May 11, 1954 P. E. LOVEDAY 2,677,938

VACUUM-INSULATED CONTAINER AND PROCESS FOR EVACUATING SAME

Filed Nov. 16, 1950 2 Sheets-Sheet 1

Fig. 1.

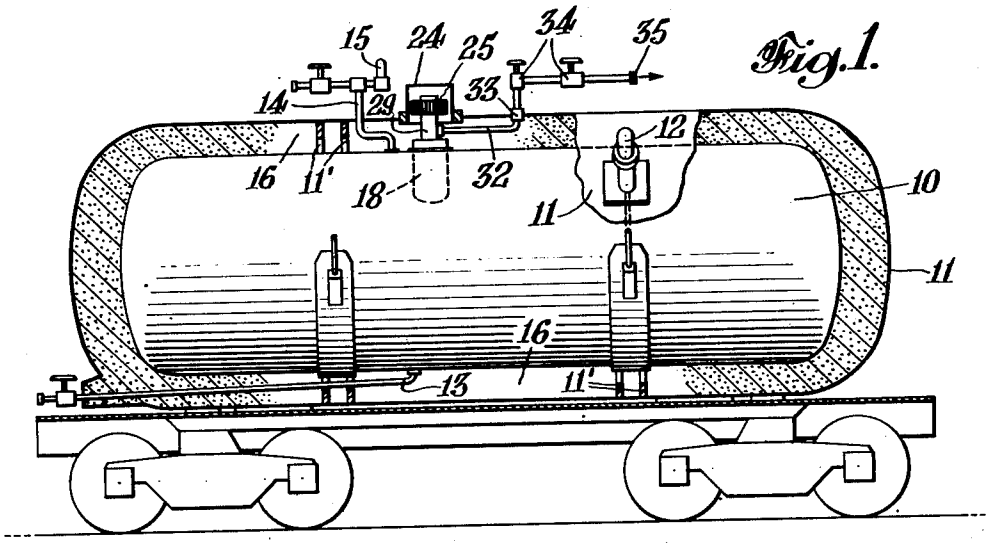
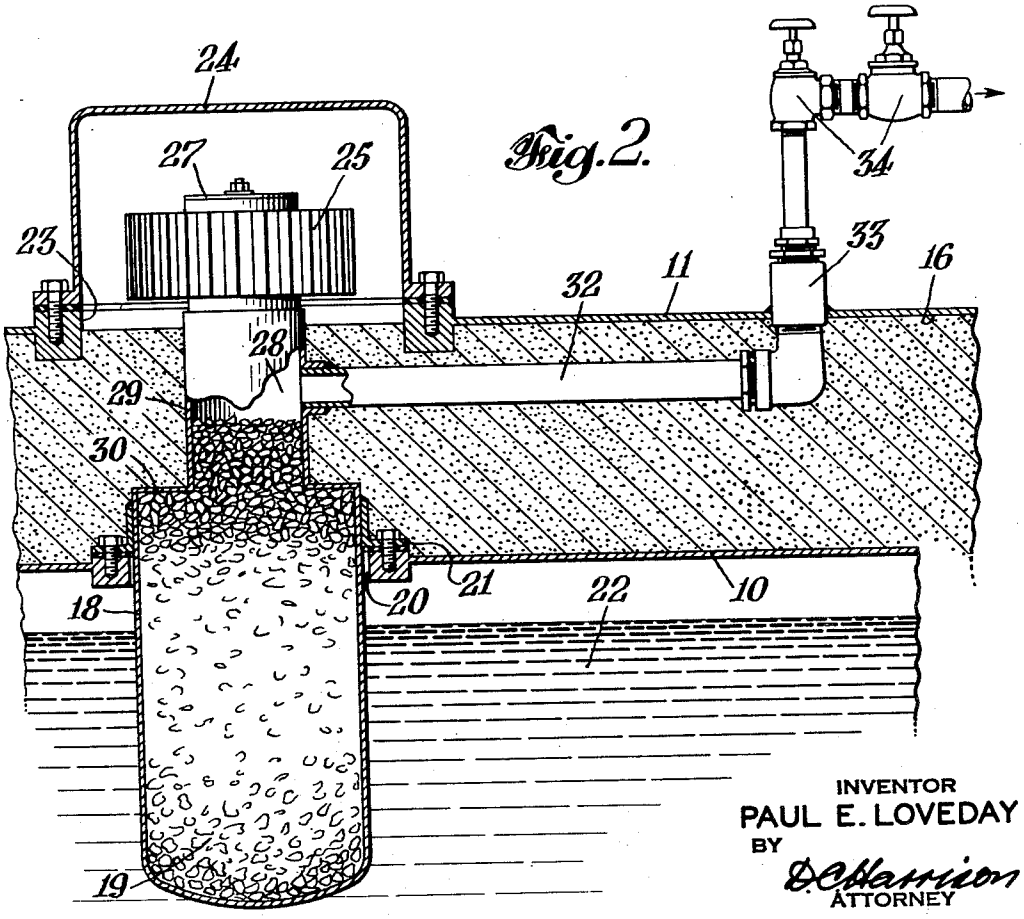



Fig. 2.



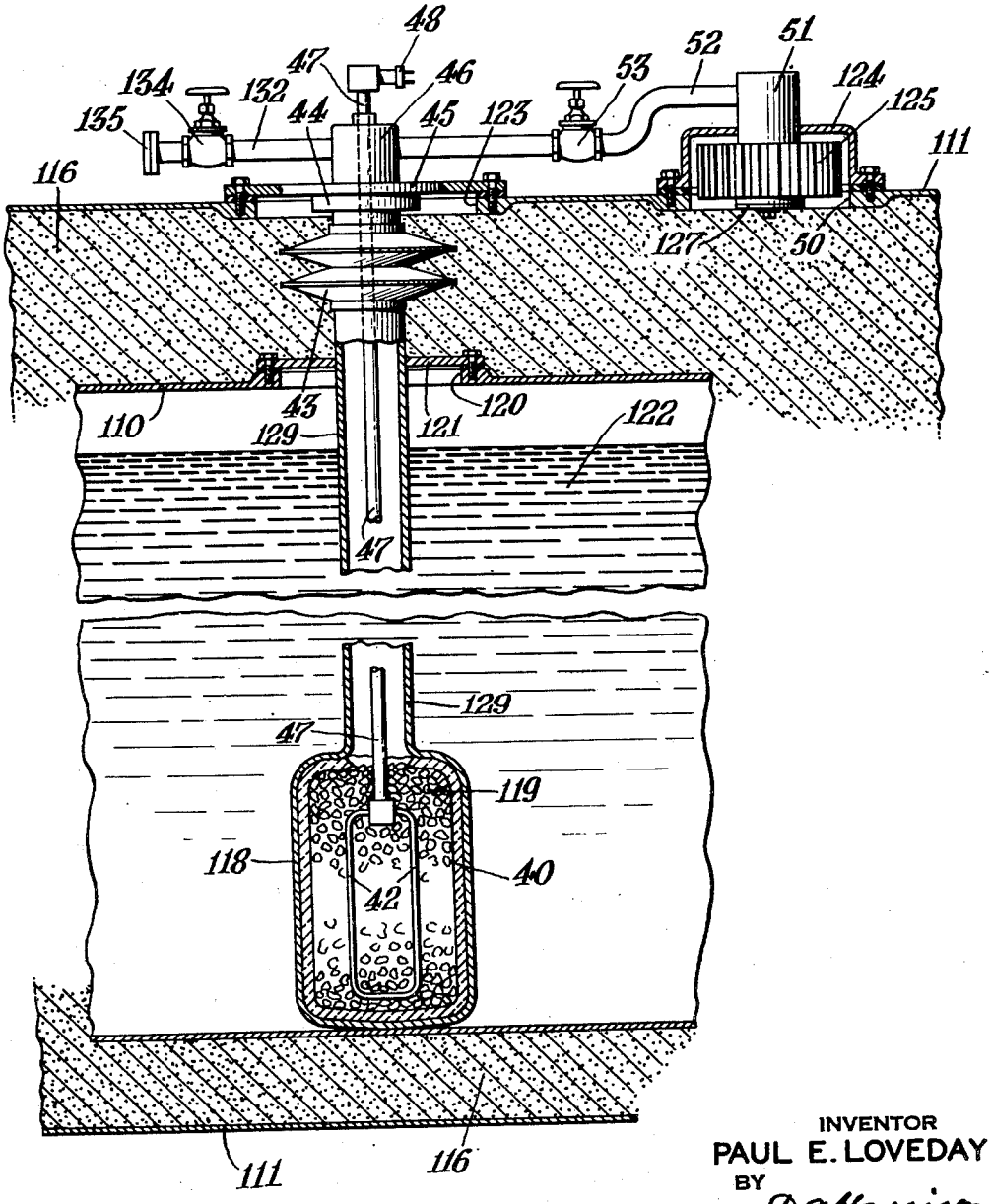

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Filed Nov. 16, 1950 2 Sheets-Sheet 2

Fig. 3.




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# UNITED STATES PATENT OFFICE

2,677,938

## VACUUM-INSULATED CONTAINER AND PROCESS FOR EVACUATING SAME

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Application November 16, 1950, Serial No. 195,937

15 Claims. (Cl. 62—1)

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This invention relates to vacuum-insulated containers and process for evacuating same, particularly powder-in-vacuum insulated containers for holding liquefied gases at low temperature, such as those having boiling points materially below 233° K. at atmospheric pressure. The invention also relates to a process for re-evacuating of gas and vapor the powder-filled insulating space between the inner liquid holding vessel and a surrounding outer shell of such a container.

The type of powder-in-vacuum insulated container referred to herein is similar to that described in United States Patent No. 2,396,459, issued March 12, 1946, to Leo I. Dana, and the present invention may be said to be in part an improvement thereon. Such insulation is extensively used in containers for valuable liquefied gases such as large storage containers and tank cars for holding and shipping liquid oxygen and liquid nitrogen at temperatures equal to or close to their boiling points at atmospheric pressure which are below 100° K. The evaporation losses due to leakage of heat from the ambient atmosphere to the inner liquid holding vessel of a storage container or tank car are within economic limits when the vacuum in the powder-filled insulation space is of a high order. It has been found that when the absolute pressure in the insulation space tends appreciably to exceed about 100 microns of mercury, the evaporation losses become noticeably higher and they become economically appreciable when the vacuum space pressure exceeds 500 microns. A frequent cause of such pressure increase appears to be the development of small, difficultly discoverable air leaks in the outer shell. When fine particle size powders are used for the insulation space filler, it is very difficult to evacuate the space because the gas and vapor move exceedingly slowly through the filling at the lower absolute pressures and it also appears that the finer powders, which have greater surface area, tend to occlude gas and vapor. Such occluded gases and vapor are released very slowly. It has been found that after evacuation for a long period, such as continuous pumping for a week or more until a satisfactory absolute pressure is reached, the vacuum pressure soon tends to rise due to the release of occluded gases. When the outer shell or casing also has minute air leaks or the inner vessel has a minute leak, such air or gas that leaks in becomes in part occluded in the insulation as well as increasing the vacuum pressure. The difficulty and expense of re-evacuation are thus greatly increased.

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Further difficulties in producing and maintaining a satisfactory degree of vacuum are caused by the small amount of moisture naturally present in the filler powder. While a considerable portion of such moisture may be released from the powder and condensed on the surface of the inner vessel when it is charged with liquefied gas, much water vapor still remains at the different temperature regions according to the vapor pressure of water occluded on the particular filler material corresponding to those temperatures. The vapor pressure of contained moisture in insulating powders is found to generally be very much lower than the vapor pressure of water at atmospheric and below atmospheric temperatures. It has been found impractical to eliminate the moisture by long continued evacuation while the container is warm, so that in practice, evacuation is completed when the inner vessel is cooled to the liquefied gas temperature when the vapor pressure of moisture is lowest. The powder also causes evacuation difficulties by its tendency to float with the movement of gas and vapor, and attempts to prevent movement of powder to the evacuation equipment by ordinary filtering devices have not been satisfactory due to clogging and excessive interference with the movement of gas to the vacuum pumps.

A principal object of the present invention is to provide means for maintaining the absolute pressure in a powder-filled vacuum insulation space of a liquefied gas container at lower absolute values to reduce evaporation losses.

Other objects of the invention are to provide means associated with a powder-in-vacuum insulated container which provides easier and quicker initial evacuation of the insulation space; which preserves the vacuum for longer periods between re-evacuation operations; which provides quicker and more effective results upon re-evacuation; and which reduces the difficulties due to occlusion of gas and vapor in powder insulating materials.

A further object of the invention is to provide an improved process for periodic re-evacuation of powder-filled vacuum insulation spaces of liquefied gas containers, particularly portable containers for the bulk transportation of liquefied gases such as liquid oxygen and liquid nitrogen.

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

Fig. 1 is a view, partly in elevation and partly

in section, of a typical liquefied gas powder-in-vacuum insulated container of the railroad car type having improvements associated with the vacuum-insulated space according to the invention;

Fig. 2 is a fragmentary enlarged cross-sectional view of said improvements; and

Fig. 3 is a fragmentary view mainly in section of another embodiment according to the invention as employed in a stationary type liquefied gas container.

The containers illustrated in the drawings represent two of the many structural forms of double-walled powder-insulated liquefied gas holding containers to which this invention may be applied. The container illustrated in Fig. 1 is representative of those employed for the bulk shipment of liquid oxygen by railroad, although for a railroad tank car, certain additional supports for the inner vessel would be employed. However, the manner of supporting the inner vessel forms no part of the present invention, it being merely essential that the inner vessel support shall provide the least possible additional path for leakage of heat from the outer shell toward the inner vessel.

In Fig. 1 the inner vessel is indicated by the reference character 10 and is a horizontal cylindrical tank. The tank 10 is suspended within an outer shell 11 which is strong enough to resist the force of external atmospheric pressure in addition to the strength required for structural stability. The inner vessel is suspended by supports 12 that are anchored to the shell 11 at points where the shell is reinforced by rings 11'.

For charging and discharging the inner vessel, and venting therefrom, a liquid line 13 and vapor line 14 communicate with the bottom and top respectively of the inner vessel and pass gas tightly through the outer shell to suitable exterior points. The vent line 14 may also communicate with a presure relief device 15 which vents gas when pressure in the inner vessel exceeds a desired value. Often such pressure value is substantially atmospheric, although the container may be constructed to operate at somewhat higher than atmospheric pressures. The insulation space 16 between the exterior wall of the inner vessel 10 and the shell 11 is filled with a finely divided or comminuted solid insulating material. This insulation space is evacuated of gas and vapor.

In Fig. 2, a preferred embodiment of apparatus according to the invention is illustrated in greater detail. An important feature is a container 18 of suitable shape for holding a body 19 of adsorbent material such as, for example, silica gel. The container 18 is secured within an opening 20 in the upper part of the inner vessel 10, being secured gas-tightly to the wall of the inner vessel by a flange 21. The container 18 is suspended so that at least a substantial part of it will be in contact with liquefied gas when the liquefied gas indicated at 22 is charged into the inner vessel to the normal full liquid level. In the wall of the outer shell 11, preferably above the opening 20, there is an opening 23 which is sealed by a cap 24 forming in effect a dome on the outer shell. Within such dome 24 there is disposed a dust filter 25 constructed so that its filtering membrane has an extended surface area, for example, the filterng membrane may be supported so as to have a multiplicity of radially extending flutes. Such dust filter 25 has an exterior filtering surface which is in communication with the insulating space 16 through the interior space of the dome 24. The filter 25 has an interior space which is closed at the upper end by a cover 27 and which is in communication with a passageway 28 defined by tubular walls 29 that join the cover 30 of the container 18. The passageway 28 preferably has a large cross-sectional area, for example, as much as one-third of the cross-sectional area of the chamber within the container 18. A suitable filter 25 may be similar to one sold under the trade name "Staynew."



Means is provided for evacuating the insulation space 16. Such means preferably is connected with the passageway 28 so that the adsorbent material 19 may be evacuated simultaneously with the insulation space 16. To this end an evacuation line 32 is secured at one end to the walls 29 and passes gas-tightly at 33 through the outer shell 11. Exteriorly the line 32 is provided with stop valves 34 and a vacuum pump coupling 35.

The filter arrangement shown is particularly useful when the filling of the insulation space is a powder of relatively fine particle size, such for example, as magnesium carbonate powder or a diatomaceous earth, one form of which is sold under the name "Silocel." The particle size of such a filler is often of the same order of size as the pores of the adsorbent material 19. Such powder would tend to clog the adsorbent material and render it ineffective. By providing an efficient large area filter membrane interposed between the interior of the container 18 and the insulation space 16, gas and vapor may flow freely from the insulation space 16 through the filter 25 and the passage 28 to the adsorbent material 19 without carrying dust particles to the adsorbent material. The filter 25 also facilitates the evacuation operation by preventing particles of the insulating powder from being carried with gas and vapor through the passage 28 and the line 32 toward the vacuum pumps. It has been found that ordinary filters interposed in the vacuum line 32 create undesired resistance to flow of attenuated gas vapor and soon clog up. The filter material 25 has so large an area that it does not clog up readily, and especially when employed in a tank car the vibration en route tends to shake off particles from the external surface of filter 25 so that they fall back into the insulation space 16.

When a container constructed as described is to have its insulation space evacuated initially, the vacuum pumps are connected at the coupling 35, the valves 34 are opened, and pumping of gas and vapor is continued until the absolute pressure in the vacuum space ceases to fall at a reasonable rate. When such initial pumping is stopped and the container is allowed to stand warm, it is found that the absolute pressure of the vacuum space rises, even though no small area leaks exist in the external shell or the inner vessel. It is believed that such rise of pressure is caused by the slow release of occluded gases and vapor. When the inner vessel, after an initial evacuation, is chilled to liquefied gas temperature such as by charging liquefied gas therein, it is found that the pressure decreases considerably, due mainly to the freezing of water vapor on the surface of the inner vessel and the consequent reduction of the vapor pressure of the moisture to a very low value. When the liquefied gas reaches the container 18, the adsorbent material 19 becomes chilled and its power to adsorb gas and vapor is greatly increased. The vacuum pumps are disconnected after the

valves 34 are shut tight, and the adsorbent material 19 then acts to keep the absolute pressure at the desired low value by adsorbing gas and vapor as they are released from the insulation material and as any air leaks in through the minute leaks that may develop in the outer shell and as any gas may leak through minor leaks in the inner vessel.

When the charge of liquefied gas is discharged from the inner vessel as by delivery to a receiving means, the upper part at least of the inner vessel will become warmed by natural heat leak and the adsorbent material 19 will tend to release or desorb some of the gas and vapor which it had previously adsorbed. After a certain amount of warming has occurred, the vacuum pumps are again connected at 35, valves 34 are opened, and the operation of re-evacuation is begun. Such re-evacuation pumping will quickly reduce the absolute pressure and also effectively desorb the adsorbent material 19. Such evacuation may be continued during the filling of the inner vessel with a new charge of liquefied gas, and when the liquefied gas level reaches the full level and the container 18 becomes chilled, the valves 34 are closed and the vacuum pumps disconnected. The adsorbent material 19 will thus have been conditioned to adsorb additional quantities of gas and vapor from the insulation space.

This re-evacuation procedure is especially useful in the operation of liquefied gas tank cars because an empty tank car tends to warm up during the time of the journey from a delivery point to the liquid oxygen plant where it is to be refilled. When such a car reaches the oxygen plant it is connected to vacuum pumps and evacuation is continued during the time that the car is being charged with liquid. The time required to fill the inner vessel is long enough for the evacuation to effectively desorb the adsorbent material 19 and reduce the absolute pressure in the insulation space 16 to a desired low value. Then during the trip of the filled tank car to a delivery point, the adsorbent material effectively maintains the absolute pressure at the desired low value throughout the entire trip so that any evaporation loss due to heat leak will be very low.

In all cases it is found preferable that the adsorbent material be maintained isolated from direct contact with the insulating material. In some cases the container of adsorbent material may be in thermal contact with the outside wall of the inner vessel. The adsorbent container 18 may also be located at a lower level, provided that the interior of the adsorbent container is connected by a large passage to one side of an extended area filter, the other side of which is in communication with the insulation space. In such cases re-evacuation is done only when the liquefied gas container is completely empty and partly warmed, the re-evacuation being discontinued when a new charge of liquefied gas enters the inner vessel.

Referring now to Fig. 3, a modification of the apparatus is illustrated which permits the re-evacuation to be efficiently carried out without completely emptying the inner container of liquefied gas. This is particularly useful for stationary storage containers.

An inner vessel 110 is supported in spaced relation to an outer shell 111 and a comminuted insulating material 116 packed in the insulation space. A container 118 for adsorbent material is disposed close to or at the bottom of the inner vessel 110. Such container 118 is lined with a moderate thickness 40 of heat insulating medium such as, for example, a layer of asbestos or glass wool, and disposed within the container 118 is an electric heater device having heating elements 42, the adsorbent material 119 being packed within the insulating liner 40 and around the heater elements 42. The liner 40 need not be a high efficiency heat insulation because some heat exchange between the adsorbent 119 and the liquefied gas is desired. An inner basket for the adsorbent providing a narrow gas space between it and the wall 118 to provide the desired insulating medium could also be employed. To the top of the container 118 there is joined the lower end of a tube 129 which passes vertically to the top of the inner vessel 110 and gastightly through a cover flange 121 which seals an opening 120 in the upper wall of the inner vessel. Above the flange 121 an expansion joint 43 is interposed in the tube 129, the upper end of the tube 129 ending in a flange 44 which is gastightly sealed to a cover plate 45. The cover plate 45 in turn seals an opening 123 in the wall of the outer shell 111 directly above the opening 120. The cover plate 45 has a central opening in alignment with the tube 129, which central opening is sealed by a cap portion 46. Electric current is supplied to the heater elements 42 through a conduit 47 that extends vertically through the tube 129 and gastightly through the top of the cap 46, and the outer end of the conduit 47 is provided with an electrical connection 48. The evacuation line 132 is connected into one side of the cap 46 and is provided with the shut-off valve 134 and vacuum pump coupling 135.

A dust filter 125 similar to the dust filter 25 of Fig. 1 is disposed within a dome 124 that covers an opening 50 in the upper part of the shell 111. In this case the central opening of the filter element 125 is closed at the bottom by a cover 127 and is provided with an extension 51 at its upper end which passes gastightly through the top of the dome 124. The upper end of the extension 51 is closed and a conduit 52 is provided connecting the extension 51 with the cap 46 in order that gas and vapor may flow from the insulation space through the filter element 125 and the conduit 52 to the tube 129. A stop valve 53 is interposed in the conduit connection 52.

This apparatus is initially evacuated when warm by coupling a vacuum pump to the coupling 135 and opening valves 134 and 53. Pumping is continued until the pressure in the insulation space fails to drop at an appreciable rate. Liquid is then charged into the inner vessel and the adsorbent material 119 gradually becomes chilled to the liquid temperature by leakage of heat through the insulation medium 40. Such adsorbent material 119 then becomes active for continuing to adsorb gas and vapor from the insulation space through the filter element 125, conduit 52, and tube 129. The valve 134 may be shut off and the vacuum pump disconnected.

After a time it will be found that the casing pressure is too high for efficient preservation of the charge of liquefied gas, then it will be preferable to reevacuate the apparatus, which may be quickly accomplished by closing the valve 53, applying the vacuum pump to connection 135, and opening valve 134, and then supplying electric power to the connection 48 to energize the heater

elements 42. The heater elements 42 will heat the adsorbent material 119 at a rate greatly in excess of the rate of loss of heat from the adsorbent material 119 through the insulating layer 40 to the liquefied gas contents of the inner vessel. In this manner the adsorbent material can be rapidly desorbed without removing the liquid from the inner vessel and without causing excessive heating of the liquefied gas. As soon as the adsorbent 119 is desorbed to a low absolute pressure, the heating is discontinued, the valve 134 is shut, and the valve 53 reopened. Gas and vapor will then again flow from the insulation space toward the adsorbent 119 to reduce and hold the pressure in the insulation space at the desired low value. If desired, the valve 53 can be opened during the evacuation of the adsorbent container toward the end of such evacuation period in order that some of the gas and vapor that initially will flow through the conduit 52 toward the cap 46 may be drawn off by the vacuum pump.

It is not essential that the tube 129 pass through the interior of the inner vessel 110 since it is contemplated that the adsorbent insulation lined container may be secured in the bottom of the inner vessel from below and the tube be wrapped around the outside wall of the inner vessel.

It has been found that at very low absolute pressure in the insulating space the particle size diameter of the insulation powder up to about .01 inch diameter has little effect on the thermal conductivity of the insulation. Above about 30 microns absolute pressure it is found that generally as the insulation particle diameter is decreased, the thermal conductivity also decreases. Thus it would appear desirable to employ very fine powders. Certain insulating powder which has an average particle diameter of .00000043 inch provides excellent thermal conductivity characteristics, but it is found to be extremely difficult to evacuate a space containing such powder since the powder moves with the gas and vapor evacuated. Diatomaceous earth insulating powders may be used which have a particle size of 200 mesh or less or .0029 inch diameter or less. It is found that diatomaceous earth insulating powders such as "Silocel," which have average particle diameters of about .000017 inch, also provide good thermal conductivity characteristics up to absolute pressures of about 500 microns but are also difficult to evacuate. However, when employed in combination with the adsorbent container according to the invention, evacuation can economically be carried out because the gas which is slowly released by such a powder is adsorbed over an indefinite period of time by the adsorbent material and because such adsorbent material can be desorbed relatively rapidly by re-evacuation.

According to the invention, insulating materials of larger particle size can also be used with advantage. For example, a perlite material, a heat-expanded crushed volcanic rock, one form of which is sold under the name "Castocell," ranging in particle size from .033 inch diameter to .001 inch diameter would provide a filling with a row packed density and a very low resistance to flow of gas and vapor during evacuation so as to provide very economical and quick evacuation operations. Further important advantages of the perlite type of insulating powder are that considerably less heat must be removed from such a powder to cool it from room temperature to the liquefied gas temperature, and therefore the evaporation loss upon refilling a container having such insulation is lower. The larger particle size filler material, however, has appreciably higher thermal conductivity at insulation space pressures above about 500 microns up to about 10,000 microns. However, according to the invention, in combination with the container of adsorbent in free gaseous communication with the insulation space, an absolute pressure below about 100 microns is easily maintained in the insulation space and it is found that at 100 microns' pressure to as low as 0.1 micron the thermal conductivity of the perlite is of the same order as that of the finest insulating powders. Thus with the perlite type insulating powder in combination with the adsorbent trap it is possible to provide a liquefied gas container which has a lower gross weight; which reduces transportation costs; which has a lower initial cost; and in which the evaporation losses of filling are lower and the efficiency of insulation can be maintained at least equally as well.

The following table provides a comparison of the evaporation losses experienced with actual tank cars for shipping liquid oxygen at various vacuums, the cars being similar in structure and the insulation space being filled with "Silocel" or perlite. The evaporation loss is given in per cent of the full capacity charge per day and the casing pressure is in microns of mercury absolute:

| Pressure | "Silocel" Loss | Perlite Loss |
|---|---|---|
| 50 | .28 | .27 |
| 100 | .33 | .33 |
| 500 | .48 | .73 |
| 1,000 | .57 | 1.01 |
| 5,000 | .92 | 1.37 |
| 10,000 | 1.16 | 1.50 |
| 1 atmo | 2.04 | 1.90 |

When the adsorbent container according to the present invention is in communication with the insulation space, pressures below 50 microns are easily maintained, the evaporation loss with perlite filling, corresponding to pressures reduced by the adsorbent from initial pressures as set forth in column 1 of the previous table, being found to be as follows:

| Initial Pressure | Pressure | Loss |
|---|---|---|
| 50 | 0.3 | .21 |
| 100 | 0.7 | .21 |
| 500 | 3 | .21 |
| 1,000 | 7 | .22 |
| 5,000 | 28 | .24 |
| 10,000 | 50 | .27 |

Pressures as low as 0.1 micron are readily provided.

The loss upon filling a warm container is an appreciable item. Where the only difference is the insulation filling material and the cars are initially at 70° F., the losses by evaporation due to cooling the inner vessel and the insulating powder adjacent to it compare as follows:

"Silocel"—8.0% of total charge.
Perlite—6.35% of total charge.

The time to reduce the casing pressure of these cars by vacuum pump from 1000 to 500 microns was 2.0 hours for "Silocel" and 1.2 hours for the perlite-filled cars, and at lower pressures the time advantage is still greater.

The great advantage of using a container of adsorbent as herein described is indicated by an

example of a tank car that had a relatively high rate of leakage into the insulation space which was filled with "Silocel." Without adsorbent the pressure rise in the insulation space was 200 microns per day when the inner vessel was full of liquid oxygen. With adsorbent, the same car with the same leak had a pressure rise in the insulation space of only 0.7 micron per day. It was found that air leakage of only one cubic foot measured at normal temperature and pressure would raise the casing pressure to about 500 microns but with the adsorbent combination over 100 cubic feet of air leakage could occur before the casing pressure reached 500 microns.

It is seen that the filter element 25 is maintained in spaced relation to the powder filling. This is an important feature as it permits accumulated particles to drop off the filter surface and thus keep it more pervious to gas. It also permits the movement of the filter surface due to pumping and to vibration to shake off accumulated material.

While any good adsorbent material may be used, it is preferable to employ one that is noncombustible and which has good adsorptive properties for air and moisture. An activated silica gel is preferred which has adsorptive capacities at —183° C. measurable as cc. at normal temperature and pressure of air adsorbed per cc. of adsorbent at certain absolute equilibrium pressures which are of the order of 25 to 40 cc. of air at 500 microns of mercury, 14 to 19 cc. of air at 100 microns, and 4.5 to 8.8 cc. at 30 microns.

While two embodiments of exemplary apparatus have been illustrated in order to disclose the principles of the present invention, it will be understood that various modifications may be made without departing from the essentials of the invention.

What is claimed is:

1. A container for holding a body of liquefied gas having a boiling point at atmospheric pressure below 233° K. comprising in combination an inner vessel for holding the body of liquefied gas; a larger gas-tight shell extending about said inner vessel and providing therewith an intervening evacuatable insulation space, the walls of said vessel and shell being sufficiently rigid to sustain the respective fluid pressures acting thereon; a filling of finely divided solid material in said insulation space; means for supporting said inner vessel in spaced relation to the shell independently of said filling; conduit means communicating with said vessel and extending through said insulation space to the exterior of said shell, said insulation space being evacuated to a combined gas and vapor pressure therein below one millimeter of mercury absolute; a container holding a body of adsorbent material that adsorbs and retains substantial amounts of gas and vapor when subject to the temperature of said body of liquefied gas, said container being disposed in heat exchange relation to said inner vessel; means defining a passage between said container and the insulation space, said passage providing free gas and vapor communication between the adsorbent contents of said container and said insulation space; and a dust filter interposed in and across said passage and positioned therein out of direct contact with the adsorbent material and the finely divided solid material in said insulation space.

2. An apparatus for holding a body of liquefied gas according to claim 1 which includes a valve controlled branch conduit adapted for connection to evacuation means, said branch conduit being connected to said passage means at a point between said adsorbent and said dust filter.

3. An apparatus substantially as defined in claim 1 in which said passage means providing communication between the adsorbent and said insulation space also has a stop valve interposed therein.

4. An apparatus substantially as defined in claim 1 in which said passage means is provided with a branch connection adapted for connection to evacuation means; and means is associated with said adsorbent container for controllably heating the adsorbent material to facilitate desorption.

5. A container for holding a body of liquefied gas having a boiling point at atmospheric pressure below 233° K. comprising in combination an inner vessel for holding the body of liquefied gas; a larger gas-tight shell extending about said inner vessel and providing therewith an intervening evacuatable insulation space, the walls of said vessel and shell being sufficiently rigid to sustain the respective fluid pressures acting thereon; a filling of finely divided solid material in said insulation space; means for supporting said inner vessel in spaced relation to the shell independently of said filling; conduit means communicating with said vessel and extending through said insulation space to the exterior of said shell, said insulation space being evacuated to a combined gas and vapor pressure therein below one millimeter of mercury absolute; a container holding a body of adsorbent material that adsorbs and retains substantial amounts of gas and vapor when subject to the temperature of said body of liquefied gas, said container being disposed in heat exchange relation to said inner vessel; means defining a passage between said container and the insulation space, said passage providing free gas and vapor communication between the adsorbent contents of said container and said insulation space; and a dust filter interposed in and across said passage and positioned therein out of direct contact with both the adsorbent material and the filling of finely divided material in the insulation space; said filling comprising mainly a processed perlite such as "Castocell" having a particle diameter between about .001 inch to about .033 inch.

6. A container for holding a body of liquefied gas having a boiling point at atmospheric pressure below 233° K. comprising in combination an inner vessel for holding the body of liquefied gas; a larger gas-tight shell extending about said inner vessel and providing therewith an intervening evacuatable insulation space, the walls of said vessel and shell being sufficiently rigid to sustain the respective fluid pressures acting thereon; a filling of finely divided solid material in said insulation space; means for supporting said inner vessel in spaced relation to the shell independently of said filling; conduit means communicating with said vessel and extending through said insulation space to the exterior of said shell, said insulation space being evacuated to a combined gas and vapor pressure therein below one millimeter of mercury absolute; a container holding a body of adsorbent material that adsorbs and retains substantial amounts of gas and vapor when subject to the temperature of said body of liquefied gas, said container being disposed in heat exchange relation to said inner vessel; means defining a passage between said container and the insulation space, said

passage providing free gas and vapor communication between the adsorbent contents of said container and said insulation space; and a dust filter interposed in and across said passage and positioned therein out of direct contact with both the adsorbent material and the filling of finely divided material in the insulation space; said filling having mainly a minimum particle size substantially larger than the average pore size of said adsorbent material.

7. A container for holding a body of liquefied gas having a boiling point at atmospheric pressure below 233° K. comprising in combination an inner vessel for holding the body of liquefied gas; a larger gas-tight shell extending about said inner vessel and providing therewith an intervening evacuatable insulation space, the walls of said vessel and shell being sufficiently rigid to sustain the respective fluid pressures acting thereon; a filling of finely divided solid material in said insulation space; means for supporting said inner vessel in spaced relation to the shell independently of said filling; conduit means communicating with said vessel and extending through said insulation space to the exterior of said shell, said insulation space being evacuated to a combined gas and vapor pressure therein below one millimeter of mercury absolute; a container holding a body of adsorbent material that adsorbs and retains substantial amounts of gas and vapor when subject to the temperature of said body of liquefied gas, said container being disposed in heat exchange relation to said inner vessel; means defining a passage between said container and the insulation space, said passage providing free gas and vapor communication between the adsorbent contents of said container and said insulation space; and a dust filter interposed in and across said passage and positioned therein out of direct contact with both the adsorbent material and the filling of finely divided material in the insulation space; said filling being a diatomaceous earth powder having a particle size of 200 mesh or less or .0029 inch diameter or less.

8. A container for holding a body of liquefied gas having a boiling point at atmospheric pressure below 233° K. comprising in combination an inner vessel for holding the body of liquefied gas; a larger gas-tight shell extending about said inner vessel and providing therewith an intervening evacuatable insulation space, the walls of said vessel and shell being sufficiently rigid to sustain the respective fluid pressures acting thereon; a filling of finely divided solid material in said insulation space; means for supporting said inner vessel in spaced relation to the shell independently of said filling; conduit means communicating with said vessel and extending through said insulation space to the exterior of said shell, said insulation space being evacuated to a combined gas and vapor pressure therein below one millimeter of mercury absolute; a container charged with a body of adsorbent material such as silica gel and mounted at an upper portion of said inner vessel such that the adsorbent therein is in heat exchanging relation to liquefied gas when the inner vessel is charged with the body of liquefied gas to a desired filling level; means providing free gas and vapor communication between the adsorbent contents of said container and said insulation space; and a dust filter interposed in said communication means.

9. A container for holding a body of liquefied gas having a boiling point at atmospheric pressure below 233° K. comprising in combination an inner vessel for holding the body of liquefied gas; a larger gas-tight shell extending about said inner vessel and providing therewith an intervening evacuatable insulation space, the walls of said vessel and shell being sufficiently rigid to sustain the respective fluid pressures acting thereon; a filling of finely divided solid material in said insulation space; means for supporting said inner vessel in spaced relation to the shell independently of said filling; conduit means communicating with said vessel and extending through said insulation space to the exterior of said shell, said insulation space being evacuated to a combined gas and vapor pressure therein below one millimeter of mercury absolute; a container charged with a body of adsorbent material such as silica gel and mounted at an upper portion of said inner vessel such that the adsorbent therein is in heat exchanging relation to liquefied gas when the inner vessel is charged with the body of liquefied gas to a desired filling level; a large area dust filter having a filter element mounted so that one side thereof is in free communication with said insulation space; means defining an unimpeded passageway connecting the interior of said adsorbent container and the other side of said filter element, said passageway having a minimum cross-sectional area that is equal to at least a substantial fraction of the cross-sectional area of said container; and an evacuation line connected to said passageway between the filter element and said container, said line being normally sealed externally of said outer shell.

10. A container for holding a body of liquefied gas having a boiling point at atmospheric pressure below 233° K. comprising in combination an inner vessel for holding the body of liquefied gas; a larger gas-tight shell extending about said inner vessel and providing therewith an intervening evacuatable insulation space, the walls of said vessel and shell being sufficiently rigid to sustain the respective fluid pressures acting thereon; a filling of finely divided solid material in said insulation space; means for supporting said inner vessel in spaced relation to the shell independently of said filling; conduit means communicating with said vessel and extending through said insulation space to the exterior of said shell, said insulation space being evacuated to a combined gas and vapor pressure therein below one millimeter of mercury absolute; a container holding a body of adsorbent material that adsorbs and retains substantial amounts of gas and vapor when subject to the temperature of said body of liquefied gas, said container being disposed in heat exchanging relation to the liquefied gas in said inner vessel and being provided with a liner constructed to retard heat exchange between the adsorbent material and the liquefied gas; passage means providing gas and vapor communication between the adsorbent in said container and said insulation space, said passage means having an evacuation connecting means; and heating means associated with said container for controllably heating said adsorbent to facilitate desorption.

11. An apparatus substantially as defined in claim 10, in which there is interposed in said passage means an extended area dust filter and a stop valve.

12. A container for holding a body of liquefied gas having a boiling point at atmospheric pres-

sure below 233° K. comprising in combination an inner vessel for holding the body of liquefied gas; a larger gas-tight shell extending about said inner vessel and providing therewith an intervening evacuatable insulation space, the walls of said vessel and shell being sufficiently rigid to sustain the respective fluid pressures acting thereon; a filling of finely divided solid material in said insulation space; means for supporting said inner vessel in spaced relation to the shell independently of said filling; conduit means communicating with said vessel and extending through said insulation space to the exterior of said shell, said insulation space being evacuated to a combined gas and vapor pressure therein below one millimeter of mercury absolute, said shell being formed to provide a powder-free space above the finely divided solid material which fills all said insulation space except such powder-free space; a large area dust filter having a filter element disposed in said powder-free space with one surface of said element exposed in said powder-free space and arranged so that particles tending to accumulate thereon may drop off, said dust filter having a chamber with walls in part defined by said filter element and walls otherwise sealing the chamber from said powder-free space; and an evacuation line communicating with said filter chamber and extending to a point external of said casing, said line being provided with sealing means and vacuum pump coupling means.

13. A process for the evacuation of gas and vapor from a powder-filled insulation space between an outer shell and an inner vessel for holding and transporting a body of liquefied gas at low temperature, which process comprises providing and maintaining a body of adsorbent material such as silica gel in gaseous communication with such insulation space; evacuating said insulation space and the adsorbent material to a low absolute pressure; cooling the inner vessel and charging same with a body of liquefied gas; during said charging, effecting heat transfer between the later charged liquefied gas and said adsorbent material to cool same only by the last portions of liquefied gas charged; discharging a major portion of the body of liquefied gas to receiving means; providing access of heat to said adsorbent material to warm it above the temperature of the liquefied gas; subjecting the body of adsorbent and the insulation space to further evacuation; and then repeating the charging of the inner vessel with another body of the liquefied gas so as to recool said body of adsorbent by effecting heat exchange between it and the last portions of liquid charged to cause same to adsorb further quantities of gas and vapor from said insulating space and thereby maintain the absolute pressure therein at a desired low value.

14. A process for the evacuation of a powder-filled insulating space according to claim 13 in which said last-mentioned evacuation is continued during the charging until said adsorbent body is so cooled.

15. A process for the evacuation of gas and vapor from a powder-filled insulation space between an outer shell and an inner vessel for holding and transporting a body of liquefied gas at low temperature, which process comprises providing and maintaining a body of adsorbent material such as silica gel in gaseous communication with such insulation space and in heat transfer relation to the liquefied gas; evacuating said insulation space to a low absolute pressure; cooling the inner vessel and charging same with liquefied gas, said adsorbent becoming chilled and acting to adsorb gas and vapor from the insulation space; shutting off gaseous communication between the adsorbent and insulation space; subjecting the adsorbent to evacuation; heating the adsorbent during such evacuation while retarding flow of heat from the adsorbent to the liquefied gas; when the adsorbent has been desorbed, opening gaseous communication between the adsorbent and the insulation space and stopping said heating, the adsorbent then gradually becoming cooled and acting to adsorb more gas and vapor from said insulation space.

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