(NASA-Case-LAR-14172-1) REUSABLE CRYOGENIC LIQUID ROCKET PROPELLANT TANK Patent Application (NASA) 11 p

N93-31295

Unclas

G3/20 0180057

P-11

Pat. Appl.

NASA CASE NO. LAR 14172-1

IN-20

PRINT FIG. 1

186057

NOTICE

The invention disclosed in this document resulted from research in aeronautical and space activities performed under programs of the National Aeronautics and Space Administration. The invention is owned by NASA and is, therefore, available for licensing in accordance with the NASA Patent Licensing Regulation (14 Code of Federal Regulations 1245.2).

To encourage commercial utilization of NASA-owned inventions, it is NASA policy to grant licenses to commercial concerns. Although NASA encourages nonexclusive licensing to promote competition and achieve the widest possible utilization, NASA will provide the necessary incentive to the licensee to achieve early practical application of the invention.

Address inquiries and all applications for license for this invention to **NASA Patent Counsel, Langley Research Center, Code 143, Hampton, Virginia 23681-0001.**

Serial No.: 08/090,838
07/12/93 LaRC

NASA Case No. LAR 14172-1

AWARDS ABSTRACT
REUSABLE CRYOGENIC LIQUID ROCKET PROPELLANT TANK

Currently, the main propellant tanks for rocket-powered Earth-to-orbit vehicles are expended and are very heavy.

A storage tank for carrying liquid fuel is provided which is reusable and is lightweight. The outer shell of the tank is made from a composite material. A foam filled honeycomb layer is bonded to the inner surface of the composite outer shell. This layer acts as insulation and as support to prevent buckling of the composite outer shell. A collapsible liner is placed within the honeycomb layer and a vacuum is created between the outer surface of the liner and the inner surface of the composite shell to pull the liner snug against the honeycomb structure. The liner may be tested before it is inserted into the shell and once again after it is in place.

The novelty of this method is found in providing a storage tank for cryogenic rocket propellant which is reusable and lightweight. The light weight of this tank also makes its use feasible for use as an expendable tank.

Inventors:
Address:

William T. Freeman
1 Freeman Lane
Poquoson, VA 23662
ss: [redacted]

Ian O. MacConochie
300 Old Landing Road
Yorktown, VA 23690
ss: [redacted]

Charles A. Breiner
Plantation Bay Magnolia Est.
8 Magnolia Lane
Ormond Beach, FL 32714
[redacted]

Charles F. Bryan, Jr.
312 Hunts Neck Road
Poquoson, VA 23662
ss: [redacted]

Employer: NASA LaRC
Evaluator: John D. Buckley

Serial No.: 08/090,838
Filed: July 12, 1993

REUSABLE CRYOGENIC LIQUID ROCKET PROPELLANT TANK

Origin of the Invention

The invention described herein was made by employees of the United States Government and may be used by and for the Government for governmental purposes without the payment of any royalties thereon or therefor.

Background of the Invention

1. Technical Field of the Invention

The present invention relates generally to storage tanks and more particularly to reusable liquid propellant tanks.

2. Discussion of the Related Art

Currently, the main propellant tanks for rocket-powered Earth-to-orbit vehicles are expendable. Examples are the multi-stage expendable rockets such as the Saturn and Atlas. On the Shuttle, the only large cryogenic tankage, namely the External Tank, is also expended. For future Earth-to-orbit transports, both reusability and lighter weights are sought for these tanks. The principal disadvantage of the prior-art tanks is that they are not reusable because of the tendency for the insulation to crack. The lightweight insulations typically are mechanically weak and the expansion coefficients do not match the metal to which they are attached or bonded. For example an aluminum may have a tensile strength of 60,000 lb/in^2 whereas the cryogenic insulation has a tensile strength of only 500 lb/in^2. The aluminum may have a thermal expansion coefficient of 13X10^{-6} in/in °F whereas the insulation may have an thermal expansion coefficient of 20X10^{-6} in/in °F.(One PVC closed cell foam has a thermal expansion coefficient of 36X10^{-6} in/in°F.)

Once the insulation cracks, the air surrounding the tank tends to cryo-pump into the crack. The condensed oxygen and nitrogen then freeze expanding in the process, damaging the insulation. For storable propellants, the thermal expansion and insulation problems are minimal.

For cryogenic propellants, one design approach to prevent cracking of the insulation was to capture the insulation between a load carrying metal liner and an outside overwrap of a composite material keeping the intermediate layer of insulation always in compression and the insulation bonded to the composite overwrapped shell. However, the metal liner must be very thin due to weight constraints and is easily flawed. Because the liner cannot be removed for inspection, it must be inspected (after every use) in place. Additionally, repair of the metal liner would be very difficult because the heat from a welding operation on the liner would damage the composite or the insulation.

It is accordingly an object of the present invention to provide a reusable tank for propellants.

It is a further object of the present invention to provide a reusable tank for propellants which is lightweight.

It is a further object of the present invention to provide a reusable tank for propellants which is easily inspected and repaired.

Additional objects and advantages of the present invention are apparent from the drawings and specification that follow.

Summary of the Invention

This invention relates to a storage tank which consists of a composite outer shell, an insulation layer attached to the inner surface of the composite outer shell and a collapsible liner located internal to the insulation layer. The composite outer shell is preferably made from a graphite fiber with an epoxy resin matrix, however other composite materials are appropriate depending on the load which will be placed on the tank, the temperature environment and the propellant which will be stored in the tank. The insulation layer is a foam-filled honeycomb sandwich which is bonded to the composite shell with an adhesive. The honeycomb sandwich is made from a light weight material which has low conductivity, preferably an organic material and is filled with a closed cell foam. The liner is made from a lightweight metallic foil or an organic film such as a ductile aluminum foil or an aluminized polyamide-saran film with a heat seal tape.

Brief Description of the Drawings

Fig. 1 is a perspective view of the invention;

Fig. 2 is a cross-sectional view taken across II-II of Fig. 1;

Fig. 3 is an angled cross-sectional view taken across III-III of Fig. 1;

Fig. 4 is a view of the inspection of the invention;

Fig. 5 is a view showing the liner before installation;

Fig. 6 is a view showing installation of the liner;

Fig. 7 is a view showing installation of the liner; and

Fig. 8 is a view of the second inspection of the invention.

Detailed Description of the Invention

The preferred embodiment of the present invention is shown in Figure 1. The invention is a tank having a replaceable liner which is suitable for re-use as a container for large quantities of liquid propellants in space craft propulsion systems such as Earth-to-orbit transports. The outer tank shell 14 is formed from a composite, preferably a graphite fiber with an epoxy resin matrix. Alternatively, any fiber may be used for fiber reinforcement and a polyimide may be used for the matrix. The composite should be selected based on the loads which will be placed on the tank, the temperature environment and the propellant which will be stored in the tank. Composites are lighter weight and stronger than metals currently used in the manufacture of propellant tanks. Additionally, composites generally have a very low coefficient of expansion allowing silica tiles to be bonded directly to the tank's outside wall without a strain isolation pad when the tank is integral to an aerospace vehicle and the outside of the tank is exposed to entry heating.

The insulation layer 16 is preferably a foam filled honeycomb sandwich bonded to the inside of the tank. In addition to providing insulation, this layer 16 provides stabilization to prevent buckling of the composite tank shell 14. Materials which may be used for the honeycomb sandwich are organic materials such as NOMEX and a closed cell foam for the filler. The material for the honeycomb sandwich should be light weight and have low conductivity. The insulation layer 16 is bonded to the composite outer shell 14 using an adhesive layer 20 such as GT301 or DuPont 46970. Other adhesives should be considered depending on the materials used for the composite shell and the honeycomb sandwich.

The collapsible liner 18 is constructed from a lightweight metallic foil or organic film such as a ductile aluminum foil or an aluminized polyamide-saran film with a heat seal tape (such as a polyamide tape with thermoplastic sealer). The polyamide is available under the trade names Nylon 616 or Mylar. Other materials which are impermeable and of sufficient mechanical strength to withstand installation and loading of propellants may be used for the liner 18.

Inspection and installation of the liner 18 is shown in Figures 4-8. The liner 18 is inflated outside of the tank 14 to check for leaks. The liner 18 is then collapsed and bundled so that it may be placed inside tank shell 14. The ends of the liner 18 are secured by retainer rings 26 at each access port 28. A vacuum is then drawn on the void between the outside of the liner 18 and the interior of the tank 14 using a network of vacuum tubes 22 within the honeycomb sandwich which are connected to ports 24 located on the interior surface of the insulation layer 16. The liner 18 is tested a second time by placing a gas such as helium inside the liner 18 through a line 30 connected to access port 28. Gaseous samples are taken from the area between the outside of the liner 18 and the interior of the tank 14 using the network of vacuum tubes 22 within the honeycomb sandwich.

An alternate embodiment of the present invention would be to use this structure for expendable tanks. The estimated reduction in weight below that of the current expendable tank or a composite tank with a thick metal liner is up to 50% making this a desirable alternative even if the tank is used only once.

Although our invention has been illustrated and described with reference to the preferred embodiment thereof, we wish to have it understood that it is in no way limited to the details of such embodiment, but is capable of numerous modifications for many mechanisms, and is capable of numerous modifications within the scope of the appended claims.

REUSABLE CRYOGENIC LIQUID ROCKET PROPELLANT TANK

Abstract of the Disclosure

A reusable liquid rocket propellant tank is provided. The tank consists of a composite outer shell, a foam-filled honeycomb sandwich insulation layer bonded to the inner surface of the composite shell and a collapsible inner lining which may be removed from the outer shell for inspection and replacement.

(NASA-Case-LAR-14172-1) REUSABLE CRYOGENIC LIQUID ROCKET PROPELLANT TANK Patent Application (NASA) 11 p

N93-31295

Unclas

G3/20 0180057

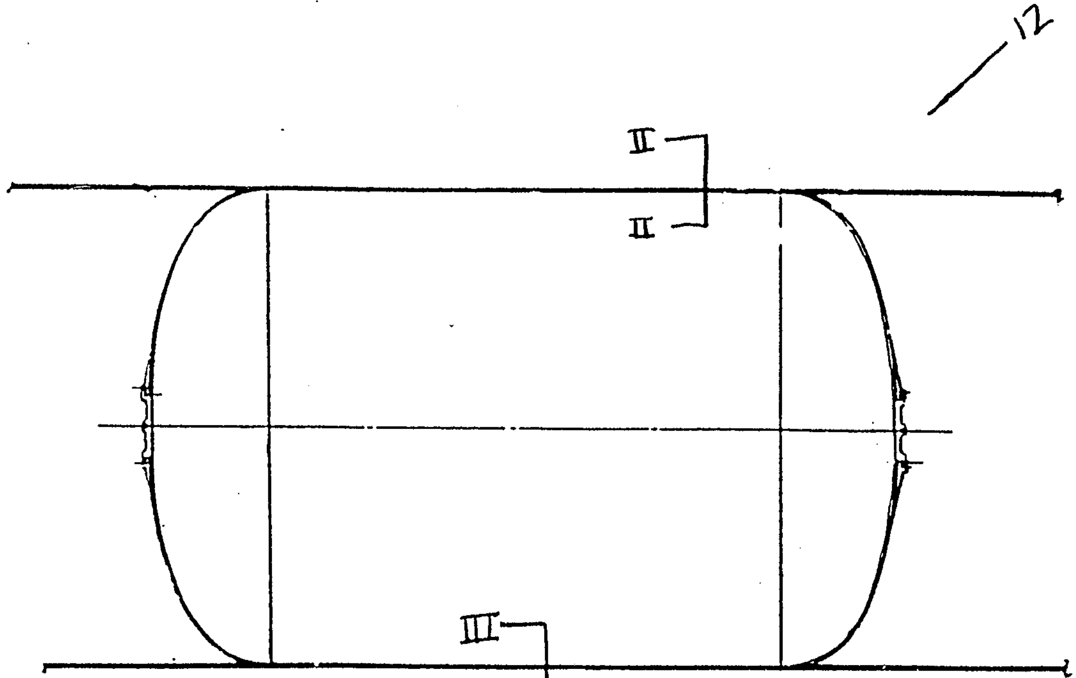

Fig. 1.

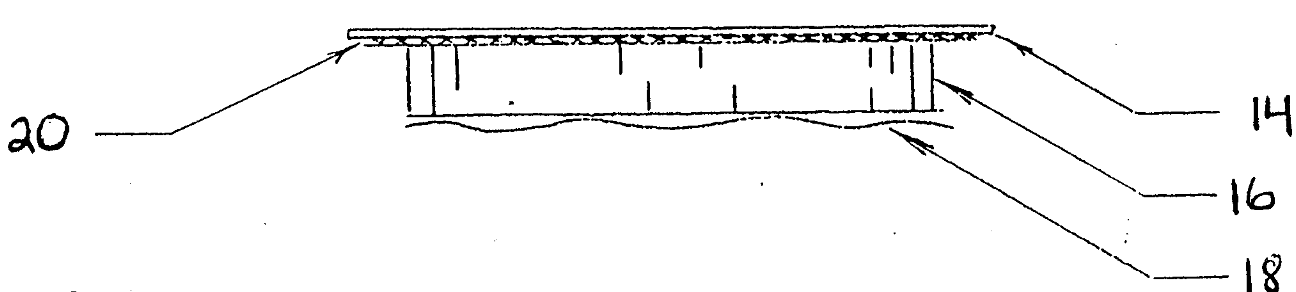

Fig. 2.

NASA CASE NO. LAR 14172-1
WILLIAM T. FREEMAN, JR. ET AL.
SHEET ___ OF 4

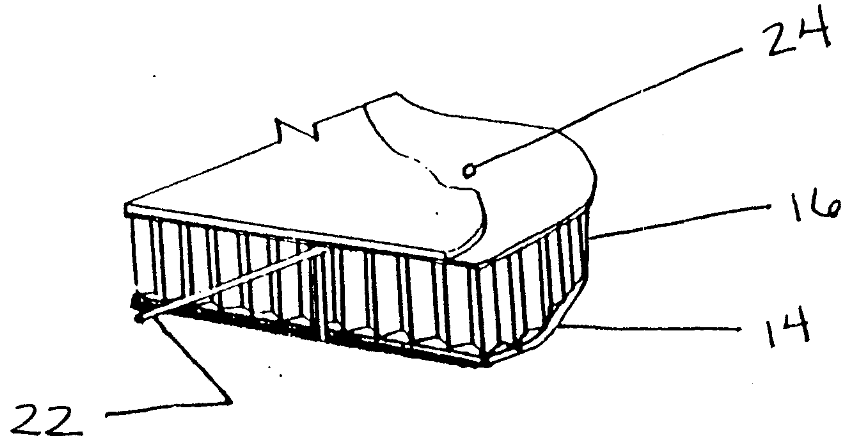

Fig. 3

STEP 1

CLEAN ROOM INFLATION TEST OF LINER

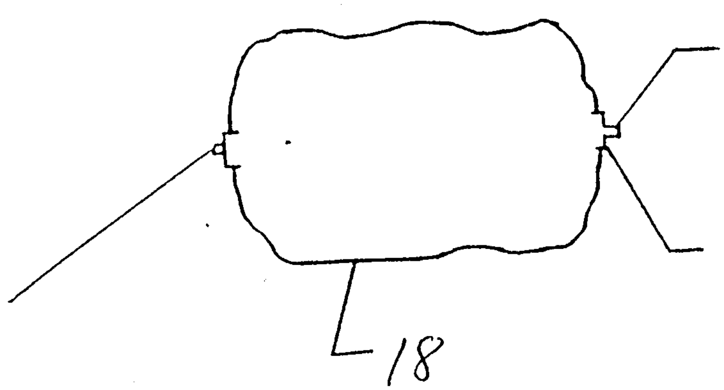

Fig. 4

NASA CASE NO. LAR 14172-1
WILLIAM T. FREEMAN, JR. ET AL.
SHEET ___ OF 4

STEP 2

COLLAP SE AND WRAP LINER
TO INSTALL IN TANK

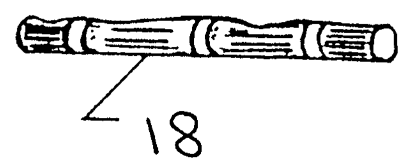

Fig. 5

STEP 3

INSTALL LINER INTO TANK

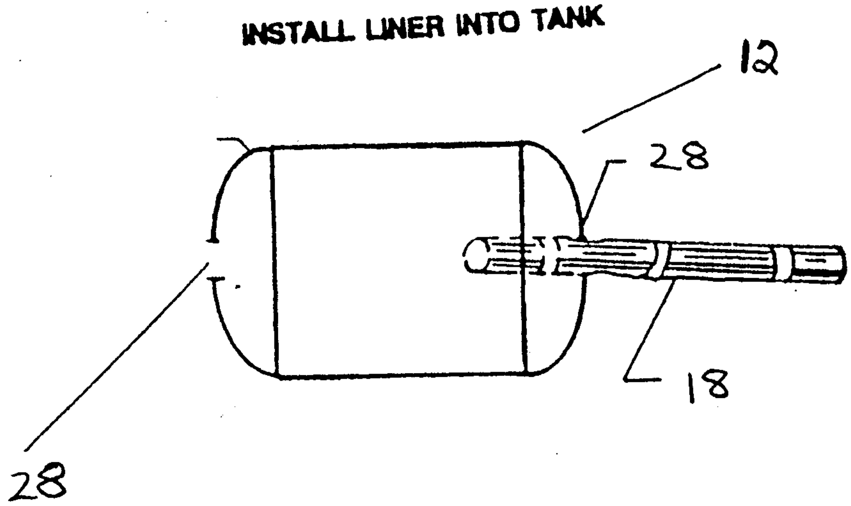

Fig. 6

STEP 4

INSTALL RETAINER RINGS AT ENDS OF TANK AND EXPAND LINER

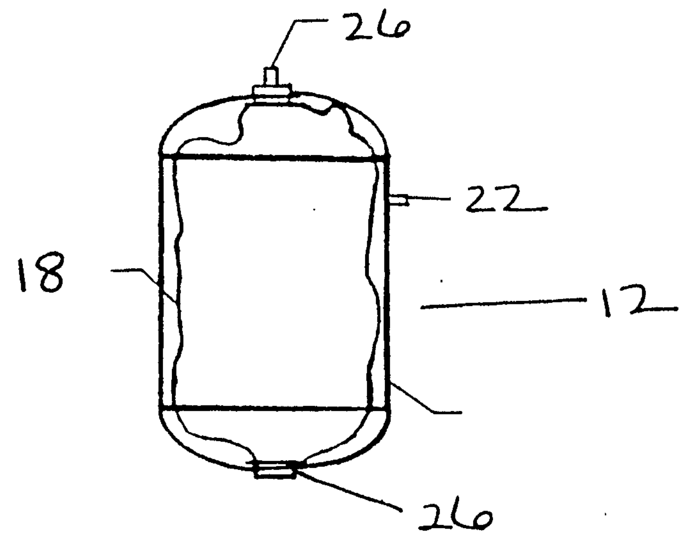

Fig. 7

STEP 5

PRE-FLIGHT PERMEABILITY TEST WITH He UNDER PRESSURE

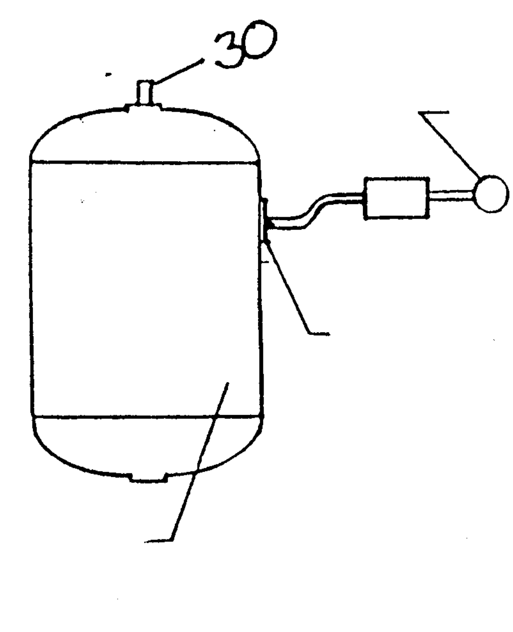

Fig. 8

NASA CASE NO. LAR 14172-1
WILLIAM T. FREEMAN, JR. ET AL.
SHEET ___ OF 4