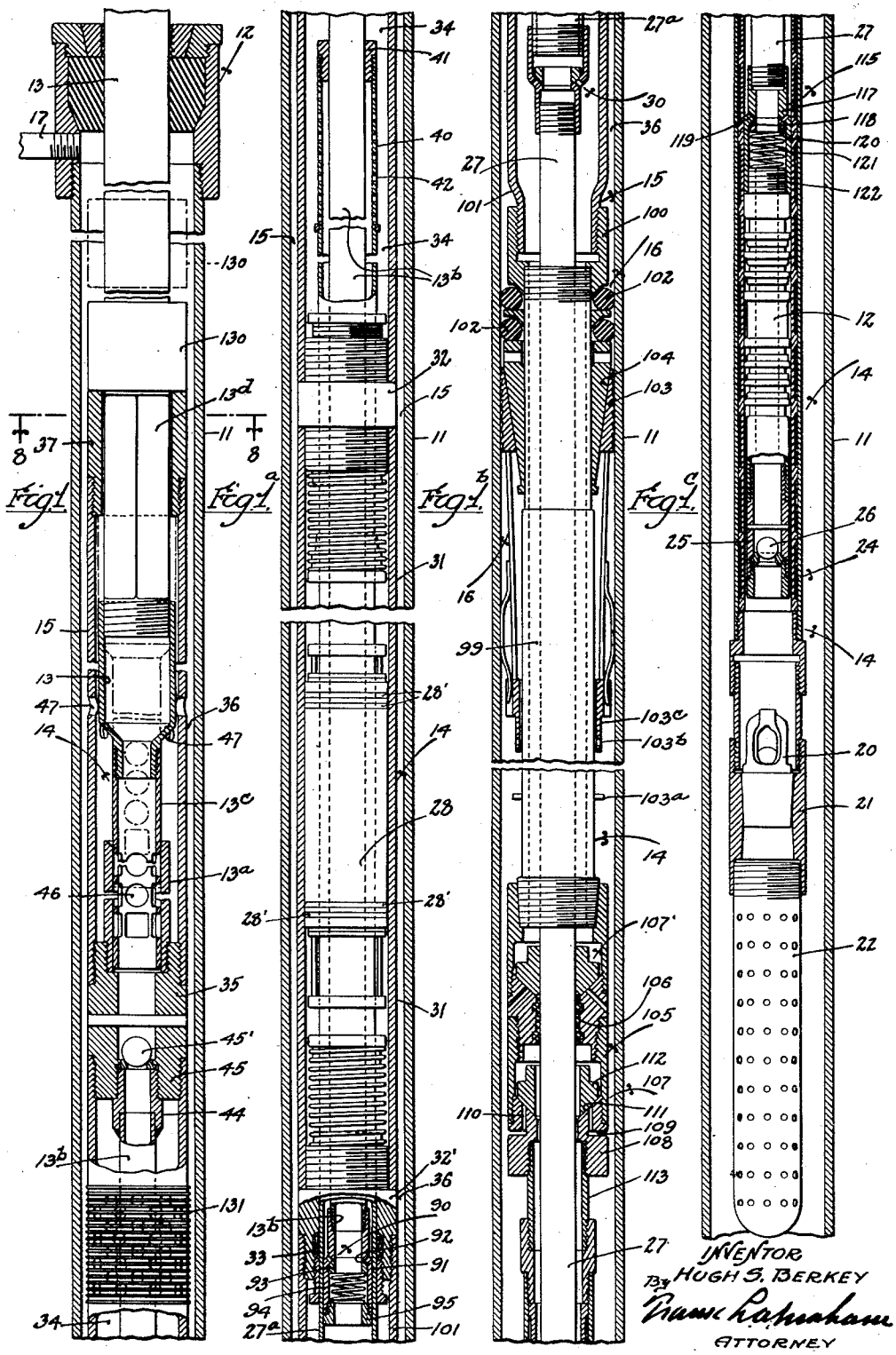
July 26, 1932. H. S. BERKEY 1,868,874

COMBINATION PUMP AND GAS LIFT

Filed Feb. 17, 1930 2 Sheets-Sheet 1



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COMBINATION PUMP AND GAS LIFT

Filed Feb. 17, 1930 2 Sheets-Sheet 2

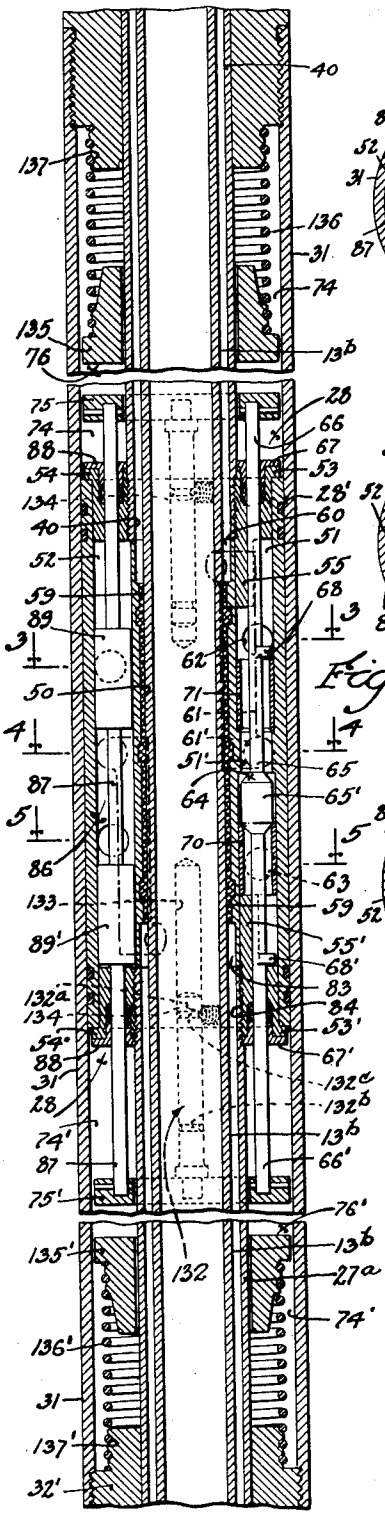


Fig. 3.

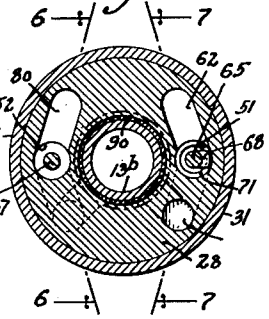


Fig. 4.

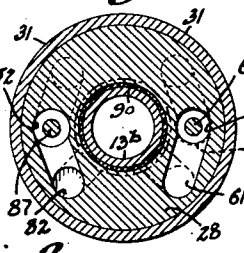


Fig. 5.

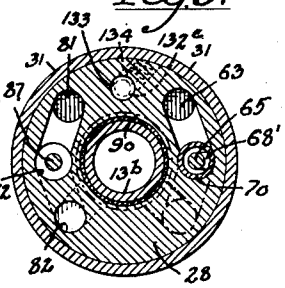


Fig. 8.

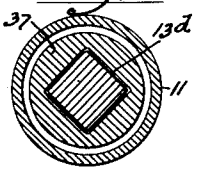


Fig. 6.

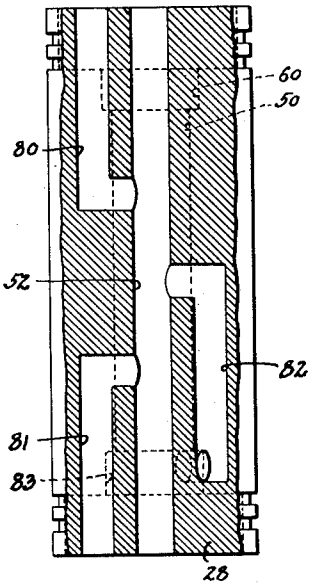
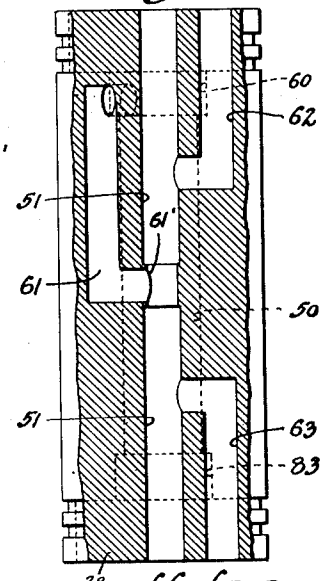


Fig. 7.



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UNITED STATES PATENT OFFICE

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COMBINATION PUMP AND GAS LIFT

Application filed February 17, 1930. Serial No. 429,033.

This invention has to do, in a general way, with well pumping apparatus and is more particularly related to oil well pumps, known as fluid operated pumps, wherein the plunger is actuated without the use of sucker rods.

I am aware of the fact that various pumps of the general type, referred to above, have been developed and have been operated with a certain degree of success, by means of a fluid, either liquid or gas. In some of these pumps, the power fluid is controlled by means of a valve unit, situated on the surface of the ground and in others the introduction of the fluid, to opposite sides of the plunger, is controlled by an intricate valve mechanism embodied in the power cylinder head.

It is the primary object of this invention to produce a pump of the class described which is of simple form and construction and is reliable and highly efficient in its operation at all depths.

It is a further object of this invention to produce a pump of the class described in which the exhaust fluid, used in operating the power piston, is introduced into the stream of pumped liquid, which is leaving the well through the macaroni or liquid delivery tubing, and thereby lessens the specific gravity of the liquid rising therein increasing the efficiency of the pump. The apparatus, contemplated by this invention, might therefore be considered as a combination plunger pump and gas lift.

It is a noteworthy feature of the apparatus, contemplated by this invention, that means are provided for drawing any gas or gas and oil, accumulating in the bottom of the well above the plunger, into the liquid delivery tubing at a point above the plunger.

It therefore becomes a further object of my invention to produce a double acting pump especially adapted for use in connection with the power piston referred to above, in which oil or oil and gas are drawn into the liquid delivery tubing during both strokes of the plunger.

The general construction of the apparatus, contemplated by this invention, consists of a liquid delivery tubing commonly known as macaroni, which extends through the casing head, and into the well casing. A power cylinder is suspended in the casing at a point near the bottom of the well, or near the region occupied by the plunger, and a pressure chamber is formed immediately above or about the power cylinder either by means of a separate string of tubing, which surrounds the macaroni, or by means of a properly positioned packer which is mounted in the casing. This power cylinder contains a piston, which is connected through the medium of a tube or sleeve with a pump plunger that is reciprocally mounted in the plunger barrel. Gas under pressure is delivered into the pressure chamber, and means are provided for delivering such gas from the pressure chamber into the piston which is contained in the power cylinder.

The piston is of a novel construction and contains a set of valves, one of which will be hereinafter referred to as a delivery valve, the other being termed an exhaust valve. The former valve is adapted to alternately release the gas, or other fluid delivered thereto, into opposite ends of the pressure cylinder, and the pressure of this gas is effective to reciprocate the piston in opposite directions, and consequently to impart the necessary reciprocating movement to the plunger. The exhaust valve is adapted to release the gas from the end of the cylinder toward which the piston is moving, and to deliver such released gas through an exhaust compartment from which it is introduced through a valve unit into the body of oil which is rising from the well through the macaroni. Both the exhaust and the delivery valve, referred to above, are mounted upon valve stems which project from opposite ends of the piston, and are synchronously operated through engagement with properly positioned valved operating members situated in the two ends of the cylinder. It is another object of this invention to construct the valves, and the valve operating members in a manner such that both the delivery and the exhaust valves are synchronously and rapidly operated, and the operation of the piston is cushioned to protect the apparatus against

undue jarring action as the piston completes its stroke.

It is another object of my invention to produce an organization, of the class described, which is so constructed that the majority of the oil, or other liquid contained in the casing or in the pressure chamber above the piston, may be forced therefrom through the macaroni, without necessitating its passage through the power cylinder and the power piston.

The details in the construction of one preferred embodiment of my invention will be best understood from the following description of the accompanying drawings, which are chosen for illustrative purposes only, and in which,

Figs. 1, 1*a*, 1*b*, and 1*c* are sectional elevations showing the elements embodied in a pumping organization contemplated by this invention, and illustrating one preferred manner in which such elements may be superimposed, with respect to each other, in a well;

Fig. 2 is an enlarged sectional elevation showing the details in the construction of the power cylinder and piston organization;

Fig. 3 is a plan section which may be considered as having been taken in planes represented by the lines 3—3 in Fig. 2;

Fig. 4 is a plan section which may be considered as having been taken in a plane represented by the line 4—4 in Fig. 2;

Fig. 5 is a plan section, taken in planes represented by lines 5—5 in Fig. 2;

Fig. 6 is a sectional elevation which may be considered as having been taken through the outlet or exhaust side of the piston in a plane represented by the line 6—6 in Fig. 3;

Fig. 7 is a sectional elevation, taken through the inlet, or delivery side of the piston, in a plane represented by the line 7—7 in Fig. 3;

Fig. 8 is a plan section taken in a plane represented by the line 8—8 in Fig. 1.

More particularly describing the invention as herein illustrated, reference numeral 11 indicates an oil well casing, of the usual type, which has a casing head 12 mounted upon its upper end portion. Suspended through the casing head 12 is a liquid delivery tubing, or macaroni, which is indicated in the drawings by reference numerals 13, 13*a*, 13*b*, 13*c* and 13*d*. Suspended in the casing 11, at a point preferably near the bottom of the well, is a pumping apparatus, generally indicated by reference numeral 14. The pumping apparatus is associated with, what I will hereinafter term, a pressure chamber indicated by reference numeral 15.

The pressure chamber 15, in the organization chosen for the purpose of illustrating this invention, is shown as comprising a part of the casing 11 and is formed by a packer indicated by reference numeral 16. The packer 16 forms a gas tight closure in the casing 11 and this construction comprises a convenient and economical means of forming the pressure chamber. It will be understood, however, that instead of employing the packer 16, in connection with the casing 11, a separate string of tubing may be lowered into the well in concentric relation with the macaroni to form the pressure chamber.

When the casing 11 is used as a pressure chamber, the casing head 12 is provided with a gas inlet pipe 17, through which gas or other fluid under pressure may be introduced into the casing from any suitable source, such as a gas compressor or a compressed gas container, (not shown).

The pumping unit 14 consists of a standing valve 20, which may be of the usual construction and is shown as being mounted in a standing valve seat 21, which in turn is mounted upon the upper end of a strainer casing or strainer shoe indicated by reference numeral 22.

A plunger barrel 24 is mounted upon the upper end of the standing valve seat 21 and contains a plunger 25, which may be of the usual construction having a working valve 26 mounted in its lower end portion. The plunger 25 is connected through the medium of a tubular plunger rod 27 with the lower end portion of a power piston 28. It will be noted that the hollow plunger rod contains an enlarged section 27*a*, provided in that region immediately above the packer 16, and having formed in its lower end portion a valve unit 30. It will also be noted that the enlarged section 27*a* is made of a diameter such that its upper end portion forms a sleeve which encloses the lower end portion 13*b* of the macaroni or liquid delivery tubing.

The piston 28 is provided with rings 28′ and is slidably contained within a power cylinder 31. The opposite ends of the cylinder 31 contain cylinder heads 32 and 32′ provided with packing glands 33. The top portion of the upper cylinder head 32 is shown as being in threaded engagement with what I may term an auxiliary pressure chamber 34. The auxiliary pressure chamber 34 is connected through the medium of a hollow coupling 35 with a secondary pressure cylinder 36, which carries at its upper end a bushing 37 through which a squared section 13*b* of the macaroni slidably extends. The top of the piston 28 is provided with a pressure fluid delivery sleeve or strainer 40, which surrounds the section 13*b* of the macaroni, and has mounted on its upper end a bushing 41 in internal sliding engagement with the macaroni. The upper end of the sleeve 40 is provided with a series of slots or apertures 42 through which gas under pressure is adapted to be delivered from the auxiliary pressure chamber into the sleeve 40 and thence into the piston 28.

From Fig. 1 it will be noted that the top portion of the section 13*b* of the macaroni is connected through the medium of a bushing 44 with the lower end of the coupling 45, and that the bushing 44 has provided on its upper end a valve 45′.

It will also be noted from Fig. 1 that the section 13*a* of the macaroni comprises a sleeve which extends upwardly from the coupling 35, and that the section 13*c* of the macaroni, which extends into the sleeve 13*a*, is provided with a plurality of apertures 46. Further that the secondary pressure cylinder 36 is also provided with apertures indicated at 47. The purpose of this construction will be more fully described in connection with the assembly and operation of the unit. Suffice to say at this time that this construction permits the removal of any oil contained in the casing above the section 13*a* without necessitating such oil being forced through the power piston 28 and the power cylinder 31.

The details in the construction of the power piston 28 and its associated parts are best shown in Figs. 2–7 inclusive, where the piston 28 is shown as consisting of a body having a central longitudinal passage 50; a delivery valve cylinder 51; and an exhaust valve cylinder 52. The delivery valve cylinder 51 has bushings 53 and 53′ mounted in its opposite ends and the exhaust valve cylinder 52 has bushings 54 and 54′ mounted in its opposite ends. The bushings 53 and 54 are identical except for the fact that the bushings 53, in the delivery cylinder, are provided with extensions 55 and 55′, the purpose of such extensions being to assist in the control of the operation of delivery valve in a manner which will be hereinafter more fully described. The central portion of the longitudinal passage 50, in the piston 28, is provided with a liner member 59, the inner surface of which is in gas tight sliding engagement with the outer surface of the macaroni section 13*b*. An annular gas delivery chamber 60 is provided in the central passage 50, immediately above the liner 59 and immediately below the lower end of the sleeve 40, which is shown as being in threaded engagement with the upper end portion of the central passage 50. Gas under pressure is delivered into this chamber from the sleeve 40 and from this chamber is delivered into the delivery valve cylinder 51 through an angular duct 61 which is formed in the manner best shown in Fig. 7. A pair of outlet ducts 62 and 63 are formed in the piston so as to connect the oppositely disposed end portions of the main pressure cylinder 31 with the two opposite end portions of the delivery valve cylinder 51. Alternate communication between the two ducts 62 and 63 and the duct 61 is effected by means of a valve organization, generally indicated by reference numeral 64.

The valve organization 64 consists essentially of a valve stem 65, which extends clear through the cylinder 51 and has opposite end portions 66 and 66′ projecting therefrom through packing glands 67 and 67′ mounted in the bushings 53 and 53′. The valve stem 65 has formed thereon, near its central portion, a piston member 65′ and in addition thereto it carries near the two end portions enclosed in the cylinder 51, a pair of bosses indicated by reference numerals 68 and 68′. The valve piston 65′ is adapted to be moved back and forth to opposite sides of the opening 61′ in the duct 61, so as to alternately establish communication between the delivery duct 61 into the outlet ducts 62 and 63.

In order that the complete closure of the outlet duct 62 (or 63) may be effected, when the other outlet duct 63 (or 62) is opened, I provide a pair of sliding sleeves 70 and 71 in the cylinder 51, such sleeves being positioned so as to be moved over the outlet ducts by means of the piston 65′ and to be moved away from the outlet ducts by means of the bosses 68 and 68′.

It will be seen from the construction in Fig. 2 that the sleeve 70 closes the outlet duct 63, and that the outlet duct 62 is in open communication with the inlet duct 61. When the delivery valve organization is in this position, gas under pressure, entering the cylinder 51 through the duct 61, is delivered through the duct 63 into the end 74 of the main power cylinder 31 above the piston 28. The pressure of this gas, entering the space 74 of the cylinder, is effective to force the piston 28 downward toward the bottom cylinder head 32′. As the piston nears the limit of its downward movement the valve stem 66 is moved upward by the engagement of a yoke 75′ with an engaging member 76′. The upward movement of the valve stem 65 is effective to carry the piston 65′ away from the sleeve 70, moving it over the port 61′ and into engagement with the sleeve 71. The continued movement of the piston 65′ moves the sleeve 71 over the port through which the duct 62 communicates with the delivery valve cylinder, such movement being stopped by the engagement of the sleeve 71, with the lower end of the projection 55 on the bushing 53. At the same time as the sleeve 71 is moved over the duct 62, the sleeve 70 is engaged by the boss 68′ and is moved away from the port through which the duct 63 communicates with the cylinder 51. This movement of the sleeve 70 is limited by a restricted central portion 51′ in the cylinder 51. When the valve has been moved to this last mentioned position, it will be seen that the port 63 is in open communication with the delivery port 61 and that gas under pressure is now being delivered into the space 74′ in the main power cylinder below the piston 28. The movement of the piston is again reversed in

the same manner described above by the engagement of a yoke 75, which is attached to the upper end 66 of the valve stem, with an engaging member 76, which is similar in construction to the engaging member 76'.

During the downward movement of the piston described above, the gas contained in the space 74', below the piston, is exhausted therefrom through the exhaust valve cylinder 52 which is provided with ducts 80 and 81, (Fig. 6) for establishing communication between the exhaust valve cylinder and opposite ends of the main power cylinder 31. The piston is also provided with an angular exhaust outlet duct 82, which extends from the central portion of the exhaust valve cylinder 52 to an annular chamber 83, provided in the longitudinal passage of the piston, below the liner 59 and above the upper end 84 of the sleeve section 27*a*, in the hollow plunger rod. The exhaust valve cylinder 52 is provided with a valve organization, generally indicated by reference numeral 86, which is shown as comprising a valve stem 87, the opposite end portions of which extend through packing glands 88 and 88' mounted in the bushings 54 and 54'; such end portions being attached to the yokes 75 and 75' to which the ends 66 and 66' of the delivery valve stem are attached. The valve stem 87 has formed thereon a pair of spaced pistons 89 and 89' which are adapted to alternately close the ports through which the ducts 80 and 81 communicate with the cylinder 52. When in the position shown in Fig. 2 the power piston 28 is being moved downwardly by the gas or pressure fluid in the upper portion of the cylinder, and the pressure fluid in the lower portion of the cylinder finds its outlet through the duct 81, from which it is introduced into the exhaust valve cylinder, and from the exhaust valve cylinder, the exhaust pressure fluid passes through the duct 82 into the annular chamber 83, passing downwardly therethrough and being exhausted through a valve unit 90 into the lower end 13*b* of the liquid delivery tubing or macaroni.

The valve unit 90 consists of a bushing 91 mounted on the lower end of the macaroni section 13*b* with its outer surface in sliding engagement with the inner surface of the enlarged section 27*a* of the hollow plunger rod. This bushing is formed with an apertured seat 92 in its upper portion and a ring valve 93 is held in yieldable engagement with the seat by means of a compression spring 94, which is retained in the bushing by means of an apertured cap 95. From this construction it will be seen that all of the gas exhausted from the power cylinder on either stroke, is delivered into the stream of oil which is being pumped from the well, and acts in the manner of a gas lift to reduce the specific gravity of the oil, thereby greatly increasing the efficiency of the apparatus as an oil well pump.

It was previously mentioned as an object of this invention, to produce a pumping apparatus of the class described which embodied a double acting pump, that is, one in which fluid in the well was drawn into the liquid delivery tubing on both strokes of the plunger. This is accomplished by the organization below the packer 16. The packer 16 may be of any well known construction and is shown as being attached, by means of a collar 100, to the lower threaded end of a pipe section 101 which is threaded to the lower cylinder head 32'. The packer consists of packing members 102 and is held in any desired position in the casing by means of slips 103 which engage a cam surface 104 formed on the body of the packer below the packing members 102. The slips are held in a contracted position by means of pins 103*a* mounted on a tubing section 99 which extends downwardly from the packer 16. The pins 103*a* are adapted to be received in notches 103*b* formed in a ring 103*c* which supports the slips. The slips are released in the usual manner by turning the tubing 99 which is effected in a manner to be hereinafter more fully described. The tubing 99 has mounted on its lower end portion a coupling 105, which will hereinafter be referred to as a plunger barrel head and contains a liner 106, through which the smaller section 27 of the hollow plunger rod slidably extends. The coupling 105 has mounted in its lower end a valve unit 107, which acts as a secondary standing valve and consists of a bushing 108 provided with an annular recess 109 and vertical apertures 110 and having a seat portion 111 formed on its upper end. A ring valve 112 rests upon the seat portion 111 and is adapted to open during the downward movement of the plunger 25, and admit gas or oil from the casing into the tubing section 113, which is shown as forming a part of the plunger barrel 24. It will be noted that the plunger 25 and the tubing section 113 have an internal diameter slightly greater than the external diameter of the hollow plunger rod section 27. It will be seen, therefore, that during the down stroke of the plunger 25, the gas and oil which have entered the tubing 113 through the valve unit 107, are admitted into the liquid delivery tubing through a valve unit 115 mounted in the upper end portion of the plunger 25, and that fluid is admitted into the tubing on both strokes of the plunger. The valve unit 115 is mounted in the lower end of the tubing section 27 and is similar in its construction to the unit indicated by reference numeral 90, comprising a bushing 117 which connects the lower end of the hollow plunger rod 27 with the upper end of the plunger and has formed therein a seating surface 118, provided with aper-

tures 119 against which a ring valve 120 is held in yieldable engagement by means of a compression spring 121. The compression spring 121 is retained in the unit against a bushing 122 formed on the upper end of the plunger 12.

It was also mentioned as an object of this invention to provide an apparatus of the class described with means whereby oil in the well, above the power cylinder, may be exhausted through the macaroni prior to the time at which the action of the pump is initiated. This object is accomplished by means of the sleeve section 13*a* and the apertured nipple 13*c*, which forms a slip joint in the macaroni. In assembling the unit, the power cylinder and the pump are lowered into position and are fastened in the usual manner by means of the slips on the packer. In order that the liquid delivery tubing 13 and its associated parts, including the tubing section 99, may be turned to release the packer, as pointed out above, I propose to make the tubing section 13*a* square or splined and I provide the bushing 37 with a correspondingly formed passage so that the rotation of the tubing 13 will be effective to rotate the section 99. After the packer is released the upper section 13 of the macaroni is positioned so that the apertured nipple 13*c* occupies the dot and dash line position, shown in Fig. 1. Gas under pressure is then introduced into the casing through the pipe 17 and forces any oil which is contained in the casing above the apertures 47, in the secondary pressure chamber 36, through such apertures and into the macaroni through the apertures in the nipple 13*c*. This oil rises through the macaroni and is delivered from the well through the usual "Christmas tree" construction, at the casing head. After all of the oil has been exhausted in this manner until dry gas is being blown from the well, the macaroni is lowered to the full line position shown in which a special collar 130 engages the shoulder, formed on the upper end of the bushing 37. When in this position the gas in the pressure chamber or the space formed between the casing and the packer, enters the auxiliary pressure chamber 34, through the "strainer section" 131. This gas is then admitted into the sleeve section 40, through the apertures 42, and is effective to operate the power piston in the manner described above. In this manner I avoid the necessity of forcing any oil, which rises in the casing to a point above the apertures 47, through the power piston since the valves are especially designed and constructed for use in connection with gas, and are somewhat sluggish when liquid is used as the pumping fluid.

The sleeve 40 and the apertures placed therein in the manner shown, prevent the possibility of trash being admitted into the power piston. This reciprocating sleeve also provides a novel construction whereby a pressure fluid may be continually delivered to the inner portion of a reciprocating piston without the use of a valve structure in the cylinder head.

Another feature of the invention, which was set forth in the objects thereof, was the provision of means for cushioning the action of the piston and effecting a positive and rapid movement of the valves. This is accomplished by making the engaging members 75 and 76 of a yieldable nature and providing a latch member 132 for retarding the movement of the valves. The details in the construction of a preferred form of engaging member, which I propose to use, are most clearly illustrated in Fig. 2. In this construction, the engaging member 76 and 76′ are shown as consisting of engagement plates or engagement hubs 135 and 135′ which are mounted in the ends of compression springs 136 and 136′. The bushings 32 and 32′, which form the cylinder head, are shown as being provided with knurled projecting ends 137, which receive the lower end portion of the spring 136 and are adapted to support the same in the power cylinder. The plate or hub members 135 and 135′ are arranged so as to be engaged by the yokes 75 and 75′ which connect the two end portions of the valve stems 65 and 87. The latch member 132 consists of a pin 132*a* mounted on the yoke 75 (or 75′) and extending into a recess or passage 133 formed in the piston. The pin is provided with notches 132*b* and 132*c* and the piston is provided with an angularly disposed spring pressed plunger 134 adapted to be received by the notches when the valves are in their two opposed positions. The engagement of the yoke 75 with the plate 135 or 135′ is effective, first to compress the spring 136 and then when the pressure in the spring is sufficient to release the plunger 134, the two valves are synchronously snapped into their opposite position. The springs 136, therefore, not only absorb the shock which might otherwise be imparted to the pump, and its associated parts, greatly increasing the life of the unit and adding materially to the smoothness of its operation, but they coact with the latch member 132 to effect a rapid change in position of the valves.

The operation of the apparatus shown, as mentioned above, is effected by introducing gas under pressure into the pressure chamber 36, formed between the casing and the packer 16. This gas enters the auxiliary pressure chamber 34 through the strainer section 131; passes through the apertures 42 in the sleeve section 40, from which it is introduced into the annular chamber 60 in the upper end of the plunger; from there, the gas enters the delivery valve cylinder 51, where its alternate delivery into opposite ends of the power

cylinder 28 is effected by means of the valve unit 64. The exhaust gas, in the end of the cylinder, opposite to which the pressure gas is admitted, is exhausted therefrom through the duct 81 (or 80) into the exhaust valve cylinder 52, from which it finds its outlet through the duct 82, into the exhaust sleeve, or the upper enlarged portion 27*a* of the hollow plunger rod. This gas, as pointed out above, is introduced into the lower end portion of the macaroni, through the valve unit 90.

It will be noted that the section 27*a* of the hollow plunger rod is of greater diameter than the section 27, and it will be apparent, therefore, that, as the pump is operated, there will be a differential pressure created in the chamber or auxiliary barrel 101, with each stroke of the piston. I propose to utilize this fluctuating pressure differential to pump additional liquid from the well by providing a valve unit 107′ in the chamber 101. This valve unit is similar to the valve 107 and admits liquid from the casing into the auxiliary barrel on the "up" stroke of the plunger.

The valve unit 30 is provided for the purpose of admitting the liquid delivered into the barrel 101, through valve 107′, into the bottom portion of the hollow plunger rod section 27*a*.

It will be understood, by those familiar with the art, that the particular assembly of elements, that is, the packer unit used in the manner described, is merely one manner in which the apparatus contemplated by this invention may be used in an oil well, and that by changing the arrangement of the various valves and ports in the tubing members, associated with the pump and power piston, the packer may be positioned above the power cylinder, or the packer may, if desired, be entirely eliminated and the pressure fluid introduced into an independent pressure chamber or pressure tubing which extends from the pumping unit to the surface of the ground.

It is to be understood, therefore, that, while I have herein described and illustrated one preferred embodiment of my invention and have shown the same as being assembled in a preferred manner, which is convenient for economical operation in deep oil wells, the invention is not limited to the precise construction set forth above, but includes within its scope whatever changes fairly come within the spirit of the appended claims.

I claim as my invention:

1. A pumping apparatus embodying the combination of: a power cylinder adapted to be suspended in a well; a piston in said power cylinder, said piston having a longitudinal passage therethrough; a liquid delivery tubing suspended in said well, and extending through the passage in said piston; means for alternately delivering a pressure fluid through said piston into said power cylinder at opposite ends thereof, for effecting reciprocation of said piston in said cylinder; means for alternately delivering exhaust pressure fluid through said piston into said delivery tubing; a plunger barrel in said well; a plunger in said barrel connected with said piston; and means for delivering liquid pumped by said plunger into said liquid delivery tubing.

2. A pumping apparatus embodying the combination of: a power cylinder adapted to be suspended in a well; a piston in said power cylinder, said piston having a longitudinal passage therethrough; a liquid delivery tubing suspended in said well and extending through the passage in said piston; a pressure chamber in said well; means for delivering fluid under pressure from said pressure chamber into said piston; means for alternately releasing said fluid into opposite ends of said cylinder thereby reciprocating said piston in said cylinder; means for alternately delivering exhaust pressure fluid through said piston into said delivery tubing; a plunger barrel in said well; a plunger in said barrel connected with said piston; and means for delivering liquid pumped by said plunger into said liquid delivery tubing.

3. A pumping apparatus for use in a well, embodying the combination of: a pressure chamber in said well; a power cylinder suspended in said well below said pressure chamber; a piston in said power cylinder, said piston having a longitudinal passage therethrough; a liquid delivery tubing suspended in said well and extending through the passage in said piston; a pressure fluid delivery sleeve mounted in the top portion of said piston and surrounding said delivery tubing; means for delivering a pressure fluid from said pressure chamber through said sleeve into said piston; means for alternately releasing said fluid into said chamber at opposite ends of said piston; means for alternately delivering exhaust pressure fluid through said piston into said delivery tubing; a plunger barrel in said well, a plunger in said barrel connected with said piston; and means for delivering liquid pumped by said plunger into said liquid delivery tubing.

4. A pumping apparatus embodying the combination of: a power cylinder adapted to be suspended in a well; a piston, in said power cylinder, said piston having a longitudinal passage therethrough; a liquid delivery tubing suspended in said well and extending through the passage in said piston; means including a valve in said piston for alternately delivering a pressure fluid through said piston into said power cylinder at opposite ends thereof, for effecting reciprocation of said piston in said cylinder; means for alternately delivering exhaust

pressure fluid through said piston into said delivery tubing; a plunger barrel in said well; a plunger in said barrel connected with said piston; and means for delivering liquid pumped by said plunger into said liquid delivery tubing.

5. A pumping apparatus embodying the combination of: a power cylinder adapted to be suspended in a well; a piston, in said power cylinder, said piston having a longitudinal passage therethrough; a liquid delivery tubing suspended in said well and extending through the passage in said piston; a pressure chamber in said well; means for delivering fluid under pressure from said pressure chamber into said piston; valve means in said piston for alternately delivering said pressure fluid into said power cylinder at opposite ends thereof; means for alternately delivering exhaust pressure fluid through said piston into said delivery tubing; a plunger barrel in said well; a plunger in said barrel connected with said piston; and means for delivering liquid pumped by said plunger into said liquid delivery tubing.

6. A pumping apparatus for use in a well embodying the combination of: a pressure chamber in said well; a power cylinder suspended in said well in cooperative relation with said pressure chamber; a piston in said power cylinder, said piston having a longitudinal passage therethrough; a liquid delivery tubing suspended in said well and extending through the passage in said piston; a pressure fluid delivery sleeve mounted in the top portion of said piston and surrounding said delivery tubing; means for delivering a pressure fluid from said pressure chamber through said sleeve into said piston; means for alternately releasing said fluid into said chamber at opposite ends of said piston; valve means in said piston for alternately delivering exhaust pressure fluid through said piston into said delivery tubing; a plunger barrel in said well; a plunger in said barrel connected with said piston; and means for delivering liquid pumped by said plunger into said liquid delivery tubing.

7. A pumping apparatus embodying the combination of: a power cylinder adapted to be suspended in a well; a piston in said power cylinder, said piston having a longitudinal passage therethrough; a liquid delivery tubing suspended in said well and extending through the passage in said piston; means for alternately delivering a pressure fluid through said piston into said power cylinder at opposite ends thereof, for effecting reciprocation of said piston in said cylinder; valve means in said piston for alternately releasing exhaust pressure fluid from opposite ends of said cylinder; means for delivering said released exhaust pressure fluid into said delivery tubing; a plunger barrel in said well; a plunger in said barrel connected with said piston; and means for delivering liquid pumped by said plunger into said liquid delivery tubing.

8. A pumping apparatus embodying the combination of: a power cylinder adapted to be suspended in a well; a piston in said power cylinder; said piston having a longitudinal passage therethrough; a liquid delivery tubing suspended in said well and extending through the passage in said piston; means for alternately delivering a pressure fluid through said piston into said power cylinder at opposite ends thereof, for effecting reciprocation of said piston in said cylinder; valve means in said piston for alternately releasing exhaust pressure fluid from opposite ends of said cylinder; additional valve means for delivering said released exhaust pressure fluid into said delivery tubing; a plunger barrel in said well; a plunger in said barrel connected with said piston; and means for delivering liquid pumped by said plunger into said liquid delivery tubing.

9. A pumping apparatus embodying the combination of: a power cylinder adapted to be suspended in a well; a piston in said power cylinder, said piston having a longitudinal passage therethrough; a liquid delivery tubing suspended in said well and extending through the passage in said piston; means for alternately delivering a pressure fluid through said piston into said power cylinder at opposite ends thereof, for effecting reciprocation of said piston in said cylinder; valve means in said piston for alternately releasing exhaust pressure fluid from opposite ends of said cylinder; means, including a sleeve mounted in the bottom portion of said piston surrounding said delivery tubing for delivering said released exhaust pressure fluid into said delivery tubing; a plunger barrel in said well; a plunger in said barrel connected with said piston; and means for delivering liquid pumped by said plunger into said liquid delivery tubing.

10. A pumping apparatus embodying the combination of: a power cylinder adapted to be suspended in a well; a piston in said power cylinder, said piston having a longitudinal passage therethrough; a liquid delivery tubing suspended in said well and extending through the passage in said piston; means for alternately delivering a pressure fluid through said piston into said power cylinder, at opposite ends thereof, for effecting reciprocation of said piston in said cylinder; valve means in said piston for alternately releasing exhaust pressure fluid from opposite ends of said cylinder; means, including a sleeve mounted in said piston surrounding the bottom of said delivery tubing, a ring on said delivery tubing in sliding engagement with the inner surface of said sleeve, and a valve in said delivery tubing above said ring,

for delivering said released exhaust pressure fluid into said delivery tubing; a plunger barrel in said well; a plunger in said barrel connected with said piston; and means for delivering liquid pumped by said plunger into said liquid delivery tubing.

11. A pumping apparatus embodying the combination of: a power cylinder adapted to be suspended in a well; a piston in said power cylinder, said piston having a longitudinal passage therethrough; a liquid delivery tubing suspended in said well and extending through the passage in said piston; means including a valve in said piston for alternately delivering a pressure fluid into said cylinder at opposite ends of said piston; means including another valve in said piston for alternately exhausting pressure fluid from opposite ends of said piston; a plunger barrel in said well; a plunger in said barrel connected with said piston; and means for delivering liquid pumped by said plunger into said liquid delivery tubing.

12. A pumping apparatus embodying the combination of: a power cylinder adapted to be suspended in a well; a piston in said power cylinder, said piston having a longitudinal passage therethrough; a liquid delivery tubing suspended in said well and extending through the passage in said piston; means including a valve in said piston for alternately delivering a pressure fluid into said cylinder at opposite ends of said piston; means including another valve in said piston for alternately exhausting pressure fluid from opposite ends of said piston; means for effecting synchronous movement of said valves; a plunger barrel in said well; a plunger in said barrel connected with said piston; and means for delivering liquid pumped by said plunger into said liquid delivery tubing.

13. A pumping apparatus embodying the combination of: a power cylinder adapted to be suspended in a well; a piston in said power cylinder, said piston having a longitudinal passage therethrough; a liquid delivery tubing suspended in said well and extending through the passage in said piston; means including a valve in said piston for alternately delivering a pressure fluid into said cylinder at opposite ends of said piston; means including another valve in said piston for alternately exhausting pressure fluid from opposite ends of said piston; means comprising valve stems extending through said power piston; engaging members in opposite ends of said power cylinder for effecting synchronous movement of said valves; a pump in said well having a plunger operated by said piston; and means for conducting fluid from said pump into said delivery tubing.

14. A pumping apparatus embodying the combination of: a power cylinder adapted to be suspended in a well; a piston in said power cylinder, said piston having a longitudinal passage therethrough; a liquid delivery tubing suspended in said well and extending through the passage in said piston; a pressure chamber in said well; a fluid delivery sleeve mounted in the upper end portion of said piston and surrounding said tubing, said sleeve being provided with an opening for admitting fluid under pressure from said pressure chamber, said piston being provided with a delivery valve cylinder and a duct connecting said valve cylinder with said sleeve; a valve unit in said cylinder adapted to alternately open and close additional ducts provided in said piston and leading to opposite ends thereof; means for exhausting expanded gas from opposite ends of said cylinder space; a plunger barrel in said well; a plunger in said barrel connected with said piston; and means for delivering liquid pumped by said plunger into said delivery tubing.

15. A pumping apparatus embodying the combination of: a power cylinder adapted to be suspended in a well; a piston in said power cylinder, said piston having a longitudinal passage therethrough; a liquid delivery tubing suspended in said well and extending through the passage in said piston; a pressure chamber in said well; a fluid delivery sleeve mounted in the upper end of said piston in internal communication with said pressure chamber, said piston being provided with valve controlled ducts for alternately establishing communication between opposite ends of said piston and said sleeve; means for exhausting gas from said power cylinder; a plunger barrel in said well; a plunger in said barrel connected with said piston; and means for delivering liquid pumped by said plunger into said delivery tubing.

16. A pumping apparatus embodying the combination of: a power cylinder adapted to be suspended in a well; a piston in said power cylinder, said piston having a longitudinal passage therethrough; a liquid delivery tubing suspended in said well and extending through the passage in said piston; means including a valve in said piston for alternately delivering a pressure fluid into said cylinder at opposite ends of said piston; means including another valve in said piston for alternately exhausting pressure fluid from opposite ends of said piston; means comprising valve stems extending through said power piston; yieldable engaging members in opposite ends of said power cylinder for effecting synchronous movement of said valves; a pump in said well having a plunger connected with said piston; and means for conducting fluid from said pump to said delivery tubing.

17. A pumping apparatus embodying the combination of: a power cylinder adapted

to be suspended in a wall; a piston in said power cylinder, said piston having a longitudinal passage therethrough; a liquid delivery tubing suspended in said well and extending through the passage in said piston; means including a valve in said piston for alternately delivering a pressure fluid into said cylinder at opposite ends of said piston; means including another valve in said piston for alternately exhausting pressure fluid from opposite ends of said piston, said valves including stems extending through opposite ends of said piston; means for effecting synchronous movement of said valves comprising compression springs mounted in opposite ends of said cylinder and plate members on said springs adapted to be engaged by said valve stems; a pump in said well having a plunger connected with said piston; and means for conducting fluid from said pump to said delivery tubing.

18. A pumping apparatus embodying the combination of: a power cylinder adapted to be suspended in a well; a piston in said power cylinder, said piston having a longitudinal passage therethrough; a liquid delivery tubing suspended in said well and extending through the passage in said piston; means for alternately delivering a pressure fluid into opposite end portions of said cylinder space; means for alternately exhausting pressure fluid from opposite end portions of said cylinder space comprising an exhaust sleeve, mounted in one end portion of said piston, and valved ducts in said piston connecting said sleeve with opposite ends of said cylinder; a plunger barrel in said well; a plunger in said barrel connected with said piston; and means for delivering liquid pumped by said plunger into said delivery tubing.

19. A pumping apparatus embodying the combination of: a power cylinder adapted to be suspended in a well; a piston in said power cylinder, said piston having a longitudinal passage therethrough; a liquid delivery tubing suspended in said well and extending through the passage in said piston; means for alternately delivering a pressure fluid into opposite end portions of said cylinder space; means for alternately exhausting expanded gas from opposite end portions of said cylinder space comprising an exhaust sleeve, mounted in the lower end portion of said piston, said piston being provided with an exhaust cylinder and a duct connecting said exhaust cylinder with said exhaust sleeve, and a valve in said exhaust cylinder for alternately establishing communication through said duct with said exhaust sleeve, and additional ducts in said piston leading to opposite ends of said power cylinder; a plunger barrel in said well; a plunger in said barrel connected with said piston; and means for delivering liquid pumped by said plunger into said delivery tubing.

20. A pumping apparatus embodying the combination of: a power cylinder adapted to be suspended in a well; a piston in said power cylinder, said piston having a longitudinal passage therethrough; a liquid delivery tubing suspended in said well and extending through the passage in said piston; means for alternately delivering a pressure fluid into opposite end portions of said cylinder space; means for alternately exhausting expanded gas from opposite end portions of said cylinder space comprising an exhaust sleeve, mounted in the lower end portion of said piston, in internal sliding engagement with an enlarged lower end portion of said liquid delivery tubing, said piston being provided with an exhaust cylinder and a duct connecting said exhaust cylinder with said exhaust sleeve; a valve in said exhaust cylinder for alternately establishing communication through said duct with said exhaust sleeve, additional ducts in said piston leading to opposite ends of said power cylinder; a valve in said liquid delivery tubing for admitting exhaust gas from said sleeve into said liquid delivery tubing; a plunger barrel in said well; a plunger in said barrel connected with said piston; and means for delivering liquid pumped by said plunger into said delivery tubing.

21. A pumping apparatus embodying the combination of: a power cylinder adapted to be suspended in a well; a piston in said power cylinder, said piston having a longitudinal passage therethrough; a liquid delivery tubing suspended in said well and extending through the passage in said piston; means for alternately delivering a pressure fluid into opposite end portions of said cylinder space; means for alternately exhausting expanded gas from opposite end portions of said cylinder space comprising an exhaust sleeve mounted in the lower end portion of said piston, in internal sliding engagement with an enlarged lower end portion of said liquid delivery tubing, said piston being provided with an exhaust cylinder and a duct connecting said exhaust cylinder with said exhaust sleeve; a valve in said exhaust cylinder for alternately establishing communication through said duct with said exhaust sleeve, additional ducts in said piston leading to opposite ends of said power cylinder; a valve in said liquid delivery tubing for admitting exhaust gas from said sleeve into said liquid delivery tubing; a plunger barrel in said well; a plunger in said plunger barrel; a hollow plunger rod connecting said plunger with said exhaust sleeve, said liquid delivery tubing having a bottom inlet opening in said hollow plunger rod.

22. A pumping apparatus embodying the combination of: a power cylinder adapted to be suspended in a well; a piston in said power cylinder, said piston having a longi-

tudinal passage therethrough, a liquid delivery tubing suspended in said well and extending through the passage in said piston; means for alternately delivering a pressure fluid into opposite end portions of said cylinder space; means for alternately exhausting expanded gas from opposite end portions of said cylinder space comprising an exhaust sleeve, mounted in the lower end portion of said piston, in internal sliding engagement with an enlarged lower end portion of said liquid delivery tubing, said piston being provided with an exhaust cylinder and a duct connecting said exhaust cylinder with said exhaust sleeve; a valve in said exhaust cylinder for alternately establishing communication through said duct with said exhaust sleeve, additional ducts in said piston leading to opposite ends of said power cylinder; a valve seat in the lower enlarged end portion of said fluid delivery tubing; a valve in yieldable engagement with said seat, said seat being provided with ports to admit fluid from said exhaust sleeve into said tubing; a plunger barrel in said well; a plunger in said plunger barrel connected with said piston; and means for delivering liquid pumped by said plunger into said delivery tubing.

23. A pumping apparatus, adapted for use in a well, embodying the combination of: a plunger barrel; a plunger in said plunger barrel; a power cylinder; a power piston in said cylinder; means connecting said plunger to said power piston; means for delivering pumped liquid from said well through said piston; and means for alternately delivering a pressure fluid through said piston into said power cylinder at opposite ends thereof, for reciprocating said piston in said cylinder.

24. A pumping apparatus, adapted for use in a well, embodying the combination of: a plunger barrel; a plunger in said plunger barrel; a power cylinder; a power piston in said cylinder; a hollow connecting member interposed between said plunger and said power piston; means for delivering pumped liquid from said well through said hollow connecting member and said piston; and means for alternately delivering a pressure fluid through said piston into said power cylinder at opposite ends thereof, for reciprocating said piston in said cylinder.

25. A pumping apparatus, adapted for use in a well, embodying the combination of: a plunger barrel; a plunger in said plunger barrel; a power cylinder; a power piston in said cylinder; means connecting said plunger to said power piston; means for delivering pumped liquid from said well through said piston; and means including a strainer sleeve, mounted in the top of said piston, for alternately delivering a pressure fluid through said piston into said power cylinder at opposite ends thereof, for reciprocating said piston in said cylinder.

26. A pumping apparatus, adapted for use in a well, embodying the combination of: a plunger barrel; a plunger in said plunger barrel; a power cylinder; a power piston in said cylinder; means connecting said plunger to said power piston; means for delivering pumped liquid from said well through said piston; and valve means in said piston for alternately delivering a pressure fluid through said piston into said power cylinder at opposite ends thereof, for reciprocating said piston in said cylinder.

27. A pumping apparatus, adapted for use in a well, embodying the combination of: a plunger barrel; a plunger in said plunger barrel; a power cylinder; a power piston in said cylinder; a hollow connecting member interposed between said plunger and said power piston; means for delivering pumped liquid from said well through said hollow connecting member and said piston; and means for alternately delivering a pressure fluid through said piston into said power cylinder at opposite ends thereof, for reciprocating said piston in said cylinder, said valve means being actuated by the engagement of end portions thereof with the opposite end portions of said pressure cylinder.

28. A pumping apparatus, adapted for use in a well, embodying the combination of: a plunger barrel; a plunger in said plunger barrel; a power cylinder; a power piston in said cylinder; means connecting said plunger with said power piston; a liquid delivery tubing for delivering pumped liquid from said well through said piston; means for alternately delivering a pressure fluid through said piston into said power cylinder at opposite ends thereof, for reciprocating said piston in said cylinder; and means for delivering exhaust pressure fluid from said cylinder into said liquid delivery tubing.

29. A pumping apparatus, adapted for use in a well, embodying the combination of: a plunger barrel; a plunger in said plunger barrel; a power cylinder; a power piston in said cylinder; means connecting said plunger with said power piston; a liquid delivery tubing for delivering pumped liquid from said well through said piston; means for alternately delivering a pressure fluid through said piston into said power cylinder at opposite ends thereof, for reciprocating said piston in said cylinder; and means for delivering exhaust pressure fluid from said cylinder through said piston into said liquid delivery tubing.

30. A pumping organization, for use in combination with a well casing, embodying the combination of: a plunger barrel; a plunger in said barrel; a power cylinder; a piston in said power cylinder; tubular connecting means interposed between said piston and said plunger; a delivery tubing for delivering pumped liquid from said barrel through

said piston; a packer in said casing forming a pressure chamber therein; and means for alternately delivering a pressure fluid from said pressure chamber through said piston and into opposite ends of said power cylinder.

31. A pumping organization for use in combination with a well casing, embodying the combination of: a plunger barrel; a plunger in said barrel; a power cylinder; a piston in said power cylinder; tubular connecting means interposed between said piston and said plunger; a delivery tubing for delivering pumped liquid from said barrel through said piston; a packer in said casing forming a pressure chamber therein; means for alternately delivering a pressure fluid from said pressure chamber into opposite ends of said power cylinder; and means for optionally admitting liquid in said pressure chamber above said packer into said delivery tubing.

32. A pumping organization, for use in combination with a well casing, embodying the combination of: a plunger barrel; a plunger in said barrel; a power cylinder; a piston in said power cylinder; tubular connecting means interposed between said piston and said plunger; a delivery tubing for delivering pumped liquid from said barrel through said piston; a packer in said casing forming a pressure chamber therein; means for alternately delivering a pressure fluid from said pressure chamber, into opposite ends of said power cylinder; and means comprising a slip joint in said delivery tubing for optionally admitting liquid in said pressure chamber above said power cylinder into said delivery tubing.

33. A pumping organization, for use in combination with a well casing, embodying the combination of: a plunger barrel; a plunger in said barrel; a power cylinder; a piston in said power cylinder; tubular connecting means interposed between said piston and said plunger; a sectional delivery tubing for delivering pumped liquid from said barrel through said piston; a packer in said casing forming a pressure chamber therein; means for alternately delivering a pressure fluid from said pressure chamber into opposite ends of said power cylinder; said delivery tubing being composed of sections which are longitudinally movable with respect to each other; and means for holding said sections against rotation with respect to each other.

34. A pumping organization, for use in combination with a well casing, embodying the combination of: a plunger barrel; a plunger in said barrel; a power cylinder; a piston in said power cylinder; tubular connecting means interposed between said piston and said plunger; a sectional delivery tubing for delivering pumped liquid from said barrel through said piston; a packer in said casing forming a pressure chamber therein; means for alternately delivering a pressure fluid from said pressure chamber into opposite ends of said power cylinder; said tubing being composed of sections which are longitudinally movable relative to each other.

35. A power unit embodying: a power cylinder; a power piston in said cylinder; means for delivering a pressure fluid into said piston; a delivery valve in said piston for alternately delivering said pressure fluid into opposite ends of said cylinder; an exhaust valve for alternately delivering exhaust pressure fluid from opposite ends of said cylinder; said exhaust valve and said delivery valve each including a valve stem which extends from opposite ends of said piston, and is adapted to engage opposite end portions of said cylinder; and latch means for yieldably holding said valve stems against movement.

36. A power unit embodying: a power cylinder; a power piston in said cylinder; means for delivering a pressure fluid into said piston; a delivery valve in said piston for alternately delivering said pressure fluid into opposite ends of said cylinder; an exhaust valve in said piston for alternately delivering exhaust pressure fluid from opposite ends of said cylinder; said valves including valve stems extending from opposite ends of said piston and adapted to engage opposite end portions of said cylinder; and means rigidly inter-connecting said valve stems.

37. A power unit embodying: a power cylinder; a power piston in said cylinder; means for delivering a pressure fluid into said piston; a delivery valve in said piston for alternately delivering said pressure fluid into opposite ends of said cylinder; an exhaust valve in said piston for alternately delivering exhaust pressure fluid from opposite ends of said cylinder; said valves including valve stems extending from opposite ends of said piston; means rigidly interconnecting said valve stems; yieldable engagement members in opposite ends of said cylinder for moving said valves; and valve latching means for yieldably holding said valves against movement.

38. A power unit embodying: a power cylinder; a power piston in said cylinder; means for delivering a pressure fluid into said piston; a delivery valve in said piston for alternately delivering said pressure fluid into opposite ends of said cylinder; an exhaust valve for alternately delivering exhaust pressure fluid from opposite ends of said cylinder; said valves including valve stems extending from opposite ends of said piston and adapted to engage opposite end portions of said cylinder; means rigidly inter-connecting said valve stems; and valve latching means comprising a pin mounted

in said stem-connecting means and extending into a recess in said piston; and a yieldable plunger mounted in said piston adjacent said recess, engaging said pin, said pin being provided with spaced notches adapted to receive said plunger.

In testimony whereof, I have hereunto set my hand at Los Angeles, California, this 5th day of February, 1930.

HUGH S. BERKEY.