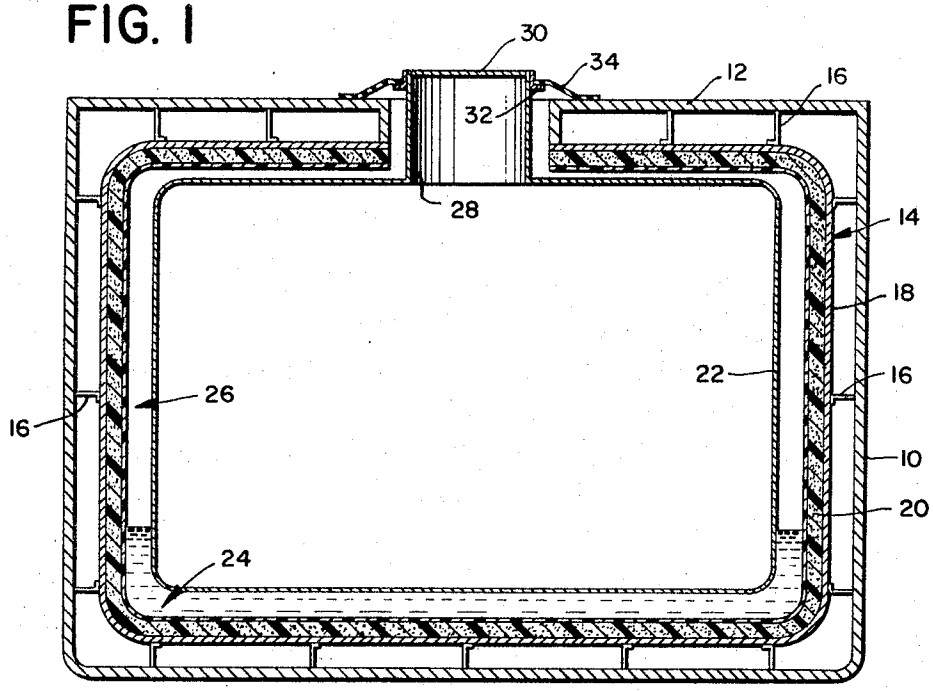
May 16, 1967 A. B. SMALL 3,319,430

LIQUID SUPPORTED CRYOGENIC CONTAINER

Filed Jan. 25, 1965

FIG. 1



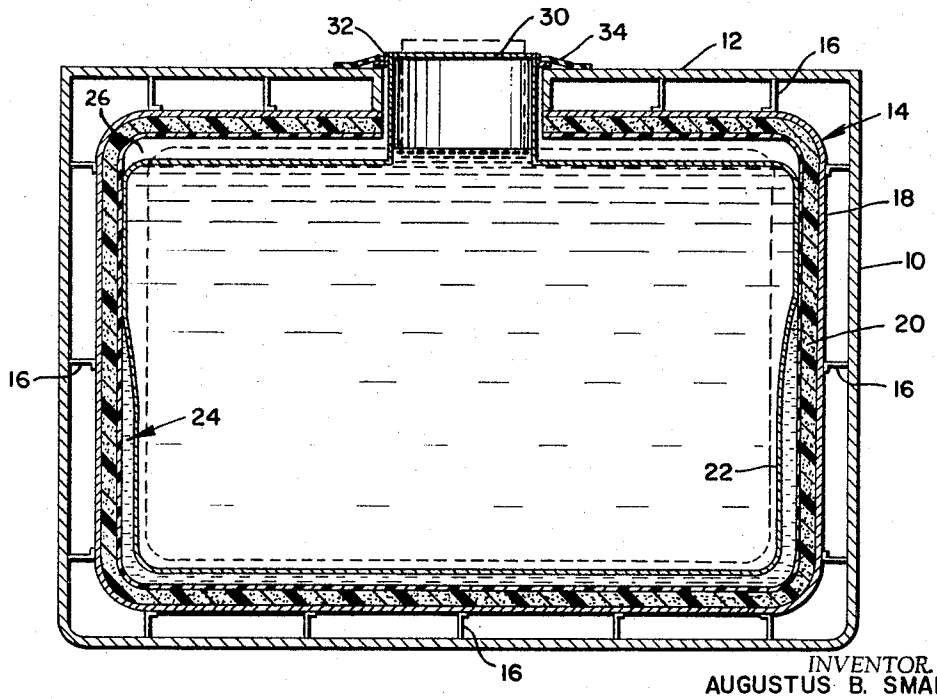


FIG. 2

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LIQUID SUPPORTED CRYOGENIC CONTAINER

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The present invention relates in general to insulated containers for use in cargo ships adapted to transport cryogenic cargoes, such as liquefied natural gas at atmospheric pressure. More particularly, the present invention relates to an improved structure and method of supporting the inner or primary tank from a surrounding insulated secondary tank affixed to the ship's hull.

In accordance with the invention, a thin walled self-supporting primary tank is supported by a small volume of non-freezing liquid of relatively high density compared to the density of the cryogenic material to be placed in the primary container. The higher density supporting liquid is maintained in the space between the primary and secondary tanks. The novel fluid suspension system of the invention balances the principle hydrostatic forces upon the primary tank to permit it to be made of substantially thinner material than would otherwise be required.

In order to transfer liquefied gas in a practical and economical manner in relatively large volumes, it is necessary to store the liquefied gas at approximately atmospheric pressure, since large pressure vessels would be impractical, if not impossible, to construct for use on seagoing tankers or the like. However, liquefied gases maintained at atmospheric pressures have extremely low boil-points, ranging from about —320° F. for liquefied nitrogen to —28° F. for liquefied ammonia, and these unusually low temperatures of the liquids present certain problems in the design and production of insulated cargo containers. Specifically, the containers must be properly thermally insulated to prevent heat losses which would lead to excessive volatilization of the stored liquefied gas and of sufficient strength to withstand the internal stresses that may be induced therein by large temperature gradients through the walls of the container. In addition, the ship must be safeguarded against uncontrolled flow of the low temperature liquid into contact with parts of the structure which could be damaged thereby. Accordingly, for the purposes of increased safety and reliability and in accordance with accepted regulatory Coast Guard codes, it has been established practice to provide a primary liquid-tight barrier and a secondary liquid-tight barrier in containers used for the storage of liquefied natural gases at cryogenic temperatures, each of which barriers is independently capable of withstanding the thermal and hydrostatic stresses imposed by the liquified gases.

In meeting the requirements briefly outlined above it has been suggested that a double walled self-supporting container be placed in an insulated space within the hold of the cargo ship. Alternatively, the regulations have been proposed to be met by a container wherein the insulation system is backed by the ship's structure and the face of the insulation system is the containing surface for the liquid cargo. The first of these suggested systems is expensive in nature in that the structural strength thereof must be provided by means independent of the ship's structure, which strength must be adequate to withstand the complete hydraulic load of the container contents. The second of the insulation techniques outlined above raises numerous problems associated with the thermal stress between the primary barrier attached to the insulation and the insulation per se, as well as problems associated with maintenance during such periods of thermal stress.

In contrast, the present invention due to its use of an

automatic counterbalancing external supporting liquid may employ a relatively thin walled and inexpensive primary barrier which need not be constructed to the rigid structural specifications normally required. Furthermore, because of the fluid support of the primary tank, differential thermal stresses between the primary tank and the ship's supporting structure are compensated for automatically without recourse to elaborate mechanical techniques. In other words, the invention produced an improved cryogenic container system wherein the primary barrier may be constructed with considerable economy because it need not be designed to take the complete hydrostatic filled load of the primary container but need only have sufficient structural rigidity to be self-supporting when in the unloaded state.

Accordingly, it is a principle of the present invention to provide an improved fluid-supported primary tank for a double walled cryogenic container used in a cargo ship.

A further object of the invention is to provide a novel method for supporting a relatively thin walled primary cargo container whereby a minimum of thermal stress is experienced and wherein differential movement between the primary and secondary walls of the cryogenic container may readily occur due to an intermediate liquid film therebetween.

Another object of the invention is to provide a novel cryogenic liquid container system wherein the hydraulic loading across the primary tank is essentially zero due to the fluid suspension thereof.

Another object of the invention is to provide a relatively inexpensive cryogenic container system which is simple in design, rugged in construction and economical to manufacture with a minimum number of parts while being trouble-free in operation.

For a better understanding of the nature of the invention, reference should be had to the accompanying drawings in which:

FIG. 1 is a cross-sectional view of the invention in an unloaded condition as it would appear in a tanker vessel; and

FIG. 2 is a view similar to FIG. 1 wherein the primary tank of the invention is shown in its loaded condition.

It will be understood that the drawings illustrate merely a preferred embodiment of the invention and that other embodiments are contemplated within the scope of the claims hereafter set forth.

Referring to the drawings in particular, a representative cross-sectional view of a tanker hull is shown. The conventional tanker hull includes an outer skin designated **10** of generally U shaped configuration which connects to an outer deck portion **12**. Located within the hull is a double walled insulated cryogenic container **14**. The container **14** is held in spaced relationship to the hull **10** by a plurality of support members **16** affixed at one end to the interior of the hull and at the other end to the exterior of the container. The support members **16** are shown in a representative manner but those skilled in the art will readily understand that numerous types of support members may be substituted without departing from the inventive concept herein described. The double walled container **14** includes an outer tank or secondary shell **18**, the interior of which is lined with a suitable cryogenic insulation system designated generally at **20**. The insulation **20** is preferably of the type impervious to liquid so that a small quantity of suspension liquid designated **24** is not absorbed into the interstices of the insulation **20**. Disposed within the interior of the void defined by the insulation **20** and buoyantly supported in the suspension liquid **24** is a thin walled inner or primary tank structure **22**. The primary tank **22** is preferably made of aluminum, stainless steel or other similar material ranging in thickness from 1/16 to 1/8 of an inch. This

thickness of material will be sufficient to render the tanks structurally rigid enough to be self-supporting when empty, yet will keep the cost of the primary tank within acceptable limits. As seen in the empty condition of the tank shown in FIG. 1, the suspension liquid **24** is of sufficient quantity to support the inner tak **22** in a buoyant fashion. A relatively large amount of air space designated **26** is shown above the level of the liquid **24** to provide space into which the liquid **24** may rise as the tank **22** is filled with the cryogenic liquid to be transported.

The suspension liquid **24** is preferably nonflammable and of a density higher than the density of the cryogenic liquid to be stored within the tank **22**. As envisioned, a density of two times is preferable so that as the tank **22** is filled the upper level of the liquid **24** when in hydraulic equilibrium with the weight of the filled tank **22** is approximately half way up the vertical height of the tank. The liquid **24** is also selected to have a freezing point lower than the temperature of the liquid to be transported within the container **22** so that the suspension liquid will remain in a liquid state at all times when the tank is loaded and thereby permit relative movement between the walls of the container without introducing mechanical stress considerations. The bottom edges of the tank **22** are rounded as shown to distribute the load and stresses which will arise when the container is filled and initially chilled by the introduction of the cryogenic liquid therein. As the tank **22** is loaded, the liquid **24** will rise in an annulus about the exterior walls of the tank **22** so that the exterior hydraulic loading across the container **22** is equal to the interior hydraulic loading. Under this condition, the pressure difference across the thin primary tank is zero or essentially zero.

It should be noted that the selection of the density of the suspension liquid **24** greater than the density of the liquid materials of the primary tank **22** results in rendering the upper portions of the loaded tank unsupported by exterior liquid. These unsupported upper side wall portions of the tank are free to expand horizontally under the force of the interior load to contact the inner walls of the insulation **20** as shown in FIG. 2. This increased diameter of the upper portion of the tank **22** is effective to locate and stabilize the filled tank within the insulation system. During initial tank loading the void area **26** is quickly cooled and assumes a partial vacuum to thereby expand the inner container. Thereafter, as the internal load of the tank increases, the hydrostatic interior load insures tank stabilization.

Referring again to FIG. 1, the upper portion of the primary tank **22** includes a neck **28** which is capped by a suitable removable closure plate schematically designated at **30**. The exterior of the neck **28** is provided with an annular flange **32** to which is secured a flexible sealing collar designated **34**. The outer periphery of the collar **34** is secured to the deck of the cargo ship. It should be noted that the height of the flange **32** in FIG. 1 is considerably above the level of the deck **12** in the unloaded condition. As the container is loaded with cryogenic material the container sinks within the suspension liquid **24** as well as contracts due to the chilling of the tank to the position indicated in full lines in FIG. 2. In FIG. 2 the prior position of the tank in the unloaded state is designated with dotted lines. As the tank **22** becomes filled to the level indicated, its sinking and contraction will gradually lower the flange **32** to the relationship shown in FIG. 2 taking some of the stress off of the centering collar **34** which assumes a plane essentially level with the ship deck.

Preferably the tank **22** is proportioned and the density of the supporting liquid **24** selected so that the net interior volume of the space between the outside of the tank **22** and the inside of the insulation film remains constant between the loaded and unloaded condition. This balancing of the expansion of the tank versus the contraction of the tank is desirable so that venting of the void area **26** to atmosphere is unnecessary during the loading operation. Furthermore, as previously pointed out, the unvented void area **26** during the initial loading and cooling cycle will be subject to a partial vacuum to expand the tank into stabilizing contact with the insulated walls. Ideally, in the loaded condition the increased volume due to the expansion of the upper wall portions of the tank **22** counterbalance and compensate for the thermal shrinking of the tank as it is cooled.

While a specific embodiment of the invention has been shown and described in detail to illustrate the application of the inventive principles, it will be understood that the invention may be embodied otherwise without departing from such principles.

What is claimed is:

1. In combination, a tanker having a cargo hold of predetermined shape and an insulated container for liquefied gas at atmospheric pressure and cryogenic temperature mounted within said hold; said container comprising, an uninsulated primary tank, a secondary tank surrounding said primary tank and spaced therefrom, liquid means at atmospheric pressure between said primary and secondary tanks for supporting said primary tank, said liquid means constituting substantially the sole means for supporting said primary tank and having a lower freezing point than the temperature of the liquefied gas to be transported within said container, said primary tank being formed of low temperature resistant metal of sufficient thickness and rigidity to be self-supporting when empty and being sufficiently flexible to expand in width when loaded into direct contact with interior portions of said secondary tank, and insulation means for maintaining the container at cryogenic temperatures.

2. The combination of claim **1** wherein said insulation means is secured to the interior surface of the secondary tank and is impervious to the liquid means container therein whereby dimensional changes in said primary tank may occur without imparting stresses to said secondary tank.

3. The combination in accordance with claim **1** wherein the specific density of said liquid means is substantially greater than the combined density of the primary tank and the liquefied gas to be placed within the primary tank whereby when said tank is fully loaded the supporting liquid means upper level rises to an approximate midportion of the primary tank leaving the upper portion of the primary tank unsupported by liquid and in direct contact with the interior surface of said insulation means.

4. Apparatus in accordance with claim **3** wherein the volume of air space exterior of the primary tank and interior of the secondary tank when the container is empty and at normal atmospheric temperature is adjusted to be substantially equal to the volume above the top of the primary tank after the primary tank has been loaded and has reached its designed normal cryogenic service temperature.

5. The method of mounting a relatively thin walled uninsulated primary cryogenic liquid container within a secondary container mounted in the hold of a ship comprising the steps of, floating the primary container within the secondary container by placing a limited predetermined quantity of liquid into the secondary container, selecting the density of said liquid to be substantially greater than the density of the cryogenic liquid to be stored within the primary container, said liquid having a freezing temperature lower than the temperature of the cryogenic liquid to be stored in said primary container, maintaining the pressure of the liquid interior and exterior of said primary container at atmospheric pressure, and insulating said secondary container to prevent transfer of the cryogenic temperature to the structure of the ship.

6. The method in accordance with claim **5** including the further step of selecting the density of the supporting liquid to be approximately two times the density of the liquid to be stored in the primary container so that when the

primary tank is fully loaded the upper level of the supporting liquid thereabout is approximately half the height of said primary tank.

7. In combination, a tanker and an insulated container for liquefied gas at atmospheric pressure and cryogenic temperature; said container comprising, a relatively thin walled uninsulated primary tank formed of low temperature resistant metal sufficiently rigid to be self-supporting when empty but requiring additional external support when full, a secondary tank connected to said tanker and spaced from and surrounding said primary tank, and liquid means at atmospheric pressure within said secondary tank for supporting said primary tank within said secondary tank, said liquid means constituting substantially the sole means for supporting said primary tank and having a freezing temperature less than the cryogenic temperature of the liquefied gas to be stored within the primary tank, said primary tank having vertical sides free to move relative to said secondary tank as it is loaded whereby said liquid means is displaced in a rising annulus about the sides of said primary tank, the upper portions of said sides expanding into direct contact with said secondary tank when said primary tank is filled.

8. The combination of claim 7 wherein said liquid means has a density of approximately twice the density of the liquefied gas to be stored within said primary container.

9. The combination of claim 8 wherein said secondary tank includes insulation means fastened upon an interior surface thereof, said insulation means being impervious to said liquid means.

References Cited by the Examiner

UNITED STATES PATENTS

2,269,994	1/1942	Sperry	220—154
2,318,414	5/1943	Palmer	220—15
2,933,902	4/1960	Howard	62—45
2,994,452	8/1961	Morrison	114—74
3,011,321	12/1961	Clauson	62—45
3,039,418	6/1962	Verslius	62—45
3,052,203	9/1962	Henry	114—74
3,097,084	7/1963	Putman	62—45
3,272,373	9/1966	Alleaume et al.	220—9

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