United States Patent [19]

Lamkin

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[54] **INVERTING LINER PRESSURIZED TANK**

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[73] Assignees: **Lee Roy Denham,** Tulsa; **Jack L. Spradling,** Bixby, both of, Okla. ; part interest to each

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[52] **U.S. Cl.** **222/386.5;** 222/389

[51] **Int. Cl.** **B67d 5/54**

[58] **Field of Search** 222/94, 95, 386, 386.5, 222/387, 388, 394, 389, 395; 61/.5

[56] **References Cited**

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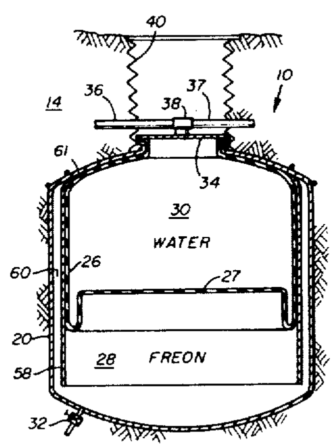
Assistant Examiner—Larry H. Martin

[57] **ABSTRACT**

This disclosure describes a tank for holding water or other liquid under a selected range of pressure. It comprises a tank with a top opening and means to close and seal the top, with conduit means penetrating the top for the entry and discharge of liquid from the tank. The tank is lined with an impervious flexible cylindrical liner which is closed at the bottom and open at the top and is fastened by sealing over the top opening of the tank. Air or other gas is injected into the tank below the inverting liner so that the liquid is maintained at a pressure equal to that of the gas below the liner. The liner is of larger diameter than the tank, and is held in intimate contact with the tank by the internal pressure of the liquid inside the liner when in the extended position and by the gas pressure when the liner is in the inverted position. In one version a condensible gas such as Freon, of a selected composition is injected into the tank below the level of the liner instead of air or other noncondensible gas. Freon, being a gas condensible at ambient temperatures, can provide a pressure which is substantially constant depending on the temperature, and can vary in volume in accordance with the space provided below the water.

12 Claims, 5 Drawing Figures



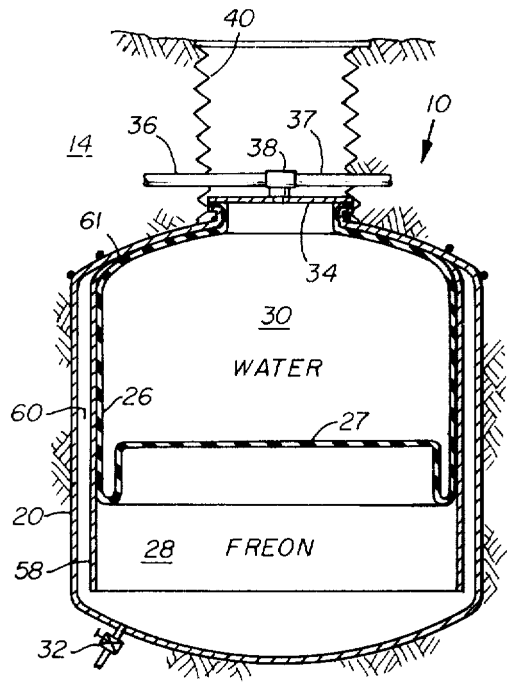


FIG. 3

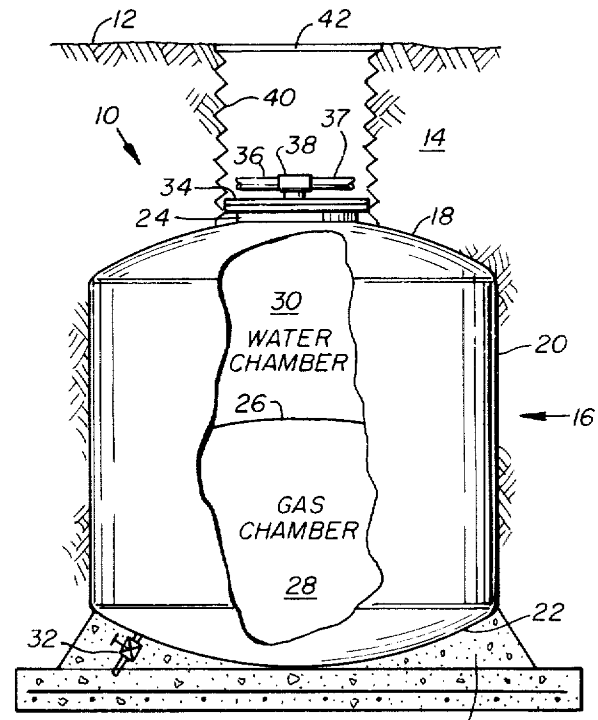


FIG. 1

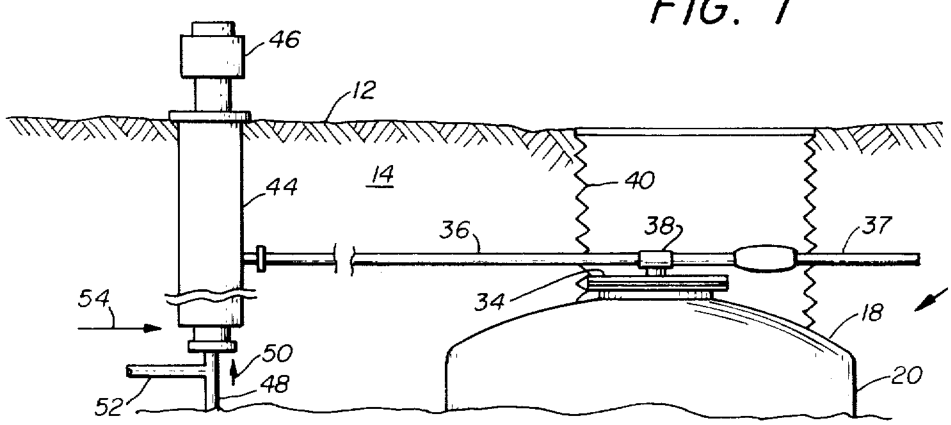


FIG. 2

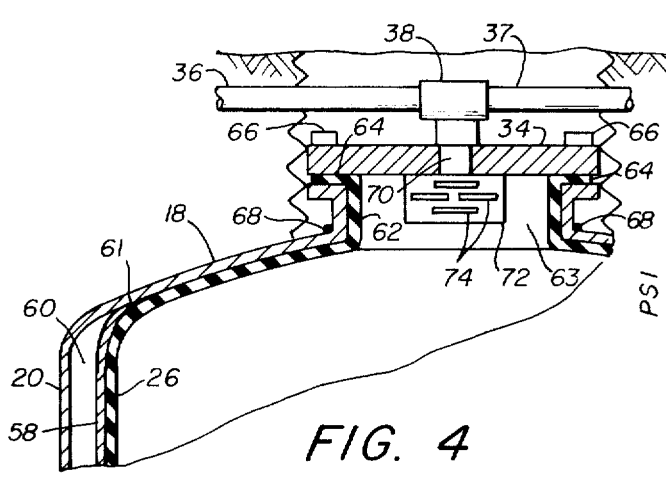


FIG. 4

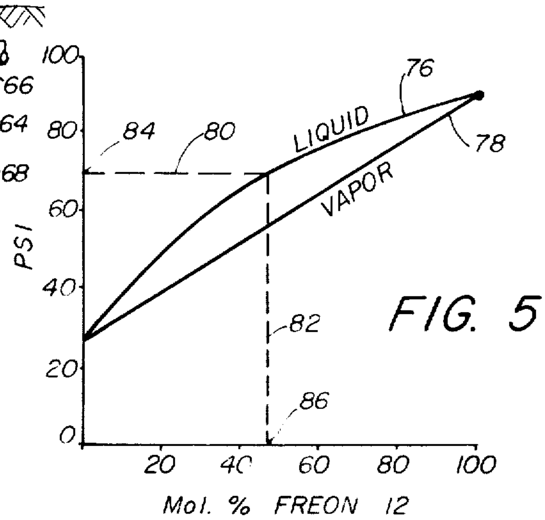


FIG. 5

INVERTING LINER PRESSURIZED TANK

BACKGROUND OF THE INVENTION

This invention lies in the field of pressurized water or other liquid storage tanks. More particularly it is concerned with pressurized water tanks which include a flexible impervious liner inside of the water tank so that the water is maintained in contact with the liner, and out of contact with the shell of the tank. The water is also separated from the gas.

An improved embodiment of this invention utilizes a gas condensible at ambient temperatures instead of a noncondensible gas, so that there is a lesser range in pressure as the gas is compressed and therefore the water can occupy an increasingly large part of the internal volume of the tank.

In the prior art there has been shown pressurized water storage tanks in which the water is separated from a pressurized gas by a flexible diaphragm, or by containment of the water in a loose bag resting on bottom. In the use of air, for example, or other type of permanent gas, as the volume of water increases on one side of the diaphragm the volume of gas on the other side decreases and the pressure in the gas can rise rapidly providing a restriction to the further increase in volume of water. Thus, when the tank is almost empty of water the permanent gas provides an unsatisfactorily low pressure, when the tank is almost filled with water the permanent gas provides too high a pressure.

SUMMARY OF THE INVENTION

This invention varies from the prior art in the use of a liner diaphragm of thin flexible material which is larger in diameter than the tank, so that while under internal pressure it is constricted by the tank walls to retain the liner diaphragm in place, preventing collapse, and allowing a controlled inverting action. Thus, it is possible to place the tank in any position with water located either at the top or the bottom of the tank. The use of a thin membrane is economical as compared to one thick enough to be self-supporting.

This invention also varies from the prior art in the use of a condensible gas, such as Freon, in place of the permanent gas, so that as the tank becomes filled with water and the gas space becomes smaller and smaller, as the pressure in the gas increases, it will condense and still maintain a suitable back pressure against the water. Thus it is possible to utilize a far greater fraction of the volume of the tank for water, when a condensible gas is used, than when a permanent gas is used. Thus a smaller size of tank can store an equal volume of water when used with a condensible gas than can be stored in a much larger tank when pressurized with a permanent gas.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates one embodiment of this invention.

FIG. 2 illustrates the use of the pressurized tank of this invention.

FIG. 3 illustrates an improved version of the water storage tank.

FIG. 4 shows a detail of FIG. 3.

FIG. 5 shows a characteristic of Freon as one of the many condensible gases that might be used in the apparatus of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings and in particular to FIG. 1 there is shown a pressurized water tank of this invention indicated generally by the numeral **10.** This is a closed, sealed cylindrical tank having a cylindrical side wall **20** and top **18** and bottom **22.** There is a large opening at the top which as shown in FIG. **4** can be sealed with a cover plate **34** through which a pipe **70** passes so that liquid can be introduced into and withdrawn from the inside of the tank.

The tank is normally buried in the earth and may rest upon a foundation **26** for example. Cylindrical tubular means **40** are provided to protect the top of the tank from the caving of earth. This tubular portion **40** may be covered with a plate **42** at the surface **12** of the earth **14.** A valve means **32** is provided through which the tank can be pressurized with a condensible gas prior to its burial inside of the earth.

In FIG. **2** is shown one way in which this pressurized tank can be used. It shows the tank submerged in the earth. A cover plate **34** has a pipe connected to the tee **38** which passes through the cover plate **34** into the tank. A horizontal line **36** leads to a pump **44** with motor **46** which draws water in through a vertical pipe **48** in accordance with the arrow **50** or it may draw water in from a horizontal pipe **52** leading to a distant source of water, the water moving in the direction of the arrow **54.** The pump pulling in the water from means **48** or **52** discharges it horizontally through line **36** into the tank from which it can be drawn back to the tee **38** and go in either direction of the pipes **36** or **37** to serve users of the water.

FIG. 3 shows in more detail the construction of the tank in cross section. There is a flexible tubular liner **26** which is of a diameter slightly greater than the inner diameter of the tank. It is closed off on the bottom by a transverse sheet **27.**

By reference to FIG. **4** it is seen that the liner **26** snugly fits the upper portion of the tank and passes through the opening **62** and is spread out as a gasket **64** to seal the cover plate **34,** which is held down by means of bolts **66.**

There is an inner wall **58** which is closely spaced **60** from the cylindrical wall of the tank **10.** This inner wall is welded to the top of the tank at point **61.** The annular space **60** is connected with the space below the diaphragm or liner, indicated by numeral **28,** which is the space into which the Freon is injected through valve **32.** The purpose of the inner wall and the space **60** is to provide a large area of contact between the Freon inside the tank, and the earth outside the tank, so that the Freon will have a good heat transfer path to derive heat from the earth in order to evaporate, and increase its volume as the pressure drops, and vice versa, to give off heat to the earth as the pressure is increased and its volume decreases.

The cylindrical wall **26** of the liner is of a diameter which is approximately 10 percent greater than the inner diameter of the tank or of the inner wall **58.** This greater diameter is provided so that when the tank is filled with water there is an internal pressure forcing the liner against the outer wall. The liner will be compressed and therefore will have a tendency to cling to the wall, and not collapse, as the pressure is reduced. This feature permits using a much thinner liner than would otherwise be necessary if the liner was to be supported by its own thickness and stiffness. The liners that can be used in this invention can be as thin as 0.030 inches up to 0.060 inches for tanks four to seven feet in diameter, and propertionately less for tanks of lesser diameter, with a consequent saving in material of the liner. The liner can be made of any rubber-like material that is elastic and compressible. A preferred material is acrylonitrile rubber.

The liner is installed in the tank in a fully inverted position and the tank is then charged by inserting air or other gas below the liner. Once the tank is charged with gas the liner can only be extended by liquid forced into the liner. This is because a liquid is required to lubricate and separate the surfaces of the inverted liner which are in intimate contact due to the inverting of the liner and the compression of the liner within the tank walls.

In FIG. **4** is shown in some detail the pipes **36** and **37** leading to the tee **38** with an entry pipe **70** going through the cover plate **34** to a terminal arrangement **72.** This is an inverted feature attached to the bottom surface of the top plate, with a plurality of very narrow slots through which water can flow into and out of the tank. By making these slots narrow the pressure of the gas against the bottom of the liner cannot force it into the openings **70** and therefore there is no danger of perforating the liner, which would be the case if these openings were on the bottom face of the cup **72** for example, and particularly if they were of substantial width.

While this invention can be used with various types of condensible gases for a number of reasons it has been found that Freon is a desirable gas for this purpose. In particular, mixtures of Freon **12** and Freon **21** provide a satisfactory characteristic of pressure, at the temperature range that might be encountered in the earth at the depth of burial of the tank. In FIG. **5** there is shown a characteristic diagram of the mixture of Freon **12** and Freon **21.** The horizontal axis gives the Mol percent Freon **12** in the mixture of Freon **12** and Freon **21.** The pressure is shown on the ordinate. Examining the curve **76** labelled liquid, it is seen that if a pressure of 70 pounds per square is desired, a horizontal line **80** is drawn from the ordinate at point **84** corresponding to 70 psi to the liquid line, and then vertically as line **82** down through to bottom line at point **86.** This indicates a Mol percent of Freon **12** of approximately 47 percent to obtain a mixture which would provide a pressure of 70 psi when all of the mixture is condensed and 58 psi when all the mixture is vaporized, at a temperature of approximately 74° F.

Similar diagrams can be drawn for other gas mixtures such as Freon **12** with Freon **22,** for example. These gases are well known in industry and are available on the market. Their pressure versus temperature characteristics are well known. For the curves shown in FIG. **5** the relationship of pressure to Mol percent for the liquid and the gas are given more precisely by the following equations:

$$P_V = 24.1 + 33.6\left(\frac{\text{Mol \%}}{50}\right)$$

$$P_L = 24.1 + 33.6\left(\frac{\text{Mol \%}}{31.6}\right)$$

Where P_V and P_L are the corresponding vapor and liquid pressures, and the Mol percent is of Freon **12** in a mixture with Freon **21.**

These relationships are well known, and a mixture can be easily designed for use in the apparatus of this invention covering any pressure and temperature range desired.

In FIG. **3** the inverted portion of the liner **27** is shown of lesser diameter than the portion **26.** This is only for purposes of illustration, and in actual operation the gas pressure inside the inverted portion will force the walls outwardly into intimate contact with the portion **26** of the liner. The water or other liquid inside the liner will provide lubrication for the portions sliding against each other.

While the invention has been described with a certain degree of particularity it is manifest that many changes may be made in the details of construction and the arrangement of components. It is understood that the invention is not to be limited to the specific embodiments set forth herein by way of exemplifying the invention, but the invention is to be limited only by the scope of the attached claim or claims, including the full range of equivalency to which each element or step thereof is entitled.

What is claimed:

1. An inverting liner pressurized liquid tank comprising:

a. a pressure tight tank open at the top and closure means to close said opening, an inner wall inside said tank sealed to said tank at its top edge and providing an annular space between said inner wall and said tank;

b. a tubular flexible, compressible, impermeable inverting liner closed off with a transverse wall at the bottom, and open at the top, adapted while subjected to internal pressure to snugly fit against the inside surface of said tank and said inner wall, the open top of said liner sealed around said top opening of said tank;

c. conduit means through said closure means for admitting a flow of water into and out of said liner; and

d. means to inject a condensible gas, of a selected pressure versus temperature relation, to provide a selected pressure range over a selected temperature range, into said tank below the bottom of said liner.

2. The tank as in claim **1** in which said condensible gas if Freon.

3. The tank as in claim **2** in which said Freon is Freon **12** intermixed with Freon **21.**

4. The tank as in claim **2** in which said Freon is Freon **12** intermixed with Freon **22.**

5. The tank as in claim **1** in which the diameter of said liner is approximately 10 percent greater than the internal diameter of said tank and said wall whereby under internal pressure said liner will be compressed and will be supported from collapsing.

6. The tank as in claim **1** in which said liner is of a thickness in the range of 0.030 inches to 0.060 inches.

7. The tank as in claim **1** in which said liner is made of rubber like material.

8. The tank as in claim **1** in which said liner is made of acrylonitrile rubber.

9. An inverting liner pressurized liquid tank comprising:

a. a pressure tight tank open at the top and closure means to close said opening, an inner wall inside said tank sealed to said tank at its top edge and providing an annular space between said inner wall and said tank;

b. a tubular, flexible, compressible, impermeable inverting liner closed off with a transverse wall at the bottom, and open at the top, the diameter of said liner larger in diameter than said tank, and adapted while subjected to internal pressure to snugly fit against the inside surface of said tank and said inner wall, the open top of said liner sealed around said top opening of said tank;

c. conduit means through said closure means for admitting a flow of liquid into and out of said liner; and

d. means to inject a selected gas, of a selected pressure versus temperature relation, to provide a selected pressure range over a selected temperature range, into said tank below the bottom of said liner.

10. The tank as in claim **9** in which the diameter of said liner is approximately 10 percent greater than the internal diameter of said tank and said wall, whereby under internal pressure said liner will be compressed and will be supported from collapsing.

11. The tank as in claim **9** in which said selected gas is a noncondensible gas.

12. The tank as in claim **9** in which said selected gas is a mixture of selected proportion of two compatible condensible gases each having a different pressure versus temperature relation such that the binary mixture of the selected components will have the desired pressure versus temperature relation.

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