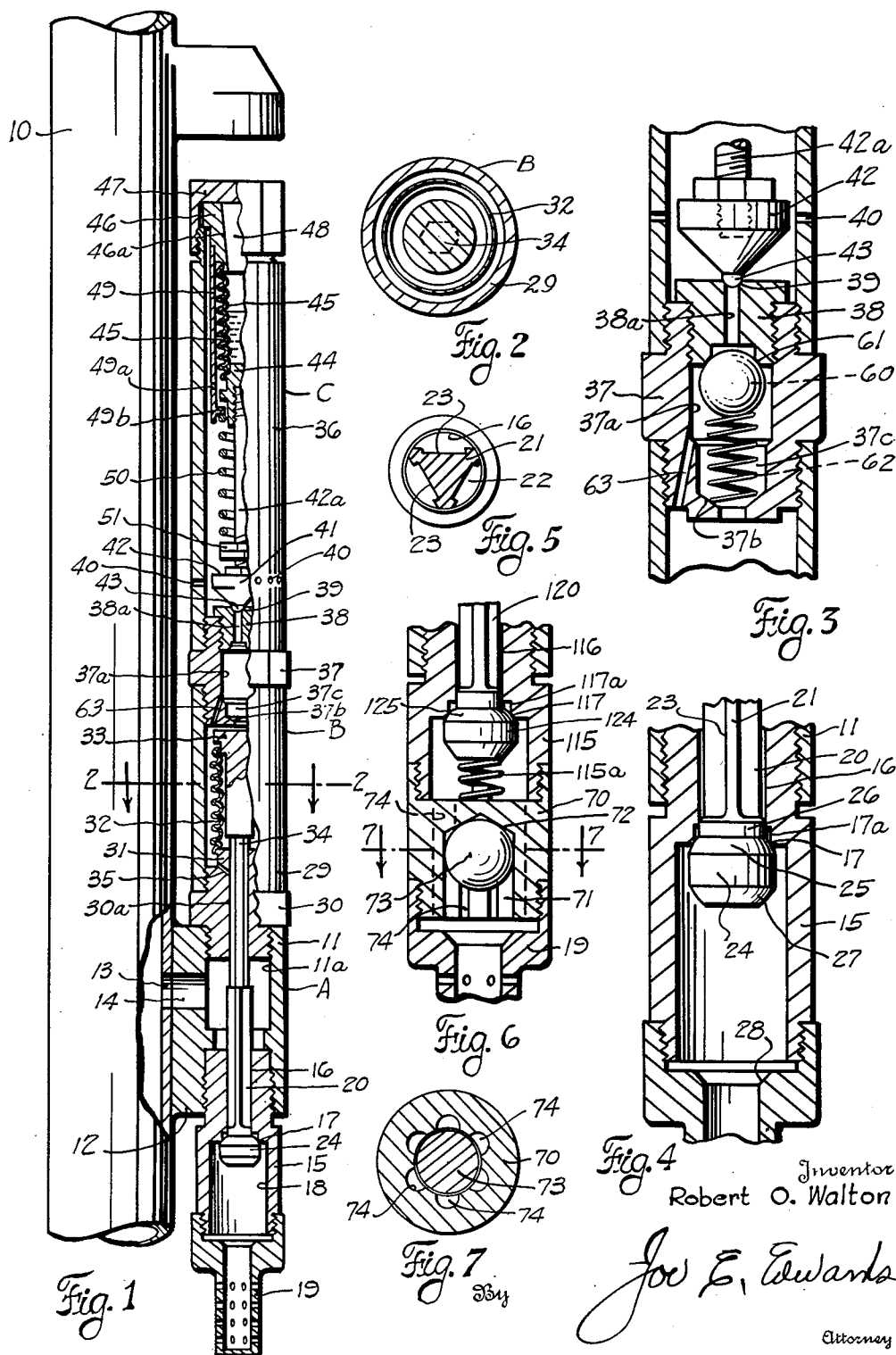


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WELL FLOW DEVICE
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WELL FLOW DEVICE

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7 Claims. (Cl. 137-111)

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This invention relates to new and useful improvements in well flow devices.

This invention is an improvement on the device shown and described in my co-pending application, Serial No. 451,570, filed July 20, 1942, now abandoned.

One object of the invention is to provide an improved device for controlling the admission of a lifting fluid, such as gas, into a liquid column within a well tubing or conductor for lifting or raising the liquid to the surface, said device being particularly adapted for use as an intermitter to intermittently admit the lifting gas at predetermined intervals in accordance with particular well conditions.

An important object of the invention is to provide an improved well flow device having all of the advantages of the device disclosed in my prior co-pending application, and in addition having an improved inlet valve assembly which includes a power bellows unit associated with a novel main valve stem construction, whereby more efficient flow control is had.

A particular object of the invention is to provide an improved flow device wherein the operation of a main valve element is controlled by actuation of a pilot valve member with both the main and pilot valves and their co-acting seats being so constructed that more efficient seating of the valves is assured and also so that "cutting out" or undue wear on said valves and seats is eliminated.

A further object of the invention is to provide an improved device, of the character described, wherein the main control valve includes a valve head having an upwardly projecting stem, with said stem being constructed to substantially shut off flow past the valve head immediately prior to said head engaging its seat, whereby "fluttering" of the main valve is eliminated and also whereby the valve head is not subjected to excessive cutting action by the fluid flowing past said head.

Still another object of the invention is to provide an improved flow device, of the character described, which is so constructed that a full back check to prevent reverse flow past both the main and pilot valves may be employed therewith without changing the various basic component parts which form the device.

The construction designed to carry out the invention will be hereinafter described together with other features of the invention.

The invention will be more readily understood from a reading of the following specification and by reference to the accompanying drawing, where-

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in an example of the invention is shown, and wherein:

Figure 1 is a view, partly in elevation and partly in section, of a flow device, constructed in accordance with the invention,

Figure 2 is an enlarged, horizontal cross-sectional view, taken on the line 2-2 of Figure 1,

Figure 3 is an enlarged, sectional detail of the pilot valve and its associated seat,

Figure 4 is an enlarged, sectional detail of the main valve and its associated seat,

Figure 5 is an enlarged, horizontal, sectional view, taken through the valve stem of the main valve,

Figure 6 is a transverse, sectional detail of a modified form of main valve unit, and

Figure 7 is a horizontal cross-sectional view, taken on the line 7-7 of Figure 6.

In the drawings, the numeral 10 designates a well tubing or conductor through which the well fluids flow upwardly. A valve device constructed in accordance with the invention is adapted to be connected with the well tubing and is arranged to control the admission of a lifting fluid such as gas or air from the space outside of said tubing and into said tubing to lift or raise the well liquids within said tubing to the surface.

The flow device includes a main intake valve assembly A, a power bellows unit B and a pilot valve assembly C, these parts being connected together, as will be explained, to form said device. As is clearly shown in Figure 1 the main intake valve assembly includes a tubular casing 11 which has a boss 12 formed on one side thereof and said boss is connected, as by welding or otherwise, to the tubing 10. The tubing is provided with a radial inlet port 13 which communicates through an opening 14 with the bore 11a of the valve casing 11. A valve seat element 15 is threaded into the lower end of the casing 11 and has its upper portion formed with an axial bore 16, the extreme lower end of which is provided with an annular, bevelled or inclined valve seat 17 which presents a flat surface. Immediately above the annular seat 17, the bore is counter-bored as indicated at 17a and the purpose of this counter-bore will be hereinafter explained. The lower portion of the element 15 has an enlarged outer bore 18 and a tubular screen pipe 19 is threaded onto the lower end of the element 15. With this construction it will be evident that the lifting gas or air exteriorly of the flow device may enter the ports of the screen 19 and then flow upwardly past the valve seat 17, through the bore 11a of the casing 11 and finally through the inlet opening

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13 into the well tubing. The admission of lifting gas or air into the liquid column will function to raise or lift the liquid to the surface.

For controlling the admission of the lifting gas or air into the tubing from exteriorly thereof, a valve element 20 is provided. This valve element includes a stem 21 which is generally triangular in cross-section and which is slidable within the bore 16 of the valve seat element 15, whereby flow passages 22 (Figure 5) are formed between the sides of the stem and the wall of the bore. To provide for increased flow past the stem, the outer surfaces of said stem may have longitudinal grooves 23 cut therein and in this manner a restricted flow past the valve stem within the bore 16 may be had. A valve head 24 is formed at the lower end of the stem and has an upper seating surface 25, this surface being arcuate or curved and being adapted to engage the annular, bevelled valve seat 17. Immediately above the curved seating surface 25 (Figure 4) of the valve element is a cylindrical section 26 which has an outer diameter substantially equal to the diameter of the bore 16 and which has a greater longitudinal width than the depth of the counter-bore 17a which is disposed immediately above the seat 17. The cylindrical surface 26 has the lower end of the grooves 23 of the stem terminating adjacent thereto and since the diameter of said surface is substantially equal to the diameter of the bore 16, a slide valve arrangement is obtained. Of course, in moving upwardly into the bore 16, the cylindrical portion must pass through the counter-bore 17a and because the length of said portion 26 is greater than the depth of the counter-bore, the cylindrical portion 26 enters the bore 16 prior to the time that the curved seating surface 25 engages the annular valve seat 17. When the curved seating surface 25 of the valve head is engaging its seat as shown in Figure 4, the cylindrical surface 26 is disposed within the bore and in such position the valve element 20 is in its raised or lifted position, whereby an upward flow of lifting gas or air into the tubing is prevented.

The lower end of the valve head is formed with a seating surface 27 which is also curved and which is similar to the upper seating surface 25. The lower seating surface 27 is adapted to engage an annular bevelled valve seat 28 which is formed at the upper end of the bore of the screen 19 and when the valve is in a completely lowered position with the surface 27 engaging said seat, a back flow of well liquids from the tubing 10 downwardly through the valve assembly A is prevented.

The pressure of the lifting gas or air which is present exteriorly of the valve device constantly acts against the lower end of the valve element 20 to hold the same in its raised position. To effect an opening of the valve element 20 to permit an admission of lifting air or gas into the tubing, the power bellows unit B is provided. This unit includes a tubular housing 29 which is coupled to the outer casing of the valve assembly A by a suitable coupling collar 30. The coupling collar has an extension 31 at its upper end and the lower end of an operating bellows 32 is connected therewith. The upper end of the bellows is suitably fastened to an enlarged head 33 which is preferably formed integral with the upper end of an operating stem 34. The stem has its lower end slidable through an axial bore 30a formed within the coupling 30 and the extreme lower end of said stem is adapted to engage the upper end

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of the valve stem 21 of the main valve element 20. The normal inherent resiliency of the bellows 32, as well as the pressure acting against the lower end of the valve 20, tends to expand said bellows and thereby hold the operating stem 34 in its raised or lifted position, as shown in Figure 1; thus, it is apparent that the main valve element 20 may be moved to its upwardly seated position by the pressure of the lifting gas or air which is acting against its lower end.

When a pressure is applied to the upper end of the head member 33 of the operating stem, the stem is moved downwardly, with the bellows 32 being collapsed by this pressure and downward movement of the operating stem imparts a downward movement to the valve element 20 to unseat the same and admit lifting gas into the well tubing 10. When pressure against the upper end of the head 33 and bellows is relieved, the bellows will function to return the operating stem 34 to its raised position and any pressure within the housing 29 exteriorly of the bellows may escape through a suitable vent passage 35 which is formed in the coupling 30 and which extends from the bore 30a. It is noted that the lower portion of the operating stem 34 is constructed of hexagonal material or it may be fluted or grooved to provide a by-pass area within the bore 30a.

The power bellows and its associated operating stem 34 are adapted to be moved downwardly to open the main valve 20 by the pressure of the lifting gas or air which is present outside of the tubing and flow device. For controlling the application of this pressure to the upper end of the bellows assembly, the pilot valve assembly C is provided. This assembly includes a tubular outer casing 36 which has its lower end connected to the outer housing 29 of the bellows unit B by means of a coupling collar 37. A valve seat member 38 is threaded into the upper end of the bore 37a of the coupling 37 and has an annular bevelled or inclined valve seat 39. The seat member 38 has an axial bore 38a and through this bore, as well as through the bore 37a of the coupling, communication is established between the interior of the outer casing 36 of the bellows assembly C and the upper end of the power bellows 32 and its head member 33. The lifting gas or air under pressure may enter the interior of the casing 36 through suitable inlet openings 40.

For controlling the flow past the valve seat 39, a pilot valve 41 is mounted within the outer casing 36.

This valve includes a head member 42 having a semi-spherical seating surface 43 at its lower end, the latter surface being adapted to seat or engage the annular, bevelled valve seat 39. An upwardly extending stem 42a is connected to the valve head 42 and projects axially within the casing 36. Through a suitable connecting coupling 44 the upper end of the valve stem is connected to a pilot bellows 45 and the latter has its upper end fastened to a cap member 46. The cap member is provided with an external flange which engages the upper end of the casing 36 and a retaining collar 47 threaded onto said casing confines the cap. The cap is formed with a tapered axial bore 46a adapted to be closed by a tapered cylindrical plug 48 and the interior of the bellows is partially filled with a suitable non-compressible liquid whereby the retraction of the bellows is limited to prevent rupturing thereof by excessive pressure. A guard sleeve 49 has its upper end engaging an annular shoulder on the cap 46 and said sleeve extends downwardly over the bellows.

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49, with sufficient clearance between the lower end of the guard sleeve and the stem 43 to permit the pressure within the casing 36 to act on the outer surface of the pilot bellows. Also a plurality of inlet ports 49a may be formed in the wall of the sleeve.

The normal inherent resiliency of the bellows moves in a direction to expand said bellows and thereby urge the pilot valve toward a seated position. For positively holding the pilot valve seated and also to control the pressure required to unseat said pilot valve, a coil spring 50 surrounds the valve stem 42a and is confined between an inwardly directed flange 49b on the guard sleeve 49 and adjusting nuts 51 threaded onto the stem. The spring also functions to hold the guard sleeve in place. Obviously by adjusting the nuts, the tension on the spring 50 may be regulated and this spring is added to the inherent resiliency of the pilot bellows 45 to urge the pilot valve to a seated position.

When the pressure of the lifting gas or air exteriorly of the device reaches a predetermined point in accordance with the size and strength of the spring 50, this pressure being present within the interior of the casing 36 acts upon the bellows 45 to collapse said bellows and thereby lift the valve stem 42a and the valve 42 against tension of the spring 50. When the pilot valve is lifted, the pressure of the lifting gas or air may pass downwardly through the bore 38a of the seating member 38 and the bore 37a of the coupling 37 and act against the upper end of the power bellows 32 to move said bellows downwardly and thereby move the operating stem 34 connected with said bellows downwardly against the main valve element 20. This results in an unseating of the main valve, which as explained, admits the lifting gas or air into the tubing 10.

In the operation of the device, the parts are normally in the position shown in Figure 1. In such position the main valve element 20 is raised and in a closed position and the power bellows 32 is in its expanded or upper position. The pilot valve is also closed, being held so by its associated coil spring 50 and the pilot bellows 45.

When the pressure of the lifting gas or air exteriorly of the device reaches a point sufficient to move the pilot bellows toward a collapsed position, the pilot valve 42 is opened and the pressure of the lifting gas is applied to the upper end of the power bellows. The cross-sectional area of the upper head member 33 of the power bellows is greater than the cross-sectional area of the main valve head which is acted upon by the lifting gas and therefore the power bellows 32 is moved toward its collapsed position, whereby the operating stem moves the main valve downwardly off of its seat 17. As soon as this occurs the lifting gas from exteriorly of the tubing may flow past the valve seat 17 and into the well tubing string 10 through the inlet port 13, whereby the well liquids within the tubing are lifted to the surface by said lifting gas or air. So long as the pilot valve remains open, the main valve is held in its unseated position and as soon as the pressure exteriorly of the device falls below a predetermined point, the pilot valve is automatically closed. Upon closing of the pilot valve, any pressure within the casing 29 and the power bellows assembly B is bled off through the bleeder passage 35 which permits the bellows 32 to return to its normal expanded position, whereby the gas pressure acting against the lower end of the main valve may again seat said valve. The parts

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remain in this position until pressure exteriorly of the tubing again reaches a point sufficient to open the pilot valve.

A particular feature of the invention is the construction of the main valve element 20. It will be noted that the seating surfaces 25 and 27 of the valve head are curved and this contour or shape reduces the danger of said surfaces being cut out or damaged by the flow thereby. The pilot valve 42 has its seating surface also curved or ball-like for the same reasons. In addition the main valve has the cylindrical surface 26 immediately above its seating surface 25 and this cylindrical surface is of substantially the same diameter as the bore 16 of the valve seat element 15. When the valve is being moved to a closed position, the cylindrical surface 26 enters the enlarged counter-bore 17a first and then moves into the bore 16 prior to the time that the seating surface 25 of the valve head engages the seat 17. As soon as the surface 26 enters the bore 16, the flow of gas through the bore 16 is substantially shut off with the restriction being at the lower end of said bore which is well above the seat 17. Therefore, as the seating surface 25 approaches the seat 17, the extremely high velocity normally occurring by the constantly decreasing restriction is not present at this point and the surface 25 and valve seat are not subjected to the exceptionally high velocities which normally damage or cut out said surfaces.

In some instances it may be desirable to provide a complete back check which would prevent the flow of well liquids from the tubing back through the main valve 20 as well as the pilot valve 42. As explained, any back flow past the main valve element would move the main valve element to its completely lowered position with its lower seating surface 27 engaging the seat 23. This would prevent any flow of liquids from the tubing back through the valve assembly A. However, a flow might occur through the bleeder passage 35, then upwardly through the casing 29 of the power bellows unit and then through the coupling 37 to act against the pilot valve. If the pressure of this liquid is sufficient, the pilot valve would be unseated which is, of course, not desirable. In order to permit a back check valve to be used to prevent reverse operation of the pilot valve in those conditions where needed, the coupling 37 may receive a ball valve indicated in dotted lines at 60 in Figure 3. A valve seat 61 is formed at the lower end of the bore 38a of the valve seat element 38. A light spring indicated by the dotted line 62 in Figure 3 is disposed beneath the ball 60 and rests upon an internal seat 37b formed within the coupling 37. The spring is only of sufficient strength to support the weight of the ball 60.

When the ball 60 is employed as a check valve, opening of the pilot valve under normal operations will cause the pressure of the lifting gas or air to move the ball 60 downwardly into a reduced chamber 37c formed in the lower end of the coupling 37. Flow past the lowered ball 60 may occur through an inclined passage 63 which is provided in the coupling 37 and through this passage the pressure may be conducted to the upper end of the power bellows. Thus, there is no interference with the normal operation.

However, in the event that a back check valve is necessary, the pressure of the well liquids which would act upwardly against the underside of the pilot valve will strike the ball valve 60 and move it into engagement with the seat 61,

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whereby the pilot valve 42 is protected against this back pressure. As stated the ball check 60 may not be necessary under all conditions and the coupling 37 is so designed that said ball may or may not be used as conditions required.

As has been noted, a back pressure in the tubing 10 may act upon the main valve element 20 to completely lower said element so that its lower seating surface 27 engages the lower seat 28. However, wells having excessively high back pressure conditions have been encountered and in such instances, the excessive pressure results in a very slow downward closing of the element 20. In Figures 6 and 7, a modified form of main valve assembly having a quick closing back check valve arrangement is shown. In this structure, a valve seat element 115, similar to element 15 of the first form is provided, said element having an axial bore 116, counter-bore 117a and bevelled seat 117. A valve element 120, similar to the element 20, has its stem slidable within the bore 116 and is formed with an upper valve seating surface 125 on its valve head 124, which surface is adapted to engage the seat 117. A coil spring 115a below the valve element normally urges the same upwardly. The operation of the valve element 120, so far as controlling the admission of a lifting fluid into the tubing, is identical to the operation of the valve element 20, hereinbefore described.

Connected to the lower end of the valve seat element 115 is a check valve housing 70 which is formed with a valve chamber 71 having its upper end inclined as indicated at 72. The spring 115a has its lower end supported on this housing. The tubular inlet screen 19 having the annular valve seat 23 at its upper end is secured to the lower end of the housing and closes the valve chamber 71. A ball check valve 73 is confined in the housing and is movable between the upper end of the chamber and the valve seat 28.

When the ball is in its normally raised position in engagement with the upper end 72 of the valve chamber, a flow of the lifting fluid entering the screen 19 may occur upwardly through by-pass passages 74 which extend upwardly through housing at the sides of the valve chamber. The pressure of the lifting gas normally holds the ball lifted so that the flow device functions in the manner explained with reference to the first form of the invention. However, if an excessive back pressure occurs in the tubing 10 this pressure acting downwardly past the main valve element 124 exerts a force on the ball 73 which has portions exposed through the passages 74 and moves said ball onto the seat 28 to shut off a back flow into the area outside of the tubing 10. It will be evident that the ball 73 is actuated solely by the pressures on opposite sides thereof and as soon as the back pressure in the tubing exceeds the pressure of the lifting fluid outside said tubing, the ball is immediately seated. This provides a quick closing back check valve, irrespective of the pressure conditions which might develop in the tubing and which would interfere with quick downward closing of the valve element 20 of the first form. The use of the assembly illustrated in Figures 6 and 7 is, of course, optional, depending upon the particular pressure conditions of the well in which the apparatus is used.

The foregoing description of the invention is explanatory thereof and various changes in the size, shape and materials, as well as in the details of the illustrated construction may be

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made, within the scope of the appended claims, without departing from the spirit of the invention.

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

1. A well flow device including, a main valve assembly having a flow passage therein with a movable main valve within the passage, said valve being adapted to be moved to an upper position to close upward flow through said passage and adapted to move to a lower position to shut off flow in a downward direction, a power bellows unit connected with the main valve assembly and including a bellows for unseating the valve from its upper position, said bellows unit being in communication with the passage of the main valve assembly, a pilot valve assembly connected with the bellows unit and including a pilot valve which controls the application of pressure to the bellows of said unit, and back check means interposed between the bellows unit and the pilot valve assembly to prevent any back pressure which may occur in the passage of the main valve assembly and in the communicating bellows unit from acting upon the pilot valve, the back check means comprising a tubular coupling having a valve seat at its upper end and receiving chamber at its lower end, with a spring-pressed ball adapted to engage the valve seat when in its upper position and arranged to move downwardly within the receiving chamber out of the line of flow through said coupling when in its lower position.

2. A well flow device including, a main valve assembly having a flow passage therein with a movable main valve within the passage, said valve being adapted to be moved to an upper position to close upward flow through said passage and adapted to be moved downwardly to open flow through the passage, a power bellows unit having a power bellows therein, an annular bored coupling connecting the lower end of the power bellows unit to the upper end of the main valve assembly and having the interior of the power bellows communicating with its bore, said coupling also having a by-pass establishing communication between the interior and exterior of the power bellows, an operating member secured to the power bellows for engaging the main valve whereby said main valve may be unseated when a predetermined pressure is applied to the exterior of the bellows, a pilot valve assembly having a pilot valve for controlling the application of pressure to the exterior of the power bellows, a coupling connecting the upper end of the power bellows unit to the pilot valve assembly and having a valve seat therein whereby if desired a back check valve which will prevent excessive pressure within the power bellows unit acting on the pilot valve may be mounted within the last-named coupling.

3. A well flow device as set forth in claim 2, wherein the coupling connecting the power bellows unit and the pilot valve assembly has an internal axial chamber with the valve seat at its upper end together with a communicating port extending from the upper portion of the chamber to the lower end of the coupling, and an upwardly seating ball check within the chamber adapted to engage the valve seat to close upward flow therethrough, downward movement of the ball check moving said check below the upper end of the communicating part to allow flow past the ball check.

4. A well flow device as set forth in claim 2,

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together with back check means in the main valve assembly below the main valve and independent thereof and adapted to be moved to a closed position when the back pressure in the flow passage of the assembly exceeds the pressure exteriorly thereof.

5. A well flow device including, a housing adapted to be connected with a well conductor, a main valve assembly forming the lower portion of the housing and having a flow passage extending therethrough, the passage having a reduced bore portion, an annular valve seat at the lower end of the reduced bore portion, a main valve element within the assembly adapted to engage the seat to shut off flow through the bore and normally held in a seated position by the pressure which is present exteriorly of the housing, a guide stem on the main valve element slidable within the reduced bore portion, a cylindrical sealing surface on the lower portion of the guide stem immediately above the seating surface of the valve element and having a diameter substantially equal to the diameter of the reduced bore portion, whereby as said sealing surface enters the bore prior to engagement of the valve element with its seat a flow past said valve and seat is substantially shut off, a coupling member having an axial bore and forming part of the housing and connected with the upper end of the main valve assembly, a power bellows within the housing connected with the coupling and having an operating member extending through the coupling and engageable with the main valve stem whereby when the bellows is moved toward a collapsed position the operating member functions to unseat said main valve and thereby allow a flow through the passage into the conductor, the coupling having a passage establishing communication between the coupling bore and the area exteriorly of the bellows with the operating stem having a loose fit within the bore of the coupling to allow flow therethrough, said bellows being normally in an expanded position to permit the main valve to be closed, and a pilot valve means within the housing above the power bellows and normally in a closed position shutting off a flow to the power bellows, said pilot valve being opened when the pressure exteriorly

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of the tubing reaches a predetermined point to admit pressure to the power bellows, whereby the bellows is moved toward a collapsed position and the main valve is opened, closure of the pilot valve allowing bleeding off of the pressure acting on the bellows through the passage and bore of the coupling.

6. A well flow device as set forth in claim 5, together with back check means in the housing independent of the main valve and below said main valve element and arranged to be moved to a closed position when the back pressure in the passage exceeds the pressure exteriorly thereof.

7. A well flow device as set forth in claim 5, together with back check means in the housing independent of the main valve and below said main valve element and arranged to be moved to a closed position when the back pressure in the passage exceeds the pressure exteriorly thereof, said back check means being exposed to the pressure exteriorly of the conductor and being held in a position out of the normal line of flow through the passage by said pressure.

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