A setting apparatus for a well packer or the like includes a body member releasably coupled to the well packer and movable by a running-in string extending to the top of the well bore. Slip means mounted on the body member are retained in retracted positions by a retaining means which can be released in response to rotation of the body member by the running-in string. After release of the retaining means, the slip means are held against upward movement by a holding member which engages the slip means as an expander is utilized to shift the slip means outwardly to expanded anchoring positions in response to upward movement of the expander by the running-in string. The body member can be selectively uncoupled from the well packer for withdrawal of the setting apparatus from the well bore.

The present invention relates generally to well tools and more specifically to an apparatus adapted to be lowered into a well on a running-in string for setting a well tool by manipulation of the running-in string at the top of the well bore.

An object of the present invention is to provide a new and improved mechanical setting tool for well tools such as well packers or the like. Another object of the present invention is to provide a new and improved setting tool for well tools such as well packers, including a retainer member for positively holding slips, or the like, in retracted position during lowering so as to prevent any premature setting thereof. Another object of the present invention is to provide a new and improved setting apparatus for a well tool, the apparatus having a retainer member for positively holding slips in retracted position during lowering, the retainer being selectively movable out of retaining relation with the slips, the apparatus further including a member for holding the slips against vertical movement in the well casing so that the slips can be shifted outwardly into gripping engagement with the well casing.

Yet another object of the present invention is to provide a new and improved setting tool for a well packer or the like, which is positive and reliable in operation, which can be operated by a minimum number of surface manipulations of the running-in string on which the setting tool and well packer are lowered into the well, and which can be withdrawn from a well when the packer is set.

These and other objects are attained in accordance with the present invention by providing an apparatus comprising a body member adapted for connection to a running-in string and for releasable connection to the well tool to be set in a well bore. Normally retracted means, such as slips, are mounted on the body member, and an expander is provided for shifting the slips outwardly. A retainer sleeve is arranged to encompass the retracted means during lowering to positively prevent outward shifting of the retracted means. Means are provided to remove the retainer sleeve from encompassing relation with the retracted means including a control means co-rotatively secured to the body member, drag means coupled to the retainer sleeve, and axial cam means between the drag means and control member for feeding the retainer sleeve upwardly in response to rotation of the body member and control member. Means coupled to the drag means are then engageable with the normally retracted means to hold them against vertical movement in the well casing as they are shifted outwardly to set condition by the expander in response to upward movement of the body member by the running-in string.

The present invention has other objects and advantages which will become more clearly apparent in connection with the following detailed description of a preferred embodiment of the present invention. The description, together with the operation of the invention, may be best understood by way of reference to the accompanying drawings, in which:

FIGURES 1A and 1B are longitudinal sectional views of the present invention with parts in retracted positions for lowering into a well, FIGURE 1B being a lower continuation of FIGURE 1A;

FIGURES 2A and 2B are views similar to FIGURE 1 except with parts in set positions within a well conduit;

FIGURE 3 is a cross section on line 3—3 of FIGURE 1B; and

FIGURES 4—6 are enlarged, fragmentary views illustrating the valve detail of the well packer.

Referring to FIGURES 1A and 1B, an apparatus which embodies the principles of the present invention broadly includes a setting tool assembly A, a packer assembly B and a valve assembly C. The entire apparatus is arranged to be lowered into a well bore on a running-in string 10 of or tubing or drill pipe. When set in the well bore, the packer assembly B packs off the annulus between the well casing and the running-in string 10. The running-in string 10 provides a conductor through which fluid under pressure can be supplied to the well bore below the packer assembly B, as well as an operating member which can be manipulated at the earth's surface for setting the packer assembly B and for opening and closing the valve assembly C.

The setting tool assembly A includes a central mandrel 11 which is coupled at its upper end by a collar 12 to the running-in string 10, and coupled at its lower end by a mounting sub 13 to an elongated mandrel extension or “stinger” 14. The mandrel 11 and extension 14 have a fluid passage 15 therethrough in communication with the bore of the running-in string 10. A control sleeve 17 is co-rotatively secured to the mandrel 11 by splines 18 or the like, the control sleeve being threadedly coupled by a sub 19 to a downwardly depending setting sleeve 20. A friction drag mechanism 21 is mounted on the control sleeve 17 and includes a tubular cage 22 having a plurality of circumferentially spaced, radially directed recesses 23, each of which receives a typical drag block 25 which is urged outwardly by coil springs 26. The drag blocks 25 are arranged to frictionally engage the inner surface of a well casing to resist both longitudinal and turning motion of the cage 22 within the well casing in a conventional manner.

The cage 22 is connected at its lower end to a retainer sleeve 27 which initially extends downwardly below the lower end of the setting sleeve 20 for purposes which will be hereinafter described. Moreover, the cage 22 is coupled to the control sleeve 17 by internal right-hand threads 28 which engage companion external threads 29 on the control sleeve. It will be appreciated that the cage 22 is vertically fixed in a lower position relative to the control sleeve during lowering into a well bore. At setting depth, right-hand rotation of the mandrel 11 and control sleeve 17 will cause upward feeding of the cage 22 and retainer sleeve 27 along the control sleeve due to interengagement of the threads 28 and 29, the cage 22
being held against rotation by frictional engagement of the drag blocks 25 with the well casing.

The control sleeve 17 will rotate with the mandrel 11 due to the interengagement of the splines 15. The control sleeve 17 is initially locked against longitudinal movement relative to the mandrel 11 by a suitable latch device which can include a ball 30 which is engaged in an aperture 31 in the control sleeve and in a mandrel detent 32, the ball being held inwardly in engaged condition by an inner surface 33 on the cage 22. However, upward movement of the control sleeve 17 as previously described, will eventually position an internal cage recess 34 opposite the ball 30 and permit the ball to shift outwardly and disengage from the mandrel detent 32 to free the mandrel 11 for upward movement relative to the control sleeve 17 and the cage 22.

The mounting sub 13 located between the mandrel 11 and the mandrel extension 14 is arranged to carry the upper slips 35 for the packer assembly B. The upper slips can be formed in segments 36 with each segment having external wickers or teeth 37 which face upwardly and are adapted to grip a well conduit wall and prevent upward movement. Each segment 36 further has an inner surface 38 which inclines downwardly and outwardly, and has an internal annular recess 39 which receives an external flange 40 on the mounting sub 13. Each segment 36 also has an upwardly extending section 42 over which the lower end portion of the retainer sleeve 27 extends to hold the segments in engagement with the sub flange 40, thereby preventing any vertical motion of the slip segments relative to the mounting sub 13 as long as the retainer sleeve 27 encompasses the upper sections 42 of the segments as shown in FIGURE 1B. Each slip segment 36 is further retained on the mounting sub 13 by a leaf spring 43 having its free end engaging in an external notch 44 formed in each segment, the other end of each leaf spring being connected to the mounting sub by a screw 45 or other suitable fastening device. It will be appreciated that the engagement of the retainer sleeve 27 over the upper sections 42 of the slip segments 36 provides a strong and rigid coupling to prevent any longitudinal motion which might result in prematurely setting the slips.

Even when the retainer sleeve 27 is removed by upward feeding of the cage 22, as previously described, the slip segments are still retained on the mounting sub 13 by the inward bias of the leaf springs 43. However, upward feeding of the retainer sleeve 27 clears the lower end surface 46 of the setting sleeve 20 for engagement with the upper end surfaces of the slip segments 36 so that the slips are held in an exerted holding force on the segments. Accordingly, when the mandrel 11 is freed from the control sleeve 17 by rotation, as previously described, the mandrel can then be elevated by upward movement of the running-in string 10 to engage the slips with the setting sleeve 20. Inasmuch as the control sleeve 17 is still coupled to the drag cage 22 by the threads 28 and 29, the drag cage 22, control sleeve 17 and setting sleeve 20 will transmit the holding force of the drag blocks 25 to the slip segments 36 to hold the segments against upward movement as the mandrel 11 is moved upwardly for shifting the slips outwardly into gripping engagement with the well casing.

As shown in FIGURE 1B, the packer assembly B includes a body 50 having a central bore 51 which is sized to receive the mandrel extension 14, the lower end of the body being constituted as a valve housing by a guide and valve body assembly 52 threaded at its lower end. Mounted at the lower portion of the packer body 50 are slips 53 of any typical construction having wickers or teeth 54 facing in a downward direction and capable of anchoring, when expanded, against downward movement in the well casing. The slips 53 rest on the guide 52 and have inner surfaces 55 inclined downward and inwardly and arranged to engage companion external surfaces 56 on a lower expander 57 mounted on the body 50. The expander 57 can be releasably secured to the body 50 by one or more shear pins 62 and can also be co-rotationally coupled to the body 50 by a lock pin 62A.

The upper end of the lower expander 57 engages the lower portion of a packing structure 58, such as a plurality of elastomeric rings, surrounding the body, the upper end of which engages an upper expander 59 initially releasably secured to the body 50 by one or more shear pins 60. The ends of the packing structure 58 can be confined by typical annular rings 58B and 58C. The lower expander 57 has an outer surface 61 which inclines upwardly and inwardly and which is companion to the inner inclined surfaces 38 on the upper slips 36.

For the purpose of locking the compression force in the packing structure 53 during setting as well as locking the slips 35 and 53 in set condition, a slip lock ring 63 is provided which has internal ratchet teeth 64 facing in an upward direction and arranged to mesh with like downwardly facing ratchet teeth 65 on the outer periphery of the body 50. The lock ring 63 also has external tapered cam teeth 66 arranged to engage companion cam surfaces 67 in the expander 57, the cam surfaces tending to urge the ratchet teeth 64 and 65 into mesh with one another. However, upward movement of the body 50 relative to the lock ring 63 can expand the lock ring outwardly, due to the lateral play between the cam surfaces 66 and 67, as long as the lock ring 63 is moved upward relative to the expander 59. The lock ring 63 functions as a one-way clutch to permit upward movement of the body 50 relative to the expander 59 but prevent converse relative movement in a conventional manner.

The mandrel extension 14 is arranged to reciprocate upwardly and downwardly with the body 50 in response to manipulation of the running-in string 10 to operate the valve assembly C. An external seal device 69, of any suitable construction, is provided to seal between the mandrel extension 14 and the body 50 so that fluid under pressure can be displaced through the valve assembly C without leakage back into the well annulus above the packing assembly B. The mandrel extension 14 is coupled to the upper end of the body 50 by a sliding ratchet arrangement 70 which permits rigid connection between the running-in string 10 and the body 50 during setting, partial release to enable positive valve assembly operation, selective disengagement by upward strain on the running-in string 10 to permit circulation of well fluids if desired, and selective engagement by downward motion of the running-in string for further operations.

As shown in FIGURES 1B and 3, this ratchet arrangement 70 includes a split ratchet nut 71 having external, upwardly facing ratchet teeth 72 formed on a left-hand helix. Due to the fact that the nut 71 is split, it is capable of assuming an unstressed expanded size where the teeth 72 are engageable with upper, larger diameter threads 73 on the body 50, and a contracted size where the teeth are engageable with lower, smaller diameter companion threads 74 on the body. The body threads 73 and 74 are formed on the same lead so that the ratchet nut 71 can readily mesh with both threads. The ratchet nut 71 is seated in an annular recess 75 in the upper portion of the mandrel extension 14, the recess being terminated at its upper end by the lower face of the lower expander 57 and at its lower end by an annular flange 76. A longitudinal spline or key 77 extends radially outwardly in the recess 75 to engage in the slot or cut 78 formed in the split ratchet nut 71 so that the nut is co-rotationally secured to the mandrel 51.

In the running-in position of parts shown in FIGURES 1A and 1B, the ratchet nut 71 occupies a lower position within the recess 75 and is contracted and threaded into the lower body threads 74. Inadvertent unthreading of the ratchet nut is precluded by a shear screw 80 engaging in the body 50 and in the mounting sub 13. Since the mounting sub 13 engages the upper end of the mandrel 50 and the extension flange 77 engages the lower surface of the
ratchet nut 71, the extension 14 and body 50 are rigidly coupled to one another. After setting, right-hand rotation of the mandrel extension 14 relative to the body 50 will shear the screw 80 and cause the ratchet nut 71 to feed upwardly and out of engagement with the lower body threads 74. When the nut clear the lower threads 74, it will expand into mesh with the upper threads 73 and continued rotation of the nut can eventually cause it to unthread out of the upper threads also. It will be noted that both the upper and lower faces of the ratchet nut threads 72 are inclined to some extent. This construction permits the threads 72 to be ratcheted through the upper body threads 74 in either longitudinal direction without rotation. That is to say, the nut can repeatedly expand and contract and ratchet through the upper body threads 74, thereby being sufficient lateral play between the inside surface of the nut and the bottom of the recess 75 when the nut 71 is adjacent to the upper body threads to permit this to occur. Due to the inclination of the upper faces of the teeth 72, the nut 71 can be released from the upper body threads 74 in response to a predetermined upward strain on the mandrel extension. In like manner, the ratchet nut 71 can be re-engaged with the upper body threads 74 by lowering the mandrel extension until the nut ratchets back into engagement with the body threads. This arrangement permits a positive yet releasable coupling between the mandrel extension 14 and the body 50 which is highly advantageous in that, initially, a rigid connection between the extension and body is effected for transmitting high setting loads to expand the packing structure 58 and to firmly set the slips 35 and 53. Then, with the ratchet nut 71 engaging the upper body threads 73, a coupling is effected which permits a limited amount of reciprocating motion between the extension and the body for operating the valve assembly C without disconnecting the extension from the body. When desired, a predetermined upward strain on the running-in string 10 will completely release same from the body 50 without rotation should a quick disconnection be advisable, and the extension 14 can later be merely lowered into the body bore 51 to re-engage the ratchet nut 71 within the upper body threads 73 for further operations. Fluid flow through the body bore 51 is controlled by the valve-assembly C which includes the valve housing 52 as previously described. The valve housing 52 has side ports 85 through the wall thereof, and the lower portion 86 of the valve housing is positioned within the bore of the valve housing 52 and arranged for upward and downward motion therein between an upper position shown in FIGURE 1B where upper and lower seal rings 88 and 89 seal above and below the side ports 85 to block fluid flow therethrough, and a lower position shown in FIGURE 2B where the side ports 85 are open for fluid flow. The valve-sleeve bore 90 provides a fluid communication path through the valve sleeve 87 so that fluid pressure will act on the sleeve in equal but opposite directions and will not tend to move the valve sleeve. An annular flange 91 is provided in the bore of the valve sleeve 87, and a coil spring 92 of any suitable construction presses upwardly against the flange 91 tending to move the valve sleeve upwardly.

The upper portion of the valve sleeve 87 is constituted as a lash device 93 comprising a plurality of circumferentially spaced, upwardly extending latch fingers 94 having enlarged head portions 95 at their upper ends. The latch fingers 94 are spring-like or resilient and inherently tend to resist outwardly to the extent shown in detail in FIGURE 4. Each head portion 95 has an inner projection 96 and an outer projection 97, each inner projection having an upwardly facing shoulder 98 and a lower upwardly and inwardly inclined surface 99, each outer projection 97 having upper and lower oppositely inclined surfaces 100 and 101. Moreover, the outer portion of each head is formed to extend upwardly beyond the shoulder 98 to provide a tang having an inner surface 103 which inclines downwardly and inwardly.

The lower end portion 105 of the mandrel extension 14 is formed for coupling with the latch device 93 and has spaced annular recesses 106 and 107 thereon in which the inner projections 96 of the finger heads 95 can engage. The lower recess 107 is formed to extend to a greater depth in the coupling portion 105 than is the upper recess 106. The valve body 52 is provided with spaced annular grooves 108 and 109 in which the outer projections 97 on the finger heads 95 can extend, the upper groove 108 extending more deeply into the valve body than the lower groove 109 and having a lower downwardly and inwardly inclined cam surface 111.

Assuming that it is desirable to lower the tool into the well with the valve sleeve 87 in its upper closed position, the valve assembly parts are positioned as shown in FIGURE 4 with the fingers 95 opposite the upper groove 108 and with the outer projections 97 extending into the upper groove and with the inner projections 96 engaging within the upper extension recess 106. The upper extension recess 106 is not sufficiently deep to allow the head fingers 95 to disengage from the upper body groove 108 and the valve sleeve 87 is locked in closed condition and cannot be move downwardly. However, when the propering assembly B is set and the ratchet nut 71 disengaged by mandrel rotation as previously described, the mandrel extension 14 can be elevated until the lower recess 107 is either somewhere above, or opposite to, the finger heads 95. The extension flange 112 can readily force or can the heads 95 outwardly and pass upwardly past the heads. Then, lowering the extension 14 will engage the extension flange 112 with the head shoulders 98 and, due to the interengagement of the inclined surfaces 101 and 110, cam the heads 95 inwardly. The lower extension recess 107 is sufficiently deep to allow the heads 95 to shift inwardly and disengage from the body groove 108. Accordingly, the valve sleeve 87 can be pushed downwardly to open position as shown in FIGURES 2B by downward movement of the extension 14. Also the valve sleeve 87 can be moved upwardly to closed position by merely elevating the extension 14 because the heads 95 are held inwardly in locked position within the lower recess 107 by the inner surface 113 of the valve body. When the heads 95 move upwardly and opposite the upper groove 108, they will resile outwardly into the groove and the end flange 114 on the extension 14 can bypass the heads to its the coupling portion 105 from the latch device 93.

Assuming that it is desired to run the tool into the well with the valve sleeve 87 in open position, the parts are assembled with the valve sleeve in the lower position and with the head portions 95 locked in engagement within the lower extension recess 107. To move the valve sleeve 87 to closed position, the extension 14 is elevated and the latch fingers 94 will pull the valve sleeve upwardly. When the upper groove 108 is reached, the head portions 95 will resile into the groove 108 to release the valve sleeve from the extension as previously described.

Moreover, a structural arrangement can be provided to permit positive recompling of the mandrel extension 14 and valve sleeve 87 even though the valve sleeve may be intermediate its open and closed positions. Should this occur, the head portions 95 will be located at some point below the upper groove 108. As the mandrel extension 14 moves downwardly, the end flange 114 will engage and push the head portions 95 downwardly until they are opposite the lower body groove which point they will resile outwardly and into the lower groove, thereby permitting the flange 114 to bypass the head portions. Then, the valve spring 92 being compressed by downward movement of the valve sleeve 87, will function to force the valve sleeve 87 and fingers 94 upwardly, camming the head portions 95 inwardly into locked engagement within the lower extension recess 107. This connection positively couples the valve sleeve 87 to the
extension 14 for further and repeated movements between open and closed positions.

**OPERATION**

In operation, the various parts of the present invention can be assembled as shown in FIGURE 1 with the mandrel 11 connected to the lower end of the running-in string 10, and then lowered into a well bore to a desired setting point. The slips 53 and the packing structure 58 are retracted, the upper slips 35 being encompassed by the retaining sleeve 27. The drag blocks 25 can slide along in frictional engagement with the well casing P and the cage 22 and the control sleeve 17 cannot move upwardly on the mandrel 11 due to the engagement of the threads 28 and 29 and the locking condition of the latch ball 30. The ratchet nut 71 is in full mesh with the lower body threads 74 and engages the extension stop flange 76. The lower surface of the mounting sub 13 abuts against the upper end of the mandrel 50 so that the mandrel 11 and the mandrel extension 14 are, in net effect, integrally connected to the packer body 50.

The valve sleeve 87 can initially occupy its upper port closing the setting sleeve 20 to grip the finger heads 95 within the upper body groove 108. This can be conveniently accomplished during assembly by exerting an upward force on the lower end of the valve sleeve 87 so that the engagement of the upper head surfaces 103 with the inclined top surface of the upper groove 108 will cause the heads 95 to extend to their fullest extent into the upper groove. Thus extended, the extension flange 112 can readily bypass downwardly beyond the heads to position upper extension recess 106 opposite the heads. On the other hand, the valve sleeve 87 can initially occupy its lower open position by making up the valve assembly C such that the finger heads 95 are engaged in the lower extension recess 107.

At setting depth, the running-in string 10 is rotated a sufficient number of turns to the right to feed the cage 22 and the retainer sleeve 27 upwardly as previously described. Upward movement of the retainer sleeve 27 disengages the sleeve from the upper sections 42 of the slip segments 36 so that the segments can be shifted outwardly. At this point, the segments 36 are still retained on the mounting sub 13 by the leaf springs 43. Upward movement of the cage 22 positions the cage recess 34 opposite the ball 30 so that the ball can move out of the lower body threads 74. When the nut 71 clears the lower threads 74, it will expand into mesh with the upper ratchet threads 73 and continued rotation to the right will feed the nut upwardly through the upper threads also. When the “free” point is indicated at the surface, the nut 71 is completely disengaged and the extension 14 is uncoupled from the packer body 50. Then the running-in string 10 can be lowered without rotation to ratchet the nut 71 back into the upper body threads 73 as shown in FIGURE 2B. With this relative position of parts, it will be appreciated that the mandrel extension 14 can be reciprocated upwardly relative to the packer body 50 to release the mandrel 11 for upward movement relative to the control sleeve 17 and the cage 22.

The mandrel 11 is then elevated by upward strain on the running-in string 10 to set the packer assembly B. The engagement of the drag blocks 25 against the well casing P produces a holding force which is transmitted through the threads 28 and 29 to the control sleeve 17, thereby resisting upward movement of the setting sleeve 20. Accordingly, as the mandrel 11 is elevated, the upper end surfaces of the slip segments 36 are brought into engagement with the lower end surface of the setting sleeve 20 and continued upward movement of the mandrel 11 causes the slip segments 36 to push the slip segments 36 out of retained relationship with the leaf springs 43 and out of engagement with the mounting sub flange 40. The setting sleeve 20 then functions to hold the segments against upward movement as the upper expander 59 is moved under the setting sleeve 20 upwardly as shown in FIGURE 2B. As the expander 59 moves upwardly, its outer inclined surfaces 61 wedge the slip segments 36 outwardly until the leaves 37 grip the well casing wall. Now, the upper expander 59 cannot move any further upwardly relative to the well casing P and is retracted upwardly on the mandrel 11 and packer body 50, after shearing the pins 60 and 62, serves to expand the lower slips 53 over the lower expander 57 and to compress and expand the packing structure 58. When a predetermined upward strain has been taken on the running-in string 10, both the upper and lower slips 35 and 53 are shifted outwardly to grip the well casing P and prevent movement in either longitudinal direction, and the packing structure 58 is expanded to pack off the annulus between the well casing and the body 50. During upward movement of the body 50 relative to the upper expander 59, the lock ring 63 will ratchet over the external body teeth 65 and trap the mandrel in the highest relative position to which it is moved, thereby trapping the compression load in the packing structure 58 and locking the slips 35 and 53 in set condition.

If it is desired to test the running-in string 10 for leakage, this can be accomplished. Should the valve sleeve 87 be initially positioned in closed condition as shown in FIGURE 4 and as previously described, the running-in string 10 will already be closed off at its lower end and can be pressure tested for leakage by applying pump pressure to the inside of the string at the earth’s surface. Should the valve sleeve 87 be initially positioned in open condition, the valve sleeve can be moved to closed position as will be subsequently described and the running-in string 10 leak tested in the same manner.

At any rate, the packer assembly B is now set and a pressure operation, such as cementing or hydraulic fracturing can be undertaken. To operate the valve assembly C, a relatively small upward strain, say 1000 pounds above the “free” point, is taken in the running-in string 10 and the string is torqued to the right. Since the packer body 50 is now fixed in the well bore due to the set condition of the packer assembly B, rotation of the mandrel extension 14 will shear the screw 80 and feed the ratchet nut 71 upwardly and out of the lower body threads 74. When the nut 71 clears the lower threads 74, it will expand into mesh with the upper ratchet threads 73 and continued rotation to the right will feed the nut upwardly through the upper threads also. When the “free” point is indicated at the surface, the nut 71 is completely disengaged and the extension 14 is uncoupled from the packer body 50. Then the running-in string 10 can be lowered without rotation to ratchet the nut 71 back into the upper body threads 73 as shown in FIGURE 2B. With this relative position of parts, it will be appreciated that the mandrel extension 14 can be reciprocated upwardly relative to the packer body 50 to release the mandrel 11 for upward movement relative to the control sleeve 17 and the ratchet nut 71, and downwardly until the mounting sub 13 bumps against the upper end of the mandrel 50. The relative travel permitted is sufficient to operate the valve assembly C while providing positive surface indications of the position of the valve sleeve 87 relative to the side ports 85 in the valve body 52.

When the mandrel extension 14 is moved upwardly during complete release of the ratchet nut 71 from the body threads 73 and 74 as previously described, the lower portion 105 of the extension is positioned at some point above the finger heads 95 which are located within the upper body groove 108. Accordingly, downward movement of the mandrel extension 14 will cause the extension flange 112 to engage the head shoulders 98 and push the valve sleeve 87 downwardly against the bias of the valve spring 92. As the heads 95 move downwardly, they are cammed inwardly out of the upper body groove 108 and downwardly against the lower body threads 74 and held locked therein by the inner surface 113 on the valve body 52 as shown in FIGURE 2B. Accordingly, the valve sleeve 87 is positively coupled to the mandrel extension 14 and downward movement of the mandrel extension will shift the valve sleeve to open position and upward movement of the sleeve 87 will open the movement of the mandrel. During upward movement, when the heads 95 move opposite the upper body groove 108, they will resile into the groove and permit the end flange 114 on the extension 14 to bypass the inner projections 96 to release the extension.
from the valve sleeve 87 and permit removal of the extension from the packer body 50. It will be appreciated that whenever the mandrel extension 14 is thus removed, the valve sleeve 87 should always be in its upper closed position shown in FIGURE 4 with the seal elements 88 and 89 spanning the side ports 85 to block fluid flow. Inasmuch as the valve seals 88 and 89 are arranged to encompass substantially the same areas, fluid pressure either within the valve body 52 or externally thereof will act in equal and opposite directions and will not tend to shift the valve sleeve 87.

However, should be desired to further operate the valve sleeve 87 and if, for some reason, the head portions 95 are located at some point below the upper body groove 108 (e.g., the valve sleeve is already in open position, or in a position intermediate its open and closed positions) the extension 14 can be again lowered into the body bore 51. When the extension end flange 114 reaches the head portions 95, the flange will push the head portions and thus the valve sleeve 87 downwardly against the bias of the valve spring 92. When the head portions 95 are moved opposite the lower body groove 109, the head portions will reseat into the lower groove and permit the mandrel, said latch 114 and projections 96. When this occurs, the valve spring 92 will force the valve sleeve 87 upwardly, camming the head portions 95 inwardly, until the head portions are again locked within the extension recess 107 as shown in FIGURE 2B. Accordingly, the parts are in relative positions for further and repeated operation.

As was previously noted, a predetermined upward strain on the running-in string 10 without rotation will cause the ratchet nut 71 to release from the upper body threads 73 by repeated contraction or ratcheting action. Therefore, it will be appreciated that the mandrel extension 14 can be removed from the member 50 with a downward pull on the running-in string 10 should circulation or reverse circulation above the packer assembly B be desirable. Any desired number of connections and disconnections of the mandrel extension 14 and packer body 50 can be effected by simply moving the running-in string 10 up and down to engage and disengage the ratchet nut 71 with the upper body threads 73.

When a pressure operation has been completed, the setting tool assembly A can be disconnected from the packer assembly B as previously described and the setting tool assembly withdrawn from the well. The valve sleeve 87 is left in closed position and will not open in response to pressure from above or below. It will be noted that a minimum number of packer parts remain in the well when the setting assembly is removed so that a drilling operation, if ever needed, would be expeditious.

A new and improved well apparatus has been disclosed which can be lowered into a well on a running-in string for setting a well packer or the like in a well bore. The apparatus includes a retaining member which encompasses slips to positively prevent premature setting of the slips during lowering. The retaining member can be selectively released from the slips to permit outward movement of the slips, and the retaining member is engaged with the slips to prevent vertical movement as the slips are set by upward movement of the running-in string. The apparatus is simple, reliable, and can be operated by a minimum number of surface manipulations of the running-in string.

Since certain changes or modifications may be made in the invention without departing from the inventive concepts involved, it is the aim of the appended claims to cover all such changes or modifications which fall within the true spirit and scope of the present invention.

We claim:

1. Apparatus for in setting a well tool having a mandrel and an expander mounted on the mandrel, comprising: a body member releasably coupled to said mandrel; slip means mounted on said body member in ad-
hold said slip means against upward movement during outward shifting thereof by said expander means.

9. The outward shifting including spring means engaging said slip means to releasably retain said slip means on said mounting portion after release of said retaining means.

10. A well tool comprising: mandrel having a bore therein; an expander mounted on said mandrel; a tubular body member received in said bore and adapted for connection to a running-in string; means for releasably coupling said body member to said mandrel; slip means mounted around said body member and said mandrel and adapted for outward shifting by said expander to engage a well conduit; retainer means initially retaining said slip means against outward shifting; means responsive to manipulation of said body member for releasing said retaining means; and means on said body member engageable with said slip means for holding said slip means against longitudinal movement in the well conduit while said body member, mandrel, and expander means are moved longitudinally relative to said slip means to shift said slip means outwardly.

11. In a setting apparatus for a well tool having a mandrel and an expander on said mandrel, the combination comprising: a tubular body telescoped within said mandrel and adapted for connection to a running-in string extending to the top of a well bore, said body having an enlarged portion arranged to abut against an upper end surface of said mandrel; means for releasably coupling said body to said mandrel; normally retracted slip means mounted around said enlarged portion and said mandrel and adapted for outward shifting by said expander; retainer means encompassing a portion of said slip means for retaining said slip means in retracted positions; and means on said body responsive to rotation of said body by the running-in string relative to said retainer means for removing said retainer means from encompassing relation to said slip means so that said slip means can be shifted outwardly by said expander means in response to upward movement of said body, mandrel and expander relative to said slip means by the running-in string.

12. In an apparatus for use in setting a well tool in a well bore, said well tool having a mandrel and an expander mounted on the mandrel, the combination comprising: a body member releasably coupled to said mandrel; slip means mounted on said body member and said mandrel and adapted to be shifted outwardly by said expander; retaining means encompassing said slip means to prevent outward shifting of said slip means; drag means connected to said retaining means and engageable with a well conduit wall to prevent rotation; a control member between said drag means and body member; means for co-rotatively securing said control means to said body member; axial cam means between said control member and drag means arranged to feed said drag means and retaining means in a direction away from said slip means upon rotation of said control member relative to said drag means by said body member, whereby said retaining means is removed from encompassing relation to said slip means and said slip means can be shifted outwardly; and holding means connected to said control member and drag means and adapted to engage said slip means to transmit holding force from said drag means to said slip means to prevent vertical movement of said slip means during outward shifting of said slip means by said expander in response to vertical movement of said body member and mandrel.

13. The combination of claim 12 further including releasable means initially latching said control member to said body member to prevent longitudinal relative movement between said control member and body member, said releasable means being releasable upon removal of said retaining means.

14. The combination of claim 13 further including releasable coupling means connecting said body member to said mandrel, said coupling means being selectively releasable after outward shifting of said slip means to disconnect said body member from said mandrel.

15. Apparatus for use in a well bore comprising: a mandrel; packing means on said mandrel for packing off a well bore; a body member coupled to said mandrel and adapted for connection to a running-in string extending to the top of a well bore; normally retracted slip means adapted to be shifted outwardly of said body member and said mandrel; expander means mounted on said mandrel and movable by said mandrel and packing means in one longitudinal direction for shifting said normally retracted slip means outwardly to expanded position; retaining means for retaining said slip means in retracted position; means responsive to rotation of said running-in string for releasing said retaining means so that said slip means can be shifted outwardly; and holding means on said body member engageable with said normally retracted means after release of said retaining means to hold said slip means against longitudinal movement in said one direction while said expander means functions to shift said slip means outwardly.

References Cited

UNITED STATES PATENTS

2,755,864 7/1956 Vaughn -------------- 166—139
2,998,073 8/1961 Clark et al. ---------- 166—139
3,013,611 12/1961 Myers -------------- 166—136
3,136,365 6/1964 Carter et al. ---------- 166—139
3,232,347 2/1966 Thrane -------------- 166—139
3,270,819 9/1966 Thrane et al. ---------- 166—136

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