Sept. 21, 1965 R. P. SKINNER ETAL 3,207,354

DOUBLE-WALLED CONTAINER

Original Filed Oct. 6, 1958 3 Sheets-Sheet 1

Fig. 1.

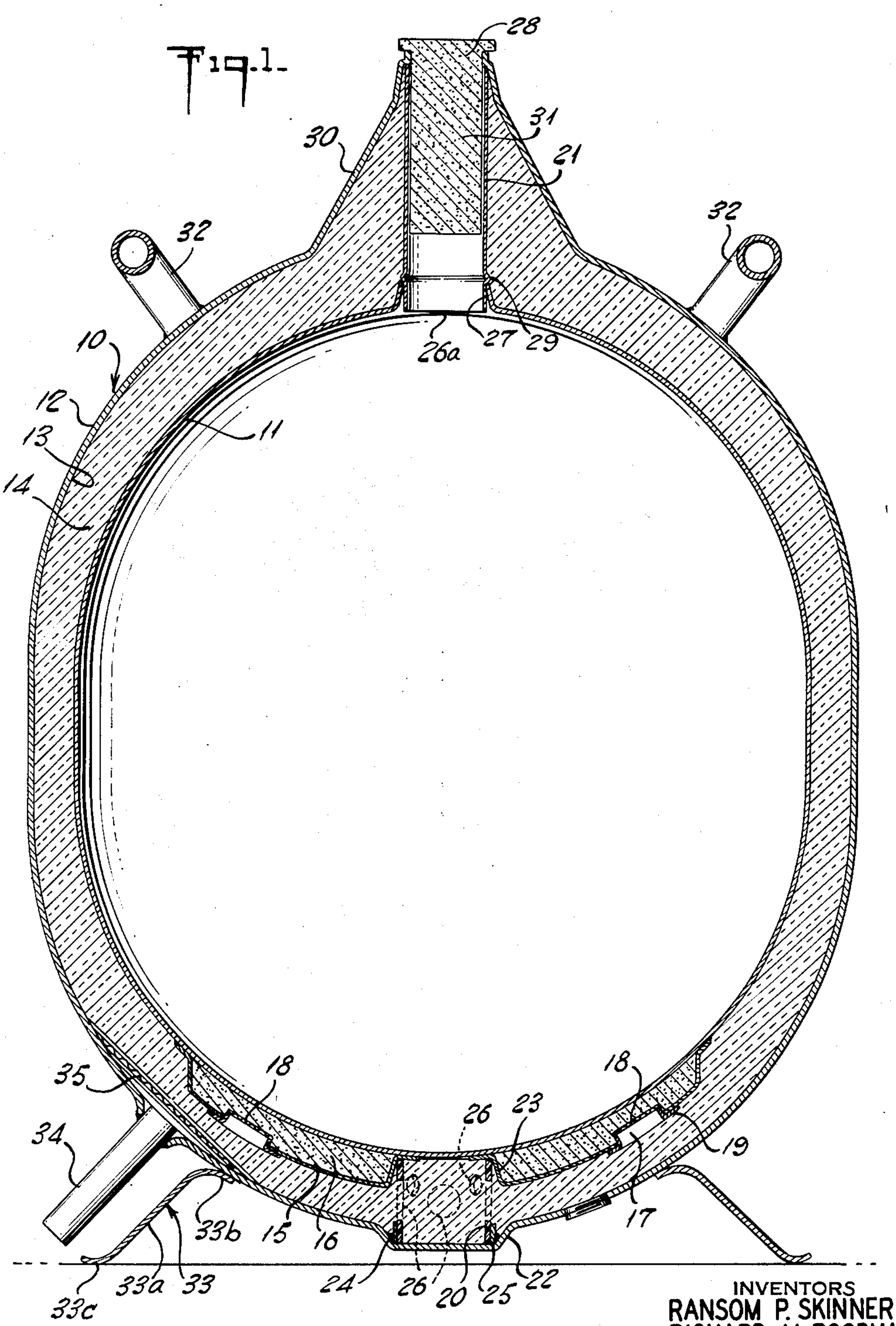


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Fig. 2.

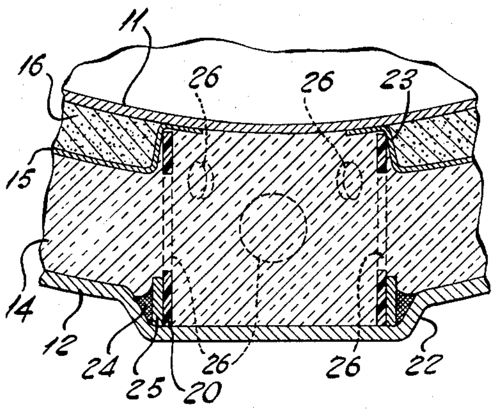



Fig. 3.

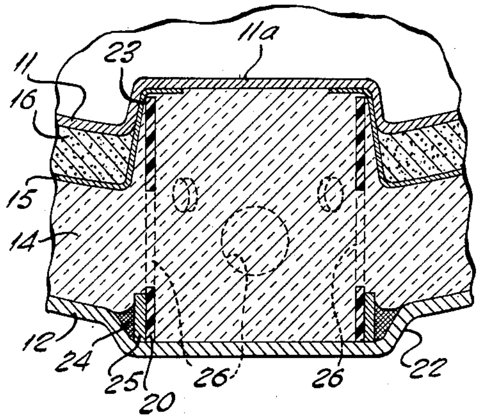
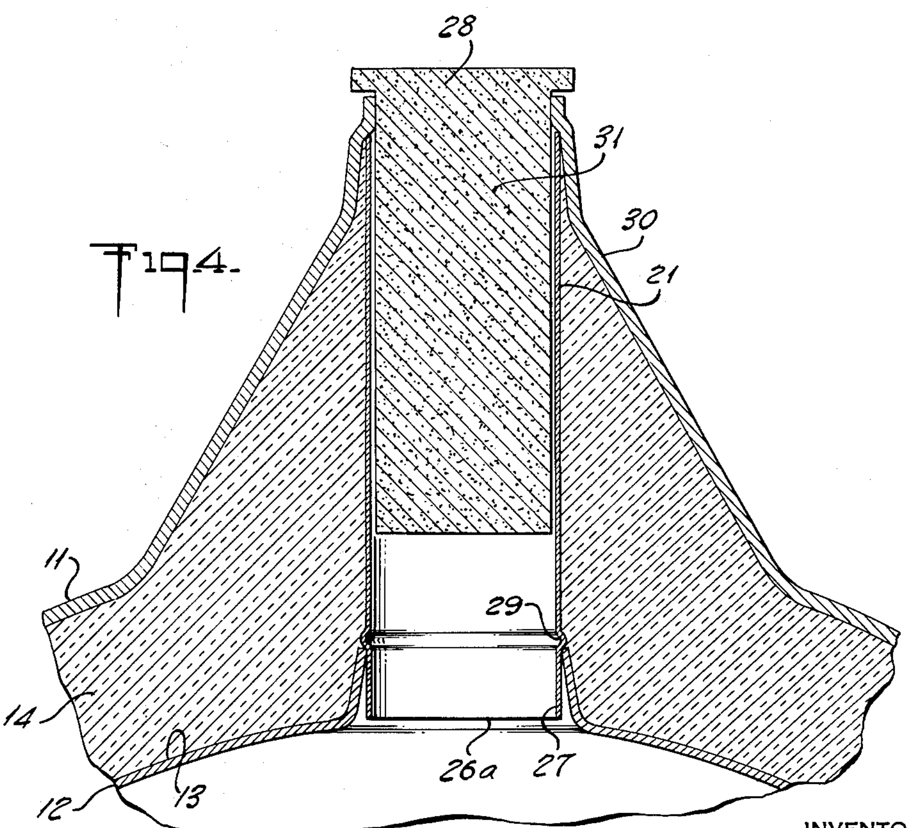



Fig. 4.

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Original Filed Oct. 6, 1958 3 Sheets-Sheet 3

Fig. 5.

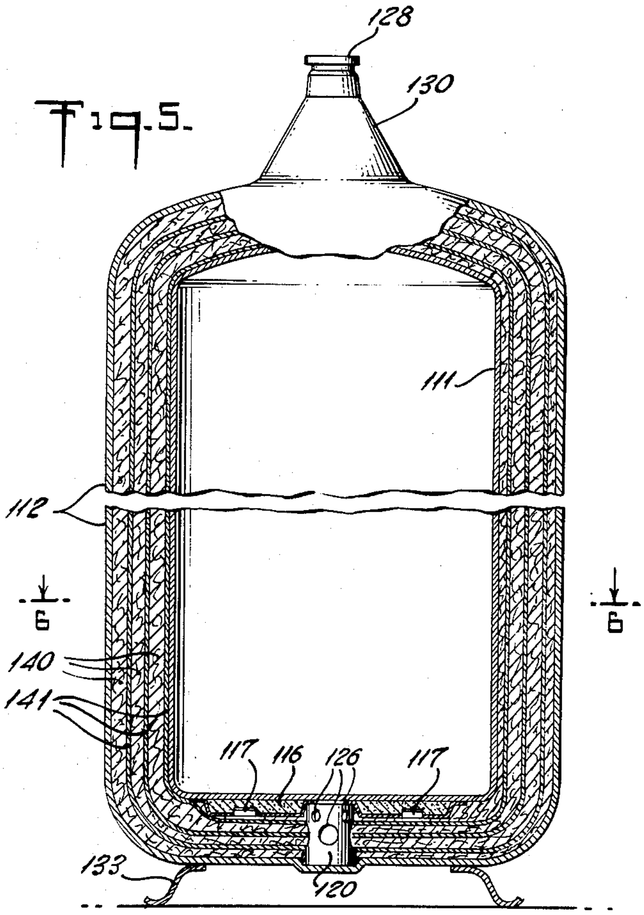
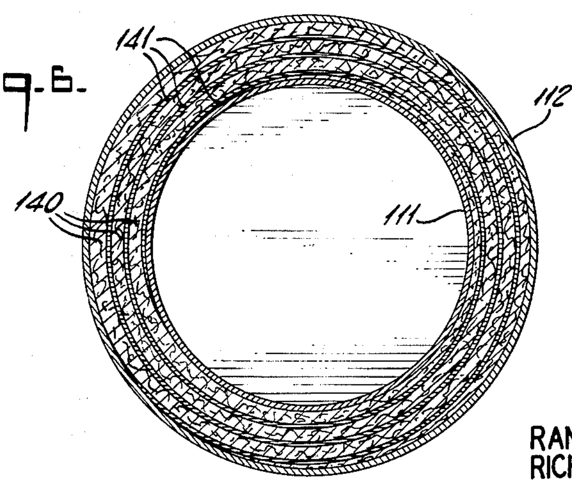



Fig. 6.

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United States Patent Office

3,207,354

Patented Sept. 21, 1965





# 3,207,354
# DOUBLE-WALLED CONTAINER

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Continuation of application Ser. No. 765,382, Oct. 6, 1958. This application Feb. 9, 1962, Ser. No. 181,833
8 Claims. (Cl. 220—15)

This invention relates to a double-walled container for holding liquefied gases for extended periods, and more particularly to portable containers for storing small quantities of low-boiling liquefied gases such as liquid oxygen and liquid nitrogen.

This application is a continuation of co-pending application Serial No. 765,382, filed October 6, 1958 and now abandoned.

Low boiling liquefied gases having boiling points below about 233° K. are widely used in industrial laboratories and other locations primarily as low temperature refrigerants. These liquefied gases are conveniently handled in quantities of less than about 50 liters since liquid containers of this capacity can be easily moved. Low boiling liquefied gas containers are usually constructed with double walls, the space between the inner and outer walls being provided to insulate the liquid in the inner vessel from the atmospheric heat. This is necessary because such liquefied gases are stored at very low temperatures, e.g., −183° C. for liquid oxygen, and without high quality insulation the liquid would vaporize very quickly.

Accordingly, industry has employed double-walled straight-vacuum insulated polished copper containers for many years to store small quantities of liquefied gases. This double-walled container was mounted in an outer protective shell and was supported solely in suspension by a spring mounting between its upper neck and the protective outer shell, the spring mounting acting as a shock absorber. These so-called Dewar containers were notoriously fragile in that the innermost container often ruptured at its narrow neck portion due to rough handling. Another disadvantage of such containers was that they were relatively large and bulky in comparison with the quantity of liquefied gas stored. For example, one commonly used 25-liter Dewar type container weighs 49 lbs. empty and 112 lbs. when full of liquid oxygen. A still further disadvantage of the heretofore proposed containers was the relatively small outlet for discharging the liquid contents. For example, the pouring spout for the aforementioned 25 liter container was only about ⅝ inch in diameter so as to reduce heat leak into the container during storage periods. Unfortunately this small outlet usually resulted in an uneven discharge of liquid when the container was inverted for pouring. Also, small samples could not be readily placed inside the container for cooling nor could small quantities of liquid be removed by a dipper.

A principal object of the invention is to provide an improved liquefied gas storage container having the characteristics of light weight, minimum heat leak, compactness, durability, and a relatively large outlet without correspondingly increasing the heat inleak from the atmosphere.

These and other objects and advantages of the invention will become apparent from the following description and the accompanying drawings in which:

FIGURE 1 is a view, mainly in vertical cross-section, of an exemplary double-walled elongated spheroidal container construction embodying the principles of the invention;

FIGURE 2 is a view on an enlarged scale of a longitudinal section of the bottom lateral support tube assembly employed in the container of FIGURE 1;

FIGURE 3 is a view on an enlarged scale of a longitudinal section of an alternative bottom lateral support tube assembly which may be employed in the container of FIGURE 1;

FIGURE 4 is a view on an enlarged scale of a longitudinal section of the liquefied gas inlet-outlet neck tube assembly employed in the container of FIGURE 1;

FIGURE 5 is a view of a longitudinal cross-section of an exemplary double-walled cylindrical container embodying another form of the invention; and

FIGURE 6 is a view of a horizontal cross-section taken along the line **6—6** of FIGURE 5.

In the drawings similar elements in the several figures are designated by similar reference characters.

In accordance with one embodiment of the present invention, a portable container for storing liquefied gas having a boiling point below 233° K. is provided which includes an inner vessel for holding a liquefied gas body and an outer casing enclosing and separating the inner vessel from the atmosphere, the inner vessel and outer casing preferably being formed from aluminum or aluminum alloy. The inner vessel may be constructed of other materials such as stainless steel, if so desired, but this will increase total container weight somewhat. A space under a vacuum pressure is provided between the inner vessel and the outer casing which contains an opacified insulating material and a gas adsorbent material communicating with the opacified insulation to maintain the space under a vacuum. The inner vessel is supported primarily by a single hollow elongated neck tube having a first open end communicating with the liquefied gas body through a relatively large access opening in the inner vessel. This neck tube bears substantially the entire vertical load of such vessel. The opposite or second end of the neck tube is open and communicates with the atmosphere for filling and emptying of the inner vessel. Lateral support of the lower portion of the inner vessel is obtained by a low thermal conductivity centering element fixedly mounted against the inside wall of the outer casing and positioned to slidably and telescopically engage the lower portion of the inner vessel outer wall. A low conductive plug is preferably receivable in and substantially fills the second open end of the hollow neck tube so as to facilitate upward flow of liquefied gas vapors in sustained contact with the neck tube surface thereby absorbing downwardly conducting heat. In this manner the sensible refrigeration of the vapor may be recovered and the net heat conducting characteristic of the neck tube reduced.

The term "vacuum" as used hereinafter is intended to apply to sub-atmospheric pressure conditions not substantially greater than 5,000 microns of mercury, and preferably below 500 microns of mercury absolute.

The term "opacified insulation" as used herein refers to a two-component insulating system comprising a low heat conductive, radiation-permeable material and a radiant heat impervious material which is capable of reducing the passage of infrared radiation rays without significantly increasing the thermal conductivity of the insulating system. Also, the term "radiant heat barrier" as used herein refers to radiation opaque or radiant heat energy impervious materials which reduce the penetration of infrared heat rays through the insulating system either by radiant heat reflection, radiant heat absorption or both. As defined, opacified insulation includes a mixture of finely divided low-conductive particles which substantially impede heat inleak by conduction and yield to heat passage by radiation, and finely divided radiant heat impervious bodies having a relatively high thermal conductivity. As more fully described and claimed in copending U.S. Serial No. 580,897, filed April 26, 1956, in the name of L. C. Matsch and A. W. Francis, the low conductive particles may be selected from the group consisting of silica, perlite, alumina, magnesia, and carbon black, and the radiant heat impervious bodies are preferably either aluminum or copper, although copper paint pigments, alumina paint pigments, magnesium oxide, zinc oxide, iron oxide, titanium give satisfactory results. Also, these bodies usually in the form of flakes or powder, preferably constitute between 1% and 80% of the total weight of the insulation.

The opacified insulation may also take the form of the combination of a low heat conductive material and a multiplicity of spaced radiation-impervious barriers. As more fully described and claimed in copending U.S. Serial No. 597,947, filed July 16, 1956, now Patent No. 3,007,596, granted November 7, 1961, in the name of L. C. Matsch, the low heat conductive material may be the previously listed powderous materials or alternatively a fiber insulation which may be produced in sheet form. Examples of the latter include a filamentary glass material such as glass wool and fiber glass, preferably having fiber diameters of less than about 50 microns. Also such fibrous materials preferably have a fiber orientation substantially perpendicular to the direction of heat flow across the insulation space. The spaced radiation-impervious barriers may comprise either a metal, metal oxide, or metal coated material, such as aluminum coated plastic film, or other radiation reflective or radiation adsorptive material or a suitable combination thereof. Radiation reflective materials comprising thin metal foils are particularly suited in the practice of the present invention, for example, reflective sheets of aluminum foil having a thickness between about 0.2 millimeter and 0.002 millimeter. Other radiation reflective materials which are susceptible of use in the practice of the invention are tin, silver, gold, copper, cadmium, or other metals. When fiber sheets are used as the low-conductive material, they may additionally serve as a support means for relatively fragile radiation impervious sheets. For example, an aluminum foil-fiber sheet insulation may be spirally wrapped around the inner liquefied gas holdings vessel with one end of the insulation wrapping in contact with the inner vessel, and the other end nearest the outer shell, or in actual contact therewith.

It would normally be concluded by one skilled in the art that the aforedescribed opacified insulation could not be economically used in portable liquefied gas containers because of the relatively heavy nature of such insulation. For example, a 50%–50% by weight mixture of silica powder with finely divided copper flakes has a bulk density of about 12 lbs. per cubic ft. However, it has been found that opacified insulation in combination with lightweight aluminum or aluminum alloy construction provides an improved liquefied gas portable container which is substantially lighter than heretofore used containers having the same storage volume and the same insulating efficiency. For example, a 25-liter container built in accordance with the preferred form of the present invention using aluminum or aluminum alloy material for both the inner vessel and outer casing weights about 20 lbs. empty as contrasted with a commonly used 25-liter container weighing 49 lbs. The present 25-liter container is even lighter than a prior art 15-liter container which weighs about 31 lbs. This remarkable result is attainable in part because the opacified insulations used in this invention have a relatively high insulating efficiency at vacuums poorer in quality than those required for vacuum-polished metal surface insulation. Because of this characteristic aluminum, which is known to produce porous welds, can be used instead of relatively heavier stainless steel or copper which can produce relatively leakproof metal joints.

The thermal insulating effectiveness of opacified insulation versus straight vacuum plus polished surfaces (no powder insulation) can be compared by using the example of two 1-square foot metal plates spaced ⅞ inch apart. When straight vacuum insulation was used, the inside surfaces of the plates were polished to an emissivity of 0.04. The outer plate was at room temperature (70° F.) and the inner plate was at liquid oxygen temperature (−297° F.). Under 50 microns pressure between the plates, an opacified insulation in this space consisting of 50%–50% by weight mixture of silica powder and finely divided copper metal flakes had a heat transmission of about 1.85 B.t.u./hr. In order for straight vacum insulation to have a comparable effectiveness, the pressure would have to be less than 0.01 micron. Under similar pressure conditions (50 microns) straight vacuum plus polished surfaces had a considerably higher heat transmission of about 43 B.t.u./hr. It can thus be seen that by using opacified insulation a highly efficient insulating system may be provided in aluminum liquefied gas portable containers even though the space between the inner vessel and the outer casing is maintained at a relatively poor vacuum because of the relatively porous nature of the aluminum-containing joints.

Even though the previously described opacified insulation is more effective than straight vacuum insulation at higher internal pressures (poorer vacuum), its effective thermal insulation life is extended if the pressure can be maintained at or below a desired level. An adsorbent, either in powder or pellet form, is used in the insulation space to remove by adsorption the gas entering through the porous aluminum-containing joints. This is an extremely important feature since no provision is made in the relatively small portable container of the present invention for re-evacuation of the insulating jacket. The adsorptive capacity of suitable adsorbents, such as natural and synthetic zeolites, silica gel and activated charcoal, generally rises with increased pressure. Therefore these adsorbents are more effective for removal of insulation jacket air leakage when opacified insulation is used than when straight vacuum is employed because of the higher vacuum space pressure involved. Furthermore, these adsorbents generally have higher adsorptive capacities at relatively lower temperatures. Consequently they are preferably mounted adjacent to the cold outer side of the inner vessel wall. Alternatively, the adsorbent may be randomly mixed in the opacified insulation. In particular, crystalline zeolitic molecular sieves having pores of at least about 5 Angstrom units in size, as disclosed in copending U.S. Serial No. 557,477, filed January 5, 1956, now Patent No. 2,900,800, granted August 25, 1959, in the name of P. E. Loveday, are preferred as the adsorbent since they have extremely high adsorptive capacity at the temperature and pressure conditions existing in the insulating jacket and are chemically inert toward any gases which might leak into the insulating jacket. Such zeolites may be either natural or synthetic. This novel combination of aluminum construction, opacified insulation and adsorbent thus facilitates construction of a liquefied gas portable container which is lighter in weight and has a longer effective life than the previously proposed container.

The present container is smaller in overall size than prior containers since it eliminates the outer protective shell around the double-walled liquid container. This protective shell was required on prior art portable liquefied gas containers to provide a means of supporting the vacuum insulated vessel as well as cushioning it from handling shocks.

In one embodiment the above described combination resulted in an elongated spherical container 22½ inches high and 15½ inches in diameter for a liquid capacity of 25 liters, as contrasted with a commonly used prior art container of similar capacity being 27¾ inches high and 16⅜ inches in diameter. The prior art has used smaller size containers such as the 15-liter capacity type more frequently than the 25-liter size since the former were lighter and easier to handle. This resulted in shorter allowable storage periods of the liquefied gases due to increased percentage loss rate of stored liquid due to heat leak in the smaller size vessels. The various container embodiments of the present invention provide a remarkable and unexpected advantage in that the reduced weight and size enable the employment of a 25-liter container with its increased storage life more conveniently than a prior art 15-liter container.

Another important advantage of the present invention is that a substantially larger access opening is provided than that used in similarly sized prior art containers. For example, one commonly employed 25-liter liquefied gas container has an access opening of about ⅝ inch diameter. In marked contrast, the access opening for a 25-liter container constructed according to the present invention is preferably about 1½ inches diameter. One skilled in the art would normally conclude that large access openings could not be employed without decreasing the insulating effectiveness of the entire container, since the heat leak will increase because a significant portion of an otherwise well insulated area is replaced by an uninsulated opening. The present invention overcomes these potential disadvantages by employing a low heat conductive plug receivable in and substantially filling the second open end of the hollow neck tube. In addition to being a heat insulator, the plug causes liquefied gas vapor, which is generated due to unavoidable heat leak, to flow upwardly close to and in contact with the walls of the neck tube. The vapor thereby absorbs any heat which would otherwise be conducted down the neck tube, and in doing so is warmed to essentially atmospheric temperature. In this manner the sensible refrigeration in the vapor or the liquefied gas which would otherwise be lost is recovered and the net heat conducting characteristic of the neck tube is effectively reduced. This permits the use of a relatively large diameter access opening and hollow neck tube without incurring serious losses from heat inleak, and thus results in minimum storage loss of liquefied gases as well as improved container handling characteristics. The larger neck tube allows easier charging of the container or pouring back unused liquid. It also enables the placement of small samples inside the container for cooling and the removal of small quantities of liquid by dipper.

Referring now more specifically to FIGS. 1–4, the portable liquefied gas container **10** includes a liquid holding inner vessel **11** which is preferably substantially spherical in form since the spherical shape provides the largest storage volume for a given weight of metal. For a given volume, a spherical shape also provides a minimum surface area for heat inleak. The inner vessel **11** is completely surrounded and separated from the atmosphere by outer casing **12**, both containers being preferably fabricated from aluminum or aluminum alloy in order to take advantage of its lightweight characteristic. The low density of aluminum especially allows a relatively thick outer shell to be used which has more resistance to handling abuse than would a relatively thin shell of equivalent weight fabricated from denser material. Space **13** under a vacuum separates the outer wall of the inner vessel **11** from the inner wall of the outer casing **12**, and is filled with the previously described opacified insulation **14** which may be a mixture of finely divided low conductive particles and radiant heat impervious bodies having a relatively high thermal conductivity. For example, a 50%–50% by weight mixture of finely silica powder having particle sizes below about 75 microns, and copper flakes smaller than about 50 microns with a flake thickness less than about 0.5 micron gives best results, although opacified insulation mixtures having larger size particles have been tested with excellent results. It has been found that the powder type opacified insulations are particularly suitable for use with substantially spherical containers because such insulation may be easily poured in the space **13** between the inner vessel **11** and outer casing **12**. However, the previously described opacified insulation comprising low heat conductive material and a multiplicity of spaced radiation-impervious barriers could alternatively be used with this container if desired. Blister or chamber **15** secured to and in heat exchange relation with th bottom section of inner vessel **11** holds a gas-adsorbing material **16** such as the previously described synthetic or natural zeolite to remove gas and vapors from the insulating jacket **14**. Adsorbent material **16** communicates with the opacified insulating jacket **14** through passages **17** in the walls of chamber **15**, the adsorbent particles being retained in chamber **16** by glass cloth sheets **18** extending across the passages and held against the chamber walls by plates **19**. It is to be understood that glass cloth sheets **18** do not interfere with vapor and gas communication between the opacified insulating jacket **14** and adsorbent material **15** although they serve to retain the latter.

The inner vessel **11** is supported and stabilized against all relative movement (both vertical and lateral) by lower support member **20** and upper elongated neck tube support member **21**. The conventional practice would be to use a metal as the construction material for lower support member **20**, but certain organic plastics have been found preferable because of their more favorable strength-to-heat conductivity ratio. Materials useful for lower support member **20** should have the properties of relatively high compression and shear strengths, low thermal conductivity, and retention of such properties at temperatures from about —191° C. to 127° C. Compositions having these properties include laminated phenolic plastics (e.g., phenol formaldehyde), melamine resins (e.g., melamine formaldehyde), and trifluorochloroethylene, all of these materials being preferably reinforced with glass fiber or other suitable high-strength filler material.

To provide lateral support at the lower portion of inner vessel **11** while minimizing heat inleak to such inner vessel, lower support member **20** is fixedly mounted against the inside wall of outer casing **12**, for example by tack weld **24** to retaining ring **25** surrounding the lower end of such member. In this manner, lower support member **20** is positioned to slidably and telescopically engage the lower portion of the inner vessel outer wall. The opposite ends of lower support member **20** are preferably positioned in inner wall depression **22** of the outer casing bottom section and depression **23** in the outer wall of adsorbent chamber **15**, see FIG. 2. These cooperating elements center inner vessel **11** within outer casing **12** and provide lateral stability by receiving and resisting side thrust loads on the container. At the same time they permit relative vertical movement between inner vessel **11** and outer casing **12** thereby allowing for thermal expansions and contractions. Alternatively, the upper end of lower support member **20** may be positioned in depression **11***a* in the bottom portion of the inner vessel outer wall **11**, see FIG. 3. Another advantage of the depressions is reduction of the longitudinal heat transfer through the lower support member **20**. Heat is transferred from the atmosphere to the inner vessel **11** by means of member **20**, and this transfer may be substantially reduced by increasing the length of the heat transfer path, which results from the use of depressions since the member **20** of necessity must be longer in this instance. Also, use of the depressions provides a more stable and easily assembled support system. Other means could be used to prevent the relative sliding movement, such as projections extending from either wall into the opacified insulating jacket **14** in contact with the support member **20**.

Holes **26** through the walls and around the periphery of lower support member **20** reduce the longitudinal heat transmission therethrough and also allow the opacified insulation to fill the support member interior thereby reducing heat leak.

Upper support member **21** which bears substantially the entire vertical load of the inner vessel 11 is an elongated hollow neck tube having a first open end 26a communicating with the liquefied gas body through relatively large access opening 27 in the top of inner vessel 11. The other or second open end 28 of member 21 communicates with the atmosphere for filling and emptying of the inner vessel therethrough. The inner vessel walls terminating in access opening 27 are outwardly flared to receive first open end 26a of support member 21, the latter two elements being joined for example by brazing. Lateral ridge 29 around the periphery of upper support member 21 serves to align such member in the flared access opening 27. The upper section of support member 21 is enclosed by concentrically aligned cone section 30 of outer casing 12, the top part of which is necked in and crimped to receive and retain the upper end of member 21. The latter is preferably constructed of relatively low thermal conductivity material such as stainless steel in order to minimize longitudinal heat transfer by conduction to the inner vessel 11. The upper ends of neck tube 21 and cone 30 may also be joined for example by brazing. This combination support system of an upper neck tube to bear the entire vertical load of the inner vessel and a lower support tube to withstand lateral movement of the inner vessel and also compensate for movement due to thermal contractions and expansions is described more fully in U.S. 2,874,865 entitled, "Double-Walled Container With Base," which issued February 24, 1959.

A low heat conductive plug 31, see FIG. 4, may preferably be used which fits loosely in and substantially fills the second open end 28 of neck tube 21. Such plug extends a substantial portion of the length of upper support member or neck tube 21, and for example may comprise a cylindrical body filled with any suitable powder insulating material. Alternatively the entire plug may be fabricated from a reasonably rigid insulation such as foamed plastic, foamed glass and cork coated with a vapor impermeable layer. As previously discussed, access opening 27 and the inner diameter of such tube 21 are relatively large as compared to similarly sized prior art containers, but low conductive plug 31 permits recovery of the sensible refrigeration from the liquefied gas vapors and effectively reduces the net heat conducting characteristic of the neck tube 21. Alternatively a cap may be placed over opening 28 in upper neck tube 21 to reduce heat leak. Such cap would have a small opening therein to allow escape of vapors formed in the inner vessel 11.

Suitable handles 32 are secured to the upper part of outer casing 12 for moving the container, which is preferably supported by ring-type base 33, the walls 33a of which are upwardly and inwardly inclined. The top rim 33b of base 33 is inwardly flared and serves as a seat on which the container casing 10 bears downwardly and to which the casing is secured. The lower end of base walls 33a are bent outwardly as at 33c for providing additional strength and for distributing the load. The base 33 has a spring-like action which enables it to absorb impact loads elastically. It is adapted to provide a predetermined amount of resiliency so that it will deform elastically under moderate impact and thereby reduce the rate of deceleration of the entire container. If too much resilience is provided, the container would bounce if dropped, and this would be undesirable from the standpoint of safety. Moreover, a relatively soft, elastic base might prevent visual deformation of the container casing when it is subjected to a severe impact while internal parts may receive damage and go unnoticed. The elastic characteristics of the base are therefore limited to a shock load which is insufficient to permanently deform the inner parts of the container, as described more fully in the previously referenced copending U.S. Serial No. 635,826. This permits the container to be subjected to vertical impact loads causing elastic but not permanent deformation of the neck tube 21. Loads in excess of this limit will cause permanent deformation to the base, and the attendant permanent absorption of considerable energy during the deformation will avoid or minimize internal damage. In this way damage will be generally confined to the base where repairs are relatively easy, inexpensive and rapid as compared to repairs which require entering the vacuum sealed casing. Furthermore, a deformed base will serve as evidence that the container has received severe impact and will signal the need for close inspection to assure serviceability and safety.

Vacuum tube connection 34 extends through the outer casing wall 12 for communication with space 13 to facilitate initial evacuation thereof. Insulation retainer screen 35 prevents drawing of insulation through vacuum tube 34, and tube 34 is sealed on completion of such evacuation.

Instead of constructing the container of the present invention in an elongated spheroidal shape as illustrated in FIG. 1, it may be fabricated in any other desired form, for example, the cylindrical shape of FIGS. 5 and 6. Although the previously described opacified powder insulation could be used in this embodiment, an insulating system comprising alternate layers of low conductive fiber sheets and radiation impervious sheets such as aluminum foil may be preferred where the vessel to be insulated is in a cylindrical form. This is because such insulation is easily wrapped or wound around the vessel. As illustrated in FIGS. 5 and 6, the opacified insulation comprising low-conductive layers 140 preferably formed of fiber glass having fiber diameters of less than about 50 microns and radiation imprevious layers 141 preferably formed of aluminum foil sheets having a thickness between about 0.2 millimeter and 0.002 millimeter may be spirally wrapped around the inner vessel with one end of the insulation wrapping in contact with the inner vessel 111 and the other end nearest the outer casing 112. Alternatively, the layers may be mounted concentrically with respect to the inner vessel 111. In either embodiment, the fibers of layer 140 are preferably oriented substantially parallel to radiation impervious layers 141 and substantially perpendicular to the direction of heat flow across the insulation space. The tightness and number of wrapping turns may be varied to suit the insulating requirements of the particular container. Tightening of the insulation wrapping causes the low conductive and resilient fibrous material to be compressed into a smaller space. This action decreases the percentage voids in the fibrous material, and increases the cross-sectional area of the effective path of solid conduction. However, the voids are reduced in size, which results in the insulation being less sensitive to pressure changes in the vacuum space. On the other hand, wrapping the insulation too loosely decreases the number of turns of radiation shielding in the insulation space, and increases heat leak by radiation. Optimum results are obtained somewhere between these extremes when the sum of the heat leaks due to radiation and conduction is a minimum. By providing a large number of turns of insulation wrappings, the passage or radiative heat is substantially eliminated, while the conductive heat flow along the spiral path is effectively reduced due to the lengthened heat path. A further advantageous feature of the wrapped insulation embodiment is that when it completely fills the insulation space wall to wall, the insulation also provides a good degree of support for the inner vessel, particularly against lateral accelerations.

It will be apparent from the foregoing description and the accompanying drawings that the preferred form of the present invention combines a number of elements including aluminum or aluminum alloy construction, an opacified insulating jacket, a gas adsorbent, upper vertical support and lower lateral support members, a relatively large access opening, and a low heat conductive plug for the opening in a manner so as to provide an improved portable container for low-boiling-liquefied gases having the characteristics of lighter weight, lower heat inleak and greater compactness and durability.

Although preferred embodiments of the invention have been described in detail, it is contemplated that modifications of the apparatus may be made and that some features may be employed without others, all within the spirit and scope of the invention.

What is claimed is:

1. A lightweight portable container for storing with relatively low vaporization losses liquefied gas having a boiling point below about 233° K., including an inner vessel of less than about 50 liters liquid capacity for holding a liquefied gas body, an outer casing enclosing and separating said inner vessel from the atmosphere, at least said outer casing being formed from material of the group consisting of aluminum and aluminum alloys to substantially reduce the overall weight of such portable container, a sealed space under a substantially permanent vacuum pressure not substantially greater than 5000 microns of mercury absolute between said inner vessl and said outer casing, said space containing an opacified insulating jacket having relatively high insulating efficiency at relatively poor vacuums, and a gas adsorbent material communicating with the opacified insulation to maintain the space under vacuum, a hollow lower support member formed of low heat conductive plastic material and having one end fixedly mounted against the inside wall of the outer casing and the other end positioned to effectively slidably and telescopically engage a lower portion of the inner vessel outer wall, a relatively large access opening in said inner vessel and a hollow elongated neck tube having an inside diameter of about 1½ inches and one open end communicating with the liquefied gas body through said large access opening and a second open end communicating with the atmosphere for filling and emptying said vessel therethrough, said hollow neck tube suspending the inner vessel from the top portion of the outer casing, a low heat conductive plug receivable in and substantially filling the second open end of said hollow neck tube to cause gas vapor formed to flow upwardly close to and in sustained contact with the inside wall surface of said hollow neck tube, thereby recovering the sensible refrigeration of such vapors, and reducing the net heat conducting characteristic of the neck tube.

2. A lightweight portable container according to claim 1 for storing liquefied gas in which the ratio of diameter of the inner vessel to diameter of the access opening is about 10.

3. A lightweight portable container according to claim 1 for storing liquefied gas in which the height of said inner vessel is about 22½ inches and the outside diameter thereof is about 15½ inches and the access opening therein is about 1½ inches in diameter.

4. A portable container according to claim 1 for storing liquefied gas, in which a mixture of finely divided silica particles and aluminum flakes comprises said opacified insulating jacket.

5. A portable container according to claim 1 for storing liquefied gas, in which a mixture of finely divided silica particles and copper flakes comprises said opacified insulating jacket.

6. A portable container for storing liquefied gas having a boiling point below about 233° K., including an inner aluminum vessel of less than about 50 liters liquid capacity for holding a liquefied gas body; an outer aluminum casing enclosure and separating the inner vessel from the atmosphere; a sealed space under a substantially permanent vacuum pressure not substantially greater than 5000 microns of mercury absolute between said inner vessel and said outer casing, said space containing an opacified insulating jacket comprising a mixture of finely divided silica particles and copper flakes which are present in an amount constituting about 50% by weight of such insulating jacket; at least one zeolitic molecular sieve gas adsorbent material having pores of at least 5 angstrom units in size and communicating with the opacified insulation to maintain the space under a vacuum; a hollow lower support member formed of low heat conductive plastic material and having one end fixedly mounted against the inner wall of the outer casing and the other end positioned to effectively slidably and telescopically engage a lower portion of the inner vessel outer wall; a hollow elongated neck tube having an inside diameter of about 1½ inches and constituting an upper support member and having a first open end communicating with the liquefied gas body through a relatively large access opening in said inner vessel and a second open end communicating with the atmosphere for filling and emptying of said vessel therethrough, said upper support member bearing substantially the entire vertical load of the inner vessel; and a low conductive plug receivable in and substantially filling the second open end of the hollow neck tube so as to facilitate the upward flow of liquefied gas vapors in sustained contact with the neck tube surface thereby recovering the sensible refrigeration of such vapors and reducing the net heat conducting characteristic of the neck tube.



7. A portable container for storing liquefied gas having a boiling point below about 233° K., including an inner aluminum vessel of less than about 50 liters liquid capacity for holding a liquefied gas body; an outer aluminum casing enclosing and separating the inner vessel from the atmosphere; a sealed space under a substantially permanent vacuum pressure not substantially greater than 5000 microns of mercury absolute between said inner vessel and said outer casing, said space containing an opacified insulating jacket comprising a multiplicity of radiation-impervious aluminum foils having a thickness between about 0.2 millmeters and 0.002 millimeters supportably carried by fiber glass having fiber diameters less than about 50 microns, such foils being disposed in parallel spaced relation to each other and said fiber glass material having a fiber orientation substantially parallel to the foils and substantially perpendicular to the direction of heat flow across said space; at least one zeolitic molecular sieve gas adsorbent material having pores of at least 5 angstrom units in size and communicating with the opacified insulation to maintain the space under a vacuum; a hollow lower support member formed of low heat conductive plastic material and having one end fixed mounted against the inner wall of the outer casing and the other end positioned to slidably and telescopically engage a lower portion of the inner vessel; an upper support member being a hollow elongated neck tube having an inside diameter of about 1½ inches and a first open end communicating with the liquefied gas body through a relatively large access opening in said inner vessel and a second open end communicating with the atmosphere for filling and emptying of said vessel therethrough, said upper support member bearing substantially the entire vertical load of the inner vessel; and a low conductive plug receivable in and substantially filling the second open end of the hollow neck tube so as to facilitate the upward flow of liquefied gas vapors in sustained contact with the neck tube surface thereby recovering the sensible refrigeration of such vapors and reducing the net heat conducting characteristic of the neck tube.

8. A light-weight double-walled portable container for storing with relatively low vaporization losses liquefied gas having a boiling point below about 233° K., including an inner vessel of less than about 50 liters liquid capacity for holding a liquefied gas body, an outer casing enclosing and separating said inner vessel from the atmosphere, at least said outer casing being formed from materials of the group consisting of aluminum and aluminum alloys; a sealed space under a substantially permanent vacuum pressure not substantially greater than 5000 microns of mercury absolute between said inner vessel and said outer casing, said space containing an opacified insulating jacket and a gas adsorbent material communicating with the opacified insulation to maintain the space under a vacuum; a hollow lower support member formed of low heat conductive plastic material and having one end fixedly

mounted against a lower portion of one wall of the container and the other end positioned to effectively slidably and telescopically engage a lower portion of the other wall of the double-walled container; and a hollow elongated neck tube having an inside diameter of at least about 1½ inches and a first open end communicating with the liquefied gas body through a relatively large access opening in said inner vessel and a second open end communicating with the atmosphere for filling and emptying of said vessel therethrough, said neck tube suspending the inner vessel from the top portion of the outer casing.

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