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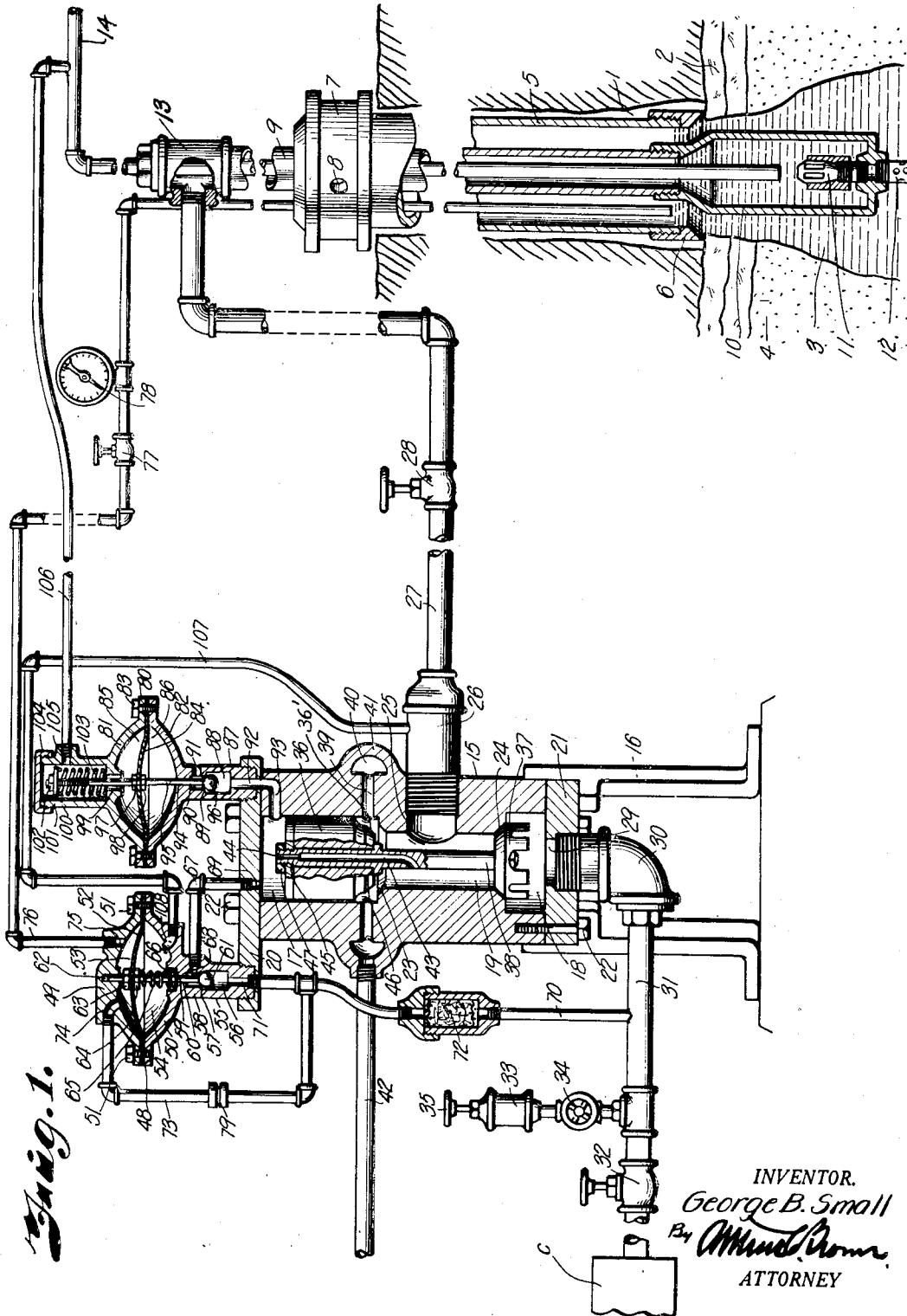
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PNEUMATIC PUMPING APPARATUS

Filed Aug. 16, 1928

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

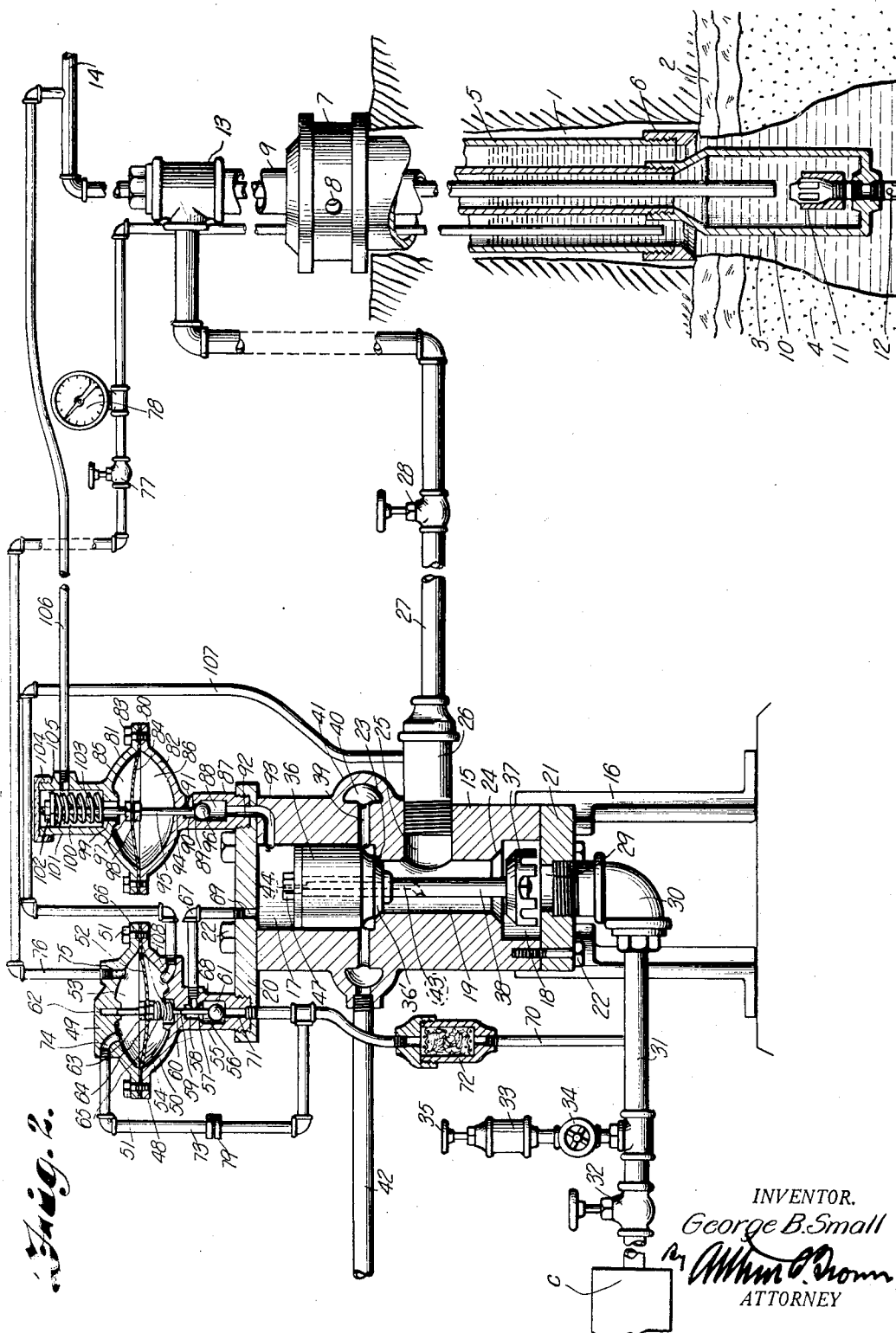


Fig. 2.

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PNEUMATIC PUMPING APPARATUS.

Application filed August 16, 1928. Serial No. 299,923.

My invention relates to apparatus for pumping wells, and more particularly to apparatus of that character for intermittently displacing accumulated charges of fluid from a well with air or gas; the present invention constituting an improvement on the apparatus disclosed in my co-pending application Serial No. 229,414, and having for its principal object to control flow of the displacing medium in response to variation in pressure in the flow line leading from the well.

A hand valve 28 on the line 27 provides means for manual control of flow of a fluid pressure medium presently mentioned through the major flow line.

In accomplishing this and other objects of the invention I have provided improved details of structure, the preferred forms of which are illustrated in the accompanying drawings, wherein:

Fig. 1 is a central vertical section of the apparatus and a well, part of the well casing, flow line and trap being in central vertical section, the apparatus being illustrated as it appears between well flowing periods.

Fig. 2 is a similar view illustrating the parts as they appear during a well flowing period.

Referring more in detail to the drawings:

1 designates a well hole leading through cap rock 2 and terminating in a shot hole 3 in oil sand 4. 5 designates a well casing supported on the cap rock by a shoe 6, and having a casing head 7 at the top of the well provided with a vent hole 8 for relieving pressure in the well to permit accumulation of well fluid from the sands. Extending through the casing head 7 and casing 5 is a tube 9 terminating at the bottom of the well in a trap 10 provided with a standing valve 11 and with the ordinary strainer extension 12 through which fluid in the well is led to the trap through the standing valve. The tubing is provided exteriorly of the casing head with a T union 13, and extending through the union 13 and tube 9 is a flow line 14 through which oil displaced from the trap is delivered from the well.

The air control valve comprises a housing 15 arranged vertically on supporting legs 16, and having end chambers 17 and 18 connected by a throat 19 and closed by top and bottom plates 20 and 21 held to the body of the housing by stud bolts 22, the chambers 17 and 18 having valve seats 23 and 24 at their junctions of the chambers with the throat 19.

Leading from the throat 19 through the

side of the housing 15 is a port 25, and threaded into said port is the reducing coupling nipple 26 of a major flow line 27, which opens into the T-union 13 for discharge through tube 9 onto oil accumulated in the trap and tube for displacing the oil through the flow line 14.

A hand valve 28 on the line 27 provides means for manual control of flow of a fluid pressure medium presently mentioned through the major flow line.

The bottom plate 21 of the housing 15 has a port 29 opening to the lower chamber 18, and threaded into said port is an elbow fitting 30 connected through a line 31 with a source of supply of fluid pressure medium such as air or gas and which may consist of a compressor indicated by the cylinder C. A hand valve 32 provides means for manually controlling flow through the line 31, and 33 designates a lubricant container connected with the line 31, through which lubricant may be supplied to the line under control of the valve 34 and hand press 35.

Located within the chamber 17 is a piston 36 having a valve head 36' at its lower end adapted for seating on the seat 23, and located in the chamber 18 is a valve 37 adapted to seat on the seat 24, the piston 36 and valve 37 being of differential area, with the piston of greater area than the valve and connected therewith by a stem 38, so that when pressure medium is admitted to the valve chamber 18 through the line 31 the valve and piston are raised as a unit to seat the valve 37 on the seat 24 and prevent flow of pressure medium to the well through the line 27. When the valve 37 is on its seat the head 36' of piston 36 is off its seat 23 and the line 27 vented through the ports 39 into a manifold channel 40 formed in a boss 41 on the housing 15 and to atmosphere through a line 42 connecting with the manifold. The outer end of the piston 36 is of greater area than the inner end of the valve head 36'; consequently when the pressure in the outer portion of chamber 17 is equal to that in throat 19 the piston is held down and the head 36' to its seat.

The stem 38 has a channel 43 opening through its side to the throat 19 and through a restricted port 44 in the top of the stem to the top of the piston chamber 17 so that when the valve 37 is open and the piston head 36' on its seat, pressure medium may

pass through the channel and restricted port to chamber 17 to balance pressure on the piston 36 so that when the parts have been set in operative position they will remain so until the balance is disturbed. Preferably the piston 36 bears on shoulders 45 and 46 on the stem 38 and is held thereto by a nut 47 on the end of the stem.

It is apparent that with the parts arranged as described when the line 31 is open the piston valve, hereinafter referred to as the primary piston valve, will be held closed as illustrated in Fig. 1 by force of the pressure medium admitted to the valve chamber 18.

Referring now to the means for unseating the primary piston valve to permit flow of pressure medium to the well through line 27, 48 designates a diaphragm housing including the outer and inner members 49 and 50, having the usual rim flanges connected by bolts 51 with a flexible diaphragm 52 held between the flanges and separating the interior of the housing into outer and inner chambers 53 and 54. The lower housing member 50 is provided with a neck 55 threaded onto an extension of the upper main housing head 20 to mount the diaphragm housing thereon, and including a valve chamber 56 having a downwardly facing seat 57 spaced below the body of the housing member 50 to provide a throat 58. A stem 59 extends snugly through an opening 60 in the housing member 50 and carries a ball valve 61 within the chamber 56 adapted to seat on the valve seat 57. The stem also extends through the diaphragm 52 into guiding seat in a socket 62 in the outer diaphragm housing member and is fixed to the diaphragm by nuts 63 and 64 arranged on the stem at opposite sides of the diaphragm.

A spring 65 surrounding the stem and bearing in a seat 66 in the inner diaphragm housing member and against the inner nut 64 normally yieldingly retains the diaphragm flexed outwardly and the valve 61 on its seat.

67 designates a connecting line leading from a port 68 opening through the neck 55 outwardly of the seat 57 to a port 69 in the housing plate 20 leading to the primary piston chamber 17. 70 designates a line leading from the major flow supply line 31 to a port 71 in the neck 54 for delivering pressure medium from the line 31 to the valve chamber 56 in minor flow, a filter 72 being preferably interposed in the line 66 to restrain particles of foreign matter that might interfere with proper seating of the valve 61. Branching from the line 70 is a line 73 opening through a port 74 into the outer diaphragm housing chamber 53, and leading from said outer chamber 53 through a port 75 is a line 76 leading through the casing head of the well and

through the casing exteriorly of the tubing to a point in the well adjacent the top of the trap 10. The line 76 is provided with a hand valve 77 for manual control of flow through the line 76 and with a gauge 78 for indicating pressure in the line. An orifice valve 79 in the branch line 73 restricts flow through the branch line, thereby reducing pressure in the line 76 below that in the supply and major flow lines. Consequently the line 76 may constitute a low pressure line and the line 27 a high pressure line because of differential in pressure induced by the orifice valve.

With the parts heretofore described automatic control of the apparatus may result from variation of conditions in the well, in that the supply of pressure medium for displacing an accumulated charge in the trap may be let into the well as follows:

Assuming that the fluid in the well is at or below the level shown in Fig. 1, then the minor flow or low pressure line 76 is exposed above the fluid in the well and pressure medium escaping through the line 70, branch 73, the outer diaphragm chamber 53 and low pressure line 76, flows freely from the open end of the line 76 and escapes through the vent 8 in the casing head, the spring 65 in the diaphragm chamber 54 retaining the diaphragm in its upwardly flexed condition and the valve 61 against its seat 57 so that none of the pressure medium is admitted through the line 67 to the top of the primary piston chamber 17.

Pressure medium admitted through the line 31 to the valve chamber 18 urges the valve 37 to its seat, shutting off flow of pressure medium to the major flow or high pressure line. When, however, fluid in the well reaches a sufficiently high level to submerge the outlet end of the minor flow line, this line is liquid sealed and pressure of the medium admitted to the line 70, branch 73, chamber 53 and line 76 from the line 31, accumulates in these elements until it gradually assumes a sufficient degree to unseat the valve 61 against the tension of the spring 65 and pressure from line 70, whereupon pressure medium is admitted through the valve seat 57, port 68 and line 67 to the top of the piston chamber 17 where it accumulates until, because of the differential area of the piston 36 and valve 37, it will unseat the valve 37 to admit the pressure medium in major or high pressure flow through the throat 19, coupling nipple 26 and line 27 to discharge into the trap for displacement of accumulated content of the trap.

Attention is here called to the fact that the differential in size of the line 67 and reduced port 44 in the primary piston stem will permit accumulation of the pressure medium in the piston chamber for displacement

ing the primary piston valve, and because of differential in area of the top of piston 36 and the face of its valve head 36' there will be a preponderance of pressure on the piston tending to hold the piston down and the valve 37 open after the pressure has balanced above and below the piston resulting from communication between the chamber 17 and throat 19 through the channel 43 in the piston valve stem.

When the major or high pressure line is open, content of the trap is discharged and the pressure medium would continue to flow into the well unless means be provided for interrupting the flow. Such interruption of the major or high pressure flow is accomplished automatically through the following mechanism:

80 designates a diaphragm housing including the outer and inner members 81 and 82 having rib flanges connected by bolts 83, and an interior flexible diaphragm 84 retained by the rib flanges and dividing the interior of the housing into outer and inner chambers 85 and 86, the housing being mounted on the upper main housing plate 20 by a neck 87 containing a valve chamber 88 provided with a downwardly facing seat 89 spaced from the body of the diaphragm housing to provide a throat 90. The throat 90 has an open port 91 leading to atmosphere and the chamber 88 connects with the outer portion of the primary piston chamber 17 through a channel 92 in the neck 87 and a registering channel 93 in the body of the primary housing.

Extending snugly through an opening 94 in the inner diaphragm housing member 85 into the chamber 88 is a stem 95 carrying a valve 96 adapted for seating on the seat 89 to close the vent channels 92 and 93 and retain pressure medium in the primary piston chamber. The stem 95 extends through the diaphragm and is connected thereto by the outer and inner nuts 97 and 98, and is projected loosely through a port 99 in the outer diaphragm housing member into a chamber 100 in an extension 101 on said housing member. A nut 102 on the outer end of the stem confines a spring 103 against the bottom of the chamber 100 and tends to normally yieldingly retain the valve 96 closed. A cap 104 seals the top of the chamber 100 to make the chamber air tight. Opening through the wall of the extension 101 is a port 105 for the chamber 100, and leading from said port to the well flow line 14 is a return pressure line 106 through which fluid medium, which may be well fluid under force of pressure medium, may be passed from the flow line into the upper diaphragm chamber 85 to flex the diaphragm 84 and unseat the valve 96, thereby relieving the primary piston chamber to permit return of the primary piston valve to initial

position, where it shuts off flow from the major or high pressure line to permit accumulation of a succeeding charge in the well.

As soon as the primary piston valve is opened to admit pressure medium in major flow to the well the supply of pressure medium to the upper portion of the piston chamber 17 is cut off by by-passing pressure medium from the major flow line back to the lower chamber 53 of the minor flow line through a line 107, preferably leading from the coupling nipple 26 through a port 108 in the lower diaphragm member 50. Cutting off supply to the top of the piston chamber 17 does not interfere with the seating of the primary valve, as pressure above and below the piston remains balanced because of the connection of the upper portion of the piston chamber with the throat 19 through the channel 43 in the piston valve stem.

Assuming the parts to be constructed and assembled as described the operation is as follows:

With the level of the liquid in the well at or below that shown in Fig. 1, the primary valve will be retained closed by pressure of the fluid medium supplied from the compressor or other source, and a minor flow under low pressure will escape through the line 70, branch 78, diaphragm chamber 53, line 76 and the annular space between the casing and tubing of the well, to atmosphere through the vent 8 in the casing head, thereby avoiding back pressure on the sand which might interfere with flow of fluid to the well.

Under these conditions fluid enters the trap through the standing valve and rises in the trap, simultaneously rising in the well about the trap. When the fluid in the well reaches a level at which the outlet end of the minor flow or low pressure line is submerged, the minor flow or low pressure line is liquid sealed and pressure continuing to flow thereinto through the line 70, etc., gradually builds up on the upper diaphragm chamber 53 until it is sufficient to displace the valve 61. When the valve 61 is displaced the pressure medium passes to the top of the piston chamber 17 and accumulates in the upper portion of the piston chamber, the relatively small port 44 in the primary piston valve stem being insufficient in size to permit escape of the pressure medium admitted through the line 67 fast enough to offset accumulation in the chamber.

When a sufficient amount of pressure has accumulated in the chamber 17 above the piston 36 the piston is shifted to open the valve 37 and seat the piston valve head 36' on its seat 23, thereby admitting the pressure medium to the well in major flow and under high pressure.

Substantially immediately upon opening of the primary valve the pressure medium is

passed through the line 107 to the lower diaphragm chamber 54 to shut off flow from the line 70 to the piston chamber 17, the primary valve remaining seated because of the balance of pressure above and below the piston induced through the stem channel 43 and preponderance of downward pressure on the piston resulting from differential in area between the top of the piston and bottom of its valve head 36'.

Pressure medium flowing through the line 42 under high pressure then displaces content of the trap through the flow line 14.

During the initial period of displacement, and until the trap and tube are substantially empty, pressure in the flow line remains at about ten pounds to the square inch, which is insufficient to overcome the tension of the spring 103 which retains the vent valve 96 closed. When the trap and flow line have been nearly emptied, pressure rapidly rises therein and, backing up through the line 106 unseats the valve 96, thereby opening the vent 91 and relieving the piston chamber 17 so that the balance on the piston is broken, whereupon pressure medium admitted through the line 31 reseats the valve 37 and lifts the piston 36, unseating the valve head 36' from its seat 23, thereby opening a passage to the vents 39 and relieving the major flow line to eliminate back pressure in the well that might interfere with inflow of fluid from the sands.

The parts remain at the position last described until the oil rises in the well to a level for again submerging the minor flow or low pressure line, whereupon the cycle of operation is repeated for discharging a subsequent charge of fluid from the well.

Thus it is apparent that the apparatus is operated automatically to admit displacing medium to the well only as it is required, irrespective of the length of time it takes the well to fill, and that when a charge is displaced the pressure medium is automatically shut off and admitted again only when another charge is to be removed.

It is apparent that wells equipped with pumping apparatus like that described do not require manual attention except for repairs and that the automatic control is effected without valves or working parts of any character within the well hole.

What I claim and desire to secure by Letters Patent is:

1. In combination with a well having a discharge line, a source of supply of fluid pressure medium having a line leading to the well, a pressure controlled valve for closing the supply line, means responsive to rise in level of fluid in the well for conducting pressure medium to controlling relation with said valve to open the valve, and means responsive to change in pressure in the discharge line controlling release of pressure

medium from controlling relation with said valve.

2. In combination with a well having a discharge line a source of supply of fluid pressure medium having major and minor flow lines leading to the well, a pressure controlled valve for closing the major flow line, a line for conducting pressure medium to actuating relation with said valve to open the valve, valve mechanism responsive to differential of effective forces in the major and minor flow lines controlling flow through the conducting line, a line for releasing said fluid pressure medium from controlling relation with said valve, and means responsive to varying pressures in the discharge line controlling the releasing line.

3. In combination with a well having a discharge line, a source of supply of fluid pressure medium having a line leading to the well, a pressure controlled valve for closing the supply line, means responsive to rise in level of fluid in the well for conducting pressure medium to controlling relation with said valve to open the valve, valve mechanism controlling release of pressure medium from controlling relation with the pressure controlled valve, and a line leading from a point in said discharge line exterior to the well for conducting pressure medium to actuating relation with said release valve mechanism.

4. In combination with a well having a discharge line, a source of supply of fluid pressure medium having a major flow line leading to the well, a pressure chamber, a pressure actuated valve normally closing the supply line and having a piston in the pressure chamber, a line for conducting pressure medium from said source of supply to the pressure chamber, including a valve chamber, a secondary piston chamber, a secondary piston dividing said secondary chamber into inner and outer portions, a secondary valve in said valve chamber connected with said secondary piston and controlling said conducting line, means for conducting pressure medium from said source of supply to the outer portion of the secondary piston chamber, lines leading respectively from the outer and inner portions of the secondary piston chamber to the well and major flow line for opening and closing the conducting line in response to varying differential pressures in the lines leading to the well, a vent line leading from said pressure chamber, including a valve chamber, a piston chamber, and a piston in said last named chamber connected with the vent valve and responsive to rise in pressure in the discharge line to open the vent valve.

5. In combination with a well having a discharge line, a source of supply of fluid pressure medium having a major flow line leading to the well, a pressure chamber, a pressure actuated valve normally closing the

supply line and having a piston in the pressure chamber, a line for conducting pressure medium from said source of supply to the pressure chamber, including a valve chamber, a secondary piston chamber, a secondary piston dividing said secondary chamber into inner and outer portions, a secondary valve in said valve chamber connected with said secondary piston and controlling said conducting line, means for conducting pressure medium from said source of supply to the outer portion of the secondary piston chamber, lines leading respectively from the outer and inner portions of the secondary piston chamber to the well and major flow line for opening and closing the conducting line in response to varying differential pressures in the lines leading to the well, a vent line leading from said pressure chamber, including a valve chamber, a piston chamber, a piston in said last named chamber connected with the vent valve and responsive to rise in pressure in the discharge line to open the vent valve, and means constantly, yieldingly urging the vent valve to close.

6. In combination with a well having a discharge line, a source of supply of fluid pressure medium, major and minor pressure lines connected with said source of supply and leading to the well, valve mechanism controlling the major pressure line including valve and piston chambers, connected, differential-area valve and piston members in the respective chambers, the piston chamber having connection with the major pressure line at the well side of said valve for balancing pressure in the piston chamber with that in said pressure line, a line connecting the piston chamber with said source of pressure medium supply, means responsive to accumulated pressure in the minor line controlling the line to the piston chamber, a vent for the piston chamber, a valve normally yieldingly closing said vent, and means responsive to rise in pressure in the well discharge line for shifting said valve.

7. In combination with a well having a discharge line, a source of supply of fluid pressure medium, major and minor pressure lines connected with said source of supply and leading to the well, valve mechanism controlling the major pressure line including valve and piston chambers, connected, differential-area valve and piston members in the respective chambers, the piston chamber having connection with the major pressure line at the well side of said valve for balancing pressure in the piston chamber with that in said pressure line, a line connecting the piston chamber with said source of pressure medium supply, means responsive to accumulated pressure in the minor line controlling the line to the piston chamber, a vent for the piston chamber, and means responsive to variation in pressure in the well discharge line controlling said vent.

7. In combination with a well having a discharge line, a source of supply of fluid pressure medium, major and minor pressure lines connected with said source of supply and leading to the well, valve mechanism controlling the major pressure line including valve and piston chambers, connected, differential-area valve and piston members in the respective chambers, the piston chamber having connection with the major pressure line at the well side of said valve for balancing pressure in the piston chamber with that in said pressure line, a line connecting the piston chamber with said source of pressure medium supply, means responsive to accumulated pressure in the minor line controlling the line to the piston chamber, a vent for the piston chamber, a valve normally yieldingly closing said vent, and means responsive to rise in pressure in the well discharge line for shifting said valve.

In testimony whereof I affix my signature.

GEORGE B. SMALL.