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(54) FLUID-TIGHT INSULATED TANK FOR LIQUEFIED GAS

(71) We, GAZ-TRANSPORT, of 50 Boulevard Haussmann, 75009 Paris, France, a French Body Corporate, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a fluid-tight insulated tank, for example such a tank integrated with the supporting structure of transporting means such as a ship, said tank comprising two successive sealing barriers, a primary sealing barrier in contact with the liquid product in the tank and a secondary sealing barrier, said secondary sealing barrier being interfitted between a primary thermal insulating barrier and a secondary thermal insulating barrier.

French Patent 1,438,330 describes tanks of this type for the transportation of liquefied gases, which are integrated into the supporting structure of a ship, and indicates that, near the transverse partitions of the ship, each of the primary and secondary sealing barriers are terminated by a rigid polygonal member which is made of a composite angle iron comprising beams connected to each other by a fixed strip of the same metal as that of the plates constituting the primary and secondary sealing barriers. The assembly of these beams constituting the rigid composite member is connected to the double hull of the ship by means of hangers positioned from point to point and attached to the structure of the ship. These rigid composite members make it possible, on the one hand, to support the stresses developed by the cargo and on the other hand to resist the forces engendered by the thermal and mechanical stresses due to the temperature of the cargo and the deformation of the structure of the ship during navigation. The use of such composite members gives general satisfaction but is relatively expensive because of the necessity of using hangers of complex structure made of stainless steel.

According to the invention there is provided a fluid-tight heat insulating tank adapted to hold a liquid product, said tank comprising two sets of successive sealing and thermal insulating barriers, a primary set positioned to contact the product contained in the tank and a secondary set located between the primary insulating barrier and an external supporting structure, at least the primary sealing barrier consisting of metallic plates having inwardly projecting flanged edges welded together and terminating at the intersection between two walls of the supporting structure in a deformable primary composite angle member comprising two flanges at right angles to each other, surfaces of the flange facing the inside of the tank each comprising a strip of the same metal as the plates of the primary sealing barrier, the plates in alignment with each strip of metal being welded thereto, each strip of metal being attached to a plurality of separate members each of a generally parallelepipedic shape which are longitudinally juxtaposed and regularly spaced one from the other, the two flanges of the composite angle member being connected to each other by said strips of metal, each of said separate members constituting one flange of the composite angle member being held against the subjacent insulating barrier by anchor bolts fixed to said supporting structure, with said separate members of one of the flanges of the angle member bearing at one edge against said separate members of the other flange.

In a first preferred embodiment of the invention, the separate members belonging to one flange of the composite angle member are held against the subjacent insulating layer by means of anchor bolts which are positioned in the spaces separating two adjacent separate members which are longitudinally juxtaposed. The ends of the anchor bolts which are not connected to the external supporting structure (of a double-hulled ship) terminate between two

adjacent separate members of one flange of the angle member in a recess defined by two opposed notches in each of two adjacent separate members. A pierced gripping plate having substantially the shape and dimensions of the section of the recesses is inserted between the bottom of said recess and a locking nut which cooperates with the threaded end of the corresponding anchor bolt. The spaces between the juxtaposed separate members constituting a given flange of the composite angle member are staggered with respect to the spaces between the juxtaposed separate members of the other flange of the composite angle member. The space which defines the distance between two successive separate members of one of the flanges of the angle member is aligned with a slot formed in the separate members constituting the other flange of the angle member, to permit the passage of an anchor bolt. In this case each slot is advantageously formed substantially in the median zone of an edge of the juxtaposed separate members of one flange on the angle iron. Each of the separate members which are provided with this slot comprises, on the zone of the longitudinal face in which this slot is formed, a shoulder constituting a bearing zone of said slotted separate members against the edges of the juxtaposed separate members of the other flange of the angle member. The sheet metal strip of each flange of the composite angle member is screwed near its two edges to the juxtaposed separate members of the flange of the angle member. The two strips of the sheet metal are attached and sealed together by means of a welded unitary angle member of the same metal as the two strips of sheet metal. The adjacent edges of the two strips of sheet metal of the composite angle member are bent at right angles over the section of the corresponding separate members. Each anchor bolt consists of a stud welded to the walls of the external supporting structure (of a ship) and connected through a connecting socket to a rod threaded at its two ends.

In a first variation of the tank forming the first preferred embodiment of the invention, the primary and secondary insulating barriers consisting of boxes, of wood for example, which contain a heat insulating product such as the one known as "PERLITE". In this case, the two primary and secondary sealing barriers are made of metal plates and the periphery of each barrier terminates near the angle which a transverse partition forms with the longitudinal walls of the supporting structure of the ship. In this embodiment the primary and secondary anchor bolts, that is to say, the bolts respectively adapted to attach the composite angle members asso-

ciated with the primary and secondary sealing barriers to the primary insulating barrier, are positioned in respective rows which are parallel to each other and connect the two barriers to the same wall of the supporting structure of the ship. The row of secondary anchor bolts is positioned between the corner which defines the angle of the supporting structure and the parallel row of the primary anchor bolts. Each primary bolt connected to one of the walls of the supporting structure and positioned in the same plane as a secondary bolt attached to the other wall of the angle of said structure. The primary bolts each pass through the space separating two adjacent separate members constituting the secondary composite angle member in the notched zone provided at the edge of said space. The plates of the secondary sealing barrier are pierced by holes adapted to pass the primary bolts, the sealing at these holes being provided by a collar formed at the periphery of a connecting socket carried by the primary bolt, said collars bearing on the edge zones of the holes and being welded thereto. The insulating boxes form a corner row on which an angle member bears and are regularly spaced from each other to permit the passage of the anchor bolts, the intermediate spaces being filled before the corresponding composite angle member is put in place, with a suitable insulating material, for example, rock wool. The boxes forming a corner row on which one flange of the angle member bears are each attached to that flange by means of screws screwed into the edge of a strip of sheet metal which is spaced away from the corner formed by said angle member. The longitudinal faces of the separate members constituting one flange of the angle member to which a strip of metal is attached have a notched edge the depth of which notch corresponds substantially to the thickness of a connecting plate which is screwed thereto, said connecting plate bearing on battens provided on the lateral transverse edge of boxes forming a row adjacent the corner row. The connecting plate is in alignment with the metal strip of the flange of the corresponding angle member and with the longitudinal face of the boxes forming the row adjacent to the corner row. The space between the corner row and the adjacent row is filled, before the connecting plate is put in position, with a thermal insulating material, for example, rock wool.

In a second embodiment of the integrated tank according to the invention, the primary and secondary insulating barriers are made of prefabricated blocks of plastic foam, which may be reinforced by glass fibers, positioned beside each other, and assembled in situ adhesively, the primary sealing

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barrier being connected to a deformable ring as above described, the primary heat insulating barrier comprising on the one of its surfaces on which a flange of the composite angle iron bears, a groove within which a reinforcing plate is adhesively secured. This plate may be made of wood and attached to said flange by means of a screw passing through the modules in the edge zone which is furthest from the corner of the angle member. The anchor bolts holding the primary ring against the supporting structure of the ship are made of stainless steel, glass fibers or resin, or of a plastic material reinforced with glass fibers.

The invention will be further described by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a sectional view taken through the dihedral angle at one corner of a tank forming a first embodiment of the invention perpendicular to the planes forming said angle, said tank comprising two insulating barriers made of wooden boxes containing a heat insulating product;

Figure 2 is a perspective view, partially broken away, showing the components shown in Figure 1;

Figure 3 is a perspective view, partially broken away, and on a larger scale, showing the components constituting one of the deformable composite angle members of Figures 1 and 2;

Figure 4 shows, in perspective, a detail of the connection between the modules of one flange of the composite angle member of Figure 3 and the anchor bolts;

Figure 5 is a detail view of another embodiment of the fluid-tight connections between the plates of the secondary sealing barrier and the primary bolts which pass therethrough; and

Figure 6 shows, in section, a dihedral angle at one corner of a second embodiment of the invention, in which embodiment the primary and secondary insulating barriers are made of plastics foam.

The two embodiments each relate to a tank integrated into the supporting structure of a double-hulled ship adapted to transport liquefied natural gas at low temperature. The structure of the ship which is illustrated consists, in these embodiments, of an inner wall 1 parallel to the flotation plane of a ship, and thus substantially horizontal, and constituting one wall of the bottom portion of the double hull of the ship. This wall 1 is connected at right angles to a partition 2 which is substantially vertical and positioned perpendicular to the longitudinal axis of the ship. The same arrangement is maintained for the dihedral angle formed between the double hull of the ship and the partition 2.

In the embodiment illustrated in Figures 1

to 4 the secondary thermal insulating barrier which covers the wall 1 and the partition 2 consists of wooden boxes 3 containing a particular insulating product known as "PERLITE". The boxes 3 which are positioned outside the zone of the dihedral angle defined by the walls 1 and 2 are attached directly thereto, for example by means of threaded studs attached to these walls, the gas permeable boxes being positioned so as to define therebetween free spaces for permitting the free circulation of gas. In the zone of the dihedral angle two rows of boxes 3 may be directly and adhesively secured to wall 1 and the partition 2.

On the layers of boxes 3 which constitute the secondary insulating layer which covers the wall 1 and the partition 2, a secondary fluid-tight sealing barrier 4 is positioned as described in French Patent 1,438,330 and consists of metallic plates made of "INVAR" (Registered Trade Mark) and welded by their flanges which extend toward the inside of the tank to the two surfaces of a metallic strip 5. The metallic strip 5 may be attached to the boxes 3 of the secondary insulating barrier by means of a sliding joint such as the one described in detail in French Patent No. 71-26652. On the secondary insulating barrier 4 is, in like manner, positioned a layer of boxes 6 constituting the primary thermal insulating barrier, which is covered in a conventional manner, by a primary fluid-tight sealing barrier 7, which is in contact with the liquid inside the tank formed in this manner. The primary sealing barrier 7 is made of metallic plates welded by their flanged edges to the two surfaces of a metallic strip 8 made of "INVAR" (Registered Trade Mark).

In the embodiment of Figures 1 to 4 the two secondary sealing barriers 4, one vertical and one horizontal, are connected, in the zone of the dihedral angle formed by the wall 1 and the partition 2, by means of a deformable member 9. This member 9 bears continuously on the subjacent secondary insulating layer. In like manner the connection, along the dihedral angle, of two primary sealing barriers 7, which are respectively vertical and horizontal, is made by means of a deformable member 11. This member 11 is held against the boxes 6 of the primary insulating barrier by bolts 12 welded to the walls 1 and 2 of the supporting structure of the ship. These bolts 12 (and also bolts 10 referred to hereinafter) may be made of metal, a plastics material, or any other material having suitable mechanical properties. They each comprise a short stud 13 welded perpendicularly to the wall of the supporting structure of the ship, a connecting socket 14 and finally a rod 15 threaded at its two ends. The studs 13 of the

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anchor bolts 10 and 12 are welded in place in a preliminary step before locating the boxes 3 on the walls 1 and 2 to form the secondary insulating barrier.

Figure 2 shows in detail the arrangement in the zone of a dihedral angle of the tank and the relationship between the different anchor bolts. A row of horizontal studs 13 is welded perpendicularly on the partition 2 and support secondary anchor bolts 10, that is to say, anchor bolts forming ties designed to urge the deformable ring 9 against the secondary vertical insulating barrier formed by the boxes 3. This row of anchor bolts 10 is substantially parallel to the wall 1 and the anchor bolts 10 are regularly spaced from each other. A row of horizontal anchor bolts 12 is also mounted perpendicularly on the vertical partition 2 at a higher level. These are used to hold the deformable member 11 against the boxes 6 of the primary vertical insulating barrier. These bolts 12 are spaced from each other by a distance substantially equal to that between two adjacent anchor bolts 10 perpendicular to the wall 2. On the horizontal supporting wall 1 is welded, near the corner defined by the dihedral angle, a row of vertical anchor bolts 10 spaced from each other by a distance equal to that between the horizontal anchor bolts 12, each vertical bolt 10 being positioned in alignment with each horizontal bolt 12. A second row of vertical bolts 12 spaced from each other by a distance equal to that which separates two horizontal bolts 12 is also positioned on the wall 1 parallel to the row of vertical bolts 10. Each vertical bolt 12 is aligned with each horizontal bolt 10.

After having welded on the studs 13 of the various vertical and horizontal anchor bolts 10 and 12, a bottom row of vertical boxes 3a is positioned in the dihedral angle formed by the supporting walls 2 and 1 against the vertical wall 2 and an end row of horizontal boxes 3b on the horizontal wall 1. The two rows of boxes 3a and 3b may then be adhesively secured to the walls of the dihedral angle. The spacing of the horizontal anchor bolts 10 corresponds substantially to the length of a box 3a while the distance which separates a horizontal anchor bolt 12 from the wall 1 corresponds substantially to the height of a box 3a. In like manner the space between vertical anchor bolts 10 corresponds to the length of the boxes 3b while the distance which separates the horizontal anchor bolts 10 from the plane of the wall 1 corresponds to the height of the boxes 3b.

The deformable member 9 which is adapted to bear against the boxes 3a and the boxes 3b is a composite angle member having a right angle section. This angle member 9 comprises a substantially horizontal flange formed from separate

members 16 in the form of which are relatively short and generally parallelepipedic in shape. Modules 16 are longitudinally juxtaposed and regularly spaced from each other. Each module 16 bears against two adjacent boxes 3b of the horizontal secondary insulating barrier. A strip of sheet metal 17, made of "INVAR" (Registered Trade Mark), is screwed at its two edges to the modules 16, thereby defining one flange of the composite angle member 9. The vertical flange of the composite angle member 9 comprises further separate members 18 in the form of modules each having a shape and dimensions substantially identical to those of each module 16. The modules 18, like the modules 16, are made of laminated wood and are longitudinally juxtaposed and regularly spaced from each other, the spaces separating two successive modules 18 being staggered with respect to those similar spaces separating two successive modules 16. On the longitudinal surfaces of the modules 18 turned toward the inside of the tank, a strip 19 of sheet metal (also of "INVAR" — see above) is also mounted by screwing its two edges to the modules. The two flanges of the composite angle member 9 are connected to each other by an auxiliary strip (of "INVAR") 20, bent at right angles, which is welded to the two sheet metal strips 17 and 19, sealing them together.

Each of the modules 18 comprises, on the face covered by the sheet metal strip 19, and in the edge adjacent two corresponding modules 16, a groove defining a shoulder 21 which bears against the inner edges of the modules 16. The inner edge of the strip 19 is bent at right angles against the shoulder 21, to which it is screwed. In like manner, the inner edge of portion the sheet metal strip 17 which is welded to the strip 20 is bent at right angles whilst the outer edge portion of strip 17 is screwed to the groove in the horizontal modules 16.

The space between the ends of two adjacent modules 16 is in alignment with a slot 22 in a module 18, the slot 22 having a rectangular right section which is formed in the wall of the modules 18. The slots 22 are positioned in the transverse median plane of the modules 18 and are adapted to permit the passage of the horizontal anchor bolts 10. All the bolts 10, both horizontal and vertical, are positioned in the spaces between the ends of the modules 16 and 18 respectively of the composite angle member 9 and substantially in the longitudinal median plane of these modules. The vertical bolts 10 each terminate in a recess 23 formed by two opposed notches in the upper corners of the modules 18. The recess 23, having a rectangular section, has a horizontal bottom

constituted by the two edges of the notches. In the same manner each of the horizontal bolts 10 passes through the spaces between two adjacent boxes 3, the slot 22 and the space between the ends of two adjacent modules 16 and enters a recess 24 having a shape and dimensions identical to those of the recess 23.

In order to connect the composite angle member 9 to the supporting walls 1 and 2 of the structure of the ship by means of the anchor bolts 10, a respective rectangular gripping plate 25 having substantially the shape and dimensions of the recess inside which it is placed is slipped on to the threaded end of each of the bolts 10. The plate 25 is brought into abutment against the bottom of the recess. The composite angle member 9 is then secured by means of a lock nut 26 against the subjacent secondary insulating barrier. The connection of the anchor bolt to the angle member module is more particularly shown in Figure 4 of the drawings.

In order to better secure the modules of the composite angle member 9 against the subjacent secondary insulating barrier, holes 27 through the walls of the modules are first provided along the outer edges of the sheet metal strips 17 and 19. When the composite angle member 9 is put in place, screws 28 are introduced into the holes 27 and screwed into the wall of the subjacent boxes or into battens formed into edges of these boxes.

Between the corner row of the boxes 3a and the adjacent row of boxes 3 which is positioned thereabove is a space in which the horizontal bolts 12 are located. (A similar space for the vertical bolts 12 is found between the end or corner row of boxes 3b and the row of boxes 3b immediately adjacent thereto resting on the supporting wall 1.) In order to ensure continuous support, in alignment with these spaces, for the secondary sealing barrier 4, a groove or notch 29 is provided in each of the modules adjacent the sheet metal strips 17, 19. In the grooves 29 of a single row of modules is located a connecting plate 30 which covers the intermediate space and bears on battens 31 fixed to boxes 3 forming the row adjacent to the angle row. The connecting plate 30 is attached to the modules of the angle member 9 by means of screws 33. As the screws 33 are inserted the connecting plate 30 acts as a lever on the battens 31 by reason of the pressure which a rib 32 formed for this purpose in the grooves 29 applies thereto. The plate 30 is advantageously in the form of a strip of laminated wood of great length so that it may be positioned as a sole common batten on several successive modules of one flange of an angle member. In this case holes are

provided in the plate 30 so as to permit the passage of anchor bolts 12 when it is put in place.

Since these connecting plates 30 are made of wood, which makes it easy to rectify their dimensions, if necessary, during mounting on board ship, they permit very large mounting tolerances. Furthermore, they assure not only continuous support for the sealing barrier but also bridge the insulating boxes adjacent the dihedral angle.

The edges of the plates of the secondary sealing barrier 4 are welded to the strips of sheet metal 17 and 19. These edges cover the zone of the side of the strip of sheet metal in which the heads of the attaching screws are located, as is shown in Figure 1 of the drawings. In order to avoid damaging the subjacent module during welding of the plates to the strips of sheet metal 17 and 19, a thermal protective strip 34 is inserted between the walls of the module and the covering strip in the zone in which the edges of the plates are welded together.

The boxes 6 constitute the primary insulating layer which comprises, at the dihedral angle, a layer of compensating material in which the metallic strips 5 which serve to join the flanged edges of the plates of the secondary barrier are embedded.

The composite angle member 11 to which the two (vertical and horizontal) primary sealing barriers are welded is identical to that of the composite angle member 9 and for this reason the components constituting the composite angle member 11 have been designated by the same reference numerals as the corresponding components of the composite angle member 9. The angle member 11 is mounted against the subjacent primary insulating barrier in the same way by introducing vertical and horizontal anchor bolts 12. It will also be noted that the length of the corner boxes 6 which are to constitute the vertical barrier is determined by the distance between two successive horizontal anchor bolts whereas the length of the corner boxes 6 which are to constitute the horizontal barrier is determined by the distance between two adjacent vertical anchor bolts 12. All the vertical and horizontal anchor bolts 12 pass through the flanges of the composite angle member 9 via the recesses 23 and 24.

In the embodiment of Figures 1 to 4, the plates of the secondary sealing barrier are pierced by holes through which the horizontal and vertical primary draw bolts 12 pass. Fluid-tightness is assured by a sealing member comprising a washer welded both to the threaded rod 15 and to the plates of the secondary sealing barrier 4. Figure 5 shows a variation in the construction of this sealing member. The primary anchor bolt 12a comprises a connecting socket 14a

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provided with a collar 46, the outer diameter of which is greater than that of the passage holes. During mounting, after having placed the secondary sealing barrier 4 in place, which barrier is pierced by holes for receiving anchor bolts 12, the sockets 14a are screwed onto the welded studs 13a until the collar 46 bears against the edge zone of the passage holes. The collar and the edge of the passage hole are then sealed together by welding.

It should be noted that all the spaces which exist between the boxes 3 and between the boxes 6 are filled with an insulating material, such as rock wool for example, so as to permit the free circulation of gas.

Figure 6 shows a second embodiment of a tank integrated with the supporting structure of a ship. The supporting structure of the ship consists, in this example, of an inner wall 35 parallel to the plane of flotation of the ship, which wall is connected at right angles to a partition 36 which is substantially vertical and transversely positioned with respect to the axis of the ship.

The horizontal wall 35 carries a row of anchor bolts 37 welded perpendicularly to said wall and parallel to the partition. In like manner, the vertical wall 36 carries a row of anchor bolts 37 welded thereto and positioned horizontally and parallel to the inner wall 35. The vertical and horizontal anchor bolts 37 are adapted to connect the supporting structure of the ship to a deformable member 38 constituted by a composite angle member. The primary vertical sealing barrier and the primary horizontal sealing barrier are connected as hereinbefore described to the composite angle member.

The secondary heat or thermal insulating barrier 39 is made of prefabricated foam plastics blocks reinforced by glass fibers. These foam blocks are positioned side by side and adhesively secured together. The secondary sealing barrier 40 consists of a layer of material such as, for example, glass cloth impregnated with resin. The primary insulating barrier 41 also consists of prefabricated blocks of plastics foam connected to each other adhesively. It should be noted that the blocks of plastics foam are adapted to be positioned in the neighborhood of the dihedral angle and may be first pierced by holes to permit the passage of the anchor bolts 37. Finally, the primary sealing barrier 42 is made as before, that is to say, from metallic plates made of "INVAR" having flanged edges bent back toward the inside of the tank, the plates being welded flange to flange on the two surfaces of a metallic strip.

The construction of the composite angle member 38 is substantially identical to that of each of the angle members 9 and 11

hereinbefore described and will not consequently be hereinafter described in detail. The foam plastic blocks of the barrier 41 comprise a groove or notch 43 on the face thereof which a flange of the angle member 38 rests. In the notch 43 is adhesively secured a reinforcing plate 44 made of laminated wood. The reinforcing plate is attached to the flange of the angle member 38 by a screw 45 passing through the corresponding module and terminating in the vicinity of the edge of the strip of "INVAR" which is remote from the corner of the composite angle member. This type of connection makes it possible to improve the pressure of the composite angle member on the subjacent primary insulating layer. Since there is no more space between the regular zone and the dihedral zone, it is no longer necessary to provide, as in the embodiment of Figures 1 to 4, connecting members.

It is important to note that by reason of the elimination of the hangers which were necessary in the device of French Patent 1,438,330, the construction of the integrated tank is simplified and its cost reduced. The working time necessary to mount it is also reduced due to the use of connecting members made of laminated wood between the regular zone and the dihedral zone of the tank.

It will of course be appreciated that the embodiments hereinbefore described have been given purely by way of illustration and example and may be modified as to detail.

WHAT WE CLAIM IS:—

1. A fluid-tight heat insulating tank adapted to hold a liquid product, said tank comprising two sets of successive sealing and thermal insulating barriers, a primary set positioned to contact the product contained in the tank and a secondary set located between the primary insulating barrier and an external supporting structure, at least the primary sealing barrier consisting of metallic plates having inwardly projecting flanged edges welded together and terminating at the intersection between two walls of the supporting structure in a deformable primary composite angle member comprising two flanges at right angles to each other, surfaces of the flanges facing the inside of the tank each comprising a strip of the same metal as the plates of the primary sealing barrier, the plates in alignment with each strip of metal being welded thereto, each strip of metal being attached to a plurality of separate members each of a generally parallelepipedic shape which are longitudinally juxtaposed and regularly spaced one from the other, the two flanges of the composite angle member being connected to each other by said strips of metal, each of said separate members



provided with a collar 46, the outer diameter of which is greater than that of the passage holes. During mounting, after having placed the secondary sealing barrier 4 in place, which barrier is pierced by holes for receiving anchor bolts 12, the sockets 14a are screwed onto the welded studs 13a until the collar 46 bears against the edge zone of the passage holes. The collar and the edge of the passage hole are then sealed together by welding.

It should be noted that all the spaces which exist between the boxes 3 and between the boxes 6 are filled with an insulating material, such as rock wool for example, so as to permit the free circulation of gas.

Figure 6 shows a second embodiment of a tank integrated with the supporting structure of a ship. The supporting structure of the ship consists, in this example, of an inner wall 35 parallel to the plane of flotation of the ship, which wall is connected at right angles to a partition 36 which is substantially vertical and transversely positioned with respect to the axis of the ship.

The horizontal wall 35 carries a row of anchor bolts 37 welded perpendicularly to said wall and parallel to the partition. In like manner, the vertical wall 36 carries a row of anchor bolts 37 welded thereto and positioned horizontally and parallel to the inner wall 35. The vertical and horizontal anchor bolts 37 are adapted to connect the supporting structure of the ship to a deformable member 38 constituted by a composite angle member. The primary vertical sealing barrier and the primary horizontal sealing barrier are connected as hereinbefore described to the composite angle member.

The secondary heat or thermal insulating barrier 39 is made of prefabricated foam plastics blocks reinforced by glass fibers. These foam blocks are positioned side by side and adhesively secured together. The secondary sealing barrier 40 consists of a layer of material such as, for example, glass cloth impregnated with resin. The primary insulating barrier 41 also consists of prefabricated blocks of plastics foam connected to each other adhesively. It should be noted that the blocks of plastics foam are adapted to be positioned in the neighborhood of the dihedral angle and may be first pierced by holes to permit the passage of the anchor bolts 37. Finally, the primary sealing barrier 42 is made as before, that is to say, from metallic plates made of "INVAR" having flanged edges bent back toward the inside of the tank, the plates being welded flange to flange on the two surfaces of a metallic strip.

The construction of the composite angle member 38 is substantially identical to that of each of the angle members 9 and 11

hereinbefore described and will not consequently be hereinafter described in detail. The foam plastic blocks of the barrier 41 comprise a groove or notch 43 on the face thereof which a flange of the angle member 38 rests. In the notch 43 is adhesively secured a reinforcing plate 44 made of laminated wood. The reinforcing plate is attached to the flange of the angle member 38 by a screw 45 passing through the corresponding module and terminating in the vicinity of the edge of the strip of "INVAR" which is remote from the corner of the composite angle member. This type of connection makes it possible to improve the pressure of the composite angle member on the subjacent primary insulating layer. Since there is no more space between the regular zone and the dihedral zone, it is no longer necessary to provide, as in the embodiment of Figures 1 to 4, connecting members.

It is important to note that by reason of the elimination of the hangers which were necessary in the device of French Patent 1,438,330, the construction of the integrated tank is simplified and its cost reduced. The working time necessary to mount it is also reduced due to the use of connecting members made of laminated wood between the regular zone and the dihedral zone of the tank.

It will of course be appreciated that the embodiments hereinbefore described have been given purely by way of illustration and example and may be modified as to detail.

WHAT WE CLAIM IS:—

1. A fluid-tight heat insulating tank adapted to hold a liquid product, said tank comprising two sets of successive sealing and thermal insulating barriers, a primary set positioned to contact the product contained in the tank and a secondary set located between the primary insulating barrier and an external supporting structure, at least the primary sealing barrier consisting of metallic plates having inwardly projecting flanged edges welded together and terminating at the intersection between two walls of the supporting structure in a deformable primary composite angle member comprising two flanges at right angles to each other, surfaces of the flanges facing the inside of the tank each comprising a strip of the same metal as the plates of the primary sealing barrier, the plates in alignment with each strip of metal being welded thereto, each strip of metal being attached to a plurality of separate members each of a generally parallelipedic shape which are longitudinally juxtaposed and regularly spaced one from the other, the two flanges of the composite angle member being connected to each other by said strips of metal, each of said separate members



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constituting one flange of the composite angle member being held against the subjacent insulating barrier by anchor bolts fixed to said supporting structure, with said separate members of one of the flanges of the angle member bearing at one edge against said separate members of the other flange.

2. A tank as claimed in Claim 1 in which the separate members of one flange of the composite angle member are held against the subjacent insulating layer by anchor bolts which are positioned in spaces separating two adjacent longitudinally juxtaposed separate members of the other flange.

3. A tank as claimed in Claim 1 or 2 in which the ends of the anchor bolts which are not connected to the external supporting structure terminate between two adjacent separate members of a flange of the angle member in recesses each defined by two notches formed opposite each other in said two adjacent separate members, a gripping plate having substantially the shape and dimensions of the section of the recess is inserted between the bottom of said recess and a locking nut is screwed onto the threaded end of the corresponding draw bolt.

4. A tank as claimed in Claim 1, 2 or 3 in which the spaces between the juxtaposed separate members of one flange of the composite angle member are staggered with respect to the spaces between the juxtaposed separate members of the other flange of the angle member, the space between two successive separate members of one of the flanges of the angle member being in alignment with a slot in the separate members constituting the other flange of the angle member, to permit the passage of an anchor bolt.

5. A tank as claimed in Claim 4 in which each slot is formed substantially in the median zone of one edge of one of the juxtaposed separate members of a flange of the angle member.

6. A tank as claimed in Claim 4 or 5 in which the slot is in a longitudinal face in which is formed a groove acting as a zone which bears against edges of the juxtaposed separate members of the other flange of the angle member.

7. A tank as claimed in any preceding Claim in which the strip of sheet metal of each flange of the composite angle member is screwed near its two edges to the juxtaposed separate members of said flange of the angle member, and the two strips of metal being sealed together by a welded unitary angle member of the same metal as the two strips of sheet metal.

8. A tank as claimed in any preceding Claim in which the adjacent edges of the

two strips of sheet metal of the composite angle member are bent at right angles over the edges of corresponding separate members of the angle member.

9. A tank as claimed in any preceding Claim in which said separate members are laminated wooden blocks.

10. A tank as claimed in any preceding Claim in which the anchor bolts each consist of a stud welded to the wall of said supporting structure and connected by a connecting socket to a rod threaded at both ends.

11. A tank as claimed in any preceding Claim in which the primary and secondary insulating barriers each consist of boxes which contain a thermally insulating product.

12. A tank as claimed in Claim 11 in which the secondary sealing barrier consists of metallic plates, each sealing barrier terminating at its edge near the intersection between a transverse partition and a longitudinal wall of the external supporting structure.

13. A tank as claimed in Claim 11 or 12 in which a row of primary ones of the anchor bolts holds the composite angle member against the primary insulating barrier and is positioned parallel to a row of secondary anchor bolts which are connected to the same wall of said supporting structure, the row of the secondary anchor bolts being positioned between the intersection between two walls of the supporting structure and the parallel row of the primary anchor bolts.

14. A tank as claimed in Claim 13 in which a primary anchor bolt connected to one of the walls of the supporting structure is positioned in the same plane as the secondary anchor bolt attached to the other intersecting wall of said structure.

15. A tank as claimed in Claim 13 or 14 in which each of the primary anchor bolts passes through a space separating two adjacent separate members of a secondary composite angle member in the zone of the notch formed at the edge of said space.

16. A tank as claimed in Claim 12 in which the plates of the secondary sealing barrier are pierced by holes adapted to permit the passage of primary anchor bolts, seals at these holes being provided by collars formed on the peripheries of connecting sockets with which the primary anchor bolts are equipped, said collars bearing on the edges of the holes and being welded thereto.

17. A tank as claimed in Claim 11 in which the boxes of insulation forming a corner row on which a flange of the angle member rests, are regularly spaced from each other to permit the passage of anchor bolts, the intermediate spaces being filled before emplacement of the corresponding com-



posite angle member with an insulating material.

5 18. A tank as claimed in Claim 17 in which the boxes forming a corner row on which a flange of the angle member bears are each attached to said flange by means of screws screwed through the edge of a metal strip which is spaced away from the corner of said angle member.

10 19. A tank as claimed in Claim 11 in which the longitudinal surfaces of consecutive separate members of a flange of an angle member to which a metal strip is attached comprise a recessed edge the depth of which corresponds substantially to the thickness of a connecting plate screwed thereto, said connecting plate bearing on battens on the transverse lateral wall of boxes forming a row adjacent the corner row.

20 20. A tank as claimed in Claim 19 in which the connecting plate is in alignment with the metal strip of the flange of the corresponding angle member and the longitudinal surface of the boxes forming the row adjacent the corner row.

25 21. A tank as claimed in Claim 11 in which the space between the corner row and the

adjacent row is filled before positioning the connecting plate, with a thermal insulating material.

30 22. A tank as claimed in Claim 1 in which the primary and secondary insulating barriers are made from prefabricated foam blocks of plastic material positioned side by side and adhesively assembled in situ.

35 23. A tank as claimed in Claim 22 in which the primary thermal insulating barrier has in the face on which a flange of the composite angle member rests, a groove in which a reinforcing plate is adhesively secured, said plate being attached to said flange by means of a screw passing through the modules in the edge furthest from the corner of the angle member.

40 24. A fluid tight heat insulating tank for holding a liquid product, substantially as herein described with reference to figures 1 to 4 or figure 5 or figure 6 of the accompanying drawings.

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