May 12, 1964 R. GABARRO ETAL 3,132,762

APPARATUS FOR DISPENSING LIQUEFIED GASES

Filed June 9, 1960

2 Sheets-Sheet 1

FIG. 1

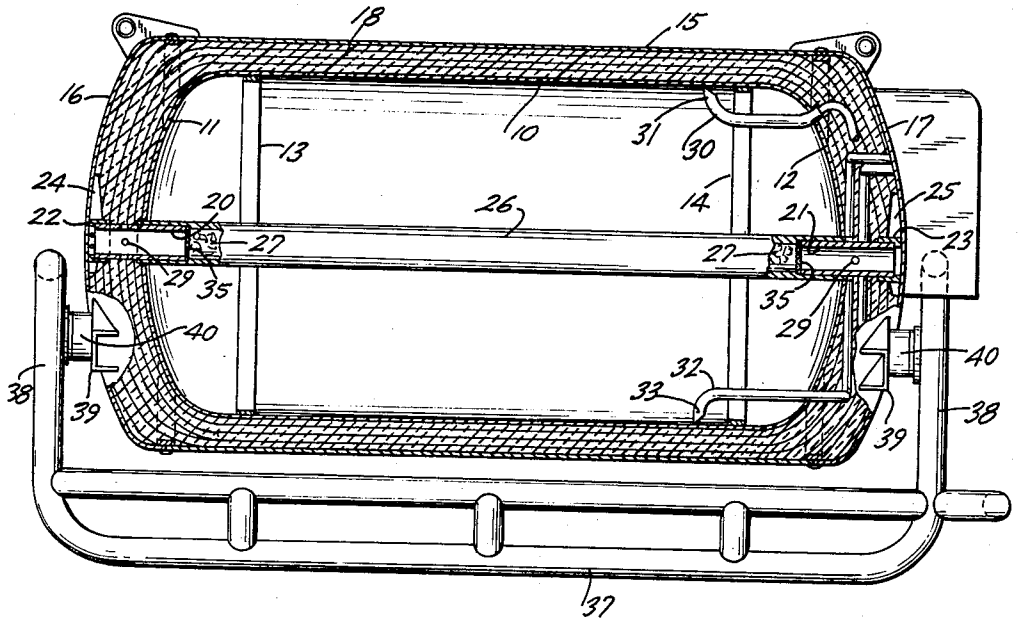
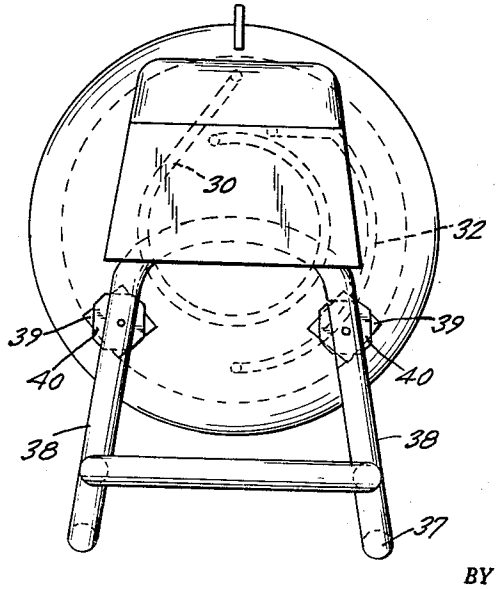


FIG. 2



INVENTORS
RAFAEL GABARRO
PAUL E. LOVEDAY
JAMES A. PROCTOR
HARRY E. SCHONBERG

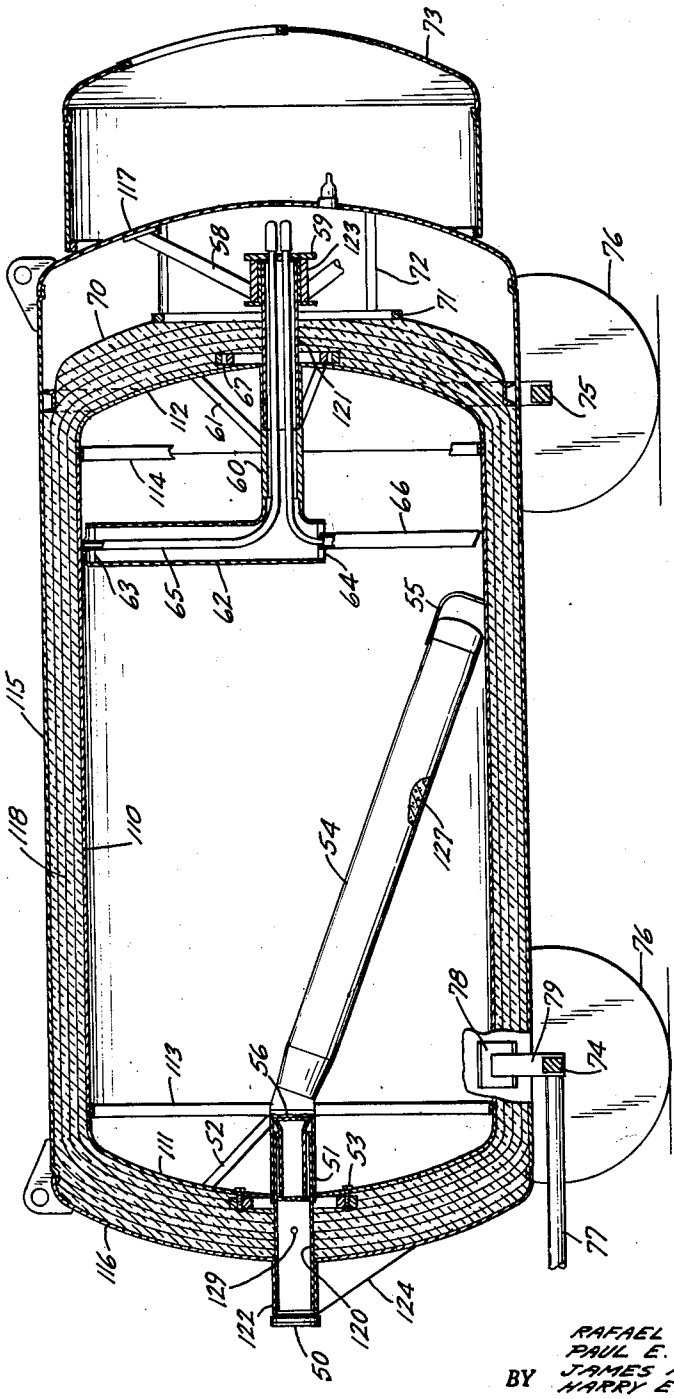
BY William F. Messinger
ATTORNEY

May 12, 1964 R. GABARRO ETAL 3,132,762

APPARATUS FOR DISPENSING LIQUEFIED GASES

Filed June 9, 1960 2 Sheets-Sheet 2

FIG. 3



INVENTORS
RAFAEL GABARRO
PAUL E. LOVEDAY
JAMES A. PROCTOR
HARRY E. SCHONBERG

BY William F. Mesinger
ATTORNEY

United States Patent Office 3,132,762
Patented May 12, 1964

3,132,762

APPARATUS FOR DISPENSING LIQUEFIED GASES

Rafael Gabarro, Grand Island, Paul E. Loveday and James A. Proctor, Tonawanda, and Harry E. Schonberg, Kenmore, N.Y., assignors to Union Carbide Corporation, a corporation of New York

Filed June 9, 1960, Ser. No. 34,953
12 Claims. (Cl. 220—15)

This invention relates to apparatus for the storage and dispensing of valuable liquefied gas material at low temperatures and more specifically to improved portable containers for liquefied gases such as liquid oxygen, nitrogen, argon, hydrogen, and helium, constructed to preserve such liquids with low evaporation loss.

Heat insulating systems for double walled containers for low temperature liquefied gas have been developed to be highly effective in reducing the transfer of heat across an evacuated insulating space by conduction, convection and radiation to extremely low values. Two of such systems are described and claimed in the applications of L. C. Matsch and A. W. Francis, Serial No. 580,897 filed April 26, 1956 and now Patent No. 2,967,152, and L. C. Matsch, Serial No. 597,947 filed July 16, 1956 and now Patent No. 3,007,596, the first named, describing an insulation system comprising, in an evacuated space, a filling of small particle size insulating powder containing an opacifying material in the form of metal flakes, and the second named describing an insulation system comprising multiple alternate layers of fiber mat and polished metal foil preferably wrapped about an inner vessel contained within a vacuum tight outer shell.

To take advantage of the high efficiency of these insulations which cannot be relied upon to provide adequate mechanical support of an inner vessel within an outer shell, it is necessary to provide adequate mechanical support constructions for an inner vessel and conduit constructions for filling, venting and emptying the inner vessel such that the leakage of heat by conduction through the supports and conduits does not become an undesirably high proportion of the total leakage of heat to the inner vessel from the outer shell which is exposed to ambient temperatures. Particularly for a portable container, it is also necessary that the supporting structure be strong enough for normal handling of the container by common carrier methods.

It is therefore a principal object of the invention to provide a double walled insulated container construction which meets the above requirements.

Among the objects of the invention are to provide a double walled insulated liquefied gas container which has a relatively low tare weight to minimize shipping costs; which can take advantage of the high efficiency insulating systems; which is rugged enough for customary commercial handling when filled with liquid; which is capable of dispensing the liquefied gas material at moderate superatmospheric pressures; which incorporates a means for preserving the desired degree of vacuum in the insulating space in a convenient and efficient manner; and which can be manufactured economically.

For other objects and advantages of the invention reference is made to the following description in connection with the accompanying drawings in which:

FIG. 1 is a view of an axial cross section through a container according to the invention;

FIG. 2 is an end view of such container; and

FIG. 3 is a view of an axial cross section through another container embodying the invention.

A container embodying the principles of the invention includes an inner vessel for holding a supply of liquefied gas, a vacuum tight outer shell surrounding the vessel and providing an intervening insulating space which is

evacuated of gas to a low vacuum pressure and preferably is filled with a solid insulation material such as in the opacified powder system or the multilayer wrapped system according to the aforementioned patent applications.

The inner vessel is supported within the outer shell at only two points by tubular cylinders at the axial poles of the vessel which tubes extend across the insulation space at the vessel heads. The tubular cylinders are made of a structural material having low heat conductivity as compared to common metals. The length and cross-sectional area of the cylinders are selected to provide as great as possible resistance to heat conduction consistent with the required structural strength, an economic balance being achieved. The tubular cylinders are in turn reinforced and supported by telescopically enclosing their outer ends in sockets secured to the outer shell end heads and telescopically retaining their inner end portions within tubular supporting means secured in the end heads of the inner vessel. In one embodiment this tubular supporting means takes the form of an axial continuous tube joining the end heads of the inner vessel. In the other embodiment the tubular support means are formed by two separate portions which have their outer ends secured gas tightly in the end heads of the vessel and having inner portions supported by angular braces extending to the wall of the inner vessel end heads. In the latter case, one portion of the tubular support means has at its inner end an otherwise sealed chamber for holding a quantity of adsorbent material in heat exchange with the liquefied gas in the vessel, and the opposite portion may have a closed header secured to its inner end with upper and lower walls through which are sealed respectively a gas conduit having its inner end opening in the gas space of the inner vessel and a liquid conduit having its inner end opening in a low part of the liquid space. The conduits pass through the header and out through the tubular support means, the tubular cylinder, and the socket bottom which has clearance holes for the free passage of the tubes and for gaseous communication to the insulating space.

The tubular cylinder is preferably axially fixed to both the socket and the tubular support means at one end of the container but at least one telescopic joint at the other end is not fixed but axially slideable so as to allow endwise expansion and contraction of the inner vessel respective to the outer shell as is caused by temperature changes when filling a warm container or when an empty container is allowed to warm up.

The container is preferably mounted on a frame for easy portability such as a skid or wheeled carriage and the outer shell is preferably secured to the frame through resilient means such as rubber shock mounts.

Referring now to the drawings and particularly to FIGS. 1 and 2, there is shown an exemplary container which is preferably horizontally mounted and has an inner vessel 10 which is cylindrical although other shapes may be employed such as spherical. The inner vessel is closed by dished end heads 11 and 12 welded to the cylindrical portion in the region of reinforcing rings 13 and 14. The inner vessel is surrounded completely by an outer shell 15 of similar shape and having end heads 16 and 17 and providing a suitable insulating space 18 between the walls of the inner vessel and the outer shell. This insulating space is evacuated to a low vacuum pressure and is preferably filled with an insulating material such as the aforementioned opacified powder or the aforementioned wrapped insulation. The construction is particularly suitable for the economical application of the wrapped type insulation because the inner vessel surfaces are substantially free of protuberances such as would be required by the customarily employed inner vessel suspension systems.

The inner vessel is supported at its axial poles by two

tubular cylinders 20 and 21 which cylinders span the insulating space between the end heads 11 and 16 and 12 and 17 respectively. The tubular cylinders 20 and 21 have an unsupported length and cross sectional area selected to provide an economical balance between adequate resistance to heat conduction calling for long length and thin walls, while providing the necessary structural strength which calls for thickness and a short span. These cylinders are reinforced to avoid distortion of their cylindrical shape due to beam action and to provide adequate support by having their outer end portions telescoped within sockets 22 and 23 which are secured to the inside of the shell end heads 16 and 17. Such sockets may be reinforced by diagonal brace gusset plates 24 and 25 which also reinforce the center portion of the end heads 16 and 17. The inner portions of the tubular cylinders 20 and 21 are telescopically supported within the ends of tubular support means here shown as a metal tube 26 completely passing axially through the inner vessel and being welded gas tightly at each end to respective end heads 11 and 12 of the inner vessel. This tube 26 also acts to provide substantial support for the end heads so that the end heads can be constructed of thinner metal to save tare weight.

The left end cylinder 20 is preferably axially fixed to both the socket and tubular support such as by cementing, a preferred material being an epoxy cement. The cylinder 21 is not fixed or cemented to allow for expansion and contraction. The material selected for the cylinders should have a low heat conductivity and a high structural strength and for this purpose certain reinforced plastic materials have been found suitable. The material preferably employed is a glass reinforced epoxy resin having an axial tensile strength at least 40,000 p.s.i. and an axial compressive strength of at least 22,000 p.s.i. Such a material is sold under the designation "Micarta" grade HY-180. The cylinders 20 and 21 are also preferably exposed inside and outside to the vacuum space. The interior of the tube 26 is also in communication with the insulating space 18 and is filled with an adsorbent material 27 that, when in heat exchange with the liquefied gas, is highly effective to adsorb residual gases and vapor from the insulating space so as to maintain the vacuum at a desired low value for long periods. Such communication is preferably provided by a series of small holes 29 in the cylinders. Alternatively the gas communication could be provided by holes in the wall of the sockets beyond the heads of the cylinders.

Conduits for filling and emptying the inner vessel are provided and are here shown as passing through the end head 12 of the inner vessel. Alternatively such conduits can be arranged to pass out through one of the supporting cylinders. Gas conduit 30 having its inner open end 31 in the gas space passes gas tightly through end head 12 and then through the insulation space wherein it is coiled and looped to provide a long length for reducing heat conduction, after which the conduit passes gas tightly out through the end head 17 of the shell. The liquid conduit 32 having its inner end 33 close to the lower portion of the liquid space is similarly constructed.

For retaining the adsorbent in tube 26 screens 35 at the inner ends of cylinders 20 and 21 may be employed. Also if desired, heat leak by convection can be reduced by filling all or part of the interior of the cylinders with a porous insulating material such as glass wool, glass fiber packing or alternate disks of metal foil and glass fiber mat material. This is not shown in the interests of clearness of the drawing.

The container may be mounted on a frame designed for ready portability such as a skid frame 37. As shown in FIGS. 1 and 2, the frame has four uprights 38 adjacent the end heads 16 and 17 of the shell opposite mounting brackets 39 secured to the end heads. Suitable shock mounts 40 preferably of the rubber-in-shear type are secured between the frame uprights 38 and the mounting brackets 39. By using such shock mounts the tubular

cylinders 20 and 21 can be constructed of somewhat thinner material to gain greater resistance to heat conductance.

Referring now to the embodiment shown in FIG. 3 which is generally more suitable for a larger container than that shown in FIG. 1, the cylindrical inner vessel 110 is provided with end heads 111 and 112, with reinforcing rings 113 and 114 and is surrounded by an outer shell 115 with corresponding end heads 116 and 117 and is insulated with insulation material 118 in the space between the inner vessel and shell. The support system differs in that the tubular support means is not axially continuous. Tubular cylinders 120 and 121 similar to those described at 20 and 21 in FIG. 1 have their outer portions telescopically supported within respective sockets 122 and 123. The left socket is preferably secured outside of the end head 116 and has its outer end sealed by a removable cover plate 50. Reinforcing gussets 124 may also be employed. The left tubular support means 51 has an outer portion welded to the end head 111 of the inner vessel and has its inner end braced securely to the end head by diagonal braces 52. The cylinder 120 is telescopically secured within the tubular support 51. A ring-shaped reinforcement 53 is also secured to the end head 111. The cylinder 120 is preferably axially fixed by cementing to the socket 122 and to the tube 51 and is provided with small vent holes 129.

The inner end of the tube 51 is welded to a tubular chamber 54 which extends inwardly and downwardly in the liquid space of the vessel. The lower end of the chamber is gas tightly closed and is supported by a bracket 55 to the wall of the vessel 110. The chamber 54 is filled with a suitable adsorbent material 127 which is preferably retained in the chamber by a screen 56 at the inner end of a sleeve 59 which extends the length of the tube 51 and is smaller in diameter than the inside diameter of the cylinder 120.

The righthand tubular cylinder 121 is telescopically secured within the socket 123 which is supported a short distance inward of the end head 117 by being mounted on outrigger brackets 58. This socket is provided with a bottom plate 59 having clearance holes for passage of conduits as well as for providing gas communication between the insulation space and the interior of the cylinder 121. The inward portion of the cylinder 121 is telescopically and slideably supported within the supporting tube 60 which has its outer end gas tightly welded to the end head 112 and which is securely braced to the end head by diagonal braces 61. The inner end of the support tube is closed by a hollow header 62 which may be T shaped and having upper and lower end walls 63 and 64. A gas conduit 65 passes gas tightly through the upper end wall 63 and has its inner end open to the gas space of the vessel. The gas conduit 65 passes through the header 62 and out through the tube 60, the cylinder 121, the clearance holes in the bottom 59 of the socket 123 and then through a circuitous path through the insulation space and gas tightly out through the end head 117 at a convenient place. A liquid conduit 66 has its open end close to the bottom of the inner vessel and similarly passes gas tightly through the lower end enclosure 64 and similarly outward to the outside of the shell. The inner vessel end head 112 may also be provided with a reinforcing ring 67 secured thereto.

The space between the end heads 112 and 117 is enlarged to provide space for the passage of the conduits 65 and 66 through the socket 123. When the wrapped type of insulation is employed, it is unnecessary that the entire space between the heads be filled with insulation. The right end of the wrapped insulation is shown at 70 and there is preferably provided a means for adequately retaining the insulation in position against the inner vessel head 112. This takes the form of a ring 71 positioned to press against the insulation end 70 and is supported from the outer shell head by suitable legs 72.

Not shown in the interest of clearness are the various

valves, withdrawal and filling connections, safety devices and liquid level gage mechanism, to which the conduits may be connected and which are preferably located outside the end head **117** and which are covered by a suitable protective cover **73**.

The container is preferably supported on a wheeled carriage having axles indicated at **74** and **75**, wheels **76** and a drawbar **77**. The outer shell is provided with four mounting pads **78** to which the carriage supports **79** are connected.

As described in connection with FIG. 1, the cylinder **120** at least may be filled with suitable insulating material. The space around conduits **65** and **66** in cylinder **121** may also be filled with a fibrous insulation. Also the conduits **65** and **66** are preferably wrapped with insulation preferably of the foil and glass mat type. When a powder insulation is used in the insulating space the holes **29** and **129** in the support cylinders may be covered with a layer of porous glass cloth to keep powder from entering and contaminating the adsorbent. By having the cover **50** of the socket **122** in FIG. 3 removable the adsorbent **127** can be charged from outside or renewed if desired. Examples of suitable adsorbents are silica gel and molecular sieve calcium zeolite 5A which latter is preferred.

Examples of containers of the two types have been tested to determine the proportion of the heat inleak through the insulation (of the wrapped type), the support system (the tubular cylinders), and the gas and liquid conduits or piping. Taking the total heat leak at a temperature difference between ambient atmosphere and the boiling point of liquid nitrogen for example at 100% the calculated percentages were as follows:

Type of Container	Fig. 1 type	Fig. 3 type
	Percent	*Percent*
Insulation	45	36
Supports	30	51
Piping	25	13

From this it will be seen that with high efficiency insulation the heat leak through the supports and piping is a major portion of the total heat leak even though the support system has a lower heat transmission than support systems for servicing containers which have previously been used. The heat leak due to the supports of this invention can be reduced from that indicated in the table by some sacrifice of increased bulk and weight of the container by a construction permitting the use of longer unsupported length of the tubular cylinders. The conduits may be made of aluminum but if a reduction of heat leak through the conduits warrants the extra expense of dissimilar metal joints, the conduits may be made mainly of a metal having lower heat conductivity such as stainless steel.

The inner vessel support according to the invention not only provides low heat leak but also provides for axial contraction of the inner vessel with movement preferably at one end; and it permits economical use of the high efficiency wrapped type insulation. The construction also provides for hermetical all metal sealing of the liquid holding space and the vacuum space, the plastic cylinders being used only for support and no plastic is involved in the vacuum sealing.

The embodiments shown are designed mainly as servicing containers for liquid withdrawal only and the normal heat leak may be relied upon to create sufficient vapor pressure for liquid delivery. If desired, an external supply of the same gas under pressure may be connected to the gas conduit to pressurize the gas space. Alternatively there can be externally connected to the gas and liquid conduits a pressure building device of the kind known in the art. While two specific embodiments have been described, various modications can be made which come within the spirit and scope of the invention.

What is claimed is:

1. Apparatus for the storage and dispensing of liquefied gas material at low temperatures comprising a closed inner vessel for holding a body of the liquefied gas and having a vapor space above the liquid space therein; a closed gas tight outer shell completely surrounding the inner vessel and spaced therefrom to provide an evacuatable insulation space between the walls of the vessel and the shell; means for supporting said inner vessel within the shell comprising two tubular cylinders in axial alignment and tubular support means, each tubular cylinder extending across the insulation space, each tubular cylinder having their outer end portions supported in sockets secured to the respective end heads of the outer shell and their inner ends supported telescopically within said tubular support means, said tubular support means being secured to and extending through the end heads of said inner vessel into said inner vessel, the unsupported length of said tubular cylinders having a thickness selected according to the diameter and strength of the material thereof to provide adequate support of the full loaded weight of the inner vessel, and the cross-sectional area and unsupported length of said tubular cylinders being selected according to the conductivity of the material to provide a desired restricted heat leak.

2. Apparatus for the storage and dispensing of liquefied gas according to claim 1 in which said tubular support means is secured gas tightly to the end heads of said inner vessel and sealed gas tightly from the interior of the inner vessel, and the interior of said tubular cylinders are in communication with the insulation space.

3. Apparatus for the storage and dispensing of liquefied gas according to claim 1 in which said tubular support means is continuous and connects the center portions of the inner vessel end heads to stiffen the heads so that they may be made of thinner metal.

4. Apparatus for the storage and dispensing of liquefied gas according to claim 1 in which said tubular support means comprises separate axially aligned tubes each welded gas tightly in a respective opening in each end head of the inner vessel and extending inwardly, and angular braces secured between said tubes and said end heads, the inner ends of said tubes being sealed.

5. Apparatus for the storage and dispensing of liquefied gas according to claim 1 in which at least a portion of said tubular support means which is in heat exchange contact with the liquefied gas material within the vessel contains an adsorbent material in gaseous communication through at least one end of the support means with said insulating space effective when subject to the temperature of the gas material for adsorbing traces of gases and vapors from the vacuum space.

6. Apparatus for the storage and dispensing of liquefied gas according to claim 1 in which said inner vessel is covered with a gas evacuatable multilayer metal foil and fiber heat insulation within said insulation space.

7. Apparatus for the storage and dispensing of liquefied gas according to claim 1 in which one of said tubular cylinders has its ends fixedly secured axially in the respective socket and tubular support means and the other of said tubular cylinders has at least the inner portion axially slideably retained in said tubular support means so that one end only of said inner vessel is free to move axially with respect to the outer shell to accommodate expansion and contraction due to temperature changes.

8. Apparatus for the storage and dispensing of liquefied gas according to claim 1 which includes a supporting frame for the outer shell when in axially horizontal position, and resilient shock mounts secured between said frame and the outer shell.

9. Apparatus for the storage and dispensing of liquefied gas according to claim 1 in which said tubular support means comprises separate axially aligned tubes each welded gas tightly in a respective opening in each end head of the inner vessel and extending inwardly, one of said

tubes having a portion extending into the liquid space of the inner vessel, the end of which portion is gas tightly closed and braced to the wall of the inner vessel and which portion contains an adsorbent material, the other of said tubes being provided at its inner end with a closed header having upper and lower walls; and gas and liquid conduits extending outwardly through said other tube and the cylinder therein, into and through the insulation space and gas tightly through the wall of said outer shell for connection to gas venting, liquid withdrawal, and filling means, the inner portion of the gas conduit passing gas tightly through the upper wall of said header and opening into the gas phase space of the inner vessel and the inner end of the liquid conduit passing gas tightly through the lower wall of said header and opening into the liquid phase space of said inner vessel.

10. Apparatus for the storage and dispensing of liquefied gas according to claim 9 in which said conduits within at least a portion of said other tube are covered with heat insulation material, the interior of said header and tube being evacuated and in communication with said insulating space.

11. Apparatus for the storage and dispensing of liquefied gas according to claim 9 in which said conduits are bent to follow an elongated path through the insulating space adjacent the end head of the outer shell.

12. Apparatus for the storage and dispensing of liquefied gas according to claim 1 in which one of said sockets is secured at a short distance inwardly of the respective end head of the outer shell by angular outrigger braces extending from said socket to the inner wall of said head, the bottom of said socket having at least one clearance opening for the passage of conduits and for providing gas communication between the insulating space and the interior of the tubular cylinder and tubular support means associated with the socket.

References Cited in the file of this patent

UNITED STATES PATENTS

1,351,395	Martineau	Aug. 31, 1920
1,561,102	Mott	Nov. 10, 1929
2,706,575	Soherr	Apr. 19, 1955
2,729,357	Nason	Jan. 3, 1956
2,799,425	Werker	July 16, 1957
2,858,136	Rind	Oct. 28, 1958
2,900,800	Loveday	Aug. 25, 1960