

Oct. 18, 1966

J. S. PAGE, JR

3,279,545

STORM CHOKE

Filed June 14, 1963

2 Sheets-Sheet 1

FIG. 1.

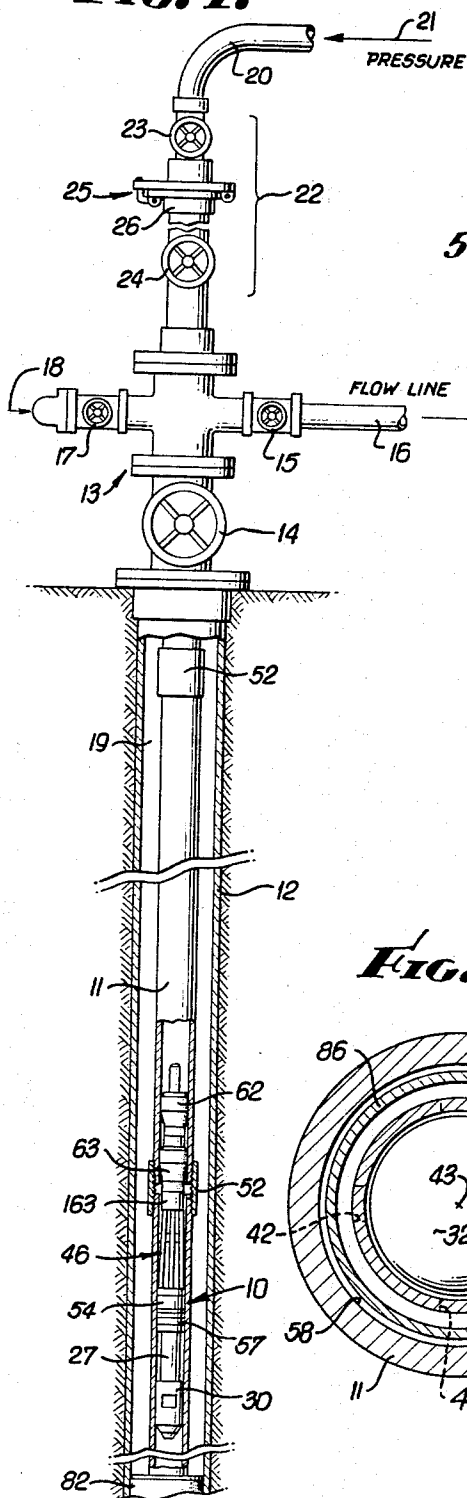


FIG. 4.

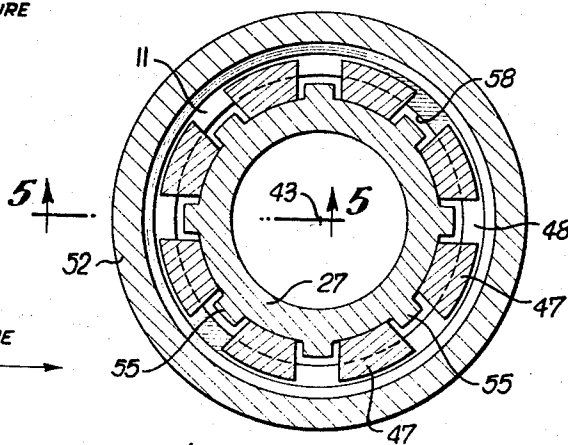


FIG. 5.

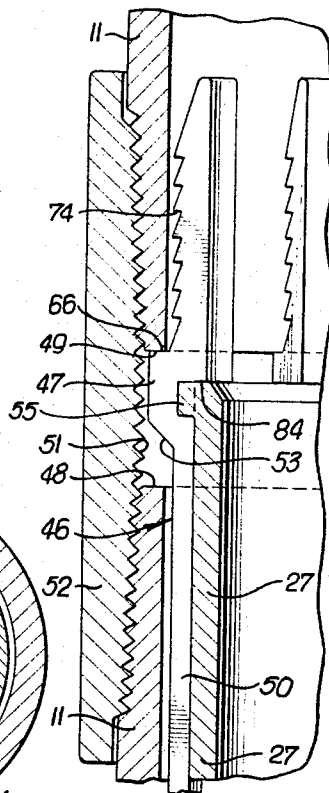
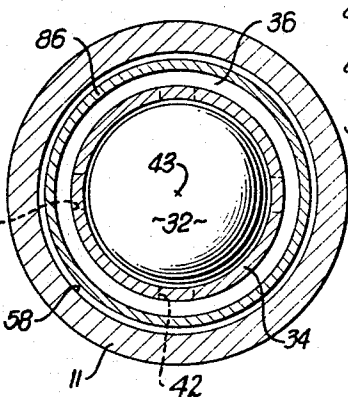


FIG. 6.



INVENTOR.
JOHN S. PAGE, JR.
BY
White & Haefliger
ATTORNEYS.

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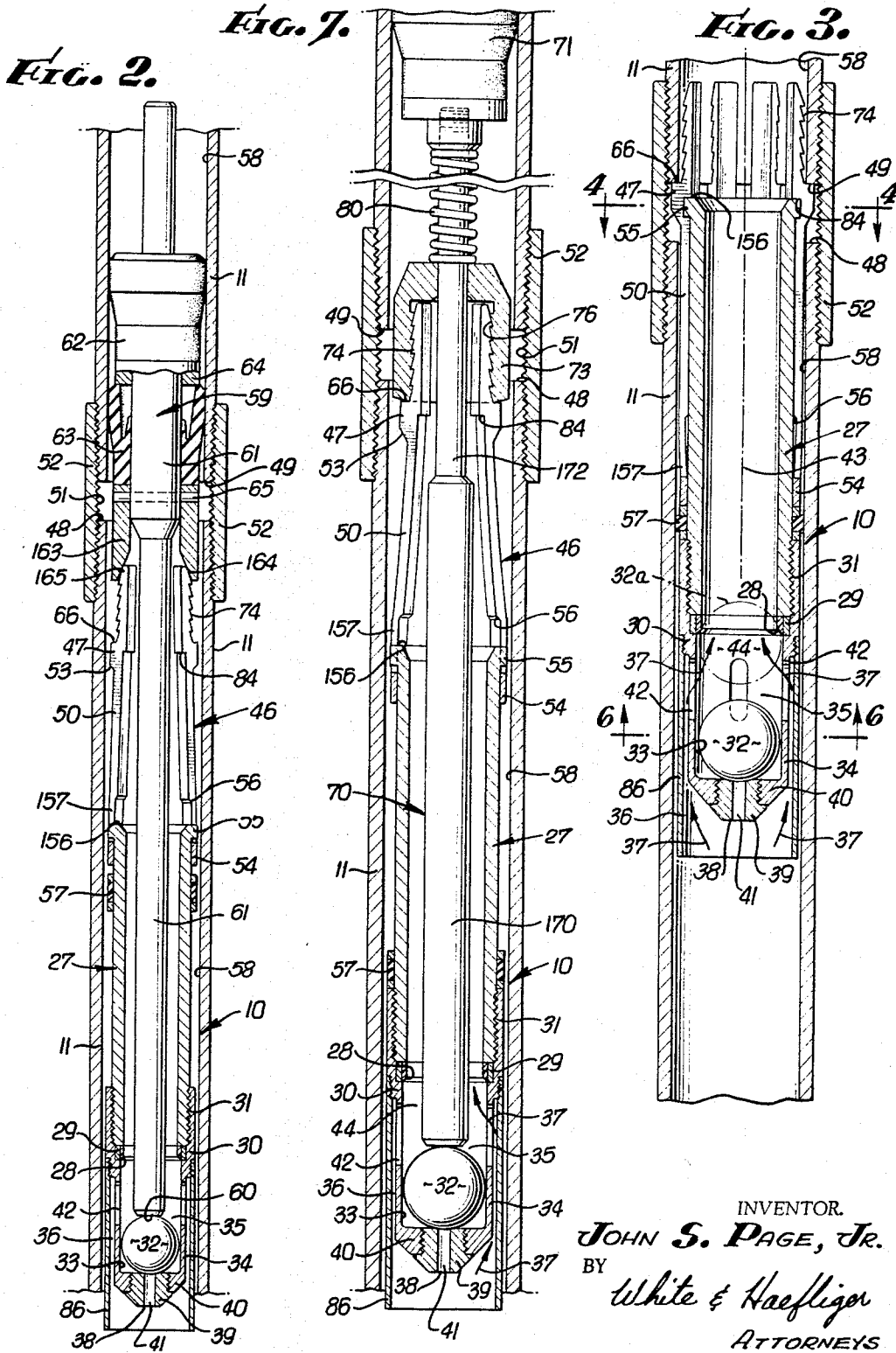
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INVENTOR.
JOHN S. PAGE, JR.
BY *White & Haefliger*
ATTORNEYS

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3,279,545 STORM CHOKE

John S. Page, Jr., 1450 El Mirador, Long Beach, Calif.
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This invention relates generally to fluid pressure responsive valves usable in wells, and more particularly concerns the construction and operation of well pressure responsive valves such as storm chokes characterized as closing off upward flow in tubing when the upward flow rate increases to a value or values within a predetermined range.

It is frequently necessary or desirable to control the upward flow of well fluid, as for example in well tubing, in such manner as to pass the flow when the pressure remains below given levels, and to block such flow upon the occurrence of undesirable flow rate levels. Past devices for accomplishing this control function have in the main lacked that simplicity of operation and construction, and versatility as respects installation and control, which characterize the present invention as will be brought out. For example, certain prior devices require auxiliary pressure lines running downwardly from the surface for communicating operating pressure to the valve at considerable depth, such lines being difficult to run into and out of a well and being subject to breakage with consequent loss of control of the valve. Also, prior devices lack the upward flow passing capacity of the present device, since their structures offer too much resistance to upward flow.

It is a major object of the present invention to provide an improved storm choke having the desirable features mentioned above, and obviating the disadvantages associated with prior well pressure responsive valves of which I am aware. Broadly considered, the apparatus of the present invention comprises an assembly sized for reception and travel in well tubing for controlling the flow of fluid therethrough, the assembly comprising a valve body having a generally annular seat, and a plug carried by the body for bodily movement between a down position in which the plug is spaced below the seat, and an up position in which the plug engages the seat to block upward flow therethrough. The assembly has porting located to by-pass the upward flowing well fluid around the plug in said down position, and also to communicate the flow pressure to upper and lower sides of the plug, the porting being sized to create a flow pressure differential across the plug sufficient to effect upward movement thereof to seat the plug when the upward flow rate reaches a value within a predetermined range. More specifically, the valve body is tubular, and the plug is typically in the form of a ball carried within reduced diameter tubular extent of the valve body directly below the generally annular seat, in the plug down position. In addition, the assembly has relatively high flow capacity first porting located to by-pass the upward flow around the plug in its down position and also to communicate the flow pressure to the upper side of the plug, as well as second porting located to communicate the flow pressure to the lower side of the plug.

Typically, the second porting is formed by a replaceable orifice member detachably carried by the valve body directly below the plug, and the mentioned high flow capacity first porting extends annularly at the outer side of the reduced diameter tubular extent of the valve body receiving the ball in its down position.

Extended to its method aspects, the invention concerns the limiting of upward flow of fluid in partially blocked tubing within a well and at selected depth. The basic steps of the method include inserting in the tubing a pressure differential responsive check valve assembly characterized as bodily movable therein, effecting downward

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flow of fluid in the tubing while restricting said flow downwardly relative to the assembly thereby to produce assembly movement to selected depth, locking the assembly for retention at said depth, and effecting upward flow of fluid in the tubing while maintaining the assembly partially axially blocked and at the same time restricting said flow upwardly through the assembly, thereby to create a pressure differential operable to close the check valve when the upward flow rate reaches a predetermined range. In this regard, the assembly may be considered as complete within itself, capable of operation at any depth within the tubing, the assembly including holding means releasably engageable with tubing terminals in such manner as to allow lowering of the assembly in a tubing string, and to resist raising of the assembly therein. Such holding means typically has latch shoulder structure exposed for engagement with tubing terminals at any desired depth, and in accordance with the invention the valve body has an axially extended position with respect to the holding means in which the latch shoulder structure is inwardly collapsible to allow lowering of the assembly in the string. The valve body also has an axially retracted position with respect to the holding means and in which the shoulder structure is displaced outwardly for latching engagement with a tubing terminal, at any desired well depth, to resist raising of the assembly in the string.

Further as respects installation of the valve assembly in a string of tubing remaining in place in the well, restriction of the downward flow to produce assembly movement to desired depth may be carried out as by inserting a downward fluid pressure responsive ram in the tubing above the assembly, in order to displace the latter downwardly. Thereafter, the ram may be lifted upwardly away from the assembly as by effecting flow of fluid upwardly through the assembly and against the ram. Also, the locking step is typically carried out by latching the assembly to the tubing at a selected terminal thereof, and collapsing the assembly axially to block unlatching of the assembly from the tubing. Finally, the method of retrieval of the assembly includes the further steps of extending the collapsed assembly axially to permit unlatching thereof from the tubing, and effecting sufficient upward flow of fluid in the tubing to raise the assembly by upward fluid pressure exertion thereagainst.

These and other objects and advantages of the invention, as well as the details of an illustrative embodiment, will be more fully understood from the following detailed description of the drawings, in which:

FIG. 1 is a vertical elevation sectioned and broken away in part to show the use of one form of valve assembly contemplated by the invention in a string of production tubing, together with installation and retrieval equipment at the well head;

FIG. 2 is an enlarged vertical elevation showing a method of installing the valve assembly downwardly in and through tubing;

FIG. 3 is a further enlarged vertical section showing the installed valve assembly including the interior construction thereof;

FIG. 4 is an enlarged section taken on line 4—4 of FIG. 3;

FIG. 5 is an enlarged fragmentary vertical section taken on line 5—5 of FIG. 4;

FIG. 6 is a horizontal section taken on line 6—6 of FIG. 3; and

FIG. 7 is an enlarged vertical section showing the valve assembly in condition for upward retrieval from operating position in the tubing.

Referring first to FIG. 1, the valve assembly 10 constructed in accordance with one form of the invention, as will be described, is shown being displaced down-

wardly within a production tubing string 11 which extends within well casing 12. The latter extends upwardly to the well head where it mounts the control equipment generally designated at 13. Such equipment includes a main valve 14 for controlling the upward flow through the tubing, a production flow control valve 15 in line 16, and an inlet flow control valve 17 through which fluid may be pumped at 18 to the annular space 19 within the well and outside the tubing 11. For example, fluid may be pumped into space 19 in order to effect upward flow within the string 11, for purposes as will be brought out.

The assembly 13 also includes a flexible line 20 through which fluid pressure may be pumped at 21 downwardly into the string 11 via the intermediate structure generally designated at 22. The latter includes shut-off valves 23 and 24 at opposite sides of a releasable coupling 25 through which access may be had to the interior of the conduit 26 in order to insert and remove the tools as will be described, such apparatus including the valve assembly 10.

Referring now to FIG. 3 wherein the valve assembly is shown in installed position at selected depth, the assembly is seen to include a tubular valve body 27 having a generally annular seat 28. The latter may be located within a carrier ring 29 held at the lower terminal of the body 27 by a tubular retainer 30 having threaded connection at 31 to the body. A plug is carried for bodily movement between a down position in which the plug is spaced below the seat, and an up position in which the plug engages the seat to prevent upward flow there-through. In the form of the invention shown, the plug comprises a metallic ball 32 shown in full lines in its down position, the broken lines 32a indicating the up position of the plug in which it engages the non-metallic, and typically plastic seat 28 to block upward flow through the body 27. The ball plug is received within the bore 33 formed by the reduced diameter lower tubular extent 34 of the body 27, the bore opening upwardly at 35 for passing the ball between its up and down positions.

The assembly 10 also has porting located to by-pass the upward flowing well fluid around the plug in its down position, and to communicate the flow pressure to upper and lower sides of the plug, the porting being sized to create a flow pressure differential across the plug sufficient to effect upward movement and seating thereof when the upward flow rate reaches a value within a predetermined range. In the illustrated embodiment, first porting designated at 36 is located to by-pass the upward flowing well fluid around the plug, as indicated by the arrows 37 in FIG. 3, and also to communicate the flow pressure to the upper side of the plug within the bore 33. Also, second porting designating generally at 38 is located to communicate the upstream flow pressure to the lower side of the plug in the bore 33, the latter receiving the ball in such manner as to facilitate creation of desired pressure differential. In the latter regard, the porting 36 and 38 is sized in such relation as to create pressure differential conditions across the plug sufficient to effect upward movement thereof to the position 32a when the upward flow rate reaches a value within a predetermined range.

As illustrated in FIG. 3, the second porting 38 is formed in a nipple type orifice member 39 threaded into the lower end 40 of the valve body, porting 38 including an entrance 41 opening at the bottom surface of the nipple, which tapers downwardly. First porting 36 is generally annular at the exterior of the valve body tubular extent or cage 34, the latter being integrally connected to the main upper portion of the valve body and forming openings 42 better seen in FIG. 6, which are circularly spaced about the axis 43 of the valve body. As is clear from FIG. 3, the annular port 36 communicates with the lower end of the valve body and through openings 42 to the space 44 directly below the seat and above the ball plug 32 in down position. Finally, the bore of cage 34

acts to guide the ball as it travels between its up and down positions. A skirt 86 threaded to the valve body surrounds the ports 36 and prevents abrasive cutting of the tubing by the upward flow through said port.

Extending the description to FIGS. 2 and 5, the assembly 10 includes holding means in the form of a collet generally indicated at 46, which is releasably engageable with tubing terminals to allow lowering of the assembly in the tubing string 11 and to resist raising of the assembly therein. Typically, the holding means includes a series of latches 47 exposed for engagement with tubing terminals as indicated at 48 and 49. In this regard, the holding means is also seen to include outwardly urged spring fingers 50 carrying the latches 47 and projecting generally axially opposite the upper end of the body 27 in FIG. 2 during downward travel of the assembly within tubing. In this configuration, the fingers 50 urge the latches 47 outwardly to ratchet into and out of the grooves 51 formed between the terminals 48 and 49 of successive tubing stands coupling together by collars 52 as shown in FIG. 5, the tapered lower shoulders 53 of the latches camming against and over the terminals 48.

The holding means or collet 46 previously mentioned also includes a carrier for the spring fingers 50, the carrier being attached to the valve body so as to allow relative axial movement of the holding means and body. In the example shown, the carrier 54 is in the form of a ring extending about the body directly below body flanging 55. A connection is provided between the holding means and body and is characterized as forcibly releasable or detachable in response to sufficient exertion of lifting force tending to raise the body relative to the carrier at times when lifting of the holding means is resisted, as for example by latching thereof to the tubing. One such connection is shown at 56 in the form of inward facing detent shoulders on the spring fingers 50 and spaced above the upper terminal lip 156 of the body 27 in FIGS. 2 and 7.

Upon sufficient lifting force exertion by the body, with upward travel of the holding means 46 prevented, the lip 156 will cam the detent shoulders 56 outwardly, as permitted by flexing of the lower extents 157 of fingers 50, to allow relative axial collapsing of the body from the lower or extended position as shown in FIG. 2 to the upper or collapsed position shown in FIG. 3. During collapsing movement the carrier 54 lands on the ring seal unit 57 which in turn lands on the upper end of the retainer 30 as seen in FIG. 3, thereby to further energize the seal. Collapsing movement ceases when upper terminal 156 lands against stop shoulder 84 on holding means 46. In this regard, the unit 57 seals off between the periphery of the valve body 27 and the bore 58 of the tubing 11, in all positions of the valve body relative to the holding means 46.

Referring back to FIG. 2, fluid pressure responsive means is provided for engagement with the assembly, displacing it downwardly within the well tubing, such means typically including a ram generally indicated at 59 and having a lower terminal 60 contacting the ball plug 32. The ram includes an elongated rod 61 projecting downwardly into the assembly 10 from an upper zone at which the ram carries upper and lower sealing cups 62 and 63, suitable attachment to the ram being provided at 64 and 65. The packing cups are adapted to be fluid pressure activated for sealing off against the tubing bore 58, and in this regard downward fluid pressure exertion on the cups results in downward displacement of the assembly 10 to selected position within the tubing. The main downward thrust is transmitted by the ram to the assembly 10 through a pusher 163 on the rod 61 and having a lower lip 164 engaging the upper terminals 165 of the holding means 46, and urging them inwardly sufficiently to help the latches 47 cam over the tubing terminals 48.

Upon arrival of the assembly 10 at selected depth accompanied by reduction of downward fluid pressure

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against ram 59, the latches 47 spring outwardly into the groove 51 as seen in FIG. 5 whereby upward displacement of the holding means 46 is prevented by engagement of the latch upper shoulder 66 with the lower terminal 49 of the upper tubing stand shown. Thereafter, fluid flow may be effected upwardly through the assembly 10 to lift the ram 59 away from the assembly 10, the ram being retrievable through the coupling 25 seen in FIG. 1. When the upward fluid flow rate is increased sufficiently, the ball 32 will seat at 28 and collapse or retract the valve body 27 upwardly relative to the holding means 46 and to the position shown in FIG. 3. Under these circumstances, the spring fingers 50 become blocked against inward collapse by the periphery of the valve body 27, whereby inadvertent unlatching of the assembly from retention within the tubing is assured. The valve assembly may then be operated in the tubing for as long as desired to control the upward flow of fluid therein, blocking such flow when it increases to a level or value within a predetermined range.

The invention also provides for retrieval of the valve assembly 10 as by upward displacement thereof to the coupling 25 for removal, inspection and replacement if necessary. In order to effect such retrieval, the valve assembly is first unlocked from the position shown in FIG. 3. For this purpose, the valve body 27 is downwardly extended from collapsed condition as for example by inserting a plunger into the tubing 11 and pumping it downwardly to a position where the plunger lands on the ball 32 in down position. A typical plunger is shown at 70 in FIG. 7 as having a peripheral sealing cup 71 contacting the bore of the tubing 11 and a rod 170 contacting ball 32, whereby continued downward pressure exertion against the plunger extends the valve body with respect to the holding means 46, and to the position shown in FIG. 7.

The assembly 10 is simultaneously unlatched from the tubing in order to prepare it for upward displacement and retrieval with the plunger. For this purpose, a tubular gripping member such as is shown at 73 in FIG. 7 is carried for axial movement along the plunger rod reduced diameter extent 172 and is urged downwardly by a spring 80 to forcibly endwise engage the upper terminal connections 74 integral with the spring fingers 50. As the plunger is forced downwardly, the compression in spring 80 increases sufficiently so that when the latches cam inwardly as caused by downward movement of the plunger the gripper 73 suddenly releases downwardly to further collapse the connections 74 and the latches 47 inwardly to traveling position shown in FIG. 7. Suitable gripping connection between the member 73 and the connections 74 is provided, by the mutually interengaged serrations 76 thereon. Finally, fluid is caused to flow upwardly through the assembly 10, creating force lifting the plunger and the entire assembly 10 by which it may be upwardly removed or retrieved from the tubing. In this regard fluid may be pumped at 18 to the annulus 19 for downward flow through packer 82 and then back up through tubing 11.

I claim:

1. An assembly sized for reception and axial travel in stationary well tubing for controlling the flow of fluid therethrough, said assembly comprising a tubular valve body having a generally annular seat, a ball plug freely carried by the body for bodily movement between a down position in which the plug is spaced below the seat and an up position in which the plug engages the seat to block upward flow therethrough, the body having a bore receiving the ball plug in said down position and opening upwardly to direct the ball upward movement toward the seat, the assembly having support structure underlying the plug in down position and first porting located to by-pass the upward flowing well fluid around the plug in said down position and also to communicate the flow pressure to the upper side of the plug in said bore, and sec-

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ond porting located to communicate the flow pressure to the lower side of the plug in said bore, said porting being sized to create a flow pressure differential across the plug sufficient to effect upward movement thereof to seat the ball plug when the upward flow rate reaches a value within a predetermined range, the assembly including holding means releasably engageable with tubing shoulders to allow lowering of the assembly in a tubing string and to resist raising of the assembly therein, the valve body and plug during said travel in the tubing being carried by said holding means, said support structure including an orifice member forming said second porting below the plug, the valve body having reduced diameter tubular extent forming said bore, said first porting being at the outer side of said tubular extent, said body also having a skirt extending about said first porting.

2. An assembly sized for reception and axial travel in stationary well tubing for controlling the flow of fluid therethrough, said assembly comprising a tubular valve body having a generally annular seat, a ball plug freely carried by the body for bodily movement between a down position in which the plug is spaced below the seat and an up position in which the plug engages the seat to block upward flow therethrough, the body having a bore receiving the ball plug in said down position and opening upwardly to direct the ball upward movement toward the seat, the assembly having support structure underlying the plug in down position and first porting located to by-pass the upward flowing well fluid around the plug in said down position and also to communicate the flow pressure to the upper side of the plug in said bore, and second porting located to communicate the flow pressure to the lower side of the plug in said bore, said porting being sized to create a flow pressure differential across the plug sufficient to effect upward movement thereof to seat the ball plug when the upward flow rate reaches a value within a predetermined range, the assembly including holding means releasably engageable with tubing shoulders to allow lowering of the assembly in a tubing string and to resist raising of the assembly therein, the valve body and plug during said travel in the tubing being carried by said holding means, said holding means having latch shoulder structure exposed for engagement with tubing shoulders, said valve body having an axially extended position with respect to said holding means in which said shoulder structure is collapsed to allow lowering of the assembly in a tubing string, and an axially retracted position with respect to said holding means in which said shoulder structure is displaced outwardly for latching engagement with a tubing terminal to resist raising of the assembly in the string, said holding means including outwardly urged spring fingers carried for telescopic displacement relative to said body between said extended position in which the fingers project generally axially opposite one end of said body and said retracted position in which the fingers are blocked against inward collapse by the periphery of said body.

3. The invention as defined in claim 2, in which said spring fingers project upwardly with respect to said body and have upper terminal connections adapted to be grasped by a tool acting to collapse the fingers for axial travel within the tubing.

4. The invention as defined in claim 2, in which said assembly includes a ring seal carried by said body for sealing off between the body periphery and the tubing bore above the level of said seat, the seal being movable axially of the body in response to displacement of the valve body from said extended to said retracted positions relative to said holding means.

5. The invention as defined in claim 2, in which said assembly includes detent means for yieldably resisting displacement of the valve body from said extended to said retracted positions relative to said holding means.

6. The invention as defined in claim 2, in which said holding means includes a carrier for said spring fingers

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and attached to the valve body in the tubing string, and a connection between the holding means and body characterized as limiting upward displacement of the body relative to the holding means and as detachable in response to sufficient exertion of lifting force tending to raise the body relative to said carrier at times when lifting of the holding means is resisted.

7. The invention as defined in claim 6, in which said connection comprises spring finger carried shoulder extending facing the upper terminal end of said body in said body extended position.

8. The invention as defined in claim 2, including a tubing string in which said assembly is received, the tubing having terminals along the string and annular spaces endwise of and adjacent said terminals, said shoulder structure being in one of said spaces.

9. The invention as defined in claim 2 including fluid pressure responsive means engageable with the assembly for displacing the assembly within well tubing.

10. The invention as defined in claim 2 in which said spring fingers project upwardly with respect to said body and have upper terminal connections, and a plunger unit having a part extending telescopically downwardly over said connections and acting to collapse them inwardly to allow axial travel of said insert in said bore, the body then being in said axially extended position.

11. The invention as defined in claim 10 in which said plunger includes a downward projection engageable with the ball plug to displace said body relative to said holding means and to said extended position.

12. The invention as defined in claim 10 in which said plunger unit includes yieldable means for transmitting force acting to urge said part against the upper terminal of said holding means to help urge the latches out of engagement with a tubing terminal.

13. An assembly sized for reception and axial travel in stationary well tubing for controlling the flow of fluid therethrough, said assembly comprising a tubular valve body having a generally annular seat, a ball plug freely carried by the body for bodily movement between a down position in which the plug is spaced below the seat and an up position in which the plug engages the seat to block upward flow therethrough, the body having a bore receiving the ball plug in said down position and opening upwardly to direct the ball upward movement toward the seat, the assembly having support structure underlying the plug in down position and first porting located to bypass the upward flowing well fluid around the plug in said down position and also to communicate the flow pressure to the upper side of the lug in said bore, and second porting located to communicate the flow pressure to the lower side of the plug in said bore, said porting being sized to create a flow pressure differential across the plug sufficient to effect upward movement thereof to seat the

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ball plug when the upward flow rate reaches a value within a predetermined range, the assembly including holding means releasably engageable with tubing shoulders to allow lowering of the assembly in a tubing string and to resist raising of the assembly therein, the valve body and plug during said travel in the tubing being carried by said holding means, and including fluid pressure responsive means with a ram having a lower terminal engageable with said ball plug for displacing the assembly downwardly within well tubing, said means also having fluid pressure activated sealing structure for sealing off against the tubing bore.

14. For use in retrieving a valve assembly sized for reception and travel in stationary well tubing to control the flow of fluid therethrough, the assembly comprising a valve body having a generally annular seat, a plug carried by the body for bodily movement between a down position in which the plug is spaced below the seat and an up position in which the plug engages the seat to block upward flow therethrough, and holding means supporting said body and including upwardly projecting and outwardly urged spring fingers having latches and upper terminal connections, the improvement that comprises a plunger unit having a part extending telescopically downwardly over said connections and acting to collapse them inwardly to allow axial travel of the valve assembly in the tubing, said plunger unit including a downward projection engageable with the plug to hold the plug in said down position when said part extends telescopically over said upper terminal connections of the fingers, and yieldable means mounted on the plunger unit for transmitting force acting to urge said part against the upper terminals of said holding means to help urge the fingers and latches inwardly.

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CHARLES E. O'CONNELL, *Primary Examiner.*

I. A. CALVERT, J. A. LEPPINK, *Assistant Examiners.*