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GAS LIFT VALVE APPARATUS

2,994,336

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2 Sheets-Sheet 1

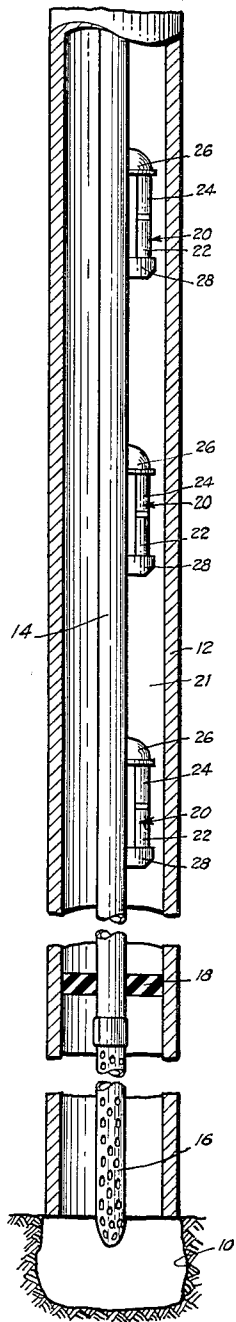


Fig. 1

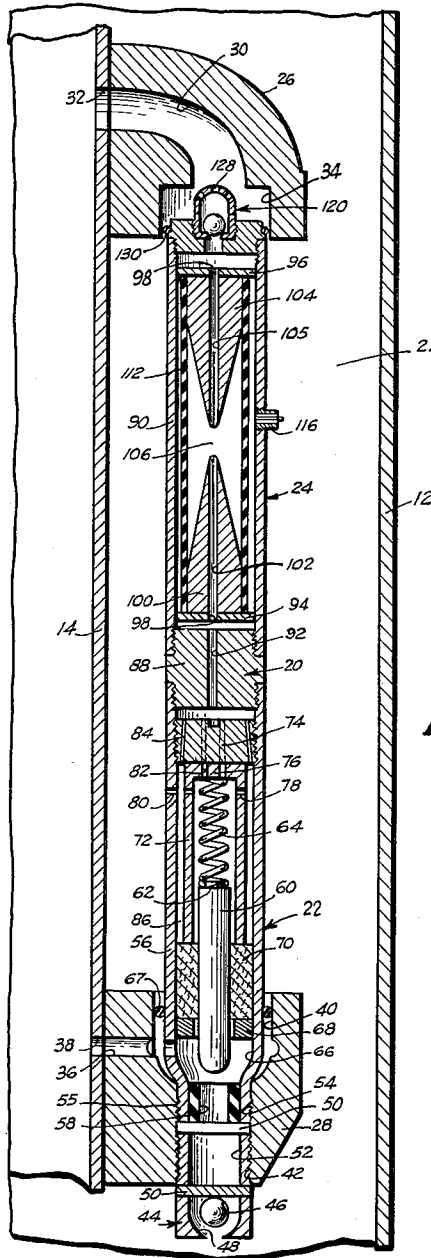


Fig. 2

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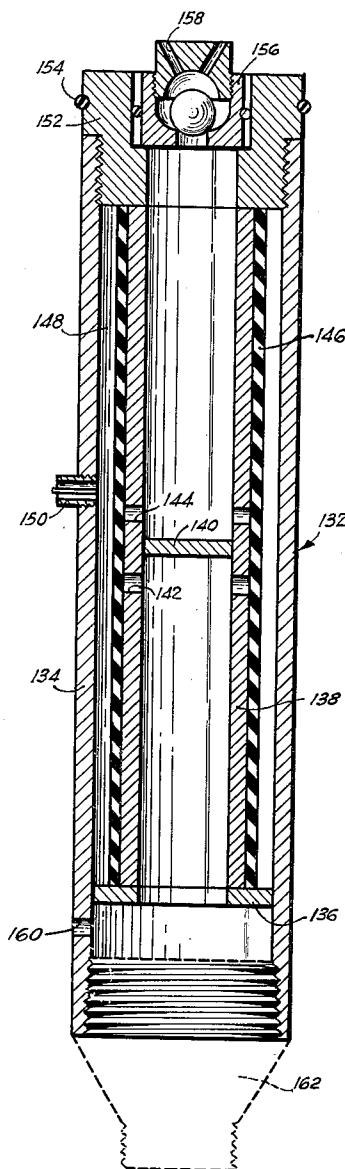
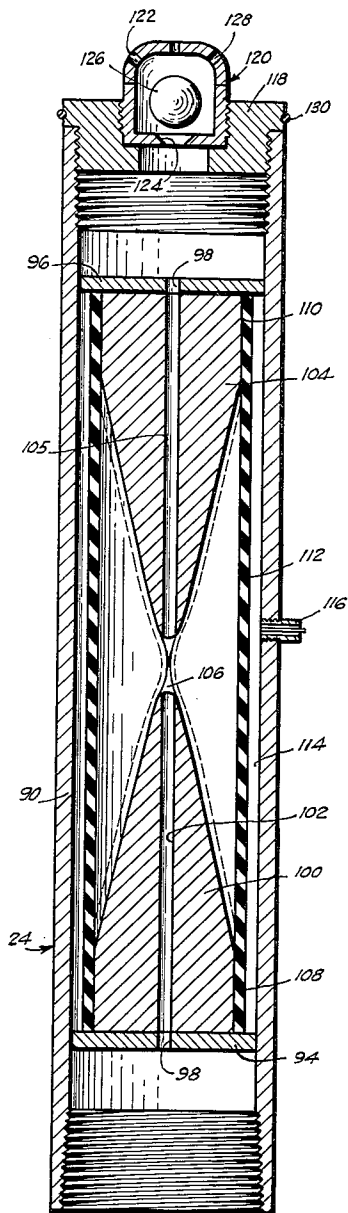
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6 Claims. (Cl. 137-155)

This invention relates to improvements in well flow devices and more particularly, but not by way of limitation, to an apparatus for elevating liquid within a well bore by means of gas or air under pressure.

Many producing oil wells of today do not have a sufficiently high subsurface gas pressure for elevating the well fluid within the well bore by a natural flow thereof. Thus, many methods of lifting the well fluid for recovery thereof are being utilized. One such method in common usage today is the elevation of the well fluid by means of gas or air under pressure. Gas is admitted to the annular space between the well casing and the well tubing for entering the well tubing and mixing with the well fluid therein. The introduction of the gas to fluid raises the fluid within the tubing for removal at the surface of the well.

A large variety of valves have been developed for automatically admitting the casing gas pressure into the well tubing for elevation of the oil within the tubing. Many of these valves are provided with a pilot valve for relieving the pressure on a main valve whereby the casing gas pressure in excess of the load pressure on the pilot valve will open the main valve for introducing the casing gas into the well tubing. One particular disadvantage of the pilot operated valves is that the main valve will not be closed until the casing gas has fallen to a pressure below the load pressure of the pilot valve, thereby causing a "blow down" of the valve, which is undesirable.

The present invention contemplates a pilot controlled flow valve for introducing gas pressure into the well tubing for elevating the well fluid therein. The pressure on the pilot valve and the main valve are maintained equal until the casing gas pressure exceeds the load pressure of the pilot valve. Thus, the main valve is held in a closed position by the pressure of the retainer spring member. When the load pressure is exceeded, the pilot valve is opened for permitting a portion of the excess pressure to escape into the tubing. However, the load pressure is maintained in the pilot valve whereby the increased casing gas pressure acts only on the main valve. The tension of the spring member may be set at substantially any predetermined pressure. Thus, the main valve will open when the casing gas pressure exceeds the tension of the spring member. The main valve will be closed instantly by the spring pressure when the casing gas pressure drops to a pressure slightly above the load pressure of the pilot valve. Thus, the main valve cannot be open during conditions of reduced pressure within the casing. All of the flow valves utilized on the well tubing may be loaded at the same pressure for the pilot valve. The tension of the spring members of each valve may be set in accordance with varied predetermined pressures in order to provide for either direct or reverse loading since the opening of the main valve is directly dependent upon the spring pressure.

It is an important object of this invention to provide an improved flow valve for introducing gas pressure into a well tubing for elevating the well fluid therein to the surface of the well.

It is another object of this invention to provide a pilot valve flow valve wherein the main valve will be opened and closed at a predetermined gas pressure for admitting gas into the well tubing at the predetermined pressure.

Another object of this invention is to provide a pilot

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valve flow valve wherein a plurality of the valves may be loaded at the same pilot valve pressure to provide for either a direct or reverse loading for elevation of well fluid within the well tubing.

5 Still another object of this invention is to provide a pilot valve flow valve wherein the main valve closes instantly upon a reduction of the casing gas pressure to the load pressure of the pilot valve.

A further object of this invention is to provide a pilot valve flow valve which is simple and efficient in operation and economical and durable in construction.

10 Other objects and advantages of the invention will be evident from the following detailed description, read in conjunction with the accompanying drawings, which illustrate my invention.

In the drawings:

15 FIGURE 1 is a broken elevational view partly in section of a well bore having a well tubing extending there-through and depicting a plurality of flow devices embodying the present invention.

20 FIGURE 2 is a sectional elevational view on an enlarged scale of a flow device embodying the invention.

FIGURE 3 is an enlarged sectional view of the pilot valve portion of the valve shown in FIG. 2.

25 FIGURE 4 is an enlarged sectional view of a modified pilot valve.

Referring to the drawings in detail, reference character 10 indicates a well bore having a casing 12 extending downwardly therein. A well tubing 14 extends downwardly within the casing 12 and is supported at the upper end thereof in any suitable manner (not shown). The lower end of the tubing 14 is preferably provided with a conventional well screen 16 for admitting the well fluid into the tubing 14. A suitable well packer member 18 is preferably provided between the tubing 14 and the casing 12 and is disposed above the perforated well screen 16, as is well known in the industry.

A plurality of flow valves, generally indicated at 20, are connected to the outer periphery of the tubing 14 in a manner as will be hereinafter set forth. The valves 20 are disposed within the annular space 21 between the casing 12 and tubing 14 and are longitudinally spaced on the tubing 14 for the admission of a lifting fluid, such as air or gas, into the tubing. The valves 20 each comprise a main valve body portion 22 and a pilot valve body portion 24 interposed between an upper lug member 26 and a lower lug member 28. The lug members 26 and 28 are preferably welded, or the like, to the outer periphery of the tubing 14 for retaining the valves 20 in position with respect thereto. The upper lug member 26 is provided with a passageway 30 in communication with an aperture 32 provided in the tubing 14 for a purpose as will be hereinafter set forth. The passageway 30 is enlarged at the lower end 34 thereof to receive the upper end of the pilot valve body portion 24. It will be apparent that the passageway 30 and aperture 32 provide communication between the top of the pilot valve body portion 24 and the interior of the tubing 14.

60 The lower lug 28 is provided with a transverse passageway 36 in communication with an aperture 38 provided in the sidewall of the tubing 14, for a purpose as will be hereinafter set forth. The passageway 36 is in communication with a longitudinal bore 40 which is provided within the lug 28 for receiving the lower end of the main valve body portion 22. The bore 40 extends longitudinally through the lower lug 28 and is provided with a reduced threaded portion 42 for receiving a suitable check valve member 44 therein. The check valve 44 is provided with a ball member 46 adapted to seat on the valve seat portion 48 in a normally closed position thereon. A suitable transverse pin member 50 extends across

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the inner bore 52 of the check valve 44 for limiting the upward movement of the ball member 46 while permitting a flow of gas or air therearound and through the bore 52 in an open position of the valve 44.

The intermediate portion of the bore 40 is reduced and threaded at 54 for receiving the lower end 55 of a tubular sleeve member 56 which functions as an outer housing for the main valve 22. A tubular valve seat insert member 58 is disposed within the end portion 55 for receiving a valve stem 60 in a closed position thereagainst. The valve stem 60 is reciprocally disposed within the tubular housing 56 and is provided with a circumferential shoulder 62 at the upper end thereof for receiving a helical spring 64. The housing 56 is preferably enlarged at 66 above the lower threaded end 55 to provide a fluid receiving chamber for a purpose as will be hereinafter set forth. An O-ring type sealing member 67 is disposed between the bore 40 and the housing 56 for precluding leakage of fluid therebetween. An annular stop or ring member 68 is disposed in the housing 56 and around the valve stem 60. The ring 68 is preferably a press fit against the inner periphery of the housing 56 and is loosely disposed around the valve stem whereby the stem may reciprocate therethrough. Suitable packing 70 is provided above the retainer ring 68 and between the valve stem 60 and housing 56 for precluding any leakage of fluid therebetween. A tubular retainer housing 72 is loosely disposed around the valve stem 60 and rests on the packing member 70 for retaining the packing securely in place and in a sealing contact between the valve stem 60 and the inner periphery of the housing 56. A retainer nut 74 is threadedly secured within the housing 56 above the retainer sleeve 72 for retaining the sleeve in position within the housing 56. The upper end of the sleeve 72 is closed at 76 to receive the upper end of the spring 64 thereagainst. It will be apparent that the tension in the spring 64 will constantly urge the valve stem 60 downwardly into seating contact with the valve seat 58.

A plurality of circumferentially spaced apertures 78 are provided in the sleeve 72 and are preferably in substantial alignment with an aperture 80 provided in the outer housing 56. In this manner, the gas pressure present in the annular space 21 is admitted into the sleeve 72 for acting downwardly on the valve stem 60, for a purpose as will be hereinafter set forth. A plurality of bores 82 are provided in the top 76 of the sleeve 72 for exhausting the gas pressure from above the valve stem 60 during the reciprocation thereof. A plurality of circumferentially spaced longitudinal bores 84 are provided in the retainer nut 74 and are in communication with the annular space 86 between the outer housing 56 and sleeve 72. Since the retainer nut 74 is not in sealing engagement with the sleeve 72 there will be sufficient fluid leakage from the ports 82 upon the upward movement of the stem 60 for exhausting pressure from the sleeve, particularly when it is considered that the upward movement of the valve stem is through a relatively short distance. It is preferable that the combined cross sectional area of the bores 84 is larger than the combined cross sectional area of the apertures 78 for a purpose as will be hereinafter set forth.

A suitable coupling member 88 is threadedly secured to the upper end of the outer housing 56 for threadedly coupling an upper tubular housing 90 in longitudinal alignment therewith. The coupling 88 is provided with a centrally disposed longitudinal bore 92 which is preferably of a diameter greater in size than the diameter of the bore 80 of the lower housing 56 for a purpose as will be hereinafter set forth. The upper housing 90 functions as an outer housing for the pilot valve 24.

The pilot valve 24 comprises a pair of longitudinally spaced circular plate members 94 and 96 rigidly secured within the housing 90. Each of the plate members 94 and 96 is provided with a central aperture 98 of substantially the same size and in alignment with the bore 92 of the coupling 88. An inwardly tapering core member 100 of

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a circular cross sectional configuration is secured to the lower plate member 94 and extends upwardly therefrom, as clearly shown in FIGS. 2 and 3. A longitudinal bore 102 in alignment with and of substantially the same size as the aperture 98 extends longitudinally throughout the length of the valve core member 100. The outer diameter of the core 100 is smaller than the inner diameter of the housing 90 for a purpose as will be hereinafter set forth. A similar tapered valve core member 104 is rigidly secured to the upper plate member 96 and extends downwardly therefrom in a direction toward the lower valve core 100. A longitudinal bore 105 extends throughout the length of the core 104 and is in substantial alignment with the bore 102 and apertures 98. It will be apparent from FIGS. 2 and 3 that the core members 100 and 104 do not extend into contact with each other, thereby providing a space 106 therebetween.

The largest end portion of each of the core members 100 and 104 is provided with a substantially straight sidewall 108 and 110, respectively, for receiving a flexible sleeve member 112. The sleeve member 112 is preferably constructed of rubber, and extends between the plate members 94 and 96. The opposed ends of the sleeve member 112 are suitably bonded to the straight portions 108 and 110 of the core members 100 and 104. In this manner, a sealed annular chamber 114 is provided between the sleeve 112 and the housing 90. A suitable loading valve 116, such as a tire valve or the like, extends through the sidewall of the housing 90 and into communication with the chamber 114 for admitting air or a suitable loading gas under pressure into the chamber. The pressure within the chamber 114 may be any desirable load pressure for maintaining the flexible sleeve 112 in a collapsed position as shown in dotted lines in FIG. 3. A collapsed position of the sleeve 112 closes the space 106 for precluding communication between the longitudinal bores 102 and 105, thereby closing the pilot valve 24. It will be apparent that the flexible sleeve 112 will remain in a collapsed position as shown in dotted lines in FIG. 3 for precluding flow of fluid through the pilot valve 24 until the pressure in the bore 102 becomes greater than the load pressure in the chamber 114, as will be hereinafter set forth. Thus, the pilot valve is a normally closed valve.

A flanged sleeve member 118 is threadedly secured in the upper end of the housing 90 for receiving a suitable check valve member 120 therein. The check valve 120 preferably comprises a cage member 122 having a tapered valve seat portion 124 at the lower end thereof. A ball member 126 is disposed within the cage member 122 for resting on the seat 124 to provide a normally closed position for the valve 120. A plurality of apertures or ports 128 are provided on the upper portion of the cage 122 for exhausting fluid from the valve. The flanged sleeve 118 is adapted to be disposed within the enlarged bore 34 of the upper lug 26 for retaining the pilot valve portion 24 therein. A suitable O-ring type packing member 130 is disposed between the outer periphery of the flanged sleeve 118 and the inner periphery of the bore 34 for precluding leakage of fluid therebetween. It will be apparent that communication is established between the underside of the lower plate 94 and the passageway 30 through the longitudinal bores 102 and 105 and the valve 120 when the flexible sleeve 112 is in an expanded position, as will be hereinafter set forth.

Operation

The flow device 20 functions for automatically introducing casing gas pressure into the interior of the well tubing 14, as will now be set forth. The chamber 114 surrounding the flexible sleeve 112 is preloaded at the desired pilot valve pressure. The spring 64 is adjusted to the desired opening tension for the main valve portion 22. After the loading of the chamber 114, the valve 116 may be broken off, as is well known, for precluding escape of the pressure and maintaining the desired pressure within the chamber 114.

Gas or air pressure is introduced into the annular space 21 between the tubing 14 and casing 12 in any well known manner (not shown). The casing gas pressure present within the chamber 21 is usually sufficiently high for opening the lower check valve 44 whereby the pressure acts on the lower portion of the main valve stem 60. Simultaneously, the casing gas pressure enters the port 80 provided in the housing 56 of the main valve 22. The fluid pressure is transmitted through the ports 78 and into the interior of the retaining sleeve 72. The pressure within the interior of the retaining sleeve 72 acts on the upper surface of the valve stem 60, thereby equalizing the pressures acting on the valve stem. It will thus be apparent that the tension pressure in the spring 64 will maintain the valve stem 60 in a lowered position adjacent the valve seat member 58. Thus, the main valve 22 is closed for precluding the flow of the casing gas pressure into the tubing 14. It will be further apparent that the main valve 22 will remain closed until the casing gas pressure increases sufficiently to overcome the load pressure in the pilot chamber 114.

The casing gas pressure flowing through port 80 and into the interior of the housing 56 also flows upwardly through the bores 84 of the retainer nut 74 and is communicated through the bore 92 into the bore 102 of the lower pilot valve core 100. Since the cross sectional area of the bores 84 is greater than the cross sectional area of the bore 80, substantially all of the increased gas pressure will escape through the bores 84 and bore 92 without materially disturbing the pressure acting on top of the valve stem 60. When the casing gas pressure exceeds the load pressure within the pilot chamber 114, the increased pressure will be communicated to the bore 102 for an expanding of the flexible sleeve 112. The expanding of the sleeve 112, as shown in full lines in FIG. 3, thereby removes the restriction of the space 106 and provides communication between the bores 102 and 105. The increased pressure then travels upwardly through the bore 105 and opens the check valve 120 for escaping through the ports 128 thereof. The pressure escaping through the ports 128 will flow through the passageway 30 and through the aperture 32 into the interior of the tubing 14. This pressure will mix with the well fluid within the tubing for facilitating and augmenting the function of the main valve for elevating the fluid within the tubing.

It will be apparent that the increased pressure, or the pressure in excess of the load pressure of the pilot chamber 114 will escape upwardly through the pilot valve. However, since the cross sectional area of the bores 84 is greater than the area of the bores 78, and the area of the bore 92 is greater than the area of the bore 80, all the fluid entering the pilot valve will escape there-through, but the pressure within the housing 56 and acting on the top of the valve stem 60 will remain substantially equal to the load pressure of the pilot valve. Thus, the main valve 22 will open only when the increased acting on the lower portion of the valve stem 60 creates a pressure differential great enough for overcoming the tension in the spring 64. When the casing gas pressure has increased sufficiently for overcoming the spring pressure, the valve stem 60 will move upwardly and away from the valve seat 58, whereby the increased gas pressure will be admitted into the passageway 36 for flowing through the aperture 38 and into the interior of the well tubing 14. The gas admitted into the tubing 14 mixes with the well fluid therein, as is well known, for elevating the fluid to the surface of the well for recovery thereof. It will be apparent that the valve stem 60 travels upwardly a relatively short distance for opening the valve seat 58 and the fluid pressure escaping or exhausting through the bores 82 and between the nut 74 and the upper end 76 of the sleeve 72, combined with any fluid which may escape through the bores 78 and

upwardly through the bores 82 is sufficient to assure efficient operation of the valve.

When the casing gas pressure drops to a pressure substantially equal to or approaching the load pressure in the pilot chamber 114, it will be apparent that the pressures acting on the valve stem 60 will once again be equalized because of the fact that the load pressure is maintained within the housing 56 of the main valve. Thus, the tension of the spring 64 will immediately urge the valve stem 60 downwardly to seat on the valve seat 58 and close the main valve 22. Thus, the main valve is closed slightly before the casing gas pressure actually drops as low as the pilot valve load pressure. A further decrease in the casing gas pressure to a pressure less than the load pressure in the chamber 114 causes the flexible sleeve 112 to contract to a position adjacent the outer periphery of the pilot valve core members 100 and 104 whereby the space 106 will be restricted for precluding the flow of fluid from the bore 102 to the bore 105. The closing of the pilot valve 24 will restore the normal conditions to the flow device 20 and the flow of the casing gas fluid into the tubing 14 will be precluded.

A plurality of the flow valves 20 are provided on the well tubing 14 in a longitudinally spaced disposition, as shown in FIG. 1. It will be apparent that the valves 20 may be set for opening at substantially any desired predetermined casing gas pressure by adjusting the tension of the spring 64 accordingly. All of the valves 20 may be provided with an equal pilot valve load pressure since the opening of the main valve 22 is directly dependent upon the tension pressure of the spring 64. The valves 20 may be so adjusted that the tension of the spring 64 increases from the uppermost valve 20 toward the lowermost valve 20, if desired. Thus, the uppermost valve will open with the least casing gas pressure with each succeeding valve therebelow set or adjusted to open at an increasingly high casing gas pressure, and the lowermost of the valves set for opening at the highest gas pressure. In this manner, an indirect loading of the valves is provided for elevation of the well fluid in the tubing. Conversely, the valves 20 may be adjusted in such a manner that the tension of the spring 64 thereof decreases from the uppermost valve toward the lowermost valve to provide for a direct loading of the valves. In this instance, the lowermost valve 20 will open under the least casing gas pressure and each succeeding valve thereabove will open at an increasingly high pressure, with the uppermost valve opening at the highest casing gas pressure.

By way of summary of operation, the pilot valve 24 and main valve 22 are normally closed for precluding the flow of casing gas pressure into the well tubing 14. The tension of the spring member 64 retains the main valve 22 closed until the casing gas pressure increases sufficiently for overcoming the pilot load pressure and the tension pressure of the spring. When the casing gas pressure has become sufficiently high for opening the main valve 22, the casing gas pressure flow into the well tubing 14 through the passageway 36 and aperture 38 elevates the well fluid therein to the surface of the well bore. The valves 20 may be adjusted for either direct or reverse loading, as desired, by setting the tension of the spring 64 accordingly. The main valve 22 is closed by the tension in the spring 64 slightly before the casing gas pressure falls to the pilot valve load pressure, thereby assuring an efficient and positive operation of the flow valves 20.

Referring now to FIG. 4, a modified pilot valve 132 is depicted therein. The pilot valve 132 comprises an outer tubular housing 134 similar to the housing 90, and adapted for threaded connection to the coupling member 88, as hereinbefore set forth in the preferred embodiment. An annular ring member 136 is suitably rigidly secured within the housing 134 and spaced above the

lower end thereof for receiving an inner sleeve member 138. A centrally disposed transverse partition or plate member 140 is secured within the sleeve member 138. A plurality of circumferentially spaced apertures 142 are provided in the sleeve 138 and spaced slightly below the central partition 140. A plurality of similar circumferentially spaced apertures 144 are provided in the sleeve 138 and are spaced slightly above the partition member 140. A flexible sleeve member 146, similar to the sleeve 112, is disposed around the inner sleeve 138. An annular space 148 is provided between the flexible sleeve 146 and the outer housing 134 for receiving gas or air under pressure from a suitable loading valve or tire valve 150 which extends through the housing 134 and into communication with the chamber 148. The pressure in the chamber 148 retains the flexible sleeve 146 tightly against the outer periphery of the inner sleeve 138 for a purpose as will be hereinafter set forth. A flanged sleeve member 152, similar to the sleeve 118, is threadedly secured to the upper end of the housing 134 and is adapted for disposition within the bore 34 of the upper lug 26 to retain the modified pilot valve 132 therein. A suitable O-ring type sealing member 154 is provided on the outer periphery of the sleeve 152 for precluding leakage of fluid between the sleeve 152 and the bore 34. A suitable check valve 156 is disposed in the sleeve 152 and is provided with exhaust ports 158 for discharge of fluid therethrough. A port 160 is provided in the outer housing 134 below the plate 136 for admitting the casing gas pressure directly into the pilot valve 132.

When the casing gas pressure is less than the load pressure within the chamber 148, the flexible sleeve 146 is held tightly against the outer periphery of the inner sleeve 138 for precluding the flow of fluid through the apertures 142. The partition 140 precludes the upward flow of fluid through the sleeve 138, and thus the main valve 22 will be maintained in a closed position as set forth in the preferred embodiment. However, when the casing gas pressure increases to a pressure above the load pressure in the chamber 148, the fluid will flow through the ports 142 for expanding the flexible sleeve 146 outwardly and away from the inner sleeve 138. Thus, communication is established between the lower ports 142 and upper ports 144. The casing gas pressure will then flow upwardly and through the ports 144 into the upper portion of the sleeve 138, thereby by-passing the partition 140. The pressure of the gas will open the check valve 156 for exhausting the pressure through the ports 158. The pressure flowing out of the ports 158 will enter the passageway 30 for discharge through the aperture 32 into the tubing 14. The opening of the pilot valve 132 will function similarly to the preferred embodiment for permitting the main valve 22 to open for introducing the casing gas into the tubing and elevating the well fluid therein.

The valve 132 may be utilized as a flow device in itself by providing a solid plug member 162 (shown in dotted lines in FIG. 4) at the lowermost end of the housing 134. In this instance, no main valve or other valve is required since the valve 132 may function for automatically admitting the casing gas fluid into the well tubing when the casing gas pressure is in excess of the load pressure within the chamber 148.

Changes may be made in the combination and arrangement of parts as heretofore set forth in the specification and shown in the drawings, it being understood that any modification in the precise embodiment of the invention may be made within the scope of the following claims without departing from the spirit of the invention.

1. In a well flowing device for a well tubing, a valve housing connected to the tubing and having a passageway providing communication between the interior of the housing and said tubing, a main valve disposed in the housing for controlling the flow of fluid through the passageway, a fluid inlet in the housing providing communication between the exterior of the housing and one side

of the main valve, check valve means disposed in the housing and disposed on the opposite side of the main valve with respect to the passageway, said check valve means providing communication between the exterior of the housing and said opposite side of the main valve whereby the pressure across the valve is equalized, resilient means associated with the main valve and holding the same closed relative to the passageway when the pressure across the valve is equalized, a deformable pilot valve disposed within the housing and communicating with the fluid inlet and biased to a closed position, said communication between the fluid inlet and the pilot valve provided by passageway means having a cross-sectional area greater than the fluid inlet, said pilot valve responsive to an increase in fluid pressure through the fluid inlet to cause an expansion thereof into an open position permitting flow of fluid past the pilot valve, and means cooperating between the housing and the tubing for receiving the flow discharged past the open pilot valve, said main valve responsive to an increased pressure through the check valve means sufficient to overcome the pressure of the resilient means to move the main valve upwardly and permit pressure fluid to flow from the exterior of the housing into the tubing.

2. In a well flowing device for a well tubing, a valve housing connected to the tubing and having a passageway providing communication between the interior of the housing and said tubing, a main valve disposed in the housing for controlling the flow of fluid through the passageway, a fluid inlet in the housing providing communication between the exterior of the housing and one side of the main valve, check valve means disposed in the housing and disposed on the opposite side of the main valve with respect to the passageway, said check valve means providing communication between the exterior of the housing and the said opposite side of the main valve whereby the pressure across the valve is equalized, resilient means associated with the main valve and holding the same closed relative to the passageway when the pressure across the valve is equalized, a pilot valve chamber within the housing, a flexible pilot valve disposed in the chamber and communicating with the fluid inlet, said communication between the pilot valve and the fluid inlet provided by passageway means having a cross-sectional area greater than the cross-sectional area of the fluid inlet, said chamber pressure loaded to normally maintain the pilot valve in a closed position, said pilot valve responsive to an increase in fluid pressure through the fluid inlet to cause an expansion thereof into an open position permitting flow of fluid past the pilot valve, and means cooperating between the housing and the tubing for receiving the flow discharging past the open pilot valve, said main valve responsive to an increased pressure through the check valve means sufficient to overcome the pressure of the resilient means to move upwardly and permit pressure fluid to flow from the exterior of the housing into the tubing.

3. In a well flowing device for a well tubing, a valve housing connected to the tubing and having a passageway providing communication between the interior of the housing and said tubing, a main valve disposed in the housing for controlling the flow of fluid through the passageway, a fluid inlet in the housing providing communication between the exterior of the housing and one side of the main valve, check valve means disposed in the housing on the opposite side of the main valve with respect to the passageway, said check valve means providing communication between the exterior of the housing and said opposite side of the main valve whereby the pressure across the valve is equalized, resilient means associated with the main valve and holding the same closed relative to the passageway when the pressure across the valve is equalized, a pilot valve chamber provided in the housing, upper and lower core members disposed in the pilot chamber and having aligned apertures in com-

munication with the fluid inlet, said communication between the core members and the fluid inlet provided by passageway means having a cross-sectional area greater than the cross-sectional area of the fluid inlet, a pilot valve comprising a flexible sleeve disposed in the chamber around the core members, said chamber pressure loaded to maintain the sleeve in a closed position, said sleeve responsive to an increase in fluid pressure through the fluid inlet to cause an expansion thereof into an open position permitting flow of fluid through the chamber, and means cooperating between the housing and the tubing for receiving the flow discharging past the open pilot valve, said main valve responsive to an increased pressure through the check valve means sufficient to overcome the pressure of the resilient means to move upwardly and permit pressure fluid to flow from the exterior of the housing into the tubing.

4. In a well flowing device for a tubing, a valve housing connected to the tubing having a plurality of flow passageways providing communication between the exterior and the interior of the tubing, a main valve disposed in the valve housing for controlling the flow through one of said passageways, said valve having opposite sides thereof exposed to fluid pressure exteriorly of the tubing whereby the pressures across the valve are equalized, resilient means for normally holding said valve in a closed position to preclude flow of fluid through the said one of said passageways, a pilot valve chamber in the housing, upper and lower core members disposed in the pilot valve chamber and having aligned apertures in communication with the exterior of the housing, a pilot valve comprising a flexible sleeve disposed in the chamber around the core members, said chamber pressure loaded to maintain the sleeve in a closed position, means providing communication between the exterior of the housing and one side of the flexible sleeve where an increase in fluid pressure will expand the flexible sleeve to an open position to permit pressure communication through the apertured core members without materially altering the fluid pressure on one side of the main valve, and means cooperating with the apertured core members to provide communication from the housing into the tubing, said main valve responsive to the opening of the pilot valve and increased fluid pressure on the opposite side of the main valve to open and permit fluid flow through the said one of said passageways into the tubing.

5. In a well flowing device for a tubing, a valve housing connected to the tubing having a plurality of flow passageways providing communication between the exterior and the interior of the tubing, a main valve disposed in the housing for controlling the flow through one of said passageways, said valve having opposite sides thereof exposed to fluid pressure exteriorly of the tubing whereby the pressures across the valve are equalized, resilient means for normally holding said valve in a closed position to preclude flow of fluid through the said one of said passageways, a pre-loaded chamber in the housing having a flexible deformable pilot valve disposed therein and maintained in closed position by the pressure force in the pre-loaded chamber, means providing communication between the exterior of the housing and one

side of the flexible pilot valve whereby upon an increase in pressure the pilot valve is moved to an open position to permit communication through the chamber without materially changing the pressure on one side of the main valve, and means cooperating between the chamber and the tubing to provide communication into the tubing, said main valve responsive to the opening of the pilot valve and an increased fluid pressure on the opposite side of the main valve to provide an opening of the main valve permitting fluid flow through the said one of said passageways into the tubing.

6. In a well flowing device for a well tubing, a valve housing connected to the tubing and having a passageway providing communication between the interior of the housing and said tubing, a main valve disposed within the housing for controlling the flow of fluid through the passageway, a fluid inlet providing communication between the exterior of the housing and one side of the main valve, check valve means disposed in the housing on the opposite side of the main valve with respect to the passageway, said check valve means providing communication between the exterior of the housing and the opposite side of the main valve whereby the pressure across the valve is equalized, resilient means associated with the main valve and holding the same closed relative to the passageway when the pressure across the valve is equalized, a pilot valve chamber in the housing, upper and lower cone shaped core members disposed in the chamber and having aligned aperture in communication with the fluid inlet, said communication between the aligned apertures and the fluid inlet provided by passageway means having cross-sectional area greater than the cross-sectional area of the fluid inlet, a pilot valve comprising a flexible deformable sleeve disposed in the chamber around the core members, said chamber pressure loaded to maintain the sleeve in a closed position between the core members, said sleeve responsive to an increase in fluid pressure through the fluid inlet to cause an expansion thereof into an open position providing communication between the apertured core members and permitting flow of fluid from the pilot valve chamber, and means cooperating between the pilot valve chamber and the tubing for receiving the flow discharging therefrom, said main valve responsive to an increase in pressure fluid flow through the check valve for overcoming the pilot load pressure to cause movement of the main valve upwardly against the resilient means to permit flow of fluid into the tubing, and alternately responsive to a reduction of pressure fluid flow through the check valve whereby the spring will close the main valve against flow of fluid into the tubing.

References Cited in the file of this patent

UNITED STATES PATENTS

2,391,605	Walton	Dec. 25, 1945
2,467,150	Nordell	Apr. 12, 1949
2,620,740	Garrett et al.	Dec. 9, 1952
2,651,319	Cummings	Sept. 8, 1953

FOREIGN PATENTS

1,022,192	France	Dec. 10, 1952
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