June 30, 1953 C. J. COBERLY 2,643,612

FLUID OPERATED PUMP WITH SINGLE-ACTING DIRECT-CONNECTED BOOSTER PUMP

Filed Jan. 22, 1949 3 Sheets-Sheet 1

Fig. 1

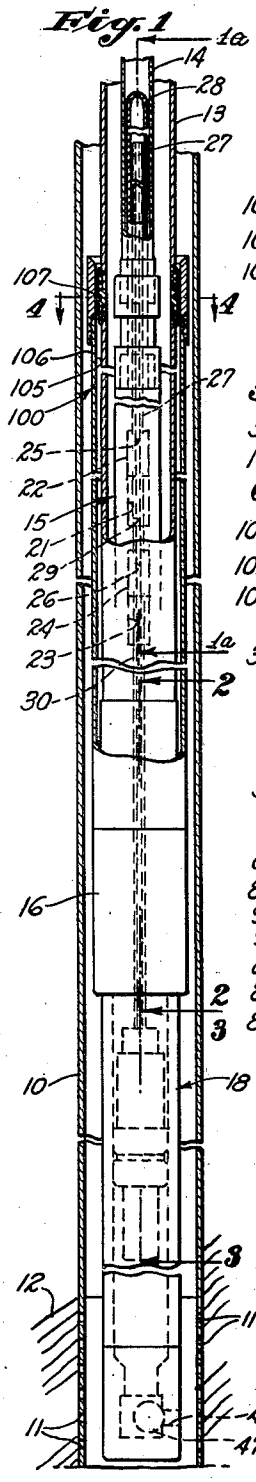


Fig. 2

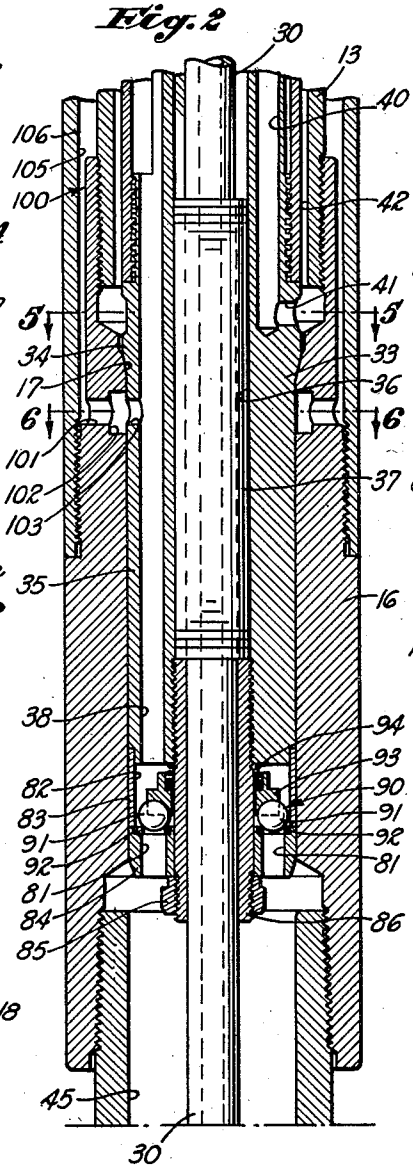
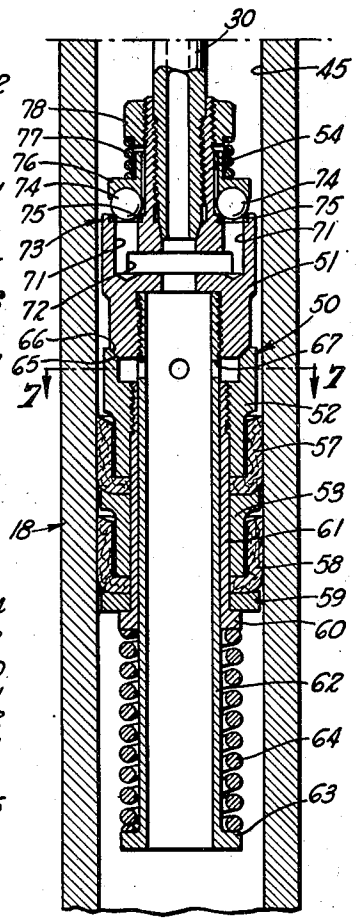


Fig. 3



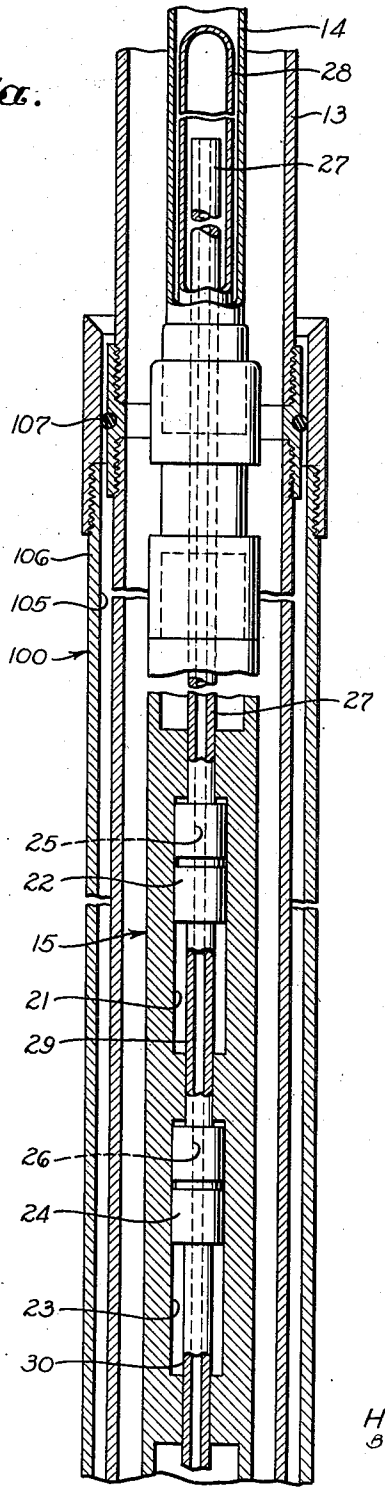
INVENTOR:
CLARENCE J. COBERLY
BY HIS ATTORNEYS
HARRIS, KIECH, FOSTER & HARRIS
By

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Filed Jan. 22, 1949 3 Sheets-Sheet 2

Fig. 1a.



INVENTOR.
CLARENCE J. COBERLY
BY HIS ATTORNEYS.
HARRIS, KIECH, FOSTER & HARRIS
BY

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Filed Jan. 22, 1949 3 Sheets-Sheet 3

Fig. 4

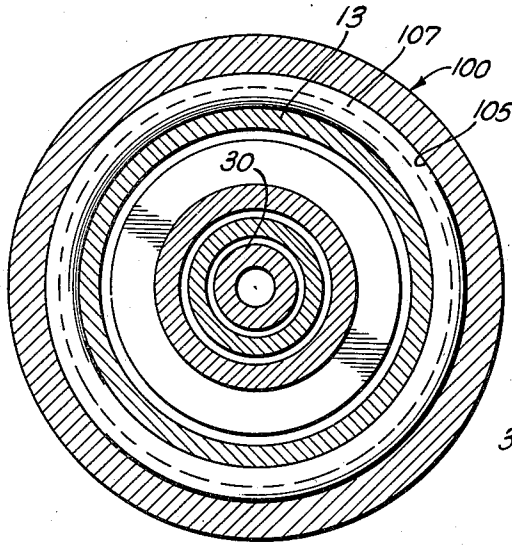


Fig. 6

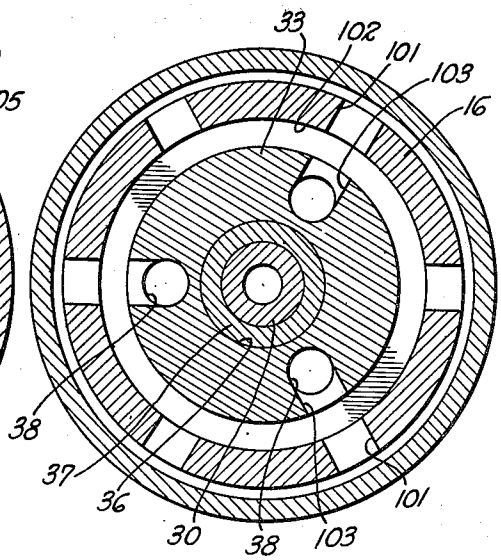


Fig. 5

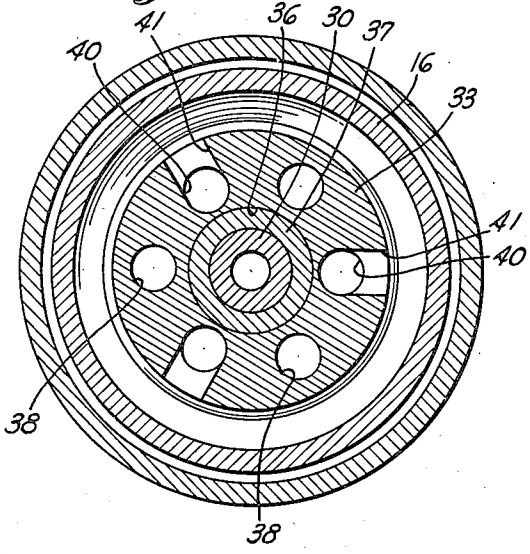
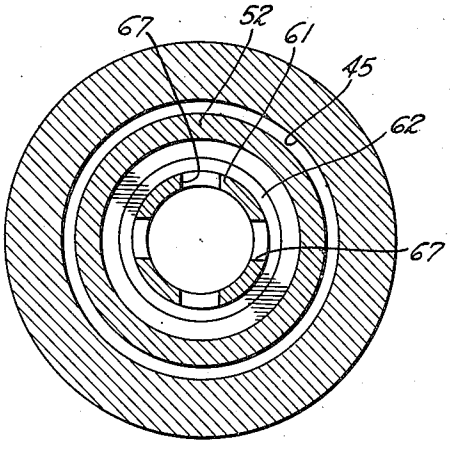


Fig. 7



INVENTOR:
CLARENCE J. COBERLY
BY HIS ATTORNEYS
HARRIS, KIECH, FOSTER & HARRIS
BY

Patented June 30, 1953

2,643,612

UNITED STATES PATENT OFFICE

2,643,612

FLUID-OPERATED PUMP WITH SINGLE-ACTING DIRECT-CONNECTED BOOSTER PUMP

Clarence J. Coberly, Los Angeles, Calif., assignor, by mesne assignments, to Dresser Equipment Company, Cleveland, Ohio, a corporation of Ohio

Application January 22, 1949, Serial No. 72,108

10 Claims. (Cl. 103—5)

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My invention relates to fluid-operated pumps for wells, and more particularly, to a fluid-operated pumping device comprising a fluid-operated main pump having an auxiliary or booster pump associated therewith for boosting the pressure of the well fluid delivered to the inlet of the main pump.

Reference is hereby made to my co-pending application Serial No. 45,048, filed August 19, 1948; Serial No. 46,776, filed August 30, 1948; and Serial No. 77,588, filed February 21, 1949.

Fluid-operated pumps are commonly used in the oil industry for pumping oil from wells, such a pump comprising, in general, a coupled motor and pump combination set in the well at the level from which oil is to be pumped. In such a combination, the motor comprises a motor piston which is actuated by alternatively admitting an operating fluid, such as clean crude oil, under relatively high pressure into opposite ends of a motor cylinder in which the motor piston is disposed so as to reciprocate the motor piston. The reciprocatory motion of the motor piston is communicated to a pump piston in the pump section of the combination so that the pump piston pumps oil from the well.

The fluid being pumped from a well may contain, in addition to oil, various other fluids such as water and natural gas, the gas being present in solution or in suspension in the oil in varying quantities depending upon the pressure and temperature conditions prevailing in the well. Also, if the well is being pumped beyond its capacity to produce, air may be present in the fluid being pumped. If the oil is saturated or supersaturated with natural gas at the conditions of pressure and temperature prevailing at the level at which the pump is set, a large portion of the gas may be released during the suction stroke of the pump piston to form a gas pocket in the pump cylinder. Also, of course, in many wells the well fluid is merely a froth composed largely of gas with a relatively small volume of oil. In either case, or if air is drawn into the pump cylinder, a pocket of gas or air in the pump cylinder results. Such pockets result in a material reduction in the pumping load until such time as the pump piston compresses the gas or air present and strikes solid well fluid in the cylinder.

Such fluid-operated pumps are frequently set at relatively great depths and, consequently, a large volume of operating fluid under relatively high pressure is confined in the supply tubing between the pump in the well and the apparatus on the surface which delivers the operating fluid

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to the pump. Due to the appreciable compressibility of this large volume of operating fluid, and due to the expansion of the supply tubing under the relatively high pressure at which the operating fluid is maintained, a large amount of energy is stored under normal operating conditions. If, because of the presence of gas or air in the pump cylinder, the load on the pump piston decreases, a sudden increase in the rate of flow of operating fluid to the pump occurs, thereby accelerating the motor and pump pistons. The speed ultimately attained may be excessive and the pump may race for a portion of a stroke or for a number of strokes, which is normally detrimental to various components of the pump. Various expedients for preventing damage to the pump mechanism under such conditions have been employed. For example, flow regulators disposed in the supply line for the operating fluid have been employed to maintain the rate of delivery of operating fluid to the motor section of the pump below a value which might be harmful to the pumping equipment. While such flow governors are practical under most conditions of operation, they have some disadvantages in that they increase the cost of the pumping equipment and render the equipment rather complicated. Also, there is some lag in their operation since they respond only after the condition requiring compensation has already developed.

Also, the presence of gas or air in the pump cylinder has a detrimental effect on the efficiency of such a fluid-operated pump. For example, if, in a given installation, thirty percent of the pump cylinder of the fluid-operated pump contains free gas or air, the efficiency of the pump, i. e., the percentage of the volume of the pump cylinder which contains solid well fluid, will be only seventy percent. In other words, under such conditions, the fluid-operated pump will pump well fluid from the well at only seventy percent of capacity.

In view of the foregoing considerations, it is a primary object of the present invention to provide, in combination with a conventional fluid-operated pump, an auxiliary or booster pump which is adapted to draw well fluid from the well and to deliver it to the inlet of the fluid-operated pump at an increased pressure such that the major portion of the gas or air in the well fluid will not flash out to form a pocket in the pump cylinder of the main pump. I accomplish this by providing a booster pump which will maintain the pressure of the well fluid pass-

ing into the pump cylinder of the main pump at a value equal to or above the pressure prevailing in the well at the inlet of the pumping device. A further object of the invention is to provide a booster pump which will compress any free gas or air entrained in the well fluid to a substantial extent before it is delivered to the inlet of the main pump.

It will be apparent that employing a booster pump in combination with a fluid-operated main pump in the foregoing manner will obviate, or at least minimize, the difficulties hereinbefore discussed. In other words, the employment of a booster pump will tend to obviate racing of the main pump and to increase the pumping efficiency thereof. As an example, let it be assumed that the pumping efficiency of the main pump is only seventy percent when the pressure at the inlet thereof is approximately equal to atmospheric pressure. With the present invention, if the particular booster pump utilized is adapted to increase the pressure of the well fluid delivered to the inlet of the main pump to three hundred pounds per square inch, the free gas or air which otherwise would occupy thirty percent of the volume of the pump cylinder of the main pump will be compressed to occupy only approximately 1.4 percent of the volume of the pump cylinder, thereby increasing the efficiency of the main pump to approximately 98.6 percent under such conditions.

Another object of the present invention is to provide such a pumping device, i. e., such a fluid-operated main pump and booster pump combination, in which the booster pump is directly connected to the main pump so as to be operable thereby. More specifically, it is an object to provide a fluid-operated pumping device wherein the booster pump includes a booster pump piston directly connected by rod means to one of the pistons of the main pump, preferably the pump piston thereof.

A further object of the invention is to provide in such a pumping device a booster pump of the single-acting type which is adapted to deliver well fluid to the inlet of the main pump, and to provide an accumulator for maintaining pressure at the inlet of the main pump during the inoperative stroke of the booster pump piston.

Another object is to provide such a pumping device with a tubular accumulator, i. e., an accumulator of annular cross section, which is adapted to receive and substantially enclose the main pump.

Another object is to provide a pumping device wherein the tubular accumulator has means connected thereto for providing a pump seat for the main pump.

Another object is to provide a pumping device wherein the main pump is removable from the tubular accumulator and wherein the booster pump piston is removable from the booster pump cylinder concomitantly with removal of the main pump from the accumulator.

Another object is to provide a pumping device wherein the accumulator and the booster pump cylinder are connected by a tubular fitting which provides the pump seat for the main pump and through which the booster pump piston may be withdrawn from the booster pump cylinder, the rod means connecting the booster pump piston with one of the pistons of the main pump extending through such tubular fitting.

Another object is to provide a booster pump piston having pressure relief valve means for bypassing well fluid from the high pressure end of the booster pump cylinder to the low pressure end thereof in the event that the pressure of the well fluid delivered to the accumulator and/or to the inlet of the main pump tends to exceed a predetermined value.

Another object of the invention is to provide such a pumping device wherein the rod means connecting the various pistons is hydraulically balanced with respect to well fluid pressure.

The foregoing objects and advantages of the present invention, together with various other objects and advantages thereof which will become apparent, may be attained through the utilization of the exemplary embodiment of the invention which is illustrated in the accompanying drawings and which is described in detail hereinafter. Referring to the drawings:

Fig. 1 is a utility view on a reduced scale showing a fluid-operated pumping device which embodies the invention as installed in a well;

Fig. 1*a* is a longitudinal sectional view taken along the arrowed line 1*a*—1*a* of Fig. 1 of the drawing;

Fig. 2 is a longitudinal sectional view of the upper end of a preferred booster pump of the invention and is taken along the broken line 2—2 of Fig. 1 of the drawings;

Fig. 3 is a downward continuation of Fig. 2 and is taken along the broken line 3—3 of Fig. 1;

Fig. 4 is a transverse sectional view taken along the broken line 4—4 of Fig. 1;

Figs. 5 and 6 are transverse sectional views taken along the broken lines 5—5 and 6—6, respectively, of Fig. 2; and

Fig. 7 is a transverse sectional view taken along the broken line 7—7 of Fig. 3 of the drawings.

Referring particularly to Fig. 1 of the drawings, I show an oil well lined with a casing 10 having perforations 11 which register with an oil producing formation 12 and through which oil and other fluids may flow into the interior of the casing, the fluids entering the casing being collectively referred to hereinafter as the well fluid. Extending downwardly into the casing 10 is a production tubing 13 which is adapted to convey well fluid to the surface of the ground, and extending downwardly into the production tubing in the particular construction illustrated is a power tubing 14 having a fluid-operated main or primary pump 15 connected to the lower end thereof. Connected to the lower end of the production tubing 13 is a tubular fitting 16 which, as best shown in Fig. 2 of the drawings, provides a tapered pump seat 17 for the main pump 15. Secured relative to the lower end of the main pump 15 in axial alignment therewith is an auxiliary or booster pump 18 which is adapted to pump well fluid from the casing 10 to the inlet of the main pump at a pressure higher than that obtaining at the intake of the booster pump, as will be discussed in more detail hereinafter.

The fluid-operated main pump 15 may be of any conventional type, such as that shown in my Patent No. 2,081,220, issued May 25, 1937, which is adapted to pump well fluid from the casing 10 upwardly through the production tubing 13 to the surface. As shown best in Fig. 1*a* of the drawings, the fluid-operated main pump 15 is provided with a motor cylinder 21 having a motor piston 22 therein, and is provided with a pump cylinder 23 having a pump piston 24 therein, the motor and pump pistons respectively being provided with longitudinal passages 25 and

26 therethrough. Connected to the upper end of the motor piston 22 and communicating with the passage 25 therethrough is an upper tubular rod 27 which extends into a balance chamber 28 at the upper end of the main pump 15. Connecting the motor and pump pistons 22 and 24 and communicating with the passages 25 and 26 therethrough is an intermediate tubular rod 29, and connected to the lower end of the pump piston is a lower tubular rod 30 for directly connecting the main pump 15 to the booster pump 18 as will be discussed in more detail hereinafter, the lower tubular rod extending through the tubular fitting 16.

Briefly, the fluid-operated main pump 15 operates as follows: Operating fluid, such as clean crude oil, under relatively high pressure is alternatively admitted into the ends of the motor cylinder 21 to reciprocate the motor piston 22 therein, such reciprocatory motion of the motor piston being communicated to the pump piston 24 by the intermediate tubular rod 29. The pump piston 24 discharges fluid into the production tubing 13, which conveys the fluid upwardly to the surface.

Considering the pumping device in more detail, the main pump 15 terminates at its lower end in a fitting 33 having a tapered head 34 which is adapted to seat on the pump seat 17 provided by the tubular fitting 16, and having a stem 35 which is insertable into the tubular fitting 16. The fitting 33 is provided with a bore 36 therethrough for the lower tubular rod 30, the latter being encircled by packing 37. As best shown in Figs. 2, 5 and 6 of the drawings, the fitting 33 is provided with a plurality of longitudinal passages 38 therethrough which act as inlet ports for the main pump 15, and is provided with a plurality of longitudinal passages 40 which terminate in radial passages 41 communicating with an annular space 42 between the production tubing 13 and the main pump 15 so as to deliver fluid pumped by the main pump to the production tubing, the passages 40 and 41 providing outlet ports for the main pump.

Connected to the lower end of the tubular fitting 16 in axial alignment with the motor and pump cylinders 21 and 23 of the main pump 15 is a pump cylinder 45 of the booster pump 18, the booster pump cylinder 45 being provided with an intake port 46 which communicates with the well casing 10 to admit well fluid into the booster pump cylinder. Outflow from the booster pump cylinder through the intake port 46 is prevented by a check valve 47.

Reciprocable in the booster pump cylinder 45 is a booster pump piston 50 which, as best shown in Fig. 3 of the drawings, includes a tubular upper section 51, a tubular intermediate section 52, and a tubular lower section 53 in the particular construction illustrated. The lower tubular rod 30 is threaded into a stem 54 on the upper section 51 of the booster pump piston so as to communicate reciprocatory motion of the motor and pump pistons 22 and 24 of the main pump 15 to the booster pump piston, as will be discussed in more detail hereinafter. As will be apparent from Fig. 3 of the drawings, the lower end of the lower tubular rod 30 is exposed to well fluid pressure, and such pressure is also communicated to the balance chamber 28 at the upper end of the main pump 15 through the lower tubular rod 30, the passage 26 through the main pump piston 24, the intermediate tubular rod 29, the passage 25 through the motor piston 22, and the upper tubular rod 27. The area of the upper end of the upper tubular rod 27 is equal to that of the lower end of the lower tubular rod 30 so that the rod assembly is hydraulically balanced with respect to well fluid pressure, which is a feature of the invention.

Referring again to Fig. 3 of the drawings, clamped between the intermediate and lower sections 52 and 53 of the booster pump piston 50 is a packing cup 57, the latter surrounding a portion of the intermediate piston section 52 in the particular construction illustrated. Surrounding a portion of the lower piston section 53 is another packing cup 58 which is clamped between the lower piston section and a washer 59, the latter being retained by a flange 60 on a tube 61 which is threaded into the intermediate piston section 52. Extending through the tube 61 and threaded into the upper piston section 51 is a tube 62 having a flange 63 at its lower end, a compression spring 64 encircling the tube 62 and being seated at its ends against the flanges 60 and 63. The function of the spring 64 is to maintain complementarily tapered surfaces 65 and 66 on the respective piston sections 51 and 52 in fluid-tight engagement, unless the pressure in the booster pump cylinder 45 above the piston 50 exceeds a predetermined value. If this occurs, the spring 64 is compressed to permit separation of the tapered surfaces 65 and 66 to permit fluid to flow from the upper end of the booster pump cylinder 45 into the lower end thereof by way of radial openings 67 in the tube 62. Thus, the booster pump piston 50 provides a pressure relief valve means for by-passing fluid from the high pressure side of the booster pump piston 50 to the low pressure side thereof, i. e., from the upper end of the booster pump cylinder 45 to the lower end thereof, in the event that the pressure on the high pressure side of the booster pump piston exceeds a value determined by the spring 64, which is a feature of the invention.

The upper section 51 of the booster pump piston 50 is provided with longitudinal passages 71 which communicate with an annular groove 72 therein, the latter communicating with the interior of the tubular upper section 51. Thus, during downward movement of the booster pump piston 50, well fluid from therebeneath may flow upwardly therethrough by way of the tube 62, the tubular upper section 51, the annular groove 72 in the tubular upper section, and the longitudinal passages 71 therein. Reverse flow through the booster pump piston 50 during upward movement thereof is prevented by a check valve means 73 comprising a plurality of ball valves 74 which are adapted to close the longitudinal passages 71, the upper piston section 51 being provided with inserts 75 which serve as seats for the ball valves. The ball valves 74 are held by a retainer 76 which is urged downwardly to retain the ball valves in engagement with their seats by a compression spring 77, the latter being seated against a nut 78 threaded on the stem 54 on the upper piston section 51. As will be apparent, the spring 77 prevents opening of the check valve means 73 during the upward, or working stroke of the booster pump piston 50, and permits opening thereof during the downward stroke of the booster pump piston. Thus, the booster pump 18 is of the single-acting type, fluid being discharged from the booster pump cylinder 45 during the upward stroke of the booster pump 50.

Fluid displaced by the booster pump piston 50 during its working stroke is discharged from the upper end of the booster pump cylinder 45 through discharge ports 81 which communicate with the inlet ports 38 for the main pump 15 through an annular space 82. The annular space 82 is defined by a sleeve 83 pressed on a reduced-diameter portion of the fitting 33, and the discharge ports 81 are formed in a valve seat member 84 which is seated against the lower end of the sleeve 83, the valve seat member being retained by a nut 85 threaded on a sleeve 86 which encircles the tubular lower rod 30 and is threaded into the lower end of the bore 36 through the fitting 33.

A check valve means 90 similar to the check valve means 73 permits upward flow through the discharge ports 81 during the upward or working stroke of the booster pump piston 50 and prevents downward flow therethrough during the downward stroke of the booster pump piston, the check valve means 90 comprising a plurality of ball valves 91 adapted to seat on inserts 92 carried by the valve seat member 84 and encircling the discharge ports 81 therethrough. The ball valves 91 are retained by a retainer 93 and are adapted to be held seated against the inserts 92 by a compression spring 94 which is disposed between the retainer 93 and the lower end of the fitting 33.

In order to maintain the fluid delivered to the inlet ports 38 of the main pump 15 under pressure during the downward stroke of the booster pump piston 50, I provide an accumulator 100 which communicates with the inlet ports 38 through radial passages 101 in the tubular fitting 16, an annular groove 102 in this fitting, and radial passages 103 in the fitting 33. The accumulator 100 is tubular, i. e., of annular cross section, and comprises an annular space 105 between the production tubing 13 and a tube or shell 106 which encircles the lower end of the production tubing and which is connected at its lower end to and extends upwardly from the tubular fitting 16, as best shown in Fig. 2 of the drawings. The shell 106 may extend upwardly from the tubular fitting 16 a distance such that the accumulator 100 receives a column of fluid of sufficient height to maintain the desired pressure in the inlet ports 38 of the main pump 15 hydrostatically, in which case the accumulator may be open at its upper end. However, in order to avoid the necessity of employing an accumulator 100 of excessive length, particularly when a high pressure is to be maintained in the inlet ports 38, I prefer to close the accumulator 100 at its upper end, as by means of a sealing ring 107 (Figs. 1 and 4) interposed between the shell 106 and the production tubing 13.

The operation of my pumping device will be apparent from the foregoing so that only a general description thereof is thought to be necessary. During the downward stroke of the motor and pump pistons 22 and 24 of the main pump 15, the booster pump piston 50 is moved downwardly in its cylinder 45, fluid from the lower end of the booster pump cylinder flowing through the booster pump piston into the upper end thereof by way of the check valve means 73. During the downward stroke of the booster pump piston, downward flow through the discharge ports 81 is prevented by the check valve means 90. As the motor piston 22 moves upwardly, it moves the booster pump piston 50 upwardly by means of the intervening connection so that the booster pump piston displaces fluid from the upper end of the booster pump cylinder past the check valve means 90, flow through the booster pump piston during its working stroke being prevented by the check valve means 73. The fluid discharged by the booster pump 18 in this manner is delivered either to the main pump 15, or to the accumulator 100. During the downward, or nonworking stroke of the booster pump piston, fluid flows into the inlet ports 38 of the main pump from the accumulator 100, the latter maintaining the desired pressure in the inlet ports during the nonworking stroke of the booster pump piston. Thus, the accumulator 100 provides a continuous flow of fluid at substantially constant pressure to the inlet ports 38 of the main pump 15.

Thus, the auxiliary or booster pump 18 delivers well fluid to the inlet ports 38 of the fluid operating main pump 15 at an elevated pressure to minimize the formation of gas or air pockets in the pump cylinder 23 of the main pump, whereby to increase the efficiency of the main pump and to minimize the possibility of damage to the components thereof which may result from the formation of gas or air pockets in the pump cylinder 23 as previously discussed. The booster pump 18 preferably delivers a relatively large volume of well fluid to the main pump at a relatively low pressure, the effective cross-sectional area of the booster pump piston 50 being substantially larger than that of the motor piston 22 to accomplish this. In practice, the ratio of booster pump piston area to motor piston area may be 4 to 1, for example. Thus, the major portion of the work necessary to pump well fluid to the surface is performed by the main pump 15, the function of the booster pump 18 being to deliver the well fluid to the main pump at a pressure sufficient only to prevent excessive formation of gas pockets in the pump cylinder 23 of the main pump, which pressure preferably exceeds the pressure obtaining at the intake port 46 of the booster pump.

In the event that the pressure developed in the accumulator 100 rises above the value determined by the spring 64 for any reason, the pressure relief valve means incorporated in the pump piston 50 will operate to by-pass fluid from the high pressure side of the booster pump piston to the low pressure side thereof, as hereinbefore discussed.

In order to facilitate removal of the main and booster pumps 15 and 18 for servicing or repair, the internal diameter of the tubular fitting 16 is preferably at least equal to the diameter of the booster pump piston 50 so that the latter may be removed from its cylinder through the tubular fitting 16 concomitantly with removal of the main pump from the tubular accumulator 100. Thus, with the exception of the booster pump cylinder 45 and the check valve 47 controlling flow through the intake port 46, all components of the pumping device which are subject to wear may be pulled in a single operation without any necessity of pulling the production tubing 13 and the accumulator 100, which is a feature of the invention.

Although I have disclosed an exemplary embodiment of the invention for purposes of illustration, it will be understood that various changes, modifications and substitutions may be incorporated in the specific embodiment disclosed without necessarily departing from the

spirit of the invention and I hereby reserve the right to all such changes, modifications and substitutions.

I claim as my invention:

1. In a fluid-operated pumping device, the combination of: a tubular accumulator adapted to be positioned in a well; means providing a pump seat secured to said accumulator; a fluid-operated main pump of the reciprocating type adapted to seat on said pump seat, said main pump being provided with an inlet port; a single-acting, auxiliary pump of the reciprocating type secured relative to said main pump in axial alignment therewith, said auxiliary pump being provided with an intake port adapted to communicate with the well and being provided with a discharge port communicating with said inlet port; means providing fluid communication between said accumulator and said discharge and inlet ports; and means mechanically connecting said auxiliary pump to said main pump for operating said auxiliary pump so as to pump well fluid from the well into said inlet port and said accumulator at a pressure higher than that in said intake port.

2. A fluid-operated pumping device as set forth in claim 1 wherein said pump seat is located adjacent the lower end of said accumulator and wherein said accumulator substantially encloses said main pump.

3. A fluid-operated pumping device as set forth in claim 1 wherein said auxiliary pump comprises a cylinder secured to said accumulator and having a pump piston therein, and wherein said main pump comprises connected motor and pump pistons, said means mechanically connecting said auxiliary pump to said main pump comprising rod means for connecting said pump piston of said auxiliary pump to said pistons of said main pump.

4. In a fluid-operated pumping device, the combination of: a tubular accumulator adapted to be positioned in a well; a tubular fitting connected to the lower end of said accumulator and provided with a pump seat; a fluid-operated main pump of the reciprocating type adapted to be positioned in said accumulator and to seat on said pump seat, said main pump including axially aligned and connected motor and pump pistons and being provided with an inlet port, a single-acting, auxiliary pump provided with an intake port adapted to communicate with the well and a discharge port adapted to communicate with said accumulator and with said inlet port, said auxiliary pump including a pump cylinder secured to the lower end of said tubular fitting and including a pump piston in said pump cylinder; passage means for connecting said discharge port, said accumulator and said inlet port; and rod means extending through said tubular fitting and directly connecting said pump piston of said auxiliary pump to said pistons of said main pump for operating said auxiliary pump so as to pump well fluid from the well into said inlet port and said accumulator at a pressure higher than that in said intake port.

5. In a fluid-operated pumping device, the combination of: a tubular fitting adapted to be positioned generally vertically in a well and provided with a pump seat; a fluid-operated main pump of the reciprocating type adapted to seat on said pump seat and including axially aligned, connected motor and pump pistons, said main pump being provided with an inlet port for well fluid and being adapted to pump well fluid from the well to the surface; an auxiliary pump of the reciprocating type including a pump cylinder connected to the lower end of said tubular fitting and axially aligned with said motor and pump pistons of said main pump, and including a pump piston reciprocable in said pump cylinder, said auxiliary pump having an intake port adapted to communicate with the well and having a discharge port; passage means independent of and out of fluid communication with said intake port for connecting said discharge port to said inlet port; and rod means extending through said tubular fitting and connecting said pump piston of said auxiliary pump to said motor and pump pistons of said main pump for operating said auxiliary pump so as to pump well fluid from the well into said inlet port at a pressure higher than that in said intake port.

6. A fluid-operated pumping device as set forth in claim 5 wherein the internal diameter of said tubular fitting is at least equal to the diameter of said pump piston of said auxiliary pump to permit withdrawal of said piston of said auxiliary pump through said tubular fitting.

7. In a fluid-operated pumping device, the combination of: a fluid-operated main pump having a balance chamber, a motor cylinder, a pump cylinder and an inlet port communicating with said pump cylinder, said main pump including a tubular motor piston in said motor cylinder, a tubular pump piston in said pump cylinder and a main tubular rod means connecting and communicating with the interiors of said motor and pump pistons and having an end extending into said balance chamber; an auxiliary pump of the reciprocating type secured relative to said main pump and including a pump cylinder having a tubular pump piston therein, said auxiliary pump being provided with an intake port adapted to communicate with the well and a discharge port communicating with said inlet port; and an auxiliary tubular rod means connecting said pump piston of said auxiliary pump to said motor and pump pistons of said main pump for operating said auxiliary pump so as to pump well fluid from the well into said inlet port at a pressure higher than that in said intake port, said auxiliary tubular rod means communicating with said main tubular rod means and said intake port.

8. In combination with production and power tubings set in a well and a pump seat connected to one of said tubings in alignment therewith, a fluid-operated pumping device movable downwardly in the well through said one tubing to seat on said pump seat and including: a fluid-operated main pump of the reciprocating type actuable by an operating fluid under pressure in said power tubing to pump well fluid into said production tubing, said main pump having an inlet port; an auxiliary pump of the reciprocating type provided with an intake port adapted to communicate with the well to receive well fluid from the well and provided with a discharge port for well fluid; means for connecting said discharge port in fluid communication with said inlet port so as to deliver well fluid discharged by said auxiliary pump to said main pump to be pumped thereby into said production tubing; and means mechanically connecting said auxiliary pump and said main pump for actuating said auxiliary pump so as to pump well fluid from said intake port into said inlet port at a pressure higher than that in said intake port.

9. A combination according to claim 8, including in addition: a tubular member connected to

and enclosing the lower end of at least said one tubing and defining therewith a tubular accumulator; and means for connecting said inlet and discharge ports in fluid communication with said accumulator.

10. A combination according to claim 9 including a tubular fitting connected to the lower ends of said one tubing and said tubular member and providing said pump seat, said auxiliary pump including a cylinder connected to said fitting in alignment therewith, the internal diameter of said fitting being at least equal to that of said cylinder.

CLARENCE J. COBERLY.

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