, and can be structurally easily calculated.
The deep-sea crane 001 does not need to have pressure resistance because the internal and external pressures are almost the same regardless of the depth in the sea. The buoyancy tank 002 is made of a lightweight metal such as duralumin or a carbon fiber resin that is lightweight and has high strength. It is a

liquid at room temperature and has a specific gravity of n cyclopentane (specific gravity 0.63) or gasoline (specific gravity 0.70). Closely fill. Gasoline has less buoyancy, but has the advantage of lower price.

[026] The deep-sea crane 001 travels back and forth between the sea floor and the sea surface by autonomous navigation, and is set to have a specific gravity larger than water when descending and smaller than water when ascending. When descending from the sea level, ballast is loaded and sinks, and when rising, seabed mineral ores are loaded instead of ballast and rises. Buoyancy corresponding to the loaded seabed mineral ores at the time of ascent is obtained by dumping ballast on the seabed. Further, controllable wings and landing legs 006 are installed in the cargo compartment 005, and control and deceleration wings are installed. In Fig. 1 and Fig. 23 (a), control wings and landing legs 006a, b, c, d are provided, and two each in the positive and negative directions of the X axis and Y symmetrical to the Z axis of the cargo compartment 005 of the deep-sea crane 001. It consists of two each in the positive and negative directions of the axis. The control wing and landing leg 006 is used in an operation in which the weights of the loads in the buoyancy tank 002 and the cargo compartment 005 are balanced, and therefore the load to be applied during landing is small. The main feature of Deep Sea Crane 001 is to replace the ballast and the collected seabed mineral ores with a lightweight and simple mechanism using gravity. On the seabed, the cargo room 005 is landed using the control wing and landing leg 006, and the buoyancy tank floats upward. There is a ore loading gap 092 between the buoyancy tank 002 and the cargo compartment 006. The collected seabed mineral ores are fed from above the cargo compartment to push out the ballasts from below and replace the ballasts with the collected seabed mineral ores. The amount of ballast dumped is adjusted to control the maintenance of landing on the seabed and the floating.

[027] Since the deep-sea crane 001 is an autonomous underwater vehicle, guidance control is essential, and underwater acoustics, image processing, inertial navigation, and control theory are applied. An optical fiber cable is used for control and image signal communication with the surface command ship 010. FIG. 17 (a-1) is a top view of the deep-sea crane 001, in which the sounding element 230 and the sound-sensing elements A to D 231-234 for guiding the deep-sea crane 001 to the surface command ship 010 at the time of ascent are installed. Fig.17 (a-2) is a bottom view of the cargo compartment 005 of the deep-sea crane 001. A sounding element 230, sound sensing elements A to D 231-234, and an image sensor 235 are installed for the purpose of guiding the deep-sea crane 001 to the landing point 011 when descending. These operation methods and examples will be described in detail in the section "II Navigation system". In FIG. 2, a power supply and signal cable 012 is connected to the deep sea crane 001, and control signals and power are supplied from the surface command ship 010. The signal cables will be made lighter by using optical fibers. It is necessary that the electric device is completely oil-immersed or water-

immersed, and the electronic circuit also has pressure resistance by a method including resin encapsulation. The power source may be a rechargeable battery equipped with a deep sea crane 001.

1. 1 Collecting seabed mineral ores in the cargo compartment

[028] The deep sea crane 001 approaches the sea floor with the buoyancy of the buoyancy tank 002 and the weight of the ballast mounted in the cargo compartment 005 slightly larger than the specific gravity of water. The landing speed can be adjusted by finely adjusting the amount of ballast dropped from the lower part of the cargo compartment. Set a fixed value determined by the mechanical strength of the deep-sea crane, about 0.7 m / s. The opening of the control wing and landing leg 006 can be automatically adjusted according to the ups and downs of the seabed.

[029] The descending path and the floating path of the deep-sea crane 001 are controlled by controlling the degree of opening and the rotation angle of the control wing and landing leg 006 of FIG. 23 (a). The control wing / landing leg 006 has a wing installed to control and brake the water flow. The control for inputting energy is not performed, but the potential energy at the time of descending or ascending is converted by the control blade into the control force. FIG. 23(c) is a diagram showing a mechanism of generation of a control force by the control blade / landing leg 006, and FIG. 23(a) shows a sinking process in which the gravity vector 309 is larger than the buoyancy vector 300 by the sinking force 303. At this time, if the inclined control blade 006 as shown in (b) exists, the control blade drag force 302 is generated at a right angle to the control blade 006, and as a result, the blade thrust force 314 is generated. In FIG. 23 (c), the blade thrust 314 moves diagonally downward, but since the deep-sea crane drag 315 cancels the blade thrust 314 in the opposite direction, it descends at a constant speed in the blade thrust 314 direction. FIG. 23 (b) shows the blade thrust on each control blade / landing leg. For the thrust in the horizontal direction, a lift force vertical to the wing surface may be used. In Fig. 26 (a), each control blade tilts in the same direction around the axis to rotate the deep-sea crane. The direction of rotation is opposite when descending and when ascending. In FIG. 26 (b), two opposing control blades are tilted in the same direction on the horizontal coordinate plane. In FIG. 26-1, a hydrofoil obtains a lift perpendicular to the blade surface with respect to a vertical water flow generated by sinking and ascending, and obtains a horizontal thrust. Furthermore, the direction of the wing surface allows rotation and horizontal movement. The other two should be vertically oriented so that no control force is generated in the horizontal direction. FIG. 25 (a) shows the case where the degree of open leg is minimized to minimize the braking force, and FIG. 25 (b) is the case where the degree of open leg is maximized to maximize the braking force. In FIG. 1, an opening / closing mechanism of the landing leg and a weight sensor 007 are provided at each root of the control wing / landing leg 006 to set the opening

[030]

angle of the control wing / landing leg 006 within the opening adjustment range 048. It is controlled by the deep sea crane controller 284. The adjustment of the braking force is performed by the control blade control system 222 based on the decelerator individual control amount calculation 220 of FIG. 14 for the deep sea crane 001.

FIG. 4 shows the situation of loading of collected seabed mineral ores on the deep sea crane 001. The collected seabed mineral ores are input from above the cargo compartment 005 by an electric power shovel, but the input amount is monitored by a weight scale (opening / closing mechanism and weight sensor 007) at the base of the landing leg, and the amount corresponding to the input amount is checked. Discard the ballast from the load discharge mechanism. Even if all ballasts are dumped, if the specific gravity of the deep-sea crane becomes larger than seawater, it will not be able to ascend. Therefore, the residual ballast amount is constantly monitored by an algorithm from the change in the weighing value at the base of the control and landing wings. The collection of seabed mineral ores is stopped and the surface is raised.

[031] (1) Structure and operation of cargo compartment

The freight room 005 has the following policies.

First, in order to exchange the seabed mineral ores to be collected with the ballast on the sea floor by utilizing the gravity of nature, the structure of the cargo room 005 carrying the ballast and the collected seabed mineral ores is determined. The cargo room 005 uses gravity to abandon the ballast, has an open shape for loading the recovered seabed mineral ores, and has a discharge port that can be opened and closed at the lower end. A suitable shape for this purpose is a truncated cone that opens upwards. The collected seabed mineral ores are loaded from above and the ballast can be discharged from the discharge port at the bottom. For the ballast, fine sand is used to ensure fluidity. Secondly, in order to avoid mixing with the ballast and the collected seabed mineral ores, a partition wall that covers the upper part of the cargo room 005 is provided. The partition wall covers the upper edge of the cargo room 005. The structure will move to the discharge port at the lower end while occupying the boundary with the ballast as it is charged. The partition wall may be a bellows type and extends downward, or may be a membrane type. [032]

Third, when exchanging the ballast with the collected seabed mineral ores, the amount of dumped ballast is controlled so that the generated buoyancy is less than the total weight of the deep sea crane (the total weight of the ballast, the collected seabed mineral ores, and the collected equipment). For this purpose, a sensor that measures the total weight of the deep-sea crane is installed, and the amount of ballast dumped is predicted and controlled by a computer. When loading of recovered seabed mineral ores is completed and levitation is started, the total weight of the deep sea crane should be smaller than that of water.
Fourth, it is necessary to secure the liquidity of the ballast. This is because it is

necessary to accurately control the total weight of the deep sea crane according to the loaded seabed mineral ores to be loaded, and the fluidity of the ballast is essential to control the ballast discharge port and the ballast discharge amount accurately. For this purpose, the structure is such that the particle size of the ballast is made fine and at the same time the water stream is jetted in order to increase the fluidity.

[033] FIG. 5 shows a mechanism for exchanging the ballast, the thrown-in ballast, and the collected seabed mineral ores, which is in the shape of a truncated cone having a structure of squeezing to the lower side. FIG. 5(a) shows that the cargo room 005 at the time of landing is filled with ballast. The ballast is fine-grained earth and sand, and the discharge amount can be finely adjusted by the discharge mechanism 008 provided at the lower end of the cargo room 005. The dumping of ballast is performed by gravity, and the transportation cost and environmental load can be reduced by using the beneficiary slag and the smelter slag of collected seabed mineral ores. By covering the upper part with the partitioning mechanism 016, even if the collected seabed mineral ores are charged from the upper part and the ballast dump is carried out from the load discharging mechanism 008 at the lower end,

It is possible to prevent dumping of collected seabed mineral ores and mixing of collected ores with ballast.FIG. 5 (d) and 5 (e) show an example of a partition mechanism having a bellows structure that can be extended downward, but a membrane structure may be used. FIG. 5 (b) shows an intermediate process of charging the collected ores, and FIG. 5 (c) shows the end of charging the collected ores. In actual operation, it is necessary to make the specific gravity of the deep-sea crane lighter than seawater when ascending, so it is necessary to leave ballast for dumping.

[034] FIG. 7(a-2) is a sectional view taken along line AB. An opening / closing mechanism / weight sensor 007 is provided at each root of the control wing / landing leg 006 to control the opening angle of the control wing / landing leg 006 within the opening adjustment range 048. FIG. 2 shows an operation example of the deep sea crane 001 of FIG.1. With the control wings and landing legs 006 of the cargo compartment 005 folded (Fig. 2 (a)), a ballast is installed in the cargo compartment 005 to bring the overall specific gravity to 1.0 + α, and the deep sea crane 001 is dropped to the seabed. After the navigation control of the inertial navigation section 090 and the acoustic navigation section 091, the deep-sea crane 001 opens the control wing and landing leg 006 at a position close to the seabed (Fig. 2 (c), decelerates, and dumps the ballast if necessary). It makes a soft landing (Fig. 2 (c)).

[035] FIG. 3 shows an example of ores loading on the seabed. The collected ores 018 are loaded from the ores loading gap 092 between the buoyancy tank 002 and the cargo compartment 009 by the seabed power shovel 015. The seabed power shovel 015 drives a hydraulic system with an electric motor. The submarine power shovel 015 has a weight of about 6 to 8 tons, and the buoyancy

due to the gasoline filled in the buoyancy tank 002 is about 10 tons in the case of the system of FIG.1 You can bring it to the sea floor. The cargo room 005 is
[036] equipped with a ballast that balances the buoyancy of the buoyancy tank 002 and is softly landed on the sea floor. seabed power shovel 015 puts the collected ores 018 into the cargo compartment 005. The deep-sea crane 001 discards ballast corresponding to the input collected ores 018 from the load discharging mechanism 008, and adjusts the discard amount so that the deep-sea crane 001 does not float. There is an opening / closing mechanism and weight sensor 007 at each root of the control wing / landing leg 006 in FIG.1. If the sum of the measured values is positive, it indicates a landing state. When the collected ores 023 is loaded into the deep-sea crane 001 in a landing state, the weight measurement value increases, so the weight corresponding to the increased amount is discarded from the load discharging mechanism 008.

It is possible to attach various attachments (FIG. 27 (b)) to the seabed power shovel 015 in advance so as to be convenient for the operation of introducing the collected ores. It is desirable that the ballast 017 be replaced by the collected ores 018 at the maximum in the input of the collected ores in FIG.4 The following measures are effective in achieving this.

(1) A discharge throttling mechanism capable of adjusting the degree of opening is installed at the exit of the load discharging mechanism 008, and the ballast is prepared with fine particles so that only the ballast is dumped and the final ores loading space is secured.

(2) In order to deal with the case where the collected ores 018 is fine particles such as rare earth mud, the ballast upper surface is covered with a blocking sheet or an expandable partition mechanism, and the portion below the partition mechanism 016 is discarded.

When loading of the collected ores 018 to the deep-sea crane 001 is completed in Fig. 2 (d), the remaining ballast is dropped to obtain buoyancy and levitate (Fig. 2 (e)). Further, the control wing / implantation leg 006 is folded (FIG. 2 (f)) to reduce resistance and rise, and as the sea surface approaches, the control wing / implantation leg 006 is opened to decelerate, It is guided near the surface command ship 010 in FIG.14.

An operation example of ores loading on the seabed will be described with
[037] reference to FIG.4. Since the cargo compartment 005 is suspended from the buoyancy tank 002 by three suspension ropes 004, there is a ores charging gap 092 between the buoyancy tank 002 and the cargo compartment 005. The seabed power shovel 015 can put the collected ores 018 there. FIG. 5(a) shows a state in which the ballast 017 is loaded in the cargo compartment 005 and brought to the seabed. There is a partition mechanism 016 that covers the ballast 017. FIG.5 (e) is a top view seen from above, and FIG. 5 (d) the partition mechanism 016 is a cutaway view. The partitioning mechanism 016 is a bellows
[038] mechanism that can expand and contract as shown in FIG. 5(d), and is in the

state of FIG. 5(a) when compressed. When the collected ores 023 is loaded into the cargo room 005 from above, the ballast 017 is discarded downward by gravity by the load discharge mechanism 008 and the collected ores 018 is mounted above the partition mechanism 016 as shown in FIG. 5(b). FIG. 5(c) shows a state when the collected ores has been loaded, the ballast 017 is completely disposed of below the load discharging mechanism 008, and the collected ores 018 is mounted above the partitioning mechanism 016. The partitioning mechanism 016 extends and is in close contact with the inside of the cargo room 005. The collected ores 018 pushes out the ballast 017 by gravity.

FIG. 6 shows an example of a water flow mechanism installed below the partition mechanism 016 on the inner wall of the cargo room 005. Water is injected from the water injection mechanism 1 023 and water injection mechanism 2 025 through the water injection hole 027 of the water injection pipe 026 to increase the fluidity of the ballast 017. The gravity of the collected ores 018 makes it easier for the ballast 017 to be pushed out of the load discharging mechanism 008. In the example of FIG. 6, the water flow mechanism is divided into two systems so as to improve reliability, and even if one system does not operate, there is no hindrance to the total weight control of the deep sea crane. The water flow generators 1 023 and 2 025 that drive the water flow are also installed in each system and are duplicated. FIG. 7 shows an example of the structure of the discharge throttle mechanism. FIG. 7 (a-2) shows the state when the discharge port is opened. In the case of the configuration example, the opening / closing mechanism has fan-shaped openings formed in the disk at intervals of 22.5 degrees and is arranged so as to be vertically stacked as shown in the (a-3) CD sectional view.

As shown in the cross-sectional view (a-2) AB, the diaphragm plate 1 028 and the diaphragm plate 2 029 are placed in an open state. When it is arranged as shown in the sectional view (b-2) AB, it is in a closed state. Opening and closing operations are shown in (a-1) top view and (b-1) top view.

[039] The rotation driving mechanism 1 028 moves the diaphragm plate 1 028 through the motor 1 021-1 and the worm gear 033-1 to move the gear cut around the diaphragm plate 1 028 to rotate. The rotation driving mechanism 2 031 causes the diaphragm plate 2 029 to rotate by moving the gear cut around the diaphragm plate 2 029 through the motor 2 021-2 and the worm gear 2033-2. This controls the open / closed state of the load discharge mechanism 008. Opening and closing the discharge restricting mechanism 008 of the cargo room 005 is extremely important for controlling the total weight of the deep-sea crane 001, because if the specific gravity cannot be made smaller than that of seawater by failing to release the ballast, it will be impossible to float to the sea surface. If the specific gravity becomes less than seawater before the end of ore loading, unintentional levitation will occur. In order to prevent such a situation, the discharge throttle mechanism of the cargo compartment divides the throttle plate into two parts so that even if one system of the rotary drive mechanism

malfunctions, the remaining system can be used to levitate. The double system is also introduced in the water flow mechanism of the cargo room shown in FIG. 6, and is configured so that the function does not stop even if one of the water injection mechanism 1 023 and the water injection mechanism 2 025 fails.

[040] The cargo room control system described in FIG. 8 controls the entire collected ore loading mechanism. The system itself is a microcomputer control system, and the strain gauge of the opening / closing mechanism and weight sensor 007 measures the load applied to each leg of the control wing and landing leg 006. Landing continues if the underwater weight is positive. The weight of the water at the time of the first landing increases by the amount added every time the collected ores 018 is added. Since the ballast weight released from the load discharging mechanism 008 can be measured, the remaining ballast amount can be calculated from the known ballast weight brought to the seabed when landing. The collected ores 018 may be added to the extent that it can float if the remaining ballast is completely discarded. The amount of ballast discharged is adjusted by adjusting the degree of opening / closing of the cargo room discharge restricting mechanism shown in FIG. 7. The rotary drive mechanism 1 030 and the rotary drive mechanism 2 031 are controlled by the 2-channel motor control device 204, and the rotational position is captured by the rotational position capturing device 205. In order to control the 2-channel water flow mechanism of FIG. 6, the water flow generator 1 019 and the water flow generator 2 020 are controlled by the 2-channel motor control device 204, and are taken in by the rotation speed intake device 205. The status values including the total weight of the deep sea crane 001 are reported to the deep sea crane power supply and control device 278 via the interface 203. Further, based on the levitation command of the deep sea crane, the discharge throttling mechanism of the cargo room in FIG. 7 is controlled to make the specific gravity of the total weight of the deep sea crane 001 by abandoning the ballast smaller than that of seawater for levitation.

[041] FIG. 9 is a graph showing an example of the time transition of the cargo compartment load composition. The actual weight that can be measured is the ballast weight brought into the seabed and the underwater weight of the entire deep-sea crane (hereinafter, “total underwater weight”)measured by the strain gauge 050 (deployment of the control wings and landing legs 006 and the weight measurement mechanism 014).

The solid line in FIG. 9 shows the change over time in the total underwater weight, which is a measurable value.

(E) shows the total underwater weight = 0, and when the total underwater weight falls below this value, it floats.

(D) The total underwater weight threshold is controlled so that it does not fall below the total underwater weight threshold in order to avoid unplanned ascent during the seabed stay.

(H) is the state when the deep-sea crane landed on the seabed, and the total underwater weight was> 0.
Total underwater weight> (D) If the total underwater weight threshold, discard ballast.
(B) The total underwater weight change due to ballast dump control shows the weight change at this time. The estimated value of the remaining amount of ballast is reduced by the reduced value at this time (curve with thick dotted line in the figure). When the collected ores are loaded into the cargo compartment 005, the weight of the entire water increases by the amount of one time of ores input. In response to this increase, the ballast is discarded until the total underwater weight reaches (d) the total underwater weight threshold. If collected ores are allowed to be loaded into the cargo compartment 005 after dumping ballast, the total weight of water will increase by (b) one time of ores input. By repeating this process, when the estimated value of remaining ballast amount reaches the threshold value of estimated remaining amount of ballast (c) at time (g), further ores inputs are stopped and the remaining ballast is discarded. If you do not, you will not be able to ascend, so throw the ballast so that the total underwater weight is (f) the ascent threshold.

[042] The freight compartment control system in FIG. 8 is a system configuration for realizing the time transition of the composition of the cargo in the freight compartment shown in FIG.9. The software of the cargo compartment control system is shown in the process flow of FIG.10. The operation of the processing system is the periodic processing by the timer, and the periodic processing is activated at the initial activation in FIG.10(a). FIG. 10(b) defines the entire cycle process. In FIG.10, a processing block 502 takes in weight measurement data which is plant measurement data, rotational positions of the rotary drive mechanisms 1 and 2, and rotational speeds of the jet pumps 1 and 2. In a processing block 503, it is calculated a change amount / change rate of the plant measurement data including rationality check and noise removal. The processing block 504 permits the input of ores when the ballast discardable amount is larger than the upper limit of the input amount of collected ores at one time, the dumping of the ballast is stopped, and the total weight of water is settled. The amount of ballast that can be disposed of is the weight of the ballast brought to the seabed, minus the integrated value of the ballast discarded, and then subtracting the safety value. The processing block 505 displays an alarm of prohibition of the input of collected ores on the console 441 of the ore collector of the surface command ship 010 in order to prevent the input of the ore into the cargo compartment 005. It is transmitted to the surface command ship 010 via the power supply and control device 278.

[043] Process block 504 determines if the harvested ores input is permitted. Input of collected ores is allowed only while ballast dumping is stopped. If the value of the strain gauge 049 that is periodically taken in is settled, and the deep sea crane console 210 of the surface command ship 010 does not permit the input of the

collected ores, it is determined that the ore input is not permitted, then proceeds to processing block 505. When it is determined that the ore charging is permitted, it is determined that it is dangerous to perform the plant (deep sea crane) control because the state is changing, and the process proceeds to the processing block 507.

[044] In processing block 507, it is determined that there is no request for dumping ballast and that dumping of ballast is not in progress. Since the ore loading is allowed only when there is no ballast dumping, the display of the ore loading disapproval display on the remote control panel of the surface command ship 010 is erased in processing block 508. If there is ballast dumping, the discharge throttling mechanism of the cargo compartment is closed in processing block 513, and an ore charging disapproval display is requested to deep sea crane console 210 of marine command vessel 010 in processing block 514.

[045] If the processing block 504 prohibits the ore charging, the ballast dump control is permitted, and the processing block 505 requests the deep sea crane console 210 of the surface command ship 010 to request an alarm display indicating that the ore charging is prohibited. The processing block 506 determines whether it is not a floating command, ores are not being put in, and the weight measurement data is normal. If the determination result is YES, it means that the ballast dumping control is performed, and if the determination result is NO, it means an emergency command from the deep sea crane console 210 of the marine command vessel 010 or a floating control by completion of loading of the ore. In processing block 509, the total underwater weight threshold of FIG.9(d) is set to the target value of the ballast dump control. In processing block 510, the levitation threshold value shown in FIG.9(f) is set to the target value for ballast dump control.

[046] The processing block 511 shifts to processing block 513 to stop the ballast dumping when the total underwater weight of the deep-sea crane is equal to or less than the threshold value. That is, the rotation drive mechanisms 1, 031 and 2.032 of the discharge throttle mechanism of the cargo compartment 005 of FIG. 7 are driven to close the throttle mechanism, and the water flow mechanism of the cargo compartment 005 of FIG. 6 for fluidizing the ballast is also stopped. If the total underwater weight of the deep-sea crane is equal to or greater than the threshold value, a PID control calculation toward the threshold value is performed in processing block 512. PID control of a digital system that is periodically activated by a timer is a known technique, and controls the opening of the discharge throttle mechanism of the cargo room 005 of FIG. 7 and, at the same time, increases the fluidity of the ballast. Water is injected into the water injection mechanism. In processing block 515, the present plant value is stored as the previous plant value in preparation for the processing of the next sample cycle, and in processing block 516, a timer is set to start the processing of the next sample cycle.

[047] 1.2 Ore collection operation using collected ore containers

The collection of the collected ore 018 can be performed using the ore
collection container 034 shown in FIG. 11 instead of using the cargo room 005. It
is also possible to collect the collected ore 018 with the ore collecting device
(seabed power shovel) 015 in the ore collecting container 034 previously carried
into the sea bottom by the deep sea crane 001 and collect the collected ore 018
with the deep sea crane 001. As an advantage, firstly, by separating the mining
by the ore collecting device 015 and the harvesting work by the deep-sea crane
001, the deep-sea crane 001 concentrates the harvesting when the sea condition
is quiet, and the sea floor is not easily affected by the sea condition. It is possible
to continue mining with the ore collecting device 015. Secondly, when the
collected ore 018 is overloaded, the risk that the deep sea crane 001 cannot be
floated and is lost can be eliminated. In particular, it is possible to discharge
excess ore from the overloaded ore collection container 034 by the ore collection
[048] device 015, and the resistance to erroneous operation increases. On the other
hand, it is necessary to dock and lift the lifting hook 047 of the cargo
compartment 005 of FIG. 26 (b) to the recovery ring 037 of the ore collection
container 034, which requires precise position control of the deep sea crane 001
(this can also be used for collecting the ore collecting device 015 from the sea
bottom). The ballast discharging mechanism of the cargo compartment 005 and
the collecting ore 018 loading mechanism are not required, but the precision
position control mechanism of the deep sea crane 001 (Fig. 26 precision control
attachment) is required. Further, a ore collection container 034 is additionally
required, and a weight sensor 035 for weighing the collected ore 018, control of
the recovery ring 037, and a docking communication function with the deep sea
crane 001 are required.

The position / speed control of the deep-sea crane 001 according to FIG. 24
cannot move upward from a stationary state because there is no active
propulsive force. In order to perform precise alignment, the precision control
attachment shown in FIG. 24 is added to the cargo compartment 005 to provide
the following functions.

(1) Horizontal thrust	Fig. 24 (a) Horizontal thrusters a to d
(2) Vertical thrust	Fig. 24 (a) Vertical thrusters A to D
(3) Imaging device for optical navigation	FIG. 24 (d) Imaging device 235
(4) Lifting hook	Fig. 24 (d)

In (1) and (2), a thrust force for precise positioning is applied, and in (3), the
target position for positioning is precisely measured from the captured image by
optical navigation. (4) The lifting hook is attached directly below the imaging
device 235, and the precision alignment recovery ring is lifted as shown in
FIG.24(e). The thrust acting on the cargo compartment 005 when the precision
control attachment is added is shown in the action vector diagram of FIG.24(c). [049]

FIG. 28 (b) shows a situation where the ore collection container 034 is brought to the seabed. Since the ore collection container 034 is empty, it is lightweight and can be brought in large quantities to the seabed instead of ballast.

FIG. 11 shows a ore collection method using the ore collection container 034 installed on the seabed. When the ore collecting container 034 is installed on the seabed and the recovery ring 037 at the tip is lightly pressed down by the ore collecting device 015 with the shroud 036 closed, the locking mechanism 040 is released, so the shroud 036 is opened being pressed lightly by the ore collecting device 015. The lock mechanism 040 is a lock of a push latch mechanism, for example, a lock of a push latch mechanism when it is pushed the first time and a lock of the lock mechanism is released when it is pushed a second time. The opening / closing mechanism 038 is opened by a spring when the lock mechanism 040 is disengaged. The shroud 036 needs to dump the ballast loaded in the cargo compartment 005 when the ore collecting container 034 is suspended and the deep-sea crane 001 floats up.

The ore collection container 034 is equipped with a microcomputer system and exchanges the following information with the deep-sea crane 001 to manage the loading of ore into the ore collection container 034 and the release of the seabed. The ore collection container control device 286 shown in FIG. 12 is installed in the ore collection container 034, and the processing flow of the ore collection container control device of FIG. 13 is performed. The identification number (ID) of the ore collection container 034 installed on the seabed is defined in advance.

[050] A series of operations from the bringing of the ore collection container 034 to the seabed to the collection by loading ore is as follows.

(1) As shown in FIG. 28 (b), a plurality of ore collection containers are carried into the seabed. The posture when placed on the seabed is not guaranteed.

(2) The moving image captured by the imaging device 283 of the ore collecting device 015 or the ultrasonic high-definition video camera 050 is monitored by the display 255 of the surface command ship 010 in FIG. 30 and the arm of the ore collecting device 015 is operated by the control stick 270 to erect and align each ore collector.

(3) Since it is necessary to know the identification number (ID) of the ore collection container 034 into which the ore is put, the acoustic transponders sequentially make inquiries. The ore collection container 034 blinks the recovery ring 037.

(4) Since the ore collection container 034 into which the ore is put is determined together with the ID, it is necessary to open the shroud 036. Therefore, since the lock mechanism 040 is a lock of the push latch mechanism, the shroud 036 is locked from above and the ore collection device is pressed. When pushed down by the 015 arm, the shroud 036 opens.

[051] (5) When the collected ore are put into the ore collection container 034, the weight increases. Since the weight sensor 035 measures the weight, the ore collection container control device 282 calculates the weight based on the ore

collection container control device processing flow (FIG. 13), and responds to the weight inquiry.

When the control device 285 of the ore collecting device determines that the specified weight has been reached, the arm of the ore collecting device 015 is operated to close the shroud 036 of each ore collecting device 034 and push down from above to lock the lock mechanism 040. Since the ore collection container control device 282 is ready for collection, it is displayed on the ore collection device console 441 through the control device 285 of the ore collection device that the collection is OK, and the collection ring 037 for lifting the ore collection container 034 is displayed. turning on the LED adjacent to the upper side

(6) The deep sea crane 001 is precisely position-controlled to be docked on the hoisting hook and the LED-lighted recovery ring 037, and the hoisting hook 047 is used for fishing as shown in FIG. 28 (d). Although FIG. 43 shows the operation of collecting the ore collecting device 015 from the seabed, the collected ore container 034 may be collected instead of the ore collecting device 015.

(7) When the ballast in the cargo compartment 005 is dumped in the state of FIG. 28 (d), the specific gravity of the deep-sea crane becomes lighter than that of seawater, and it floats above the sea surface.

［052］ 2. Ore collector

Since deep sea crane 001 does not collect the ore by the lift pipe, it does not need to make the ore into a slurry or to granulate it, and can be collected in a state close to the original shape. Therefore, the ore collecting apparatus 015 can apply its know-how to the maximum by analogy with ore mining on the ground. Mining itself is done on the ground with mining equipment, and supports various vein conditions. There are the following types of seabed resources, and each has different characteristics when mining.

(1) Seawater hydrothermal deposits exist as rock masses in the form of mounds
(2) Cobalt-rich crust exists on the seabed in the shape of pillows
(3) Manganese nodules scatter as nodules of 10 centimeters or more
(4) Rare earth mud exists several meters to 10 meters below the seabed mud in layers of several meters to 10 meters.

［053］ All mining equipment is a large-scale construction machine, and if you add various attachments (bucket, breaker, rotary crusher, rocking swing gripper, etc.) to the construction machine, for example, the power shovel shown in Fig. 29, It can handle different forms of resource existence on the seabed. Since the drive mechanism of the construction machine is operated by a hydraulic mechanism and the drive force is a differential pressure, the high pressure on the seabed is not related to the differential pressure, so there is no obstacle in principle. Since a construction machine on the ground operates a hydraulic pump by an internal combustion engine, it can be operated in water by using it as an electric motor. Construction equipment that operates underwater with a remote control has already been put to practical use. FIG. 29 shows an example of a remote control underwater construction machine. In order to be operated by the surface command ship 010, a power signal cable 012 is connected to transmit power from a generator on the surface command ship, and a signal is sent by an optical cable.

Since the seabed may not receive light because it does not reach light and the visibility may not be guaranteed, an ultrasonic video camera (for example, http://www.soundmetrics.com/) is installed in addition to the floodlight and optical imaging device. The recovery ring 037 is used when the ore collection container 034 is collected from the sea bottom by the deep sea crane 001. An LED light emitter and an acoustic transponder are provided around the circular ring, and the deep sea crane 001 is precisely guided. It is used for the purpose of guiding the lifting hook of 001 so that it can be easily fitted.

[054] 2.1 Installation and collection operation

The deep-sea crane 001 needs to collect the collected ore from the sea bottom, and also to carry in the ballast (electric power shovel) of the ore collecting device 005 from the sea to the sea bottom and to collect the ores from the sea bottom to the sea. In order to perform this operation, the following points are different from the case where the collected ore are loaded from the seabed into the cargo compartment 005 and collected.

(1) Bringing the ore collecting device 015 to the seabed

When descending to the seabed, as shown in FIG. 27 (a), a ore collecting device 015 can be suspended in the cargo room 005 to descend and be softly landed on the seabed. The position accuracy and landing speed may be the same as when collecting and collecting ore. When descending, a ballast for adjustment is installed to satisfy the above conditions with respect to the buoyancy of the buoyancy tank 002, and when approaching the seabed, the control wing and landing leg 006 are opened and dumped while adjusting the ballast and landing speed.

After the ore collecting device 015 is installed on the seabed, there is no ballast in the cargo room 005, and because there is no ore collecting device 015 that is a load, the buoyancy becomes excessive and the cargo room rapidly rises, causing damage to the cargo room, and stress due to floating at sea. The buoyancy tank may be damaged. To prevent this situation, the braking parachute is opened when climbing (FIG. 27 (b)). The ore collecting device 015 can also be lowered to the seabed by the crane 065 of the gut crane ship 067.

[055] (2) Recovery of the ore collector from the seabed

In order to collect the ore collecting device 015 existing on the seabed, it is necessary to hook it on the hook 047 installed at the lower part of the cargo room 005, and precision control of millimeter order in position accuracy and several centimeters per second in relative speed is required. After hooking the ore collecting device 015 on the hook 047, the ballast in the cargo compartment 005

is discarded, and the specific gravity of the deep-sea crane 001 is made lighter than that of seawater and floated to the surface of the sea.
Since the operations of (1) and (2) of the ore collection device 015 require precise control unlike the collection of collected ore, the partition mechanism 016 for separating the ballast and the collected ore from the upper part of the cargo room 005 is replaced. The precision control attachment shown in FIG.24. As shown in FIG. 24, four electric vertical thrusters and four horizontal thrusters are provided, and a secondary battery is attached as a power source. The thruster is controlled by an image from the image sensor 235 provided on the hook. When the ore collecting device 015 is installed on the seabed and then floats, there is too much buoyancy, and a parachute 064 for deceleration is prepared and opened to prevent damage to the cargo room 005 and the buoyancy tank 001 when the sea surface floats due to excessive stress.

[056] FIG. 27(a) is a diagram showing the operation when the ore collecting device 015 is installed on the seabed. FIG. 28(c) and FIG. 43 are diagrams showing the operation when the ore collecting device 015 is collected from the seabed. Since recovery from the seabed is not a frequent operation, a precision control attachment is installed at the top of the cargo hold. The weight of the precision control attachment and the ore collecting device 015 needs to be less than the ore collecting capacity of the deep sea crane 001. FIG. 43 shows an operation example when the ore collecting device 015 is collected from the seabed for the purpose of maintenance or the like. A ballast is mounted on the deep-sea crane 001 and lowered to the seabed (Fig. 43 (1)). When approaching the seabed for precise position guidance, the control wing / landing leg 006 is opened to precisely position the vehicle, the speed is decelerated to the maximum extent, and the ballast is also adjusted and discarded to stop at the seabed (Fig. 43 (2)). The hoisting hook 047 is hung and the hoisting hook 047 is precisely and optically guided to the collecting ring 037 attached to the upper part of the ore collecting device (electric power shovel) 015 by the imaging element 235 at the tip, and the holing hook 047 is used to move the collecting ring 037 to the collecting ring 037 and is suspended (Fig. 43 (3)). The ballast for the ore collecting device 015 is dropped and floated (FIG. 43 (4)).

[057] 3. Surface command ship

3.1 Selection of ship type

In the operation of the deep-sea crane 001 of the present invention, since no underwater structure such as an offshore drilling rig is used, a fixed position control mechanism such as a moon pool and a bow thruster is not required. In addition, the cargo handling method will be devised so that it can be handled by a small crane on board and can be operated by a 699 ton class gut ore carrier, so that it can be used as a surface command ship 010. The gut ore carrier can also be used as a collection ore carrier.

The carrier carries the ballast from the departure port, functions as a surface command ship 010, carries the collected ores in place of the ballast, returns to the port of departure, and repeats this round trip. Since the ballast is allowed to fall freely to the seabed from the cargo discharge mechanism 009 at the lower end of the cargo room 005, fine-grained ones are essential, and quantitatively, it is convenient to use a slag from which metal has been extracted for convenience of transportation.

[058] The surface command ship 010 occupies the seasurface of the collection seabed, directs the mining of resources, maintains equipment, carries one or more deep sea cranes 001 and a seabed power shovel 015, and advances to the ore collection point and deploys them in the sea. The surface command ship 010 controls the operation of all related equipment.

The functions that the surface command ship 010 should have are as follows.

(1) From the mother port, equipped with a plurality of deep-sea cranes 001, seabed marine power shovels power generation equipment to advance to a mineral collection point, occupy the sea of the collection seabed, deploy these equipment in the sea and on the sea surface, In addition, it will be guided from the sea to its own ship and collected.

(2) An acoustic position marker 075 for guiding the deep-sea crane 001 is dropped and installed at a suitable place for collecting minerals.

(3) Accurately maintain its own position with respect to the ocean currents in the Pacific Ocean where there are submarine resources.

(4) The location will be changed depending on the resource status of the seabed and the new location will be deployed.

(5) Collect and maintain equipment that is deployed in the sea or on the surface of the sea.

(6) Supply power to equipment deployed underwater and on the surface of the sea.

(7) A deep-sea crane 001 and ballast are mounted to settle toward the sea floor and the mineral resources collected from the sea floor are recovered.

[059] 3.2 Cargo handling method

The gut crane ship is a small standard cargo ship in which one or two compartments for loading gravel as shown in FIG. 32 are provided and a crane used to lift gravel from the seabed is mounted on the ship. Assuming the operation of the seabed resources, the assumed operating area is legally classified as “near sea” and must be at least 699 tons. Loading capacity is possible up to about 1300 tons. Consider operation in which a ballast is installed up to an offshore mining point to advance, and exchange with the collected ore to return. Gut crane ships have the advantage of low charter costs, but they must be operated in a manner that suits their capabilities, including cargo handling methods, as shown below.

(1) Fixed point maintenance function

The bow thruster, which is not equipped, corrects the ship position by measuring the position by GPS against the direction in which the sea current and the wind flow. By using the Japanese GPS positioning satellite "MICHIBIKI", the position itself can be grasped with high accuracy. The direction of the ship depends on the sea condition, but there is no undersea structure. It is necessary to equip the automatic position holding function by GPS in order to reduce the load on the personnel.

[060] (2) Cargo handling

Since the crane 065 shown in FIG. 32 is used for cargo handling in the open sea, it is necessary to take measures against wind storms. Since the buoyancy tank 002 of the deep-sea crane 001 has a weight of 30 tons or more, avoid collecting the whole deep-sea crane 002 and collect only the cargo room 005 or less that remains on the sea surface. FIG. 33 shows the cargo handling equipment. In order to separate and collect the cargo compartment 005 from the buoyancy tank 001, it is desirable that the connection point between the buoyancy tank 001 and the cargo compartment 005 be on the sea surface in the center of the buoyancy tank being divided into 3 parts to form a void in the center (FIGs. 31 (b) and (c), FIG.31-1(a), (b), (c)).

Each of the three divided main buoyancy tanks 055 to 057 shown in FIG. 33 (a) is provided with a sub-buoyancy tank 059 with a cargo room lifting hook 062 so that the sub-buoyancy tank 059 can be floated above the sea surface. The tip of the crane 065 is hooked at sea surface work (Fig. 34 (b), FIG.34-1(b)) and pulled up. When the load applied to the sub buoyancy tank 059 becomes large, the connection with the main buoyancy tank is automatically disconnected (Fig. 33 (c), FIG.31-1(b)), and the main buoyancy tank is separated and floats on the sea surface as shown in Fig. 34 (c), FIG.34-1(b). It becomes a state. Further, as shown in FIG. 34 (d), FIG34-1(c) the ore is collected by fishing from the sea surface. The cargo compartment 005 loaded with ballast is also hung on the sea surface as shown in FIG. 34 (d), FIG.34-1(c)and the marker float of the main buoyancy tank on the sea surface and the buoyancy tank changeover switch are adjacent to each other on the sea surface as shown in FIG. 34 (e) or FIG.34-1(d) Therefore, the connection between the two is made by sea surface work. When the cargo compartment is further lowered to the sea surface, the buoyancy source is switched to the main buoyancy tank and the descent is started (FIGS. 34 (b) (a), FIG.34-1(a)).

[061] The cargo room 005 caught by the crane has a size and weight that can be loaded on the ship. In the case of descending, the tip of the crane wire is released in Fig. 34 (b), FIG.34-1(a). Work to hook the tip of the crane to the cargo room of the deep-sea crane that has floated to the surface of the sea (Figs. 34 (a), (b), FIG.34-1(a)) and work to connect the cargo chamber to the main buoyancy tank before descending to the sea floor (Fig. 34(e), FIG.34-1(d), FIG.34(b), and, FIG.34-1(a)) and the work of releasing the tip of the crane wire must be performed manually on the sea. With the device shown in FIG. 33,

FIG.33-1, FIG. 34, FIG.34-1 cargo handling by a gut crane was possible and diving work could be avoided, but this is a work carried out with a small boat lower than the gut crane ship, and it is necessary that the wind and waves be calm to some extent. On the seabed, electric construction machines are operated by remote control for mining, but preparation work such as mining, crushing, and accumulation is required before loading into the cargo compartment. Since work on the seabed is not affected by wind and sea on the surface of the sea, these preparatory works are performed when the work on the surface of the sea is not possible due to wind and waves, and the collection of collected resources is scheduled to be concentrated when the work on the surface of the sea is possible.

［062］ 4. Acoustic position marker

Positioning by radio waves such as GPS is not possible on the bottom of the sea, including the deep sea, so a precise position reference on the sea surface is obtained by GPS. An acoustic position marker will be installed directly below it to serve as a precise position reference on the seabed, and work using position information on the seabed will be possible. Position markers are placed on the seabed in a form that allows the latitude and longitude to be referenced, and open pit digging on the seabed can be efficiently advanced. Since the GPS latitude / longitude information can be obtained with high accuracy on the sea surface, there is a technical feature in using the high-precision latitude / longitude on the sea surface as a fixed point position reference for the sea floor immediately below. As a method of guiding the acoustic position marker from the sea surface to the sea floor immediately below the high-accuracy latitude and longitude on the sea surface, there are a method of using sound and a method of inertial navigation as described below.

4.1 Installation by acoustic guidance

As a technical feature,

Firstly, the only sound wave that can be used as an information transmission means is used as a means for setting a position marker between the sea surface and the sea bottom, but the sound wave is characterized by refraction and not going straight because the temperature distribution in the sea is not uniform. .. For this reason, we pay the utmost attention to the sound propagation characteristics in the sea for position location. That is, the temperature distribution changes in layers with respect to the depth in the sea, and there is the characteristic that straightness is guaranteed without refraction in the direction perpendicular to the layer, and acoustic signals can be used in the range near the direct point.

Secondly, the acoustic marker is guided and installed under the fixed point position reference on the sea surface by the signal processing and control technology using the acoustic signal.

［063］

An example of the configuration and installation procedure of the acoustic position marker will be described with reference to FIG. FIG. 37 (a) is an outline view of the acoustic position marker 078, which sinks in the sea by gravity. At the time of sinking, the X-axis steering blade 076 and the Y-axis steering blade 077 are controlled to change the sinking path. As shown in Fig. 36 (c) Acoustic position marker setting method, the position marker ship 070 is occupied on the surface of the sea, the acoustic position marker 075 is lowered immediately below, and the position of the acoustic position marker 075 is located on the seabed 009 by its own weight by the penetrating weight 079. The flow velocity on the seabed is 1 to 2 cm / sec in the deep sea, and the localization can be continued by setting the X-axis steering wing 076 and the Y-axis steering 077 horizontally on the seabed.

[064] FIG. 37 shows the structure of the acoustic position marker 079. FIG. 37 (a) is a front view showing that an X-axis steering blade 076 for guidance and a Y-axis steering blade 077 for guidance are installed orthogonal to the long axis of the cylindrical acoustic position marker 075. FIG. 37(b) is a side sectional view of the acoustic position marker 079. There are an X-axis steering wing 075 and a Y-axis steering wing 075 outside the acoustic position marker 075, and an X-axis steering wing servo drive device 271 and a Y-axis steering wing servo drive device 272 are incorporated to control the angle for guidance. Since the acoustic position indicator 079 needs to withstand the high-pressure environment in the deep sea, the inside must be oil-immersed and the equipment inside must function completely in the oil-immersed state. The X and Y axis steering wing servo drive device may be of a level realized by a radio control machine.
The sound emitter 276 and the sound senser 277 are installed at the tail of the acoustic position marker 079. The dynamic characteristic for the guidance control is defined by the motion characteristic acting force vector in FIG. 37 (c). By placing the center of the reaction force including the X-axis steering wing 076, the Y-axis steering wing 077, and the acoustic position marker 075 in the tail, the X-axis steering wing 076 and the Y-axis steering wing 077 are operated to be able to control the dropping direction.of the acoustic position marker 075. The steering component force Ws and the steering component force Rs act on the acoustic position marker 075 as a rotational moment.

[065] After the acoustic position marker 075 is installed on the seabed, it is used as a transponder for a long time as an acoustic position marker. For this reason, a battery 031 that can be used for a long time is built in, a power supply control circuit 039 is also provided, and circuits other than those essential to the transponder are shut off to prepare for long-term operation. Since the acoustic position indicator 075 is operated by a battery, a means for recovering to the sea surface is prepared as a countermeasure when the battery is consumed. As shown in FIG. 37 (b), a buoyancy tank 081 in which an acoustic position marker 075 is filled with gasoline and a penetrating weight 079, which is, for example, an

[066] iron weight, are connected and integrated by a disengagement mechanism 080.

The specific gravity of 075 is larger than that of seawater, and when the penetrating weight 079 is separated, it becomes lighter than seawater so that it can be floated and collected on the surface of the sea. In the detachment mechanism 080, when the digital output is turned on by the acoustic position marker control unit 287 of FIG. 38 (c), the explosion bolt 078 is detached. The acoustic position marking portions other than the penetrating weight 079 can be reused by recharging after ascending. Fig. 42 In the acoustic transponder common infrastructure, the penetrating weight 079 is detached by a blast bolt or the like by a "floating command". The levitation command is issued by monitoring the operation time after the acoustic position indicator 075 is input by the deep sea crane monitoring control system 209 of the surface command ship 010.

[067] FIG. 38 (c) shows the system configuration in the acoustic position marker 075. The arithmetic unit 200, the ROM 201, and the RAM 202 are similar to the acoustic transponder common processing unit, and the X-axis steering wing servo drive device 271 and the Y-axis wing servo drive device 272 are publicly implemented in a radio-controlled system. The vibration control 274 and the vibration control 275 are circuits that drive sound-generating elements and sound-sensing elements, which are piezoelectric elements, and are publicly implemented to convert sound waves and electric signals. The power supply control circuit 273 controls ON / OFF of power supply to system components in the acoustic position indicator 075 shown in FIG. 38(b) to reduce power consumption of the battery when operating as a transponder after installation on the seabed. It is implemented by the software described in FIG. 38 (a-2).

The acoustic position marker 075 has the following operation modes.

(1) Guidance control mode
(2) Transponder mode

Before putting the acoustic position indicator 075 into the sea, initialization is performed to set the guidance control mode in FIG. 38 (a-1), and the transponder mode is turned off to set the guidance control mode.

When the guided acoustic signals are received from the position-marking vessel 070 on the sea surface and the unmanned auxiliary vessels A to D, the guidance process of FIG. 38 (a-2) calculates the steering wheel operation amount 682 by the guidance logic 682 (FIG. 39) and guides. The signal reception monitoring timer is reset 667. In the guidance monitoring process of FIG. 38 (a-2), when the guidance signal is not continuously received N times of the timer setting value, it is determined that the guidance control is not performed, and the mode is changed to the transponder mode (processing block 657).), And shifts to the energy saving mode (processing block 659). If the vibration is received within the timer set value, it is determined that the guidance control is continuously performed, and the monitoring timer for checking that there is no vibration is reset in processing block 667.

[068] The accuracy of the guidance system is evaluated in FIG.39(a). As shown in FIG. 36 (a) and FIG. 39 (a) water surface view (XY), the auxiliary position marker

ships A, C are located at a distance of d in the X-axis and Y-axis directions around the position marker ship 070. B and D 071-074 are placed, and acoustic oscillation is wirelessly commanded and controlled by the position marker ship 070. Although the distance of d can be made large, the acoustic position marker 075 is moving toward the seabed, so that the auxiliary position marker ships A and C and the auxiliary position marker ships B and D do not oscillate at the same time. The propagation path difference for 075 cannot be obtained. There are two vibration sources and they oscillate at the same time. In order to distinguish the received vibration, the oscillation frequencies of the auxiliary position marking vessels A and C are made different, 2.0 kHz to 2.4 kHz and 2.6 kHz to 3.0 kHz, respectively. Of the chirp signal. FIG. 39 (a) is a vertical plane (XZ) diagram of the guidance. When the acoustic position marker 075 at the depth D is deviated from the vertical line by Δ, the auxiliary position marker ship A is separated from the auxiliary position marker 070 by d. 071 and the auxiliary position marker ship C073, the propagation path difference is calculated to be (Equation 001).

$$\text{Difference of propagation path length} \quad \approx 4\mathrm{d}\Delta/(D^2+d^2)^{\frac{1}{2}}$$

[equation 01]

Since the propagation path difference is shown by (Equation 001), when the seabed depth is large, the installation error on the seabed can be reduced by increasing d. When d = 100 m, a propagation path difference of 0.8 m can be ensured with an error of 10 m even for a depth of 5000 m, which is sufficiently practical.

[069] The process block 662 guidance logic of FIG. 38 is as shown in the guidance logic of the audio position indicator of FIG.39 The auxiliary position marker ship A 071 and the auxiliary position marker ship C 073 simultaneously generate an auxiliary position marker ship A oscillating sound 082 and an auxiliary position marker ship C oscillating sound 084. In order to be identifiable by the acoustic position marker 075, the oscillating frequencies of the auxiliary position marker ships A and C and the auxiliary position marker ships B and D are made different, for example, 2.0 kHz to 2.4 kHz and 2.6 kHz to 3 respectively. A chirp signal of 0.0 kHz is used. Auxiliary position marking ship A oscillating sound 082 and auxiliary position marking ship C oscillating sound 084 linearly increase in frequency with time, while auxiliary position marking ship B oscillating sound 083 and auxiliary position marking ship D oscillating sound 085 have linear frequency By decreasing in time, the deviation in the X-axis direction and the deviation in the Y-axis direction are identified. Although the sound propagation diagram in FIG. 39 (a) is for obtaining the deviation in the X-axis direction, the same discussion can be made in the Y-axis direction.

[070] The auxiliary position marking ship A oscillating sound 082 and the auxiliary position marking ship C oscillating sound 084 are received as the acoustic

position target sounding sound 086 by overlapping with the acoustic position sign
075 with a time shift due to the difference in the propagation distance. The
received signal is digitally sampled, and the correlation calculation processing
247 performs correlation calculation with each of the auxiliary position marker
ship A oscillation sound 082 and the auxiliary position marker ship C oscillation
sound 084 stored in advance in the ROM.
As a result, the auxiliary position marking ship A oscillation sound timing 088 and
the auxiliary position marking ship C oscillation sound timing 089 can be
[071] obtained, and the difference between them is Δt 093 and the response delay of
the auxiliary position marking ship C 023 and the acoustic position marking 075.
Since the depth of the acoustic sign 075 can be known, the X-axis component of
the deviation Δ from the vertical line can be obtained from the processing block
244. Based on this deviation, the X-axis steering amount is obtained in the
processing block 245, and the X-axis steering blade 076 and the Y-axis steering
blade 077 can be operated to eliminate Δ. The same process is performed for the
Y axis, and the X axis and the Y axis are alternately processed to perform
guidance control.
As shown in FIG. 40 (a), the position marker ship 070 is placed on the ocean at
the latitude and longitude where the acoustic position marker 075 is installed, and
the auxiliary position marker ship A 071 is located at both sides dm in the
orthogonal X axis and Y axis directions. , Auxiliary Position Marker C073,
Auxiliary Position Marker B072, and Auxiliary Position Marker D074 are
deployed. The position-marking vessel 070 is assumed to be a small boat that is
operated offshore when laying an acoustic position-marker, and the auxiliary
position-marking vessels A, B, C, and D are assumed to be unmanned self-propelled boats.
[072] FIG. 40 (b) shows a control system for the position marker ship 070, which has
the following four functions.
(1) Fixed point maintenance function for specified latitude and longitude
(2) Fixed point holding monitoring and control command function for the auxiliary
position marking ship A071, auxiliary position marking ship B072, auxiliary
position marking ship C073, auxiliary position marking ship D074
(3) Precise guidance mode oscillation command function for auxiliary position
marking ship A071, auxiliary position marking ship B072, auxiliary position
marking ship C073, auxiliary position marking ship D074
(4) Acoustic position marker 075 tracking and monitoring function

[073] (1) Fixed point maintenance function for specified latitude and longitude
The direction and propulsive force of the thruster 100 are controlled by the
directional control device 101 and the propulsive force control device 102 to
match the current position latitude / longitude measured by the GPS 107 with the
target position latitude / longitude specified by the console 105. Since the thrust
[074] of the thruster 100 is at a level capable of holding its own position against

disturbances such as tidal currents, the position marker ship 070 is operated to move to the target position. The arithmetic unit 200 carries out the processing of FIG. 41 (C-b).

(2) Fixed point holding monitoring and control command functions for the auxiliary position marking ship A071, the auxiliary position marking ship B072, the auxiliary position marking ship C073, and the auxiliary position marking ship D074

Auxiliary position marker ship A071, auxiliary position marker ship B072, auxiliary position marker ship C073, and auxiliary position marker ship D074 are lowered from the position marker ship 070 to the sea surface and deployed to fixed positions. Until the deployment, it can be realized by the technology of remote-controlled boat that is publicly implemented. After reaching the vicinity of the predetermined position, the positions of the auxiliary position marking ships A to D are periodically measured in the processing block 587 by the function of FIG. 41 (C-c-1), and the deviation from the fixed position is calculated in the processing block 588. The processing block 589 calculates the movement amount, and the processing block 589 transmits the movement amount to each of the auxiliary position marker ships A to D via the wireless communication device 107. Processing block 591 is a timer setting for periodic execution. The [075] laser distance measurement and laser azimuth measurement of the processing block 587 are assisted by locating the auxiliary position marking ships A to D by the laser position locating device 107, then locking on and tracking by the automatic tracking device 103. Even if the position marker ships A to D disturb their positions due to tidal currents and waves, the laser position locator 104 can continue tracking, and the distance and direction of the auxiliary position marker ships A to D can be continuously and automatically acquired. Such automatic tracking devices have been publicly implemented.

The movement amount transmitted to each of the auxiliary position marking ships A to D by the wireless communication device 107 is received by the processing block 581 in FIG. 41 (XY-a), while the processing block 582 determines the own ship position from the measured value of the GSP 106. The accuracy of GPS has improved to 6 cm, and if such GPS is available, instead of tracking by the laser position locator 104 and the automatic tracking device 103, the latitude / longitude position is determined by the GPS 106 in FIG. 40 (c). Measurement is performed, and the own ship position location value by GPS is used in processing block 584 of FIG. 41 (XY-a). A processing block 584 calculates a movement amount, a processing block 585 obtains a thruster control command, and the directional control device 101 and the propulsion force control device 102 of FIG.40 (c) control to a fixed position.

[076] When the position of the position marker ship shown in FIG. 40 (a) is held, the acoustic position marker 075 can be guided to the seabed in the guidance mode. The position marker ship 070 in FIG. 40 (b) is initialized in FIG. 41 (C-a). In the processing block 136, the guidance can be enabled when the certain depth Dm is

exceeded (FIG. 41 (C-d)). This is because until the depth exceeds a certain depth Dm, the angle of the propagation path of the sound wave with the sea surface is small and accurate guidance cannot be performed. In FIG. 41 (C-e), the acoustic position marker 075 is controlled so that the auxiliary position marker ships A, B, C and D oscillate acoustic signals. Since the oscillation is periodically performed, a timer is set in the processing block 602 to periodically activate the timer. At processing block 595, it is determined whether the eligibility is guidance. This is because the sounding body is installed at a horizontal distance d, and unless a certain depth is provided, the sound wave has no straightness and cannot be guided. The processing block 596 determines whether the positions of the auxiliary position marking ships A, B, C, D are settled, and if the positions are settled, acoustic oscillation is performed. The processing blocks 597 to 601 are for alternately oscillating the group of the auxiliary marker ships A and C and the group of the auxiliary marker ships A and D, and alternately measuring and guiding the deviation between the X axis and the Y axis.

［077］ 4.2 Installation by inertial guidance

An inertial navigation sensor that uses a solid vibrating body as a position sensor and an acceleration sensor can be used as a small-sized, low-cost solid package for smartphones and robots. If the error accumulation due to the descent time is within a range that does not cause a problem, inertial navigation that can simplify the system can be used. FIG. 45 shows a method of installing an acoustic position marker by inertial guidance. First, in (b-1), an acoustic position marker is hung from a position marker ship 070 capable of accurately measuring latitude and longitude by a rope to settle it, and an inertial navigation sensor is initialized. When the hanging rope 113 is cut, it descends along the vertical line 111 toward the seabed as shown in (b-2). The X-axis steering wing 076 and the Y-axis steering wing 077 are controlled so as to eliminate the deviation from the vertical line 111, and trace the acoustic position marker descent path 112 to penetrate the seabed 009.

The external shape of the inertial guidance acoustic position marker is the same as that of the acoustic guidance sound position marker (FIG. 37) although a position acceleration sensor 295 is added as shown in FIG.46.

FIG. 47 shows the configuration of the control device for the inertial guidance acoustic position marker. While the position acceleration sensor 295 is added as compared with FIG. 38(c), the process of the guidance logic of the acoustic guidance shown in FIG. 39 can be omitted. When the guidance logic of FIG. 39 is processed by software, the software executed by the arithmetic unit 200 is changed (deleted).

［078］ Fig.48 (a) and 48 (b) define the processing flow of the inertial guidance acoustic position marker control device. Prior to FIG. 45 (b-1), the initialization process of FIG. 48 (a) is executed once. When the cycle timer of the processing block 670 is started, (b) the acoustic position marker guiding process is started.

In the process block 672, the state value of the position acceleration sensor 295 is read, and when there is no depth change in the process block 673, the initialization of the position / velocity variable of the acoustic position marker is repeated corresponding to FIG. 48 (b-1). Since the depth changes when the suspension cord is cut in FIG. 45 (b-2), the process branches to descent guidance at a processing block 673. The guidance logic of the processing block 675 obtains the deviations in the X-axis direction and the Y-axis direction from the vertical line 111, and the operation amount is calculated in the processing block 676 by the control logic including the well-known PID control. Output to the servo system is performed in a processing block 677, and the steering blade is driven by the X-axis steering blade servo drive device 076 and the Y-axis steering blade servo drive device 077 in FIG. 47 (a). When the acoustic position marker reaches the seabed 009 in FIG. 45 (b-3), the depth does not change, and the cycle timer is stopped in processing block 678 in FIG. 48 (b) to stop the guidance processing in (b). After the guidance control is stopped, since it functions as an acoustic transponder, the actuator power is turned off in processing block 679 to start the transponder processing (FIG. 42). The processing of the position marker ship 070 that installs the inertial guidance acoustic position marker is shown in FIG. 49 (a). 47 (b) shows the hardware, in which the precise latitude / longitude is taken in by the GPS 106, and the latitude / longitude is continuously taken in from the GPS 106 in the processing block 683 while the hanging rope 113 is not cut, and the information is updated (processing. Block 684). At the same time as cutting the hanging rope 113, it is set that the hanging rope 113 is cut from the console 105 (PC keyboard) in FIG.47(b). Once the suspension cord 113 has been cut, the transponder is periodically activated for monitoring (processing block 685). Response requests are sent periodically until there is a response from the acoustic position indicator installed in FIG. 49 (a-2). Fig. 49 (a-3) is activated when there is a response signal from the installed acoustic position marker, and if the ID matches the matching ID, it is determined that the installation is complete, and the acoustic position marker ID, latitude / longitude, and installation time are registered. (Input to the deep sea crane monitoring control system 209 of the surface command ship 010 using a USB memory or the like)

[079] II. Navigation system

1. Composition principles

In the lift-off using the buoyancy of the present invention, the deep-sea crane 001 which is a pick-up device autonomously travels between the starting point and the arrival point (the support ship on the sea surface or the base on the seabed) by the control technology, It eliminates the need for mechanically connected structures such as pipes, and relaxes the mechanical constraints required for the system. It has the following physical properties in the sea:

(1) In the sea, radio waves with straightness cannot be used and GPS cannot be
used as a position sensor.
(2) The error of the inertial position sensor increases with time after initial setting
(3) The magnetic compass can be used because the pressure resistant shell of
the magnetic body is not used.
(4) Sound waves with good propagating in the sea are not suitable for distance
measurement and target azimuth detection when they deviate from the vertical
direction.
(5) Optical distance measurement is indispensable for precise position
measurement, but there is no guarantee of visibility in the sea except in the
immediate vicinity. Furthermore, the movement of the seabed resources is
mainly in the vertical direction, and the distance is as short as 6.5 km at most, but
the landing point control is characterized by the requirement of meter order
accuracy. In addition, although the navigation control requires a large amount of
[080] information to be transmitted, optical fiber communication is suitable because a
radio wave does not pass through the sea and a sound wave with good
propagation has a small amount of information. Sensors that can be used
underwater include (1) inertial position sensor, (2) depth gauge, (3) acoustic
sensor, (4) optical sensor, and (5) geomagnetic sensor. For navigation control
using these, There are inertial navigation, acoustic navigation, and optical
navigation. These sensors are used in combination with the characteristics of
navigation.
FIG. 16 (a) shows the entire navigation control for the deep sea crane 001 to
reciprocate between the surface command ship 010 and the landing point 011.
During the inertial navigation section 090, less time has passed since departure
and the initial position can be accurately known. Therefore, the inertial sensor,
depth gauge, and geomagnetic sensor (magnetic compass) are used together to
determine the position / speed / attitude and the descent target. It is guided so as
to minimize the deviation from the path 043. The descent target route 043 is set
in the initial inertial navigation section 090 so as to be occupied in a range close
to immediately above the landing point on the seabed, which is a target at the
time of descent, and a range close to immediately below the target surface
command ship 010 when ascending. In the succeeding acoustic navigation
section 091, the influence of the bending of the sound ray due to the undersea
temperature distribution is eliminated by reducing the deviation from just below
and above the target when descending and when ascending. When the deep-sea
crane 001 floats on the sea surface 032, the sea water is almost stopped at the
sea bottom, so the disturbance to the position and speed is small, but on the sea
surface, it is necessary to consider the relative motion of the waves with the
support ship. In order to avoid the effects of sea waves, it is possible to
concentrate the bottom of the sea when the sea elephant is calm, or concentrate
on the sea bottom when the sea weather is not suitable.

[081]

3. Navigation control system

The navigation control system 212 in FIG. 14 operates according to the operation flowchart of the navigation control system in FIG.15.

In processing block 520, it is determined whether the deep sea crane 001 leaves the surface command ship 010 before or after the surface command ship 010 is separated. The GPS positioning data 402 of 209 is acquired as initialization data. If the deep sea crane 001 has not yet started floating from the seabed, the processing block 526 sets the position data held by the deep sea crane 001 as the initialization data. After the ascent or descent is started, the inertial navigation system will take measures to prevent the accuracy from deteriorating over time due to drift accumulation. At processing block 521, navigation data including an inertial sensor, a digital compass, and a depth gauge is acquired. At process block 522, a branch is made according to the navigation mode (inertial navigation, acoustic navigation, optical navigation). The navigation command 404 is given to the integrated control 215 of the operation control system 291 in the processing block 523. The default setting at the start of ascent or descent is inertial navigation.

[082] 4 inertial navigation

The operation of the inertial navigation system is described in FIG.16 The pitch, yaw, and roll shown in FIG. 23A are assigned to the deep-sea crane 001. Since GPS cannot be used underwater, inertial navigation will accumulate position errors due to drift over time after initialization to the standard coordinates. For this reason, it is used at the initial stage where drift does not accumulate during both ascent and descent (inertial navigation section 090), the deep-sea crane 001 is brought close to the target as much as possible in the horizontal plane, and the acoustic navigation of the next stage is performed to reach the target making sure the proximity is directly above or below. By making the sound wave propagation path closer to the vertical, the influence of refraction of sound wave propagation is eliminated. In the early stage of the path, the inertial sensor drifts down or rises at a time when the drift error is small, guides directly above or below the target, and switches to acoustic guidance to minimize refraction of sound wave propagation due to seawater temperature distribution.

[083] The process of inertial navigation 227 follows the process flow of the operation of the inertial navigation system shown in FIG.16(b) Since GPS cannot be used, the current position is calculated by adding the moving distance obtained by the inertial navigation system to the initial position obtained at processing block 524 or 526 in FIG. 15 (processing block 530). In processing block 531, the drift of the inertial navigation sensor is estimated from the moving direction obtained from the depth system data and the electronic compass. In processing block 532, the maximum likelihood latitude / longitude depth, velocity, and attitude corrected by the drift estimated value are obtained, and the deviation from the target route is further obtained. In consideration of the refraction of the sound wave propagation

path, the acoustic distance measuring range 091 has a cone that is directly above or directly below the final target point (sea bottom landing point 011 when descending, surface command ship 010 position when ascending) with high straightness. Set to the shape. When it is confirmed in processing block 533 that deep sea crane 001 has entered the acoustic ranging range 042 in the inertial navigation system, processing block 534 issues a sounding command to acoustic navigation system 228. A processing block 535 receives and confirms an echo from an acoustic position indicator (transponder) installed at the target point, and a processing block 536 confirms that the signal level exceeds the threshold value and the distance is equal to or less than the threshold value. At block 537, switching to the acoustic navigation mode is performed.

[084] 5 Acoustic navigation

The principle and method of realizing acoustic distance measurement are described in FIGs.17~19.

The sound sensing elements A to D 231 to 234 and the sound generating element 230 are arranged on the top of the deep sea crane 001 (Fig. 17 (a-1)) and the bottom of the deep sea crane 001 (Fig. 17 (a-2). 17 (b) and (c), the acoustic navigation is used after the inertial navigation in the acoustic navigation section 042 of FIG.16. This is because there is an error in position localization because the straightness of sound waves is not guaranteed due to the temperature distribution of seawater.

This is because it is suitable to use in the medium and short distances because the light does not reach anywhere except the immediate vicinity in the sea. The temperature distribution of seawater exists in the depth direction, but is generally uniform in the horizontal direction. When positioning with a target using a transponder, the azimuth in the horizontal direction can be grasped relatively accurately, but the error in the depression direction increases as the angle with the vertical direction increases. If the sound wave propagation is more than 20 ° away from directly above or below, the sound wave will not reach the target reliably.

[085] The principle and implementation method of the acoustic navigation 228 are shown in FIG17(b)(c). The sound sensing element A 231, the sound sensing element B 232, the sound sensing element C 233, and the sound sensing element D 234 are installed on the surface 292 of the traveling direction (bending) of the deep sea crane 001. A sounding element 230 is installed at the center of these, and when the acoustic navigation section 091 is entered, a sound is generated periodically. When the transponder installed at the arrival target (seafloor landing position) returns an echo, there is a time lag in arrival of the echo signal with respect to each of the sound sensing elements, as shown in FIG.17(b)(c). That is, in FIG. 17B, the echo from the transponder 236 reaches the sound sensing element C 233 on the sound wave transmitting surface 1 237 and reaches the sound sensing element A 232 on the sound wave transmitting

surface 2 238, causing a time shift. FIG. 18 shows this situation three-dimensionally. It shows that the transponder azimuth vector 239 is obtained by calculation from the deviation of the arrival time of the echo signals to the four sound sensing elements A to D 231-234 surrounding the origin O on the XY plane. The distance to the transponder 236 can also be obtained from the difference between the sounding time and the arrival time of the echo. If the sound source is a point sound source, the calculation is not easy, but if the sound source is sufficiently far compared to the distance between the sound-sensing elements and can be approximated to a surface sound source, it is relatively simple to calculate the The direction and distance can be calculated. Acoustic distance measurement uses the same principle as active sonar, but (1) it is not necessary to create an image of the target, and (2) a transponder can be installed on the target. (3) The purpose is to guide directly below or above the target. (4) System simplification and lower output power are possible because the precise target orientation is left to optical navigation.

［086］ FIG. 20 shows the configuration and operation of a device used in acoustic navigation.

Fig. 20 (b) Piezoelectric ceramics widely used in active sonars as the sound-sensing elements A to D 231-234 and the sounding element 230 of the acoustic navigation device. Recently, high-power piezoelectric ceramics have been marketed as general consumer demand.　A constant frequency voltage of the vibration transmission signal pattern of FIG. 20(a) is applied to the piezoelectric vibrator to oscillate a sound wave. In FIG. 20 (b), the vibration transmission and the vibration reception are performed by different piezoelectric elements, but they may be shared. In order to control the deep sea crane 001, the acoustic navigation device in FIG. 20 (b) is installed in the deep sea crane 001, and the transponder in FIG. 42 is installed on the surface command ship 010 side. The operation of the acoustic navigation is as described in the processing sequence of FIG. 20 (c), and the acoustic navigation device performs (2)signal vibration according to the vibration command from the navigation control system. After the forward propagation time, the transponder detects (3)vibration reception and immediately transmits (4)echo vibration. After the return propagation time, (5) to (8) Ch0 to 3 echoes are received by the acoustic navigation device 141. Immediately after transmitting the vibration, the CH0-3 data is recorded in (9) standby. Correlation between the standby recording data and the transmission signal is performed in (10) and (11) to obtain the propagation delay time for each vibration receiving element. (FIG. 20 (e1) to (e3) Processing flow 1 to 3)

［087］ FIG. 19 is a processing flow describing the operation of the acoustic navigation system using the acoustic navigation device. In FIG. 20, processing block 546 and processing block 550 acquire the round-trip sound wave propagation delay of each of the vibration receiving elements A, B, C, and D, and processing block 551 obtains the distance from the target from the average delay time of each element and the sound velocity in the sea.

A case where the sound source is approximated by a surface sound source will be described in detail with reference to FIGS. 18 (a) to 18 (c).
In FIG. 18(a), the transponder azimuth vector 239 indicates the sound wave intrusion direction, and the angle formed with the XY plane is φ, and the angle formed with the projection on the XY plane with the X axis is θ. AB is the arrival direction of the sound wave, and FIG.18(b) is a view seen from above the Z axis. FIG.18(c) is a sectional view of FIG.18(b) taken along a plane including the sound wave arrival direction AB and the Z axis, and shows the relationship between the sound wave propagation path and the delay time with respect to the sound sensing elements A to D 231 to 234. If the sound receiving time (seconds) of the sound-sensing elements A to D 231-234 is ta, tb, tc, and td, respectively, and the sound velocity in the sea is s m/sec,
propagation distance between the sound sensing elements A and C and distance due to the time difference of propagation, then If the sound receiving time (seconds) of the sound-sensing elements A to D 231-234 is ta, tb, tc, and td, respectively, and the sound velocity in the sea is sm / sec,then from the propagation distances of the sound sensing elements B and D and the distances due to the propagation time difference, the following is obtained. [088]

$$(t_c - t_a)s = rcos\varphi cos\theta$$

$$(t_d - t_b)s = rcos\varphi sin\theta$$

$$\cos\varphi = \pm\frac{s}{2r}\sqrt{(t_c - t_a)^2 + (t_d - t_b)^2}$$

$$sin\theta = \pm\frac{(t_d - t_b)}{\sqrt{(t_c - t_a)^2 + (t_d - t_b)^2}}$$

[equation 02]

Then, the processing block 551 is obtained. In Expression (002), cos φ = 0 and sin θ cannot be obtained unless there is a propagation delay time difference with respect to the sound sensor. cos φ = 0 means that the control purpose is achieved because the transponder is directly below or above.
In processing block 552, the transponder azimuth is corrected based on the attitude data obtained from the inertial sensor, and in processing block 553, the position of the deep sea crane 001 on the vibration transmitting side, which is the control target, is obtained from the known transponder position.

[089] 6 Optical navigation

Especially on the seabed, the reaching distance of light is shortened by the mud that rolls up, but since accurate positioning is possible at a short distance of 10 to several meters or less, it is used for precise position control using an LED light emitting element. The principle of optical navigation will be described with reference to FIGS. 21 (a) (b) (c) (d). When the image pickup device 235 detects

the light emitted from the light emitting devices A to D 240 to 243 of the recovery ring 037 by the image pickup device 235 at the tip of the lifting hook 047 of the cargo room 005 of the deep sea crane 001, the process shifts to optical navigation 229.
Since the recovery rings of the light emitting elements A to D 240 to 243 are used for pulling up the ore collecting device 015 (electric power shovel) and the mineral collecting container 034, it may be assumed that they are in the vertical relationship shown in FIG. 24 (e).
The image pickup device 235 is installed above the lifting hook 047 of the cargo compartment 005 of the deep-sea crane 001, and is installed in a horizontal plane at a right angle of 90 degrees. One of the four image pickup devices 235 is a light emitting element A to D 240 to 243. A recovery ring consisting of 068 is to be caught in sight.
The central axis of the imaging device 235
When it is shifted to the light emitting element AB side, the image of (d1) of FIG21(c).
When it is shifted to the light emitting element BC side, the image of (d2) in FIG.21(c)
When it is shifted to the light emitting element CD side, the image of (d3) in FIG.21(c)
When it is shifted to the light emitting element DA side, the image in (d4) of FIG.21(c)

[090] When the central axis is not displaced, the image of (d0) in FIG.21(c) is obtained.

FIG. 21(b) shows the principle of optical navigation. The image pickup device 235 installed at the tip of the lifting hook 047 is an ordinary electronic camera, and it is assumed that the viewing angle is 90 ° at 1000 × 1000 to 4000 × 4000 pixels. FaFbFcFd in FIG. 21B is the imaging surface 293, and the images of the light emitting elements A to D 240 to 243 are formed as shown in FIG. 21(c).
Optical navigation in Fig.21 and Fig.22;
(1) Pixel positions of images of the light emitting elements A to D 240 to 243 on the imaging surface 293
Light emitting device A (Ha, Va), light emitting device B (Hb, Vb), light emitting device C (Hc, Vc), light emitting device D (Hd, Vd)
(2) Identification information of light emitting elements A to D 240 to 243
(3) Focal length Lf 155 of the image pickup device 235
(4) Vertical and horizontal angle of view (αV, αH) and number of vertical and horizontal pixels (Vmax, Hmax) of the image pickup device 235
(5) Angle β formed by the line AC connecting the light emitting elements A and C 240 to 243 with the XY plane
(6) The angle γ formed by the line BD connecting the light emitting elements B and D240 to 243 with the XY plane
(7) Angle δ that straight line BD makes with the Y-axis

Then, the following data (A) and (B) can be obtained by the method described below. The above (1) and (2) are measurement data of the image pickup device 235, and (3) and (4) are unique data of the image pickup device 235, which are all known.
(A) Position of deep sea crane 001 (latitude / longitude (LatT, LonT), depth (DpT))
(B) Posture of deep sea crane 001 (pitch pb, yaw yb, roll rb)

[091] Determine the above (A) and (B) using quaterion.
A reference coordinate system (XYZ X axis: horizontal Y axis: vertical Z axis: front and rear) P at the position of the image pickup device 235 is defined, and a coordinate system (XbYbZb) Pb representing the posture of the image pickup device 235 is defined. It is assumed that the recovery ring aiming 068 in FIG. 21(b) is rotated by the quaterion Qt with respect to the reference coordinate P and becomes the view coordinate Pt of the target direction vector 157.

$$\boldsymbol{P_t} = \boldsymbol{Q_T P Q_T}^{*} \qquad \text{[equation 03]}$$

The recovery ring aim 068 in this coordinate system is projected on the imaging surface 293 to obtain the image in FIG. 21 (c). Since the recovery ring aim 068 is on a plane orthogonal to the Z axis of the reference coordinate P and is located at a position deviated from the Z axis of the reference coordinate P, the plane formed by the target orientation vector 310 and the recovery ring aim 068 is not vertical. Details of the PAC and PBD of FIG. 21 (b) are shown in FIG. 22 (a) (b).

[092] A indicates the presence of the light emitting device A 240, and the same applies to BCD. M is the intersection of AC and BD. FIG. 22(c) shows the image forming coordinates of the image pickup surfaces 293 of A, B, C, and D. In the HV coordinates, the upper left is (0,0) and the lower right is (Hmax, Vmax). The coordinates of the intersection M of the line AC connecting the light emitting elements A and C and the line BD connecting the light emitting elements B and D are given below.

$$\begin{bmatrix} H_m \\ V_m \end{bmatrix} = \begin{bmatrix} V_b - V_d & -H_b + H_d \\ -V_a + V_c & H_a - H_c \end{bmatrix}^{-1} \begin{bmatrix} H_d V_b \\ H_c V_c \end{bmatrix} \qquad \text{[equation 04]}$$

Fig.22 (a) and 22 (b), from the viewpoint P, the angles that allow the line segments AM and MC to be seen are α and β, and the angles that the line segments BM and MD are seen are γ and δ, which are given by (Equation 003).

Here, R is the distance from the viewpoint P to the intersection M of the AC and BD, r is the distance between the light emitting element and M, and ω and φ are the angles formed by the line segments AC and BD with respect to the plane orthogonal to the line-of-sight vector PM. Then, it is given by (Equation 005).

[093]

$$\tan\alpha = \frac{rcos\omega}{R - rsin\omega}$$

$$\tan\beta = \frac{rcos\omega}{R + rsin\omega}$$

$$\tan\gamma = \frac{rcos\varphi}{R - rsin\varphi}$$

$$\tan\delta = \frac{rcos\varphi}{R + rsin\varphi}$$

$$\mathrm{R} = \frac{r(tan\alpha + tan\beta)}{\sqrt{(tan\alpha - tan\beta)^2 + 4tan^2\alpha tan^2\beta}}$$

or

$$\mathrm{R} = \frac{r(tan\gamma + tan\delta)}{\sqrt{(tan\gamma - tan\delta)^2 + 4tan^2\gamma tan^2\delta}}$$

taking the average

$$\mathrm{R} = \frac{1}{2}\left(\frac{r(tan\alpha + tan\beta)}{\sqrt{(tan\alpha - tan\beta)^2 + 4tan^2\alpha tan^2\beta}} + \frac{r(tan\gamma + tan\delta)}{\sqrt{(tan\gamma - tan\delta)^2 + 4tan^2\gamma tan^2\delta}}\right)$$

$$\sin\omega = \frac{R}{r}\frac{tan\alpha - tan\beta}{tan\alpha + tan\beta}$$

$$\sin\varphi = \frac{R}{r}\frac{tan\gamma - tan\delta}{tan\gamma + tan\delta}$$

[equation 05]

On the other hand, since α, β, γ, and δ are obtained from the coordinates of the image of the light emitting element on the imaging surface 293 as in (Equation 005), the values of R, ω, and φ in (Equation 006) are determined.

$$\alpha = \sqrt{\left\{\frac{(H_a - H_m)\alpha_H}{H_{max}}\right\}^2 + \left\{\frac{(V_a - V_m)\alpha_v}{V_{max}}\right\}^2}$$

$$\beta = \sqrt{\left\{\frac{(H_c - H_m)\alpha_H}{H_{max}}\right\}^2 + \left\{\frac{(V_c - V_m)\alpha_v}{V_{max}}\right\}^2}$$

$$\gamma = \sqrt{\left\{\frac{(H_b - H_m)\alpha_H}{H_{max}}\right\}^2 + \left\{\frac{(V_b - V_m)\alpha_v}{V_{max}}\right\}^2}$$

$$\delta = \sqrt{\left\{\frac{(H_d - H_m)\alpha_H}{H_{max}}\right\}^2 + \left\{\frac{(V_d - V_m)\alpha_v}{V_{max}}\right\}^2}$$

$$\tan\rho = \frac{V_a - V_c}{H_a - H_c}$$

[equation 06]

It should be noted that ρ represents a rotation around the line-of-sight vector PM with respect to the reference coordinates.In (Equation 005), the recovery ring standard 068 is assumed on the XY plane, but it is generally inclined with a certain posture angle. As shown in FIG. 21(a), when the X * axis is inclined α with respect to the horizontal and the Y * axis is inclined β with respect to the horizontal, rcos ε and rcos τ may be used instead of r.

[094] From FIG. 22 (c), the relationship between Pb and the view coordinate Pt of the target direction vector 157 (Equation 007) can be obtained in the coordinate system (XbYbZb) representing the attitude of the deep-sea crane 001. The definitions of Pitch, Yaw, and Roll follow FIG.23.

$$\mathrm{Roll} = \frac{H_m - \frac{H_{max}}{2}}{H_{max}} \alpha_H$$

$$\mathrm{Pitch} = -\frac{V_m - \frac{V_{max}}{2}}{V_{max}} \alpha_V$$

$$\mathrm{Yaw} = tan^{-1}\left(\frac{V_a - V_c}{H_a - H_c}\right)$$

[equation 07]

If the rotation quaterion of (Equation 007) is Qt, then (Equation 008) is obtained.

$$\boldsymbol{P_t} = \boldsymbol{Q_t P_b Q_t}^*$$

[equation 08]

[095] (Equation 09) is obtained from (Equation 008) and (Equation 003), and the posture of the imaging device 235 with respect to the reference coordinate P is clarified.

$$\boldsymbol{P_b} = \boldsymbol{Q_t}^{-1}\boldsymbol{Q_T P Q_T}^*\boldsymbol{Q_t}^{*-1}$$

[equation 09]

The processing block 561 in FIG. 21(d) is obtained from (Equation 005) and (Equation 006), and the processing block 562 is obtained from (Equation 008). As a result of the optical navigation 229, the command value is calculated to the operation control system in the processing block 523 of FIG. 15, and the deep sea crane 001 is brought close to the recovery ring aim 068 by the operation control system of FIG.14.

[096] III control system

1. Control principle

1.1 Control system configuration

FIG. 14 is a block diagram showing the control logic.
The measured values of the navigation sensor 115 including the inertial position sensor, the depth gauge, the acoustic sensor, the optical sensor, and the geomagnetic sensor are input to the position / speed control system 216. Pitch, yaw, and roll signals from the attitude sensor 214 are input to the attitude control system 217. The navigation control system 110 gives a navigation command 404 to the position / speed control system 216 according to the navigation mode selected in the processing block 522 of FIG.15. The navigation command 404 is a time function of the target position, and includes the seabed landing position that is the arrival target position, and the movement trajectory that is the time function between the current position of the deep-sea crane 001 that is the control target and the target position. The attitude control system 217 has a shape similar to that of a deep sea crane 001 in which a cargo room 005 is suspended in a buoyancy tank 002 (FIGs. 1 and 31), and the attitude is practically ignored except for rotation around a vertical axis. In the case of the inertial navigation 227 and the acoustic navigation 228, the position / speed control system 216 measures the control amount by (Equation 015) and (Equation 016), and controls the control blade by the control blade individual control amount calculation 219 and the reducer individual control amount calculation 220 command signal to the system 222 is calculated.

In the case of inertial navigation 227 and acoustic navigation 228, braking and rotation or horizontal thrust is obtained by controlling the opening angle and rotation angle of the control wing and landing leg in the cargo room as shown in FIG. 26 (a) (b)).

[097] When performing precise position / velocity control by optical navigation 229, the position / velocity control system 216 measures the control amount by (Equation 015) and (Equation 016), and the individual propulsion machine control system 221 outputs the command signal to the individual propulsion device. When performing the precise position / velocity control by the optical navigation 229, the precise position control is performed by adding a precision control attachment with a thruster added to the cargo compartment 005 as shown in FIGS. 24 (b) and 44 (b). The precise control is performed only when the rendezvous control is performed in order to hoist the collection ring 037 of the mineral collection device 015 (electric power shovel) and the mineral collection container 034 by the collection hook 177. Other than that, the potential energy is used by passively converting the potential energy without using thrusters for the round-trip collection between the sea surface and the seabed. The control of the deep sea crane 001 is common to all of the following operation modes (inertial navigation, acoustic navigation, optical navigation) in that it controls thrust of individual propulsion units and command values to control wings, so The individual control is performed by changing the diagonal component corresponding to the state variable of the diagonal matrix A of (Equation 016) and the feedback coefficient of (Equation 016) in the position / speed control system 216 and the attitude control

system 217 by the integrated control 215. realizable. The deep sea crane 001 is controlled by controlling the thrust of the individual propulsion unit and the command value to the control blades. Since this is common to all of the following operation modes (inertial navigation, acoustic navigation, optical navigation), the individual control for each operation phase is that the integrated control 215 is the position / speed control system 216 and the attitude control system 217. It is realized by changing the feedback coefficient of the diagonal component (Equation 016) corresponding to the state variable of the diagonal matrix A.

The operation control system 291 shown in FIG. 14 will be described in detail. The structure and coordinate system are as shown in FIG.23 and 24. Fig.23(b),24(c), and Fig.44(c) model the external force vector acting on the cargo compartment 005 of the deep-sea crane 001.

The attitude control is virtually meaningless except for the rotation about the vertical axis because the shape of the deep-sea crane is axisymmetric. When hoisting the container 034, it is necessary to face the recovery ring 037 of the rendezvous target (FIG. 24 (e), FIG. 44 (e)). There are the following two measures as this solution.

(1) Since the shape of a deep-sea crane is axisymmetric and the attitude control is meaningless, and if the rotation control in the axial direction is performed, it will be absorbed by the twist of the suspension rope and it will be difficult to control the behavior. Therefor no rotation control is performed. The recovery ring 037 of the rendezvous target (Fig. 24 (e)) can be directly faced regardless of the axial rotational position. For example, four photographing devices 235 having a viewing angle of 90 degrees are arranged orthogonally, and four lifting hooks 047 are provided so as to face the center of the visual field of the photographing device 235. In FIGs. 24(b) and 24(d), the imaging device 235 suspended in the cargo compartment 005 keeps the entire circumference in view. Of these, the image capturing device 235 that captures the rendezvous target (FIG. 24 (e)) is selected to perform precise position / speed control. In this case, the horizontal thruster of FIG. 24 (a) is not provided with a thruster for rotating the cargo room 005 around its axis.

(2) The policy is to control the rotation around the axis of the deep-sea crane, and the rotation control speed is slowed down so that the problem due to the twisting of the hanging rope does not occur, and the recovery ring 037 of the rendezvous target (FIG. 44 (e)) is generated. 44 (b) and (d), the attitude control (rotation control) is performed so that the imaging device 235 suspended in the cargo compartment 005 is within the field of view. In this case, thrusters e and f for rotating the cargo compartment 005 of FIG. 44 (a) around an axis are provided.

[099] 1. 2 Position and speed control

In the case of inertial navigation 227 and acoustic navigation 228, braking and lateral thrust are obtained by controlling the degree of opening of the four control wing landing legs 006 shown in FIG.23(a) and the rotation angle of the control wing. The degree of open leg and the rotation angle of the control blade are the same for the control blade / implantation leg a and c, and the same for the control blade / implantation leg b and d.

Ra = Rc

Rb = Rd

The components of the above vector are defined as follows.

$$\boldsymbol{R}_a = \begin{bmatrix} 0 \\ \mathrm{R}_{\mathrm{ay}} \\ \mathrm{R}_{\mathrm{az}} \end{bmatrix} \quad \boldsymbol{R}_b = \begin{bmatrix} \mathrm{R}_{\mathrm{bx}} \\ 0 \\ \mathrm{R}_{\mathrm{bz}} \end{bmatrix}$$

[equation 10]

The drag force is defined by the following parameters.

Degree of spread: αa (subscript indicates leg for landing control wing)

Control blade rotation angle: βa (subscript indicates control blade landing leg)

Settling force or levitation force S = W-F

Cargo compartment weight W

The function Fxy is an empirical formula that generates a thrust component with respect to the horizontal plane.

The function Fz is an empirical formula that generates a thrust component in the vertical direction. Since the vertical thrust is generated by the passive resistance vanes, it acts only as a resistance that counteracts the difference between buoyancy and gravity.

$R_{ay} = F_{xy}(S,W, \alpha_a, \beta_a)$

$R_{az} = F_z(S,W, \alpha_a, \beta_a)$

The following is obtained by integrating each component.

$$\boldsymbol{T} = 2 \begin{bmatrix} \mathrm{R}_{\mathrm{bx}} \\ \mathrm{R}_{\mathrm{ay}} \\ \mathrm{R}_{\mathrm{az}} + \mathrm{R}_{\mathrm{bz}} \end{bmatrix}$$

[equation 11]

［100］ 1. 3 Precision position / speed control

When the precise position / velocity control is performed by the optical navigation 229, FIG.24 (c) and Fig.44(c) show forces acting on the deep-sea crane 001.

Before performing the precise position / speed control, the ballast is adjusted to balance the buoyancy and gravity of the deep-sea crane, and the crane is once stopped before moving to the rendezvous by the precise position / speed control. Although the position and speed of the cargo compartment 005 are controlled, in FIG. 24, the cargo compartment 005 is suspended by a rope from buoyancy tanks. It is not necessary to control the posture of the lifting hook 047 and the

imaging device 235 because of the structure. In FIG. 44, the attitude control is performed so that the hoisting hook 047 and the imaging device 235 in which the cargo compartment 005 is suspended by a rope in the buoyancy tank face the rendezvous target (FIG. 44 (e)).
In the precise position / speed control, the thrusts of the vertical thrusters A to D in Fig. 44 (b) are TA, TB, TC, TD, and the thrusts of the horizontal thrusters a to f are Ta, Tb, Tc, Td, Te, and Tf. (In the case of FIG. 24 (b), Te = Tf = 0)
Since the control in the vertical direction is performed while maintaining the horizontal posture, the thrust of the vertical thruster is the same.

Tz = TA = TB = TC = TD

Expressing the components of the above vector,

$$\boldsymbol{T}_z = \begin{bmatrix} 0 \\ 0 \\ \mathrm{T_z} \end{bmatrix}$$

[equation 12]

[101] Since the thrusters in the horizontal direction are on the X-axis or Y-axis, the thrust may be the same for each axis because of the horizontal movement.

Ta = Tc
Tb = Td
Te = —Tf

Vector notation,

$$\boldsymbol{T}_a = \begin{bmatrix} \mathrm{T_a} \\ 0 \\ 0 \end{bmatrix} \quad \boldsymbol{T}_b = \begin{bmatrix} 0 \\ \mathrm{T_b} \\ 0 \end{bmatrix}$$

[equation 13]

The following is obtained by integrating each component.

$$\boldsymbol{T} = \begin{bmatrix} 2\mathrm{T_a} \\ 2\mathrm{T_b} \\ 4\mathrm{T_z} \end{bmatrix}$$

[equation 14]

If there is attitude control and the z-axis (vertical axis) torque is Rz, Rz = 2Te・b
Where b is the distance from the z axis of the thruster.

[102] Rendezvous mechanism

The precise position / velocity control is used to lift the mineral collection device 015 (electric power shovel) and the collection ring 037 of the mineral collection container 034 by the lifting hook 177 of the cargo compartment of the deep sea crane 001. The rendezvous mechanism of FIG.24(d) and Fig.44(d) is specially constructed for this purpose. Passing through the recovery ring 037 through the hanging hook 047 and pull it up. The recovery ring is located above the object to be lifted and has a light-emitting body with four LEDs on the upper part, and the imaging element 235 on the upper part of the lifting hook 047 captures the visual field and guides the deep-sea crane 001 by an optical method to lift the lifting hook 047 through collection ring 037. The height of the light emitting LED is set so that the image sensor 235 can easily capture it.

[103] 1. 4 Control law

The deep sea crane 001 has a specific gravity of around 1.0, a low moving speed of about 1 m / sec, and a low resistance symmetrical shape. However, with respect to movement in the x-axis, y-axis, and z-axis directions, the deep sea crane 001 receives water resistance proportional to speed. R is a water resistance coefficient and the equation of motion can be expressed by (Equation 015).

$$\boldsymbol{T}(\mathrm{t}) = \mathrm{M}\ddot{\boldsymbol{X}}(t) + R\dot{X}(t)$$
$$r(\mathrm{t}) = \mathrm{m}\ddot{\omega}(t) + s\dot{\omega}(t)$$

[equation 15]

Here, M is the mass of the deep sea crane 001, R is the resistance coefficient, and X (t) is the position of the center of gravity G 053 in the reference coordinate system. T (t) is the thrust in the reference coordinate system obtained from the navigation control system and the levitation control system for the deep-sea crane 001. r is the torque around the z-axis, m is the rotation moment, and s is the resistance torque against rotation. (R (t) is considered only when attitude control is performed)
A control system is configured for the dynamic characteristics of (Equation 015). It suffices to find T(t) that minimizes the following. When performing attitude control, also obtain r(t).

[104] Then minimizing the next equation,

$$\int \left(\boldsymbol{W(t)} - \boldsymbol{W_T(t)}\right)^{\boldsymbol{T}} \boldsymbol{A}\left(\left(\boldsymbol{W(t)} - \boldsymbol{W_T(t)}\right)\right) dt$$

Where,

$$\boldsymbol{W(t)} = \begin{bmatrix} X(t) & 0_{3x3} \\ 0_{3x3} & \dot{X}(t) \end{bmatrix}$$

$$\boldsymbol{W_T(t)} = \begin{bmatrix} X_T(t) & 0_{3x3} \\ 0_{3x3} & \dot{X}_T(t) \end{bmatrix}$$

When attitude control is performed, the next equation is minimized.

$$\int (r(t) - r_T(t)))^2 \, dt$$

[equation 16]

A is a 6 × 6 constant matrix whose diagonal elements are aij> 0 i = 0,5.
The lower right subscript in WT (t), XT (t), and rT (t) in (Equation 016) indicates the target value, and the upper right subscript indicates the transposed matrix.

【0105】

[105] VI supervisory control system

The equipment that composes the seabed resource has been described above, and the contents to be monitored and controlled for these equipment are as follows. These are all carried out by the surface command ship 010 by the supervisory control system 287. Considering that the surface command ship 010 uses a standard ore carrier ship, the standard ore carrier ship will be changed to a surface command ship as a PC-based small-sized portable system to facilitate operation.

(1) Navigation control
(2) Resource collection device control
(3) Sound position marker management
(4) Power control
(5) Surface command ship control

[106] The monitoring control system 287 includes a part relating to the deep-sea crane control device 284 shown in FIG. 35 and a part relating to the mineral collecting device control device 285 shown in FIG.30.

In the part relating to the deep sea crane control device 284 shown in the monitoring control system of FIG. 35, the deep sea crane console 210 on the surface command ship 010 performs the next monitoring control of the deep sea crane 001 via the optical interface 211.

(1) The state of the deep-sea crane 001 is monitored, the landing to and lifting from the seabed is controlled, the operation management such as ore loading, and the ballast control information are managed and controlled.

(2) The image of the imaging device 235 is monitored at the time of precise speed position control, and manual control is performed if necessary.

In addition to the functions related to the deep sea crane control device 284, the deep sea crane console 210 of the supervisory control system of FIG. 35 performs the following.

(1) Based on the GPS positioning data 402 captured by the deep sea crane monitoring and control system 209, a speed and steering command for canceling the influence of ocean current and wind are issued to the surface command ship 010 in order to maintain a fixed point.

(2) The identification number (ID) of the acoustic position marker set by the position marker ship 070, the latitude and longitude, and the installation time are collectively managed. Every time the acoustic position marker is installed and collected, the information is updated by the acoustic position marker control device (FIG. 38, FIG. 48) of the position marker ship 070 and the medium. Since the acoustic position marker is driven by a battery, the battery consumption is managed, the floating recovery command information is managed, and the position marker ship 070 is provided.

(3) As the submarine equipment management, information such as the identification number (ID), the latitude and longitude, and the installation time of

the mineral collecting device 015 (electric power shovel) and the mineral collecting container 034 is managed.
(4) Collect and manage geographic information (video information, resource excavation information) on the seabed.

[107] In the part relating to the mineral collection device control device 285 shown in the monitoring control system of FIG. 30, the deep sea crane console 210 on the surface command ship 010 performs the next monitoring control of the ore collecting device 015 via the optical interface 211.
(1) While watching the image of the ultrasonic high-definition video camera 050 on the display 255, operate the ore collecting device 015 with the control stick 270. When the seabed visibility is good, the image of the image pickup device 235 is used.
(2) According to the instruction of the deep sea crane console 210, the mineral loading target is selected and the mineral loading is performed.
(3) The ore collecting device 015 is remotely controlled by operating the control stick 270 and the resource collecting device console 441 via the resource collecting device control interface 262.
The power supply control board 251 controls the generator 470 by the power supply monitoring system 250 shown in FIG. 35 to perform the following.
(1) Power is supplied to the resource collection device power mechanism 267 of the ore collecting device 015 through the power transmission interface 253 and the undersea power cable 269.
(2) Power is supplied to the deep-sea crane controller 284 via the power transmission interface 253 and the undersea power cable 269. The attachment for detailed position / speed control has a thruster and requires electric power for driving, but there is also a method of mounting a high-performance secondary battery and omitting the undersea power supply cable 269.
The power supply device monitoring control system 250 controls the charging device 252 via the power supply control panel 251 to charge the acoustic position indicator and the secondary battery for the deep sea crane control device 284.

INDUSTRIAL APPLICABILITY

[108] The seabed resource collection device of the present invention can collect and collect mineral resources distributed on the seabed. It can be made equal at any seafloor depth without having a special pressure resistance mechanism, and there is no mechanical restriction because it does not include the pumping of fluid. Since the buoyancy is used by slightly lowering the gravity of the seabed resources than the specific gravity of the surrounding seawater, the energy required for the harvesting does not increase with depth. That is, it is possible to operate from a depth of less than 1000m at which seabed resources exist to a depth of more than 6500m. Due to such flexibility of operation, it is possible to

selectively move and recover the sea area with high-grade minerals, which is highly profitable.
The numerical values shown in the examples are for feasibility and can be scaled up or down.

BRIEF DESCRIPTION OF THE DRAWINGS

[109] **FIG. 1** is a diagram showing an outline view of a deep-sea crane of the present invention.
FIG. 2 is a diagram showing an overall view of a seabed resource collection system of the present invention.
FIG. 3 is a diagram and table showing buoyancy tank volume and buoyancy specifications of the present invention.
FIG. 4 is a diagram showing ore loading (cargo compartment) of the deep-sea crane of the present invention.
FIG. 5 is a diagram showing ore loading in the deep sea crane cargo compartment of the present invention.
FIG. 6 is a diagram showing an example of a water flow mechanism of a cargo compartment of the present invention.
FIG. 7 is a diagram showing an example of a discharge restricting mechanism for a cargo compartment of the present invention.
FIG. 8 is a diagram showing a cargo compartment control processing unit of the present invention.
FIG. 9 is a diagram showing a time transition of the cargo compartment loading structure of the present invention.
FIG. 10 is a diagram showing a processing flow of a cargo compartment control processing unit of the present invention.
FIG. 11 is a diagram showing ore loading (collected mineral container) of the deep-sea crane of the present invention.
FIG. 12 is a diagram showing a configuration of a mineral collection container control device of the present invention.
FIG. 13 is a diagram showing a processing flow of the mineral collection container control device of the present invention.
FIG. 14 is a diagram showing a block diagram of a supervisory control system of the present invention.
FIG. 15 is a diagram showing a processing flow of the navigation control system of the deep-sea crane of the present invention.
FIG. 16 is a diagram showing the operation of the inertial navigation system of the deep-sea crane of the present invention.

FIG. 17 is a diagram showing an example of mounting sensors of the present invention.

FIG. 18 is a diagram showing the principle of acoustic navigation of the present invention.

FIG. 19 is a processing flow showing the operation of the acoustic navigation system of the present invention.

FIG. 20 is a diagram showing the principle and operation of acoustic distance measurement according to the present invention.

FIG. 21 is a diagram showing the principle (1) of the optical distance measurement according to the present invention.

FIG. 22 is a diagram showing a principle (2) of optical distance measurement according to the present invention.

FIG. 23 is a diagram showing an operation of the control system of the deep sea crane of the present invention.

FIG. 24 is a view showing precision control attachments of the present invention.

FIG. 25 is a diagram showing control (No. 1) of the deep-sea crane of the present invention.

FIG. 26 is a diagram showing control (No. 2) of the deep-sea crane of the present invention.

FIG. 26-1 is a diagram showing control (No. 3) of the deep-sea crane of the present invention.

FIG. 27 is a view showing installation of mineral collecting apparatuses of the present invention on the seabed.

FIG. 28 is a diagram showing recovery of the mineral collecting apparatus and the collected mineral container of the present invention from the seabed.

FIG. 29 is a diagram showing a mineral collecting apparatus (seabed power shovel) of the present invention.

FIG. 30 is a diagram showing a supervisory control device (2) of the present invention.

FIG. 31 is a view showing division of the buoyancy tank of the deep sea crane (No.1) of the present invention.

FIG. 31-1 is a view showing division of the buoyancy tank of the deep sea crane (No.2) of the present invention.

FIG. 32 is a diagram showing an example of a maritime command ship of the present invention, a gut crane ship.

FIG. 33 is a diagram showing cargo handling equipment of the deep-sea crane of the present invention. ··

FIG. 34 is a diagram showing a cargo handling procedure of the deep-sea crane (N0.1) of the present invention.

FIG. 34-1 is a diagram showing a cargo handling procedure of the deep-sea crane (N0.2) of the present invention.

FIG. 35 is a diagram showing a configuration diagram of a supervisory control device (No. 1) of the present invention.

FIG. 36 is a diagram showing installation of the acoustically guided acoustic position marker of the present invention.
FIG. 37 is a diagram showing a configuration example of an acoustically guided acoustic position marker of the present invention.
FIG. 38 is a diagram showing an acoustically guided acoustic position marker control device of the present invention.
FIG. 39 is a diagram showing the guidance logic of the acoustically guided acoustic position marker of the present invention.
FIG. 40 is a diagram showing a configuration of a signal processing / control system of the acoustically guided acoustic position marker installation system of the present invention.
FIG. 41 is a diagram showing a processing flow of a signal processing / control system of the acoustically guided acoustic position marker installation system of the present invention.
FIG. 42 is a diagram showing a processing flow of an acoustic transponder common infrastructure of the present invention.
FIG. 43 is a diagram showing an example of recovery operation from the seabed of the mineral collecting apparatus (electric power shovel) of the present invention.
FIG. 44 is a view showing a precision control attachment (2) of the present invention.
FIG. 45 is a diagram showing the installation of the inertially guided acoustic position markers of the present invention.
FIG. 46 is a diagram showing a configuration example of the inertially guided acoustic position marker of the present invention.
FIG. 47 is a diagram showing the configuration of an inertially guided acoustic position marker control device of the present invention.
FIG. 48 is a diagram showing a processing flow of the inertially guided acoustic position marker control device of the present invention.
FIG. 49 is a diagram showing a processing flow of a position marker ship control device for inertially guided acoustic position markers of the present invention.

Claims

1. The present invention is a deep sea crane and a seabed resource collecting device for collecting mineral resources from the seabed to the sea surface, which is configured by including a part of or all of a marine command ship, a seabed resource collecting device, and a position marker.

The deep-sea crane is characterized by including all or part of the following four items.

First, a buoyancy tank in which a liquid containing n-cyclopentane or gasoline, which is in a liquid phase at room temperature and has a lower specific gravity than water, is hermetically filled.

Secondly, a cargo room to collect seabed resources from the seabed,

Third, a mechanism for connecting the cargo compartment to a buoyancy tank,

Fourthly, a control device including control wings and landing legs for landing the cargo compartment on the seabed and controlling the position and attitude in the sea.

The deep sea crane descends to the sea floor by making the specific gravity of the entire deep sea crane including the ballast mounted in the cargo compartment larger than seawater.

After landing on the seabed, the ballast mounted in the cargo compartment is exchanged for seabed resources.

After that, the specific gravity of the entire deep-sea crane is made smaller than that of surrounding seawater, and the seabed resources are collected by floating on the sea surface by buoyancy.

The deep sea crane is made of solid and liquid to equalize the internal pressure of the deep sea crane with the ambient seawater, thereby avoiding mechanical stress due to high pressure.

2. The deep sea crane according to claim 1 is characterized by the following three items.

Firstly, with a gap in the lower part of the buoyancy tank, the cargo compartment having a structure capable of smoothly dropping a load from above by gravity is suspended in water.

Secondly, the seabed resource collecting device from the void puts the seabed mineral resources into the cargo compartment from above, Thirdly, the gravity of the seabed mineral resources is used to push the ballast loaded in the cargo compartment downward and to discard the ballast, thereby exchanging the ballast with the seabed mineral resources.

In order to realize this feature, the following items are featured.

Firstly, an emission control mechanism including a passage prevention function is provided at the lower end of the cargo room, and in order to prevent mixing of the ballast brought in from the sea surface and the collected minerals introduced from above the sea floor, the ballast is lowered when descending from the sea surface. A movable film-shaped or expandable and movable partitioning mechanism is provided on the upper surface.

Secondly, the ballast can be dropped and discharged by the ballast discharge control mechanism at the lower end of the cargo room.

Thirdly, a weighing scale for measuring the load on the seabed is installed on a part or all of the control wing and landing leg for landing, and the underwater weight of the entire deep-sea crane is constantly monitored from the measured value. The amount of ballast is controlled within a range in which the cargo room can continue landing on the seabed in accordance with the weight of the seabed mineral resource collecting minerals fed from above the cargo room.

Fourthly, after the loading of the collected minerals into the cargo compartment is completed, the ballast discharge is controlled when floating from the seabed to float on the floor so that the specific gravity of the deep-sea crane is smaller than that of the surrounding seawater.

3. The control blade and landing leg of the deep-sea crane according to claim 1 are configured by the following features, and the horizontal movement and the lifting speed of the deep-sea crane can be controlled.

First, on the outer peripheral portion of the upper part of the cargo room, control wings and landing legs are provided which can individually control the opening degree in the horizontal direction from the vertical direction toward the outer periphery in the radial direction.

Secondly, the rotation can be controlled individually around the support pillar of each control blade and landing leg.

4. The deep sea crane according to claim 1 includes a route guidance control function for guiding and controlling a movement route between a seabed landing point and the marine command ship, and includes the following features.

First, when the deep sea crane descends from the sea surface, inertial navigation and acoustic navigation can be switched according to the positional relationship with the seabed landing point, which is the target point when descending.

Secondly, when the deep-sea crane rises from the seabed landing point, inertial navigation and acoustic navigation are switched according to the positional relationship with the marine command ship, which is the target point when rising.

The depth data and inertial navigation data are used in the range where sound waves do not reach due to the temperature distribution in the sea or the straightness is not sufficient to measure the target direction, and the depth data and sound are used in the range where acoustic measurement is sufficient to measure the target direction.

The acoustic navigation is configured to include the following three features.

First, an acoustic transponder is installed on the seabed landing point and the marine command ship, and the acoustic transponder generates an echo in response to an acoustic oscillator installed in the deep-sea crane, thereby making a round trip time of an acoustic signal. To measure.

Secondly, when the deep sea crane is floating, the distance between the deep sea crane and the marine mother ship is measured, and the presence direction of the marine command ship is determined from the phase difference between the vibration receiving elements installed apart from the deep sea crane. To detect.

Third, when the deep sea crane descends, in addition to measuring the distance between the deep sea crane and the seabed landing point including the seabed landing point, from the phase difference between the vibration receiving elements installed at a distance to the deepwater crane. It is possible to detect the existence direction of the seabed landing point including the seabed landing point.

5. The buoyancy tank of the deep-sea crane according to claim 1 is divided into three or more equal-volume balls and is made of a lightweight and tough material containing carbon fiber resin,

In order to disperse the suspension stress on each sphere, a net is squeezed from the upper part of each sphere to the side surface to cover the rope, and the cargo room is suspended by the rope from each sphere.

As a result, the deep-sea crane can operate the following items.

That is, when collecting the minerals collected on the ship, the cargo chamber is caught by the ship crane of the marine command ship from the void in the center of each ball in a state where the balls are floating on the sea surface, When descending to the seabed, ballast is loaded in the cargo compartment and suspended from the center of each ball floating above the sea surface with the on-board crane of the marine command ship and connected to each ball to descend to the seabed.

6. The position sign in claim 1 is an acoustic sign installed on the seabed in correspondence with the latitude and longitude, and includes the following three features.

First, the acoustic sign is set immediately below the sign ship whose latitude and longitude are measured on the sea surface by GPS by a method including guidance by an acoustic signal or inertial guidance.

Secondly, on the surface of the sea, oscillate an acoustic signal from the apex of the polygon that encloses the marker ship with different latitude and longitude surrounding the marker ship, and deviate from the vertical line directly under the marker ship by the principle of triangulation. Then, the control is performed so as to eliminate the shift by the steering shafts of the respective axes, and the acoustic sign is guided to a point directly below the sign ship and landed.

Third, after the acoustic sign has landed on the seabed, the acoustic sign functions as a transponder in response to an interrogation signal from a deep sea crane.

7. The integrated supervisory control device of the marine command ship according to claim 1, supplies power to the mineral collecting device, performs communication by optical fiber, and controls the descending of the deep-sea crane from the marine mother ship to the seabed landing point. However, commanding and control of getting out of the seabed landing point and ascending to the sea command ship is characterized by the following items.

First, the power generation device of the marine command ship supplies power to the deep sea crane by power transmission or charging to control it.

Secondly, the transfer of the minerals collected from the deep sea crane to the sea command ship is controlled.

8. A mineral collection container that can be separated and connected to the cargo compartment of the deep-sea crane according to claim 1 and that can measure underwater weight is added to the components of the seabed resource collection device, and has the following three features.

First, the following three operations are performed when descending from the sea surface of the deep-sea crane to the sea floor.

1. A ballast for dumping is loaded in the cargo compartment.
2. The seabed resource collection device or one or more of the mineral collection containers are suspended.
3. The specific gravity of the deep-sea crane is larger than that of seawater.

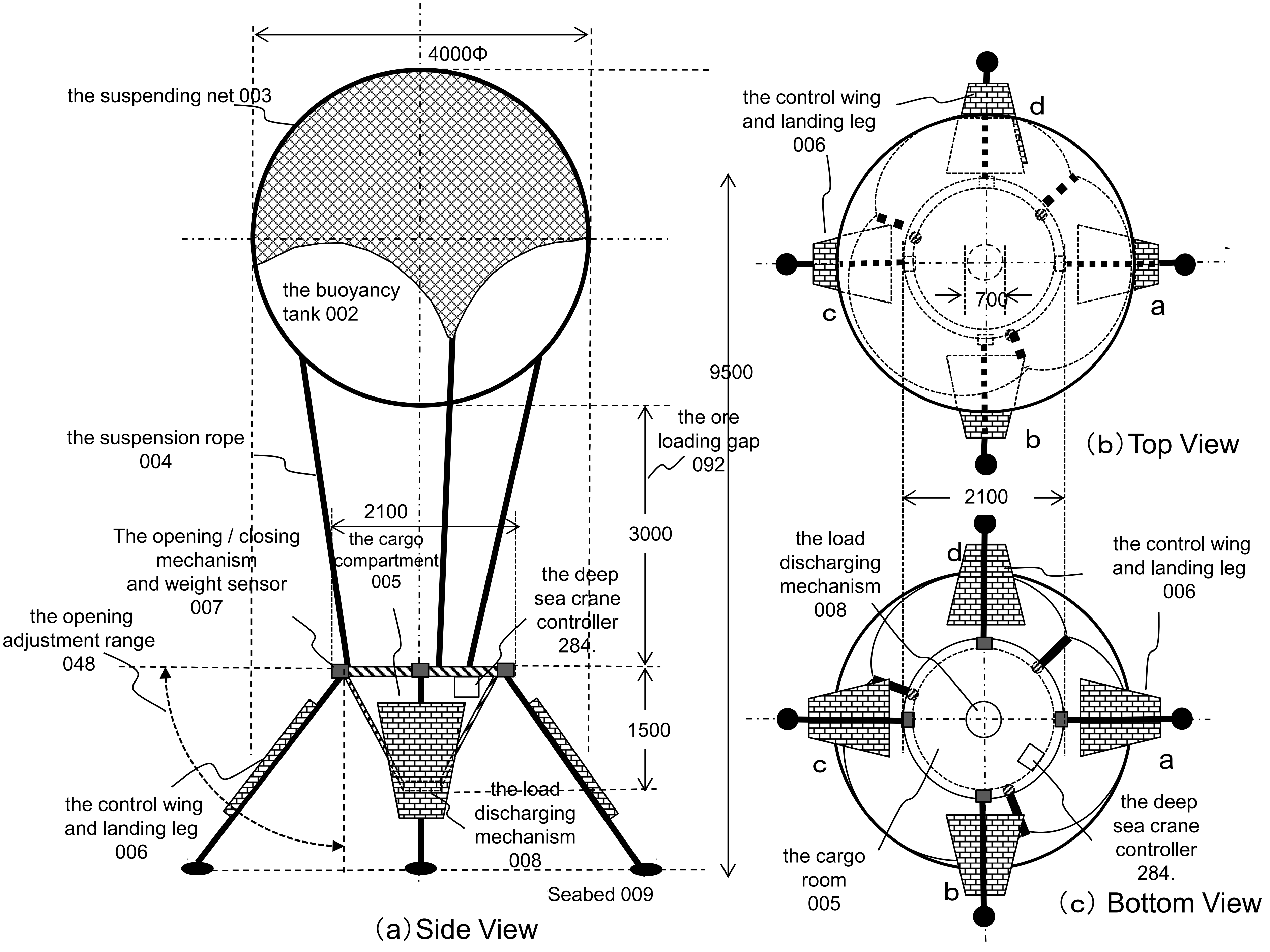
Secondly, after the deep-sea crane has landed on the seabed, the operations of the following 3 items are performed.

1. The seabed resource collecting device is characterized in that the prime mover of the hydraulic mechanism of the power shovel of the construction machine used on land is replaced with a motor, and is driven by a hydraulic differential pressure motor. The seabed resource collection device or the collected mineral container is installed on the seabed after the suspension from the cargo compartment is released.
2. The seabed resource collecting apparatus is remotely operated from the marine command ship using an image monitoring apparatus including an ultrasonic high-definition video camera, and the collected minerals are loaded in the mineral collecting container.
3. Monitoring the limit at which the underwater weight of the mineral collection container can float and detecting when the submarine resource collection device should stop loading the collected mineral into the mineral collection container.

Thirdly, when the deep-sea crane collects the seabed resource collection device or the mineral collection container loaded with the collected minerals on the sea surface, the following two operations are performed.

1. A mechanism for lifting including a ring provided in the seabed resource collecting device or a mechanism for lifting including a ring provided in a shroud of the mineral collection container, and a mechanism for lifting including a hook at the lower part of the cargo compartment Induce and integrate.
2. After the preceding paragraph, the ballast in the cargo compartment is discarded, the specific gravity of the deep-sea crane is made smaller than the surrounding seawater, and the cargo is levitated near the maritime command ship.

Fig. 1 Overview of the Deep-sea Crane



（a）Side View

（b）Top View

（c）Bottom View

Fig. 2

an overall view of the seabed resource collection system

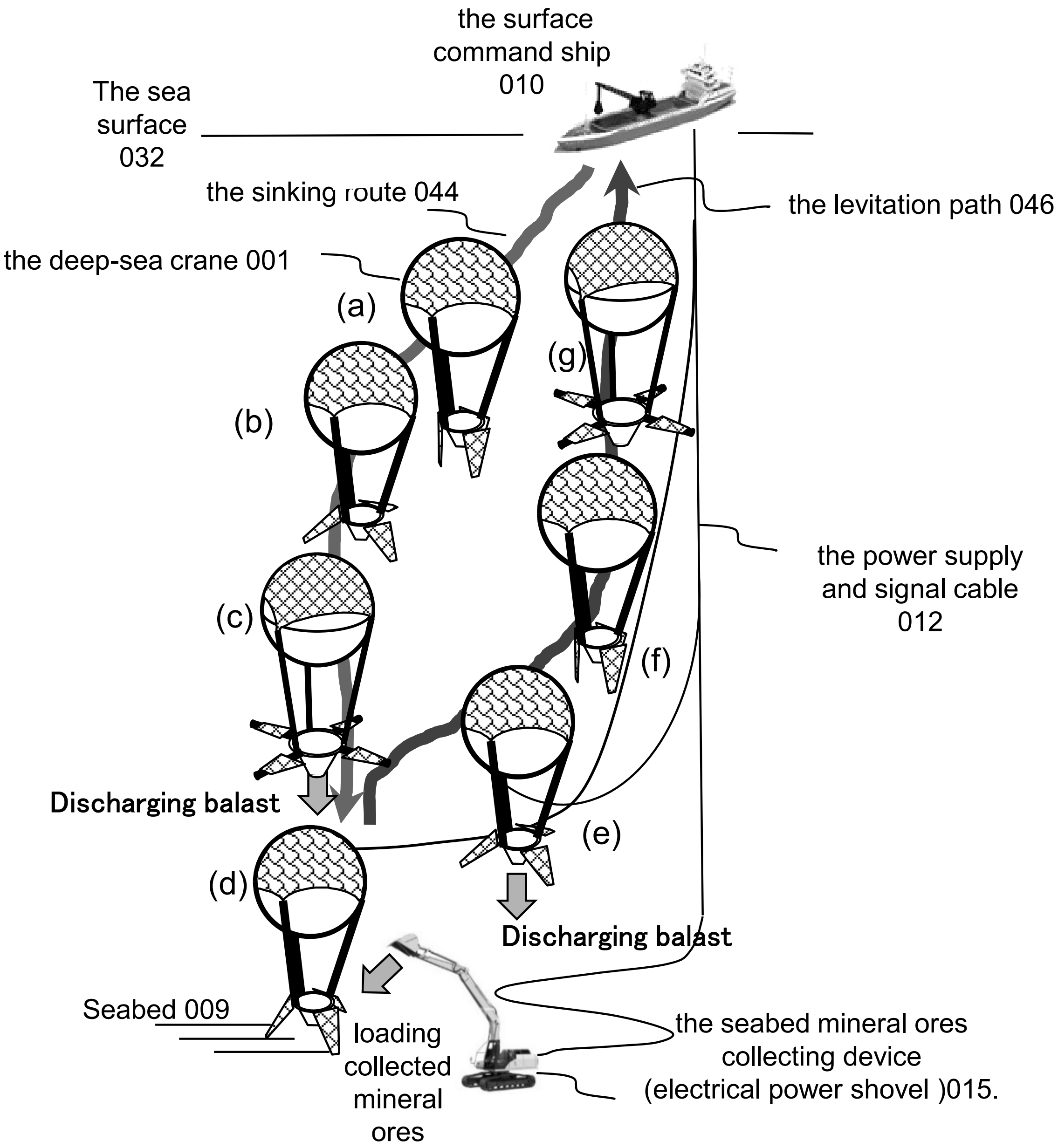
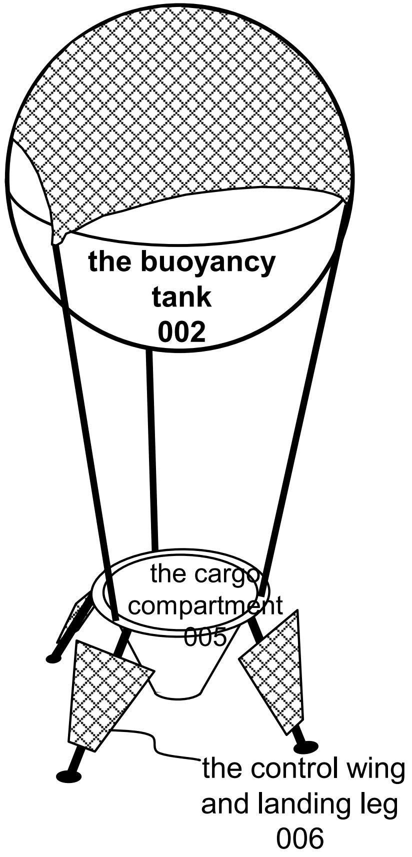


Fig. 3

Table showing buoyancy tank volume and buoyancy specifications



（a）Deep -sea Crane

（b）Buoyancy Tank Specifications

radius m	diameter m	volume m3	buoyancy（Ton） gasoline	n-pentane	cost Gasoline M¥
1.20	2.40	7.24	2.17	2.73	0.72
1.30	2.60	9.20	2.76	3.47	0.92
1.40	2.80	11.49	3.45	4.33	1.15
1.50	3.00	14.14	4.24	5.33	1.41
1.60	3.20	17.16	5.15	6.47	1.72
1.70	3.40	20.58	6.17	7.76	2.06
1.80	3.60	24.43	7.33	9.21	2.44
1.90	3.80	28.73	8.62	10.83	2.87
2.00	4.00	33.51	10.05	12.63	3.35
2.10	4.20	38.79	11.64	14.62	3.88
2.20	4.40	44.60	13.38	16.82	4.46
2.30	4.60	50.97	15.29	19.21	5.10
2.40	4.80	57.91	17.37	21.83	5.79
2.50	5.00	65.45	19.63	24.67	6.54
2.60	5.20	73.62	22.09	27.76	7.36
2.70	5.40	82.45	24.73	31.08	8.24
2.80	5.60	91.95	27.59	34.67	9.20
2.90	5.80	102.16	30.65	38.51	10.22
3.00	6.00	113.10	33.93	42.64	11.31
3.10	6.20	124.79	37.44	47.05	12.48
3.20	6.40	137.26	41.18	51.75	13.73
3.30	6.60	150.53	45.16	56.75	15.05
3.40	6.80	164.64	49.39	62.07	16.46
3.50	7.00	179.59	53.88	67.71	17.96
3.60	7.20	195.43	58.63	73.68	19.54
3.70	7.40	212.17	63.65	79.99	21.22
3.80	7.60	229.85	68.95	86.65	22.98
3.90	7.80	248.47	74.54	93.68	24.85
4.00	8.00	268.08	80.42	101.07	26.81
4.10	8.20	288.70	86.61	108.84	28.87
4.20	8.40	310.34	93.10	117.00	31.03
4.30	8.60	333.04	99.91	125.56	33.30
4.40	8.80	356.82	107.05	134.52	35.68
4.50	9.00	381.70	114.51	143.90	38.17

gasoline price　¥100/litter

Fig. 4

A diagram showing ore loading

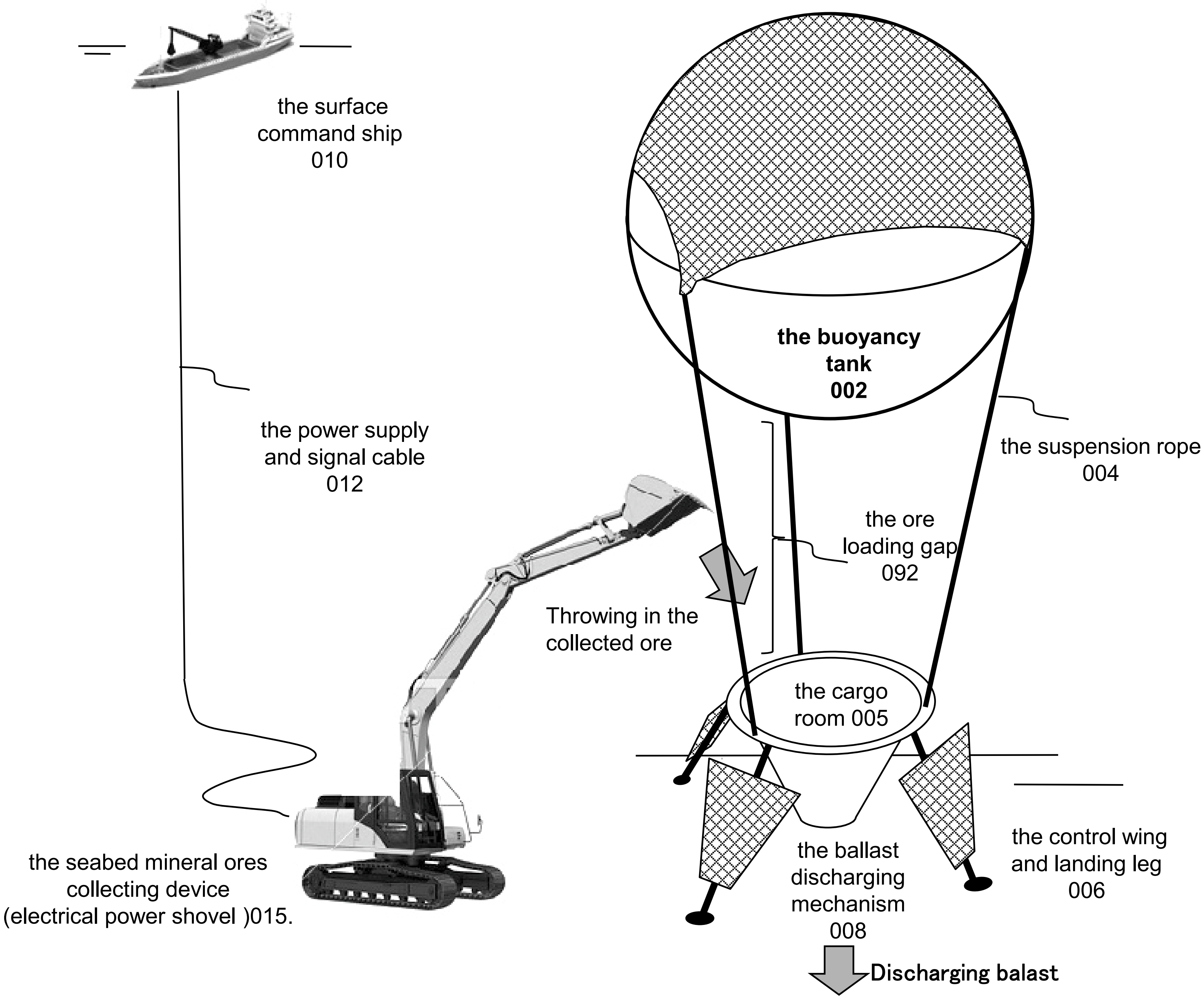
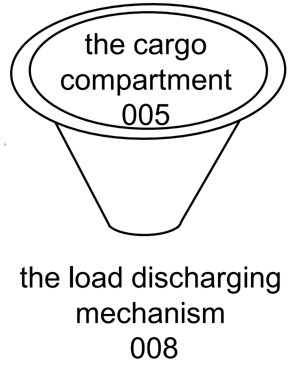
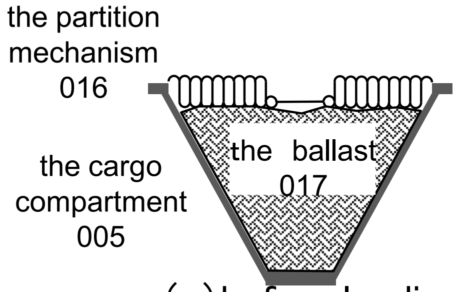


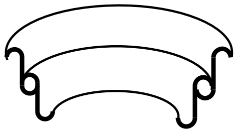
Fig. 5

a diagram showing ore loading in the deep sea crane cargo compartment

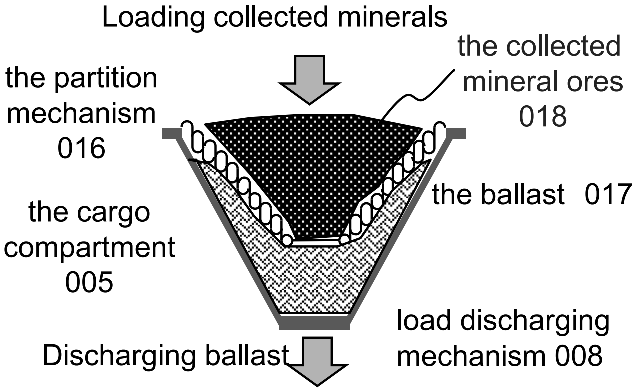




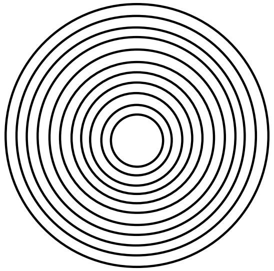
(a) before loading collected minerals



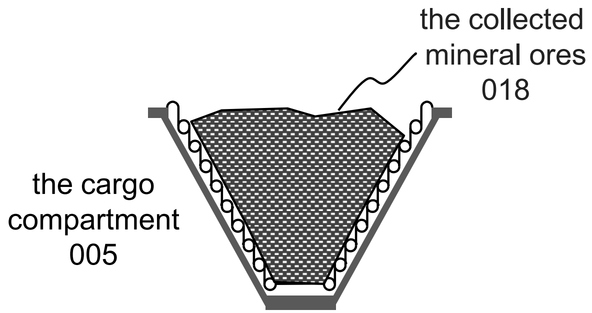
(d) Partition mechanism Cross section



(b) loading collected minerals



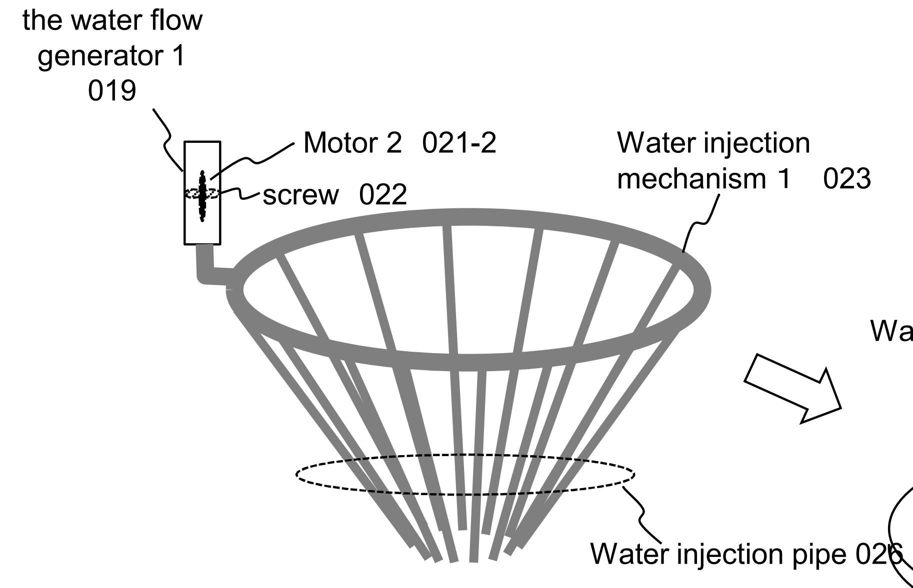
(e) Partition mechanism Top View



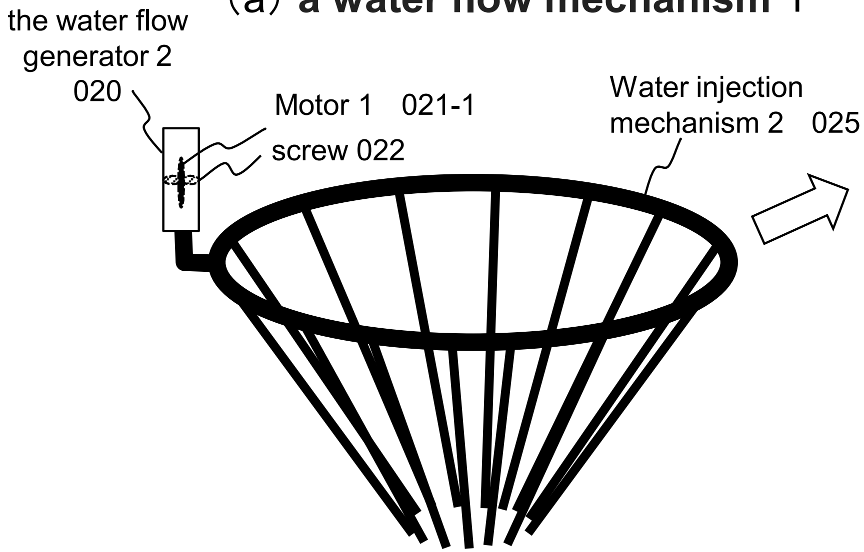
(c) mineral loading completed

Fig. 6

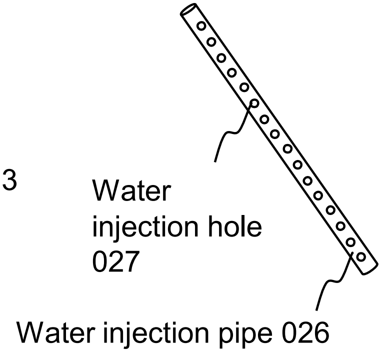
an example of a water flow mechanism of a cargo compartment



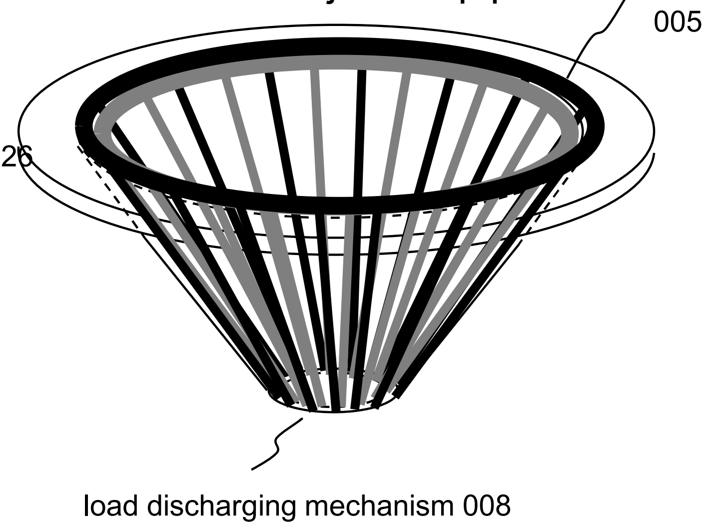
（a）a water flow mechanism 1



（b）a water flow mechanism 2



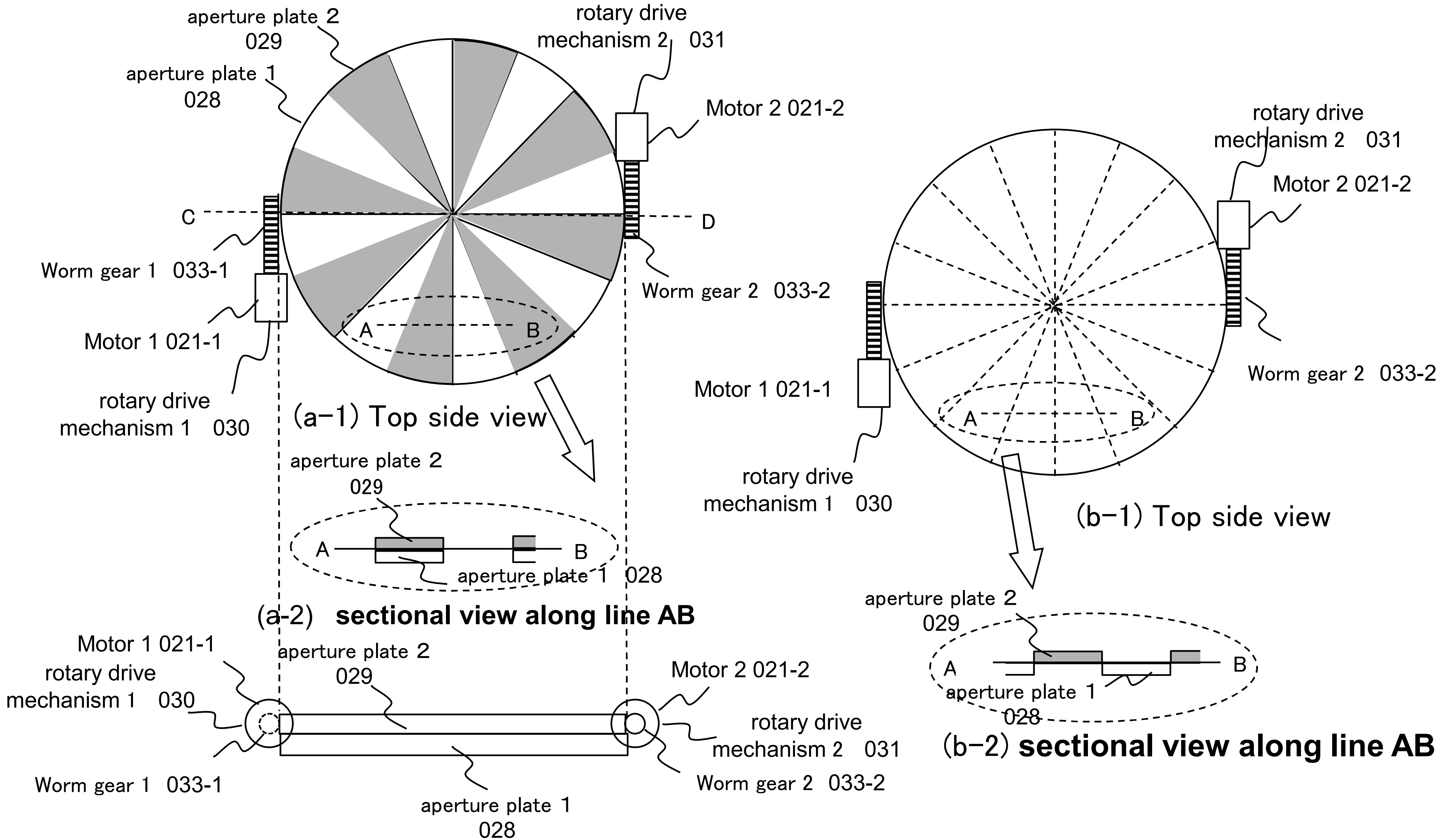
（d）a water injection pipe



（c）a cargo unit and water flow mechanism

Fig. 7

an example of a discharge restricting mechanism for a cargo compartment



(a-1) Top side view

(a-2) sectional view along line AB

(a-3) sectional view along line CD

(b-1) Top side view

(b-2) sectional view along line AB

(a) Aperture Mechanism (open)

(b) Aperture Mechanism (closure)

Fig. 8

a diagram showing a cargo compartment control processing unit

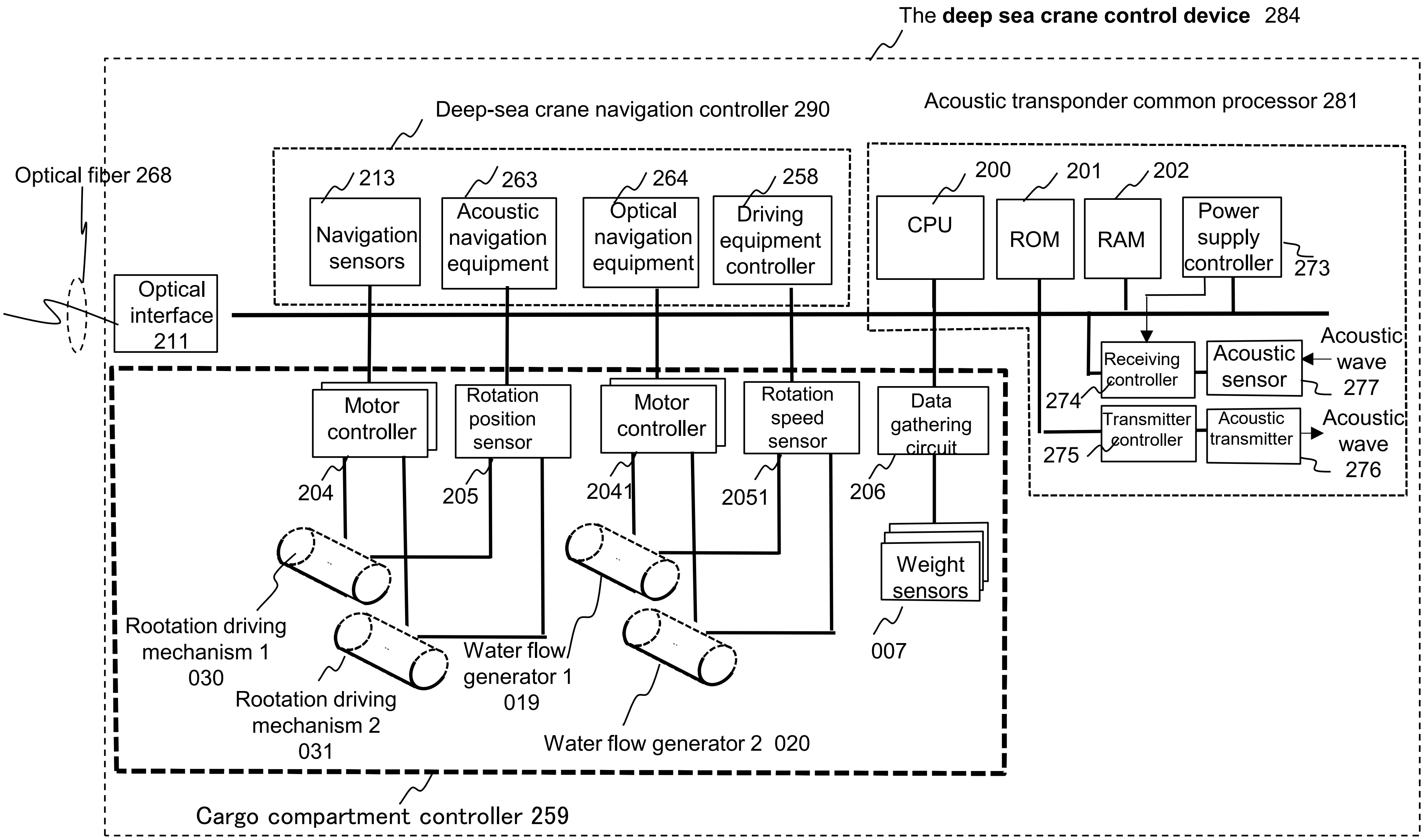


Fig. 9

a diagram showing a time transition of the cargo compartment loading structure

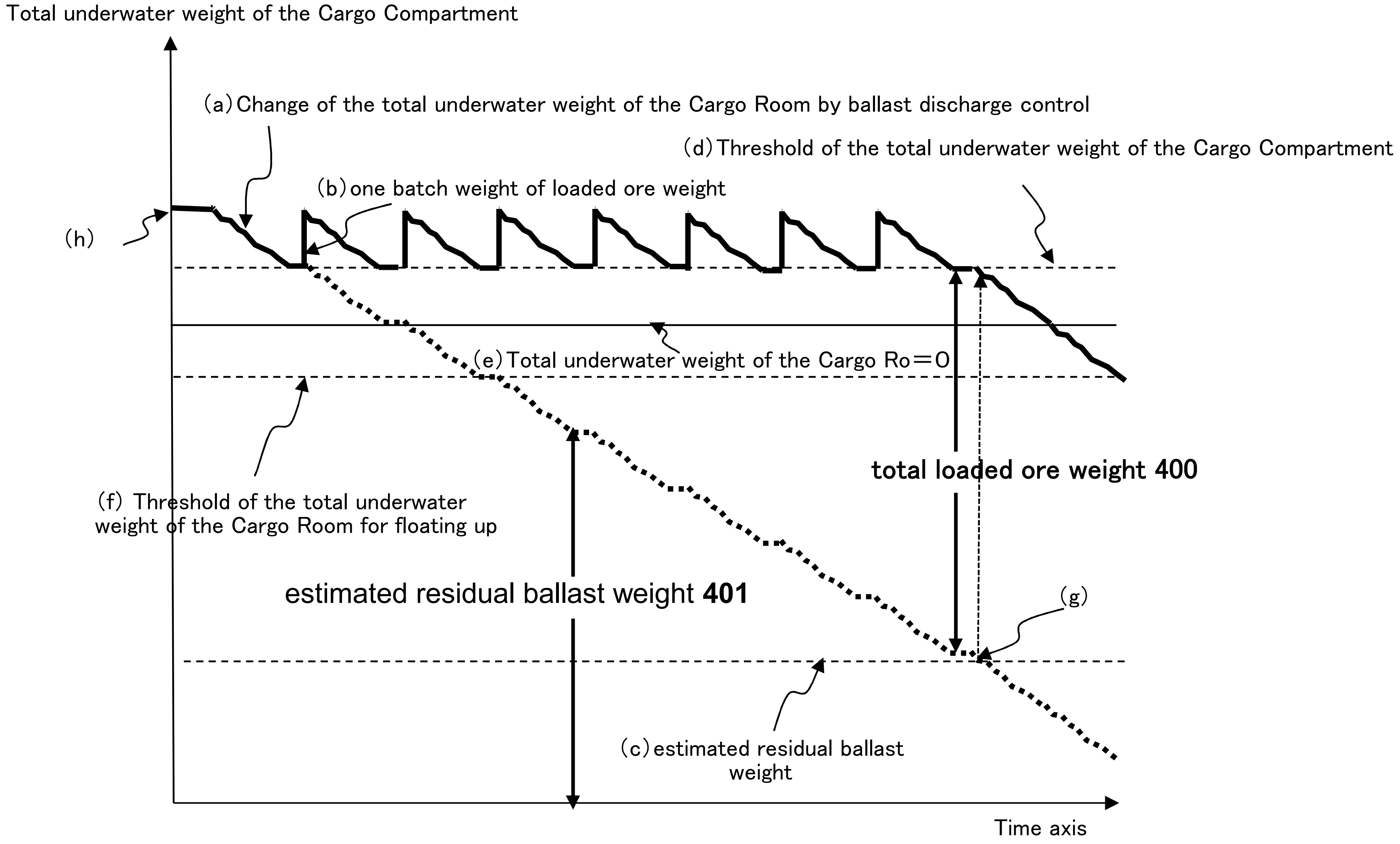


Fig. 10

a diagram showing a processing flow of a cargo compartment control processing unit

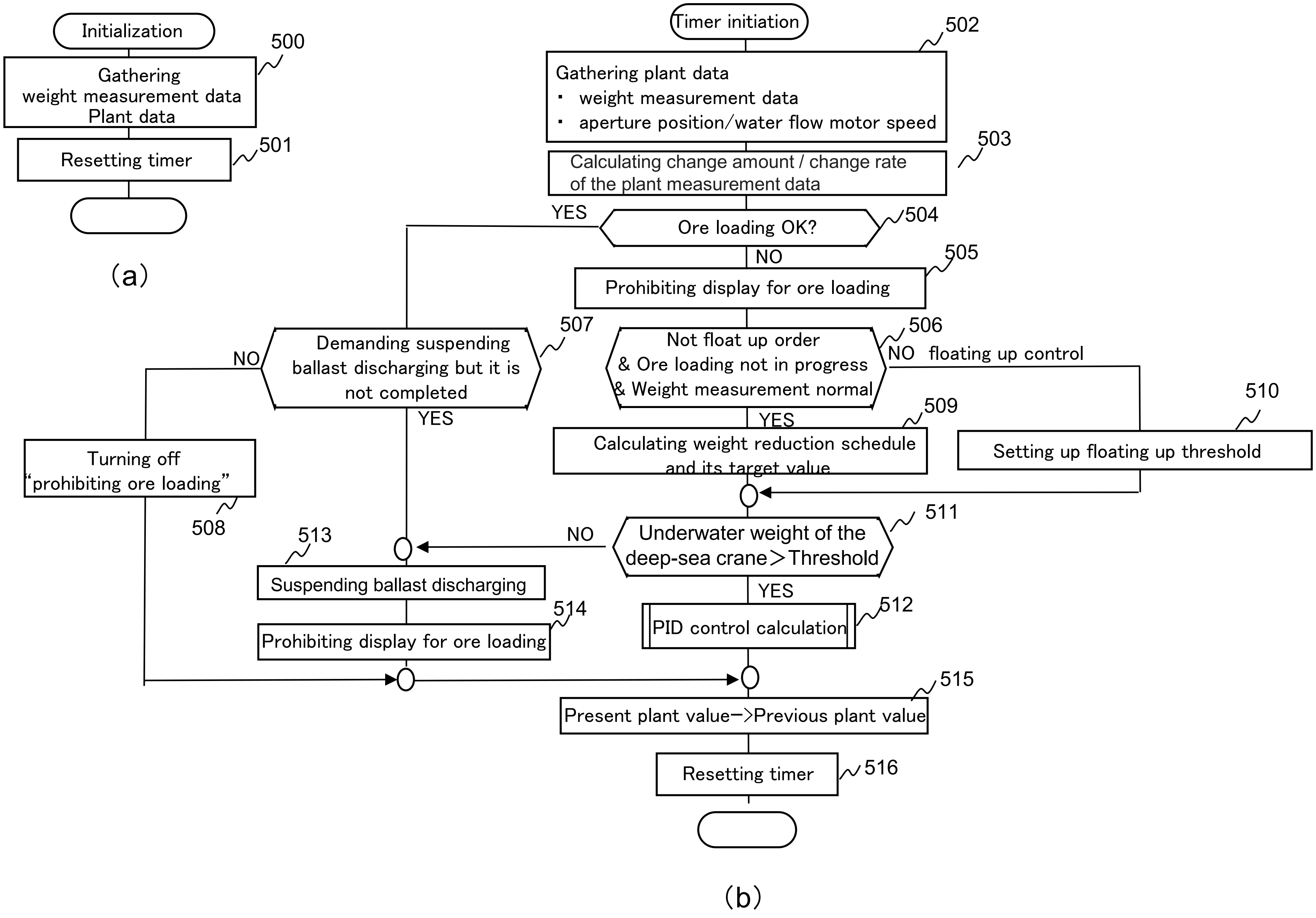
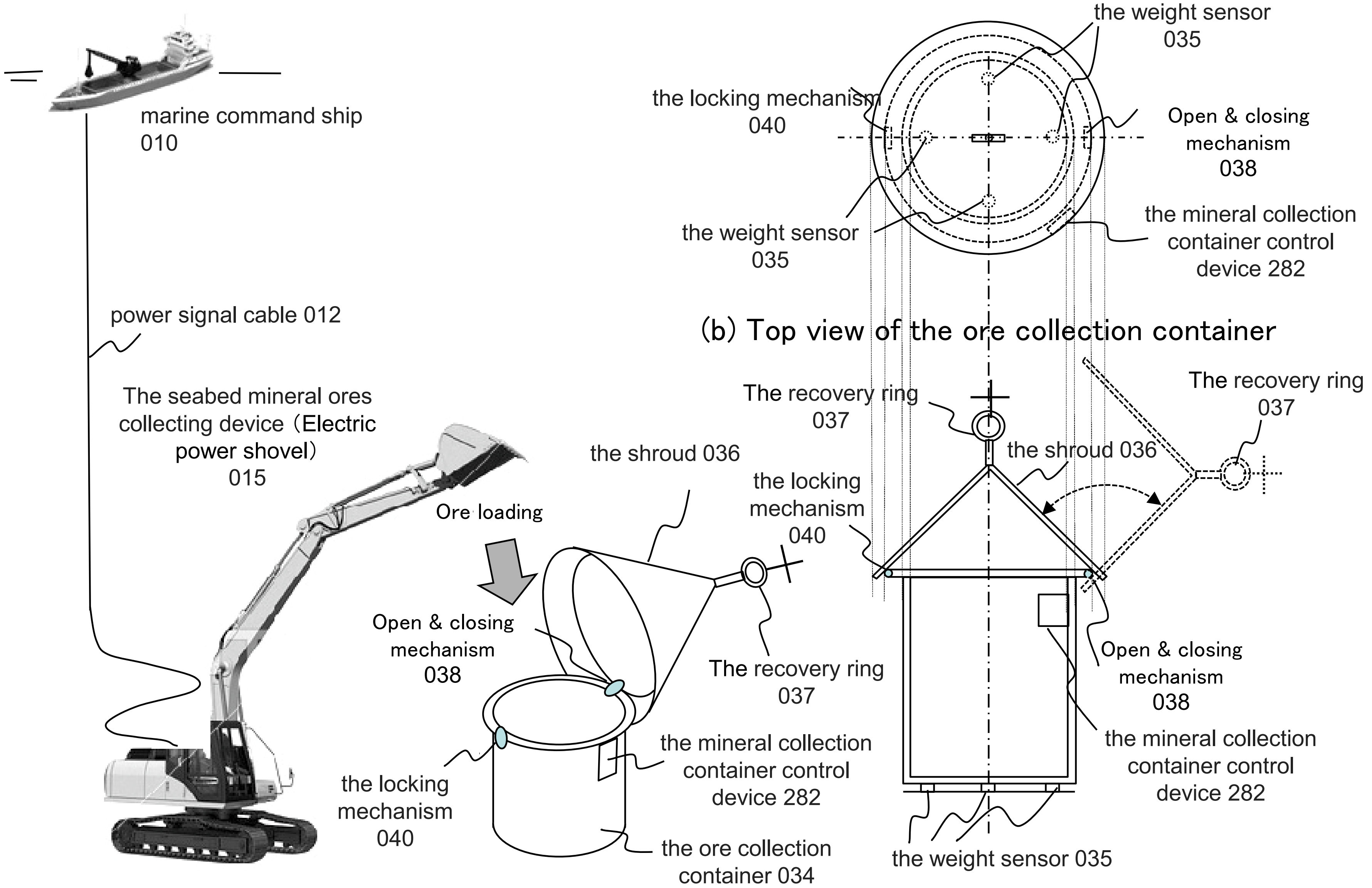


Fig. 11

a diagram showing ore loading (ore collection container) of the deep-sea crane



(a) Ore loading to the ore collection container

(b) Top view of the ore collection container

(c) Side view of the ore collection container

Fig. 12

a diagram showing a configuration of a ore collection container control device

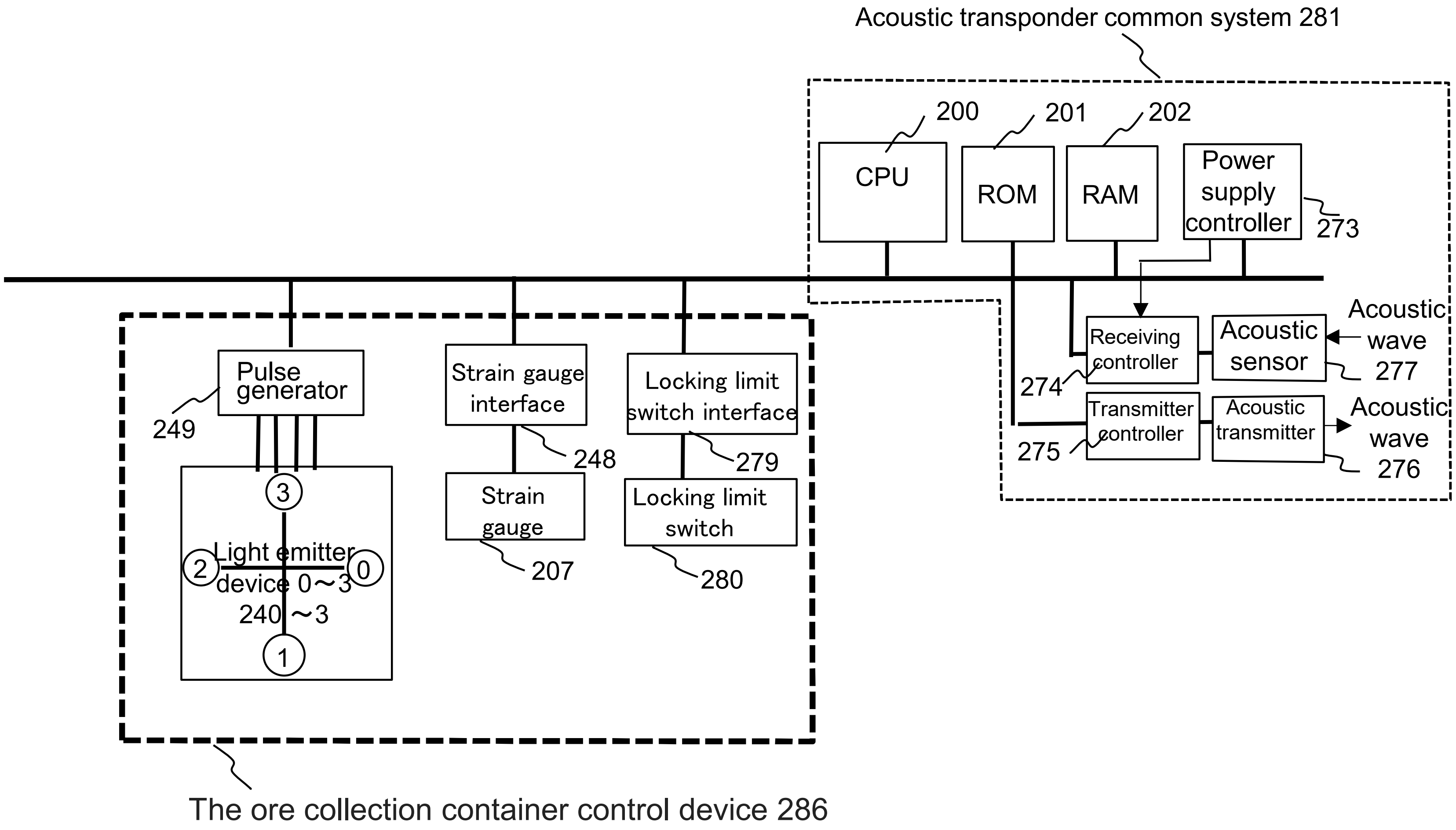
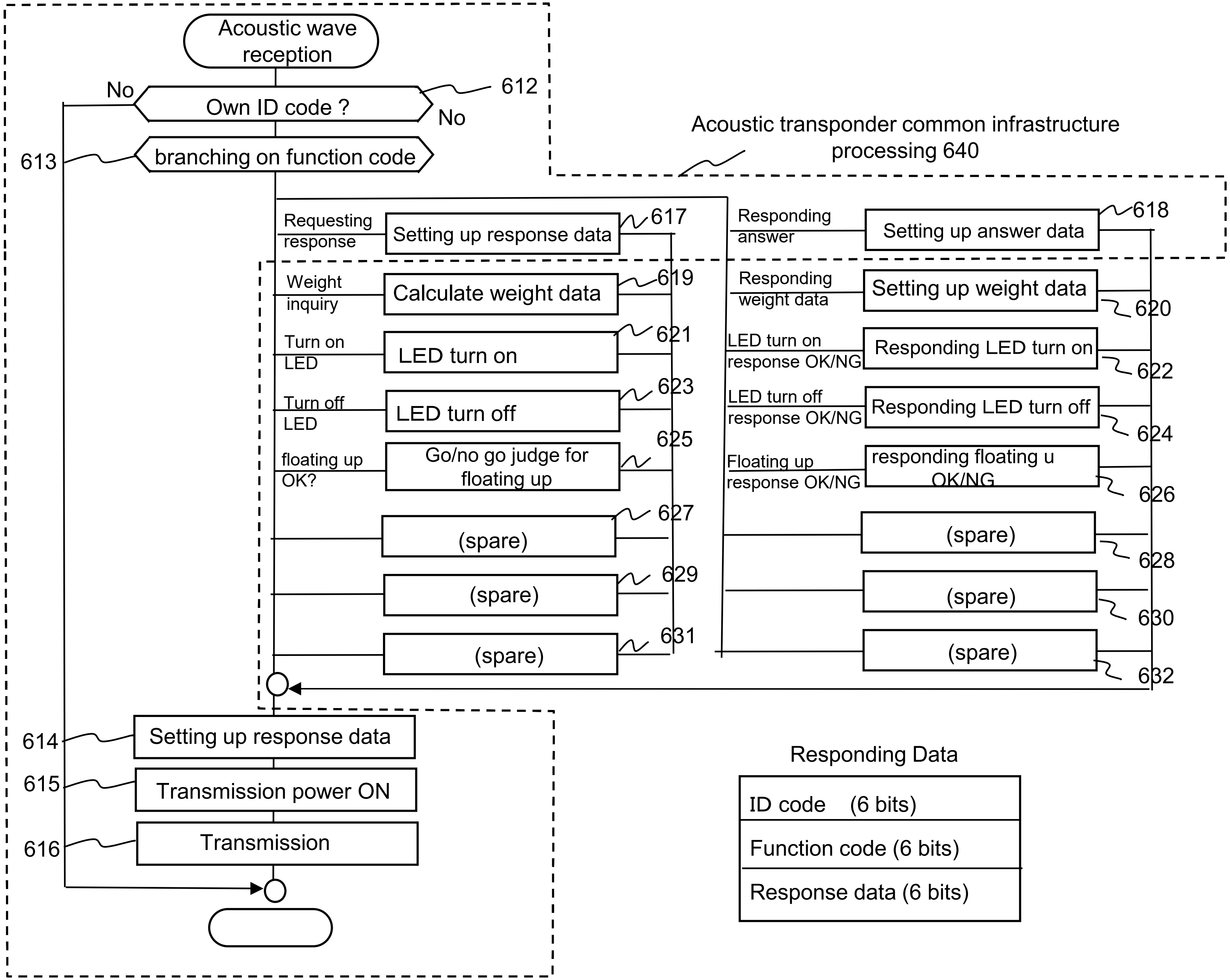


Fig. 13

a diagram showing a processing flow of the mineral collection container control device



Responding Data

ID code (6 bits)
Function code (6 bits)
Response data (6 bits)

Fig. 14

a diagram showing a block diagram of a supervisory control system

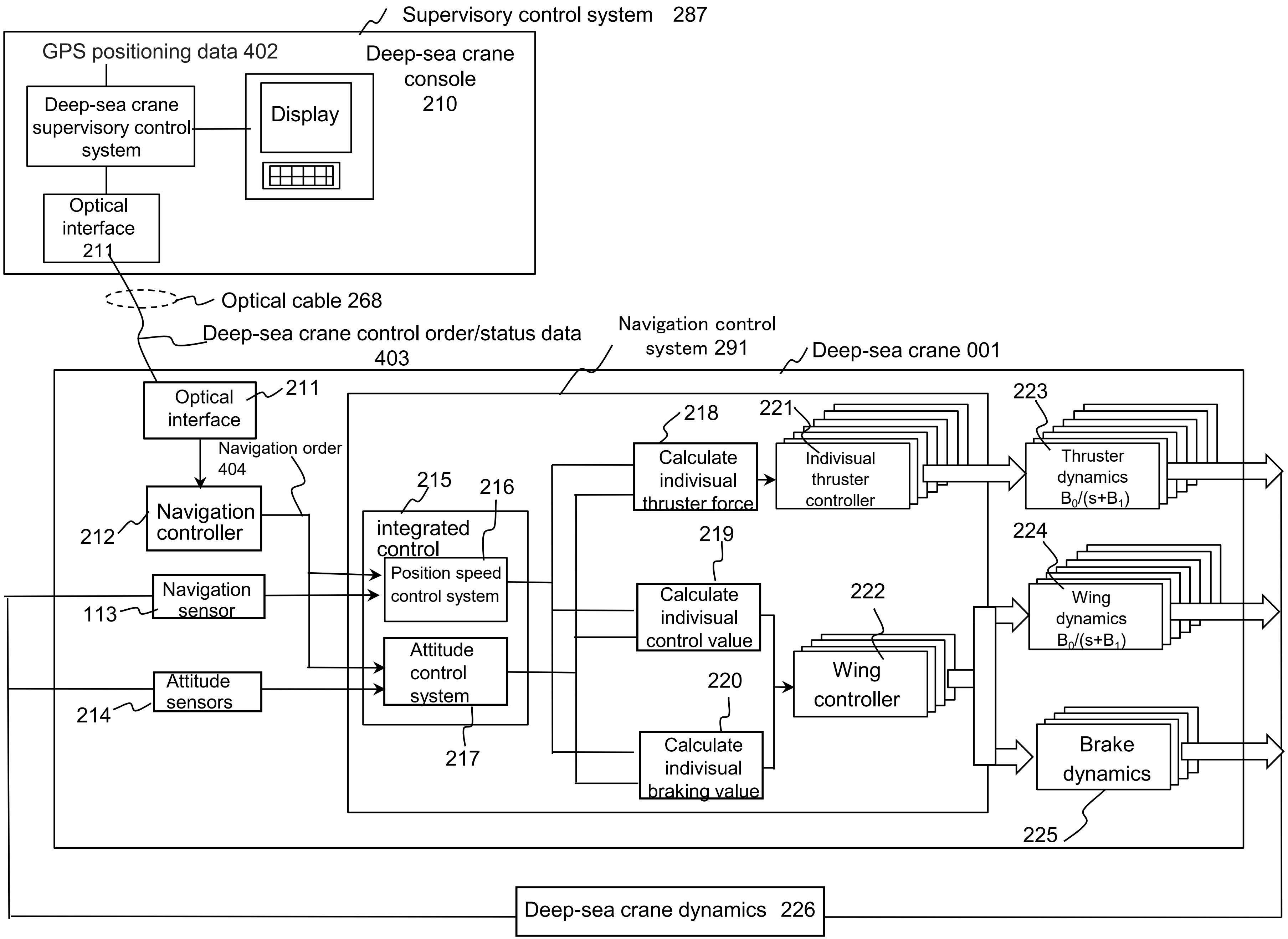


Fig. 15

a diagram showing a processing flow of the navigation control system of the deep-sea crane

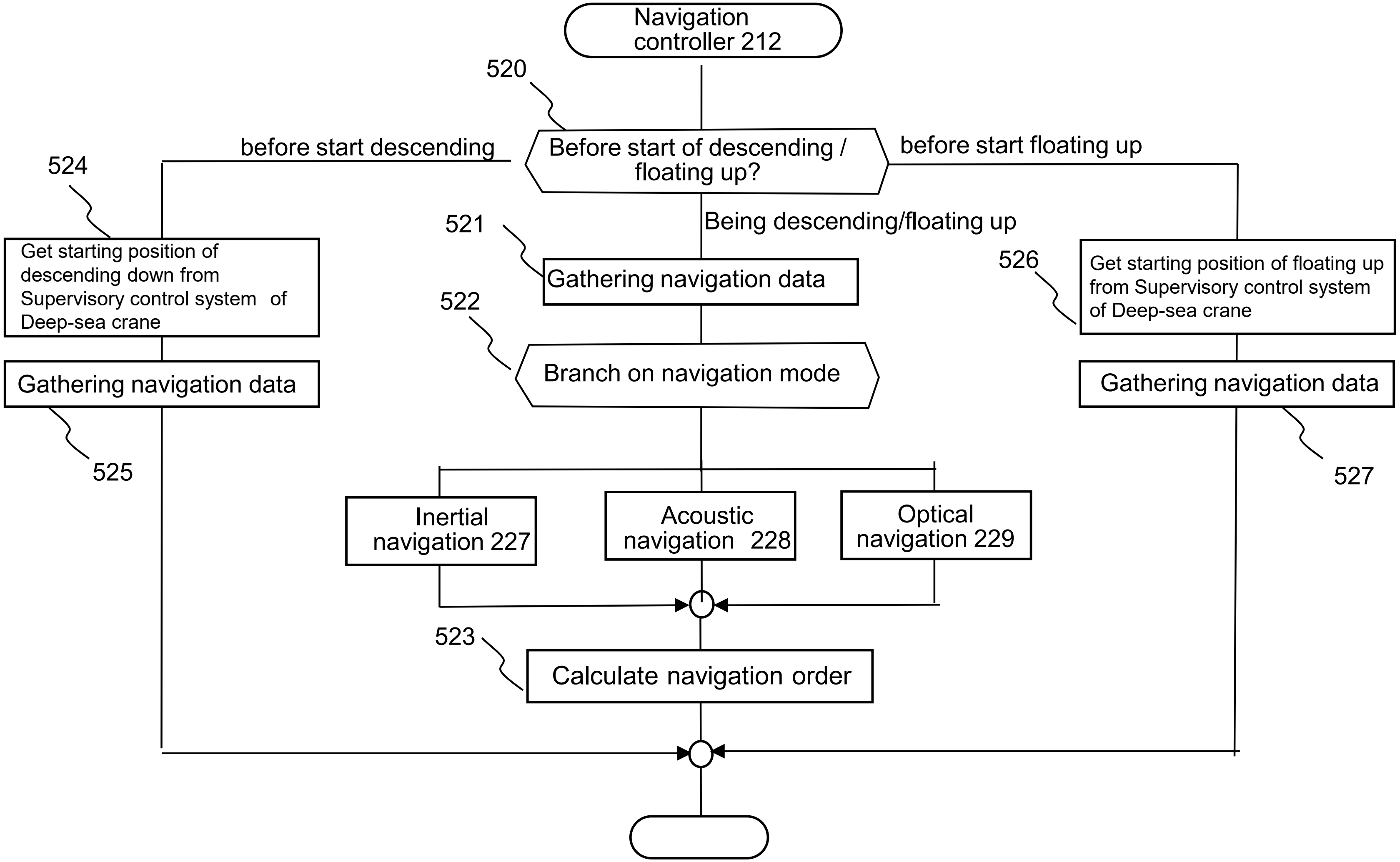
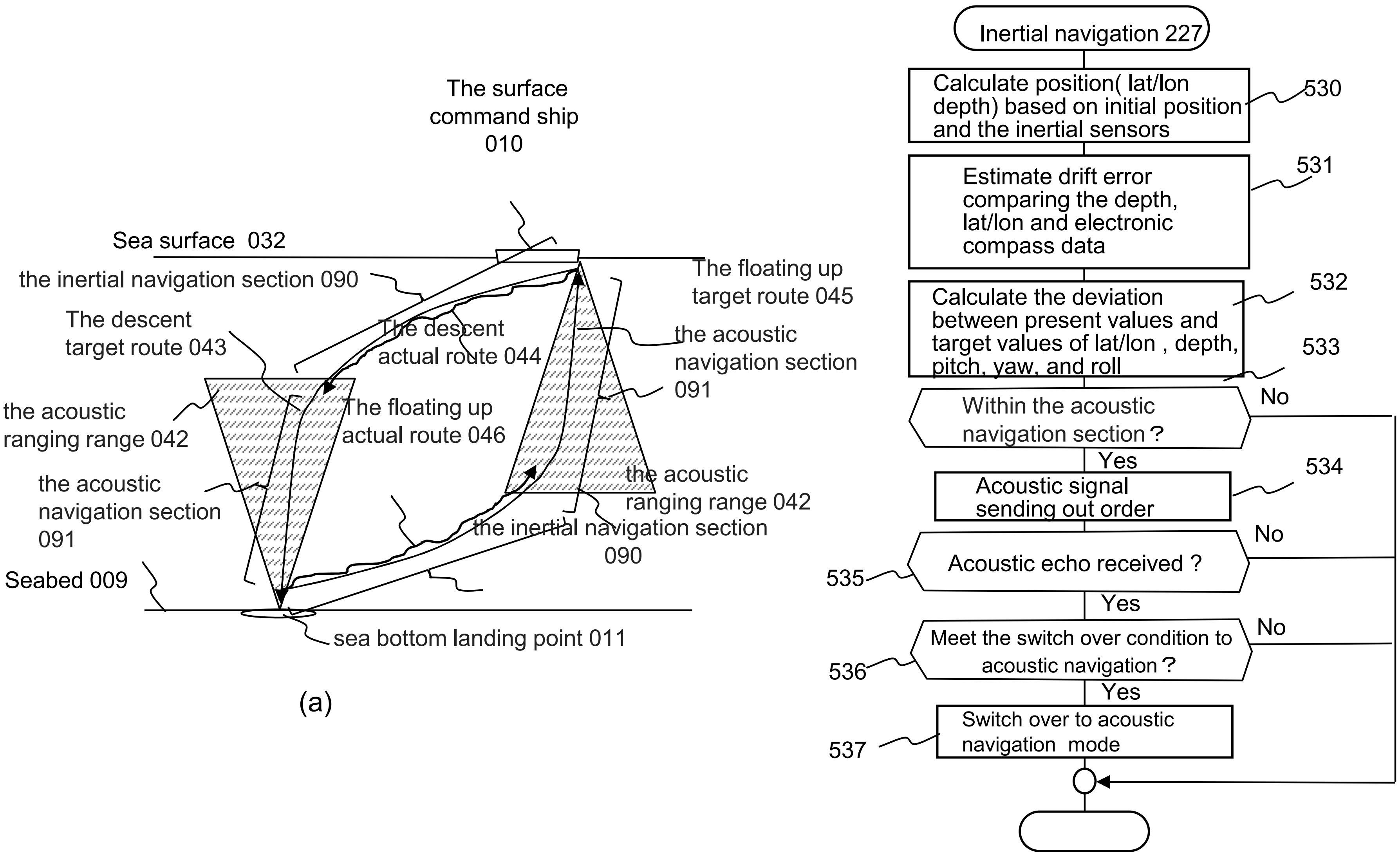


Fig. 16

a diagram showing the operation of the inertial navigation system of the deep-sea crane



(a)

(b)Operation flow of the inertial navigation system

Fig. 17

an example of mounting sensors

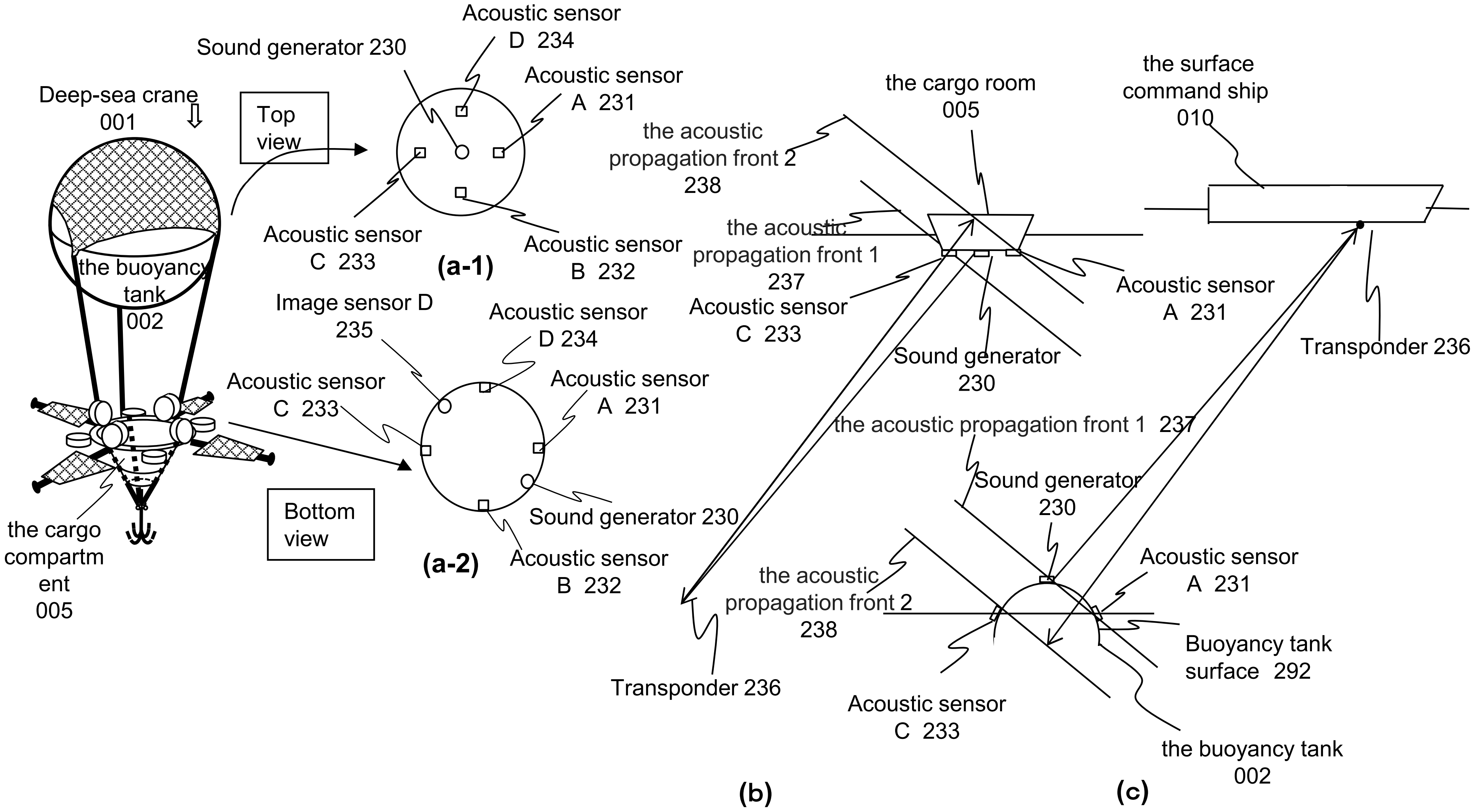
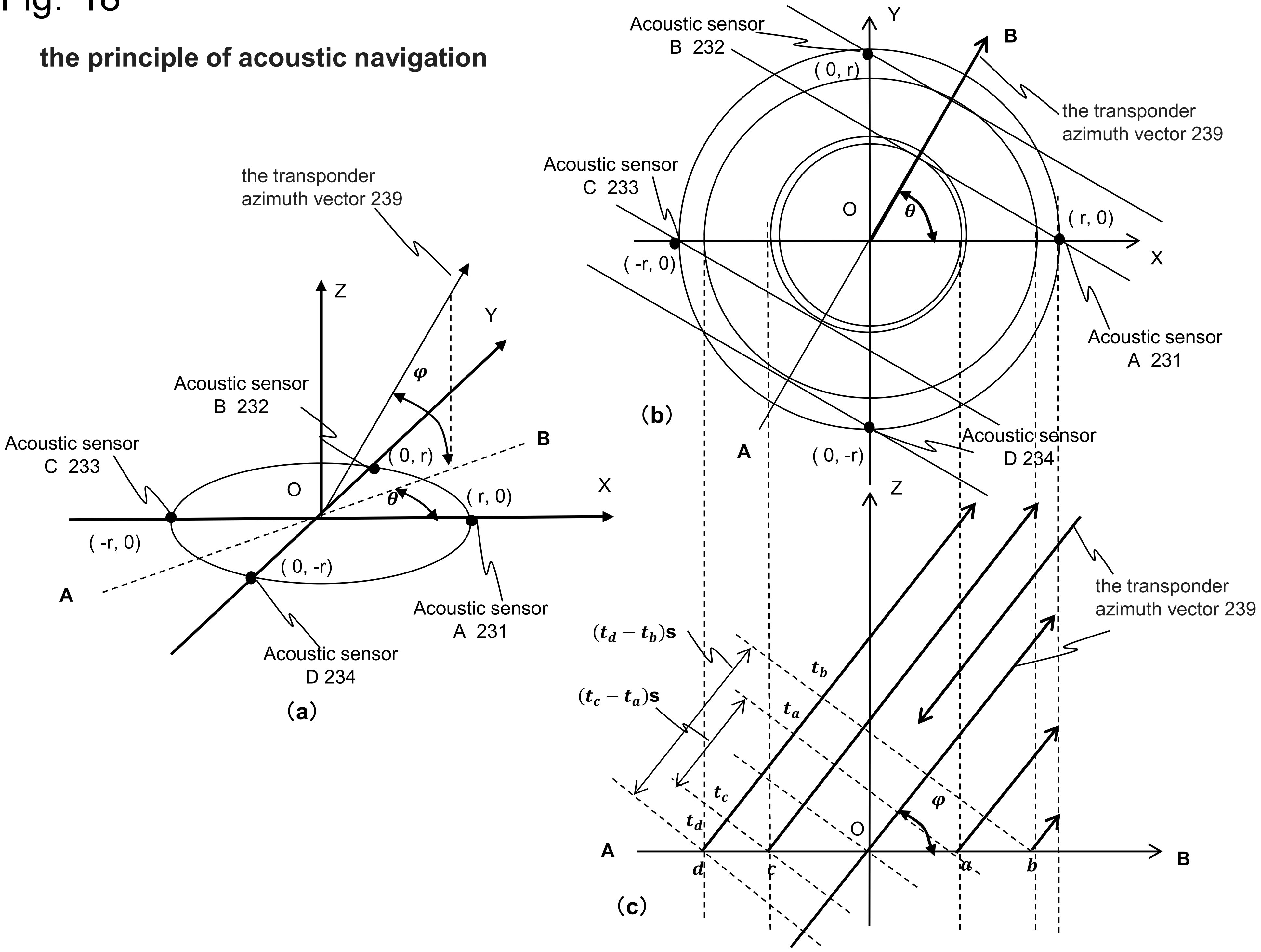


Fig. 18

the principle of acoustic navigation



(a)

(b)

(c)

Fig. 19

a processing flow showing the operation of the acoustic navigation system

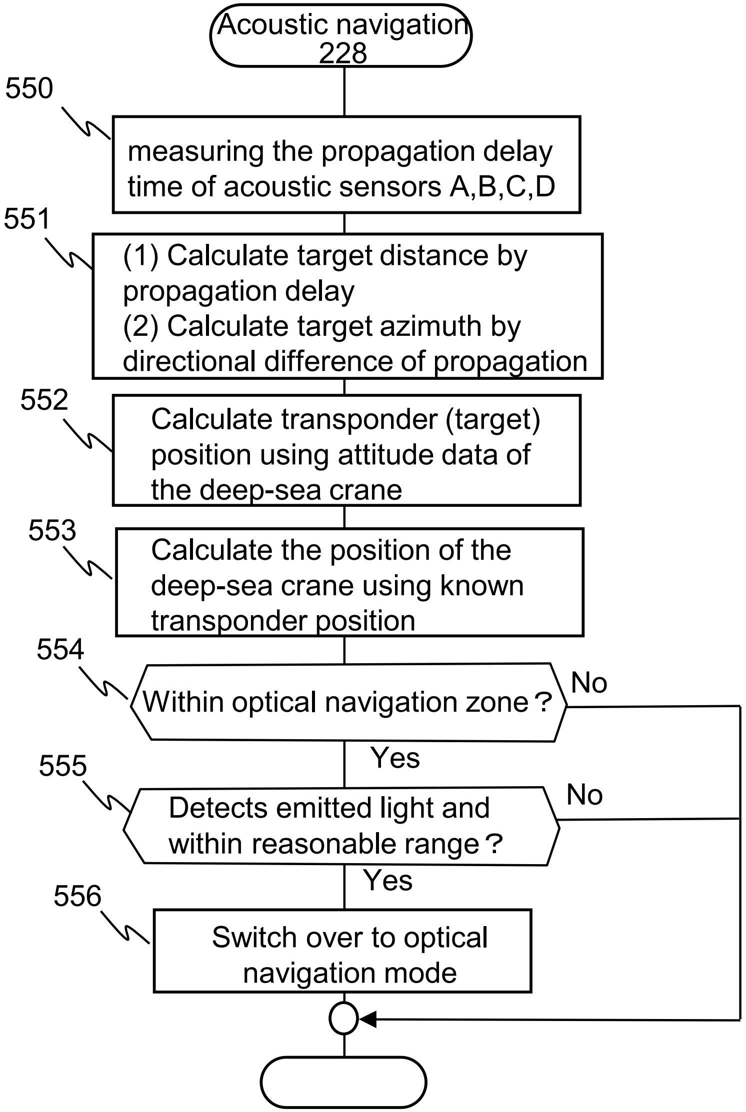
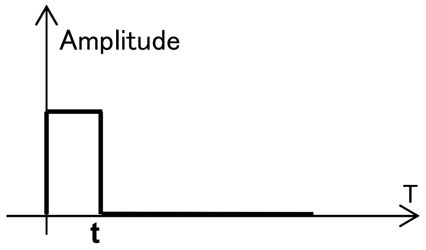
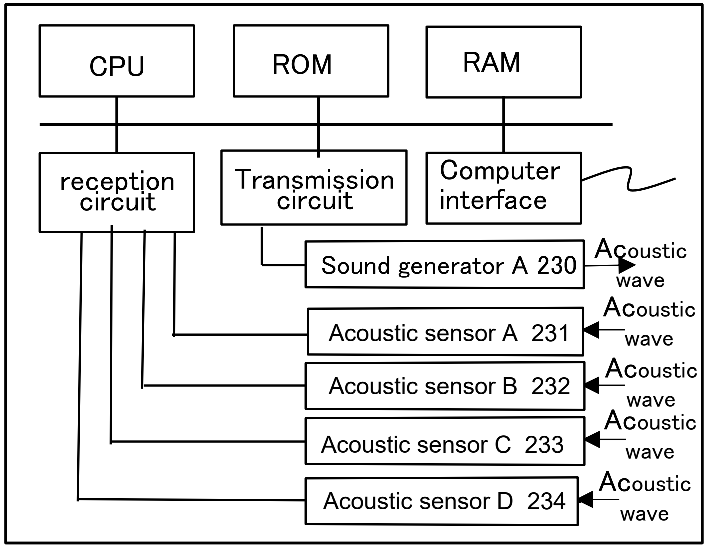


Fig. 20

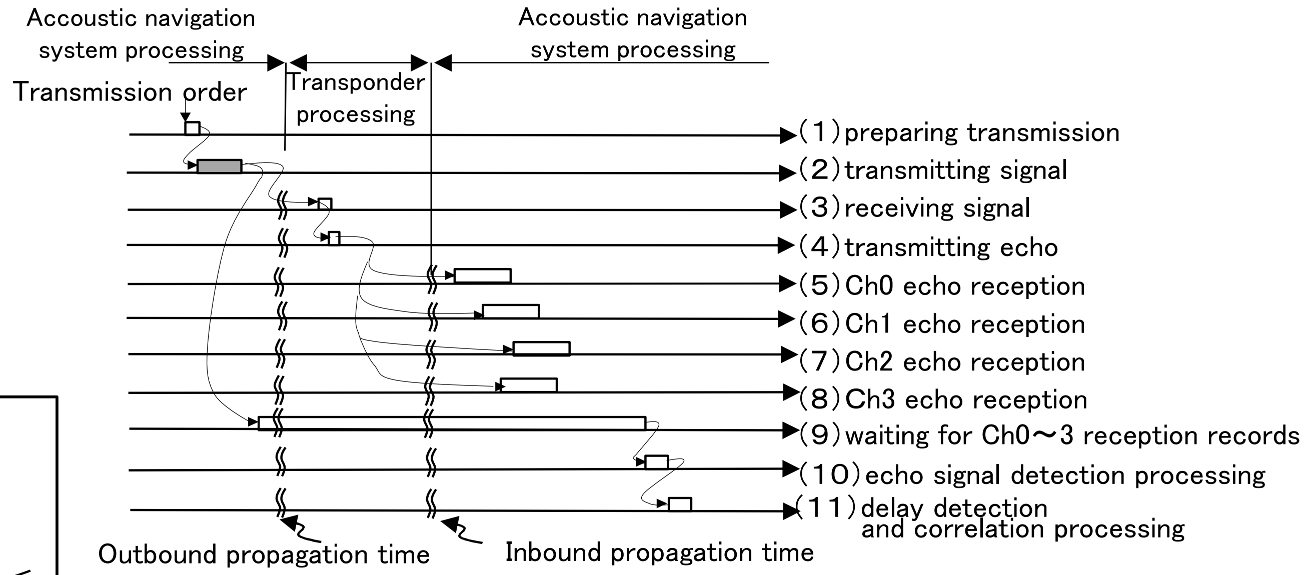
a diagram showing the principle and operation of acoustic distance measurement



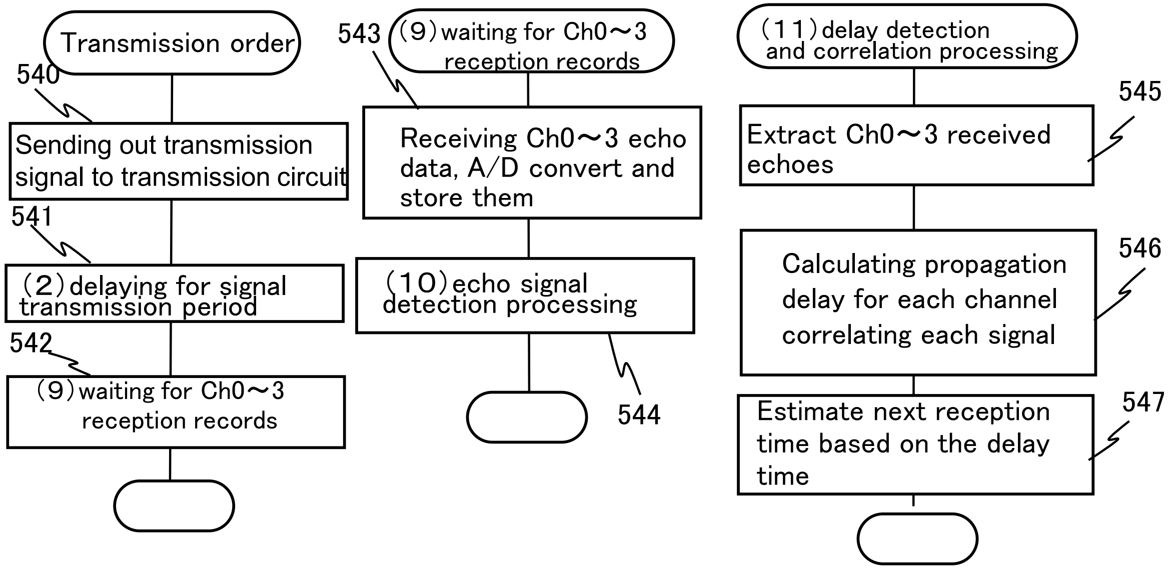
(a) Transmission signal pattern



(b) Acoustic navigation system 141



(c) Processing sequence



(e1) Processing flow 1 (e2) Processing flow 2 (e3) Processing flow 3

Fig. 21

a diagram showing the principle (1) of the optical distance measurement

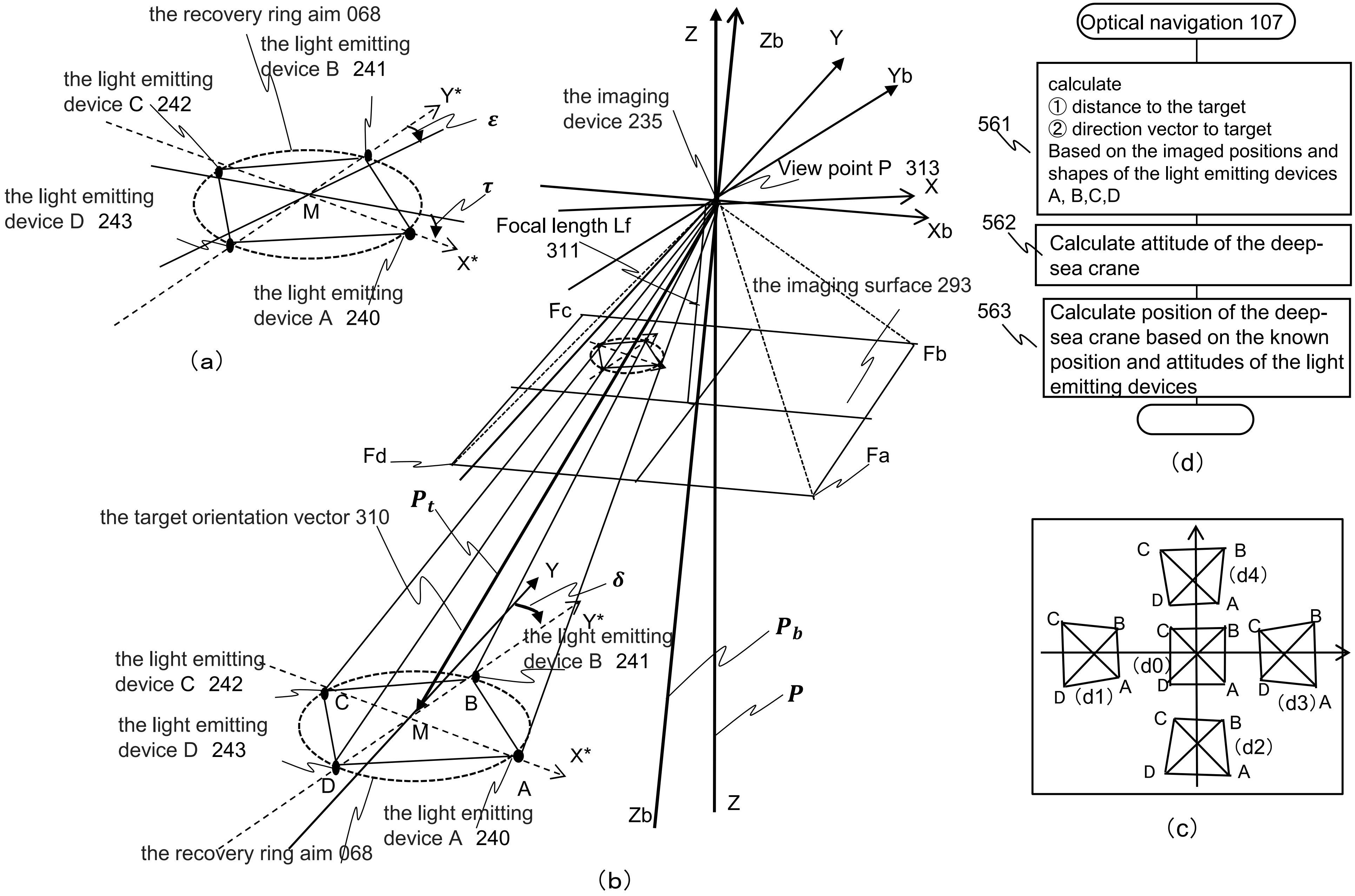


Fig. 22

a diagram showing a principle (2) of optical distance measurement

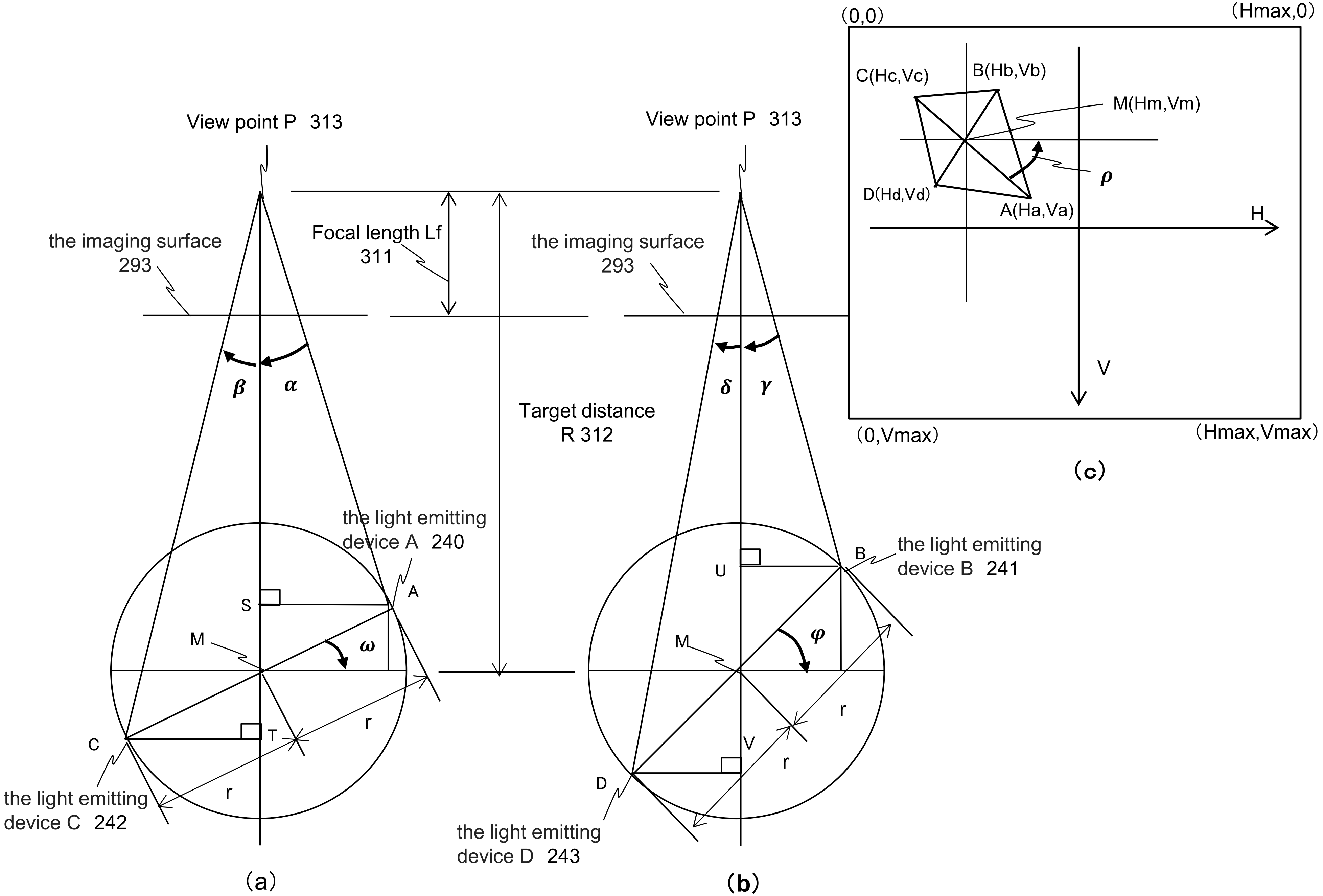
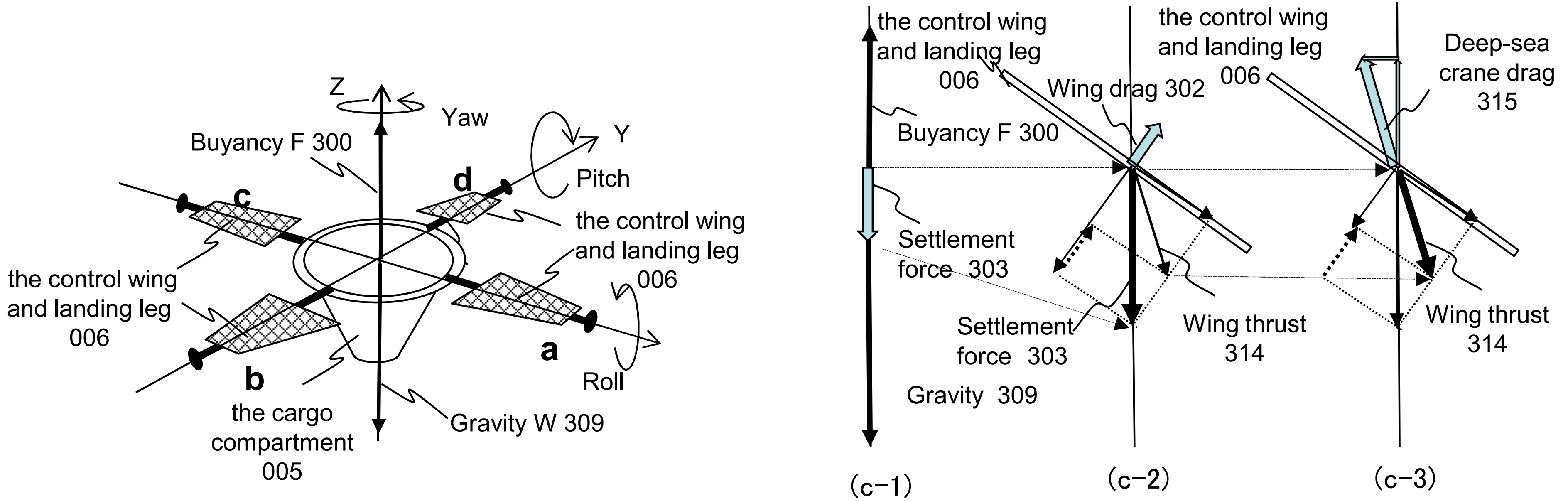


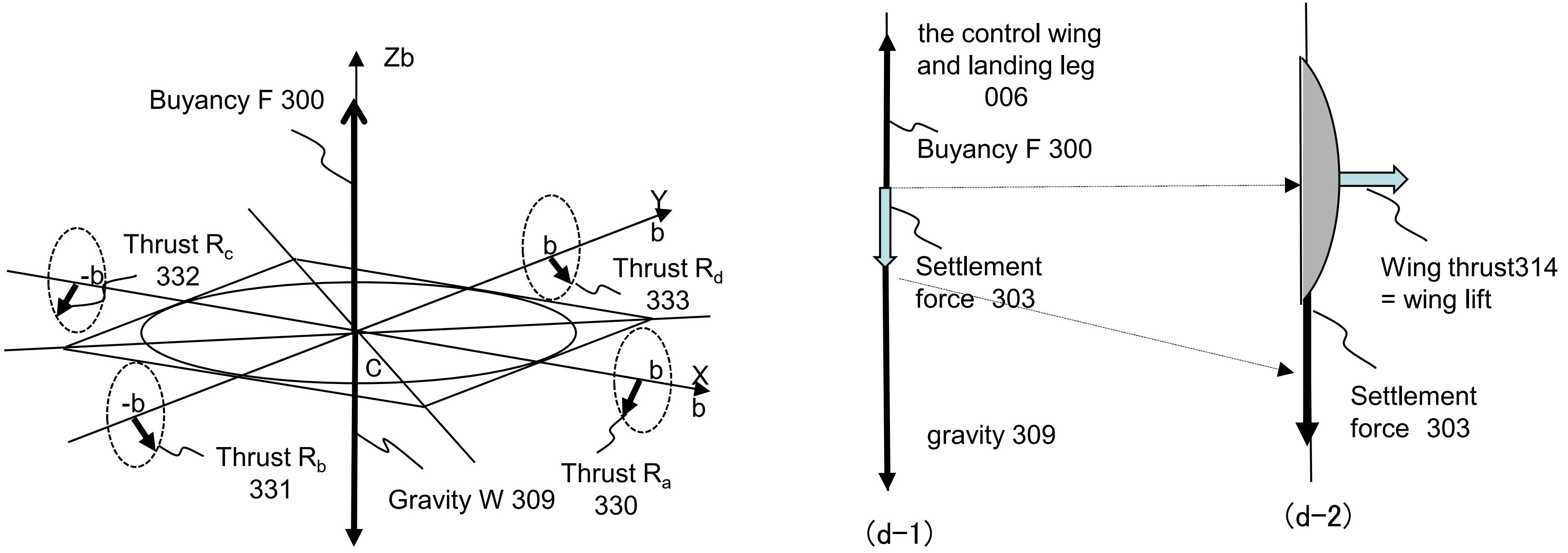
Fig. 23

a diagram showing an operation of the control system of the deep sea crane



(a) Overwiew of position/speed control system

(c) Generation of thrust by the wing

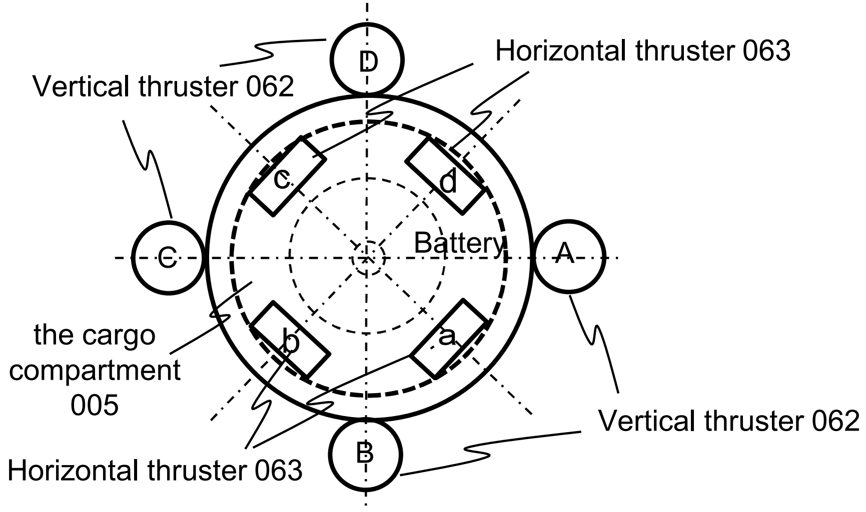


(b) Force vectors

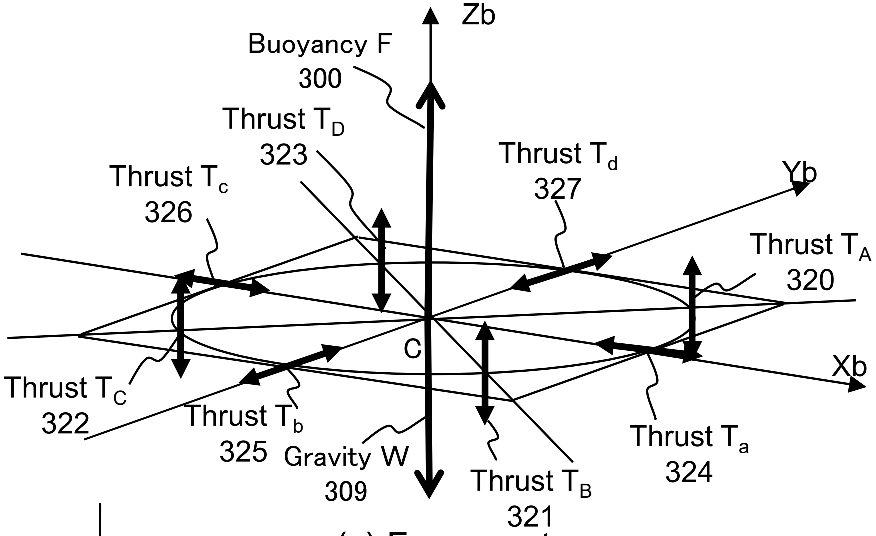
(d) Lift generation by wing

Fig. 24

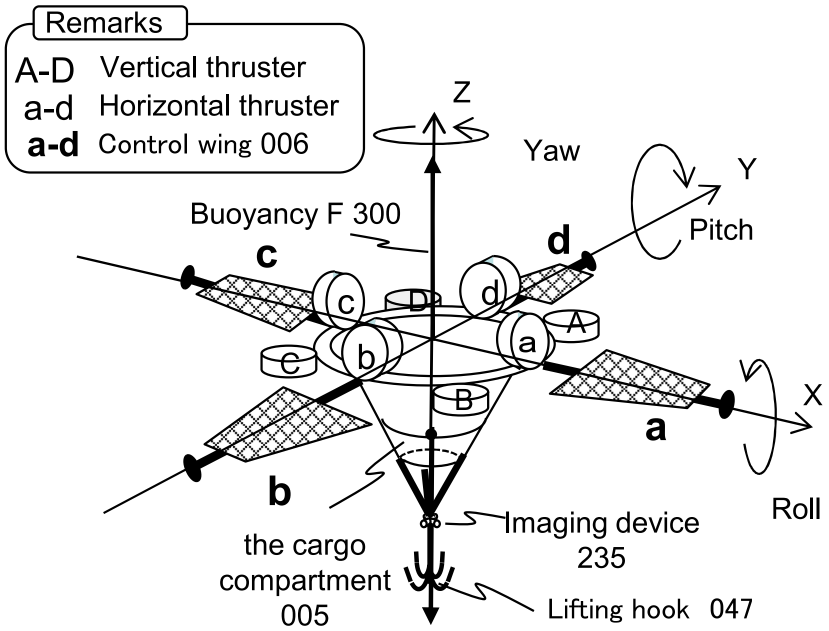
a view showing precision control attachments



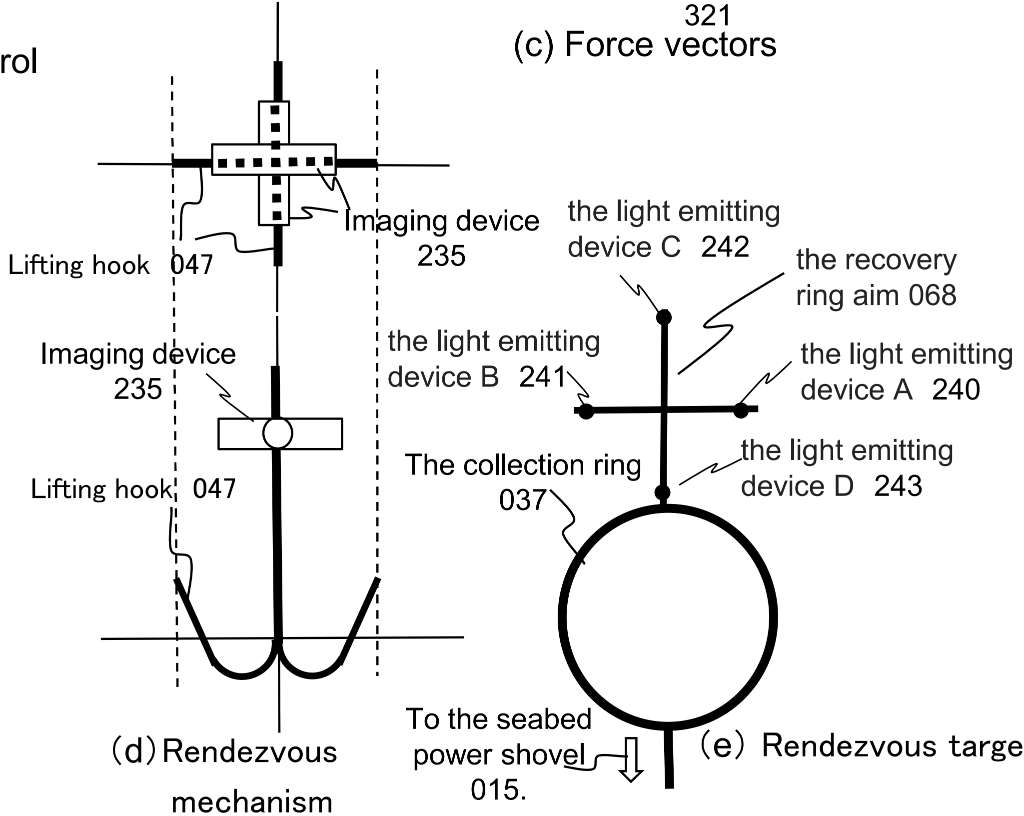
（a） Top view of attachment for precision control



(c) Force vectors



(b) Overview of the of attachment for precision control

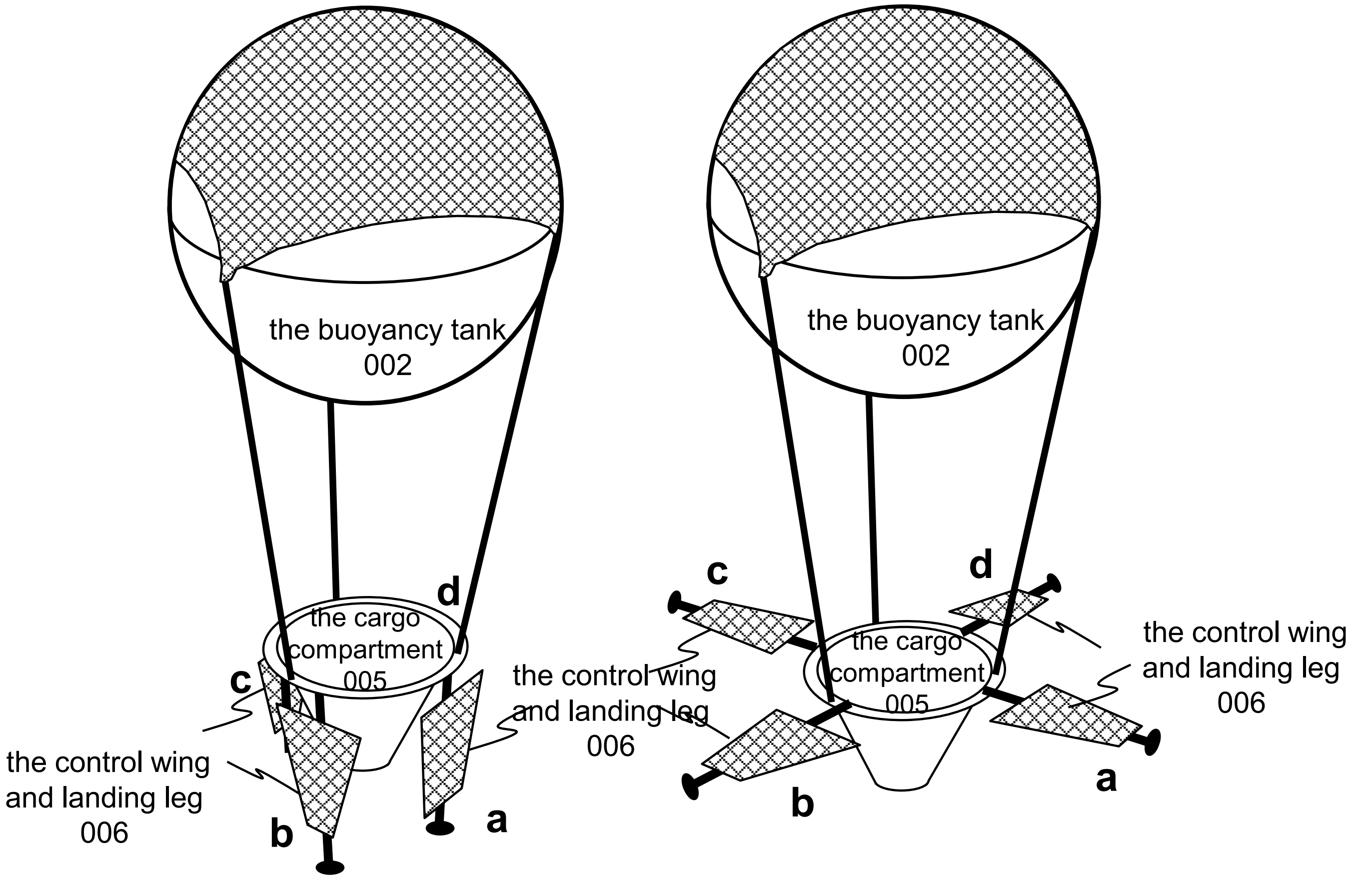


(d) Rendezvous mechanism

(e) Rendezvous target

Fig. 25

a diagram showing control (No. 1) of the deep-sea crane

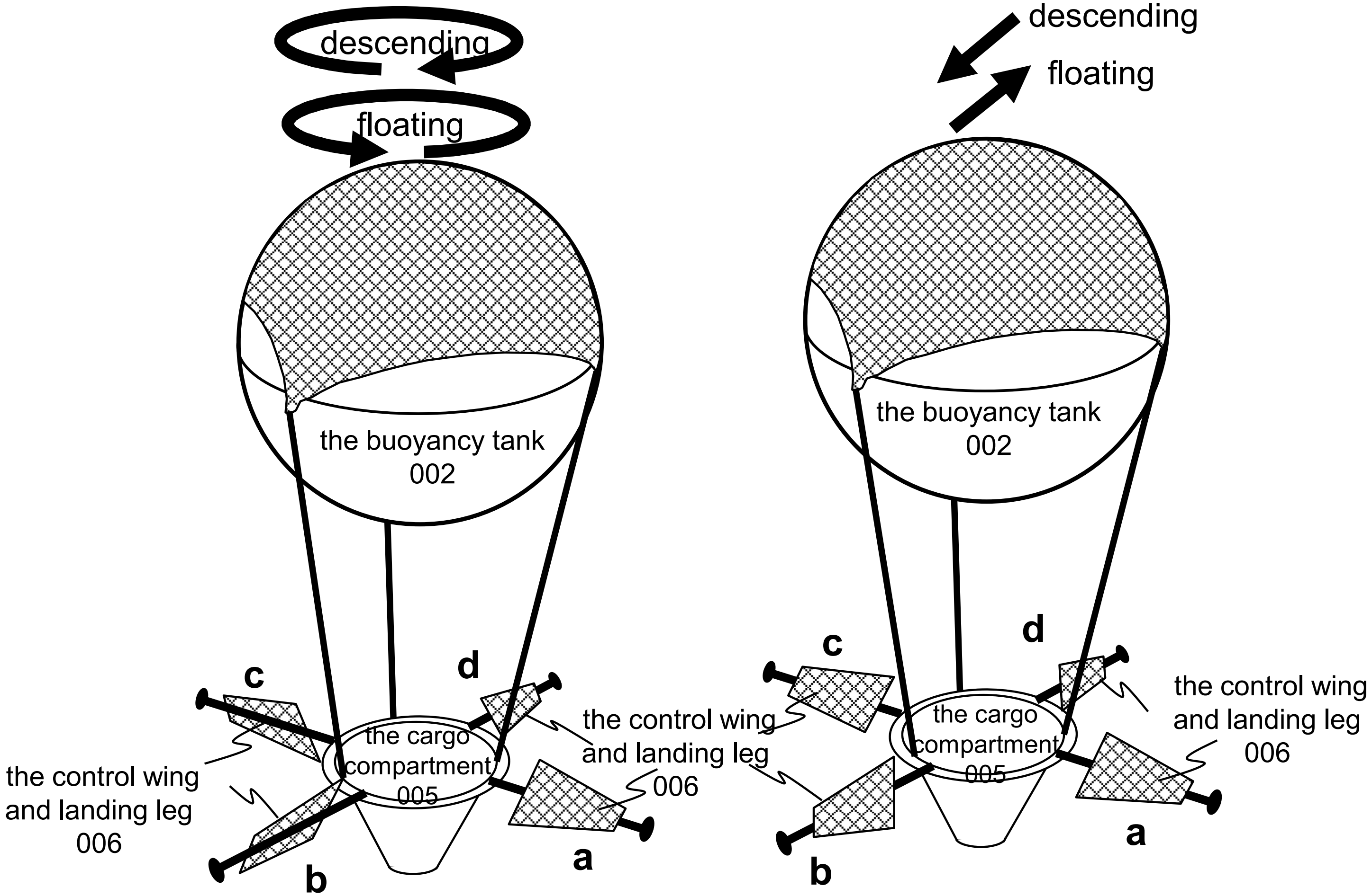


（c） No braking

（d） Full braking

Fig. 26

a diagram showing control (No. 1) of the deep-sea crane

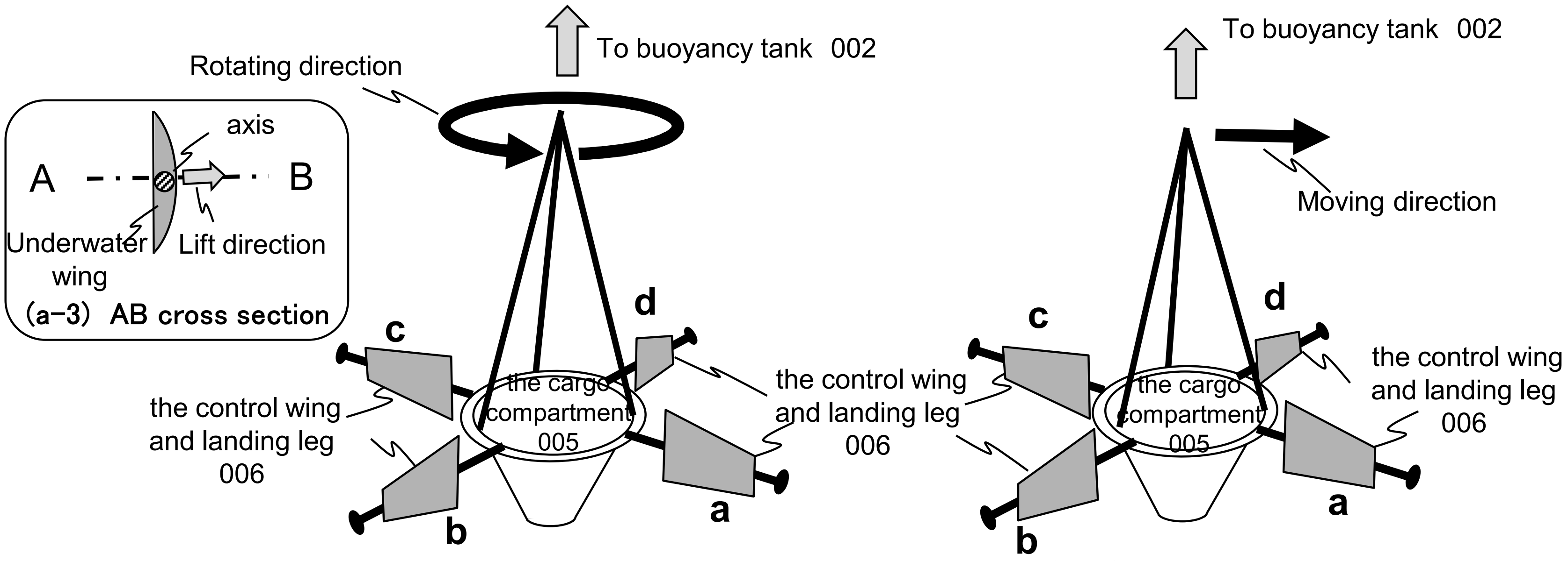


（a） Rotation

（b） horizontal mone

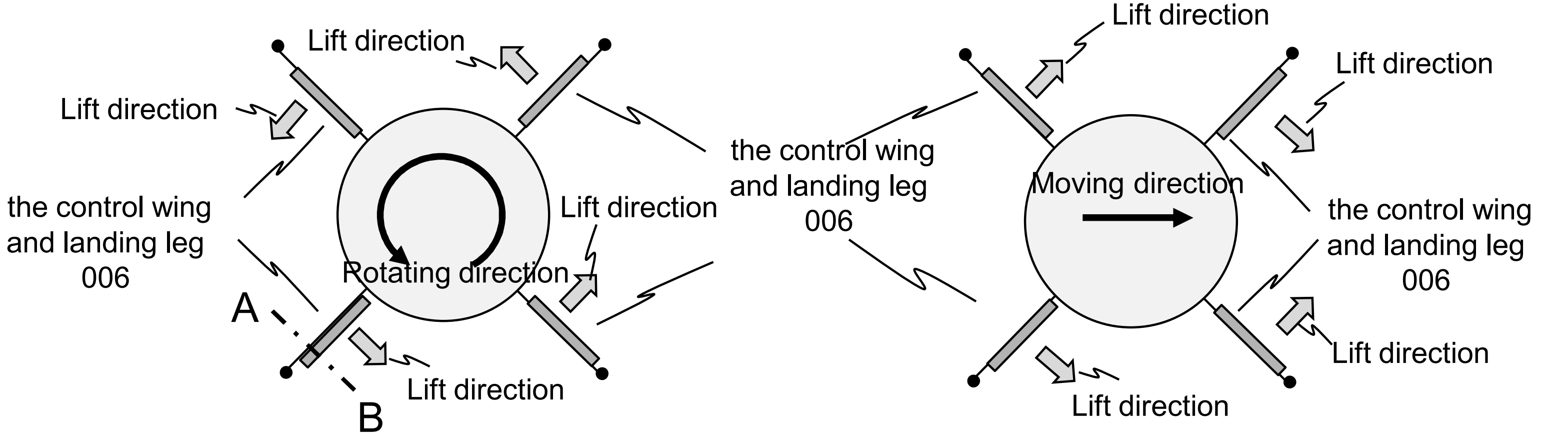
Fig. 26-1

a diagram showing control (No. 3) of the deep-sea crane



(a-1) Diagonally above wiew

(b-1) Diagonally above wiew



(a-2) Top view

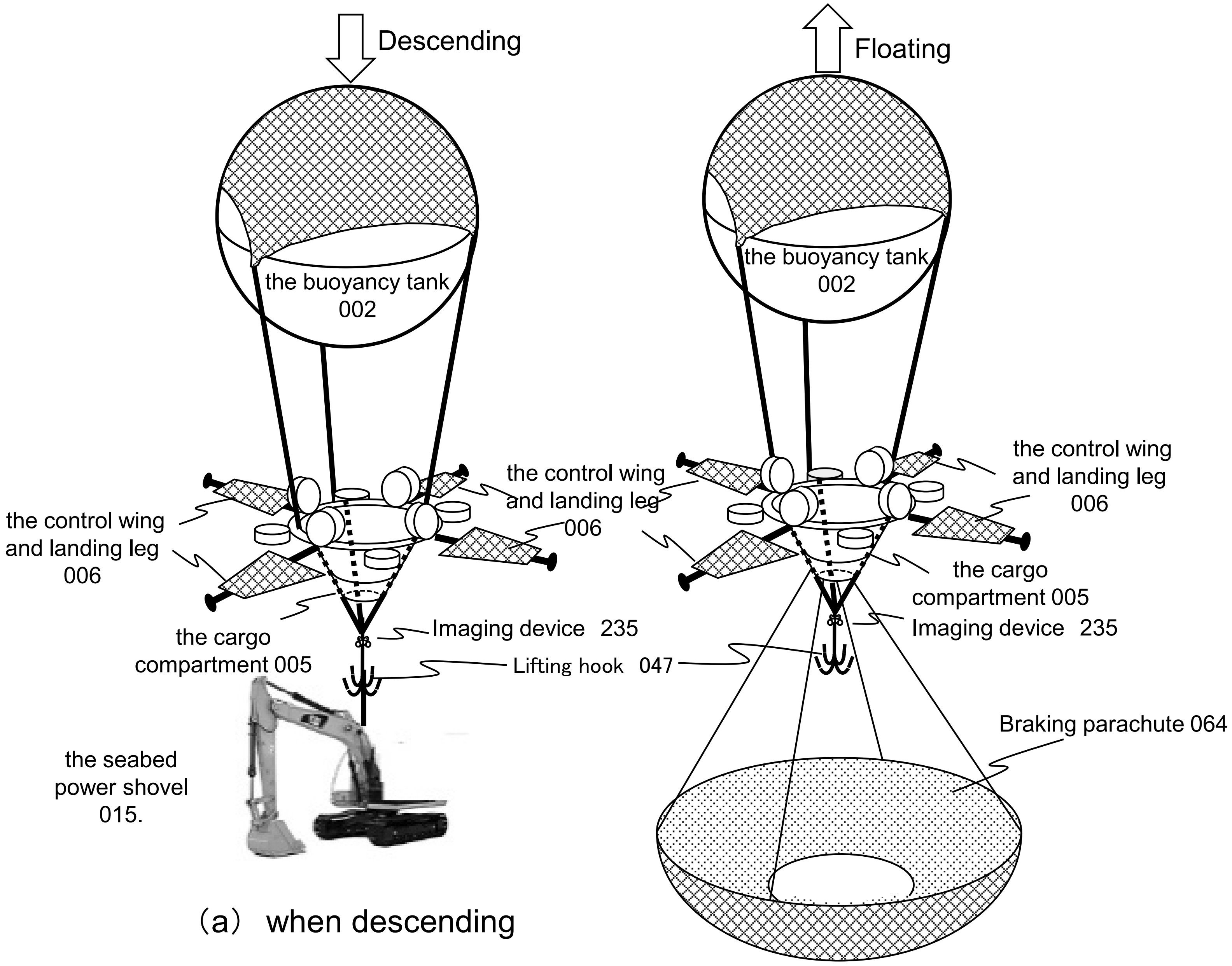
(b-2) Top view

(a) Rotation(common to descend and float)

(b) horizontal move(common to descend and float)

Fig. 27

a view showing installation of mineral collecting apparatuses

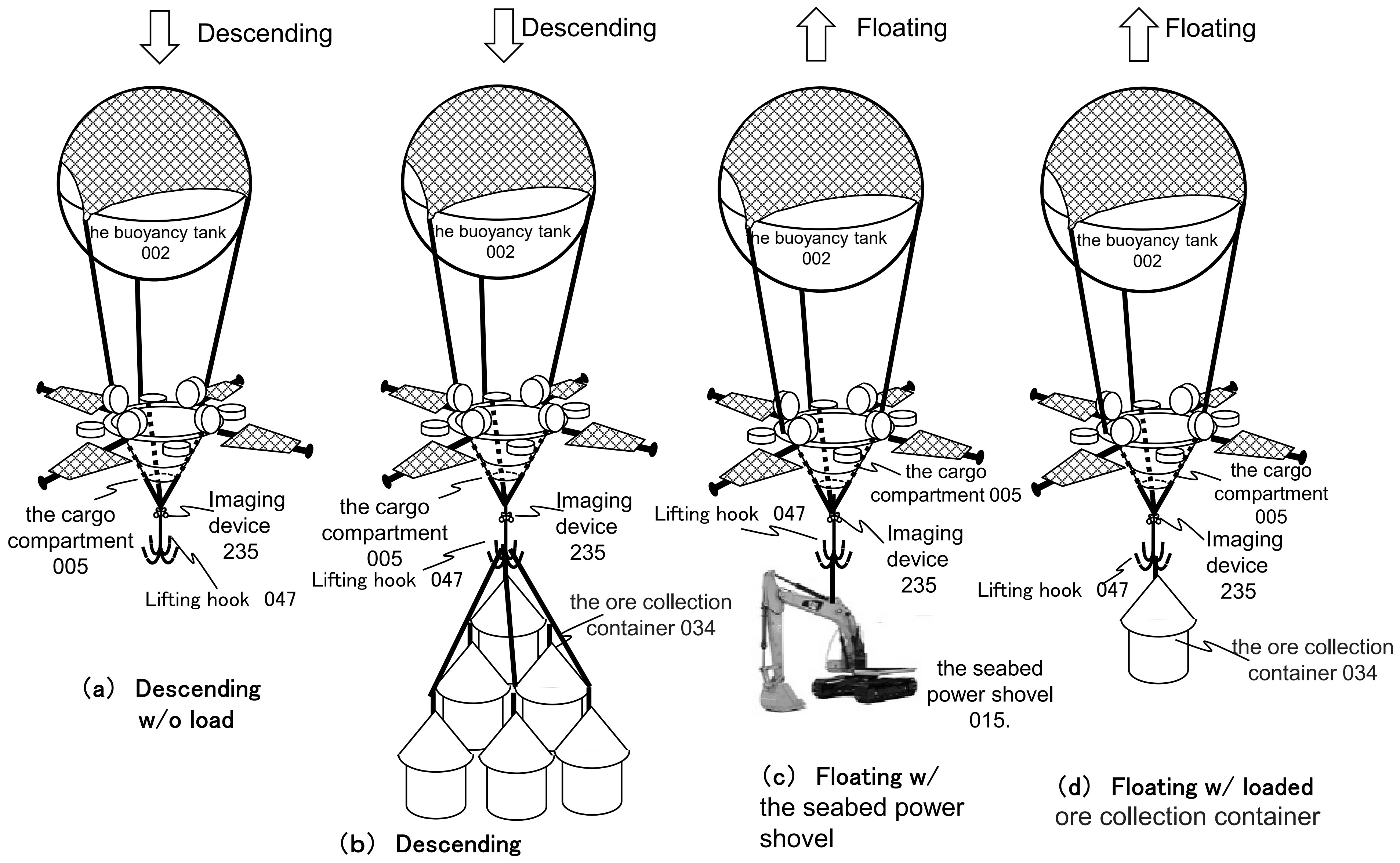


（a） when descending

（b） when floating up after placing
the seabed power shovel

Fig. 28

a diagram showing recovery of the mineral collecting apparatus and the collected mineral container



(a) **Descending w/o load**

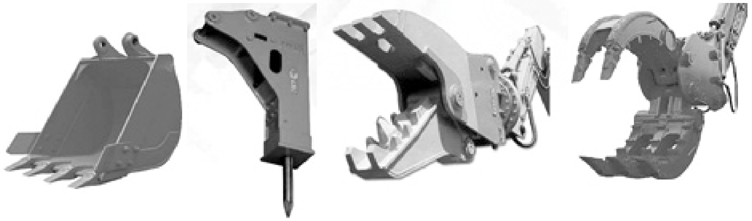
(b) **Descending** w/ the ore collection containers

(c) **Floating w/** the seabed power shovel

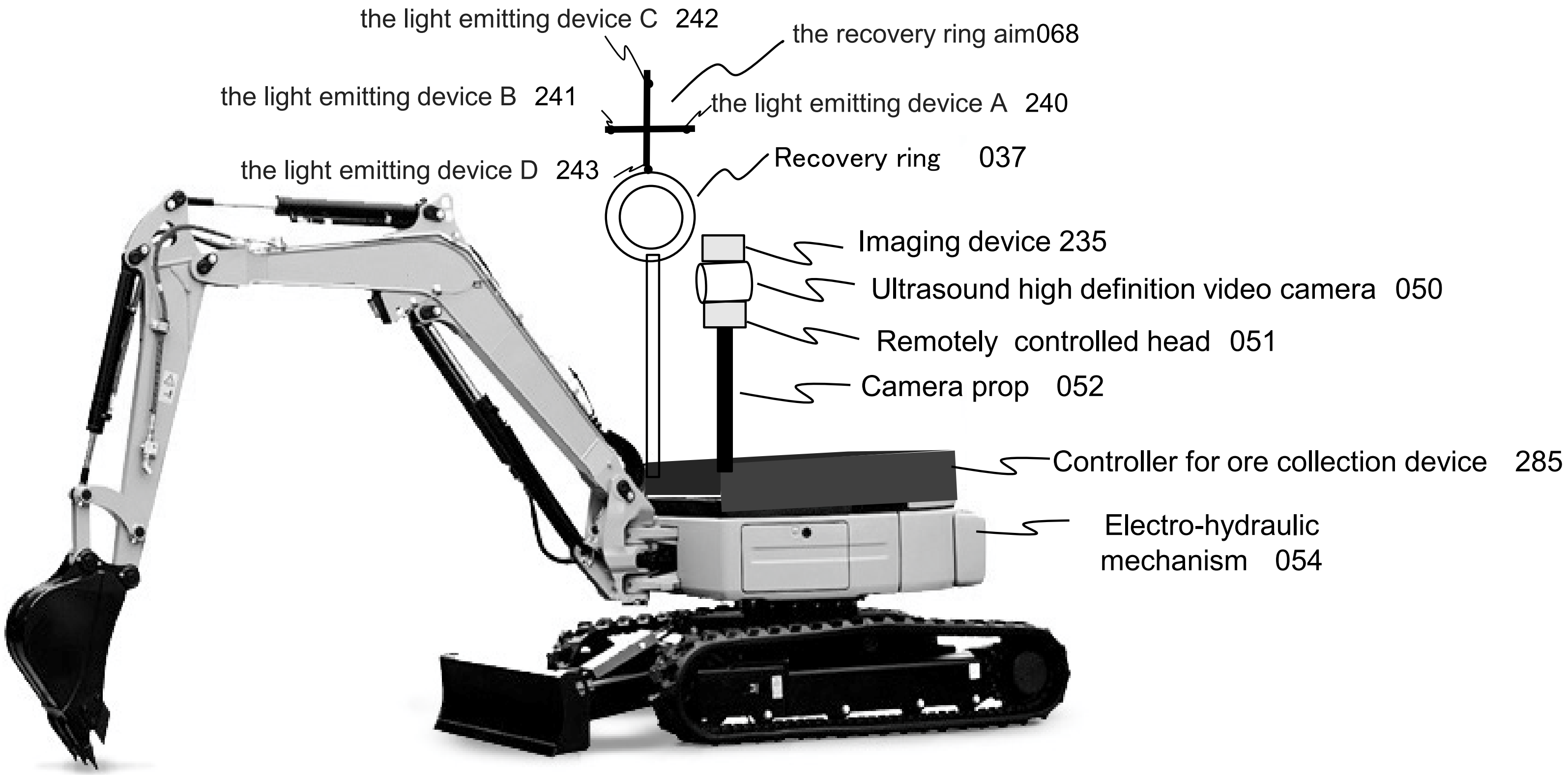
(d) **Floating w/ loaded** ore collection container

Fig. 29

a diagram showing a mineral collecting apparatus (seabed power shovel)



（b） **Various attachments**



（a） Ore collection device (seabed power shovel) 015

Fig. 30

a diagram showing a supervisory control device (2)

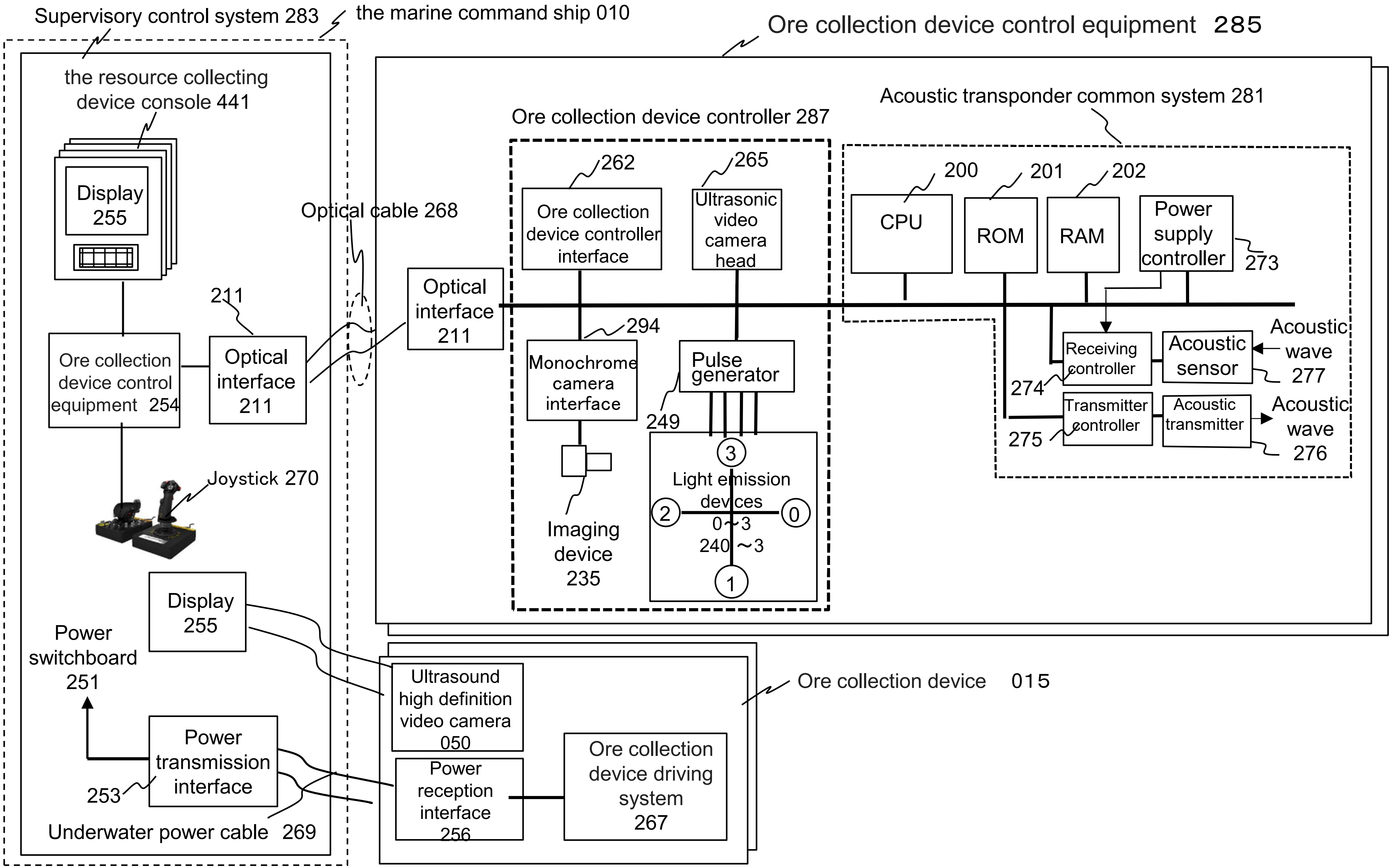
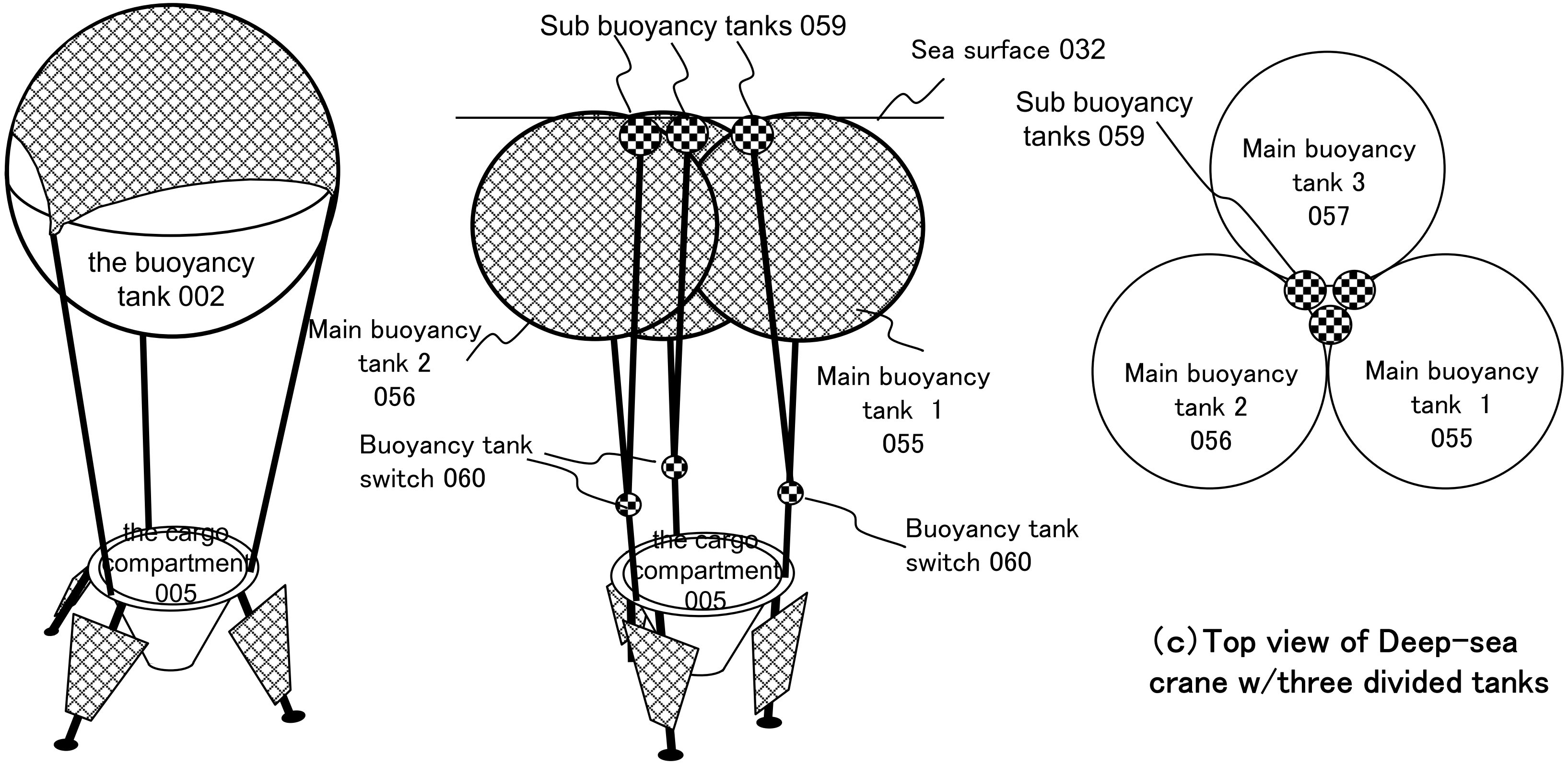


Fig. 31

a view showing division of the buoyancy tank of the deep sea crane



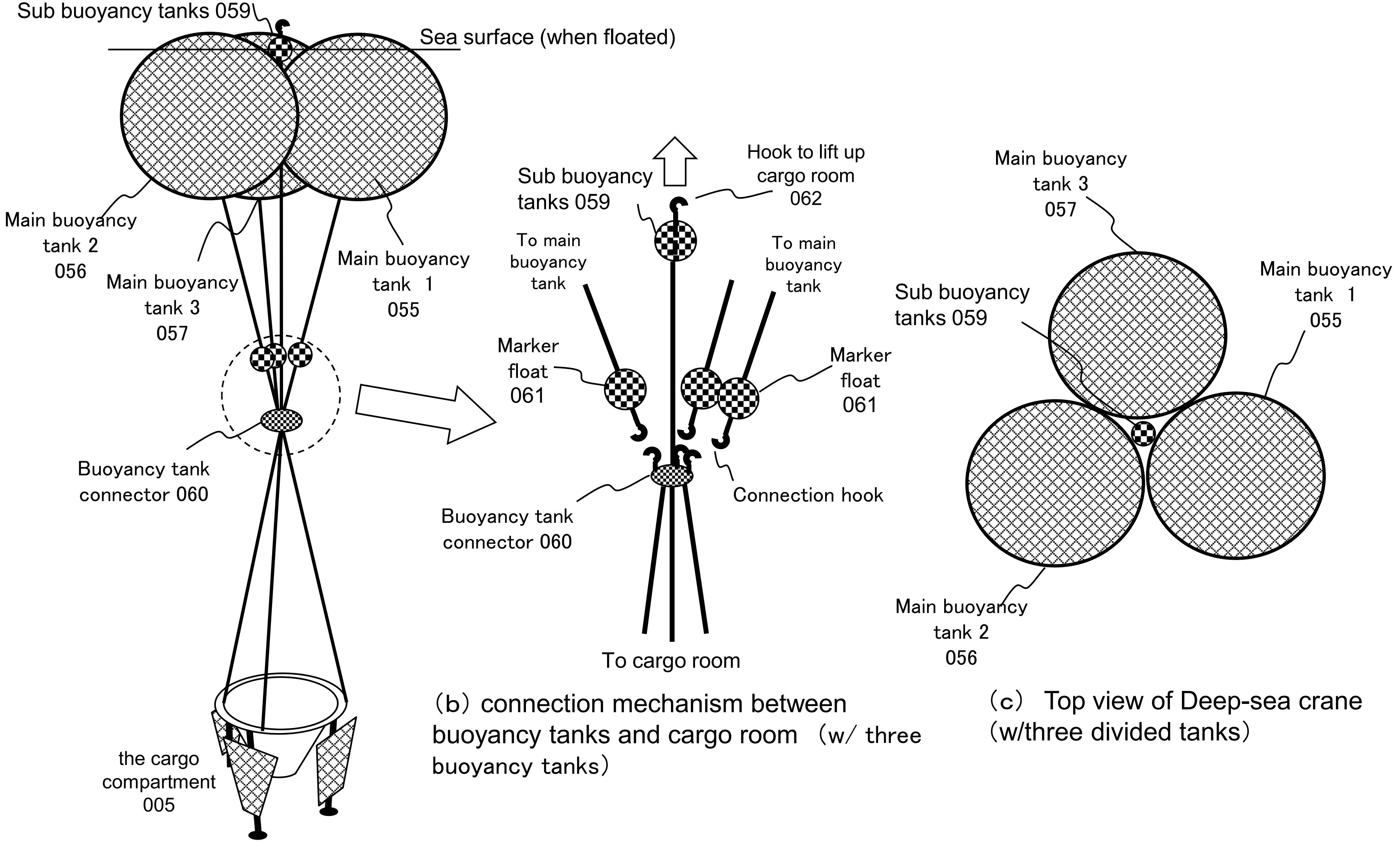
(a) Deep-sea crane (one buoyancy tank)

(b) Deep-sea crane (three divided tanks)

(c) Top view of Deep-sea crane w/three divided tanks

Fig. 31-1

a diagram showing cargo handling equipment of the deep-sea crane



（a） Deep-sea crane（three divided tanks）

（b）connection mechanism between buoyancy tanks and cargo room （w/ three buoyancy tanks）

（c） Top view of Deep-sea crane（w/three divided tanks）

Fig. 32

a diagram showing an example of a maritime command ship, a gut crane ship

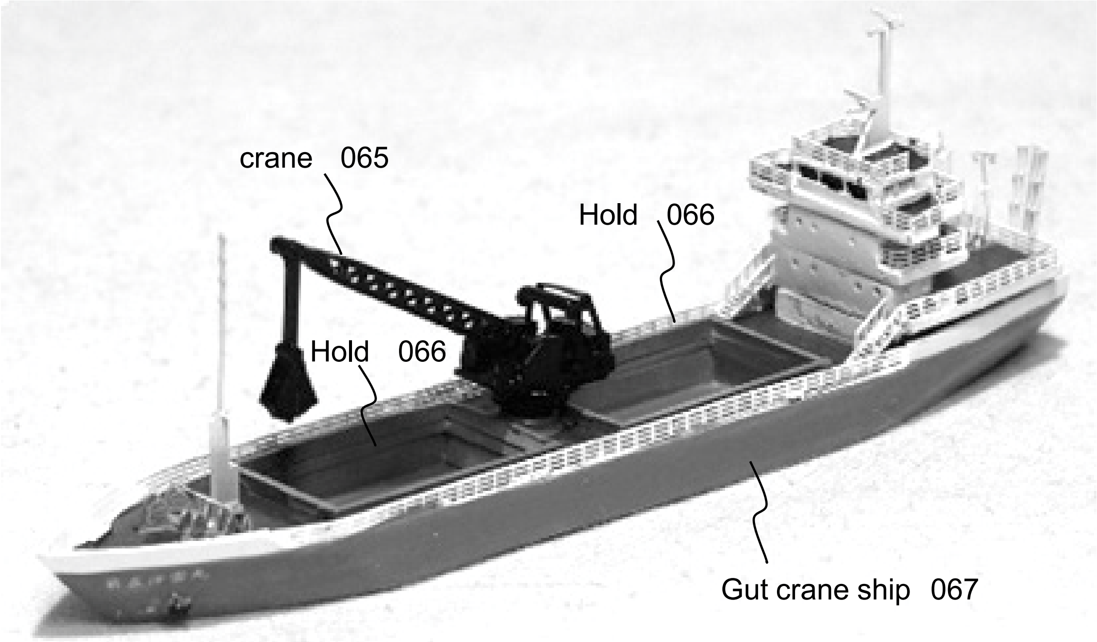
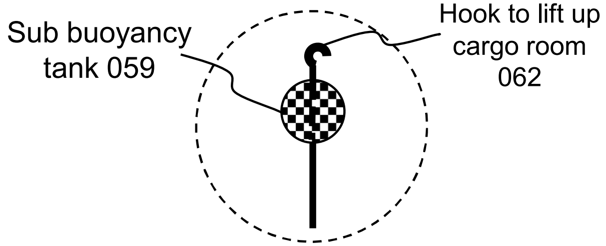
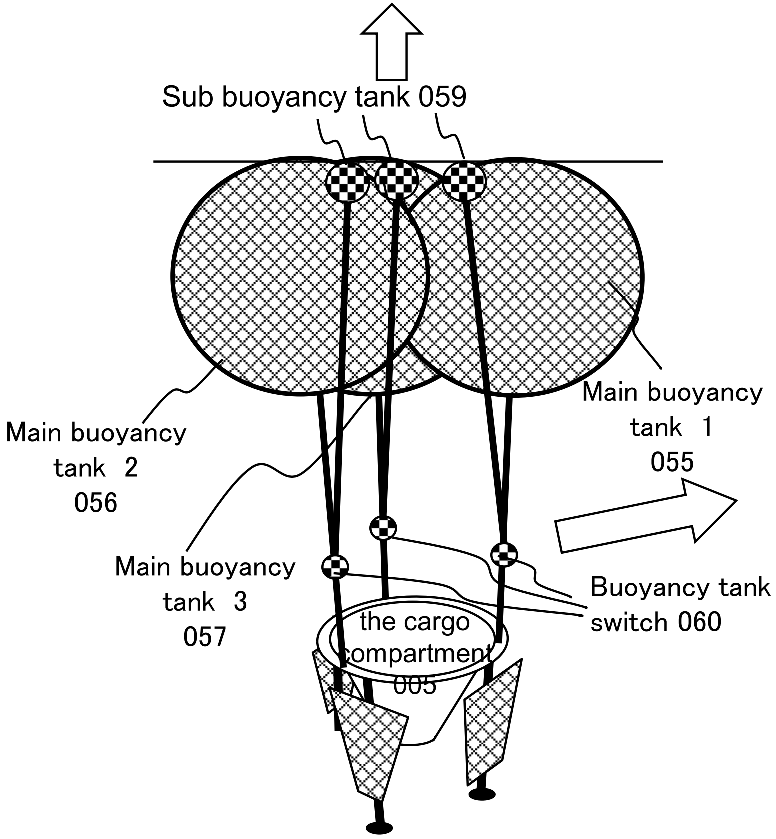


Fig. 33

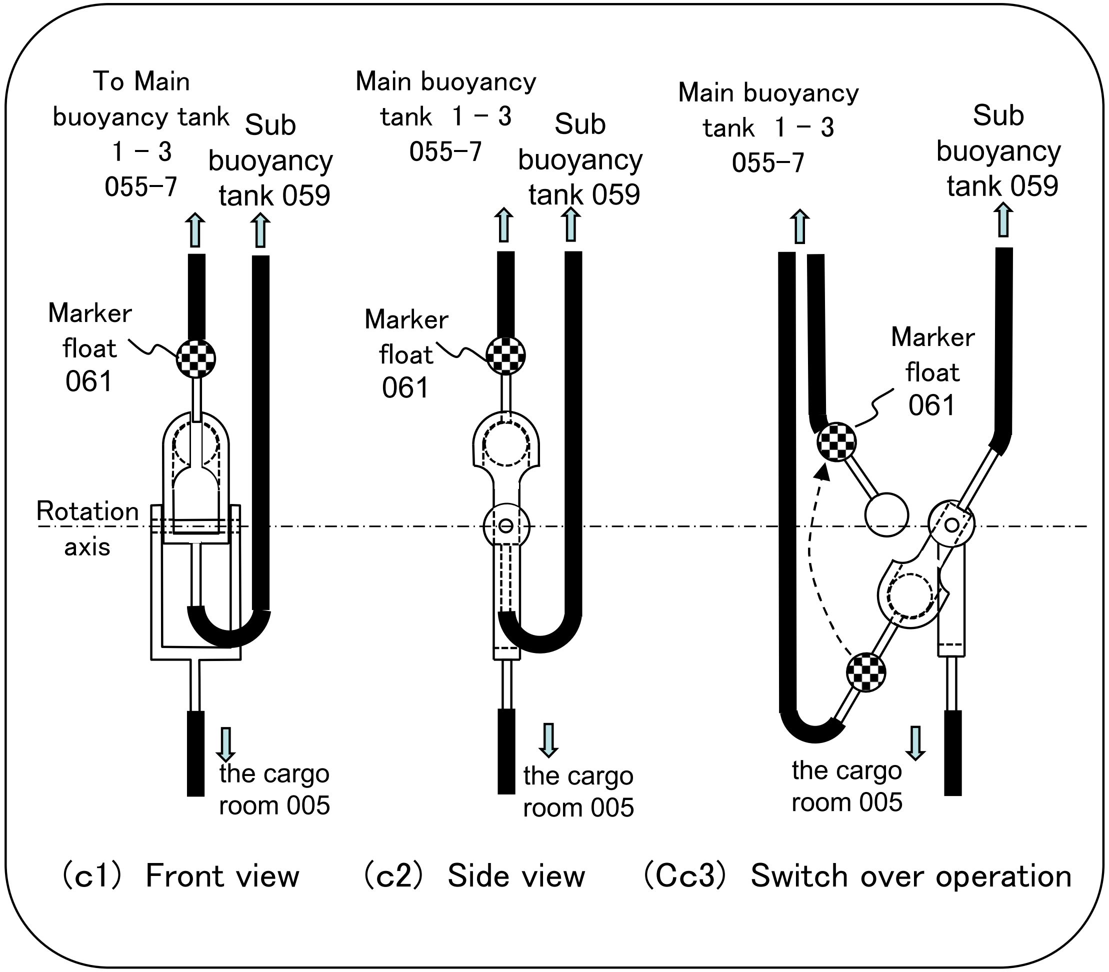
a diagram showing cargo handling equipment



（b）sub buoyancy tank



（a） Deep-sea crane



（c） Buoyancy tank switch 060

Fig. 34

a diagram showing a cargo handling procedure (1)

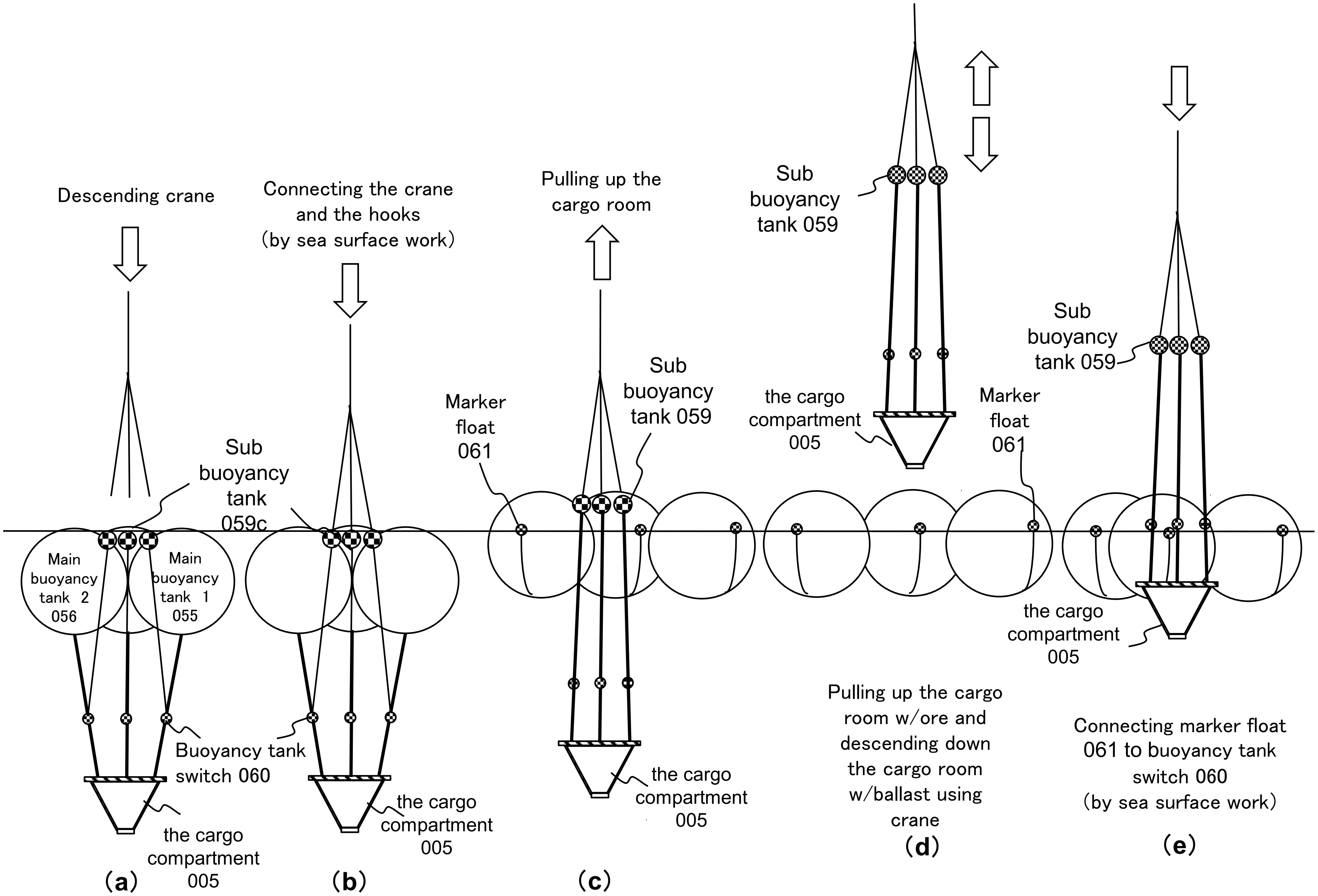


Fig. 34-1

a diagram showing a cargo handling procedure (1)

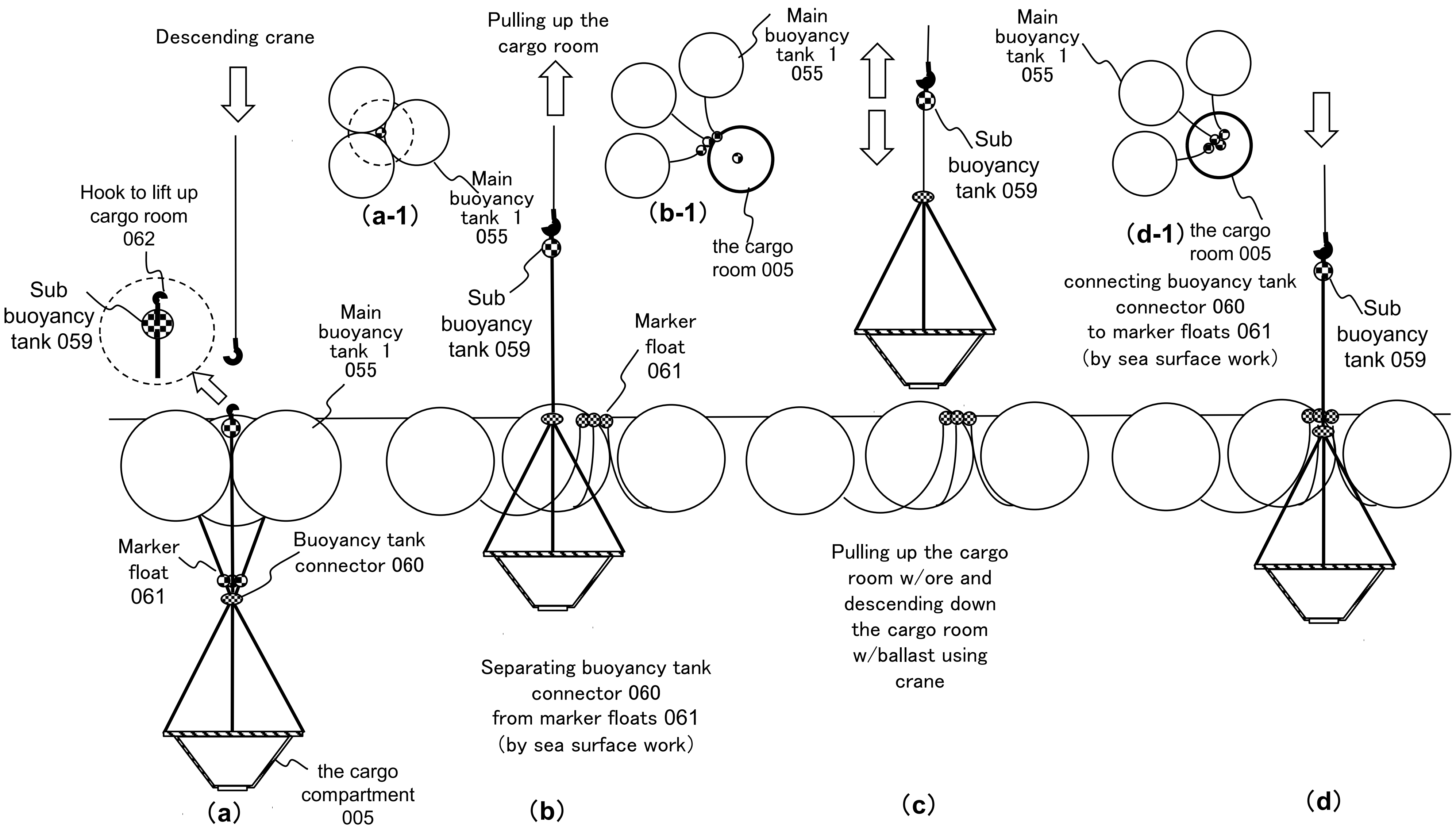


Fig. 35

a diagram showing a configuration diagram of a supervisory control device (No. 1)

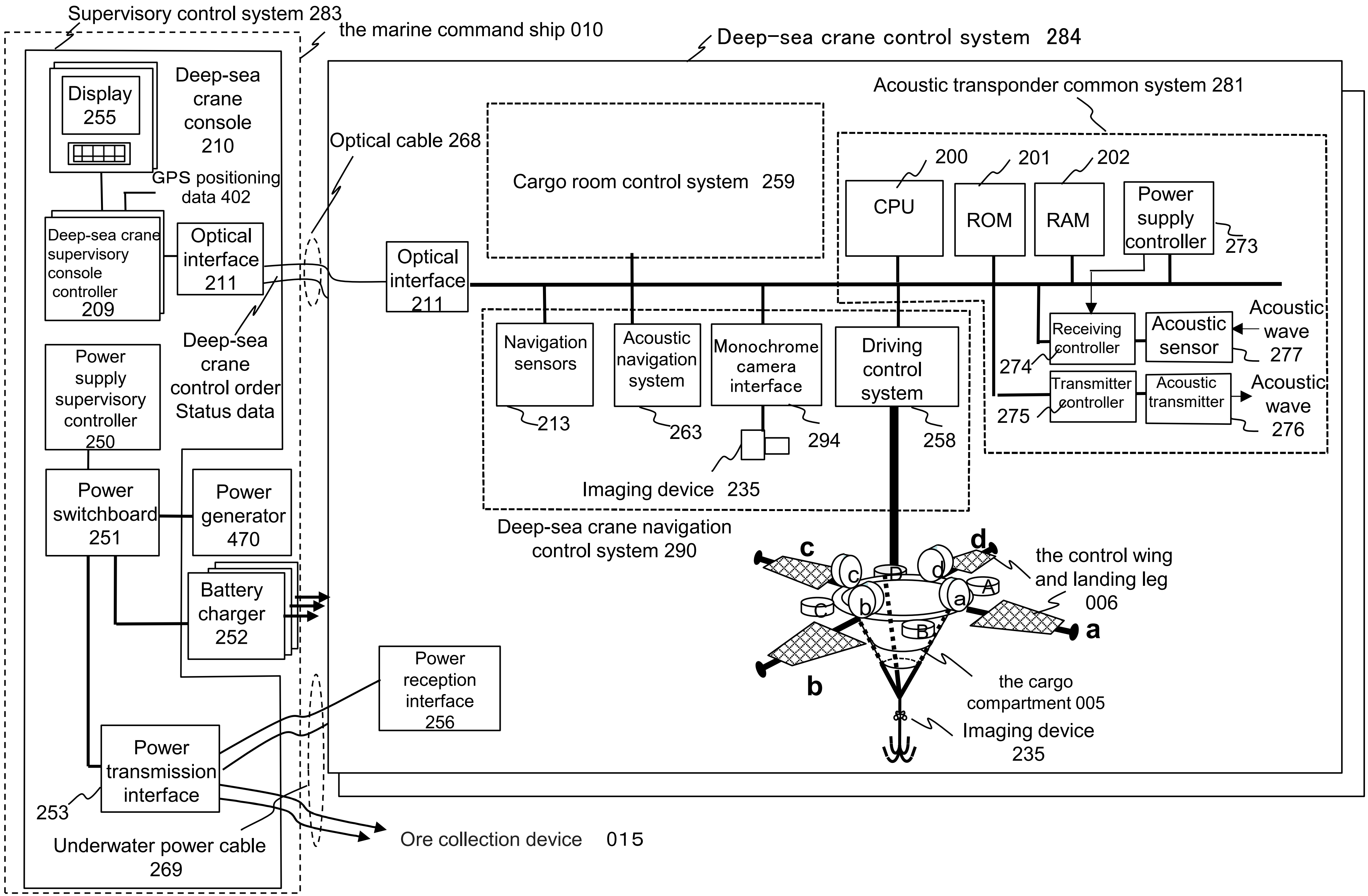
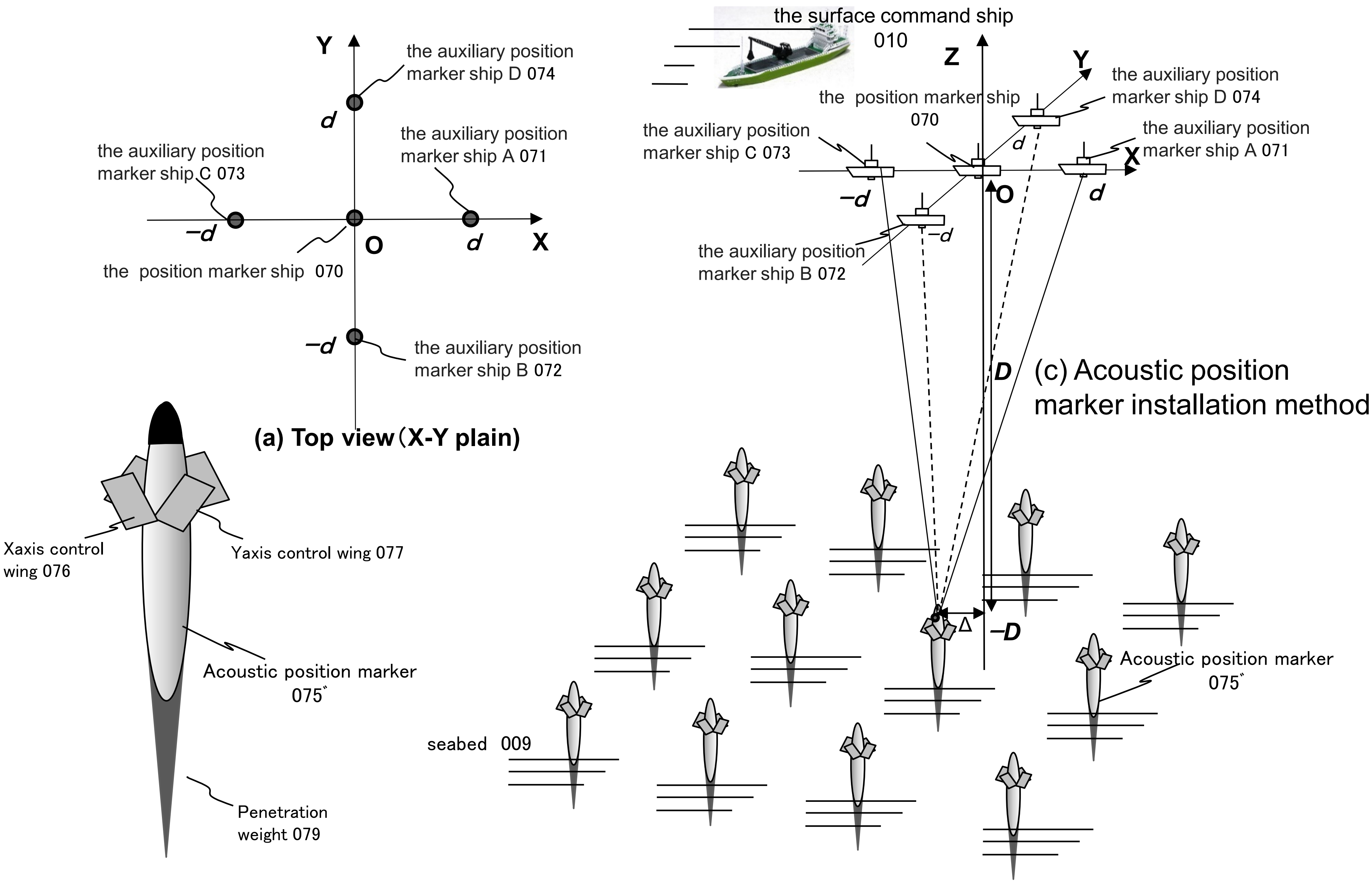


Fig. 35

a diagram showing installation of the acoustically guided acoustic position markers



(a) Top view（X-Y plain)

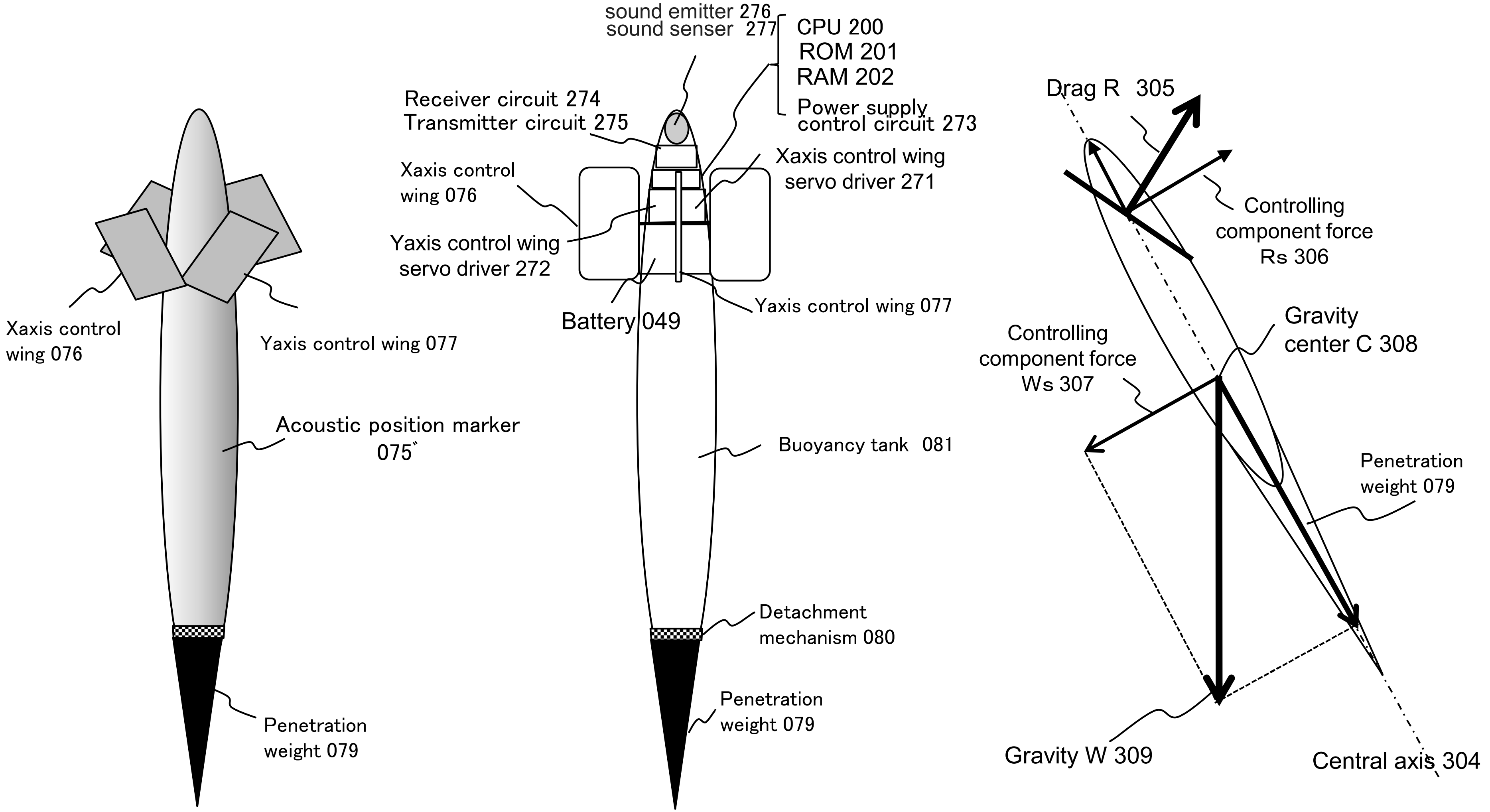
(c) Acoustic position marker installation method

(a) Acoustic position marker

(b) Acoustic position marker field

Fig. 37

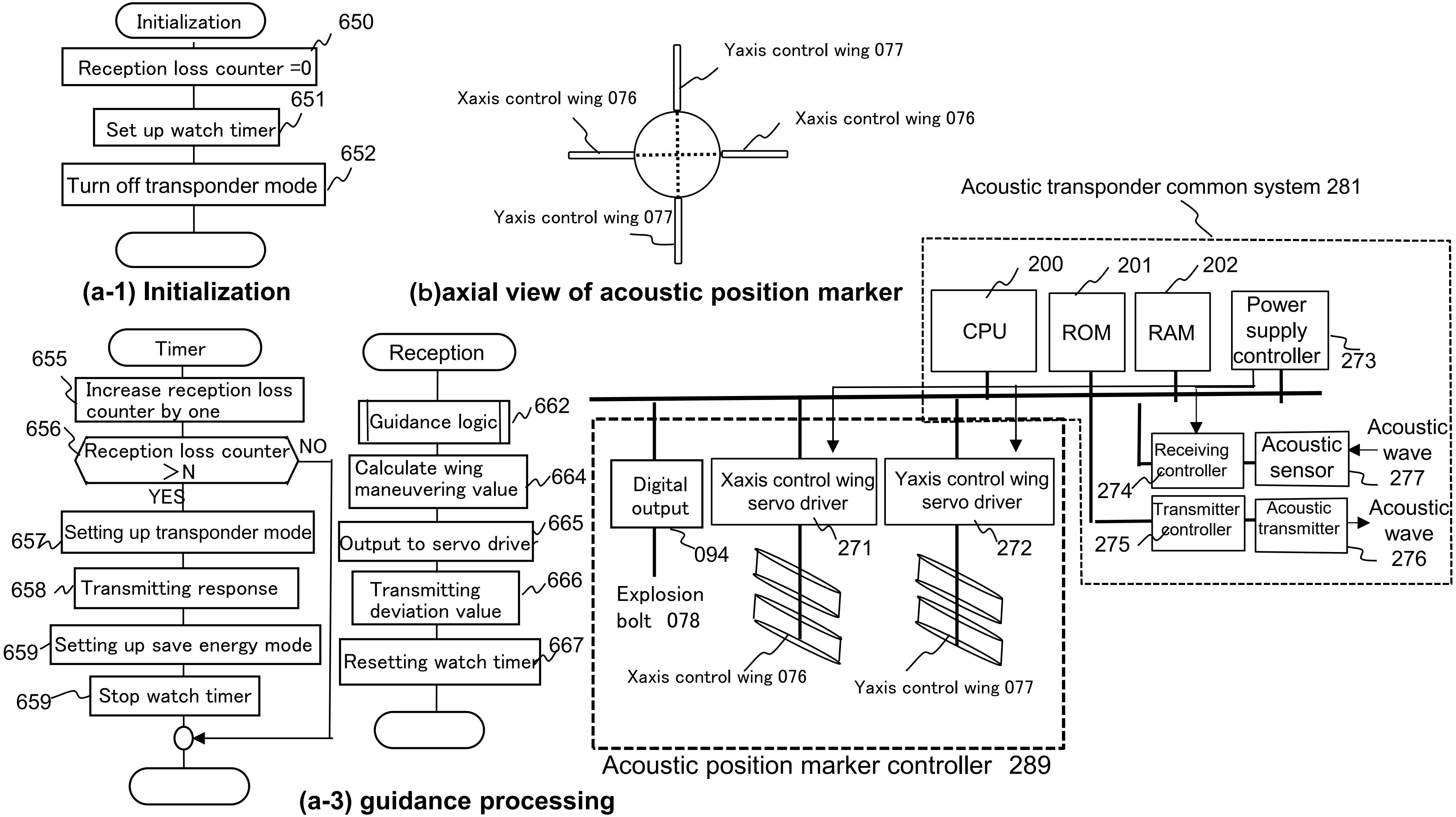
a configuration example of an acoustically guided acoustic position marker



(a) Over view of Acoustic position marker (b) Structure of Acoustic position marker (c) Operating force vectors

Fig. 38

a diagram showing an acoustically guided acoustic position marker control device



(a-1) Initialization

(b)axial view of acoustic position marker

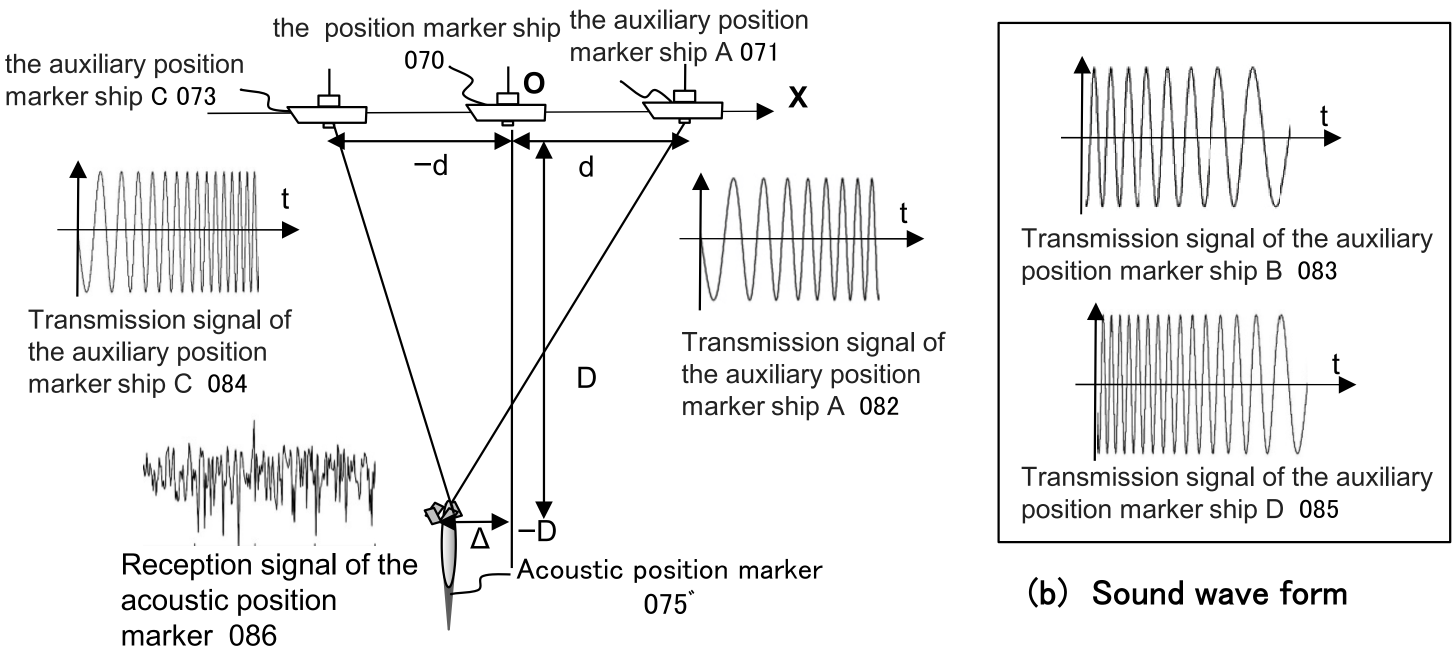
(a-3) guidance processing

(a-2) guidance supervision

(c) Acoustic position marker control system

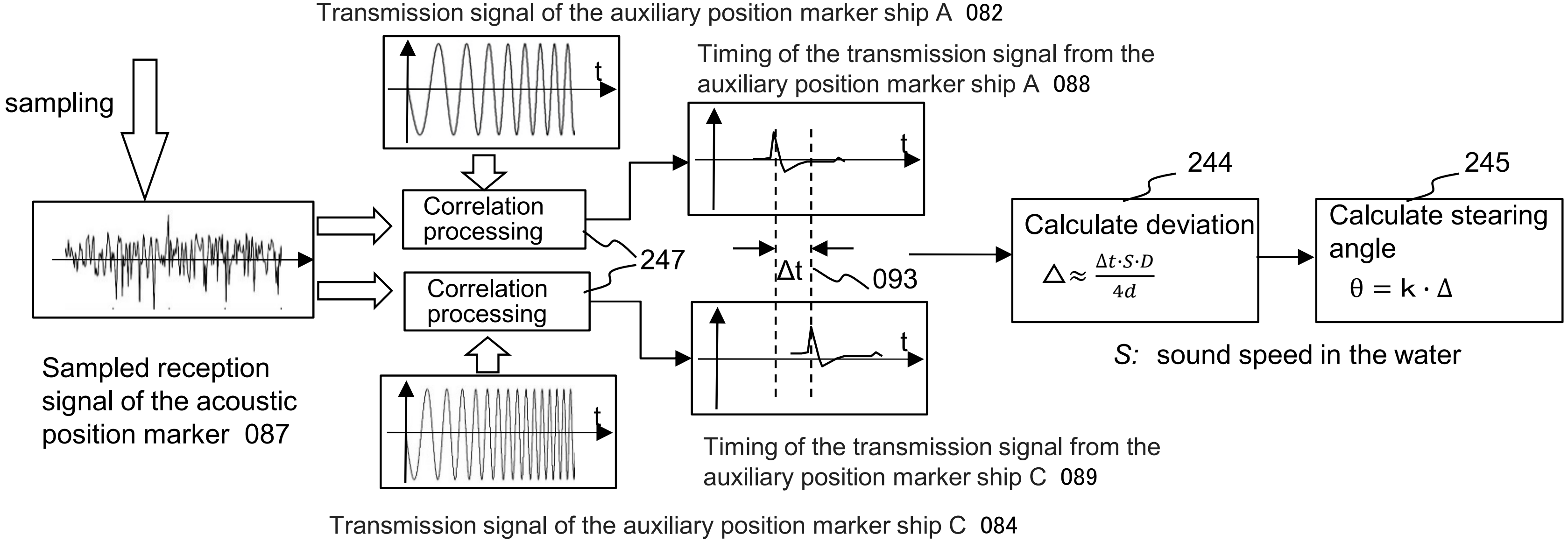
Fig. 39

a diagram showing the guidance logic of the acoustically guided acoustic position marker



(a) Sound propagation diagram

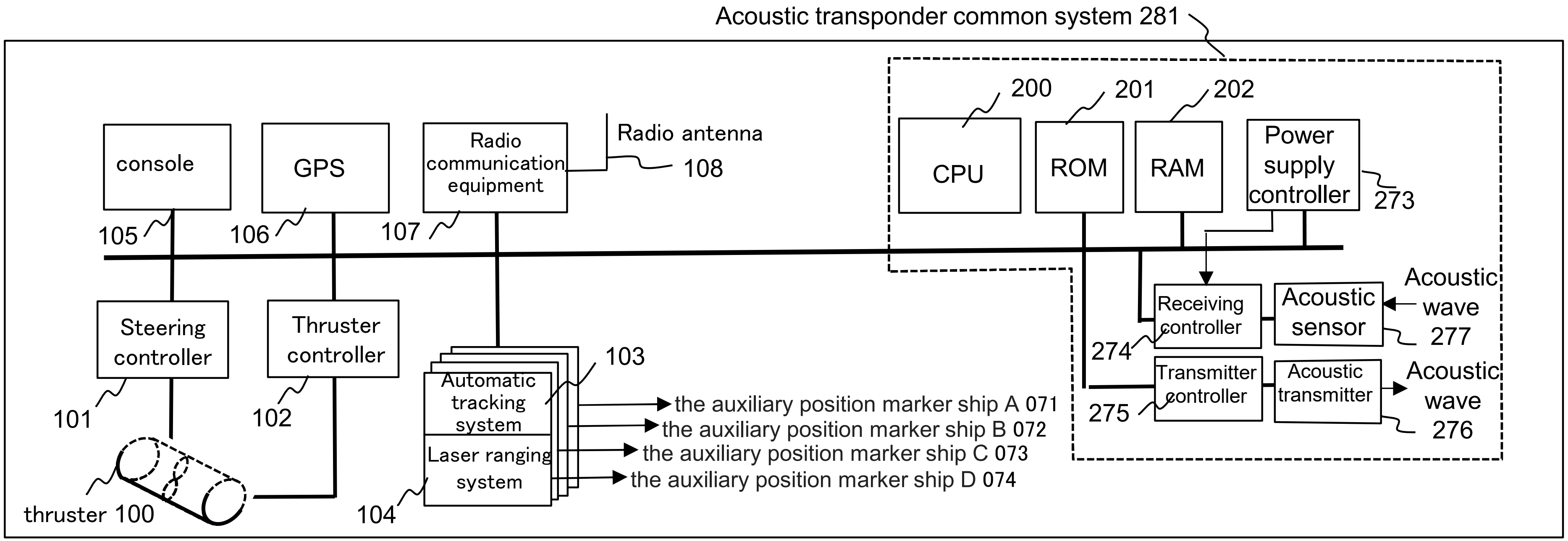
(b) Sound wave form



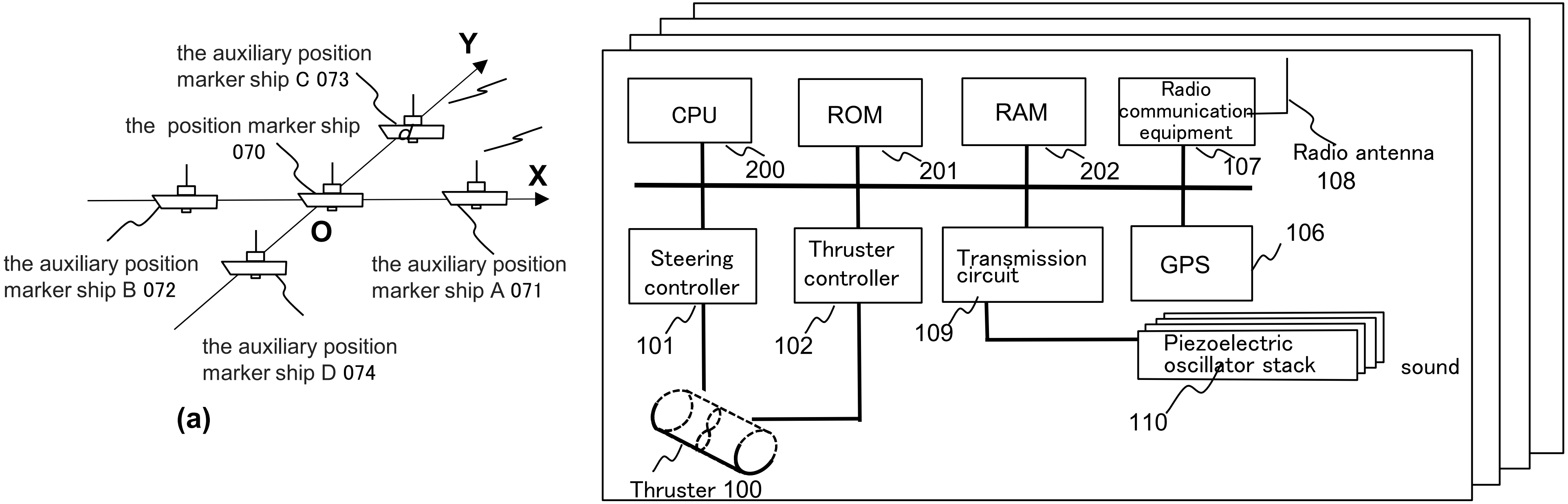
(c) Signal processing logic

Fig. 40

a diagram showing a configuration example of an acoustically guided acoustic position marker



(b) the position marker ship 070



(a)

(c) the auxiliary position marker ship A、B、C、D 071～074

Fig. 41

a diagram showing a processing flow of a signal processing / control system of the acoustically guided acoustic position marker installation system

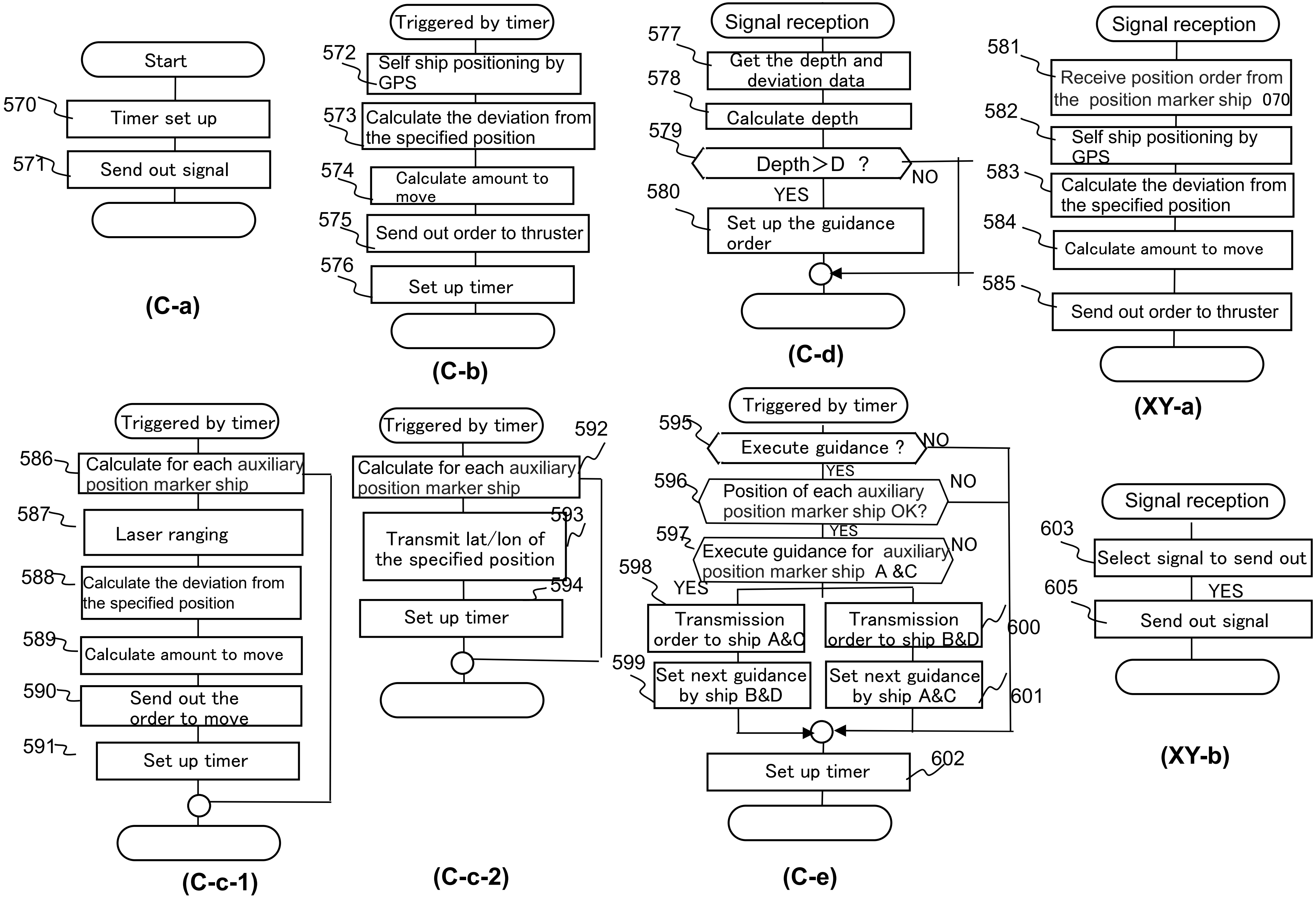
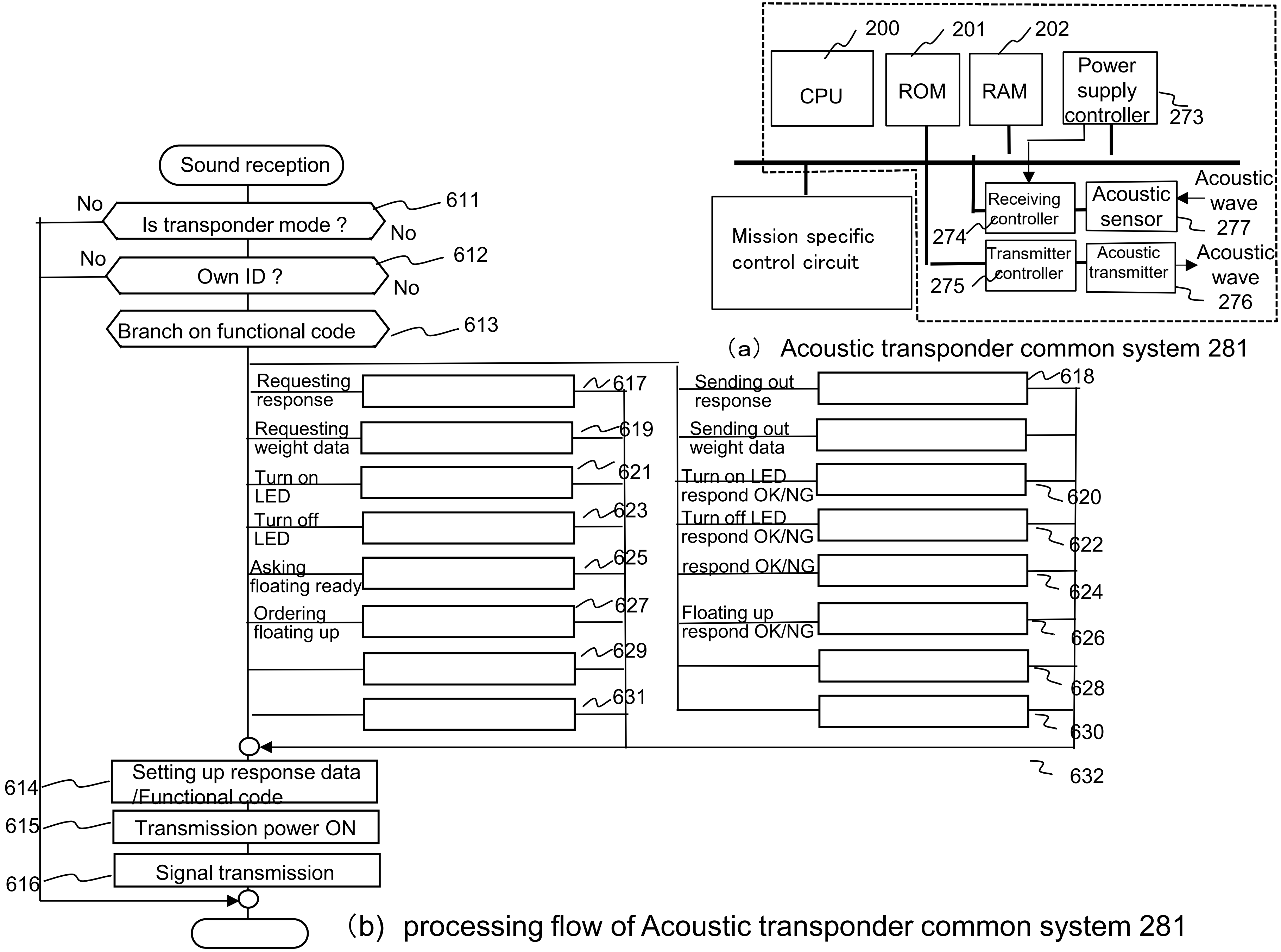


Fig. 42

a processing flow diagram of an acoustic transponder common infrastructure



（a） Acoustic transponder common system 281

（b） processing flow of Acoustic transponder common system 281

Fig. 43

a recovery operation diagram of the mineral collecting apparatus (electric power shovel) from the seabed

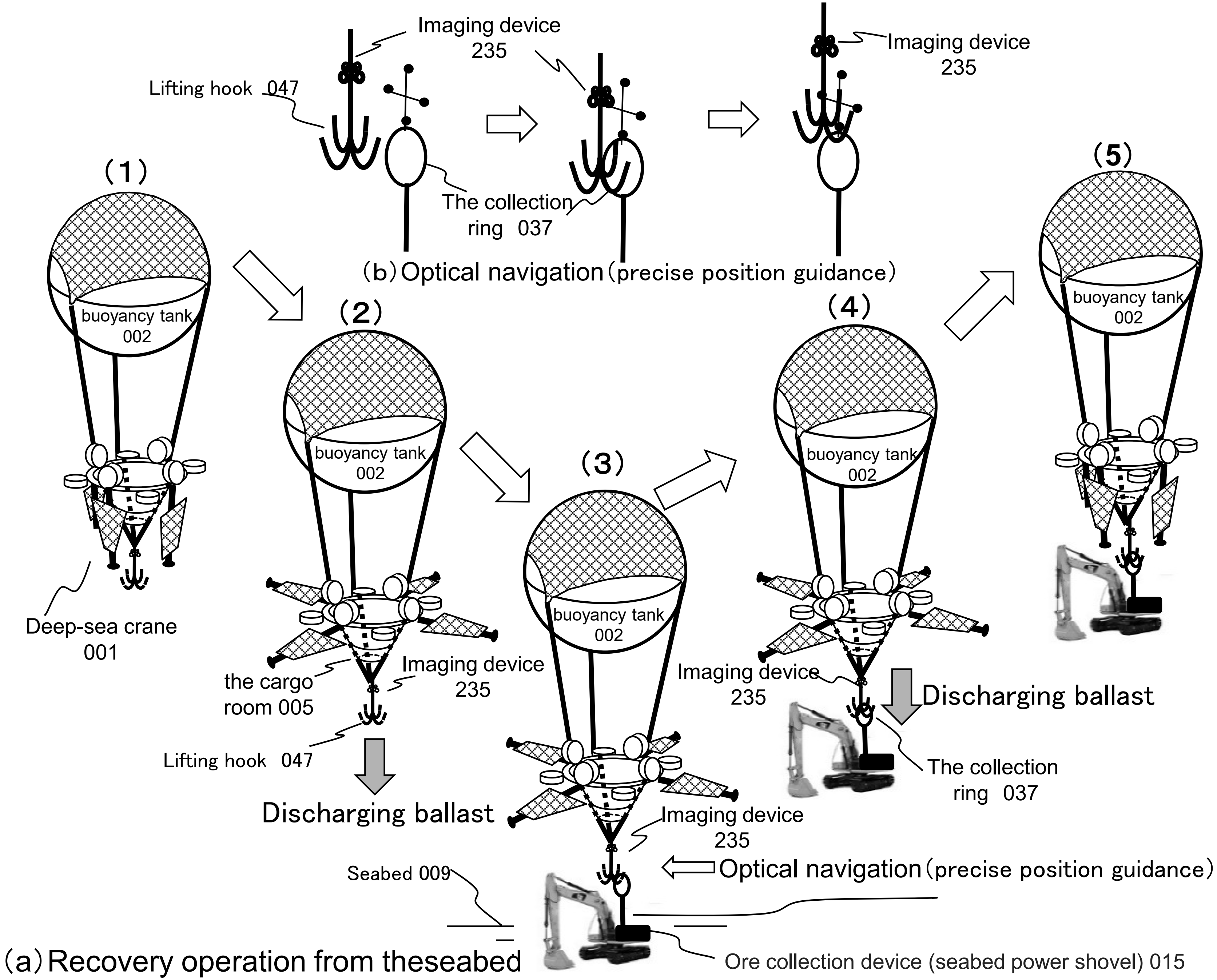
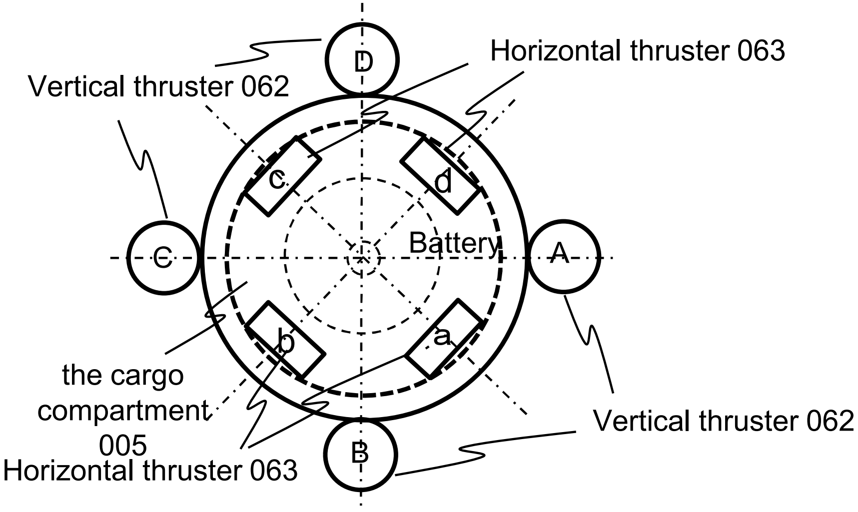
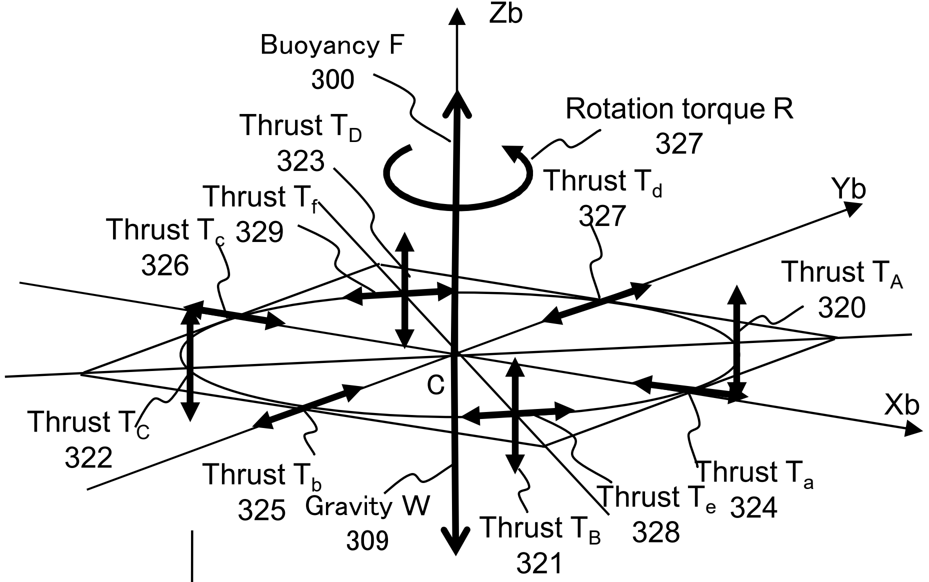


Fig. 44

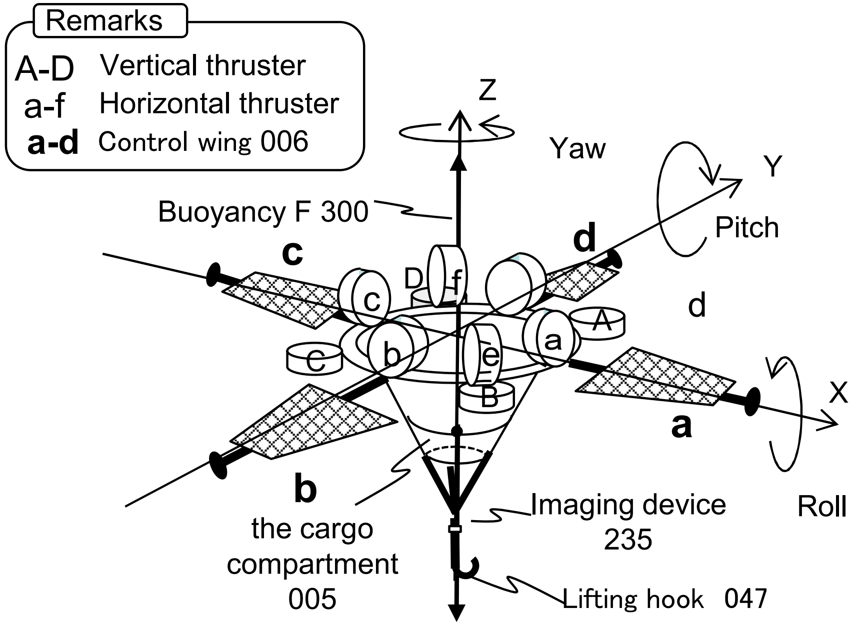
a view showing a precision control attachment (2)



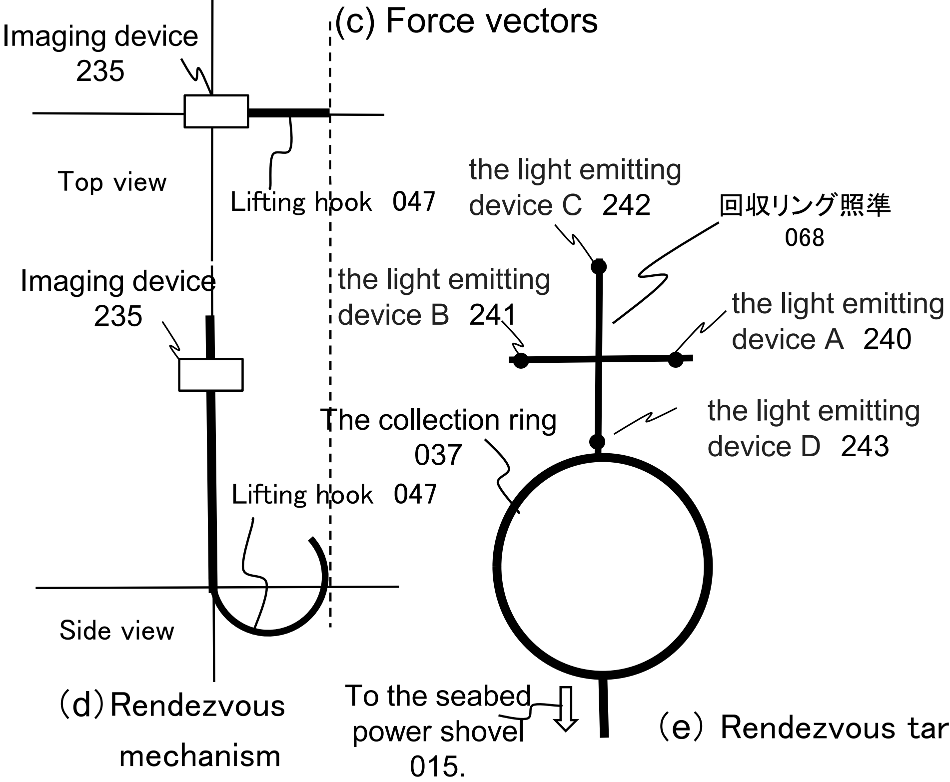
（a） Top view of attachment for precision control



(c) Force vectors



(b) Overview of the of attachment for precision control

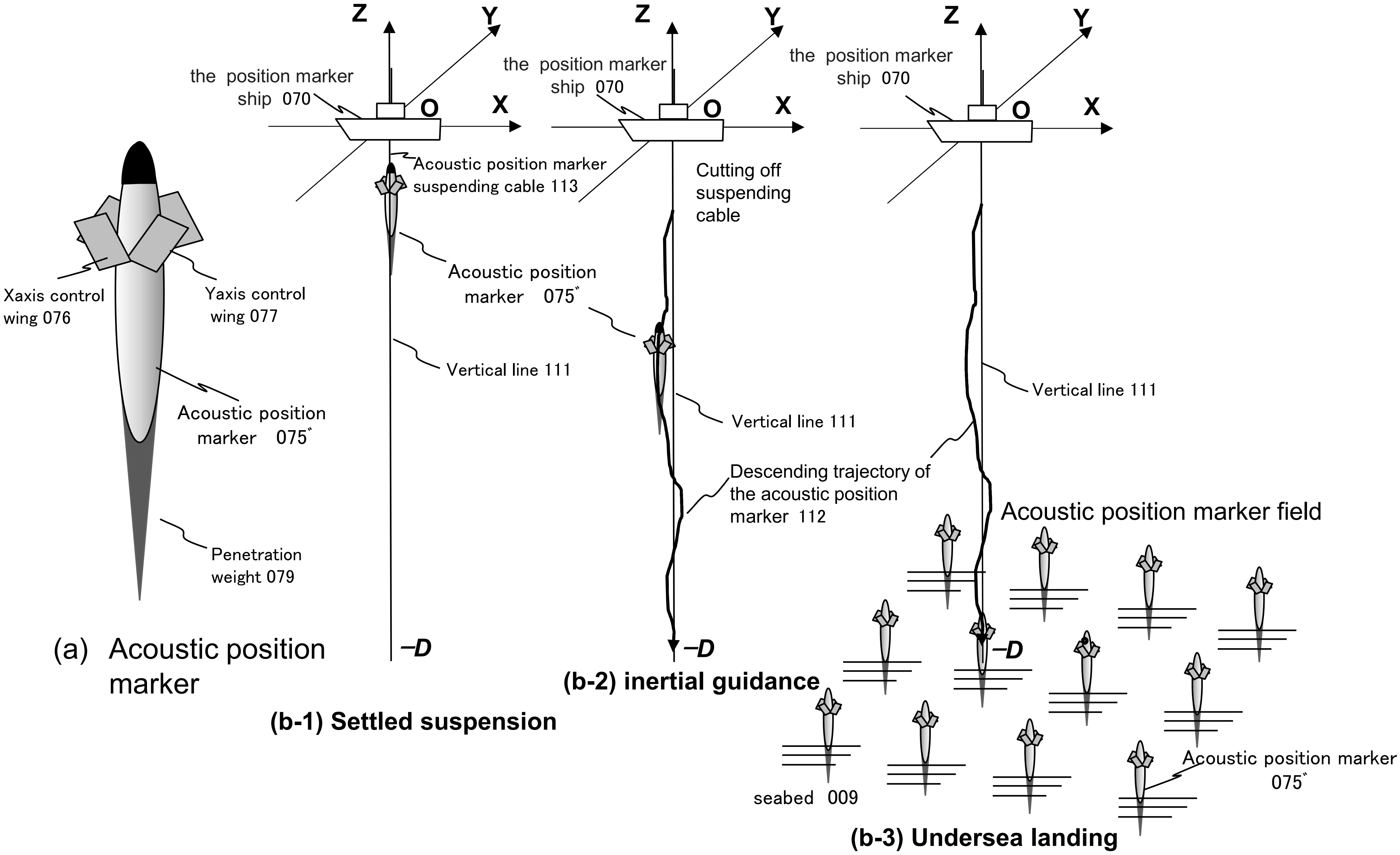


（d）Rendezvous mechanism

（e） Rendezvous target

Fig. 45

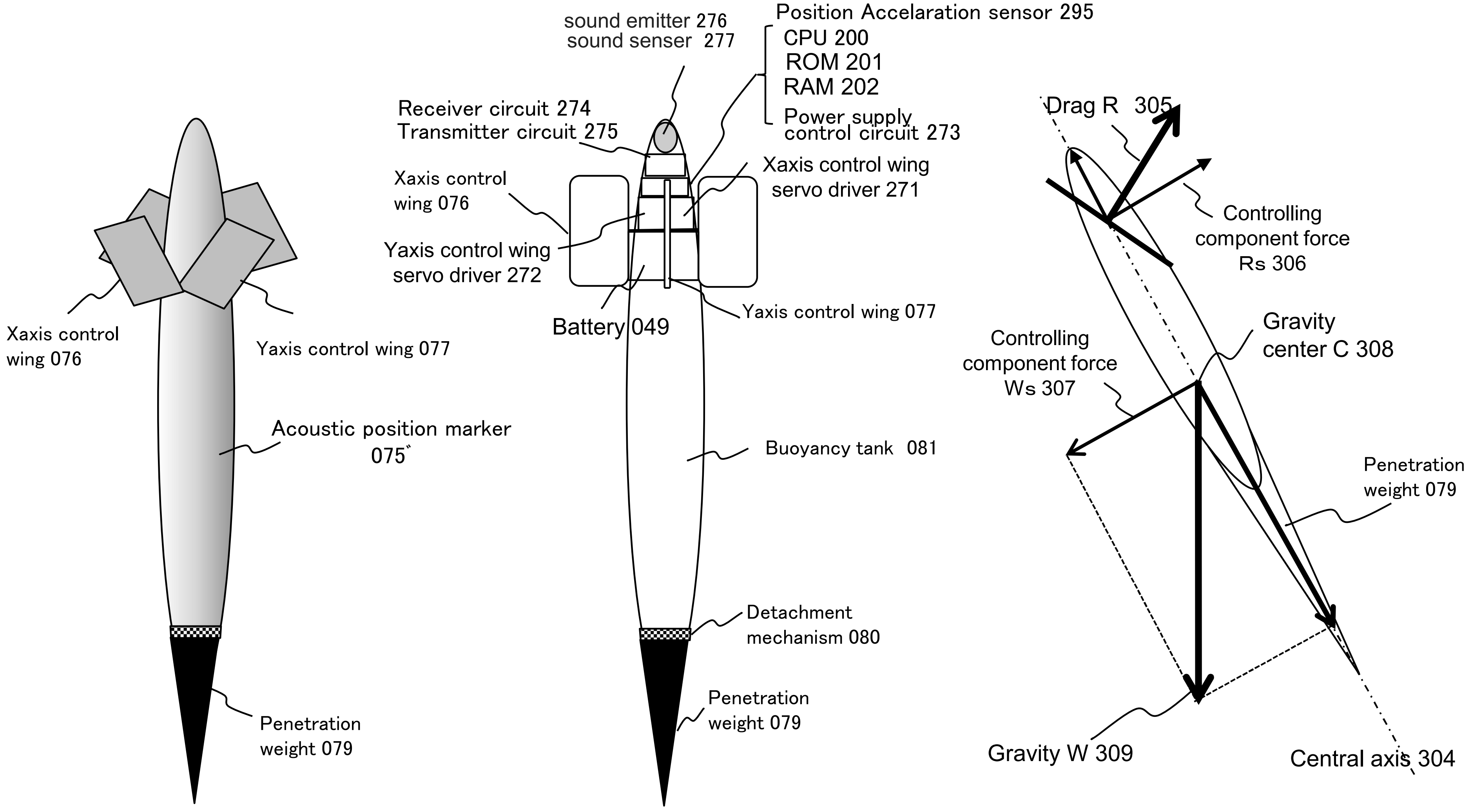
a diagram showing the installation of the inertially guided acoustic position markers



(b) Installation method of the acoustic position markers

Fig. 46

a configuration example of an acoustically guided acoustic position marker



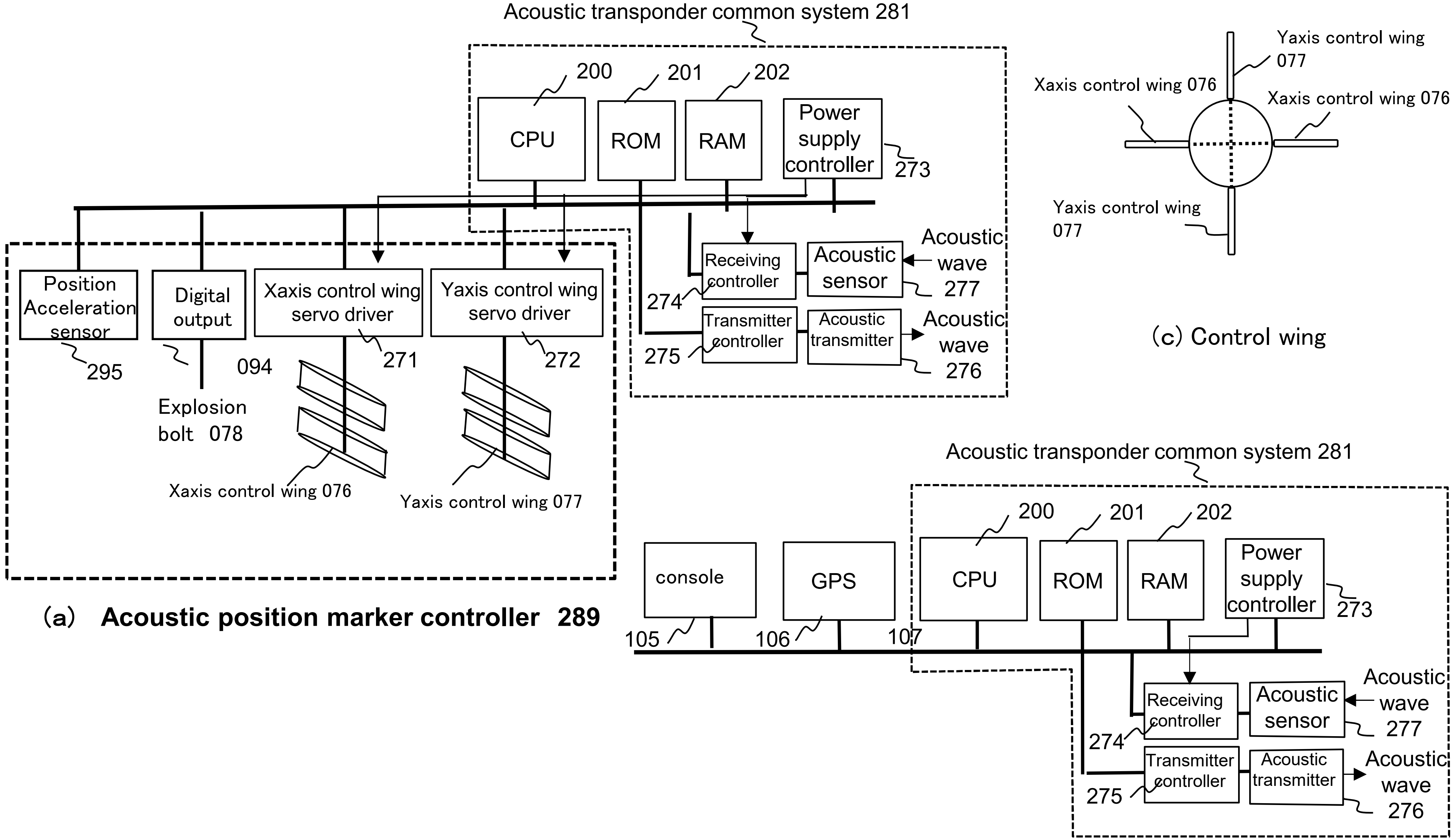
(a) Over view of Acoustic position marker

(b) Structure of Acoustic position marker

(c) Operating force vectors

Fig. 47

a diagram showing the configuration of an inertially guided acoustic position marker control device



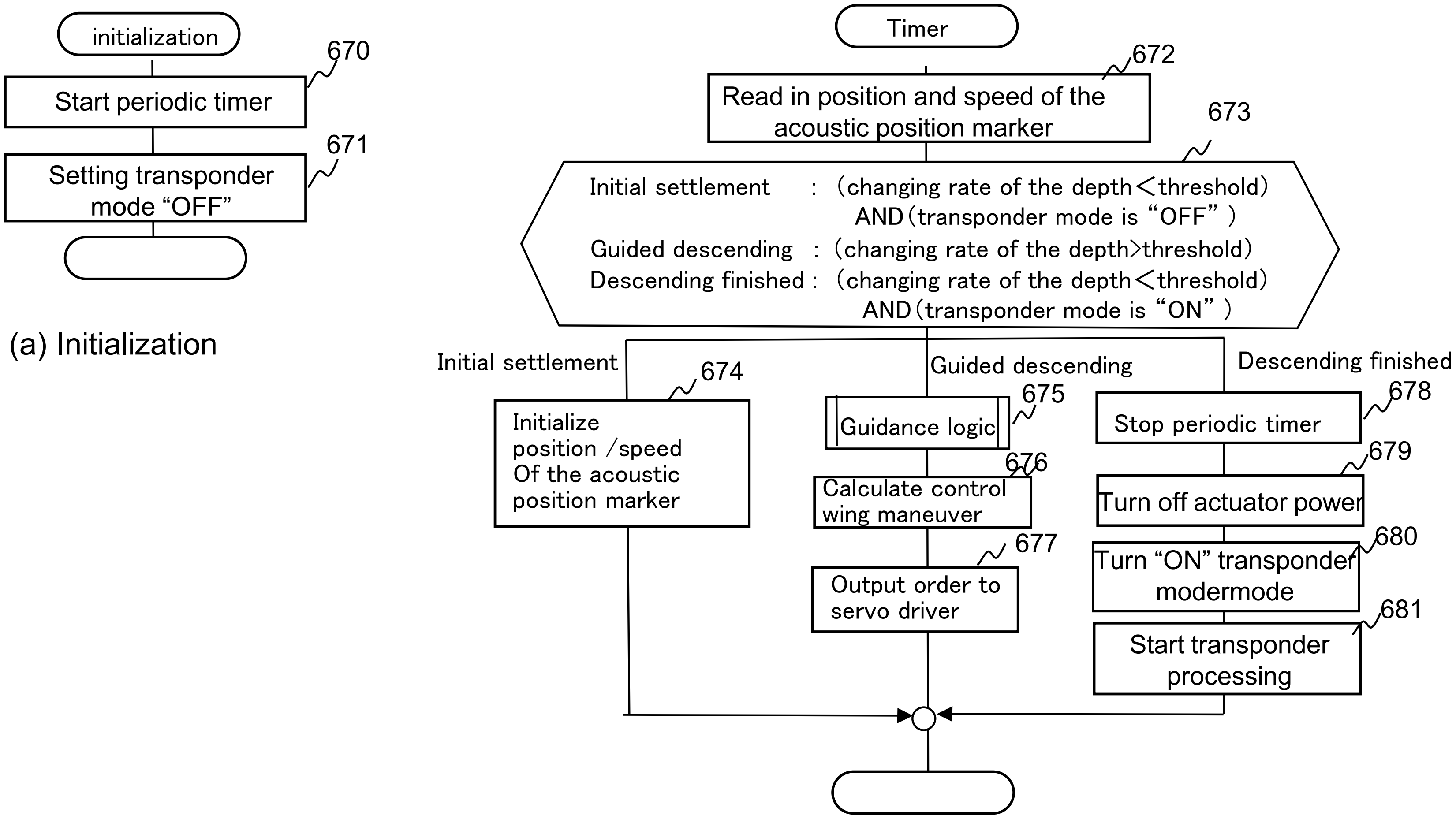
(a) **Acoustic position marker controller 289**

(b) the position marker ship control system

(c) Control wing

Fig. 48

a processing flow diagram of the inertially guided acoustic position marker control device

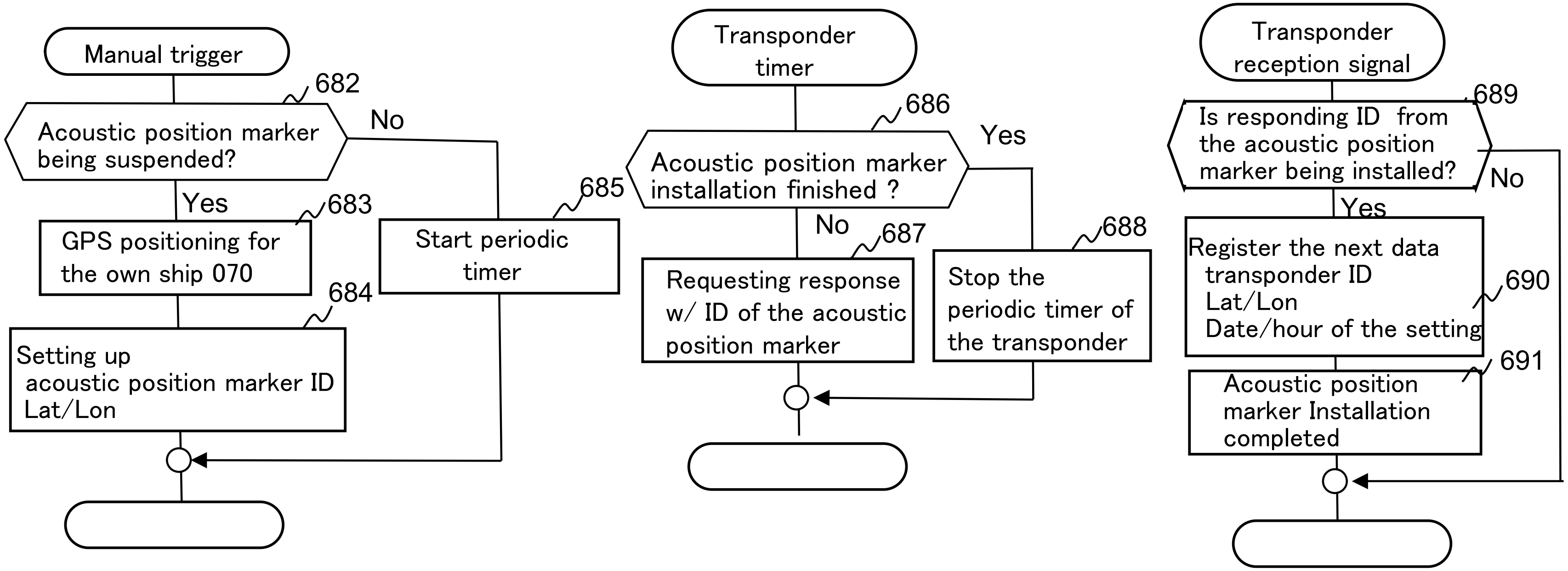


(a) Initialization

(b) processing flow of guidance of acoustic position marker

Fig. 49

processing flow diagrams of a position marker ship control device for inertially guided acoustic position markers



(a－1) processing of the position marker ship 070

(a－2)

(a－3)

ABSTRACT

The present invention pertains to: a system for collecting and lifting seabed mineral resources; and an apparatus for lifting the seabed mineral resources to the sea surface by filling a buoyancy tank with a liquid having a lower liquid-phase specific gravity than that of water at a normal temperature and sealing the tank to utilize the buoyancy thereof. According to the present invention, an autonomous underwater vehicle loads, in a cargo compartment, ballast for counteracting the buoyancy of the buoyancy tank when descending from the sea surface, descends by setting the specific gravity of the entire seabed resource lifting apparatus to be greater than 1.0, replaces the ballast with mineral resources on the seabed, and floats by setting the specific gravity of the entire seabed resource lifting apparatus to be less than 1.0. On the seabed, the ballast is replaced with the mineral resources by means of gravity.