FLUID LIFT VALVE

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This invention relates to apparatus for pumping liquid from a well or the like, and particularly pertains to that class of pumping equipment shown in Patent No. 1,803,837 issued to me May 5, 1931; the present invention being entitled "Fluid lift valve," and being a division of my pending application entitled "Fluid operated means," filed April 21, 1938, Serial Number 203,452, patented August 5, 1941, No. 2,251,323.

In well pumping practice in which the liquid of the well is elevated to the ground surface level by the introduction of a gas under pressure to the bottom of the well where a pumping action is obtained, it has been common practice to introduce the gas in a manner to aerate the liquid so that the weight of the liquid will be decreased and its elevation will take place as an aerated fluid column. It has also been an attempted practice to introduce a gas into the bottom of the well and so release and control the discharge of the gas into the bottom of the well as to prevent appreciable aeration of a quantity of a liquid so that the accumulated quantity of liquid within the pumping equipment at the bottom of the well will be lifted bodily by the gas in what might be termed a mechanical pumping action to move a slug of liquid upwardly from the well. Such a method of procedure and apparatus therefore was disclosed in my Patent No. 1,803,837, as previously mentioned.

In equipment of this particular type the valve control mechanism is of essential importance, since the valve must be subjected to rough usage in a well due to the action of suspended solids in the liquid, such as is prevalent in an oil well, and for the additional reason that the valve must respond directly and function correctly when a quantity of gas is introduced into the well for pumping purposes. It is also necessary in this type of equipment to provide means for controlling the flow of gas to the well, so that quantities of the gas may be intermittently introduced into the well with direct reference to the liquid producing capacity of the well. Some structures have been devised which depend upon the control and regulating action of a float. The present invention is concerned with a suitable type of intermittent fluid control and a particular type of valve which may be interposed at a desired position in the length of a string of flow pipe in a well, and which has operating means characterized as permitting an uninterrupted flow of fluid through a central tube and an intermittent flow of fluid around the central tube and within a pumping tube, all of which structures may be arranged concentrically and employ concentrically arranged valve members.

The present invention contemplates the provision of a string of flow tube which may be lowered into a well and within which a macaroni tube is positioned. The lower end of the macaroni tube is continuously open while the lower end of the flow tube is provided with a lifting foot valve, whereby fluid may flow upwardly into the flow tube and around and along the macaroni tube, the said macaroni tube and flow tube having cooperating means at a selected point in their length for shutting off the lower space within the flow tube from the upper space and being further provided with an automatic valve member acting to admit and interrupt the flow of fluid from the flow tube into the macaroni tube and to cause a slug of the fluid which has accumulated in the macaroni tube to be elevated there through.

The invention is illustrated by way of example in the accompanying drawings in which:

Figure 1 is a view in sectional elevation with parts broken away to show a typical installation of the invention in well pumping practice.

Fig. 2 is an enlarged fragmentary view in central vertical section through the displacement valve, showing the valve in a closed position.

Fig. 3 is a view similar to Fig. 2, showing the displacement valve with its movable members in their pumping position.

Fig. 4 is a view in transverse section through the displacement valve as seen on the line 4—4 of Fig. 2.

Referring more particularly to Fig. 1 of the drawings, 10 indicates a well casing formed at its lower end with a perforated screen or liner 11. The upper end of the well casing is closed in with suitable means, such as that generally indicated at 12, and extending downwardly through the packing member 13 is a fluid lift pumping mechanism broadly comprising a tubing 14 within which a macaroni tube 15 is positioned. At the lower end of the tubing 13 a foot valve 15 is provided, and at a point in the length of the macaroni tubing 14 and housed within the tubing 13 is a displacement valve structure generally indicated at 16. The details of the displacement valve structure are more clearly shown in Figs. 2, 3 and 4 of the drawings.

Above the surface of the ground a structure designated as an intermitter is indicated at 17. A structure of this type is shown in my application Serial No. 203,452, patented August 5, 1941, No. 2,251,323, of which this is a division.

The lower end of the macaroni tubing 14 ter-
minates short of the length of the well tubing 13 within which it is housed. This permits the free flow of fluid from the pump tubing 13 into the macaroni tubing 14 when the foot valve 15 is closed and insures that when the foot valve 15 is opened the fluid may flow freely through the perforated casing 11, thence through the foot valve 15 and into the well tubing 13 and the macaroni tubing 14. As shown in the drawings, the macaroni tubing 14 is of materially less diameter than the internal diameter of the well tubing 13, thus, an annular fluid space 18 occurs between the tubing 13 and 14 and circumscribes the tubing 14.

By reference to Figs. 2 and 3 of the drawings it will be seen that the fluid space 18 is interrupted at a point in its length by a valve collar 19, which is in the form of an annular ring fitting into the well tubing 13 and suitably held as by welding. This collar circumscribes a tubular steel nipple 20, which is interposed between ends of sections of the macaroni tubing 14 and is held assembled therewith by a valve head 21 and valve base 22. Thus, the tubular nipple 20 provides a passageway between adjacent ends of the macaroni tubing, whereby a free flow of fluid may take place through the tubing and the nipple.

The outside diameter of the head 21 is greater than the inside diameter of the collar 19 and fits thereinagainst. The abutting faces of the head and collar are inclined, as indicated at 23 and 24, and may be provided with intervening packing means 25 by which a fluid seal will be effected.

The outside diameter of the base member 22 is less than the inside diameter of the collar 19 so that the base member and the associated displacement valve structure, which will be hereinafter described, may be lowered through the collar to a position where the valve head 21 will seat and seal the fluid space 18 which occurs in the pump tubing 13 below it.

The valve head 21 is formed with a plurality of longitudinally extending flow ducts 26 through which fluid may flow under circumstances to be hereinafter set forth. The lower ends of these ducts terminate within an annular recess 27 formed on the lower transverse face of the head 21. Disposed directly beneath the head 21 and mounted against a shoulder 28 on the nipple 20 is an upper valve seat 29. Attention is directed to the fact that in the valve structure here described, the valve seat and the valve element itself are circular and circumscribing the macaroni tube through which tube fluid may flow freely regardless of the relative position of the parts of the valve mechanism. It is believed, therefore, that the valve structure, as here disclosed, presents a new and novel device, which is of particular value in its present application.

The upper valve seat 29 is in the form of a ring having an annular recess 30 in its lower face, the opposite lower edges of the recessed portion being formed within inclined seat faces 31 and 32. A plurality of ducts 33 extend through the valve seat and communicate with the recess 27 in the valve head. Sealing gaskets 34 are interposed between the contiguous faces of the valve head 21 and the upper valve seat 29; thus, when the head 21 is tightened in position upon the steel nipple 20 and the upper valve seat 29 is forced against the shoulder 28, the packing gasket 34 will form a fluid seal between the parts. It will be understood that the upper valve seat 29 may be formed as a one-piece ring or that an outer shell may be provided to circumscribe the body of the seat and form the outer wall of the recess 30 if desired. In any event the recess is provided to receive the upwardly projecting tubular end 35 of a cylindrical and tubular displacement valve 36 which terminates in a fluid circumscribes the macaroni tube 14 and fits therearound with a sliding fit. The circumscribing wall of the valve member 36 is in contact with the steel nipple 20. The nipple 20 is formed with a plurality of annular fluid grooves 20' spaced throughout the wall surface and acting to form a fluid pack between the two relatively reciprocating parts.

As previously stated, the upper end of the valve element 36 is provided with an annular portion 35, which is of lesser diameter than the annular recess 30 into which it projects. The side walls of the recess are straight and parallel and the side walls of the annular portion or lip of the valve element 35 are straight and parallel but are of a sectional width materially less than the sectional width of the recess 30. These straight parallel sides of the valve element 35 are provided with outwardly flaring inclined shoulders, which in their seated positions are complementary to the faces 31 and 32 of the upper valve seat.

Attention is also directed to the fact that the upper edge of the lip 35 is flat and lies in a plane at right angles to the longitudinal axis of the valve structure and in spaced parallel relation to the end face of the recess 30 formed in the upper valve seat. It is also to be pointed out that the effective area of the lip 35, which is presented to the action of a fluid under pressure delivered to the recess through the ducts 33 is so proportioned as to properly operate and balance the sleeve valve 38 and to insure that after the valve has opened to move the lip 35 out of the recess 30 an increased pressure area of the valve sleeve 35 will be presented to the fluid under pressure, tending to maintain the valve in its opened position until an oppositely unbalanced condition arises, whereupon the sleeve valve will move to its original closed position.

The lower end of the sleeve valve 36 is formed with a relatively long tubular portion 37 which extends down into an annular closed chamber 38 of a lower valve seat 39. The lower valve seat fits upon the steel nipple 20 and abuts at its upper edge against a shoulder 40. It is held in position by the base member 22. A packing gasket 41 is interposed between the lower end of the lower valve seat 39 and the upper face of the base member 22. An annular groove 42 is formed in the upper face 32' and communicates with a duct 43 extending through the base and fitted with a bleeder check valve 44. The lower sleeve extension 37 fits within the closed chamber 38 with a sliding fit since the annular walls are parallel. Fluid sealing grooves 45 are formed in these walls to provide a fluid seal between the parts. At the bottom of the closed chamber 38 ducts 46 occur which establish communication between the closed chamber 38 and the annular recess 42 formed in the base.

The upper marginal edges of the walls of the closed chamber 38 are formed with inclined seats 47 and 48 against which complementary shoulders of the valve sleeve seat when the valve sleeve is in its lowermost position may bear. It is to be understood that the length of the tubular extension 37 of the valve sleeve 36 is less than the depth of the chamber 38 so that the inclined shoulders on the sleeve may be forced to a seated
position upon the inclined faces 41 and 48 of the valve seat. Attention is directed to the fact that a plurality of lateral perforations 43 are formed through the wall of the perforated nipple directly above the valve seat 8, and that a complementary plurality of perforations 50 are formed through the tubular extension 37 of the valve sleeve 36 at a point directly below the inclined shoulders on the valve sleeve so that when the valve sleeve is in its uppermost position communication may be established between the bottom of the steel nipple 20 and the space 18 within the pump tubing 13. These perforations 43 and 50 are exhaust ports and fluid passing through them is interrupted when the valve sleeve 36 is in its lowermost position.

Threaded on to the valve sleeve 36 is an adjusting nut 51 against which the upper end of a spring 52 abuts. The lower end of the spring 52 rests against the upper face of the base member 22; thus, the expansive action of the spring 52 tends to lift the sleeve valve 36 and to hold the sleeve valve in its upper seated position until the force exerted by the spring has been overcome by the force exerted by the fluid under pressure delivered through the tubing 13 and the ducts 26.

One of the principal objects of the present invention is to produce a valve which will function when submerged within the fluid in which it operates and which is pumped by it to the surface of the ground. This is accomplished by utilizing the enclosed chamber 36 here shown as being in the form of an annular channel and into which the cylindrical and tubular valve member 36 of the valve extends. The enclosed chamber 36 is connected to the chamber 18' by a port in which check valve 44 is located. The check valve 44 permits the fluid which has accumulated within the enclosed chamber 36 to be expelled therefrom but not to enter. The valve 36, as shown in Fig. 2 of the drawings, is located in the upper part of the fluid chamber 18' and is subjected to a relatively low fluid pressure as exerted from the hydrostatic head of the liquid during the time the chamber 18' is filling and at which time the valve 36 is closed, as shown in Fig. 2 of the drawings.

The enclosed chamber 36 is not sealed at the shoulders 47 and 48 when the valve member 36 is in its uppermost and closed position and at that time any fluid which may leak into the chamber 36 will flow downwardly and accumulate below the valve and within the chamber 42 from which it will be forced when the valve 36 moves the lower tubular extension 37 downwardly into the chamber 38. Also, it is to be understood that when the valve 36 moves downwardly to its opened position the operating fluid forces the valve element 36 downwardly until the chamber 38 is sealed at the shoulders 47 and 48. The operating fluid is then prevented from exerting its force against or around the enclosed end of the lower tubular extension 31 while the fluid is being forced from the well, and it is, therefore, possible to establish a predetermined resistance against the movable element 36 by the springs 42 and the adjusting nut 51.

It will, therefore, be recognized that an important feature of this invention is concerned with the uninterrupted flow of the well to the ground surface through the central flow tube 14, and that this is obtained due to the design of the valve arrangement whereby a cylindrical valve member 36 circum

scribes the flow tube and may be moved to and from its seated position without in any wise interfering or obstructing the liquid flow passage way. Thus, structure, there is eliminated the occurrence of any irregular spaces in the direct path of the flowing fluid which would produce eddy currents and the like in the gas and oil passing therethrough, and by which the gas and oil might be mixed, cut or emulsified in a manner to disturb the condition of gravity of the fluids, and thus, in an objectionable way unbalance the conditions under which the apparatus has been calculated to operate.

As previously stated, it is intended that the pressure fluid delivered through the tubing 13 and the ducts 26 to the displacement valve be directly controlled both as to volume and duration of flow by the intermitter, generally indicated at 17 in Fig. 1 of the drawings, and that an example of such a structure is shown in my co-pending application entitled "Fluid operated means," Serial No. 203,653, division, patented August 5, 1941, No. 2,251,323.

In operation of the present invention it is to be understood that the casing 10 has been set in a well together with a perforated casing section 11, so that fluid from the geological formation may enter the well and will, due to the pressure on the foot valve 15 and flow into the pump tubing 13 and the macaroni tubing 14. If the pressure is sufficiently great the fluid will then fill the chamber 18' between the two tubings until it has reached the valve head 21, where it will be stopped. It is possible that the quantity of liquid in the well will not reach such a high level. The liquid within the macaroni tubing will also reach a level as determined by the pressure of the fluid within the well and the quantity which will accumulate in a predetermined idle period of the lift. It will thus be evident that the quantity of fluid standing in the macaroni tube 14 and the quantity standing within the chamber 18' surrounding the macaroni tube in a given period will be the quantity to be elevated from the well at one pumping impulse.

When the well is filling with liquid, as previously described, a fluid is introduced through a suitable control valve 17 from a source of supply. The control valve 17 is intermittent in its operation and at regular intervals will cause a predetermined volume of gas under predetermined pressure to be forced into the tube 13 through a pipe 13' at the top of the well. The fluid will then flow downwardly in the space 18, which occurs within the pipe 13 and around the macaroni tube 14 and above the collar 19 and the head 21. The gas under pressure will then force the fluid downwardly through the ducts 25 in the heel 21 and will then exert a pressure against the end face of the lip 35 in the recess 30 of the upper valve seat 29. When this pressure has increased to the point where it will overcome the strength of the spring 52 the sleeve valve 36 will move downwardly and unseat the shoulders of the upper end of the sleeve valve from the valve faces 31 and 32. This at the same time will force the tubular extension 37 of the sleeve valve downwardly into the recess 38 of the lower valve seat 39, and if any fluid has accumulated in the bottom of the recess 38 it will be replaced by the ducts 46 and the bleeder valve 44. Just as soon as the seal between the shoulders of the sleeve valve and the valve faces 31 and 32 has been broken an increased surface area of the sleeve valve 36 will be presented to the gas which
passes through the valve seat 29 through the ducts 25. This will tend to add increased force to hold the sleeve 26 in its lowermost position while allowing the gas to pass from the space 18 through the ducts 23 and 33 and into the space 18. The gas will thus be above the accumulated body of liquid within the space 18, and since the exhaust ports 49 and 50 have been closed by the downward movement of the sleeve valve this gas will act upon the body of accumulated liquid in the space 18 and within the macaroni tube 14 to displace the liquid from the space 18 in the pump tubing 13 and move the entire accumulated body of liquid upward through the macaroni tube 14.

Attention is directed to the fact that the sectional area of the chamber 18 and the macaroni tube is so proportioned with relation to the volume of gas entering the chamber 18 and the velocity with which it enters as to insure that the gas will act against the accumulated body of liquid to produce a ram action. In this way the accumulated body of liquid will be moved as one liquid mass without aeration and will travel upward through the macaroni tube 14 as a slug of liquid. Thus, by this arrangement a slug of liquid will travel upward through the macaroni tube 14 to the well outlet.

When the intermittent valve 17 is closed the pressure of the gas in the passageway 13 will be discontinued, and the spring 52 will then act to force the sleeve valve 26 upward until its shoulders seat against the faces 41 and 42 of the upper valve seat 29. At this time the lower end of the valve sleeve 26 will move upward to move the shoulders thereof away from the inclined faces 47 and 48 of the lower valve seat 33. At this time the ports 35 in the sleeve valve 26 will be opened to establish communication from the chamber 18 through the ports 49 and 50 to the interior of the macaroni tube 14. Accumulated fluids may exhaust through these ports from the chamber 18 into macaroni tube 14 while the sleeve valve 35 stands in the position shown in Fig. 2 of the drawings.

In the event that it is desired to "pull" the string of macaroni tubing from the well it will be seen that the head 21 with the entire sleeve valve structure can be lifted and withdrawn from the well through the collar 18 and the pump tubing 13, and that a working condition can be re-established by lowering the structure in the well until the head 21 seats against the collar 18. It will thus be seen that the invention here disclosed provides simple means for introducing a fluid lift apparatus into a well of any depth, and that it insures the definite and positive pumping of liquid from the well by fluid action only, the structure being capable of accurate adjustment to adapt itself to varying conditions as they may arise.

While I have shown the preferred form of my invention as now known to me, it will be understood that various changes may be made in the combination, construction and arrangement of parts by those skilled in the art without departing from the spirit of the invention as shown.

Having thus described my invention what I claim by Letters Patent is:

1. Fluid lift apparatus comprising a well tubing, a foot valve at the bottom thereof, a flow tube within the well tubing and terminating with an opened lower end, through which tubing an unrestricted flow of fluid may take place, means closing off a space between the tubing and the flow tube at a desired depth in the well, whereby a liquid chamber is created, said closing off means including passageways through which a fluid under pressure from within the tubing may flow to the liquid chamber, a valve mounted within the liquid chamber and being capable of being opened by direct pressure of a pressure fluid flowing downwardly through the closing off means, means yieldingly depressing said movement until a predetermined pressure is exerted on the valve, said valve including a fixed annular seat circumferencing the flow tube, and a valve sleeve of tubular construction also circumferencing the flow tube and resisting against the annular seat.

2. A fluid lift device including a tubing disposed in a well, a flow tube extending downwardly into the tubing to a point adjacent the lower end thereof, said flow tube having an unrestricted passageway therethrough and being open at its lower end, a foot valve at the lower end of the tubing to permit the inflow of fluid only, cooperating means between the tubing and the flow tube for sealing off the space within the tubing and around the flow tube at a point in the length thereof, whereby a fluid pressure chamber will be formed within the tubing below the sealing off means and a gas conduit will occur in the space above said sealing off means, the sealing off means being provided with fluid passageways establishing communication between the opposite sides thereof, and a valve disposed within the fluid chamber and acting under direct pressure of the fluid under pressure thereabove to be opened and to be held open during the extent of a predetermined pressure and flow period.

3. A fluid lift device including a tubing disposed in a well, a flow tube extending downwardly into the tubing to a point adjacent the lower end thereof, said flow tube having an unrestricted passageway therethrough and being open at its lower end, a foot valve at the lower end of the tubing to permit the inflow of liquid only, cooperating means between the tubing and the flow tube for sealing off the space within the tubing and around the flow tube at a point in the length thereof, whereby a fluid pressure chamber will be formed within the tubing below the sealing off means and a gas conduit will occur in the space above said sealing off means, the sealing off means being provided with fluid passageways establishing communication between the opposite sides thereof, a valve disposed within the fluid chamber and acting under direct pressure of the fluid under pressure thereabove to be opened and to be held open during the extent of a predetermined pressure and flow period, said valve including means whereby it will be over-balanced and held in an opened position after the fluid pressure has moved the valve element from its seat.

4. A fluid lift device including a tubing disposed in a well, a flow tube extending downwardly into the tubing to a point adjacent the lower end thereof, said flow tube having an unrestricted passageway therethrough and being open at its lower end, a foot valve at the lower end of the tubing to permit the inflow of liquid only, cooperating means between the tubing and the flow tube for sealing off the space within the tubing and around the flow tube at a point in the length thereof, whereby a fluid pressure chamber will be formed within the tubing below the sealing off means and a gas conduit will occur in the space above said sealing off means, the sealing off means being provided with fluid passageways establishing communication between the opposite sides thereof, a valve disposed within the fluid chamber and acting under direct pressure of the fluid under pressure thereabove to be opened and to be held open during the extent of a predetermined pressure and flow period, said valve including means whereby it will be over-balanced and held in an opened position after the fluid pressure has moved the valve element from its seat.
ways establishing communication between the opposite sides thereof, a valve disposed within the fluid chamber and acting under direct pressure of the fluid under pressure thereabove to be opened and to be held open during the extent of a predetermined pressure and flow period, said valve including means whereby it will be over-balanced and held in an opened position after the fluid pressure has moved the valve element from its seat, and timing means for establishing and controlling the delivery of fluid under pressure to said tubing and for a predetermined period.

5. Fluid lift pumping apparatus, comprising a well tubing, a foot valve at the bottom thereof, a flow tube within the well tubing and terminating with an opened lower end, through which tubing an unrestricted flow of fluid may take place, means closing off a space between the tubing and the flow tube at a desired depth in the well whereby a liquid chamber is created, said closing off means including a passageway through which fluid under pressure from within the tubing may flow to the liquid chamber, a valve structure within said liquid chamber to close and open said passageway, said valve structure including a movable valve element having a downwardly projecting portion, a valve body having an enclosed chamber into which said projecting portion of the valve element moves and whereby fluid pressure is prevented from being exerted against the projecting portion of the valve element within the enclosed chamber, means for sealing the enclosed chamber while liquid is being forced through the flow tube and from the well, and means for exhausting accumulated liquid from within said enclosed chamber.

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