This invention relates to well tools, and more particularly to lock devices for determining the operation of such tools in well bores.

In United States Patent No. 2,386,401, patented January 30, 1945, a ratchet or one-way clutch type of lock device is used for selectively preventing or permitting relative movement between the parts of a sub-surface well tool. As an example, the lock device may prevent the outward expansion of casing engaging slips, or of a packing structure, or both, until desired. The specific type of lock mechanism illustrated in the above patent is rendered ineffectual upon turning the tubular string to which the tool is secured. Such turning unlatches or uncouples the lock and allows the tubular string and the portion of the well tool attached thereto to be elevated, in order to shift parts of the tool relative to other parts of the tool. Thus, elevation of the tubular string may shift an expander within the slips, effecting outward expansion of the latter against the casing.

Because of various factors, the tubular string will not necessarily remain in the position to which it has been turned in effecting unlatching of the lock device. The flexibility or elasticity of the tubular string, pump pulsations incident to the forcing of fluids through the tubular string, and other conditions, sometimes causes inadvertent and undesired reverse rotation of the tubular string to an extent sufficient to recouple the lock device. It, therefore, becomes essential to turn the tubular string and then elevate it each time it is desired to expand a slip and packing. This operation prevents immediate setting of the slips and packing against the casing, the time delay possibly introducing errors in the work being performed in the well bore.

It is, accordingly, an object of the present invention to provide a lock device in a sub-surface well tool, which will not tend to revert inadvertently to its locked position after having been uncoupled.

Another object of the invention is to provide a lock device in a sub-surface well tool which is unlocked by rotation of the tubular string to which the tool is secured, and which will remain in such unlocked condition until purposely released.

A further object of the invention is to provide a lock device in a sub-surface well tool, which can be preconditioned in an unlocked or uncoupled position, in order that the tool may be manipulated immediately in effecting an operation in the well bore, without the necessity for time consumption in first operating a lock device.

This invention possesses many other advantages, and has other objects which may be 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:

Figure 1 is a longitudinal view, partly in section, and partly in elevation, of a well packer within a well casing, with its parts in retracted position.

Figure 2 is a longitudinal section, on an enlarged scale, of the locking portion of the device shown in Fig. 1.

Figure 3 is a view similar to Fig. 1 of the well packer anchored in packed-off condition within the well casing.

Figure 4 is a cross-section taken along the line 4--4 on Fig. 2, of the lock portion of the tool.

Figure 5 is a cross-section taken along the line 5--5 on Fig. 2.

Figure 6 is a view similar to Fig. 4 of the lock device in another position; and

Figure 7 is a view similar to Fig. 5, illustrating the coupling in its latched or clutched position.

The invention is exemplified in the drawings as forming part of a well packer A of the retrievable type. It is to be understood, however, that the invention is also applicable to other well tools, and for controlling elements other than slips and packings hereinafter referred to.

The packer A is adapted to be run in a well bore or casing B on the end of a tubular running-in string C threadedly, or otherwise attached, to the upper end of the tubular mandrel or body portion 10 of the packer. The lower end of this mandrel or body portion 10 is threadedly inserted into the upper end of a lower tubular packer body 11, to which is attached a packing actuator 12 in the form of a guide.

A tapered expander 13 is mounted on the body part 11. It is preferably prevented from turning with respect to the latter by a key 14 secured to the exterior of the body and received within a keyway 15 in the expander; so as to permit relative longitudinal movement between the body 11 and expander 13 while preventing rotation therebetween. When the tubular string C and body 10, 11 are elevated, the packing actuator 12 is moved toward the expander 13 to compress an intervening packing sleeve 16, surrounding the body, and force it outwardly into engagement with the wall of the casing B. Such actuation of the packing sleeve 16 only occurs when the tapered expander 13 is prevented from moving upwardly, which results from shifting of the expander within a plurality of slips 17, and outward expansion of the latter against the wall of the casing.

The slips 17 have tapered inner surfaces cooperating with companion tapered surfaces 19.
on the expander, the inclination of such surfaces being such as to move the slips 17 outwardly toward the casing when the expander 13 is elevated. Correctly positioned, the expander 13 slip receptacle to the slips 17 permits the latter to release from the casing wall and move inwardly to retracted position.

It is, accordingly, apparent that elevation of the tubular string C and packer body 10, 11 can effect anchoring of the tool, through engagement of the slips 17 with the casing 5 under the influence of the tapered expander 13. Such elevation can also effect compression or foreshortening of the rubber packing sleeve 16 between the expander 13 and guide 12, to produce its radial outward expansion into sealing engagement with the casing wall.

The slips 17 are held together for joint movement along the tapered expander 13 to and from engagement with the casing B by pin-connecting them to the lower ends of links 20, whose upper ends extend between the fingers 21 of a slip ring 22. This ring is also provided with a peripheral groove 23 into which pins 24, projecting in both directions from the sides of the links 20, may extend, in order to couple all of the links 20 and slips 17 for movement jointly with the slip ring 22. Radial outward movement of the upper ends of the links 20 is prevented by a stop ring 25 suitably secured to the slip ring 22.

The slip ring is connected to a drag device 26 by a swivel mechanism 27, in order to permit rotation of the slips 17 and slip ring 22 without correspondingly rotating the drag device 26. The main purpose of the drag device 26 is to resist longitudinal movement of the slips 17 within the well casing B.

The drag device 26 includes an outer ratchet member 28, consisting of a lower ring 29 threaded into an upper ratchet sleeve or clutch collar 30. The ratchet ring 29 and slip ring 22 are adjacent one another, and are provided with outwardly directed flanges 31, 32 receivable within an internal circumferential groove 33 in a tie ring 34 having upper and lower inwardly directed flanges 35, 36 disposed above and below the ratchet ring and tie ring flanges 31, 32, respectively. For convenience of assembly, the tie ring 34 may be made in two halves that are moved radially inwardly to dispose the flanges 35, 36 above and below the ratchet ring and slip ring flanges 31, 32. This two-piece ratchet ring is prevented from coming apart by an encompassing circumferentially continuous sleeve 37, which is prevented from dropping off the ring by one or more screws 38 threaded into the ring and disposed within holes 39 in the sleeve. It is apparent that the tie ring 34 and the flanges 31, 32 on the ratchet ring 29 and slip ring 22 form a swivel connection 27 between the drag device 26 and the slips 17.

The drag and lock device 26 comprises the outer ratchet member 28, 29, which may slide relatively with the mandrel 10. The sleeve 30 of this member receives the lower end of a plurality of circumferentially spaced outwardly bowed leaf springs 40, held against the sleeve 30 by a ring 41 fastened to it by a plurality of screws 42. These springs extend upwardly along the mandrel 10, with one end secured to an upper drag collar 43 by an upper ring 44 suitably fastened to the latter, as by screws 45. This upper collar 43 is slidable along the mandrel or body part 10.

It is to be noted that the frictional engage-
Because of the ratchet or one-way clutch type of lock device described, the mandrel 10 can be moved downwardly without interference by the lock device, since the mandrel ratchet teeth 55 will merely ratchet freely over the companion teeth 53 on the segments 55. However, upward movement of the mandrel 10 will cause its teeth 54 to engage the segment teeth 53 and move the segments 55 upwardly with it, shifting them slightly toward the narrow portion of the tapered surface 59 in the ratchet sleeve 30 and wedging the segments firmly between the mandrel 10 and ratchet sleeve 30, 31 which effectively couples the mandrel 10 and drag device 25 together against relative upward movement. In other words, the two parts 10, 25 are locked together for upward movement as a unit. Accordingly, the slips 17 are also locked to the mandrel 10 and will move upwardly with it.

When it is desired to shift the mandrel 10 upwardly within the drag device 25, and with respect to the slips 17, in order to anchor the slips to the casing B, the tubular string C and upper body or mandrel 10 connected thereto are rotated a partial revolution, preferably to the right. Such rotation causes the mandrel 10 to act upon the segment key 59 and expand the segments 55 outwardly to the extent in which their teeth 53 are completely out of engagement with the mandrel teeth 54. Such expansion will occur, since the other end of the segments is prevented from moving by the stop 55 secured to the ratchet sleeve 30. When the mandrel is thus turned to free the segments 55 from its teeth 54, the mandrel 10 may be moved upwardly within the segments 55 and the ratchet sleeve 30, in order to shift the expander 13 upwardly within the slips 17 and urge the latter into anchoring engagement with the casing B. As above indicated, a continuation of this upward movement shortens the packing sleeve 16 and expands it outwardly against the casing.

When the slips 17 and packing 16 are to be retracted, it is merely necessary to lower the tubular string C and mandrel 10, which will lower the abutment 12 away from the expander 13, allowing the packing sleeve 16 to retract and also cause the body shoulder 46 to engage the expander shoulder 47, shifting the expander downwardly relative to the slips 17 and effecting retraction of the latter. Such downward movement can occur without regard to the imposing of turning effort on the tubular string C and packer body 10, 11, because of the one-way ratchet arrangement between the mandrel threads 54 and segmented ring threads 53.

With the segmented ring 52 released by reverse turning of the tubular string C and packer body 10, 11, upward movement of these latter members will again automatically couple the mandrel 10 to the ratchet sleeve 30 and drag device 25, in order that upward movement of the tubular string C and packer body 10, 11 will be ineffective to anchor the packer to the well casing. The well tool can, therefore, be removed to the top of the well bore.

From the foregoing description, the tubular string C and packer body 10, 11 must be rotated to the right, to unclutch the segmented ring 52 and prevent its coupling engagement with the mandrel 10 during setting of the tool. The packer body 10, 11 may not remain in the position to which it has been turned, and may inadvertently return to its original position, allowing the segmented ring 52 to again couple the mandrel 10 to the ratchet sleeve 30. As an example, it is sometimes desired to lower the tool in a well casing to a predetermined location and then unlock the tool for upward movement of its body 10, 11 in effecting rapid setting of the slips 17 and packing 16 when the slips 17 and packing 16 are withdrawn. While in such unlocked condition, a charge of cement slurry may be pumped through the tubing string C with the packer elements retracted, in order to allow the tubing fluid ahead of the cement slurry to flow out of the lower end of the packer A upwardly around the packer A and out through the charge of cement slurry has reached the vicinity of the well packer, it is desired to immediately anchor the packer A in packed-off condition against the casing B, for the purpose of forcing the cement slurry into the formation and preventing its upward travel around the packer.

Such rapid packing-off can occur if the lock device has been previously conditioned to hold its segmented ring 52 unclutched from the mandrel or upper body portion 10. With this condition, it is merely necessary to pull up on the tubular string C to anchor the packer A in packed-off condition against the well casing. At times, however, certain well conditions cause the coupling elements 53, 54 to reengage, so that it is necessary to first rotate the tubing string C and mandrel 10 secured thereto, to insure the unclutching of the lock device before the tubing string is elevated. The relatively short time required for the rotary operation may be sufficient to allow part of the cement slurry to flow out of the packer and upwardly around the packer.

The present invention contemplates the provision of a lock device 70 for holding the clutch in uncoupled condition, and for preventing its inadvertent return to clamping or coupling position.

The lock device 70 includes a coupling pin 71 having a conical or partially spherical head 72 adapted to ride on the exterior of the mandrel 10, and also to be received within the mandrel longitudinal groove or keyway 80. The coupling pin has a stem 73 extending radially outward from its head and alidable through a spring retainer or seat 75 threaded into an arcuate segment 78 adjustably secured to the ratchet sleeve or clutch collar 30, as by means of cap screws 76. A helical compression spring 77 surrounds the pin stem 73, with its inner end bearing against the head 72 and its outer end against the spring seat 74, in order to urge the head inwardly at all times. This spring is enclosed within a sleeve 78 threaded into the same hole in the arcuate segment 78 as the spring seat 74.

In order to permit angular adjustment of the coupling pin 71 relative to the ratchet sleeve 30, the sleeve 30 is provided with an arcuate slot 79 through which the pin 71 and its enclosing sleeve 78 extend. In addition, the arcuate segment 78 has its ends 80 slotted for reception of the cap screws 76. When the cap screws are loosened, the arcuate segment 78 and the coupling pin 71 carried thereby can be shifted relative to the ratchet sleeve 30, whereupon the cap screws 76 are retightened to secure the segment 78 to the sleeve 30. Such adjustment is desired in order to locate the coupling pin 71 relative to the mandrel keyway 80 and the segmented ring 52.

When the segmented ring 52 is in its coupled position, with its teeth 53 in engagement with the mandrel teeth 54, the coupling pin 71 is disposed out of the longitudinal mandrel groove 80 and rests upon its arcuate threads 84.
determined arcuate extent from the groove 60 (Fig. 6). When it is desired to uncouple the segmented ring 52 from the mandrel 10, the tubular string C and mandrel 10 are rotated, as described above, to effect expansion of the segmented ring 52 away from the mandrel teeth 54. Since the coupling pin 71 is mounted on the drag device, it is prevented from rotating by the frictional engagement of the springs 40 with the casing wall. Accordingly, rotation of the mandrel 10 to the extent required to unclutch the segmented ring 52 from the mandrel 10 places the longitudinal groove 60 in alignment with the coupling pin 71, its spring 77 forcing it into the longitudinal keyway 66. The rotational restraint or torque may now be removed from the tubular string C and mandrel 10, if desired, the coupling pin 71 effecting clutching the mandrel 10 to the ratchet sleeve 30 and preventing their relative rotation. As a result, the segmented ring 52 is held in its outwardly expanded position (see Figs. 1 to 5).

When such locked condition has been achieved, the tool can be manipulated through longitudinal movement of the tubular string C, in order to set and release the well packer A as many times as desired, without fear that the segmented ring 52 has inadvertently moved back to its clutching position, because of inadvertent reverse rotation of the tubular string C and mandrel 10.

When coupling pin 71 is again desired, the tubular string C is rotated in a reverse direction or to the left. The spring 77 holds the coupling pin or dent 71 in the mandrel groove 60 with just sufficient force to prevent inadvertent rotation of the mandrel 10 with respect to the ratchet sleeve 30. However, such spring does not exert sufficient force to prevent purposeful rotation of the tubular string C and mandrel 10, which will act upon the tapered head 72 of the coupling pin and force it out of the mandrel groove 60, allowing the segmented ring 52 to return inwardly into engagement with the mandrel teeth 54. The parts of the tool are now locked against relative upward movement, allowing the packer A, with its slips 17 and packing 16 retracted, to be elevated within the well casing E.

It is accordingly apparent that a lock device for well tools has been disclosed, in which the one-way clutch 52—54 can be held in its ineffectual position so long as desired, and without fear that the inherent elasticity in the tubing string, or the pump pulsations, or other factors, will cause inadvertent reengagement of the clutch.

The inventor claims:

1. In a well tool adapted for operation in a well bore: inner and outer members movable with respect to each other; clutch means movable with respect to both of said members and engageable with said members for coupling said members together against relative longitudinal movement; means on one of said members engageable with said clutch means to shift said clutch means to an uncoupling position upon rotation of said one of said members, in order to allow relative longitudinal movement between said members; and means on one of said members for holding said members in the relative position they occupy when the clutch means is uncoupled.

2. In a well tool adapted for operation in a well bore: a mandrel connectable to a running-in string for moving said tool within said well bore; a clutch collar surrounding said mandrel; an expansible clutch ring movable with respect to said mandrel and collar and engageable with said mandrel and collar for said mandrel and collar for preventing said mandrel and collar for preventing reverse rotation of said mandrel within said collar, in order to maintain said ring expanded from engagement with said mandrel.

3. In a well tool adapted for operation in a well bore: a mandrel connectable to a running-in string for moving said tool within said well bore; a collar surrounding said mandrel; an expansible clutch ring engageable with said mandrel and collar for coupling them together against relative longitudinal movement; means on said collar engageable with said ring to prevent its rotation; said mandrel having a longitudinal groove therein; means on said ring disposed in said groove and engageable with said mandrel, in order that rotation of said mandrel within said collar will expand said ring from clutching engagement with said mandrel; and means on said collar shiftable into said groove, upon rotation of the mandrel within said collar, to hold said ring in its expanded condition.

4. In a well tool adapted for operation in a well bore: inner and outer members movable with respect to each other; clutch means movable with respect to both of said members and disposed between said members for coupling said members together against relative longitudinal movement; means on one of said members engageable with said clutch means to shift said clutch means to anuncoupling position upon rotation of said one of said members, in order to allow relative longitudinal movement between said members; and a coupling device on said outer member disengaged from said inner member when said clutch means couples said members together and shiftable into releasable engagement with said inner member when said clutch means is being shifted from said coupled to uncoupled condition to hold said clutch means in said uncoupled condition to permit relative longitudinal movement between said members.

5. In a well tool adapted for operation in a well bore: inner and outer members movable with respect to each other; clutch means movable with respect to both of said members and engageable with said members for coupling said members together against relative longitudinal movement when said members occupy a first relative rotary position, means on one of said members engageable with said clutch means to shift said clutch means to an uncoupling position by rotation of said one member with respect to another member to a second relative rotary position; a coupling device mounted on one of said members movable into a position holding the other of said members upon relative rotation of said members to said second position; and means for angularly adjusting said coupling device with respect to the member on which it is mounted.

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