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3,396,793

GAS WELL DEWATERING CONTROLLER

Filed July 5, 1966

2 Sheets-Sheet 1

FIG. 3

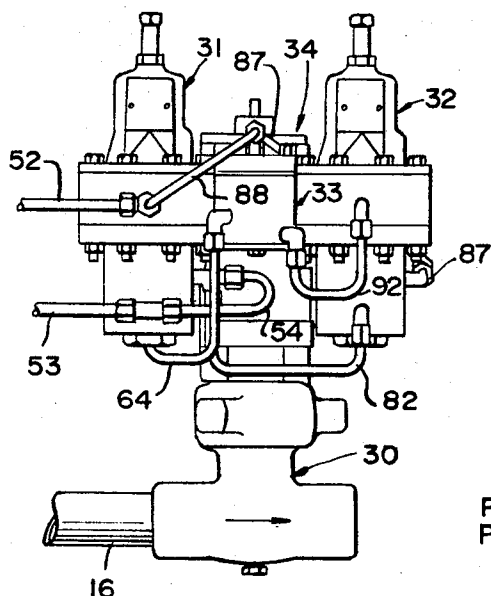


FIG. 4

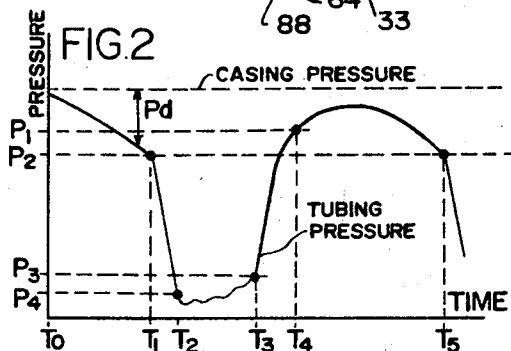
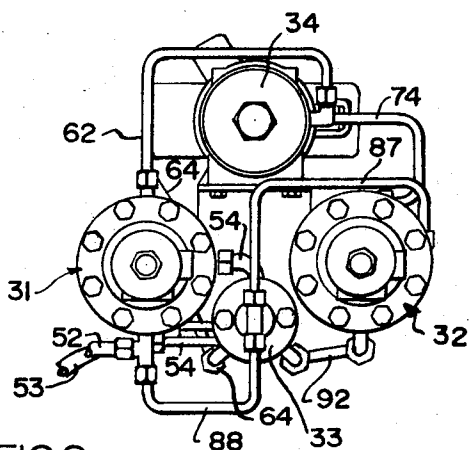
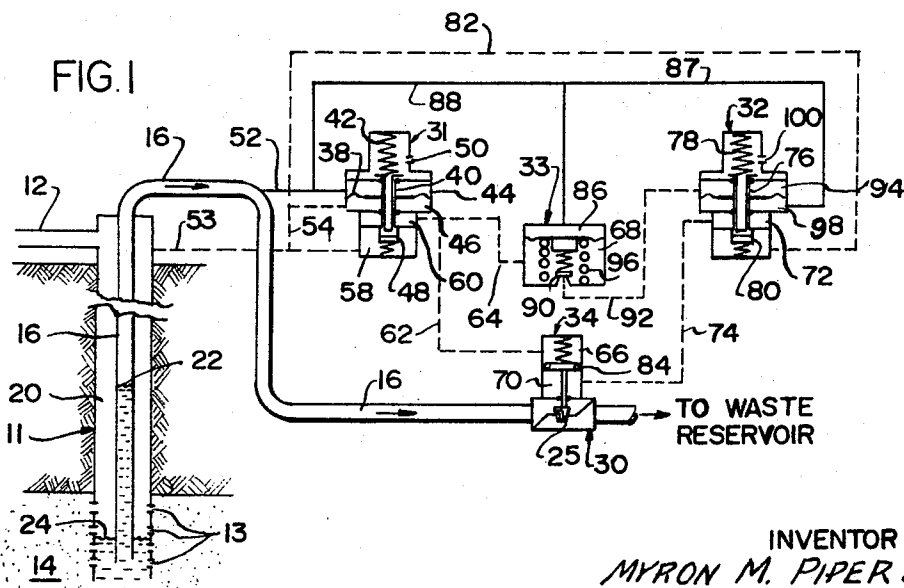


FIG. 1



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FIG. 5

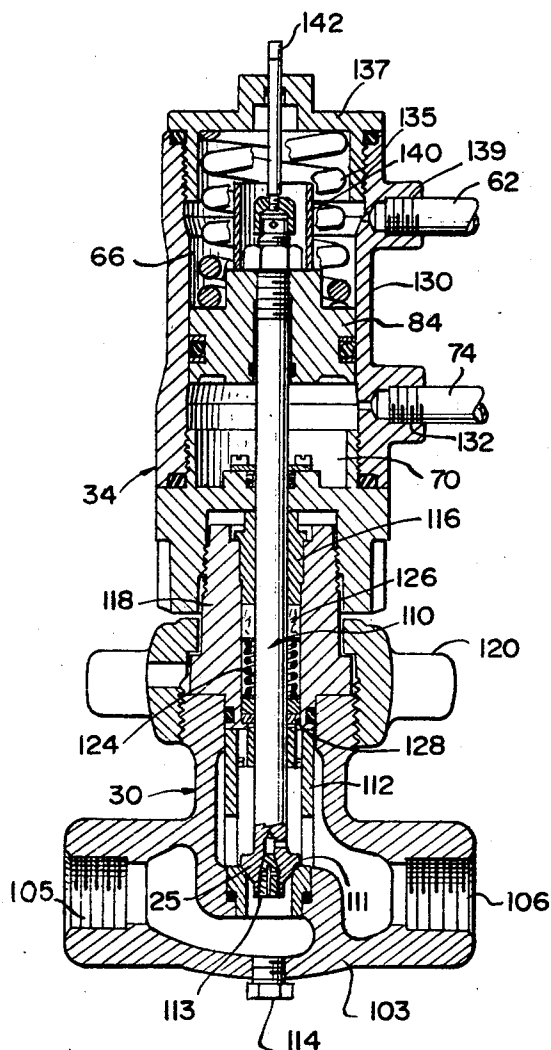


FIG. 6

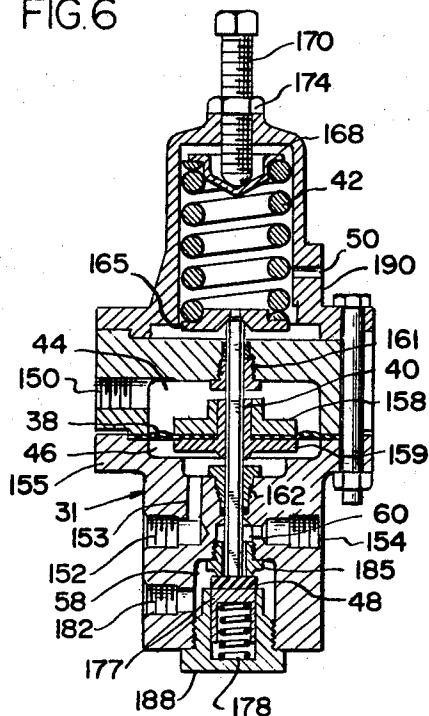
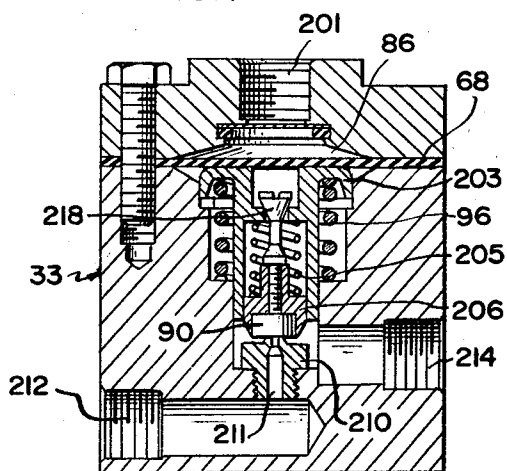


FIG. 7



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GAS WELL DEWATERING CONTROLLER

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5 Claims. (Cl. 166—53)

ABSTRACT OF THE DISCLOSURE

A gas well dewatering controller arrangement including a main valve for controlling flow through a conduit communicating tubing in a gas well casing with a reservoir. The arrangement includes a differential pilot, a shut-in valve and a block valve operatively connected to one another and to the main valve. The differential pilot is responsive to the difference between tubing pressure and casing pressure and opens the main valve whenever the pressure difference increases to a predetermined value. The block valve is tripped when the tubing pressure falls to a sufficiently low level. The shut-in valve trips after tubing pressure increases from a minimum value to cause the main valve to close. The arrangement resets when the difference between tubing pressure and casing pressure again reaches a first value which is below the original threshold value required to trip the differential pilot.

Summary of the invention

This invention relates to automatic systems for removing liquids from gas producing wells.

Gas wells often produce liquid in addition to the desired gas. This liquid is normally water, but in some cases, oil or a hydrate may be produced as well. The liquid enters the well casing along with the gas from the surrounding formation. In some high production wells, the velocity of gas flow is sufficient to suspend and lift the liquids to the surface where they may be separated from the gas. Where production pressures are low, however, significant quantities of liquids can accumulate at the bottom of the casing to create a substantial back pressure which may significantly reduce or even shut-down gas flow from the well.

In order to prevent undue accumulation of liquids in such wells, it is a known practice to place a tubing within the casing through which the undesirable liquid may be removed. A bleed hole placed in the tubing at the well head allows gas to be slowly exhausted to reduce the pressure in the tubing at the well head. Gas pressure within the casing, in combination with the pressure produced by the collected liquid in the casing, forces a substantial column of liquid up the tubing. The difference between casing pressure and tubing pressure at the well head provide a measure of the height of this liquid column.

As disclosed in U.S. Patent No. 3,053,188, which issued to Robert W. Dinning et al. on Sept. 11, 1962, the difference between tubing pressure and casing pressure at the well head may be sensed to initiate opening of an outlet valve which allows the liquid column to exhaust from the tubing into a waste reservoir. In the prior art arrangements, a piston which is loosely mounted within the tubing follows the collected column of water upward as the exhaust valve is opened. Means have then been employed for detecting the presence of the piston as it reaches the well head to cause the outlet valve to close.

The inside surface of the tubing and the size of the piston must be constructed to allow free sliding movement of the piston. Should the required tolerances not be observed or should the piston come in contact with an obstruction within the tubing, the piston may become

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lodged, thereby rendering the liquid pumping arrangement inoperative. To place the system back in operation, it is often necessary to completely remove the tubing from the casing to dislodge the piston. Moreover, the sensing apparatus for detecting the presence of the piston at the well head level increases the cost and complexity of the pumping arrangement.

One object of the present invention is to provide an automatic system for removing liquid from a gas well casing wherein the necessity for employing a piston within the tubing in such casing is obviated.

In the prior piston operated systems, the tubing outlet valve closes when the piston reaches the detector at the well head level. At this time, however, a relatively low level of pressure still exists with the tubing and, were other steps not taken, the apparatus for sensing the difference of pressure between the tubing and the casing would tend to immediately open the exhaust valve as soon as it had closed. To prevent this from occurring, it is a common practice to include a time delay arrangement for preventing the exhaust valve from re-opening until pressure within the tubing again builds up above the threshold value. Because of the vast difference in production rates of wells, this time delay period must be preset for a duration considerably longer than normally necessary. Since the pumping system can not recycle until the delay period has elapsed, the duration of the time delay sets an upper limit on the rate at which liquid may be removed from the well.

It is accordingly another object of the present invention to increase the maximum pumping rate of a system for removing liquid from a gas well.

Broadly, the present invention takes the form of an automatic system for removing the liquid which accumulates within a gas well casing, such system including a well casing which extends downwardly from a well head level to a subterranean level and including a tubing positioned within the casing which also extends downwardly from the well head level to a point adjacent to but spaced above the bottom of the casing. An outlet valve is employed for selectively opening and closing a passageway between this tubing and a waste reservoir at the well head level. In accordance with a first feature of the invention, means are employed for opening this outlet valve in response to an increase in the difference of pressure in the tubing and the pressure in the casing from a first predetermined differential value to a second predetermined differential value.

It is another feature of the invention to employ means for closing the outlet valve in response to a preselected increase in the pressure within the tubing after this pressure reaches its minimum value.

The invention relates to an automatic system for removing liquid from a gas well casing into a water reservoir. The casing extends downwardly from a well head to a subterranean level and tubing extends downwardly within the casing from the well head level. Fluid flow through a passageway communicating the tubing and the reservoir is controlled by an outlet valve. A first pilot valve responsive to the difference between tubing pressure and casing pressure opens the outlet valve whenever the pressure difference increases above a first preset value. The system includes a block valve and a second pilot valve. The second pilot valve is responsive to the difference between tubing pressure and casing pressure to close the outlet valve. The block valve communicates with the pilot valves and is responsive to a second predetermined value of tubing pressure (lower than said first predetermined value) to actuate the second pilot valve to keep the outlet valve open. The tubing pressure decreases as liquid is forced up the tubing end and through the outlet

valve until most of the liquid is removed. Then the tubing pressure starts to increase. The second pilot valve is responsive to the increase of tubing pressure above a third predetermined value higher than said second predetermined value to close the outlet valve. The system is reset upon attainment of a fourth value to keep the outlet valve open. The tubing pressure decreases as liquid is forced up the tubing and through the outlet valve until most of the liquid is removed. Then the tubing pressure starts to increase. The second pilot valve is responsive to the increase of tubing pressure above a third predetermined value higher than said second predetermined value to close the outlet valve. The system is reset upon attainment of a fourth predetermined value of tubing pressure, which fourth predetermined value is higher than said first predetermined value.

These novel features, and the novel structural components and their mode of functioning may be more clearly understood through a consideration of the following detailed description. In the course of this description, reference will frequently be made to the attached drawing wherein:

Brief description of the drawing

FIGURE 1 schematically illustrates an automatic system embodying the present invention;

FIGURE 2 is a graph of system operation illustrating a typical variation in tubing pressure during an operating cycle of a presently preferred embodiment of the invention;

FIGURE 3 is a front view of the arrangement of the control valve means in a presently preferred embodiment of the invention;

FIGURE 4 is a top view of the arrangement shown in FIGURE 3;

FIGURE 5 is a cross-sectional view of the exhaust valve assembly which forms a portion of the arrangement shown in FIGURES 3 and 4;

FIGURE 6 is a cross-sectional view of one of the pilot valve assemblies employed in the arrangement shown in FIGURES 3 and 4; and

FIGURE 7 is a cross-sectional view of the block valve assembly employed in the arrangement shown in FIGURES 3 and 4.

Description of a preferred embodiment

The structure of a typical gas well is shown schematically at the left in FIGURE 1. A well casing indicated generally at 11 is provided with an outlet 12 through which "sales gas" flows to a commercial transmission line. The casing 11 extends downwardly to a subterranean level where a plurality of holes 13 allow both gas and liquid to enter the casing from formation 14. A tubing 16 extends downwardly from the well head to a point adjacent but spaced above the opening bottom of the casing. The inside diameter of the casing is large compared to the outside diameter of the tubing 16 such that the annular space 20 defined between tubing 16 and casing 11 permits the flow of gas upward toward the outlet 12 with low flowing friction. As long as the well is free from water, tubing and casing pressure are equal.

Water entering the well separates from the gas and falls to the bottom of casing 11. Such accumulation of water tends to create substantial back pressure due to the height of the liquid column in the casing which significantly reduces or may even completely stop the production of gas in the well.

By allowing gas to be bled from the tubing 16 at the well head a pressure difference is created between the interior of the tubing 16 and the annular space 20 in casing 11. A column of liquid accordingly rises within the tubing 16 to a level 22 which is substantially higher than the liquid level 24 in the casing 11. In the embodiment of the invention shown schematically in FIGURE 1, this liquid column is produced by allowing a small flow

rate of gas to bleed through a valve plug 25 in exhaust valve 30. When the main port within exhaust valve 30 is suddenly opened, pressure within the tubing 16 at the well head falls to near atmospheric pressure and the gas and liquid pressure within the casing 11 forces the column of water accumulated within the tubing 16 upward through the tubing 16 and out of the valve 30 into an available waste reservoir.

An important feature of the present invention is the provision of control means for opening the outlet valve 30 whenever the difference P_d between the pressure in the tubing 16 and the pressure in the casing 11 increases from a first predetermined value, at tubing pressure P_1 , to a second predetermined value (at a lower value of tubing pressure P_2). The graph of FIGURE 2 illustrates this feature of the invention. At time T_0 , when very little liquid has accumulated within the tubing 16, the pressure within tubing 16 is essentially equal to the pressure within casing 11. As the column of water begins to rise in tubing 16, however, the tubing pressure drops with respect to the casing pressure such that a substantial pressure difference P_d begins to develop. This difference in pressure provides a direct measurement of the height of the water column since the pressure difference P_d is equal to the water column height times a constant liquid gradient (commonly expressed in pounds per square inch per foot of depth). For purposes of the discussion here, the casing pressure can be assumed to be essentially constant with time as illustrated by the upper horizontal broken line in FIGURE 2.

When the tubing pressure falls to the predetermined value P_2 , a control valve arrangement responsive to the difference in pressure between the casing 11 and the tubing 16 opens the outlet valve 30. This occurs at time T_1 as shown in FIGURE 2. Thereafter, the tubing pressure falls quite rapidly to a value below the valve P_4 as the water column is ejected from the tubing 16. As the casing pressure forces water up the tube 16 and out the outlet valve 30, tubing pressure drops toward atmospheric pressure. After most of the liquid has been expelled from the tube 16, tubing pressure begins to increase from its maximum value as shown between times T_2 and T_3 of FIGURE 2. Control means responsive to this increase are provided for closing the outlet valve 30 at time T_3 . Thereafter the tubing pressure rises rapidly to a value P_1 whereupon the system is reset for operation.

Until the system resets at tubing pressure P_1 , reopening of the outlet valve is prevented even though the pressure difference between the interior of the tubing 16 and annular space 20 in the casing 11 is larger than the value which existed at time T_1 . This insures that the outlet valve will not reopen prematurely.

The control functions depicted in FIGURE 2 of the drawings may be simply and accurately accomplished by means of the arrangement shown schematically in FIGURE 1 of the drawings. This arrangement includes a pair of differential pilot valves 31 and 32, respectively, a block valve 33, and a piston type actuator 34 associated with outlet valve 30.

The differential pilot valve 31 includes a diaphragm 38 which carries a centrally located hollow stem 40. Spring 42 disposed within the valve 31 biases the stem 40 and diaphragm 38 downwardly. The diaphragm 38 separates upper and lower diaphragm chambers 44 and 46 respectively. When the stem 40 is moved fully downward, its lower extremity bears against a valve disc 48, which is normally biased to close a port which communicates chambers 58 and 60 in valve 31. An opening 50 in that portion of the casing of differential pilot valve 31 which surrounds spring 42 provides an exhaust port for the valve 31.

As shown in FIGURE 1, pressure from the tubing 16 is communicated through a pressure line 52 to the upper diaphragm chamber 44 of the valve 31. The lower diaphragm chamber 46 of valve 31 receives pressure from

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the annular space 20 within casing 11 through the serially connected pressure lines 53 and 54. Casing pressure is also applied to supply chamber 58 of the differential pilot valve 31 via pressure line 53. The control chamber 60 is connected to the junction between pressure lines 62 and 64. Line 62 communicates pressure variations between the control chamber 60 and the upper chamber 66 of actuator 34 while line 64 communicates pressure variations between the control chamber 60 of pilot valve 31 and the lower chamber 68 of block valve 33.

As the difference in pressure between the interior of tubing 16 and casing 11 increases (as shown between time T_0 and T_1 in FIGURE 2) the pressure differential between the upper and lower chambers 44 and 46 respectively of pilot valve 31 increasingly tends to force the stem 40 upward against the force of spring 42. When, at time T_1 , the pressure differential is sufficient, stem 40 moves upward allowing the valve disc 48 to close the opening which formerly existed between supply chamber 58 and control chamber 60. At the same time, a passageway is created through the hollow stem 40 and exhaust port 50 to allow the pressure within the control chamber 60 to fall to atmospheric pressure.

When pilot valve 31 trips in this fashion, the actuator 34 opens the outlet valve 30. Actuator 34 includes a lower chamber 70 which is connected to the control chamber 72 of pilot valve 32 by virtue of the pressure line 74. Since stem 76 of pilot valve 32 is initially held in its downward position by spring 78, the pressure line 74 receives casing pressure through the valve mechanism 80 from pressure line 82. Line 82 is in turn connected to the casing 11 by way of line 53. Since casing pressure is applied to the lower chamber 70 of actuator 34 at this time, the loss of pressure in the upper chamber 66 causes piston 84 to move upwardly carrying with it the valve plug 25 to open the main valve 30.

Block valve 33 includes an upper chamber 86 which is connected to the tubing 16 through pressure lines 88 and 52. Prior to time T_1 , casing pressure was communicated to the lower chamber 68 of block valve 33 for opening the valve mechanism 90 to allow casing pressure to be transmitted by way of pressure line 92 to upper chamber 94 of pilot valve 32. Since casing pressure is vented from the lower chamber 68 when pilot valve 31 trips, the tubing pressure in upper chamber 86 closes the valve mechanism 90 to trap casing pressure in the upper diaphragm chamber 94 of pilot valve 32. With the outlet valve 30 open between times T_1 and T_2 tubing pressure drops quite rapidly.

At time T_2 , the block valve 33 is reopened by the pressure from spring 96, allowing the locked in casing pressure in the upper chamber 94 of pilot valve 32 to vent through the exhaust port 50 of pilot valve 31. Pilot valve 32 is thereby conditioned to measure the difference between tubing pressure and atmospheric pressure. Even though the upper chamber 94 of pilot valve 32 between times T_2 and T_3 is a substantially atmospheric pressure, the pressure applied by spring 78 is sufficient to hold the stem 76 in position since the tubing pressure in the lower chamber 98 is very low.

After most of the liquid has been expelled from tubing 16 through outlet valve 30, tubing pressure increases from its minimum value. The tubing pressure in chamber 98 then forces stem 76 upward seating the valve disc 80 and venting the lower chamber 70 of actuator 34 through an exhaust port 100 in the casing of shut-in pilot valve 32. With the loss of casing pressure in the lower chamber 70, the piston 84 moves downward under the force of spring 66 to again close the outlet valve 30 at time T_3 and cause an increase in tubing pressure.

Between times T_3 and T_4 as shown in FIGURE 2, tubing pressure rises quite rapidly until the pressure in the upper chamber 44 of pilot valve 31 reaches a pressure P_1 (greater than the initial trip pressure P_2) sufficient to force the stem 40 downward, closing the access to the exhaust port 50 and moving the valve disc 48 from its

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seat. Casing pressure is again communicated to the lower chamber 68 of the block valve 33 and to the upper chamber 66 of the actuator 34. The block valve 33 opens so that casing pressure is introduced to upper chamber 94 and registers on top of the diaphragm of shut-in pilot 32. Pilot valve 32 opens and pressure is applied to the bottom of the piston in actuator 34. The system is now reset.

FIGURES 3 and 4 show the manner in which the two pilot valves 31 and 32, the block valve 33, and the actuator 34 are interconnected. The numerals which are used to designate the various pressure lines in the schematic of FIGURE 1 are also employed in FIGURES 3 and 4. These four valve mechanisms are mounted in a cluster upon the tubing 16.

The individual valve mechanisms are described in more detail in conjunction with FIGURES 5 through 7 of the drawings. The outlet valve 30 (FIGURE 5) includes a valve body 103 having a threaded inlet 105 into which the tubing 16 is fitted and a threaded outlet 106 for receiving a line communicating the valve to the waste reservoir. The valve plug 25 which forms the end of valve plug assembly 110 bears against the beveled seat 111 of valve cage 112 when the outlet valve 30 is closed as shown in FIGURE 5. A bleed passageway through the valve plug 25 permits the gas pressure existing at inlet 105 to be bled slowly at a rate depending upon the setting of the interior threaded member 113 so that a differential pressure can be obtained when water enters tubing 16. A removable pipe plug 114 positioned at the bottom of body 103 facilitates maintenance of the valve 30 and permit access to adjust member 113.

The valve plug assembly 110 extends upwardly through a retainer 116 which is mounted within a bonnet 118. Lug nut 120 secures bonnet 118 to valve body 103. To provide a good seal between valve 30 and actuator 34 a spring 124 bears against a packing assembly 126 at its upper end and against a packing assembly 128 at its lower extremity.

The valve plug assembly 110 is connected at its upper end to piston 84. The lower surface of piston 84 cooperates with the interior of case 130 to define chamber 70, which is communicated through a threaded opening 132 to the pressure line 74. Spring 135 urges piston 84 downwardly for biasing the valve plug assembly downwardly and thereby urging valve plug 25 against seat 11. Closing cap 137 is threadably engaged with the cylindrical casing 130 and defines the ceiling of the upper chamber 66 of the actuator 34. A threaded opening 139 connects the chamber 66 to the line 62. A travel stop 140 is positioned within the coil spring 135 and a travel indicator 142 extends upwardly through the travel stop 140 and the closing cap 137 to provide a visual indication of the position of the actuator 34 and outlet valve 30.

As will be apparent to those skilled in the art, valve plug 25 is normally held in a closed position by the co-operative action of spring 135 and the pressure communicated to the upper chamber 66 by way of line 62. Upon actuation of the differential pilot valve 31 as explained in conjunction with FIGURE 1, the pressure in line 62 drops to atmospheric pressure. At that time, the casing pressure which is communicated to chamber 70 by way of line 74 is sufficient to move the piston 84 upwardly until travel stop 140 engages with closing cap 137. The valve plug 25 is lifted from its seat 111 to open a substantial passageway between the inlet 105 and the outlet 106.

FIGURE 6 of the drawings illustrates the interior details of pilot valve 31. Since valves 31 and 32 are essentially identical in their structure only pilot valve 31 need be described in detail. Pilot valve 31 is actuated by the difference in pressure existing between the upper chamber 44 and the lower chamber 46 which are separated by the diaphragm 38. Pressure is communicated to the upper chamber 44 by way of a threaded inlet 150 which is connected to the junction between pressure lines 52 and 82

as shown in FIGURE 1. The lower diaphragm chamber 46 receives pressure through a threaded inlet 152 which is connected to the chamber 46 by a passageway 153 through center section 155. (It should be noted that, for purposes of illustration, the inlet 152 and an opposing threaded inlet 154 as well as the passageway 153 are shown rotated 90° from their actual position.)

The diaphragm 38 is held peripherally between an upper diaphragm head 158 and a lower diaphragm head 159 which are rigidly mounted on the stem 40. Stem 40 is carried by the upper retainer 161 and the lower retainer 162 and at its upper extremity bears against a spring seat 165. Spring 42 is compressed between the lower seat 165 and an upper spring seat 168. The amount of spring compression is adjustable by rotating a screw 170 which, after adjustment, is held in place by tightening nut 174. The pressure differential required to "trip" the pilot valve 31 may accordingly be adjusted over a substantial range.

As described in connection with the schematic drawings of FIGURE 1, the stem 40 in its downwardmost position, bears against the valve disc 48, which is secured to the top of valve holder 177, thereby compressing spring 178. Valve holder 177 is slidably retained within an adjustable valve guide 188 threadably mounted within the body 155. A threaded inlet 182 provides access to the supply chamber 58. With the valve stem 40 down, gas pressure is communicated from chamber 58 to the control chamber 60 through the annular orifice which exists between the stem 40 and member 185. Simultaneously, gas pressure is prevented from escaping past valve disc 48 through which it would otherwise exhaust through the stem 40 and port 50 in the spring case 190.

With sufficient gas pressure in the lower chamber 46, the valve stem 40 is forced upward against the combination of the pressure of spring 42 and the pressure in the upper chamber 44. With the stem 40 in its upper position, valve disc 48 seats against member 185 to close the passageway between inlets 182 and 154. Gas pressure in the control chamber 60 is then allowed to escape upwardly through the stem 40 and out the exhaust port 50.

The block valve 33 is shown in detail in FIGURE 7 of the drawings. The upper chamber 86 is connected to the junction between pressure lines 88 and 84 (shown in FIGURE 1) through the threaded opening 201. Spring 96 biases diaphragm head 203 upwardly (FIGURE 7). When the pressure force in chamber 86 overcomes the force of spring 96, diaphragm 68 will urge diaphragm head 203 downwardly to the position shown in FIGURE 7. The valve holder assembly 206 including spring 205 is carried with the diaphragm head to seat valve disc 90 against the orifice 210 mounted in the body of block valve 33 so as to close the passageway 211 which communicates opening 212 to opening 214. Threaded opening 212 is connected to line 92 and threaded opening 214 is connected to line 64.

As the pressure in chamber 86 decreases, spring 96 will urge diaphragm 68 upward, said valve disc 90 carried by valve disc holder 206 will be moved away from the orifice 210, since the holder 206 is operatively connected for movement with diaphragm head 203 by screw 218. This will open passageway 211.

The block valve functions by a differential pressure on either side of its diaphragm. When the valve disc 90 is seated against the orifice defining member 210, pressure is locked above the diaphragm of shut-in pilot valve 32, allowing the shut-in pilot to remain open.

From the foregoing it is seen that the outlet valve 30 is controlled by the combination of a pair of pilot valves and a block valve, all three of which operate in response to pressure differences. These valves are suitably connected so as to operate in a predetermined sequence. The first pilot valve or differential pilot valve 31 is responsive to the difference between tubing pressure and casing pressure and serves to open the outlet

valve whenever this pressure difference increases from a first value to a second value. With the outlet or exhaust valve open, this pressure difference increases even more as tubing pressure drops rapidly toward atmospheric pressure. Operation of the first pilot valve also conditions the block valve 33 for measurement of the difference between tubing pressure and atmospheric pressure. The block valve 33 is tripped when tubing pressure falls to a sufficiently low level, whereupon the second pilot valve (shut-in pilot 32) is operative to sense difference between tubing pressure and atmospheric pressure. This second pilot valve then trips after tubing pressure exhibits an increase from its minimum value to cause the exhaust valve to close. The system resets when the difference between tubing pressure and casing pressure again falls to a first value which is below the original threshold level required to trip the first pilot valve. In accordance with the invention, the outlet valve cannot reopen until tubing pressure rises to this first value to reset the system.

The system according to the invention eliminates the need for a sliding piston or plunger within the tubing. In addition, the arrangement contemplated by the present invention provides rapid and efficient liquid removal. According to the principles of the invention, these advantages are obtained by automatically sensing various pressures during the operating cycle of the novel system.

While we have described a preferred embodiment of the invention, it will be understood that the invention is not limited thereto, since it may be otherwise embodied within the scope of the claims.

We claim:

1. An automatic system for removing liquid from a gas well casing into a waste reservoir wherein said casing extends downwardly from a well head level to a subterranean level and wherein a tubing extends downwardly within said casing from said well head level which comprises, in combination, an outlet valve for opening and closing a substantial passageway between said tubing and said reservoir, first control means responsive to the difference between the pressure within said tubing and the pressure within said casing for opening said outlet valve whenever said difference increases from a first predetermined value to a second predetermined value, and second control means responsive to fluctuations in tubing pressure for closing said outlet valve whenever said tubing pressure rises to a third predetermined value from a fourth predetermined value, the third and fourth predetermined values being lower than the tubing pressures which aid in producing the first and second predetermined values, with the casing pressure being substantially constant, said first control means comprising, in combination, a diaphragm operated valve, means for applying tubing pressure to one side of said diaphragm, means for applying casing pressure to the other side of said diaphragm, biasing means aided by said tubing pressure for moving said diaphragm from a first to a second position whenever the difference between said tubing pressure and said casing pressure is less than said first predetermined value, said diaphragm moving from said first position to said second position whenever said difference exceeds said second predetermined value, and means responsive to the movement of said diaphragm from said first to said second position for opening said outlet valve, said second control means comprising, in combination, a valve operated by a second diaphragm, means for applying tubing pressure to one side of said second diaphragm, means for detecting values of tubing pressure below said fourth predetermined value, means responsive to said detection means for applying atmospheric pressure to the other side of said second diaphragm whenever tubing pressure falls below said fourth value, and means responsive to the movement of said second diaphragm for closing said outlet valve whenever tubing pressure rises above said third predetermined value.

2. An automatic system as in claim 1 wherein said out-

let valve includes integral bleed means for constantly bleeding a small amount of gas to obtain a differential pressure in the tubing when liquid enters the tubing.

3. An automatic system for removing liquid from a gas well casing into a waste reservoir wherein said casing extends downwardly from a well head to a subterranean level and wherein a tubing extends downwardly within said casing from said well head level which comprises, in combination, an outlet valve for opening and closing a passageway between said tubing and said reservoir, a first pilot valve responsive to the difference between the pressure within said tubing and the pressure within said casing for opening the outlet valve whenever said pressure difference increases above a first preset value and the tubing pressure is at a first predetermined value, a block valve, a second pilot valve operative in response to the difference between the tubing pressure and the casing pressure for closing the outlet valve, said block valve being in communication with the first and second pilot valves and being operable in response to a second predetermined value of tubing pressure to actuate the second pilot valve to keep the outlet valve open, the second predetermined value of tubing pressure being less than the first predetermined value, the tubing pressure decreasing as the liquid is forced up the tubing and out of the outlet valve until most of the liquid is removed, at which time the tubing pressure begins to increase, the second pilot valve being responsive to increase of tubing pressure above a third predetermined value higher than said second predetermined value to close the outlet valve, the system being reset upon attainment of a fourth predetermined value of tubing pressure, said

fourth predetermined value being higher than said first predetermined value.

4. An automatic system as in claim 3 wherein the first and second pilot valves each include a diaphragm operatively connected to a hollow stem and valve arrangement for venting casing pressure to atmosphere, with tubing pressure acting on one side of each diaphragm and with casing pressure acting on the opposite side of each diaphragm, the tubing pressure urging the diaphragms so as to stop exhaust flow through the first pilot valve and to permit exhaust flow through the second pilot valve.

5. An automatic system as in claim 4 wherein the outlet valve includes an actuator member operatively connected to a valve element, the first pilot valve being adapted to control the supply of casing pressure to one side of said actuator member for urging the valve element to close the passageway and the second pilot valve being adapted to control the supply of casing pressure to the opposite side of said actuator member for urging the valve member to open the passageway.

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