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Guilhem et al.

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[54] **INSULATED STORAGE TANK FOR LIQUID OR LIQUEFIED PRODUCTS**

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[30] **Foreign Application Priority Data**

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[51] **Int. Cl.²** **B65D 87/24;** B63B 3/68; B63B 25/08

[58] **Field of Search** ..... 220/9 A, 9 LG, 15, 9 F, 220/10; 52/573; 114/74 A

[56] **References Cited**

UNITED STATES PATENTS

2,922,287	1/1960	Rae	220/9 LG
3,357,585	12/1967	Morrison	220/9 F
3,399,800	9/1968	Gilles	114/74 A
3,403,651	10/1968	Gilles	220/9 LG
3,759,209	9/1973	Iarossi et al.	114/74 A
3,785,320	1/1974	Bourgeois et al.	114/74 A

FOREIGN PATENTS OR APPLICATIONS

791,488	8/1968	Canada	220/9 A
455,853	7/1968	Switzerland	220/15
1,183,891	3/1970	United Kingdom	220/15

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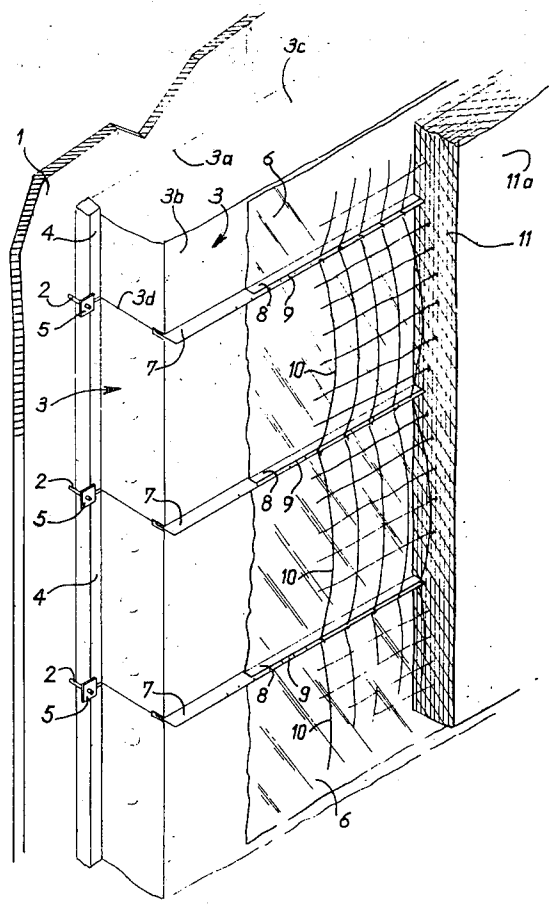
[57] **ABSTRACT**

A leakproof and isothermal tank for the storage or the transportation of a liquid or of a liquefied product is provided which includes a primary leakproof assembly in contact with the product contained in the tank and a secondary assembly located between the primary assembly and the tank carrying structure, the secondary assembly comprising boxes filled with a heat insulating material and held directly against the carrying structure and a secondary leak-proof barrier of metallic sheets having edges projecting toward the inside of the tank which are welded together, and the primary assembly comprising a layer of plastic foam disposed between the product contained in the tank and said secondary leakproof barrier.

1 Claim, 3 Drawing Figures



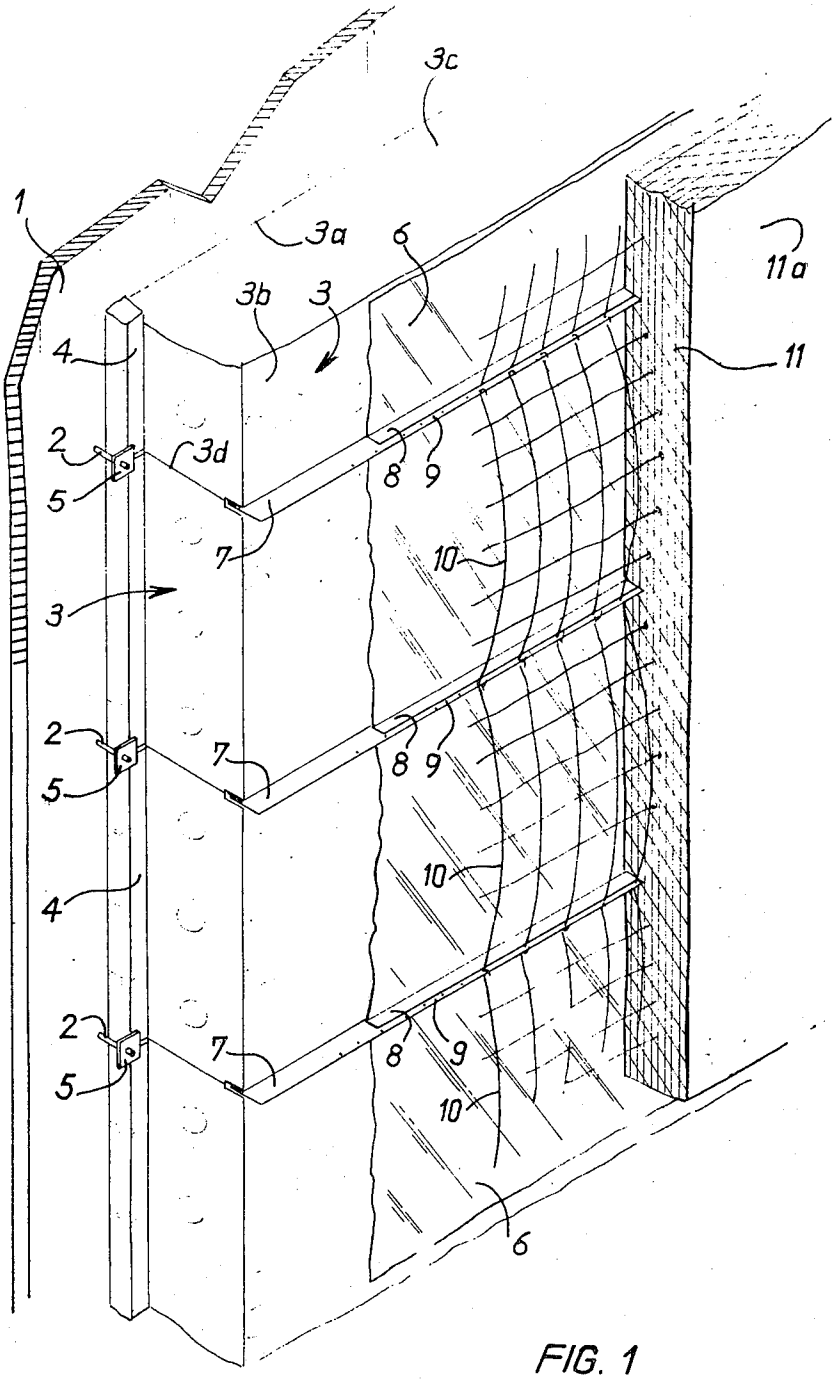


FIG. 1

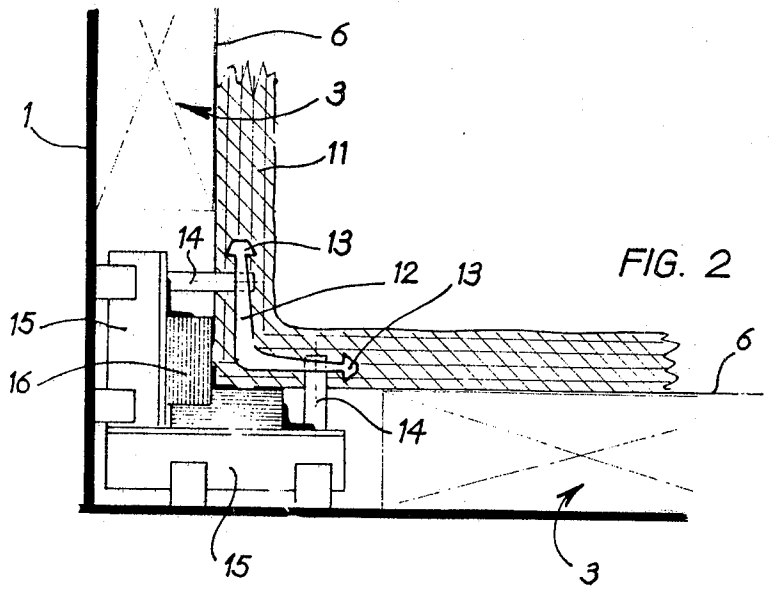


FIG. 2

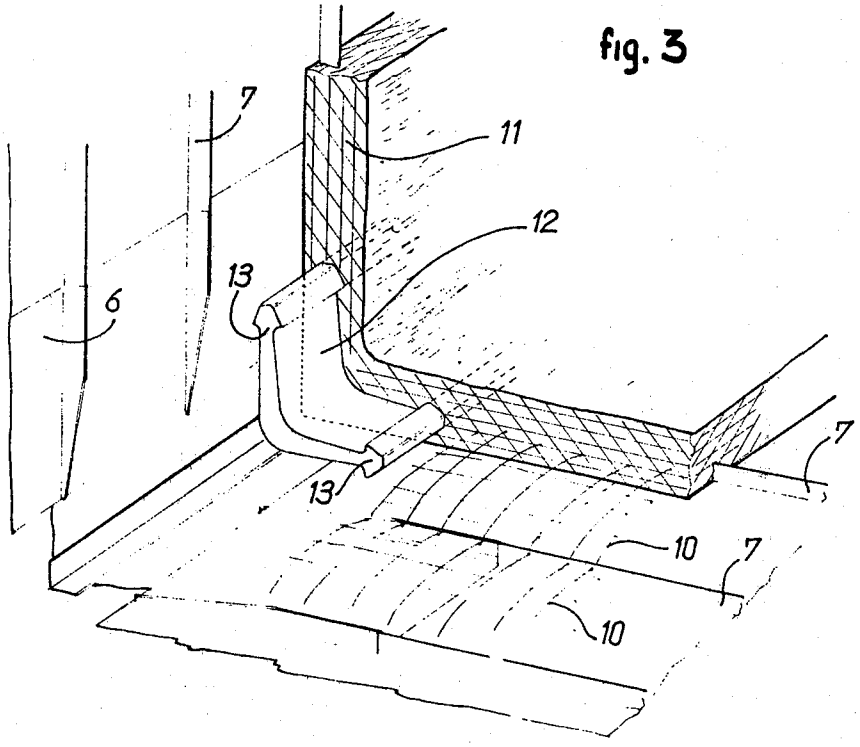


fig. 3

INSULATED STORAGE TANK FOR LIQUID OR LIQUEFIED PRODUCTS

The present invention relates to the storage of liquid or liquefied products inside insulating tanks, and more especially, to the storage of low temperature liquefied gases, such as liquefied natural gases having a high methane content. The tanks according to the present invention prove especially useful in the form of tanks integrated to the structure of a ship, said tanks making it possible to transport liquefied gases by sea.

Insulating tanks are known which consist of two successive water-tight barriers, a primary one in contact with the product contained in the tank, and a secondary one, located between the primary barrier and the carrying structure of the ship, said two water-tight barriers being alternated with two insulating barriers, the secondary insulating barrier consisting of boxes filled with a heat-insulating material, directly affixed against the double hull or the double wall of the ship, by means of ordinary threaded pins fixed to said walls, the secondary water-tight barrier consisting of metallic invar sheets, the edges of which are raised toward the inside of the tank, the height of which is approximately equal to the height of the aforementioned heat-insulating boxes, said metal sheets being welded edge to edge by their raised edges, on the two faces of a metal wing which can slide with respect to the underlying insulating barrier, the primary insulating barrier consisting of boxes filled with a heat-insulating material and the primary water-tight barrier being constituted as the aforementioned secondary water-tight barrier, the assembling of the metal sheets of the primary barrier, among themselves being done by welding of their raised edges on the two faces of a rectangular flat sheet hooked by a sliding joint on one of the sides of each one of the boxes; said tanks are characterized by the fact that in the first place the metallic wing which serves for the edge to edge welding of the metallic sheets of the secondary tightness barrier is inserted in the planes of horizontal joints of the heat-insulating boxes of the secondary insulating barrier, and held, with respect to those boxes, by means of a sliding assembling, and by the fact that in second place, clamps are positioned from place to place, along said aforementioned metallic wings, and are affixed to said wings, each clamp being, in addition fixed by means of a member which presents an elastic deformation in the direction perpendicular to the secondary water-tight barrier, means of fixation which insures the connection of the boxes of heat insulating material of the primary insulating barrier with the aforementioned metallic wing.

The present invention has as its object the new industrial product constituted by a leakproof and isothermal tank, means for the storing or the transportation of a liquid or liquefied product, said tank comprising successive assemblies of water-tight and of thermal insulation barriers, a primary assembly in contact with the product contained in the tank, and a secondary assembly located between the primary barrier and the tank carrying structure, the secondary insulating barrier consisting of boxes filled with a heat-insulating material and directly affixed against the carrying structure by means of threaded pins fastened to the walls of said structure, the secondary water-tight barrier comprising metallic sheets the edges of which project toward the inside of the tank, the height of which is approximately

equal to the height of the aforementioned boxes of heat-insulating material, said sheets being welded edge to edge by their projecting or raised edges over the two faces of a metallic flange the metallic flange which serves for the edge to edge welding of the water-tight sheets of the secondary water-tight barrier being inserted in the planes of horizontal joints of the heat-insulating boxes of the secondary insulating barrier, and being retained with respect to said boxes, characterized by the fact that the primary water-tightness and thermal insulation barriers are constituted by a layer of plastic foam having a low thermal contraction or expansion coefficient within the range of the temperature used, said layer being inserted between the product contained in the tank and the secondary water-tight barrier.

In one preferred mode of execution, there are provided for, between two adjacent metallic wings or flanges which serve for the edge to edge welding of the metallic sheets of the secondary water-tight barrier, metallic screens or grids hooked to said wings or flanges, said screens or grids being entirely contained within the thickness of the layer of plastic material foam which constitutes the primary barrier; the plastic material foam has a surface skin which makes it possible to insure water-tightness, constituting a primary leakproof barrier; the plastic material foam is applied on the secondary water-tight barrier by projection with a gun; the thermal contration or expansion coefficient of the foam of plastic material, within the range of the temperatures of use, is less than 50×10^{-6} per degree centigrade; the carrying structure of the tank is the double hull or the double wall of a ship; the layer of plastic material foam is re-enforced in the tank angles by means of a corner iron buried inside the layer of foam, said corner iron just mentioned has the profile of a square and it has, on both arms of the square, anchoring elements; the aforementioned corner iron is made of plastic material or of metal.

In one embodiment, the layer of plastic foam material, which constitutes the primary barrier, is made of blocks of plastic foam material, prefabricated and placed side by side and joined together in situ by the setting into place of joints, preferably of plastic foam material, said setting into place or tuck pointing being preferably simultaneously executed with a thin coating placed over the whole surface of the plastic foam material. Said manner of operation makes it possible to limit the quantity of plastic foam material to be set into place in situ by gun projection; in that case, it is possible to provide for a screen or grid placed in a manner such that the blocks of plastic material are maintained in place between the screen or grid and the secondary tightness barrier, the screen or grid being buried by the layer of plastic foam material which is set into place by gun projection.

It will be possible advantageously to use, as plastic foam materials meant to form the primary barriers, foams which are obtained by expansion of the polystyrene type of materials, or polyurethane or polyvinyl chloride type of materials, without said indications being in any way limitative from the point of view of the type of plastic material to be used. The plastic foam materials which are meant to form the primary leakproof barrier may advantageously have a volume mass ranging between 20 kg/m^3 and 150 kg/m^3. The screen or grid placed between the metallic wings or flanges of

the secondary leakproof barrier may advantageously have from 5 to 20 meshes per meter; it is necessary to specify that said screen or grid serves both for the mechanical anchoring of the layer of plastic foam material on the secondary barrier, for the limitation of the thermal contraction or expansion of the layer of foam, and for the mechanical re-enforcing of said layer, especially for the purpose of improving the resistance of the whole to vibrations.

In a first variation of the invention, the metallic wing or flange which serves for the edge to edge welding of the metallic sheets or plates of the secondary leakproof barrier is the central element being enclosed over part of its width, between two laths, made of wood, for example, the sliding assembly resulting from the fact that the aforementioned composite beam is inserted between two adjacent heat-insulating boxes of the secondary insulating barrier, so that the laths of the composite beam are retained in the direction of the inside of the tank by elements which are affixed to the boxes of the secondary insulating barrier. In a second variation, the sliding assembly of the metallic wing or flange which serves for the edge to edge welding of the metallic sheets or plates of the secondary leakproof barrier is constituted by a sliding joint formed by the bent edge of the aforementioned metallic wing, and by the bent edge, in the opposite direction, of a metallic strip affixed to the edge of one of the horizontal faces of each box of the secondary insulating barrier, a horizontal lath which constitutes a stopping wedge or block for the folds of the sliding joint being inserted between the sliding joint and that of the heat insulating boxes which does not carry the aformentioned metallic strip, the whole constituted by the sliding joint and its stopping-wedge-forming lath being placed in longitudinal hollowed out portions recessed along the edges of the horizontal faces of each box of the secondary insulating barrier.

In a known manner, the metallic wing or flange, on both sides of which there are welded the metallic sheets or plates of the secondary leakproof barrier, consists of a strip made of steel which contains a high percentage of nickel, and preferably of invar; the metallic sheets or plates which constitute the secondary leakproof barrier are generally constituted also of steel sheets with a high percentage of nickel, and preferably of invar.

When the first variation is used, which has been mentioned above, the laths which enclose the central wing of each composite beam, are wooden laths, cut into sections of equal length, the sections of the upper and of the lower laths or battens being accurately superposed, and two successive sections being separated by a space inside which the composite beam is reduced to its central wing. The elements which are affixed to the boxes of the secondary insulating barrier, which elements ensure the holding of the laths of each composite beam, are tenons or studs affixed along one edge of each heat-insulating box which has the shape of a parallelpipede-rectangle; the laths of the composite beam are affixed to the central wing of said beam by hooking.

When the second one of the abovementioned variations is used, the boxes of heat-insulating material which form the secondary insulating barrier have on the inside along the horizontal edge on which there is fixed the bent strip which constitutes a part of the sliding fixation joint, a re-enforcing stud or tenon, possibly constituted by several elements distributed side by side over the whole length of the box; the fixation, on the box of heat-insulating material, of the bent strip which constitutes one of the parts of the sliding joint of the secondary barrier, is done by means of screws which run through the wall of the heat-insulating material and which penetrate into the re-enforcing tenons placed inside the box; each box of heat-insulating material which constitutes the secondary insulating barrier has horizontal faces which are extended toward the outside of the box, beyond the vertical faces which are perpendicular to the wall of the carrying structure of the tank, each one of said extensions carrying near the wall of the carrying structure an anchoring tenon joined with said extension, for example, by hooking or by gluing. The four adjacent hooking tenons of four boxes of heat-insulating material which are adjacent in the secondary insulating barrier, may be held with respect to the tank carrying structure by means of a fixture consisting, for example, of two square shaped plates, one wing of each plate being fixed by a threaded pin and nut on the hull or bulkhead of the ship, the other two wings being joined together by bolting.

In order to better understand the object of the invention, there is now described, by way of example which is purely illustrative and not limitative, an embodiment shown in the accompanying drawings.

In the drawings:

FIG. 1 represents in perspective, with parts broken away, one view of an assembly of primary and secondary barriers which constitute the tank according to the invention;

FIG. 2 is a section of a corner of the tank of the invention, perpendicular to the edge of said corner; and

FIG. 3 represents, in perspective, with parts broken away, elements of FIG. 2;

The embodiment, which is described by way of example is a tank disposed in the interior of a ship adapted to transport liquefied natural gases principally methane. The structure supporting the tank consists of a double supporting hull 1 of a ship. Hull 1 contains threaded pins 2 welded perpendicularly to said bull. The pins 2 are welded in vertical rows interiorly spaced according to the height of a parallelpiped rectangular box 3 adapted to form a secondary insulating barrier. The spacing of two adjacent rows of pins 2 determines the length of boxes 3, the said boxes being disposed in such a way there is a pin 2 at each of their corners. The boxes 3 are made, for example, of wood; they contain a thermal insulating product, preferably "perlite." The faces of boxes 3 which are supported by hull 1 are designated 3*a* and the opposing faces 3*b*. Each box 3 consists vertically, on each side of the face 3*a*, of tenons 4, which are fastened on the vertical lateral faces of each box 3. In the zone of intersection of four adjacent boxes 3 a space permits the passage of pin 2; the end of pin 2 is threaded and cooperates with a nut which supports a square clamping plate 5. Each clamping plate 5 thus simultaneously permits securing four corners of four adjacent boxes. The boxes 3 are piled one above the other along the hull 1 between the rows of pins 2 and they are fixed to the hull 1 by plates 5 which are mounted on tenons 4 of four adjacent blocks 3. The spaces between the boxes 3 are filled with rock wool to provide thermal insulation.

Between two horizontal rows of boxes 3, there is disposed a metallic flange 7 of invar steel, approximately

perpendicular to the hull and running along the length of the horizontal joints between two different boxes **3**. The superposition of boxes **3** having formed a secondary insulating barrier, there is disposed on the faces **3***b* of boxes **3** smooth metallic sheets **6** with turned up sides **8**, the distance separating the two turned up sides **8** of the same metallic member **6**, being equal to the distance separating two consecutive metallic flanges **7** of the secondary thermal barrier. By automatic welding the fixing of the turned up portions **8** of two members **6** disposed one above the other is effected, the sides **8** enclosing between them flanges **7** and the weld thus solidifying the three thicknesses of metal. A secondary watertight barrier is thereby obtained.

On the lips of metallic flanges **7** perforations **9** are spaced regularly along the length of each flange **7** and wires are hooked in the perforations to form a grill **10** which is disposed on two adjacent flanges **7**, forming a secondary watertight barrier. A plastic material adapted to form in situ a layer of expanded plastic material **11** is applied with a gun to grill work **10**. The layer **11** may consists, for example, of a closed cell polyurethane foam. The setting of the bed or layer **11** occurs with the formation of a skin surface **11***a*. The grillwork **10** comprises about 10 meshes per meter. The layer **11** has a thickness of about 10 cm. The mass volume of the foam which constitutes layer **11** is about 50 kg/m^3. It may be stated that the grillwork **10** not only permits the fastening of the layer **11** on the secondary barrier, but equally, constitutes a mechanical reenforcement of layer **11** and permits limiting thermal contractions and expansion of layer **11** in contact with liquefied gas which may be introduced into the tank. In order to reenforce layer **11** in the zone at the lower corners of the tank, an angle member **12** of plastic material is set in place. The angle member **12** has a right angle profile and each of the arms of the angle terminates in a protuberance **13** having a trapezoidal cross section. The angle member **12** is sunk in the interior of the layer **11** and it is anchored in the interior of the layer by means of the trapezoidal protuberances **13**. The angle member **12** is supported by tubular elements **14** which are themselves fixed, by intermediate elements **15**, to the ship's hull. Between the ship's hull **1** and the lower corner formed by the secondary watertight barrier **6** is disposed an assembly of in one part the elements **15** and in another part a composite angle member **16** made of a thermal insulating material. The composite angle member **16** supports, in the lower zone, the sheets **6** which form the secondary watertight barrier.

It will be understood that variations and modifications may be made without departing from the invention.

The invention is hereby claimed as follows:

1. A leakproof and isothermal tank for the storage or the transportation of a liquid or of a liquefied product, said tank comprising two assemblies of leakproof and thermal insulation barriers, in succession, including a primary assembly in contact with the product contained in the tank, and a secondary assembly located between the primary barrier and the tank carrying structure, the secondary assembly comprising boxes filled with a heat-insulating material and held directly against said carrying structure by means of threaded pins which are fastened to the walls of said structure and a secondary leakproof barrier of metallic sheets with edges projecting toward the inside of the tank, the height of which is approximately equal to the height of said boxes of heat-insulating material, said sheets being secured together edge to edge at their projecting edges on the two faces of a metallic flange, said metallic flanges being inserted in the planes of horizontal joints of said boxes of heat-insulating material and extending toward the inside of the tank, and a metallic grid hooked on said metallic flanges, said grid being entirely contained within the thickness of a layer of plastic foam which has a low thermal contraction or expansion coefficient within the range of the temperature of use, said layer being inserted between the product contained in the tank and said secondary leakproof barrier.

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