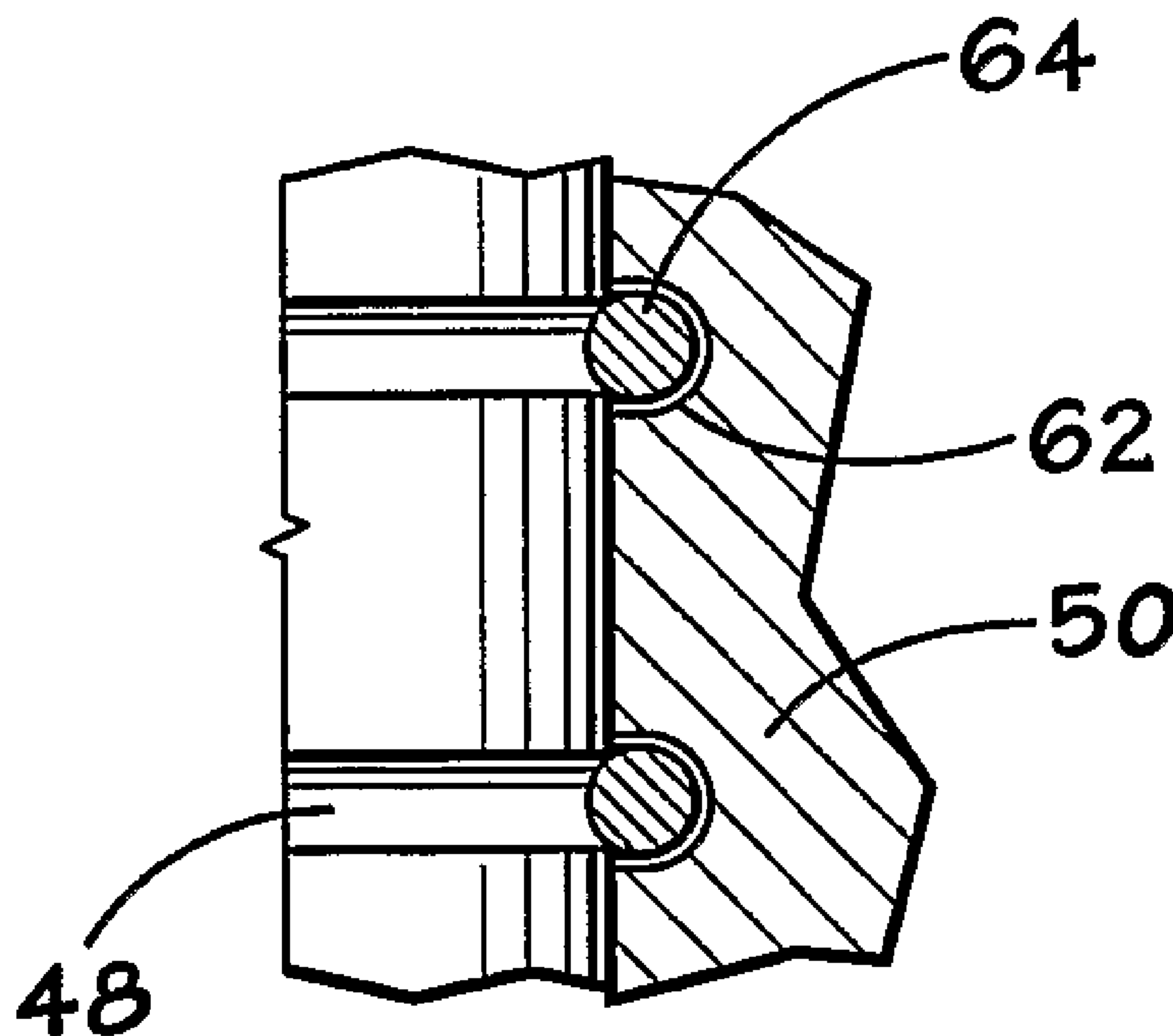




(86) Date de dépôt PCT/PCT Filing Date: 2002/11/27
(87) Date publication PCT/PCT Publication Date: 2003/06/12
(45) Date de délivrance/Issue Date: 2008/07/22
(85) Entrée phase nationale/National Entry: 2004/05/27
(86) N° demande PCT/PCT Application No.: GB 2002/005354
(87) N° publication PCT/PCT Publication No.: 2003/048506
(30) Priorité/Priority: 2001/11/28 (US09/995,942)

(51) Cl.Int./Int.Cl. *E21B 17/046* (2006.01),
E21B 33/127 (2006.01)
(72) Inventeurs/Inventors:
GUILLORY, BRETT W., US;
TOKAR, JOHN W., CA
(73) Propriétaire/Owner:
WEATHERFORD/LAMB, INC., US
(74) Agent: MARKS & CLERK

(54) Titre : APPAREIL DE RETENUE D'OUTIL DE FOND
(54) Title: DOWNHOLE TOOL RETENTION APPARATUS



(57) Abrégé/Abstract:

Apparatus for attaching a downhole isolation, production, or testing tool is disclosed such that the tool is mechanically attached to a mandrel in a manner that is highly resistant to axial movement. The mechanical connection resists high temperatures, high pressures, and corrosive fluids and gases that may be encountered in the well without the use of welding to a casing mandrel. In general, the connection includes at least one groove or channel (48) cut in an outer wall of the casing mandrel, and at least one partially or fully annular slot (62) on the inside surface of the tool oriented to correspond with the groove(s) in the outer wall of the casing mandrel. At least one lock (64) is situated in the corresponding slot (62) and the groove (48). The lock (64) engages the flanks of the slot (62) and groove (48) sufficiently to resist shears loads applied by compression or tension in the string, and thereby restrains axial movement of the valve assembly relative to the casing mandrel. In one embodiment, the lock is one or more wires (64), although other mechanical locking devices may be installed to provide the same function.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
12 June 2003 (12.06.2003)

PCT

(10) International Publication Number
WO 03/048506 A1

(51) International Patent Classification⁷: **E21B 17/046**

(21) International Application Number: PCT/GB02/05354

(22) International Filing Date:
27 November 2002 (27.11.2002)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
09/995,942 28 November 2001 (28.11.2001) US

(71) Applicant (for all designated States except US): **WEATHERFORD/LAMB, INC.** [US/US]; 515 Post Oak Blvd, Suite 600, Houston, TX 77027 (US).

(71) Applicant (for IS only): **HARDING, Richard, Patrick** [GB/GB]; Marks & Clerk, 4220 Nash Court, Oxford Business Park South, Oxford, Oxfordshire OX4 2RU (GB).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **GUILLORY, Brett, W.** [US/US]; 107 N. Winterport, The Woodlands, TX 77382 (US). **TOKAR, John, W.** [CA/CA]; 188 Regency Drive, Sherwood Park, Alberta T8A-5R8 (CA).

(74) Agents: **HARDING, Richard, Patrick** et al.; Marks & Clerk, 4220 Nash Court, Oxford Business Park South, Oxford, Oxfordshire OX4 2RU (GB).

(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SC, SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

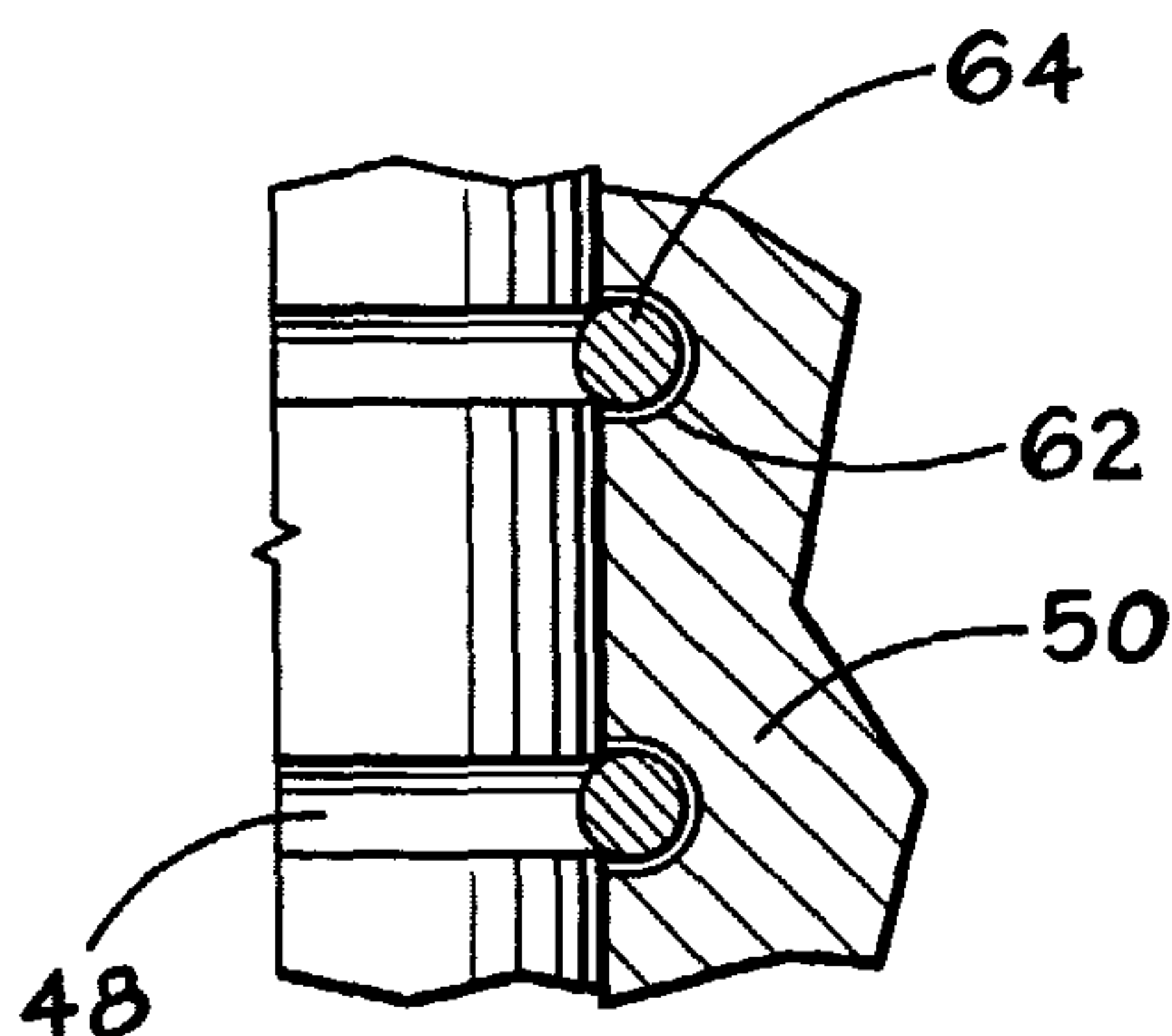
(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

- with international search report
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: DOWNHOLE TOOL RETENTION APPARATUS



(57) **Abstract:** Apparatus for attaching a downhole isolation, production, or testing tool is disclosed such that the tool is mechanically attached to a mandrel in a manner that is highly resistant to axial movement. The mechanical connection resists high temperatures, high pressures, and corrosive fluids and gases that may be encountered in the well without the use of welding to a casing mandrel. In general, the connection includes at least one groove or channel (48) cut in an outer wall of the casing mandrel, and at least one partially or fully annular slot (62) on the inside surface of the tool oriented to correspond with the groove(s) in the outer wall of the casing mandrel. At least one lock (64) is situated in the corresponding slot (62) and the groove (48). The lock (64) engages the flanks of the slot (62) and groove (48) sufficiently to resist shears loads applied by compression or tension in the string, and thereby restrains axial movement of the valve assembly relative to the casing mandrel. In one embodiment, the lock is one or more wires (64), although other mechanical locking devices may be installed to provide the same function.

WO 03/048506 A1

DOWNHOLE TOOL RETENTION APPARATUS

This invention relates generally to well drilling or completion operations, and to the attachment of downhole isolation, production, or testing tools to casing or other work strings. In particular, the invention is directed to the attachment of isolation tools, such as an inflatable casing packer, or other production or testing tools, in a manner that reduces or eliminates welded connections.

In the oilfield industry, isolation, production, or testing tools are often attached to casing or other work strings in order to run the tool downhole into the wellbore. A casing string, or work string, is generally made up of a series of jointed steel pipe or tubing. The string is run into the wellbore with tools attached to perform one or more specific functions. The current invention relates primarily to the use of a tool known as a packer.

A packer is used to plug an area in a well by sealing off the annulus between the string on which the packer is run and the next outer casing (or the wellbore itself). Packers are well known in the art. One particular type of packer is an inflatable packer. Inflatable packers are run on the casing string, and inflated when the desired position in the well is reached, sealing the annulus at that particular location. Such inflatable packers, also called annulus casing packers, have a number of uses in well operations, including isolating producing zones, preventing gas migration, supporting or squeezing cement, or isolating liner hangers.

In general, inflatable casing annulus packers are made up of a casing mandrel, an inflatable element, and an inflation mechanism. The prior art annulus casing packers were commonly constructed such that the body of the tool was welded to the casing mandrel. Often multiple welds were employed, welding the casing to a sleeve disposed between the inflation mechanism and the coupling at the end of the tool, and welding the sleeve to the inflation mechanism. These welds add time and expense to the development of the tool. More importantly, welding can affect the metallurgy of the casing, making the welded area subject to attack, for example by corrosive well fluids. As such, welding to the casing or to coupling is at minimum undesirable, and may be prohibited under certain industry standard regulations.

1 Alternatively to the welded connection, it has been attempted to connect the
2 inflation mechanism to the casing mandrel using adhesive or epoxy. However, the
3 extreme conditions to which the tool is subject when run downhole into the portion of the
4 wellbore that is of interest can include several thousand psi of pressure and/or
5 temperatures over several hundred degrees Fahrenheit. Such conditions can have a
6 detrimental effect on adhesion, potentially resulting in a failure of tool. As such,
7 mechanical connections are preferable.

8 The ability to mechanically thread the casing mandrel to the inflation mechanism
9 is limited by the need to maintain a minimum acceptable wall thickness, and inside
10 diameter, in the casing mandrel. In general, for a five-inch nominal diameter casing the
11 depth of a thread or groove in the casing mandrel should be no more than $\frac{1}{2}$ of one
12 percent of the inside diameter. This makes it difficult to create a threaded connection that
13 is sufficient to resist the various tensile, compressive, and shear forces imposed on the
14 fully loaded tool.

15 The disadvantages of welded, adhesive, and threaded connections in the coupling
16 of the inflation assembly to the casing mandrel in an inflatable annulus casing packer to
17 the casing mandrel are overcome by the present invention.

18 In addition, although the connection of the present invention is described with
19 regard to its use with an inflatable packer, the invention is applicable to various other
20 oilfield tools that are connected to casing or work strings for use in drilling, completion,
21 production, or workover operations.

22 It is an aspect of the current invention that a tool, such as the inflatable annulus
23 casing packer described in detail below or other isolation, production, or testing tool, may
24 be attached to a mandrel in a manner that is highly resistant to axial movement. It is a
25 further aspect of the invention that the mechanical connection is made using non-
26 adhesive components combined in such a manner that they will resist the high
27 temperatures, high pressures, and corrosive fluids and gases that may be encountered in
28 the well.

29 In the embodiment described herein, the system of the present invention provides
30 a high-strength non-welded mechanical connection between a casing mandrel and a valve
31 assembly used to regulate hydraulic pressure and thereby inflate the inflatable element of

1 a casing annulus packer. In general, the connection system includes at least one groove
2 or channel cut in an outer wall of the casing mandrel. In preferred embodiments, the
3 groove or channel is sufficiently shallow to avoid significantly thinning the wall
4 thickness of the casing, and thereby ensures that compliance with industry standards is
5 maintained.

6 The inside surface of the valve assembly, or other inflation mechanism, contains
7 at least one partially or fully annular slot oriented to correspond with the groove(s) in the
8 outer wall of the casing mandrel.

9 At least one lock is situated in the corresponding slot and the groove. The lock
10 engages the flanks of the slot and groove sufficiently to resist shears loads applied by
11 compression or tension in the string, and thereby restrains axial movement of the valve
12 assembly relative to the casing mandrel. In a preferred embodiment, the lock is one or
13 more wires, although other mechanical locking devices may be installed to provide the
14 same function.

15 In a preferred embodiment, the system includes annular grooves in both the inner
16 casing mandrel and the inflation mechanism or other tool. When multiple grooves are
17 employed the grooves may be spaced apart, and a plurality of wires fed into the channels
18 created by the corresponding pairs of grooves. In other embodiments there may be a
19 single pair of aligned helical grooves, and a single wire or other lock installed.

20 In an embodiment of the invention, the wire or lock has relatively greater yield
21 strength than the tool or the mandrel. As such, if the bearing surfaces of the connection
22 begin to fail under shear, the yielded metal of the tool or the mandrel will be pushed
23 axially, eventually bunching up and jamming the mechanism from further axial
24 movement. As such, the current invention also provides a failure mode in which the
25 inflation mechanism is rigidly fixed by the yielded metal, sealing the packer in its
26 position and preventing failure of the inflatable portion.

27 It is another aspect of the current invention that the time to manufacture the tool,
28 and the expenses involved, may be reduced by the novel form of attachment. In addition,
29 welding between the valve element and the casing is eliminated, which reduces changes
30 to the metallurgy of the tool, the invention reduces the number of areas particularly
31 vulnerable to corrosive attack.

3a

1 In one aspect, the invention provides a mechanical coupling between a casing
2 mandrel and an isolation, production, or testing tool journaled about the casing mandrel,
3 the coupling comprising:

- 4 at least one indent in the casing mandrel outer wall;
- 5 at least one indent in an inner surface of the tool; and
- 6 at least one locking element at least partially located in the indent in the casing mandrel
7 outer wall and at least partially in the indent in the inner surface of the tool to resist axial
8 movement of the tool relative to the casing mandrel.

9 In one aspect, the invention provides a mechanical coupling between a casing and
10 an isolation, production, or testing tool installed on the casing, the coupling comprising:

- 11 at least one indent in the casing outer wall;
- 12 at least one indent in an inner surface of the tool; and
- 13 a wire radially located in the indent in the casing outer wall and in the indent in the
14 inner surface of the tool to resist movement of the tool relative to the casing.

15 In one aspect, the invention provides a mechanical coupling between a casing and
16 an isolation, production, or testing tool installed on the casing, the coupling comprising:

- 17 at least one semi-circular groove in the casing outer wall;
- 18 at least one semi-circular groove in an inner surface of the tool; and
- 19 a plurality of bearings located at least partially in the groove in the casing outer wall and
20 located at least partially in the groove in the inner surface of the tool to resist movement
21 of the tool relative to the casing.

22 In one aspect, the invention provides a tool assembly comprising:

- 23 a casing;
- 24 a casing mandrel coupled to the casing;
- 25 a valve assembly journaled on the casing mandrel;
- 26 a slot on an outer wall of the casing mandrel;
- 27 a groove, at least partially annular, on an inside surface of the valve assembly oriented
28 with the slot; and
- 29 at least one lock situated in the slot and the groove.

30 In one aspect, the invention provides a tool assembly comprising:

- 31 a casing;
- 32 a casing mandrel coupled to the casing;
- 33 a valve assembly journaled on the casing mandrel;

3b

- 1 a slot on an outer wall of the casing mandrel;
- 2 a groove, at least partially annular, on an inside surface of the valve assembly oriented
- 3 with the slots; and
- 4 at least one wire situated in the slot and the groove.

5 In one aspect, the invention provides an inflatable packer comprising:

- 6 a mandrel;
- 7 an inflatable element journaled around the mandrel;
- 8 seals disposed between the mandrel and the element;
- 9 an inflation mechanism disposed on the mandrel and coupled to the inflatable element;
- 10 at least one retention groove between the mandrel and the inflatable element; and
- 11 at least one locking element disposed in the retention groove.

12 In one aspect, the invention provides an inflatable packer comprising:

- 13 a mandrel having a generally cylindrical wall defining an internal bore through the
- 14 length of the mandrel;
- 15 a first flow port extending through the wall of the mandrel;
- 16 a valve apparatus installed about the mandrel, the valve apparatus having a flow passage
- 17 aligned with the first flow port;
- 18 an element journaled about the mandrel, the element being expandable in response to
- 19 increased pressure in the valve apparatus;
- 20 at least one set of corresponding grooves in an outer surface of the wall of the mandrel
- 21 and an inner surface of the valve apparatus; and
- 22 at least one wire situated in the at least one set of corresponding grooves.

23 In one aspect, the invention provides a downhole packer comprising:

- 24 a mandrel;
- 25 a packing element disposed on the mandrel;
- 26 a setting element disposed on the mandrel;
- 27 at least one groove between the mandrel and the setting element; and
- 28 at least one locking element disposed in the groove.

1

2 In order that the invention may be more fully understood, reference will now be
3 made, by way of example, to the accompanying drawings, in which:

4 FIG. 1 is a sectional elevation of a wellbore showing a casing string and an
5 inflatable packer run in the well;

6 FIG. 2A is a partial sectional elevation of the up-stream portion of the inflatable
7 packer;

8 FIG. 2B is a partial sectional elevation of the down-stream portion of the
9 inflatable packer;

10 FIG. 3 is an enlarged partial section of the inflatable packer showing an interface
11 between the casing mandrel, an inflatable element, and an inflation mechanism; and

12 FIG. 4 is an enlarged partial section of one embodiment of the retention apparatus
13 coupling the inflation mechanism to the casing mandrel.

14

15 In FIG. 1 a casing or work string 20 is shown in a wellbore 10. The casing or
16 work string is made up of a series of jointed steel pipe or tubing, and may contain one or
17 more downhole tools. In FIG. 1, the casing string includes an inflatable packer 30. The
18 inflatable packer is shown isolating a producing zone 12 in wellbore 10.

19 Although the use of the inventive tool retention apparatus is shown on an
20 inflatable packer, the invention is not limited to use on this particular tool. The inventive
21 concept of journaling a tool about a casing and using channels cut into the tool and casing
22 with one or more wire locks, bearings, or other locking mechanisms to restrain axial
23 movement is applicable to other forms of packers, such as compression set packers, as
24 well as to other downhole isolation, production or testing tools. The inflatable packer
25 shown in the accompanying figures is only one possible embodiment.

26 Referring now to FIGS. 2A and 2B, the inflatable annulus casing packer 30 is
27 shown in partial sectional elevations. In other embodiments, packer 30 may be a
28 compression set packer, or other tool similarly journalled about a casing mandrel 40.
29 FIGS. 2A and 2B respectively represent upper and lower portions of the tool, but are not
30 intended to be contiguous.

1 In FIG. 2A, a threaded coupling 22 connects the casing (not shown) to the casing
2 mandrel 40 of the inflatable packer 30. Casing mandrel 40 is generally cylindrical and
3 contains a generally cylindrical internal through bore 42. Bore 42 is co-extensive with
4 the bore of the casing, allowing full diameter flow of fluids to or from the surface and
5 into or out of the well, including the high pressure drilling fluids.

6 At least one port 44 extends through the side wall of the casing mandrel 40. Prior
7 to inflating the element 70 of packer 30, the port 44 is closed to flow by a knock-off rod
8 46 that projects into the central bore 42 while the tool is being run. When the casing
9 packer 30 is run to its desired position, a ball, dart, or other device is run down the string
10 and shears the exposed portion of knock-off rod 46. This exposes the port 44 to the high
11 pressure fluid in the string 20. The fluid is channeled from the port to a valve assembly,
12 other inflation mechanism, or other setting element 50. In a compression set packer or
13 other tool, the valve assembly could be a mechanical or hydraulically actuated setting
14 element.

15 Assembly 50 is journaled about the outer wall of casing mandrel 40. A radial
16 channel 52 is cut in the inner wall of the casing mandrel 40 to create an increased
17 diameter portion that is aligned with flow port 44 to receive fluid flow. Seals 54 and 55
18 are located upstream and downstream of radial channel 52 to create a gallery and isolate
19 fluid passage to the communication between flow port 44 and channel 52. Seals 54 and
20 55 may be O-ring seals or other types of seals commonly known.

21 Fluid flow from the radial channel 52, used to hydraulically actuate the inflatable
22 packer, is controlled through one or more inflation valves 56. The valves 56 can be shear
23 pinned at pre-determined pressures to activate at a specific differential pressure to prevent
24 the valve from circulating high pressure fluid during run-in of the tool and prematurely
25 inflating the packer, and to avoid pressure bleed off once the packer is fully inflated.
26 Fluid from the outlet (offset and not shown) of the valves 56 passes through a port 58,
27 generally parallel to the central bore 42, and is directed to the inflatable element 70.

28 It is a particular aspect of the current invention to restrict axial movement of the
29 inflation mechanism 50 relative to the casing mandrel 40. As element 70 is inflated,
30 outward force on the element 70 creates a draw force on the mechanism 50. If the
31 inflation mechanism 50 is movable along the axis of the tool, the packer will be unable to

1 develop sufficient sealing pressure against the annulus wall. For this reason, prior
2 inflatable packers have generally welded the valve assembly 50 to the casing 20 or
3 coupling 22. The present invention avoids this welding, or reduces the total number of
4 welds.

5 In one embodiment of the current invention, as shown in FIG. 2A and FIG. 4, one
6 or more grooves, or a series of radial grooves 48, is cut in the external wall of the casing
7 mandrel 40. Grooves 48 need not be deeply cut into the outside diameter of the casing
8 mandrel 40, and could be little more than indentations, aligned with a series of one or
9 more corresponding annular grooves 62 in the inner wall of the valve assembly 50. Each
10 annular groove 62 is connected to a lateral bore (not shown) between the groove and the
11 external surface of the valve assembly 50.

12 With the valve assembly 50, or other inflation mechanism or setting element
13 journaled about the casing mandrel 40, and the grooves 62 and 48 aligned, a wire or
14 series of wires 64 can be disposed in the grooves 62 and 48. Wires 64 can be installed
15 through the lateral bores, cut to appropriate lengths, and the opening of the lateral bores
16 closed if desired.

17 Wires 64 bear on the flanks of grooves 62 and 48 to resist axial movement of the
18 inflation mechanism 50 relative to the casing mandrel 40. In a preferred embodiment, the
19 yield point of wires 64 will be greater than the yield point of the casing mandrel 40 and
20 the valve assembly 50. For example, the steel of the casing mandrel 40 and valve
21 assembly 50 may be typically 80 lb. yield. The wires 64 can be 250 lb. yield, without
22 adding any appreciable expense to the device.

23 Because of the difference in the yield points, the metal of the casing mandrel 40
24 and valve assembly 50 will deform or fail due to shear forces before the wires 64. In the
25 event of such a failure under shear, the yielded metal of the inflation mechanism 50 or the
26 casing mandrel 40 will deform according to the axial forces, resulting eventually in the
27 deformed metal bunching up and jamming the connection between the tool and the casing
28 mandrel, and preventing further axial movement. As such, the current invention also
29 provides a failure mode in which the inflation mechanism 50 is rigidly fixed by the
30 yielded metal, sealing the packer 30 in its position and preventing failure of the inflatable
31 portion 70.

1 In alternate embodiments, grooves 62 and 48 could be single helical grooves, and
2 a single wire 64 could be threaded into the helical grooves. In addition, grooves 48 could
3 be fully or partial channels, keyways, or other passageways. Wires 64 could be replaced
4 by a series of ball bearings sized for the grooves, roller-type bearings, or wires or keys.

5 Seal 55, and an additional seal 66, are disposed above and below the grooves 48
6 and 62 and the wires 64 to prevent or reduce fluid infiltration into the grooves.
7 Infiltration of fluid into the bearing area could induce separation of the casing mandrel 40
8 and the valve assembly 50, as well as lubricating the grooves 48 and 62, reducing the
9 effectiveness of the retention apparatus.

10 Referring now to FIG. 2A and FIG. 3, the connection of the valve assembly or
11 other inflation mechanism 50 and the element 70, both journaled around the casing
12 mandrel 40, is shown. The connection allows the passage of hydraulic (or drilling) fluid
13 through slots 74 in nut 76. The fluid is used to pressurize the space in inflatable element
14 70 between the casing mandrel 40 and rubber core 80.

15 Nut 76 is threaded to engage threads on the interior of end sleeve 72. The internal
16 threads of end sleeve 72 also engage threads on the proximate end of valve mechanism
17 50.

18 A rubber core 80 is wrapped around the circumference of the casing mandrel 40
19 and is held tight to the end sleeve by a wedge 78 and both the wedge and the first end of
20 the rubber core 80 are held in place by the threaded nut 74. A plurality of steel ribs 82
21 surround the rubber core 80, and have first ends held in place within the end sleeve 72.
22 As shown in more detail in FIG. 3, the first ends of steel ribs 82 may have a welded
23 connection 83 to the end sleeve 72. Ribs 82 may be continuous along the length of the
24 tool, but need not be.

25 An outer rubber layer 84 may be installed to protect the steel ribs 82 and rubber
26 core 80 from the annular surface that packer 30 is expanded against. Outer layer 84 also
27 helps to protect the inflatable portion from the conditions in the well 10. In this respect,
28 outer rubber layer 84 may be fused to the steel ribs 82 and to the end sleeve 72 (and the
29 other end sleeve 86) prior to running the tool.

30 It should be noted that similar materials may be substituted for the rubber of
31 rubber core 80 and outer layer 84, and for the steel of steel ribs 82. The purpose of these

1 components and the particular materials is to allow the inflatable element to expand, yet
2 maintain structural rigidity and resistance to the pressure and temperature conditions in
3 the well. Any materials that accomplish such purposes could be substituted.

4 Referring now to FIG. 2B, the lower distal end of the rubber core 80 and steel ribs
5 82 are housed within a second end sleeve 86. A lock nut 88 and a wedge 90 are held by
6 threaded connection between nut 88 and internal threads on end sleeve 86.

7 A seal housing 92 is threaded onto the second end sleeve 86 and extends axially
8 from the end sleeve. Redundant seals 93 and 94 are disposed between the seal housing
9 and the outer surface of the casing mandrel 40, substantially checking or preventing the
10 passage of fluid and pressure.

11 In operation, the annulus casing packer 30 is run downhole on casing or work
12 string 20. At the desired location, knock-off rod 46 is sheared, allowing high pressure
13 fluid into port 58. Valves 56 control the flow through port 58 and into counterbore 60.
14 The fluid passes through slots 76 and 79 in the nut 74 and wedge 78, and into the annular
15 space between the rubber core 80 and the circumference of casing mandrel 40. However,
16 further passage of fluid is checked by the seals 93 and 94 in the lower end sleeve.
17 Increased pressure thus causes the rubber core 80 and the steel ribs 82 to expand outward
18 from the casing mandrel 40 sealing off the annular space. It should be noted that any
19 sliding movement of the inflation mechanism 50 relative to the casing mandrel 40 during
20 or after the inflation of element 70 would result in decreased or no annulus sealing
21 capability. Therefore, it is a feature of the invention that wire 64 in conjunction with
22 grooves 48 and 62 restrain axial movement of the valve assembly relative to the casing
23 mandrel 40.

24 The mechanical coupling discussed in detail above can be readily adapted to other
25 isolation, production, or testing tools for downhole use. In such embodiments, a casing
26 mandrel having a wall defining a lengthwise throughbore has at least one indent in the
27 casing outer wall, at least one indent in an inner surface of the tool, and a lock at least
28 partially located in the indent in the casing outer wall and at least partially in the indent in
29 the inner surface of the tool to resist movement of the tool relative to the casing. The
30 lock could be a wire, a mechanical key of any shape conducive to resisting the relative
31 movement, bearings, or other mechanical components.

WO 03/048506

PCT/GB02/05354

9

1 While the apparatus, compositions, and methods of this invention have been
2 described in terms of preferred and illustrative embodiments, it will be apparent to those
3 of skill in the art that variations may be applied without departing from the concept and
4 scope of the invention. All such similar substitutes and modifications apparent to those
5 skilled in the art are deemed to be within the scope and concept of the invention.

6

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A mechanical coupling between a casing mandrel and an isolation, production, or testing tool journaled about the casing mandrel, the coupling comprising:
 - at least one indent in the casing mandrel outer wall;
 - at least one indent in an inner surface of the tool; and
 - at least one locking element at least partially located in the indent in the casing mandrel outer wall and at least partially in the indent in the inner surface of the tool to resist axial movement of the tool relative to the casing mandrel.
2. The mechanical coupling of claim 1, wherein the at least one locking element comprises at least one wire radially located in the indent in the casing mandrel outer wall and in the indent in the inner surface of the tool.
3. The mechanical coupling of claim 1 or 2, wherein the at least one locking element comprises at least one mechanical key.
4. The mechanical coupling of claim 1 or 3, wherein:
 - the at least one indent in the casing mandrel outer wall comprises at least one groove or slot; and
 - the at least one indent in the inner surface of the tool comprises at least one groove.
5. The mechanical coupling of claim 2, wherein:
 - the at least one indent in the casing mandrel outer wall comprises at least one groove or slot; and
 - the at least one indent in the inner surface of the tool comprises at least one groove.
6. The mechanical coupling of claim 4 or 5, wherein the at least one locking element comprises a plurality of bearings located at least partially in the at least one groove or slot in the casing mandrel outer wall and located at least partially in the at least one groove in the inner surface of the tool.

7. The mechanical coupling of claim 6, wherein at least one slot or groove in the casing mandrel outer wall or the inner surface of the tool is semi-circular.
8. A tool assembly comprising:
 - a casing mandrel;
 - a tool journaled about the casing mandrel; and
 - a mechanical coupling as claimed in any one of claims 1, 3 or 6 or 7, between the casing mandrel and the tool.
9. A tool assembly comprising:
 - a casing mandrel;
 - a tool journaled about the casing mandrel; and
 - a mechanical coupling as claimed in claim 2, between the casing mandrel and the tool.
10. A tool assembly comprising:
 - a casing mandrel;
 - a tool journaled about the casing mandrel; and
 - a mechanical coupling as claimed in claim 4, between the casing mandrel and the tool.
11. A tool assembly comprising:
 - a casing mandrel;
 - a tool journaled about the casing mandrel; and
 - a mechanical coupling as claimed in claim 5, between the casing mandrel and the tool.
12. The tool assembly of claim 10, wherein the tool is a valve assembly and wherein the at least one groove in the inner surface of the valve assembly is at least partially annular and is oriented with the at least one groove or slot in the casing mandrel outer wall.
13. The tool assembly of any one of claims 8 or 10 to 12, further comprising:
 - a packing element journaled about the casing mandrel and actuated by a fluid pressure asserted on the valve assembly.

14. The tool assembly of claim 9, further comprising:
a packing element journaled about the casing mandrel and actuated by a fluid pressure asserted on the valve assembly.
15. The tool assembly of any one of claims 9, 11 or 14, wherein the at least one wire has a yield point greater than the yield point of the casing mandrel.
16. The tool assembly of any one of claims 8 to 15, comprising a single helical slot oriented with a single helical groove.
17. The tool assembly of any one of claims 8 to 16, further comprising a casing coupled to the casing mandrel.
18. An inflatable packer comprising a tool assembly as claimed in any one of claims 8, 10 or 11, wherein the tool is an inflation mechanism, and further comprising:
an inflatable element journaled about the casing mandrel and coupled to the inflation mechanism; and
seals disposed between the casing mandrel and the inflatable element.
19. An inflatable packer comprising a tool assembly as claimed in claim 9, wherein the tool is an inflation mechanism, and further comprising:
an inflatable element journaled about the casing mandrel and coupled to the inflation mechanism; and
seals disposed between the casing mandrel and the inflatable element.
20. An inflatable packer as claimed in claim 19, wherein:
the casing mandrel comprises a generally cylindrical wall defining an internal bore through the length of the casing mandrel, with a first flow port extending through the wall of the casing mandrel;
the inflation mechanism comprises a valve apparatus having a flow passage aligned with the first flow port; and
the inflatable element is expandable in response to increased pressure in the valve apparatus.

21. A downhole packer comprising a tool assembly as claimed in any one of claims 8 to 11, wherein the tool is a setting element, and further comprising a packing element journaled about the casing mandrel and coupled to the setting element.
22. A mechanical coupling between a casing and an isolation, production, or testing tool installed on the casing, the coupling comprising:
- at least one indent in the casing outer wall;
 - at least one indent in an inner surface of the tool; and
 - a wire radially located in the indent in the casing outer wall and in the indent in the inner surface of the tool to resist movement of the tool relative to the casing.
23. A mechanical coupling between a casing and an isolation, production, or testing tool installed on the casing, the coupling comprising:
- at least one semi-circular groove in the casing outer wall;
 - at least one semi-circular groove in an inner surface of the tool; and
 - a plurality of bearings located at least partially in the groove in the casing outer wall and located at least partially in the groove in the inner surface of the tool to resist movement of the tool relative to the casing.
24. A tool assembly comprising:
- a casing;
 - a casing mandrel coupled to the casing;
 - a valve assembly journaled on the casing mandrel;
 - a slot on an outer wall of the casing mandrel;
 - a groove, at least partially annular, on an inside surface of the valve assembly oriented with the slot; and
 - at least one lock situated in the slot and the groove.
25. The tool assembly of claim 24, wherein the at least one lock comprises a plurality of bearings.
26. The tool assembly of claim 24, wherein the at least one lock comprises at least one mechanical key.

27. A tool assembly comprising:

- a casing;
- a casing mandrel coupled to the casing;
- a valve assembly journaled on the casing mandrel;
- a slot on an outer wall of the casing mandrel;
- a groove, at least partially annular, on an inside surface of the valve assembly oriented with the slots; and
- at least one wire situated in the slot and the groove.

28. The tool assembly of claim 27, further comprising: a packing element disposed on the casing mandrel and actuated by a fluid pressure asserted on the valve assembly.

29. The tool assembly of claim 27 or 28, wherein the at least one wire has a yield point greater than the yield point of the casing mandrel.

30. The tool assembly of any one of claims 27 to 29, wherein there are a plurality of slots, and a plurality of grooves oriented with the slots.

31. The tool assembly of any one of claims 27 to 30, wherein there is a single helical slot oriented with a single helical groove.

32. An inflatable packer comprising:

- a mandrel;
- an inflatable element journaled around the mandrel;
- seals disposed between the mandrel and the element;
- an inflation mechanism disposed on the mandrel and coupled to the inflatable element;
- at least one retention groove between the mandrel and the inflatable element; and
- at least one locking element disposed in the retention groove.

33. An inflatable packer comprising:

- a mandrel having a generally cylindrical wall defining an internal bore through the length of the mandrel;
- a first flow port extending through the wall of the mandrel;

a valve apparatus installed about the mandrel, the valve apparatus having a flow passage aligned with the first flow port;

an element journaled about the mandrel, the element being expandable in response to increased pressure in the valve apparatus;

at least one set of corresponding grooves in an outer surface of the wall of the mandrel and an inner surface of the valve apparatus; and

at least one wire situated in the at least one set of corresponding grooves.

34. A downhole packer comprising:

a mandrel;

a packing element disposed on the mandrel;

a setting element disposed on the mandrel;

at least one groove between the mandrel and the setting element; and

at least one locking element disposed in the groove.

FIG. 1

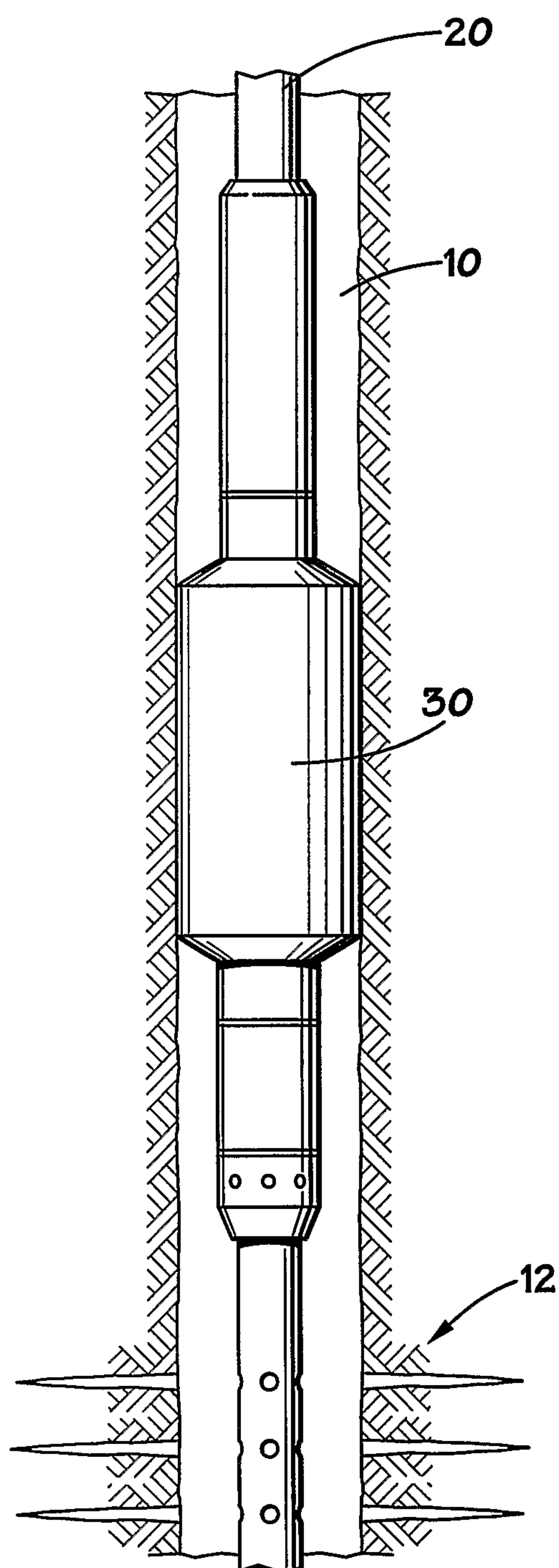


FIG. 3

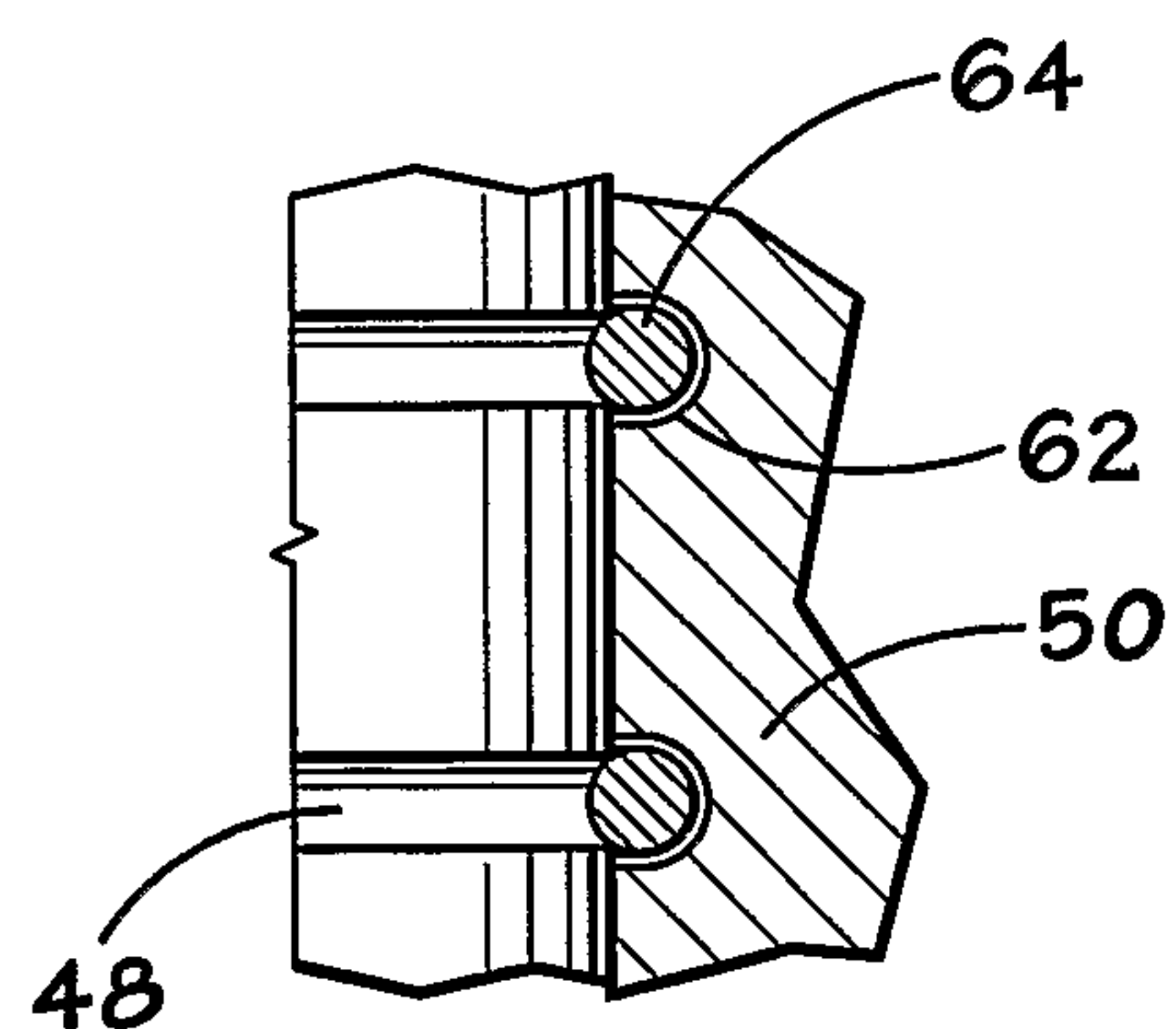
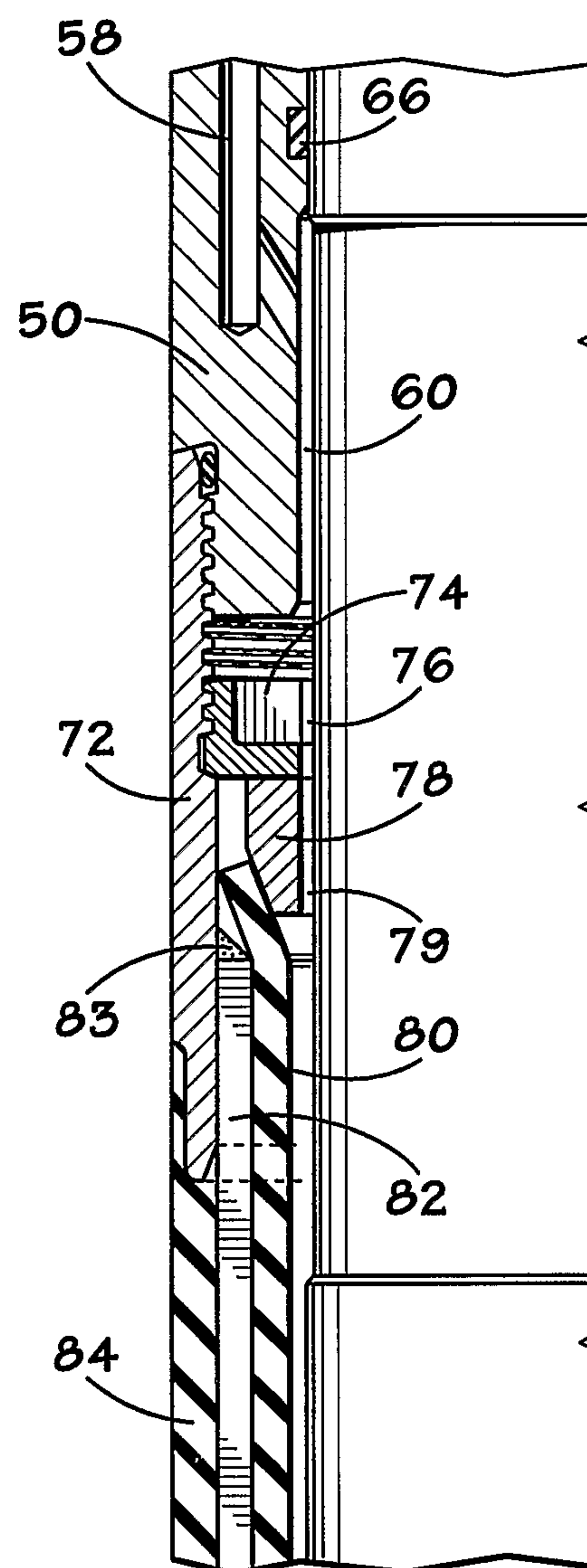


FIG. 4

