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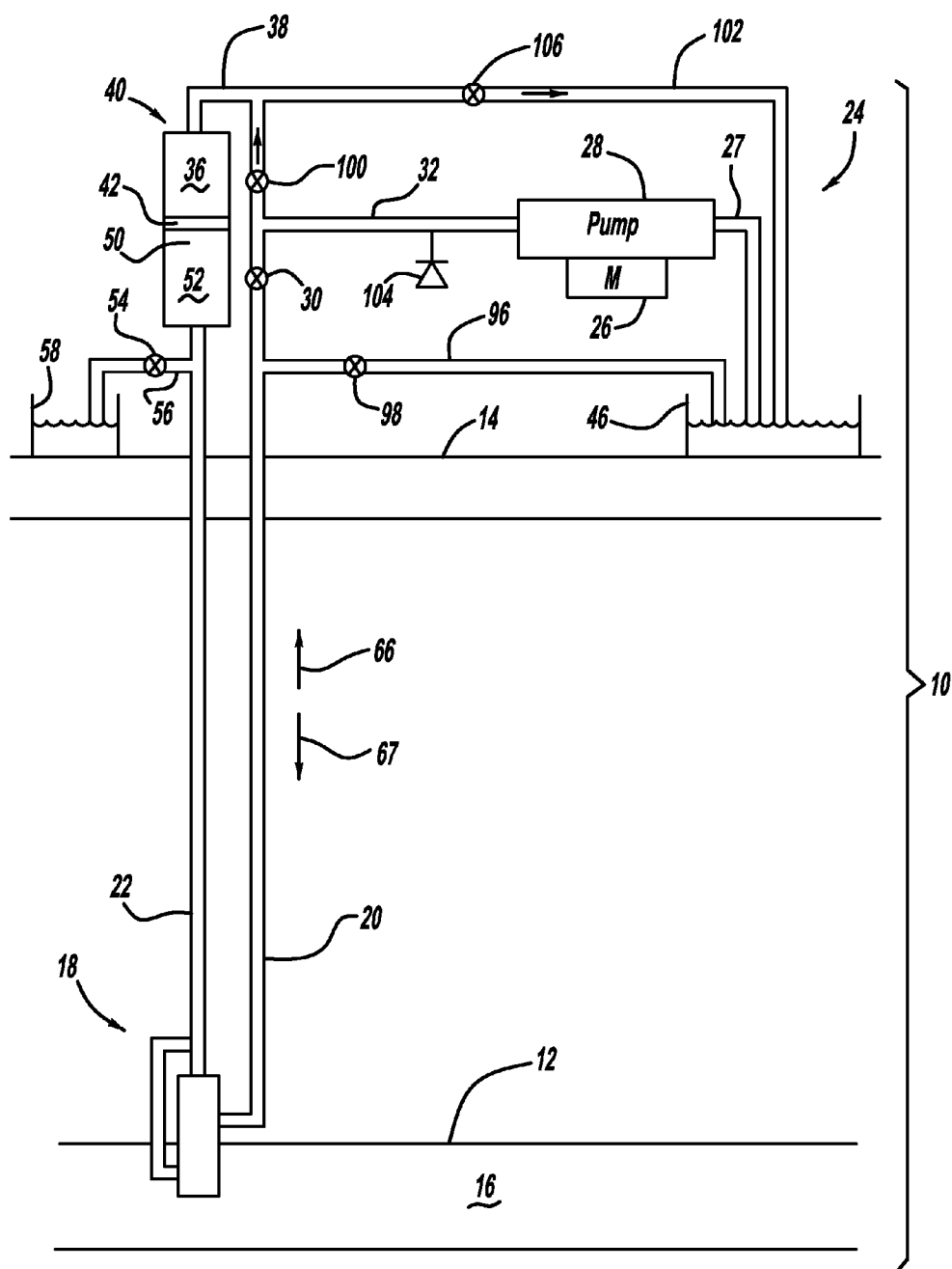


FIG - 1

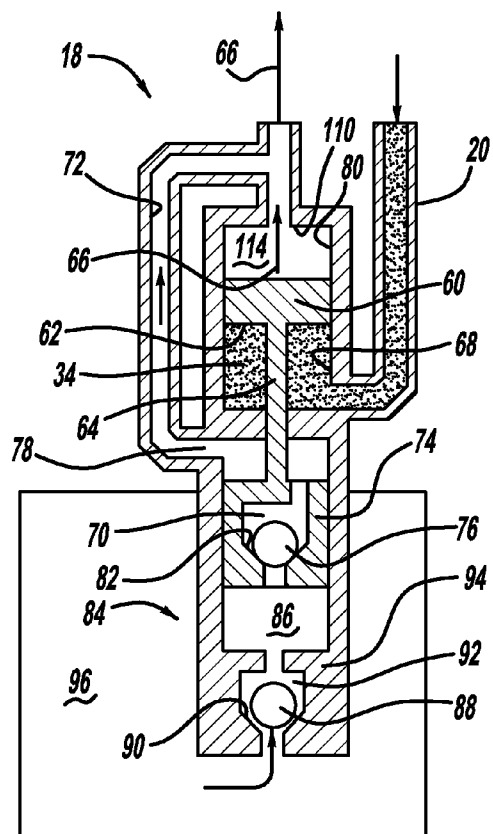
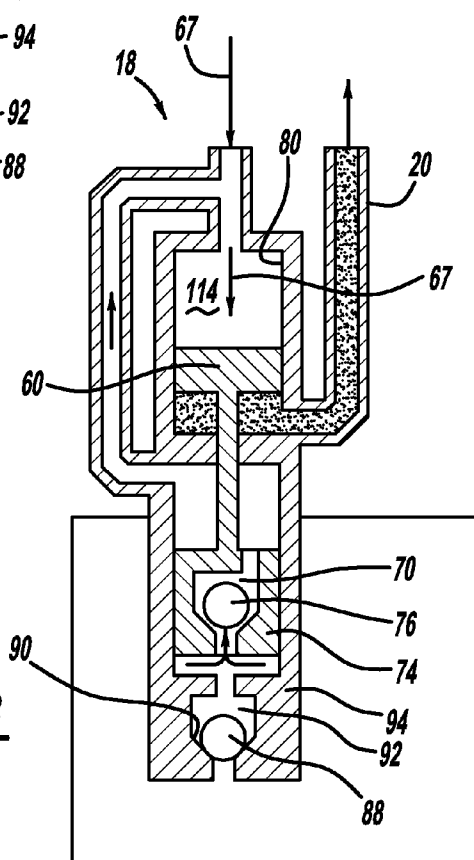
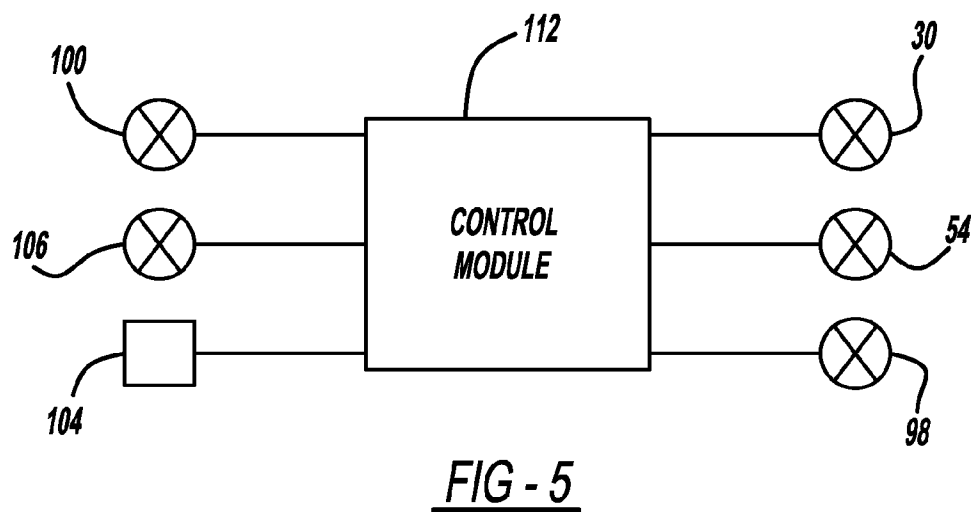
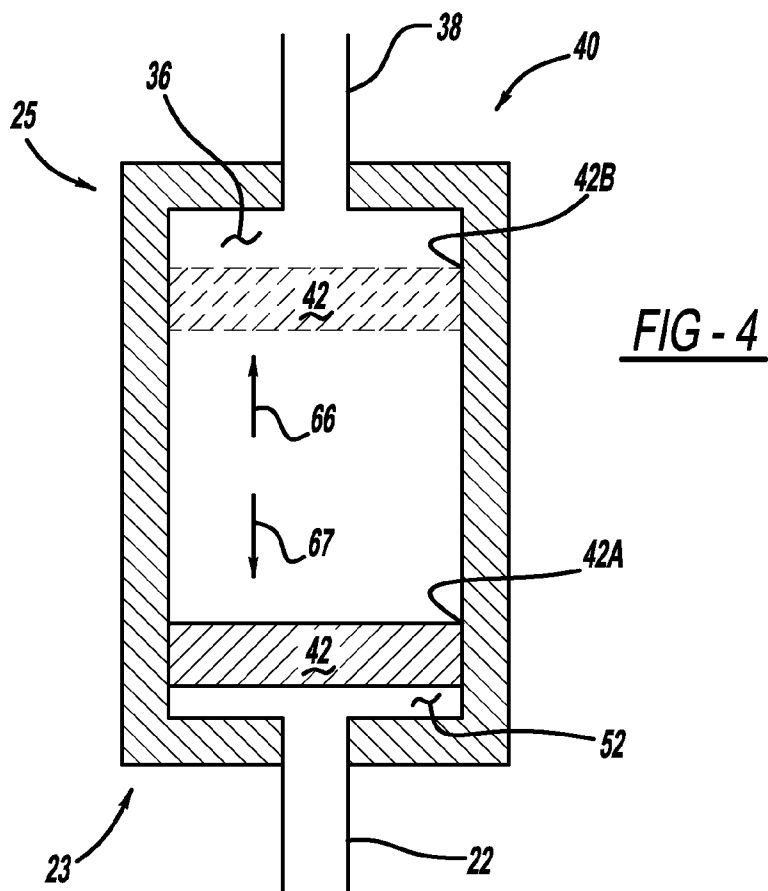


FIG - 2

FIG - 3





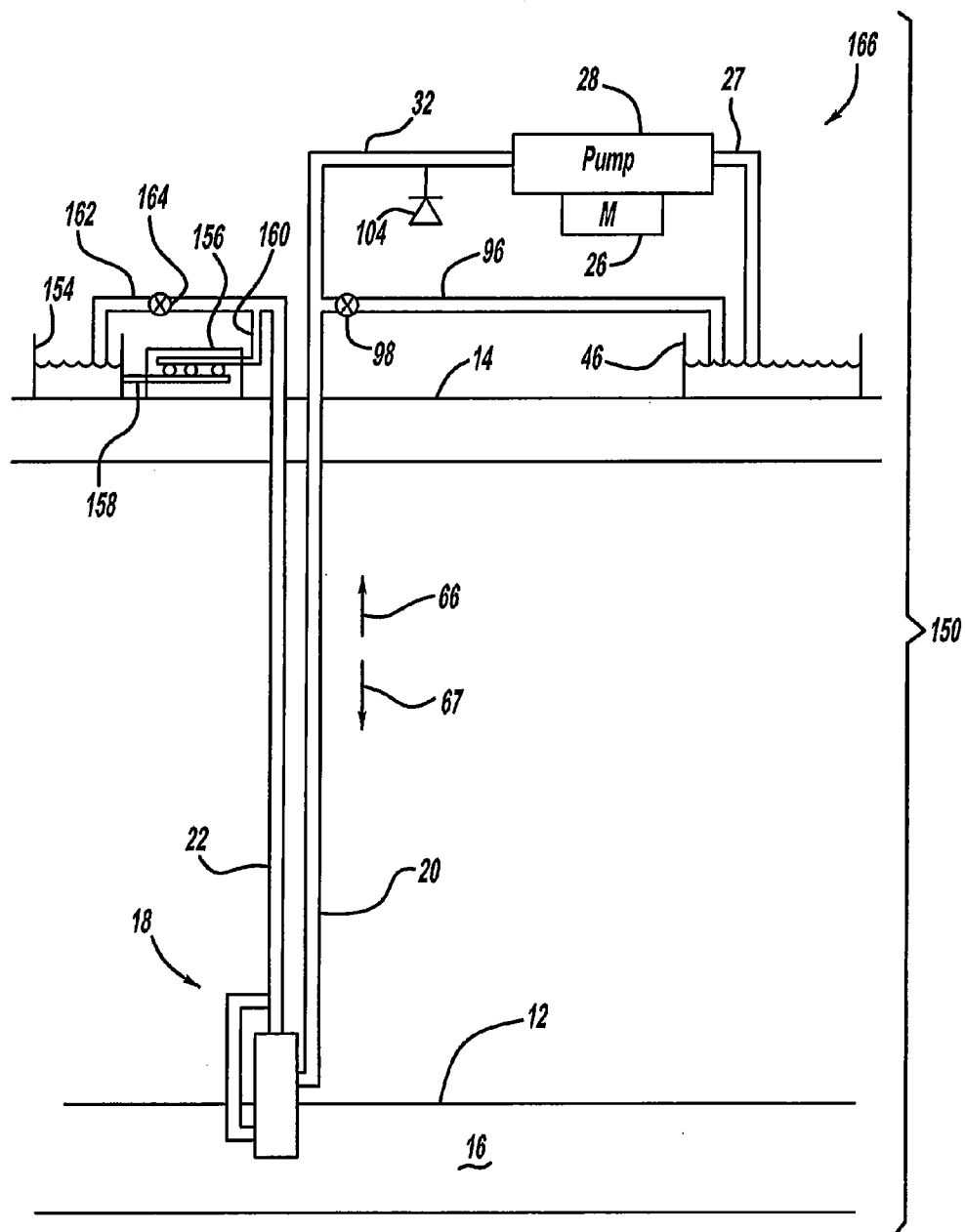


FIG - 6

SINGLE CIRCUIT DOUBLE-ACTING PUMP

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] None.

FIELD OF THE DISCLOSURE

[0002] This disclosure relates to a pump driven by hydraulic fluid for pumping water and related fluids from a downhole location.

BACKGROUND OF THE DISCLOSURE

[0003] Water pumps located downhole and utilized for extracting or pumping water from subterranean wells, such as oil wells, are known. Such water pumps may be powered, at least in part, by a hydraulic pump located on the surface of the Earth. Hydraulic oil lines permit hydraulic fluid to flow to the water pump to drive a piston within the pump.

[0004] In one such combination of a hydraulic pump and a subterranean water pump, the water pump may be double-actuated, which generally means that the piston within the water pump utilizes two hydraulic lines that run from the hydraulic pump on the surface of the Earth to the water pump. A first hydraulic line may be connected to a first side or rod side of a piston of the water pump, and a second hydraulic line may be connected to a second side of the water pump that is a non-rod side of the piston of the water pump. In operation, hydraulic fluid of a predetermined pressure flows to the rod side of the piston to drive the piston in a first direction. Upon the piston reaching a maximum travel position from the pressurized hydraulic fluid in the first hydraulic line acting on the rod side of the piston, the hydraulic pressure in the first hydraulic line is lowered to a predetermined pressure and the hydraulic pressure in the second hydraulic line is increased to some predetermined hydraulic pressure to drive the piston in a second direction, opposite from the first direction. Using two hydraulic lines from the surface hydraulic pump to the subterranean water pump, water is evacuated from the subterranean reservoir in which the water pump resides.

[0005] In another combination of a hydraulic pump and a subterranean water pump, the water pump may be single-actuated, which generally means that the piston within the water pump utilizes one hydraulic line that runs from the hydraulic pump on the surface of the Earth to the water pump. The hydraulic line is connected to only one chamber, which is the chamber adjacent the rod side of the piston of the water pump. In operation, hydraulic fluid of a predetermined pressure flows to the chamber of the rod side of the piston to drive the piston in a first direction. Upon the piston reaching a maximum travel position from the pressurized hydraulic fluid in the first hydraulic line acting on the rod side of the piston, the hydraulic pressure in the hydraulic line is lowered to a predetermined pressure and the pressure created by the column of water contacting the non-rod side of the piston drives the piston in a second direction, opposite from the first direction. The pressure created by the column of water may be created by the force of gravity acting on the column of water or from an accumulator or a back pressure valve at the surface of the Earth. Such pressure from an accumulator or back pressure valve may always be present. Any hydraulic fluid injected to the rod side of the piston must act against this pressure due to the column of water. Thus, using only one hydraulic line from the surface hydraulic pump to feed only

one chamber on the rod side of the piston of the subterranean water pump, water is evacuated from the subterranean reservoir in which the water pump resides.

[0006] While the above-described hydraulically actuated water pumps have proven satisfactory for their given purpose, each is not without its share of limitations. Double-actuated pumps necessarily require two hydraulic lines and a water removal line that all reach from a subterranean water pump location to an Earthen surface. Single actuated pumps necessarily require one hydraulic line and a water removal line that both reach from a subterranean water pump location to an Earthen surface; however, such a single actuated pump operates at a much lower speed, in terms of water pump piston cycles, than a double-actuated water pump. Additional hydraulic pressure is also required during the pumping stroke (also called a power stroke), since pressure on the non-rod side is not reduced. What is needed then is a water pump that benefits from operational speeds greater than a single action water pump while maintaining a minimal quantity of hydraulic lines.

BRIEF SUMMARY OF THE DISCLOSURE

[0007] The invention may more particularly include a method of removing fluid such as water from a subterranean formation to an earthen surface such that the method may include providing a hydraulic oil pump at the earthen surface, providing a downhole water pump, providing a hydraulic accumulator at the earthen surface, supplying only one downhole hydraulic oil line from the hydraulic oil pump to the downhole water pump, supplying only one downhole water line from the downhole water pump to the hydraulic accumulator, and supplying a hydraulic accumulator hydraulic oil line from the hydraulic oil pump to the hydraulic accumulator. Moreover, providing a hydraulic accumulator may further comprise providing a hydraulic accumulator that defines an internal chamber, a first inlet/outlet at a first end of the hydraulic accumulator, a second inlet/outlet at a second end of the hydraulic accumulator and a hydraulic accumulator piston within the internal chamber that divides the internal chamber into two varying-volume chambers such as a hydraulic accumulator water chamber and a hydraulic accumulator hydraulic oil chamber.

[0008] Pumping hydraulic fluid from the hydraulic oil pump via the only one downhole hydraulic oil line to a rod side of a piston within the downhole water pump causes movement of the piston in a first direction, such as a pumping direction. The pumping direction may be that direction of the piston that directly and immediately causes water to move toward the earthen surface or through the only one downhole water line toward the earthen surface. The method may further entail pumping hydraulic oil from the hydraulic oil pump through the hydraulic accumulator hydraulic oil line to the hydraulic accumulator and increasing an internal pressure of the hydraulic accumulator hydraulic oil chamber, which may cause movement of the hydraulic accumulator piston away from the hydraulic accumulator hydraulic oil chamber. Movement of the hydraulic accumulator piston away from the hydraulic accumulator hydraulic oil chamber may cause an increasing of pressure within the only one downhole water line thereby increasing force against a non-rod-side of the water pump piston within the downhole water pump thereby moving the piston in a second direction, opposite from the pumping direction. A water valve may be provided in the downhole water line at the earthen surface and opening the

water valve when the water pump piston reaches a prescribed position with the downhole water pump may be accomplished to evacuate water from the downhole water line.

[0009] Another method of removing water from a subterranean formation to an earthen surface may entail pumping hydraulic oil from a hydraulic oil pump at the earthen surface to a downhole water pump through only one downhole hydraulic oil line from the hydraulic oil pump to the downhole water pump thereby driving or causing movement of a water-pushing piston in the downhole water pump to effectuate pumping water from the downhole water pump to the earthen surface through the only one downhole water line from the downhole water pump to the earthen surface. The method may include providing a hydraulic accumulator at the earthen surface and a hydraulic accumulator hydraulic oil line from the hydraulic oil pump to the hydraulic accumulator. Dividing the hydraulic accumulator into a hydraulic oil chamber and a water chamber separated by a movable piston, permits providing and connecting only one downhole water line from the downhole water pump to the hydraulic accumulator at the earthen surface. Pumping hydraulic fluid from the hydraulic oil pump via the only one downhole hydraulic oil line to a rod side of a downhole water pump piston thereby moving the downhole water pump piston in a first direction and pumping water into the hydraulic accumulator water chamber causes pressure to build within each chamber of the hydraulic accumulator. Pumping hydraulic oil from the hydraulic oil pump through the hydraulic accumulator hydraulic oil line to a hydraulic oil chamber of the hydraulic accumulator thereby increasing an internal pressure of the hydraulic accumulator hydraulic oil chamber moves the hydraulic accumulator piston away from the hydraulic accumulator hydraulic oil chamber due to increasing internal pressure of the hydraulic accumulator hydraulic oil chamber. Increasing pressure within the hydraulic accumulator hydraulic oil chamber causes the piston to move toward the hydraulic accumulator hydraulic water chamber thereby increasing pressure within the only one downhole water line and at the same time increasing force against a non-rod-side of the water pump piston. Increasing the force against the non-rod-side of the water pump piston causes the water pump piston to begin moving in a second non-pumping direction. Providing a water valve in the downhole water line at the earthen surface and then opening the water valve to release or evacuate water at the earthen surface and from the downhole water line, such as when the water pump piston reaches its extreme or maximum downward position in the non-pumping direction permits water to be removed from the subterranean reservoir.

[0010] In another method of removing water from a subterranean formation to an earthen surface may include the steps of providing a hydraulic oil pump at the earthen surface, providing a downhole water pump, providing a surface water pump at the earthen surface, supplying only one downhole hydraulic oil line from the hydraulic oil pump to the downhole water pump, and supplying only one downhole water line from the downhole water pump to the surface water pump. The method may further comprise pumping hydraulic fluid from the hydraulic oil pump via the only one downhole hydraulic oil line to a rod-side of a downhole water pump piston within the downhole water pump thereby moving the downhole water pump piston in a water-pumping direction and also moving water through the downhole water line to the earthen surface. This method may not utilize a hydraulic accumulator, but may still engage in moving water through a

water repository water valve in a water repository filling tube and then depositing water into a water repository at the earthen surface.

[0011] Subsequently, the method may involve closing the water repository water valve and pumping water with the surface water pump at the earthen surface into the downhole water pump via the water removal line to cause pumping of water to a non-rod-side of the downhole water pump piston within the downhole water pump. With water striking a non-rod-side of the downhole water pump piston, a result may be moving the water pump piston in a direction opposite to the water-pumping direction. When the water pump piston moving or arriving at a prescribed location with the water pump, opening a hydraulic drain line valve in a hydraulic drain line at the earthen surface may permit moving hydraulic oil through the hydraulic drain line valve and into the hydraulic fluid tank as the water pump piston is moving in a direction opposite to the water-pumping direction.

[0012] In the methods describe above, valves may be opened and closed by a controller based upon pressures, for example.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] A more complete understanding of the present disclosure and benefits thereof may be acquired by referring to the follow description taken in conjunction with the accompanying drawings in which:

[0014] FIG. 1 is a schematic of a water evacuation system of a first embodiment in accordance with the present disclosure;

[0015] FIG. 2 is a cross-sectional view of a downhole water pump in accordance with the present disclosure;

[0016] FIG. 3 is a cross-sectional view of a downhole water pump in accordance with the present disclosure;

[0017] FIG. 4 is a cross-sectional view of a hydraulic accumulator in accordance with the present disclosure;

[0018] FIG. 5 is a schematic view of a control module, valves and sensors in accordance with the present disclosure; and

[0019] FIG. 6 is a schematic of a water evacuation system of a second embodiment in accordance with the present disclosure.

DETAILED DESCRIPTION

[0020] Turning now to FIGS. 1-6, a detailed description of the preferred arrangement or arrangements of the present disclosure will be presented. It should be understood that the inventive features and concepts may be manifested in other arrangements and that the scope of the disclosure is not limited to the embodiments described or illustrated.

[0021] FIG. 1 depicts a water evacuation system 10 for extracting water from a subterranean location 12, such as an oil and gas well, or other well, that traverses a distance from an earthen surface 14 to a water source 16 located below earthen surface 14. A subterranean water pump 18 may be located within water source 16. A downhole hydraulic line 20 and a water removal line 22 may each be connected to the subterranean water pump 18. Water removal line 22 may be connected to a hydraulic accumulator 40, which may be part of a pumping unit 24 located on earthen surface 14. Pumping unit 24 may be a hydraulic pumping unit and may employ a multitude of components to enable functioning of subterranean water pump 18 and hydraulic accumulator 40. Pumping

unit 24 may employ an electric motor 26, which may drive or turn hydraulic pump 28 thereby forcing or pumping hydraulic fluid toward a hydraulic control valve 30 located in downhole hydraulic line 20. A hydraulic pump line 32 may be valveless and lead from hydraulic pump 28 and branch into a hydraulic line that leads to hydraulic accumulator 40 and downhole hydraulic line 20. Hydraulic pump line 32 that leads from hydraulic pump 28 may be a relatively high pressure hydraulic line that is a conduit that supplies pressurized hydraulic fluid for passage or distribution to downhole water pump 18 to energize or drive downhole water pump 18. Downhole water pump 18 may have only one downhole hydraulic line 20 and only one water removal line 22 that are attached to it and that run between or fluidly link downhole water pump 18 and earthen surface 14.

[0022] During a pumping stroke of water pump 18, a water pump piston 60 within water pump 18 may have high pressure hydraulic fluid forced against a rod-side 62 of water pump piston 60 as depicted in FIG. 2. Rod 64 is connected to water pump piston 60 and thus, the side of water pump piston 60 to which rod 64 is connected is referred to as "rod-side." Rod side of water pump piston 60 may also form part of a boundary of a rod side chamber 34, which is a reservoir that varies in volume and that houses hydraulic fluid pumped in from downhole hydraulic line 20. Force of hydraulic fluid against rod-side 62 of water pump piston 60 causes water pump piston 60 to move upwards, with reference to its normal installation orientation as depicted in FIG. 2, in accordance with arrow 66 (FIG. 1). As water pump piston 60 moves upward within piston sleeve 68 in accordance with arrow 66, water within traveling valve chamber 70 moves upward and into water channel 72, which may be vertical or substantially vertical within water pump 18. Traveling valve chamber 70 may be formed within a plunger, which is commonly referred to as a plunger 74, that is attached to an opposite end of rod 64 as water pump piston 60; thus, water pump piston 60, rod 64 and plunger 74 move together as a collective unit during pumping strokes and water drawing strokes of water pump 18 (FIG. 1). A pumping stroke occurs when water is forced into water removal line 22 and toward earthen surface 14. A water drawing stroke occurs when water is drawn into water chamber 114 of water pump 18 when piston 60 moves in an opposite direction as a pumping stroke of piston 60.

[0023] Continuing with an explanation of water pump 18, water within traveling valve chamber 70, water located immediately above plunger 74, water within water channel 72, water within water channel 78, and water located immediately above water pump piston 60, is able to be lifted or pumped through water removal line 22 because ball 76 seats and seals against ball seat 82 of plunger 74. Water channel 72 and water channel 78 permit water to pass around piston chamber 80 within which water pump piston 60 resides. Ball seat 82 and ball 76 of plunger 74 are also referred to as a travelling valve because plunger 74 moves within a sump casing, also known as a standing 94. As water pump piston 60, rod 64 and plunger 74 together translate upwards in accordance with arrow 66, water is drawn into bottom sump 84 of water pump 18. More specifically, water is drawn into bottom sump reservoir 86 when sump ball 88 lifts from sump ball seat 90 of standing 94. Sump ball 88 and sump ball seat 90 of standing 94 are referred to as a stationary valve. Plunger 74 fits within standing 94 to permit movement of plunger 74 within interior walls of standing 94. When plunger 74 moves away from sump ball valve chamber 92 within standing 94, a

volume of sump reservoir 86 increases while a vacuum is created within sump reservoir 86. The vacuum causes water to be drawn from subterranean location 12 below standing 94, past sump ball 88 and into sump ball valve chamber 92 and subsequently into sump reservoir 86. Upward pumping movement of water pump piston 60 causes water to move through water removal line 22, and with valve 54 closed during upward movement of water pump piston 60 during this stroke, water enters water chamber 52 of hydraulic accumulator 40 thereby causing floating piston 42 within hydraulic accumulator 40 to move upward, which is away from water inlet of hydraulic accumulator 40, thereby causing displacement of hydraulic fluid out of hydraulic fluid chamber 36 of hydraulic accumulator 40, subsequently through open accumulator drain line valve 106 (hydraulic accumulator fill valve 100 is closed when volume of hydraulic fluid chamber 36 is decreasing), and into hydraulic fluid tank 46.

[0024] When downhole hydraulic line 20 is energized by hydraulic pump 28 with hydraulic pressure sufficient to generate enough force to cause water pump piston 60 to move upwards in a pumping stroke that removes water from xxx 16, hydraulic fluid is drawn from hydraulic fluid tank 46, into hydraulic pump feed line 27, through hydraulic pump 28, through hydraulic pump line 32, through an open downhole hydraulic line valve 30 and into downhole hydraulic line 20 to a rod side of water pump piston 60 of water pump 18.

[0025] At the same time that downhole hydraulic line valve 30 permits hydraulic fluid to flow into downhole hydraulic line 20, hydraulic fluid is prevented from flowing into hydraulic fluid tank 46 through hydraulic drain line 96 because hydraulic drain line valve 98 is closed. Additionally at the same time, hydraulic fluid is prevented from flowing into hydraulic fluid chamber 36 of hydraulic accumulator 40 during upward motion of water pump piston 60 because hydraulic accumulator fill valve 100 is also closed, thus preventing pumped hydraulic fluid and associated hydraulic pressure intended for downhole hydraulic line 20 from escaping into hydraulic accumulator 40 or into hydraulic accumulator drain line 102. Upon water pump piston 60 moving during a pumping stroke (upward stroke to move water to hydraulic accumulator 40), water moves upward toward earthen surface 14 through water removal line 22 and into water chamber 52 of hydraulic accumulator 40 with water valve 54 closed. A pumping stroke of water pump piston 60 occurs from a lowest possible position of piston 60 within piston chamber 80 of water pump 18, also known as a lowest bottom position, to a highest possible position, also known as a highest top position, of water pump piston 60 within piston chamber 80 of water pump 18. When piston 60 reaches its highest top position, which is completion of a pumping stroke, a pressure sensor 104 located within hydraulic pump line 32, such as near hydraulic pump 28, senses hydraulic pressure within hydraulic pump line 32 and causes a control module 112 to actuate hydraulic drain line valve 30 to a closed position and to actuate hydraulic accumulator fill valve 100 to an open position.

[0026] During each pumping or upward stroke of water pump piston 60 of downhole water pump 18, floating transfer piston 42 moves within hydraulic accumulator 40 causing a progressive increase in the volume of water chamber 52 and a corresponding progressive decrease in the volume of hydraulic fluid chamber 36. Piston 42 maintains a contact fit against the cylindrical interior wall of hydraulic accumulator 40 to maintain a leak-proof sealing fit between water chamber

52 and hydraulic fluid chamber 36 so that water and hydraulic fluid are always separated and are prevented from mixing. Despite such a leak-proof seal, floating transfer piston 42 may move when subjected to a force; such as a force caused by hydraulic pressure, such as hydraulic water pressure within water removal line 22 and water chamber 52, or hydraulic oil pressure generated within hydraulic fluid chamber 36 from hydraulic fluid pumped through hydraulic accumulator hydraulic oil line 38 from hydraulic pump 28. Thus, each upward movement of water pump piston 60 of water pump 18 causes floating transfer piston 42 to move so as to increase the volume of water chamber 50 with water valve 54 closed. Also, during movement of floating transfer piston 42 due to water chamber 52 filling with water, a volume of hydraulic fluid equal to a volume of hydraulic fluid displaced by movement of floating transfer piston 42 flows out of hydraulic fluid chamber 36 and into hydraulic accumulator hydraulic oil line 38, through accumulator drain line valve 106 resident within hydraulic accumulator drain line 102 and into hydraulic fluid tank 46. When hydraulic accumulator drain line valve 106 is open, hydraulic accumulator fill valve 100 is closed. Hydraulic accumulator fill valve 100 is located in a fluid path between hydraulic pump 28 and hydraulic fluid chamber 36 of hydraulic accumulator 40 and is normally closed when hydraulic fluid is flowing into hydraulic fluid tank 46 during movement of floating transfer piston 42 due to water filling water chamber 52 of hydraulic accumulator 40.

[0027] Thus, with continued reference to FIGS. 1-4, in an exemplary cycle of water evacuation system 10, with accumulator drain line valve 106 open, hydraulic accumulator fill valve 100 closed, hydraulic drain line valve 98 closed, water valve 54 closed, and hydraulic control valve 30 open, hydraulic pump 28 pumps hydraulic fluid to rod side chamber 34 thus pressurizing rod side chamber 34. As water pump piston 60 rises, water that plunger 74 forces into water channel 78 and water channel 72, which route water around cylinder housing piston 60, is forced into water removal line 22. More specifically, water pump piston 60 may force water into water removal line 22, which leads in a vertical or generally vertical direction toward earthen surface 14.

[0028] Because hydraulic pump 28 operates continuously and thereby continuously draws fluid from hydraulic tank 46, upon water pump piston 60 reaching its upper stroke limit within xxx 18, such as when water pump piston 60 resides adjacent interior cylinder end 110, pressure within downhole hydraulic line 20 and hydraulic pump line 32 will increase, which pressure sensor 104 will detect. Upon pressure sensor 104 sensing an increase in hydraulic pressure at or above a predetermined or threshold pressure within hydraulic pump line 32, which may exhibit the same pressure as downhole hydraulic line 20, a control module 112 (FIG. 5) in communication with sensor 104 causes a series of valve changes to occur. With hydraulic pump 28 continuing to operate and pump hydraulic fluid, accumulator drain line valve 106 switches from open to close, hydraulic accumulator fill valve 100 switches from closed to open, hydraulic drain line valve 98 switches from closed to open, water valve 54 switches from open to close, and hydraulic control valve 30 switches from open to close. Thus, upon valves 30, 54, 98, 100, and 106 changing positions as noted above, hydraulic fluid exiting hydraulic pump 28 flows only through hydraulic accumulator fill valve 100, through hydraulic accumulator hydraulic oil line 38 and into hydraulic fluid chamber 36. With hydraulic fluid flowing into hydraulic fluid chamber 36 and thus

increasing pressure within hydraulic fluid chamber 36, floating transfer piston 42 begins to move within hydraulic accumulator 40 thereby increasing a volume of hydraulic fluid chamber 36 and decreasing a volume of water chamber 52. With water valve 54 closed, water pressure builds within water removal line 22 as hydraulic pressure in hydraulic fluid chamber 36 increases and floating transfer piston 42 moving to evacuate water from water chamber 52. Increasing water pressure in water chamber 52 and water removal line 22 forces water pump piston 60 downward in accordance with a direction of arrow 67, which is also a direction opposite that of a water-pumping stroke as depicted with direction of arrow 66.

[0029] As depicted in FIG. 3, as water pump piston 60 moves in accordance with direction of arrow 67, water pump piston 60 is returned back to a position from which a pumping stroke may begin. Because water valve 54 in water tank filling tube 56 is closed, water is prevented from exiting through water valve 54 and permitting water pressure to build within water removal line 22 and fully act upon water pump piston 60 as pressure builds within hydraulic fluid chamber 36 of hydraulic accumulator 40. When water pump piston 60 moves due to increasing force against the non-rod-side of piston 60, volume of rod side chamber 34 decreases and hydraulic fluid is forced into downhole hydraulic line 20 in a direction that is opposite from the flow direction during a pumping stroke. That is, because of motion of water pump piston 60, hydraulic fluid is forced into downhole hydraulic line 20, through open hydraulic drain line valve 98 of hydraulic drain line 96 and into hydraulic fluid tank 46 while hydraulic control valve 30 is closed. That is, hydraulic control valve 30 is closed at the time of a non-pumping stroke, otherwise known as a return stroke, of water pump piston 60 to require hydraulic fluid to pass through hydraulic drain line valve 98 of hydraulic drain line 96 and into hydraulic fluid tank 46. Thus, by reversing the direction of water flow through water removal line 22 and by reversing the direction of hydraulic fluid flow through downhole hydraulic line 20 during a return stroke of water pump piston 60, water pump piston 60 may quickly be returned to either a lower position within piston chamber 80, or its lowest position within piston chamber 80, to begin a new pumping stroke. As an example, the lowest possible position that water pump piston 60 might achieve before beginning its pumping stroke may be when plunger end surface 118 resides adjacent to sump reservoir end interior surface 120 or when surfaces 118, 120 actually contact. When water pump piston 60 is at its position, such as its lowest possible position, before beginning its return to a water-pumping stroke, water valve 54 changes from a closed position to an open position to permit water from hydraulic accumulator 40 and water removal line 22 to exit through water tank filling tube 56 and into water repository 58. In some cycles, water valve 54 may only be opened to permit water to exit hydraulic accumulator 40 and water removal line 22 into water repository 58 when water pump piston 60 is at its lowest position in its cycle, which is before water pump piston 60 begins its pumping stroke or movement toward interior cylinder end 110 of piston chamber 80.

[0030] FIG. 4 depicts exemplary positions of floating transfer piston 42 within hydraulic accumulator 40 during a pumping stroke of water pump piston 60 and a subsequent return stroke of water pump piston 60 during operation of water evacuation system 10. When water pump piston 60 of water pump 18 begins to move toward water removal line 22 to

force or pump water through water removal line 22, and toward and into water chamber 52 of hydraulic accumulator 40, floating transfer piston 42 initially may be at a position 42A, and may begin to move toward position 42B throughout such a pumping stroke. Initial position 42A may be a position closest to an end 23 of hydraulic accumulator 40 that connects to water removal line 22. Exactly how far floating transfer piston 42 may move within hydraulic accumulator 40 depends upon the size, such as a length and internal volume, of hydraulic accumulator 40, and the acceleration, speed and force of water against piston 42.

[0031] Floating transfer piston 42 moves upward in accordance with arrow 66 due to a hydraulic force created during such pumping stroke of water pump piston 60. As a result, floating transfer piston 42 may reach a position 42B, as depicted in FIG. 4. Position 42B may be a position anywhere between position 42A and an end 25 of hydraulic accumulator 40. When water pump piston 60 reaches its maximum pumping stroke position and pressure sensor 104 senses an increase in hydraulic pressure that is above a predetermined or threshold pressure limit, control module (FIG. 5) may trigger a switching of valves 30, 54, 98, 100 and 106 so that water pump piston 60 may reverse direction to be reset for continued pumping of water from water source 16 of subterranean location 12, as previously described. Pressure may be used to optimize the cycle time, but pressure measurement is not required. Although floating transfer piston 42 may be hydraulically forced to position 42A from position 42B, for example, to cause water pump piston 60 to return to its position within water pump 18 such that plunger end surface 118 is immediately adjacent sump reservoir end interior surface 120, water valve 54 may not necessarily be opened on every pump cycle when water pump piston 60 is so positioned. Opening of water valve 54 may be accomplished upon sensing a position of floating transfer piston 42. More specifically, sensing a position of floating transfer piston 42 within hydraulic accumulator 40 may be accomplished by using a tube 122 centered longitudinally in hydraulic accumulator 40 that spans the entire length of the hydraulic accumulator 40. The tube may house a sensor coil 124, which may communicate with control module 112 and traverse some length, an entire length, or specific portions of tube 122, to detect a magnet 126 in floating transfer piston 42. In this manner the position of floating transfer piston 42 within hydraulic accumulator 40 may be known at all times and communicated to control module 112. Sensing positions of floating transfer pistons within hydraulic accumulators is known in the art. Water valve 54 may or may not be opened upon water pump piston 60 reaching a specific position within piston chamber 80 of water pump 18 because opening of water valve 54 to expel water into water repository 58 is dependent upon a position of floating transfer piston 42 within hydraulic accumulator 18 and not only a position of water pump piston 60 reaching a specific position within piston chamber 80. Such a specific position of water pump piston 60 may be a position within piston chamber 80 that is immediately before water pump piston 60 begins a new pumping stroke. Thus, water pump piston 60 may be in a position to immediately begin a pumping stroke with plunger end surface 118 located immediately adjacent to sump reservoir end interior surface 120 such that no further travel of plunger end surface 118 toward sump reservoir end interior surface 120 is possible or effective.

[0032] In another example of a specific position of water pump piston 60 at which water pump piston 60 is in a position within piston chamber 80 to begin a new pumping stroke, piston rod-side surface 62 of water pump piston 60 may be aligned with an inside diameter of hydraulic line inlet into rod-side chamber 34 of piston chamber 80 such that the full diameter or complete cross-sectional area of hydraulic fluid inlet into rod-side chamber 34 is capable of delivering fluid into rod-side chamber 34 in an unobstructed delivery by any part of water pump piston 60.

[0033] In yet another example of a specific position of water pump piston 60 at which water pump piston 60 is in a position within piston chamber 80 to begin a new pumping stroke, piston rod-side surface 62 of water pump piston 60 may be aligned with an inside diameter of hydraulic line inlet into rod-side chamber 34 of piston chamber 80 such that the full diameter or complete cross-sectional area of hydraulic fluid inlet into rod-side chamber 34 is capable of delivering fluid into rod-side chamber 34 in an unobstructed delivery by any part of water pump piston 60, and plunger end surface 118 is located immediately adjacent to sump reservoir end interior surface 120 such that no further travel of plunger end surface 118 toward sump reservoir end interior surface 120 is possible or effective. As previously stated, water valve 54 may not be opened on every pump cycle, or water valve may be opened on every pump cycle. A pump cycle may be defined as the motion of plunger end surface 118 moving from an initial position adjacent to sump reservoir end interior surface 120 to its farthest possible location from sump reservoir end interior surface 120, and then returning to the same position adjacent to sump reservoir end interior surface 120 from which plunger end surface 118 began.

[0034] Turning now to FIG. 6, a detailed description of another embodiment of the present disclosure will be presented. FIG. 6 depicts a water evacuation system 150 for extracting water from a subterranean location 12, such as an oil and gas well, or other well, that traverses a distance from an earthen surface 14 to a water source 16 located below earthen surface 14. As can be seen in a comparison of FIGS. 1 and FIG. 6, FIG. 6 shares many of the same components as the apparatus depicted in FIG. 1. One difference, however, is in a backflow mechanism 152, which includes water repository 154, surface water pump 156, water pump draw pipe 158, water pump feeder pipe 160, water tank filling tube 162 and water dump valve 164.

[0035] Water evacuation system 150 may have subterranean water pump 18 located within water source 16. Downhole hydraulic line 20 and downhole water removal line 22 may each be connected to the subterranean water pump 18. Downhole water removal line 22 may be connected to water tank filling tube 162, which may be located at earthen surface 14 (i.e. not subsurface) and which may be part of a pumping unit 166 located on earthen surface 14. Downhole water removal line 22 may also be part of a backflow mechanism 152 of pumping unit 166. Pumping unit 166 may be a hydraulic pumping unit and may employ a multitude of components to enable functioning of subterranean water pump 18 and backflow mechanism 152, including surface water pump 156. Pumping unit 166 may employ an electric motor 26, which may drive or turn hydraulic pump 28 thereby forcing or pumping hydraulic fluid into downhole hydraulic line 20 and into water pump 18 to energize or drive downhole water pump 18. Downhole water pump 18 may utilize only one downhole hydraulic line 20 and only one downhole water removal line

22 for operation. Downhole hydraulic line 20 and downhole water removal line 22 run between or fluidly link downhole water pump 18 and components on earthen surface 14. Details of internal components of water pump 18 are explained above in conjunction with FIGS. 2 and 3.

[0036] When downhole hydraulic line 20 is energized by hydraulic pump 28 with hydraulic pressure sufficient to generate enough force to cause water pump piston 60 to move upwards in a pumping stroke that removes water from water source 16, hydraulic fluid is drawn from hydraulic fluid tank 46, into hydraulic pump feed line 27, through hydraulic pump 28, through hydraulic pump line 32 and into downhole hydraulic line 20 to a rod side of water pump piston 60 of water pump 18. At the same time that hydraulic fluid flows into downhole hydraulic line 20 during a water pumping stroke of water pump 18, hydraulic fluid is prevented from flowing into hydraulic fluid tank 46 through hydraulic drain line 96 because hydraulic drain line valve 98 is closed. Upon water pump piston 60 moving during a pumping stroke (upward stroke in FIG. 2), water moves upward toward earthen surface 14 through downhole water removal line 22 and into water tank filling tube 162 with water valve 164 in water tank filling tube 162 open. A pumping stroke of water pump piston 60 occurs from a lowest possible position of piston 60 within piston chamber 80 of water pump 18, also known as a lowest bottom position, to a highest possible position, also known as a highest top position, of water pump piston 60 within piston chamber 80 of water pump 18. When piston 60 reaches its highest top position, which is completion of a pumping stroke, a pressure sensor 104 located within hydraulic pump line 32, such as near hydraulic pump 28, senses hydraulic pressure within hydraulic pump line 32 and causes a control module 112 to actuate hydraulic drain line valve 30 to a closed position and to actuate hydraulic accumulator fill valve 1500 to an open position.

[0037] During each pumping or upward stroke of water pump piston 60 of downhole water pump 18, hydraulic pump 28 pumps hydraulic fluid to rod side chamber 34 thus pressurizing rod side chamber 34. As water pump piston 60 rises, water that plunger 74 forces into water channel 78 and water channel 72, which route water around cylinder housing piston 60, is forced into downhole water removal line 22. More specifically, water pump piston 60 may force water into downhole water removal line 22, which leads in a vertical or generally vertical direction toward earthen surface 14.

[0038] Because hydraulic pump 28 continuously operates and draws fluid from hydraulic tank 46, upon water pump piston 60 reaching its upper stroke limit within downhole water pump 18, such as when water pump piston 60 resides adjacent interior cylinder end 110, pressure within downhole hydraulic line 20 and hydraulic pump line 32 will increase, which pressure sensor 104 will detect. Pressure within downhole hydraulic line 20 and hydraulic pump line 32 could also be measured by a human-readable pressure gage. Upon pressure sensor 104 or a gage sensing or indicating an increase in hydraulic pressure at or above a predetermined or threshold pressure within hydraulic pump line 32, a series of valve changes may occur. With hydraulic pump 28 continuing to operate and pump hydraulic fluid, hydraulic drain line valve 98 switches from closed to opened, and water valve 164 switches from open to close. Additionally, surface water pump 156 pumps water into water pump feeder pipe 160 and into downhole water removal line 22 toward downhole water pump 18. Water pressure builds within downhole water

removal line 22 which forces water pump piston 60 downward in accordance with a direction of arrow 67, which is also a direction opposite that of a water-pumping stroke as depicted with direction of arrow 66.

[0039] As depicted in FIG. 3, as water pump piston 60 moves in accordance with direction of arrow 67, water pump piston 60 is returned back to a position from which a full and complete pumping stroke may begin. Because water valve 164 in water tank filling tube 162 is closed, water is prevented from exiting through water valve 164 and permits water pressure to build within downhole water removal line 22 and cause motion of water pump piston 60. When water pump piston 60 moves due to increasing force against the non-rod-side of piston 60, hydraulic fluid is forced into downhole hydraulic line 20 in a direction that is opposite from the flow direction during a pumping stroke. That is, because of motion of water pump piston 60, hydraulic fluid is forced into downhole hydraulic line 20, through open hydraulic drain line valve 98 of hydraulic drain line 96 and into hydraulic fluid tank 46. Pump 28 may continue to pump and discharge hydraulic fluid into hydraulic drain line 96 and into hydraulic fluid tank 46. Thus, during a non-pumping stroke of downhole water pump 18 hydraulic fluid passes through hydraulic drain line valve 98 of hydraulic drain line 96 and into hydraulic fluid tank 46. Thus, by reversing the direction of water flow through downhole water removal line 22 using surface water pump 156 and by reversing the direction of hydraulic fluid flow through downhole hydraulic line 20 during a return stroke of water pump piston 60, water pump piston 60 may quickly be returned to either a lower position within piston chamber 80, or its lowest position within piston chamber 80, to begin a new pumping stroke.

[0040] With reference again including FIGS. 2 and 3, as an example, the lowest possible position that water pump piston 60 might achieve before beginning its pumping stroke may be when plunger end surface 118 resides adjacent to sump reservoir end interior surface 120 or when surfaces 118, 120 actually contact. When water pump piston 60 is at its position, such as its lowest possible position, before beginning its return to a water-pumping stroke, water valve 164 changes from an open position to a closed position to permit water from water removal line 22 to only flow toward downhole water pump 18 to move piston from the end of a pumping stroke to the beginning of a pumping stroke. A complete cycle or pumping cycle of water pump piston 60, may be the greatest linear length of motion possible during a pumping stroke and subsequent return stroke or resetting of water pump piston 60 to begin a subsequent pumping stroke. For instance, a complete cycle water pump piston 60 may be the combined motion of rod-side surface 62 from alignment with surface of tube 122 to non-rod-side surface of piston 60 positioned adjacent to interior cylinder end 110 and then rod-side surface 62 re-aligning with surface of tube 122. Thus, water pump piston 60 may be in a position to immediately begin a pumping stroke with plunger end surface 118 located immediately adjacent to sump reservoir end interior surface 120 such that no further travel of plunger end surface 118 toward sump reservoir end interior surface 120 is possible or effective.

[0041] In another example of a specific position of water pump piston 60 at which water pump piston 60 is in a position within piston chamber 80 to begin a new pumping stroke, piston rod-side surface 62 of water pump piston 60 may be aligned with an inside diameter of hydraulic line inlet into rod-side chamber 34 of piston chamber 80 such that the full

diameter or complete cross-sectional area of hydraulic fluid inlet into rod-side chamber 34 is capable of delivering fluid into rod-side chamber 34 in an unobstructed delivery by any part of water pump piston 60. A pump cycle also may be defined as the motion of plunger end surface 118 moving from an initial position adjacent to sump reservoir end interior surface 120 to its farthest possible location from sump reservoir end interior surface 120, and then returning to the same position adjacent to sump reservoir end interior surface 120 from which plunger end surface 118 began.

[0042] In yet another example of a specific position of water pump piston 60 at which water pump piston 60 is in a position within piston chamber 80 to begin a new pumping stroke, piston rod-side surface 62 of water pump piston 60 may be aligned with an inside diameter of hydraulic line inlet into rod-side chamber 34 of piston chamber 80 such that the full diameter or complete cross-sectional area of hydraulic fluid inlet into rod-side chamber 34 is capable of delivering fluid into rod-side chamber 34 in an unobstructed delivery by any part of water pump piston 60, and plunger end surface 118 is located immediately adjacent to sump reservoir end interior surface 120 such that no further travel of plunger end surface 118 toward sump reservoir end interior surface 120 is possible or alternatively, effective.

[0043] In the above-described embodiments, in closing and opening all valves, and turning on or off all electric pumps, a controller may be employed to automate such processes. Manually causing closing and opening all valves, and turning on or off all electric pumps is also envisioned.

[0044] Although the systems and processes have been described herein in detail, it should be understood that various changes, substitutions, and alterations can be made without departing from the spirit and scope of the invention as defined by the following claims. Those skilled in the art may be able to study the preferred embodiments and identify other ways to practice the invention that are not exactly as described herein. It is the intent of the inventors that variations and equivalents of the invention are within the scope of the claims while the description, abstract and drawings are not to be used to limit the scope of the invention. The invention is specifically intended to be as broad as the claims below and their equivalents.

1. A method of removing fluid from a subterranean formation to an earthen surface, the method comprising:

- providing a hydraulic oil pump at the earthen surface;
- providing a downhole water pump;
- providing a hydraulic accumulator at the earthen surface;
- supplying only one downhole hydraulic oil line from the hydraulic oil pump to the downhole water pump;
- supplying only one downhole water line from the downhole water pump to the hydraulic accumulator; and
- supplying a hydraulic accumulator hydraulic oil line from the hydraulic oil pump to the hydraulic accumulator.

2. The method according to claim 1, wherein providing a hydraulic accumulator further comprises providing a hydraulic accumulator that defines an internal chamber, a first inlet/outlet at a first end of the hydraulic accumulator, a second inlet/outlet at a second end of the hydraulic accumulator and a hydraulic accumulator piston within the internal chamber that divides the internal chamber into a hydraulic accumulator water chamber and a hydraulic accumulator hydraulic oil chamber.

3. The method according to claim 2, further comprising: pumping hydraulic fluid from the hydraulic oil pump via the only one downhole hydraulic oil line to a rod side of a piston within the downhole water pump thereby moving the piston in a first direction.

4. The method according to claim 3, further comprising: pumping hydraulic oil from the hydraulic oil pump through the hydraulic accumulator hydraulic oil line to the hydraulic accumulator and increasing an internal pressure of the hydraulic accumulator hydraulic oil chamber;

moving the hydraulic accumulator piston away from the hydraulic accumulator hydraulic oil chamber;

increasing pressure within the only one downhole water line; and

increasing force against a non-rod-side of the water pump piston within the downhole water pump thereby moving the piston in a second direction.

5. The method according to claim 4, further comprising: providing a water valve in the downhole water line at the earthen surface; and

opening the water valve when the water pump piston reaches a prescribed position with the downhole water pump to evacuate water from the downhole water line.

6. A method of removing water from a subterranean formation to an earthen surface, the method comprising:

pumping hydraulic oil from a hydraulic oil pump at the earthen surface to a downhole water pump through only one downhole hydraulic oil line from the hydraulic oil pump to the downhole water pump; and

pumping water from the downhole water pump to the earthen surface through only one downhole water line from the downhole water pump to the earthen surface.

7. The method according to claim 6, further comprising: providing a hydraulic accumulator at the earthen surface and a hydraulic accumulator hydraulic oil line from the hydraulic oil pump to the hydraulic accumulator; and

wherein providing only one downhole water line from the downhole water pump to the earthen surface further comprises providing one downhole water line from the downhole water pump to the hydraulic accumulator.

8. The method according to claim 7, further comprising: pumping hydraulic fluid from the hydraulic oil pump via the only one downhole hydraulic oil line to a rod side of a downhole water pump piston thereby moving the downhole water pump piston in a first direction and pumping water into a hydraulic accumulator water chamber;

pumping hydraulic oil from the hydraulic oil pump through the hydraulic accumulator hydraulic oil line to a hydraulic oil chamber of the hydraulic accumulator thereby increasing an internal pressure of the hydraulic accumulator hydraulic oil chamber;

moving a hydraulic accumulator piston away from the hydraulic accumulator hydraulic oil chamber due to the internal pressure of the hydraulic accumulator hydraulic oil chamber;

increasing pressure within the only one downhole water line; and

increasing force against a non-rod-side of the water pump piston thereby moving the water pump piston in a second direction.

9. The method according to claim **8**, further comprising:
providing a water valve in the downhole water line at the earthen surface;
moving the water pump piston in a non-pumping direction;
and
opening the water valve when the water pump piston reaches a prescribed position within the downhole water pump thereby evacuating water from the downhole water line.

10. A method of removing water from a subterranean formation to an earthen surface, the method comprising:
providing a hydraulic oil pump at the earthen surface;
providing a downhole water pump;
providing a surface water pump at the earthen surface;
supplying only one downhole hydraulic oil line from the hydraulic oil pump to the downhole water pump; and
supplying only one downhole water line from the downhole water pump to the surface water pump.

11. The method according to claim **10**, further comprising:
pumping hydraulic fluid from the hydraulic oil pump via the only one downhole hydraulic oil line to a rod-side of a downhole water pump piston within the downhole water pump;
moving the downhole water pump piston in a water-pumping direction; and
moving water through the downhole water line to the earthen surface.

12. The method according to claim **11**, further comprising:
moving water through a water repository water valve in a water repository filling tube; and
depositing water into a water repository at the earthen surface.

13. The method according to claim **12**, further comprising:
closing the water repository water valve; and
pumping water with the surface water pump at the earthen surface to the downhole water pump via the water removal line.

14. The method according to claim **13**, wherein pumping water with the surface water pump at the earthen surface to the downhole water pump via the water removal line further comprises:

pumping water to a non-rod-side of the downhole water pump piston within the downhole water pump.

15. The method according to claim **14**, further comprising:
moving the water pump piston in a direction opposite to the water-pumping direction.

16. The method according to claim **15**, further comprising:
opening a hydraulic drain line valve in a hydraulic drain line at the earthen surface; and
moving hydraulic oil through the hydraulic drain line valve and into the hydraulic fluid tank as the water pump piston is moving in a direction opposite to the water-pumping direction.

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