Sept. 13, 1960 R. S. HAMPTON ET AL 2,952,380

VESSEL SUPPORT STRUCTURE

Filed Nov. 26, 1957

3 Sheets-Sheet 1

Fig. 1

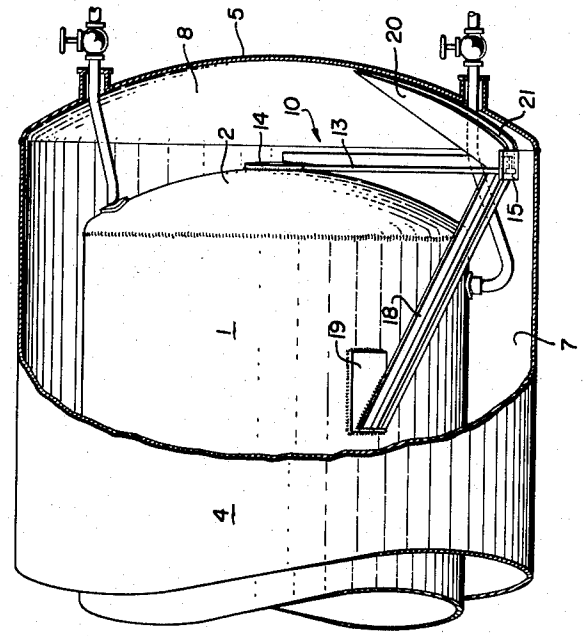

Fig. 2

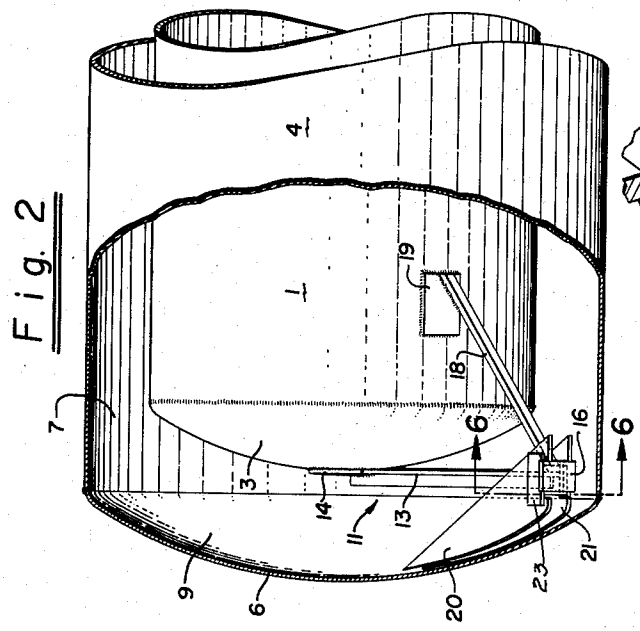

Fig. 6

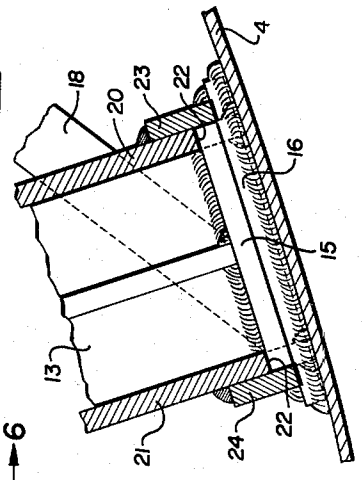

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Fig. 4

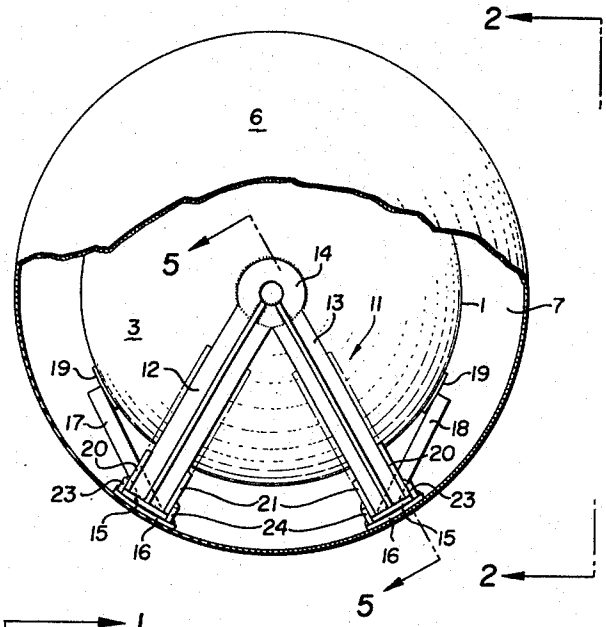
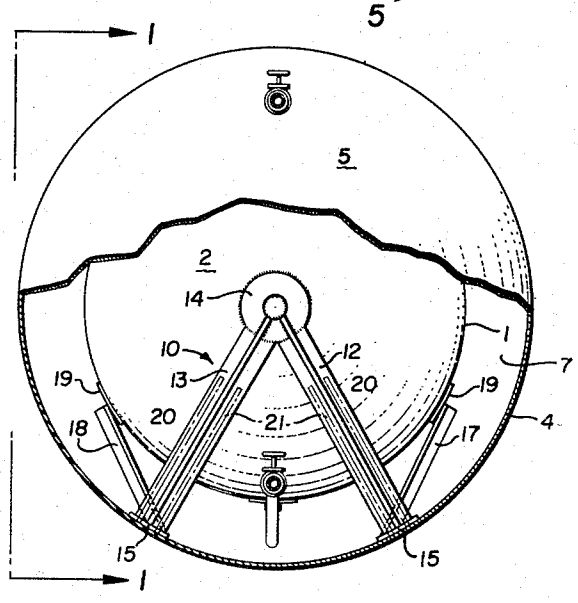


Fig. 3



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VESSEL SUPPORT STRUCTURE

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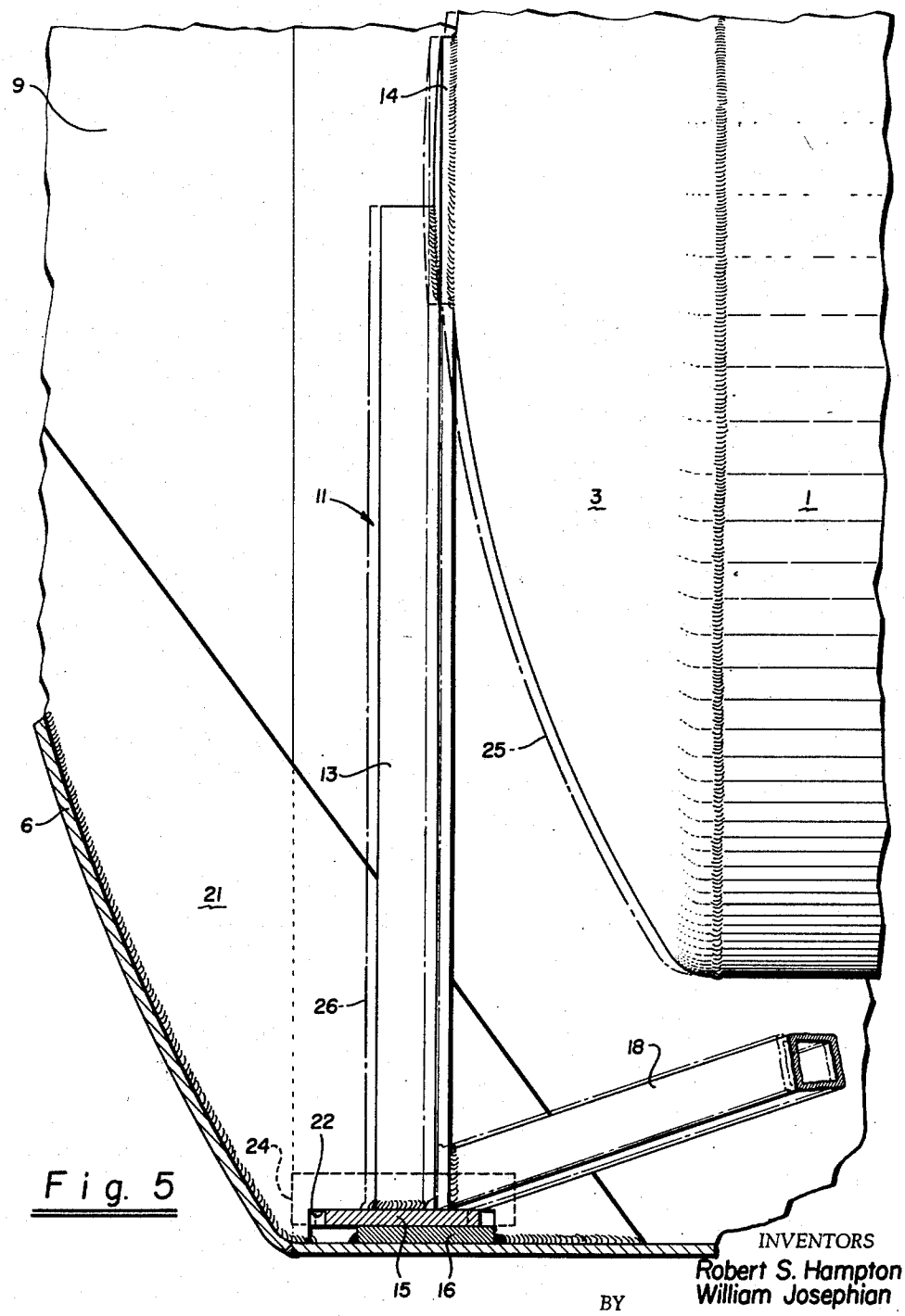

Fig. 5

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VESSEL SUPPORT STRUCTURE

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3 Claims. (Cl. 220—15)

This invention relates to vessel support structure, and more particularly, to means for supporting a horizontally extending, generally cylindrical vessel at its opposed convex heads, the term convex as used herein referring to the shape as viewed from outside the vessel.

In storing and transporting liquids, such as liquified gases, under high pressure and low temperature conditions, it is common practice to employ cylindrical vessels or tanks the ends of which are closed by domed or convex heads. Tanks of this type are particularly strong for resisting high internal pressures and may be constructed so as to be supported with their axes extending either generally horizontally, or generally vertically. This invention is concerned only with those vessels supported generally horizontally.

Heretofore, it has been the practice to support such cylinders by means of saddles, or like structures, engaging the cylinder at its peripheral side wall at two or more points intermediate the vessel heads. In the larger sizes of vessels some reinforcing of the shell of the cylinder has been found necessary in conjunction with these prior known forms of tank support. This results from the fact that in supporting a tank in a horizontal position on its cylindrical shell the weight of the cylinder and contents tends to flatten the cylindrical shape to an extent detracting from its strength as a beam, and also introducing stress concentrations which may result in cracks or rupture at the points of support.

It is therefore a main object of this invention to provide structure for supporting a horizontal, closed cylindrical vessel, which structure distributes the load evenly to the cylindrical shell of the vessel.

Another object of this invention is the provision of supporting structure for a generally cylindrical vessel having convex heads, which structure supports the weight of said vessel on said heads.

It is still another object of this invention to provide supporting structure for a horizontal, generally cylindrical vessel having opposed convex heads, which structure carries the vertical and transverse loads applied to the vessel generally tangentially of the heads, and which carries the axial loads applied to the vessel generally tangentially of the cylindrical shell thereof.

It is also an object of this invention to provide necessary structural support for the inner vessel in a vacuum jacketed vessel with a minimum practical heat conduction through such supports, combined with simplicity and economy in material and labor of fabrication.

A further object of this invention is the provision of means for supporting a horizontal, generally cylindrical vessel within an outer vacuum insulating jacket, with a minimum complication of said jacket with extra welded seams subject to possible leakage and thus loss of necessary vacuum.

A still further object of this invention is the provision of means for supporting a horizontal, generally cylindrical vessel within an outer insulating jacket, and which

means contributes to the strength of the vessel being supported.

Other objects and advantages will become apparent from the following description taken in connection with the following drawings in which:

Figs. 1, 2 are side elevational views of the opposite ends of a jacketed vessel, with the outer jacket broken away to show the supporting structure of this invention, as seen generally from lines 1—1, and 2—2, respectively, of Figs. 3, 4.

Figs. 3, 4 are end elevational views of the opposite ends of the jacketed vessel of Figs. 1, 2, respectively, with the outer jacket broken away to show details of the supporting structure of this invention;

Fig. 5 is an enlarged elevational view of the support means for the movable end of the tank, as seen generally from line 5—5 of Fig. 4; and,

Fig. 6 is a greatly enlarged cross-sectional view taken generally along line 6—6 of Fig. 2.

In detail, referring to Figs. 1, 2, the support structure of this invention is described for use with a jacketed vessel comprising a pair of horizontally extending tanks, one of which is enclosed within the other. The inner tank or vessel has a cylindrical shell 1, provided with opposed domed or convex heads 2, 3, and the outer tank or jacket is likewise provided with a cylindrical shell 4 and opposed convex heads 5, 6. Vessel 1 is adapted to contain liquid under pressure and is mounted within jacket 4 so as to provide an annular insulating space 7 between the shells of said tanks, and end spaces 8, 9, between heads 2, 5, and 3, 6, respectively.

Annular space 7 and the communicating end spaces 8, 9 are adapted to be evacuated and filled with an insulating material whereby vessel 1 becomes an efficient container for storing and transporting liquified gases, such as oxygen, nitrogen, hydrogen, and the like under substantially high pressures and low temperatures. For example, liquid oxygen may be maintained at temperatures as low as minus 207 degrees Fahrenheit and at pressures of 300 pounds per square inch or higher, in tank 1.

It will be understood that the supporting structure of this invention is not restricted to the particular jacketed vessel shown, but may be applied to any cylindrical tank having opposed convex heads. The particular use of the supporting structure here described, is for purposes of illustration only.

In the larger sizes, vessel 1 may be fabricated from a plurality of curved plates welded together into the form of a cylindrical shell. The heads 2, 3 either formed in one piece, or from a plurality of welded sections, are continuously welded to opposite ends of the shell 1 so as to provide a completely enclosed cylinder. Even though such cylinder may be fabricated from relatively thin plate and still withstand the required pressures, the weight of the tank will be substantial, especially when including the weight of the liquid it contains. Not only are relatively strong support members necessary, but it is also essential that tank 1 be supported in a manner to prevent excessive deformation of the cylinder from its circular cross-section.

Inner cylinder 1 is supported centrally of outer cylinder 4 by means of a pair of supporting structures, generally designated 10, 11, at its opposite heads 2, 3. These support structures are generally similar and the like reference numerals will be applied to each, except where differences exist.

Each of the structures 10, 11, comprises a pair of vertical and transverse load support members 12, 13, which diverge radially of cylinder 1 from the central portions of its heads across space 7 into engagement with the shell of cylinder 4 adjacent its heads. Members 12, 13, are

rigidly secured, as by the welding, to the central projecting portion of each head 2, 3 of tank 1. Said central portion may be reinforced by a plate or ring 14 (Figs. 3, 4) welded rigidly thereto. As previously described, one of the ends of each of the members 12, 13, are welded adjacent each other to the ring 14 and the head, and said members extend radially from said ring, and substantially tangent to the head, into engagement with the inner side of the shell of jacket 4. Members 12, 13 preferably diverge from the central portion of the heads 2, 3 toward jacket shell 4 at an acute included angle so as to provide both the vertical support for the weight of vessel 1 and transverse stability for the side loads on said vessel.

Members 12, 13 may be combined into a single load-supporting member as long as the points of engagement between said member and the supporting surface of jacket 4 are spaced circumferentially as shown. Members 12, 13 may be of any suitable construction, the T-bar shown being preferred.

The outer ends of members 12, 13 terminate in curved plates or shoes 15 adjacent the supporting surface of jacket shell 4 near heads 5, 6.

The end of vessel 1 at head 2 is the fixed end, i.e., it is adapted to remain stationary with respect to the supporting jacket 4. On the other hand, the end of vessel 1 at head 3 is permitted limited movement occasioned by the elongation and contraction of vessel 1 under varying temperature conditions. It is obvious that in the service of transporting or storing liquids at low temperatures, vessel 1 will be subjected to temperatures between atmospheric and the low temperature of the liquid, thereby causing it to elongate and contract axially in response to said temperature changes.

The shoes 15 at supporting structure 10 at the fixed end of tank 1 therefore constitute reinforcing plates which are rigidly secured, as by welding, to jacket shell 4. The shoes 15 in the supporting structure 11 at the movable end of the inner vessel are adapted to slide on a reinforcing plate 16 (Figs. 5, 6) on jacket shell 4 in a manner to be described.

Extending from members 12, 13, at points adjacent shoes 15, are a pair of axial support elements 17, 18 (Figs. 1–4). Elements 17, 18 extend into engagement with the peripheral side wall or shell of vessel 1 at opposed points which are spaced axially from heads 2, 3 and are preferably circumferentially spaced at an obtuse angle. Elements 17, 18 constitute thrust members for carrying the axial load applied to tank 1 by earthquake, or acceleration during transport, or the like. At one end each of elements 17, 18 is welded to its corresponding member 12, 13, and at its opposite end each separate element is rigidly secured to a reinforcing plate 19, which is in turn welded to the vessel wall 1. Thrust elements 17, 18, thereby brace the outer ends of members 12, 13 with respect to vessel 1 and carry any axial loads applied to said vessel essentially tangentially of its shell to the outer jacket 4.

In order to further strengthen the heads 5, 6 and the shell 4 of the outer jacket at the points which carry the load of vessel 1, a pair of gusset plates 20, 21 may be welded across the joint between said heads and said shell of said outer jacket. At the fixed end of tank 1, plates 20, 21 may be welded to members 12, 13 and shoes 15 so as to further rigidly secure the supporting structure and distribute the load over a broader area of outer tank 4. These gussets 20 and 21 may be located either externally of the jacket or internally as shown.

The gusset plates 20, 21 at the movable end of tank 1 embrace opposite sides of the members 12, 13 of support structure 11 (Figs. 2, 4, 5, 6). An elongated slot 22 (Figs. 5, 6) is formed in each gusset plate 20, 21 adjacent outer tank shell 4 at the movable end of tank 1 for receiving the edges of shoes 15 therein. A pair of side plates 23, 24 are welded to gusset plates 20, 21, respectively, and extend over the outer sides of slots 22 and the outer edges of shoes 15 (Fig. 6). As previously described, a wear plate 16 is welded to jacket shell 4 and to the lower edges of side plates 23, 24.

The shoes 15 at the outer ends of members 12, 13 of support structure 11 are adapted to slide on the wear plate 16 while confined within the slots 22 and side plates 23, 24. In effect, the slots 22 in the gusset plates 20, 21 and the side plates 23, 24, constitute guide means extending axially of the tanks for constraining the sliding movement of shoes 15 to an axial or longitudinal direction.

Hence, under a change in temperature sufficient to cause elongation of inner vessel 1, the head 3 of said vessel would be caused to move to the dot-dash line 25 of Fig. 5 thereby causing movement of the support structure 11 to the dot-dash position 26 by sliding shoes 15 on wear plate 16. The ends of members 12, 13, of course, confined to movement between gusset plates 20, 21 and are prevented from movement away from outer jacket 4 by means of shoes 15 engaging under the edges of slots 22 in said gusset plates. The members 12, 13 remain in a vertical plane during said sliding as a result of the bracing of thrust elements 17, 18.

It will be understood that the support structures of this invention carry not only the vertical weight load of the inner tank 1, but also the transverse loads and axial loads to which such tank is subjected during movement. The weight load and transverse loads are carried by members 12, 13 nearly tangentially of the heads 2, 3 at the central portions thereof so that no excessive bending moment is applied to said heads. In addition, this manner of supporting the tank 1 distributes the load evenly through the heads 2, 3 to the tank shell to assist in keeping said shell circular at the plane of loading. This increases the strength of the cylindrical tank 1 and a relatively long tank may be supported as a beam by the structure of this invention without requiring any special structural supports such as collars or the like. It will also be noted that axial thrust loads on inner tank 1 are carried generally tangentially of the cylindrical shell of said tank in order to prevent undue deformation of said tank.

In the particular application of the support structure herein disclosed it is also important to reduce as much as possible the heat leak from the outer jacket 4 to inner vessel 1. One method minimizing such heat leak through the support members is to provide relatively long support members because the heat leak is proportioned to their length. In previously used structures the support members have been extended through the outer jacket to a separate frame to provide the required length and have been separately jacketed. This not only complicates the fabrication at increased cost, but adds more welded joints as a source of possible leaks to reduce effectiveness of the vacuum insulation.

By supporting the vessel of this invention on the heads, the structural members 12, 13 may be extended to nearly half the diameter of the outer jacket, while remaining entirely within the normal bounds of the jacket. On the members 17, 18 that take the axial load, the desired length can easily be achieved without going outside the jacket shell. By the structure of this invention, therefore, relatively long and yet simply constructed support members may be used to reduce heat leak to a minimum without requiring unduly complex joints or connections.

Although the invention has been described and illustrated in detail, it is obvious that modifications could be made therein without departing from the spirit and scope of the appended claims.

We claim:

1. In a horizontally extending jacketed vessel in which an inner cylindrical vessel having opposed, convex heads is enclosed in an outer cylindrical jacket providing an annular insulating space therebetween, structure for supporting said vessel in said jacket, comprising: at each said head, a radially extending vertical and transverse load support member rigidly secured to said head centrally

thereof and extending into supporting engagement with said jacket at at least two peripherally spaced points thereon, and a pair of axial load support elements rigidly secured to said member adjacent said points and divergently extending into generally tangential securement with the peripheral wall of said vessel spaced from said head.

2. In a horizontally extending jacketed vessel in which an inner cylindrical vessel having opposed, convex heads is enclosed in an outer cylindrical jacket providing an annular insulating space therebetween, structure for supporting said vessel in said jacket, comprising: at each said head, a radially extending vertical and transverse load support member rigidly secured to said head centrally thereof and extending into supporting engagement with said jacket at at least two peripherally spaced points thereon, and a pair of axial load support elements rigidly secured to said member adjacent said points and divergently extending into generally tangential securement with the peripheral wall of said vessel spaced from said head, said member at one head of said vessel being rigidly secured to said jacket at said points, and means at said points at the other of said heads supporting said member for sliding longitudinally of said jacket in response to longitudinal dimensional changes in said vessel.

3. In a horizontally extending jacketed vessel in which an inner cylindrical vessel having opposed, convex heads is enclosed in an outer cylindrical jacket providing an annular insulating space therebetween, structure for supporting said vessel in said jacket, comprising: at each said head, a radially extending vertical and transverse load support member rigidly secured to said head centrally thereof and extending into supporting engagement with said jacket at at least two peripherally spaced points thereon, and a pair of axial load support elements rigidly secured to said member adjacent said points and divergently extending into generally tangential securement with the peripheral wall of said vessel spaced from said head, said member at one head of said vessel being rigidly secured to said jacket at said points, and means at said points at the other of said heads supporting said member for sliding longitudinally of said jacket in response to longitudinal dimensional changes in said vessel, said means including a sliding shoe mounted on the end of said member and in engagement with the wall of said jacket, and a guide rigidly secured to said jacket and embracing said shoe for constraining the same for movement in a direction longitudinally of said jacket.

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