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[54] COMPOSITE INSULATION FOR CRYOGENIC VESSEL

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

[51] **Int. Cl.** **F17c 9/02**

[58] **Field of Search** .....220/9 LG, 10, 15; 62/45, 50

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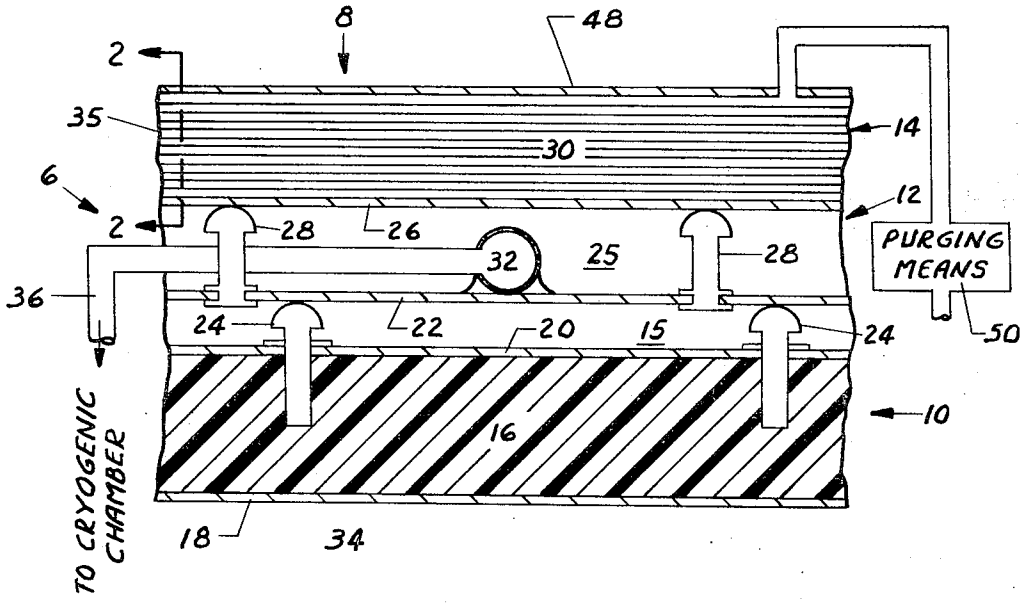
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[57] **ABSTRACT**

A pressure vessel having a series of discrete insulating members for reducing the transfer of conductive, convective and radiant energy from an environmental atmosphere to the surface of the vessel.

1 Claim, 2 Drawing Figures



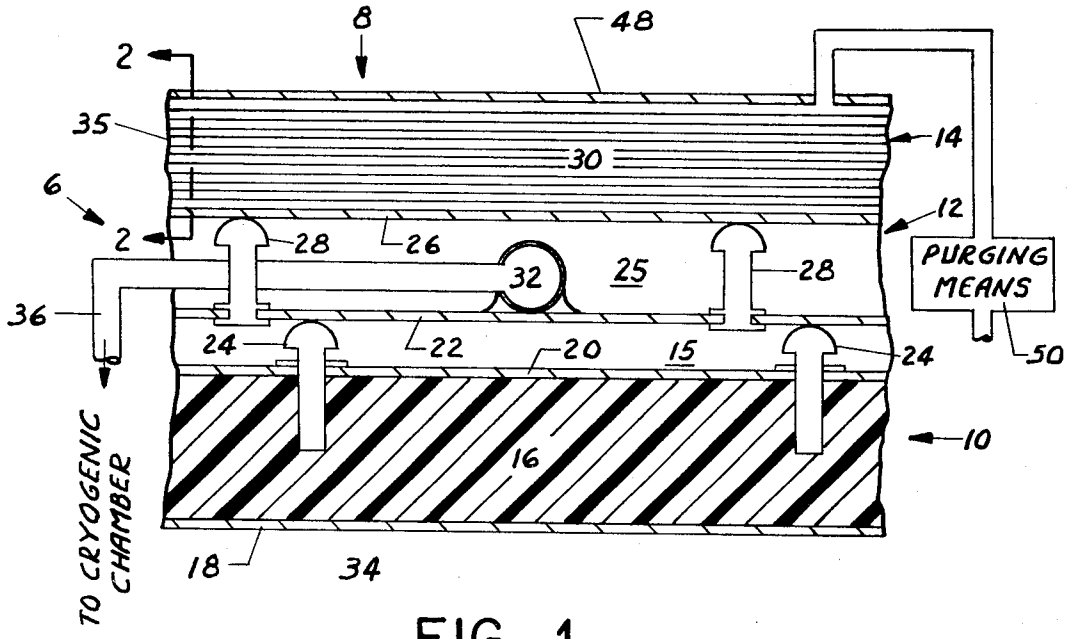


FIG. 1

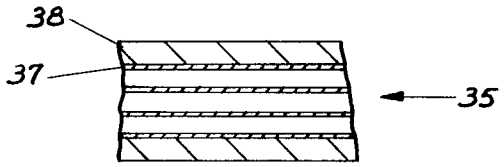


FIG. 2

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COMPOSITE INSULATION FOR CRYOGENIC VESSEL

BACKGROUND OF THE INVENTION

In prior art pressure vessels, liquid propellants are normally stored in insulated double walled vessels. This insulation and second wall represents a large weight penalty on the payload in the event the pressure vessel is used for a space booster. Attempts have been made to reduce the weight penalty by using an uninsulated vessel. But when an uninsulated vessel is used, a high thermal transfer between the environmental atmosphere and the walls of the vessel occurs. This thermal transfer will result not only because of gaseous conduction and radiation, but also from the action of gaseous convection while in the earth's atmosphere. As a consequence, liquid propellant cryogens such as: hydrogen, nitrogen and oxygen, will boil causing a loss of stored liquid. To prevent the loss of liquid by boiling during storage, double walled pressure vessels are used with the area between the walls evacuated to a sufficiently low pressure to eliminate thermal transfer by gaseous conduction. Yet, thermal transfer by radiation would remain to dissipate heat to the stored liquid.

SUMMARY OF THE INVENTION

To reduce, the thermal energy transfer experienced by the use of prior art pressure vessels, we have invented an insulating means for a single wall pressure vessel for storage of liquid cryogens.

This single wall pressure vessel is insulated by a series of discrete layers of lightweight members which disperse thermal energy from an external environmental source away from the surface of the pressure vessel.

An inner insulating layer is composed of a closed cell foam member secured to the outside surface of the storage vessel having a reflective metallic coating on the outside of the foam member. The closed cell foam member will reduce the transfer of heat by convection while the reflective metallic coating will disperse radiant energy received while in an earth type atmosphere.

An intermediate insulating layer overlying the inner layer, has a network of cooling lines positioned in an area between protective radiation shields. The cooling lines are operatively connected to the cryogenic storage area of the pressure vessel. Since the boiling temperature of liquid cryogens is below that of the environment, the vapor given off is circulated in the cooling lines and serves as a refrigerant cooling the radiation shield to which it is attached and hence cooling the outer surface of the storage chamber.

An outer insulating layer, supported by the outside protective radiation shield of the intermediate layer, has a plurality of laminated sheets having one or both sides coated with a reflective material, such as Mylar or alternate layers of aluminum foil and fiber glass or dexiglas paper. This reflective material will form the initial radiation shield for dispersing radiant energy received by the pressure vessel back to an external environmental source.

Low thermal conductive standoff members are placed between the inner insulating layer and the intermediate layers to prevent heat transfer by conduction. In addition, the area between protective radiation shields in the intermediate layer or layers also have the same type of standoff members to eliminate conductive transfer between the intermediate layers and from the outer insulating members.

It is therefore an object of this invention to provide a means of reducing the transfer of convective, conductive and radiant energy from an environment to a pressure vessel.

It is another object of this invention to provide an insulated single wall cryogenic pressure vessel with the means to utilize the liquid stored in the vessel as a refrigerant to cool its outside surface.

It is still a further object of this invention to provide a lightweight storage vessel with a high thermal efficiency and reliability.

These and other objects will become apparent to those skilled in the art from reading the specification and viewing the drawings.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a cross sectional view of an insulated pressure vessel according to the principles of my invention;

FIG. 2 is an enlarged sectional view of the laminated layers of the initial radiation shield taken along line 2—2 of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

While this invention will be described in conjunction with a storage vessel for a liquid propellant, it is envisioned to be fully applicable to any type of surface for maintaining the transfer of thermal energy between an environment and the surface at a minimum.

In the cross sectional view of the single wall pressure vessel **8**, shown in FIG. **1**, an inner insulating member **10**, an intermediate insulating member **12** and an outer insulating member **14** are combined into an effective, thermal regulating, and protective covering **6** for the single wall pressure vessel **8**.

The inner insulating member **10** has a closed cell foam member **16**, such as freon expanded polyurethane, secured to the outer surface of wall **18** of the pressure vessel **8**. A reflective metallic member or film **20** is applied to the external surface of the foam member **16** to seal the closed cell foam from exposure of purge gases communicated to purge chamber **15** to form an inner radiation shield. The reflective member **20** will disperse radiant energy which may be transmitted to this surface, while the closed cell foam insulating member **16** will reduce convective heat transfer in an earth type atmosphere, as described in U. S. application Ser. No. 37,072, filed May 14, 1970 and owned by the common assignee of this invention and incorporated herein by reference.

The intermediate insulating member **12** has one or more radiation shields only one of which is shown forming the inner wall **22**. The inner wall **22** is held a predetermined distance from the reflective metallic member **20** on the closed foam member **16** by standoff spacer **24**, to form a purge chamber **15** around inner insulating member **10**. Standoff spacers **24** are constructed of a low thermal conductive material such as Teflon or Kel-f to reduce the transfer of energy from inner wall **22** to reflective surface **20**. A network of cooling lines **32** are attached to one or more of the radiation shields forming the inner wall **22**. Cooling lines **32** are connected to the pressure chamber **34** by

conduit 36 in wall 18. Standoffs 28, constructed of the same low thermal conductive material as standoffs 24, position outer wall 26 constructed of one or more radiation shields, only one of which is shown, away from cooling lines 32 or other intermediate radiation shields to form a cooling chamber 25 adjacent the purge chamber and reduces the possibility of thermal conduction between them. Each of the standoffs 24 and 28 has a spherical head to provide a point contact with walls 22 and 26 to further reduce the transfer of thermal energy through conductance.

Each of the radiation shields used in the inner wall 22 and outer wall 26 are coated with a highly reflective metallic coating on both sides to form an intermediate radiation shield assembly to rapidly disperse radiant energy. Any radiant energy converted to thermal energy between the reflective surface on the outer wall 26 and inner wall 22 will be dissipated by the cooling lines. Any radiant energy which is transmitted through inner wall 22 will be reflected off metallic member 20 and carried by the purging means 50 while in the earth's environment.

The outer insulating layer 14 is a typical laminar insulation system having a plurality of radiation shield members 35 supported by the outer wall 26 of intermediate insulating member 12. The radiation shield members 35 have a reflective metallic coating 37 on the inner side and a laminated insulation 38 on the external surface (see FIG. 2) or the radiation shield member 35 may be an insulation member having highly reflective metallic coatings on both sides. This insulating member may be also a composition of alternate layers of aluminum foil and fiber glass or dexiglas paper. The reflective member 14 being the initial radiation shield to disperse the radiant energy from the environment.

MODE OF OPERATION OF THE PREFERRED EMBODIMENT

In normal operation, the closed cell foam insulating member 16 applied to outside surface 18 of pressure vessel 8 will be maintained in a low conductive gas atmosphere by purging means 50 operatively connected to plastic membrane or bag 48, surrounding pressure vessel 8. The low conductive gas atmosphere will be maintained until the pressure vessel is charged in a manner fully described in the aforementioned U. S. application Ser. No. 37,072 May 14, 1970.

Just prior to charging, pressure vessel 8 with a liquid cryogen, the low conductive gas in chamber 14 is changed to a gas, such as helium or nitrogen, having a normal boiling below that of the cryogen being charged. By maintaining the purge chamber 14 in a helium or nitrogen atmosphere during the charging operation, deleterious condensable gases will be excluded from the entire insulation system and hence condensation of such gases as water vapor into water or frost on the outside of the foam insulating member 16 will be prevented.

Upon leaving the earth's atmosphere, the plastic membrane 48 will rupture since the helium or purge gas atmosphere will be greater than absolute vacuum in space. The vacuum in space will replace the gas in the purge chamber to isothermally isolate the cooling chamber 25 from the closed foam insulating member 16.

Radiation and conduction are the principal modes of heat transfer in space or a high vacuum environment. The reflective metallic members 20 and 37, in addition to the reflective coating on walls 22 and 26, will effectively reduce and disperse any radiant energy from an external environmental source. The reflectivity of each of the metallic members 20 and 37 and coatings on walls 22 and 26 will be approximately the same to uniformity reduced from one surface to the next. The radiant energy which is not dispersed causes the liquid cryogen to boil, the vapor thus produced is circulated in cooling lines 32. With the refrigerant circulating in cooling lines 32, the heat received at the inner wall 22 will be absorbed to cool the insulating system.

Since the discrete insulating members 12 and 14 are separated by the low thermal conductive spacers 24 and 28, respectively, the transfer of thermal energy in space from an environmental source to the surface 18 of pressure vessel 8 is reduced to a tolerable limit.

Thus, the transfer of thermal energy is uniformly reduced through the low convection properties of the closed cell foam insulating member 16, through the low thermal conductive spacers 24 and 28, and through radiation by the proportionate dispersement of the reflective metallic members 20, 22 and 37 to maintain a cryogenic storage vessel in a stable thermal condition.

We claim:

1. A single wall cryogen storage vessel having means to substantially reduce the transfer of thermal energy between an outside surface of the vessel and an environmental source, said means comprising:

a closed cell foam insulating member secured to said outside surface, said foam insulation reducing the transfer of thermal energy by gaseous convection in an earth type atmosphere;

a first reflective metallic coating applied to and sealing the outer surface of said closed foam insulating member to form a radiation shield for dispersing radiant thermal energy of an environmental source away from the storage vessel;

a first reflective shield separated a predetermined distance from said metallic coating by a thermal non-conductive spacer, to form a purge chamber surrounding the closed foam insulating member;

a second reflective shield separated a predetermined distance from said first reflective shield by a thermal non-conductive spacer to form a cooling chamber adjacent said purge chamber, said first and second reflective shields having a reflective metallic coating on their internal and external surfaces for dispersing radiant energy;

a network of cooling lines located between the first and second reflective shield operatively connected to said pressure vessel, said cooling lines being adapted to carry refrigerant for dissipating of thermal energy caused by radiant energy diverted by the reflective metallic on the surfaces of the first and second reflective shields;

a laminated member having a reflective metallic coating secured to an insulating backing secured to the external surface of said second reflective shield, said laminated member initially uniformly dispersing radiant energy from said environmental source, said reflective metallic coatings on the closed foam insulating member, first reflective shield, second reflective shield and laminated

member being substantially equal and thereby uniformly reducing the transfer radiant energy therebetween; and

a flexible membrane surrounding said storage vessel and connected to said purge chamber, said membrane being connected to a source of low thermal conductive gas to maintain the closed cell foam in an inert condition in an earth type atmosphere to reduce conductive thermal transfer between the storage vessel and said first reflective metallic coating, said low thermal conductive gas in the purge chamber dissipating radiant thermal energy diverted to the purge chamber by the reflective coating on said first reflective shield, said flexible membrane being ruptured by the low thermal gas upon transfer of the storage vessel to a vacuum environment to permit the low thermal gas to escape from the purge chamber and a vacuum be established in the purge chamber to isothermally isolate the cooling chamber from the closed foam insulating member.

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