United States Patent

Eifel et al.

[15] **3,696,959**

[45] **Oct. 10, 1972**

[54] **CRYOGENIC STORAGE VESSEL CONSTRUCTED OF DISSIMILAR MATERIALS**

[72] Inventors: **Paul J. Eifel**, Walnut Creek; **Cesar E. Cavanna**, Livermore, both of Calif.

[73] Assignee: **Lox Equipment Company**, Livermore, Calif.

[22] Filed: **Jan. 11, 1971**

[21] Appl. No.: **105,413**

[52] **U.S. Cl.** **220/15**, 220/10

[51] **Int. Cl.** **B65d 25/00**

[58] **Field of Search** ..... 220/15, 10, 9 LG

[56] **References Cited**

UNITED STATES PATENTS

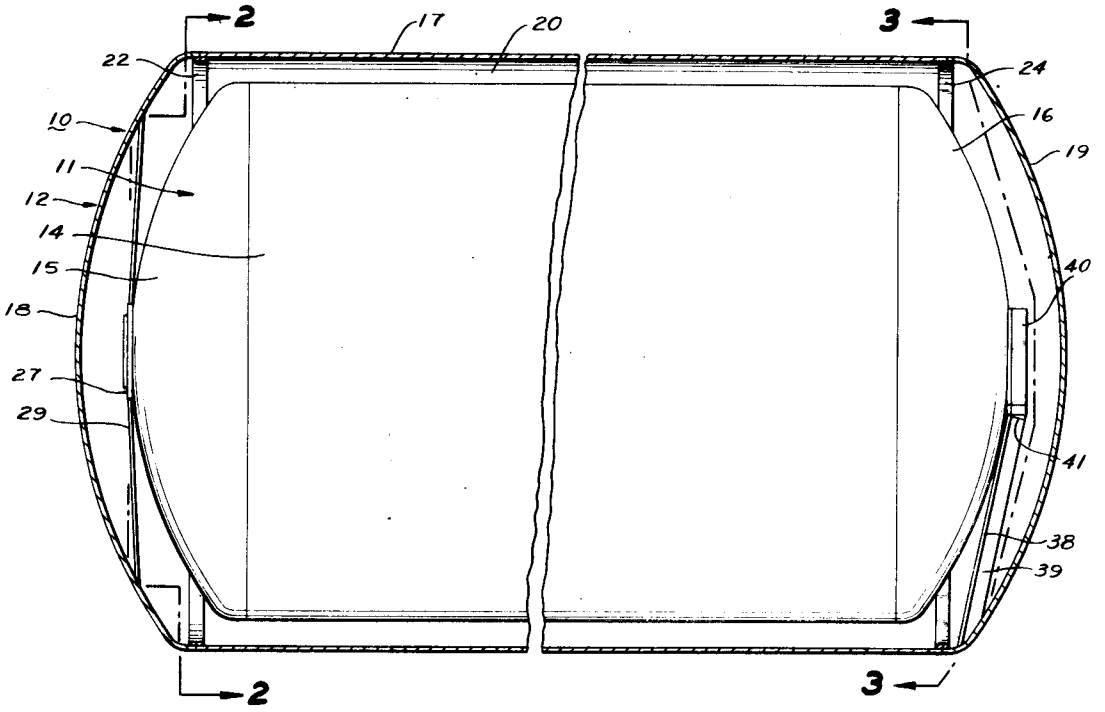
2,925,934	2/1960	Hampton et al.	220/15
2,952,380	9/1960	Hampton et al.	220/15
3,446,388	5/1969	Greenberg	220/15
3,460,706	8/1969	Hoover	220/15
3,481,505	12/1969	Nason et al.	220/15

Primary Examiner—M. Henson Wood, Jr.
Assistant Examiner—Thomas C. Culp, Jr.
Attorney—Joseph B. Gardner

[57] **ABSTRACT**

A vessel for storing and transporting cryogenic fluids such as liquid hydrogen, nitrogen and helium. The vessel comprises inner and outer elongated containers supported one within another in coaxial circumjacent relation by support means that includes transverse support structure adjacent each end of the vessel to constrain the containers against transverse or radial displacements relative to each other. The inner and outer containers are constructed of materials having different coefficients of thermal expansion; the inner container being formed of a material having a high coefficient such as aluminum and the outer container being formed of material having a lower coefficient such as steel. The transverse support structure includes elements comprised of each such material, and the invention is particularly concerned with a means for uniting the dissimilar materials at their junction adjacent the ends of the inner container.

12 Claims, 7 Drawing Figures



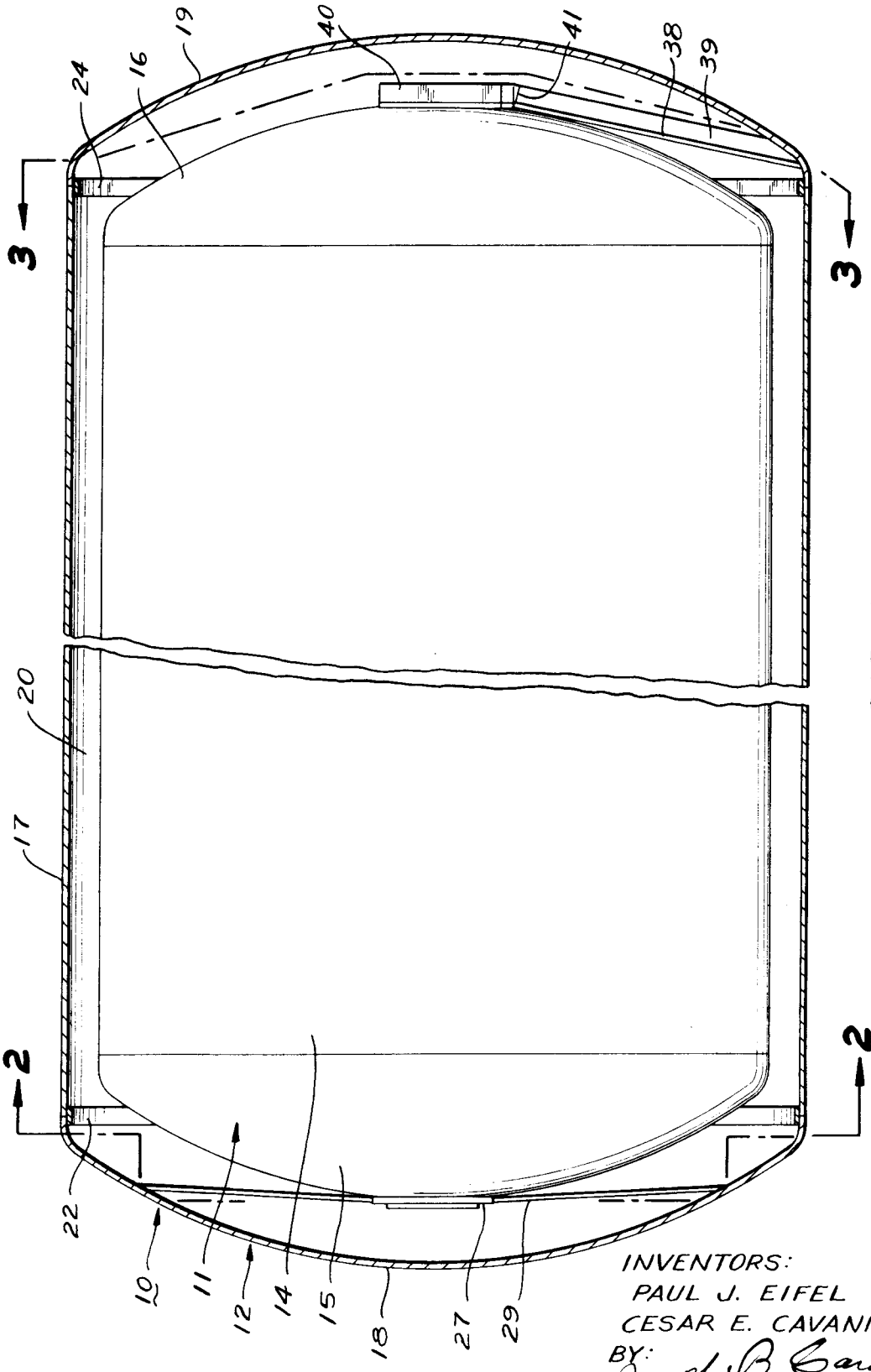


FIG. 1

INVENTORS:
PAUL J. EIFEL
CESAR E. CAVANNA
BY: Joseph B. Gardner
ATTORNEY

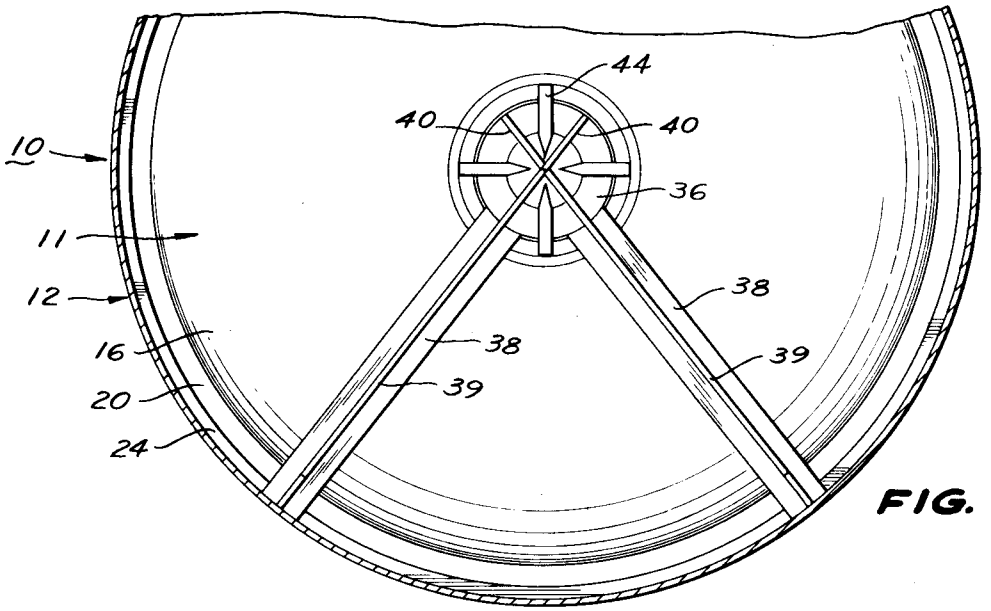


FIG. 3

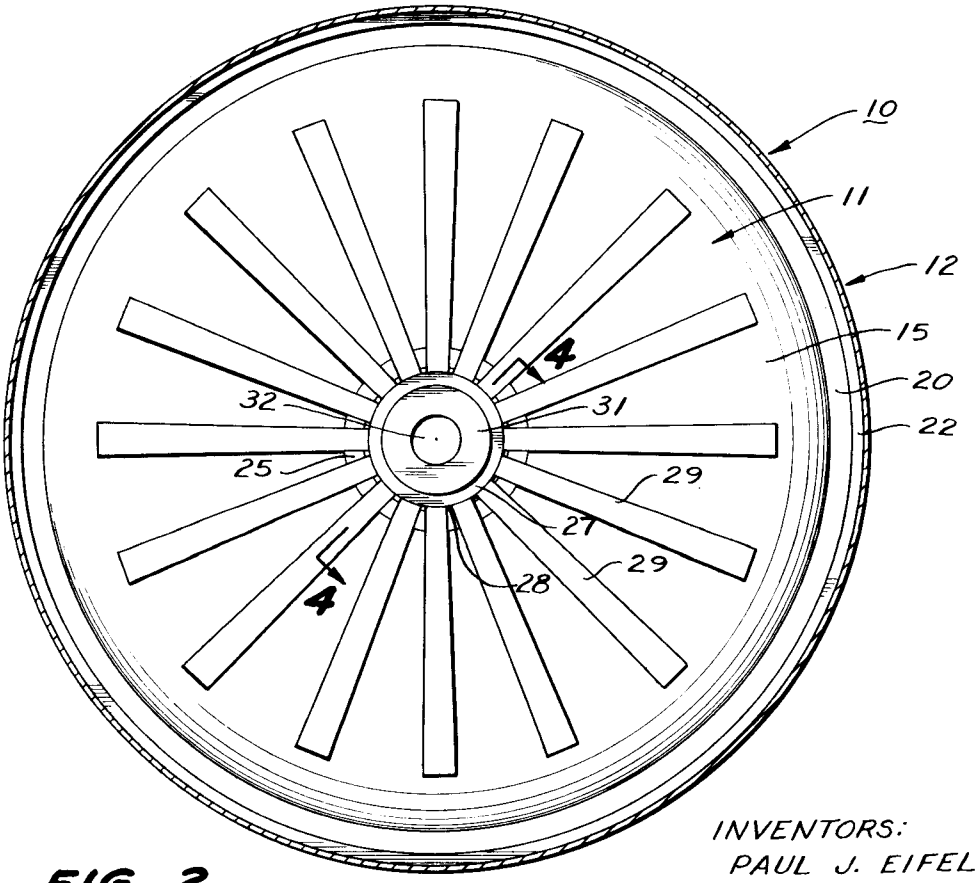


FIG. 2

INVENTORS:
PAUL J. EIFEL
CESAR E. CAVANNA
BY: Joseph B. Gardner
ATTORNEY

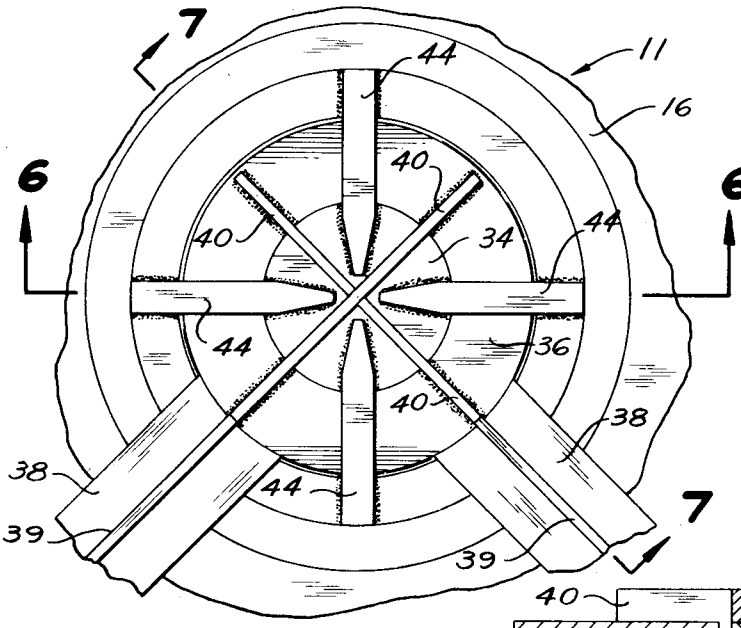


FIG. 5

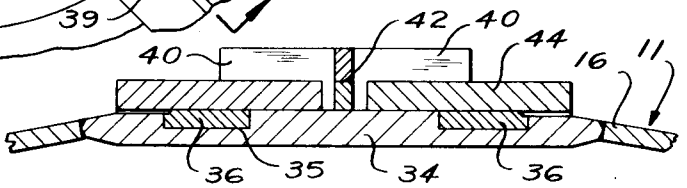


FIG. 6

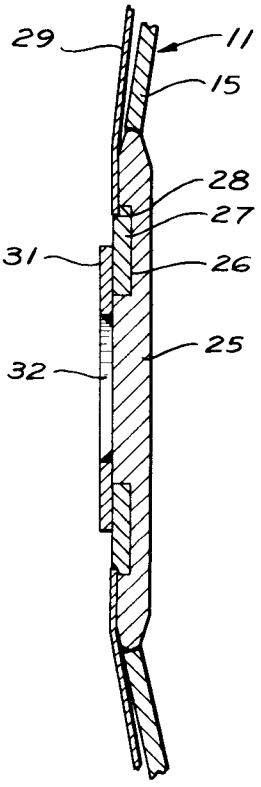


FIG. 4

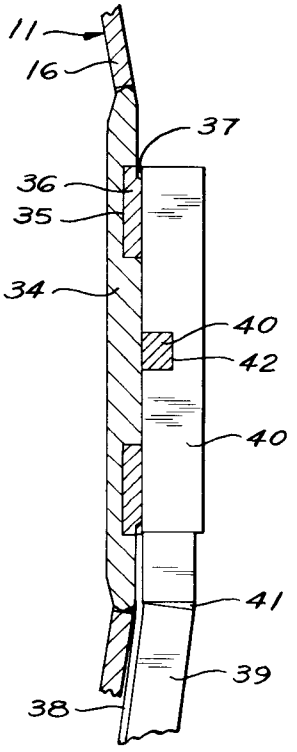


FIG. 7

INVENTORS:
PAUL J. EIFEL
CESAR E. CAVANNA
BY: Joseph B. Sindner
ATTORNEY

CRYOGENIC STORAGE VESSEL CONSTRUCTED OF DISSIMILAR MATERIALS

This invention relates to a vessel for storing and transporting cryogenic fluids such as hydrogen, nitrogen, and helium either in their liquid phase or as a cold gas so that large quantities of such fluid can be handled economically and have maximum refrigerative properties when used.

With liquids of this type, it is desirable to store and transport the same at very low temperatures, preferably at temperatures sufficiently low to maintain the fluids in their liquid phase, and because of the very low temperatures required (the critical temperature for helium, for example, being slightly less than −450° F at which temperature liquefaction can be effected at approximately 2.26 atmospheres), it will be apparent that very special equipment must be provided. Stated generally, the vessels used for storing and transporting cryogenic fluids are large Dewar vessels constituting an inner container for the fluid and an outer insulating shell or jacket enclosing the same. Since such storage vessels necessarily have considerable size and capacity, typically handling from 10,000 to 20,000 gallons of a cryogenic fluid, they must be quite strong and sturdy structures in order to support the heavy weights of such large quantities of fluid and to accommodate the rather large dymanic loads imparted thereto during transport of such vessel.

It will be apparent that a storage vessel of such large capacity is necessarily quite heavy, and it will be most advantageous to reduce the weight thereof as much as possible to maximize the ratio of payload to tare weight when the vessel is transported. In this reference, if two containers having the same pressure ratings are respectively made of aluminum and steel, the aluminum container is found to weigh significantly less. Therefore, it is desirable as a weight-saving technique to use aluminum for construction of the inner fluid-receiving container of a cryogenic storage vessel. However, since greater mechanical strength is required for the outer container and interconnecting support structure than is ordinarily available from aluminum, higher strength materials such as carbon steel and stainless steel are used to advantage therefor. Utilizing materials such as aluminum and steels having disparate thermal characteristics in a single cryogenic vessel creates problems of union therebetween since such dissimilar materials must be united in a manner defining a strong interconnection at their juncture.

In view of the foregoing, an object of the present invention is to provide an improved weight-reduced cryogenic storage vessel comprising inner and outer containers supported one within another and constructed of different materials having certain advantageous properties but also having the undesirable characteristic of not being susceptable of joinder one to another by welding as, for example, an inner container constructed of aluminum and an outer container constructed of steel.

Additional objects, among others, of the present invention are in the provision of an improved cryogenic storage vessel of the character described that is of reduced weight but has great strength; that is formed of dissimilar materials respectively providing light weight and considerable mechanical strength; that has radial or transverse support structure at each end of the vessel

which includes a plurality of angularly spaced and radially extending spokes interconnecting the inner and outer containers, the spokes being constructed of high strength stainless steel connected at their outer ends to the outer steel container and secured at their inner ends to a stainless steel mounting plate united with an aluminum pad forming a part of the end wall of the inner aluminum container; and in which the mounting plate and pad are thermally united or bonded in a manner utlizing the different coefficients of thermal expansion thereof so that one grips the other with a thermally-induced compressive stress both at ordinary ambient temperatures and at the very low cryogenic temperatures.

Additional objects and advantages of the invention, especially as concerns particular features and details thereof, will become apparent as the specification continues.

An embodiment of the invention is illustrated in the accompanying drawings, in which:

FIG. 1 is a longitudinal sectional view, partly in elevation, of a cryogenic storage vessel embodying the invention;

FIG. 2 is a transverse sectional view of the flexible end of the storage vessel taken along the line 2—2 of FIG. 1;

FIG. 3 is a broken transverse sectional view of the fixed end of the storage vessel taken along the line 3—3 of FIG. 1;

FIG. 4 is an enlarged, broken radial sectional view taken along the line 4—4 of FIG. 2;

FIG. 5 is an enlarged, broken front view in elevation of the center portion of the structural assemblage shown in FIG. 3;

FIG. 6 is a broken radial sectional view taken along the line 6—6 of FIG. 5; and

FIG. 7 is a broken radial sectional view taken along the line 7—7 of FIG. 5.

The storage vessel illustrated in FIG. 1 is intended for use with cryogenic fluids that are necessarily stored and transported at very low temperatures in an effort to maintain the fluid in an essentially liquid phase. In any case, the storage temperatures are very low and considering helium as an example, the critical temperature thereof is slightly below −450° F at which temperature liquefaction can be effected at approximately 2.26 atmospheres.

The vessel generally illustrated in FIG. 1 is designated in its entirety with the numeral 10, and it may be used either for stationary storage or for mobile storage and transport. In the latter case, the vessel 10 will be equipped with wheels, not shown, that enable it to be rollingly transported by any suitable truck tractor as disclosed in the copending patent application of Cesar E. Cavanna, Ser. No. 817,986, Filed Apr. 21, 1969. Although the size and capacity of any particular vessel 10 may vary considerably, by way of indicating a general order of magnitude of typical vessels of this type, the overall length of one wheel-equipped vessel intended to transport approximately 10,500 gallons of liquid helium is about 40 feet and it has an outer diameter of about 8.0 feet.

The vessel 10 includes a plurality of axially elongated containers disposed one within another in substantially concentric relation, but it should be noted that exact

coaxiality is not a requisit although in the usual case the containers will be coaxially supported one within another in radially spaced relation. As shown in FIG. 1, the particular vessel 10 illustrated includes two containers, the first being an inner storage container 11, and the second an outer container or jacket 12 enclosing the inner container 11 therewithin. The inner storage container 11 is adapted to receive and store the cryogenic fluid therewithin, and a fluid flow system is necessarily associated therewith to permit such fluid to be supplied thereto and removed therefrom. For convenience of illustration and because it forms no part of the present invention, the filler and discharge systems for the container 11 have been omitted, but should details concerning the same be desired, reference may be made to the copending patent applications of Robert S. Hampton, Ser. No. 808,765, Filed Mar. 20, 1969 and of Hampton et al., Ser. No. 42,052, Filed June 1, 1970.

The vessel 10 is generally similar from end-to-end thereof, but there is some departure therebetween as concerns the support means interconnecting the two containers 11 and 12. In this respect, a functional difference between the two ends exists, and the left-hand end of the vessel, as it is shown in FIG. 1, may be referred to as the "flexible end" and the right-hand end as the "fixed end." As a result of these functional differences, the structural components respectively associated with the opposite ends of the vessel differ somewhat, as will become apparent hereinafter.

The inner container 11 includes a hollow cylindrical side wall or sleeve 14 respectively equipped at the ends thereof with bulk heads 15 and 16 which are outwardly convex or dish shaped and are welded or otherwise rigidly and sealingly related to the side wall 14. The entire container 11 is formed of a light weight material to reduce its weight, and a suitable material therefor is aluminum.

Similarly, the outer container or jacket 12 is formed of an elongated hollow cylindrical sleeve 17 having a greater diameter than that of the sleeve 14 so as to be spaced radially outwardly therefrom, and it is also of greater length. Adjacent its opposite ends, the sleeve 17 is equipped with end closures or bulk heads 18 and 19 that are each outwardly convex or dish shaped and approximate the curvature of the respectively adjacent bulk heads 15 and 16 of the inner container 11. The bulk heads 18 and 19 are welded or otherwise rigidly and sealingly connected to the sleeve 17, and together therewith define a compartment 20 about the inner container 11. The outer container 12 is made of a high strength material, and a typical material suitable for fabrication of the outer container 12 is steel, ordinary carbon steel being a specific example thereof.

Evidently, the containers 11 and 12 require support means interconnecting the same to enforce the spaced apart relationship shown and described, and such support means includes radial or transverse support structure preventing transverse displacements of one container relative to the other, and further includes longitudinal support structure preventing bodily displacements of one container relative to the other in axial directions. The longitudinal support structure employed forms no part of the present invention and is omitted for purposes of simplifying the present disclosure. A longitudinal support system that may be used to interconnect the two containers 11 and 12 is disclosed the aforementioned Hampton et al., application Ser. No. 42,052 to which reference can be made should details concerning this system be desired. The outer container 12 may be strengthened by reinforcing ribs (not shown), and annular reinforcing bands 22 and 24 may underlie the junctures of the sleeve 17 with the respective bulk heads 18 and 19 so as to facilitate and strengthen the welded interconnection therebetween.

The support structure used at the flexible end of the vessel 10 will first be described with reference being made in particular to FIGS. 1, 2 and 4 of the drawings. As shown in these figures, the bulk head 15 is provided centrally with a pad or mounting plate 25 rigidly anchored thereto. In the form shown, the mounting plate 25 is a separate component seated within an opening provided therefor centrally in the bulk head 15 and welded thereto. The mounting plate 25 is greater in cross section than the remainder of the bulk head 15, and may have a thickness about twice the cross section thereof. Along its outer surface, the pad 25 is provided with an annular channel or recess 26 dimensioned to snugly seat an annulus or ring-shaped mounting plate 27 therein which is rigidly attached to the pad 25, in a manner described hereinafter.

The mounting plate 27 has an offset step or circumferential groove 28 formed along the outer circumferential edge thereof and into which seat the inner ends of a plurality of spokes or arms 29. The spokes 29 are welded to the mounting plate 27 and extend outwardly therefrom in angularly spaced relation that, in the particular configuration shown, are radially oriented with respect to the center of the mounting plate 27 and to the longitudinal axis of the vessel 10. At their outer ends, each of the spokes 29 is fixedly secured to the bulk head 18 of the outer container 11, as explained in detail in the aforementioned application Ser. No. 42,052

Confining means in the form of an annular ring or plate 31 is rigidly secured to the pad 25 along the outer surface thereof, and it is dimensioned to overlie a portion of the mounting plate 27 so as to insure confinement thereof within the channel 26. Both the pad 25 and confining ring 31 are aluminum so that the two may be united in a weld joint, as shown along the inner circumferential edge portion of the ring 31 bordering the central hole or opening 32 defined therein. Analogously, the mounting plate 27 and spokes 29 are formed of stainless steel so that they may be united by welding along the circumferential groove 28 of the plate 27 seating the spokes therein. The inner corners of the annular channel 26 are relieved to reduce stress concentrations.

By way of indicating a general order of magnitude of the components comprised by the mounting structure at the flexible end of the vessel 10, in one particular embodiment of the invention the pad 25 has a diameter approximating 22 inches, the mounting plate 27 has an inner diameter slightly less than 8 inches and an outer diameter slightly greater than 15 inches, and the confining ring 31 has inner and outer diameters of about 5 and 12 inches, respectively.

The support structure used at the fixed end of the vessel 10 will now be described with reference being

made in particular to FIGS. 1, 3, and 5 through 7 of the drawings. As illustrated in these figures, the bulk head 16 is provided centrally with a pad or mounting plate 34 rigidly anchored thereto. In the from shown, the mounting plate 34 is a separate component seated within an opening in the bulk head; and the mounting plate 34 is greater in cross section, about twice the cross section thereof. Along its outer surface, the pad 34 is provided with an annular channel or recess 35 dimensioned to snugly seat an annulus or ring-shaped mounting plate 36 therein which is rigidly attached to the pad 34, in a manner described hereinafter.

The mounting plate 36 is relieved slightly at the outer corner portion thereof by a circumferential groove 37 and into which seat the inner ends of a pair of angularly spaced spokes of generally T-shaped configuration each comprising a flat flange or cross bar 38 and a relatively narrow web or stem 39 disposed at right angles with respect thereto. The flat flanges 38 of the spokes are welded to the mounting plate 36 and extend radially outwardly therefrom, and are fixedly secured at their outer ends to the bulk head 19 of the outer container 11. At their inner ends, the spokes 38, 39 are equipped with extensions 40 effectively constituting continuations of the webs 39, being welded or otherwise rigidly related thereto, and extending across the mounting plate 36 in intersecting relation. The extensions 40 are angularly disposed relative to the main portions of the spokes 38, 39 (as shown best in FIG. 1), and wedge-shaped fillers 41 are used to accommodate the relative angular dispositions thereof. The extensions 40 have a somewhat greater width than the webs 39 to permit provisions of interfitting notches, as shown at 42 in FIGS. 6 and 7, defining the intersection of the extensions without significant loss of strength.

Confining means in the form of a plurality of angularly spaced ribs 44 are rigidly secured to the pad 34 along the outer surface thereof, and the ribs are dimensioned to overlie a portion of the mounting plate 36 to insure confinement thereof within the channel 35. In the form shown, there are four ribs 44 angularly spaced from each other at 90 degree intervals respectively interposed between adjacent segments of the web extensions 40. Both the pad 34 and confining ribs 44 are aluminum so that they may be united in weld joints, as shown in FIG. 5 along the marginal edge portions of the ribs where contiguous with the pad. Analogously, the mounting plate 36 and spokes 38, 39 together with the extensions 40 thereof are formed of stainless steel and may be united by welding along the circumferential groove 37 of the plate 36 and along the edge portions of the extensions 40 where they overlie the mounting plate 36, as illustrated in FIG. 5. As in the case of the channel 26, the inner corners of the annular channel 35 may be relieved to reduce stress concentrations. The order of magnitude of the components comprised by the mounting structure at the fixed end of the vessel 10 is substantially the same as that at the flexible end thereof and for this reason, will not be specifically set forth.

In contrast to the aforementioned spokes 29 at the flexible end of the vessel 10 which are all relatively thin, generally planar components, the T-shaped spokes 38, 39 at the fixed end of the vessel provide considerable resistance to flexure along the longitudinal axis of the vessel because of the presence of the web 39 of each spoke which is disposed at right angles to the flange 38 thereof. Each of the spokes 38, 39 also provides resistance to transverse flexure because in such direction, the flanges 38 lie in the planes of such tendency toward flexure and serve as beam webs to resist bending moments oriented in generally transverse directions. Accordingly, the spokes 38, 39 and components associated therewith establish a relatively rigid interconnection of the outer container or jacket 12 with the inner container 11. Such relatively rigid interconnection of the two containers at the fixed end of the vessel 10 is augmented by longitudinal support structure, not shown because it forms no part of the present invention, which constrains the containers against significant longitudinal or axial displacements relative to each other in contrast to the opposite end which permits and accommodates thermally induced relative longitudinal displacements of the containers.

The containers 11 and 12 will also be thermally insulated one from another to sharply restrict the rate of heat migration therebetween and, in conventional manner, the space 20 surrounding the inner container 11 will be evacuated or vacuumized and/or filed with one of the very effective modern insulations used extensively in the cryogenic field. Since such insulating techniques and the materials employed therefor are conventional and form no part of the present invention they are not further discussed.

As explained hereinbefore, the present invention is a realization of a vessel having the dual advantages of relatively light weight and mechanical strength, the inner container 11 being formed of light weight aluminum and the outer container 12 and support structure interconnecting the two being formed of ordinary carbon steel and stainless steel, respectively, having a much greater strength than aluminum. The combination of such materials which are not weldable to each other and have different coefficients of thermal expansion, requires junction of these dissimilar metals in a manner accommodating such differences and at the same time providing the strength necessary to carry the heavy weights defined by the liquid cryogenic fluids stores within the container 11 (for example, some 11,000 gallons in certain embodiments of the invention) and the large G-loadings to which the vessel 10 is subjected during transport. The transverse support structure at both the flexible and fixed ends of the vessel 10 provide this result and constitute a rigid unification or integration of the dissimilar materials (i.e., aluminum and stainless steel) which might be accomplished by various procedures including both rolling and explosive bonding techniques.

In the particular embodiment of the invention being considered, thermal integration of the dissimilar materials is employed, the different coefficients of thermal expansion being used to advantage. More particular, and considering the structural assemblage at the flexible end of the vessel illustrated in FIGS. 2 and 4, the stainless steel mounting plate or ring 27 has a smaller inner diameter than that of the channel or recess 26, and the outer diameter of the plate is also smaller than the outer diameter of the channel. The stainless steel ring plate 27 has the temperature thereof elevated relative to that of the aluminum pad 25 until

the ring expands sufficiently to permit it to seat by means of a press fit within the recess **26**, the inner diameter of the ring being somewhat larger at this time than the inner diameter of the recess. The outer diameter of the ring, however, remains somewhat less than that of the recess. As the ring **27** cools, it shrinks or contracts until it tightly grips the pad **25** along the edge thereof defining the inner boundry of the recess **26**. Although, stainless steel has a much greater strength than that of aluminum, the pad **25** is a thick, solid integer throughout the area against which compressive force is applied by the contracting ring **27** and, accordingly, there is little tendency for the aluminum to break or fracture under the magnitude of the compressive force applied thereto. Also, the aluminum pad **25** is sufficiently thick to resist flexural deformation as a response to the compressive force being applied thereto.

When the pad **25** and ring **26** are used in a vessel **10** within which a cryogenic fluid is stored, the very cold temperatures to which the inner vessel **11** is thereby subjected cause all of the components comprising a part of the vessel and those components associated therewith to contract. Since the coefficient of thermal contraction and expansion of aluminum is significantly greater than that of stainless steel, the pad **25** shrinks to a greater extent than the ring **27** and causes the edge of the pad defining the outer boundry of the recess **26** to shrink into tight compressive engagement with the outer circumferential edge of the ring **27**, thereby causing the pad **25** to grip the ring **27** with a unifying compressive force.

At the same time, the inner circumference of the ring **27** remains in engagement with the boundry of the recess **26** although the degree of engagement therebetween is substantially reduced because of the shrinkage differential as between the aluminum **25** and stainless steel ring **27**. Accordingly, at all times a thermally derived compressive force integrates or unifies the pad **25** and ring **27** along the inner circumferential edge of the ring when these components are at or near normal ambient temperatures, and along the outer circumferential edge of the ring (and to some extent along the inner circumferential edge thereof) when the vessel **11** is subjected to the low temperature values of cryogenic fluids.

By way of amplifying the preceding discussion, in one particular embodiment of the invention the aluminum pad **25** has a recess **26** providing an outer diameter approximating 15 inches and an inner diameter approximating 8 inches held to tolerances of less than a few thousandths of an inch in each instance. The ring **27** in this embodiment of the invention has outer and inner diameters slightly smaller, respectively, than those of the recess **26** and held to the same close tolerances. For purposes of seating the ring **27** in the recess **26**, the temperature of the ring is elevated relative to the pad **25** but not sufficiently to cause the ring **27** to drop freely into the recess **26**, a press fit being required to seat the ring therein. A relatively firm engagement between the inner boundry of the recess **26** and circumjacent inner edge of the ring **27** obtains even with the vessel **11** at the reduced cryogenic temperatures to which it is ordinarily subjected, but reliance need not be placed thereon for maintenance of the ring within the recess.

Precisely the same interrelationships pertain as respects the aluminum pad **34** and stainless steel ring **36** located at the fixed end of the vessel **10**. In the case of the pad **25** and ring **27**, a confining ring **31** welded to the pad **25** is used to provide further confinement of the mounting plate **27** within the recess **26**; whereas in the case of the pad **34** and ring **36**, a plurality of angularly spaced confining ribs **44** are used for this same purpose. The confining ribs **44** are welded to the pad **34** along each side of the mounting plate **36**, as hereinbefore explained. In the case of the mounting plate **27**, the spokes **29** are welded thereto and, similarly, the spokes **38, 39** are welded to mounting plate **36**.

It will be evident from the foregoing that the described arrangement enables a cryogenic storage vessel to be provided which has both the superior weight advantage of aluminum and the superior strength characteristics of stainless steel, and at the same time accommodates the significantly different coefficients of linear expansion (13×10^{-6} per degree F for aluminum as against 6.1×10^{-6} per degree F for steel) over the very extended range of temperatures to which the vessel is subjected varying from usual ambient atmospheric temperatures to as low as about −450° F when the cryogenic fluid constitutes helium.

While in the foregoing specification an embodiment of the invention has been set forth in considerable detail for purposes of making a complete disclosure thereof, it will be apparent to those skilled in the art that numerous changes may be made in such details without departing from the spirit and principles of the invention.

What is claimed is:

1. In a vessel for cryogenic fluids and the like provided with a pair of longitudinally extending containers supported one within another in space apart relation, apparatus for structurally interconnecting the inner container of said vessel with the outer container thereof, comprising: a pad fixedly related to an end wall of said inner container adjacent the longitudinal center thereof; a mounting plate rigidly united with said pad; and a plurality of outwardly extending spokes fixedly secured at their inner ends to said mounting plate and attached at their outer ends to said outer container; said inner container and pad being formed of lightweight material and said outer container, spokes, and mounting plate being formed of a material having superior strength characteristics relative to said inner container and being non-weldable thereto.

2. The vessel of claim **1** and further comprising an additional pad, mounting plate and plurality of spokes interrelated one with another and with said inner and outer containers as aforesaid at the opposite end of said vessel, the spokes at one end vessel being flexible to accommodate thermally induced relative expansion and contraction of said containers and being stiff at the opposite end of said vessel to fixedly relate said inner and outer containers thereat.

3. The vessel of claim **2** in which each of said pads comprises a unitary part of the associated end wall of said inner container; and in which said inner container and pads are aluminum, said outer container is carbon steel, and said spokes and mounting plates are stainless steel.

4. The vessel of claim **1** in which said pad has an annular channel in the outer surface thereof, and in which

said mounting plate is ring-shaped and is seated within said annular channel.

5. The vessel of claim 4 in which said inner container and pad and said outer container, spokes and mounting plate are formed of materials having different coefficients of linear expansion with the coefficient of said inner container and pad being substantially greater than that of said outer container, spokes, and mounting plate, the inner and outer diameters of said annular channel and of said ring-shaped mounting plate being held to relatively close tolerances, and the inner diameter of said mounting plate being smaller than the inner diameter of said annular channel at ordinary ambient temperatures, said mounting plate being thermally fitted at least in part within said channel so as to compressively grip the inner circumferential edge of said channel at ordinary ambient temperatures and be compressively gripped by the circumjacent edge of said channel at cryogenic temperatures.

6. The vessel of claim 5 and further comprising an additional pad, mounting plate and plurality of spokes interrelated one with another and with said inner and outer containers as aforesaid at the opposite end of said vessel, the spokes at one end of said vessel being flexible to accommodate thermally induced relative expansion and contraction of said containers and being stiff at the opposite end of said vessel to fixedly relate said inner and outer containers thereat.

7. The vessel of claim 5 and further comprising confining means secured to said pad in overlying relation with said mounting plate to insure confinement thereof within said channel.

8. The vessel of claim 7 in which said confining means is a ring secured to said pad and at least partially overlying said mounting plate.

9. The vessel of claim 7 in which said confining means comprises a plurality of angularly spaced ribs each secured to said pad and overlying said mounting plate throughout a restricted area thereof.

10. The vessel of claim 7 and further comprising an additional pad, mounting plate and plurality of spokes interrelated one with another and with said inner and outer containers as aforesaid at the opposite end of said vessel, the spokes at one end said vessel being flexible to accommodate thermally induced relative expansion and contraction of said vessel to fixedly relate said inner and outer containers thereat.

11. The vessel of claim 10 in which said confining means comprises at the flexible end of said vessel a ring secured to said pad and at least partially overlying said mounting plate, and comprises at the fixed end of said vessel a plurality of angularly spaced ribs each secured to the associated pad and overlying the associated mounting plate throughout a restricted area thereof.

12. The vessel of claim 11 in which each of said pads comprises a unitary part of the associated end wall of said inner container; and in which said inner container and pads are aluminum, said outer container is carbon steel, and said mounting plates are stainless steel; said confining ring and confining ribs being welded to the respectively associated pads and said spokes being welded to the respectively associated mounting plates.

* * * * *