May 14, 1935. E. K. BURGHER 2,001,012

PISTON LIFT FOR PUMPING OF LIQUIDS

Filed March 21, 1934 2 Sheets-Sheet 1

Fig. 3.

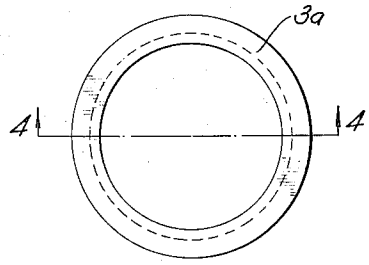


Fig. 1.

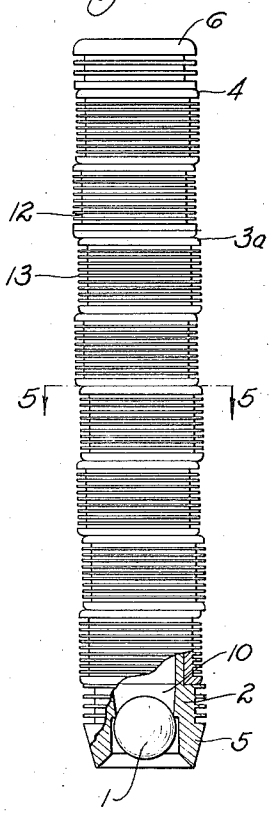


Fig. 2.

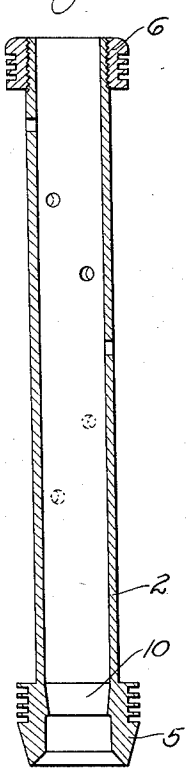


Fig. 4.

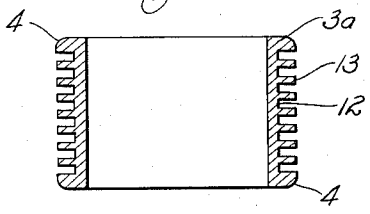
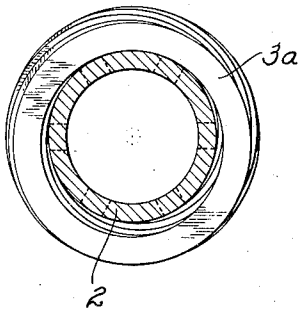


Fig. 5.



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PISTON LIFT FOR PUMPING OF LIQUIDS

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Fig. 9.

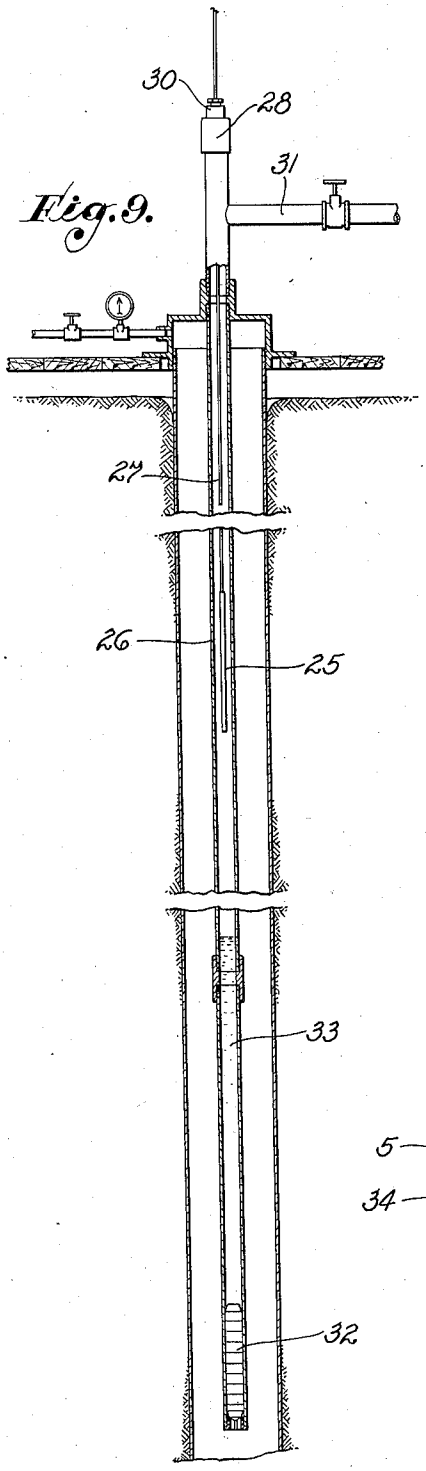


Fig. 10.

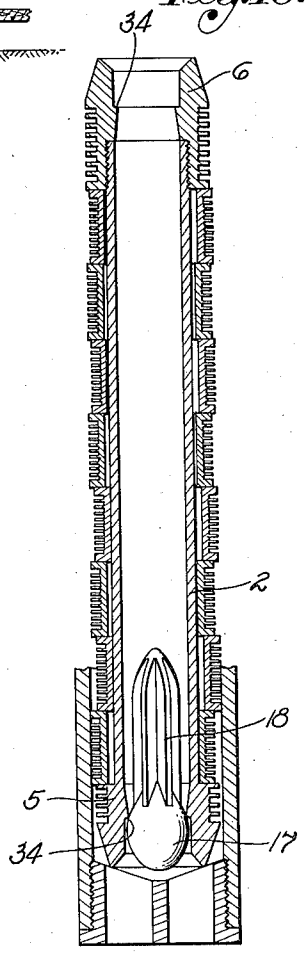


Fig. 7.

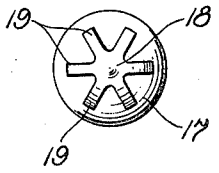


Fig. 6.

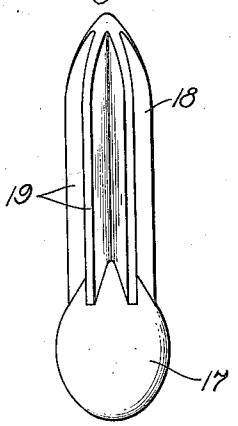
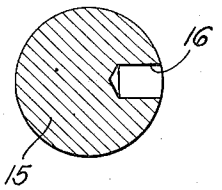


Fig. 8.



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Patented May 14, 1935

2,001,012

UNITED STATES PATENT OFFICE

2,001,012

PISTON LIFT FOR PUMPING OF LIQUIDS

Everett K. Burgher, Puerto Mexico, Mexico

Application March 21, 1934, Serial No. 716,615
In Mexico November 1, 1933

12 Claims. (Cl. 103—52)

My invention relates to apparatus for pumping oil from wells by means of gas pressure, which means also functions to keep the oil lift tubing continuously free from accumulations of paraffin.

The apparatus hereinafter explained has as its main object that of facilitating the flow of oil in a well to the surface and conserving gas by applying the pressure of the gas to the oil in such a manner that the maximum production of oil is obtained by use of a minimum flow of gas.

Many oil wells at the start thereof have a natural flow due to subterranean pressure or due to gas pressure. In many instances the upward flow of gas through the oil tube of the well carries therewith a flow of oil. After the flow of gas diminishes to such a point that it will not lift the oil, or will not lift the oil in commercial quantities, it is often the practice to supplement the natural gas of the formation with gas from a compressor disposed at a convenient point. The fundamental principle upon which this invention is based consists in the use of a piston-like member which is adapted to move from the bottom of the oil tube to the top thereof, or to a point near the top thereof, and which member functions as a "seal" between a body of oil in the tube and gas which is entering the tube under pressure below the body of oil so that the pressure of the gas will force the body of oil and the seal to the top of the well without percolation of gas through the body of oil as occurs in ordinary gas lift pumping arrangements. Broadly speaking, the invention consists of a seal for the propulsion of a fluid upwardly through a tube in a well, whether such fluid be crude oil, water, or other liquid, by means of any gas such as air, natural gas from the well, or gas injected into the well. The preferred use of the invention in question is in the petroleum industry wherein the liquid, namely, crude oil, is ordinarily encountered with gas under such pressure that this gas may be employed to pump the oil from the well.

It is an object of the invention to provide a seal or separating means adapted for vertical movement within a well or lift tube consisting of a piston with an axial opening therethrough and means detachable from the piston for closing the axial opening thereof. In the simple form of my invention the tubular piston has a seat in the lower end thereof, and the valve means for closing the axial opening comprises a round ball which may come to rest on a suitable support within the lower end of a lift tube so that the piston will operatively engage the same when it drops through the oil in the lower end of the lift tube. Engagement of the tubular piston with the valve ball results in closing the axial opening of the piston so that pressure of gas entering the lower end of the lift tube forces the piston and the body of oil thereabove toward the upper end of the lift tube, the oil being discharged through suitable delivery piping which extends from the upper end of the lift tube. A feature of the invention is that when the piston and valve ball reach a desired point near the upper end of the lift tube, the valve ball drops free of the piston to the lower end of the lift tube and is followed by the tubular piston so that when the piston again comes into engagement with the valve ball at the lower end of the lift tube, a new cycle of operation is initiated. The release of the valve ball from the piston may be accomplished by the release of gas pressure from under the piston when it arrives at the upper end of the lift tube, or the valve member may be mechanically dislodged from the piston at a selected distance below the upper end of the lift tube so that the valve member, and then the piston, may return to the bottom of the well while the pressure of gas in the lift tube functions to complete the ejection from the upper end of the lift tube of the body of oil which has been previously raised by the action of gas pressure against the valve-closed piston.

It is a further object of the invention to provide a piston which may be employed in commercial tubing, and which piston is so constructed that it will not readily become bound by reason of the flexible character of the piston resulting from the use of a plurality of cooperating ring members which are relatively adjustable in lateral direction.

A further object of the invention is to provide a piston having labyrinth means in the surface thereof for restricting the upward flow of gas around the piston in such a manner that an effective gas-oil seal is formed around the piston without the necessity of a tight fit between the piston and the wall of the lift tube, this making it possible to use standard pipe or tubing and avoiding the necessity of boring or reaming the tubing to accurate inside diameter.

It is well known that in the exploitation of a well and the flowing of its product to the surface, gas accompanying the liquids plays a very important part. The gas, by its own nature, on finding free exit and having the pressure broken

which kept it in the pool, tends to expand rapidly and then, acting according to the well known law relative to the expansion of gases, to lower the temperature not only of the gas but also of the liquid which it accompanies, thus causing the precipitation of some of the paraffinous particles found in the petroleum, which particles on account of the lowering of the temperature pass from the state of suspension in the oil to that of a sediment, adhering to the walls of the tubing or casing and frequently badly obstructing the flow, thereby reducing the producing capacity of the well and its flowing life and causing besides losses of time expended in cleaning and repairing the tubing or casing.

By the use of apparatus which is now being described, the functioning of which will be hereinafter explained, such inconveniences are avoided, because while acting as a "seal" in the tubing, it prevents the rapid expansion of which reference has been made, avoids the precipitation of the paraffinous particles, and, thereby keeping the tubing clean, avoids the loss of time expended in the cleaning and reconditioning of wells, and finally insures a more economical exploitation of the pool. The same remarks apply where gas is initially injected into the well as a lifting agent, since the invention minimizes losses and always mantains the necessary qualities of a propelling agent used in wells exploited by the system of "intermittent gas lift". As already explained, an important advantage of the invention is that it may be used directly in piping of standard commercial sizes known in the petroleum industry, whether called "tubing" or "casing", as well as on any other class of piping which may be used as a conductor for the flowing of oil from the sub-soil to the surface of the well. It furthermore has the advantage of being designed to work with the existing materials on sale in the petroleum market, and it can work in tubing of any size, from the minimum size already known to the largest that may be found in the market. Of particular importance is the fact that it is immaterial whether the interior of the tubing or casing is perfectly straight or cylindrical, since the apparatus adapts itself to all imperfections in the tubing or casing.

Further objects and advantages of the invention will be made evident throughout the following part of the specification.

Referring to the drawings, which are for illustrative purposes only,

Fig. 1 is a side elevation of the tubular piston or seal forming a part of my invention.

Fig. 2 is a vertically sectioned view of the tubular mandrel forming the core of the piston.

Fig. 3 is a plan view of one of the adjustable annular piston elements employed in the piston.

Fig. 4 is a cross section on a plane represented by the line **4**—**4** of Fig. 3.

Fig. 5 is a cross section on a plane represented by the line **5**—**5** of Fig. 1.

Fig. 6 is an enlarged view of an alternative form of valve member designed to move rapidly to the lower end of a lift tube after its disengagement from the tubular piston.

Fig. 7 is a plan view corresponding to Fig. 6.

Fig. 8 is a sectional view of a spherical valve member equipped with means tending to prevent rotation thereof during its downward movement through the lift tube.

Fig. 9 is a schematic view showing a manner of use of the invention in a well and showing a manner in which the valve member may be mechanically disengaged from the piston at a point below the upper end of the lift tube.

Fig. 10 is an enlarged, vertically sectioned view showing the lower end of the lift tube and piston and valve means disposed at the lower end thereof ready to start a pumping stroke.

As shown in Fig. 1, I may employ a spherical valve member **1** made of a metal appropriate to avoid corrosion due to chemical action of liquids or gases in which it functions. This valve member or ball is adapted to close the lower end of a hollow mandrel **2** which is also made of selected metal. Mounted on the mandrel **2** are a plurality of rings **3***a* which are of larger internal diameter than the exterior of the mandrel so that they may move through a limited distance into laterally offset positions, as clearly shown in Figs. 1 and 5. The ends **4** of the rings **3***a* are beveled so that they will readily pass over small shoulders which may be encountered in an oil lift tube. It will be perceived that the rings **3***a* may move laterally upon the mandrel **2** as may be required by conditions encountered in the lift tube, so as to substantially or practically fill the opening of the lift tube when arranged as shown in Figs. 1 and 5.

So that the rings may be readily secured in operative position upon the mandrel **2**, such mandrel may be provided with a head **5** at its lower end and a nut **6** at its upper end which may be threaded onto the upper end of the mandrel after the rings **3***a* have been placed in consecutive order, as shown in Fig. 1. In the use of the invention it is placed in an oil lift tube having an obstruction at the lower end thereof, such, for instance, as a bar or spider, onto which the valve ball **1** may drop. The ball is first dropped into the lift tube, and when the discharge fitting or Christmas tree at the upper end of the well is ready for connection to the casing-head, the piston assembly shown in Fig. 1 is dropped into the oil tube, and the upper end of the oil tube is closed except for an oil discharge outlet. When the piston reaches the lower end of the lift tube, it engages the valve ball **1**, and the passage **10** therethrough is closed by the valve ball **1**. Gas pressure then entering the lower end of the lift tube is exerted directly against the closed piston and results in the lifting of the piston and the body of oil above the piston to the top of the lift tube, the body of oil being discharged through the outlet provided at the upper end of the lift tube so that the piston finally passes a gas discharge opening, which gas discharge opening under some instances of operation may be the oil outlet. The gas pressure is then released from below the piston so that the ball valve **1** drops from the lower end of the piston to the lower end of the lift tube, to be thereafter followed by the piston. The release of the gas pressure may be accomplished by moving the piston into a position above the discharge outlet of the lift tube, or by mechanically dislodging the valve as will be hereinafter described. A feature of the invention is that the ball **1** moves downwardly in the lift tube a considerable distance in advance of the piston so that there is no obstructing means at the forward end of the passage **10** which can create a turbulence of a character to slow down the downward movement of the piston. Therefore, the piston is returned to the bottom of the lift

tube ready for a subsequent pumping or upstroke in a minimum length of time.

An additional feature of the invention consists in the providing of the piston with pockets which will produce an external turbulence and form a seal around the piston to resist passage of gas into the body of oil which is being lifted. These pockets or labyrinth depressions may be in the form of walls defining circular recesses or may be spiral grooves, but they are preferably in the form of annular grooves 12 separated by annular fins or walls 13, as shown in Figs. 1 and 4.

Although eminently satisfactory results are obtained from the use of the invention as shown in Figs. 1 to 5, I find that the speed of downward movement of the valve member may be materially increased by so forming the valve member that it will drop in a straight line and substantially centrally through the fluid contained in the lift tube, instead of assuming a gyrational or spiral path downward through the lift tube, which is apparently characteristic of the balanced spherical form of the valve ball 1. To achieve this improved result, I use an unbalanced valve ball 15, as shown in Fig. 8, having an opening 16 in one side thereof, which opening may or may not be filled with either a lighter or heavier metal. I prefer, however, to produce this desired condition by equipping a valve ball 17, as shown in Figs. 6 and 7, with an upwardly projecting tail 18 which is pointed and is longitudinally grooved so as to provide fins 19.

I have also found that additional economy in the operation of my pumping device may be accomplished by causing release of the valve member from the hollow piston at a point below the discharge outlet, so that, as the discharge of the body of oil is being completed by fluid pressure, the valve and piston are returning in proper order to the lower end of the lift tube preparatory to starting another cycle of operation. This I prefer to accomplish, as shown in Fig. 9, by suspending an obstruction 25 in a lift tube 26. This obstruction may be in the form of a bar which extends downwardly from the upper end of the lift tube or may consist of a short bar suspended by means of a cable 27 which extends downwardly from a fitting 28 placed at the upper end of the lift tube 26. The cable 27 may pass out through a packing member 30 so that it may be raised or lowered to produce a desired position of operation of the bar 25. In one instance of installation the obstruction 25 is placed five hundred feet below a production outlet pipe 31 connected to the upper portion of the lift tube 26. The result is that when a piston 32 moves upwardly through the lift tube 26 from the position in which it is shown in Fig. 9, it will lift the superposed body of fluid 33, which is principally oil, through the lift tube 26 so that the body of fluid 33 will discharge through the outlet pipe 31. When the piston 32 passes over the rod 25, the lower end of such rod 25 will dislodge the valve member 17 from the lower end of the piston 32, whereupon the valve member 17 will immediately descend within the lift tube 26. Momentum, and also the action of gases in upward direction, may carry the now open piston 32 upwardly beyond the lower end of the rod 25. The weight of the piston 32 soon brings it to a stop, however, after which the piston descends through the lift tube 26 into engagement with the valve member 17, as shown in Fig. 10. The body of oil in the upper end of the lift tube 26, after the piston 32 starts its downward travel, is substantially entirely ejected by gas pressure through the outlet 31.

The form of piston shown in Figs. 9 and 10 has both ends thereof flared so that the piston may be reversed, and such piston may have valve seats 34 formed in both ends thereof. The flared lower end of the piston 32 enables it to readily engage the valve member 17, and the flared upper end of the piston 32 serves to guide the lower end of the rod 25 into the axial opening thereof as the piston approaches the upper end of its travel.

I have found that my invention produces a material saving in gas, or, in other words, reduces the gas-oil ratio of the production of a well. This is of material importance in those states having regulations concerning the gas-oil ratios of flowing wells. Of greater importance, however, is the fact that the invention conserves gas and therefore makes it possible to keep a well under production by use of the natural gas pressure therein for a maximum period of time and to thereafter continue production from the well by use of recycled or compressor gas at a minimum cost. For example, it is possible to place my invention in a well which is flowing under its own pressure and by so doing to materially reduce the gas-oil ratio so that the well will continue to flow under its own power for a maximum period of time. Should the pressure in the well be relatively high at the time of equipping the same with my invention, either the inlet or outlet of the lift tube, or both, may be restricted by use of a standard form of flow bean. As the gas pressure in the well decreases, the flow capacity of the flow bean may be proportionately increased.

I claim is my invention:

1. A labyrinth piston for the pumping of liquid from a well through a production tube by use of the pressure of gas, comprising: a plurality of labyrinthic beveled rings in end-to-end relation; and means for supporting said rings in said relation with sufficient looseness to allow said rings to adopt eccentric positions wherein they will constitute a seal between said piston and the walls of said tube.

2. A means for pumping a heavy fluid from a well by means of a light fluid under pressure, for use with a lift tube extending down into the production zone of the well, said lift tube having a stop at the lower end thereof and a discharge opening in the upper end thereof, comprising: a piston adapted for movement through said lift tube, said piston having a longitudinal passage from end to end thereof; a valve for closing said passage when said piston is near the lower end of said lift tube so that fluid pressure may operate to move said piston upwardly; and means in the upper part of said lift tube operating to dislodge said valve from the lower end of said passage before said piston reaches said discharge opening.

3. A means for pumping a heavy fluid from a well by means of a light fluid under pressure, for use with a lift tube extending down into the production zone of the well, said lift tube having a stop at the lower end thereof and a discharge opening in the upper end thereof, comprising: a piston adapted for movement through said lift tube, said piston having a longitudinal passage from end to end thereof; a valve for closing said passage when said piston is near the lower

end of said lift tube so that fluid pressure may operate to move said piston upwardly; and a bar extending downwardly in the upper part of said lift tube to engage said valve and dislodge the same from its position closing said discharge opening.

4. A means for pumping a heavy fluid from a well by means of a light fluid under pressure, for use with a lift tube extending down into the production zone of the well, said lift tube having a stop at the lower end thereof and a discharge opening in the upper end thereof, comprising: a piston adapted for movement through said lift tube, said piston having a longitudinal passage from end to end thereof; a valve for closing said passage when said piston is near the lower end of said lift tube so that fluid pressure may operate to move said piston upwardly, said valve being adapted to be held in closing relation to said passage by fluid pressure during the upward movement of said piston, to drop free of said piston when dislodged from said lift tube, and to descend independently of said piston to said stop at the lower end of said lift tube; and a bar member extending downwardly within the upper portion of said lift tube to a point below said discharge opening and being adapted to pass through said passage and dislodge said valve.

5. A means for pumping a heavy fluid from a well by means of a light fluid under pressure, for use with a lift tube extending down into the production zone of the well, said lift tube having a stop at the lower end thereof and a discharge opening in the upper end thereof, comprising: a tubular piston adapted for movement through said lift tube, said piston having a longitudinal passage from end to end thereof; a valve for closing the lower end of said passage when said piston is near the lower end of said lift tube so that fluid pressure may operate to move said piston upwardly, said valve being adapted to drop free of said piston when dislodged from the lower end of said passage and to descend independently of said piston to said stop at the lower end of said lift tube; a head closing the upper end of said lift tube; and a bar extending downwardly from said head to a point below said discharge opening and being adapted to pass through said passage and dislodge said valve.

6. A means for pumping a heavy fluid from a well by means of a light fluid under pressure, for use with a lift tube extending down into the production zone of the well, said lift tube having a stop at the lower end thereof and a discharge opening in the upper end thereof, comprising: a tubular piston adapted for movement through said lift tube, said piston having a longitudinal passage from end to end thereof; a valve for closing the lower end of said passage when said piston is near the lower end of said lift tube so that fluid pressure may operate to move said piston upwardly, said valve being adapted to be held in closing relation to said passage by fluid pressure during the upward movement of said piston, to drop free of said piston when dislodged from the lower end of said passage, and to descend independently of said piston to said stop at the lower end of said lift tube; a head closing the upper end of said lift tube; and a bar extending downwardly from said head and being adapted to pass through said passage and dislodge said valve.

7. A means for pumping a heavy fluid from a well by means of a light fluid under pressure, for use with a lift tube extending down into the production zone of the well, said lift tube having a stop at the lower end thereof and a discharge opening in the upper end thereof, comprising: a tubular piston adapted for movement through said lift tube, said piston having a longitudinal passage from end to end thereof; a valve for closing the lower end of said passage when said piston is near the lower end of said lift tube so that fluid pressure may operate to move said piston upwardly, said valve being adapted to be held in closing relation to said passage by fluid pressure during the upward movement of said piston, to drop free of said piston when said piston reaches the upper end of said lift tube, and to descend independently of said piston to said stop at the lower end of said lift tube; and means projecting down into the lift tube at a point below said discharge opening for dislodging said valve from the lower end of said passage when said piston reaches a selected position in said lift tube below said discharge opening to start the downward movement of said piston and said valve at such position so that said piston and said valve will travel downwardly through said lift tube as the discharge of said heavy fluid is completed by the pressure of said light fluid.

8. A means for pumping a heavy fluid from a well by means of a light fluid under pressure, for use with a lift tube extending down into the production zone of the well, said lift tube having a stop at the lower end thereof and a discharge opening in the upper end thereof, comprising: a piston adapted for movement through said lift tube, said piston having a longitudinal passage from end to end thereof, and said piston comprising a tubular mandrel having a plurality of cylindrical members thereon, said cylindrical members being of smaller diameter that the interior of said lift tube and being loose on said mandrel so as to be laterally adjustable relative to said mandrel; and a valve for closing said passage when said piston is near the lower end of said lift tube so that fluid pressure may operate to move said piston upwardly, said valve being adapted to move into open relation to said passage when said piston reaches the upper end of said lift tube.

9. A means for pumping a heavy fluid from a well by means of a light fluid under pressure, for use with a lift tube extending down into the production zone of the well, said lift tube having a stop at the lower end thereof and a discharge opening in the upper end thereof, comprising: a piston adapted for movement through said lift tube, said piston having a longitudinal passage from end to end thereof; and a valve for closing said passage when said piston is near the lower end of said lift tube so that fluid pressure may operate to move said piston upwardly, said valve being adapted to drop free of said piston when said piston reaches the upper end of said lift tube and to descend independently of said piston to said stop at the lower end of said lift tube, said valve being unbalanced so as to resist rotation while dropping through said lift tube.

10. A means for pumping a heavy fluid from a well by means of a light fluid under pressure, for use with a lift tube extending down into the production zone of the well, said lift tube hav-

ing a stop at the lower end thereof and a discharge opening in the upper end thereof, comprising: a piston adapted for movement through said lift tube, said piston having a longitudinal passage from end to end thereof, and said piston comprising a tubular mandrel having a plurality of cylindrical members thereon, said cylindrical members being loose on said mandrel so as to be freely laterally adjustable relative to said mandrel; and a valve for closing said passage when said piston is near the lower end of said lift tube so that fluid pressure may operate to move said piston upwardly, said valve being adapted to move into open relation to said passage when said piston reaches the upper end of said lift tube, said cylindrical members having walls and recesses on the exterior thereof forming labyrinth flow restricting means to seal around said piston.

11. A piston for a gas lift pumping mechanism of the character described having a lift tube, including: a tubular mandrel through which fluid may pass from end to end; and a plurality of cylindrical members on said mandrel, said members being of larger internal diameter than the exterior of and loose on said mandrel so as to be freely laterally adjustable relative thereto, and being of smaller external diameter than the interior of said lift tube.

12. A piston for a gas lift pumping mechanism of the character described having a lift tube, including: a tubular mandrel through which fluid may pass from end to end; and a plurality of cylindrical members on said mandrel, said members being of larger internal diameter than the exterior of and loose on said mandrel so as to be laterally adjustable relative thereto, and being of smaller external diameter than the interior of said lift tube and having walls and recesses on the exterior thereof forming labyrinth flow restricting means to seal around said piston.

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