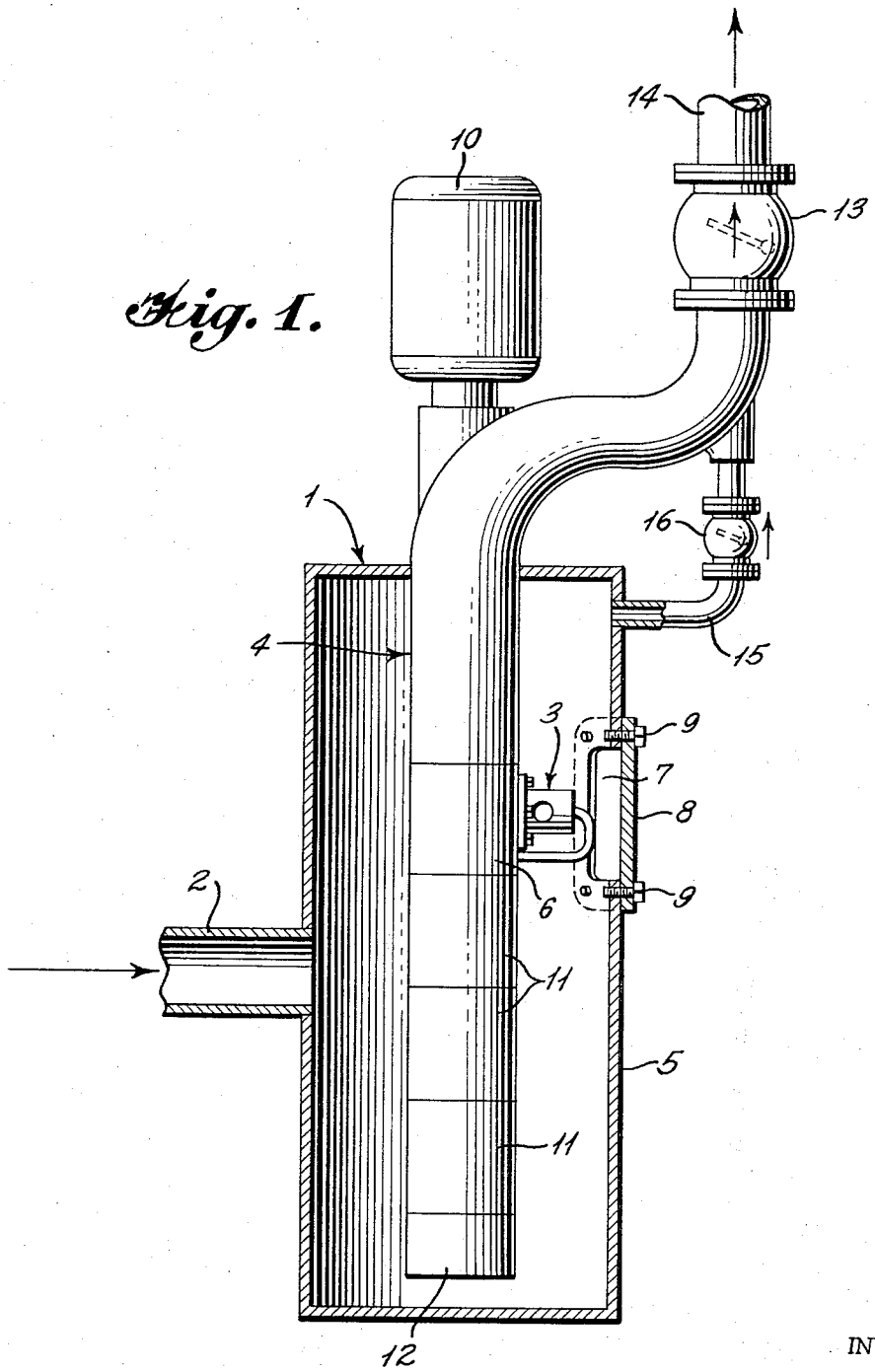
Feb. 27, 1968 P. E. NAPOLITANO 3,370,604

SELF-PRIMING LIQUID PUMPING SYSTEM AND PRIMER VALVE

Filed Dec. 16, 1964 4 Sheets-Sheet 1

Fig. 1.



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Filed Dec. 16, 1964 4 Sheets-Sheet 2

Fig. 2.

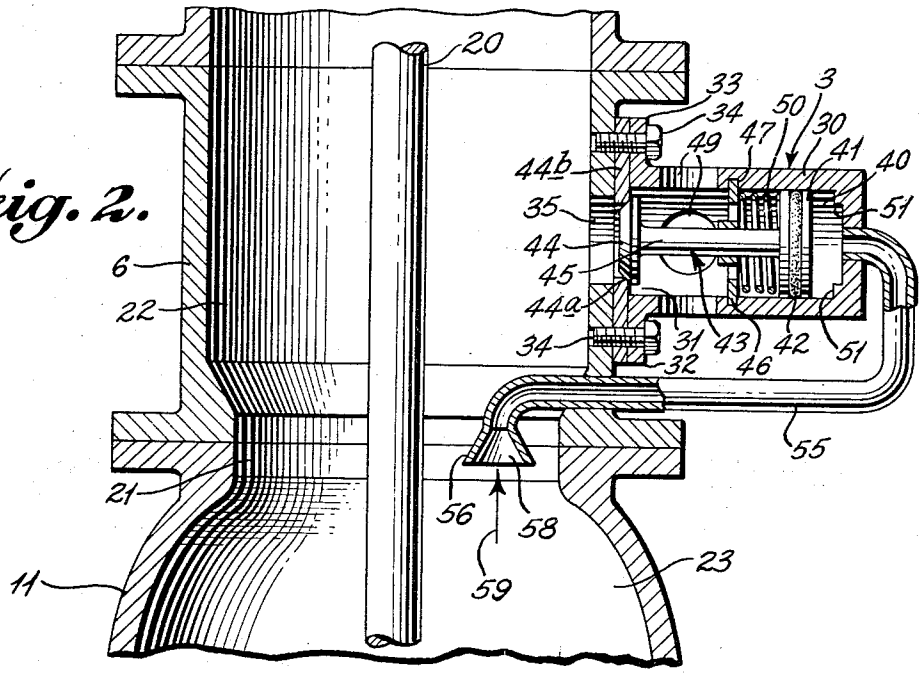

Fig. 3.

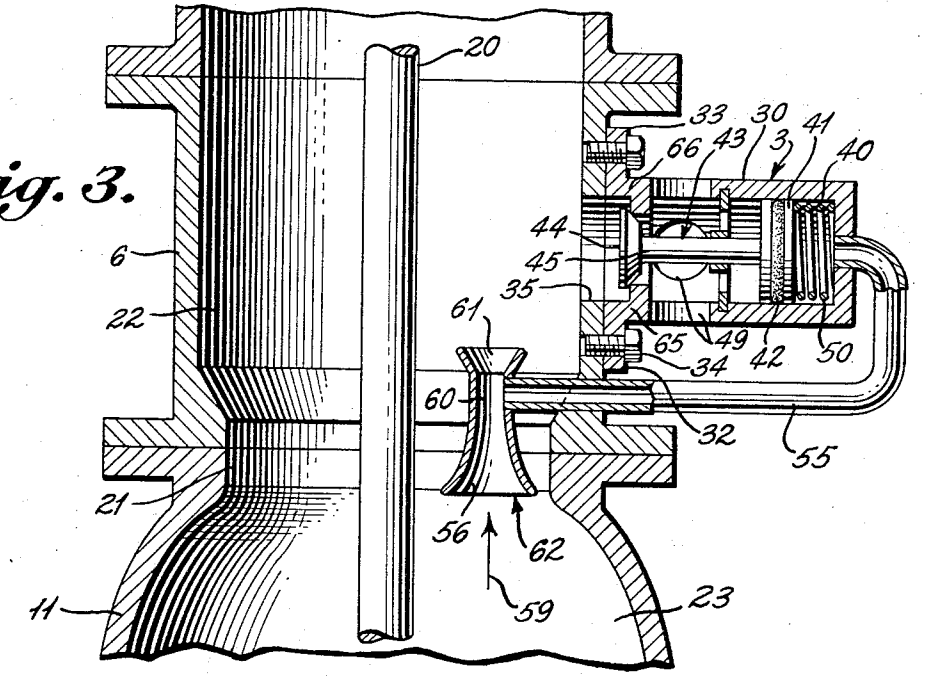

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Fig. 4.

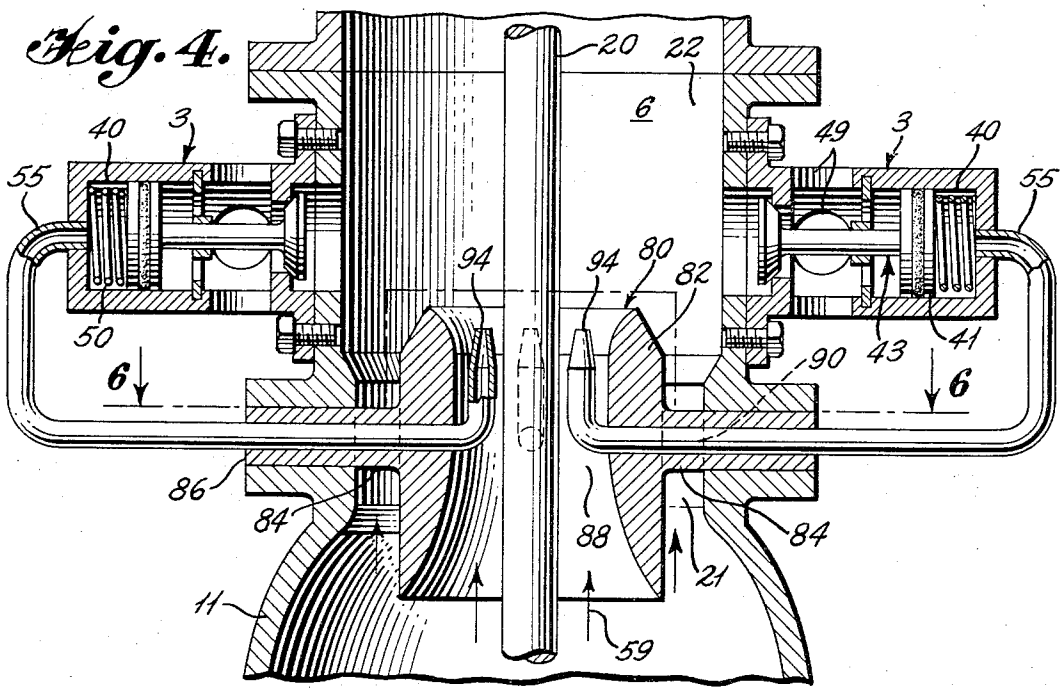
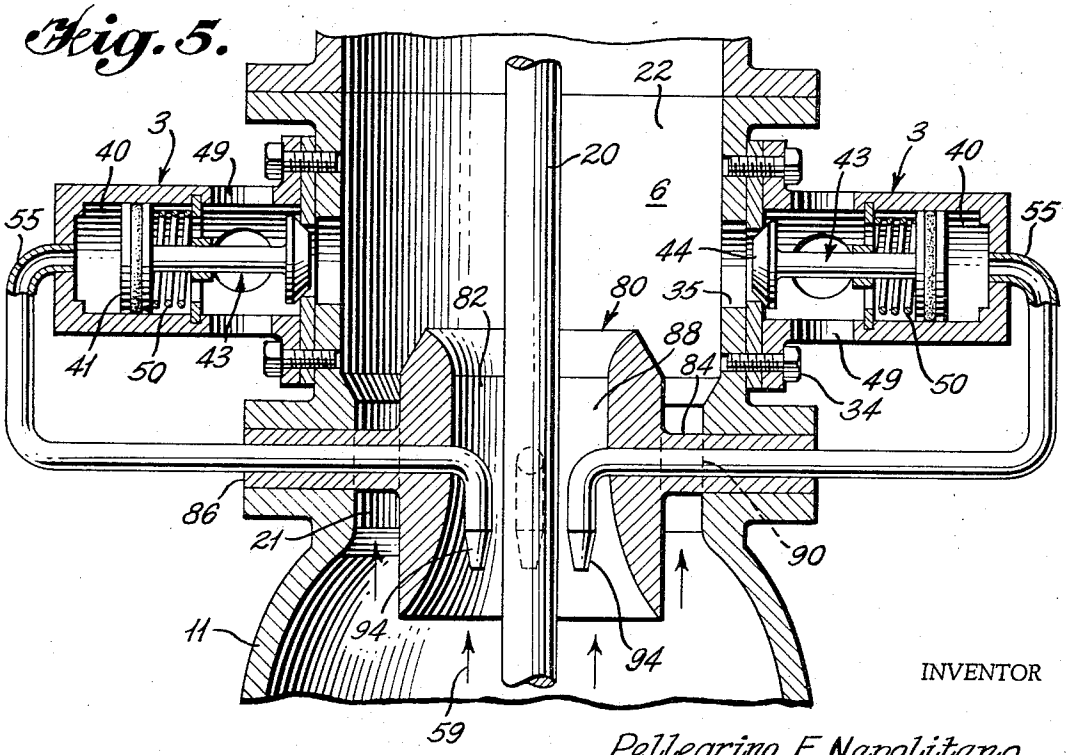


Fig. 5.



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SELF-PRIMING LIQUID PUMPING SYSTEM AND PRIMER VALVE

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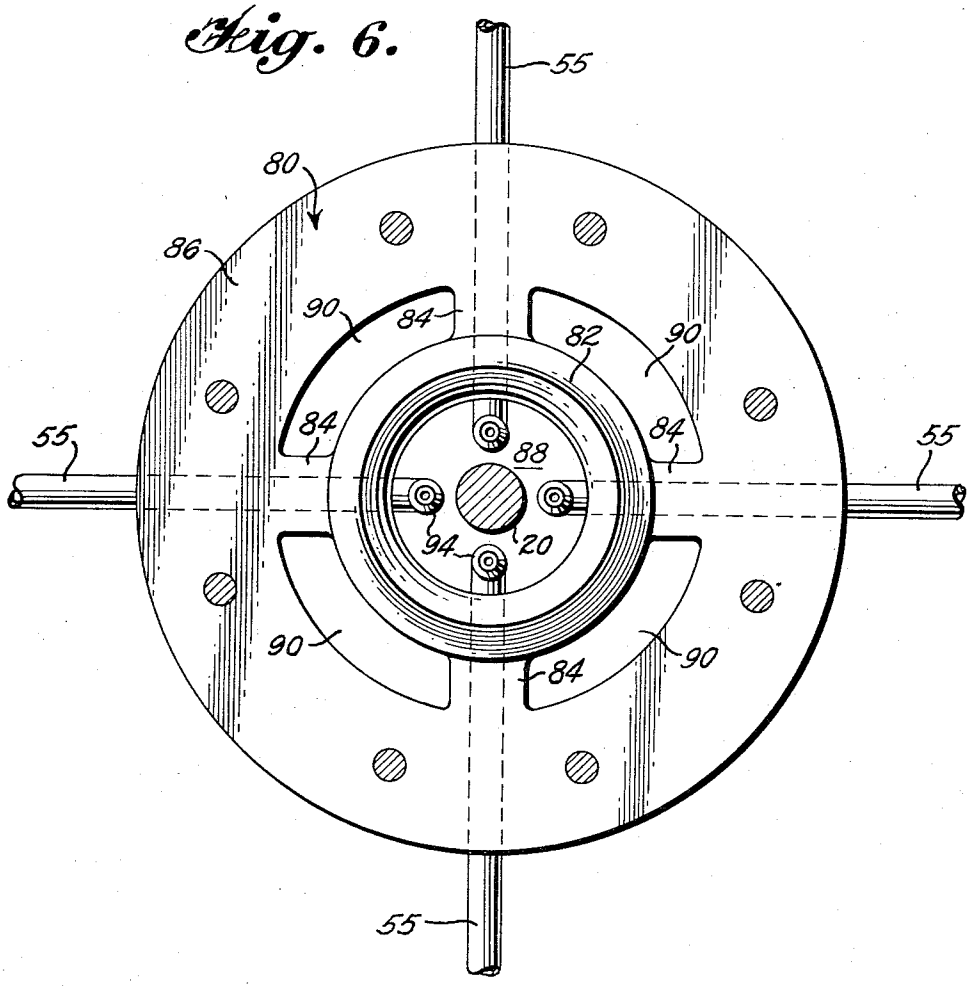
Fig. 6.



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3,370,604

SELF-PRIMING LIQUID PUMPING SYSTEM AND PRIMER VALVE

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8 Claims. (Cl. 137—117)

ABSTRACT OF THE DISCLOSURE

A primer valve is positioned at the outside of a discharge conduit from a pump with a valve element normally closing a port in the discharge conduit. Upon a reduction in fluid flow through the discharge conduit due to loss of suction at the pump, the valve element of said primer valve is moved to its open position to enable a predetermined quantity of fluid in the discharge conduit to pass through the port for recycle to the suction side of the pump in order to reprime the pump.

The present invention relates to self-priming liquid pumping systems and, more particularly, to an improved primer valve construction for effecting automatic self-priming of a liquid pump without interfering with the normal operation of the pump or complicating its maintenance.

In the past, there have been many different devices developed to automatically prime a liquid pump when the pump runs dry due to an insufficient amount of liquid being present at the pump inlet and to prevent air from being introduced to the suction side of the pump. These devices are essential to the efficient operation of a pumping system, since as is well known, once air is admitted to the suction passage in sufficient quantities to allow the pump to exhaust the supply of liquid in the suction well, the pump no longer is able to maintain suction to pump the liquid. Consequently, the pumping operation would be stopped and the attention of an operator would be required if no automatic means for repriming the system is provided.

One type of device for accomplishing repriming, effects self-priming of the pump by a primer valve located in the discharge passage of the pump which closes the discharge passage and opens a port communicating the discharge passage with the well surrounding the pump whereby a quantity of previously pumped and stored liquid is recycled back to the suction well and pump inlet. The recycled liquid is pumped, forcing the primer valve to assume a position which opens the discharge passage and closes the port. If the pump is not fully reprimed, the primer valve again closes the discharge passage and opens the port for another recycle. This recycling through the pump unit continues in this fashion until the suction inlet is once again submerged in liquid and the normal pumping cycle is restored. An example of an apparatus operating on this principle of self-priming is described in the Meyer et al., Patent No. 2,902,940, issued Sept. 8, 1959.

The heart of the recycle type of self-priming system described, is the primer valve that closes the discharge passage and opens a port to the suction well of the pump unit to allow the stored liquid to once again be pumped in order to restore normal suction at the pump inlet. In this type prior art system, the primer valve is located inside the discharge passage and includes a sliding valve element or the like mounted for movement along or relative to the central axis of the pump unit. While this arrangement has proven to be generally satisfactory for the purpose indicated, there has been a long felt need in the art for an improved primer valve arrangement for this type of pumping system because maintenance of the valve requires removal of the pump shaft. Also, simple replacement of a valve necessitates dismantling the pump.

Therefore, my invention is directed generally to the type of system and valve described and particularly to a novel primer valve and associated actuator construction that gives improved operation of the self-priming pumping system. Basically, this improved operation is due to location of the valve of the invention outside of the discharge passage of the system rather than inside as taught by the prior art. The improved valve also includes a remote sensor element in the discharge passage for initiating actuation of said valve.

According to another and related aspect of this invention, a valve assembly is provided that is simple in construction and which has improved operating characteristics for the purpose indicated.

Accordingly, it is one object of the present invention to provide an automatic means for priming a pumping system wherein the primer valve element is located outside of the conduit defining the liquid flow path thereby allowing substantially free, unobstructed flow of liquid along said flow path during the pumping operation.

It is another object of the present invention to provide an automatic primer valve responsive to the dynamic pressure of the liquid flow with only a small remote sensor located in the flow path.

It is still another object of the present invention to provide an improved primer valve and actuator construction wherein the primer valve is located along the outside of the discharge passage above the normal level intake liquid in the suction well and the sensor means for actuating the valve element is selectively mounted along the flow path of the pumping system so as to be capable of detecting the dynamic pressure of the flow at the desired position along said path.

A further object of the present invention is to provide a primer valve characterized by a simple design wherein the parts do not require finishing to close tolerances and which, therefore, will not become clogged by chemicals or other foreign matter in the liquid that operates the same.

One of the more important and significant objects of the present invention is to provide a primer valve that is easily accessible for service or replacement and which does not require disassembly of the pump and shaft for removal of or installation of said valve.

A still further object of the present invention is to provide a primer valve of the poppet type and control means that has a rapid response to a change in the condition of discharge flow to thereby speed the priming operation of the associated pump.

The above and still further objects, features and advantages of the present invention will become apparent upon consideration of the following detailed description of one specific embodiment thereof, especially when taken in conjunction with the accompanying drawings, wherein:

FIGURE 1 is a schematic illustration of a pumping system embodying the improved valve construction of the present invention;

FIGURE 2 is an enlarged sectional view illustrating the structure of the valve assembly of this invention;

FIGURE 3 is another embodiment of the valve assembly constructed in accordance with the present invention;

FIGURE 4 is another embodiment of hte valve assembly constructed in accordance with the present invention;

FIGURE 5 is another embodiment of the valve assem-

bly constructed in accordance with the present invention; and

FIGURE 6 is a sectional view taken along line 6—6 of FIGURE 4.

The device of the invention is or may be associated with a conventional center shaft centrifugal pump, as illustrated in FIGURE 1, but it is to be understood that it can be utilized with other types of pumps if desired. Pumping system **1** raises the liquid to the desired location by suction and reprimes itself automatically. That is, upon the entrance of air into the system via inlet or suction pipe **2** and the resultant discontinuance of the normal flow of liquid through said pipe **2**, the primer valve, generally represented by reference numeral **3** in the accompanying drawings, opens discharge pipe **4** to suction well **5** so that the system **1** is primed with previously pumped liquid stored in upper portions of the discharge passage of the pipe **4**, whereby normal pumping operations can be resumed. If the suction pipe **2** continues to admit air to the suction well **5** in sufficient quantities to prevent normal pump operation after the liquid from the upper portions of the discharge pipe **4** has been recycled to the bottom portion of the suction well **5** by gravity and the priming cycle is incomplete, the same priming liquid will be recycled indefinitely until the end of the inlet pipe **2** is once again sufficiently submerged in liquid to establish a continuous pumping operation.

In accordance with the present invention and as clearly illustrated in FIGURE 1, the primer valve **3** is mounted outside the discharge pipe **4**, preferably on the wall of a removable section **6** of said pipe **4**. As previously indicated, this arrangement has been found to give improved results and advantages over the prior designs wherein the valve element was mounted inside the discharge passage and conflicted with pump shaft **20**. More specifically, by bringing the valve **3** outside the discharge passage, the tortuous flow path required to conduct the liquid past the valve element during the pumping operation is eliminated, whereby a source of resistance in the system is removed thereby increasing the overall efficiency of the pumping operation. Further, and in accordance with the present invention, the valve construction is such as to improve the operation of the priming cycle as will be discussed later in the detailed description of the valve **3**.

An inspection window **7** is provided along the wall of the suction well **5** opposite the primer valve assembly **3** for easy access to the valve **3** for service or replacement if required. A plate **8** having suitable fastener means **9** is provided to seal the window **7** during the pumping operation so that suction can be maintained in the well **5**, for reasons which will subsequently become apparent. As illustrated in FIGURE 1, the valve **3** and the window **7** are preferably located above the normal liquid level at the inlet pipe **2**, but in some cases it may be desirable to provide the inlet pipe **2** at the top of the well **5** to increase the amount of liquid available for pumping before the system will run dry.

Continuing now with a more detailed description of those parts of the pumping system **1** illustrated in FIGURE 1 that may be considered to be conventional, a motor **10** is provided to turn any number of pump elements or sections **11**, as schematically illustrated in the figure; it being understood that the pump elements **11** are interconnected with said motor **10** through a suitable drive shaft **20** (not shown in FIGURE 1) extending through the center of the discharge pipe **4**. The motor **10** drives the pump elements **11** continually. An intake skirt **12** is provided to supply the pump elements **11** with the liquid contained in the bottom of the suction well **5**. As liquid is pumped from the suction well **5** and discharged through the discharge pipe **4**, it passes through check valve **13**, which prevents liquid in delivery conduit **14** from flowing by gravity back into the pumping system if the pumping operation is discontinued. A relief conduit **15** interconnects the upper portion of the suction well **5** and

the upper portion of the discharge pipe **4** so that a vacuum will not be created in the discharge pipe **4** and so that suction will be maintained in the suction well **5** as the liquid flows back down the pipe **4** and through the primer valve **3** during the priming cycle. A check valve **16** is provided in the relief conduit **15** to prevent feedback of liquid to the suction well during the pumping operation. In the manner just described, the pumping system **1** will pump liquid until the admission of air into the system causes a discontinuance of normal suction whereupon the system will reprime itself until normal operation is resumed.

Referring now to FIGURE 2 of the accompanying drawings, there is illustrated a detailed view of the novel valve assembly **3** of the invention mounted on the outside of the pipe section **6** of the discharge pipe **4**. As previously mentioned, a drive shaft **20** extends through a central discharge passage **21** of the discharge pipe **4**, including the valve mounting section **6**. The shaft **20** also extends through pump passage **23** for connection to the impeller blades (not shown) of the pump elements **11**.

The valve assembly **3** has a housing **30**, which may be fabricated in tubular or any other convenient configuration. The housing **30** is open at one end, as indicated by reference numeral **31**, and it is this end **31** of the housing **30** that is adapted for mating relationship with the outside of pipe section **6**. Suitable mounting flanges **32** and **33** having any number of mounting bolts **34** fasten the housing **30** into position opposite a port **35** in the side wall of the pipe section **6**. It should be noted at this point that whereas only one valve assembly is illustrated, as many valves as are necessary to accomplish repriming at given rates of speed and/or pressure can be utilized. For example, any number of ports **35** could be positioned around the pipe section **6**, each with its associated valve assembly **3**.

The inside of the housing **30** is machined to provide a cylindrical control chamber **40** in which is mounted a piston **41** adapted for reciprocation and having a conventional O-ring **42** for sealing purposes. The piston **41** carries a poppet type valve element, generally represented by reference numeral **43**, having a poppet portion **44** for cooperation with a seat **44*a*** formed on a ring **44*b*** and a stem portion **45**. Seat **44*a*** may be formed on the rim of port **35** but use of ring **44*b*** is preferred. A ring **46** is fixed in a groove **47** around the inner periphery of the housing **30**. Several exit ports **49** are formed around the housing **30** to provide the path of communication to the suction well **5** for the liquid from the discharge passage **22**. Thus, when the poppet **44** is opened and the end **31** of the housing **30** is flooded, as during the priming cycle of the system **1**, the liquid from the passage **22** ean quickly fill the suction well **5** through the housing ports **49**.

Acting on the left-hand side of piston **41** and urging the poppet valve **43** to its open position is a spring **50** which reacts against the ring **46**. Stop shoulders **51** are provided along the end of the housing **30** to limit the movement of the piston **41** as the poppet valve **43** is opened by the combined spring and fluid pressure force on the left-hand side of the poppet **44**. The force acting on the right-hand side of piston **41** to effect closing of the valve **43** is gained through controlled pressurization of the chamber **40**, now to be explained.

A control duct **55** adapted for pressurization, extends through the end of the housing **30** and communicates at one of its ends with the control chamber **40**, as indicated in FIGURE 2. The other end of the control duct **55** extends through the wall of the pipe section **6** and terminates in a funnel-shaped sensor element **56**. The funnel-shaped sensor **56** has an opening **58** which receives the flow of liquid from the pump passage **23**, since as will be remembered the pump elements **11** discharge liquid upwardly as indicated by the arrow **59**. By directing the opening **58** of the sensor **56** so that the total pressure (static pressure plus dynamic pressure) of the discharge

stream is available in control duct 55, I am able to provide a substantial fluid force against the right hand end of cylinder 41 for effecting rapid actuation of the poppet valve 43 to the closed position of FIGURE 2. Thus, when the pumping system 1 is operating normally and liquid is flowing upwardly from the pump passage 23, the total pressure (P_T), including both the static pressure factor (P_s) and the dynamic pressure factor ($\frac{1}{2}pV^2$, where p=density and V=velocity) of the stream, acts against the piston 41 via the duct 55 to hold the valve 43 in the closed position. Conversely, if liquid flow from the pump passage 23 is replaced by a slug of air, there is an immediate reducton in the pressure acting on said opening 58 hence there is not sufficient pressure on liquid in the control duct 55 under sufficient pressure to retain the valve 43 in its closed position. This reduction in total pressure at the sensor 56 is due to the rapid loss of dynamic pressure in the pump passage 23 since as the pump 11 fails to maintain suction and the velocity of the fluid past the sensor 56 goes to zero, the dynamic pressure factor ($\frac{1}{2}pV^2$) also goes to zero.

Before starting the pumping system 1, the suction well 5 is filled with a sufficient amount of liquid to submerge the intake skirt 12. In accordance with this invention, it is not necessary to fill the suction manifold or piping 2 or to vent any part of the suction system. The liquid initially disposed in the suction well 5 is delivered to the discharge pipe 4 when the pump is started. As the liquid passes the dynamic pressure sensor 56 the poppet valve 43 closes the port 35, thus allowing the liquid to pass through the discharge passage 22 in the pipe 4 and out the main check valve 13. The pumping of the liquid initially placed in the suction well 5 creates a vacuum in the upper portion of the well 5 causing new liquid to flow into the system through the suction pipe 2. As the pumping operation continues, the poppet valve 43 is held closed by the liquid being pumped, and liquid continues to be pumped through the system 1 at full capacity as long as air is not introduced into the suction pipe 2.

In the event that a slug of air is introduced into the suction pipe 2, as for example, when the liquid level in the container being emptied falls below a predetermined low level, the suction by the pump elements 11 is interrupted as previously discussed, and the flow or liquid thereto is stopped. When this occurs, the automatic self-priming feature of the system 1 is placed in motion. That is, when the flow of liquid through the pump passage 23 to the discharge passage 22 is sufficiently reduced, the dynamic pressure factor in the control duct 55 and control chamber 40 goes to zero and the poppet valve 43 pops open due to the static pressure acting on the left hand side of the poppet 44 and the force of the spring 50. Thus, with the port 35 open, the column of liquid in discharge passage 22 is directed out into the end 31 of the housing 30 and thence through the exit ports 49 to prime the suction well 5 because the pump elements 11 are continually driven. This column of liquid from discharge passage 22 flowing backward through the primer valve 3 is replaced by an equal amount of air from the suction well 5 through the relief conduit 15, as previously explained, and the priming cycle is repeated until the normal flow through the pumping system is re-established.

Results and advantages of the above mentioned arrangement of the primer valve and associated sensor and actuator will now be apparent. In the arrangement described, the entire valve assembly 3 except for a remote sensor element 56 is located outside of the discharge passage so that there is no obstruction to fluid flow in the discharge passage 22. Further, the provision of a remote sensor allows me to vary the conditions under which actuation of the valve element 43 takes place. For example, the sensor 56 could be placed between a selected two of the pump elements 11 instead of downstream of the final pump element 11 in the discharge passage 22, as described, whereupon an earlier opening of the poppet valve 43 would be effected upon loss of suction since the velocity factor in the upstream pump elements 11 would tend to go to zero first. Thus, in effect, by choosing the point at which I sense the condition of the liquid column being pumped, a selective type of actuation of the poppet valve of the invention is effected and the priming cycle is advantageously capable of being controlled, as desired.

Also the poppet valve type of construction of the present invention is simple in construction and does not require machining to close tolerances as in previous sliding type valves. More particularly, the use of a piston 41 with the O-ring sealing arrangment allows increased clearance between the moving parts of the valve assembly 3. The presence of such increased clearance is of substantial importance in the present design in view of the fact that water and other liquids which come incontact with the parts tend to deposit chemicals or other foreign matter which would impair the operation if it were not for the fact that sufficient clearance can be allowed between the parts to allow for such deposits without interfering with the sensitivity and rapid operation of the poppet type device.

In FIGURES 3, 4, 5 and 6 there are illustrated other embodiments of the apparatus of the present invention wherein like reference numerals have been employed to refer to corresponding parts of the invention as portrayed in FIGURE 2. In the embodiment of FIGURE 3, the dynamic pressure factor is detected by increasing the velocity of the flowing liquid with a venturi tube device thus lowering the static pressure at a static pressure tap in the throat of the device to create a sucking action that operates the primer valve 3.

More particularly, the funnel-shaped sensor 56 has additional structure that forms a throat section 60 and divergent section 61, which added combination converts the sensor 56 into a venturi tube or nozzle, generally designated by the reference numeral 62 for ease of description. The sensing end of the control conduit 55 communicates with the throat section 60 of the venturi tube 62 so that the static pressure in said throat 60 is present in the conduit 55 and the control chamber 40. As will be apparent to those skilled in this art, this type of sensing device is capable of detecting the dynamic pressure in the upwardly flowing stream represented by the arrow 59 since the suction or the reduced static pressure in the conduit 55 is proportional to the velocity and thus the dynamic pressure factor ($\frac{1}{2}pV^2$) of the fluid flowing through the venturi tube 62.

To explain the operation of this type of sensing device and associated valve actuator further, assume that liquid is flowing from the pump passage 23 to the discharge passage 22 in the normal fashion. In this case, the velocity of the liquid in the throat 60 of the tube 62 is greater than the ambient velocity because of the acceleration of the liquid caused by the converging walls of sensor 56 and therefore the pressure in the conduit 55 is lower than the ambient pressure. Thus, a sucking action is created to evacuate the chamber 40 and pull the valve element 43 to the closed position illustrated in the figure. When the velocity of the liquid flowing in the system 1 reaches a predetermined low value, as for example, when air is introduced into the system 1, then the spring 50 represents an unbalanced force causing the poppet 44 to move left, as viewed in FIGURE 3, and the column of liquid in the discharge passage 22 escapes through the ports 35 and 49 to the suction well 5, as before.

The mounting flanges 32, 33 of the embodiment illustrated in FIGURE 3 incorporate a step portion 65, 66 to insure that the poppet 44 is free of the discharge passage and the liquid flowing therein at all times. In this way, it is insured that the valve assembly 3 does not in any substantial sense interfere with the free flow of discharge liquid, as in the embodiment of FIGURE 2.

In the embodiments of FIGURES 4, 5 and 6 a flanged venturi element 80 is mounted in the pump discharge as

shown. The element 80 includes a venturi section 82 supported by webs 84 from an outer ring or flange 86. The design is such that there is a divided flow pattern, part of which passes through the venturi throat 88 and the remainder flowing outside the venturi section 82 through passages 90. By varying the area of the two paths relative to each other, varying velocities can be achieved in the venturi and likewise predetermined pressure losses in the system.

A pitot tube 94 in the throat 88 of the venturi senses pressure drop and/or creates suction in valve chamber 40 thereby operating the suction type priming valve unit as illustrated in FIGURES 4 and 6.

By turning the pitot tube 94 down or toward the oncoming stream, as illustrated in FIGURE 5, the tube will sense velocity through the venturi as a pressure increase and will operate the pressure type primer valve unit illustrated.

Having described pressure and vacuum actuated embodiments of a primer valve for a liquid pumping system, it is believed obvious that modifications and variations of my invention are possible in light of the above. It is therefore to be understood that changes may be made in the particular embodiments of my invention described which do not depart from the intended scope of the invention as defined by the following claims.

I claim:

1. A pumping system comprising a pump, a discharge conduit defining a flow path for liquid from said pump, and at least one primer valve operatively connected to said discharge conduit, each primer valve comprising a valve housing positioned on the outside of said discharge conduit, a poppet element within said housing and movable between positions opening and closing a port provided in the side of said discharge conduit, said housing being provided with at least one vent port positioned to enable liquid flowing through said vent port to return to the suction side of said pump, means including a piston connected to said poppet element to define a closed chamber within said housing, sensor means positioned within said discharge conduit to detect the flow condition thereof, said sensor means at all times being in free communication with said port through said discharge conduit, a control duct connecting said sensor means to said closed chamber to establish a pressure within said closed chamber which is effective to maintain said poppet element in the closed position during normal pumping operation, and bias means to bias said poppet element towards its open position whereby upon termination of fluid flow through said discharge conduit the pressure at the port and the pressure within said chamber are substantially equal so that said poppet element is moved to its open position by said bias means enabling liquid flow from said discharge conduit through said port into said housing and out of said vent port.

2. Apparatus according to claim 1, wherein said sensor means includes a flared funnel shaped element having a large end and small end, the larger end being positioned upstream in the flow path through said discharge conduit.

3. A pumping system comprising a pump, a discharge conduit defining a flow path for liquid from said pump, and at least one primer valve operatively connected to said discharge conduit, each primer valve comprising a valve housing positioned on the outside of said discharge conduit, a poppet element within said housing and movable between positions opening and closing a port provided in the side of said discharge conduit, said housing being provided with at least one vent port positioned to enable liquid flowing through said vent port to return to the suction side of said pump, means including a piston connected to said poppet element to define a closed chamber within said housing, sensor means positioned within said discharge conduit to detect the flow condition thereof, a control duct connecting said sensor means to said closed chamber to establish a pressure within said closed chamber which is effective to maintain said poppet element in the closed position during normal pumping operation, and bias means to bias said poppet element towards its open position whereby upon termination of fluid flow through said discharge conduit said poppet element is moved to its open position enabling liquid flow from said discharge conduit through said port into said housing and out of said vent port, and, wherein said sensor means includes a venturi element mounted within said discharge conduit, and spaced from the wall of said discharge conduit, and said control duct is connected to said venturi element so that the pressure in said closed chamber is less than the fluid pressure in said discharge conduit during normal operation, said bias means comprising a spring acting on one side of said piston, the bias of said spring being normally overcome by the reduced pressure in said closed chamber to maintain said poppet element in its closed position during normal operation.

4. Apparatus according to claim 3, further comprising a plurality of primer valves positioned on the outside of said discharge conduit, and said pump having a drive shaft having a portion thereof extending axially through said venturi element.

5. The combination of claim 2, wherein said funnel shaped element comprises a venturi tube having a throat section at its smaller end, said control duct being connected to said throat section.

6. The combination of claim 3 wherein the sensor means includes a pitot tube mounted in the venturi element and connected to said control duct.

7. The combination of claim 6 wherein the pitot tube faces upstream.

8. The combination of claim 6 wherein the pitot tube faces downstream.

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STANLEY N. GILREATH, *Primary Examiner.*