My invention relates to well flowing apparatus and particularly to automatic control means for wells wherein a motive fluid such as air is introduced into the well or well casing or chamber forming part of the well apparatus in order to discharge liquid, such as petroleum, therefrom.

The purpose of my invention is to provide an entirely automatic mechanism which is highly efficient in discharging wells which are of such nature as make it necessary to alternately discharge the well and allow the well to head up. In the apparatus of my invention, a plurality of factors combine to give an automatic cycle of operations, these factors being, in the preferred form, a state of discharge of the well and variation of pressure in the well casing. My invention also involves retaining means for valve mechanism operating to control supply of motive fluid to the well casing and means to shift factors of control for cycle operation while the well is heading up.

Further objects, characteristics and features of my invention will be apparent from the following description taken in connection with the accompanying drawing which shows a preferred embodiment of my invention.

On the accompanying drawing, reference character 17 designates a well casing which is set into the ground and which has a shoe seated on the cap rock 3 above the oil sand 4. Within the well casing is a receiver column 5, the lower end of which is enlarged to form a receiver chamber or trap 6. Receiver column 5 passes out through casing head 7 and is connected to a four-way coupling 8. The receiver column passes in tight union through the top of the casing head. The casing head seals off the well casing in such a manner as to permit pressure other than atmospheric to exist in the well casing. At the bottom of the receiver chamber is a foot valve 9 which may be of any desired type so long as it functions to permit oil to flow into chamber 6 when the pressure in the shot hole 10 exceeds the pressure in chamber 6. In other words, the foot valve is a check valve opening into the receiver chamber.

Within the receiver column and the receiver chamber is an eduction pipe 11 which passes upwardly through the receiver column and is open at the bottom to the inside of the receiver chamber and which serves for the discharge of liquid from the well. The eduction pipe passes through four-way connection 8 and is connected to a T-connection 12. An oil discharge pipe 13 is connected to one opening of T-connection 12. If desired booster holes may be formed in eduction pipe 11 as indicated at 14.

Connected to casing head 7 is a gas connection 15 to gas field lines. In connection 15 is placed an orifice 16 of constant size which is so inserted in order to cause variations of gas pressure in the well casing for the purpose of causing regulation as will presently appear.

Reference character 17 designates a main supply conduit for motive fluid such as air or other aeriform flowing medium such as natural or artificial gas under pressure. Conduit 17 is connected to four-way connection 8 and is therefore in communication with receiver column 5 and chamber 6 so that air under pressure supplied through conduit 17 can close foot valve 9 and discharge oil accumulating in chamber 6 through eduction pipe 11. In conduit 17 is a main valve 18, which is preferably of the balance type as indicated. The valve is arranged to close on downward movement. A valve stem 19 attached to valve disks 20 is connected to a servo-motor 21 comprising a housing enclosing a servo-motor chamber 22 on one side of which is formed a diaphragm 23. Change of pressure in servo-motor chamber 22 causes movement of valve stem 19. A rise of pressure against the diaphragm 23 causes closing of the valve. When the pressure is released or falls below a predetermined value in chamber 22 weight 24 attached to lever 25 causes opening of the valve.

Connected to the conduit 17 on the supply side of valve 18 is an auxiliary conduit 26. Interposed in conduit 26 is a first auxiliary valve 27 which is moved to open and close by a piston 28 or other member which is movable by change in pressure. Piston 28 is in a chamber 29 formed in the bottom of hous-
This chamber is connected by means of conduit 31 with the casing head 7 or the upper part of well casing 3. Thus changes of pressure are transmitted from the well casing through conduit 31 and onto the under side of piston 28. Opposed to the pressure acting on the under side of piston 28 is a spring 32 which is arranged to act against valve stem 33 and which can be adjusted to a predetermined value for operation by means of set-screw 34. In the side of housing 30 is a port to which is connected a conduit 35 which is connected in turn to a conduit 36. Conduit 36 is connected by means of conduit 37 with the servo motor chamber 22. A valve 38 or other restriction serves as a leak port for conduit 36, conduit 37 and chamber 22. The arrangement is such that an increase of pressure in the well casing transmitted through conduit 31 is able to raise piston 28 and the pressure fluid derived from the casing can pass through conduit 35, conduit 36 and conduit 37 to chamber 22. If the pressure is such that a pressure is built up in chamber 22 despite the small leak through valve 38, diaphragm 23 will move downwardly to close the main valve.

Set on top of the well casing is a housing 39. Housing 39 contains a relief valve 40 and a second auxiliary valve 41. These two valves may be connected to a common stem. In the preferred form they are arranged so that movement of one valve moves the other, the stem being parted as indicated at 42. This arrangement is such that an upward movement of the lower part of the stem takes place before the upper part of the stem attached to valve 41 is moved. The movement of the valves is either simultaneous or substantially simultaneous. The valve stem attached to valve 40 is indicated at 43 and the continuation attached to valve 41 is indicated at 44. Valve stem 45 is connected to a diaphragm 46 formed on one side of a pressure chamber 47 which is within housing 48, which housing may form a lower part of the housing 39. Pressure chamber 47 is connected by means of conduit 49 to T-connection 12. On the underneath side of pressure chamber 47 is conduit 59 in which is situated valve 60, so constructed that the flow of liquid through it may be readily pinched off. This conduit 59 may open to atmosphere or be connected to the oil receiver or tank, which is open to atmosphere or contains low pressure fluid. In conduit 49 are interposed in series a check valve 50 arranged to close downwardly and open upwardly and a throttle valve 51 which is preferably of such type that it may be set as a restricted orifice with relatively considerable precision. A conduit 52 is connected to housing 39, 48, on the one hand to the underside of valve 41 and on the other hand into chamber 47. The upper side of valve 41 (the reference to the "upper side" contem-
because there is less liquid head above the expelling air, and either this increased velocity of the liquid or the pressure of the air itself causes an increase of pressure to be transmitted through conduit 49. Prior to the stage at present under consideration, chamber 47 has been at relatively low pressure and valves 40 and 41 have been closed. This is in part determined by the setting of throttle valve 51 and also by the setting of valve 60 in conduit 59. When, as above stated, most of the oil has been flowed out, an increase of pressure is transmitted through conduit 49 and acts against diaphragm 46 to move valve stem 45 upwardly and to open valves 40 and 41.

Opening of valve 40 causes relief of pressure in members 5 and 6 through conduits 53 and 54. At the same time the second auxiliary valve 41 has been opened and, since valve 27 is already open, auxiliary fluid passes through auxiliary conduit 26, past valve 27 and 41 and into chamber 47, keeping the diaphragm 46 raised and the valves 40 and 41 open for a period, so that the auxiliary air of fluid continues to act on the diaphragm 23 to keep the main valve 20 closed, until this duty is taken over by fluid or pressure transmitted through the path 31, 35, 36, and 37. The increase of pressure in the chamber 47 closes check valve 50 and the fluid thus entering chamber 47 through conduit 52 is further transmitted through conduit 53, past check valve 52, through conduits 56 and 57 and into chamber 22, where the increase of pressure causes a lowering of diaphragm 23 and a closure of valve 18.

Since relief valve 40 is open, the pressure in chamber 6 and conduit 5 is reduced and the liquid around chamber 6 falls and enters the same through foot valve 9, thus causing an increased volume of gas to try to escape through orifice 16 and consequently the pressure of gas builds up within casing 11 which in turn acts on piston 28 through conduit 31 and forces piston 28 upwardly, closing the valve 27 and admitting gas pressure through conduit 33, conduit 36 and conduit 37 to act on diaphragm 23 and maintain the main valve 18 in closed position. This movement of the piston 28 also closes the valve 27. Thus at this time the factor for keeping the main valve 18 closed is shifted from the pressure controlled device 46, 47 and the auxiliary valves 41 and 27 to the device 28 and associated parts. Flow of fluid is now cut off through conduit 26 and the pressure reduces in chamber 47, causing the valves 40 and 41 to close, and the apparatus returns to the first described position where a heading up of the well causes a reduced pressure which permits lowering of piston 28. The valve 20, which was temporarily kept closed by auxiliary pressure fluid supplied through the path 26, 52, 55, 36, 37, is now kept closed by the pressure of gas transmitted from the well through line 31.

While I have described one form of my invention, it is to be understood that I am not limited to the apparatus described but that many variations are possible within the scope of the invention.

I claim:

1. Well flowing apparatus comprising a well casing, means to supply motive fluid to the well to discharge liquid therefrom, fluid pressure means adapted to shut off the supply of motive fluid including a fluid pressure conduit and a valve for controlling flow through said conduit, means to move said valve in response to a state of discharge of the well and to retain the valve in such moved position, and means to release the retaining means in response to change of pressure in the well casing.

2. Well flowing apparatus comprising a well casing, a trapped receiver column, an eduction pipe, means to supply motive fluid to the well to discharge liquid from the receiver column through the eduction pipe, fluid pressure means adapted to shut off the supply of motive fluid including a fluid pressure conduit and a valve for controlling flow through said conduit, means to release the pressure of motive fluid in said receiver column and open said valve in response to a state of discharge of the well, the last-mentioned means operating to cause the valve to be retained in open position and means to release the valve retaining means on rise of pressure in the well casing.

3. Well flowing apparatus comprising a well casing, means to supply motive fluid to the well to discharge fluid therefrom, fluid pressure means adapted to shut off the supply of motive fluid including a fluid pressure conduit and a valve for controlling flow through said conduit, means to open said valve on a given state of discharge of the well and to retain the valve in open position, and means to release the retaining means on rise of pressure in the well casing beyond a predetermined amount.

4. Well flowing apparatus comprising a well casing, a receiver column, an eduction pipe, means for closing off the receiver column and the eduction pipe from the well casing, means to supply motive fluid to discharge liquid through the eduction pipe, means to shut off the supply of motive fluid including a fluid pressure conduit and a valve for controlling flow through said conduit, means to close said valve, a connection between the last mentioned means and the eduction pipe, and means to close said valve when the pressure in the casing rises beyond a predetermined value and to open said valve when said pressure falls below said value.

5. Well flowing apparatus comprising a well, a main conduit for supplying motive fluid
fluid to the well to expel liquid therefrom, a main valve in said conduit, a servo-motor to operate said main valve, an auxiliary conduit for motive fluid for operating the servo-motor, a first valve in said auxiliary conduit operated in response to variations of pressure in the well casing, and a second valve in said auxiliary conduit operated in response to variations in state of discharge of the well.

6. Well flowing apparatus comprising a main conduit for supplying motive fluid to the well to expel liquid therefrom, a main valve in said conduit, a servo-motor to operate said main valve, an auxiliary conduit for motive fluid for operating the servo-motor, a first valve, a second valve and a chamber arranged in series in said auxiliary conduit, means to move said first valve in accordance with pressure in the well casing, means to move said second valve in accordance with pressure in said chamber, an education pipe for discharging liquid from the well, and a conduit connecting said chamber with said education pipe.

7. Well flowing apparatus comprising a main conduit for supplying motive fluid to said well to expel liquid therefrom, a main valve in said conduit, a servo-motor to operate said main valve, an auxiliary conduit for motive fluid for operating the servo-motor, a first valve in said auxiliary conduit operated in response to variations of pressure in the well casing, and a second valve in said auxiliary conduit operated in response to variations in state of discharge of the well, the first valve being arranged to render the second valve ineffective.

8. Well flowing apparatus comprising a well casing, a receiver column, an education pipe, means for closing off the receiver column and the education pipe from the well casing comprising a foot valve, a main motive fluid conduit for supplying motive fluid to the receiver column, a main valve in said conduit, means controlling said main valve, said means being responsive to variations in gas pressure in the well casing so that the valve remains closed while the well is heading up and is opened on predetermined decrease of pressure in the casing, a fluid-pressure device, a relief valve for relieving pressure in the well casing, a first auxiliary valve and means whereby the same is opened on decrease of pressure in the well casing, a second auxiliary valve, means whereby the second auxiliary valve and the relief valve are simultaneously opened by increase of pressure against said fluid-pressure device, conduits forming a passage for auxiliary fluid through the auxiliary valves to supply fluid under pressure to said fluid-pressure device and to the means which controls the main valve, a connection between said fluid-pressure device and the education pipe, a check valve in the said connection, and means for closing off the receiver.
column and the eduction pipe from the well casing comprising a foot valve, a main motive fluid conduit for supplying motive fluid to the receiver column, a main valve in said conduit, means controlling said main valve, said means being responsive to variations in gas pressure in the well casing so that the valve stays closed while the well is heading up and is opened on predetermined decrease of pressure in the casing, a fluid-pressure device, a relief valve for relieving pressure in the well casing, a first auxiliary valve and means whereby the same is opened on decrease of pressure in the well casing, a second auxiliary valve, means whereby the second auxiliary valve and the relief valve are simultaneously opened by increase of pressure against said fluid-pressure device, conduits forming a passage for auxiliary fluid through the auxiliary valves to supply fluid under pressure to said fluid-pressure device and to the means which controls the main valve, a connection between said fluid-pressure device and the eduction pipe, and means to cause the closing of the first auxiliary valve on rise of pressure in the casing.

13. In well-flowing apparatus, a well-casing, an eduction pipe, a conduit for supplying aeriform fluid to the well to flow liquid out through said eduction pipe, valve means for opening and closing said conduit, fluid-pressure means for controlling said valve means, means responsive to changes of pressure in the well-casing and connected with said fluid-pressure means for causing said valve means to be kept closed while such pressure is above a predetermined value and to be opened when the pressure decreases, and means connected on the one hand with the upper part of the eduction pipe and on the other hand with said fluid-pressure means to bring about closing of said valve means in response to increased pressure in the upper part of said pipe.

14. In well-flowing apparatus, an eduction pipe, a conduit for supplying aeriform fluid to the well to flow liquid out through said eduction pipe, a valve for opening and closing said conduit, fluid-pressure means controlling said valve, conduits forming a path for auxiliary fluid connected with said fluid-pressure means, two auxiliary valves in said path, a fluid-pressure device also connected in said path to be supplied with auxiliary fluid when said auxiliary valves are open, a connection between said device and the upper part of the eduction pipe, one of said auxiliary valves being associated for simultaneous operation with said fluid pressure device, means whereby the other of said auxiliary valves is controlled in accordance with changes of pressure due to changes of condition in the well, conduits providing a path for flow for aeriform fluid from the well to said fluid-pressure means, and means for controlling the latter path in accordance with changes of pressure due to changes of condition in the well.

15. In well-flowing apparatus, an eduction pipe, a conduit for supplying aeriform fluid to the well to flow liquid out through said eduction pipe, valve means for opening and closing said conduit, fluid-pressure means controlling said valve means, conduits forming a path for auxiliary fluid connected with said fluid-pressure means, two auxiliary valves in said path, a fluid pressure device also connected in said path to be supplied with auxiliary fluid when said auxiliary valves are open, a connection between said device and the upper part of the eduction pipe, one of said auxiliary valves being associated for simultaneous operation with said fluid pressure device, means whereby the other of said auxiliary valves is controlled in accordance with changes of pressure due to changes of condition in the well, conduits providing a path for flow for aeriform fluid from the well to said fluid-pressure means, and means for controlling the latter path in accordance with changes of pressure due to changes of condition in the well.

16. In well-flowing apparatus, an eduction pipe, a conduit for supplying aeriform fluid to the well to flow liquid out through said eduction pipe, valve means for opening and closing said conduit, fluid-pressure means controlling said valve means, conduits forming a path for auxiliary fluid connected with said fluid-pressure means, two auxiliary valves in said path, a fluid pressure device also connected in said path to be supplied with auxiliary fluid when said auxiliary valves are open, a connection between said device and the upper part of the eduction pipe, one of said auxiliary valves being associated for simultaneous operation with said fluid pressure device, means whereby the other of said auxiliary valves is controlled in accordance with changes of pressure due to changes of condition in the well, conduits providing a path for flow for aeriform fluid from the well to said fluid-pressure means, and a device connected with the latter path for controlling flow through said path in accordance with changes of pressure in the well, the other auxiliary valve being operatively connected with said device.

17. In well-flowing apparatus, a well-casing, an eduction pipe, a receiver column provided with a trap in the lower part of the well, a conduit for supplying aeriform fluid to the receiver column to flow liquid out through the eduction pipe, a main valve for opening and closing said conduit, servo-motor means for said valve, conduits forming a path from the interior of the well casing to said servo-motor means, said path having a restricted outlet, a fluid-pressure controlled valve in said path, conduits forming a path for auxiliary fluid connected with the servo-motor means, two auxiliary valves in said path, one of said auxiliary valves being associated for simultaneous operation with said fluid-pressure controlled valve, a fluid-pressure device also connected in the second-named path to be supplied with auxiliary fluid when said auxiliary valves are open.
the other of said auxiliary valves being associated for simultaneous operation with said fluid-pressure device, and a connection for communicating pressure from the upper part of the eduction pipe to open the last-mentioned auxiliary valve.

18. In well-flowing apparatus, a well casing, an eduction pipe, a receiver column provided with a trap in the lower part of the well, a conduit for supplying aeriform fluid to the receiver column to flow liquid out through the eduction pipe, a main valve for opening and closing said conduit, servo-motor means for said valve, conduits forming a path from the interior of the well casing to said servo-motor means, said path having a restricted outlet, a fluid-pressure controlled valve in said path, conduits forming a path for auxiliary fluid connected with the servo-motor means, two auxiliary valves in said path, one of said auxiliary valves being associated for simultaneous operation with said fluid-pressure controlled valve, a fluid-pressure device also connected in the second-named path to be supplied with auxiliary fluid when said auxiliary valves are open, the other of said auxiliary valves being associated for simultaneous operation with said fluid-pressure device, a connection for communicating pressure from the upper part of the eduction pipe to open the last-mentioned auxiliary valve, and a check valve in the second-mentioned path between said fluid-pressure device and said servo-motor.

19. In well-flowing apparatus, a well casing, an eduction pipe, a receiver column provided with a trap in the lower part of the well, a conduit for supplying aeriform fluid to the receiver column to flow liquid out through the eduction pipe, a main valve for opening and closing said conduit, servo-motor means for said valve, conduits forming a path from the interior of the well casing to said servo-motor means, said path having a restricted outlet, a fluid-pressure controlled valve in said path, conduits forming a path for auxiliary fluid connected with the servo-motor means, two auxiliary valves in said path, one of said auxiliary valves being associated with said fluid-pressure controlled valve, a fluid-pressure device also connected in the second-named path to be supplied with auxiliary fluid when said auxiliary valves are open, the other of said auxiliary valves being associated for operation simultaneously with said fluid pressure device, a connection for communicating pressure from the upper part of the eduction pipe to open this auxiliary valve, and a relief valve for relieving pressure in the receiver column also associated for operation with said fluid-pressure device.

20. In well-flowing apparatus, an eduction pipe, a conduit for supplying motive fluid to the well to flow liquid out through said eduction pipe, main valve means for opening and closing said conduit, fluid-pressure means for controlling said valve means, conduits providing a path for gas from the well to the main valve-controlling means, conduits providing a path for auxiliary fluid to the main valve controlling means, a valve in the gas path, two valves in the auxiliary fluid path, means whereby the valve in the gas path and one of the valves in the auxiliary fluid path are controlled in accordance with changes of pressure in the well, means whereby the other of said two valves will be held open by pressure of the auxiliary fluid when the two valves are open, and means whereby this valve is opened by pressure communicated from the upper part of the eduction pipe.

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