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IMPROVEMENTS IN OR RELATING TO SHIFTING TOOLS

This invention relates to shifting tools, primarily for use with downhole equipment.

A rotary shifting tool according to the invention comprises a rotatable outer mandrel means for releasably engaging a desired rotatable means of a piece of equipment, an inner mandrel means slidable in a longitudinal direction within said rotatable outer mandrel means, wherein said inner mandrel contains at least one at least partially curved or inclined groove along the longitudinal axis of the inner mandrel means, a travel means for travelling within the groove of the inner mandrel means, the travel means connected to the rotatable outer mandrel means, wherein the travel means rotates as the travel means travels along the curved or inclined portion of the groove, thereby causing the outer mandrel means to rotate, and a diametrically retractable means for prevention of rotation of the inner mandrel means through which the inner mandrel means can slide and which allows rotation of the outer mandrel means and the travel means.

The adoption of a rotary shifter according to the invention can have a specific advantage over the use of longitudinally or vertically movable shifting means because with these latter means unintended shifting can easily take place. In contrast, it is unlikely that standard wireline tools can provide enough torque to

unintentionally rotate a rotary member. If a rotary member is used to provide selective communication between a surface control line and the internal bore of a landing nipple premature lockout can therefore be prevented.

The invention will be described by way of example with reference to the accompanying drawings, in which:

Fig. 1 is an elevational view in cross-section of a landing nipple with which the shifting tool of the invention may be employed,

Figs. 2A-B are cross-sectional views of the landing nipple taken along line A-A of Fig. 1,

Fig. 3 is an elevational view in cross-section of the landing nipple with a rotary shifter according to the invention in place in its unextended position,

Figs. 4A-B are cross-sectional views of the landing nipple with the rotary shifter in place taken along line B-B of Fig. 3,

Figs. 5A-C are cross-sectional views of the landing nipple with the rotary shifter in place taken along line C-C of Fig. 3,

Fig. 6 is an elevational view in cross-section of the landing nipple with the rotary shifter in place in its fully extended position,

Fig. 7 is an elevational view in cross-section of the rotary shifter in its fully extended position, and

Fig. 8 is an elevational view of the inner mandrel of the rotary shifter showing the curved grooves

in the inner mandrel.

Fig. 1 shows landing nipple 10 with control line 12 to the well surface control manifold. Landing nipple 10 is operated by rotation as will be explained, and is made up of a nipple profile sub 28 which is threaded to landing nipple housing 56.

Rotary sleeve 34 is provided with one or more slots 26 and extended slots 27 and is positioned inside nipple profile sub 28. The slots 26 and 27 are provided in the sleeve 34 for engagement by one or more keys 30 of a rotary shifter 24, as discussed further below. The slots 26 and 27 are held in radial alignment with slot 20 in guide sleeve 16. Because of the narrow width of slots 26, extended slots 27 and slot 20 and the spacing of the 45° angles at each end, only a unique shifter 24 can be used to provide a unique selective communication, so avoiding accidental shifting.

Rotary sleeve 34 is also provided with one or more apertures 14, preferably a plurality of apertures 14, which provide access to internal bore 21 of landing nipple 10 and communication between the internal diameter of rotary sleeve 34 and the outside diameter of rotary sleeve 34. Rotary sleeve 34 may be of any suitable configuration whereby rotation can be achieved.

Fig. 2A shows a cross-sectional view of Fig. 1 taken along line A-A which shows nipple profile sub 28 and sleeve 34 before sleeve 34 has been rotated.

An optional means for guiding rotary shifter 24

into engagement with rotary sleeve 34, preferably guide shoe 16, may be positioned inside nipple profile sub 28, contiguous to sleeve 34. Rectangular key 18 is positioned in the housing of nipple profile sub 28 and guide shoe 16. Key 18 holds stationary slot 20 and orienting slots 22 in guide shoe 16 in the desired position. Compression spring 19 applies an upward acting force on key 18 and a downward force on guide shoe 16.

Guide shoe 16 is provided with orienting slots 22 which assist in positioning or orienting the rotary shifter 24 along stationary slot 20. Guide shoe 16 is also provided with lobe 23 which is better illustrated in Fig. 2A, taken along section A-A of Fig. 1. In the preferred embodiment, there are four lobes 23 spaced apart in guide shoe 16. Lobes 23 reduce to point 9 as shown in Fig. 1 and Fig. 2A. Guide shoe 16 is not necessary but represents a preferred embodiment.

Fig. 2B shows a cross-sectional view of Fig. 1 taken along line A-A which shows nipple profile sub 28 and sleeve 34 after sleeve 34 has been rotated 45°. Rectangular key 18 is in extended slot 27. When the release position is reached, keys 30 are moved radially inward by the points 9 and the square shoulder cannot engage. At the release position, rectangular key 18 is pushed upward by spring 19 into extended slot 27 in sleeve 34. This locks sleeve 34 from further rotational movement and ensures that sheared end 25 is held several degrees away from the end of plug fitting 13.

Still referring to Fig. 1, a shearable means, preferably a metal-to-metal plug fitting 13 is attached to control line 12 by fitting adapter 15. It should be understood that plug fitting 13 is only one of many means by which communication between control line 12 and the internal bore 21 of landing nipple 10, and thus an insert safety valve if desired, can be established, by use of rotary sleeve 34.

Fig. 3 shows the landing nipple 10 with the rotary shifter 24 in place in the non-extended position. The rotary shifter 24 is preferably run below landing nipple 10 and then picked up or pulled up through it. The top of keys 30 are preferably pointed so that keys 30 will engage in orienting slots 22 in the lower end of guide shoe 16 and be directed into slots 26 and extended slots 27 in order to rotate sleeve 34. Because the entire shifter 24 can rotate, keys 30 and cross pin 35 are rotated into alignment with slots 26 and extended slots 27 of rotary sleeve 34. The upward facing square shoulders of keys 30 engage against the downward facing square shoulder of sleeve 34.

Fig. 7 shows the rotary shifter assembly 24 in its fully extended position. A travel means, preferably rotary cross pin 35, passes through inner mandrel 32. Cross pin 35 is shown passing through the upper end of the straight, axially directed portion of slots 33 in the inner mandrel, and pin 35 rotates as it travels along the curved or inclined portion of the slots 33, causing outer

mandrel 38 to rotate. Key retainer housing 37 is secured to rotary cross pin 35 so that housing 37 will turn when rotary pin 35 turns. Outer mandrel 38 of rotary shifter assembly 24 and keys 30 are designed to turn when rotary pin 35 turns. Preferably, rotary sleeve 34 is rotated by applying sufficient upward force on shifter 24 to cause end 25 of plug 13 to shear although a downward force could be used instead.

Grooves can be substituted for the slots 33, with appropriate adaptation of their connection to the housing 37 and outer mandrel 38.

Rotary shifter assembly 24 is provided with a diametrically retractable means for prevention of rotation of inner mandrel 32 through which inner mandrel 32 can slide and which allows rotation of outer mandrel 38 and cross pin 35. Preferably, this means is a lug sub assembly 48 which comprises lugs 49 retained by connector 52 and pins 51. Springs 50 allow lugs 49 to retract and compress in order to pass through honed bores and other restrictions. Lugs 49 are provided with grooves 54 and ears 53 which releasably fit in a groove in shear sleeve 46 to expandably secure lug sub assembly to shear sleeve 46.

Rotatable outer mandrel means 38 for releasably engaging a desired rotatable means of a piece of equipment preferably comprises a retractable means for that releasable engagement. The retractable means preferably comprises at least one key 30 and leaf spring 40 in the

key retainer housing 37. The spring 40 provides an outward force on keys 30 to maintain them in the protracted position during rotation.

Rotatable outer mandrel means 38 also preferably includes shear sleeve 46 which is contiguous to inner mandrel 32 and the retractable means.

Referring to Fig. 8, inner mandrel 32 is shown with two "J" mandrel slots 33 approximately 180° apart, which represents the preferred configuration for the inner mandrel. Inner mandrel 32 should have at least one at least partially curved or inclined groove along the longitudinal axis of inner mandrel 32. Preferably, slots 33 form an inclined plane relative to the longitudinal axis of inner mandrel 32 and are helical.

Fig. 4A shows nipple profile sub 28 and sleeve 34 with rotary shifter 24 in the non-extended position before any rotation of sleeve 34 has taken place. Plug fitting 13 is shown next to cutter 29. Sleeve 34 is contiguous to key retainer housing 37 and shear sleeve 46. Inner mandrel 32 is shown with slots 33 and lug 49 with pin 51.

Fig. 4B shows nipple profile sub 28 and sleeve 34 with rotary shifter 24 in a semi-extended position after rotation of sleeve 34 22.5°. End 25 is shown after having been sheared.

Fig. 5A shows nipple profile sub 28 and sleeve 34 with rotary shifter 24 in the non-extended position before any rotation of sleeve 34 has taken place. Keys 30

are shown in a fully extended position within lobes 23. Cantilever spring 40 is shown under keys 30.

Fig. 5B shows nipple profile sub 28 and sleeve 34 with rotary shifter 24 in a semi-extended position after rotation of sleeve 34 through 22.5°. Keys 30 are moved through lobe 23 toward a retracted position.

Fig. 5C shows nipple profile sub 28 and sleeve 34 with rotary shifter 24 in a fully extended position after a 45° rotation of sleeve 34. Keys 30 are fully retracted in this position and are now at point 9 of lobes 23 in guide shoe 16.

After sleeve 34 rotates, and shears end 25 of plug fitting 13, continued upward jar blows cause keys 30 to rotate to the release position. Keys 30 release because of four off-centre turned surfaces which are machined into the upper end of guide shoe 16. The first release position is reached after sleeve 34 has been rotated 45°.

Sleeve 34 is locked from further rotational movement, thus preventing premature lockout and shifter 24 may be removed.

Other alternatives within the scope of the invention will be obvious to one of ordinary skill in the art.

The accompanying drawings also appear in our corresponding Application No. 9302630.0 which is directed to a landing nipple, such as may be acted on by a shifting tool according to the invention, comprising a nipple

profile sub, a landing nipple housing connected to the nipple profile sub, a rotary member positioned inside the nipple profile sub, wherein the rotary member contains at least one slot or protrusion therein for engagement by one or more lugs of a rotary shifter, a bore in the wall of the nipple profile sub, to which is connected a surface control line and a means for selectively providing communication between the surface control line and the internal bore of said landing nipple. That application is also concerned with a method of providing communication within the landing nipple between a surface control line and an internal bore of the landing nipple and its contents are incorporated herein by reference.

CLAIMS

1. A rotary shifting tool comprising:

a rotatable outer mandrel means for releasably engaging a desired rotatable means of a piece of equipment,

an inner mandrel means slidable in a longitudinal direction within said rotatable outer mandrel means, wherein said inner mandrel contains at least one at least partially curved or inclined groove or slot along the longitudinal axis of said inner mandrel means,

a travel means for travelling within said groove or slot of said inner mandrel means and being connected to said rotatable outer mandrel means, wherein said travel means rotates as it travels along at least a curved or inclined portion of said groove, thereby causing said outer mandrel means to rotate; and

a diametrically retractable means for prevention of rotation of said inner mandrel means through which said inner mandrel means can slide and which allows rotation of said outer mandrel means and said travel means.

2. The rotary shifting tool of claim 1, wherein said rotatable outer mandrel means for releasably engaging a desired rotatable means of a piece of equipment includes a retractable means for releasably engaging a desired rotatable means of a piece of equipment.

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3. The rotary shifting tool of claim 1 or claim 2, wherein said rotatable outer mandrel means comprises a shear sleeve contiguous to said inner mandrel means and said retractable means.

4. The rotary shifting tool of any one of claims 1 to 3, wherein said curved groove or slot forms an inclined plane relative to said longitudinal axis of said inner mandrel means.

5. The rotary shifting tool of any one of claims 1 to 4 wherein said travel means is a rotary cross pin.

6. The rotary shifting tool of any one of claims 1 to 5 wherein said diametrically retractable means comprises a lug sub assembly.

7. The rotary shifting tool of claim 6, wherein said lug sub assembly comprises a lug, two pins, two springs and a connector and wherein said lug has an ear which is releasably secured in a groove or slot in said inner mandrel.

8. A rotary shifting tool comprising:

a rotatable outer mandrel for releasably engaging a desired rotatable means of a piece of equipment, said outer mandrel comprising a retractable means for releasably engaging a desired rotatable means of

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a piece of equipment, and a shear sleeve contiguous to said retractable means,

an inner mandrel slidable in a longitudinal direction within said outer mandrel, wherein said inner mandrel contains at least one at least partially curved groove or slot which forms an inclined plane relative to the longitudinal axis of said inner mandrel,

a travel means comprising a rotary cross pin for travelling within said groove or slot of said inner mandrel, said pin connected to said outer mandrel, wherein said rotary cross pin rotates as said rotary cross pin travels along the curved portion of said groove or slot, thereby causing said outer mandrel to rotate; and

a diametrically retractable means comprising a lug sub assembly for prevention of rotation of said inner mandrel through which said inner mandrel can slide and which allows rotation of said outer mandrel and said rotary cross pin.

9. The rotary shifting tool of claim 8, wherein said diametrically retractable lug sub assembly comprises a lug, two pins, two springs and a connector, wherein said lug has an ear which is releasably secured in a groove in said inner mandrel.

10. The rotary shifting tool of any one of claims 1 to 9, wherein said retractable means comprises at least one key and spring in a key retainer housing for

releasably engaging a desired rotatable means of a piece of equipment.

11. The rotary shifting tool of any one of claims 1 to 10 wherein said curved groove is helical.

12. A rotary shifting tool comprising:

a rotatable outer mandrel for releasably engaging a desired rotatable means of a piece of equipment, said outer mandrel comprising a retractable means for releasably engaging a desired rotatable means of a piece of equipment, said retractable means comprising at least one key and spring in a key retainer housing and a shear sleeve contiguous to said retractable means,

an inner mandrel slidable in a longitudinal direction within said outer mandrel, wherein said inner mandrel contains two at least partially curved helical grooves or slots, where said grooves form an inclined plane relative to the longitudinal axis of said inner mandrel,

a travel means comprising a rotary cross pin for travelling within said grooves or slots of said inner mandrel, said pin connected to said outer mandrel, wherein said rotary cross-pin rotates as said rotary cross pin travels along the curved portion of said grooves or slots, thereby causing said outer mandrel to rotate; and

a diametrically retractable means comprising a lug sub assembly for prevention of rotation of said inner

mandrel through which said inner mandrel can slide and which allows rotation of said outer mandrel and said rotary cross pin.

13. The rotary shifting tool of claim 12, wherein said diametrically retractable lug sub assembly comprises a lug, two pins, two springs and a connector, wherein said lug has an ear which is releasably secured in a groove in said inner mandrel.

14. A rotary shifting tool constructed and arranged for use and operation substantially as described herein with reference to the accompanying drawings.