

May 22, 1962

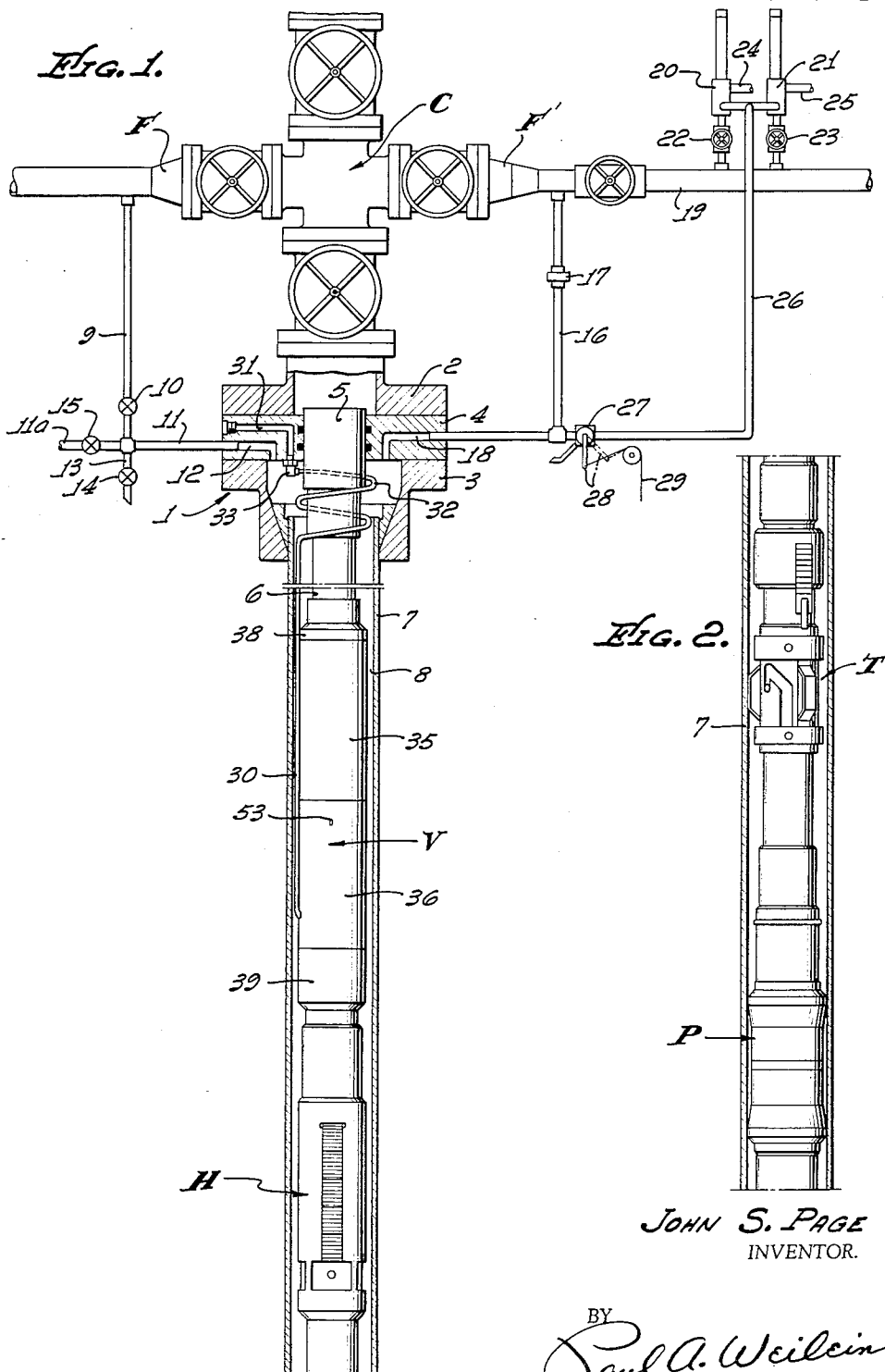
J. S. PAGE

3,035,641

DOWN TUBING SELF-CLOSING FLOW CONTROL VALVE

Filed Nov. 15, 1957

3 Sheets-Sheet 1



May 22, 1962

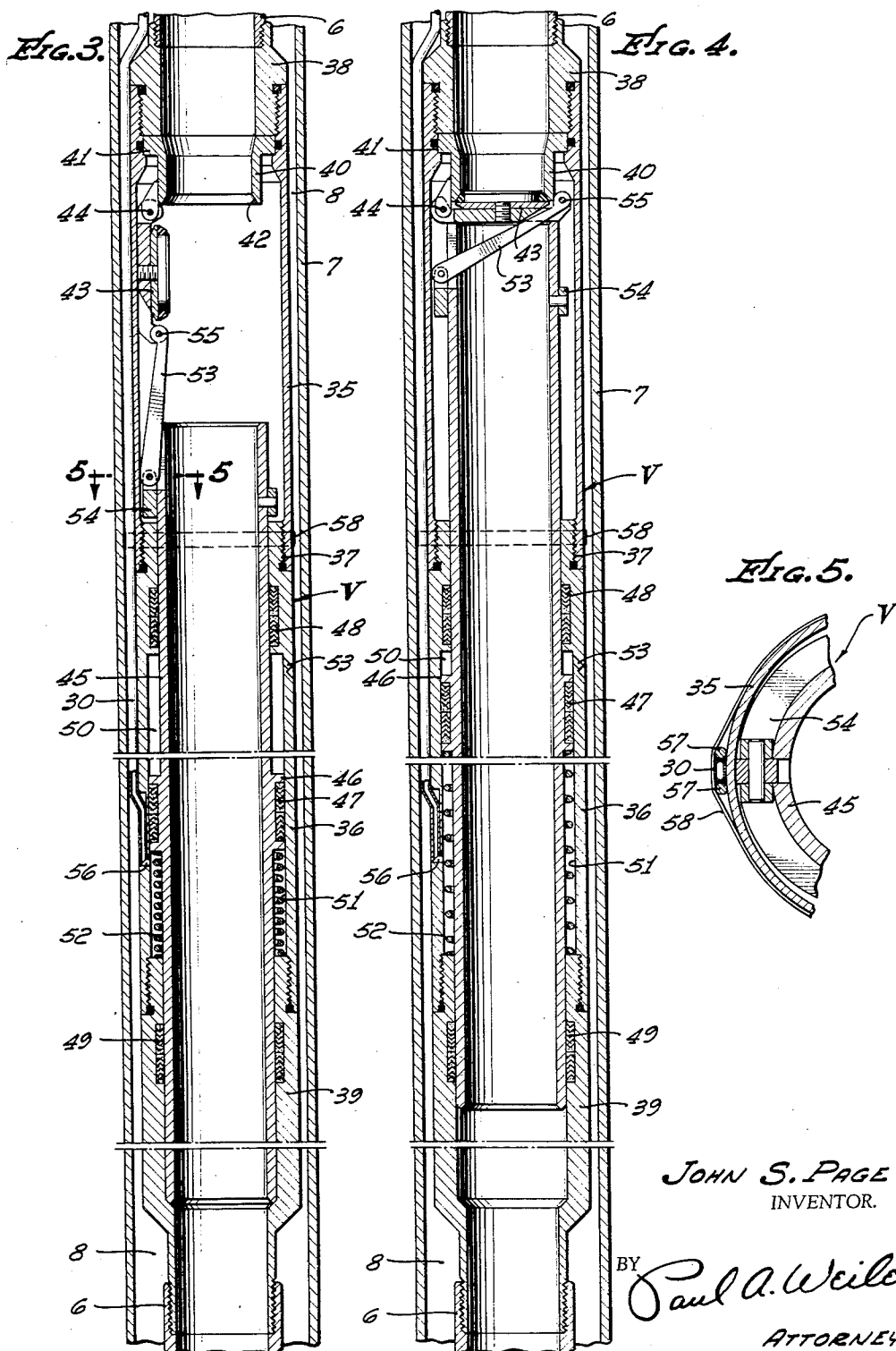
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DOWN TUBING SELF-CLOSING FLOW CONTROL VALVE

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3 Sheets-Sheet 2



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3,035,641

DOWN TUBING SELF-CLOSING FLOW CONTROL VALVE

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8 Claims. (Cl. 166—72)

The present invention relates to well flow control means and more particularly to a novel and improved valve adapted to be installed in tubing down in the well for controlling the flow of fluid therefrom according to an improved method.

Heretofore, valves have been provided for installation in production tubing in an oil well, such valves being responsive to the flow of production fluid through the valve for closing the valve upon certain occurrences. In my copending application, Serial No. 669,043, filed July 1, 1957, there is disclosed a novel method, as well as an improved apparatus, for automatically shutting off the flow of production fluid through tubing, such method contemplating interposing in the tubing string a fluid pressure operated valve and packing off the annulus above and below the valve, while admitting fluid under pressure into the packed off annulus space corresponding to the production fluid pressure flowing through the tubing. In accordance with the above identified method, the valve is automatically closed if the well head should become disrupted and perhaps blown off the casing or knocked therefrom by collision of some object therewith, or upon collision of some object with a platform such as an offshore barge, or even upon excessive tubing flow pressure or an unsafe reduction in tubing flow pressure, as well as manually. The method and apparatus of that application are ideally suited for wells where flow pressure is substantial.

However, in certain sections of the oil producing world, there are wells which will produce a fairly high volume of fluid, but at comparatively low flow pressures which cannot be relied upon to effect valve actuation such as can be done in a high pressure well.

A primary object of the present invention, therefore, is to provide a well flow control valve which is self-closing, that is, one which does not rely upon flow pressure to effect operation thereof, but which is automatically self-operating under certain conditions which will hereinafter more fully appear.

Another object is to provide a well flow control method, including a valve in accordance with the preceding objective, wherein production tubing is hung within well casing from a point spaced substantially downwardly from the well head, the space above the tubing-supporting means being provided with a packer, and the valve aforementioned being disposed in the tubing string above said packer. In accordance with the invention, the system is such that the annulus above the packer is filled with a fluid such as sweet oil, and such sweet oil is subjected to the pressure of the production fluid passing through the Christmas tree at the well head. The valve is so constructed and arranged that nominal pressures, say on the order of about 15 p.s.i. are effective to maintain the valve open so that fluid is free to continue flowing through the tubing, but upon the removal of such flow pressure from the sweet oil in the annulus, the valve will automatically close so as to prevent production of the well.

In accordance with the preceding objective, it is a further object to provide a valve which is spring-loaded to a closed position, and which is fluid pressure actuated to an open position, whereby, in a system as just referred to above, the sweet oil in the annulus will serve to sub-

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stantially offset the effect of the spring, and only nominal pressure in addition to the hydrostatic head of sweet oil is necessary in order to effect opening of the valve against the spring.

Briefly stated, the invention contemplates the provision of a fluid pressure operated valve including an axially movable sleeve disposed within an elongated hollow valve housing, and said sleeve and said housing defining therebetween an actuator cylinder adapted to be subjected to fluid pressure so as to shift the sleeve in one direction, movement of said sleeve in said one direction being resisted by a spring disposed between the sleeve and the valve housing, the spring being engaged with a member constituting the piston of the fluid pressure operated actuator means, and the valve including means for venting the side of the assembly in which the spring is disposed to the atmosphere, whereby the spring is the sole force tending to resist opening movement of the valve sleeve responsive to fluid pressure. In such a construction, the spring may be calibrated so as to exert a valve sleeve shifting force which is just short of adequate force to counterbalance the hydrostatic head of sweet oil in the packed off annulus section in a system as referred to above, and the spring loaded side of the piston may readily be vented to the atmosphere through a tube communicating with the space between the sleeve and the valve housing and extending upwardly through the annulus to the atmosphere at the well head.

Other objects and advantages of the invention will hereinafter be described or will become apparent to those skilled in the art, and the novel features thereof will be defined in the appended claims.

In the accompanying drawings:

FIG. 1 is a view partly in elevation and partly in section showing well head equipment associated with well casing and production tubing, and showing in the tubing a valve made in accordance with the invention, together with means for holding down the tubing in the casing;

FIG. 2 is a downward extension of FIG. 1 showing a hookwall tubing anchor as illustrative of one means for supporting the tubing in the casing at a point substantially beneath the well head, and showing a packer beneath the hooked wall tubing;

FIG. 3 is an enlarged fragmentary view in section as taken axially through an illustrative valve for use in the present invention, said valve being in a full open position;

FIG. 4 is a view of the valve of FIG. 3 showing the same in a closed position;

FIG. 5 is an enlarged fragmentary view in section as taken on the line 5—5 of FIG. 3;

FIG. 6 is a view in axial section as taken through another type of valve suitable for use in accordance with the invention, this valve being shown in an open condition;

FIG. 7 is a view of the valve in FIG. 6 showing the same in a closed condition; and

FIG. 8 is an enlarged fragmentary view in section as taken on the line 8—8 of FIG. 6.

Like reference characters in the several views of the drawings and in the following detailed description designate corresponding parts.

Referring first to FIGS. 1 and 2, there is shown a Christmas tree C having flow lines F and F' extending therefrom. The Christmas tree C is mounted upon a casing head assembly 1 including an upper section 2 and a lower section 3 interconnected with a tubing landing flange 4 therebetween, the landing flange 4 having an opening therethrough in which is disposed a landing sub 5 from which depends a string of tubing 6 into well casing 7, with an annulus 8 defined therebetween as is customary. It will be noted that in the assembly as shown, the landing sub 5 extends through the landing flange 4

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so that the landing flange acts as a barrier separating the normal flow opening through the landing sub 5 from the annulus 8 between the tubing and the casing.

The flow line F, however, is in communication with the annulus 8 through a line 9 having a valve 10 therein and communicating with a line 11 which is tapped into the landing flange 4, the latter having a passage 12 there-through for establishing communication between the line 11 and the annulus 8 as is clearly illustrated. The lines 10 and 11 are preferably vented through a vent 13 under the control of a valve 14 and the line 11 is also provided with an extension 11a having a valve 15 therein whereby fluid under pressure may be initially supplied from a source (not shown) so as fill the casing annulus 8 with sweet oil for a purpose which will hereinafter be more fully described.

The flow line F' is also in communication with the annulus 8 through a line 16 preferably having an orifice union 17 therein, said line 16 extending into and being tapped into the landing flange 4 in communication with a passage 18 for establishing communication between the line 16 and the annulus 8 and an extension 19 of flow line F', having over and under pressure valves 20 and 21 respectively connected therewith through valved couplings 22 and 23 respectively. These over and under pressure valves 20 and 21 constitute relief valves and are adapted to be vented to the atmosphere through vents 24 and 25, whereby in the case of excessive pressure in the flow line F or in the case of an undue reduction in pressure therein, the vents 24 and 25 will respectively be connected with a vent line 26 communicating with the line 16 previously referred to. In addition, a further vent valve 27 may be installed in the line 26 or elsewhere in the system, particularly in those instances where the well head assembly as herein shown is adapted to be employed on an offshore rig. The valve 27 is adapted to be actuated through a lever 28 which is connected to a line or cable 29, the latter being adapted for operation by a trip line, as is more particularly described and claimed in my copending application above referred to.

Accordingly, it will be noted that sweet oil in the annulus 8 will be subjected to production fluid pressure from either or both of the flow lines F and F' as long as valves 14 and 15 are closed, valve 10 is open, and vents 24, 25 and 27 are inoperative.

Installed in the tubing string 6 is a valve assembly generally designated V, in accordance with the invention. This assembly, for a purpose which will hereinafter more fully appear, includes a vent tube 30 extending from the valve assembly V upwardly through the annulus 8 into communication with a passage 31 through the landing flange 4 and thence to the atmosphere. The tube 30 is preferably spiralled about the upper end of the tubing string 6 and the landing sub 5 through a suitable number of turns as at 32 and is connected to the landing flange 4 with a fitting 33. The spirals 32 in the line or tube 30 enable the landing flange 4 to be lifted axially from the landing sub 5 and to be reinstalled thereon.

Beneath the valve assembly V and the tubing string 6 is an appropriate hold-down device H which may be of either the mechanical or hydraulically operated type. The device generally illustrated in FIG. 1 is of the hydraulically operated type as exemplified in United States Patent No. 2,658,459, dated November 10, 1953, to J. S. Page, and United States Patent No. 2,603,292, dated July 15, 1952, to J. S. Page. The hold-down H will serve to prevent jacking up of the entire tubing string when the valve V is closed thus completely trapping in the tubing pressure tending to cause flow of fluid therethrough.

Referring to FIG. 2 there is shown a conventional hookwall tubing anchor T, this anchor being illustrative of a means for supporting the tubing within the casing at a point spaced substantially downwardly from the well head. Such a tubing anchor is well known in the field and manufactured by Page Oil Tools, Inc. of Long Beach, California, as their model No. HW845.

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Disposed beneath the wall anchor T in the tubing string 6 is a two-cup packer P which is also a conventional oil tool which is manufactured by the above identified Page Oil Tools, Inc., as model No. CP845.

The hold down H, the tubing anchor T and the packer P are all conventional elements which as pointed out above are well known, and therefore these elements need no further description herein.

Passing now to FIG. 3, there is shown one form of valve embodying the present invention.

The valve V comprises an elongated hollow housing composed of upper and lower sections 35 and 36, respectively, threadedly inter-connected as at 37, the upper housing section 35 being threaded or otherwise suitably connected to a coupling member 38 adapted to be connected in the tubing string 6, while the lower housing section 36 is threadedly connected to a coupling member 39 adapted to be connected to the tubing string. A valve seat member 40 is provided, this member preferably having a flange 41 secured between opposing portions of the coupling 38 and a shoulder on the upper housing section 35. The seat member 40 provides an annular tapered seat 42 with which is engageable a tapered gate valve 43 which is pivotally connected to the seat member 40 as at 44 for movement into engagement with the seat 42 from the position shown in FIG. 3, that is, a full open position so that the valve 43 offers no obstruction to the passage of wire line tools or the like downwardly through the valve housing.

Means are provided for operating the valve gate 43, and in this connection an axially shiftable valve actuator sleeve 45 is shiftable disposed within the valve housing and includes intermediate its ends a radial collar 46 having an annular depression therein in which are disposed a suitable number of chevron packings 47 for effecting sealing engagement with the inner periphery of the valve housing 35. In addition, seals or chevron packings 48 are provided adjacent the upper end of the sleeve 45 while additional seals or chevron packings 49 are provided adjacent the lower end of the sleeve 45. As illustrated, the packings 48 and 49 are disposed in the housing section 36. Thus, between the seal 48 and the seal 47, as well as between the seal 49 and the seal 47, there is provided a pair of chambers 50 and 51 respectively. Interposed in the chamber 51 and normally tending to shift the sleeve 45 axially toward the seat member 40 is a coiled compression spring 52. The chamber 50 is provided with one or more ports 53 for admitting fluid from the annulus 8 into the chamber 50 for shifting the sleeve 45 against the bias of the spring 52.

Accordingly, it will be noted that the pressure in the annulus tends to shift the sleeve 45 in a direction away from the valve seat member 40. Since the sleeve 45 is interconnected with the valve gate 43, through an actuator link 53, which is pivotally connected to a collar 54 on the sleeve 45 and is pivotally connected to the valve member 43 at 55, when pressure in the chamber 50 is sufficient to overcome the spring 52, the valve assembly will be maintained in the position shown in FIG. 3. In order to enable a predetermined control of valve actuation, that is, in order to prevent interference of fluid pressure in the chamber 51 with downward movement of the sleeve 45, the chamber 51 is vented through a port 56 and through the tube 30 previously described, so that the chamber 51 is subjected to only atmospheric pressure through the tube 30. In order to secure the tube 30 in place against the valve housing, a pair of spacer members 57 are disposed closely adjacent to the tube 30 at its opposite sides and a band 58 is pulled tightly about the valve housing so as to secure the tube 30 in place, the spacers 57 preventing injury to the tube by the band 58. It should be noted that the sleeve 45 is constructed with equal end areas exposed to well fluid in the valve housing. Therefore, production fluid pressure has no significant effect on actuation of the valve except when production fluid

pressure is imposed on the fluid column in the annulus 8 at the top of the well.

Referring to FIGS. 6 and 7, an analogous valve construction is shown and primed reference characters are employed to designate those parts which are the same as those in the valve V. As illustrated, the housing 36' may be a unitary construction as distinguished from the two-piece housing construction illustratively shown in FIGS. 3 and 4. The sleeve 45' defines with the housing of the valve, which is generally designated V', chambers 50' and 51' similar to those of FIGS. 3 and 4, the chamber 51' having a spring 52' therein and being vented through a tube 30' to the atmosphere. However, instead of the present valve V' including a pivoted gate such as the gate 43, the valve V' includes a seat assembly 60 including an annular shell 61 which is supported in the valve housing as by means of a series of webs 62, the webs and the housing having co-engaged shoulders as at 63 for positioning the sleeve 61. Defined between the shell 61 and the valve housing is a by-pass flow passage 64 which preferably has a flow area greater than the area through the sleeve 45', so that no reduction of flow through the valve will be caused by the disposition of the shell 61 therein. Removably disposed within the shell 61 is a retrievable plug assembly 65, the plug 65 and the shell 61 having cooperatively engaged means as at 66 for retaining the plug 65 in place. However, the plug is retrievable as by a tool which is appropriately formed for engaging spring fingers 67 on the plug assembly 65 for releasing the cooperatively engaged means 66 so that the plug 65 may be pulled from the well to enable the passage through the valve V' of suitable wire line instruments, tools or the like. The shell 61 has a member 68 preferably threadedly mounted therein adjacent the base thereof there being a valve seat element 69 of resilient material secured in place therebetween.

Accordingly, it will be noted that the tendency of the spring 52' is to shift the sleeve 45' towards the resilient seat 69 so as to close off the by-pass passage 64, while pressure in chamber 50' is adapted to overcome the spring 52' so as to retain the sleeve 45' in the position shown in FIG. 6.

In FIGS. 4 and 7 respectively, the valves V and V' are shown in their closed positions which will prevent the flow of well fluids through the respective valves. Each of the valves will be closed by the respective springs 52 and 52' upon reduction in fluid in chambers 50 and 50' to such an extent that pressure therein does not overcome the springs 52 and 52'. In practice, the springs 52 and 52' of the respective valves V and V' are so calibrated that they will exert somewhat more force in a valve closing direction than is exerted by annulus fluid pressure in the chambers 50 and 50' respectively of the valves V and V', so that it can be said that the tubing valves are each normally closed or spring loaded to a closed position. The valves V and V' are merely illustrative of valves of different types which are adapted to actuation in the manner of the invention, and a more detailed explanation of the structure and operation of these specific valves may be obtained upon reference to copending applications, Serial No. 669,012, filed July 1, 1957, and Serial No. 669,043 filed July 1, 1957. The present invention is not concerned with the specific valve structure but only with the valve operating means, namely, the means for shifting the sleeves 45 and 45' respectively of the valves V and V' to a valve closing position, per se, and in combination with means for opening of the valves. In order to open the valves V and V' upon initial installation in a well, it will be understood that it is merely necessary to impose upon the sweet oil in the annulus 8 or 8', when the annulus is filled, sufficient pressure to overcome the effect of the springs 52 or 52'. Such pressure may be conveniently derived from the source of fluid under pressure from which the casing annulus 8 is filled with sweet oil as described above, or if preferred, pressure may be derived

from a source of gas pressure such as that illustrated in U.S. Patent No. 2,780,290 dated February 5, 1957, or other conventional pressure pumps or sources of pressure may be availed of as will be obvious to those skilled in the art.

In accordance with the method of the present invention, the valves V and V' are adapted, as has been hereinbefore specifically described, so that fluid pressure in the annulus will retain the valves open, provided such fluid pressure is in excess of the valve closing force exerted by the respective springs 52 and 52'. Preferably, the valve opening force is derived from production fluid pressure which is imposed upon static head in the annulus 8 through the lines 11 and 16 previously referred to. However, responsive to operation of either of over or under pressure control vent valves 20 or 21, or responsive to actuation manually or automatically of the valves 14 and 27, respectively, as well as responsive to destruction of the well head equipment as previously described, production fluid pressure will no longer be exerted upon static head in the annulus 8, and the springs 52 and 52' of the respective valves V and V' will automatically act to close off the valves thus preventing further flow of the production fluid from the well.

The novel spring loaded valve arrangement has particular application to wells which are being produced in certain sections of the world where production pressures are rather low, although production volume is high. In those applications, previously developed valve assemblies which respond to substantial flow pressures to effect closing off of the flow of production fluid are not entirely serviceable, but the method and apparatus of the present invention are ideally suited to this type of production problem.

While the specific details of the method and apparatus hereof have been herein shown and described, changes and alterations may be resorted to without departing from the spirit of the invention as defined in the appended claims.

I claim:

1. Well flow control equipment for shutting off the flow of fluid from a well, comprising: production tubing extending into said well and forming with the wall of the well an annular space about the outside of the tubing; valve means in the tubing; means packing off the space about the outside of said tubing below said valve means; said space above said packing means being filled with fluid; means for directing production fluid pressure at the top of the well into the space above said packing means; said valve means having operating means responsive to fluid pressure in said space to maintain said valve open; and said operating means including means tending to normally close said valve means.

2. Well flow control equipment for shutting off the flow of fluid from a well, comprising: production tubing extending into said well and forming with the wall of the well an annular space about the outside of the tubing; valve means in the tubing; means packing off the space about the outside of said tubing below said valve means; said space above said packing means being filled with fluid; means for directing production fluid pressure at the top of the well into the space above said packing means; said valve means having operating means responsive to fluid pressure in said space to maintain said valve open; and a spring tending to normally close said valve means.

3. Well flow control equipment for shutting off the flow of fluid from a well, comprising: production tubing extending into said well and forming with the wall of the well an annular space about the outside of the tubing; valve means in the tubing; means packing off the space about the outside of said tubing below said valve means; said space above said packing means being filled with fluid; means for directing production fluid pressure at the top of the well into the space above said packing

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means; said valve means having operating means for opening and closing said valve; said operating means including a fluid pressure actuated member; means on said member responsive to the head of fluid in said space for opening said valve; and means operative on said member for balancing the head of fluid in said space to close said valve upon a reduction in production fluid pressure.

4. Well flow control equipment for shutting off the flow of fluid from a well, comprising: production tubing extending into said well and forming with the wall of the well an annular space about the outside of the tubing; valve means in the tubing; means packing off the space about the outside of said tubing below said valve means; said space above said packing means being filled with fluid; means for directing production fluid pressure from the top of the well into the space above said packing means; said valve means having operating means for opening and closing said valve; said operating means including a fluid pressure actuated member; means on said member responsive to the head of fluid in said space for opening said valve; and a spring operative on said member for balancing the head of fluid in said space to close said valve upon a reduction in production fluid pressure.

5. Well flow control equipment for shutting off the flow of fluid from a well, comprising: production tubing extending into said well and forming with the wall of the well an annular space about the outside of the tubing; valve means in the tubing; means packing off the space about the outside of said tubing below said valve means; said space above said packing means being filled with fluid; means for directing production fluid pressure from the top of the well into the space above said packing means; said valve means having operating means; said operating means including a pair of chambers; a piston between said chambers; means providing a port leading to one of said chambers from said space for subjecting said one chamber and said piston to the head of fluid in said space at one side of the piston to open the valve means; and means for venting to atmosphere the chamber at the other side of said piston.

6. Well flow control equipment for shutting off the flow of fluid from a well, comprising: production tubing extending into said well and forming with the wall of the well an annular space about the outside of the tubing; valve means in the tubing; means packing off the space about the outside of said tubing below said valve means; said space above said packing means being filled with fluid; means for directing production fluid pressure from the top of the well into the space above said packing means; said valve means having operating means; said operating means including a pair of chambers; a piston between said chambers; means providing a port leading to one of said chambers from said space for subjecting said one chamber and said piston to the head

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of fluid in said space at one side of the piston to open the valve means; and means for venting to atmosphere the chamber at the other side of said piston; said latter chamber having means therein for biasing said piston in a direction to close that valve against the pressure of said fluid head in said space.

7. Well flow control equipment for shutting off the flow of fluid from a well, comprising: production tubing extending into said well and forming with the wall of the well an annular space about the outside of the tubing; valve means in the tubing; means packing off the space about the outside of said tubing below said valve means; said space above said packing means being filled with fluid; means for directing production fluid pressure at the top of the well into the space above said packing means; said valve means having operating means; said operating means including a pair of chambers; a piston between said chambers; means providing a port leading to one of said chambers from said space for subjecting said one chamber and said piston to the head of fluid in said space at one side of the piston to open the valve means; and means for venting to atmosphere the chamber at the other side of said piston; said latter chamber having means therein for biasing said piston in a direction to close that valve against the pressure of said fluid head in said space; said venting means including a tube communicating with said latter chamber and extending through said space outside said tubing and communicating with the atmosphere at the top of the well.

8. A flow control valve for wells, comprising: a housing adapted to be installed in a tubing string in a well; said housing having a flow passage therethrough; a valve seat in said housing; a valve member shiftably mounted in said passage for movement into and out of engagement with said seat for closing off said passage and opening said passage; and means for shifting said valve member including a piston carried by said member; means defining a chamber at opposite sides of said piston and having a port communicating one of said chambers with a source of pressure fluid for shifting the member in one direction; and means venting the other chamber to the atmosphere; said latter chamber having spring means therein for shifting the member in the opposite direction.

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