

Sept. 18, 1962

J. R. BAKER ET AL
SLEEVE VALVE APPARATUS

3,054,415

Filed Aug. 3, 1959

3 Sheets-Sheet 1

FIG. 2.

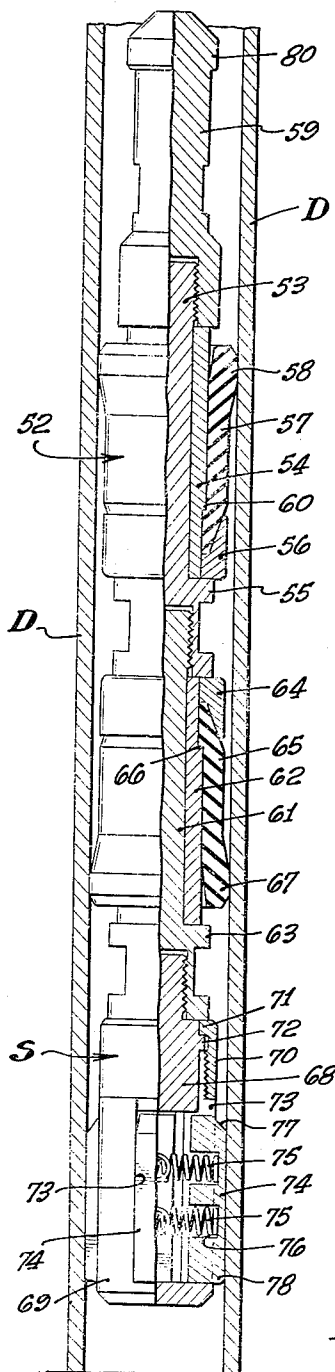


FIG. 2a.

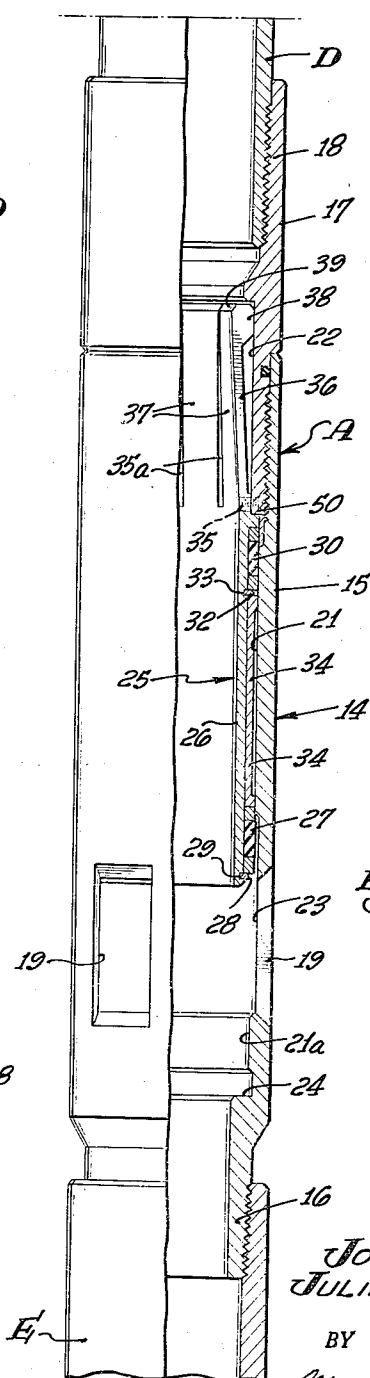
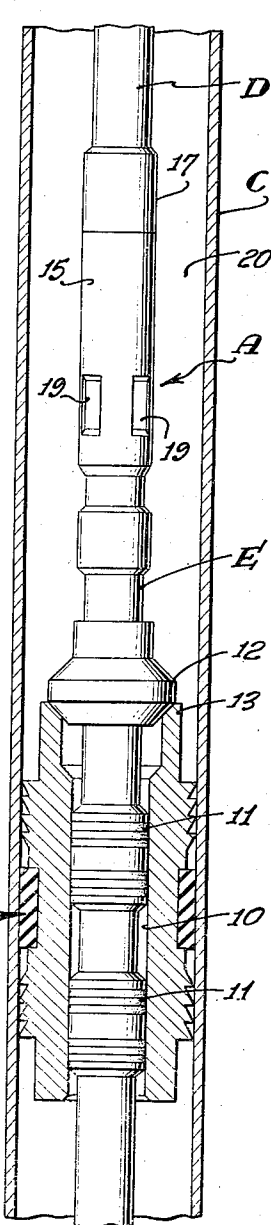


FIG. 1.



JOHN R. BAKER
JULIAN D. KEITHAHN
INVENTORS.

BY

Mellin and Haneson
ATTORNEYS.

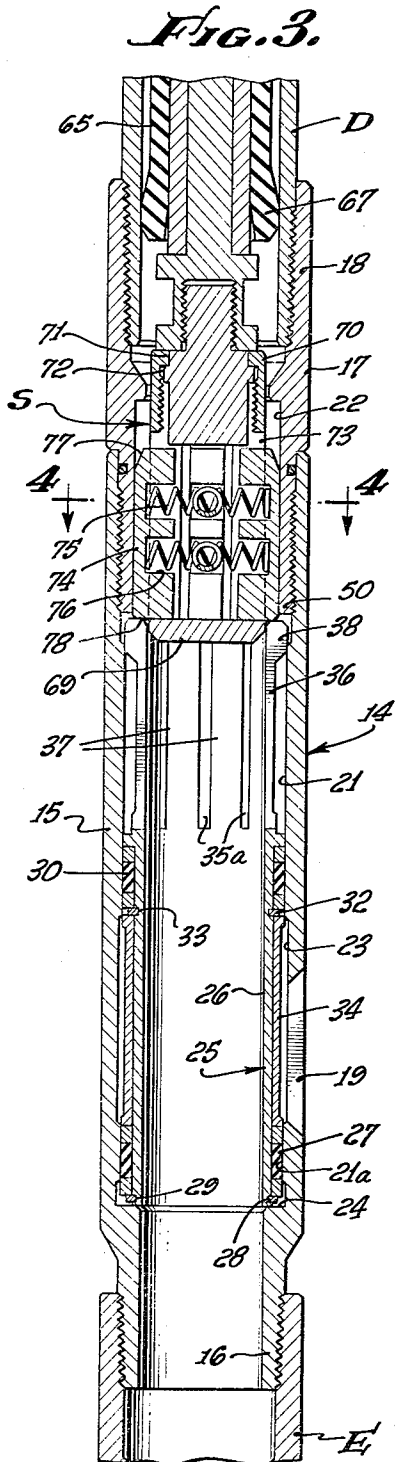
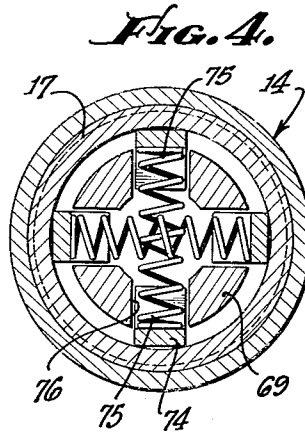
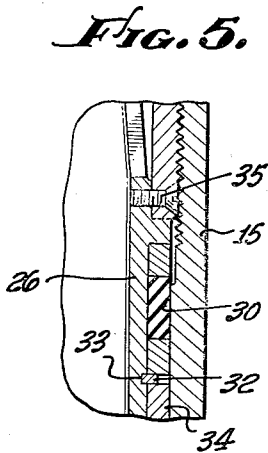
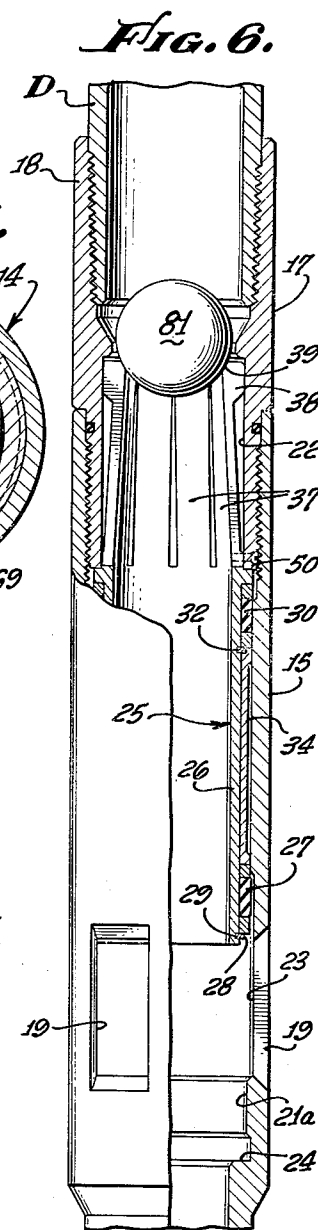
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JOHN R. BAKER
JULIAN D. KEITHAHN
INVENTORS.

BY

Mellin and Hanson
ATTORNEYS.

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FIG. 7.

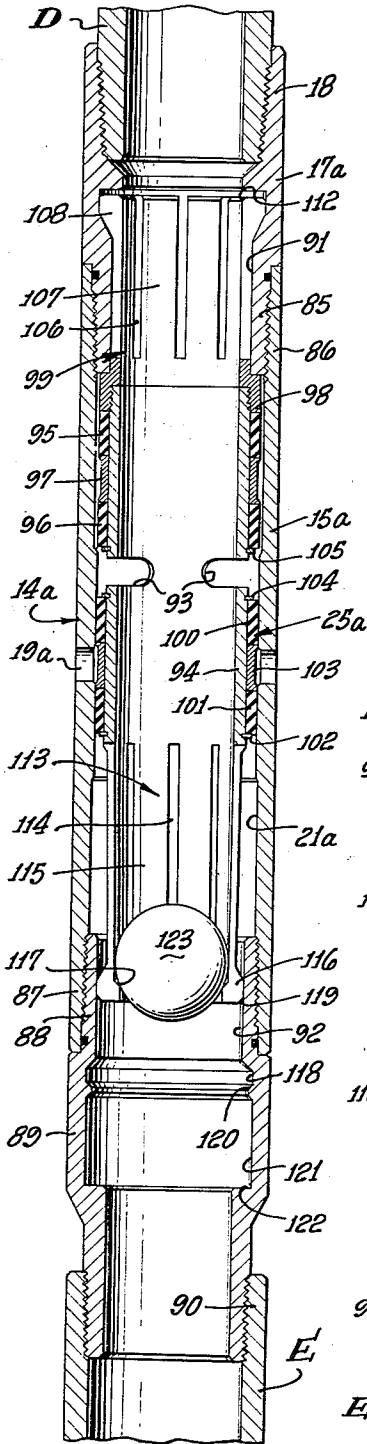


FIG. 8.

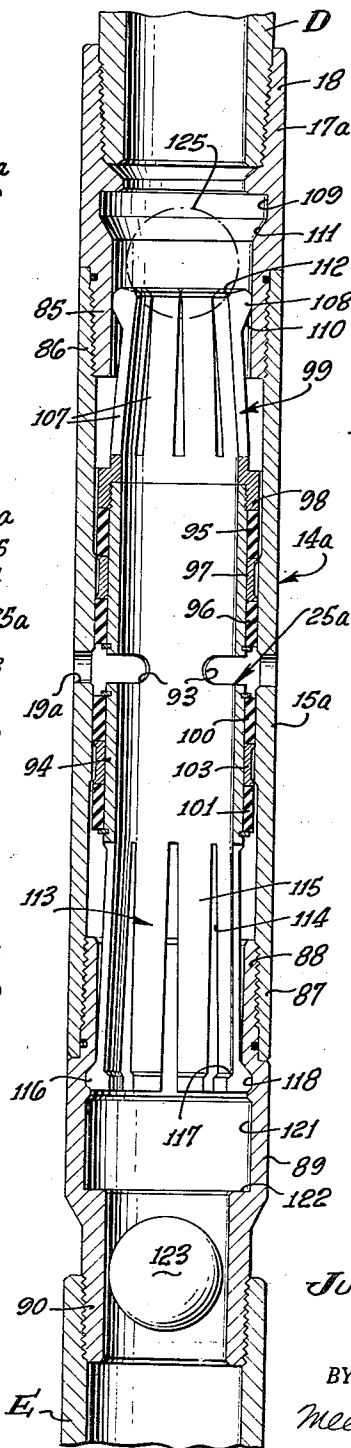
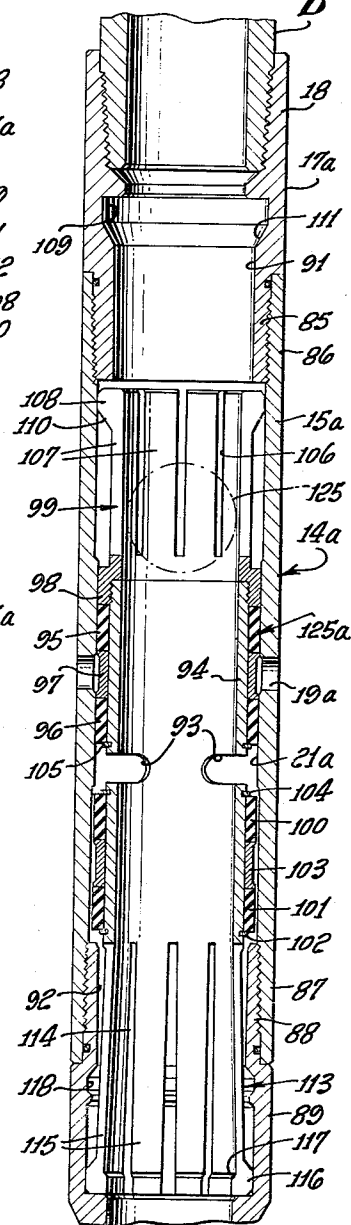


FIG. 9.



JOHN R. BAKER
JULIAN D. KEITHAHN
INVENTORS

BY
Mellin and Hancorn
ATTORNEYS.

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3,054,415

SLEEVE VALVE APPARATUS

John R. Baker, Pasadena, and Julian D. Keithahn, Anaheim, Calif., assignors to Baker Oil Tools, Inc., Los Angeles, Calif., a corporation of California

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13 Claims. (Cl. 137-68)

The present invention relates to valve apparatus, and more particularly to valve apparatus adapted to be incorporated in a tubular string lowered in a well bore, to determine the flow of fluid between the interior of the tubular string and the annular space in the well bore surrounding it.

An object of the invention is to provide a valve apparatus adapted to be incorporated in a tubular string to be lowered in a well bore and having ports controlled by an internal valve sleeve, the sleeve being mechanically shifted with respect to the ports and having an unobstructed bore therethrough after the shifting has been effected.

Another object of the invention is to provide a valve apparatus adapted to be incorporated in a tubular string to be lowered in a well bore and having ports controlled by an internal sleeve valve having an initial minimum diameter substantially less than the internal diameter of the tubular string, the sleeve valve being mechanically shifted with respect to the ports and its minimum diameter automatically increasing after its shifting has been effected, to provide an unobstructed bore through the tubular string and valve apparatus.

A further object of the invention is to provide a valve apparatus of the character above indicated in combination with a valve sleeve shifting device that is readily removable from the location of the valve apparatus after it has shifted the valve sleeve.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of several forms in which it may be embodied. Such forms are shown in the drawings accompanying and forming part of the present specification. These forms 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:

FIGURE 1 is a longitudinal section through a well casing illustrating the apparatus in combination with a well packer (disclosed diagrammatically);

FIGS. 2 and 2a together constitute a combined side elevational view and longitudinal section through the valve portion of the apparatus and the valve actuating device, the valve being disclosed in open position, FIG. 2a constituting a lower continuation of FIG. 2;

FIG. 3 is a longitudinal section through the apparatus disclosed in FIGS. 2 and 2a after the valve sleeve shifting device has performed its operation;

FIG. 4 is an enlarged cross-section taken along the line 4-4 on FIG. 3;

FIG. 5 is an enlarged fragmentary longitudinal section through a portion of the apparatus illustrated in FIG. 2a;

FIG. 6 is a longitudinal section, with parts shown in side elevation, through the valve apparatus with a modified form of valve sleeve shifting device;

FIG. 7 is a longitudinal section through still another form of the invention, with the valve in closed position;

FIG. 8 is a view of the apparatus shown in FIG. 7, with the valve in open position;

FIG. 9 is a view of the apparatus shown in FIGS. 7 and 8, with the valve again in a closed position.

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As illustrated in the drawings, and particularly in FIG. 1, a valve apparatus A may be used in conjunction with another apparatus B in the well bore, such as a well packer which may have been previously anchored in packed-off condition in a well casing C. The valve apparatus is lowered in the well casing by means of a tubular string D, such as a string of tubing extending to the top of the hole, and has a suitable tubing E secured thereto and depending therefrom which is adapted to extend through the bore 10 of the well packer. The tubing has suitable side seals 11 thereon sealing against the wall of the well packer, the seals being located appropriately in the well packer by engagement of a head 12 on the tubing with the upper end 13 of the well packer.

The valve apparatus A includes an outer tubular housing member 14 which may be made in several sections. Thus, a lower section 15 may have a threaded pin 16 for threadedly attaching the lower portion of the housing to the tubing E depending therefrom, this lower housing section being threadedly attached to an upper housing section 17 having an upper threaded box 18 for threadedly securing the housing to the tubing string D, which extends through the well casing C to the top of the well bore. The lower housing section 15 has a plurality of circumferentially spaced side door openings or ports 19 therethrough, preferably of comparatively large area, to provide communication between the interior of the valve housing 14 and the tubing string D and the tubing-casing annulus 20 surrounding the housing and the tubing string. The side ports 19 extend through the housing member 14 in a region where it has an enlarged bore 21 of an internal diameter substantially greater than the internal diameter through the tubing string D that extends to the top of the hole. The upper housing section 18 also has an enlarged bore 22 of an internal diameter that is greater than the internal diameter through the tubing string D thereabove. However, the internal diameter of this enlarged bore 22 is substantially less than the internal diameter of the bore 21 in the lower housing member. In the region 23 of the ports 19, the lower housing member 15 may have a still greater internal diameter for a purpose that will be described hereinafter. However, the lower housing member 15 below the ports 19 has an internal diameter 21a equal to the internal diameter of the enlarged bore 21 substantially above the ports, there also being a transverse stop shoulder 24 in the lower housing member below the ports 19, which extends in an inward direction.

Initially, the ports 19 are open, but they can be closed upon downward movement of a valve sleeve 25 disposed in the housing member 14. This valve sleeve has an imperforate lower portion 26 of an internal diameter that is preferably no less than the internal diameter through the tubing string D. It carries a lower seal structure 27, of any suitable type, which may be supported by a split snap ring 28 fitting within a companion groove 29 in the lower portion of the valve sleeve. There is also an upper seal ring structure 30 mounted on the valve sleeve and held in place by a split snap ring 32 engaging the lower portion of the structure and received within a peripheral groove 33 in the valve sleeve portion 26. A suitable spacer sleeve 34 is mounted on the valve sleeve 26 between the upper and lower seals 30, 27 to insure their retention in appropriate longitudinal spaced relation on the valve sleeve.

Initially, the valve sleeve 25 is retained in its upper position above the side ports 19 by a releasable holding device in the form of one or more shear screws 35 extending through the upper housing member 17 and threadedly into the valve sleeve 25 above its upper seal 30. The upper portion 36 of the valve sleeve 25 is formed as a latching and seating device. Thus, a plurality of cir-

cumferentially spaced longitudinal slots 35a are provided in the upper portion 36 of the valve sleeve, opening through the upper end of the latter to provide latch arms 37 that tend to spring inherently outwardly. Initially, the upper portions of these arms are constituted as outwardly extending latch fingers 38 which engage the inner wall 22 of the upper housing member 17 to project the latch fingers and arms inwardly so that they form a seat 39 of an internal diameter substantially less than the internal diameter of the tubing string D.

A suitable device S can engage the upper latch fingers 38 of the valve sleeve 25 and exert a downward force on the valve sleeve to disrupt the shear screws 35, after which the valve sleeve moves downwardly to a position across the ports 19, as limited by engagement of the lower end of the sleeve with the stop shoulder 24. At this time the lower seal 27 will be in sealing engagement with the lower seat 21a below the ports and the upper seal 30 will remain in sealing engagement with the inner wall 21 of the enlarged bore. The relieved portion 23 of the lower housing section in the region of the side ports 19 will insure against the lower seal 27 engaging the housing member and sliding across the edges of the ports 19 in moving toward its position of engagement with the lower seat 21a, thereby precluding mechanical damage to the rubber or rubber-like material of which the lower seal 27 is made.

When the valve sleeve 25 has been shifted to its lowermost position in engagement with the stop shoulder 24, the upper and lower seals 30, 27 will be disposed in sealing engagement with the housing member on opposite sides of the ports or door openings 19, to close the latter. When in this position, the latch fingers 38 will move below the lower end or shoulder 50 of the upper housing section 17 and can expand inherently outwardly into the enlarged bore 21 of the lower housing section 15, at which time the minimum diameter through the latch arms 37 and latch fingers 38 will be no less than the internal diameter through the tubing string D, leaving the bore through the valve apparatus A unobstructed, so that any devices that can pass down through the tubing string D can pass through the entire valve structure as well. When disposed in the enlarged bore 21, the latch fingers 38 are engageable with the downwardly facing shoulder 50 provided by the lower end of the upper housing section 17, which will positively prevent upward shifting of the valve sleeve 25 to port opening position.

The device S for shearing the screws 35 and for shifting the valve sleeve 25 downwardly in the housing, shown in FIGS. 1 to 4, inclusive, includes a mandrel 52 consisting of several sections. The mandrel may include an upper section 53 on which an upper spacer sleeve 54 is mounted, this spacer sleeve engaging a mandrel shoulder 55 on which a thimble 56 rests, there being an upwardly facing swab cup 57, of rubber or rubber-like material, surrounding the sleeve 54 and having an upper lip portion 58 adapted to sealingly engage the wall of the tubular string D. An upper sub 59 is threaded on the upper end of the upper mandrel section 53 and bears against the spacer sleeve 54 to clamp a shoulder 60 on the latter against the swab cup 57 and hold the latter against and within the thimble 56, which bears upon the shoulder 55.

A similar swab cup construction is mounted upon an intermediate mandrel section 61, the upper end of which is threadedly secured to the lower portion of the upper mandrel section 53. A lower spacer sleeve 62 surrounds the intermediate mandrel section, its lower end bearing against a mandrel shoulder 63 and its upper end bearing against the lower end of the upper mandrel section 53, which also engages a thimble 64 that receives the upper portion of an inverted downwardly facing swab cup 65, of rubber or rubber-like material, mounted on the spacer sleeve 62, the latter having a shoulder 66 holding the swab cup against and within the thimble 64. This swab

cup 65 has a lower lip portion 67 adapted to slidably and sealingly engage the wall of the tubing D.

The intermediate mandrel section 61 is threadedly attached to the upper end of a lower mandrel section 68 on which a hollow body 69 is mounted. This hollow body is secured to the lower mandrel section 68 by a connector sleeve 70 threaded on the upper portion of the body and having an inwardly directed flange 71 engaging a mandrel flange 72. The body 69 has a plurality of slots or openings 73 therethrough slidably receiving latch blocks or drag blocks 74 urged outwardly by helical compression spring 75 received within sockets 76 in the blocks. The upper outer corners 77 of these blocks are tapered or beveled so that the blocks will ride past corners and coupling spaces; whereas, the lower ends 78 of the blocks project outwardly beyond the body 69 and are adapted to engage the upper ends 39 of the latch fingers 38, when such fingers have been expanded into the sleeve 25 downwardly in the housing 14 to port closing enlarged housing recess 21, following shifting of the valve position.

In the use of the apparatus heretofore described, the packer B has previously been installed at the desired location in the well casing C. The valve apparatus A is secured to the lower end of the tubing string D and will have the tubing E attached to and depending therefrom, the sleeve valve 25 being in its upper port opening position, in which it is retained by the shear screw or screws 35. The tubular string D is lowered in the well casing and the lower tubing E received within the packer passage 10, as determined by engagement of the head 12 with the upper end 13 of the packer, at which time the tubing seals 11 engage the wall of the well packer and prevent leakage of fluid therearound. Circulation may now be established down through the tubing string D, a lighter fluid being pumped down the tubular string and usually displacing a heavier fluid ahead of it, forcing the heavier fluid out through the open side ports 19 and then upwardly through the tubing-casing annulus 20 to the top of the well bore, until the heavier fluid has been fully displaced from the hole. The shifting apparatus S may now be inserted in the tubular string D, its swab cups or packing members 57, 65 sealingly engaging the wall of the tubing string. Such shifting apparatus is pumped down through the tubing string. Since its latch blocks 74 have a length substantially greater than the usual coupling spaces found in tubing strings D, they will merely slide past such coupling spaces. The shifting apparatus S is pumped down through the tubing string until its lower body 69 engages the inwardly extending latch fingers 38. The imposition of sufficient pressure on the shifting device will now effect a shearing of the screws 35 and a downward shifting of the valve sleeve 25 to its port closing position shown in FIG. 3, at which time the valve fingers 38 will have snapped outwardly into the enlarged bore 21, so that there are no restrictions through the valve sleeve 25. It is to be noted that the latch blocks 74 will have expanded outwardly into the enlarged bore 21 in the upper housing section 15 and will rest upon the upper ends of the latch arms or fingers 38 so as to preclude downward pumping of the shifting device S through the valve sleeve 25.

The side ports 19 of the valve device are now closed, and, if desired, the shifting device S may be retrieved. One manner of effecting such retrieval is merely to flow the well, the well production passing upwardly into the tubing E and acting upon the downwardly facing swab cup or packing element 65 to force the shifting device S upwardly through the tubing string D. The beveled upper ends 77 of the latch or drag blocks 74 enable the latter to shift inwardly against the force of their springs 75, the blocks then sliding along the wall of the tubing string D, until the entire device S is removed at the top of the well bore.

If the shifting device S is not retrieved by flowing the

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well in the manner just described, then a suitable over-shot (not shown) can be lowered on a wire line (not shown) through the tubing string D for coupling with a retrieving head 80 formed on the upper sub 59. The line is thereby connected to the shifting device S. Accordingly, elevation of the line will bring the shifting device upwardly through the well tubing D to the top of the well bore.

In lieu of shifting the valve sleeve 25 to port closing position by means of the shifting device S illustrated in FIGS. 2 to 4, inclusive, it can be shifted hydraulically through use of a ball valve element 81, such as disclosed in FIG. 6. This ball valve element has a diameter that may closely approximate the inside diameter of the tubing string D, but which diameter will be substantially greater than the minimum diameter across the latch fingers 38 when they are disposed in the position illustrated in FIGS. 2a and 6. The ball 81 can be pumped down the tubing string D, or will be allowed to gravitate therethrough, and will come to rest on the upper ends 39 of the latch fingers. Hydraulic pressure can then be imparted to the fluid in the tubing string D above the ball, such pressure acting downwardly on the ball and the valve sleeve 25 to shear the screws 35. The ball and valve sleeve then move downwardly in the housing 14 until the valve sleeve 25 shifts across the port 19 and comes to rest upon the stop shoulder 24. When this occurs, the fingers 38 will be disposed in the enlarged bore 21 of the housing, and will snap outwardly into such enlarged bore, the effective minimum diameter through the latch fingers then being greater than the diameter of the ball, allowing the ball to pass completely through the sleeve 25 and the housing 14, and continue on down through the tubing E extending through the well packer B, to drop into the well bore therebelow. Usually the ball 81 will drop to the bottom of the well bore, in which position it will not interfere with the normal operation of the apparatus in the well bore, and the securing of production from the well bore. If, however, it is not desired to have the element 81 in the well at all, then the other shifting device S can be used and retrieved from the well tubing D.

In the form of invention illustrated in FIGS. 7, 8 and 9, the apparatus is run in the well bore with the valve in the closed position. It can be shifted to the open position, such as shown in FIG. 8, whenever desired, and after the operation in the well bore has been completed it can be reshifted to the closed position, such as shown in FIG. 9. Following such reshifting, the bore through the apparatus is unobstructed.

The apparatus shown in FIGS. 7, 8 and 9 includes an outer tubular housing 14a made of a plurality of sections. It includes an upper section 17a having a threaded box 18 for threadedly securing the housing to the lower end of the tubular string D. This upper section has a lower pin 85 threadedly attached to the upper threaded box 86 of a lower or intermediate housing section 15a, the lower end of which has a threaded box 87 threadedly attached to the upper pin end 88 of a bottom section 89, which has a lower pin 90 threadedly securing it to the upper end of the tubing E depending therebelow. The lower housing section 15a has an inner, enlarged bore 21a which is substantially greater than the inner diameter of the tubing string D. The upper and bottom sections 17a, 89 also have enlarged bores 91, 92 adjacent to the enlarged bore 21a of the intermediate section 15a, which are also of greater diameter than the inside diameter of the tubular string D, but of a lesser diameter than the internal diameter of the intermediate housing section.

The intermediate housing section 15a has a plurality of side door openings or ports 19a which are initially closed by a sleeve valve structure 25a having a plurality of side door openings or ports 93 adapted to be placed in alignment with the housing ports 19a and out of align-

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ment therewith. The sleeve valve structure 25a includes an intermediate sleeve 94 through which the ports 93 extend. Above the ports 93 is mounted an upper set of an upper seal 95 and a lower seal 96 spaced from each other by a spacer sleeve 97. The upper seal 95 engages a shoulder 98 provided by the lower end of an upper latching and feeding device 99 constituting part of the sleeve valve structure 25a and threadedly attached to the upper end of the sleeve 94. A set of longitudinally spaced upper and lower seals 100, 101 is also mounted on the sleeve 94 below the ports 93. The lower seal 101 of this set rests upon a snap ring 102 mounted on the sleeve 94, its upper end engaging a spacer sleeve 103 which, in turn, engages the lower end of the upper seal 100, held in place by an upper snap ring 104 mounted on the sleeve 94. The lower seal 96 of the upper set is held in place by a snap ring 105 mounted on the sleeve 94 above the ports 93.

Initially, the housing ports 19a are closed by the upward positioning of the sleeve valve structure 25a within the housing 14a, with the upper and lower seals 100, 101 of the lower set disposed on opposite sides of the ports 19a and in sealing engagement with the inner wall of the housing, such as shown in FIG. 7. The sleeve valve structure is held in this position by the upper latching and sealing device 99, which has a plurality of circumferentially spaced longitudinal slots 106 formed therein and opening through its upper end to form a plurality of latch arms 107 terminating in outwardly directed latch fingers 108. These arms tend inherently to spring outwardly and will lie against the inner wall of the upper housing section 85 with the latch fingers 108 disposed within an upper recess 109 in the upper housing section. The latch fingers 108 have lower tapered surfaces 110 inclined in a downward and inward direction and bearing against a companion cam shoulder 111 forming the lower end of the recess 109. When the fingers 108 are disposed in the groove 109, the effective diameter through the latch arms 107 and fingers 108 is no less, and preferably greater, than the inside diameter through the tubular string D thereabove, so as to present no obstruction to the passage of devices into the sleeve valve structure 25a. As described hereinbelow, the upper inner portion 112 of the latch fingers 108 or arms 107 constitutes a valve seat or stop shoulder.

The sleeve valve structure 25a also includes a lower latching and seating device 113 which may be integral with, or otherwise suitably secured, to the sleeve portion 94 of the structure 25a that carries the sets of seal rings 95, 96 and 100, 101. As shown, the lower device 113 is provided with a plurality of circumferentially spaced longitudinal slots 114 forming longitudinally extending arms 115 that inherently tend to spring outwardly, these arms terminating in latch fingers 116, which, when the parts are in the positions disclosed in FIG. 7, will engage the inner wall 92 of the bottom housing section 89 to project inner valve seat or stop portions 117 of the fingers 116 in an inward direction, and thereby provide a valve seat 117 having a lesser diameter than the inside diameter through the tubular string D. As described hereinbelow, when the sleeve valve structure 25a is shifted downwardly the latch fingers 116 can snap outwardly into a lower recess 118 in the bottom housing section 89 with the tapered ends 119 on the latch fingers engaging a companion tapered cam shoulder 120 on the bottom section defining the lower end of the recess 118. The direction of taper is in an inward and downward direction, so as to tend to cam the fingers 116 inwardly, as described hereinbelow, whereupon the entire sleeve valve structure 25a can shift downwardly to the position disclosed in FIG. 9, in which the latch fingers 116 snap into an enlarged bore 121 in the bottom housing section and come to rest against a lower transverse stop shoulder 122 in the bottom housing section, which will then locate the upper set

of seal rings 95, 96 on opposite sides of the ports 19a or in a valve closing position.

In the use of the apparatus illustrated in FIGS. 7, 8 and 9, it is run in the well conduit with the sleeve valve structure 25a in the closed position illustrated in FIG. 7, in which the lower set of seals 100, 101 is disposed on opposite sides of the housing ports 19a to close the same. This set of seals is releasably held in this position by the disposition of the upper latch fingers 108 outwardly in the upper recess 109. At this time, the lower latch fingers 116 are engaging the wall 92 of the upper portion of the bottom housing section 89, to dispose the valve seat 117 in an inward position.

When the apparatus has been lowered to the desired position in the well conduit, as after the head 12 (FIG. 1) on the tubing E engages the upper end 13 of the well packer, a lower valve element 123, such as a trip ball, can be pumped down the tubing string D, or allowed to gravitate therethrough. This ball has a greater diameter than the effective inside diameter through the lower fingers 116 when in their contracted position shown in FIG. 7, and will come to rest on the lower valve seat 117. Pressure can now be built up in the tubular string D and the sleeve valve structure 25a to shift the latter downwardly, the upper cam shoulder 111 camming the latch fingers 108 inwardly, and allowing the sleeve valve structure 25a to slide downwardly within the housing 14a until the lower fingers 116 come opposite the lower recess 118, whereupon the fingers 116 snap outwardly into such recess. The extent of expansion of the fingers 116 on the lower arms 115 is such that the minimum diameter through the fingers 116 is then greater than the diameter of the lower trip ball 123, which then drops through the fingers 116 and through the tubing E and packer B therebelow.

When the lower fingers 116 have snapped into the lower recess 118, the lower and upper sets of seals 100, 101 and 95, 96 are disposed on opposite sides of the side ports 19a, such as disclosed in FIG. 8, with the sleeve ports 93 in alignment therewith. At this time, the upper arms 107 and fingers 108 have been forced inwardly of the upper housing section 17a by the inner wall 91 of the latter, to decrease the effective diameter of the valve seat 112 to a substantially lesser value than the inside diameter through the tubular string D. Circulation may now be established down through the tubing string D, the circulating fluid being pumped down the tubing string D and displacing the fluid in the string ahead of it, forcing this fluid out through the sleeve ports 93 and housing ports 19a, and then upwardly through the tubing-casing annulus 20 to the top of the well bore.

After the well bore has been conditioned, the sleeve valve structure 25a is shifted further downwardly to a port closing position by dropping an upper valve element or trip ball 125 down through the tubular string D, which, as is true of the lower ball valve element 123, has a diameter that may closely approximate the inside diameter of the tubular string D. The diameter of the trip ball 125, however, is greater than the effective restricted diameter of the upper valve seat 112. The upper ball, if it is pumped down the tubing string or allowed to gravitate therethrough, will come to rest on the upper ends of valve seat 112 of the upper latch fingers 108, allowing hydraulic pressure to be built up in the fluid in the tubular string D above the ball 125, which will act downwardly thereon and also on the sleeve valve structure 25a to cause the lower cam shoulder 120 to cam the lower latch fingers 116 inwardly of the bottom housing section 89 and release the sleeve valve structure. The entire structure 25a is then forced downwardly by the hydraulic fluid until the lower fingers 116 come to rest upon the stop shoulder 122, these fingers 116 and the arms 115 of which they form a part expanding outwardly so as to leave the lower sleeve valve structure 113 unobstructed. When the fingers 116 engage the shoulder 122 the upper and lower seals 95, 96 of the upper set

will be disposed on opposite sides of the housing ports 19a (FIG. 9) to close the same. At this time the fingers 108 of the upper latch and sealing device 99 will be disposed within the enlarged bore of the intermediate housing section 15a, such fingers and their arms 107 snapping outwardly into such enlarged bore, in which the minimum effective diameter through the upper latch and sealing device 99 is greater than the diameter of the upper ball 125. This upper ball can, therefore, be forced downwardly, or will gravitate, through the sleeve valve structure 25a, passing freely through the lower latch and seating device 113, which is now in the expanded position shown in FIG. 9, and continuing on down through the tubing string E to the bottom of the well bore, where it will not interfere with the normal operation of the apparatus in the well bore.

It is to be noted that both the upper and lower fingers 108, 116 have expanded outwardly to an effective diameter that is no less than the inside diameter through the tubular string D. Accordingly, the valve is in a closed condition and the bore through the sleeve valve structure 25a is unobstructed, permitting free passage of other apparatus through the valve structure, as well as unrestricted flow of fluid therethrough.

The inventors claim:

1. In a valve apparatus: a tubular housing adapted to be connected to a tubular string to be disposed in a well bore, said housing having a side port; a sleeve shiftable in said housing between positions opening and closing said port, said sleeve having a first portion adapted to be disposed across said port to close the same and an outwardly expandable second portion projecting inwardly across the passage through said first portion; means securing said sleeve to said housing with said sleeve in one of said positions and with said second portion projecting inwardly, whereby said inwardly projecting second portion is adapted to be engaged by a companion device to release said securing means and shift said sleeve relative to said port from said one position to a position in which said second portion expands laterally outwardly from its position across said passage.

2. In a valve apparatus: a tubular housing adapted to be connected to a tubular string to be disposed in a well bore, said housing having a side port; a sleeve shiftable in said housing from a position opening said port to a position closing said port, said sleeve having a first portion adapted to be disposed across said port to close the same and an outwardly expandable second portion projecting inwardly across the passage through said first portion; means securing said sleeve to said housing with said sleeve in port opening position and with said second portion projecting inwardly, whereby said inwardly projecting second portion is adapted to be engaged by a companion device to release said securing means and shift said sleeve in said housing from port opening position to port closing position in which said second portion expands laterally outwardly from its position across said passage.

3. In a valve apparatus: a tubular housing adapted to be connected to a tubular string to be disposed in a well bore, said housing having a side port; a sleeve shiftable in said housing between positions opening and closing said port, said sleeve having a first portion adapted to be disposed across said port to close the same and an outwardly expandable second portion comprising spring arms projecting inwardly across the passage through said first portion; means securing said sleeve to said housing to initially retain said sleeve in one of said positions with said spring arms projecting inwardly, whereby said inwardly projecting spring arms are adapted to be engaged by a companion device to release said securing means and shift said sleeve relative to said port from said one position to a position in which said spring arms expand laterally outwardly from their position across said passage.

4. In a valve apparatus: a ported tubular housing adapted to be connected to a tubular string to be disposed in a well bore, said housing having a first portion with

a relatively large internal diameter and a second portion to one side of said first portion of relatively smaller internal diameter; a sleeve shiftable in said housing between positions opening and closing the housing port, means securing said sleeve to said housing to initially retain said sleeve in one of said positions, said sleeve having a first portion slidable in said first housing portion and an outwardly expansible second portion in said second housing portion held by said second housing portion in a position projecting inwardly across the passage through said first sleeve portion, said second sleeve portion being adapted for engagement by a companion device to release said securing means and shift said sleeve relative to the housing port to a position in which said second sleeve portion expands into said first housing portion and laterally outwardly from its position across said passage.

5. In a valve apparatus: a ported tubular housing adapted to be connected to a tubular string to be disposed in a well bore, said housing having a first portion with a relatively large internal diameter and a second portion to one side of said first portion of relatively smaller internal diameter; a sleeve shiftable in said housing between positions opening and closing the housing port, means securing said sleeve to said housing to initially retain said sleeve in one of said positions, said sleeve having a first portion slidable in said first housing portion and an outwardly expansible second portion in said second housing portion comprising spring arms held by said second housing portion in a position projecting inwardly across the passage through said first sleeve portion, said spring arms being adapted to be engaged by a companion device to release said securing means and shift said sleeve relative to the housing port to a position in which said spring arms expand into said first housing portion and laterally outwardly from their position across said passage.

6. In a valve apparatus: a ported tubular housing adapted to be connected to a tubular string to be disposed in a well bore, said housing having a first portion with a relatively large internal diameter and a second portion to one side of said first portion of relatively smaller internal diameter; a sleeve shiftable in said housing between positions opening and closing the housing port, means securing said sleeve to said housing to initially retain said sleeve in one of said positions, said sleeve having a first portion slidable in said first housing portion and an outwardly expansible second portion in said second housing portion held by said second housing portion in a position projecting inwardly across the passage through said first sleeve portion; and a device movable downwardly through the tubular string into engagement with said second sleeve portion to release said securing means and shift said sleeve relative to the housing port and to move said second sleeve portion into said first housing portion where said second sleeve portion can expand laterally outwardly from its position across said passage.

7. In a valve apparatus: a ported tubular housing adapted to be connected to a tubular string to be disposed in a well bore, said housing having a first portion with a relatively large internal diameter and a second portion to one side of said first portion of relatively smaller internal diameter; a sleeve shiftable in said housing between positions opening and closing the housing port, means securing said sleeve to said housing to initially retain said sleeve in one of said positions, said sleeve having a first portion slidable in said first housing portion and an outwardly expansible second portion in said second housing portion held by said second housing portion in a position projecting inwardly across the passage through said first sleeve portion; a device movable downwardly through the tubular string into engagement with said second sleeve portion to release said securing means and shift said sleeve relative to the housing port and to move said second sleeve portion into said first housing portion where said second sleeve portion can expand laterally outwardly from its position across said passage, said device having

a diameter less than the diameter of the passage through said first sleeve portion, whereby said device can move through said passage upon expansion of said second sleeve portion.

8. In a valve apparatus: a ported tubular housing adapted to be connected to a tubular string to be disposed in a well bore, said housing having a first portion with a relatively large internal diameter and a second portion to one side of said first portion of relatively smaller internal diameter; a sleeve shiftable in said housing between positions opening and closing the housing port, means securing said sleeve to said housing to initially retain said sleeve in one of said positions, said sleeve having a first portion slidable in said first housing portion and an outwardly expansible second portion in said second housing portion comprising spring arms held by said second housing portion in a position projecting inwardly across the passage through said first sleeve portion; and a device movable downwardly through the tubular string into engagement with said spring arms to release said securing means and shift said sleeve relative to the housing port and to move said spring arms into said first housing portion where said spring arms can expand laterally outwardly from their position across said passage.

9. In a valve apparatus: a ported tubular housing adapted to be connected to a tubular string to be disposed in a well bore, said housing having a first portion with a relatively large internal diameter and a second portion to one side of said first portion of relatively smaller internal diameter; a sleeve shiftable in said housing between positions opening and closing the housing port, means securing said sleeve to said housing to initially retain said sleeve in one of said positions, said sleeve having a first portion slidable in said first housing portion and an outwardly expansible second portion in said second housing portion held by said second housing portion in a position projecting inwardly across the passage through said first sleeve portion; and a device for shifting said sleeve in said housing comprising a mandrel, packing means on said mandrel adapted to slidably seal against the tubular string, and latch means carried by the mandrel and adapted to engage said second sleeve portion, whereby said device can release said securing means and shift said sleeve relative to the housing port and to move said second sleeve portion into said first housing portion where said second sleeve portion can expand laterally outwardly from its position across said passage.

10. In a valve apparatus: a ported tubular housing adapted to be connected to a tubular string to be disposed in a well bore, said housing having a first portion with a relatively large internal diameter and a second portion to one side of said first portion of relatively smaller internal diameter; a sleeve shiftable in said housing between positions opening and closing the housing port, means securing said sleeve to said housing to initially retain said sleeve in one of said positions, said sleeve having a first portion slidable in said first housing portion and an outwardly expansible second portion in said second housing portion held by said second housing portion in a position projecting inwardly across the passage through said first sleeve portion; a device for shifting said sleeve on said housing comprising a mandrel, packing means on said mandrel adapted to slidably seal against the tubular string, and latch means carried by the mandrel and adapted to engage said second sleeve portion, whereby said device can release said securing means and shift said sleeve relative to the housing port and to move said second sleeve portion into said first housing portion where said second sleeve portion can expand laterally outwardly from its position across said passage, said latch being expandable into said second housing portion and remaining in a position for engagement with said second sleeve portion after expansion of said second sleeve portion into said first housing portion.

11. In a valve apparatus: a tubular housing adapted

to be connected to a tubular string to be disposed in a well bore, said housing having a side port; a sleeve shiftable in said housing from a position closing said port to a position opening said port, said sleeve having a first portion adapted to be disposed across said port to close the same, an outwardly expansible second portion projecting inwardly across the passage through said first portion; means securing said sleeve to said housing with said sleeve in one of said positions and with said second portion projecting inwardly, whereby said inwardly projecting second portion is adapted to be engaged by a companion device to release said securing means and shift said sleeve in said housing to port opening position in which said second portion expands laterally outwardly from its position across said passage, and an outwardly expansible third portion projecting inwardly across the passage through said first portion and adapted to be engaged by a companion device to shift said sleeve in said housing to port closing position in which said third portion expands laterally outwardly from its position across said passage.

12. In a valve apparatus: a ported tubular housing adapted to be connected to a tubular string to be disposed in a well bore, said housing having a first portion with a relatively large internal diameter, a second portion to one side of said first portion of relatively smaller internal diameter, and a third portion to one side of said first portion of relatively smaller internal diameter; a sleeve shiftable in said housing between positions opening and closing the housing port, said sleeve having a first portion slidable in said first housing portion, an outwardly expansible second portion in said second housing portion held by said second housing portion in a position projecting inwardly across the passage through said first sleeve portion, and an outwardly expansible third portion initially expanded outwardly and shiftable into said third housing portion to be retracted and held by said third housing portion in a position projecting inwardly across the passage through said first sleeve portion, said second sleeve portion being adapted for engagement by a companion device to shift said sleeve relative to the housing port to a position in which said second sleeve portion expands laterally outwardly from its position across said passage, said third sleeve portion being adapted for engagement by a companion device, when projecting inwardly across the passage, to shift said sleeve relative to the housing

port to a position in which said third sleeve portion expands laterally outwardly from its position across said passage.

13. In a valve apparatus: a ported tubular housing adapted to be connected to a tubular string to be disposed in a well bore, said housing having a first portion with a relatively large internal diameter, a second portion below said first portion of relatively smaller internal diameter, and a third portion above said first portion of relatively smaller internal diameter than said first portion; a sleeve shiftable in said housing between positions opening and closing the housing port, said sleeve having a first portion slidable in said first housing portion, an outwardly expansible second portion in said second housing portion comprising spring arms adapted to be held by said second housing portion in a position projecting inwardly across the passage through said first sleeve portion, and an outwardly expansible third portion comprising spring arms initially expanded outwardly and shiftable into said third housing portion to be retracted and held by said third housing portion in a position projecting inwardly across the passage through said first sleeve portion; a device movable downwardly through the tubular string into engagement with said spring arms of said second portion to shift said sleeve relative to the housing port and to move said spring arms of said second portion to a position where said spring arms can expand laterally outwardly from their position across said passage and to move said spring arms of said third portion into said third housing portion to be retracted thereby; and a device movable downwardly through the tubular string into engagement with said retracted spring arms of said third portion to shift said sleeve relative to the housing port and to move said spring arms of said third portion to a position where said spring arms of said third portion can expand laterally outwardly from their position across said passage.

References Cited in the file of this patent

UNITED STATES PATENTS

2,606,616	Otis	Aug. 12, 1952
2,675,874	Springer	Apr. 20, 1954
2,723,677	Middleton	Nov. 15, 1955
2,947,363	Sackett et al.	Aug. 2, 1960