

United States Patent

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[72] Inventor **Henry Leo Smith**
Route 4, Box 63, Springfield, Tenn. 37172

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Primary Examiner—William R. Cline
Attorney—Harrington A. Lackey

[54] PNEUMATICALLY CONTROLLED WATER STORAGE SYSTEM
8 Claims, 5 Drawing Figs.

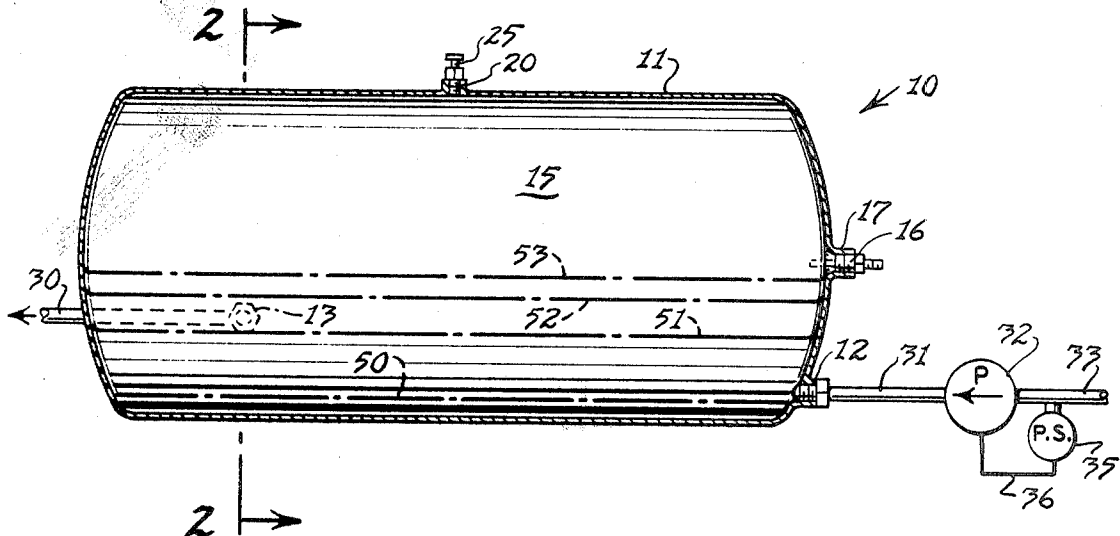
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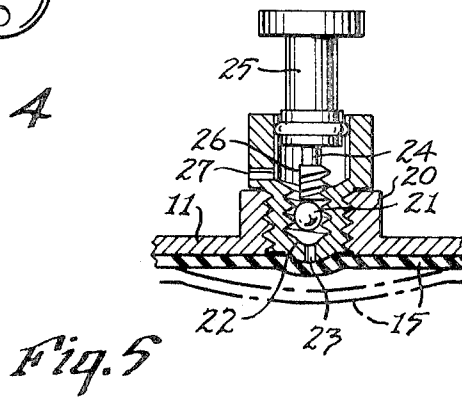
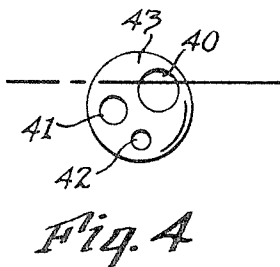
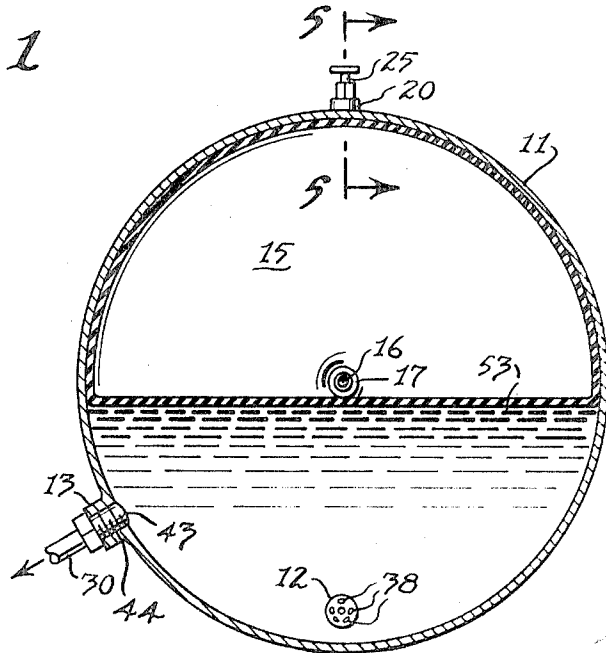
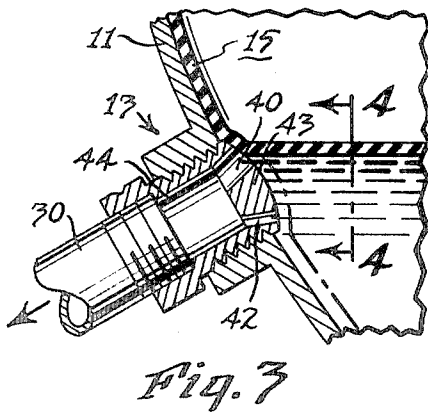
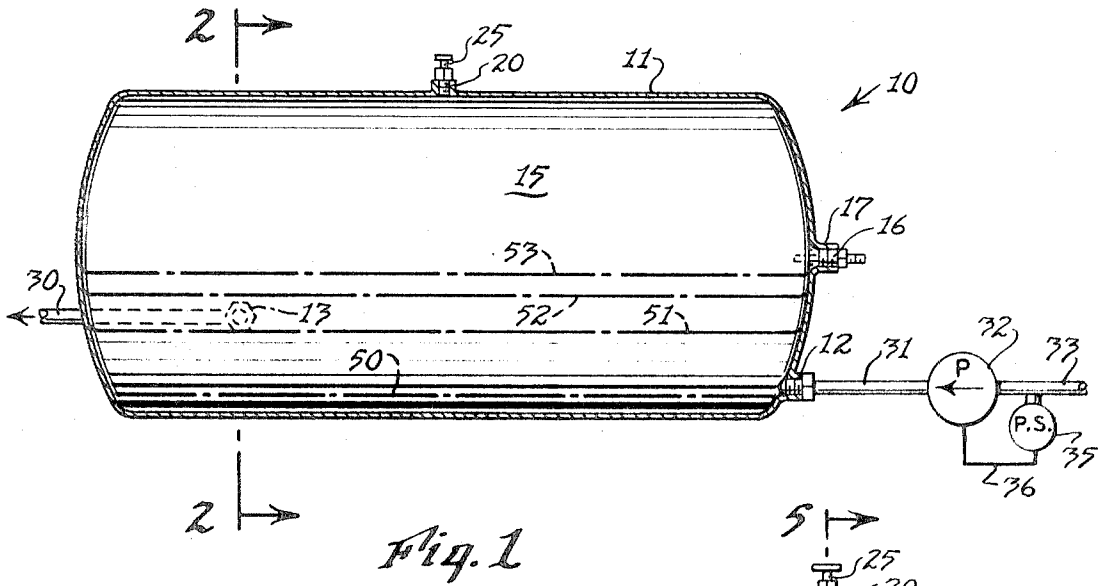
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ABSTRACT: A pneumatically controlled water storage system including a water tank having an inlet and an outlet at different water levels, and a precharged, expandible gas envelope within said tank to open and close the water outlet and the water inlet in response to changes in water pressure, and air volume control means for normally maintaining a water reservoir within said tank between maximum and minimum pressures.

This invention also contemplates an air discharge valve in the top of the tank adapted to be normally closed by the pressurized gas envelope, for venting air or other gases trapped between the top of the tank and the gas envelope.





INVENTOR:
HENRY LEO SMITH
 BY
Harrington A. Lacey
 ATTORNEY

PNEUMATICALLY CONTROLLED WATER STORAGE SYSTEM

BACKGROUND OF THE INVENTION

This invention relates to a pneumatically controlled water system, and more particularly to an air-pressurized water storage tank.

Air volume controlled water storage systems are well known, particularly in water supply systems for rural areas which must rely on water wells, pumps and water storage tanks. In order to maintain adequate water pressure for the water distribution system, a predetermined volume of air is maintained within the water storage tank and pressure is developed by pumping water into the tank to contract the volume of air. As water is bled from the distribution system, the air expands to force the water through it. As the pressure gradually decreases to a minimum value, a pressure-sensitive switch is actuated to start the pump. When the tank is filled with water to its maximum pressure, the pump automatically cuts off.

The difficulty with such air volume control systems is that the air gradually mixes in the water, particularly under pressure, and becomes "waterlogged". Accordingly, the air must be replaced periodically.

Various methods have been designed to overcome the "waterlog" problem. One method is to have a vertical cylindrical tank in which is disposed a floating disc of substantially the same diameter as the inner diameter of the cylindrical tank wall. Another method is to place a flexible diaphragm extending across the water tank to separate the air and the water from each other. In both cases, as the water pressure is increased, the disc and diaphragm are elevated to compress the air, and vice versa. Both of these systems involve maintenance problems in affording adequate seals around the peripheries of the separating members and the walls of the cylindrical tank.

SUMMARY OF THE INVENTION

It is an object of this invention to provide an air volume control water storage system including a water storage tank having an inlet and an outlet, and a pressurized gas envelope or bag contained within the water tank and precharged to a predetermined internal gas pressure. The material from which the gas envelope is made must not only be flexible, but also impermeable to the passage of air or water. In this manner, the air and water are completely separated at all times.

The invention further contemplates the utilization of the gas envelope as a valve for each of the inlet and the outlet. The expansion of the gas forces the wall of the envelope against and covers the tank inlet and outlet ports. Thus, the locations of the inlet and outlet in relation to each other, the various water levels, and the gas pressures are important to the successful function of the invention.

This water storage system also includes an air discharge port or outlet in the top wall of the tank, to provide a vent for any gases or air which become trapped between the gas envelope and the tank top wall. Thus, any air which might be pumped into the tank from the well can be eliminated from the water system in the storage tank, before the air is introduced into the water distribution system. Moreover, any such trapped air will not affect the pressure balance within the storage tank between the gas envelope and the water reservoir, which could disturb the desired water levels.

The water storage tank made in accordance with this invention, not only provides a pressurized water reservoir for the distribution system during normal operation, but will also automatically seal the water inlet and the water outlet when the water pressure becomes too low for any reason. Thus, if water is drawn too fast from the storage tank, the water outlet will be sealed to maintain sufficient water pressure within the inlet pipe to prime and lubricate the pump. Moreover, the outlet will be closed in the event the well or stream source is lower or weak, and thus will maintain sufficient water pressure for priming the pump.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side sectional elevation of the water storage tank made in accordance with this invention incorporated in a water system shown schematically, and also disclosing various positions of the gas envelope for varying water pressures;

FIG. 2 is an enlarged section taken along the line 2-2 of FIG. 1, showing the gas envelope under maximum pressure;

FIG. 3 is an enlarged fragmentary sectional elevation of a portion of the tank and gas envelope in the vicinity of the water outlet;

FIG. 4 is a schematic view of the water outlet head taken along the line 4-4 of FIG. 3; and

FIG. 5 is an enlarged section taken along the line 5-5 of FIG. 2, disclosing the air discharge outlet.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings in more detail, FIG. 1 discloses schematically a water storage system 10 made in accordance with this invention. The system 10 includes an elongated cylindrical water storage tank 11 shown with its longitudinal axis horizontal.

Disposed through one end wall adjacent the bottom of the tank 11 is a water inlet 12. The water inlet 12 should be located at a very low level in the water tank 11 and could be disposed in the very bottom of the tank 11, if desired. However, by locating the water inlet 12 slightly above the bottom of the tank 11 a sump is provided for the collection of sediment.

Formed through the wall of the water tank 11 at a higher level than the inlet 12 is a water outlet 13.

Disposed within the tank 11 is a flexible, and preferably expandable or elastic, gas envelope 15, in the form of a bag or balloon, completely closed except for the single, gas charging inlet valve 16. The gas inlet 16 also extends through an opening formed by the collar or boss 17 in one end wall of the tank 11. The gas charging inlet valve 16 is similar in principle to that of a tire valve for an automotive vehicle, and permits the precharging of the gas envelope with a gas, such as air, to a predetermined internal pressure. The pressure should be at least sufficient to expand the wall of envelope 15 until it completely engages the entire inner surface of the tank 11, when there is no water in the tank, and when the pressure at the water inlet 12 is no greater than a minimum value, such as 10 p.s.i. In the fully expanded position, the wall of the gas envelope 15 will completely close the water outlet port 13 and also the water inlet port 12.

In a preferred form of the invention, a gas or air discharge valve 20 is formed through the top wall of the water tank 11. Although the air discharge valve 20 could be in the form of a simple vent hole, nevertheless, the outlet 20 is provided with an adjustable ball check valve 21 (FIG. 5) which normally rests by gravity upon its seat 22 to close the port 23. When air or gas is trapped and squeezed between the upper portion of the gas envelope 15 and the tank wall 11, the pressurized air passing through the port 23 forces upward the ball valve 21 against the stem 24 of an adjustment member 25. The stem 24 is threaded for vertical adjustment and is provided with a cutaway segment 26 to permit passage of pressurized air past the ball valve 21 and the threaded portion of the stem 24 and out through the exhaust port 27. By screwing down the adjustment member 25, the ball valve 21 may be maintained against its seat 22 to permanently close the opening 23, if desired.

The water outlet 13 is connected to an outlet conduit 30, which in turn is connected with the water distribution piping, including the various taps and faucets for a residential or commercial building, not shown.

The water inlet 12 is connected to a water inlet pipe 31, which in turn is connected to a pump 32 supplied with water through a pump inlet pipe 33 from a well or stream.

In order to operate the pump at the maximum and minimum operating pressures, a pressure-sensitive switch 35 is mounted in fluid communication with the inlet side of pump 32. The sensed pressure is converted into an electrical signal which is

transmitted through the lead 36 to an appropriate mechanism within the pump 32 for turning the pump 32 on and off, in a conventional manner.

It has been found that by forming several small apertures or ports 38 in the end of the inlet conduit 12, instead of one continuous opening, that the forces acting upon opposite sides of the portion of the envelope covering the opening 12, are more nearly equalized. Where a continuous single opening 12 is employed in the inlet port 12, the water pressure of the incoming water from the pipe 31 has to sometimes rise as high as 40 p.s.i. in order to overcome a 10 p.s.i. gas pressure. This differential arises because of the greater interior surface area of the wall of the envelope upon which the gas pressure acts, as opposed to the limited area directly exposed to the interior of the inlet 12. By providing several smaller apertures 38 and spreading them over a slightly greater area, a lesser value of water pressure is required to open the inlet port 12. In fact, when the apertures 38 are properly formed and spaced, the water pressure required to open the inlet port 12 is approximately equal to the opposing gas pressure.

As best disclosed in FIGS. 3 and 4, the water outlet 13 is also provided with a plurality of smaller apertures 40, 41 and 42 in the outlet head 43, having diameters smaller than the inner diameter of the pipe section 44. These apertures are employed for a purpose similar to the apertures 38 employed in the inlet 12. However, in the outlet 13, the upper port 40 is larger than the next lower port 41, which in turn is slightly larger than the next lower or lowest port 42. It has been found that this sequential variation in size of the several exit ports 40, 41 and 42, makes the opening and closing of these ports by the opposing section of the envelope 15 more gradual, smoother and with less noise than a large single outlet port. It has been found that when the head 43 is not employed and the envelope 15 covers and uncovers such a large opening, the differences in pressure on opposite sides of the envelope section produce a snap-acting effect which is noisy and also produces unnecessary wear upon the envelope wall, which can be quite thin.

In the operation of the invention, the tank 11 is installed at the desired site. The outlet 13 is connected to the outlet pipe 30 in an existing water distribution system. The inlet 12 is connected to the inlet pipe 31 of the well pump 32. The gas-charging inlet valve 16 is attached to any convenient source of compressed air and the gas envelope 15 is charged to the desired internal gas pressure, such as 10 p.s.i. When the desired internal pressure has been attained, the envelope will expand to the same size and configuration as the inner surface of the tank wall 11. In this position, the gas envelope 15 not only occupies the entire internal space of the tank 11, but also closes the air exhaust port 20, the water outlet 13, and the water inlet 12. The ports 20, 13 and 12 formed in the wall of the tank 11 preferably terminate in substantially flush and smooth surfaces with the interior surface of the wall so as not to snag the engaging portions of the envelope wall 15. Moreover, these port surfaces are smooth so that the corresponding covering portions of the envelope wall 15 will effect a complete and fluidtight seal.

With the pump 32 turned on, the pressure-sensing device 35 will immediately sense a pressure of 10 p.s.i. which is substantially below the 20-40 p.s.i. operating pump range and will permit the pump to continue pumping water from the source of supply through the lines 33 and 31 into the inlet 12. When the water pressure in the inlet 12 exceeds 10 p.s.i. it will force the covering portion of the envelope 15 away from the inlet to permit the discharge of water from the line 31 into the bottom of the tank 11. The bottom of the envelope at 10 p.s.i. is shown by the phantom line 50 in FIG. 1.

As the water continues to flow into the bottom of the tank 11, the envelope 15 is gradually compressed and contracted, causing the gas pressure to simultaneously increase from its minimum value of 10 p.s.i. When the equalizing pressure between the envelope 15 and the water in the bottom of the tank 11 is approximately 16 p.s.i., the bottom of the envelope

15 will occupy a position illustrated by the phantom line 51, in which position, the inlet 12 is still open and the outlet 13 is still, but just barely, closed. As the pressure gradually builds up to about 20 p.s.i., the bottom of the gas envelope 15 contracts to the position illustrated by the phantom line 52. With the water level at 52, the outlet 13 is now opened and water is freely flowing into, through and out of the bottom portion of the tank 11. As long as the taps in the water distribution system connected to the outlet line 30 are closed, the water pressure in the tank will continue to increase as long as the pump 32 is operating.

After the water level has risen to the position illustrated by the phantom line 53, for example, the water pressure and the equalizing gas pressure will be approximately 40 p.s.i., which is the maximum value of the operating range of the pump 32. Accordingly, the pump 32 will cut off and the water level will rise no higher than the level 53. As water is gradually drawn off through the outlet line 30, just before the outlet port 13 is closed by the descending envelope 15, the pressure device 35 will sense the lower operating limit pressure of 20 p.s.i. and again start the pump 32 to restore the water level 53, and the cycle is repeated.

If any air is pumped into the tank 11 from the well or stream, or if such air should leak into the pump 32 or any other part of the system, such air, if in excessive amounts, will rise and find its way between the exterior surface of the envelope 15 and the interior surface of the tank wall 11, until it is trapped in the top portion of the tank in the vicinity of the discharge port 20, as illustrated by the dashed-line position of the envelope wall 15 in FIG. 5. If the pressure of the trapped air exceeds the weight of the check valve 21, then it will vent to the atmosphere through the ports 23 and 27.

If the discharge port 20 does not exist, any air trapped in the top of the tank 11 would occupy space occupied by an equal volume of the gas envelope 15. Accordingly, the gas envelope 15 would be displaced downward by the equivalent volume of the entrapped air and thereby close the outlet 13 at water pressures greater than the pressures for which the system 10 was designed.

If for some reason the pump 32 fails to operate, such as through a mechanical malfunction or loss of electrical power, the envelope 15 will continue to expand as water is drawn off through the outlet conduit 30. When the water pressure in the tank 11 has declined to about 16 p.s.i. represented by the water level 51, then the outlet 13 is automatically closed so that no further water can be drawn off from the tank 11. This fact in itself would indicate a functional defect in the water system 10. Nevertheless, if such defect is not observed or detected, and the water pressure continues to decline, such as by water draining back through the inlet line 31 and the pump line 33, then when the envelope 15 has expanded to the position 50, the inlet port will also be closed to shut off any further flow of the small amount of water remaining in the bottom of the tank 11.

In the event that the water supply is weak or low, and only a small amount of water is being pumped into the tank 11, along with air which is sucked up with the water, then the excess air will be discharged eventually through the discharge port 20, while the water pressure will gradually decrease until the outlet 13 is closed by the gas envelope 15. Ordinarily, the pump 32 would be cut on when the water level has declined to the level 52, but if the water pressure in the bottom of the tank 11 is augmented by the pressure of the air being pumped into the tank, then the sensing device 35 may not sense a pressure of 20 p.s.i. or lower until the bottom of the envelope 15 has descended to a much lower level. In any event, ultimately, the outlet 13 will be closed by the envelope 15 and maintain water in the tank 11, line 31, the pump 32, and the line 33 to provide a priming water supply as well as to cool and lubricate the pump 32, even though, through some malfunction, the pump is still pumping air.

It will thus be seen that a pneumatically controlled water storage system has been provided which not only completely

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separates the pressurized gas or air from the water and thereby eliminates "waterlogging," but also provides automatically operating and easily maintained flexible valves, to maintain a minimum water head for priming the pump and maintaining the water system for resumption of the operations after malfunctions or failures have been overcome.

Moreover, assuming the reliability of the air charging valve 16, an air volume of a predetermined internal pressure can be maintained in the envelope 15 for the life of the system 10.

The flexible valved, water storage tank 11 will also provide a minimum pressure for restarting the pump even when the water level is at its lowest value, line 50.

Since the envelope 15 is preferably made of a flexible plastic or rubber, the material is inert to water minerals and other corrosive actions. The envelope valves are moved only by air pressure and gravity and provide effective seating action, all with a minimum of parts and maintenance.

Since no compressed air or gas is lost through "waterlogging" the tank 11 may be designed for minimum capacity.

It will be further noted that the envelope 15 has only a single attachment to the tank 11, and that is through the threaded connection of the valve 16 to the boss 17, so that the walls of the envelope 15 are free to expand and contract within the tank 11.

What I claim is:

1. A water storage system comprising:

- a. a closed water storage tank,
- b. a water inlet in said tank,
- c. a water outlet in said tank spaced from said water inlet,
- d. a closed expansible flexible material gas envelope within said tank, said envelope having a wall impermeable to water which when expanded conforms generally to the interior shape of said storage tank,
- e. said envelope having a gas inlet for charging said envelope with a gas at a predetermined internal pressure,
- f. said internal pressure forcing said envelope wall to expand against substantially the entire inner surface of said tank to normally close said water inlet and said water outlet, in the absence of water in said tank.

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2. The invention according to claim 1 in which said water inlet and said water outlet are spaced apart in the normal path of expansion of said gas envelope, so that as said envelope expands said water outlet is closed first, and continued expansion of said envelope will subsequently close said water inlet.

3. The invention according to claim 2 in which said tank has a top and a bottom, said inlet is adjacent the bottom of said tank and said outlet is at a higher level than said inlet.

4. The invention according to claim 3 further comprising an air discharge outlet normally being closed by said envelope wall, said air discharge outlet being opened by air trapped within said tank between the top portion of said tank and said envelope wall.

5. The invention according to claim 1 in which each of said water inlet and said water outlet comprise open ports through the wall of said tank, each of said ports being adapted to be completely closed by the expansion of corresponding portions of said envelope against said port.

6. The invention according to claim 5 in which said inlet comprises a conduit section extending through the wall of said tank, an inlet head in said conduit section, and a plurality of ports through said inlet head.

7. The invention according to claim 1 in which said water outlet comprises a conduit section extending through the wall of said tank, an outlet head and a plurality of ports through said outlet head of varying sizes, said ports being located at different levels, the size of each port varying with its level location, the highest port being largest.

8. The invention according to claim 1 in which said water inlet is in fluid communication with a water pump, and said water outlet is in fluid communication with a water distribution system, a pressure switch responsive to the water pressure within said pump and operatively connected to said pump to start said pump and operatively connected to said pump to stop said pump at a predetermined maximum pressure, so that said envelope closes said water outlet only at water pressures below said minimum pressure.

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