Oct. 8, 1968 H. I. WAXMAN 3,404,813

TANK WITH METALLIC BLADDER

Filed Aug. 29, 1966 4 Sheets-Sheet 1

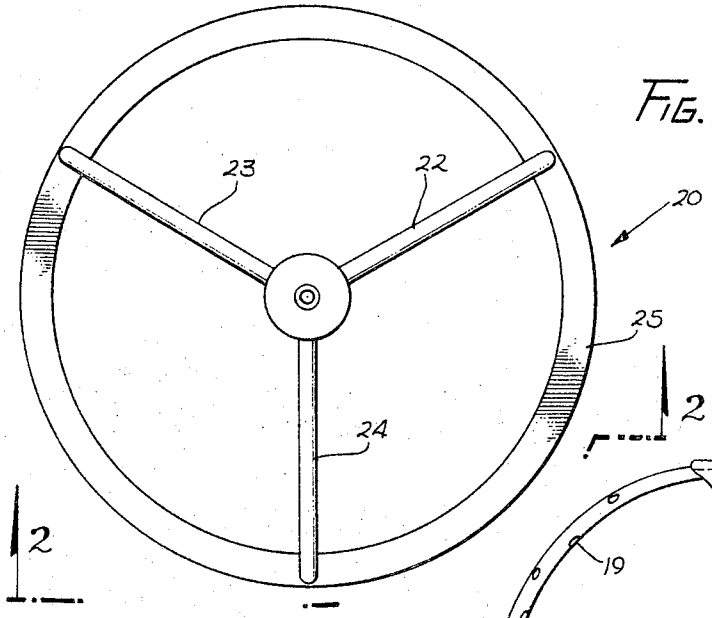


FIG. 1

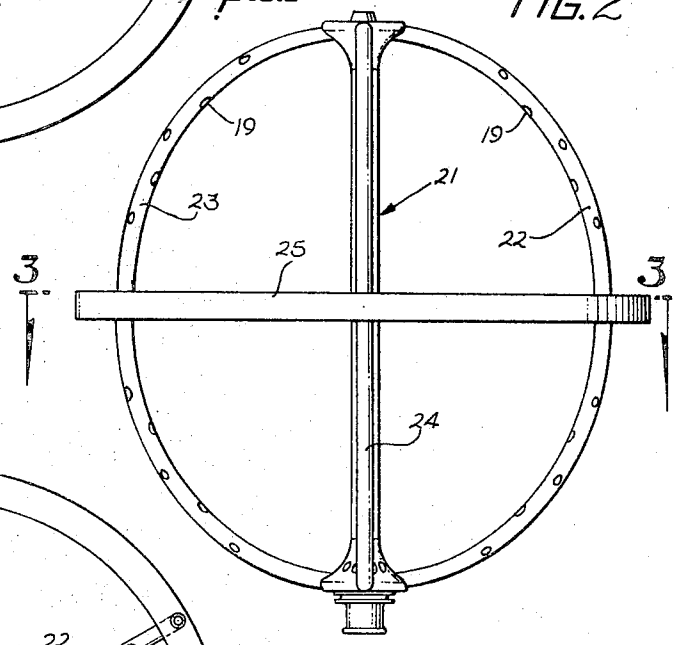


FIG. 2

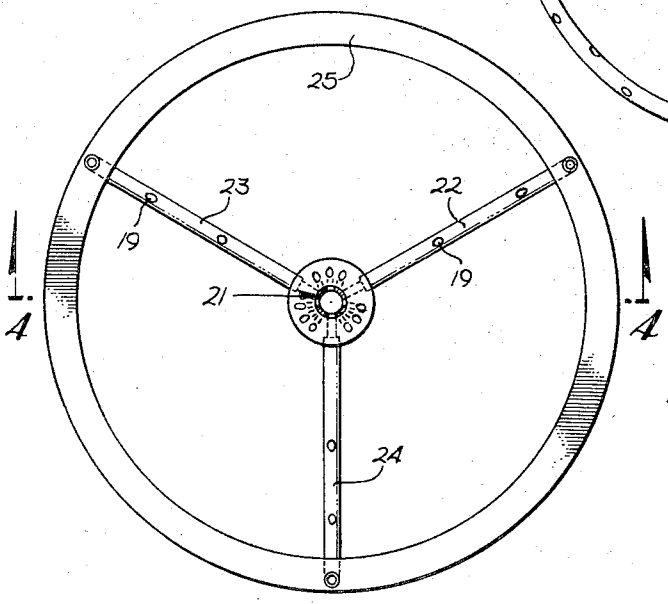


FIG. 3

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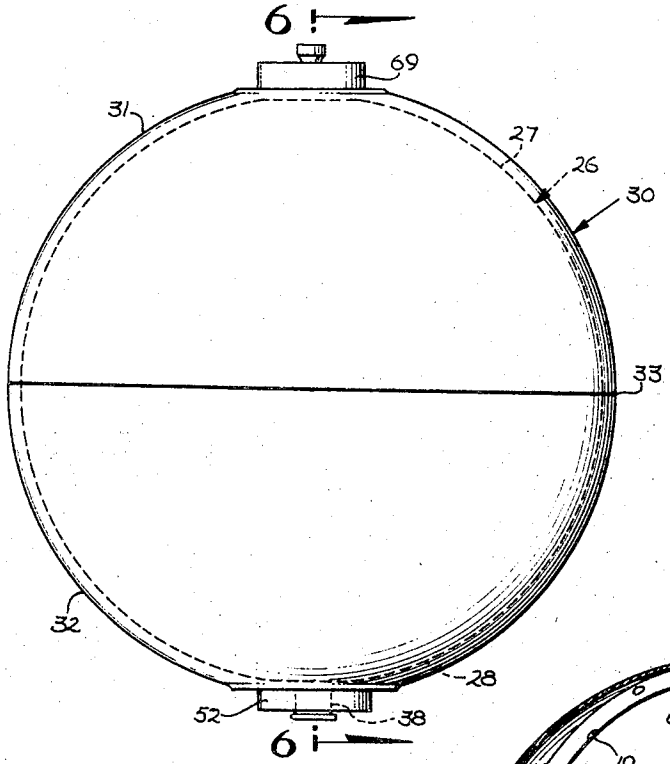
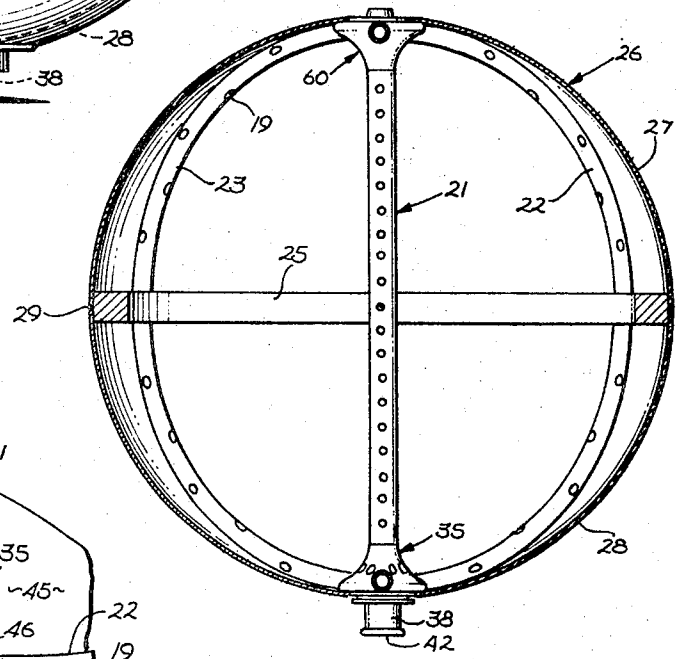


FIG. 5

FIG. 4



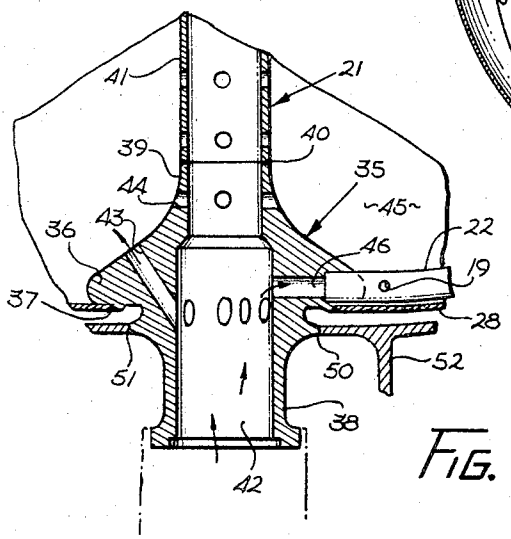


FIG. 7

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TANK WITH METALLIC BLADDER

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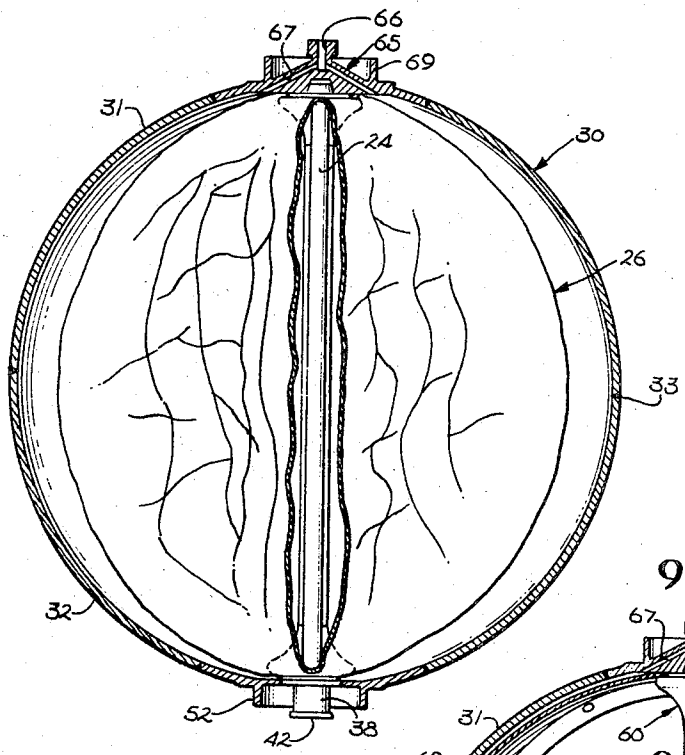


FIG. 11

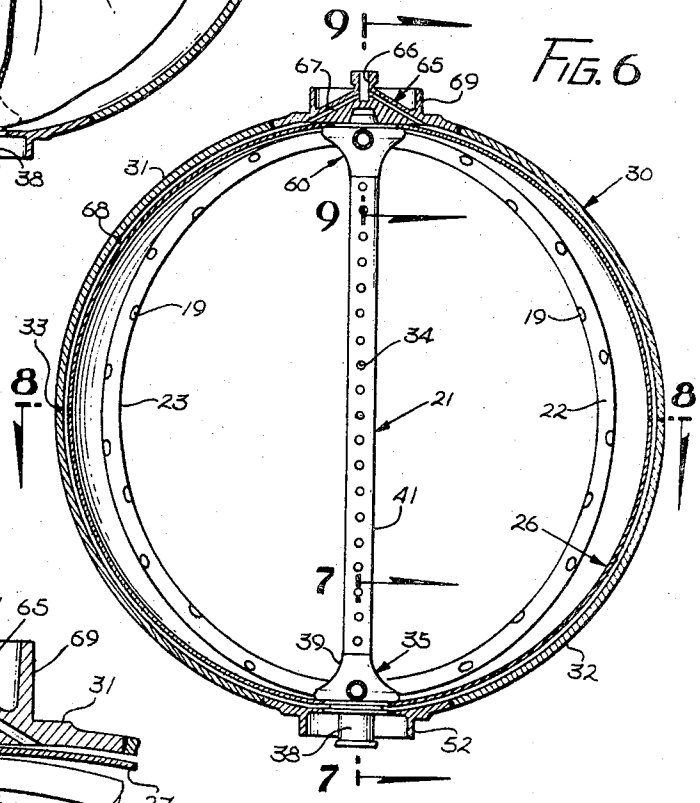
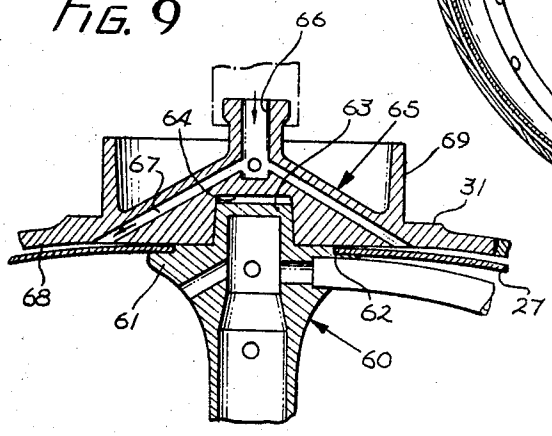


FIG. 6

FIG. 9



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TANK WITH METALLIC BLADDER

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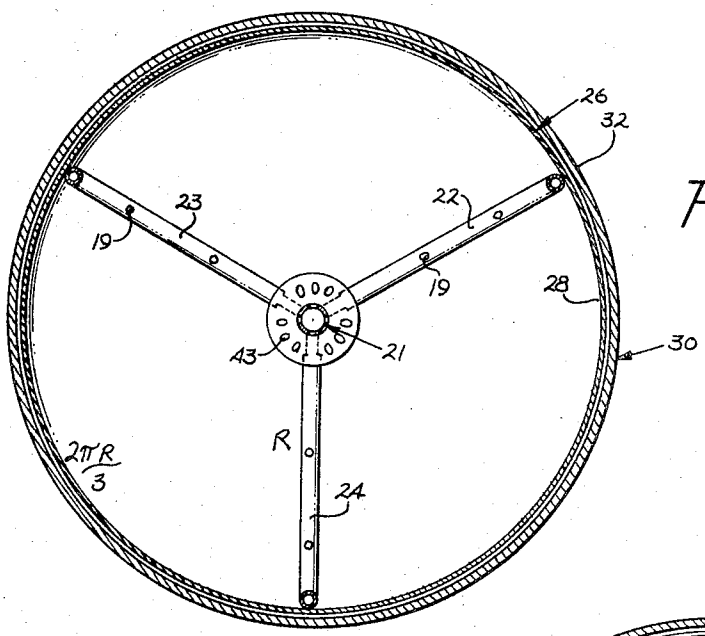


FIG. 8

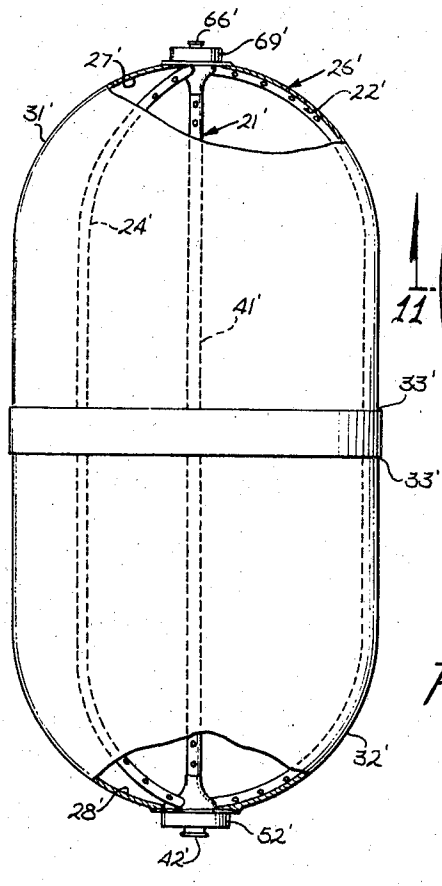


FIG. 12

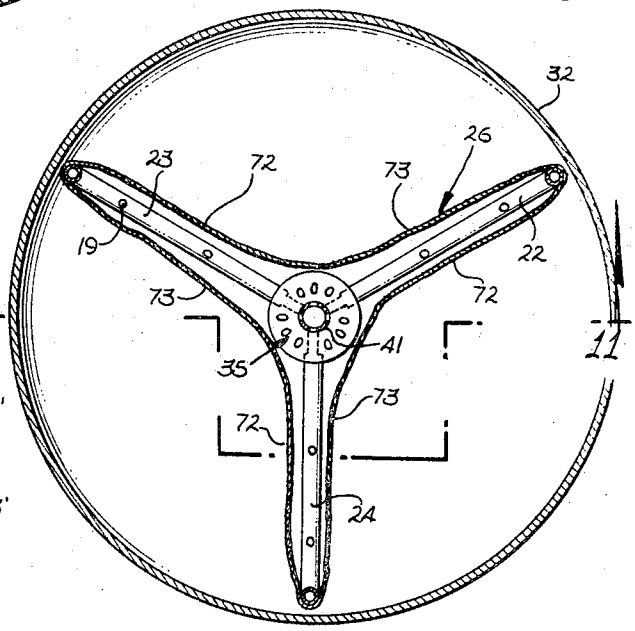


FIG. 10

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3,404,813

TANK WITH METALLIC BLADDER

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Filed Aug. 29, 1966, Ser. No. 575,676
2 Claims. (Cl. 222—386.5)

ABSTRACT OF THE DISCLOSURE

The tank has a bladder made of a thin, metallic, corrosive resistant material which surrounds three equally spaced ribs located along perimetrical lines of the tank and around a central standpipe. The central standpipe runs the full length of the bladder and the ends of the ribs are attached at opposite ends of the standpipe. The tank surrounds the bladder and is spaced therefrom to provide a space which can be pressurized to collapse the bladder between the ribs and thereby discharge fluid from the bladder through openings in the ribs and in the standpipe.

This invention relates to a tank with a metallic bladder and method of constructing same and, more particularly, to a tank and bladder assembly in which a liquid can be enclosed for long periods of time without deterioration of the bladder or tank.

In some cases, it is desirable to fill a tank with liquid some time prior to the installation of the tank at its point of use. This is particularly desirable for propellant and oxidant tanks used in missiles and aircraft. After installation, it is important to have a simple means by which the tank can be substantially emptied if this cannot be accomplished by gravity flow. Rubber and plastic liners have been utilized in tanks and the application of pressure to the exterior of the liner forces the liquid substance out of the tank. However, since such liner materials are deteriorated by corrosive liquid substances, such as corrosive propellants, the liners cannot be utilized to store such substances for any substantial period of time.

In the present invention, a very thin metallic bladder of a corrosion resistant steel is surrounded by a steel tank which takes the main structural load. The frame for the bladder comprises a plurality of ribs which are located on perimetrical lines of the tank and in different axial planes spaced around a central standpipe. The central standpipe runs the full length of the bladder and the ends of the ribs are attached at opposite ends of the standpipe. When fluid pressure is introduced between the bladder and the tank, the bladder is collapsed about the ribs and the liquid is forced out through the standpipe. Preferably, three ribs are spaced on perimetrical lines 120° apart about the central standpipe so that the bladder surface between the ribs permits the bladder surface to collapse substantially into the axial planes of the ribs.

An aluminum alloy ring is located at the longitudinal center of the standpipe and is supported by all of the ribs. The bladder is formed in two sections and the sections are placed over the frame from opposite ends and into edge abutment opposite the aluminum ring. Thereafter, the halves are welded together at their edges and the aluminum ring is etched out of the interior of the bladder. Thus, the aluminum ring provides a fixture for positioning the bladder sections for the butt welding and for chilling the sections at the weld.

The outer tank has the same shape as the bladder and is formed of two sections which are placed around the bladder and welded together. The tank and bladder can

be formed in a variety of shapes, such as spherical or cylindrical, and can be constructed from a variety of corrosion resistant materials.

It is therefore an object of the present invention to provide a tank with metallic bladder in which corrosive liquid substances can be totally enclosed and stored for long periods of time.

Another object of the invention is to provide a tank with metallic bladder in which the bladder is supported by an interior frame consisting of a central standpipe and a plurality of ribs located along the perimeter of the bladder so that the liquid within the tank can be expelled by collapsing the bladder between the ribs.

Another object of the invention is to provide a method of constructing a tank with metallic bladder comprising the steps of forming the bladder around an internal frame having a removable, back-up ring centrally located to serve as a support and chilling member during the welding of the bladder sections and thereafter removing said ring.

A further object of the invention is to provide a tank and metallic bladder in which the bladder is first assembled and the outer tank then assembled around the bladder so that the outer surface of the bladder can be pressurized to collapse the bladder and discharge the liquid contained therein.

Another object of the invention is to provide a tank with metallic bladder in which the bladder is supported by three ribs located along perimeter lines of the bladder and equally spaced apart.

These and other objects of the invention not specifically set forth above will become readily apparent from the accompanying description and drawings in which:

FIGURE 1 is an end elevational view of the bladder frame showing the spaced ribs and the back-up ring;

FIGURE 2 is a side elevational view along line **2—2** of FIGURE 1 showing the central standpipe to which the ribs are connected;

FIGURE 3 is a horizontal section along line **3—3** of FIGURE 2;

FIGURE 4 is a sectional view along line **4—4** of FIGURE 3 showing the bladder sections welded together opposite the back-up ring;

FIGURE 5 is a side elevational view of the tank in which the bladder is located;

FIGURE 6 is a vertical section similar to FIGURE 4 through the tank showing the bladder supported by the internal frame and surrounded by the tank;

FIGURE 7 is a vertical section along line **7—7** of FIGURE 6 showing the liquid conduit connected with the bladder;

FIGURE 8 is a horizontal section along line 8—8 of FIGURE 6;

FIGURE 9 is a vertical section along line **9—9** of FIGURE 6 showing the passages through which the pressurized fluid is introduced to the space between the bladder and the tank;

FIGURE 10 is a section similar to FIGURE 8 showing the bladder collapsed between the ribs;

FIGURE 11 is a vertical section along line **11—11** of FIGURE 10 showing the collapsed bladder; and

FIGURE 12 is a sectional view of a modified tank having a substantially cylindrical shape.

Referring to FIGURES 1–3, the interior bladder frame assembly **20** comprises a central standpipe **21** and three ribs **22, 23** and **24**. Each of the ribs consist of a semicircular tube having openings **19** along its length and having its ends rigidly connected to opposite ends of the standpipe **21**. A back-up ring **25** is located at the central, transverse plane of the standpipe **21** and has openings ad-

jacent its outer periphery for receiving the three ribs **22–24**. Bladder **25** is fabricated of two sections **27** and **28**, each of which is a half-spherical shell, and when the shells are placed over the ribs, they meet at the line **29** which is located opposite the ring **25**. During the welding operation, the ring serves as an assembly fixture for holding the shells in place and also serves to chill the material at the weld so that a suitable butt weld can be accomplished between the edges at line **29**. The ring **25** is preferably fabricated from an aluminum alloy which can be etched out with a caustic solution after the weld is completed. The caustic etching solution can be inserted through the standpipe into the bladder for this purpose and the bladder is cleaned inside and out after the etching is completed. After completion of the bladder assembly illustrated in FIGURE 4 and the removal of the ring **25**, the tank **30** is placed around the bladder **26** and consists of two sections **31** and **32** which are butt welded at the line **33**. The tank material is considerably thicker than the bladder material since the tank resists the internal and external forces and protects the bladder.

Referring to FIGURE 7, one end of the standpipe **21** comprises a liquid conduit fitting **35** connecting with the interior of the bladder. A flange **36** on the fitting is welded to the edge of a circular opening **37** in bladder section **28**, and end **38** of the fitting projects to the exterior of the bladder. The other end **39** of the fitting is welded at line **40** to the cylindrical portion **41** of the standpipe **21** which contains openings **34**. A passage **42** extends through fitting **35** and contains a plurality of angular openings **43** and a plurality of radial openings **44** which lead to the interior space **45** of the bladder. Also, the end of each rib is secured in a radial passage **46** in the fitting. An enlarged flange **50** on end **38** is secured by welding to the edge of opening **51** in the tank section **32** of tank **30**. Since both the tank and the bladder are rigidly connected to the fitting **35**, no relative movement of these members at this point will result. The tank section **32** carries a mounting flange **52** for rigidly supporting both the tank and the bladder. Fluid to be stored is introduced through the passage **42** and enters the bladder space **45** through the passages **43**, **44** and **46**. After the bladder is filled, the passage **42** can be closed by any suitable closure means, such as a valve (not shown).

Referring to FIGURE 9, the other end **60** of the standpipe **21** comprises a fitting which has a flange **61** welded to the edge **62** of a circular opening in bladder section **27**. Cap end **63** of fitting **60** projects into a cavity **64** in the enlarged portion **65** of the tank section **31**. The cavity **64** serves as a guide for the cap **63** so that the bladder can move relative to the tank while maintaining axial alignment with the tank. The enlarged portion **65** contains a passage **66** which connects with a plurality of branch passages **67** leading to the space **68** between the bladder and the tank. Also, the enlarged portion carries a flange **69** which, along with the flange **52**, serves to provide a support for the outer tank **30**.

After assembly of the complete tank, the tank can be filled with liquid through the liquid conduit **42** and the liquid can be stored in the tank for long periods of time since the metallic bladder will resist any corrosive action of the liquid. Preferably, the bladder and tank are constructed of CRES 321 stainless steel alloy to assure long term compatability with the liquid. The thin shell is maintained in its spherical configuration since it is supported at three separate locations by the ribs. When it is desired to expel the liquid from the tank, a pressurized fluid is introduced into space **68** through passages **66** and **67**. Under the influence of this pressure, the bladder material will collapse inwardly towards the standpipe **21** in order to expel the liquid through the openings **19** in the ribs and openings **34** in the standpipe, all connecting with passage **42** which is opened to empty the bladder. Prior to collapse, the bladder has a 3-lobe configuration with each lobe surface being located between two ribs. When the bladder is collapsed inwardly, each lobe forms sides **72** and **73** lying closely adjacent to the axial plane of adjacent ribs. Therefore, the volume within the bladder is reduced to a very small value.

Referring to FIGURE 8, the arc between a pair of ribs is $2\pi R/3$ and the distance between the standpipe at the lobe surface is designated as R. Thus, sufficient bladder surface is available to expel all the stored liquid since the arc length $2\pi R/3$ of the lobe is virtually equal to its collapsed length, namely 2R. The openings **19** in the ribs assure expulsion from all areas of the bladder and prevent local fluid entrapment so that expulsion efficiencies of over 98% can be obtained in a single cycle operation without developing holes or tears in the bladder material. The fully collapsed bladder is illustrated in FIGURES 10 and 11 and it is apparent that the bladder will bend inwardly to the collapsible position without substantial crinkling except in the direction of the longitudinal axis of the standpipe **21**. In this axial direction, there is about 30% excess of material as illustrated in FIGURE 11 which pleats very rapidly without any difficulty.

FIGURE 12 illustrates a modified tank which is substantially cylindrical in shape and primed numerals designate parts corresponding to those of the prior embodiment. It is understood that the same standpipe fittings can be utilized although the ribs, bladder and tank have a different shape. The cylindrical configuration has the advantage that there is much less material along the longitudinal axis of the standpipe which must be pleated.

The present invention provides a single cycle expulsion system which operates under a positive external expelling pressure and the thin metallic bladder material is supported by an internal rigid frame which prevents the inward collapse of the bladder in the absence of an expelling pressure. The bladder collapses in the tri-lobe configuration and propellant is expelled through the central standpipe which runs the full length of the pipe. The sections of the bladder and tank can be produced by shear forming or other suitable process which develops high strength in the material permitting the wall thickness to be minimized. Because of the very thin walls of the bladder, only a small differential pressure against the bladder is required to collapse the bladder and only a small amount of pressurized fluid is required since the clearance space **68** is very small. It is understood that the shape of the tank and the number of ribs can be varied and that various means can be utilized for connecting the bladder and tank together and for mounting the tank. Also, various means can be used to conduct the stored liquid and the pressurized fluid. Various other modifications are contemplated by those skilled in the art without departing from the spirit and scope of the invention as hereinafter defined by the appended claims.

What is claimed is:

1. A tank for storing substances such as corrosive liquids comprising:

a frame assembly comprising three equally spaced ribs located along perimetrical lines of the tank about an axis of said tank;

a bladder comprising a thin metal shell closely surrounding said ribs;

said tank comprising a wall of considerably greater strength than said shell placed around said bladder and spaced therefrom to provide a pressurizing space between said bladder and said tank;

liquid conduit means for introducing a liquid to be stored into said bladder;

means for introducing a pressurized fluid into said space in order to collapse the portions of said bladder between said ribs and discharge said liquid; and

said bladder and said tank being cylindrical in cross section in a plane transverse to said axis so that each of said portions of said bladder over at least a part of the axial length thereof has a circumferential length between ribs substantially equal to the length

of said portion when collapsed substantially into the planes of the ribs.

2. A tank as defined in claim 1 having:

a central standpipe extending longitudinally along said axis through said bladder and connected to said ribs at its opposite ends; and

means for rigidly connecting said bladder and said tank to one end of said standpipe and means for slidably connecting said bladder and said tank at the other end of said standpipe.

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