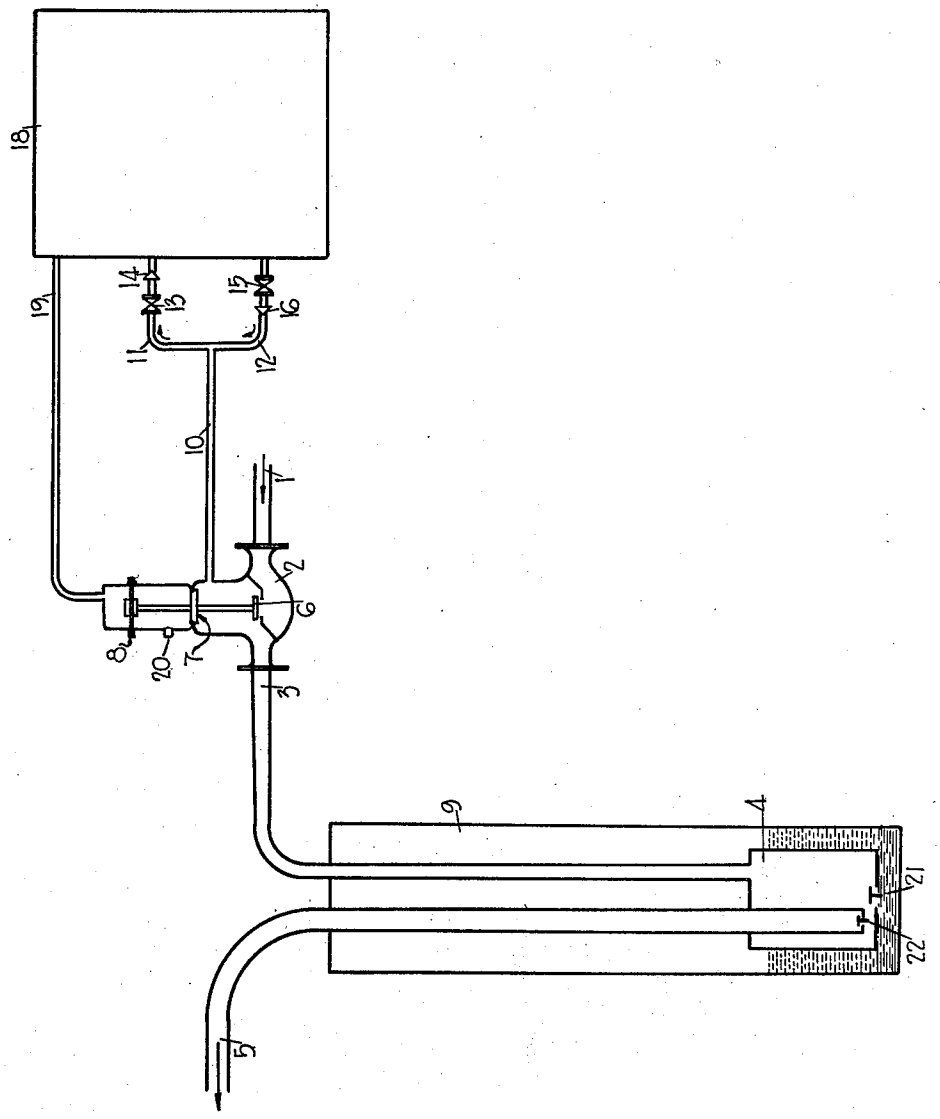
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APPARATUS FOR LIFTING LIQUIDS

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APPARATUS FOR LIFTING LIQUIDS

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This invention relates to methods and apparatus for lifting liquids by means of a compressed gas, and is more particularly concerned with a device for controlling the intermittent supply of the working gas to said apparatus.

In the process of lifting liquids from underground wells, and especially in the petroleum industry, where it is customary to apply the so-called gas-lift method for flowing deep wells, various devices have been developed to admit and cut off at regular intervals the supply of the working gas to the wells. However, these devices, such, for example, as electrical timers which are now extensively used, have the drawbacks of being of a rather complicated construction and requiring a separate source of energy.

It is a purpose of this invention to provide the desired control by utilizing the pressure fluctuations in a special reservoir intermittently connected with a supply of gas under pressure and the atmosphere. In this manner a simple and inexpensive device can be obtained, which does not require for its operation any other source of energy than that of the gas under pressure, which is usually available in the form of the working gas for oil-lifting operations.

This invention will be better understood from the following description taken with reference to the accompanying drawing, which illustrates diagrammatically and in cross-section, a preferred embodiment of this invention.

On the drawing, 9 represents an oil well, or any other reservoir from which liquid has to be lifted. An enclosed reservoir 4 is placed near the bottom of the well. This latter reservoir may be constructed in the form of a pipe extending throughout the length of the well; it is equipped with a check-valve 21 admitting the liquid from the well 9 until the pressure in 4 is raised sufficiently to close this valve. A gas supply pipe 3 and a liquid discharge pipe 5 which ends a short distance from the bottom of the enclosed reservoir 4 are provided for flowing gas to and from the enclosed reservoir 4 and for flowing the liquid therefrom, respectively. In operation, liquid from the well 9 is allowed to fill the reservoir 4 through the check valve 21 when the pressure in 4 is sufficiently reduced; the accumulated liquid is then lifted through the discharge pipe 5 by the compressed gas supplied through the pipe 3; a check valve 22 may be provided at the lower end of the pipe 5 to prevent the back flow of liquid therefrom. To effect this operation of elements 3, 4, 5, 9, 21 and 22, or their equivalents, which, in combination, may be referred to as a liquid lifting pump, the working gas supplied to the system from a high-pressure line 1 is alternately admitted into the pipe 3 and shut off therefrom by means of an automatic valve structure such as 2. The valve structure 2 is shown to consist of a casing in which are assembled: a valve 6 opening upwards, a valve 7 opening downwards, and a diaphragm 8; valves 6 and 7 are rigidly connected to the diaphragm 8 and move together between two alternate positions in which one of the valves is open and the other closed. The diameter of the diaphragm 8 is preferably made larger than that of the valve 7, which is in turn usually larger than that of the valve 6. A gas pipe 10 is connected to the casing between the valves 6 and 7; the casing enclosure between the valve 7 and the diaphragm 8 communicates with the atmosphere or a space of low pressure through a vent 20, while the space within the casing and above the diaphragm is connected by a line 19 to a gas reservoir 18. The gas pipe 10 is connected to the reservoir 18 by means of two branch pipes 11 and 12. These two branches are provided with adjustable valves 13 and 15 of relatively small cross-sections and check valves 14 and 16, so that the flow of gas through each branch is possible only in one direction, as shown by the arrows. To prevent the clogging of valves, special filters, not shown on the drawing, may also be installed in pipes 11 and 12.

The operation of the device is as follows:

Assuming that working gas is being supplied to the well, the valve 6 will be opened by the pressure applied to its lower face. Valve 7 will be accordingly closed. The line 10 being thus in communication with the line 1, gas will flow through the pipes 10 and 11 and slowly fill the reservoir 18, in which a low pressure prevails at this moment, just as in the line 19 and in the space above the diaphragm 8. At the same time a gas pressure will be applied through the pipe 3 to the reservoir 4, and, with the valve 21 closed, the liquid which is present in the reservoir 4 will be forced to flow through the pipe 5.

The pressure on the diaphragm 8 gradually will increase owing to the continuous supply of gas to the reservoir 18, until it overcomes the upward pressure of the working gas on the lower face of the valve 7. The valves 6 and 7 then will move downwards, so that the valve 6 will shut off the supply of working gas, while the valve 7 will open, putting the lines 10 and 3 in communication with the space above the valve

7, which space is open to the atmosphere or a low pressure space through vent 20. Now the reservoir 18 will gradually be emptied through the line 12 and the reservoir 4 through the line 3, so that the pressure in the reservoirs and in the space above the diaphragm 8 will continuously decrease. During this time, i. e. after the supply of the working gas is shut off and after the pressure within the reservoir 4 decreased below a certain value, the valve 21 will open and admit the liquid from the well 9 into the reservoir 4, while the valve 22 will be closed.

When the force exercised by the gas pressure through the pipe 19 on the diaphragm 8 becomes less than the upward force of the pressure of the working gas on the lower surface of valve 6, the valves 6 and 7 will then be raised again, so that valve 6 will open, and valve 7 will close, the mechanism thus returning to its original position for the next cycle.

The length of the period during which gas is supplied to the well should, of course, correspond to the time required for removing of the desired quantity of the liquid from the reservoir 4, while the length of the period during which the valve 6 remains closed should correspond to the time required for filling said reservoir with the liquid from the well 9. Both periods can be accurately adjusted by means of valves 13 and 15, needle valves being especially suitable for the purpose.

Such parts of the apparatus which are of no consequence to the principle of the invention, but may be advisable in practice, such as filters, by-pass lines, additional valves etc., are not shown on the drawing.

It is possible to modify the construction of the valve mechanism particularly described and shown on the drawing; the only essential requirement being that the main valve 6 be alternately opened and closed on two pressure limits being reached in the reservoir 18, thus quickly switching the reservoirs 4 and 18 from a high pressure space to a low pressure space, or inversely.

Further, the effect of the gas pressure on the diaphragm may be modified, for example, by the action of a weight or a spring. If so desired, a relay control device may also be used, although this results in the apparatus becoming more complicated.

The arrangement and construction of the various parts of the system is, of course, quite arbitrary, thus, for example, in many cases the separate enclosed reservoir 4 may be dispensed with and a closed well used for collecting the liquid to be lifted.

I claim as my invention:

1. In a system for lifting liquids by means of compressed gas, a reservoir for the liquid to be lifted, a reservoir for gas, a supply of compressed gas, a casing in communication therewith, a vent to the atmosphere in the casing, conduits connecting the casing to both reservoirs, pressure responsive means within the casing adapted to oppose continuously the pressure of the supply gas to the pressure of the gas in the reservoir, and means adapted to put both reservoirs in communication with the supply gas when the force exerted by the pressure of the supply gas on the pressure responsive means exceeds the force exerted thereon by the pressure in the gas reservoir, and to vent both reservoirs when the force exerted by the pressure in the gas reservoir on the pressure responsive means exceeds the force exerted thereon by the supply gas.

2. In a system for lifting liquids by means of compressed gas, a reservoir for the liquid to be lifted, a reservoir for gas, a supply of compressed gas, a casing in communication therewith, pressure responsive means adapted to oppose continuously the pressure of the supply gas to the pressure of the gas in the reservoir, said means dividing the casing into two sections, a conduit connecting one of the sections to the gas reservoir, a vent to the atmosphere in the other section, conduits connecting this other section to both reservoirs, and automatic valve means adapted to put both reservoirs in communication with the supply gas when the force exerted by the pressure of the supply gas on the pressure responsive means exceeds the force exerted thereon by the pressure of the gas in the reservoir, and to vent both reservoirs when the force exerted by the pressure of the gas in the reservoir on the pressure-responsive means exceeds the force exerted thereon by the pressure of the supply gas.

3. In a system for lifting liquids by means of compressed gas, a reservoir for the liquid to be lifted, a reservoir for gas, a supply of compressed gas, a casing, a pressure responsive diaphragm dividing said casing into two sections, a conduit connecting one of said sections to the gas reservoir, a vent to the atmosphere in the other section, conduits connecting this other section to both reservoirs, means comprising a valve rigidly connected to the diaphragm continuously opposing the pressure of the supply gas to the pressure of the gas in the reservoir, and means adapted to put both reservoirs in communication with the supply gas when the force exerted by the first pressure exceeds the force exerted by the second pressure, and to vent both reservoirs when the force exerted by the second pressure exceeds the force exerted by the first pressure.

4. In a system for lifting liquids by means of compressed gas, a reservoir for the liquid to be lifted, a reservoir for gas, a supply of compressed gas, a casing, a pressure responsive diaphragm dividing said casing into two sections, a conduit connecting one of said sections to the gas reservoir, a vent to the atmosphere in the other section, conduits connecting this other section to both reservoirs, a valve located in this section for disconnecting the gas supply from the vent and actuated by the differential pressure between the supply gas and the gas in the reservoir, and means adapted to put both reservoirs in communication with the supply gas when the force exerted by the pressure of the supply gas is greater than the force exerted by the pressure of the gas in the reservoir, and to vent both reservoirs when the second force is greater than the first force.

5. In a system for lifting liquids by means of compressed gas, a reservoir for the liquid to be lifted, a reservoir for gas, a supply of compressed gas, a casing, a diaphragm responsive to the pressure in the gas reservoir dividing said casing into two sections, a conduit connecting one of said sections to the gas reservoir, a vent to the atmosphere in the other section, conduits connecting this other section to both reservoirs, means comprising a valve rigidly connected to the diaphragm continuously opposing the pressure of the supply gas to the pressure of the

gas in the reservoir, said valve having an effective surface exposed to the pressure of the gas supply smaller than the effective surface of the diaphragm exposed to the pressure of the gas in the reservoir, and means adapted to put both reservoirs in communication with the supply gas when the force exerted by the first pressure exceeds the force exerted by the second pressure, and to vent both reservoirs when the force exerted by the second pressure exceeds the force exerted by the first pressure.

6. In a system for lifting liquids by means of compressed gas, a reservoir for the liquid to be lifted, a reservoir for gas, a supply of compressed gas, a casing in communication therewith, a pressure responsive means adapted to oppose continuously the pressure of the supply gas to the pressure of the gas in the reservoir, said means dividing the casing into two sections, a conduit connecting one of the sections to the gas reservoir, a vent to the atmosphere in the other section, conduits connecting this other section to the liquid reservoir, a separate conduit connecting this section to the gas reservoir, adjustable metering means in said conduit, whereby the rate of change of pressure in said gas reservoir is regulated, and means adapted to put both reservoirs in communication with the supply gas when the force exerted by the pressure of the supply gas on the pressure-responsive means exceeds the force exerted thereon by the pressure of the gas in the reservoir, and to vent both reservoirs when the force exerted by the pressure of the gas in the reservoir on the pressure responsive means exceeds the force exerted thereon by the pressure of the supply gas.

7. In a system for lifting liquids by means of compressed gas, a reservoir for the liquid to be lifted, a reservoir for gas, a supply of compressed gas, a casing, a pressure responsive diaphragm dividing said casing into two sections, a conduit connecting one of said sections to the gas reservoir, a vent to the atmosphere in the other section, a conduit connecting this other section to the liquid reservoir, another conduit connecting this other section to the gas reservoir, metering means in this conduit whereby the rate of change of pressure in said reservoir is regulated, means comprising a valve rigidly connected to the diaphragm continuously opposing the pressure of the supply gas to the pressure of the gas in the reservoir, and means adapted to put both reservoirs in communication with the supply gas when the force exerted by the first pressure exceeds the force exerted by the second pressure, and to vent both reservoirs when the force exerted by the second pressure exceeds the force exerted by the first pressure.

8. In a system for lifting liquids by means of compressed gas, a reservoir for the liquid to be lifted, a reservoir for gas, a supply of compressed gas, a casing, a pressure responsive diaphragm dividing said casing into two sections, a conduit connecting one of said sections to the gas reservoir, a vent to the atmosphere in the other section, a conduit connecting this section to the liquid reservoir, two separate conduits connecting this section to the gas reservoir, adjustable metering means in the first of these two conduits whereby the rate of increase of pressure in the gas reservoir is independently regulated, adjustable metering means in the second of these two conduits whereby the rate of decrease of pressure in the gas reservoir is independently regulated, means comprising a valve rigidly connected to the diaphragm continuously opposing the pressure of the supply gas to the pressure of the gas in the reservoir, and means adapted to put both reservoirs in communication with the supply gas when the force exerted by the first pressure exceeds the force exerted by the second pressure, and to vent both reservoirs when the force exerted by the second pressure exceeds the force exerted by the first pressure.

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