May 9, 1933. A. G. GAGE 1,907,953

WELL PUMP

Original Filed April 10, 1931

Fig 1.

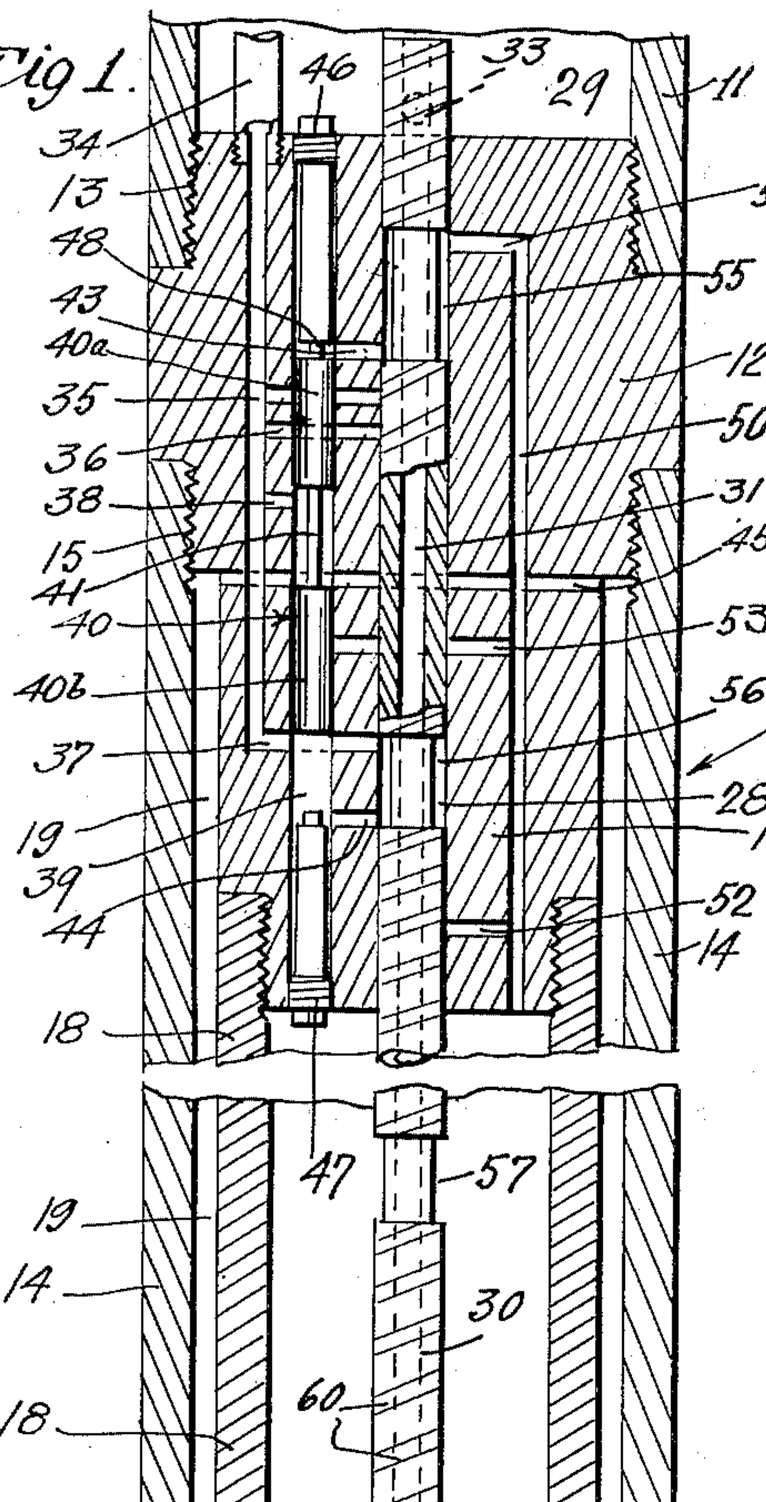


Fig 2

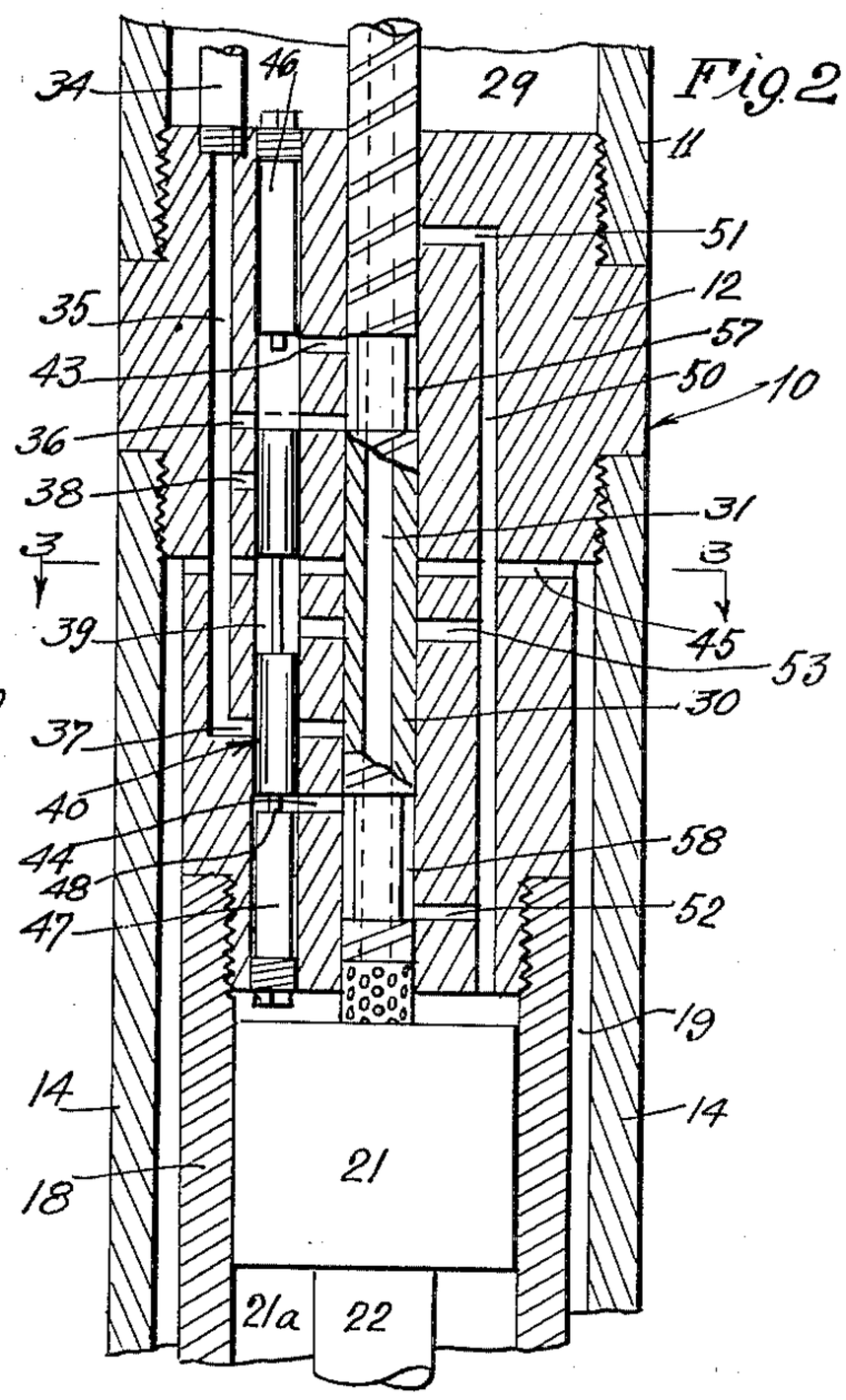
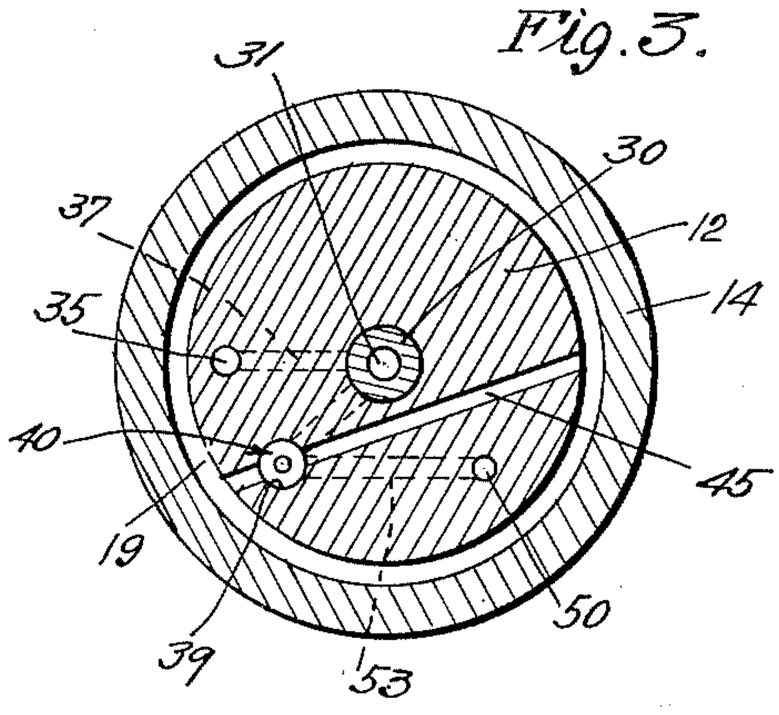


Fig. 3.



Inventor.
Arthur G. Gage.

Attorney

Patented May 9, 1933 1,907,953

UNITED STATES PATENT OFFICE

ARTHUR G. GAGE, OF LOS ANGELES, CALIFORNIA

WELL PUMP

Application filed April 10, 1931, Serial No. 529,061. Renewed October 7, 1932.

This invention has reference to deep well pumps of the fluid pressure operated type in which the pump is carried on the lower end of the well pipe and the pump piston is actuated by high pressure fluid conducted downwardly through the well pipe, the well liquid being discharged by the pump into a pumping column also within the well pipe. The invention may be further characterized as having to do with fluid pressure operated well pumps in which the pump piston is moved on its down stroke by pumping column pressure, that is the pressure of the column of liquid to which the pump discharges.

In my copending application on Fluid pressure actuated well pumps, Ser. No. 378,922, filed July 17, 1929, I describe a pump of this general character in which the piston is operated on its down stroke by pumping column pressure, the application of the pump column pressure in this case however being directly against an upper pressure area on the piston and controlled by a valve mechanism in the pump head. With respect to its operation by pumping column pressure, the present pump differs from that described in my copending application referred to, in that the pumping column pressure, instead of being applied directly to the piston and controlled by a valve mechanism, is applied to piston actuating member operatively connected to the piston and extending upwardly through the pump head into the pumping column, said member being subjected at all times to pumping column pressure. In operation, the piston is moved on its up stroke by high pressure actuating fluid having an effective upward pressure on the piston sufficient to overcome the downward pressure on the said member exposed to pumping column pressure. At the limit of the up stroke of the piston, the actuating fluid pressure is cut off from the under side of the piston so as to permit the latter to be operated on its return stroke by pumping column pressure applied to the piston operating member.

In addition to the purpose mentioned, the pumping column pressure actuated member may, though not necessarily in certain aspects of the invention, be utilized as a valve for controlling the application of high pressure fluid to the piston, since the said member is movable with the piston by virtue of its association therewith. In my preferred embodiment of the invention, the piston actuating member extends from the piston entirely through the valve head into the pumping column, and operates essentially as a pilot valve to control the operation of the fluid pressure actuated master valve, which, in turn, controls the delivery of high pressure fluid to the piston chamber to operate the piston on its up stroke. I may state at this point that while I have shown, for purposes of describing the invention, one particular type of valve mechanism, it is to be understood that in the broad aspects of the invention, any suitable type of valve mechanism may be used for the purpose of intermittently applying high pressure fluid to the piston to move the latter on its up stroke.

The various objects and aspects of the invention will be understood more fully and as to details, from the following description of a typical and preferred embodiment thereof, reference being had throughout the description to the accompanying drawing in which:

Fig. 1 is a medial longitudinal sectional view of the pump, the piston being shown at the limit of its down stroke and the valve parts illustrated in corresponding positions;

Fig. 2 is a fragmentary sectional view of the upper portion of the pump showing the piston at substantially the limit of its up stroke and the valve parts in corresponding positions; and

Fig. 3 is a horizontal section on line 3—3 of Fig. 2 illustrating the true relative positions of the valve bores and certain of the fluid passages in the valve head.

In Figs. 1 and 2 of the drawing I have shown, for purposes of clarity, developed views of the valve head and the various bores and passages therein, the parts being illustrated as lying in a single plane. As stated, however, the true relative positions of the valves and certain of the fluid passages are represented in Fig. 3.

Referring now to Fig. 1, the pump, gen-

erally indicated at 10, is shown to be suspended on the lower end of the well pipe 11, the pump being submerged beneath the standing lever of the well liquid to be pumped. The pump parts comprise a valve head 12 threaded at 13 in the well pipe 11, and an outer pipe or casing 14 threaded at 15 on the valve head. The lower end of the casing 14 is closed by plug 16 which carries a depending sleeve 17 within which the lower reduced portion of the piston works, as will hereinafter appear.

Carried on the lower end of the valve head is a piston barrel 18 which, together with the lower portion 12*a* of the valve head, is annularly spaced at 19 from the pump casing 14. The lower end of the piston barrel is spaced at 20 from the lower end closure 16 of the casing so as to provide for communication between space 19 and the piston chamber beneath the piston 21. Within barrel 18 is a tubular piston 21 having a tubular reduced diameter portion 22 extending downwardly within sleeve 17, portion 22 of the piston having a sliding fit within the sleeve. A check valve 23 is carried within the lower section of the piston, valve 23 permitting the well liquid, during the down stroke of the piston, to flow upwardly through bore 24 in the piston into chamber 21*a* thereabove.

An annular downwardly facing pressure area 25 is provided on the piston around the reduced diameter section 22, high pressure fluid being directed through spaces 19 and 20 against the pressure area 25 to move the piston on its up stroke. A suitable abutment, such as a raised portion 26 on plug 16, is provided for arresting the downward movement of the piston to prevent its closing off communication between the pump chamber and space 19 by covering the annular opening 20.

A bore 28 extends through the valve head 12 and in axial alinement with the piston, and extending from the piston through bore 28 into the interior 29, hereinafter termed the pumping column, of the well pipe, is a piston actuating member or valve 30. The valve preferably is formed integrally with the piston, though this may not necessarily be the case since, as will hereinafter appear, the valve is caused to move with the plunger whether joined thereto or not. Valve 30 preferably is tubular in order to provide a discharge conduit for the well liquid in the piston chamber expelled therefrom during the up stroke of the piston. The valve bore 31 communicates at its lower end with the piston chamber 21*a* through a plurality of openings 32, which preferably are located in the valve immediately above the piston. In the upper end of the valve is carried a check valve 33 which prevents return flow from the pumping column into chamber 21*a* during the down stroke of the piston.

High pressure operating fluid, which may be any suitable gas or liquid, preferably a clean oil, is delivered to the pump through a conduit or tubing 34 extending downwardly through the well pipe and communicating at its lower end with a bore 35 in the valve head. Bore 35 is communicable with the valve bore 28 by way of transverse passages 36 and 37, and through port 38 with the master valve bore 39. Within the latter is a fluid pressure operated valve 40, hereinafter termed the master valve, consisting of upper and lower piston sections 40*a*, 40*b*, respectively, interconnected by a reduced diameter portion 41. The master valve bore 39 communicates with valve bore 28 by way of ports 43 and 44, and with the annular space 19 between the outer pump casing and barrel 18, by way of transverse port 45. The upper and lower ends of the master valve bore are closed by plugs 46 and 47, each having a small end projection 48 which serves to arrest the movement of the master valve so that the latter is prevented from closing ports 43 and 44, and permits a large portion of the end area of the valve to be exposed to the fluid pressure communicated through these ports.

Valve bore 28 is communicable with the piston chamber 21*a* through bore 50 and the upper and lower ports 51 and 52, the master valve bore 39 also being communicable with bore 50 by way of passage 53. It may be mentioned that bore 50 and the branch passages leading to the valve bores are provided primarily for the purpose of conveying to the piston chamber, fluid from the master valve bore at opposite ends of the valve to permit movement of the latter, as will presently appear.

Valve 30 is provided with two sets of annular grooves, 55, 56, and 57, 58, respectively, these grooves being adapted to register with the transverse ports in the valve head leading into bore 28, as indicated in the two positions of the valve shown in Figs. 1 and 2. With the piston and valve 30 in its lowermost position, grooves 55 and 56 are in such positions as to establish communication between ports 43 and 51, and 37 and 44, respectively. In the upper position of the valve, grooves 57 and 58 are so positioned as to permit communication by way of the valve bore between ports 43 and 36, and ports 44 and 32, respectively. I may state at this point that preferably valve 30 will have a series of spiral grooves 60 cut in its outer surface in order that as pressures applied against the valve through the several ports in the valve head, which ordinarily would tend to force the valve into tight engagement with the valve bore wall opposite the point at which the pressure is applied, groove 60 will serve to equalize the lateral pressures on the valve by conducting a small amount of the high pressure fluid around its entire surface.

I shall now describe the operation of the pump assuming the piston to be starting on its up stroke with the parts in the positions shown in Fig. 1. High pressure fluid passes from bore 35 through port 38, the master valve bore between sleeve sections 40*a*, 40*b*, thence through passage 45, and the annular space 19, into chamber 21 beneath the piston. The pressure fluid so applied to the lower end of the piston forces the latter upward to the limiting position shown in Fig. 2. Throughout the up stroke of the piston, well liquid in chamber 21*a* is discharged through openings 32 and the valve bore 31 into the pumping column 29.

The master valve is held in its raised position of Fig. 1 by the application of high pressure fluid from bore 35 to its lower end, by way of port 37, the valve groove 56 and port 44. Piston chamber or pumping column pressure is applied to the upper end of the master valve by way of passage 50, the annular valve groove 55, and port 43. The pumping column pressure will of course be less than the operating fluid pressure, and the differential between these pressures as applied to the opposite ends of the master valve, will be such as to securely hold the valve in raised position. As valve 30 moves upward, the master valve is retained in raised position due to the fact that upon closing of port 44 by the piston actuated valve, the fluid previously introduced into the master valve shown beneath the valve is sealed therein until such time as it is released by way of the lower valve groove 58.

When the piston reaches its upper limiting position shown in Fig. 2, high pressure fluid from bore 35 is applied to the upper end of the master valve by way of port 36, valve groove 57 and port 43, the master valve thereby being thrown down to its lower position to close off the delivery of actuating fluid to the piston chamber by covering port 38. The lower piston section 40*b* of the master valve moves below port 53 so as to establish communication between space 19 and the piston chamber by way of ports 45, bore 39 between the valve sections, bore 53 and bore 50.

After movement of the master valve to the position of Fig. 2, the piston is moved on its down stroke by the application of pumping column pressure to the upper end of valve 30. During the down stroke, the spent actuating fluid in the piston chamber below the piston is transferred to the upper interior of said chamber above the piston, by way of the annular space 19, passage 45, the master valve bore between the valve sections, port 53 and bore 50. It may be mentioned that this feature of enabling the spent actuating fluid to be passed into the pumping chamber for admixture with the well liquid, is of particular advantage in that in the event extremely sandy oil is being pumped from the well, the admission of clean actuating fluid therewith will serve to so dilute the well liquid as to enable it to be readily handled by the pump without the latter becoming sanded. During the piston down stroke, well liquid is taken through the piston bore past foot valve 23, and through openings 32, into the pumping chamber.

Referring now more particularly to the action of the piston operated valve 30, it will be noted that as the valve moves upwardly from the position of Fig. 1, groove 57 is caused to pass and transiently put ports 37 and 44 into communication. The temporary application of high pressure fluid to the lower end of the valve will of course have the effect of keeping it in raised position. I may state that the spacing between ports 44 and 52, and ports 37 and 53, will be somewhat greater than the length of valve groove 56, so as to prevent first, should groove 56 be permitted to put ports 44 and 52 into communication, the release of pressure on the bottom and of the master valve through these ports; and second, to prevent the flow of high pressure fluid through ports 37, 53 and bore 50 to the pumping chamber above the piston, as would be the case if groove 56 were permitted to put ports 37 and 53 into communication.

As valve 30 moves on up, groove 56 will temporarily put ports 36 and 43 into communication, with a resultant transient application of high pressure fluid to the upper end of the master valve. However, the fluid acting against the lower end of the master valve to hold same in raised position, will be sealed in the lower end of the valve bore due to port 44 being closed off by the valve 30 intermediate grooves 56 and 57, so that such transient application of pressure fluid to the upper end of the master valve will be ineffectual in causing any substantial downward movement of the latter. I may state that those ports opening into the master valve bore which would be subject to a partial closing as a result of comparatively slight movement of the master valve from either of its positions, may be made of such size that the effect of slight movement of the valve in tending to close these ports, will be of no consequence.

Ports 43 and the opening of passage 50 at its upper end into the valve bore 28, will also be spaced far enough apart so that valve groove 56, upon passing these openings, will not put them into communication. Groove 57 will be of similar dimensions as groove 56 so that upon moving to its uppermost position, it will not put ports 44 and 52 or 37 and 53 into communication upon passing them.

As valve 30 moves downward from the position of Fig. 2, groove 57 will cause a transient application of high pressure fluid to the lower end of the master valve upon pass-

ing ports 37 and 44. However, such application of pressure fluid to the valve will be ineffectual in raising same, due to the fact that the fluid in the upper end of the valve bore will be sealed against escape by port 43 being closed by valve 30 intermediate grooves 56 and 57. And as stated, the spacing of ports 37 and 53 will be greater than the lengths of grooves 56 or 57 so as to prevent the flow of high pressure fluid into the pumping chamber above the piston as these grooves move past ports 37 and 53.

I claim:

1. A well pump adapted to exhaust the well liquid upward into a pumping column, comprising a piston chamber communicable with said pumping column and a fluid pressure operated piston in said chamber, means for applying a high pressure fluid to said piston including a valve for controlling the flow of said fluid to the piston, said valve being operated by the piston substantially throughout the piston stroke.

2. A well pump adapted to exhaust the well liquid upward into a pumping column, comprising a piston chamber communicable with said pumping column and a fluid pressure operated piston in said chamber, means for applying a high pressure fluid to said piston including a valve for controlling the flow of said fluid to the piston, said valve being movable with the piston substantially throughout both strokes of the piston.

3. A well pump adapted to exhaust the well liquid upward into a pumping column, comprising a piston chamber communicable with said pumping column and a fluid pressure operated piston in said chamber, means for applying a high pressure fluid to said piston including a valve for controlling the flow of said fluid to the piston, said valve being substantially integral with the piston and movable therewith.

4. A well pump adapted to exhaust the well liquid upward into a pumping column, comprising a piston chamber communicable with said pumping column and a fluid pressure operated piston in said chamber, means for applying a high pressure fluid to said piston including a valve for controlling the flow of said fluid to the piston, said piston being movable in one direction by fluid pressure applied to the valve.

5. A well pump adapted to exhaust the well liquid upward into a pumping column, comprising a piston chamber communicable with said pumping column and a fluid pressure operated piston in said chamber, means for applying a high pressure fluid to said piston including a valve for controlling the flow of said fluid to the piston, said piston being movable in one direction by pumping column fluid pressure applied to the valve.

6. A well pump adapted to exhaust the well liquid upward into a pumping column, comprising a piston chamber communicable with said pumping column and a fluid pressure operated piston in said chamber, means for applying a high pressure fluid to said piston including a valve for controlling the flow of said fluid to said piston, said valve having a fluid passage therein communicable with said piston chamber.

7. A well pump adapted to exhaust the well liquid upward into a pumping column, comprising a piston chamber communicable with said pumping column and a fluid pressure operated piston in said chamber, means for applying a high pressure fluid to said piston including a valve for controlling the flow of said fluid to said piston, said valve having a fluid passage therein through which fluid is discharged from the piston chamber into said pumping column.

8. A well pump adapted to exhaust the well liquid upward into a pumping column, comprising a piston chamber communicable with said pumping column and a fluid pressure operated piston in said chamber, means for applying a high pressure fluid to said piston including a pilot valve for controlling the operation of the piston, said valve being operated by the piston substantially throughout the piston stroke, and a master valve operated in accordance with the operation of said pilot valve controlling the flow of high pressure fluid to operate the piston.

9. A well pump adapted to exhaust the well liquid upward into a pumping column comprising, a valve head and a piston chamber below said head, said piston chamber being communicable with the pumping column through said valve head, a fluid pressure operated piston in said chamber, and means for operating said piston on one of its strokes by high pressure fluid including a valve extending through said valve head and movable with the piston throughout its stroke, said valve controlling the application of high pressure fluid to the piston.

10. A well pump adapted to exhaust the well liquid upward into a pumping column comprising, a valve head and a piston chamber below said head, said piston chamber being communicable with the pumping column through said valve head, a fluid pressure operated piston in said chamber, and means for operating said piston on one of its strokes by high pressure fluid including a tubular valve movable with the piston and extending upwardly through the valve head into the pumping column, said valve controlling the application of high pressure fluid to the piston.

11. A well pump adapted to exhaust the well liquid upward into a pumping column comprising, a valve head and a piston chamber below said head, a fluid pressure operated piston in said chamber, means for applying actuating fluid to the piston to operate it on

its up stroke including a tubular valve movable with the piston and extending from the piston chamber through the valve head into the pumping column, and a check valve within said tubular valve, the piston being moved on its down stroke by pumping column pressure applied to said tubular valve and said valve controlling the application of high pressure fluid to the piston.

12. A well pump adapted to exhaust the well liquid upward into a pumping column comprising, a valve head and a piston chamber below said head, a fluid pressure operated piston in said chamber, means for conducting actuating fluid to the piston to operate it on its up stroke, a tubular pilot valve movable with the piston and extending from the piston chamber through the valve head into the pumping column, a check valve within said tubular valve, the piston being moved on its down stroke by pumping column pressure applied to said tubular valve, and a master valve for controlling the application of high pressure fluid to said piston, the operation of said master valve being controlled by the pilot valve.

13. A well pump adapted to exhaust well liquid upward into a pumping column comprising, a valve head and a piston cylinder depending from said valve head, a tubular fluid pressure operated piston in said cylinder, said piston having a lower reduced diameter tubular portion extending through the lower end of said cylinder, a check valve in said lower reduced diameter portion of the piston, means for conducting high pressure fluid to said piston chamber below the piston to operate the latter on its up stroke, a tubular valve on the upper end of the plunger and extending through the valve head into the pumping column, said valve controlling the application of operating fluid to the piston, said valve having openings leading into the piston chamber above the piston, well liquid being taken into the piston chamber through said openings and subsequently discharged through said openings and the valve into the pumping column, and a check valve within said tubular valve, the piston being moved on its down stroke by pumping column pressure applied to said tubular valve.

14. A well pump adapted to exhaust the well liquid upward into a pumping column comprising, a valve head and a piston chamber below said head, said piston chamber being communicable with the pumping column through said valve head, a fluid pressure operated piston in said chamber, said piston being moved on its up stroke by high pressure fluid, and a member extending from said piston chamber upwardly through the valve head into said pumping column, said piston being moved on its down stroke by pumping column pressure applied to said member.

15. A well pump adapted to exhaust the well liquid upward into a pumping column comprising, a valve head and a piston chamber below said head, said piston chamber being communicable with the pumping column through said valve head, a fluid pressure operated piston in said chamber, said piston being moved on its up stroke by high pressure fluid, and a vertically movable tubular member extending from said piston chamber upwardly through the valve head into said pumping column, a check valve in said member, well liquid being discharged from the piston chamber through said tubular member into the pumping column during the up stroke of the piston, and said piston being moved on its down stroke by pumping column pressure applied to said member.

16. A well pump adapted to exhaust the well liquid upward into a pumping column comprising, a valve head and a piston chamber below said head, said piston chamber being communicable with the pumping column through said valve head, a fluid pressure operated piston in said chamber, means providing passages for conducting operating fluid through the valve head to said chamber beneath the piston to move said piston on its up stroke, and means for transferring the fluid used in moving the piston in its up stroke to said piston chamber during the down stroke of the piston, the last mentioned means including a vertically movable member extending from said piston chamber upwardly through the valve head into said pumping column, said piston being moved on its down stroke by pumping column pressure applied to said member.

17. A well pump adapted to exhaust the well liquid upward into a pumping column comprising, a valve head and a piston chamber below said head, said piston chamber, being communicable with the pumping column through said valve head, a fluid pressure operated piston in said chamber, means providing passages for conducting operating fluid through the valve head to said chamber beneath the piston to move said piston on its up stroke, and means for transferring the fluid used in moving the piston in its up stroke to said piston chamber during the down stroke of the piston, the last mentioned means including a vertically movable valve extending from said piston chamber upwardly through the valve head into said pumping column, said piston being moved on its down stroke by pumping column pressure applied to said valve, said valve controlling the application of high pressure fluid to operate the piston on its up stroke.

In witness that I claim the foregoing I have hereunto subscribed my name this 28th day of August 1930.

ARTHUR G. GAGE.