



(86) Date de dépôt PCT/PCT Filing Date: 2016/04/06

(87) Date publication PCT/PCT Publication Date: 2017/03/09

(85) Entrée phase nationale/National Entry: 2017/04/10

(86) N° demande PCT/PCT Application No.: JP 2016/061280

(87) N° publication PCT/PCT Publication No.: 2017/038148

(30) Priorité/Priority: 2015/08/28 (JP2015-182281)

(51) Cl.Int./Int.Cl. *E21C 50/00* (2006.01)

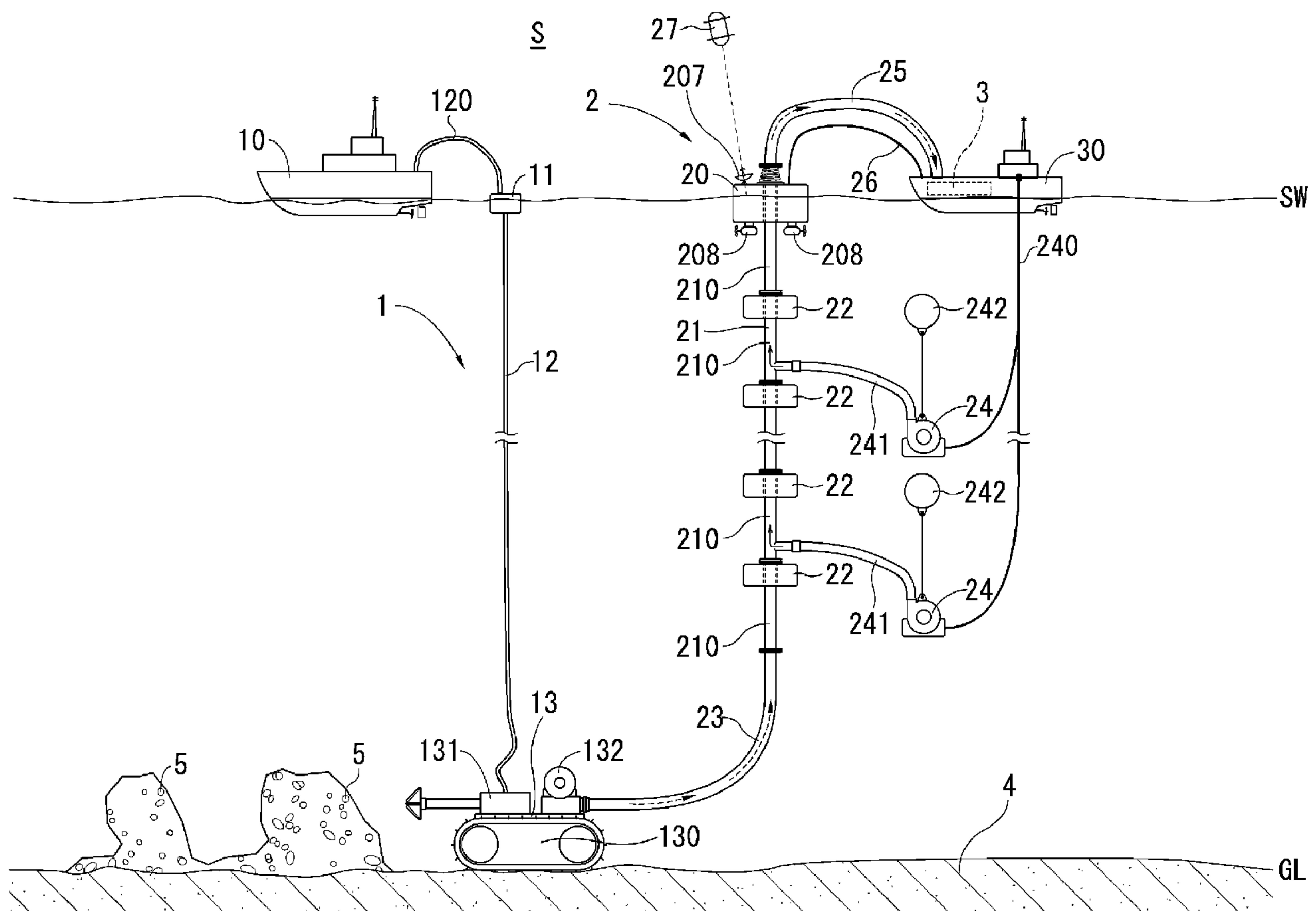
(71) Demandeurs/Applicants:
NAGATA, TETSUZO, JP;
NAKATANI, YUTAKA, JP

(72) Inventeurs/Inventors:
NAGATA, TETSUZO, JP;
NAKATANI, YUTAKA, JP

(74) Agent: NELLIGAN O'BRIEN PAYNE LLP

(54) Titre : SYSTÈME DE LEVAGE DE MINÉRAUX ET PROCÉDE DE LEVAGE DE MINÉRAUX

(54) Title: MINERAL LIFTING SYSTEM AND MINERAL LIFTING METHOD



(57) Abrégé/Abstract:

A mineral lifting system S comprises: a seabed work machine 13 comprising an excavator 131 to excavate minerals from the seabed, and a slurry pump 132 to suction and pump a solid-liquid mixture of minerals and seawater; a power generator to supply

(57) **Abrégé(suite)/Abstract(continued):**

power by electrical power cables 12 to the seabed work machine 13; a main float 20; a mineral lifting pipe 21 to feed the solid-liquid mixture to the main float 20 side; an auxiliary float 22 that is mounted on the mineral lifting pipe 21 at required intervals to impart buoyancy; and a selecting unit 3 to select and collect minerals from the solid-liquid mixture transported to the main float 20 side.

ABSTRACT

[Abstract]

A mineral lifting system S includes a seabed working machine 13, having an excavator 131, excavating minerals at a seabed, and a slurry pump 132, sucking in and pumping a solid-liquid mixture of the minerals and seawater, a generator, supplying electric power to the seabed working machine 13 by an electric power cable 12, a main float 20, a mineral lifting pipe 21, conveying the solid-liquid mixture to the main float 20 side, auxiliary floats 22, mounted to the mineral lifting pipe 21 at predetermined intervals and imparting a buoyancy, and a sorting unit 3, sorting and collecting the minerals from the solid-liquid mixture conveyed to the main float 20 side.

DESCRIPTION

TITLE OF INVENTION: MINERAL LIFTING SYSTEM AND MINERAL LIFTING METHOD

Technical Field

[0001] The present invention relates to a mineral lifting system and a mineral lifting method for mining and mineral lifting of valuable metals and other mineral resources present on a seabed.

Background Art

[0002] For example, an art, by which sand iron, tin, etc., contained in seabed sand in a shallow sea of approximately 20 m water depth, are sucked in together with the sand by a pump and conveyed onto land, has been established and is already being put to practical use industrially. Also, an art, by which bedrock, etc., containing mineral ore, is pulverized and fragmented at such a shallow seabed, is an art that is widely used in the mining field.

[0003] However in recent years, it has become clear, from actual surveys, etc., that numerous seabed mineral deposits are present in the territorial waters and the Exclusive Economic Zone (EEZ) of Japan. If iron, copper, zinc, gold, etc., contained in such mineral deposits can be mined and these metals can be conveyed to above a sea surface, even Japan, which is basically deemed to be poor in resources and has depended exclusively on imports, will be able to obtain resources domestically. Industries can thereby be activated further, especially domestically, and contributions can also be made to

the global supply of resources.

[0004] An art of pulverizing mineral ore on a deep seabed of, for example, 1600 to 5000 m water depth by a drilling machine already exists. However, an art for conveying the mineral ore, which has been pulverized in the deep sea, to above a sea surface has yet to be established. Although pump conveying and mechanical type (bucket type) conveying may be considered as conveying arts, mechanical types are extremely low in productivity and presently, pump type arrangements are mainly proposed. As an example of such a pump type arrangement, there is a mineral lifting apparatus described in Patent Literature 1.

[0005] The mineral lifting apparatus described in Patent Literature 1 has an arrangement where a U-pipe, with one side being a downcomer and the other side being a riser (corresponding to a mineral lifting pipe), is held vertically from a deep seabed to a sea surface, seawater is transported from an upper end opening of the riser to an upper end opening of the downcomer so that the seawater circulates inside the U-pipe, mineral masses mined at the deep seabed are delivered to a bottom portion of the riser, and, the characteristic of the U-pipe that liquid levels at the opening portions at both ends are maintained at the same height is used to make the mineral masses ride on the rising seawater rising through the riser and float to the sea surface.

Citation List

Patent Literature

[0006] Patent Literature 1: Japanese Published Unexamined Patent Application No. 2003-269070

Summary of Invention

Technical Problem

[0007] However, the conventional mineral lifting apparatus described above has the following problems.

That is, in a case of lowering and installing a steel mineral lifting pipe onto a seabed of, for example, 1600 to 5000 m water depth from a mineral ore processing ship, even if some buoyancy acts on the mineral lifting pipe itself, its practical weight will still be 50 to 150 tons. To support the mineral lifting pipe, which is such a heavy object, a large-scale mineral ore processing ship, etc., that is sturdy and has surplus buoyancy so as to be capable of bearing such weight sufficiently is required.

[0008] Also, with a long mineral lifting pipe that is connected to a mineral ore processing ship, etc., and is formed by connecting a large number of pipe bodies, which are constituent units, a large load such as mentioned above is more likely to be applied to a connection portion, the closer it is to the sea surface, and it was therefore an extremely difficult problem as to how to arrange a structure to firmly connect the respective pipe bodies.

[0009] Further difficulties such as the following are expected when an extremely long and heavy mineral lifting pipe such as described above is lowered and put in operation from a mineral ore processing ship or supporting ship. First, due

to agitation of the sea surface due to waves, the mineral ore processing ship, etc., will undergo movement such that the mineral lifting pipe shakes or bends relatively and there is a high possibility for this to become a cause leading to damage or destruction of the mineral lifting pipe.

[0010] Another point is that when the mineral ore processing ship, etc., must temporarily leave for safety when the weather is rough, as in a typhoon, etc., the mineral lifting pipe may have to be disconnected because travel may be obstructed if the mineral lifting pipe is kept connected. In such a case, there are such major problems as to how to disconnect the mineral lifting pipe, how to recover the disconnected mineral lifting pipe, etc.

[0011] Further, a problem, next to the mineral lifting pipe, is the development of a pump system capable of conveying the seawater, containing the pulverized mineral ore, from the deep seabed to the mineral ore processing ship on the sea surface. That is, although such conveying as described above from a deep sea of, for example, 1600 to 6000 m inevitably exceeds the capacity of a single pump and a pump system arranged by combining a plurality or a large number of pumps is thus needed, sufficient measures have not been taken conventionally.

[0012] The present invention has been invented in view of the above points, and an object thereof is to provide a mineral lifting system and a mineral lifting method incorporating a pump system capable of conveying seawater, containing pulverized mineral ore, from a deep seabed to a mineral ore processing ship

on a sea surface and being arranged so that a mineral lifting pipe, lowered to deep sea, will not drop off due to its own weight from a connection portion of a pipe body, etc., so that a mineral ore processing ship, etc., that supports the mineral lifting pipe does not have to be made larger than necessary to secure buoyancy, and so that when the sea is rough due to a typhoon, etc., the mineral lifting pipe will not become damaged due to rocking by waves of the mineral ore processing ship, etc., and the mineral ore processing ship, etc., will not have to discard the mineral lifting pipe in leaving for safety.

Solution to Problem

[0013] (1) To achieve the above object, a mineral lifting system according to the present invention is a mineral lifting system including a seabed working machine, capable of being operated to move and having an excavating portion, excavating minerals on a seabed surface or below a seabed, and a pump, sucking in and pumping a solid-liquid mixture containing the minerals obtained by excavating and seawater, an electric power supplying portion, having an electric power cable that supplies electric power to power the seabed working machine, a main float, having a predetermined buoyancy and floated on a sea surface or undersea, a mineral lifting pipe, having a predetermined length, connecting the main float and a pump of the seabed working machine, and conveying the solid-liquid mixture, sucked in by the pump and containing the minerals and seawater, to the main float side, auxiliary floats, disposed at predetermined intervals along a length direction of the mineral lifting pipe

and imparting a predetermined buoyancy to the mineral lifting pipe, and a mineral sorting portion, sorting and collecting the minerals from the solid-liquid mixture conveyed to the main float side by the mineral lifting pipe.

[0014] Actions of the mineral lifting system according to the present invention shall now be described for an operation of lifting valuable metals in a deep sea to above a sea surface as an example.

With the mineral lifting system, the seabed working machine is disposed at a prescribed deep seabed with a mineral deposit and the main float floats on the sea surface. Also, the mineral sorting portion or the electric power supplying portion, etc., can be installed, for example, on a mother ship or other working ship, and the electric power cable that constitutes the electric power supplying portion is connected to an electric power receiving portion of the seabed working machine. A traveling portion, the excavating portion, and the pump of the seabed working machine are driven by the electric power that is supplied.

[0015] Also, a signal cable, performing exchange of signals for performing control of the excavating portion, control of the traveling portion, or control of the pump, etc., of the seabed working machine, may be installed together with the electric power cable in a form of being attached thereto.

[0016] The pump of the seabed working machine and the main float are connected by the long mineral lifting pipe that is suspended in a vertical direction from the main float, and the

solid-liquid mixture conveyed by the mineral lifting pipe is arranged to be conveyed further to the mineral sorting portion installed on the working ship, etc.

[0017] A large number of the auxiliary floats are mounted to predetermined locations, for example, at fixed intervals of the mineral lifting pipe and impart the prescribed buoyancy to the mineral lifting pipe. The mineral lifting pipe is thereby floated so as not to drop to the seabed. Also, a lower end portion of the mineral lifting pipe close to the seabed and the pump of the seabed working machine are preferably connected with a flexible pipe so as not to hinder moving operations of the seabed working machine or so as not to cause hindrance even when a position of the mineral lifting pipe, which is buoyant undersea, changes.

[0018] By means of the main float and the auxiliary floats, the mineral lifting system imparts, to the long mineral lifting pipe, a buoyancy of a degree such that the mineral lifting pipe will not drop to the seabed. The auxiliary floats are disposed at predetermined intervals in the long direction of the mineral floating pipe and the weight of the mineral lifting pipe is sharingly supported by the auxiliary floats.

[0019] That is, if, when a large number of the auxiliary floats are mounted at predetermined intervals in the length direction of the mineral lifting pipe, each auxiliary float is made to impart a buoyancy corresponding to just the weight of a length of the mineral lifting pipe between each auxiliary float, the load of the long mineral lifting pipe can, in theory,

be prevented from acting on an upper portion of the mineral lifting pipe.

[0020] By thus making an appropriate buoyancy be imparted by the auxiliary floats, a large load in the gravity direction will not act biasedly on a certain portion, and the above arrangement is also effective in terms of making the load be applied evenly at predetermined intervals in the length direction of the mineral lifting pipe. Also by the above, the mineral lifting pipe can be prevented from breaking in the middle due to its own large load, and if the mineral lifting pipe is arranged by connecting a large number of pipe bodies, destruction of a connection portion of a pipe body, etc., can be prevented so that the mineral lifting pipe will not drop to the seabed.

[0021] Although the total buoyancy of the main float and the respective auxiliary floats that float the mineral lifting pipe is set as suited, a buoyancy sufficient to make the uppermost main float float on the sea surface is not necessarily required, and it is preferable for the buoyancy to be such that at least the lower end portion of the mineral lifting pipe can be made buoyant so as to be maintained in a state of not dropping to the seabed (a state of being adrift undersea without sinking).

[0022] Also, it is preferable for the buoyancy to be such that can maintain a state where, even if the lower end portion side of the mineral lifting pipe contacts the seabed, at least a further upper portion side is vertically buoyant undersea.

The mineral lifting pipe, which is a heavy object, is imparted with buoyancy by the main float and the respective auxiliary floats so that the mother ship or other working ship or processing ship that performs control of the mineral lifting system is not necessarily required to support the mineral lifting pipe, and therefore there is no need to make the ship large.

[0023] Also, while the system is in operation, the practical weight of the mineral lifting pipe will be heavier than when it is empty because the weight of the solid-liquid mixture conveyed through its interior is added thereto. Therefore, the buoyancy provided by the respective floats must obviously be set in consideration of this point and must not be set on the basis of the weight of the empty mineral lifting pipe.

[0024] By remote operation, the seabed working machine is made to move as suited and in the meantime, for example, excavation by the excavating portion is performed on or below the seabed with the mineral deposit to obtain mineral granules pulverized to a predetermined particle diameter. The mineral granules, together with the surrounding sand and seawater, are sucked in by the pump, passed through the mineral lifting pipe as a solid-liquid mixture, and conveyed to the main float side on the sea surface. The solid-liquid mixture that has been conveyed to the main float side is conveyed to the mineral sorting portion, and valuable minerals are collected therefrom.

[0025] The seabed working machine is used upon being placed

on the seabed in a region that not only has valuable minerals, such as noble metals, rare metals, etc., present on the seabed surface or below the seabed at a water depth, for example, of several thousand meters, but also has large amounts of useful resources, such as methane hydrate (for example, near-surface methane hydrate), which is a fossil fuel, etc. The mineral lifting system is also usable as a system that lifts useful resources other than minerals from a deep seabed to above a sea surface.

[0026] (2) The present invention may be of an arrangement where the pump that the seabed working machine has is a slurry pump.

In this case, the solid-liquid mixture that contains the minerals and seawater can be conveyed (pumped) without damaging movable portions of the pump. Also, with a slurry pump, a solid-liquid mixture that contains a comparatively large amount of sand and mineral granules can be conveyed. With the present arrangement, even when a ratio of the solid, such as sand or the mineral granules, etc., and seawater changes during operation, this can be accommodated flexibly without difficulty and operation can be continued. Further, a slurry pump is structurally excellent in suction ability and can perform conveying of the solid-liquid mixture efficiently.

[0027] The slurry pump is not restricted in particular in type or structure as long as it can convey the above-described solid-liquid mixture without damaging the movable portions. A gravel pump, sand pump, or hose pump, etc., can be cited as

examples.

[0028] (3) The present invention may be of a structure that includes an auxiliary pump that injects a liquid flow of predetermined pressure to a predetermined location of the mineral lifting pipe to assist the conveying of the solid-liquid mixture.

In this case, even if a pump, capable of singly conveying the solid-liquid mixture to above the sea surface from a deep seabed of, for example, several thousand meters, is not available, conveying of a long distance of, for example, several thousand meters from the deep seabed to above the sea surface is made possible by the auxiliary pump assisting the conveying by injecting the liquid flow of predetermined pressure to an intermediate portion of the mineral lifting pipe.

[0029] From the above-described purpose, the auxiliary pump is not required to inject the solid-liquid mixture into the mineral lifting pipe and suffices to inject seawater in the surroundings, and therefore a pump other than a slurry pump, for example, a pump, such as a multistage centrifugal pump having an impeller or a diaphragm pump, etc., may be adopted.

[0030] Presently, it is considered difficult to develop a practical pulverized mineral ore conveying pump for a deep sea, for example, of not less than 1600 m, and it is easily imagined that development of superabyssal parts of 4000 to 6000 m is extremely difficult. As a solution, it is effective to combine a plurality or a large number of existing pumps. When the mineral lifting pipe becomes as long as several thousand meters,

a solid-liquid mixture, containing pulverized mineral ore, cannot be conveyed in particular to a working ship on the sea surface by a single sea-submerged lift pump (mixed flow or diagonal flow).

[0031] However, if the problem is that there is insufficient energy to convey the solid-liquid mixture to an intermediate portion of the mineral lifting pipe, this can be solved by injecting high-pressure seawater at a low flow rate into the intermediate portion of the mineral lifting pipe by a pump. The power (energy) that a pump transmits to a fluid is determined by the product $P \times Q$ of pressure P and flow rate Q , and therefore a pump with a pressure that is an ultrahigh pressure and an extremely low flow rate is favorable for improving efficiency. Also, the pump can be made compact if the flow rate is low.

[0032] (4) The present invention may be of an arrangement that includes a GPS receiver and a position correcting apparatus, which compares position information, received by the GPS receiver, with a predetermined set position of the mineral lifting system to perform correction of position so as to maintain the set position.

In this case, a GPS (global positioning system) can be used to maintain the position of the mineral lifting system that has been set in advance. That is, the position information, indicating the position of the mineral lifting system, is acquired by the GPS receiver that is installed at a predetermined location (for example, on the main float, etc.)

of the mineral lifting system.

[0033] Next, position information, which is set in advance and serves as a basis, and the position information acquired by the GPS receiver are compared by means of the position correcting apparatus. Then, based on the difference, the position of the mineral lifting system (the position of the main float in the present case) is corrected by being moved by the position correcting apparatus so as to maintain the position (set position) serving as the basis or so as to approach (move toward) the position serving as the basis. The correction of position may be performed constantly during the operation of the system or may be performed at every fixed time interval.

[0034] The position correcting apparatus is disposed at a predetermined position of the mineral lifting system, which is buoyant in the sea as a whole, and is capable of moving a portion or an entirety of the system. The arrangement of the position correcting apparatus is not restricted in particular as long as it can compare the position information, obtained by the GPS receiver, and the basis position information, determined in advance, and can correct the position based on the difference.

[0035] For example, there are a motor, a plurality of screws, driven by the motor and differing in propulsion direction, a battery, which is to be a drive source of the motor, a control portion, which compares the position information and selectively drives the motor and the screws according to the comparison result, etc. Also, a plurality of position correcting apparatuses may be disposed inside the system.

[0036] Also, although the position correcting apparatus is preferably provided at a member on which the GPS receiver is installed, this does not have to be so necessarily, and setting may be performed as suited. For example, both the GPS receiver and the position correcting apparatus may be provided on the main float, or the GPS receiver may be provided at a float that supports the electric power cable if such a float is provided and the position correcting apparatus may be provided on the main float. Even in the latter case, correction of position is made possible practically without any difference to the former case as long as a distance between the float that is the supporting portion of the electric power cable and the main float is structurally kept fixed or substantially fixed.

[0037] (5) The present invention may be of an arrangement that includes a water feeding/draining apparatus that adjusts the buoyancy of the main float by feeding water into an interior and draining water to an exterior of the same float.

In this case, the buoyancy of the main float itself can be adjusted by taking seawater into the interior of the main float or draining the seawater in the interior to the exterior by means of the water feeding/draining apparatus. By thus adjusting the buoyancy of the main float, a portion of the main float can be exposed from the sea surface or the entirety can be sunken below the sea surface. Also, when made to sink, the main float can be adjusted in height below the sea surface.

[0038] When the main float is sunken below the sea surface, the main float is made less likely to be influenced by waves

(up/down motion of the sea surface). For example, if, when the weather is rough, as in a typhoon or when a typhoon approaches, the main float is kept floating on the sea surface, it will receive the influence of violent waves and undergo up/down motion and rolling repeatedly, thereby increasing a possibility of deformation or damage of a mounting portion of the mineral lifting pipe connected to the main float or a peripheral portion thereof. Waves at the sea surface occur from several meters to approximately 10 m below the sea surface in many cases, and therefore if the main float can be maintained to be buoyant at a deeper position, the influence of waves can mostly be avoided even in a typhoon.

[0039] Although the structure of the water feeding/draining apparatus is not restricted in particular, the structure may be such that the main float is equipped with a waterproof lithium storage battery, a pump driven by the electric power of the battery, a water intake valve, and a water draining valve, and seawater in a space in the interior of the main float can be drained or water can be taken in from the outside by driving of the pump to adjust the amount of seawater.

[0040] (6) The present invention may be of an arrangement that includes a working ship and where the working ship has the electric power supplying portion and the mineral sorting portion, and the electric power cable, constituting the electric power supplying portion, and a feed pipe, constituting the mineral sorting portion and receiving the solid-liquid mixture from the mineral lifting pipe, can be disconnected in

a state enabling recovery of system operation.

[0041] In this case, the electric power cable and the feed pipe are connected and are functioning respectively during system operation. When the working ship must leave the site sea area, such as when the working ship must call at a port, for example, when the weather is rough due to the approaching of a typhoon or by some other reason, etc., the electric power cable or the feed pipe can be disconnected.

[0042] In such a case, even after being disconnected, the disconnected side is arranged to be in a state of being fixed or connected to some supporting portion, such as a float, etc., so that the electric power cable or the feed pipe will not sink undersea or drop to the seabed even upon disconnection.

[0043] When the reason for causing the working ship to leave is resolved, system operation can be restarted by making the working ship return to the working sea area, connecting the electric power cable or the feed pipe to the working ship side, and recovering the mineral lifting system to the original state. Disengagement and recovery of the working ship from and to the system are thus enabled, and the system can thus be employed readily because movement of the working ship can be performed flexibly without occurrence of a circumstance where, for example, the ship must leave for safety upon discarding the main float or the mineral lifting pipe, etc.

[0044] (7) The present invention may be of an arrangement having a suspension apparatus, supporting the same mineral lifting pipe, at a portion of the main float to which the mineral

lifting pipe is connected, and where, at a vicinity of the suspension apparatus, the same mineral lifting pipe is made capable of vibrating within a predetermined range of deflection inside a gap through which the same mineral lifting pipe is passed.

In this case, the mineral lifting pipe is supported by the suspension apparatus at the main float, through or to which the mineral lifting pipe is passed or connected, and moreover, at the vicinity of the suspension apparatus, the same mineral lifting pipe is made capable of vibrating or swinging within a predetermined range of deflection inside the gap, and therefore the corresponding portion of the mineral lifting pipe is high in degree of freedom of movement and will not be in a fixed state.

[0045] With the present arrangement, especially when the main float is floating on the sea surface, the mineral lifting pipe can undergo advancing and retreating movements in the length direction, vibration or swinging in a diameter direction, etc., and thus move freely to some degree in a state of not accompanying much deformation at the vicinity of the suspension apparatus even if the main float undergoes up/down motion and rolling repeatedly upon receiving the influence of waves, and therefore damage or destruction due, for example, to metal fatigue is unlikely to occur.

[0046] Although the structure of the suspension apparatus is not restricted in particular, it is constituted, for example, of a link mechanism, etc., combined with a coil spring or

energizing body capable of supporting the mineral lifting pipe. The suspension apparatus has an arrangement capable of supporting the practical weight of the mineral lifting pipe, to which buoyancy is imparted by the auxiliary floats at the undersea side, and having a cushioning action when the mineral lifting pipe undergoes advancing and retreating movements in its length direction.

[0047] (8) The present invention may be of an arrangement where auxiliary floats are disposed at predetermined intervals in a length direction of the electric power cable and impart a predetermined buoyancy to the electric power cable. In this case, as in the case of the mineral lifting pipe described above, the predetermined buoyancy is imparted to the electric power cable by the buoyancy of the auxiliary floats. The electric power cable can thereby be prevented from breaking at an intermediate portion in the length direction due to its own weight.

[0048] (9) The present invention may also be of an arrangement where the mineral sorting portion includes a wastewater processing apparatus. In this case, at the same time as sorting and collecting the minerals by means of the mineral sorting portion, clarified water, resulting from applying a predetermined processing to wastewater by means of the wastewater processing apparatus, can be disposed of by ocean disposal (also referred to as "ocean dumping"), etc.

[0049] (10) The present invention may also be of an arrangement where the mineral sorting portion includes a

magnetizing apparatus that magnetizes and sorts the minerals. In this case, to counter a problem where seabed mud, which rises together with the lifted water, becomes a cause of environmental destruction, metals or minerals contained in the lifted sea can be collected by the magnetizing apparatus, which is an electric type magnet, etc., provided on a mineral ore processing ship, and thereafter, the seabed mud can be eliminated by the same method as a method used in general sewage processing, such as a sedimentation method, etc. That is, the present arrangement may be accommodated by the working ship being a mineral ore processing ship equipped with the wastewater processing device.

[0050] Iron, chromium, nickel, cobalt, etc., can be cited as examples of minerals with magnetic properties. All of these minerals are valuable metals and can be collected by performing sorting efficiently from lifted water lifted from the seabed to above the sea surface.

[0051] (11) The present invention may be of an arrangement where the mineral lifting pipe has a double pipe structure made of steel and a light alloy, a structure, with which a steel pipe is reinforced with carbon fibers, or a structure, with which a peripheral wall is made hollow. In this case, the mineral lifting pipe can be made light in weight. In the first place, the greatest problem with a mineral lifting system is how to lighten the weight of the mineral lifting pipe that may reach several thousand meters in total length. For lightening the weight of the mineral lifting pipe, there is, in addition to the method of lightening the practical weight by imparting

buoyancy to the mineral lifting pipe as described above, the method of lightening the weight of the mineral lifting pipe itself as in the invention of the present clause.

[0052] As a method of lightening the weight of the mineral lifting pipe itself, there is, for example, a method of arranging the mineral lifting pipe to have a double pipe structure made of light alloy or steel and having an airtight space between an inner pipe and an outer pipe. It is also possible to provide an airtight space in a peripheral wall to cancel out, by its buoyancy, a portion of the weight of the mineral lifting pipe, and burdening of another location due to the weight of the mineral lifting pipe itself can thereby be alleviated.

[0053] As another method for lightening the weight of the mineral lifting pipe itself, there is, for example, a method of arranging the mineral lifting pipe to be one where an outer surface of an inner pipe, manufactured from steel, is made of resin reinforced with carbon fibers. A reinforcing pipe made of resin also contributes to protection of an inner pipe made of metal.

[0054] (12) The present invention is a mineral lifting method where a mineral lifting pipe, conveying a solid-liquid mixture, containing minerals, excavated at a seabed surface or below the seabed and pulverized, and seawater, to above a sea surface, is imparted with a predetermined buoyancy by a float. With the present method, when the mineral lifting pipe is supported using a main float, floating on the sea surface, etc.,

so that the mineral lifting pipe does not sink to the seabed, the predetermined buoyancy can be imparted to the mineral lifting pipe so that, for example, by making the weight of the mineral lifting pipe be the same as the weight resulting from subtracting the buoyancy from the weight of the mineral lifting pipe, weight is practically made not to act on the main float that supports the mineral lifting pipe. Also, by making the buoyancy due to the float slightly less than that described above, the mineral lifting pipe can be kept balanced so as to be oriented in a vertical direction.

[0055] The present invention is one where the mineral lifting pipe and a communication/electric power cable are supported by a float to lighten a gravitational force on the mineral lifting pipe. Also, the present invention may incorporate a large float, which is made of metal, is buoyant on the sea surface, and has a cavity in its interior, and a mineral lifting pipe and a communication/electric power cable that are supported by the float, and may also incorporate a large float, having seawater draining and seawater intake valves for buoyancy adjustment to accommodate the weight of the mineral lifting pipe.

[0056] Also, by driving a waterproof storage battery and a pump made to ride on (installed on) the large float and feeding and draining seawater to and from a cavity portion at a lower portion of the large float, the large float can be made to have a submerging function.

[0057] Further, to lighten the weight of the mineral

lifting pipe supported by the large float, a set of small floats, installed at intermediate portions of the mineral lifting pipe sea undersea, may also be included. Also, a mineral lifting pipe, made of resin reinforced with carbon fibers to lighten weight and maintain strength, may be included.

[0058] To lighten the weight, a mineral lifting pipe having a cavity in a gap of a double pipe may be included. A structure may be arranged with which the mineral lifting pipe and the communication/electric power cable that are supported by a large float can be disengaged from a mineral ore processing ship during rough weather or when the mineral ore processing ship leaves a site.

[0059] A system may be arranged where a mineral ore conveying pump is made to ride on (is installed on) a seabed mineral ore mining machine and an intake pipe is shortened. A pump system, which injects pressurized water into an intermediate portion of the mineral lifting pipe to supply fluid energy, may also be included.

[0060] Further, an electric type or permanent magnet type magnet apparatus, arranged to collect mineral ore from seawater, which contains pulverized mineral ore (finely granulated mineral ore) and is conveyed from the mineral lifting pipe to the mineral ore processing ship on the sea surface, may be included. Also, an apparatus that performs wastewater processing after mineral ore collection may be equipped on the mineral ore processing ship.

Advantageous Effects of the Invention

[0061] The present invention can provide a mineral lifting system and a mineral lifting method incorporating a pump system capable of conveying seawater, containing pulverized mineral ore, from a deep seabed to a mineral ore processing ship on a sea surface and being arranged so that a mineral lifting pipe, lowered to the deep seabed, will not drop off due to its own weight from a connection portion of a pipe body, etc., so that a mineral ore processing ship, etc., that supports the mineral lifting pipe does not have to be made larger than necessary to secure buoyancy, and so that when the sea is rough due to a typhoon, etc., the mineral lifting pipe will not become damaged due to rocking by waves of the mineral ore processing ship, etc., and the mineral ore processing ship, etc., will not have to discard the mineral lifting pipe in leaving for safety.

Brief Description of Drawings

[0062] [Fig. 1] is an explanatory diagram of an embodiment of a mineral lifting system according to the present invention.

[Fig. 2] is a partially-omitted sectional explanatory diagram of a structure that suspends a mineral lifting pipe by means of a main float and auxiliary floats.

[Fig. 3] is a sectional explanatory diagram of a structure of the main float and its vicinity.

[Fig. 4] is an explanatory diagram of a structure of a wastewater processing apparatus included in a working ship used in the mineral lifting system.

[Fig. 5] is a sectional explanatory diagram of a structure of a pipe body that constitutes the mineral lifting pipe used

in the mineral lifting system.

[Fig. 6] is a sectional explanatory diagram of another structure of a pipe body that constitutes the mineral lifting pipe used in the mineral lifting system.

[Fig. 7] shows another structure of an auxiliary float, with Fig. 7(a) being a vertical sectional explanatory diagram and Fig. 7(b) being a sectional explanatory diagram corresponding to A-A.

Description of Embodiments

[0063] An embodiment of the present invention shall now be described in further detail with reference to Fig. 1 to Fig. 6.

A mineral lifting system S includes a mining unit 1, which performs mining of minerals at a seabed, a mineral lifting unit 2, which lifts the mined minerals and seawater to above a sea surface, and a sorting unit 3, which is a mineral sorting portion that sorts valuable minerals from a solid-liquid mixture lifted by the mineral lifting unit 2.

[0064] (Mining Unit 1)

The mining unit 1 has a seabed working machine 13 that can be externally operated to move. The seabed working machine 13 includes a crawler traveling machine 130, an excavator 131, installed on an upper portion thereof, and a slurry pump 132, which sucks in and pumps the solid-liquid mixture containing the mineral, obtained by excavation, and seawater. The seabed working machine 13 is arranged with a structure capable of working under high pressure at a deep seabed by making

respective portions highly watertight, etc. The slurry pump 132, together with respective pressure injection pumps 24 to be described later, constitutes a pump system.

[0065] The excavator 131 is arranged to be capable of pulverizing and excavating minerals of a mineral deposit by rotation or vibration of a drill at a tip. Another structure may be adopted instead for the excavator. The slurry pump 132 is capable of pumping the mixture (solid-liquid mixture) of the excavated and pulverized minerals and seawater and, for example, a diagonal flow type or a mixed flow type may be adopted.

[0066] The slurry pump 132 is not restricted in particular in pumping capability and suffices to have a capability of being able to lift the solid-liquid mixture of seawater and the pulverized minerals to above the sea surface, at least in cooperation with the pressure injection pumps 24 that are auxiliary pumps to be described later. In this case, for example, a conveying energy from the slurry pump 132 to a lower portion of a mineral lifting pipe 21, to be described later, may be supplied by the slurry pump 132, and a conveying energy inside the mineral lifting pipe 21 further upward may be supplied by the pressure injection pumps 24, which are a plurality of auxiliary pumps to be described later that are provided at intermediate portions of the mineral lifting pipe 21.

[0067] In the seabed working machine 13, an electric power cable 12 arranged to supply electric power to power the crawler traveling machine 130, the excavator 131, and the slurry pump

132, is connected to an electric power receiving portion (symbol omitted). An end portion at a side of the electric power cable 12 above the sea surface is connected once to a float 11 floating on the sea surface and a weight of the electric power cable 12 is thus supported by the float 11. To lighten the weight of the electric power cable 12 applied to the float 11, an auxiliary float that imparts buoyancy may be mounted in the same manner as with the mineral lifting pipe 21 to be described later.

[0068] Electric power from a generator (not shown), which is an electric power supplying portion installed on a working ship 10, which is a mother ship, is arranged to be supplied via an electric power cable 120 to the electric power cable 12 connected to the float 11. Also, a signal cable (not shown), which exchanges signals for performing control of the excavator 131, control of the crawler traveling machine 130, or control of the slurry pump 132 of the seabed working machine 13, etc., with a control portion included in the working ship 10, is installed on the power cables 12 and 120 in a form of being attached thereto.

[0069] (Mineral Lifting Unit 2)

The mineral lifting unit 2 has the mineral lifting pipe 21. The mineral lifting pipe 21 is formed by connecting a large number of pipe bodies 210 of predetermined length to a length, for example, of 5000 m in correspondence to a depth of a sea area to be subject to mineral lifting work. The structure of each pipe body 210 shall be described in detail later. The long mineral lifting pipe 21 is practically connected to a main float

20 so as to be hung thereon with an upper end side floating on the sea surface. Also, at an undersea side, the mineral lifting pipe 21 is practically connected to auxiliary floats 22 so as to be hung thereon at every predetermined interval in a length direction (at every pipe body 210 in the present embodiment).

[0070] First, a structure of the main float 20 and a structure connecting the mineral lifting pipe 21 to the main float 20 shall be described with reference to Fig. 3.

The main float 20 has a sealed case 200 with a structure that is watertight and hollow. An outer shape of the sealed case 200 is a so-called donut shape and a space portion 201 is formed in an interior so as to draw a circle in plan view. Also, a through hole 202 of circular hole shape, which is separated by a wall portion from the space portion 201, is provided so as to penetrate through a central portion of the sealed case 200.

[0071] The space portion 201 inside the sealed case 200 is divided into upper and lower portions in a liquid-tight state by a separating member 203 that is fixed across an entire circumference at a substantially middle position in an up/down direction. A water feeding/draining pump 204, which is fixed to the separating member 203 and constitutes a water feeding/draining apparatus, is disposed in an upper space portion 201a. Also, similarly, a battery 205 is disposed that is fixed to the separating member 203, and as the battery 205 in the present embodiment, a waterproof lithium storage battery is adopted and supplies electric power to the water

feeding/draining pump 204.

[0072] The battery 205 is connected to a control board 206, and an electric power cable 26 is connected from the exterior to the control board 206. The electric power cable 26 is connected to a generator (not shown), which is an electric power supplying portion installed on a mineral processing ship 30 to be described later, and electric power supplied from the generator is stored in the battery 205.

[0073] A lower space portion 201b, which is divided by the separating member 203 inside the sealed case 200, is a water storage tank, and an arrangement is made so that a water amount (and if necessary an air amount) in an interior of the lower space portion 201b can be adjusted by the water feeding/draining pump 204. By adjustment of the water amount, the main float 20 can be made to float on the sea surface by increasing its buoyancy or can be made to submerge by decreasing the buoyancy as necessary. The submerging may be performed so that just the main float 20 becomes submerged or so that an entirety, including the mineral lifting pipe 21, becomes submerged and a selection can be made as suited.

[0074] A GPS receiver 207, which receives signals from a GPS satellite 27, is installed on an upper surface of the sealed case 200. Electric power is arranged to be supplied via the electric power cable 26 to the GPS receiver 207 as well. Also, a plurality of propulsion machines 208, which constitute a position correcting apparatus, are mounted to a lower surface of the sealed case 200. Each propulsion machine 208 has a

structure by which a propulsive force is obtained by rotating a screw by a motor.

[0075] The arrangement of the position correcting apparatus includes the control board 206, which is a control portion capable of comparing position information, obtained by the GPS receiver, and basis position information, determined in advance, and actuating the respective propulsion machines 208 based on the difference to correct a position. The respective propulsion machines 208 are arranged to be supplied with the electric power from the battery 205, and by suitably combining and driving the respective propulsion machines 208 by automatic control based on GPS, the main float 20 can be moved in a predetermined direction on the sea surface.

[0076] A pipe body 210 at an upper end portion of the mineral lifting pipe 21 is passed through the through hole 202 of the sealed case 200. Each of the large number of pipe bodies 210 that constitute the mineral lifting pipe 21 has the structure shown in Fig. 5. Each pipe body 210 has connection flanges 211 and 212 at respective ends in a length direction and the pipe portion has a double pipe structure constituted of an inner pipe 213 and an outer pipe 214. A space portion 215 of so-to-speak circular pipe shape, which gives rise to buoyancy to achieve lightweightness, is formed between the inner pipe 213 and the outer pipe 214.

[0077] An outer diameter of the outer pipe 214 of the pipe body 210 is formed to a diameter smaller than an inner diameter of the through hole 202 of the sealed case 200, and a gap 209

is provided between the pipe body 210 and the through hole 202. Also, with the uppermost pipe body 210, the flange 211 (attached after inserting the pipe body 210 through the through hole 202) is at an upper side of the sealed case 200 and a compression coil spring 28, which is made gradually smaller in diameter at an upper portion side, is disposed between the upper surface of the sealed case 200 and the flange 211.

[0078] By the present structure, the pipe body 210 and the large number of other pipe bodies 210 connected therebelow are cushioned by an energizing force of the compression coil spring 28 even upon moving up and down, and impacts and large loads applied to the main float 20 can be lightened. Also, by an action of the gap 209, the pipe body 210 is made capable of moving freely or swinging within a certain fixed range in an interior of the through hole 202. A flexible supply pipe 25 is connected to an upper end of the pipe body 210 at the upper end portion, and a tip side of the supply pipe 25 is introduced into the sorting unit 3 to be described later.

[0079] As described above, the mineral lifting pipe 21 is arranged by connecting the large number of pipe bodies 210 in watertight manner, and one end portion of a flexible relay pipe 23 of predetermined length is connected to a lower end portion of a lowermost pipe body 210. Another end portion of the relay pipe 23 is connected to a discharge port (symbol omitted) of the slurry pump 132. An intake port (symbol omitted) of the slurry pump 132 is disposed at a vicinity of a drill of the excavator 131 and is made capable of sucking in excavated and

pulverized minerals together with seawater.

[0080] As mentioned above, at the undersea side, the long mineral lifting pipe 21 is practically connected at every pipe body 210 to the auxiliary floats 22 in a length direction in a manner such that the upper portion side flanges 211 are hung thereon. Each auxiliary float 22 has a sealed case 220 with a structure that is watertight and hollow. An outer shape of the sealed case 220 is a so-called donut shape and a space portion 221 is formed in an interior so as to draw a circle in plan view. Also, a through hole 222 of circular hole shape, which is separated by a wall portion from the space portion 221, is provided so as to penetrate through a central portion of the sealed case 220.

[0081] An outer diameter of the outer pipe 214 of each pipe body 210 is formed to a diameter smaller than an inner diameter of the through hole 222 of the sealed case 220, and a gap 229 is provided between the pipe body 210 and the through hole 222. Although a specific structure of the auxiliary float 22 is not shown, it is a structure (known structure) that enables installment in a fitting manner onto and detachment from a pipe portion of the pipe body 210 in a lateral direction.

[0082] With the present structure, the large number of auxiliary floats 22 are capable of sliding relative to the respective pipe bodies 210 even when the respective pipe bodies 210 move up and down, and the sliding relative to each other stops when an auxiliary float 22 contacts the flange 211 of a pipe body 210 or contacts an injection pipe 241 of a pressure

injection pump 24 to be described below. There is effective mutual clearance between the auxiliary floats 22 and the respective pipe bodies 210 and therefore impacts and large loads are unlikely to act. Also, by an action of the gap 229, each pipe body 210 is made capable of moving freely or swinging within a certain fixed range in an interior of the through hole 202.

[0083] Also, the respective auxiliary floats 22 are capable of imparting a predetermined buoyancy to the mineral lifting pipe 21. This buoyancy may be set, for example, to be the same as a weight of the mineral lifting pipe 21 so that the weight of the mineral lifting pipe 21 is hardly applied to the main float 20. Or, the buoyancy may be set to be slightly less than the weight of the mineral lifting pipe 21 so that the weight of the mineral lifting pipe 21 is applied suitably to the main float 20 and the mineral lifting pipe 21 is more stabilized undersea. An auxiliary float 22 that is positioned in a deep sea may include a rib structure for reinforcement in its interior as in an auxiliary float 22a to be described later so as to withstand high water pressure.

[0084] Injection pipes 241, each connected to a discharge port (symbol omitted) of a pressure injection pump 24, are connected to pipe portions of pipe bodies 210, which, among the pipe bodies 210 constituting the mineral lifting pipe 21, are positioned at predetermined intervals. Each pressure injection pump 24 sucks in seawater in its surroundings and injects it into an interior of the mineral lifting pipe 21 and assists upward conveying (pumping) of the lifted water

(solid-liquid mixture) passing through the mineral lifting pipe 21.

[0085] Each pressure injection pump 24 is arranged to be maintained at a predetermined depth by being imparted with a buoyancy of a float 242 connected by a suspending wire 243. Also, electric power is supplied to each pressure injection pump 24 via an electric power cable 240 connected to the generator on the mineral processing ship 30 that is the working ship. A float for imparting buoyancy may also be attached to the electric power cable 240.

[0086] The electric power cable 120, connecting the working ship 10 to the float 11, is of a structure enabling disconnection from the float 11. Also, the mineral processing ship 30 is of a structure capable of disconnecting the supply pipe 25 and the electric power cable 26 from the main float 20. By these arrangements, when the working ship 10 and the mineral processing ship 30 are to call at a port, etc., the ships can be made to leave a work site in a state enabling recovery subsequently.

[0087] (Sorting Unit 3)

The sorting unit 3 is installed on the mineral processing ship 30. The generator (not shown) is installed on the mineral processing ship 30 and this generator supplies electric power to the main float 20 and the respective pressure injection pumps 24. The sorting unit 3 sorts valuable minerals from the solid-liquid mixture of seawater and pulverized minerals lifted by the mineral lifting unit 2.

[0088] Fig. 4 shall now be referenced. A method for processing the solid-liquid mixture, which contains pulverized minerals 50 and has risen inside the mineral lifting pipe 21 and has reached the mineral ore processing ship 30 on the sea surface through the supply pipe 25, shall now be described.

The sorting unit 3 includes, in the order of processing, a sorting tank 31, a sedimentation tank 32, a water storage tank 33, and a collection tank 34. The sedimentation tank 32, the water storage tank 33, and the collection tank 34 constitute a wastewater processing apparatus.

[0089] The solid-liquid mixture that contains the pulverized minerals 50 is conveyed to the sorting tank 31 from the supply pipe 25. Pulverized minerals 50 that are magnetic materials are magnetized and collected by an electromagnet (symbol omitted) mounted to a tip of an arm of a rotating body 311. Minerals that are not magnetic materials and other valuable minerals are collected by any of various known means, for example, by using a sieve, etc.

[0090] Also, seawater containing sludge, which has passed through the sorting tank 31, is conveyed to the sedimentation tank 32 upon passing through a screen 320 and the sludge sediments to a tank bottom and is thereby separated. The seawater removed of the sludge is conveyed to the water storage tank 33 upon passing through a screen 331 and is conveyed to the subsequent collection tank 34 by a pump 330. Inside the collection tank 34, finer sludge is made to sediment by chemical processing, etc., and is thereby removed, and the clarified

seawater after processing is made to pass through a drain pipe 35 and be discharged to the exterior (sea) by a waterwheel 340.

[0091] (Actions)

Actions of the mineral lifting system S according to the present invention shall now be described by way of a case of performing a process of lifting valuable minerals in the deep sea to above the sea surface as an example.

As shown in Fig. 1, with the mineral lifting system S, the seabed working machine 13 is disposed at a prescribed deep seabed 4 with a mineral deposit 5 and the main float 20 floats on the sea surface.

[0092] The seabed working machine 13 is operated by signals from a control portion on the working ship 10 and using the electric power supplied via the electric power cable 120 to perform excavation by means of the excavator 131 while moving by means of the traveling machine 130. In parallel to the excavation, the mixture (solid-liquid mixture) of the pulverized minerals 50 (shown in Fig. 4) and seawater is sucked in and pumped upward, from the relay pipe 23 and through the mineral lifting pipe 21, by the slurry pump 132. In this process, energy due to water flows is injected by the large number of pressure injection pumps 24 into a vertical direction path of the mineral lifting pipe 21, the solid-liquid mixture is lifted to the sorting unit 3 on the mineral processing ship 30 at the upper side, and just the clarified processed water is dumped to the sea.

[0093] Also, the large number of auxiliary floats 22 are

connected to the mineral lifting pipe 21 and impart the prescribed buoyancy to the mineral lifting pipe 21. With the mineral lifting system S, a buoyancy that is approximately such that the long mineral lifting pipe 21 of several thousand meters will not drop to the seabed 4 is imparted to the mineral lifting pipe 21 by the main float 20 and the respective auxiliary floats 22. A predetermined number (a large number) of the auxiliary floats 22 are disposed in the length direction of the mineral lifting pipe 21, and therefore the weight of the mineral lifting pipe 21 is sharingly supported according to the pipe bodies 210 by the auxiliary floats 22.

[0094] That is, if when the large number of auxiliary floats 22 are mounted at predetermined intervals in the length direction of the mineral lifting pipe 21, each auxiliary float 22 is made to impart a buoyancy corresponding to just the weight of a length of the mineral lifting pipe 21 between each auxiliary float 22, the load of the long mineral lifting pipe 21 can, in theory, be prevented from acting on an upper portion of the mineral lifting pipe 21.

[0095] By thus making an appropriate buoyancy be imparted by the auxiliary floats 22, a large load in the gravity direction will not act biasedly on a certain portion. The above arrangement is thus also effective in terms of making the load be applied evenly at predetermined intervals in the length direction of the mineral lifting pipe 21. Also by the above, the mineral lifting pipe 21 can be prevented from breaking in the middle due to its own large load and destruction of a

connection portion of a pipe body 210, etc., can be prevented so that a problem of the mineral lifting pipe 21 dropping to the seabed will not occur.

[0096] Although the total buoyancy of the main float 20 and the respective auxiliary floats 22 that float the mineral lifting pipe 21 is set as suited, a buoyancy sufficient to make the uppermost main float 20 float on the sea surface is not necessarily required, and it is preferable for the buoyancy to be such that at least the lower end portion of the mineral lifting pipe 21 can be made buoyant so as to be maintained in a state of not dropping to the seabed, that is, in a state of being adrift undersea without sinking. Also, it is preferable for the buoyancy to be such that can maintain a state where, even if the lower end portion side of the mineral lifting pipe 21 contacts the seabed, at least a further upper portion side is vertically buoyant undersea.

[0097] The mineral lifting pipe, which is a heavy object, is imparted with buoyancy by the main float and the respective auxiliary floats so that the working ship 10 or the mineral ore processing ship 30 that performs control of the mineral lifting system is not necessarily required to support the mineral lifting pipe, and therefore there is no need to make the ships large.

[0098] Also, while the system is in operation, the practical weight of the mineral lifting pipe 21 will be heavier because the weight of the solid-liquid mixture conveyed through its interior is added thereto. Therefore, the buoyancy

provided by the respective floats 2 and 22 must be set in consideration of this point and must not be set on the basis of the weight of the empty mineral lifting pipe 21.

[0099] Also, the main float 20 can be adjusted in buoyancy by adjusting the amount of water in its interior by means of the water feeding/draining pump 204. A portion of the main float 20 can thereby be exposed from the sea surface or the entirety can be sunken below the sea surface, for example, like a submarine. Also, when made to sink, the main float 20 can be adjusted in height (depth) below the sea surface.

[0100] When the main float 20 is sunken below the sea surface, the main float 20 is made less likely to be influenced by waves. For example, if, when the weather is rough, as in a typhoon or when a typhoon approaches, the main float 20 is kept floating on the sea surface, it will receive the influence of violent waves and undergo up/down motion and rolling repeatedly, thereby increasing a possibility of deformation or damage of a mounting portion of the mineral lifting pipe 21 connected to the main float 20 or a peripheral portion thereof.

[0101] Waves at the sea surface occur from several meters to approximately 10 m below the sea surface in many cases, and therefore if the main float 20 can be maintained, by remote operation, to be buoyant at a deeper position together with an upper portion of the mineral lifting pipe 21 and floating up of the main float 20 thereafter is made possible, the influence of waves can mostly be avoided even in a typhoon.

[0102] Also the main float 20 includes the GPS receiver 207

and the propulsion machines 208 and a GPS can thus be used to maintain the position of the mineral lifting system S that has been set in advance. That is, the position information, indicating the position of the mineral lifting system, is acquired by the GPS receiver 207 installed on the main float 20, and the position information, which is set in advance and serves as the basis, and the position information acquired by the GPS receiver 207 are compared by means of the position correcting apparatus.

[0103] Then, based on the difference, the position correcting apparatus performs correction of position by actuating the respective propulsion machines 208 so that the position of the main float 20 is maintained at the position (set position) serving as the basis or made to approach (move toward) the position serving as the basis. The correction of position may be performed constantly during the operation of the mineral lifting system S or may be performed at every fixed time interval (intermittently).

[0104] The seabed working machine 13 may be used upon being placed on the seabed in a region that not only has valuable minerals, such as noble metals, rare metals, etc., present on the seabed surface 4 or below the seabed at a water depth, for example, of several thousand meters, but also has large amounts of useful resources, such as methane hydrate (for example, near-surface methane hydrate), which is a fossil fuel, etc. The mineral lifting system S is also usable as a system that lifts such useful resources other than minerals from a deep seabed

to above a sea surface.

[0105] Fig. 6 shall now be referenced. Fig. 6 shows another structure of a pipe body that constitutes the mineral lifting pipe used in the mineral lifting system.

A pipe body 210a has a double pipe structure, with which an outer pipe 214a of an inner pipe 213a, made of steel, is formed integrally from acrylic resin reinforced with carbon fibers. The pipe body 210a is thereby made light in weight and increased in tensile strength. Also, flanges 211a and 212a are provided at respective end portions of the pipe body 210a. By combining the inner pipe 213a, which is made of steel and has sufficient strength, and the lightweight and tough outer pipe 214a, the weight can be suppressed to be equivalent to the pipe body 210 described above while maintaining a prescribed strength.

[0106] Fig. 7 shall now be referenced. An auxiliary float 22a shown in Fig. 7 has a sealed case 220a, formed to be watertight and having an outer shape that is a circular columnar shape. In a space portion 221a in an interior of the sealed case 220a, reinforcing ribs 225, arranged by combining ribs horizontally and vertically, are provided so as to be fixed to an inner surface of the sealed case 220a. The auxiliary float 22a is mounted to the mineral lifting pipe 21 via a coupling member 226. A prescribed buoyancy is thereby imparted to the mineral lifting pipe 21.

[0107] Also, by being provided with the reinforcing ribs 225 in its interior, the auxiliary float 22a can secure the space portion and maintain the prescribed buoyancy without collapsing

under deep sea high pressure.

[0108] The terms and expressions used in the present description and the claims are only descriptive, are by no means restrictive, and are not intended to exclude terms and expressions equivalent to features and portions thereof described in the present description and the claims. Also, obviously, various modified modes are possible within a scope of the technical concept of the present invention.

Reference Signs List

[0109] S Mineral lifting system

1 Excavating unit, 10 Working ship, 11 Float,
12 Electric power cable, 120 Electric power cable,
13 Seabed working machine, 130 Crawler traveling machine,
131 Excavator, 132 Slurry pump,
2 Mineral lifting unit, 20 Main float, 200 Sealed case,
201 Space portion, 201a Upper space portion, 201b Lower
space portion,
202 Through hole, 203 Separating member, 204 Water
feeding/drainage pump,
205 Battery, 206 Control board,
207 GPS receiver, 208 Propulsion machine, 209 Gap,
21 Mineral lifting pipe, 210 Pipe body, 211, 212 Flange,
213 Inner pipe, 214 Outer pipe, 215 Space portion,
210a Pipe body, 211a, 212a Flange, 213a Inner pipe,
214a Outer pipe,
22 Auxiliary float, 220 Sealed case, 221 Space portion,
222 Through hole,

22a Auxiliary float, 220a Sealed case, 221a Space portion,
225 Reinforcing rib, 226 Coupling member, 229 Gap,
23 Relay pipe, 24 Pressure injection pump, 240 Electric
power cable,
241 Injection pipe, 242 Float, 243 Suspending wire,
25 Supply pipe, 26 Electric power cable, 27 GPS satellite,
28 Compression coil spring,
3 Sorting unit, 30 Mineral processing ship, 31 Sorting
tank,
311 Rotating body,
32 Sedimentation tank, 320 Screen, 33 Water storage tank,
330 Pump, 331 Screen, 34 Collection tank, 340 Waterwheel,
35 Drain pipe
5 Mineral deposit, 50 Pulverized minerals

CLAIMS

[Claim 1]

A mineral lifting system comprising:

a seabed working machine, capable of being operated to move and having an excavating portion, excavating minerals on a seabed surface or below a seabed, and a pump, sucking in and pumping a solid-liquid mixture containing the minerals obtained by excavating and seawater;

an electric power supplying portion, having an electric power cable that supplies electric power to power the seabed working machine;

a main float, having a predetermined buoyancy and floated on a sea surface or undersea;

a mineral lifting pipe, having a predetermined length, connecting the main float and a pump of the seabed working machine, and conveying the solid-liquid mixture, sucked in by the pump and containing the minerals and seawater, to the main float side;

auxiliary floats, disposed at predetermined intervals along a length direction of the mineral lifting pipe and imparting a predetermined buoyancy to the mineral lifting pipe; and

a mineral sorting portion, sorting and collecting the minerals from the solid-liquid mixture conveyed to the main float side by the mineral lifting pipe.

[Claim 2]

The mineral lifting system according to Claim 1, wherein

the pump that the seabed working machine has is a slurry pump.

[Claim 3]

The mineral lifting system according to Claim 1, comprising:

an auxiliary pump that injects a liquid flow of predetermined pressure to a predetermined location of the mineral lifting pipe to assist the conveying of the solid-liquid mixture.

[Claim 4]

The mineral lifting system according to Claim 1, comprising:

a GPS receiver and a position correcting apparatus, which compares position information, received by the GPS receiver, with a predetermined set position of the mineral lifting system to perform correction of position so as to maintain the set position.

[Claim 5]

The mineral lifting system according to Claim 1, comprising:

a water feeding/draining apparatus that adjusts the buoyancy of the same main float by feeding water into an interior and draining water to an exterior of the main float.

[Claim 6]

The mineral lifting system according to Claim 1, comprising:

a working ship; and wherein the working ship has the

electric power supplying portion and the mineral sorting portion, and the electric power cable, constituting the electric power supplying portion, and a feed pipe, constituting the mineral sorting portion and receiving the solid-liquid mixture from the mineral lifting pipe, can be disconnected in a state enabling recovery of system operation.

[Claim 7]

The mineral lifting system according to Claim 1, comprising:

a suspension apparatus, supporting the same mineral lifting pipe, at a portion of the main float to which the mineral lifting pipe is connected, and wherein, at a vicinity of the suspension apparatus, the same mineral lifting pipe is made capable of vibrating within a predetermined range of deflection inside a gap through which the same mineral lifting pipe is passed.

[Claim 8]

The mineral lifting system according to Claim 1, wherein auxiliary floats are disposed at predetermined intervals in a length direction of the electric power cable and impart a predetermined buoyancy to the electric power cable.

[Claim 9]

The mineral lifting system according to Claim 1, wherein the mineral sorting portion includes a wastewater processing apparatus.

[Claim 10]

The mineral lifting system according to Claim 1, wherein

the wastewater processing apparatus includes a magnetizing apparatus that magnetizes and sorts the minerals.

[Claim 11]

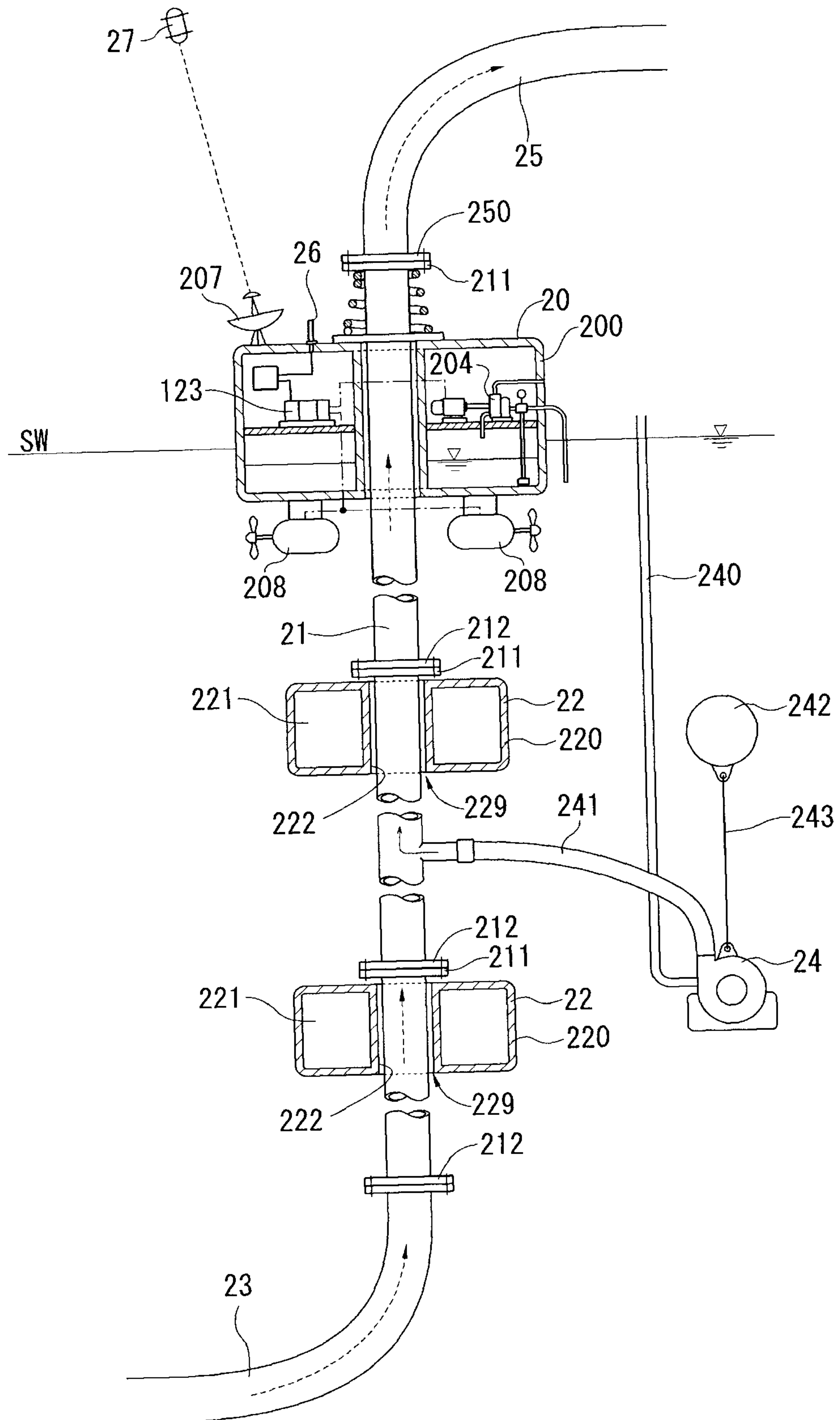
The mineral lifting system according to Claim 1, wherein the mineral lifting pipe has a double pipe structure made of steel and a light alloy, a structure, with which a steel pipe is reinforced with carbon fibers, or a structure, with which a peripheral wall is made hollow.

[Claim 12]

A mineral lifting method wherein a mineral lifting pipe, conveying a solid-liquid mixture, containing minerals, excavated at a seabed surface or below the seabed and pulverized, and seawater, to above a sea surface, is imparted with a predetermined buoyancy by a float.

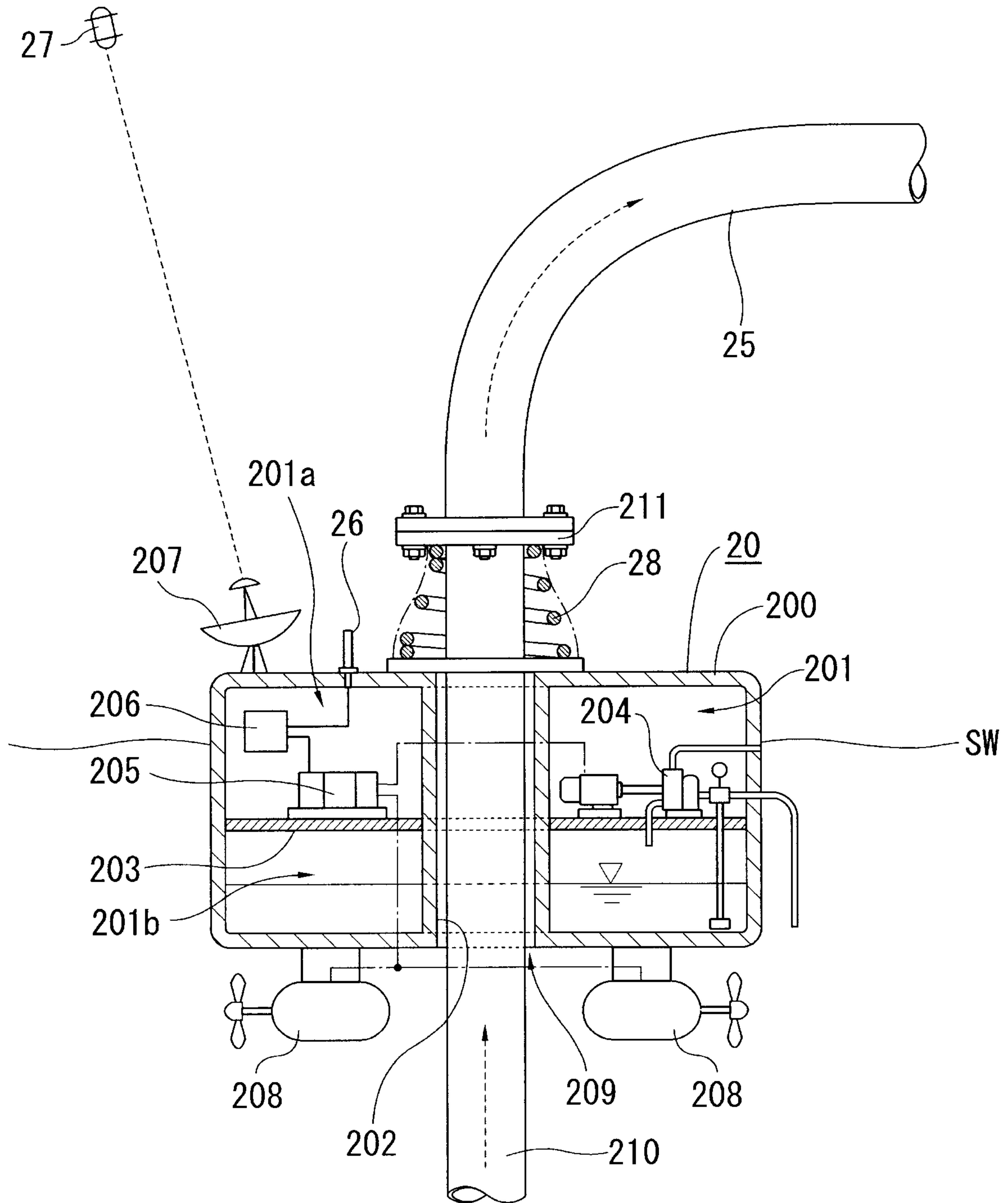
2/7

[Fig. 2]



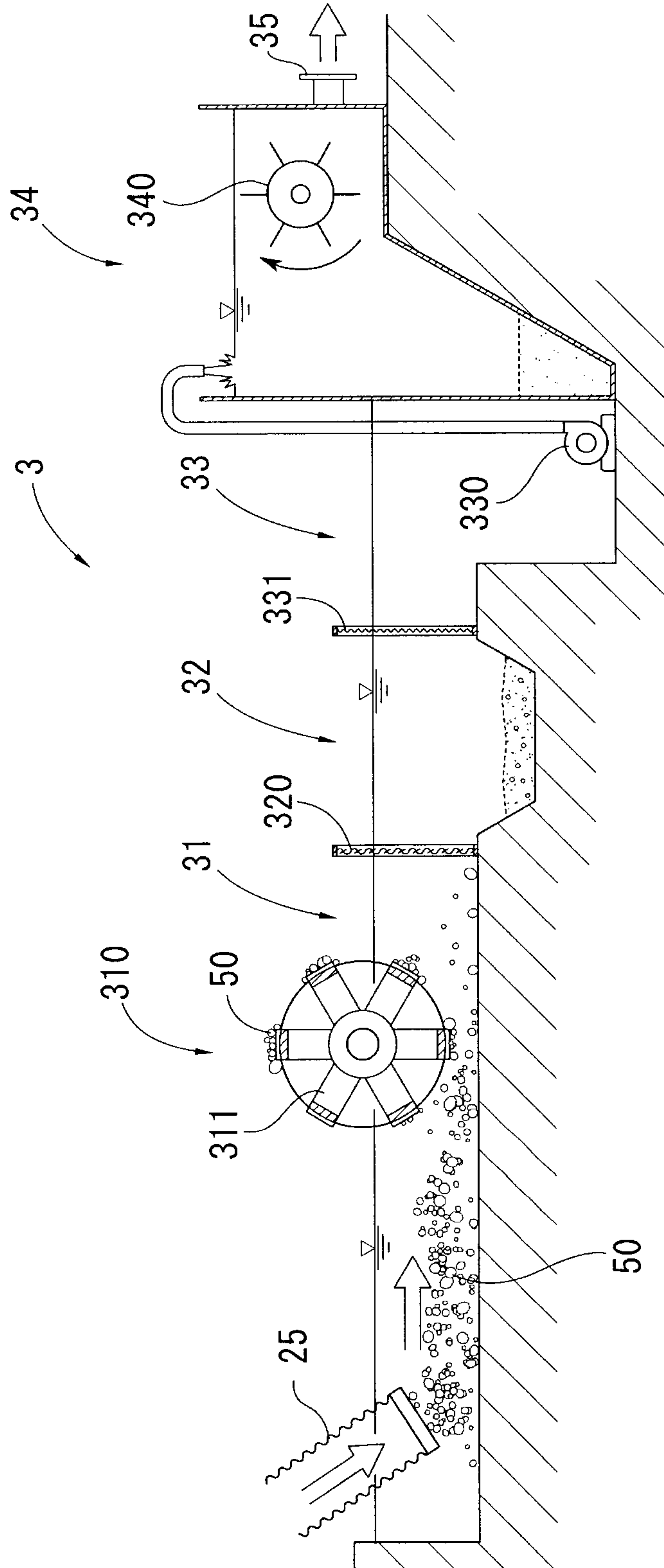
3/7

[Fig. 3]



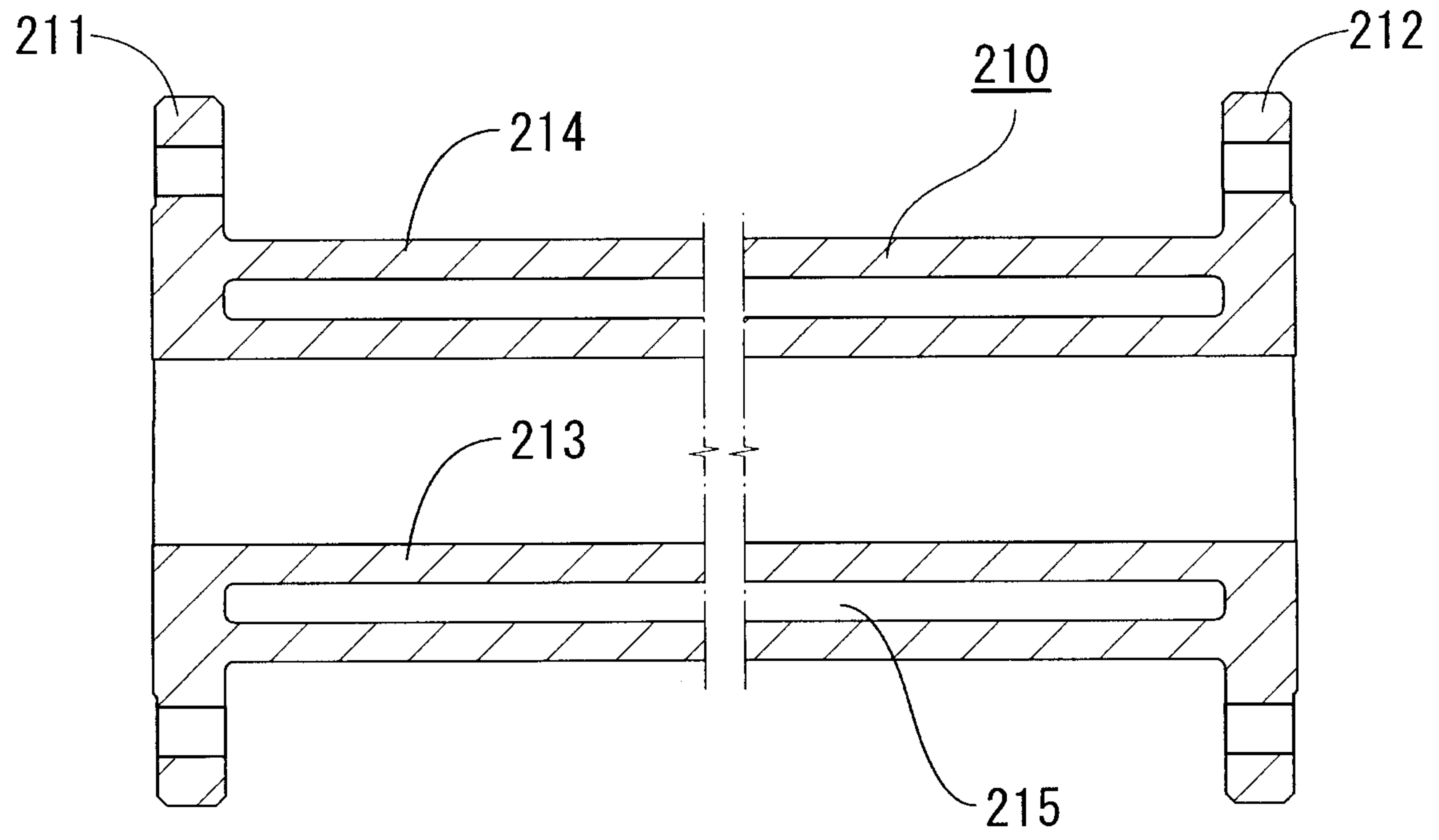
4/7

[Fig. 4]



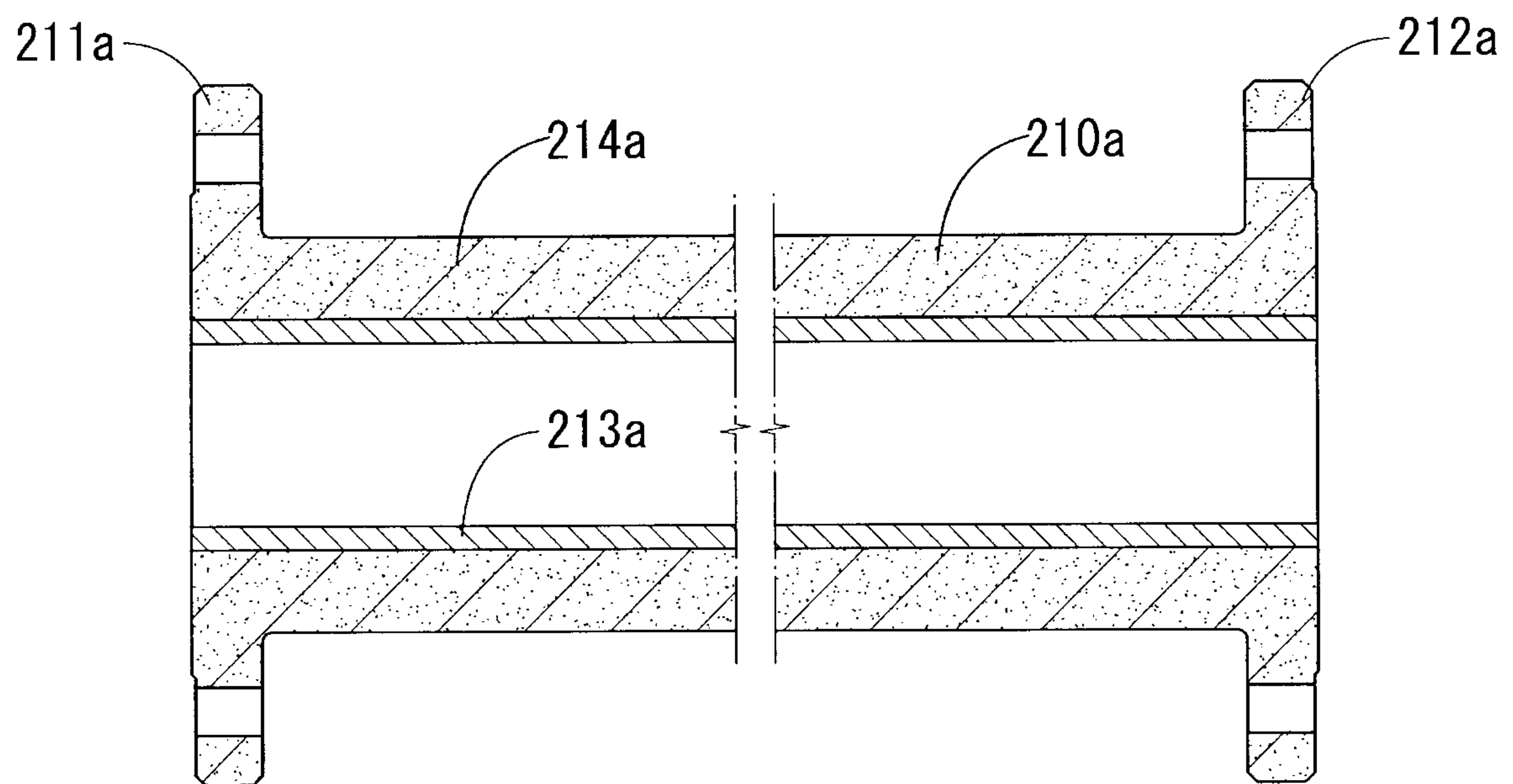
5/7

[Fig. 5]



6/7

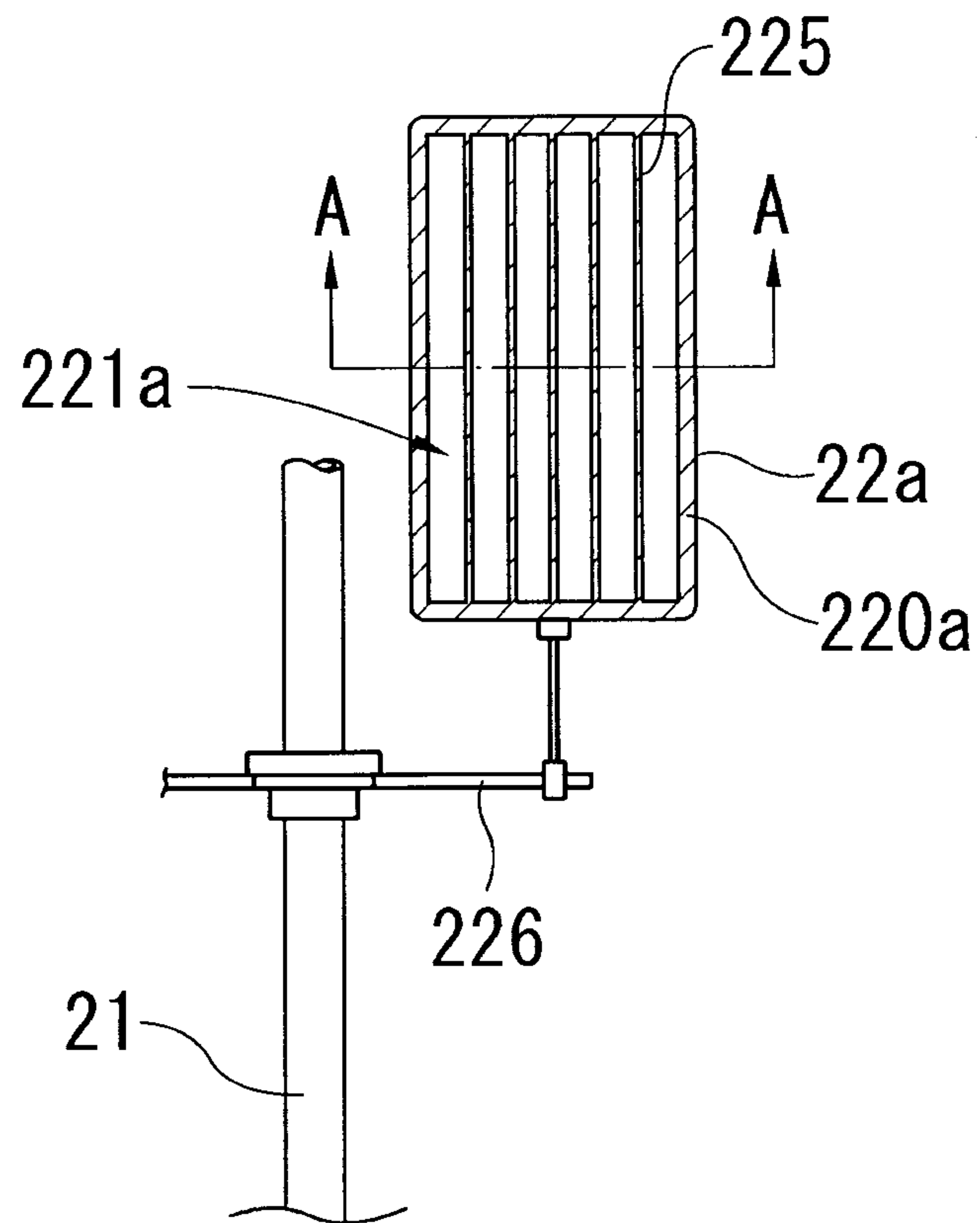
[Fig. 6]



7/7

[Fig. 7]

(a)



(b)

