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(71) Applicant: **JTSS Ltd.**
Tokyo 108-0075 (JP)

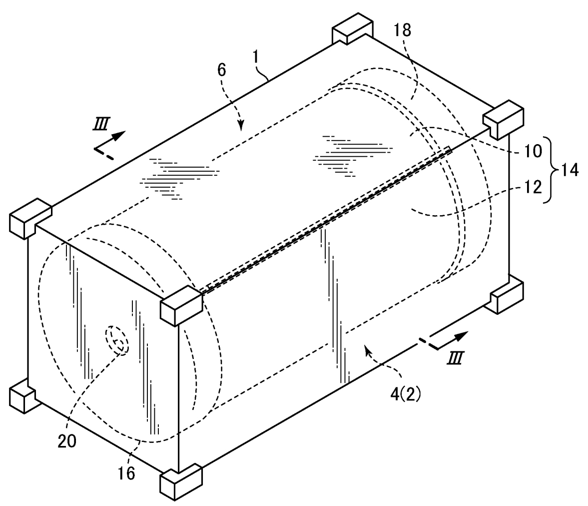
(72) Inventor: **MATSUMIYA, Akira**
Tokyo 108-0075 (JP)

(74) Representative: **Zimmermann & Partner Patentanwälte mbB**
Postfach 330 920
80069 München (DE)

(54) **CARBON DIOXIDE TRANSPORT CONTAINER, CARBON DIOXIDE TRANSPORT METHOD, AND CARBON DIOXIDE DISCHARGE METHOD**

(57) It is intended to provide a carbon dioxide transport reservoir having good loading space utilization efficiency when it does not contain ant carbon dioxide. Provided is a carbon dioxide transport reservoir (2) which comprises a reservoir body (4) configured to be disposed inside a rigid outer support (1), wherein the reservoir body comprises a rigid hollow-cylindrical tank part (6), and a balloon-shaped flexible inner tube (8) for containing carbon dioxide, the flexible inner tube being provided with a blowing port (32), and disposed inside the tank part in an expandable and contractible manner in a state in which the blowing port is connected to one end of the tank part, wherein the tank part is configured to be disassemblable.

FIG.1



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Description

TECHNICAL FIELD

[0001] The present invention relates to a carbon dioxide transport reservoir, a carbon dioxide transport method and a carbon dioxide discharge method, and more specifically to a carbon dioxide transport reservoir having a relatively small capacity and an overall size placeable in the internal space of an existing freight transport container, a method of transporting carbon dioxide d using such a reservoir, and a method of discharging carbon dioxide from such a reservoir.

BACKGROUND ART

[0002] From the perspective of preventing global warming, the emission of carbon dioxide into the atmosphere has become seen as a problem. In order to address this problem, there has been proposed a technique of collecting carbon dioxide produced at a thermal power plant or other facility, and storing the collected carbon dioxide in a storage facility provided under the ground, etc.

[0003] In general, it is often the case that a storage area where such a storage facility is constructed is far from the carbon dioxide source facility such as a thermal power plant. Thus, it is necessary to transport the carbon dioxide collected at the carbon dioxide source facility such as a thermal power plant to the remote storage area, and in some cases, this transport can include marine transport by a freight vessel.

[0004] From the standpoint of transport efficiency, it is desirable that such carbon dioxide transport is performed in a state in which the carbon dioxide is contained in a large capacity reservoir or tank.

[0005] However, there is a situation where the carbon dioxide source facility or the carbon dioxide storage area is located in a place where it is difficult to carry in a large capacity reservoir or tank. In this situation, it is necessary, e.g., to prepare a large number of small-capacity reservoirs or tanks like containers used for freight transport, as carbon dioxide transport reservoirs, and perform carbon dioxide transport in a state in which carbon dioxide is contained in the small-capacity reservoirs or tanks.

[0006] Further, since carbon dioxide is transported under high pressure from the viewpoint of transport efficiency, each of the carbon dioxide transport reservoirs or tanks used for the carbon dioxide transport needs to have a pressure-resistant reservoir body made of metal or the like.

SUMMARY OF INVENTION

[Technical Problem]

[0007] The carbon dioxide transport reservoir or tank having the pressure-resistant reservoir body made of metal or the like is transported to transport carbon dioxide from a carbon dioxide source facility such as a thermal power plant to a storage area in an outward traveling, and then transported back to the carbon dioxide source facility for the next carbon dioxide transport.

[0008] In this return traveling, when there is no suitable freight to be transported to the carbon dioxide source facility using the carbon dioxide transport reservoir or tank, the carbon dioxide transport reservoir or tank comprising the pressure-resistant reservoir body made of metal or the like will be transported from the storage facility to the source facility in an empty state.

[0009] However, due to bulkiness of the carbon dioxide transport reservoir or tank comprising the pressure-resistant reservoir body made of metal or the like, the transport for returning the empty reservoir or tank to the carbon dioxide source facility becomes extremely poor in terms of utilization efficiency of the loading space of a freight vessel, etc.

[0010] Further, in a conventional reservoir or tank, when the pressure of carbon dioxide in the reservoir or tank is greater than atmospheric pressure, at the initial stage of a process of discharging carbon dioxide from the reservoir or tank in a storage area, the carbon dioxide blows out from the reservoir or tank. However, when the discharge continues and the pressure of carbon dioxide in the reservoir or tank becomes approximately equal to atmospheric pressure, the blowout of the carbon dioxide from the reservoir or tank undesirably stops.

[0011] Here, from the viewpoint of preventing global warming, it is desired that the carbon dioxide contained in the reservoir or tank is almost completely discharged from the reservoir or tank without remaining in the reservoir or tank and stored. This requires additional work such as purging the reservoir or tank with a fluid such as water to completely discharge the carbon dioxide from the reservoir or tank.

[0012] Thus, it is necessary to inject a fluid such as water into each of the large number of reservoirs or tanks to completely discharge the carbon dioxide therefrom, and then discharge the fluid from each of the reservoirs or tanks. As a result, there is a problem that it takes a longer period of time required to discharge the carbon dioxide.

[0013] The present invention has been made in view of the above circumstance, and an obj ect thereof is to provide a carbon dioxide transport reservoir having good loading space utilization efficiency when it does not contain any carbon dioxide.

[0014] It is an another object of the present invention to provide a method of transporting carbon dioxide using a carbon dioxide transport reservoir which has good loading space utilization efficiency when it does not contain any carbon dioxide.

[0015] Further, the present invention has been made in view of the above circumstance, and a yet another object thereof is to provide a carbon dioxide transport reservoir capable of discharging carbon dioxide contained therein almost completely in a short time.

[0016] It is a still another object of the present invention to provide a method of transporting carbon dioxide using a carbon dioxide transport reservoir which is easy to discharge carbon dioxide contained therein almost completely in a short time.

[0017] It is yet still another object of the present invention to provide a method capable of discharging carbon dioxide from a carbon dioxide transport reservoir in a short time.

[Solution to Technical Problem]

[0018] According to a first aspect of the present invention, there is provided a carbon dioxide transport reservoir comprising a reservoir body configured to be disposed inside a rigid outer support, wherein the reservoir body comprises: a rigid hollow-cylindrical tank part; and a balloon-shaped flexible inner tube for containing carbon dioxide, the flexible inner tube being provided with a blowing port and disposed inside the tank part in an expandable and contractible manner in a state in which the blowing port is connected to one end of the tank part, wherein the tank part is configured to be disassemblable

[0019] According to this feature, the inner tube can prevent leakage of the carbon dioxide as a fluid, and the rigid tank part located outside the inner tube can receive a pressure from the carbon dioxide contained in the inner tube in a pressurized state, so that it is possible to safely contain the pressurized carbon dioxide.

[0020] Further, the tank part receiving the pressure is configured to be disassemblable, so that after transporting the carbon dioxide to a storage facility, the rigid tank part can be disassembled to reduce an occupied space, and loaded onto a freight vessel or the like for transport to a carbon dioxide source facility. This makes it possible to improve utilization efficiency of the loading space of transport means in return traveling.

[0021] In addition, since the tank part configured to be disassemblable makes it possible to reduce an occupied space, it is also possible to reduce a storage space during non-use of the carbon dioxide transport reservoir, thereby improving storage space utilization efficiency.

[0022] In a first preferred embodiment of the first aspect of the present invention, the tank part comprises: a hollow-semicylindrical upper half segment, a hollow-semicylindrical lower half segment, a first end-side cap for closing a first one of opposite ends of the tank part, and a second end-side cap for closing a second one of the opposite ends of the tank part, and wherein the upper half segment, the lower half segment, the first end-side cap and the second end-side cap are detachably connected together.

[0023] According to this feature, the tank part can be disassembled into smaller components, so that it is possible to more improve utilization efficiency of the loading space of transport means in return traveling.

[0024] In a second preferred embodiment of the first aspect of the present invention, the upper half segment has a flange extending radially outwardly from each of opposite edges of a circumferential opening thereof, and the lower half segment has a flange extending radially outwardly from each of opposite edges of a circumferential opening thereof, wherein the upper half segment and the lower half segment are connected together with the flanges of the upper half segment and the lower half segment butted against each other.

[0025] According to this feature, the flanges can be used to allow the tank part requiring pressure resistance to be readily assembled from a disassembled state.

[0026] In a third preferred embodiment of the first aspect of the present invention, the carbon dioxide transport reservoir comprises coupling means to couple the flange of the upper half segment and the flange of the lower half segment together.

[0027] In a fourth preferred embodiment of the first aspect of the present invention, the coupling means comprises: two sets of a plurality of through-holes, each provided in the upper half segment and the lower half segment such that the two sets of the plurality of through-holes are aligned to form plural pairs of aligned through-holes when the upper half segment and the lower half segment are connected together; and a plurality of fasteners each configured to be inserted into a respective one of the plural pairs of aligned through-holes to connect the flange of the upper half segment and the flange of the lower half segment together, thereby connecting and fastening the upper half segment and the lower half segment together.

[0028] According to this feature, the through-holes provided in the flanged and the fasteners configured to be inserted into the through-holes can be used to allow the tank part requiring pressure resistance to be readily assembled from a disassembled state.

[0029] In a fifth preferred embodiment of the first aspect of the present invention, each of the fasteners comprises a bolt configured to be inserted into each of the aligned pairs of through-holes, and a nut configured to be attached to the bolt.

[0030] According to this feature, the upper half segment and the lower half segment can be connected and fastened by a simple operation of inserting the bolt into each of the aligned pairs of through-holes, and tightening the nut attached to the bolt.

[0031] In a sixth preferred embodiment of the first aspect of the present invention, the carbon dioxide transport reservoir comprises: a mounting flange provided at each of axially-opposite open ends of the connected upper and lower half segments; and a connection part provided at an open end of each of the first end-side cap and the second end-side cap and configured to be releasably connected to the mounting flange.

[0032] According to this feature, the mounting flange and the connection part can be used to allow each of the first end-side cap and the second end-side cap to be readily mounted to the connected upper and lower half segments.

[0033] In a seventh preferred embodiment of the first aspect of the present invention, the mounting flange and the connection part are configured to be movable between a lock position where the first end-side cap or the second end-side cap is non-detachable from the connected upper and lower half segments, and an unlock position where the first end-side cap or the second end-side cap is detachable from the connected upper and lower half segments, according to a relative rotation between the first end-side cap or the second end-side cap and the connected upper and lower half segments.

[0034] According to this feature, the first end-side cap or the second end-side cap can be mounted to the connected upper and lower half segments by a simple operation of performing the relative rotation between the first end-side cap or the second end-side cap and the connected upper and lower half segments.

[0035] In an eighth preferred embodiment of the first aspect of the present invention, the outer support is a freight transport container.

[0036] According to this feature, carbon dioxide can be transported using an existing freight transport container.

[0037] In a ninth preferred embodiment of the first aspect of the present invention, the outer support is an approximately-rectangular rigid frame.

[0038] In a tenth preferred embodiment of the first aspect of the present invention, the rigid frame is an assembly type rigid frame.

[0039] According to this feature, in return traveling, the rigid outer support supporting the carbon dioxide transport reservoir can also be disassembled and transported in a compacted state.

[0040] According to a second aspect of the present invention, there is provided a method of transporting carbon dioxide, wherein the method comprises: charging pressurized carbon dioxide in the carbon dioxide transport reservoir according to the first aspect of the present invention; and transporting the carbon dioxide transport reservoir containing the pressurized carbon dioxide

[0041] According to a third aspect of the present invention, there is provided a carbon dioxide transport reservoir comprising a reservoir body configured to be disposed inside a rigid outer support, wherein the reservoir body comprises: a rigid hollow-cylindrical tank part; a balloon-shaped flexible inner tube for containing carbon dioxide, the flexible inner tube being provided with a blowing port and disposed inside the tank part in an expandable and contractible manner in a state in which the blowing port is connected to one end of the tank part; and a pushing device disposed inside the tank part on the side of an end of the inner tube facing the other end of the tank part and configured to press the inner tube toward the one end of the tank part.

[0042] According to this feature, when the discharge of the high-pressure carbon dioxide from the blowing port of the inner tube continues and the pressure of the carbon dioxide inside the inner tube becomes close to atmospheric pressure, the pushing device inside the tank part can be actuated to push and contract the inner tube, so that it is possible to efficiently discharge the carbon dioxide remaining in the inner tube.

[0043] As a result, it becomes possible to discharger the carbon dioxide contained in the inner tube in a short time.

[0044] In a first preferred embodiment of the third aspect of the present invention, the pushing device comprises a gas-purging tube which is expandable and contractible inside the tank part, the gas-purging tube being configured to be expandable to have a volume which fills an internal space of the tank part.

[0045] According to this feature, the gas-purging tube can be expanded to the volume which fills the internal space of the tank part, so that it becomes possible to almost completely discharge the carbon dioxide contained in the inner tube in a short time.

[0046] In a second preferred embodiment of the third aspect of the present invention, , the pushing device comprises: a pushing plate disposed inside the tank part to extend in a direction orthogonal to a longitudinal axis of the tank part; and a pushing rod configured to push the pushing plate toward the one end of the tank part.

[0047] According to this feature, the pushing plate can be moved to the one end of the tank part by the pushing rod, so that it becomes possible to almost completely discharge the carbon dioxide contained in the inner tube in a short time.

[0048] In a third preferred embodiment of the third aspect of the present invention, the tank part has a hollow cylindrical shape comprising an upper half segment and a lower half segment which are disassemblably connected together.

[0049] According to this feature, the tank part can be disassembled into two segments. Thus, when the carbon dioxide transport reservoir does not contain any carbon dioxide, the tank part can be transported or stored in a disassembled state, so that it is possible to realize space saving.

[0050] In a fourth preferred embodiment of the third aspect of the present invention, the tank part further comprises a cap part disposed on the side of the one end of the tank part and provided with a carbon dioxide inlet-outlet opening, wherein the carbon dioxide inlet-outlet port of the inner tube is attached to the carbon dioxide inlet-outlet opening of the cap part.

[0051] In a fifth preferred embodiment of the third aspect of the present invention, the outer support is a freight transport container.

[0052] According to this feature, carbon dioxide can be transported using an existing freight transport container.

[0053] In a sixth preferred embodiment of the third aspect of the present invention, the outer support is an approximately-rectangular rigid frame.

[0054] In a seventh preferred embodiment of the third aspect of the present invention, the rigid frame is an assembly type rigid frame.

[0055] According to this feature, for example, when storing or transporting the carbon dioxide transport reservoir containing no carbon dioxide, the outer support can also be disassembled, so that it is possible to realize space saving.

[0056] In an eighth preferred embodiment of the third aspect of the present invention, the tank part further comprises a reinforcing bracket for connecting the tank part and each of opposed corners of the outer support.

[0057] According to this feature, the tank body can be fixed inside the outer support such as a freight transport container, so that it is possible to suppress a situation where deformation of the tank body occurs due to an external force applied thereto.

[0058] According to a fourth aspect of the present invention, there is provided a method of transporting carbon dioxide, wherein the method comprises: charging pressurized carbon dioxide in the carbon dioxide transport reservoir according to the third aspect of the present invention; and transporting the carbon dioxide transport reservoir containing the pressurized carbon dioxide.

[0059] According to a fifth aspect of the present invention, there is provided a method of discharging dioxide discharge from the carbon dioxide transport reservoir according to the third aspect of the present invention, wherein the method comprises discharging dioxide discharge from the inner tube while actuating the pushing device to push the inner tube.

[Effect of Invention]

[0060] The present invention can provide a carbon dioxide transport reservoir having good loading space utilization efficiency when it does not contain any carbon dioxide.

[0061] The present invention can also provide a method of transporting carbon dioxide using a carbon dioxide transport reservoir which has good loading space utilization efficiency when it does not contain any carbon dioxide.

[0062] Further, the present invention can provide a carbon dioxide transport reservoir capable of discharging carbon dioxide contained therein almost completely in a short time.

[0063] Further, the present invention can provide a method of transporting carbon dioxide using a carbon dioxide transport reservoir which is easy to discharge carbon dioxide contained therein almost completely in a short time.

[0064] Further, the present invention can provide a method capable of discharging carbon dioxide from a carbon dioxide transport reservoir in a short time.

BRIEF DESCRIPTION OF DRAWINGS

[0065]

FIG. 1 is a schematic perspective view showing the configuration of a carbon dioxide transport reservoir according to a preferred embodiment of the present invention, disposed inside a freight transport container.

FIG. 2 is an exploded perspective view of the carbon dioxide transport reservoir in FIG. 1.

FIG. 3 is a sectional view of the carbon dioxide transport reservoir, taken along the line III-III of FIG. 1.

FIG. 4 is a schematic sectional view of the carbon dioxide transport reservoir in a state in which no carbon dioxide is charged inside an inner tube of the carbon dioxide transport reservoir.

FIG. 5 is a schematic sectional view of the carbon dioxide transport reservoir in a state in which carbon dioxide is charged inside the inner tube.

FIG. 6 is a schematic diagram of a jig used for assembling of a tank part of the carbon dioxide transport reservoir according to the embodiment of the present invention.

FIG. 7 is a schematic diagram for explaining the assembling of the tank part of the carbon dioxide transport reservoir according to the embodiment of the present invention.

FIG. 8 is a plan view showing the configuration of an upper half segment (lower half segment) used for the tank part of the carbon dioxide transport reservoir according to the embodiment of the present invention.

FIG. 9 is a schematic diagram for explaining the assembling of the tank part of the carbon dioxide transport reservoir according to the embodiment of the present invention.

FIG. 10 is a schematic diagram for explaining the assembling of the tank part of the carbon dioxide transport reservoir according to the embodiment of the present invention.

FIG. 11 is a schematic diagram for explaining the assembling of the tank part of the carbon dioxide transport reservoir according to the embodiment of the present invention.

FIG. 12 is a schematic diagram for explaining the assembling of the tank part of the carbon dioxide transport reservoir according to the embodiment of the present invention.

FIG. 13 is a schematic diagram for explaining mounting of a first end-side cap of the carbon dioxide transport reservoir according to the embodiment of the present invention.

FIG. 14 is a schematic diagram for explaining a configuration for mounting the first end-side cap of the carbon dioxide transport reservoir according to the embodiment of the present invention.

FIG. 15 is a schematic diagram for explaining a configuration for mounting a first end-side cap of a carbon dioxide transport reservoir according to one modification of the embodiment of the present invention.

FIG. 16 is a schematic diagram for explaining the configuration for mounting the first end-side cap of the carbon dioxide transport reservoir according to the one modification of the embodiment of the present invention.

FIG. 17 is a schematic diagram for explaining a configuration for mounting a first end-side cap of a carbon dioxide transport reservoir according to another modification of the embodiment of the present invention.

FIG. 18 is a schematic diagram for explaining a configuration for mounting a first end-side cap of a carbon dioxide transport reservoir according to yet another modification of the embodiment of the present invention.

FIG. 19 is a schematic perspective view of a rectangular frame used as an outer support as substitute for the freight transport container.

FIG. 20 is a schematic perspective view showing the configuration of a carbon dioxide transport reservoir according to another preferred embodiment of the present invention.

FIG. 21 is a sectional view of the carbon dioxide transport reservoir, taken along the line XXI-XXI of FIG. 20.

FIG. 22 is a sectional view of the carbon dioxide transport reservoir, taken along the line XXII-XXII of FIG. 20.

FIG. 23 is a schematic exploded perspective view of a tank part of the carbon dioxide transport reservoir in FIG. 20.

FIG. 24 is a schematic sectional view of the carbon dioxide transport reservoir in FIG. 20, taken in the same manner as FIG. 21, for explaining a step of charging carbon dioxide in the carbon dioxide transport reservoir.

FIG. 25 is a schematic sectional view of the carbon dioxide transport reservoir in FIG. 20, taken in the same manner as FIG. 21, for explaining a step of discharging carbon dioxide from the carbon dioxide transport reservoir.

FIG. 26 is a schematic sectional view taken in the same manner as FIG. 21, showing a carbon dioxide filled state of a carbon dioxide transport reservoir according to yet another preferred embodiment of the present invention.

FIG. 27 is a schematic sectional view taken in the same manner as FIG. 21, for explaining a step of discharging carbon dioxide from the carbon dioxide transport reservoir according to said yet another preferred embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

[0066] A carbon dioxide transport reservoir according to one preferred embodiment of the present invention will now be described along with the drawings. FIG. 1 is a schematic perspective view showing the configuration of the carbon dioxide transport reservoir 2 disposed inside a freight transport container 1. FIG. 2 is an exploded perspective view of the carbon dioxide transport reservoir 2 in FIG. 1, and FIG. 3 is a sectional view of the carbon dioxide transport reservoir, taken along the line III-III of FIG. 1.

[0067] It should be noted here that as used in this specification, the term "carbon dioxide" means not only pure carbon dioxide but also any fluid consisting mainly of carbon dioxide.

[0068] In this embodiment, as the freight transport container 1 which is a rigid outer support, it is preferable to use a freight transport container made of steel, aluminum or the like and formed in a standardized rectangular parallelepiped shape, based on ISO standards. Specific examples thereof include, but not limited to, a freight transport container having a width of 2.352 m, a height of 2.395 m, and a depth of 12.03 m.

[0069] When transporting carbon dioxide at low temperatures to prevent rise in temperature of the carbon dioxide inside the freight transport container during transport, the freight transport container 1 is preferably composed of a so-called reefer container capable of adjusting the internal temperature thereof.

[0070] The carbon dioxide transport reservoir 2 according to this embodiment is disposed inside such a freight transport container 1 and configured to contain high-pressure carbon dioxide thereinside.

[0071] As shown in FIGS. 1 to 3, the carbon dioxide transport reservoir 2 comprises a reservoir body 4. In this embodiment, the reservoir body 4 has an approximately hollow-cylindrical shape whose opposite ends are closed, and an overall size almost filling the internal space of the freight transport container 1.

[0072] The reservoir body 4 comprises a rigid tank part 6 arranged in a relatively outer position, and an inner tube 8 disposed inside the tank part 6 and configured to contain carbon dioxide.

[0073] The tank part 6 is composed of a pressure-resistant reservoir made of a rigid material such as metal, and formed to define the outer shape of the reservoir body having an approximately hollow-cylindrical shape whose opposite ends are closed. The inner or outer surface of the tank part 6 is provided with a layer of heat-insulating material such as heat-insulating paint, on an as-needed basis.

[0074] The inner tube 8 is made of a material having flexibility, stretchability and impermeability to carbon dioxide, such as rubber, and formed in a balloon shape having a blowing port.

[0075] As shown in FIG. 2, the tank part 6 comprises: a hollow-cylindrical tank body 14 capable of being disassembled into an upper half segment 10 and a lower half segment 12; a first end-side cap 16 for closing a first one of opposite ends of the tank part 14; a second end-side cap 18 for closing a second one of the opposite ends of the tank part 14. An opening (through-opening) 20 is formed at the center of the first end-side cap 16.

[0076] In this embodiment, the upper half segment 10 and the lower half segment 12 have approximately the same hollow semicylindrical shapes, respectively. Further, the upper half segment 10 has a flange 22 extending radially outwardly from each of opposite edges of a circumferential opening thereof, and the lower half segment 12 has a flange 24 extending radially outwardly from each of opposite edges of a circumferential opening thereof. Each of the flanges 22, 24 has an elongate rectangular shape, and extends over the overall length of each edge of the circumferential opening of a corresponding one of the upper half segment 10 and the lower half segment 12, except axially-opposite end regions thereof. The upper half segment 10 and the lower half segment 12 are connected together with the flanges 22, 23 butted against each other, thereby forming the hollow-cylindrical tank body 14.

[0077] As shown in FIG. 2, each of the two flanges 22 of the upper half segment 10 has a plurality of (in this embodiment, six) through-holes 26 formed at even intervals. Similarly, each of the two flanges 24 of the lower half segment 12 has a plurality of (in this embodiment, six) through-holes 28 formed at even intervals.

[0078] A first set of the through-holes 26 in each of the flanges 22 of the upper half segment 10 and a second set of the through-holes 28 in each of the flanges 24 of the lower half segment 12 are arranged such that the first and second sets of the through-holes 26, 28 are aligned to form plural pairs of aligned through-holes when the flanges 22 of the upper half segment 10 are butted against the respective flanges 24 of the lower half segment 14.

[0079] In the carbon dioxide transport reservoir 2 according to this embodiment, a bolt 30 serving as a fastener is inserted into each of the plural pairs of aligned through-holes 26, 28, and a nut 32 is threadingly engaged with the bolt 30 to fasten the flanges 22 of the upper half segment 10 and the flanges 24 of the lower half segment 12 together, so that the upper half segment 10 and the lower half segment 12 are connected and fastened together. A shear nut may be used as the fastener.

[0080] As mentioned later, a mounting flange is provided at each of axially-opposite open ends of the connected upper and lower half segments 10, 12. Further, a connection part is provided at an open end of each of the first end-side cap 16 and the second end-side cap 18 and configured to be releasably connected to the mounting flange.

[0081] As mentioned later, the mounting flange and the connection part are configured to be movable between a lock position where the first end-side cap or the second end-side cap is non-detachable from the connected upper and lower half segments, and an unlock position where the first end-side cap or the second end-side cap is detachable from the connected upper and lower half segments, according to a relative rotation between the first end-side cap or the second end-side cap and the connected upper and lower half segments.

[0082] The inner tube 8 is a balloon-shaped member made of a flexible material such as rubber as mentioned above, and capable of being expanded and contracted by charging and discharging carbon dioxide thereinto and therefrom through the blowing port 34. The inner tube 8 is expandable to have a volume greater than the size of the internal space of the tank part 6. Thus, when pressurized carbon dioxide is charged into the inner tube 8 housed in the tank part 6, the inner tube 8 is expanded up to a size causing the inner tube 8 to come into contact with the inner peripheral surface of the tank part 6, so that further expansion is restricted by the tank part 6. Therefore, in this state, the internal pressure of the inner tube 8 is supported by the tank part 6.

[0083] The blowing port 34 of the inner tube 8 is attached to the opening 20 formed in the first end-side cap 16 of the tank part 6.

[0084] In the carbon dioxide transport reservoir 2 according to this embodiment, the tank part 6 further comprises a reinforcing bracket 36 for connecting the tank part 6 and each of opposed corners of the freight transport container 1, as shown in FIG. 3.

[0085] The reinforcing bracket 36 comprises a flange holder-adjusting gear unit 38 disposed between the butted flanges 22, 24 of the tank part 6 and a frame stationary part 1a of the container 1 at a position where it does not interfere with the bolts 30.

[0086] As shown in FIG. 3, the flange holder-adjusting gear unit 38 comprises an adjusting rod 38a having a spirally threaded outer peripheral surface and rotatable about a longitudinal axis thereof as indicated by the arrowed line A. The adjusting rod 38a has one end screwed into the butted flanges 22, 24 of the tank part 6 and the other end screwed into the frame stationary part 1a of the container 1. In this embodiment, the adjusting rod 38a is configured to be rotated so as to adjust the tension between the butted flanges 22, 24 of the tank part 6 and the frame stationary part 1a of the container 1.

[0087] Specifically, an adjusting gear 38b is fixed onto the adjusting rod 38a such that it is rotated integrally together with the adjusting rod 38a.

[0088] Further, the flange holder-adjusting gear unit 38 comprises an actuation rod 38c having a spirally threaded outer peripheral surface and configured to be driven by a non-illustrated drive source to rotate in a direction indicated by the arrowed line B. The spiral thread on the outer peripheral surface of the actuation rod 38c is meshed with the adjusting gear 38b.

[0089] Thus, the rotation of the actuation rod 38c is converted to rotation of the adjusting rod 38a via the adjusting gear 38b to adjust the tension between the butted flanges 22, 24 of the tank part 6 and the frame stationary part 1a of the container 1.

[0090] Next, charging of carbon dioxide into the carbon dioxide transport reservoir 2 and discharging of carbon dioxide from the carbon dioxide transport reservoir 2 will be described.

[0091] FIG. 4 is a schematic sectional view of the carbon dioxide transport reservoir 2 in a state in which no carbon dioxide is charged inside the inner tube 8, and FIG. 5 is a schematic sectional view of the carbon dioxide transport reservoir 2 in a state in which carbon dioxide is charged inside the inner tube, taken in the same manner as FIG. 4.

[0092] When introducing carbon dioxide into the carbon dioxide transport reservoir 2 (FIG. 4) disposed inside the freight transport container 1, the freight transport container 1 is partly opened, and carbon dioxide at a pressure of, e.g., about 200 Bar, is introduced into the inner tube 8 from the blowing port 34 of the inner tube 8 attached to the first end-side cap 16.

[0093] Then, when the inner tube 8 is expanded by the introduced carbon dioxide to completely fill the inner space of the tank part 6 (FIG. 5), the introduction of carbon dioxide is terminated, and a high-pressure valve (not illustrated) provided at the blowing port 34 of the inner tube 8 is closed to close the blowing port 34 of the inner tube 8.

[0094] Subsequently, after closing the freight transport container 1, the freight transport container 1 housing the carbon dioxide transport reservoir 2 is transported to a destination such as a carbon dioxide storage area by transport means such as a truck or a marine vessel.

[0095] In a case where the freight transport container 1 is a reefer container or the like capable of adjusting an internal environment such as temperature thereof, the transport is performed while the internal environment of the freight transport container 1 is appropriately adjusted.

[0096] When the carbon dioxide transport reservoir 2 containing carbon dioxide has arrived at the destination such as a carbon dioxide storage area, the carbon dioxide is discharged from the carbon dioxide transport reservoir 2.

[0097] The carbon dioxide is contained in the carbon dioxide transport reservoir 2 in a pressurized state, as mentioned above. Thus, when opening the blowing port 34 of the inner tube 8, the carbon dioxide blows out from an inlet-outlet port of the carbon dioxide transport reservoir 2 until the pressure of the carbon dioxide inside the inner tube 8 is reduced to a pressure close to atmospheric pressure.

[0098] Then when the pressure of the carbon dioxide inside the inner tube 8 is reduced to a pressure close to atmospheric pressure, the velocity of the blowout from the inlet-outlet port of the carbon dioxide transport reservoir 2 is reduced. In this state, discharge of the carbon dioxide inside the inner tube 8 is promoted. e.g., by pushing the inner tube 8 from therebehind, or externally evacuating the inside of the inner tube 8 using a vacuum pump. Then, when the carbon dioxide inside the inner tube 8 is completely discharged, the discharge operation is finished.

[0099] Next, one example of a method of assembling the carbon dioxide transport reservoir 2 according to this embodiment will be described.

[0100] FIG. 6 is a schematic diagram of a jig 50 used for assembling of the tank part 6. The jig 50 comprises: a pair of upwardly-extending flange cradles 54 disposed on right and left sides of a base 52; and a lifter 56 disposed between the flange cradles 54 and equipped with a transfer roller. Two locating pins 58 are attached to a top surface of each of the flange cradles 54.

[0101] In assembling of the tank part 6, firstly, the lower half segment 12 is placed on the jig 50, as shown in FIG. 7. In this process, the lower half segment 12 is placed on the jig 50 such that the locating pins 58 are inserted, respectively, into two locating holes 40a (FIG. 8) formed in each of the flanges 24 of the lower half segment 12.

[0102] Subsequently, the upper half segment 10 is placed to cover the lower half segment 12 on the jig 50, as shown in FIG. 9. In this process, the upper half segment 10 is disposed such that the locating pins 58 of the jig 50 are inserted, respectively, into two locating holes formed in each of the flanges 22 of the upper half segment 10, so that the first set of the plurality of through-holes 26 in each of the flanges 22 of the upper half segment 10 and the second set of the plurality of through-holes 28 in each of the flanges 24 of the lower half segment 12 are aligned in an up-down direction.

[0103] Subsequently, as shown in FIG. 10, the bolt 30 is attached to penetrate through each of plural pairs of up-down directionally aligned through-holes 26, 28 of the butted upper and lower half segments 10, 12, and the nut 43 is screwed onto the bolt 30, thereby fastening the flanges 22 of the upper half segment 10 and the flanges 24 of the lower half segment 12 together.

[0104] When the bolts 30 are attached to penetrate through all of the aligned pairs of through-holes 26, 28, respectively, and the nuts 43 are screwed onto the bolts 30, respectively, as shown in FIGS. 11 and 12, an operation of connecting and fastening the the upper half segment 10 and the lower half segment 12 together is completed, and the hollow-cylindrical tank body 14 comprised of the upper half segment 10 and the lower half segment 12 is completed.

[0105] Subsequently, the first end-side cap 16 is mounted to the tank body 14. FIG. 13 is a diagram for explaining mounting of the first end-side cap 16 to the tank body 14.

[0106] As shown in FIG. 13, a plurality of mounting flanges 60 each extending radially inwardly are provided at each of axially-opposite open ends of the connected upper and lower half segments 10, 12, at intervals circumferentially.

[0107] On the other hand, a plurality of connection parts 62 are provided at an open end of the first end-side cap 16, at intervals circumferentially.

[0108] Each of the connection parts 62 is configured to have a circumferential length less than a circumferential distance between any adj acent two of the mounting flanges 60, so that it is insertable between any adjacent two of the mounting flanges 60 when the the first end-side cap 16 is mounted to one of the open ends of the hollow-cylindrical tank body 14 comprised of the upper half segment 10 and the lower half segment 12.

[0109] Further, a radially-outward portion of each of the connection parts 62 is formed with a groove 64 having a shape complementary to that of each of the mounting flanges 60 and extending circumferentially. This groove 64 is formed at a position where the groove 64 is circumferentially aligned to the mounting flanges 60 when the first end-side cap 16 is mounted to the open end of the hollow-cylindrical tank body 14.

[0110] When mounting the first end-side cap 16 to the tank body 14 comprised of the upper half segment 10 and the lower half segment 12, the first end-side cap 16 is disposed at a rotational position. At that time, the grooves 64 of the connection parts 62 of the first end-side cap 16 are circumferentially aligned to the mounting flanges 60 of the tank body 14. In this state, the connection parts 62 of the first end-side cap 16 are in an unlock position where an unlock position where the first end-side cap 16 is non-detachable from the connected upper and lower half segments.

[0111] Then, when the first end-side cap 16 is rotated by a given angle, each of the mounting flanges 60 of the tank body 14 is received in a respective one of the grooves 64 of the connection parts 62 of the first end-side cap 16. In this state, the mounting flanges 60 and the connection parts 62 are disposed in a lock position where the first end-side cap is non-detachable from the connected upper and lower half segments, so that the first end-side cap 16 becomes unable to be moved or detached in the axial direction.

[0112] Mounting of the second end-side cap 18 to the tank body 14 is performed in a similar manner as the mounting of the first end-side cap 16 to the tank body 14. As a result, assembling of the tank part 6 is completed, and assembling of the carbon dioxide transport reservoir 2 is completed.

[0113] Before the mounting of the first end-side cap 16, the inner tube 8 is attached to the side of a back surface of the first end-side cap 16, as shown in FIG. 14. In this process, the blowing port 34 of the inner tube 8 is attached to the opening 20 formed in the first end-side cap 16 of the tank part, 6 through a swivel feature for preventing the blowing port 34 from being rotate when the first end-side cap 16 is rotated

[0114] The carbon dioxide transport reservoir 2 assembled in the above manner is carried in an outer support such as the freight transport container 1 using a crane or the like, and fixed inside the outer support using the reinforcing bracket 36, etc.

[0115] In the above embodiment, the first end-side cap 16 and the second end-side cap 18 are connected to the tank body 14 in a lockable manner by the mounting flanges and the connection parts. However, the first end-side cap 16 and the second end-side cap 18 may be connected to the tank body 14 by any other suitable means.

[0116] For example, as shown in FIGS. 15 and 16, an internal thread 162 may be provided on an inner peripheral surface of an open end of each of a first end-side cap 160 and a second end-side cap, and an external thread 142 threadingly engageable with the internal thread 162 of each of the caps may be provided on an outer peripheral surface of each of opposite open ends of a tank body 140. Then, each of the first end-side cap 160 the second end-side cap may be detachably mounted to the tank body 140 by screwing the internal thread 162 of each of the first end-side cap 160 and the second end-side cap to the external thread 142 of a corresponding one of the open ends of the tank body 140.

[0117] Additionally, a pair of approximately L-shaped swingable fasteners 180 as shown in FIGS. 15 and 16 may be provided in each of the first end-side cap 160 and the second end-side cap, and after threadingly engage the first end-side cap 160 and the second end-side cap with the tank body 140, each of the fasteners 180 may be swung in a direction indicated by the arrowed line C such that an opening 182 formed at a distal end of each of the fasteners is aligned to an opening in a respective one of two pairs of flanges 220, 240 of the tank body 140, and may be fixed to the respective one of the two pairs of flanges 220, 240 of the tank body 140 by the bolt 30 and the nut 32.

[0118] It is to be understood that such fasteners 180 may be added to the connection mechanism based on the mounting flanges and the connection parts in the above embodiment.

[0119] Alternatively, as shown in FIG. 17, each of opposite open ends of a tank body 144 and an open end of each of a first end-side cap 164 and a second end-side cap may be provided, respectively, with a radially outwardly-extending flange 148 having a plurality of through-holes 146 and a radially outwardly-extending flange 168 having a plurality of through-holes 166, and each of the first end-side cap 164 and the second end-side cap may be detachably fixed to the tank body 144 by: butting the two flanges such that the through-holes are aligned to form plural pairs of aligned through-holes; inserting a plurality of bolts 300 into the plural pairs of aligned through-holes, respectively (in FIG. 17, only one bolt is illustrated); and threadingly engaging a plurality of nuts 320 with the bolts, respectively.

[0120] Alternatively, as shown in FIG. 18, an open end of a first end-side cap 170 and an open end of a second end-side cap 180 may be provided, respectively, with a radially-outwardly extending flange 174 having a plurality of through-holes 172, and a radially-outwardly extending flange 184 having a plurality of through-holes 182.

[0121] In this structure, a rod spacer 202 having threaded holes 200, respectively, at opposite ends thereof is disposed between each of plural pairs of corresponding through-holes 172, 182 of the opposed flanges 174, 184 (in FIG. 18, only one rod spacer is illustrated), the first end-side cap 170 and the second end-side cap 180 may be fixed to a tank body 240 by: screwing a screw 209 into each of the threaded holes 200 of the rod spacers 202 through a respective one of the through-holes 172, 182 of the two flanges 174, 184 to press the two flanges 174, 184 inwardly.

[0122] In the description about the carbon dioxide transport reservoir in the above first embodiment, the rigid outer support is a freight transport container. However, the outer support is not limited to a freight transport container, but may be an assembly-type rigid rectangular-shaped frame 400, as shown in FIG. 19.

[0123] The rectangular-shaped frame 400 is formed such that twelve rod-shaped members 404 are detachably connected to connection members 402 disposed, respectively, at eight corners. Each of the connection members 402 and the rod-shaped members 404 is made of a highly-rigid material such as metal.

[0124] An internal space surrounded by the rectangular-shaped frame 400 has a size capable of housing the carbon dioxide transport reservoir 2 (reservoir body 4). Preferably, the size and shape of the entirety of the rectangular-shaped frame 400 is set to be identical to the aforementioned size and shape of the freight transport container. This makes it possible to transport the rectangular-shaped frame 400 housing the carbon dioxide transport reservoir 2 by a truck, a railroad freight car, a marine vessel or the like for freight transport containers, or to load it in such a manner as to be mixed with a freight transport container.

[0125] The carbon dioxide transport reservoir 2 (reservoir body 4) housed in the internal space surrounded by the rectangular-shaped frame 400 will be fixed to the rectangular-shaped frame 400 by a fastener such as the reinforcing bracket 36.

[0126] Next, a carbon dioxide transport reservoir according to another preferred embodiment of the present invention will be described. FIG. 20 is a schematic perspective view showing the configuration of the carbon dioxide transport reservoir 1002 disposed inside a freight transport container 1001. FIG. 21 is a sectional view of the carbon dioxide transport reservoir 1002, taken along the line XXI-XXI of FIG. 20, and FIG. 22 is a sectional view of the carbon dioxide transport reservoir 1002, taken along the line XXII-XXII of FIG. 20. FIGS. 21 and 22 illustrate a state in which carbon dioxide is almost fully filled inside the reservoir.

[0127] In this second embodiment, as the freight transport container 1001 which is a rigid outer support, it is preferable to use a freight transport container made of steel, aluminum or the like and formed in a standardized rectangular parallelepiped shape, based on ISO standards. Specific examples thereof include, but not limited to, a freight transport container having a width of 2.352 m, a height of 2.395 m, and a depth of 12.03 m.

[0128] When transporting carbon dioxide at low temperatures to prevent rise in temperature of the carbon dioxide inside the freight transport container during transport, the freight transport container 1001 is preferably composed of a so-called reefer container capable of adjusting the internal temperature thereof.

[0129] The carbon dioxide transport reservoir 1002 according to the second embodiment is disposed inside such a freight transport container 1001 and configured to contain high-pressure carbon dioxide thereinside.

[0130] As shown in FIGS. 20 to 22, the carbon dioxide transport reservoir 1002 comprises a reservoir body 1004 configured to be disposed inside the freight transport container 1001 and contain carbon dioxide.

[0131] In the second embodiment, the reservoir body 1004 has an approximately hollow-cylindrical shape whose opposite ends are closed, and an overall size almost filling the internal space of the freight transport container 1001. The the reservoir body 1004 also has an inlet-outlet port 1006 provided at one of longitudinally opposite ends thereof and configured to introduce and discharge carbon dioxide with respect to the inside thereof.

[0132] The reservoir body 1004 comprises a rigid tank part 1008 arranged in the outer position, and an inner tube 1010 disposed inside the tank part 1008 and having flexibility and stretchability. The tank part 1008 is made of a rigid material such as metal, and formed in an approximately hollow-cylindrical shape by closing opposite ends of the reservoir body 1004.

[0133] FIG. 23 is a schematic exploded perspective view of the tank part 1008.

[0134] As shown in FIG. 23, the tank part 1008 comprises: a hollow-cylindrical tank body 1016 capable of being disassembled into an upper half segment 1012 and a lower half segment 1014; a first end-side cap 1018 for closing a first one of opposite ends of the tank part 1016; a second end-side cap 1020 for closing a second one of the opposite ends of the tank part 1016.

[0135] In the second embodiment, the upper half segment 1012 and the lower half segment 1014 have approximately the same hollow semicylindrical shapes, respectively. Each of the upper and lower half segments 1012, 1014 has an outwardly-extending flange provided along each of opposed lateral edges thereof, wherein the respective flanges of the upper and lower half segments 1012, 1014 are connected together by a connector (not illustrated) such as a bolt, so as to form the hollow-cylindrical tank body 1016. A shear nut may be used as the connector.

[0136] An internal thread is provided on an open end of a peripheral wall of each of the first end-side cap 1018 and the second end-side cap 1020. This internal thread is screwed to an external thread formed on an outer peripheral surface of each of the first and second open ends of the tank body 1016, so that the first end-side cap 1018 and the second end-side cap 1020 are mounted to the tank body 1016 to form the tank part 1008.

[0137] The first end-side cap 1018 is also formed with an opening 1022 serving as the inlet-outlet port 1006 of the reservoir body 1004.

[0138] The inner tube 1010 is a balloon-shaped member which is made of a material having impermeability to carbon dioxide to be contained, flexibility and expandability, such as rubber, and is expandable and contractible inside the tank part 1008 by introducing and discharging carbon dioxide with respect to the inside thereof. When expanded, the inner tube 1010 has a size which fills the internal space of the tank part 1008.

[0139] The inner tube 1010 also has a blowing port 1024 which is attached to the opening 1022 formed in the first end-side cap 1018 of the tank part 1008, so that carbon dioxide can be introduced from outside the reservoir body into the inner tube 1010 via the blowing port 1024, and discharged from the inside of the inner tube 1010 to the outside of the reservoir body via the blowing port 1024.

[0140] The inner tube 1010 is expandable to have a volume greater than the size of the internal space of the tank part 1008. Thus, when pressurized carbon dioxide is charged into the inner tube 1010 housed in the tank part 1008, the inner tube 1010 is expanded up to a size causing the inner tube 1010 to come into contact with the inner peripheral surface of the tank part 1008, so that further expansion is restricted by the tank part 1008. Therefore, in this state, the internal pressure of the inner tube 1010 is supported by the tank part 1008.

[0141] Further, a flexible gas-purging tube 1026 serving as a pushing device is disposed inside the tank part 1008 on the side of an end of the inner tube 1010 facing the second end of the tank part 1008. That is, the gas-purging tube 1026 is located on the side opposite to the inlet-outlet port 1006 of the reservoir body 1004 across the inner tube 1010. The gas-purging tube 1026 is also a balloon-shaped member which is made of a material having flexibility and stretchability, such as rubber, and configured to be expandable and contractible inside the tank part 1008. The gas-purging tube 1026 is configured to be expandable to have a volume which fills the internal space of the tank part 1008 by introducing a fluid such as air thereinto.

[0142] In the second embodiment, the gas-purging tube 1026 is attached to the second end-side cap 1020 of the tank part 1008. Further, a valve (not illustrated) communicated with a blowing port of the gas-purging tube 1026 is attached to the second end-side cap 1020. In the second embodiment, an externally-provided compressor is communicated with the inside of the gas-purging tube 1026 via the above valve. In the second embodiment, the gas-purging tube 1026 can be expanded by opening the valve, and in this state, introducing a high-pressure fluid from the compressor into the gas-purging tube 1026.

[0143] Further, in the carbon dioxide transport reservoir 1002 according to the second embodiment, the tank part 1008 further comprises a reinforcing bracket 1030 for connecting the tank part 1008 and each of opposed corners of the freight transport container 1001, as shown in FIG. 22.

[0144] More specifically, the reinforcing bracket 1030 comprises a flange holder-adjusting gear unit 1031 disposed between a pair of coupled flanges 1008a of the tank part 1008 and a frame stationary part 1001a of the container 1001.

[0145] As shown in FIG. 22, the flange holder-adjusting gear unit 1031 comprises an adjusting rod 1031a having a spirally threaded outer peripheral surface and rotatable about a longitudinal axis thereof as indicated by the arrowed line D. The adjusting rod 1031a has one end screwed into the coupled flanges 1008a of the tank part 1008 and the other end screwed into the frame stationary part 1001a of the container 1001. In the second embodiment, the adjusting rod 1031a is configured to be rotated so as to adjust the tension between the coupled flanges 1008a of the tank part 1008 and the frame stationary part 1001a of the container 1001.

[0146] Specifically, an adjusting gear 1031b is fixed onto the adjusting rod 1031a such that it is rotated integrally together with the adjusting rod 1031a.

[0147] Further, the flange holder-adjusting gear unit 1031 comprises an actuation rod 1031c having a spirally threaded outer peripheral surface and configured to be driven by a non-illustrated drive source to rotate in a direction indicated by the arrowed line E. The spiral thread on the outer peripheral surface of the actuation rod 1031c is meshed with the adjusting gear 1031b.

[0148] Thus, the rotation of the actuation rod 1031c is converted to rotation of the adjusting rod 1031a via the adjusting gear 1031b to adjust the tension between the coupled flanges 1008a of the tank part 1008 and the frame stationary part 1001a of the container 1001.

[0149] Next, charging of carbon dioxide into the carbon dioxide transport reservoir 1002 and discharging of carbon dioxide from the carbon dioxide transport reservoir 1002 will be described.

[0150] FIG. 24 is a schematic sectional view of the carbon dioxide transport reservoir 1002 in a state in which no carbon dioxide is charged inside the inner tube 1010, taken in the same manner as FIG. 21. FIG. 25 is a schematic sectional view of the carbon dioxide transport reservoir 1002, taken in the same manner as FIG. 24, for explaining a state in which the gas-purging tube is being expanded to promote discharge of carbon dioxide from the inner tube 1010.

[0151] When introducing carbon dioxide into the carbon dioxide transport reservoir 1002 (FIG. 24) disposed inside the freight transport container 1001, the freight transport container 1001 is partly opened, and carbon dioxide at a pressure of, e.g., about 200 Bar, is introduced into the inner tube 1010 from the blowing port 1024 of the inner tube 1010 attached to the first end-side cap 1018.

[0152] Then, when the inner tube 1010 is expanded by the introduced carbon dioxide to completely fill the inner space of the tank part 1008 (FIG. 21), the introduction of carbon dioxide is terminated, and a high-pressure valve (not illustrated) provided at the blowing port 1024 of the inner tube 1010 is closed to close the blowing port 1024 of the inner tube.

[0153] Subsequently, after closing the freight transport container 1001, the freight transport container 1002 is transported to a destination such as a carbon dioxide storage area by transport means such as a truck or a marine vessel.

[0154] In a case where the freight transport container 1001 is a reefer container or the like capable of adjusting an internal environment such as temperature thereof, the transport is performed while the internal environment of the freight transport container 1001 is appropriately adjusted.

[0155] When the carbon dioxide transport reservoir 1002 containing carbon dioxide has arrived at the destination such as a carbon dioxide storage area, the carbon dioxide is discharged from the carbon dioxide transport reservoir 1002.

[0156] The carbon dioxide is contained in the carbon dioxide transport reservoir 1002 in a pressurized state, as mentioned above. Thus, when opening the blowing port 1024 of the inner tube 1010, the carbon dioxide blows out from an inlet-outlet port of the carbon dioxide transport reservoir 1002 until the pressure of the carbon dioxide inside the inner tube 1010 is reduced to a pressure close to atmospheric pressure.

[0157] Then when the pressure of the carbon dioxide inside the inner tube 1010 is reduced to a pressure close to atmospheric pressure, the velocity of the blowout from the inlet-outlet port of the carbon dioxide transport reservoir 1002 is reduced. At this stage, as shown in FIG. 25, air is fed into the gas-purging tube as indicated by the arrowed line F to expand the gas-purging tube, thereby pushing the inner tube 1010 in a direction from the side of the second end toward the side of the first end as indicated by the arrowed line G to push the carbon dioxide remaining in the inner tube 1010 out of the inner tube 1010 as indicated by the arrowed line H.

[0158] It should be noted that the expansion of the gas-purging tube may be started when the pressure of the carbon dioxide inside the inner tube 1010 is greater than atmospheric pressure.

[0159] The carbon dioxide inside the inner tube 1010 can be almost completely discharged by expanding the gas-purging tube to have a volume which fills the internal space of the tank part 1008.

[0160] Next, a carbon dioxide transport reservoir 1040 according to yet another preferred embodiment of the present invention will be described. FIG. 26 is a schematic sectional view taken in the same manner as FIG. 21, showing a carbon dioxide filled state of the carbon dioxide transport reservoir according to this third embodiment of the present invention, and FIG. 27 is a schematic sectional view taken in the same manner as FIG. 21, for explaining a step of discharging carbon dioxide from the carbon dioxide transport reservoir according to the third embodiment of the present invention.

[0161] The carbon dioxide transport reservoir 1040 according to the third embodiment has a basic configuration similar to that of the carbon dioxide transport reservoir 1002. A difference between the carbon dioxide transport reservoir 1040 and the carbon dioxide transport reservoir 1002 is that the carbon dioxide transport reservoir 1040 is provided with a pushing device comprising a pushing plate 1042 and a pushing rod 1044, in place of the gas-purging tube 1026.

[0162] The pushing plate 1042 constituting the pushing device of the carbon dioxide transport reservoir 1040 is a plate-shaped member which has the same size and shape as those of a cross-section in a direction orthogonal to the longitudinal axis of the hollow-cylindrical tank part, and whose surface extends in a direction orthogonal to the longitudinal axis of the tank part, wherein it is disposed inside the tank part 1008 on the side of an end of the inner tube 1010 facing the other end (second end) of the tank part 1008.

[0163] The pushing rod 1044 is configured to penetrate through the second end-side cap 1020 of the tank part 1009 and extend inside the tank part 1008, and to have a distal end connected to a back surface (a surface facing to the second end of the tank part 1008) of the pushing plate 1042. The pushing rod 1044 is configured to be reciprocatingly moved along the longitudinal axis of the tank part 1008 by a non-illustrated driver source to move the pushing plate 1042 from the second end (right end in FIG. 26) to the first end (left end in FIG. 26) of the tank part 1008, thereby pushing the inner tube 1010 located on the side of a front surface of the pushing plate 1042 facing to the first end of the tank part 1008, toward the first end of the tank part 1008 to squash the inner tube 1010.

[0164] Next, charging of carbon dioxide into the carbon dioxide transport reservoir 1040 and discharging of carbon dioxide from the carbon dioxide transport reservoir 1040 will be described.

[0165] When charging of carbon dioxide into the carbon dioxide transport reservoir 1040, in a state in which the pushing plate 1042 is disposed on the second end (right end in FIG. 26) of the tank part 1008, the freight transport container 1001 is partly opened, and carbon dioxide at a pressure of, e.g., about 200 Bar, is introduced into the inner tube 1010 from the blowing port 1024 of the inner tube 1010 attached to the first end-side cap 1018, as with the embodiment using the carbon dioxide transport reservoir 1002.

[0166] Then, when the inner tube 1010 is expanded by the introduced carbon dioxide to completely fill the inner space of the tank part 1008, the introduction of carbon dioxide is terminated, and a high-pressure valve provided at the blowing port 1024 of the inner tube 1010 is closed to close the blowing port 1024 of the inner tube (FIG. 26).

[0167] Subsequently, after closing the freight transport container 1001, the freight transport container 1040 is transported to a destination such as a carbon dioxide storage area by transport means such as a truck or a marine vessel.

[0168] When the carbon dioxide transport reservoir 1040 containing carbon dioxide has arrived at the destination such as a carbon dioxide storage area, the carbon dioxide is discharged from the carbon dioxide transport reservoir 1040.

[0169] The carbon dioxide is contained in the carbon dioxide transport reservoir 1040 in a pressurized state, as mentioned above. Thus, when opening the blowing port 1024 of the inner tube 1010, the carbon dioxide blows out from an inlet-outlet port of the carbon dioxide transport reservoir 1040 until the pressure of the carbon dioxide inside the inner tube 1010 is reduced to a pressure close to atmospheric pressure.

[0170] Then when the pressure of the carbon dioxide inside the inner tube 1010 is reduced to a pressure close to atmospheric pressure, the velocity of the blowout from the inlet-outlet port of the carbon dioxide transport reservoir 1040 is reduced. As shown in FIG. 27, at this stage, the pushing plate 1042 is moved by the pushing rod 1044 as indicated by the arrowed line I to push the inner tube 1010 in a direction from the second end toward the first end of the tank part 1008 to squash the inner tube 1010, thereby pushing the carbon dioxide remaining in the inner tube 1010 out of the inner tube 1010 as indicated by the arrowed line J.

[0171] It should be noted that the pushing by the pushing plate 1042 may be started when the pressure of the carbon dioxide inside the inner tube 1010 is greater than atmospheric pressure.

[0172] In the description about the carbon dioxide transport reservoir in the above third embodiment, the rigid outer support is a freight transport container. However, the outer support is not limited to a freight transport container, but may be an assembly-type rigid rectangular-shaped frame.

LIST OF REFERENCE SIGNS

[0173]

1, 1001: freight transport container
2, 1002: carbon dioxide transport reservoir
4, 1004: reservoir body
6, 1008: tank part
8, 1010: inner tube
10: upper half segment
12: lower half segment
14: tank body
16: first end-side cap
18: second end-side cap
20: opening
32: nut
34, 1024: blowing port
36: reinforcing bracket
38: flange holder-adjusting gear unit
50: jig
52: base
54: flange cradle
56: lifter equipped with transfer roller
58: locating pin
60: mounting flange
62: connection part
64: groove
400: rectangular-shaped frame

Claims

1. A carbon dioxide transport reservoir comprising a reservoir body configured to be disposed inside a rigid outer support, wherein the reservoir body comprises:

    a rigid hollow-cylindrical tank part; and
    a balloon-shaped flexible inner tube for containing carbon dioxide, the flexible inner tube being provided with a blowing port and disposed inside the tank part in an expandable and contractible manner in a state in which the blowing port is connected to one end of the tank part,
    wherein the tank part is configured to be disassemblable

2. The carbon dioxide transport reservoir according to claim 1, wherein the tank part comprises: a hollow-semicylindrical upper half segment, a hollow-semicylindrical lower half segment, a first end-side cap for closing a first one of opposite ends of the tank part, and a second end-side cap for closing a second one of the opposite ends of the tank part, and wherein the upper half segment, the lower half segment, the first end-side cap and the second end-side cap are detachably connected together.

3. The carbon dioxide transport reservoir according to claim 2, wherein

    the upper half segment has a flange extending radially outwardly from each of opposite edges of a circumferential opening thereof, and
    the lower half segment has a flange extending radially outwardly from each of opposite edges of a circumferential opening thereof,
    wherein the upper half segment and the lower half segment are connected together with the respective flanges of the upper half segment and the lower half segment butted against each other.

4. The carbon dioxide transport reservoir according to claim 3, comprising coupling means to couple the flange of the upper half segment and the flange of the lower half segment together.

5. The carbon dioxide transport reservoir according to claim 4, wherein the coupling means comprises: two sets of a plurality of through-holes, each provided in the upper half segment and the lower half segment such that the two sets of the plurality of through-holes are aligned to form plural pairs of aligned through-holes when the upper half segment and the lower half segment are connected together; and a plurality of fasteners each configured to be inserted into a respective one of the plural pairs of aligned through-

holes to connect the flange of the upper half segment and the flange of the lower half segment together, thereby connecting and fastening the upper half segment and the lower half segment together.

6. The carbon dioxide transport reservoir according to claim 5, wherein each of the fasteners comprises a bolt configured to be inserted into each of the aligned pairs of through-holes, and a nut configured to be attached to the bolt.

7. The carbon dioxide transport reservoir according to claim 2, comprising:

   a mounting flange provided at each of axially-opposite open ends of the connected upper and lower half segments; and
   a connection part provided at an open end of each of the first end-side cap and the second end-side cap and configured to be releasably connected to the mounting flange.

8. The carbon dioxide transport reservoir according to claim 7, wherein the mounting flange and the connection part are configured to be movable between a lock position where the first end-side cap or the second end-side cap is non-detachable from the connected upper and lower half segments, and an unlock position where the first end-side cap or the second end-side cap is detachable from the connected upper and lower half segments, according to a relative rotation between the first end-side cap or the second end-side cap and the connected upper and lower half segments.

9. The carbon dioxide transport reservoir according to claim 1, wherein the outer support is a freight transport container.

10. The carbon dioxide transport reservoir according to claim 1, wherein the outer support is an approximately-rectangular rigid frame.

11. The carbon dioxide transport reservoir according to claim 10, wherein the rigid frame is an assembly type rigid frame.

12. A carbon dioxide transport method comprising transporting carbon dioxide which pressurized and charged in the carbon dioxide transport reservoir according to claim 1.

13. A carbon dioxide transport reservoir comprising a reservoir body configured to be disposed inside a rigid outer support, wherein the reservoir body comprises:

   a rigid hollow-cylindrical tank part;
   a balloon-shaped flexible inner tube for containing carbon dioxide, the flexible inner tube being provided with a blowing port and disposed inside the tank part in an expandable and contractible manner in a state in which the blowing port is connected to one of opposite ends of the tank part; and
   a pushing device disposed inside the tank part on the side of an end of the inner tube facing the other end of the tank part and configured to press the inner tube toward the one end of the tank part.

14. The carbon dioxide transport reservoir according to claim 13, wherein the pushing device comprises a gas-purging tube which is expandable and contractible inside the tank part, the gas-purging tube being configured to be expandable to have a volume which fills an internal space of the tank part.

15. The carbon dioxide transport reservoir according to claim 13, wherein the pushing device comprises: a pushing plate disposed inside the tank part to extend in a direction orthogonal to a longitudinal axis of the tank part; and a pushing rod configured to push the pushing plate toward the one end of the tank part.

16. The carbon dioxide transport reservoir according to claim 15, wherein the tank part further comprises a cap part disposed on the side of the one end of the tank part and provided with a carbon dioxide inlet-outlet opening, and wherein the blowing port of the inner tube is attached to the carbon dioxide inlet-outlet opening of the cap part.

17. The carbon dioxide transport reservoir according to claim 13, wherein the outer support is a freight transport container.

18. The carbon dioxide transport reservoir according to claim 13, wherein the outer support is an approximately-rectangular rigid frame.

19. The carbon dioxide transport reservoir according to claim 18, wherein the rigid frame is an assembly type rigid frame.

20. The carbon dioxide transport reservoir according to claim 17, wherein the tank part further comprises a reinforcing bracket for connecting the tank part and each of opposed corners of the outer support.

21. A method of transporting carbon dioxide, wherein the method comprises: charging pressurized carbon dioxide in the carbon dioxide transport reservoir according to claim 13; and transporting the carbon dioxide transport reservoir containing the pressurized carbon dioxide.

22. A method of discharging dioxide discharge from the carbon dioxide transport reservoir according to claim 13, wherein the method comprises discharging carbon dioxide from the inner tube while actuating the pushing device to push the inner tube.

FIG.1

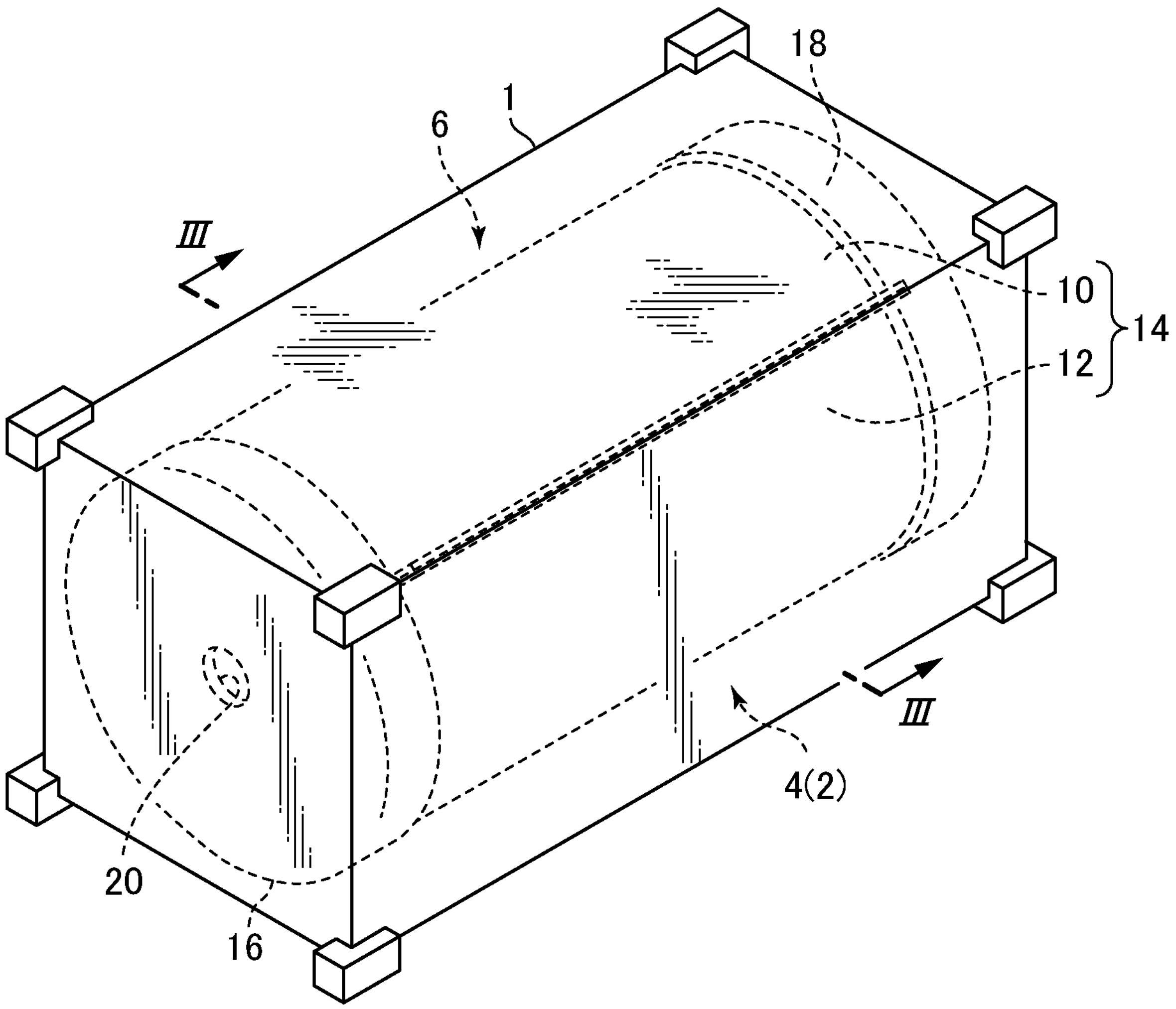

FIG.2

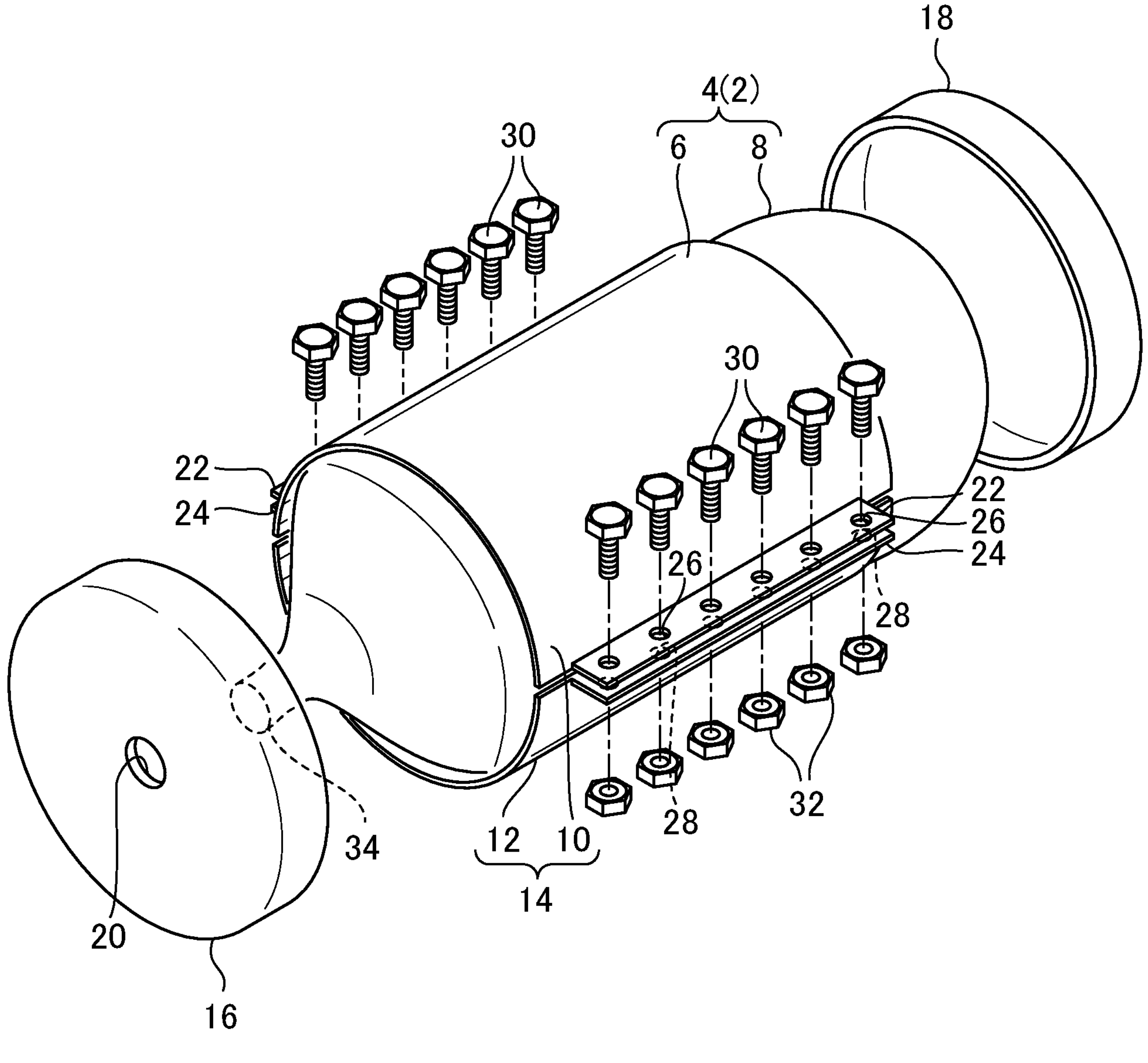

FIG.3

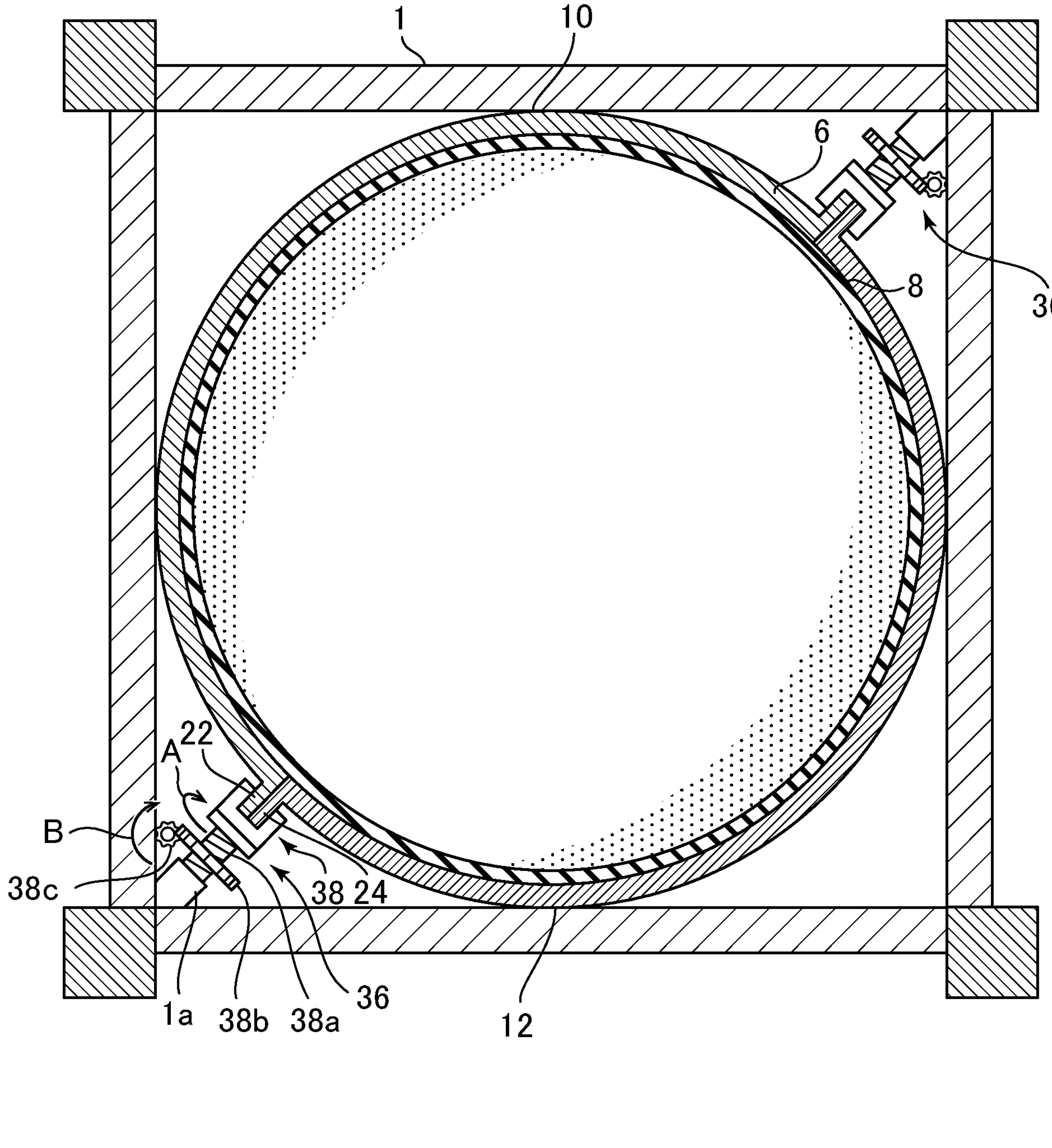

FIG.4

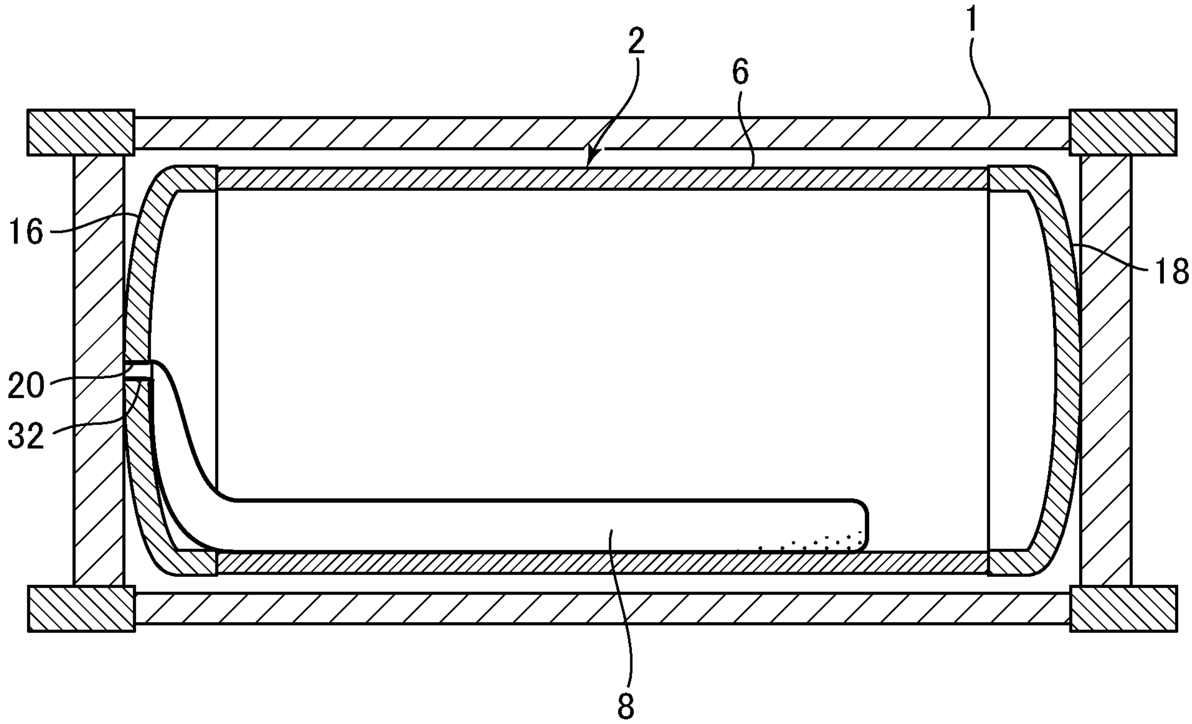

FIG.5

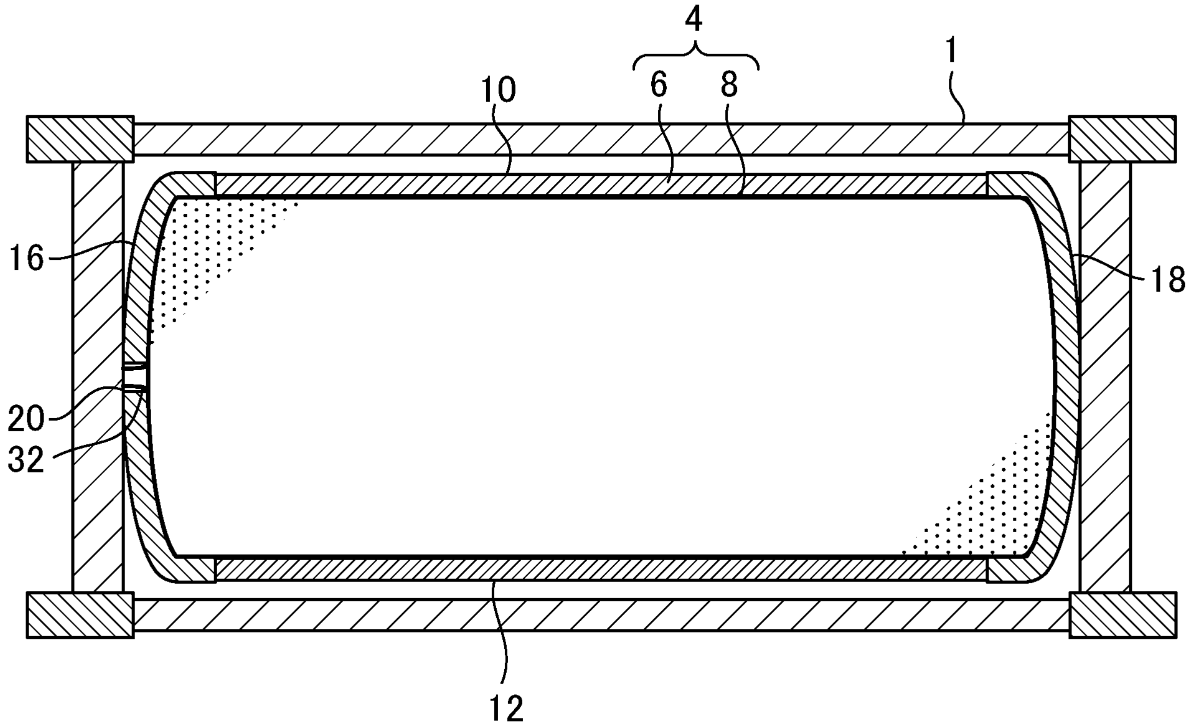

FIG.6

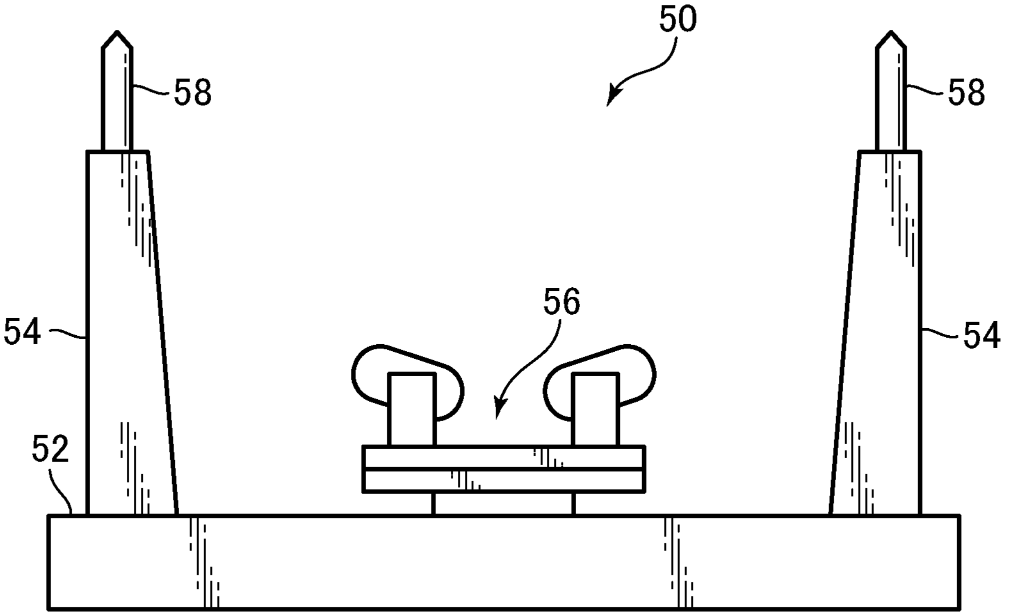

FIG.7

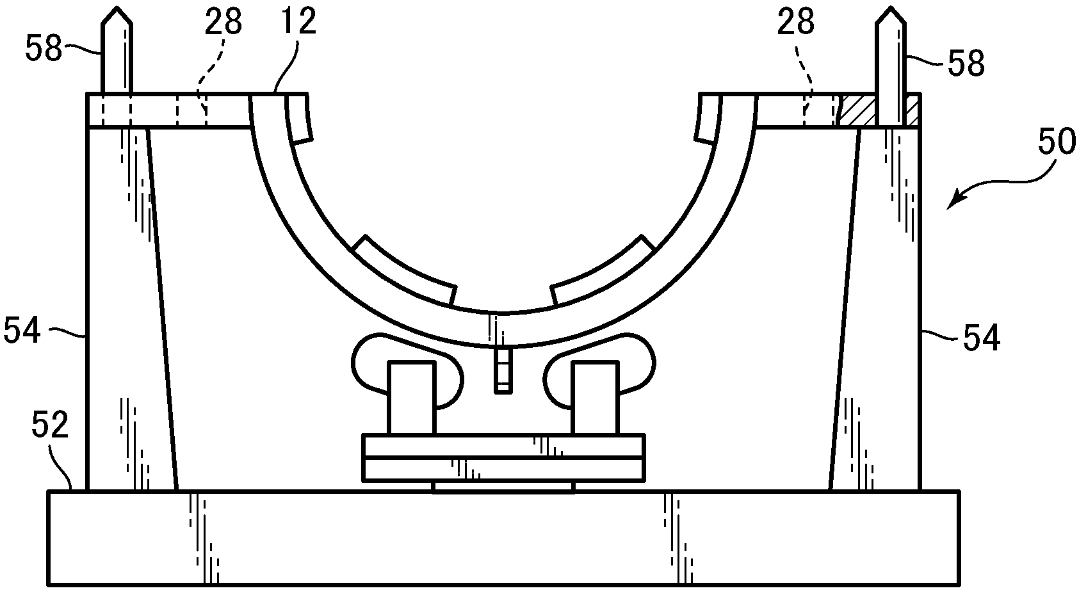

FIG.8

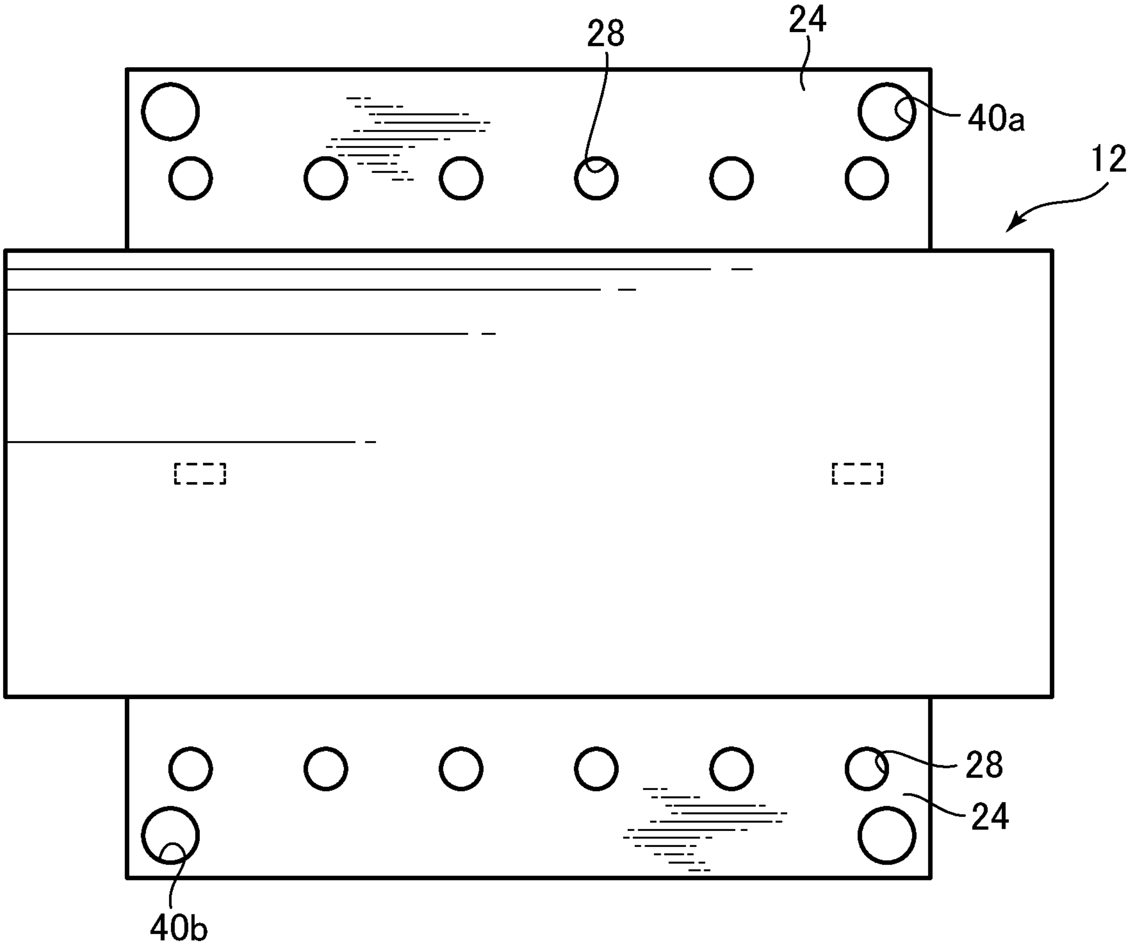

FIG.9

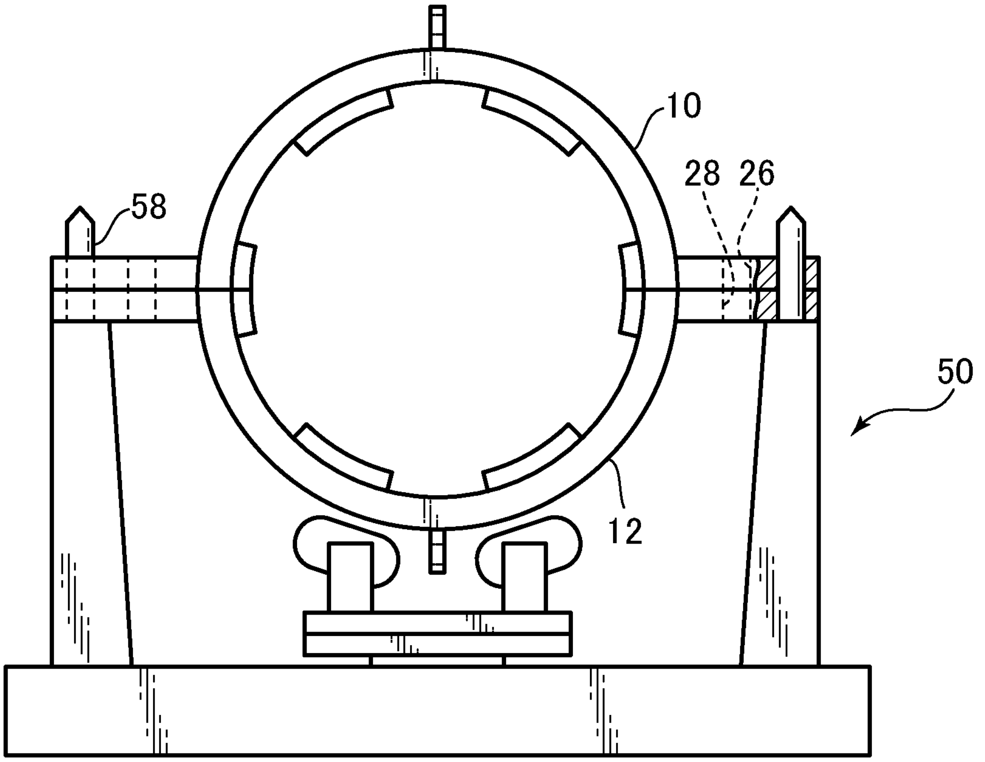

FIG.10

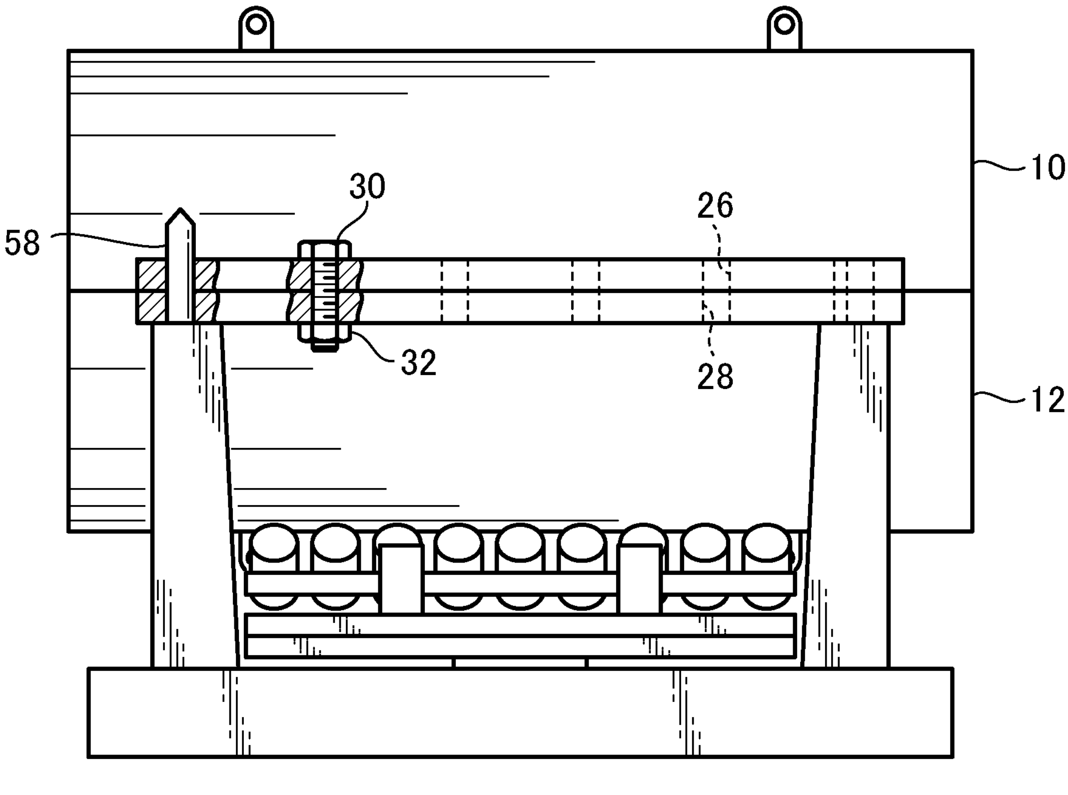

FIG.11

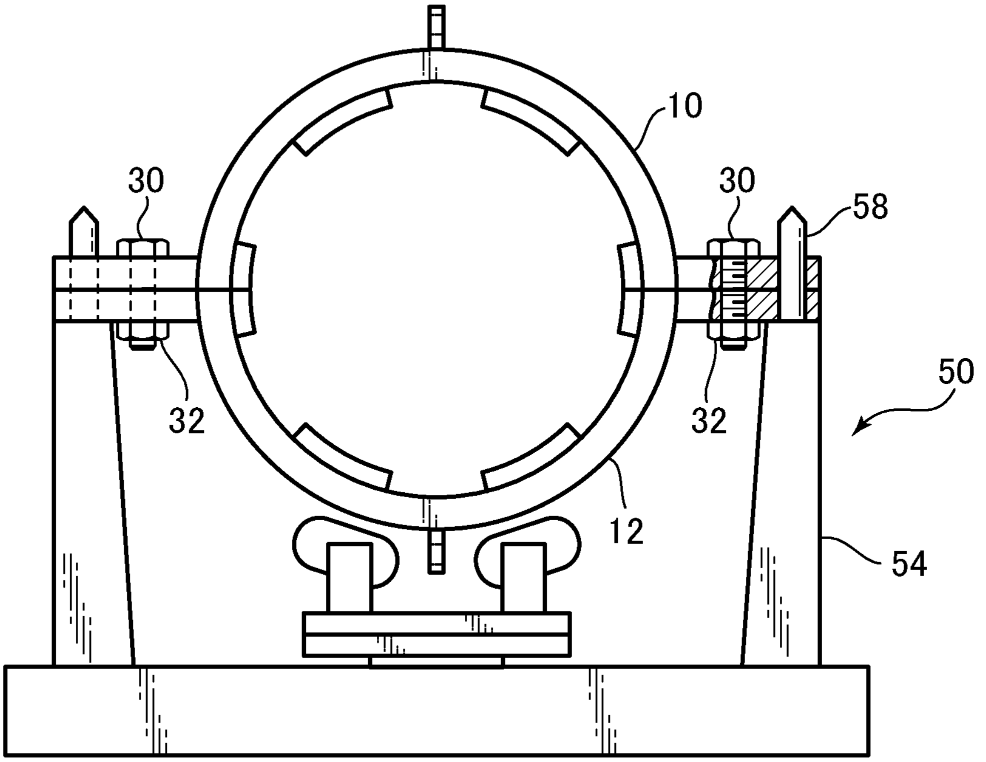

FIG.12

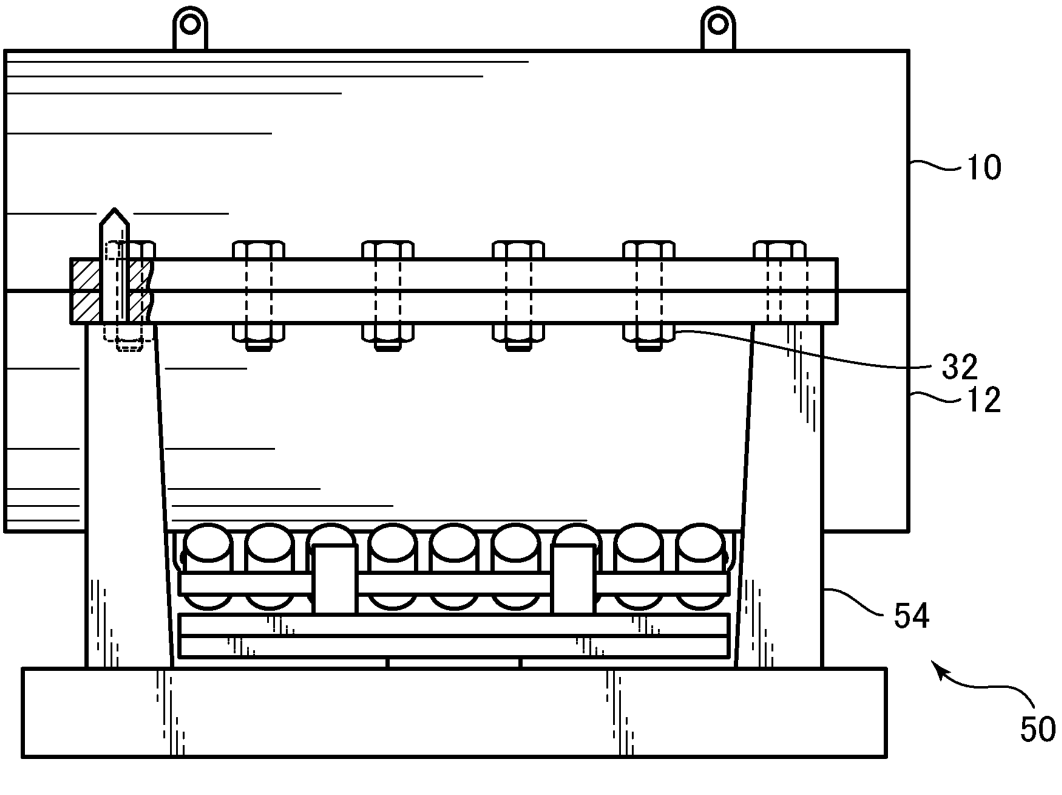

FIG.13

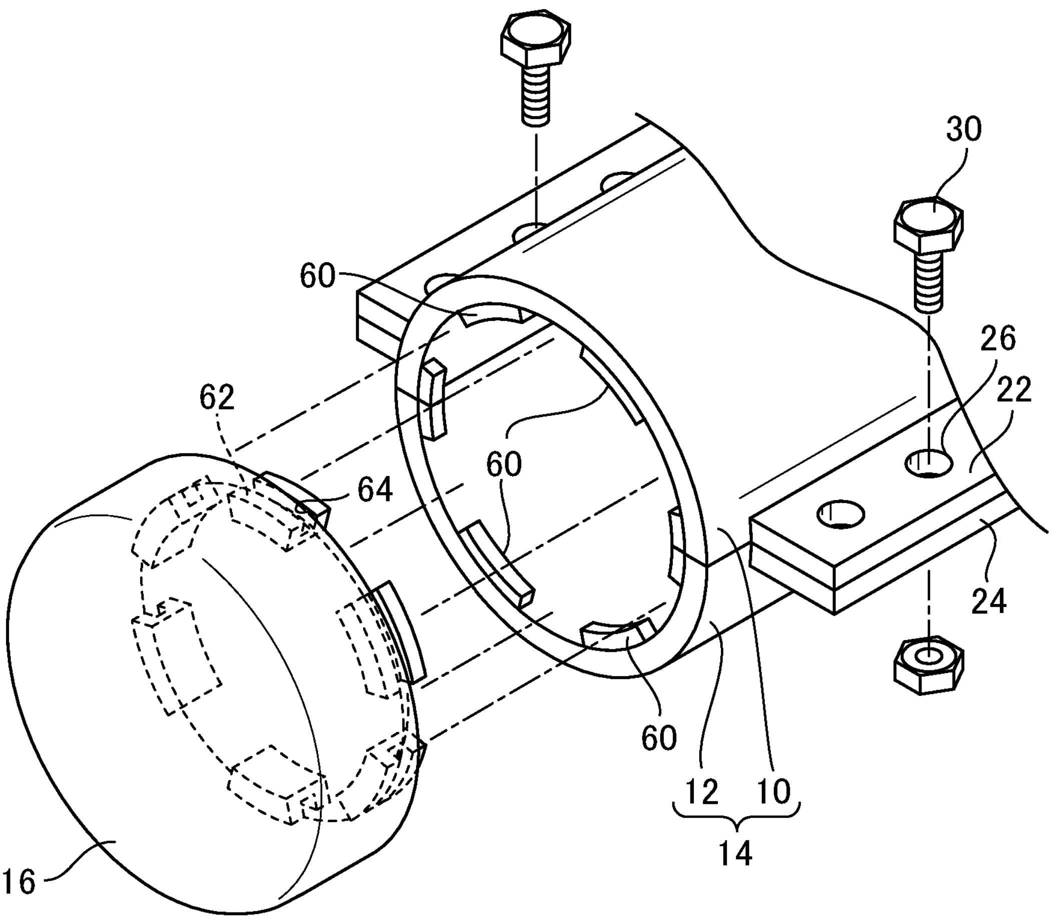

FIG.14

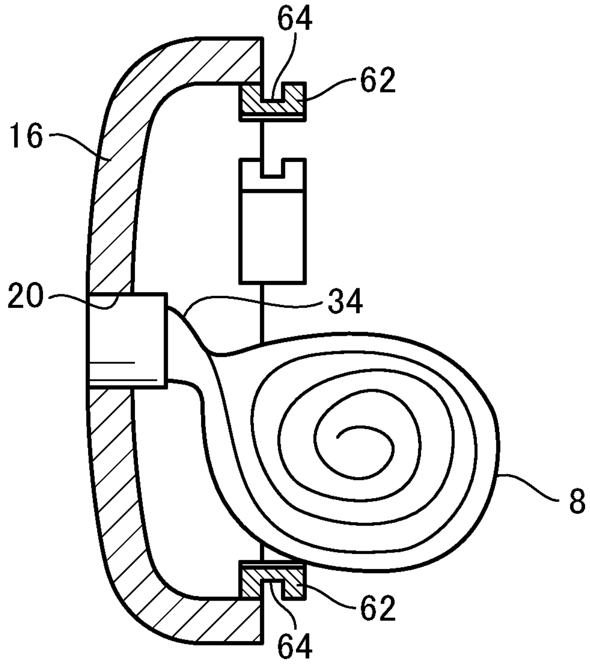

FIG.15

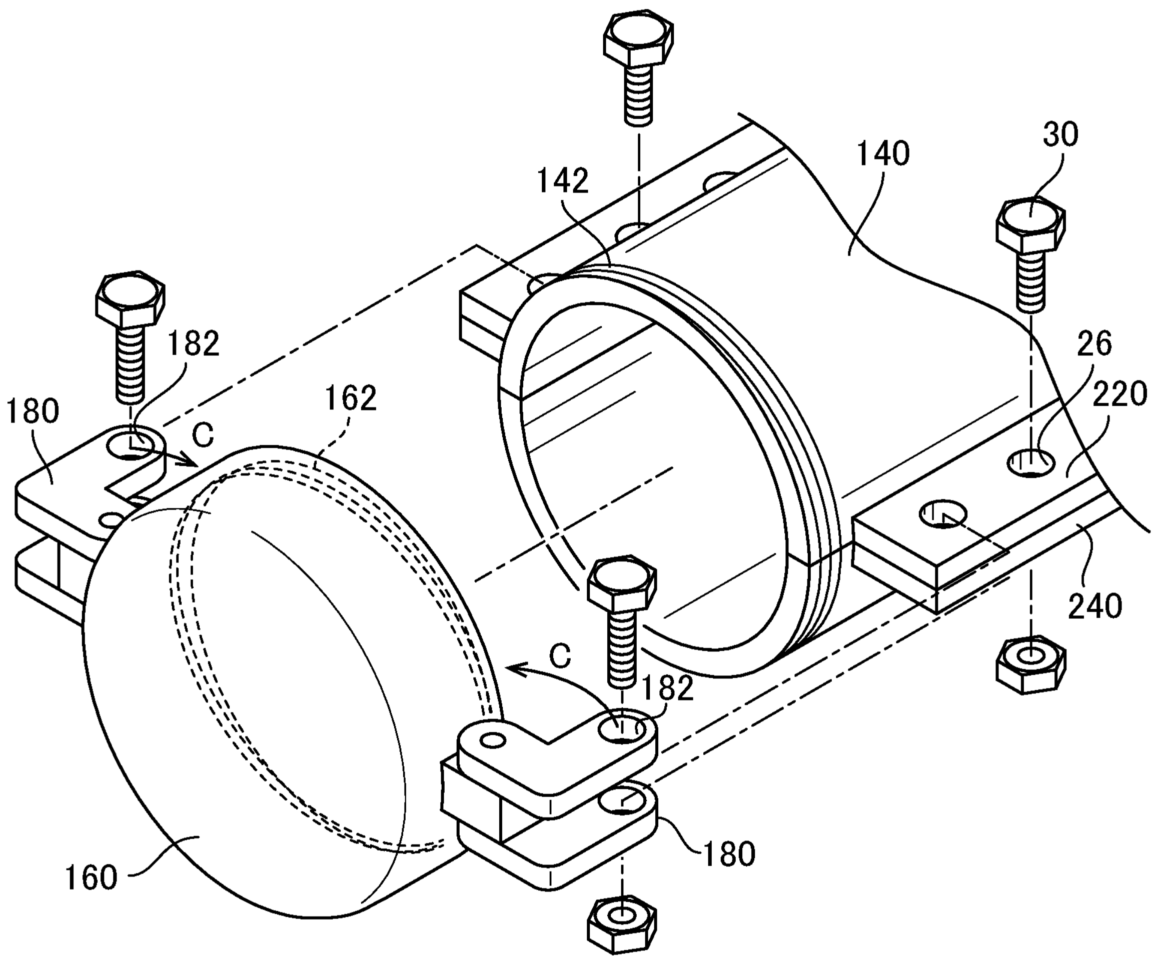

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FIG.16

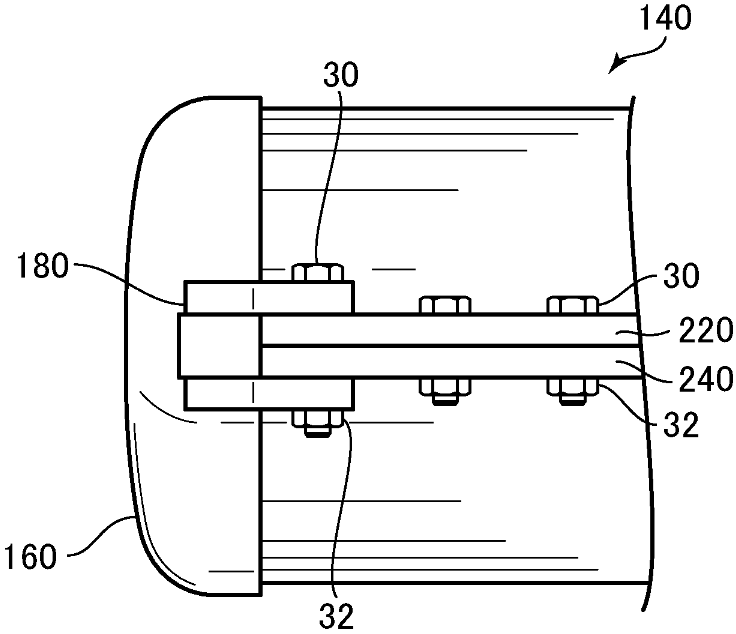

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FIG.17

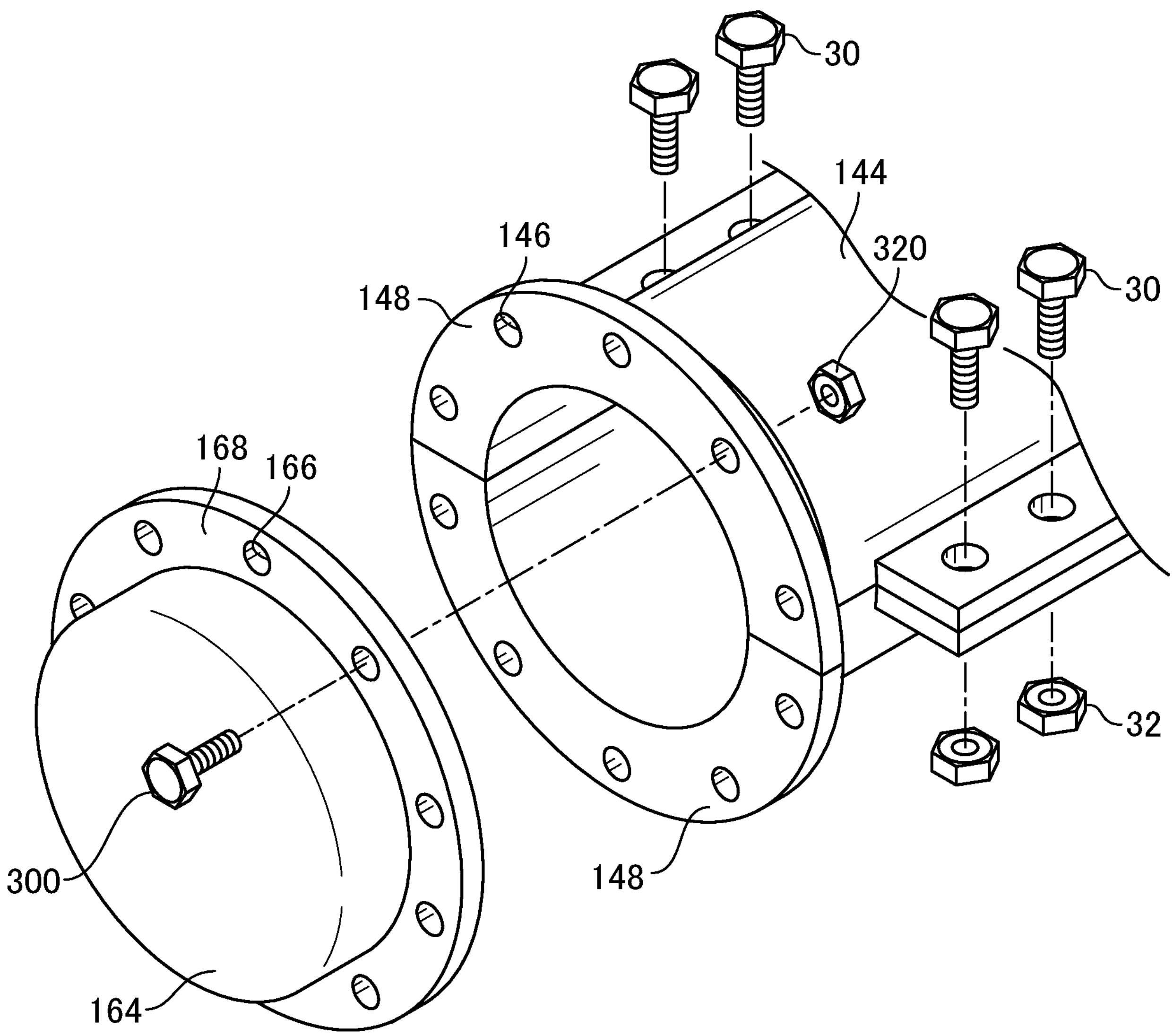

FIG.18

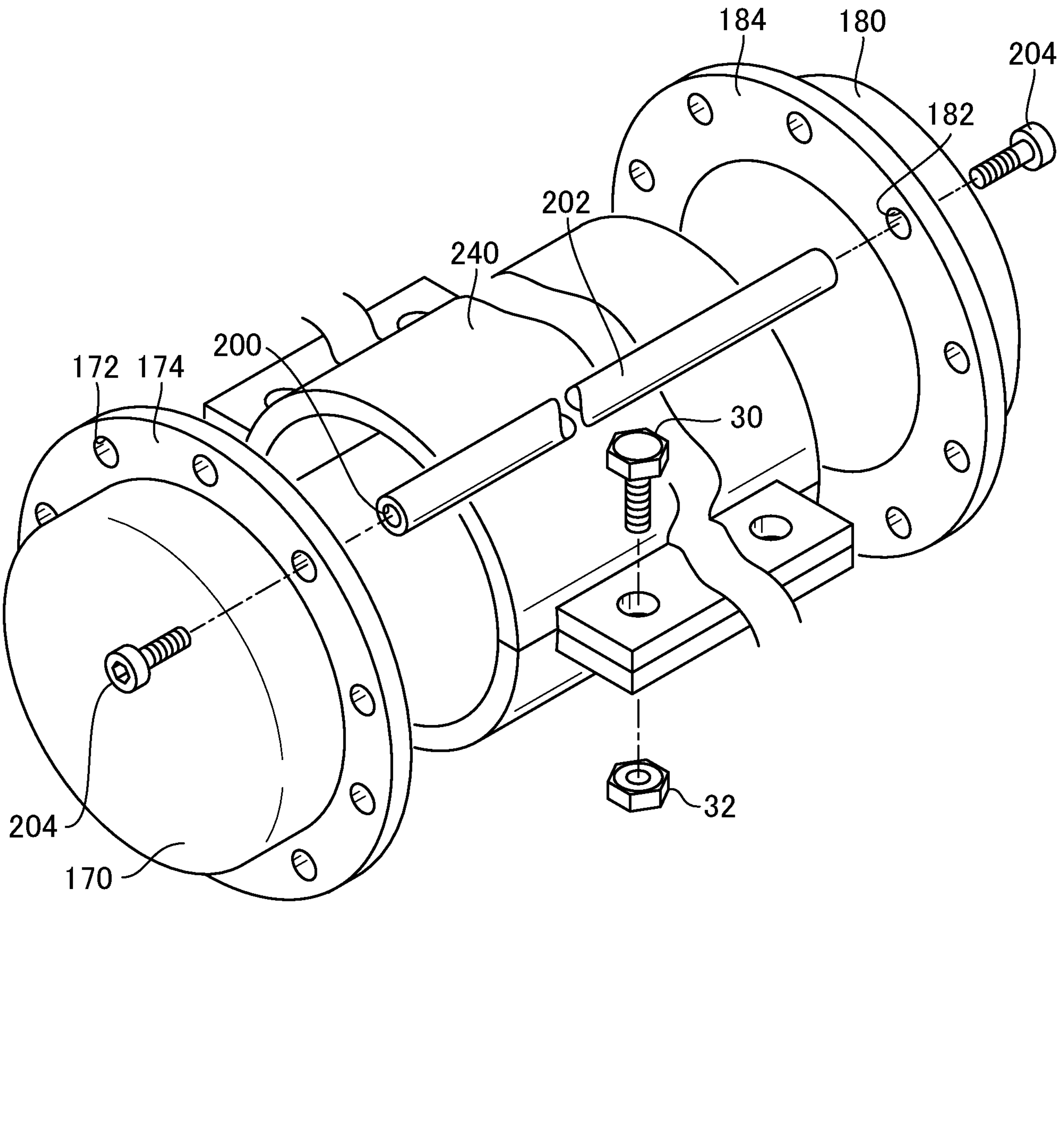

FIG.19

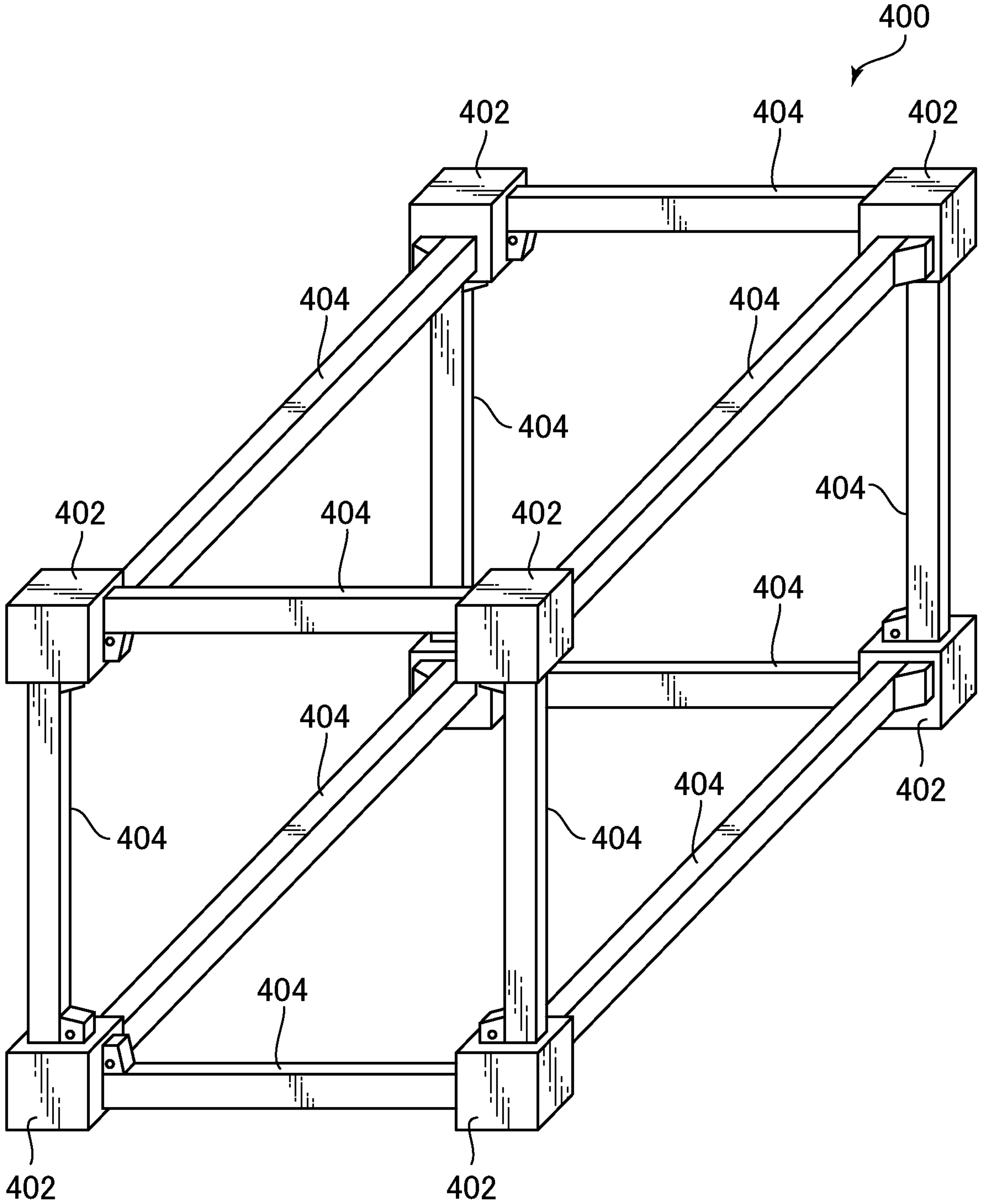

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FIG.20

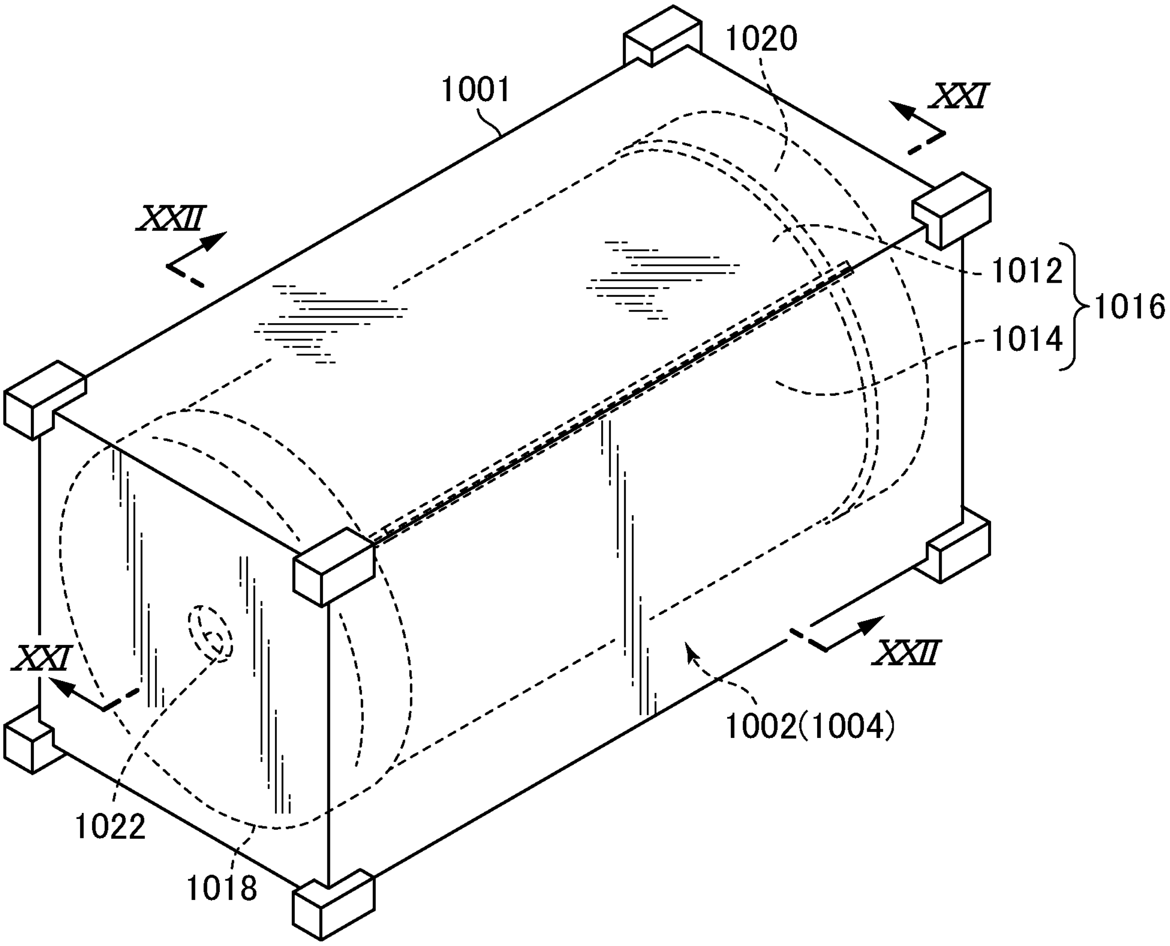
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FIG.21

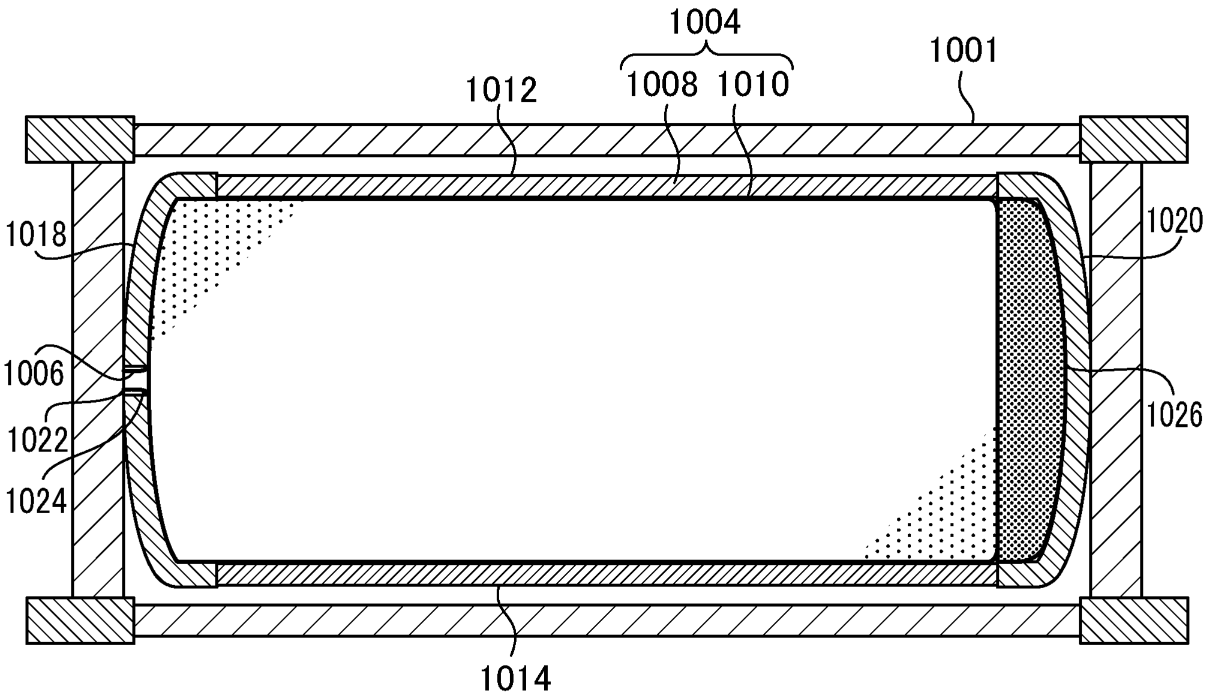
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FIG.22

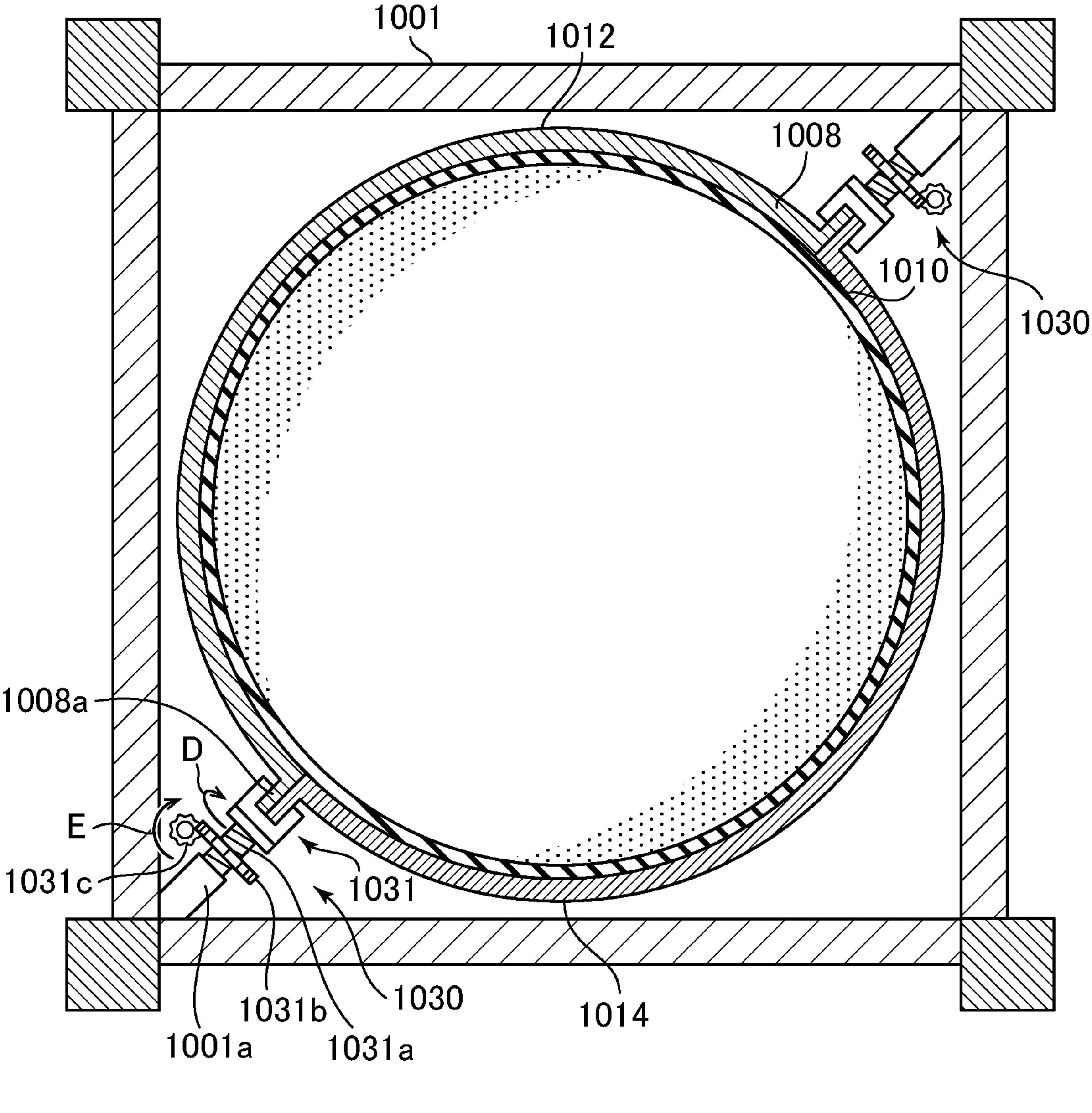
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FIG.23

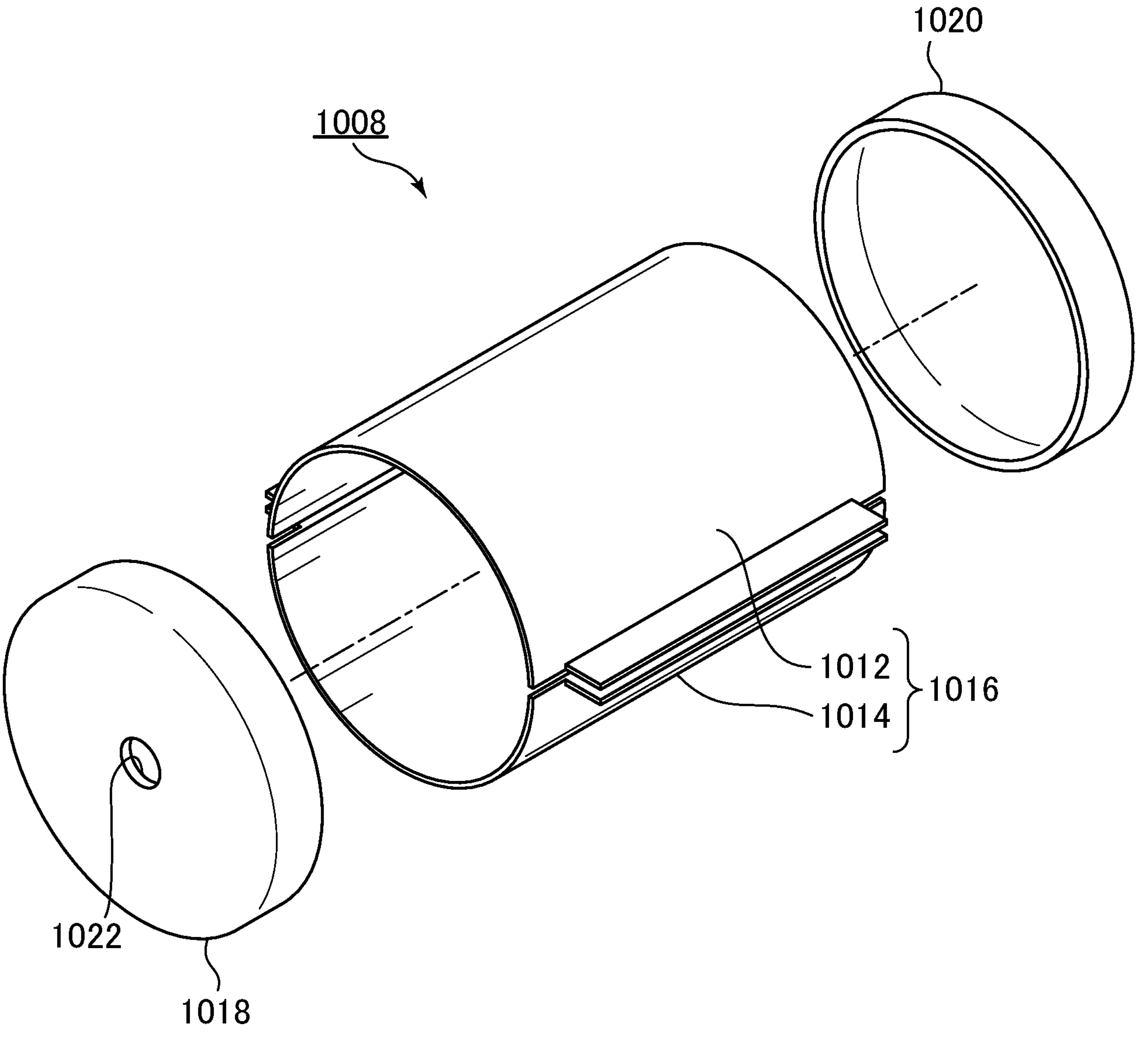

FIG.24

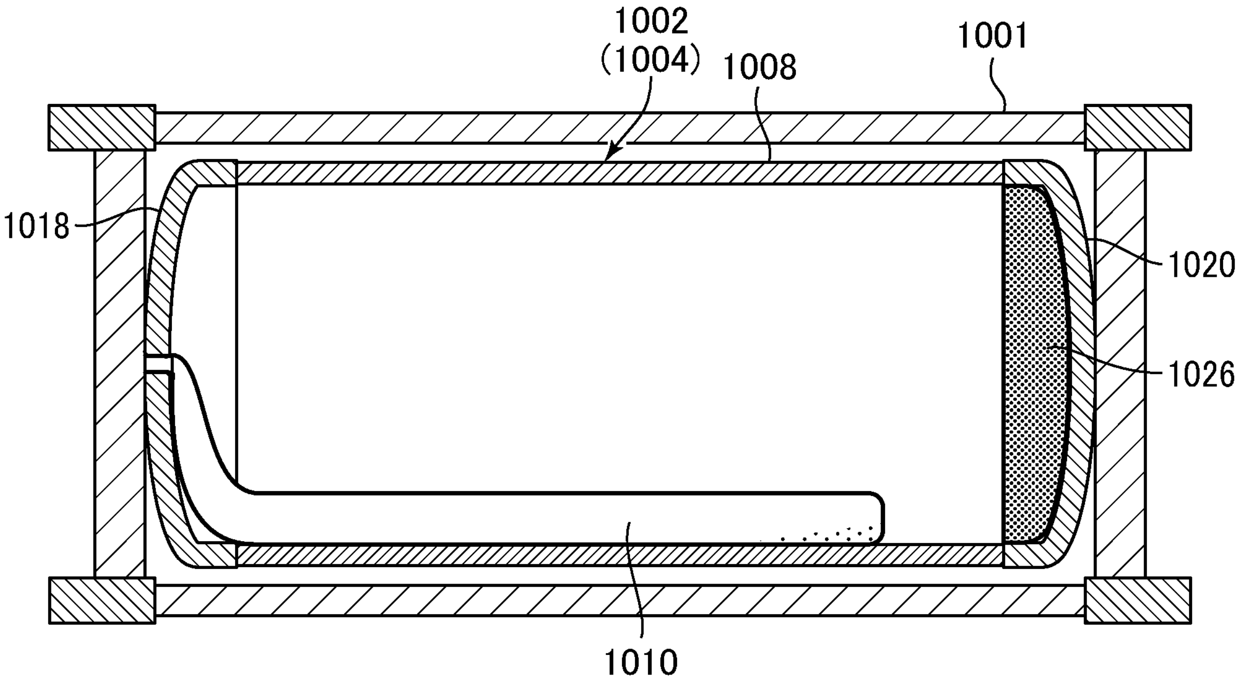
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FIG.25

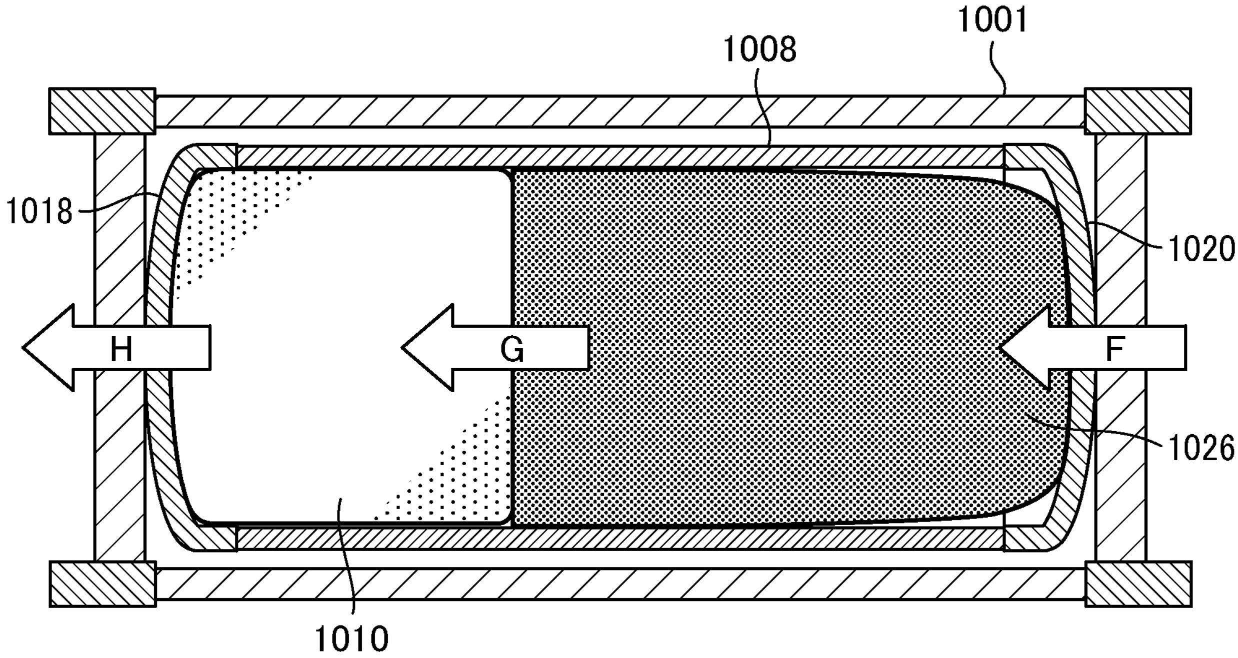
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FIG.26

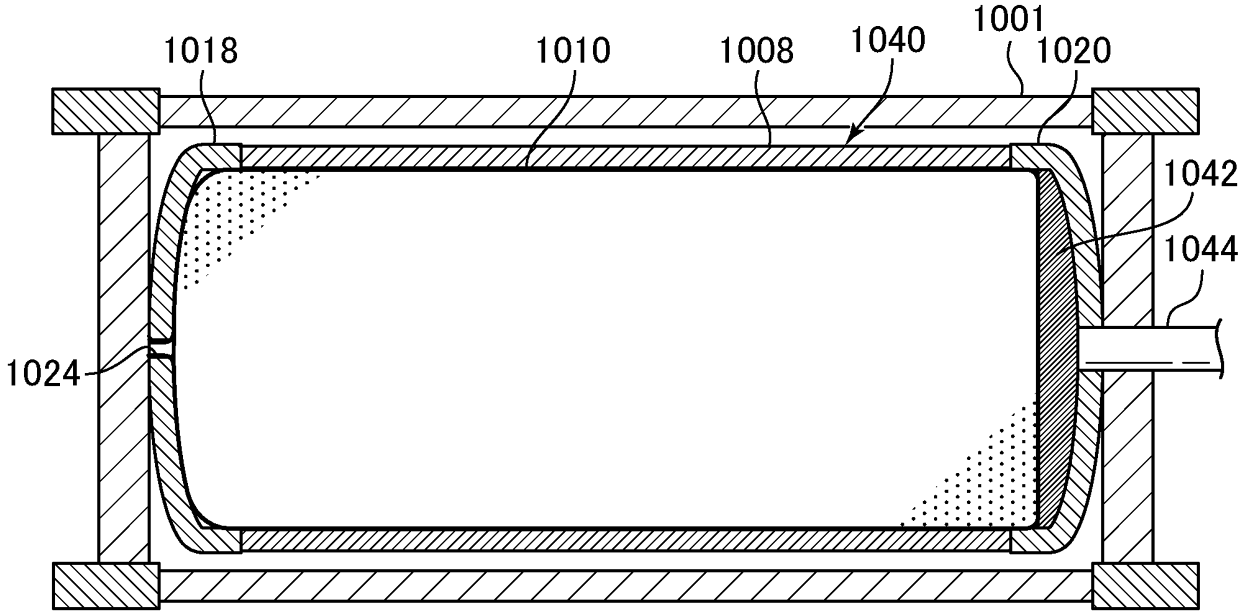
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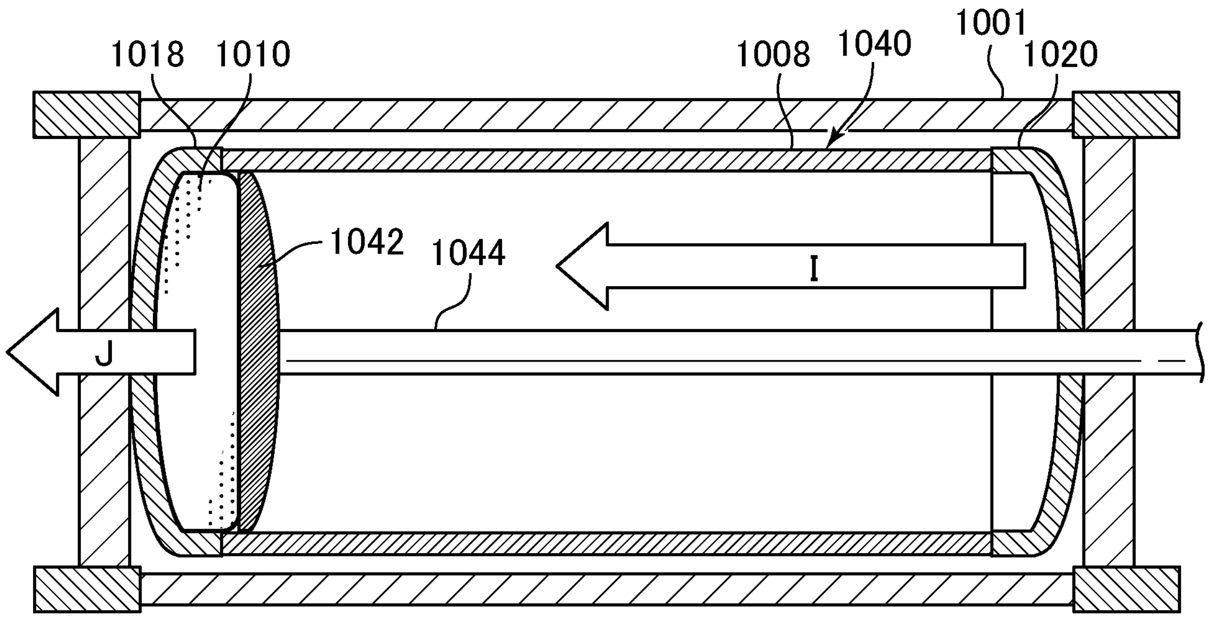
FIG.27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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2022/003509

A. CLASSIFICATION OF SUBJECT MATTER

F17C 1/00(2006.01)i; ***F17C 13/00***(2006.01)i; ***B65D 88/12***(2006.01)i
FI: F17C13/00 301Z; F17C1/00 Z; B65D88/12 K

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F17C1/00; F17C13/00; B65D88/12

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2022
Registered utility model specifications of Japan 1996-2022
Published registered utility model applications of Japan 1994-2022

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2010-525242 A (ENERSEA TRANSPORT LLC) 22 July 2010 (2010-07-22) paragraphs [0019]-[0180], fig. 1-14	1, 9-12 2-8, 13-22
Y A	JP 2007-308156 A (KAWASAKI HEAVY IND LTD) 29 November 2007 (2007-11-29) paragraphs [0001], [0018]-[0019], fig. 1	1, 9-12 2-8, 13-22
Y A	JP 03-176700 A (NUCLEAR FUEL IND LTD) 31 July 1991 (1991-07-31) p. 2, lower right column, line 4 to p. 3, lower left column, line 10, fig. 1-6	1, 9-12 2-8, 13-22
A	JP 2007-170633 A (HONDA MOTOR CO LTD) 05 July 2007 (2007-07-05) paragraph [0017], fig. 2	1-22
A	WO 2001/000509 A2 (GOH, Enghock) 04 January 2001 (2001-01-04)	1-22
A	US 2019/0162366 A1 (CRYOGENIC FUELS INC.) 30 May 2019 (2019-05-30)	1-22

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

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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
09 March 2022	**12 April 2022**

Name and mailing address of the ISA/JP	Authorized officer
Japan Patent Office (ISA/JP) **3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915** **Japan**	Telephone No.

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2022/003509

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JP 2007-308156 A	29 November 2007	(Family: none)	
JP 03-176700 A	31 July 1991	(Family: none)	
JP 2007-170633 A	05 July 2007	(Family: none)	
WO 2001/000509 A2	04 January 2001	GB 2369098 A	
US 2019/0162366 A1	30 May 2019	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)