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US 4033640

(58) Field of search
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(54) Rotating liner hanger and running tool

(57) Running tool 50 releasably connects hanger 35 (consisting of tube 36 composed of a plurality of sections 36*a* to 36*c*) to workstring in a first position (Figure 4B) with connector means 56 releasably engaging threads 59 in section 36*b* and snap ring 65 locating in groove 66. In this condition, the tool 50 can both rotate the hanger or move it axially, and the hanger 35 is lowered by the workstring to the desired depth in a well casing where the workstring is manipulated to release a slip carrier from 9 J-slot connector. Lowering of workstring 47 then causes expander 28 to force slip means 23 firmly to engage with the well casing to arrest tube 36, whereafter snap ring 65 disengages from groove 66 and engages an upper groove (not shown).

Workstring 47 is now raised to move fingers 62 out of their recesses 150 and until shoulder 55*a* abuts nut 56, whereupon rotation of workstring 47 disengages nut 56 from the tube 36 after which the workstring 47 is free to move axially within the hanger 35, and is lowered to re-engage the fingers 62. Now, the running tool 50 can only rotate with its attached liner, bearing assembly 70, comprising alternating thrust washers and support rings permitting this during cementing operations to obtain the advantages known to be achieved by such rotation.

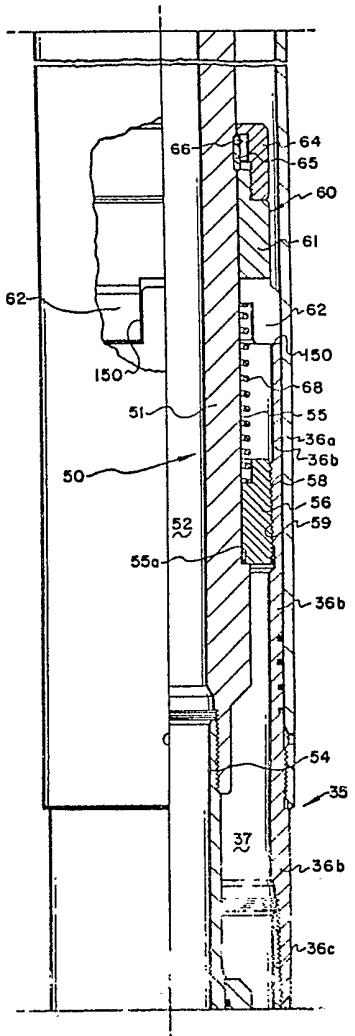

FIG. 4B

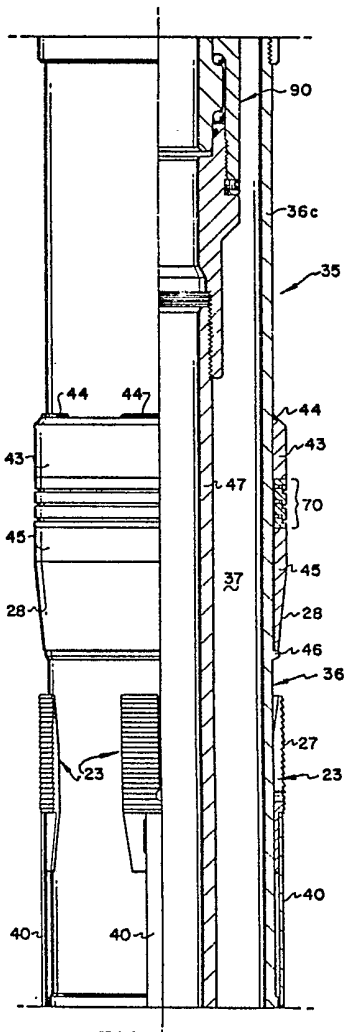

FIG. 4C

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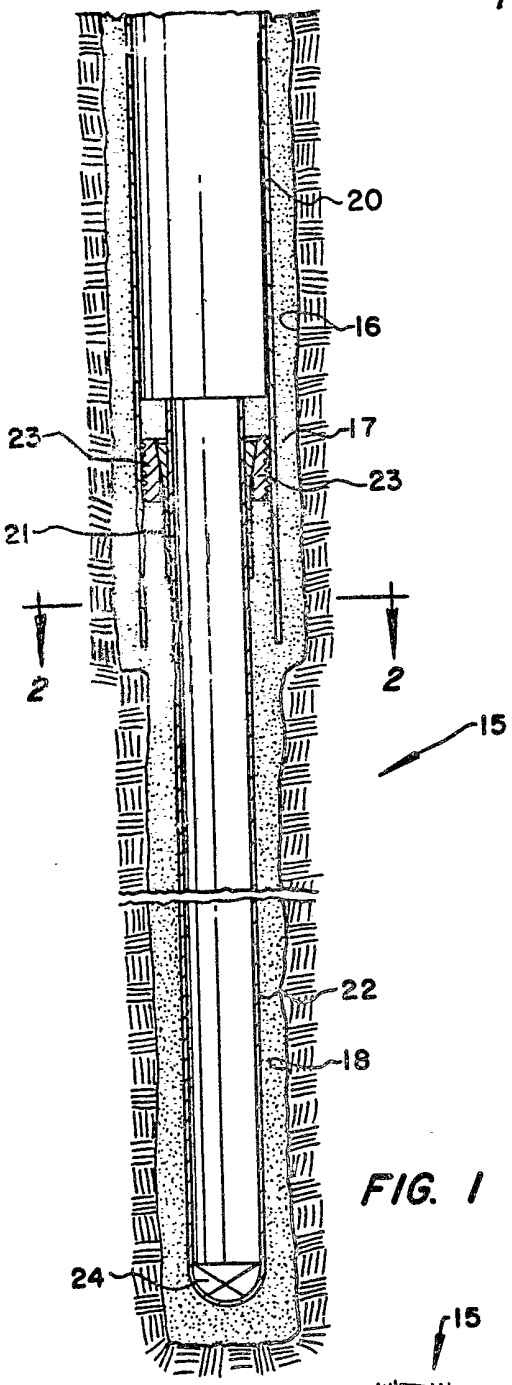

FIG. 1

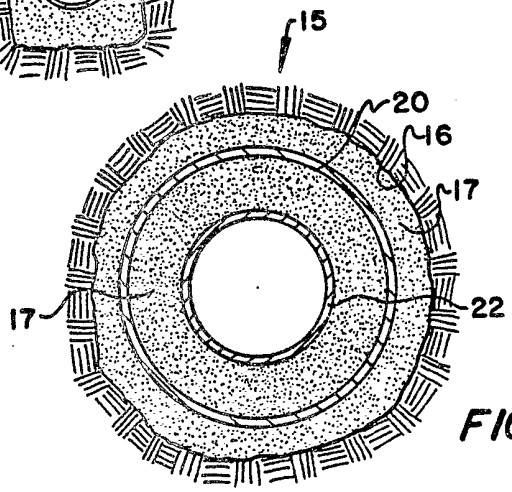

FIG. 2

PRIOR ART

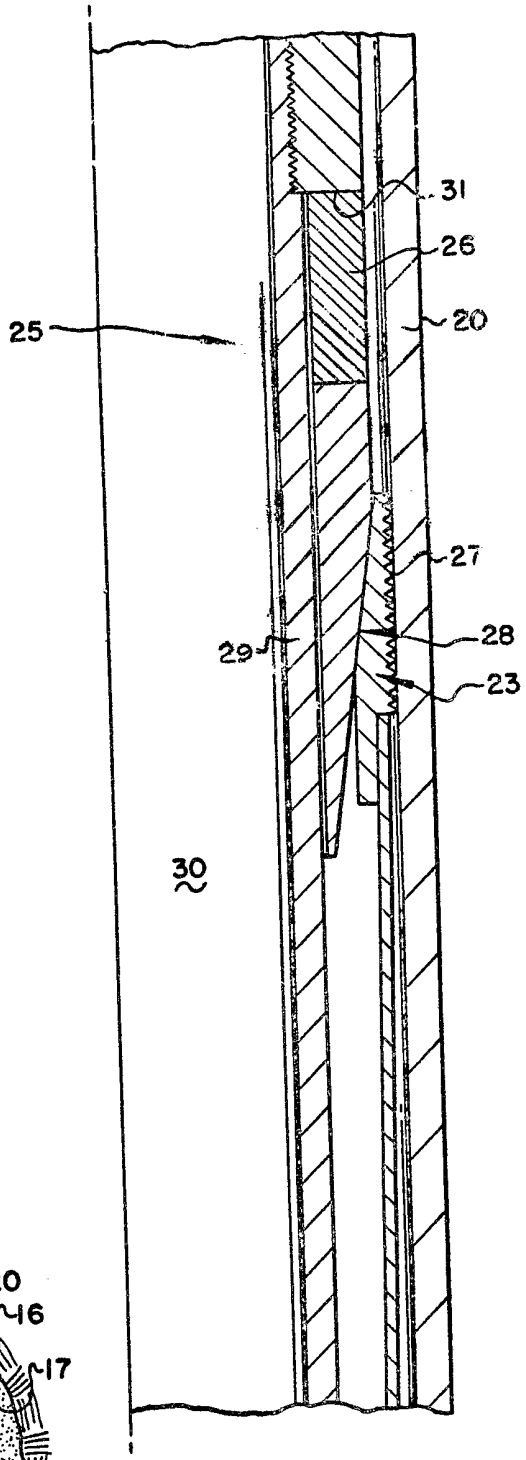

FIG. 3

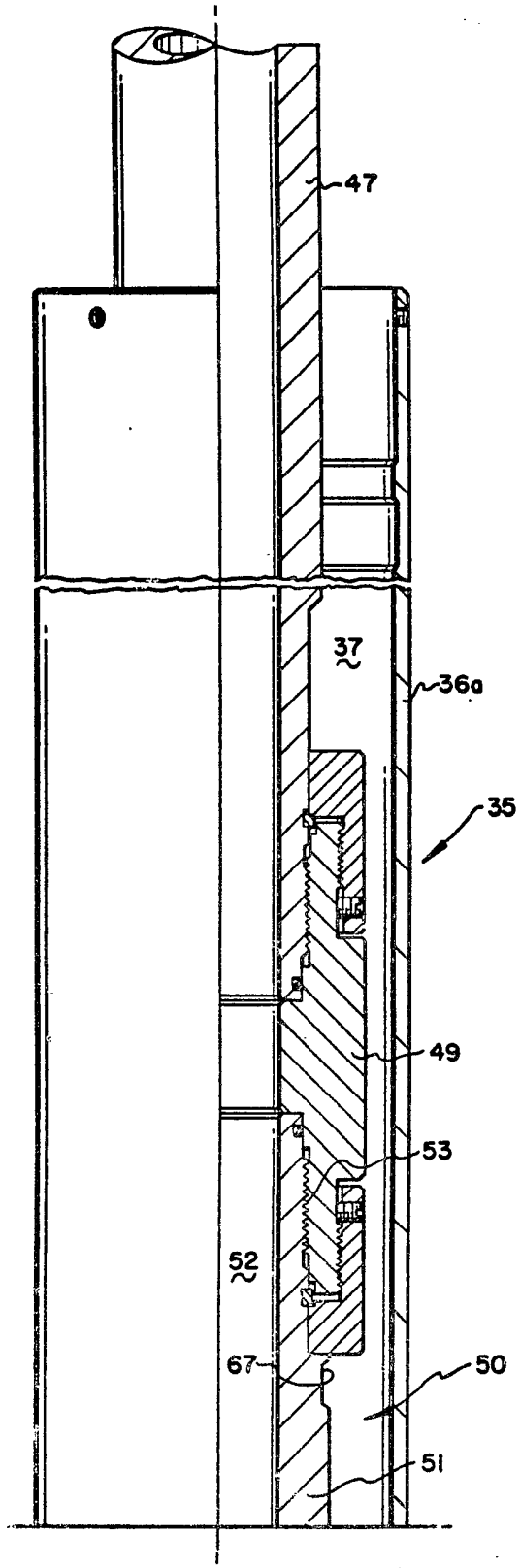
47
37
36a
35
49
53
52
67
50
51

FIG. 4A

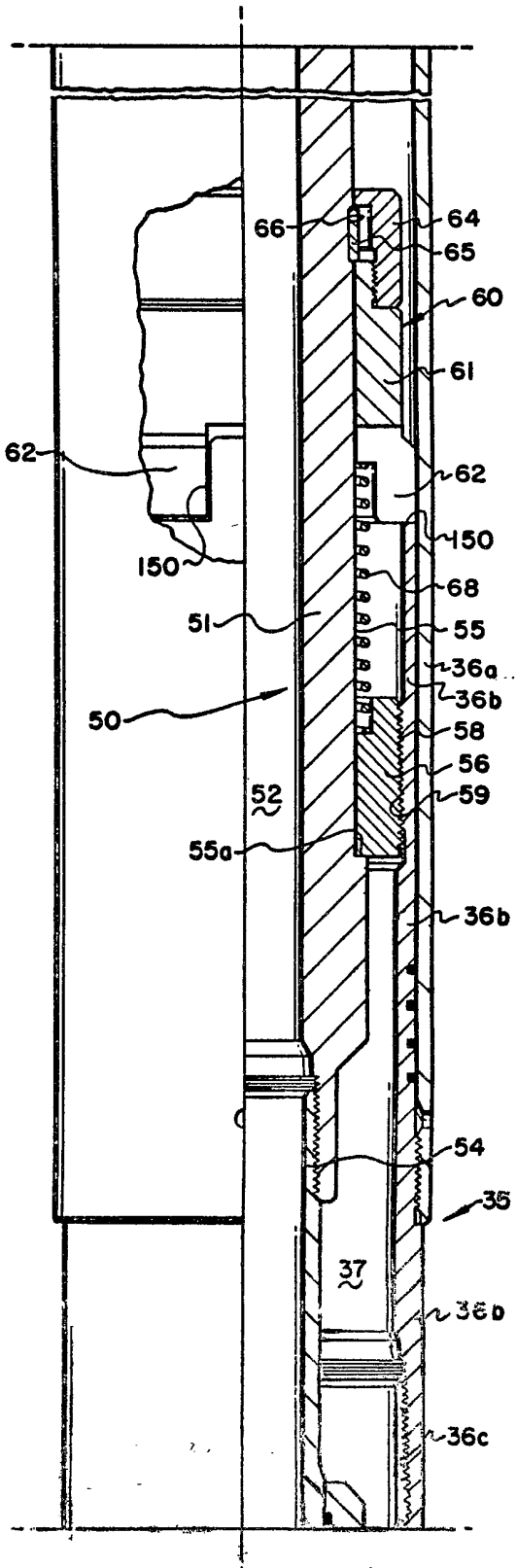
66
64
65
60
61
62
62
150
150
68
51
55
36a
36b
50
58
56
52
59
55a
36b
54
35
37
36b
36c

FIG. 4B

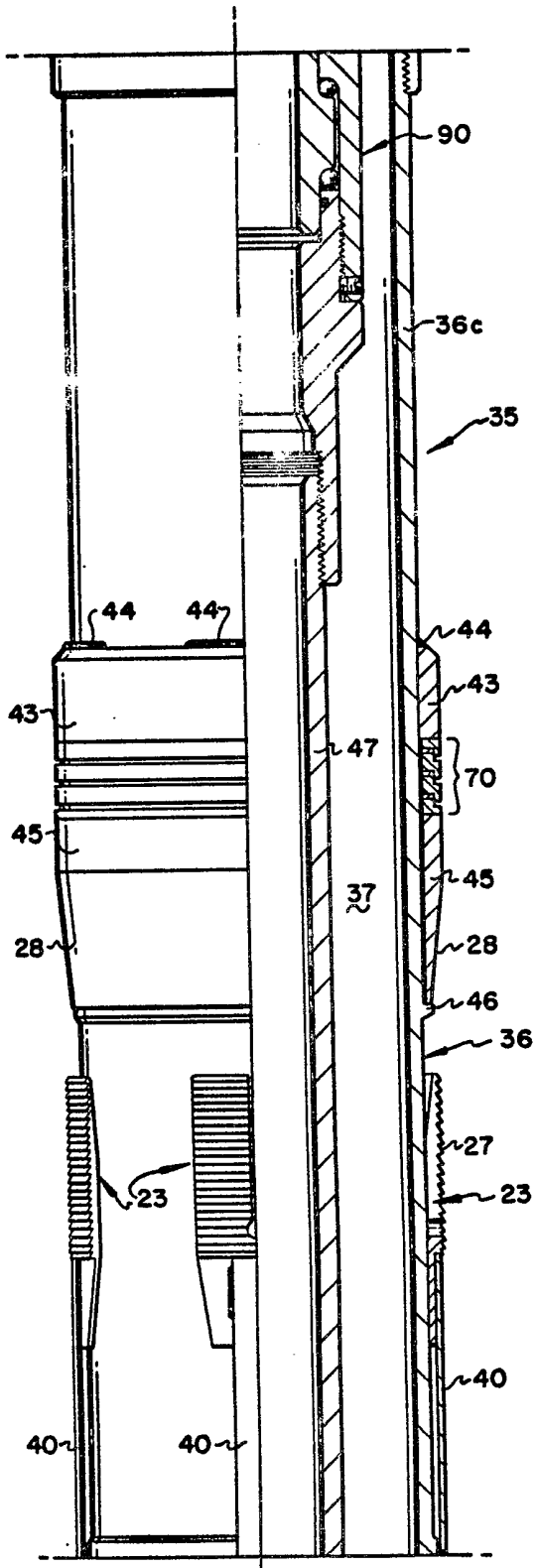
90
36c
35
44
44
44
43
43
47
70
45
45
37
28
28
46
36
27
23
23
40
40
40

FIG. 4C

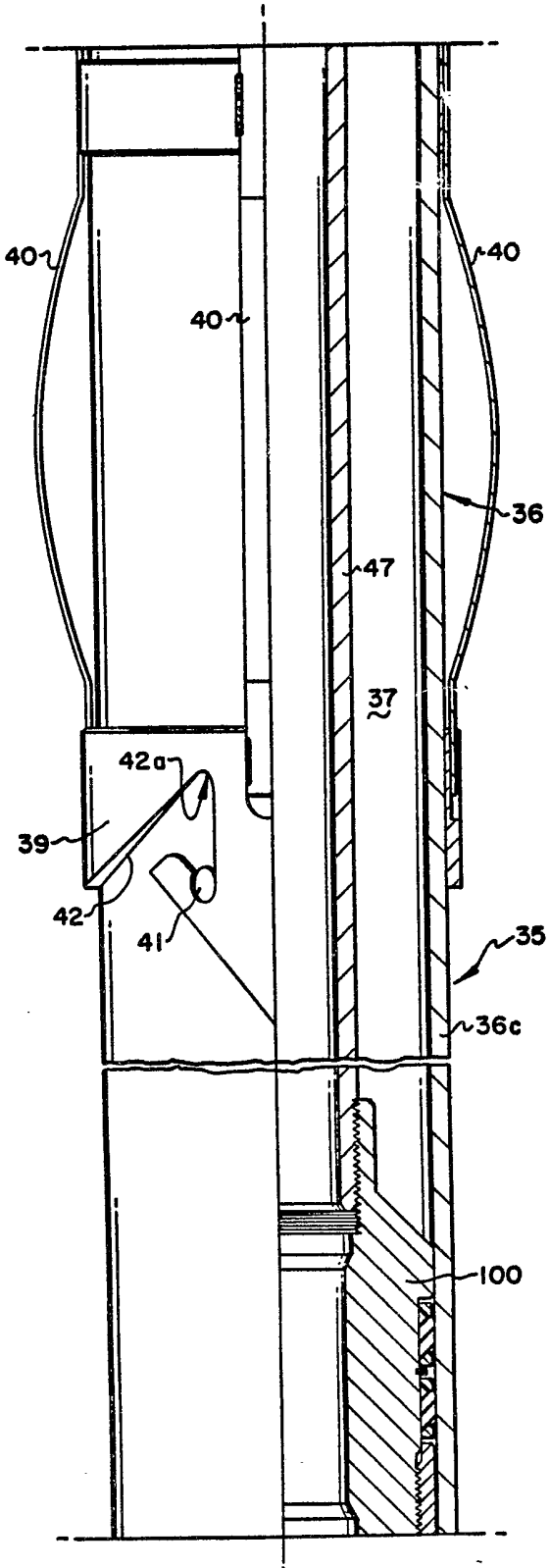
40
40
40
36
47
37
42a
39
42
41
35
36c
100

FIG. 4D

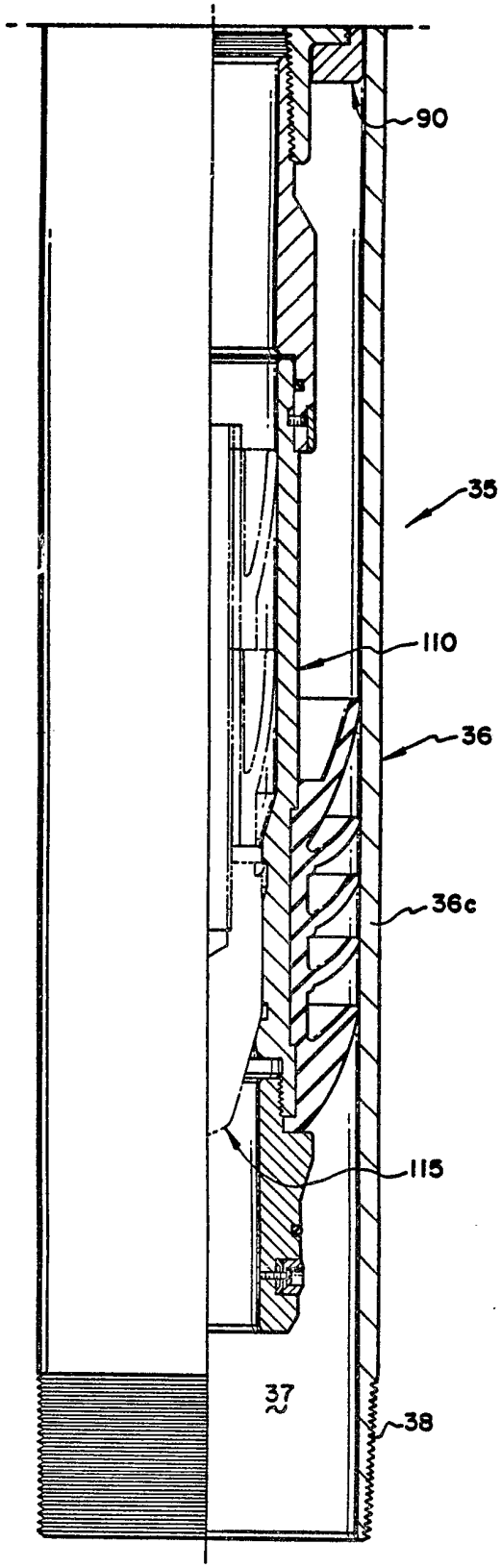
90
35
110
36
36c
115
37
38

FIG. 4E

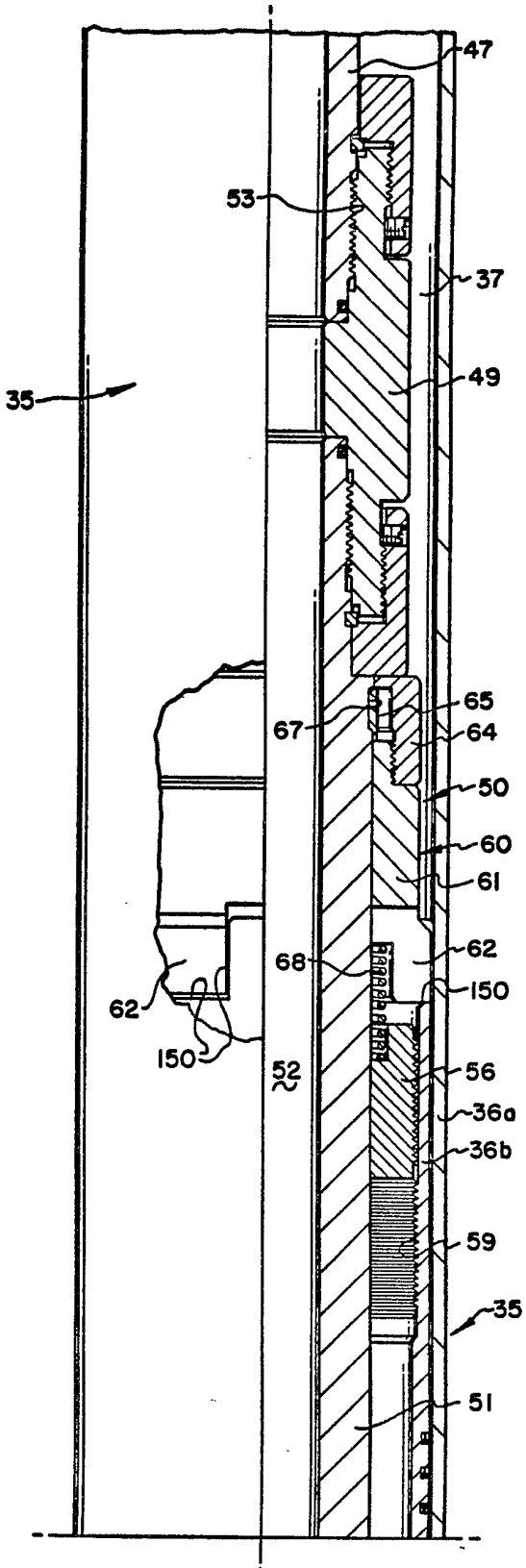
47
53
37
49
35
65
67
64
50
60
61
62
68
150
62
150
52
56
36a
36b
59
35
51

FIG. 5A

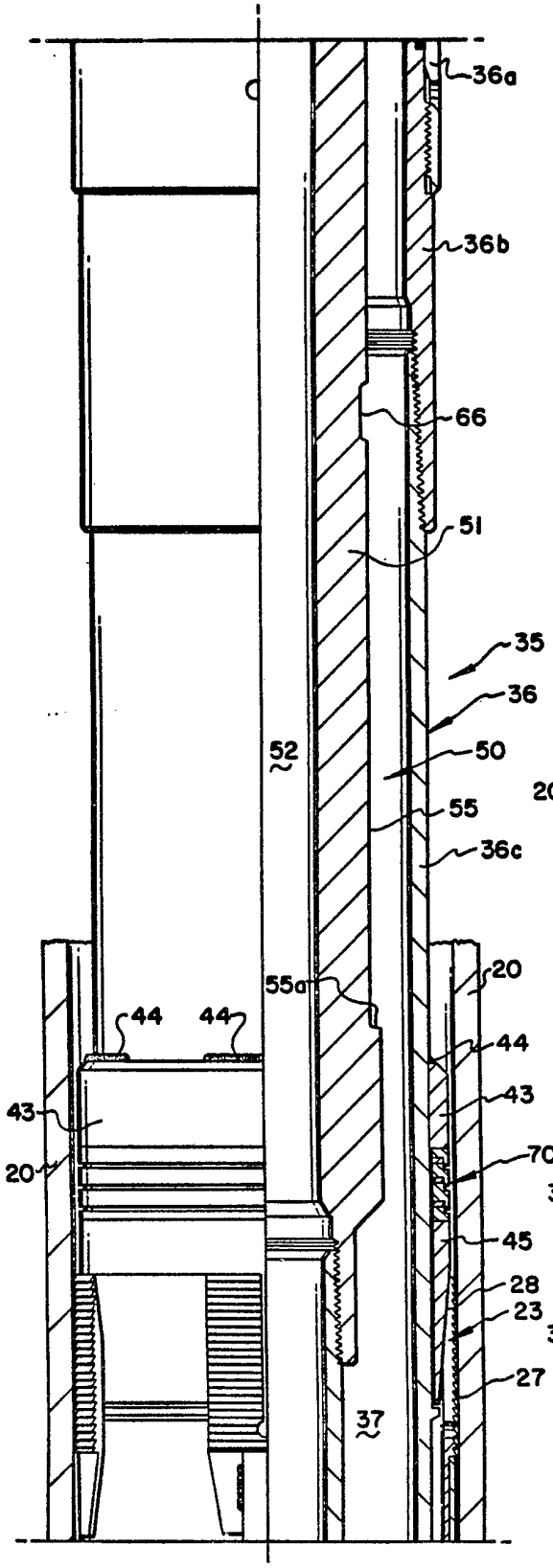
36a
36b
66
51
35
36
52
50
55
36c
20
55a
44
44
44
43
43
20
70
45
28
23
27
37

FIG. 5B

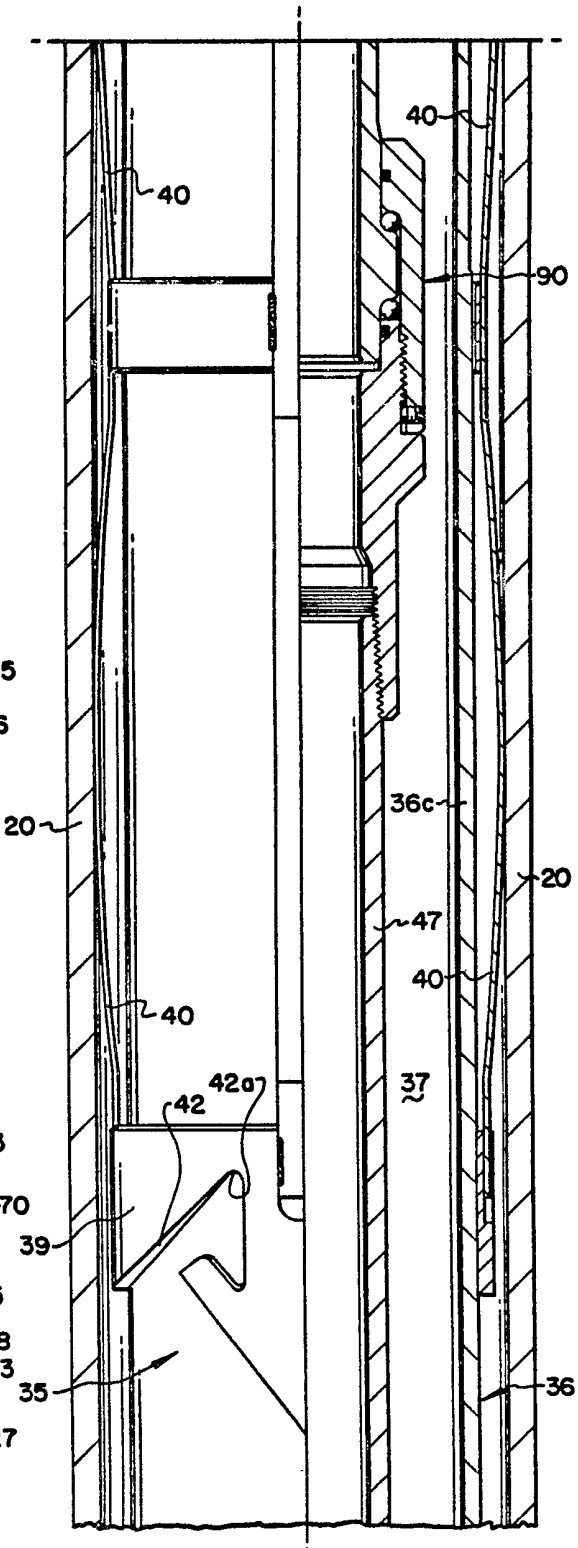
40
40
90
36c
20
20
47
40
40
37
42
42a
39
35
36

FIG. 5C

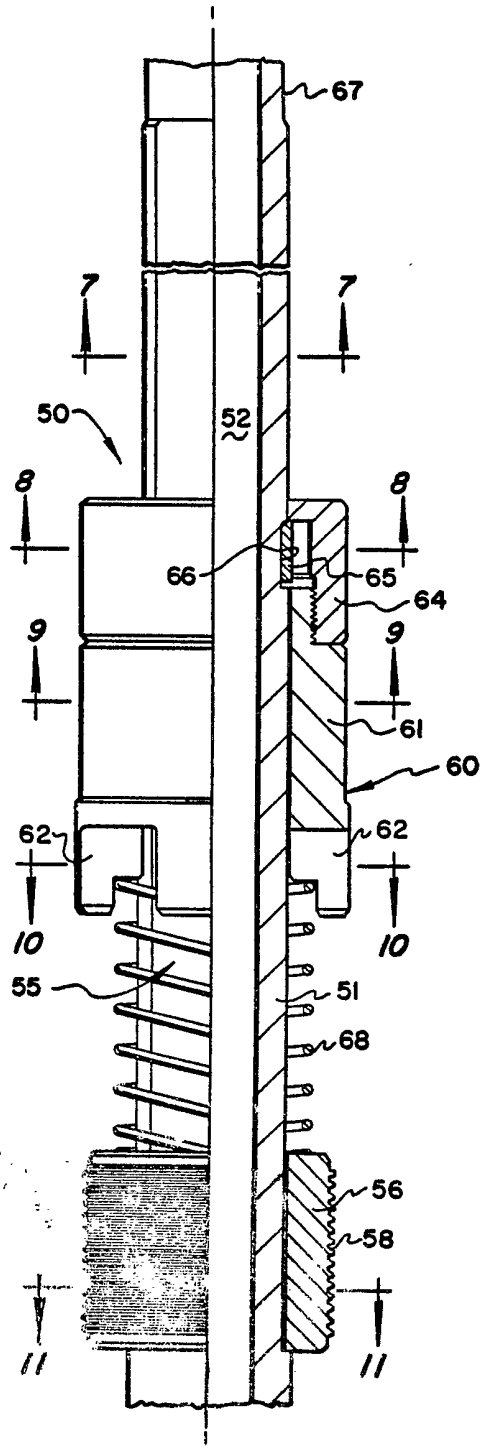

FIG. 6

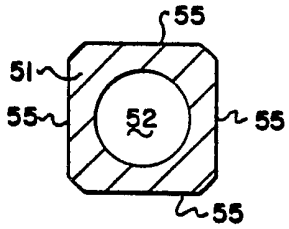

FIG. 7

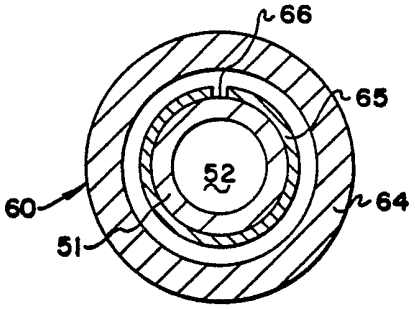

FIG. 8

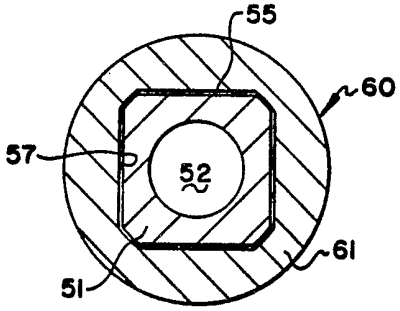

FIG. 9

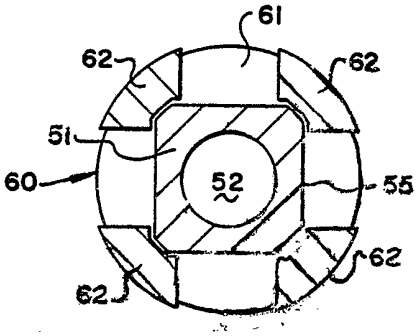

FIG. 10

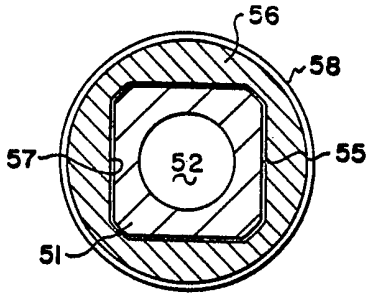

FIG. 11

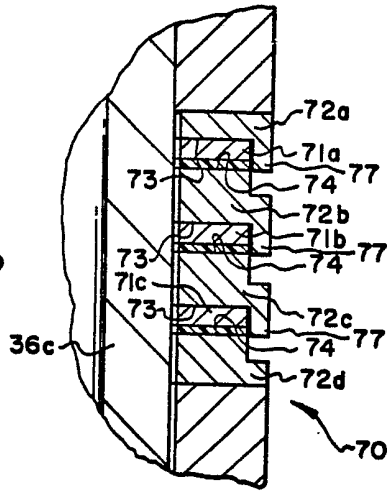

FIG. 12

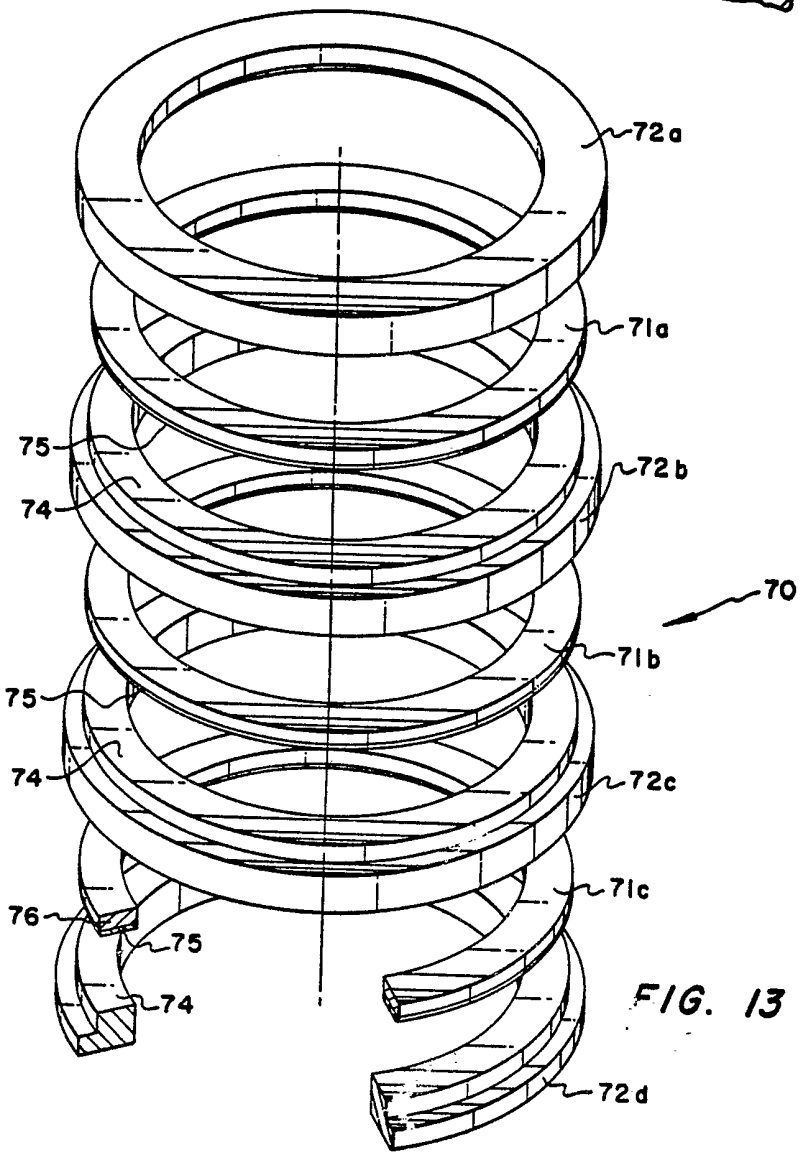

FIG. 13

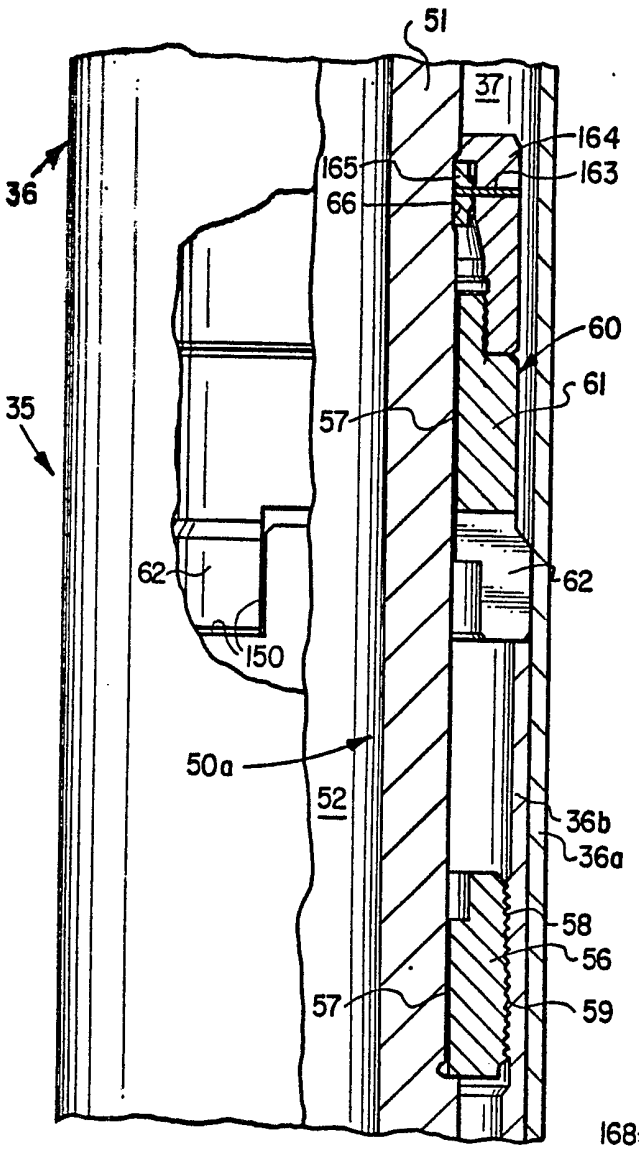

FIG. 14

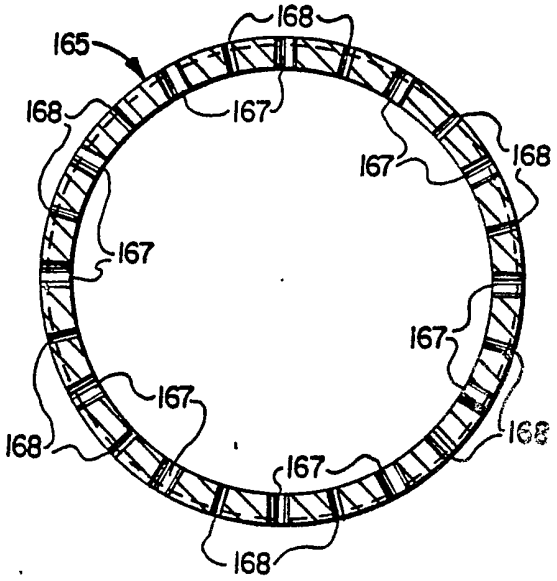

FIG. 16

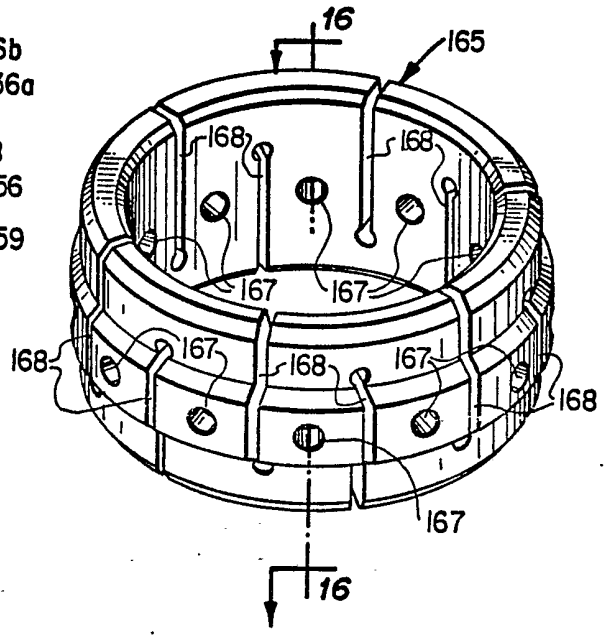

FIG. 15

SPECIFICATION

Rotating liner hanger and running tool

Background of the Invention

1. Field of the Invention

This invention relates generally to apparatus and methods for hanging a liner within a well bore and rotating the liner during cementing operations.

2. Prior Art

For many years, liners have been positioned in a well bore defined in part by a well casing. U.S. Patents 3,910,349; 3,920,075; 3,934,652; and 4,281,711 disclose methods and apparatus currently used to install liners within a well bore. The advantages of rotating the liner during cementing operations are also well known. U. S. Patents 4,010,804; 4,033,640; and 4,190,300 disclose methods and apparatus for rotating liners.

The preceding patents are incorporated by reference for all purposes within this application.

Summary of the Invention

Many complexes, high cost bearings, such as roller or ball type bearings, are commercially available to allow downhole rotation of a liner while cementing the liner within a well bore. Such bearings are frequently designed for continuous service with an almost unlimited duty cycle. These operating characteristics are generally achieved by sealing the internal components of the bearing from the surrounding environment. Cementing such expensive bearings within a well bore is not a reasonable expenditure. The present invention discloses a non-sealed bearing assembly having a limited duty cycle appropriate for intermittent service during completion of a well bore.

The present invention also includes a running tool for positioning a hanger, having the bearing assembly, and its attached liner within a well bore and rotating the liner during cementing operations. The running tool minimizes the number of steps required to position the hanger within the casing and to begin rotating the liner. The running tool can be easily released from the hanger to allow quick removal of the running tool and its associated workstring upon completion of cementing operations. Failure to quickly remove the running tool from the hanger might result in excess cement, which is normally displaced from around the top of the hanger, settling on the running tool and trapping it in place. The present invention of the running tool and bearing assembly results in improved methods for well completion.

One object of the present invention is to provide a low cost, highly reliable non-sealed bearing assembly to allow rotation of a liner during well completion.

Another object of the present invention is to provide a running tool for positioning a liner hanger within a well casing and rotating its associated liner with only a minimal amount of manipulation of the workstring attached to the running tool.

A further object of the present invention is to provide a running tool with an improved snap ring to releasably secure connector means on the running tool in either their first or second positions.

Additional objects and advantages of the present invention will be readily apparent to those skilled in the art after studying the following written description and claims in conjunction with the drawings.

Brief Description of the Drawings

Figure 1 is a schematic drawing in longitudinal section showing a liner positioned in a well bore by a hanger.

Figure 2 is an enlarged drawing in horizontal section taken along line 2-2 of Figure 1.

Figure 3 is a schematic drawing in longitudinal section depicting a portion of a prior art hanger positioned in a casing and having a bearing assembly to allow rotation of the liner.

Figures 4A-E are drawings, partially in elevation and partially in longitudinal section with portions broken away, showing the running tool and liner hanger of the present invention prior to installation in a well bore.

Figures 5A-C are drawings, partially in elevation and partially in longitudinal section with portions broken away, showing the liner hanger of the present invention engaged with the casing and the running tool positioned to rotate the liner.

Figure 6 is a drawing, partially in elevation and partially in longitudinal section with portions broken away, showing the running tool of the present invention.

Figure 7 is a horizontal section taken along line 7-7 of Figure 6.

Figure 8 is a horizontal section taken along line 8-8 of Figure 6.

Figure 9 is a horizontal section taken along line 9-9 of Figure 6.

Figure 10 is a horizontal section taken along line 10-10 of Figure 6.

Figure 11 is a horizontal section taken along line 11-11 of Figure 6.

Figure 12 is an enlarged drawing in longitudinal section of the bearing assembly of the present invention.

Figure 13 is an exploded isometric view, with portions broken away, of the bearing assembly of the present invention.

Figure 14 is an enlarged drawing, partially in section and partially in elevation with portions broken away, showing an alternative embodiment of the running tool engaged with the liner hanger of the present invention prior to installation in a well bore.

Figure 15 is an enlarged isometric view of the snap ring shown in Figure 14.

Figure 16 is an enlarged cross section drawing of the snap ring taken along line 16-16 of Figure 15.

Detailed Description of the Preferred Embodiments

To facilitate the drilling of well bores, especially wells having a depth greater than 15,000 feet, it is common practice to reduce the diameter of the well bore as depth increases. Figure 1 illustrates such a well bore 15. Well casing or casing 20 is disposed within enlarged inside diameter portion 16 of well bore 15. Cement 17 forms a fluid seal between the

exterior of casing 20 and inside diameter portion 16. Cement 17 also provides mechanical support for and anchors casing 20 within well bore 15.

The use of liner hanger or hanger 21 to position liner 22 within reduced inside diameter portion 18 of well bore 15 is a common well completion method. Hanger 21 is engaged by slip means 23 to the inside diameter of casing 20 near the lower end thereof with liner 22 suspended therefrom. Cement shoe 24 is provided at the extreme lower end of liner 22 to allow cement 17 to be discharged from the lower end of liner 22. Cement 17 fills the annulus between the exterior of liner 22 and inside diameter portion 18 to form a fluid barrier and support liner 22 in the same manner as previously described for casing 20. For very deep wells, multiple liners are frequently installed in a stair-step fashion. Well bore 15 of Figure 1 could be extended to a deeper depth by drilling out cement shoe 24 and continuing drilling operations after cementing liner 22 in place.

The mechanical and fluid integrity of the cement bond between the exterior of liner 22 and inside diameter portion 18 of well bore 15 can be significantly increased by reciprocating and/or rotating liner 22 during cementing operations. Figure 3 is a schematic representation of a prior art liner hanger 25 having bearing means 26 to allow rotation of a liner (not shown in Figure 3) suspended from hanger 25. Liner hanger 25 includes tubular means 29 with lingitudinal passageway 30 extending therethrough. Various components of hanger 25 are carried on the exterior of tubular means 29 including slip means 23, bearing means 26, wedge or expander means 28, and first shoulder means 31. Slip means 23 has teeth 27 which bite into the inner wall of casing 20 and are held stationary relative thereto by expander means 28. Bearing means 26 is disposed between first shoulder means 31 and expander means 28 and surrounds tubular means 29. Bearing means 26 allows rotation of tubular means 29 including first shoulder means 31 relative to expander means 28 and slip means 23.

The present invention includes running tool 50 and bearing assembly 70 as shown in Figures 4A-E plus the methods used to position liner hanger 35 within casing 20 and to rotate a liner attached to hanger 35 during cementing operations. The various components which comprise hanger 35 are attached to or carried by tubular means 36. For ease of manufacture and assembly, tubular means 36 is made from several subassemblies of generally hollow, cylindrical tubes threadedly engaged with each other to define longitudinal passageway 37 extending therethrough. The subassemblies are designated 36a, 36b and 36c. The lower portion of subassembly 36c has threads 38 machined on its exterior to provide means for attaching a liner such as liner 22 to hanger 35.

Slip means 23 are slidably carried on the exterior of tubular means 36 to provide a portion of the means for engaging hanger 35 with the interior of casing 20 at a desired downhole location. Slip carrier 39 with a plurality of bow springs 40 extending longitudinally therefrom surrounds tubular means 36. Slip means 23 are attached to each bow spring 40. Lug 41 on the exterior of tubular subassembly 36c cooperates with J-slot 42 in carrier 39 to hold slip means 23 in their retracted or inactive position until hanger 35 is lowered to the desired location in casing 20. The use of J-slot 42, lug 41 and slip means 23 to install a liner hanger is well known in the art.

Bearing assembly 70 which allows rotation of tubular means 36 and its attached liner relative to casing 20 is incorported into the means for engaging hanger 35 with casing 20. First sleeve 43 is fixed to the exterior of tubular subassembly 36c by multiple welds 44. Welds 44 prevent rotational and longitudinal movement of first sleeve 43 relative to tubular means 36. Welds 44 support the full weight of hanger 35 and its attached liner. Second sleeve 45 is carried on the exterior of tubular means 36. Bearing assembly 70 is disposed between first sleeve 43 and second sleeve 45. The inside diameter of second sleeve 45 is slightly larger than the outside diameter of tubular subassembly 36c adjacent thereto. This difference in diameter allows rotation of tubular means 36 relative to second sleeve 45. A small flange 46 is formed on the exterior of tubular subassembly 36c to limit lonitudinal movement of second sleeve 45 relative to first sleeve 43. A portion of the exterior of second sleeve 45 has a tapered outside diameter to form slip expander means or wedge 28.

Bearing assembly 70 is a differential type thrust bearing designed for intermittent service and limited duty cycle. Bearing assembly 70 has a plurality of thrust washers 71a-c alternately disposed between a plurality of support rings 72a-d. Support rings 72a-d are arranged in sets of pairs. Those skilled in the art will readily appreciate the bearing assembly 70 is a non-sealed bearing because support rings 72a-d and thrust washers 71a-c are exposed to any fluids surrounding bearing assembly 70. As shown in Figures 12 and 13, thrust washers 71a-c are identical with each other. Each thrust washer 71a, 71b, and 71c is disposed between its respective pair of support rings: 72a and 72b, 72b, 27b and 72c, and 72c and 72d. Each pair of support rings has a first ring with recess 73 formed therein to receive its respective thrust washer 71a, b, or c. The second ring of each pair has a thrust face 74 sized to engage its respective thrust washer 71a, b, or c. End support rings 71a and d vary slightly in design from middle support rings 72b and c because middle support rings 72b and c function as both a first support ring and a second support ring depending upon which thrust washer is being considered.

Each thrust washer has at least one surface covered or coated with lubricating material 75. Lubricating material 75 can be applied to thrust washers 71a-c by various coating techniques including electroplating. Lubricating material 75 can also be bonded to base material 76 by using powder metallurgy or other manufacturing procedures. Lubricating material 75 can be selected from a wide variety of compounds and elements including bronze, lead, copolymers and polytetrafluoroethylene. Base material or babbitt 76 may be selected from various alloys of tin, bronze, zinc or aluminium. Some alloys of steel or ceramic com-

pounds can also be used as base material 76 depending upon the mechanical strength characteristic required for bearing assembly 70.

Thrust face 74 of each support ring 72b, c and d contacts lubricating material 75. If desired, thrust face 74 could also be coated with a material such as chromium to improve its wearing characteristics. Each thrust face 74 and respective thrust washer 71a, b or c allows rotation of the first associated support ring relative to the second support ring. An important feature of the present invention is lip 77 formed on the outside diameter of each support ring 72a, b, and c and extending from recess 73 to overlap both thrust washer 71a, b or c disposed therein and a portion of the other support ring 72b, 72c, or 72d adjacent thereto.

When a heavy thrust load is placed on bearing assembly 70, the resulting axial force will tend to extrude lubricating material 75 radially from the contact between respective thrust face 74 and thrust washer 71a, b or c. This same force may also tend to extrude base material 76. Lip 77 substantially limits such extrusion, thereby increasing both the service life and axial load carrying ability of bearing assembly 70. Lip 77 also blocks undesired contamination of bearing assembly 70 by fluids surrounding hanger 35 such as drilling mud or cement. These fluids can cause excessive wear of both thrust face 74 and lubricating material 75 since bearing assembly 70 is not sealed.

Bearing assembly 70 contains three thrust washers 71a, b, and c. Therefore, each thrust washer and its associated pair of support rings needs to make only one-third of a revolution to allow one complete revolution of bearing assembly 70. Additional thrust washers and support rings may be added to bearing assembly 70 as desired. Multiple thrust washers and support rings are an important feature of the present invention because they greatly improve the reliability of bearing assembly 70. If one thrust washer 71 and its associated support rings 72 should fail (freeze), additional thrust washers 71 and support rings 72 are available to allow continued rotation.

Workstring 47 with running tool 50 attached thereto is used to lower hanger 35 and its attached liner through casing 20 to the desired downhole location. Workstring 47 and running tool 50 are then manipulated to engage hanger 35 with casing 20 and to rotate the attached liner while cementing it within the well bore.

Running tool 50 is attached to workstring 47 by threaded coupling 49 which has the usual seal rings to prevent fluid leakage through the joint. As will be more fully explained, running tool 50 has a first position which allows engagement of hanger 35 with casing 20 and a second position which allows rotation of tubular means 36 and its attached liner relative to casing 20. The various components of running tool 50 are attached to or carried by mandrel means 51. Longitudinal bore 52 extends through mandrel means 51. Threads 53 and 54 on opposite ends of mandrel means 51 and longitudinal bore 52 cooperate with each other to provide means for attaching mandrel means 51 to workstring 47 to allow fluid communication via similar bores in workstring 47 and other well tools attached thereto. Threads 53 and coupling 49 also provide means for rotation of running tool 50 as part of workstring 47.

The exterior of mandrel means 51 has a generally square exterior cross section throughout most of its length as shown in Figures 7, 9, 10 and 11. The interior of mandrel means 51 has a generally circular cross section which defines bore 52.

First connector means or nut 56 has generally square opening 57 therethrough and is slidably carried on the portion of mandrel means 51 which has square exterior cross section 55. Square opening 57 and square cross section 55 cooperate with each other to allow nut 56 to slide longitudinally relative to mandrel means 51, but rotation of mandrel means 51 causes rotation of nut 56. Threads 58 are formed on the exterior of nut 56 to engage matching threads 59 on the interior of tubular means 36. Nut 56 and threads 58 and 59 provide means for releasably engaging running tool 50 with hanger 35 so that workstring 47 can move hanger 35 longitudinally within casing 20.

Second connector means 60 is slidably carried on the same exterior portion of mandrel means 51 as nut 56. Second connector means 60 includes cylindrical drive means 61 with the same generally square opening 57 extending therethrough. Drive means 61 can be rotated by mandrel means 51 in the same manner as nut 56. A plurality of downwardly projecting fingers 62 are formed on the extreme end of drive means 61 which faces nut 56. The interior of tubular subassembly 36b has a matching number of longitudinal recesses 150 extending partially therethrough to receive fingers 62. Recesses 150 and fingers 62 function as a clutch. When they are engaged, rotation of drive means 61 by mandrel means 51 causes tubular means 36 to rotate. When they are disengaged, rotation of drive means 61 has no effect upon tubular means 36.

Second connector means 60 also has cap 64 threadedly engaged with the end of drive means 61 opposite fingers 62. Snap ring 65 is secured to second connector means 60 by cap 64. Snap ring 65 is sized to fit snugly around mandrel means 51. Grooves 66 and 67 are provided in the exterior of mandrel means 51 and spaced longitudinally from each other. Snap ring 65 is sized to fit within either groove 66 or 67. Spring 68 is disposed around the exterior of mandrel means 51 between first connector means 56 and second connector means 60. The purpose of spring 68 is to assist with the engagement of threads 58 on the exterior of nut 56 with threads 59 of tubular means 36b prior to inserting liner hanger 35 into the well bore.

In addition to running tool 50, workstring 47 has several other well tools attached thereto to assist with securing hanger 35 at the desired downhole location and cementing its attached liner within the well bore. The other well tools include ball bearing assembly 90, seal unit 100, and liner wiper plug 110. Ball bearing assembly 90 allows workstring 47 to rotate running tool 50 without having to also rotate seal unit 100 or liner wiper plug 110. Thus, both of these well tools are subject to less wear and

maintain a better fluid barrier within tubular means 36. Relatively expensive ball bearing assembly 90 is appropriate for use in workstring 47 because it is retrieved when the well completion is finished and can be reused several times.

Operating Sequence

Liner hanger 35 and its attached liner are assembled and inserted into casing 20 using conventional well completion techniques. Running tool 50 is used to releasably connect hanger 35 to workstring 47. The first position of running tool 50 is defined by first connector means 56 releasably engaging threads 59 of tubular subassembly 36b and snap ring 65 resting in groove 66. In its first position as shown in Figure 4B, running tool 50 can both rotate hanger 35 or move it longitudinally. Again, using conventional well completion techniques, hanger 35 and its associated liner are lowered by workstring 47 to the desired location within the well bore.

Bow springs 40 rub against the inner wall of casing 20 while lowering hanger 35. This contact creates a force which tends to move slip means 23 towards expander means 28. However, slip means 23 are limited in longitudinal movement relative to tubular means 36 by the engagement of lug 41 with J-slot 42 in slip carrier 39. In Figure 4D, lug 41 is shown at the bottom of J-slot 42. While lowering hanger 35, slip carrier 39 would move longitudinally relative to tubular means 36 until lug 41 contacts the upper portion 42a of J-slot 42. This intermediate position is not shown in the drawings. When hanger 35 reaches the desired location, workstring 47 is rotated a preselected number of turns to cause rotation of tubular means 36. Contact between bow springs 40 and casing 20 restricts rotation of slip carrier 39, causing lug 41 to move out of J-slot 42. Workstring 47 is next lowered a few inches which causes expander means 28 to move toward slip means 23 and force teeth 27 into contact with the inner wall of casing 20 as shown in Figure 5B. Further downward movement of hanger 35 is thus prevented by slip means 23 and expander means 28. Since both connector means 56 and 60 are still engaged with tubular means 36, further lowering of workstring 47 forces snap ring 65 out of groove 66 to allow longitudinal movement of mandrel means 51 relative to connector means 56 and 60. This movement continues until threaded coupling 49 abuts cap 64 and snap ring 65 engages groove 67 as shown in Figure 5A. Further downward movement of workstring 47 is now blocked.

Workstring 47 is next raised to shift running tool 50 to an intermediate position (not shown) between its first position as shown in Figure 4B and second position as shown in Figure 5A. Since snap ring 65 is secured within groove 67, raising workstring 47 moves fingers 62 of second connector means 60 longitudinally out of recesses 150. The upward movement of workstring 47 can continue until shoulder 55a of mandrel means 51 contacts nut 56. Workstring 47 is then rotated to disengage nut 56 from tubular means 36. Tubular means 36 does not rotate at this time because fingers 62 are held longitudinally spaced from recesses 150. When first connector means 56 has been disengaged from threads 59, workstring 47 and running tool 50 are free to move longitudinally relative to hanger 35. Workstring 47 is next lowered to reengage fingers 62 with recesses 150. Nut 56 slides toward second connector means 60 compressing spring 68 because threads 58 and 59 block reentry of nut 56 into this portion of tubular subassembly 36b. Running tool 50 is thus shifted to its second position as shown in Figure 5A in which running tool 50 can only rotate tubular means 36 and its attached liner. Snap ring 65 and grooves 66 and 67 cooperate to provide a portion of the means for releasably securing both connector means 56 and 60 in either their first or second positions.

With running tool 50 in its second position, bearing assembly 70 allows workstring 47 to rotate tubular means 36 and its attached liner. Cement or another suitable bonding agent is pumped through workstring 47 during such rotation. U. S. Patent 4,378,838 to James D. Ogden et al describes cementing methods using liner wiper plug 110 and pump-down plug 115. Plug 115 is shown by dotted lines in Figure 4E because it is pumped through workstring 47 after the desired amount of cement has been pumped into the annulus between the well bore and the exterior of the liner. As previously noted, standard cementing procedures result in displacement of excess cement from around the top of liner hanger 35. This excess cement will fall down into longitudinal passageway 37 on top of running tool 50. If workstring 47 and running tool 50 are not withdrawn quickly from longitudinal passageway 37 following completion of cementing, this excess cement will harden and trap workstring 47 in place. The engagement of fingers 62 with longitudinal recesses 150 readily facilitates quick removal of running tool 50 by straight upward pull or workstring 47.

Alternative Embodiment

Modified running tool 50a with an alternative embodiment of the present invention is shown in Figure 14. The same numerals are used for previously described components. Running tool 50a has a first position and a second position as previously defined.

In running tool 50a, previously described snap ring 65 and cap 64 have been replaced by modified snap ring 165 and cap 164. The modification includes installing one or more shear pins 163 to releasably secure snap ring 165 to cap 164 when running tool 50a is in its first position as shown in Figure 14. Shear pins 163 are selected to establish a preselected amount of weight which must be applied to mandrel means 51 via workstring 47 to release snap ring 165 from recess 66.

As best shown in Figures 15 and 16, snap ring 165 is a relatively thin-walled hollow cylinder. A plurality of holes 167 extend radially through snap ring 165 around its diameter midway between each end. Twelve holes 167 are shown in Figure 15, so that if two, three, four or six shear pins 163 are used, the shear pins will be equally spaced around the circumference of snap ring 165.

A plurality of slots 168 are cut out of snap ring 165

in between holes 167. Slots 168 extend radially through the wall of ring 165 with a length equal to approximately two-thirds of the height of ring 165. Slots 168 are alternately machined from opposite ends of ring 165. Slots or cutouts 168 improve the flexibility of snap ring 165 after pins 163 are sheared. Shear pins 163 provide frangible means for releasably engaging snap ring 165 to cap 64 when connector means 60 is in its first position.

If desired, cap 164 or drive head 61 could be modified to include a frangible means (shear pin, shear screws, shear ring, etc.) that directly connects cap 164 or drive head 61 to mandrel means 51 when running tool 50a is in its first position. This additional modification would allow elimination of snap ring 65 or 165 and recess 66 and 67 in mandrel means 51. Connector means 60 would not be held in its second position as previously described but would be slidable over the exterior of mandrel means 51.

The previous description is illustrative of only some embodiments of the present invention. Those skilled in the art will readily see additional changes and modifications for use in well completions. Such changes and modifications may be made without departing from the scope of the invention which is defined in the claims.

CLAIMS

1. A non-sealed bearing assembly for use in a liner hanger comprising:

a. a plurality of thrust washers;

b. a plurality of support rings;

c. each thrust washer disposed between a pair of support rings;

d. each pair of support rings having a first ring with a recess sized to receive the thrust washer therein and the second ring having a thrust face sized to engage the thrust washer whereby the first ring and thrust washer can rotate relative to the second ring; and

e. a lip formed on the outside diameter of the first ring and extending from the recess to overlap both the thrust washer and a portion of the second ring adjacent to the thrust face.

2. A non-sealed bearing assembly as defined in claim 1 further comprising:

a. the thrust washer having a lubricating material deposited on at least one surface and the thrust face of the second support ring in substantial contact with the lubricating material; and

b. the lip of the first support ring limiting extrusion of the lubricating material as increased load is placed on the bearing assembly.

3. A non-sealed bearing assembly as defined in claim 2 wherein the lubricating material is selected from the group consisting of bronze, lead, polytetrafluroethylene, or a combination thereof.

4. Apparatus for positioning a liner in a well bore defined in part by a well casing, comprising:

a. a liner hanger with a tubular means extending therethrough;

b. means for attaching the liner to the tubular means;

c. means for engaging the liner hanger with the interior of the casing at a desired downhole location;

d. the engaging means further comprising:

(1) a non-sealed bearing assembly which allows rotation of the tubular means and the liner relative to the casing;

(2) a first sleeve fixed to the exterior of the tubular means and rotatable therewith;

(3) a second sleeve carried on the exterior of the tubular means and sized to allow rotation of the tubular means relative thereto;

(4) the bearing assembly disposed between the first sleeve and the second sleeve; and

(5) a slip expander means formed on the exterior of the second sleeve; and

e. the bearing assembly comprising:

(1) a plurality of thrust washers;

(2) a plurality of support rings;

(3) each thrust washer disposed between a pair of support rings;

(4) each pair of support rings having a first ring with a recess sized to receive the thrust washer therein and the second ring having a thrust face sized to engage the thrust washer; and

(5) a lip formed on the outside diameter of the first ring and extending from the recess to overlap both the thrust washer and a portion of the second ring adjacent to the thrust face.

5. Apparatus for positioning a liner in a well bore as defined in claim 4, further comprising:

a. a running tool attached to a workstring; and

b. the running tool having a first position which allows engagement of the liner hanger with the interior of the casing and a second position which allows rotation of the tubular means and attached liner relative to the well bore.

6. A liner hanger running tool for positioning a liner hanger with a bearing assembly and its associated liner within a well bore defined in part by a well casing and for rotating the liner while cementing the liner within the well bore, comprising:

a. mandrel means having a longitudinal bore extending therethrough;

b. means for attaching the mandrel means to a workstring to allow fluid communication through the longitudinal bore and rotation of the running tool as part of the workstring.

c. first connector means for releasably engaging the running tool with the liner hanger to allow longitudinal movenent of the liner hanger by the workstring;

d. second connector means for releasably engaging the running tool with the hanger whereby rotation of the workstring causes rotation of the liner;

e. the first and second connector means slidably carried on the exterior of the mandrel means; and

f. means for releasably securing both connector means in a first position allowing longitudinal movement and rotation of the liner by the running tool or a second position allowing only rotation of the liner by the running tool.

7. A running tool as defined in claim 6 wherein the first connector means is operable by rotation of the mandrel to release the running tool for longitudinal movement relative to the liner hanger.

8. A running tool as defined in claim 7 wherein the first connector means comprises a nut member having threads on its exterior for engagement with matching threads on the interior of the liner hanger.

9. A running tool as defined in claim 6 wherein the second connector means comprises:

a. drive means rotatably carried by the mandrel means;

b. a plurality of fingers projecting longitudinally from one end of the drive means; and

c. the fingers sized to be engaged with matching longitudinal recesses on the interior of the liner hanger whereby rotation of the workstring is transmitted via the mandrel means, the drive means, its fingers and their respective recesses to the hanger and its associated liner.

10. A running tool as defined in claim 9 wherein the second connector means further comprises:

a. a cap attached to the drive means opposite from the fingers;

b. a snap ring secured to the second connector means by the cap;

c. grooves in the exterior of the mandrel means sized to receive the snap ring; and

d. the grooves and snap ring cooperating to provide a portion of the releasable securing means.

11. A running tool as defined in claim 10 wherein the means for releasably securing both connector means further comprises:

a. frangible means for releasably engaging the snap ring to the cap when the connector means are in their first position; and

b. a plurality of cutouts extending through the wall of the snap ring.

12. A method for completing well bores defined in part by a well casing comprising:

a. releasably connecting a hanger having a bearing assembly and its associated liner to a workstring by using a running tool having a first position and a second position;

b. lowering the hanger and its associated liner with the workstring to a desired location within the well bore;

c. engaging the hanger with the casing at the desired location;

d. rotating the workstring to release the hanger from the running tool;

e. moving the workstring longitudinally with respect to the hanger to shift the running tool from its first position to its second position;

f. reconnecting the hanger with the running tool in its second position;

g. rotating the liner by rotation of the workstring;

h. discharging cement through the workstring to form a bond with the exterior of the liner during rotation; and

i. raising the workstring to disconnect the running tool from the hanger upon completion of cementing.

13. The method of claim 12 wherein the hanger is engaged with the casing by a combination of longitudinal and rotational movement of the workstring with the running tool in its first position.

14. The method of claim 12 wherein the cementing step further comprises:

a. discharging cement through the workstring and into the well bore around the liner via a cement shoe at the lower end of the liner;

b. moving the workstring longitudinally upward to release the running tool from the hanger; and

c. continued upward movement to retrieve the workstring and running tool from the well bore.

15. A non-sealed bearing assembly for use in a liner hanger substantially as hereinbefore described with reference to and as illustrated in Figures 3 to 15 of the accompanying drawings.

16. Apparatus for positioning a liner in a well bore substantially as hereinbefore described with reference to and as illustrated in Figure 1 and Figures 3 to 15 of the accompanying drawings.

17. A liner hanger running tool substantially as hereinbefore described with reference to and as illustrated in Figure 1 and Figures 3 to 15 of the accompanying drawings.

18. A method for completing a well bore defined in part by a well casing substantially as hereinbefore described with reference to and as illustrated in Figure 1 and Figures 3 to 15 of the accompanying drawings.

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