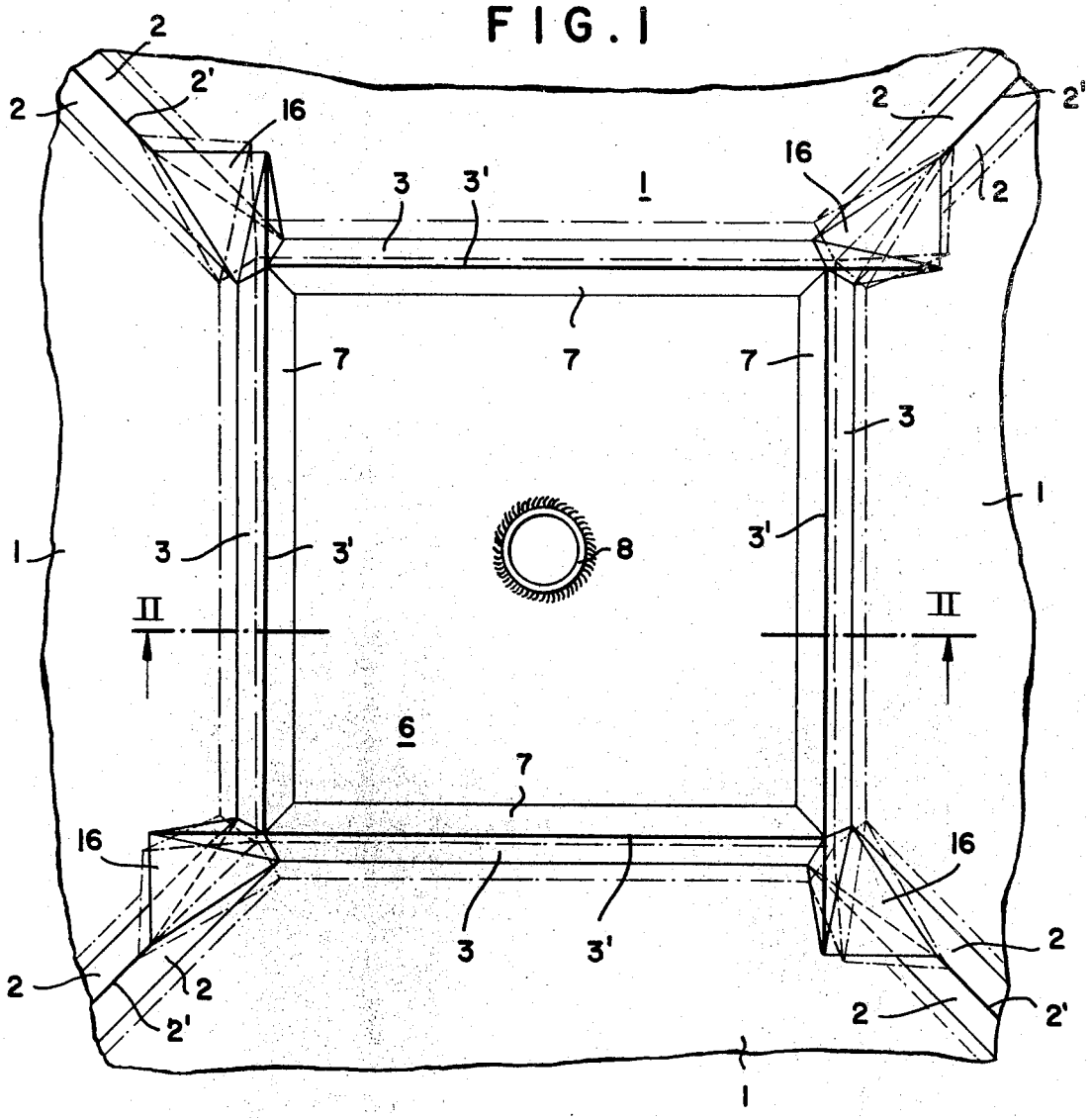
June 30, 1970 R. VON SALDERN ET AL 3,517,850

YIELDABLE WALL ASSEMBLY FOR CONTAINERS FOR THE TRANSPORTATION OF LOW-TEMPERATURE FLUIDS

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FIG. 1



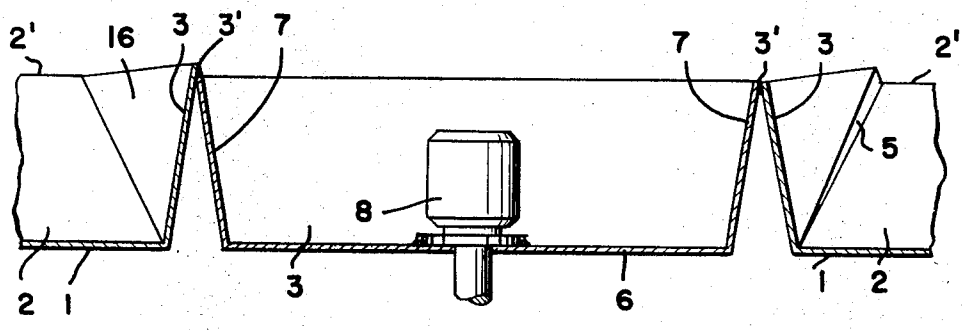
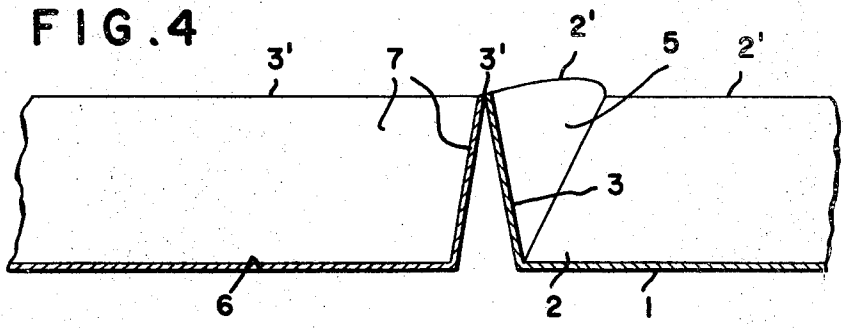


FIG. 2

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FIG. 4



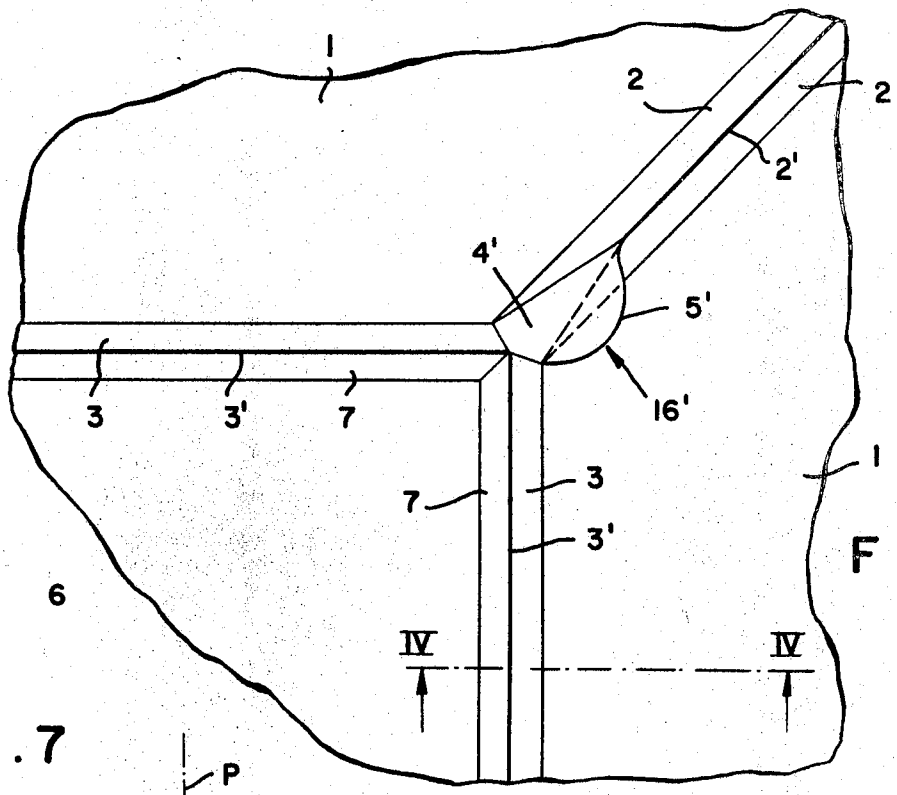
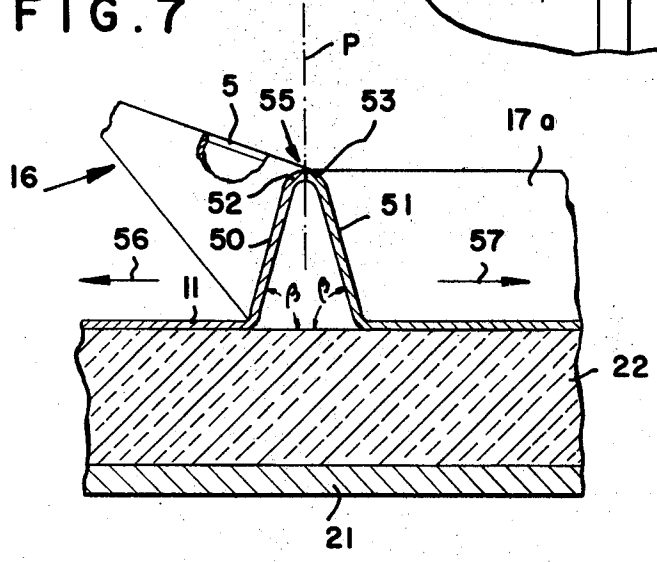


FIG. 3

FIG. 7



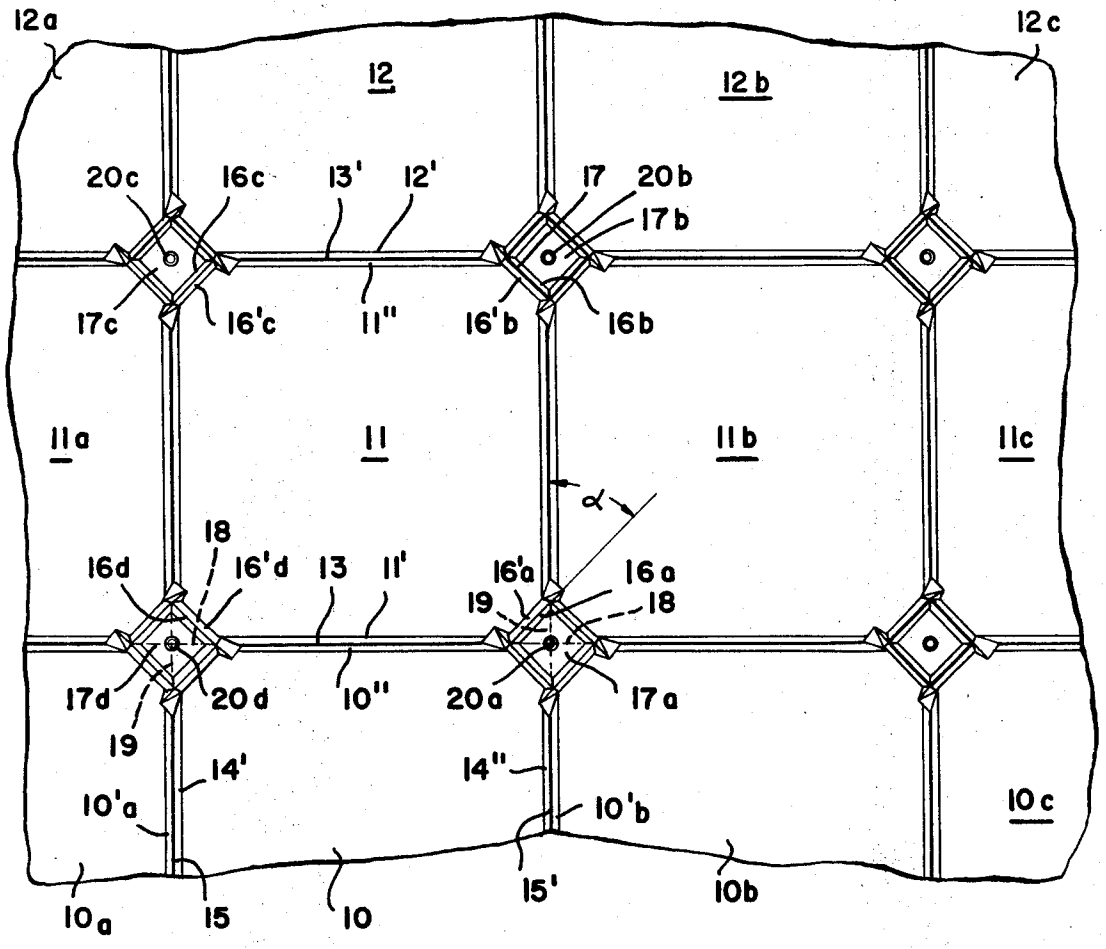
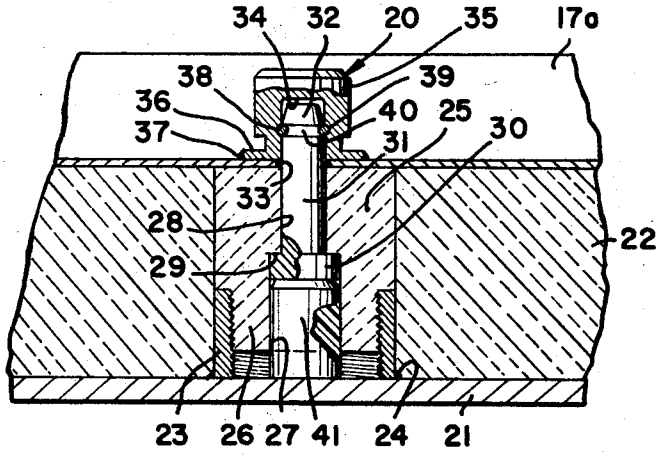

12a
12c
12
12b
20c
16c
13'
12'
17
20b
17b
17c
16'c
11"
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16b
11a
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11b
11c
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16d
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16'a
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19
18
17d
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10"
20a
17a
19
14'
14"
10'a
10'b
10c
10a
15
10
15'
10b

FIG. 5

FIG. 6


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3,517,850

YIELDABLE WALL ASSEMBLY FOR CONTAINERS FOR THE TRANSPORTATION OF LOW-TEMPERATURE FLUIDS

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Claims priority, application Germany, May 24, 1967, L 56,582
Int. Cl. B65d 25/18
U.S. Cl. 220—9 10 Claims

ABSTRACT OF THE DISCLOSURE

A yieldable wall assembly adapted to be mounted via load-supporting insulation and thermally insulating bolt constructions upon the rigid wall of a tankship in which the wall is formed by laterally and longitudinally contiguous coplanar sheet-metal main plates of relatively large area whose corners are cut at a bias of 45° to accommodate relatively small-area square corner plates, all of the plates having upwardly turned flanges welded together to form flanged seams with gussets being provided in the flanged seams of the main plates at the junctions of these flanged seams with the corners of the auxiliary or corner plates. The gussets are formed by bending the flanges of the welded seam alternately inwardly and outwardly so that the upper edge of an outer fold of the flange of one main plate bears upon and is welded to the inwardly bent flange portion of a laterally or longitudinally contiguous main plate.

Our present invention relates to a container for the transportation of low-temperature fluids and, more particularly, to a tank or compartment in a seagoing vessel for the transportation of liquefied gases (e.g. methane) at low temperatures.

In the commonly assigned copending applications Ser. No. 664,066, filed Aug. 29, 1967, now Pat. No. 3,459,158 (entitled "Tankship for Liquefied Gases"); Ser. No. 721,042 filed Apr. 12, 1968 and entitled "Tank Assembly for the Transportation of Low-Temperature Fluids" and application Ser. No. 721,043 filed Apr. 12, 1968 and entitled "Yieldable Wall Assembly for the Transportation of Low-Temperature Fluids," there are disclosed tankships for the transportation of liquefied gases (e.g. liquid hydrocarbons) such as methane, ethane or propane, or air-rectification products (such as nitrogen or ammonium) with rigid hulls forming holds containing a plurality of tanks thermally insulated from the hull and having fluid-containing compartments which may be separated from the rigid wall by a continuous sheet-metal skin.

The skin, which may flex in response to temperature fluctuations is, as described in applications Ser. No. 664,066, now Pat. No. 3,459,158, composed of plates welded together in fluid-tight relationship along their peripheries at upstanding flanges so that the welded peripheries of the trays or plates form expansion joints or folds accommodating thermal expansion and contraction of the skin.

Between the sheet-metal skin and the hull of the ship, there is provided a filling of one or more layers of thermal insulation preferably of load-supporting or relatively incompressible character.

An earlier application, Ser. No. 663,577, filed Aug. 28, 1967 and also assigned to the owner of the present invention, describes an improvement in which insulating bolt assemblies attach the sheet-metal outer wall of a double-wall container to the hull of the ship via an intervening

layer of load-supporting thermal insulation. As pointed out there, a further layer of insulation, preferably of the nonsupporting type, may be interposed between the inner wall of the vessel and the intermediate sheet-metal layer. The bolt assembly comprised a bolt head welded sealingly to the sheet-metal layer and having a shank threaded into a cylindrical post of thermally insulating material, the post being threadedly anchored in a sleeve upstanding from and welded to the rigid wall or hull of the vessel.

In such arrangements, using an intermediate skin adapted to yield with temperature variations, elasticity is gained and stress is reduced by providing the sheet-metal wall of a plurality of plates in contiguous relationship, the plates having upturned flanges at the peripheries which are welded together at the corners of the plate to form individual pans or trays therefrom. The flanges of adjacent trays, which diverge upwardly are welded together at outwardly turned lips to form a continuous partition or wall precluding passage of fluid therepast. The flanges, when welded together, form folds in the continuous wall which, like accordion plates, permit expansion and contraction of the sheets or trays in the plane thereof in response to the high-temperature fluctuations sustained by the walls upon filling of the tank with a low-temperature fluid or upon discharging the cargo.

Additional stress reduction is provided in accordance with the further improvement described in application Ser. No. 721,043, filed Apr. 5, 1968 and entitled "Yieldable Wall Assembly for the Transportation of Low-temperature Fluids." In that system, the stress developed in the individual plates, which are preferably welded together in contiguous relationship to form the continuous fluid-tight partition mentioned earlier, is relieved by offsetting the junctions between the plates, from plate to plate, along the continuous skin. This is accomplished by imparting to the plates a geometric configuration which corresponds substantially to a double trapezoid joint at the corresponding small base. More specifically, the plates are provided with a pair of parallel end edges and a pair of inwardly directed lateral edges and are joined together in laterally overlapping relationship so that the junction between a pair of ends of end-aligned plates is located substantially intermediate the ends of the neighboring side-aligned plates. Thus the plates of the last-mentioned application are connected end-to-end in adjacent rows which are offset substantially by about half the length of the plates and each plate is widest at its end and narrowest at an intermediate region corresponding to the location of closest approach of the inwardly turned lateral sides. Preferably, this intermediate location lies at the center of the plate. A single bolt assembly (e.g. as described in copending application Ser. No. 721,042, entitled "Tank Assembly for the Transportation of Low-temperature Fluids") secures each plate to the rigid wall at the center of the plate.

In the flexible sheet-metal skin arrangement of the character described, problems may remain with respect to the corner junctions of the several plates. Thus, it appears that arrangements in which the flanges, upon welding together, form relative rigid nets restrict expansion and contraction in both mutually perpendicular directions in the plane of this wall with particular stressing at the corners. Furthermore, this phenomenon is all the more significant when the trays are generally rectangular.

An object of the present invention is, therefore, to provide a corner junction for the plates of a yieldable wall assembly for the purposes indicated which reduces the stress applied to the wall upon thermal dimensional fluctuations.

In the commonly assigned, concurrently filed application Ser. No. 729,049 filed by Rüdiger von Saldern, one of the present joint inventors, and entitled "Yieldable Wall Assembly for Containers for the Transportation of

Low-temperature Fluids," there is described an arrangement whereby it is possible to describe the stresses arising from the netlike arrangement of the seams between the plates or trays which are contiguously connected into the thermally expandible and contractible wall assembly. That system provides, at each intersection point of the orthogonally welded flanged seams, a corner junction which includes one or more gussets in the seam of at least one of the pairs of plates and welded to the corner junction portions of the adjoining pairs at the particular junction. Each gusset is formed by outwardly bending the flange of one plate and inwardly bending the corresponding portion of the flange of a contiguously adjoining plate.

The intersection of orthogonal seams is constituted, according to that arrangement, by providing a plurality of lateral and longitudinally contiguous, generally coplanar, plates or trays whose upturned flanges are welded together with or without mutually confronting lips as described in the last-mentioned applications, for example, whereby the seams of four such plates constitute a corner junction. Each seam (consisting of two upturned parallel and converging flanges welded together along a seam line defining the edges of the plates) is provided at its ends with a gusset formed by bending the adjoining seam flanges in opposite directions (i.e. inwardly and outwardly) so that, with respect to a perpendicular plane through that seam, the weld at the inner and outer bends, runs away from and toward this plane.

The term "perpendicular plane" is here used to describe the plane through the weld seam perpendicular to the plate and, therefore, the plane toward which the seam flanges converge upwardly. Each junction point is provided at the intersection of two such planes which are mutually perpendicular. Consequently, when the yieldable wall forms a horizontal floor, the intersecting perpendicular planes are vertical and, when the yieldable wall is vertical, one of the intersecting perpendicular planes is generally horizontal while the other is vertical. Preferably, the junction is constituted at the corners of four plates longitudinally contiguous in pairs, with the pairs being laterally contiguous so that the mutually perpendicular planes pass through the laterally seamed edges and the longitudinal-end edges of the plate. The gussets may be angular (formed as trapezoidal or triangular prisms) or arcuate (e.g. petal-shaped), provided only that the gussets are formed by portions extending first toward one side of the respective perpendicular planes and thence back to the latter. The gussets all terminate at a common point at the intersection of the orthogonal perpendicular planes and in the respective perpendicular plane at least when the apex of the seamed flange is considered. Each of the seamed flanges is thus of triangular cross-section and may be integral (i.e. one piece) with the gusset whereby only the weld seam is fully bent out of the respective perpendicular plane and thus back toward the latter. As a consequence, the gusset, in the direction of the point or line junction of the four-plate corners, has an outwardly turned fold and an inner fold. When the junction of the four-seamed flanges is considered, therefore, the flanges of the seam are respectively bent inwardly and outwardly such that the upper edge of an outer fold of the edge of one of the plates of a contiguous pair abuts and is welded to an inner fold of the neighboring edge of the other laterally or longitudinally contiguous plate. The gussets at opposite ends of the seamed flange of any pair of plates are oriented in opposite senses and thus are of reciprocal symmetry.

We have now discovered that it is possible to decrease the stresses developed at the corner junctions of a yieldable wall assembly of the general character described when, at each corner junction, the relatively large-area main plates are cut at a bias of 45° (i.e. the corners are truncated at 45°), and an auxiliary or corner plate of relatively small area is disposed between the bias-cut

portions of the main plates and has its upturned flanges welded at their upper extremities to the welded seams of the adjoining flange of the plates. Each of the corner plates, according to the invention, serves as the means for affixing the yieldable wall assembly to a rigid wall (e.g. the tankship hull) and can be provided with a bolt construction of the type described in application Ser. No. 721,042. Thus, the present assembly can be considered to comprise a multiplicity of laterally and longitudinally contiguous main plates having edge flanges turned upwardly at angles of less than 90° as previously described and welded together to form mutually orthogonal arrays of welded flanged seams at the junctions of which square corner plates are disposed so that their diagonals are aligned with the flanged seams of the respective arrays, a plug-and-socket type of bolt construction being disposed at the intersection of these diagonals. The upturned flanges of the corner plates, which are also bent upwardly at angles of less than 90°, may be welded together to constitute the corner plates respective trays of the character described. Best results are obtainable when the square plates have sides of 100–300 mm. in length and are joined to the flanged seams of the main plates via prismatic or arcuate gussets as previously discussed. The bias edges of the main plates are welded to the sides of the corner plates over substantially the entire length thereof.

The above and other objects, features and advantages of the present invention will become more readily apparent from the following description, reference being made to the accompanying drawing in which:

FIG. 1 is a plan view illustrating a corner junction of a flexible wall assembly in accordance with the present invention;

FIG. 2 is a cross-sectional view taken generally along the line II—II of FIG. 1;

FIG. 3 is a detail view, drawn to an enlarged scale, of the corner construction at the junction between a corner plate and a main plate in accordance with this invention;

FIG. 4 is a cross-sectional view taken along the line IV—IV of FIG. 3;

FIG. 5 is a plan view of a larger portion of the flexible wall assembly illustrating the relationship of corner plates to main plates;

FIG. 6 is a vertical cross-sectional view through the bolt assembly of FIG. 2 illustrating its construction in gerater detail; and

FIG. 7 is a cross-sectional detail view of a gusset (partly broken way) similar to that used in FIG. 1.

Referring first to FIG. 5, in which we show the overall construction of the yieldable wall assembly in plan view, it can be observed that the wall comprises a multiplicity of longitudinally contiguous plates **10**, **11** and **12** whose opposite longitudinal ends are formed with upturned flanges **10''**, **11'**, **11''** and **12'**. The flange **10''** at one end of plate **10** is welded to the flange **11'** at the opposite longitudinal side of the plate **11** along the weld seam **13** extending laterally. Similarly a lateral weld seam **13'** is formed between the opposite end flanges **11''** and **12'** of the plates **11** and **12**. The longitudinal plate array **10**, **11** and **12** is laterally welded to adjoining longitudinal arrays **10***a*, **11***a* and **12***a* on one side and **10***b*, **11***b* and **12***b* on the opposite side of the array **10**, **11**, **12**. A further array of main plates is shown at **10***c*, **11***c* and **12***c*. At their laterally contiguous edges, the plates **10**, **11** and **12** have flanges **14'** and **14''** joined to the flanges **10***a'* and **10***b'*, for example, by weld seams **15** and **15'** running in the longitudinal direction. Thus, the main plates are joined together by othogonal arrays of laterally extending flanged seams **13**, **13'**, etc. and arrays of flanged seams **15**, **15'**, etc. extending in the longitudinal direction (upwardly in FIG. 5.) The arrays of flanged seams would, in accordance with earlier practice, intercept at corner junctions which may be made flexible as described in the commonly assigned concurrently filed copending applica-

tion Ser. No. 729,049 or would have been realtively riged. However, we have found that it is possible to eliminate such rigidity by cutting the corners of the main plates **10**–**10***c*, **11**–**11***c* and **12**–**12***c* at a bias as shown at the corners **16***a*, **16***b*, **16***c* and **16***d* of the plate **11**. The cut is made at an angle α to the respective side of the main plates which, although shown to be square in FIG. 5, may also be rectangular. At each of these bias-cut corners, at which the angle α is preferably 45°, we provide an upturned flange **16***a'*, **16***b'*, **16***c'* and **16***d'* which adjoins the previously described flanges **11'**, **11''** at gussets **16** described in greater detail in connection with FIGS. 1–4. The bias-cut flanges **16***a*–**16***c* are welded to the side of flanges **17**, for example, of corner plates **17***a*, **17***b*, **17***c* and **17***d* at each of the corners of the main plate **11**. The corner plates, which are square and have a side length of 100–300 mm., are provided with bolt assemblies generally represented at **20***a*, **20***b*, **20***c* and **20***d* at the intersection of the diagonals **18** and **19** of the corner plates (see corner plate **17***b*). The diagonals **18** and **19** are aligned with the seams **16'** and **13'** respectively.

Each of the bolt assemblies is, according to this invention, of the type described in the copending application Ser. No. 721,042 and, as shown in FIG. 6, connects the sheet-metal skin via the respective corner plate **17***a* to the rigid wall **21** of the ship. A layer **22** of load-supporting thermal insulation, as described in application Ser. No. 664,066, is disposed between the sheet-metal skin and the wall **21** of the vessel to form a thermal barrier preventing heat loss from the tank compartment defined by the sheet-metal skin to the wall of the vessel. A typical insulating material is Ferrozel which is shear-resistant and compression-resistant-glass fiber reinforced phenolic resin (see French Pat. 1,490,834). Each bolt assembly **20** comprises an upstanding internally threaded sleeve **23** which has a height equal only to a small fraction of the spacing of the plates **17***a*, etc. from the hull **21** and is welded peripherally to the latter along a seam **24**. A post **25** of load-supporting material of poor thermal conductivity (e.g. Ferrozel or a ceramic thermal insulator) has a threaded portion **26** screwed into the sleeve **23** so that the outer periphery of the post **25** is flush with the outer periphery of this sleeve. The post **25** is formed with a stepped bore whose large-diameter portion **27** joins the small-diameter portion **28** at a shoulder **29** serving to anchor the head **30** of a pin **31** extending upwardly through the small-diameter portion **28** and having a frustoconical end **32**. Each of the corner plates **17***a*, **17***b*, etc. is provided with a respective aperture **33** at the intersection of the diagonals **18** and **19**, registering with the bore **27**, **28** and with the internal cavity **34** of a cap **35** mounted upon the corner plate at this intersection. At its lower end, the cap **35** is formed with an outwardly extending annular flange **36** lying flat against the sheet metal of the corner plate **17***a*, **17***b*, etc. and preferably welded thereto at **37**. Within the interior **34** of the cap **35**, there is provided an inwardly open peripheral groove **38** which receives a spring ring **39** adapted to be wedged outwardly by the frustoconical upper end **32** of the bolt **31** as the cap **35** is thrust over this bolt. Behind the frustoconical end **32**, the bolt or pin **11** is formed with an outwardly open circumferential groove **40** adapted to receive part of the ring **39** when the latter springs back after it has been wedged outwardly. To support the bolt **31**, there is provided a cylindrical backing block **41** which fills the large-diameter portion **27** of the bore of post **25** as it is seated against the hull **21** of the vessel.

As has been described in application Ser. No. 721,042 and as can be seen from FIG. 6 of the present case, the frustoconical end **32** of the pin **31** has an outer diameter which is less than the inner diameter of the ring **39** in its relaxed position. After the cap **35** is welded in place upon its corner plate **17***a*, **17***b*, etc., these plates may be placed with their apertures **33** over the pins **31** and set by relatively light hammer taps upon the caps **35**. The taps drive the caps **35** over the frustoconical tips **32** of the pins **31** until the rings **39**, which initially are spread outwardly, spring back into the respective grooves **40**, thereby retaining the plates upon the pins. An externally rapid rate of assembly is thus permitted.

In FIG. 7, we have shown in somewhat greater detail the basic elements of the flanged seams of a yieldable wall assembly for tankships and the like adapted to carry low-temperature fluid such as methane.

The main plate **11** and the corner plate **17***a* thus have upwardly extending peripheral flanges which are represented in detail in FIG. 7 at **50** and **51** and are welded together about the periphery of each plate so as to impart a tray-like configuration to the plates. These flanges **50** and **51** have lips **52** and **53** which are turned generally toward one another (parallel to the plane of the plates **11** and **17***a*) and are welded together along seams **54**. The flanges **50** and **51** diverge somewhat outwardly, having been folded up through angles β of less than 90°, and thus converge in the direction of a respective perpendicular plane P extending along the weld seam **54** perpendicularly to the plane of the plates **11** and **17***a*. The seam illustrated in FIG. 7 (in which the perpendicular plane P is shown to be vertical and orthogonal to the plane of the drawing) is designated at **55** and corresponds to the seam formed along each of the edges of the rectangular plates **11**, etc. and **17***a*, etc. This seam is of triangular section and has an upper edge formed at **54** by the actual weld junction.

Upon shrinkage of the plates **11** and **17***b* (arrows **56** and **57**), the flanges **50** and **51** are flattened somewhat as fully described in the commonly assigned copending application Ser. No. 721,043, entitled "Yieldable Wall Assembly for the Transportation of Low-temperature Fluids." According to the principles of the present invention, each of the weld seams **55** between each pair of laterally and longitudinally contiguous plates is provided at its opposite ends with gussets **16**, the gussets being geometrically similar to one another and of triangular prismatic or arcuate configuration, as described in greater detail in connection with FIGS. 1–4.

From FIGS. 1 and 2, it will be seen that each main plate is provided along its periphery with upwardly bent flanges **2** whose lips are welded together at **2'** contiguously and in both lateral and longitudinal directions (see FIG. 5). The upwardly bent flanges **3** along the biased cut corners of the main plates are provided at their junctions with flanges **2** whose gussets **16** are here represented as consisting of outwardly bent portions **4** of one flange and inwardly bent portions **5** of the contiguous flange. In the gap between the upper edges **3'** of the biased cut edges of the plates, the square corner plate **6** is inset so that its bent flanges **7** are welded at their upper edges or lips to the contiguous edge flanges **3** of the main plates. The corner plates **6** are attached by the bolt assemblies **8** of low-thermal conductivity to the rigid outer wall of the ship (see FIG. 6), the bolt assembly being located at the center of the corner plates **6**. The gussets **16** at the corners of the junctions between the main plates **1** and the corner plates **6** increase the elasticity along the weld seams and prevent direct stress along the latter. The stress is substantially uniformly distributed along the corner plates **6**. As shown in FIGS. 3 and 4, the outer edges **4'** and **5'** are bent outwardly and inwardly in arcuate configuration and are welded along the bend to form a gusset **16'** (FIG. 3). In this case, the stresses which otherwise might be concentrated along angular junctions are distributed more uniformly over the curved seam.

We claim:

1. A yieldable wall assembly for containers used in the transportation of low-temperature fluids, comprising a plurality of laterally and longitudinally contiguous octagonal sheet metal main plates each with two pairs of parallel main edges, each pair of edges being perpendicular to

the edges of the other pair, each of said plates having upwardly turned flanges along said edges, the distal edges of the flanges of adjacent plates being welded together along respective mutually orthogonal arrays of flanged seams forming main-edge junctions between the adjacent plates, and secondary edges of substantially less length than said main edges alternating with the main edges, said secondary edges being formed by the truncated corners of each plate and being disposed at a bias of 45° to said main edges; and a corner-junction structure wherein each of the truncated corners of the main plates are joined to the truncated corners of adjacent main plates, such junction being formed by providing each of the respective truncated secondary edges with an upwardly turned flange, said corner junction structure also including a square corner plate of an area less than that of the main plates and having each of its edges of substantially the same length as each of said secondary edges and provided with an upwardly turned flange welded to the distal edge of an upwardly turned flange of said main-plate secondary edges along weld seams connecting said flanged seams, said upwardly turned flanges of each main plate being joined into a continuous peripheral flange, said main plates being arranged in straight rows at right angles to each other.

2. The assembly defined in claim **1** wherein said corner plate has sides of a length of 100 to 300 mm.

3. The assembly defined in claim **1** wherein each of said plates has a planar central portion surrounded by the respective flanges, said upwardly turned flanges being bent upwardly from the planar central portion of the respective plates to include an angle greater than 90°.

4. The assembly defined in claim **1**, further comprising a gusset formed in each of the flanged seams of said main plates in the region of said corner plate for accommodating shrinkage of the wall assembly longitudinally of the flanged seams associated with the respective gussets.

5. The structure defined in claim **4** wherein each gusset is formed in a respective one of the flanged seams formed by a pair of said main plates and has an outer bend of the flange of the one plate of said pair and an inner bend of the adjoining flange of the plate of said pair whereby said one of said flanged seams has a respective perpendicular plane and the flanges thereof are welded together along a weld line bent alternately away from said plane and toward said plate at the gusset.

6. A yieldable wall assembly for containers used in the transportation of low-temperature fluids, comprising a plurality of laterally and longitudinally contiguous octagonal sheet metal main plates each with two pairs of parallel main edges, each pair of edges being perpendicular to the edges of the other pair, each of said plates having upwardly turned flanges along said edges, the distal edges of the flanges of adjacent plates being welded together along respective mutually orthogonal arrays of flanged seams forming main-edge junctions between the adjacent plates, and secondary edges of substantially less length than said main edges alternating with the main edges, said secondary edges being formed by the truncated corners of each

plate and being disposed at a bias of 45° to said main edges; and a corner-junction structure wherein each of truncated corners of the main plates are joined to the truncated corners of adjacent main plates, such junction being formed by providing each of the respective truncated secondary edges with an upwardly turned flange, said corner junction structure also including a square corner plate of an area less than that of the main plates and having each of its edges of substantially the same length as each of said secondary edges and provided with an upwardly turned flange welded to the distal edge of an upwardly turned flange of said main-plate secondary edges along weld seams connecting said flanged seams, said upwardly turned flanges of each main plate being joined into a continuous peripheral flange, said main plates being arranged in straight rows at right angles to each other, said assembly further comprising a bolt assembly of low thermal conductivity connecting said corner plate with a rigid support wall.

7. The assembly defined in claim **6** wherein a layer of load-supporting thermal insulation is disposed between said yieldable wall assembly and said rigid wall and said bolt assembly includes a load-supporting post secured to said rigid wall and extending toward said corner plate, a pin anchored in said post and extending therebeyond away from said rigid wall, and a cap anchored to said corner plate for receiving an end of said pin projecting beyond said post.

8. The assembly defined in claim **7** wherein said cap is located substantially at the intersection of the diagonals of said corner plates and said corner plate is provided at said intersection with an aperture aligned with said cap, said cap and said pin being formed with spring-ring means for locking said cap onto said pin upon insertion of said pin into said cap.

9. The assembly as defined in claim **8** wherein said cap is formed with an inward open peripheral groove, said spring means including a resilient ring received in said groove, said end of said pin having a frustoconical configuration and being receivable in said ring to expand same, said pin being provided with an outwardly open circumferntial groove behind said end to receive said ring upon its expansion by said end of said pin.

10. The assembly as defined in claim **9** wherein said post is composed of load-supporting thermal insulation.

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