Aug. 28, 1962 J. R. LILES, JR., ET AL 3,051,237

APPARATUS FOR VARYING WELL PUMP STROKE

Filed Jan. 30, 1961 2 Sheets-Sheet 1

FIG. 1.

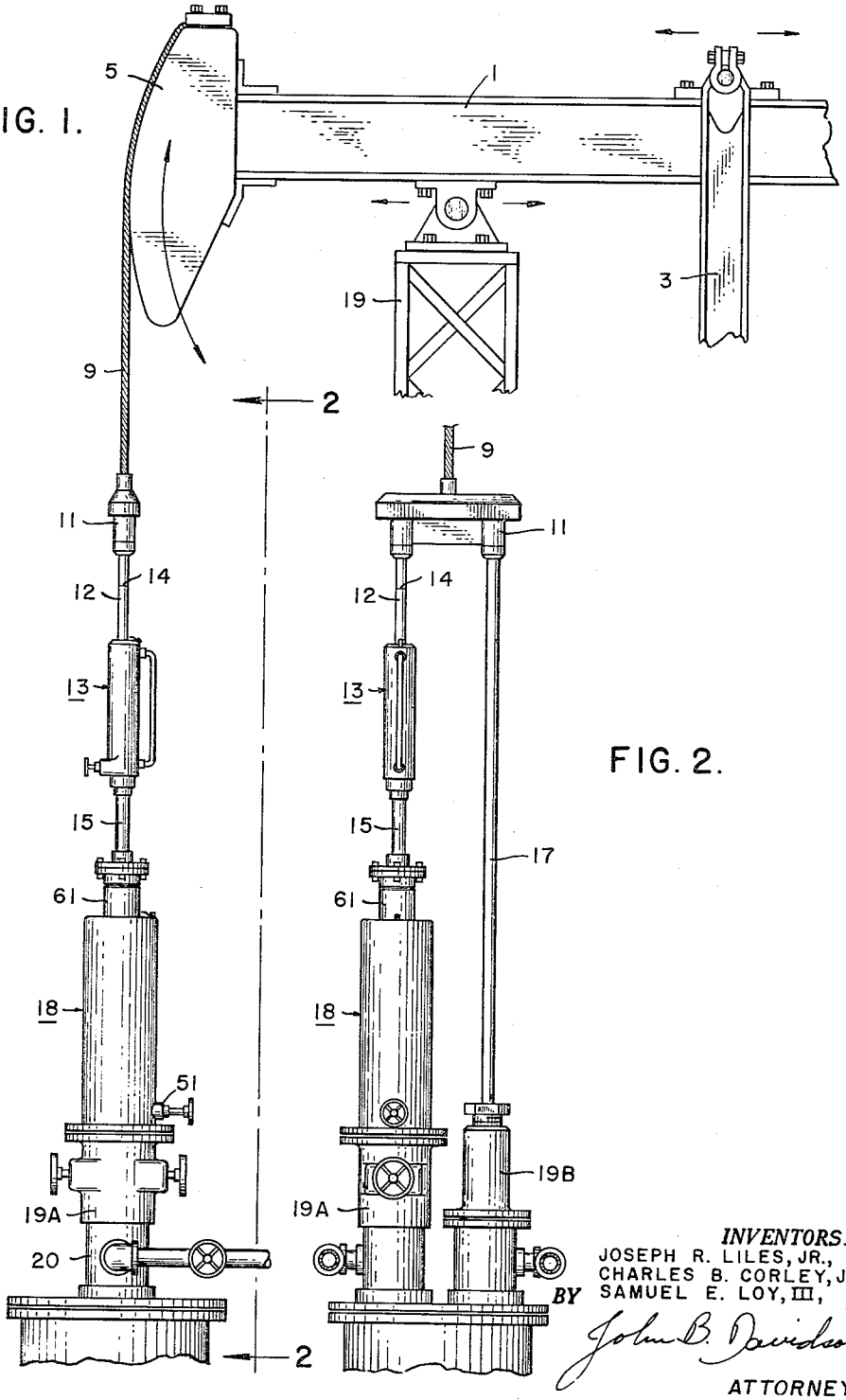

FIG. 2.

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Filed Jan. 30, 1961 2 Sheets-Sheet 2

FIG. 3.

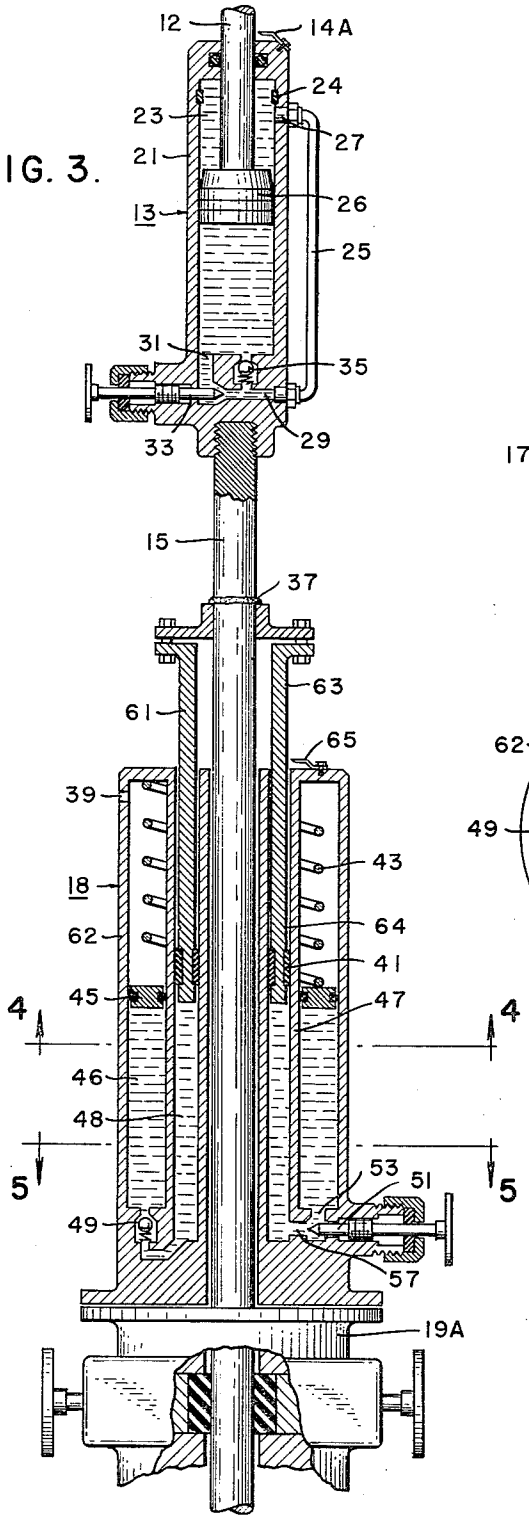
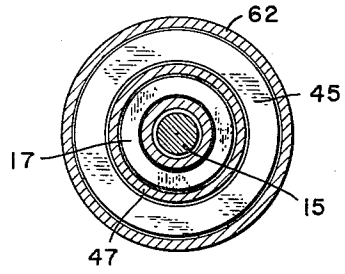


FIG. 4.



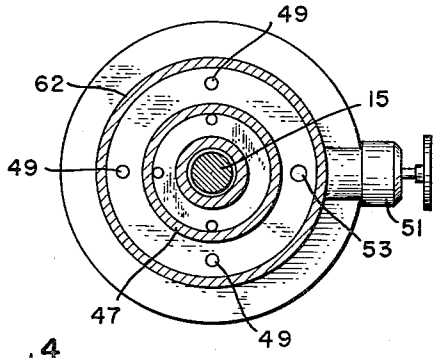


FIG. 5.

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United States Patent Office 3,051,237 Patented Aug. 28, 1962

3,051,237 APPARATUS FOR VARYING WELL PUMP STROKE

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Filed Jan. 30, 1961, Ser. No. 85,889
4 Claims. (Cl. 166—75)

This invention relates to the pumping of well liquids to the earth's surface, and more particularly to a system for varying the stroke of a reciprocating downhole pump while maintaining constant the stroke of a pump actuating apparatus at the earth's surface.

Various types of artificial lift are used to bring well liquids to the earth's surface when pressures in an oil reservoir have fallen to the point where a well will not produce liquids by natural reservoir energy. A usual type of pumping apparatus involves the use of a downhole rod pump located at the bottom end of a tubing string, and reciprocably driven therein through a sucker rod string by a prime mover at the earth's surface. The prime mover may be a pump jack or a hydraulic-powered sucker rod pump, such as are described at pages 21–23 of the booklet "Primer of Oil and Gas Production," published by the American Petroleum Institute (1954).

When it is desired to artificially lift fluids from two or more earth formations by means of separate flow tubing strings in a common borehole, it is the usual practice to use separate drive mechanisms at the earth's surface to drive the downhole pumps. One reason for this practice is that usually it is desirable to have different stroke lengths for the traveling valves of the pumps. Manifestly, it is preferable to use a single pump jack or hydraulic-powered drive mechanism in order to minimize the initial cost of the pumping system and also to minimize maintenance expenses.

The present invention contemplates the use of an apparatus connected between the drive mechanism and the polished rod that extends through the wellhead, that is adapted to hydraulically vary the ratio of the length of movement of the sucker rod string to the length of movement of the reciprocating portion of the drive mechanism. The apparatus includes a piston connected to the drive mechanism and adapted to reciprocate in a liquid-filled piston cylinder, a flow line and metering valve serially connected between the ends of the piston cylinder to provide restricted liquid flow therebetween when the piston moves from bottom to top of the cylinder, and a check valve hydraulically connected in parallel with the metering valve to provide substantially greater unrestricted flow of liquid when the piston moves from top to bottom of the piston cylinder. For the purpose of retarding the fall of the pump rods so that there can be relative movement between the piston and the cylinder, there is provided first and second additional piston cylinders connected to the well head. These additional piston cylinders are interconnected at the lower ends thereof by valve means adapted to provide restricted liquid flow from the first to the second of the additional piston cylinders, and substantially greater unrestricted flow of liquid from the second to the first additional piston cylinders. A spring-biased piston in the second cylinder is used to force liquid from the second to the first of the additional cylinders. A piston connected to the polished rod extends into the first of the additional cylinders so as to force liquid through the valve means into the second of the additional piston cylinders against the force of the spring-biased piston. Thus, the pump rods can be made to fall at different speeds by varying the flow rate of liquid

from the first to the second additional cylinders and by adjusting the metering valve in the assembly between the first and second additional piston cylinders.

Objects and features of the invention not apparent from the above discussion will become evident upon consideration of the following descriptive matter taken in connection with the accompanying drawings, wherein:

FIG. 1 is an elevational view of a surface pumping apparatus in accordance with the invention;

FIG. 2 is a view of a portion of the apparatus of FIG. 1 as viewed from plane 2—2 of FIG. 1;

FIG. 3 is a cross-sectional view of a portion of the apparatus of FIG. 1 illustrating an embodiment of the invention;

FIG. 4 is a sectional view taken along section 4—4 of FIG. 3; and

FIG. 5 is a sectional view taken along section 5—5 of FIG. 3.

With reference now to FIGS. 1 and 2, there is shown a conventional pump jack type of a surface drive mechanism including a walking beam 1 pivotally affixed to a conventional Samson post 19. A pitman arm 3 is connected between the walking beam 1 and a prime mover such as an internal combustion engine or an electric motor (not shown). A horsehead 5 is connected to the end of the walking beam opposite the pitman arm 3 and the usual counterbalance (not shown).

Wellhead 20, which may be of a conventional design for multiple completions, includes a pair of stuffing boxes 19A and 19B through which individually extends polished rods 15 and 17. The polished rods 15 and 17 are connected to the usual sucker rod strings and downhole pumps (not shown).

The upper end of polished rod 17 is connected to the horsehead bridle cable 9 through a carrier bar 11. The carrier bar 11 is for the purpose of providing a mechanical driving connection between the bridle cable 9 and a plurality of pump actuating rod strings. A drive rod 12 and a stroke compensator apparatus 13 (to be described in detail with reference to FIG. 3) provide mechanical and hydraulic connection between the carrier bar 11 and the polished rod 15.

As illustrated in FIG. 3, the stroke compensator 13 includes a housing 21 for a liquid-tight chamber 23 filled with a suitable noncorrosive liquid such as a light mineral oil. The lower end of the housing 21 is screw-threadedly connected to the polished rod 15. Disposed within the housing 21 is a piston 26 connected to the drive rod 12 extending through the upper end of the housing to the carrier bar 11. The piston 26 is adapted to reciprocate within the piston chamber 23 by virtue of the hydraulic relief provided through port 31, metering valve 33, passageway 29, bypass tube 25, and port 27 in the upper end of the housing. A check valve 35 provides a hydraulic bypass around metering valve 33 from the lower end of chamber 23 to passageway 29. The check valve is adapted to close when the pressure in the upper end of chamber 23 (above piston 26) exceeds the pressure in the lower end of chamber 23. The check valve is adapted to open when the pressure in the lower end of chamber 23 exceeds the pressure in the upper end thereof so as to provide substantially greater unrestricted flow of liquid through the bypass tube 25 when the piston is moving downwardly through the chamber than when the piston is moving upwardly through the chamber. A packing ring 24 is provided within housing 21 to prevent overextension of the drive rod 12. A pointer 14A mounted on housing 21 and a scribed line 14 on drive rod 12 cooperate so as to indicate the desired limit of retraction of drive rod 12 to prevent pounding on the lower end of chamber 23.

Resting on an affixed to the wellhead 20, most con-

veniently on the stuffing box 19A, is a hydraulic polished rod support device 18 including a housing 62 for piston chambers 46 and 48. Most conveniently, the piston chambers 46 and 48 are annular in shape, with the chamber 48 disposed within the chamber 46. Thus, the device 18 may be annular and may include a dividing wall 47 to divide the interior of the housing through piston chambers 46 and 48. Chamber 48 is open-topped, while chamber 46 is closed with a port 39 providing hydraulic relief therefor. Disposed within chamber 46 is an annular free piston 45 biased downwardly by a coil spring 43. An annular sleeve piston 61 is affixed to polished rod 15 above device 18 by a weld 37. The sleeve piston 61 encircles the polished rod 15 and extends downwardly into the chamber 48. A packing 41 is provided to furnish a liquid-tight seal between the sleeve piston 61 and the sides of the chamber 48. It is to be noted that sleeve piston 61 is provided with limit grooves 63 and 64 adjacent the upper and lower ends thereof, and a pointer 65 affixed to housing 62. The pointer and limit grooves insure the sleeve piston is operated within safe limits.

Refer now to FIGS. 3 and 5 in conjunction. At the bottom end of chamber 46 there is provided a port 53 which is hydraulically connected to a port 57 at the bottom of chamber 48 through a metering valve assembly 51. Also provided at the bottom of the chambers 46 and 48 are a plurality of check valves 49 adapted to close when pressure in chamber 48 is greater than the pressure in chamber 46, and adapted to open when the pressure in chamber 46 is greater than that of chamber 48. The check valves 49 are further adapted to provide substantially greater liquid flow rate from chamber 46 to chamber 48 than the liquid flow rate from chamber 48 to chamber 46 through metering valve 51 when the metering valve is adjusted for proper operation.

The operation of the apparatus described above is as follows. Let it be assumed that piston 26 is at the bottom of chamber 23 and that piston 61 extends to the bottom of chamber 48. On the upstroke of the horsehead 5, check valve 35 will be closed and will remain closed. Hydraulic fluid will flow from the upper end of chamber 23 through bypass tube 25 and metering valve 33 into the lower end of chamber 23. Polished rod 15 will rise at a substantially slower rate than will rod 12 because of the hydraulic cushion provided by the stroke compensator 13. As the piston 61 rises with polished rod 15, check valve 49 will open and liquid will flow rapidly into chamber 48. At the top of the stroke of horsehead 5, check valve 49 will close. When the horsehead 5 begins its downstroke, the pressure in the lower end of chamber 23 will open check valve 35 so that liquid will flow rapidly through bypass tube 25. The polished rod 15 will fall relatively slowly because of the metered liquid flow from chamber 48 to chamber 46 through metering valve 51. When the metering valves 33 and 51 are properly adjusted, the piston 26 reaches the bottom of chamber 23 and piston 61 is fully extended into chamber 48 at substantially the same time. Thus, it can be seen that various stroke lengths can be obtained simply by varying the flow rate of liquid through metering valve 33. With each adjustment of metering valve 33, metering valve 51 should be readjusted to insure that the polished rod support device 18 continues to contribute to the proper stroking operation of the stroke compensator 13.

Manifestly, more than two earth formations can be produced through a single wellhead by providing a plurality of sets of stroke compensators 13 and hydraulic polished rod support devices 18, one set for each additional rod string that extends through the wellhead.

The invention is not to be restricted to the specific structural details or arrangement of parts herein set forth, as various modifications thereof may be effected without departing from the spirit and scope of this invention.

The objects and features of the invention having been completely described, what is claimed is:

1. For use in an oil well pumping system including a wellhead, a downhole pump, and a rod string in the well connected to the pump and extending toward the earth's surface, and pump drive apparatus at the earth's surface adapted to impart reciprocating motion to the rod string, the combination comprising:

a polished rod adapted to be connected to the rod string and to extend through the wellhead;

a liquid-filled piston cylinder connected to the upper end of the polished rod;

a piston in said cylinder adapted to be connected to the pump drive apparatus;

a metering valve and a flow line serially connected between the upper and lower ends of said cylinder for metering the flow of liquid from the upper end to the lower end of said cylinder as said piston moves upwardly through the cylinder;

a check valve connected in parallel with said metering valve to bypass said metering valve and thereby permit substantially unrestricted flow of liquid through said flow line from the lower end to the upper end of said cylinder as said piston moves downwardly through the cylinder;

an annular liquid reservoir encircling said polished rod and adapted to be connected to the wellhead;

means including an annular dividing wall in said reservoir, dividing said reservoir into a closed outer chamber and an open-topped inner chamber;

an annular free piston in said outer chamber;

spring means in said outer chamber biasing said annular piston in a downward direction;

an annular sleeve piston affixed to said polished rod and extending into said inner chamber;

an adjustable metering valve hydraulically interconnecting the lower ends of said chambers adapted to meter the flow of liquids therebetween;

a check valve interconnecting the lower ends of said pistons adapted to close when said sleeve piston moves downwardly and to open under the impetus of said spring and annular free piston when said sleeve piston moves upwardly to permit substantially unrestricted flow of liquid from said outer chamber to said inner chamber; and

a relief port in the upper end of said outer chamber.

2. For use in an oil well pumping system including a wellhead, a downhole pump, and a rod string in the well connected to the pump and extending toward the earth's surface, and pump drive apparatus at the earth's surface adapted to impart reciprocating motion to the rod string, the combination comprising:

a polished rod adapted to be connected to the rod string and to extend through the wellhead;

a liquid-filled piston cylinder connected to the upper end of the polished rod;

a piston in said cylinder adapted to be connected to the pump drive apparatus;

a metering valve and a flow line connected between the upper and lower ends of said cylinder for metering the flow of liquid from the upper to the lower end of said cylinder as said piston moves upwardly through the cylinder;

a check valve connected in parallel with said metering valve to bypass said metering valve and to permit substantially unrestricted flow of liquid through said flow line from the lower end to the upper end of said cylinder as said piston moves downwardly through the cylinder;

first and second coaxial annular piston cylinders adapted to contain liquid encircling said polished rod and adapted to be affixed to the wellhead;

an annular piston in said first cylinder;

a spring in said first cylinder downwardly biasing said annular piston therein;

an adjustable second metering valve hydraulically interconnecting the lower ends of said annular piston cylinders;

a second check valve hydraulically interconnecting the lower ends of said annular piston cylinders so as to oppose liquid flow from said second to said first annular cylinders; and

an annular sleeve piston affixed to said polished rod and extending downwardly into said second annular piston cylinder adapted to exert pressure on liquid therein to overcome the force of said spring and said first annular piston, and to force liquid through said second metering valve into said first annular piston cylinder

3. For use in an oil well pumping system including a wellhead, a downhole pump, and a rod string in the well connected to the pump and extending toward the earth's surface, and pump drive apparatus at the earth's surface adapted to impart reciprocating motion to the rod string, the combination comprising:

a polished rod adapted to be connected to the rod string and to extend through the wellhead;

a liquid-filled piston cylinder connected to the upper end of the polished rod;

a piston in said cylinder adapted to be connected to the pump drive apparatus;

a metering valve and a flow line connected between the upper and lower ends of said cylinder for metering the flow of liquid from the upper to the lower end of said cylinder as said piston moves upwardly through the cylinder;

a check valve connected in parallel with said metering valve to bypass said metering valve and to permit substantially unrestricted flow of liquid through said flow line from the lower end to the upper end of said cylinder as said piston moves downwardly through the cylinder;

first and second additional piston cylinders adapted to contain a liquid and further adapted to be affixed to the wellhead;

a second piston in said first additional cylinder;

spring means in said first additional cylinder downwardly biasing said second piston therein;

an adjustable second metering valve hydraulically interconnecting the lower ends of said first and second additional piston cylinders;

a second check valve hydraulically interconnecting the lower ends of said additional piston cylinders so as to oppose liquid flow from said second additional cylinder to said first additional cylinder; and

a third piston affixed to said polished rod and extending downwardly into said second additional piston

cylinder adapted to exert pressure on the liquid therein to overcome the force of said spring and second piston so as to force liquid through said second metering valve into said first additional piston cylinder.

4. For use in an oil well pumping system including a wellhead, a downhole pump, and a rod string in the well connected to the pump and extending toward the earth's surface, and pump drive apparatus at the earth's surface adapted to impart reciprocating motion to the rod string, the combination comprising:

a polished rod adapted to be connected to the rod string and to extend through the wellhead;

a liquid-filled piston cylinder connected to the upper end of the polished rod;

a piston in said cylinder adapted to be connected to the pump drive apparatus;

a metering valve and a flow line connected between the upper and lower ends of said cylinder for metering the flow of liquid from the upper to the lower end of said cylinder as said piston moves upwardly through the cylinder;

a check valve connected in parallel with said metering valve to bypass said metering valve and to permit substantially unrestricted flow of liquid through said flow line from the lower end to the upper end of said cylinder as said piston moves downwardly through the cylinder;

first and second additional piston cylinders adapted to contain a liquid and further adapted to be affixed to the wellhead;

a second piston in said first additional cylinder;

spring means in said first additional cylinder downwardly biasing said second piston therein;

valve means hydraulically interconnecting the lower ends of said additional piston cylinders so as to permit substantially greater unrestricted flow of liquid from said first to said second additional cylinders than from said second to said first additional cylinder; and

a piston affixed to said polished rod and extending downwardly into said second additional piston cylinder adapted to exert pressure on the liquid therein to overcome the force of said spring and said first annular piston and to force liquid through said valve means into said first additional piston cylinder.

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