

April 20, 1954

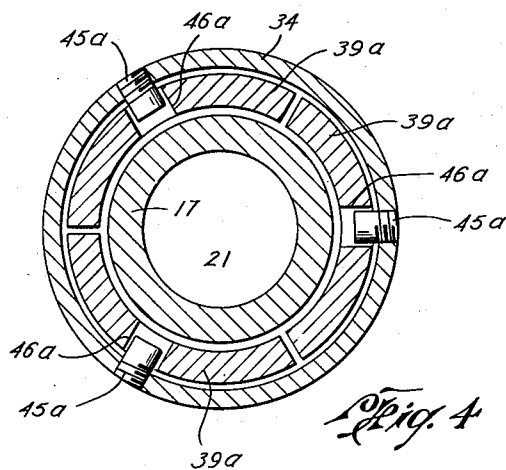
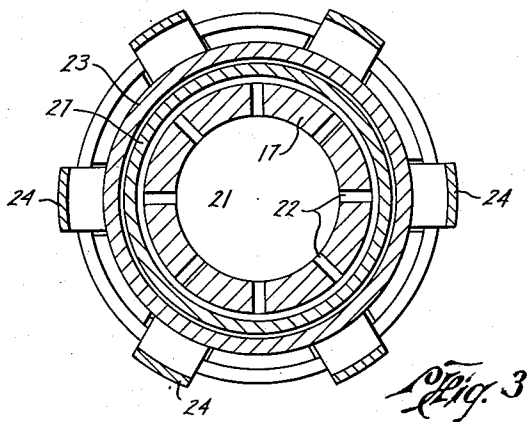
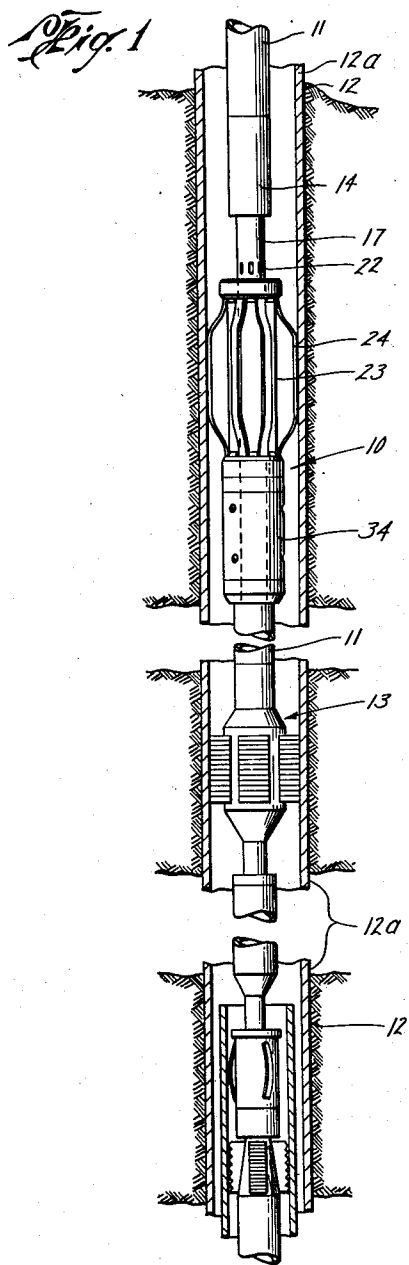
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2,675,875

PRESSURE EQUALIZING VALVE FOR WELL STRINGS

Filed May 12, 1951

3 Sheets-Sheet 1



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Fig. 2

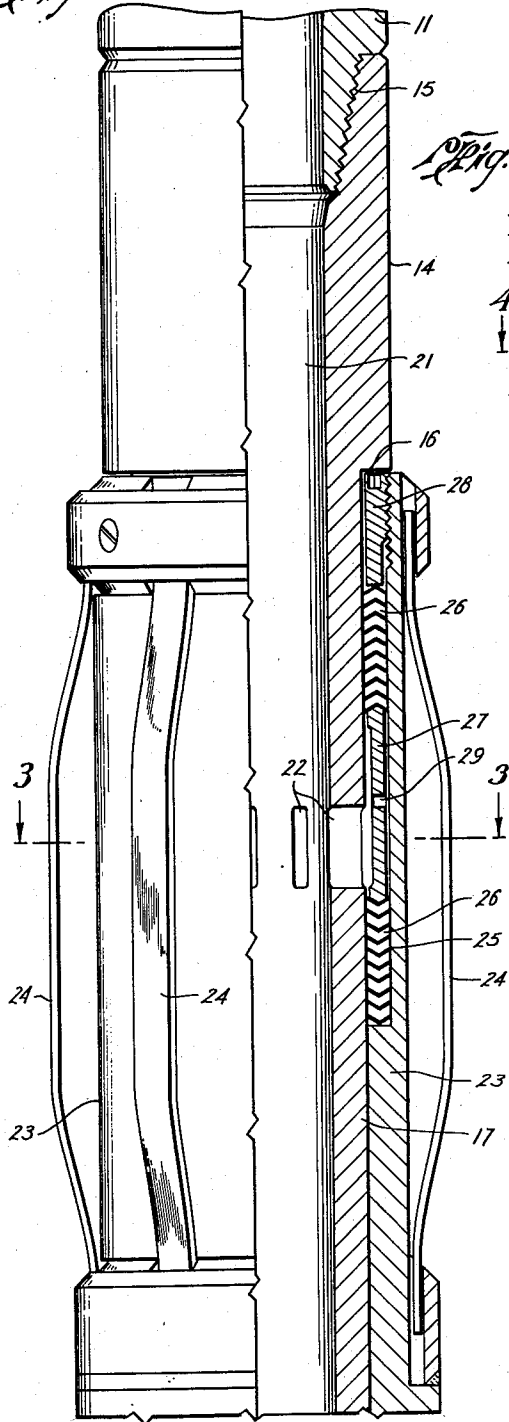
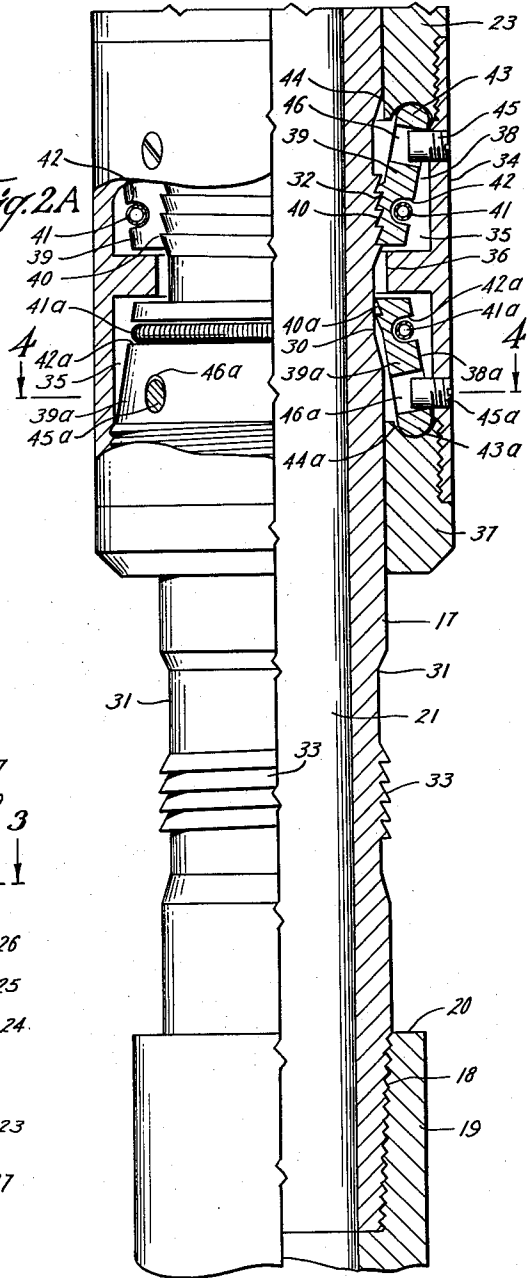


Fig. 2A



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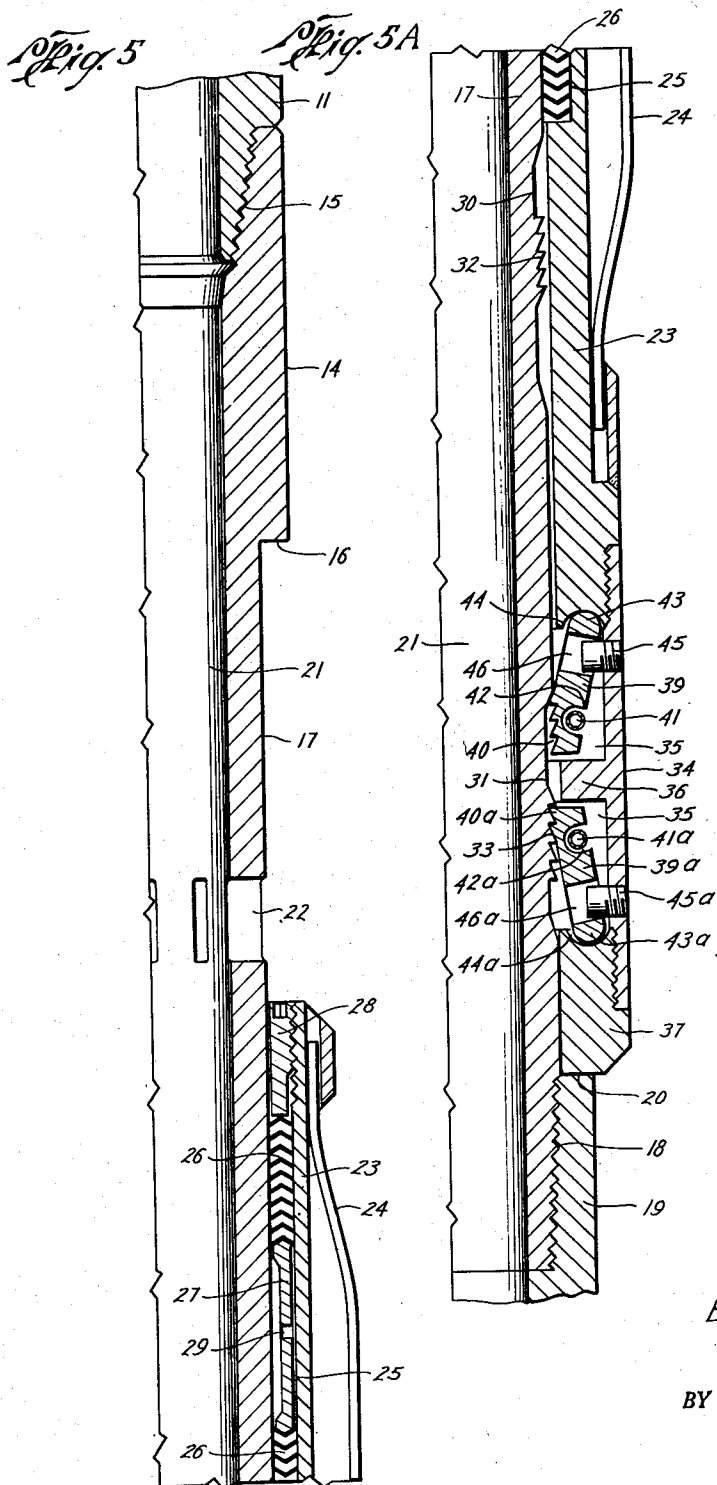
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PRESSURE EQUALIZING VALVE FOR WELL STRINGS

Filed May 12, 1951

3 Sheets-Sheet 3



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PRESSURE EQUALIZING VALVE FOR WELL STRINGS

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10 Claims. (Cl. 166—1)

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This invention relates to pressure equalizing valves and particularly to a pressure equalizing valve adapted for installation in a pipe string employed for operating tools in a well, such as an oil well or the like, which contains fluid or through which fluid is circulated during operation of the tools.

In many operations conducted in a well, such as fishing, liner pulling, cutting, etc., the tools employed are ordinarily connected to a string of pipe which is employed to raise and lower the tools, to manipulate the tools, and to conduct fluid to the tools for operating them by hydraulic pressure, or for circulating fluid through the pipe and the surrounding well bore for washing-over objects which have been stuck or lost in the well, or for other purposes well-known in the art.

Many of such operations are conducted during the course of drilling and often when the well bore is in communication with earth formations containing gas, oil or water under high pressure, so that the well bore must ordinarily be kept filled with high specific gravity liquids, such as mud-laden liquids, so as to maintain a relatively high hydrostatic head in the well in order to prevent blow-outs by the high-pressure connate fluids in the earth formations, during the operations being conducted in the well. The danger of such blow-outs and other related hazards is greatest while running in and withdrawing the tool string due to the swabbing and pumping action of the withdrawal and insertion operations. Also, when withdrawing a hollow operating string, the bore of such strings will often be filled with the hydrostatic liquid trapped within the string, and as the string must be withdrawn in sections, the liquid in the withdrawn sections will spill therefrom as the sections are broken apart at the top of the well. This results in the loss of relatively expensive weighting fluid, dangerous reduction in the hydrostatic head in the well, and the creation of unpleasant and dangerous working conditions for the men operating the tools at the top of the well.

Accordingly, the present invention has for its principal object the provision of a valve structure which is adapted to be installed in the operating pipe, and which may be opened and closed by a simple manipulation of the operating pipe, in order to open and close communication between the operating pipe and the well bore, as may be required or desirable to obviate the undesirable conditions noted above.

An important object is to provide a valve structure of the kind described which may be opened

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and closed by rotation of the operating pipe in one direction only.

Another object is to provide a valve structure including a body adapted to be installed in the operating pipe string and having radial openings, and a sleeve-type closure therefore frictionally engageable with the wall of the well bore and operable by relative longitudinal and rotational movement between the body and the closure to open and close the ports in the body.

A more specific object is to provide a series of latching elements between the body and closure which are relatively so positioned and constructed as to permit opening and closing of the valve with a minimum amount of manipulation of the operating string and with assurance that the valve is effectively open or closed, as the case may be.

Other and more specific objects and advantages of this invention will become more readily apparent from the following detailed description when read in conjunction with the accompanying drawings which illustrate one embodiment in accordance with this invention.

In the drawings:

Fig. 1 is a view showing the valve device installed in an operating pipe string extending into a well and connected to a tool such as a liner-pulling tool;

Figs. 2 and 2A together constitute an enlarged longitudinal quarter-sectional view of the valve structure showing the parts thereof in the positions when the valve is closed;

Fig. 3 is a cross-sectional view on line 3—3 of

Fig. 2;

Fig. 4 is a cross-sectional view on line 4—4 of Fig. 2A; and

Figs. 5 and 5A are longitudinal quarter-sectional views generally similar to Figs. 2 and 2A but showing the parts in the positions when the valve is open.

In Fig. 1, the valve device in accordance with the present invention, designated generally by the numeral 10, as shown installed in an operating pipe string 11, which may be a conventional drill stem or any other suitable tubular pipe string ordinarily employed in well operations and extending into the bore of a well 12, which may be lined with the usual casing 12a. The lower end of pipe string 11 may be connected to a tool, designated generally by the numeral 13, which is to be operated by manipulation of the pipe string or by hydraulic fluid conducted through the bore of the pipe string and ordinarily pumped therethrough by pumps (not shown) at

the surface. Tool 13 in Fig. 1 is a liner pulling tool, such as that described in my co-pending application, Serial No. 139,267, filed January 18, 1950, which is adapted to be operated by hydraulic pressure fluid supplied through an operating pipe, such as pipe string 11. It will be understood, however, that tool 13 may be any other type of tool commonly employed for conducting operations in the well, such tool, of itself, forming no part of the present invention.

Valve device 10 is composed of a tubular body 14 having a conventional threaded connection 15 at its upper end for connecting the upper end of the body into pipe string 11. At a point beginning somewhat below its upper end, body 14 is reduced in diameter to its lower end, to provide a reduced cylindrical portion 17, and thereby forming a downwardly facing annular shoulder 16 at the upper end of reduced portion 17. At its lower end, reduced portion 17 is externally threaded at 18 and screwed into a sub or collar 19 of somewhat larger diameter than reduced portion 17, the upper end of collar 19 forming an upwardly facing shoulder 20. The diameter of collar 19 will preferably have the same diameter as the upper portion of body 14. Collar 19 forms means for connecting the lower end of body 14 into the pipe string so as to become a part thereof and body 14 is provided with a bore 21 which registers with the bore of pipe string 11 and forms a continuous part thereof. A plurality of angularly spaced ports 22 is provided in the wall of portion 17 at a level somewhat below shoulder 16.

It will be understood that valve device 10 may be located at any desired point in pipe string 11 but that ordinarily it will be positioned at the lower end of the string immediately above tool 13.

A tubular sleeve 23, substantially shorter in length than reduced portion 17, is arranged for longitudinal sliding movement thereon and has mounted on the exterior thereof a plurality of angularly spaced friction members 24 adapted to frictionally engage casing 12a lining the wall of well 12. Friction members 24 may be in the form of the well-known bow springs, as illustrated, or may be of any other conventional form adapted to frictionally engage the well wall for the purpose of holding sleeve 23 stationary while permitting body 14 to engage in longitudinal or rotational movement relative thereto. Sleeve 23 is adapted to form a closure for ports 22, opening and closing of the ports being effected by longitudinal movement of body 14 relative to the sleeve.

The upper portion of the bore of sleeve 23 is enlarged to form an annular stuffing box 25 in which is mounted packing rings 26—26, spaced apart longitudinally by means of a metal spacing collar 27 so that the packing rings will be positioned above and below ports 22 when sleeve 23 is in the valve-closing position, as shown in Fig. 2. A threaded gland ring 28 is screwed into the upper end of stuffing box 25 to compress the packing rings longitudinally whereby to cause them to expand radially into fluid-tight sealing engagement between the exterior of portion 17 and the opposite wall of stuffing box 25. Packing rings 26 may be constructed of any conventional type of flexible packing material but are preferably of the well-known self-actuating, marginal lip construction whereby fluid pressure exerted against the interior of the marginal lips will serve to force the lips outwardly into sealing engage-

ment with the adjacent walls of the bodies between which the packing is to form a seal, while still permitting sliding movement between the bodies. The wall of spacer collar 27 is preferably made somewhat narrower than the width of stuffing box 25 and is provided with one or more small ports 29 adapted to transmit fluid pressure from the bore of spacer collar 27 to the exterior thereof so that equalized fluid pressure may be exerted on both the inner and outer marginal lips of packing rings 26—26 to assure that both will be effectively actuated at all times.

Portion 17 is provided, between ports 22 and shoulder 20, with upper and lower longitudinally spaced recesses 30 and 31, respectively, the bottoms of which are provided with upper and lower threaded sections 32 and 33, respectively, the peaks of the threads extending outwardly substantially flush with the exterior of reduced portion 17. Upper threaded section 32 is composed of left-hand threads, while lower threaded section 33 is composed of right-hand threads.

A tubular cage 34 is threaded or otherwise suitably connected to the lower end of sleeve 23 and is preferably externally dimensioned to form a flush extension of the lower end of sleeve 23, and is internally dimensioned to provide an annular chamber 35 which may be provided with an internal annular flange 36 intermediate the ends of cage 34. The lower end of cage 34 is closed by an annular bushing 37 which is screwed into the end of the cage and slidably surrounds reduced portion 17.

Mounted in the upper portion of chamber 35, surrounding portion 17, is a latching collar 38, of a generally downwardly and inwardly tapering, frusto-conical form, composed of a plurality of complementary arcuate segments 39—39 which are provided internally at their lower ends with threads 40 adapted to complement the threads of upper threaded section 32. A circular coil spring 41, commonly termed a "garter" spring, is seated in a spring-receiving groove 42 cut into the outer wall of collar 38 adjacent its lower end, and normally acts to resiliently urge the lower ends of segments 39—39 radially inwardly into circumferential end-to-end arrangement, whereby to form the continuous collar 38, but which will also allow some degree of radial outward movement of segments 39. The upper ends of segments 39 are rounded, as at 43, and are pivotally seated in an annular groove 44 provided in the lower end of sleeve 23. Groove 44 is arcuate in cross section and has a radius somewhat greater than that of the rounded ends 43 so as to permit a degree of pivotal movement of segments 39 in groove 44. A plurality of angularly spaced guide pins 45 project inwardly from the wall of cage 34 and are adapted to extend into holes 46 provided in segments 39 above garter spring 41. Holes 46 are made slightly larger in diameter than guide pins 45 so as to permit the desired degree of pivotal movement of segments 39 while preventing relative rotation between the segments and cage 34.

In the lower portion of chamber 35 below flange 36 there is mounted a second latching collar 38a, of substantial identical construction to collar 38 but tapering upwardly, and composed of a plurality of complementary arcuate segments 39a—39a which are provided internally at their upper ends with threads 40a adapted to complement the threads of lower threaded section 33. A garter spring 41a is seated in a spring-receiving groove 42a cut in the outer wall of collar 38a

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adjacent its upper end and adapted normally to resiliently urge the upper ends of segments 39a radially inwardly, while permitting some degree of radial outward movement thereof. The lower ends of segments 39a are rounded, as at 43a, and are pivotally seated in an annular groove 44a provided in the upper end of bushing 37 and having a somewhat larger cross-sectional radius than rounded ends 43a. Guide pins 45a project inwardly from the wall of cage 34 and cooperate with holes 46a in segments 39a for the same purpose and in the same manner as pins 45 and holes 46.

The threads forming upper threaded section 32 are preferably of the upwardly-facing buttress type adapted to lock with threads 40 on segments 39 to prevent upward movement of body 14 relative to latching collar 38, while permitting downward movement of the body relative to the collar in response to a downward force on body 14 great enough to overcome the inward radial pressure of garter spring 41. The threads forming lower threaded section 33 are likewise of the buttress type but are downwardly facing so as to lock with threads 40a on segments 39a to prevent downward movement of body 14 relative to latching collar 38a while permitting upward movement of the body relative to latching collar 38a by outward displacement of segments 39a against the resistance of spring 41a. It will be understood that when threads 40 are engaged with the left hand threads of upper threaded section 32, and sleeve 34 is held against rotation, right-hand rotation of body 14 will cause sections 32 to screw upwardly through threads 40, thereby releasing body 14 for upward movement relative to sleeve 34. Likewise, when the right-hand threads of lower threaded section 33 are engaged with threads 40a on segments 39a, right-hand rotation of body 14 will screw the latter downwardly through segments 39a thereby releasing the body for downward movement relative to sleeve 34. The number of threads 40 and 40a is preferably less than the number of threads constituting threaded sections 32 and 33, respectively. From the foregoing, it will be understood that latching collars 38 and 38a may operate, in cooperation with the respective threaded sections 32 and 33, both as screw collars or as ratchet-and-pawl connections between body 14 and the valve closure formed by sleeve 23 and cage 34. Since threaded sections 32 and 33 are more distantly spaced apart longitudinally than collars 38 and 38a, only one of the threaded sections can be engaged with only one of the collars at any position.

The above-described device may be operated in the following manner: Valve device 10 will be installed in pipe string 11, having tool 13 connected below valve device 10, all as generally illustrated in Fig. 1. Prior to running the tool string into a well, sleeve 23 and cage 34 will be set in the downward position on body 14 to open ports 22, the parts of the valve structure being in the positions shown in Fig. 1, and particularly in Figs. 5 and 5A. At this stage, it will be noted that lower threaded section 33 will be engaged with threads 40a of latching collar 38a while latching collar 38 will be below upper threaded section 32. As the device is run into the well, the engagement of segments 39a will act as spring-pressed pawls having threads 40a engaged with the downwardly facing buttress threads of lower threaded section 33 to prevent downward movement of body 14 relative to the closure sleeve,

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so that the position of the latter on body 14 will be fixed throughout the downward movement in the well, the frictional engagement of friction members 24 with the wall of the well acting in opposition to the downward movement of body 14 to intensify the engagement between threads 40a and threaded section 33. With ports 22 thus open, the interior of the tool string will be open to the well bore so as to allow fluid in the well bore, through which the string descends, to flow upwardly through bore 21 and out through ports 22 into the well bore, thereby continuously maintaining balanced fluid pressure inside and outside the tool string while the string descends, thus allowing the tool string to descend freely and avoiding a piston effect on the well bore fluid below the tool.

When the tools have attained the desired point in the well at which they are to be operated and it is desired to close ports 22 in order that fluid may be pumped through the bore of the string to operate tool 13 or for any other purpose, the upper end of pipe string 11 will be rotated in the right-hand direction. Since the threads of lower threaded section 33 are left-hand threads, right-hand rotation of the pipe string will cause lower threaded section 33 to screw downwardly through the threads on latching collar 38a. The latter will, of course, remain stationary, being connected through pins 45a to cage 34 and sleeve 23 which will be held against rotation by the frictional engagement of friction members 24 with the wall of the well. When threaded section 33 has thus been screwed entirely through latching collar 38a, the tool string and body 14 will be released for further downward movement relative to sleeve 23 and will then be lowered until shoulder 16 comes down against the upper end of sleeve 23, at which point packing rings 26—26 will be in position above and below ports 22, as best seen in Fig. 2, thereby closing these ports. At the same time upper threaded section 32 will have been caused to slide downwardly through latching collar 38. Due to the relative shapes of the threads of threaded section 32 and threads 40 on segments 39, the latter will be thrust radially outwardly by the weight of the tool string which will overcome the resistance of spring 41 so as to allow the necessary degree of outward movement of the collar segments. Threaded section 32 is so positioned on reduced portion 17 of the body relative to shoulder 16, that when the upper end of sleeve 23 is against shoulder 16, threads 40 will be in registration with some of the threads on section 32, preferably the lower ones, and will be in threaded engagement therewith, thereby locking closure sleeve 23 to body 14 with ports 22 closed. Latching collar 38a will be positioned between threaded sections 32 and 33, as shown in Fig. 1. Fluid may now be pumped through the bore of the pipe string to the tool for operations as desired.

When it is desired to withdraw the string of tools from the well and to open ports 22 before doing so, the upper end of pipe string 11 will again be rotated to the right, which, by reason of the left-hand threads of threaded section 32, will cause this threaded section to screw upwardly through the threads on segments 39, an upward pull being maintained at the same time on the pipe string. As soon as threaded section 32 has cleared the threads on segments 39, the pipe string may be drawn upwardly through the closure elements until the lower end of bushing 37 at the bottom of cage 34 strikes shoulder 20,

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at which point threads 40a on segments 39a will again engage threaded section 33, which because of the shape of its threads relative to threads 40a, will be able to slide upwardly through segments 39a which will be forced outwardly against the resistance of garter spring 41a to allow upward passage therethrough of threaded section 33. It will be understood that threaded section 33 will be so positioned longitudinally above shoulder 20 that when bushing 37 rests on shoulder 20, threads 40a will be in registration with some of the threads 40 on section 33, preferably the upper ones, and in threaded engagement therewith. Closure sleeve 23 will thus again be locked in its downward position on body 14 at which ports 22 will again be open, as in Figs. 5 and 5A. The pipe string and its attached tools may now be drawn upwardly from the well, and open communication will be provided through ports 22 between the interior of the pipe string and the well, so that as the pipe string is drawn out of the well, any fluid trapped in the interior thereof will flow out through ports 22 into the well bore. In this way no fluid will be lifted out of the well bore by the emerging pipe but will instead remain in the well bore to thus maintain full hydrostatic head of the column of fluid on the earth formations penetrated by the well. The pressure will be continuously equalized between the interior of the pipe string and the well bore throughout the withdrawal operation, and swabbing action by the upwardly moving tools will be obviated.

It will be understood that by the described construction, the valve may be either open or closed when the tool string is run into, or withdrawn from, the well, as may be desired. It will also be seen that locking of the valve in the open or closed position is effected automatically, thereby avoiding the necessity of "hunting" the proper locking and unlocking positions, as required in more conventional tools, and that both the opening and closing of the valve may be effected by rotation of the operating pipe in the same direction, generally the right-hand direction, which has the advantage that such rotation will always be in the direction which will tighten the usual screw connections between sections of the operating pipe string.

It will be understood that numerous alterations and changes may be made in the details of the illustrative embodiment within the scope of the appended claims without departing from the spirit of this invention.

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

1. A pressure equalizing valve for well strings, comprising, a tubular body having radial ports through the wall thereof, a tubular sleeve rotatably mounted on said body and slidably movable thereon between positions for opening and closing said ports, friction elements secured to said sleeve and extending into frictional engagement with a well wall to hold said sleeve against rotation on said body, laterally extending abutment members on said body on opposite sides of said ports to limit longitudinal movement of the sleeve relative to the body, a pair of longitudinally spaced external thread sections on said body between said ports and the lower abutment member, and a pair of longitudinally spaced pawl members pivotally mounted on said sleeve for radial movement relative to said thread sections and releasably engageable therewith in response

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to relative movement between said body and said sleeve, the longitudinal spacing between the pawl members being less than that between said thread sections.

2. A pressure equalizing valve for well strings, comprising, the tubular body having radial ports through the wall thereof, a tubular sleeve rotatably mounted on said body and slidably movable thereon between positions for opening and closing said ports, friction elements secured to said sleeve and extending into frictional engagement with a well wall to hold said sleeve against rotation on said body, a pair of longitudinally spaced external thread sections on said body below said ports, and a pair of longitudinally spaced pawl members pivotally mounted on said sleeve for radial movement relative to said thread sections and releasably engageable therewith in response to relative movement between said body and said sleeve, the longitudinal spacing between said pawl members being less than that between said thread sections.

3. A pressure equalizing valve according to claim 2 wherein said pawl members are provided at their axially adjacent end portions with internal threads complementary in shape to the threads of said thread sections.

4. A pressure equalizing valve according to claim 2 wherein said pawl members comprise segmental frusto-conical collars surrounding said body, the smaller ends of which are directed toward each other and are provided with internal threads complementary in shape to the threads of said thread sections.

5. A pressure equalizing valve according to claim 2 wherein said pawl members comprise segmental frusto-conical collars surrounding said body, the smaller ends of which are directed toward each other and are provided with internal threads complementary in shape to the threads of said thread sections, and resilient means normally urging the segments of the collar radially inwardly toward said body.

6. A pressure equalizing valve according to claim 2 wherein the bore of said sleeve is provided with annular packing elements spaced apart longitudinally to form seals between said sleeve and said body above and below said ports when said sleeve is in the port-closing position.

7. A pressure equalizing valve for well strings, comprising, a tubular body having radial ports through the wall thereof, a tubular sleeve rotatably mounted on said body and slidably movable thereon between positions for opening and closing said ports, friction elements secured to said sleeve and extending into frictional engagement with a well wall to hold said sleeve against rotation on said body, a pair of longitudinally spaced external thread sections on said body below said ports, the upper one of said thread sections being composed of left-hand upwardly facing buttress threads and the lower one of said thread sections being composed of right-hand downwardly facing buttress threads, a pair of longitudinally spaced pawl members pivotally mounted on said sleeve for radial movement relative to said thread sections and releasably engageable therewith in response to relative movement between said body and said sleeve, said pawl members having internal threads complementary in shape to the threads of said thread sections, the longitudinal spacing between said pawl members being less than that between said thread sections.

8. A pressure equalizing valve according to

claim 7 wherein said pawl members comprise segmental frusto-conical collars surrounding said body having their smaller ends directed toward each other, and resilient means normally urging the segments of said collar radially inwardly toward said body.

9. A pressure equalizing valve according to claim 7 wherein the bore of said sleeve is provided with annular packing elements spaced apart longitudinally to form seals between said sleeve and said body above and below said ports when said sleeve is in the port-closing position.

10. A pressure equalizing valve according to claim 7 wherein said body is provided with laterally extending abutment members located on

said body respectively above said ports and below the lower one of said thread sections to limit the longitudinal travel of said sleeve relative to said body.

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