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VALVE STRUCTURE FOR PREVENTING AIR LOCK IN PUMPS

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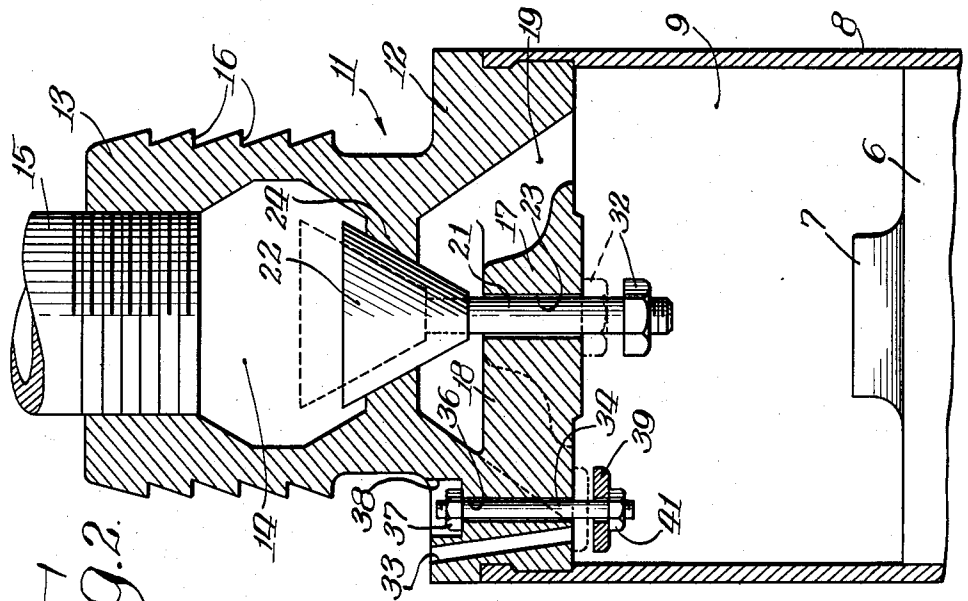


Fig. 2.

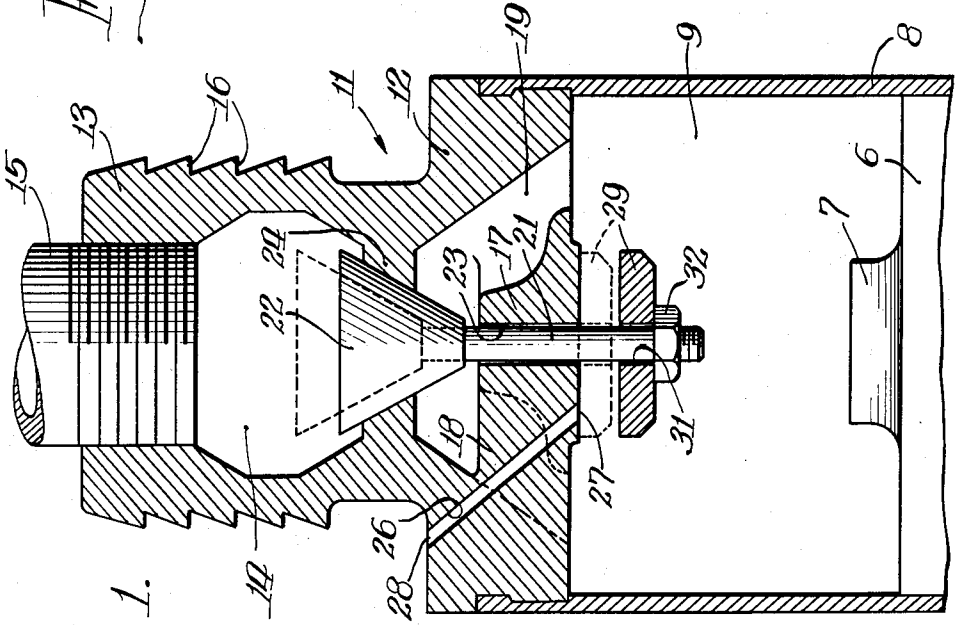


Fig. 1.

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VALVE STRUCTURE FOR PREVENTING AIR LOCK IN PUMPS

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This invention relates to novel means for preventing air lock in pumps and more particularly to novel valve structure for use in submersible deep well pumps.

With the rapidly expanding use of submersible deep well pumps, it is becoming increasingly apparent that low water conditions in wells occur more frequently than had been realized, the situation being particularly critical in certain regions of the country. Not only do low water conditions present a serious problem of protecting motors and pumps, but frequently when the normal water level returns it is found that the pump is air locked and will not operate satisfactorily.

One method heretofore used of protecting the pump against air lock has been to drill a small hole just below the check valve at the discharge side of the pump which permits the air to escape into the well casing. However, if the hole is drilled large enough to permit effective venting of air from the pump, there is also an appreciable water loss or leakage during operation of the pump which, of course, decreases the effective pump output and efficiency. As will hereinafter appear, my invention accomplishes the desired air venting in a simple manner but without the necessity of sacrificing pump output and efficiency.

Accordingly, a primary object of my invention is to provide novel means for preventing air lock in a pump, particularly a submersible deep well pump.

A further object of the invention is to provide novel means for venting air from a pump which does not result in a decrease in the pump output or efficiency.

Another object of the invention is to provide a novel valve structure for preventing air lock in pumps, particularly submersible deep well pumps.

Other objects and advantages of the invention will become apparent from the subsequent detailed description taken in conjunction with the accompanying drawing, wherein:

Fig. 1 is a vertical sectional view of the upper end of a submersible pump illustrating a preferred embodiment of the invention; and

Fig. 2 is a view similar to Fig. 1 but showing a modified form of the invention.

Referring first to Fig. 1, the invention is illustrated in connection with a submersible deep well pump shown fragmentarily at 6 and having a discharge outlet 7 and an exterior casing 8. It will be understood that a motor (not shown) is operatively connected to the pump 6, the entire motor-pump unit being suspended in the well below the normal water level for the region and the water being pumped upwardly through a suitable conduit or tubing to a pressure tank or other storage receptacle.

In this form of the invention, the upper end of the pump casing 8 is extended to provide a chamber 9 beyond the discharge outlet 7, and a closure, indicated generally at 11, is secured to the upper end of the casing 8. The closure 11 has a body or flange portion 12

having a tight rigid fit with the casing 8, and an axial extension 13 projects upwardly from the body 12 providing a main fluid discharge passage 14 and having a threaded attachment to the end of a section of discharge tubing or conduit 15. The exterior of the axial extension 13 is provided with a plurality of sharp projections or teeth 16 in order to facilitate grasping of the motor-pump unit with a grappling tool or the like in the event that the discharge tubing or stringer 15 is ever broken and the unit must be withdrawn from the well.

The body 12 of the closure 11 includes a spider comprising a central hub portion 17 and a plurality of radially extending arm portions 18 having open spaces 19 therebetween. A check valve member comprising an upright stem portion 21 and a tapered plug portion 22 rigidly carried at the upper end of the stem 21 is operably mounted in the closure 11 for controlling the flow of fluid through the main discharge passage 14 into the discharge tubing 15. The stem 21 extends through an aperture or bore 23 in the hub portion 17 in slidable relation with the latter, and the tapered plug portion 22 is adapted to seat against a similarly tapered valve seat or shoulder portion 24 provided in the closure 11. Thus, it will be seen that when water or other working liquid is discharged upwardly from the pump outlet 7 and passes through the open spaces 19 of the spider, the flow of liquid will cause the tapered plug portion 22 of the check valve to be lifted from the check valve seat 24 in the usual manner to permit the normal discharge of pumped liquid.

In order to prevent air lock due to the accumulation of air in the valve chamber 9 after the pump has been shut down during a low water level period, one of the arm portions 18 of the spider is provided with an angularly extending bore or air vent passage 26 having an inlet end 27 in the hub portion 17 adjacent the central bore 23 and also having an outlet 28 communicating with the well casing and exteriorly of the pump unit. Consequently, when the pump is at rest with the plug portion 22 of the check valve in closed position (as indicated in full lines in Fig. 1) it will be seen that the chamber 9 is vented to the well casing through the open passage 26. When the pump 6 is started and working liquid begins to discharge from the outlet 7, the air accumulated in the chamber 9 will gradually be displaced through the open air vent passage 26 thereby avoiding air lock of the pump. When all of the air is displaced from chamber 9 and working liquid reaches the plug portion 22 of the check valve, the plug 22 will then be lifted to the open dotted line position shown in Fig. 1.

At the same time, in order to prevent the loss of discharge liquid through the air vent passage 26, I provide an auxiliary valve member in the form of a disk or washer 29 having a central aperture 31 and loosely carried at the lower end of the stem 21 in slidable relation therewith. A nut 32 is threaded to the lower end of the stem 21 for retaining the washer 29 thereon. As the plug portion 22 and the stem 21 are lifted upwardly in response to discharge of working liquid through the main fluid passage 14 of the unit, the disk 29 carried at the end of the stem 21 is likewise lifted until it seats against the under side of the hub portion 17 of the closure 11 (as seen in dotted lines in Fig. 1) thereby closing or sealing off the inlet end 27 of the air vent passage 26. Thus, the main fluid passage 14 from the unit is opened and the air vent passage 26 is simultaneously closed by the action of a unitary valve mechanism in response to the discharge of working liquid from the unit. Accordingly, the invention permits venting

of air from the chamber 9 to prevent air lock during initial operation of the pump and at the same time the air vent passage 26 is automatically closed when the pump begins to discharge liquid so as to prevent loss of working liquid through the air vent passage.

As hereinbefore pointed out, the auxiliary valve member comprising the washer or disk 29 is slidable on the valve stem 21. Although for purposes of effecting simultaneous opening of the main discharge passage 14 and closing of the air vent passage 26 it would be possible to mount the disk 29 rigidly on the stem 21, I have found that for most effective operation the slidable mounting of the disk 29 on the stem 21 is preferred. For example, it frequently happens that when the pump is stopped after a period of operation the average pressure inside the pump is higher than atmospheric pressure even though the pump is shut off. This is explained by the fact that there is a momentary back flow of water through the open check valve 22—24 when the pump is first shut off which produces a back pressure in the chamber 9 due to the flow resistance of the restricted fluid passages of the pump. If the disk 29 were rigid with the stem 21, this back pressure acting against the disk 29 would often be sufficient to hold the check valve 22—24 in open position. This difficulty is avoided by the slidable mounting of the disk 29 on the stem 21 as shown in Fig. 1. With this construction, when the pump is stopped the back flow of water causes the plug portion 22 to seat in the normal manner for closing the main fluid discharge passage 14 so as to interrupt the back flow of water into the pump. Because of the temporarily higher pressure within the chamber 9, the disk 29 will remain in seated relation against the inlet 27 of the air vent passage 26 for a brief period of time until the pressure within the pump becomes equal to the exterior pressure in the well casing. When the pressures are thus substantially equalized the disk 29 will automatically drop down on the stem 21 by gravity and thus open the air vent passage 26 so as to prevent air lock during the next subsequent operating period of the pump.

In Fig. 2, a modification of the invention is illustrated wherein the venting of air from the pump casing is controlled by an auxiliary valve means which functions independently of the main check valve. In Fig. 2, the portions of the device which are the same as shown in Fig. 1 are identified by the same reference numerals. Thus, the closure 11 has the same general construction including the spider arrangement, but in this case the check valve for the main fluid discharge passage comprises merely the tapered plug portion 22, the depending stem 21, and the retaining nut 32 at the lower end of the stem. An air vent passage 33 extends at a slight angle through the body portion or flange 12 of the closure 11 adjacent the outer periphery thereof, i. e. beyond the arms 18 of the spider. Immediately adjacent the angular air vent passage 33, a stud or stem 34 extends downwardly through a bore 36 into the valve chamber 9 and is retained at its upper end by a nut 37 seated in a recess 38. At the lower end of the stem 34 an apertured washer or disk 39 is slidably mounted on the stem 34 and is retained by a lowermost nut 41. The diameter of the disk or washer 39 is large enough to overlie the lower end of the air vent passage 33.

When operation of the pump 6 is started after a low water period, the check valve 22—24 in the main fluid passage 14 remains closed while air is displaced from the chamber 9 through the air vent passage 33 which remains open during this period. When all of the air in the chamber 9 is finally displaced the discharge of working liquid from the pump outlet 7 causes the tapered plug portion 22 to be lifted to open position in normal fashion and at the same time the flow of liquid also lifts the movable washer 39 into seated engagement at the under side of the closure 11 thereby sealing off the air vent passage 33 and preventing loss of working liquid. When the pump is

stopped and the internal pressure becomes equal to the pressure in the well casing, the washer or disk 39 will drop by gravity to its open position in the same manner as in the Fig. 1 embodiment.

Consequently, it will be seen that the same general operating principle is employed as in Fig. 1, namely, that the valve for the main fluid discharge passage is opened and at substantially the same time the valve means for the air vent passage is closed, both valve means being so operated in response to discharge of working liquid. Although the disk 39 is shown as slidable on the stem 34 in Fig. 2, it is also possible to make this disk rigid with the stem 34 without encountering the difficulty heretofore described in connection with Fig. 1.

Although the invention has been described with particular reference to certain specific structural embodiments thereof, it will be understood that various modifications and equivalent structures may be resorted to without departing from the scope of the invention as defined in the appended claims.

I claim:

1. In a submersible pump having a discharge outlet, a casing surrounding the pump and extending beyond said outlet whereby to define an upright discharge chamber, a closure member at the upper end of said chamber providing a main fluid discharge passage therefrom and a separate air vent passage for venting air from said chamber to the exterior of the pump, a check valve operably mounted in said closure member for opening and closing said main passage, and valve means comprising a movable disk member operably disposed within said chamber for opening and closing said air vent passage, said check valve being openable and said valve means being closable in response to discharge of working liquid from said chamber whereby to permit venting of air from said chamber until working liquid is discharged through said main passage.

2. In a submersible pump, means defining an upright valve chamber at the discharge side of the pump, a closure member at the upper end of said chamber providing a main fluid discharge passage therefrom, a check valve operably mounted in said closure member for opening and closing said main passage, said closure member also being provided with an air vent passage for venting air from said chamber to the exterior of the pump, and means comprising a liftable valve member adapted to seat against the under side of said closure member for sealing off said air vent passage, said check valve being openable and said valve member being liftable into closed position in response to the discharge of working liquid from said chamber.

3. In a submersible pump, means defining an upright chamber at the discharge side of the pump, a closure member at the upper end of said chamber providing a main fluid discharge passage therefrom, a check valve operably mounted in said closure member for opening and closing said main passage, said closure member also being provided with an air vent passage for venting air from said chamber to the exterior of the pump, and means for closing said air vent passage comprising a stem depending from said closure member into said chamber adjacent said air vent passage and a disk slidable on said stem and adapted to seat against the under side of said closure member for sealing off said air vent passage, said check valve being openable and said disk being liftable into closed position in response to the discharge of working liquid from said chamber.

4. In a submersible pump, means defining a chamber at the discharge side of the pump, means providing a main fluid discharge passage from said chamber, a check valve including a plug portion operably mounted for opening and closing said main passage and a stem portion extending from said plug portion, means providing an air vent passage from said chamber to the exterior of said pump, and a secondary valve comprising an aper-

tured disk member carried on said stem portion in slidable relation therewith and adapted to close said air vent passage, said disk member being movable for closing said air vent passage upon movement of said check valve to open position in response to the discharge of working liquid from said chamber.

5. In a submersible pump, means defining an upright chamber at the discharge side of the pump, a closure member at the upper end of said chamber, said closure member having a main fluid discharge passage and an auxiliary air vent passage for venting air from said chamber to the exterior of the pump, and valve means operably supported in said closure member, said valve means including an upright stem slidable in said closure member, a check valve member rigidly carried at the upper end of said stem for opening and closing said main fluid passage, and an apertured disk slidably supported on said stem below said closure member and adapted to overlie the lower end of said air vent passage for sealing off the same, said disk being liftable into seated engagement with the under side of said closure member for sealing said air vent passage upon movement of said check valve member to open position in response to the discharge of working liquid from said chamber.

6. In a submersible pump, means defining an upright chamber at the discharge side of the pump, closure means for the upper end of said chamber including a spider having a central hub portion and radially extending arm portions, said closure means providing a main fluid discharge passage above said spider and said spider providing an air vent passage extending through one of said arm portions for venting air from said chamber to the exterior of the pump, and valve means operably supported in said closure means, said valve means including an upright stem slidable in said hub portion, a tapered plug portion rigidly carried at the upper end of said stem and comprising a check valve for opening and closing said main passage, and a secondary valve member slidably supported on said stem below said closure means and adapted to coact with the lower end of said air vent passage for sealing the same, said secondary valve member being movable with said stem into closed position for sealing said air vent passage upon movement of said plug portion to open position in response to the discharge of working liquid from said chamber.

7. The device of claim 6 further characterized in that said secondary valve member comprises an apertured disk slidably mounted on said stem and said stem has a retainer at its lower end for holding the disk thereon and for lifting the disk upon upward movement of the stem.

8. In a submersible pump, means defining a chamber at the discharge side of the pump, closure means at the upper end of said chamber providing a main fluid discharge passage from said chamber, a check valve operably mounted in said closure means for opening and closing said main passage, said closure means also having an air vent passage for venting air from said chamber to the exterior of the pump, and a separate valve member operably mounted on said closure means adjacent the inlet of said air vent passage, said check valve being openable and said separate valve member being closable in response to the discharge of working liquid from said chamber whereby to permit venting of air from said chamber until working liquid is discharged from said main passage, and said separate valve member being

openable by gravity upon substantial equalization of pressure between said chamber and the exterior of the pump.

9. In a submersible pump, means defining an upright chamber at the discharge side of the pump, closure means at the upper end of said chamber providing a main fluid discharge passage from said chamber and also providing a separate air vent passage for venting air from said chamber to the exterior of the pump, a check valve operably mounted in said closure means for opening and closing said main passage, and auxiliary valve means for opening and closing said air vent passage, said auxiliary valve means comprising a stem depending from said closure means into said chamber and a disk member mounted on said stem and adapted to seat against the under side of said closure means for sealing said air vent passage, said check valve being openable and said disk being liftable into seated engagement against said closure means in response to the discharge of working liquid from said chamber.

10. The device of claim 9 further characterized in that said disk member is slidable relative to said stem.

11. In combination, a pump for use in a well, means providing a main fluid passage at the discharge side of the pump, a check valve operably mounted for opening and closing said main passage, means providing an air vent passage from the space below said check valve at the discharge side of said pump to the exterior of the pump, and movable valve means for opening and closing said air vent passage comprising a depending stem adjacent said air vent passage and a disk slidable on said stem and adapted to seal said air vent passage, said check valve being openable and said disk being liftable into closed position in response to the discharge of working liquid through said main passage whereby to permit venting of air from the discharge side of the pump through said air vent passage until working liquid is discharged through said main passage, and said disk being slidable downwardly to open position in response to substantial equalization of pressure between the exterior of the pump and the space below said check valve at the discharge side of the pump.

12. In combination, a pump for use in a well, a discharge conduit extending upwardly from said pump at the discharge side thereof, a check valve mounted for controlling the flow of working liquid through said conduit, means providing an air vent from below said check valve at the discharge side of the pump to the exterior of said casing and said conduit, and valve means for closing said air vent comprising a depending stem adjacent said air vent and a disk slidable on said stem and adapted to seal said air vent for closing the same, said disk being openable by gravity and being closable in response to the discharge of working liquid through said conduit whereby to permit venting of air from the discharge side of the pump until said check valve is opened by the action of working liquid under discharge pressure.

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