Dec. 31, 1940. A. W. STEENBERGH 2,226,537

GAS LIFT APPARATUS

Filed March 8, 1940 2 Sheets-Sheet 1

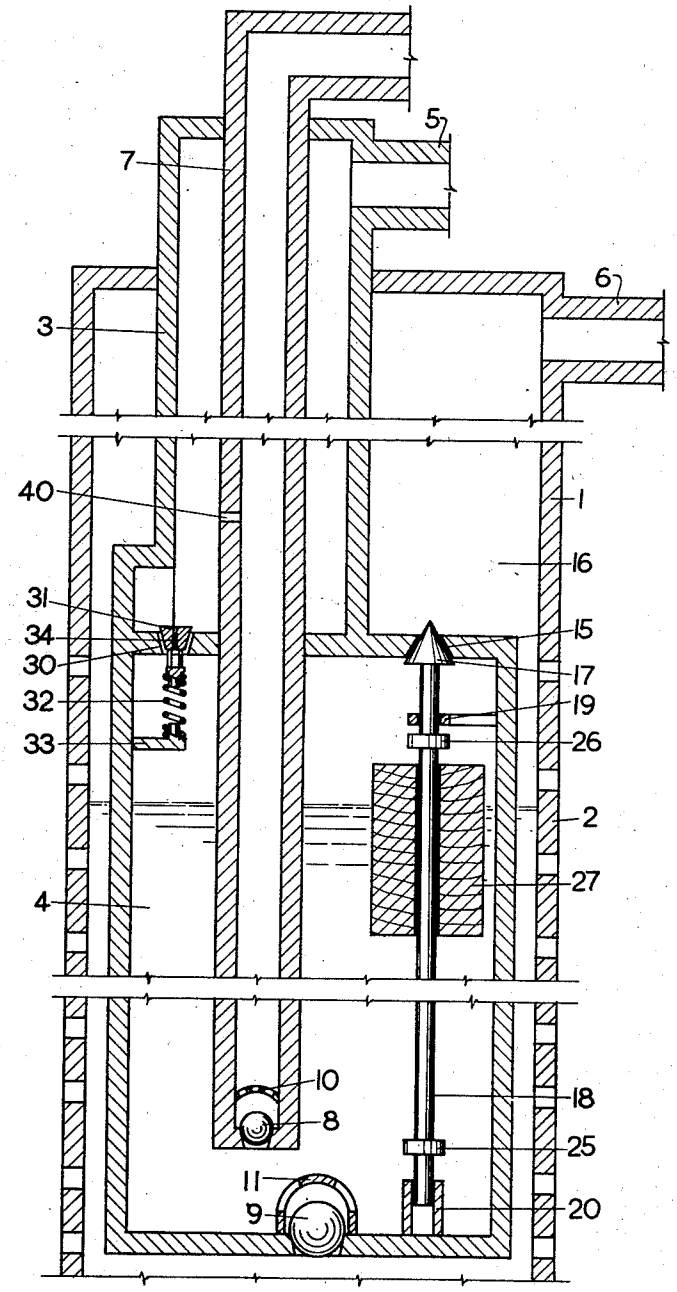


Fig. I

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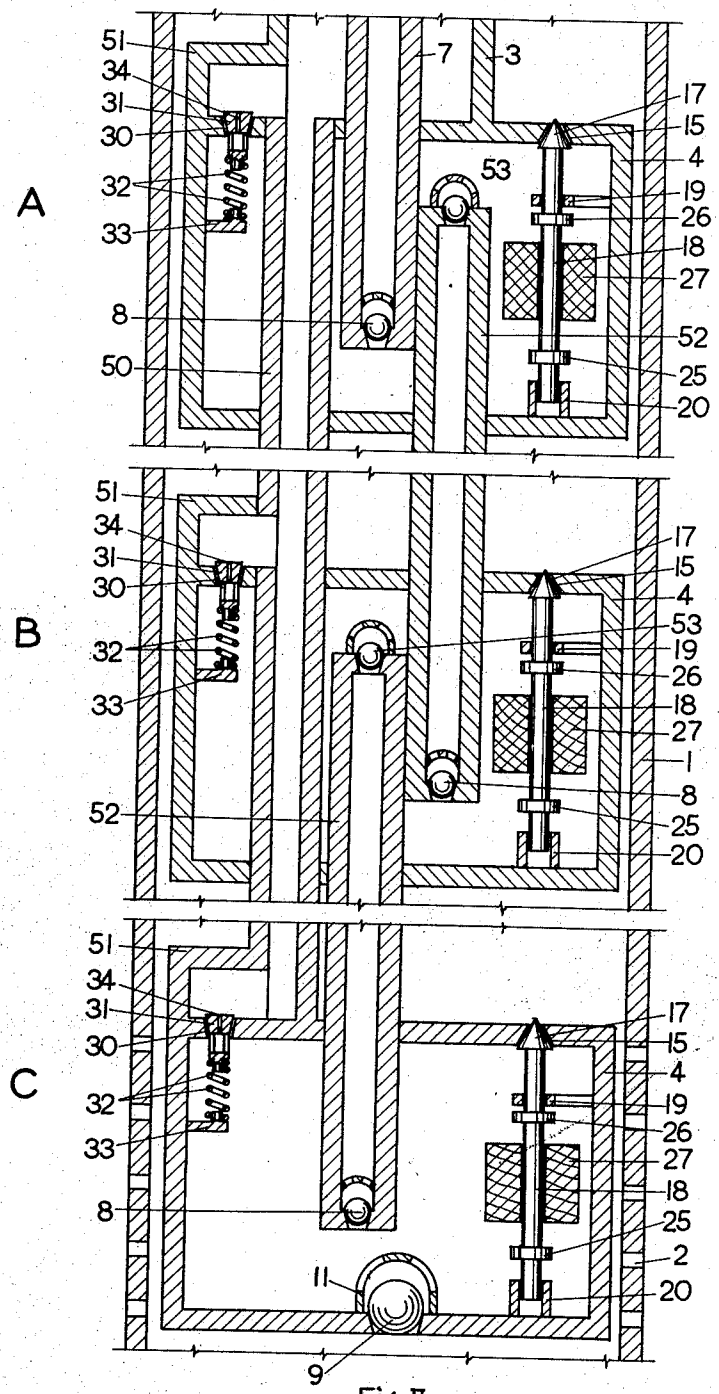


Fig. II

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2,226,537

GAS LIFT APPARATUS

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5 Claims. (Cl. 103—231)

The present invention relates to gas lift pumps having a chamber for the accumulation of well liquids and pertains more particularly to such pumps in which the accumulation chamber is provided with a device for continuously supplying pressure gas thereinto and with a gas discharge device which is responsive to the liquid level in said chamber.

It has heretofore been proposed to supply pressure gas continuously to an accumulation chamber which is provided with a level-responsive gas discharge device to vent the pressure gas to the space between the well casing and the gas supply string. However, the disadvantage of such an arrangement is that a considerable amount of pressure gas is wasted and, consequently, in some wells, due to the cost of this wasted pressure gas, the production of oil therefrom is uneconomical.

It is, therefore, an object of this invention to provide a pumping arrangement having an accumulation chamber which is provided with a level-responsive discharge device and a gas supply device automatically controlling the area of passage of pressure gas to the accumulation chamber, whereby the gas supply to the chamber is restricted during the period of liquid accumulation, and the amount of pressure gas wasted is considerably diminished.

Other objects and advantages will be apparent from the following description taken in reference to the drawings, wherein:

Figure I is a schematic vertical sectional view of a preferred embodiment of the present apparatus.

Figure II is a schematic vertical sectional view of an adaptation of the present invention to deep well pumping.

Briefly, the present invention comprises a liquid accumulation chamber, an eduction tube depending thereinto, a level-responsive discharge device in said chamber, and a pressure-responsive device adapted to supply pressure gas to said chamber at a restricted rate during the period of liquid accumulation in said chamber.

Referring to Figure I of the drawings, within a well casing 1 provided with a perforated lower portion 2, such as a liner screen, depends a tubing string forming a gas-supply column 3, which has fastened to its lower end a liquid accumulation chamber 4. The upper end of the gas supply string 3 is provided with a conduit 5, leading to a source of pressure gas, and the upper end of the casing 1 is provided with a conduit 6 for venting the space between the casing 1 and gas supply string 3 and/or other usual or desired purposes. Within the gas supply string 3 and depending into the accumulation chamber 4 is a tubing string or eduction tube 7.

The lower ends of the eduction tube 7 and the accumulation chamber 4 are provided with upwardly-opening one-way valves, such as ball valves 8 and 9 which are provided with cages 10 and 11, respectively.

An opening 15 communicates between the accumulation chamber 4 and a low pressure zone, such as the annular space 16 between the casing 1 and the gas supply string 3. For the purpose of opening and closing said opening 15 responsive to the liquid level within the accumulation chamber 4, a valve 17 registering with said opening 15 is carried by an elongated valve stem 18. The stem 18 fits slidably within suitable guides, such as guide members 19 and 20 which are fastened within the accumulation chamber 4. Near its lower end and near its upper end the valve stem 18 is fitted with stop members 25 and 26, respectively. Freely movable in a vertical direction about the valve stem 18 and between the stop members 25 and 26 thereon, is a float 27 constructed so as to have a specific gravity less than oil well liquids. The float 27, for example, may be of material such as wood (as shown) or may be of a hollow metal or other suitable construction.

Communication between the gas supply string 3 and the accumulation chamber 4 is provided by means of an opening 30 containing an upwardly-opening valve member 31 normally held in open position by resilient means, such as helical spring 32, carried by spring support 33. In a preferred arrangement the valve member 31 is constructed with a small bore 34 therethrough so that pressure gas can flow at all times although sometimes at a restricted rate into the accumulation chamber 4 irrespective of the position of the valve member 31. It is apparent that an equally efficacious arrangement is obtained if the gas passage formed by the small bore 34 is provided outside the valve 31 at some other suitable place in the partition between the gas supply string 3 and the accumulation chamber or any arrangement providing for continuous leakage from the gas supply string to the accumulation chamber.

To lighten further the column of well liquids rising in the eduction tube 7, a port 40 may be provided if desired for communication between the supply string 3 and the eduction tube 7 at a point preferably near the accumulation chamber 4. The port 40 allows pressure gas to bubble up through the well liquids in the eduction tube 7 which decreases the density of said liquids and

thereby allows a reduction in the required lifting pressure.

In the operation of the present gas-lift pump, starting with the accumulation chamber 4 empty, the float 27 rests on the lower stop member 25 of the valve stem 18 causing the valve 17 attached thereto to expose the opening 15. As the pressure in the chamber 4 is thus allowed to escape into the annular space 16, the resultant difference in pressure between the accumulation chamber 4 and the gas supply string 3 causes the valve 31 to close the opening 30 against the action of the spring 32 due to the greater pressure on the upper face of the downwardly closing valve 31. Hence, by adjusting the tension of the spring 32 and properly selecting the areas of the valve exposed to the pressures in the gas supply string and in the chamber, the valve 31 can be caused to close when the pressure in the gas supply string 3 exceeds the pressure in the chamber 4 by any predetermined value.

However, a restricted flow of pressure gas is permitted to flow into the chamber 4 through the small bore 34 in the valve 31. Due to the low pressure in the chamber 4 the ball valve 9 lifts to permit well liquids to flow from the formation through the perforated portion 2 of the casing 1 and valve 9 to the accumulation chamber 4. As the liquid level in the chamber 4 rises, the float 27 rises until it contacts the upper stop member 26 of the valve stem 18, whereby further rise of liquid level causes the float 27 to close the opening 15 with the valve 17. Then, as the gas flowing slowly into the chamber 4 through the small bore 34 is prevented from escaping, the pressure within the chamber 4 builds up until a predetermined value is reached at which value the spring 32 is strong enough to overcome the decreased difference in pressures between the supply string 3 and the chamber 4 and forces the valve 31 into an open position. The full pressure from the gas supply string 3 is then impressed on the liquid in the chamber 4 through the opening 30 and causes the ball valve 9 to close and the ball valve 8 to open, whereby the liquid in the chamber 4 is forced upwards in the eduction tube 7 and on to the well head where it is discharged to suitable receivers. As the liquid level in chamber 4 falls, the float 27 falls until it rests on the lower stop member 25 and thus moves the valve stem 18 and valve 17 downward and exposes the opening 15, whereby the gas is discharged from the chamber 4 and the pressure therein quickly lowered so that the valve 31 is caused to close the opening 30 and another period of liquid accumulation begins.

When it is preferable to lift the well liquids in several stages, such as in a deep well, several chambers 4 may be arranged one above the other as shown in Figure II, wherein like numerals indicate parts similar to those of the one-stage embodiment shown in Figure I. In this multistage embodiment A denotes the uppermost stage, B the intermediate stage, of which there may be several, and C the lowermost stage. An extension 50 of the gas supply string 3 passes down through stages A and B and is provided with side conduits 51 opening above the valves 31 in each of stages A, B, and C. The modified eduction tubes 52 in each of stages B and C extend from the lower portion of each chamber 4 to the chamber 4 of the stage above it and are provided with upwardly-opening ball valves 8 at their lower ends and, although this may not be strictly necessary, with upwardly-opening ball valves 53 at their upper ends.

By this arrangement well liquids enter the lowermost stage C as in the single stage embodiment of Figure I and are lifted through the modified eduction tube 52 and empty into the stage B above it and so on until the well liquids are raised to the well head and discharged.

By suitably adjusting the springs 32 of the valves 31 and the floats of the valves 17, the operation of each stage may be made responsive to a desired pressure difference, if necessary.

It will be understood that various changes and modifications can be made without departing from the spirit of the present invention. For instance, it will be apparent that the float operating the valve 17 for discharging the gas supply to chamber 4 during the period of liquid accumulation may be replaced by a diaphragm.

This diaphragm should preferably be located in the lower portion of chamber 4 and should be exposed, for example, on one side to the pressure of the liquid rising and falling in said chamber and on the other side to the pressure of the gas above said liquid.

The diaphragm may be connected to valve stem 18 by means of a suitable lever mechanism.

I claim as my invention:

1. In a gas lift system, a liquid collecting chamber, adapted to be placed in a well, non-return liquid inlet and gas outlet valves between said chamber and the well, level responsive means within the chamber to close the gas outlet valve, an eduction tube in communication with said chamber, a non-return inlet valve in the lower portion of said tube, a gas supply tube, reduced orifice means in continuous communication between said tube and said chamber, and loaded valve means adapted to open between said tube and said chamber when the pressure difference therebetween falls below a predetermined value.

2. In a gas lift system, the combination of a tubular string extending into a well, a liquid accumulating chamber attached to the lower portion of said tubular string, a non-return inlet valve opening to said chamber from the well, an eduction tube depending into said chamber, a non-return inlet valve in the lower portion of said tube, an opening communicating between said chamber and a space of low pressure, float-operated means responsive to the rise and fall of liquid level in said chamber to close and open said opening, and means for delivering pressure gas through said tubular string to said chamber, said means comprising a valve, resilient means holding said valve in open position, said valve being adapted to close against the action of said resilient means when the pressure in said tubular string exceeds the pressure in said chamber by a predetermined amount, and a restricted passage between said tubular string and said chamber adapted to allow continuous flow of a small amount of pressure fluid into said chamber.

3. In a gas lift system, the combination of a tubular string extending into a well, a liquid accumulating chamber attached to the lower portion of said tubular string, a non-return inlet valve opening to said chamber from the well, an eduction tube depending into said chamber, a non-return inlet valve in the lower portion of said tube, an opening communicating between said chamber and a space of low pressure, float-operated means responsive to the rise and fall of liquid level in said chamber to close and open said opening and means for delivering pressure

gas through said tubular string to said chamber, said means comprising a valve, resilient means holding said valve in open position, said valve means being adapted to close against the action of said resilient means when the pressure in said tubular string exceeds the pressure in said chamber by a predetermined amount, and a small bore in said valve forming a restricted passage between said tubular string and said chamber adapted to allow continuous flow of a small amount of pressure fluid into said chamber.

4. In a gas lift system, the combination of a tubular string extending into a well, a liquid accumulating chamber attached to the lower portion of said tubular string, a non-return inlet valve opening to said chamber from the well, an eduction tube depending into said chamber, a non-return inlet valve in the lower portion of said tube, an opening communicating between said chamber and a space of low pressure, float-operated means responsive to the rise and fall of liquid level in said chamber to close and open said opening, passage means communicating between said tubular string and said eduction tube at a point above said chamber, and means for delivering pressure gas through said tubular string to said chamber, said means comprising a valve, resilient means holding said valve in open position, said valve being adapted to close against the action of said resilient means when the pressure in said tubular string exceeds the pressure in said chamber by a predetermined amount, and a restricted passage between said tubular string and said chamber adapted to allow continuous flow of a small amount of pressure fluid into said chamber.

5. In a gas lift system, the combination of a tubular string extending into a well, a plurality of liquid accumulating chambers vertically spaced in said well, a non-return inlet valve opening to the lowermost of said chamber from the well eduction tubes depending into each of said chambers, the eduction tube depending into the uppermost chamber extending to the surface of the well, each of the other eduction tubes extending from one chamber and opening into the chamber above said one chamber, one-way inlet valves in the lower portion of said tubes, and means associated with each of said chambers comprising an opening communicating between the chamber and a space of low pressure, float-operated means responsive to the rise and fall of liquid level in the chamber to close and open said opening and means for delivering pressure gas through said tubular string to the chamber said means comprising a valve, resilient means holding said valve in open position, said valve being adapted to close against the action of said resilient means when the pressure in said tubular string exceeds the pressure in the chamber by a predetermined amount, and a restricted passage between said tubular string and said chamber adapted to allow continuous flow of a small amount of pressure fluid into the chamber.

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