United States Patent [19]

Young

[11] **3,749,167**

[45] **July 31, 1973**

[54] **WELL TOOL ANCHORING APPARATUS**

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[22] Filed: **May 26, 1972**

[21] Appl. No.: **257,086**

[52] **U.S. Cl.** **166/217,** 166/134

[51] **Int. Cl.** **E21b 23/06**

[58] **Field of Search** 166/216, 217, 206, 166/118, 134, 135, 138, 139

[56] **References Cited**

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Attorney—Ernest R. Archambeau, Jr., David L. Moseley et al.

[57] **ABSTRACT**

In accordance with an illustrative embodiment of this invention, an anchoring system for a retrievable well tool includes unitary slip elements that are expanded and retracted by the movement of associated slip expanders in opposite longitudinal directions. The expanders and slip elements have companion inclined expander surfaces and oppositely disposed retractor surfaces with the angle of inclination of the retractor surfaces being substantially greater than the angle of inclination of the expander surfaces to prevent binding during expansion of the slip elements.

12 Claims, 5 Drawing Figures

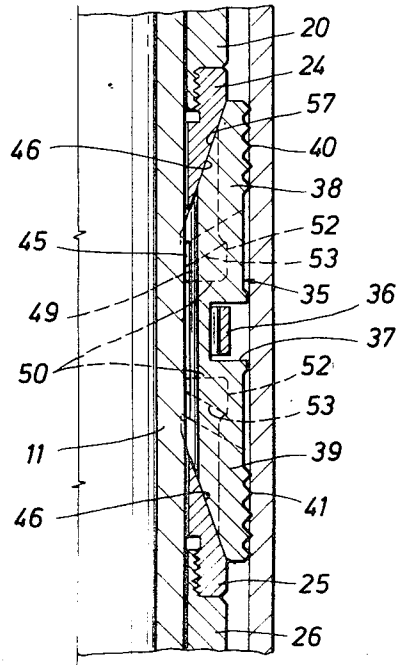


FIG. 1

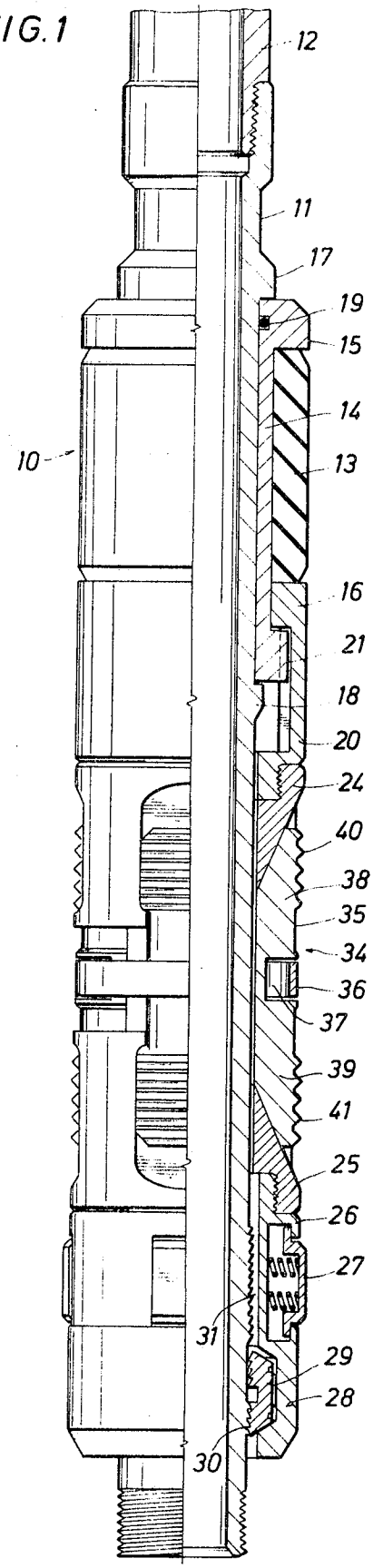


FIG. 2

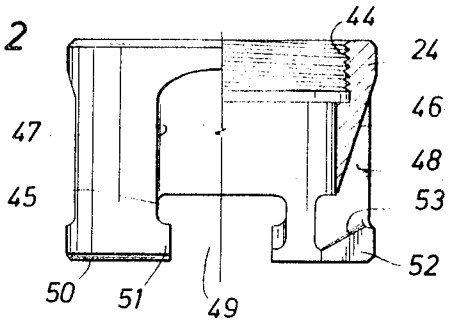


FIG. 3

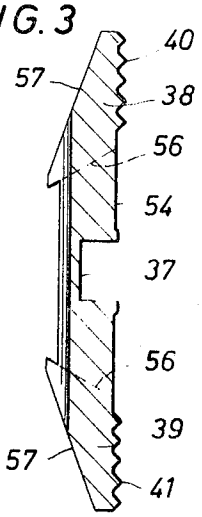


FIG. 4

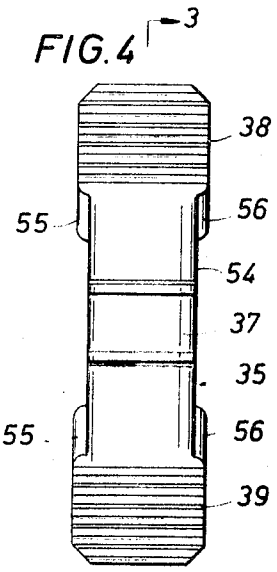
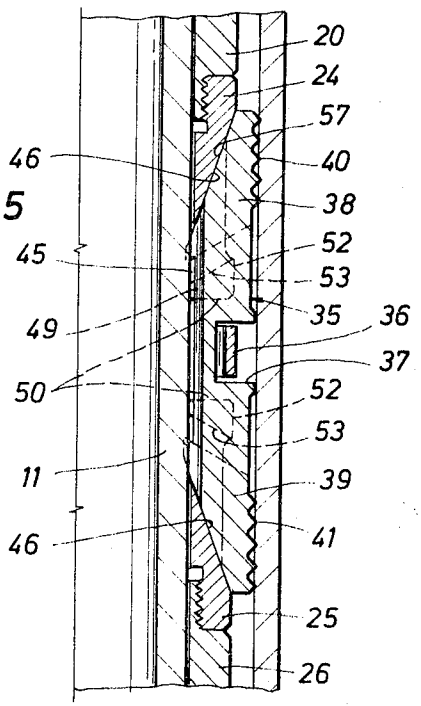


FIG. 5



WELL TOOL ANCHORING APPARATUS

This invention relates generally to well tools that are anchored against longitudinal movement in a well bore, and more specifically to a new and improved anchoring system for a well tool, such as a retrievable packer or a plug or the like, including slips that are expanded and positively retracted by associated expander means.

It is typical practice in anchoring a well tool against movement in either longitudinal direction to provide opposed expanders that are movable relatively toward each other in order to expand a set of normally retracted slips. The expanders each have outwardly facing inclined surfaces that slide against mating inner surfaces on the respective slip elements to wedge the slips laterally outwardly until the toothed outer peripheries thereof bite into and grip the surrounding well casing wall. Moreover, where the well tool is to be retrievable it is desirable to be able to reposition the slip elements in the retracted position when the expanders are moved relatively away from one another. Retractive movement has been accomplished in several ways with perhaps the most typical construction being to provide tongue and groove slidable spline connections between the rear or the side surfaces of each slip element and companion surfaces of the expanders, the connections causing each slip element to be drawn inwardly. An overriding consideration in the design of such structures is to prevent binding of the slidable splines during expansion of the slip elements, since once binding occurs the effects are cumulative and additional force will only generate a greater binding action and can prevent the slips from being set at all.

Several mechanisms have been used heretofore for setting as well as retracting a plurality of circumferentially spaced slip elements. One system is disclosed in U. S. Pat. No. 3,507,327, wherein upper and lower separate sets of slips have slidable spline connections to the respective adjacent expanders and to a carrier ring located between the sets of slips. The slidable splines are in the form of tongue and groove connections between the side faces of the slips and the expanders as discussed above, and between the ends of the slips and the carrier ring. This construction, although reducing the possibility of binding action during setting, is considered to be an unduly complex structural arrangement resulting in elevated manufacturing costs, due primarily to the sheer magnitude of separate connections involved. Another system is shown in U. S. Pat. No. 3,279,542, wherein the slip elements are single units that are disposed within windows of a slip cage and are not directly coupled to the opposed expanders. In this case the slip elements are not positively retracted by movement of expanders away from one another, which means that the slip elements can possibly drag against, or hang up on, internal wall surfaces of the well casing during running and retrieving, with resultant damage to the slip teeth or other parts of the packer.

The principle object of this invention is to provide a new and improved anchoring system including slip elements that are both expanded and positively retracted in response to movement of opposed expanders relative to each other, the system being constructed and arranged to prevent binding during setting as well as being simplified to reduce manufacturing costs.

This and other objects are attained in accordance with the concepts of the present invention through the provision of an anchoring structure comprising a body member that carries a plurality of unitary slip means located between opposed expander means that are movable relatively toward each other and have inclined outer surfaces that slide against inclined inner surfaces on the slip means to shift the slip means outwardly. The slip and expander means are further provided with coengageable retractor surfaces that are also inclined and adapted to shift the slip means inwardly in response to movement of the expander means away from each other. However, the retractor surfaces are spaced longitudinally and angularly arranged with respect to the expander surfaces in a manner such that the retractor surfaces are in engagement only over the initial and the final portions of movement of the expanders with respect to the slip means. The spacing prevents any binding action during expansion and yet provides for positive retraction of the slip elements by the expanders to enable retrieval. As an additional feature of the present invention, the angle of the retractor surfaces with respect to vertical is chosen such that the rate of lateral movement of the slip elements is substantially greater during retraction than during expansion.

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, taken in conjunction with the accompanying drawings in which:

FIG. 1 is a somewhat schematic view of a well packer apparatus that incorporates the present invention and is shown with parts in the running-in position;

FIG. 2 is a sectional view, with portions in side elevation, of a slip expander member in accordance with this invention;

FIGS. 3 and 4 are side sections and frontal views, respectively, of a slip member that coacts with the expander member of FIG. 2; and

FIG. 5 is fragmentary cross-sectional view to illustrate the relationship of the parts when the slips are set against a well casing.

Referring initially to FIG. 1, there is shown somewhat schematically a well tool 10 which incorporates an anchoring system that is constructed in accordance with the principles of the present invention. The well tool 10 includes a central body member or mandrel 11 having its upper end connected to a tubing string 12 and which carries settable packing 13 mounted around a compression sleeve 14 having a fixed upper abutment 15 that engages the upper end of the packing. A lower abutment 16 engages the lower end of the packing 13 and is movable relatively along the sleeve 14, the abutments being movable toward each other to cause compression and expansion of the packing into sealing contact with a well casing wall. The compression sleeve 14 can be coupled against movement along the mandrel 11 by spaced apart, outwardly directed shoulder 17 and 18, and a suitable seal ring 19 prevents fluid leakage between the members. Alternatively, a fluid bypass passage can be arranged between the sleeve 14 and the mandrel 11 and adapted to be closed off by a valve head at the upper end portion of the mandrel. The lower abutment 16 is fixed to the upper end of a support sleeve 20 that is corotatively coupled by splines 21 to the lower end section of the compression sleeve, the support sleeve having its lower end connected to an

upper expander member 24. A lower expander expander member 25 is carried by the mandrel 11 and is disposed in opposition to the upper expander member 24, and a friction drag assembly 26 that may include, for example, spring biased drag blocks 27, in connected to the lower expander member. A clutch mechanism 28 is located between the drag assembly 26 and the mandrel 11 and includes a segmented clutch nut 29 having opposite hand threads that coact with spaced threaded sections 30 and 31 of the mandrel 11 to releasably lock the parts in either the running-in or the set position. The clutch is released in either case by rotating the mandrel 11 as will be recognized by those skilled in the art, and further details both as to construction and operation may be had by reference to U. S. Pat. No. 3,420,951, assigned to the assignee of this invention.

A set 34 of normally retracted, unitary slip elements 35 are disposed around the mandrel 11 in between the upper and the lower expander members 24 and 25. The plurality of slip elements, for example four, are maintained in the same horizontal plane through use of a band 36 that encircles the elements and is engaged within inwardly directed recesses 37 in each element. The head portions 38 and 39 of each slip element 35 are provided with wickers or teeth 40 and 41 that are adapted to grip the wall of a well casing to prevent movement in either longitudinal direction. The slip elements 35 are arranged to be shifted outwardly by movement of the expander members 24 and 25 toward each other, and to be shifted inwardly to retracted positions by movement in the opposite direction as will be described more fully herebelow.

FIG. 2 is a view to show detail of the upper expander member 24, and it will be appreciated that the lower expander member 25 has a substantially identical configuration but with opposite orientation, so that reference numerals apply equally to both parts. The expander member 24 is formed to have a generally tubular configuration and has internal threads 44 for connection to the sleeve 20. The member 24 is provided at circumferentially spaced locations with recesses 45 that receive the upper head portions 38 of the slip elements 35. Each recess 45 is defined by a flat rear wall surface 46 that is inclined downwardly and inwardly and extends between parallel side walls 47 and 48. The recess 45 opens at 49 through the lower end surface 50 of the member 24 on a circumferential dimension that is less than the width of the inclined surface 46 so

Referring now to FIGS. 3 and 4, the head portions 38 and 39 to either end of each slip element 35 are somewhat wider than the connecting central portion 54, thereby to provide side projections with forwardly facing retractor surfaces 55 and 56 that are inclined on same angle as the respective retractor surfaces 53 of the expander members. As shown each head portion is wedge-shaped to have an inner surface 57 that is companion in shape and inclination to the respective inclined surface 46 of the expander member 24. When the parts are fitted together, of course the head portions 38 and 39 are disposed with the recesses 45, and the connecting portions 54 extend through the openings 49.

In operation, the parts are assembled as shown in the drawing and the slip elements 35 and the packing 13 occupy retracted positions as the tool is lowered into the well bore to setting depth. The expander members 24 and 25 are spaced the maximum distance away from one another, and the retractor surfaces 53 and 56 are engaged to hold the slip elements 35 in their inner positions along side the mandrel 11. Of course the packing 13 is not loaded and is also retracted. The drag blocks 27 slide along the casing, and the parts are locked in retracted positions since the clutch nut 29 is engaged with the lower mandrel threads 30.

To set the tool, the pipe string 12 is rotated to the right to unthread from the clutch nut 29, whereupon the pipe string is lowered away to set the slip elements 35 and to expand the packing 13. Since the drag blocks 27 prevent downward movement of the lower expander member 25, lowering the mandrel 11 results in advancing the upper expander member 24 toward the lower expander member. The inclined surfaces 46 and 57 slide relative to one another to cuase outward shifting of each slip element 35 until the teeth 40 and 41 grip the wall of the well casing as shown in FIG. 5. When this occurs, the upper expander member 24 cannot be moved any further downwardly, and thus supports the lower abutment 16 against downward movement. The application of the weight of the pipe string 12 to the mandrel 11 causes the compression sleeve 14 withthe fixed abutment 15 to move downwardly relative to the lower abutment, thereby compressing and exapnding the packing 13 into sealing contact with the well casing. The upper threads 31 on the mandrel 11 ratchet into the clutch nut 29, which traps the mandrel and the balance of the parts in the set condition.

In set condition, of course, the inclined surfaces 46 and 57 are of course engaged, however the retractor surfaces 53 and 56 have moved substantially apart due to the high inclination angle of the retractor surfaces in relation to the expander surfaces. Thus during setting movement it is highly unlikely, if not impossible, for the slip elements 35 to bind because of slight tilting action that may occur during such movement. In other words, during a substantial portion to the relative movement that occurs during setting, the retractor surfaces 53 and 55 are receeding from one another and will not come into binding contact. Moreover, it is possible for one expander member to move somewhat away from the other, for one reason or another after the slips are set, without any inward force being exerted on the slip element which is advantageous in retaining the anchored condition during pressure reversals or the like after the tool has been set.

When it is desired to retract the slip elements 35 and the packing 13, the mandrel 11 is rotated to the right to unthread upwardly out of the clutch nut 29, whereupon the mandrel can be elevated. The upper abutment 15 is moved away from the lower abutment 16 so that the packing 13 can inherently relax, and the upper expander member 24 eventually is moved upwardly away from the lower expander meber 25. Over a final portion of the movement of the expanders away from one another, the retractor surfaces 53 and 55 come back into engagement and cam the slip elements 35 inwardly. Due to the relatively large angle of the retractor surfaces, the slip elements 35 are shifted rather abruptly inwardly compared to the rate of outward movement. When the lower mandrel threads 31 have ratcheted back into engagement with the clutch nut 29, the parts of the packer are in the running position for removal from the well, or perhaps dispatch to another setting level in the well.

It will now be recognized that a new and improved anchoring system has been disclosed for use in connection with retrievable well tools such as packers, plugs and tubing anchors. The unique arrangement of expander and retractor surfaces prevents binding during setting, and provides for positive retraction of the slips during release. The present invention has particular utility in connection with permanent-retrievable well packers of the type disclosed in my copending application Ser. No. 257,405, filed May 26, 1972, assigned to the assignee of this invention.

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

I claim:

1. Means for anchoring a well tool in a well bore including a slip element having oppositely disposed head portions joined together by a central connecting portion, each head portion having a toothed outer peripheral surface and an inclined inner surface, each head portion further having a retractor surface that is inclined at an angle that is substantially greater than the angle of inclination of said inner surface but less than 90°.

2. The anchoring means of claim 1 wherein each head portion is wider than said connecting portion to provide said retractor surface to the side thereof.

3. The anchoring means of claim 2 wherein said slip element further includes a recess extending inwardly of said connection portion, said recess being arranged and adapted to receive a slip element retaining member.

4. The anchoring means of claim 1 wherein said angle of inclination of said retractor surface is about 60° and the angle of inclination of said inner surface is about 20°.

5. Apparatus for anchoring a well tool against longitudinal movement in a well bore, comprising: slip and expander means movable longitudinally relative to each other to cause lateral movement of said slip means, said slip and expander means having companion inclined expander surfaces to cause lateral outward movement and companion inclined retractor surfaces to cause lateral inward movement, said retractor surfaces being inclined at an angle that is substantially greater than the angle of inclination of said expander surfaces but less than 90°.

6. The apparatus of claim 5 wherein said slip means has a head portion that is generally wedge shaped in such a manner that the expander surface thereof faces inwardly and the retractor surface thereof faces outwardly, said expander means having oppositely facing companion surfaces.

7. The apparatus of claim 5 wherein said slip means has a head portion that is generally wedge shaped in such a manner as to provide a rearwardly facing expander surface and forwardly facing retractor surfaces to either side thereof, said expander means having oppositely facing companion surfaces.

8. The apparatus of claim 7 wherein said expander means comprises a generally tubular body having a recess therein that is defined in part by said inclined expander surface, said body having retractor dogs to either side of said expander surface with wall portions providing inwardly facing retractor surfaces.

9. Apparatus for anchoring a well tool against longitudinal movement in a well bore, comprising: upper and lower expander means movable relatively toward each other and away from each other; normally retracted slip means disposed between and engaging said upper and lower expander means and adapted to be shifted outwardly in response to movement of said expander means toward each other and to be shifted inwardly in response to movement of said expander means away from each other; each slip means including an upper head portion coacting with said upper expander means and a lower head portion coacting with said lower expander means, said head portions being joined together by a connecting portion to provide a unitary construction; each head portion having an inner inclined surface and outer inclined surfaces, said inner inclined surface being slidably engaged by a companion outer surface on a respective expander means, said outer inclined surfaces being adapted to coact with companion inner surfaces on a respective expander means to cause retraction of said slip means; the angle of inclination with respect to vertical of said outer inclined surfaces being greater than the angle of inclination of said inner inclined surface.

10. The apparatus of claim 9 wherein said head portions are wider than said connecting portion to provide transverse sections to either side thereof, said transverse sections being defined in part by said outer inclined surfaces.

11. The apparatus of claim 10 wherein each expander means is tubular in form and has external recesses shaped and adapted to receive respective ones of said head portions, each recess being defined in part by said companion outer surface; each expander means having circumferentially projecting dog portions located to either side of said recess and being defined in part by said companion inner surfaces.

12. The apparatus of claim 11 wherein said inner surfaces are inclined at an angle of about 20° and said outer surfaces are inclined at an angle of about 60°.

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