## Technical scope of the invention

This invention refers to the construction of sealed and heat insulated tanks forming part of a bearing structure, more particularly the hull of a ship designed to transport liquefied gases by sea and especially, the transport of Liquefied Natural Gas (LNG) with a high methane content.

## State of the technique

Figure 1 shows a ship 1 for the transport of LNG by sea. Ship 1 includes three or four cylindrical tanks 2, octagonal in section, and a bow tank 3, also referred to as the tank, matching the shape of the prow of ship 1. The tanks are incorporated in a bearing structure consisting of the double hull of ship 1.

Figure 2 represents bow tank 3 in greater detail. As can be seen, bow tank 3 has a forward bulkhead 4 and an aft bulkhead 5 perpendicular to the longitudinal direction of ship 1, a bottom bulkhead 6 and a ceiling bulkhead 7, two side bulkheads 8 and 9 and four inclined bulkheads 10, 11, 12 and 13, connecting the side bulkheads to the bottom and ceiling bulkheads.

In a known manner, each of the aforementioned bulkheads includes, from the inside of the tank towards its outside, a primary sealed barrier, a primary heat insulating barrier, a secondary sealed barrier and a secondary heat insulating barrier.

The primary sealed barrier and possibly the secondary sealed barrier are made up respectively of strakes with raised metal edges towards the inside of the tank, said strakes being made of thin metal sheet with a low expansion coefficient and being butt welded.

Figure 2 shows that barriers 14 of inclined bulkhead 13 extend from forward bulkhead to aft bulkhead 5 parallel to ridge 15 formed by the edges of bulkheads 13 and 6. At bulkheads 4 and 5, strakes 14 are attached to the bearing structure by corner structures (not shown). During the cooling of tank 3, strakes 14 undergo heat contraction. The corresponding forces represented by arrows 16 are transmitted to the bearing structure through the corner structures.

On bottom bulkhead 6, the strakes extend in parallel to the longitudinal direction of ship 1, from aft bulkhead 5 to forward bulkhead 4. Some of these strakes (not shown) extend as far as bulkhead 4. Other strakes 17 extend from bulkhead 5 to ridge 15 where they have a truncated edge. To take up the forces caused by heat contraction, represented by arrows 18, strakes 17 must be attached to the bearing structure at ridge 15. The same requirement applies to the ridges formed respectively by the intersection of bulkheads 6 and 12, bulkheads 7 and 11 and bulkheads 7 and 10.

In a known embodiment, the attachment of each strake 17 to the bearing structure, at ridge 15, is obtained by pillar 19 shown in figure 3. Pillar 19 includes body 20 consisting of a stainless steel tube. Body 20 is attached to the bearing structure by anchoring strips 21. Pillar 19 also includes a primary plate 22 and a secondary plate 23. A primary wedge 24 is arranged at primary plate 22 and a secondary wedge 25 is arranged at secondary plate 23. Secondary wedge 25 is used for positioning the box structures forming the secondary heat insulating barrier.

The truncated end of a strake 17 is attached to a plywood beam (not shown), itself attached to pillar 19 by a primary wedge 24. In addition, the truncated end of a strake (not shown) of the secondary sealed barrier is welded onto plate 23.

The shape of tank 3 offers the advantage of being simple. However, this shape has the drawback of reducing the transport capacity of ship 1 and making the prow architecture of the ship more complicated. Therefore, it is desirable to be able to use other shapes for the bow tank to improve the transport capacity and simplify the architecture of the prow. However, a bow tank of another shape must not be too complicated to manufacture with respect to bow tank 3. It is necessary to avoid the advantages of this shape being cancelled out by manufacturing difficulties.

Document FR 2 826 630 describes a ship having a bow tank of the same shape as bow tank 3. This document proposes an arrangement for the Invar strakes of the bottom bulkhead.

This arrangement means using specific panels in the bottom bulkhead symmetry plane.

**Abstract of the invention**

One problem that this invention proposes to solve is that of supplying a ship not having at least some of the aforementioned drawbacks of the prior embodiment. In particular, one purpose of the invention is to propose a bow tank whose shape improves the transport capacity and simplifies the architecture of the prow. Another purpose of the invention is to

supply a tank like this which is easy to manufacture, by limiting the number of parts to be manufactured and assembled.

The solution proposed by the invention involves a ship including a bearing structure and a sealed and heat insulated bow tank designed to contain liquefied natural gas, said bow tank having several tank bulkheads attached to said bearing structure with each tank bulkhead having successively, in the direction of the thickness, from the inside to the outside of said bow tank, a primary sealed barrier, a primary heat insulating barrier, a secondary sealed barrier and a secondary heat insulating barrier, a first bulkhead and a second bulkhead among said tank bulkheads, being adjacent to a ridge, with the primary sealed barrier of said first bulkhead including at least one strake connected at said ridge to said bearing structure by a pillar, characterised by the fact that the primary sealed barrier of said second bulkhead includes at least a second strake connected at said ridge to said bearing structure by means of said pillar.

Thanks to these characteristics, a single pillar can connect the truncated ends of two strakes of two adjacent bulkheads to the bearing structure. This limits the number of pillars to be manufactured and installed. In addition, it allows the design of a tank shape in which two adjacent bulkheads have strakes connected at their truncated ends to the bearing structure through a common ridge. One proposed tank shape allows the transport capacity of LNG to be increased and simplifies the architecture of the ship's prow.

Preferably, said bearing structure has a first section parallel to said first bulkhead and a second section parallel to said second bulkhead with said pillar being attached to said first section.

In this case, the strakes of two adjacent bulkheads are connected to the same section of the bearing structure. This avoids the system becoming hyperstatic.

In an advantageous embodiment, said pillar includes at least one plate, having a first portion parallel to the first section and a second portion parallel to the second section, said first strake being attached to the pillar at said first portion and said second strake being attached to the pillar at said second section.

With a structure like this, the first portion of the plate can be located at the first bulkhead and the second portion of the plate offset towards the second bulkhead.

According to one embodiment, said first strake is attached to a beam connected to said pillar, said pillar having a dropped edge preventing the beam from moving away from said first bulkhead. Similarly, the second strake can be attached to a beam located behind a dropped edge. The beam and the dropped edge enabled pillar to take up one of the vertical components of the forces generated in the strakes.

Preferably, said bow tank includes among said several tank bulkheads, a ceiling bulkhead and two inclined bulkheads adjacent to the ceiling bulkhead, said ceiling bulkhead and said two inclined bulkheads being rectangular in shape.

Rectangular bulkheads are easy to build and do not require the use of pillars.

Advantageously, said first bulkhead and said second bulkhead have a trapezoid shape and are parallel to a longitudinal direction of the ship.

According to one specific embodiment, said first and second strakes run parallel to said longitudinal direction.

This bow tank shape allows the transport capacity of LNG to be increased and simplifies the architecture of the ship's prow.

**Brief description of figures**

The invention will be better understood and further objects, details, features and advantages thereof will appear more clearly in the following description of a particular embodiment of the invention given purely by way of illustration and not limiting, with reference to the annexed drawings. In these drawings:

- figure 1 is a perspective view of an LNG transport ship according to a prior embodiment,
- figure 2 is a perspective view of ship's tank No. 1 of figure 1,
- figure 3 is a perspective view of a pillar of the tank in figure 2,
- figure 4 is a perspective view of a tank according to one embodiment of the invention,
- figures 5 and 6 are sectional views of the tank in figure 4,
- figures 7 and 8 are respectively perspective and side views of a tank pillar in figure 4.

**Detailed description of an embodiment of the invention**

Figures 4 to 6 represents a bow tank 53 having a different shape from bow tank 3.

Bow tank 53 includes a front bulkhead 54 and rear bulkhead 55 perpendicular to the longitudinal direction of the ship. Bow tank 53 also includes an aft bulkhead 56, a ceiling bulkhead 57, two side bulkheads 58 and 59 and four inclined bulkheads 60, 61, 62 and 63 which extend from forward bulkhead 54 to aft bulkhead 55

It can be seen that ceiling bulkhead 57 and inclined bulkheads 60 and 61 are rectangular and parallel to the longitudinal direction of the vessel. In other words, at the top, bow tank 53 is identical to a standard cylindrical tank 2.

In the lower part, side bulkheads 58 and 59, sloping bulkheads 62 and 63 and bottom bulkhead 56 are trapezoidal and are arranged parallel to the longitudinal direction of the vessel.

With respect to bow tank 3, the shape of bow tank 53 increases the LNG transporting capacity and simplifies the architecture of the ship's bow.

As in the case of the bow tank 3, each bulkhead of bow tank 53 comprises, from inside the tank to the exterior of the tank, a primary sealed barrier, a primary heat insulating barrier, a secondary sealed barrier and secondary heat insulating barrier. Primary sealed barrier and secondary sealed barrier are made up respectively of metal strakes with edges raised towards the inside of the tank, said stakes being made of thin metal sheet with a low expansion coefficient and being butt welded.

The strakes of inclined bulkheads 63 extend from forward bulkhead 54 to aft bulkhead 5, in parallel to the vessel's longitudinal direction. Some of these strakes (not shown) extend as far as aft bulkhead 55. In figure 4, it can be seen that other strakes 64 extend from forward bulkhead 54 to ridge 65 formed by the intersection of bulkheads 63 and 56, where their edge is truncated.

To take up the forces caused by a heat contraction, represented by arrows 66, strakes 64 must be attached to the bearing structure, at ridge 65.

On bottom bulkhead 56, the strakes extend in parallel to the longitudinal direction of the ship, from aft bulkhead 55 to forward bulkhead 54. Some of these strakes (not shown) extend as far as bulkhead 54. Other strakes 67 extend from bulkhead 55 to ridge 65 where they have a truncated edge. To take up the forces caused by a heat contraction, represented by arrows 68, strakes 67 must be attached to the bearing structure, at ridge 15.

In other words, at ridge 65, two series of strakes must be connected to the bearing structure, one for each bulkhead. The same need arises at the ridges formed respectively by the intersection of bulkheads 56 and 62, bulkheads 62 and 58 and bulkheads 63 and 59.

A simple solution in terms of its design would consist in using for ridge 65, two series of pillars identical to pillar 19, each series of pillars being used for connecting the strakes of a respective bulkhead to the bearing structure. However, this would entail manufacturing a great number of pillars and installing them in the tank. This would make the manufacture of the tank fastidious and costly.

This is why, according to one embodiment of the invention, strakes 64 and strakes 67 are connected to the bearing structure at ridge 65 by a single series of pillars of a new design. These pillars are referred to as "bi-oblique" pillars of which an example is given in figures 7 and 8.

Pillar 69 has a body 70 consisting of a stainless steel tube. Body 70 is fastened to the bearing structure by anchoring strips 71. Figure 8 shows that the bearing structure includes more particularly a section 81 to which bottom bulkhead 56 is attached and section 82 to which inclined bulkhead 63 is attached. Figure 8 also shows anchoring devices 83 for attaching a box-structure (not shown) of the secondary heat insulating barrier. Body 70 extends perpendicular to section 81 and anchoring strips 71 are welded to section 81. It can be seen that the configuration of body 70 and anchoring strips 71 is the same as in the aft section of bow tank 3. Thus for the ship builder, the number of part references in production is limited. In addition, he can use the same tools and processes for welding anchoring strips 71 and body 70. In the same way as anchoring strips 18, anchoring strips 71 allow height adjustment. Pillar 69 also includes a primary plate 72 and a secondary plate 73 attached to body 71. Primary plate 72 has a portion 78 parallel to section 81 and a portion 79, offset and parallel to section 82. Secondary plate 73 includes a portion 80 parallel to section 81 and an offset portion 86 parallel to section 82.

Reinforcing plates 76 connect housing 72 second plate 73 and two anchoring strips 71. A tube 77 connects portion 86 of second plate 73 to portion 79 of first plate 72. Reinforcing plates 76 and tube 77 contribute to rendering the structure of pillar 69, capable of transmitting forces from the strakes to section 81 of the bearing structure. In addition, because pillar 69 is a way of anchoring the strakes to two adjacent bulkheads on the same section of bearing structure, the system is prevented from being hypostatic.

Two primary wedges 74 are arranged at primary plate 72, respectively in portions 78 and 79. Each primary wedge 74 has a dropped edge 84. Two secondary wedges 75 are arranged and secondary plate 73, respectively in portions of 80 and 86. Each secondary wedge 75 has a dropped edge 85.

The truncated end of a strake 67 is fastened to a plywood beam (not shown) itself fastened to pillar 69 by a primary wedge 74 of portion 78 and the truncated end of a strake 64 fastened to a plywood beam (not shown) itself integral with pillar 69 through a primary wedge 74 of portion 79. In addition, the truncated ends of the strakes (not shown) of the secondary sealed barrier are welded to 2 secondary plate 73, respectively in portions 80 and 86. Accordingly, thanks to portion 79 of primary plate 72 and portion 86 of secondary plate 73, pillar 69 transmits the forces generated in the sealed barriers of inclined bulkhead 63, in addition to the forces generated in the sealed barriers of bottom bulkhead 56. Therefore, the number of pillars to be manufactured and installed is limited. The manufacturing of bow tank 53 is therefore simplified and less costly. In addition, to weld the strakes to the wedges, the

shipbuilder can use the same tools and processes as for pillar 19, thus taking advantage of a mastered and approved technology.

From observation of figure 4, it can be deduced that the forces represented by arrows 66 and 68 have a vertical component, that is, perpendicular to section 81. The plywood beams mentioned below are arranged under dropped edges 84. In this way, these forces are taken up at the primary level by dropped edge 84. At secondary level, they are taken up by the welding of the strakes to secondary plate 73.

Although this invention is described in conjunction with a particular embodiment, it is obvious that it is not limited to this, and includes every technical equivalent means described, and their combinations, if they fall within the scope of the invention.

## CLAIMS

1. Ship including a bearing structure and a sealed and heat insulated bow tank (53) designed to contain liquefied natural gas, said bow tank having several tank bulkheads (54, 55, 56, 57, 58, 59, 60, 61, 62, 63) attached to said bearing structure with each tank bulkhead having successively, in the direction of the thickness, from the inside to the outside of said bow tank, a primary sealed barrier, a primary heat insulating barrier, a secondary sealed barrier and a secondary heat insulating barrier, a first bulkhead (56) and a second bulkhead (63) among the said tank bulkheads, being adjacent to a ridge, with the primary sealed barrier of said first bulkhead including at least a first strake (67) connected at said ridge to said bearing structure by a pillar (69), characterised by the fact that the primary sealed barrier of said second bulkhead includes at least a second strake (64) connected at said ridge to said bearing structure by means of said pillar (69).

2. Ship according to the previous claim in which said bearing structure has a first section (81) parallel to said first bulkhead and a second section (82) parallel to said second bulkhead with said pillar being attached to said first section.

3. Ship according to the previous claim in which said pillar includes at least one plate (72, 73) said one plate having a first portion (78, 80) parallel to the first section and a second portion (79, 86) parallel to the second section said first strake being attached to the pillar at first portion and said second strake being attached to the pillar at said second portion.

4. Ship according to one of the previous claims in which said first strake is attached to a beam connected to said pillar, said pillar having a dropped edge (84) preventing the beam from moving away from said first bulkhead.

5. Ship according to one of the previous claims in which said bow tank includes among said several bulkheads of the tank, a ceiling bulkhead (57) and two inclined bulkheads (60, 61) adjacent to the ceiling bulkhead said ceiling bulkhead and said two inclined bulkheads being rectangular in shape.

6. Ship according to the previous claim in which said first bulkhead and said second bulkhead have a trapezoid shape and are parallel to a longitudinal direction of the ship.

7. Ship according to the previous claim in which said first strake and send second strake extend in parallel to said longitudinal direction.