July 1, 1947. C. M. O'LEARY 2,423,111

PNEUMATIC PUMPING MECHANISM

Filed July 10, 1944

FIG. 1.

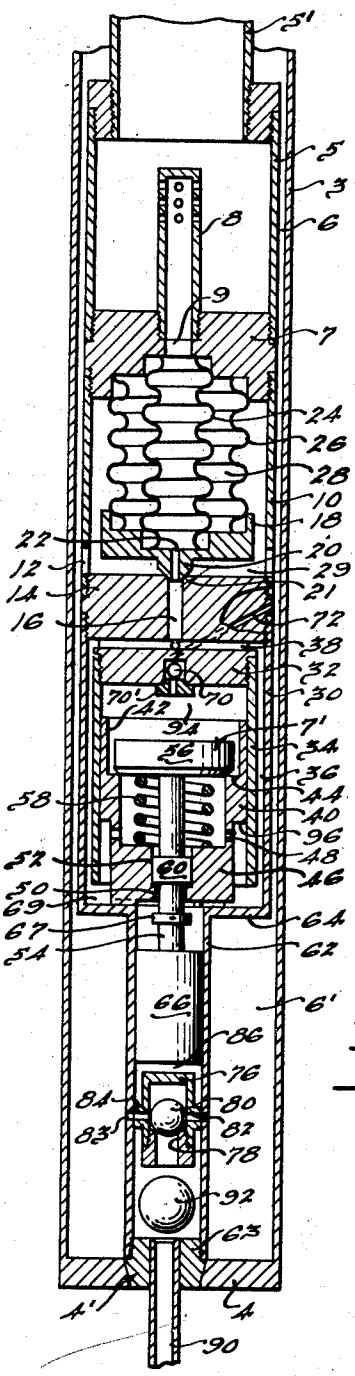


FIG. 2.

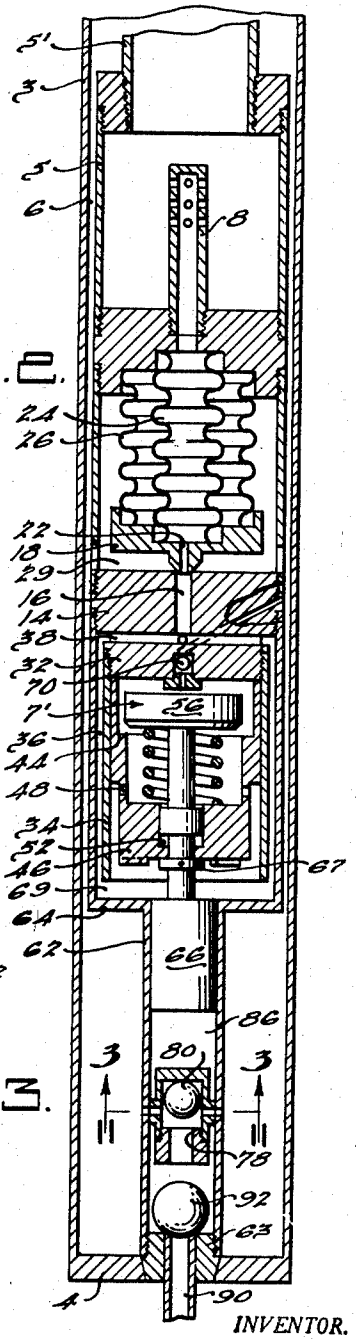
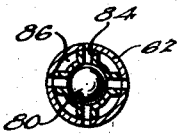


FIG. 3.



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PNEUMATIC PUMPING MECHANISM

Charles M. O'Leary, Detroit, Mich.

Application July 10, 1944, Serial No. 544,209

20 Claims. (Cl. 103—5)

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The present invention relates to an apparatus for causing outflow of well fluid from wells of low productivity index, and constitutes an improvement over the apparatus set forth in my co-pending application Serial No. 429,939, filed February 7, 1942. The present application, however, covers certain features common to the two.

The primary object is to provide in the bottom of the well an improved gas-operated reciprocating pump. Another object is to produce, by operation of the pump, continuous aeration of the well fluid by exhausted power gas and hence a constant outflow of aerated well fluid.

Another object of the invention is to provide an improved intermitter valve which opens to produce a blow-off in the event that the well fluid becomes too dense for aerated flow.

Other objects which will become apparent from the following specification and accompanying drawing, include the provision of an apparatus of the type mentioned which may be readily lowered into the outflow tubing of a well on the gas tubing and which is simple and rugged in design and construction.

The invention is fully disclosed by way of example in the following description and in the accompanying drawings in which:

Figure 1 is a vertical section of the device, at the beginning of the suction stroke;

Figure 2 is a similar section showing the position of parts at the beginning of the pressure stroke, and

Figure 3 is a section on the line 3—3 of Figure 2.

In Figure 1 is shown the well outflow tubing 3 which extends substantially to the bottom of the well bore within the usual well casing, not shown. In the bottom of the tubing 3 is fitted an end piece 4 formed with a seat 4'. Within the tubing 3, in turn, is mounted the power gas tubing or pressure flow tube 5' to the lower end of which is fixed an enlarged tube 5 carrying a pumping mechanism designated generally by the numeral 7'.

In the tube 5 is mounted a block 7 having mounted in its upper end a strainer or scale trap 8 communicating with a central passage 9 formed in the block. To the block 7 is secured a downwardly extending sleeve 10 formed with a series of ports 12 for a purpose that will presently be described. Beneath the ports a crossover 14 is attached to the sleeve 10 and is formed with an axial passage 16 for a purpose that will presently appear. Over the passage and within the sleeve 10 is mounted an unloader valve 18 having a head 20 adapted to seat on a seat 21 at the upper end of the passage 16. The valve 18 is formed with an axial passage 22, and is suspended from the block 7 by a bellows 24 communicating with the passage 9. Another bellows 26 also joins the members 7 and 18 and forms an annular chamber 28 around the bellows 24, which chamber is sealed at substantially atmospheric pressure. When the unloader valve is seated, the body thereof forms a space 29 above the crossover 14 and in communication with the ports 12.

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A jacket or extension tube 30 is suspended from the crossover 14 and is also spaced from the tubing 3 to form a continuation of the annular chamber 6 between tube 3 and the aligned tubes 5, 10, and 30. The lower end of the crossover is formed as a motor piston cylinder head 32 from which is suspended a motor piston cylinder 34 spaced annularly at 36 from the jacket 30. Between the crossover 14 and the head 32 is formed a number of radial ports 38 communicating with the axial passage 16.

In the cylinder 34 is slidably mounted a motor piston including a cylindrical sleeve 40 formed at its upper end with a skirt 42 of somewhat larger internal diameter. The juncture of the two diameters forms a valve seat 44. At the lower end of the motor piston is formed a head 46, and near the head are ports 48 forming a passage to the interior of the piston. The head 46 is formed with an axial bore 50 which has its upper end enlarged at 52 for a purpose that will presently be described. A pump plunger rod 54 passes through the bore 50 with slight clearance therein and carries at its upper end a motor piston valve head 56 adapted to close on the seat 44.

A spring 58 is inserted between the valve head and the lower piston head 46 and holds the valve head 56 open under certain conditions that will presently be described. The rod 54 is formed with a collar 60 having a sliding fit in the enlarged bore 52.

On the lower end of the extension 30 is secured a downwardly extending barrel 62 of smaller diameter and joined to the extension by an annular disk connector 64. The lower end of barrel 62 carries a fitting 63 inserted in the seat 4'.

The lower end of the pump plunger rod 54 carries a pump plunger 66 working in barrel 62. The area of the plunger 66 is smaller than the area of the seat 44. Pump rod 54 is provided with stop collar 67 which limits the separation

of the valve 56 and piston 40 in the open position of the valve.

The power gas flows through the space 69 between the connector 64 and the lower end of the motor piston cylinder 34. While disc connector acts as a lower stop for piston 40, contact between the piston and disc 64 does not block communication between space 69 and the pump barrel 62.

In the lower surface of the cylinder head 32 is mounted an upwardly opening check valve including a ball 70 adapted to close on a seat 70'. The valve communicates through a restricted lateral passage 72 in the crossover 14 with the space 6. The passageway 72 does not communicate with the ports 38.

In the lower end of the pump barrel 62 is mounted a discharge valve housing 76 provided in its lower end with a seat 78. The housing 76 contains a ball valve 80 adapted to close downwardly in the seat 78 and is formed with a suitable number of laterally extending ports 82 registering with ports 83 in the barrel through connecting nipples 84, thereby bringing the valve housing into communication with the lower end 6' of the well fluid space. The pump chamber 86 between the housing 76 and pump plunger 66 is in communication with the space within barrel 62 and below housing 76 through the passages between the nipples 84, as best shown in Fig. 3.

A fluid intake pipe 90 from the well is inserted in the fitting 63 to communicate with the lower end of barrel 62. A ball valve 92 mounted between the housing 76 and the fitting 63 is adapted to seat in the upper end of the fitting 63 and, with the fitting, constitutes the standing valve or intake valve assembly.

In Fig. 2 the parts are illustrated in the position they assume at the beginning of the pumping or downward stroke of plunger 66. The power gas flows down tubing 5' through the trap 8, bellows 24, passages 22 and 16, ports 38, spaces 36 and 69, ports 48 and the open valve seat 44 into the chamber 94 above the valve head 56. The chamber 94 communicates through the restricted passage 72 with the space 6 which is at a pressure determined by the head of well fluid standing therein and less than the power gas pressure. However, due to the restricted passageway 72, the pressure in chamber 94 may be substantially equal to the pressure of the power gas supply. This same pressure acts on both sides of valve 56, both sides of piston 40, and also on the top of plunger 66. During this condition, therefore, the pressures on the piston 40 itself are balanced, and the power gas moves the plunger 66 downwardly through its pumping stroke by reason of the fact that it is acting on an excess upwardly-facing area on the plunger and valve unit 66 and 56 equal to the cross-sectional area of plunger 66. During the pumping stroke, that portion of the power gas which flows through passage 72 enters the column of oil in tube 3 and provides a gas lift effect. During the pumping stroke spring 58 holds the valve 56 open by moving the then balanced piston 40 downwardly in advance of the valve. However, near the end of the pumping stroke, piston 40 engages disc 64 and is brought to a stop. Thereupon continued downward movement of plunger 66 compresses spring 58 and valve 56 comes to rest on seat 44. The valve 56 is now held on its seat by the pressure above the motor piston 40 and the power gas pressure acting on plunger 66. When the valve 56 is seated, the pressure effective area of the upper side of the valve is greater than the pressure effective area of its lower side by the cross-sectional area of the plunger 66 which is attached to valve 56 by rod 60.

The downward pressure in chamber 94 is now diminishing through the restricted exhaust passage 72 while the upward gas pressure at the space 69 remains constant against the lower end of motor piston 40. The pressure effective area of the lower side of motor piston 40 which is subject to power gas pressure is its area minus the area of pump plunger 66. When the pressure in chamber 94 above the motor piston 40 drops to a point where the pressure gas on the lower side of piston 40 exerts a force greater than the force on its upper side, the piston 40, valve 56, rod 60 and plunger 66 move upward. The suction stroke of the plunger 66 is thus initiated, raising the valve 92 and seating the valve 80 by suction in the chamber 86, as shown in Figure 1, drawing well fluid into the chamber 86.

As the motor piston moves upward its speed is controlled by the size of the passage 72, the power gas pressure and the well fluid pressure against which it is exhausted. The size of the opening 72 and the relative diameters of piston 40, valve 56 and plunger 66 are so chosen for any given power gas pressure and well fluid pressure that valve 56 remains closed during the suction stroke until the skirt 42 of piston 40 strikes the cylinder head 32.

When the extended skirt 42 strikes the head 32 at the end of its suction stroke, the pressure in chamber 94 further reduces, until the tension of spring 58 and the pressure responsive area on the underside of seated valve 56 are sufficient to open the valve against its upper pressure area as shown in Figure 2. There is now equal unit pressure on both sides of the motor piston 40 and the pressure gas now exerts a resultant downward force against the area of plunger 66 to initiate the downstroke as previously described. The opening of valve 56 in relation to seat 44 is limited by stop collar 67.

Once the valve 56 is seated it cannot come off its seat because the effective pressure area on the upper side of the valve is greater than on the lower side by an amount at least sufficient to overcome the spring 58 and hold the valve seated.

On the downstroke of pump plunger 66 the valve 92 is seated and valve 80 is unseated by pressure in the chamber 86, as shown in Figure 2. The well fluid that was previously drawn into barrel 62 is now discharged into the space 6', 6.

The motor piston 40 having come to rest on connector 64, permits the plunger 66, its pony rod 60 and valve head 56 to continue their downward movement against the tension of spring 58. This latter movement is cushioned by the enlargement on rod 60 which exerts pressure on fluid entrapped in bore 52. The escape of entrapped fluid is restricted at 50 permitting cushioning of the valve seating operation.

Exhaust of power gas through passage 72 on the suction stroke has already been mentioned. It is obvious that there is exhaust of power gas on the power stroke, so that the flow of gas into the head of well fluid is continuous. This flow of gas is ordinarily sufficient to produce a constantly flowing discharge of aerated well fluid to the surface of the ground.

Back flow of well fluid into the chamber 94 is prevented by the inwardly closing check valve 70 on its seat 70'.

In the event that the head of well fluid becomes too dense for continuous aerated discharge, the

unloader valve 18 provides means for a blow-off. This is brought about by well fluid pressure being built up in the outflow tubing and reacting against the area of the unloader valve 18 exposed to well fluid at the space 29. The unloader valve 18 is normally held seated by pressure gas acting on that portion of valve 18 confined by bellows 24, this area being substantially larger than the seated area of valve 18 on its seat 21. The passage 22 through valve 18 is smaller in cross sectional area than the area of valve seat 21. This provides a continuous pressure on the valve 18 tending to hold it upon its seat 21.

When the unloader valve 18 is raised and the gas pressure is communicated to the head of well fluid at the ports 12, the friction of the flowing fluid in chamber 6 imposes a greater pressure in space 29 and on the valve 18 than at the time the valve was first unseated. This additional force insures that the valve 18 will remain open until such time as the well fluid starts to discharge at the surface. The back pressure of the discharging fluid eventually drops to a point where the pressure in bellows 24 is sufficient to seat the valve. The fluid remaining in tubing 3 continues to discharge by the expansion of the power gas trapped in the tubing by the seating of valve 18. The quick action of the valve thus saves pressure gas and permits the pumping mechanism to commence operation without waiting for a complete blow down of the well. A balanced pressure condition, holding the pump inoperative, would be of only momentary duration.

Thus, it is not necessary with this unloader valve to blow the tubing dry in order to close the valve. The result of this characteristic is a very positive and economical operation.

It is preferable that the well fluid pressure responsive parts of valve 18 be of a larger area than the power gas pressure responsive parts tending to hold the valve upon its seat 21, whereby to permit the opening of valve 18 by low well fluid heads.

It will be noted that the cross sectional area of passage 22 is smaller than the area of bellows 24. When the valve 18 is away from its seat 21, the pressure in the area confined by bellows 24 and flowing through the restricted passage 22 urges the valve on its seat. It is this force that moves the valve toward its seat when a portion of the well fluid has been ejected at the surface and permits operation of the pumping mechanism, as previously set forth.

The higher the pressure in the system the greater the slug or head of well fluid must be to overcome the greater force exerted on the gas pressure responsive parts. If the pressure be lowered, a correspondingly smaller head will be required to open the unloader valve. A definite differential can be established between all the parts of the pumping mechanism and the unloader valve to be applicable over a wide range of varying well conditions by control of the power gas pressure.

The parts of the unloading valve are so proportioned that when the column of fluid loads up to a predetermined pressure where the performance of the pumping mechanism is retarded, the valve opens and the power gas ejects the fluid from the tubing. Such loading up of the tubing is sometimes brought about by a slug of water or by a drop in gas pressure at its source or by the cutting in of other wells on the same line, which will also reduce the gas pressure.

By regulation of input gas pressure, the head of well fluid necessary to open the blow-off valve 18 can be controlled. The relation of the respective pressure responsive areas to each other can be so designed to operate under varied well conditions and by regulation of the gas pressure can be made to pump deep or shallow wells with a minimum of gas.

It is understood that various areas of motor pistons, valves, pump plungers and various spring tensions and sizes of vents may be used to meet various well conditions.

The disclosed pumping mechanism can be of the insert type removable with the power gas string, as illustrated, or of the tubing type requiring removal of both strings to service the pump. The pump can be so arranged as to produce the well fluid through the smaller string of pipe, in which case the outer string of pipe would be used to conduct power gas to the pumping mechanism.

Although a specific embodiment of the invention has been illustrated and described, it will be understood that various alterations in the details of construction may be made without departing from the scope of the invention as indicated by the appended claims.

What I claim is:

1. In a gas-operated well-pumping mechanism, a single-acting plunger pump adapted to draw liquid from a body of liquid standing in the well and discharge that liquid into the well tubing, said pump including a cylinder having a pumping chamber at one end and a pumping plunger in said cylinder, a motor cylinder of larger diameter than the pumping cylinder and having one end in constant fluid communication with the opposite end of the pumping cylinder, a piston in the motor cylinder, a mechanical connection between the piston and plunger, means for supplying gas under pressure alternately, first to both ends of said motor cylinder and then only to the said one end of the motor cylinder, said motor cylinder having at its opposite end a restricted outlet.

2. In a gas-operated well-pumping mechanism, a single-acting plunger pump adapted to draw liquid from a body of liquid standing in the well and discharge that liquid into the well tubing, said pump including a cylinder having a pumping chamber at one end and a pumping plunger in said cylinder, a motor cylinder of larger diameter than the pumping cylinder and having one end in constant fluid communication with the opposite end of the pumping cylinder, a piston in the motor cylinder, a mechanical connection between the piston and plunger, means for supplying gas under pressure alternately, first to both ends of said motor cylinder and then only to the said one end of the motor cylinder, said motor cylinder having at its opposite end a restricted outlet which communicates with the liquid discharged by the pump at a point in the vicinity of the pumping mechanism in order to supply lift gas to the discharged liquid.

3. In a gas-operated well-pumping mechanism, a single-acting plunger pump adapted to draw liquid from a body of liquid standing in the well, and discharge that liquid into the well tubing, said pump including a cylinder having a pumping chamber at one end and a pumping plunger in said cylinder, a motor cylinder of larger diameter than the pumping cylinder and having one end in constant fluid communication with the opposite end of the pumping cylinder, a piston in the motor cylinder, a mechanical connection

between the piston and plunger, means for supplying gas under pressure continuously to said one end of the motor cylinder, valve means operated automatically at the end of each stroke of the piston for placing the opposite end of the cylinder in communication with the source of gas under pressure at the end of the suction stroke and closing communication at the end of the pumping stroke, said motor cylinder having at its opposite end a restricted outlet.

4. In a gas-operated well-pumping mechanism adapted for attachment to the well tubing, a single-acting plunger pump adapted to draw liquid from a body of liquid standing in the well, and discharge that liquid into the well tubing, said pump including a cylinder having a pumping chamber at one end and a pumping plunger in said cylinder, a motor cylinder of larger diameter than the pumping cylinder and having one end in constant fluid communication with the opposite end of the pumping cylinder, a piston in the motor cylinder, a mechanical connection between the piston and plunger, means for supplying gas under pressure continuously to said one end of the motor cylinder, valve means operated automatically at the end of each stroke of the piston for placing the opposite end of the cylinder in communication with the source of gas under pressure at the end of the suction stroke and closing communication at the end of the pumping stroke, said motor cylinder having at its opposite end a restricted outlet adapted to communicate with the well tubing in order to supply lift gas to the discharged liquid.

5. In a gas-operated well-pumping mechanism, a single-acting plunger pump adapted to draw liquid from a body of liquid standing in the well, and discharge that liquid into the well tubing, said pump including a cylinder having a pumping chamber at one end and a pumping plunger in said cylinder, a motor cylinder of larger diameter than the pumping cylinder and having one end in constant fluid communication with the opposite end of the pumping cylinder, a piston in the motor cylinder, a mechanical connection between the piston and plunger, means for supplying gas under pressure continuously to said one end of the motor cylinder, valve means carried by the piston and operated automatically at the end of each stroke of the piston for placing the opposite end of the cylinder in communication with the source of gas under pressure at the end of the suction stroke and closing communication at the end of the pumping stroke, said motor cylinder having at its opposite end a restricted outlet.

6. In a gas-operated well-pumping mechanism adapted for attachment to the well tubing, a single-acting plunger pump adapted to draw liquid from a body of liquid standing in the well, and discharge that liquid into the well tubing, said pump including a cylinder having a pumping chamber at one end and a pumping plunger in said cylinder, a motor cylinder of larger diameter than the pumping cylinder and having one end in constant fluid communication with the opposite end of the pumping cylinder, a piston in the motor cylinder, a mechanical connection between the piston and plunger, means for supplying gas under pressure continuously to said one end of the motor cylinder, valve means carried by the piston and operated automatically at the end of each stroke of the piston for placing the opposite end of the cylinder in communication with the source of gas under pressure at the end of the suction stroke and closing communication at the end of the pumping stroke, said motor cylinder having at its opposite end a restricted outlet adapted to communicate with the well tubing in order to supply lift gas to the discharged liquid.

7. In a gas-operated well-pumping mechanism, a plunger pump adapted to draw liquid from a body of liquid standing in the well and discharge that liquid into the lower end of the well tubing, said pump having a cylinder and pump plunger, a motor cylinder, a piston assembly in said motor cylinder, said assembly comprising a valve element and a valve seat element adapted when the valve is seated to constitute a movable piston in the cylinder and adapted when unseated to permit flow of fluid from one end of the motor cylinder to the other past the piston assembly, said pump plunger being connected to one of said elements for movement therewith, said elements being adapted to move into seating relation when the pump plunger moves away from the other element, a spring between said elements acting in a direction to unseat said valve, means for limiting movement of said other element toward both ends of the motor cylinder, means for supplying gas under pressure to that end of the motor cylinder closest to the pumping cylinder, said motor cylinder having a restricted outlet at its opposite end, the net effective areas of the valve element and the piston assembly and the strength of the spring being such that when the valve element is unseated the pressure acting on the assembly effects a stroke of the pump plunger in one direction, while the spring holds the valve element unseated until said other element engages said limiting means and the pressure acting on the assembly when the valve is seated effects a stroke of the pump plunger in the opposite direction and produces sufficient back pressure at said opposite end of the motor cylinder to keep said valve element seated until said other element engages its limiting means in that direction.

8. In a gas-operated well-pumping mechanism, a plunger pump adapted to draw liquid from a body of liquid standing in the well and discharge that liquid into the lower end of the well tubing, said pump having a cylinder and pump plunger, a motor cylinder, a piston assembly in said motor cylinder, said assembly comprising a valve element and a valve seat element adapted when the valve is seated to constitute a movable piston in the cylinder and adapted when unseated to permit flow of fluid from one end of the motor cylinder to the other past the piston assembly, said pump plunger being connected to one of said elements for movement therewith, said elements being adapted to move into seating relation when the pump plunger moves away from the other element, a spring between said elements acting in a direction to unseat said valve, means for limiting movement of said other element toward both ends of the motor cylinder, means for supplying gas under pressure to that end of the motor cylinder closest to the pumping cylinder, said motor cylinder having a restricted outlet at its opposite end which communicates with the liquid discharged by the pump at a point in the vicinity of the pumping mechanism, the net effective areas of the valve element and the piston assembly and the strength of the spring being such that when the valve element is unseated the pressure acting on the

assembly effects a stroke of the pump plunger in one direction, while the spring holds the valve element unseated until said other element engages said limiting means and the pressure acting on the assembly when the valve is seated effects a stroke of the pump plunger in the opposite direction and produces sufficient back pressure at said opposite end of the motor cylinder to keep said valve element seated until said other element engages its limiting means in that direction.

9. In a gas-operated well-pumping mechanism, a single-acting plunger pump adapted to draw liquid from a body of liquid standing in the well and discharge that liquid into the well tubing, said pump including a cylinder having a pumping chamber at one end and a pumping plunger in said cylinder, a motor cylinder of larger diameter than the pumping cylinder and having one end in constant fluid communication with the opposite end of the pumping cylinder, a piston assembly in said motor cylinder, said assembly comprising a valve element and a valve seat element adapted when the valve is seated to constitute a movable piston in the cylinder and adapted when unseated to permit flow of fluid from one end of the motor cylinder to the other past the piston assembly, said pump plunger being connected to one of said elements for movement therewith, said elements being adapted to move into seating relation when the pump plunger moves away from the other element, a spring between said elements acting in a direction to unseat said valve, means for limiting movement of said other element toward both ends of the motor cylinder, means for supplying gas under pressure to said one end of the motor cylinder, said motor cylinder having a restricted outlet at its opposite end, the areas of said valve element and seat element and plunger and the strength of said spring being such that when the valve element is unseated the gas pressure, acting on the valve and plunger, effects a pumping stroke thereof, while the spring holds the valve element unseated until said other element engages said limiting means and the pressure acting on the net effective area of the piston assembly when the valve element is seated effects a suction stroke of the plunger and produces sufficient back pressure at said opposite end of the motor cylinder to hold the valve element seated against the force of the spring until said other element engages said limiting means in the opposite direction.

10. In a gas-operated well-pumping mechanism, a single-acting plunger pump adapted to draw liquid from a body of liquid standing in the well and discharge that liquid into the well tubing, said pump including a cylinder having a pumping chamber at one end and a pumping plunger in said cylinder, a motor cylinder of larger diameter than the pumping cylinder and having one end in constant fluid communication with the opposite end of the pumping cylinder, a piston assembly in said motor cylinder, said assembly comprising a valve element and a valve seat element adapted when the valve is seated to constitute a movable piston in the cylinder and adapted when unseated to permit flow of fluid from one end of the motor cylinder to the other past the piston assembly, said pump plunger being connected to one of said elements for movement therewith, said elements being adapted to move into seating relation when the pump plunger moves away from the other element, a spring between said elements acting in a direction to unseat said valve, means for limiting movement of said other element toward both ends of the motor cylinder, means for supplying gas under pressure to said one end of the motor cylinder, said motor cylinder having a restricted outlet at its opposite end communicating with the liquid discharged by the pump at a point in the vicinity of the pumping mechanism in order to supply lift gas to the discharged liquid, the areas of said valve element and seat element and plunger and the strength of said spring being such that when the valve element is unseated the gas pressure, acting on the valve and plunger, effects a pumping stroke thereof, while the spring holds the valve element unseated until said other element engages said limiting means and the pressure acting on the net effective area of the piston assembly when the valve element is seated effects a suction stroke of the plunger and produces sufficient back pressure at said opposite end of the motor cylinder to hold the valve element seated against the force of the spring until said other element engages said limiting means in the opposite direction.

11. In a gas-operated well-pumping mechanism, a plunger pump adapted to draw liquid from a body of liquid standing in the well and discharge that liquid into the lower end of the well tubing, said pump having a cylinder and pump plunger, a motor cylinder, a rodless piston in said motor cylinder and provided with an opening therethrough, a valve carried by said piston for controlling said opening and having a valve rod connected to said plunger, said valve being adapted to close said opening on separating movement of said piston and plunger, a spring between the piston and valve acting in a direction to open said valve, means for limiting movement of the piston in both directions, means for supplying gas under pressure to that end of the motor cylinder adjacent said plunger, said motor cylinder having a restricted outlet at its opposite end, the net effective areas of said piston and valve and the strength of said spring being such that when the valve is open the pressure acting on the valve effects a stroke of the plunger in one direction while the spring holds the valve open until the piston engages said limiting means and the pressure acting on the piston and valve when the valve is closed effects a stroke of the plunger in the opposite direction and produces sufficient back pressure at said opposite end of the motor cylinder to hold the valve closed until the piston engages its limiting means in that direction.

12. In a gas-operated well-pumping mechanism, a plunger pump adapted to draw liquid from a body of liquid standing in the well and discharge that liquid into the lower end of the well tubing, said pump having a cylinder and pump plunger, a motor cylinder, a rodless piston in said motor cylinder and provided with an opening therethrough, a valve carried by said piston for controlling said opening and having a valve rod connected to said plunger, said valve being adapted to close said opening on separating movement of said piston and plunger, a spring between the piston and valve acting in a direction to open said valve, means for limiting movement of the piston in both directions, means for supplying gas under pressure to that end of the motor cylinder adjacent said plunger, said motor cylinder having a restricted outlet at its opposite end which communicates with the liquid discharged by the pump at a point in the vicinity of the pumping mechanism, the net effective areas

of said piston and valve and the strength of said spring being such that when the valve is open the pressure acting on the valve effects a stroke of the plunger in one direction while the spring holds the valve open until the piston engages said limiting means and the pressure acting on the piston and valve when the valve is closed effects a stroke of the plunger in the opposite direction and produces sufficient back pressure at said opposite end of the motor cylinder to hold the valve closed until the piston engages its limiting means in that direction.

13. In a gas-operated well-pumping mechanism, a single-acting plunger pump adapted to draw liquid from a body of liquid standing in the well and discharge that liquid into the well tubing, said pump including a cylinder having a pumping chamber at one end and a pumping plunger in said cylinder, a motor cylinder of larger diameter than the pumping cylinder and having one end in constant fluid communication with the opposite end of the pumping cylinder, a rodless piston in said motor cylinder and provided with an opening therethrough, a valve carried by said piston for controlling said opening and having a valve rod connected to said plunger, said valve being adapted to close said opening on separating movement of said piston and plunger, a spring between the piston and valve acting in a direction to open said valve, means for limiting movement of the piston in both directions, means for supplying gas under pressure to said one end of the motor cylinder, said motor cylinder having a restricted outlet at its opposite end, the areas of said valve and piston and plunger and the strength of said spring being such that when the valve is open the gas pressure acting on the valve and plunger effects a pumping stroke thereof while the spring holds the valve open until the piston engages said limiting means, and the pressure acting on the piston and the net effective area of the valve when the valve is closed effects a stroke of the plunger in the opposite direction and produces sufficient back pressure at said opposite side of the motor cylinder to hold the valve closed until the piston engages its limiting means in that direction.

14. In a gas-operated well-pumping mechanism, a single-acting plunger pump adapted to draw liquid from a body of liquid standing in the well and discharge that liquid into the well tubing, said pump including a cylinder having a pumping chamber at one end a pumping plunger in said cylinder, a motor cylinder of larger diameter than the pumping cylinder and having one end in constant fluid communication with the opposite end of the pumping cylinder, a rodless piston in said motor cylinder and provided with an opening therethrough, a valve carried by said piston for controlling said opening and having a valve rod connected to said plunger, said valve being adapted to close said opening on separating movement of said piston and plunger, a spring between the piston and valve acting in a direction to open said valve, means for limiting movement of the piston in both directions, means for supplying gas under pressure to said one end of the motor cylinder, said motor cylinder having a restricted outlet at its opposite end which communicates with the liquid discharged by the pump at a point in the vicinity of the pumping mechanism, the areas of said valve and piston and plunger and the strength of said spring being such that when the valve is open the gas pressure acting on the valve and plunger effects a pumping stroke thereof while the spring holds the valve open until the piston engages said limiting means, and the pressure acting on the piston and the net effective area of the valve when the valve is closed effects a stroke of the plunger in the opposite direction and produces sufficient back pressure at said opposite side of the motor cylinder to hold the valve closed until the piston engages its limiting means in that direction.

15. In a gas-operated well-pumping mechanism, a plunger pump adapted to draw liquid from a body of liquid standing in the well and discharge that liquid into the well tubing, a pump-operating motor comprising a cylinder and a piston therein, said piston being connected to the pump plunger, means for supplying gas under pressure to one end of said cylinder, a restricted outlet for the other end of the cylinder, a valve for by-passing said piston, said valve being held closed during a stroke of the piston toward said other end of the cylinder by the back pressure developed at said end by the restricted outlet, a spring for opening said valve on a drop in said back pressure, and means for closing said valve when the piston completes its stroke in the opposite direction.

16. In a gas-operated well-pumping mechanism, a plunger pump adapted to draw liquid from a body of liquid standing in the well and discharge that liquid into the well tubing, a pump-operating motor comprising a cylinder and a piston therein, said piston being connected to the pump plunger, means for supplying gas under pressure to one end of said cylinder, a restricted outlet for the other end of the cylinder which communicates with the liquid discharged by the pump at a point in the vicinity of the pumping mechanism in order to supply lift gas to the discharged liquid, a valve for by-passing said piston, said valve being held closed during a stroke of the piston toward said other end of the cylinder by the back pressure developed at said end by the restricted outlet, a spring for opening said valve on a drop in said back pressure, and means for closing said valve when the piston completes its stroke in the opposite direction.

17. In a gas-operated well-pumping mechanism, a single-acting plunger pump adapted to draw liquid from a body of liquid standing in the well and discharge that liquid into the well tubing, said pump including a cylinder having a pumping chamber at one end and a pumping plunger in said cylinder, a motor cylinder of larger diameter than the pumping cylinder and having one end in constant fluid communication with the opposite end of the pumping cylinder, a piston in the motor cylinder, a mechanical connection between the piston and plunger, means for supplying gas under pressure to said one end of said cylinder, a restricted outlet for the other end of the cylinder, a valve for by-passing said piston, said valve being held closed during a stroke of the piston toward said other end of the cylinder by the back pressure developed at said end by the restricted outlet, a spring for opening said valve on a drop in said back pressure, and means for closing said valve when the piston completes its stroke in the opposite direction.

18. In a gas-operated well-pumping mechanism, a single-acting plunger pump adapted to draw liquid from a body of liquid standing in the well and discharge that liquid into the well tubing, said pump including a cylinder having a pumping chamber at one end and a pumping plunger in said cylinder, a motor cylinder of

larger diameter than the pumping cylinder and having one end in constant fluid communication with the opposite end of the pumping cylinder, a piston in the motor cylinder, a mechanical connection between the piston and plunger, means for supplying gas under pressure to said one end of said cylinder, a restricted outlet for the other end of the cylinder which communicates with the liquid discharged by the pump at a point in the vicinity of the pumping mechanism in order to supply lift gas to the discharged liquid, a valve for by-passing said piston, said valve being held closed during a stroke of the piston toward said other end of the cylinder by the back pressure developed at said end by the restricted outlet, a spring for opening said valve on a drop in said back pressure, and means for closing said valve when the piston completes its stroke in the opposite direction.

19. In a gas-operated well-pumping mechanism, a tubular casing constituting an extension of the well outflow tubing, a cylindrical housing co-axially mounted within and in spaced relation to said casing and having two spaced transverse walls intermediate its ends, the upper end of said housing being adapted to be secured to and in axial alignment with a gas supply pipe located within the well outflow tubing, a centrally located axial opening in the upper transverse wall, an upwardly projecting scale trap secured in said opening, a gas-operated reciprocating motor including a co-axial motor cylinder fixed with respect to and below the lower transverse wall in spaced relation to the cylindrical housing, said lower transverse wall having a passage for flow of gas from the space between the transverse walls into the space between the motor cylinder and the housing, a gas inlet port for said motor communicating with the space between the cylinder and housing, valve means in the space between said transverse walls and operable in response to a predetermined pressure on the outside of said housing for opening communication between said gas supply opening in the upper transverse wall and the space between

the housing and casing, and a plunger pump secured to and depending from said housing and adapted to be operated by said motor to draw liquid from the well and discharge it into the space between the housing and casing.

20. In a gas-operated well-pumping mechanism adapted to be carried by a gas supply pipe and inserted with said pipe into the outflow tubing of the well while such tubing is in place, a cylindrical housing adapted to be secured to the lower end of the gas supply pipe and being of slightly less outside diameter than the inside diameter of the outflow tubing, a transverse wall in said housing, a reciprocating gas-operated motor having a cylinder secured to the lower side of said wall and extending downwardly therefrom in spaced relation to the housing, means for supplying gas to said motor including a gas flow passage connecting the space above the transverse wall with the space between the cylinder and the housing and an inlet port for the lower end of the motor cylinder communicating with the space between the cylinder and housing, a plunger pump depending from and fixed to said housing and having an inlet communicating with the well space exteriorly of the outflow tubing, and an outlet communicating with the space between the housing and tubing, and means effective to close the lower end of the tubing when the pumping mechanism is placed in position.

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