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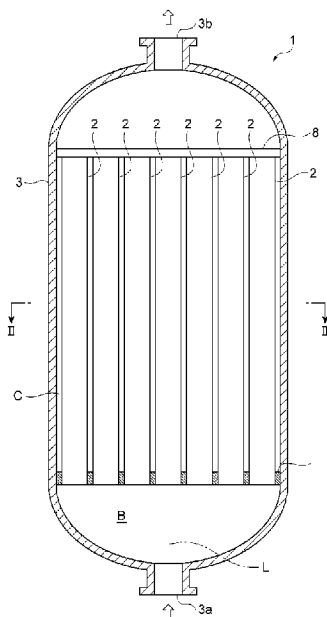
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(54) Titre : SYSTEME DE DEGAZAGE, PROCEDE DE DEGAZAGE DE LIQUIDES, UNITE DE DEGAZAGE, MODULE DE DEGAZAGE, ET PROCEDE DE FABRICATION DE SYSTEME DE DEGAZAGE ET PROCEDE DE PRODUCTION A PARTIR DERESSOURCES NATURELLES

(54) Title: DEGASSING SYSTEM, METHOD FOR DEGASSING LIQUIDS, DEGASSING UNIT, DEGASSING MODULE, AND DEGASSING-SYSTEM MANUFACTURING METHOD AND METHOD OF PRODUCTION FROM NATURAL RESOURCES



(57) **Abrégé/Abstract:**

A degasification system includes a plurality of degasification units which degasifies a liquid and a cylindrical housing which houses the plurality of degasification units in parallel. Each of the plurality of degasification units includes a hollow fiber membrane bundle in which a plurality of hollow fiber membranes are bundled in a cylindrical shape and a cylinder in which the hollow fiber membrane bundle is housed. The housing has an inlet through which the liquid is supplied from outside, an outlet through which the liquid is discharged to the outside, and a housing sealing portion which partitions an internal space of the housing into an upstream side region on the inlet side and a downstream side region on the outlet side via the plurality of degasification units. The plurality of degasification units are configured such that pressure losses of the liquid differ depending on a distance from a central axis of the housing.



ABSTRACT

A degasification system includes a plurality of degasification units which degasifies a liquid and a cylindrical housing which houses the plurality of degasification units in parallel. Each of the plurality of degasification units includes a hollow fiber membrane bundle in which a plurality of hollow fiber membranes are bundled in a cylindrical shape and a cylinder in which the hollow fiber membrane bundle is housed. The housing has an inlet through which the liquid is supplied from outside, an outlet through which the liquid is discharged to the outside, and a housing sealing portion which partitions an internal space of the housing into an upstream side region on the inlet side and a downstream side region on the outlet side via the plurality of degasification units. The plurality of degasification units are configured such that pressure losses of the liquid differ depending on a distance from a central axis of the housing.

DESCRIPTION

Title of Invention

5 DEGASSING SYSTEM, METHOD FOR DEGASSING LIQUIDS,
 DEGASSING UNIT, DEGASSING MODULE, AND
 DEGASSING-SYSTEM MANUFACTURING METHOD AND
 METHOD OF PRODUCTION FROM NATURAL RESOURCES

Technical Field

10 [0001] An aspect of the present invention relates to a degasification
 system in which a plurality of degasification units are housed in parallel
 in a housing, a liquid degasification method using the degasification
 system, a degasification unit used in the degasification system, a
 degasification module used in the degasification system, a method for
 manufacturing the degasification system, and a method for producing
 15 natural resources.

Background Art

[0002] In the related art, a degasification unit that degasifies a liquid
 using hollow fiber membranes is known. Further, a degasification
 system in which a plurality of degasification units are housed in a
 20 housing to cope with an increase in size or flow rate is also known (see
 Patent Literature 1, for example).

Citation List

Patent Literature

[0003] [Patent Literature 1] Japanese Patent No. 4593719

25 **Summary of Invention**

Technical Problem

[0004] Incidentally, in a case in which a plurality of degasification units are housed in parallel in a housing, it was thought that a liquid flows through all the degasification units with the same flow rate. However, as a result of research by the present inventors, it has been found that a liquid may not always flow through all the degasification units with the same flow rate. That is, it has been found that the flow rates of the liquid flowing through the degasification units differ depending on the distance from the central axis of the housing. Since the degasification performance of a degasification unit changes depending on the flow rate of the liquid flowing through the degasification unit, it is assumed that the degasification performance of the entire degasification system deteriorates when the flow rates of the liquid flowing through each of the degasification units differ.

[0005] Therefore, an object of the aspect of the present invention is to provide a degasification system capable of reducing deviation in the flow rate of a liquid flowing through a plurality of degasification units, a liquid degasification method using the degasification system, a degasification unit used in the degasification system, a degasification module used in the degasification system, a method for manufacturing the degasification system, and a method for producing natural resources.

Solution to Problem

[0006] A degasification system according to an aspect of the present invention includes a plurality of degasification units configured to degasify a liquid; and a cylindrical housing configured to house the plurality of degasification units in parallel, wherein each of the plurality of degasification units includes a hollow fiber membrane bundle in

which a plurality of hollow fiber membranes are bundled in a
 cylindrical shape and a cylinder in which the hollow fiber membrane
 bundle is housed, wherein the housing has an inlet through which the
 liquid is supplied from outside, an outlet through which the liquid is
 5 discharged to the outside, and a sealing portion which partitions an
 internal space of the housing into an upstream side region on the inlet
 side and a downstream side region on the outlet side via the plurality of
 degasification units, and wherein the plurality of degasification units are
 configured such that pressure losses of the liquid differ depending on a
 10 distance from a central axis of the housing.

[0007] In the degasification system, the plurality of degasification units
 are housed in parallel in the cylindrical housing. Here, in a case in
 which the pressure losses of the liquid flowing through the plurality of
 degasification units are the same, the flow rates of the liquid flowing
 15 through the degasification units differ depending on the distance from
 the central axis of the housing. However, in this degasification system,
 the plurality of degasification units are configured such that the pressure
 losses of the liquid differ depending on the distance from the central
 axis of the housing. This difference in the pressure loss acts to offset
 20 the above difference in the flow rate. As a result, it is possible to
 reduce the deviation in the flow rate of the liquid flowing through the
 plurality of degasification units. As a result, for example, the
 degasification performance of the degasification system in its entirety
 can be improved.

25 [0008] The degasification system may further include a suction pipe
 communicating with an inside of the hollow fiber membranes and

penetrating the housing to suction the inside of the hollow fiber membranes. In the degasification system, by providing the suction pipe, it is possible to appropriately degasify the liquid in the degasification unit, and it is possible to appropriately discharge the degasification gas to the outside of the housing.

[0009] Among the plurality of degasification units, the degasification unit that overlaps the inlet when seen in a direction along the central axis may be configured such that the pressure loss of the liquid therein is larger than that in the degasification unit that does not overlap the inlet when seen in a direction along the central axis. Since the degasification unit that overlaps the inlet when seen in a direction along the central axis receives a stronger supply pressure of the liquid from the inlet than that in the degasification unit that does not overlap the inlet when seen in a direction along the central axis, the liquid easily flows in the degasification unit that overlaps the inlet when seen in a direction along the central axis. In the degasification system, since the degasification unit that overlaps the inlet when seen in a direction along the central axis is configured such that the pressure loss of the liquid therein is larger than that in the degasification unit that does not overlap the inlet when seen in a direction along the central axis, this difference in the pressure loss acts to offset the difference in the supply pressure of the liquid. As a result, it is possible to reduce the deviation in the flow rate of the liquid flowing through these degasification units.

[0010] Incidentally, as described above, in a case in which the pressure losses of the liquid flowing through the plurality of degasification units are the same, the flow rate of the liquid flowing through the

degasification unit tends to decrease as the degasification unit becomes further away from the central axis of the housing. However, as a result of research by the present inventors, it was found that the above tendency is reversed in an outer region from the inner peripheral surface of the housing to a position corresponding to 0.7 times the outer diameter of the degasification unit toward the central axis side. That is, it was found that in the outer region, the flow rate of the liquid flowing through the degasification unit tends to increase as the degasification unit becomes further away from the central axis of the housing. It is assumed that this is because, in the outer region, the liquid flowing in the housing is pushed back against the inner peripheral surface of the housing, and thus the flow rate of the liquid flowing through the degasification unit increases.

[0011] Based on this findings, in a case in which a region from an inner peripheral surface of the housing to a position corresponding to 0.7 times an outer diameter of the degasification unit toward the central axis side is defined as an outer region and a region inside the outer region is defined as an inner region, in the inner region, the plurality of degasification units may have an inner degasification unit and an outer degasification unit which is farther from the central axis than the inner degasification unit, and the inner degasification unit may be configured such that the pressure loss of the liquid therein is larger than that in the outer degasification unit. In a case in which the pressure losses of the liquid flowing through the plurality of degasification units are the same, in the inner region, the flow rate of the liquid flowing through the degasification unit tends to decrease as the degasification unit becomes

further away from the central axis of the housing. In the degasification system, since the inner degasification unit is configured such that the pressure loss of the liquid therein is larger than that in the outer degasification unit, this difference in the pressure loss acts to offset the above difference in the flow rate. As a result, it is possible to reduce the deviation in the flow rate of the liquid flowing through the inner degasification unit and the outer degasification unit.

[0012] Further, in a case in which a region from an inner peripheral surface of the housing to a position corresponding to 0.7 times an outer diameter of the degasification unit toward the central axis side is defined as an outer region, a region inside the outer region is defined as an inner region, and all the degasification units are disposed in the inner region, the plurality of degasification units may be configured such that the pressure loss of the liquid increases as the degasification unit becomes closer to the central axis. In the degasification system, in a case in which all the degasification units are disposed in the inner region, the plurality of degasification units are configured such that the pressure loss of the liquid increases as the degasification unit becomes closer to the central axis, and thus it is possible to appropriately reduce the deviation in the flow rate of the liquid flowing through the plurality of degasification units.

[0013] On the other hand, in a case in which a region from an inner peripheral surface of the housing to a position corresponding to 0.7 times an outer diameter of the degasification unit toward the central axis side is defined as an outer region, a region inside the outer region is defined as an inner region, at least one degasification unit is disposed in

the outer region, and remaining degasification units are disposed in the inner region, the degasification units disposed in the inner region may be configured such that the pressure loss of the liquid increases as the degasification unit becomes closer to the central axis. In the degasification system, in a case in which at least one degasification unit is disposed in the outer region and the remaining degasification units are disposed in the inner region, the degasification units disposed in the inner region are configured such that the pressure loss of the liquid increases as the degasification unit becomes closer to the central axis, and thus it is possible to appropriately reduce the deviation in the flow rate of the liquid flowing through the degasification units in the inner region.

[0014] In this case, the degasification unit disposed in the outer region may be configured such that the pressure loss of the liquid therein is larger than that in the degasification unit closest to the outer region among the degasification units disposed in the inner region. In the degasification system, since the degasification unit disposed in the outer region is configured such that the pressure loss of the liquid therein is larger than that in the degasification unit closest to the outer region among the degasification units disposed in the inner region, it is possible to appropriately reduce the deviation in the flow rate of the liquid even between this degasification unit disposed in the inner region and the degasification unit disposed in the outer region.

[0015] In the degasification unit, a plurality of degasification modules may be connected, each of the plurality of the degasification modules may include a hollow fiber membrane bundle having a plurality of

hollow fiber membranes arranged around a liquid supply path through which a liquid is supplied and a cylinder which houses the hollow fiber membrane bundle and in which discharge ports for discharging the liquid are formed, and the degasification unit may have a connection supply pipe which connects the liquid supply paths of the plurality of degasification modules in series and in which openings through which the liquid passes are formed at positions corresponding to the plurality of degasification modules such that the liquid is supplied to the hollow fiber membrane bundles of the plurality of degasification modules in parallel.

[0016] A liquid degasification method according to an aspect of the present invention in any one of the above degasification systems includes degasifying a liquid by supplying the liquid from the inlet to the plurality of degasification units and depressurizing an inside of the plurality of hollow fiber membranes of each of the plurality of degasification units.

[0017] A degasification unit according to an aspect of the present invention used in any one of the above degasification systems includes a hollow fiber membrane bundle in which a plurality of hollow fiber membranes are bundled in a cylindrical shape; and a cylinder in which the hollow fiber membrane bundle is housed.

[0018] A degasification module according to an aspect of the present invention used in the above degasification system includes a hollow fiber membrane bundle having a plurality of hollow fiber membranes arranged around a liquid supply path through which a liquid is supplied;

and a cylinder which houses the hollow fiber membrane bundle and in which discharge ports for discharging the liquid are formed.

[0019] A method for manufacturing a degasification system according to an aspect of the present invention includes preparing a plurality of degasification units, a housing which houses the plurality of degasification units and has an inlet through which a liquid is supplied from outside and an outlet through which the liquid is discharged to the outside, and a suction pipe; fixing the plurality of the degasification units to the housing with a sealing portion which partitions an internal space of the housing into an upstream side region on the inlet side and a downstream side region on the outlet side via the plurality of degasification units; and making pressure losses of the liquid of the plurality of degasification units different depending on a distance from a central axis of the housing.

[0020] In this case, the method for manufacturing a degasification system may further include preparing a plurality of degasification modules each having a hollow fiber membrane bundle having a plurality of hollow fiber membranes arranged around a liquid supply path through which a liquid is supplied and a cylinder which houses the hollow fiber membrane bundle and in which discharge ports for discharging the liquid are formed, and a connection supply pipe in which a plurality of openings through which the liquid passes are formed; and inserting the connection supply pipe into the liquid supply paths of the plurality of degasification modules to connect the liquid supply paths of the plurality of degasification modules in series by the connection supply pipe and disposing the plurality of openings at

positions corresponding to the plurality of degasification modules such that the liquid is supplied to the hollow fiber membrane bundles of the plurality of degasification modules in parallel, to manufacture the degasification unit.

5 [0021] A method for producing natural resources according to an aspect of the present invention in any one of the degasification systems includes a degasification step of degasifying a liquid by supplying the liquid from the inlet to the plurality of degasification units and depressurizing an inside of the plurality of hollow fiber membranes of
10 each of the plurality of degasification units; and a press-in step of pressing-in the liquid degasified in the degasification step into a natural resource mining site.

Advantageous Effects of Invention

[0022] According to the aspect of the present invention, a degasification
15 system capable of reducing deviation in the flow rate of a liquid flowing through a plurality of degasification units is provided.

Brief Description of Drawings

[0023] FIG. 1 is a schematic cross-sectional view of a degasification system according to an embodiment.

20 FIG. 2 is a schematic cross-sectional view along line II-II shown in FIG. 1.

FIG. 3 is a schematic cross-sectional view of a degasification system for explaining an example of a degasification unit.

25 FIG. 4 is a schematic cross-sectional view of a degasification system for explaining an example of a degasification unit.

FIG. 5 is a schematic cross-sectional view along line V-V shown in FIG. 3 or 4.

FIG. 6 is a schematic front view of the degasification unit.

FIG. 7 is a schematic cross-sectional view of the degasification unit.

FIG. 8 is a schematic cross-sectional view of an end portion of a hollow fiber membrane bundle.

FIG. 9 is a schematic cross-sectional view of a degasification system of reference examples.

FIG. 10 is a table showing the conditions of each reference example.

FIG. 11 is a table showing the flow rates of degasification units in each row in Reference Examples 1 to 8.

FIG. 12 is a graph showing the flow rates of degasification units in each row in Reference Examples 1 to 4.

FIG. 13 is a graph showing the flow rates of degasification units in each row in Reference Examples 2 and 5.

FIG. 14 is a graph showing the flow rates of degasification units in each row in Reference Examples 6 to 8.

FIG. 15 is a view for explaining an outer region and an inner region of a housing.

Description of Embodiments

[0024] Hereinafter, in the description based on the drawings, the same elements or similar elements having the same functions are designated by the same reference signs, and duplicate descriptions will be omitted.

[0025] The degasification system of the present embodiment is a system for degasifying a liquid. As the liquid to be degasified by the degasification system, water is exemplified. As shown in FIGS. 1 and 2, the degasification system 1 of the present embodiment includes a plurality of degasification units 2, a housing 3 which houses the degasification unit 2, and a suction pipe 4 (see FIGS. 3 to 5).

[0026] [Degasification unit]

For example, the degasification unit 2 may be constituted by a plurality of degasification modules 5 being connected to each other as in a degasification unit 2A shown in FIG. 3 and may be constituted by one degasification module 5 as in a degasification unit 2B shown in FIG. 4. The degasification unit 2A shown in FIG. 3 and the degasification unit 2B shown in FIG. 4 each show an example of the degasification unit 2. Further, in FIGS. 3 and 4, to make the drawings easier to see, only one of the plurality of degasification units 2 is illustrated, and the remaining degasification units 2 are omitted.

[0027] As shown in FIGS. 6 and 7, the degasification module 5 includes, for example, a module inner pipe 11, a hollow fiber membrane bundle 12, and a module container (a cylinder) 13.

[0028] The module inner pipe 11 is a pipe on an inner peripheral side of which a liquid supply path 10 to which a liquid such as water is supplied is formed. The module inner pipe 11 is formed, for example, in a circular pipe shape extending linearly. A plurality of inner pipe openings 11a are formed in the module inner pipe 11. The inner pipe openings 11a are for passing the liquid supplied to the liquid supply path 10 of the module inner pipe 11. The number, the positions, the

sizes, and the like of the inner pipe openings 11a are not particularly limited.

[0029] The hollow fiber membrane bundle 12 has a plurality of hollow fiber membranes 14 arranged around the module inner pipe 11.

5 Therefore, the liquid supply path 10 is disposed on the inner peripheral side of the hollow fiber membrane bundle 12. The hollow fiber membrane bundle 12 is configured by, for example, the plurality of hollow fiber membranes 14 being bundled in a cylindrical shape such as a circular cylindrical shape. The hollow fiber membrane 14 is a
10 hollow fiber-like membrane that allows a gas to permeate but does not allow a liquid to permeate. Then, in the hollow fiber membrane bundle 12, the inside of the hollow fiber membrane 14 is depressurized, and thus the liquid flowing out from the inner pipe openings 11a of the module inner pipe 11 is degasified.

15 [0030] A material, a membrane shape, a membrane form, and the like of the hollow fiber membrane 14 are not particularly limited. Examples of the material of the hollow fiber membrane 14 include polyolefin-based resins such as polypropylene and poly(4-methylpentene-1), silicone-based resins such as
20 polydimethylsiloxane and copolymers thereof, and fluorine-based resins such as PTFE and vinylidene fluoride. Examples of the membrane shape (a side wall shape) of the hollow fiber membrane 14 include a porous membrane, a microporous membrane, and a homogeneous membrane having no porous material (a non-porous membrane).
25 Examples of the membrane form of the hollow fiber membrane 14 include a symmetric membrane (a homogeneous membrane) in which a

chemical or physical structure of the entire membrane is homogeneous and an asymmetric membrane (an inhomogeneous membrane) in which chemical or physical structures of the membrane differ depending on a portion of the membrane. The asymmetric membrane (the inhomogeneous membrane) is a membrane having a non-porous dense layer and the porous material. In this case, the dense layer may be formed in any portion of the membrane such as a surface layer portion of the membrane or the inside of the porous membrane. The inhomogeneous membrane also includes a composite film having different chemical structures and a multilayer structure film such as a three-layer structure.

[0031] The hollow fiber membrane bundle 12 can be formed, for example, by a woven fabric (not shown) in which the plurality of hollow fiber membranes 14 which are weft threads are woven with warp threads. This woven fabric is also called a hollow fiber membrane sheet, and the plurality of hollow fiber membranes 14 are woven in a bamboo blind shape. This woven fabric is constituted by, for example, 30 to 90 hollow fiber membranes 14 per inch. Then, it is possible to configure the hollow fiber membrane bundle 12 in a circular cylindrical shape by winding the woven fabric around the module inner pipe 11 (the periphery of the liquid supply path) such that the plurality of hollow fiber membranes 14 extend in an axial direction of the module inner pipe 11 (the liquid supply path 10).

[0032] The module container 13 is a container that houses the hollow fiber membrane bundle 12. A region between the module inner pipe 11 and the module container 13 is a degasification region A in which the

liquid is degasified by the hollow fiber membrane bundle 12. The module container 13 is formed, for example, in a circular cylindrical shape extending in the axial direction of the module inner pipe 11 (the liquid supply path 10), and both ends thereof are open. A plurality of

5 discharge ports 13a are formed in the module container 13. The discharge ports 13a are for discharging the liquid that has passed through the hollow fiber membrane bundle 12 in the degasification region A from the module container 13 (the degasification module 5). The number, the positions, the sizes, and the like of the discharge ports

10 13a are not particularly limited.

[0033] As shown in FIG. 8, end portions 12a on both sides of the hollow fiber membrane bundle 12 are fixed to the module inner pipe 11 and the module container 13 by a sealing portion 15.

[0034] The sealing portion 15 is formed of, for example, a resin.

15 Examples of the resin used for the sealing portion 15 include an epoxy resin, a urethane resin, an ultraviolet curable resin, and a polyolefin resin such as polyethylene and polypropylene. The sealing portion 15 fills the entire region between the module inner pipe 11 and the module container 13 except for the inside of the hollow fiber membrane 14.

20 That is, the sealing portion 15 fills a portion between the hollow fiber membranes 14, a portion between the hollow fiber membrane bundle 12 and the module inner pipe 11, and a portion between the hollow fiber membranes 14 and the module container 13, but does not fill the inside of the hollow fiber membrane 14. Therefore, the inside of the hollow

25 fiber membrane 14 is open from the sealing portion 15 to both end sides of the degasification module 5, and it is possible to suction the inside of

the hollow fiber membrane 14 from both end sides of the degasification module 5. That is, openings at both ends of the module container 13 are suction openings that open or expose the inside of the hollow fiber membrane 14 to allow suctioning and depressurizing of the inside of the hollow fiber membrane 14.

[0035] As shown in FIGS. 3 and 5, the degasification unit 2A constituted by the plurality of degasification modules 5 being connected to each other has, for example, a connection supply pipe 6A that connects the liquid supply paths 10 of the plurality of degasification modules 5 in series. The connection supply pipe 6A is one long pipe connected to the plurality of degasification modules 5, and the liquid supply paths 10 of the plurality of degasification modules 5 are formed on an inner peripheral side thereof. Therefore, the plurality of degasification modules 5 are connected in series by the connection supply pipe 6A in appearance. The number of degasification modules 5 constituting the degasification unit 2A is not particularly limited, but will be described below as an example in which four degasification modules 5 are connected. The four degasification modules 5 are referred to as a degasification module 5A, a degasification module 5B, a degasification module 5C, and a degasification module 5D in the order of a flow direction of the liquid in the connection supply pipe 6A. The degasification module 5A is a degasification module 5 which is disposed on the furthest upstream side, and the degasification module 5D is a degasification module 5 which is disposed on the furthest downstream side. The degasification unit 2A is erected in the vertical direction, for example, such that the liquid flows from the bottom to the

top in the connection supply pipe 6A. In this case, the degasification module 5A which is disposed on the furthest upstream side is disposed on the lowermost side, and the degasification module 5D which is disposed on the furthest downstream side is disposed on the uppermost side.

[0036] A supply port 6a through which the liquid is supplied to the connection supply pipe 6A is formed at an upstream end of the connection supply pipe 6A. A downstream end of the connection supply pipe 6A is sealed. The inner peripheral side of the connection supply pipe 6A forming the liquid supply paths 10 of the plurality of degasification modules 5 is penetrated from an upstream side to a downstream side. Therefore, on the inner peripheral side of the connection supply pipe 6A (the module inner pipe 11 of each degasification module 5), a member that becomes a resistance to the flow of the liquid may be disposed, but a member that seals the connection supply pipe 6A to block the flow of the liquid is not disposed. Then, the liquid supplied from the supply port 6a is supplied to the liquid supply paths 10 of the plurality of degasification modules 5 in series by the connection supply pipe 6A.

[0037] In the connection supply pipe 6A, openings 6b through which the liquid passes are formed at positions corresponding to the plurality of degasification modules 5 such that the liquid is supplied to the hollow fiber membrane bundles 12 of the plurality of degasification modules 5 in parallel. Therefore, the liquid supplied to the supply port 6a of the connection supply pipe 6A is supplied (flows out) to the degasification region A of each degasification module 5 from the openings 6b formed

at a position corresponding to each degasification module 5. Accordingly, the liquid is supplied to the hollow fiber membrane bundles 12 of the plurality of degasification modules 5 in parallel.

[0038] Each degasification module 5 and the connection supply pipe 6A

5 may be in close contact with each other or may be separated from each other. In a case in which each degasification module 5 and the connection supply pipe 6A are in close contact with each other, the inner pipe openings 11a of each degasification module 5 and the openings 6b of the connection supply pipe 6A are formed at positions where they
10 overlap at least in part, and thus it is possible to supply the liquid from the connection supply pipe 6A to the degasification region A of each degasification module 5. On the other hand, in a case in which each degasification module 5 and the connection supply pipe 6A are separated from each other, a flow path through which the liquid flows is
15 formed in a space therebetween, and thus it is possible to supply the liquid from the connection supply pipe 6A to the degasification region A of each degasification module 5 regardless of a positional relationship between the inner pipe openings 11a of each degasification module 5 and the openings 6b of the connection supply pipe 6A.

20 [0039] As shown in FIGS. 4 and 5, the degasification unit 2B constituted by one degasification module 5 has, for example, a connection supply pipe 6B that is inserted into the module inner pipe 11 of the degasification module 5 to form the liquid supply path 10 of the degasification module 5 on the inner peripheral side thereof.

25 [0040] A supply port 6a through which the liquid is supplied to the connection supply pipe 6B is formed at an upstream end of the

connection supply pipe 6B. A downstream end of the connection supply pipe 6B is sealed. The inner peripheral side of the connection supply pipe 6B forming the liquid supply path 10 of the degasification module 5 is penetrated from an upstream side to a downstream side.

5 Therefore, on the inner peripheral side of the connection supply pipe 6B (the module inner pipe 11 of the degasification module 5), a member that becomes a resistance to the flow of the liquid may be disposed, but a member that seals the connection supply pipe 6B to block the flow of the liquid is not disposed. Then, the liquid supplied from the supply
10 port 6a is supplied to the liquid supply path 10 of the degasification module 5 by the connection supply pipe 6B.

[0041] In the connection supply pipe 6B, openings 6b through which the liquid passes are formed such that the liquid is supplied to the hollow fiber membrane bundle 12 of the degasification module 5.

15 Therefore, the liquid supplied to the supply port 6a of the connection supply pipe 6B is supplied (flows out) to the degasification region A of the degasification module 5 from the openings 6b. Accordingly, the liquid is supplied to the hollow fiber membrane bundle 12 of the degasification module 5.

20 [0042] The degasification module 5 and the connection supply pipe 6B may be in close contact with each other or may be separated from each other. In a case in which the degasification module 5 and the connection supply pipe 6B are in close contact with each other, the inner pipe openings 11a of the degasification module 5 and the openings 6b of
25 the connection supply pipe 6B are formed at positions where they overlap at least in part, and thus it is possible to supply the liquid from

the connection supply pipe 6B to the degasification region A of the degasification module 5. On the other hand, in a case in which the degasification module 5 and the connection supply pipe 6B are separated from each other, a flow path through which the liquid flows is formed in a space therebetween, and thus it is possible to supply the liquid from the connection supply pipe 6B to the degasification region A of the degasification module 5 regardless of a positional relationship between the inner pipe openings 11a of the degasification module 5 and the openings 6b of the connection supply pipe 6B.

[0043] Unless otherwise specified, the connection supply pipe 6A and the connection supply pipe 6B are collectively referred to as a connection supply pipe 6. Further, the degasification unit 2B may not be provided with the connection supply pipe 6B, and the module inner pipe 11 may also serve as the connection supply pipe 6B. In this case, for example, a supply port through the liquid is supplied to the module inner pipe 11 is formed at the upstream end of the module inner pipe 11, and the downstream end of the module inner pipe 11 is sealed.

[0044] [Housing]

As shown in FIGS. 1 to 5, the housing 3 is formed in a cylindrical shape. The housing 3 houses a plurality of degasification units 2 in parallel such that the plurality of degasification units 2 are disposed in parallel with a central axis L of the housing 3.

[0045] An inlet 3a is formed, for example, at a lower end portion of the housing 3. The inlet 3a communicates with the supply port 6a of each degasification unit 2. Therefore, the liquid supplied from the inlet 3a

is supplied to the liquid supply path 10 of each degasification unit 2 from the supply port 6a of each degasification unit 2.

[0046] An outlet 3b is formed, for example, at an upper end portion of the housing 3. The outlet 3b communicates with the discharge ports 13a of each degasification unit 2. Therefore, the liquid discharged from the discharge ports 13a of each degasification unit 2 is discharged from the outlet 3b of the housing 3.

[0047] The housing 3 is provided with a housing sealing portion (a sealing portion) 7 and a degasification unit supporting portion 8.

[0048] The housing sealing portion 7 fixes an upstream end portion (a lower end portion) of the connection supply pipe 6 (the connection supply pipe 6A or the connection supply pipe 6B) to an inner peripheral surface of the housing 3. Further, the housing sealing portion 7 partitions an internal space of the housing 3 into an upstream side region B on the inlet 3a side and a downstream side region C on the outlet 3b side via the plurality of degasification units 2. As the housing sealing portion 7, for example, a resin lined with a metal such as stainless steel, a fiber reinforced plastic (FRP), or a metal such as iron is used.

[0049] The housing sealing portion 7 fills the entire region between the connection supply pipe 6 and the housing 3 except for the inside of the connection supply pipe 6. That is, the housing sealing portion 7 fills a portion between the connection supply pipe 6 and the housing 3, but does not fill the inside of the connection supply pipe 6. Therefore, the inside of the connection supply pipe 6 is opened from the supply port 6a to the upstream side region B. The liquid supplied from the inlet 3a to the upstream side region B is supplied to the inside of the connection

supply pipe 6 from only the supply port 6a and is further supplied to the degasification region A of the degasification module 5 from the openings 6b and the inner pipe openings 11a.

5 [0050] Further, the housing sealing portion 7 is disposed on the upstream side of all the discharge ports 13a in the flow direction of the liquid flowing through the connection supply pipe 6. Therefore, the inside of the module container 13 is opened from the discharge ports 13a to the downstream side region C. The liquid supplied from the openings 6b and the inner pipe openings 11a to the degasification region
10 A is discharged to the downstream side region C from only the discharge ports 13a and is further discharged to the outside of the housing 3 from the outlet 3b.

[0051] The degasification unit supporting portion 8 is fixed to a downstream end portion (an upper end portion) of the degasification unit 2 and the housing 3 and supports the downstream end portion of the
15 degasification unit 2. The degasification unit supporting portion 8 is formed, for example, in a rod shape extending from the degasification unit 2 to the housing 3 and does not seal a portion between the degasification unit 2 and the housing 3. Therefore, the liquid
20 discharged from the discharge ports 13a to the downstream side region C is discharged from the outlet 3b to the outside of the housing 3 without being blocked by the degasification unit supporting portion 8.

[0052] The inner diameter of the housing 3 is not particularly limited, but is preferably 400 mm or more and 1800 mm or less, more preferably
25 600 mm or more and 1650 mm or less, and further preferably 470 mm or more and 800 mm or less, for example.

[0053] The diameter of the degasification unit 2 is not particularly limited, but is preferably 114 mm or more and 318 mm or less, more preferably 125 mm or more and 216 mm or less, and further preferably 160 mm or more and 170 mm or less, for example. The diameter of the degasification unit 2 refers to the diameter of the module container 13.

[0054] The number of degasification units 2 housed in the housing 3 is not particularly limited, but from the viewpoint of being able to ensure an installability of the degasification system 1 and to increase the flow rate, is preferably 50 or more and 200 or less, more preferably 76 or more and 180 or less, and further preferably 150 or more and 160 or less, for example.

[0055] The flow rate of the liquid which is supplied to the housing 3 is not particularly limited, but from the viewpoint of being able to improve degasification efficiency of the degasification unit 2, is preferably 150 m³/h or more and 1200 m³/h or less, more preferably 200 m³/h or more and 1000 m³/h or more, and further preferably 450 m³/h or more and 960 m³/h or less, for example.

[0056] The ideal retention time of the liquid in the housing 3 is not particularly limited, but from the viewpoint of being able to increase the flow rate while preventing the housing 3 from becoming too large, is preferably 7 seconds or more and 35 seconds or less, more preferably 17 seconds or more and 28 seconds or less, and further preferably 20 seconds or more and 22 seconds or less, for example. The ideal retention time of the liquid in the housing 3 refers to a value (V/Q)

obtained by dividing the volume Vm^3 of the housing 3 by the flow rate Qm^3/h of the liquid.

[0057] The ideal retention time of the liquid in the upstream side region B is not particularly limited, but from the viewpoint of appropriately supplying the liquid to each degasification unit 2 while preventing the degasification system 1 from becoming too large, is preferably 3 seconds or more and 12 seconds or less, more preferably 4 seconds or more and 8 seconds or less, and further preferably 5 seconds or more and 6 seconds or less, for example. The ideal retention time of the liquid in the upstream side region B refers to a value (V/Q) obtained by dividing the volume Vm^3 of the upstream side region B by the flow rate Qm^3/h of the liquid.

[0058] [Suction pipe]

The suction pipe 4 communicates with the inside of the hollow fiber membrane 14 to suction (to vacuum-evacuate) the inside of the hollow fiber membrane 14. Further, the suction pipe 4 penetrates the housing 3 and extends to the outside of the housing 3 for the suction by a suction pump such as a vacuum pump provided outside the housing 3. As described above, the inside of the hollow fiber membrane 14 is opened from the sealing portion 15 to both end sides of the degasification module 5. Therefore, the suction pipe 4 is connected to both ends of the degasification module 5 to which the inside of the hollow fiber membrane 14 is opened. Accordingly, it is possible to suction the inside of the hollow fiber membrane 14 from both end sides of the degasification module 5 by suctioning the suction pipe 4.

[0059] Further, in the degasification unit 2A shown in FIG. 3, since the plurality of degasification modules 5 are connected in series by the connection supply pipe 6 in appearance, end faces of the degasification modules on opposite sides are disposed to face each other between the degasification modules 5 adjacent to each other along the connection supply pipe 6. Therefore, one suction pipe 4 may be connected to the facing end faces.

[0060] The suction pipe 4 may be provided for each of the plurality of degasification units 2, or may be provided in one for the plurality of degasification units 2. Further, in a case in which one degasification unit 2 is constituted by the plurality of degasification modules 5 as in the degasification unit 2A shown in FIG. 3, the suction pipe 4 may be connected to each of the plurality of degasification modules 5, or one suction pipe 4 may be connected to the plurality of degasification modules 5. Further, in the degasification unit 2A shown in FIG. 3, since the plurality of degasification modules 5 are connected in series by the connection supply pipe 6 in appearance, end faces of the degasification modules on opposite sides are disposed to face each other between the degasification modules 5 adjacent to each other along the connection supply pipe 6. Therefore, one suction pipe 4 may be connected to the facing end faces.

[0061] [Degasification method]

Next, a liquid degasification method by the degasification system 1 will be described.

[0062] First, a liquid such as water is supplied from the inlet 3a of the housing 3 to the upstream side region B of the housing 3. Then, the

liquid supplied to the upstream side region B is supplied to the connection supply pipe 6 from the supply port 6a and is supplied to the degasification region A of the degasification module 5 through the openings 6b of the connection supply pipe 6 and the inner pipe openings 11a of the degasification module 5. Accordingly, the liquid is supplied to the hollow fiber membrane bundle 12 of the degasification module 5. In the degasification region A, the liquid supplied from the inner pipe openings 11a passes between the plurality of hollow fiber membranes 14 in the hollow fiber membrane bundle 12 and then is discharged from the discharge ports 13a. At this time, the suction pipe 4 is suctioned, and the inside of the plurality of hollow fiber membranes 14 is depressurized, and thus a dissolved gas, bubbles, and the like of the liquid passing between the plurality of hollow fiber membranes 14 are removed. Then, the degasified liquid is discharged from the discharge ports 13a to the downstream side region C and further discharged from the outlet 3b to the outside of the housing 3.

[0063] [Flow rate analysis]

Here, the present inventors analyzed a flow rate of the liquid flowing through each degasification unit 22 for degasification systems 21 of Reference Examples 1 to 8 in which 39 degasification units 22 are housed in parallel in a housing 23 as shown in FIG. 9. FIG. 9 shows only half of the degasification unit 22. Each degasification unit 22 was set to be constituted by four degasification modules connected to each other as in the degasification unit 2A shown in FIG. 3, and all the degasification units 22 were set to be the same.

[0064] In the degasification system 21, the plurality of degasification units 22 were disposed in four rows from the central axis of the housing 23 toward the inner peripheral surface side of the housing 23. Specifically, the degasification unit 22 which is disposed on the most central side was designated as a degasification unit 22A in a first row. The degasification unit 22 disposed on the outer peripheral side of the degasification unit 22A in the first row was designated as a degasification unit 22B in a second row. The degasification unit 22 which is disposed on the outer peripheral side of the degasification unit 22B in the second row was designated as a degasification unit 22C in a third row. The degasification unit 22 which is disposed on the outer peripheral side of the degasification unit 22C in the third row and is disposed on the outermost peripheral side was designated as a degasification unit 22D in a fourth row. The degasification unit 22A in the first row is constituted by one degasification unit 22 disposed on the central axis of the housing 23. The degasification unit 22B in the second row is constituted by six degasification units 22 to surround the degasification unit 22A in the first row. The degasification unit 22C in the third row is constituted by 13 degasification units 22 to surround the degasification unit 22B in the second row. The degasification unit 22D in the fourth row is constituted by 19 degasification units 22 to surround the degasification unit 22C in the third row.

[0065] As analysis software, ANSYS Fluent Ver. 19.0 was used. For the liquid, seawater was used as a model, and a density thereof was set to 1025.5 kg/m³ and a viscosity thereof was set to 0.001164 Pa·s. For the hollow fiber membrane bundle, a porous material (a flow path

having a pressure resistance) was used as a model, and a pressure coefficient thereof was set to 1.9×10^{10} from an analysis value of one degasification module. In the analysis for obtaining the pressure coefficient, EF-040P manufactured by DIC Corporation was used.

5 [0066] (Reference Example 1)

As shown in FIGS. 9 and 10, in the degasification system 21 of Reference Example 1, the inner diameter of the housing 23 was set to 1645 mm, the outer diameter D1 of the degasification unit 22 was set to 163 mm, and the distance D2 from the plurality of degasification units 22 to the inner peripheral surface of the housing 23 was set to 200 mm. The distance D2 from the plurality of degasification units 22 to the inner peripheral surface of the housing 23 refers to the shortest distance from the circumscribed circle of the plurality of degasification units 22 to the inner peripheral surface of the housing 23. The distance D2 is about 1.23 times the outer diameter D1 of the degasification unit 22. In other words, the ratio (D2/D1) of the distance D2 to the outer diameter D1 of the degasification unit 22 is about 1.23. Further, the diameter of the inlet 3a of the housing 23 was set to 350 mm, and it was set such that all of the degasification unit 22A in the first row overlaps the inlet 3a, a part of the degasification unit 22B in the second row overlaps the inlet 3a, and the degasification unit 22C in the third row and the degasification unit 22D in the fourth row do not overlap the inlet 3a at all, when seen in a direction along the central axis of the housing 23. Further, the total flow rate of the liquid which is supplied to the degasification system 21 was set to 663 m³/h, and the ideal retention

time of the liquid in the upstream side region B (see FIG. 1) of the housing 23 was set to 5.1 seconds.

[0067] (Reference Example 2)

As shown in FIGS. 9 and 10, in the degasification system 21 of Reference Example 2, the inner diameter of the housing 23 was set to 1607 mm, the outer diameter D1 of the degasification unit 22 was set to 163 mm, and the distance D2 from the plurality of degasification units 22 to the inner peripheral surface of the housing 23 was set to 182 mm. The distance D2 is about 1.12 times the outer diameter D1 of the degasification unit 22. In other words, the ratio (D2/D1) of the distance D2 to the outer diameter D1 of the degasification unit 22 is about 1.12. Further, the diameter of the inlet 3a of the housing 23 was set to 350 mm, and it was set such that all of the degasification unit 22A in the first row overlaps the inlet 3a, a part of the degasification unit 22B in the second row overlaps the inlet 3a, and the degasification unit 22C in the third row and the degasification unit 22D in the fourth row do not overlap the inlet 3a at all, when seen in a direction along the central axis of the housing 23. Further, the total flow rate of the liquid which is supplied to the degasification system 21 was set to 663 m³/h, and the ideal retention time of the liquid in the upstream side region B of the housing 23 was set to 4.7 seconds.

[0068] (Reference Example 3)

As shown in FIGS. 9 and 10, in the degasification system 21 of Reference Example 3, the inner diameter of the housing 23 was set to 1405 mm, the outer diameter D1 of the degasification unit 22 was set to 163 mm, and the distance D2 from the plurality of degasification units

22 to the inner peripheral surface of the housing 23 was set to 81 mm. The distance D2 is about 0.50 times the outer diameter D1 of the degasification unit 22. In other words, the ratio (D2/D1) of the distance D2 to the outer diameter D1 of the degasification unit 22 is about 0.50. Further, the diameter of the inlet 3a of the housing 23 was set to 350 mm, and it was set such that all of the degasification unit 22A in the first row overlaps the inlet 3a, a part of the degasification unit 22B in the second row overlaps the inlet 3a, and the degasification unit 22C in the third row and the degasification unit 22D in the fourth row do not overlap the inlet 3a at all, when seen in a direction along the central axis of the housing 23. Further, the total flow rate of the liquid which is supplied to the degasification system 21 was set to 663 m³/h, and the ideal retention time of the liquid in the upstream side region B of the housing 23 was set to 3.7 seconds.

[0069] (Reference Example 4)

As shown in FIGS. 9 and 10, in the degasification system 21 of Reference Example 4, the inner diameter of the housing 23 was set to 1270 mm, the outer diameter D1 of the degasification unit 22 was set to 163 mm, and the distance D2 from the plurality of degasification units 22 to the inner peripheral surface of the housing 23 was set to 28.5 mm. The distance D2 is about 0.17 times the outer diameter D1 of the degasification unit 22. In other words, the ratio (D2/D1) of the distance D2 to the outer diameter D1 of the degasification unit 22 is about 0.17. Further, the diameter of the inlet 3a of the housing 23 was set to 350 mm, and it was set such that all of the degasification unit 22A in the first row overlaps the inlet 3a, a part of the degasification unit

22B in the second row overlaps the inlet 3a, and the degasification unit 22C in the third row and the degasification unit 22D in the fourth row do not overlap the inlet 3a at all, when seen in a direction along the central axis of the housing 23. Further, the total flow rate of the liquid which is supplied to the degasification system 21 was set to 663 m³/h, and the ideal retention time of the liquid in the upstream side region B of the housing 23 was set to 3.0 seconds.

[0070] (Reference Example 5)

As shown in FIGS. 9 and 10, in the degasification system 21 of Reference Example 5, the inner diameter of the housing 23 was set to 1645 mm, the outer diameter D1 of the degasification unit 22 was set to 163 mm, and the distance D2 from the plurality of degasification units 22 to the inner peripheral surface of the housing 23 was set to 200 mm. The distance D2 is about 1.23 times the outer diameter D1 of the degasification unit 22. In other words, the ratio (D2/D1) of the distance D2 to the outer diameter D1 of the degasification unit 22 is about 1.23. Further, the diameter of the inlet 3a of the housing 23 was set to 420 mm, and it was set such that all of the degasification unit 22A in the first row and all of the degasification unit 22B in the second row overlap the inlet 3a, and the degasification unit 22C in the third row and the degasification unit 22D in the fourth row do not overlap the inlet 3a at all, when seen in a direction along the central axis of the housing 23. Further, the total flow rate of the liquid which is supplied to the degasification system 21 was set to 663 m³/h, and the ideal retention time of the liquid in the upstream side region B of the housing 23 was set to 5.1 seconds.

[0071] (Reference Example 6)

As shown in FIGS. 9 and 10, in the degasification system 21 of Reference Example 6, the inner diameter of the housing 23 was set to 1645 mm, the outer diameter D1 of the degasification unit 22 was set to 163 mm, and the distance D2 from the plurality of degasification units 22 to the inner peripheral surface of the housing 23 was set to 200 mm. The distance D2 is about 1.23 times the outer diameter D1 of the degasification unit 22. In other words, the ratio ($D2/D1$) of the distance D2 to the outer diameter D1 of the degasification unit 22 is about 1.23. Further, the diameter of the inlet 3a of the housing 23 was set to 350 mm, and it was set such that all of the degasification unit 22A in the first row overlaps the inlet 3a, a part of the degasification unit 22B in the second row overlaps the inlet 3a, and the degasification unit 22C in the third row and the degasification unit 22D in the fourth row do not overlap the inlet 3a at all, when seen in a direction along the central axis of the housing 23. Further, the total flow rate of the liquid which is supplied to the degasification system 21 was set to 663 m³/h, and the ideal retention time of the liquid in the upstream side region B of the housing 23 was set to 3.4 seconds. The ideal retention time of the upstream side region B of Reference Example 6 is 0.72 times the ideal retention time of the upstream side region B of Reference Example 2. In other words, the ratio ($T6/T2$) of the ideal retention time T6 of the upstream side region B of Reference Example 6 to the ideal retention time T2 of the upstream side region B of Reference Example 2 is 0.72.

[0072] (Reference Example 7)

As shown in FIGS. 9 and 10, in the degasification system 21 of Reference Example 7, the inner diameter of the housing 23 was set to 1645 mm, the outer diameter D1 of the degasification unit 22 was set to 163 mm, and the distance D2 from the plurality of degasification units 22 to the inner peripheral surface of the housing 23 was set to 200 mm. The distance D2 is about 1.23 times the outer diameter D1 of the degasification unit 22. In other words, the ratio (D2/D1) of the distance D2 to the outer diameter D1 of the degasification unit 22 is about 1.23. Further, the diameter of the inlet 3a of the housing 23 was set to 350 mm, and it was set such that all of the degasification unit 22A in the first row overlaps the inlet 3a, a part of the degasification unit 22B in the second row overlaps the inlet 3a, and the degasification unit 22C in the third row and the degasification unit 22D in the fourth row do not overlap the inlet 3a at all, when seen in a direction along the central axis of the housing 23. Further, the total flow rate of the liquid which is supplied to the degasification system 21 was set to 663 m³/h, and the ideal retention time of the liquid in the upstream side region B of the housing 23 was set to 8.3 seconds. The ideal retention time of the upstream side region B of Reference Example 7 is 1.77 times the ideal retention time of the upstream side region B of Reference Example 2. In other words, the ratio (T7/T2) of the ideal retention time T7 of the upstream side region B of Reference Example 7 to the ideal retention time T2 of the upstream side region B of Reference Example 2 is 1.77.

[0073] (Reference Example 8)

As shown in FIGS. 9 and 10, in the degasification system 21 of Reference Example 8, the inner diameter of the housing 23 was set to 1645 mm, the outer diameter D1 of the degasification unit 22 was set to 163 mm, and the distance D2 from the plurality of degasification units 22 to the inner peripheral surface of the housing 23 was set to 200 mm. The distance D2 is about 1.23 times the outer diameter D1 of the degasification unit 22. In other words, the ratio (D2/D1) of the distance D2 to the outer diameter D1 of the degasification unit 22 is about 1.23. Further, the diameter of the inlet 3a of the housing 23 was set to 350 mm, and it was set such that all of the degasification unit 22A in the first row overlaps the inlet 3a, a part of the degasification unit 22B in the second row overlaps the inlet 3a, and the degasification unit 22C in the third row and the degasification unit 22D in the fourth row do not overlap the inlet 3a at all, when seen in a direction along the central axis of the housing 23. Further, the total flow rate of the liquid which is supplied to the degasification system 21 was set to 663 m³/h, and the ideal retention time of the liquid in the upstream side region B of the housing 23 was set to 11.5 seconds. The ideal retention time of the upstream side region B of Reference Example 8 is 2.45 times the ideal retention time of the upstream side region B of Reference Example 2. In other words, the ratio (T8/T2) of the ideal retention time T8 of the upstream side region B of Reference Example 8 to the ideal retention time T2 of the upstream side region B of Reference Example 2 is 2.45.

[0074] (Analysis results and examinations)

The flow rates of the degasification units 22 in each row in Reference Examples 1 to 8 are shown in FIG.11. As the flow rate of the degasification unit 22B in the second row, the flow rate of the degasification unit 22C in the third row, and the flow rate of the degasification unit 22D in the fourth row, an average value of the flow rates of all the degasification units 22 disposed in each row was used.

[0075] (Examination 1)

FIG. 12 is a graph showing the relationship between the flow rates of the degasification units 22 in each row and the ratio ($D2/D1$) of the distance D2 to the outer diameter D1 of the degasification unit 22 in Reference Examples 1 to 4. As shown in FIG. 12, as a whole, the flow rate of the degasification unit 22 tends to increase as the degasification unit 22 is close to the central axis of the housing 23, and the flow rate of the degasification unit 22 tends to decrease as the degasification unit 22 becomes further away from the central axis of the housing 23.

[0076] Therefore, it is assumed that by increasing a pressure loss of the liquid flowing through the degasification unit 22 as the degasification unit 22 is close to the central axis of the housing 23, it is possible to reduce deviation in the flow rate of the liquid flowing through each degasification unit 22.

[0077] On the other hand, in Reference Examples 3 and 4, the magnitude relationship between the flow rate of the degasification unit 22C in the third row and the flow rate of the degasification unit 22D in the fourth row is reversed. That is, in Reference Examples 3 and 4, the flow rate of the degasification unit 22D in the fourth row is larger than the flow rate of the degasification unit 22C in the third row. From a

line connecting the flow rates of the degasification units 22 in each row in Reference Examples 1 to 4, it can be seen that the magnitude relationship between the flow rate of the degasification unit 22C in the third row and the flow rate of the degasification unit 22D in the fourth row is reversed at a point where the ratio ($D2/D1$) of the distance D2 to the outer diameter D1 of the degasification unit 22 is 0.7.

[0078] From this result, it was found that the flow rate of the liquid flowing through the degasification unit 22 tends to decrease as the degasification unit 22 becomes further away from the central axis of the housing 23, but the above tendency is reversed in an outer region from the inner peripheral surface of the housing 23 to a position corresponding to 0.7 times or 0.5 times the outer diameter D1 of the degasification unit 22 toward the central axis side. That is, it was found that the flow rate of the liquid flowing through the degasification unit 22 tends to be higher in the outer region than in an inner region. Further, it was found that in the outer region, the flow rate of the liquid flowing through the degasification unit 22 tends to increase as the degasification unit 22 becomes further away from the central axis of the housing 23 (as the degasification unit 22 is close to the inner peripheral surface of the housing 23). It is assumed that this is because, in the outer region, the liquid flowing in the housing 23 is pushed back against the inner peripheral surface of the housing 23, and thus the flow rate of the liquid flowing through the degasification unit 22 increases.

[0079] Therefore, it is assumed that by making the pressure loss of the liquid in the degasification unit 2 disposed in the outer region 16 larger than that in the degasification unit 2 closest to the outer region 16

among the degasification units 2 disposed in the inner region 17, it is possible to reduce deviation in the flow rate of the liquid flowing through each degasification unit 22. Further, it is assumed that in the outer region, by increasing the pressure loss of the liquid flowing through the degasification unit 22 as the degasification unit 22 becomes further away from the central axis of the housing 23, it is possible to reduce deviation in the flow rate of the liquid flowing through each degasification unit 22.

[0080] (Examination 2)

FIG. 13 is a graph showing the relationship between each row and the flow rates of degasification units 22 in Reference Examples 2 and 5. As shown in FIG. 10, in Reference Example 2 and Reference Example 5, the degree of overlap between the degasification unit 22 and the inlet 3a when seen in a direction along the central axis of the housing 23 is different. However, as shown in FIG. 13, in both Reference Example 2 and Reference Example 5, the tendency that the flow rate of the degasification unit 22 that overlaps the inlet 3a when seen in a direction along the central axis of the housing 23 is larger than that of the degasification unit 22 that does not overlap the inlet 3a when seen in a direction along the central axis of the housing 23 does not change.

[0081] From this result, it was found that the flow rate of the degasification unit 22 that overlaps the inlet 3a when seen in a direction along the central axis of the housing 23 is larger than that of the degasification unit 22 that does not overlap the inlet 3a when seen in a direction along the central axis of the housing 23 regardless of the

difference in the degree of overlap between the degasification unit 22 and the inlet 3a when seen in a direction along the central axis of the housing 23.

[0082] Therefore, it is assumed that by making the pressure loss of the liquid in the degasification unit 22 that overlaps the inlet 3a when seen in a direction along the central axis of the housing 23 larger than that in the degasification unit 22 that does not overlap the inlet 3a when seen in a direction along the central axis of the housing 23 regardless of the difference in the degree of overlap between the degasification unit 22 and the inlet 3a when seen in a direction along the central axis of the housing 23, it is possible to reduce deviation in the flow rate of the liquid flowing through each degasification unit 22.

[0083] (Examination 3)

FIG. 14 is a graph showing the relationship between the flow rates of degasification units 22 in each row and the ideal retention time of the upstream side region B of the housing 23 in Reference Examples 6 to 8. As shown in FIG. 14, in Reference Examples 6 to 8, the ideal retention time of the upstream side region B of the housing 23 is different. However, in all of Reference Examples 6 to 8, the tendency that the flow rate of the liquid flowing through the degasification unit 22 increases as the degasification unit 22 is close to the central axis of the housing 23 does not change.

[0084] From this result, it was found that the flow rate of the liquid flowing through the degasification unit 22 increases as the degasification unit 22 is close to the central axis of the housing 23

regardless of the difference in the ideal retention time of the upstream side region B of the housing 23.

[0085] Therefore, it is assumed that by increasing the pressure loss of the liquid flowing through the degasification unit 22 as the degasification unit 22 is close to the central axis of the housing 23 regardless of the difference in the ideal retention time of the upstream side region B, it is possible to reduce deviation in the flow rate of the liquid flowing through each degasification unit 22.

[0086] [Pressure loss of each degasification unit]

In view of the analysis results and examinations of the above reference example, in the present embodiment, the plurality of degasification units 2 are configured such that the pressure losses of the liquid differ depending on the distance from the central axis L of the housing 3, and thus the deviation in the flow rate of the liquid flowing through each degasification unit 22 is reduced, and the degasification performance of the degasification system 1 in its entirety is improved.

[0087] Specifically, among the plurality of degasification units 2, the degasification unit 2 that overlaps the inlet 3a when seen in a direction along the central axis L may be configured such that the pressure loss of the liquid therein is larger than that in the degasification unit 2 that does not overlap the inlet 3a when seen in a direction along the central axis L of the housing 23 (see Reference Examples 2 and 5 and FIG. 13). In the present specification, the pressure loss refers to a pressure loss of the liquid flowing through the degasification unit 2.

[0088] Here, as shown in FIG. 15, a region from the inner peripheral surface 3c of the housing 3 to a position of a predetermined distance D

toward the central axis L side is defined as the outer region 16, and a region inside the outer region 16 is defined as the inner region 17. This predetermined distance D is a distance at which the magnitude relationship of the flow rates of the degasification units 2 is reversed in a case in which the pressure losses of the plurality of degasification units 2 are the same. From the above Examination 1, the predetermined distance may be 0.7 times the outer diameter D1 of the degasification unit 2 or 0.5 times the outer diameter D1 of the degasification unit 2.

[0089] In this case, in the inner region 17, the plurality of degasification units 2 have an inner degasification unit which is an arbitrary one degasification unit 2 and an outer degasification unit which is a degasification unit 2 farther from the central axis L than the inner degasification unit and the inner degasification unit may be configured such that the pressure loss of the liquid therein is larger than that in the outer degasification unit (see Reference Examples 1 to 4 and FIG. 12). For example, in a case in which all the degasification modules are disposed in the inner region 17 and the degasification unit 2A in the first row is set as an inner degasification module, any of the degasification unit 2B in the second row, the degasification unit 2C in the third row, and the degasification unit 2D in the fourth row serves as the outer degasification module. In the inner region 17, it is sufficient that the pressure losses of any two degasification units 2 among the plurality of degasification units 2 satisfy the above relationship. For example, the pressure losses of the degasification units 2 adjacent to each other in a radial direction of the housing 3 may be the same (substantially the

same). The fact that the pressure losses are the same means that it also includes a case in which the pressure losses differ by, for example, about 30% due to a manufacturing error or the like.

[0090] Further, in a case in which all the degasification units 2 are disposed in the inner region 17, the plurality of degasification units 2 may be configured such that the pressure loss of the liquid increases as the degasification unit 2 becomes closer to the central axis L.

[0091] On the other hand, in a case in which at least one degasification unit 2 is disposed in the outer region 16 and the remaining degasification units 2 are disposed in the inner region 17, the degasification units 2 disposed in the inner region 17 may be configured such that the pressure loss of the liquid increases as the degasification unit 2 becomes closer to the central axis L. In this case, the degasification unit 2 disposed in the outer region 16 may be configured such that the pressure loss of the liquid therein is larger than that in the degasification unit 2 closest to the outer region 16 among the degasification units 2 disposed in the inner region 17. Further, the degasification units 2 disposed in the outer region 16 may be configured such that the pressure loss of the liquid increases as the degasification unit 2 becomes further away from the central axis L of the housing 23.

[0092] It is possible to obtain the pressure loss of the liquid flowing through the degasification unit 2, for example, by measuring the pressure of the liquid in the supply port 6a (see FIGS. 3 and 4) and the pressure of the liquid in each of the discharge ports 13a (see FIGS. 3 and 4) of the degasification unit 2 with a pressure gauge or the like and calculating the difference therebetween.

[0093] Here, the pressure loss of the liquid in each degasification unit 2 is the sum of, for example, [1] a pressure loss of the liquid in the liquid supply path 10 (the connection supply pipe 6), [2] a pressure loss of the liquid in the openings 6b of the connection supply pipe 6, [3] a pressure loss of the liquid in the inner pipe openings 11a of the module inner pipe 11, [4] a pressure loss of the liquid in the hollow fiber membrane bundle 12, and [5] a pressure loss of the liquid in the discharge ports 13a of the module container 13. Therefore, for example, by adjusting a part or all of them, that is, by adjusting at least one of them, it is possible to adjust the pressure loss of the liquid in each degasification unit 2.

[0094] [1] For example, by reducing the inner diameter of the connection supply pipe 6, it is possible to increase the pressure loss of the liquid in the liquid supply path 10. In this case, for example, as the connection supply pipe 6, a pipe having an inner diameter that narrows in a tapered shape from the upstream side toward the downstream side or a pipe having an inner diameter that gradually narrows from the upstream side toward the downstream side may be used, and thus the inner diameter of the connection supply pipe 6 may be reduced.

[0095] [2] For example, by reducing the total area of the openings 6b of the connection supply pipe 6, reducing the number of openings 6b of the connection supply pipe 6, or reducing the size of each of the openings 6b of the connection supply pipe 6, it is possible to increase the pressure loss of the liquid at the openings 6b of the connection supply pipe 6.

[0096] [3] For example, by reducing the total area of the inner pipe openings 11a of the degasification module 5, reducing the number of the

inner pipe openings 11a of the degasification module 5, or reducing the size of each of the inner pipe openings 11a of the degasification module 5, it is possible to increase the pressure loss of the liquid at the inner pipe openings 11a of the module inner pipe 11.

5 [0097] [4] For example, by making the density of the plurality of hollow fiber membranes 14 in the degasification module 5 high, it is possible to increase the pressure loss of the liquid in the hollow fiber membrane bundle 12. Specifically, when the density of the plurality of hollow fiber membranes 14 is made high, a gap between the plurality of
10 hollow fiber membranes 14 is narrowed, and the passage resistance of the liquid to the hollow fiber membrane bundle 12 is increased. As a result, the pressure loss of the liquid in the hollow fiber membrane bundle 12 becomes large.

[0098] Further, for example, by increasing the thickness of the hollow
15 fiber membrane bundle 12 in the degasification module 5, it is possible to increase the pressure loss of the liquid in the hollow fiber membrane bundle 12. Specifically, when the thickness of the hollow fiber membrane bundle 12 is made thick, the passage resistance of the liquid to the hollow fiber membrane bundle 12 is increased. As a result, the
20 pressure loss of the liquid in the hollow fiber membrane bundle 12 becomes large.

[0099] Further, in a case in which the hollow fiber membrane bundle 12 is formed by a woven fabric obtained by weaving the plurality of hollow fiber membranes 14, which are weft threads, with warp threads being
25 wound around the module inner pipe 11 (the periphery of the liquid supply path 10), for example, by making the winding pressure of the

woven fabric in the degasification module 5 high, it is possible to increase the pressure loss of the liquid in the hollow fiber membrane bundle 12. Specifically, when the winding pressure of the wound woven fabric is made high, a gap between the plurality of hollow fiber membranes 14 is narrowed, and the passage resistance of the liquid to the hollow fiber membrane bundle 12 is increased. As a result, the pressure loss of the liquid in the hollow fiber membrane bundle 12 becomes large. In this case, the woven fabric may be wound around the module inner pipe 11 (the periphery of the liquid supply path 10) such that the plurality of hollow fiber membranes 14 extend in the axial direction of the module inner pipe 11 (the liquid supply path 10).

[0100] Similarly, in a case in which the hollow fiber membrane bundle 12 is formed by a woven fabric obtained by weaving the plurality of hollow fiber membranes 14, which are weft threads, with warp threads being wound around the module inner pipe 11 (the periphery of the liquid supply path 10) such that the plurality of hollow fiber membranes 14 extend in the axial direction of the module inner pipe 11 (the liquid supply path 10), for example, by making a pitch between the warp threads in the degasification module 5 long, it is possible to increase the pressure loss of the liquid in the hollow fiber membrane bundle 12. Specifically, when the woven fabric is wound around the module inner pipe 11, the hollow fiber membrane 14 on the outer peripheral side tends to enter between the adjacent hollow fiber membranes 14 on the inner peripheral side. In this case, if the pitch between the warp threads in the degasification module 5 is short, a gap between the hollow fiber membranes on the inner peripheral side which are

supported by the warp threads is narrowed, and thus the hollow fiber membrane 14 on the outer peripheral side is difficult to enter between the adjacent hollow fiber membranes 14 on the inner peripheral side. As a result, the density of the hollow fiber membranes 14 becomes low.

5 As a result, the pressure loss of the liquid in the hollow fiber membrane bundle 12 becomes small. On the other hand, if the pitch between the warp threads in the degasification module 5 is long, a gap between the hollow fiber membranes on the inner peripheral side which are supported by the warp threads is lengthened, and thus the hollow fiber

10 membrane 14 on the outer peripheral side easily enters between the adjacent hollow fiber membranes 14 on the inner peripheral side. As a result, the density of the hollow fiber membranes 14 becomes high. As a result, the pressure loss of the liquid in the hollow fiber membrane bundle 12 becomes large.

15 [0101] Further, for example, by increasing the outer diameter of the hollow fiber membrane 14 in the degasification module 5, it is possible to increase the pressure loss of the liquid in the hollow fiber membrane bundle 12. Specifically, for example, in a case in which the number of the hollow fiber membranes 14 is the same, when the outer diameter of

20 the hollow fiber membrane 14 is made large, a gap between the hollow fiber membranes 14 is narrowed, and the passage resistance of the liquid to the hollow fiber membrane bundle 12 is increased. As a result, the pressure loss of the liquid in the hollow fiber membrane bundle 12 becomes large.

25 [0102] Further, for example, by making the hydrophilicity of the hollow fiber membrane 14 in the degasification module 5 high, it is possible to

increase the pressure loss of the liquid in the hollow fiber membrane bundle 12. Specifically, when the hydrophilicity of the hollow fiber membrane 14 is made high, the contact resistance of the liquid to the hollow fiber membrane 14 is increased. As a result, the pressure loss of the liquid in the hollow fiber membrane bundle 12 becomes large.

[0103] [5] For example, by reducing the total area of the discharge ports 13a of the degasification module 5, reducing the number of the discharge ports 13a of the degasification module 5, or reducing the size of each of the discharge ports 13a of the degasification module 5, it is possible to increase the pressure loss of the liquid at the discharge ports 13a of the module container 13.

[0104] As described above, in the degasification system 1 according to the present embodiment, the plurality of degasification units 2 are housed in parallel in the cylindrical housing 3. Here, in a case in which the pressure losses of the liquid flowing through the plurality of degasification units 2 are the same, the flow rates of the liquid flowing through the degasification units 2 differ depending on the distance from the central axis L of the housing 3. However, in this degasification system 1, the plurality of degasification units 2 are configured such that the pressure losses of the liquid differ depending on the distance from the central axis L of the housing 3. This difference in the pressure loss acts to offset the above difference in the flow rate. As a result, it is possible to reduce the deviation in the flow rate of the liquid flowing through the plurality of degasification units 2. As a result, for example, the degasification performance of the degasification system 1 in its entirety can be improved.

[0105] Further, by providing the suction pipe 4, it is possible to appropriately degasify the liquid in the degasification unit 2, and it is possible to appropriately discharge the degasification gas to the outside of the housing 3.

5 [0106] Since the degasification unit 2 that overlaps the inlet 3a when seen in a direction along the central axis L receives a stronger supply pressure of the liquid from the inlet 3a than that in the degasification unit 2 that does not overlap the inlet 3a when seen in a direction along the central axis L, the liquid easily flows in the degasification unit 2 that
10 overlaps the inlet 3a when seen in a direction along the central axis L. Here, since the degasification unit 2 that overlaps the inlet 3a when seen in a direction along the central axis L is configured such that the pressure loss of the liquid therein is larger than that in the degasification unit 2 that does not overlap the inlet 3a when seen in a direction along
15 the central axis L, this difference in the pressure loss acts to offset the difference in the supply pressure of the liquid. As a result, it is possible to reduce the deviation in the flow rate of the liquid flowing through these degasification units 2.

[0107] Incidentally, as described above, in a case in which the pressure
20 losses of the liquid flowing through the plurality of degasification units 2 are the same, the flow rate of the liquid flowing through the degasification unit 2 tends to decrease as the degasification unit 2 becomes further away from the central axis L of the housing 3. However, the above tendency is reversed in the outer region from the
25 inner peripheral surface of the housing 3 to the position of the predetermined distance D toward the central axis side.

[0108] Therefore, since the inner degasification unit is configured such that the pressure loss of the liquid therein is larger than that in the outer degasification unit, this difference in the pressure loss acts to offset the above difference in the flow rate. As a result, it is possible to reduce the deviation in the flow rate of the liquid flowing through the inner degasification unit and the outer degasification unit.

[0109] Further, in a case in which all the degasification units 2 are disposed in the inner region 17, the plurality of degasification units 2 are configured such that the pressure loss of the liquid increases as the degasification unit 2 becomes closer to the central axis L, and thus it is possible to appropriately reduce the deviation in the flow rate of the liquid flowing through the plurality of degasification units 2.

[0110] On the other hand, in a case in which at least one degasification unit 2 is disposed in the outer region 16 and the remaining degasification units 2 are disposed in the inner region 17, the degasification units 2 disposed in the inner region 17 are configured such that the pressure loss of the liquid increases as the degasification unit 2 becomes closer to the central axis L, and thus it is possible to appropriately reduce the deviation in the flow rate of the liquid flowing through the degasification units 2 in the inner region 17.

[0111] In this case, since the degasification unit 2 disposed in the outer region 16 is configured such that the pressure loss of the liquid therein is larger than that in the degasification unit 2 closest to the outer region 16 among the degasification units 2 disposed in the inner region 17, it is possible to appropriately reduce the deviation in the flow rate of the

liquid even between the degasification unit 2 disposed in the inner region 17 and the degasification unit 2 disposed in the outer region 16.

[0112] [Method for manufacturing degasification system]

Next, a method for manufacturing the degasification system 1 will be described.

[0113] In a case in which one degasification unit 2 is constituted by a plurality of degasification modules 5 as in the degasification unit 2A shown in FIG. 3, first, a plurality of degasification modules 5 and a connection supply pipe 6 are prepared. Next, the connection supply pipe 6 is inserted into the liquid supply paths 10 of the plurality of degasification modules 5. Then, the liquid supply paths 10 of the plurality of degasification modules 5 are connected in series by the connection supply pipe 6. Further, the plurality of openings 6b of the connection supply pipe 6 are disposed at positions corresponding to the plurality of degasification modules 5 such that the liquid is supplied to the hollow fiber membrane bundles 12 of the plurality of degasification modules 5 in parallel. As a result, one degasification unit 2 is formed.

In a case in which one degasification unit 2 is constituted by one degasification module 5 as in the degasification unit 2B shown in FIG. 4, such a procedure is not necessary.

[0114] A plurality of degasification units 2, a housing 3 which houses the plurality of degasification units 2 and has an inlet 3a through which the liquid is supplied from outside and an outlet 3b through which the liquid is discharged to the outside, and a suction pipe 4 are prepared.

Next, with the housing sealing portion 7 which partitions the internal space of the housing 3 into the upstream side region B on the inlet 3a

side and the downstream side region C on the outlet 3b side via the plurality of degasification units 2, the plurality of the degasification units 2 are fixed to the housing 3. Further, the suction pipe 4 is installed such that the suction pipe 4 penetrates the housing 3 and is connected to both ends of the degasification module 5 to which the inside of the hollow fiber membrane 14 is opened. Then, the pressure losses of the liquid of the plurality of degasification units 2 are made different depending on the distance from the central axis L of the housing 3. Such setting of the pressure loss of the liquid can be performed by the various methods described above.

[0115] In the above, the embodiment of the present invention has been described, but the present invention is not limited to the above embodiments. For example, in the above embodiment, the configuration of the degasification unit has been specifically described, but as the degasification unit, degasification units in various configurations can be used. Further, in the above embodiment, it has been described that each degasification module includes a module inner pipe, but each degasification module may not include such a module inner pipe. In this case, for example, the hollow fiber membrane bundle (the woven fabric) of each degasification module is wound around the connection supply pipe directly.

[0116] Further, a use method and a utilization method of the degasification system of the present invention are not particularly limited, and the degasification system of the present invention can be used in the technical field for producing natural resources such as a jet boring method, an in situ leaching method (ISL), and water flooding.

Specifically, the degasification system of the present invention may be used in the following method for producing natural resources. That is, the method for producing natural resources in the degasification system of the present invention includes a step of degasifying a liquid by supplying the liquid from the inlet to the plurality of degasification units and depressurizing an inside of the plurality of hollow fiber membranes of each of the plurality of degasification modules, and a press-in step of pressing-in the liquid degasified in the degasification step into a natural resource mining site. Here, examples of natural resources include metallic minerals such as copper and uranium, and fuel minerals such as crude oil, natural gas, shale oil, and shale gas. As the liquid, water is exemplified. In a case in which the natural resources are fuel minerals, examples of the liquid include seawater, accompanying water, and fracturing fluid. The accompanying water is the water generated when natural resources are produced. The degasification unit used in the present invention can be transferred to the place of use after the degasification unit is manufactured in advance by the connection of a plurality of degasification modules or can be manufactured by the connection of the degasification modules individually transported in the place of use of the degasification system of the present invention. In the unlikely event that a problem occurs in any one of the degasification modules or the degasification units, it is only necessary to replace the corresponding degasification module or the degasification unit, which is excellent in handleability during transportation in manufacturing and maintainability during use. Therefore, for example, it is also suitable for use at a mining site for natural resources.

Reference Signs List

[0117]	1 Degasification system
	2, 2A, 2B, 2C, 2D Degasification unit
	3 Housing
5	3a Inlet
	3b Outlet
	3c Inner peripheral surface
	4 Suction pipe
	5, 5A, 5B, 5C, 5D Degasification module
10	6, 6A, 6B Connection supply pipe
	6a Supply port
	6b Opening
	7 Housing sealing portion (sealing portion)
	8 Degasification unit supporting portion
15	10 Liquid supply path
	11 Module inner pipe
	11a Inner pipe opening
	12 Hollow fiber membrane bundle
	12a End portion
20	13 Module container (cylinder)
	13a Discharge port
	14 Hollow fiber membrane
	15 Sealing portion
	16 Outer region
25	17 Inner region
	21 Degasification system

- 5 22, 22A, 22B, 22C, 22D Degasification unit
23 Housing
A Degasification region
B Upstream side region
C Downstream side region
L Central axis

CLAIMS

[Claim 1]

A degasification system comprising:

a plurality of degasification units configured to degasify a liquid; and

a cylindrical housing configured to house the plurality of degasification units in parallel,

wherein each of the plurality of degasification units includes a hollow fiber membrane bundle in which a plurality of hollow fiber membranes are bundled in a cylindrical shape and a cylinder in which the hollow fiber membrane bundle is housed,

wherein the housing has an inlet through which the liquid is supplied from outside, an outlet through which the liquid is discharged to the outside, and a sealing portion which partitions an internal space of the housing into an upstream side region on the inlet side and a downstream side region on the outlet side via the plurality of degasification units, and

wherein the plurality of degasification units are configured such that pressure losses of the liquid differ depending on a distance from a central axis of the housing.

[Claim 2]

The degasification system according to claim 1, further comprising: a suction pipe communicating with an inside of the hollow fiber membranes and penetrating the housing to suction the inside of the hollow fiber membranes.

[Claim 3]

The degasification system according to claim 1 or 2, wherein, among the plurality of degasification units, the degasification unit that overlaps the inlet when seen in a direction along the central axis is configured such that the pressure loss of the liquid therein is larger than that in the degasification unit that does not overlap the inlet when seen in a direction along the central axis.

[Claim 4]

The degasification system according to any one of claims 1 to 3,

wherein, in a case in which a region from an inner peripheral surface of the housing to a position corresponding to 0.7 times an outer diameter of the degasification unit toward the central axis side is defined as an outer region and a region inside the outer region is defined as an inner region,

in the inner region, the plurality of degasification units have an inner degasification unit and an outer degasification unit which is farther from the central axis than the inner degasification unit, and

the inner degasification unit is configured such that the pressure loss of the liquid therein is larger than that in the outer degasification unit.

[Claim 5]

The degasification system according to any one of claims 1 to 4,

wherein, in a case in which a region from an inner peripheral surface of the housing to a position corresponding to 0.7 times an

outer diameter of the degasification unit toward the central axis side is defined as an outer region, a region inside the outer region is defined as an inner region, and all the degasification units are disposed in the inner region,

the plurality of degasification units are configured such that the pressure loss of the liquid increases as the degasification unit becomes closer to the central axis.

[Claim 6]

The degasification system according to any one of claims 1 to 4,

wherein, in a case in which a region from an inner peripheral surface of the housing to a position corresponding to 0.7 times an outer diameter of the degasification unit toward the central axis side is defined as an outer region, a region inside the outer region is defined as an inner region, at least one degasification unit is disposed in the outer region, and remaining degasification units are disposed in the inner region,

the degasification units disposed in the inner region are configured such that the pressure loss of the liquid increases as the degasification unit becomes closer to the central axis.

[Claim 7]

The degasification system according to claim 6, wherein the degasification unit disposed in the outer region is configured such that the pressure loss of the liquid therein is larger than that in the degasification unit closest to the outer region among the degasification units disposed in the inner region.

[Claim 8]

The degasification system according to any one of claims 1 to 7,

wherein, in the degasification unit, a plurality of degasification modules are connected,

wherein each of the plurality of the degasification modules includes a hollow fiber membrane bundle having a plurality of hollow fiber membranes arranged around a liquid supply path through which a liquid is supplied and a cylinder which houses the hollow fiber membrane bundle and in which discharge ports for discharging the liquid are formed, and

wherein the degasification unit has a connection supply pipe which connects the liquid supply paths of the plurality of degasification modules in series and in which openings through which the liquid passes are formed at positions corresponding to the plurality of degasification modules such that the liquid is supplied to the hollow fiber membrane bundles of the plurality of degasification modules in parallel.

[Claim 9]

A liquid degasification method in the degasification system according to any one of claims 1 to 8, comprising:

degasifying a liquid by supplying the liquid from the inlet to the plurality of degasification units and depressurizing an inside of the plurality of hollow fiber membranes of each of the plurality of degasification units.

[Claim 10]

A degasification unit used in the degasification system according to any one of claims 1 to 8, comprising:

a hollow fiber membrane bundle in which a plurality of hollow fiber membranes are bundled in a cylindrical shape; and

a cylinder in which the hollow fiber membrane bundle is housed.

[Claim 11]

A degasification module used in the degasification system according to claim 8, comprising:

a hollow fiber membrane bundle having a plurality of hollow fiber membranes arranged around a liquid supply path through which a liquid is supplied; and

a cylinder which houses the hollow fiber membrane bundle and in which discharge ports for discharging the liquid are formed.

[Claim 12]

A method for manufacturing a degasification system comprising:

preparing a plurality of degasification units, a housing which houses the plurality of degasification units and has an inlet through which a liquid is supplied from outside and an outlet through which the liquid is discharged to the outside, and a suction pipe;

fixing the plurality of the degasification units to the housing with a sealing portion which partitions an internal space of the housing into an upstream side region on the inlet side and a

downstream side region on the outlet side via the plurality of degasification units; and

making pressure losses of the liquid of the plurality of degasification units different depending on a distance from a central axis of the housing.

[Claim 13]

The method for manufacturing a degasification system according to claim 12, further comprising:

preparing a plurality of degasification modules each having a hollow fiber membrane bundle having a plurality of hollow fiber membranes arranged around a liquid supply path through which a liquid is supplied and a cylinder which houses the hollow fiber membrane bundle and in which discharge ports for discharging the liquid are formed, and a connection supply pipe in which a plurality of openings through which the liquid passes are formed; and

inserting the connection supply pipe into the liquid supply paths of the plurality of degasification modules to connect the liquid supply paths of the plurality of degasification modules in series by the connection supply pipe and disposing the plurality of openings at positions corresponding to the plurality of degasification modules such that the liquid is supplied to the hollow fiber membrane bundles of the plurality of degasification modules in parallel, to manufacture the degasification unit.

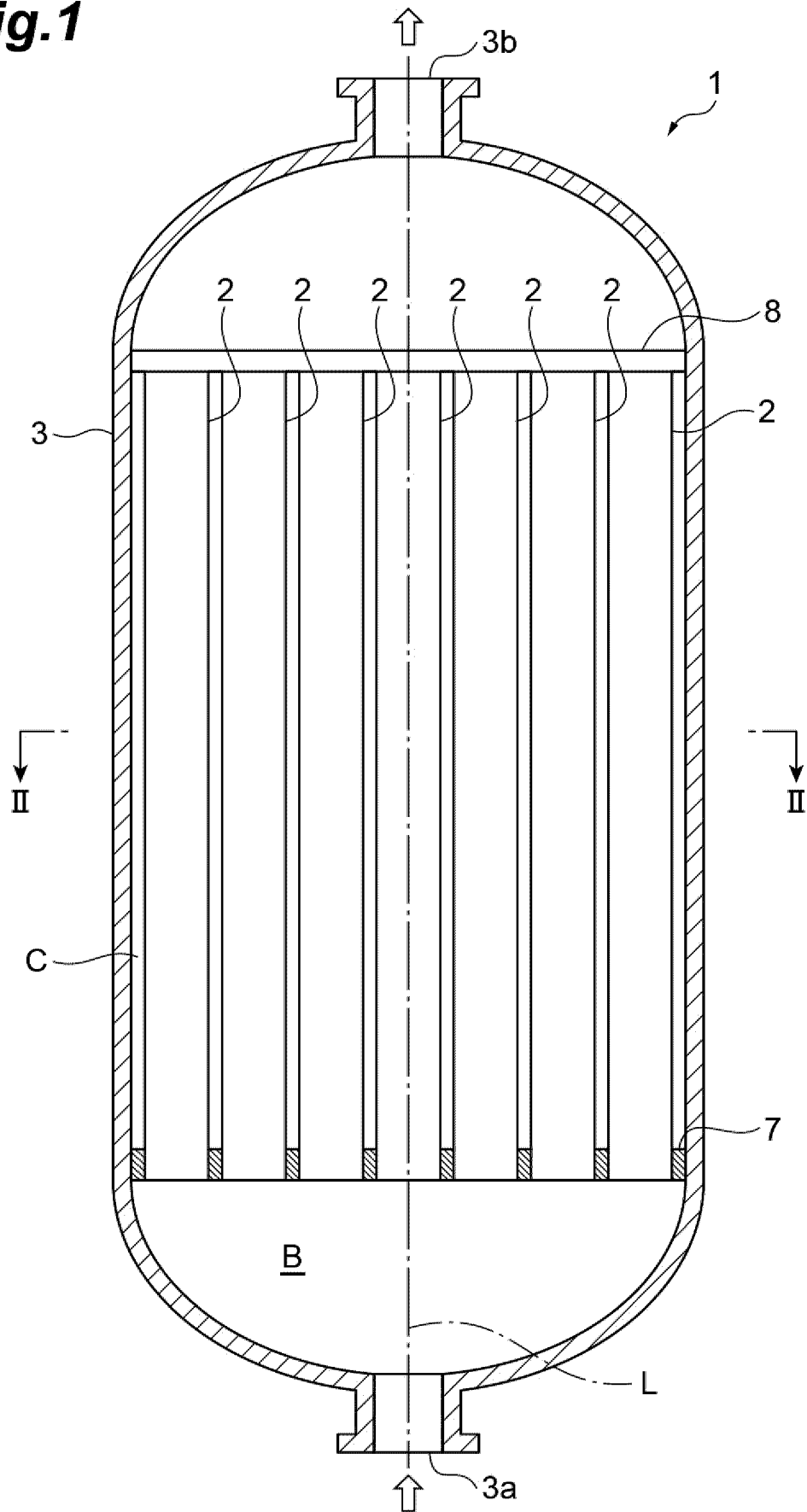
[Claim 14]

A method for producing natural resources in the degasification system according to any one of claims 1 to 8, comprising:

a degasification step of degasifying a liquid by supplying the liquid from the inlet to the plurality of degasification units and depressurizing an inside of the plurality of hollow fiber membranes of each of the plurality of degasification units; and
a press-in step of pressing-in the liquid degasified in the degasification step into a natural resource mining site.

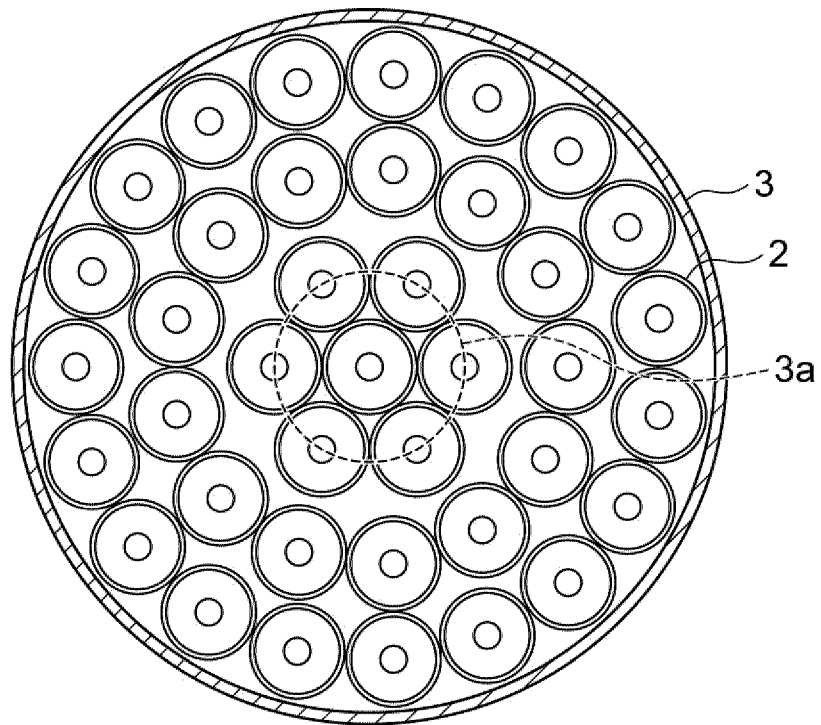
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Fig.1

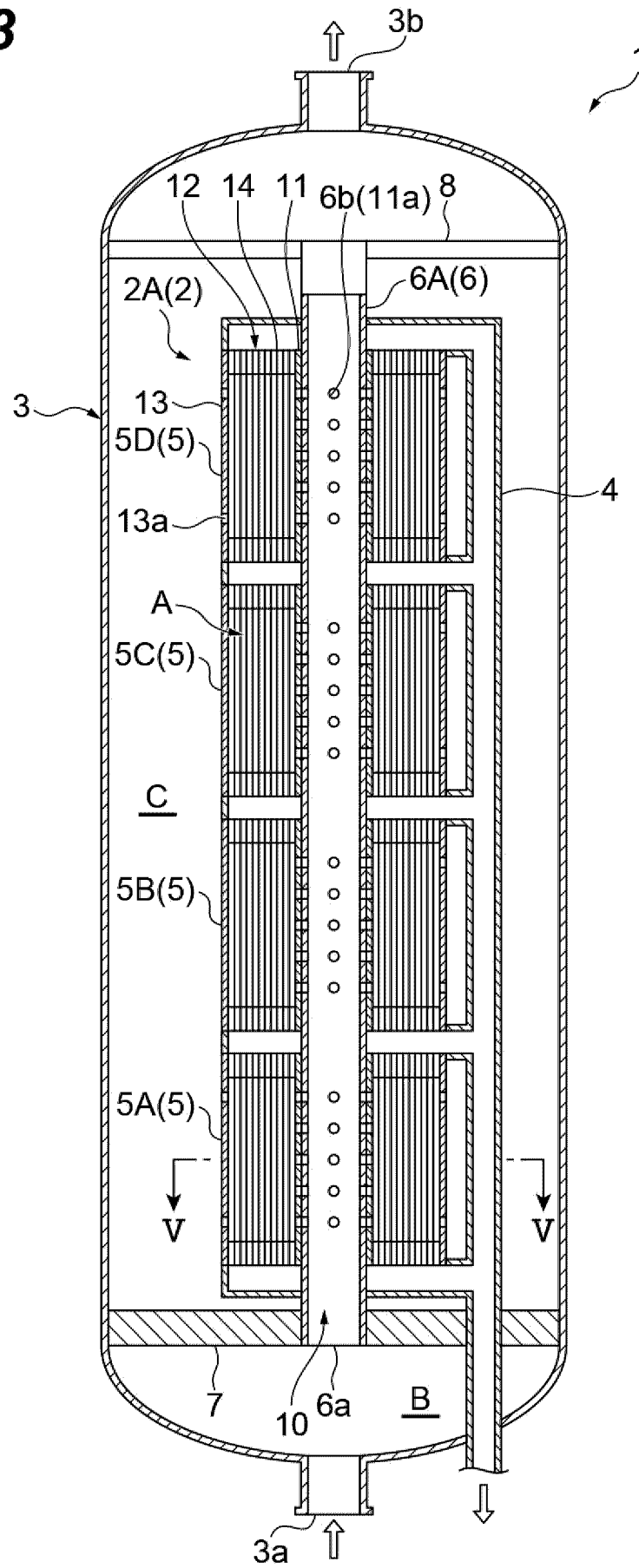


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Fig.2



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Fig.3

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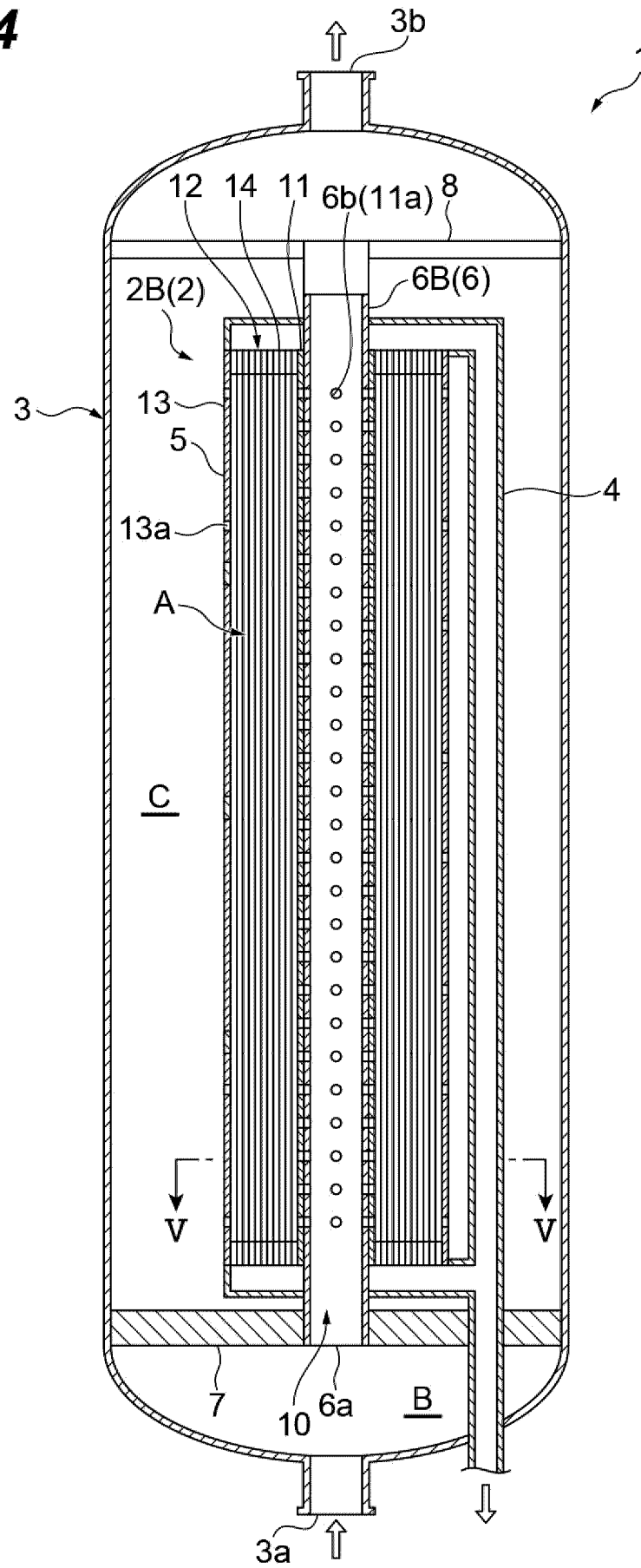
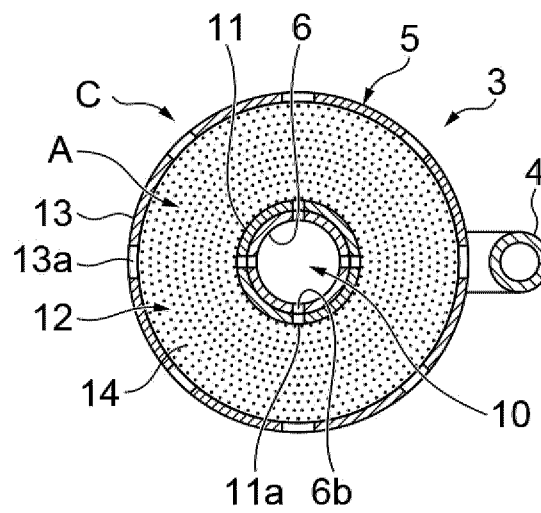
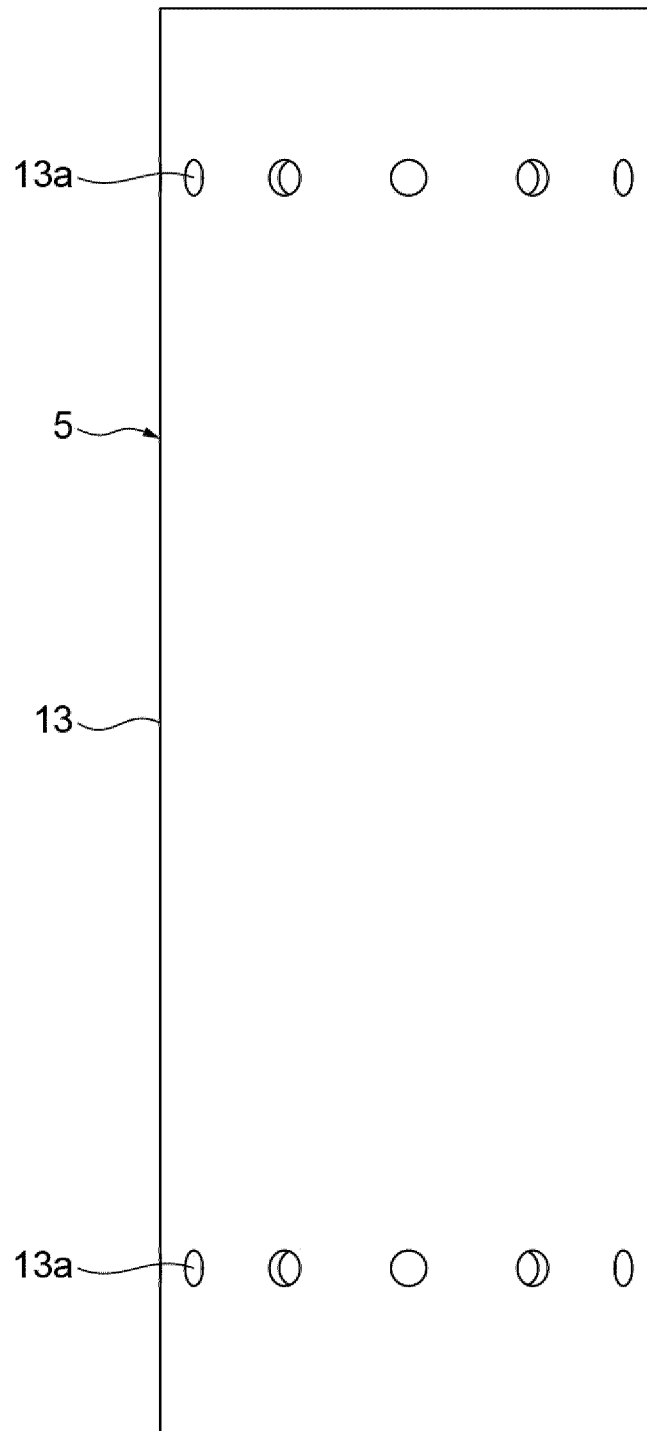
Fig.4

Fig.5

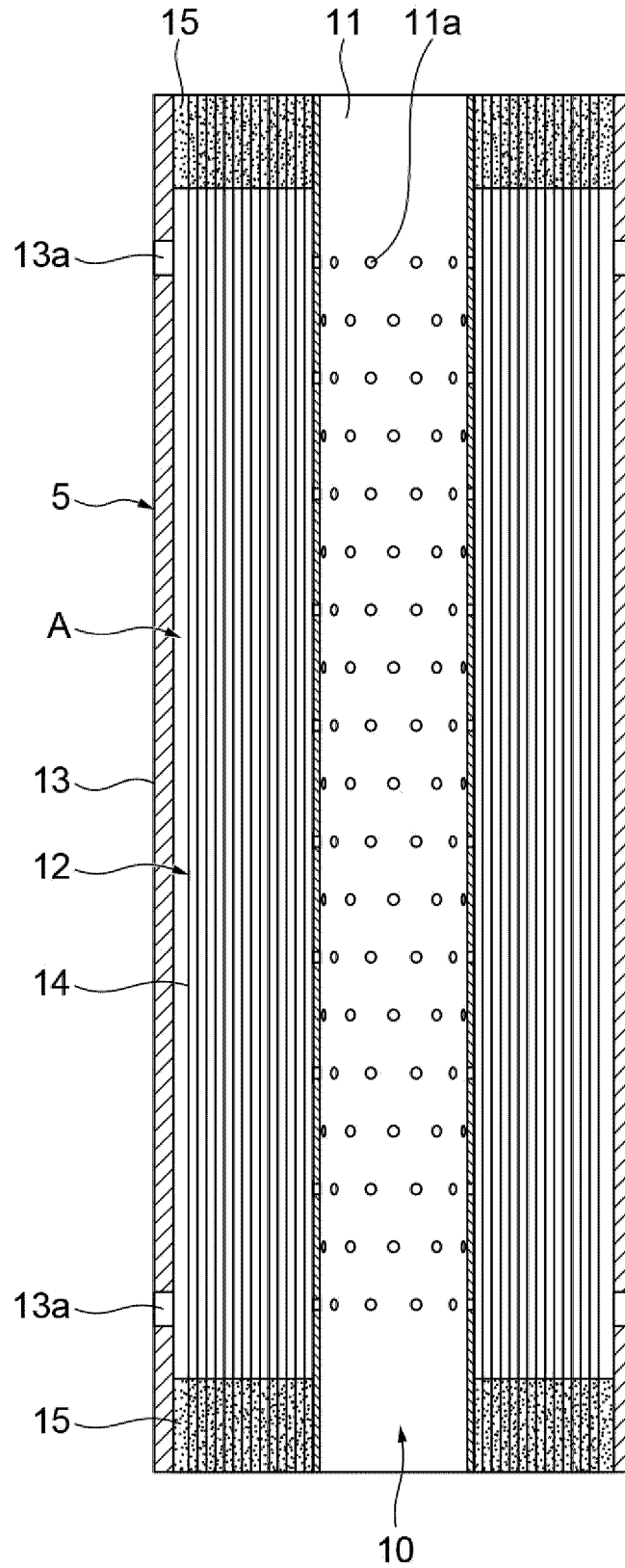


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Fig.6



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Fig.7

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Fig.8

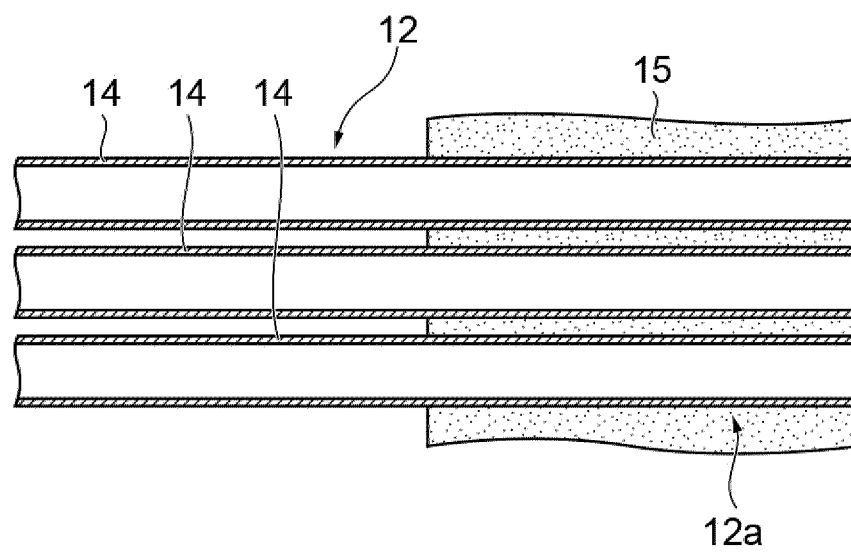
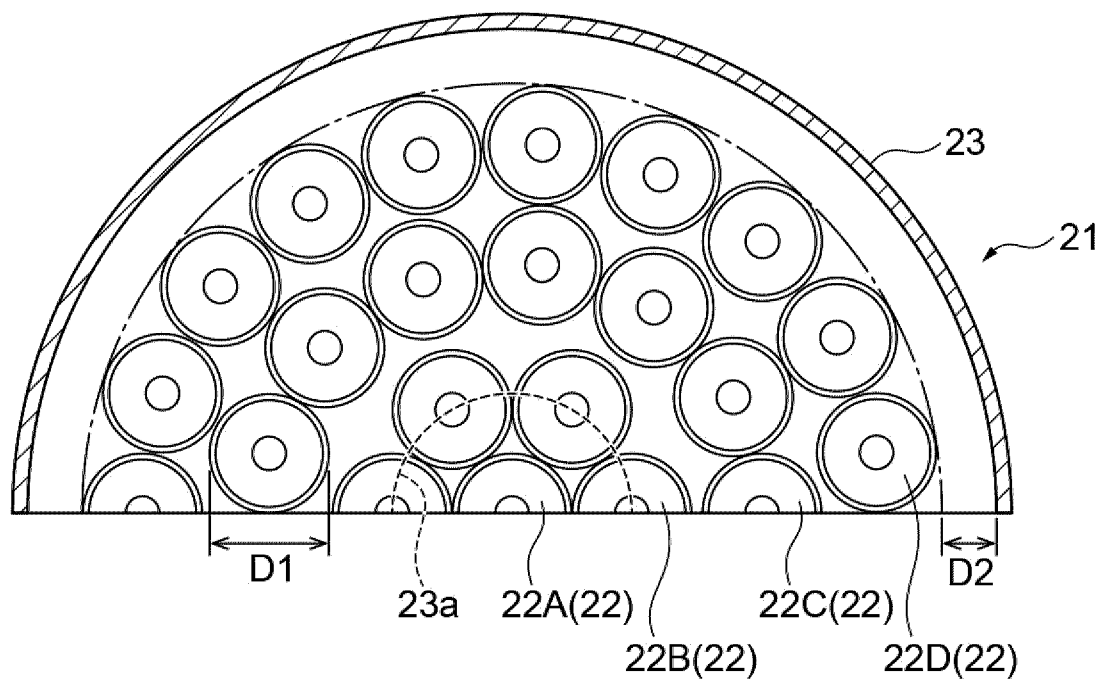


Fig.9

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Fig.10

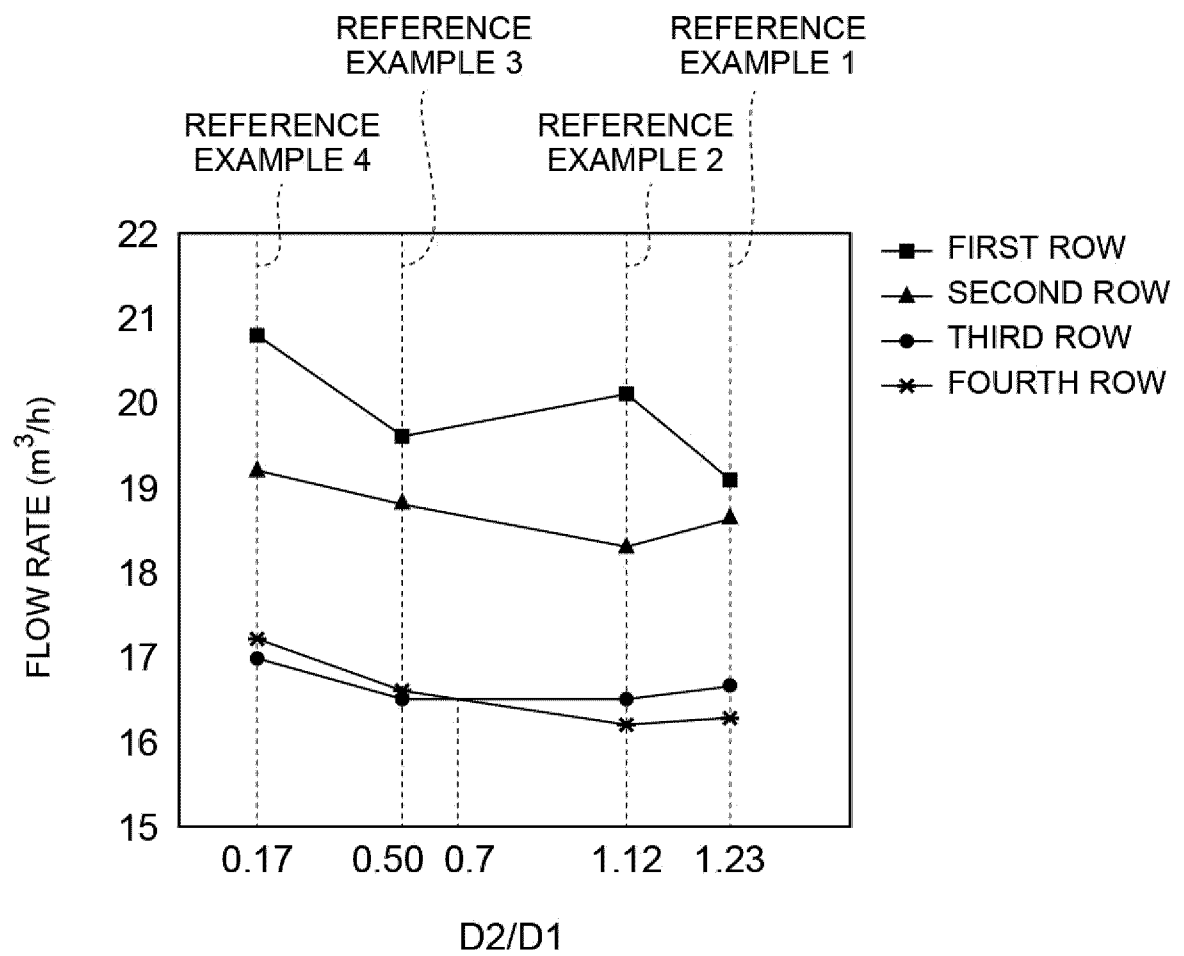
	THE NUMBER OF DEGASIFICATION UNITS	D1 (mm)	D2 (mm)	D2/D1	DEGASIFICATION UNIT THAT OVERLAPS INLET	IDEAL RETENTION TIME OF UPSTREAM SIDE REGION (SECONDS)	RATIO OF IDEAL RETENTION TIME OF UPSTREAM SIDE REGION TO THAT OF REFERENCE EXAMPLE 2
REFERENCE EXAMPLE 1	39	163	200	1.23	ALL IN FIRST ROW AND A PART IN SECOND ROW	5.1	—
REFERENCE EXAMPLE 2	39	163	182	1.12	ALL IN FIRST ROW AND A PART IN SECOND ROW	4.7	100
REFERENCE EXAMPLE 3	39	163	81	0.50	ALL IN FIRST ROW AND A PART IN SECOND ROW	3.7	—
REFERENCE EXAMPLE 4	39	163	28.5	0.17	ALL IN FIRST ROW AND A PART IN SECOND ROW	3.0	—
REFERENCE EXAMPLE 5	39	163	200	1.23	ALL IN FIRST ROW AND SECOND ROW	5.1	—
REFERENCE EXAMPLE 6	39	163	200	1.23	ALL IN FIRST ROW AND A PART IN SECOND ROW	3.4	0.72
REFERENCE EXAMPLE 7	39	163	200	1.23	ALL IN FIRST ROW AND A PART IN SECOND ROW	8.3	1.77
REFERENCE EXAMPLE 8	39	163	200	1.23	ALL IN FIRST ROW AND A PART IN SECOND ROW	11.5	2.45

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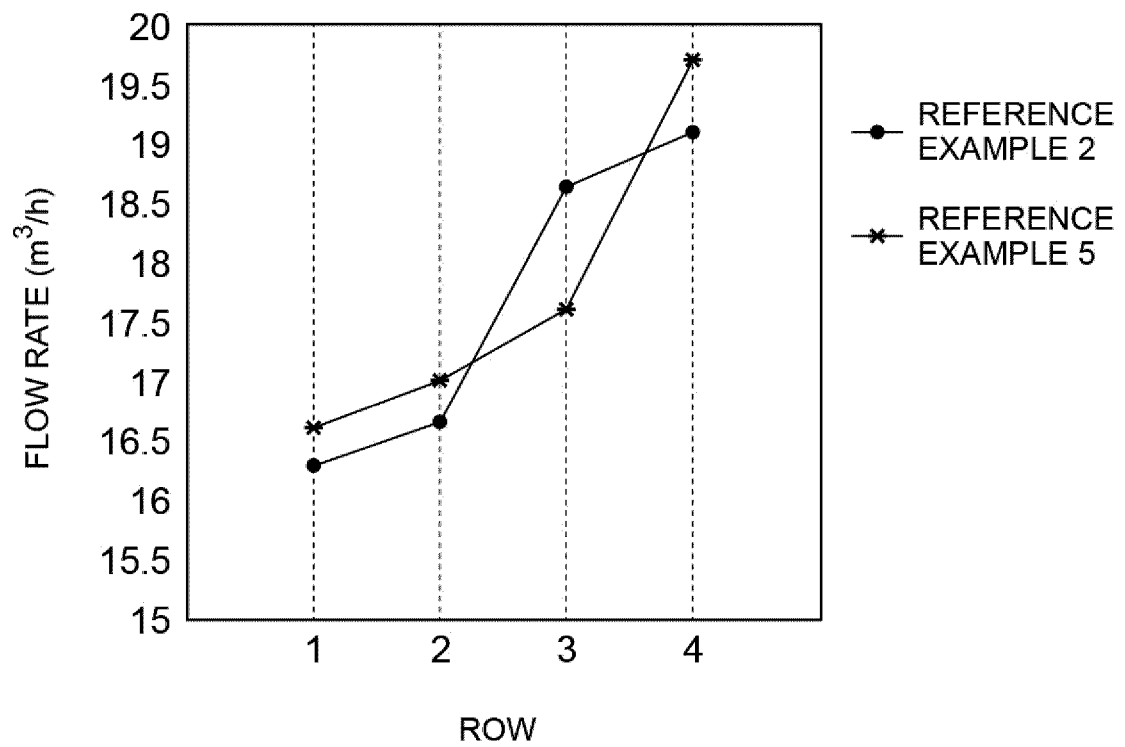
Fig.11

FLOW RATE (m ³ /h)	DEGASIFICATION UNIT IN FIRST ROW	DEGASIFICATION UNIT IN SECOND ROW	DEGASIFICATION UNIT IN THIRD ROW	DEGASIFICATION UNIT IN FOURTH ROW
REFERENCE EXAMPLE 1	19.1	18.6	16.7	16.3
REFERENCE EXAMPLE 2	20.1	18.3	16.5	16.2
REFERENCE EXAMPLE 3	19.6	18.8	16.5	16.6
REFERENCE EXAMPLE 4	20.8	19.2	17.0	17.2
REFERENCE EXAMPLE 5	19.7	17.6	17.0	16.6
REFERENCE EXAMPLE 6	20.2	18.5	16.8	16.7
REFERENCE EXAMPLE 7	20.2	18.4	17.3	16.3
REFERENCE EXAMPLE 8	20.3	18.0	16.4	16.4

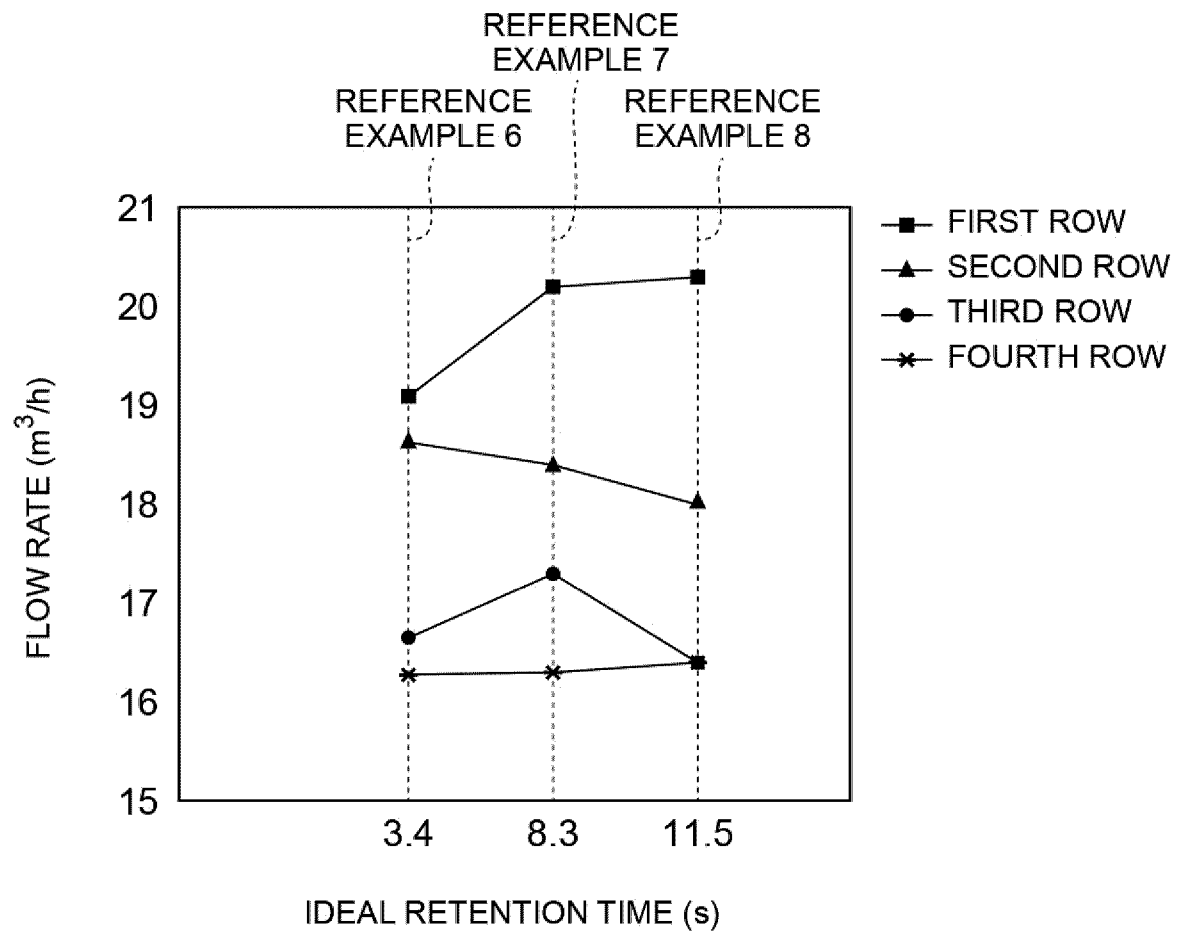
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Fig.12

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Fig.13

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Fig.14

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Fig.15

