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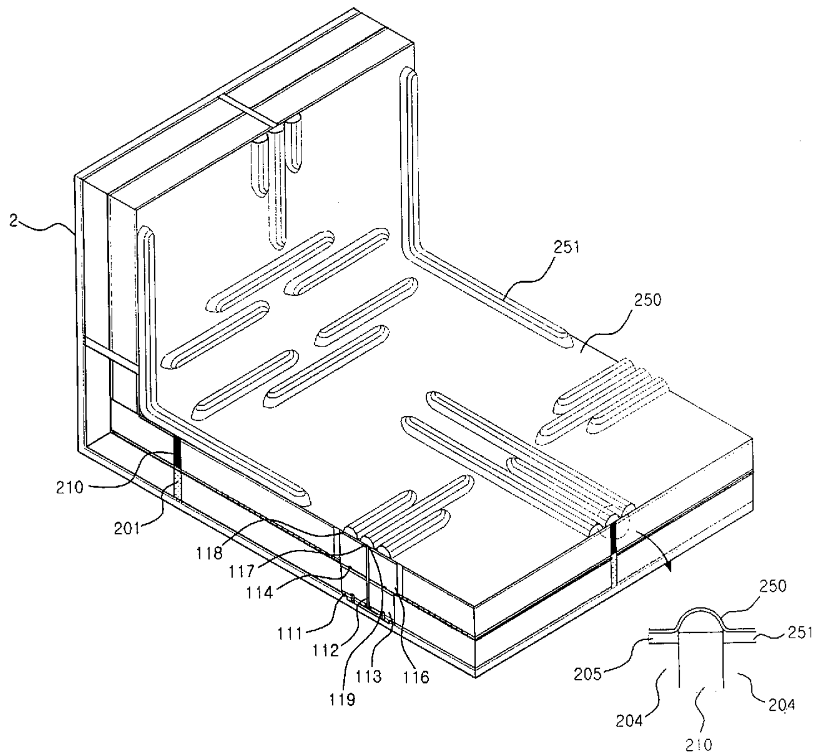
(54) Title: LNG STORAGE TANK AND CONSTRUCTING METHOD THEREOF



(57) Abstract: The present invention relates to a liquefied natural gas storage tank and a method of constructing the same. An object of the present invention is to provide a liquefied natural gas storage tank capable of minimizing loss of the liquefied natural gas due to its vaporization by simplifying a structure of tank for storing the liquefied nature gas corresponding to cryogenic liquid to shorten a fabricating process and by causing the stress created due to mechanical deformation to be easily reduced while firmly maintaining the liquid-tight characteristics. To this end, the liquefied natural gas storage tank of the present invention is a type of liquefied natural gas storage tank installed within constructions and includes two successive sealing barriers and two insulation barriers, among which a first sealing barrier of the sealing barriers is brought into contact with liquefied natural gas stored in the storage tank, and a first insulation barrier, a second sealing barrier and a second insulation barrier are sequentially disposed on a lower surface of the first sealing barrier, wherein the first sealing barrier is supported by an anchor structure mechanically fastened to a bottom floor of the tank, and the insulation barriers are slidably installed between the first sealing barrier and the bottom floor of the tank.

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LNG STORAGE TANK AND CONSTRUCTING METHOD THEREOF

Technical Field

The present invention relates to a liquefied natural gas (LNG) storage tank installed within constructions such as ships, ground tanks and vehicles and a construction method thereof. More particularly, the present invention relates to a liquefied natural gas (LNG) storage tank and a construction method thereof, wherein a fabricating process can be shortened by simplifying a structure of tank for storing liquefied nature gas corresponding to cryogenic liquid and stress created due to mechanical deformation can also be reduced while the liquid-tight characteristics are firmly maintained.

Background Art

In general, liquefied natural gas ("LNG") is obtained by causing natural gas, one of fossil fuels, to be liquefied. An LNG storage tank is classified into a ground storage tank, which is installed on the ground or buried in the ground according to installation positions, and a mobile storage tank, which is mounted on transportation means such as automobiles and ships.

The aforementioned LNG is stored in a cryogenic state and is explosive when it is exposed to shock. Thus, the LNG storage tank should be constructed such that shock resistance and liquid-tight characteristics thereof can be firmly maintained. The LNG storage tank installed on a mobile automobile or ship is slightly different from the ground storage tank with little motion in view of their configurations in that it should provide a means for overcoming mechanical stress due to the motion thereof. However, the LNG storage tank, which is installed on a ship and provided with a means for overcoming the mechanical stress, can also be used as a ground storage tank. Therefore, the structure of an LNG storage tank installed on a ship will be described herein by way of example.

First, an LNG storage tank installed within an LNG carrier may be classified into an independent tank type and a membrane type. This corresponds to classification according to whether cargo load is applied directly to an insulating material, and detailed description thereof will be discussed as follows.

As shown in Table 1, GT type made in Gaz Transport and TGZ type made in Technigaz are renamed and used as GTT NO 96-2 and GTT Mark III, respectively, as Gaz Transport (GT) and Technigaz (TGZ) are merged into and renamed as Gaztransport & Technigaz (GTT) in 1995.

The structures of the aforementioned GT type and TGZ type tanks are described in U.S. Patent No. 6,035,795, U.S. Patent No. 6,378,722, U.S. Patent No. 5,586,513, U.S. Patent Laid-Open Publication No. 2003-0000949, Korean Patent Laid-Open Publication No. 2000-0011346, and the like.

Table 1

Classification of LNG storage tanks

Item	Membrane Type		Independent Type	
	GTT Mark III	GTT NO 96-2	MOSS	IHI - SPB
Tank Material - thickness	SUS 304L - 1.2 mm	Invar Steel - 0.7 mm	Al Alloy Steel - 50 mm	Al Alloy Steel - Max. 30 mm
Insulating Material - thickness	Reinforced Polyurethane Foam - 250 mm	Plywood Box + Perlite - 530 mm	Polyurethane Foam - 250 mm	Polyurethane Foam - 200 mm

The membrane type LNG carrier of GTT is configured in such a manner that cargo load is directly applied to an insulating material or ship's hull and a cofferdam is installed between adjacent cargo tanks to avoid danger due to mechanical/thermal characteristics. Further, an air temperature in the cofferdam should be kept at a temperature of +5 °C or more in order to prevent low-temperature brittleness in an inner plate at a side of the cofferdam. To this end, a heating means such as a heating coil is generally installed to utilize a heat source such as steam or hot water. In order to construct the insulating material, a scaffold is first installed at a ship's hull, and scaffold materials, insulation boxes and membranes manufactured on land, and other materials are then carried and installed. A working hour before launch is longer in case of an old tank, whereas a working hour after launch is longer in a membrane type.

As shown in Figs. 1 and 2, a GTT NO 96-2 type carrier among the GTT membrane type carriers is made of Invar steel (36% Ni) with a thickness of 0.5 ~ 0.7 mm, and first and second sealing barriers 10 and 15 have the almost same liquid-tight characteristics and strength as each other. Therefore, cargo can be safely carried using only the second sealing barrier 15 in a substantial period of time even when the first sealing barrier 10 leaks. Further, since a membrane of the sealing barriers 10 and 15 of the GTT NO 96-2 is straight, it can be more conveniently welded than a Mark III type corrugated membrane. Accordingly, the automation ratio of GTT NO 96-2 type is higher than that of GTT Mark III type, whereas the overall length of GTT NO 96-2 type to be welded is longer than that of GTT Mark III type.

Furthermore, the currently employed GTT NO 96-2 type is most different from the conventional GT type in that instead of U-shaped bars, a plurality of double couples 17 are used to support the insulation box 11 and 16 (insulation barrier). The functions of main parts of heat-insulating sections of the GTT NO 96-2 type storage tank of the LNG carrier are as shown in Table 2.

Table 2

Main parts of heat-insulating sections of GTT NO 96-2 type storage tank

Item	Function
Tongue	It is installed at an insulation box and welded in three-ply way between membrane sheets to connect them, and it allows the membrane and insulation box to be connected to each other.
Joist	It is installed between the insulation boxes to reduce horizontal displacement and prevent high stress from being created.
First and second insulation barriers (Perlite)	It prevents heat from being transferred into the storage tank.
First sealing barrier (Invar)	It provides a primary countermeasure and is a portion that comes into direct contact with the cargo having a temperature of -163 °C and primarily defines the storage tank.

Second sealing barrier (Invar)	It provides a secondary countermeasure and performs a function of preventing cargo from leaking out during a predetermined period of time when the first sealing barrier is broken down.

On the other hand, as shown in Figs. 3 and 4, a GTT Mark III type is made of a stainless steel membrane with waveforms having a thickness of 1.2 mm, as a first sealing barrier 20, attached thereto. In such a case, since contraction due to low temperature is absorbed in folds of the corrugations, large stress is hardly created in the membrane. Further, insulation barriers 21 and 26 are made of glass wool, Triplex or the like. The Mark III type is constructed in such a manner that the first and second insulation barriers 21 and 26 are manufactured on land and then integrated thereto. Therefore, the construction of the Mark III type is relatively easy as compared with the GTT NO 96-2 type in which the first and second insulation boxes 21 and 26 are respectively installed.

The functions of main parts of heat-insulating sections of the GTT Mark III type storage tank of the LNG carrier are as shown in Table 3.

Table 3

Main parts of heat-insulating sections of GTT Mark III type storage tank

Item	Function
Mastic	It transfers cargo load to the ship's hull.
Plywood	It is installed between the first and second sealing barriers and the first and second insulation barriers, allows constant load to be applied to the sealing barriers due to the uniform arrangement of the insulation barriers, and reduces the displacement created due to vertical load.
Glass wool	It is installed between the insulation boxes, reduces the horizontal displacement and prevents the occurrence of high stress.
First and second insulation barriers (Polyurethane foam)	It prevents heat from being transferred into the storage tank.

Second sealing barrier (Triplex)	It has a function of preventing the cargo from leaking out during a predetermined period of time when the first membrane, i.e. the first sealing barrier, and is configured such that the glass cloth is bonded to both surfaces of Al foils.
First sealing barrier (SUS 304L)	It is a first membrane with which cargo with a temperature of about -163°C is brought into contact, primarily defines a cargo tank, and is constructed to have such a corrugated structure that it can withstand thermal stress.

An important part of the GTT NO 96-2 type and GTT Mark III type storage tanks so configured is a corner part.

Here, the corner part (edge part) of the LNG storage tank is a region to which load created due to thermal stress of the respective sealing barriers (membranes) of the storage tank is asymmetrically applied. This corner part should be constructed such that the stress created from the storage tank can be eliminated by distributing the asymmetrical load.

A recent technology for the corner part (edge part) of the LNG storage tank includes "a water-tight and thermally insulating tank with an improved corner structure, built into the bearing structure of a ship" described in Korean Patent Laid-Open Publication No. 2000-0011347.

As shown in Fig. 5, the corner structure disclosed in the above Korean publication No. 2000-0011347 causes a prefabricated composite girder 30 to be fixed at a right angled region where a cross bulkhead 2 and an inner face 1 of the ship's hull join together. The composite bulkhead 30 comprises a heat-insulating material 40 including reinforced webs 39 (shown in a dotted line) that are formed at a regular interval on a hard W-shaped metal body 31.

This type of prefabricated composite girder 30 is configured in such a manner that portions brought into surface contact with the cross bulkhead 2 and inner face 1 of the ship's hull are fixed thereto via polymeric resin 34 and opposite branched surfaces are mechanically fastened to the bearing structure of the ship's hull by means of fixing means

32 and 33 that are supported on the cross bulkhead 2 and inner face 1 of the hull, respectively.

In addition, a bottom surface of the prefabricated composite girder 30 has an inclined surface 42 such that a drainage space 41 is formed at the right-angled portion where the inner face 1 and cross bulkhead 2 join together.

The technology for fabricating the corner part of the LNG storage tank using the aforementioned prefabricated composite girder 30 has advantages in that the installation costs become inexpensive thanks to its simple structure and resistance of the sealing barriers against the mechanical impact can be improved without impairing the painted portion of the double bulkhead. However, the fabricating process for the corner part is not easy because the prefabricated composite girder 30, i.e. a basic unit of the corner part of the storage tank, includes the hard metal body 31 which in turn is manually fixed to the cross bulkhead 2 and inner face 1 of the hull by means of mechanical fixing means 32 and 33 (e.g., bolts and nuts) fixedly formed on the bulkhead and inner face.

The corner structure of the aforementioned membrane type LNG storage tank is a structure where the prefabricated composite girder 30, i.e. the basic unit of the corner part of the aforementioned storage tank, is firmly fixed to the cross bulkhead 2 and inner face 1 of the ship's hull. Therefore, any stress may be partially produced due to a wave or when the hull is moved, and thus, may be concentrated on the corner part. Accordingly, some efforts to reduce the stress concentration are made for several decades and continuous efforts to reduce the stress concentration are further needed.

Furthermore, continuous efforts to reduce boil of gas (BOG), i.e. loss due to vaporization of cryogenic LNG, and to simplify the structure and manufacturing process of the LNG storage tank are further made.

Disclosure of Invention

Technical Problem

The aforementioned membrane type LNG storage tank has been improved over several decades in view of the reduction of boil of gas (BOG), i.e. loss due to vaporization of cryogenic liquefied natural gas (LNG), the simplification of structure of complicated insulation barriers and sealing barriers, the reduction of tank construction period due to a simple manufacturing process, the reduction of stress in the corner parts and sealing barriers of the tank, and the like. However, further improvements are still required.

Accordingly, the present invention is conceived to solve several problems described above by inventing a novel membrane type LNG storage tank that is different from a conventional membrane type LNG storage tank in view of their structures.

Further, a heat-insulating system installed on a floor surface of the storage tank includes a plurality of planar structures, each of which is fixed by means of an anchor structure. Furthermore, the insulation barriers of the ship's hull are deformed due to waves or cargo sloshing when the ship is moved, and mechanical stress is produced accordingly. Consequently, continuous technical developments have been made to eliminate the mechanical stress.

Accordingly, an object of the present invention is to provide a novel LNG storage tank and construction method thereof, wherein thermal/mechanical stress created by the storage and/or discharge of liquefied natural gas into and/or from the storage tank can be efficiently eliminated and a tank construction period can also be reduced due to the simplification of fabricating structure and manufacturing process, by proposing a novel membrane type LNG storage tank that is different from the conventional membrane type LNG storage tank in view of their structures.

Technical Solution

According to an aspect of the present invention for achieving the above object, there is provided a liquefied natural gas storage tank including two successive sealing barriers and two insulation barriers, among which a first sealing barrier of the sealing barriers is brought into contact with liquefied natural gas stored in the storage tank, and a first insulation barrier, a second sealing barrier and a second insulation barrier are sequentially disposed on a lower surface of the first sealing barrier, wherein the first sealing barrier is supported by an anchor structure mechanically fastened to a bottom floor of the tank, and the insulation barriers are slidably installed between the first sealing barrier and the bottom floor of the tank. However, although load of cargo in the tank is equally applied to the anchor structure and the insulation barriers, the insulation barriers can be slightly slid with respect to the first sealing barrier because the first sealing barrier is only welded to and supported by the anchor structure. In a case where a construction in which the tank is installed is a double-hull ship, it is obvious that the "bottom floor of the tank" or "inner surface" is meant to include inner barriers on lateral sides and floor of the hull, an upper barrier(ceiling) of the hull, and a cross bulkhead.

Here, an insulation system of the tank including the first and second insulation barriers is brought into contact with the inner barriers of the hull. Thus, if in case of a ship, waves or the like creates the distortion and thus the bending in the hull, the bending stress is also applied to the insulation system. Therefore, the sliding means that the insulation barrier units can be slightly moved in a lateral direction while not destroying the insulation system in spite of the bending stress.

Preferably, the first and second insulation barriers are bonded with adhesive to upper and lower surfaces of the second sealing barrier, respectively. The insulation barriers and sealing barrier are manufactured into a prefabricated assembly to be an assembly unit when fabricating the tank. In the present invention, a corner structure installed at the corner of the tank and a planar structure installed on a planar floor of the tank may be manufactured in the form of a prefabricated assembly. The second insulation barrier may comprise insulation made of polyurethane foam and a plate made of plywood and bonded to a lower surface of the insulation. Moreover, the first insulation barrier may comprise insulation made of polyurethane foam and plates made of plywood and bonded to upper and lower surfaces of the insulation. Further, the second sealing barrier may be made of an aluminum sheet or flexible sheet (triplex, more preferably, rigid triplex).

Furthermore, the second sealing barrier is formed to protrude from a side of the first and second insulation barriers such that it is connected together with a second sealing barrier of the adjacent prefabricated assembly (planar structure) or a second sealing barrier of an adjacent anchor structure when the units of the prefabricated assemblies are fabricated. Here, the shape or material of the first insulation barrier is not specifically limited. As described in the patents referenced by the present applicant(s) or owned by TGZ, the first sealing barrier may be made of stainless steel or include a corrugated portion.

In addition, a side space defined between the second insulation barriers may be filled with insulation made of polyurethane foam. On the other hand, a side space defined between the first insulation barriers may be filled with insulation made of glass wool.

Further, the second sealing barrier extends into the space defined by the insulation barriers (i.e., between the sides of the insulation barriers), an end of the second sealing barrier is connected within the space by means of upper and lower fixing plates, and coupling surfaces of the upper and lower fixing plates include a recessed portion in which the end of second sealing barrier can be inserted. Here, the recessed portion may be curved, and the assembled lower and upper fixing plates may be curved slightly in a longitudinal direction to have an excess length, whereby stress created when the sealing barrier is contacted due to the cooling can be absorbed.

According to another embodiment of the present invention, the second sealing barrier is preferably coated with a resin material on top and bottom surfaces thereof and extends into a side space defined by the neighboring insulation barriers. Further, upper and lower connection members brought into contact with the end of the second sealing barrier are included in the space, coupling surfaces of the upper and lower connection members are formed with convex and concave portions such that the resin material coated on the top and bottom surfaces of the second sealing barrier is compressed and bonded. Such a coupling method can further improve the sealing characteristics of the second sealing barrier.

According to an embodiment of the present invention related to the connection of the second sealing barrier, corner structures fastened to edge portions in the tank, planar structures slidably positioned on flat surfaces in the tank, and anchor structures fastened to the tank to attach the planar structures onto inner surfaces of the tank are included.

Here, the planar structure is preferably fabricated in such a manner that a side thereof is fixed by corner boundary projections to which the corner structure is fixed and includes a second insulation barrier installed at the same height as the second insulation barrier of the corner structure, a second sealing barrier formed on an upper surface of the second insulation barrier and a first insulation barrier formed on an upper surface of the second insulation barrier.

The anchor structure may include an anchor support rod fixed onto an anchor lower plate mechanically fastened to a portion where the planar structures join together; a second insulation barrier penetrated by the anchor support rod at a central portion thereof and installed at the same height as a second insulation barrier of the planar structure; a second sealing barrier penetrated by the anchor support rod at a central portion thereof and fixed onto an upper surface of the second insulation barrier and fastened to an adjacent second sealing barrier of the planar structure; a first insulation barrier penetrated by the anchor support rod at a central portion thereof and fixed onto an upper surface of the second sealing barrier; and an upper cap fixed to an upper end of the anchor support rod.

In this configuration, the anchor lower plate causes a lower plate of the second insulation barrier of a unit structure of the adjacent prefabricated assembly to be fixed to the inner surface of a ship's hull. Further, the second sealing barrier of the anchor structure may include a corrugated portion formed at an outer peripheral portion thereof. Here, the second sealing barrier of the anchor structure protrudes from a side of the first insulation barrier of the anchor structure to be connected to the second sealing barrier of the adjacent prefabricated assembly. In addition, the first and second insulation barriers of the anchor structure are bonded with adhesive to upper and lower surfaces of the second sealing barrier of the anchor structure, respectively.

Furthermore, the second insulation barrier of the anchor structure may include insulation made of polyurethane foam and a plate made of plywood and bonded to an upper surface of the insulation. The first insulation barrier of the anchor structure may also include insulation made of polyurethane foam and plates made of plywood and bonded to upper and lower surfaces of the insulation. The plywood plate bonded to a lower end of the second insulation barrier of the prefabricated assembly protrudes from the side of the second insulation barrier and is thus fixed onto the bottom floor by means of the anchor lower plate of the anchor structure. Accordingly, the insulation barriers cannot be moved upward but can be slightly moved in a horizontal direction even though they are fixed in the same direction.

The corner structure is manufactured into a prefabricated assembly including an L-shaped second insulation barrier brought into contact with a corner where the inner surfaces of the tank join together, a second sealing barrier formed on an upper surface of the second insulation barrier, a first insulation barrier formed on an upper surface of the second sealing barrier, and an L-shaped corner support plate formed on an upper surface of the first insulation barrier for bearing load of cargo, whereby the prefabricated assembly is fixed by means of corner boundary projections formed on the inner surfaces of the tank.

The corner support plate may be slidably installed to the first insulation barrier of the corner structure such that the support plate can be contracted and expanded. Further, the first and second insulation barriers of the corner structure are bonded with adhesive to upper and lower surfaces of the second sealing barrier of the corner structure. Moreover, the first insulation barrier, the second sealing barrier, the second insulation barrier and the corner support plate are manufactured into a prefabricated assembly.

Furthermore, the prefabricated assembly (the corner structure) is fixed by means of the corner boundary projections formed on the inner surfaces of the tank. In addition, the second sealing barrier is formed to protrude from a side of the first and second insulation barriers. Moreover, plates are formed on lower surfaces of the first and second insulation barriers such that side ends thereof protrude further from sides of the insulation barriers, and thus, the plates are fixed onto the bottom floor of the hull by means of the fixing stand. Further, the lower surface of the second insulation barrier is preferably bonded with adhesive onto the bottom floor of the hull.

In addition, the first and second insulation barriers may be mechanically coupled to each other by means of a connection reinforcement bar for connecting and fixing an upper end of a lower support rod, which penetrates and protrudes from the second insulation barrier, and a lower end of an upper support rod which penetrates the first insulation barrier. The lower support rod may be fitted and fastened to a rod support cap fixed onto a lower surface of the second insulation barrier, penetrate the second insulation barrier and be then fixed to the connection reinforcement bar. Further, the upper support rod may be fitted and fastened to a rod support cap, which is fixed to a lower surface of the first insulation barrier and the connection reinforcement bar, penetrate the first insulation barrier and support the corner support plate. To this end, the upper support rod is preferably welded to the corner support plate. The first sealing barrier is placed onto the upper surface of the corner support plate, and they are welded to each other. With such configuration, the first sealing barrier of the corner structure is stably supported by the lower support rod coupled to the bottom floor of the hull, the upper support rod coupled to the lower support rod and the corner support plate coupled to the upper support rod. In addition, since the corner support plate is made of a slightly thick plate, the first sealing barrier of the corner structure from which asymmetrical stress is created can be more stably supported. Also, since the corner support plate is weakly connected directly to the first insulation barrier of the corner structure, it can be slightly slid with respect to the first insulation barrier. Accordingly, the mechanical stress created due to the difference in contraction owing to temperature change between the first insulation barrier and the corner support plate or first sealing barrier can also be reduced or eliminated.

According to a further embodiment of the present invention, the anchor structure may include an anchor support rod fixed onto an anchor lower plate mechanically fastened to a portion where the planar structures join together; a second insulation barrier penetrated by the anchor support rod at a central portion thereof and installed at the same height as a second insulation barrier of the planar structure; a second sealing barrier penetrated by the anchor support rod at a central portion thereof and fixed onto an upper surface of the second insulation barrier and mechanically fastened to an adjacent second sealing barrier of the planar structure; a first insulation barrier penetrated by the anchor support rod at a central portion thereof and fixed onto an upper surface of the second sealing barrier; and an upper cap fixed to an upper end of the anchor support rod corresponding to an upper center of the first insulation barrier of the anchor structure.

The anchor lower plate serves to fix a lower plate of the second insulation barrier of an adjacent unit structure to the inner surface of a ship's hull. The second sealing barrier of the anchor structure preferably includes a corrugated portion formed at an outer peripheral portion thereof. In addition, the first and second insulation barriers of the anchor structure are bonded with adhesive to upper and lower surfaces of the second sealing barrier of the anchor structure, respectively.

According to a still further embodiment of the present invention, the anchor structure includes an anchor lower plate for fixing an anchor base plate with a rod support cap built therein, said anchor base plate being installed at a regular interval(spacing) on the internal surfaces of the tank and being formed with a fastening hole; an anchor support rod fixed vertically to the rod support cap; a second insulation barrier penetrated by the anchor support rod at a central portion thereof; a second sealing barrier penetrated by the anchor support rod at a central portion thereof and fixed onto an upper surface of the second insulation barrier of the anchor structure; a first insulation barrier penetrated by the anchor support rod at a central portion thereof and fixed onto an upper surface of the second sealing barrier of the anchor structure; an upper cap fixed to an upper end of the anchor support rod for fixing the first insulation barrier of the anchor structure; and a connection insulation barrier placed adjacent to a side of the first insulation barriers and to an upper surface of the second sealing barriers, spaced apart by a predetermined distance from the first insulation barrier of the anchor structure, and fixed to upper surfaces of the second sealing barriers of the adjacent planar structure and anchor structure. Preferably, the connection insulation barrier is placed adjacent to side surfaces of the respective first insulation barriers of the adjacent planar structures and to an upper surface of the second sealing barriers of the planar structure fixed onto the second insulation barriers of the planar structures, and the connection insulation barrier is also bonded with to the second sealing barriers of the planar and anchor structures. The insulation is filled into a gap between the connection insulation barrier and the first insulation barrier of the anchor structure.

According to another aspect of the present invention, there is provided a method of manufacturing a liquefied natural gas storage tank including two successive sealing barriers and two insulation barriers, among which a first sealing barrier of the sealing barriers is brought into contact with liquefied natural gas stored in the storage tank, and a first insulation barrier, a second sealing barrier and a second insulation barrier are sequentially disposed on a lower surface of the first sealing barrier, comprising the steps of forming boundary projections near inner corners of the tank and fixedly installing anchor base plates onto inner surfaces of the tank at a regular interval; fixedly attaching prefabricated corner structures, each of which includes a second insulation barrier, a second sealing barrier, a first insulation barrier and a corner support plate, between the formed boundary projections; fixing the fixed corner structures to the boundary projections with fixing stands and simultaneously fixing anchor lower plates onto upper surfaces of the anchor base plates and then vertically fixing anchor support rods onto center portions of the anchor lower plates; fitting and fixing sides of prefabricated planar structures, each of which includes a second insulation barrier, a second sealing barrier and a first insulation barrier, to sides of the fixing stands by which the corner structures are fixed, and fitting and fixing other sides of the planar structures to gaps defined by anchor base plates and the anchor lower plates; filling insulations into spaces defined between the second insulation barriers of the corner and planar structures and simultaneously fitting second insulation and sealing barriers of anchor structures around the anchor support rods; fastening the second sealing barriers of the corner structures and the second sealing barriers of the adjacent planar structures to each other, fastening the second sealing barriers of the planar structures to each other, and also fastening the second sealing barriers of the planar structures and the second sealing barriers of the anchor structures to each other; fitting first insulation barriers of the anchor structures around the anchor support rods, and fixing anchor upper plates and anchor insulation plates onto the first insulation barriers and fixing anchor upper caps to the anchor support rods to complete fabricating the anchor structures; filling insulations into spaces defined between the first insulation barriers of the corner structures, planar structures and anchor structures; and fixing first sealing barriers with corrugated portions onto upper surfaces of the corner structures, planar structures and anchor structures.

The step of fixing the anchor lower plates onto the upper surfaces of the anchor base plates and then vertically fixing the anchor support rods onto the center portions of the anchor lower plates may comprise the steps of bolting the anchor lower plates to the anchor base plates, fixing rod support caps to the centers of the anchor lower plates and bolting the anchor support rods to the rod support caps. The step of filling the insulation into the spaces defined between the second insulation barriers of the corner structures and planar structures may comprise the step of filling the spaces with insulations made of polyurethane foam.

Further, the step of fastening the second sealing barriers of the corner structures and the second sealing barriers of the adjacent planar structures to each other, fastening the second sealing barriers of the planar structures to each other, and also fastening the second sealing barriers of the planar structures and the second sealing barriers of the anchor structures to each other may comprise the step of bolting lower fixing plates placed below the second sealing barriers and upper fixing plates placed above the second sealing barriers to face the lower fixing plates.

The LNG storage tank of the present invention described above can be installed to all kinds of ships, ground tanks and vehicles irrespective of whether there is any cargo motion therein.

Advantageous Effects

According to the present invention, a fabricating process can be shortened by simplifying the configuration of the corner structure for connecting the planar structures of the storage tank that are installed within a ship for transporting liquefied nature gas corresponding to cryogenic liquid and the liquid-tight characteristics of the anchor structure can be firmly maintained by tightly connecting the neighboring planar structures. Further, in a case where distortion is created in a ship's hull due to waves or the like when the ship is sailing, since the first sealing barrier of the insulation system of the present invention is fastened directly to the anchor structure and weakly connected to the insulation barriers, the insulation barriers can be slightly slid with respect to the first sealing barrier and thus they conform to the distortion of the hull. Therefore, the insulation system can be hardly destroyed.

Further, by simplifying the corner structure installed within the hull of a ship for storing liquefied nature gas corresponding to cryogenic liquid to shorten the assembling process and simultaneously installing thick plates capable of supporting the corner structure while firmly maintaining the liquid-tight characteristics of the corner structure, the stress created by mechanical/thermal contraction and expansion of the storage tank can be easily reduced or eliminated. Therefore, more reliable ship can be provided.

Furthermore, since the connection insulation barrier is bonded with adhesive to the underlying second sealing barriers which in turn are coupled to each other by means of the upper and lower connection members, the fixing characteristics of the second sealing barriers near the anchor structure are further improved, whereby liquid-tight characteristics and safety are further increased.

Brief Description of Drawings

Figs. 1 and 2 are sectional and perspective views showing a GTT NO 96-2 type LNG storage tank, i.e. a conventional membrane type LNG storage tank.

Figs. 3 and 4 are sectional and perspective views showing a GTT Mark III type LNG storage tank, i.e. a conventional membrane type LNG storage tank.

Fig. 5 is a sectional view showing the structure of a corner part of the conventional LNG storage tank.

Fig. 6 (a) and (b) show the inner configuration of the corner structure of the LNG storage tank according to an embodiment of the present invention.

Fig. 7 is a whole perspective view illustrating the connection relationship between the corner structures of the LNG storage tank installed within a ship according to the present invention.

Fig. 8 is a partially enlarged sectional perspective view showing the corner structure of the LNG storage tank installed within the ship according to an embodiment of the present invention.

Figs. 9 to 23 are perspective views sequentially illustrating processes of fabricating the LNG storage tank into an inner space of a ship's hull according to an embodiment of the present invention.

Fig. 24 is an enlarged sectional view showing a means for interlocking second sealing barriers of the LNG storage tank according to an embodiment of the present invention.

Fig. 25 is an enlarged perspective view showing a means for interlocking second sealing barriers of the LNG storage tank according to an embodiment of the present invention.

Fig. 26 (a) and (b) are partially enlarged sectional views illustrating the connection relationship between anchor structures of the LNG storage tank according to an embodiment of the present invention.

Fig. 27 is a partially cut-away perspective view of an LNG storage tank according to another embodiment of the present invention.

Figs. 28 to 36 are perspective views sequentially illustrating processes of fabricating the LNG storage tank into an inner space of a ship's hull according to another embodiment of the present invention.

Figs. 37 and 38 are enlarged sectional views showing a state where second sealing barriers are interlocked in the LNG storage tank according to the present invention.

<Explanation of reference numerals for designating main components in the drawings>

50: Corner support plate	51: First insulation barrier of corner part
52: Second sealing barrier of corner part	
53: Second insulation barrier of corner part	
54, 56: Plates	57, 58: Insulations
60: Lower support rod	61: Rod support cap
70: Upper support rod	80, 81: Boundary projection of corner part
90: Connection support	100: Corner structure
101: Fixing stand	109: Stud pin
110: Anchor base plate	111: Anchor lower plate
113: Second insulation barrier of anchor structure	

114: Second sealing barrier of anchor structure

115: Corrugated portion 119: Upper cap of anchor structure

150: Anchor structure 200: Planar structure

201: Lower plate material

202: Second insulation barrier of planar structure

203: Second sealing barrier of planar structure

204: First insulation barrier of planar structure

205: Upper plate 211: Insulation

212: Upper fixing plate 213: Lower fixing plate

214: Fixing bolt 250: First sealing barrier

251: Corrugated portion

Best Mode for Carrying Out the Invention

Hereinafter, the configuration of the present invention will be described in detail with reference to the accompanying drawings.

The present invention is directed to a liquefied natural gas storage tank in which liquefied natural gas (LNG) is stored in a high pressure and extremely low temperature state. To this end, the LNG storage tank is constructed such that impact resistance and liquid-tight characteristics are firmly maintained.

The LNG storage tank mounted to an automobile or ship, in which cargo is moved, is different from the ground storage tank with little motion in that suitable countermeasures should be prepared against mechanical stress due to the cargo motion in the storage tank. However, the LNG storage tank mounted to a ship to which the countermeasures against the mechanical stress are provided can also be applied to the ground storage tank. Thus, the configuration of an LNG storage tank mounted to a ship will be explained herein by way of example.

The LNG storage tank of the present invention comprises a second insulation barrier installed to be brought into surface contact with an inner surface of a hull of the ship, a second sealing barrier formed on an upper surface of the second insulation barrier, and a first insulation barrier formed on an upper surface of the second sealing barrier. In the present invention, it is preferable to beforehand manufacture corner structures and planar structures into prefabricated assemblies outside of a ship and to fabricate the structures into an inner space of the storage tank.

That is, the prefabricated corner structures are first fixed in the interior of a ship's hull and the planar structures are then fabricated to the corner structures. In such a case, the planar structures are securely fastened to the hull by fabricating anchor structures on a tank fabrication site.

Fig. 6 is a sectional view illustrating the inner configuration of the corner structure of the LNG storage tank according to an embodiment of the present invention, and Fig. 7 is a whole perspective view illustrating the connection relationship between the corner structures of the LNG storage tank installed within the ship according to an embodiment of the present invention. Further, Fig. 8 is a partially enlarged sectional perspective view showing the corner structure of the LNG storage tank installed within the ship according to an embodiment of the present invention.

As shown in Figs. 6 to 8, the corner structure 100 according to an embodiment of the present invention is prefabricated to have such a configuration that its second insulation barrier 53 is L-shaped to come into surface contact with a corner position where surfaces of the ship's hull join together, its second sealing barrier 52 is attached and fixed to an upper surface of the second insulation barrier in the same manner as above, and its first insulation barrier 51 is also formed on an upper surface of the second sealing barrier. Here, it is preferred that the first and second insulation barriers 51 and 53 of the corner structure be firmly and securely bonded with adhesive to the upper and lower surfaces of the second sealing barrier 52.

The aforementioned connection relationship between a corner support plate 50, the first and second insulation barriers 51 and 53, the second sealing barrier 52, and upper and lower support rods 70 and 60 will be explained more in detail, as follows.

The interior of a ship for storing LNG is composed of a bottom floor 1 and a bulkhead 2 integrally formed therewith and includes an inner space in which the corner structure of the present invention can be installed. More specifically, the present invention is directed to a corner structure installed at a position where the aforementioned bottom floor 1 and cross or lateral bulkhead 2 join together at a predetermined angle. Therefore, the shape of the second insulation barrier may be different from the L shape because the angle that the tank surfaces join together varies according to the tank shapes or corner positions.

As described above, the L-shaped second insulation barrier 53 that is brought into surface contact with the bottom floor 1 and bulkhead 2 is formed at a position where the bottom floor 1 and the bulkhead 2 join together at a predetermined angle. In the present invention, the terms 'first' and 'second' are used to distinguish whether the liquefied natural gas stored in the storage tank is primarily or secondarily sealed and insulated by means of a certain barrier.

The second insulation barrier 53 is composed of a second insulation 58 that is made of polyurethane foam, and a second insulating plate 56 that is made of plywood and bonded to a lower surface of the second insulation. The second insulating plate 56 is brought into surface contact with the bottom floor 1 and bulkhead 2 that are defined as inner surfaces of the ship's hull. The manufacturing methods, shapes, materials, etc. of the insulation barrier are described in U.S. Patent Nos. 4,747,513, 5,501,359, 5,586,513 and 6,035,795, International Publication No. WO 1989/09909, Japanese Patent Laid-Open Publication Nos. 2000-038190 and 2001-122386, and the like, all of which are incorporated herein by reference. The insulation barrier and timber bonded thereto, which are described in the above documents, may be used herein.

After the second insulation barrier 53 has been formed, the second sealing barrier 52 is placed onto the upper surface thereof. The second sealing barrier 52 serves to secondarily prevent the LNG stored in the storage tank from leaking out from the storage tank. An upper surface of the second insulation 58 of the second insulation barrier 53 is bonded to a lower surface of the second sealing barrier 52 by means of an adhesive. It is preferred that the second sealing barrier 52 be made of aluminum sheet or flexible sheet (alias, "Triplex"). The above referenced U.S. Patent No. 6,035,795 discloses a flexible triplex, but a harder rigid triplex is preferably used in the present invention.

As described above, after the second insulation barrier 53 and the second sealing barrier 52 have been bonded to each other, lower support rods 60 that will be fixed to the first insulation barrier 51 formed on the upper surface of the second sealing barrier 52 penetrate the second insulation barrier 53 and the second sealing barrier 52.

That is, a plurality of holes through which the lower support rods 60 can pass are formed in the second insulation barrier 53 at a regular interval. Each of rod support caps 61 to which a lower end of the lower support rod 60 can be firmly fixed is inserted into and supported by a lower end of the hole formed in the second insulating plate 56.

The lower support rod 60 is inserted into the rod support cap 61 to pass through the second sealing barrier 53, and the lower end of the lower support rod 60 is firmly fastened by means of a fixing nut 62 within the support cap 61.

Further, an upper end of the lower support rod 60 that has penetrated the second insulation barrier 53 also penetrates the second sealing barrier 52 that is fixed onto the upper surface of the second insulation barrier 53. The second sealing barrier 52 is fixed to the lower support rod 60 by means of a support nut 63 and sealing barrier fixing nut 64 fastened to the upper portion of the lower support rod 60.

The upper end of the lower support rod 60 that penetrates the second insulation barrier 53 and second sealing barrier 52 to cause them to be fixed to the first insulation barrier 51 is penetrated through and fixed to a lower portion of the first insulation barrier 51.

That is, the first insulation barrier 51 is brought into surface contact with and fixedly bonded to the second sealing barrier 52 fixed to the upper surface of the second insulation barrier 53. The first insulation barrier 51 is composed of a lower plate 55 that is brought into surface contact with and fixedly bonded to the second sealing barrier 52 by means of an adhesive, a first insulation 57 that is formed on an upper surface of the lower plate 55, and an upper plate 54 that is fixedly bonded to an upper surface of the first insulation 57. The upper and lower plates 54 and 55 of the first insulation barrier are made of plywood, whereas the first insulation 57 is made of polyurethane foam.

At this time, a connection reinforcement bar 90 is placed onto the lower plate 55 of the first insulation barrier 51, through which the lower support rod 60 has passed, so as to connect the lower support rod and an upper support rod to be described later. That is, the upper end of the lower support rod 60 that has passed through the second insulation barrier 53 and sealing barrier 52 penetrates the connection reinforcement bar 90 placed onto the lower plate 55 of the first insulation barrier 51 such that they can be fastened to each other in a bolt-nut fastening manner.

A plurality (pair in the figures of the present invention) of lower ends of the upper rods 70 are fixed to the connection reinforcement bar 90 in such a manner that the upper support rod 70 is inserted into a rod support cap 71, which is fixed, e.g. welded, to a bottom surface of the connection reinforcement bar 90, and then fastened to the connection reinforcement bar 90 by means of the fixing nut 72.

Therefore, the upper end of the lower support rod 60, which penetrates the second insulation barrier 53 and sealing barrier 52, and the lower end of the upper support rod 70, which penetrates the first insulation barrier 51, are securely fixed to the connection reinforcement bar 90.

As shown in Fig. 6 (a), the upper support rod 70 is fixed to and supported by the first insulation barrier 51 and the upper plate 54 of the insulation barrier 51, and the L-shaped corner support plate 50 is placed and supported on the upper surface of the upper plate 54 of the first insulation barrier 51 such that asymmetrical load created from the aforementioned storage tank may be applied thereto. Here, the corner support plate 50 is not bonded with adhesive but mechanically coupled to the first insulation barrier 51 such that it can be slid onto the first insulation barrier 51 even though there is the contraction and expansion of the corner support plate occur due to heat. A first sealing barrier 250 to be explained later is placed onto and coupled to the corner support plate 50 in such a manner as the welding.

Fig. 6 (b) shows another example for a method of coupling the upper support rod 70 to the corner support plate 50. That is, the upper rod 70 penetrates the first insulation barrier 51 and the upper plate 54 disposed thereon and is directly coupled to the corner support plate 50 so as to support the corner support plate 50. At this time, there is a small space between the upper support rod 70 and the first insulation barrier 51 of the corner part, and there is no direct coupling, via adhesive, between the corner support plate 50 and the first insulation barrier 51. Therefore, the corner support plate 50 can be slid slightly with respect to the first insulation barrier 51. This sliding of the corner support plate can overcome the contraction and expansion difference between the first insulation barrier 51 and the corner support plate 50, in temperature change resulting from the material difference. Further, thanks to the above configuration, the first sealing barrier of the corner part can be stably supported by the lower support rod 60 coupled to inner surfaces of the tank, the upper support rod 70 coupled to the lower support rod 60 and the corner support plate 50 coupled to the upper support rod 70. Furthermore, since the corner support plate 50 is manufactured of a slightly thick plate, it can stably and sufficiently support the first sealing barrier of the corner part from which asymmetrical stress is created.

In addition, the second sealing barrier 52 of the corner structure 100 according to the present invention is made of aluminum sheet or flexible sheet (Triplex). The second sealing barrier 52 is formed to further protrude from the side of the first and second insulation barriers 51 and 53, and thus fastened to a second sealing barrier 203 of a prefabricated adjacent planar structure during the next process.

Fig. 9 shows a planar structure constructing the LNG storage tank according to the present invention. Referring to Fig. 9, the planar structure 200 of the present invention is introduced into the ship's hull after it has been prefabricated outside of the hull. The planar structure 200 has the configuration similar to the corner structure 100. In such a case, an upper plate 205 made of plywood is installed to a top portion of a first insulation barrier 204 of the planar structure.

That is, the planar structure is configured in such a manner that a lower plate 201 brought into surface contact with the inner surface 1 of the ship's hull is provided on a second insulation barrier 202 of the planar structure which is made of polyurethane foam, the second sealing barrier 203 made of aluminum sheet or flexible sheet (triplex, preferably rigid triplex) is again bonded to an upper surface of the second insulation barrier, and the first insulation barrier 204 made of polyurethane foam and the upper plate 205 made of plywood are then bonded to an upper surface of the second sealing barrier 203.

Further, the lower plate 201 and second sealing barrier 203 of the second insulation barrier of the planar structure protrude slightly from the side of the first and second insulation barrier 202 and 204 such that they are interlocked with and fixed to adjacent planar structure 200 or corner structure 100 during the next process. The opposite edge side of the planar structure brought into contact with the corner structure 100 is configured to take the shape of a partially cut-away step such it can be fabricated and fixed by means of an anchor structure 150 of the present invention. The planar structure 200 of the present invention is configured to have the same height as that of the adjacent corner structure 100.

Fig. 10 is a perspective view showing a state where boundary projections and stud pins 109 are installed at an inner surface of a ship's hull; Fig. 11 is a perspective view showing a state where a corner structure is fitted to the boundary projections of Fig. 10; Fig. 12 is a perspective view showing a state where the corner structure of Fig. 11 is fastened to the hull; Fig. 13 is a perspective view showing a state where a planar structure is placed adjacent to the corner structure of Fig. 12; Fig. 14 is a perspective view showing a state where the planar structure of Fig. 13 is fastened to the hull and anchor support rods are coupled thereto; Fig. 15 is a perspective view showing a state where second sealing barriers and insulation barriers of the anchor structure are installed to the anchor support rods; Fig. 16 is a perspective view showing a state where a plurality of planar structures are fixed to the ship's hull; Fig. 17 is a perspective view showing a state where the second sealing barriers of the anchor structure are fastened to those of the planar structures of Fig. 16; Fig. 18 is a perspective view showing a state where the first insulation barriers of the anchor structure are inserted onto the second sealing barriers of Fig. 17; Fig. 19 is a perspective view showing a state where anchor upper plate is fixed on the first insulation barriers of Fig. 18 are fixed; Fig. 20 is a perspective view showing a state where an anchor insulation plate is installed onto the first insulation barriers of the anchor structure of Fig. 19; Fig. 21 is a perspective view showing a state where the anchor insulation plate of Fig. 20 is fixed; Fig. 22 is a perspective view showing a state where first insulations are filled; and Fig. 23

is a perspective view showing a state where a first sealing barrier is installed onto the fabricated structure of Fig. 22.

Hereinafter, an LNG storage tank and a process of fabricating the storage tank according to an embodiment of the present invention will be described in detail with reference to Figs. 10 to 23.

The LNG storage tank of the present invention is installed onto a bottom floor 1 of the ship's hull and a cross or lateral bulkhead 2 extending from the bottom floor in a cross or lateral direction at a right or predetermined angle.

First, the boundary projections 80 and 81 of the corner structure for use in fixing the corner structure 100 are fixed to the bottom floor 1 and the cross bulkhead 2. At this time, it is preferred that the boundary projections 80 and 81 be fixed through the welding and their spacing from the corner be determined such that the prefabricated corner structure can be inserted into the spacing. After the corner structure 100 has been inserted between the boundary projections 80 and 81, some gaps are formed between the corner structure and the boundary projections.

As shown in Figs. 10 to 12, if the corner structure 100 is installed between the boundary projections 80 and 81, a fixing stand 101 is fixed to the boundary projections 80 and 81. At this time, the fixing stand 101 is preferably bolted to the boundary projections 80 and 81. The fixing stand 101 is preferably formed with a protrusion corresponding to the gap defined between the corner structure 100 and the boundary projections 80 or 81 such that it is tightly fitted into the gap between the corner structure 100 and the boundary projections 80 or 81 to prevent the corner structure from moving between the boundary projections. The corner structure 100 is primarily bonded onto the bottom floor 1 or cross bulkhead 2 of the ship's hull at its bottom surface and secondarily attached to the inner boundary projections 80 and 81 by means of the fixing stand 101.

As shown in Fig. 13, an anchor base plate 110 of an anchor structure 150 for fixing the planar structure 200 installed in series from the corner structure 100 is also fixed onto surfaces of the bottom floor 1 and cross head 2 at a regular interval. To this end, a group of stud pins 109 are formed on the inner surface of the hull at the regular interval. At this time, a portion of the stud pin 109, which is brought into contact with the bottom floor 1 or cross bulkhead 2, is sharpened and pressed such that the stud pin 109 is welded onto the inner surface of the hull.

Next, the anchor base plate 110 is formed with through-holes corresponding to the stud pins 109 such that the stud pins 109 are fitted into the anchor base plate 110 by means of the holes. At this time, the anchor base plate 110 is coupled, i.e. welded or bonded, to the inner surface of the hull. Further, the thickness of anchor base plate 110 is the same as that of the lower plate 201 of the second insulation barrier of the planar structure.

Then, as shown in Fig. 14, an anchor lower plate 111 is coupled to an upper surface of the anchor base plate 110 such that it can cover the lower plate 201 of the second insulation barrier of the planar structure. To this end, a plurality of through-holes are formed on the anchor lower plate 111 at positions corresponding to the stud pins 109. Then, the anchor base plate 110 is completely fixed by fastening a nut to the stud pin 109 that has penetrated the anchor lower plate 111.

As such, the planar structure 200 is limited in its upward motion because the lower plate 201 is fixed by means of the fixing stand 101 or anchor lower plate 111, but can be slightly slid in a horizontal direction.

Next, as shown in Figs. 14 and 15, an anchor support rod 112 is vertically fixed at the center of the anchor lower plate 111.

To this end, a predetermined recessed space is formed at the center of the anchor lower plate 111. Further, the anchor base plate 110 is positioned below the anchor lower plate 111. At this time, the anchor base plate 110 with a plurality of through-holes formed at positions corresponding to the stud pins 109 is installed in a state where the stud pins 109 pass through the holes. Next, the anchor base plate 110 is fixed by fastening a nut to the stud pin 109.

A rod support cap 120 is installed in the recessed space of the anchor lower plate 111 through a central hole of the anchor base plate 110. The rod support cap 120 is configured in such a manner that a nut is included therein or integrally formed thereon. In the present invention, the rod support cap 120 is processed to have a nut-shaped portion at the center thereof and the aforementioned anchor support rod 112 is vertically coupled to the rod support cap 120. Here, the rod support cap 120 and the nut are used in the same manner as the rod support cap 61 and the fixing nut 62 as shown in Fig. 8.

Furthermore, heat may be transferred upward or downward through the anchor support rod 112, but it is preferred that the diameter and heat transfer rate of the anchor support rod 112 be taken into consideration, when it is designed, such that the heat transfer from the liquefied natural gas in the storage tank to the ship's hull can be minimized.

This anchor support rod 112 serves to primarily support load created from the first sealing barrier, which will be attached during the next process. The prefabricated assembly of the insulation barriers is bonded with adhesive directly but weakly to the first sealing barrier. Therefore, the prefabricated assembly can be slightly slid with respect to the first sealing barrier unlike the conventional insulation barrier assembly, and thus, the stability of the tank structure against the hull deformation can also be improved.

The respective planar structures 200 are positioned in place and fixed with respect to the anchor lower plate 111 and anchor support rod 112 of the present invention in the same fixing manner as described above. At this time, each of the planar structures 200 is positioned and fixed on a specific space on the inner surface 1 of the ship's hull defined by the anchor lower plate 111.

The aforementioned planar structure 200 is introduced into the ship's hull in a state where it has been already fabricated at a site outside of the hull. An upper plate 205 is bonded to an upper surface of the first insulation barrier 204 of the planar structure 200.

That is, the planar structure 200 of the present invention is configured in such a manner that the lower plate 201 of the second insulation barrier, which is brought into surface contact with the inner surface 1 of the ship's hull, is provided; the second insulation barrier 202 made polyurethane foam is bonded to the upper surface of the lower plate; the second sealing barrier 203 made of aluminum sheet or flexible sheet (triplex) is again bonded to the upper surface of the second insulation barrier; the first insulation barrier 204 made of polyurethane foam is then bonded to the upper surface of the second sealing barrier; and the upper plate 205 made of plywood is again bonded to the upper surface of the first insulation barrier.

Further, the lower plate 201 and second sealing barrier 203 of the second insulation barrier of the planar structure protrude slightly from the side of the first and second insulation barrier 202 and 204 such that they are interlocked with and fixed to the second sealing barrier of the adjacent planar structure 200 or corner structure 100 during the next process. The opposite edge side of the planar structure brought into contact with the corner structure 100 is configured to take the shape of a partially cut-away step such it can be fabricated and fixed by means of an anchor structure 150 of the present invention. The planar structure 200 of the present invention is configured to have the same height as that of the adjacent corner structure 100.

The prefabricated planar structure 200 of the present invention is fixed to the inner surface of the ship's hull is such a manner that one side of the lower plate 201 of the planar structure, which protrudes from the side of the second insulation barrier 202 of the planar structure facing the corner structure (not shown), is inserted into a gap between the inner surface of the hull and a side of the fixing stand used to fix the corner structure to the boundary projections, and the other side of the lower plate 201 of the planar structure, which protrudes from the other side of the second insulation barrier 202 of the planar structure, is simultaneously inserted into a gap that is formed by the anchor base plate 110 made of metal and fixed onto the inner surface 1 of the hull and the anchor lower plate 111 made of plywood and fixed onto the upper surface of the anchor base plate.

As described above, if the planar structure 200 is inserted and fixed with reference to the anchor base plate 111 and anchor support rod 112 of the anchor structure of the present invention, a second insulation barrier 113 of the anchor structure is placed onto the anchor lower plate 111 as shown in Fig. 15. Further, a second sealing barrier 114 with a circular corrugated portion 115 formed thereon is placed onto an upper surface of the second insulation barrier 113 of the anchor structure. Furthermore, the second sealing barrier 114 is fitted into and supported by a catching step 121 formed on the anchor support rod 112 and is then firmly fixed by means of a fixing nut 123 bolted to the support rod 112.

If the planar structure 200 is placed and fixed, a space defined by the second insulation barriers 53 and 202 of the corner structure 100 and planar structure 200 is filled with an insulating material made of polyurethane foam and the second insulation barrier 113 and second sealing barrier 114 of the anchor structure are fitted around the anchor support rod 112, as shown in Figs. 15 to 22.

The second insulation barrier 113 of the anchor structure is shaped as a hexahedron and is composed of insulations made of polyurethane foam and plates made of plywood. The second sealing barrier 114 of the anchor structure, which is attached and fixed to the upper surface of the second insulation barrier, is made of aluminum sheet or flexible sheet (triplex).

In a ship with the aforementioned LNG storage tank mounted thereto, a ship's hull is bent due to waves and the like and is partially subjected to mechanical stress when a ship is moving. Further, if the hull is deformed accordingly, the mechanical stress applied to the insulation barrier and second sealing barrier is increased. To reduce the mechanical stress applied to the sealing barriers, therefore, the circular corrugated portion 115 is preferably formed at the second sealing barrier 114 as shown in Fig. 23. That is, since the corrugated portion 115 is stretched or contracted in its sliding direction when the planar structure 200 is slid on the inner surface of the hull, mechanical or thermal deformation is hardly applied to the insulation or sealing barrier.

Further, the gap between the respective planar structures 200 tends to increase due to the mechanical stress applied to layers of the insulation barriers. Since the planar structure 200 of the storage tank according to the present invention is caught in the anchor lower plate 111 of the anchor structure 150, however, it can be slightly slid on the inner surface of the hull without being taken off from the anchor lower plate.

For the above reasons, the insulation barriers themselves can absorb the deformation of the hull, because the corner structure 100 is fixed to the hull but the respective planar structures 200 can be partially slid in a lateral direction even though the stress is created at the hull.

As described above, after the corner structure 100 and respective planar structures 200 of the present invention have been mounted to the inner surfaces of the hull, the gaps defined by their respective second insulation barriers are filled with insulations 211 made of polyurethane foam. Then, the respective adjacent second insulation barriers will be connected and fixed to one another by means of the fixing means.

That is, the second sealing barrier 52 of the corner structure 100 are fastened to the sealing barrier 203 of the adjacent planar structure 200, the second sealing barriers 203 of the two adjacent planar structures 200 are fastened to each other, and the second sealing barrier 203 of the planar structure 200 is fastened to the sealing barrier 114 of the anchor structure.

Further, gaps defined by the respective first insulation barriers are filled with insulations 210 made of polyurethane foam.

Then, the first sealing barrier 250 is coupled onto the assembled structures. The first sealing barrier is welded (preferably, fillet welded) to the anchor structure, preferably to an upper cap 119 of the anchor structure. The first sealing barrier will be explained later in detail.

Fig. 24 is an enlarged sectional view showing a means for interlocking the second sealing barriers of the LNG storage tank according to the present invention, and Fig. 25 is an enlarged perspective view showing the means for interlocking the second sealing barriers of the LNG storage tank according to the present invention. Further, Fig. 26 is a partially enlarged sectional view illustrating the connection relationship between the anchor structures of the LNG storage tank according to the present invention.

The second sealing barriers of the present invention are connected and fixed using the fixing means shown in Figs. 24 and 25. Such a fixing method can be applied to all the second sealing barriers of the present invention.

That is, by way of example, lower and upper fixing plates 213 and 212 are placed near a position where the second sealing barriers 52 and 203, which protrude respectively into the space defined by the first and second insulation barriers 57 and 58 of the corner structure and the first and second insulation barriers 204 and 202 of the planar structure (i.e., space between the insulation barriers), are adjacent to each other, such that the second sealing barriers are interposed between the upper and lower plates, as shown Fig. 24. At this time, the second sealing barriers 52 and 203 are firmly fixed by fastening the lower and upper plates 213 and 212 to each other with a fixing bolt 214, although it is not specifically limited thereto. Here, the lower and upper plates 213 and 212 are made of metal.

Further, the lower and upper plates 213 and 212 cause the second sealing barriers 52 and 203 to be connected and fixed to each other in such a state where the barriers are curved. This can be made by making mutually facing portions of the lower and upper plates 213 and 212 into curved concave portions corresponding to each other. Since a distal end of the second sealing barrier is curved as described above, the sealing characteristics of the second sealing barrier can be improved against any possible LNG leakage through the first sealing barrier.

In addition, an assembly of the lower and upper plates 213 and 212 is preferably curved slightly in a longitudinal direction to have an excess length. Thus, even though the assembly is contracted due to temperature decrease when the storage tank is filled with liquefied natural gas, the assembly can afford to easily absorb the stress created due to its contraction and further overcome the load created due to the thermal/mechanical contraction and expansion.

Furthermore, since the second sealing barriers are coupled to one another irrespective of the insulation barriers and the ship's hull, a certain degree of freedom can be provided to the insulation barriers, and thus, damage of the insulation barriers due to the deformation of inner surfaces of the hull can also be prevented.

As described above, the lower spaces defined by the corner structure 100 and planar structure 200 is filled with insulations and the second sealing barriers are then fixed to each other using the aforementioned fixing means. Next, a nut with a washer integrally formed on a lower end thereof is furred around and fastened to the anchor support rod 112. At this time, the nut washer is maintained at a state where it pushes down an upper surface of the insulations with a predetermined pressure. Here, after the LNG is stored in the storage tank of a ship, the volume, i.e. thickness, of the insulations may be decreased by means of the increasing pressure of the LNG cargo. Therefore, the nut should be designed in consideration of the foregoing thickness reduction of the insulations.

Then, an anchor insulation plate 118 is also fixed onto the first anchor insulation barrier 116, and the circular anchor upper cap 119 is further inserted into and fixed to the end of the anchor. To this end, a predetermined recessed space is formed at the center of the upper surface of the first anchor insulation plate 118 and the anchor upper cap 119 is placed into the recessed space. Since the anchor upper cap 119 includes a nut or is integrally formed with a nut structure, it can be easily fastened to the upper end of the anchor support rod 112. Accordingly, the assembly of the anchor structure 150 is completed.

Fig. 26 is a partially enlarged sectional view illustrating the coupling relationship between anchor structures of the LNG storage tank according to the present invention. The anchor structure 150 of the present invention fabricated through a series of processes has the same coupling structure as shown in Fig. 26.

If the corner structures 100 and the planar structures 200 of the present invention are installed onto the inner surfaces of the ship's hull and the anchor structures 150 are also assembled, upper spaces between the first insulation barriers 204 of the corner structures 100, planar structures 200 and anchor structures 150 (i.e., spaces positioned above the spaces defined by the second insulation barriers) are filled with insulations. Glass wool is used as the insulations with which the upper spaces are filled, so as to more flexibly cope with the thermal contraction of the first insulation barrier and to more easily solve the problem resulting from the thermal stress. Further, there is also an advantage in that even though the ship's hull is distorted, the prefabricated units can slightly move in conformity to the hull distortion.

As described above, after the spaces between the first insulation barriers defined by the respective fabricated structures have been filled with the insulations such as glass wool, the first membrane-type sealing barrier 250 with a corrugated portion 251 is fixed onto the assembled structures. The first sealing barrier 250 is generally made of stainless steel with excellent corrosion resistance and thermal stability.

Furthermore, the first insulation barrier 250 may be made of materials that have been known from the conventional Mark III type tank or proposed in the patents (Korean

Patent Application No. 2001-0010438 or 2001-0010152) referenced by the present inventor(s). The materials and shapes of the first insulation barriers may be modified. Further, the first insulation barrier described in U.S. Patent Nos. 3,299,598, 3,302,359 and 3,510,278 may also be employed herein.

In addition, the corrugated portion 251 is formed in a longitudinal direction along the spaces defined by the respective assembled structures 100, 150 and 200, and the other additional corrugated portions are also formed near the corrugated portion 251. Since the thermal contraction and expansion of the first sealing barrier 250 brought into direct contact with the LNG stored in the tank is produced most excessively at this corrugated portion 251, the corrugated portion should be formed in this way such that the thermal deformation can be flexibly coped with and easily reduced. Further, the reason that the corrugated portions 251 are formed in the longitudinal direction above the spaces defined between the respective first insulation barriers is that the thermal stress applied to the storage tank can be easily reduced by mutually coping with the thermal contraction and expansion of the second sealing barrier attached to the first insulation barrier.

Fig. 27 is a partially cut-away perspective view of the LNG storage tank according to another embodiment of the present invention.

As shown in Fig. 27, the LNG storage tank according to another embodiment of the present invention is configured in such a manner that a second insulation barrier 292 is installed to a space defined in the construction such as a ship for storing liquefied natural gas therein, and a second sealing barrier 292 and a first insulation barrier 294 are sequentially installed onto an upper surface of the second insulation barrier.

Here, a predetermined space is formed between adjacent ends of the first insulation barriers 294 above ends of the second insulation barriers 292, and a connection insulation barrier 297 that is coupled to the first insulation barrier.

Further, a first insulation barrier 276 of an anchor structure is installed at the center of the connection insulation barrier 297, and insulations 325 made of glass wool is filled between the connection insulation barrier 297 and the first insulation barrier 276 of the anchor structure.

The process of fabricating the LNG storage tank according to another embodiment of the present invention described above will be explained as follows.

Figs. 28 to 36 are perspective views sequentially illustrating the processes of fabricating the LNG storage tank into the inner space of a ship's hull according to another embodiment of the present invention.

When reference numerals are added to the respective components in the respective figures for the explanation of the present invention, it should be understood that same reference numerals are used to designate same components although the same components are shown in the different figures.

Moreover, the process of fixing the planar or corner structure according to another embodiment of the present invention is the same as that of the previous embodiment of the present invention. Therefore, the description for the same process will be omitted herein.

As shown in Figs. 28 and 29, after the planar structure 200 is inserted and fixed with respect to the anchor lower plate 111 and anchor support rod 112 of the anchor structure 150, the second insulation barrier 113 of the anchor structure is inserted.

The second sealing barrier 114 with a circular corrugated portion 115 formed thereon is placed onto an upper surface of the second insulation barrier 113 of the anchor structure. The second sealing barrier 114 is fitted into and supported by a catching step 121 formed on the anchor support rod 112 and is then firmly fixed by means of the fixing nut 123 bolted to the support rod 112.

Further, referring to Fig. 30, the connection insulation barrier 297 installed to be connected to side surfaces of the respective adjacent first insulation barriers 294 of the planar structure and to an upper surface of the second sealing barrier 293 bonded onto an upper surface of the second insulation barrier 292 of the planar structure. In this embodiment of the present invention, the connection insulation barrier 297 may be bonded, using an adhesive P, to an upper surface of the second sealing barrier 293 of the planar structure and the first sealing barrier 114 of the anchor structure.

Accordingly, the connection insulation barrier 297 is more firmly coupled to the second sealing barrier 114 and 293 by means of the adhesive.

At this time, the connection insulation barrier 297 may be spaced apart by a predetermined gap (1 ~ 4 mm) from the adjacent side surfaces of the first insulation barrier 294 of the planar structure. This gap corresponds to a space in which the planar structure 200 can be moved when a ship's hull is deformed, and it can also serve to absorb the deformation.

Further, the connection insulation barrier 297 is placed onto the upper surface of the adjacent second sealing barrier 293 and causes ends of the second sealing barriers 114 and 293 to be sealed.

Since the connection insulation barrier 297 is strongly coupled to the second sealing barrier 114 or 293 by means of the adhesive P as described above, the LNG cannot reach up to the second sealing barrier 293 of the planar structure or the second sealing barrier 114 of the anchor structure. Therefore, the leakage of the LNG can be certainly prevented.

As described above, the respective second sealing barriers 114 and 293 are fixed to each other by means of the fixing means. Then, in the order shown in Figs. 31 to 36, the first insulation barrier 116 of the anchor structure is fitted around the anchor support rod 112 and an anchor upper plate 337 is inserted into a circular recessed space formed on the upper surface of the first insulation barrier 116 such that it can be fixed to the upper end of the anchor support rod 112.

Thereafter, an anchor insulation plate 338 is attached to and fixed onto the upper surface of the anchor upper plate 337, and an anchor upper cap 339 is again inserted into and fixed to the center of the anchor insulation plate. To this end, a predetermined recessed space is formed at the center of the upper surface of the first anchor insulation plate 338 and the anchor upper cap 339 is placed into the recessed space. Since the anchor upper cap 339 includes a nut or is integrally formed with a nut structure, it can be easily fastened to the upper end of the anchor support rod 112. Accordingly, the assembly of the anchor structure 150 is completed.

After the above process has been completed, a space between the first insulation barriers 276 and 297 of the anchor structure according to the present invention (i.e., a space positioned above a space defined by the second insulation barriers) can be filled with insulations. Glass wool 325 is used as the insulations with which the upper space is filled, so as to more flexibly cope with the thermal contraction of the first insulation barriers 276 and 297 and to more easily solve the problem resulting from the thermal stress.

After the spaces defined by the first insulation barriers 276 and 297 have been filled with the insulations such as glass wool 325, the first membrane-type sealing barrier 250 with a corrugated portion 251 is fixed onto the assembled structures. The first sealing barrier 250 is generally made of stainless steel with excellent corrosion resistance and thermal stability. Furthermore, the first insulation barrier 250 may be made of materials that have been known from the conventional Mark III type tank or proposed in the patents (Korean Patent Application No. 2001-0010438 or 2001-0010152) referenced by the present inventor(s). The shapes of the first insulation barriers may be modified.

Figs. 37 and 38 are enlarged sectional views showing a state where second sealing barriers are interlocked in the LNG storage tank according to the present invention.

Here, the second sealing barriers 293 of the present invention are connected and fixed using the fixing means shown in Figs. 37 and 38. Such a fixing method can be applied to all the second sealing barriers of the present invention.

That is, by way of example, upper and lower connection members 312 and 313 are installed near a position where the second sealing barriers 293, which protrude respectively into the space defined by the first and second insulation barriers 292 and 294 of the corner structure and the first and second insulation barriers 204 and 202 of the planar structure (i.e., space between the insulation barriers), are adjacent to each other, such that they are brought into contact with ends of the second sealing barriers 293, as shown Fig. 37.

Further, the second sealing barrier 293 is coated with resin materials 293a on the top and bottom surfaces and extends into the space defined by the adjacent insulation barriers.

At this time, the second sealing barriers 293 are firmly fixed by fastening the upper and lower members 312 and 313 to each other with a self drilling screw 314, although it is not specifically limited thereto. To this end, a perforated portion 297a through which the self drilling screw 314 is inserted is formed on the connection insulation barrier 297.

Here, the fixing bolt or screw 314 is a structure for fixing the upper and lower connection members 312 and 313 to each other while directly penetrating the members. If this fixing bolt or screw is used, the fixing operation can be made without forming additional bolt-fastening holes on the members. For example, the self drilling screw may be employed in the present invention.

Further, a plain washer 314a or spring washer 314b is included in the fixing screw 314 such that the washer is maintained at a state where it pushes down an upper surface of the insulations with a predetermined pressure. Here, it is preferred that the fixing screw 314 be fastened in consideration of the reduction in volume, i.e. thickness, of the insulation due to the increasing pressure of the LNG cargo.

Furthermore, a recessed portion in which the second sealing barriers 293 are accommodated is formed on coupling surfaces of the upper and lower members 312 and 313. In addition, convex portions 312a and 313a that face each other or alternate with each other are formed on both ends of the recessed portion. The aforementioned upper and lower members 312 and 313 allow the convex portions 312a and 313a to press the resin materials 293a coated onto the second sealing barriers 293 when the members are fixed by means of the fixing bolt 314.

At this time, the resin materials 293a are accommodated in concave portions formed between the convex portions 312a and 313a and allows gaps between the upper or lower member 312 or 313 and the second sealing barrier 293 to be sealed up. Here, the resin materials 293a are made of curable resins, and they are compression molded and then cured.

Therefore, the sealing characteristics of the second sealing barriers can be improved against any possible LNG leakage through the first sealing barrier 250.

Although the present invention has been described in connection with the embodiments of the present invention illustrated in the accompanying drawings, the present invention is not limited thereto and those skilled in the art can make various modifications and changes thereto without departing from the spirit and scope of the invention.

Moreover, it is apparent that the present invention can be applied to an LNG storage tank installed on the ground as well as an LNG storage tank installed within a ship's hull.

Industrial Applicability

As described above, the LNG storage tank of the present invention has advantages in that a fabricating process can be shortened by simplifying an installation structure of a tank which is installed within a ship for transporting liquefied nature gas corresponding to cryogenic liquid and the stress created due to mechanical deformation upon the loading or unloading of the liquefied natural gas can also be easily reduced while the liquid-tight characteristics are firmly maintained.

CLAIMS

1. A liquefied natural gas storage tank including two successive sealing barriers and two insulation barriers, among which a first sealing barrier of the sealing barriers is brought into contact with liquefied natural gas stored in the storage tank, and a first insulation barrier, a second sealing barrier and a second insulation barrier are sequentially disposed on a lower surface of the first sealing barrier, wherein:

the first sealing barrier is supported by an anchor structure mechanically fastened to a bottom floor of the tank, and

the insulation barriers are slidably installed between the first sealing barrier and the bottom floor of the tank.

2. The liquefied natural gas storage tank as claimed in claim 1, wherein the first and second insulation barriers are bonded with adhesive to upper and lower surfaces of the second sealing barrier, respectively.

3. The liquefied natural gas storage tank as claimed in claim 1 or 2, wherein the second insulation barrier comprises insulation made of polyurethane foam and a plate made of plywood and bonded to a lower surface of the insulation.

4. The liquefied natural gas storage tank as claimed in claim 1 or 2, wherein the first insulation barrier comprises insulation made of polyurethane foam and plates made of plywood and bonded to upper and lower surfaces of the insulation.

5. The liquefied natural gas storage tank as claimed in claim 1 or 2, wherein the second sealing barrier is made of an aluminum sheet or flexible sheet (triplex).

6. The liquefied natural gas storage tank as claimed in claim 1 or 2, wherein the second sealing barrier is formed to protrude from a side of the first and second insulation

barriers.

7. The liquefied natural gas storage tank as claimed in claim 1 or 2, wherein the first sealing barrier is made of stainless steel.

8. The liquefied natural gas storage tank as claimed in claim 1 or 2, wherein the first sealing barrier includes a corrugated portion.

9. The liquefied natural gas storage tank as claimed in claim 1 or 2, wherein a space defined between the second insulation barriers is filled with insulation made of polyurethane foam.

10. The liquefied natural gas storage tank as claimed in claim 1 or 2, wherein a space defined between the first insulation barriers is filled with insulation made of glass wool.

11. The liquefied natural gas storage tank as claimed in claim 1 or 2, wherein the second sealing barrier extends into a space defined by sides of the insulation barriers, an end of the extended second sealing barrier is fixed by means of upper and lower fixing plates, and coupling surfaces of the upper and lower fixing plates include a recessed portion in which the end of second sealing barrier can be inserted.

12. The liquefied natural gas storage tank as claimed in claim 11, wherein the recessed portion is formed to be curved.

13. The liquefied natural gas storage tank as claimed in claim 11, wherein an assembly of the lower and upper fixing plates is curved slightly in a longitudinal direction to have an excess length.

14. The liquefied natural gas storage tank as claimed in claim 1 or 2, wherein the

second sealing barrier is coated with resin at upper and lower surfaces thereof by pressing the resin onto the upper and lower surfaces.

15. The liquefied natural gas storage tank as claimed in claim 14, wherein the resin is a curable one.

16. The liquefied natural gas storage tank as claimed in claim 14 or 15, wherein concave and convex portions are formed to face each other.

17. The liquefied natural gas storage tank as claimed in claim 1 or 2, comprising:

corner structures fastened to edge portions in the tank;

planar structures slidably positioned on flat surfaces in the tank; and

anchor structures fastened to the bottom floor of the tank to attach the planar structures onto inner surfaces of the tank.

18. The liquefied natural gas storage tank as claimed in claim 17, wherein the planar structure is manufactured into a prefabricated assembly including a second insulation barrier, a second sealing barrier formed on an upper surface of the second insulation barrier and a first insulation barrier formed on an upper surface of the second insulation barrier.

19. The liquefied natural gas storage tank as claimed in claim 17, wherein the anchor structure includes:

an anchor support rod fixed onto an anchor lower plate mechanically fastened to a portion where the planar structures join together;

a second insulation barrier penetrated by the anchor support rod at a central portion thereof and installed at the same height as a second insulation barrier of the planar structure;

a second sealing barrier penetrated by the anchor support rod at a central portion thereof and fixed onto an upper surface of the second insulation barrier and fastened to an adjacent second sealing barrier of the planar structure;

a first insulation barrier penetrated by the anchor support rod at a central portion thereof and fixed onto an upper surface of the second sealing barrier; and

an upper cap fixed to an upper end of the anchor support rod corresponding to an upper center of the first insulation barrier of the anchor structure.

20. The liquefied natural gas storage tank as claimed in claim 19, wherein the anchor lower plate causes a lower plate of the second insulation barrier of the adjacent planar structure to be fixed to the inner surface of a ship's hull.

21. The liquefied natural gas storage tank as claimed in claim 19 or 20, wherein the second sealing barrier of the anchor structure includes a corrugated portion formed at an outer peripheral portion thereof.

22. The liquefied natural gas storage tank as claimed in claim 19 or 20, wherein the second sealing barrier of the anchor structure is formed to protrude from a side of the first insulation barrier of the anchor structure.

23. The liquefied natural gas storage tank as claimed in claim 19 or 20, wherein the first and second insulation barriers of the anchor structure are bonded with adhesive to upper and lower surfaces of the second sealing barrier of the anchor structure, respectively.

24. The liquefied natural gas storage tank as claimed in claim 19 or 20, wherein the second insulation barrier of the anchor structure includes insulation made of polyurethane foam and a plate made of plywood and bonded to an upper surface of the insulation.

25. The liquefied natural gas storage tank as claimed in claim 19 or 20, wherein the first insulation barrier of the anchor structure includes insulation made of polyurethane foam and plates made of plywood and bonded to upper and lower surfaces of the insulation.

26. The liquefied natural gas storage tank as claimed in claim 17, wherein the anchor structure includes:

an anchor lower plate for fixing an anchor base plate with a rod support cap built therein, said anchor base plate being installed at a regular interval on the bottom floor and a bulkhead of an internal space of the tank and being formed with a fastening hole;

an anchor support rod fixed vertically to the rod support cap;

a second insulation barrier penetrated by the anchor support rod at a central portion thereof;

a second sealing barrier penetrated by the anchor support rod at a central portion thereof and fixed onto an upper surface of the second insulation barrier of the anchor structure;

a first insulation barrier penetrated by the anchor support rod at a central portion thereof and fixed onto an upper surface of the second sealing barrier of the anchor structure;

an upper cap fixed to an upper end of the anchor support rod for fixing the first insulation barrier of the anchor structure; and

a connection insulation barrier placed adjacent to a side of the first insulation barriers and to an upper surface of the second sealing barriers, spaced apart by a predetermined distance from the first insulation barrier of the anchor structure, and bonded to upper surfaces of the second sealing barriers of the adjacent planar structure and anchor structure.

27. The liquefied natural gas storage tank as claimed in claim 26, wherein the connection insulation barrier is fixed to side surfaces of the respective first insulation barriers of the adjacent planar structures and to an upper surface of the second sealing barriers of the planar structure bonded onto the second insulation barriers of the planar structures.

28. The liquefied natural gas storage tank as claimed in claim 26 or 27, wherein the

connection insulation barrier is fixed with to the second sealing barriers of the planar and anchor structures.

29. The liquefied natural gas storage tank as claimed in claim 26 or 27, wherein a gap between the connection insulation barrier and the first insulation barrier of the anchor structure is filled with insulation.

30. The liquefied natural gas storage tank as claimed in claim 29, wherein the insulation is made of glass wool.

31. The liquefied natural gas storage tank as claimed in claim 17, wherein the corner structure is manufactured into a prefabricated assembly including an L-shaped second insulation wall brought into contact with a corner where the tank surfaces join together, a second sealing wall formed on an upper surface of the second insulation wall, a first insulation wall formed on an upper surface of the second sealing wall, and an L-shaped corner support plate formed on an upper surface of the first insulation wall for bearing load of the storage tank, whereby the prefabricated assembly is fixed by means of corner boundary projections formed on the inner surfaces of the tank.

32. The liquefied natural gas storage tank as claimed in claim 31, wherein the corner support plate is slidably installed to the first insulation barrier of the corner structure such that the support plate can be contracted and expanded.

33. The liquefied natural gas storage tank as claimed in claim 31, wherein the first and second insulation barriers of the corner structure are bonded with adhesive to upper and lower surfaces of the second sealing barrier of the corner structure.

34. The liquefied natural gas storage tank as claimed in any one of claims 31 to 33, wherein the first insulation barrier, the second sealing barrier, the second insulation barrier

and the corner support plate are manufactured into a prefabricated assembly.

35. The liquefied natural gas storage tank as claimed in claim 34, wherein the prefabricated assembly is fixed by means of the corner boundary projections formed on the inner surfaces of the tank.

36. The liquefied natural gas storage tank as claimed in any one of claims 31 to 33, wherein the second sealing barrier is formed to protrude from a side of the first and second insulation barriers.

37. The liquefied natural gas storage tank as claimed in any one of claims 31 to 33, wherein plates are formed on lower surfaces of the first and second insulation barriers and side ends of the plates protrude further from sides of the insulation barriers.

38. The liquefied natural gas storage tank as claimed in any one of claims 31 to 33, wherein the first and second insulation barriers are mechanically coupled to each other by means of a connection reinforcement bar for connecting and fixing an upper end of a lower support rod, which penetrates and protrudes from the second insulation barrier, and a lower end of an upper support rod which penetrates the first insulation barrier.

39. The liquefied natural gas storage tank as claimed in claim 38, wherein the lower support rod is fitted and fastened to a rod support cap fixed onto a lower surface of the second insulation barrier, penetrates the second insulation barrier and is then fixed to the connection reinforcement bar.

40. The liquefied natural gas storage tank as claimed in claim 38, wherein the upper support rod is fitted and fastened to a rod support cap, which is fixed to a lower surface of the first insulation barrier and the connection reinforcement bar, penetrates the first insulation barrier and supports the corner support plate.

41. A method of manufacturing a liquefied natural gas storage tank including two successive sealing barriers and two insulation barriers, among which a first sealing barrier of the sealing barriers is brought into contact with liquefied natural gas stored in the storage tank, and a first insulation barrier, a second sealing barrier and a second insulation barrier are sequentially disposed on a lower surface of the first sealing barrier, comprising the steps of:

forming boundary projections near inner corners of the tank and fixedly installing anchor base plates onto inner surfaces of the tank at a regular interval;

fixedly attaching prefabricated corner structures, each of which includes a second insulation barrier, a second sealing barrier, a first insulation barrier and a corner support plate, between the formed boundary projections;

fixing the fixed corner structures to the boundary projections with fixing stands and simultaneously fixing anchor lower plates onto upper surfaces of the anchor base plates and then vertically fixing anchor support rods onto center portions of the anchor lower plates;

fitting and fixing sides of prefabricated planar structures, each of which includes a second insulation barrier, a second sealing barrier and a first insulation barrier, to sides of the fixing stands by which the corner structures are fixed, and fitting and fixing other sides of the planar structures to gaps defined by anchor base plates and the anchor lower plates;

filling insulations into spaces defined between the second insulation barriers of the corner and planar structures and simultaneously fitting second insulation and sealing barriers of anchor structures around the anchor support rods;

fastening the second sealing barriers of the corner structures and the second sealing barriers of the adjacent planar structures to each other, fastening the second sealing barriers of the planar structures to each other, and also fastening the second sealing barriers of the planar structures and the second sealing barriers of the anchor structures to each other;

fitting first insulation barriers of the anchor structures around the anchor support rods, and fixing anchor upper plates and anchor insulation plates onto the first insulation barriers and fixing anchor upper caps to the anchor support rods to complete fabricating the anchor structures;

filling insulations into spaces defined between the first insulation barriers of the corner structures, planar structures and anchor structures; and

fixing first sealing barriers with corrugated portions onto upper surfaces of the corner structures, planar structures and anchor structures.

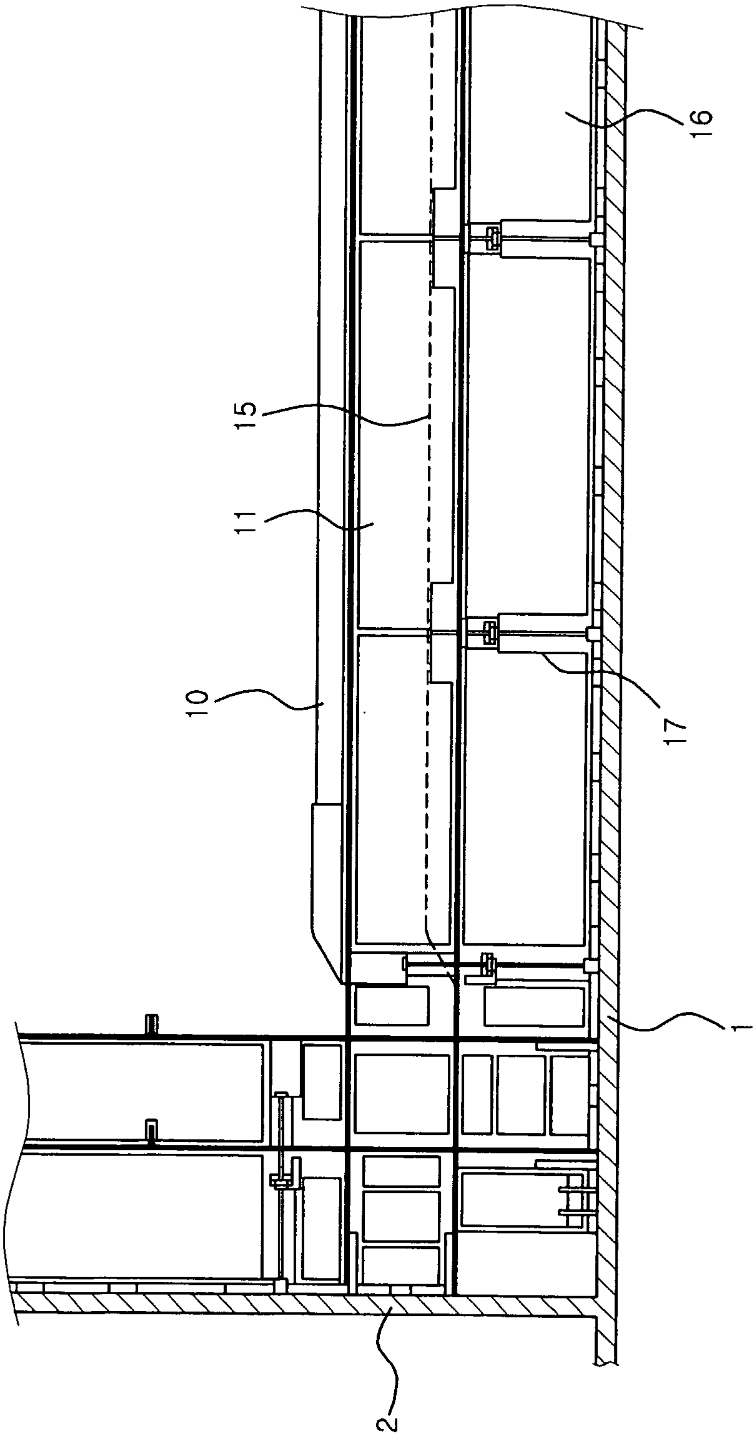
42. The method as claimed in claim 41, wherein the step of fixing the anchor lower plates onto the upper surfaces of the anchor base plates and then vertically fixing the anchor support rods onto the center portions of the anchor lower plates comprises the steps of bolting the anchor lower plates to the anchor base plates, fixing rod support caps to the centers of the anchor lower plates and bolting the anchor support rods to the rod support caps.

43. The method as claimed in claim 41 or 42, wherein the step of filling the insulation into the spaces defined between the second insulation barriers of the corner structures and planar structures comprises the step of filling the spaces with insulations made of polyurethane foam.

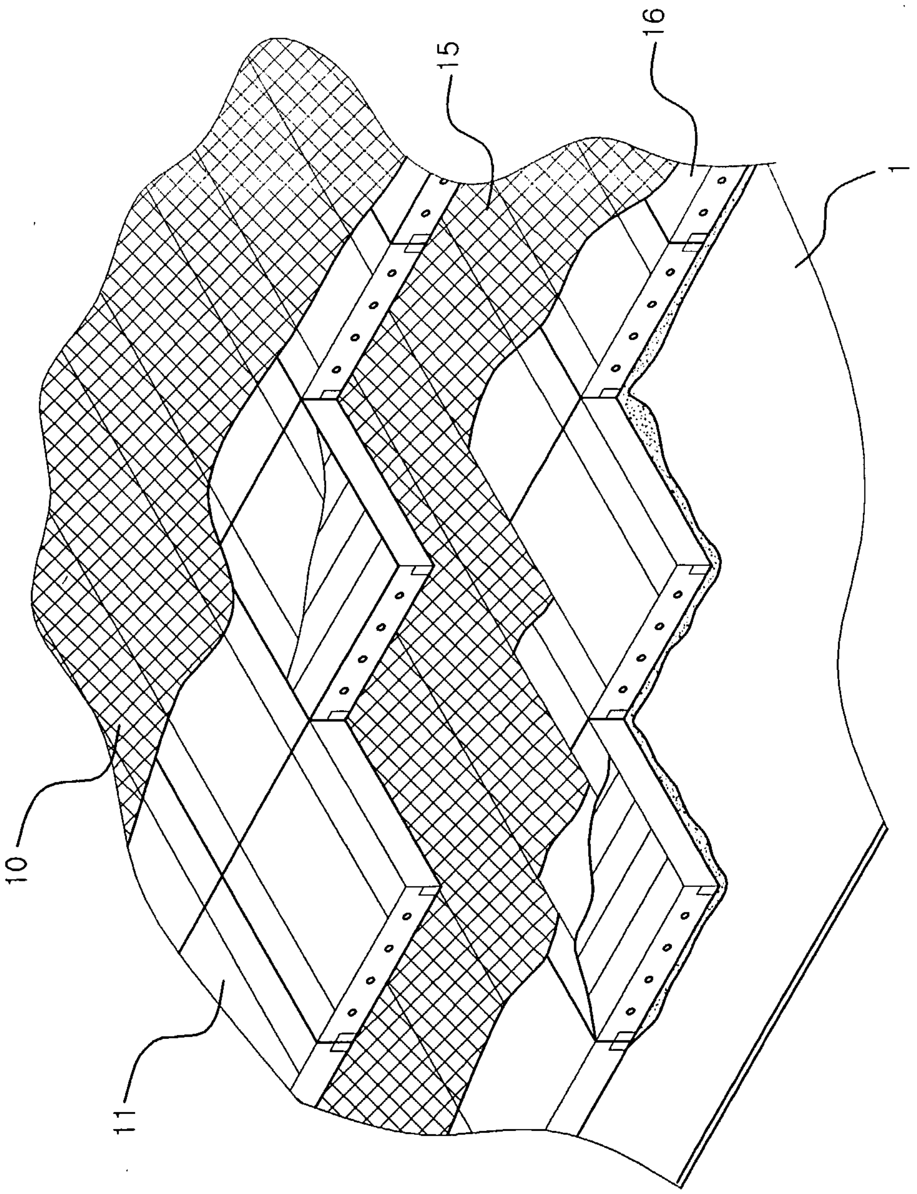
44. The method as claimed in claim 40 or 41, wherein the step of fastening the second sealing barriers of the corner structures and the second sealing barriers of the adjacent planar structures to each other, fastening the second sealing barriers of the planar structures to each other, and also fastening the second sealing barriers of the planar structures and the second sealing barriers of the anchor structures to each other comprises the step of bolting lower fixing plates placed below the second sealing barriers and upper fixing plates placed above the second sealing barriers to face the lower fixing plates.

45. The method as claimed in claim 44, wherein the lower and upper fixing plates are curved.

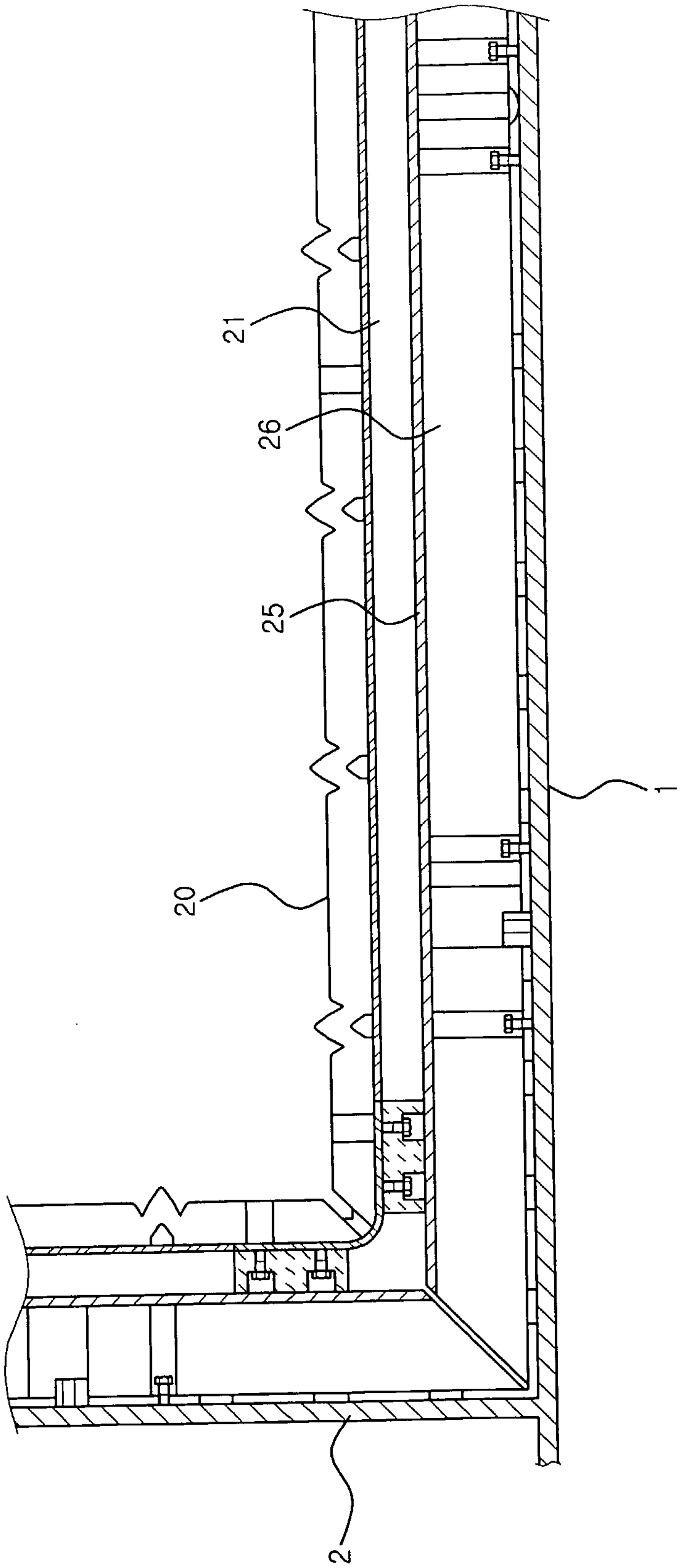
【FIG 1】



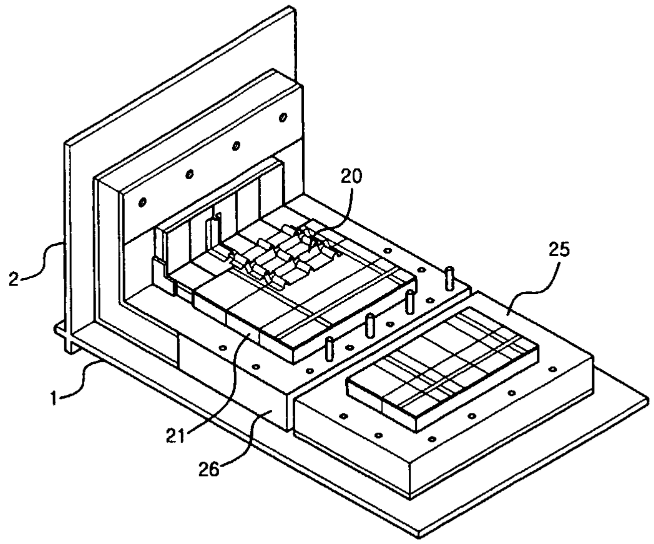
【FIG 2】



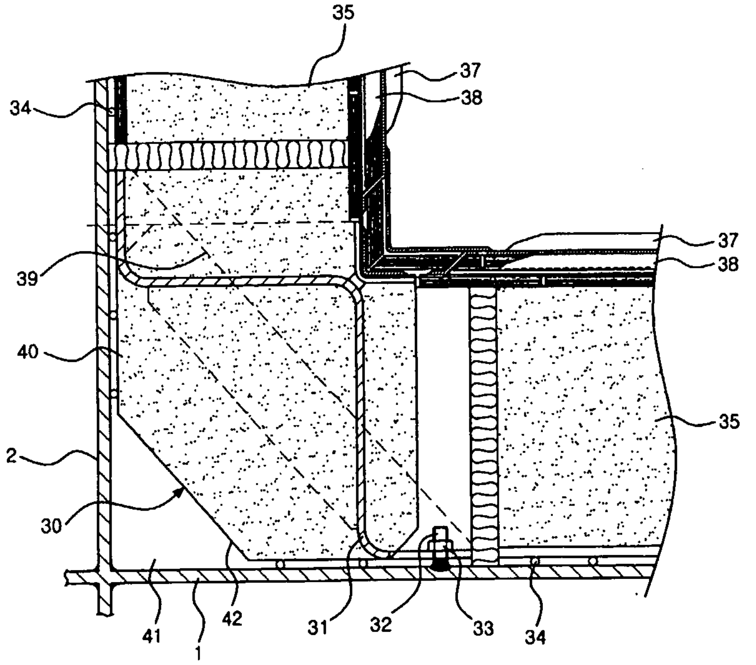
【FIG 3】



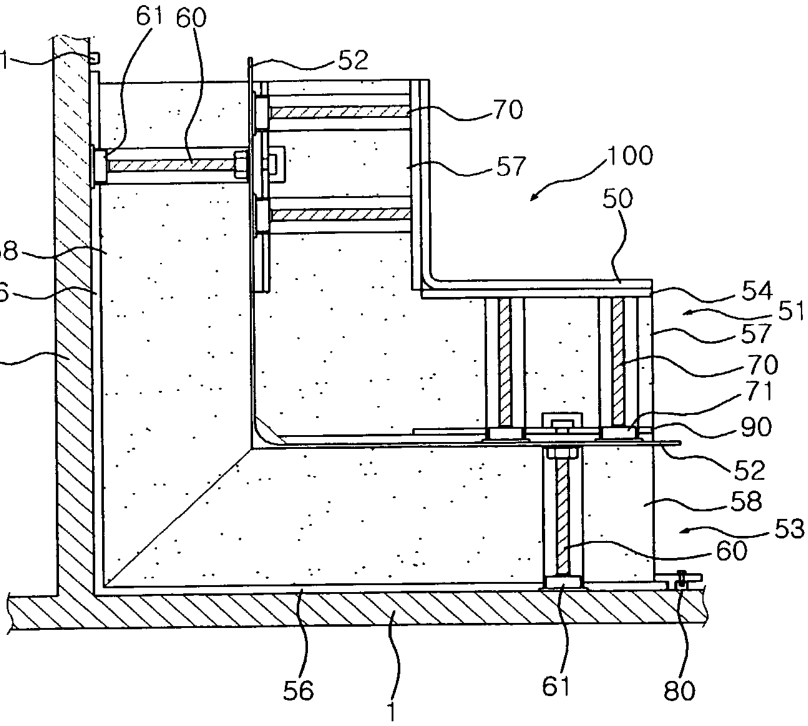
【FIG 4】



【FIG 5】



【FIG 6】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57
100
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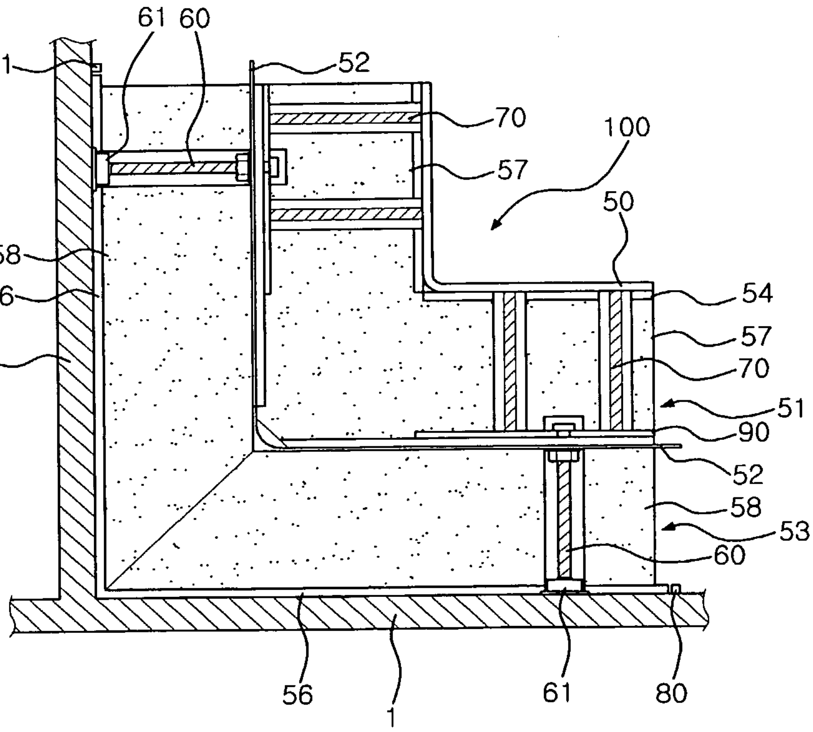
80

(a)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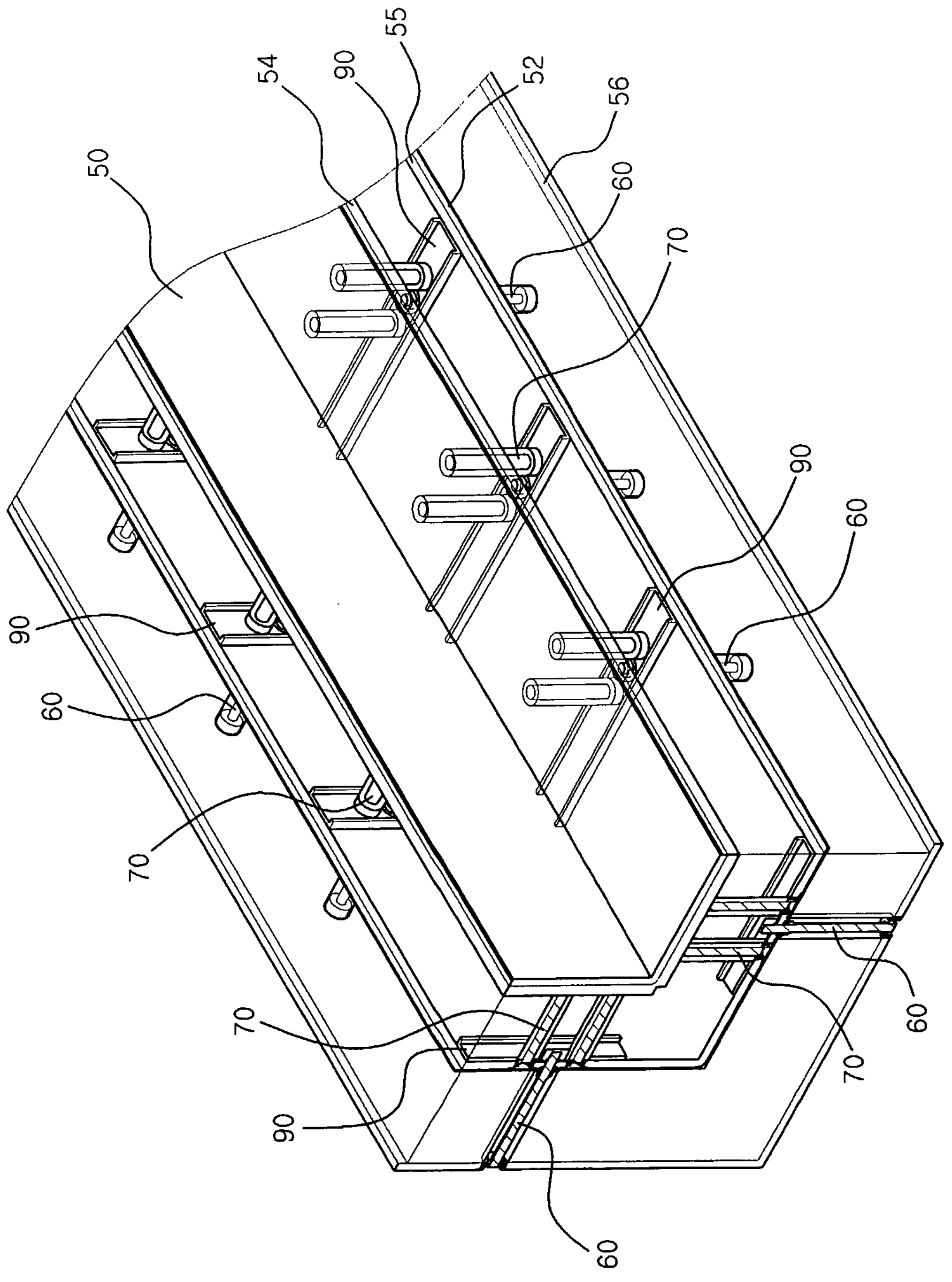
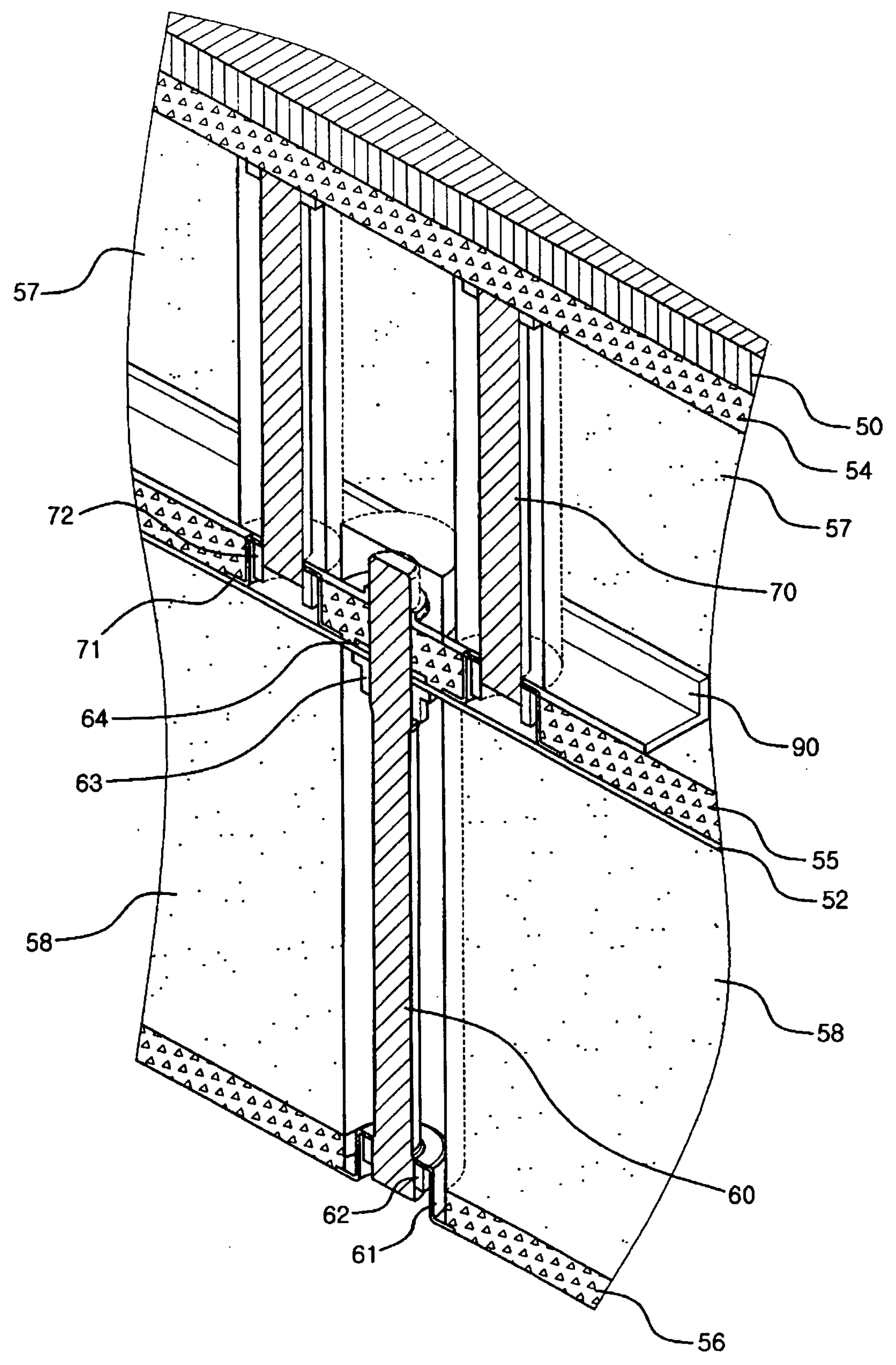
80

(b)

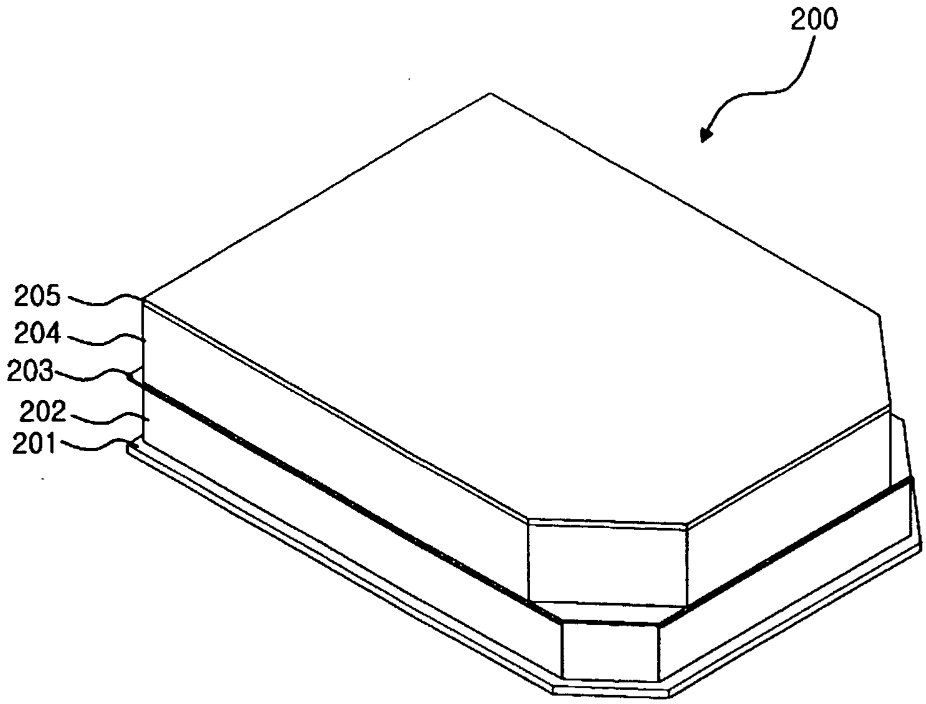
【FIG 7】



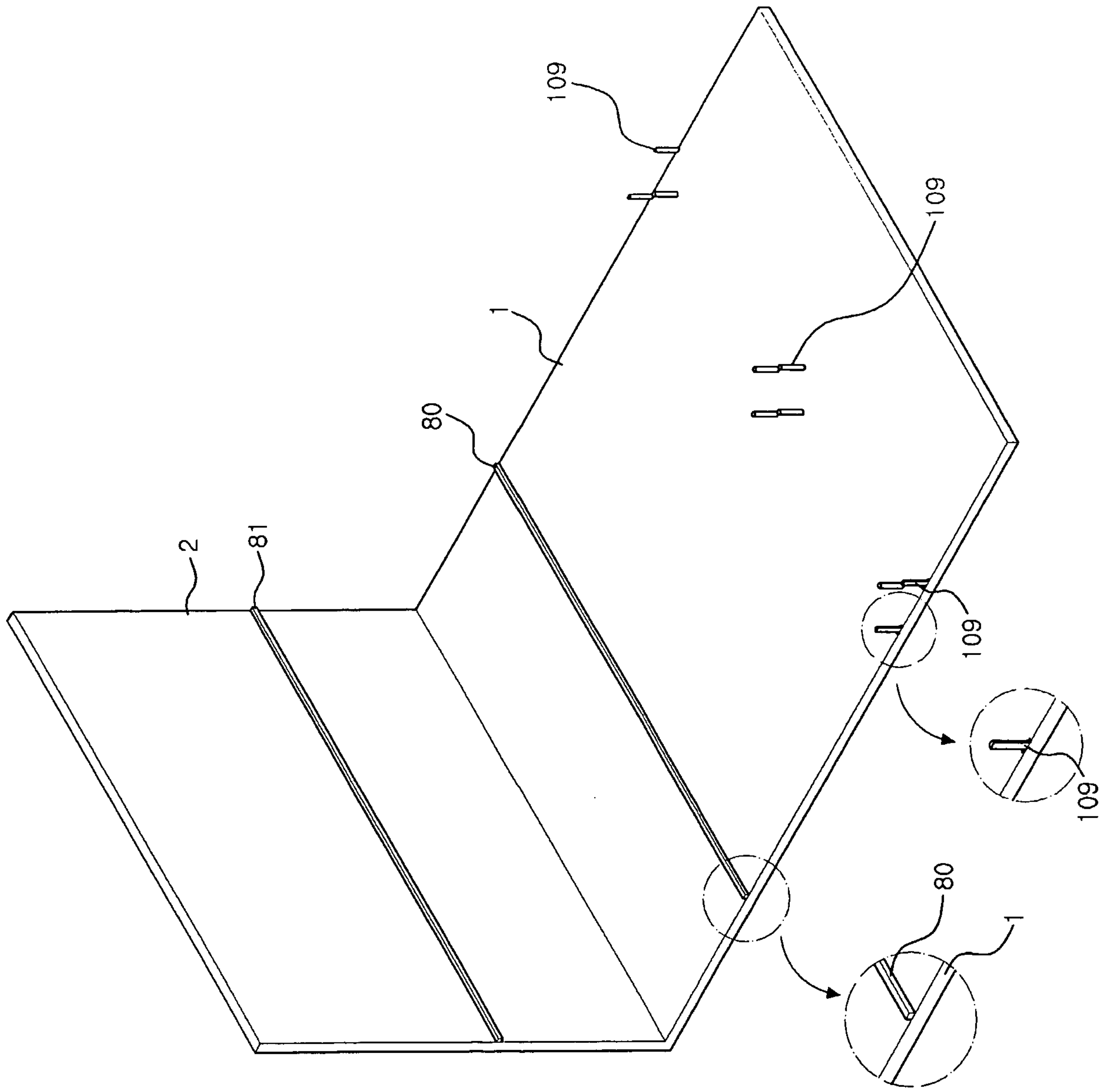
【FIG 8】



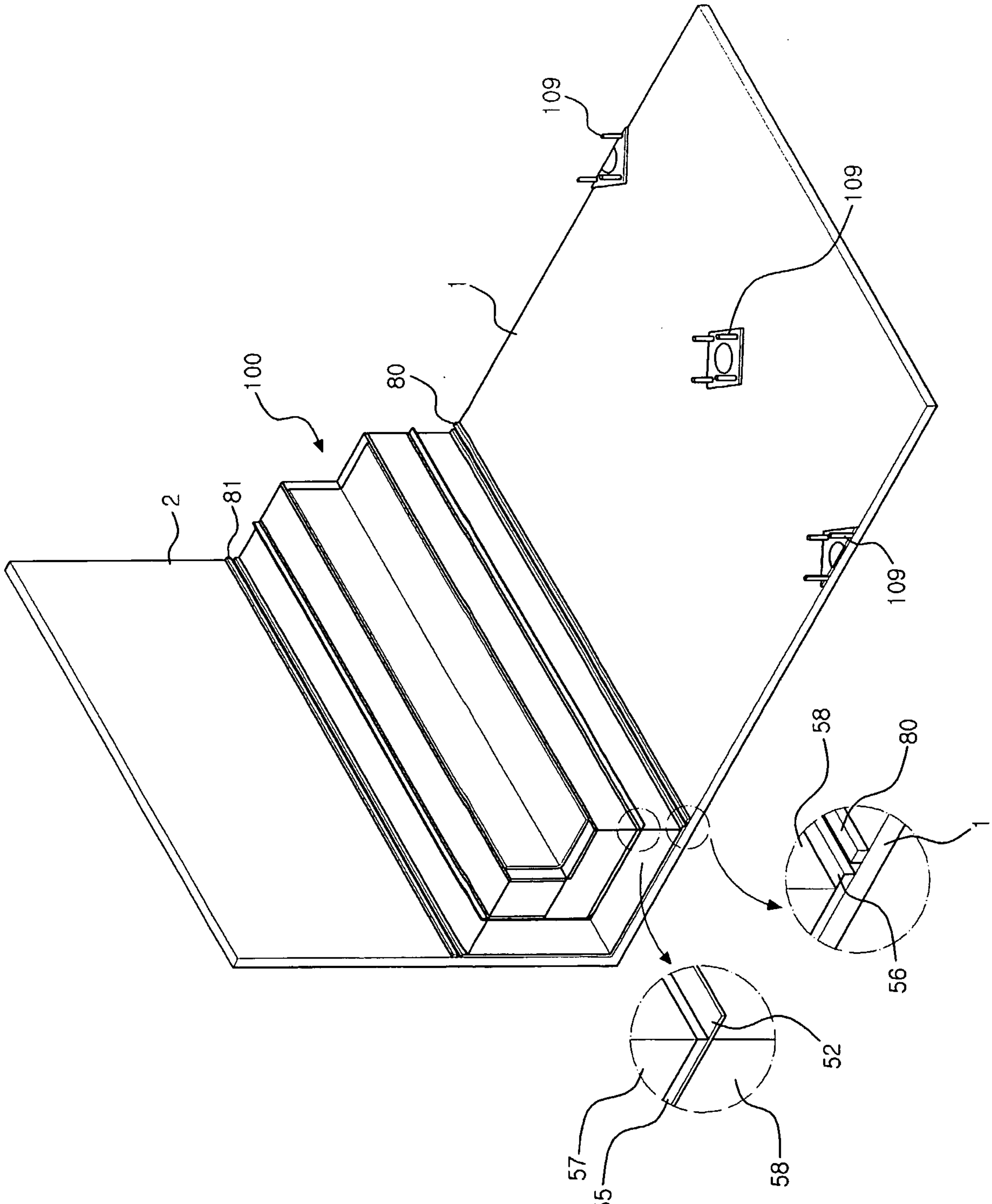
【FIG 9】



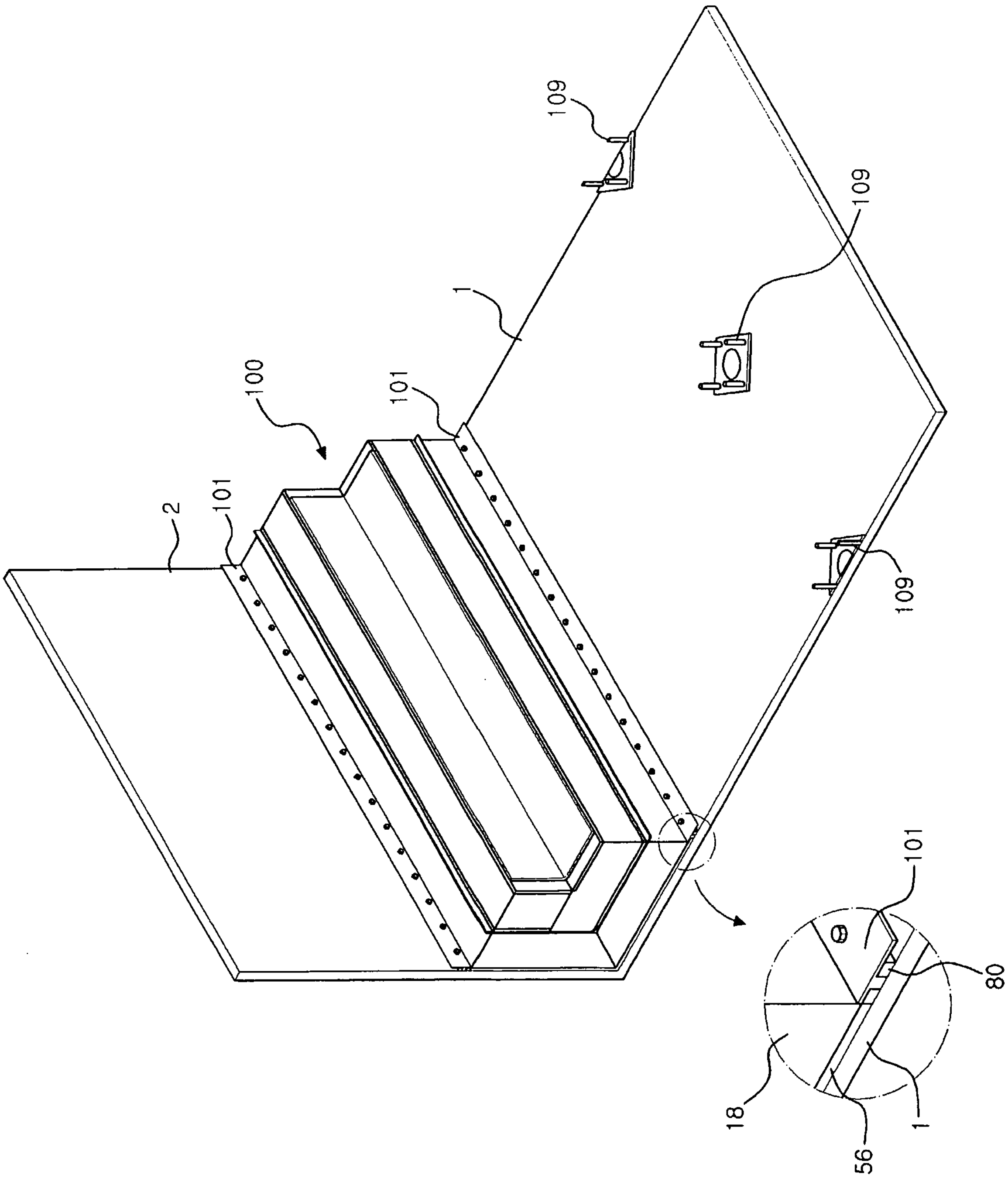
【FIG 10】



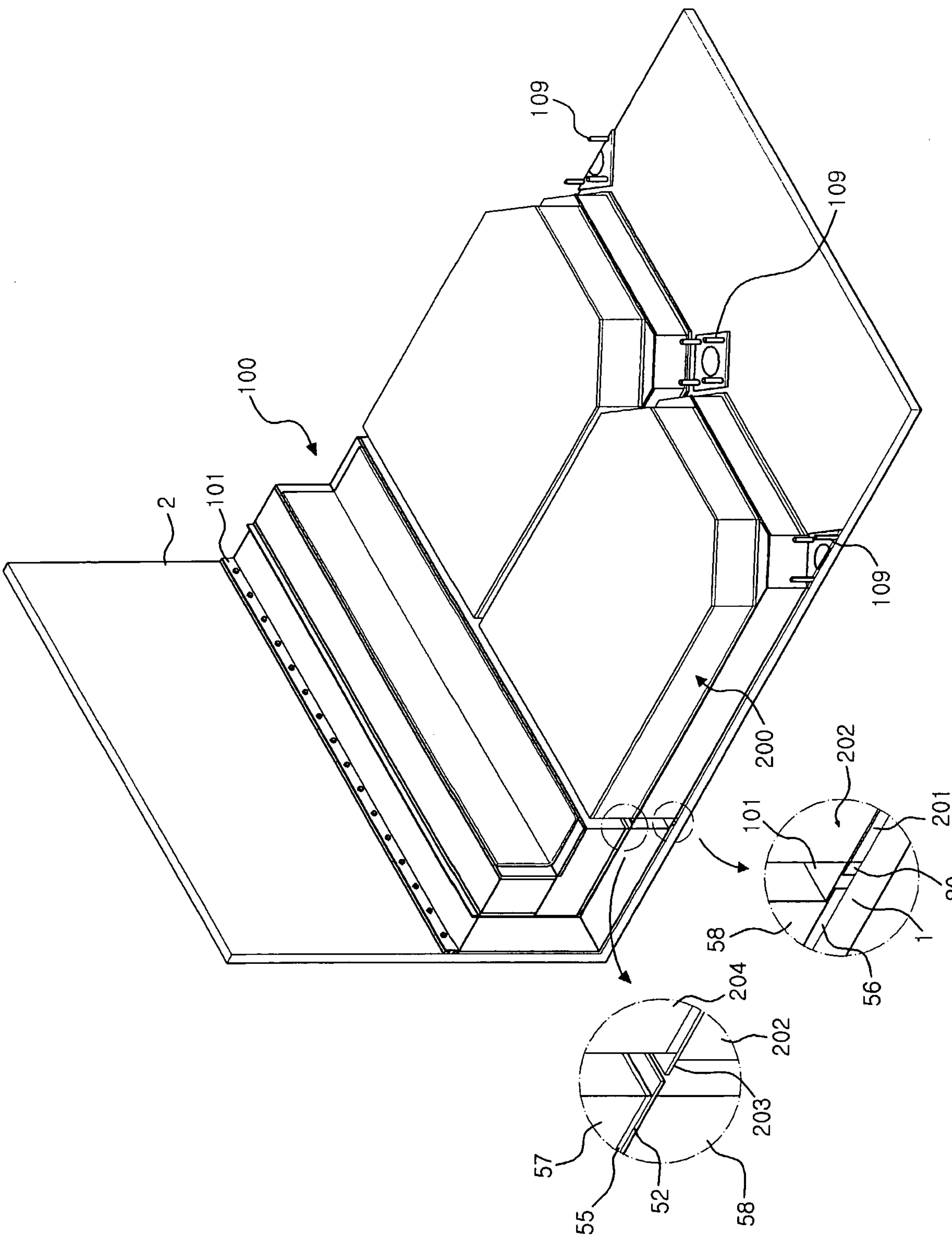
【FIG 11】



【FIG 12】



【FIG 13】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101
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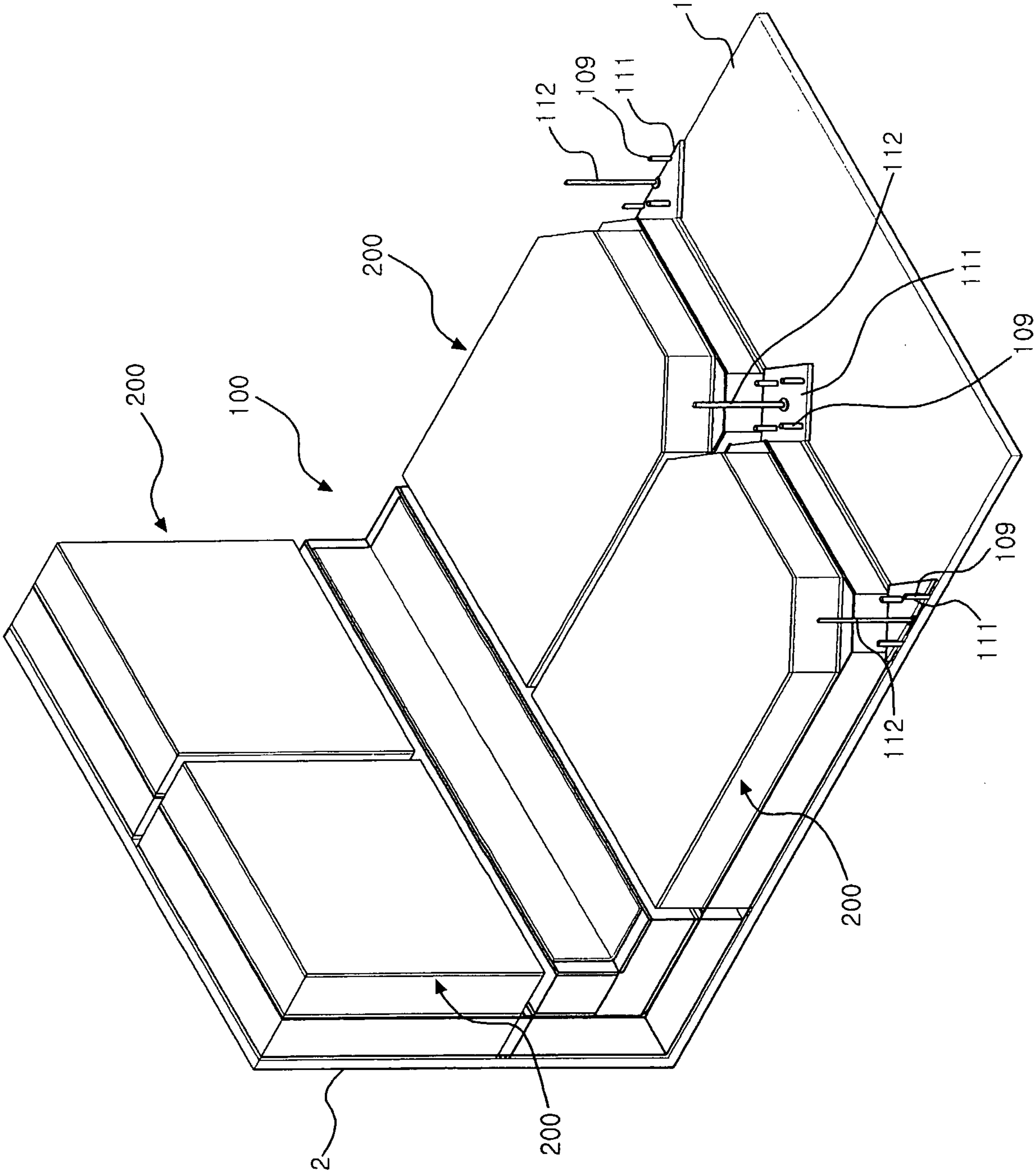
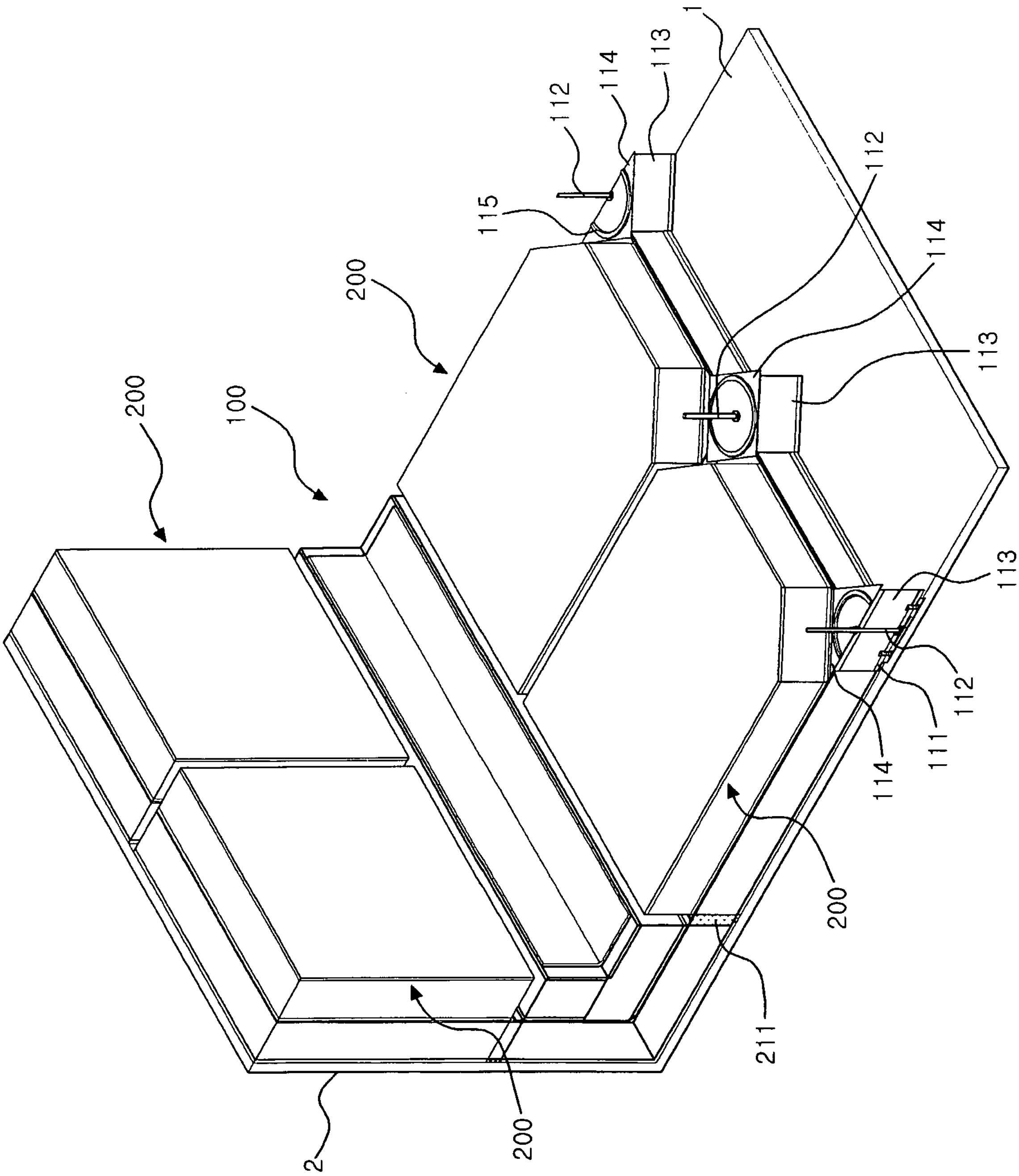
52
58

【FIG 14】



【FIG 15】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113
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200
112
114
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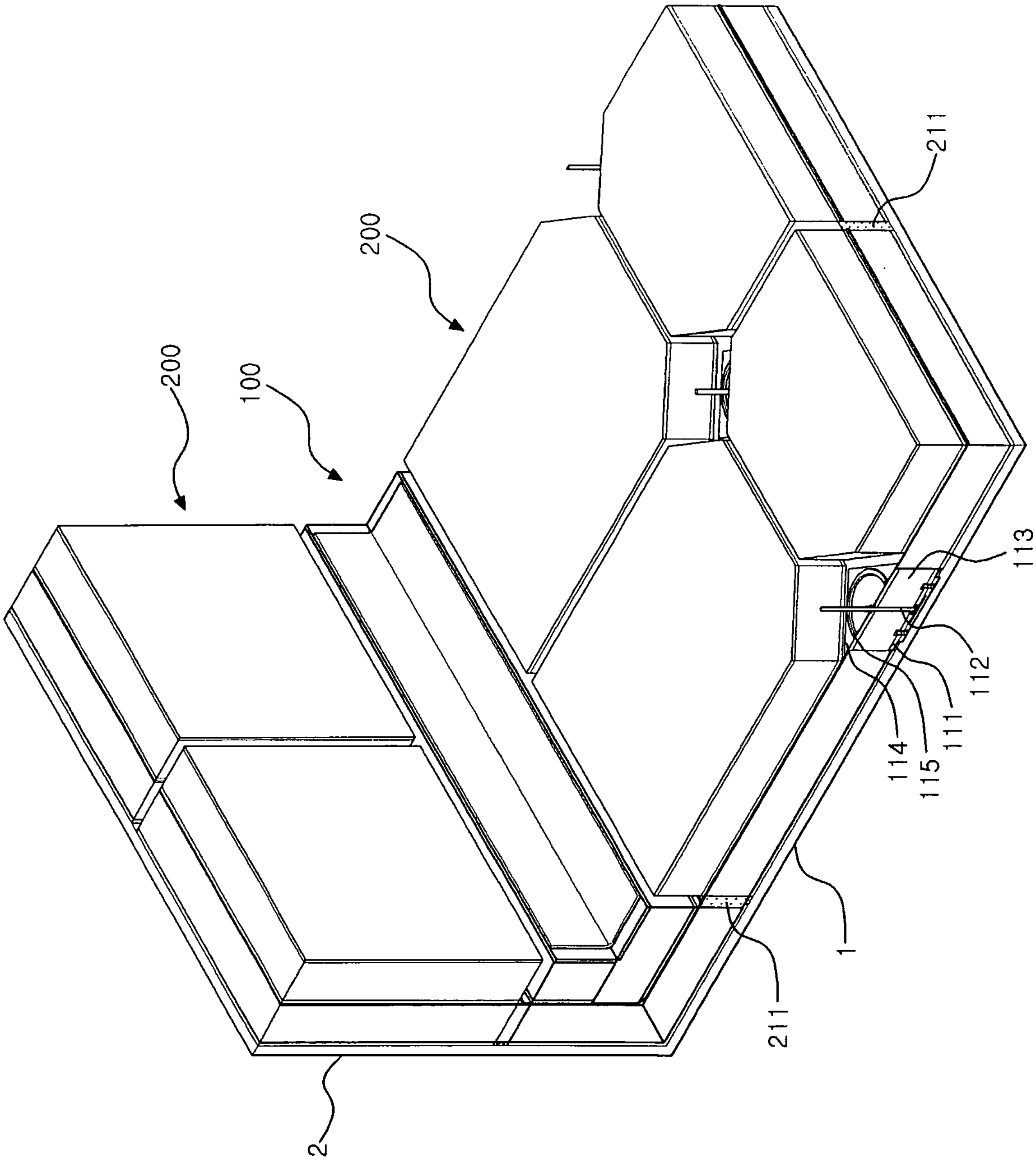
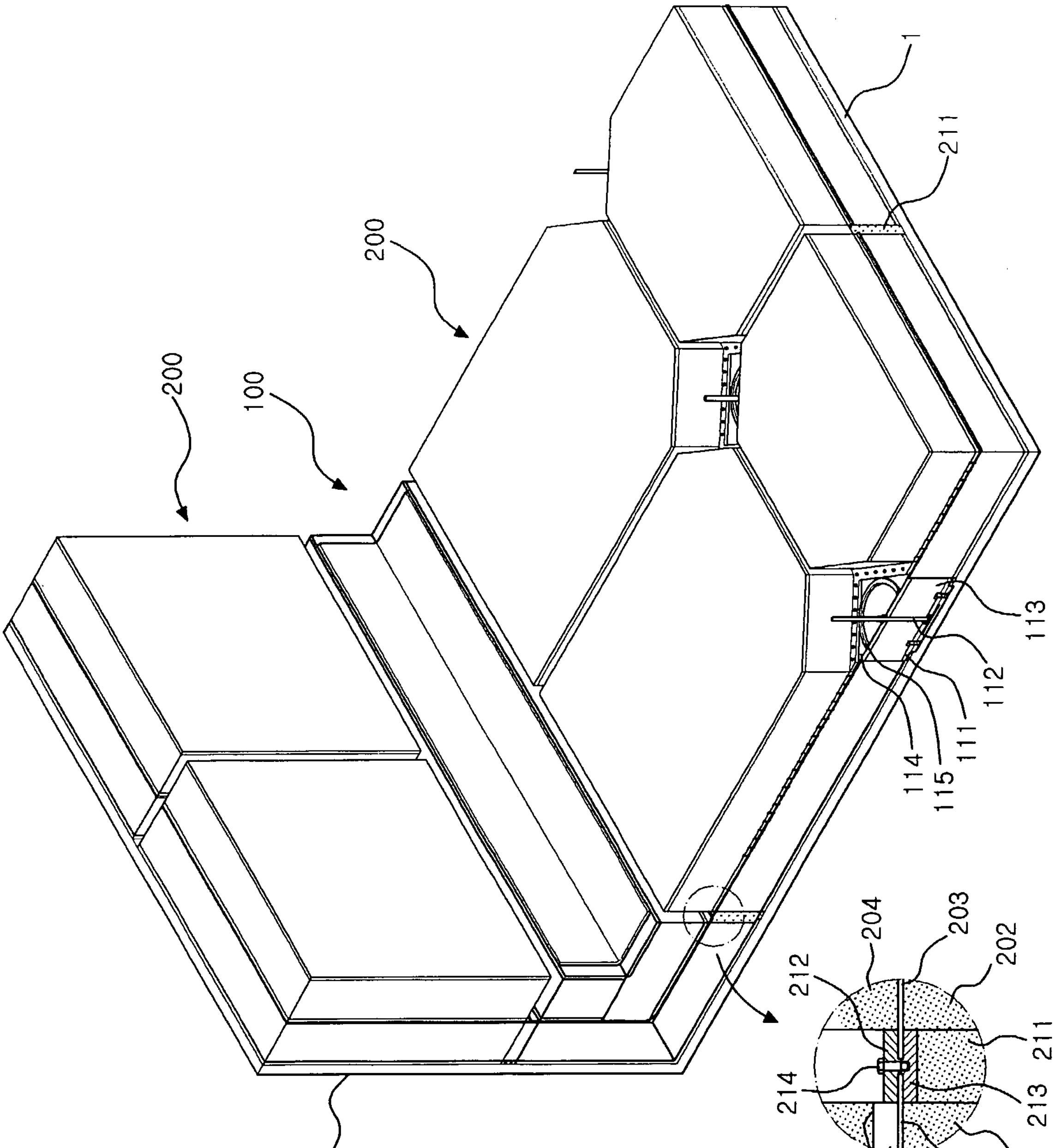
100
113
112
111
114
200
211
200
2

【FIG 16】



【FIG 17】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200
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214
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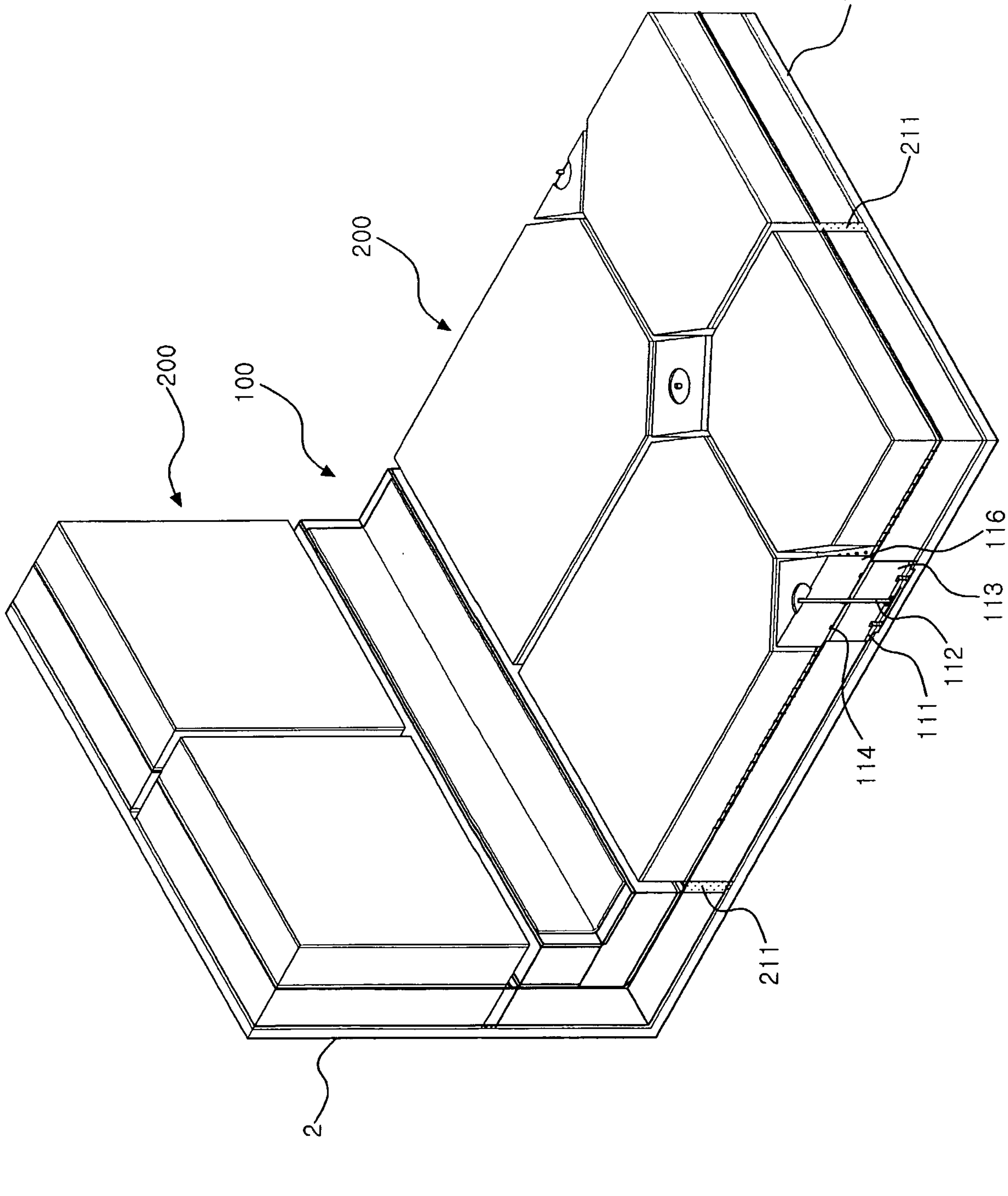
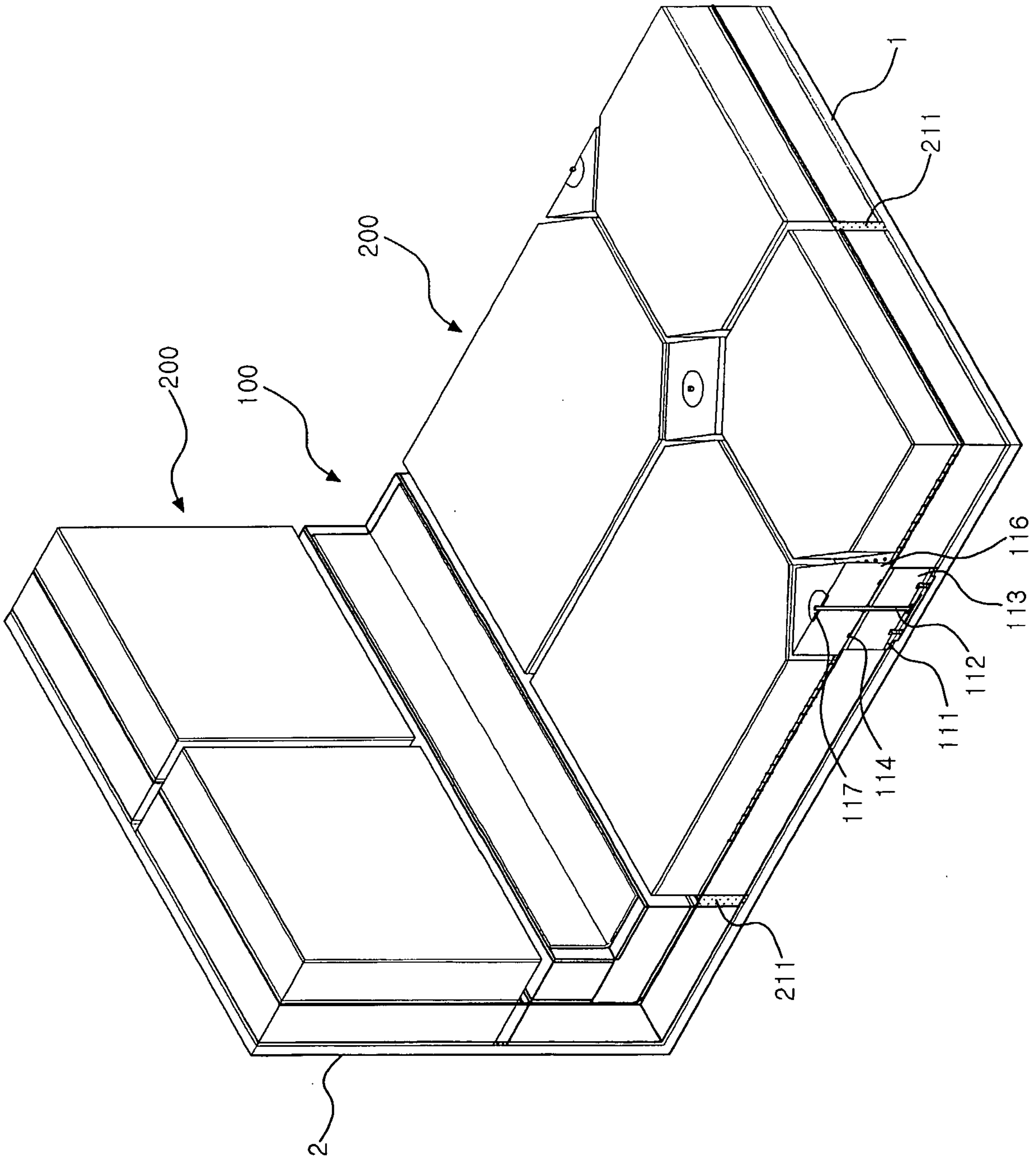
55

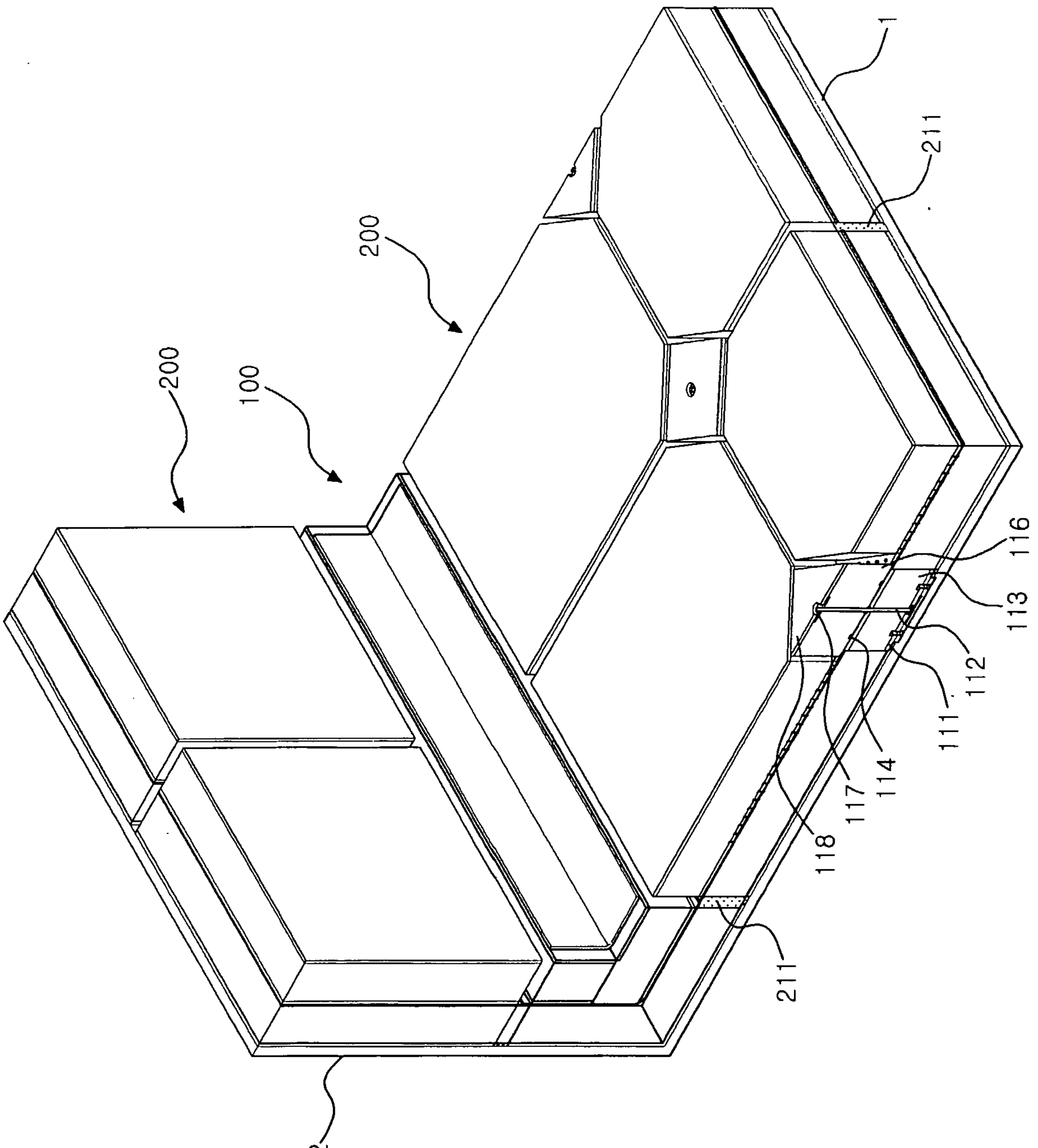
【FIG 18】



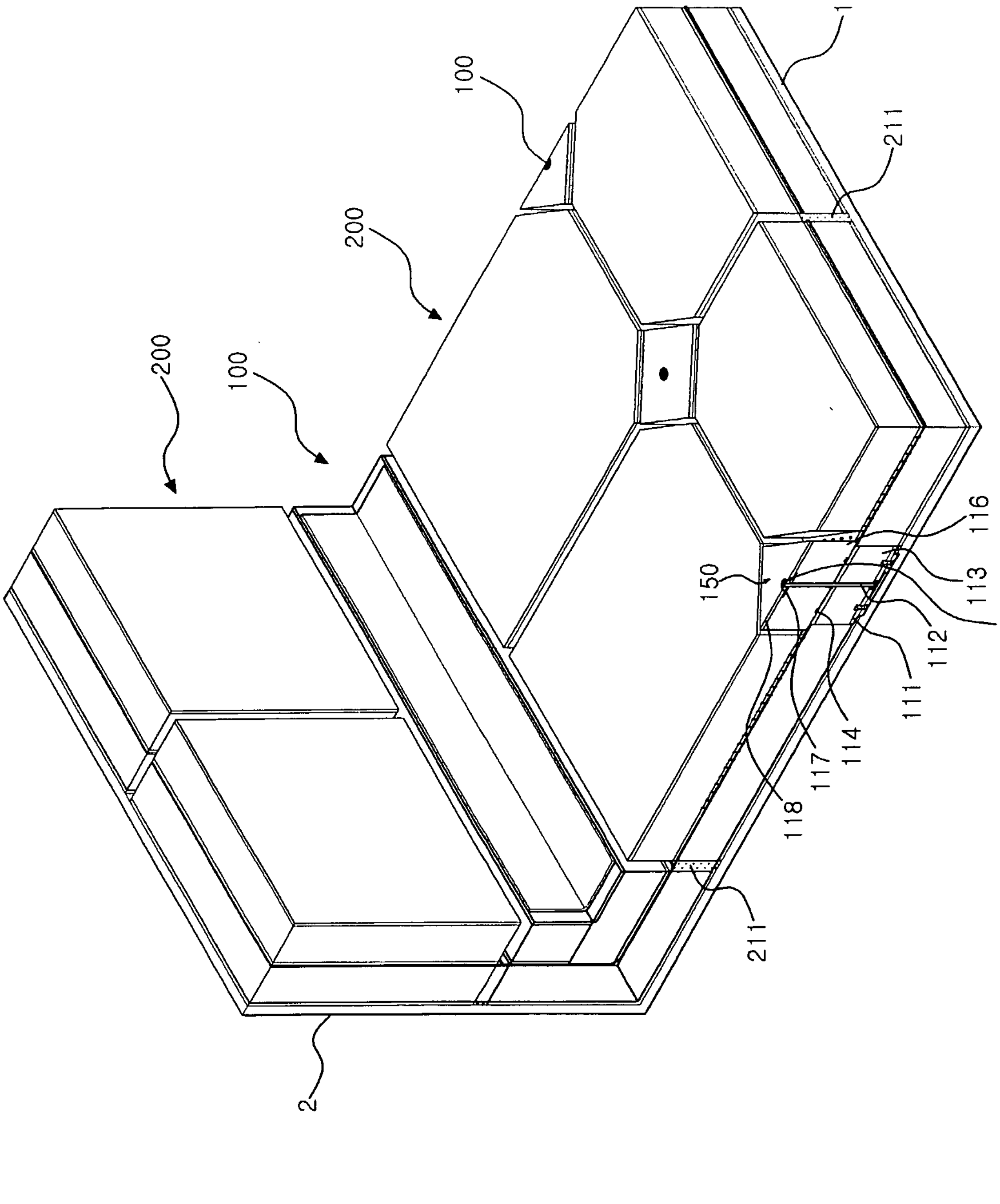
【FIG 19】



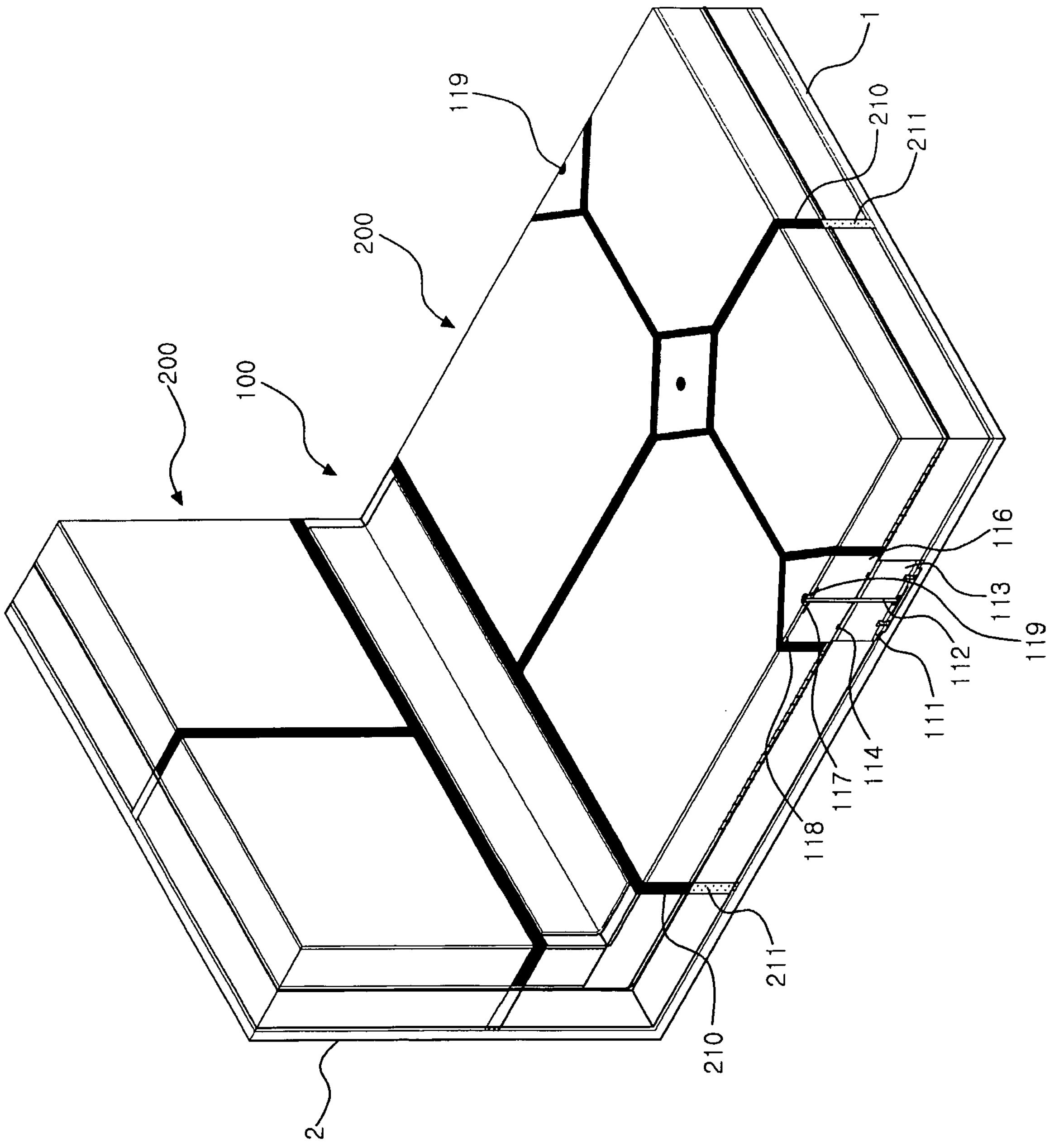
【FIG 20】



【FIG 21】



【FIG 22】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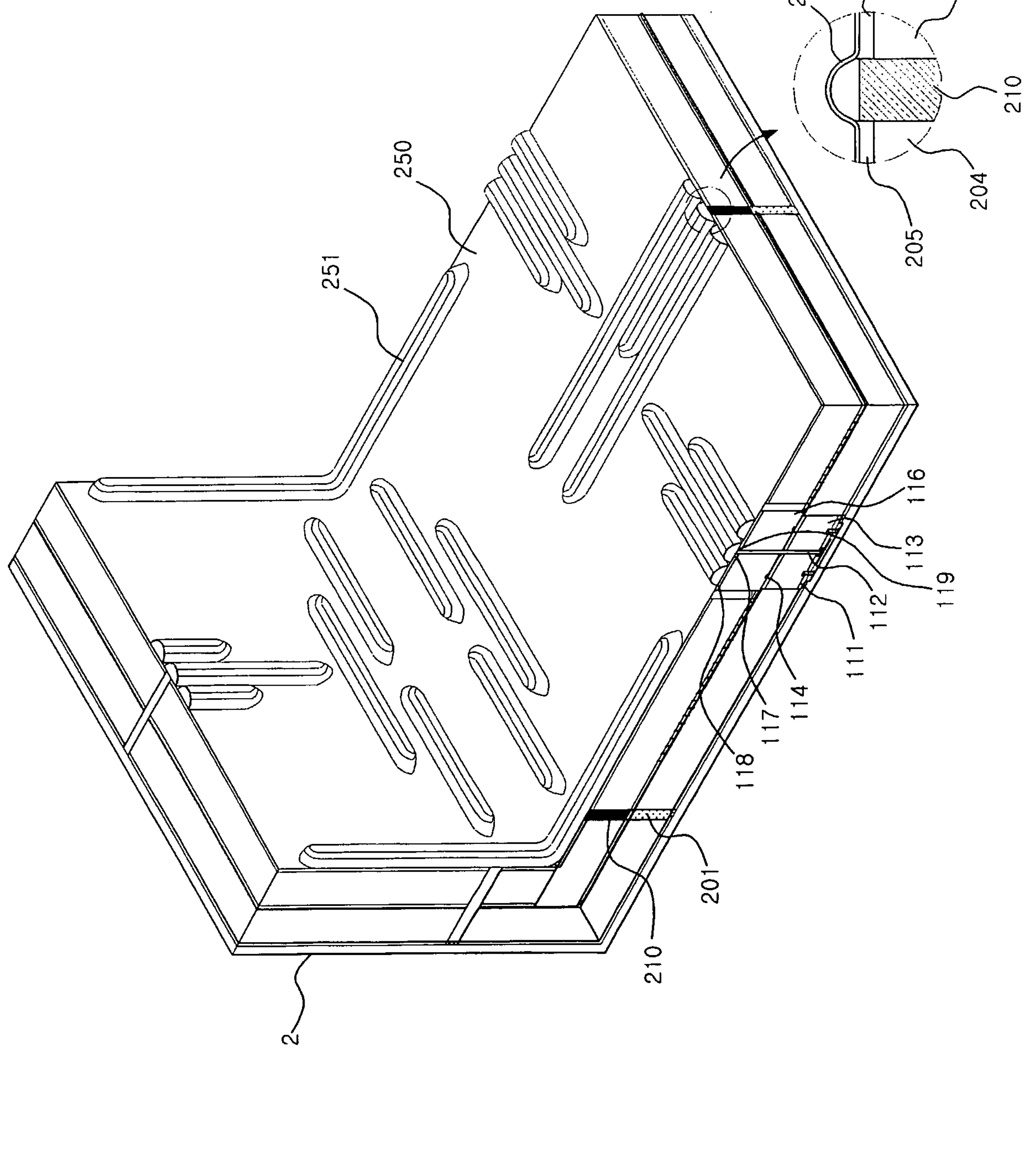
2

【FIG 23】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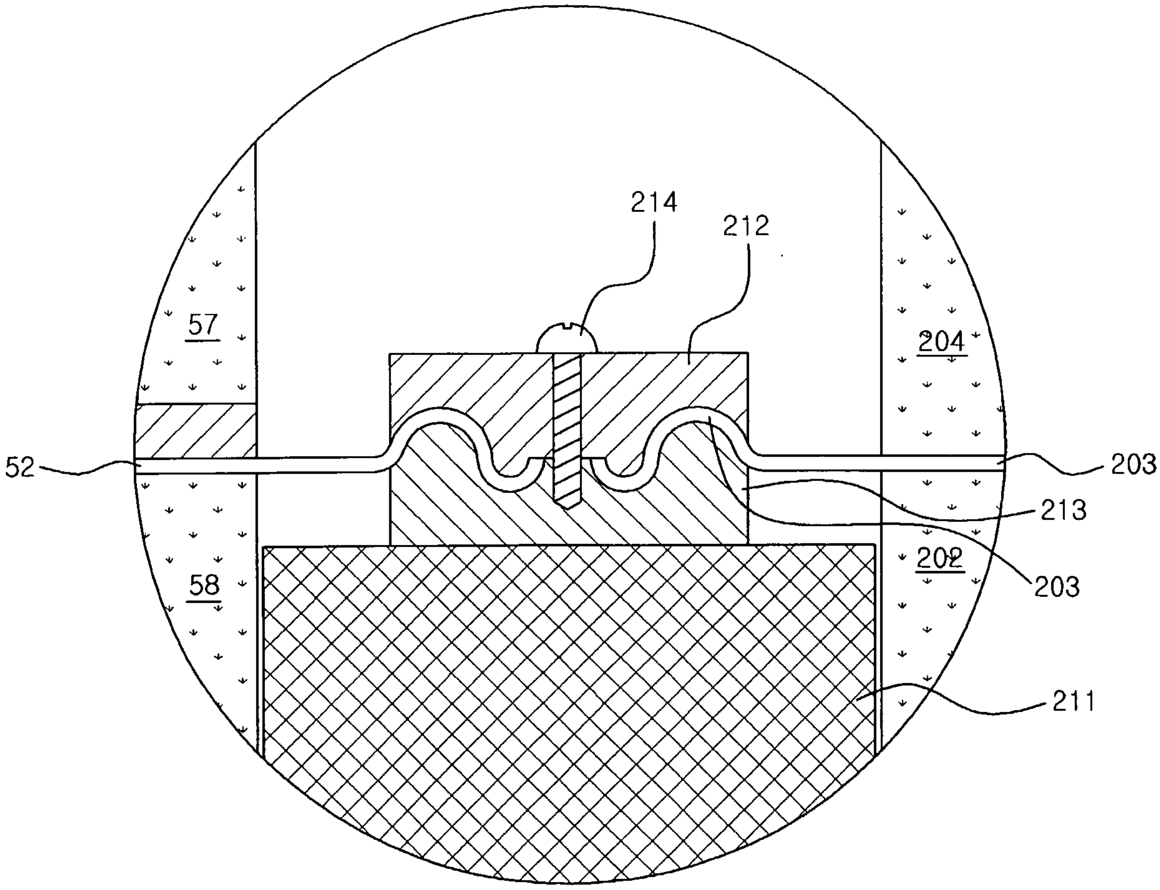
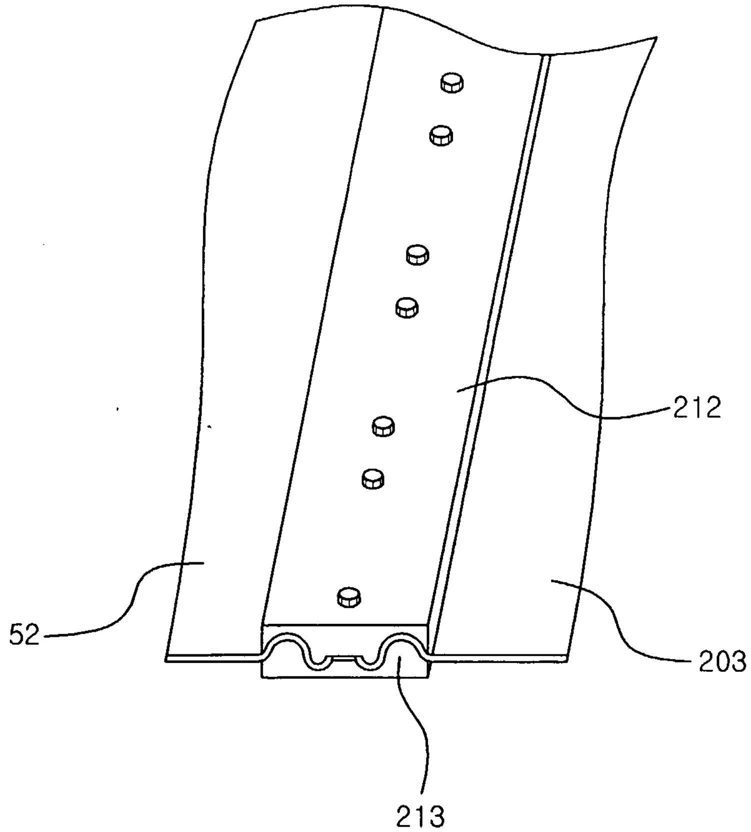
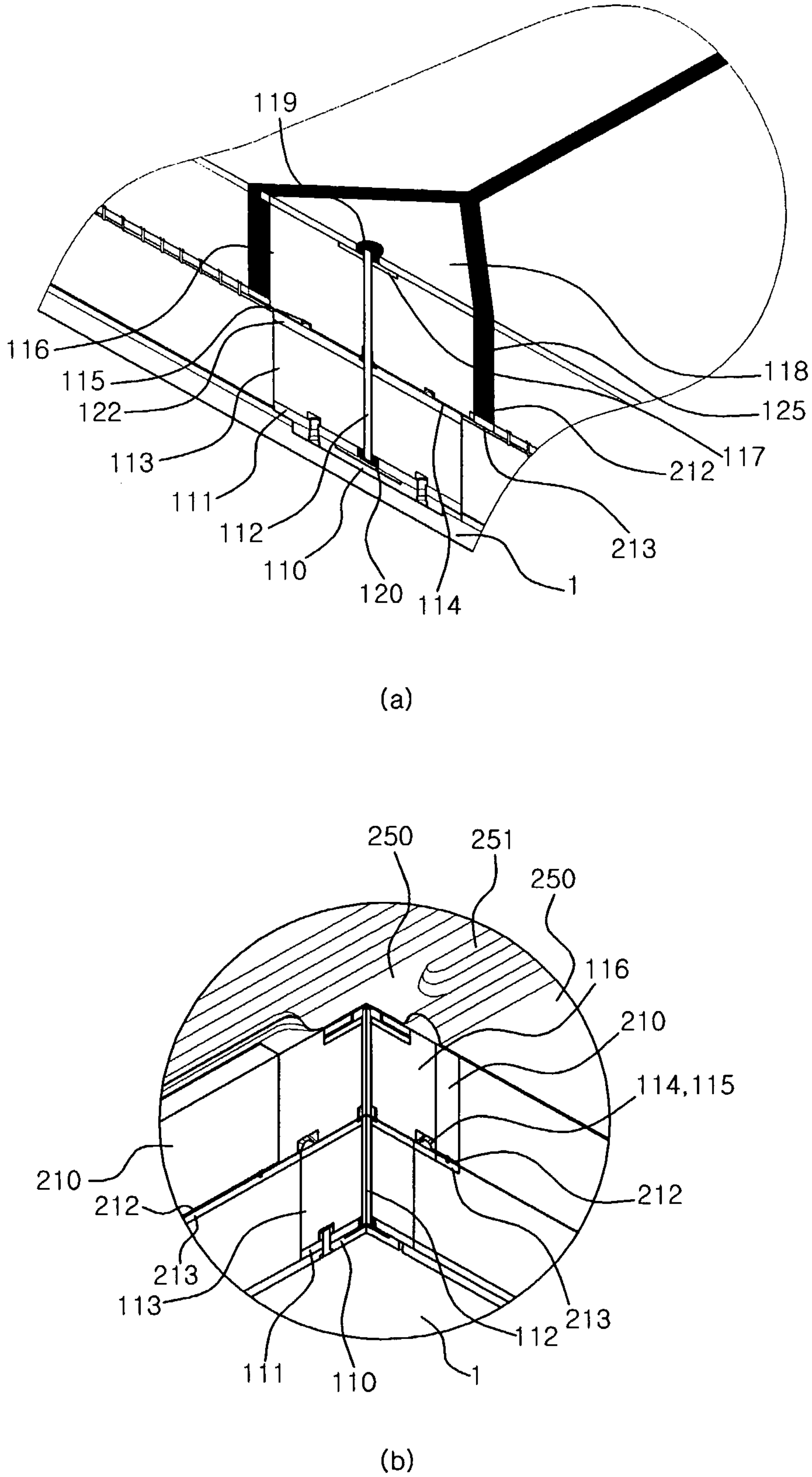
【FIG 24】



【FIG 25】



【FIG 26】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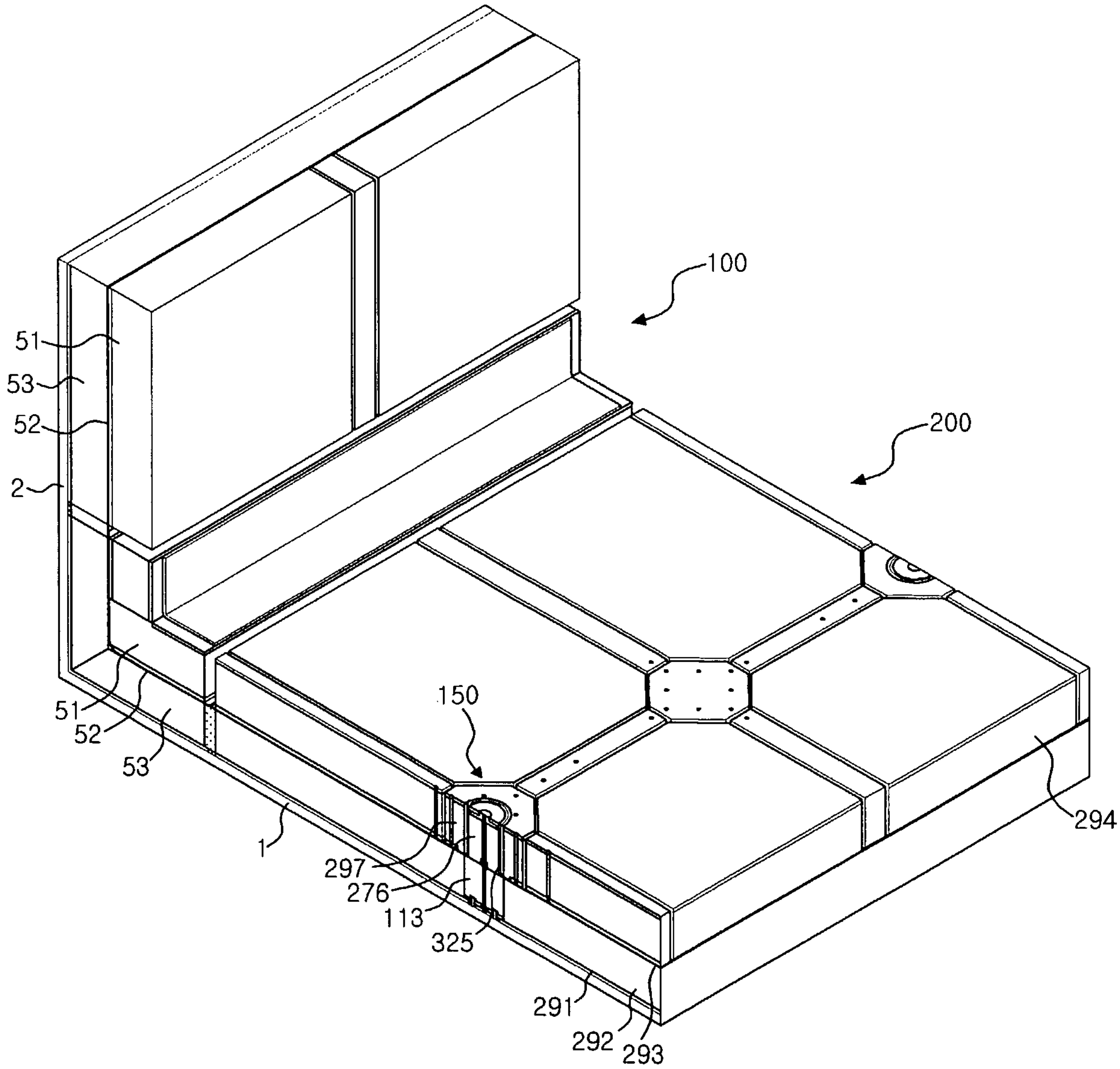
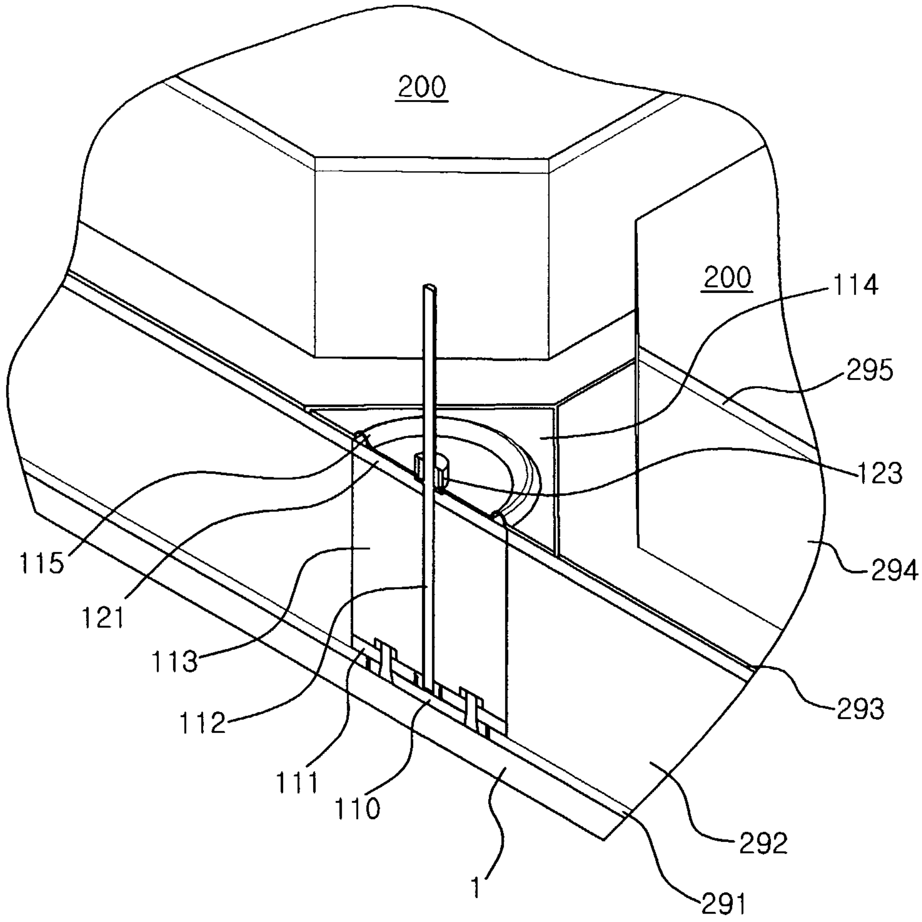
(b)

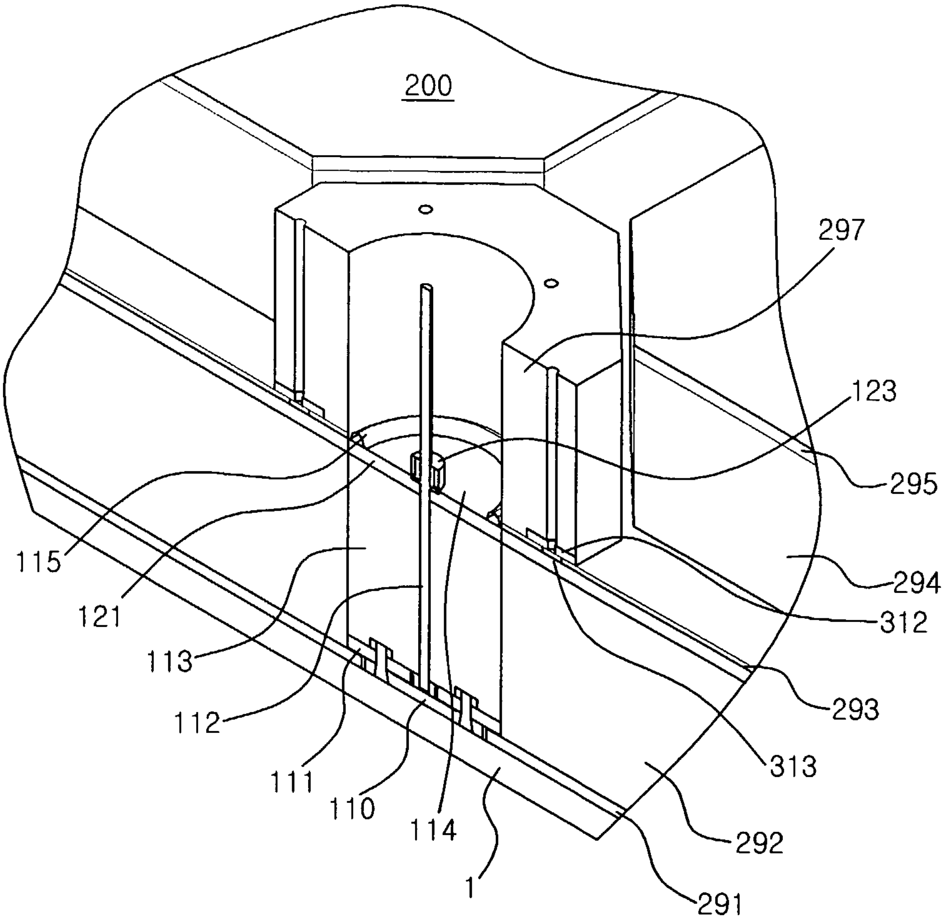
【FIG 27】



【FIG 28】



【FIG 29】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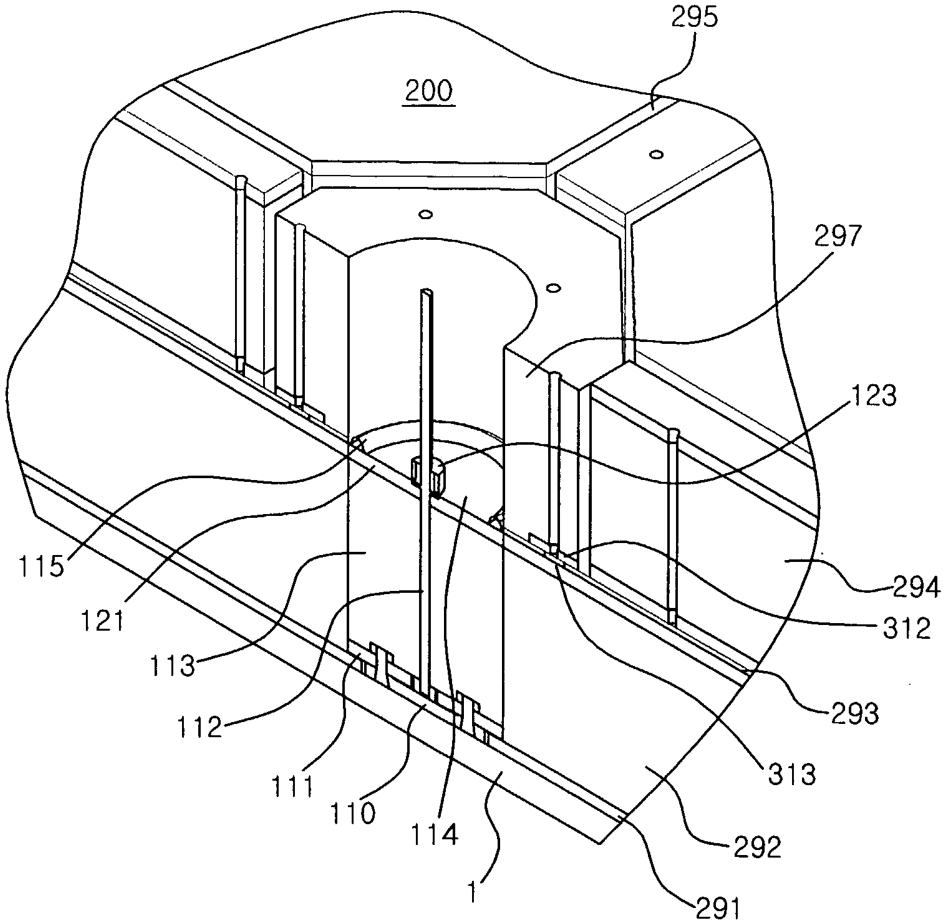
【FIG 30】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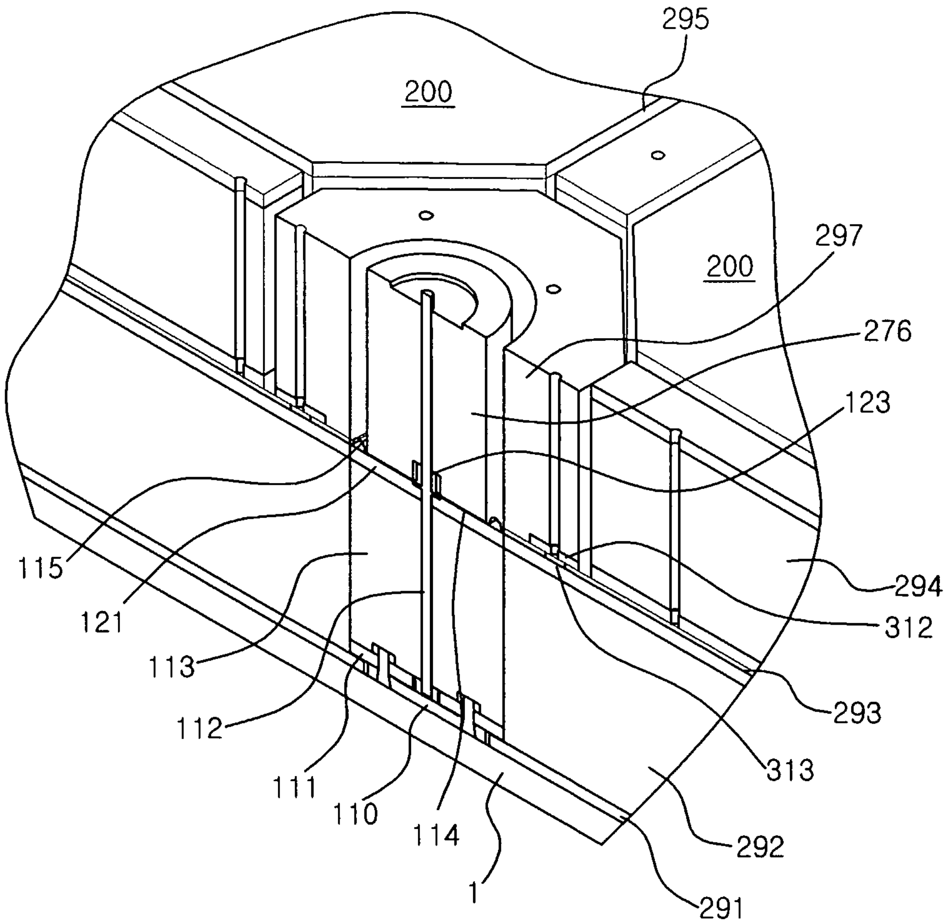
【FIG 31】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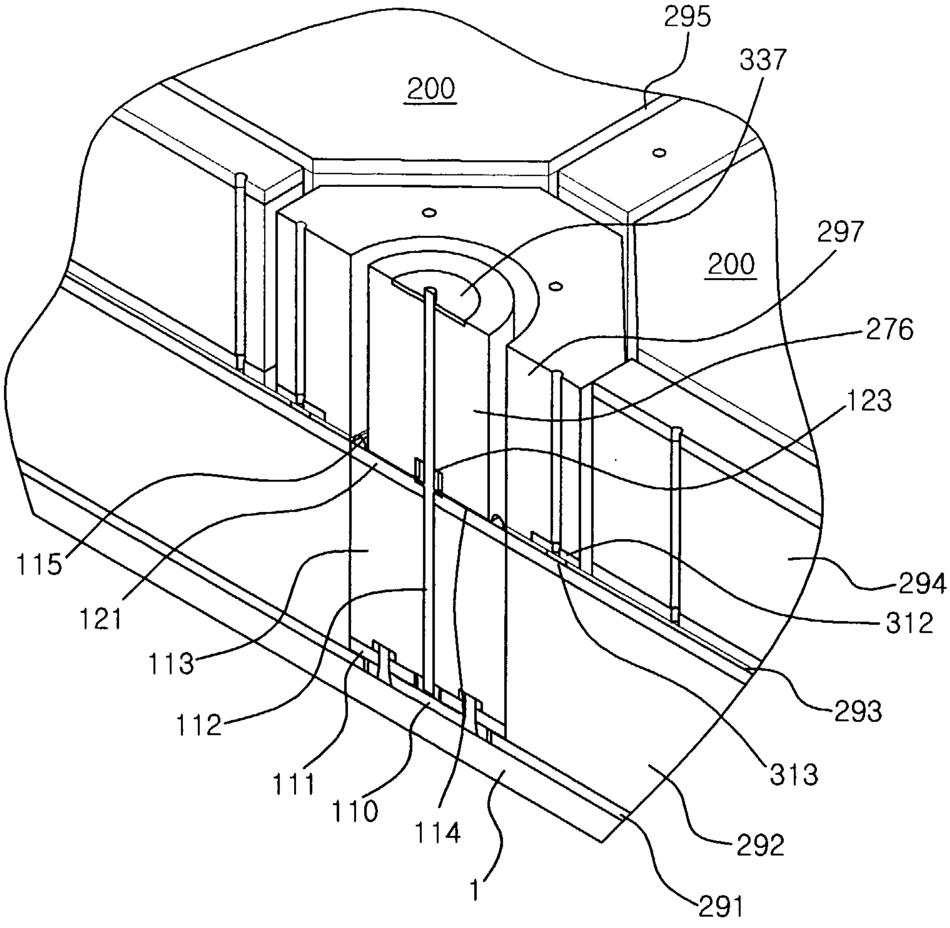
【FIG 32】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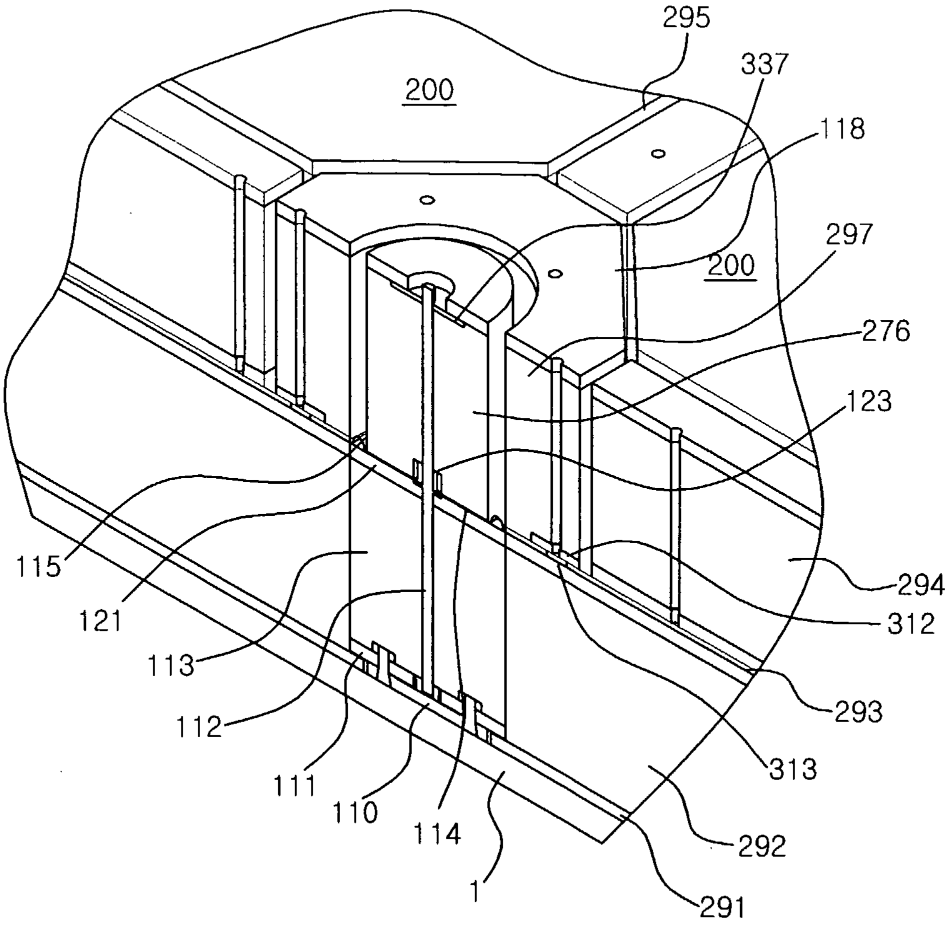
【FIG 33】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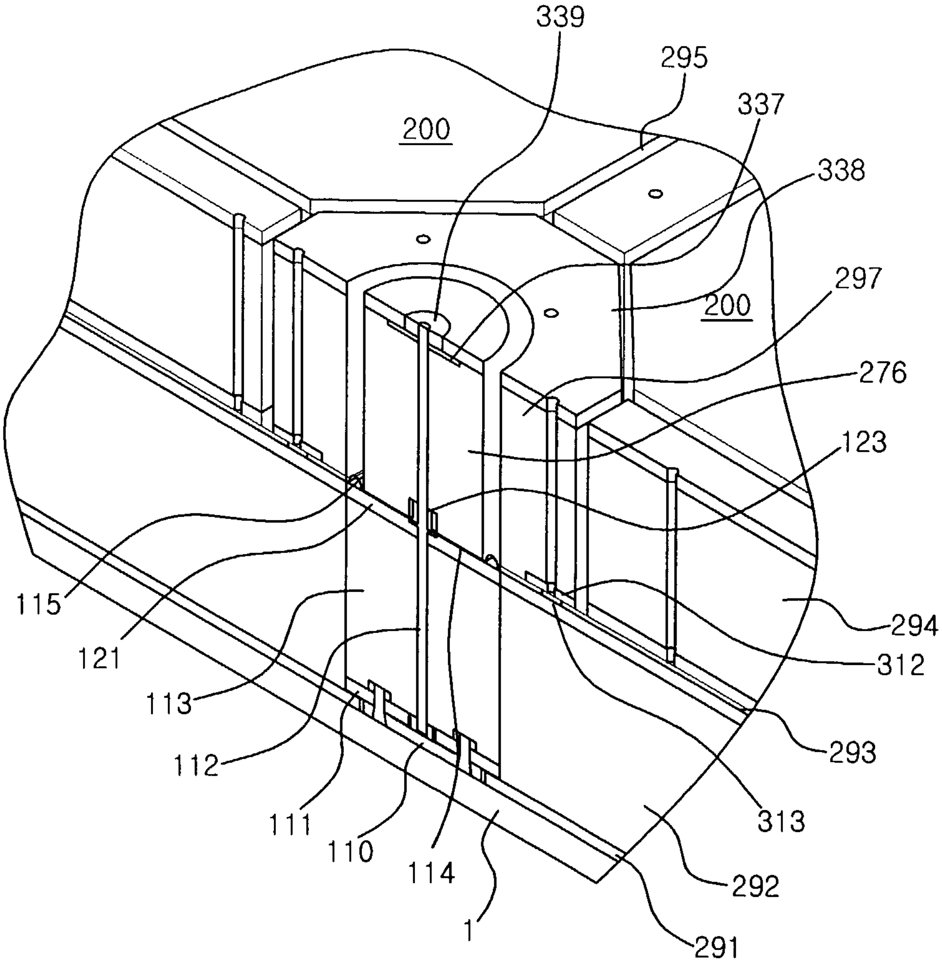
【FIG 34】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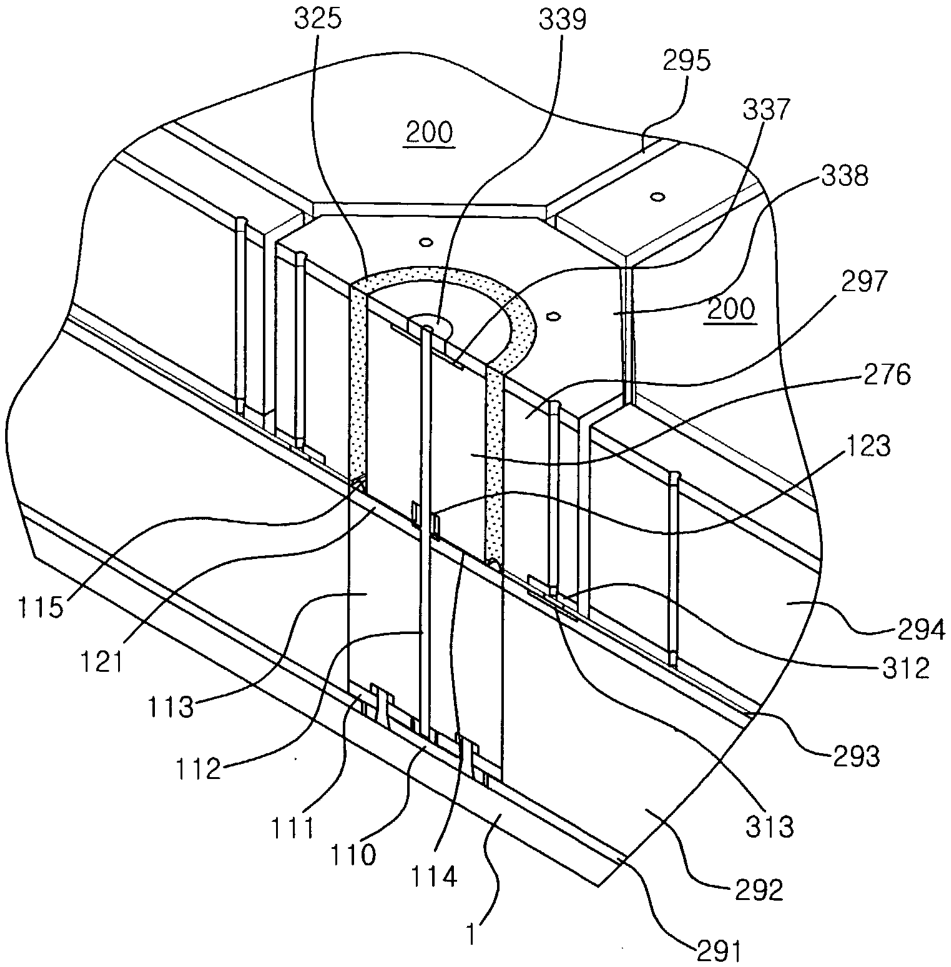
【FIG 35】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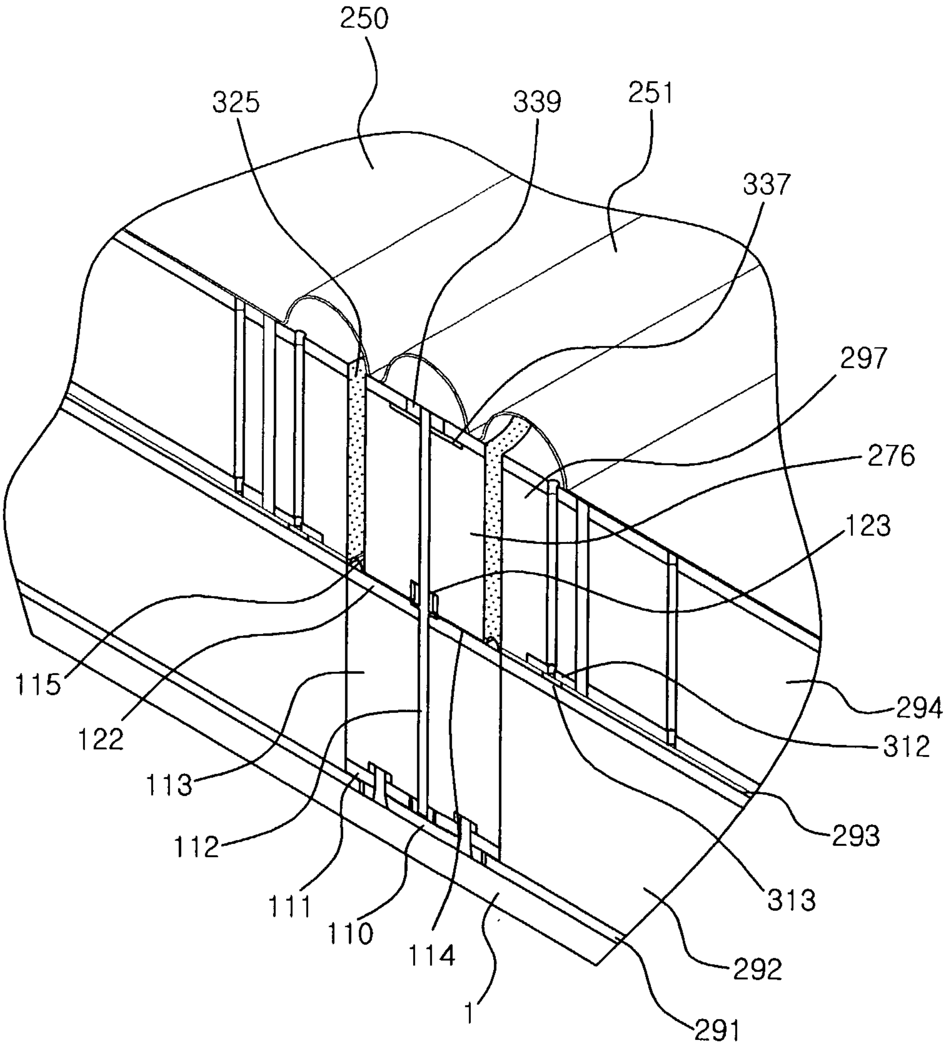
【FIG 36】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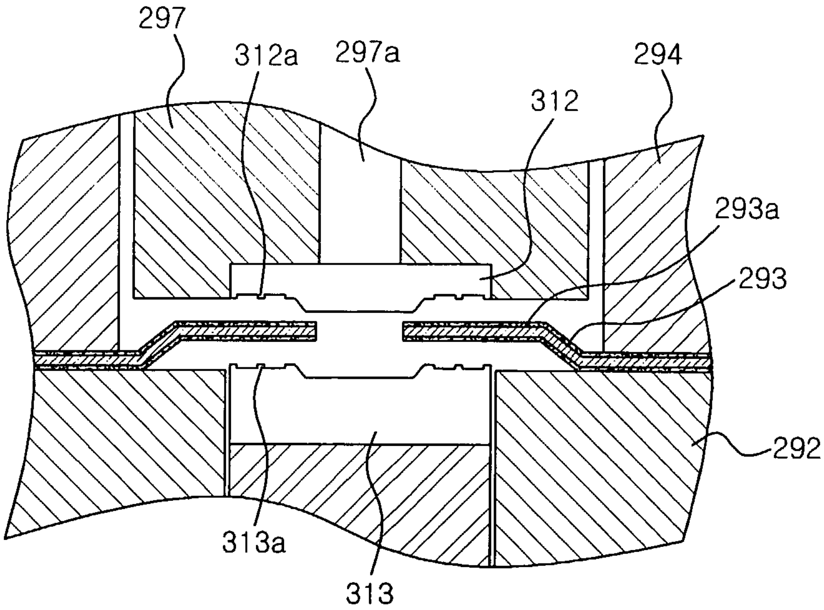
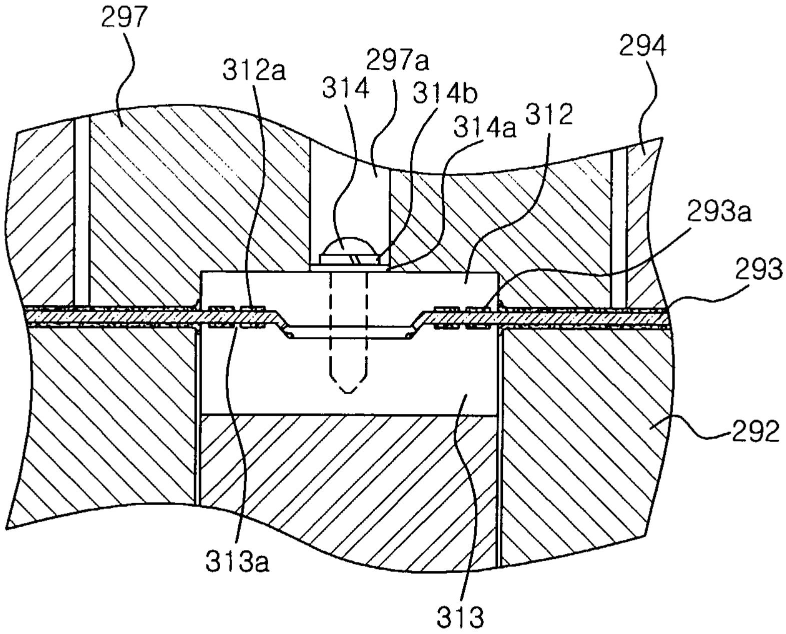
【FIG 37】



【FIG 38】



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2005/000327

A. CLASSIFICATION OF SUBJECT MATTER

IPC7 B63B 25/08

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)
IPC 7 B63B 25/08 B63B 25/16

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
KR : IPC as above
Korean Patents and applications for inventions since 1975
Japanese Utility models and application for Utility models since 1975

Electronic data base consulted during the intertnational search (name of data base and, where practicable, search terms used)
KIPO NPS System : "liquefied", "natural", "gas", "lng", "wall", "connect", "anchor", "bolt", "corner", "flange", "panel", "barrier", "seal*", "insulation" and "slid*"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4155482 A (OWENS-CORNING FIBERGLAS CORP.) 22 MAY 1979 See the whole document	1 - 45
A	JP 12 - 079987 A (GAZ TRANSPORT ET TECHNIGAZ) 21 MARCH 2000 See the whole document	1 - 45
A	JP 57 - 027600 U (GAZ TRANSPORT) 13 FEBRUARY 1982 See the whole document	1 - 45
A	KR 01 - 0050440 A (GAZ TRANSPORT ET TECHNIGAZ) 15 JUNE 2001 See the whole document	1 - 45

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

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"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
07 SEPTEMBER 2005 (07.09.2005)	**09 SEPTEMBER 2005 (09.09.2005)**

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Facsimile No. 82-42-472-7140	Telephone No. 82-42-481-8140

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/KR2005/000327

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JP 12 - 079987 A	21.03.2000	FR2781556B1 US6035795A	15.09.2000 14.03.2000
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