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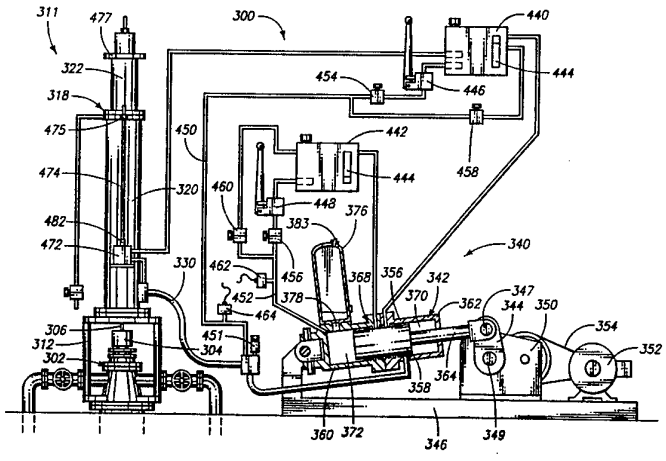
(57) Abstract

A hydraulic oil well pump drive system (100) for driving an oil well sucker rod (not shown) includes a master piston (158) positioned within a master cylinder (156) for axial displacement between first and second ends of the master cylinder (156). The master piston (158) has a piston drive rod (164) which extends through one end of the master cylinder (156). The drive rod (164) is connected to a crankpin (147) of an eccentric crank (144). The eccentric crank (144) is driven at a constant rotational speed to reciprocate the master piston (158) within the master cylinder (156) at a sinusoidal rate. A center seal assembly (168) divides the master cylinder (156) into a working chamber (170) and a pressure chamber (172) in opposite ends of the master cylinder (156). Each respective chamber defines a fluid volume which varies with the displacement of the master piston (158). The master piston (158) displacement creates a bi-directional flow of working fluid from the working chamber (170). A wellhead hydraulic assembly (111) is operably connected to the oil well sucker rod and is in fluid communication with the master cylinder working chamber (170) to receive the working fluid flow. The wellhead hydraulic assembly (111) is responsive to the working fluid flow to reciprocate an oil well sucker rod at a rate which relates to the rate of master piston (158) displacement. A gas accumulator (176) is in fluid communication with the master cylinder pressure chamber (172) to bias the master piston (158) toward the master cylinder working end, providing an upward biasing force at the wellhead hydraulic assembly (111).



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AMENDED CLAIMS

[received by the International Bureau on 3 February 1994 (03.02.94);
original claims 1-61 replaced by new claims 1-25;
original claims 62-72 replaced by new claims 26-37 (10 pages)]

1. A hydraulic oil well pump drive system for driving an oil well sucker rod, the drive system comprising:

a wellhead hydraulic assembly (311) for operable connection to the oil well sucker rod to reciprocally displace the sucker rod;

a master hydraulic source (340) in closed fluid communication with the wellhead hydraulic assembly to form a closed hydraulic system, the closed hydraulic system containing a volume of working fluid; the master hydraulic source being of a type which produces an alternating bi-directional flow of the working fluid to and from the wellhead hydraulic assembly to reciprocally displace the sucker rod between upper and lower extremes, said lower extreme of sucker rod displacement being determined at least in part by the volume of the working fluid contained within the closed hydraulic system;

a fluid injector (472) which is positioned to be actuated by downward displacement of the sucker rod beyond a lower limit, the fluid injector being connected to inject additional working fluid into the volume contained by the closed hydraulic system to raise the lower extreme of sucker rod displacement when the fluid injector is actuated.

2. An oil well pump drive system in accordance with claim 1, wherein the master hydraulic source comprises:

a master cylinder (356);

a master piston (358) positioned within the master cylinder for reciprocal motion to produce the alternating bi-directional working fluid flow.

3. An oil well pump drive system in accordance with claim 1, the wellhead hydraulic assembly including an actuator (474, 477) positioned to actuate the fluid injector upon said downward displacement of the sucker rod beyond the lower limit.

4. An oil well pump drive system in accordance with claim 1, the wellhead hydraulic assembly (311) including an actuator (474, 477) which is mounted for movement with the sucker rod and which is positioned to actuate the fluid injector upon said downward displacement of the sucker rod beyond the lower limit.

5. An oil well pump drive system in accordance with claim 1, the fluid injector comprising a mechanically-driven injector pump; the wellhead hydraulic assembly including a pump driver (474, 477) which is mounted for movement with the sucker rod and which is positioned to drive the injector pump upon said downward displacement of the sucker rod beyond the lower limit.

6. A hydraulic oil well pump drive system in accordance with claim 1, wherein:

the wellhead hydraulic assembly comprises a wellhead slave cylinder and piston assembly;

the master hydraulic source comprises a master cylinder (356) and a master piston (358), the master piston being positioned within the master cylinder for reciprocal motion to thereby produce the alternating bi-directional flow of the working fluid, the wellhead slave cylinder and piston assembly being responsive to the alternating bi-directional flow of working fluid to reciprocally displace the sucker rod.

7. An oil well pump drive system in accordance with claim 6, the master hydraulic source further comprising:

a frame (346);

the master cylinder being pivotally connected to the frame;

a piston drive rod (364) connected to the master piston;

a drive crank (344) rotatably mounted on the frame, the drive crank having a crank pin (347) which is connected to the piston drive rod to reciprocate the master piston within the master cylinder.

8. An oil well pump drive system in accordance with claim 1 or 6, further comprising a gas accumulator (376) connected outside of the closed hydraulic system to apply a biasing force to the master piston and to thereby assist in producing upward displacement of the sucker rod.

9. An oil well pump drive system in accordance with claim 1 or 6, wherein the closed hydraulic system does not include a pressure accumulator.

10. A hydraulic oil well pump drive system for driving an oil well sucker rod, the drive system comprising:

a drive assembly frame (346);

a master cylinder (356);

a master piston (358) which is received within the master cylinder for axial reciprocation;

a piston drive rod (364) connected to the master piston, the piston drive rod being maintained in axial alignment with the master cylinder and master piston, the piston drive rod extending axially from the master cylinder;

the master cylinder and the piston drive rod each having a pivotable connection;

a crank assembly (344) connected to the drive assembly frame;

a first of the pivotable connections being pivotably connected to the drive assembly frame;

a second of the pivotable connections being pivotably connected to the crank assembly to reciprocate the master piston relative to the master cylinder and to thereby produce a bi-directional working fluid flow to and from the master cylinder to reciprocally displace the sucker rod between upper and lower extremes, the upper and lower extremes defining a sucker rod stroke length;

the pivotal connections allowing the master cylinder to pivot angularly in relation to the drive assembly frame during reciprocation of the master piston relative to the master cylinder.

11. An oil well pump drive system in accordance with claim 10, further comprising a center seal assembly (368) within the master cylinder, the center seal assembly being mounted in a fixed axial position relative to the master cylinder, the master piston being slidably received through the center seal assembly.

12. An oil well pump drive system in accordance with claim 10, wherein the master piston defines a pressure chamber (372) and a working chamber (370) in opposite ends of the master cylinder, each respective chamber defining a fluid volume which varies with the reciprocation of the master piston; the oil well pump drive system further comprising:

a gas chamber (376) in fluid communication with the master cylinder pressure chamber, the gas chamber containing a pressurized gas which biases the master piston toward the master cylinder working chamber.

13. A hydraulic oil well pump drive system for driving an oil well sucker rod, the drive system comprising:

a master hydraulic cylinder (356) having first and second opposite axial ends;

a master piston (358) positioned for axial reciprocation within the master cylinder, the master piston defining a working chamber (370) and a pressure chamber (372) in the opposite ends, respectively, of the master cylinder;

a pressure end hydraulic seal (402), the pressure end hydraulic seal surrounding the master piston to restrict fluid passage from the pressure chamber of the master cylinder;

a working end hydraulic seal (404) spaced axially toward the master cylinder working chamber from the pressure end hydraulic seal, the working end hydraulic seal surrounding the master piston to restrict fluid passage from the working chamber of the master cylinder; and

a dividing seal (406, 407) surrounding the master piston between the pressure end hydraulic seal and the working end hydraulic seal, the dividing seal defining a pressure end seal gap between the dividing seal and the pressure end hydraulic seal, the dividing seal defining a working end seal gap between the dividing seal and the working end hydraulic seal.

14. An oil well pump drive system in accordance with claim 13, further comprising:

a working end fluid reservoir (440) in fluid communication with the working end seal gap to receive fluid which leaks past the working end hydraulic seal from the working chamber.

15. An oil well pump drive system in accordance with claim 13, further comprising:

a working end fluid reservoir (440) in fluid communication with the working end seal gap to receive fluid which leaks past the working end hydraulic seal from the working chamber; and

a working end fluid injector (472) to inject fluid from the working end fluid reservoir into the working chamber.

16. An oil well pump drive system in accordance with claim 13, further comprising:

a working end fluid reservoir (440) in fluid communication with the working end seal gap to receive fluid which leaks past the working end hydraulic seal from the working chamber; and

a working end fluid injector (472) which is responsive to excessive downward sucker rod displacement to inject fluid from the working end fluid reservoir into the working chamber.

17. An oil well pump drive system in accordance with claim 13, further comprising a pressure end fluid reservoir (442) in fluid communication with the pressure end seal gap to receive fluid which leaks past the pressure end hydraulic seal from the pressure chamber.

18. An oil well pump drive system in accordance with claim 13, further comprising:

a pressure end fluid reservoir (442) in fluid communication with the pressure end seal gap to receive fluid which leaks past the pressure end hydraulic seal from the pressure chamber; and

a pressure end fluid injector (448) to inject fluid from the pressure end fluid reservoir into the master cylinder pressure chamber.

19. An oil well pump drive system in accordance with claim 13, further comprising:

a pressure end fluid reservoir (442) in fluid communication with the pressure end seal gap to receive fluid which leaks past the pressure end hydraulic seal from the pressure chamber;

a fluid level indicator (444) in the pressure end fluid reservoir, the fluid level indicator showing the leaked fluid volume received from the pressure chamber; and

a pressure end fluid injector (448) to inject fluid from the pressure end fluid reservoir into the master cylinder pressure chamber when the leaked fluid volume from the pressure chamber exceeds a predetermined limit.

20. An oil well pump drive system in accordance with claim 13, further comprising a gas chamber (376) in fluid communication with the master cylinder pressure chamber, the gas chamber containing a pressurized gas which biases the master piston toward the master cylinder working chamber.

21. An oil well pump drive system in accordance with claim 13, further comprising:

a working end fluid reservoir (440) in fluid communication with the working end seal gap to receive fluid which leaks past the working end hydraulic seal from the working chamber; and

a pressure end fluid reservoir (442) in fluid communication with the pressure end seal gap to receive fluid which leaks past the pressure end hydraulic seal from the pressure chamber.

22. A hydraulic oil well pump drive system in accordance with claim 13, further comprising:

a seal retaining ring (408) within the master cylinder, the seal retaining ring having an inner periphery which is complementary in diameter to the master piston to slidably receive the master piston therethrough, the seal retaining ring having an annular groove (410) about its inner periphery;

the dividing seal being received within the retaining ring annular groove;

the pressure end and working end hydraulic seals being spaced from opposite sides of the dividing seal;

a pressure end fluid passage (420) extending from the inner periphery of the seal retaining ring between the dividing seal and the pressure end hydraulic seal; and

a working end fluid passage (422) extending from the inner periphery of the seal retaining ring between the dividing seal and the working end hydraulic seal.

23. An oil well pump drive system in accordance with claim 22, the master piston having a piston drive rod (364) which extends through one end of the master cylinder.

24. An oil well pump drive system in accordance with claim 22, further comprising a fluid reservoir (440, 442) in fluid communication with one of the fluid passages to receive leaked fluid.

25. An oil well pump drive system in accordance with claim 22, further comprising one or more fluid reservoirs (440, 442) in fluid communication with the fluid passages to receive leaked fluid.

26. A wellhead transfer pump assembly for operation at a wellhead, the wellhead including a reciprocating sucker rod within a production tube, the transfer pump comprising:

a pump chamber (750) which is connectable for fluid communication with the production tube;

a pump piston (708) in the pump chamber, the pump piston being operably connected to reciprocate in synchronization with the reciprocating sucker rod;

an inlet check valve (751) positioned between the production tube and the pump chamber to allow oil into the pump chamber from the well production tube and to prevent passage of oil from the pump chamber back into the well production tube;

wherein oil flows from the production tube, through the check valve, and into the pump chamber during sucker rod upstrokes; and wherein the pump piston forces oil out of the pump chamber and into an oil production output line during sucker rod downstrokes.

27. A wellhead transfer pump assembly in accordance with claim 26, and further comprising an outlet check valve (757) to allow oil to be pumped into the oil production output line from the pump chamber and to prevent passage of oil back into the pump chamber from the oil production output line.

28. A wellhead transfer pump assembly in accordance with claim 26, further comprising:

a polished rod (736) which extends upward from the sucker rod, the polished rod being connected to the pump piston for reciprocal motion with the pump piston.

29. A wellhead transfer pump assembly in accordance with claim 26, further comprising:

a polished rod (736) which extends upward from the sucker rod and through the pump chamber; and

the polished rod being connected to and extending upward through the pump piston, the polished rod being reciprocally driven at its upper end to reciprocate the pump piston and the sucker rod.

30. A wellhead transfer pump assembly in accordance with claim 26, further comprising:

a working chamber (712) which receives a working fluid flow, the working chamber being connected to and axially aligned with the pump chamber, the working chamber and pump chamber being mountable to the wellhead;

a slave piston (708) received within the cylindrical working chamber for axial reciprocation in response to the working fluid flow, the slave piston having a pump portion which extends from the working chamber into the pump chamber to form the pump piston;

a hydraulic seal (732) which surrounds the slave piston to seal the working chamber from the pump chamber; and

a polished rod (736) which extends upward from the sucker rod, the polished rod being connected to the slave piston to reciprocate with the slave piston and to drive the sucker rod.

31. A wellhead transfer pump assembly in accordance with claim 30, wherein the polished rod extends coaxially through the working chamber and the pump chamber, the polished rod being driven by the slave piston.

32. A wellhead transfer pump assembly in accordance with claim 30, wherein the polished rod extends coaxially through the working chamber and the pump chamber, the polished rod being connected to and extending upward coaxially through the slave piston to be driven by the slave piston.

33. A wellhead transfer pump assembly for operation at a wellhead, the wellhead including a reciprocating sucker rod within a production tube, the transfer pump comprising:

a pump chamber (750) having an internal volume which is connectable for fluid communication with the production tube;

a pump piston (708) in the pump chamber, the pump piston being operably connected to reciprocate in synchronization with the reciprocating sucker rod to vary the internal volume of the pump chamber, the pump piston being positioned to increase the internal volume of the pump chamber during sucker rod upstrokes and to decrease the internal volume of the pump chamber during sucker rod downstrokes;

an inlet check valve (751) positioned between the production tube and the pump chamber to allow oil into the pump chamber from the well production tube and to prevent passage of oil from the pump chamber back into the well production tube;

wherein oil flows from the production tube, through the check valve, and into the pump chamber during sucker rod upstrokes; and wherein the pump piston forces oil out of the pump chamber and into an oil production output line during sucker rod downstrokes.

34. A wellhead hydraulic assembly for operable connection to an oil well sucker rod, the wellhead hydraulic assembly comprising:

a cylindrical working chamber (712) which receives a working fluid flow;

a cylindrical pump chamber (750) which is connected to and axially aligned with the working chamber, the working chamber and pump chamber being mountable to the wellhead, the pump chamber being connectable for fluid communication with a well production tube and with an oil production output line;

a slave piston (708) received within the cylindrical working chamber for axial reciprocation in response to the working fluid flow, the slave piston having a pump portion which extends from the working chamber into the pump chamber;

a hydraulic seal (732) which surrounds the slave piston to seal the working chamber from the pump chamber;

a polished rod (736) which extends upward from the oil well sucker rod, the polished rod being connected to the slave piston to reciprocate with the slave piston;

an inlet check valve (751) positioned between the production tube and the pump chamber to allow oil into the pump chamber from the well production

tube and to prevent passage of oil from the pump chamber back into the well production tube;

wherein oil flows from the production tube, through the check valve, and into the pump chamber during sucker rod upstrokes; and wherein the pump piston forces oil out of the pump chamber and into an oil production output line during sucker rod downstrokes.

35. A wellhead hydraulic assembly in accordance with claim 34, and further comprising an outlet check valve (757) to allow oil to be pumped into the oil production output line from the pump chamber and to prevent passage of oil back into the pump chamber from the oil production output line.

36. A wellhead hydraulic assembly in accordance with claim 34, wherein the polished rod extends coaxially through the working chamber and the pump chamber, the polished rod being driven by the slave piston.

37. A wellhead hydraulic assembly in accordance with claim 34, wherein the polished rod extends coaxially through the working chamber and the pump chamber, the polished rod being connected to and extending upward coaxially through the slave piston to be driven by the slave piston.