Jan. 28, 1941. E. L. BOYNTON 2,229,914

AIR LIFT

Filed June 23, 1938 3 Sheets-Sheet 1

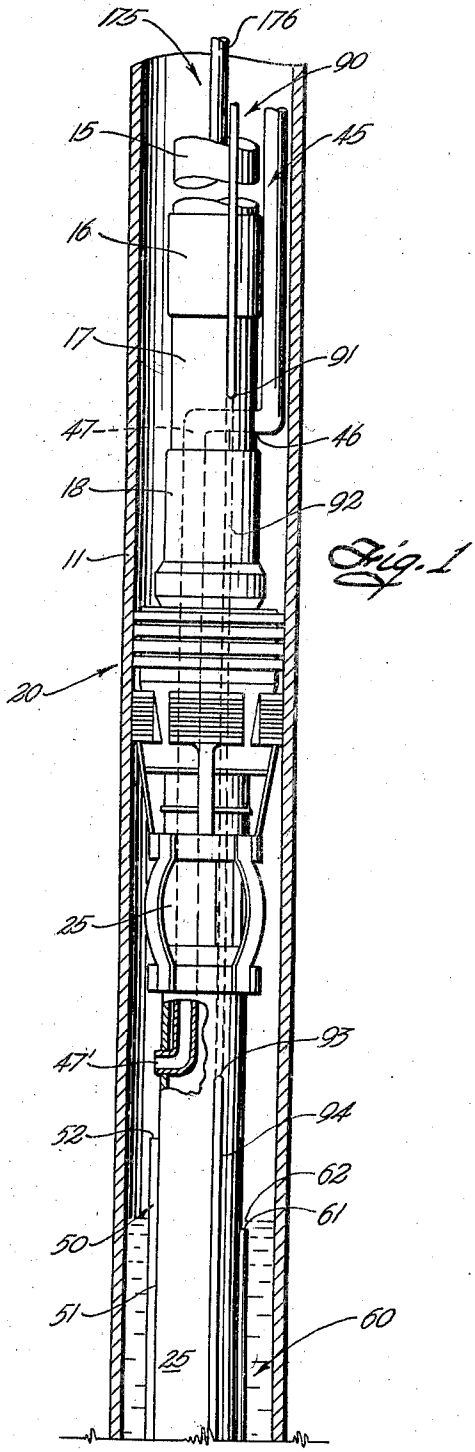
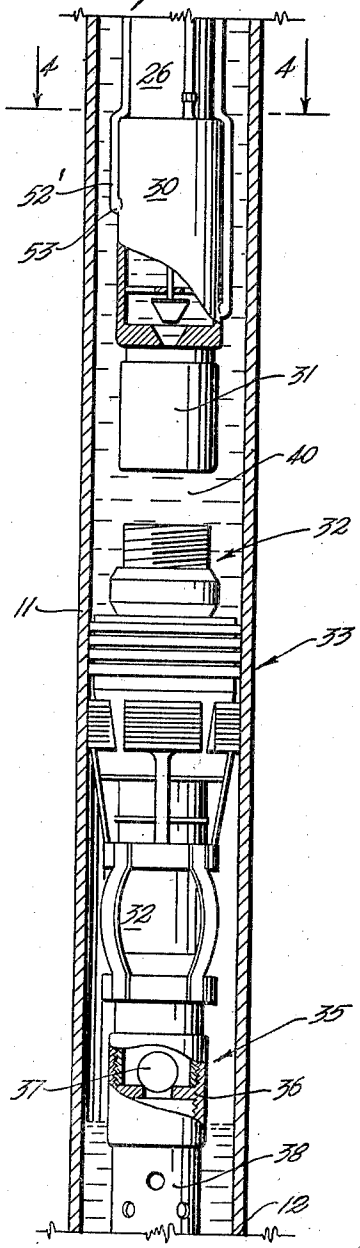


Fig. 1

Fig. 2



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Fig. 3

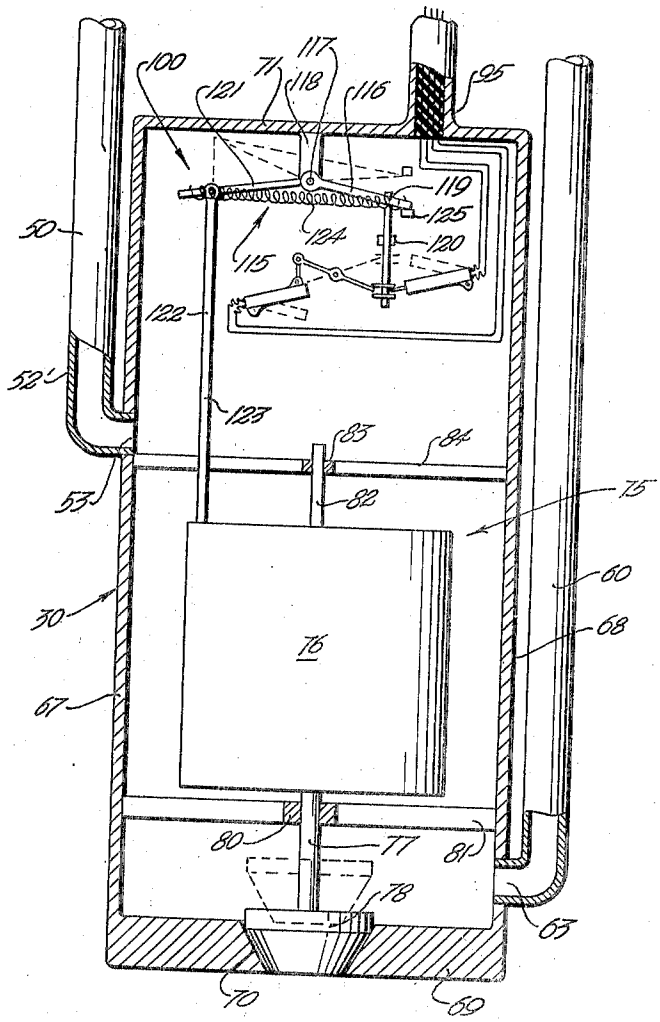
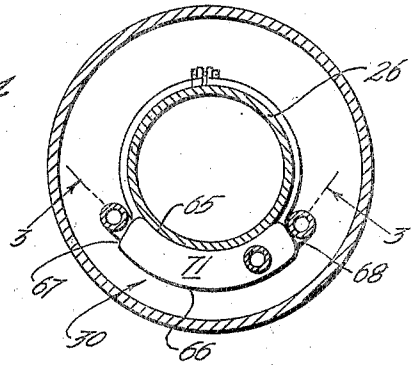


Fig. 4



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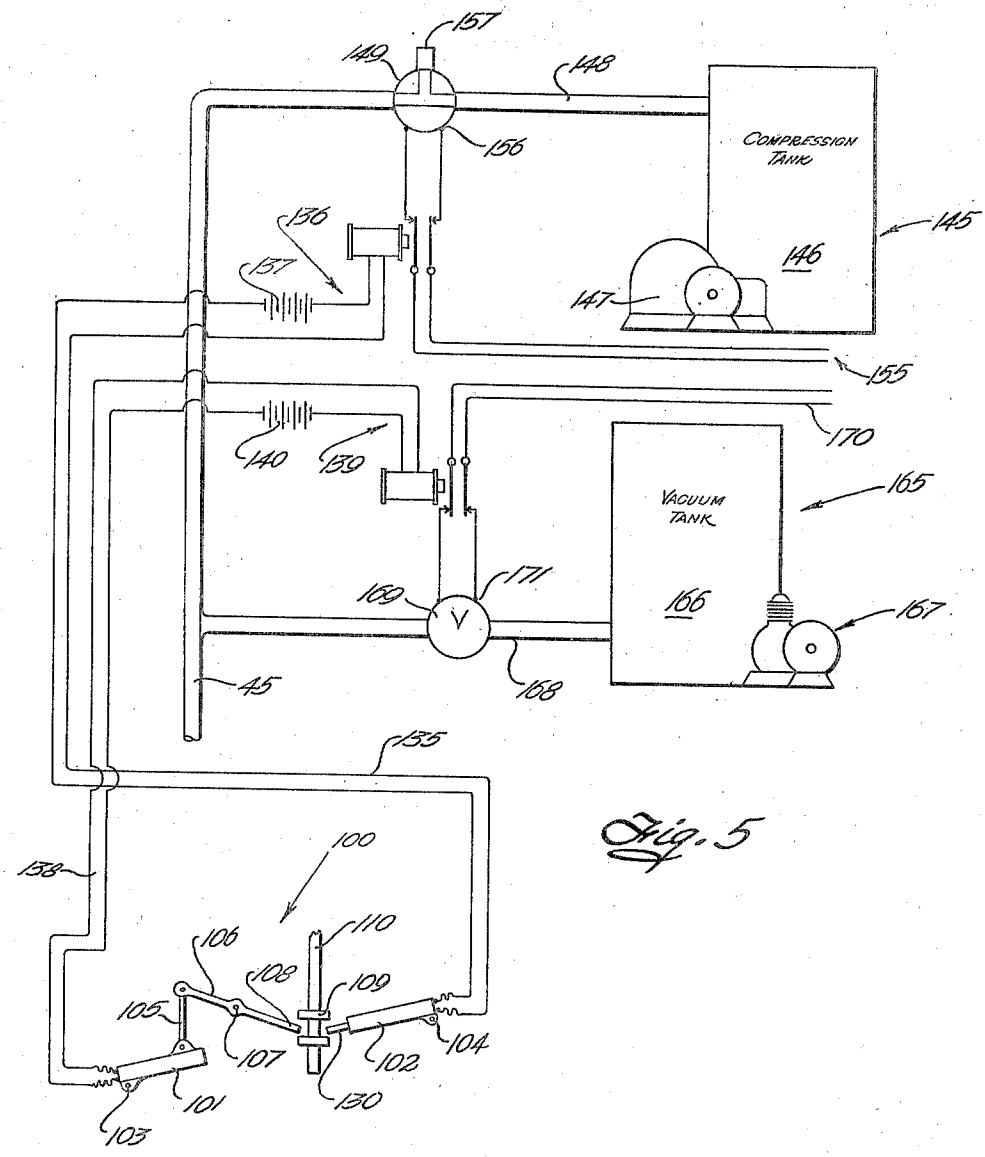


Fig. 5

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UNITED STATES PATENT OFFICE

2,229,914

AIR LIFT

Eugene L. Boynton, Balboa Island, Calif.

Application June 23, 1938, Serial No. 215,369

4 Claims. (Cl. 103—235)

My invention pertains to a form of air lift used in connection with deep well pumping such as in pumping oil wells. My invention is particularly applicable to oil wells of the type in which there is an insufficient gas or other pressure to force the oil to a sufficient height in the well casing and to supply sufficient amount of oil to allow pumping by ordinary methods on a remunerative basis.

It is well known that in order for the oil from oil sands or the like to flow into the perforated casing of the well it is necessary that the hydraulic head or pressure be less in the lower portion of the casing than in the well formation, therefore one of the features of my invention consists of cutting off or separating the lower portion of the casing from the upper part of the well, then by means of the reduced or partial vacuum of air by a suction or similar equipment at the top of the well, the pressure in the cut-off or separated section of the casing is reduced thus developing an inflow of oil. This is readily accomplished by inserting a packer or the like a sufficient distance above the bottom of the well so that the oil may rise through an oil pipe above the packer and in the separated space between the lower and an upper packer.

A further feature of my invention after a sufficient amount of oil has been accumulated either by the negative pressure in the separated space between the packer or by the pressure in the formation, a positive air pressure is created by pumping compressed air downwardly into the separated space or chamber. This pressure then drives the oil into an oil pipe leading to the top of the well and forcing such oil upwardly above a check valve. The positive pressure is then cut off and the negative pressure or partial vacuum communicated from the top of the well to the separated chamber again creates an inflow from the well formation.

Another feature of my invention resides in either providing an indication for control of the alternate flow of compressed air and the rarification or creation of a partial vacuum through the medium of a float controlling a valve and also controlling an electric signalling or control operated mechanism. In my construction a valve having a float for control of same is located in a float valve housing which has a communication by a pipe extending upwardly adjacent an oil pipe to a position below the upper packer. Thus when the oil reaches a predetermined level in the separated chamber between the two packers, such oil flows downwardly through the oil pipe and operates the float. An air vent pipe leading from the float casing or housing also communicates upwardly above the highest point reached by the oil in the confined or separated chamber.

On the positive air pressure part of the cycle as the oil is forced downwardly it drains from the float valve chamber and as the float drops it closes the outlet valve for the oil from the float valve housing. At the same time the motion of the float valve controls electric switches which may give a signal to an operator at the top of the well. On such signal apprising the operator to control the positive flow of air under pressure, the exhaust of such air and the creation of the partial vacuum, the electric circuits closing and opening by the switches may be used as release to afford an automatic control of the supply of air under pressure and the creation of the suction or partial vacuum.

A further feature of my invention is providing an automatic control by electric switches operated by the float valve which, by a relay connection at the top of the well, govern the application of the compressed air for the hoisting stroke on the oil and the creation of the rarification or partial vacuum for the inflow of the well oil.

My invention is illustrated in connection with the accompanying drawings, in which:

Fig. 1 is a vertical section showing the portion of a well casing in section with my invention incorporated therein, this showing the part adjacent an upper packer. These features are shown in elevation and partly broken away.

Fig. 2 is a continuation of the vertical section of Fig. 1 illustrating the portion adjacent and below the lower packer shown in elevation partly broken away illustrating the inlet and bottom standing valve and the float controlled valve.

Fig. 3 is a developed vertical section on the line 3—3 of Fig. 4 of the float controlled valve and its housing.

Fig. 4 is an enlarged section on the line 4—4 of Fig. 2 in the direction of the arrows showing in section the oil pipe and in plan the float valve chamber.

Fig. 5 is an electrical and mechanical diagram to illustrate the indicators and air control mechanism at the top of the well actuated through the medium of the operation of the float valve and the electric switches.

In my invention a well casing is designated by the numeral 11. This may be of the usual form and extends downwardly in a well below the

broken lower section 12. The well casing may include only a portion of the well or the whole of the well where such casing is employed but in the latter case the casing usually increases in diameter towards the top of the well. While the section of the casing illustrated is of the same diameter, it will be understood that the upper portion may be of larger diameter than the lower portion. With my invention I employ a standard or conventional string of oil tubing 15. This extends to the top of the well and is connected stand by stand in the ordinary manner for lowering the equipment into the well. Immediately below the lower stand I provide a check valve assembly 16 which may be of a ball type and can be considered as an upper valve. A sub 17 below the check valve leads to a coupling 18 to which is connected a standard type of packer 20.

Extending below this packer I employ a pipe section 25. This is an oil pipe and continues downwardly as far as desired and adjacent its lower end 26 has the float valve housing assembly 30 arcuate in cross section mounted on the end 26, this being described in detail hereunder. A joint or coupling 31 is on the lower end of the pipe and in lowering the equipment has a screw threaded connection to a lower pipe 32 on which is mounted a lower packer 33. This packer again is of a standard type and not described in detail. A standing valve assembly 35 is connected at the lower end of the pipe 32. This standing valve is illustrated as having a ported seat 36 with a ball 37 fitted thereon. A perforated inlet pipe 38 extends below the check valve and into a section of the well supplied by oil either by the pressure of the formation or by the pressure in the formation together with the lowered or decreased pressure caused by a vacuum suction as hereunder mentioned.

In the operation of setting the equipment, the lower packer 33 is first set, this being connected to a string of oil tubing. The packer is of a standard character. It is lowered to the desired position, then by a left hand unthreading, the tubing string is removed from the packer, run out of the hole and then a special tool for setting the packer is run in the hole. With the type of packer I prefer using, this is firmly set by a one-quarter turn for this tool. The special tool is then removed. The upper packer is of a type which can be set by the weight of the tubing thereon with a quarter turn. In this case I also employ a standard type of packer. The necessary characteristics are that there must be a space 40 between the lower end 31, that is, the coupling depending from the upper packer, and the pipe end 32 which extends upwardly above the lower packer. This is to allow the free upward flow of oil to fill the space or chamber above the lower packer and extending upwardly around the oil pipe 25 to the desired height towards the upper packer.

In conjunction with my invention I employ a vertical string or line of air pipe 45 extending downwardly in the well between the oil tubing 15 and the casing 11. This leads to a position below the check valve assembly 16. In order to carry this air pipe below the upper packer, I provide a transverse air connection unit 46 extending inwardly through the pipe section 17 from the main pipe 45 and from this there is a downwardly extending internal air pipe 47 which leads through the packer 20 to a position well below the packer and has an air port end 47' leading through the wall of the pipe 25. By this means there is a direct air connection from this port from below the upper packer, that is, from the separated space in the casing between the upper and lower packers to the top of the well. The upper or downwardly extending string of air pipe may be connected in stands in the usual manner, and clamped to oil tubing 15.

The air vent assembly 50 employs an air vent pipe 51 which is preferably secured to the outside of the pipe 25 by welding or similar attachment and this has its upper vent end 52 located above any possible height that the oil may reach in the separated space or chamber between the upper and lower packers. This vent pipe leads down to the float valve housing 30 and has a lower section 52' extending downwardly outside of the end of the float valve housing and having an air port connection 53 communicating with the interior of the float valve housing structure 30. This air port is illustrated as connecting about one-half way between the top and bottom of the float valve housing for the purpose hereunder described.

An oil overflow pipe 60 is secured or mounted on the outside of the pipe 25 in any usual or known manner such as by welding thereto or the like and has an upper intake end 61 designed when the oil level indicated at 62 is in its uppermost position. This overflow pipe is immersed and allows downward flow of oil through the pipe 60 for the purpose hereunder designated. This oil overflow pipe has a ported connection 63 to the float valve housing adjacent the bottom thereof, the purpose being described hereunder.

The float valve housing is constructed substantially as follows having reference particularly to Figs. 2, 3 and 4. The pipe 25 with its lower portion 26 is preferably cylindrical and the float valve housing 30 has an inner side 65 concentric with the pipe section 26, an outer side 66 also concentric and the opposite ends 67, 68. It has a bottom closure wall 69 with a valve seat 70 therein. This valve seat may be arcuate conforming to the curved shape of the bottom 69. The top 71 is closed except for a conduit entrance hereunder described and is also arcuate, thus forming a closed float valve chamber. In this valve housing there is mounted the float valve assembly 75, this having a float 76 also preferably arcuate or there may be a number of these floats. The float is provided with a float stem or rod 77 which extends downwardly and has a cone type of valve plug 78 secured thereto and adapted to engage the seat 70 of the lower end 69 and form a positive closure. The stem of the float valve operates through a lower guide hub 80 connected by an open spider construction 81 to the sides and/or ends of the housing and an upper section 82 of the stem operates through an upper guide hub 83 also supported by a similar spider or the equivalent 84. The float and its valve plug 78 are thus mounted for straight reciprocating motion.

An electric cable assembly 90 has a cable extending downwardly from the top of the well between the oil tube 15 and the well casing and preferably is structurally a separate unit from the air pipe 45 but manifestly these may be connected together where such is desired. The electric conduit or cable however is properly insulated so that the conducting wires are not exposed. This conduit has an oil tight lead in section 91 extending from the portion outside of the oil tubing to the inside of the pipe 17 below the

upper check valve assembly 16. From thence there is a downwardly extending cable section 92 leading through the upper packer assembly 20. There is an outwardly extending section 93 of the cable leading outwardly through the pipe 25 and from thence there is a downwardly extending section 94 which may be secured to the outside surface of the pipe 25. This cable has an oil and gas tight connection indicated at 95 to the top wall 71 of the float valve housing 30.

The control equipment for compressing the air or gas for pumping and creation of the vacuum or suction employs an electric switch assembly designated 100, note particularly Figs. 3 and 5. This employs two mercury switches 101 and 102, each having a pivotal mounting as 103 and 104 to a fixed part or structure of the float valve housing 30. Considering the assembly of switch 101, this is shown as having a link 105 connected thereto which is itself pivoted to a double lever 106, pivoted at 107 to a fixed structure, this lever having a projecting end 108 aligned to engage a neck or reduced collar 109 on a stem or rod 110 connected to a toggle lever and spring assembly 115, note Fig. 3. This assembly employs a pivoted arm 116 pivoted at 117 to a bracket 118 depending from the top 71 of the valve housing. The rod or stem 110 is pivotally connected at 119 to the arm 116 with a somewhat loose pivot so that the stem 110 has a direct reciprocating motion through a guide 120. A second toggle arm 121 is mounted on the same pivot 117 and has an operating rod 122 pivotally connected thereto and attached at the bottom 123 to the float 76. A toggle acting spring 124 connects the opposite ends of the arms 121 and 116. The stop 125 is utilized to limit the downward motion of the arm 116.

The mercury switch 102 has a projecting rod 130 positioned to be engaged by the reduced neck or the collars 109 on the stem 110. It will therefore be seen that as the float 76 rises and falls, the movement of the lever arm 121 past the center in moving the spring also past such center causes the spring to give a quick action to the arm 116 and hence a snap movement to the stem 110 and a quick reversal of the mercury switches. These switches it will be noted operate in a diametrically opposed manner, that is, when one switch is closed, the other switch is open and vice versa.

The operating or control connections to the ground from the switch assembly includes leads 135 from the switch 102, these being connected to a relay 136, there being an intermediary power source 137. From the switch 101 there is a second pair of leads 138 to the relay 139 having the source of power 140. The power source is illustrated as a battery. Manifestly these relays may be utilized to give a signal or indication to an operator who may manually control or actuate the devices for controlling the compression of the air or gases in the pump portion of the assembly and the creation of the vacuum in the lower portion of the pump equipment to develop the flow of oil from the ground formation.

However an automatic control is illustrated. The air pipe 45 is indicated in Fig. 5, this leading to the top of the well. In connection with this I employ a compression assembly 145. This has a compression tank 146 in which air is substantially continuously charged into the tank by a compressor 147, this compressor being operated in any suitable manner as by an electric motor. A supply pipe 148 leads from the compression tank 146 to the pipe 45 through the medium of a three-way control valve 149. The drawings illustrate a diagrammatic manner of operating a control circuit to electrically operate the valve, this having the power lines 155 operated by the relay assembly 136 for opening and closing and having an actuating means 156 with a delayed action to operate the valve 149, this valve having an exhaust port 157 to exhaust the compressed air to atmosphere. There is also a vacuum tank assembly 165 which employs a vacuum tank 166, this being under a continuous suction by a suction pump 167 preferably actuated by an electric motor. A suction or vacuum pipe 168 leads through a closure valve 169 to the air pipe 45. This valve is controlled electrically by the relay 139, there being power leads 170 through the relay 139 and illustrated in diagram as having electrical connections 171 and an electric means to turn the valve 169.

In deep wells, above the check valve assembly 16, it may be desirable to operate a mechanical pump such as a lift pump and this is indicated by the assembly numeral 175, note Fig. 1, which has the sucker rod 176. As this is a standard type of pump, it is not described or illustrated in detail.

The cycle of operations after the packers have been set and the equipment is ready for operation may be considered substantially as follows: with the valve 78 seated and thus closed, the float 76 is in its lowermost position and thus the oil has been exhausted from the float valve assembly by flowing downwardly out of the port 79 and thence the oil may be considered as having been forced upwardly by the air pressure and in such positive forcing of the oil upwardly, the standing valve 37 is closed. The electric switches have been set by the movement of the float valve so that the valve 149 first exhausts from pipe 45 to the atmosphere and then is closed, shutting off the connection between 45 and the atmosphere and the compression tank 146. The valve 169 has been actuated and, due to a suitable time delay, forms a vacuum connection through pipe 168 to the air pipe 45 and the vacuum tank 165. This exhausts the air from the space between the upper and lower packers, the air in such space centering at the port 47 and being exhausted upwardly. This relieves the pressure between the packers. It also relieves the pressure above the standing valve 37 so that oil is drawn in from the well formation through the intake of pipe 33 upwardly through the standing valve 37, flowing outwardly through the upper end of the pipe 32. This oil fills up the space between the two packers rising above the float valve housing and assembly 30 until the level of the oil indicated at 62, note Fig. 1, rises above the level of the top of the oil pipe 60, this being a downward flow pipe. The oil therefore drains downwardly through the pipe 60, the lower part of the float chamber and fills this with oil above the closed valve 78. Such action causes a rising of the float 76 and at the same time an exhaustion or venting of the air in this float chamber through the air port 53 and the air vent pipe 50. This air is discharged at the upper open end 52 above the possible level of oil between the two packers. When the float 76 rises to a sufficient height, it reverses the position of the mercury switches. It will be noted however that this action only takes place substantially when the oil has accumulated to its maximum amount as the oil does not enter the

float chamber until the oil has risen above the top 61 of the pipe 60. This reversal of the mercury switches may be used to give a signal to an operator at the top of the well who may manually control the change from suction to compression but in the automatic arrangement the valve 169 leading to the vacuum tank 166 is closed, thus shutting off the connection from the pipe 45. The valve 149 connecting the air pipe 45 and the compression tank 146 is opened, thus allowing a quick and sudden charging of the air pump with air under compression, this flowing downwardly through the air pipe 45 and out of the port 47 below the upper packer. This air pressure manifestly is sufficiently great to force the oil downwardly around the oil pipe 26 and upwardly through the intake at the bottom 31 and past the check valve 16, thus giving a lift to the column of oil. The air pressure also acting down through the vent pipe 50 into the float chamber causes an expulsion of the oil through the downflow oil pipe 60 and through the open port 78 so long as this is open. However the oil remains in the float chamber until the level of oil between the two packers has been reduced to permit the float to drop and thereby closing the port 78 and again reversing the switches. The cycle of operations is then repeated.

Various changes may be made in the details of the construction without departing from the spirit or scope of the invention as defined by the appended claims.

I claim:

1. An air lift for oil comprising in combination a well casing, an oil tube with a check valve extending downwardly in the well casing, an upper sealing means between the lower end of the tube and the casing, an oil pipe extending downwardly in the well casing from the sealing means and having an inlet opening at the bottom and a flow communication with the oil tube, a lower sealing means in the well casing and an intake oil pipe extending downwardly therefrom and having a standing valve, said intake oil pipe delivering to the space between said upper and lower sealing means, an air connection from below the upper sealing means and above the lower sealing means connecting to the top of the well adapted for flow of compressed air or gases to the space in the casing between the two sealing means and for the exhaust of air therefrom whereby oil from the said space may be forced upwardly through the first mentioned oil pipe and tube due to the positive air pressure and, on the decrease of such air pressure, oil due to a differential pressure in the well formation and in the said space flows into such space, a float valve casing having a float controlled valve therein located in the said space between the upper and lower sealing means and below the air connection, an air vent leading from said float valve casing, a downflow oil pipe extending from said space into said float valve casing and upwardly towards the upper sealing means, and means at the top of the well actuated by the rise and fall of the float valve and responsive thereto to control the air flow in said air connection.

2. An air lift for oil comprising in combination a well casing, an oil tube with a check valve extending downwardly in the well casing, an upper sealing means between the lower end of the tube and the casing, an oil pipe extending downwardly in the well casing from the sealing means and having an inlet opening at the bottom and a flow communication with the oil tube, a lower sealing means in the well casing and an intake oil pipe extending downwardly therefrom and having a standing valve, said intake oil pipe delivering to the space between said upper and lower sealing means, an air connection from below the upper sealing means and above the lower sealing means connecting to the top of the well adapted for flow of compressed air or gases to the space in the casing between the two sealing means and for the exhaust of air therefrom whereby oil from the said space may be forced upwardly through the first mentioned oil pipe and tube due to the positive air pressure and, on the decrease of such air pressure, oil due to a differential pressure in the well formation and in the said space flows into such space, a float valve housing mounted on the oil pipe and positioned above the intake of said pipe above the lower sealing means, a float valve therein, an air vent pipe connected to the upper part of the housing and extending upwardly along the oil pipe to a position below the said air connection, an oil downflow pipe extending upwardly along the oil pipe from the float valve housing for downflow of oil therein, and an electric switch means with electric circuits, the switch means being operatively connected to the float valve and the circuits having a connection to the top of the well with means responsive to the position of the float valve to control the air flow in said air connection.

3. An air lift for oil comprising in combination a well casing having means at the bottom for the intake of oil from the well formation, an oil tube extending downwardly and having an upper packer, said oil tube having a check valve therein, an oil pipe extending downwardly from the packer and having an inlet for oil at the bottom, a lower packer below said inlet for oil, a lower oil pipe discharging upward in the space between the two packers extending downwardly from the lower packer and having an inlet with a standing check valve, an air pipe leading from the top of the well and provided with an air port located adjacent the upper packer communicating with the space defined by the two packers and the casing, means to force air under pressure downwardly through said pipe to create a pressure on oil in the said space and force such oil upwardly through the oil pipe, the oil tubing and the check valve thereof, means to release such air pressure whereby the pressure may be reduced to create a differential pressure between that of the well in the formation and the pressure in the said space, a float valve housing having an oil actuated float control valve, an air vent pipe connected from said housing and extending upwardly to a position above any possible elevation of oil level in the space between the two packers, a downflow oil pipe connected to the said housing and extending upwardly and having an open upper end located below a possible low oil elevation in such space whereby on the oil rising in the said space, such oil flows downwardly in the downflow oil pipe to the said housing, causing an opening of the float valve, the air in the said housing being vented through the air vent, and means at the top of the well associated with the flow of air in the air pipe actuated by the rise and fall of the float valve and responsive thereto to control the air flow in said air pipe.

4. An air lift for oil comprising in combination a well casing having means at the bottom for the intake of oil from the well formation,

an oil tube extending downwardly and having an upper packer, said oil tube having a check valve therein, an oil pipe extending downwardly from the packer and having an inlet for oil at the bottom, a lower packer below said inlet for oil, a lower oil pipe discharging upward in the space between the two packers extending downwardly from the lower packer and having an inlet with a standing check valve, an air pipe leading from the top of the well and provided with an air port located adjacent the upper packer communicating with the space defined by the two packers and the casing, means to force air under pressure downwardly through said pipe to create a pressure on oil in the said space and force such oil upwardly through the oil pipe, the oil tubing and the check valve thereof, means to release such air pressure whereby the pressure may be reduced to create a differential pressure between that of the well in the formation and the pressure in the said space, a float valve housing having an oil actuated float control valve, an air vent pipe connected from said housing and extending upwardly to a position above any possible elevation of oil level in the space between the two packers, a downflow oil pipe connected to the said housing and extending upwardly and having an open upper end located below a possible low oil elevation in such space whereby on the oil rising in the said space, such oil flows downwardly in the downflow oil pipe to the said housing, causing an opening of the float valve, the air in the said housing being vented through the air vent, a pair of electric switches, an operating connection between said switches and the float valve, circuit connections from each switch to the top of the well and an electrical relay means actuated by said circuit and responsive to the rise and fall of the float valve and means controlled by the electrical relay to regulate the air flow in said air pipe.

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