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Johnson et al.

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[54] **CRYOGENIC STORAGE DEWAR**

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[52] **U.S. Cl.** .....**62/45**, 62/50, 62/51, 220/9 LG, 220/15

[51] **Int. Cl.**.....**F17c 7/02**

[58] **Field of Search** .....220/9 LG, 9 D, 10, 15; 62/45

[56] **References Cited**

UNITED STATES PATENTS

3,304,729	2/1967	Chandler et al.	62/45
2,814,410	11/1957	Hanson	220/15
2,871,669	2/1959	Mann et al.	220/10 X
3,460,706	8/1969	Hoover	220/15

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[57] **ABSTRACT**

A non-continuous venting dewar for safely storing a cryogenic fluid during a prolonged period of transit with minimized evaporation of the cryogenic fluid. The dewar is characterized in that between the inner storage tank of the traditional vacuum-jacketed cryogenic storage dewar and the outer shell thereof, there is placed a plurality of spaced-apart radiation shields, the innermost of which is of relatively greater mass than the others and can be reduced in temperature to approximately the level of the stored cryogenic fluid as the dewar is filled.

7 Claims, 2 Drawing Figures

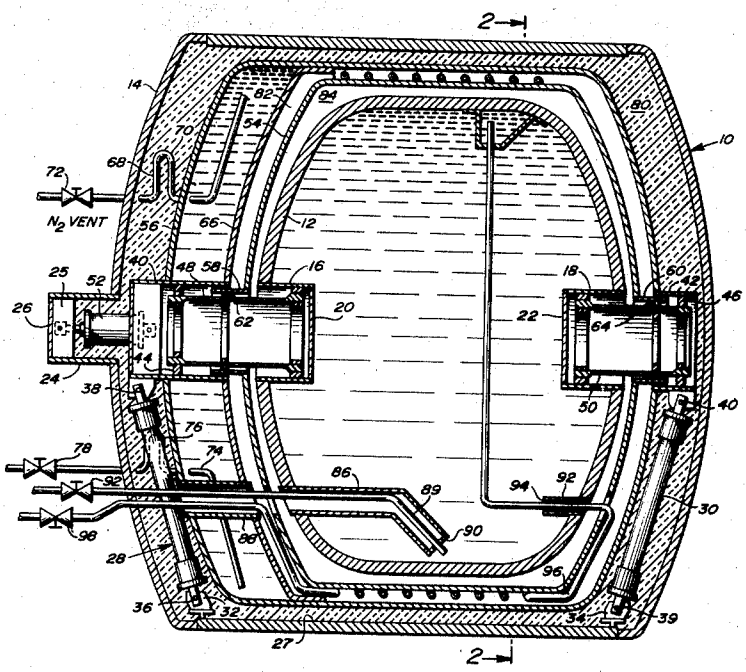
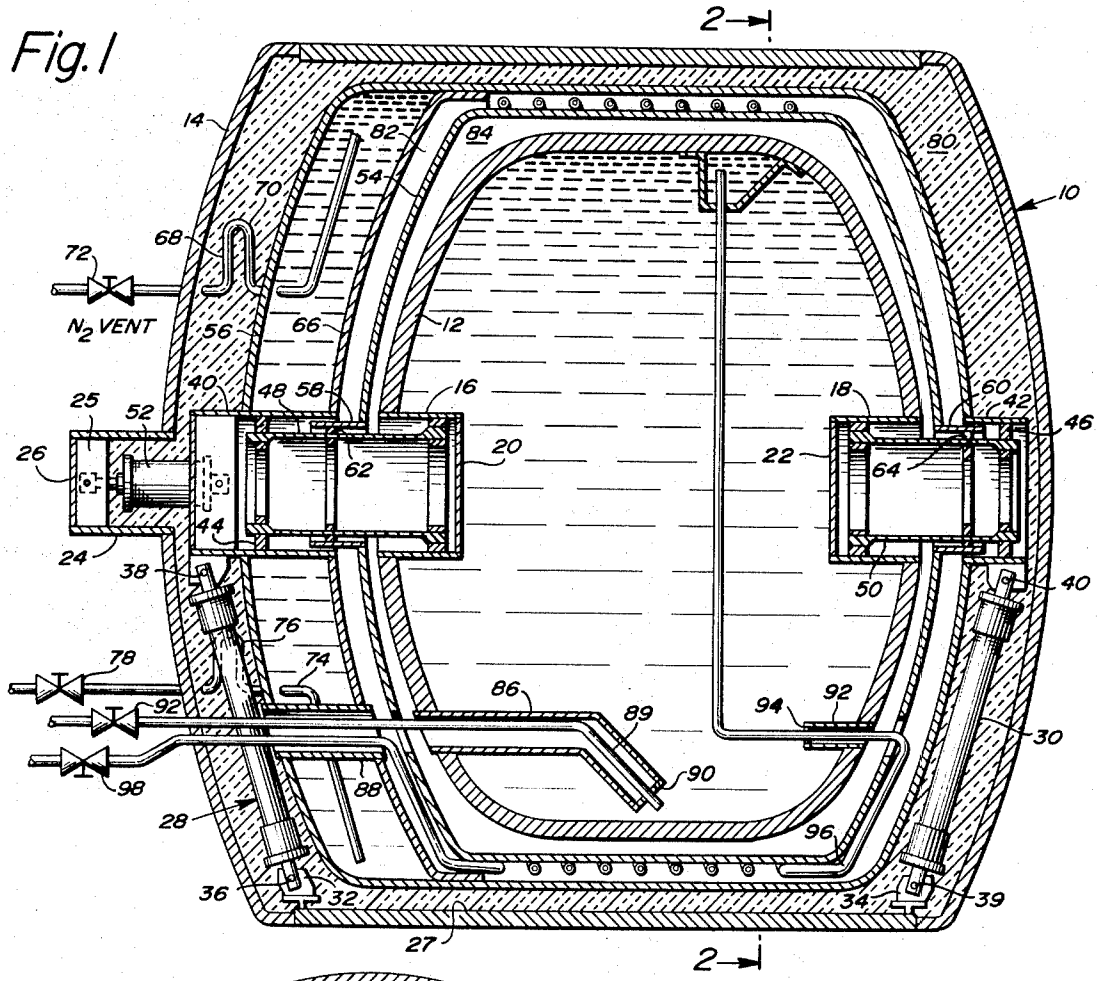


Fig. 1



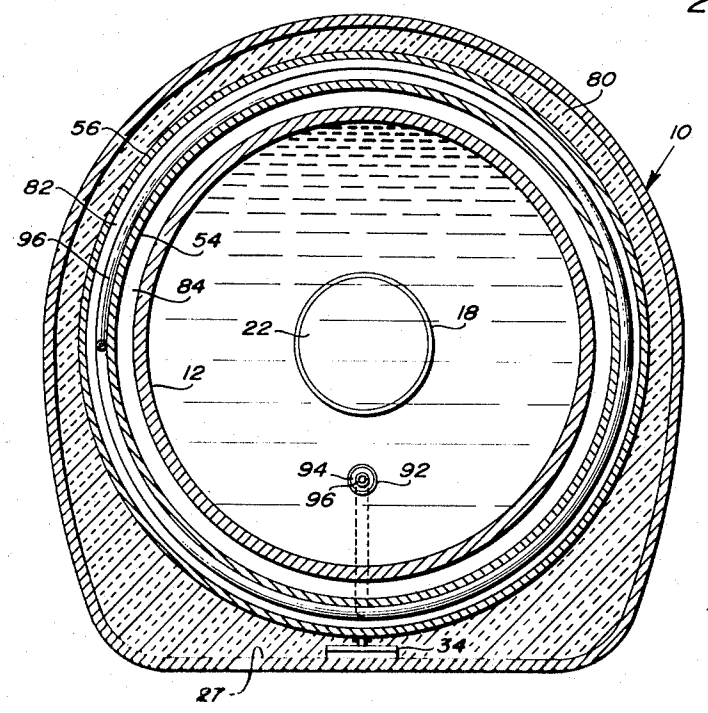


Fig. 2

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CRYOGENIC STORAGE DEWAR

BACKGROUND OF THE INVENTION

This invention pertains to cryogenic storage dewars of the vacuum-jacketed type suitable for storing cryogenic fluids, such as liquid helium, for transportation from the source of filling the cryogenic fluid to the point of use.

Examples of such dewars are shown in U.S. Pat. Nos. 3,119,238 and 3,304,729. In the prior art devices there is usually an inner tank for holding the cryogenic fluid. Surrounding the inner tank in spaced apart relationship therefrom is a shell. Disposed within the shell are generally a plurality of spaced-apart radiation shields for preventing heat influx to the inner storage tank. The dewar also contains a source of a second cryogenic fluid surrounding either the inner tank or one of the radiation shields to provide additional insulation to prevent heat influx to the inner tank. Those portions of the dewar inside the shell that do not contain liquid are generally evacuated to further aid in the insulation of the inner tank from ambient temperature. In the storage and transportation of liquid helium in prior art dewars, it has generally been necessary to continuously vent the inner tank during storage and/or transit so that excessive vapor pressure does not buildup within the inner tank due to evaporation of the helium. The evaporation takes place since no system can prevent some heat buildup within the inner tank. The prior art tanks have utilized the venting gas to cool the radiation shields in order to prevent excessive heat leak into the inner tank and consequently excessive loss of the stored cryogenic fluid, e.g., liquid helium.

In spite of the venting of the helium around the radiation shield it has been extremely difficult to transport liquid helium over great distances without a large loss of helium. For example, if a dewar of the prior art type is filled with helium in Kansas and the dewar was then shipped by ocean going vessel to Japan or to Great Britain it is expected that about 20 percent of liquid helium would boil away prior to the dewar reaching its destination.

SUMMARY OF THE INVENTION

In order to overcome the above described problems and to provide a more effective method and apparatus for transporting cryogenic fluids over long distances it has been discovered that if the innermost radiation shield of the dewar is of relatively greater mass than the other self-supporting radiation shields and this shield is brought to the temperature of the stored cryogenic fluid as the vessel is filled, it is possible to then seal the dewar and to thereby minimize vaporization loss of the cryogenic fluid during an extended period of transit to destination. In effect since the stored fluid is not continually vented to the atmosphere and the pressure buildup is slow during transit the entire quantity of liquid put into the tank is delivered to the destination in the form of liquid plus the vapor buildup.

The massive shield between the storage tank and the remaining radiation shields in effect creates a large heatsink which drastically reduces the radiant influx to the inner tank.

Therefore, it is the primary object of this invention to provide an improved cryogenic storage dewar.

It is another object of this invention to provide a cryogenic storage dewar that minimizes loss by evaporation of cryogenic fluid during extended periods of transit of the dewar.

It is still another object of this invention to provide a method and apparatus for conservation of liquid helium by allowing a slow contained pressure buildup during extended periods of storage without requiring venting of the vaporized helium.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a cross-sectional view of a cryogenic storage dewar according to the present invention.

FIG. 2 is a section taken along line 2—2 of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawing and in particular to FIG. 1, there is shown a cryogenic storage dewar **10** comprising an inner tank **12** and an outer shell **14**. The inner tank **12** contains hollow cylindrical support members **16, 18**. The support members **16, 18** are fastened to the inner tank **12** as by welding at the surface by suitable circumferential welds not shown. The members **16, 18** have suitable closure heads **20, 22** respectively to prevent escape of the fluid from the inner tank **12**. The outer shell **14** contains a suitable end closure **24** with an end cover **26** to facilitate construction of the tank as is well-known in the art. Disposed in the bottom surface **27** of the shell **14** are a plurality of pinned radial support struts shown generally as **28** and **30**. The support struts **28** and **30** are fastened at the bottom by a suitable plate **32, 34** as by pinned connectors **36** and **39** respectively. At the upper end struts **28, 30** are similar pin connections **38, 40** which are in turn connected to hollow cylindrical support members **40** and **42** respectively. The hollow support members **40, 42** have suitable receiving members **44, 46** for engaging hollow elongate trunions **48, 50** for supporting the inner vessel in spaced relationship from the shell **14**. The hollow elongate members **48, 50** are generally fabricated from a non-metallic material such as an epoxy glass resin to minimize heat infiltration by conduction.

Cylindrical member **40** is secured to the end cap **26** as by strut **52** which is pinned to structural member **25** which is fastened as by welding to member **24** to assure positive positioning of the inner vessel as is well-known. At the opposite end there is provided suitable slide connections between the radiation shields **54** and **56** and the trunion **50** to allow for normal expansion and contraction of the inner vessel.

Disposed between the inner tank **12** and the outer shell **14** are radiation shields **54** and **56**. The radiation shield **54** is carried by sleeve members **58** and **60** that are spaced apart from the hollow trunion members **48, 50** by spacers **62, 64** respectively to provide optimum insulation of the radiation shield **54** in respect to the other members of the dewar. Between radiation shield **54** and outer shell **14** there is disposed radiation shield **56** which is carried by hollow cylindrical support members **40** and **42** respectively.

Radiation shield **56** has spaced apart from it on the closure end of the dewar **10** a second complimentary member **66**, which with the complimentary portion of shield **56** forms a storage vessel for a second cryogenic

fluid. This source of second cryogenic fluid has a vent pipe 68 containing a liquid trap 70 and a control valve 72 outwardly of the dewar. The second cryogenic storage tank has a fill pipe 74 which also contains a liquid trap 76 and an outside valve 78.

The spaces 80, 82 and 84 are evacuated. The spaces 80, 82, and 84 may contain what is known in the art as super-insulation such as layers of a plastic material between which are layers of aluminum foil. It is preferable to provide suitable insulation in space 80.

The inner tank 12 has disposed therein a fill pipe 86 the lower end of which is disposed at an angle toward the bottom of the tank 12. Contained within the fill pipe 86 is a fill conduit 89 which passes through end cap 90 of fill pipe 86. The conduit 89 passes through a further pipe 88 which passes through the second cryogenic fluid tank and is sealed to prevent loss of the second cryogenic fluid but enabling the conduit 89 to pass outwardly of the dewar to a valve 92 for filling the inner tank. Disposed within the lower portion of tank 12 is a second conduit 96 that is contained within a pipe 92 which contains an end cap 94 to prevent leakage of the stored cryogenic fluid out of the tank 12. The conduit 96 passes through the second radiation shield 54 and is disposed there around for at least a major portion of the surface and then passes outwardly of the tank through pipe 88 and to a control valve 98. Conduit 96 can be replaced with a plurality of parallel wound conduits which serve to increase the flow area of the cryogenic fluid from tank 12. The pipes 92, 86, and 88 are constructed so that the inner areas thereof are evacuated for additional vacuum insulation of the fill and vent pipes 88 and 96 respectively.

The inner tank 12 may also be provided with a safety pressure relief valve to the atmosphere (not shown) in order to satisfy existing transportation regulations.

The cryogenic dewar described in connection with FIG. 1 and FIG. 2 is ideally suited for transporting liquid helium over long distances. For example, liquid helium has been transmitted from the filling station in the state of Kansas to a user in Japan without the need for continual venting of the inner tank and consequently loss of precious helium.

After the cryogenic dewar has been constructed and tested to see that there are no leaks and that all vacuum systems are secure the dewar is sent to the place for receiving the charge of liquid helium. At the liquid helium filling station the second cryogenic storage area is filled through valve 78 and conduit 74 with a second cryogenic fluid such as liquid nitrogen. When this second vessel is completely filled with liquid nitrogen, the valve 78 is closed and the control valve 72 set. The inner tank 12 is then purged with helium. After purging, the source of helium is connected to conduit 89 via valve 92. Valve 98 is opened and valve 92 opened to commence the flow of liquid helium into the tank 12. As the liquid helium enters the tank 12 vapor is expelled therefrom and when the liquid helium reaches the level of that portion of conduit 96 communicating with the interior portion of tank 12 helium begins to flow into conduit 96 and is conducted throughout the entire length of conduit 96 and outwardly of the dewar through valve 98. Because the cold helium is flowing in the conduit 96, which is intimate contact with radiation shield 54, radiation shield 54, which is of greater mass than radiation shield 56, is brought to approximately the temperature of liquid helium i.e., 4° K. When the inner tank 12 is filled with liquid helium, valves 92 and 98 are closed.

With the vessel now filled, it can be safely loaded aboard the proper form of conveyance for transportation to destination. The radiation shield 54, having been brought to approximately the temperature of the liquid helium, it functions as a large heatsink for preventing heat influx to the inner tank 12. The second cryogenic liquid (nitrogen) prevents large heat influx to shield 54. Over-all heat loss is minimized because of the various vacuum-jacketed areas 80, 82, 84 and the multi-layer insulation within the vacuum spaces.

With a tank as described above, filled with liquid helium it has been found that in a period of 30 days covering transportation from the filling station in the state of Kansas to the point of use in Japan that the pressure buildup within tank 12 was no more than 90 PSIG. This pressure buildup is well within existing safety regulations and obviates the need for continual venting of the inner tank 12 thereby minimizing the loss of helium. The liquid inventory has changed but the total inventory of helium remains constant.

It has been found that the relative difference in mass between self-supporting radiation shields as known in the prior art and the radiation shield closest to the inner tank of this invention should be about 1 to 40.

With the dewar of the instant invention there is an overall conservation of helium because the inner radiation shield is brought to equilibrium when it is being filled and not by a continual venting procedure. It has been shown that by doing this although some helium is lost initially during the filling operation, it can be recycled for future use, whereas the continually vented helium is lost to the atmosphere.

Having thus described our invention what is claimed is

We claim:

1. A dewar for transporting cryogenic fluid with minimum loss by evaporation of the fluid comprising in combination:

an inner tank for receiving and holding the cryogenic fluid;

an outer shell spaced apart from and surrounding said inner tank in vacuum tight relationship thereto;

low conductivity means for supporting said inner tank in spaced relationship from said outer shell;

means for preventing heat influx into said inner tank, said means comprising a massive self-supporting radiation shield spaced apart from and surrounding said inner vessel with venting means disposed around a major portion of the surface of said shield, said venting means for venting said inner vessel outwardly of the dewar so that said radiation shield can be precooled during filling of the inner vessel to about 4° K, thereby acting as a large heatsink to prevent heat influx into the inner vessel;

a second radiation shield spaced apart from and between said first shield and said shell;

means for filling said inner vessel; and

means for holding a second volume of cryogenic fluid against a portion of the surface of said second shield.

2. A vessel according to claim 1 wherein the second volume of cryogenic fluid is held in a vessel defined by a portion of the surface of the second shield and a spaced apart complimentary structural member.

3. A vessel according to claim 1 wherein the inner vessel is supported by a system including hollow elongate trunions of low conductivity material between said inner vessel and said low conductivity support means on the inner surface of said outer shell to minimize heat conduction to said inner vessel.

4. A vessel according to claim 1 wherein said inner vessel surfaces and said radiation shield surfaces exposed to the vacuum are coated with a low emissivity coating.

5. A vessel according to claim 1 wherein between said outer shell and said second radiation shield there is disposed a multi-layer super insulation.

6. A method for transporting a cryogenic fluid over long distances in a storage dewar having an inner vessel including a filling conduit, to hold the cryogenic fluid, spaced apart and in vacuum tight relation with the inner vessel an outer shell with at least one radiation shield of significant mass to act as a heatsink when precooled to approximately 4° K and having an inner vessel vent conduit in intimate contact with a major portion of said shield comprising the steps of:

introducing into the inner vessel the cryogenic fluid to be transported;

allowing a portion of the cryogenic fluid to escape from the vent during filling of the vessel to precool the radiation shield and establish the heatsink;

filling the inner vessel to capacity;

sealing the inner vessel, filling and venting conduits to prevent further escape of the cryogenic fluid; and

transporting the dewar to destination.

7. A method according to claim 6 wherein the first cryogenic fluid is helium and the second cryogenic fluid is nitrogen.

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