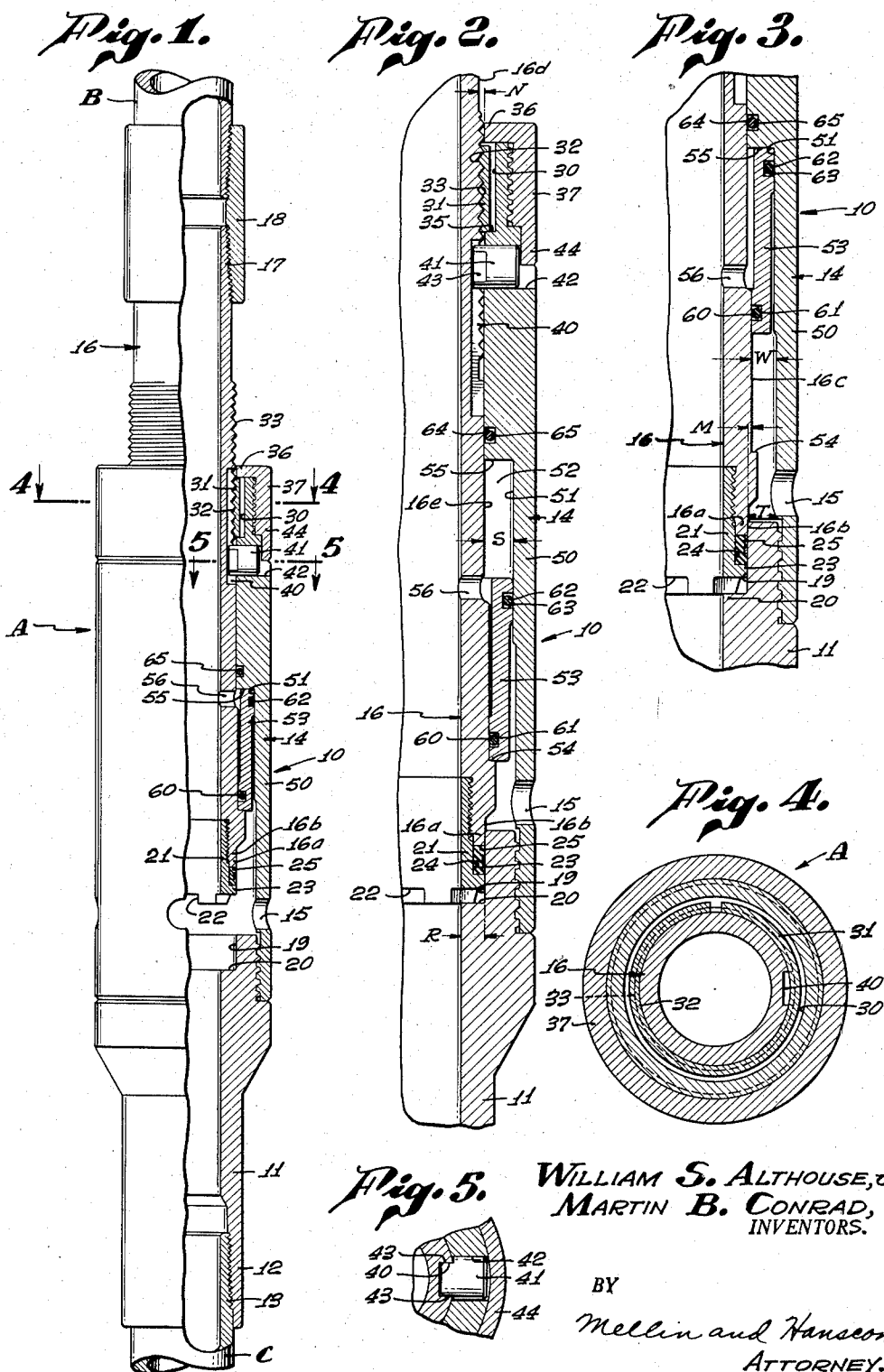


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SUBSURFACE FLUID CONTROL VALVE

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## SUBSURFACE FLUID CONTROL VALVE

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The present invention relates to fluid control valves, and more particularly to subsurface valve devices for controlling the flow of fluid between the interior of a tubular string disposed in a well bore and the annulus externally of said tubular string.

Valve apparatus is incorporated in a tubular string disposed in a well bore to either permit or prevent the passage of fluid between the interior of the tubular string and the annular space surrounding the latter. When the valve is open, fluid may pass from the interior of the tubular string to its exterior, or vice versa. With the valve closed, fluid is prevented from flowing in either direction between the interior and exterior of the tubular string. With the valve in closed position, fluid under pressure within the tubular string may tend to open the valve, or tend to hold the valve closed, depending upon the particular arrangement of the valve parts. Similarly, with the valve closed, fluid pressure externally of the tubular string may tend to open the valve, or tend to hold it closed, depending upon the arrangement of the valve parts. Accordingly, it has heretofore become necessary to impose a restraining force on the tubular string to offset the particular tendency of the fluid pressure, for the purpose of maintaining the valve in closed position, or to shift it to open position.

An object of the present invention is to provide a valve apparatus to be secured to a tubular string for disposition in a well bore, in which the fluid pressure internally and externally of the tubular string is utilized to completely, or at least partially, offset the tendency of such fluid pressure to shift the valve between open and closed positions.

Another object of the invention is to provide valve apparatus to be secured to a tubular string for disposition in a well bore, in which any tendency for fluid under pressure externally of the tubular string and valve apparatus to shift the latter to open position is completely eliminated, or at least considerably minimized.

A further object of the invention is to provide valve apparatus to be secured to a tubular string for use in a well bore, in which any tendency for fluid under pressure, both within the tubular string and valve apparatus and externally thereof, to shift the valve apparatus to open position is completely eliminated, or at least considerably minimized.

Yet another object of the invention is to provide a valve apparatus of the type indicated which can be easily shifted by the tubular string between open and closed positions, despite the presence of fluid pressure either internally or externally of the tubular string.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of a form in which it may be embodied. This form is shown in the drawings accompanying and forming part of the present specification. It will now be described in detail, for the purpose of illustrating the general principles of the invention; but it is to be understood that such detailed description is not

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to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

Figure 1 is a combined longitudinal sectional and side elevational view of an embodiment of the invention with the valve disclosed in open position;

Fig. 2 is a longitudinal sectional view of the apparatus disclosed in Fig. 1, on an enlarged scale, with the valve in closed position;

Fig. 3 is a fragmentary sectional view, similar to Fig. 2, with the valve still in closed position, but with parts of the apparatus occupying another relative position;

Fig. 4 is an enlarged cross-section taken along the line 4—4 on Fig. 1;

Fig. 5 is an enlarged fragmentary cross-section taken along the line 5—5 on Fig. 1.

As disclosed in the drawings, a control valve device A is connected to the lower portion of the tubular string B, the lower portion of the valve device, in turn, being connected to the body or mandrel C of another tool disposed therebelow, such as a well packer adapted to be set against the wall of a confining well casing (not shown) in which the entire apparatus may be lowered and used.

The control valve apparatus A includes an elongate tubular outer housing or body 10, which for convenience of manufacture and assembly is made of several parts. Thus, the housing 10 includes a lower portion 11 having a lower threaded box 12 for the reception of the upper threaded pin 13 of the body of the lower tool C. The upper end of the lower housing portion 11 is threadedly received within and is attached to the lower end of an upper housing portion 14 which has a plurality of circumferentially spaced side ports or openings 15 there-through through which fluid can flow between the interior and the exterior of the housing.

A tubular mandrel 16 is telescopically received within the housing 10, the upper end of this mandrel having a threaded pin 17 for threaded attachment to a collar or coupling sleeve 18, which, in turn, is threaded onto the lower end of the string of tubing B, or similar tubular string, that extends to the top of the well bore in which the apparatus A is to be used, and by means of which the apparatus is lowered or raised within the well bore.

The outer housing or body 10 has a generally cylindrical valve seat 19 formed in its lower portion below the circulation ports 15 for cooperation with the lower end of the inner mandrel 16 to control the passage of fluid through the ports 15 between the interior of the tubular string B and the valve apparatus A and the annular space in the well bore surrounding the tubular string and the valve apparatus. This cylindrical valve seat is formed within a counterbore portion of the lower housing member 11, terminating in a lower transverse shoulder 20 adapted to be engaged by the lower end of the mandrel 16. Actually, the lower end of the mandrel is provided on a separate mandrel member 21 threaded into the main portion of the mandrel, this lower mandrel member having a plurality of circumferentially spaced notches 22 formed through its side wall and terminating in an outwardly directed flange 23 immediately above the notches, which is slidable along the cylindrical valve seat 19. This flange is disposed below the lower end 16a of the main portion of the inner mandrel 16 to provide an external groove 24 in which a rubber seal ring 25 is disposed, this rubber seal ring being adapted to slidably seal against the cylindrical valve seat 19. The periphery of the flange 23 and the periphery of the main portion of the mandrel immediately above the seal ring 25 are cylindrical, having an external diameter but slightly less than the internal diameter of the cylindrical valve seat 19 so as to slidably seal thereagainst and provide a minimum of clearance through which the rubber or

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rubber-like seal ring 25 can be forced by relatively high fluid pressures both internally and externally of the valve device.

The circulation ports 15 are open or closed, depending upon the position of the mandrel 16 within the housing 10. When the mandrel is disposed in a lower position within the housing with its seal ring 25 in sealing engagement with the cylindrical valve seat 19, the ports are closed against passage of fluid therethrough between the interior and the exterior of the valve device. When the mandrel is elevated within the housing, the lower end of the mandrel 16, as well as its seal ring 25, are disposed a substantial distance above the upper end of the cylindrical valve seat 19, which will allow fluid to flow in either direction between the interior and the exterior of the valve apparatus.

The mandrel 16 is moved in an upward or downward direction with respect to the housing 10, to either open or close the circulation ports 15, by longitudinal movement of the tubular string B. To secure the appropriate relative movement between the mandrel and the housing, the movement of the housing is resisted or restrained. Such restraint may be provided by the lower tool C secured to the lower end of the housing 10. As indicated above, this tool may be a known form of packer device which can be anchored in packed up condition against the well casing by moving the body of the tool in a downward direction. Ordinarily such a tool also incorporates friction drag springs, or drag blocks, adapted to frictionally engage the wall of the well casing, to resist movement of the lower tool therewithin. The details of the lower tool are unnecessary to an understanding of the present invention, since they are old and well-known. It is sufficient to state that the lower tool embodies elements for resisting longitudinal movement of the housing 10 within a well casing in which the apparatus is to be used.

During the lowering of the apparatus A in a well casing or well bore, it may be desired to retain the valve in open position. However, the downward force being imposed by the tubular string B on the inner mandrel 16 would tend to shift the mandrel downwardly, to dispose of the valve head 16b and seal 25 on its lower portion within the cylindrical seat 19, thereby closing the circulation ports 15. Such downward movement is prevented by a releasable retaining or holding device provided between the mandrel and the housing. As specifically disclosed, the upper portion of the housing 10 is provided with an internal groove 30, in which is received a split, inherently contractile ratchet sleeve 31. This sleeve has internal teeth 32 that tend to mesh with external teeth 33 provided on the upper portion of the mandrel 16. The teeth 32, 33 are circumferential, and may be actually formed as internal helical threads within the ratchet sleeve 31 and as companion external helical threads on the mandrel 16, the threads being generally V-shaped in cross-section, so that a downward or upward force of sufficient magnitude imposed on the inner mandrel 16 will tend to cause its circumferential teeth 33 to cam or expand the ratchet sleeve 31 and permit the mandrel to move downwardly within the ratchet sleeve 31 and the housing 10. Such outward expansion is permitted by providing a sufficient annular clearance between the periphery of the ratchet sleeve 31 and the base of the circumferential groove 30 formed in the housing. The ratchet sleeve itself is precluded from partaking of any substantial longitudinal movement by engaging the lower side 35 of the groove and also the upper side of the groove, which may be provided by an inwardly directed flange 36 of a retainer nut 37 threaded on the upper end of the housing section 14.

In the manipulation of the lower tool C it is oftentimes necessary for its body to be partially turned or rotated in one direction or the other. In the present instance, rotary motion may be transmitted from the tubular string B and the inner mandrel 16 of the valve apparatus to

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the housing 10, and from the housing to the body of the lower tool C, by means of a keyway connection. Thus, a longitudinal keyway or key slot 40 is provided in the exterior of the mandrel for the purpose of receiving a key 41 which is inserted in place through a lateral hole 42 extending through the housing immediately below the ratchet sleeve 31. The key may be constituted by a cylindrical pin having flat, opposed sides 43 slidably engageable with the opposed walls of the keyway 40. The key 41 is prevented from shifting outwardly by virtue of a depending skirt 44 on the retainer nut 37 partially overlying the lateral hole 42 through the housing.

It is apparent that the key 41 permits upward and downward movement of the mandrel 16 with respect to the housing 10, and regardless of the relative position between the mandrel and housing, rotation of the mandrel 16 in either direction can be transmitted to the housing 10, such motion being conveyed from the latter to the body of the lower tool C.

When the apparatus A has been disposed in the well casing with the valve in the closed position, such as shown in Fig. 2, any pressure in the fluid within the tubular string B and the valve apparatus is acting over the cross-sectional area of the lower end of the mandrel 16, which is the area across the cylindrical valve seat 19, tending to elevate the mandrel 16 and the tubular string B to which it is attached, or conversely tending to shift the housing 10 downwardly, for the purposes of opening the valve. It is desired to completely or at least partially counterbalance this tendency, and for that reason a counterbalancing hydraulic device is incorporated in the apparatus. Similarly, any fluid pressure in the annulus between the tubular string B and the apparatus and the well casing may tend to act on the housing for the purpose of shifting it in a downward direction, inadvertently opening the valve. The present invention overcomes both of the aforementioned tendencies by providing a counterbalancing device that is acted on by the hydraulic pressure either within the apparatus or externally thereof, as the case may be, so that the pressure has substantially no effect, or very little effect, in tending to alter the relative position between the mandrel 16 and the housing 10.

The housing 10 includes a cylinder portion 50 having an internal cylinder wall 51 of a substantially greater diameter than the periphery of the mandrel 16 and of the cylindrical seat 19 to provide an annular space 52 therebetween in which an annular floating piston 53 is received. This piston is disposed above the cylindrical seat 19 and the circulation ports or openings 15, and is capable of sliding movement along both the cylindrical wall 51 of the cylinder and the periphery of the mandrel. The piston 53 may occupy a lower position along the mandrel 16, as determined by its engagement with an external shoulder 54 on the mandrel, and it may also move upwardly along the cylindrical wall of the cylinder into engagement with the upper cylinder head or shoulder 55. When the piston 53 is engaged with the mandrel shoulder 54, it can be acted on by fluid under pressure within the mandrel 16 and urged in a downward direction, this fluid under pressure entering the cylinder space 52 above the piston through one or more side ports 56 provided in the mandrel. Such fluid under pressure acts in a downward direction on the piston 53, the force on the piston being transmitted in a downward direction to the inner mandrel 16, by virtue of the abutting of the piston against the mandrel shoulder 54. When the piston 53 is in its upper position within the cylinder, in engagement with the upper cylinder head 55, then it can be acted upon by fluid under pressure externally of the apparatus, the fluid under pressure passing through the circulation ports 15 into the annular cylinder space below the piston, the force of this fluid acting in an upward direction on the piston 53 and being transmitted by the piston to the cylinder 50 and outer housing 10 through the cylinder head 55.

Leakage of fluid between the periphery of the mandrel

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16 and the piston 53 is prevented by a rubber or rubber-like seal ring 60, such as an "O" ring disposed in an internal circumferential groove 61 in the lower portion of the piston, which slidably engages the periphery of the mandrel. Leakage of fluid between the cylinder wall 51 and the piston 53 may be prevented by the provision of a rubber or rubber-like side seal ring 62, such as a rubber O ring, in an external circumferential groove 63 on the upper portion of the piston, this seal ring slidably and sealingly engaging the cylinder wall. These two rings 60, 62 will jointly prevent fluid from passing in a downward direction out of the cylinder space 52 above the piston 53 and along the inner and exterior surfaces of the latter. Fluid under pressure is prevented from passing in an upward direction out of the cylinder space 52 by providing an internal circumferential groove 64 in the cylinder head which contains a seal ring 65, such as a rubber or rubber-like O ring, that can slidably and sealingly engage the periphery of the mandrel.

When the mandrel 16 has been disposed in its lower position within the housing 10, and with the seal ring 25 in the engagement with the cylindrical valve seat 29, fluid under pressure within the tubular string B and the mandrel 16 will pass through the upper port 56 into the cylinder space 52 above the piston 53, urging the piston in a downward direction into engagement with the mandrel shoulder 54 (as seen in Fig. 2). This fluid under pressure will act in a downward direction on the piston 53, as well as over a portion of the mandrel itself, the area over which the fluid under pressure acts being the annular area existing between the periphery of the mandrel 16 above the piston and the cylindrical wall 51. Thus, the fluid under pressure is acting on the mandrel 16 in a downward direction over this area, which has been designated as the area "S" in the drawings. If this area is made equal to the cross-sectional area of the mandrel, which is the area R across the cylindrical seat 19 over which the fluid pressure is acting in an upward direction, tending to elevate the mandrel 16, then the hydraulic forces are completely counterbalanced, and there will be no tendency for fluid under pressure internally of the apparatus to tend to shift the valve device in either direction. Accordingly, it is unnecessary to impose any downward force on the tubular string B and inner mandrel 16 to hold the valve in closed position.

It is not essential that the areas R and S be made equal. If desired, some variance between the areas may be embodied in the apparatus. Thus, if the area S is somewhat less than the area R then the hydraulic pressure will not be completely counterbalanced, and it will be necessary to impose some downward force on the mandrel to hold the valve in closed position. Then again, the area S may be made somewhat greater than the area R in which event the hydraulic forces will retain the valve in closed position, and it will then be necessary to exert some upward effort on the tubular string B and inner mandrel 16, to overcome the unbalanced hydraulic forces, in shifting the valve to open position with pressure still present within the tubular string and mandrel.

Assuming the valve to be in closed position, with a predominance of pressure in the annulus between the tubular string B and apparatus A, on the one hand, and the well casing, on the other hand, the hydraulic counterbalancing arrangement is effective to prevent such fluid pressure from tending to open the valve. Thus, with a predominance of fluid pressure externally of the apparatus, such fluid pressure will pass through the circulation ports or openings 15, acting on the lower end of the piston 53 and shifting it upwardly along the mandrel 16 and cylinder wall 51 into engagement with the upper cylinder head 55. Thereafter, the hydraulic force acting in an upward direction on the piston 53 is being transmitted through the cylinder head 55 to

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the outer housing 10, tending to shift the housing in an upward direction. Such hydraulic force is acting on the piston 53 over a downwardly facing resultant transverse surface above the ports 15 having an annular area W, which is the annular area between the periphery of the mandrel 16 below the piston 53 and the opposite cylindrical wall. However, such upward hydraulic force is offset by the action of the fluid pressure in acting in a downward direction over an upwardly facing resultant transverse surface in the housing 10 having the annular area T, this area being the annular area of the housing between the cylindrical valve seat 19 and the cylindrical wall of the housing below the piston. Thus, the fluid will act in a downward direction over the housing 10, such as the upper end of the lower housing portion 11, over the area T, tending to urge the housing in a downward direction. If the areas W and T are made equal, then the external fluid pressure is counterbalanced, insofar as the housing 10 is concerned, and there will be no tendency for the fluid pressure to shift the housing in one direction or the other, the valve remaining in a closed position. Of course, the areas W and T can be made dissimilar, if desired. With the area W made greater than the area T, then there will be a tendency for the external fluid pressure to hold the valve in closed position, whereas the making of the area W less than the area T will still provide some tendency for the external fluid pressure to shift the housing 10 downwardly to open position, which tendency must be overcome by some other forces.

The external, fluid pressure is also acting on the mandrel within the cylinder below the piston 53 over an area M, which is the annular area between the cylindrical valve seat 19 and the periphery 16c of the mandrel below the piston. If the diameter of the cylindrical seat 19 and the diameter of such peripheral portion 16c of the mandrel are made equal, then, of course, there is no resultant area over which the external fluid pressure within the cylinder is acting on the mandrel. However, the fluid pressure is also acting in a downward direction on the mandrel over the area N, which is the projected annular area between the periphery 16d of the mandrel at its upper end and the periphery 16e of the mandrel which is slidable with the cylindrical head 55 and the head seal ring 65. If the area N is made equal to the area M, then the effect of the hydraulic pressure externally of the apparatus on the mandrel 16 is nullified. Of course, the diameters of the upper portion 16d of the inner mandrel and of its portion 16e slidable along the cylinder head can be made equal, in which event the resultant area N would not exist.

In the use of the apparatus A, its upper end is connected to the lower portion of the tubular string B and its lower end to the tool C secured therebelow. Preferably, the valve apparatus is disposed in open position, such as shown in Fig. 1, the releasable ratchet sleeve 31 engaging the inner mandrel 16, to preclude its inadvertent downward movement within the housing 10 to close the valve ports 15. The apparatus is run in the well bore until the location is reached at which it is to be used. The tubular string B and inner mandrel 16 are rotated, to transmit the motion of the mandrel 16 through the key 41 to the housing 10, and from the housing to the body of the lower tool C, to unlatch the lower tool and enable it to be anchored in packed-off condition against the well casing. Ordinarily, such packing-off occurs by not only turning the tubular string B, inner mandrel 16, housing 10 and lower tool body C in a proper direction, but also by exerting a downward force on the body of the lower tool. The tubular string B is lowered to exert such downward force, which is transmitted through the mandrel 16a and ratchet sleeve 31 to the housing 10, and from the housing to the body of the tool C. Since the anchoring of the lower tool C to the casing will preclude further downward move-

ment of the valve housing 10, the exertion of a downward force on the tubular string B and inner mandrel 16 will cause the V-shaped ratchet teeth 33 of the mandrel to cam the ratchet sleeve 31 laterally outward and allow the inner mandrel 16 to move downwardly within the housing 10, to dispose the valve head 16b and seal 25 completely within the cylindrical valve seat 19, as determined by engagement of the lower end of the mandrel with the housing shoulder 20, whereupon the ratchet sleeve 31 can relock itself against the inner mandrel 16.

Fluid under pressure may now be pumped down the tubular string B, this fluid under pressure passing through the inner mandrel 16 into the inner housing 10, and through the body of the lower tool C to a location below the latter. This fluid under pressure is acting through the port 56 and will shift the piston 53 in a downward direction along the mandrel 16 into engagement with the mandrel shoulder 54, the fluid force then being imposed in a downward direction on the piston and the mandrel over the annular area S, in order to offset the action of the fluid under pressure acting in an upward direction on the mandrel over the cross-sectional area R. If these areas R and S are made equal, there is no hydraulic forces tending to shift the mandrel 16, and it will remain in its closed position. At any time that the valve is to be opened, it is merely necessary to take an upward pull on the tubular string B, which will cause the mandrel ratchet teeth 33 to cam and expand the ratchet sleeve 31 out of engagement therewith, allowing the mandrel 16 to move upwardly in the housing to the port opening position shown in Fig. 1.

In the event the annulus around the tubular string and apparatus is subject to pressure, which can be accomplished by forcing fluid down through the annulus, or by swabbing the interior of the tubular string B to remove fluid therefrom, the fluid under pressure externally of the apparatus will pass through the valve ports 15 and shift the floating piston 53 upwardly into engagement with the cylinder head 55. Such fluid under pressure will then have no tendency to shift the housing 10, inasmuch as it is acting in an upward direction over the piston and housing over the annular area W and in a downward direction on the housing over the annular area T. If these areas are made equal to each other, the fluid under pressure is counterbalanced. Accordingly, there is no tendency to open the valve, or, for that matter, to hold it in closed position. When desired, the valve is shifted to open position merely by elevating the tubular string B and the mandrel 16 with respect to the housing 10. Such elevating tendency is not prevented by the external hydraulic pressure, inasmuch as the annular area N over which the external pressure is acting in a downward direction on the mandrel may be made substantially equal to the annular area M over which the hydraulic pressure is acting in an upward direction on the mandrel.

Once the valve has been shifted to open position, it will remain in such open position during elevation of the apparatus in the well bore, since the tubular string and mandrel are being moved in the upward direction. In any event, mere downward movement of the tubular string and mandrel will not reshift the valve to closed position, since the releasable ratchet sleeve 31 will secure the mandrel 16 to the housing 10 and prevent downward telescoping of the mandrel within the housing.

It is, accordingly, apparent that a subsurface valve apparatus has been provided, in which the effect of the fluid pressure on the valve, both internally and externally thereof, and tending to shift the valve, is nullified. Internal pressures cannot shift the valve to open position, and this is also true of external pressures.

The inventors claim:

1. In a tubular control valve adapted to be secured

to a tubular string for operation in a well bore; upper and lower tubular members telescopically arranged with respect to one another; said lower member having a port; coengageable seal means on said upper and lower members to prevent flow of fluid through said port between the exterior of said lower member and the interior of said upper member; portions of said members being spaced from one another to provide an annular cylinder; means for feeding fluid from the interior of one of said members to said annular cylinder; and means adapted to coact with said upper member and lower member and responsive to the pressure of fluid within said upper member and cylinder to exert a downward force on said upper member, said means being responsive to the pressure of fluid externally of said upper member and passing through said port to exert an upward force on said lower member.

2. In a tubular control valve adapted to be secured to a tubular string for operation in a well bore; upper and lower tubular members telescopically arranged with respect to one another; said lower member having a side port through its wall; coengageable seal means on said upper and lower members below said side port when coengaged to prevent flow of fluid through said port between the exterior of said lower member and the interior of said upper member; said seal means being disengaged upon telescopic movement between said members to permit such flow of fluid; portions of said members being spaced from one another to form an annular cylinder commencing at and extending upwardly from said port; and means in said cylinder above said port coacting with said lower member, said means in said cylinder and the portion of said lower member above said port together having transversely extending parts which collectively provide a resultant transverse surface of substantial area facing in a downward direction which is subject to the pressure of fluid externally of said upper member and passing through said port to exert an upward force on said lower member.

3. In a tubular control valve adapted to be secured to a tubular string for operation in a well bore; upper and lower tubular members telescopically arranged with respect to one another; said lower member having a side port through its wall; coengageable seal means on said upper and lower members below said side port when coengaged to prevent flow of fluid through said port between the exterior of said lower member and the interior of said upper member; said seal means being disengaged upon telescopic movement between said members to permit such flow of fluid; portions of said members being spaced from one another to form an annular cylinder commencing at and extending upwardly from said port; and means in said cylinder above said port coacting with said lower member, said means in said cylinder and the portion of said lower member above said port together having transversely extending parts which collectively provide a resultant transverse surface of substantial area facing in a downward direction which is subject to the pressure of fluid externally of said upper member and passing through said port to exert an upward force on said lower member; said lower member having a resultant upwardly facing transverse portion below said port subject to the pressure of fluid externally of said upper member and passing through said port to exert a downward force on said lower member.

4. In a tubular control valve as defined in claim 3; wherein the cross-sectional areas of said means in said cylinder and said transverse portion are substantially equal.

5. In a tubular control valve adapted to be secured to a tubular string for operation in a well bore; tubular body means having a first port; a tubular member connectible to the tubular string and telescopically arranged within said body means; a valve seat in said body means below said first port; a valve head on said tubular member en-

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gageable with said seat to close said first port upon downward movement of said tubular member in said body means; said body means including a cylinder above said first port slidably and sealingly engaging said tubular member; a piston in said cylinder above said first port slidable downwardly therein into engagement with said tubular member and slidable upwardly therein into engagement with said tubular body means; said tubular member having a second port for feeding fluid under pressure into said cylinder above said piston to urge said piston downwardly against said tubular member; fluid under pressure being adapted to pass from the exterior of said body means through said first port into said body means below said piston to urge said piston upwardly against said body means.

6. In a tubular control valve adapted to be secured to a tubular string for operation in a well bore; tubular body means having a first port; a tubular member connectible to the tubular string and telescopically arranged within said body means; a valve seat in said body means below said first port; a valve head on said tubular member engageable with said seat to close said first port upon downward movement of said tubular member in said body means; said body means including a cylinder above said first port slidably and sealingly engaging said tubular member; a piston in said cylinder above said first port slidable downwardly therein into engagement with said tubular member and slidable upwardly therein into engagement with said tubular body means; said tubular member having a second port for feeding fluid under pressure into said cylinder above said piston to urge said piston downwardly against said tubular member; fluid under pressure being adapted to pass from the exterior of said body means through said first port into said body means below said piston to urge said piston upwardly against said body means; said tubular member having a first portion subject to the pressure of fluid in said tubular member to exert a lifting force on said tubular member; said body means having a second portion below said first port subject to the pressure of fluid externally of said body means to exert a downward force on said body means.

7. In a tubular control valve as defined in claim 6; wherein the cross-sectional areas of said piston and said first portion are substantially equal; the cross-sectional areas of said piston and said second portion also being substantially equal.

8. In a tubular control valve adapted to be secured to a tubular string for operation in a well bore; tubular body means having a first port; a tubular member connectible to the tubular string and telescopically arranged within said body means; a valve seat in said body means below said first port; a valve head on said tubular member engageable with said seat to close said port upon downward movement of said tubular member in said body means; said body means and tubular member hav-

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ing portions spaced from each other to provide an annular cylinder therebetween; an annular piston in said cylinder above said first port slidable along said tubular member and body means; said body means having an upper abutment engaged by said piston when moved upwardly in said cylinder along said body means; said tubular member having a lower abutment engaged by said piston when moved downwardly in said cylinder along said tubular member; said tubular member having a second port for feeding fluid under pressure into said cylinder above said piston to urge said piston in a downward direction against said lower abutment; fluid under pressure externally of said apparatus entering said cylinder below said piston to urge said piston in an upward direction against said upper abutment.

9. In a tubular control valve adapted to be secured to a tubular string for operation in a well bore; tubular body means having a first port; a tubular member connectible to the tubular string and telescopically arranged within said body means; a valve seat in said body means below said first port; a valve head on said tubular member engageable with said seat to close said port upon downward movement of said tubular member in said body means; said body means and tubular member having portions spaced from each other to provide an annular cylinder therebetween; an annular piston in said cylinder above said first port slidable along said tubular member and body means; said body means having an upper abutment engaged by said piston when moved upwardly in said cylinder along said body means; said tubular member having a lower abutment engaged by said piston when moved downwardly in said cylinder along said tubular member; said tubular member having a second port for feeding fluid under pressure into said cylinder above said piston to urge said piston in a downward direction against said lower abutment; fluid under pressure externally of said apparatus entering said cylinder below said piston to urge said piston in an upward direction against said upper abutment; said tubular member having a first transverse portion subject to the pressure of fluid in said tubular member to exert a lifting force on said tubular member; said body means having a second transverse portion below said first port subject to the pressure of fluid externally of said body means to exert a downward force on said body means.

10. In a tubular control valve as defined in claim 9; wherein the cross-sectional areas of said piston and said first transverse portion are substantially equal; the cross-sectional areas of said piston and said second transverse portion also being substantially equal.

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