Jan. 28, 1964 R. T. EVANS 3,119,450

PLURAL WELL PACKERS

Filed April 4, 1961 3 Sheets-Sheet 1

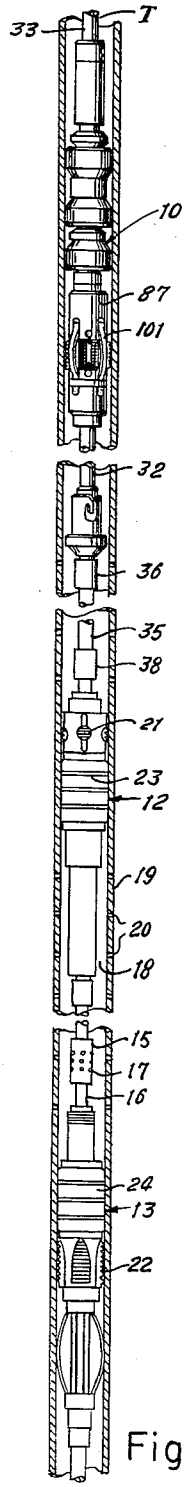


Fig. 1

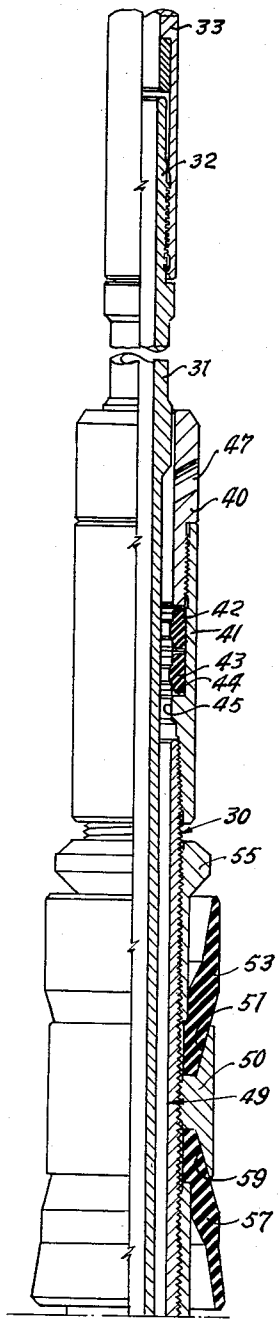


Fig. 2

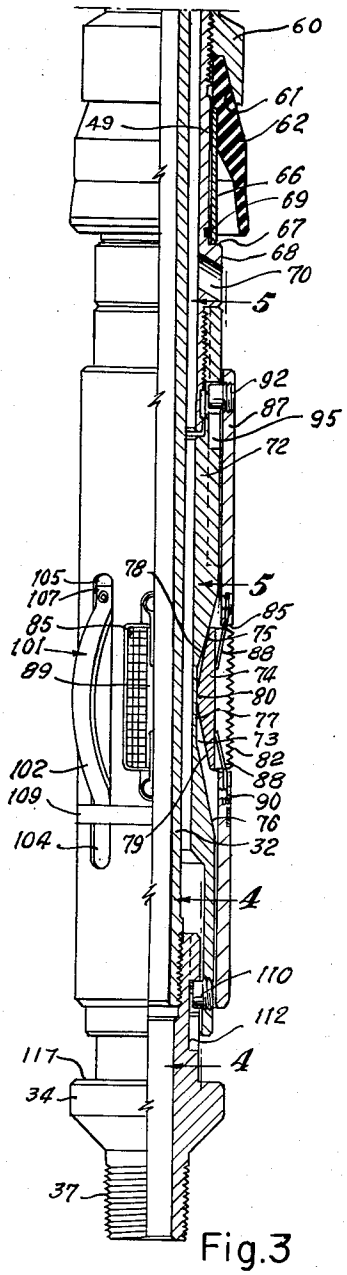


Fig. 3

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Jan. 28, 1964 R. T. EVANS 3,119,450

PLURAL WELL PACKERS

Filed April 4, 1961 3 Sheets-Sheet 2

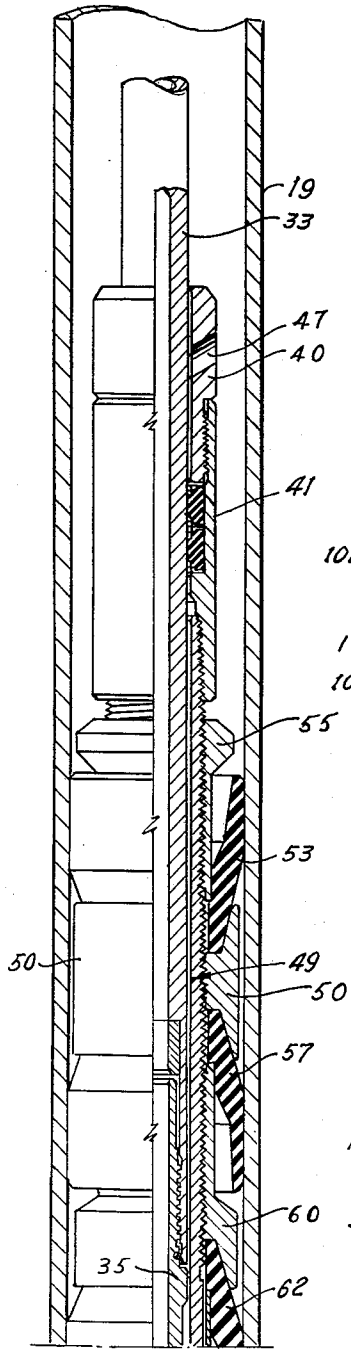


Fig. 6

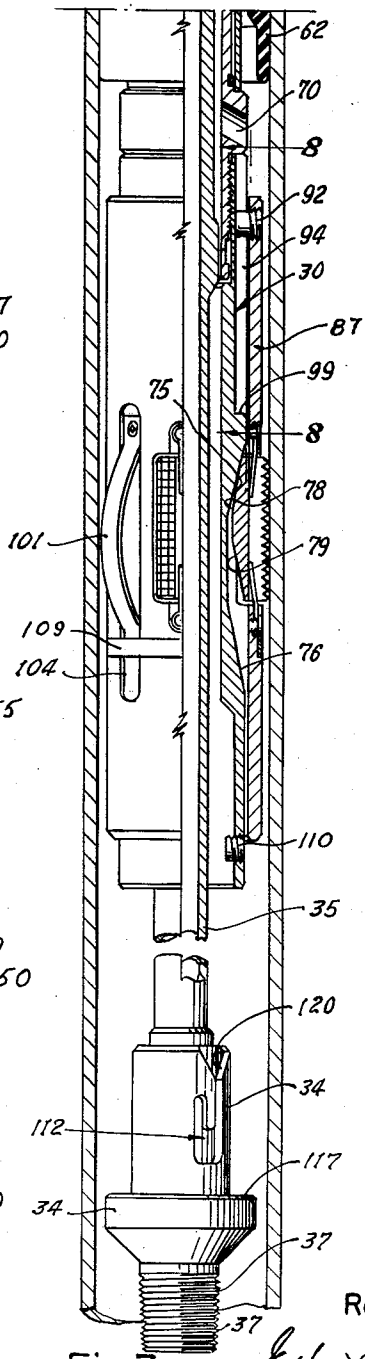


Fig. 7

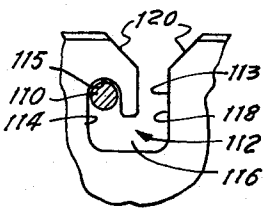


Fig. 4

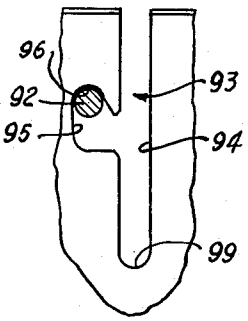


Fig. 5

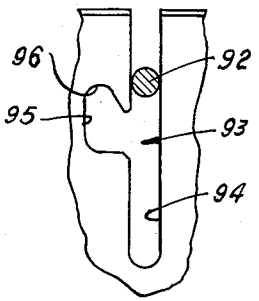


Fig. 8

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Jan. 28, 1964 R. T. EVANS 3,119,450

PLURAL WELL PACKERS

Filed April 4, 1961 3 Sheets-Sheet 3

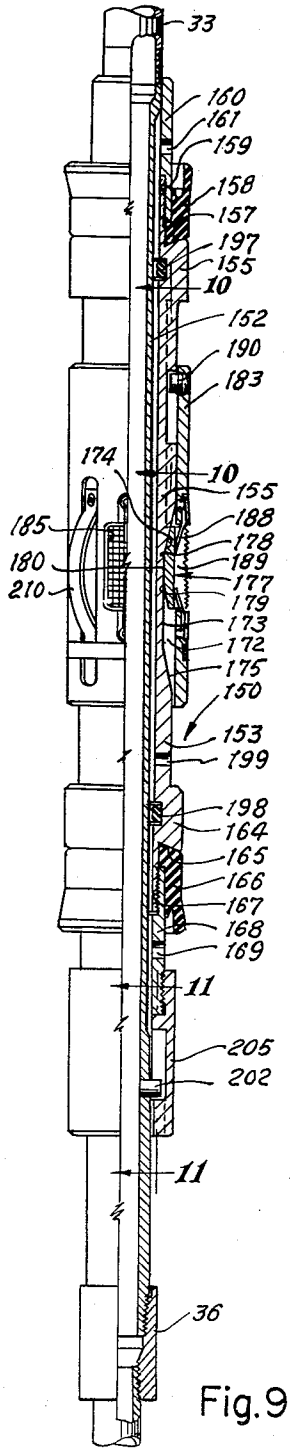


Fig. 9

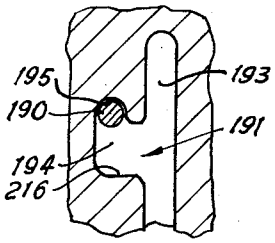


Fig. 10

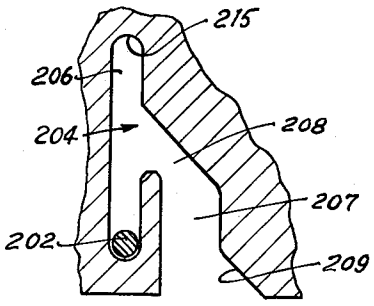


Fig. 11

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Patented Jan. 28, 1964

3,119,450

PLURAL WELL PACKERS

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Filed Apr. 4, 1961, Ser. No. 100,638
13 Claims. (Cl. 166—119)

This invention relates to well tools and more particularly to a well packer for closing and sealing the cylindrical space or annulus between two telescoped well flow conductors, such as a tubing string and a well casing and to an apparatus employing well packers.

In certain well operations, such as the treating of earth formations with sand consolidation material, the treating fluid or material is introduced into the well through a well flow conductor, such as a tubing string, and is forced outwardly into the annulus between the tubing string and the well casing through ports of the tubing located between a pair of longitudinally spaced straddle packers carried by the tubing string which isolate a section of the well casing so that the fluid in the annulus between the straddle packers is forced outwardly into the formations through perforations in the casing at such location. The straddle packers, the upper of which may be the upper assembly HM straddle packer and the lower of which may be the lower assembly HM straddle packer illustrated and described on page 2381 of the Composite Catalog of Oilfield Equipment and Services, 1960–61 Edition. Such upper straddle packer may be set into operative position in sealing engagement with the well casing by fluid pressure introduced into the tubing string and such lower straddle packer may be set by longitudinal or rotary movement imparted to the tubing string. These packers may be freed for movement from engagement with the well casing by release of the fluid pressure in the tubing string and by longitudinal and rotational movement of the tubing string.

If the earth formation or zone is of appreciable thickness, the straddle packers may have to be set and then released at several different longitudinally spaced locations in the well in order to secure uniform distribution of the treating fluid or material over the entire formation. It is desirable that a well packer for sealing between the tubing string and the well casing above the straddle packers be provided in order to prevent the hydrostatic pressure or load in the annulus above the straddle packers from displacing the treating fluid or material too far back into the formation when the straddle packers are moved out of sealing engagement with the well casing when the straddle packers are to be moved to new locations and to retain the pressure below such packer in the event that the formation breaks around the upper straddle packer through the perforations of the well casing above and below the upper straddle packer and through the formation therebetween. It is desirable that such packer permit both rotational and longitudinal movement of the tubing therethrough after it has been set to close and seal the annulus above the formation which is to be treated to permit successive settings and releases of the straddle packers and their longitudinal displacement in the well casing to permit treatment of successive longitudinal sections of the formation.

Accordingly, it is an object of this invention to provide a new and improved well packer for sealing the cylindrical space or annulus between a tubing and a well casing of a well.

Another object is to provide a well packer having an anchoring means for securing the well packer against longitudinal movement in the well casing and a sealing means for sealing between the well casing and the tubing, which packer permits rotational and longitudinal movement of the tubing whereby other well tools, such as packers,

secured to the tubing may be operated by longitudinal or rotational movement of the tubing while the well packer is in sealing engagement with the well casing.

A further object of the invention is to provide a well packer having anchoring means which are initially held in a retracted position and are movable to expanded position to anchor the well packer in a well casing upon rotational and then longitudinal movement of the tubing string relative to the packer, the tubing thereafter being movable downwardly and rotationally to move, set and release other packers secured to the tubing string therebelow while the well packer is in sealing engagement with the well casing, the anchoring means and sealing means of the well packer being freed to move to retracted position upon subsequent upward movement of the tubing string whereby the tubing string may be removed from the well.

A still further object is to provide an apparatus for treating a well which includes a top well packer and a pair of longitudinally spaced straddle packers mounted on a tubing string below the top packer wherein the straddle packers and the tubing may be moved longitudinally and rotationally while the top well packer seals the annulus between the tubing and the well casing.

Another object is to provide a well apparatus having a plurality of longitudinally spaced packers for sealing between the tubing string and the well casing wherein the tubing string is longitudinally movable relative to the uppermost well packer after the uppermost well packer has been anchored against longitudinal movement in the well casing.

Additional objects and advantages of the invention will be readily apparent from the reading of the following description of a device constructed in accordance with the invention, and reference to the accompanying drawings thereof, wherein:

FIGURE 1 is a vertical view of a tubing string having a pair of straddle packers and a top well packer embodying the invention showing the packers anchored in sealing engagement with the well casing;

FIGURE 2 is a vertical partly sectional view of the upper portions of a packer embodying the invention;

FIGURE 3 is a view similar to FIGURE 2, being a continuation thereof, showing the lower portions of the well packer;

FIGURE 4 is a fragmentary view taken on line 4—4 of FIGURE 3;

FIGURE 5 is a fragmentary view taken on line 5—5 of FIGURE 3;

FIGURE 6 is a vertical partly sectional view showing the upper portions of the well packer with the sealing means in sealing engagement with the well casing and the tubing string released for longitudinal movement relative to the packer;

FIGURE 7 is a view similar to FIGURE 6 being a continuation thereof, showing the lower portions of the well packer;

FIGURE 8 is a fragmentary sectional view taken on line 8—8 of FIGURE 7;

FIGURE 9 is a vertical partly sectional view of modified form of the well packer embodying the invention;

FIGURE 10 is a fragmentary sectional view taken on line 10—10 of FIGURE 9, and

FIGURE 11 is a fragmentary sectional view taken on line 11—11 of FIGURE 9.

Referring now particularly to FIGURE 1 of the drawings, the top well packer 10 embodying the invention is shown mounted on a tubing string T above a pair of straddle packers 12 and 13 connected to the tubing string in the usual manner. The section 15 of the tubing string T between the upper and lower straddle packers is provided with a tubular adapter 16 having a closed lower

end and a plurality of lateral ports 17 through which fluid introduced into the tubing string at the surface may flow outwardly into the annulus 18 between the tubing and the well casing 19 of the well and thence through the perforations 20 thereof into an earth formation. The adapter prevents flow of fluid from the tubing string to the lower straddle packer and also connects the lower straddle packer to the lower end of the tubing string.

The upper and lower straddle packers 12 and 13 may be the upper and lower HM straddle packers and illustrated in the Composite Catalog of Oilfield Equipment and Services, page 2381, referred to above, having anchoring means 21 and 22, respectively, for rigidly securing the straddle packers against movement in the well casing and having sealing elements 23 and 24, respectively, for sealing between the tubing and the well casing. The anchoring means 22 and the sealing means 24 of the lower straddle packer 13 and the sealing means 23 of the upper straddle packer are moved to expanded well casing engagement position upon a predetermined rotational and then downward movement of the tubing string while the anchoring means 21 of the upper straddle packer 12 are moved outwardly into well casing engaging position by fluid pressure introduced into the tubing string at the surface.

The anchoring and sealing means of the straddle packers are moved to retracted positions out of engagement with the well casing upon subsequent upward longitudinal movement of the tubing string and may then be again moved to anchoring and sealing positions at a different location in the well casing. The structure and mode of operation of the straddle packers being well known in the art, they will not be described in further detail.

The top well packer 10 includes a main mandrel 30 longitudinally mounted on a reduced tubing section 31 of the tubing string T. The tubing section 31 has an upper end portion 32 threaded into the lower end of flush joint section 33 of greater outer diameter than the tubing section 31, a plurality of which may be connected in the tubing string to constitute a section thereof above the well packer 10. A J-slot member 34 is threaded on the lower end of the tubing section 32 and is connected to a tubing section 35 by the usual coupling 36 threaded on the lower reduced end portion 37 of the J-slot member. The tubing section 35 is connected to the packer 12 in the same manner by a coupling 38.

The mandrel 30 includes an upper sub section 40 whose lower end is threaded into the upper end of an upper seal section 41 to retain the internal resilient sealing elements 42 and 43 in place between the upwardly facing shoulder 44 of an internal annular flange 45 of the seal section 41 and the lower end of the upper sub 40. The upper sub has one or more lateral ports 47 providing communication between the interior and exterior thereof. An intermediate seal section 49 of the mandrel 30 has an upper end threaded into the upper seal section 41 and has a packer retainer 50 threaded thereon. The packer retainer has an annular internal upwardly facing recess 51 in which is received the lower end portion of a tubular packer element 53 whose upper free annular end portion is free to flex outwardly in sealing engagement with the well casing. The upper packer element 53 may be bonded or otherwise secured to the packer retainer 50 and in addition a sleeve 55 threaded on the intermediate sealing section of the mandrel telescopes into the upper packer element 53 to further secure the upper packer element against longitudinal movement relative to the intermediate sealing section 49 and the packer retainer. A middle packer element 57 has an upper portion received in the internal annular downwardly facing recess 59 of the packer retainer 50 and may be bonded or otherwise secured to the packer retainer 50. The middle packer element 57 is further held against displacement from the packer retainer 50 by the upper portion of a lower packer retainer 60 threaded on the mandrel and provided with a downwardly facing annular recess 61 in which is disposed the upper end of a downwardly facing lower packer element 62. The packer element 62 may be bonded to the lower packer retainer and may be further held against downward displacement by a retainer sleeve 66 slidably disposed on the intermediate seal section 49 of the mandrel and held against downward displacement by the upwardly facing shoulder 67 provided by an external annular flange 68 of the intermediate seal section. The intermediate seal section has an external annular recess above the shoulder 67 in which is received an O-ring 69 or other suitable sealing element which seals between the mandrel and the retainer sleeve 66. It will be apparent that the annular free end portion of the upper packer element 53 is free to flex outwardly to engage the well casing to prevent flow of fluids downwardly between the mandrel 30 and a well casing and that the annular free end portions of the middle and lower packer elements 57 and 62 are free to flex outwardly to sealingly engage the well casing to prevent upward flow of fluids past the mandrel 30.

The intermediate seal section has one or more ports 70 below the packer elements which in addition with the ports 47 of the upper sub section permit flow of fluids past the packer elements through the mandrel as long as the upper flush joint tubing sections are disposed above the internal sealing elements 42 and 43 of the mandrel.

The upper end portion of a slip carrier section 72 of the mandrel 30 is threaded on the lower end of the intermediate seal section 49 of the mandrel and has an external annular groove or recess 73 in which are disposed a plurality of slips 74. The external recess 73 of the slip carrier section has upper and lower annular shoulders 75 and 76 which extend divergently outwardly from an intermediate cylindrical surface 77. Each of the slips has an upwardly and outwardly extending cam surface 78 which is adapted to engage the upper shoulder 75 of the external recess upon upward movement of the slip in the external recess to cause the slip to move outwardly of the mandrel 30 and into gripping engagement with the well casing. Each of the slips also has a lower downwardly and outwardly facing cam shoulder 79 which is engageable with the lower shoulder 76 of the external recess, the camming engagement between the shoulders 79 and 76 moving the slip outwardly of the mandrel into gripping engagement with the well casing. Each of the shoulders 79 and 78 extend divergently outwardly from the planar inner intermediate surface 80 of each slip. The slips of course are in their retracted inner positions when the intermediate surfaces 80 of the slips are aligned with and in engagement with the inner surface 73 of the external recess. The outer surfaces of the slips are provided with teeth 82 for digging or biting into the well casing.

Each of the slips extends outwardly through a substantially rectangular recess 85 of a slip retainer 87 disposed about the slip carrier section 72 of the mandrel 30. The slip retainer has a pair of leaf springs 88 adjacent each aperture 85 whose free ends extend inwardly into the aperture 85 and into the slip recess 89 of the slip to bias the slips inwardly into the external recess 73. The leaf springs may be secured to the slip retainer 87 in any suitable manner as by rivets 90.

Longitudinal and rotational movement of the slip retainer 87 on the slip carrier section is controlled by the inwardly extending pin 92 threaded in a suitable bore of the retainer adjacent the upper end thereof, which extends into an external guide recess 93 of the slip carrier section. The guide recess has a vertical portion 94 and a laterally offset portion 95 which communicates at an intermediate point with the longitudinal portion 94. When the guide pin 92 is in the upper portion 96 of the offset portion of the guide slot 93, the slips 74 are held in the retracted positions within the external recess 73 of the slip carrier section 72 and will not engage the well

casing. When the slip carrier section is moved upwardly and then rotated in a clockwise manner, as seen from above, relative to the slip retainer 87, the slot is so disposed relative to the guide pin 92 that the guide pin 92 is aligned in the longitudinal section of the guide slot 93 thus permitting longitudinal movement of the slip carrier, and therefore the slips, relative to the slip carrier section of the mandrel. If the slip carrier now moves downwardly relative to the slip retainer 87, the camming action between the shoulders 75 and 78 of the slip carrier section of the mandrel and of the slips causes the slips to move outwardly of the mandrel through the apertures 85 and into engagement with the casing as shown in FIGURE 7. Similarly, if the mandrel is moved upwardly relative to the slip retainer, the camming engagement between shoulders 76 and 79 of the slip carrier section and the slips moves the slips toward expanded position and into engagement with the well casing. Downward movement of the mandrel relative to the slip retainer is limited by the engagement of the guide pin 92 with the lower surface of the external flange 68 of the intermediate seal section 49 of the mandrel while upward movement of the mandrel relative to the slip retainer is limited by the engagement of the guide pin 92 with the surface 99 defining the lower end of longitudinal portion of the guide slot 93.

The slip retainer 87 has a plurality of drag springs 101 each of which has an arcuate portion 102 which extends outwardly of the slip carrier into engagement with the well casing and with end portions 104 and 105 disposed in an external elongate recess 107 of the slip retainer 87. The drag springs are secured to the slip carrier by a retainer ring 109, disposed in a suitable external annular recess of the slip carrier which extends over the lower end portions 104 of the drag spring to retain them in the recess 107 of the slip retainer. The drag springs 101 serve to hinder both rotational and longitudinal movement of the slip carrier through the well casing so that relative movement may take place between the mandrel and the slip carrier when the mandrel is moved either rotationally or longitudinally while the well packer is in a well casing.

The mandrel 30 is releasably secured to the tubing string T for both rotational and longitudinal movement therewith by means of the guide pin 110, threaded in a suitable bore at the lower end of the slip carrier section 72 of the mandrel, which extends inwardly into the J-slot 112 of the member 34 of the tubing string. The J-slot or recess 112 has a vertical portion 113 which opens upwardly of the upper end of the J-slot member and a laterally offset portion 114 whose upper end is defined or closed by the arcuate surface 115 adapted to engage the guide pin 110 to prevent both rotational and upward longitudinal movement of the mandrel relative to the tubing string. It will be apparent that if the tubing string is moved upwardly and then rotated in a clockwise direction, as seen from above, relative to the mandrel, the intermediate portion guide pin 110 is first moved in alignment with the transverse lateral portion 116 of the J-slot and then into alignment with the longitudinal portion 113 so that the tubing string can then be moved downwardly while the mandrel and slip retainer 87 mounted thereon are left anchored in an upper position in the well casing. Since the resilient packer elements 53, 57 and 62 engage the well casing and tend to hinder or prevent movement of the mandrel 30 through the well casing and since the slip retainer 87 is provided with the drag springs 101 which similarly tend to hinder or prevent movement of the slip retainer in the well casing, upward and then clockwise rotational movement of the tubing string frees the slip retainer 87 and therefore the slips 74 for movement relative to the mandrel and simultaneously frees the tubing for downward movement relative to the mandrel. Any longitudinal movement of the mandrel either upwardly or downwardly in the well casing now causes the slips to move outwardly into engagement with the well casing and anchor the mandrel and the slip retainer against movement in the well casing. The mandrel, of course, would tend to move upwardly if a pressure differential were created across the mandrel tending to cause flow of fluids upwardly therepast and would tend to move downwardly if the pressure differential across the mandrel tended to cause fluids to flow downwardly therepast.

In use, when it is desired to perform such well operations as the treatment of an earth formation with sand consolidation materials, the usual straddle packers 12 and 13 are connected to a tubing string in the usual manner. Top well packer 10 is then connected in the tubing string above the straddle packers in the manner shown in FIGURES 1 through 3. The reduced tubing section 32 is now disposed in the mandrel 30 so that the internal sealing elements 42 and 43 of the mandrel are not in engagement with the tubing section and will permit flow of fluids through the ports 70, the annular space between the reduced tubing section and the mandrel and the ports 47 past the packer elements 53, 57 and 62 as the tubing string with the top packer is moved through the well casing thus facilitating movement of the tubing string through the well casing and preventing swabbing engagement of the packer elements with the well casing.

The guide pin 110 is now in position in the J-slot 112 illustrated in FIGURES 3 and 4 so that the engagement of the pin 110 with the arcuate shoulder 115 of the J-slot member 34 now prevents downward movement of the J-slot member and of the tubing string relative to the mandrel 30. The slip retainer is now held against longitudinal movement relative to the mandrel by the engagement of the guide pin 92 with the arcuate shoulder 96 defining the upper portion of the lateral extension 95 of the guide slot 93 of the slip carrier section of the mandrel 30. The slip retainer is thus in an intermediate longitudinal position relative to the slip carrier section of the mandrel 30 due to the location of the guide pin 92 in the laterally offset portion 95 of the guide slot 93 of the slip carrier section so that the slips are in their retracted positions in the external recess 73 of the slip carrier section and are held against outward movement toward expanded positions by the leaf springs 88.

As the complete assembly of well packers is moved downwardly through the well casing to a desired location therein, the engagement of the packer elements of the mandrel and the drag springs 101 of the slip retainer 87 of the top well packer with the well casing tends to keep the slip carrier, the slip retainer and the slips in the positions relative to each other and to the reduced tubing section 32 illustrated in FIGURES 2 and 3 of the drawing. When the well packers have been lowered to the desired location in the well, the top packer is set first by lifting upwardly on the tubing string at the surface to cause the J-slot member to move upwardly relative to the mandrel and to then cause the mandrel to move upwardly relative to the slip retainer 87 once the shoulder 117 of the J-slot member engages the lower end of the mandrel. Since the slip carrier is restrained against upward movement by the drag springs 101, such further upward movement of the tubing string and the mandrel causes the guide pin 92 to move downwardly in the lateral extension 95 of the guide slot 93 so that subsequent clockwise rotation of the tubing string moves the tubing string and the J-slot member in a clockwise direction relative to the guide pin 92 and/or the guide pin 110. The lateral intermediate transverse portion 116 of the J-slot member moves past the guide pin and vertical portion 113 moves into alignment with the guide pin which then engages the vertical shoulder 118 defining one edge of the vertical portion. Continued rotational movement of the tubing string in a clockwise direction then causes rotational movement of the mandrel relative to the slip retainer 87 causing the longitudinal vertical section 94 of the guide slot or recess 93 to move into alignment with the guide pin 92. When

the guide pin 92 is disposed in the longitudinal vertical portion of the guide slot 93, the mandrel 30 is free to move relative to the slips. If the pressure differential across the mandrel now causes the mandrel to move downwardly relative to the slip retainer as the camming action of the shoulders 75 and 78 of the recess 73 and of the slips 74, respectively, causes the slips to move outwardly against the biasing force of the springs 88 into engagement with the well casing and anchor the mandrel 30 in the well casing against downward movement in the well casing. The drag springs 101 of course hinder movement of the slip retainer in the well casing.

If the pressure differential now causes the mandrel to move upwardly relative to the slip retainer, the camming action of the shoulders 76 and 79 of the mandrel and the slips, respectively, causes the slips to move outwardly and anchor the mandrel against upward movement in the well casing.

The tubing string may then be moved downwardly relative to the mandrel which is now anchored against movement in the well casing with its packer elements in sealing engagement with the well casing closing and sealing the annulus between the mandrel and the well casing. As the tubing string is then moved downwardly through the well casing and the packer mandrel, the J-slot member 34 moves downwardly relative to the guide pin 110, the guide pin passing through the upper open end of the vertical portion 113 of the J-slot 12. The tubing string is thus freed from the mandrel for downward movement relative to the mandrel which is left in anchored position in the well casing.

As the reduced tubing section 32 moves through the tubing string and the flush joint tubing sections 33 enter into the mandrel, the internal seal means 42 and 43 engage the flush joint tubing to seal between the tubing and the well casing thus preventing any flow of fluids therebetween. The tubing may then be moved downwardly to position the straddle packers at a desired location in the well casing.

The straddle packers may be set by rotational and longitudinal movement imparted to the tubing string which causes the anchoring elements or means 21 of the lower straddle packer 13 to anchor the lower straddle packer against movement in the well casing and the sealing means 23 and 24 of the straddle packers to move into sealing engagement with the well casing. Subsequent increase in fluid pressure introduced in the tubing string causes the anchoring elements 20 of the upper straddle packer into anchoring engagement with the well casing.

The fluid or material with which the earth formation between the straddle packers is to be treated is then pumped downwardly through the tubing string and out of the lateral ports 17 of the adapter 16 into the well casing and then through the lateral perforations of the casing into the formation. Should the formation break down about the upper straddle packer, which would tend to permit the treating fluid to flow through the formation back into the annulus above the upper straddle packer and upwardly to the surface, the upper top well packer 10 prevents such flow since it closes the annulus between the tubing and the well casing above the upper straddle packer since the downwardly facing intermediate and lower packer elements 57 and 62 will be forced outwardly into tight sealing engagement by the upwardly acting pressure differential thereacross. Similarly, the upper packer element 53 of the top well packer prevents any downward flow of fluid past the top packer into the well casing below and thence through the perforations above the upper straddle packer into the earth formation.

When a particular portion of the formation has been treated with the treating material, the straddle packers may be released in the usual manner and the tubing string may then be moved downwardly or upwardly to position the straddle packers at another location below the top packer and to reset the straddle packers to permit treatment of another section of the earth formation with the treating material. During such movement of the tubing string and the setting and releasing of the straddle packers, the top well packer prevents any flow of fluids either upwardly or downwardly past the top well packer so that there is no loss of the treating liquid during such setting and resetting of the straddle packers and no flow of fluids disposed in the well casing above the top packer into the formation.

When the desired operations in which the straddle packers are employed have been completed and it is desired to remove the apparatus from the well, the straddle packers are released in the usual manner by decreasing the fluid pressure within the tubing string and by imparting rotational and longitudinal movement to the tubing string. The tubing string is then lifted upwardly until the guide pin 110 again enters into the J-slot 112, the divergent upwardly facing shoulders 120 facilitating such movement of the guide pin into the vertical section 113 of the J-slot, it being apparent that rotational movement may need to be imparted to the tubing string to cause the vertical portion 113 of the J-slot to be aligned with the guide pin. Further upward movement of the tubing string then causes the lower end of the mandrel to engage the upwardly facing annular shoulder 117 of the J-slot member 34 whereupon further upward movement causes upward movement of the mandrel relative to the slips and the retainer 87. Such upward movement of the mandrel causes the inner surface 77 of the recess 73 to be aligned with the intermediate surfaces 80 of the slips so that the slips are free to move inwardly out of engagement with the well casing thus freeing the slips for inward movement into the recess. When this occurs, the lower end of the slip retainer also engages the shoulder 117 preventing further upward movement of the mandrel relative to the slip retainer. Since the slips are now not cammed outwardly by either the shoulder 75 or the shoulder 76, the slips are in their inner retracted positions and no longer prevent upward movement of the slip retainer and the mandrel upwardly through the well casing, being biased outwardly out of engagement with the well casing by the springs 88.

During such upward movement of the tubing string, the flush joint tubing sections 33 again move upwardly out of engagement with the internal seal elements 42 and 43 of the mandrel so that fluid may again flow past the packer elements through the ports 47 and 70 and the annular cylindrical passage between the mandrel and the reduced tubing section 32. The tubing string and the packers may now be moved upwardly through the well casing.

The modified well packer 150 illustrated in FIGURES 9 through 11 includes a tubing section 152 of reduced external diameter which is threaded to the flush joint tubing sections 33 at its upper end and by means of the coupling 36 to the tubing section 35 at its lower end. A mandrel 153 is mounted on the reduced tubing section 152 and includes an intermediate section 155 having an annular external flange 156 adjacent its upper end which provides an upwardly facing shoulder 157. The annular flange limits downward movement of an annular resilient packer element 158 disposed about an upper reduced portion 159 of the intermediate section. An upper packer element retainer section 160 is threaded on the upper end portion of the intermediate section and engages the packer element to hold it in place. The packer element of course may be bonded or adhesively secured to the intermediate mandrel section. The upper packer retainer section has one or more ports 161 which provide communication between the interior and the exterior of the mandrel above the packer element 58.

The lower end portion of the intermediate packer mandrel section has a similar external annular flange 164 which provides a downwardly facing shoulder 165 which limits upward movement of the lower resilient packer element 166 disposed about the reduced end portion 167 of

the intermediate mandrel section. A lower packer element retainer section 168 of the mandrel is threaded on the reduced portion 167 of the intermediate mandrel section and engages the lower packer element to hold it against displacement. The resilient packer element of course may be bonded or adhesively secured to the intermediate section and to the lower retainer section. The lower packer element retainer 168 is provided with one or more ports 169 which communicate between the interior and exterior of the mandrel.

The intermediate section has an external annular recess 172 having an inner intermediate vertical cylindrical surface 173 from which extend divergently outwardly the upper and lower annular cam shoulders 174 and 175. A plurality of slips 177 are disposed in the external recess 172 and have upper and lower outwardly divergently extending shoulders 178 and 179 which extend from the intermediate vertical surfaces 180. The slips are held in place in the recess by means of a tubular slip retainer 183 disposed about the intermediate mandrel section 153 and which has a plurality of lateral windows or apertures 185 into which the slips extend. The slips are biased inwardly into the external recess by the leaf springs 188 whose free ends extend into slots 189 of the slips. The other ends of the springs are secured to the slip retainer by means of rivets or in any other suitable manner. The external recess 172 and the slips 177 obviously operate in the same manner as the slips and the external recess of the slip carrier section of the well packer 10 illustrated in FIGURES 1 through 8, the slips being cammed outwardly into well casing engaging position upon relative longitudinal movement between the slip retainer and the mandrel.

Rotational and limited longitudinal movement of the slip retainer on the mandrel between the external flanges 156 and 164 of the mandrel is governed by the guide pin 190 which extends inwardly into the guide slot or recess 191 of the intermediate mandrel section 153. The guide slot 191 has a vertical longitudinal section 193 and a laterally offset portion 194 which communicates with the vertical section thereof and provides an arcuate downwardly facing shoulder 195 which is engageable with the guide pin 190. When the guide pin 190 is in the laterally offset portion 194 of the guide slot 191 as illustrated in FIGURE 10, the intermediate surfaces 180 of the slips 177 are aligned with and engage the inner vertical surface 173 of the external recess and are thus in their inner retracted positions. When the mandrel is rotated in a clockwise manner, as seen from above, relative to the slip mandrel after a limited upward movement of the mandrel relative to the slip retainer, the guide pin 190 is positioned in the vertical longitudinal portion 193 of the mandrel whereby a further longitudinal movement may take place between the mandrel and the slip retainer to cause the slips to be cammed outwardly by the engagement of either their upper or lower shoulders with the upper or lower shoulders, respectively, of the external recess into anchoring engagement with the well casing.

The intermediate mandrel section also has a pair of internal annular recesses in which are disposed the internal resilient sealing means 197 and 198. The mandrel has one or more ports 199 disposed between the slip recesses and the lower external flange 164 which also afford communication between the interior and the exterior of the mandrel.

The mandrel is releasably secured to the reduced section 152 of the tubing string by a guide pin 202 which extends outwardly from the reduced tubing section into a guide slot 204 of the bottom mandrel section 205 threaded on the lower end of the lower retainer section 168. The guide slot 204 has an elongate longitudinal portion 206 and a downwardly opening portion 207 which is connected with an intermediate portion of the longitudinal portion 205 by the intermediate lateral portion 208. It will be apparent that when the tubing section is moved upwardly and then rotated in a clockwise manner, as seen from above, the guide pin 202 will move through the lateral portion 208 of the guide slot into the downwardly opening slot portion 207 whereupon the tubing may be moved downwardly relative to the mandrel since the guide pin 202 may then move downwardly out of engagement with the bottom section 205 of the mandrel.

It will be apparent that the top well packer 150 may be secured to the tubing string in the same manner as the top well packer 10 illustrated in FIGURES 1 through 8 and operate in the same manner to seal the annulus or space between the tubing string and the well casing while permitting longitudinal and rotational movement of the tubing so that other well tools, such as the usual straddle well packers, may be operated in the well below the top well packer. Briefly, the top well packer is run into a well casing with its operative elements in the positions illustrated in FIGURES 6 through 11. When the tubing string has been lowered to the desired level in the well, the tubing is lifted to position the guide pin 190 out of engagement with the arcuate shoulder 195 and to position the guide pin 202 in alignment with the lateral portion 208 of the guide slot 204. The slip retainer is of course held against such upward movement by the drag springs 210 thereof which engage the well casing. The slip retainer 183 is thus freed for longitudinal movement relative to the packer mandrel so that longitudinal movement of the mandrel causes the slips to move outwardly and anchor the slip retainer, and therefore the mandrel, against longitudinal movement in the well casing. The tubing string may then be moved downwardly relative to the packer mandrel, the guide pin 202 passing down through the open end of the open slot portion 207 of the guide slot 204. The inner sealing means 197 and 198 of the mandrel engage the flush joint tubing sections 33 as the tubing is moved downwardly through the mandrel and seal therebetween. The top well packer then seals the annulus between the well casing and tubing string and prevents flow of fluids therebetween while at the same time it permits further downward longitudinal and rotational movement of the tubing string which may be required to operate other well tools secured to the tubing string below the top well packer, such as straddle packers, or the like.

When it is desired to remove the tubing string from the well, the tubing string is lifted upwardly and rotated as may be required to align the guide pin 202 thereof with the downwardly opening end of the downwardly opening section 217 of the guide slot 204, the cam shoulder 209 facilitating the movement of the guide pin into the guide slot. Further upward and then counter-clockwise rotation of the tubing string then moves the guide pin 202 into the transverse connecting section 208 of the guide slot 204 and at the same time positions the lateral portion 194 of the guide slot 191 in alignment with the guide pin 190 which enters therein. The recess 174 is then moved to cause its intermediate surfaces 173 to move into alignment with the intermediate shoulders 180 of the slips which are then freed for movement to retracted position. When the guide pin 202 engages the arcuate shoulder 215 of the slot 204, further upward movement of the tubing string causes upward movement of the mandrel and when the pin 190 of the slip retainer engages the upwardly facing shoulder 216 of the guide slot 191, also upward movement of the slip retainer. The tubing string may then be removed from the well.

It will now be seen that a new and improved top well packer for use with a well flow conductor, such as a tubing string, has been illustrated and described which includes a mandrel releasably mounted on a reduced portion of the tubing string and having anchoring means and sealing means for anchoring the mandrel against longitudinal movement in the well casing and

for sealing the annulus between the mandrel and the well casing.

It will further be seen that the mandrel is releasably secured on the tubing and provided with internal seals so that upon rotational and longitudinal movement of the tubing string relative to the mandrel, the tubing string is released for downward movement relative to the mandrel whereby, when the reduced tubing section passes downwardly through the well packing, the internal seal means engage the tubing string and seal between the mandrel and the tubing string.

It will further be seen that a tubing string is then movable longitudinally and rotationally relative to the mandrel so that the other well tools secured to the tubing string below such packer may be operated by longitudinal and rotational movement of the tubing string and be positioned at different positions in the well.

It will further be seen that the mandrel is provided with port means for permitting flow of fluid through the mandrel past the external packer elements while the mandrel is releasably secured to the mandrel against longitudinal movement relative thereto to facilitate movement of the packer through the well casing and preclude swabbing action by the external packer elements of the mandrel.

It will further be seen that the anchoring means of the mandrel is movable to retracted position upon upward movement of the tubing string to the position wherein the reduced tubing section is again aligned with the mandrel whereby further upward movement of the tubing string may then take place permitting removal of the well packer from the well.

While the well packer embodying the invention has been illustrated and described in connection with the use of straddle packers in such operations as the treatment of an earth formation with sand consolidation material, the well packer may also have such other uses as, for example, a downhole blowout preventer or drilling head. In this case, the well packer would be mounted on a drill pipe or tubing string having an outside diameter smaller than the internal seals of the mandrel and having an enlarged section below the packer which would be movable into sealing engagement with the internal seals of the mandrel. In the event of a blowout, lost circulation, or other condition of the well, requiring closing of the annulus between the drill pipe and the well bore, the drill string would be raised until the enlarged section of the string would engage the internal seals in the packer thus shutting off flow through the packer until remedial measures could be taken. The well packer, of course, would be anchored in sealing engagement with the well casing, and the large port section moved downwardly through it prior to the commencement of drilling operations.

The foregoing description of the invention is explanatory only, and changes in the details of the construction illustrated may be made by those skilled in the art, within the scope of the appended claims, without departing from the spirit of the invention.

What is claimed and desired to be secured by Letters Patent is:

1. A well apparatus for use in a well including: an elongate flow conductor positionable in the well; a well packer; cooperable means on said well packer and said flow conductor engageable for connecting said packer to said flow conductor whereby said packer is releasably secured to said flow conductor for movement therewith into the well, said well packer having means thereon for sealing between said packer and the bore wall of the well; anchoring means on said packer initially in retracted non-anchoring position thereon; said packer having expander means thereon movable in either direction longitudinally relative to said anchoring means for anchoring said well packer in said well upon rotational and then longitudinal movement of said expander means relative to said anchoring means, said flow conductor being movable rotationally and longitudinally relative to the well packer after said well packer has been anchored in said well; and well tool means secured to said flow conductor below said well packer whereby said well tool means may be operated by rotational and longitudinal movement of said flow conductor while said well packer closes the annulus between the flow conductor and the wall of the well bore above said well tool means.

2. A well apparatus for use in a well including: an elongate flow conductor positionable in the well; a well packer; pin and slot means on said flow conductor and said well packer engageable to releasably connect said well packer to said flow conductor for movement therewith into the well, said well packer having means thereon for sealing between said packer and the bore wall of the well; anchoring means longitudinally movably mounted on said packer initially in retracted non-anchoring position thereon; said packer having expander means thereon movable in either direction relative to said anchoring means to engage and move said anchoring means to anchoring position for anchoring said well packer in said well upon rotational and then longitudinal movement of said expander mean relative to said anchoring means, said flow conductor being movable rotationally and longitudinally relative to the well packer after said well packer has been anchored in said well; and well tool means secured to said flow conductor below said well packer whereby said well tool means may be operated by rotational and longitudinal movement of said flow conductor while said well packer closes the annulus between the flow conductor and the bore wall of the well above said well tool means, said well tool means comprising a pair of longitudinally spaced straddle packers.

3. A well tool including: a flow conductor; a tubular member disposed about the flow conductor; seal means on said tubular member for sealing between said tubular member and said flow conductor; first cooperable means on said tubular member and said flow conductor for releasably holding the flow conductor against longitudinal movement relative to said tubular member; means carried by said tubular member for anchoring said tubular member in a well; second cooperable means on said tubular member and said anchoring means engageable for releasably holding said anchoring means against longitudinal movement relative to said tubular member, said means being releasable upon rotational and longitudinal movement of said tubular member relative to said anchoring means whereby said tubular member may be moved in either longitudinal direction relative to said anchoring means to move said anchoring means to anchoring position; and seal means carried by said tubular member for closing the annular space between the tubular member and the well when said well tool is disposed in a well, said flow conductor being movable rotationally and longitudinally relative to said tubular member when said first cooperable means release said flow conductor for movement relative to said tubular member.

4. A well tool including: a flow conductor having a longitudinally extending section of reduced external diameter; a tubular member disposed about said flow conductor; first cooperable means on said tubular member and said flow conductor for releasably holding the tubular member in alignment with said reduced section of said flow conductor and against longitudinal movement relative to said flow conductor; seal means carried by said member for sealing between said tubular member and said flow conductor when said flow conductor is moved longitudinally relative to said tubular member to move said reduced section of the flow conductor out of alignment with said tubular member; means longitudinally movably carried by said tubular member for anchoring said tubular member in a well; expander means on said tubular member engageable with said anchoring means upon longitudinal movement of said tubular member rel-

ative to said anchoring means for moving said anchoring means outwardly for anchoring said tubular member in a well; second cooperable means on said tubular member and said anchoring means engageable to hold said anchoring means against such longitudinal movement in inoperative non-anchoring position relative to said expander means and releasable to permit longitudinal movement of said tubular member relative to said anchoring means; and external seal means carried by said tubular member for sealing between said tubular member and the internal wall of a well when the tubular member is disposed in the well; said first cooperable means releasing said flow conductor for longitudinal movement relative to said tubular member upon rotational movement in a predetermined direction and then longitudinal movement of said flow conductor relative to said tubular member.

5. A well tool including: a flow conductor having a longitudinally extending section of reduced external diameter; a tubular member disposed about said flow conductor; first cooperable means on said tubular member and said flow conductor for releasably holding the tubular member in alignment with said reduced section of said flow conductor and against longitudinal movement relative to said flow conductor; seal means carried by said member for sealing between said tubular member and said flow conductor when said flow conductor is moved longitudinally relative to said tubular member to move said reduced section of the flow conductor out of alignment with said tubular member; means longitudinally movably carried by said tubular member for anchoring said tubular member in a well; expander means on said tubular member engageable with said anchoring means upon longitudinal movement of said tubular member relative to said anchoring means for moving said anchoring means outwardly to engage the wall of the well bore for anchoring said tubular member in a well; second cooperable means on said tubular member and said anchoring means engageable to hold said anchoring means against such longitudinal movement in inoperative non-anchoring position relative to said expander means and releasable to permit longitudinal movement of said tubular member relative to said anchoring means; and external seal means carried by said tubular member for sealing between said tubular member and the internal wall of a well when the tubular member is disposed in the well; said first cooperable means releasing said flow conductor for longitudinal movement relative to said tubular member upon rotational movement in a predetermined direction and then longitudinal movement of said flow conductor relative to said tubular member, said second cooperable means also being released upon rotation of said tubular member in said predetermined direction relative to said anchoring means to free said anchoring means for movement to anchoring position.

6. A well packer for sealing between a flow conductor and the casing of a well including: a tubular mandrel disposed about the flow conductor and having an external seal means for sealing between the mandrel and the well casing when the well packer is disposed in the well; anchoring means longitudinally movably carried by said mandrel for anchoring said mandrel against movement in said well casing; first cooperable means on said mandrel and said anchoring means engageable for releasably holding said mandrel against longitudinal movement relative to said anchoring means, said first cooperable means holding said mandrel against movement relative to said anchoring means being releasable to free said mandrel for movement longitudinally in either direction to move said anchoring means to engagement with the well casing upon rotational movement of said mandrel in a predetermined direction relative to said anchoring means; second cooperable means on said mandrel and said flow conductor for releasably holding said mandrel against longitudinal movement relative to the flow conductor, said flow conductor being released upon rotational movement of said flow conductor relative to said mandrel in said predetermined direction to disengage said second cooperable means to free said flow conductor for longitudinal and rotational movement relative to the mandrel; and seal means carried by said mandrel and engageable with said flow conductor for sealing between the flow conductor and said mandrel upon longitudinal movement of said flow conductor relative to said mandrel.

7. A well packer for sealing between a flow conductor and a casing of a well including: a mandrel disposed about the flow conductor and having an external sealing means for sealing between the mandrel and the well casing when the well packer is disposed in the well; anchoring means longitudinally movably carried by said mandrel for anchoring said mandrel against movement in said well; first cooperable means on said mandrel and said anchoring means engageable for releasably holding said mandrel against longitudinal movement relative to said anchoring means, said first cooperable means holding said mandrel against movement relative to said anchoring means being releasable to free said mandrel for movement longitudinally in either direction to move said anchoring means into engagement with the well casing upon rotational movement of said mandrel in a predetermined direction relative to said anchoring means; second cooperable means on said mandrel and said flow conductor for releasably holding said mandrel against longitudinal movement relative to the flow conductor, said flow conductor being released from said mandrel upon rotational movement of said flow conductor relative to said mandrel in said predetermined direction to disengage said second cooperable means to free said flow conductor for longitudinal and rotational movement relative to the mandrel, said mandrel and said flow conductor having means providing a flow passage past said seal means when said mandrel is held against longitudinal movement relative to the flow conductor by said cooperable means; and seal means carried by said mandrel and engageable with said flow conductor for sealing between the flow conductor and said mandrel for closing said flow passage when said flow conductor is released from the mandrel and moved longitudinally relative thereto.

8. A well packer for sealing between a flow conductor and a casing of a well including: a mandrel disposed about the flow conductor and having an external sealing means for sealing between the mandrel and the well casing when the well packer is disposed in the well; anchoring means longitudinally movably carried by said mandrel for anchoring said mandrel against movement in said well; first cooperable means on said mandrel and said anchoring means engageable for releasably holding said mandrel against longitudinal movement relative to said anchoring means, said first cooperable means holding said mandrel against movement relative to said anchoring means being releasable to free said mandrel for movement longitudinally in either direction to move said anchoring means into engagement with the well casing upon rotational movement of said mandrel in a predetermined direction relative to said anchoring means; means on said mandrel engageable with said anchoring means upon longitudinal movement of said mandrel relative to said anchoring means in either longitudinal direction for moving said anchoring means to anchoring position; second cooperable means on said mandrel and said flow conductor for releasably holding said mandrel against longitudinal movement relative to the flow conductor, said flow conductor being released from said mandrel upon rotational movement of said flow conductor relative to said mandrel in said predetermined direction to disengage said second cooperable means to free said flow conductor for longitudinal and rotational movement relative to the mandrel, said flow conductor having a longitudinal section of reduced external diameter, said second cooperable means holding the said mandrel longitudinally aligned with said reduced portion of said flow conductor whereby a flow passage

past said seal means is provided; and seal means carried by said mandrel and engageable with said flow conductor for sealing between the flow conductor and said mandrel for closing said flow passage when said flow conductor is released from the mandrel and moved longitudinally relative thereto.

9. A well packer for sealing between a flow conductor and a casing of a well including: a mandrel disposed about the flow conductor and having an external sealing means for sealing between the mandrel and the well casing when the well packer is disposed in the well; anchoring means longitudinally movably carried by said mandrel for anchoring said mandrel against movement in said well; first cooperable means on said mandrel and said anchoring means engageable for releasably holding said mandrel against longitudinal movement relative to said anchoring means, said first cooperable means holding said mandrel against movement relative to said anchoring means being releasable to free said mandrel for movement longitudinally in either direction to move said anchoring means into engagement with the well casing upon rotational movement of said mandrel in a predetermined direction relative to said anchoring means; second cooperable means on said mandrel and said flow conductor for releasably holding said mandrel against longitudinal movement relative to the flow conductor, said flow conductor being released from said mandrel upon rotational movement of said flow conductor relative to said mandrel in said predetermined direction to disengage said second cooperable means to free said flow conductor for longitudinal and rotational movement relative to the mandrel, said mandrel and said flow conductor having means providing a flow passage past said seal means when said mandrel is held against longitudinal movement relative to the flow conductor by said cooperable means, and seal means carried by said mandrel and engageable with said flow conductor for sealing between the flow conductor and said mandrel for closing said flow passage when said flow conductor is released from the mandrel and moved longitudinally relative thereto, said anchoring means being disposed below said sealing means.

10. A well packer for sealing between a flow conductor and a casing of a well including: a mandrel disposed about the flow conductor and having an external sealing means for sealing between the mandrel and the well casing when the well packer is disposed in the well; anchoring means longitudinally movably carried by said mandrel for anchoring said mandrel against movement in said well; first cooperable means on said mandrel and said anchoring means releasably engageable to prevent longitudinal movement of said mandrel relative to said anchoring means, said anchoring means being in inoperative retracted position while said first cooperable means are engaged; means on said mandrel engageable with said anchoring means for moving said anchoring means outwardly to expanded anchoring position upon longitudinal movement of said mandrel in either longitudinal direction relative to said anchoring means; said first cooperable means on said mandrel and said anchoring means being releasable for movement of said mandrel relative to said anchoring means to move said anchoring means into engagement with the well casing upon rotational movement of said mandrel in a predetermined direction relative to said anchoring means; second cooperable means on said mandrel and said flow conductor for releasably holding said mandrel against longitudinal movement relative to the flow conductor, said flow conductor being released from said mandrel upon rotational movement of said flow conductor relative to said mandrel in said predetermined direction to disengage said second cooperable means to free said flow conductor for longitudinal and rotational movement relative to the mandrel, said mandrel and said flow conductor having means providing a flow passage past said external sealing means when said mandrel is held against longitudinal movement relative to the flow conductor by said second cooperable means; and second seal means carried by said mandrel engageable with said flow conductor for sealing between the flow conductor and said mandrel for closing said flow passage when said flow conductor is released from the mandrel and moved longitudinally relative thereto, said external sealing means comprising a plurality of longitudinally spaced elements, said anchoring means being disposed between said elements.

11. A well packer for sealing between a flow conductor having a section of reduced external outer diameter and a casing of a well, said packer including: a mandrel having a longitudinal bore therethrough and adapted to be disposed about the reduced portion of the flow conductor; said mandrel having internal seal means of greater inside diameter than the outer diameter of said reduced section of said flow conductor and engageable with said flow conductor for sealing between the mandrel and the flow conductor when the flow conductor is moved longitudinally relative to the mandrel to move the reduced portion of the flow conductor out of alignment with the mandrel; and anchoring means longitudinally movably carried by the mandrel for anchoring the mandrel in the well casing; expander means on said mandrel engageable with said anchoring means upon longitudinal movement of said mandrel in either direction longitudinally relative to said anchoring means for expanding said anchoring means to anchoring position; said mandrel and said anchoring means having cooperable means for releasably holding the anchoring means against longitudinal movement relative to said mandrel and out of engagement with said expander means on said mandrel whereby said anchoring means is in retracted position out of anchoring engagement with the well casing, said mandrel and said flow conductor having releasable means for holding the mandrel in alignment with the reduced section of the flow conductor.

12. A well packer for sealing between a flow conductor and a casing of a well including: a mandrel having a longitudinal bore therethrough and disposable about the flow conductor, said mandrel having internal seal means for sealing between the mandrel and the flow conductor; anchoring means longitudinally movably carried by the mandrel for anchoring the mandrel in the well casing; expander means on said mandrel engageable with said anchoring means upon longitudinal movement of said mandrel in either direction longitudinally relative to said anchoring means for expanding said anchoring means to anchoring position; said mandrel and said anchoring means having cooperable means for releasably holding the anchoring means against longitudinal movement relative to said mandrel and out of engagement by said expander means on said mandrel whereby said anchoring means is in retracted position out of anchoring engagement with the well casing; releasable means for holding the mandrel against longitudinal movement relative to the flow conductor; and external sealing means carried by the mandrel for sealing between the mandrel and a casing of a well.

13. A well packer for sealing between a flow conductor and a casing of a well including: a mandrel having a longitudinal bore therethrough and disposable about the flow conductor, said mandrel having internal seal means for sealing between the mandrel and the flow conductor; anchoring means longitudinally movably carried by the mandrel for anchoring the mandrel in the well casing; expander means on said mandrel engageable with said anchoring means upon longitudinal movement of said mandrel in either direction longitudinally relative to said anchoring means for expanding said anchoring means to anchoring position; said mandrel and said anchoring means having cooperable means for releasably holding the anchoring means against longitudinal movement relative to said mandrel and out of engagement by said expander means on said mandrel whereby said anchoring means is in retracted position out of anchoring engagement with the well casing; releasable means for holding the mandrel against longitudinal movement relative to the flow conduc-

tor; and external sealing means carried by the mandrel for sealing between the mandrel and a casing of a well, said cooperable means and said releasable means being operable upon rotational movement of said flow conductor in a single direction to free said anchoring means for movement to anchoring engagement and said flow conductor for longitudinal and rotational movement relative to the mandrel.

References Cited in the file of this patent

UNITED STATES PATENTS

2,716,456	Brown	Aug. 30, 1955
2,893,492	Brown	July 7, 1959
2,990,882	Brown	July 4, 1961
2,998,072	Crowe	Aug. 29, 1961