

Dec. 3, 1963

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3,112,795

RETRIEVABLE SUBSURFACE WELL TOOL

Filed Nov. 14, 1960

4 Sheets-Sheet 1

FIG. 1.

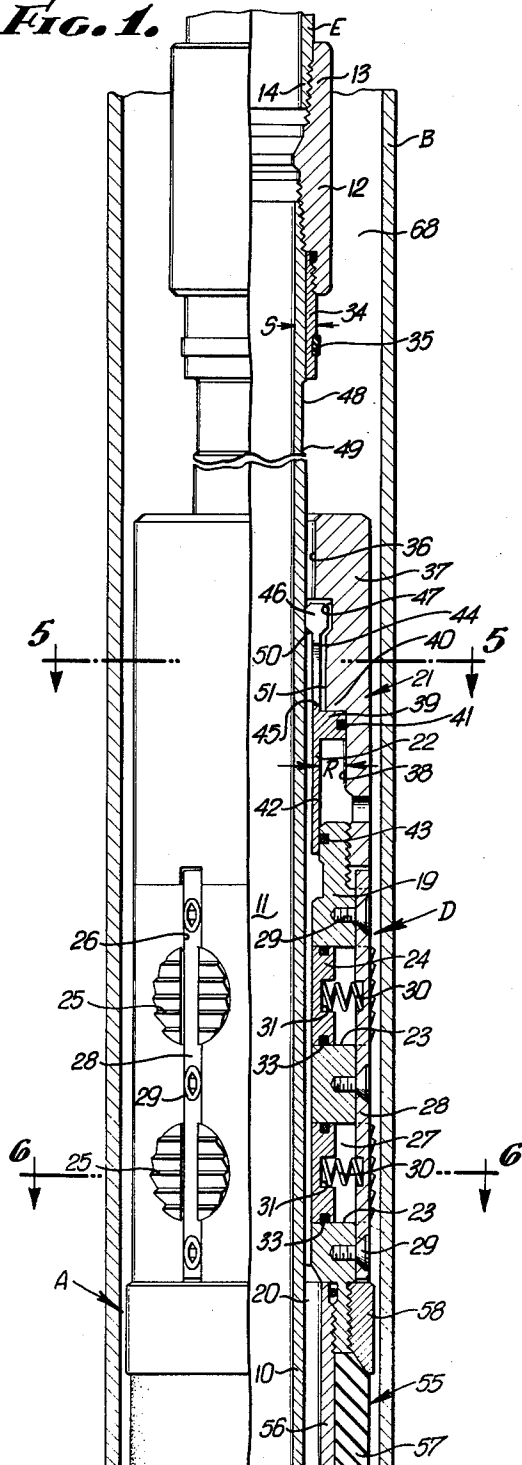
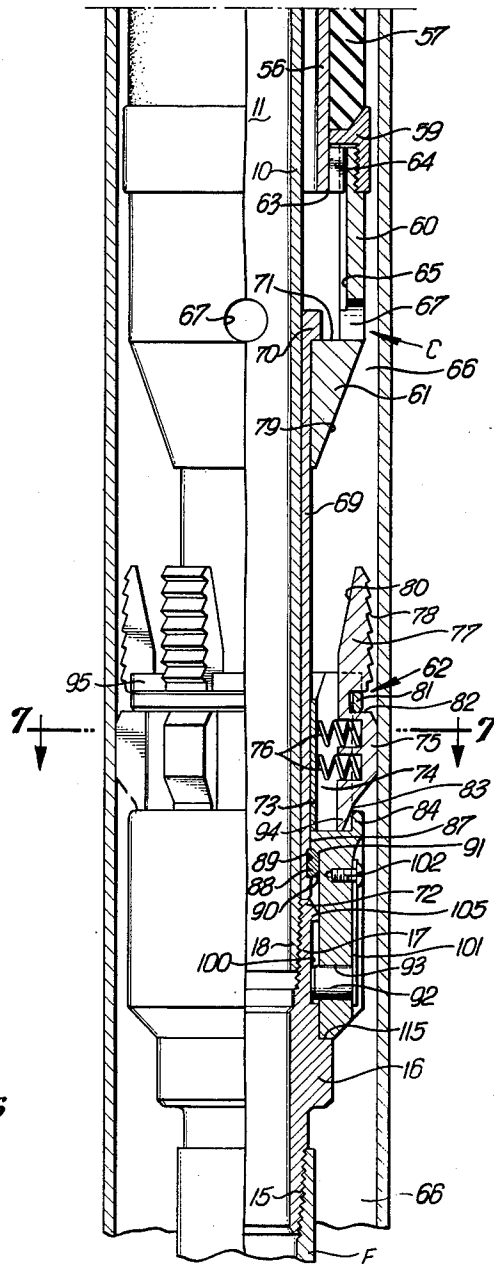


FIG. 1a.



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4 Sheets-Sheet 2

FIG. 2.

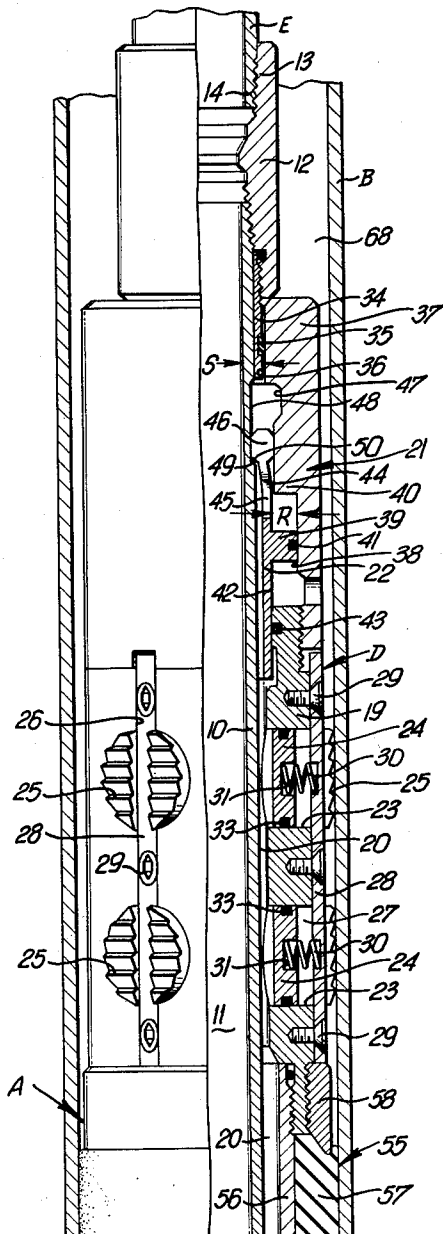
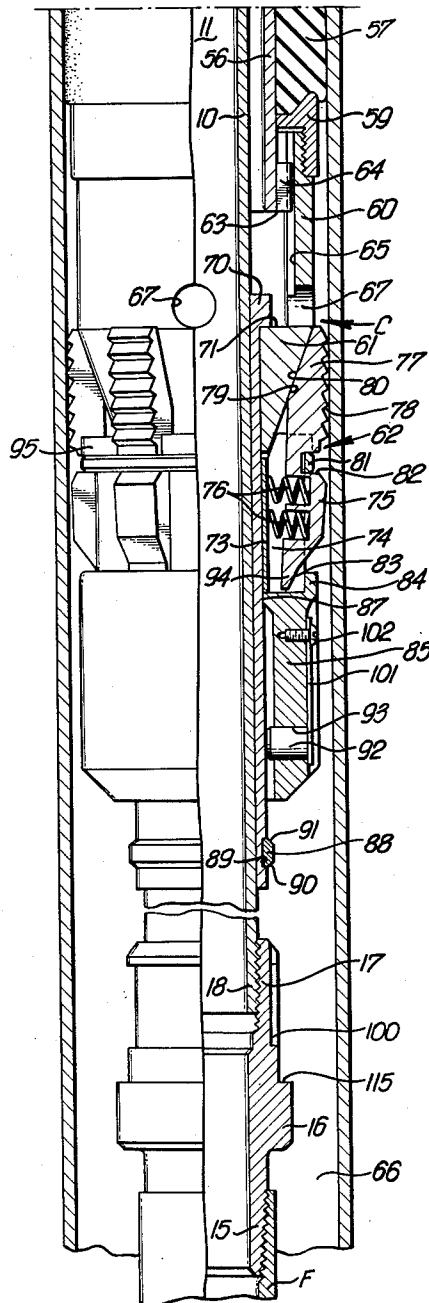


FIG. 2a.



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4 Sheets-Sheet 3

FIG. 3.

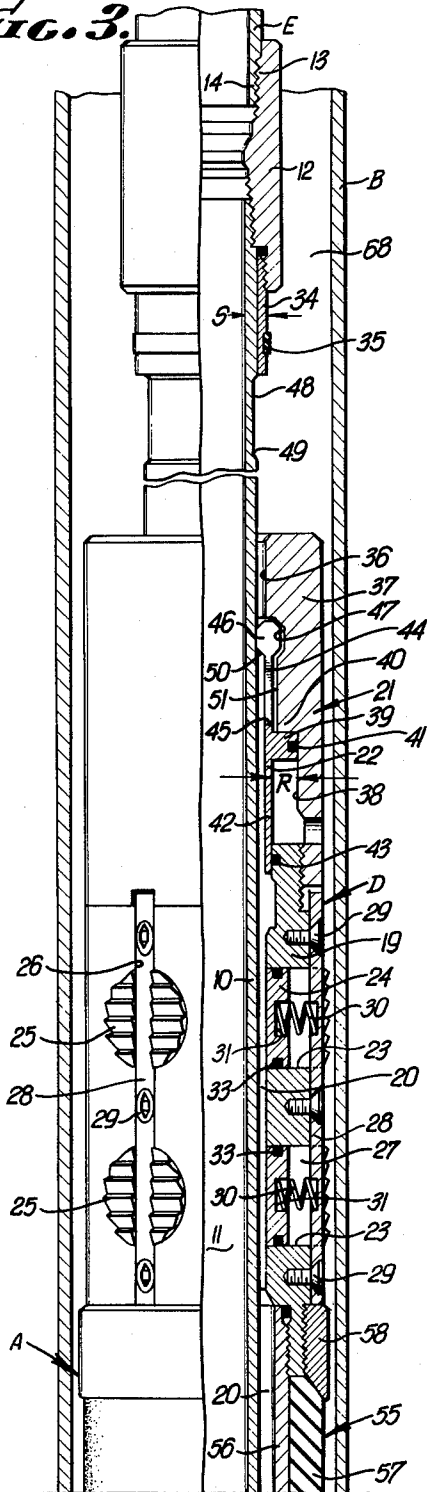
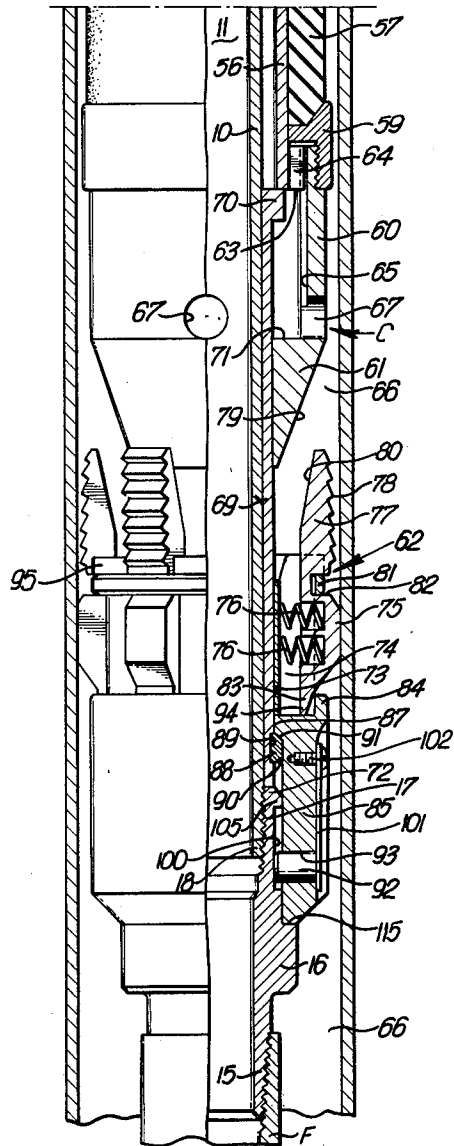


FIG. 3a.



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4 Sheets-Sheet 4

FIG. 4.

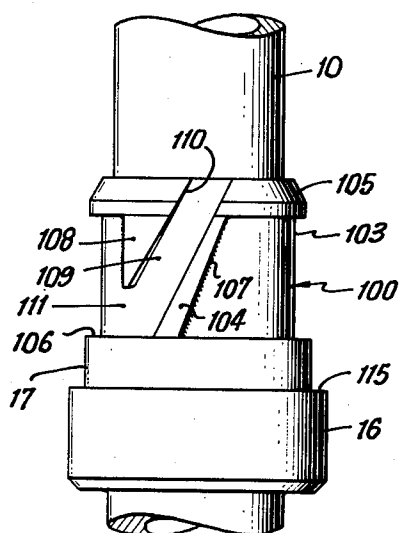


FIG. 5.

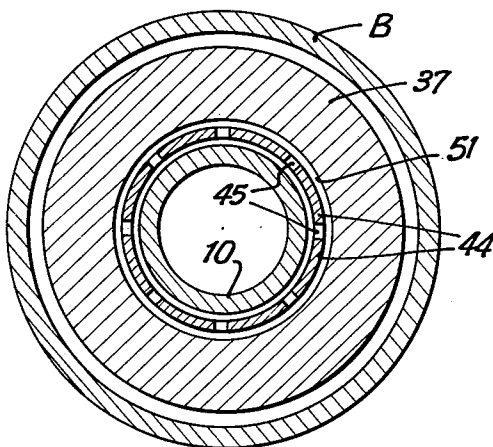


FIG. 6.

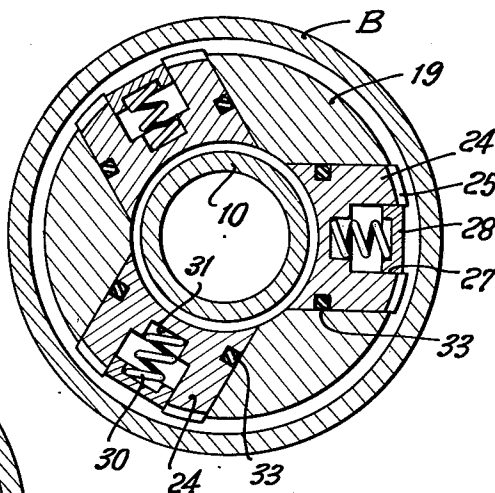
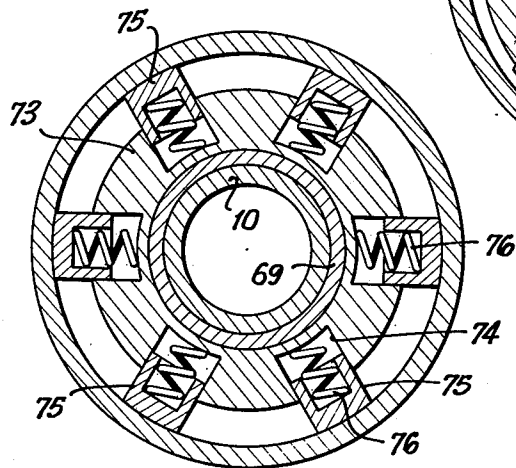


FIG. 7.



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RETRIEVABLE SUBSURFACE WELL TOOL

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16 Claims. (Cl. 166—120)

The present invention relates to subsurface well tools, and more particularly to packers and anchors adapted to be run and set in well casing, and similar conduit strings, disposed in well bores.

An object of the invention is to provide a subsurface well tool adapted to be operated by manipulation of a tubular string secured to the well tool, the well tool embodying a valve device shiftable between open and closed conditions by longitudinal movement of the tubular string through a relatively long stroke, the well tool being pressure balanced so that pressure differentials cannot open the valve device inadvertently from its closed condition.

Another object of the invention is to provide a subsurface well tool, as above set forth, in which the valve device can be shifted readily from closed to open condition by manipulation of the tubular string despite the presence of comparatively high pressure differentials on the tool.

A further object of the invention is to provide a subsurface well tool embodying a valve device that can be readily shifted to a closed condition by manipulation of a tubular string secured to the well tool, and in which the valve device becomes automatically latched in its closed condition and incapable of being opened inadvertently by pressure differentials to which the well tool is subjected, the valve device still being easily shifted to an open condition despite the continued imposition of pressure differential on the tool.

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

Referring to the drawings:

FIGURES 1 and 1a together constitute a combined side elevational and longitudinal sectional view through an apparatus embodying the invention, with ports disposed in condition for moving the tool longitudinally through a well casing, FIG. 1a constituting a lower continuation of FIG. 1;

FIGS. 2 and 2a are views similar to FIGS. 1 and 1a disclosing the tool anchored in packed-off condition in the well casing;

FIGS. 3 and 3a are views corresponding to FIGS. 1 and 1a disclosing the tool after having been released from the well casing;

FIG. 4 is a side elevational view of the control portion of the packer;

FIG. 5 is a cross-section on an enlarged scale taken along the line 5—5 on FIG. 1;

FIG. 6 is a cross-section on an enlarged scale taken along the line 6—6 on FIG. 1;

FIG. 7 is a cross-section on an enlarged scale taken along the line 7—7 on FIG. 1a.

As disclosed in the drawings, a retrievable well packer A is adapted to be anchored to a well casing B against movement in both an upward and downward direction,

2

and to be packed-off against the wall of the well casing to prevent leakage of fluid thereby. The lower portion C of the tool is a set-down type of well packer, the upper portion D of the tool being constituted as an anchor to prevent upward movement of the apparatus in the well casing. The apparatus is lowered in the well casing on a tubular string E, such as tubing or drill pipe, extending to the top of the well bore, and through which fluent substances under pressure, such as cement slurry, acid, and the like, can be pumped, flowing through the central passage of the tool for discharge from its lower portion.

The well packer A includes a central main body or mandrel 10 having a passage 11 therethrough that may be of relatively large diameter. The upper portion of this body is threadedly secured to a top body sub 12 having a threaded box 13 for attachment to the lower threaded pin end 14 of the tubular string E. The mandrel 10 of the body extends downwardly through the entire length of the tool A and has a lower threaded pin 15 for threaded attachment to a lower section of tubing or a lower tool F. The lower portion 16 of the body is actually constituted as a lower body sub having a threaded box 17 threadedly secured to the lower pin end 18 of the main section of the body or mandrel 10.

The upper portion D of the tool includes an anchor body 19 surrounding the mandrel 10, and which may be laterally spaced therefrom to provide an annular space 20 therebetween. This annular space extends upwardly through a housing 21 for a control valve and a balance sleeve 22, the lower end of the housing being threadedly attached to the upper end of the anchor body 19. The anchor body has a plurality of circumferentially spaced cylindrical bores 23 therethrough, each containing a piston gripping element 24 slidable radially therein. Each cylindrical bore 23 is open to the interior of the anchor body 19 and also to the exterior thereof. The piston gripping elements 24 have external wickers or teeth 25 that may face in an upward direction to anchor the apparatus A to the well casing B against upward movement therewithin. As shown, a plurality of cylinders 23 and gripping elements 24 are provided in longitudinal alignment with one another, there being sets of such longitudinally aligned gripping elements 24 disposed around the circumference of the anchor body 19.

The anchor body has external grooves 26 on opposite sides of aligned cylinders in each set, these grooves merging into companion grooves 27 formed in the outer portions of the longitudinally aligned gripping elements 24. Disposed in the body and gripping element grooves are retainer members and spring seats 28 in the form of bars suitably secured to the anchor body, as by use of screws 29. Each bar retains the piston gripping elements 24 properly oriented with their wickers or teeth 25 facing in an upward direction. Each bar also serves as the outer spring seat for a helical compression spring 30 disposed in and bearing against the socket portion 31 of each piston gripping element 24, tending to urge each piston gripping element inwardly to its fullest extent, but yieldably permitting its inward and outward radial movement.

The piston gripping elements 24 are expanded outwardly whenever fluid pressure differential, sufficient to overcome the compressive force of the springs 30, is present interiorly of the anchor body 19. In the present case, such fluid pressure is derived from the exterior of the tool below the anchor portion D of the apparatus, which pressure can pass through the annular space 20 between the body or mandrel 10 of the tool and the anchor body 19 to each of the cylinders 23. The fluid pressure differential for expanding the gripping elements is actually derived from a location in the well casing below the set-down type of well packer portion C of the

tool, passing from such location into the annular space 20 through a path described hereinbelow. Fluid pressure in the cylinders 23 urges each piston 24 outwardly, leakage of fluid along each piston being prevented by a suitable piston ring or side seal ring 33 in the piston slidably sealing against the wall of its companion cylinder 23.

The inner mandrel or body 10 is shiftable longitudinally with respect to the anchor body 19 and the housing 21 secured thereto to open and close the annular passage 20. Thus, the mandrel carries a valve head 34 threadedly attached to the top or body sub 12, which has a suitable peripheral seal ring 35 thereon, the head and seal ring being adapted to move downwardly within a cylindrical seat 36 formed in the valve head portion 37 of the housing 21. When the mandrel 10 is shifted downwardly relative to the anchor body 19 and the housing 21, its valve head 34 and seal ring 35 are moved within the cylindrical seat 36, closing the upper portion of the annular passage 20, and enabling the pressure below the tool and tending to elevate the mandrel 10 to be counterbalanced, so as to prevent inadvertent opening of the valve device. The annular balancing sleeve 22 is disposed in an annular cylinder portion 38 of the housing 21. This sleeve or piston 22 includes a head 39 initially occupying an upward position adjacent to a cylinder head 40, the piston head being slidable along the wall of the cylinder 38. Leakage of fluid between the piston and cylinder is prevented by a suitable piston ring 41 carried by the piston and slidably sealing against the wall of the cylinder 38. The piston has a skirt 42 depending from its head 39, which is slidable along and within the upper portion of the anchor body 19, leakage of fluid therebetween being prevented by suitable side seal 43 mounted in the anchor body and slidably sealing against the outer periphery of the skirt 42. The piston device 22 has an internal diameter substantially greater than the external diameter of the body or mandrel 10, so as not to obstruct the annular passage 20 between the body 10 of the tool and the housing 21 and anchor body 19 surrounding the body 10.

Integral with the balancing member 22 are upwardly extending arms 44 formed by providing circumferentially spaced longitudinal slots 45 in an upper portion of the balance member, these arms terminating in upper fingers or heads 46 initially disposed in an internal groove 47 in the housing 21, the heads 46 tending to spring inwardly and initially engaging the periphery of the tool body. When the mandrel 10 is moved downwardly within the anchor body 19 and housing 21, to dispose the valve head 34 and seal 35 within the valve seat 36, and thereby close the valve portion of the device, a peripheral groove 48 in the mandrel 10 below the valve head 34 is located opposite the fingers or heads 46, such fingers or heads then springing inwardly within such groove 48 and out of the internal circumferential groove 47 in the valve head. Any pressure in the closed annular passage 20 will now act in a downward direction on the piston head 39, such downward force being transmitted through the fingers 46 to the lower side 49 of the mandrel groove 48, thereby tending to urge the body or mandrel 10 in a downward direction. The lower side 49 of the mandrel groove and the lower inner portions 50 of the fingers or heads are inclined in an inward and upward direction, so that upward movement of the mandrel 10 relative to the fingers or heads will cam the latter outwardly when they are disposed opposite the internal housing groove 47. When the fingers or heads are disposed in the mandrel groove 48, they are out of the housing groove 47 and are free to move into the lower smaller diameter portion 51 of the housing 21, the balance device 22 then being free from the housing 21 and capable of exerting a downward force on the body or mandrel 10.

The fluid pressure within the tool A when in its set conditions tends to act in an upward direction over the cross-sectional area of the body 10 and its valve head 34, desig-

nated by the letter S, tending to shift the mandrel 10 in an upward direction with respect to the valve seat 36, which would effect opening of the valve. Such upward movement is counterbalanced, in the present instance, by making the annular area R of the balance piston 39 substantially equal to the area S. The fluid pressure within the tool is acting in a downward direction on the piston over the area R, and such downward force is transmitted through the latch fingers or heads 46 to the mandrel 10. Thus, substantially equal and opposite forces are being exerted by the fluid pressure on the body or mandrel 10, precluding its inadvertent shifting under the action of fluid pressure to a valve opening condition. If desired, the area R can be made slightly greater than the area S so that the fluid pressure is actually tending to maintain the body or mandrel 10 in a downward direction, to insure against inadvertent opening of the valve device and the annular passage 20.

The valve device can readily be shifted to an open condition merely by elevating the tubular string E, which will shift the body or mandrel 10 upwardly with respect to the anchor body 19 and the housing 21. There is very little, if any, resistance by fluid pressure to such upward movement of the mandrel, in view of the balancing action of the fluid pressure acting in an upward direction over the area S and in a downward direction over the area R. Accordingly, the mandrel 10 and the balance sleeve 22 latched thereto are moved upwardly until the fingers 46 are disposed opposite the circumferential groove 47 in the housing 21, whereupon the lower shoulder or side 49 of the mandrel groove can cam the fingers outwardly into the housing groove 47, the fingers thereby being free to the mandrel groove 48 to allow the mandrel 10 to move upwardly to its fullest extent, free from restraint by the fingers 46.

The upper anchor portion D of the apparatus is secured to the downwardly acting set down type of well packer C. This packer includes a normally retracted packing device 55 surrounding the tubular body or mandrel 10, which includes an inner support sleeve 56 threadedly attached to the lower end of the anchor body 19 and spaced laterally from the body to provide a continuation of the annular passage 20 through which fluid can pass. Surrounding the support sleeve is a packing structure 57, such as a rubber or rubber-like packing sleeve, which is normally retracted. The upper end of the packing structure 57 is adapted to engage the lower end of the anchor body 19, which serves as an upper abutment. It also engages an upper gauge ring 58 threaded on the lower end of the anchor body 19, and serving as an outer extension of the upper abutment. The lower end of the packing sleeve 57 is engageable with a lower abutment 59 slidable on the support sleeve 56 and threadedly connected to an expander sleeve portion or sleeve extension 60, which is integral with a lower expander 61 of generally frusto-conical shape adapted to coact with a plurality of circumferentially spaced lower slips 62 for anchoring the apparatus in the well casing. When the packing structure 57 is in retracted position, the lower abutment 59 may engage an external lower flange 63 of the support sleeve 56. The support sleeve and the expander sleeve portion 60 may be non-rotatably secured to one another, while permitting their relative telescopic movement, by attaching a key 64 to the flange portion of the support sleeve which is slidable in a longitudinal keyway or slot 65 in the interior of the expander sleeve 60.

Fluid can pass through the annular space 66 surrounding the apparatus and around the expander 61, flowing inwardly through a plurality of circumferentially spaced ports or openings 67 in the expander sleeve portion 60 to its interior and then flowing upwardly through the annular passage 20, discharging through the valve seat 36 and into the annulus 68 around the body 10 and the tubular string E. Downward movement of the tubular string E and body 10 relative to the members surrounding

5

the body will, as has been described above, place the valve head 34 in engagement with the valve seat 35 to close the annular passage 29 around the body.

A connector sleeve 69 is slidably mounted on the exterior of the body 10, its upper portion extending within the expander 61 and terminating in an upper stop or flange 70 that projects outwardly and is adapted to engage the upper end 71 of the expander. The lower end of the connector sleeve 69 may rest upon the upper end or stop portion 72 of the lower body sub 16. Surrounding the connector sleeve is a slip sleeve 73 slidable thereon and having a plurality of longitudinally extending circumferentially spaced grooves 74 in which the slips 62 are laterally movable. These slips each include a lower drag portion 75 adapted to frictionally engage the inner wall of the well casing B, being urged outwardly thereagainst by one or a plurality of compression springs 76 engaging the bases of the grooves 74 and the drag portions 75 of the slips. The slips 62 include upper anchor portions 77 having downwardly facing wickers or teeth 78 adapted to engage and embed themselves in the wall of the well casing B, to prevent downward movement of the slips therealong when expanded outwardly by the expander 61. The expander has a downward and inwardly inclined tapered surface 79 adapted to coast with companion inner tapered surfaces 80 on the anchor portions 77 of the slips.

Outward expansion of the slips 62 under the influence of the springs 76 is limited by a retainer ring 81 encompassing the central portions of the slips and received within external grooves 82 therewithin. Outward movement is also limited by engagement of lower terminals 83 of the slips, below the drag portions 75, with an upper rim 84 of a stop and control sleeve or member 85 surrounding the body 10 of the tool and releasably connected thereto by a lock device. The stop and control member or sleeve 85 and the slip sleeve 73 are secured together by a plurality of longitudinally extending screws 86, so that they move as a unit. When the stop and control member 85, slip sleeve 73 and slips 62 are disposed in a lower position on the body, such as illustrated in FIG. 1a, an upper inner flange 87 on the stop and control member is engageable with a split snap ring 88 mounted in a peripheral groove 89 in the connector sleeve 69, to limit the upward position of the connector sleeve relative to the stop and control member 85, as well as relative to the slip sleeve 73. This snap ring has a lower beveled corner 90 inclined in a downward and inward direction, and an upper beveled corner 91 inclined in an upward and inward direction. Such beveling is obtained so that a laterally movable control pin 92 slidable radially in a companion bore 93 in the control member 85 can ride over the snap ring 88 during operation of the apparatus.

The slips 62 are prevented from having substantial longitudinal movement relative to the slip sleeve 73 by engagement of the lower ends 94 of the slips with the upper end of the control member 85 and also by engagement of the retainer ring 81 with an upper external flange 95 of the slip sleeve. When the slip sleeve 73 is moved downwardly, its upper flange 95 engages the retainer ring 81, which engages the lower sides of the slip grooves 82 to pull the slips 62 downwardly in the well casing. When the slip sleeve 73 and the control member 85 are moved upwardly, the upper end of the control member engages the lower ends 94 of the slips and shifts them upwardly along the wall of the well casing. The slips themselves are of the rocker type, in that the anchor portions 77 are removed from engagement with the wall of the well casing when the springs 76 are permitted to force the drag members 75 into full contact with the wall of the well casing. However, when the expander 61 moves downwardly within and behind the anchor portions 77 of the slips, the latter will rock outwardly about the upper parts of the drag portions 75 as a fulcrum on the casing, to

6

shift the teeth 78 outwardly against the well casing and embed them therewithin.

The packer body or mandrel 10 moves downwardly with respect to the parts that surround it in order to engage the valve head 34 with its companion valve seat 36, to expand the packing structure 57 against the wall of the well casing B, and to engage the expander 61 with the anchor portions 77 of the slips and expand the latter outwardly into anchoring engagement with the wall of the well casing. The ability of the body 10 of the tool to move in the manner just described is dependent upon the control mechanism provided between the slip mounting portions 73, 85 of the apparatus and the body 10 of the tool.

As disclosed in the drawings, the laterally or radially shiftable control pin 92 has its inner portion yieldably disposed within a control slot or groove 100 in the periphery of the lower body sub 16 by a leaf spring 101 engaging the outer end of the control pin 92 and secured to the control member in any suitable manner, as by a screw 102. The control slot or groove includes a circumferential groove portion 103 terminating at one end in a stop segment 104 that extends between an upper stop flange 105 of the sub and the lower side 106 of the circumferential groove, being secured thereto as by welding material 107. Another segment 108 is suitably secured to the sub 16, as by welding, and this segment is spaced arcuately from the stop segment 104 to provide a longitudinal inclined slot 109 communicating with an extension of the slot or opening 110 extending completely through the stop flange 105. The lower end of the segment 108 terminates above the lower side 106 of the circumferential groove 103 to provide a communicating opening 111 between the circumferential groove portion 103 and the longitudinal inclined slot or groove portion 109 through which the control pin 92 passes from one slot portion into the other portion. It is to be noted that the segments are so disposed that the longitudinal slot portion 109 defined therebetween is preferably inclined in an upward direction toward the right.

The apparatus can only be set in the well casing upon removal of the control pin 92 from the circumferential groove portion 103. Movement of the control pin 92, the outer control mechanism 85 surrounding the body 10 of the tool, and the connector sleeve 69, as well as movement of the slips 62, is resisted or prevented by the frictional engagement of the drag portions 75 of the slips against the wall of the well casing B. As a result, the tubular string E and body 10 of the tool can be moved upwardly to insure that the control pin 92 is in the lower portion of the circumferential groove 103, which location can be provided by causing an upwardly facing shoulder 115 on the body sub 16 to engage the lower end of the control member 85, such as shown in FIG. 1a. With this condition pertaining, the tubing string E and body 10 are rotated to the right, which will turn the lower body member 16 within the control pin 92 until the latter passes relatively through the communicating passage 111 between the circumferential groove portion 103 and the inclined groove or slot portion 109 and engages the inclined wall 116 of the stop segment 104. The body 10 of the tool can now be lowered, the control pin 92 passing relatively upwardly through the inclined slot portion 109 and through the opening 110 in the flange to a position thereabove. The control pin actually does not move longitudinally, but the body 10 and its groove 100 lower with respect thereto, the downward movement of the control pin 92 being resisted by the friction drag portions 75 of the slips. Downward movement of the body can now continue, to effect closing of the valves 34, 36 and setting of the tool. The control pin 92 engages the lower end 90 of the snap ring 88 and will, at first, prevent downward movement of the connector sleeve 69 with the body of the tool. However, upon engagement of the lower end of the support sleeve 56 with the upper end of the connector

sleeve, the snap ring 88 will force the control pin 92 outwardly so that the latter can, in effect, ride over the snap ring to a position thereabove, and thereby enable the setting of the well packer to be completed. After the control pin 92 rides relatively past the snap ring, the connector sleeve 69 may drop downwardly until its upper stop flange 70 again engages the expander shoulder 71.

The apparatus A is run in the well casing with the parts in the position disclosed in FIGS. 1 and 1a, the control pin 92 being disposed in the locking or circumferential groove portion 103. During the lowering action, the upper side 105 of the groove will engage the pin and result in pulling of the slip mechanism downwardly within the casing B and along the casing wall. The inner flange 87 of the control member 85 engages the snap ring 88 and insures the downward pulling of the connector sleeve 69 with the body 10 and the control member. The contact of the stop flange 70 with the expander shoulder 71 insures downward movement of the expander and its sleeve portion 60, which will cause the lower abutment 59 to engage the flange 63 of the support sleeve 56 and pull the latter downwardly in the well casing with it. Since the support sleeve is connected to the anchor portion 19 of the apparatus, the latter is also pulled downwardly in the well casing. At this time, the piston gripping elements 24 are in their retracted position, being held in such position by the springs 39 and being precluded from inadvertent outward expansion by the fact that fluid is flowing upwardly along the exteriors of the piston elements and also along their interiors, because of the fact that the annular passage 20 is open. Also at this time, the pliant, elastic packing structure 57 is in its retracted position since the lower abutment 59 is disposed downwardly to its maximum extent with respect to the upper abutment or anchor body 19, 58. The anchor body 19 and housing 21 are precluded from moving relatively upwardly along the mandrel or body 10 of the tool to prevent engagement of the valve head 34 with the valve seat 36, thereby insuring that the annular passage 20 remains open.

As stated above, because of the fact that the annular passage 20 is open, lowering of the tool through fluid in the well casing or well bore will cause such fluid to pass upwardly through the tubular body member 10 and into the tubular string E thereabove, this fluid also passing relatively around the exterior of the lower portion of the apparatus and then through the ports 67 to the interior of the expander sleeve 60, and continuing upwardly through the annular passage 20 and the valve seat 36 into the annulus 68 between the tubular string E and casing 12 above the packer apparatus A. Fluid also flows relatively around the outside of the packing structure 57 itself into the annulus 68 between the tubular string and casing above the packer apparatus.

After the setting location of the well packer in the casing has been reached, the tool is lowered a short additional distance in the well casing and is then elevated so that the body 10 of the tool is moved upwardly with respect to the control member 85 and pin 92, the control pin then being disposed adjacent to the lower side 106 of the circumferential groove 103. The tubular running-in string E and body 10 are now turned to the right to rotate the body sub 16 and its groove 100 relative to the pin, whereby the pin 92 passes relatively into the lower end of the inclined slot portion 109. Thereafter, the tubular string E and body 10 of the tool are lowered. Downward movement of the body 10 of the tool can continue relative to the control member 85 and its pin 92 since the latter then passes relatively upwardly through the entire inclined slot portion 109, 110 to a position above the upper stop flange 105 of the sub 16. As described above, downward movement of the control member 85 and pin 92 is resisted by the drag portions 75 of the slips.

Downward movement of the body 10 now continues, the valve head 34 and seal ring 35 moving downwardly

into the cylindrical valve seat 36 to close the annular passage 20, the downward movement of the body 10 then moving the housing 21 and anchor body 19 and support sleeve 56 therewith, the packing structure 57 and the lower abutment 59 also being moved downwardly for the purpose of shifting the expander sleeve portion 60 and the expander 61 downwardly, accompanied by the connector sleeve 69. The expander 61 moves downward toward the slips 62, which are prevented from moving downwardly by engagement of their drag portions 75 with the wall of the well casing B. The connector sleeve 69 moves downwardly with the expander 61 and the body 10 and within the slip structure, the snap ring 88 camming the control pin 92 out of the way and allowing the snap ring to move past the control pin, which will now slide upon the periphery of the connector sleeve. The downward movement of the body 10 and the parts surrounding it, with the exception of the slip structure surrounding the connector sleeve 69, will now continue until the expander 61 moves within and behind the anchor portions 77 of the slips, shifting the latter outwardly into engagement with the wall of the well casing. When this occurs, the expander 61 cannot move downwardly any further. Accordingly, the continued downward movement of the body 10 of the tool causes the anchor portion or upper abutment 19, 58 to move toward the lower abutment 59, which is prevented from moving downwardly by being connected to the expander 61, compressing or shortening the packing sleeve 57 and expanding it outwardly into sealing engagement with the wall of the well casing. The parts are now in the condition illustrated in FIGS. 2 and 2a.

As described above, upon downward movement of the body 10 within the anchor portion D and housing 21 of the tool, the peripheral groove 48 of the body is disposed opposite the latch fingers or heads 46, the latter snapping into such groove and out of the housing groove 47, whereupon the fingers or heads are adapted to bear against the lower shoulder 49 on the mandrel, and then being disposed below the internal housing groove 47 and adapted to slide downwardly along the housing portion 51, at least to a small extent. The balance device 22 is now in condition to offset any pressure differentials in the apparatus, or therebelow, that would otherwise tend to shift the body or mandrel 10 upwardly and inadvertently open the valve and the annular passage 20 between the body 10 of the tool and the anchor portion D and the packing device 55.

A suitable operation can now be performed with the set packer A. Thus, fluid under pressure is pumped down the tubular string E and through the body or mandrel 10. Such fluid under pressure is also imposed on the fluid in the well bore below the set packing structure 55, passing through the ports 67 and into the annulus 20 between the mandrel 10 and the anchor portion D and housing 21 connected to the anchor body. The fluid pressure acts on the gripping members 24 and urges them outwardly into gripping engagement with the wall of the well casing. In the event the apparatus is subjected to high pressure differentials, the anchoring action of the gripping members 24 against the well casing will prevent upward pumping or movement of the packer apparatus A in the well casing. At the same time, as has been noted above, such fluid pressure in the annulus 20 between the body or mandrel 10 and the housing 21 acts in a downward direction on the piston 39, the downward force being imposed through the latch heads 46 on the mandrel shoulder 49 urging the body or mandrel 10 in a downward direction and offsetting the tendency of the fluid pressure acting over the area S of the mandrel and tending to shift it in an upward direction.

After the operation in the well bore has been completed, the tool A can be released from the well casing B and removed therefrom, if desired. If the fluid pressure has been relieved, release will occur simply as the result

9

of elevating the tubing string E and the body or mandrel 10 in the casing. Even if fluid pressure has not been relieved, the release still can occur as the result of elevating the tubing string and body in the casing. Because of the hydraulic counterbalance feature, the fluid pressure is substantially balanced on the body or mandrel 10, so that the latter can be shifted upwardly with exertion of comparatively little force on the tubular string E. At first the body moves upwardly to carry the valve head 34 upwardly within the cylindrical valve seat 36, and also to carry the fingers or heads 46 upwardly with it until the latter are disposed opposite the release groove 47 in the housing 21, whereupon the body or mandrel 10 will cam the latch heads or heads 46 outwardly free from the groove 43. The mandrel 10 can then shift upwardly to the extent required, the valve head and its seal moving out of the valve seat 36 in order to open the annular passage 20 around the mandrel 10, thereby enabling the fluid pressure to be equalized internally and externally of the apparatus. Following equalizing of the fluid pressure, the springs 30 shift the piston gripping elements 24 to their retracted position free from engagement with the wall of the well casing.

During the initial phase of upward movement of the mandrel 10, the upper end 72 of the body sub 16 will engage the lower end of the connector sleeve 69 and carry the latter upwardly with the body until its upper end 70 engages the upper end of the support sleeve 56, whereupon the support sleeve and the anchor portion D connected thereto are shifted upwardly with the body 10, to move the upper abutment constituted by the anchor body 19 and gauge ring 58 away from the lower abutment 59, which will permit the packing sleeve 57 to retract to its initial position. The support sleeve 56 moves upwardly with the body 10 and the connector sleeve 69 until its lower flange 63 engages the lower abutment 59, which will then elevate the expander sleeve portion 60 and the expander 61 from the anchor portions 77 of the slips 62, allowing the springs 76 to rock the drag portions 75 of the slips back into full surface contact with the wall of the well casing and pivot the anchor portions 77 inwardly from engagement with the wall of the well casing. The expander 61 can move upwardly of the slips until the control member 85 engages the upwardly facing shoulder 115 on the lower body sub 16 or its flange 87 engages the snap ring 88. The control pin 92 itself moves automatically into its locking circumferential groove portion 103 inasmuch as it merely rides upon the upper beveled end 91 of the snap ring and past this ring, then engaging the inclined end 120 of the body sub, riding past the flange 105 and back into the circumferential groove portion 103. The control pin 92 can shift outwardly against the force of the leaf spring 101, which will shift it inwardly into the groove 103 after it rides past the stop flange 105.

The parts are now in the position they occupy during elevation of the apparatus in the well casing, which is illustrated in FIGS. 3 and 3a. During such elevating movement through fluid in the well casing, the resistance of such fluid cannot inadvertently expand the piston gripping elements 24 and the packing structure 57 against the wall of the well casing, since the fluid force is disposed internally of the gripping elements 24, as well as externally thereof, and it is also prevented from acting on and moving the upper abutment or anchor body 19 relatively downwardly toward the lower abutment 59, which would effect a shortening of the packing structure 57 and its outward expansion. The downward force imposed by the fluid on the anchor body 19 and the sleeve 56 is not transmitted to the packing element 57, but, instead, is by-passed completely to the connector sleeve 69, the lower end of which is in engagement with the body shoulder 72. Thus, the downward force is transmitted directly to the body 10 without being imposed on the packing element 57. During upward movement of the

10

apparatus in the well casing, the fluid passing through the annular passage 20 and around the packing structure 57 does not tend to move the lower abutment 59 upwardly toward the anchor body 19, but, instead, actually tends to hold the lower abutment in a downward position in which the packing sleeve is fully retracted. The apparatus can be elevated in the well casing and removed entirely therefrom at the top of the hole.

It is, accordingly, evident that a subsurface well tool has been provided in which the mandrel or body 10 can be moved by the tubular string E through a relatively long stroke with respect to the well tool parts surrounding it, for the purpose of securing opening and closing of the valve portion of the apparatus, setting of the lower slips 62, and expanding of its packing structure 57, and also closing of the annular passage 20 so that the fluid pressure can shift the anchor gripping elements 24 outwardly into engagement with the well casing. Despite such a long stroke, it is unnecessary to move the balance sleeve 22 to the same extent, which can be made comparatively short. The balance sleeve is only operatively connected to the body or mandrel 10 so as to be available for the purpose of counteracting the tendency of fluid pressure to shift the body or mandrel upwardly, after the stroke of the mandrel 10 relative to the surrounding housing 21 has been substantially completed. The valve device is pressure balanced so that it can be opened very readily even in the presence of a relatively high pressure differential imposed on the apparatus. The tubular string E can be elevated to elevate the body or mandrel 10 and dispose the latch devices 46 opposite the release groove 47 in the housing or body 21, the latch fingers 46 then being cammed into such groove to free them from the mandrel 10, which is now free from any restraint imposed by the balance device 22 and capable of moving freely upwardly to elevate the valve head 34 from and above the valve seat 36, thereby opening the annular passage 20 through the apparatus.

I claim:

1. In apparatus adapted to be operated in a well bore: an outer tubular member; an inner tubular member telescoped in said outer member; a piston movable within said outer member and along which said inner member is movable; and latch means connecting said piston to said inner member when said inner member is disposed in one position along said piston, said latch means disconnecting said piston from said inner member when said inner member is disposed in another position along said piston.

2. In apparatus adapted to be operated in a well bore: an outer tubular member; an inner tubular member telescoped in said outer member; a piston movable within said outer member and along which one of said members is movable; and latch means connecting said piston to said one member when said one member is disposed in one position along said piston, said latch means disconnecting said piston from said one member when said one member is disposed in another position along the piston.

3. In apparatus adapted to be operated in a well bore: an outer tubular member; an inner tubular member telescoped in said outer member; hydraulically operable means movable within said outer member and along which said inner member is movable; and latch means connecting said hydraulically operable means to said inner member when said inner member is disposed in one position along said hydraulically operable means to transmit hydraulic force on said hydraulic operable means to said inner member; said latch means disconnecting said hydraulically operable means from said inner member when said inner member is disposed in another position along said hydraulically operable means.

4. In apparatus adapted to be operated in a well bore: an outer tubular member; an inner tubular member telescoped in said outer member; hydraulically operable means movable within said outer member and along

which one of said members is movable; and latch means connecting said hydraulically operable means to said one member when said one member is disposed in one position along said hydraulically operable means, to transmit hydraulic force on said hydraulically operable means to said one member, said latch means disconnecting said hydraulically operable means from said one member when said one member is disposed in another position along said hydraulically operable means.

5. In apparatus adapted to be secured to a tubular running-in string for operation in a well bore: first and second tubular members telescoped one within the other; means on said first tubular member for securing said first member to the tubular running-in string, whereby fluid under pressure in the tubular running-in string and first member tends to elevate said first member; hydraulically operable means in said second member along which said first member is movable and subject to fluid pressure substantially the same as the pressure of fluid in said first member and urged thereby in a downward direction; and releasable latch means connecting said hydraulically operable means to said first member when said first member is disposed in one position along said hydraulically operable means, whereby fluid pressure acting on said hydraulically operable means urges said first member downwardly, said latch means disconnecting said hydraulically operable means from said first member when said first member is disposed in another position along said hydraulically operable means.

6. In apparatus adapted to be secured to a tubular running-in string for operation in a well bore: first and second tubular members telescoped one within the other and providing a fluid passage; coengageable valve elements on said members for controlling fluid flow through said passage; means on said first tubular member for securing said first member to the running-in string, whereby fluid under pressure in the running-in string and first member tends to elevate said first member and disengage said valve elements from each other; hydraulically operable means in said second member along which said first member is movable and subject to fluid pressure substantially the same as fluid pressure in said first member and urged thereby in a downward direction; and releasable latch means connecting said hydraulically operable means to said first member when said first member is disposed in one position along said hydraulically operable means with said valve elements coengaged, whereby fluid pressure acting on said hydraulically operable means urges said first member downwardly and offsets the fluid pressure tending to elevate said first member, said latch means disconnecting said hydraulically operable means from said first member when said first member is disposed in another position along said hydraulically operable means.

7. In apparatus adapted to be operated in a well bore: first and second tubular members telescoped one within the other and providing a fluid passage; coengageable valve elements on said members for controlling fluid flow through said passage; said first member being subject to fluid pressure in the well bore tending to move said first member longitudinally in one direction to disengage said valve elements from each other; hydraulically operable means in said second member along which said first member is movable and subject to fluid pressure in the well bore and urged thereby in the opposite longitudinal direction; and releasable latch means connecting said hydraulically operable means to said first member when said first member is disposed in one position along said hydraulically operable means with said valve elements coengaged, whereby fluid pressure acting on said hydraulically operable means urges said first member in said opposite longitudinal direction and offsets the fluid pressure tending to move said first member in said one longitudinal direction, said latch means disconnecting said hydraulically operable means from said first member when said

first member is disposed in another position along said hydraulically operable means.

8. In apparatus adapted to be operated in a well bore: an outer tubular member; an inner tubular member telescoped within said outer member and providing a fluid passage with said outer member disposed therebetween; coengageable valve elements on said members for controlling flow of fluid through said passage, said elements being coengageable when said inner member is in a lower position in said outer member and being disengaged from each other when said inner member is in an upper position in said outer member; hydraulically operable means between said members along which said inner member is movable and subject to fluid pressure in said passage and urged thereby in a downward direction; and releasable latch means connecting said hydraulically operable means to said inner member when said inner member is disposed in said lower position in said outer member, said latch means disconnecting said hydraulically operable means from said inner member when said inner member is disposed in said upper position in said outer member.

9. In apparatus adapted to be operated in a well bore: an outer tubular member; an inner tubular member telescoped within said outer member and providing a fluid passage with said outer member disposed therebetween; coengageable valve elements on said members for controlling flow of fluid through said passage, said elements being coengaged when said inner member is disposed in one position in said outer member and being disengaged from each other when said inner member is disposed in another position in said outer member longitudinally removed from said one position; said inner member being subject to fluid pressure in the well bore tending to move said inner member longitudinally in one direction in said outer member to said another position to disengage said valve elements from each other; hydraulically operable means between said members along which said inner member is movable and subject to fluid pressure in said passage and urged thereby longitudinally in the opposite direction; and releasable latch means connecting said hydraulically operable means to said inner member when said inner member is disposed in said one position in said outer member, said latch means disconnecting said hydraulically operable means from said inner member when said inner member is disposed in said another position in said outer member.

10. In apparatus adapted to be operated in a well bore: an outer tubular member; an inner tubular member telescoped within said outer member and providing a fluid passage with said outer member disposed therebetween; coengageable valve elements on said members for controlling flow of fluid through said passage, said elements being coengageable when said inner member is in a lower position in said outer member and being disengaged from each other when said inner member is in an upper position in said outer member; a piston between said members along which said inner member is movable and subject to fluid pressure in said passage and urged thereby in a downward direction; and releasable latch means secured to said piston and adapted to connect said piston to said inner member when said inner member is disposed in said lower position in said outer member, said latch means disconnecting said piston from said inner member when said inner member is disposed in said upper position in said outer member.

11. In apparatus adapted to be operated in a well bore: an outer tubular member; an inner tubular member telescoped within said outer member and providing a fluid passage with said outer member disposed therebetween; coengageable valve elements on said members for controlling flow of fluid through said passage, said elements being coengageable when said inner member is in a lower position in said outer member and being disengaged from each other when said inner member is in an upper position

13

tion in said outer member; a piston between said members along which said inner member is movable and subject to fluid pressure in said passage and urged thereby in a downward direction; said inner member having a groove; and releasable latch means secured to said piston and movable into said groove to connect said piston to said inner member when said inner member is disposed in said lower position in said outer member, said latch means being out of said groove to disconnect said piston from said inner member when said inner member is in said upper position in said outer member.

12. In apparatus adapted to be operated in a well bore: an outer tubular member; an inner tubular member telescoped within said outer member and providing a fluid passage with said outer member disposed therebetween; coengageable valve elements on said members for controlling flow of fluid through said passage, said elements being coengaged when said inner member is in one position in said outer member and being disengaged from each other when said inner member is in another position in said outer member; said inner member being subject to fluid pressure in the well bore tending to move said inner member longitudinally in one direction to said other position in said outer member to disengage said valve elements from each other; a piston between said members along which said inner member is movable and subject to fluid pressure in said passage and urged thereby in the opposite longitudinal direction; said inner member having a groove; and releasable latch means secured to said piston and movable into said groove to connect said piston to said inner member when said inner member is disposed in said one position in said outer member, said latch means being out of said groove to disconnect said piston from said inner member when said inner member is in said other position in said outer member.

13. In apparatus adapted to be operated in a well bore: an outer tubular member; an inner tubular member telescoped within said outer member and providing a fluid passage with said outer member disposed therebetween; coengageable valve elements on said members for controlling flow of fluid through said passage, said elements being coengageable when said inner member is in a lower position in said outer member and being disengaged from each other when said inner member is in an upper position in said outer member; a piston between said members along which said inner member is movable and subject to fluid pressure in said passage and urged thereby in a downward direction; said inner and outer members having grooves; releasable latch means secured to said piston and disposed in said outer member groove and movable from said outer member groove into said inner member groove to connect said piston to said inner member upon movement of said inner member to said lower position in said outer member; and means on said inner member for shifting said latch means out of said inner member groove and into said outer member groove upon movement of said inner member to said upper position.

14. In apparatus adapted to be operated in a well bore: an outer tubular member; an inner tubular member telescoped within said outer member and providing a fluid passage with said outer member disposed therebetween;

14

coengageable valve elements on said members for controlling flow of fluid through said passage, said elements being coengaged when said inner member is in one position in said outer member and being disengaged from each other when said inner member is in another position in said outer member; said inner member being subject to fluid pressure in the well bore tending to move said inner member longitudinally in one direction to said other position in said outer member to disengage said valve elements from each other; a piston between said members along which said inner member is movable and subject to fluid pressure in said passage and urged thereby in the opposite longitudinal direction; said inner and outer members having grooves; releasable latch means secured to said piston and disposed in said outer member groove and movable from said outer member groove into said inner member groove to connect said piston to said inner member upon movement of said inner member to said one position in said outer member; and means on said inner member for shifting said latch means out of said inner member groove and into said outer member groove upon movement of said inner member to said other position.

15. In apparatus adapted to be operated in a well bore: an outer tubular member; an inner tubular member telescoped within said outer member and providing a fluid passage with said outer member disposed therebetween; a piston between said members along which said inner member is movable and subject to fluid pressure in said passage and urged thereby in a downward direction; said inner member having a groove; and releasable latch means secured to said piston and movable into said groove to connect said piston to said inner member when said inner member is disposed in a lower position in said outer member, said latch means being out of said groove to disconnect said piston from said inner member when said inner member is in an upper position in said outer member.

16. In apparatus adapted to be operated in a well bore: an outer tubular member; an inner tubular member telescoped within said outer member and providing a fluid passage with said outer member disposed therebetween; a piston between said members along which said inner member is movable and subject to fluid pressure in said passage and urged thereby in a downward direction; said inner and outer member having grooves; releasable latch means secured to said piston and disposed in said outer member groove and movable from said outer member groove into said inner member groove to connect said piston to said inner member upon downward movement of said inner member in said outer member; and means on said inner member for shifting said latch means out of said inner member groove and into said outer member groove upon upward movement of said inner member in said outer member.

References Cited in the file of this patent

UNITED STATES PATENTS

2,878,877	Baker	Mar. 24, 1959
2,893,492	Brown	July 7, 1959
2,962,096	Knox	Nov. 29, 1960