June 19, 1956 R. C. BAKER ET AL 2,751,017

RETRIEVABLE WELL PACKER

Filed Sept. 8, 1953 3 Sheets-Sheet 1

Fig. 1.

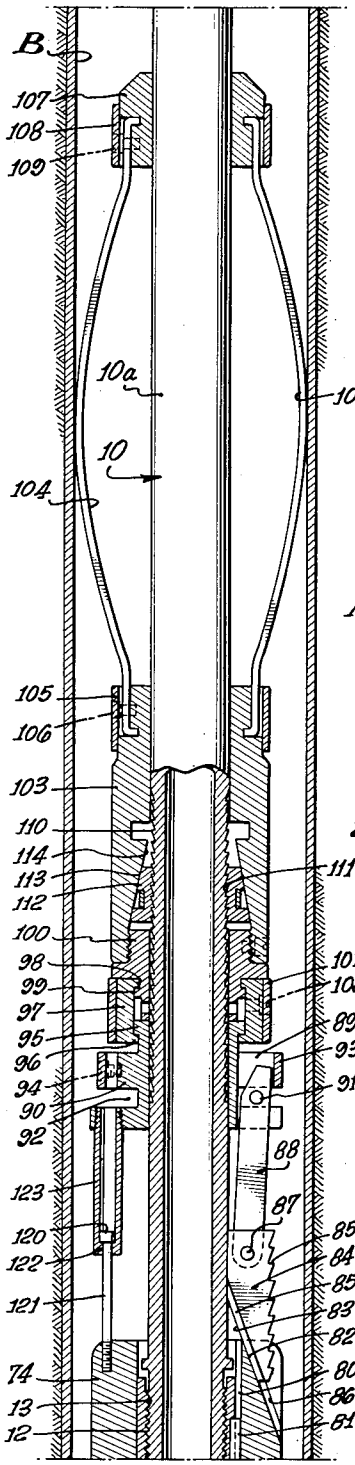


Fig. 1a.

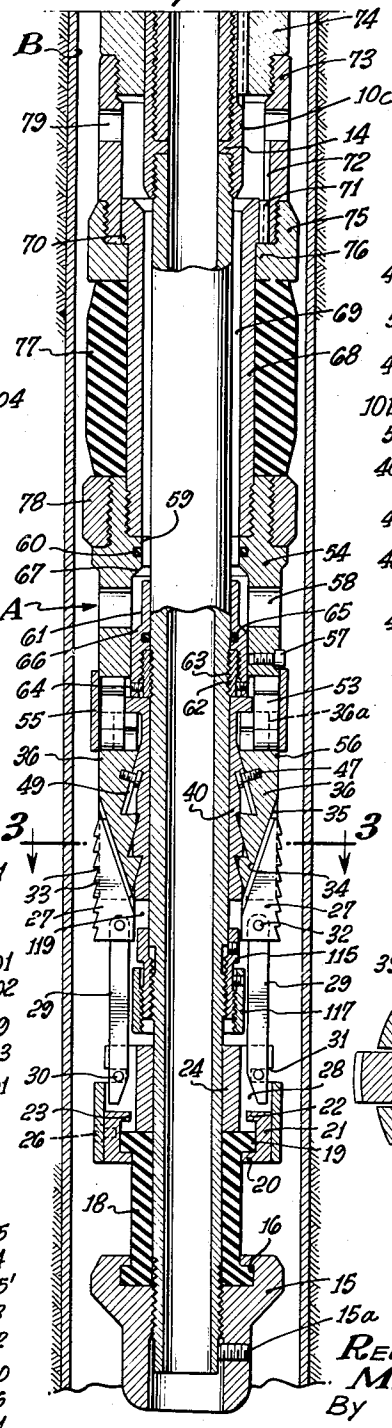


Fig. 2.

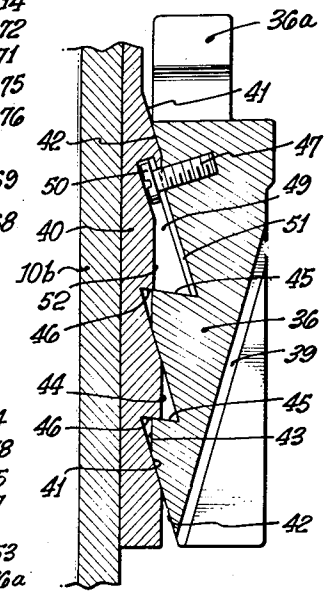
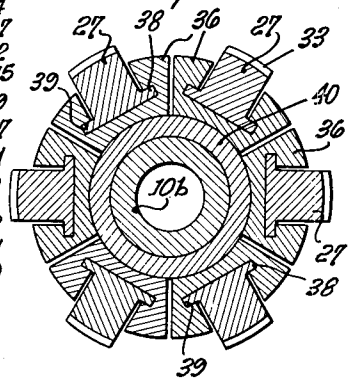


Fig. 3.



INVENTORS.
REUBEN C. BAKER,
MARTIN B. CONRAD,
By
Meelin and Hanscom
ATTORNEYS

June 19, 1956 R. C. BAKER ET AL 2,751,017

RETRIEVABLE WELL PACKER

Filed Sept. 8, 1953 3 Sheets-Sheet 2

Fig. 4.

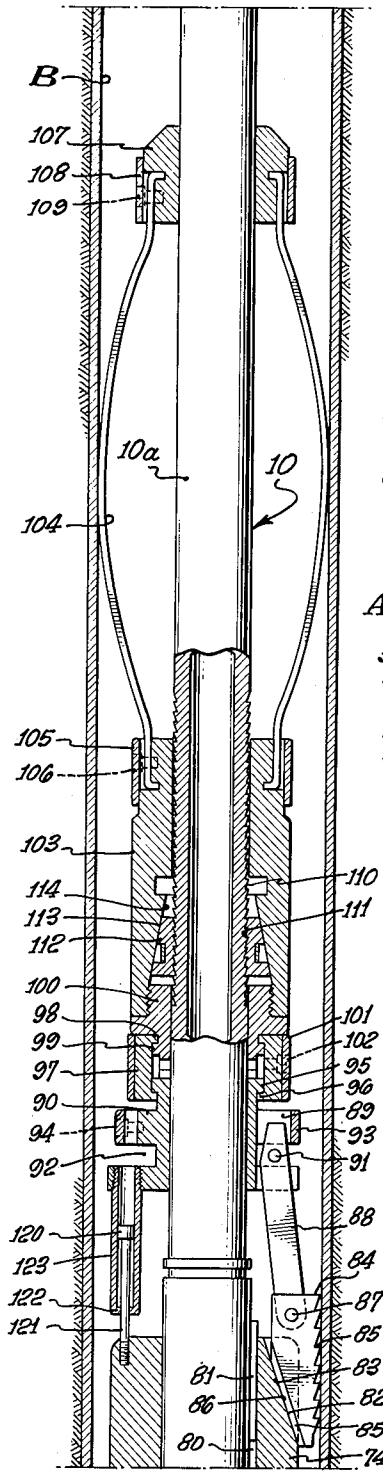


Fig. 4a.

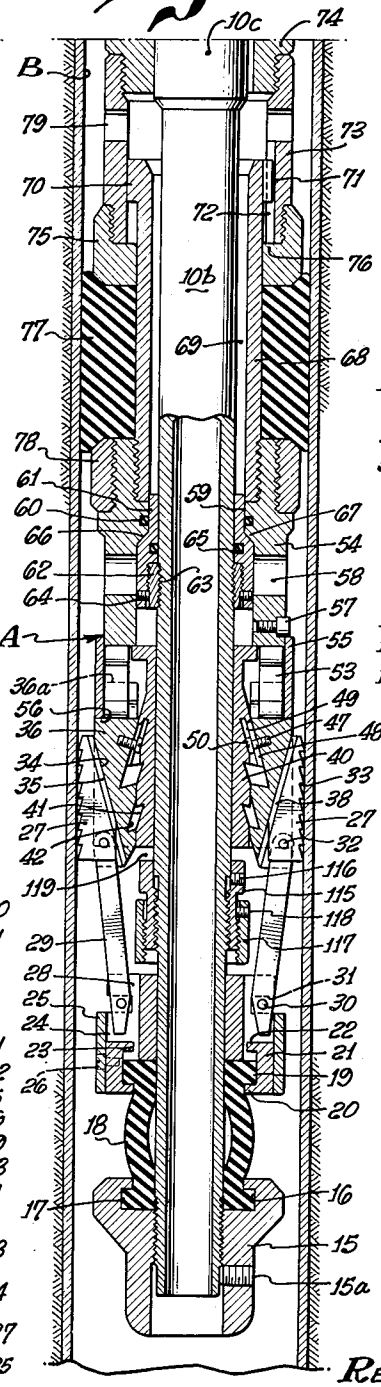
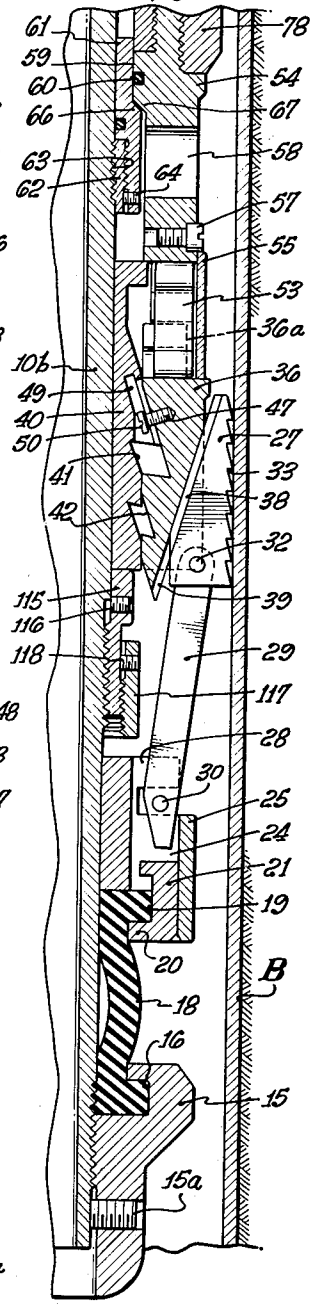


Fig. 5.



INVENTORS.
REUBEN C. BAKER,
MARTIN B. CONRAD,
By
Mellin and Hanscom
ATTORNEYS

June 19, 1956 R. C. BAKER ET AL 2,751,017

RETRIEVABLE WELL PACKER

Filed Sept. 8, 1953 3 Sheets-Sheet 3

Fig. 8.

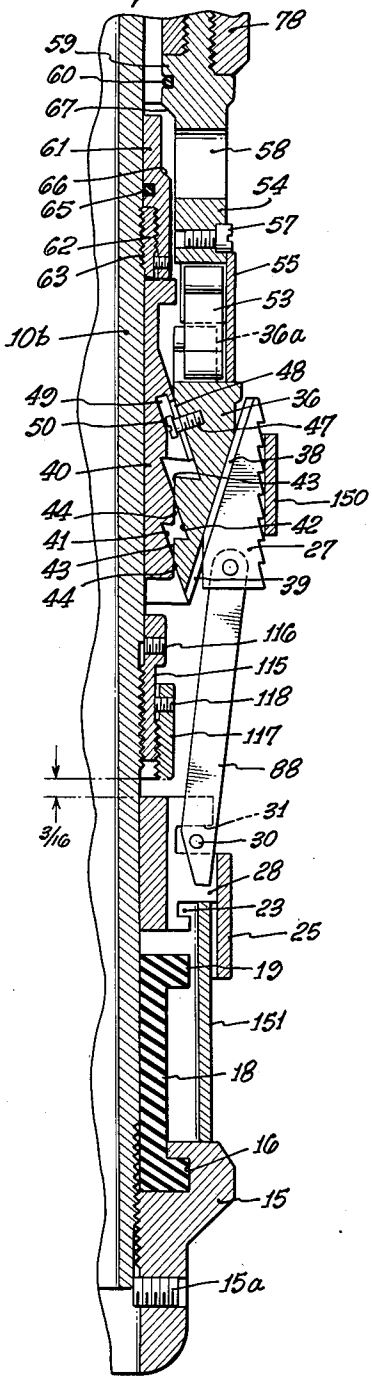


Fig. 6.

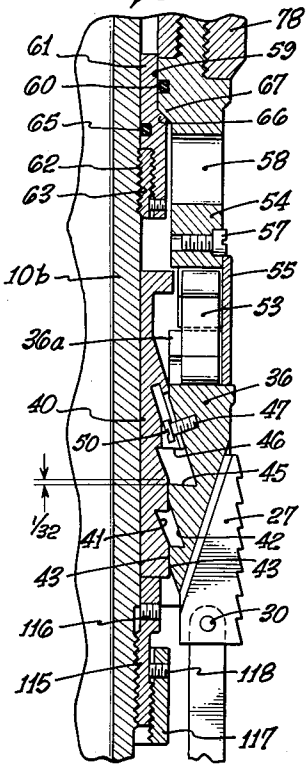


Fig. 7.

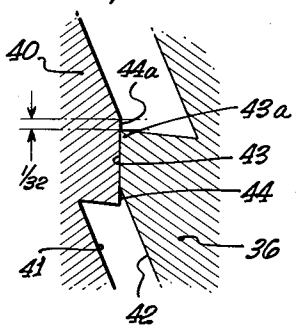
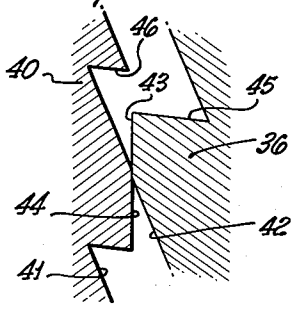


Fig. 9.



REUBEN C. BAKER,
MARTIN B. CONRAD,
INVENTORS.

BY

Mellin and Hanscom
ATTORNEYS

United States Patent Office 2,751,017 Patented June 19, 1956

2,751,017

RETRIEVABLE WELL PACKER

Reuben C. Baker, Coalinga, and Martin B. Conrad, Downey, Calif., assignors to Baker Oil Tools, Inc., Los Angeles, Calif., a corporation of California

Application September 8, 1953, Serial No. 378,704

13 Claims. (Cl. 166—216)

The present invention relates to subsurface well tools, and more particularly to tools capable of performing testing, pressuring, swabbing, producing, cementing, washing, acidizing and similar operations in well bores.

This application is a continuation-in-part of our application for "Retrievable Well Packer," Serial No. 243,982, filed August 28, 1951, now Patent No. 2,681,113.

In the above-identified patent application, a retrievable well packer is shown and described which is capable of being anchored in packed-off condition in a well casing against movement in upward and downward directions. Downward movement is prevented by a lower set of casing engaging slips slidably contacting outer expander segments which, in turn, engage an inner expander mounted on the body of the packer. Pressure in the casing above the packer is transferred to the expander segments, and from them to the lower slips, the latter being anchored against the wall of the well casing. The expander segments impose a wedging action on the inner expander, pinching it and transferring it in a downward direction. Such downward transferring movement has later prevented release of the lower slips from the casing by merely lowering the body of the packer, which action also effects release of the upper slips that engage the casing to prevent upward movement of the packer. Instead, it is first necessary to equalize the pressure in the casing, both above and below the packer, and then take an upward pull on the body of the tool to relocate the inner expander and the outer expander segments in their approximate initial position with respect to each other and the lower slips, which they occupied prior to the pinching and transferring movement of the inner expander by the segments. Thereafter, the body of the packer is lowered to effect withdrawal of both the lower and upper slips from the well casing to their initial retracted positions, allowing the well packer to be moved longitudinally in the well casing, as in an upward direction, for withdrawal to the top of the well bore.

Accordingly, it is an object of the present invention to avoid the necessity of taking a pull-up strain on the body of the tool prior to lowering of the tool body, for the purpose of releasing the tool from the well casing in which it has been anchored.

Another object of the invention is to provide a well tool of the character indicated in which the downward shifting or transferring of the inner expander by the outer expander segments cannot occur.

A further object of the invention is to provide a well packer of the character indicated which is anchored against movement in both longitudinal directions by taking an upward strain on the body of the packer, and which will remain in such anchored position despite the relieving of such upward strain on the body of the packer.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of a form in which it may be embodied. This form is shown in the drawings accompanying and forming part of the present specification. It will now be described in detail, for the purpose of illustrating the general principles of the invention; but it is to be understood that such detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

Figures 1 and 1*a* together constitute a longitudinal section through a well tool, with its parts disposed in retracted position for running the tool in a well casing, or similar well conduit, Fig. 1*a* constituting a lower continuation of Fig. 1;

Fig. 2 is a fragmentary enlarged longitudinal section of the lower expander segments and inner expander part of the tool;

Fig. 3 is a cross-section taken along the line **3—3** on Fig. 1*a*;

Figs. 4 and 4*a* together constitute a longitudinal section through the well tool, with certain of its parts expanded against the well casing;

Fig. 5 is a fragmentary enlarged sectional view of the lower portion of the tool shown in Fig. 4*a*;

Fig. 6 is a fragmentary longitudinal section illustrating the manner of adjusting the lower portion of the tool to insure its proper operation;

Fig. 7 is a further fragmentary enlargement disclosing the engagement between the expander portions of the tool shown in Fig. 6;

Fig. 8 is a longitudinal section disclosing another step in the proper adjustment of the lower portion of the tool;

Fig. 9 is an enlarged fragmentary section disclosing the cooperative engagement between portions of the expander and expander segments shown in Fig. 8.

As disclosed in the drawings, a well packer A is lowered in a well casing B by means of a tubular string (not shown) of drill pipe or tubing to a point in the casing at which the packer is to be set in packed-off condition. The packer is of the retrievable type, in that it can be anchored to the well casing and released therefrom at the will of the operator. It is also capable of resisting longitudinal movement in both directions within the well casing, despite the presence of comparatively high pressure differentials that might tend to pump or force the tool up the casing or down the casing.

The well packer A includes a tubular member **10** that may extend substantially the entire length of the apparatus. This tubular member includes a tubular upper body or mandrel **10***a* which is intended to be threadedly secured to the lower end of the tubular string (not shown). The upper body or mandrel **10***a* is also attached to a lower body or mandrel member **10***b* by means of a body coupling collar **10***c* whose upper portion is threaded to the lower portion of the upper body member **10***a* and whose lower portion is threaded onto the upper end of the lower body member **10***b*. The upper body member **10***a* has an external left-hand thread **12** engaging a companion internal thread **13** in the coupling collar **10***c*. The upper mandrel portion **10***a* is normally completely threaded into the collar **10***c*, with its lower end engaging an inturned flange **14** on the collar.

Surrounding the lower body member **10***b* is an arrangement for anchoring the well tool A to the casing B against downward movement therein, the anchoring means being releasable and retractable when desired. Such anchoring means includes a guide **15** threaded on the lower end of the lower body member **10***b* and having an internal groove **16** therein in which a lower outwardly directed flange **17** of a spring-like member, in the form of a rubber sleeve **18**, is positioned, to couple the lower end of the rubber sleeve to the guide. The elastic rubber sleeve **18** constitutes a tie member surrounding the lower body **10***b*, and with its upper end also having an external flange **19** overlapping an inwardly

directed flange 20 of a lower two-piece connector ring 21 having a flange 22 received within a groove 23 of a lower slip ring 24 surrounding the body 10*b*. The two-piece connector ring 21 is held in place by an encompassing sleeve 25 secured to the ring by one or more screws 26.

The lower slip ring 24 couples a set of lower slips 27 together for longitudinal movement in unison. It is provided with circumferentially spaced, longitudinally extending grooves 28 in which the lower end of links 29 are positioned, each link having a pin 30 extending transversely from the sides thereof for disposition within a peripheral groove 31 in the slip ring 24. The longitudinal slots 28 extend on both sides of the groove 31, the portion of each link 29 below the groove 31 being engageable with the sleeve 25, which prevents its removal from appropriate assembled position on the slip ring 24. The pins 30 are engageable with the upper and lower faces of the peripheral groove 31 to prevent substantial longitudinal movement between the links 29 and the slip ring 24. Each link, however, can rock on the slip ring 24 by virtue of the rolling engagement of its pin 30 against either side of the peripheral groove 31.

The lower set of links 29 extends upwardly from the slip ring 24 for connection to the lower portion of the set of lower slips 27 by means of pins 32. Each lower slip has downwardly facing wickers or teeth 33 for embedding in the wall of the well casing B, and it is also provided with an inner surface 34 inclined upwardly in a direction away from the axis of the body 10 for cooperation with a companion surface 35 on an outer expander segment 36. There is one outer expander segment 36 for each lower slip 27, and these segments together constitute an outer expander for wedging the slips 27 against the well casing B. Each segment 36 is slidably connected to its companion slip 27 by side tongues 38 on each slip engageable in grooves 39 in each segment, so that relative longitudinal movement between the segments 36 and slips 27 effects radial movement of the slips 27 to or from the wall of the well casing B.

The outer segmental expanders 36 are also movable radially upon being shifted relatively longitudinally of an inner expander 40 encompassing the lower body member 10*b*. The inner expander 40 is circumferentially continuous and is slidable to a limited longitudinal extent with respect to the body member 10*b*. The inner expander has longitudinally spaced tapered surfaces 41 that converge in an upward direction, being engageable with companion tapered inner surfaces 42 on the segments 36 of the outer expander.

The upper end of the inner surfaces 42 on each segment 36 merge into longitudinally directed surfaces 43 that are preferably parallel to the axis of the body 10 of the well packer A. These surfaces are engageable, as described hereinbelow, with companion longitudinally extending surfaces 44 provided at the lower portions of the inner expander tapered surfaces 41. These latter surfaces 44 are also preferably parallel to the axis of the well packer. Thus, the longitudinal surfaces 43 on the outer expander segments 36 are provided between the inner tapered surfaces 42 and transverse shoulders 45 on the segments extending outwardly from the surfaces 43; whereas the companion longitudinal surfaces 44 on the inner expander 40 are formed between the tapered expander surfaces 41 and lower or downwardly directed transverse shoulders 46 on the expander extending inwardly from the surfaces 44.

Upon moving the inner expander 40 upwardly within the outer expander segments 36, the latter are urged in a radial outward direction. The limit of such radial outward movement is determined by the engagement of the longitudinal surfaces 44 on the inner expander with the longitudinal surfaces 43 on the outer expander segments 36. Thereafter, relative longitudinal movement between the parts will have no effect in moving the outer segments 36 in a radial outward direction to a further extent. Conversely, movement of the inner expander 40 in a downward direction will at first cause the longitudinal surfaces 44, 43 to ride off each other, and then will forcibly shift the outer expander segments 36 radially inward by virtue of a tongue and groove connection between each segment 36 and inner expander 40. As specifically disclosed in the drawings, this connection is constituted by a screw 47 threaded into the inner portion of each outer expander segment 36 substantially at right angles to an inner surface 42 of the expander segment. This screw 47 extends through a longitudinal slot 48 in the inner expander 40, which merges into side grooves 49 formed in the inner expander 40 on opposite sides of the slot 48 and extending parallel to the expander surface 41 on the inner expander. The enlarged head 50 of the screw 47 slidably fits within such grooves 49, thereby forming a tongue and groove or dovetailed connection between each outer expander segment 36 and the inner expander 40. Accordingly, it is evident that relative downward movement of the inner expander 40 will shift the outer expander segments 36 radially inward until the inner expander shoulders 46 engage the outer expander shoulders 45. As disclosed in the drawings, these companion shoulders 45, 46 are preferably inclined inwardly and slightly upwardly to cause the inner expander 40 to positively hold the outer expander 36 in fully retracted position, to preclude inadvertent outward movement of the outer segments 36.

It will be noted that the uppermost tapered surface 42 on each outer expander segment 36 engages a companion tapered surface 41 on the inner expander 40 above the slot 48 provided in the latter, and that there is actually a clearance or space 51 between the upper innermost tapered surface 42 and the portion of the expander 40 containing the slots, so that each expander segment 36 can move downwardly relative to the inner expander 40 when the longitudinal surfaces 43, 44 engage without interference from the upper tapered portion 41 of the inner expander. Moreover, the inner expander 40 is provided with relieved portions 52 which will avoid interference with the heads 50 of the screws 47 during longitudinal downward movement of the outer segments 36 with respect to the inner expander 40 after the longitudinal surfaces 43, 44 coengage.

The outer expander segments 36 are movable longitudinally in unison by connecting them to a coupling device that allows the outer expander segments 36 to move radially. The coupling device includes a tie link 53 of generally dumbbell shape radially slidably connected to each segment 36 and also to a valve housing 54. Further details of the coupling arrangement will be found in our application Serial No. 243,982 above referred to. The tie links 53 are prevented from shifting radially out of their coupling relation to the outer expander segments 36 and valve housing 54 by a sleeve 55 that encompasses the socket portion of the valve housing 54, tie links 53 and the head portions 36*a* of the outer segments 36. This sleeve 55 is prevented from dropping downwardly by engaging upper shoulders 56 on the expander segments 36, and it is also prevented from moving upwardly by engaging a screw 57 threaded into the valve housing 54.

The tie link coupling arrangement allows the outer expander segments 36 to move radially inward and outward, the expander segments sliding on the lower bell portions of the tie links 53, whereas the tie links and valve housing 54 couple all of the segments 36 for longitudinal movement together, and hold such segments in their appropriate longitudinal relationship.

The valve housing 54 extends upwardly from the tie links 53 and has a plurality of radial ports 58 therein through which fluid can pass between the interior and exterior of the housing. The housing has an internal circumferential valve seat 59 therein that contains a rubber

or rubber-like seal ring 60, which may be of round cross-section, and which is engageable with a cylindrical valve head 61 secured to the lower body member 10*b*. The cylindrical valve head 61 has a lower portion threaded onto a coupling nut 62 formed in two pieces so that it can be moved laterally into engagement with external threads 63 on the lower body member. Inadvertent rotation of the valve head 61 on the nut 62 is prevented by a suitable set screw 64 threaded through the lower portion of the head 61 and engaging the segmental nut. Leakage between the lower body member 10*b* and the cylindrical valve head 61 is prevented by a thread seal 65 in the valve head engaging the periphery of the lower body member 10*b*.

When the lower body member 10*b* is moved upwardly, it carries the cylindrical valve head 61 upwardly with it, to dispose it within the cylindrical seat 59 in the valve housing 54 and in sealing engagement with the rubber seal ring 60. Such relative upward movement of the cylindrical valve head within the housing is limited by engagement of a tapered shoulder or stop member 66 on the valve head with a companion shoulder or stop 67 on the valve housing 54 below its seal ring 60.

The upper portion of the valve housing 54 is threaded onto the lower end of a circulation sleeve 68 which is spaced from the lower body member 10*b* to form an annular circulating by-pass passage 69 therewith, which can be opened or closed, depending upon the position of the cylindrical valve head 61 relative to its seat 59. The upper end of the circulation sleeve 68 has an external flange 70 thereon, to which one or more keys 71 are secured for slidable movement in internal longitudinal keyways 72 formed in an upper member 73 threadedly secured to and depending from an upper expander 74 surrounding the packer body 10. The lower portion of the member 73 is threaded into an upper abutment 75 that has an inwardly directed flange 76 engaged by the circulation sleeve flange or shoulder 70.

The circulation sleeve 68 is encompassed by a packing element 77 in the form of a rubber sleeve whose upper end engages the upper abutment 75 and whose lower end engages the upper end of the valve housing 54, which, in effect, constitutes a lower packing abutment, and also a ring 78 threaded on the upper portion of the valve housing 54, which also functions as part of the lower abutment.

The circulation sleeve 68 is movable upwardly with respect to the upper abutment 75 and expander member 73, to move the abutments 54, 78 and 75 toward each other, thereby foreshortening the packing sleeve 77 and expanding it outwardly against the well casing B, in the manner described hereinafter.

The annular passage 69 between the circulation sleeve 68 and body 10 continues in an upward direction between the body and the member 73 depending from the upper expander 74, this passage communicating with the exterior of the upper member 73 through one or more side ports 79 through the latter.

The upper expander member 74 forms part of the mechanism for anchoring the well packer A to the well casing B against upward movement therein. This expander is provided with one or more longitudinal internal keyways 80 in which keys 81 are slidable that are secured to the collar body member 10*c*, so that the body 10 may be moved upwardly within the expander 74. The expander has a plurality of circumferentially spaced tapered surfaces 82 inclined in an upward and inward direction for cooperation with companion internal surfaces 83 of upper slips 84 having external wickers 85 thereon facing in an upward direction for embedding in the wall of the well casing B, to anchor the tool A thereto against upward movement. While the companion tapered surfaces 82, 83 insure radial outward movement of the slips 84 upon longitudinal upward movement of the expander 74 within the latter, radial inward movement of the slips 84 to retracted position is obtained by providing side tongues 85′ on each slip slidable in companion grooves 86 in the expander 74, in order that longitudinal separating movement between the expander and slips insures the retraction of the latter from the well casing.

The slips 84 are maintained in transverse alignment with respect to one another, and are removable relatively longitudinally in unison, by connecting them through pins 87 to the lower ends of links 88 whose upper ends extend into the longitudinal grooves 89 formed in an upper slip ring 90 encompassing the body 10. The link arrangement 88 is substantially the same as described above in connection with the lower set of slips 27, the upper portion of each link 88 having a pin 91 extending transversely from either side for disposition in a peripheral groove 92 in the slip ring, the pins 91 being engageable with the upper and lower sides of this groove 92 to prevent substantial longitudinal movement of the links 88 relative to the slip ring 90. The portions of the links 88 above the pins 91 are engageable with a stop ring 93 encompassing the slip ring 90 and secured thereto by one or more screws 94, to preclude outward movement of the upper ends of the links.

The slip ring 90 is secured to a lock device, which determines the ability to set the tool in the well casing, by means of a swivel connection. Thus, the upper end of the slip ring 90 has an external flange 95 that rests upon a shoulder 96 of a sectional tie ring 97, the upper end of the tie ring having a shoulder 98 resting upon an external flange 99 on the lower portion of a ratchet sleeve ring 100 encompassing the body 10. The sections of the tie ring 97 are prevented from moving radially outward by an encompassing sleeve 101 secured to the tie ring by one or more screws 102. Because of the swivel connection 95—102, the slips 84 may be rotated in the casing B without rotating the ratchet sleeves ring 100.

The ratchet sleeve ring 100 is threaded, or otherwise secured, to a ratchet sleeve and lower drag collar 103, to which the lower ends of outwardly bowed drag springs 104 are secured by an encompassing ring 105 attached to the lower drag collar by one or more screws 106. The outwardly bowed springs 104 frictionally engage the wall of the well casing B, their upper ends being secured to an upper collar 107 by an encompassing ring 108 secured to the upper collar by screws 109. The drag springs 104 tend to resist rotation of the ratchet sleeve 103, and they also tend to resist longitudinal movement of the upper set of slips 84. If the upper tapered expander 74 can be moved upwardly relative to the upper slips 84, the latter will be shifted outwardly into engagement with the well casing B. The ability to so move the expander 84 upwardly, and, for that matter, to shift all of the other parts relatively in an upward direction, is governed by a lock device acting between the ratchet sleeve 103 and the upper mandrel or body member 10*a*.

The exterior of the upper body member or mandrel 10*a* is provided with a plurality of circular ratchet teeth 110 facing in an upward direction, which are engageable with companion internal ratchet teeth 111 formed collectively in a split ratchet or clutch ring 112. The ring 112 has an externally tapered surface 113 inclined in an upward and inward direction engaging a companion tapered surface 114 in the ratchet sleeve 103. Any tendency for the body member 10*a* to move upwardly causes the ratchet ring 112 to be wedged between the body member and the ratchet sleeve 103, locking the latter two members together and precluding setting of the upper slips 84. However, the lock ring 112 can be expanded out of engagement with the teeth 110 on the mandrel 10*a* to allow the latter to move upwardly within the ratchet sleeve to set the tool in the well bore, as explained in our above-identified patent application and in United States Patent No. 2,368,401. For purposes of the present application, it is sufficient to state that the turning of the body 10 of the tool to the right will effect an outward expansion of

the ratchet ring 112 out of engagement with the teeth 110 of the mandrel 10a, and will allow the body 10 of the tool to be moved upwardly within the ratchet sleeve 103 for the purpose of effecting setting of the parts against the well casing B.

Initially, the lower end of the inner expander 40 is disposed above a stop nut 115 threaded on the lower body member 10*b* and held in position by a set screw 116 bearing against the lower body member. An adjusting sleeve 117 is threaded on the stop nut 115, being secured in adjusted position by a set screw 118 bearing against the stop nut. A space 119 between the stop nut 115 and the lower end of the inner expander member 40 is allowed, so that the lower set of slips 27 will first be moved up along the outer expander segments 36 and radially outward to a certain extent before the nut 115 engages the inner expander 40. This latter part is then moved upwardly upon upper movement of the lower body member 10*b* to expand the outer expander segments 36 and thereby shift the lower slips 27 radially outward to a further extent. Such outward shifting is limited by engagement of the stop shoulder 66 on the valve head 61 with the companion shoulder 67 on the valve housing 54. When this occurs, the lower slips 27 engage the wall of the housing in a relatively light manner. After such engagement, a downward force imposed on the expander segments 36 will cause them to shift along the tapered surfaces 41 of the inner expander 40, and then provide for the coengagement between the longitudinal surfaces 44, 43 on the inner and outer expanders 40, 36 to wedge the lower slips 27 firmly into the wall of the well casing B, locking the tool against downward movement therewithin.

The well apparatus is assembled with the parts occupying the relative position disclosed in Figs. 1 and 1*a*, the lower slips 27 and outer expander segments 36 being in retracted position, the circulation valve 59, 61 open and the upper slips 84 in retracted position. Such retracted position is limited by engagement of the upper heads 120 of rods 121, which are threaded into the upper expander 74, with the lower flanges 122 of tubes 123 threaded into and depending from the upper slip ring 90. The rods 121 and tubes 123 form telescopic connections which do not interfere with radial movement of the upper slips 84 to and from engagement with the casing B. When the slips 84 are fully retracted, the tubes 123 and rods 121 support the upper expander 74, preventing it and the parts depending therefrom from dropping downwardly to a further extent with respect to the packer body 10.

When the point in the well casing is reached at which the tool is to be anchored in packed-off condition, the tubular string (not shown) to which the tool is attached is rotated a partial revolution to the right to expand the ratchet lock ring 112 out of engagement from the mandrel 10, allowing the latter and its lower body portion 10*b* to move upwardly. None of the other parts can at first move upwardly, since there is no connection between them and the mandrel except for the valve head 61, stop nut 115 and adjusting sleeve 117, and the lower set of slips 27 that are connected to the lower end of the body 10 through the lower slip ring 24, connecting member 21, rubber tie sleeve 18 and guide 15. The initial upward movement of the mandrel 10 thus causes the guide 15, tie sleeve 18, segmental connector ring 21, slip ring 24 and links 29 to shift the lower slips 27 upwardly along their companion outer expander segments 36 to a certain extent, and partially toward the wall of the casing B, until the stop nut 115 engages the lower end of the inner expander 40. At this time, the valve head 61 that is connected to the lower body member 10*b* has been moved upwardly until its cylindrical periphery engages the valve seal ring 60, thus closing the by-pass circulation passage 69 around the rubber packing sleeve 77.

A continuation of the upward movement of the body 10 then shifts the inner expander member 40 upwardly with it within the outer expander segments 36, causing the latter to shift outwardly toward the casing B, and further carrying the lower slips 27 laterally toward the casing. At the same time, the slips 27 are also being moved to a further extent upwardly along the outer expander surface segments 36, the combined result being the engagement of the slips with the wall of the well casing. Actually, the slips 27 may engage the wall of the well casing B, and the body member 10*b* moved upwardly to a slight further extent until the valve head shoulder 66 engages the valve housing shoulder 67, such continued movement of the body being permitted, despite engagement of the slips 27 with the well casing B, by a bulging or compressing of the tie rubber sleeve 18. However, before the valve head shoulder 66 engages the valve housing shoulder 67, the tapered surfaces 41 of the inner expander 40 and the outer expander surfaces 42 ride off one another and their longitudinal surfaces 44, 43 coengage, these surfaces being in full engagement when the head and housing shoulders 66, 67 contact one another (Fig. 4*a*).

Following engagement of the valve shoulders 66, 67, a continuation of the upward movement of the packer body 10 shifts the valve housing 54, inner expander 40, outer expander segments 36 and slips 27 upwardly with the body as a unit, the slips 27 sliding along the wall of the well casing B. The drag springs 104 are resisting upward movement of the upper segmental slips 84, so that such upward movement of the body 10 causes the valve housing 54 to move upwardly, shifting the circulation sleeve 68, rubber packing sleeve 77, expander member 73 and expander 74 upwardly with it, the upper tapered expander being moved up within the slips 84, urging the latter radially outward into anchoring engagement with the wall of the well casing B. When such anchoring engagement occurs, the upper expander member 73 and upper abutment 75 are precluded from movement upwardly to any further extent. Accordingly, a continuation of the upward movement of the packer body 10 then moves the valve housing and lower abutment 54, together with the circulation sleeve 68, upwardly toward the upper abutment 75, foreshortening the packing sleeve 77 and expanding it radially outward into firm sealing engagement with the wall of the well casing B, all of the parts now occupying the position illustrated in Figs. 4 and 4*a*.

Fluid under pressure can now be pumped down the tubular string (not shown) and through the packer body 10, the fluid under pressure acting on the underside of the packing sleeve 77 and tending to embed the upper expander 74 more firmly into the upper slips 84, thereby preventing displacement of the well packer A in an upward direction within the well casing B. In the event that a differential pressure is now imposed on the fluid or liquid in the annulus between the tubular string connected to the upper end of the body 10 and the well casing B, the lower slips 27 come into play to preclude downward movement of the well packer. Such differential pressure may be obtained, for example, by actually applying pressure by a pump (not shown) at the top of the well bore, or by swabbing the interior of the tubular string. The pressure in the annulus acts downwardly over the area of the expanded packing sleeve 77, exerting its downward force through the valve housing 54 onto the outer expander segments 36. Since the inner expander 40 is bearing upon the stop nut 115 secured to the body 10, it cannot move downwardly with respect to the expander. Moreover, such downward movement of the outer expander segments 36 does not tend to shift the inner expander 40 downwardly, in view of the coengagement between the longitudinal surfaces 43, 44. The net result is that the expander segments 36 will merely slide longitudinally down along the inner expander member 40 and will wedge the lower slips 27 more firmly into the wall of the well casing B.

When it is desired to release the tool from the well casing and return its parts to retracted positions, the pressure in the annulus above the tool may be relieved and

the tubing string and the packer body **10** moved in a downward direction. During such downward movement, the lower end of the valve head **61** engages the upper end of the inner expander **40**, moving the latter in a downward direction until the longitudinal surfaces **43**, **44** come out of contact and the tapered surfaces **41**, **42** are again in a position to coengage. Continued downward movement then causes the screws **47** fitting in the grooves **49** in the inner expander **40** to pull the outer expander segments **36** in an inward direction. When such inward movement or retraction occurs, the slips **27** are also retracted and the rubber tie sleeve **18**, which has been placed in tension as a result of moving the body **10** in a downward direction, is then effective to pull the slips **27** downwardly to their fully retracted position.

Further downward movement of the body then carries the inner and outer expanders **40**, **36** with them, in view of the fact that the shoulders **45**, **46** will coengage and, through the tie links **53**, exert a downward pull on the valve housing **54**, shifting it away from the upper abutment **75** and allowing the packing sleeve **77** to retract to its initial position. When the upper shoulder **70** on the circulation sleeve **68** engages the upper abutment **75**, further downward movement of the body shifts the upper expander **74** downwardly, causing the upper slips **84** to be moved inwardly to retracted position.

The tool may now be elevated in the well bore, since the lock ring **112** will wedge between the body **10** and the ratchet sleeve **103**, to preclude relative upward movement between the parts. The load of the parts below the upper slips **84** is carried by the upper slip ring **90** through the tubes **123** and the rods **121**. During upward movement of the tool in the well casing, fluid can by-pass around the retracted packing sleeve **77** through the open passages **58**, **69**, **79**. It can also, of course, flow relatively down along the exterior of the retracted packing sleeve **77**. The tool may be removed entirely from the well bore or shifted to some other position therewithin where it is to be anchored in packed-off condition.

In our prior filed application, Serial No. 243,982, the longitudinal coengaging surfaces **43**, **44** on the outer expander segments **36** and inner expander **40** were not provided. Instead, the tapered surfaces **41**, **42** were always in engagement. As a result, when a pressure differential was present in the casing fluid above the well packer A, such fluid would act downwardly through the packing sleeve **77** and be imposed on the segments **36**, urging them in a downward direction. This downward movement would produce a transferring action on the inner expander **40**, moving it downwardly with the body until the shoulders **45**, **46** engaged. Because of such coengagement of the shoulders, the lower slips **27** could not be released as a result of merely lowering the packer body **10**, inasmuch as the lowering action produced a downward movement of both the inner expander **40** and outer expander segments **36**, which functioned as a unit. As a result of such downward movement, the tendency would be to wedge the lower slips **27** more firmly into engagement with the wall of the casing. Accordingly, it was necessary to first exert a substantial upward pull or strain on the body **10** to retransfer the inner expander **40** with respect to the outer segments **36** to a position in which the shoulders **45**, **46** no longer engaged and were spaced a substantial distance from each other. Thereafter, the body **10** could be lowered to lower the inner expander **40**, which would then retract the outer expander segments **36** and, in so doing, would retract the lower slips **27**, causing the rubber tie sleeve **18** to pull them inwardly to their retracted position.

In the specific apparatus disclosed in the drawings, the transferring force of the outer expander segments **36** upon the inner expander **40** as a result of high pressures acting in the casing above the tool cannot take place. The high pressure can do nothing more than urge the outer expander segments **36** in a downward direction, to wedge them more firmly into the slips **27**. However, such wedging action has no effect in urging the inner expander **40** in a downward direction with the body **10**, since the longitudinal surfaces **43**, **44** are substantially parallel to the axis of the tool, and any wedging force is transmitted between the outer expander segments **36** and the inner expander **40** in a direction normal to the axis of the tool, leaving no component of force acting in a downward direction and urging the expander in that downward direction, which would cause the inner expander shoulders **46** to be shifted downwardly into engagement with the outer expander segment shoulders **45**, as in the prior device. Accordingly, since there is a substantial longitudinal distance between these shoulders when the lower slips **27** are to be retracted, it is only necessary to relieve the pressure differential in the well casing above the tool and then merely move the body **10** downwardly, which will cause the circulation valve **59**, **61** to open and the valve member **61** to engage the upper end of the inner expander **40**, moving the latter downwardly of the outer expander segments **36** until the longitudinal surfaces **43**, **44** come out of engagement, whereupon the dovetailed connection elements **49**, **50** can move the outer expander segments **36** inwardly, as permitted by the tapered expander surfaces **41**, **42**, which will effect a retraction of the slips **27** from the well casing. A continuation of the downward movement will then retract the upper slips **84**, as explained above.

In order for the lower portion of the apparatus to operate properly and prevent the downward transferring of the inner expander **40** by the outer expander segments **36**, the parts must be properly adjusted with respect to each other. Figs. 6 to 9, inclusive, indicate how such adjustment can be made.

The first adjustment is disclosed in Figs. 6 and 7. Before the first adjustment is made, the entire tool is assembled completely, with the exception of the lowermost portion. The lower slips **27** are disposed in their retracted position upon the outer expander segments **36** and the body **10***b* of the tool is moved upwardly until the valve head shoulder **66** engages the valve housing shoulder **67**. The inner expander member **40** is then moved upwardly until its longitudinal surfaces **44** engage the longitudinal surfaces **43** on the expander segments **36** to their fullest extent. As a matter of fact, the upper ends **44***a* of the expander surfaces **44** may be adjusted slightly above the upper ends **43***a* of the segment surfaces, as, for example, they may be placed about $\frac{1}{32}$ of an inch above the latter (Fig. 7). With the inner expander **40** in this position, the stop nut **115** is then threaded upwardly on the lower body section **10***b* until its upper end engages the lower end of the inner expander **40**, whereupon the set screw **116** is tightened against the body **10** to hold the stop nut **115** in this adjusted position.

The second adjustment is illustrated in Figs. 8 and 9, and consists in moving the body **10** downwardly until the valve head **61** engages the upper end of the inner expander **40**, to shift the latter downwardly along the outer expander segments **36** until the longitudinal surfaces **43**, **44** are on the verge of coming out of engagement with each other and the tapered surfaces **41**, **42** are in position to coengage, which will allow the outer segments **36** to be retracted inwardly of the inner expander **40**. The lower slips **27** are then moved upwardly along the outer segments **36**, which will shift them radially outward until they engage a gauging sleeve **150** that will have been placed over the slips. This gauging sleeve will have an inside diameter corresponding to the inside diameter of the casing B in the well bore in which the well tool is to be run. One mode of moving the slips **27** upwardly is to provide an adjusting ring **151** between the lower guide **15** and the lower slip ring **24**, the lower guide being threaded upwardly on the body **10**, this upward movement being transferred through the adjusting ring **151** to the slip ring

24, which will be moved upwardly along the body 10 to shift the slips 27 up along the outer expander segments 36 through the agency of the links 29 and outwardly into engagement with the gauging sleeve 150. When such engagement occurs, the adjusting sleeve 117 can be threaded on the adjusting nut 115 until it is spaced upwardly above the slip ring 24 by a substantial amount, as, for example, 3/16 of an inch. Thereafter, the set screw 118 can be tightened against the stop nut 115, to hold the sleeve 117 in this adjusted position.

The guide 15 is then unscrewed from the body 10*b*, and the adjusted sleeve 151 removed, whereupon the remaining portions of the well packer A can then be assembled in proper position on its lower portion. That is, the connector member 21 and connector sleeve 25 may be mounted on the lower slip ring 24 and the tie rubber sleeve 18 secured to the guide 15 and member 21.

The final adjustment is then made by screwing the guide 15 up on the body, with the valve head 61 engaging the valve housing 54, until the lower slips 27 firmly contact the gauging sleeve 150. The set screw 15*a* threaded into the guide 15 is then tightened against the body 10*b*.

With the foregoing adjustment, it is evident that the longitudinal surfaces 43, 44 will be fully engaged when the valve head 61 engages the valve housing 54. Assurance is also had that the slips 27 will contact the wall of the well casing when such engagement occurs, any downward movement of the outer expander segments 36 relative to the inner expander 40 causing the slips 27 to wedge more firmly into the casing. Similarly, when the tool is to be released, the body 10 is moved downwardly to open the valve 59, 61 and to shift the inner expander 40 downwardly with respect to the segments 36. The adjusting sleeve 117 will not engage the lower slip ring 24 until after the longitudinal surfaces 43, 44 are on the point of disengaging from each other, the tapered surfaces 41, 42 being about to come into cooperative position. By providing the space (say 3/16") between the lower adjusting sleeve 117 and the upper end of the lower slip ring 24, when the inner expander 40 and expander segments 36 occupy this position, assurance is had that further downward movement of the body 10 will occur to effect a retraction of the segments 36 before the lower adjusting sleeve 117 engages the upper end of the lower slip ring 24, which engagement will then produce a downward movement of the lower slips 27 along the outer expander segments 36 and their retraction. Ordinarily, the rubber sleeve 18 will have already pulled sufficiently on the slips 27 to produce such retraction, so that the adjusting sleeve 117 does not engage the lower slip ring 24 at all. But if the slips 27, for some reason, remain out against the wall of the well casing B, then the adjusting sleeve 117 will engage the lower slip ring 24 and forcibly effect retraction of the slips 27.

The inventors claim:

1. In apparatus of the character described: a body; an inner expander on said body; a segmental outer expander slidable on said inner expander and initially occupying a retracted position on said inner expander; slips engageable with said outer expander to be expanded laterally outward; said inner and outer expanders having coengaging surfaces tapering in one longitudinal direction toward the axis of said body; said inner and outer expanders also having coengaging surfaces facing outwardly and inwardly, respectively, and disposed substantially parallel to the axis of said body which engage each other to hold said outer expander laterally outward; said outer expander and slips having coengaging surfaces tapering in the opposite longitudinal direction toward the axis of the body; means on said body for moving said inner expander longitudinally of said outer expander to shift said outer expander laterally outward and enable said surfaces substantially parallel to the axis of said body to coengage to hold said outer expander laterally outward; and means on said body for moving said slips longitudinally of said outer expander and laterally outward.

2. In apparatus of the character described: a body; an inner expander on said body; a segmental outer expander slidable on said inner expander and initially occupying a retracted position on said inner expander; slips engageable with said outer expander to be expanded laterally outward; said inner and outer expanders having coengaging surfaces tapering in one longitudinal direction toward the axis of said body; said inner and outer expanders also having coengaging surfaces facing outwardly and inwardly, respectively, and disposed substantially parallel to the axis of said body which engage each other to hold said outer expander laterally outward; said outer expander and slips having coengaging surfaces tapering in the opposite longitudinal direction toward the axis of the body; and means on said body for moving said inner expander longitudinally of said outer expander to shift said outer expander laterally outward and enable said surfaces substantially parallel to the axis of said body to coengage to hold said outer expander laterally outward.

3. In apparatus of the character described: a body; an inner expander on said body; a segmental outer expander slidable on said inner expander and initially occupying a retracted position on said inner expander; slips engageable with said outer expander to be expanded laterally outward; said inner and outer expanders having coengaging surfaces tapering in one longitudinal direction toward the axis of said body; said inner and outer expanders also having coengaging surfaces facing outwardly and inwardly, respectively, and disposed substantially parallel to the axis of said body which engage each other to hold said outer expander laterally outward; said outer expander and slips having coengaging surfaces tapering in the opposite longitudinal direction toward the axis of the body; and means for moving said inner expander, outer expander and slips longitudinally with respect to each other to shift said slips laterally outward and to shift said outer expander laterally outward to a position in which said surfaces substantially parallel to the axis of said body coengage to hold said outer expander laterally outward.

4. In apparatus of the character described: a body; an inner expander on said body; a segmental outer expander slidable on said inner expander and initially occupying a retracted position on said inner expander; slips cooperable with said outer expander to be expanded laterally outward; said inner and outer expanders having coengaging surfaces tapering in one longitudinal direction toward the axis of said body, said inner and outer expanders also having coengaging surfaces facing outwardly and inwardly, respectively, and disposed substantially parallel to the axis of said body which engage each other to hold said outer expander laterally outward; and means for moving said inner expander, outer expander and slips longitudinally with respect to each other to shift said slips laterally outward and to shift said outer expander laterally outward to a position in which said surfaces substantially parallel to the axis of said body coengage to hold said outer expander laterally outward.

5. In apparatus of the character described; a body; an inner expander on said body; a segmental outer expander slidable on said inner expander; slips engageable with said outer expander to be expanded laterally outward; said inner and outer expanders having coengaging tapered surfaces converging in an upward direction, said inner expander having surfaces substantially parallel to the axis of said body at the lower end of said inner expander tapered surfaces and said outer expander having surfaces at the upper ends of said outer expander tapered surfaces substantially parallel to the axis of said body; said outer expander and slips having coengaging surfaces converging in a downward direction; and means for effecting upward movement of said inner expander and slips with respect to said outer expander to shift said slips laterally outward and to shift said outer expander laterally outward to a position in which said surfaces on said inner expander and outer expander which

are substantially parallel to the axis of said body coengage.

6. In apparatus of the character described: a body; an inner expander on said body; a segmental outer expander slidable on said inner expander and initially occupying a retracted position on said inner expander; slips engageable with said outer expander to be expanded laterally outward; said inner and outer expanders having coengaging surfaces tapering in one longitudinal direction toward the axis of said body; said inner and outer expanders also having coengaging surfaces facing outwardly and inwardly, respectively, and disposed substantially parallel to the axis of said body which engage each other to hold said outer expander laterally outward; said outer expander and slips having coengaging surfaces tapering in the opposite longitudinal direction toward the axis of the body; means on said body for moving said inner expander longitudinally of said outer expander to shift said outer expander laterally outward and enable said surfaces substantially parallel to the axis of said body to coengage to hold said outer expander laterally outward; and coengageable stop means operatively connected to said body and outer expander for limiting longitudinal movement of said inner expander within said outer expander to an extent insuring substantially full engagement between said surfaces substantially parallel to the axis of said body.

7. In apparatus of the character described: a body; an inner expander on said body; a segmental outer expander slidable on said inner expander and initially occupying a retracted position on said inner expander; slips engageable with said outer expander to be expanded laterally outward; said inner and outer expanders having coengaging surfaces tapering in one longitudinal direction toward the axis of said body; said inner and outer expanders also having coengaging surfaces facing outwardly and inwardly, respectively, and disposed substantially parallel to the axis of said body which engage each other to hold said outer expander laterally outward; said outer expander and slips having coengaging surfaces tapering in the opposite longitudinal direction toward the axis of the body; means on said body for moving said inner expander longitudinally of said outer expander to shift said outer expander laterally outward and enable said surfaces substantially parallel to the axis of said body to coengage to hold said outer expander laterally outward; and means on said body for moving said inner expander longitudinally of said outer expander in the opposite direction to bring said substantially parallel surfaces out of engagement and enable said outer expander to shift laterally inward.

8. In apparatus of the character described: a body; an inner expander on said body; a segmental outer expander slidable on said inner expander and initially occupying a retracted position on said inner expander; slips engageable with said outer expander to be expanded laterally outward; said inner and outer expanders having coengaging surfaces tapering in one longitudinal direction toward the axis of said body; said inner and outer expanders also having coengaging surfaces facing outwardly and inwardly, respectively, and disposed substantially parallel to the axis of said body which engage each other to hold said outer expander laterally outward; said outer expander and slips having coengaging surfaces tapering in the opposite longitudinal direction toward the axis of the body; means on said body for moving said inner expander longitudinally of said outer expander to shift said outer expander laterally outward and enable said surfaces substantially parallel to the axis of said body to coengage to hold said outer expander laterally outward; coengageable stop means operatively connected to said body and outer expander for limiting longitudinal movement of said inner expander within said outer expander to an extent insuring substantially full engagement between said surfaces substantially parallel to the axis of said body; and means on said body for moving said inner expander longitudinally of said outer expander in the opposite direction to bring said substantially parallel surfaces out of engagement and enable said outer expander to shift laterally inward.

9. In apparatus of the character described: a body; an inner expander on said body; a segmental outer expander slidable on said inner expander and initially occupying a retracted position on said inner expander; slips engageable with said outer expander to be expanded laterally outward; said inner and outer expanders having coengaging surfaces tapering in one longitudinal direction toward the axis of said body, said inner and outer expanders also having coengaging surfaces facing outwardly and inwardly, respectively, and disposed substantially parallel to the axis of said body which engage each other to hold said outer expander laterally outward; said outer expander and slips having coengaging surfaces tapering in the opposite longitudinal direction toward the axis of the body; first means on said body for moving said inner expander longitudinally of said outer expander to shift said outer expander laterally outward and enable said substantially parallel surfaces to coengage to hold said outer expander laterally outward; second means on said body connected to said slips for effecting longitudinal movement of said slips in unison; third means on said body engageable with said second means to shift said slips to retracted position; and fourth means on said body for moving said inner expander longitudinally of said outer expander in the opposite longitudinal direction to bring said substantially parallel surfaces out of engagement prior to engagement of said third means with said second means.

10. In apparatus of the character described: a body; an inner expander on said body; a segmental outer expander slidable on said inner expander and initially occupying a retracted position on said inner expander; slips engageable with said outer expander to be expanded laterally outward; said inner and outer expanders having coengaging upwardly converging surfaces; said inner and outer expanders also having coengaging surfaces facing outwardly and inwardly, respectively, and disposed substantially parallel to the axis of said body which engage each other to hold said outer expander laterally outward; said outer expander and slips having coengaging downwardly converging surfaces; first means on said body for moving said inner expander upwardly of said outer expander to shift said outer expander laterally outward and enable said substantially parallel surfaces to coengage to hold said outer expander laterally outward; second means on said body connected to said slips for effecting longitudinal movement of said slips in unison; third means on said body engageable with said second means to shift said slips downwardly of said outer expander to retracted position; and fourth means on said body for moving said inner expander downwardly of said outer expander to bring said substantially parallel surfaces out of engagement prior to engagement of said second means with said third means.

11. In apparatus of the character described: a body; an inner expander on said body; a segmental outer expander slidable on said inner expander and initially occupying a retracted position on said inner expander; slips engageable with said outer expander to be expanded laterally outward; said inner and outer expanders having coengaging upwardly converging surfaces; said inner and outer expanders also having coengaging surfaces facing outwardly and inwardly, respectively, and disposed substantially parallel to the axis of said body which engage each other to hold said outer expander laterally outward; said outer expander and slips having coengaging downwardly converging surfaces; means on said body for moving said inner expander upwardly of said outer expander to shift said outer expander laterally outward and enable said surfaces substantially parallel to the axis of said

body to coengage to hold said outer expander laterally outward; and means on said body for moving said inner expander downwardly of said outer expander to bring said substantially parallel surfaces out of engagement and enable said outer expander to shift laterally inward.

12. In apparatus of the character described: a body; an inner expander on said body; a segmental outer expander slidable on said inner expander and initially occupying a retracted position on said inner expander; slips engageable with said outer expander to be expanded laterally outward; said inner and outer expanders having coengaging upwardly converging surfaces; said inner and outer expanders also having coengaging surfaces facing outwardly and inwardly, respectively, and disposed substantially parallel to the axis of said body which engage each other to hold said outer expander laterally outward; said outer expander and slips having coengaging downwardly converging surfaces; first means on said body for moving said inner expander upwardly of said outer expander to shift said outer expander laterally outward and enable said substantially parallel surfaces to coengage to hold said outer expander laterally outward; second means on said body connected to said slips for effecting longitudinal movement of said slips in unison; third means on said body engageable with said second means to shift said slips downwardly of said outer expander to retracted position; fourth means on said body for moving said inner expander downwardly of said outer expander to bring said substantially parallel surfaces out of engagement prior to engagement of said second means with said third means; and means on said body engageable with said second means for moving said slips upwardly of said outer expander and laterally outward.

13. In apparatus of the character described: a body; an inner expander on said body; a segmental outer expander slidable on said inner expander; slips engageable with said outer expander to be expanded laterally outward; said inner and outer expanders having coengaging tapered surfaces converging in one longitudinal direction, said inner expander having surfaces substantially parallel to the axis of said body at the outer end of said inner expander tapered surfaces and said outer expander having surfaces at the inner end of said outer expander tapered surfaces substantially parallel to the axis of said body; said outer expander and slips having coengaging surfaces converging in the opposite longitudinal direction; and means for effecting movement of said inner expander and slips in said one longitudinal direction with respect to said outer expander to shift said slips laterally outward and to shift said outer expander laterally outward to a position in which said surfaces on said inner expander and outer expander which are substantially parallel to the axis of said body coengage.

References Cited in the file of this patent

UNITED STATES PATENTS

2,173,351	Bradshaw	Sept. 19, 1939
2,274,940	Stoddard	Mar. 3, 1942
2,442,121	Earley	May 25, 1948
2,551,240	Bonner	May 1, 1951
2,632,514	Fitzpatrick	Mar. 24, 1953