An automatic air release valve is connected to the discharge side of a self-priming centrifugal pump for venting air from the pumping system during the priming cycle. The valve automatically closes upon completion of the priming cycle to prevent venting of liquid during the pumping cycle. A flow responsive actuator maintains the valve closed.
Fig. 14

Fig. 15

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SELF-PRIMING CENTRIFUGAL PUMP WITH AUTOMATIC AIR RELEASE VALVE

BACKGROUND OF THE INVENTION

The present invention relates generally to the centrifugal pump art, and more particularly to pumping systems including a self-priming centrifugal pump and an automatic air release valve connected to the discharge side of the pump for venting air from the system during the priming cycle.

During the priming cycle of a centrifugal self-priming pump, the air or gas in the pump suction line is evacuated to provide the suction lift. In so-called force main systems in which a head of liquid is maintained in the discharge line downstream from the pump, suitable provision must be made for venting such air or gas from the pumping system.

It has been conventional to provide centrifugal pumping systems with a constantly open vent communicating with the discharge side of the pump. One typical vent structure which has been used is a flow restrictor device comprising a closed cylindrical housing having a tangential inlet communicating with the pump discharge line and an axial outlet communicating with a sump or a return line or the like.

The gas or air evacuated from the pump suction lines during the priming cycle is vented through the flow restrictor together with a portion of the liquid which is forced from the discharge chamber of the pump. After the pump has been fully primed pumped liquid flows through the flow restrictor during the entire time that the pump is in operation.

The flow restrictor of the prior art is constructed to minimize the flow of liquid therethrough during the pumping cycle. Nevertheless, the constant venting of a portion of the liquid being pumped through the flow restrictor is both wasteful and expensive and decreases the efficiency of the pump.

Another disadvantage of many of the prior art vent arrangements is that they are subject to malfunction under conditions which may result in clogging of the vent lines. Centrifugal pumps are often used to handle liquids containing heavy concentrations of foreign materials or solids which tend to clog the vent lines and the flow restrictor itself and thereby prolong or even prevent priming. Furthermore, the closed housing of the conventional flow restrictor device described above is difficult to clean and is responsible for increased costs.

SUMMARY OF THE INVENTION

The present invention provides a new and improved air venting valve for a self-priming pumping system in which a flow actuated vent valving member is moved toward a position in which venting terminates by fluid flow in the system and wherein a flow responsive actuator complements operation of the valving member to assure that the valving member closes completely when the pump is primed.

The new air release valve is associated with the discharge side of a centrifugal pump for encouraging pump priming while minimizing inefficiencies connected with continuously venting systems. The valve is open during the priming cycle to vent the air or gas evacuated from the pump suction lines and automatically closes when the pump is fully primed. This avoids venting liquid during the pumping cycle.

The air release valve is responsive to the conditions of fluid flow through it so that the valve remains open so long as pumped fluid flow is below a given level. When the pump output flow rate reaches a predetermined level, indicating the pump is primed, the valve closes.

The air release valve comprises a housing which defines a vortex chamber having a tangential inlet and a relatively larger axial outlet. A valving member is mounted in the housing and is biased to a normally open position permitting flows of gas or mixtures of gas and liquid through the valve. The valving member is movable from its open position to a closed position in response to liquid flow.

The valving member is preferably biased to its open position by a spring. The biasing spring force acting on the valving member is adjustable so that the valving member closes at a particular condition point of the pumping system; that is, the point at which the pump commences to pump liquid at the rated capacity and head.

When a pumping cycle is completed and the pump is shut off, the valve is automatically opened by the biasing spring force. If for any reason the suction head is lost before the next pumping cycle, the valve remains open upon reactivation of the pump until a full prime is attained, whereupon the valve again automatically closes. If pump suction head is not lost, the valve closes immediately when the pump is started.

The biasing spring force is adjustable so that the air release valve closes at a desired pump discharge flow rate depending on the pumping system in which it is used. That is to say, individual systems produce different liquid flow rates through the venting valves when the system pump is primed. The valve is adjusted to close when this "primed" flow rate occurs.

The new venting valve is constructed and arranged so that once the pump is primed and operating the valve is maintained closed notwithstanding variations in pump operation pressures or flow rates which may occur during normal operation of a pumping system over a period of time. The new valve thus insures against any tendency for the valving member to "hunt," i.e., periodically move between positions, or otherwise fail to close completely due to such pressure or flow variations.

In a preferred construction, a flow responsive actuator is associated with the valving member to assure that the valving member is maintained in its closed position when the pump is primed during the pumping cycle. The actuator comprises a solenoid coil which has an armature in force transmitting relationship with the valving member. The energization circuit for the solenoid coil includes a control switch which completes the circuit when the pump is primed. In one preferred system, a check valve is located downstream from the pump and the air venting valve. The check valve opens in response to pump discharge pressure when the pump is primed. When the pump is at its condition point the
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check valve is fully opened. The control switch is actuated to its closed position by movement of the check valve toward the open position and when the check valve closes the control switch is opened to interrupt the solenoid energizing circuit.

One preferred control switch includes an operating arm actuated by a movable part of the check valve. The operating arm is resiliently deflectable and is situated so that the control switch closes before the pump discharge pressure and flow conditions reach the condition point levels. The operating arm deflects after the switch is initially closed so that the switch is maintained closed as the discharge pressure and flow conditions proceed to the condition point levels. Thereafter, if the pressure or flow levels should vary somewhat from the condition point, the switch operating arm maintains the switch contacts closed.

In another preferred construction, the switch is a mercury switch mounted on a movable part of the check valve. As the pressure and flow levels increase toward the condition point levels the mercury switch is tipped and closes just prior to the check valve opening fully. The mercury switch remains closed throughout a range of system operating flow conditions.

Another preferred construction employs a switch formed by a pressure actuated contact arm which engages a second movable contact arm throughout a range of detected pump discharge pressures. The pressure actuated arm can be driven, for example, by a Bourdon tube gauge needle driving mechanism. The Bourdon tube communicates with the pump discharge pipe via a suitable pressure fitting.

A principal object of the invention is the provision of a new and improved self-priming pumping system including a flow actuated air release valve which is open to vent part of the system while a pump is being primed and wherein the air release valve is closed in response to liquid flowing through it at a predetermined rate and is maintained closed after the pump is primed by a flow condition responsive actuator.

Other objects, features and advantages of the invention will be apparent from the following detailed description made with reference to the accompanying drawings which form part of the specification.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic illustration of a pumping system embodying an air release valve forming part of the invention;

FIG. 2 is a cross sectional view of the air release valve embodied in the system illustrated in FIG. 1 having portions shown in elevation and on a scale larger than the scale of FIG. 1;

FIG. 3 is a cross-sectional view taken on the line 3—3 of FIG. 2;

FIG. 4 is a cross-sectional, fragmentary view of a modified air release valve including check valve structure;

FIG. 5 is a cross-sectional view taken on the line 5—5 of FIG. 4;

FIG. 6 is a cross-sectional view of a portion of the valve of FIG. 4;

FIG. 7 is a view similar to FIG. 4 illustrating another modified air release valve construction including check valve structure;

FIG. 8 is a view taken on the line 8—8 of FIG. 7;

FIG. 9 is an elevational view with portions broken away of still another modified valve construction;

FIG. 10 is a view taken on the line 10—10 of FIG. 9;

FIG. 11 is a view of a portion of still another modified valve constructed according to the invention;

FIG. 12 is an elevational view of still another modified valve constructed according to the invention;

FIG. 13 is a schematic view of another modified system employing a supplemental actuator for a flow actuated air release valve;

FIG. 14 shows a modification of part of the system of FIG. 13; and,

FIG. 15 shows another modification of part of the system of FIG. 13.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, and to FIG. 1 in particular, there is shown a conventional centrifugal self-priming pump 10 which includes a casing 11 having a rear wall 11, a front wall 12, and a partition wall 13. The walls of the casing cooperate to define a suction chamber 14 and a discharge chamber 15. An impeller 16 is disposed within the pump casing and is supported on a shaft 17 which extends rearwardly through the rear casing wall 11 and is connected to a suitable motor 18.

An inlet pipe fitting 25 is connected to the front wall 12 of the casing and opens into the suction chamber 14 through a hole in the front wall which is equipped with a suction check valve 26. An outlet pipe fitting 27 also is connected to the casing and opens into discharge chamber 15.

The pump 10 is illustrated as being embodied in a so-called force main system in which a static condition of liquid is maintained at all times in the discharge line of the pump. The system includes an inlet pipe 35 which is connected to the inlet fitting 25 and extends down into a suitable reservoir or tank 36 containing the liquid to be pumped. A discharge pipe 37 is connected to the discharge fitting 27 and extends upwardly from the pump 10. This discharge line 37 is equipped with a check valve 38 downstream from the pump 10 which serves to maintain a static head of liquid in the discharge pipe above the valve 38 when the pump 10 is not operating at rated capacity and head.

When the pump 10 has been fully primed and is operating in its pumping cycle at rated capacity and head, a column of liquid is maintained in the suction inlet pipe 35 and a vacuum exists in the suction chamber 14 above the level of liquid therein. The impeller 16 operates to pump the liquid from the suction chamber 14 into the discharge chamber 15 and out of the pump 10 through the discharge line 37 and then through the check valve 38.

During the priming cycle of the pump 10, which will occur upon initial operation of the pump and when, for some reason, the suction head is lost between pumping cycles, air or gas will be contained in the inlet pipe 35 and in the chamber 14 of the pump. When the pump 10 is ready for priming, a quantity of liquid is contained in the suction and discharge chambers somewhat as indicated in FIG. 1. The pump motor 18 is energized to start rotation of the impeller 16 to move a quantity of the liquid and air from the suction chamber 14 into the discharge chamber 15, thus creating a partial vacuum on the suction side of the pump. Atmospheric pressure exerted on the liquid to be pumped forces the liquid up
the inlet pipe 35 to a height depending upon the volume of liquid pumped out of the suction chamber and the internal dimension of the pipe 35. In some applications, the liquid may rise four to five feet up the pipe 35 each time the liquid is pumped out of the suction chamber. Continued actuation of the impeller 16 continues to move quantities of liquid and air from the suction chamber into the discharge chamber, thus causing the height of the liquid in the pipe 35 to progressively increase. The priming cycle is completed when a vacuum has been established in the suction chamber 14 and the pump is operating at its rated capacity and head.

It will be apparent from the foregoing description that it is necessary to vent the air or gas which is pumped by the impeller 16 into the discharge chamber during the priming cycle so that the pressure in the discharge chamber remains relatively low. Such air or gas cannot be forced through the main discharge line 37 past the valve 38 because of the relatively larger static pressure of the liquid which is maintained in the discharge line downstream from the valve. In order to vent the air or gas which is evacuated from the suction inlet pipe 35 and the chamber 14 during the priming cycle, the invention provides a new air release valve assembly 45 which is connected to the discharge pipe 37 between the discharge side of the pump 10 and the valve 38. As generally explained above, the new air release valve 45 is open during the priming cycle to vent the air or gas evacuated from the suction inlet line and automatically closes at the end of the priming cycle to prevent the venting of liquid through the valve 45 during the pumping cycle.

Referring now to FIGS. 2 and 3, the new air release valve assembly 45 is shown to comprise a valve body housing 46 including a cup-like base member 47 and a cover 48 removably attached to the base member. The base member 47 carries studs 49 which are threaded into the rim 50 of the base member at spaced locations around its circumference and which project upwardly through openings in the cover 48 near its periphery. Wing nuts 51 or the like are threaded on the upper ends of the studs 49 to hold the cover 48 in place. The wing nuts 51 permit the cover 48 to be quickly removed from the base member 47 so that the valve housing 46 can be easily cleaned whenever necessary. A suitable O-ring seal 52 is provided between the cover 48 and the rim 50 of the base member 47 to prevent leakage of fluid between these parts.

The interior of the housing 46 formed by the members 47, 48 defines a generally cylindrical vortex chamber 54. At least one inlet port 55 is formed through the side wall or rim 50 of the base member 47 to direct fluid tangentially into the vortex chamber 54. As is most clearly shown in FIG. 3, the inlet port 55 is formed through an external cone structure 56 which is part of the base member side wall.

An inlet line 57 is connected to the discharge line 37 and communicates with the inlet port 55. In the preferred construction of the invention, a second tangential inlet port 60 is formed through the corner structure 56 into communication with the vortex chamber 54 at right angles to the inlet 55. The two ports 55 and 60, only one of which is used, permit either right or left hand installation of the valve 45. The inlet port which is not in use, for example, the port 60, is normally closed by a suitable threaded plug 61 and may serve as a drain when the plug is removed. The valve body housing 46 is also provided with an outlet port 62 which extends axially from the vortex chamber 54 through a centrally located, outwardly extending boss 63 of the base member 47. The outlet port 62 may be connected to an outlet or discharge line 64 by a transparent nipple 65 which is threaded into the boss 63. As more fully explained below, observation of liquid flow through the transparent nipple 65 facilitates proper adjustment of the valve 45.

A valve seat ring 66 having a frusto-conical seating surface 67 is mounted in a recess formed in the bottom of the base member 47 around the mouth of the outlet port 62. As shown, an O-ring 68 is carried in a peripheral groove formed in the side wall of the seat ring 66 and is disposed in sealing engagement with the side wall of the recess in which the seat ring is mounted. In the preferred construction of the valve 45, a resilient back-up ring 69 is disposed between the seat ring 66 and the bottom of the recess in which the seat ring is mounted. The back-up ring 69 permits limited floating movement of the seat ring 66 to assure complete closing of the outlet port 62 as described presently.

A valve member 75 is carried by the housing cover 48 for movement axially of the housing into and away from engagement with the valve seat ring 66 for opening and closing the outlet port 62. The valve member 75 has a stem portion 76 and a head 77. The head 77 is formed to have a generally hemispherical or dome-like upper portion 78 and a generally frusto-conical lower portion 79 which converges from the upper portion 78 to the bottom of the head, as viewed in FIG. 2. The frusto-conical portion 79 is engageable with the seating surface 67 of the seat ring 66 to close the outlet port 62.

In the illustrated embodiment of the invention, the stem 76 of the valve member 75 extends through a central, axially outwardly projecting hub portion 80 of the housing cover 48. A bushing 81 is threaded into the inner end of the hub portion 80 around the stem 76 and serves to support the valve member 75 for sliding movement between its open and closed positions. The valve member 75 is urged to a normally open position by a spring 82 which is connected to the end of the stem 76 and to the end of an adjustment screw 83. The spring 82 and the adjustment screw 83 are disposed within a sleeve 84 which has one end threaded into the hub 80 and its opposite end closed by a cap 85. The adjustment screw 83 extends outwardly through a threaded opening in the cap 85, and a locknut 86 and a suitable sealing washer 87 are carried on the adjustment screw for engagement with the outer surface of the cap 85.

The outwardly projecting end of the adjustment screw 83 is shown as having a slot 88 suitable for receiving a screw driver of the like whereby the adjustment screw 83 can be rotated to advance it in and out of the sleeve 84. Selective adjustment of the screw 83 serves to vary the tension of the spring 82, thereby changing the biasing force urging the valve member 75 to its normally open position.

The operation of the valve 45 is dependent upon the creation of a pressure differential across the housing with the inlet pressure being greater than the outlet pressure. To this end, the outlet port 62 of the housing 46 is made larger than the inlet port. In the preferred construction of the valve, the outlet port 62 has a diam-
eter which is preferably 25% larger than that of the inlet port. In order to prevent debris, such as rags and other solids, from clogging the inlet port of the valve, it has been found desirable to form the inlet port with a one inch diameter. Thus, in a valve construction having a one inch inlet port, the outlet port should preferably be one and one quarter inches in diameter.

When fluid is introduced into the valve 45 through one of the inlet ports 55 or 60, a vortex flow is created within the chamber 54 so that the fluid swirls inwardly of the housing across the inner surface of the cover 48. This vortex flow of fluid is such that the pressure at the upper hemispherical portion of the valve head 77 is greater than the pressure on the frusto-conical lower portion 79. As the flow rate of liquid into the chamber 54 increases, the pressure differential across the head 77 also increases to gradually pull the valving member 75 into engagement with the seat ring 66 against the biasing force of the spring 82 thereby closing the outlet port 62. By adjusting the tension of the spring 82, the valving member 75 can be made to close upon any desired condition of liquid flow through the housing 46.

The operation of the valve 45 in the illustrated pumping system will be largely apparent from the foregoing description. Assuming that the pump 10 is unprimed, the valve 45 will remain in its normally open position when the pump motor is turned on to initiate the priming cycle described above so that the air and fluid evacuated from the pump suction lines and discharged from the pumping chamber 15 can flow through the open valve 45 and the connected outlet line 64. As the flow of liquid through the valve 45 increases during the priming cycle, the valving member 75 will be pulled toward the seat ring 66 against the biasing force of the spring 82. When the priming cycle has been completed and the pump 10 is operating at rated capacity and head, the liquid flowing through the valve will pull the valving member 75 to its fully closed position, thereby preventing any further discharge of liquid through the valve during the pumping cycle. When the pump motor is shut off at the end of the pumping cycle the valve 45 will automatically open, but will close immediately when the pump is restarted if the pump suction has not been lost. If for some reason the pump suction is lost before restarting the pump, the valve will remain open to allow the pump to recycle and will close when full prime has again been attained.

An important feature of the invention resides in the construction which permits the valve 45 to be adjusted to operate at the condition point of any pumping system, which condition point varies from system to system depending upon such factors as the pressure drop in the pipes or lines, the output capacity of the system, etc. The spring-loaded valving member 75 may be adjusted to close at the condition point of the system in which it is installed by loosening the locknut 86 and turning the adjustment screw 83. Inward adjustment of the screw 83 decreases the tension of the spring 82 so that the valving member 75 can close quickly under conditions of low head. Outward adjustment of the screw 83 increases the spring tension and the closing time of the valving member, as is required under conditions of the high head.

The spring loaded valving member 75 is preferably adjusted after the pump has been operated to complete its first priming cycle. Such adjustment is facilitated by the transparent nipple 65 connected to the outlet of the valve 45. The priming cycle is completed when full liquid flow is observed through the nipple, and at that time the tension of the spring 82 is properly adjusted so that the valving member closes and remains closed during the pumping cycle. When adjusted, the valve 45 will operate automatically during subsequent cycles of the pump and no further attention is required.

Reference is now made to FIGS. 4-12 which illustrate different check valve arrangements which may be associated with the air release valve 45 for the purpose of preventing a reverse flow of air through the valve 45 into the pumping chamber 15 when the pump is not in operation. As previously described, the valve 45 opens automatically at the conclusion of each pumping cycle. Any reverse flow of air through the valve when the pump has been stopped could result in a loss of pump suction if the suction valve 26 is not completely closed. The check valve arrangements of FIGS. 4-12 insure against loss of pump suction by blocking reverse flow of air through the valve 45 when it is open.

Referring particularly to FIGS. 4-6 there is shown a check valve construction 115 which is disposed in the vortex chamber of the pump 45 and adapted to block the inlet port 55 when the pressure in the vortex chamber 54 approaches the pressure in the inlet line 57. The check valve assembly 115 includes a rectangular pad-like check valve member 116 of resilient rubber-like material which extends across ports 55, 60 so that, when the check valve member 116 is in the position illustrated in FIG. 4, air flow from the vortex chamber through the inlet line 57 is prevented. The check valve member 116 is urged to its closed position by a spring construction including spring strips 120, 121 which are formed of suitable corrosion resistant material, such as stainless steel, and connected to the member 116 by rivets 122. The check valve member 116 and the spring strips 120, 121 are supported in the chamber 54 by a pindle 125, the ends of which are received in cylindrical cavities 126, 127 formed in the cover and base of the valve 45 respectively. The spring strip 121 is bent to define a loop 130 medially of its ends through which the pindle 125 extends.

FIG. 6 illustrates the check valve construction 115 in a relaxed condition. It is apparent that when the check valve construction is mounted in the chamber the spring strips 120, 121 are deflected from their relaxed condition and urge the check valve member 116 firmly against the side wall of the chamber. Accordingly the check member prevents flow from the vortex chamber through the inlet line 57 when the fluid pressure force in the vortex chamber and the force of the springs 120, 121 are greater than the pressure force exerted on the valve member by the fluid pressure in the inlet port 55.

The check valve construction 115 permits tangential flows of gas and the liquid into the vortex chamber 54 regardless of whether the flow is introduced through the inlet port 55 or the inlet port 60. When flow is directed into the chamber 54 through the inlet port 55, the end 131 of the check valve member 116 is deflected toward the center of the chamber. The opposite end 132 of the check valve member is maintained in the closed position. If the flow is directed into the chamber through the inlet port 60 the end 132 is deflected into the vortex chamber 54 while the end 131 remains stationary.
FIGS. 7 and 8 illustrate a modified check valve assembly 135 disposed in the vortex chamber 54. The check valve assembly 135 includes a flapper-like valve member 136 in the form of a rectangular strip of rubber-like material positioned across the inlet ports 55, 60 and supported in position by a clamp 137. The clamp 137 is connected to the side wall of the vortex chamber by screws 142 extending into tapped holes 145 in the side wall which cause the clamp to tightly grip the valve member 136.

The inherent resilience of the valve member 136 normally maintains it closed across the inlet ports 55, 60 (see FIG. 7). The end 143 of the valve member is deflected into the vortex chamber 54 only in response to fluid flow into the chamber through the inlet port 55.

In applications in which fluid is introduced through the port 60 the check valve assembly 135 is turned end for end in the chamber and the screws 142 are threaded into holes 145 so that fluid flow from the inlet port 60 is directed tangentially into the vortex chamber past the free end of the valve member.

FIGS. 9 and 10 illustrate a gas venting assembly valve 45 utilizing a “duck bill” type check valve 150 for preventing reverse air flow through the valve 45. The check valve 150 is formed of a rubber-like material and includes a pair of lips 151, 152 and an integral annular flange 153. The check valve 150 is held in position by engagement of the flange 153 below the seat ring 66 so that the lips 151, 152 can close the outlet port 62. The flow of liquid through the valve 45 forces the lips 151, 152 apart permitting relatively unimpeded flow of the fluid to the discharge pipe 64. When the pressure in the discharge pipe is equal to or greater than the pressure in the chamber, the lips 151, 152 move together to close the outlet port 62 and prevent air flow from the pipe 64 into the chamber 54.

FIG. 11 illustrates a modified check valve 150’ which is substantially the same as the check valve 150 FIGS. 9 and 10 except that four lips 160–163 are provided. The modified check valve 150’ is disposed in the air release valve 45 in the same manner as the valve 150, and since it operates substantially in the same manner as the check valve 150, further description is unnecessary.

FIG. 12 illustrates a further modified air release valve 45 including swing-type check valves 170, 171 in the inlet and outlet lines 57, 64 respectively. Each valve assembly includes a housing 173 which supports a swing-type valve member 174 rotatable about a hinged support 175 in the housing. The valve member 174 moves about a pivot axis 176 to permit flow from the pipe 57 through the valve 45 to the outlet pipe 64. The valve member closes to prevent flow in the opposite direction and in the illustrated construction is moved to the closed position by gravity. Although two check valves 170 are illustrated in FIG. 12, in practice, only one of these check valves is necessary to prevent the reverse flow of air through the valve 45.

A modified force main pumping system 200 is illustrated in FIG. 13. The system 200 comprises a pump 202, a pump inlet pipe 204 and a pump discharge pipe 206. The pump 202 draws liquid upwardly through the inlet pipe 204 and forces the liquid through the discharge pipe 206 via a discharge check valve 208. An air release valve assembly 210 communicates with the discharge pipe 206 between the check valve 208 and the pump 202. When the pump is being primed and the check valve 208 is closed, air or other gas in the pump is vented to the atmosphere. This enables the pump to be primed. When the pump is primed and operating, the air release valve 210 closes so that pumped liquid from the discharge pipe cannot vent from the system. The pump 202 may be of any suitable or conventional construction and can be the same as the pump 10 described above in reference to FIGS. 1–12.

The check valve 208 functions the same as the check valve 38 referred to in connection with FIG. 1. That is, when the pump is not operating, the check valve 208 is closed to maintain a head of liquid in the discharge pipe above the check valve. The valve 208 remains closed during priming of the pump to allow the pump to vent air through the air release valve. When the pump is primed and operating the discharge pressure opens the check valve 208 and liquid is pumped through the discharge pipe.

The check valve 208 comprises a tubular valve housing 212 integral with the pump discharge pipe and a movable valve member 214 which is disposed in the valve housing 212 for movement between a closed position, illustrated in FIG. 13, and an open position in which pumped liquid passes upwardly through the valve housing and the discharge pipe 206. The valve member 214 is fixed on a pivot shaft 216 which is journaled in the valve housing 212.

The valve member 214 is biased to its closed position. The pivot shaft 216 carries a lever arm 218 which is connected to the shaft on the exterior of the valve housing. The lever arm 218 is connected to a return spring 220 which is preferably a helical tension spring having its opposite end anchored to the housing 212. The spring 220 maintains the lever arm and valve plate member 214 in the positions corresponding to the closed position of the valve.

The air release valve unit 210 is connected between the pump and the check valve 208 for venting the discharge pipe when the pump is priming. The valve unit 210 comprises a cylindrical valve housing 222 which defines a cylindrical vortex chamber 224. An inlet pipe 226 extends between the pump discharge pipe 206 and the housing 222. The inlet pipe opens tangentially into the cylindrical chamber. An outlet pipe 228 extends the housing 222 along the axis of the cylindrical chamber so that the liquid flowing through the chamber forms a vortex having its center located over an output port 230 in the lower wall of the chamber along the axis of the housing. The housing 222 and associated parts thus far described are shown schematically and may be the same as is described in reference to FIGS. 1–13.

Flow through the chamber 224 is controlled by a flow regulated valve member 232 movably disposed in the housing 222. The valve member 232 includes a head portion 234 disposed in the vortex chamber and a cylindrical valve stem 236 which projects through an opening 238 in the upper wall of the housing. A seal 240 surrounds the valve stem 236 and prevents the escape of liquid from the chamber between the valve body and the housing 222. The valve member 232 is biased towards its open position by a spring 242. The biasing spring 242 is preferably a helical compression spring which surrounds the valve stem and is compressed by a boss area.
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244 surrounding the opening 238 and an annular collar 246 which is carried on the valve stem. The collar 246 is movable along the valve stem by a suitable screw thread adjusting arrangement which is not illustrated in detail. The general operation of the air venting valve unit 210 as thus far described is the same as has been described in reference to FIGS. 1–12.

The modified system 200 differs in that operation of the air release valve unit is augmented by a flow condition responsive actuator 250 which applies a positive valve stem closing force to the arm 223 in response to predetermined flow conditions of the liquid in the pump discharge pipe. As is illustrated in FIG. 13, the actuator 250 includes a solenoid coil assembly 252 which is connected across a suitable electrical power supply (not shown) by conductors 256, 258 in series with a control switch 260. An armature 261 of the solenoid assembly is connected to the valve stem 236 so that when the solenoid coil 252 is energized the armature 261 is “pulled in” and forces the valve stem to a position in which the head 234 covers the outlet port 230.

In the illustrated embodiment, the control switch 260 is preferably a normally open switch of the micro switch type which is mounted adjacent the lever arm 218. The contacts of the switch 260 are actuated to the closed position by a cat-whisker spring lever 262 which is positioned for engagement by the lever arm 218 whenever the check valve 208 has moved from the closed position toward a predetermined at least partly open position.

As noted above, the valve 208 does not open at all until the pump discharge liquid pressure is greater than the head pressure of the liquid standing over the check valve 208. When this occurs the pump is primed and flow through the valve housing 212 opens the valve 208. When the valve member 214 has moved a predetermined amount from the closed position the cat-whisker spring lever 262 is engaged by the lever arm 218 and the switch 260 closes. This energizes the solenoid 252 to force the valve member 232 to its closed position, if it is not already closed. The actuator 250 thereafter prevents the valve member from moving from its closed position.

The lever arm 218 maintains engagement with the spring lever 262 so that the solenoid remains energized so long as the pump is primed and is pumping at about its operating condition to force liquid upwardly through the discharge pipe. In the event the pump discharge pressure is momentarily reduced for any reason, the check valve 208 will move toward its closed position. So long as the discharge pressure does not drop below a predetermined level, the lever arm 218 maintains contact with the spring lever 262 so that the solenoid assembly 252 is maintained energized through the range of pump discharge pressures.

An alternate switch 270 is illustrated in FIG. 14 for controlling the solenoid assembly 252. The switch 270 is a pressure responsive switch having rotatable contact arms 272, 274. The contact arms 272, 274 are connected in an energizing circuit for the solenoid 252 so that when the arms are engaged the solenoid is energized and when the arms are disengaged the solenoid is deenergized. The contact arm 272 is mounted on a rocker member that is in turn connected to a Bourdon tube gauge needle actuator 278 which is shown schematically. The actuator 278 may be of any suitable well-known construction and is therefore not described in detail. The Bourdon tube of the actuator 278 communicates with the pump discharge pipe through a pressure fitting 280. When the pump discharge pressure increases, the contact arm 272 is rotated clockwise as seen in FIG. 14 with the amount of rotation of the arm being proportional to the pressure level.

When the pump is primed, the liquid pressure in the discharge pipe increases toward the condition point pressure level causing the contact arm 272 to rotate clockwise as shown in FIG. 14. The contact arm 274 has a rest position, shown in FIG. 14, at which the arm 274 remains during the priming cycle. When the pump is primed and the discharge pressure increases toward the condition point level the arm 272 engages the arm 274 at its rest position whereupon the solenoid 252 is energized. As the discharge pressure continues to increase, the arm 272 moves the contact arm 274 clockwise from its rest position maintaining the solenoid 252 energized. The contact arm 272 has a finger 281 which extends into the plane of the contact arm 274 to assure engagement between the contact arms. The switch contact arm 274 is connected to a shaft 282 which is rotatably supported adjacent the shaft 276. The arm 274 and the shaft 282 are biased toward the rest position of the arm so that when the discharge pressure is reduced, the arm 274 and the shaft 282 move counterclockwise toward the rest position. The arm 274 can be adjusted circumferentially on the shaft 282 so that the rest position assumed by the contact arm 274 is adjustable. As is shown in FIG. 14, the arm 274 is set to be engaged by the arm 272 when the pump discharge pressure moves the arm 272 to extend along the line 286. As the pressure continues to increase, the arms 272, 274 are maintained in engagement so that the solenoid 252 is maintained energized to positively close the air release valve. The pump reaches its operating point when the arm 272 extends along the line 288.

Since the switch arm 274 is biased toward its position illustrated in FIG. 14, any momentary reductions in the pump discharge pressure from the condition point level do not open the switch so long as the discharge pressure remains in the range between the lines 286, 288 indicated by the arrow 289.

FIG. 15 illustrates another alternate switching arrangement employing a mercury switch assembly 290 for controlling the solenoid assembly 252. The switch assembly 290 comprises a housing 292 which is connected to the lever arm 218 by a bracket 294. The housing 292 defines a chamber 296 in which contacts 298, 300 are positioned at one end. A mass of mercury 302 is disposed in the chamber 296 and is free to move back and forth in the chamber as the chamber is tilted relative to horizontal. The bracket 294 is adjustable to enable the orientation of the housing 292 to be adjusted as desired relative to horizontal. When the check valve member has opened a predetermined amount, the mercury mass 302 moves under influence of gravity to engage the contacts 298, 300 and thereby complete an electrical energizing circuit for the solenoid coil assembly 252 resulting in the valve member being urged into closed position by the armature 261.

It can now be seen that the objects heretofore enumerated and others have been accomplished and that a new air release/valve control for a pump has been provided which vents gas from the pump discharge during priming and automatically closes to prevent
pumped liquid from venting when the pump operates at rated head and capacity. While a number of different embodiments of the invention have been illustrated and described, the invention is not to be considered limited to the precise constructions disclosed. It is intended that all adaptations, modifications and uses of the invention falling within the scope of the appended claims be covered.

We claim:
1. In combination with a pump having inlet means and outlet means, an air release valve assembly comprising:
   a. a chamber;
   b. said chamber having an outlet port;
   c. chamber inlet means communicating said chamber with said pump outlet means;
   d. valving means including:
      1. a valve seat in said chamber surrounding said outlet port;
      2. a valve member movably supported in said chamber; and,
      3. biasing means urging said valve member toward an open position spaced from said seat;
   e. said valving means having a closed position wherein said valve member is in engagement with said seat to block fluid flow through said outlet port;
   f. said chamber inlet means directing pump effluent into said chamber along a flow path for impingement on said valve member to create a pressure force on said valve member urging said valve member toward said closed position; and,
   g. actuator means associated with said valve member for moving said valve member to said closed position in response to liquid flow conditions through said pump outlet means.
2. A pump as claimed in claim 1 wherein said actuator means comprises an electrically energized actuator element, a control switch in circuit relation with said actuator element, and means for actuating said control switch in response to flow conditions in said pump outlet means.
3. A pump as claimed in claim 2 wherein said pump outlet means includes a check valve having means movable between open and closed positions, said control switch being operated in response to movement of said check valve means.
4. The pump claimed in claim 2 wherein said means for actuating said control switch includes a member which is movable in proportion to pressure of liquid in said pump outlet means.
5. In combination:
   a. pump means operable through a priming cycle and a pumping cycle, said pump means including an inlet opening and an outlet opening;
   b. discharge valve means connected to said outlet opening for permitting fluid flow therethrough during said pumping cycle and for blocking fluid flow therethrough during said priming cycle;
   c. air release valve means connected between said pump outlet opening and said discharge valve means for permitting fluid flow therethrough during said priming cycle and blocking fluid flow therethrough during said pumping cycle, said air release valve means comprising:
   1. a valve housing defining a vortex chamber having a cylindrical chamber wall portion;
   2. means defining a valve inlet opening for directing pump effluent into said chamber substantially tangentially along said wall portion to create vortical fluid in said chamber;
   3. an axial valve outlet opening from said chamber;
   4. a valve seat surrounding said valve chamber;
   5. a valve member supported by said housing for movement toward and away from said valve seat, said valve member being biased away from said seat and including a surface portion impinged upon by vortical flow of pump effluent in said chamber which moves said valve member toward said valve seat; and,
   d. an actuator for urging said valve member toward engagement with said seat in response to sensed pump outlet liquid conditions whereby when said pump means is primed said air release valve is maintained closed.
6. The combination claimed in claim 5 wherein said discharge valve means comprises a check valve member which opens only during said pumping cycle, and means for operating said actuator means in response to movement of said check valve member toward an open position.
7. The combination claimed in claim 6 wherein said actuator means is electrically energized through a control circuit and said means for operating said actuator means comprises a control switch actuated by movement of a part connected to said check valve member away from a position corresponding to the closed position of said check valve member.
8. The combination claimed in claim 7 wherein said discharge valve means further comprises a pivot shaft supporting said check valve member for pivotal movement between its open and closed positions, said switch actuating part connected to said pivot shaft for movement therewith.
9. The combination claimed in claim 8 wherein said control switch comprises a mercury switch and said part comprises a bracket supporting said mercury switch for tipping movement relative to horizontal when said pivot shaft rotates.
10. The combination claimed in claim 7 wherein said discharge valve means further comprises a pivot shaft supporting said check valve member for pivotal movement, said switch actuating part connected to said pivot shaft and movable therewith to engage a switch operating lever when said valve member has moved a pre-determined amount away from said closed position.
11. The combination claimed in claim 5 further including control means for operating said actuator, said control means comprising at least one control member which is movable in response to changes in pressure of liquid in the vicinity of said pump outlet opening.

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