SLIDING VALVE DOWNHOLE PUMP

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Abstract

Downhole pumps for producing hydrocarbons and/or other fluids from a well bore include a barrel having a plunger or plunger valve disposed therein and a stationary valve engaged with the barrel. The valve(s) include(s) an outer housing and an inner piston movable within the outer housing. Responsive to movement of the plunger or plunger valve relative to the barrel, the inner piston(s) is(are) movable between a first position that permits fluid flow through the valve and a second position that prevents fluid flow therethrough.
SLIDING VALVE DOWNHOLE PUMP FIELD

[0001] Embodiments usable within the scope of the present disclosure relate, generally, to downhole pumps and methods for producing a well, e.g. through a secondary recovery process.

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] In the detailed description of various embodiments of the present invention presented below, reference is made to the accompanying drawings, in which:

[0003] FIG. 1A depicts a diagrammatic cross-sectional view of an embodiment of a downhole pump usable within the scope of the present disclosure, during a downstroke of the plunger rod.

[0004] FIG. 1B depicts a diagrammatic cross-sectional view of the downhole pump of FIG. 1A during an upstroke of the plunger rod.

[0005] FIG. 2A depicts a diagrammatic cross-sectional view of an embodiment of a standing valve, usable within the downhole pump of FIGS. 1A and 1B, in a closed position.

[0006] FIG. 2B depicts a diagrammatic cross-sectional view of the standing valve of FIG. 2A in an open position.

[0007] FIG. 3 depicts a perspective view of an embodiment of the outer housing of a standing valve.

[0008] FIG. 4A depicts a perspective view of an embodiment of an inner piston of a standing valve.

[0009] FIG. 4B depicts an end view of the inner piston of FIG. 4A.

[0010] FIG. 5A depicts an end view of an alternate embodiment of an inner piston of a standing valve.

[0011] FIG. 5B depicts a side view of the inner piston of FIG. 5A.

[0012] FIG. 5C depicts a perspective view of the inner piston of FIGS. 5A and 5B.

[0013] FIG. 6A depicts a diagrammatic cross-sectional view of an embodiment of a plunger valve, usable within the downhole pump of FIGS. 1A and 1B, in a closed position.

[0014] FIG. 6B depicts a diagrammatic cross-sectional view of the plunger valve of FIG. 6A in an open position.

[0015] FIG. 7 depicts a perspective view of an embodiment of the outer housing of a plunger valve.

[0016] FIG. 8A depicts a diagrammatic cross-sectional view of an embodiment of a valve usable within the scope of the present disclosure, in a first position for flowing fluid from a production zone into a pump barrel.

[0017] FIG. 8B depicts a diagrammatic cross-sectional view of the valve of FIG. 8A, in a second position for flowing fluid from the pump barrel into production tubing.

[0018] FIG. 9A depicts a diagrammatic cross-sectional view of an embodiment of a downhole pump that includes the valve of FIGS. 8A and 8B, during a downstroke of the plunger.

[0019] FIG. 9B depicts a diagrammatic cross-sectional view of the valve of FIG. 9A, during an upstroke of the plunger.

[0020] FIG. 10 depicts a diagrammatic view of the downhole pump of FIGS. 1A and 1B, coupled with a reciprocating surface device.

[0021] Embodiments of the present invention are described below with reference to the listed Figures.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0022] Before describing selected embodiments of the present invention in detail, it is to be understood that the present invention is not limited to the particular embodiments described herein. The disclosure and description herein is illustrative and explanatory of one or more presently preferred embodiments of the invention and variations thereof, and it will be appreciated by those skilled in the art that various changes in the design, organization, order of operation, means of operation, equipment structures and location, methodology, and use of mechanical equivalents, as well as in the details of the illustrated construction or combinations of features of the various elements, may be made without departing from the spirit of the invention.

[0023] As well, the drawings are intended to describe the concepts of the invention so that the presently preferred embodiments of the invention will be plainly disclosed to one of skill in the art, but are not intended to be manufacturing level drawings or renditions of final products and may include simplified conceptual views as desired for easier and quicker understanding or explanation of the invention. As well, the relative size and arrangement of the components may differ from that shown and still operate within the spirit of the invention as described throughout the present application.

[0024] Moreover, it will be understood that various directions such as “upper,” “lower,” “bottom,” “top,” “left,” “right,” “uphole,” and “downhole,” and so forth are made only with respect to explanation and clarity in conjunction with the drawings, and that the components may be oriented differently, for instance, during transportation and manufacturing as well as operation. Because many varying and different embodiments may be made within the scope of the inventive concept(s) herein taught, and because many modifications may be made in the embodiments described herein, it is to be understood that the details herein are to be interpreted as illustrative and non-limiting.

[0025] Embodiments usable within the scope of the present disclosure relate, generally, to downhole pumps, including both insertion pumps and tubing pumps, and methods for producing hydrocarbons and other fluids (e.g., water, drilling fluids, and/or carbon dioxide or other gasses) from a well bore, that utilize a smaller number of moving parts than conventional pumps, thereby reducing wear and decreasing the potential for vapor locking of the valves, while providing for an improved flow capacity.

[0026] A conventional downhole pump (e.g. an insertion or tubing pump) includes at least two ball check valves, which open and close in alternating fashion, though various existing downhole pumps can include as many as six or more valves. Each valve, seat, and sealing surface of these pumps are prone to wear and failure, requiring frequent repair and/or replacement. Also, when gas is produced from the well bore simultaneously with liquid, it is common for the gas to become trapped in the pump, preventing the build up of fluid pressure necessary to continue actuating the valves (e.g. known as gas or vapor locking). Additionally, the flow capacity of an insertion pump is limited by the diameter and configuration of the pump, which must be sized to pass through a production conduit as a single unit, and by the limited flow capacity of the ball valves. As a result, insertion pumps may be insufficient for production of wells where a significant volume of fluid flow must be accommodated.
Referring now to FIGS. 1A and 1B, a diagrammatic view of embodiment of a downhole pump usable within the scope of the present disclosure is depicted, secured to a lower end of a string of production tubing (10), or a similar conduit through which fluid can be transported. The pump, generally, includes a first, stationary valve, e.g., a standing valve (12), shown engaged to a pump barrel (16) via threads (18), and a second valve, e.g., a plunger valve (14), disposed within the pump barrel (16). A plunger rod (20), which can be connected to and/or a part of a sucker rod string or similar string of connecting members extending to the surface for reciprocation by a pump jack or similar device, extends through the standing valve (12), and is shown secured to the plunger valve (14) via interior threads (22). The depicted plunger valve (14) can be retained in a fixed position relative to the plunger rod (20) using lock nuts (24), or other similar fasteners and/or securing methods (e.g., steel roll pins, C-clips, cotter keys, etc.).

The standing valve (12) is shown having an inner piston (26) movable within an outer housing (28), e.g., between a first, closed position, shown in FIG. 1A, and a second, open position, shown in FIG. 1B. While FIGS. 1A and 1B depict the inner piston (26) abutting the lower end of the outer housing (28) in the closed position, and abutting the upper end of the outer housing (28) in the open position, it should be understood that various configurations of the standing valve (12) that enable movement of the inner piston (26) in any direction relative to the outer housing (28) to open and close the standing valve (12) are possible. When the standing valve (12) is in the open position, shown in FIG. 1B, fluid flow through the standing valve (12) is permitted. Specifically, fluid from within the pump barrel (16) enters a first opening in the outer housing (28), e.g., an inlet opening (30), passes through one or more channels (34) in the inner piston (26), then into the production tubing (10) through a second opening in the outer housing (28), e.g., an outlet opening (32). When the standing valve (12) is in the closed position, shown in FIG. 1A, fluid flow through the channels (34) of the inner piston (26) is prevented, e.g., through use of sealing surfaces. Operation of the depicted embodiment of the standing valve (12) is further described and depicted in FIGS. 2A and 2B.

The plunger valve (14) is similarly shown having an inner piston (36) movable within an outer housing (38) between a first, open position, shown in FIG. 1A, and a second, closed position, shown in FIG. 1B. When the plunger valve (14) is in the open position, shown in FIG. 1A, fluid flow through the plunger valve (14) is permitted. Specifically, fluid flow from the exterior of the pump barrel (16) (e.g., from within a production zone of a wellbore) enters a first opening in the outer housing (38), e.g., an intake opening (40), passes through one or more plunger channels (44) in the inner piston (36), then into the pump barrel (16) through a second opening in the outer housing (38), e.g., an output opening (42). When the plunger valve (14) is in the closed position, shown in FIG. 1B, fluid through the plunger channels (44) is prevented, e.g., through use of sealing surfaces. Operation of the depicted embodiment of the plunger valve (14) is further described and depicted in FIGS. 3A and 3B.

During typical operations, the standing valve (12) and the plunger valve (14) will function in tandem, opening and closing in alternating fashion with each stroke of the plunger rod (20). FIG. 1A depicts the downhole pump during a downstroke of the plunger rod (20) (e.g., movement of the plunger rod (20) and plunger valve (14) in a downhole direction via lowering of an attached sucker rod string or similar string of connecting members). As the plunger rod (20) is moved in a downhole direction, it slides through a bore in the standing valve (12), which remains generally stationary, while the plunger valve (14) is moved in the downhole direction via its connection to the plunger rod (20). Increased fluid pressure at the lower end of the plunger valve (14), caused by the movement thereof, causes the inner piston (36) of the plunger valve (14) to move upward, thereby opening the valve and permitting fluid to flow through the plunger valve (14) into the pump barrel (16). Increased fluid pressure at the upper end of the standing valve (12), caused in part by the downstroke of the plunger rod (20), causes the inner piston (26) of the standing valve (12) to move downward, thereby closing the valve and preventing the reverse-flow of fluid from the production tubing (10) through the standing valve (12).

FIG. 1B depicts the downhole pump during an upstroke of the plunger rod (20) (e.g., movement of the plunger rod (20) and plunger valve (14) in an uphole direction by raising a sucker rod string or similar connector attached to the plunger rod (20)). As the plunger rod (20) is moved in an upstroke direction, it slides through the bore of the standing valve (12), which remains generally stationary, while the plunger valve (14) is moved in the upstroke direction via its connection to the plunger rod (20). Increased fluid pressure at the lower end of the standing valve (12), caused by the upward movement of the plunger rod (20) and the plunger valve (14), causes the inner piston (26) of the standing valve (12) to move upward, thereby opening the valve and permitting the flow of fluid from the pump barrel (16) to the production tubing (10). Increased fluid pressure at the upper end of the plunger valve (14), caused by the upward movement of the plunger rod (20) and the plunger valve (14), causes the inner piston (36) of the plunger valve (14) to move in a downward direction, thereby closing the valve and preventing the reverse-flow of fluid from the pump barrel (16) to the exterior thereof.

It should be understood that while the standing valve (12) and/or the plunger valve (14) can be actuated through fluid pressure at either end thereof, in various embodiments, the valves (12, 14) can be actuated through electrical, hydraulic, pneumatic, and/or mechanical means, or any similar method of actuation.

Referring now to FIGS. 2A and 2B, a diagrammatic cross-sectional view of an embodiment of a standing valve (12) is shown, having an inner piston (26) movable within an outer housing (28). The outer housing (28) is shown having exterior threads (18) for securing the standing valve (12) to a pump barrel, a conduit, or a similar object; however, it should be understood that any manner of securing device, sealing member, fastener, and/or hold down assembly can be used to secure the standing valve (12) within or proximate to a production conduit and/or a pump barrel. The outer housing (28) is also shown having an inlet opening (30) and an outlet opening (32) for accommodating fluid flow through the standing valve (12), and a bore (46) for accommodating passage of a plunger rod and/or similar connecting rod. The diameter of the bore (46) can be selected such that the plunger and/or connecting rod can freely slide within the standing valve (12) without affecting the position of the standing valve (12) or causing significant wear thereto. The inlet and outlet openings (30, 32) can include any number and any type of orifice, slot, bore, channel, or other manner of opening. While the outer housing (28) is shown as a generally cylindrical struc-
ture, it should be understood that the outer housing (28) can have any shape or dimension, and can be formed as a unitary structure or a structure having multiple parts, e.g., a body with an end threadably secured thereto to permit opening of the outer housing (28) to access the inner piston (26). The outer housing (28) can be formed from any generally rigid materials suitable for use within a wellbore environment, such as metal, plastic, and/or one or more polymers or composites. The inner piston (26) is also shown having one or more channels (34) for permitting fluid flow, and one or more sealing surfaces (48, 50) for abutting against the outer housing (28) to isolate the channels (34) from and/or place the channels (34) into communication with the inlet and outlet openings (30, 32), defining a fluid pathway through the standing valve (12). While the inner piston (26) is shown as a generally cylindrical structure, it should be understood that the inner piston (26) can have any shape or dimension able to fit within the outer housing (28), and can be formed as a unitary structure or a structure having multiple parts. Additionally, while the channels (34) are shown as flutes and/or notches, formed at the exterior of the inner piston (26), it should be understood that any number and type of channels, bores, slots, and/or orifices can be used to flow fluid through any portion of the inner piston (26). The inner piston (26) can be formed from any generally rigid materials suitable for use within a wellbore environment, such as metal, plastic, and/or one or more polymers or composites. In an embodiment, the material of the inner piston (26) can be selected based on the desired weight of the inner piston (26) and/or the desired fluid pressure necessary to move the inner piston (26) to open and/or close the standing valve (12). For example, the inner piston (26) can be formed from plastic to minimize weight and enable the standing valve (12) to be operated using a minimum of energy.

[0035] FIG. 2A depicts the standing valve (12) in a closed position, e.g., during a downstroke of the plunger rod and plunger valve. In this position, increased fluid pressure at the upper end of the standing valve (12) impart a force against the upper surface of the inner piston (26), causing downward movement of the inner piston (26) until the lower sealing surface (50) abuts the lower end of the outer housing (28). In this position, the lower sealing surface (50) prevents communication between the inlet opening (30) and the channels (34), thereby preventing the flow of fluid through the standing valve (12).

[0036] FIG. 2B depicts the standing valve (12) in an open position, e.g., during an upstroke of the plunger rod and plunger valve. In this position, increased fluid pressure at the lower end of the standing valve (12) impart a force against the lower surface of the inner piston (26), causing upward movement of the inner piston (26), thereby permitting the flow of fluid through the inlet opening (30), the channels (34), and the outlet opening (32), defining a fluid pathway (52) for accommodating the flow of fluid through the standing valve (12). The upper sealing surface (48) can isolate the fluid pathway (52) from other regions within the standing valve (12). It should be noted that while FIGS. 2A and 2B depict upper and lower sealing surfaces (48, 50), any number of sealing surfaces can be positioned throughout the standing valve (12) (e.g., along the sides thereof) to isolate the fluid pathway (52) and/or prevent fluid flow when the inner piston (26) is in a closed position. The sealing surfaces (48, 50) can include any manner of sealing member, such as an O-ring or similar compressible member, or a protruding portion of the inner piston (26) that forms a seal through abutment with the inner surface of the outer housing (28).

[0037] Referring now to FIG. 3, an embodiment of the outer housing (28) of a standing valve is shown. Specifically, the outer housing (28) is shown as a two-part, cylindrical structure having a lower portion (54) with a central shaft (58) therein, adapted to engage an upper portion (56) via complementary threads (60). While FIG. 3 depicts a two-part housing, it should be understood that a single-piece housing, or an outer housing having more than two parts is also usable within the scope of the present disclosure, and that any means of securing, threaded or otherwise, can be used. The lower portion (54) is shown having external threads (18) formed thereon for securing the standing valve to a pump barrel or similar conduit, inlet openings (30) for permitting fluid flow into the outer housing (28), and a bore (46) for accommodating passage of a plunger rod or similar connecting member. A series of holes, notches, bores, and/or orifices (62) for are also shown for enabling the outer housing (28) to be gripped and/or manipulated by a spanner wrench or similar tool. The upper portion (56) is shown having outlet openings (32), and a central opening (64) coincident with the bore (46) of the lower portion (54) for permitting passage of the plunger rod.

[0038] Referring now to FIGS. 4A and 4B, an embodiment of an inner piston (26) usable within the outer housing of FIG. 3 is shown. Specifically, FIG. 4A shows a perspective view of the inner piston (26), while FIG. 4B depicts an end view thereof. The inner piston (26) is shown having channels (34) formed therethrough for accommodating the passage of fluid through the standing valve. A central bore (66) is also shown for permitting passage of the shaft (58, shown in FIG. 3) of the outer housing to pass therethrough. The central bore (66) can be sized such that the inner piston (26) is slidable within the outer housing responsive to fluid pressure at either end thereof.

[0039] While FIGS. 4A and 4B depict the channels (34) as generally elongate, curved openings extending through the length of the inner piston (26), it should be understood that the inner piston (26) can include any number and configuration of channels (34). For example, FIGS. 5A, 5B, and 5C depict an alternate embodiment of an inner piston (26), having channels (34) formed as notches and/or flutes within the exterior surface thereof. Specifically, FIG. 5A depicts an end view of the inner piston (26), within which the central bore (66) is visible. FIG. 5B depicts a side view of the inner piston (26), and FIG. 5C depicts a perspective view thereof. Formation of flutes and/or notches within the exterior surface of the inner piston (26) facilitates ease of manufacture, while also accommodating a greater fluid flow than drilled holes or similar, restrictive channels therethrough.

[0040] Referring now to FIGS. 6A and 6B, a diagrammatic cross-sectional view of an embodiment of a plunger valve (14) is shown, having an inner piston (36) movable within an outer housing (38). The outer housing (38) is shown having interior threads (22) for securing the plunger valve (14) to a plunger rod or similar connecting member, such that the plunger valve (14) is movable concurrent with reciprocation of the connecting member, e.g., through reciprocation of a sucker rod string from the surface. While FIGS. 6A and 6B depict interior threads (22), it should be understood that any manner of securing device, sealing member, fastener, and/or
hold down assembly can be used to secure the plunger valve (14) to the plunger rod. The outer housing (38) is shown having an intake opening (40) and an output opening (42) for accommodating fluid flow through the plunger valve (14), and a bore (68) for accommodating the plunger rod and/or a similar connecting rod. The intake and outtake openings (40, 42) can include any number and any type of orifice, slot, bore, channel, or other manner of opening. While the outer housing (38) is shown as a generally cylindrical structure, it should be understood that the outer housing (38) can have any shape or dimension, and can be formed as a unitary structure or a structure having multiple parts, e.g., a body with an end threadably secured thereto to permit opening of the outer housing (38) to access the inner piston (36). The outer housing (38) can be formed from any generally rigid materials suitable for use within a wellbore environment, such as metal, plastic, and/or one or more polymers or composites.

[0041] The inner piston (36) is shown having a central opening coincident with the bore (68) of the outer housing (38) to permit the passage of the outer housing (38) and sliding movement of the inner piston (36) therein. The inner piston (36) is also shown having one or more channels (44) for permitting fluid flow, and one or more sealing surfaces (70, 72) for abutting against the outer housing (38) to isolate the channels (44) from and/or place the channels (44) into communication with the intake and outtake openings (40, 42), defining a fluid pathway through the plunger valve (14). While the inner piston (36) is shown as a generally cylindrical structure, it should be understood that the inner piston (36) can have any shape or dimension able to fit within the outer housing (38), and can be formed as a unitary structure or a structure having multiple parts. Additionally, while the channels (44) are shown as flutes and/or notches, formed at the exterior of the inner piston (36), it should be understood that any number and type of channels, bores, slots, and/or orifices can be used to flow fluid through any portion of the inner piston (36). The inner piston (36) can be formed from any generally rigid materials suitable for use within a wellbore environment, such as metal, plastic, and/or one or more polymers or composites. In an embodiment, the material of the inner piston (36) can be selected based on the desired weight of the inner piston (36) and/or the desired fluid pressure necessary to move the inner piston (36) to open and/or close the plunger valve (14). For example, the inner piston (36) can be formed from plastic to minimize weight and enable the plunger valve (14) to be operated using a minimum of energy.

[0042] FIG. 6A depicts the plunger valve (14) in a closed position, e.g., during an upstroke of the plunger rod and plunger valve (14). In this position, increased fluid pressure at the upper end of the plunger valve (14), caused in part by movement thereof, imparts a force against the upper surface of the inner piston (36), causing downward movement of the inner piston (36) until the lower sealing surface (72) abuts the lower end of the outer housing (38). In this position, the lower sealing surface (72) prevents communication between the intake opening (40) and the channels (44), thereby preventing the flow of fluid through the plunger valve (14).

[0043] FIG. 6B depicts the plunger valve (14) in an open position, e.g., during a downstroke of the plunger rod and plunger valve (14). In this position, increased fluid pressure at the lower end of the plunger valve (14), caused in part by the movement thereof, imparts a force against the lower surface of the inner piston (36), causing upward movement of the inner piston (36), thereby permitting the flow of fluid through the intake opening (40), the channels (44), and the output opening (42), defining a fluid pathway (74) for accommodating the flow of fluid through the plunger valve (14). The upper sealing surface (70) can isolate the fluid pathway (74) from other regions within the plunger valve (14). While FIGS. 6A and 6B depict upper and lower sealing surfaces (70, 72), it should be noted that any number and type of sealing surfaces throughout the plunger valve (14) to isolate the fluid pathway (74) and/or prevent the flow of fluid when the inner piston (36) is in a closed position. The sealing surfaces (70, 72) can include any manner of sealing member, such as an O-ring or similar compressible member, or a protruding portion of the inner piston (36) that forms a seal through abutment with the inner surface of the outer housing (38).

[0044] Referring now to FIG. 7, an embodiment of the outer housing (38) of a plunger valve is shown. The outer housing (38) is shown as a two-part, cylindrical structure having a lower portion (76) with a central shaft (80) therein, adapted to engage an upper portion (78) via complementary threads (82). It should be understood that a single-piece housing, or an outer housing having more than two parts is also usable within the scope of the present disclosure, and that any means of securing, threaded or otherwise, can be used. The lower portion (76) is shown having intake openings (40) for permitting fluid flow into the outer housing (38), and a bore (68) within which the plunger rod or a similar connecting member can be secured. One or more of holes, notches, bores, and/or orifices (84) are also shown, for enabling the outer housing (38) to be gripped and/or manipulated by a spanner wrench or similar tool. The upper portion (78) is shown having output openings (42), and a central opening (86) coincident with the bore (68) of the lower portion (76) for permitting passage and/or securing the plunger rod.

[0045] The inner piston of the plunger valve may be of similar construction to that of the standing valve, depicted in FIGS. 4A, 4B, 5A, 5B, and 5C, for example, having channels (e.g., holes, slots, notches, and/or flutes) extending therethrough and a central bore or opening to accommodate passage of the central shaft (80) of the outer housing (38) and permit sliding movement of the inner piston therein.

[0046] Referring now to FIGS. 8A and 8B, an embodiment of a valve (88) is shown, which is usable within downhole pumps that include a single valve (e.g., a standing valve), for use in conjunction with a plunger and a pump barrel. The valve (88) is depicted having an inner piston (90) movable within an outer housing (92). The outer housing (92) includes a central shaft (94) with a bore (96) therein for accommodating passage of a plunger rod or similar connecting member. The shaft (94) passes through a bore (98) of the inner piston (90) to retain the inner piston (90) while permitting sliding movement thereof.

[0047] The outer housing (92) is shown having an inlet opening (102) at a first end thereof, and an outlet opening (104) at a second end thereof. The outer housing (92) is further shown having an intake opening (100) in a side surface thereof. The inner piston (90) is shown having flow channels (110) extending between ends thereof, a recession (106) formed in an outer surface thereof, and intake channels (108) extending from the recession (106) to the lower end of the inner piston (90). Upper and lower sealing surfaces (112, 114) shown on the inner piston (90) are usable to isolate the channels (108, 110) from the inlet and outlet openings (102, 104), depending on the position of the inner piston (90) within the outer housing (92).
Specifically, FIG. 8A depicts the valve (88) during a downstroke of a plunger and/or connecting rod, enabling the flow of fluid from the exterior of the valve (88) (e.g., within a production zone), through the valve (88), and into a pump barrel. As the plunger is moved in a downward direction, fluid pressure at the upper end of the inner piston (90) can cause the inner piston (90) to move in a downward direction until the lower sealing surface (114) abuts the outer housing (92). The recession (106) of the inner piston (90) is thereby aligned with the intake opening (100) in the side surface of the outer housing (92), enabling fluid to pass through the intake opening (100) into the recession (106), then flow through the intake channels (108) and the inlet opening (102) into a pump barrel disposed beneath the valve (88).

FIG. 8B depicts the valve (88) during an upstroke of a plunger and/or connecting rod, enabling the flow of fluid from a pump barrel beneath the valve (88) through the valve (88) and into production tubing or a similar conduit above the valve (88). As the plunger is moved in an upward direction, fluid pressure at the lower end of the inner piston (90) can cause the inner piston (90) to move in an upward direction until the upper sealing surface (112) abuts the outer housing (92), thereby preventing reverse-flow of fluid through the intake channels (108) and intake opening (100), while permitting fluid to flow from the pump barrel through inlet opening (102) and flow channels (110) of the inner piston (90), then through the outlet opening (104) of the outer housing (92) into an adjacent conduit (e.g., production tubing).

Referring now to FIGS. 9A and 9B, a diagrammatic cross-sectional view of an embodiment of a downhole pump (116) usable within the scope of the present disclosure is shown. Generally, the downhole pump (116) includes a valve (88), such as that depicted in FIGS. 8A and 8B, a pump barrel (118) secured to the valve (88), e.g., through use of a threaded connection, fasteners or securing devices, hold down assemblies, sealing members, welding, or other similar methods of connection, and a plunger (124) disposed with the pump barrel (118) and secured to a string of connecting members (126) that extends through the valve (88). The downhole pump (116) is shown secured at a lower end of a conduit (120), such as a string of production tubing, using a securing assembly (122), which can include various sealing members, hold-down assemblies, packers, welding, threaded connections, or similar devices as known in the art.

Specifically, FIG. 9A depicts the downhole pump (116) during a downstroke of the plunger (124), such that fluid pressure within the valve (88) causes movement of the inner piston (90) toward a lowered position, as shown. FIG. 9B depicts the downhole pump (116) during an upstroke of the plunger (124), such that fluid pressure within the valve (88) causes movement of the inner piston (90) toward a raised position, as shown.

During operation, the string of connecting members (126) (e.g., a string of sucker rods or similar connecting members) can be reciprocated using a pump jack or similar surface device, causing movement of the plunger (124) within the pump barrel (118). This movement can generate fluid pressure that causes the inner piston (90) to move in a manner that defines an inlet passage, as described previously, enabling the flow of fluid from the exterior of the valve (88) to flow into the pump barrel (118) along the flow path (128). During an upstroke of the plunger (124), the inner piston (90) is moved to define an outlet passage, as described previously, enabling the flow of fluid from the pump barrel (118) through the valve (88) and into the conduit (120) along the flow path (130).

It should be understood that while FIGS. 9A and 9B depict the pump barrel (118) secured in a downhole direction relative to the valve (88), with the plunger (124) disposed within the pump barrel (118), other configurations are also usable to cause reciprocation of the inner piston (90) within the outer housing (92). For example, the inner piston (90) and/or the outer housing (92) could be inverted, the plunger (124) and/or the pump barrel (118) could be secured in an uphole direction relative to the valve, or combinations thereof. In an alternate embodiment, the plunger (124) can be secured in a fixed position relative to the conduit (120), e.g., through use of threaded connections and/or other types of securing assemblies, such that reciprocation of the string of connecting rods (126) causes movement and reciprocation of the valve (118) about the plunger (124), thereby causing movement of the inner piston (90) within the outer housing (92).

Referring now to FIG. 10, a diagrammatic view of an embodiment of a downhole pump is shown in which the outer housing (28) and inner piston (26) of a first valve, the outer housing (38) and inner piston (36) of a second valve, and a pump barrel have been lowered through a conduit string (10) (e.g., as a single unit in the manner of an insertion pump), then secured in a desired position relative to the conduit string (10) using a securing assembly (122). A string of connecting rods (20), which can include an integral or separate plunger rod at the lower end thereof, extends through the outer housing (28) and inner piston (26) of the first valve, connecting the outer housing (38) and/or the inner piston (36) of the second valve to a pump jack (130) or similar reciprocating apparatus at the surface. As known in the art, the pump jack (130) can engage the string of connecting rods (20) via a polished rod, stuffing box, and/or other surface equipment (not shown). Reciprocation of the string of connecting rods (20) by the pump jack (130) causes reciprocation of the outer housing (38) and inner piston (36) of the second valve within the barrel (16), which reciprocates the inner pistons (26, 36) of both valves through changes in fluid pressure.

As described previously, each stroke of the pump jack (130) and thereby, each stroke of the inner pistons (26, 36) can draw fluid from the exterior of the pump barrel (16) through the second valve and into the pump barrel (16), and from the pump barrel (16) through the first valve and into the conduit string (120), and move fluid upward through the conduit string (10). Also, as described above, it should be noted that reciprocation of the second valve can cause movement of one or both inner pistons (26, 36) independent of its placement or its movement relative to the first valve. As such, in alternate embodiments, the second valve could be disposed in an uphole direction relative to the first valve, and/or the second valve could be secured in a fixed position relative to the conduit string (10) while the pump barrel (16) and/or the first valve is reciprocated by the pump jack (130).

Additionally, while FIG. 10 depicts the pump jack (130) coupled to a downhole pump similar to that shown in FIGS. 1A and 1B, for illustrative purposes, it should be readily understood that a downhole pump similar to that shown in FIGS. 9A and 9B is also usable in the manner described above.

Embodiments described herein thereby provide downhole pumps and methods having a minimum of moving
parts, that can provide an improved flow capacity over that of conventional downhole pumps.

[0058] While various embodiments of the present invention have been described with emphasis, it should be understood that within the scope of the appended claims, the present invention might be practiced other than as specifically described herein.

What is claimed is:

1. A downhole pump for producing fluids from a well bore, the pump comprising:
   - a stationary valve comprising an outer housing with an inlet opening and an outlet opening and an inner piston movably within the outer housing, wherein the inner piston includes a channel extending therethrough;
   - a barrel engaged with the stationary valve; and
   - a plunger valve disposed within the barrel and engaged with a connecting rod that extends through a bore in the stationary valve, wherein the plunger valve comprises a plunger housing with an intake opening and an output opening and a plunger piston movably within the plunger housing, wherein the plunger piston includes a plunger channel extending therethrough,
   wherein the inner piston is movable between a first position in which the channel is in communication with the inlet opening and a second position in which the channel is isolated from communication with at least one of the inlet opening and the outlet opening, and wherein the plunger piston is movable between an open position in which the plunger channel is in communication with the intake opening and the output opening to define a plunger fluid pathway and a closed position in which the plunger channel is isolated from communication with at least one of the intake opening and the output opening.

2. The downhole pump of claim 1, further comprising at least one securing member engaging the connecting rod, the plunger valve, or combinations thereof for retaining the plunger valve in a fixed position relative to the connecting rod.

3. The downhole pump of claim 1, wherein the outer housing of the stationary valve further comprises a securing member for retaining the outer housing of the stationary valve and the barrel in a fixed position for facilitating reciprocation of the plunger valve.

4. The downhole pump of claim 1, further comprising a securing member for retaining the plunger valve in a fixed position for facilitating reciprocation of the barrel.

5. The downhole pump of claim 1, wherein the lower end of the inner piston of the stationary valve comprises a sealing surface for isolating the outlet opening from the channel, the plunger piston comprises a sealing surface for isolating the output opening from the plunger channel, or combinations thereof.

6. A method for producing fluids from a well bore, the method comprising the steps of:
   - lowering a downhole pump into the wellbore, wherein the downhole pump comprises a stationary valve engaged with a conduit and a barrel, and a plunger valve within the barrel, wherein the stationary valve comprises a standing housing and a standing piston, and wherein the plunger valve comprises a plunger housing and a plunger piston;
   - causing movement of the plunger valve in a first direction relative to the barrel, thereby moving the plunger piston into an open position that enables flow of fluid through the plunger valve into the barrel and moving the standing piston into a closed position that prevents flow of fluid from the conduit into the barrel; and
   - causing upward movement of the plunger valve in a second direction relative to the barrel, thereby moving the plunger piston into a closed position that prevents flow of fluid through the plunger valve and moving the standing position into an open position that enables flow of fluid from the barrel through the stationary valve and into the conduit.

7. The method of claim 6, wherein the step of lowering the downhole pump into the wellbore comprises engaging a string of connecting members to the downhole pump and inserting the downhole pump through the conduit by extending successive joints of the string of connecting members into the wellbore to position the downhole pump a selected position for production of fluid.

8. The method of claim 6, wherein the step of lowering the downhole pump into the well bore comprises engaging a securing member within the wellbore to retain the standing housing or the plunger housing in a fixed position relative to the conduit.

9. The method of claim 6, wherein the step of causing movement of the plunger valve in the first direction relative to the barrel, the step of causing movement of the plunger valve in the second direction relative to the barrel, or combinations thereof, comprises reciprocating a connecting member engaged with the downhole pump to cause movement of the plunger valve within the barrel, thereby displacing fluid to cause movement of the plunger piston and the standing piston.

10. The method of claim 6, wherein the step of causing movement of the plunger valve in the first direction relative to the barrel, the step of causing movement of the plunger valve in the second direction relative to the barrel, or combinations thereof, comprises reciprocating a connecting member engaged with the downhole pump to cause movement of the barrel about the plunger valve, thereby displacing fluid to cause movement of the plunger piston and the standing piston.

11. A downhole pump for producing fluid from a well bore, the pump comprising:
   - a stationary valve;
   - a barrel engaged with the stationary valve; and
   - a plunger disposed within the barrel and engaged with a connecting rod extending through a bore in the stationary valve,
   wherein the stationary valve comprises an outer housing with an inlet opening and an outlet opening and an inner piston movable within the outer housing, wherein the inner piston includes a channel extending therethrough, and wherein the inner piston is movable between a first position in which the channel is in communication with the inlet opening and the outlet opening to define a fluid pathway and a second position in which the channel is isolated from communication with at least one of the inlet opening and the outlet opening; and
   wherein movement of the plunger relative to the barrel causes movement of the inner piston between the first position and the second position.
12. The downhole pump of claim 11, wherein the plunger comprises:

a plunger valve having an outer housing and an inner piston movable within the outer housing, wherein the outer housing comprises a first end having an inlet opening and a second end having an outlet opening, wherein the inner piston comprises an upper end, a lower end, and a channel and a bore extending between the upper end and the lower end, wherein the inner piston is movable between a first position in which the channel is in communication with the inlet opening and the outlet opening to define a fluid pathway and a second position in which the channel is isolated from communication with at least one of the inlet opening and the outlet opening, wherein downward movement of the plunger relative to the barrel causes movement the inner piston of the plunger valve toward the first position and further causes movement of the inner piston of the stationary valve toward the second position, thereby permitting fluid flow into the barrel through the fluid pathway of the plunger valve while preventing fluid flow through the stationary valve, and

wherein upward movement of the plunger relative to the barrel causes movement of the inner piston of the plunger valve toward the second position and further causes movement of the inner piston of the stationary valve toward the first position, thereby permitting fluid flow from the barrel through the fluid pathway of the plunger valve while preventing fluid flow through the stationary valve.

13. The downhole pump of claim 12, further comprising at least one securing member engaging the connecting rod, the plunger valve, or combinations thereof for retaining the plunger valve in a fixed position relative to the connecting rod.

14. The downhole pump of claim 12, wherein the outer housing of the stationary valve further comprises a securing member for retaining the outer housing of the stationary valve and the barrel in a fixed position for facilitating reciprocation of the plunger valve.

15. The downhole pump of claim 12, further comprising a securing member for retaining the plunger in a fixed position for facilitating reciprocation of the barrel.

16. The downhole pump of claim 12, wherein the lower end of the inner piston of the stationary valve, the lower end of the inner piston of the plunger valve, or combinations thereof, comprise a sealing surface for isolating the outlet opening from the channel.

17. The downhole pump of claim 11, wherein the outer housing of the stationary valve further comprises a side surface having an intake opening, wherein the inner piston further comprises an outer surface having a recession formed therein and an intake channel extending from the recession to the lower end of the inner piston.

wherein downward movement of the plunger relative to the barrel causes movement of the inner piston within the outer housing to align the recession with the intake opening, thereby defining an intake passage from the intake opening through the intake channel and the intake opening for permitting flow of fluid into the barrel, and

wherein upward movement of the plunger relative to the barrel causes movement of the inner piston to define an outlet passage from the inlet opening through the channel and the outlet opening for permitting flow of fluid from the barrel through the stationary valve.

18. The downhole pump of claim 17, wherein the lower end of the inner piston comprises a sealing surface for engaging a surface of the second end of the outer housing to isolate the intake channel from the fluid pathway.

19. The downhole pump of claim 17, wherein the upper end of the inner piston comprises a sealing surface for engaging a surface of the first end of the outer housing to isolate the fluid pathway.

20. The downhole pump of claim 17, wherein the second end of the outer housing further comprises a securing member for retaining the outer housing and barrel in a fixed position for facilitating reciprocation of the plunger.

21. The downhole pump of claim 17, further comprising a securing member for retaining the plunger in a fixed position for facilitating reciprocation of the barrel.

22. A method for producing fluid from a well bore, the method comprising the steps of:

engaging a valve with a barrel, wherein the valve comprises an outer housing and an inner piston movable within the outer housing, wherein the barrel comprises a plunger disposed therein, and wherein the plunger is engaged with a connecting member that extends through the barrel and valve;

lowering the valve and the barrel through a conduit into the well bore;

engaging the connecting member with a device adapted to impart motion to the connecting member;

 imparting motion to the connecting member to cause downward movement of the plunger relative to the barrel, thereby moving the inner piston to a first position that enables flow of fluid through the valve into the barrel; and

 imparting motion to the connecting member to cause upward movement of the plunger relative to the barrel, thereby moving the inner piston to a second position that enables flow of fluid from the barrel through the valve to the conduit.

23. The method of claim 22, wherein the step of engaging the valve with the barrel comprises threadably connecting a lower end of the outer housing to an upper end of the barrel.

24. The method of claim 22, wherein the step of lowering the valve and the barrel through the conduit into the well bore comprises extending successive joints of the connecting member into the well bore to position the valve and the barrel at a selected position for production of fluid.

25. The method of claim 22, wherein the step of lowering the valve and the barrel through the conduit into the well bore further comprises engaging a securing member within the wellbore to retain an upper end of the outer housing or the plunger in a fixed position relative to the conduit.

26. The method of claim 22, wherein the step of imparting motion to the connecting member comprises reciprocating the connecting member using the device disposed above the wellbore to cause movement of the plunger within the barrel, thereby displacing fluid to cause movement of the inner piston.
27. The method of claim 22, wherein the step of imparting motion to the connecting member comprises reciprocating the connecting member using the device disposed above the wellbore to cause movement of the barrel about the plunger, thereby causing displacement of fluid to impart movement to the inner piston.

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