United States Patent [19]

Putch

[11] **3,918,747**

[45] **Nov. 11, 1975**

[54] **WELL SUSPENSION SYSTEM**

[75] Inventor: **Samuel W. Putch,** Houston, Tex.

[73] Assignee: **Norman A. Nelson,** Houston, Tex. ; a part interest

[22] Filed: **Sept. 27, 1973**

[21] Appl. No.: **401,510**

[52] **U.S. Cl.** **285/4;** 285/39; 285/18; 285/141; 285/315; 285/330; 285/DIG. 21; 166/208; 166/217

[51] **Int. Cl.** **F16l 35/00**

[58] **Field of Search** ..... **285/321, 3, 4, 307, 39, 141,** 285/140, 330, 142, 143, 18, 24, 27, 133 R, 133 A, 93, DIG. 21, 315; 166/208, 217, 131, 149, 150, 184, 224, 123

[56] **References Cited**

UNITED STATES PATENTS

2,178,549	11/1939	Block	285/141
2,766,831	10/1956	Otis	166/123 X
3,321,217	5/1967	Ahlstone	285/18
3,333,870	8/1967	Wotkins	285/18
3,338,596	8/1967	Knox	285/351 X
3,341,227	9/1967	Pierce	285/141 X
3,353,847	11/1967	Brown	285/321 X
3,357,486	12/1967	Brown	285/142 X
3,420,308	1/1969	Putch	285/140 X
3,455,578	7/1969	Hones	285/141 X

Primary Examiner—Dave W. Arola
Attorney, Agent, or Firm—Fulbright & Jaworski

[57] **ABSTRACT**

A well tubular suspension system, particularly adaptable for underwater support of casings and well completions. A casing hanger assembly which eliminates threads from the top portion of the hanger and which may be engaged by a well tool telescopically engaging the exterior of the hanger and releasably connected thereto. The well tool includes locking means which may be actuated by longitudinal movement. The well tool may be disconnected from the hanger by rotational movement. Wash ports are eliminated from the wall of the hanger by providing the ports in the wall of the well tool. The well tool may be mechanically or hydraulically actuated. Sealing means between the well tool and the hanger may be utilized including a metal seal and a testing line may be included in the well tool behind the seals for testing and/or monitoring seal integrity. The hanger body may include a male hub which makes it possible to install a squeeze seal packoff between hangers without adding additional members to the system. An improved hanger assembly for connection to a second tubular member is provided in which a locking ring is provided having shearable holding means intermediate the ends of the locking ring for reducing the tendency of the ring to cock when locked. The locking ring also includes improved tapered surfaces for positively expanding, and locking the ring between the tubular members.

17 Claims, 23 Drawing Figures

FIG. 1

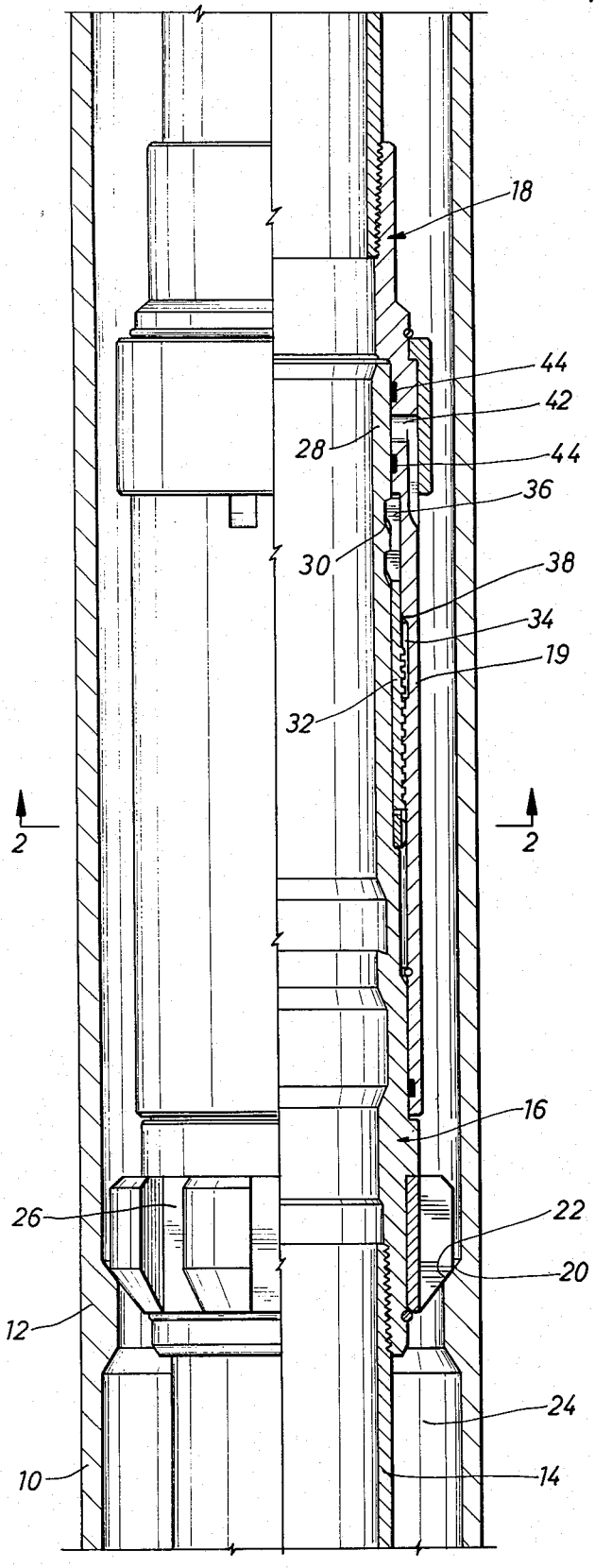


FIG. 2

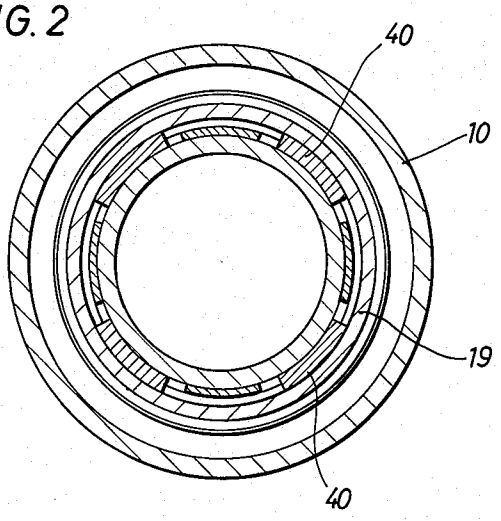


FIG. 3

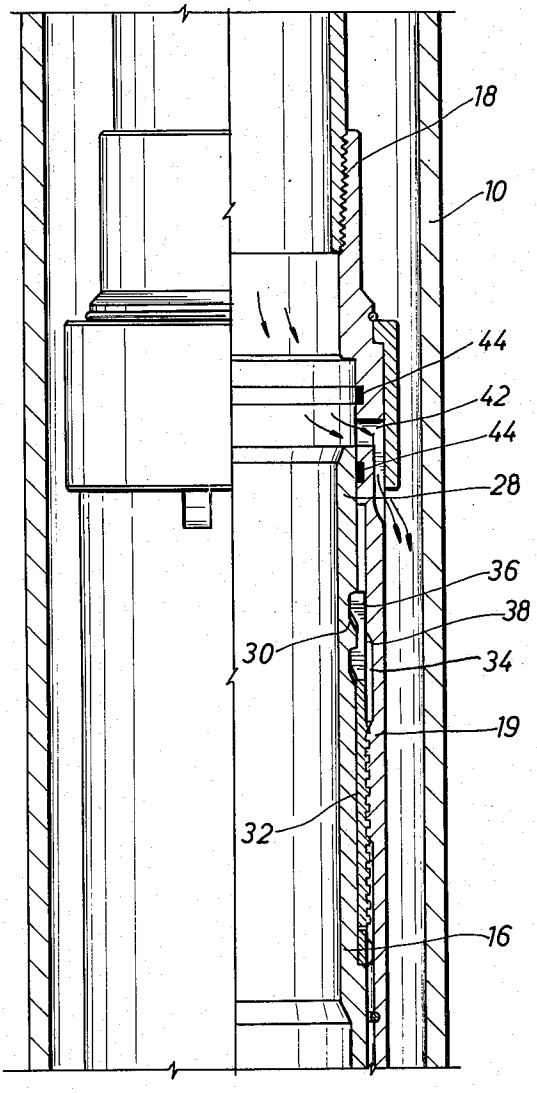


FIG. 4

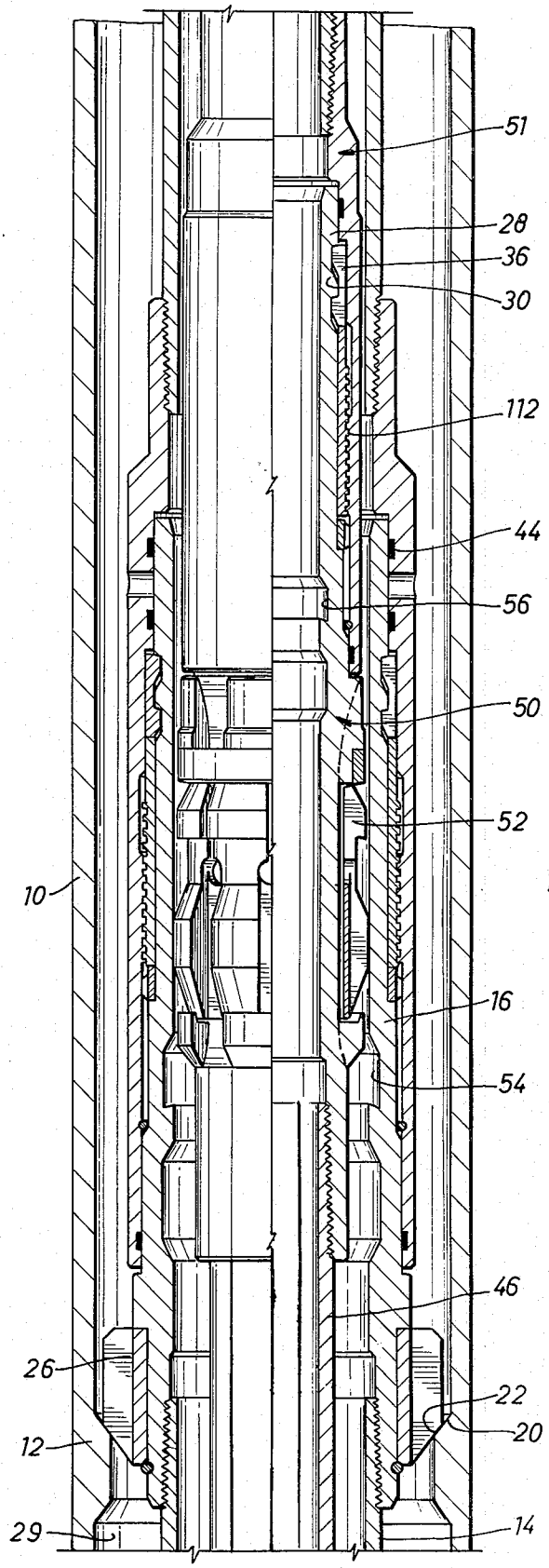

51
28
36
30
112
44
56
50
52
10
16
54
46
26
22
20
12
29
14

FIG. 5

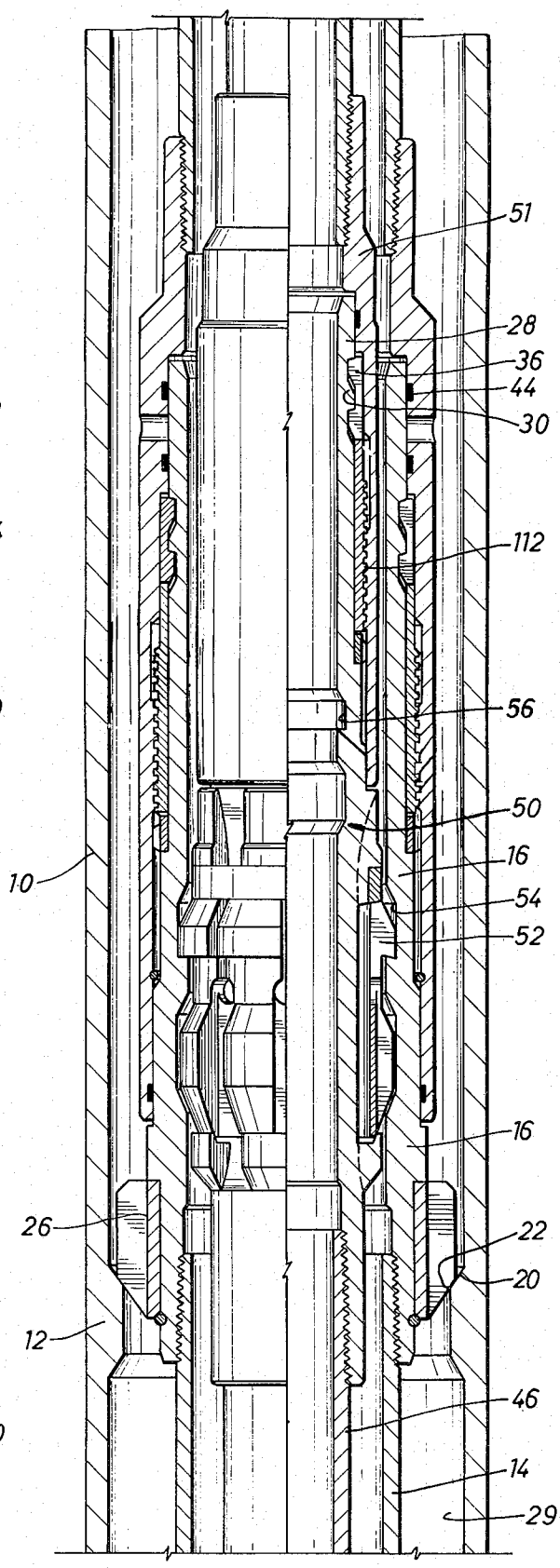

51
28
36
44
30
112
56
50
16
54
52
10
16
26
22
20
12
46
14
29

FIG. 6A

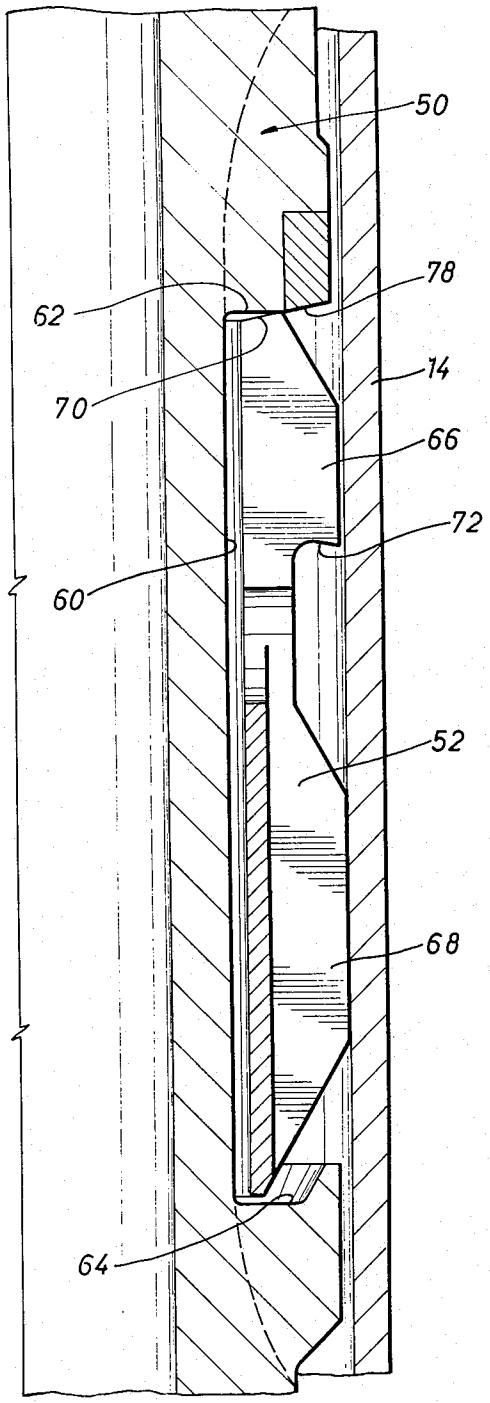


FIG. 6B

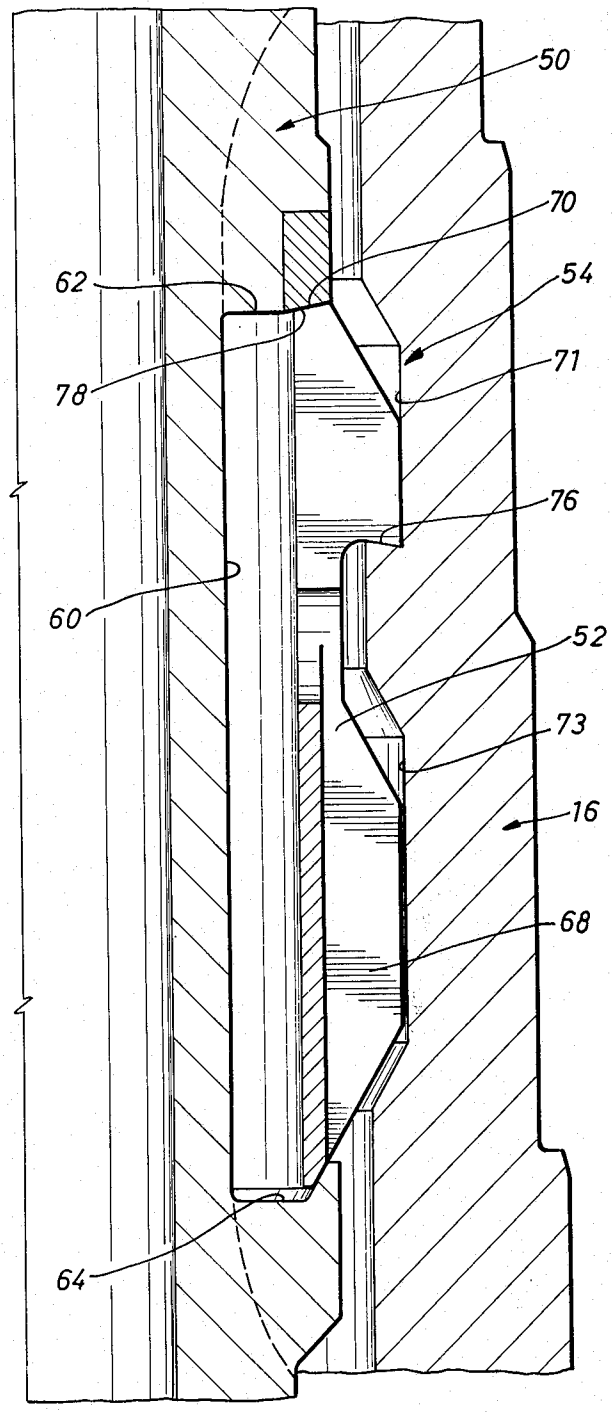


FIG. 7A

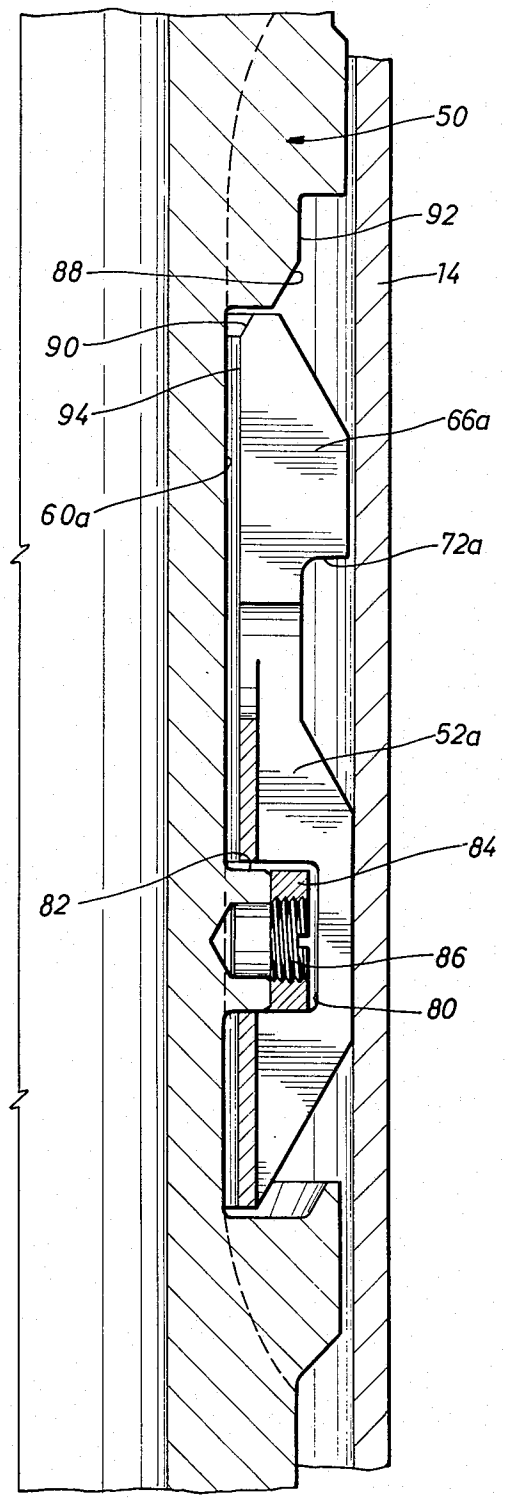

50
92
88
14
90
94
66a
60a
72a
52a
84
82
86
80

FIG. 7B

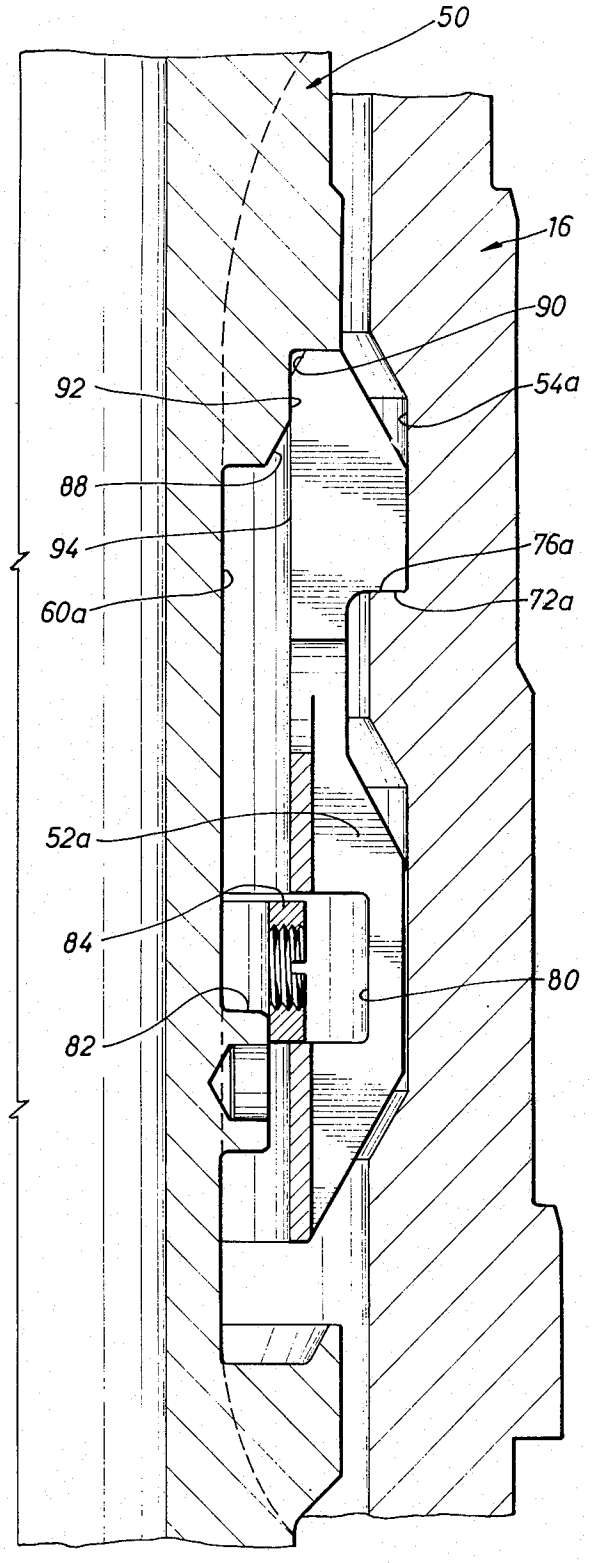

50
16
90
92
54a
88
94
76a
60a
72a
52a
84
80
82

FIG. 8A

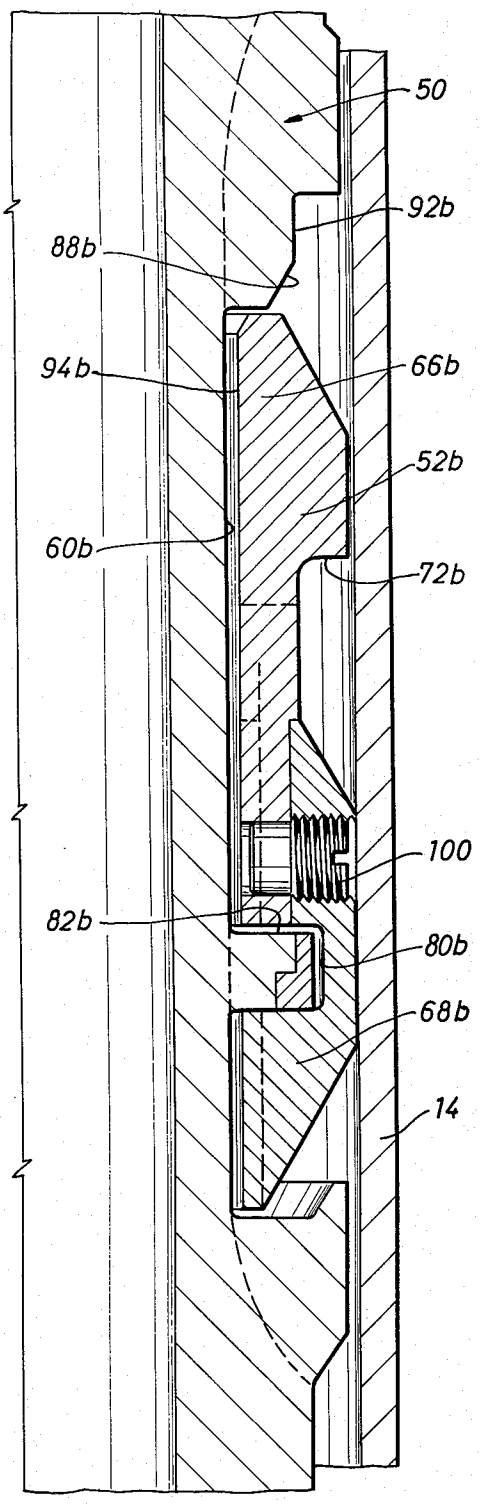

50
92b
88b
94b
66b
52b
60b
72b
100
82b
80b
68b
14

FIG. 8B

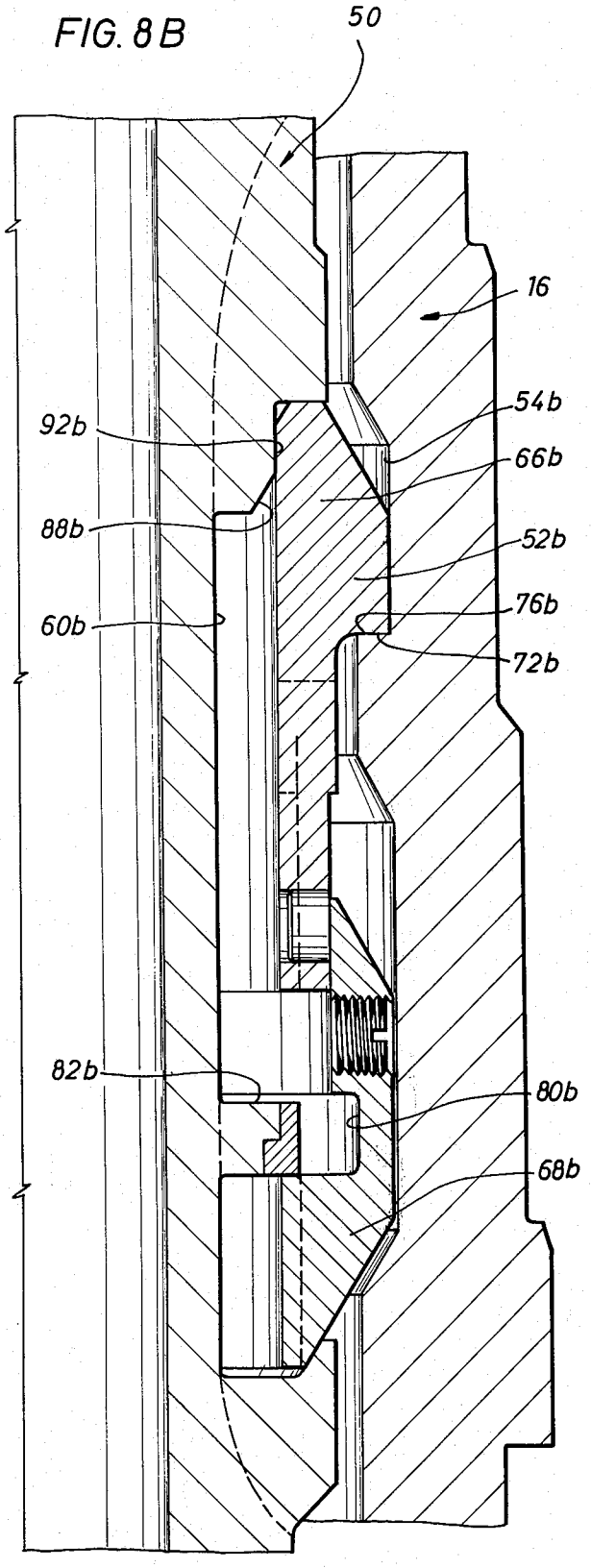

50
16
54b
92b
66b
88b
52b
76b
60b
72b
82b
80b
68b

FIG. 9A

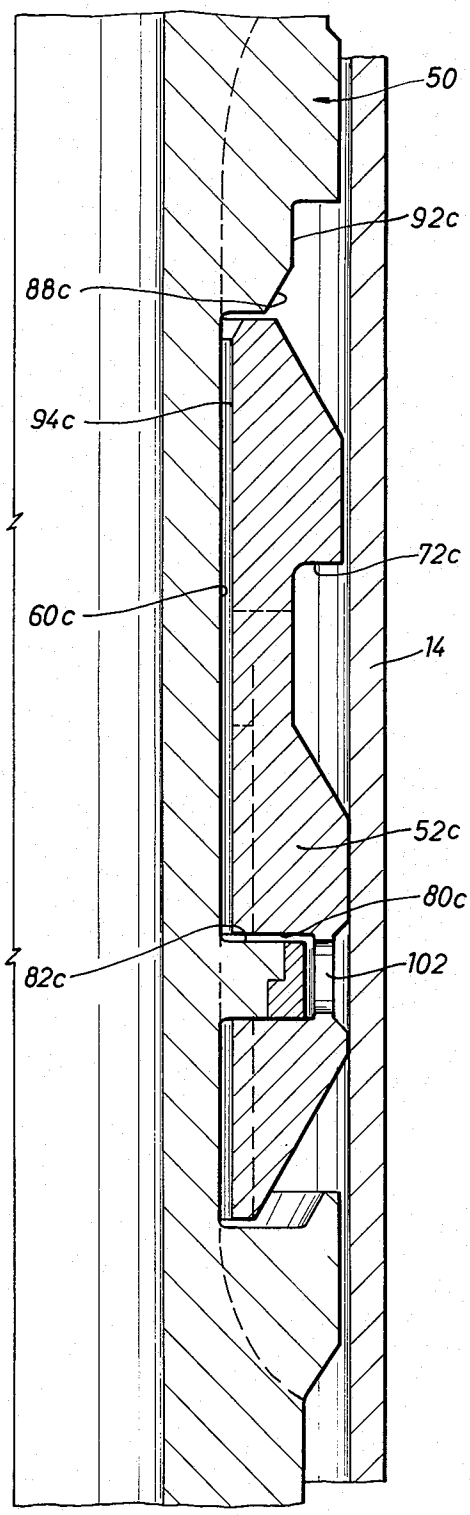

50
92c
88c
94c
72c
60c
14
52c
80c
82c
102

FIG. 9B

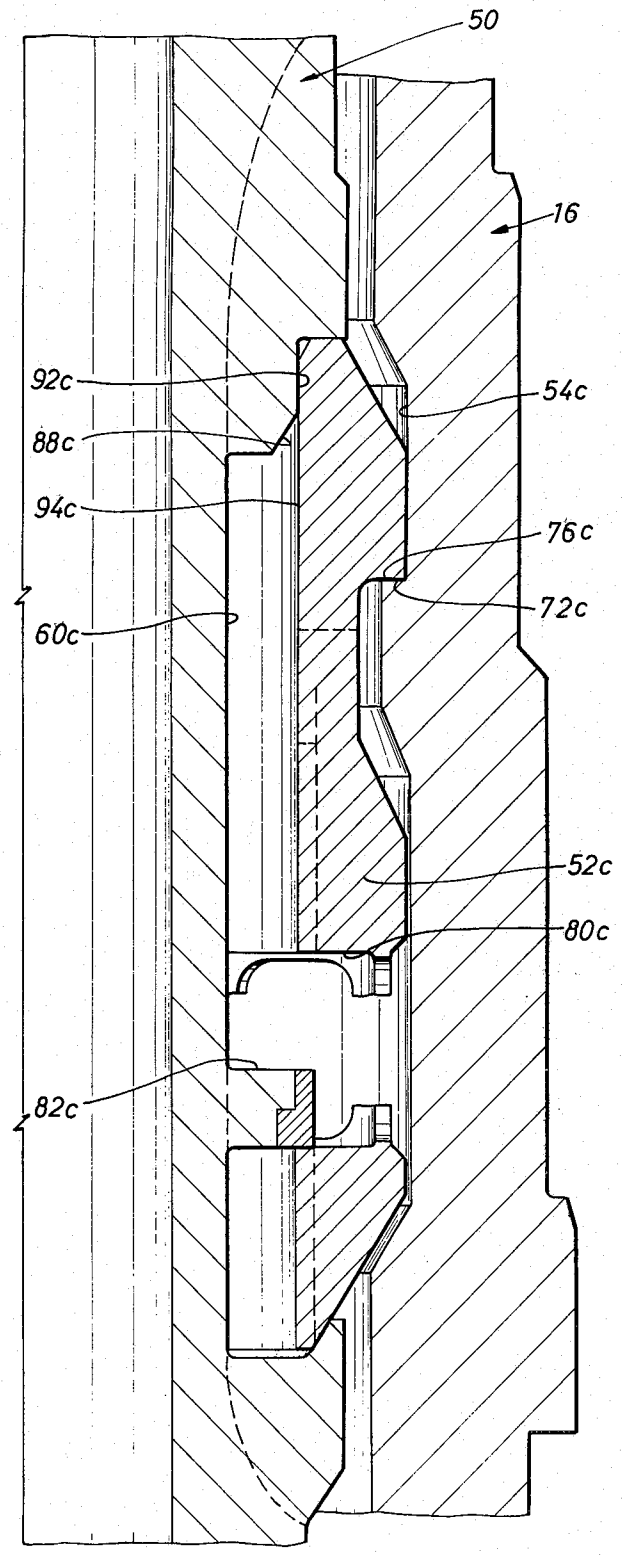

50
16
92c
54c
88c
94c
76c
72c
60c
52c
80c
82c

FIG.10

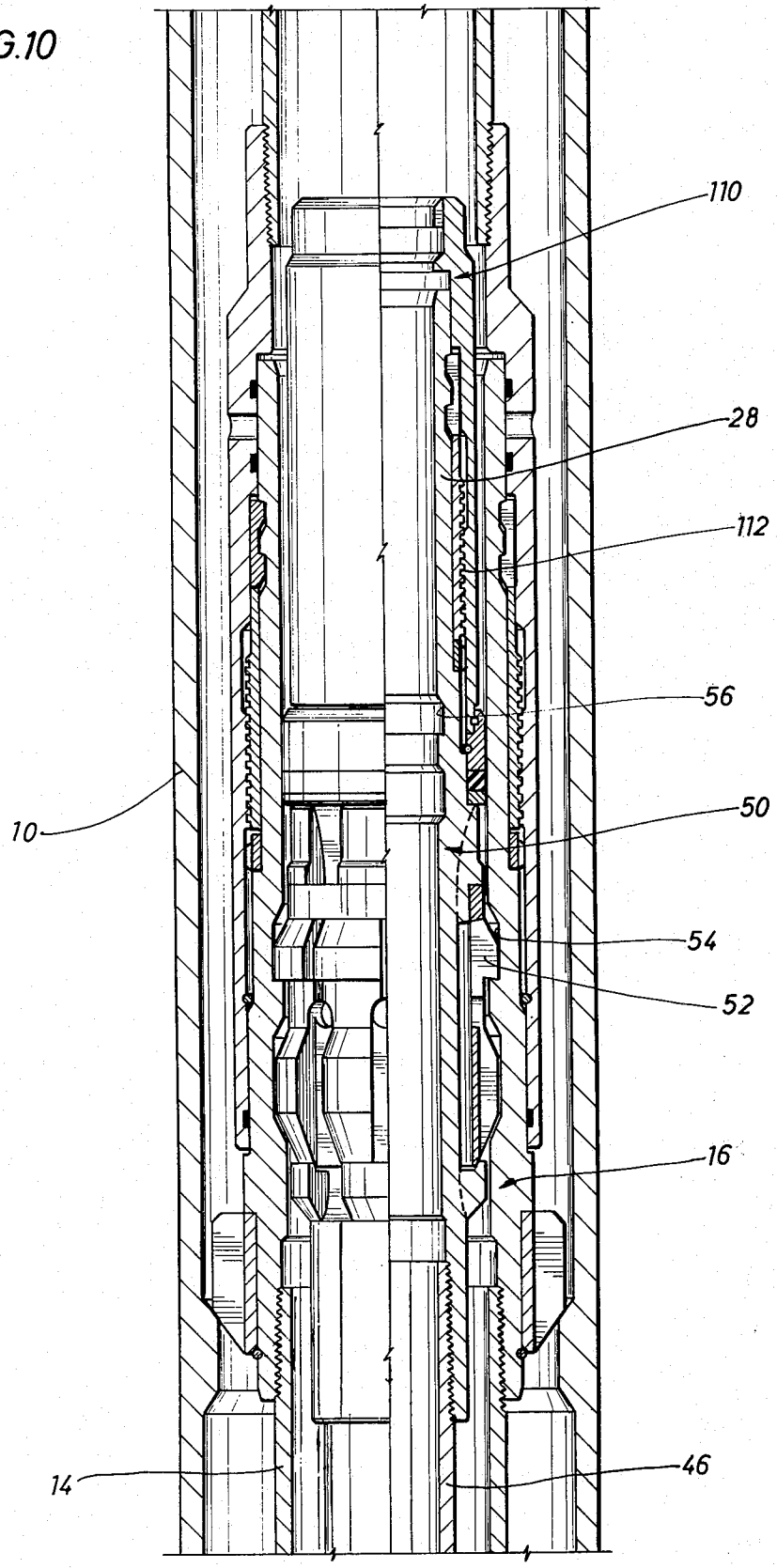


FIG. 11

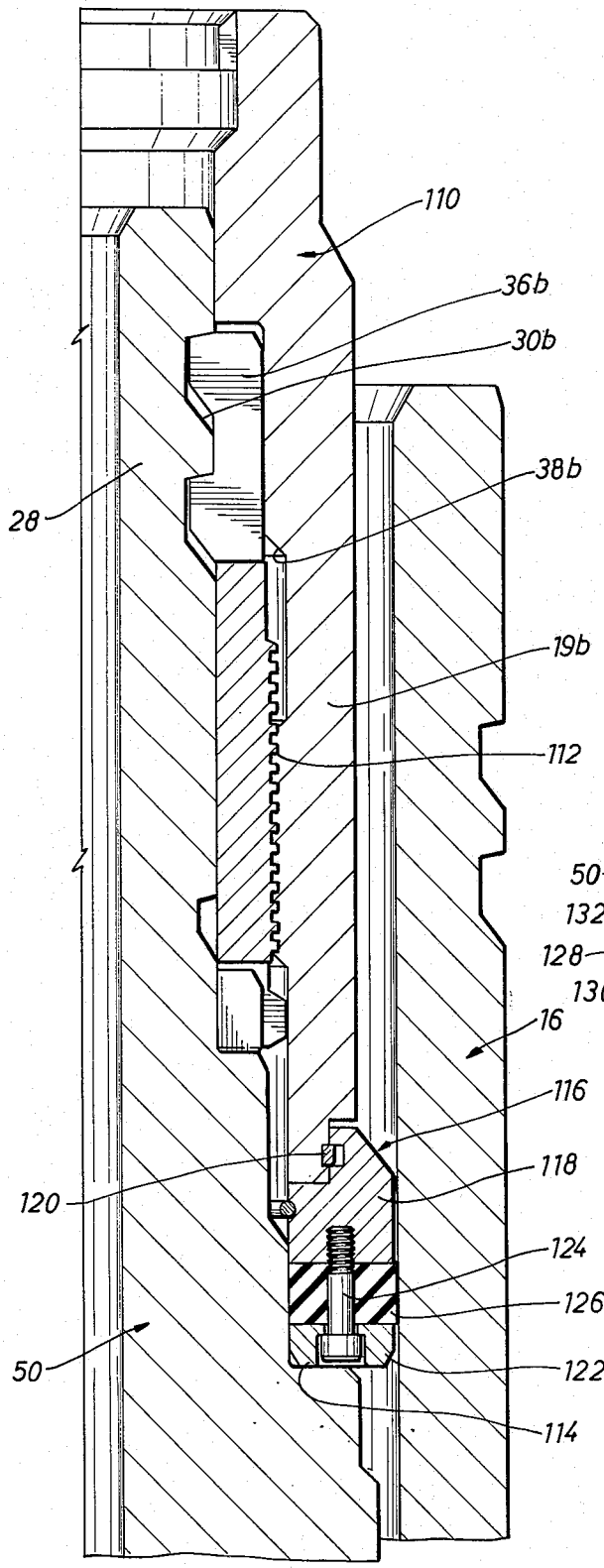

110
36b
30b
38b
28
19b
112
16
116
120
118
124
126
50
122
114

FIG. 12

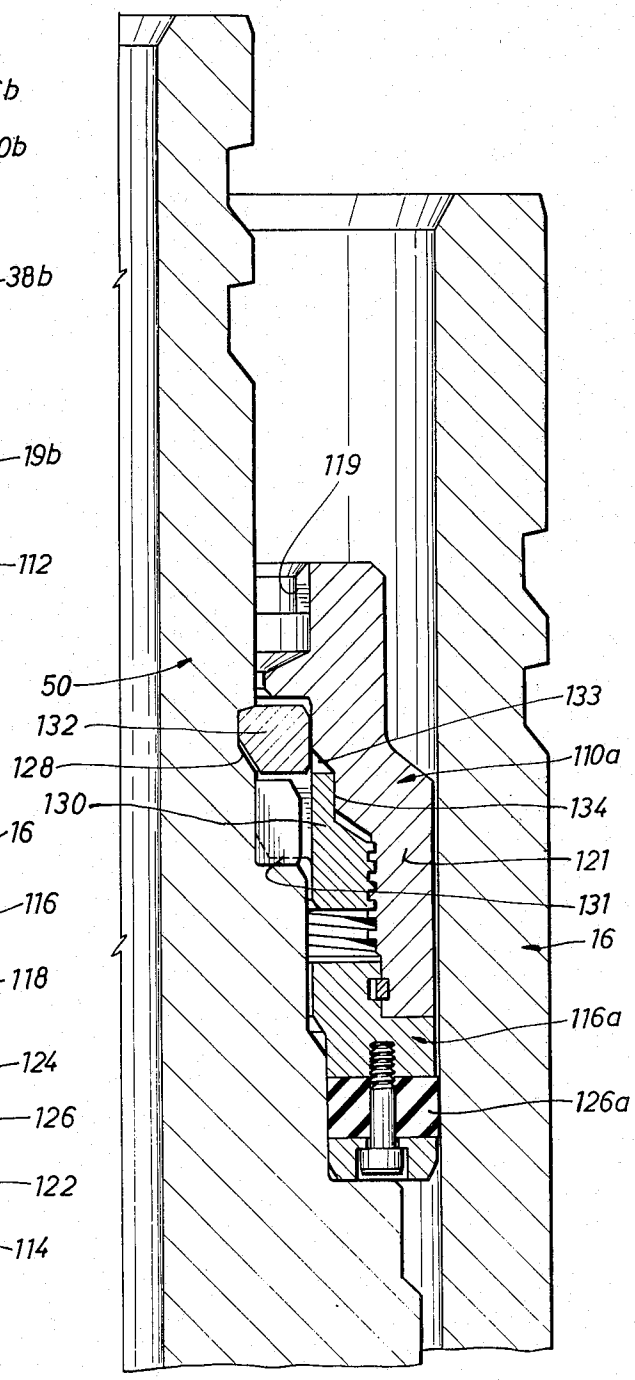

119
50
133
132
110a
128
134
130
121
131
16
116a
126a

FIG. 13

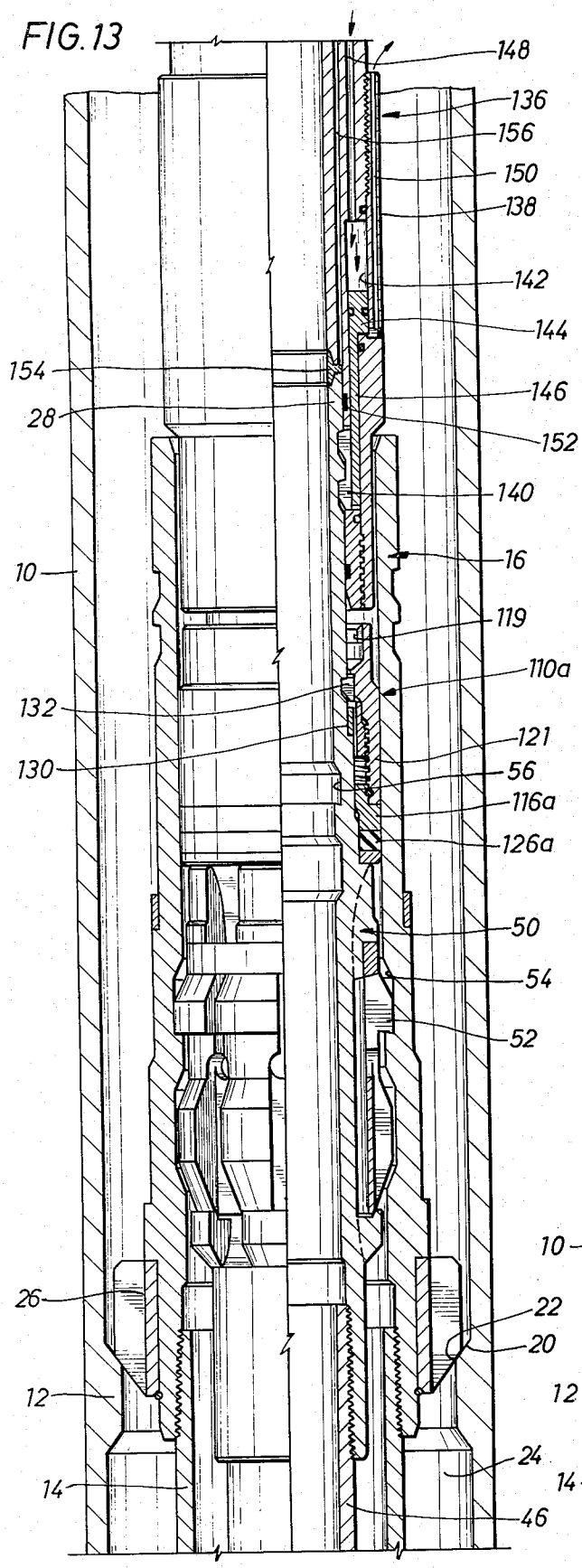

148
136
156
150
138
142
144
154
146
28
152
140
16
10
119
110a
132
121
130
56
116a
126a
50
54
52
26
22
20
12
24
14
46

FIG. 14

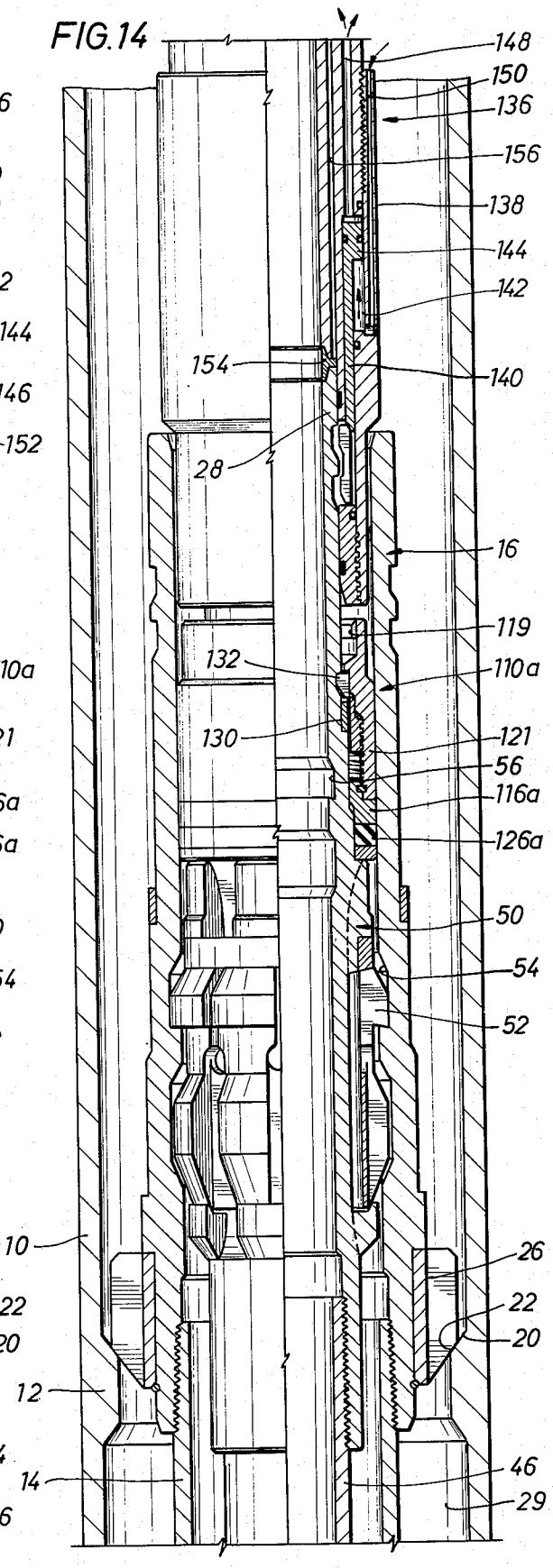

148
150
136
156
138
144
142
154
140
28
16
119
132
110a
130
121
56
116a
126a
50
54
52
10
26
22
20
12
46
14
29

FIG. 15A

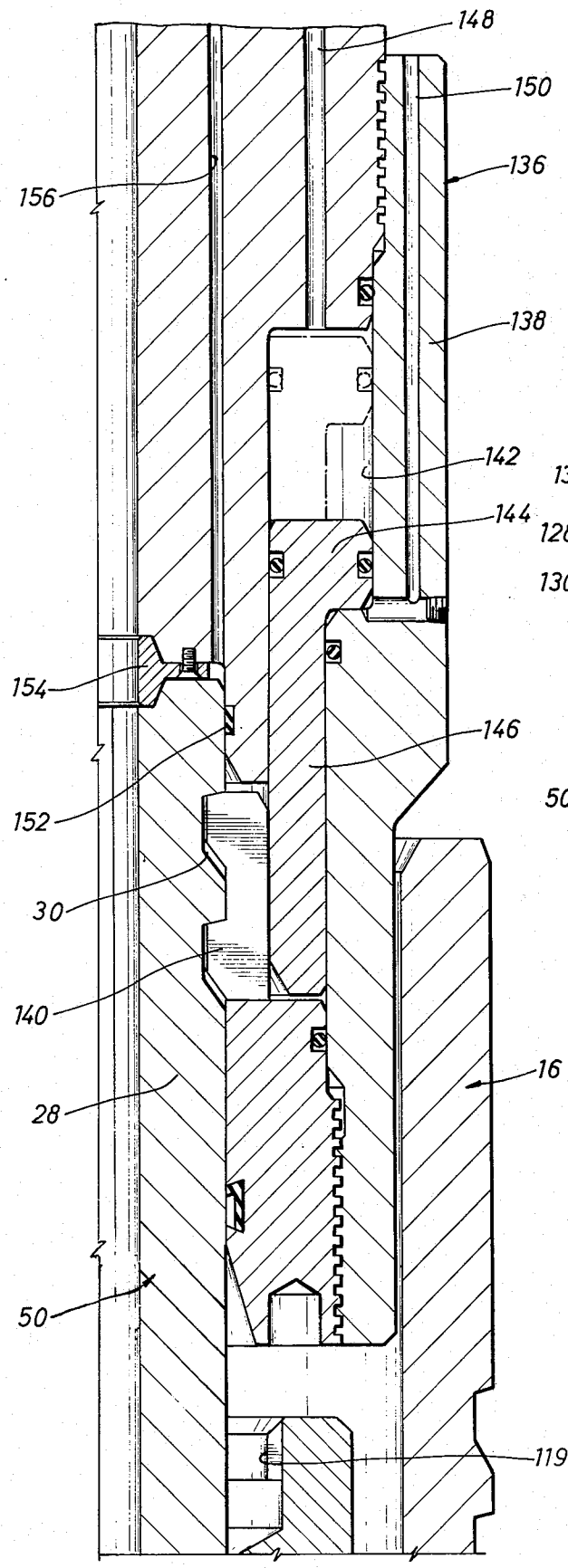


FIG. 15B

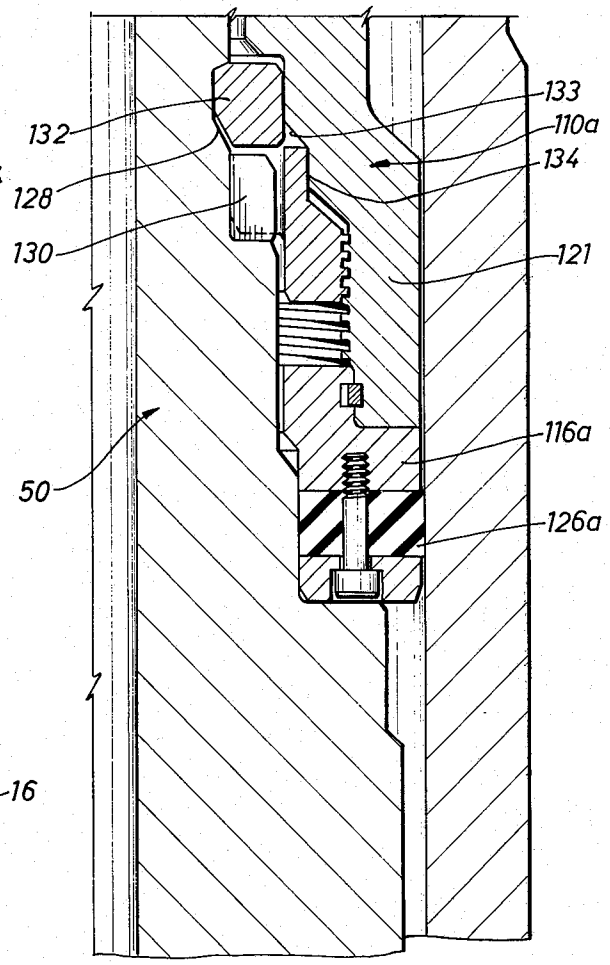


FIG. 16

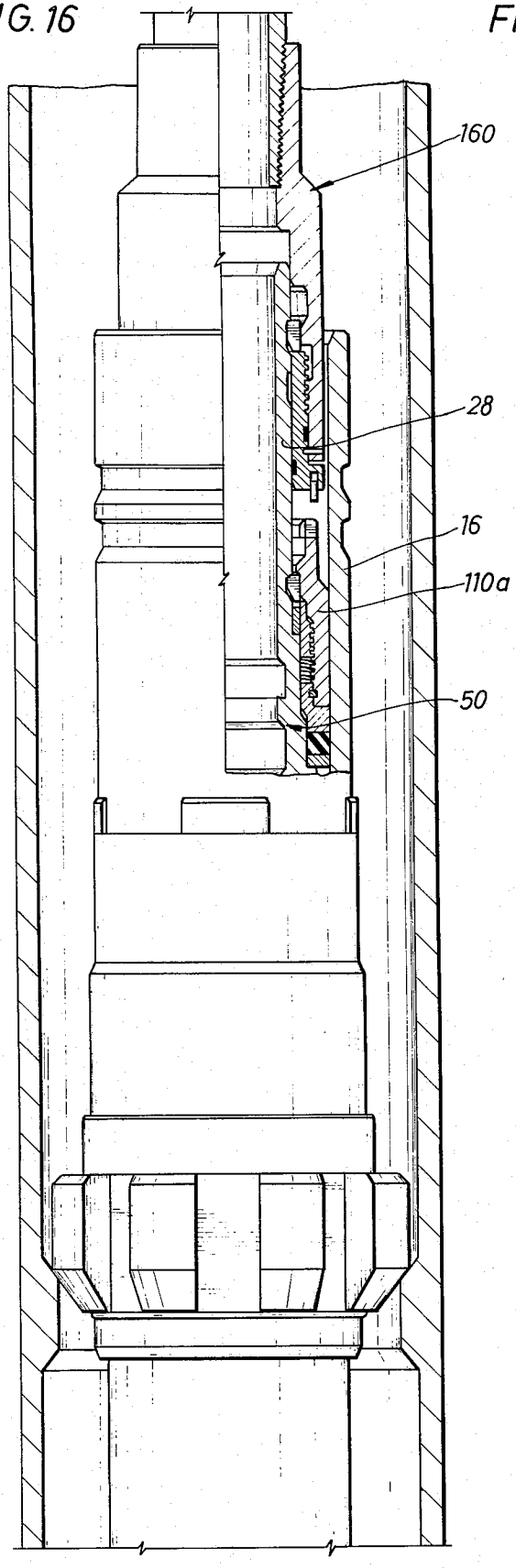


FIG. 17

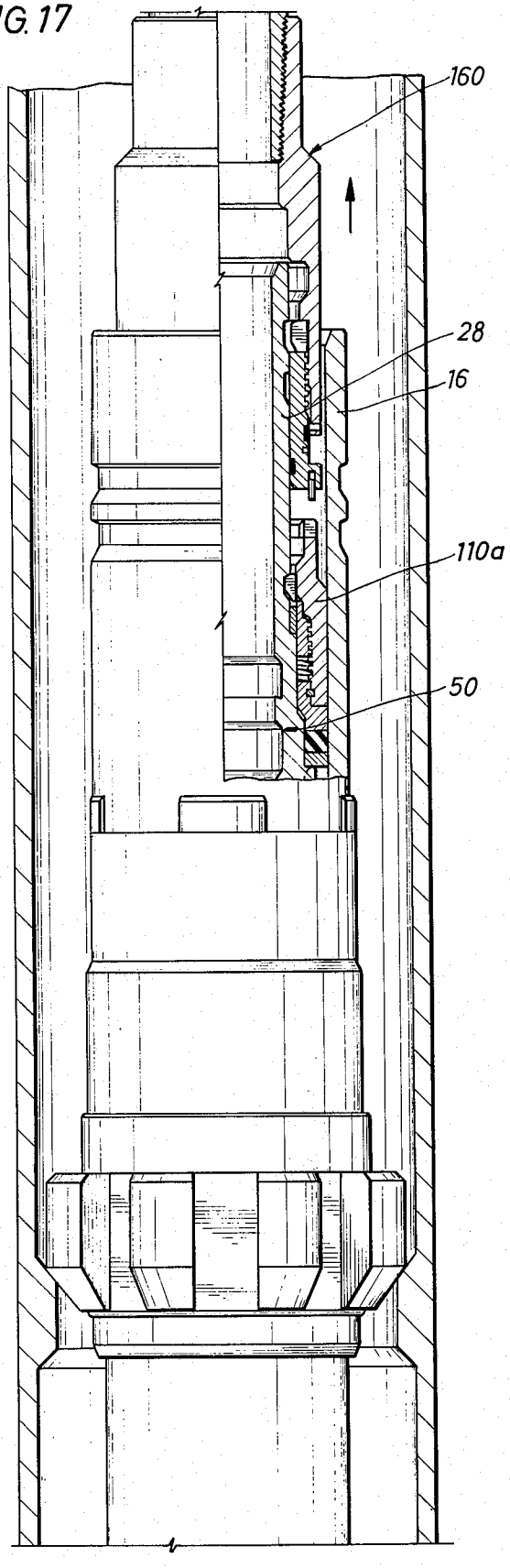
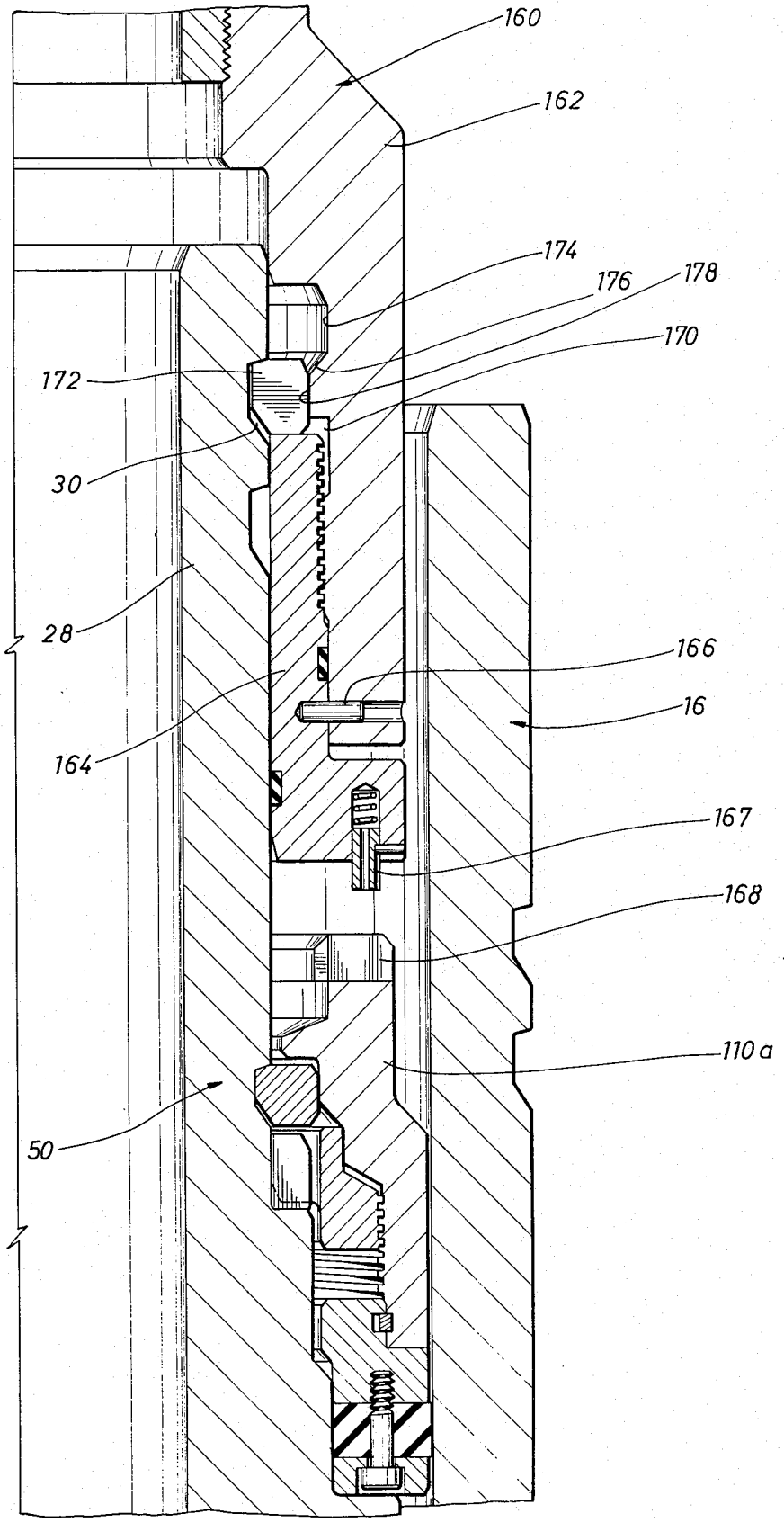


FIG. 18



WELL SUSPENSION SYSTEM

BACKGROUND OF THE INVENTION

The present invention is directed to a well suspension system, and primarily, an underwater mudline suspension system for supporting casing near the ocean mudline with improved reliability. Various improvements to the present suspension system are provided. One is an improved locking mechanism between adjacent tubular members which is weight sensitive so that the weight helps energize or expand the locking mechanism so that it will positively expand and seat, and reduce the chance of collapsing and dropping of pipe. Other improvements are directed to improved sealing mechanisms, improved casing hangers, and provide alternate ways of connecting onto the casing hangers.

The present suspension system can be used to drill a well, temporarily abandon the well, re-enter the well, extend the well to the surface for completion, or complete the well underwater.

SUMMARY

The present invention is directed to a well suspension system having various improvements providing greater reliability and flexibility by providing improved underwater connectors, seals, locking assemblies and casing hangers while simplifying the equipment.

One feature of the present invention is the elimination of the usual threads on the top portion of a casing hanger because such threads must be engaged remotely, and, if damaged, cause problems of connection. The present invention provides a re-connecting mechanism in which the casing hanger has an upwardly directed male member having non-threadable connecting means on its outside diameter which may be connected to a telescoping female well tool. The connection may be made by a longitudinal downward movement for actuating a resiliently expandable and contracting locking ring between the casing hanger and the well tool. Rotative means may be provided for rotatively releasing the well tool from the casing hanger.

Another feature of the present invention is the elimination of wash ports through the wall of the casing hanger thereby eliminating possible leaks, simplifying the equipment and adding flexibility and versatility by providing wash ports in the wall of the well tool which is removable. The effectiveness of the wash ports may be increased by directing their discharge downwardly.

A still further feature of the present invention is the provision of a well tool for connection to a well casing hanger which may be either manually actuated to provide a longitudinal stab-on connection and a rotatable releasing connection or by providing a well tool which includes a double acting fluid piston and cylinder assembly for providing a hydraulic connection to and release from the casing hanger.

Yet a still further object of the present invention is the provision of a resilient seal means connected to the well tool for engaging the casing hanger body, and a metal seal connected to the well tool for engaging the casing hanger body which may be readily changed when damaged, but yet provide a rugged and superior seal. A testing conduit may extend from the exterior of the well tool to a point intermediate the resilient seal and the metal seal for testing the seal.

A still further object of the present invention is the provision of a well suspension system having improved annulus packoff by providing a squeeze seal packoff about the upstanding male hub of the casing hanger to provide a seal between the hanger and an outer tubular member without requiring additional members to be connected to the system. In addition, the seal packoff may be connected to the well tool and positioned about the hanger at the same time the well tool is connected to the hanger.

Still a further object of the present invention is the provision of a packoff seal assembly between the exterior of the well hanger and the concentric tubular member which includes latching means for connecting the seal assembly to the outside of the hanger body and rotative means for actuating and releasing the seal assembly.

Still a further object is the provision of an improved locking assembly for connecting first and second tubular members together which includes a resiliently expandable and contractible locking ring axially movable on one of the members for engagement with the second member in which shearable holding means is provided intermediate the ends of the locking ring which is sheared by downward longitudinal movement of the first member for allowing the upper portion of the ring to releasably lock the first and second members together. The intermediate holding means insures that the locking ring does not cock but will uniformly be actuated and locked.

Still a further object of the present invention is the improvement of a locking assembly for connecting first and second tubular members together including a resiliently expandable and contracting locking ring having tapered surfaces at the top of the ring and under the locking shoulder for coacting with the first and second members for positively and securely providing a weight sensitive locking mechanism which will, when expanded and seated, reduce the chance of collapsing and dropping of the casing.

Still other and further objects, features and advantages will be apparent from the following description of presently preferred embodiments of the invention, given for the purpose of disclosure and taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an elevational view, partly in cross section, showing a landing sub connected to a fluted casing hanger assembly which supports an inner string of pipe inside of a drive pipe,

FIG. 2 is a cross-sectional view taken along the line 2—2 of FIG. 1,

FIG. 3 is a fragmentary elevational view, partly in cross section, showing the wash ports on the landing sub of FIG. 1 in the open position while attached to the casing hanger,

FIG. 4 is an elevational view, partly in cross section, showing an expanding casing hanger being run through casing and into the fluted casing hanger of FIG. 1,

FIG. 5 is an elevational view, partly in cross section, illustrating the expanding casing hanger of FIG. 4 in position inside the fluted casing hanger to prevent further downward movement,

FIG. 6A is an enlarged view of a portion of the expanding casing hanger shown in FIG. 5 illustrating the hanger locking mechanism being run inside of a casing,

FIG. 6B is a view similar to that of FIG. 6A showing the hanger locking mechanism in locked position in the fluted casing hanger,

FIG. 7A is an enlarged view of a modified casing hanger locking mechanism being run inside of a casing,

FIG. 7B is a view similar to that of FIG. 7A showing the locking mechanism locked in the fluted hanger,

FIG. 8A is an enlarged view of a portion of an expanding casing hanger showing another modified hanger locking mechanism being run inside a casing,

FIG. 8B is a view similar to that of FIG. 8A showing the locking mechanism positioned in the locked position in a second casing hanger,

FIG. 9A is an enlarged view of a portion of an expanding casing hanger showing a still further modified version of a hanger locking mechanism being run inside a casing,

FIG. 9B is a view similar to that of FIG. 9A showing the modified hanger locking mechanism of FIG. 9A locked in place in a second casing hanger,

FIG. 10 is an elevational view, in cross section, of an expanding casing hanger set inside a fluted casing hanger and a seal packoff assembly installed between the two hangers,

FIG. 11 is an enlarged cross-sectional view of the seal packoff assembly of FIG. 10,

FIG. 12 is an enlarged elevational cross-sectional view showing a modified packoff assembly locked into place on the body of an expanding casing hanger,

FIG. 13 is an elevational view, in cross section, of a casing hanger having the packoff assembly of FIG. 12 connected thereon, and a remote control hydraulic operated connecting well tool locked onto the expanding casing hanger,

FIG. 14 is a view similar to FIG. 13 showing the remote control hydraulic connector well tool unlocked from the expanding casing hanger,

FIG. 15A and 15B are continuations of each other and are enlarged fragmentary elevational views in cross section showing the remote hydraulic connector well tool and pack off of FIGS. 13 and 14,

FIG. 16 is an elevational view, in cross section showing a remote stab-on mechanical connector locked into the expanding casing hanger,

FIG. 17 is a view similar to FIG. 16 showing the remote stab-on mechanical connector unlocked from the expanding casing hanger, and

FIG. 18 is an enlarged elevational view, in cross section, showing the remote stab-on mechanical connector locked onto the top of the expanding casing hanger.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, and particularly to FIG. 1, in the drilling of an oil and/or gas well, a drive pipe 10 is drilled, jetted or otherwise driven into place, and a butt weld sub 12 is installed at the desired location in the drive pipe 10. In underwater applications, the drive pipe 10 would extend upwardly to the drilling rig.

A drill bit is run inside the drive pipe 10 and drilled to the required depth for the first casing string. After the hole is drilled, the bit is removed and a casing 14 is run inside the drive pipe 10 and suspended from a fluted casing hanger assembly 16 by a landing sub assembly 18. A shoulder 20 on the outside diameter of the fluted casing hanger assembly 16 engages the seat 22 in the butt weld sub and supports or hangs the casing 14. Cement is pumped through the inside and out of the bottom of the casing 14 and comes up the annulus 24 between the casing 14 and the drive pipe 10. Returning cement passes up through the flutes 26 and back up to the drilling rig. The above-named description of initially suspending a casing hanger is generally conventional.

However, casing hangers frequently have an upstanding threaded female member which must be engaged remotely in various operations. However, if the threads on the hanger become damaged, connecting equipment to the hanger causes problems. One of the features of the present invention is the provision of a well tool such as the landing sub 18, which includes a downwardly directed female member for engaging a non-threaded upper male end 28 of a casing hanger 16, and connects to the outside diameter of the end 28. The non-threaded connection may include an annular engaging notch 30 on the outside diameter of the upper end 28 of the casing hanger 16. The landing sub 18 includes an actuating nut 32 threadably secured to the body of the landing sub 18. A recess 34 is provided in the landing sub for initially holding a resiliently expandable and retracting locking ring 36 prior to connecting the landing sub 18 to the upper end 28 of the hanger assembly 16. A tapered surface 38 is provided which is axially movable relative to the ring 36 for forcing the ring 36 inwardly and into the notch 30. The axial movement may be provided by rotation of the landing sub 18 relative to the actuating nut 32. In order to provide for the rotation between the actuating nut 32 and the skirt 19, the lower end of the actuating nut 32 engages stop lugs 40 on the outside diameter of the upper end 28 of the hanger 16. Therefore, connection and disconnection of the landing sub 18 and the hanger assembly 16 may be provided by rotative movement therebetween.

In addition, in the past, it has been a general practice to provide wash ports in the casing hanger assembly to wash out cement from the annulus above the hanger assembly 16 and the pipe 10. However, such wash ports create possible leaks. The present invention provides the wash ports 42 in the well tool 18 between seals 44. Therefore, in order to insure that the landing sub 18 is not cemented into the drive pipe 10, the landing sub 18 is rotated, as best seen in FIG. 3, a sufficient number of turns, exposing the wash ports 42 through the interior of the landing sub 18. Fluid can now be pumped down the inside of the landing tool 18 out the wash ports 42 and back up the annulus 24 between the landing sub 18 and the drive pipe 10 washing out the cement. It is noted in FIG. 3 that the landing sub 18 is only backed off sufficiently for the wash ports 42 to clear the upper end 28 of the casing hanger assembly 16 but not sufficiently so that the taper 38 is removed from the back of locking ring 36 which would inadvertently release the connection between the landing sub 18 and the hanger assembly 16. It is also noted that it is preferable to have the wash ports 42 directed downwardly when washing out to increase the washing action in the annulus 24. After washing out, the landing sub 18 is rotated back to its initial position as best seen in FIG. 1.

After washing out and the cement has set, a bit is run inside the casing 14 and a hole drilled to the depth required for the next smaller size casing string. After the hole is drilled, the bit is removed, and as best seen in

FIGS. 4 and 5, casing 46 is run inside of the casing 14 and supported from an expanding casing hanger assembly 50 and a landing sub 51. The expanding casing hanger assembly 50 includes a resiliently expandable and contracting locking ring 52 and is shown in a contracted position in FIG. 4 as the casing hanger 50 is being run through casing 14 and the fluted casing hanger assembly 16. A locking notch 54 is provided in the fluted casing hanger assembly for engagement by the locking ring 52, as best seen in FIG. 5, for supporting the expanding casing hanger assembly 50 from the fluted casing hanger assembly 16. In addition, the expanded casing hanger assembly 50 may include on its interior a locking notch 56 for landing a still smaller string of casing in another expanding casing hanger assembly therein.

One of the features of the present invention is the provision of various improvements in a resilient locking ring. Referring now to FIGS. 6A and 6B, an enlarged view of the resilient locking ring 52 of FIGS. 4 and 5 is best seen. The casing hanger assembly 50 includes an annular recess 60 for carrying the resilient locking ring 52. An upward radially extending stop shoulder 62 is provided at the top of the recess 60 and a lower radially extending stop shoulder 64 is provided at the bottom end of the recess 60. The recess 60 carries the locking ring 52 and allows it to contract inwardly into the recess 60 as the hanger assembly 50 is moved downhole through a casing 14, as best seen in FIG. 6A. The ring 52 includes an upper locking portion 66 and a lower key portion 68 for coacting with the locking notch 54 in the casing assembly 16, as best seen in FIG. 6B. The locking notch 54 includes an upper locking portion 71 and a lower key receiving portion 73. The key 68 prevents the locking portion 66 of the ring 52 from expanding outwardly and engaging shoulders in the well string until the key 68 is located adjacent the key receiving portion 73. The locking notch 71 includes a locking shoulder 76 at its lower end which tapers upwardly toward the casing hanger 50. The recess 60 includes a locking surface 78 having a tapered shoulder at its upper end extending toward the casing assembly 16 and directed upwardly and extending to the outer peripheral surface of the casing assembly 50. The locking portion 66 of the locking ring 52 includes coacting tapered surfaces 70 and 72 which coact with the tapered shoulders 78 and 76, respectively, whereby when the locking portion 66 becomes positioned adjacent the portion 71 of the locking notch 54 in the casing assembly 16, the ring 52 will be urged outwardly, the tapered shoulder 78 will engage the tapered surface 78 on the upper portion 66 of the locking ring urging the upper portion 66 outwardly and holding it in an outward position so long as weight is exerted downwardly on the casing assembly 50. In addition, the tapered locking surface 72 will coact with the tapered locking shoulder 76 on the casing assembly 16 to securely hold the casing assembly 50 suspended and seated in the casing assembly 16 so that so long as the weight of the casing hanger assembly 50 and its connected string is maintained on the locking ring 52, the locking ring will be expanded and seated and reduce the chance of collapsing and dropping the string.

Other and further modifications of a locking ring mechanism may be provided as best seen in FIGS. 7A, 7B, 8A, 8B, 9A and 9B where like character references refer to like parts with the addition of the suffix "*a*", "*b*", and "*c*". Referring now to FIGS. 7A and 7B, a resiliently expandable and contractible locking ring 52*a* is carried in a recess 60*a* in the casing hanger 50 and is retractable therein when moving through a casing 14 and is expandable for engaging a locking notch 54*a* in the casing hanger assembly 16. The ring 52*a* includes a transversely extending opening 80 which initially fits over a holding shoulder 82 on the casing assembly 50 for allowing limited radial and axial movement of the expandable and retracting ring 52*a* on the shoulder 82 as the assembly 50 is moved downhole. A ring 84 is connected to the shoulder 82 by a shear pin 86 for initially restricting the longitudinal or axial movement of the locking ring 52*a* relative to the recess 60*a*. When the locking ring 52*a* is brought into alignment with the locking notch 54*a* on the casing hanger assembly 16 a locking shoulder 72*a* on the ring 52*a* engages locking shoulder 76*a* on the casing assembly 16. Further downward force shears pin 86. Tapered surface 88 on hanger assembly 50, upon further downward movement, contacts and engages taper 90 on the back of locking ring 52*a* forcing upper portion 66*a* of the locking ring 52*a* into the locking notch 54*a*. Further downward movement of the casing hanger assembly 50 brings locking shoulder 92 against the back 94 of the locking ring holding the upper portion 66*a* in the expanded and locked position. While releasable locking rings, such as shown in U.S. Pat. No. 3,420,308, have been used in the past, the present ring 84 and shear pin 86 are provided intermediate the ends of the locking ring 52*a* which has the advantage that the locking ring 52*a* is not subject to cocking and misalignment in the latching mechanism.

Referring now to FIGS. 8A and 8B, a modified locking ring 52*b* is provided having a transverse opening 80*b* coacting with a shoulder 82*b* on the casing hanger assembly 50 for allowing transverse movement of the locking ring 52*b* into and out of the recess 60*b*. In this embodiment the shear means consists of a shear pin 100 initially securing upper portion 66*b* and key portion 68*b* together. When the locking shoulder 72*b* on the ring 52*a* encounters and engages the locking shoulder 76*b* on the casing hanger assembly 16, further downward movement of the casing hanger assembly 50 will shear the shear pin 100 allowing the locking shoulder 92*b* to move downward behind the back 94*b* of the locking ring 52*b* holding the casing assembly 50 locked to and supported from the casing assembly 16.

Still a further modification of the locking ring is best shown in FIGS. 9A and 9B in which the locking ring 52*c* is retractable and expandable in a recess 60*c* in the casing hanger assembly 50 for engagement in a locking notch 54*c* in the casing hanger 16. The locking ring 52*c* may include a transverse opening 80*c* for transversely moving relative to a shoulder 82*c* on the casing hanger assembly 50 into and out of the recess 60*c*. In this embodiment, the shear means intermediate the ends of the ends of the locking ring 52*c* includes a thin walled section 102 which parts in tension when the locking shoulder 72*c* engages the locking shoulder 76*c* on the outer casing hanger assembly 16 allowing the locking shoulder 92*c* to move behind the back 94*c* of the locking ring 52*c* for hanging the casing hanger assembly 50 from the casing hanger assembly 16.

Referring now to FIG. 5, the landing sub 51 may be removed by rotation from the expanding casing hanger assembly 50. The landing sub is connected to the ex-

panding casing hanger assembly **50** with a connection similar to that between the landing sub **18** and the fluted casing hanger assembly **16**, as more fully described in connection with FIG. **1**. Referring now to FIG. **10**, after the landing sub assembly **51** has been removed, a packoff assembly generally indicated by the reference number **110** may be installed on the expanding casing hanger assembly **50** by rotation by a suitable connecting tool (not shown). Generally, the connecting assembly for connecting the downwardly extending female member of the packoff assembly **110** to the upstanding male upper end **28** of the casing hanger assembly is similar to that of FIG. **1**. Another feature of the present invention is the availability of using a squeeze seal packoff between the male upper end **28** of the casing hanger assembly **50** and the fluted casing hanger assembly **16**. This is accomplished by providing, as best seen in FIGS. **10** and **11**, an upwardly directed shoulder **114** on the casing hanger **50** and a squeeze seal packoff generally indicated by the reference numeral **116** which is connected to the packoff assembly **110**. The packoff assembly **116** includes a body **118** which is secured to the packoff assembly **110** by a ring **120** and has attached thereto a supporting ring **122** connected by bolts **124** and includes the seal member **126**. As previously noted, the packoff assembly **110** is longitudinally inserted over the upper end **28** of the hanger assembly **50** and right-hand rotation of the packoff assembly **110** causes the latching ring **36***b* to be forced into the engaging notch **30***b* as the taper **38***b* is rotated behind the ring **36***b*. With the ring **36***b* locked in the engaging notch **30***b* further rotative movement of the packoff assembly **110** will cause the skirt **19***b* to rotate downwardly against the packoff assembly **110** squeezing the packoff seal **126** between the hanger assembly **50** and the hanger assembly **16** to provide an annulus seal.

If desired, a squeeze packoff seal may be inserted in the casing hanger **50** and the casing hanger **16** independently of a connecting type packoff assembly **110**, as best seen in FIG. **12**. The modified compact packoff assembly **110***a* includes a body **121** having a skirt connection **119** for connection to a suitable tool (not shown) for attachment thereto to provide a rotative movement of the body **121** for actuating and/or release of the seal assembly **116***a*. The hanger assembly **50** includes a locking notch **128** for securing the packoff assembly **110***a* thereto. The packoff assembly **110***a* includes an actuating nut **130** threadably connected to the body **121**, and a seal **126***a*. The body **121** includes a tapered surface **133** for forcing a locking ring **132** outwardly into the locking notch **128** and a recess **134** for initially receiving the locking ring **132** in an expanded position. Downward movement of the packer assembly **110***a* will bring the actuating nut **130** into engagement with coacting lugs on the casing assembly **50** and position the locking ring **132** adjacent the locking notch **128**. Rotative movement of the body **121** will move the tapered surface **133** behind the locking ring **132** for securing it in the notch **128** thereby securing the packer assembly **116***a* to the casing assembly **50**. Also rotative movement of the body **121** will then compress the seal **126***a* between the casing hanger assembly **50** and the casing hanger assembly **16** to provide the desired annulus seal.

The use of the compact packoff assembly **110***a* allows increased flexibility and versatility by allowing various types of connections to be made to the upper end **28** of the casing hanger assembly **50**. As best seen in FIGS. **13**, **14** and **15A**, a remote control hydraulic connector generally indicated by the reference numeral **136** may be provided. The connector **136** includes a body **138** carrying a locking ring **140** for connection to the locking notch **30** of the upper end **28** of the casing hanger assembly **50**, a hydraulic piston and cylinder assembly having a cylinder **142** with a piston **144** movable therein having an actuator sleeve **146** for moving relative to the resilient locking ring **140** for moving ring **140** into and out of the engaging latch **30**. Fluid ports are provided at either end of the hydraulic cylinder **142** such as port **148** which may lead to the well surface for supplying fluid therefrom for moving the actuator sleeve **146** into a locking position and a second port **150** which may also lead to the well surface for supplying fluid therefrom for supplying fluid to actuate the actuator sleeve **146** to a retracted position. The hydraulic connector **136** may be suitably sealed to the upper end **28** of the casing hanger assembly **50** by providing a flexible seal **152** and a metal seal **154**. A fluid conduit **156** may be provided leading to a position between the seals **152** and **154** for leading to the well surface for testing and/or monitoring the seals. The seals **152** and **154** may be readily changed when damaged since they are attached to the removable hydraulic connector **136**. FIG. **13** shows the hydraulic connector connected to the upper end **28** of the casing hanger assembly **50** by applying fluid through the port **148**. FIG. **14** shows the hydraulic connector **136** being disconnected from the casing hanger assembly **50** by applying fluid through the port **150** and retracting the actuator sleeve **146**.

The flexibility and versatility of the present system is also shown in which another type of connector is provided for connecting to the upper end **28** of the well casing hanger assembly **50**, such as a manual stab-on connector generally indicated by the reference numeral **160** and shown in FIGS. **16**, **17** and **18**. The connector operates by a straight longitudinal downward movement to connect onto the casing hanger **50** and can be disconnected by rotation. The stab-on connector **160** includes a body **162**, a threaded actuator **164** which may, if desired, be shear pinned by pin **166** to the body **162** and may include an actuating pin **167** which will prevent rotation when engaged in a spline connection such as **168** in the top of packoff assembly **110***a*. A locking ring **172** is provided which is initially positioned within a recess **174** and a tapered member **176**. The resilient locking ring **172** is initially carried in the recess **174** until the body **162** telescopes over the upstanding male upper end **28** of the hanger assembly **50** and the ring **172** becomes positioned adjacent and engages the locking notch **30** in the casing hanger **50**. Upward movement of the body **162** moves the sleeve surface **178** behind the locking ring **172** securely engaging the stab-on connector **160** to the casing hanger assembly **50**. To release, the weight is slacked off of the body **162** so that the pin **167** engages spline connection **168** in the packer assembly **110***a*. Rotation of the body **162** to the right will break shear pin **166** allowing the body **162** to move upwardly moving the sleeve surface **178** upwardly from behind the resilient locking ring **172** and into a second recess **170**. The connector **160** is then in the position shown in FIG. **17** and can be longitudinally moved off of the well hanger assembly **50**.

The present invention, therefore, is well adapted to carry out the objects and attain the ends and advantages mentioned as well as others inherent therein. While presently preferred embodiments of the invention are given for the purpose of disclosure, numerous changes in the details of construction and arrangement of parts may be made which will readily suggest themselves to those skilled in the art and which are encompassed within the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. A pipe hanger assembly for connecting a casing hanger to a pipe comprising,
- an elongated tubular hanger body with upper and lower ends, said lower end adapted for releasable connection to a pipe, said upper end having an annular engaging notch on the outside diameter,
- a well tool adapted to be connected to the pipe and lowered for connection and release from the exterior of the hanger body, said tool having a lower end adapted to telescopically engage the outside of the end of the hanger body,
- a resiliently expandable and contracting locking ring carried by and facing inwardly from the well tool and adapted to engage the notch on the hanger body for connecting the tool to the body,
- a tapering member carried by the tool for axial slidable movement relative to said ring for locking said ring and for releasing said ring from the notch upon axial movement of the member, said hanger includes axial extending groove means on the exterior and rotative means for axially moving the tapering member away from the locking ring including,
- a thread on said well tool,
- a threaded nut coacting with the thread on said tool, said nut including longitudinal extending spline means for engaging said hanger groove means whereby rotation of the well tool will provide axial movement of the well tool and tapering member for releasing the ring from the notch.

2. The apparatus of claim 1 wherein the body includes an external upwardly facing shoulder and the well tool includes a seal at the lower end thereof for seating on said shoulder and sealing off between the outside of the body and the inside of an outer pipe surrounding said body.

3. The apparatus of claim 1 including,
- said well tool including a double acting fluid piston and cylinder assembly connected to the tapering member for axially moving the member relative to the ring.

4. The apparatus of claim 3 including a fluid conduit in said tool connected to the cylinder and a port connected to the cylinder and extending externally of said tool for actuating the piston.

5. The apparatus of claim 1 including an improvement in an assembly for connecting the tubular hanger body to a third pipe coaxially surrounding the hanger in which the body includes an annular recess in its peripheral surface adjacent the third pipe, a radially extending stop shoulder on the body at each end of the recess, a resiliently expandable and contractible locking ring positioned in said recess and axially slidable between said stop shoulders, locking means on the body for locking the ring in an expanded position, and a locking notch on the third pipe for receiving the expanded and locked ring, the improvement comprising,
- said locking notch including a locking shoulder at its lower end, said locking shoulder tapering upwardly toward the hanger body,
- said annular recess including a tapered shoulder at its upper end extending toward the third pipe and extending to the peripheral surface of the body adjacent the third pipe,
- the top of the locking ring consisting of a tapered surface for coacting with the tapered shoulder at the upper end of the recess, and
- the locking ring including a tapered locking surface for coacting with the tapered locking shoulder on the third pipe.

6. The apparatus of claim 1 including, seal means on the interior of the well tool for sealingly engaging the exterior of the hanger body.

7. The apparatus of claim 2 wherein the seal is connected to the well tool by a rotatable connection.

8. A pipe hanger assembly for connecting a casing hanger to a pipe comprising,
- an elongated tubular hanger body with upper and lower ends, said lower end adapted for releasable connection to a pipe, said upper end having an annular engaging notch on the outside diameter,
- a well tool adapted to be connected to the pipe and lowered for connection and release from the exterior of the hanger body, said tool having a lower end adapted to telescopically engage the outside of the upper end of the hanger body,
- an inwardly biased resiliently expandable and contracting locking ring carried by and facing inwardly from the well tool and adapted to engage the notch on the hanger body for connecting the tool to the body,
- a tapering member carried by the tool for axial slidable movement relative to said ring for locking said ring and for releasing said ring from the notch upon axial movement of the member,
- the well tool including a receiving recess positioned above the tapering member for normally receiving the locking ring whereby the well tool may be moved longitudinally downwardly over the upper end of the body until the ring is resiliently biased into and engages the notch on the body after which an upper pull on the well tool moves the tapering member against the back of the ring thereby locking the tool to the body without requiring rotative movement, and
- said well tool including rotative means for axially moving the tapering member above the locking ring for unlocking the ring from the notch.

9. In an assembly for connecting first and second tubular members to and from each other in a well by longitudinal movement of the first member, said first member including an annular recess in its peripheral surface adjacent the second member, a radially extending stop shoulder on the first member at each end of the recess, a resiliently expandable and contractible locking ring positioned in said recess and axially slidable thereon between said stop shoulders, locking means on the first member for locking said ring in an expandable position, a locking notch on the second member in its peripheral surface adjacent the first member for receiving the expanded and locked ring, the improvement comprising,

shearable holding means intermediate the ends of the locking ring which when sheared by downward longitudinal movement of the first member allows the upper portion of the ring to releasably lock the first and second members together, said locking ring includes upper and lower sections and the shearable means includes a shear pin interconnecting said sections.

10. In an assembly for connecting first and second tubular members to and from each other in a well by longitudinal movement of the first member, said first member including an annular recess in its peripheral surface adjacent the second member, a radially extending stop shoulder on the first member at each end of the recess, a resiliently expandable and contractible locking ring positioned in said recess and axially slidable thereon between said stop shoulders, locking means on the first member for locking said ring in an expandable position, a locking notch on the second member in its peripheral surface adjacent the first member for receiving the expanded and locked ring, the improvement comprising,

shearable holding means intermediate the ends of the locking ring which when sheared by downward longitudinal movement of the first member allows the upper portion of the ring to releasably lock the first and second members together, said shearable means includes a thin walled section in said locking ring.

11. In an assembly for connecting first and second tubular members to and from each other in a well by longitudinal movement of the first member, said first member including an annular recess in its peripheral surface adjacent the second member, a radially extending stop shoulder on the first member at each end of the recess, a resiliently expandable and contractible locking ring positioned in said recess and axially slidable thereon between said stop shoulders and including an opening in the back of said ring, locking means on the first member for locking said ring in an expandable position, a locking notch on the second member in its peripheral surface adjacent the first member for receiving the expanded and locked ring, the improvement comprising,

shearable holding means intermediate the ends of the locking ring which when sheared by downward longitudinal movement of the first member allows the upper portion of the ring to releasably lock the first and second members together, said shearable holding means including,

a shoulder on the first member, and

shear means positioned on the end of the shoulder and extending into said opening on the back of said locking ring.

12. In an assembly for connecting first and second tubular members to and from each other in a well by longitudinal movement of the first member, said first member including an annular recess in its peripheral surface adjacent the second member, a radially extending stop shoulder on the first member at each end of the recess, a resiliently outwardly biased expandable and contractible locking ring positioned in said recess and axially slidable thereon between said stop shoulders, locking means on the first member for locking said ring in an expandable position, a locking notch on the second member in its peripheral surface adjacent the first member for receiving the expanded and locked ring, the improvement comprising,

said locking notch including a locking shoulder at its lower end, said locking shoulder tapering upwardly toward the first member,

said annular recess including a tapered shoulder at its upper end extending upwardly and toward the second member and extending to the peripheral surface of the first member adjacent the second member,

the top of the locking ring including a tapered surface for coacting with the tapered shoulder at the upper end of the recess, and

the locking ring including a tapered locking surface extending outwardly and downwardly for coacting with the tapered locking shoulder on the second member when the first member moves downwardly relative to the second member and the ring is positioned adjacent the locking notch.

13. A pipe hanger assembly for connecting a casing hanger to a coaxial pipe positioned about the casing hanger comprising,

an elongated tubular hanger body with upper and lower ends, said body including means for connecting the hanger to the interior of coaxial pipe, said lower end adapted for a releasable connection to a pipe, said upper end having an annular engaging notch on the outside diameter of the body,

a well tool adapted to be connected to a pipe and lowered for connection and release from the exterior of the hanger body, said tool having a lower end adapted to telescopically engage the outside of the upper end of the hanger body,

a resiliently expandable and contracting locking ring carried by and facing inwardly from the well tool and adapted to engage the notch on the hanger body for connecting the tool to the body,

a tapering member carried by the tool for axial slidable movement relative to said ring for locking said ring and for releasing said ring from the notch upon axial movement of the member,

rotative means for axially moving the tapering member toward and away from the locking ring including,

axial extending groove means on the exterior of the hanger body,

a thread on the well tool,

a threaded nut coacting with the thread on the tool, said nut including longitudinal extending spline means for engaging said hanger groove means whereby rotation of the well tool will provide axial movement of the tapering member relative to the ring,

a packoff seal rotatably carried by the well tool, said seal adapted to seal between the exterior of the hanger body and the interior of the coaxial pipe, and

said hanger body including an external upwardly facing shoulder on which the seal may seat and set and released by the well tool.

14. The apparatus of claim **13** including,

a longitudinal engagable and releasable connection at the top of the well tool.

15. The apparatus of claim **13** including,

a second well tool adapted to be connected to a pipe and lowered for connection and release from the exterior of the hanger body,

a second annular notch on the outside of the diameter of the hanger body,

a second resiliently expandable and contracting locking ring carried by the second tool for engaging the second notch,

a second tapering member carried by the second tool for axially slidable movement relative toward the second ring for locking said second ring and movement away from the second ring for releasing said second ring from the notch,

means for longitudinally but nonrotatably moving said second tapering member relative to the said ring for locking said second ring into the second notch.

16. The apparatus of claim **13** wherein the means for longitudinally but nonrotatatively moving the second member includes a double acting fluid piston and cylinder assembly connected to the second member for longitudinally moving the second member relative to the second ring.

17. The apparatus of claim **13** wherein the means for longitudinally but nonrotatively moving the second member wherein the well tool includes a ring receiving recess positioned above the second locking ring for normally holding said second ring and said second tapering member tapers downwardly and towards said hanger body whereby upward pull on the second well tool will move the second ring into the second annular notch on the hanger body.

* * * * *