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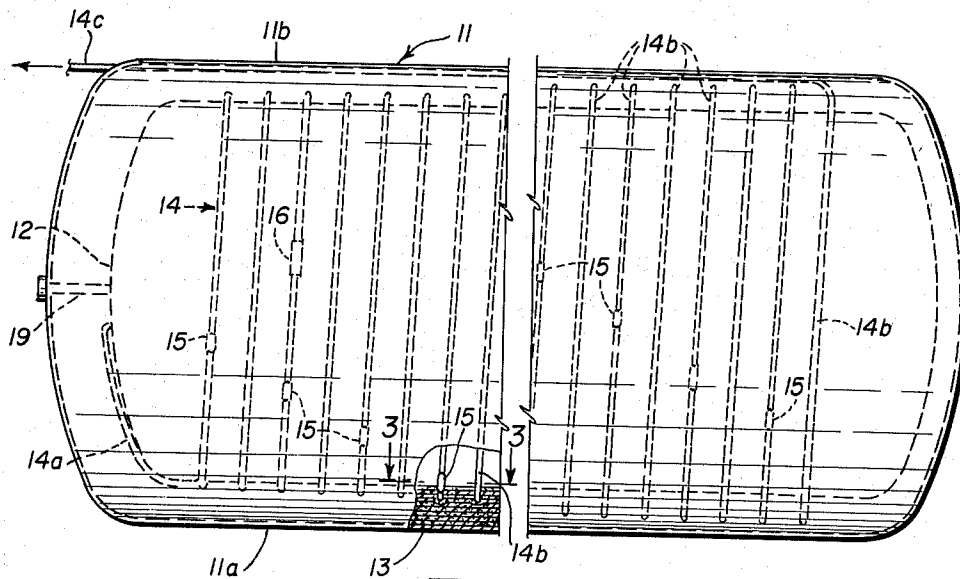


Fig - 1

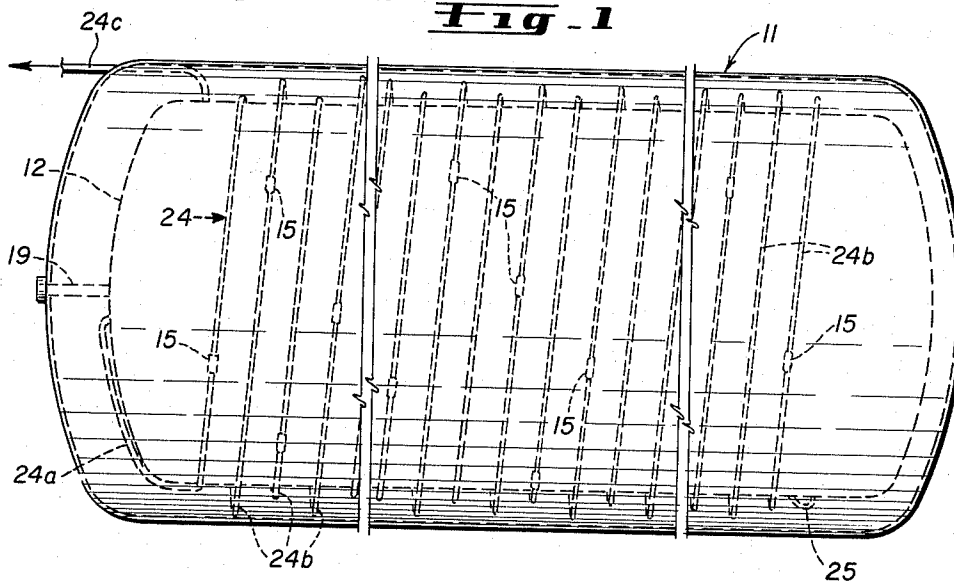


Fig - 2

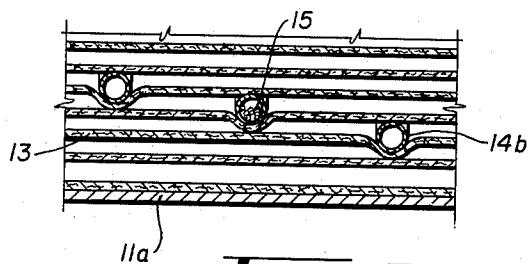


Fig - 3

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GAS REFRIGERATED STORAGE CONTAINER AND INSULATION SYSTEM FOR SUCH CONTAINERS

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6 Claims. (Cl. 62-54)

This invention relates to a storage container for cryogenic fluids and to an insulation system for such containers.

Containers of the dewar type are used extensively for storage of cryogenic fluids and other materials maintained at low temperatures. In order to prevent any substantial heat leak between the inner container and the outer shell portion, a variety of support systems are employed and various types of insulation materials have been utilized in the space between the inner and outer members, usually in conjunction with gas evacuation. It also has been proposed to employ gas release for its refrigerating effect in structures of the dewar type, but in the arrangements developed to date, such systems have been effective only at limited temperature levels.

The present invention represents an innovation over prior practice in combining laminated insulation material with a special type of conduit system disposed within the insulation filling the space between the inner and outer members and by the combination of the structural arrangement and controlled gas release and catalytic conversion of para to ortho hydrogen for hydrogen containers. My invention attains maximum utilization of the cold gas in a simple manner.

Accordingly, it is the object of my invention to provide a novel type of container for low temperature storage of material which utilizes controlled gas cooling to maintain desired temperatures in the storage receptacle for protracted periods.

Another object of my invention is to provide a simple, durable and efficient gas cooled insulation system for storage containers of the dewar type which effectively minimizes heat leaks between an inner container and an outer shell over protracted intervals.

Other objects and advantages reside in novel details of construction and novel combinations and arrangements of parts, all of which will be set forth in the course of the following description.

The practice of my invention will be described with reference to the accompanying drawings illustrating a typical structural embodiment. In the drawings:

FIG. 1 is a side elevation of one embodiment of a storage container for cryogenic liquids utilizing the gas cooled insulation system of my invention, inclusive of a spiral-wound conduit of progressively increasing diameter in a downstream direction and partially broken to show the arrangement of parts comprising the insulation system;

FIG. 2 is a side elevation of another embodiment of storage container for cryogenic liquids utilizing a conduit in which the spiral winding arrangement is repeated in an opposite direction along the length of the container; and

FIG. 3 is a developed section taken along the line 3-3 of FIG. 1.

FIG. 1 illustrates a typical installation utilizing the gas cooled insulation system of my invention. As shown, a dewar-type storage container comprising an outer shell or member 11 substantially encloses an inner container or member 12 for storage of material to be maintained

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at cryogenic temperatures, including a cryogenic liquid (not shown). Outer member 11 is closed on its sides 11a and both ends 11b so as to permit gas evacuation of the space between said members after final assembly.

Container 12 is of smaller diameter than the shell 11 and is supported in any suitable manner (not shown) in substantially uniformly spaced relation to shell 11. Container 12 is covered by laminated insulation 13 and in a typical installation this may comprise on the order of fifty wraps of glass paper and aluminum foil laminates. A continuous tube or conduit 14 of heat-conductive composition is wrapped within the insulation 13, and has an inlet portion 14a in advance of a convoluted portion 14b encompassing the portion of container 12 within shell 11, and an exterior discharge portion 14c for the final gas release.

In the arrangement shown, I dispose catalyst beds 15 at intervals along the conduit, with more frequent intervals at the upstream end, for example, at five foot intervals and at greater intervals through the remainder of the convoluted portion, for example, at ten feet, and in a preferred form, the extreme downstream portion within the enclosed space may have a spacing interval on the order of twenty feet. A typical installation as described may have a total line length of two hundred and fifty feet wrapped in the insulation at a spacing of two inches per convolution, for example, and containing twelve beds of catalyst. The first five beds were placed at 5 foot intervals, the next four at 10 foot intervals and the last three at 20 foot intervals. Such spacing is indicated in FIG. 1, although the intervals shown are not to scale.

Different materials may be utilized in forming such a line. The first or upstream portion may be stainless steel tubing, and the remainder copper tubing joined by a suitable coupling 16. As the convoluted portion 14b is wrapped spirally along the length of container 12 in a progressively increasing diameter toward its downstream end, there is only one thickness of tubing at any increment of length in the space between side 11a of the outer member and the container 12.

The catalyst is used to take advantage of the back conversion of para to ortho hydrogen resulting in an increase in the amount of refrigeration available in the system. With the arrangement described, the cold boil-off gas moves progressively through tubular portion 14b to the exterior discharge portion 14c with the cold gas available at successively higher temperature levels. I obtain the maximum utilization of the cold gas from this arrangement. Various catalyst compositions may be utilized in the system, such as hydrous ferric oxide, hydrous chromic oxide, and various nickel catalysts. I have found hydrous ferric oxide to be particularly effective in such a system. It should be understood that if the storage container is not to be used with hydrogen no catalyst would be required or desirable.

A dewar-type container of the type shown in FIG. 1 may be installed for operation at any required site and will have the voids in insulation 13 gas evacuated when it is to begin operation. The interior of container 12 will contain the material or fluid to be maintained at low temperatures, for example, liquid (para) hydrogen, and the flow of such fluid through line 14 is regulated either by a valve (not shown) or by limiting the size of the passage in conduit 14 and the fill of catalyst beds 15. Once started, the flow through conduit 14 is continuous to provide the aforementioned continuous gas refrigeration and restrict heat exchange between the inner and outer members.

The arrangement shown and described refrigerates at

all available temperature levels from the temperature of the boiling liquid to ambient temperature and utilizes the refrigeration available on warming the liquid hydrogen from 20° K. to approximately 300° K. While the conversion loads are small, I have found that the more active the catalyst, the less is required, and in a typical installation, the beds 15 will be on the order of one inch in length. The conversion of para to ortho hydrogen results in an increase in the amount of refrigeration available, and I have found it advantageous to have the conversion at lower temperatures. Consequently, I provide more beds at closer intervals along the upstream end of portion 14b where they are disposed close to inner container member 12 and at a distance from shell 11.

In order to demonstrate the effectiveness of the aforesaid system, a unit of the type shown in FIG. 1 was subjected to comparative testing by providing gas cooling in one operation and operating without gas cooling in the next as though the gas-cooling tube had been omitted from the assembly. The boil-off rate with gas cooling was measured as 1.03% and without such cooling, it was 2.06%. Thus, it is evident that the utilization of the present invention provides a desirable low boil-off rate.

FIG. 2 illustrates another form of dewar-type container utilizing features of my invention. This container also is shown as having catalyst beds 15 in the gas-cooling tube, but it will be understood that such beds are not provided when cryogenic fluids other than liquid hydrogen are stored in the container. As the assembly shown in FIG. 2 differs from FIG. 1 only in the tube winding details similar reference numerals have been applied to all duplicate components.

The gas-cooling tube 24 of FIG. 2 comprises an inlet portion 24a, a convoluted portion 24b and an exterior discharge portion 24c. Again in this form the initial upstream winding or wrap is disposed in close proximity to the exterior surface of inner member 12 and succeeding wraps widen progressively in the downstream direction to an intermediate point 25 near the opposite end of inner member 12, where the tubing is bent at a substantial angle and wound in a reverse direction but at the same pitch and in a progressively widening diameter with the convolutions of the reverse winding located about midway between the convolutions located upstream from point 25.

It will be noted that the spacing between turns in the convoluted portion extending to point 25 is substantially greater than in the FIG. 1 arrangement, and may be four inches rather than the two inch spacing of the example previously given. Each turn or wrap between inlet portion 24a and point 25 will be disposed between different layers of the laminar insulation and the same will be true of the reverse winding pattern. This arrangement also provides one wrap of tubing between each insulation layer encompassing inner container 12. While the arrangement of FIG. 2 is considered to provide a more effective utilization and distribution of the refrigeration effect such advantage is offset somewhat by the increased difficulty in fabrication.

Both forms of containers illustrated and described herein are effective in attaining the objects of my invention and the efficiency of such units more than offsets any added costs of fabrication. In each, the inner container is charged through a suitable passage, indicated in FIGS. 1 and 2 as a tube 19 which is capped when the container is filled so that the only gas release is through the discharge portions 14c or 24c. The discharge portions 14c and 24c indicate discharge to atmosphere but it will be understood that such discharge may be directed into a suitable collector or container for recovery and reuse of such material.

It will be understood that changes in the shape, proportions and positions of the units may be made in accordance with their intended uses. They may be trans-

ported, mounted or supported in any well known manner. The dimensional references in the description have been provided to assist others in the practice of my invention and where the composition of materials have been cited, they are intended merely as illustrative. Changes and modifications may be availed of within the spirit and scope of the invention as set forth in the hereunto appended claims.

I claim:

1. A container for low temperature storage of fluids, comprising an inner storage container for cryogenic fluids having closed sides and ends and supported within an outer shell with its sides and ends spaced from enclosing surfaces of the shell, the space between the inner and outer surfaces being gas evacuated, and a gas-cooled insulation system disposed in the space between the inner and outer surfaces, said system including a laminated body of metal foil and fibrous material in alternate arrangement encompassing the inner container, means for conducting boil-off gases from the contained cryogenic fluids in the inner container through a continuous succession of spiral turns exteriorly of the inner container and extending substantially throughout the length of the shell, each convolution thereof disposed at a different distance from the inner container than the next adjacent convolution and between different layers of the laminated body, whereby a gas-refrigerating action is utilized in heat exchange at all temperature levels between the temperature of the boiling fluid and ambient temperature on the outside of the outer shell in the progressive flow of boil-off gases through the gas-conducting means, and means for discharging spent boil-off gases from the downstream end of the conductive means exteriorly of the outer shell.

2. A container for low temperature storage of fluids, comprising an inner storage container for cryogenic fluids having closed sides and ends and supported within an outer shell with its sides and ends spaced from enclosing surfaces of the shell, the space between the inner and outer surfaces being gas evacuated, and a gas-cooled insulation system disposed in the space between the inner and outer surfaces, said system including a laminated body of metal foil and fibrous material in alternate arrangement encompassing the inner container, means for conducting boil-off para hydrogen from the contained hydrogen fluid in the inner container through a continuous succession of spiral turns exteriorly of the inner container and extending substantially throughout the length of the shell, each convolution thereof disposed at a different distance from the inner container than the next adjacent convolution and between different layers of the laminated body, whereby a gas-refrigerating action is utilized in heat exchange at all temperature levels between the temperature of the boiling fluid and ambient temperature on the outside of the outer shell in the progressive flow of boil-off gases through the gas-conducting means, a plurality of catalyst beds disposed in the gas-conducting means at intervals throughout the succession of spiral turns for conversion of para to ortho hydrogen and the intervals in the upstream portion being shorter than in the downstream portion, and means for discharging spent boil-off gases from the downstream end of the conductive means exteriorly of the outer shell.

3. A container for low temperature storage of fluids, comprising an inner storage container for cryogenic fluids having closed sides and ends and supported within an outer shell with its sides and ends spaced from enclosing surfaces of the shell, the space between the inner and outer surfaces being gas evacuated, and a gas-cooled insulation system disposed in the space between the inner and outer surfaces, said system including a laminated body of metal foil and fibrous material in alternate arrangement encompassing the inner container, means for conducting boil-off para hydrogen from the contained

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hydrogen fluid in the inner container through a continuous succession of spiral turns exteriorly of the inner container and extending substantially throughout the length of the shell, each convolution thereof disposed at a different distance from the inner container than the next adjacent convolution and between different layers of the laminated body, whereby a gas-refrigerating action is utilized in heat exchange at all temperature levels between the temperature of the boiling fluid and ambient temperature on the outside of the outer shell in the progressive flow of boil-off gases through the gas-conducting means, a plurality of catalyst beds disposed in the gas-conducting means at intervals throughout the succession of spiral turns for conversion of para to ortho hydrogen, and means for discharging spent boil-off gases from the downstream end of the conductive means exteriorly of the outer shell.

4. A container for low temperature storage of fluids, comprising an inner storage container for cryogenic fluids having closed sides and ends and supported within an outer shell with its sides and ends spaced from enclosing surfaces of the shell, the space between the inner and outer surfaces being gas evacuated, and a gas-cooled insulation system disposed in the space between the inner and outer surfaces, said system including a laminated body of metal foil and fibrous material in alternate arrangement encompassing the inner container, means for conducting boil-off gases from the contained cryogenic fluids in the inner container through a continuous succession of spiral turns exteriorly of the inner container and extending substantially throughout the length of the shell, each convolution thereof disposed at a greater distance from the inner container in a downstream direction than the next adjacent upstream convolution and between different layers of the laminated body, whereby a gas-refrigerating action is utilized in heat exchange at all temperature levels between the temperature of the boiling fluid and ambient temperature on the outside of the outer shell in the progressive flow of boil-off gases through the gas-conducting means, and means for discharging spent boil-off gases from the downstream end of the conductive means exteriorly of the outer shell.

5. A container for low temperature storage of fluids, comprising an inner storage container for cryogenic fluids having closed sides and ends and supported within an outer shell with its sides and ends spaced from enclosing surfaces of the shell, the space between the inner and outer surfaces being gas evacuated, and a gas-cooled insulation system disposed in the space between the inner and outer surfaces, said system including a laminated body of metal foil and fibrous material in alternate arrangement encompassing the inner container, means for conducting boil-off gases from the contained cryogenic fluids in the inner container through a continuous succession of spiral turns exteriorly of the inner container

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of increasing diameter in a downstream direction to a point adjacent the opposite end of the shell and reverse wound in turns of increasing diameter between said point and the intake end of the container and between different layers of the laminated body, whereby a gas-refrigerating action is utilized in heat exchange at all temperature levels between the temperature of the boiling fluid and ambient temperature on the outside of the outer shell in the progressive flow of boil-off gases through the gas-conducting means, and means for discharging spent boil-off gases from the downstream end of the conductive means exteriorly of the outer shell.

6. A container for low temperature storage of fluids, comprising an inner storage container for cryogenic fluids having closed sides and ends and supported within an outer shell with its sides and ends spaced from enclosing surfaces of the shell, the space between the inner and outer surfaces being gas evacuated, and a gas-cooled insulation system disposed in the space between the inner and outer surfaces, said system including a laminated body of metal foil and fibrous material in alternate arrangement encompassing the inner container, a conduit for conducting boil-off gases from the contained cryogenic fluids in the inner container through a continuous succession of spiral turns exteriorly of the inner container and extending substantially throughout the length of the shell, an upstream portion of the conduit being stainless steel and the remainder being copper, each convolution thereof disposed at a different distance from the inner container than the next adjacent convolution and between different layers of the laminated body, whereby a gas-refrigerating action is utilized in heat exchange at all temperature levels between the temperature of the boiling fluid and ambient temperature on the outside of the outer shell in the progressive flow of boil-off gases through the gas-conducting means, and means for discharging spent boil-off gases from the downstream end of the conductive means exteriorly of the outer shell.

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ROBERT A. O'LEARY, *Primary Examiner*.