

March 25, 1969

M. BERMAN ETAL

3,434,430

SELF-PRIMING PUMP SYSTEM WITH EXTERNAL ACTUATING MEANS

Filed April 18, 1967

Sheet 1 of 5

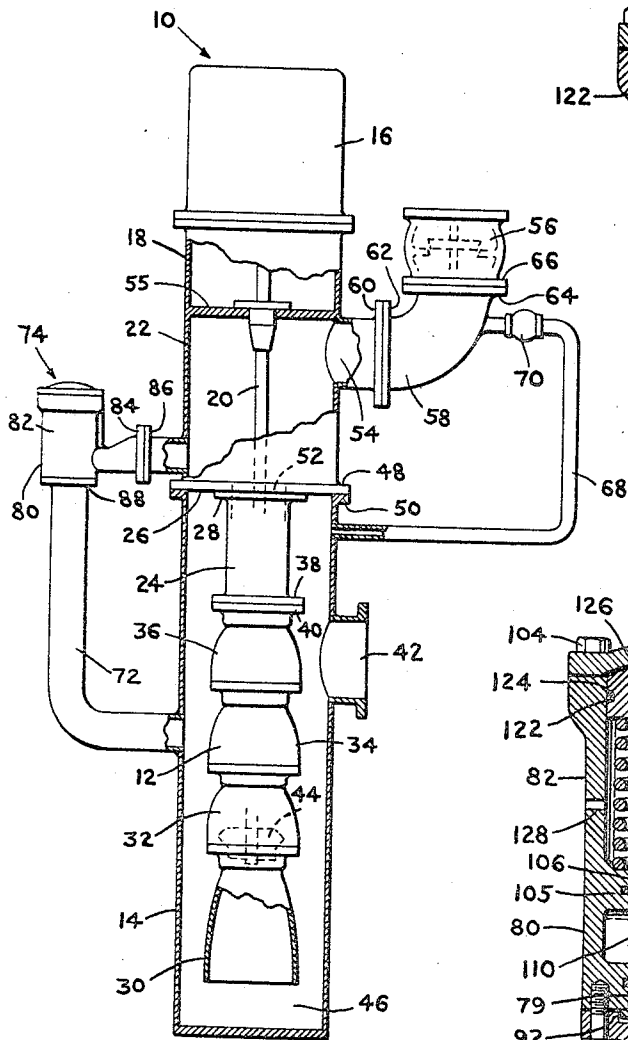


FIG. 1

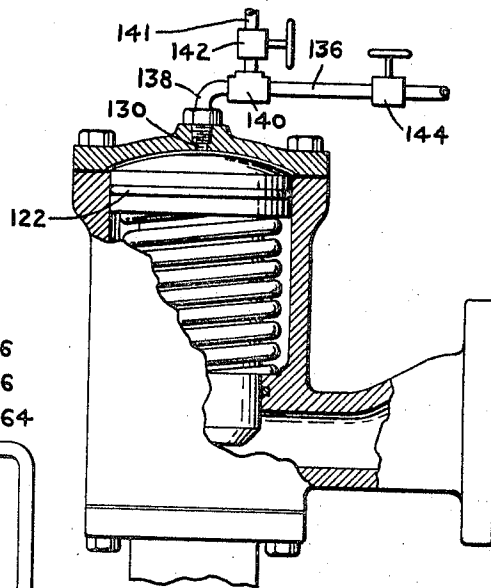


FIG. 3

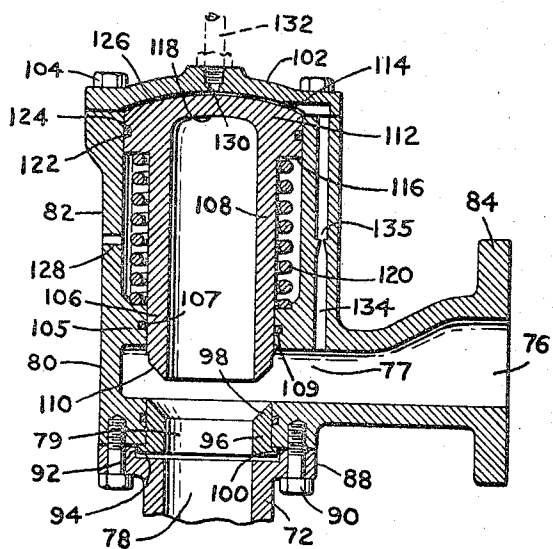


FIG. 2

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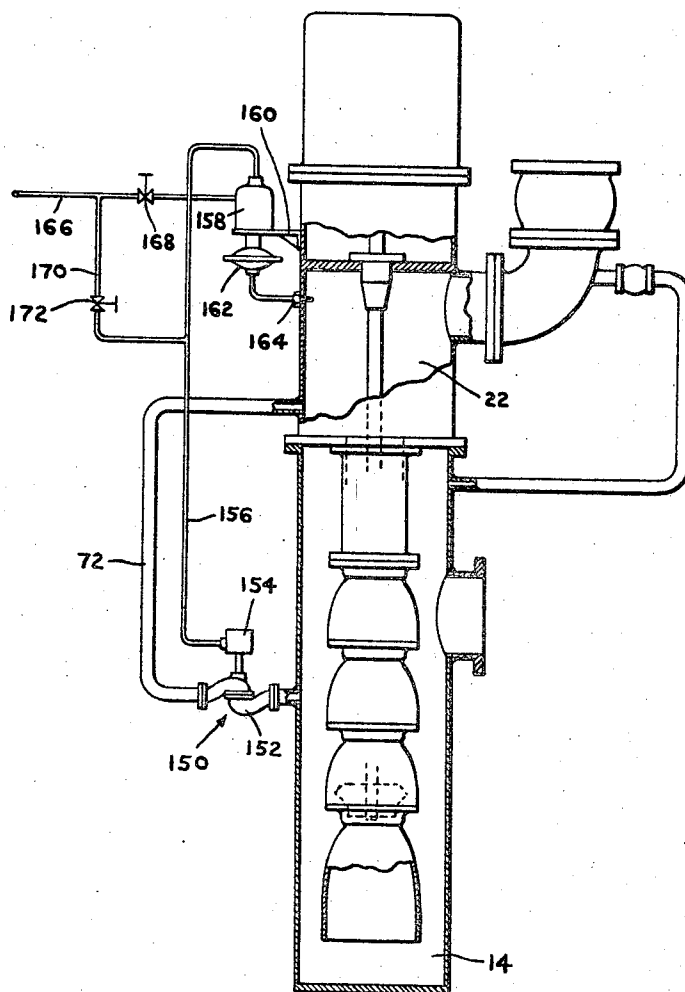


FIG. 4

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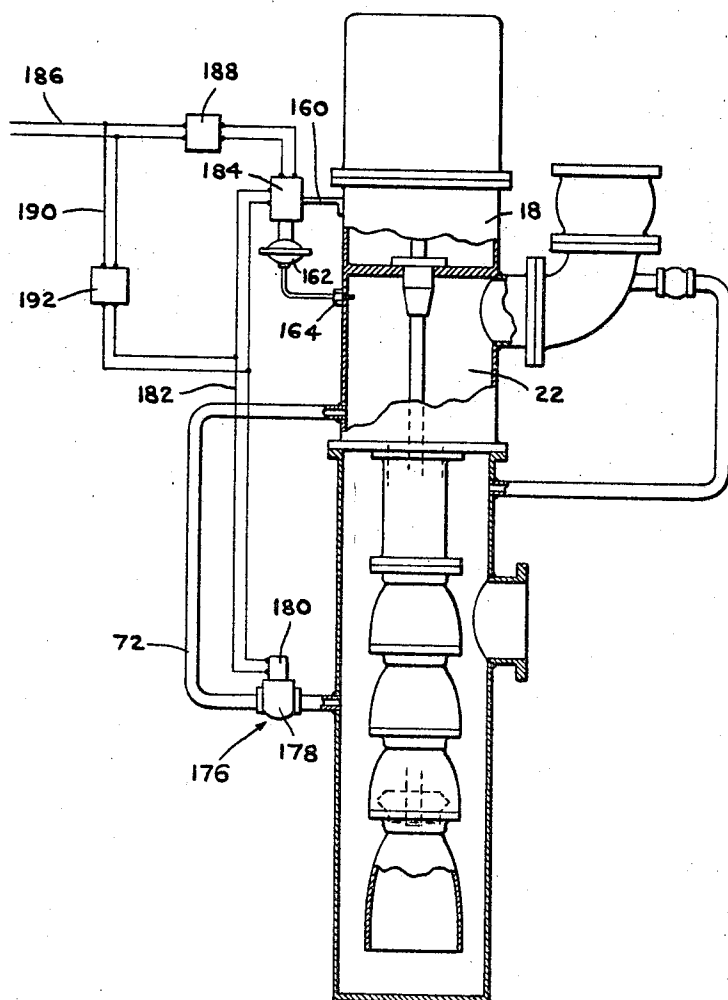


FIG. 5

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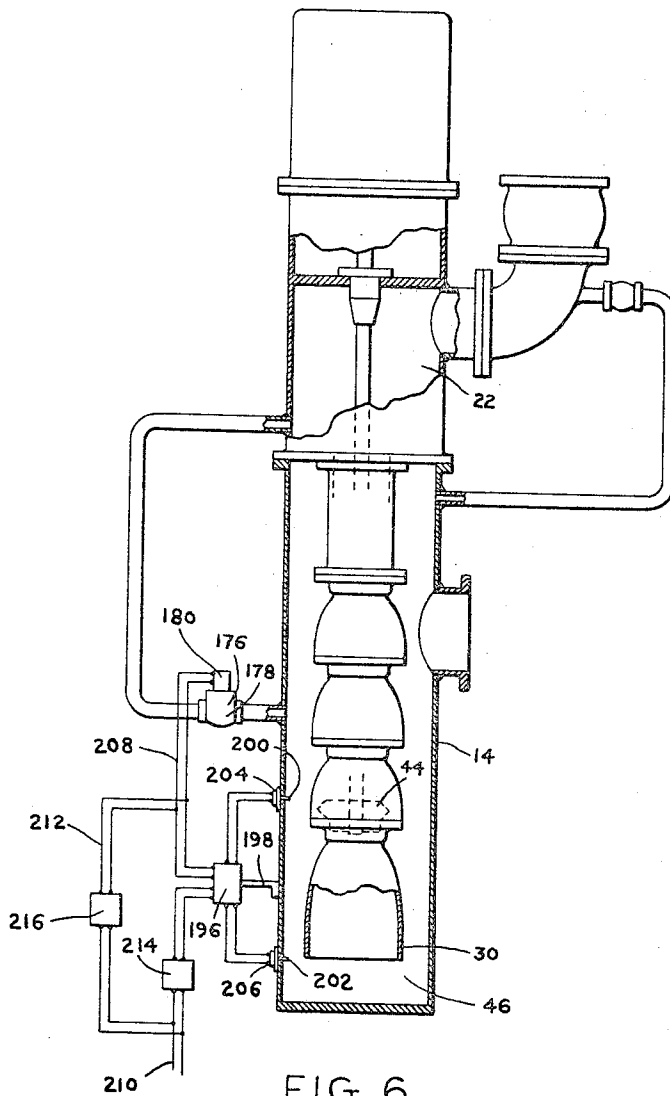
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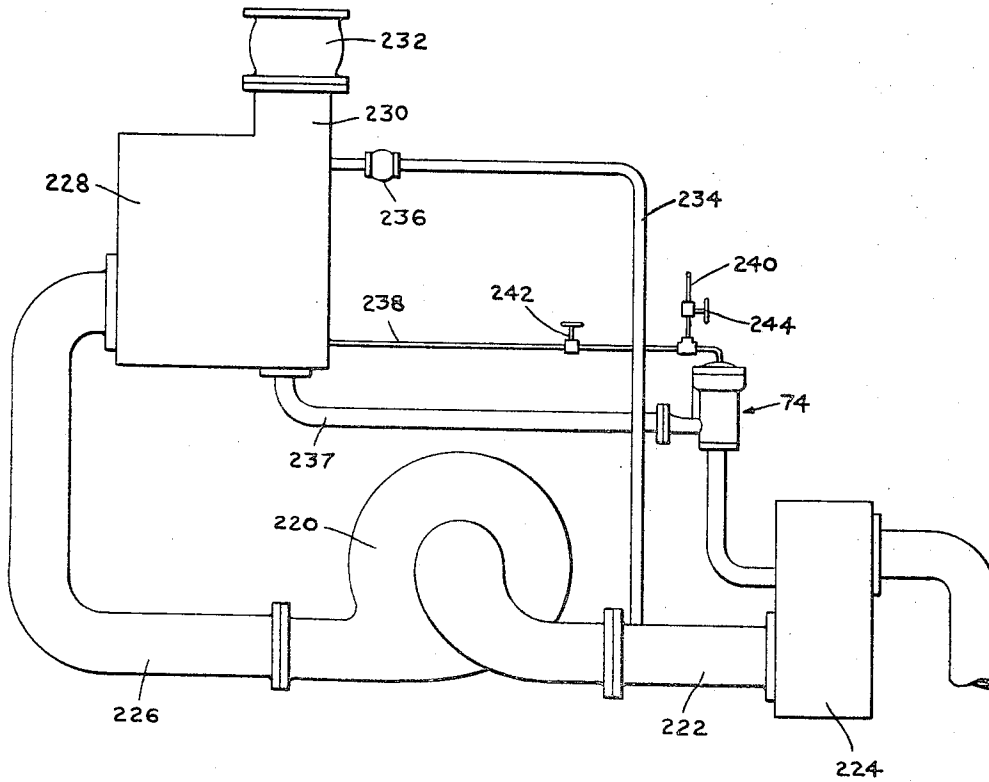


FIG. 7

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SELF-PRIMING PUMP SYSTEM WITH EXTERNAL ACTUATING MEANS

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Int. Cl. F04d 9/02

U.S. Cl. 103—113

12 Claims

ABSTRACT OF THE DISCLOSURE

A pumping system for pumping liquids containing large quantities of gas or vapors adapted for pumping operations requiring stripping of liquid storage tanks. The system incorporates apparatus for repriming the pump including a bypass which communicates an accumulation of pump discharge with the suction well of the pump to reprime the pump and a repriming valve associated with the bypass to control the flow of repriming liquid. The repriming valve may be actuated manually or by predetermined operating parameters of the pumping system.

BACKGROUND OF THE INVENTION

The present invention resides in the class of devices which are adapted for priming centrifugal pumps preliminary to starting or for maintaining such pumps in a primed condition during operation, and includes systems associated with the pump for filling the pump chamber with liquid and for removing air or noncondensable vapor from such chamber.

Installations using centrifugal pumps to lift liquids through a suction line from storage tanks have always been faced with the problem of maintaining the prime of the pump, as the level of the liquid in the storage tank drops. When large quantities of air or uncondensed vapor are drawn into the pump, as often happens when the level of the liquid in the storage tanks is low, the pump loses its prime and can no longer produce the suction necessary to draw liquid through the suction line from the tank to the inlet of the pump. The pump must then be reprimed before further pumping operations can be carried on.

This repriming requirement for centrifugal pumps seriously limits the effectiveness of these pumps where it is necessary to empty fairly large storage tanks from above. The centrifugal pumps cannot efficiently empty the bottom sections of these tanks because of the frequent delays required to reprime the pumps and, therefore, it has been necessary to equip many of these storage tanks with separate small pumps known as "stripping" pumps to empty the bottom sections of the tanks.

SUMMARY OF THE INVENTION

The present invention overcomes these problems by providing self-priming apparatus for centrifugal pumping systems wherein a bypass communicates an accumulation of pump discharge with the suction well of the pump. A repriming valve associated with the bypass is disposed remotely from the pump discharge and controls the flow of repriming liquid. The repriming valve may be actuated manually from a point remote from the pumping system or automatically by any pumping parameter such as the level of liquid in the suction well of the pump, or the static or dynamic pressure of the liquid at any point of the pumping system.

Accordingly, it is an object of the present invention to provide self-priming apparatus for a centrifugal pumping system.

It is a further object of this invention to provide self-priming apparatus for a centrifugal pump which utilizes

pump discharge to reprime the pump and to drive gases and uncondensed vapor from the suction well of the pump into the discharge system.

It is another object of this invention to provide self-priming apparatus for a pumping system which produces a minimum of interference in the normal operations of the pumping system.

It is yet another object of this invention to provide self-priming apparatus for a pumping system which is easily accessible during pumping operations.

Still another object of this invention is to provide a self-priming pumping system readily adaptable to varying pumping requirements.

It is a further object of this invention to provide a simplified repriming valve adapted for use in self-priming pumping systems.

Still, another object of this invention is to provide self-priming apparatus for a pumping system which may be actuated by predetermined conditions occurring at a point in the pumping system remote from the location of the self-priming apparatus.

It is another object of the present invention to provide a self-priming apparatus for a pumping system which may be manually controlled from a point remote from the pumping system.

Still, a further object of this invention is to provide apparatus for self-priming pumping systems which can be actuated at any point in the pumping cycle by any predetermined pumping parameter.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 shows a side elevation, in partial section, of a self-priming, vertical, centrifugal pumping system in accordance with the teachings of the present invention.

FIGURE 2 shows a side elevation in partial section of a repriming valve for use in the self-priming pumping system shown in FIGURE 1 with alternate pressure means indicated in phantomized form.

FIGURE 3 shows a side elevation in partial section of another repriming valve for use in a self-priming pumping system shown in FIGURE 1.

FIGURE 4 shows a side elevation, in partial section, of another self-priming, vertical, centrifugal pumping system in accordance with the teachings of the present invention.

FIGURE 5 shows a side elevation, in partial section, of still another self-priming, vertical, centrifugal pumping system in accordance with the teachings of the present invention.

FIGURE 6 shows a side elevation, in partial section of yet another self-priming, vertical, centrifugal pumping system in accordance with the teachings of the present invention.

FIGURE 7 shows a self-priming, non-vertical, centrifugal pumping system in accordance with the teachings of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIGURE 1 shows a vertical, centrifugal pumping system generally indicated at 10 having a multistage centrifugal pump generally indicated at 12 enclosed in a suction well 14. A motor 16 in a motor housing 18 powers the centrifugal pump by means of a drive shaft 20 extending from motor housing 18 through an accumulating chamber 22 (to be more fully described hereinafter) to suction well 14.

Centrifugal pump 12 is mounted in suction well 14 from a discharge pipe 24 which is bolted to the bottom wall 26 of accumulating chamber 22 by means of a flange 28 on the end of the discharge pipe. The centrifugal pump has a suction inlet 30 connected in the conventional manner to the first pumping stage 32 of three series connected pumping stages 32, 34, and 36 designating, re-

spectively, the first or inlet pumping stage, the second or intermediate pumping stage, and the third or discharge pumping stage. Third pumping stage 36 is connected to the bottom of discharge pipe 24 by means of flanges 38 and 40 on the discharge pipe and pumping stage, respectively.

Suction well 14 has an inlet port 42 above the level of the first pumping stage impeller 44. The suction well below the level of the inlet port defines a storage chamber 46 for fluid to be pumped. Suction inlet 30 of first pumping stage 32 is in communication with storage chamber 46 and during normal pumping conditions the storage chamber is filled with liquid to be pumped to prevent air from entering the suction inlet of the pump which would cause the pump to lose its prime.

Accumulating chamber 22 is mounted on top of suction well 14 by means of flanges 48 and 50, respectively, on the bottom wall 26 of the accumulating chamber and the upper end of the suction well. An inlet 52 is located in bottom wall 26 of the accumulating chamber to receive liquid from discharge pipe 24, and a large discharge port 54 is located near the upper wall 55 of the accumulating chamber through which the liquid pumped is discharged during normal pumping conditions.

A discharge check valve 56 is connected to the discharge port of the accumulating chamber by means of an elbow 58 to prevent liquid discharged from accumulating chamber 22 from backflowing into the chamber. Elbow 58 is connected at one end to the discharge port 54 by means of flanges 60 and 62 on the discharge port and the elbow, respectively, and is connected at the other end to check valve 56 by means of flanges 64 and 66 on the elbow and check valve, respectively.

A gas bleed conduit 68 leads from the top of suction well 14 to elbow 58 to communicate the suction well with the accumulating chamber. Though shown as connected to elbow 58, gas bleed conduit 68 could be connected to any point which communicates with the accumulating chamber. A check valve 70 is disposed in gas bleed conduit 68 to prevent backflow of fluid from the accumulating chamber to the suction well through the gas bleed conduit.

A bypass conduit 72 is connected to suction well 14 and the bottom of accumulating chamber 22 providing a pathway for liquid from the accumulating chamber to quickly reach the suction well 14 to reprime the pump when normal pumping operation ceases, as is hereinafter described. A repriming valve 74 is disposed in bypass conduit 72 to control the flow of repriming liquid from accumulating chamber 22 to suction well 14 of the pump. The valve can be actuated automatically, in response to the requirements of the pumping system, or manually from a remote position.

Repriming valve

As shown in FIGURE 2 repriming valve 74 has a valve body 80 with a generally cylindrical housing 82 formed on the top thereof. The valve body has an inlet 76 and inlet bore 77, and an outlet 78 and outlet bore 79.

The repriming valve is connected at the inlet thereof to the bypass conduit by flanges 84 and 86, respectively, on inlet 76 and bypass conduit 72. The valve body is secured at the outlet thereof to a flange 88 on bypass conduit 72 by a plurality of bolts 90.

Flange 88 has a raised shoulder 92 which is narrower than the bottom surface of valve body 80, therefore, a lip 94 is left protruding from the valve body above the flange of the bypass conduit. A cylindrical valve seat 96 having a seating surface 98 on the upper portion thereof is mounted in valve body 80 by means of a shoulder 100 on the bottom end of the valve seat which seats between lip 94 of the valve body and flange 88 of the bypass conduit.

Cylindrical housing 82 on valve body 80 has a head 102 which is bolted to the wall of the housing by a plu-

ality of bolts 104. The bottom wall 105 of housing 82 has a passage 106 therein leading to inlet bore 77 of the valve body proximate valve seat 96. A tubular valve element 108 having a seating surface 110 on the lower end thereof is mounted in housing 82 with seating surface 110 extending through passage 106 to operatively associate with valve seat 96. An O-ring 107 is mounted in a groove 109 in passage 106 and coacts with tubular valve element 108 to seal valve body 80 from cylindrical housing 82.

The upper end of valve element 108 is formed into a piston 112. The piston has an upper surface 114 and two lower surfaces, an annular surface 116 between the outer wall of the tubular element and the inner wall of housing 82, and a circular surface 118 closing the upper end of the tubular section. An O-ring 122 is mounted in a groove 124 in the circumference of the piston to seal the upper surface 114 from the lower annular surface 116 of the piston. The upper surface 114 of the piston 112 coacts with the bottom surface of cover 102 to form a compression chamber 126 above the piston even when the piston is in the upwardmost position.

Four forces act on piston 112 to position the piston and consequently to position valve element 108. The pressure in compression chamber 126 urges the piston downward, and three forces urge the piston upward. A spring 120 surrounds the outer surface of the tubular valve element and is in contact with bottom wall 105 of housing 82 and the lower annular surface of the piston to bias the piston in the upwardmost position. Secondly, the pressure of the ambient atmosphere, communicated to the inside of housing 82 by a bleed passage 128 in the wall of the housing, exerts an upward force on annular surface 116. Thirdly, the pressure of the liquid in inlet bore 77 is communicated to the circular surface 118 on the bottom of the piston and exerts an upward force.

The pressure of the liquid in inlet bore 77 is also communicated to compression chamber 126 by means of a passage 134 in the wall of housing 82. Since surfaces 114 and 118 are acted upon by the same liquid and the area of surface 114 is larger than that of surface 118, there will be a resultant downward force exerted on piston 112 by the liquid in inlet bore 77. Repriming valve 74 will be set in the closed position when this resultant downward force from the liquid is greater than the forces exerted on piston 112 by spring 120 and the ambient atmosphere acting on surface 116.

Other means can be used to pressurize compression chamber 126 to seat valve element 108. As shown in the phantomized portion of FIGURE 2, a passage 130 in cover 102 is adapted to receive a pressure control conduit 132 which introduces pressurized fluid into the compression chamber, or can also bleed off pressurizing fluid from the compression chamber. The pressure of the fluid in pressure control conduit 132 may be controlled manually or automatically from a point remote from the pumping system by any of the means well known in the instrumentation art, which need not be elaborated on herein.

If a pressure control conduit 132 is utilized to pressurize compression chamber 126, a tapered orifice 135 may be incorporated in passage 134 to allow for easier communication in the direction from valve bore 77 to compression chamber 126 than in the opposite direction. This flow restriction prevents excessive fluid flow from the compression chamber and, therefore, facilitates rapid pressure buildup in the compression chamber when pressurizing fluid is injected into compression chamber 126 through passage 130 to actuate repriming valve 74. However, communication is readily maintained between the inlet bore of the valve and the compression chamber to automatically position the repriming valve in response to the pressure in inlet bore 77.

As shown in FIGURE 3, the pressure of the liquid in the pumping system which automatically actuates the repriming valve need not come only from inlet bore 77. A separate, external, system pressure conduit 136 can be

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connected from any preselected point in the pumping system to transmit the pressure of the liquid at that point to compression chamber 126. Thus, one port of a pipe T 140 is connected to system pressure conduit 136, a second port of pipe T 140 is connected to a pressure control conduit 141, which performs a function identical to that of pressure control conduit 132 in FIGURE 2, and the third port of the pipe T is connected to a common conduit 138 which is connected to passage 130 to cover 102.

Valves 142 and 144 are positioned, respectively, in pressure control conduit 141 and system pressure conduit 136 to selectively communicate pressure control conduit 141 and system pressure conduit 136 with compression chamber 126. Valves 142 and 144 are shown for purposes of simplicity as being manually operated. However, solenoid valves or pressure actuated valves, purchasable on the open market, or any number of remotely controlled valves known in the instrumentation art could be substituted.

OPERATION

During normal operation the pump is primed prior to startup by filling the suction well 14 with enough liquid to immerse the first stage impeller 44. The pump is started, and as the liquid is pumped from the suction well, the pressure in suction well 14 will drop and draw liquid through a suitable suction line (not shown) connected to inlet port 42 into suction well 14 to refill chamber 46. The liquid is drawn from chamber 46 in suction well 14 through suction inlet 30 into the first pumping stage 32 and is discharged into discharge pipe 24 from third pumping stage 36. From the discharge pipe, the liquid enters accumulating chamber 22 through inlet 52 in lower wall 26 thereof and, after filling the accumulating chamber, passes out through outlet port 54, past check valve 56 to a convenient delivery line (also not shown) connected to the outlet port 54 at a point downstream of the check valve 56.

During normal pumping conditions, check valve 56 is kept in the open position by the force of the liquid passing from the accumulating chamber, and check valve 70 in gas bleed conduit 68 is kept in the closed position because the pressure in elbow 58 is greater than that in suction well 14. Repriming valve 74 is kept in the closed position during normal pumping conditions because the pressure in compression chamber 126 exerts a force on upper surface 114 of piston 112 which is greater than the forces exerted by spring 120 and the pressures on annular and circular surfaces 116 and 118, respectively, and, therefore, holds piston 112 in the lower position to seat valve element 108. Repriming valve 74 is closed to prevent back flow of liquid from accumulating chamber 22 to the suction well 14 of the pump.

When the quantity of air and noncondensable vapors in suction well 14 are sufficient to drive the level of liquid in storage chamber 46 of suction well 14 below the bottom of suction inlet 30, the pump loses its suction and will fail to discharge fluid through discharge pipe 24. The pressure in accumulating chamber 22 will drop causing the check valve 56 to close. The pressure in inlet bore 77 of repriming valve 74 will also drop, reducing the pressure in compression chamber 126 until the forces exerted by spring 120 and the pressures on surfaces 116 and 118 raise valve element 108 to open repriming valve 74.

Once open, repriming valve 74 allows a flow of liquid from accumulating chamber 22 through conduit 72 into suction well 14 for the pump. As the liquid from the accumulating chamber fills the suction well, the gases or uncondensed vapor in storage chamber 46 of the suction well 14 are driven towards the top of the suction well 14. Since the discharge check valve 56 is closed and liquid is flowing from accumulating chamber 22, the pressure in the accumulating chamber soon drops below the pressure of the gas driven to the top of the suction well 14 causing gas bleed check valve 70 in gas bleed conduit 68 to open. The gas from the suction well then enters the

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upper portion of accumulating chamber 22 by way of elbow 58 and discharge port 54.

When enough liquid to reprime the pump has passed from accumulating chamber 22 through bypass conduit 72 to storage chamber 46, the pump will commence discharging fluid to the accumulating chamber as above described. The pressure of this fluid will open discharge check valve 56 and close repriming valve 74. The pressure of the pump discharge will also close gas bleed check valve 70 to prevent the gas which has been driven to the accumulating chamber from returning to the suction well.

As the reprimed pump continues to operate, the liquid in suction well 14 is pumped back into and fills accumulating chamber 22 and drives out, through check valve 56, the collected gas and noncondensable vapors which entered the accumulating chamber through gas bleed conduit 68. As the level of the liquid in accumulating chamber 22 rises, the level of the liquid in suction well 14 will drop thereby reducing the pressure in suction well 14 and, once again, liquid will be drawn through inlet 42 from the source to which it is connected.

If the increased suction in the suction well 14 does not draw liquid to the suction well for the pump, the pump will again lose its prime. Consequently, as mentioned above, the pump discharge pressure will again drop, causing check valve 56 to close and repriming valve 74 and gas bleed check valve 70 to open. The pump will be reprimed; gases and noncondensable vapors will be driven from the suction well; the discharge pressure will increase reversing the setting of valves 56, 70 and 74; and, if fluid is drawn into suction well 14, pumping will continue. Otherwise, this repriming cycle will continue until all the gas and noncondensable vapors have been driven from the suction well and the source being pumped, and sufficient liquid is being drawn into the suction well for the system to operate.

OTHER FORMS OF THE INVENTION

The pumping systems shown in FIGURES 4, 5 and 6 are similar to that shown in FIGURE 1. For purposes of simplicity, similar elements of the system shown in FIGURES 4, 5 and 6 which were described previously in FIGURE 1 will be similarly numbered.

FIGURE 4 shows a pumping system in which a pressure actuated valve 150 is used as the repriming valve in bypass conduit 72. One such valve is the "Domotor" control valve, manufactured by the Worthington Controls Company, which is easily purchased on the open market. Pressure actuated valve 150 has a valve body 152 and pressure actuator 154 mounted on the valve body which opens and closes the valve in response to the pressure transmitted to the pressure actuator through a pressure transmitting conduit 156 from a pressure transmitter 158. The pressure transmitter is mounted to motor housing 18 by a bracket 160 and transmits pressure to pressure actuator 154 in relation to the pressure sensed by a pressure sensing element 162 positioned in a pressure fitting 164 disposed near the upper end of the accumulating chamber 22. A pressure fluid supply line 166 having a valve 168 disposed therein is connected to pressure transmitter 158. A transmitter bypass line 170 having a valve 172 disposed therein connects pressure transmitting conduit 156 with pressure fluid supply line 166 at a point upstream of valve 168.

The manner of operation of pressure actuated valve 150 and pressure transmitter 158 are well known to those skilled in the instrumentation art and need not be elaborated on herein. It should be sufficient to state that pressure transmitter 158 regulates a pressurized fluid provided to the pressure transmitter by pressure fluid supply line 166 in relation to the pressure sensed by pressure sensing element 162. When the pump loses its prime and the pressure in accumulating chamber 22 drops, pressure sensing element 162 will communicate the drop in pressure to pressure transmitter 158 which will regulate the pressure

in pressure transmitting conduit 156 to actuate pressure actuated valve 150 and start the repriming cycle. When the pressure in accumulating chamber 22 returns to the normal operating range, pressure sensing element 162 will communicate the increased pressure to pressure transmitter 158 which will regulate pressure actuated valve 150 to prevent additional liquid from flowing through bypass column 72 to the suction well of the pump.

Valves 168 and 172 in the pressure fluid supply line and the transmitter bypass line, respectively, can be adjusted to selectively communicate pressure transmitting conduit 156 with pressure transmitter 158 and pressure fluid supply line 166 in order to control pressure actuated valve 150 by means of pressure sensing element 162 or from a remote point. For purposes of simplicity, valves or pressure actuated valves, purchasable on the open market, 168 and 172 are illustrated as being manually operated. However, any number of remotely controlled valves known in the instrumentation art could be substituted to perform the same function.

It should be noted that the position of pressure sensing element 162 as shown in FIGURE 4 illustrates only one of many locations in the pumping system where the pressure sensing element could be placed to effectively monitor the operation of the pumping system.

FIGURE 5 shows a pumping system in which a solenoid valve 176 is used as the repriming valve in bypass conduit 72. One such valve is the "ASCO" solenoid valve, manufactured by Automatic Switch Company which is easily purchasable on the open market. The solenoid valve has a valve body 178 and a solenoid 180 mounted on the valve body which opens and closes the valve in response to the electrical current carried in an electrical line 182 connecting solenoid 180 with a pressure sensitive switch 184. The pressure sensitive switch is mounted to motor housing 18 by bracket 160 and controls the current in electrical line 182 in relation to the pressure sensed by pressure sensing element 162 positioned in pressure fitting 164. A power supply line 186 having a switch 188 disposed therein is connected to pressure actuated switch 184. A pressure switch bypass line 190 having a switch 192 disposed therein connects electrical connecting line 182 with electrical power supply line 186 at a point upstream of switch 188.

The manner of operation of solenoid valve 176 and pressure actuated switch 184 are well known to those skilled in the instrumentation art and need not be elaborated on herein. It should be sufficient to state that when the pump loses its prime and the pressure in accumulating chamber 22 drops, pressure sensing element 162 will communicate the drop in pressure to pressure actuated switch 184 which will control the current in electrical connecting line 182 to actuate solenoid valve 176 and start the repriming cycle. Solenoid valve 176 will remain in the repriming position until pressure sensing element 162 again senses the normal operating pressure at its location in the pumping system.

Switches 188 and 192 in electrical power supply line 186 and pressure switch bypass line 190, respectively, can be set to selectively communicate electrical connecting line 182 with pressure actuated switch 184 and electrical power supply line 186 in order to control solenoid valve 176 by means of pressure sensing element 162 or from a remote point.

FIGURE 6 shows a pumping system similar to that shown in FIGURE 5 in which a liquid level actuated switch 196 controls the position of solenoid valve 176. Liquid level actuated switch 196 is mounted to pump casing 14 by a bracket 198 and controls the current in electrical connecting line 208 to solenoid 180 in relation to the level of liquid in suction well 14 as sensed by upper and lower liquid level sensing elements 200 and 202, respectively, mounted in pressure fittings 204 and 206 which are disposed in the suction well near the level of first stage impeller 44 and the bottom of suction inlet 30. A power

supply line 210 having a switch 214 disposed therein is connected to liquid level actuated switch 196. A bypass line 212 having a switch 216 disposed therein connects electrical connecting line 208 with electrical power supply line 210 at a point before switch 214.

The manner of operation of solenoid bypass valve 176 and liquid level actuated switch 196 are well known to those skilled in the art and need not be elaborated on herein. It should be sufficient to state that when the level of liquid in suction well 14 drops to the level of lower liquid level sensing element 202 liquid level actuated switch 196 will control the current in electrical connecting line 208 to actuate solenoid valve 176 and start the repriming cycle. When the liquid level in suction well 14 rises to the height of upper liquid level sensing element 200, liquid level actuated switch 196 will actuate solenoid valve 176, by means of electrical connecting line 208, to prevent the flow of additional liquid from accumulating chamber 22 to suction well 14.

Switches 214 and 216, in power supply line 210 and switch bypass line 212, can be set to selectively communicate the source of current to solenoid valve 176 in order to control the solenoid bypass valve by means of liquid level sensing elements 200 and 202 or from a point remote from the pumping system.

Self-priming system using a horizontal pump

FIGURE 7 shows a self-priming centrifugal pumping system using a horizontal centrifugal pump 220 connected by a suction inlet line 222 to an inlet storage chamber 224. A discharge line 226 leads from the discharge of the centrifugal pump to an accumulator chamber 228 disposed above the suction inlet line. Accumulating chamber 228 has an outlet 230 with a check valve 232 connected thereto to prevent back flow of fluid into the accumulating chamber after it has passed the check valve. An air bleed conduit 234 connects suction inlet 222 of centrifugal pump 220 with accumulating chamber 228. As in the other embodiments of the invention previously described, air bleed conduit 234 has a check valve 236 therein to prevent back flow from accumulating chamber 228 to suction inlet 222 of the pump. A bypass conduit 237 communicates the bottom of accumulating chamber 228 with inlet storage chamber 224.

Repriming valve 74 (illustrated in FIGURE 3) is disposed in bypass conduit 237. A system pressure transmitting conduit 238 communicates repriming valve 74 with accumulating chamber 228 so that the repriming valve is responsive to the pressure of the liquid in accumulating chamber 228. An external source of pressurizing fluid is also provided by means of a pressurizing conduit 240. Valves 242 and 244 disposed, respectively, in system pressure conduit 238 and pressurizing conduit 240, can be adjusted to control repriming valve 74 by means of system pressure transmitting conduit 238 or from a point remote from the pumping system.

The system shown in FIGURE 7 operates similarly to the system shown in FIGURE 1. When the pump 220 loses its prime during normal pumping conditions, the pressure in accumulating chamber 228 will drop causing discharge check valve 232 to close and repriming valve 74 and gas bleed check valve 236 to open. Repriming liquid from accumulating chamber 228 enters inlet storage chamber 224 and drives the gases and uncondensed vapors in inlet storage chamber 224 and suction inlet line 222 through gas bleed bypass 234 into the upper portion of accumulating chamber 228. As the pump discharge from the reprimed pump fills accumulating chamber 228, driving the gases therein through check valve 232, the level of liquid in inlet storage chamber 224 will drop increasing the suction therein to draw additional liquid to the inlet storage chamber from the tank (not shown) which is being emptied by pump 220.

It will be understood that various changes in the details, material and arrangements in parts which have been herein described and illustrated in order to explain the

nature of the invention may be made by those skilled in the art within the principle and scope of the invention as expressed in the appended claims.

It will be further understood that the "abstract of the disclosure" set forth above is intended to provide a non-legal technical statement of the contents of the disclosure in compliance with the Rules of Practice of the United States Patent Office and is not intended to limit the scope of the invention described and claimed herein.

What is claimed is:

1. A self-priming liquid pumping system comprising:
 - (a) suction well means connected to a source of liquid to be pumped;
 - (b) pump means for pumping liquid from said suction well means having a suction inlet operatively associated with said suction well means and a discharge outlet;
 - (c) discharge line means connected to the discharge outlet of said pump means;
 - (d) a liquid accumulating means in said discharge line means to accumulate a quantity of liquid discharged from said pump means;
 - (e) check valve means disposed in said discharge line means downstream of said accumulating means to prevent backflow of fluid into said accumulating means;
 - (f) gas bleed means communicating said suction well means with the upper portion of said accumulating means;
 - (g) valve means in said gas bleed means to prevent backflow through said gas bleed means from said accumulating means to said suction well means;
 - (h) a liquid bypass means comprising a conduit communicating the lower portion of said accumulating means with said suction well means;
 - (i) repriming valve means in said bypass means disposed remotely from said discharge line means to control a flow of liquid from said accumulating means to said suction well means to reprime said pump means upon actuation of said repriming valve means;
 - (j) means to actuate said repriming valve means in response to predetermined operating parameters of said pumping system occurring at preselected points in the pumping system, said means to actuate said repriming valve means comprising:
 - (1) pressure sensing means disposed at a preselected point in said pumping system to sense the pressure of the liquid at said preselected point;
 - (2) transmitting means to receive the pressure sensed by said pressure sensing means and transmitting a pressure signal proportional to the pressure sensed to said repriming valve means; and
 - (3) said repriming valve means comprising pressure responsive control means to position said repriming valve means in response to the pressure transmitted by said pressure transmitter means.
2. A self-priming liquid pumping system comprising:
 - (a) suction well means connected to a source of liquid to be pumped;
 - (b) pump means for pumping liquid from said suction well means having a suction inlet operatively associated with said suction well means and a discharge outlet;
 - (c) discharge line means connected to the discharge outlet of said pump means;
 - (d) a liquid accumulating means in said discharge line means to accumulate a quantity of liquid discharged from said pump means;
 - (e) check valve means disposed in said discharge line means downstream of said accumulating means to prevent backflow of fluid into said accumulating means;

- (f) gas bleed means communicating said suction well means with the upper portion of said accumulating means;
- (g) valve means in said gas bleed means to prevent backflow through said gas bleed means from said accumulating means to said suction well means;
- (h) a liquid bypass means comprising a conduit communicating the lower portion of said accumulating means with said suction well means;
- (i) repriming valve means in said bypass means disposed remotely from said discharge line means to control a flow of liquid from said accumulating means to said suction well means to reprime said pump means upon actuation of said repriming valve means;
- (j) means to actuate said repriming valve means in response to predetermined operating parameters of said pumping system occurring at preselected points in the pumping system, said actuating means comprising:
 - (1) pressure sensing means disposed at a preselected point in said pumping system to sense the pressure of the liquid at said preselected point;
 - (2) electrical switch means responsive to pressure communicating said pressure sensing means with said repriming means;
 - (3) electrically actuated control means in said repriming valve means comprising means operatively associated with said electrical switch means to position said repriming valve means in response to the pressure sensed by said pressure sensing means.
3. A self-priming liquid pumping system comprising:
 - (a) suction well means connected to a source of liquid to be pumped;
 - (b) pump means for pumping liquid from said suction well means having a suction inlet operatively associated with said suction well means and a discharge outlet;
 - (c) discharge lines means connected to the discharge outlet of said pump means;
 - (d) a liquid accumulating means in said discharge line means to accumulate a quantity of liquid discharged from said pump means;
 - (e) check valve means disposed in said discharge line means downstream of said accumulating means to prevent backflow of fluid into said accumulating means;
 - (f) gas bleed means communicating said suction well means with the upper portion of said accumulating means;
 - (g) valve means in said gas bleed means to prevent backflow through said gas bleed means from said accumulating means to said suction well means;
 - (h) a liquid bypass means comprising a conduit communicating the lower portion of said accumulating means with said suction well means;
 - (i) repriming valve means in said bypass means disposed remotely from said discharge line means to control a flow of liquid from said accumulating means to said suction well means to reprime said pump means upon actuation of said repriming valve means;
 - (j) means to actuate said repriming valve means in response to predetermined operating parameters of said pumping system occurring at preselected points in the pumping system, said actuated means comprising:
 - (1) liquid level sensing means disposed in said suction well means to sense the liquid level therein;
 - (2) means communicating said liquid level sensing means to said repriming valve means; and
 - (3) said repriming valve means including control means operatively associated with said liquid

level sensing means to position said repriming valve means in response to the liquid level sensed by said liquid level sensing means.

4. The combination claimed in claim 3 wherein said control means normally position said repriming valve means in the closed position and open said valve means when the level of liquid sensed by said liquid level sensing means drops below a predetermined point.

5. The combination claimed in claim 3 wherein:

- (a) said liquid level sensing means comprise electrical switch means; and
- (b) said control means for said repriming valve means comprise solenoid means to position said repriming valve means.

6. In a pumping system having a suction well with an inlet port connected to a source of liquid to be pumped, pump means in said suction well for pumping liquid therefrom having a suction inlet operatively associated with said suction well and a discharge outlet, apparatus to reprime the pumping system comprising:

- (a) a liquid accumulating means having an inlet and an outlet connected to said discharge outlet of said pump means to accumulate a quantity of pump discharge;
- (b) check valve means disposed in the outlet of said accumulating means to prevent backflow of fluid into said accumulating means;
- (c) bleed means in said suction well to bleed gases and noncondensable vapor from said suction well;
- (d) a liquid bypass means communicating said suction well with a lower portion of said accumulating chamber;
- (e) pressure actuated repriming valve means in said bypass means to control a flow of liquid from said accumulating means to said suction well to reprime said pump, said repriming valve means comprising:
 - (1) a valve body having an inlet and an outlet;
 - (2) a valve element operatively disposed in said valve body to control flow between said inlet and said outlet thereof;
 - (3) chamber means forming a chamber associated with said valve body;
 - (4) piston means in said chamber means adapted to position said valve element;
 - (5) resilient means connected to said chamber means and said piston means to urge said piston means toward one end of said chamber means and thereby position said valve element with respect to said inlet and said outlet;
 - (6) said piston means comprising:
 - (A) a first pressure face acted upon by the pressure in said chamber means;
 - (B) a second pressure face substantially smaller than said first pressure face and oppositely facing therefrom;
 - (C) means sealing said first pressure face from said second pressure face;
 - (D) balance conduit means communicating liquid from said pumping system with said second pressure face to provide a source of pressure to act on said piston means in conjunction with said resilient means;
- (f) pressurizing means communicating said repriming valve means with a preselected point in said pumping system to supply a source of pressure fluid to actuate said repriming valve.

7. The combination claimed in claim 6 wherein said resilient means connected to said chamber means and said piston means comprise spring means to urge said piston means to position said valve element in a normally open position with respect to said inlet and said outlet of said valve body whereby said repriming valve means will allow flow of liquid to reprime said pump means when the pressure from said pressurizing means communi-

cated to said chamber means in said repriming valve means drop below a predetermined value.

8. In a pumping system having a suction well with an inlet port connected to a source of liquid to be pumped, pump means in said suction well for pumping liquid therefrom having a suction inlet operatively associated with said suction well and a discharge outlet, apparatus to reprime the pumping system comprising:

- (a) a liquid accumulating means having an inlet and an outlet connected to said discharge outlet of said pump means to accumulate a quantity of pump discharge;
- (b) check valve means disposed in the outlet of said accumulating means to prevent backflow of fluid into said accumulating means;
- (c) bleed means in said suction well to bleed gases and noncondensable vapor from said suction well;
- (d) a liquid bypass means communicating said suction well with a lower portion of said accumulating chamber;
- (e) pressure actuated repriming valve means in said bypass means to control a flow of liquid from said accumulating means to said suction well to reprime said pump upon actuation of said repriming valve means;
- (f) said repriming valve means comprising:
 - (1) a valve body having an inlet and an outlet;
 - (2) a valve element operatively disposed in said valve body to control flow between said inlet and said outlet thereof;
 - (3) chamber means forming a chamber associated with said valve body;
 - (4) piston means in said chamber means connected to said valve element and adapted to position said valve element;
 - (5) resilient means connected to said chamber means and said piston means to urge said piston means toward one end of said chamber means and thereby position said valve element with respect to said inlet and said outlet;
 - (6) first pressure conduit means connected to said chamber means and a preselected point in said pumping system;
 - (7) second pressure conduit means connected to said chamber means and a remote source of pressure fluid; and
 - (8) selection means selectively communicating said first pressure conduit means and said second conduit means with said chamber means to select the pressure fluid to actuate said repriming valve means.

9. The combination claimed in claim 8 wherein said selection means comprise flow restriction means in said first pressure conduit means to restrict flow of fluid from said chamber means to said preselected point in said pumping system.

10. A valve adaptable for use in a self-priming pumping system comprising:

- (a) a valve body having an inlet and an outlet;
- (b) a valve element operatively disposed in said valve body to vary communication between said inlet and said outlet;
- (c) a housing operatively associated with said valve body;
- (d) a piston in said housing operatively associated with said valve element to position said valve element;
- (e) said piston and said housing cooperatively associated to define a sealed chamber means in said housing, the volume of said sealed chamber means variable in response to the pressure in said sealed chamber means;
- (f) a first conduit communicating the inlet of said valve body with said sealed chamber means to provide fluid from said inlet of said valve body to said sealed chamber means to pressurize said sealed chamber

- means and thereby exert a force against said piston;
- (g) resilient means connected to said piston and said housing to urge said piston towards one end of said housing to act in opposition to the force on said piston exerted by said fluid from said inlet of said valve body; 5
- (h) a second conduit connected to said sealed chamber means to communicate said sealed chamber means with a source of controlled pressure remote therefrom; and 10
- (i) control means operatively associated with said first and second conduits to control communication between said sealed chamber means and said source of controlled pressure remote therefrom to selectively augment and reduce the pressure in said sealed chamber means produced by the fluid from said inlet of said valve body. 15
11. The combination claimed in claim 10 wherein said control means operatively associated with said first and second conduits comprise: 20
- (a) valve means in said second conduit;
- (b) flow restriction means in said first conduit to provide restricted flow from said sealed chamber means to said inlet of said valve body and provide unrestricted flow from said inlet of said valve body to said sealed chamber means. 25
12. A self-priming liquid pumping system comprising:
- (a) suction well means connected to a source of liquid to be pumped;
- (b) pump means for pumping liquid from said suction well means having a suction inlet operatively associated with said suction well means and a discharge outlet; 30
- (c) discharge line means connected to the discharge outlet of said pump means; 35
- (d) a liquid accumulating means in said discharge line means to accumulate a quantity of liquid discharged from said pump means;
- (e) check valve means disposed in said discharge line means downstream of said accumulating means to prevent backflow of fluid into said accumulating means; 40
- (f) gas bleed means communicating said suction well

- means with the upper portion of said accumulating means;
- (g) valve means in said gas bleed means to prevent backflow through said gas bleed means from said accumulating means to said suction well means;
- (h) a liquid bypass means communicating said suction well means with the lower portion of said accumulating means;
- (i) repriming valve means in said bypass means disposed remotely from said discharge line means to control a flow of liquid from said accumulating means to said suction well means to reprime said pump means upon actuation of said repriming valve means;
- (j) means to actuate said repriming valve means in response to predetermined operating parameters of said pumping system occurring at preselected points in the pumping system; and
- (k) means to manually actuate said repriming valve means. 45

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