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3,045,752

MILLING APPARATUS FOR REMOVING OBJECTS FROM WELL BORES

Filed March 25, 1958

3 Sheets-Sheet 1

Fig. 1.

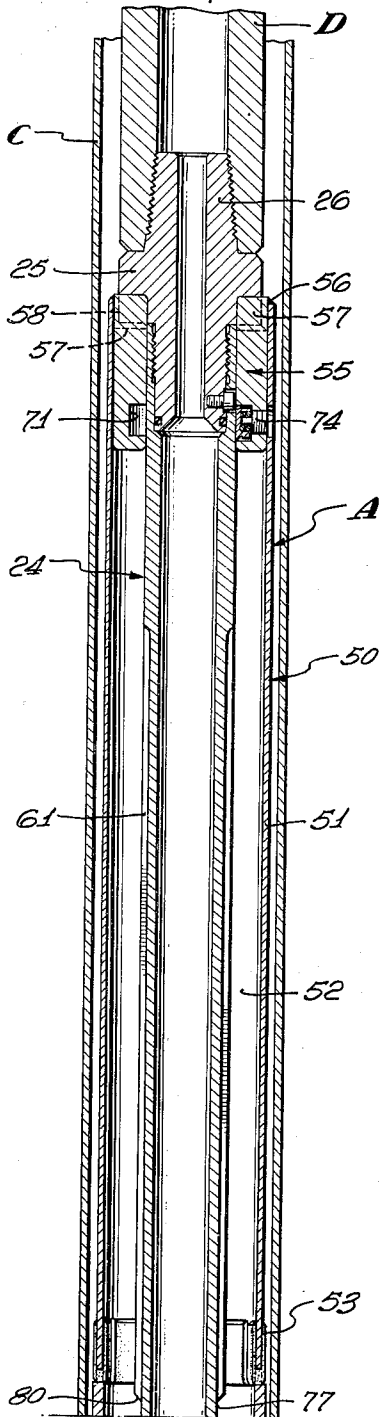
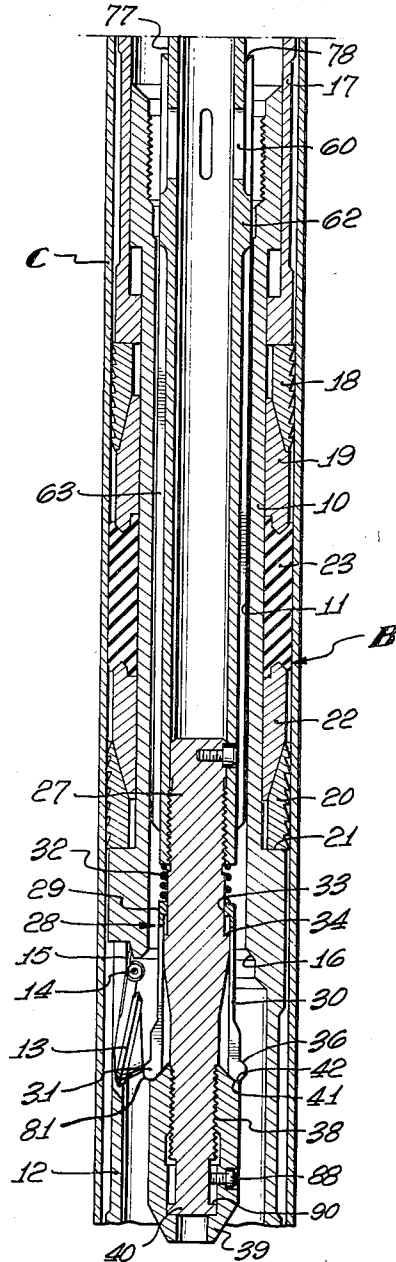


Fig. 1a.



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Fig. 2.

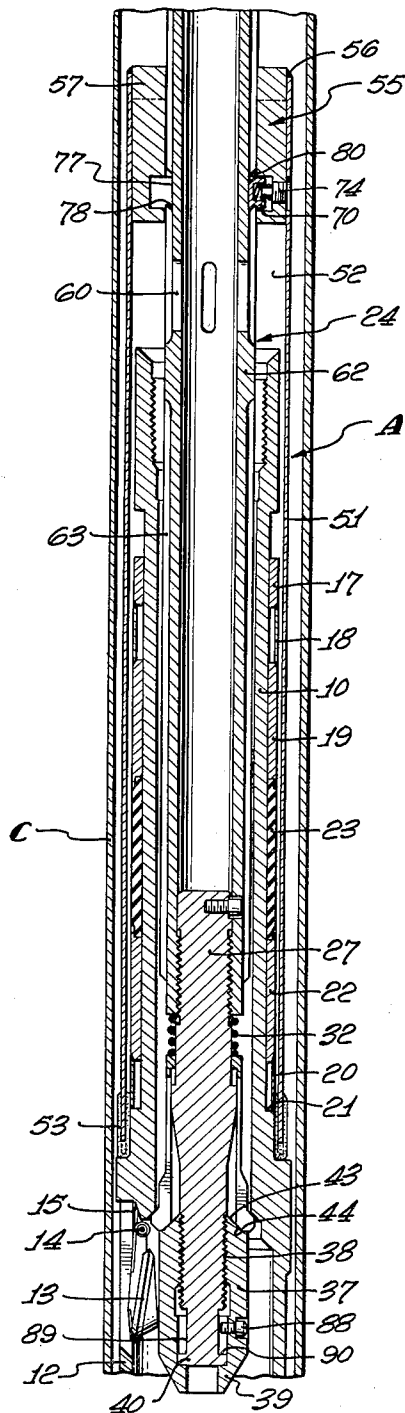
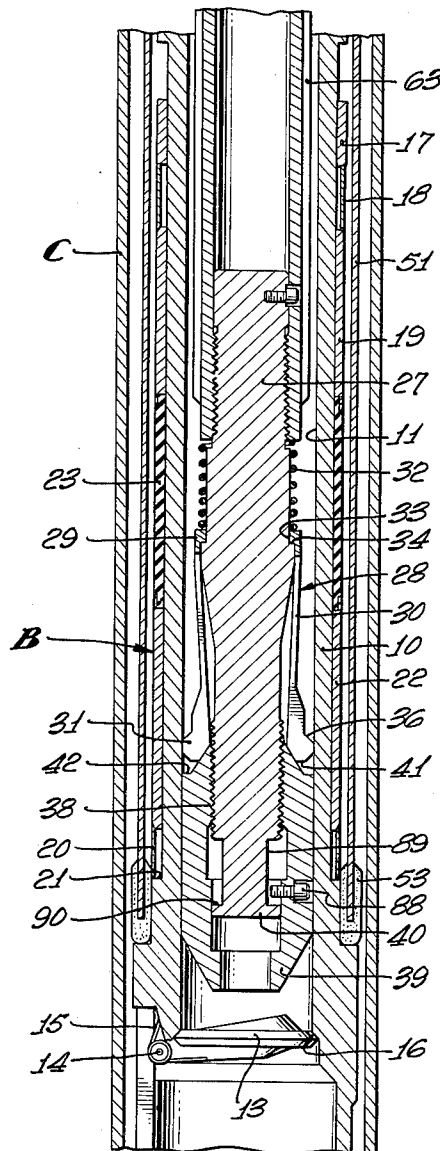


Fig. 3.



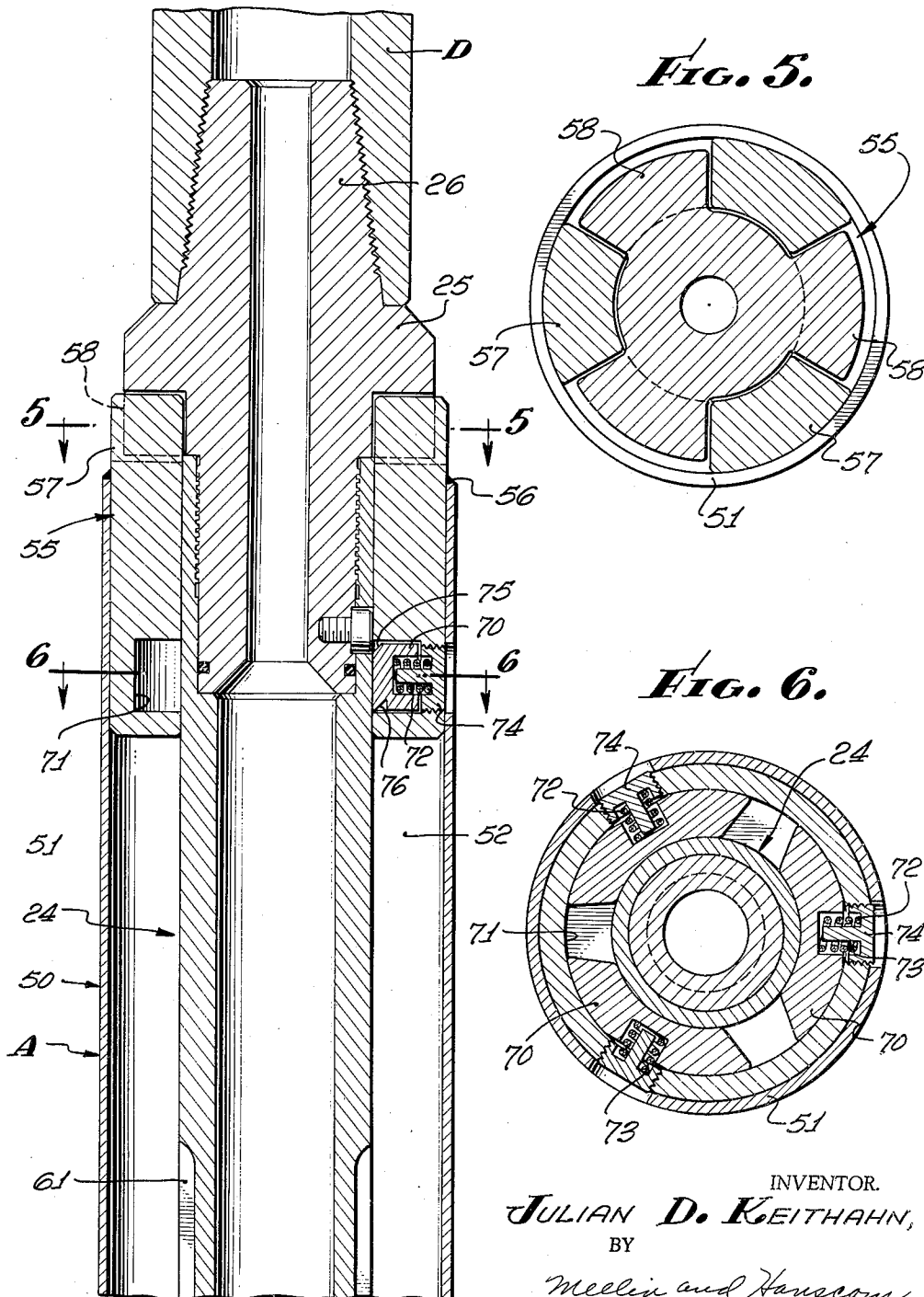
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3 Sheets-Sheet 3

FIG. 5.



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**MILLING APPARATUS FOR REMOVING OBJECTS
FROM WELL BORES****Julian D. Keithahn, Anaheim, Calif., assignor to Baker
Oil Tools, Inc., Los Angeles, Calif., a corporation of
California****Filed Mar. 25, 1958, Ser. No. 723,734****9 Claims. (Cl. 166—55)**

The present invention relates to apparatus for milling away objects from well bores, and more particularly, to milling apparatus for removing well packers, plugs, and the like, secured in well casing, or similar conduits, disposed in the well bores.

An object of the present invention is to provide milling apparatus for releasing a well packer, or similar obstruction, from well casing disposed in a well bore, in which the apparatus need mill or drill away only a comparatively small portion of the packer to effect its release from the well casing and permit bodily removal of the remaining portion of the packer from the well casing. The relatively small portion milled away by the apparatus is the outer or peripheral part of the packer adjacent to the wall of the well casing, the remainder and major portion of the packer remaining intact for withdrawal by the milling apparatus to the top of the well bore.

Another object of the invention is to provide an apparatus capable of milling away and removing, in a comparatively short time, a well packer, or the like, set in a well casing disposed in a bore hole.

A further object of the invention is to provide an apparatus capable of milling away and removing a well packer, or the like, set in a well casing disposed in a well bore, in which only a portion of the packer need be milled away to release it from the well casing, the apparatus being capable of protecting the remainder of the packer as it is withdrawn bodily from the well bore to prevent jamming of a part or parts of the remaining packer against the well casing, which might prevent removal of the packer from the well casing.

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 1a together constitute a longitudinal section of a milling and removing apparatus disposed in conjunction with a well packer set in a well casing, FIG. 1a constituting a lower continuation of FIG. 1;

FIG. 2 is a longitudinal section through the milling apparatus after a portion of the well packer has been milled away, the parts being in relative position for removing the remainder of the well packer from the well casing;

FIG. 3 is a longitudinal section, on an enlarged scale, illustrating the manner of releasing the catch or spear portion of the apparatus to prevent its remaining coupled to the well packer;

FIG. 4 is an enlarged longitudinal section through the upper portion of the milling apparatus;

FIG. 5 is a cross-section taken along the line 5—5 on FIG. 4;

FIG. 6 is a cross-section taken along the line 6—6 on FIG. 4.

The milling and removal apparatus A is specifically illustrated in the drawings in connection with a well packer B anchored in packed-off condition in the well casing C.

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The apparatus is lowered in the well casing to the location of the well packer by means of a tubular running-in string D, such as drill pipe or tubing, extending to the top of the hole. It is through the agency of the tubular running-in string D that the milling apparatus A is rotated to disintegrate a portion of the packer B, and is otherwise manipulated to become coupled to the well packer and effect bodily removal of its major portion from the well casing after the milling action has effected release of the well packer from the casing.

The well packer B illustrated by way of example in the drawings is of a known type. Specific details thereof may be found in U.S. Patent No. 2,624,412. In general, it comprises a tubular body 10 having a central passage 11 therethrough, the lower portion of the body being constituted as a junk pusher and catcher 12 for preventing inadvertent tripping of the well packer when it is run in the well casing and preparatory to its purposeful setting therein. To the lower portion of the body 10 of the tool, a flapper valve 13 is pivotally mounted on a hinge pin 14, being urged upwardly by a spring 15 into sealing engagement with a valve seat 16 in the body surrounding the lower portion of its passage 11, this valve seat being tapered in upward and inward direction, and also functioning as a catch shoulder for the catching or spear portion of the apparatus to be described hereinbelow.

The well packer B further includes an upper setting sleeve 17 engaging the upper ends of a set of upper segmental slips 18 wedged and held outwardly into anchoring engagement with the well casing by an upper expander 19 mounted on the body of the tool. The upper expander 19 and upper slips 18 anchor the well packer against upward movement in the well casing. A lower set of segmental slips 20 rest upon a lower shoulder 21 on the body 10 of the tool and coacts with a lower expander 22 that holds it in anchoring engagement with the wall of the well casing C to prevent downward movement of the well packer therewithin. Between the upper and lower expanders 19, 22 is a packing sleeve 23 of rubber or rubber-like material, which has been foreshortened and expanded outwardly into firm sealing engagement with the wall of the well casing C and the packer body 10. It is desired to release the well packer B from the well casing C and to remove it completely therefrom, so it no longer remains as an obstruction in the well casing. Such purpose is accomplished through use of the milling and removal tool A now to be described.

This last-mentioned tool includes a tubular mandrel 24, the upper end of which is threadedly secured onto an upper sub 25 having an upper threaded pin 26 for threaded attachment to the lower end of the tubular running-in string D which extends to the top of the well bore. The tubular mandrel is elongate and can extend downwardly into the central passage 11 through the body 10 of the well packer, its lower portion being threadedly secured onto the upper end of a pilot mandrel 27, which has a catch sleeve 28 mounted thereon. This catch sleeve 28 has a circumferentially continuous upper portion 29 and a plurality of circumferentially spaced spring-like legs 30 terminating in foot portions 31. The sleeve 28 is urged in a downward direction by a helical compression spring 32 surrounding the pilot mandrel 27, its upper end engaging the tubular mandrel 24 and its lower end engaging the catch sleeve 28. Downward movement of the catch sleeve along the pilot mandrel is limited by engagement of an inwardly directed flange 33 of the catch sleeve with an upwardly facing shoulder 34 on the pilot mandrel 27.

The catch sleeve 28 is adapted to be coupled to the body 10 of the tool when the mandrel 24 is moved upwardly, the spring legs 30 moving up within the body passage 10 and the foot portions 31 being engageable

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with the tapered valve seat or catch shoulder 16. The upper ends 36 of the feet are tapered in an upward and inward direction so as to properly engage with the catch shoulder 16 over a surface of contact. When the feet 31 engage the shoulder 16, they are held in such engaged position by a holding and safety member 37 in the form of a sub threaded onto the lower end of the pilot mandrel 27 by a left-hand threaded connection 38, the upper position of the sub on the pilot mandrel being determined by engagement of the lower end 39 of the sub with the lower end 40 of the pilot mandrel. When the sub is in the position just referred to, the spring 32 urges the catch sleeve 28 downwardly to place the lower ends 41 of its feet in engagement with a transverse shoulder 42 on the holding sub which is at right angles to the axis of the pilot mandrel 27, at which time an upwardly and inwardly tapering holding surface 43 on the sub engage companion surfaces 44 on the inner, lower portions of the feet. The flange 33 of the catch sleeve will then be spaced above the shoulder 34 on the pilot mandrel, the feet 31 projecting laterally outwardly beyond the diameter of the body passage 11, so that the inclined catch surfaces 36 on the feet can engage the catch shoulder or valve seat 16 at the lower portion of the body 10.

Surrounding the tubular mandrel 24 and in laterally spaced relation thereto is a drilling bit or milling tool 50, which includes an elongate shank 51 forming an annular space 52 with the tubular mandrel 24. The lower portion of the tool shank 51 is suitably secured to a washover shoe 53 of generally annular shape, which is also spaced substantially from the exterior of the tubular mandrel 24. This washover shoe has cutting elements suitably welded or brazed thereon, such as tungsten carbide or diamonds held in a suitable matrix, in a known manner. The outside diameter of the washover shoe 53, and, for that matter, of the shank 51 of the tool, is but slightly less than the inside diameter of the well casing C, whereas the inside diameter of the washover shoe, and also of the tool shank, is also quite large, being substantially greater than the inside diameter of the body passage 11, and, for that matter, substantially greater than the inside diameter of the expanders 19, 22 of the well packer. The washover shoe 53 has a radial thickness sufficient for adequate strength, so that it will withstand the drilling load to which it is subjected when operating in the well bore.

The washover portion of the tool 50 is coupled to the mandrel portion 24 and the upper sub 25 thereof to rotate therewith. Thus, the shank 51 of the tool is disposed around and is suitably secured to a driven clutch member 55, as by means of welding material 56, this driven clutch member being slidable along the tubular mandrel 24 and adapted to occupy an upper position in engagement with the upper sub 25. When in such upper position, circumferentially spaced axial clutch teeth or dogs 57 on the driven member are disposed between companion driving clutch teeth 58 on the upper sub 25, such that the sub 25 and the milling tool 50 are coupled to one another for rotation, the rotary motion of the tubular drill string D then being transferred through the sub 25 to the washover tool 50, so that its shoe 53 is caused to rotate upon the well packer B and mill or drill portions of it away.

It is to be noted that the tubular mandrel 24 and the pilot mandrel 27 will extend into the body passage 11 when the washover shoe 53 engages the upper end of the well packer B, such as the upper end of its sleeve 17. In fact, when the washover shoe 53 first engages the well packer, the catch sleeve 28 and its feet 31 may be disposed below the body catch shoulder 16. Rotation of the drill string D and the milling and washover tool 50 may now commence, the washover shoe 53 performing a cutting action on the packer sleeve 17. During such rotation and cutting action, drilling fluid is circulated down through the drill string D, through the sub 25 and

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the tubular mandrel 24, the fluid discharging through circulation ports 60 in the mandrel and then passing upwardly around the mandrel 24 into the shank 51 from where the fluid will flow around the lower portion of the washover shoe 53, the lower end of which may have radial water grooves or passages therein (in a known manner) to carry the cuttings away from the cutting region and flush them upwardly around the milling tool 50 and the tubular string D back towards the top of the hole. To insure that the circulating fluid will pass out through the circulation ports 60 and then upwardly around the tubular mandrel 24, the exterior of the mandrel is provided with a plurality of longitudinal extending circulation grooves 61. The lower ends of these grooves terminate in an ungrooved or circumferentially continuous barrier portion 62 which may make a close fit with the wall of the packer body passage 11. The fit actually need not be a close one, but may be somewhat loose, the fluid still being prevented from passing to any substantial extent downwardly past the circumferentially continuous barrier portion 62. It is found that a somewhat loose fit of the mandrel 24 in the packer body 10 enables the apparatus to perform more effectively in milling away portions of the well packer or other barrier in the well casing. To insure that the mandrel 24 will not become stuck in the body 10 of the well packer, in the event that small particles of milled away material drop into the body passage 11, the lower portion of the mandrel may also be provided with a plurality of longitudinal relief grooves 63 opening into the lower portion of the mandrel. Any cuttings that might tend to drop into the body passage 11 can continue through the longitudinal relief grooves 63 and drop out through the lower end of the packer passage 11.

The apparatus is rotated at the proper speed and the appropriate amount of drilling weight imparted to the washover shoe 53, which will mill away the outer peripheral portions of the well packer B adjacent to the wall of the well casing. As the washover shoe proceeds to disintegrate such outer portions of the well packer, the tubular mandrel 24 will move down to a further extent into the packer body 10. However, the circulating fluid will still pass out through the circulation ports 60 up through the interior of the packer body 10 and around its upper end into the milling tool 50, passing around the upper end of the body 10 and down between the body and the shank 51 of the milling tool to the washover shoe 53, where it will flush the cuttings away from the cutting region and carrying them upwardly around the shank 51 of the milling tool 50 and the exterior of the tubular running-in string D toward the top of the well bore. During the time that the washover shoe 53 is cutting away the outer portions of the well packer B, the remaining inner portions of the well packer can pass relatively upwardly into the annular space 52 between the tubular mandrel 24 and the shank 51 of the tool.

The milling action continues until the well packer B has been released from the well casing, which usually will occur when the shoe 53 has disintegrated the outer portions of the well packer down through the lower slips 20 (FIG. 2). When this occurs, the body 10 of the tool and the remaining packer portions surrounding it, such as parts of the upper slips 18, upper expander 19, packing sleeve 23, lower expander 22, and lower slips 20, will drop downwardly by gravity with respect to the milling tool 50, as limited by engagement of the catch shoulder or valve seat 16 with the catch sleeve feet 31. The tubular string D is now elevated, to raise the upper sub 25 and the mandrel 24, the catch feet 31 being coupled to the catch shoulder 16 and body 10, carrying all the parts upwardly, until the shoe 53 reengages the well packer once again at the point where drilling ceased. Elevation of the tubular string D and the apparatus A can then continue, the remaining portions of the well

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packer being held between the mandrel 24 and the milling tool 50, and being brought with such apparatus upwardly to the top of the well bore.

When the tubular mandrel 24 is elevated for the purpose of engaging the catch members 31 with the catch shoulder 16 on the body, the driving and driven clutch teeth 58, 57 become uncoupled, and the milling tool 50 moves downwardly relatively along the tubular mandrel 24. Such downward movement is limited by coupling elements 70 carried by the driven head or clutch element 55 of the milling tool. These coupling elements 70, which are best seen in FIGS. 4 and 6, may consist of arcuate segments disposed in an internal groove 71 in the driven clutch head and urged inwardly by helical compression springs 72 disposed in sockets 73 in each segment or dog and bearing against spring seats 74 threaded radially into the driven clutch member 55. The upper ends 75 of the segments are dubbed, tapering in a downward and inward direction, whereas their lower ends 76 are undercut so as to provide tapered shoulders inclined in a downward and inward direction.

The tubular mandrel 24 can be elevated relatively to the shank 51 of the milling tool to the extent limited by inward movement of the dogs or arcuate coupling segments 70 into an external groove 77 provided in the tubular mandrel. When the segments 70 are shifted by the springs 72 into this groove, further upward movement of the tubular mandrel 24 relative to the shank 51 of the tool 50 and the driven clutch head 55 cannot occur. The lower shoulder 78 defining the lower side of the groove is inclined in a downward and inward direction, engaging the companion lower surfaces 76 of the dogs 70 to hold them in an inward position. The groove 77 is located in such position that the segments 70 cannot enter it, upon elevation of the tubular mandrel 24, before the catch feet 31 engage the catch shoulder 16 on the body 10. Normally, the catch sleeve feet will engage the catch shoulder before the segments 70 can enter the groove 77, the upward elevation of the tubular mandrel 24 then carrying the body 10 upwardly with it, this body engaging the washover shoe 53 to carry the latter upwardly in the well casing C with it. However, if, for some reason, the foot portions 31 of the catch sleeve do not become coupled to the body 10 of the tool, then upward movement of the tubular mandrel 24 can occur relative to the milling tool 50 until the groove 77 of the mandrel is opposite the segments 70, whereupon the latter will spring into the groove and couple the mandrel 24 to the milling tool 50, the mandrel and milling tool then moving upwardly as a unit.

When the tubular mandrel 24 is moved upwardly, the clutch teeth 57, 58 become disengaged and rotary motion can no longer be transmitted from the drill string D to the milling tool 50. If the tubular mandrel 24 has been elevated for some reason to the extent in which the lock segments 70 enter the groove 77, lowering of the apparatus toward the well packer B can result in a release of the lock segments 70 from the groove 77 and a downward movement of the tubular mandrel 24 within the milling tool 50 to the extent in which the clutch teeth 57, 58 reengage, so that rotary motion can again be transmitted from the drill string D to the milling tool 50. Such release of the segments 70 occurs because of the engagement of the upper inclined side 80 of the mandrel groove, which tapers in a downward and inward direction, with the companion tapered portions 75 on the segments, such engagement camming the segments 70 outwardly, whereupon they will then slide along the periphery of the mandrel 24 as the latter is lowered with respect to the milling tool 50.

It will be evident that, upon lowering the apparatus A in the well casing C toward the well packer B which is to be removed, the feet 31 of the catch sleeve 28 will engage the upper end of the packer body 10, the outer lower portions 81 of such feet being tapered in a down-

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ward and inward direction, causing the sleeve 28 to move upwardly along the pilot mandrel 27 against the force of the compression spring 32 and allowing the feet 31 to shift inwardly of the holding portion or sub 37 attached to the mandrel 27 and move into and through the body 10 of the well packer to a position below the catch shoulder 16. When disposed below the catch shoulder the spring 32 will reshift the catch sleeve 28 downwardly, its feet moving along the tapered holding surface 43 and shoulder 42 to place the outer portions of the feet 31 laterally outward beyond the internal diameter of the body, placing them in position to engage the catch shoulder 16 when the mandrel 24 is elevated within the packer body 10.

After the milling operation has been performed on the well packer B to the desired extent, in which the latter is free from the well casing C, and the catch feet 31 have engaged under the catch shoulder 16, should upward movement of the well packer not occur for some reason, the catch feet can be released from the shoulder by rotating the tubular running-in string D, sub 25 and mandrels 24, 27 to the right, while the catch feet 31 engage the shoulder 16. During such engagement, the holding and safety sub 37 is prevented from rotation, the rotation of the mandrels moving them upwardly, due to the threading action of the pilot mandrel 27 within the safety sub 37, the mandrel shoulder 34 engaging the catch sleeve flange 33 to pull the catch sleeve upwardly of the body 10 of the tool, the feet 31 being forced by the inclined catch shoulder 16 inwardly until they are disposed within the body passage 11. The mandrel 24 can then be moved upwardly completely through the body passage 11, the mandrel groove 77 coming opposite the segments 70, which will spring thereto, the mandrel 24 then carrying the milling tool 50 upwardly with it for withdrawal from the well bore.

To insure against the complete unthreading of the holding and safety sub 37 from the pilot mandrel 27, a stop device is provided in the form of a screw 88 threaded laterally into the sub 37 and extending into an elongate circumferential groove 89 in the pilot mandrel. Relative unthreading of the sub can only occur to the extent in which the screw 88 engages the lower end 90 of the groove 89.

It is accordingly, apparent that an apparatus for milling and removing objects from well bores has been provided which need only mill away a comparatively small portion of the object, which is the portion adjacent the wall of the well casing, to effect release of the object from the well casing, whereupon the apparatus becomes coupled to the remaining portion of the object and can elevate it from the well casing to the top of the bore hole. In view of the fact that only a relatively small portion of the object need be milled away, release of the object occurs in a comparatively short period, effecting great savings in rig time and money. The remaining portions of the well packer are protected by the milling tool itself, thereby preventing inadvertent jamming of such packer portion against the well casing while the apparatus and the remaining packer portion are being withdrawn from the well casing. The milling tool, in effect, serves as a protective shield for the well packer. In the event the well packer portion that remains cannot be withdrawn from the well casing, the apparatus is releasable from the well packer for removal from the well casing.

The inventor claims:

1. In apparatus for milling a well tool set in a well conduit disposed in a bore hole, the well tool having a passage therein; supporting means adapted to be run in the well conduit to the well tool on a running-in string; cutter means operatively connected to and rotatable with said supporting means and having a portion spaced outwardly therefrom to cut an outer portion of the well tool and to define an annular space with said supporting means for reception of the inner portion of the well tool; a pilot

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secured to said supporting means and adapted for insertion in the passage to center the cutter means with respect to the well tool; and means on said pilot adapted to be coupled to the well tool to enable the running-in string to elevate the well tool in the well conduit with the cutter means enclosing the inner portion of the well tool.

2. In apparatus for milling a well tool set in a well conduit disposed in a bore hole, the well tool having a passage therein: a mandrel adapted to be connected to a tubular running-in string and lowered in the well conduit to the well tool; an elongate milling tool including a hollow shank secured to said mandrel to rotate therewith and an annular milling shoe on the lower end of said shank, said shank and shoe being spaced laterally outwardly of said mandrel to define an annular space therewith extending upwardly from said shoe, whereby said shoe is adapted to cut an outer portion of the well tool while the remaining inner portion of the well tool enters said annular space; a pilot secured to said mandrel for reception in the passage to center the milling tool with respect to the well tool; and means on said pilot adapted to be coupled to the well tool to enable the running-in string to elevate the well tool in the well conduit with said shank enclosing the inner portion of the well tool.

3. In apparatus for milling a well tool set in a well conduit disposed in a bore hole, the well tool having a passage therein: a mandrel adapted to be connected to a tubular running-in string and lowered in the well conduit to the well tool; an elongate milling tool surrounding and slidable along said mandrel including a hollow shank and an annular milling shoe on the lower end of said shank; clutch means on said shank and mandrel for coupling said shank and mandrel to each other, said clutch means being engaged when said mandrel is in a lower position with respect to said shank and released when said mandrel is in an upper position with respect to said shank; said shank and shoe being spaced laterally outwardly of said mandrel to define an annular space therewith extending upwardly from said shoe, whereby said shoe is adapted to cut an outer portion of the well tool while the remaining inner portion of the well tool enters said annular space; a pilot secured to said mandrel for reception in the passage to center the milling tool with respect to the well tool; and means on said pilot adapted to be coupled to the well tool to enable the running-in string to elevate the well tool in the well conduit after cutting of the outer portion of the well tool.

4. In apparatus for milling a well tool set in a well conduit disposed in a bore hole, the well tool having a passage therein: a mandrel adapted to be connected to a tubular running-in string and lowered in the well conduit to the well tool; an elongate milling tool surrounding and slidable along said mandrel including a hollow shank and an annular milling shoe on the lower end of said shank; clutch means on said shank and mandrel for coupling said shank and mandrel to each other, said clutch means being engaged when said mandrel is in a lower position with respect to said shank and released when said mandrel is in an upper position with respect to said shank; said shank and shoe being spaced laterally outwardly of said mandrel to define an annular space therewith extending upwardly from said shoe, whereby said shoe is adapted to cut an outer portion of the well tool while the remaining inner portion of the well tool enters said annular space; a pilot secured to said mandrel for reception in the passage to center the milling tool with respect to the well tool; and means on said pilot adapted to be coupled to the well tool to enable the running-in string to elevate the well tool in the well conduit with said shank enclosing the inner portion of the well tool.

5. In apparatus for milling a well tool set in a well conduit disposed in a bore hole, the well tool having a passage therein: a mandrel adapted to be connected to a tubular running-in string and lowered in the well conduit

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to the well tool; an elongate milling tool surrounding and slidable along said mandrel including a hollow shank and an annular milling shoe on the lower end of said shank; clutch means on said shank and mandrel for coupling said shank and mandrel to each other, said clutch means being engaged when said mandrel is in a lower position with respect to said shank and released when said mandrel is in an upper position with respect to said shank; said shank and shoe being spaced laterally outwardly of said mandrel to define an annular space therewith extending upwardly from said shoe, whereby said shoe is adapted to cut an outer portion of the well tool while the remaining inner portion of the well tool enters said annular space; a pilot secured to said mandrel for reception in the passage to center the milling tool with respect to the well tool; means on said pilot adapted to be coupled to the well tool to enable the running-in string to elevate the well tool in the well conduit after cutting of the outer portion of the well tool; and means for connecting said mandrel to said milling tool for joint longitudinal movement when said mandrel is in an upper position with respect to said shank.

6. In apparatus for milling a well tool set in a well conduit disposed in a bore hole, the well tool having a passage therein and a downwardly facing shoulder surrounding said passage: a mandrel adapted to be connected to a tubular running-in string and lowered in the well conduit to the well tool; an elongate milling tool surrounding and slidable along said mandrel including a hollow shank and an annular milling shoe on the lower end of said shank; clutch means on said shank and mandrel for coupling said shank and mandrel to each other, said clutch means being engaged when said mandrel is in a lower position with respect to said shank and released when said mandrel is in an upper position with respect to said shank; said shank and shoe being spaced laterally outwardly of said mandrel to define an annular space therewith extending upwardly from said shoe, whereby said shoe is adapted to cut an outer portion of the well tool while the remaining inner portion of the well tool enters said annular space; a pilot secured to said mandrel for reception in the passage to center the milling tool with respect to the well tool; and means on said pilot adapted to be coupled to said shoulder to enable the running-in string to elevate the well tool in the well conduit with said shank enclosing the inner portion of the well tool.

7. In apparatus for milling a well tool set in a well conduit disposed in a bore hole, the well tool having a passage therein and a downwardly facing shoulder surrounding said passage: a mandrel adapted to be connected to a tubular running-in string and lowered in the well conduit to the well tool; an elongate milling tool surrounding and slidable along said mandrel including a hollow shank and an annular milling shoe on the lower end of said shank; clutch means on said shank and mandrel for coupling said shank and mandrel to each other, said clutch means being engaged when said mandrel is in a lower position with respect to said shank and released when said mandrel is in an upper position with respect to said shank; said shank and shoe being spaced laterally outwardly of said mandrel to define an annular space therewith extending upwardly from said shoe, whereby said shoe is adapted to cut an outer portion of the well tool while the remaining inner portion of the well tool enters said annular space; a pilot secured to said mandrel for reception in the passage to center the milling tool with respect to the well tool; and means on said pilot adapted to be coupled to said shoulder to enable the running-in string to elevate the well tool in the well conduit with said shank enclosing the inner portion of the well tool; said coupling means being so located with respect to said clutch means as to be disposed below the shoulder when the clutch means is engaged and said shoe is contacting the well tool.

8. In apparatus for milling a well tool set in a well conduit disposed in a bore hole, the well tool having a passage therein and a downwardly facing shoulder surround-

ing said passage: a mandrel adapted to be connected to a tubular running-in string and lowered in the well conduit to the well tool; an elongate milling tool surrounding and slidable along said mandrel including a hollow shank and an annular milling shoe on the lower end of said shank; clutch means on said shank and mandrel for coupling said shank and mandrel to each other, said clutch means being engaged when said mandrel is in a lower position with respect to said shank and released when said mandrel is in an upper position with respect to said shank; said shank and shoe being spaced laterally outwardly of said mandrel to define an annular space therewith extending upwardly from said shoe, whereby said shoe is adapted to cut an outer portion of the well tool while the remaining inner portion of the well tool enters said annular space; a pilot secured to said mandrel for reception in the passage to center the milling tool with respect to the well tool; means on said pilot adapted to be coupled to said shoulder to enable the running-in string to elevate the well tool in the well conduit with said shank enclosing the inner portion of the well tool; said coupling means being so located with respect to said clutch means as to be disposed below the shoulder when the clutch means is engaged and said shoe is contacting the well tool; and means for connecting said mandrel to said milling shoe for joint longitudinal movement when said mandrel is in an upper position with respect to said shank.

9. In apparatus for milling a well tool set in a well conduit disposed in a bore hole; a mandrel adapted to be connected to a tubular running-in string and lowered in the

well conduit to the well tool; an elongate milling tool surrounding and slidable along said mandrel including a hollow shank and an annular milling shoe on the lower end of said shank; clutch means on said shank and mandrel for coupling said shank and mandrel to each other, said clutch means being engaged when said mandrel is in a lower position with respect to said shank and released when said mandrel is in an upper position with respect to said shank; said shank and shoe being spaced laterally outwardly of said mandrel to define an annular space therewith extending upwardly from said shoe, whereby said shoe is adapted to cut an outer portion of the well tool while the remaining inner portion of the well tool enters said annular space; and means on said mandrel for coupling said mandrel to the well tool to enable the running-in string to elevate the well tool in the well conduit after cutting of the outer portion of the well tool.

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