

Description

Title of the invention: Storage facility for liquefied gas

Technical field

[1] The invention relates to the field of sealed and thermally insulating membrane tanks. The invention relates in particular to the field of sealed and thermally insulating tanks for the storage and/or the transport of liquefied gas at low temperature, such as tanks for the transport of liquefied petroleum gas (LPG) for example at a temperature between -50°C and 0°C inclusive or for the transport of liquefied natural gas (LNG) at approximately -162°C at atmospheric pressure. These tanks can be installed on land or on a floating structure. In the case of a floating structure the tank may be intended for the transport of liquefied gas or to receive liquefied gas serving as fuel for the propulsion of the floating structure.

Technological background

[2] The document FR2549575 describes a sealed and thermally insulating tank integrated into the supporting structure of the ship, comprising a secondary thermally insulating barrier, a secondary sealing membrane, a primary thermally insulating barrier, and a primary sealing membrane. The sealing membranes are formed by a plurality of metal plates welded to one another. The sealing membranes are fixed to the supporting structure in the corners of the tank with the aid of connecting rings. Each connecting ring is therefore fixed on the one hand to the supporting structure and the other hand to the sealing membranes in order to enable the transfer of forces between the membranes and the hull of the ship, thereby rendering the overall structure of the tank solid.

[3] During loading and offloading of LNG the change of temperature and the state of filling of the tanks impose high stresses on the membranes of the tank. Similarly, during transport at sea the movement of the ship exerts high forces on the barriers of the tank. In order to prevent the sealing and insulation characteristics of the tank from being degraded, at least the secondary sealing membrane is anchored to the supporting structure with the aid of a connecting structure at the level of the corners.

[4] The connecting ring makes it possible in particular to absorb the tension forces resulting from the thermal contraction of the metal plates forming the sealing membrane, from the deformation of the hull, and from the state of filling of the tank.

[5] The connecting ring is formed of a plurality of metal plates assembled to one another in such a manner that some of the metal plates are connected to a sealing membrane of a

first tank wall and other metal plates are connected to a sealing membrane of a second tank wall. The connecting ring from the document FR2549575 therefore enables connection in the plane formed by the sealing membrane of the sealing membrane to the supporting structure with the aid of metal plates.

5 [6] In this kind of structure, at the level of a corner of the tank, the secondary thermally insulating barrier is therefore traversed by metal plates of the connecting ring, which induces a phenomenon of thermal bridging between the sealing membrane and the supporting structure.

10 [7] The document FR2798358 also describes a sealed and thermally insulating tank integrated into the supporting structure of a ship that is provided with a connecting ring. In that document the connecting ring is made up of a plurality of metal couplers enabling fixing of the sealing membrane to the supporting structure. In the same manner as in the document FR2549575, the couplers from the document FR2798358 enable connection in the plane formed by the sealing membrane of the sealing membrane to the supporting structure. In order to make this connection, the couplers also traverse the thermally insulating barrier. In the same manner as previously, the connecting ring induces a phenomenon of thermal bridging between the sealing membrane and the supporting structure. Moreover, the couplers are fairly complicated to mount.

[8] The invention aims to remedy the problems encountered in the prior art systems.

20 **Summary**

[9] One idea behind the invention is to modify the fixing of the sealing membrane to the supporting structure in order to improve the insulation of the thermally insulating barrier.

[10] Another idea behind the invention is to simplify the fixing of the sealing membrane to the supporting structure.

25 [11] In accordance with one embodiment the invention provides a storage installation for a liquefied gas comprising a supporting structure and a sealed and thermally insulating tank arranged in the supporting structure, the tank comprising at least a first tank wall fixed to a first supporting wall of the supporting structure and a second tank wall fixed to a second supporting wall of the supporting structure, each tank wall comprising at least one sealing membrane and at least one thermally insulating barrier, the thermally insulating barrier being placed between the sealing membrane and the supporting structure, the first supporting wall forming a corner with the second supporting wall along an edge, the sealing membrane of the first tank wall including a plurality of metal plates,

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in which the thermally insulating barrier of the first tank wall comprises an insulating fixing beam anchored to the first supporting wall and including an upper face maintained at a distance from the first supporting wall by a plurality of shear webs, the shear webs being situated between the upper face and the first supporting wall and oriented perpendicularly to the edge, the insulating fixing beam including an insulating packing arranged between the shear webs, and the insulating fixing beam also including a metal covering element comprising a plane portion forming the upper face, an end edge of the sealing membrane of the first tank wall being welded to the plane portion of the metal covering element,

and in which the supporting structure comprises an abutment device projecting from the first supporting wall in the direction of the interior of the tank, the abutment device having a length extending parallel to the edge, the abutment device being placed along an edge of the insulating fixing beam opposite the edge and being configured to form an abutment limiting the movement of the insulating fixing beam in a direction away from the second tank wall.

[12] Thanks to the above features, the sealing membrane of the tank is fixed directly to the insulating fixing beam of the thermally insulating barrier with the aid of the metal covering element so that, in contrast to the prior art, no metal element connects the sealing membrane directly to the supporting structure. Fixing the sealing membrane to the supporting structure with the aid of the insulating fixing beam is therefore a simple way to enable improvement of the insulation of the thermally insulating barrier by avoiding metal elements traversing the thermally insulating barrier. Moreover, the shear webs enable the insulating fixing beam to be stronger, in particular more resistant to shear forces caused by contraction/expansion of the sealing membrane and elongation of the beam of the ship corresponding to movements of the hull of the ship in response to the sea swell. Those shear forces are transmitted to the insulating fixing beam with the aid of the metal covering element and the first abutment device. Moreover, the upper face enables seating of the sealing membrane to be assured.

[13] In accordance with embodiments, this kind of storage installation may include one or more of the following features.

[14] In accordance with one embodiment, the tank comprises a metal seal comprising a first flat and a second flat forming a corner with the first flat, the first flat being welded in sealed manner to the sealing membrane of the first tank wall and the second flat being welded in sealed manner to the sealing membrane of the second tank wall, the corrugated seal being configured to connect in sealed manner the sealing membrane of the first tank

wall and the sealing membrane of the second tank wall, the first flat being supported by the metal covering element of the insulating fixing beam.

- [15] In accordance with one embodiment, the metal covering element comprises a plane metal plate including a supporting portion projecting from the shear webs in the direction of the sealing membrane and in a direction away from the edge so that an end of the supporting portion rests on an insulating panel of the thermally insulating barrier adjacent to the insulating fixing beam.
- [16] In accordance with one embodiment, the plane metal plate has a dimension in the direction of the edge equal to the separation between two adjacent shear webs and is arranged so as to extend between the two adjacent shear webs.
- [17] In accordance with one embodiment, the shear webs are made of composite material including a polymer resin and fibers.
- [18] In accordance with one embodiment, the fibers are at least partly oriented at an angle of $\pm 45^\circ$ relative to a direction of thickness of the tank wall. This kind of feature enables cumulative good resistance to shear and for example good resistance to traction in a direction of thickness of the tank wall with fibers oriented in the same direction.
- [19] In accordance with one embodiment, the insulating fixing beam comprises a fixing angle-iron including a first angle-iron flange and a second angle-iron flange connected to the first angle-iron flange, the second angle-iron flange being fixed to one of the shear webs and the first angle-iron flange being welded to the metal covering element.
- [20] In accordance with one embodiment, the insulating fixing beam comprises a fixing angle-iron including a first angle-iron flange and a second angle-iron flange connected to the first angle-iron flange, the second angle-iron flange being fixed to one of the shear webs and the first angle-iron flange comprising at least one fixing orifice coinciding with a fixing orifice of the metal covering element so as to fix the first angle-iron flange to the plane metal plate by means of a fixing device traversing the fixing orifice in the metal covering element and the fixing orifice in the first angle-iron flange.
- [21] In accordance with one embodiment, the second angle-iron flange is glued to one of the shear webs.
- [22] In accordance with one embodiment, the second angle-iron flange includes at an angle remote from the first angle-iron flange a beveled portion to limit the stresses in the glue.
- [23] In accordance with one embodiment, the insulating fixing beam includes a cleat fixed to a face of the shear web perpendicular to the edge and extending parallel to the metal

covering element, the cleat including a principal portion, an upper extension and a lower extension on respective opposite sides of the principal portion, the principal portion, the upper extension and the lower extension being fixed to the shear web, the upper extension and the lower extension enabling the cleat fixing area to be increased,

5 and in which the cleat is fixed to the supporting structure with the aid of anchoring studs distributed over a length of the cleat, the anchoring studs coming to exert a clamping force against an upper face of the principal portion of the cleat.

[24] In accordance with one embodiment, the upper extension and the lower extension are glued to the shear web, the upper extension and the lower extension enabling the cleat
10 gluing area to be increased.

[25] In accordance with one embodiment, the upper extension is beveled so as to have a thickness decreasing in the direction away from the principal portion in order to limit the stresses in the fixing or in the glue.

[26] In accordance with one embodiment, the shear webs are regularly distributed along
15 the insulating fixing beam and/or the first insulating fixing beam and/or the second insulating fixing beam.

[27] In accordance with one embodiment, the distance between a first shear web of said shear webs and a second shear web directly adjacent to the first shear web is less than 340 mm.

20 [28] In accordance with one embodiment, the thickness of the shear webs is between 5 and 25 mm inclusive.

[29] In accordance with one embodiment, the shear webs are made of a material such as plywood, wood, a composite material, or any other material having sufficient stiffness and a limited ratio of thermal conductivity to stiffness.

25 [30] In accordance with one embodiment, the insulating fixing beam is a first insulating fixing beam, the abutment device is a first abutment device and the sealing membrane of the first tank wall including a plurality of metal plates or a plurality of strakes parallel to a longitudinal direction perpendicular or oblique to said edge, each strake including a plane central portion pressing on an upper surface of the thermally insulating barrier and two
30 raised edges projecting toward the interior of the tank relative to the central portion, the strakes being juxtaposed in accordance with a repeated pattern and welded together in sealed manner at the level of the raised edges, and the thermally insulating barrier of the second tank wall comprises a second insulating fixing beam including an upper face held at a distance from the second supporting wall by a plurality of shear webs, the shear webs

being situated between the upper face and the second supporting wall and oriented perpendicularly to the edge, the second insulating beam including an insulating packing arranged between the shear webs, and the second insulating fixing beam also including a metal covering element comprising a plane portion forming the upper face, an end edge of the sealing membrane of the second tank wall being welded to the plane portion of the metal covering element,

and in which the supporting structure comprises a second abutment device projecting from the second supporting wall in the direction of the interior of the tank, the second abutment device having a length extending parallel to the edge, the second abutment device being placed along an edge of the second insulating beam opposite the edge and being configured to form an abutment limiting the movement of the second insulating fixing beam in a direction away from the first tank wall.

[31] In accordance with one embodiment, the metal covering element of the insulating fixing beam and/or of the first insulating fixing beam and/or of the second insulating fixing beam comprises a first lateral flange extending perpendicularly to the shear webs and in the direction of the first supporting wall or of the second supporting wall, respectively, the first lateral flange sandwiching the shear webs with the abutment device or the first abutment device and/or the second abutment device, respectively, in order to absorb shear forces exerted by the sealing membrane.

[32] Accordingly, the first lateral flange enables improved transmission to the insulating fixing beam of the forces coming from the sealing membrane, in particular its tension during thermal contraction due for example to cooling when loading LNG or an elongation of the beam of the ship.

[33] In accordance with one embodiment, the metal covering element of the insulating fixing beam comprises a third plane flange in line with the plane portion of the metal covering element of the insulating fixing beam and extending in the direction of the edge in order for the metal covering elements of the insulating fixing beams of the two walls forming the edge virtually to join.

[34] The metal covering elements of the insulating fixing beams of the two walls therefore assure seating of the sealing membrane in the corner.

[35] In accordance with one embodiment, the metal covering element of the insulating fixing beam and/or of the first insulating fixing beam and/or of the second insulating fixing beam comprises a second lateral flange extending perpendicularly to the shear webs and in the direction of the first supporting wall or of the second supporting wall, respectively, so that

the first lateral flange and the second lateral flange bracket the shear webs, the first lateral flange being situated closer to the edge than the second lateral flange.

[36] Thanks to the above features, the second lateral flange, in the same manner as the first lateral flange, allows improved transmission to the insulating fixing beam of forces coming from the sealing membrane. Moreover, by bracketing the shear webs the lateral flanges make it possible to prevent rotation of the metal covering element about the shear webs, which could compromise the absorption of forces.

[37] In accordance with one embodiment, the first lateral flange and/or the second lateral flange is/are connected to the plane portion of the metal covering element and the first lateral flange and the second lateral flange are preferably connected to the plane portion at the level of two opposite ends.

[38] In accordance with one embodiment, the insulating fixing beam and/or the first insulating fixing beam and/or the second insulating fixing beam include(s) an external anti-buckling portion extending the shear webs in the direction of the edge and extending over a portion of the dimension separating the first supporting wall or the second supporting wall, respectively, from the metal covering element, the external anti-buckling portion being fixed by a fixing means to the first supporting wall and/or to the second supporting wall, respectively.

[39] In accordance with one embodiment, the supporting structure comprises an additional abutment device or a first additional abutment device projecting from the first supporting wall in the direction of the interior of the tank, the additional abutment device or the first additional abutment device having a length extending parallel to the edge, the additional abutment device or the first additional abutment device being placed along an edge of the insulating fixing beam or of the first insulating fixing beam adjacent to the edge and being configured to form an abutment limiting movement of the insulating fixing beam or of the first insulating fixing beam in a direction opposite to the direction of the abutment device or of the first abutment device.

[40] In accordance with one embodiment, the supporting structure comprises a second additional abutment device projecting from the second supporting wall in the direction of the interior of the tank, the second additional abutment device having a length extending parallel to the edge, the second additional abutment device being placed along an edge of the second insulating fixing beam adjacent to the edge and being configured to form an abutment limiting movement of the second insulating fixing beam in a direction opposite the direction of the second abutment bar.

- [41] In accordance with one embodiment, the tank comprises a corrugated or uncorrugated seal comprising a first flat and a second flat forming a corner with the first flat, the first flat being welded in sealed manner to the sealing membrane of the first tank wall and the second flat being welded in sealed manner to the sealing membrane of the second tank wall, the corrugated seal being configured to connect in sealed manner the sealing membrane of the first tank wall and the sealing membrane of the second tank wall in order to form a sealing membrane that is continuous at the level of a corner of the tank.
- [42] In accordance with one embodiment, the sealing membrane includes a metal anchoring strip welded to the metal covering element, one of the metal plates being welded in sealed manner to a portion of the metal anchoring strip and the metal seal being welded in sealed manner to another portion of the metal anchoring strip.
- [43] In accordance with one embodiment, the secondary insulating panel adjacent to the insulating fixing beam includes an upper plate provided with a recess extending in the direction of the edge and situated at the nearest end of the edge of the upper plate, an end of the metal covering element being placed in the recess in order to obtain a plane support surface for the sealing membrane.
- [44] In accordance with one embodiment, the tank comprises a corner insulation block situated in line with the thermally insulating barrier of the first tank wall and of the thermally insulating barrier of the second tank wall at the level of the edge, the corner insulation block being configured to assure continuity of the thermally insulating barrier of the first tank wall and of the thermally insulating barrier of the second tank wall at the level of the edge of the supporting structure.
- [45] In accordance with one embodiment, the corner insulation block comprises a first face situated against the first supporting wall, a second face situated against the second supporting wall, a third face configured to offer a bearing surface to the first flat of the corrugated seal, and a fourth face configured to offer a bearing surface to the second flat of the corrugated seal.
- [46] In accordance with one embodiment, the corrugated seal is a metal corrugated seal.
- [47] In accordance with one embodiment, at least one or each corrugation of the corrugated seal extends parallel to the edge.
- [48] In accordance with one embodiment, the first insulating fixing beam and/or the second insulating fixing beam is/are juxtaposed to the corner insulation block.
- [49] In accordance with one embodiment, the abutment device or the first abutment device and/or the second abutment device include(s) an abutment bar or a first abutment bar

and/or a second abutment bar, respectively, the abutment bar or the first abutment bar and/or the second abutment bar extending in a continuous manner parallel to the edge along the edge opposite the edge of the insulating fixing beam or the first insulating fixing beam and/or the second insulating fixing beam, respectively.

5 [50] In accordance with one embodiment, the additional abutment device or the first additional abutment device and/or the second additional abutment device include(s) an additional abutment bar or a first additional abutment bar and/or a second additional abutment bar, respectively, the additional abutment bar or the first additionally abutment bar and the second additional abutment bar extending in a continuous manner parallel to
10 the edge along the edge adjacent the edge of the insulating fixing beam along the first insulating fixing beam and/or of the second insulating fixing beam, respectively.

[51] In accordance with one embodiment, the abutment device or the first abutment device and/or the second abutment device include(s) a plurality of abutment lugs or a plurality of first abutment lugs and/or a plurality of second abutment lugs, respectively, the abutment
15 lugs or the first abutment lugs and/or the second abutment lugs being regularly spaced along the edge opposite the edge of the insulating fixing beam or of the first insulating fixing beam and/or of the second insulating fixing beam, respectively.

[52] In accordance with one embodiment, the additional abutment device or the first additional abutment device and/or the second additional abutment device include(s) a
20 plurality of additionally abutment lugs or a plurality of first additional abutment lugs and/or a plurality of second additional abutment lugs, respectively, the additional abutment lugs or the first additional abutment lugs and/or the second additionally abutment lugs being regularly spaced along the edge adjacent to the edge of the insulating fixing beam or of the first insulating fixing beam or of the second insulating fixing beam, respectively.

25 [53] In accordance with one embodiment, the additional abutment device or the first additional abutment device and/or the second additional abutment device include(s) a hook-forming device configured to fix the external anti-buckling portion to the first supporting wall, the hook-forming device constituting said fixing means.

[54] In accordance with one embodiment, one of the or the abutment lugs or one of the or
30 the additional abutment lugs take(s) the form of a hook so as to form the hook-forming device.

[55] In accordance with one embodiment, one of the or the abutment bars, or one of the or the additional abutment bars take(s) the form of a hook so as to form the hook-forming device.

- [56] In accordance with one embodiment, the insulating fixing beam and/or the first insulating fixing beam and/or the second insulating fixing beam include(s) an internal anti-buckling portion extending the shear webs in a direction away from the edge and extending over a portion of the dimension separating the first supporting wall or the second supporting wall, respectively, from the metal covering element, the internal anti-buckling portion being fixed by a fixing means to the first supporting wall and/or the second supporting wall, respectively, and the abutment device or the first abutment device includes a hook-forming device or a first hook-forming device configured to fix the internal anti-buckling portion to the first supporting wall.
- [57] Accordingly, the internal anti-buckling portion makes it possible to prevent deformation or even buckling of the insulating fixing beam if the sealing membrane exerts a high force on the latter in an opposite direction relative to the external anti-buckling portion.
- [58] In accordance with one embodiment, the fixing means comprises a stud fixing the external anti-buckling portion or the internal anti-buckling portion to the supporting structure so that a first end of the stud is anchored to the supporting structure and a second end of the stud opposite the first end is equipped with a nut coming to bear directly or indirectly on the external anti-buckling portion or the internal anti-buckling portion. For example, the stud may traverse completely or be placed beside the external anti-buckling portion or the internal anti-buckling portion.
- [59] In accordance with one embodiment, the fixing means comprises a reinforcing plate placed between the nut and the external anti-buckling portion or the internal anti-buckling portion so as to propagate the clamping force of the nut to a surface corresponding to the surface of the reinforcing plate.
- [60] In accordance with one embodiment, the external anti-buckling portion and/or the internal anti-buckling portion is formed by portions extending the shear webs.
- [61] In accordance with one embodiment, the external anti-buckling portion comprises a first lateral bar extending parallel to the edge, the first lateral bar including a wall pressed against a lateral surface of the shear webs.
- [62] In accordance with one embodiment, the internal anti-buckling portion comprises a second lateral bar extending parallel to the edge, the second lateral bar including a wall pressed against another lateral surface of the shear webs, the first lateral bar and the second lateral bar bracketing the shear webs.
- [63] In accordance with one embodiment, at least one of the or the first abutment lugs and/or at least one of the or the second abutment lugs comprise(s) a first lug portion

extending in a plane parallel to the lower face of the first insulating fixing beam and/or of the second insulating beam, respectively, the first lug portion coming to overlap the internal anti-buckling portion.

[64] In accordance with one embodiment, at least one of the or the first abutment lugs and/or at least one of the or the second abutment lugs comprise(s) a second lug portion extending in a plane orthogonal to the first lug portion and orthogonal to the shear webs.

[65] In accordance with one embodiment, at least one of the or the first additional abutment lugs and/or at least one of the or the second additional abutment lugs comprise(s) a second lug portion extending in a plane parallel to the lower face of the first insulating fixing beam and/or of the second insulating fixing beam, respectively, the first lug portion coming to overlap the external anti-buckling portion.

[66] In accordance with one embodiment, at least one of the or the first additional abutment lugs and/or at least one of the or the second additional abutment lugs comprise(s) a second lug portion extending in a plane orthogonal to the first lug portion and orthogonal to the shear webs.

[67] In accordance with one embodiment, the insulating fixing beam and/or the first insulating fixing beam and/or the second insulating fixing beam comprise(s) an upper plate situated under the metal covering element and extending along the insulating fixing beam and/or the first insulating fixing beam and/or the second insulating fixing beam, respectively, and each shear web comprises on an upper edge two upper tenons separated from one another in such a manner as to form an upper notch, the upper plate comprising a plurality of grooves extending parallel to the shear webs and having a shape complementary to the upper tenons in such a manner that the upper tenons are accommodated in the grooves in the upper plate in order to form a mortise and tenon assembly between the shear webs and the upper plate.

[68] In accordance with one embodiment, the insulating fixing beam and/or the first insulating fixing beam and/or the second insulating fixing beam comprises N shear webs, N being a natural integer, N preferably being greater than or equal to 3, N preferentially being greater than or equal to 5.

[69] In accordance with one embodiment, the insulating fixing beam and/or the first insulating fixing beam and/or the second insulating fixing beam comprise(s) a lower plate situated on the first supporting wall and extending along the insulating fixing beam and/or the first insulating fixing beam and/or the second insulating fixing beam, respectively, and each shear web comprises on a lower edge two lower tenons separated from one another

in such a manner as to form a lower notch, the lower plate comprising a plurality of grooves extending parallel to the shear webs and having a shape complementary to the lower tenons in such a manner that the lower tenons are accommodated in the grooves in the lower plate in such a manner as to form a mortise and tenon assembly between the shear webs and the lower plate.

[70] In accordance with one embodiment, the upper plate and/or the lower plate comprises 2N grooves so that each upper tenon and/or each lower tenon of the fixing insulating beam and/or the first insulating fixing beam and/or the second insulating fixing beam is accommodated in one of the grooves in the upper and/or lower plate, respectively.

10 [71] In accordance with one embodiment, the thermally insulating barrier of the first tank wall and/or the thermally insulating barrier of the second tank wall comprises a plurality of insulating panels including a lower wall situated close to the first supporting wall and/or the second supporting wall, respectively, an upper wall and a structural insulating packing maintaining the upper wall at a distance from the lower wall, the insulating packing being
15 composed of fiber-reinforced polymer foam.

[72] In accordance with one embodiment, the thermally insulating barrier is a secondary thermally insulating barrier and the sealing membrane is a secondary sealing membrane and the first tank wall and the second tank wall further include, in a direction of thickness from the exterior to the interior of the tank, a primary thermally insulating barrier carried by
20 the secondary sealing membrane and a primary sealing membrane carried by the primary thermally insulating barrier.

[73] In accordance with one embodiment, the primary sealing membrane includes a plurality of corrugated metal plates, the corrugated metal plates being juxtaposed in accordance with a repeated pattern and welded together in sealed manner.

25 [74] In accordance with one embodiment, the sealing membrane or the secondary sealing membrane is made of an alloy of iron and nickel having a coefficient of thermal expansion between 0.5×10^{-6} and $2 \times 10^{-6} \text{ K}^{-1}$ inclusive.

[75] In accordance with one embodiment, the primary sealing membrane is made of stainless steel.

30 [76] In accordance with one embodiment, the metal covering element is made of stainless steel or an alloy based on iron with a high content of manganese.

[77] In accordance with one embodiment, the corrugated seal is made of the same material as the secondary sealing membrane, preferably an alloy of iron and nickel having a coefficient of thermal expansion between 0.5×10^{-6} and $2 \times 10^{-6} \text{ K}^{-1}$ inclusive.

- [78] In accordance with one embodiment, the insulating packing of the insulating fixing beam and/or of the first insulating fixing beam and/or of the second insulating fixing beam is made of perlite, of glass wool, of foam or of any other appropriate thermally insulating material.
- 5 [79] In accordance with one embodiment, the primary thermally insulating barrier comprises at least one primary corner insulating panel, the primary corner insulating panel being fixed to the first insulating fixing beam and/or the second insulating fixing beam with the aid of a coupler.
- 10 [80] In accordance with one embodiment, the first tank wall and or the second tank wall comprise(s) bands of mastic disposed between the insulating fixing beam and the first supporting wall or between the first insulating fixing beam and the first supporting wall and/or between the second insulating fixing beam and the second supporting wall.]
- [81] In accordance with one embodiment, the bands of mastic are stuck to the supporting structure.
- 15 [82] In accordance with one embodiment, the sealing membrane includes a plurality of strakes parallel to a longitudinal direction perpendicular or oblique to said edge, each strake including a plane central portion resting on an upper surface of the thermally insulating barrier and two raised edges projecting toward the interior of the tank relative to the central portion, the strakes being juxtaposed in accordance with a repeated pattern
- 20 and welded together in sealed manner at the level of the raised edges.
- [83] In accordance with embodiments, the insulating fixing beam includes a lower face, that is to say a surface facing toward the first supporting wall, that may be produced in a continuous manner, for example in the form of a bottom wall, or a discontinuous manner, for example by lower edge surfaces or lower sole plates of the shear webs.
- 25 [84] In accordance with one embodiment, the shear webs comprise a central portion oriented perpendicularly to the edge and two peripheral portions extending perpendicularly to the central portion, the peripheral portions being parallel to one another and bracketing the central portion.
- 30 [85] In accordance with one embodiment, the peripheral portions include a lower sole plate and an upper sole plate extending parallel to the first supporting wall, the lower sole plates of all the shear webs forming a continuous or discontinuous bottom wall, the upper sole plates of all the shear webs forming a continuous or discontinuous covering wall.
- [86] In accordance with one embodiment, the peripheral portions include a front sole plate and a rear sole plate extending perpendicularly to the first supporting wall, the front sole

plates of all the shear webs forming a continuous or discontinuous front wall facing away from the edge, the rear sole plates of all the shear webs forming a continuous or discontinuous rear wall facing toward the edge.

- 5 [87] In accordance with one embodiment, the insulating fixing beam comprises a bottom element including a plane portion resting on the first supporting wall and two lateral walls bracketing the shear webs and extending parallel to the shear webs in the direction of the metal covering element, the lateral flanges being fixed by a fixing means to the central portion of end shear webs, the end shear webs being two shear webs formed at the ends of the insulating fixing beam in the direction of the edge.
- 10 [88] In accordance with one embodiment, the bottom element comprises at least one bearing element fixed to one of the lateral flanges, the bearing element projecting from one of the end shear webs, the anchoring means comprising a hook-forming device situated on the bearing element and configured to fix the insulating fixing beam to the first supporting wall.
- 15 [89] In accordance with one embodiment, the bearing element is fixed to one end of a lateral flange of the bottom element.
- [90] In accordance with one embodiment, the bearing element is fixed to one of the lateral flanges in such a manner as to sandwich an end shear web.
- [91] In accordance with one embodiment, the bottom element is made of metal or
20 composite material.
- [92] In accordance with one embodiment, the metal covering element comprises two internal flanges extending at the ends of the plane portions and parallel to the first lateral flange and to the second lateral flange, the internal flanges being situated between the peripheral portions of the shear webs, the first lateral flange and the second lateral flange
25 bracketing the peripheral portions of the shear webs, the first lateral flange being fixed by a fixing means to one of the internal flanges and the second lateral flange being fixed by a fixing means to the other of the internal flanges.
- [93] In accordance with one embodiment, an internal flange includes a plurality of flange portions spaced from one another in the direction of the edge, a shear web or the principal
30 portion of a shear web being disposed between two adjacent flange portions.
- [94] This kind of storage installation may be a terrestrial storage installation, for example for storing LNG, or a floating, coastal or deep water storage installation, in particular on a methane tanker ship, a floating storage and regassification unit (FSRU), a floating

production storage and offloading (FPSO) unit, etc. This kind of storage installation may also serve as a fuel tank in any type of ship.

5 [95] In accordance with one embodiment, a ship for the transport of a cold liquid product includes a double hull and a storage installation as mentioned above, a portion of the double hull forming the supporting structure of the storage installation.

[96] In accordance with one embodiment, the invention also provides a transfer system for a cold liquid product, the system including the aforementioned ship, insulated pipes arranged in such a manner as to connect the tank installed in the hull of the ship to a floating or terrestrial storage installation, and a pump for driving a flow of cold liquid product
10 through the insulated pipes from or to the floating or terrestrial storage installation to or from the tank of the ship.

[97] In accordance with one embodiment, the invention also provides a method of loading or offloading a ship of the above kind, in which a cold liquid product is routed through insulated pipes from or to a floating or terrestrial storage installation to or from the tank of
15 the ship.

Brief description of the figures

[98] The invention will be better understood and other aims, details, features and advantages thereof will become more clearly apparent in the course of the following description of particular embodiments of the invention given by way of nonlimiting
20 illustration only with reference to the appended drawings.

[99] [fig.1] Figure 1 represents a view in section of a tank at the level of a corner formed by two tank walls in accordance with a first embodiment.

[100] [fig.2] Figure 2 represents a view in section of a tank at the level of a corner formed by two tank walls in accordance with a second embodiment.

25 [101] [fig.3] Figure 3 represents a view in section of a tank at the level of a corner formed by two tank walls in accordance with a third embodiment.

[102] [fig.4] Figure 4 is a perspective view of a corner formed by two tank walls in accordance with the first embodiment where only the first insulating fixing beam and the second insulating fixing beam are represented.

30 [103] [fig.5] Figure 5 represents a schematic front view of an insulating fixing beam with an abutment device in accordance with a fourth embodiment.

[104] [fig.6] Figure 6 represents a schematic perspective view of an insulating fixing beam in accordance with the fourth embodiment.

- [105] [fig.7] Figure 7 represents a schematic perspective view of a corner formed by two tank walls where only the first insulating fixing beam and the second insulating fixing beam are represented in accordance with a fifth embodiment.
- 5 [106] [fig.8] Figure 8 represents an exploded view of an insulating fixing beam in accordance with a sixth embodiment.
- [107] [fig.9] Figure 9 represents a schematic perspective view of an insulating fixing beam in accordance with a seventh embodiment.
- 10 [108] [fig.10] Figure 10 represents a perspective view of an insulating fixing beam in accordance with an eighth embodiment, the metal covering element being shown at a distance from the shear webs.
- [109] [fig.11] Figure 11 represents a perspective view of an insulating fixing beam in accordance with a ninth embodiment, the metal covering element being shown at a distance from the shear webs.
- 15 [110] [fig.12] Figure 12 represents an exploded view of an insulating fixing beam in accordance with a tenth embodiment.
- [111] [fig.13] Figure 13 represents a perspective view of the insulating fixing beam in accordance with the tenth embodiment.
- [112] [fig.14] Figure 14 represents an exploded view of an insulating fixing beam in accordance with an eleventh embodiment.
- 20 [113] [fig.15] Figure 15 represents a perspective view of the insulating fixing beam in accordance with the eleventh embodiment.
- [114] [fig.16] Figure 16 represents an exploded view of the insulating fixing beam in accordance with the fifth embodiment.
- 25 [115] [fig.17] Figure 17 represents a perspective view of the insulating fixing beam in accordance with the fifth embodiment.
- [116] [fig.18] Figure 18 represents a schematic perspective view of a corner formed by two tank walls illustrating in particular the first insulating fixing beam and the second insulating fixing beam in accordance with a twelfth embodiment.
- 30 [117] [fig.19] Figure 19 represents a detail view XIX of figure 18 illustrating in particular the fixing of the secondary sealing member to the insulating fixing beam.
- [118] [fig.20] Figure 20 represents a perspective view of the insulating fixing beam in accordance with the twelfth embodiment.

[119] [fig.21] Figure 21 represents a front view of the insulating fixing beam in accordance with the twelfth embodiment.

[120] [fig.22] Figure 22 is a cutaway schematic representation of a methane tanker ship including a storage installation for a liquefied gas and a terminal for loading/offloading that
5 installation.

Description of embodiments

[121] By convention, “over” or “above” or “superior” means a position situated closer to the interior of the tank and “under” or “below” or “lower” means a position situated closer to the supporting structure, regardless of the orientation of the tank wall relative to the
10 terrestrial gravity field.

[122] In figure 1 there has been represented the multilayer structure of two tank walls 1 and 101 of a sealed and thermally insulating tank for the storage of a liquefied gas such as liquefied natural gas (LNG). Each tank wall 1, 101 includes successively, in the direction of the thickness, from the exterior toward the interior of the tank, a secondary thermal
15 insulating barrier 2, 102 retained on a supporting wall 3, 103, a secondary sealing member 4, 104 resting against the secondary thermally insulating barrier 2, 102, a primary thermally insulating barrier 5, 105 resting against the secondary sealing member 4, 104 and a primary sealing membrane 6, 106 intended to be in contact with the liquefied natural gas contained in the tank.

[123] The supporting structure may in particular be formed by the hull or the double hull of a ship. The supporting structure includes a plurality of supporting walls 3, 103 defining the general shape of the tank, usually a polyhedral shape. The two supporting walls 3 and 103 are joined at the level of an edge 100, forming a dihedral angle that could have different values. Here an angle of 90° is represented.

[124] Outside the corner zone the secondary thermally insulating barrier 2, 102 includes a plurality of secondary insulating panels 7, 107 that are anchored to the supporting wall 3, 103 by means of retaining devices (not represented) known in themselves.

[125] A secondary insulating panel 7, 107 includes a bottom plate, a cover plate and possibly an intermediate plate, made for example of plywood. The secondary insulating panel 7, 107 also includes one or more layers of insulating polymer foam sandwiched between the
30 bottom plate, the cover plate and where applicable the intermediate plate and glued to the latter. The insulating polymer foam may in particular be a foam based on polyurethane, optionally reinforced by fibers.

- [126] The secondary sealing member 4, 104 includes a continuous layer of metal strakes with raised edges. The strakes are welded by their raised edges to parallel weld supports that are fixed in grooves formed on the cover plates of the secondary insulating panels 7, 107. The strakes are made for example of Invar®: that is to say an alloy of iron and nickel the coefficient of expansion of which is typically between 1.2×10^{-6} and $2 \times 10^{-6} \text{ K}^{-1}$. It is also possible to use alloys of iron and manganese the coefficient of expansion of which is typically of the order of 7 to $9 \times 10^{-6} \text{ K}^{-1}$.
- [127] The primary thermally insulating barrier 5, 105 includes a plurality of primary insulating panels 8, 108 that may be produced with various structures known in themselves.
- [128] The primary sealing member 6, 106 may be produced in various ways. In figure 1 it includes as continuous layer of plate that features two mutually perpendicular series of corrugations. The first series of corrugations 9, 109 extends perpendicularly to the edge 100. The second series of corrugations 10, 110 extends parallel to the edge 100. The two series of corrugations may have a regular spacing or a periodic irregular spacing.
- [129] The structure of the secondary element of the tank at the level of the join between the two tank walls 1 and 101 will now be described more particularly, in particular with reference to figures 1 and 2.
- [130] The secondary sealing membrane 4 of the first tank wall 1 and the secondary sealing member 104 of the second tank wall 101 are anchored to the supporting structure with the aid of a first insulating fixing beam 11 and a second insulating fixing beam 111, respectively, at the level of a corner of the tank, that is to say near the edge 100 at which the two supporting walls 3 and 103 join.
- [131] In effect, the secondary thermally insulating barrier 2 of the first tank wall 1 and the secondary thermally insulating barrier 102 of the second tank wall 101 comprise near the edge 100 a first insulating fixing beam 11 and a second insulating fixing beam 111, respectively, the first insulating fixing beam 11 and the second insulating fixing beam 111 being in continuity with the secondary insulating panels 7, 107.
- [132] The first insulating fixing beam 11 and the second insulating fixing beam 111 are anchored to the first supporting wall 3 and to the second supporting wall 103, respectively, and have a length extending parallel to the edge 100. Each insulating fixing beam 11, 111 includes a lower face 12 situated against the supporting wall 3, 103 and an upper face 3 held at a distance from the lower face 12 by a plurality of shear webs 14.
- [133] The shear webs 14 are plain walls situated between the upper face and the lower face and oriented perpendicularly to the edge 100. Each insulating fixing beam 11, 111 includes

a thermally insulating packing, such as glass wool or perlite or a block of foam, between the shear webs 14. The shear webs 14 are regularly distributed along the insulating fixing beams 11, 111, as can be seen in figures 4 and 6.

[134] Each insulating fixing beam 11, 111 also includes an upper plate 40 at the level of the upper face 13 enabling the shear webs 14 to be fixed to one another in an upper portion. In the same manner, each insulating fixing beam 11, 111 includes a lower plate 41 at the level of the lower face 12 enabling the shear webs 14 to be fixed to one another in a lower portion.

[135] As can be seen in figures 1 and 2 the insulating fixing beams 11, 111 comprise a metal covering element 15 including a plane portion 16 situated against the upper face 13, a first lateral flange 17 extending perpendicularly to the shear webs 14 against an edge of the webs 14 adjacent to the edge 100 and in the direction of the lower face 12, and a second lateral flange 18 extending perpendicularly to the shear webs 14 against an edge of the webs 14 opposite the edge 100 and in the direction of the lower face 12. An end edge of the secondary sealing membrane 4, 104 is welded to the plane portion 16 of the metal covering element 15.

[136] The first lateral flange 17 and the second lateral flange 18 are connected to the plane portion 16 at the level of its two opposite ends. Accordingly, the metal covering element 15 is placed against three faces of the insulating fixing beams 11, 111 in order to transmit traction/compression forces from the secondary sealing membrane 4, 104 to the insulating fixing beam 11, 111.

[137] The supporting structure comprises a first abutment device 19 projecting from the first supporting wall 3 in the direction of the interior of the tank, the first abutment device 19 having a length extending parallel to the edge 100. The first abutment device 19 is placed along an edge of the first insulating fixing beam 11 opposite the edge 100 and is configured to form an abutment limiting the movement of the first insulating fixing beam 11 in the longitudinal direction of the strakes of the secondary sealing membrane 4 of the first tank wall 1. The supporting structure also comprises a first additional abutment device 20 projecting from the first supporting wall 3 in the direction of the interior of the tank, the first additional abutment device 20 having a length extending parallel to the edge 100. The first additional abutment device is placed along an edge of the first insulating fixing beam 11 adjacent to the edge 100 and is configured to form an abutment limiting movement of the first insulating fixing beam 11 in a direction away from the first abutment device 19. Accordingly, the first abutment device 19 and the additional abutment device 20 block

movement in translation of the first insulating fixing beam 11 in the longitudinal direction of the strakes of the secondary sealing membrane 4.

[138] In an analogous manner the supporting structure comprises a second abutment device 119 and a second additional abutment device 120 that project from the second supporting wall 103 and that block movement in translation of the second insulating fixing beam 111 in the longitudinal direction of the strakes of the second receiving membrane 104.

[139] In the first embodiment illustrated in figure 1 and in the second embodiment illustrated in figure 2 the first abutment device 19 includes a first abutment bar 30 extending in a continuous manner parallel to the edge 100 along the edge of the first insulating fixing beam 11 opposite the edge 100 and the first additional abutment device 20 includes a first additional abutment bar 31 extending in a continuous manner parallel to the edge 100 along the edge adjacent to the edge 100 of the first insulating fixing beam 11. In an analogous manner the second abutment device 119 comprises a second abutment bar 130 and the second additional abutment device 120 comprises a second additional abutment bar 131.

[140] Moreover, as illustrated in the first embodiment and the second embodiment, the insulating fixing beams 11, 111 each include an external anti-buckling portion 21 extending the lower face 12 in the direction of the edge 100 and extending over a portion of the dimension separating the lower face 12 and the upper face 13. The external anti-buckling portion is fixed to the supporting structure by a fixing means 47.

[141] Accordingly, as can be seen in figure 4, which shows a view in which the supporting structure has been omitted, the external anti-buckling portion 21 is formed by portions 43 extending the shear webs 14, that is to say portions of the webs 14 that extend beyond the principal portion situated under the metal covering element 15. Moreover, the lower plate 41 may be extended in the same direction as the extending portions 43 in order to be placed under the latter. In this embodiment the fixing means 47 is formed by a stud traversing the external anti-buckling portion 21 completely so that a first end of the stud is anchored to the supporting structure and a second end of the stud opposite the first end is equipped with a nut. The fixing means 47 also comprises a reinforcing plate placed between the nut and the external anti-buckling portion 21 so that the clamping force of the nut is exerted over all the surface of the reinforcement plate in order to fix the insulating fixing beams 11, 111 to the supporting structure.

[142] In an embodiment that is not represented the insulating fixing beams 11, 111 may comprise an internal anti-buckling portion 22 formed by the extension portions 43, the internal anti-buckling portion 22 extending the lower face 12 in a direction away from the

external anti-buckling portion 21 and extending over a portion of the dimension separating the lower face 12 and the upper face 13.

[143] In order to connect the secondary sealing membranes 4, 104 at the level of the dihedron formed by the tank walls 1, 101 there is provision for fixing a metal seal 23 comprising a first flat and a second flat forming an angle with the first equal to the angle of the dihedron. The first flat is welded in sealed manner to the secondary sealing membrane 4 of the first tank wall 1 and the second flat is welded in sealed manner to the secondary sealing membrane 104 of the second tank wall 101 in order to form a sealing membrane that is continuous at the level of the corner of the tank.

[144] In the embodiment represented in figure 1 the fixing means 47 of the first tank wall 1 is offset laterally from the edge 100 in order not to be in alignment with the secondary sealing membrane 104 and the secondary thermally isolated barrier 102 of the second tank wall 101 so as to facilitate the fixing of the external anti-buckling portion 21 to the supporting structure during assembly of the tank. The same goes for the fixing means 47 of the second tank wall 101.

[145] This offset for fixing the first anti-buckling portions 21 induces an offset of the insulating fixing beams 11, 111 thereby increasing the size of the joint 23 between the secondary sealing membranes 4, 104.

[146] In the first embodiment the tank therefore comprises a corner insulation block 25 situated in line with the secondary thermally insulating barrier 2 of the first tank wall 1 and the secondary thermally insulating barrier 102 of the second tank wall 101 at the level of the edge 100. The corner insulation block 25 comprises a first face 26 situated against the first supporting wall 3, a second face 27 situated against the second supporting wall 103, a third face 28 configured to form a bearing surface for the first flat of the metal seal 23, and a fourth face 29 configured to form a bearing surface for the second flat of the metal seal 23. The corner insulation block 25 therefore serves to support the metal seal 23 to prevent the latter from being unsupported, given its large size due to the lateral offset.

[147] As illustrated in figure 1, a space exists between the corner insulation block 25 and the insulating fixing beams 11, 111 so as to allow fixing of the fixing means 47. This space is however filled with insulating packing 48 after fixing in order not to degrade the thermal insulation property of the secondary thermally insulating barrier 2, 102.

[148] Moreover, the metal seal 23 in the first embodiment is produced with an outward corrugation 24 situated on its first flat and an outward corrugation 24 situated on its second flat, the corrugations 24 being situated at the level of the space separating the corner

insulation block 25 and the insulating fixing beams 11, 111, so as to form a corrugated metal seal 23. The corrugations 24 in particular make it possible to absorb the tension force in the secondary sealing membrane 4, 104.

[149] Figure 5 represents a third embodiment that differs from the first embodiment from figure 1 by the shape of the metal seal 23. In effect, in this embodiment the metal seal 23 comprises re-entrant corrugations 24 on its first flat and on its second flat so as to form a corrugated metal seal 23.

[150] Figure 1 also represents the junction between the primary thermal insulating barrier 5 of the first tank wall 1 and the primary thermally insulating barrier 105 of the second tank wall 101 at the level of the corner of the dihedron. As can be seen, the tank comprises a primary corner insulation block 50 that is fixed by a coupler 46 to the first insulating fixing beam 11 and by a coupler 46 to the second insulating fixing beam 111.

[151] The second embodiment illustrated in figure 2 differs in particular from the first embodiment in that the fixing means 47 are not offset laterally relative to the edge 100. Accordingly, in this embodiment, the fixing means 47 of the external anti-buckling portion 21 of the first insulating fixing beam 11 is in alignment with the secondary sealing membrane 104 of the second tank wall 101. The same goes for the second insulating fixing beam 111. Because of this, the metal seal 23 of the second embodiment is sufficiently supported by the metal covering elements 15 of the insulating fixing beams 11, 111. The second embodiment therefore comprises no corner block at the junction of the secondary thermally insulating barriers 2, 102. Accordingly, only an insulating packing 48 is placed between the insulating fixing beams 11, 111 at the level of the edge 100 in this embodiment.

[152] Figures 5 and 6 represents a fourth embodiment of the insulating fixing beams 11, 111 and the abutment devices 19, 20, 119, 120.

[153] In effect, as can be seen in figure 5, in this embodiment each insulating fixing beam 11, 111 comprises an external anti-buckling portion 21 and an internal anti-buckling portion 22. Here the external anti-buckling portion 21 comprises a first lateral bar 44 extending parallel to the edge and including a wall fixed against a lateral surface of the shear webs 14. In the same manner, the internal anti-buckling portion 22 comprises a second lateral bar 45 in such a manner that the first lateral bar 44 and the second lateral bar 45 bracket the shear webs 14.

[154] Moreover, in the fourth embodiment the abutment devices 19, 119 include a plurality of abutment lugs 32, 132 regularly spaced along the edge of the insulating fixing beams 11, 111, respectively, opposite the edge 100. In the same manner, the additional abutment

devices 20, 120 include a plurality of additional abutment lugs 33, 133 regularly spaced along the edge adjacent the edge 100 of the insulating fixing beams 11, 111, respectively.

[155] As can be seen in figure 5, the abutment lugs 32, 132 comprise a first lug portion 34 extending in a plane parallel to the lower face 12 of the insulating fixing beams 11, 111 where the first lug portion 34 comes to overlap the internal anti-buckling portion 22. Moreover, the additional abutment lugs 33, 133 comprise a first lug portion 34 extending in a plane parallel to the lower face 12 of the insulating fixing beams 11, 111 where the first lug portion 34 comes to overlap the external anti-buckling portion 21. The abutment lugs 32, 132 and the additional abutment lugs comprise a second lug portion 35 extending in a plane orthogonal to the first lug portion 34 and orthogonal to the shear webs 14. The second lug portion 35 is fixed to the supporting walls 3, 103. Accordingly, the abutment lugs form a hook-forming anchoring device enabling the insulating fixing beam 11, 111 to be fixed to the supporting structure.

[156] Figure 6 illustrates the assembly in the fourth embodiment between the upper plate 40 and lower plate 41 and the shear webs 14.

[157] In effect, as can be seen in this figure, the shear webs 14 comprise on their upper edge two upper tenons 36 separated from one another in such a manner as to form an upper notch 37. The upper plate 40 for its part comprises a plurality of grooves 42 extending parallel to the shear webs 14 and having a complementary shape to the upper tenons 36 in such a manner that the upper tenons 36 are accommodated in the grooves 42 in the upper plate 40 in order to form a mortise and tenon assembly between the shear webs 14 and the upper plate 40. The upper plate 40 therefore extends across the shear webs 14 in the upper notches 37.

[158] In an analogous manner, the shear webs 14 comprise on their lower edge two lower tenons 38 separated from one another in such a manner as to form a lower notch 39. For its part the lower plate 41 comprises a plurality of grooves 42 extending parallel to the shear webs 14 and having a shape complementary to the lower tenons 38 in such a manner that the lower tenons 38 are accommodated in the groove 42 in the lower plate 41 in order to form a mortise and tenon assembly between the shear webs 14 and the lower plate 41. The lower plate 41 therefore extends across the shear webs 14 in the lower notches 39.

[159] This assembly between the upper plate 40, the lower plate 41 and the shear webs 14 allows improved transmission of shear forces in the insulating fixing beam 11, 111.

[160] The fifth embodiment illustrated in figure 7 differs in particular from the first embodiment by the very structure of the insulating fixing beam 11, 111. In effect, in this embodiment the shear webs are fixed differently to the metal covering element. Moreover, in this embodiment the insulating fixing beam 11, 111 comprises a bottom element 53. This embodiment will be explained in more detail hereinafter with reference to figures 16 and 17.

[161] In an embodiment that is not represented the metal covering element 15 may comprise a plane additional flange formed in line with the plane portion 16 of the metal covering element 15 and extending in the direction of the edge 100. Accordingly, the plane additional flange of the first insulating fixing beam 11 may extend in such a manner as to have one of its ends situated in line with or close to in line with the sealing membrane 104 of the second tank wall 101. In an analogous manner, the plane additional flange of the second insulating fixing beam 111 may extend in such a manner as to have one of its ends situated in line with or close to in line with the sealing membrane 4 of the first tank wall 1. The additional flange therefore has in particular the function of a seating surface for the sealing membrane at the level of the edge of the tank, and in particular seating of the seal 23.

[162] Hereinafter the two shear webs 14 formed at the ends of the insulating fixing beam 11, 111 in the direction of the edge will be referred to as end shear webs 56.

[163] Figure 8 represents a sixth embodiment of the insulating fixing beam 11, 111. In this embodiment the metal covering element 15 is similar to that of the first embodiment in that it comprises a plane portion 16, a first lateral flange 17 arranged at a first end of the plane portion 16 and a second lateral flange 18 arranged at a second end of the plane portion 16, the metal covering element 15 being formed here in one piece.

[164] As can be seen in figure 8 the shear webs 14, 56 include a central portion 51 oriented perpendicularly to the edge as is already the case in the first embodiment. However, in this embodiment the shear webs 14, 56 also comprise two sole plates 52 extending perpendicularly to the central portion 51. The lower and upper sole plates 252 are parallel to one another and bracket the central portion 51. The central portion 51 of the end shear webs 56 comprises in a lower part a step 61 projecting toward the exterior of the insulating fixing beam 11, 111. This step 61 enables, with the aid of a hook-forming anchoring device, the insulating fixing beam 11, 111 to be fixed to the supporting structure, covering the step 61.

[165] In the sixth embodiment from figure 8 the sole plates 52 extend parallel to the first supporting wall 3 so as to form lower and upper sole plates 252. Accordingly, the lower

sole plates 252 placed end to end on a lower side of the shear webs 14, 56 form a continuous bottom wall parallel to the metal covering element 15. In an embodiment that is not illustrated this surface could be discontinuous. Similarly, the upper sole plates 252 placed end to end form a continuous covering wall.

5 [166] Figure 9 represents a seventh embodiment of the insulating fixing beam 11, 111. This embodiment is very similar to the sixth embodiment. In effect, here the insulating fixing beam 11, 111 includes shear webs 14, 56 formed two by two in one piece so that the shear webs form shear tubes extending in the direction of the shear webs 14, 56. The shear tubes are fixed to one another in such a manner as to form the insulating fixing beam 11,
10 111.

[167] Figure 10 represents an eighth embodiment of the insulating fixing beam 11, 111. The structure of this insulating fixing beam 11, 111 is similar to that of the sixth embodiment. In effect, in this embodiment only the orientation of the sole plates 52 is different. The sole plates 52 extend perpendicularly to the first supporting wall 3 so as to form front and rear
15 sole plates 152. Accordingly, the front sole plates 152 placed end to end on an opposite side of the shear webs 14, 56 to the edge 100 form a continuous front wall perpendicular to the metal covering element 15. Similarly, the rear sole plates 152 form a continuous rear wall. In an embodiment that is not illustrated these walls could be discontinuous.

[168] Figure 11 represents a ninth embodiment of the insulating fixing beam 11, 111. This
20 embodiment differs from the eighth embodiment in the number of shear webs 14, 56. In effect, in this embodiment the insulating fixing beam 11, 111 comprises only two end shear webs 56 so as to form a box-shape insulating fixing beam 11, 111.

[169] Figures 12 and 13 represent a tenth embodiment of the insulating fixing beam 11, 111. In this embodiment the shear webs 14, 56 are formed in the same manner as in the eighth
25 embodiment. However, the tenth embodiment differs from the previous embodiments in the presence of a bottom element 53 and a metal covering element 15 having a different structure. In effect, the metal covering element 15 comprises two internal flanges 58 extending at the ends of the plane portion 16 and parallel to the first lateral flange 17 and to the second lateral flange 18. The internal flanges 58 are situated between the front and
30 rear sole plates 152 of the shear webs 14 so that an internal flange 58 is situated against an internal face of a sole plate 52.

[170] Moreover, the internal flanges 58 includes a plurality of flange portions 59 spaced from one another in the direction of the edge 100 so that a shear web 14, 56 is disposed between two adjacent flange portions 59. In this embodiment the first lateral flange 17 and
35 the second lateral flange 18 are formed of a plate fixed to an internal flange 58 through the

front and rear sole plates 52 by fixing means 60, for example of nut and bolt type. In the embodiment illustrated the plate forming one of the lateral flanges 17, 18 is fixed to each of the flange portions 59 of an internal flange 58 at the level of the join between two adjacent sole plates 52.

5 [171] In the tenth embodiment from figures 12 and 13 the bottom element 53 is a metal bottom element 53 including a plane portion 54 forming the lower face 12 of the insulating fixing beam 11, 111. The bottom element 53 also includes two lateral flanges 55 extending parallel to the shear webs 14, 56 and in the direction of the metal covering element 15. Here the lateral flanges 55 are situated against an internal face of the central portion 51 of the end shear webs 56. Moreover, the lateral flanges 55 are fixed by a plurality of fixing means 60, for example of nut and bolt type, to the central portion 51 of the end shear webs 56. Here each lateral flange 55 is formed by two lateral flange portions 55 spaced from one another.

15 [172] The bottom element 53 also comprises bearing elements 57 fixed to the lateral flanges 55 and projecting from one of the principal portions 51 of the end shear webs 56 toward the exterior of the insulating fixing beam 11, 111. The bearing elements 57 have an upper bearing surface enabling, with the aid of a hook-forming anchoring device, the insulating fixing beam 11, 111 to be fixed to the supporting structure and covering the upper bearing surface.

20 [173] In this embodiment the bearing elements 57 are apertured thick plates 57 through which passes one of the fixing means 60 serving to fix one of the lateral flanges 55. The thick plates 57 are fixed to an external face of the central portion 51 of the end shear webs 56.

25 [174] Figures 14 and 15 represent an eleventh embodiment of the insulating fixing beam 11, 111. This embodiment is very similar to the second embodiment and differs therefrom only in certain features of the bottom element 53. In effect, in this embodiment the bottom element 53 is made of composite material. Each lateral flange 55 is situated at one end of the plane portion 54 and extends over all the dimension of the bottom element 53 in the direction of the shear webs 14, 56. Here the lateral flanges 55 are situated against an external face of the central portion 51 of the end shear webs 56. In this embodiment the bearing element 57 is a lateral flange extension extending orthogonally to the lateral flange 55 in such a manner as to project toward the exterior of the insulating fixing beam 11, 111. As previously the bearing element includes an upper bearing surface enabling the insulating fixing beam 11, 111 to be anchored to the supporting structure.

[175] In the embodiments from figures 10 to 15 the front and rear sole plates 152 of the end shear webs 56 do not project toward the exterior of the insulating fixing beam 11, 111 relative to the central portion 51. In effect, the sole plates 52 of the end shear webs 56 extend only from the central portion 51 toward the adjacent shear web 14.

5 [176] Figures 16 and 17 show in more detail the fifth embodiment of the insulating fixing beam 11, 111 shown in figure 7. The fifth embodiment is similar to the eleventh embodiment from figures 14 and 15 and differs therefrom only in the front and rear sole plates 152 of the end shear webs 56. In effect, in contrast to the embodiments from figures 10 to 15, the sole plates 52 of the end shear webs 56 extend completely across
10 the central portion 51 in the direction of the edge 100. Accordingly, in this embodiment the bearing elements 57 indeed project from the central portion 51 of the end shear webs 56 but not as far as the sole plates 52 of the end shear webs 56. This separation enables an anchoring device to be accommodated more easily.

[177] In some embodiments, as can be seen in figure 1, bands of mastic 49 are disposed
15 between the supporting structure and the insulating fixing beams 11, 111 in order to make up for flatness irregularities of the supporting structure. Moreover, bands of mastic 49 may also be disposed between the abutment devices 19, 119 and the insulating fixing beams 11, 111 and between the additional abutment devices 20, 120 and the insulating fixing beams 11, 111 in order to compensate any assembly play.

20 [178] Figures 18 to 21 represent a twelfth embodiment of the insulating fixing beam 11, 111. The twelfth embodiment differs in particular from the fifth embodiment illustrated in figure 7 by the very structure of the insulating fixing beam 11, 111. In effect, in this embodiment the shear webs 14 are fixed differently to the metal covering element 15. Moreover, the metal covering element 15 and the elements enabling fixing to the supporting structure are
25 designed differently.

[179] Figure 18 particularly represents the assembly of the insulating fixing beam 11, 111 to the other elements of the storage insulation.

[180] As can be seen in figure 20 in particular, each insulating fixing beam 11, 111 therefore includes a plurality of shear webs 14, thermally insulating packings 62 situated between
30 the shear webs 14, a lower plate 41 at the level of the lower plate 12 between two adjacent shear webs 14, and metal covering elements 15 connecting two adjacent shear webs 14 at the level of an upper face of the shear webs 14.

[181] The metal covering elements 15 include a plane metal plate 63 provided with fixing orifices 64 passing completely through it. The fixing orifices 64 are configured to allow the

passage of a fixing device 47, for example of nut and bolt type, that fixes the metal covering element 15 to one of the shear webs 14. The plane metal plate 63 has a dimension in the direction of the edge 100 equal to the spacing between two adjacent shear webs 14 so as to be situated and fixed in line with these two adjacent shear webs 14. The plane metal plate 63 includes a supporting portion 65 projecting from the shear webs 14 in the direction of the secondary sealing membrane 4 away from the edge 100, as can be seen in figures 19 and 21, so that the end of the support portion 65 rests on the adjacent secondary insulating panel 7. The support portion 65 enables the secondary sealing membrane 4 to be supported between the insulating fixing beam 11, 111 and the secondary insulating panel 7 adjacent to the insulating fixing beam 11, 111. The end of the support portion 65 also includes fixing orifices 64 configured to allow the passage of a fixing device 47, for example of nut and bolt type, enabling the metal covering element 15 to be fixed to the adjacent secondary insulating panel 7. However, the fixing of the metal covering element 15 to the adjacent secondary insulating panel 7 is optional, as the support portion 65 of the metal covering element 15 could simply rest on the adjacent secondary insulating panel 7.

[182] Moreover, the metal covering element 15 may comprise a rim 66 connected to the plane metal plate 63 and extending against one face of the shear webs 14 close to the edge 100 and extending in the direction of the supporting structure, as illustrated in figure 18.

[183] In this embodiment the shear webs 14 are made of fiber-reinforced composite material, the fibers 99 being oriented at $\pm 45^\circ$ as schematically represented in figure 20. The insulating fixing beam 11, 111 comprises fixing angle-irons 67 including a first angle-iron flange 68 and a second angle-iron flange 69 connected to the first angle-iron flange 68 so as to form a right-angle angle-iron. The second angle-iron flange 69 is glued to one of the shear webs 14 in an upper part thereof. For its part the first angle-iron flange 68 is provided with fixing orifices 64 coinciding with the orifices 64 in the metal covering element 15 so as to fix the first angle-iron flange 68 with the plane metal plate 63 by means of the fixing devices 47. Accordingly, two adjacent shear webs 14, the metal covering element 15 and the lower plate 41 form a parallelepipedal box where the angle-irons 67 are situated at the level of two upper corners inside said box. To limit the stresses in the glue, at its end remote from the first angle-iron flange 68 the second angle-iron flange 69 includes a beveled portion 82, as can be seen in figure 21.

[184] In another embodiment that is not represented the plane metal plate 63 is fixed to the first angle-iron flange 68 by welding it thereto so that it is not necessary for the plane metal

plate 63 and the first angle-iron flange 68 to comprise fixing orifices 64 enabling them to be fixed to one another. However, in another embodiment the plane metal plate 63 and the first angle-iron flange 68 still comprise fixing orifices 64 to enable fixing in addition to welding.

5 [185] The insulating fixing beam 11, 111 includes on one face of each shear web 14 opposite to the position of the fixing angle-iron 67 a cleat 83 extending in a direction from the abutment device 19, 119 to the additional abutment device 20, 120. The cleat 83 includes a principal portion 84, an upper extension 85 and a lower extension 86 on either side of the principal portion 84. The principal portion 84, the upper extension 85 and the lower
10 extension 86 are glued to the shear web 14, the upper extension 85 and the lower extension 86 enabling the gluing area of the cleat 83 to be increased. The upper extension 85 is beveled so as to have a decrease in thickness in the direction away from the principal portion 84 in order to limit the stresses in the glue.

[186] The cleat 83 enables the insulating fixing beam 11, 111 to be fixed to the supporting
15 structure with the aid of anchoring stud 92 distributed over the length of the cleat 83, for example two in number as illustrated in figure 18. The anchoring stud 92 is for example provided with a clamping plate coming up against an upper face of the principal portion 84 of the cleat 83 in order to retain the cleat 83 in position and thus to fix the shear web 14 to the supporting structure.

20 [187] The insulating fixing beam 11, 111 is placed between the abutment device 19, 119 and the additional abutment device 20, 120 in order to limit the movement of the insulating fixing beam 11, 111 in the longitudinal direction of the strakes of the secondary sealing membrane 4. Each abutment device 19, 119 includes an abutment bar 30, 130 extending in a continuous manner parallel to the edge 100 along the edge of the insulating fixing
25 beam 11, 111 opposite the edge 100. Each additional abutment device 20, 120 includes an additional abutment bar 31, 131 extending in a continuous manner parallel to the edge 100 along the edge of the insulating fixing beam 11, 111 opposite the edge 100.

[188] In another embodiment that is not represented the abutment device 19, 119 includes a U-shaped abutment element comprising a central part extending parallel to the edge 100
30 along the edge of the insulating fixing beam 11, 111 opposite the edge 100, a first branch connected to the central part and extending perpendicularly to the edge 100 in the direction thereof so as to come to be fixed to one of the anchoring studs 92, and a second branch connected to the central part opposite the first branch and extending perpendicularly to the edge 100 in the direction thereof so as to come to be fixed to one of the anchoring
35 studs 92. Accordingly, the abutment element comes to bracket on either side in the

direction of the edge 100 the insulating fixing beam 11, 111 by coming to be fixed to the anchor studs 92.

[189] Returning to figure 18 and in the same manner as in the first embodiment, in order to connect the secondary sealing membranes 4, 104 at the level of the dihedron formed by the tank walls 1, 101 there is provision for fixing a metal seal 23 comprising a first flat and a second flat forming a corner with the first equal to the angle of the dihedron. Moreover, the metal seal 23 comprises re-entrant corrugations 24 on its first flat and on its second flat so as to form a corrugated metal seal 23. These corrugations 24 are situated on a part of the metal seal 23 that is not supported by the insulating fixing beams 11, 111, the metal seal 23 being supported on that part by a corner insulation block 25 having a surface of complementary shape to the metal seal 23, as illustrated in figure 18.

[190] However, in contrast to the first embodiment, the metal seal 23 is not connected directly to an end metal strake 87 of the secondary sealing membrane 4, 104. In effect, in this twelfth embodiment, the secondary sealing membrane 4, 104 includes a metal anchoring strip 88 welded to the supporting portion 65 of the metal covering element 15. The end metal strake 87 is then welded in sealed manner to a portion of the metal anchoring strip 88 and the metal seal 23 is welded in sealed manner to another portion of the metal anchoring strip 88. The seal may also have a remote portion 89 so as to come to cover the strip 88 in part.

[191] In another embodiment that is not represented the metal seal 23 is welded in sealed manner directly to the metal covering element 15 while the end metal strake 87 is welded in sealed manner to a portion of the metal anchoring strip 88. Thus it is not necessary in this embodiment to provide a remote portion 89 on the metal seal 23. In another embodiment that is not represented the metal seal 23 and the end metal strake 87 are welded in sealed manner directly to the metal covering element 15 so that a portion of the metal covering element 15 serves as an extension of the secondary sealing membrane 4. It is therefore not necessary in this embodiment to provide a metal anchoring strip 88.

[192] The secondary insulating panel 7 adjacent to the insulating fixing beam 11, 111 includes in particular an upper plate 90, a block of insulating foam and a lower plate. The upper plate 90 comprises a recess 91 extending in the direction of the edge 100 and situated at the end closest to the edge 100 of the upper plate 90. The recess 91 is produced over a thickness of the upper plate 90 equal to the thickness of the metal covering element 15 plus the thickness of the metal anchoring strip 88. The recess 91 therefore enables good flatness of the secondary sealing membrane 4, 104 to be maintained at the level of

the connection with the metal seal 23 and the end strake 87. The end of the support portion 65 therefore comes to be placed in the recess 91 in the secondary insulating panel 7.

[193] Figure 18 also represents the junction between the primary thermally insulating barrier 5 of the first tank wall 1 and the primary thermally insulating barrier 105 of the second tank wall 101 at the level of the corner of the dihedron. As can be seen, the tank comprises a primary corner insulation block 50 that is fixed by two couplers 46 to the first insulating fixing beam 11 and by two couplers 46 to the second insulating fixing beam 111. In effect, as can be seen in figure 20, the metal covering element 15 also comprises fixing orifices 64 situated in the middle of the plane metal plate 63 between the shear webs 14 so as to enable the couplers 46 to fix the primary corner block 50 to the insulating fixing beams 11, 111.

[194] Referring to figure 22, a cutaway of a methane tanker ship 70 shows a sealed and insulated tank 71 of prismatic general shape mounted in the double hull 72 of the ship. The wall of the tank 71 includes a primary sealing barrier intended to be in contact with the LNG contained in the tank, a secondary sealing barrier arranged between the primary sealing barrier and the double hull 72 of the ship, and two insulating barriers respectively arranged between the primary sealing barrier and the secondary sealing barrier and between the secondary sealing barrier and the double hull 72.

[195] In a manner known in itself loading/offloading pipes 73 disposed on the top deck of the ship may be connected by means of appropriate connectors to a maritime or harbor terminal to transfer a cargo of LNG from or to the tank 71.

[196] Figure 22 shows an example of a maritime terminal including a loading and offloading station 75, an underwater pipe 76 and a terrestrial installation 77. The loading and offloading station 75 is a fixed off-shore installation including a mobile arm 74 and a tower 78 that supports the mobile arm 74. The mobile arm 74 carries a bundle of insulated flexible tubes 79 that can be connected to the loading/offloading pipes 73. The orientable mobile arm 74 adapts to all methane tanker loading gauges. A connecting pipe that is not shown extends inside the tower 78. The loading and offloading station 75 enables loading and offloading of the methane tanker 70 from or to the terrestrial installation 77. The latter includes liquefied gas storage tanks 80 and connecting pipes 81 connected via the underwater pipe 76 to the loading or offloading station 75. The underwater pipe 76 enables transfer of the liquefied gas between the loading or offloading station 75 and the terrestrial installation 77 over a great distance, for example 5 km, which enables the methane tanker ship 70 to remain at a great distance from the coast during loading and offloading operations.

[197] Pumps onboard the ship 70 and/or pumps equipping the terrestrial installation 77 and/or pumps equipping the loading and offloading station 75 are used to generate the pressure necessary to transfer the liquefied gas.

5 [198] Although the invention has been described in connection with a plurality of particular embodiments, it is obvious that it is in no way limited to them and that it encompasses all technical equivalents and combinations of the means described if the latter fall within the scope of the invention.

[199] The use of the verb "to include" or "to comprise" and conjugate forms thereof does not exclude the presence of elements or steps other than those stated in a claim.

10 [200] In the claims, any reference sign between parentheses should not be interpreted as a limitation of the claim.

Claims

[Claim 1] A storage installation for a liquefied gas comprising a supporting structure and a sealed and thermally insulating tank arranged in the supporting structure, the tank comprising at least a first tank wall (1) fixed to a first supporting wall (3) of the supporting structure and a second tank wall (101) fixed to a second supporting wall (103) of the supporting structure, each tank wall (1, 101) comprising at least one sealing membrane (4, 104) and at least one thermally insulating barrier (2, 102), the thermally insulating barrier (2, 102) being placed between the sealing membrane (4, 104) and the supporting structure, the first supporting wall (3) forming a corner with the second supporting wall (103) along an edge (100), the sealing membrane (4) of the first tank wall (3) including a plurality of metal plates,

in which the thermally insulating barrier (2) of the first tank wall (1) comprises an insulating fixing beam (11) anchored to the first supporting wall (3) and having a length extending parallel to the edge (100), the insulating fixing beam (11) including an upper face (13) maintained at a distance from the first supporting wall (3) by a plurality of shear webs (14), the shear webs (14) being situated between the upper face (13) and the first supporting wall (3) and oriented perpendicularly to the edge (100), the insulating fixing beam (11) including an insulating packing arranged between the shear webs (14), and the insulating fixing beam (11) also including a metal covering element (15) comprising a plane portion (16) forming the upper face (13), an end edge of the sealing membrane (4) of the first tank wall (1) being welded to the plane portion (16) of the metal covering element (15),

and in which the supporting structure comprises an abutment device (19) projecting from the first supporting wall (3) in the direction of the interior of the tank, the abutment device (19) having a length extending parallel to the edge (100), the abutment device (19) being placed along an edge of the insulating fixing beam (11) opposite the edge (100) and being configured to form an abutment limiting the movement of the insulating fixing beam (11) in a direction away from the second tank wall (101).

[Claim 2] The storage installation as claimed in claim 1, in which the metal covering element (15) comprises a plane metal plate (63) including a supporting portion (65) projecting from the shear webs (14) in the direction of the sealing membrane (4, 104) and in a direction away from the edge (100) so that an end of the supporting portion (65) rests on an insulating panel (7) of the thermally insulating barrier (2, 102) adjacent to the insulating fixing beam (11, 111).

[Claim 3] The storage installation as claimed in claim 2, in which the plane metal plate (63) has a dimension in the direction of the edge (100) equal to the separation between two adjacent shear webs (14) and is arranged so as to extend between the two adjacent shear webs (14).

5 [Claim 4] The storage installation as claimed in any one of claims 1 to 3, in which the shear webs (14) are made of composite material including a polymer resin and fibers (99).

[Claim 5] The storage installation as claimed in claim 4, in which the fibers (99) are oriented at an angle of $\pm 45^\circ$ relative to a direction of thickness of the tank wall.

10 [Claim 6] The storage installation as claimed in any one of claims 1 to 5, in which the insulating fixing beam (11, 111) comprises a fixing angle-iron (67) including a first angle-iron flange (68) and a second angle-iron flange (69) connected to the first angle-iron flange (68), the second angle-iron flange (69) being fixed to one of the shear webs (14) and the first angle-iron flange (68) being welded to the metal covering element (15).

15 [Claim 7] The storage installation as claimed in any one of claims 1 to 5, in which the insulating fixing beam (11, 111) comprises a fixing angle-iron (67) including a first angle-iron flange (68) and a second angle-iron flange (69) connected to the first angle-iron flange (68), the second angle-iron flange (69) being fixed to one of the shear webs (14) and the first angle-iron flange (68) comprising at least one fixing orifice (64)
20 coinciding with a fixing orifice (64) of the metal covering element (15) so as to fix the first angle-iron flange (68) to the plane metal plate (63) by means of a fixing device (47) traversing the fixing orifice (64) in the metal covering element (15) and the fixing orifice (64) in the first angle-iron flange (68).

[Claim 8] The storage installation as claimed in claim 6 or claim 7, in which the second
25 angle-iron flange (69) includes a beveled portion (82) at an end remote from the first angle-iron flange (68).

[Claim 9] The storage installation as claimed in any one of claims 1 to 8, in which the
30 insulting fixing beam (11, 111) includes a cleat (83) fixed to a face of the shear web (14) perpendicular to the edge (100) and extending parallel to the metal covering element (15), the cleat (83) including a principal portion (84), an upper extension (85) and a lower extension (86) on respective opposite sides of the principal portion (84), the principal portion (84), the upper extension (85) and the lower extension (86) being fixed to the shear web (14),

and in which the cleat (83) is fixed to the supporting structure with the aid of anchoring studs (92) distributed over a length of the cleat (83), the anchoring studs (92) coming to exert a clamping force against an upper face of the principal portion (84) of the cleat (83).

5 [Claim 10] The storage installation as claimed in claim 9, in which the upper extension (85) is beveled so as to have a thickness that decreases in the direction away from the principal portion (84).

[Claim 11] The storage installation as claimed in any one of claims 1 to 10, in which the
10 abutment device (19) includes an abutment bar (30), the abutment bar (30) extending in a continuous manner parallel to the edge (100) along the edge opposite the edge (100) of the insulating fixing beam (11).

[Claim 12] The storage installation as claimed in any one of claims 1 to 10, in which the
15 abutment device (19) includes a plurality of abutment lugs (32), the abutment lugs (32) being regularly spaced along the edge opposite the edge (100) of the insulating fixing beam (11).

[Claim 13] The storage installation as claimed in any one of claims 1 to 12, in which the
20 insulating fixing beam (11) include(s) an internal anti-buckling portion (22) extending the shear webs (14) in a direction away from the edge (100) and extending over a portion of the dimension separating the first supporting wall (3) from the metal covering element (15), the internal anti-buckling portion (22) being fixed by at least one fixing means (19, 47) to the first tank wall (3), and in which the abutment device (19) includes a hook-forming device configured to fix the internal anti-buckling portion (22) to the first supporting wall (3).

[Claim 14] The storage installation as claimed in any one of claims 1 to 13, in which the
25 insulating fixing beam (11) includes an external anti-buckling portion (21) extending the shear webs (14) in the direction of the edge (100) and extending over a portion of the dimension separating the first supporting wall (3) from the metal covering element (15), the external anti-buckling portion (21) being fixed by a fixing means (47) to the first supporting wall (3).

30 [Claim 15] The storage installation as claimed in claim 13 or 14, in which the fixing means (47) comprises a stud fixing the external anti-buckling portion (21) or the internal anti-buckling portion (22) to the supporting structure so that a first end of the stud is anchored to the supporting structure and a second end of the stud opposite the first

end is equipped with a nut coming to bear on the external anti-buckling portion (21) or the internal anti-buckling portion (22).

5 [Claim 16] The storage installation as claimed in any one of claims 1 to 15, in which the supporting structure comprises an additional abutment device (20) projecting from the first supporting wall (3) in the direction of the interior of the tank, the additional abutment device (20) having a length extending parallel to the edge (100), the additional abutment device (20) being placed along an edge of the insulating fixing beam (11) adjacent to the edge (100) and being configured to form an abutment limiting the movement of the insulating fixing beam (11) in a direction opposite to the direction of the abutment device (19).

[Claim 17] The storage installation as claimed in claim 16, in which the additional abutment device (20) includes an additional abutment bar (31), the additional abutment bar (31) extending in a continuous manner parallel to the edge (100) along the edge opposite the edge (100) of the insulating fixing beam (11).

15 [Claim 18] The storage installation as claimed in claim 16, in which the additional abutment device (20) includes a plurality of additional abutment lugs (33), the additional abutment lugs (33) being regularly spaced along the edge opposite the edge (100) of the insulating fixing beam (11).

20 [Claim 19] The storage installation as claimed in any one of claims 16 to 18 in combination with claim 14, in which the additional abutment device (20) includes a hook-forming device configured to fix the external anti-buckling portion (21) to the first supporting wall (3), the hook-forming device constituting said fixing means (47).

25 [Claim 20] The storage installation as claimed in claim 13 or claim 14, in which the external anti-buckling portion (21) and/or the internal anti-buckling portion (22) is/are formed by portions (43) extending the shear webs (14).

30 [Claim 21] The storage installation as claimed in claim 13 and 14 in combination, in which the external anti-buckling portion (21) comprises a first lateral bar (44) extending parallel to the edge (100), the first lateral bar (44) including a wall pressed against a lateral surface of the shear webs (14), and the internal anti-buckling portion (22) comprises a second lateral bar (45) extending parallel to the edge (100), the second lateral bar (45) including a wall pressed against another lateral surface of the shear webs (14), the first lateral bar (44) and the second lateral bar (45) bracketing the shear webs (14).

[Claim 22] The storage installation as claimed in any one of claims 1 to 21, in which the metal covering element (15) of the insulating fixing beam (11) comprises a first lateral flange (17) extending perpendicularly to the shear webs (14) and in the direction of the first supporting wall (3), the first lateral flange (17) sandwiching the shear webs (14) with the abutment device (19) in order to absorb shear forces exerted by the sealing membrane (4, 104).

[Claim 23] The storage installation as claimed in claim 22, in which the metal covering element (15) of the insulating fixing beam (11) comprises a second lateral flange (18) extending perpendicularly to the shear webs (14) and in the direction of the first supporting wall (3) so that the first lateral flange (17) and the second lateral flange (18) bracket the shear webs (14), the first lateral flange (17) being situated closer to the edge (100) than the second lateral flange (18).

[Claim 24] The storage installation as claimed in any one of claims 1 to 23, in which the tank comprises a corrugated seal (23) comprising a first flat and a second flat forming a corner with the first flat, the first flat being welded in sealed manner to the sealing membrane (4) of the first tank wall (1) and the second flat being welded in sealed manner to the sealing member (104) of the second tank wall (101), the corrugated seal (23) being configured to connect in sealed manner the sealing membrane (4) of the first tank wall (1) and the sealing membrane (104) of the second tank wall (101).

[Claim 25] The storage installation as claimed in claim 24, in which the sealing membrane (4, 104) includes a metal anchoring strip (88) welded to the metal covering element (15), one of the metal plates (87) being welded in sealed manner to a portion of the metal anchoring strip (88) and the metal seal (23) being welded in sealed manner to another portion of the metal anchoring strip (88).

[Claim 26] The storage installation as claimed in claim 25, in which the secondary insulating panel (7) adjacent to the insulating fixing beam (11, 111) includes an upper plate (90) provided with a recess (91) extending in the direction of the edge (100) and situated at the end closest to the edge (100) of the upper plate (90), one end of the metal covering element (15) being placed in the recess (91) in order to obtain a plane support surface for the sealing membrane (4, 104).

[Claim 27] The storage installation as claimed in any one of claims 1 to 26, in which the tank comprises a corner insulation block (25) situated in line with the thermally insulating barrier (2) of the first tank wall (1) and the thermally insulating barrier (102) of the second tank wall (101) at the level of the edge (100), the corner insulation block (25) being configured to ensure the continuity of the thermally insulating barrier (2) of

the first tank wall (1) and of the thermally insulating barrier (102) of the second tank wall (101) at the level of the edge (100) of the supporting structure.

[Claim 28] The storage installation as claimed in claims 24 and 27 in combination, in which the corner insulation block (25) comprises a first face (26) situated against the first supporting wall (3), a second face (27) situated against the second supporting wall (103), a third face (28) configured to offer a bearing surface to the first flat of the corrugated seal (23) and a fourth face (29) configured to offer a bearing surface to the second flat of the corrugated seal (23).

[Claim 29] The storage installation as claimed in any one of claims 1 to 28, in which the insulating fixing beam (11) comprises an upper plate (40) situated under the metal covering element (15) and extending along the insulating fixing beam (11) and in which each shear web (14) comprises on an upper edge two upper tenons (36) separated from one another in such a manner as to form an upper notch (37), the upper plate (40) comprising a plurality of grooves (42) extending parallel to the shear webs (14) and having a shape complementary to the upper tenons (36) in such a manner that the upper tenons (36) are accommodated in the grooves (42) in the upper plate (40) in order to form a mortise and tenon assembly between the shear webs (14) and the upper plate (40).

[Claim 30] The storage installation as claimed in any one of claims 1 to 29, in which the insulating fixing beam (11) comprises a lower plate (41) situated on the first supporting wall (3) and extending along the insulating fixing beam (11) and in which each shear web (14) comprises on a lower edge two lower tenons (38) separated from one another in such a manner as to form a lower notch (39), the lower plate (41) comprising a plurality of grooves (42) extending parallel to the shear webs (14) and having a shape complementary to the lower tenons (38) in such a manner that the lower tenons (38) are accommodated in the grooves (42) in the lower plate (41) in such a manner as to form a mortise and tenon assembly between the shear webs (14) and the lower plate (41).

[Claim 31] The storage installation as claimed in any one of claims 1 to 30, in which the thermally insulating barrier (2) of the first tank wall (1) or the thermally insulating barrier (102) of the second tank wall (101) comprises a plurality of insulating panels (7, 107) including a lower wall situated close to the first supporting wall (3) or the second supporting wall (103), respectively, an upper wall and a structural insulating packing maintaining the upper wall at a distance from the lower wall, the insulating packing being composed of fiber-reinforced polymer foam.

[Claim 32] The storage installation as claimed in any one of claims 1 to 31, in which the thermally insulating barrier is a secondary thermally insulating barrier (2, 102) and the sealing membrane is a secondary sealing membrane (4, 104) and in which the first tank wall (1) and the second tank wall (101) further include, in a direction of thickness

5 from the exterior to the interior of the tank, a primary thermally insulating barrier (5, 105) carried by the secondary sealing membrane (4, 104) and a primary sealing membrane (6, 106) carried by the primary thermally insulating barrier (5, 105).

[Claim 33] The storage installation as claimed in claim 32, in which the primary sealing membrane (6, 106) includes a plurality of corrugated metal plates, the corrugated metal

10 plates being juxtaposed in accordance with a repeated pattern and welded together in sealed manner.

[Claim 34] The storage installation as claimed in any one of claims 1 to 33, in which the first tank wall (1) comprises bands of mastic (49) disposed between the insulating fixing beam (11) and the first supporting wall (3).

[Claim 35] The storage installation as claimed in any one of claims 1 to 34, in which the sealing membrane (24) includes a plurality of strakes parallel to a longitudinal direction perpendicular or oblique to said edge (100), each strake including a plane central portion resting on an upper surface of the thermally insulating barrier and two raised edges projecting toward the interior of the tank relative to the central portion, the

15 strakes being juxtaposed in accordance with a repeated pattern and welded together in sealed manner at the level of the raised edges.

20

[Claim 36] The storage installation as claimed in any one of claims 1 to 35, in which the shear webs (14) comprise a central portion (51) oriented perpendicularly to the edge (100) and two peripheral portions (52) extending perpendicularly to the central portion (51), the peripheral portions (52) being parallel to one another and bracketing the central portion (51).

25

[Claim 37] The storage installation as claimed in claim 36, in which the peripheral portions (52) include a lower sole plate (252) and an upper sole plate (252) extending parallel to the first walls (3), the lower sole plates (252) of all the shear webs (14) forming a continuous or discontinuous bottom wall, the upper sole plates (252) forming a

30 continuous or discontinuous covering wall.

[Claim 38] The storage installation as claimed in claim 36, in which the peripheral portions (52) include a front sole plate (152) and a rear sole plate (152) extending perpendicularly to the first supporting wall (3), the front sole plates (152) of all the shear

webs (14) forming a continuous or discontinuous front wall facing away from the edge (100), the rear sole plates (152) of all the shear webs (14) forming a continuous or discontinuous rear wall facing toward the edge (100).

5 [Claim 39] The storage installation as claimed in any one of claims 1 to 38, in which the insulating fixing beam (11) comprises a bottom element (53) including a plane portion (54) resting on the first supporting wall (3) and two lateral walls (55) bracketing the shear webs (14) and extending parallel to the shear webs (14) in the direction of the metal covering element (15), the lateral flanges (55) being fixed by an anchoring means to a central portion (51) of end shear webs (56), the end shear webs (56) being
10 two shear webs (14) formed at the ends of the insulating fixing beam (11) in the direction of the edge (100).

[Claim 40] The storage installation as claimed in claim 39, in which the bottom element (53) comprises at least one bearing element (57) fixed to one of the lateral flanges (55), the bearing element (57) projecting from one of the end shear webs (56), the anchoring
15 means comprising a hook-forming device situated on the bearing element (57) and configured to fix the insulating fixing beam (11) to the first supporting wall (3).

[Claim 41] The storage installation as claimed in claim 39 or claim 40, in which the bottom element (53) is made of metal or of composite material.

[Claim 42] The storage installation as claimed in claims 23 and 39 in combination, in which
20 the metal covering element (15) comprises two internal flanges (58) extending at the ends of the plane portions (16) of the metal covering element (15) and parallel to the first lateral flange (17) and to the second lateral flange (18), the internal flanges (58) being situated between the front and rear sole plates (152) of the shear webs (14), the first lateral flange (17) and the second lateral flange (18) bracketing the front and rear
25 sole plates (152) of the shear webs (14), the first lateral flange (17) being fixed by a fixing means (60) to one of the internal flanges (58) and the second lateral flange (18) being fixed by a fixing means (60) to the other of the internal flanges (58).

[Claim 43] The storage installation as claimed in any one of claims 1 to 42, in which the insulating fixing beam is a first insulating fixing beam (11), the abutment device is a
30 first abutment device (19), and the sealing member (104) of the second tank wall (103) includes a plurality of metal plates or a plurality of strakes parallel to a longitudinal direction perpendicular or oblique to said edge (100), each strake including a plane central portion resting on an upper surface of the thermally insulating barrier (102) and two raised edges projecting toward the interior of the tank relative to the central portion,
35 the strakes being juxtaposed in accordance with a repeated pattern and welded

together in sealed manner at the level of the raised edges, and the thermally insulating barrier (102) of the second tank wall (101) comprises a second insulating fixing beam (111) including an upper face (13) maintained at a distance from the second supporting wall (103) by a plurality of shear webs (14), the shear webs (14) being situated between the upper face (13) and the second supporting wall (103) and oriented perpendicularly to the edge (100), the second insulating beam (111) including an insulating packing arranged between the shear webs (14), and the second insulating fixing beams (111) also including a metal covering element (15) comprising a plane portion (16) forming the upper face (13), an end edge of the sealing membrane (104) of the second tank wall (101) being welded to the plane portions (16) of the metal covering element (15), and in which the supporting structure comprises a second abutment device (119) projecting from the second supporting wall (103) in the direction of the interior of the tank, the second abutment device (119) having a length extending parallel to the edge (100), the second abutment device (119) being placed along an edge of the second insulating beam (11) opposite the edge (100) and being configured to form an abutment limiting the movement of the second insulating fixing beam (111) in a direction away from the first tank wall (1).

[Claim 44] A ship (70) for the transport of a cold liquid product, the ship including a double hull (72) and a storage installation (71) as claimed in any one of claims 1 to 43, a portion of the double hull forming the supporting structure of the storage installation.

[Claim 45] A transfer system for a cold liquid product, the system including a ship (70) as claimed in claim 44, insulated pipes (73, 79, 76, 81) arranged in such a manner as to connect the tank (71) installed in the hull of the ship to a floating or terrestrial storage installation (77), and a pump for driving a flow of cold liquid product through the insulated pipes from or to the floating or terrestrial storage installation to or from the tank of the ship.

[Claim 46] A method of loading or offloading a ship (70) as claimed in claim 44, in which a cold liquid product is routed through insulated pipes (73, 79, 76, 81) from or to a floating or terrestrial storage installation (77) to or from the tank (71) of the ship.