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R. E. BIEHL ET AL

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PRE-FILLED PROPELLANT TANK FOR ROCKETS

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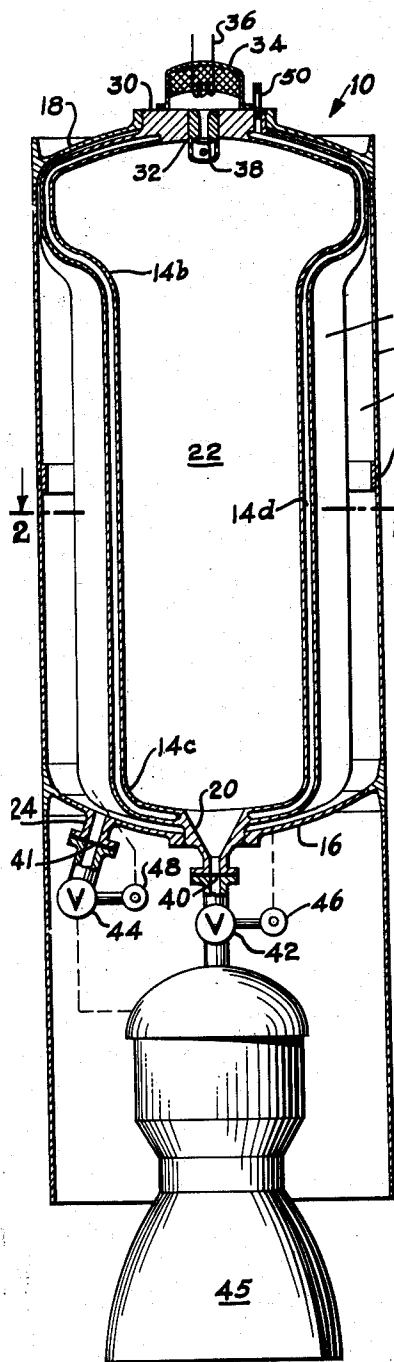


FIG. 1

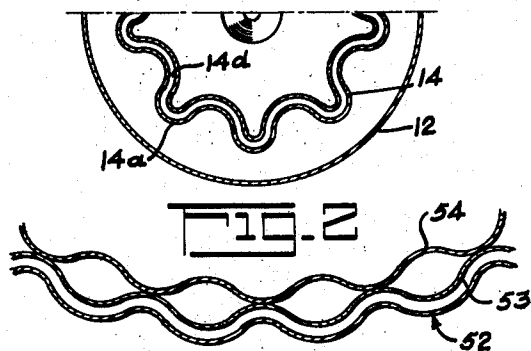


FIG. 2

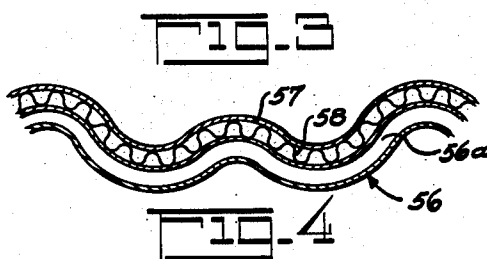


FIG. 3

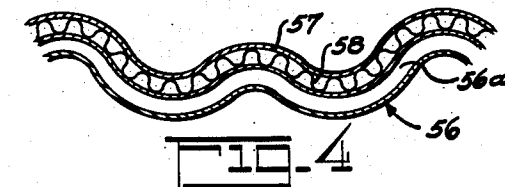


FIG. 4

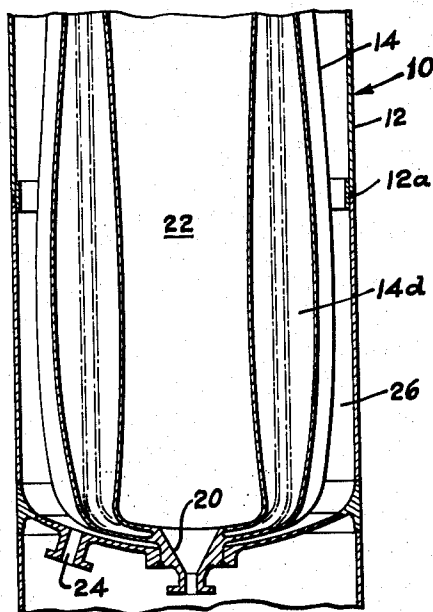


FIG. 5

INVENTORS
RICHARD E. BIEHL
HARRY N. PRICE
MARVIN STERNBERG

BY

Nathaniel Ely
ATTORNEY

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PRE-FILLED PROPELLANT TANK FOR ROCKETS
 Richard E. Biehl, Pearl River, N.Y., Harry N. Price, East
 Paterson, N.J., and Marvin Sternberg, San Fernando,
 Calif., assignors to Curtiss-Wright Corporation, a cor-
 poration of Delaware
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This invention relates to improvements in tanks and particularly to pre-filled and sealed propellant tanks suitable for storing and dispensing rocket propellants and to the use of such tanks as a packaged propellant unit for a rocket.

Liquid propelled, as distinguished from solid propelled, rockets have been considered to have certain disadvantages because of the propellant handling problem. Some components can not, ordinarily, be stored economically and most liquid components require separate handling because of their highly reactive nature. This characteristic has also required elaborate pumping systems, all of which results in expensive installations and often involves excessive space and weight requirements. Furthermore, the lack of instant availability of liquid propellants due to handling delays in filling tanks tends to limit the use of liquid rockets for strategic purposes.

The principal object of our invention is to provide an improved rocket propellant tank as a package unit of minimum weight and size which is adapted to be pre-filled, sealed, and stored if desired, such tank being provided with an inner liner having a developed surface equivalent to the tank wall such liner being normally folded to form inner and outer chambers for receiving separate liquids, the inner chamber being adapted to receive gas under pressure which will open up the folded liner and discharge the separate liquids simultaneously.

A further object of our invention is to provide an improved storage container for reactant liquids in which the container is divided into internal and external liquid containing chambers separated by a common expandable wall having a developed size and shape of the container whereby the application of gas pressure to the internal chamber will not only discharge the liquid from the internal chamber but will expand the wall of the internal chamber against the container wall to simultaneously, completely and uniformly discharge the liquid from the external chamber.

A still further object of our invention is to provide a tank with a double walled internal container which is folded to form an external liquid chamber, an intermediate cavity between the container walls, and an internal liquid chamber with the intermediate cavity available to detect leakage from either of the liquid chambers through their respective walls.

A still further object of our invention is to provide a tank with a double walled internal container which is folded to form an external liquid chamber, an intermediate cavity between the container walls, and an internal liquid chamber in which, after the external chamber and the internal chamber have been substantially filled with liquids, the intermediate cavity may be pressurized to cause a partial expansion of the intermediate cavity and thus a reduction in volume of the liquid containing chambers to drive out gases from said chambers prior to sealing, and thereafter the inner cavity is depressed whereby said intermediate walls serve to maintain a uniform pressure on the liquid filled chambers without stress on the container wall.

A further object of our invention is to provide a new method and means for fueling a rocket with liquid propellants by prefilling and sealing a multi-compartment tank having an inner compartment surrounded by an outer com-

partment, the common wall being flexible and having the developed length and circumference of the outer wall of the tank, such tank having a solid gas generator mounted for pressurizing the inner compartment whereby, on actuation, the gas will drive out the liquid propellants, simultaneously and completely, to the combustion chamber of the rocket engine.

Further objects and advantages of our invention will appear from the following description of preferred forms of embodiment thereof, when taken in conjunction with the attached drawings illustrative thereof, and in which:

FIG. 1 is a central vertical section through a fuel container adapted for rocket operation with the rocket engine shown schematically.

FIG. 2 is a horizontal cross section through the container and taken along the line 2-2 of FIG. 1.

FIG. 3 is an enlarged partial cross section on a horizontal axis showing a modified form of wall for the inner container.

FIG. 4 is an enlarged partial cross section similar to FIG. 3 and showing a further modified form of wall for the inner container.

FIG. 5 is a partial vertical cross section through a fuel container with the double wall of the inner container in a partially expanded position due to pressurization of the cavity between the walls.

In accordance with our invention, the container or fuel tank 10 has an outside wall 12 which may be of spherical or of tubular shape and within which is mounted an inner container 14. This inner container is preferably sealed as by welding to the tank at the ends 16 and 18 of the tank. At the lower end for example, the inner container 14 may have a port 20 for liquid inlet and outlet to the inner chamber 22 therein and such nozzle may be welded to the tank end 16.

A suitable port 24 also in tank end 16 serves as the liquid inlet and outlet to the external chamber 26. This chamber substantially surrounds or embraces the inner chamber 22 and is formed by the wall of the inner container 14 and the outside wall 12 of the tank. The outside wall of the tank may be formed in two halves being centrally welded together as at 12a.

As shown in FIGS. 1 and 2, the wall of the inner container 14 is formed into a series of inwardly projecting folds 14a which extend along the length of the container from the upper inwardly curved portions 14b to the lower outwardly curved portions 14c. This folded arrangement thus gives a substantial volume to the outer chamber 26 and, as will be apparent, the proportions may be selected so that each of the chambers 22 and 26 may be equal in volume or have any desired volumetric ratio, one to the other.

The wall of the inner container has a developed size in circumference and length equivalent to the size of the inside of the wall 12 of the tank. By expanding this inner container 14, the wall moves into complete engagement with the tank wall 12 and a complete evacuation of the outer chamber 26 results. Expansion of the wall of the inner container into its developed surface is accomplished by applying a gas pressure to the inner chamber 14.

As shown in FIG. 1, the upper end of the inner container is provided with a flange 30 which may be secured to the tank end 18 by welding. This flange is conveniently provided with a central hole or nozzle 32 which serves as a gas inlet to the inner chamber 22. This nozzle may be connected to a gas bottle or generator as is well understood in the art. However, we prefer to use a solid charge gas generator as indicated at 34. This may be submerged in the inner container 14 or mounted on the tank flange 30. An initiator for such generator is indicated as a hot wire or other type of squib 36 which can be suitably energized by automatic controls in a well known manner.

A suitable sealing disc 38 will normally prevent any contact of liquid in chamber 22 with the gas generator and serve to permit pressurization and sealing of chamber 22.

With properly proportioned sizes of the chambers 22 and 26, the application of gas pressure to the inner chamber will not only discharge the liquid from such chamber through port 20, but will simultaneously exert a pressure on the wall of container 14 to thereby force it into its expanded and developed position. This will simultaneously exert pressure (nearly equal to the inner chamber pressure) on the liquid in the outer chamber to force the other liquid out of its port 24. With a common single pressure source on both chambers, flow from the ports will be substantially proportional, one to the other.

A tank of this type is especially suitable for the storing and dispensing of two combustible liquids such as hypergolic rocket propellants. As an example of such liquids, reference is made to Inhibited Red Fuming Nitric Acid (IRFNA) and Unsymmetrical Dimethylhydrazine (UDMH). Another combination is Hydrazine and Nitrogen Tetroxide. In the usual case, the fuel component, being less corrosive is placed in the outer chamber 26 while the oxidizer is normally placed within the inner chamber 22.

For a rocket construction as schematically disclosed in FIG. 1, the ports 20 and 24, which are normally sealed by rupturable discs 40 and 41, are connected through valves 42 and 44 with the combustion chamber of the rocket engine 45. Automatic controls 46 and 48 may be used to regulate, precisely, the liquid flow based on conditions of density, pressure, temperature or other liquid conditions in the responsive chambers 22 and 26. With initiation of the gas generator, the various discs 38, 40 and 41 will be ruptured for instant and direct flow of liquids to the rocket engine.

Preferably we make the container wall 14 of double thickness thereby forming an intermediate cavity 14d. Such a construction provides a safety factor which is especially important with highly reactant liquids such as rocket propellant components. If one wall of the inner container should leak due to damage in handling of the fuel tank, a leak into cavity 14d will not be critical for the other wall will maintain the separation. Furthermore, the leak may be detected by connecting a suitable detector to line 50 which is connected to the cavity through the flange 30. If both walls of the container 14 should become broken, there would be a premature reaction, the exothermic results of which would be observed or detected thereby permitting destruction of the fuel tank before an explosion could occur.

Filling of the fuel tank for storage purposes is normally accomplished by first filling the containers with an inert gas such as nitrogen and displacing the gas with the liquids after which the chambers are sealed with the discs heretofore mentioned. Alternately, however, advantage may be taken of the expansible character of the intermediate cavity 14d formed by the double wall thickness of container 14 which cavity may be pressurized through line 50.

As shown in FIG. 5, pressure on this cavity 14d will tend to force the walls apart, thus reducing the volume of the liquid chambers 22 and 26. If, after filling these chambers to the desired extent, a gas under pressure is then applied to cavity 14d, and the walls bulged outwardly all gas will be driven from the respective chambers 22 and 26. The chamber ports may then be sealed with rupturable discs as heretofore indicated.

On removing the pressure in the cavity 14d the walls will be free to contract or expand to accommodate thermal expansion and contraction of the liquids within the chambers. The cavity 14d thus, in effect, tends to breathe to accommodate the thermal expansion and contractions without any change of internal pressure and therefore without imposing any stress changes on the outer walls 12 of the fuel tank 10. In such condition the tank 10 may be stored for any desired period without fuel de-

terioration and yet be an instantly available source of rocket propellant. The inner cavity 14d may, of course, be continuously maintained under pressure and this may be desirable with components having high vapor pressure.

The inner container 14 may be constructed of any ductile material capable of withstanding the conditions to which it is to be subjected, as for example, the loads due to handling and resulting from a difference in density of the two liquid propellants, the temperatures of the pressurizing gas and the corrosive properties of the said gas and the two liquids. As an example, such materials may be of the stainless steel group such as 18% Cr and 8% Ni or they may be made of aluminum or aluminum alloy or certain plastics sold under the tradenames Teflon or Kel F. It is found that such materials require a relatively small pressure to bring about a complete unfurling of the inner container.

While stainless steel is a preferred material with high temperature and corrosive conditions, the aluminum alloys are quite effective where other conditions are such that the heat resistance of stainless steel is not required as for example where a nitrogen bottle or helium gas is used for discharge. In either case, as the contour of the inner container is folded rather than stretched into its original shape as shown, and subsequently is unfolded to the empty position, there is no objectionable work hardening. There is thus a relatively small collapsing force required to unfold the inner container and although it tends to increase slightly, toward the full open position, there is no requirement of excessive crushing forces. The small increase of pressure required to completely deform (expand) the folded wall into its developed condition against the fuel tank outer wall does not materially change the substantially uniform pressure differential on the two liquids.

The folded wall of the inner container may be reinforced if tank size or other conditions require it. In FIG. 3 we show a folded wall 52 for the inner container, which wall may be of double thickness having the inner lining represented at 53. To this inner lining 53 may be welded a supplemental corrugated sheet 54 with the corrugations welded back to back. As the supplemental sheet 54 also has substantially the same developed surface as does the inner lining 53 to which it is attached, internal pressure on the inner container will expand this wall as in the structure shown in FIG. 1.

Another form of reinforcing is shown in FIG. 4 in which the wall 56 of the inner container includes the inner lining 57 which is of double thick character having an intermediate corrugated strip 58 forming a sandwich construction. The outside wall 56 forms a cavity 56a with the inner lining which serves both to detect leakage as well as to serve as a pressure chamber as does cavity 14d. However, if pressurization is not required, the sandwich construction of inner lining 57 will serve as a leak detector if the interior is connected to line 50 through flange 30. In each case whether of double or triple inner container walls, each are of a contoured shape such that in the application of the desired discharge pressure, each wall will unfold against its next outer adjacent wall so that there is a complete evacuation of the outer chamber.

It will thus be understood that we have produced a new form of propellant tank which can be pre-filled, stored with the liquids under constant pressure and surveillance and automatically discharged by a common pressure source with a substantially uniform flow of liquids and complete evacuation. While the invention is of particular advantage for liquid fueled rockets, it is adapted to other uses.

While we have described our invention in detail in its preferred embodiment, it will be obvious to those skilled in the art, after understanding the invention, that various changes and modifications may be made therein without departing from the spirit or scope thereof. We aim in the appended claims to cover all such modifications.

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We claim as our invention:

1. Apparatus for storing two liquids out of contact with each other and for supplying said liquids through individual ports, said apparatus comprising a container having an outer wall with opposed end wall portions interconnected by a generally cylindrical side wall portion; an inner tubular flexible wall dividing the interior of said container into an outer chamber and an inner chamber for separate storage of liquids therein, said tubular flexible wall being secured at its ends with said outer wall end portions and said tubular flexible wall having a plurality of circumferentially-spaced longitudinally-extending folds for unfolding outwardly toward the outer wall cylindrical portions to decrease the volume of said outer chamber; said container also having a pair of outlet passages, one for each of said chambers; liquid stored in each of said chambers; and means for supplying a gas under pressure against the liquid within said inner chamber for forcing liquid therein out of said inner chamber through its outlet passage and for unfolding said tubular flexible wall outwardly toward the outer wall cylindrical portion to decrease the volume of said outer chamber for forcing liquid therein out of said outer chamber through its outlet passage, said gas supplying means being disposed adjacent to one of the end wall portions of the container outer wall and said outlet passages being disposed adjacent to the other end wall portion of the container outer wall, said folds in the flexible tubular wall extending from the end wall portion of the container ad-

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jacent to the outlet passages to a point short of the other end wall portion of the container with the remaining portion of the flexible tubular wall adjacent to said other end wall being substantially cylindrical and having a diameter substantially equal to the diameter of the adjacent side wall of the container and with the longitudinal length and circumferential perimeter of the flexible tubular wall being substantially the same as the corresponding dimensions of the container cylindrical wall toward which the flexible wall expands under the gas pressure.

2. Apparatus as claimed in claim 1 and in which said flexible wall comprises a pair of spaced flexible wall members, and further in which passage means are provided through the container outer wall for communication with the space between said spaced wall members.

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