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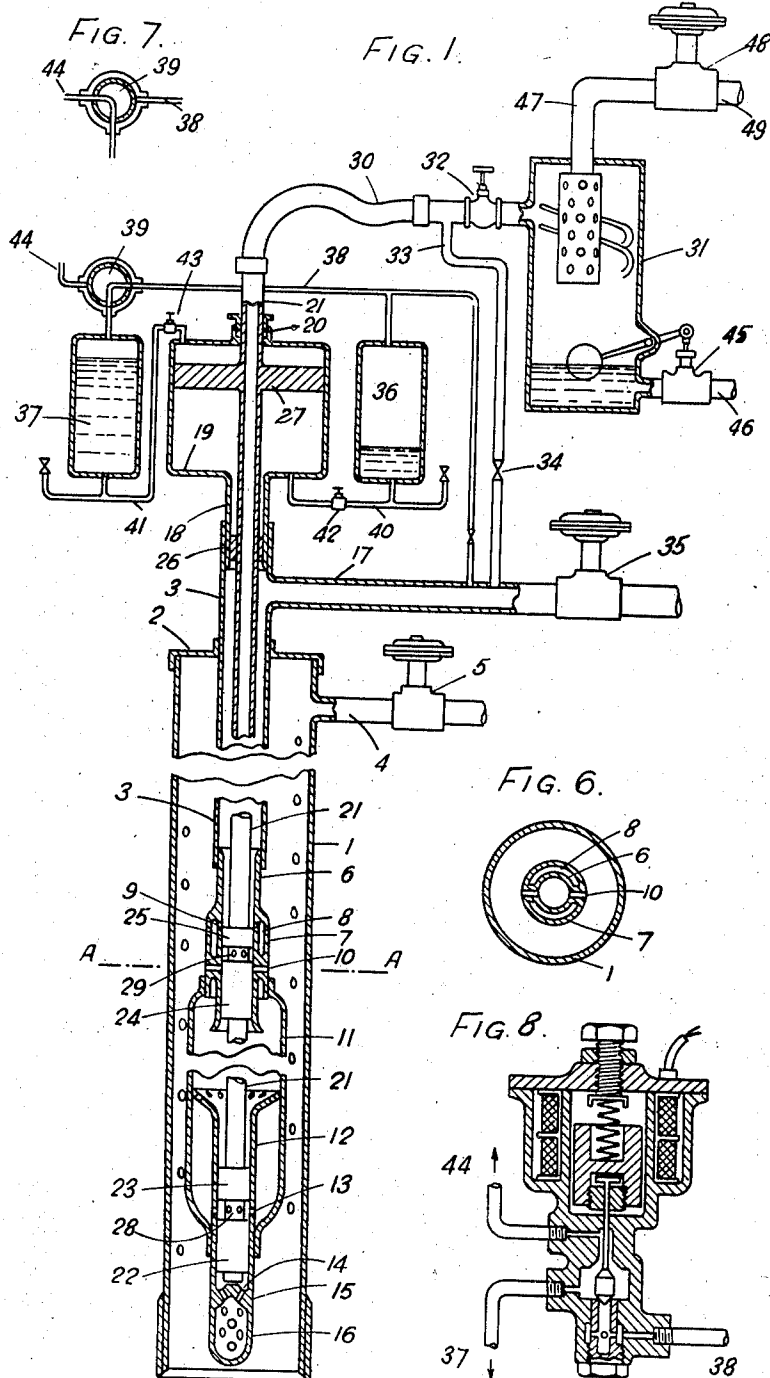
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2,162,418

APPARATUS FOR RAISING NATURAL OILS AND OTHER LIQUIDS BY GASEOUS PRESSURE

Filed April 14, 1938

2 Sheets-Sheet 1



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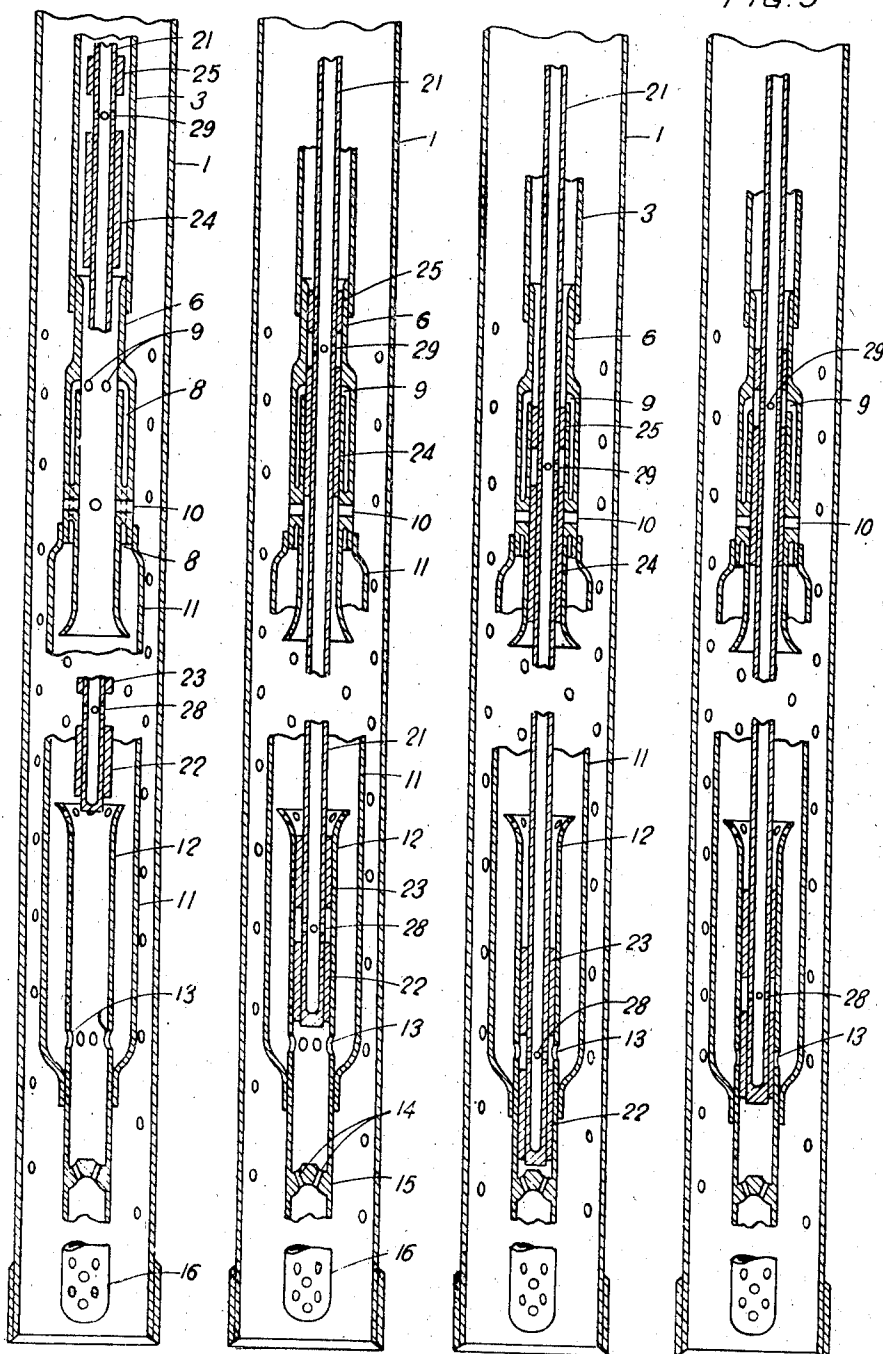
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FIG. 2.

FIG. 3

FIG. 4.

FIG. 5



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UNITED STATES PATENT OFFICE

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APPARATUS FOR RAISING NATURAL OILS
AND OTHER LIQUIDS BY GASEOUS PRES-
SURE

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13 Claims. (Cl. 103—231)

This invention relates primarily to the raising of oil from oil wells by gaseous pressure and will hereinafter be described with reference thereto, but it will be understood that the invention is applicable to raising other liquids.

In known methods of raising liquids by gaseous pressure the operations of the apparatus employed are controlled by the pressure conditions obtaining from time to time in a chamber to which liquid is admitted from a space around the chamber and in the gaseous pressure conditions maintained in the casing exterior to the chamber. Such known apparatus involved the use of spring controlled valves or check valves or both which were located below ground level or the use of a partition in the eduction pipe for leading liquid to the surface, which partition obstructed the bore of the pipe and prevented solid matter in the pipe from being easily cleared.

Among the objects of the invention are to provide an improved apparatus for raising liquids which avoids the use of such valves or obstructions in the eduction pipe and in which the operation of the apparatus is substantially unaffected by increases in the gaseous pressure conditions obtaining in the casing space or by increases in the pressure of the liquid in the well.

Accordingly in the apparatus according to the invention the admission to and the exhaust of gas from and the admission to and delivery from the chamber of liquid is effected by means which are actuated independently of the pressure conditions in the chamber and the casing.

The invention further comprises apparatus for carrying out the above invention in which the pumping operation is independent of self-actuating or automatically operating apparatus, e. g. spring-controlled or check valves located below ground level, the apparatus comprising a member, actuatable from the top of the well, which is arranged to actuate valve members which, in one position of the member, are arranged to open passages to permit liquid to flow from the space outside the casing into the lower part of the chamber and to permit gas to be exhausted from the upper part of the chamber and in another position of the member to close the said passages and to open a passage between the upper part of the chamber and a source of pressure gas and another passage between the lower part of the chamber and the pipe located therein for leading the liquid to the top of the well, entry of liquid to the eduction pipe which leads the liquid to the surface being prevented while liquid is being admitted to the chamber from the well.

Further features of the invention are described with reference to the accompanying drawings which illustrate an embodiment thereof and in which—

Fig. 1 is a schematic diagram illustrating the lay-out of liquid raising apparatus embodying the invention.

Figs. 2, 3, 4 and 5 illustrate the working of the apparatus and

Fig. 6 is a section on the line A—A of Fig. 1. Fig. 7 is a view of a part of the apparatus of Fig. 1 and

Fig. 8 shows an alternative construction of this part.

Referring to Fig. 1, an oil well casing 1 shown perforated to admit oil from surrounding strata, is provided with a shoe at its lower end. At its upper end which is above ground, the casing is closed by a casing head 2, this head supporting a pipe 3 which extends through the casing head down into the well provided by the well casing 1. A pipe connection 4 opening to the upper part of the casing 1 is provided to carry gas from the casing, a regulator valve 5 being provided to control the pressure of gas above the oil in casing 1, as is common oil field practice. The bottom of the pipe 3 opens into a cylinder 6 having a smaller bore than that of pipe 3. The lower part of cylinder 6 is enclosed in a jacket 7, shown in the drawings as being integral with the cylinder 6, which leaves an annular space 8 between the outside of cylinder 6 and the inside of jacket 7, which space is open at the bottom and closed at the top. The cylinder 6 has ports 9 which communicate with the space 8 and ports 10 which communicate, through the jacket 7, with the casing 1 but do not communicate with the annular space 8. This arrangement is illustrated more clearly by Fig. 6. To the lower end of the jacket 7 is attached the upper end of a chamber 11 which is usually as large as can conveniently and reasonably be accommodated by the casing 1. The length of the chamber 11 is primarily designed to contain such a quantity of oil that, when displaced into the oil tubing 21, will form a column of oil of length such that the working (normal) gas pressure of the system can force the column upwards at a reasonable velocity. At the lower end of chamber 11 and extending through it is a cylinder 12 of the same internal bore as the cylinder 6. The cylinder 12 has ports 13 communicating with the inside of chamber 11 and ports 14 which pass through a fixed plug 15. A lower perforated pipe extension 16 is attached under the plug 15 and conforms to common oil

field practice. The upper and lower ends of the cylinder 6 and the upper end of the cylinder 12 are so shaped as to facilitate the entry of plungers thereto. Opening to the pipe 3 above the casing head 2 is a pipe connection 17 for conveying to the pipe 3 a supply of gas under pressure from an outside source (not shown). Above the junction of the pipe 17 with the pipe 3, the latter pipe supports a cylinder 18 preferably of the same bore as cylinders 6 and 12. The cylinder 18 at its upper end supports and opens into a cylinder 19 of greater bore than the bore of the cylinder 18. Extending down through a stuffing box 20 in the top cover of the cylinder 19 and down through the cylinders 19, 18, the pipe 3, the cylinder 6, the chamber 11 and the cylinder 12 towards the plug 15 is an oil pipe 21. This oil pipe is closed at its lower end and carries affixed to it, plungers 22 and 23 which are within the cylinder 12, plungers 24 and 25 disposed within the cylinder 6, plunger 26 disposed within the cylinder 18, and piston 27 disposed within the cylinder 19. The oil pipe 21 has perforations 28 between the top of plunger 22 and the bottom of plunger 23 and perforations 29 between the top of plunger 24 and the bottom of plunger 25.

The plungers 22, 23, 24, 25 and 26 and the piston 27 fit closely and slidably in their respective cylinders. The oil pipe 21 carries, on its upper end, a flexible connection 30 for leading oil to an oil and gas separator 31. In pipe 30, before the pipe opens into the separator, is a valve 32. Connected to the pipe 30 on the well side of the valve 32 is a pipe 33 which is provided with valve 34 and opens to the pressure gas supply pipe 17. A pressure regulating valve 35 may be used on the supply pipe 17 to control the pressure under which gas is fed to the pipe 3 for normal working conditions. Two hydraulic chambers 36 and 37 are arranged conveniently near the cylinder 19. A pipe 38 draws a gas supply from the supply pipe 17 at pressure and opens directly to the top of the chamber 36 and indirectly through a pilot control valve 39 to the top of the chamber 37. A pipe 40 connects the bottom of chamber 36 with the bottom of cylinder 19 and a pipe 41 connects the bottom of chamber 37 with the top of cylinder 19. Throttle valves 42 and 43 are mounted in pipes 40 and 41 in order to control the rate of flow of suitable liquid between the chambers 36 and 37 and the cylinder 19 and so ensure smooth operating conditions. The pilot control valve 39 serves to connect the gas supply from the pipe 38 to the chamber 37 while closing an atmospheric port 44 or alternatively to close the gas supply from pipe 38 to the chamber 37 and open a connection between the chamber 37 and atmosphere as shown in Fig. 7. The oil and gas separator 31 is provided with a float valve 45 which is adapted to allow oil to pass via the pipe 46 to an oil collecting tank (not shown), and with a gas pipe 47 which conveys gas via a pressure regulator valve 48 and a pipe 49 to a gas collecting plant (not shown).

The respective areas of the piston 27 and the plunger 26 are such that when the upper part of the chamber 37 is open to atmosphere via the valve 39 and the pipe 44, the differential pressure due to liquid displaced from the chamber 36 under the influence of gas pressure from the pipe 38 exerts an upward thrust on pipe 21 of a value greater than the total weight of the said oil pipe 21 and the plungers attached to it. The oil pipe is thus lifted to an extent which may be regulated

in any suitable manner as by limiting the stroke of the piston 27.

When the piston 27 is in its uppermost working position, it is arranged that the ports 28 and 29 in the oil pipe 21 are opposite blank portions of the cylinders 12 and 6 respectively, and that the ports 13 in the cylinder 12 and the ports 10 in cylinder 6 are uncovered by the plungers 22 and 24 respectively. This is illustrated in Fig. 3. In the position shown in Fig. 3, oil is allowed to flow freely from the lower pipe extension 16 via the ports 14 in the plug 15 and the ports 13 in the cylinder 12 into the chamber 11 and gas left in the chamber 11 is displaced upwards and escapes to the casing 1 via the ports 10.

When the piston 27 is in its lowest position, it is arranged that the bottom of the oil pipe 21 rests on the plug 15, that the ports 28 in the oil pipe 21 are horizontally aligned with the ports 13 in the cylinder 12, that the ports 10 in the cylinder 6 are closed by the plunger 24, that the ports 29 in the oil pipe 21 are opposite a blank portion of the cylinder 6, and that the ports 9 in the cylinder 6 are uncovered by the top of plunger 25. This positioning is illustrated in Fig. 4.

In the position shown in Fig. 4, gas at normal working pressure flows from the pipe 3 via the ports 9 and the annular passage 8 to the chamber 11. This pressure acts on the surface of oil contained in the chamber 11 and displaces this oil via the ports 13 in the cylinder 12 and the ports 28 in the oil pipe 21 and forms in the pipe a liquid column of definite length which is proportional to the designed capacity of the chamber 11. The gas raises the whole column upwards towards the top of the well.

When the oil has travelled a certain proportion of the distance from the bottom to the top of the oil pipe 21, the piston 27 raises the oil pipe 21 to the position shown in Fig. 5, which position is intermediate those shown in Figs. 3 and 4. In the position shown in Fig. 5 it is arranged that the ports 28 in the oil pipe 21 are opposite a blank portion of the cylinder 12, that the ports 13 in the cylinder 12 and the ports 10 in the cylinder 6 are closed by the plungers 22 and 24 respectively, that the plunger 25 shuts off further admission of pressure gas from the pipe 3 to the chamber 11 and that the ports 29 in the oil pipe 21 are in horizontal alignment with the ports 9 in the cylinder 6.

In this position, all the gas contained in the chamber 11 and in the oil pipe 21 beneath the column of oil now on its way upward, is used expansively to complete the forcing of that column of oil up to the top of the well.

After the piston 27 has been held in this position, for a predetermined period, by a balance of the hydraulic forces acting on the said piston suitably controlled by the valve 39 or by other suitable means (not shown), the piston 27 is then moved to its uppermost normal position and the oil pipe 21 assumes once more the position shown in Fig. 3.

In this position the equipment remains stationary for a predetermined period of time before recommencing the cycle of operations hereinbefore described.

When this equipment is being installed in a well in which the liquid level is for any reason higher than would obtain during normal production conditions, the pipe 3, with all the equipment down to the pipe 16 which is mounted on it, is run into the well to its predetermined working depth. The oil tube 21 carrying the plungers 22, 25

23, 24 and 25 is then run in until the foot of oil pipe 21 rests upon the bottom plug 14 and thereafter all apparatus at the surface is completely assembled. The pressure gas supply is then admitted to the pipe 17 leading to the pipe 3. The valves of the pipes 38 and 33 are opened and valve 32 in the oil pipe 30 leading to the receiving separator, closed. The piston 27 is then allowed to rise to its extreme top position (above its uppermost normal position as shown in Fig. 3) when it is arranged that the bottoms of the plungers 22 and 24 are higher than the tops of the cylinders 12 and 6 respectively. In this position which is shown in Fig. 2, pressure gas is admitted to the top of both pipes 3 and 21 and all oil which may have entered to them while the equipment was being lowered into the well is expelled into the casing 1 via the ports 10 and 14 until the oil level is reduced to the level of the ports 10 in the cylinder 6. The piston 27 and the oil pipe 21 are then lowered, while gas pressure in pipes 3 and 21 is maintained, to the position shown in Fig. 4. The valve 34 in the gas by-pass pipe 33 is then closed and the valve 32 in oil pipe 30 is opened. The pressure gas in oil pipe 21 then escapes to the separator 31 and normal working conditions are immediately obtained without being adversely affected in any way by the quantity or height of the liquid in the casing 1 or by any excess pressure which is maintained in this casing 1, and acts on the surface of oil therein, by the control valve 5. Since the maximum quantity of oil that can be admitted to the chamber 11 is fixed, and since no oil can enter the oil pipe 21 during the chamber filling period, the gas pressure required to operate the system need never exceed the predetermined value on which the designed capacity of chamber 11 is based, and no higher pressure is ever required.

It is to be observed that all outlets to the casing 1 are necessarily closed before pressure gas is admitted from pipe 3 to chamber 11; that all inlets from the chamber 11 to the oil pipe 21 are necessarily closed before the refilling of chamber 11 commences; that the oil pipe 21 is completely open from top to bottom, and that no impedance whatever is offered to the flow of oil; and that there are no spring and/or weight loaded automatic valves whatever in the equipment in the well.

The pipe 13 which is shown as a simple perforated pipe may be of any suitable form to exclude grit or to effect a separation of gas from oil as the conditions in any particular well may require.

It will be appreciated that the particular arrangement described above for effecting the raising and lowering of the oil pipe 21, i. e. the cylinder 19, the piston 27 the chambers 36 and 37, may be modified and other means may be employed to perform the same operations while the valve 39 may be replaced by, for example, an electromagnetically operating valve such as is shown diagrammatically in Fig. 8 which can be controlled by a remotely located switching device.

Means may be provided above the cylinder 6 to prevent foreign matter, e. g. grit or pipe scale, from entering the cylinder 6 with the incoming gas.

The plungers on the pipe 21 are preferably made of a non-metallic material in order to minimize the frictional or abrasive effect of foreign matter which may appear.

A small pressure reducing device may be in-

serted in the gas pipe 38 which leads to the valve 39 in order to control the behavior of the piston 27 while the pipe 44 may be connected to the pipes 49 or 4. Means may be provided to terminate the waiting period when the parts are in the position shown in Fig. 5 and the oil reaches the surface.

Should any matter, e. g. paraffin wax, lodge in the pipe 21 this may readily be removed by lowering a swab into the pipe without extracting the pipe, owing to the fact that the bore of this pipe is unimpeded throughout its length.

Owing to the absence of a loaded valve which must be maintained open by the action of gas flowing through it as in known systems, in the system provided by the invention the various gas passages may be made sufficiently large to minimize the resistance to gas flow appreciably and, therefore, the maximum gas pressure necessary is lower than hitherto, while the available gas pressure in the chamber 11, when the gas supply thereto is cut off, is used to the maximum extent possible as the oil pipe 21 is unobstructed.

Furthermore, the ability of grit and other foreign matter adversely to affect the operation of the apparatus is reduced by the absence of spring and like loaded valves.

It will be observed that the oil admitted to the pump chamber is limited to about the capacity of the chamber and is a fixed predetermined quantity.

I claim:

1. Apparatus for raising liquids in wells by gaseous pressure comprising a chamber adapted to be disposed below liquid level in a well, a gas pipe opening to the chamber, a source of gaseous pressure, means connecting said source to said gas pipe, an eduction pipe vertically reciprocable in said chamber, a plurality of valve means actuable by said eduction pipe upon reciprocation thereof to one position for admitting liquid to the chamber from a space around the chamber while opening a vent between the upper part of the chamber and the said space and closing the eduction pipe from the chamber, and upon reciprocation of the eduction pipe to another position for closing said chamber from said space while admitting gaseous fluid to the upper part of said chamber and opening the eduction pipe to be lower part of the chamber.

2. Apparatus for raising liquids in wells by gaseous pressure comprising a chamber adapted to be disposed below liquid level in a well, a gas pipe opening to the chamber, a source of gaseous pressure, means connecting said source to said gas pipe, an eduction pipe vertically reciprocable in said chamber, a plurality valve means actuable by said eduction pipe upon reciprocation thereof to one position for admitting liquid to the chamber from a space around the chamber while opening a vent between the upper part of the chamber and the said space and closing the eduction pipe from the chamber, and upon reciprocation of the eduction pipe to another position for closing said chamber from said space while admitting gaseous fluid to the upper part of said chamber and opening the eduction pipe to the lower part of the chamber, means for maintaining the eduction pipe in a position intermediate the aforesaid two positions for closing the source of gaseous pressure from the chamber while maintaining the chamber closed from the said space and open to the eduction pipe.

3. In apparatus for raising liquids in wells by gaseous pressure comprising a chamber adapted

to be disposed below liquid level in a well, said chamber having ports for the admission of liquid to the chamber and ports for the admission of gaseous fluid to the chamber, a gas pipe opening to the chamber, a source of gaseous pressure, means connecting said source to said gas pipe, a plurality of valve means vertically reciprocable to open and close the said ports to control the flow of gaseous fluid and liquid to and from the chamber, an eduction pipe extending into said chamber for carrying the liquid to the surface of the well, said eduction pipe having ports for the admission of liquid to the eduction pipe located in the chamber and having an unobstructed bore above said ports.

4. Apparatus for raising liquids in wells by gaseous pressure comprising a chamber adapted to be disposed below liquid level in a well, a liquid inlet at the lower part of said chamber and a gas vent at the upper part thereof, a gas pipe opening to the chamber, a source of gaseous pressure, means connecting said source to said gas pipe, an eduction pipe vertically reciprocable in said chamber, said eduction pipe having ports longitudinally displaced along the pipe, valve means for opening ports at the lower end of the pipe for admitting liquid from the chamber to the eduction pipe, valve means for closing the chamber inlet and valve means for closing the gas vent, in one position of said pipe, valve means for closing upper ports located above said lower ports while said liquid is admitted to said lower ports, means for moving said eduction pipe to a position wherein said first-mentioned valve means close said lower ports and the last-mentioned valve means open the upper ports to the chamber for permitting gas in said chamber to expand in the eduction pipe and force liquid above said upper ports up through the eduction pipe.

5. Apparatus for raising liquids in wells by gaseous pressure comprising a chamber adapted to be disposed below liquid level in a well, a gas pipe opening to the chamber, a source of gaseous pressure, means connecting said source to said gas pipe, a vertically reciprocable eduction pipe having a closed lower end, a cylinder in the lower part of said chamber, said cylinder having ports which connect the interior of the cylinder with the chamber space outside the cylinder, a cylinder in the upper part of the chamber having its upper end open to the gas pipe and its lower end open to the upper part of the chamber space, a jacket around and spaced from said cylinder, the walls of said cylinder having ports which connect the interior of the cylinder with the space between the cylinder and the jacket, the interior of said cylinder being connected with the space outside the chamber by ports located below the ports connecting the interior of the cylinder with the space between the cylinder and the jacket, plungers on the eduction pipe located in one position of the eduction pipe to admit liquid from the well to the chamber space via the ports in the cylinder in the lower part of the chamber, while permitting gas to escape via the ports connecting the cylinder in the upper part of the chamber with the space outside the chamber and closing ports in the eduction pipe to prevent liquid entering the said pipe from the chamber, and at the same time to close the cylinder in the upper part of the chamber from the gas pipe and thereby prevent gas entering the chamber, the plungers also, in another position of the eduction pipe being located to close the ports in the cylinder in the lower part of the chamber and prevent

liquid entering the chamber from the well and closing the ports connecting the interior of the cylinder in the upper part of the chamber with the space outside the chamber, while exposing the said ports in the eduction pipe to admit liquid from the chamber to the eduction pipe and opening the cylinder in the upper part of the chamber to the gas pipe thereby permitting gas to enter the upper part of the chamber via the ports connecting the interior of said cylinder with the space between the cylinder and the jacket.

6. Apparatus as claimed in claim 5 wherein the plungers are located, in a third position of the eduction pipe, to expose further ports in the eduction pipe, which are located above the ports for admitting liquid to the eduction pipe from the chamber, to the space between the said cylinder and the jacket while closing the said cylinder from the gas pipe, closing the ports between the said cylinder and the space outside the chamber, closing the ports in the cylinder in the lower part of the chamber and closing the ports in the eduction pipe for admitting liquid to the said pipe from the chamber.

7. Apparatus for raising liquids in wells by gaseous pressure comprising a chamber adapted to be disposed below liquid level in a well, a source of gaseous pressure, means connecting said source with said chamber, a vertically reciprocable eduction pipe having its lower end located in the chamber, valve means actuable to permit the admission of liquid from the well to the chamber while preventing the admission of liquid to the eduction pipe through ports in said pipe located in the chamber, valve means actuable to place the upper part of said chamber in communication with the space outside the chamber and to close the connection between the upper part of the chamber and the source of gaseous pressure while liquid is admitted to the chamber.

8. Apparatus for raising liquids in wells by gaseous pressure as claimed in claim 7, comprising an eduction pipe having a closure at its lower end which is located in the chamber and an unobstructed bore above the closure.

9. Apparatus for raising liquids in wells by gaseous pressure as claimed in claim 2, comprising means for lifting the eduction pipe to a position above either of said two positions and means for connecting the eduction pipe with the source of gaseous pressure while the eduction pipe is in the raised position.

10. Apparatus for raising liquids by gaseous pressure comprising a chamber adapted to be disposed below liquid level in a well, a source of gaseous pressure, means for connecting said source with said chamber, an eduction pipe vertically reciprocable in said chamber, valve means controlling the flow of liquid to said chamber and the flow of liquid to the eduction pipe, valve means controlling the flow of gas to and from said chamber, means connecting said valve means with said eduction pipe, a pair of fixed cylinders of different diameters open to one another, pistons fixed to the eduction pipe and movable in said cylinders and defining a space between the pistons, the smaller of said pistons being exposed to the pressure of gas in the means connecting the said source with the chamber, and means for introducing a fluid to the space between the pistons to lift the eduction pipe.

11. Apparatus for raising liquids in wells by gaseous pressure as claimed in claim 10, comprising means for introducing a fluid to the cylinder of larger diameter on the side of the

piston therein opposite to the said space to depress the eduction pipe.

12. Apparatus for raising liquids by gaseous pressure comprising a chamber adapted to be disposed below liquid level in a well, a liquid inlet in the lower part of the chamber, a gas vent at the upper part of the chamber, a source of gaseous pressure, means for connecting said source with said chamber, a vertically reciprocable eduction pipe, valve means for controlling the flow of liquid into the chamber, valve means for controlling the flow of gas through said vent, valve means for controlling the flow of liquid to the eduction pipe, valve means for controlling the flow of gaseous fluid to the chamber, means connecting the eduction pipe with said valve means, a fixed cylinder, a piston fixed to said eduction

pipe and movable in said cylinder, a second fixed cylinder of diameter larger than the diameter of the first cylinder and located above and open to said first cylinder, a piston fixed to said eduction pipe and movable in said second cylinder, means connecting the first cylinder below the piston therein with the means connecting the said source with the chamber, means for introducing a pressure fluid to the cylinders between said pistons, valve means for controlling the flow of fluid to the second cylinder above the piston therein and means for actuating said valve means.

13. Apparatus for raising liquids by gaseous pressure as claimed in claim 12 comprising hydraulic reservoirs for supplying fluid to the cylinders.

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