AIR CONTROL FOR A HYDROPNEUMATIC SYSTEM

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ABSTRACT

An air chamber assembly has a flexible diaphragm therein, one side of which defines a wall of an air storage chamber therein, and has a sniffer valve to permit taking air from atmosphere to the storage chamber, and a valved connection from the air storage chamber to a water storage tank to permit air discharge from the chamber to the tank, but prevent passage of water from the tank to the chamber. There is a passageway to the opposite side of the diaphragm from the upstream side of a check valve in the supply line from a pressure source (such as a pump, for example) to the tank, to respond to source pressure against the diaphragm to force air into the tank, and respond to termination of flow from the source by discharging water through a poppet to a drain. In one embodiment, a spring is used against the diaphragm in the air chamber assembly, to force water against a head, to a drain; and in another embodiment there is a drain back into the well casing, obviating the need of a spring in the chamber assembly. Ample drain port size, and positive drain valve action, assure reliability.

33 Claims, 9 Drawing Figures
AIR CONTROL FOR A HYDROPNEUMATIC SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention
This invention relates generally to water systems, and more particularly to means for adding and maintenance of air over water in a storage tank.

2. Description of the Prior Art
Various methods and apparatus have been employed in the past to establish and maintain a desirable volume and pressure of air over water in a storage tank for various reasons, including reduction of frequency of pump operation, flow stabilization, and capacity compensation, for example. Several prior art systems known to us and disclosed in patents are described in U.S. Pat Nos. as follows:

2,622,531 issued Dec. 23, 1952 to Francis E. Brady, Jr.;
2,709,964 issued June 7, 1955 to Francis E. Brady, Jr.; and

The systems described in these patents (and we are confident that there may be other patents also disclosing such systems), add air as needed to a water storage tank. Other systems use a diaphragm in a tank to separate air from the water so that no absorption of air by the water can occur. Other systems use a float on top of the water to minimize exposure of the air to the water and thus minimize absorption of the air by the water.

Most of the prior art systems of which we are aware, and which add air to the tank upon pump operation, provide the desired result when new, but have some disadvantages including the number, complexity, or cost of components, or susceptibility of components to malfunction due to clogging with rust or foreign matter. Therefore it remains desirable to provide a system which is comparatively inexpensive, simple, and trouble-free, for adding air to a water storage tank and maintaining the desired amount of air therein. The present invention is directed to that objective, particularly where a submersible pump is used.

SUMMARY OF THE INVENTION

Described briefly, in one embodiment of the present invention, an air control chamber assembly is mounted to a water tank, and is divided into two chambers (an air chamber and a control fluid chamber) by a flexible diaphragm. The air chamber has a passageway through a check valve into the tank, the check valve being capable of permitting passage of air either way therethrough, but precluding passage of water from the tank into the air chamber. The air chamber has another passageway associated with a sniffer valve, accommodating entrance of air from atmosphere but precluding discharge of air from the air chamber to atmosphere.

There is a check valve between a source of water pressure (such as a pump) and the tank. There is a passageway providing communication between the control fluid chamber and a point on the upstream side of the check valve, whereby upstream pressure can move the diaphragm to discharge air from the air chamber into the tank.

A drain valve, which is opened by the check valve upon termination of flow from the pressure source, opens a drain tube for draining water from the control fluid chamber. During the draining of water from the control fluid chamber, the diaphragm returns and air is admitted to the air chamber through the sniffer valve, unless the water level of the tank is below the chamber connection to the tank, whereupon air will return to the chamber from the tank and be shuttled back and forth between the chamber and tank during each pump operation until the water level tends to rise above the tank connection, whereupon more air will be admitted through the sniffer valve and discharged into the tank.

In one embodiment, a spring is used in the air chamber, to drive water out the drain against a head, when flow from the pressure source is terminated.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an elevational view of a system incorporating the typical embodiment of the present invention.
FIG. 2 is a vertical section through the air control chamber.
FIG. 3 is an end view of the actuator valve assembly taken through the upstream end.
FIG. 4 is a section therethrough taken at line 4—4 in FIG. 3 and viewed in the direction of the arrows.
FIG. 5 is a view of the drain poppet valve taken at line 5—5 in FIG. 3 and viewed in the direction of the arrows.
FIG. 6 is a view of the drain poppet valve taken at line 6—6 in FIG. 3 and viewed in the direction of the arrows.
FIG. 7 is an elevational view of a simplified system incorporating some features of the present invention.
FIG. 8 is a section similar to that of FIG. 2 but showing the modification of the air control chamber incorporated in the embodiment of FIG. 7.
FIG. 9, similar to FIG. 7, shows another embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings in detail, and particularly to FIG. 1, a water storage tank 11 is provided with fittings 12, 13, 14 and 16 for a water inlet, outlet, air control connection, and pressure switch, respectively. An electric pump 17 of the submersible type can supply water from a well through the piping 18 and through an actuator valve body 19 and inlet pipe 21 to the tank 11. The outlet pipe 22 is connected to the water using system. This may be in a residence, for example. An air control line 23, normally containing water, is connected from the actuator body 19 to the air control chamber assembly 24. A drain tube 26 is connected to the actuator body and may be directed to a suitable drain line or ditch, for example. The pressure switch 27 is connected by suitable electric conductors in conduit 28 to the pump 17. The pressure switch is responsive to pressure in the tank to turn on the pump when the pressure gets below a certain pre-determined level such as 20 pounds per square inch gauge (PSIG), for example, and stop the pump when the pressure has risen to 40 PSIG, for example. The dotted line 29 illustrates the capability of the system of the present invention for operation although the drain tube outlet may be above
the top of the tank. This will be described in more detail hereinafter.

Referring now to FIG. 2, the air chamber assembly is a generally circular unit about a central axis 31 including a mounting shell 32 and cover shell 33 which are secured together by a series of circularly spaced bolts 34 received through apertures in the flanges of the respective shells. A diaphragm 36 is sandwiched between the flanges of the shells, and is flexible to conform to the interior contour of the shells and particularly outer shell 33 when urged against it by a disc 37 having an aperture receiving a boss 38 on the inner face of the diaphragm, serving as a pilot for a small end turn 39 of a coil spring 41, the large turn of which is seated in the mounting shell 32. This air control spring 41 normally urges the diaphragm against the inner wall of the outer shell 33 closing the port 42 to which the air control line 23 (FIG. 1) is connected. Notice that the portion of the diaphragm spanning the chamber joins a thicker mounting portion 36B sandwiched between the flanges of the shells at the edge of the mounting portion nearest the outer shell 33. The extra space thereby provided on the spring or air chamber side of the diaphragm permits it to completely invert during operation. This has been found to improve endurance significantly.

The air control mounting shell 32 has a sniffer valve 43 therein including a seat 44, check ball 46, and spring 47. The spring normally holds the ball against the seat.

The mounting shell also has a water check valve assembly 48 in the fitting 49 by which it is mounted to the fitting 14 of the tank. The water check valve includes a floatable ball 51 which will normally rest below the center of the seat 52, and not close on the seat 52 unless water has risen to or above that level in the tank, tending to help the ball to seat. Thus this check valve will accommodate passage of air back and forth through it, but will preclude the passage of water from the tank into the air chamber 53 of the air control assembly 24.

Referring now specifically to FIGS. 3 and 4, the actuator body 19 includes therein an axially located, streamlined and stationary diffuser 56 receiving the stem of the actuator poppet 57 having a circular "dead" rubber (typically butyl rubber) seal 58 thereon and loaded by the actuator spring 59. When the pump is off, this valve is in the closed position shown.

A streamlined arch 61 is tightly fitted and stationary in the actuator body immediately upstream of the poppet valve seat and extends through an arc of approximately 270° as best shown in FIG. 3 where the arch ends at lines 62 and 63. A drain poppet holder 64 is provided between the ends of the arch 61 and has a pair of pins 66 and 67 force fitted into the actuator body to support the drain poppet holder 64 in the position shown. The drain poppet itself includes a stem 68 slidingly received in the drain poppet holder 64 and having an upwardly extending arm with a downstream sealing face thereof facing the resilient annular seal 69, the apertured end portions of which receive pins 66 and 67 therethrough and are secured in a sandwich between the poppet holder and actuator body. The drain poppet stem also has a downwardly projecting leg 71 having a face 72 engaging the upstream face 73 of the actuator poppet 57. Accordingly, when the actuator poppet is sealed as shown in FIG. 4, the downstream seal face of the drain poppet is held away from the seal 69 around the aperture 75 in the actuator body leading to the drain tube 26 which is secured to the actuator body by conventional compression fittings 76. The air control tube 23 is also connected to the actuator body by conventional compression fittings 77.

OPERATION

In the operation of the system, assuming that the storage tank is empty, the pressure switch 27 will respond to the absence of pressure in the tank and energize the water pump. As soon as the pressure upstream of actuator poppet 57 rises sufficiently to overcome the closing force thereon applied by spring 59, the actuator poppet will open and admit water through the fill line 21 into the tank 11. At the same time, as the actuator poppet opens, it permits the drain poppet to move in the direction of water flow and seal against seal 69, around aperture 75. This closes the drain line.

Water supplied by the pump also passes through aperture 78 (FIG. 4) in the streamlined arch 61 and into the mating passageway in the actuator body 19 and from there into the air control line 23. The rising pressure of water in port 42 on the control fluid chamber side of diaphragm 36 will force the diaphragm in the air control chamber assembly to the right in direction of arrow 79 against the spring load, enlarging the control fluid chamber as it fills with water. As the control fluid chamber enlarges, the air chamber 53 must become smaller, so that air from chamber 53 will be pushed into the tank. The water from the pump continues to enter the tank through line 21 until the pressure rises to the upper limit of the pressure switch 27, whereupon the pump stops.

When the pump stops, the actuator poppet returns to its seat. It thereupon forces the drain poppet off its seat to open the upstream side of the actuator poppet to the drain tube. When this occurs, the spring in the air chamber 53 can then push the diaphragm back to its original position shown in FIG. 2. As it does so, it forces water from the air control line 23 out through the drain tube to the drain. As this occurs, air must enter chamber 53. If the water level in the tank is below the level of the check valve 48, the air will enter from the tank into the chamber 53. It will then be pushed back into the tank the next time the pump starts. On the other hand, if so much air in the tank has been absorbed by water in the tank that the water level is above the check valve assembly 48, then the check ball 51 will seal on the seat 52 when the air control spring 41 moves the diaphragm against the seal 33 so air will enter the chamber 53 from the atmosphere through the sniffer valve 43. Then the next time the pump starts, the air in chamber 53 will be pushed into the tank by pressure in port 42 forcing the diaphragm against the spring load to reduce the volume of chamber 53. It is in this way that air is added to the tank whenever the pump starts at a time after water has risen above the check valve assembly 48.

In the example illustrated in FIG. 1, the outlet of drain tube 26 is above the air control assembly so there will be a gravity head in the end of the actuator body upstream of the poppet 57 when the pump is off. It is an important feature of this embodiment of the invention that the air control spring 41 will push water from the control fluid chamber out tube 26 against the drain head. The check valve 55 is used to prevent siphoning back from the drain outlet into the water system or...
A wire bridge 55A prevents seating of ball 55 in the upper outlet 55B. Downstream of the poppet 57, the system pressure exists as established by the air charge in the tank. It is this pressure to which the pressure switch responds to control the pump.

For proper functioning of the system, the drain poppet should close well before the flow through the actuator poppet has risen enough that the total flow through the poppet equals the capacity of the pump. This is necessary in order to assure that the drain poppet will close and avoid leakage through the drain during pump operation. For example, it is desirable that the actuator poppet be sufficiently opened to allow the drain poppet to be swept closed by water passing it toward the drain when the flow through the actuator poppet has risen to approximately 4 gallons per minute (gpm). The diameters of the actuator poppet and the air control chamber diaphragm, and the actuator spring and air control spring values are selected so that the pressure differential established across the actuator poppet when the pump is running is sufficient for the pressure upstream of the poppet to effectively collapse the spring in the air control and thus exhaust air from chamber 53 effectively into the tank 11 during pump operation. By using a low friction loss actuator valve, a stronger actuator spring can be employed, enabling use of a larger drain valve seat diameter and yet being assured that the actuator poppet will push the drain poppet off its seat against higher upstream pressures. For example, with the present invention, it is possible to open a drain poppet on a seat 0.100 inch diameter against 100 psi.

The air charge of the tank will depend upon the height of the air control thereon, and the "kill pressure" of the pump. Usually the air control will be midway up on the tank. When this is the case, the supercharge of the tank (defined below) will be in accordance to the following chart, where the "kill pressure" is the pressure at which the pressure switch will shut off the pump. The various values shown below would be established by selecting pressure switches for the various kill pressures listed:

<table>
<thead>
<tr>
<th>Kill Pressure</th>
<th>Air Super Charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSIG</td>
<td>PSIG</td>
</tr>
<tr>
<td>40</td>
<td>12.6</td>
</tr>
<tr>
<td>50</td>
<td>17.6</td>
</tr>
<tr>
<td>60</td>
<td>22.6</td>
</tr>
<tr>
<td>70</td>
<td>27.6</td>
</tr>
<tr>
<td>80</td>
<td>32.6</td>
</tr>
</tbody>
</table>

The above indicated super charge values represent the pressure which would exist in the tank if it were completely emptied of water without any loss of air therefrom as water is drawn out beginning at a corresponding tank pressure identified as the kill pressure.

The amount of air drawn during each cycle of pump operation, depends upon the volume of the air control assembly, the force of the spring therein, the diameter thereof, and the height of the drain tube outlet. For example, it is possible that in some installations it would be necessary to drain water at a level above the top of the tank. This possibility is indicated by the dotted line 29 in FIG. 1. It was mentioned above that diameters and spring values are selected for effective collapse of the air control spring during pump operation to discharge air from the air control chamber 53 into the tank 11 during pump operation. For example, if one decides to use an air control chamber having a 15 cubic inch total volume and having a given effective area of the diaphragm thereof and wants to discharge water from the drain tube at an 8 foot drain head (drain tube outlet 8 feet higher than the center line of the air control chamber assembly), and wants to draw in 2 cubic inches of air at atmospheric pressure into the air control each time the pump stops, these parameters serve as a basis for the spring selection. They determine the force (64 pounds in this instance where the diaphragm area at full collapse is 9.8 square inches) of the air control spring necessary to move water out the drain when the pump shuts off. With that determined, the actuator spring can be selected such that it will cause a sufficient pressure rise on the upstream side of the actuator poppet upon pump operation to effectively collapse the air control spring and discharge air from the air control into the tank.

From the foregoing it can be seen that various combinations will work together, and that because of the interaction of the components, there is some interrelationship between the parameters and their effects. For example, the higher the head requirement, the stronger the air control spring must be; the stronger the air control spring is; the stronger the actuator spring must be; the greater the pressure loss across the actuator poppet. Thus the spring selection will generally involve a compromise between an acceptable air intake volume of the air control at an acceptable drain head, and pressure loss across the actuator poppet.

It has been found that using the air control described in the above example, the maximum height of the drain tube itself may be as much as fifteen feet above the air control, and the system will still work. Where the drain tube outlet is below the maximum height, as in the illustrated example, syphoning action reduces the effective pressure to be overcome in the drain tube by the spring, to the height of the outlet of the drain tube above the air control, i.e., the drain head. Using this same air control assembly with drain tubes having different outlet levels, the volume of air which can be taken in for adding to the tank during each pump operating cycle, will vary according to the following chart:

<table>
<thead>
<tr>
<th>Head of Drain Feet Water</th>
<th>Air Intake In Cubic Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>1.8</td>
</tr>
<tr>
<td>7</td>
<td>2.3</td>
</tr>
<tr>
<td>6</td>
<td>4.3</td>
</tr>
<tr>
<td>5</td>
<td>6.1</td>
</tr>
<tr>
<td>4</td>
<td>8.6</td>
</tr>
<tr>
<td>3</td>
<td>10.4</td>
</tr>
<tr>
<td>2</td>
<td>11.6</td>
</tr>
<tr>
<td>1</td>
<td>12.5</td>
</tr>
</tbody>
</table>

In this example, it can be seen that this particular air control assembly having the above mentioned dimension and values will not work if the drain tube discharge is at a level which exceeds ten feet above the center line of the air control. Apart from that, its performance in terms of adding air depends only upon the drain head.

It should be understood that this invention will work on all types of water systems, including not only submersible pump supplied systems but also systems using other types of pumps including piston pumps and jet pumps, and systems where the water supply from some remote source of pressure is controlled by an on-off valve operated by a solenoid or other means, for example.
Referring now to FIGS. 7 and 8, some parts therein which may be of a type of construction identical to those in the previously described figures, are given the same reference numerals. However, in this embodiment the air chamber assembly 84 is somewhat different in the respect that no spring is employed either with the diaphragm or with the snifter valve. The normal relaxed configuration of diaphragm 87 is as shown, against the outer shell 86 of the chamber assembly. The central portion is thickened at 85 to minimize the chance of its being deformed into the central port which receives the tube 23 (FIG. 7).

Another difference in the construction of this embodiment is that the actuator body 88 does not include the drain poppet or drain line connections of the first described embodiment so the drain port is plugged at 90. The air control line 23 is connected thereto in the same manner as described above with reference to the embodiment of FIGS. 1 and 4.

One further feature of the embodiment of FIG. 7 which is not necessary in that of FIG. 1, is the provision of a bleed hole 89 in the delivery pipe from the pump 17 to the actuator body 88. In the embodiment illustrated, this hole is of approximately 1/16 inch diameter and located approximately 8 feet below the centerline of connection of the air control tube 23 to the air control chamber assembly 84. This is dimension "H" in FIG. 7. Of course dimension "H" could be considerably less or more than 8 feet. If the natural, unstrressed configuration of diaphragm 87 is as shown in FIG. 8, "H" can be virtually zero, and the intention will still work.

In this embodiment of the invention, while the pump is running, pressure in line 23 upstream of the actuator poppet may hold the diaphragm 87 against the inner or mounting shell of the assembly. When the pump turns off, the bleed hole provides a point from which the column of water in the pipe above it to the air control chamber tends to drain. This provides a negative head of dimension "H." It thus establishes a vacuum, enabling and encouraging the diaphragm 87 to return toward the outer shell 86. This will result in entry of air through either the snifter valve 43 or the check valve 48, depending upon whether or not the water level in the tank is above the water check valve 48. If the water is above the check valve 48, air will enter through the snifter valve. Then, when the pump turns on, the diaphragm returns, forcing air from the air chamber 53, out through the check valve 48 into the tank. This same cycle repeats for every on-off operation of the pump, so long as the check ball in the adaptor 49 is below the water level in the tank at the pump "kill pressure." When the adaptor is exposed to air in the tank, air enters the air chamber from the tank rather than through the snifter, during the off period of the pump.

Another embodiment may be mentioned here as employing an air control chamber assembly like that in FIG. 2 in combination with the actuator assembly of FIG. 4 but with the drain poppet omitted and simply a bleed hole provided downstream of the actuator valve and either associated with a tube such as 26 in FIG. 1, or some where in the supply line from the pump to the actuator assembly at either a zero head or even a slight positive head, in contrast to the eight foot negative head of the embodiment of FIG. 7. In such case, when the pump starts, the friction head across the actuator valve is sufficient to compress a rather weak spring in

the air chamber assembly and push air into the tank from the air chamber. When the pump stops, the friction head disappears, allowing the spring to return the diaphragm, closing the water check valve in the adaptor assembly 49 and pulling air in the snifter valve, whenever the water level is above the adaptor check valve. As in the previously described embodiments, when the water level is below the adaptor check valve, air will simply shuttle back and forth between the air chamber and tank for each pump cycle. In the FIG. 9 embodiment, which uses air chamber assembly 84 of FIG. 8, the drain line 26 enters the supply piping 18 between the pump and the actuator poppet body 88 and extend therein to outlet 91 below the top of the well casing, where it discharges into the well casing. There is no communication (inside piping 18) between the water in the line 26 and water in the piping 18. The outlet 91 may be located any suitable distance below the centerline of connection of the air control tube 23 to the air control chamber assembly 84. This is dimension "H" in FIG. 7.

This embodiment of the invention, while it operates the air control similarly to the FIG. 7 embodiment and is a little more complicated than the embodiment of FIG. 7, has the advantage of a large diameter drain port and tube as in FIG. 1, and avoids bleeding of pump pressure, which occurs to at least some limited extent through bleeder hole 89 in FIG. 7 while the pump is running. "O" rings 91 on the stem of poppet and engaging the inner guide wall of diffuser 56, help reduce or avoid chatter of the actuator poppet. Therefore seal 58 may be smaller than might otherwise be needed to avoid chatter if "O" rings were not used. The smaller seal is desirable to provide consistency of closure of actuator poppet 57 at low flow rates. It thus promotes consistency of opening the drain poppet when desired.

The invention claims:

1. An air control for a hydropneumatic system comprising:
an air storage chamber assembly including a housing having a cavity therein with control fluid therein and air therein, the respective volumes of fluid and air therein being variable, first aperture means in said housing to permit entrance of air to said cavity, and additional aperture means in said housing to permit entrance and departure of said control fluid;
a control fluid conduit coupled to said additional aperture means;
a liquid check valve assembly including a valve body with a one-way check valve therein movably in a downstream direction to open;
said control fluid conduit communicating with said check valve assembly upstream of said check valve to conduct pressure upstream of said check valve to said additional aperture means to expel said air from said cavity.

2. The combination of claim 1 and further comprising:
a liquid supply pipe upstream of said check valve and extending to a point below the level of said air storage chamber assembly;
an opening in said pipe at said point;
said pipe cooperating with said check valve when closed, and with said control fluid conduit to form
a closed passageway from said control fluid in said cavity down to said opening.

3. The combination of claim 2 and further comprising:
a pump connected to said liquid supply pipe upstream of said opening for supplying liquid to said conduit and check valve assembly.

4. The combination of claim 3 and further comprising:
a water storage tank containing water therein, coupling means connected to said chamber assembly and to said tank and providing communication between said first aperture means of said chamber assembly and said tank for transfer of air from said cavity to said tank.

5. The combination of claim 4 wherein:
said coupling means include a valve closable upon attainment of the level of said valve, by water in said tank to preclude passage of water outward from said tank through said valve toward said storage chamber assembly, and
a one-way snifter valve is coupled between said first aperture means and atmosphere to accommodate entry of air from atmosphere to said cavity, but preventing venting of air from said cavity to atmosphere.

6. The combination of claim 5 wherein:
a movable wall in said chamber assembly divides said cavity into a control fluid chamber containing water as the control fluid, and an air chamber containing air admitted by said snifter valve; and
said check valve is biased to establish a pressure drop thereacross during flow therethrough, to apply a pressure drop across said movable wall for urging said movable wall toward a wall of said air chamber to reduce the volume of said air chamber, thereby driving air from said chamber through said valve in said coupling means into said tank.

7. The combination of claim 1 wherein:
a movable wall in said chamber assembly divides said cavity into a control fluid chamber containing water as the control fluid, and an air chamber containing air admitted by said first aperture means; and
said storage chamber assembly includes resilient means urging said movable wall away from a wall of said air chamber to increase the volume of said air chamber and accommodate entrance of air into said air chamber through said first aperture means.

8. The combination of claim 7 and further comprising:
a liquid supply pipe upstream of said check valve;
a pump connected to said liquid supply pipe upstream of said check valve;
a water storage tank;
a fill pipe connected downstream of said check valve and connected to said tank; and
coupling means connected to said chamber assembly and to said tank and providing communication between said first aperture means of said chamber assembly and said tank for transfer of air from said air chamber to said tank.

9. The combination of claim 8 and further comprising:
drain means communicating with said supply pipe.

10. The combination of claim 9 wherein:
said drain means include a drain opening in said check valve body.

11. The combination of claim 9 wherein said drain means include:
a drain opening in said check valve body;
a drain valve normally open in the absence of flow through said check valve, and closable during pump operation to prevent loss of water through said drain opening.

12. The combination of claim 11 wherein said drain means further include:
a drain line connected to said valve body and communicating with said drain opening, and extending to an elevation above the top of said tank.

13. The combination of claim 11 wherein:
said drain valve is a poppet valve, and
said drain means include a poppet holder secured in said valve body upstream of said check valve, said poppet valve having a stem slingly received in said poppet holder.

14. The combination of claim 13 and further comprising:
force transmitting means between said check valve and said poppet valve whereby said poppet valve is held open by said check valve when said check valve is closed.

15. The combination of claim 14 wherein:
said poppet valve has a portion in the flow path of water through said valve body to said check valve for sweeping closed said poppet valve by water flowing from said pump through said valve body when said check valve is open.

16. The combination of claim 15 wherein:
said valve body has a pressure take-off aperture therein upstream of said check valve, said control fluid conduit being coupled to said pressure take-off aperture.

17. The combination of claim 1 wherein said liquid check valve assembly includes:
a drain opening in said valve body upstream of said check valve;
a drain poppet valve disposed to seal and unseal said drain opening, said check valve being an actuator poppet valve, an actuator spring normally urging said actuator poppet valve closed, one of said poppet valves having means thereon engaging the other of said valves precluding simultaneous closure of both of said poppet valves.

18. The combination of claim 17 wherein:
said drain poppet valve has a portion in the flow path of water through said valve body from upstream of said check valve to said drain opening for sweeping closed said drain poppet quickly by water flowing into said drain opening when said check valve is opened.

19. The combination of claim 1 wherein:
a movable wall is provided in said housing, dividing said cavity into an air chamber and a control fluid chamber; and
said chamber assembly housing includes shells on opposite sides of said movable wall and providing said chambers on opposite sides of said wall of sufficient volume to accommodate complete mirror image inversion of said wall from a position against an inner wall of one of said chambers to a position...
3,805,820

11 toward the opposite facing inner wall of the other of said chambers.

20. The combination of claim 19 and further comprising:
a one way valve coupled to said first aperture means
and precluding flow outward from said air chamber through said first aperture means.

21. The combination of claim 20 wherein:
said movable wall is resilient and isolates said chambers from each other.

22. The combination comprising:
a water line check valve assembly including a valve body,
and a one-way check valve therein;
a drain opening in said valve body upstream of said check valve;
a drain valve disposed to seal and unseal said drain opening,
said check valve being an actuator poppet valve,
an actuator spring normally urging said actuator poppet valve closed, one of said valves having means thereon engaging the other of said valves precluding simultaneous closure of both of said valves.

23. The combination of claim 22 wherein:
said drain valve is a poppet valve and has a portion in the flow path of water through said valve body from upstream of said check valve to said drain opening for sweeping closed said drain poppet valve quickly by water flowing into said drain opening when said check valve is opened.

24. An air chamber assembly comprising:
a housing having a cavity therein, with first and second facing interior walls and a chamber wall between said walls dividing said cavity into an air chamber and a control fluid chamber, said chamber wall being movable to vary the respective volumes of said chambers,
first aperture means in said housing communicating with said air chamber to permit entrance of air to said air chamber;
additional aperture means in said housing communicating with said control fluid chamber, resilient means in said cavity urging said movable wall toward said first interior wall of said cavity thereby tending to reduce the volume of one of said chambers and increase the volume of the other of said chambers;
said movable wall being mounted nearer to one of said interior walls than to the other of said interior walls, to accommodate inversion of said movable wall in response to change of pressure differentials between said chambers.

25. The combination of claim 24 wherein:
said housing includes a pair of shells fastened together, one of said interior walls being on one of the shells and the other of said interior walls being on the other of said shells;
said movable wall is a diaphragm having a marginal portion sandwiched between said shells, said marginal portion being substantially thicker than the central portion of said diaphragm and offset with respect to the plane of the central portion to locate the said central portion nearer to one of said interior walls than to the other.

26. An air control for a hydropneumatic system comprising:
an air storage chamber assembly including a housing having a cavity therein with control fluid therein
and air therein, the respective volumes of fluid and air therein being variable, first aperture means in said housing to permit entrance of air to said cavity, and additional aperture means in said housing to permit entrance and departure of said control fluid;
a control fluid conduit coupled to said additional aperture means;
a liquid check valve assembly including a valve body with a one-way check valve therein movable in a downstream direction to open;
said control fluid conduit communicating with said check valve assembly upstream of said check valve to conduct pressure upstream of said check valve to said additional aperture means to expel said air from said cavity;
water supply pipe means having said valve body therein;
a drain opening in said check valve body upstream of said check valve;
a drain valve associated with said drain opening and normally open in the absence of water flow through said check valve, but closable to prevent loss of water through said drain opening, during water flow through said check valve.

27. The combination of claim 26 and further comprising:
a drain line connected to said valve body and communicating with said drain opening.

28. The combination of claim 27 and further comprising:
a well casing;
a submersible pump in said casing and connected to said water supply pipe means;
said drain line having an outlet inside said well casing.

29. The combination of claim 28 wherein:
said drain line extends inside a portion of said pipe means and exits therefrom inside said well casing.

30. The combination of claim 26 and further comprising:
a water storage tank, said supply pipe means being connected to said tank downstream of said check valve;
and coupling means connected to said chamber assembly and to said tank and providing communication between said chamber assembly and said tank for transfer of air from said air chamber assembly to said tank.

31. An air chamber assembly comprising:
a housing having a cavity therein, with first and second facing interior walls and a chamber wall between said walls dividing said cavity into an air chamber and a control fluid chamber, said chamber wall being movable to vary the respective volumes of said chambers,
first aperture means in said housing communicating with said air chamber to permit entrance of air to said air chamber;
additional aperture means in said housing communicating with said control fluid chamber, resilient means in said cavity urging said movable wall toward said first interior wall of said cavity thereby tending to reduce the volume of said control fluid chamber and increase the volume of said air chamber.
32. The combination of claim 31 wherein: said resilient means include a spring compressed by pressure of control fluid in said control fluid chamber.

33. The combination of claim 31 wherein: said movable wall is mounted nearer to one of said interior walls than to the other of said interior walls, to accommodate inversion of said movable wall in response to change of pressure differentials between said chambers.

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