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WELL PACKER

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2 SHEETS—SHEET 1



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2 SHEETS—SHEET 2

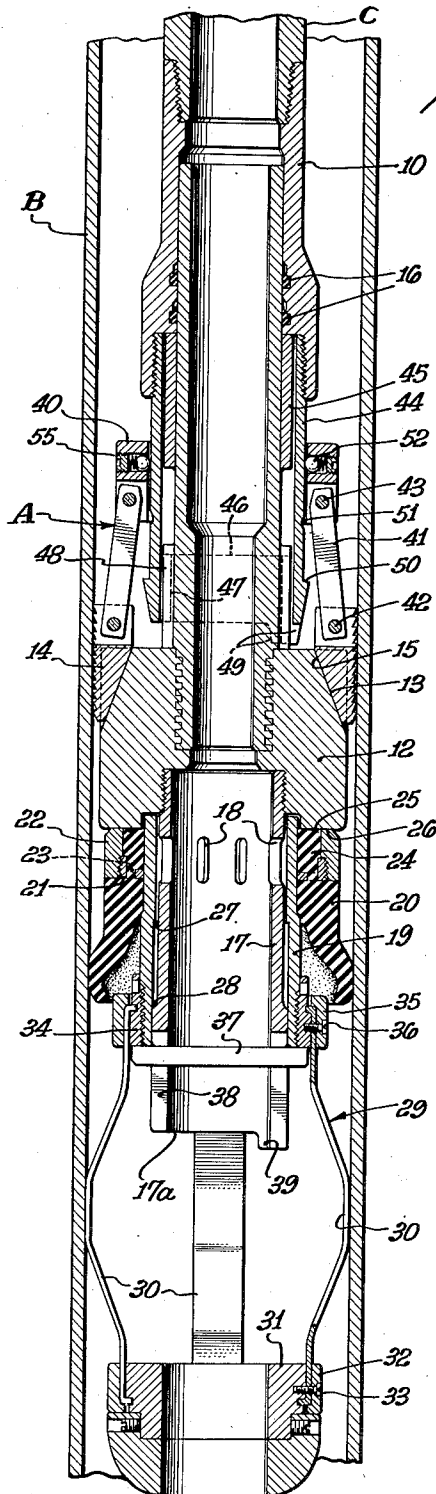


Fig. 3.

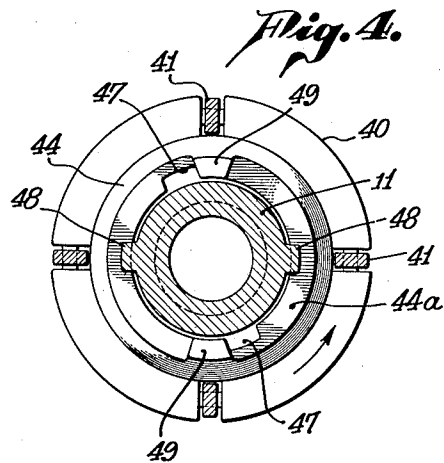


Fig. 4.

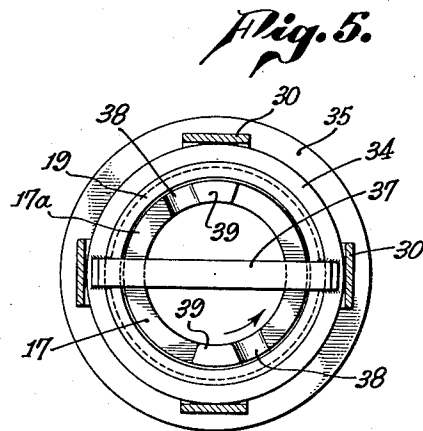


Fig. 5.

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WELL PACKER

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17 Claims. (Cl. 166—12)

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This invention relates to well tools, and more particularly to subsurface well tools employed in the performance of cementing, acidizing, testing, circulating, anchoring, production and similar functions in well bores.

An object of the invention is to provide a well tool of simple construction and operation which can be anchored readily in a well bore against upward movement and easily released from such anchored condition for elevation in the well bore.

Another object of the invention is to effect anchoring of a well packer against upward movement in a well bore and close an associated control valve by subjecting them to a downward thrust, release from anchored position being easily accomplished and opening of the valve effected upon upward movement of the packer.

Still another object of the invention is to provide an improved well packer apparatus utilizing its packing structure for controlling flow of fluid in, around and through the apparatus.

Yet a further object of the invention is to provide a well packer apparatus capable of being anchored in a well bore against upward movement and positively releasable from such anchored condition despite the presence of high pressures in the well tending to maintain the anchored condition of the apparatus.

Another object of the invention is to provide an improved packing structure for a well packer capable of forming part of a circulation control valve.

Still another object of the invention is to provide a well packer capable of being anchored against upward movement in a well bore, whose anchoring elements are held automatically in retracted position and whose valve mechanism is held open automatically during upward movement of the packer in the well bore.

The invention has other objects that will become apparent from a consideration of the embodiment shown in the drawings accompanying and forming part of the present specification. This form will now be described in detail, but it is to be understood that such detailed description is not to be taken in a limited sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

Figure 1 is a longitudinal view of a well packer embodying the invention located in a well casing, with its anchoring elements in retracted position;

Figure 2 is a partial longitudinal section of part of the well packer shown in Figure 1;

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Figure 3 is a view similar to Figure 1, showing the well packer anchored against the well casing;

Figure 4 is a cross-section taken along the line 4—4 in Figure 1; and

Figure 5 is a cross-section taken along the line 5—5 in Figure 1.

The embodiment of the invention shown in the drawings includes a well packer apparatus A designed to be run in well casings or similar conduits B on the lower end of a string of tubing or drill pipe C, and to be anchored to the casing in packed off position against upward movement.

The well packer includes an upper outer mandrel 10 telescopically arranged with respect to a lower inner mandrel or body member 11 threadedly secured to an intermediate body member 12 having upwardly and inwardly directed tapered surfaces 13 cooperating with slips 14 having companion tapered surfaces 15. The slips are movable outwardly along the inclined faces of the intermediate body member or expander 12 into anchoring engagement with the conduit C, and have upwardly directed wickers designed to penetrate the casing wall and prevent upward movement of the packer apparatus. Side seals 16 are mounted in the outer mandrel 10 in slidable leakproof engagement with the exterior of the inner mandrel 11 to prevent leakage therebetween.

A lower tubular body member or valve body 17 is threaded or otherwise suitably secured in the lower end of the intermediate body expander member 12, and has one or more side ports or outlets 18 adjacent the lower end of the intermediate body member through which fluid may flow between the interior and exterior of the well apparatus. A valve sleeve 19 is slidably mounted on the ported valve body, with a generally cup-shaped or similar packing 20 secured to it, which faces downwardly, with its free end slidably engageable with the wall of the casing to prevent upward passage of fluids between the valve sleeve 19 and casing wall.

The packing member 20, of rubber or equivalent material, may be secured to the valve sleeve 19 in any suitable manner. As shown in the drawings, a perforated flange 21 is welded on the sleeve, on which an abutment ring 22 is threaded in spaced relation to the exterior of the valve sleeve above the flange. The packing cup 20 is molded on the sleeve and extends through the flange perforations or holes 23 to the other side of the flange 21, thereby firmly anchoring it to the sleeve 19. A valve seal ring

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24, of rubber or similar material, is also disposed between the ring 22 and valve sleeve 19, being provided with an end, circular, inwardly directed lip 25 adapted for engagement with the lower end 26 of the intermediate body member 12 to effect a seal therewith whenever the ports 18 are to be closed. The valve seal ring 24 may be molded integrally with the packing cup 20, if desired.

Relative downward movement of the valve sleeve 19, packing cup 20 and valve sealing member 24 along the valve body 17 is limited by engagement between an inner shoulder 27 on the valve sleeve with an outer shoulder 28 on the valve body. When in this position, the lip seal 25 and sleeve 19 are disposed below the ports or outlets 18, permitting circulating fluid pumped down the tubular string B, mandrel 10 and body 11, 12, 17 to pass outwardly into the annulus between the apparatus and casing wall, for passage around the tubular string to the top of the well bore. Relative elevating movement of the valve sleeve 19 and its attached packing cup 20 and valve packing 24 upwardly along the valve body 17 will produce closing of the ports 18 upon engagement of the valve ring 24 with the intermediate body sealing surface 26, preventing outward passage of fluids from within the body through the ports 18. Fluid under pressure acts outwardly against the lip 25 to press it upwardly against the body seal surface 26, preventing leakage past the lip seal.

Relative movement between the parts just referred to may be effected by moving the valve body 17 down, the valve sleeve 19, seal ring 24 and packing 20 tending to remain immovable by the frictional engagement of the packing cup 20 with the casing wall. This frictional force of engagement, if insufficient may be supplemented by a suitable casing engaging drag device 29, including outwardly bowed springs 30 frictionally engageable with the wall of the casing C. The drag springs are coupled together for joint operation, their lower ends being suitably secured to a lower collar 31, as by an encircling ring 32 and screws 33, and their upper ends to an upper collar 34 by an encircling ring 35 and screws 33. The connection between the drag device 29 and valve sleeve 19 is effected by threadedly attaching the upper drag collar 34 to the lower end of the sleeve 19.

The ports 18 may be closed upon lowering of the valve body 17 with respect to the valve sleeve 19, to bring the valve ring 24 into engagement with the body sealing surface 26. Conversely, the ports 18 may be opened by elevating the valve body 17 with respect to the valve sleeve 19. The drag device 29 and packing 20, by bearing against the casing wall, tend to hold the valve sleeve 19 and attached members relatively stationary, permitting elevating and lowering of the valve body 17 to open or close the ports. However, the two parts 17, 19 may be coupled for movement in unison longitudinally in a downward direction through the casing by attaching a pin or cross-piece 37 to the upper collar 34 of the drag device, extending across and engageable with the lower end 17a of the valve body 17. When the valve sleeve 19 is in its lowermost position on the valve body 17, the shoulders 27, 28 abut to prevent further downward movement of the sleeve 19 on the body 17. The engagement of the cross-piece 37 with the lower end 17a of the valve body prevents relative upward movement of the valve sleeve along the latter. The shoulders 27, 28 and cross-piece 37 thus prevent relative movement between the valve sleeve and valve body in both longitu-

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dinal directions, the ports 18 remaining uncovered and fully open to the passage of fluid in either direction between the interior and exterior of the well apparatus.

When the ports 18 are to be closed, the turning of the valve body 17 relative to the valve sleeve 19 aligns the cross-piece 37 with a longitudinally extending valve body slot 38, and permits the body 17 to be lowered with respect to the valve sleeve 19 over the cross-piece 37 to produce engagement of the lip seal ring 24 with the intermediate body member 12, thereby closing the ports 18. The drag device 29 tends to hold the valve sleeve 19 and the cross-piece 37 stationary, allowing turning of the valve body 17, as in a clockwise direction (looking down), to engage a depending alignment lug 39 at the lower end of the valve body with the cross-piece and align it with the slot 38, whereupon lowering movement of the valve body 17 is permitted by entry of the cross-piece 37 into and along the slot 38, and the intermediate body 12 secured to the valve body may be engaged with the seal ring 24 to effect closing of the valve.

The slips 14 are mounted for movement in unison by being coupled to a slip ring 40 through the agency of links 41, whose lower ends are pivotally connected to the slips by pins 42 and whose upper ends are also pivotally attached to the slip ring by pins 43. The slip coupling ring or sleeve 40 is secured releasably to a tubular slip and valve actuator 44 threadedly attached to the telescopic upper mandrel 10, and, in effect, forming a part thereof. The actuator 44 is spaced from the inner mandrel or body 11 and extends over a cylindrical sleeve 45 suitably secured to the inner mandrel 11, as by welding material, with the lower end of the actuator having an inwardly directed head 46 below the sleeve 45 adapted to engage its lower end. One or more longitudinal keyways or grooves 47 are formed in the head for reception of lower keys 48 secured on the inner mandrel 11, alignment between the keyways and keys being obtained by lugs 49 depending from the actuator 44 between the keys 48 and engageable with their sides.

The slip coupling ring or sleeve 40 is preferably releasably connected to the tubular actuator 44, its lower end being engageable with a lower shoulder 50 on the actuator. The latter member has a peripheral groove 51 in which one or more coupling balls 52 may be engaged. These are located within pockets 53 in the coupling sleeve 40, containing springs 54 bearing against the balls 52 and against plugs 55 threaded into the sleeve. The springs 54 tend to maintain the balls 52 in the groove 51, but downward movement of the actuator 44 with respect to the slip sleeve 40 can take place upon overcoming the force of the springs.

The tool is secured to the tubular string with the valve in open position, as determined by misalignment of the cross-piece 37 with its cooperable slot 38, the cross-piece engaging the lower end 17a of the valve body to hold the valve open during lowering of the tool in the well casing. Similarly, the slips 14 are in retracted position on their tapered expander 12 and cannot move outwardly during lowering of the tool in the casing, because of misalignment of the keys 48 with respect to the keyways 47. Instead of allowing the keys 48 to enter the keyways, their upper ends engage the lower end 44a of the tubular actuator 44. The slip ring 40 is coupled to the telescopic upper mandrel 10 and its actuator 44 by engagement of the balls 52 in the peripheral recess 51.

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Thus, relative movement between the valve sleeve 19 and valve body 17, and between the slips 14 and expander 12, are prevented during downward movement of the well packer apparatus A in the casing C; since the engagement of the cross-piece 37 with the underside 17a of the valve body prevents relative upward travel of the valve sleeve 19 on the body 17; and engagement of the lower end 44a of the actuator with the upper ends of the keys 48 prevents the slips 14 from moving downwardly along the tapered expander 12, in view of the attachment of the keys to the inner mandrel 11, which is threadedly secured to the expander 12. During lowering of the well packer, the fluid may by-pass around the packing 20 and the tool by flowing upwardly into the lower body member 17 and out through the open ports 18.

When the tool has been lowered to the desired point in the well bore at which it is to be anchored, the tubular string B is rotated clockwise (looking down) to rotate its attached upper mandrel 10 and actuator 44 in the same direction with respect to the body 11, until the actuator lugs 49 engage the keys 48, whereupon the rotary movement is transmitted to the inner mandrel 11 and tapered expander 12 to the lower valve body member 17, turning it with respect to the cross-piece 37 and its attached valve sleeve 19, and the packing 20 and seal ring 24 secured thereto. Such relative turning occurs because the latter members are prevented from rotating by virtue of the drag spring 30 and packing 20 engagement with the casing C.

Turning of the valve body 17 continues until its depending locating lug 39 engages the cross-piece 37, aligning the latter with the longitudinal slot 38. The tubular string may now be lowered, to correspondingly shift the apparatus downwardly, with the exception of the valve sleeve 19 and its attached parts, which are held stationary by the drag device 29. The cross-piece 37 passes into the slot 38, allowing the valve body 17 to move down within the valve sleeve 19, until the lip seal 24, 25 firmly engages its companion seating surface 26 at the lower end of the intermediate body member 12. Such engagement causes the drag device 29 to resist further downward movement of the intermediate body member 12 and its attached inner mandrel 11, allowing the telescopic upper mandrel 10 and actuator 44, together with the slip ring 40 coupled to it, and the depending links 41 and slips 14, to be moved downwardly with respect to the expander 12, sliding the slips 14 along the tapered surfaces 13 of the expander and laterally outward into engagement with the casing wall. This action is permitted by entry of the keys 48 into the keyways 47. After the slips 14 have engaged the casing C, the slip ring 40 is arrested, so that further downward movement of the telescopic upper mandrel 10 and actuator 44 forces the spring pressed balls 52 from the peripheral groove 51 and lowers the actuator 44 within the slip ring toward the expander 12. In effect, removal of the balls 52 from the groove 51 disconnects the slips 14 and slip ring 40 from the actuator 44 and its telescopic upper mandrel 10.

Since the ports 18 have now been closed and the slips 14 engaged with the casing, the subjection of the fluid in the tubular string B and well apparatus A to pressure produces an upward hydraulic force on the packing cup 20, which tends to wedge the abutting expander 12 upwardly within the slips 14, anchoring the latter firmly in the wall of the casing C.

After the desired operation has been performed

in the well bore, the tubular string B may be lowered sufficiently to move the upper mandrel 10 and its actuator 44 downwardly and cause the lower end of the lugs 49 to strike against the upper end of the expander 12, driving it downwardly (only a slight distance is sufficient) out of wedging relation with the slips 14 and freeing them from anchoring engagement with the casing C. Thereafter, the tubular string B may be raised to elevate the upper mandrel 10 and its actuator 44 along the inner mandrel 11, slips 14 and their links 41, until the shoulder 50 on the actuator engages the lower end of the slip ring 40 and the balls 52 reengage the groove 51. Such engagement of the shoulder 50 causes the upward pulling of the outer mandrel 10 to be transmitted to the slips 14, sliding them upwardly and inwardly of the tapered expander 12 to retracted position.

Following retraction of the slips, the actuator head 46 engages the inner mandrel sleeve 45, transmitting the upward motion of the outer mandrel 10 to the inner mandrel 11, and to its attached tapered expander 12 and valve body 17, moving the latter upwardly with respect to the valve sleeve 19 to open the ports 18. As the valve body 17 rises, its shoulder 28 contacts the sleeve shoulder 27 and moves the sleeve 19 and its attached parts 20, 24, 29, etc. upwardly. The ports 18 are now open, and circulating fluid may be pumped down the tubing string B, through the ports 18 and up the tubing-casing annulus. The circulating fluid may also be pumped down the tubing-casing annulus for passage through the ports 18 into the tool, and upwardly through the tubing string to the top of the well bore.

Following cleaning of the tool by the circulating fluid, the tubular string B may be elevated to raise the whole tool to the surface of the bore. During such raising movement the slips 14 are automatically urged and held in retracted position and the valve ports 18 are automatically held open, since a direct upward pull is transmitted to the slips 14 and expander 12 simultaneously, allowing no tendency to occur for wedging upward movement of the expander in the slips. The upward movement also holds the ports 18 elevated above the packing ring 24 and valve sleeve 19, since the latter tend to occupy a lower position, because of the frictional dragging of the springs 30 and packing 20 on the casing wall.

It is, accordingly, apparent that an apparatus has been provided of relatively simple construction; one which is safe to use, since there is no danger of the slips 14 being moved into anchoring engagement with the casing during upward movement of the tool therein. Upward movement holds the slips in retracted position and also maintains the valve in open position to permit by-passing of fluid around the packing cup. Pressures acting upwardly on the packing cup 20 and tending to hold the slips 14 in anchored engagement with the casing are readily overcome by downward movement of the tubular string B and mandrel 10, to deliver a striking blow against the upper end of the tapered expander 12 and drive it slightly downwardly of the slips 14 a sufficient distance to release the latter from the well casing, whereupon, upward movement of the upper mandrel 10 positively moves the slips inwardly of the tapered expander 12.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. A tool for use in a well conduit, including ported tubular means having an outwardly ex-

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tending sealing surface disposed on one side of its port and transversely to the axis of said tubular means, packing means on said tubular means engageable with said well conduit and disposed on the other side of said port to permit flow of fluid therethrough, said tubular means being movable within said packing means to engage said packing means with said transverse sealing surface and close said port by axially compressing said packing means against said sealing surface.

2. A tool for use in a well conduit, including ported tubular means having an outwardly extending sealing surface disposed on one side of its port and transversely to the axis of said tubular means, packing means on said tubular means engageable with said well conduit and disposed on the other side of its port to permit flow of fluid therethrough, said packing means having an inwardly directed circular lip engageable with said transverse sealing surface to close said port by axially compressing said lip against said sealing surface.

3. A tool for use in a well conduit, including ported tubular means having an outwardly extending sealing surface disposed on one side of its port and transversely to the axis of said tubular means, a valve sleeve slidable on said tubular means, conduit engaging packing means secured to said sleeve, and elastic, pliant seal means secured to said sleeve and engageable with said transverse sealing surface to close said port by axially compressing said seal means against said sealing surface.

4. A tool for use in a well conduit, including ported tubular means having an outwardly extending sealing surface disposed on one side of its port and transversely to the axis of said tubular means, a valve sleeve slidable on said tubular means, conduit engaging packing means secured to said sleeve, elastic, pliant seal means secured to said sleeve, and cooperable releasable lock means on said tubular means and sleeve for holding said seal means for engagement with said surface to permit fluid flow through said port, said lock means being releasable to allow relative longitudinal movement between said tubular means and sleeve to bring said seal means and transverse sealing surface into engagement with each other to close said port by axially compressing said seal means against said sealing surface.

5. A tool for use in a well conduit, including ported tubular means having an outwardly extending sealing surface disposed on one side of its port, a valve sleeve slidable on said tubular means, conduit engaging packing means secured to said sleeve, seal means secured to said sleeve, said tubular means having a longitudinal slot, a cross-piece secured to said sleeve and engageable with an end of said tubular means to hold said seal means from engagement with said surface to permit fluid flow through said port, said cross-piece being movable within said slot to allow relative longitudinal movement between said tubular means and sleeve and engagement of said seal means with said sealing surface to close said port.

6. A tool for use in a well conduit, including inner and outer telescopically arranged body members, said outer body member being connectable to a running-in string, an expander on said inner body member, slips cooperable with said expander, means releasably coupling said slips to the outer body member for movement with said outer body member, lock means on said

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body members for holding said slips in retracted position by preventing their movement with respect to said expander, said outer body member being rotatable in response to movement of said running-in string to release said lock means and allow said outer body member to move said slips longitudinally along said expander and outwardly into engagement with said conduit, whereupon said coupling means is releasable to allow said outer body member to move longitudinally of said slips.

7. A tool for use in a well conduit, including inner and outer telescopically arranged body members, said outer body member being connectable to a running-in string, an expander on said inner body member, slips cooperable with said expander, means releasably coupling said slips to the outer body member for movement with said outer body member, one of said body members having a key and the other of said body members having a groove, said key engaging the other of said body members when disaligned from said groove to prevent movement of said slips with respect to said expander, and said key entering said groove when in alignment therewith to permit said outer body member to shift said slips longitudinally along said expander and outwardly into engagement with said conduit, whereupon said coupling means is releasable to allow said outer body member to move longitudinally of said slips.

8. A tool for use in a well conduit, including inner and outer telescopically arranged body members, said outer body member being connectable to a running-in string, an expander on said inner body member, slips cooperable with said expander, means releasably coupling said slips to the outer body member for movement with said outer body member, one of said body members having a key and the other of said body members having a groove, said key engaging the other of said body members when disaligned from said groove to prevent movement of said slips with respect to said expander, and means for aligning said key with said groove upon relative rotation between said body members to permit entry of said key in said groove and to thereby allow said outer body member to shift said slips longitudinally along said expander and outwardly into engagement with said conduit, whereupon said coupling means is releasable to allow said outer body member to move longitudinally of said slips.

9. A tool for use in a well conduit, including inner and outer telescopically arranged body members, said outer body member being connectable to a running-in string, an expander on said inner body member, slips cooperable with said expander, means releasably coupling said slips to the outer body member for longitudinal movement with said outer body member and to allow longitudinal movement of said outer body member relative to said slips, and releasable lock means on said body members for initially holding said slips in retracted position by preventing their movement with respect to said expander.

10. A tool for use in a well conduit, including inner and outer telescopically arranged body members, an expander on said inner body member, slips cooperable with said expander, automatically releasable means for coupling said slips to said outer body member, releasable lock means on said body members for initially holding said slips in retracted position by preventing their movement with respect to said expander, said lock means being releasable upon rotation of said

outer body member to allow said outer body member to move said slips longitudinally along said expander and outwardly into engagement with said conduit, said outer body member being released from said slips upon engagement of the latter with said conduit to permit said outer body member to move longitudinally into engagement with said expander.

11. A tool for use in a well conduit, including a ported tubular body, packing means on said tubular body engageable with said well conduit and adapted to close the body port upon downward movement of said body in said packing means, an expander on said body, slips cooperable with said expander, a mandrel telescopically arranged with respect to said body, means coupling said slips for movement with said mandrel, lock means on said body and packing means for preventing downward movement of said body in said packing means, lock means on said mandrel and body for preventing downward movement of said slips along said expander, both of said lock means being releasable in response to rotation of said mandrel to permit said mandrel to move said body downwardly of said packing means to close said port and to move said slips downwardly along said expander into engagement with said conduit.

12. A tool for use in a well conduit, including a ported tubular body, packing means on said tubular body engageable with said well conduit and adapted to close the body port upon downward movement of said body in said packing means, an expander on said body, slips cooperable with said expander, a mandrel telescopically arranged with respect to said body, means coupling said slips for longitudinal movement with said mandrel, said body having a slot and said packing means having a cross-piece initially engageable with the end of said body to prevent downward movement of said body along said packing, said mandrel having a keyway and said body having a key initially engaging said mandrel to prevent downward movement of said slips along said expander, and means on said mandrel and body for aligning said key with said keyway and said cross-piece with said slot upon rotation of said mandrel to permit downward movement of said body within said packing means to close said port and downward movement of said slips along said expander into engagement with said conduit.

13. A tool for use in a well conduit, including inner and outer telescopically arranged body members, said outer body member being connectable to a tubular running-in string, an expander on said inner body member, slips cooperable with said expander for anchoring said tool to said conduit against upward movement, means releasably coupling said slips to the outer body member for movement with said outer body member, lock means on said body members for holding said slips in retracted position by preventing their movement with respect to said expander, said outer body member being rotatable in response to rotation of said tubular running-in string to release said lock means and allow said outer body member to move said slips longitudinally along said expander and outwardly into engagement with said conduit, whereupon said coupling means is releasable to allow said outer body member to move longitudinally of said slips.

14. A tool for use in a well conduit, including inner and outer telescopically arranged body members, an expander on said inner body member, slips cooperable with said expander for anchoring said tool to said conduit against upward movement, automatically releasable means for coupling said slips to said outer body member, releasable lock means on said body members for initially holding said slips in retracted position by preventing their movement with respect to said expander, said lock means being releasable upon rotation of said outer body member to allow said outer body member to move said slips longitudinally along said expander and outwardly into engagement with said conduit, said outer body member being released from said slips upon engagement of the latter with said conduit to permit said outer body member to move longitudinally into engagement with said expander.

15. A tool for use in a well conduit, including a ported inner body member, an outer body member telescoped over said inner body member, an expander on said inner body member, slips cooperable with said expander, means coupling said slips to the outer body member for movement with said outer body member, releasable lock means on said body members for initially holding said slips in retracted position by preventing their movement with respect to said expander, and packing means on said inner member engageable with said well conduit and movable longitudinally relative to said inner member and slips to close the port in said inner member.

16. A tool for use in a well conduit, including inner and outer telescopically arranged body members, an expander on said inner body, slips cooperable with said expander, automatically releasable means for coupling said slips to said outer body member for movement by said outer body member along said expander and outwardly into engagement with the well conduit, said outer body member being released from said slips upon engagement of the latter with said conduit to permit said outer body member to move longitudinally into engagement with said expander.

17. A tool for use in a well conduit, including inner and outer telescopically arranged body members, an expander on one of said body members, slips cooperable with said expander, automatically releasable means for coupling said slips to the other of said body members for movement by said other of said body members along said expander and outwardly into engagement with said conduit, said other of said body members being released from said slips upon engagement of the latter with said conduit to permit said other of said body members to move longitudinally into engagement with said expander.

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