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A. W. MEYER ET AL
SELF-PRIMING PUMPING SYSTEM

2,902,940

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3 Sheets-Sheet 1

FIG. 1.

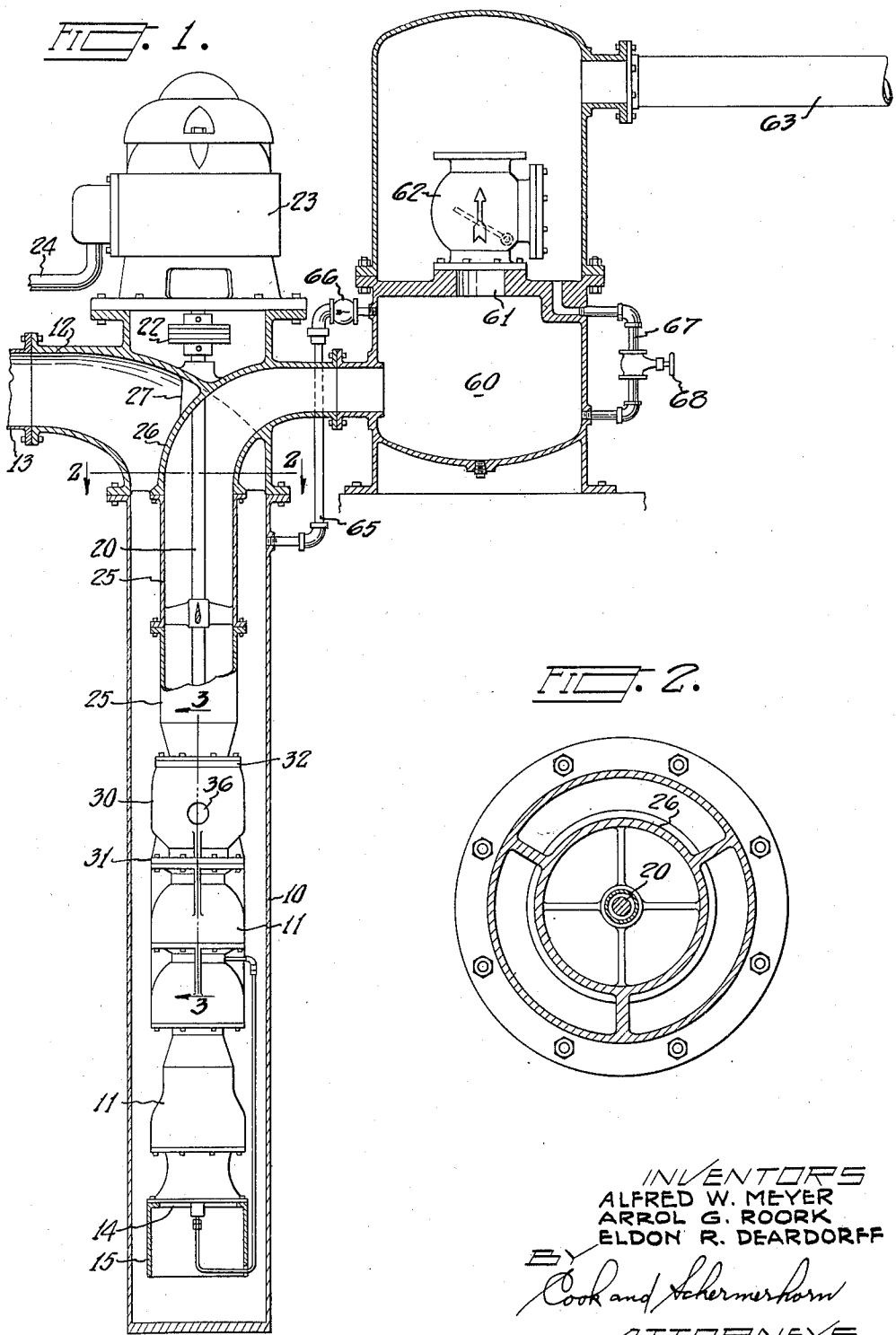
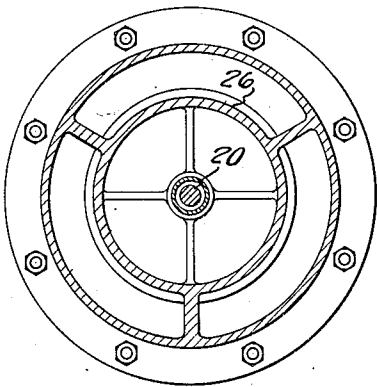


FIG. 2.



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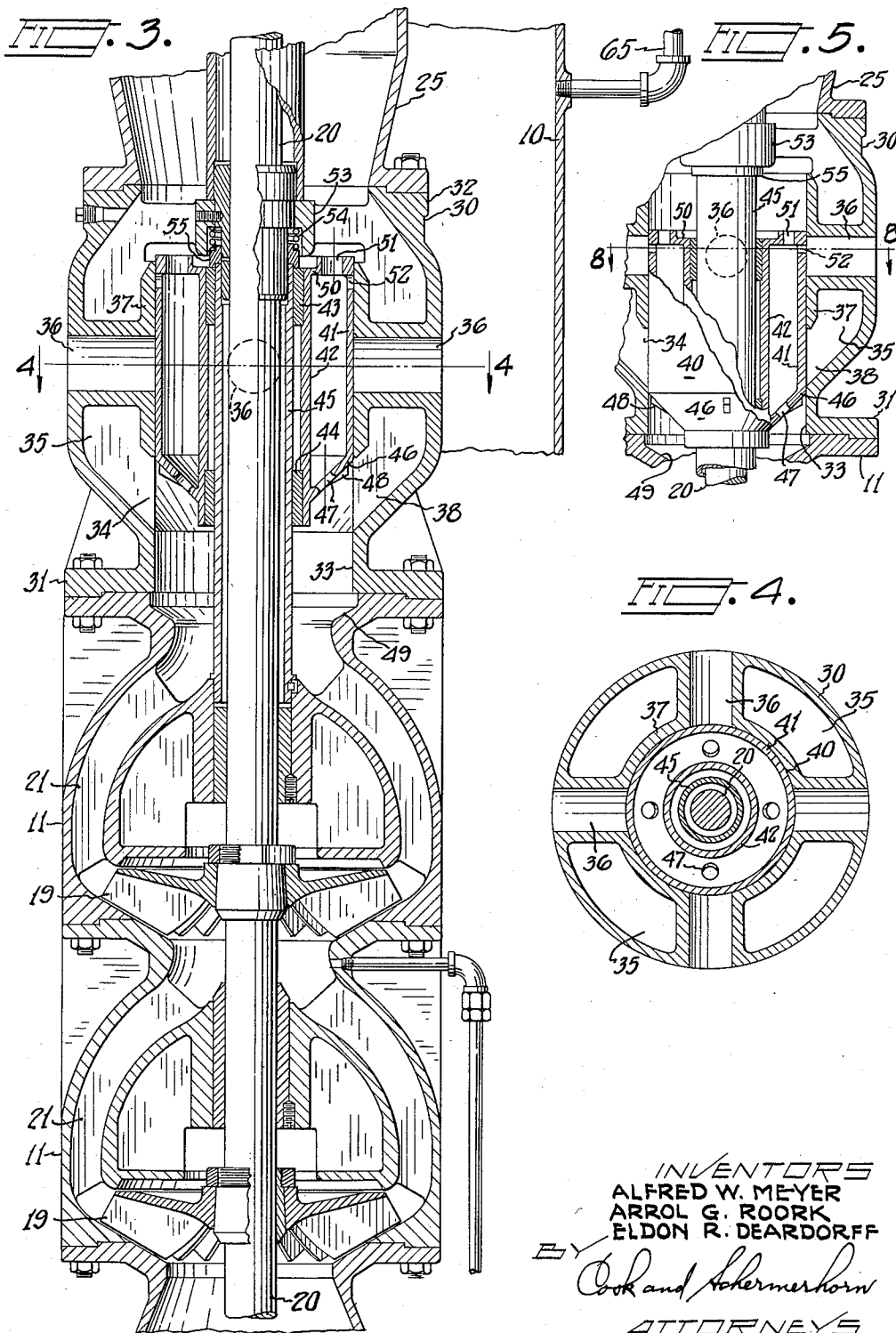
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FIG. 6.

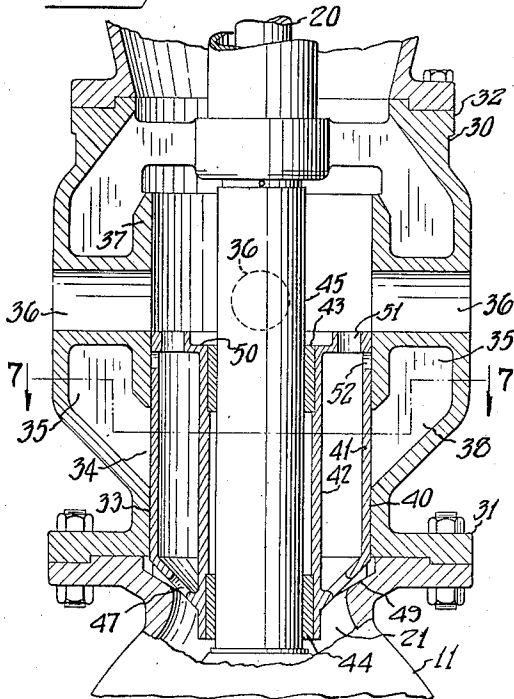


FIG. 7.

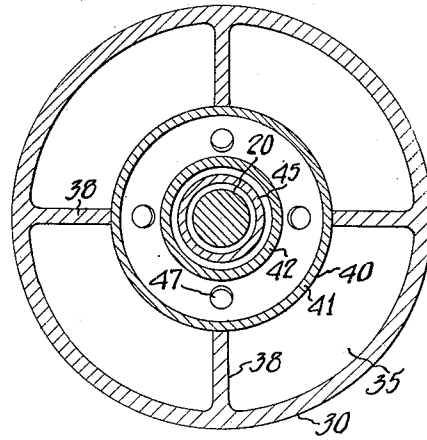


FIG. 8.

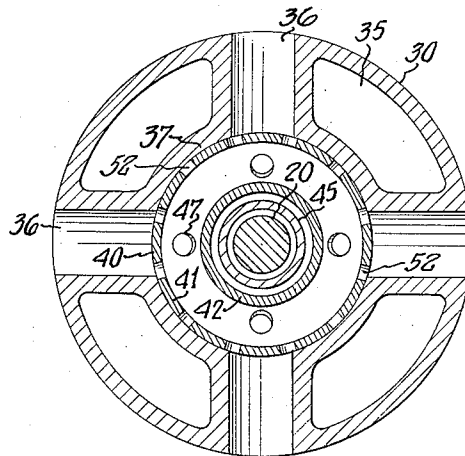
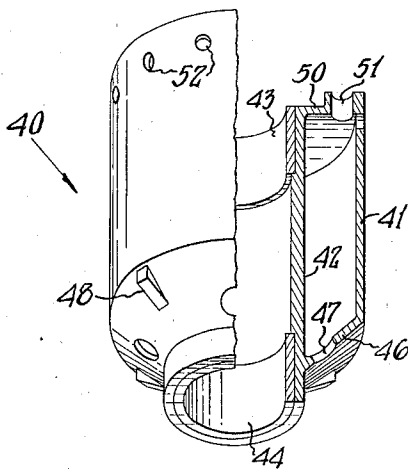


FIG. 9.



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SELF-PRIMING PUMPING SYSTEM

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Application May 12, 1953, Serial No. 354,484

9 Claims. (Cl. 103—113)

This invention relates to self-priming liquid pumping systems, in general, and has particular reference to suction pumps used for lifting a liquid out of a barge, vessel or tank by means of a suction conduit which may admit air into the pump at times, causing a conventional pump to run dry and lose its ability to maintain suction.

In emptying an oil tank barge, for example, the oil is lifted by a suction conduit through a hatch opening in the deck of the barge to a pump on a dock alongside. As the individual compartments are pumped out, air may be introduced into the suction conduit from time to time before the entire barge has been emptied. When a quantity of air enters a conventional centrifugal type suction pump, the pump element becomes incapable of maintaining sufficient suction to lift the liquid up to the pump element and start the flow from a different compartment. This necessitates priming the pump, requiring the attention of an operator and delaying the pumping operation.

The general object of the present invention is to provide means for automatically priming a suction pump after air has been introduced, to re-establish suction and permit resumption of the pumping operation without requiring the attention of the operator.

More particular objects are to provide accumulating means for retaining a supply of priming liquid after the pump element runs dry and a novel valve operable in response to cessation of discharge flow from the pump to return the accumulated liquid to the pump element and re-establish normal suction. Another object is to provide fittings and associated equipment to make a conventional centrifugal type of suction pump self-priming with a relatively small change in the pump structure, whereby conventional pumps may readily be converted into self-priming pumps.

The invention comprises a novel discharge flow responsive valve and accumulating means for holding in reserve a sufficient quantity of liquid to prime the pump element after it has run dry. Upon cessation of a substantial discharge flow the valve acts automatically to return the stored liquid to the suction side of the pump. When the liquid enters the pump element normal suction is re-established and if the suction conduit is closed to the entrance of air and submerged in the liquid to be pumped normal pump operation will be resumed. As long as the suction conduit continues to admit air the priming cycle is repeated indefinitely by continued recirculation of the priming liquid.

Additional objects and advantages will become apparent and the invention will be better understood with reference to the accompanying drawings illustrating a preferred embodiment of the invention. Various changes may be made in the construction and arrangement of parts and certain features may be used without others without departing from the spirit and scope of the appended claims.

In the drawings:

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Figure 1 illustrates a sectional view of a pumping system embodying the principles of the invention;

Figure 2 is a cross sectional view taken on the line 2—2 of Figure 1;

Figure 3 is an enlarged longitudinal sectional view taken on the line 3—3 of Figure 1, showing the structure of the pump and valve mechanism, the valve member being in its upper position;

Figure 4 is a cross sectional view taken on the line 4—4 of Figure 3;

Figure 5 is a view of a portion of the structure shown in Figure 3 with the valve in intermediate position;

Figure 6 is a view similar to Figure 5, showing the valve in its lower position;

Figure 7 is a cross sectional view taken on the line 7—7 of Figure 6;

Figure 8 is a cross sectional view taken on the line 8—8 of Figure 5; and

Figure 9 is a perspective view, with parts broken away, showing the valve member illustrated in the preceding figures.

Referring first to Figures 1 and 3, an outer casing 10 forms a suction well for the pump unit 11. Casing 10 is entirely closed except at its point of connection 12 with a suction hose or pipe 13. Liquid entering the suction well by way of the hose 13 is drawn into the pump inlet 14 which is surrounded by a depending skirt 15 extending into proximity with the bottom of the well, whereby the pump will not run dry until substantially all of the liquid in the well has been withdrawn.

In the present illustration, the pump unit 11 comprises a plurality of centrifugal impeller stages 19 mounted on a common vertical shaft 20. The liquid is pumped upwardly from one stage to the next through passages 21 surrounding the shaft 20. The upper end of shaft 20 is connected through a coupling 22 with an electric motor 23 having suitable power connections at 24. The pump unit 11 discharges its liquid upwardly through a vertical discharge conduit 25 equipped with an elbow 26 projecting outside of the casing 10 for the purpose of making external connection. The numeral 27 designates an upper bearing and packing gland for the shaft 20 to maintain a seal at the point where the shaft passes through the elbow portion of the discharge conduit and through the top wall of the casing 10.

The parts thus far described, except skirt 15, may be considered as conventional in order to illustrate the application of the invention, it being understood that other forms of pump structure may be employed. When the present type of pump is used for pumping out oil barges and the like, the unit comprising casing 10, pump 11, and motor 23, are ordinarily mounted on the dock alongside which the barge is moored, and suction hose or pipe 13 is connected with a manifold piping system communicating with the various compartments of the barge, usually requiring the liquid in the barge to be lifted at least as high as the dock by pump suction. It will be appreciated by persons skilled in the art that if a considerable quantity of air is introduced into the suction hose 13 the liquid will be rapidly exhausted from the bottom of the suction well and discharged above the pump element, causing the pump to run "dry" and develop insufficient suction to restart the flow when the admission of air is shut off and suction inlet or inlets are again submerged in the liquid to be pumped. In a conventional pump, this situation ordinarily calls for some priming procedure to introduce sufficient liquid into the suction well 10 to re-establish the necessary suction and restart the flow. Automatic means will now be described for performing this function as soon as the pump exhausts the last of the liquid remaining in the suction well and

ceases to discharge a steady flow of liquid through the discharge conduit 25.

In the present construction, a valve housing 30, generally resembling one of the pump stages, is interposed between the uppermost pump stage and the discharge conduit 25, as shown in Figures 1 and 3. The housing 30 has a bottom flange 31 for connection with the last stage of the pump unit 11 and a top flange 32 for connection with the discharge conduit 25. Immediately above the bottom flange 31 is a cylindrical valve bore 33 terminating at a port 34 which opens into a vertical passageway 35 similar to the passages 21 in the pump. The upper end of passageway 35 communicates with discharge conduit 25. Passageways 35 and 21 and the lower end of bore 33 are thus a part of the discharge conduit from the impeller stages 19. Extending across the vertical, or longitudinal, passageway 35 are four transverse passageways 36 which open through a cylindrical wall 37 aligned with the bore 33. A hollow cylindrical valve member 40 is mounted for vertical movement within the bore surfaces 33, 37. Vertical fins 38 guide valve member 40 across port 34.

Valve member 40 has an outer cylindrical wall 41 engaging the bore walls 33 and 37 and fins 38 in a loose sliding fit, and an inner cylindrical wall 42 equipped with upper and lower bearing elements 43 and 44 to slide on a stationary guide tube 45 concentric with shaft 20. The lower end of guide tube 45 is secured in the body of the uppermost pump stage. Guide tube 45 may be omitted, if desired, and the valve member 40 is then designed to slide on the rotating pump shaft 20. The lower end of valve member 40 has a wall 46 equipped with a number of openings 47 and impact feet 48 which rest on a shoulder 49 in the uppermost pump stage when the valve member is in its lower position shown in Figure 6. In this position of the valve member the openings 47 communicate with the discharge passageway 21 of the uppermost pump stage, and the top wall 50 of the valve member is disposed on a level with the bottom sides of the transverse passageways 36. The top wall 50 is equipped with openings 51, and immediately beneath the top wall the outer side wall 41 is apertured at 52. In the illustrated embodiment the openings 47 and 51 provide communication at all times between conduit 25 and the pump.

Upward movement of the valve member 40 is limited by a stop collar 53 secured to a stationary part of the structure. An annular recess in this collar houses a bumper spring 54 for an annular bumper 55.

When the valve member 40 is in its lower position shown in Figure 6, the outer wall 41 closes port 34, permitting only restricted communication through the valve member by way of openings 47 and 51. When the valve member is in its upper position shown in Figure 3, the port 34 is opened and the transverse passageways 36 are closed by the cylindrical outer wall 41. At certain stages in the operation, as will be hereinafter described, the valve member 40 may assume an intermediate position as shown in Figure 5, with the apertures 52 in communication with transverse passageways 36, while the port 34 remains closed by the outer wall 41.

The elbow portion 26 of discharge conduit 25 connects with an accumulating chamber or reservoir 60. The normal discharge flow of the pump passes through this chamber and leaves by way of a port 61 equipped with a check valve 62 to prevent back flow from the discharge pipe 63. An air evacuating pipe 65 having a check valve 66 interconnects the upper end of the suction well housing 10 with the upper part of chamber 60.

A makeup pipe 67 equipped with a manual valve 68 by-passes the port 61 and check valve 62. Valve 68 is ordinarily closed and is not operated in the normal functioning of the system, but it may be opened to supply liquid to the suction well 10 at any time when the well may have insufficient liquid to prime the pump.

Operation

When the pump is shut down after a period of operation, the check valve 62 prevents back flow from the pipe 63, but the liquid in accumulating chamber 60 flows back through discharge conduit 25. Valve member 40 drops to its lower position shown in Figure 6, and the contents of accumulating chamber 60 and discharge conduit 25 flow out through transverse passageways 36 to fill the suction well 10. As the liquid flows out of chamber 60 the chamber fills with air through pipe 65. The normal condition of the system upon starting the pump, then, is that the suction well 10 is filled with liquid and the accumulating chamber 60 is filled with air.

When the pump is started the upward discharge flow from passages 21 lifts the valve member 40 to its upper position shown in Figure 3, opening the port 34 and allowing the discharge flow to pass through passageway 35, discharge conduit 25, and into accumulating chamber 60. As soon as the pump pressure developed in accumulating chamber 60 exceeds the static head in the pipe 63, check valve 62 opens and discharge flow is started through pipe 63. This discharge flow establishes sub-atmospheric pressure, or so-called suction condition, in the suction well 10 which is communicated to the suction hose 13. If the suction inlet or inlets are submerged in the liquid to be pumped, normal flow will be initiated, after sufficient cycles have occurred to exhaust the air from the suction system. Normal flow will be maintained until such time as a considerable quantity of air may be admitted into the suction hose as occurs in pumping a tank or barge hold dry.

When a large quantity of air is admitted into the suction hose 13, the pump, of course, immediately exhausts the liquid supply from suction well 10, and as the pump element starts to run dry the discharge pressure in accumulating chamber 60 falls below the back pressure in pipe 63, causing check valve 62 to close. Valve member 40 is responsive to the normal discharge flow from the pump element, and when the discharge flow diminishes to the point where there is insufficient liquid pressure exerted to hold the valve member in its raised position, the valve member starts to drop.

When valve member 40 descends to approximately the level shown in Figure 5, the liquid pressure against the bottom of the valve member maintained by the column of liquid supported by the impellers 19 is vented through openings 47 and 52 into transverse passage 36 to the suction well 10. This allows valve member 40 to drop rapidly to its lowermost position shown in Figure 6, thereby permitting free flow from conduit 25 through passage 36 into suction well 10. As the liquid leaves accumulating chamber 60 it is replaced by air from the upper part of the suction well 10, flowing through pipe 65 and check valve 66.

With the suction well thus refilled, the pump resumes normal pumping operation, producing a full discharge flow acting as a liquid piston which immediately lifts the valve member 40 again to its upper position shown in Figure 3, the main discharge flow passing around the valve member through passageway 35, discharge conduit 25, and into accumulating chamber 60, forcing some or all of the air in chamber 60 out through check valve 62. In the illustrated embodiment a portion of the upward flow passes through ports 47 and 51. This re-establishes sub-atmospheric pressure or suction conditions in suction well 10 and suction hose 13, whereby, if the open end or ends of the suction hose or manifold again become submerged in some remaining liquid to be pumped, normal suction flow will be resumed. Normally, it will require several cycles completely to re-establish suction.

If the suction hose 13 is not closed to atmosphere and submerged in liquid by the time the contents of suction well 10 have been discharged above the valve member

40, the above described cycle will repeat until the suction hose is submerged and suction re-established or the pump shut off. In each cycle a quantity of air is withdrawn from the suction well 10 and transferred to chamber 60 through pipe 65 to maintain a suction pressure in the suction well. In this way the pump will repeatedly prime itself without manipulation or attention by the operator, and the tank or space in which the suction hose is inserted may be drained to the point where there is insufficient liquid remaining to submerge the end of the suction hose. Also, the pumping operation may be transferred from one tank or hold space to another without shutting off the pump.

Skirt 15 serves to increase the volume of liquid available to form a liquid piston for forcing air in the top of chamber 60 out through check valve 62 when the liquid piston is moving upward. When the liquid piston is moving downward its volume determines the amount of replacement air drawn by suction through pipe 65 into chamber 60. Thus, when hose 13 is not filled with liquid, the liquid piston forms a reciprocating air pump to evacuate the air from suction well 10 and hose 13.

Bottom holes 47 in valve member 40 facilitate upward liquid displacement through the hollow member at the stage in the cycle when it is desired to drop quickly for rapid re-cycling.

Having now described our invention and in what manner the same may be used, what we claim as new and desire to protect by Letters Patent is:

1. An automatic primer valve for a liquid pump having a vertical shaft extending through an upwardly directed pump outlet comprising a valve housing adapted to be mounted on the pump outlet concentric with said shaft, a vertical discharge passageway through said housing, a transverse passageway opening through said housing, and a vertically slidable valve member in said housing movable to a lower position in response to gravity to close said discharge passageway at a point below said transverse passageway and open said transverse passageway, and movable to an upper position in response to discharge flow from the pump to close said transverse passageway and open said discharge passageway.

2. An automatic primer valve for a liquid pump comprising a valve housing, a cylindrical wall defining a bore within said housing, a hollow cylindrical valve member having a sliding fit in said bore, a passageway extending longitudinally around a portion of the length of said bore, a transverse passageway intersecting said bore, openings in one end of said valve member, and lateral openings in said valve member arranged to register with said transverse passageway in one position of said valve member to establish communication between said transverse passageway and said longitudinal passageway through said end openings in the valve member.

3. A self-priming pumping system comprising a closed suction well arranged to hold a quantity of priming liquid, an inlet suction connection in said well, a pump in said well, an accumulating chamber above said well, a discharge pipe communicating with the top of said chamber, means to prevent back flow from said pipe to said chamber, a discharge conduit from said pump to said chamber, a port in said conduit communicating with said well, a valve in said conduit actuated by pump discharge pressure to close said port and pass discharge from the pump through said conduit to said chamber and responsive to cessation of said discharge to pass a return flow from said chamber through said port to said well, an air supply pipe for said chamber connected with said well, and means to prevent back flow through said air supply pipe from said chamber to said well.

4. In a self-priming pumping system, a pump housing having a top discharge outlet, a valve housing connected to said pump outlet, a vertical discharge pipe connected to said valve housing, a vertical pump impeller shaft

extending longitudinally through said pipe and said valve housing to said pump, a longitudinal vertical bore in said valve housing communicating with said pump outlet and said pipe, a first port in said bore open to the outside of said valve housing, a longitudinal discharge passage in said valve housing having an upper end communicating with said pipe and a lower end communicating with a second port in said bore between said first port and said pump outlet, a valve member slidable in said bore actuated by pump discharge pressure to close said first port and open said second port and responsive to cessation of said discharge to close said second port and open said first port, and a longitudinal bore in said valve member receiving said shaft.

5. A system as defined in claim 4, said valve member being hollow and having inner and outer vertical cylindrical walls and top and bottom walls, and said bottom wall and outer cylindrical wall having openings therein.

6. A self-priming valve assembly for a liquid pump comprising a valve housing having inlet and outlet openings on opposite ends thereof, a bore in said housing communicating with said openings, a lateral port in said bore open to the outside of said housing, a longitudinal passage in said housing communicating at one end with a second port in said bore between said first port and said inlet opening and communicating at its other end with said outlet opening, and a valve member slidable in said bore, said valve member having a bore to receive a pump shaft extending through said inlet and outlet openings of said housing.

7. A self-priming pumping system comprising a closed suction well arranged to hold a quantity of priming liquid, an inlet suction connection at the top of said well, a pump in said well, an accumulating chamber above said well, a discharge pipe communicating with the top of said chamber, means to prevent back flow from said pipe to said chamber, a discharge conduit from said pump to the bottom of said chamber, a port in said conduit communicating with said well, a valve in said conduit actuated by pump discharge pressure to close said port and pass discharge from the pump through said conduit to said chamber and responsive to cessation of said discharge to pass a return gravity flow from said chamber through said port to said well, an air evacuating pipe connected between the top of said well and the top of said chamber, and means to restrict back flow through said evacuating pipe from said chamber to said well.

8. In a self-priming pumping system having a pump in a suction well and a vertical, upward flow discharge conduit from said pump, a valve housing connected in said series with said conduit, a vertical bore in said housing, an upper port in said bore communicating with said well exteriorly of said valve housing and said conduit, a discharge passage in said housing around said upper port having an upper open end above the upper end of said bore and a lower end communicating with a lower port in said bore, and a hollow cylindrical valve member slidable upward in said bore by pump discharge pressure on the bottom end of the valve member to close said upper port and open said lower port for pump discharge flow through said discharge passage, said valve member being slidable downward in said bore by gravity in response to cessation of said discharge pressure to close said lower port and open said upper port, said valve member having openings in its lower end and in its side adjacent its upper end, said side openings communicating with said upper port as said valve member passes said upper port.

9. A self-priming pumping system comprising a closed suction well arranged to hold a quantity of priming liquid, an inlet suction connection at the top of said well, a pump in said well, an accumulating chamber above said well, a discharge pipe communicating with the top of said chamber, means to prevent back flow from said pipe to said chamber, a discharge conduit from said

pump to the bottom of said chamber, a port in said conduit communicating with said well, and a valve in said conduit actuated in one direction by pump discharge pressure to close said port and pass discharge from the pump through said conduit to said chamber and actuated in the opposite direction by return gravity flow from said chamber upon cessation of said pump discharge pressure when the pump has lost its prime to open said port and pass said return gravity flow through said port to said well to re-prime the pump and create suction pressure in said chamber whereby air is displaced from said well to said chamber so that the discharge of priming liquid from said well into said chamber in the next pumping cycle will force said air from said well out of the top of said chamber into said discharge pipe.

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